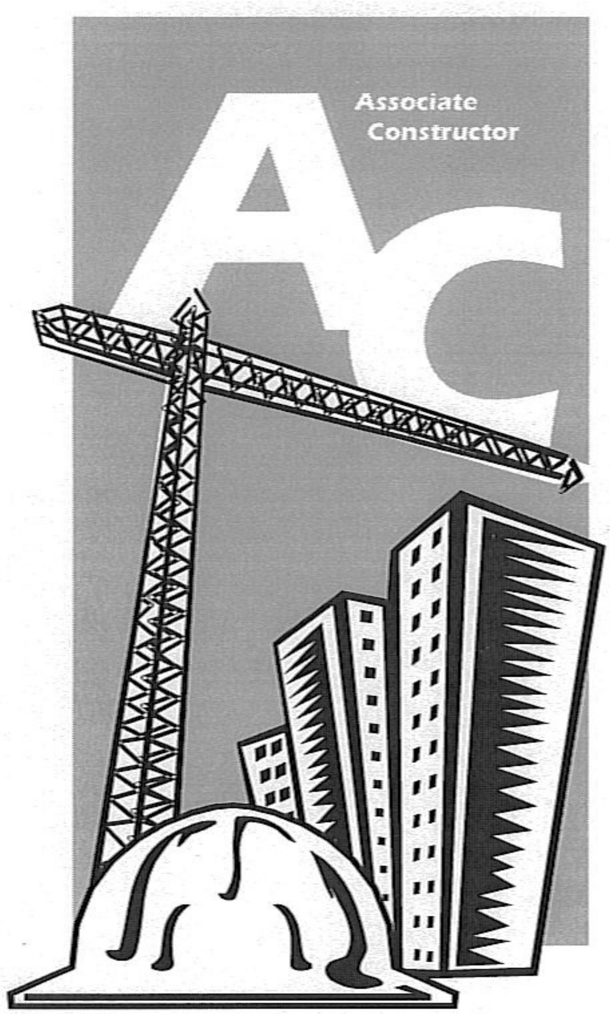
American Institute of Constructors
Constructor Certification Commission



ASSOCIATE CONSTRUCTOR STUDY GUIDE

LEVEL 1 - CONSTRUCTION FUNDAMENTALS

A Review for the
Construction Fundamentals Examination

Revised and Printed May 11, 2005

The following study materials on the examination topics are suggested to assist in preparation for the Associate Constructor (AC) Level 1 - Construction Fundamentals Examination. Candidates are encouraged to review these materials, as well as other related sources of information.

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LEVEL 1 - CONSTRUCTION FUNDAMENTALS

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ASSOCIATE CONSTRUCTOR EXAMINATION

Examination Qualifications for the Associate Constructor

To qualify for the Associate Constructor, an individual must have completed four (4) years of Acceptable Education from an accredited institution and/or have Acceptable Experience Equivalence at the time of application. The standard for the educational requirement is based on a four-year baccalaureate degree in an accredited construction program. Thus a graduate from one of these programs will receive four (4) years of credit toward qualifying for the Level 1 Construction Fundamentals Examination. Other undergraduate and graduate degrees and acceptable work experience will receive varying amounts of credit toward meeting the four-year pre-qualification requirement for the Level 1 Examination.

Specific information concerning the qualifications necessary to sit for the Level 1 Construction Fundamentals Examination can be found in the Certified Professional Constructor Candidate Handbook, published by the AIC Constructor Certification Commission.

Associate Constructor Examination Objectives
The Level 1 Construction Fundamentals Examination is designed to measure the broad spectrum of fundamental construction knowledge required of an entry-level professional constructor. The orientation of this examination is toward the measurement of academic knowledge expected of the entry-level constructor professional. While applied knowledge questions are included, the applications are relatively basic and do not rely on extensive experience to answer.

Passing the Level 1 Construction Fundamentals Examination Documentation
Upon passing the Level 1 Construction Fundamentals Examination, The Associate Constructor (AC) designation is awarded. Before receiving your Associate Constructor Certificate and card, you must have an Official Transcript indicating your graduation date sent directly to the AIC Constructor Certification Commission office immediately upon graduation. This should be done within sixty days after graduation.

The Level 1 Examination Content Areas

The Level 1 Construction Fundamentals Examination is a two-part written examination composed of a maximum of 300 multiple-choice, objective questions and several writing samples with a total testing time of eight (8) hours. The questions for the examination are obtained from individuals with expertise in construction and they are reviewed for construction accuracy by the AIC Constructor Certification Commission.

The Construction Fundamentals Examination consists of ten major subject areas or content areas. The number of questions in each subject area is determined from data derived from validation studies on relative frequency of use and importance of the knowledge tested. The approximate percentage of questions for each of the ten subject areas is shown in the following table.

CONSTRUCTION FUNDAMENTALS EXAMINATION	
Approximate Percentages of Subject Areas	
Subject Area	% of Questions
Communication Skills	6.0%
Engineering Concepts	9.0%
Management Concepts	4.5%
Materials, Methods and Plan Reading	10.5%
Bidding and Estimating	15.0%
Budgeting, Costs and Cost Control	11.0%
Planning, Scheduling & Schedule Control	17.0%
Construction Safety	8.0%
Construction Surveying and Project Layout	4.0%
Project Administration	15.0%

Level 1 Construction Fundamentals Study Guide

Detailed Content Outline for the Level 1 Examination

The ten subject areas of the examination specification have been further broken down into its component parts to clarify the level of understanding expected. The following information provides the name of each subject area, the subject area percentage, a written description of the focus for each subject, an outline of the content in each subject area with bullets emphasizing the objectives and the level of understanding expected for the Level1 Construction Fundamentals Examination.

I. Communication Skills 6%

This section focuses on the application of oral, written communication skills, listening skills necessary to enhance the communication process. The oral communication section focuses on defining different forms of communication. The written communication section contains writing business letters and memos. These writing situations will be evaluated based upon the following criteria: Followed the directions, provided a clear purpose, addressed the audience, developed coherent paragraphs, supported your claims with concrete examples, contained statements that are logical, contained proper sentence structure, grammar and spelling and selected the proper words.

A. Oral Communication

1. Presentations, Telephone and Listening
    - Identify effective Oral Communication practices.

2. Written Communications

1. Business Letters
    - Write a formal Business Letter with proper grammar and spelling.

2. Memorandums
    - Write a Memo with proper grammar and spelling.

3. Job Diary
    - Identify the content and legal requirements for an effective diary.

4. Construction Reports
    - Read information and a complete Construction Report accurately.

II. Engineering Concepts 9%

This section concentrates on the properties of engineering materials, soil mechanics, concrete formwork design and applied mechanics, air mechanics and fluid mechanics. These areas are described in detail below.

Material Science. The study of the physical properties of aggregate, concrete, structural steel, and wood.

Soil Mechanics. The study of the soil properties, laboratory testing methods, soil investigation testing methods, compaction methods, and the soil boring reports.

Formwork Design and Applied Mechanics. The design of concrete formwork components for walls and elevated slabs. Using the American Concrete Institutes, *Formwork for Concrete* book. The study of the effects of static, dynamic forces and motion on materials. Examples include loads and spacing of formwork and beam loads.

Air and Fluid Mechanics. This area covers psychrometry and hydrology. Psychrometry is the study of properties of air-water mixtures. Hydrology is the study of the pressure and flow of water.

A. Engineering Material Properties

1. Aggregate
   - Describe the weight, gradation, strength, permeability and uses.
2. Concrete and Reinforcement
   - Identify the weight, compressive strength, air entrainment, ASTM, workability, Portland Cement properties, water-cement reaction, admixtures, mixing, placement and testing methods, and curing.
3. Masonry
   - Describe the Types of Mortar, workability, compressive strength, proportions, sizes, types of masonry units, efflorescence, bond beam, pilaster, expansion joints, corbeling, coping and methods.
4. Steel
   - Defines the structural shapes and symbols, types of connections, tensile strength, reinforcing bar sizes, heat treatment, and placement methods.
5. Wood
   - Cites species, strength properties, compression, bending stress, shear, lumber classification and grading, grain effect, board foot, moisture content, plywood and plyform properties, plywood grades, nominal dimension, glued laminated wood and fasteners.

B. Soil Mechanics

1. Soil Composition, Types and properties
   - Identify soil properties, name laboratory testing methods.

2. Soil investigation testing methods and Soil Borings.
   - Describe Soil sampling methods, standard penetration tests (SPT), determine the water table and the penetration resistance level from the soil borings and compare to a standard soil classification chart.

3. Types of Foundations
   - Identify strip foundation, spread footing, continuous footing, mat foundations, pile foundations and types of piles and caissons.

4. Field Soil Identification Methods
   - Describe plasticity test, dry test, thumb penetration test, pentrometer, and unconfined compressive strength.

5. Volume Changes and Compaction Methods
   - Calculate swell percentage, shrinkage percentage of various soils, define optimum moisture content, compare standard proctor and modified proctor testing methods.

C. Mechanics and Strength of Materials

1. Formwork Design
   - Calculate a formwork load on walers, studs, and ties, determine the spacing of walers, studs and ties
2. Beam Loads
   - Calculate beam loads.

D. Air and Fluid Mechanics

1. Psychrometry
   - Determines atmospheric air properties and the relationships between them such as Absolute humidity, Relative humidity, Humidity Ratio, Dry Bulb Temperature, Wet-Bulb Temperature, Enthalpy, Saturation Temperature, and define BTU.
2. Hydrology
   - Calculate wetted perimeters and determine a cross-sectional flow rate of fluids.

III. Management Concepts 4.5%

This content area examines the contract formation principles, types of business entities, accounting principles and financial ratios, management systems and business ethics including the Constructor's Code of Ethics.

A. Contract Types
   1. Elements of a Contract
   2. Lump Sum
   3. Unit Price
   4. Design Build
   5. Cost Plus
      - Identify various types of contracts such as Design/Build, unit price, cost plus, lump sum, identify the elements of a contract.

B. Business Entities
   1. Sole Proprietors
   2. Partnerships and Joint Ventures
   3. Corporations and LLC
      - Describe business entities such as a corporation, partnership, a joint venture, sole proprietor, limited liability corporation.

C. Accounting and Financial Systems
   1. Accounting Principles
   2. Financial Reports and Ratios
      - Interpret accounting, determine assets, liabilities and owner equity, calculate forms of depreciation, and calculate financial ratios.

D. Management Systems
   1. Total Quality Management
   2. ISO 9000 and Statistical Process Control
   3. Partnering
      - Define TQM, ISO, partnering, and Statistical Process Control

E. Business Ethics
   1. Constructor's Code of Ethics
   2. Bidding, Purchasing and Professional Practice
      - Describe ethical practices from the Constructor's Code of Ethics.
      - Identify the proper procedure for handling ethical situations.

IV. CSI Materials, Methods, Plan Reading, Specification 10.5%

This section is the interpretation of plans and schedules of the materials and methods found in the sixteen Construction Specifications Institutes (CSI) Divisions. This section focuses on the entire construction process including the ability to read civil, architectural, structural, mechanical and electrical schedules and plans. Another objective is the ability to identify which CSI Master format Division and Section number contains specific items.

A. Construction Equipment
1. Piling Equipment
2. Sheet Piling, Cofferdams, Tie-backs
3. Excavation Equipment
4. Compaction Equipment
5. Cranes and Lifting Equipment

- Selects proper construction equipment for based upon sling angles and boom angles, lifting capacity and the type of soil and determine the compaction depth.

B. Plan and Schedule Reading
1. Sitework
2. Concrete, Forms and Rebar
3. Structural Steel
4. Carpentry
5. Exterior Finishes
6. Doors and Windows
7. Interior Finishes
8. Mechanical
9. Electrical

- Read site layout plans, find reinforced concrete rebar requirements from the schedules, identify mortar and mix design principles, identify the structural steel components from the schedules, describe the door and window requirements from the schedules, determine the interior finish specified from the plans and schedules, identify the plumbing requirements from the schedules, determine the HVAC requirements from the schedules, read the electrical diagram, determine the power requirements, and identify the panel box circuits, determine the lighting needs, and describe the communication requirements from the schedules.

V. Bidding and Estimating 15%

This section focuses on the entire bidding process including the ability to identify appropriate codes, site conditions, perform quantity takeoff, calculate equipment productivity, calculate total material's costs from components, generate total estimated costs, and develop area and future cost estimates.

A. Bidding Process
   1. Bid Documents
   2. Scales
   3. Types of Specifications
   4. Laws, Regulations, and Codes
   5. Site Evaluation and walk-thru
   6. Insurance and Bonds
   7. Value Engineering and Life cycle Costing
   8. Temporary Site Layout

   - Define bidding terms such as conceptual estimate, detailed estimate, addenda, alternates, contingencies, allowances, identify appropriate codes, define performance specs, method, specs, proprietary of specifications, identify site conditions, defines bond and insurance requirements, calculate a bond premium, determine life cycle costs, and identify value engineering principles.

B. Estimates
   1. Conceptual
   2. Total Future Costs
   3. Material Components
   4. Equipment Productivity

C. Quantity Takeoff
   1. Excavation
   2. Forms, Rebar and Concrete
   3. Rough Carpentry
   4. Interior Finishes

   - Perform quantity takeoff for excavation, concrete, rebar, rough framing, formwork, roofing and painting, calculate labor and equipment productivity, calculate total material costs from components, analyze subcontractor bids, generate total estimated costs, develop area and future cost estimates.

VI. Budgeting, Costs and Cost Control 11%

This section concentrates on the complete cost control process including the ability to compute the budget, develop a work breakdown structure, calculate productivity rates, prepare cost reports and forecast expenditures at completion.

A. Budgeting

1. Work Breakdown Structure

- Compute the budget, define a work breakdown structure, identify project control methods.

B. Cost Control

1. Productivity Rates and Earned Workhours

- Calculate productivity rates, determine total workhours budgeted and actual, compare a budget rate to the actual rate, generate the number of days, calculate labor, material and equipment unit costs

2. Labor Unit Costs

- Calculate labor unit costs, determine total labor costs budgeted and actual, compare budget labor unit costs to the actual labor unit costs, generate the number of days, calculate labor, material and equipment unit costs

3. Forecasts at Completion Gains and Losses

- Calculate forecasted cost at completion for labor, materials and equipment and determine gains or losses in labor, material, subcontracts and equipment.

C. Progress Costs

1. Retainage
2. Back charges
3. Payments

- Define retainage and back charges, determine progress payment and final payment procedures.

VII. Planning, Scheduling and Schedule Control 17%

This section is concerned with the overall scheduling process including the ability to distinguish design, procurement and construction in order to establish a project plan showing the logical sequence of activities and their estimated time durations. Also, this section focuses on the ability to crash a schedule, determine the impact, and identify an alternative plan of action.

A. Logical Sequences of Design, Procurement and Construction

1. Multi Crew, Phase Durations, Activity Durations and Effective Durations

- Distinguish design, procurement and construction activities, identify logical sequences of activities, estimate activity time durations, determine effective (actual) durations using multi-crews

B. Event Times, Calculations, and Scheduling Terminology

1. Leadtime, Forward Pass, Backward Pass

- Identify design and leadtime activities, define fast tracking, describe critical activities and near critical activities, describe crashing, describe ES, EF, LS, LF, define total float, free float, and describe job acceleration.

2. Total Float, Free Float, ES, EF, LS, LF, Critical Path(s), Completion Time

- Calculate event times using forward and backward pass procedures, determine floats, identify the critical path(s).

C. Schedule Analysis

1. Crashing and Impact

- Crash a schedule and determine the impact, describe methods to update /revise the schedule and identify an alternative plan of action.

VIII. Construction Safety 8%

This section centers on the construction safety standards including the ability to interpret the OSHA construction standards, establish safety and health procedures on the job site, perform hazard analysis and enforce safety procedures.

A. OSHA Administrative Requirements
   1. EMR
   2. General Duty Clause
   3. Site Procedures, MSDS
   4. Competent Person and Due Diligence

      - Describe the general duty clause, define hazard analysis, describe EMR, identify the criteria of a competent person, define MSDS, and describe due diligence.

B. Standard Safety Procedures
   1. Handrails
   2. Ladders
   3. Fire Extinguishers
   4. Excavations set backs, travel distances
   5. Recordkeeping and Employee Posters

      - Identify standard safety procedures for hand rails, ladder extensions, ladder angle or horizontal distance, fire extinguisher travel distance, excavation spoil setback, excavation horizontal travel to exit, determine standard employee recordkeeping and posting procedures, describe proper safety and health documentation and inspection procedures.

C. Safety Procedures Interpretation
   1. Sloped and Shored Excavations
   2. Scaffolding
   3. Personal Protection Equipment
   4. Electrical Protection

      - Interpret the OSHA construction safety standard requirements for sloped and shored excavation, scaffolding, personal protection and electrical protection.

IX. Surveying and Project Layout 4%

This section concentrates on the ability to establish distances and elevations from established points, the setup of an instrument, the layout of the project and interpret the topography map.

A. Equipment
   1. Tapes, Plumb Bobs, level, transit, laser, Batter Boards

      - Describe the purpose of different types of surveying equipment.

B. Topography Map
   1. Contours

      - Read a topography map, calculate cut/fill volumes, and interpret site information.

C. Calculations
   1. Horizontal Distances

      - Calculate distances using trigonometry functions, convert measurements.

   2. Vertical Control Elevations

      - Calculate height of the instrument, determine total elevations, calculate invert elevations and inverted rod readings.

X. Project Administration 15%

This section is concerned with the overall field administration at the construction site including developing a site plan, evaluating vendors and subcontractors and their progress payment requests, writing field purchase orders and maintaining field records, such as purchase orders, change orders, subcontract agreements, shop drawings, as built drawings, daily job diaries and construction reports.

A. Procurement of Resources
   1. Subcontractors
   2. Materials
   3. Equipment

      - Identify the procurement process, define purchase orders, define UCC rules, explain a bill of lading, identify discount terms, state subcontractor procedures.

B. Duties and Responsibilities
   1. Construction Management and Engineering Job Descriptions
   2. Organizational Chart
   3. Design, Procurement and Construction Team

      - Determine the duties and responsibilities of the owner, A/E, inspector, utility company, contractor, subcontractor and vendors.

   4. Craft trade Descriptions

      - Identify duties and responsibilities of the construction crafts.

C. Job Site Administration

1. Site Layout Considerations

   - Identify the location of the field office, temporary facilities and storage areas at the project

2. Shop Drawing, Product Data Submittal and Review Process

   - Describe shop drawing submittal procedures, claims procedures, change procedures, dispute resolution methods, substantial completion procedures, an occupancy certificate and state the project closeout procedures using AIA General Conditions and/or the EJCDC General Conditions.

3. Contract Clauses, Changes, Claims, Dispute Resolution Methods

   - Define Notice of Award, Notice to Proceed, Stop Work Orders, Stop Work Notices, Schedule of Values, Sworn Statements, contract Change Orders, Change Directives, Minor Changes and Extra Work Orders, Certificate of Substantial Completion.

   - Using Standard Construction Documents such as AIA or EJCDC General Conditions and Advertisement to Bidders, Instructions to Bidders, Information Available to Bidders, Supplementary Conditions, General Requirements (01) and the Technical Specifications (02 -16) based upon the CSI Master Format. Name the specific document which contains common clauses for the contract administrative procedures, insurance requirements, insurance coverages, temporary facilities, and project closeout procedures.

4. Quality Control, Inspection and Regulations

   - Identify material quality control procedures, inspection procedures and government regulations.

D. Project Records

1. Human Resources

- Determine the content of meeting documentation, identify meeting leadership skills, identify employment law requirements, define team work, recognize effective public relation techniques.

2. Project Documentation

- Cite appropriate content for agenda and minutes.

E. Project Closeout

1. Punch Lists, Substantial Completion, Occupancy

2. Documentation Turnover

3. Final Payment and Final Completion

- Define a punch list, identify the owners' documentation necessary to closeout a project, and compare substantial completion and final completion.

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EXAMINATION PREPARATION AND EXAM TAKING STRATEGIES

How to Prepare for the Examination

1. Familiarize yourself with the examination process.
   Determine how long the examination will be and what kinds of questions will be on it. Ask which concepts are most important, which content to focus on, and what you will have to do on the examination. Your aim is to determine both the content of the questions and the type of memory and intellectual skills you will be asked to use. These skills include the following.

   Comparing, contrasting, and otherwise interpreting meaning in the information.

   Applying principles and theories to solve problems. These may not be explicitly covered.

   Predicting possible outcomes given a set of variables.

   Evaluating the usefulness of certain ideas, concepts, or methods for a given event.

2. Establish an overall study schedule to review all the work to be done.
   On the basis of your familiarity with the examination content, make a list of all the tasks you must complete to prepare for it. Given what topics you expect to be most important on the test, set priorities among your study tasks and plan to do the most important ones first. In scheduling your test preparation work, maintain your own routines.

Associate Constructor Material Mastery

The Level 1 Construction Fundamentals Examination is designed to measure the broad spectrum of fundamental knowledge required of an entry-level professional constructor. This examination is designed to make you think independently - do not count on recognizing the correct answer. Instead, prepare yourself to make a fine discrimination to determine the “correct answer”. In other words, the incorrect choices are all plausible answers, one is just the correct answer for the situation encountered.

You know you have mastered the information if you can complete the following tasks.

1. Distinguish the ways in which facts, concepts, principles, procedures etc. differ from each other. Also, you should be able to categorize according to the ways these are similar.

2. Answer the questions and solve the problems in the reference material.

3. Create your own questions.

4. Evaluate specific situations and identify the ideas, concepts, principles or procedures.

5. Predict the best possible outcome given a set of correct options.

Examination Preparation - Months Prior to the Examination

1. Familiarize yourself with the examination content areas.

2. Identify your strengths and weakness in each content area of the examination.

3. Study each content even if it is a strength to recognize other approaches to the content.

4. Acquaint yourself with the examination process. An 8-hour examination consisting of two four-hour sessions and the demands placed upon you.

Examination Preparation - The Day Before the Examination - Relieving the Anxiety

1. Set out all necessary materials to bring with you to the test center (your letter, photo identification, a calculator with fresh batteries, your watch, a snack, some water, and of course, plenty of extra number 2 pencils. The use of a calculator with trigonometry functions is permitted as long as it is non-printing, non-programmable, and it does not have an alpha keyboard.

2. Make sure you have arranged a ride to the testing location and know where it is.

3. Eat a good meal prior to the examination, exercise to reduce tension and stimulate thinking and take a shower to help you relax.

4. Allow enough time to arrive at the designated location without hurrying.

5. Provide yourself with time in the classroom to relax and compose yourself.

Items Allowable Inside the Examination Site

The only items allowable in the examination center are a Calculator with Trigonometry functions. This is essential but the calculator must be non-programmable, non-printing, and it cannot have an alpha keyboard. The only other items allowable are #2 pencils with an eraser.

Examination Preparation - The Day of the Examination

1. Bring all necessary materials with you to the test center (your letter, photo identification, a calculator with fresh batteries, your watch, a snack, some water, and of course, plenty of extra number 2 pencils). The use of a calculator with trigonometry functions is permitted as long as it is non-printing, non-programmable, and it does not have an alpha keyboard.

2. Eat a good breakfast.

3. Arrive early so you can have enough time to compose yourself.
   - If you're early, don't discuss the test with other candidates. Their concerns and worries will increase any anxieties you might have.
   - If you're late, you may miss important verbal directions. Arriving late also makes you feel anxious. If so, take a minute to relax and organize your thoughts.

4. Reference your notes to the test question number on the paper provided in the booklet.
   - Find the formula page(s) and paper provided in the booklet.

5. Preview the entire examination. Estimate the amount of time to spend on each item.

6. Read all directions slowly and carefully. Many candidates ignore the directions. However, directions often state information you need to receive full credit. They also provide information about the way answers should be marked on the scantron sheet.
   - Underline key terms and steps in directions and in the test item.

7. Answer the easiest questions first. This builds your confidence and triggers your memory.

8. Answer every question, even with a best guess as you go. Place a mark next to the questions you are not sure of and review later.

9. Change answers ONLY if you are sure they are wrong.

10. Work at you own pace. Don't be concerned about others. They may be just guessing.

11. If time permits, review all of your answers. Verify that you marked all responses.

Examination Strategies - During the Examination

1. Maximum your chances of passing the examination by maximizing your effort.
   Don’t spend too much time on one question. If, you don’t know the answer to a question, mark it, go on to the next question, and return to those difficult questions if time permits.

2. If a question is presented in a context you are unfamiliar with, do not assume that you cannot answer the question due to its context. The application problem presented in the question will probably be applicable to all types of projects. For example, if the question focuses on a problem at a hospital, and you have never done a hospital project, DO NOT PASS OVER the questions.

3. Fill out the answer sheet carefully and keep track of where you are in the test at all times.

4. Don't spend too much time on one question.

5. Guess wisely, eliminate choices.

6. Try to relax, keep things in perspective.

7. You are allowed to leave the room and go to the bathroom with a pass. Only one person is allowed out of the room at a time and they will be monitored.

Multiple-Choice Test Questions
The Level 1 Construction Fundamentals Examination maximum score is 300 point which consists of 293 multiple-choice questions and several writing activities worth a maximum of 7 points. These writing activities are designed to test your ability to solve construction-related problems. Each multiple-choice test questions consist of 2 parts. They are called the Stem and the Response Options and they are.

The *stem* is the statement or question.

The *response options* are the four-choices for each stem.
The four responses contains *one correct response* and *three distractors or plausible distractors*. The key word here is *plausible* which means reasonably persuasive at first sight with a hint of a possibility of not answering the question being asked. These are considered the incorrect responses which do not receive any credit.

Question Strategies - Selection of the Best Response

These multiple choice questions are used to test your ability to understand fundamental construction information. Therefore, some helpful hints are provided below.

1. Read the stem as if it were an independent, free standing statement. Anticipate the phrase that would complete the thought expressed, then evaluate *each* answer choice against your anticipated answer. It is important that you read each option, even if the first choice matches the answer you anticipated because there may be a *more plausible or better* response.

2. Read the stem together with each answer choice as if it were a true-false statement. If the answer makes the statement a false one, cross it out. Mark the choices that complete the stem as true. Suspend judgment about the true choices until you have read all the options.

3. Beware of words like *not, but, except*. Mark these words because they specify the direction and limits of the answer.

4. Watch out for words like *always, never,* and *only* . These must be interpreted as meaning all of the time, not just 99% of the time. These options are frequently incorrect because there are few statements that have no exceptions.

5. If there are two or more options that could be the correct answer, compare them to each other to determine the differences between them. Then, relate these differences with the stem to deduce which of the responses is the best response or the most complete.

6. Make an educated guess by eliminating the options that you know are incorrect.

7. Test questions which ask for the best answer requires you to make a fine discrimination. The best approach if you don't know the answer to is to apply the following strategies.

    A. Examine the responses for partially false statements.

    B. Consider the responses which are more general and eliminate.

    C. Look for statements which are false or impossible.

COMMUNICATION SKILLS

Effective Written Communication Skills

These are an essential skill in the construction industry. As technology and construction projects become more complex, and our work force more diversified, more companies are being taken to court for their poor writing correspondence, contracts and instructional materials. Therefore, all correspondence must be clear, accurate, and brief. This section will discuss the purpose and intent of formal business letters and memorandums.

There are two basic written forms of communication. They are the formal business letters and the memorandum. The business letter is utilized between individuals who work for different companies such as the Owner and Contractor or the Architect and the Contractor. The memorandum is used to correspondence within a company.

Memorandums

A *Memorandum* is a form of correspondence utilized with a company. This form of communications is usually a less formal type of communication. These are primarily utilized to advise people of procedures, procedural changes, a disciplinary issue or to clarify existing procedures. A memorandum contains the date, the To: the name of the primary receiver(s), the From: the person sending the memo, the intent of the correspondence with the Job number, and carbon copies. An example of a Memorandum is shown below.

MEMORANDUM

Date : August 19, 20 _ _

To : Jim Angelo, Project Manager Contractor, Inc

From : Jim Bow, Superintendent

Hello Steve:

I sent a letter to Steve Blume, the Architect with Brayton AEC concerning the concrete mix design submittal required from Western Concrete through their subcontractor LA Testing.

Mr. Blume stated that the concrete mix design must be based upon an Air Entrainment method. He also said that the design must be submitted before August 25, 20_ _ addressed to his attention. He will review and determine the adequacy of the design. We must have his approval prior to the pouring of any concrete.

cc : File

Business Letters

Business Letters are formal forms of communication which contain the date, name and address of the sender, the name and address of the receiver, the intent of the correspondence with the Job number, a formal introduction, a salutation and carbon copies. Below is an example of a formal business letter.

Contractor, Inc

12909 Royal Road	Big Rapids, MI 49307	(231) 591-2370

August 19, 20_ _

James Bow, Superintendent

Steve Blume, Architect
Brayton AEC
P.O. Box 224, 001 Maple Street
Big Rapids, MI 49307

RE: Jobsite, USA
Project Number 001

Dear Mr. Blume:

This is to confirm our telephone conversation on August 18, concerning the concrete mix design criteria that will be utilized on the Jobsite, USA project. You stated that the L.A. Testing company must submit a concrete mix design form based upon an Air Entrainment method before August 25, 20_ _ for your review and approval prior to the pouring of any concrete. I talked with Mike Lineman of L.A. Testing yesterday and he has agreed that the mix design will be submitted to you for your approval on or before August 21. Your response to the mix design prior to August 25, 20_ _ would be appreciated. If you have any question please contact me at (231) 555-2323.

Sincerely,

Jim Bow
Superintendent

cc: Mike Lineman, L.A. Testing
bc: Carl Walker, Western Concrete

Effective Meeting Skills

The purpose of an *Effective Meeting* is to bring together a group of people with a common interest that have relevant knowledge and expertise to accomplish some purpose or goal through a process of group interaction. Therefore, there are two essentials steps in a productive meeting. First, we must carefully preplan the meeting. Second we must provide meeting leadership while conducting the meeting.

The pre planning of a meeting requires the leader to ask several basic questions to clarify the purpose of the meeting, the roles of the group members and the specific tasks that must be accomplished during the meeting. Answering the following questions prior to conducting the meeting will improve your chances of a productive and successful meeting.

1. What do I want to accomplish? You may have a general idea of what must be accomplished, but have you clearly stated your objective? Is the objective realistic and measurable? Are there too many objectives for the meeting and should some of these objectives be accomplished using an informal meeting with the individuals?

2. Are the members attending the meeting really necessary for its success? Many times people are invited as a matter of courtesy this is a waste of their time and their participation may disrupt the objectives of the meeting. Therefore, have you determined who should be there, what their interest is and how they will contribute to the objectives established?

3. What do I need from each person to accomplish the objectives of this meeting? You should know in advance the skills, expertise and knowledge of each person attending the meeting. Therefore, have you determined what expertise they will bring with them? How will this expertise contribute to the tasks or meeting objectives being discussed? Will there be any attitude or personality clashes and what effect will this have on the group decision making process?

4. Have I provided each group member with a descriptive working agenda far enough in advance? A working agenda provides a greater opportunity for the members to focus their attention on the meeting objectives, and to clearly develop ideas and solutions. Therefore to ensure the success of your meeting, have you discussed the topics prior to the meeting for initial input and commitment? Have you identified and discussed with each group member what information they need to have available? Is there any advance preparation the members should do? Can the objectives be met in the time allotted?

A successful meeting requires the leader to set specific, realistic and measurable objectives that can be used to provide satisfaction to the group members when they are accomplished and the ability to reassess their efforts when they are not accomplished.

Some of the most common purposes or goals of a task-oriented meeting are to: plan, make a decision, implement a plan, evaluate, solve a problem, identify a problem, inform, train, build cooperation and commitment or to provide involvement.

Working Agenda Content

The *Working Agenda* should include the following items. Who should attend? When and where should the meeting be held? What is the subject of the meeting? What is the purpose? What are the specific objectives? Have you described each topic in paragraph from outlining who should come prepared? Have you set time frames for each topic? Are the agenda items sequenced properly? The following working agenda will provide you with the format and content:

TO:	Jim, Carol, Ken, Vicki, Keith, Deb	
FROM:	Ed B.	
PROJECT:	Jobsite, USA	PROJECT NO. 001
SUBJECT:	Activities Planned for September 2 - 15	
DATE/TIME:	Wednesday, August 27 from 10:00 A.M. - 11:15 A.M.	
PLACE:	Jobsite, USA in the Conference Room 107	
PURPOSE:	To Identify Potential Problems with the Schedule	
SPECIFIC OBJECTIVES:	Review the Planned Activities Generate Ideas for the Material Delay and Sub Problems	
10:00 - 10:15	CONSTRUCTION ACTIVITIES THAT MUST BE COMPLETED Ed will discuss the completion dates of the activities for two weeks.	
10:15 - 10:30	MATERIAL DELAYS Carol says there will be a two week delay on CU #1 & ACCU #4. Jim will discuss the impact on the erection of the structural steel. Keith will discuss the impact on the electrical and HVAC. Vicki will discuss the impact on the process piping and instrumentation.	
10:30 - 10:45	INCREASE IN CREW SIZES AND AREA RESTRAINTS The structural concrete, steel erection and precast concrete erection are behind schedule. Carol, Deb, and Jim will discuss increasing crew sizes.	
10:45 - 11:00	DESIGN CHANGES We will discuss how these changes will be implemented. There has been a major footing design change to Pier F2. Ken will discuss the completion.	

Meeting Minutes Content

The *Meeting Minutes* should be recorded during the meeting. The minutes should include the Members in Attendance, Members Absent, Date/Time, Place, Agenda Topics, A Summary of the Topics Discussed, Action to be Taken, Names of the person(s) responsible for Implementing and a Time Limit for Completion. The Minutes should be distributed within 24 hours to provide immediate feedback. The following minutes will provide you with the format and content:

SUBJECT:	MINUTES OF THE PLANNING MEETING	
DATE/TIME:	Wednesday, August 27 from 10:00 A.M. - 10:45 A.M.	
PLACE:	Jobsite, USA in the Conference Room 107	
PRESENT:	Carol, Ken, Vicki, Keith, Deb, Ed	
ABSENT:	Jim - Vacation	
PROJECT:	Jobsite, USA	PROJECT NO. 001

CONSTRUCTION ACTIVITIES THAT MUST BE COMPLETED

Ed indicated that the redesigned Pier Footing F2 must be stripped by Sept. 6, all step footings by Sept. 8, and structural steel columns and beams by Sept. 12. Deb indicated that the South wall footing detail is needed. Ed said he would obtain a drawing by Aug. 28 at 10:00 A.M.

MATERIAL DELAYS

Carol indicated that the supplier said that Cooling Unit #1 (ACCU #1) will not arrive at the site until Sept. 27. Ken suggested that we leave an opening in the Roof to drop the unit through. Bob indicated that this will effect the Crane expected to leave the site on Sept. 15. Deb agreed to call and request that the date be extended to Sept. 17.

INCREASE IN CREW SIZES AND AREA RESTRAINTS

Deb and Ken agreed to increase their crew sizes on the structural concrete and steel erection. There will be 10 concrete workers and 6 ironworkers. Due to limited storage Keith and Carol will store their materials and equipment at the Maple Street Building.

DESIGN CHANGES

Carol asked for a Contract Change Order for drawing E3, Revision #7. Ken said that the footing design change to Pier F2 is expected to be complete by Sept. 2.

ADDITIONAL CONCERNS

Deb said that the unloading of deliveries has been extremely difficult, therefore we will implement a daily schedule of times for material arrivals. Ed said he would develop a sign-up sheet by Aug 28.

.

NEXT MEETING: Thursday September 6, at 3:45 PM in Conference Room 107

Pre-construction Meeting Content

Many times the General Requirements (01) state that the contractor must call a *Pre-construction* Meeting normally within 15 days of the Notice to Proceed. This meeting will be attended by the Owner's Representative, Architect, Contractor's Superintendent(s), Major Subcontractors and Suppliers. Therefore, the working agenda should follow the guidelines in the specifications. The working agenda should list the topics and describe the attendance and submittal requirements in paragraph form. The Pre-Construction meeting should cover topics such as List of contacts; Insurance certificates needed with amounts; Planned schedule with expected crew sizes; Material delivery requirements; Submittal dates for Shop-drawings, etc; Permits; Change order procedures; Progress payments; Warranties; Record drawings; Operation and Maintenance manuals; Safety program; Ordinances; Inspections; Site storage; Progress meeting attendance; Underground utilities; Collective bargaining and Prevailing wage requirements.

Meeting Leadership Skills

The *Meeting Leadership* needed to conduct a productive meeting requires the leader to provide group leadership skills in the following areas. The first area is that the leader must *Listen attentively*. One approach you might want to try is to paraphrase in a sentence or two, the major idea presented by the group member. This technique has two advantages. First, you will be better able to understand what others in the group are trying to communicate. Second, your example will encourage others to better understand the ideas presented in the meeting.

The leader must also *Respond constructively to ideas*. This can be done through a technique developed by William Gordon and George Prince, founders of Synectics, Inc., called the Spectrum Approach. The *Spectrum Approach* is designed to encourage group members to build on the contributions of their peers by identifying and correcting noticeable weaknesses in ideas in a positive constructive manner. The Spectrum approach requires a leader to do the following after an idea has been expressed: 1) State what you like about the idea, 2) State what you think are its weaknesses, 3) Provide a suggestion for each weakness and always follow these in sequence. A third area the leader must be cognizant of is to *match their decision-making style to each situation*. Successful leaders make decisions for the group sometimes and other times allow the group to make the decision depending on the situation. The fourth area is the leader must ensure that they *solicit ideas from all group members* and resolve conflicts within the group. A leader must be constantly aware of silence and dominance within the group. This requires leaders to sometimes solicit ideas from the silent members or to politely intervene if one person is dominating the conversation.

Finally, in a meeting, people should be facing each other. All other arrangements have one person doing all of the talking. As a senior member who is relinquishing authority, you should be aware of the power positions in the room such as away from the door, near the blackboard, back to the window. You may want to avoid these positions since they can add immensely to the intimidation factor that you are trying to minimize.

David Hon in his book titled, *Meetings That Matter,* says that "In a Task-oriented meeting, the most important aspect of the meeting should be the productivity that is possible through a group mind" (p 21). He also states that for the group to achieve high productivity they must follow a six step mental sequence for each topic. The leaders responsibility, in a *Task-oriented Meeting*, is to ensure that all activities are covered thoroughly. The leader must also decide which activities to concentrate on with the group. An outline of Hon's six mental activity sequence that should be taken into consideration, for each topic being discussed, is provided below (p 22).

Goal Setting

1. Set the boundaries of the meeting.
2. Solicit ideas from the group without direction.
3. Obtain the groups dedication to the project by letting:
    a. The group feel capable of achieving the results.
    b. Everyone feel they had a chance to shape the goals.

Information Gathering

1. Require that each subordinate have the information necessary to develop the ideas.
2. Summarize the facts, opinions and conclusions to one page and distribute the information to all group members before the meeting.
3. Ask questions such as: "Is there backup data on that?" or "How reliable have those been."

Problem Solving

1. The leader coordinates the group to:
    a. Identify the problem and sort out causes and effects.
    b. Develop a range of solutions from the group.
    c. Sort out best solutions agreed upon by the group.
    d. Restate the best solutions and let someone write them on the board.

Decision Making

1. Inform the group of your decision as soon as possible and thank them for their help.
2. Delegate the activities according to closeness of a members ideas and let the group decide on how to complete the activities.

Action

1. Divide the activities up.
2. Commit to a schedule for each segment.
3. Estimate the materials and equipment required.
4. Sequence the activities.

Coordinating

1. Monitor the progress by establishing milestones and measurable results.

Effective Oral Communication Skills

Some people would say that managing people would require primarily leadership and motivational skills. These skills depend completely on *Effective Oral Communication Skills* because you cannot effectively lead or motivate someone that you cannot communicate with, therefore, managing people means communicating effectively. Communication is defined as the actual exchange of understanding so that the other person behaves in a manner which demonstrates understanding. Whenever contact is made communication occurs, but the meanings embedded in the conversation are in the people not in the words that are exchanged. This means that meanings cannot be transferred from one mind to another, only the words can be transferred. The difficulty is that words have multiple meanings . For example, studies have shown that the 500 most common words in construction have more than 14,000 definitions.

The actual exchange of understanding so that both the sender and receiver understand the message in exactly the same manner after stating it only once is not normal. Therefore, the sender must constantly analyze the situation to ensure that you are communicating effectively and that the message is being understood. Communicating makes up approximately 80% of your time and most of this is done verbally. According to some oral research studies, the research has proven that the *Retention Rate of the Listener* (Receiver) is:

10% of What they Hear

20% of What they Read

30% of What they See and

50% of What they Hear and See

What is even more impressive about the research is that the *Sender remembers*:

70% of What they Say and

90% of What they Say and Do.

This suggests that it is extremely valuable for you to have the listener restate in their own words what they have understood to be the message. In conclusion, if you want to effectively communicate with another person and find out what part of the communication they understood you must execute these things. First, ask open-ended questions and make the words come out of their mouth. Finally, if you are communicating procedures they must be in writing so that the receiver has something to refer to if they are unsure of the steps or the sequence.

Communication Skills Exercise

1. Which of the following documents is utilized for correspondence between the A/E or Owner and the Contractor?

- ○ A. Job Diary.
- ○ B. Memorandum.
- ○ C. Construction Report.
- ○ D. Formal Business Letter.

2. Which of the following documents is used for correspondence between the home office and the job site?

- ○ A. Job Diary.
- ○ B. Memorandum.
- ○ C. Construction Report.
- ○ D. Formal Business Letter.

3. What is the best time to distribute the Working Agenda to the Participants?

- ○ A. As a follow-up to the meeting.
- ○ B. At the beginning of the meeting.
- ○ C. About one day after the meeting.
- ○ D. About one day prior to the meeting.

4. Which document describes the Suggested Agenda for the Preconstruction Meeting?

- ○ A. General Conditions
- ○ B. General Requirements
- ○ C. Technical Specifications
- ○ D. Supplementary Conditions

5. What is the best time to distribute the Meeting Minutes to the Participants?

- ○ A. At the beginning of the meeting.
- ○ B. About one day after the meeting.
- ○ C. About one hour prior to the meeting.
- ○ D. About one day prior to the meeting.

Communication Skills Exercise

6. Which of the following descriptions are the primary content items for the meeting minutes?

- A. To, from, project, date, time place and subject.
- B. Purpose, specific objectives, time frame, topical headings with paragraph, role.
- C. Objective clear and measurable, attendance, role of each person, their expertise.
- D. Attendance, topical headings with paragraph stating person assigned, completion.

7. Which of the following descriptions are the content items for the working agenda?

- A. Plan with goals and specific activities, priority, time needed, scheduled events.
- B. Purpose, specific objectives, time frame, topical headings with paragraph, role.
- C. Activity description, days, information needed crew size, material & equipment.
- D. Attendance, topical headings with paragraph stating person assigned, completion.

8. What is the name of the approach designed to encourage group members to build on the contributions of their peers when responding to an idea in a meeting?

- A. Spectrum Approach.
- B. Task-oriented Approach.
- C. Decision Making Approach.
- D. Listening Attentively Approach.

9. What are the mental activities that must be taken into consideration for each topic during the planning phase of a meeting?

- A. Coordinating, Listening Attentively, Responding Critically, and Soliciting Ideas.
- B. Planning, Timing, Coordinating, Probing, Responding Critically, and Follow-up.
- C. Goals, Gathering, Problem Solving, Decision Making, Action Plan & Monitoring.
- D. Goals, Planning, Scheduling, Priorities, Analyzing, Delegating, and Monitoring.

10. What are the leadership skills needed to conduct a productive meeting?

- A. Planning, Probing Questions, Responding Critically, and Decision Making.
- B. Planning, Timing, Coordinating, Probing, Responding Critically, and Followup.
- C. Listening Attentively, Responding Constructively, Soliciting All Ideas, and Matching Decision Making to the Situation.
- D. Coordinating, Listening Selectively, Responding Critically, Soliciting supportive Ideas and Adjusting Decision Making to the situation.

Communication Skills Exercise

11. Which one of the following is transferred from one mind to another?

- A. Words.
- B. Meaning.
- C. Information.
- D. Understanding.

12. What is the retention percentage of a listener in an oral conversation?

- A. 10
- B. 20
- C. 50
- D. 90

13. What percentage of a conversation does the sender remember of what they say and do?

- A. 10
- B. 50
- C. 70
- D. 90

14. Which of the following communication methods is the most effective in knowing that the communication has been understood?

- A. You the sender should ask closed ended-questions and tell them twice.
- B. You the sender should ask open-ended questions and make them speak.
- C. You the sender should ask how they feel and their attitude toward the activity.
- D. You the sender should tell them what to do and get them back to work quickly.

15. Which of the following is the best example of an open-ended question?

- A. Do you understand what work is suppose to be completed?
- B. Please go to the tool shed and get me a shovel.
- C. What steps are you going to take to complete the activity?
- D. How do you feel about completing the activities assigned?

Check Answers

Evaluation Criteria for a Memorandum

Effective business writing requires the writer to be precise in their word use, clear in purpose, accurate in stating the facts, and always aware of the legal implications of what is being written and recorded. It should be understood that all writing including post-it notes, graphics, or electronic transmissions are considered a business document and every document has the potential to become a public document which is permanent.

A *Memo*, whether they are in paper or electronic form, is used to transmit information within an organization or company, therefore, they must be accurate, correct, and complete. The evaluation criteria for a complete memorandum is shown below.

The Memorandum Format:

- Used correct format with the internal address including the

  (To: From: Date: Subject);

- Contained your initials next to your typed name in paper memos to demonstrate that you have personally reviewed the contents;
- Skipped a line between paragraphs;
- Informed the proper party in a positive light.

The Memorandum Structure:

- Started with a brief statement giving the background and purpose;
- Identified the main points quickly but completely and the memo should include recommendations and rationales.
- Concluded by describing the next step including the people you have contacted, the expected completion date and the person the task has been assigned to.
- Offered to provide follow up or help with implementation.

Finally, The Memorandum must be:

- Proofread and run through spell check and grammar check.

Evaluation Criteria for a Business Letter and E-mail

The *Business Letter* whether they are in paper or electronic form, is used to transmit information to professionals in other companies. Therefore, they must be accurate, correct, and complete. The evaluation criteria for a complete business letter is shown below.

The Business Letter Format:

- Contained the correct date, proper addresses, project address, tracking number, project name/number, salutation, closing, signature and title, cc, bc, enclosure.

The Business Letter Content:

- Contained a professional tone which was complete and correctly stated.
- Referenced the complete scope content items.
- Created and developed a detailed explanation of the individual items and the total impact.
- Referenced all other documents which may impact the decision.
- Requested confirmation and provided numerous contact options.
- Stated acceptance time required to proceed.

The Business Letter Style:

- Used a professional tone.
- Used advanced and correct grammar with sophisticated punctuation, compound and complex sentence structure and proper page design.

The E-mail Format:

- Adopted the same high standards of communication as a business letter.
- Followed the evaluation criteria stated above and proofread your work.

Project Writing Situations Communication Skill Instructions

All of these case incidents utilize this general information concerning the Taggart Building project and the construction company. This is Project Number: 234

Client	Architect	Project Manager
Offices International	Pro Design	Ruse Construction
Keith Corbeil, Owner Rep	Mary Bockstahler, AIA	Ernest Meyer, CPC
676 Bell Street	775 Riverfront ST.	345 Michigan Avenue
Big Rapids. MI 49307	Cadillac, MI 49601	Mount Pleasant, MI 48858
(231) 796-6122	(231) 594-3100	(517) 485- 8535
corbeilk@officesint.com	bocckstahler@prodesign.com	Ernie@ruse.com

The superintendent at the job site is Rick Fornsorg. The phone number at the Taggart job site is (517) 555-1213. Rick's cell phone number is (231) 250- 5555 and his e-mail address is rick@ruse.com. The job site is located seventy five miles from the home office.

ORGANIZATION - Four employees report directly to Ruse: Jeff Skala, Chief Financial Officer; Ernest Meyer, V.P., Estimating/Project Management; Carol Pery, Office Manager; and John Fryberger, General Superintendent.

OFFICERS - Bruce Ruse, President; Jeff Skala, Chief Financial Officer and Treasurer; Ernest Meyer, Vice President; Carol Percy, Office Manager and Secretary.

BOARD OF DIRECTORS - Bruce Ruse, Chairperson; Jeff Skala; Ernest Meyer; John Fryberger, Harley Wallace, Attorney; and Claude Cook, President of Commercial Bank.

PROPERTY - The company owns an office building located outside Manton, Michigan. Ruse Construction also owns a yard where all company equipment is stored. The yard is located across the street from the office. Finally, the company owns or leases considerable equipment including four office trailers for use by its field employees.

Given the Gimpy Case Communication Exercise and the Design Omission Case Communication Exercise, and that these incidents all occurred on the same day at the job site, complete the correspondence appropriate for the incidents described on the following pages. Your written correspondence will be evaluated using the evaluation criteria provided.

Communication Skill Instructions for the Gimpy Case

Case: Gimpy

Participants: Roy Stokes, Laborer (Gimpy)
Stan Jackson, Carpenter
Mike Wards, Carpenter Foreman

Your Position: Job Superintendent - Rick Fornsorg

It's Wednesday August 13 at 10:45 A.M. and everything had been going great until you heard the clatter of shattering glass. You ran to the door to see what had happened. Roy saw you just as you spotted him, and he slowly dropped his raised arm. But he knew you had seen him, and he also knew that you hadn't missed noticing that the front window on the truck was smashed. You didn't even have to tell him to come to the trailer, but as he entered the door his first words were, "It's all Stan Jackson's fault." So you went back to the door and called Stan to come into the trailer.

Almost as soon as Jackson joined you and Roy Stokes, Roy launched into his tale of woe. "I just can't take it any more, Rick. Sure, I threw the rock at Jackson, but a man can just take so much. Everybody's got a breaking point. He wont' leave me alone. Gimpy this, Gimpy that. Gotcha, Gimpy. Hey, Gimpy the eighth dwarf, where's Snow White? I mean, he just doesn't let up."

Before you could get a word out, Stan piped up with his side, "Hey, can't a guy kid a pal? He takes everything so serious. He can't even take a joke. He's getting dangerous! Hell, if I got mad at everybody that kidded me, I'd..."

Additional Information:

1. Roy Stokes hurt his leg in an auto accident about two years ago and ever since has had a noticeable limp.

2. The above incident represents the first time company equipment has been broken as a result of a fight.

3. Neither Stokes nor Jackson have been involved in any fights on the job before.

4. The company has a written policy which says that employees who engage in fighting are subject to dismissal.

Project Writing Exercise for the Gimpy Case

Correspondence

Instructions: Given the Gimpy Case information provided, if anyone else must be informed about this incident, write a brief memo outlining the incident and what action you have taken.

CASE NAME _____Gimpy__

MEMORANDUM

TO:_________________________

FROM:_______________________

SUBJECT: ____________________

DATE: ______________________

PROJECT NAME ___________________

PROJECT NUMBER ________________

____

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Communication Skill Instructions for the Design Omission Case

Case:	Design Omission
Participants:	John Fryberger, General Superintendent Sidewalk Subcontractor
Your Position	Job Superintendent - Rick Fornsorg

Last week you called the surveying firm to set the grade stakes for the curb and gutter. It's Wednesday August 13 at 12:30 P.M. and you have just instructed the sidewalk, curb, and gutter subcontractor on what needs to be done when you notice that the building entrance is about 10 feet higher than the curb and gutter grade. The building is set back from the road about ten feet, therefore a retaining wall is required. You make a note to yourself to check the plans for a retaining wall. You arrive at the job trailer at 1:12 P.M. and you review the plans and find that none of the drawings indicate a retaining wall. You also realize that a retaining wall is along a state business route and it will be required with this much of a change in elevation. Plans for a retaining wall will have to be submitted based upon their standard plan details to the Michigan Department of Transportation (MDOT) and shop drawings must be submitted and approved by MDOT before installation begins. The preliminary design for the retaining wall indicates it will be 12 feet high, 15 inches thick and 100 feet long, with #4 rebar horizontally and vertically. You expected to attain your occupancy permit by next Monday.

As you turn to walk away the curb and gutter subcontractor calls you over and he says "Look at these grade stakes, the slope of the road on each side is different," and you indicate that the surveying firm must have staked the road wrong.

Project Writing Exercise for the Design Omission Case

Correspondence
Instructions: Given the Design Omission Case information provided, write a formal business letter to the Architect on the page provided below. The formal letter is to inform the Architect of this design omission and any impact it may have on the project.

BUSINESS LETTER

ENGINEERING CONCEPTS

Constructors must have a basic understanding of the natural characteristics of materials which are incorporated into the construction process. This information can be obtained from published technical reports and advertising material prepared by suppliers. Some sources of information concerning technical properties of specific materials can be found in these sources.

Sweets Catalog compiles technical construction material advertising literature published by suppliers. It is organized by the Construction Specification Institute's Master Format which is organized by 16 Divisions. *American Society for Testing and Materials* (ASTM) is an organization engaged in the standardization of technical specifications and testing methods. *American Standards Association* (ASA) develops national industrial standards representing manufacturers, technical organizations and government agencies. *Underwriters Laboratories* (UL) is a nonprofit organization which investigates and tests materials, products, equipment, construction methods and construction systems in its laboratories. A UL-APPROVED seal of approval is recognized as a safeguard against hazards to life and property. Many specifications require UL approvals. *Thomas' Register* complies manufacturers' information on various manufactured products.

Engineering Material Properties

The *Materials* most widely used in the construction industry are aggregates, asphalt, Portland cement concrete, masonry, iron, steel and wood. Therefore, a basic understanding of their material properties is reviewed here. The Specifications are developed to provide the contractor with an in-depth description of what materials to use, the characteristics the materials must have, the installation procedures the contractor must follow, the manufacturer's instructions and the inspection and testing procedures that will be utilized to verify the proper installation and strengths. The properties most often considered when selecting materials are outlined below.

Aggregate Properties

Aggregates are particles of random shape and size. They are found in nature as sand, gravel, or rock that can be crushed into particles. Aggregate sizes vary from several inches to the smallest grains of sand. Particles smaller than the size of a grain of sand are considered impurities. Aggregates are normally used as bases placed on top of the soil to uniformly distribute the load over the soil for a footing or road. The qualities that indicate the usefulness of aggregate for the construction industry are the weight, the strength of the particles to resist repetitive freezing and thawing, the strength of the mass to transmit a compressive force, the strength of the individual particles to resist being crushed the strength of the aggregate particles to resist wear by abrasion, the adhesion of the aggregate particles to a cementing agent such as Portland cement or asphalt and the permeability of the mass. Weight is important for large stone used for riprap. *Riprap* is placed at the end of culverts or along the edge of a body of water to prevent erosion. The aggregate quality of resisting weathering is called *soundness* of the aggregate. The aggregate particles at the surface of asphalt or concrete are subject to abrasion from the vehicle wheels. Also, in an asphalt pavement the aggregate particles throughout the asphalt pavement are subject to abrasion because the pavement is continuously shifting under the weight of the vehicles which causes the particles to rub against each other. Finally, *permeability* is a measure of the ease with which water will flow through an aggregate's voids. High permeability is needed if the aggregate is used as a filter or drain.

Aggregate Size and Gradation are important for all construction applications. The most important features are range of sizes and gradation. *Gradation* is the distribution within the range covered. A set of sieves stacked on top of each other is used to determine size and gradation. A sample of the aggregate to be analyzed is placed in the top sieve which has the largest holes. The Sieve sizes commonly used for aggregates in the construction industry and the actual dimensions, the sizes designated in millimeters and inches or fractions of an inch are shown below. The sieve designations indicate the clear openings between wires which are squares with the given dimensions. When a size is given as a number, such as a No. 40 sieve, it means there are that number of holes in a lineal inch. Therefore, the No. 40 sieve has a total of 40 openings per lineal inch and 1600 openings in a square inch. The openings are not 1/40 of an inch in width because the wires take up much of the space. Therefore, the openings are actually smaller but it is an approximate method for estimating opening sizes in inches.

Sieve Designation		Sieve	Aggregate Description
mm	inches	Opening Size in Inches	
	4 inches	4.00	Cobbles above 3inches
75 mm	3 inches	3.00	Coarse Gravels 3" - 3/4"
37.5 mm	1-1/2 inches	1.50	
19.0 mm	3/4 inch	0.75	
12.5	½ inch	0.50	Fine Gravels 3/4 - No. 4
6.3 mm	1/4 inch	0.25	
4.76 mm	No. 4	0.187	
2.36 mm	No. 8	0.0937	Course Sand No. 4-10
1.18 mm	No. 16	0.0469	Medium Sands No 10 - No 40
0.6 mm	No. 30	0.0234	
0.3 mm	No. 50	0.0117	Fine Sands No. 40 - No. 200 Below 200 Silt/Clay
0.15 mm	No. 100	0.0059	
0.074 mm	No. 200	0.0029	

Gradations can be identified on a graph as well graded, uniform, or gap graded. *Well-graded* means sizes of particles within the entire range are in approximately equal amounts. *Uniform* gradation means that a large percentage of the particles are of approximately the same size. *Gap graded* means that most of the particles are of a large size or a small size with very few particles of an intermediate size. The result of a sieve analysis is normally graphed using the percentage retained for each gradation level and plotted on a gradation curve. The shape of the curve provides visual help in identifying the type of gradation. A line nearly vertical indicates that a large quantity of materials is retained on one or possibly two sieves. This is considered a Uniform gradation. A line with a constant slope indicates that approximately the same amount of material is retained on each successive sieve. This is considered a well-graded gradation. A horizontal line or nearly horizontal line indicates that is no change or little change in percentage finer through several successive sieves. This is considered a Gap gradation.

The American Society for Testing Materials ASTM Standard C125 defines various types of aggregates as follows. *Course Aggregate* is defined as aggregate predominately retained on the No. 4 (4.76-mm) sieve. *Fine aggregate* is defined as aggregate passing the 3/8 inch sieve and almost entirely passing the No. 4 sieve and predominately retained on the No. 200 sieve. *Gravel* is a granular material predominately retained on the No. 4 sieve and resulting from natural disintegration of rock. *Sand* is a granular material passing the 3/8 inch sieve and almost entirely passing the No. 4 sieve and predominately retained on the No. 200 sieve. *Bank Gravel* is a gravel found in natural deposits, usually more or less intermixed with fine material, such as sand or clay. Normally referred to as gravelly clay, gravelly sand, clayey gravel, and sandy gravel.

Concrete Mix Properties

Concrete is composed of 60-80 percent aggregates, Sand and gravel, and 20-40 percent of active ingredients which is water and Portland cement. The commonly used aggregates and Portland cement and water normally produces a concrete mixture which weighs 150 - 154 pounds per cubic foot. There are numerous variables that affect the properties of concrete. The ease with which concrete can be modified by its variables can often work to the disadvantage of the user unless quality control measures are followed precisely. The Portland cement when mixed with the water produces a chemical reaction called *hydration* and it forms a bond to other cement particles, to the aggregates, and to any reinforcement that it contacts. Portland cement does not need air to harden or set. The chemical reaction will harden as well under water as well as if it is exposed to air. The heat generated when the Portland cement and water chemically react is called the heat of hydration, and can be a critical factor in the use of concrete.

Portland Cement for individual use is shipped in 90 pound bags. ASTM identifies five types of Portland cement with are produced for different applications as outlined below. Type 1 Portland cement is reasonably resistant to most forms of chemical attack that might occur naturally. A Type II Portland is used where resistance to moderate sulfate attack is important, as in areas where sulfate concentration in groundwater is higher than normal but not severe.

A Type III Portland cement is called a High-Early-Strength because it achieves its specified strength in 7 days rather than in 28 days, but there is also a corresponding increase in the heat of hydration. A Type IV Portland cement referred to as Low Heat is used where the rate and amount of heat generated must be minimized. It is primarily used in large mass placements of concrete such as deep or thick foundations. A Type V Portland cement has high resistance to sulfate attack is important. It is primarily used where the soil or ground water contains high sulfate concentrations.

The *Water/Cement Ratio* determines the strength of Portland cement concrete. This ratio is the most important parameter used to control the compressive strength of concrete. There is a minimum Water/cement ratio required for complete hydration of all the cement molecules. But, an excessive amount of water reduces its strength, hardness, durability and resistance to chemical attack and resistance to freeze-thaw. Thus the construction worker who adds water to the mix to make it more workable is significantly reducing all the desirable characteristics of the finished concrete. All of the desirable properties of the finished concrete, such as durability, hardness, abrasion resistance, etc. are improved as the strength increases.

Air-Entrainment of Portland cements is the process of adding microscopic bubbles of air which are distributed uniformly throughout the mix. Air entrainment provides improved resistance to freeze-thaw and to scaling caused by chemicals and salts used for ice and snow removal.

Concrete Reinforcement

Concrete Reinforcement is used in most structural applications because Portland cement concrete is quite weak in tension. Therefore, it is reinforced for tension with deformed reinforcing bar also known as rebar. In the United States, the Concrete Reinforcing Steel Institute (CRSI) *Manual of Standard Practice* describes the selection, use and standard placement methods for bar supports and reinforcing bar. The bar supports are commonly known as chairs and bolsters. Reinforcing is manufactured for a variety of yield stresses or grades. The most common reinforcement grades are Grade 40, Grade 50, Grade 60 and Grade 75. For these grades, the yield stress is 40,000, 50,000, 60,000, and 75,000 psi, respectively. Reinforcement is rolled into round bars with deformed surfaces designed to improve the adhesion to the concrete.

There are a few different types of *Concrete Reinforcement*. The two primary types used in the United States are Welded Wire Fabric (WWF) and Deformed reinforcing. *Welded Wire Fabric* (WWF) containing of wires arranged in a square or rectangular configuration and welded at their intersection. This designation identifies a Plain wire is denoted by the letter “W” [MW] and deformed wire by the letter “D” [MD”]. The brackets [ ] indicate Metric Units.

The Welded Wire fabric designation of: WWF 6 x 12 - W16 x W8 [152 x 305 - MW103 x MW52]. This is identified as follows. The 6 indicates the Spacing (inches) of the longitudinal wires which is 6 inches [152mm] in this example. The 12 indicates the Spacing (inches) of the traverse wires which is 12 inches [305 mm] in this example. The W16 [MW103] indicates the longitudinal plain wire size and the W8 [MW52] indicates the traverse wire size.

Deformed Reinforcing Bar is specified as a bar number such as a #3 bar or #4 bar. The diameter is determined by taking the bar # and dividing by 8. Therefore, a #3 bar is 3/8 inch in diameter. A #4 bar is 4/8 or ½ inch. The Deformed Rebar table below provides the identifying number on reinforcing and its corresponding Nominal Dimension in inches, the Diameter and the Weight per Foot in Pounds.

Bar No.	Bar size in inches	Diameter in inches	Area Sq. in.	Perimeter in inches	Weight-lbs per foot
1	1/8				
2	1/4 Rd.	0.250	0.05	0.786	0.167
3	3/8 rd.	0.375	0.11	1.178	0.376
4	½ rd.	0.500	0.20	1.571	0.668
5	5/8 rd.	0.625	0.31	1.963	1.043
6	3/4 rd.	0.750	0.44	2.356	1.502
7	7/8 rd.	1.875	0.60	2.749	2.044
8	1 rd.	1.000	0.79	3.142	2.670
9	1 sq.	1.128	1000	3.544	3.400
10	1 1/8 sq.	1.270	1.27	3.990	4.303
11	1 1/4 sq.	1.410	1.56	4.430	5.313
14	1 ½ sq.	1.693	2,25	5.320	7.650
18	2 sq.	2.257	4.00	7.909	13.600

Types of Bar Supports

Bar supports are used to position reinforcing bars in reinforced concrete to ensure a minimum amount of concrete cover over the rebar. The bar supports may be made of steel wire, plastic or precast concrete. Bar supports are not normally shown on the plans and they are not furnished by the reinforcing steel supplier which generally means that the contractor must follow the standard which is incorporated by reference and the reference standard is found in the Technical Specifications. Normally, the Bar Supports are not found on the Contractor's plans.

Reinforcement Placement

Concrete Reinforcement is Placed according to a moment diagram for a beam that is supported by two columns under typical load conditions. The beam will be under tension on the bottom of the section at mid span between the two columns and it will be under tension on the top of the section over the columns. Therefore, you must place the proper size of reinforcing bar, located in the correct position in both regions to sustain these tensile forces.

As a general rule, the minimum standard *Concrete Cover over Reinforcement* is specified from the outside of the bar to the face of the concrete and they are based on the size of the bar and the location as follows. Three inches at sides where concrete is cast against earth and on bottoms of footings. Two inches for bars larger than a #5 where concrete surfaces would be exposed to the weather and 1-1/2 inches for smaller than #5 bars. 1-1/2 inches over spirals and ties in columns. 1-1/2 inches to nearest bars on the top, bottom and sides of beams and girders. Also, a 3/4 of an inch cover is needed for #11 rebar and smaller bars on top, bottom and sides of joists and on top and bottom of slabs where concrete surfaces are not exposed to the ground or weather. 1-1/2 inches for #14 and #18 bars. Also, 3/4 of an inch cover is required from the faces of all walls not exposed directly to the ground for #11 and smaller bars.

Masonry Properties

Organizations such as the International Masonry Institute (IMA), and the Brick Institute of America (BIA) have established an engineered approach to *Masonry Design and Construction*. Their efforts continue to provide the latest in engineering data, design guidelines, and construction practices for masonry construction. Masonry wall units are held together with mortar and the quality of the mortar mix effects the wall. *Mortar* binds the masonry units together into a single permanent structure and it seals the joints against moisture and air penetration. The mortar acts as the bond for the various components of the masonry structure such as reinforcement rebar, metal ties and anchor bolts. Portland cement, lime, sand and water are combined to produce mortars which have good durability and high compressive strengths. But, masonry cement, sand, and water are combined for convenience. The *masonry cement* is pre-blended by the manufacturer and it will normally include lime, an air-entraining agent, and other ingredients which produce the desired properties. The properties of the individual ingredients are provided below.

Portland cement used in mortars allows Types I, II, and III. Air-entraining Portland cement should be used with extreme caution since the research has shown that there are wide variations in the actual measured air content at the job site. The compressive strength of the mortar depends upon the proportion of Portland cement in the mix.

Hydrated Lime is essential to good quality mortar. It is a key ingredient and it is important to understand its characteristics and effects on mortar. The lime component improves *workability, elasticity* and *water retention.* Water retention in a mortar prevents rapid loss of water from mortar in contact with the masonry units. Lime also improves its bond strength and improves the mortar's plasticity and flexibility. Lime undergoes the least amount of change in volume which means it shrinks the least after hardening. Mortar is resistant to weather and should be able to resist strong winds, freezing temperatures, and alternate wet and dry weather. These cycles are beneficial to lime-based mortar, and they increase the overall strength of the mortar as it ages.

Sand acts as a filler in mortar which contributes to the strength of the mix. Natural sand is used in most mortars. Sand decreases the shrinkage of mortar which occurs in setting and drying, therefore, minimizing cracking. It is important to use a good grade of sand. *Water* used in mortar should be clean and free from alkalis, salts, acids, and organic matter. *Retempering* is the addition of water to mortar mixes that have lost water while sitting on the mortar board. The practice of retempering will reduce the compressive strength, but it increases the bond strength of the mortar mix. Many times, the CSI Division 04 Masonry, the technical specifications limit the number of times that retempering is permitted and establishes a time limit for the use of a mortar.

Types of Masonry Cement

As mentioned before, *Masonry Cement* is a pre-blended by the manufacturer and used for convenience at the job site. The American Society for Testing Materials (ASTM) recognizes five types of mortars for masonry. They are types M, S, N, O, and K. Type M is the strongest. Types O and K are the weakest. Until recently, the masonry codes recognized all five mortar types, but, the latest masonry codes focus primarily on the use of Type S and Type N.

Type N mortar is a medium-strength mortar recommended for use in exposed masonry above grade. Typically it is used for exposed exterior building walls, interior load-bearing walls and interior non load-bearing walls or partitions, chimneys, and parapet walls. *Type S mortar* is a medium-high strength mortar which is used where high bond strength and lateral strength are important. Type S mortar is recommended for use in foundations, basements, exterior walls, interior load-bearing walls, reinforced walls and non-reinforced masonry where maximum flexural strength is required.

Types of Masonry Walls and Their Components

Masonry Walls are formed from various types of masonry units and their backing can be block, brick, wood or concrete. The descriptions below describe the most common types of masonry walls. The *concrete block wall* consists of masonry units bonded together with mortar to form load bearing or non-load bearing walls above or below grade. The concrete masonry block units come in various sizes and wall thicknesses. The *solid brick wall* consists of two tiers or wythes of brick which is bonded together with header bricks. The *composite wall* consists of face brick with a header brick interlocked back into a block backup wall containing header blocks to receive the header brick and regular block. The *insulated cavity wall* consists of two tiers or wythes of masonry separated by a continuous air space and bonded together using metal ties to provide water drainage using flashing and weep holes. The Brick Institute of America recommends the construction of cavity walls where there is severe weather exposure, or where a maximum resistance to rain penetration is desired. Finally, a *veneer masonry wall* is a single thickness of masonry units attached to the backing with corrugated metal ties but it is not bonded to the backing. A *veneer wall* is a non-load bearing wall used primarily for decorative purposes.

There are various types of *metal ties* used to bind the face wall to the backup wall. For instance, the dovetail anchor is used to tie masonry units to a concrete wall. The anchor fits into a slot embedded in the concrete wall. The galvanized metal tie is used to bind the veneer brick wall to the backing. The rectangular tie is used to tie the face wall to the backup wall in a composite wall or a cavity wall. The *reinforced masonry wall* consists of masonry units tied together using horizontal reinforcing wire or metal ties and vertical reinforcing bars. The vertical reinforcing bars in the masonry cores are grouted in either a low-lift or high-lift grouting process depending upon what it calls for in the technical specifications.

A Masonry Wall contains the following components. *Horizontal joint reinforcement* is used to tie masonry units together to form a single structural unit. There are some types of metal joint reinforcement which are embedded in the horizontal mortar joint. The ladder or truss type reinforcement is used to tie masonry units together. *Control joints* are vertical joints that separate walls into sections and allow freedom of movement. They occur at specified intervals in long, straight walls or where abrupt changes in wall thicknesses occur. They also should be placed at openings; at intersections of main walls and cross walls; and at locations of structural columns in main walls.

A *bond beam* is a continuous, cast-in-place lintel block with reinforcement bars placed in the core of the lintel block. Bond beams may run around the perimeter of a building or between control joints. They may also be utilized as a lintel over an opening. Bond Beams are used as a continuous tie for exterior block walls where control joints are not required. They also act as structural members transmitting lateral loads to other structural members, and they can provide bearing for beams and joists. *Lintels* are used over openings in block walls to carry the load around the opening. They can consist of precast concrete units, structural steel shapes, a bond beam with reinforcement or a combination of materials. Bond beams and lintel are installed in conjunction with the masonry wall is being placed.

Masonry Brick Positions and Patterns

Brick is laid in various positions in the construction of solid brick walls, reinforced brick walls, or cavity walls. There are six *Brick Positions*. The *stretcher position* is a brick laid in a horizontal position with the longest, narrowest side facing the front of the wall. The stretcher position is the most common brick position. The *header position* is a brick laid in a horizontal position with the shortest, narrowest side facing the front of the wall. This is also referred to the header course where a masonry unit is laid over two individual wythes of walls, thereby tying them together. The *soldier position* is a brick laid in a vertical position with its longest, narrowest side facing the front of the wall. The *shiner position* is a brick laid in a horizontal position with the largest side facing the front face of the wall. The *rowlock position* is a brick laid in a horizontal position with the narrowest side or face edge placed in the bed of mortar and the longest side running back into the wall. The rowlock position is commonly used on window sills. The *Sailor position* is a brick that is laid in a vertical position with the largest side facing the front of the masonry wall.

Many times the brick positions are arranged in a wall to form a Brick Pattern or recurring design which is referred to as a *Brick Pattern Bond*. There are five basic structural bond patterns for brick and they are described below. The *Running bond pattern* consists of all bricks laid in a stretcher position with a one-half or one-third lap. This is commonly referred to as the stretcher bond pattern. The *Common or American bond pattern* consists of all stretchers with a course of header brick at a specified interval such as fifth course, sixth course or seventh course header. Another version is the header course contains a Flemish header. The *Flemish bond pattern* consists of alternating stretcher and header bricks on the same course. The headers on every other course should be centered over the stretcher below. The *English bond pattern* consists of alternating courses of header and stretcher bricks. The *Stack bond pattern* consists of masonry units laid directly over one another so that all of the head joints line up in a plumb vertical position. The stack bond is used for decorative purposes and structurally it is the poorest of all of the bonds discussed since there is not overlapping of the masonry units.

Structural Steel

The most common Structural Steel Shapes are the Wide Flange (W), the Standard I section (S), the Channels (C), the Hollow Structural Sections (HSS), Structural Tees (T, ST or TS), Angle iron with equal and unequal legs (∠), the I-shaped steel pile section (HP), and plate steel. Wide Flange (W), the Standard I section (S), the Channels (C) all follow the same designation format. The letter indicates the steel shape, the first number indicates the nominal depth of the steel member and the second number indicates the nominal weight per foot. For example, the steel shape designation of W 14 x 90 means the capital letter W tells you that the shape is a Wide Flange (W), the 14 indicates that the nominal depth is 14 inches, and the 90 indicates that the nominal weight per foot is 90 pounds per lineal foot.

Channels use the same designation sequence as the W and S except the structural steel shape and design properties are different. Channels are usually used as secondary framing members when loads and spans are too great. They are used as wall girts which are horizontal members attached to the columns to support siding. Channel is also used as roof purlins which are the framing members spanning between the roof beams to support the roof deck. Channel can also be used for door and window frames, stairs, stringers, and as web and cord members in trusses. Angles are used as the connecting pieces for beams, as chord and web members in light trusses and joists. They are also used as bracing, and as reinforcing around openings normally called lintels and as supports for mechanical equipment. The American Institute of Steel Construction (AISC) publishes a manual titled, *Specification for the Design, Fabrication and Erection of Structural Steel for Buildings*. This manual covers structural steel design properties with nominal dimensions and weight, and steels construction methods.

Prior to the fabrication of each structural steel member the manufacturer must submit to the contractor a shop drawing indicating the size of the member, the detailed dimensions for the connectors and dimensions for each member in the structure. During the structural steel fabrication process at the manufacturers location, each piece of steel is given an erection mark that allows the contractor to identify each member at the job site. The erection markings for each member are then organized into a set of *erection drawings* which are issued to the contractor indicating the locations and proper positioning of each piece of steel within the structure.

Open-web Steel Joists
These are lightweight trusses that are used for supporting roofs and floors. The most common joist series are the K-Series, the LH Series, the DLH Series and the Joist Girders. The K series is normally fabricated in depths that range from 8 inches thru 30 inches and spans up to 60 feet. The LH is fabricated in depths that range from 18 inches thru 48 inches and spans up to 96 feet. The DLH is fabricated in depths that range from 52 inches thru 72 inches and spans up to 144 feet. The Steel Joist Institute (SJI) publishes numerous manuals such as the *Standard Specifications, Load Tables, and Weight Tables for Steel Joists and Joist Girders.*

Steel Floor and Roof Deck
These are roll formed metal in varying configurations for composite metal decks, non-composite metal decks and metal roofs. Composite floor deck is designated Type “VL”, “VLI”, and “VLR”. The non-composite floor deck is designated Type “C” and the Roof deck is designated Type “B”, “F”, “A”, “N”, and “E”. The Steel Deck Institute publishes numerous manuals such as the *SDI Manual of Construction with Steel Deck*.

Structural steel and metal decking are extremely susceptible to fire, therefore, they must be fireproofed based upon the *major occupancy classification* which is assigned to each building during the initial design stages of the project. Some typical occupancy classifications include arena and theater type occupancies, health care and detention type occupancies, business type occupancies, industrial occupancies and residential occupancies.

Fireproofing Structural Steel
The amount of *fireproofing* that is applied to a structural steel member depends on the fire-resistance rating required and the type of material that is to be protected. Materials normally used for the protection of a structural steel frame include regular and lightweight concrete, cellular concrete, gypsum wall board, plaster, and sprayed-on mineral wool. There are three common methods for fireproofing structural steel. You can encase the steel member in concrete. Second, you can encase the steel member with gypsum wallboard. Finally, you can protect the structural

steel beams, columns and decking with sprayed-on insulation.

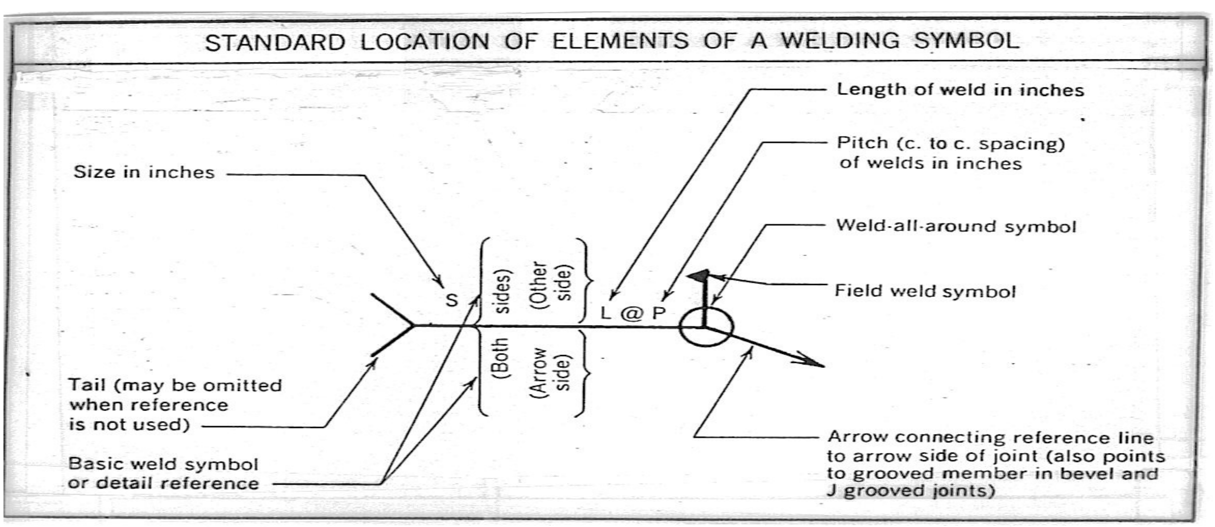
Welding Symbols

The two most common methods for connecting structural steel members in structural steel frame construction are bolting and welding. Welding can be done in the manufacturers shop under controlled conditions and it can be done at the construction site. Welding is the fusing of two pieces of metal together. The two most often used types of welded connections are the *fillet weld* and the *butt or groove weld*. A fillet weld is used to weld two pieces of metal together that are perpendicular to each other. A butt weld is used to weld two pieces of metal together that are set end to end or parallel to each other. The typical *butt welded, joints* are the Square butt weld, the single-V butt weld, and the Single Bevel butt joint. The American Welding Society has established the basic welding symbols for fillet and butt welds, some supplementary weld symbols and a standard location for elements of a welding symbol. Below is an example of the welding arrow symbol and their meanings.

Welding Arrow Symbol

BASIC WELDING SYMBOLS				SUPPLEMENTARY WELD SYMBOLS			
FILLET	BUTT OR GROOVE TYPE			WELD ALL AROUND	FIELD WELD	CONTOUR	
	SQUARE	V	BEVEL			FLUSH	CONVEX
◺	||	\/	|	○	◂|	–	∩

Adapted from the American Welding Society manual titled *Structural Welding Code D1.1.*



Structural Lumber

Each piece of lumber is assigned on the basis of its expected use to the category of factory and shop lumber or yard lumber. Yard lumber is used structurally and includes most of the lumber for construction. Yard lumber is further divided according to size and shape into boards, dimension lumber and timbers. Most of the lumber in construction falls into the category of dimensional lumber also called *Structural Lumber*. *Boards* are defined as 1" to 1-1/2" thick and 2“ to 12" wide. Boards are further classified as a common grade or rough sawn or surfaced grade or dressed. *Dimension lumber* is 2" to 4" thick and 2" and wider. *Timbers* are 5" and thicker and 5" and wider. Boards and dimensional lumber are known by their nominal size such as a 2 x 4 which is not 2" thick by 4" wide. Its actual dimensions are 1-1/2" thick x 3-1/2" wide.

Dimension lumber is further divided into Joists and Planks, Light Framing and Decking. *Joists* are members that are 2 inches to 4 inches in nominal thickness and at least 6 inches wide. They are graded according to their bending strength on their narrow edge. *Planks* have the same dimensions as joists but they are graded on their wider dimension. *Light Framing* are members that are 2 inches to 4 inches nominal thickness and 2 inches to 4 inches wide. They are sometimes referred to as wood frame construction which consists of studs, plates, joists, and rafters. *Decking* is 2 inches to 4 inches thick and 4 inches or wider, but they are used on their wider dimension.

Timbers are further divided into Beams and Stringers and Posts and Timbers. *Beams and Stringers* are members with a width more than 2 inches greater than the thickness. Normally, something called a Beam or Stringer is at least 4 inches thick and at least 2 inches wider than they are thick. They are installed horizontally and they are ranked according to the Extreme Fiber Bending stress (F_b) when loaded on the narrower of the two dimensions. *Posts and Timbers* have a width that is no more than 2 inches greater than the thickness. These are members that are either square or nearly square in cross section. Normally, they are installed vertically and they are ranked according to their Compression Parallel to the Grain (F_c //) because the loads are carried on the cross section.

Structural lumber, also referred to as dimensional lumber, is a classification of lumber for pieces at least 2 inches thick and it is graded according to its ultimate use and its strength in resisting the stresses placed on each piece in that use. The top grade of most species is *select structural grade*, which is used only where high strength, stiffness, and good appearance are all required. The next lower grade is *No. 1 grade* lumber which may have tiny knots but otherwise it has almost the same qualities as select structural. The *No. 2 grade* lumber may have larger knots than No. 1, but they the knots are tight, and the grade is excellent for floor and roof framing members. The *No. 3 grade* has still more and larger defects and it can be used for sills and some plate members in residential construction. The *Construction grade* falls somewhere between Select Structural and No. 1 grade and it is used for extreme fiber stress in bending. Construction grade is the standard where straightness and strength are more important, such as in concrete formwork. The *Stud* *grade* is stiff, straight lumber with a high Compression Parallel to the Grain (F_c //) value. The stud grade is excellent for vertical walls in residential construction. *The Standard grade* and the *Utility grade* are still lower grades than stud grade lumber. The bottom grade is *Economy grade* which is used for nonstructural purposes. The surfaces of a piece of lumber can be rough sawn or dressed. A dressed piece of lumber with the designation of S1S means smooth on one side. The designation of S2S means smooth two sides and S4S means smooth on all four sides. Dressed can also be designated S1E which means smooth on one edge or S1S1E which means smooth one side and one edge.

The ASTM D2555 standard titled *Methods for Establishing Clear Wood Strength Values*, established the stresses at failure and an accurate modulus of elasticity for each wood species. The samples tested under ASTM D2555 have no defects to reduce their strength or stiffness. Allowable stresses for lumber are determined by reducing the stresses in the samples tested under ASTM D2555 to provide for a safety factor of approximately 2.5. These allowable stresses and the modulus of elasticity are published in ASTM D245, *Methods for Establishing Structural Grades for Visually Graded Lumber*. The National Forest Products Association (NFPA) publishes a manual titled *National Design Specifications for Stress-Grade Lumber and Its Fasteners*. This manual includes grades established for each species of wood with allowable stresses for each grade. These stresses are derived by multiplying the basic allowable clear wood stresses by ratios.

Grading standards for softwoods are published by the U.S. Department of Commerce in Product Standard PS 20 titled the *American Softwood Lumber Standard*. The grading rules for each region are established by numerous organizations whose rules conform to the PS 20 grading standard with additions for the special conditions in each region. Then each regional manufacturer's association adjusts or refines their grading rules to categorize its lumber products according to their conditions. Some of the regional associations are the Western Wood Products Association (WWPA), the Southern Forest Products Association (SFPA), the Northeastern Lumber Manufacturers' Association and the National Hardwood Lumber Association.

Each manufacturers' association then places their *Grading mark or stamp* on each piece of lumber. A typical grading mark shows in the upper left portion of the stamp the sawmill number that processes the lumber and just below it is the logotype of the manufacturers' organization establishing the grading rules. In the lower right portion of the stamp is the species abbreviation such as ES-AF which means Englemann spruce and Alpine fir, or Hem Fir for Hemlock and Fir, or the symbol of a backwards P and a forward P together which means Ponderosa Pine or LP for Lodgepole pine. The upper right portion of the stamp states the grade or stress rating such as SEL for Select or CONST for Construction or 2 & BTR STUD which means a No 2. or better grading for Studs. The upper right portion of the stamp may contain the stress rating instead of the grade such as 1650 f or 1500 f 1.4 E. The remaining information which appears in the middle portion of the stamp may contain its moisture content such as MC 15 which means surfaced at Moisture content of 15% or less. Another abbreviation is S-DRY which means surfaced at M.C. of 19% or less. Dry lumber has been seasoned to a moisture content of 19 percent or less. Green lumber has a moisture content in excess of 19 percent.

Allowable Stresses and Strengths

The *allowable stresses and strengths* of wood are divided into the following types. The *Extreme Fiber Bending* stress (F_b), as single member uses or repetitive member uses, is the stress that must be resisted in a beam undergoing bending. The F_b value of a beam is the strength of extreme fibers in bending when a member is used horizontally such as a floor joist. This generally means that the top fibers of a joist will be in compression and the bottom fibers will be in tension. The F_b rating value is the pounds per square inch (psi) that the beam will resist a force exerted downward at the center of the joist.

The *Compression Perpendicular to the Grain* ($F_c \perp$) is the stress induced by pressing the fibers together in a traverse direction. There is no appreciable difference in strength to resist this compression perpendicular to the annual rings or parallel to the rings. The *Compression Parallel to the Grain* (F_c //) is the stress induced by pressing the fibers together longitudinally. The *Horizontal Shear Parallel to the Grain* (F_v //) is the stress induced by the tendency for the upper fibers to slide over the lower fibers as a beam bends. The *Tension parallel to the grain* (F_t //) is the stress induced by pulling apart in a longitudinal direction. The resistance to tension perpendicular to the grain is extremely weak that it is usually considered negligible. The *Modulus of Elasticity* (E) is a measure of the stiffness or resistance to deflection. The Modulus of Elasticity is a measure of the ability to resist failure due to excessive deformation. It is used to predict movement under a load and avoid failure due to excessive movement. The modulus of Elasticity (E) value of a piece of lumber is the ratio between the load of the member and the amount the member will deflect under the load. The higher the E value, the stiffer the lumber. Among common woods used for structural lumber Douglas fir and Southern yellow pine have the highest F and E values. The table below provides the allowable stresses for some typical species of structural lumber. These stresses were derived from recommendations of the National Forest Products Association (NFPA) and the American Concrete Institute (ACI).

Plywood and Plyform

Plywood contains thin layers or plies of wood called veneers. The veneers are bonded together with glues under heat and pressure. Plywood always has an odd number of plies such as three, five or seven. The grain of the plies is alternated and glued at right angles to each other for maximum strength. Plyform uses seven plies and water resistant glues for formwork.

Allowable Unit Stresses for Dimension Lumber Derived from the National Design Specification for Stress-Grade Lumber and the American Concrete Institute' *Formwork for Concrete*. Sixth Edition. (p 4-6). *

Species	Grade	Size in inches t = Thick w = Wide	Extreme Fiber Bending in psi		Compression		Horizontal Shear F_v //	Tension Parallel to Grain F_t //	Modulus of Elasticity E
			Single F_b	Repetitive F_b	Perpendicular $F_c \perp$	Parallel F_c //			
Douglas Fir-Larch	No. 2	2-4 t, 2" & w	875		625	1300	95	575	1,600,000
	Construction	2-4 t, 2-4 w	1000		625	1600	95	650	1,500,000
Douglas Fir- South	No. 2	2-4 t, 2" & w	825		520	1300	90	525	1,200,000
	Construction	2-4 t, 2-4 w	925		520	1550	90	600	1,200,000
Southern Pine	No. 2	2-4 t, 2-4 w	1500		565	1650	90		1,600,000
	No. 2	2-4 t, 5-6 w	1250		565	1600	90		1,600,000
	No. 2	2-4 t, 8 w	1200		565	1550	90		1,600,000
	Construction	2-4 t, 4 w	1100		565	1800	100		1,500,000
Spruce-Pine-Fir	No. 2	2-4 t, 2 & w	875		425	1100	70		1,400,000
	Construction	2-4 t, 4 w	975		425	1350	70		1,300,000
Hem-Fir	No. 2	2-4 t, 2 & w	850		405	1250	75	500	1,300,000
	Construction	2-4 t, 2-4 w	975		405	1500	75	575	1,300,000
Plyform B-B, Used Wet	Class 1		1545**		Face 210		57		1,500,000

Note: * Design values are in pounds per square inch.

* Plywood stresses include an experience factor of 1.3 recommended by the APA.

Plywood contains a center ply which is called the core, and the exposed plies are called the faces. Any other plies between the core and the faces are called the cross bands. The standard width of a sheet of plywood is four feet and the most common length is 8 feet. The Plywood sheet thicknesses commonly available are 3/8", ½", 5/8" and 3/4" for residential structural purposes. Plyform uses 5/8", 3/4", 1", 1-1/8" and 1-1/4". The 3/4" plyform is common.

Each piece of Plywood contains a grading mark or stamp. The American Plywood Association (APA) organizes their plywood into Appearance grades and Engineered grades of plywood. These grade tables are further subdivided into Interior and Exterior Types of plywood. The *interior types* of plywood are made with glue that is adequate for indoor use. The *exterior types* of plywood are made with hot resin glue that is unaffected by water and resists weathering. These types are further subdivided by *Grade Designation* such as interior, structural I, sturd-i-floor, underlayment, plugged and B-B Plyform.

The *engineered grade's stamp* indicates the grade of the veneers, the species group number, the identification index numbers or the species group, the type of plywood use, the thickness, the mill number or product standard and the type of glue is specified. Across the top of most grade stamps are two letters separated by a hyphen. The first letter is the grade of the veneer on the panel face and the second letter is the grade of the veneer on the panel back. The only letters used to *grade the face veneers* qualities are A, B, C, D, and N. A *grade A* face veneer is smooth, has no open defects, but may have some neat repairs. A *grade B* veneer has a solid surface with no splits wider than 1/32" and all of the defects are repaired with smooth plugs. The *grade C* veneer may have splits up to ½" and knot holes up to 1-1/2" as long as they do not affect the required strength of the plywood. The *grade D* veneer is the poorest grade and it has a rough appearance and knots. The identification index has two numbers. The first *identification index number* states the maximum span if the plywood sheet is used on the roof. The second identification number, to the right of the slash provides the maximum span if the plywood is used for a sub flooring.

The *B-B Plyform* Class I or Class II is a concrete grade with a high reuse factor. This has a smooth surface on both sides with no splits and all of the defects are plugged. The Plyform is seven plies, it is water resistant, and it is milled oiled to resist concrete adhering to the surface. Plyform is made only from certain wood species which conform to the APA specifications. Plyform is also available in High Density Overlay (HDO) and Structural 1 grades. Class 1 is the most commonly available plyform.

Statics and Strength of Materials

All construction materials must resist a force. A force is a push or pull on a material and the most common force in construction is the pull of gravity. However, other forces that must be taken into consideration are wind and water. A force exerted on the surface of an object is assumed to be uniform over the internal areas of the object. Stress is a force per unit area over which the force acts and it is calculated by dividing the force by the areas on which it acts and it is expressed as pounds per square inch (psi) of kips per square inch (Ksi) where a kip is equal to 1000 pounds. The strength of a material is the ability to resist a force. Also, the strength of a material in technical terms is equal to the stress that the material can resist. Therefore, the strength of a material has the same units as stress which are expressed in psi or Ksi. This also means that the useful strength of a material is equal to the stress at the point of failure. Failure takes place when a material can no longer resist the weight applied upon it and the material either breaks or it deforms. *Deformation* is defined as a change in the outside dimension of a material caused by a force. This deformation is expressed in terms of strain which is the total change in the dimension divided by the original dimension. The term strain means the total change in dimension divided by the original dimension. Strain is a ratio, therefore, it has no units, but the amount of deformation and the original length must utilize the same unit to provide a correct ratio. They are usually measured in inches. The deformation that can be allowed a material depends upon its intended use. A material that deforms slowly when a force is applied to it for an extended period of years, even though the force is too small to cause failure in a short period of time. This deformation is called *creep*.

The engineering profession has determined the stress that causes failure for various materials. However, nothing is designed to be stressed to the point of failure. Instead, a lower stress called the *allowable stress* is selected. The failure stress is greater than the allowable stress by a factor which is called the safety factor. The *safety factor* and the allowable stresses for various materials are published by various organizations. Some organizations that publish allowable stresses are the American Concrete Institute (ACI) American Institute of Steel Construction (AISC), the Concrete Reinforcing Steel Institute (CRSI), the Steel Joist Institute (SJI) and the National Forest Products Association. Economy requires that the actual stress be near the allowable. If it is not, then the material is being used inefficiently because using less material would be adequate. The actual stress is called the *working stress*. There are three types of stresses and corresponding strengths. They are compressive, tensile and shearing. Each depends upon the position of the forces with respect to the object.

In Joseph Wujek's (1999) book titled *Applied Statics, Strength of Materials, and Building Structure Design* he describes the following terms. A beam is a structural member that rests on certain reactions and it is subject to forces acting normally perpendicular to its longitudinal axis, thereby causing it to bend. In structural design, a beam is a horizontally positioned load-bearing structural member used in buildings. However, in construction, joists, girders, headers, lintels or purlins behave like and are treated as beams. A *load* is an external force applied to beams and other structural forces. The reacting forces at the beam supports which counter the applied load and keep the beam in static equilibrium are called *reactions*. The loads and reactions combine to cause the beam to bend.

There are numerous types of beams. The *simple beam* spans between two reactions located at the extreme ends of the beam. The *overhanging beam* is a beam that rests on two reactions and extends beyond one bearing point. The *double overhanging* beam rests on two reactions and both beams ends extend beyond the reactions. The continuous beam is supported by three or more reactions. A *cantilever beam* extends from a single reaction (p 72).

Moment

The moment of a force is a measure of its ability to cause turning, rotating or twisting about an axis of rotation. The *moment (M)* can be determined as the product of a force, P, and the perpendicular distance, d, from the line of action of the force to the axis of rotation about which we can find the moment.

The *moment (M)* = Pd. A moment is always expressed in unit of force (P) times distance (d) and the common units for moments (M) are pound-inches (lb-in.), pound-feet (lb-ft.), newton-meters (N-m), and kip-feet (k-ft.). A kip is 1000 pounds.

The equations of static equilibrium indicate that the sums of the horizontal forces must be zero. This is expressed as $\sum F_x = 0$. Second, the sum of the vertical forces with an upward force assigned a positive (+) sign and a downward force given a negative (-) sign and setting them equal to zero. This is expressed as $\sum F_v = 0$. Third, the sum of the moments about any axis must be zero. This is expressed as $\sum M = 0$ (p 74).

For example, a wooden beam 12 feet long and it carries a concentrated load of 150 pounds at a distance of 4 feet from Reaction (R_2). Reaction (R_1) is pinned 8 feet from the load. What are the values for R_1 and R_2?

Using the three equations of static equilibrium from above and the wooden beam example described above, the sum of the horizontal forces is zero since there are no horizontal forces provided. Therefore, $\sum F_x = 0$. Second, the sum of the vertical forces must be equal to zero. In the example, $\sum F_v = 0$ which is: 150 lbs - R_1 - R_2 = 0. We also know that $R_1 + R_2$ = 150 lbs.

We know that Reaction R_1 is pinned which is the axis of rotation and R_2 is 12 feet from the axis of rotation and is acting with a tendency to cause counterclockwise rotation about R_1. Therefore,

$$\sum M = \quad 0 = +(R_2 \text{ x } 12 \text{ feet}) - (150 \text{ pounds x } 8 \text{ feet})$$

$$0 = 12\ R_2 - 1200 \text{ lb-ft}$$

$$12\ R_2 = 1200 \text{ lb-ft}$$

$$\frac{12 \text{ ft } R_2}{12 \text{ ft}} = \frac{1200 \text{ lb-ft}}{12 \text{ ft}}$$

$$R_2 = 100 \text{ lb}$$

Finally, $\sum F_v = 0 =$ $R_1 + R_2$ - 150 lb. Also, R_2 = 100 lbs.
Therefore, R_1 + 100 lbs - 150 lbs.
0 = R_1- 50 lbs

R_1 = 50 lbs

Shear
A beam is designed to resist the bending and shearing stresses that are induced by the effects of the applied loads and the resulting reactions. The designer utilizes the loads and the resultant forces to determine the shear forces and the bending moments across the beam length. The shear forces and bending moments determine the beam material properties and cross section required to withstand these stresses. Shear stress occurs when two forces with parallel but offset lines of action act in opposite directions on the beam.

A beam under a load has the tendencies for it to fail due to either vertical shear or horizontal shear. *Vertical shear* is the shearing force that tends to cause a member to fail by cutting perpendicular to the beam's longitudinal axis. This occurs at or near the beam supports. This type of failure is often a concern in short beams carrying heavy loads. *Horizontal Shear* is the tendency of theoretical layers in a member to slide horizontally.

Joseph Wujek (1999) says that *Vertical shear* (V) is calculated at any point along a beam by summing any forces acting upward (F_{up}) and subtracting any forces acting downward (F_{down}) to the left of the section under consideration. This method assumes that the beam is in static equilibrium. The definition for calculating a vertical shear force (V) is the vertical shear force at the section under consideration is equal to the sum of the forces acting upward minus the sum of the forces acting downward calculated to the left of the section. The formula is $V @ x = \sum F_{up} - \sum F_{down}$ to the left of the section under consideration (p 189).

The section under consideration and the shear force calculations are cited as a measurement from the left end of the beam. For example, V @ 2 feet indicates that the computation is made with the section placed 2 feet away from the left end of the beam. Also, the location of the section of the shear force calculation is followed by a negative (-) or positive (+) symbol which denotes placement of the section just to the left (-) or just to the right (+) of the concentrated force.

Also, there is no vertical shear force that exists directly below a reaction or concentrated load because a shear force requires offsetting forces. Therefore, a reaction or concentrated force has no offsetting forces, hence the vertical shear is undefined at these locations. Consequently, the calculation of the shear force must be made a small distance to the right and left of the reaction or the concentrated force (p189).

Using a wooden beam 12 feet long and it carries a concentrated load of 150 pounds at a distance of 4 feet from Reaction (R_2). Reaction (R_1) is pinned 8 feet from the load. Reaction R_1 = 50 lbs and Reaction R_2 = 100 lbs. The vertical shear forces at just to the right (+) of R_1 at location R_1 + and ending at just to the left (-) of R_2 at intervals of 4-feet along the length of the beam. What are the vertical shear forces at various locations along the beam? The vertical shear forces are calculated below.

V @ x	$= \sum F_{up} - \sum F_{down}$ to the left of the section under consideration.
V@ R_1 +	= 50 lbs - 0 = 50 lbs
V @ 4 foot	= 50 lbs - 0 = 50 lbs.
V @ 8 feet -	= 50 lbs - 0 = 50 lbs
V @ 8 feet +	= 50 lbs - 150 lbs = -100 lbs.
V @ 10 feet	= 50 lbs - 150 lbs = -100 lbs.
V @ R_2 -	= 50 lbs - 150 lbs = -100 lbs

Therefore, the maximum vertical shear is 100 lbs

Joseph Wujek (1999) defines the *bending moment* (M), as a moment found by summing the moments of the external loads and reactions about a selected section. The bending moment is calculated about any section in a beam by the following method. The sum of the moments of the upward forces to the left of the section under consideration minus the moments of the downward forces to the left of the section result in the Moment (M). The formula is $M = \sum M$ up - $\sum M$ down to the left of the section under consideration (p 212). Using the wooden beam 12 feet long and it carries a concentrated load of 150 pounds at a distance of 4 feet from Reaction (R_2). Reaction (R_1) is pinned 8 feet from the load. Reaction R_1 = 50 lbs and Reaction R_2 = 100 lbs. The bending moments at just to the right (+) of R_1 at location R_1 + and ending at just to the left (-) of R_2 at intervals of 4-feet along the length of the beam. What are the bending moments at different intervals along the beam?

$M = \sum M$ up - $\sum M$ down to the left of the section under consideration.

M@ R_1	= (50 lb-ft. x 0) - 0	= 00 lb-ft.
M @ 4 foot	= (50 lb-ft. x 4) - 0	= 200 lb-ft.
M @ 8 feet	= (50 lb-ft. x 8) - 0	= 400 lb-ft.
M @ 10 feet	= (50 lb-ft x 10) - (150 x 2)	= 200 lb-ft.
M @ R_2 -	= (50 lb-ft x 12) - (150 x 4)	= 0

Therefore, the maximum bending moment is 400 lb-ft.

Engineering Materials Exercise

1. Which source or organization promotes a uniform organization system for organizing construction materials, specifications and documentation into Divisions and Sections for projects.

   - ○ A. Sweet's Catalog.
   - ○ B. Underwriters Laboratory.
   - ○ C. Construction Specifications Institute.
   - ○ D. American Society for Testing Materials.

2. You are interested in finding all of the manufacturers technical lifting data for a permanent overhead crane that the Contractor will install in a manufacturing facility. What is the name of the Reference source?

   - ○ A. Sweet's Catalog.
   - ○ B. Thomas' Register.
   - ○ C Engineering News Record.
   - ○ D. Crane and Riggers Association.

3. Which organization is engaged in the standardization of technical specifications and testing methods?

   - ○ A. Underwriters Laboratories.
   - ○ B. American Standards Association.
   - ○ C. Construction Specifications Institute.
   - ○ D. American Society for Testing Materials.

4. Which organization investigates and tests materials, products, equipment, construction methods and construction systems to safeguard against hazards to life and property?

   - ○ A. Underwriters Laboratories.
   - ○ B. American Standards Association.
   - ○ C. Construction Specifications Institute.
   - ○ D. American Society for Testing Materials.

Engineering Materials Exercise

5. What are Large stones that are placed at the end of culverts or along the edge of a body of water to prevent erosion called?

- ○ A. Riprap.
- ○ B. Impurities.
- ○ C. Weathering.
- ○ D. Permeability.

6. What are aggregate particles smaller than the size of a grain of sand called?

- ○ A. Riprap.
- ○ B. Abrasion.
- ○ C. Impurities.
- ○ D. Permeability.

7. What is a measure of the ease with which water will flow through an aggregate's voids called?

- ○ A. Riprap.
- ○ B. Impurities.
- ○ C. Weathering.
- ○ D. Permeability.

8. What is the aggregate quality of resisting weathering called?

- ○ A. Abrasion.
- ○ B. Adhesion.
- ○ C. Soundness.
- ○ D. Permeability.

9. What type of pavement system is subject to abrasion throughout because the pavement continuously flexes under the weight of traffic?

- ○ A. Asphalt.
- ○ B. Concrete.
- ○ C. Gravel road.
- ○ D. Sandy road

Engineering Materials Exercise

10. What does a sieve size of No. 40, mean?

- ○ A. There are 40 openings per lineal inch.
- ○ B. There are 40 openings per lineal foot.
- ○ C. There are 40 inches of surface area.
- ○ D. There are 1600 inches of surface area.

11. Which sieve size are the aggregates initially placed into for analysis?

- ○ A. 4 inches.
- ○ B. 1/4 inch
- ○ C. No. 4
- ○ D. No. 200

12. A gradation chart shows a line with a constant slope which indicates that approximately the same amount of material is retained on each successive sieve. What is this gradation called?

- ○ A. Gap graded.
- ○ B. Well graded.
- ○ C. Skip graded.
- ○ D. Uniform gradation.

13. What is the weight of a Cubic Yard of concrete?

- ○ A. 150 pounds
- ○ B. 1350 pounds
- ○ C. 2430 pounds
- ○ D. 4050 pounds

14. What is the term for a material that strains slowly when a force is applied to it for an extended period of years, even though the force is too small to cause failure in a short period of time?

- ○ A. Creep.
- ○ B. Deformation.
- ○ C. Working stress.
- ○ D. Allowable stress.

Engineering Materials Exercise

15. What is the chemical reaction called when Portland cement is mixed with the water?

- ○ A. Setting
- ○ B. Adhesion.
- ○ C. Hydration.
- ○ D. Air-entrainment.

16. Which of the following types of soil has high permeability?

- ○ A. Clay.
- ○ B. Gravel.
- ○ C. Solid Rock.
- ○ D. Fine Sands & Silts.

17. Which type of Portland cement is used where an early strength gain is important?

- ○ A. Type I.
- ○ B. Type III.
- ○ C. Type M.
- ○ D. Type O.

18. Which concrete characteristic is improved by air-entraining the concrete?

- ○ A. Strength.
- ○ B. Hydration.
- ○ C. Sulfate resistance.
- ○ D. Freeze-thaw resistance.

19. What is the most important parameter used to control the strength of concrete?

- ○ A. Air-entrainment.
- ○ B. Water/Cement Ratio.
- ○ C. Type of Portland Cement.
- ○ D. Coarse/Fine Aggregate Ratio.

Engineering Materials Exercise

20. What is Air-entrained Portland cement Concrete quite weak in?

- A. Tension.
- B. Durability.
- C. Compression.
- D. Bond Strength.

21. Which technical resource must be consulted to determine the bar support spacing for a Concrete Bridge deck?

- A. American Concrete Institute.
- B. Concrete Reinforcing Steel Institute.
- C. Construction Specifications Institute.
- D. American Society for Testing Materials.

22. What is the diameter in inches of a #8 bar?

- A. 1/8
- B. ½
- C. 1.0
- D. 8.0

23. What is the weight of a bag of Portland Cement in pounds?

- A. 50
- B. 90
- C. 120
- D. 150

24. What is the weight of a #5 deformed bar in pounds?

- A. 0.310
- B. 0.625
- C. 1.043
- D. 1.963

Engineering Materials Exercise

25. Which materials are incorporated by reference and not normally shown on the plans or in the Technical Specifications?

- A. Concrete.
- B. Bar Supports.
- C. Reinforcement.
- D. Welded Wire Fabric.

26. Which type of masonry cement is used where bond and lateral strength are important?

- A. Type I.
- B. Type III.
- C. Type N.
- D. Type S.

27. Which type of masonry cement is used for foundation walls and isolated piers?

- A. Type K.
- B. Type N.
- C. Type O.
- D. Type S.

28. Which type of masonry cement is used for reinforced masonry?

- A. Type K.
- B. Type N.
- C. Type O.
- D. Type S.

29. Which of the following mortar ingredients improves the mortar's workability?

- A. Lime.
- B. Sand.
- C. Gravel.
- D. Portland cement.

Engineering Materials Exercise

30. Which of the following mortar ingredients decreases the shrinkage of mortar while setting and drying?

- ○ A. Lime.
- ○ B. Sand.
- ○ C. Water.
- ○ D. Portland cement.

31. What ingredient is added to mortar for retempering?

- ○ A. Lime.
- ○ B. Sand.
- ○ C. Water.
- ○ D. Portland cement.

32. Which mortar property is increased by retempering?

- ○ A. Oxidation.
- ○ B. Bond Strength.
- ○ C. Weather Resistance.
- ○ D. Compressive Strength.

33. What is the strongest overlap of masonry units when building a wall?

- ○ A. No lap.
- ○ B. One-quarter lap.
- ○ C. One-half lap.
- ○ D. One-third lap.

34. Structural bonding can be accomplished by tying two wythes together with a brick. When it is laid in this position, what is the brick position called?

- ○ A. Sailor.
- ○ B. Header.
- ○ C. Soldier.
- ○ D. Stretcher.

Engineering Materials Exercise

35. What is the most common brick position?

- ○ A. Shiner.
- ○ B. Header.
- ○ C. Rowlock.
- ○ D. Stretcher.

36. What brick position is commonly used on window sills?

- ○ A. Sailor.
- ○ B. Header.
- ○ C. Soldier.
- ○ D. Rowlock.

37. What is the weakest pattern bond?

- ○ A. Stack.
- ○ A. Flemish.
- ○ B. Running.
- ○ C. Common.

38. Which of the following masonry components allows freedom of movement in a masonry wall?

- ○ A. Bond Beam.
- ○ B. Control Joint.
- ○ C. Vertical Joint reinforcement.
- ○ D. Horizontal Joint reinforcement.

39. Which of the following masonry components are continuous, they may run around the perimeter of a building or between control joints and act as structural members, and they can provide bearing for beams and joists?

- ○ A. Lintels.
- ○ B. Bond Beam.
- ○ C. Control Joint.
- ○ D. Vertical Joint reinforcement.

Engineering Materials Exercise

40. Which of the following masonry components are used over openings in block walls to carry the load around the opening?

- A. Lintels.
- B. Bond Beam.
- C. Control Joint.
- D. Vertical Joint reinforcement.

41. Which type of wall is desired where there is severe weather exposure, or where a maximum resistance to rain penetration is desired?

- A. Cavity.
- B. Veneer.
- C. Composite.
- D. Reinforced Masonry.

42. What does the steel designation C 12 x 20.7 mean?

- A. C is the steel shape, 12 is the nominal depth and 20.7 is the pounds per foot.
- B. C is the steel shape, 12 is the pounds per foot and 20.7 is the nominal depth.
- C. C is the steel series, 12 is the nominal depth and 20.7 is the pounds per foot.
- D. C is the flange width series, 12 is the pounds per foot, and 20.7 is the nominal depth.

43. Which organization publishes structural steel design properties manuals and manuals that cover steel construction methods?

- A. American Welding Society.
- B. The American Iron and Steel Institute.
- C. American Society for Testing Materials.
- D. American Institute of Steel Construction.

44. What are the drawings called that are issued to the contractor from the manufacturer indicating the locations and proper positioning of each piece of steel within the structure?

- A. Shop Drawings.
- B. Erection Drawings.
- C. Working Drawings.
- D. Architectural Drawings.

Engineering Materials Exercise

45. What structural steel component is the steel designation "VL" referring to?

- A. Angle.
- B. Steel Shape.
- C. Metal Decking.
- D. Open-web joist.

46. What structural steel component is the steel designation "LH" referring to?

- A. Channel.
- B. Steel Shape.
- C. Metal Decking.
- D. Open-web joist.

47. Which of the following is structural steel most susceptible to for failure?

- A. Fire.
- B. Rain.
- C. Snow.
- D. Chemical.

48. What is sprayed onto structural steel to increase its fire resistance capability?

- A. Paint.
- B. Creosote.
- C. Preservative.
- D. Mineral wool.

49. How is the fireproofing of a steel structure determined?

- A. Size.
- B. Height.
- C. Occupancy.
- D. Adjacent structures.

Engineering Materials Exercise

50. What type of weld fits two pieces of metal together end-to-end for welding?

- A. Slot.
- B. Butt.
- C. Plug.
- D. Fillet.

51. Assume you have a fillet weld symbol on the top of the welding symbol arrow. Which side will the weld be placed on?

- A. The ends are welded.
- B. All sides all the way around.
- C. Arrow side that it is pointing to.
- D. Other side from where the arrow is pointing.

52. Assume you have a square weld symbol with a solid flag on a pole coming up from the change in direction of the arrow. What does the solid backwards flag on a pole tell you?

- A. Field weld.
- B. Flush weld.
- C. Contour weld.
- D. Weld all the way around.

53. If the weld is supposed to be on all four sides, what symbol will be used?

- A. Circle.
- B. Single- V.
- C. Convex.
- D. Right Triangle.

54. What is the wood member called that is graded according to its bending strength on its narrow edge which is 2-4 inches thick and at least 6 inches wide?

- A. Joists.
- B. Planks.
- C. Boards.
- D. Timbers.

Engineering Materials Exercise

55. What is the wood member called that is graded according to its bending strength on its narrow edge which is at least 4 inches thick and at least 2 inches wider than they are thick?

- ○ A. Planks.
- ○ B. Light Framing.
- ○ C. Post and Timbers.
- ○ D. Beams and Stringers.

56. What is the stress term called that has the narrow dimension carrying the load with the fibers at the top in compression and the bottom fibers are in tension?

- ○ A. Modulus of Elasticity (E).
- ○ B. Extreme Fiber Bending (F_b).
- ○ C. Horizontal Shear Parallel to the Grain (F_v //).
- ○ D. Compression Perpendicular to the Grain ($F_c \perp$).

57. What is the stress term called in a wood frame structure which works in unison to support the load on the structure and allows part of the load from a weaker member to be distributed to adjacent members?

- ○ A. Modulus of Elasticity (E).
- ○ B. Tension parallel to the grain (F_t //)
- ○ C. Extreme Fiber Bending (F_b) in a Single member.
- ○ D. Extreme Fiber Bending (F_b) in Repetitive members.

58. What is the wood member called that is graded according to its bending strength on its wider dimension which is 2-4 inches thick and at least 6 inches wide?

- ○ A. Joists.
- ○ B. Planks.
- ○ C. Boards.
- ○ D. Posts and Timbers.

Engineering Materials Exercise

59. What is the wood member called that is graded according to its load being are carried on the cross section?

- ○ A. Joists.
- ○ B. Planks.
- ○ C. Boards.
- ○ D. Posts and Timbers.

60. What is the stress term called that is induced by pressing the fiber together longitudinally on its cross section?

- ○ A. Tension parallel to the grain (F_t //)
- ○ B. Compression Parallel to the Grain (F_c //)
- ○ C. Horizontal Shear Parallel to the Grain (F_v //).
- ○ D. Compression Perpendicular to the Grain ($F_c \perp$).

61. What is the stress term called that is induced by the tendency for the upper fibers to slide over the lower fibers as a beam bends?

- ○ A. Tension parallel to the grain (F_t //)
- ○ B. Compression Parallel to the Grain (F_c //)
- ○ C. Horizontal Shear Parallel to the Grain (F_v //).
- ○ D. Compression Perpendicular to the Grain ($F_c \perp$).

62. What is the stress term called which is a measure of the stiffness or resistance to deflection?

- ○ A. Modulus of Elasticity (E).
- ○ B. Extreme Fiber Bending (F_b).
- ○ C. Horizontal Shear Parallel to the Grain (F_v //).
- ○ D. Compression Perpendicular to the Grain ($F_c \perp$).

63. Which of the following values is a typical number for the Modulus of Elasticity (E)?

- ○ A. 90
- ○ B. 800
- ○ C. 1,800
- ○ D. 1,300,000

Engineering Materials Exercise

64. Which of the following soft wood species used for structural lumber have the highest Fiber bending and Modulus of Elasticity (E) values?

- ○ A. Cedar and Larch.
- ○ B. Loblolly Pine and Ponderosa Pine.
- ○ C. White spruce and Western White Pine.
- ○ D. Douglas Fir and Southern Yellow Pine.

65. Under the structural lumber classification system, What is the name of the top grade?

- ○ A. No. 1
- ○ B. Stud Grade.
- ○ C. Construction Grade.
- ○ D. Select Structural Grade.

66. What is the structural lumber grade used where straightness and strength are the most important consideration such as in concrete formwork?

- ○ A. No. 1.
- ○ B. Standard Grade.
- ○ C. Construction Grade.
- ○ D. Select Structural Grade.

67. What does the abbreviation of S2S stamp on a piece of lumber mean?

- ○ A. Select Two Sides.
- ○ B. Select Two Edges.
- ○ C. Smooth Two Sides.
- ○ D. Smooth Two Edges.

68. What is the moisture content percentage of the lumber stamp abbreviation of S-DRY?

- ○ A. 1
- ○ B. 8
- ○ C. Less than 19.
- ○ D. Greater than 19.

Engineering Materials Exercise

69. What does the B-B designation plyform refer to?

- A. The category classification of lumber.
- B. The group number of relating to the number of plies.
- C. The front and back surface plies which have knots up to 1 inch on both sides.
- D. The front and back surface plies have a solid surface with smooth repair plugs.

70. What is the term for a material that deforms slowly when a force is applied to it for an extended period of years, even though the force is too small to cause failure in a short period of time?

- A. Creep.
- B. Strain.
- C. Tension.
- D. Compression.

71. What is the stress term called that when the stress is induced by pulling apart in a longitudinal direction?

- A. Tension parallel to the grain (F_t //)
- B. Compression Parallel to the Grain (F_c //)
- C. Horizontal Shear Parallel to the Grain (F_v //).
- D. Compression Perpendicular to the Grain ($F_c \perp$).

72. What is the term called that is a measure of its ability to cause turning, rotating or twisting about an axis of rotation?

- A. Tension.
- B. Moment.
- C. Vertical Shear.
- D. Horizontal Shear.

73. What is the term called where the force tends to cause a member to fail by cutting perpendicular to the beam's longitudinal axis at or near the beam's supports?

- A. Tension.
- B. Moment.
- C. Vertical Shear.
- D. Horizontal Shear.

Engineering Materials Exercise

74. Assume you have a wooden beam that is 20 feet long and it carries a concentrated load of 500 pounds at a distance of 15 feet from Reaction (R_2). Reaction (R_1) is pinned 5 feet from the load. What are the values in lbs for R_1 and R_2?

- A. 475 and 25.
- B. 500 and 00.
- C. 375 and 125.
- D. 125 and 375.

75. Assume you have a beam that is 16 feet long and it carries a concentrated load of 900 pounds at a distance of 4 feet from R_2. Reaction (R_1) is pinned 12 feet from the load. Reaction R_1 = 225 lbs and R_2 = 675. What is the maximum shear in lbs?

- A. 225
- B. 675
- C. 900
- D. 1800

76. Assume you have a beam that is 16 feet long and it carries a concentrated load of 900 pounds at a distance of 4 feet from R_2. Reaction (R_1) is pinned 12 feet from the load. Reaction R_1 = 225 lbs and R_2 = 675 lbs. What is the maximum bending moment in lb-ft?

- A. 900
- B. 1800
- C. 2700
- D. 3600

Check Answers

Concrete Formwork

The design and use of concrete forms either job built or prefabricated is a common feature of construction work. Most formwork is not shown on the plans or designed by a Registered Professional Engineer, but rather it is designed in the field by the field engineer or project engineer. It is therefore important that construction professionals have a demonstrated understanding of the design principles for concrete formwork.

The American Concrete Institute's (1995) book titled, *Formwork for Concrete,* is the primary reference for the design of vertical formwork for walls, the design of column formwork and the design of horizontal formwork for elevated slabs. This publication is also referred to as ACI Committee 347 *Recommended Practice for Concrete Formwork* and ACI SP-4 *Formwork for Concrete*. This publication is normally incorporated by reference in Division 03 titled Concrete, Section 100 titled Concrete Formwork, and Part 1 titled General. For example, under Part 1.04 titled Reference Standards, under item D it states that "Each Contractor shall maintain a copy of this publication shall be on the job site at all times." Also, Part 1.05 titled Quality Assurance it states under item A. "Design of formwork is the Contractor's responsibility" and under item B. "Tolerances recommended in ACI 347 shall govern, . . ." In conclusion, a copy of the book titled *Formwork for Concrete*, shall be on the job site at all times for the field engineer to consult.

Concrete Rate of Pour
The *Rate of Pour* depends on the type of equipment that is being used to place the concrete. Cast-in-place concrete can be placed by direct chute, crane and bucket, concrete pump, motorized concrete buggy, a conveyor, or by hand using a Georgia buggy. The rate of pour is expressed in Feet (vertical) per hour.

Assume that you are pouring a wall that is 200' long by 8 feet high and it is 8 inches thick and you are given the following information. The crew can place 345 Cubic Yards in a 10 - hour day and the crew consists of 1 - Crew Leader, 5 - Building Laborers and 1 - Finisher. Calculate the Concrete Rate of Pour for the Wall. The Placing Rate in cubic feet per hour is:

$$\frac{345}{10} = 34.5\ \frac{CY}{Hr} \times \frac{27\ CF}{CY} = 931.5 \text{ cubic feet per hour}$$

The Plan area in square feet for the wall forms is = $200' \times \frac{8''}{12''} = 133.33$ square feet

The Rate of pour in Feet (vertical) per hour is = $\frac{931.5}{133.33}$ = 6.98 Feet per Hour

An alternative method to calculate the rate of pour for the 200' long by 8 Feet High by 8 inches thick wall. Assume the pour is 40 feet above grade. The bucket capacity is 1.5 cubic yards, and the rate of travel up for the bucket is 90 feet per minute and the rate of travel down is 120 feet per minute. Assume the load time is 20 seconds and the unload time is 1.5 minutes. The crane and bucket cycle time is:

Activities	Calculations	Minutes
Load time	20 seconds/60 seconds	0.333
Travel up	40' / 90 ft/minute =	0.444
Unload time	1.5 minutes	1.500
Travel down	40' / 120 ft/minute	0.333
	Total Minutes per Cycle	2.610

The Rate of delivery in cubic yards per hour is:

$$\frac{\text{60 minutes}}{\text{2.610 minutes per cycle}} = \text{23 cycles per hour x 1.5 CY bucket/cycle} = \text{34.48 CY per hour}$$

The Volume of concrete in cubic yards to be poured is:

$$\text{200 feet x 8 feet x 8"/12"} = \frac{\text{1066.666 CF}}{\text{27 CF/CY}} = \text{39.704 Cubic Yards.}$$

The number of hours required to pour 39.704 cubic yards of concrete is:

$$\frac{\text{39.704 CY}}{\text{34.480 CY/ hr.}} = \text{1.15 hours}$$

The Rate of pour in feet per hour is: $\frac{\text{8 feet high}}{\text{1.15 hours}} = \text{6.96 Feet per Hour}$

Finally, the rate of pour using a concrete pump which has a capacity of 930 cubic feet per hour. The Volume of the concrete in cubic feet for the 200 feet x 8 feet x 0.667 = 1066.666 CF. Therefore, the number of hours required to pour the concrete using the pump is:

$$\frac{\text{1066.666 CF}}{\text{930 CF/Hour}} = \text{1.147 hours}$$

The Rate of pour in feet per hour is: $\frac{\text{8 feet high}}{\text{1.147 hours}} = \text{6.97 Feet per Hour}$

Lateral Concrete Pressure on Wall Forms

The *Lateral Concrete Pressure* exerted on vertical formwork is affected by several factors. First, the freshly placed concrete initially acts as a fluid exerting hydrostatic pressure against the vertical formwork. Second, the weight of the concrete exerts pressure on the forms and concrete is assumed to weigh between 150 and 154 pounds per cubic foot. Third, the placement rate of concrete affects the lateral pressure. The greater the height of the wall allows the concrete to behave as a fluid which has a greater lateral pressure at the bottom. Fourth, The temperature of the concrete and the atmospheric conditions affect the setting time which affects the pressure on the forms. Fifth, vibration of the concrete increases the lateral pressure because the concrete acts as a fluid for the full depth being vibrated. Sixth, the consistency of the concrete mix affects the lateral pressure. In conclusion, the lateral concrete pressure is a function of the hydrostatic pressure, the weight of the concrete, the rate of the pour, the temperature of the concrete, the consolidation of concrete by vibration and the consistency of the concrete mix all effect the lateral concrete pressure.

The ACI 347 Committee has developed the following formulas for calculating the *maximum lateral pressure (p) for the design of wall forms*. The lateral pressure (p) is expressed in pounds per square foot (psf). The ACI 347 Committee also insists that these formulas were developed for very specific conditions. The basic lateral pressure formulas for the wall forms are based upon the following placement conditions. The concrete is made with a Type I cement weighing 150 pounds per cubic foot, containing no pozzolans or admixtures, with a maximum slump of 4 inches. The internal vibration is limited to a depth of 4 feet or less below the concrete surface, and the maximum rate of pour cannot exceed 10 feet per hour (p 5-12). The ACI 347 Committee recommends these formulas with limitations for the lateral pressure on wall forms as follows. For Walls with placement rates of less than 7 feet per hour, the pressure is:

$$p = 150 + \frac{9000R}{T}$$

For Wall with placement rates of 7 feet per hour and up to10 feet per hour, the pressure is:

$$p = 150 + \frac{43{,}400}{T} + \frac{2800\,R}{T}$$

The abbreviations in the formulas represent the following units:

p = lateral pressure in pounds per square foot (psf)
R = the rate of concrete placement in feet per hour
T = the temperature of the concrete in the form, in degrees Fahrenheit.

Finally, the lateral pressure on the wall forms is limited as follows. The Maximum pressure is 2000 psf but in no case greater than 150 times the height of the wall, whichever is less. This is expressed as p = 150h. The minimum pressure is 600 psf.

An *example of the maximum lateral concrete pressure for the design of wall forms* for a 12-foot high wall that will be placed at 5 feet per hour. The temperature of the concrete at the time of the pour will be 75F. Also, Type 1 cement was used without admixtures, and the slump with this mix is typically 4 inches or less. The top 3 feet of the concrete must be vibrated according to the specifications. For this case, the maximum fluid pressure is calculated under the assumption that the unit weight of the concrete will be approximately 150 pounds per cubic foot (pcf). Therefore, for walls with a placement rate of less than 7 feet per hour, the maximum pressure is:

$$p = \quad 150 + \frac{9000R}{T}$$

$$p = \quad 150 + \frac{9000\,(5)}{75} = 750 \text{ psf}$$

Check for maximum pressure: the lesser of 2,000 psf and 150h, whichever is less:

$$p = \quad 150h = 150\,(12) = 1800 \text{ psf}$$

In this example, use the formula value of 750 psf because the conditions for the placement of the concrete match the assumptions for the rate of placement formula, so that this maximum will be reduced by the initial set within the lower portions of the concrete.

This pressure will build up as a fluid pressure based on the 150 pounds per cubic foot (pcf) unit weight of the fluid. To determine the height of the maximum pressure, the 150h represents the pressure of concrete in its liquid state which can be equated to the maximum pressure calculated. The formula is p = 150h which can be expressed in terms of the distance (h) from the top of the concrete pour as:

$$h = \quad \frac{p}{150}$$

The h represents the distance from the top of the concrete pour to where the calculated maximum pressure begins. In this example, the distance from the top of the pour to the point of maximum pressure is:

$$h = \quad \frac{750 \text{ psf}}{150 \text{ p}} = 5 \text{ feet}$$

Lateral Concrete Pressure on Column Forms

The ACI 347 Committee has also developed the following formula for calculating the *maximum lateral pressure for the design of column forms.* The lateral pressure is expressed in pounds per square foot (psf). The ACI 347 Committee also insists that the column formula was developed for very specific conditions. The basic lateral pressure formula for the column forms is based upon the following placement conditions which are similar to the wall form formula. The concrete is made with a Type I cement weighing 150 pounds per cubic foot, containing no pozzolans or admixtures, with a maximum slump of 4 inches. The internal vibration is limited to a depth of 4 feet or less below the concrete surface (p 5-13).

The ACI 347 Committee states that the column forms are small enough that the concrete is frequently placed to their full height within the time that it takes the concrete to begin to set. Also, the vibration of the concrete frequently extends the full height of the form which results in greater maximum lateral pressures than those that occur in wall forms. Therefore, the pressure in column forms is essentially a fluid (p 5-13). The ACI 347 Committee recommends this formula with limitations for the lateral pressure on columns as follows:

For Columns, where the maximum height of a single lift of concrete for the pour does not exceed 18 feet per hour, the pressure is:

$$p = 150 + \frac{9000R}{T}$$

Finally, the lateral pressure on the column forms is limited as follows. The Maximum pressure is 3000 psf but in no case greater than 150 times the height of the column, whichever is less. This is expressed as p = 150h. The minimum pressure is 600 psf.

An *example of the maximum lateral concrete pressure for the design of column forms* given the following conditions is shown below.

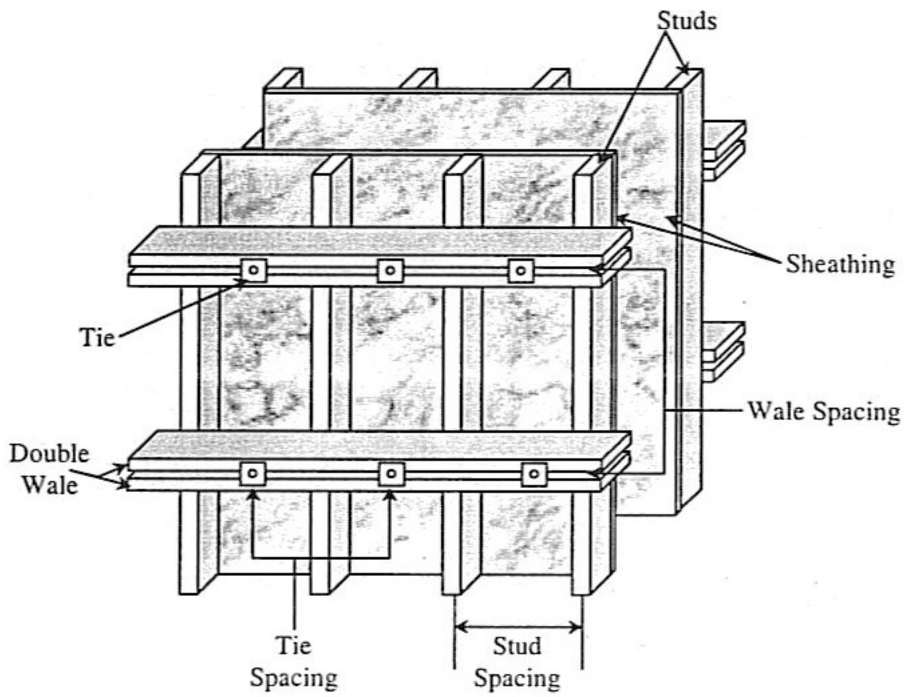
Height of column	=	15 Feet
Rate of pour (R)	=	10 Feet per hour
Concrete Temperature (T)	=	40 Degrees Fahrenheit

For columns, the maximum concrete pressure on the column is?

$$p = 150 + 9000\,\frac{10}{40} \quad = \quad 2400 \text{ psf}$$

Check for maximum pressure: the lesser of 3000 psf and 150h = 150 x 15= 2250 psf. Therefore, in this example, use the 150h = 2250 psf as the maximum pressure instead of the formula value.

Wall Formwork Components
Once the lateral pressure from the concrete has been determined, then the size and on-center spacing of each component within the form system can be designed to withstand the forces due to the fluid concrete. The *components of a wall form system* consist of sheathing, studs, wales, ties and lateral bracing. The design proceeds out from the concrete pressures established. First, the concrete is supported by the sheathing, which in turn is supported by studs, which are supported by joists, which are supported by the ties as shown below.

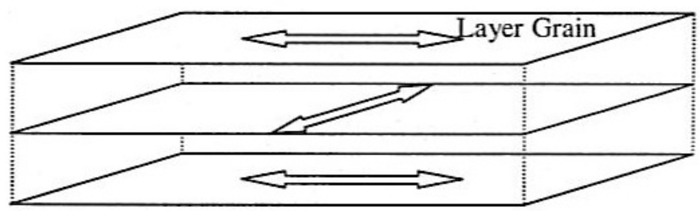


It should be noted that a number of additional components would be provided in practice, including perhaps a bottom plate or mud sill to prevent kickout of the bottom of the form and a *Wall Bracing* system is installed to maintain the vertical orientation of the wall. The braces are angled members and run between the ground and a point near the top of the wall form. These components will not be treated in the design procedures outlined herein. Also note that the function of this section is to review the design procedures outlined by ACI, not to replace them. Readers are directed to the ACI's publication titled, *Formwork for Concrete SP-4* for more complete design guidelines.

The design of each component is a balance between the size of that component and the spacing of the support for that component. For example, one can select thin sheathing with closely spaced studs, or thick sheathing with widely spaced studs, or something in between. There are economic implications: if new materials are to be acquired, or based on the materials already available.

Plyform Sheathing and Sheathing Tables

Sheathing is the material in contact with the concrete. The most common sheathing material for job-built formwork is plyform. The American Plywood Association (APA) defines plyform as a composite material made by gluing together thin layers or plies of wood. The quality of the plies used for the surface has an impact on the smoothness of the concrete surface. Plyform for concrete is graded B-B which is sanded smooth with some plugs allowed. The Plyform strength is given by its Class; most plyform is Class 1 which is the stronger class. The grain direction is alternated in each layer to provide resistance to warping and curling of the plywood. In the United States, the plyform is made with an odd number of layers so that there is one more layer with its grain in the same direction as the face grain than there is perpendicular to that direction as shown below.



Plywood Grain Directions

As a result, the plywood is stronger when the face grain runs in the direction of the span. Since the sheathing "spans" from stud to stud, the plywood is usually used with the face grain running from one stud to the next, rather than parallel to the studs. This orientation is called "face grain parallel to the span." In the United States the plywood and the plyform is made with the face grain parallel to the long dimension of the plywood.

The *American Concrete Institute* (ACI) has calculated the safe spans for numerous formwork components and developed a series of formwork tables that provide the field engineer with a quick method for selecting the appropriate spacing for the material sizes available. The tables have been arranged into four groups. Tables 7-2, 7-3 and 7-4 are called plywood sheathing tables and they are utilized to determine the maximum stud spacing. Tables 7-5, 7-6, 7-7 are called joists, studs, stringers or any other beam components of the formwork where the framing members are used singly. The joist tables are used to determine the maximum wale spacing. Tables 7-8, 7-9, 7-10 are called double wale tables where the members are used double. The wale tables are used to determine the maximum allowable wall tie spacing.

In summary, the design of a wall form system uses plywood sheathing tables 7-2, 7-3 and 7-4 to determine the stud spacing. It uses the joist, stud, and stringer tables 7-5, 7-6, 7-7 to determine the wale spacing and it uses the double wale tables 7-8, 7-9, 7-10 to determine the maximum wall tie spacing.

Maximum Allowable Stud Spacing

The formwork design process begins with the selected sheathing and the tables are used to determine the *maximum stud spacing*. It is common to start with an assumed sheathing thickness, and with that thickness to calculate a stud spacing. The stud spacing comes from the ACI's *Plywood Sheathing Design Tables* 7-2, 7-3 and 7-4. They are for plyform sheathing utilized in the construction of walls, columns and elevated slabs. These tables cover three different load situations. Table 7-2 is titled Safe Spacing, in Inches, of Supports for Plywood Sheathing, Continuous over Four or More Supports (p 7-7). Table 7-3 is titled, Safe Spacing, in Inches, of Supports for Plywood Sheathing, Continuous over Two Spans (p 7-8). Table 7-4 is titled Safe Spacing, in Inches, of Supports for Plywood Sheathing with only two points of support (p 7-9). The continuous over many spans approach is usually assumed, because ordinarily there are at most 24" spacing over the 8-foot side of the plywood; hence, there will be at least four spans.

To use the sheathing design tables 7-2, 7-3 or 7-4, first calculate the maximum concrete pressure. Then, select a sheathing thickness, and decide whether the loading will be short term or long term. Short term loading is often referred to as a single use. Long term loading is often referred to as forms that will be used several times. The Sheathing Design Tables 7-2, 7-3 and 7-4 were calculated for both short term and long term using the working stresses for Class 1 concrete plyform. The tables contain the concrete pressures down the left-hand side. Horizontally, the table is divided into two halves by the vertical double line. The values to the left of this double vertical line are the *short term loads* and the values to the right of the double vertical line are the *long-term loads*. The long term loading is the more common in practice.

The Sheathing Design Tables also contain the parameters for the allowable bending stress *(F'_b)*, the rolling shear, and the allowable design value for the modulus of elasticity (E') using B-B Class 1 Plyform. The *allowable bending stress (F'_b)* is either 1930 psi or 1545 psi. The *rolling shear* is either 72 psi or 57 psi. The *allowable modulus of elasticity* (E') is 1,500,000. Next, the designer must consider the orientation of the plywood and make a selection of which of the two columns on each side of the double line will be used. The *orientation of the plywood* options on each side of the double line is Face grain parallel to the span and Face grain perpendicular to the span. Face grain parallel to the span is more common, but the Face grain perpendicular orientation is sometimes used. After determining the proper portion of the table, it is a matter of finding the intersection of the column for the sheathing thickness and the row for the maximum expected pressure. The intersection will be the maximum allowable spacing of the studs. An example for determining the *maximum allowable spacing of studs* for a wall form system based upon the following conditions is:

Concrete pressure:	750 psf.
Stud Support Conditions:	Continuous over 3 or more spans
Loading Duration:	Short term
Sheathing:	1" B-B Class 1 Plyform, Face Grain Parallel to Span

Using the Partial ACI Sheathing Design Table 7-2 titled, Safe Spacing, in Inches, of Supports for Plywood Sheathing, Continuous over Four or More Supports provided below with a maximum concrete pressure of 750 psi. The Short term loading is to the left of the double vertical line which results in an allowable bending stress *(F'_b)* of 1930 psi. The Plywood is 1 inch thick and the orientation is given as Face grain is parallel to span, Therefore, use the Short Term Loads half of the table with the heading of Face grain parallel to span and the intersection of the column and the concrete pressure which results in a stud spacing of between 14 and 15 inches. This value is shown on the table as shaded. An interpolation of the spacing would be 14.5 inches, but plywood sheathing is normally 4 feet wide by 8 feet long, therefore, the stud spacing would probably be reduced to 12 inches to accommodate the modular spacing of the materials.

The *Joists, Studs and Beam Design Tables* 7-5, 7-6 and 7-7 are applicable to formwork members which are loaded uniformly as a beam. The tables in the 7-5 series, 7-5.1, 7-5.2, 7-5.3 and 7-5.4, are all titled, Safe Spacing, in Inches, of Supports for Joists, Studs, or Other Beam Components of Formwork, Continuous over Three or More Spans, but each table within the series has a different adjusted horizontal shear (F'_v) as shown in the table. All the tables indicate bending (F'_b) varies with each member and the Modulus of Elasticity (E) is either 1,600,000 or 1,300,000 psi. The America Concrete Institute has recommended the following adjusted allowable stresses (p 7-2).

Bending F'_b	Horizontal shear (F'_v)	Modulus of Elasticity (E)	Use of No. 2 Lumber of indicated species
960 to 1440 psi	180 psi	1,600,000 psi	Southern Pine and Douglas-Fir-Larch
1200 to 1810 psi	225 psi	1,600,000 psi	
940 to 1400 psi	140 psi	1,300,000 psi	Spruce-Pine-Fir and Hem-Fir
1170 to 1750 psi	175	1,300,000 psi	

The tables in the 7-6 series, 7-6.1, 7-6.2, 7-6.3 and 7-6.4, are all titled, Safe Spacing, in Inches, of Supports for Joists, Studs, or Other Beam Components of Formwork, Single Span, but each table within the series has a different adjusted horizontal shear (F'_v) as shown in the table. The Tables in the 7-7 series, 7-7.1, 7-7.2, 7-7.3 and 7-7.4, are all titled, Safe Spacing, in Inches, of Supports for Joists, Studs, or Other Beam Components of Formwork, Continuous Over Two Spans, but each table in the series has a different adjusted horizontal shear (F'_v) as shown in the table.

Partial ACI Table 7-2: SAFE SPACING, IN INCHES, OF SUPPORTS FOR PLYWOOD SHEATHING, CONTINUOUS OVER FOUR OR MORE SUPPORTS

Maximum deflection 1/360 of span, but not more than 1/16 inch.																
Pressure or load of concrete, pounds per square foot	Stresses and spans for short duration loads, for all sanded grades of Group 1 plywood, E modified for deflection calculations								Stresses and spans for long duration loads, for all sanded grades of Group 1 plywood, E modified for deflection calculations							
	(F'_b) = 1930 psi. rolling shear = 72 psi; E' = 1,500,000 psi								(F'_b) = 1545 psi. rolling shear = 57 psi; E' = 1,500,000 psi							
	sanded thickness, face grain parallel to span				sanded thickness, face grain perpendicular to span				sanded thickness, face grain parallel to span				sanded thickness, face grain perpendicular to span			
	½"	5/8"	3/4"	1"	½ in	5/8"	3/4"	1 in	½ in	5/8"	3/4"	1 in	½ "	5/8"	3/4"	1 in
500	10	12	14	18	5	7	10	14	9	11	12	16	5	7	10	14
600	10	11	13	16	5	7	9	13	9	10	11	14	5	7	9	13
700	9	11	12	15	5	7	9	12	8	9	10	13	5	7	8	12
800	9	10	11	14	4	6	8	12	7	9	10	12	4	6	7	12
900	8	9	10	13	4	6	8	11	7	8	9	12	4	5	7	10
1000	7	9	10	12	4	6	7	11	7	8	9	11	4	5	6	10
1100	7	8	9	12	4	6	7	11	6	8	8	11	4	5	6	9
1200	7	8	9	11	4	5	6	10	6	7	8	10	4	4	5	8

Note: Above solid, deflection controls span. Below dash line, rolling shear governs. Between the lines, bending controls. Spans are given center to center of supports., assuming 1-1/2 inch support width for shear spans. If supports of a different width are used, detailed calculations should be made to check spans in the range now shown as controlled by shear. Adapted from American Concrete Institute's publication *Formwork for Concrete*. Sixth Edition, Table 7-2 (p 7-7). This is a partial table for educational purposes only and you must reference ACI's publications for complete and accurate information.

Uniform Stud Load and the Allowable Wale Spacing

To use the stud design table 7-5.1: titled, Safe Spacing, in Inches, of Supports for Joists, Studs, or Other Beam Components of Formwork, Continuous over Three or More Spans, first calculate the uniform load on the studs in pounds per lineal feet which equals the maximum pressure in psf times the stud spacing from the sheathing design table previously. The studs are loaded by the concrete pressure on that portion of the sheathing supported by each stud. From the previous example, the maximum concrete pressure was 750 psf and the spacing was found to be 14.5 inches but it was reduced to 12 inches. Therefore, the uniform load on the stud is as follows:

$$\text{Uniform Stud Load} = 750 \text{ psf} \times \frac{12 \text{ inches}}{12 \text{ inches}} \times 1 \text{ foot} = 750 \text{ pounds per lineal foot}$$

Next, determine the stud size available and the allowable horizontal shear (F'_v) based upon the materials provided. After you have selected the correct stud design table based upon the adjusted horizontal shear (F'_v), the Bending F'_b and the Modulus of Elasticity (E'). Then it is a matter of finding the intersection of the uniform stud load and the size of the material available. The intersection will be the maximum allowable spacing of the wales.

An example for determining the *maximum allowable spacing of wales* for a wall form system given the following conditions wall formwork design criteria:

Concrete pressure:	750 psf.
Rate of Pour:	5 feet per hour
Temperature of Concrete:	75 Degrees Fahrenheit
Wall Height:	12 feet
Wall Thickness	10 inches
Loading Duration:	Long term
Sheathing:	1" B-B Class 1 Plyform, Face Grain Parallel to Span
Stud Load:	750 pounds per lineal foot (plf)
Stud Lumber:	No. 2 Douglas Fir-Larch, S4S
Stud Support Conditions:	Continuous over 3 or more spans
Stud Horizontal Shear (F'_v)	180 psi
Studs	2 x 4 studs, spaced 12 inches center-to-center

Using the Partial ACI Stud Design Table 7-5.1 below titled, Safe Spacing, in Inches, of Supports for Joists, Studs, or Other Beam Components of Formwork, Continuous over Three or More Spans, and a stud Horizontal Shear (F'_v) of 180 psi stated above. Find the row containing the uniform load of 750 plf and find the 2 x4 column, the intersection of the row and column will provide you with the maximum wale spacing. The shaded area on the table shows that the wale spacing is between 23 inches and 25 inches. The *Maximum Wale Spacing* is 24 inches.

Partial ACI TABLE 7-5.1: SAFE SPACING, IN INCHES, OF SUPPORTS FOR JOISTS, STUDS, OR OTHER BEAM COMPONENTS OF FORMWORK, CONTINUOUS OVER THREE OR MORE SPANS.

Maximum deflection is 1/360 of the span or 1/4 in., whichever is smaller.

Uniform load, lb per lineal feet (equals uniform load on forms times spacing between joists or studs (feet)	F'_b varies with member				E' = 1,600,000 psi			F'_v = 180 psi	
	Nominal size of SxS lumber								
	2x4	2x6	2 x 8	2 x 10	3 x 4	3x6	3x8	3x10	4x2
	F'_b psi								
	1310	1140	1050	960	1310	1140	1050	960	1440
500	31	45	58	70	40	59	74	91	21
600	28	42	53	64	37	54	68	83	19
700	25	38	49	59	34	50	63	77	18
800	23	36	45	55	32	46	59	72	17
900	21	33	43	52	30	44	55	68	16
1000	20	31	41	50	28	42	53	64	15
1100	18	29	38	47	26	40	50	61	14
1200	18	28	36	44	25	38	48	58	14
1300	17	26	35	42	23	36	46	56	13

NOTE: Span values above solid line are controlled by deflection. Within the dashed box horizontal shear governs span. Elsewhere bending controls span. Adapted from American Concrete Institute's publication *Formwork for Concrete*. Sixth Edition, Design Table 7-5.1 (p 7-10). This is a partial table for educational purposes only and you must reference ACI's publications for complete and accurate information.

The *Wale Design Tables* 7-8, 7-9 and 7-10 are for double members which are commonly used for wales and frequently used for stringers. A stringer is a member used in the design of elevated slabs. The 7-8 series, 7-8.1 and 7-8.2 are both for Double Wales, Continuous over Three or More Spans, but 7-8.1 covers adjusted horizontal shear (F'_v) of 180 psi and 225 psi respectively and the Modulus of Elasticity (E') is 1,300,000. Table 7-8.2 covers adjusted horizontal shear (F'_v) of 140 psi and 175 psi respectively, and the Modulus of Elasticity (E') is 1,300,000. Tables 7-9.1 and 7-9.2 are both for Double Wales, Single Span. Table 7-9.1 covers adjusted horizontal shear (F'_v) of 180 psi and 225 psi respectively. Table 7-9.2 covers adjusted horizontal shear (F'_v) of 140 psi and 175 psi respectively. Tables 7-10.1 and 7-10.2 are both for Double Wales, Continuous Over Two Spans. Table 7-10.1 covers horizontal shear (F'_v) of 180 psi and 225 psi respectively. Table 7-10.2 covers horizontal shear (F'_v) of 140 psi and 175 psi respectively.

Uniform Wale Load and the Maximum Allowable Tie Spacing
To use the Wales design table 7-8.1: titled, Safe Spacing, in Inches, of Supports for Double Wales, Continuous over Three or More Spans, first calculate the uniform load on the wales in pounds per lineal foot which equals uniform load in pounds per square foot times the spacing of the wales. This uniform load was calculated from the previous design tables and the spacing of the wales was found in the previous stud design table. From the previous example, the uniform load on the stud was 750 pounds per lineal foot (plf) and the spacing of the wales was 24 inches. Therefore, the uniform load on the wales is as follows:

$$\text{Uniform Wale Load} = 750 \text{ plf on the stud} \times \frac{24 \text{ inches}}{12 \text{ inches}} \times 1 \text{ foot} = 1500 \text{ pounds per foot}$$

Next, determine the wale size available and the allowable horizontal shear (F'_v) based upon the materials provided. After you have selected the correct wale design table based upon the adjusted horizontal shear (F'_v), the Bending F'_b and the Modulus of Elasticity (E'). Then it is a matter of finding the intersection of the uniform wale load and the size of the material available. The intersection will be the maximum allowable spacing of the wall ties.

An example for determining the *maximum allowable spacing of wall ties* for a wall form system given the following conditions wall formwork design criteria:

Concrete pressure:	750 psf.
Stud Lumber:	No. 2 Douglas Fir-Larch, S4S
Stud Support Conditions:	Continuous over 3 or more spans
Stud Horizontal Shear (F'_v)	180 psi
Studs	2 x 4 studs, spaced 12 inches center-to-center
Wale Load:	1500 pounds per lineal foot (plf)
Wale Lumber:	No. 2 Douglas-Fir-Larch, S4S
Wale Support Conditions:	Continuous over 3 or more spans
Wale Horizontal Shear (F'_v)	180 psi
Wales	2 x 6 double wales at 24 inches center-to-center.

Using the Partial Double Wales Design Table 7-8.1: titled, Safe Spacing, in Inches, of Supports for Double Wales, Continuous over Three or More Spans and a Wale Horizontal Shear (F'_v) of 180 psi stated above. Find the row containing the uniform wale load of 1500 plf and find the 2 x6 column, the intersection of the row and column will provide you with the maximum tie spacing. The table shows that the wale spacing is 37 inches which is shown on the table as a shaded area. Therefore, the *maximum allowable tie spacing is 37 inches*.

Partial ACI Table7-8.1: SAFE SPACING, IN INCHES, OF SUPPORTS FOR DOUBLE WALES, CONTINUOUS OVER THREE OR MORE SPANS

Uniform load, lb per lineal feet (equals uniform load, psf, on forms times spacing of wales in ft.)	F'_b varies with member E' = 1,600,000 psi F'_v = 180 psi								F'_b varies with member E' = 1,600,000 psi F'_v = 225 psi							
	Nominal size of S4S lumber								Nominal size of S4S lumber							
	2x4	2x6	2x8	3x4	3x6	3x8	4x4	4x6	2x4	2x6	2x8	3x4	3x6	3x8	4x4	4x6
	1310	1140	1050	1310	1140	1050	1310	1140	1640	1420	1310	1640	1420	1310	1640	1420
600	40	59	74	52	76	96	61	90	45	66	83	58	85	107	68	100
700	37	54	69	48	70	89	57	83	41	61	77	54	78	99	63	93
800	35	51	64	45	66	83	53	78	39	57	72	50	73	93	59	87
900	33	48	61	42	62	78	50	73	37	53	68	47	69	87	56	82
1000	31	45	58	40	59	74	47	69	35	51	64	45	66	83	53	78
1100	30	43	55	38	56	71	45	66	33	48	61	43	62	79	51	74
1200	28	42	53	37	54	68	43	63	32	46	59	41	60	76	48	71
1300	26	40	50	35	51	65	42	61	30	45	56	39	57	73	46	68
1400	25	38	49	34	50	63	40	59	29	43	54	38	55	70	45	66
1500	24	37	47	33	48	61	39	57	28	41	52	37	53	68	43	63
1600	23	36	45	32	46	59	37	55	27	40	51	35	52	66	42	61

NOTE: Span values above solid line are controlled by deflection. Within the dashed box horizontal shear governs span. Elsewhere bending controls span.
Adapted from American Concrete Institute's publication *Formwork for Concrete*. Sixth Edition, Design Table 7-8.1 (p 7-22). This is a partial table for educational purposes only and you must reference ACI's publications for complete and accurate information.

Load Capacity of Available Wall Ties
The *load capacity of available wall ties* is the last step in the process. This requires the selection of a wall tie that can resist the load, which will be applied to it. The load applied to the wall tie is the concrete pressure times the wale spacing and times the tie spacing. The design process simply requires determining whether the value calculated is less than the manufacturer's rating for the tie intended for use. When the expected load is less than the tie can resist, the tie is used. When the expected load is too high, one must either reduce the tie spacing to reduce the load, or find a bigger tie. An example for verifying the wall tie load capacity for a wall form system given the following conditions wall formwork design criteria are as follows:

Concrete pressure:	750 psf.
Rate of Pour:	5 feet per hour
Temperature of Concrete:	75 Degrees Fahrenheit
Wall Height:	12 feet
Wall Thickness	10 inches
Loading Duration:	Long term
Sheathing:	1" B-B Class 1 Plyform, Face Grain Parallel to Span
Stud Lumber:	No. 2 Douglas Fir-Larch, S4S
Stud Support Conditions:	Continuous over 3 or more spans
Stud Horizontal Shear (F'_v)	180 psi
Studs	2 x 4 studs, spaced 12 inches center-to-center
Wale Load:	1500 pounds per lineal foot (plf)
Wale Lumber:	No. 2 Douglas Fir-Larch, S4S
Wale Support Conditions:	Continuous over 3 or more spans
Wale Horizontal Shear (F'_v)	180 psi
Wales	2 x 6 double wales at 24 inches center-to-center.
Maximum Tie Spacing	37 inches

From the example, the concrete pressure is 750 psf, the wale spacing is 24 inches and the maximum tie spacing is 37 inches. Therefore, the load capacity on the wall ties is as follows:

Wall Tie Load Capacity = 750 psf x 24/12 x 37/12 = 4,625 pounds

A wall tie with a safe working load of 5,000 pounds will resist the 4,625 pound load calculated above. But based upon uniform or modular spacing, the 2 x 6 double wales would be more practical if a tie spacing of 36 inches was utilized. Therefore, the tie spacing would be less than the maximum allowed by table 7-8.1, and the average wall tie load would be reduced to:

Tie Load Capacity = 750 psf x 24/12 x 36/12 = 4500 pounds

Elevated Slab Form Load

The *Vertical Load* on elevated slab forms must be designed to resist the dead loads and the various live loads during construction. Elevated slab forms must also be capable of resisting lateral loads from the placement of the concrete, the movement of construction equipment and the wind. The ACI 347 Committee suggests that the dead load consists of the weight of the fresh concrete, the weight of the reinforcing bar, and the weight of the forms (p 5-1). For example, assume that you have concrete that weighs 154 pounds per cubic foot. It will place a load on the forms of 12.83 pounds per square foot for each inch of slab thickness as shown below.

$$\frac{154}{12} = 12.8333 \text{ pounds per Square Foot}$$

Therefore, the *Dead Load* for a 6" thick slab is 12.8333 pounds per Square Foot x 6 inches = 76.999 pounds per square foot

The ACI Committee 347 recommends that a single story-elevated slab be designed for a minimum *Live Load* 50 psf to provide for weight of workers, runways, screeds and other equipment. This does not include the weight of the concrete formwork. If motorized concrete buggies are being used, then the minimum live load should be 75 pounds per square foot (psf). The ACI 347 Committee also says that "regardless of slab thickness, the minimum design value for combined dead and live loads should be 100 psf, or 125 psf if motorized buggies are used" (p 5-1). Using the 6-inch slab dead load from above, and the recommended live load excluding the weight of the forms. Then the minimum total horizontal design load is:

77 psf dead load + 50 psf live load = 127 pounds per square foot (psf)

Using the 6-inch slab dead load from above, and the recommended live load for motorized concrete buggies excluding the weight of the forms. Then the minimum total horizontal design load is: 77 psf dead load + 75 psf live load = 152 pounds per square foot (psf)

The design for an *Elevated Slab* consists of plyform sheathing, joists, stringer and shores or posts. The ACI's Plywood Sheathing Design Tables 7-2, 7-3 and 7-4 are used to determine the maximum joist spacing. Tables 7-5, 7-6 and 7-7 are used for the stringers to determine the member sizes which can be used for the stringer span designated. Stringers are members placed side by side with their longer dimensions as the depth of the beam. Finally, Tables 7-11 and 7-12 are for selecting the allowable loads on the posts. Table 7-11 is titled, Allowable Axial Load (Pounds) on Simple Wood Shores of the Indicated Strength and Effective Length. Table 7-12: is titled, Allowable Load Based on Maximum Shore Area in Direct Contact with Wood Member Being Supported.

Formwork Design Exercise

1. Which of the following references is incorporated by reference for the design of vertical and horizontal forms and a copy shall be maintained on the job site at all times?

   - A. American Concrete Institute's publication ACI 347 titled, *Formwork for Concrete*.
   - B. American Society for Testing Materials publication ASTM C 94 titled, *Ready-Mixed Concrete.*
   - C. American Concrete Institute's publication ACI 301 titled, *Specifications for Structural Concrete for Buildings*.
   - D. Concrete Reinforcing Steel Institute's publication CRSI 65 titled, *Recommended Practice for Placing Bar Supports, Specifications and Nomenclature*.

2. Which party is responsible for the design of the concrete formwork?

   - A. Owner.
   - B. Field Engineer.
   - C. Concrete Supplier.
   - D. Architect/Engineer.

3. According to the ACI 347 Committee, What is the Maximum Rate of Pour allowed for a Wall in feet per hour?

   - A. 7 feet per hour
   - B. 10 Feet per hour
   - C. 18 feet per hour
   - D. 150 feet per hour

4. What is the weight range of a cubic foot of normal concrete for design purposes?

   - A. 65 - 90
   - B. 91 - 120.
   - C. 121 - 140
   - D. 150 - 154

Formwork Design Exercise

5. Assume that you are pouring a wall that is 151 feet - 4 inches long, 14 Feet high and 16 inches thick and the daily placement rate is 375 cubic yards per 8-hour day. What is the Rate of pour in feet per hour?

- A. 00.23
- B. 06.27
- C. 07.51
- D. 60.11

The information provided below is for Questions 6 through 11.
Assume that you are pouring a wall that is 151 feet - 4 inches long by 16 Feet High by 16 inches thick wall, and the placement will be done using a crane and bucket.

6. Assume the bucket has a capacity of 2.5 cubic yards. The pour is 55 feet above the ground and the rate of travel up for the bucket is 80 feet per minute and the rate of travel down is 100 feet per minute. Assume the load time is 30 seconds and the unload time is 4.0 minutes. What is the cycle time in minutes?

- A. 4.55 minutes
- B. 5.74 minutes
- C. 7.77 minutes
- D. 35.24 minutes

7. Assume the bucket has a capacity of 2.5 cubic yards and it takes 7 minutes per cycle. What is the rate of delivery in cubic yards per hour?

- A. 2.86
- B. 8.57
- C. 12.86
- D. 21.43

8. What is the volume of concrete to be poured in cubic yards?

- A. 89.68
- B. 119.27
- C. 1434.83
- D. 3220.30

Formwork Design Exercise

9. Assume that you can place 33 Cubic Yards per hour. How many hours are required to pour the cubic yards of concrete?

- A. 0.28
- B. 3.61
- C. 14.91
- D. 2385.40

10. Assume that it takes 2.25 hours to pour the 151 feet - 4 inches long by 16 Feet High by 16 inches thick wall. What is the rate of pour in feet(vertical) per hour?

- A. 0.14
- B. 7.11
- C. 10.00
- D. 14.91

11. Assume the pour is using a concrete pump with a capacity of 635 cubic feet per hour. How many hours are required to pour the cubic yards of concrete?

- A. 0.03
- B. 5.07
- C. 10.00
- D. 39.69

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12. Given the following design conditions for a wall form system:

Wall height	=	10 Feet high
Rate of Pour (R)	=	6 Feet per hour
Concrete Temperature (T)	=	70 Degrees Fahrenheit
Wall Thickness	=	15 inches

What is the maximum pressure on the wall in pounds per square foot (psf)?

- A. 771
- B. 921
- C. 1010
- D. 1436

Formwork Design Exercise

13. A wall form system has the following design conditions:

Wall height	=	12 feet high
Rate of Pour (R)	=	10 feet per hour
Concrete Temperature (T)	=	75 Degrees Fahrenheit
Wall Thickness	=	15 inches

What is the maximum pressure on the wall in pounds per square foot (psf)?

- A. 1102
- B. 1200
- C. 1350
- D. 1800

14. A wall form system has the following design conditions:

Wall height	=	6 Feet high
Rate of Pour (R)	=	10 Feet per hour
Concrete Temperature (T)	=	60 Degrees Fahrenheit
Wall Thickness	=	15 inches

What is the maximum pressure on the wall in pounds per square foot (psf)?

- A. 900
- B. 1340
- C. 1500
- D. 1650

15. A column system has the following design conditions:

Column Height	=	15 Feet
Rate of Pour (R)	=	20 Feet per Hour
Concrete Temperature (T)	=	70 Degrees Fahrenheit
Column Thickness	=	24 inches by 24 inches

What is the maximum pressure on the wall in pounds per square foot (psf)?

- A. 1527
- B. 2250
- C. 2571
- D. 2721

Formwork Design Exercise

16. Using the Partial ACI Design Tables 7-2, 7-5.1, 7-5.2 and 7-8.1 provided at the end of this exercise, and given the following conditions for a wall form system:

Concrete pressure:	1102 psf.
Rate of Pour:	10 feet per hour
Temperature of Concrete:	75F
Wall Height:	22 feet
Wall Thickness	15 inches
Loading Duration:	Long term
Sheathing:	3/4" B-B Class 1 Plyform, Face Grain Parallel to Span

What is the maximum allowable spacing of the studs in inches?

- A. 7
- B. 8
- C. 9
- D. 12

17. Given the following conditions for a wall form system:

Concrete pressure:	1102 psf.
Rate of Pour:	10 feet per hour
Temperature of Concrete:	75F
Wall Height:	22 feet
Wall Thickness	15 inches
Stud Load:	
Stud Lumber:	No. 2 Southern Pine, S4S
Stud Support Conditions:	Continuous over 3 or more spans
Stud Horizontal Shear (F'_v)	225 psi
Studs	2 x 8 studs, spaced 10 inches center-to-center

What is the uniform Stud load (rounded) in pounds per lineal foot?

- A. 220
- B. 918
- C. 1102
- D. 1322

Formwork Design Exercise

18. Using the Partial ACI Design Tables 7-2, 7-5.1, 7-5.2 and 7-8.1 and given the following conditions for a wall form system:

Concrete pressure:	1102 psf.
Rate of Pour:	10 feet per hour
Temperature of Concrete:	75F
Wall Height:	22 feet
Wall Thickness	15 inches
Stud Load:	1050 pounds per lineal foot
Stud Lumber:	No. 2 Southern Pine, S4S
Stud Support Conditions:	Continuous over 3 or more spans
Stud Horizontal Shear (F'_v)	225 psi
Studs	2 x 8 studs, spaced 10 inches center-to-center

What is the maximum allowable spacing of the wales?

- A. 19.0
- B. 30.0
- C. 39.5
- D. 44.0

19. Given the following conditions for a wall form system:

Concrete pressure:	1102 psf.
Stud Load:	1000 pounds per lineal foot
Stud Lumber:	No. 2 Southern Pine, S4S
Stud Support Conditions:	Continuous over 3 or more spans
Stud Horizontal Shear (F'_v)	225 psi
Studs	2 x 8 studs, spaced 10 inches center-to-center
Wale Lumber:	No. 2 Southern Pine, S4S
Wale Support Conditions:	Continuous over 3 or more spans
Wale Horizontal Shear (F'_v)	225 psi
Wales	2 x 8 double wales at 36 inches center-to-center.

What is the uniform Wale load (rounded) in pounds per lineal foot?

- A. 225
- B. 833
- C. 1000
- D. 3000

Formwork Design Exercise

20. Using the Partial ACI Design Tables 7-2, 7-5.1, 7-5.2 and 7-8.1 and given the following conditions for a wall form system:

Wale load	1550 pounds per lineal foot
Wale Lumber:	No. 2 Southern Pine, S4S
Wale Support Conditions:	Continuous over 3 or more spans
Wale Horizontal Shear (F'_v)	225 psi
Wales	2 x 8 double wales at 36 inches center-to-center.

What is the maximum allowable tie spacing in inches?

- A. 36.5
- B. 40.5
- C. 46.0
- D. 51.5

21. Given the following conditions for a wall form system:

Concrete pressure:	1102 psf.
Stud Load:	1000 pounds per lineal foot
Stud Lumber:	No. 2 Southern Pine, S4S
Stud Support Conditions:	Continuous over 3 or more spans
Stud Horizontal Shear (F'_v)	225 psi
Studs	2 x 8 studs, spaced 10 inches center-to-center
Wale Load:	2000 pounds per lineal foot (plf)
Wale Lumber:	No. 2 Southern Pine, S4S
Wale Support Conditions:	Continuous over 3 or more spans
Wale Horizontal Shear (F'_v)	225 psi
Wales	2 x 8 double wales at 36 inches center-to-center.
Maximum Tie Spacing:	45 inches

What is the Wall Tie load capacity in pounds (rounded to whole number)?

- A. 2000
- B. 2755
- C. 2918
- D. 12398

Formwork Design Exercise

22. Assume that you have concrete that weighs 150 pounds per cubic foot and the concrete slab is 10 inches thick. What is the dead load in pounds per square foot?

- A. 12.5
- B. 50.0
- C. 75.0
- D. 125.0

23. What is the minimum Live Load for motorized buggies in pounds per square foot?

- A. 25
- B. 50
- C. 75
- D. 100

24. Which of the plyform orientations provides the strongest formwork system?

- A. Parallel to the span.
- B. Parallel to the studs.
- C. Perpendicular to the span.
- D. Perpendicular to the Wales

25. You are ordering the wall ties, which of the following items must you provide the supplier with to have a complete description?

- A. Wall height, wall length, shear strength, and allowable deflection.
- B. Wall thickness, tie load capacity, break back, and tie extension.
- C. Lumber orientation, Type of lumber, wind force, and vibration.
- D. Lateral Pressure, sheathing thickness, bending, and rolling shear.

26. What is the standard in North America for the outer layer of plyform?

- A. The grain of the outer layer is parallel to the long dimension.
- B. The grain of the outer layer is perpendicular to the long dimension.
- C. The grain of the outer layer is at a 45-degree angle to the long dimension.
- D. The grain of the outer layer is at a 45-degree angle to the short dimension.

Check Answers

Formwork Exercise - Partial ACI Table 7-2: SAFE SPACING, IN INCHES, OF SUPPORTS FOR PLYWOOD SHEATHING, CONTINUOUS OVER FOUR OR MORE SUPPORTS

Maximum deflection 1/360 of span, but not more than 1/16 inch.																
Pressure or load of concrete, pounds per square foot	Stresses and spans for short duration loads, for all sanded grades of Group 1 plywood, E modified for deflection calculations								Stresses and spans for long duration loads, for all sanded grades of Group 1 plywood, E modified for deflection calculations							
	(F'_b) = 1930 psi. rolling shear = 72 psi; E' = 1,500,000 psi								(F'_b) = 1545 psi. rolling shear = 57 psi; E' = 1,500,000 psi							
	sanded thickness, face grain parallel to span				sanded thickness, face grain perpendicular to span				sanded thickness, face grain parallel to span				sanded thickness, face grain perpendicular to span			
	½"	5/8"	3/4"	1"	½ in	5/8"	3/4"	1 in	½ in	5/8"	3/4"	1 in	½ "	5/8"	3/4"	1 in
500	10	12	14	18	5	7	10	14	9	11	12	16	5	7	10	14
600	10	11	13	16	5	7	9	13	9	10	11	14	5	7	9	13
700	9	11	12	15	5	7	9	12	8	9	10	13	5	7	8	12
800	9	10	11	14	4	6	8	12	7	9	10	12	4	6	7	12
900	8	9	10	13	4	6	8	11	7	8	9	12	4	5	7	10
1000	7	9	10	12	4	6	7	11	7	8	9	11	4	5	6	10
1100	7	8	9	12	4	6	7	11	6	8	8	11	4	5	6	9
1200	7	8	9	11	4	5	6	10	6	7	8	10	4	4	5	8

Note: Above solid, deflection controls span. Below dash line, rolling shear governs. Between the lines, bending controls. Spans are given center to center of supports., assuming 1-1/2 inch support width for shear spans. If supports of a different with are used, detailed calculations should be made to check spans in the range now shown as controlled by shear. Adapted from American Concrete Institute's publication *Formwork for Concrete*. Sixth Edition, Design Table 7-2 (p 7-7). This is a partial table for educational purposes only and you must reference ACI's publications for complete and accurate information.

Formwork Exercise Partial ACI TABLE 7-5.1: SAFE SPACING, IN INCHES, OF SUPPORTS FOR JOISTS, STUDS, OR OTHER BEAM COMPONENTS OF FORMWORK, CONTINUOUS OVER THREE OR MORE SPANS.

Maximum deflection is 1/360 of the span or 1/4 in., whichever is smaller.

Uniform load, lb per lineal feet (equals uniform load on forms times spacing between joists or studs (feet)	F'_b varies with member						E' = 1,600,000 psi							F'_v = 180 psi	
	Nominal size of SxS lumber														
	2x4	2x6	2 x 8	2 x 10	3 x 4	3x6	3x8	3x10	4x2	4 x 4	4 x 6	4 x 8	6 x 2	6 x 4	8 x 2
	F'_b, psi														
	1310	1140	1050	960	1310	1140	1050	960	1440	1310	1140	1140	1310	1190	1210
500	31	45	58	70	40	59	74	91	21	47	69	92	25	57	28
600	28	42	53	64	37	54	68	83	19	43	63	84	23	52	26
700	25	38	49	59	34	50	63	77	18	40	59	77	22	48	24
800	23	36	45	55	32	46	59	72	17	37	55	72	20	45	22
900	21	33	43	52	30	44	55	68	16	35	52	68	19	42	21
1000	20	31	41	50	28	42	53	64	15	34	49	65	18	40	20
1100	18	29	38	47	26	40	50	61	14	32	47	62	17	38	19
1200	18	28	36	44	25	38	48	58	14	31	45	59	16	37	18
1300	17	26	35	42	23	36	46	56	13	29	43	57	16	35	17

NOTE: Span values above solid line are controlled by deflection. Within the dashed box horizontal shear governs span. Elsewhere bending controls span. Adapted from American Concrete Institute's publication *Formwork for Concrete*. Sixth Edition, Design Table 7-5.1 (p 7-10). This is a partial table for educational purposes only and you must reference ACI's publications for complete and accurate information.

Formwork Exercise - Partial ACI TABLE 7-5.2: SAFE SPACING, IN INCHES, OF SUPPORTS FOR JOISTS, STUDS, OR OTHER BEAM COMPONENTS OF FORMWORK, CONTINUOUS OVER THREE OR MORE SPANS.

Maximum deflection is 1/360 of the span or 1/4 in., whichever is smaller.

Uniform load, lb per lineal feet (equals uniform load on forms times spacing between joists or studs (feet)	F'_b varies with member						E' = 1,600,000 psi							F'_v = 225 psi	
	Nominal size of SxS lumber														
	2x4	2x6	2 x 8	2 x 10	3 x 4	3x6	3x8	3x10	4x2	4 x 4	4 x 6	4 x 8	6 x 2	6 x 4	8 x 2
	F'_b, psi														
	1640	1422	1310	1200	1640	1420	1310	1200	1810	1640	1420	1420	1640	1490	1510
500	35	51	64	78	45	66	83	101	24	53	78	102	28	63	31
600	32	46	59	72	41	60	76	92	22	48	71	93	26	58	29
700	29	43	54	66	38	55	70	86	20	45	66	86	24	54	27
800	27	40	51	62	35	52	66	80	19	42	61	81	23	50	25
900	25	38	48	58	33	49	62	75	18	40	58	76	21	47	23
1000	23	36	45	55	32	46	59	72	17	37	55	72	20	45	22
1100	21	34	43	53	30	44	56	68	16	36	52	69	19	43	21
1200	20	32	41	51	29	42	54	65	15	34	50	66	18	41	20
1300	19	30	40	49	27	41	51	63	15	33	48	63	18	39	19

NOTE: Span values above solid line are controlled by deflection. Within the dashed box horizontal shear governs span. Elsewhere bending controls span. Adapted from American Concrete Institute's publication *Formwork for Concrete*. Sixth Edition, Design Table 7-5.2 (p 7-11). This is a partial table for educational purposes only and you must reference ACI's publications for complete and accurate information.

Formwork Exercise - Partial ACI Table7-8.1: SAFE SPACING, IN INCHES, OF SUPPORTS FOR DOUBLE WALES, CONTINUOUS OVER THREE OR MORE SPANS

Uniform load, lb per lineal feet (equals uniform load, psf, on forms times spacing of wales in ft.)	F'_b varies with member E' = 1,600,000 psi F'_v = 180 psi								F'_b varies with member E' = 1,600,000 psi F'_v = 225 psi							
	Nominal size of S4S lumber								Nominal size of S4S lumber							
	2x4	2x6	2x8	3x4	3x6	3x8	4x4	4x6	2x4	2x6	2x8	3x4	3x6	3x8	4x4	4x6
	1310	1140	1050	1310	1140	1050	1310	1140	1640	1420	1310	1640	1420	1310	1640	1420
600	40	59	74	52	76	96	61	90	45	66	83	58	85	107	68	100
700	37	54	69	48	70	89	57	83	41	61	77	54	78	99	63	93
800	35	51	64	45	66	83	53	78	39	57	72	50	73	93	59	87
900	33	48	61	42	62	78	50	73	37	53	68	47	69	87	56	82
1000	31	45	58	40	59	74	47	69	35	51	64	45	66	83	53	78
1100	30	43	55	38	56	71	45	66	33	48	61	43	62	79	51	74
1200	28	42	53	37	54	68	43	63	32	46	59	41	60	76	48	71
1300	26	40	50	35	51	65	42	61	30	45	56	39	57	73	46	68
1400	25	38	49	34	50	63	40	59	29	43	54	38	55	70	45	66
1500	24	37	47	33	48	61	39	57	28	41	52	37	53	68	43	63
1600	23	36	45	32	46	59	37	55	27	40	51	35	52	66	42	61

NOTE: Span values above solid line are controlled by deflection. Within the dashed box horizontal shear governs span. Elsewhere bending controls span. Adapted from American Concrete Institute's publication *Formwork for Concrete*. Sixth Edition, Design Table 7-8.1 (p 7-22). This is a partial table for educational purposes only and you must reference ACI's publications for complete and accurate information.

Soil Mechanics

Soil Investigation Tests

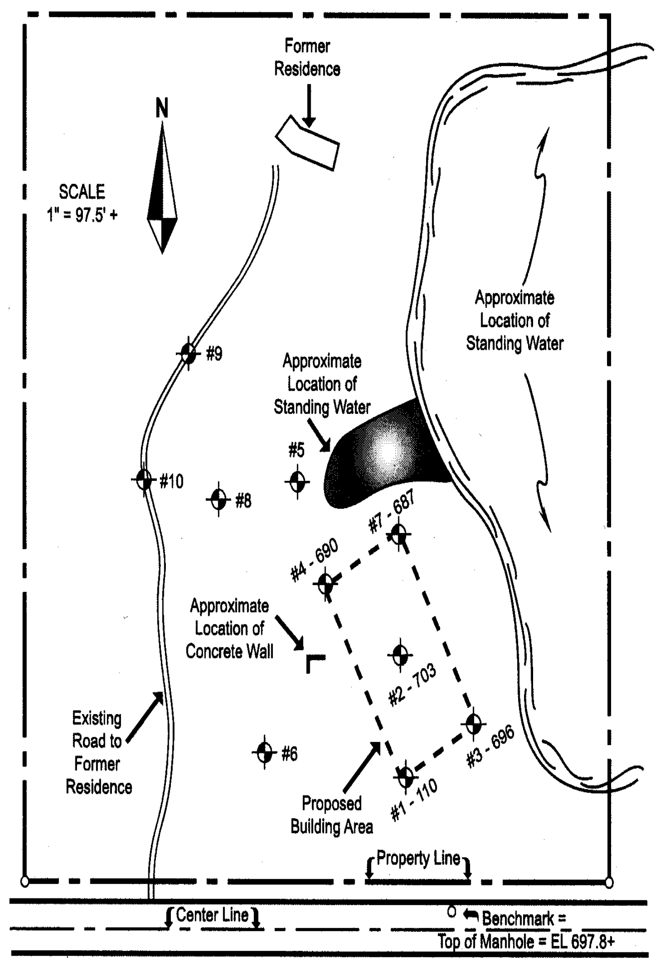
Soil Investigation or Soil Exploration consists of three steps: boring, sampling and testing. First, the boring refers to the drilling of a hole in the ground. Some of the most common types of borings are auger borings, wash borings, test pits, and core borings. Second, sampling refers to the removing the soil from the holes. Samples may be classified as either disturbed or undisturbed. Auger borings and wash boring methods bring the soil sample to the surface where samples are collected. Soil samples by these methods are considered disturbed samples ans some of their characteristics are changed. Soil sampling is the equipment used to extract, contain and seal the samples from the borings during the subsurface soil investigation. At the surface, the disturbed soil samples should be placed in airtight containers and labeled for the lab. Third, testing refers to the lab and field tests that can be conducted to determine the soil properties.

There are numerous tests that can be made to evaluate various soil properties, but the most common test in the United States is the Standard Penetration Test (SPT). The *Standard Penetration Test (SPT)* is useful in determining certain properties of cohesionless soils. The SPT utilizes a split spoon sampler which has an outside diameter (O.D.) of 2 inches and it is 18 - 24 inches long. The sampler is attached to the bottom of a drilling rod and driven into the soil with a 140 pound hammer falling 30 inches. As the sampler is driven the 18 inches into the sampler, the number of blows required to penetrate each of the three 6 inch increments is recorded separately on the boring log. The standard penetration resistance “N” value is the number of blows required to penetrate the last 12 inches. Below is an example of a partial Geotechnical or Soil Investigation Report and on the following pages is an example of the Soil Boring Location Plan, the Soil Boring #8 and the Relative Density and Consistency Table. These are the Proposed Public Service Building Procedures:

The borings were drilled using a CME model 45 “skid” drill rig. The drill rig utilized hollow stem augers to sample depths where samples were obtained in a two-inch O.D. split spoon sampler driven by a 140 pound hammer falling 30 inches. The number of blows required to drive the sampler three six-inch increments are recorded on the boring logs. The first six inches is considered the seating drive. The summation of the number of blows required for the second and third six inches is termed the penetration resistance “N” value in blows per foot (bpf). This field procedure is referred to as the Standard Penetration Test (SPT) and is an American Society for Testing and Materials test procedure (ASTM D-1586).

The “N” values from the SPT are used for the determination of the relative density of granular soils (sand, gravel, low plasticity silt, and mixtures of sand and gravel) or the consistency of cohesive soils (clay and plastic silts). A chart is provided in the back of this report which provides a correlation between “N” values and the relative density of granular soils or the consistency of cohesive soils.

Proposed Public Service Building Soil Boring Location Plan



Soil Investigation Report

The Soil Investigation Report is used to identify the drilling procedures and the penetration resistance "N" value. From each Soil Boring, you can extract the water table, the Penetration Blow Counts and the Soil Classification provided by the testing firm. Finally, it is the Contractor's responsibility to determine the Penetration "N" value from the Soil Boring, which is the summation of the number of blows required for the second and third penetration counts. Then using this total number of blows, you must determine the relative density of sand or the consistency of clay and compare the table's description to the to the Soil Classification Description on the soil boring.

Proposed Public Service Building Soil Boring Example

PROJECT	Blue Lake County Office	DATE STARTED	12/17/2039
LOCATION	Blue Ridge Lane	DATE COMPLETED	12/17/2039
CLIENT	Brayton AEC	DRILLER: S. Dweb	HELPER: M. Buck
PROJECT NO.	15-1291	DRAWING: # 1	Date: 12/19/

Boring No.	8 (Pavement Area)	Weather	Cloudy
Ground Surface Elev.	683.6±	Rig No.	807
Datum	Top of Sanitary Manhole = EL 697.8	Water Data	3' During drilling (EL 680.6±)
	For location - see drawing #2		

DEPTH	SAMPLE	SAMPLING METHOD	PENETRATION BLOW COUNT 1	2	3	LINER √	SOIL CLASSIFICATION
			2	2	3	0.67'	Organic Topsoil
			2	3	3		
			2	2	3		Very Loose to Loose Brown Fine to Coarse Sand
5			2	3	3		
			3	3	3	7.5'	
							Boring Terminated at 7.5'
10							
15							
20							
25							
30							

Plugging Method Natural Soil Job. No. 15-1291

IAB - 20

Reading the Soil Boring
From the Soil Boring provided you can determine the following information.

Soil Boring Number	#8 (Pavement Area)
Ground Surface Elevation	683.6 Feet
Read the Report and Review the Borings for Unsuitable Soil	Not Provided
Read the Report and Review the Boring for the elevation of Water Data	During Drilling at 680.6 Feet
Read the Report and Review the Borings to Determine depth of the water Table	3 Feet
Read the Report and Calculate the Penetration Resistance "N" value in blows per foot (bpf)	2 + 3 = 5
Read the Soil Borings and for #8 at 3 feet the Soil Classification is stated as	Very Loose to Loose Brown Fine to Course Sand

Relative Density and Consistency Table
Finally, the Report of Soil Investigation contains a standard table for determining the relative density for sand and silt and the consistency of clay. This table is called the Relative Density and Consistency Table and it is provided below. It is utilized by the Contractor to compare what is called out at each depth of a soil boring to what the table indicates. The material relative density and consistency is based upon blow count. For example, using the Penetration Resistance "N" value of 5 found on soil boring #8 above at 3 feet, and using the Sand and Silt, Relative Density portion of the table below for the blow count of 5, the soil should be classified as Loose Sand. This matches the Boring #8 at 3 feet called a Very Loose to Loose Brown Fine to Course Sand.

Sand and Silt, Relative Density		**Consistency of Clay**	
No. of blows required to drive a sampler I foot, using a 140# hammer falling 30" 2" O.D. Samplers	RELATIVE DENSITY	No. of blows required to drive a sampler I foot, using a 140# hammer falling 30" 2" O.D. Samplers	CONSISTENCY
< 4	Very Loose	< 2	Very Soft
4 - 10	Loose	2-4	Soft
11-15	Medium Loose	5-6	Medium Soft
16-30	Medium Dense	7-8	Medium Stiff
31-50	Dense	9-15	Stiff
> 50	Very Dense	16-30	Very Stiff
		>30	Hard

Soil Categories
Soils are separated in three broad categories. They are cohesionless, cohesive and organic soils. *Cohensionless soils* are gravel, sand, and silt. Gravel has particle sizes of 3 inches down to a #4 sieve. Sand particles range from a #4 sieve down to a #200 sieve. Sand and gravel can be further divided into fine and course such as fine sand and course sand. Finally, clay or the fines is a #200 sieve on down. The common type of *cohesive soil* is clay which has particle sizes less than a #200 sieve. Organic soil are undesirable for supporting structures and must not contaminate the desirable sands and gravels. Finally, Loam roughly contains equal parts of sand, silt and clay.

A cohesive soils particle sizes may be determined by the hydrometer method which is a process for indirectly observing the settling velocities of the particles in a soil-water mixture. Another technique for analyzing cohesive soils is by use of the *Atterberg limits* method. Atterberg define four states of consistency for cohesive soils. They are liquid, plastic, semisolid, and solid.

Soil properties and characteristics are influenced by changes in water content and there are three phenomena that are directly related to the water in the soil. They are permeability, capillarity, and frost heave. *Permeability* is the movement of water within a soil. *Capillarity* is the rise of water above the ground water table against the pull of gravity but is in contact with the water table as its source. *Frost heave* is the vertical expansion of soil caused by water freezing.

Soil Classification Systems
The most commonly used *Soil Classification Systems* based upon grain size are the *Unified Soil Classification System (USCS). and the American Association of State Highway and Transportation Officials (AASHTO) system*. The OSHA Standards for the Construction Industry in 29 CFR PART 1926.650 in Appendix A of Subpart P titled *Soil Classification* paragraph (c) Requirements (1) Classification and (2) Basis of classification it states that "the classification of the soil deposits shall be made based on the results of at least one visual inspection and at least one manual analysis (p 257). The standard also incorporates by reference the American Society for Testing Materials (ASTM) standard D2488 titled, *Standard Recommended Practices Description of Soils*. Therefore, a person must have a basic understanding of soil terminology so that they can properly identify and classify the soil. Your daily excavation inspections will require you to use the following soil terminology. According to OSHA 1926 Appendix A paragraph (b) Definitions it states that "the definitions and example . . are based on, in whole or in part, the following: American Society for Testing Materials (ASTM) Standards D653-85 and D2488; The Unified Soils Classification System; The U.S. Department of Agriculture (USDA) Textural Classification Scheme; and the National Bureau of Standards Report BSS-121.

A *Cemented Soil* means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-size sample cannot be crushed into a powder or individual soil particles by finger pressure. Cemented soils include hardpan. These soils are also extremely hard to excavate.

A *Clay* is a soil that is hard to break up when dry, but can be crushed to a powder (fine grained soil) and can be moldable when wet and sticks together (cohesive). A *Cohesive Soil* is a soil with a high clay content which sticks together when wet or dry. Cohesive soil does not crumble, can be excavated with vertical side slopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged under water. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay. A *Cohensionless soil* is a loose sand or granular gravel that freely runs. A *Dry Soil* is a soil that does not exhibit visible signs of moisture content.

A *Granular Soil* means a gravel , sand or silt with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry. A *Layered System* means two or more distinctly different soils or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered. *Moist soil* means a soil condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles. A *Plastic soil* means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

A *Saturated Soil* is a soil in which the voids are filled with water. Saturation does not require flow. Saturation or near saturation, is necessary for the proper use of instruments such as a pocket pentrometer or torvane. A *Spoil* refers to the earth and material drawn from an excavation. The term *Submerged Soil* means soil which is under water or is free seeping. *Wet soil* means soil that contains significantly more moisture than moist soil, but in such range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

According to the standards, the acceptable *Field Soil Visual Tests* shall be conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the soil. Visual analysis is conducted to determine the qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as examples from excavated material. Therefore, it is imperative that while making a visual inspection that you look for distress and the signs of trench failure. It should be understood that *Clay* is one of the most dangerous materials because the vertical walls of an excavation appear to be solid and stable. However, clay is drastically effected by water, wind, and pressure. Water causes it to swell, wind causes it to dry and shrink rapidly, and the soil pressure causes clay to bulge. Any or all of the conditions described above can cause trench failure. Below are the definitions of the types of distress that result in trench failure.

Types of Distress that Result in Trench Failure

Distress means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or surface of an open excavation; the subsidence of the horizontal plane of an excavation; the bulging of the face of an excavation; the heaving of material from the bottom of an excavation; the spalling of material from the face of a rock excavation; the raveling of small amounts of material trickling down into the excavation; and the seeping of water into the excavation.

The initial signs of trench failure begin immediately after removing the soil**,** the trench becomes unstable and the soil in the trench walls begins to move into the excavation. This movement usually is not visible but the soil is moving because the surface of the ground is in tension, therefore, the weight of the soil causes surface cracks parallel to the trench, approximately one-third to two-thirds of the trench depth from the trench edge. For example, if the depth of the trench is 9 feet deep, these surface tension cracks may be found somewhere between three (3) feet and six (6) feet from the edge of the trench. The edge of the excavation may also subside but this is hard to see.

The second sign of trench failure is in the face of the excavation, Cracks, normally horizontal, may appear on the face and the walls of the excavation may bulge into the excavation but these signs of failure are also hard to see. The third sign of progressive trench failure is when the bottom of the trench initially fails or kicks into the excavation. This leaves the upper portion of the face unsupported and the trench wall is hanging on by the shear force. A second failure will occur soon after the first failure as the upper portion of the excavation collapses into the trench. Often a worker is trapped by the initial cave-in and co-workers will jump into the trench to help, unaware that multiple cave-ins are likely. Normally, the second and third cave-ins are the ones that will kill or injure the rescuers. Therefore, you should be aware that cave-ins normally occur in multiples. The final sign of trench failure is rain flowing into the surface cracks will increase the surcharge load in the soil. These fissures may appear to close while wet but they will reappear wider after some drying takes place. Water will also be retained in the spoil pile and this will create an increase in the surcharge load on the trench.

Field Visual Inspections for Excavation

There are over fifteen potential *Types of Distress That Result in Trench Failure* that you must periodically visually inspect for when an excavation is open. The following distresses are defined below to help you identify the potential types of soil conditions at the job site that may lead to a trench failure. *Fissured* means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface such as on the existing horizontal surface or on the excavation face. The excavation face means the vertical or inclined earth surfaces formed as a result of the excavation work. This is sometimes referred to as the excavation sides.

Unsupported Faces or Walls are immediately developed once an excavation is excavated and the weight of the soil, due to gravity places vertical and horizontal (lateral) pressure on the wall. This gravity translates directly to weight. In many cases, one cubic foot of soil weights an average of 120 pounds per cubic foot. A column of soil one foot wide, five feet deep and six long weighing 120 pounds per cubic foot would weigh 3600 pounds per side. (1 foot wide x 5 feet deep x 6 feet long x 120 pounds per cubic foot). If you multiply each vertical wall by two, a full cave-in could easily be 7200 pounds.

Other visual inspections are for *Bulging* which occurs as a result of the vertical and lateral forces being exerted on the unsupported walls. Bulging will first appear on the face of the wall as protrusions into the open excavation. *Subsidence* occurs as a result of unbalanced stresses in the soil. Subsidence causes the soil to sink on the surface and bulging of the vertical face of the trench. If uncorrected, this condition can cause face failure and entrapment of workers in the trench. *Heaving or squeezing* is caused by the downward pressure created by the weight of adjoining soil. This pressure causes a bulge in the bottom of the cut. Heaving and squeezing can occur even when shoring or shielding has been properly installed. *Boiling* is evidenced by an upward water flow into the bottom of the cut. A high water table is one of the causes of boiling. Boiling produces a "quick" condition in the bottom of the cut, and can occur even when shoring or trench boxes are used. Some additional visual inspections are for *Raveling* which is evidenced by small amounts of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation. *Spalling* is evidenced by small fragments of rock break up or scale off the excavation face. This is caused by vibration near a fractured unstable rock face.

Other visual inspections are for a *Surcharge Load* means an excessive vertical load or weight caused by the spoil pile being too close to the trench edge or equipment being too close to the trench edge. These activities effect the trench stability. *Vibration* is a dynamic force introduced into the ground from blasting, pile driving, traffic, construction equipment and proximity to railroad tracks and industrial turbines. *Undercutting* is caused by excavating below the existing foundation of a nearby structures and not providing enough clearance area. A *Previously Disturbed Soil* is a soil which will never return to its original position or stability. The previously disturbed soil will slide or ravel into the new excavation. Finally, you must inspect for a *Layered Soil System* where two or more distinctly different soils or rock types are arranged in layers. The soil layers slope into the excavation at a four Horizontal to one Vertical (4H:IV) or steeper slope. A layered system is controlled by its weakest layer and this can result in a wedge failure.

Some trench failure terms are *Sliding or slumping* may occur as a result of tension cracks, weak soil, water soaked soil, hard soil or rock on top of a weak soil layer. *Toppling* is also caused by tension cracks. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation. *Sloughing* is where the sides cave into the trench during excavation.

Field Tests for Soil Analysis

The OSHA standards states that the classification of soil shall be made based upon the results of at least one *Field Manual Soil Analysis Test*. The OSHA standards describes these manual tests that can be performed by a qualified person at the test site. The manual tests are the plasticity test, the pat test, the dry strength test, the thumb penetration or pocket pentrometer test and the drying test. The *plasticity test* requires you to mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8 of an inch in diameter by two inches in length. Then the soil sample is held by one end and if the soil sample does not tear or break then it is considered a cohesive soil. The *Pat Test* is used to determine the presence of a cohesive clay or silt. This test is conducted by spreading a 1/8 inch to 1/4 inch thick sample of wet soil on the palm of your hand and then remove any visible water from the surface. With the sample in the palm of your hand, slap the back of the hand moderately approximately eight times. If the surface appears shiny due to water rising to the surface, this soil consists mostly of granular silt or sand and it is considered a weaker soil. If no water appears on the surface, the soil consists of mostly cohesive clay and this is considered a stronger soil.

The *Dry Strength Test* is used to determine the amount of strength and the presence of fissures in dry soils. If the soil is dry and crumbles on its own or with moderate pressure into individual grains of fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and fall into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand, or silt. If the dry soil breaks into clumps which do not break into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

The *Thumb Penetration Test* can be used to estimate the unconfined compressive strength of cohesive soils. This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488 titled *Standard Recommended Practice for Description of Soils (Visual - Manual Procedure*). This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly. The thumb penetration test is used to estimate the unconfined compressive strength of cohesive soils. From the thumb penetration level you can determine the type of soil using the following chart from ASTM Standard Test D 2488.

THUMB PENETRATION	UNCONFINED	SOIL TYPE
1/4 " or less	1.5 Tons per sq.ft.	A
1/4" to 1"	0.5 to 1.5 Tons per sq. ft.	B
1" or more	0.5 Tons per sq.ft.	C

The Unconfined Compressive Strength is the load per unit area at which soil will fail in compression. This measure can be determined by laboratory testing or it can be estimated in the field using the Thumb Penetration test a pocket penetrometer, or a shearvane (Torvane) test. The *Pocket Pentrometer* is used to determine the unconfined compression strength on the trench face or on a large clump of soil. Penetrometers are direct reading, spring-operated instruments that are used to determine the unconfined compressive strength of saturated cohesive soils. Once pushed into the soil, an indicator sleeve displays the reading. The instrument is calibrated in either tons per square foot (tsf) or kilograms per square centimeter (kPa). However, penetrometers have error rates in the range of plus or minus 20-40 percent. Another hand operated strength test instrument is the shearvane or torvane. The *Shearvane* has blades which are pressed into a level section of undisturbed soil, and the torsional knob is slowly turned until soil failure occurs. The direct instrument reading must be multiplied by 2 to provide results in tons per square foot (tsf) or kilograms per square centimeter (kPa).

The *Drying Test* is used to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry. After drying, If the sample develops cracks as it dries, significant fissures are indicated. Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as an unfissured cohesive material and the unconfined compressive strength should be determined. Finally, If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

The table is provided below to help you differentiate between the soils using the dry test.

UNFISSURED COHESIVE SOIL	FISSURED SOIL
Surface drying cracks are not visible	Surface drying cracks are visible
Sample breaks with force	Sample breaks easily by hand
Clumps do not crush easily by hand or when stepped on.	Clumps do not crush easily by hand or when stepped on
Granular Soil	
Clumps crush easily	

Volume Changes, Swell Percentage and Shrinkage Percentage

Soil is found in three fundamental conditions or states. They are Bank, Loose and Compacted states. *Bank material* is in its natural or undisturbed condition. Bank is often referred to as "in place" or "in situ." The unit volume is identified as a bank cubic yard (BCY). The *Loose Material* state is material that has been excavated, stockpiled or loaded a piece of equipment. The unit volume is identified as a loose cubic yard (LCY). The Compacted Material is after applying some type of compaction equipment to consolidate the material. The unit volume is identified as compacted cubic yards (CCY). In conclusion, soil swells if disturbed and shrinks under pressure. Therefore, volume corrections must be made depending on the soils' change in state. The table below provides the formula for the swell percentage which is used for hauling material and the shrinkage percentage is used for compacting material. Also, the other table below provides the average soil weights for calculating swell and shrinkage percentages based on the soils weight in the various states and conditions.

AVERAGE SOIL WEIGHTS AND VOLUME CHANGE FORMULAS

SOIL TYPE	LCY	BCY	CCY 100% STANDARD PROCTOR	CCY 100% MODIFIED PROCTOR	LOAD FACTOR
Clay - Dry	2050	2675	2835	3159	.81
Clay - Natural Bed Wet	2800	3400	3575	3959	.82
Sand - Dry	2420	2740	3362	3510	.85
Sand - Damp	2760	3130	3362	3510	.85
Gravel - Damp	2623	2980	3375	3645	.85
Common Earth - Dry	2185	2883	3375	3510	.80
Common Earth - Moist	2463	3160	3375	3510	.79
Loam	2100	2600	2835	3150	.81

$Sw\ \% = \left(\frac{BCY}{LCY} - 1\right)100$	$\text{Load Factor (LF)} = \frac{100\%}{100\% + \%\ \text{Swell}}$
$Sh\ \% = \left(1 - \frac{BCY}{CCY}\right)100$	$LCY \times LF = BCY$
$\text{Shrinkage Factor (SF)} = \frac{CCY}{BCY}$	$BCY \times SF = CCY$

Using the tables above and assume that you are excavating a Natural Bed Wet Clay. The Swell percentage is = $\text{Swell \%} = \left(\frac{BCY}{LCY} - 1\right)100$ Wet Clay = $\left(\frac{3400}{2800} - 1\right) 100 = (1.214 - 1) = 21.43\%$

Now assume that you are compacting a wet sand around the structure. The shrinkage percentage is:

$$\text{Shrinkage \%} = \left(1 - \frac{BCY}{CCY}\right)100 \quad \text{Damp Sand} = \left(1 - \frac{3{,}130}{3{,}510}\right) 100 = (1 - .892) = 10.8\%$$

Compaction is defined as the voids in the soil are reduced as portions of the air and moisture are driven out by the use of mechanical compaction equipment such as rollers, vibrating rollers and tampers. Reduced voids and increased density produce a more stable earth fill., which will provide a greater weight carrying capacity.

A standard laboratory test called a Proctor Test has been developed to evaluate a soil's moisture-density relationship under specified compaction conditions. Actually, there are two Proctor tests which have been standardized by the American Society for Testing Materials and (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO). These are the Standard Proctor Test and the Modified Proctor Test.

The *Standard Proctor Test* is performed using a steel cylinder mold 4 inch in diameter with a height of 4.59 inches and it is filled with a sample of the proposed material in three layers. Each layer is struck with 25 blows from a 5.5-pound, 2 inch diameter hammer dropped from a height of 12 inches. The *Modified Proctor Test* is performed using the same cylinder and the sample is placed in 5 layers. Each layer is struck with 25 blows with a 10-pound, 2 inch diameter hammer dropped from a height of 18 inches (stroke). The Modified Proctor is specified for fill material designated for use under areas where high design loads are anticipated such as airport run ways and paved areas.

The relationship between moisture content and density of the soil is similar with most soils. Therefore, the amount of moisture required for the soil to attain its maximum density under compaction is called the Optimum Moisture Content. The *Optimum Moisture Content* is the primary factor that will determine if the desired density will be achieved in the least number of passes. Normally the Technical Specifications specify the proctor test that will be utilized, the density percentage that must be achieved and the optimum moisture content range.

Another factor that will effect whether density is attained is the thickness of the compacted material normally referred to as the lift. The normal lift for compaction purposes is between 6 inches and 12 inches.

Soil Mechanics Exercise
Questions 1 through 16 pertain to the Soil Investigation Report and Soil Boring Procedures and the Relative Density and Consistency Table provided at the end of this exercise. Answer the following questions.

1. The Soil Report discusses the Penetration Resistance "N" Blow Count Summation procedure, What is the correct summation procedure?

- A. Add Blow Counts 1 and 2.
- B. Add Blow Counts 1 and 3.
- C. Add Blow Counts 2 and 3.
- D. Add Blow Counts 1, 2, and 3.

2. What type of hammer and fall distance was utilized for sampling the soil borings?

- A. a 5-pound hammer falling 12-inches.
- B. a 10-pound hammer falling 18-inches.
- C. a 100-pound hammer falling 18-inches.
- D. a 140-pound hammer falling 30-inches.

3. Which party is responsible for comparing the soil borings to the standard Relative Density and Consistency Table provided in the Soil Report?

- A. Owner.
- B. Vendor.
- C. Contractor.
- D. Architect/Engineer.

4. What does the abbreviation bpf mean?

- A. Bulk per foot.
- B. Bank per foot.
- C. Blows per foot.
- D. Borings per foot.

5. What does the abbreviation SPT mean?

- A. Stiff Penetration Test.
- B. Standard Proctor Test.
- C. Standard Penetration Test.
- D. Society for Proctor Testing.

Soil Mechanics Exercise

6. Which organization established the penetration test boring procedures?

- ○ A. Testing Services.
- ○ B. Standard Penetration Testing.
- ○ C. Society for Proctor Testing.
- ○ D. American Society for Testing and Materials.

7. What is the Ground Elevation for Soil Boring #5?

- ○ A. 682.3'
- ○ B. 683.3'
- ○ C. 697.8'
- ○ D. 807.0'

8. At what depth did they hit water during drilling for Soil Boring #5?

- ○ A. 0.0 Feet.
- ○ B. 1.0 Foot.
- ○ C. 2.5 Feet
- ○ D. 15.0 Feet

9. Using Soil Boring #5, What is the Penetration Resistance "N" at 4 Feet in bpf?

- ○ A. 3
- ○ B. 6
- ○ C. 7
- ○ D. 10

10. Using Soil Boring #5, is there any unsuitable soil?

- ○ A. Organic Topsoil.
- ○ B. Rock and Boulders.
- ○ C. Very Stiff Clay and Gravel.
- ○ D. Loose to Very Loose Brown Fine to Course Sand.

Soil Mechanics Exercise

11. Using Soil Boring #5. What is the depth of the unsuitable soil in feet?

- A. 0.00'
- B. 1.00'
- C. 2.50'
- D. 3.08'

12. What is the Soil Classification for Boring #5 shown at 6 feet?

- A. Organic Topsoil.
- B. Rock and Boulders.
- C. Very Stiff Clay and Gravel.
- D. Loose to Very Loose Brown Fine to Course Sand.

13. Using the Relative Density and Consistency Table, Soil Boring #5 and assume the Penetration Resistance “N” is 7. What is the material description from the table?

- A. Soft.
- B. Loose.
- C. Medium Stiff.
- D. Medium Dense.

14. At what depth was Boring #5 drilling operation stopped?

- A. 0.0 Feet.
- B. 1.0 Foot.
- C. 2.5 Feet
- D. 15.0 Feet

15. Assume the Penetration Resistance “N” is 29 for a clay, from the Relative Density and Consistency table what is the material description?

- A. Dense.
- B. Very Stiff.
- C. Medium Stiff.
- D. Medium Dense.

Soil Mechanics Exercise

16. Using the Relative Density and Consistency table, If the soil boring indicated a Sand what term are you looking for at the top of the Table?

- A. Consistency.
- B. Medium Stiff.
- C. Medium Dense.
- D. Relative Density.

17. Which of the following soils is considered cohesionless?

- A. Silt.
- B. Clay
- C. Gravel.
- D. Topsoil.

18. Which of the following soils is considered cohesive?

- A. Clay
- B. Sand.
- C. Gravel.
- D. Topsoil.

19. Which of the following tests is performed on cohesionless soil to determine the distribution of grain size?

- A. Vane Test.
- B. Sieve Analysis.
- C. Atterberg Limits.
- D. Penetration Test.

20. Which of the following techniques is used to determine the liquid, plastic, semisolid, and solid states of consistency for a cohesive soil?

- A. Vane Test.
- B. Sieve Analysis.
- C. Atterberg Limits.
- D. Penetration Test.

Soil Mechanics Exercise

21. Which of the following terms refers to the ability of water to flow through a soil by traveling through the void spaces?

- ○ A. Capillarity.
- ○ B. Frost heave.
- ○ C. Permeability.
- ○ D. Ground Water Table.

22. What are the most commonly used soil classification systems based on grain size?

- ○ A. Atterberg Limits and Permeability.
- ○ B. The U.S. Department of Agriculture (USDA) Textural Classification Scheme and the National Bureau of Standards Report BSS-121.
- ○ C. The Construction Specification Institute's Master Format and the U.S. Governments Master Work Breakdown Structure (WBS).
- ○ D. Unified Soil Classification System (USCS) and the American Association of State Highway and Transportation Officials (AASHTO).

23. What is the earth material drawn from an excavation called?

- ○ A. Spoil.
- ○ B. Saturated Soil.
- ○ C. Submerged Soil.
- ○ D. Cohesionless Soil.

24. What type of soil is the most dangerous because the excavated faces appear to be solid and stable, but they are drastically affected by water, wind, and pressure?

- ○ A. Clay.
- ○ B. Sand.
- ○ C. Gravel.
- ○ D. Stable Rock.

25. According to OSHA, what is the minimum ratio for a layered soil system?

- ○ A. 1H:1V
- ○ B. 3H:1V
- ○ C. 4H:1V
- ○ D. 1H:4V.

Soil Mechanics Exercise

26. A small amount of material suddenly separates from the face of an excavation and trickles or rolls down into the excavation. What is the visual inspection term called?

- A. Spalling.
- B. Heaving.
- C. Toppling.
- D. Raveling.

27. The layers on the face of the excavation slope at a ratio of four horizontal to one vertical (4H:1V) or greater. What is the visual inspection term called?

- A. Sliding.
- B. Toppling.
- C. Undercutting.
- D. Sloped system.

28. There is upward water flow into the bottom of the excavation. What is the visual inspection term called?

- A. Boiling.
- B. Sloughing.
- C. Submerged.
- D. Surcharge Load.

29. The soil has sunk on the horizontal surface. What is the visual inspection term called?

- A. Boiling.
- B. Bulging.
- C. Heaving.
- D. Subsidence.

30. The soil is protruding from the face of the open excavation into the excavation. What is the visual inspection term called?

- A. Boiling.
- B. Bulging.
- C. Heaving.
- D. Subsidence.

Soil Mechanics Exercise

31. the soil is protruding up from the bottom of the excavation. What is the visual inspection term called?

- A. Boiling.
- B. Bulging.
- C. Heaving.
- D. Subsidence.

32. the soil has open cracks on the horizontal ground or on the open face of the excavation. What is the visual inspection term called?

- A. Fissure.
- B. Bulging.
- C. Sloughing.
- D. Subsidence.

33. What is the term for an excessive vertical load caused by the spoil pile or construction equipment being too close to the trench edge?

- A. Impact load.
- B. Undercutting.
- C. Underpinning.
- D. Surcharge load.

34. What do the field thumb penetration, pocket penetrometer and the shearvane measure?

- A. Shear Stress.
- B. Impact Load.
- C. Surcharge Load.
- D. Unconfined Compressive Strength.

35. Which field manual test is used to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material?

- A. Pat Test.
- B. Drying Test.
- C. Plasticity Test.
- D. Dry Strength Test.

36. Which field manual test checks for a cohesive soil?

- A. Pat Test.
- B. Drying Test.
- C. Plasticity Test.
- D. Thumb Penetration Test.

37. Which field manual test is used to determine the presence of a cohesive clay or silt?

- A. Pat Test.
- B. Drying Test.
- C. Plasticity Test.
- D. Thumb Penetration Test.

38. What is another name for a soil that contains equal parts of sand, silt and clay?

- A. Spoil.
- B. Loam.
- C. Moist Soil.
- D. Common Earth.

39. Which of the following soil has no cohesive strength?

- A. Clay.
- B. Moist Soil.
- C. Layered Soil.
- D. Granular Soil.

40. What is the soil state called if it is in its natural, or in place or in situ or undisturbed state?

- A. Bank.
- B. Loose
- C. Solid.
- D. Compacted.

41. What is the soil state called when the soil is excavated?

- A. Bank.
- B. Loose
- C. Solid.
- D. Compacted.

Soil Mechanics Exercise

42. Using the Average Soil Weights Table, What is the swell percentage using a Loam?

- A. 08.3%
- B. 23.8%
- C. 31.9%
- D. 81.0%

43. Using the Average Soil Weights Table, What is the shrinkage percentage for a Damp Sand under the Modified Proctor method, What is the shrinkage percentage? .

- A. 10.8
- B. 12.1
- C. 13.4
- D. 85.0

44. Which of the following is the primary factor that will determine if 97% density using the Modified Proctor Test will be achieved in a predetermined number of passes?

- A. Soil Type.
- B. Moisture Content.
- C. Swell Percentage.
- D. Shrinkage Percentage.

45. Which of the following procedures describes the Modified Proctor Test?

- A. It uses a 5-pound hammer dropped from a height of 12 inches.
- B. It uses a 10-pound hammer dropped from a height of 18 inches.
- C. It uses a 13,000 pound hammer dropped from a height of 20 feet.
- D. It uses a 140-pound hammer dropped from a height of 30 inches.

46. Which of the following procedures describes the Standard Proctor Test?

- A. It uses a 5-pound hammer dropped from a height of 12 inches.
- B. It uses a 10-pound hammer dropped from a height of 18 inches.
- C. It uses a 13,000 pound hammer dropped from a height of 20 feet.
- D. It uses a 140-pound hammer dropped from a height of 30 inches.

Soil Mechanics Exercise

47. What is the normal lift range in inches stated in the documents for attaining the specified density percentage when compacting structural fill?

- A. 6 - 12.
- B. 13 - 24.
- C. 25 - 48.
- D. 49 - 60.

48. Which document specifies the Proctor Test and the percentage range and the Optimum Moisture Content?

- A. Bid Documents.
- B. General Requirements.
- C. Technical Specifications.
- D. Supplementary Conditions.

49. Which test is specified for fill material designated for use under areas where high design loads are anticipated such as airport run ways and paved areas?

- A. Shearvane.
- B. Penetrometer
- C. Standard Proctor.
- D. Modified Proctor.

50. The Soil Tables and formulas contain the abbreviation BCY, What does BCY mean?

- A. Bulk Cubic Yards.
- B. Bank Cubic Yards.
- C. Basic Cubic Yards.
- D. Borrow Cubic Yards.

51. Which test instrument measures the unconfined compressive strength of soil?

- A. Standard Proctor.
- B. Modified Proctor.
- C. Pocket Penetrometer.
- D. Standard Penetration.

Check Answers

Soil Mechanics Exercise - Soil Investigation Report

Geotechnical Investigation Report

The purpose of this report is to present the results of a soil investigation performed at the project site located in Big Rapids Township, Michigan. We have appended Drawing No. 1 which identifies the project site location in Big Rapids Township.

The borings were drilled by Testing Services (TS), Inc., using a CME model 45 “skid” drill rig. The drill rig utilized hollow stem augers to sample depths where samples were obtained in a two-inch O.D. split spoon sampler driven by a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler three six-inch increments are recorded on the boring logs. The first six inches are considered the seating drive. The summation of the number of blows required for the second and third six inches are termed the penetration resistance “N” value in blows per foot (bpf). This field procedure is referred to as the Standard Penetration Test (SPT) and is an American Society for Testing and Materials test procedure (ASTM D-1586). The “N” values from the SPT are used for the determination of the relative density of granular soils (sand, gravel, low plasticity silt, and mixtures of sand and gravel) or the consistency of cohesive oils (clay and plastic silts). A chart is provided in the back of this report which provides a correlation between “N” values and the relative density of granular soils or the consistency of cohesive soils.

Relative Density and Consistency Table

Sand and Silt, Relative Density		**Consistency of Clay**	
No. of blows required to drive a sampler 1 foot, using a 140# hammer falling 30" 2" O.D. Samplers	RELATIVE DENSITY	No. of blows required to drive a sampler 1 foot, using a 140# hammer falling 30" 2" O.D. Samplers	CONSISTENCY
< 4	Very Loose	< 2	Very Soft
4 - 10	Loose	2-4	Soft
11-15	Medium Loose	5-6	Medium Soft
16-30	Medium Dense	7-8	Medium Stiff
31-50	Dense	9-15	Stiff
> 50	Very Dense	16-30	Very Stiff
		>30	Hard

Soil Mechanics Exercise - Soil Boring #5

PROJECT	Blue Lake County Office	DATE STARTED	12/17/2039
LOCATION	Blue Ridge Lane	DATE COMPLETED	12/17/2039
CLIENT	Brayton AEC	DRILLER: S. Dweb	HELPER: M. Buck
PROJECT NO.	15-1291	DRAWING: # 1	Date: 12/19/

Boring No.	5 (Pavement Area)	Weather	Cloudy and Snow
Ground Surface Elev.	683.3±	Rig No.	807
Datum	Top of Sanitary Manhole = EL 697.8	Water Data	1' During drilling (EL 682.3±)
	For location - see drawing #2		

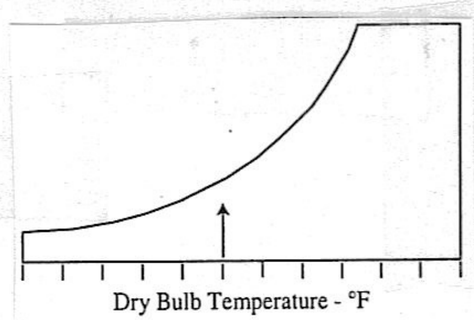
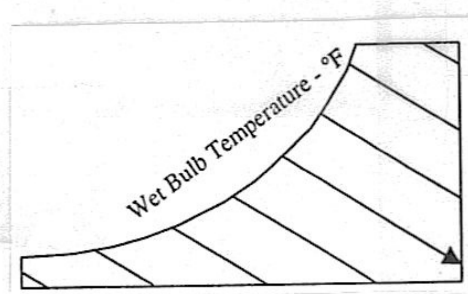
DEPTH	SAMPLE	SAMPLING METHOD	PENETRATION BLOW COUNT 1	2	3	LINER √	SOIL CLASSIFICATION
				1/12"	1		Organic Topsoil
				1/12"	3	2.5'	
			3	3	4		
5			2	2	2		Loose to Very Loose Brown Fine to Coarse Sand
			2	1	1		
			3	1/12"	1		
10			2	2	3		
15			3	4	4	15.0'	
							Boring Terminated at 15.0'
20							
25							
30							

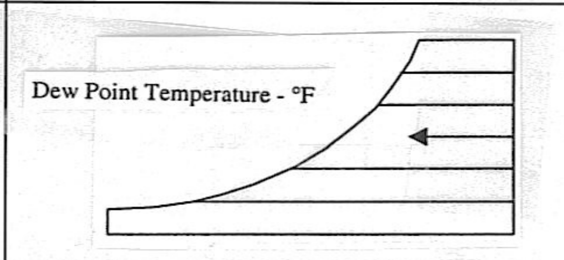
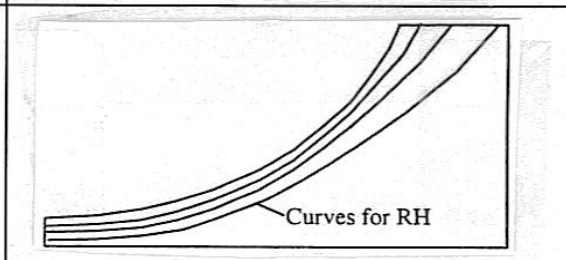
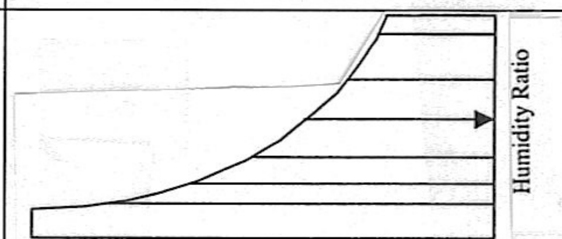
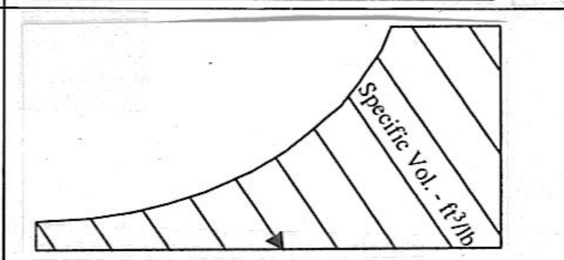
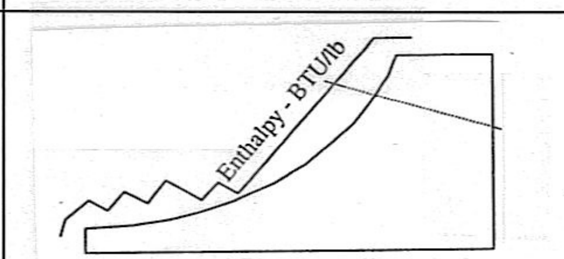
Plugging Method Natural Soil Job. No. 15-1291

Psychrometry and the Psychrometric Chart

This is the field of study concerned with the behavior of atmospheric air. Air in the atmosphere is a mixture of gases including oxygen and nitrogen, and water vapor. When one wishes to condition an air space to create comfort for the occupants of the space, one will make changes in important properties of the air, including the temperature and the humidity. The impact of these changes on the comfort of the occupants is determined by considering the changes in a number of other properties, which could result. The most common approach to evaluate this impact is by using a chart solution of a number of thermodynamic relationships.

The *psychrometric chart* is a representation of all the important properties of atmospheric air and the relationships between them. There are a number of properties shown, and a great many axes which run in different, often curving directions. The various properties and the direction of the appropriate axis are shown below.

Psychrometric Property	Direction of Axis on the Psychrometric Chart
Dry Bulb Temperature: The reading on a thermometer in the air. Read vertically from the axis across the bottom.	
Wet Bulb Temperature: The reading on a thermometer inserted in a saturated cotton wick. Read axis printed along the upper curve, and follow the diagonal axis down to the right down	

Psychrometric Property (continued)	Direction of Axis on the Psychrometric Chart
Dew Point Temperature: The temperature at which water will begin to condense. Using the intersection between the Dry-Bulb and the Wet-Bulb Temperatures and then draw a horizontal line to the left side which intersects with the upper curve	
Relative Humidity: The ratio of the partial pressure of water vapor to the saturation pressure at that temperature. Read from th internal curves which start at 10 percent relative humidity and finish at 90 percent. These internal curves start in the lower left-hand side and curve up to the upper right- hand side.	
Humidity Ratio: The ratio of the mass of water to the mass of air in a given volume of air. Read horizontally to the right side of the chart.	
Specific Volume: The volume of air per unit weight of dry air. Read on the Steeper of the tilted aces shown on the chart.	
Enthalpy: The heat content of the air, including the water vapor. Using the intersection between the Dry-Bulb and the Wet-Bulb Temperatures and then follow the diagonal line to the upper left side which passes through the upper curve. Read by identifying the tick mark on the upper jagged axis titled Enthalpy.	

Problems in psychometrics are solved by connecting lines on any two intersecting axes to identify a point which represents the properties of the air under the conditions of the problem. The remaining properties can be read on the other axes.

Psychrometry Example

Using the Psychrometric chart, and given a Dry-Bulb (DB) Temperature is 90 degrees Fahrenheit and the Wet-bulb (WB) Temperature is 76 degrees Fahrenheit, Determine the following values.

First, what is the Relative Humidity (RH) value from the chart?

> This found by following the downward curving lines and it reads greater than 50% and less than 60%. Therefore, the interpolation would be 54%.

Second, what is the Humidity Ratio (HR) value from the chart?

> This is found by using the point of intersection between the Dry-bulb and the Wet-Bulb Temperatures and then drawing a horizontal line to the right side. The Humidity ratio reads 0.0162. This is the humidity ratio or the pounds of moisture per pound of dry air.

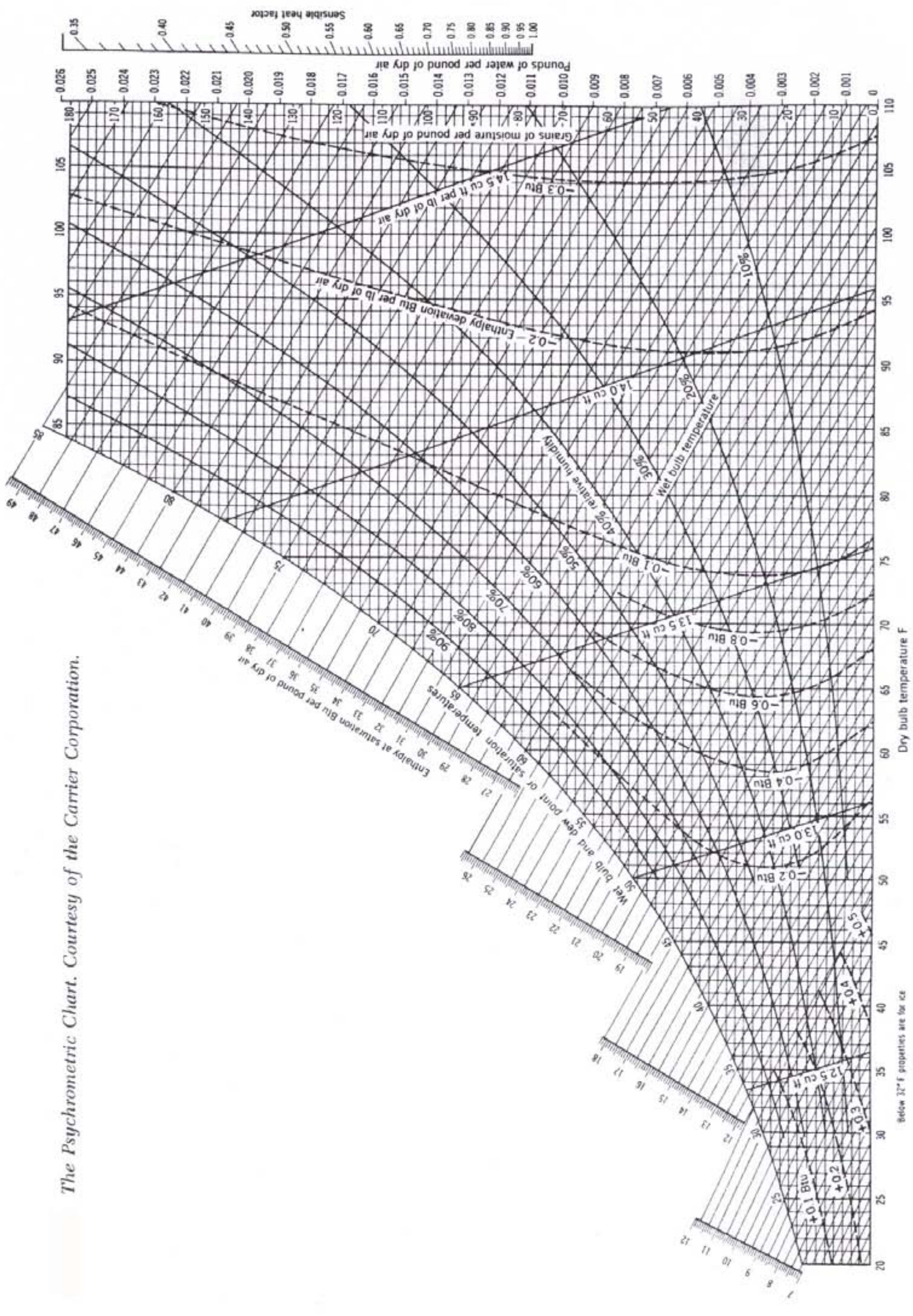
Third, What is the Dew Point (DP) value from the chart?

> This is found by using the point of intersection between the Dry-Bulb and the Wet-Bulb Temperatures and then drawing a horizontal line to the left side. The Dew Point reads 71 degrees F. This is the Dew Point of saturation.

Fourth, What is the Enthalpy value from the chart?

> This is found using the point of intersection between the Dry-Bulb and the Wet-Bulb Temperatures and then following the diagonal line to the left side. The Enthalpy reads 39.6 Btu per lb of dry air.

Heat is measured in *British Thermal units*, or BTU. A BTU is the amount of heat required to raise 1 pound of water 1 degree F. The rate of heat flow is measured in BTU per hour abbreviated btuh. Heating, Ventilating and Air Conditioning (HVAC systems use fluids to transport heat and cold to satisfy loads and maintain comfort. The fluids such as air, water, steam, and refrigerant are used to transport the heat and cold.



The Psychrometric Chart. Courtesy of the Carrier Corporation.

Psychrometric Exercise

Using the Psychrometric Chart and given a Dry Bulb Temperature of 85 degrees F and a Wet Bulb Temperature of 65F answer the following questions.

1. What is the Relative Humidity (RH) value?

- ○ A. 28
- ○ B. 34
- ○ C. 57
- ○ D. 72

2. What is the Humidity Ratio (HR) value?

- ○ A. 0.0030
- ○ B. 0.0088
- ○ C. 30.0000
- ○ D. 52.0000

3. What is the Dew Point (DP) value?

- ○ A. 0.0030
- ○ B. 0.0088
- ○ C. 30.0000
- ○ D. 52.0000

4. What is the Enthalpy value?

- ○ A. 0.0030
- ○ B. 0.0088
- ○ C. 30.0000
- ○ D. 52.0000

5. What is it called that measures the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit?

- ○ A. Enthalpy.
- ○ B. Saturated.
- ○ C. Relative Humidity.
- ○ D. British thermal units.

Psychrometric Exercise

Using the Psychrometric Chart and given a Dry- Bulb Temperature of 75 degrees F and Relative Humidity of 50% answer the following questions.

6. What is the Wet-Bulb (WB) value?

- A. 56
- B. 63
- C. 70
- D. 90

7. What is the Humidity Ratio (HR) value?

- A. 0.0092
- B. 28.5000
- C. 56.0000
- D. 69.0000

8. What is the Dew Point (DP) value?

- A. 0.0092
- B. 28.5000
- C. 56.0000
- D. 69.0000

9. What is the Enthalpy value?

- A. 0.0092
- B. 28.5000
- C. 56.0000
- D. 69.0000

10. What is another term for the total heat content of air?

- A. Enthalpy.
- B. Saturated.
- C. Relative Humidity.
- D. British thermal units.

Check Answers

MANAGEMENT CONCEPTS

Legal Entities

The major Legal Entities in the Construction Industry are the sole proprietorship, the partnership and the corporation. The *sole proprietorship* is a business owned by one person. The advantages of a sole proprietorship are the individual owns, operates, makes all decisions and they have personal control of the business. This is the simplest form of ownership because no legal documents are needed. One of the disadvantages is that the owner has unlimited liability for all loss which extends to their personal assets. Another disadvantage is you are taxed on the full earnings of the business whether or not they are withdrawn. A third disadvantage is the company ceases to exist when the owner dies or is injured and cannot conduct business. Finally, because only one person has all of the personal assets it is extremely difficult to generate new capital to expand the business.

A *partnership* is a business which consists of two or more persons pooling their assets such as cash, property, equipment and talent for a common goal. Each general partner has a voice in the daily management of the company. All of the partnerships assets are considered personal assets, but they are the sums of all partners, therefore, the credit line is greater than a sole proprietorship. Company profits or losses are normally allocated to each partner in the same proportion as the distribution of ownership. For tax purposes the partnership is not considered a legal entity, therefore, the partnership does not pay income taxes. But they must file an informational tax return and the individual partners must pay income taxes on their portion of the profits or losses. The primary disadvantage is unlimited liability and each partner is held individually responsibility for all contracts, debts and torts of the business and its employees. This means one partner can be personally liable for all debts incurred by the partnership if the other partner cannot pay. Then one partner is required to use their personal assets to satisfy all of the businesses' obligations. A *joint venture* is a form of partnership. It is an agreement between two or more construction companies to combine their resources to build a specific project. Legally there is little if any difference between a partnership and a joint venture. The joint venture is formed for a specific project and for a limited amount of time.

A *corporation* is considered a separate legal entity created by state law through a charter which is filed with the secretary of state. The corporation is separate and apart from the officers who operate it and/or the shareholders who own it. A corporation can own property, issue stock and it can sue or be sued. Some of the advantages are that the corporation can sell stock to generate capital to expand the company. The sale of stock is not subject to repayment. The corporation's liability is limited to the assets in the corporation and the corporation is perpetual. The major disadvantage is that the corporation is taxed twice. Another form of a corporation is a Subchapter S corporation. A Subchapter S is used for federal government taxation purposes only. A Subchapter S corporation's income and deductions flow through to the individual tax returns of the shareholders and it avoids federal income taxes as a corporation.

Management Systems

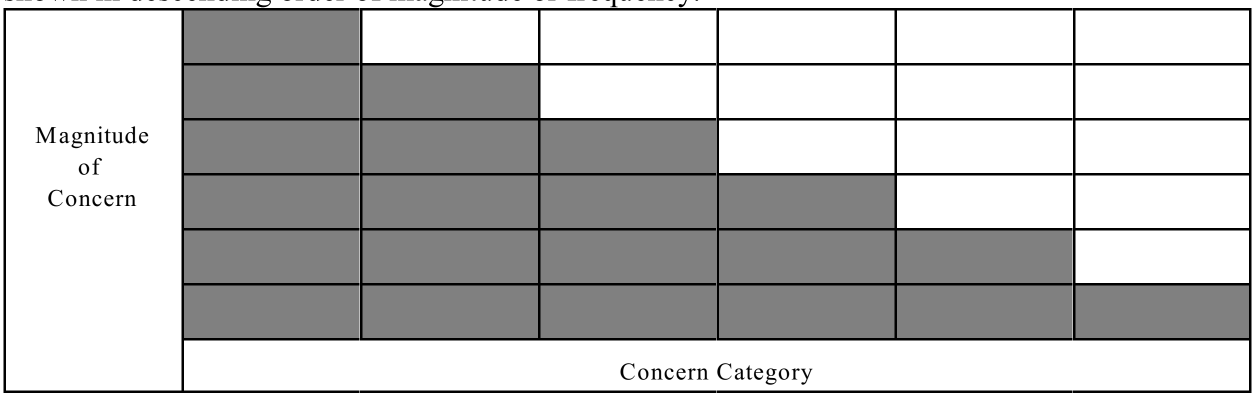
Partnering is normally initiated by the Owner during the conceptual phase of a project. The primary goal of partnering is to get commitment from the top management of all project participants and stakeholders to develop open communications and cooperation instead of the traditional adversarial relationships. Some of the typical project participants and stakeholders are the A/E firm, the Contractor, the Subcontractors, the major Vendors, and possibly the Public. Normally partnering involves a meeting with all stakeholders and a third-party facilitator who helps the parties discuss and agree to mutual goals and develop a charter for the project.

Total Quality Management (TQM) is a philosophy which was developed by Dr. W. Edwards Deming. TQM focuses on customer focus, customer satisfaction, continuous improvement, and total involvement. According to David Goetsch (2003) in his book, *Construction Safety and Health* he defines the concept of TQM as "an approach to doing business that maximizes the competitiveness of an organization through continuous improvement of its products, services, people, processes, and environments (p 449). He insists that there are ten characteristics that "describe how TQM achieves its purpose' (p 449). They are Customer Focus, Obsession with quality, a Scientific approach, Long term commitment, Teamwork, Continual process improvements, Education and Training, Freedom through control, Unity of purpose and Empowerment (p 450). The foundation of total quality is continuous improvement. Some methods to measure improvement are through participation with the International Organization of Standardization referred to in the U.S. as the International Standards Organization (ISO) 9000 series. These standards represent an international movement to establish world wide quality standards for manufactured products and services. Another guide utilized to improve an organization and evaluate their progress toward becoming the best in their field is the Malcolm Baldrige National Quality Award. The Baldrige Award consists of 18 criteria items and it describes the characteristics of excellence for each item.

Total Safety Management (TSM) was introduced to the safety profession by David Goetsch (1997) in his book, *Implementing Total Safety Management*. Goetsch insists that "TQM has proven itself to be an effective way to maximize an organization's long-term competitiveness" . . . by eliminating the problem of isolation and "making quality everybody's job and casting the quality manager in the role of facilitator and catalyst" (p 450). He suggests that the principles of TQM can solve the safety isolation problem by making "making safety everybody's job and casting the safety manager in the role of facilitator and catalyst." Therefore, Total Safety Management follows the same principles as TQM. David Goetsch (2003) defines TSM as

> "A performance and process-oriented approach to safety and health management that gives organizations a sustainable competitive advantage in the marketplace by establishing a safe and healthy work environment that is conducive to consistent peak performance and that is improved continually. It involves applying the principles of TQM to the management of safety and health" (p 452).

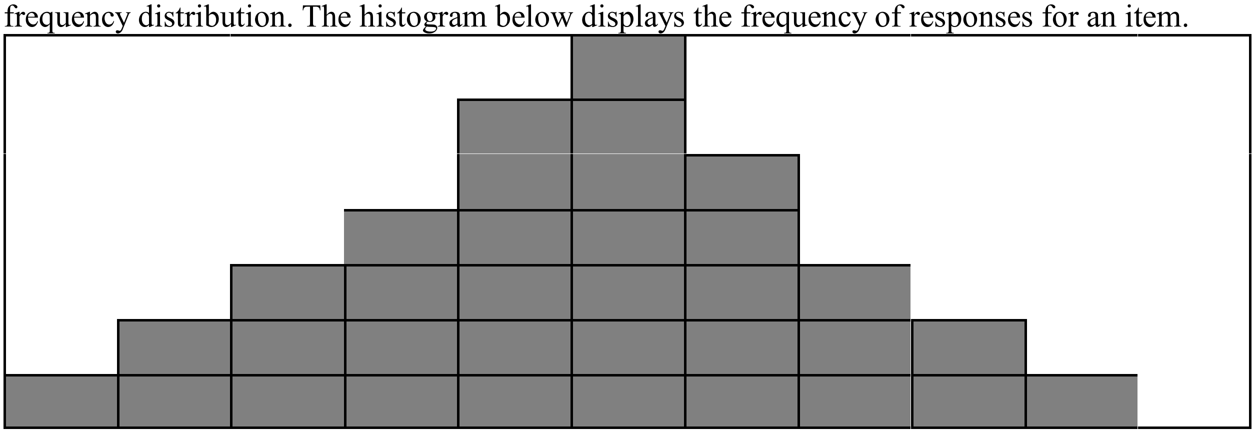
Statistical Process Control (SPC) the Tools of Quality
There are numerous graphical tools used by teams to assist them in studying processes. Below is a brief overview of these measurement tools. *Pareto Chart* is a bar graph of identified causes shown in descending order of magnitude or frequency.



A second graphical tool is the *Fishbone Chart* . This chart displays the causes and effects on a diagram for analyzing problems and the factors that contribute to them. The example below shows the categories of potential problems or Causes and the Effect

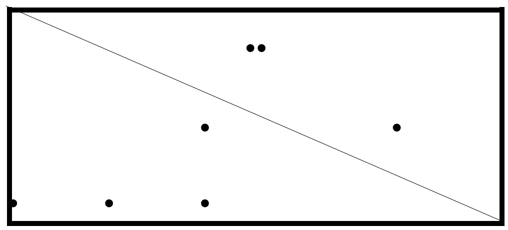
Environment Factor	**Methods**	**Workers**	Effect Soft Tissue Injuries
Weather	No Training	No Exercise	
➔	➔	➔	
Technology Factor	**Materials**	**Machinery Factor**	
No Ergonomics	Bags	Throwing	

A third graphical tool used is the *Histogram*. The Histogram is a bar graph displaying a frequency distribution. The histogram below displays the frequency of responses for an item.



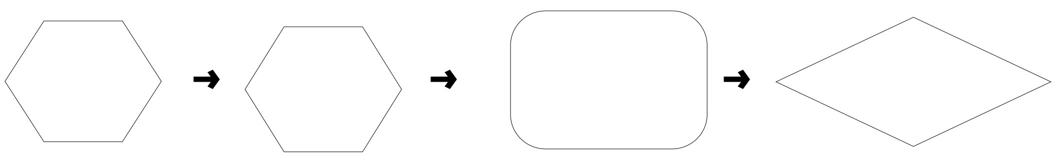
A fourth graphical tool is the *Scatter Diagram*. This is a graph displaying the correlation of two characteristics. For example, the scatter diagram below is used to compare the tensile strength of a wire versus its diameter.

TENSILE

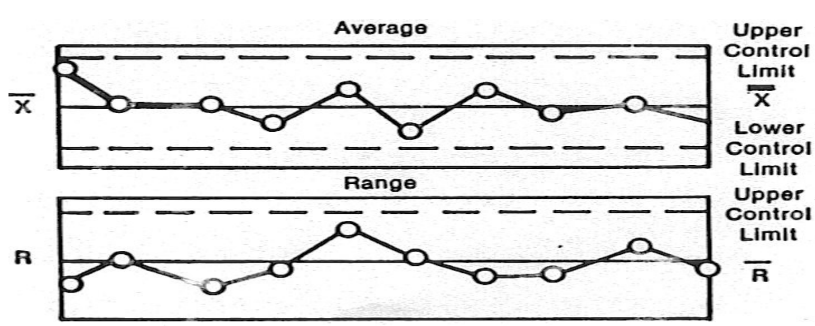


WIRE DIAMETER

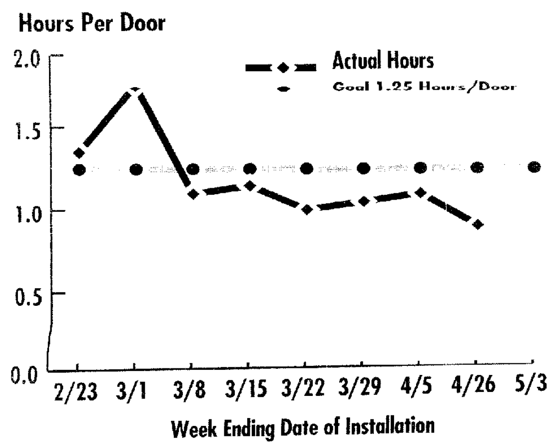
A fifth graphical tool is the *flowchart*. This is a pictorial representation of a process.



A sixth graphical tool is the *Control Chart*. Control Charts are line graphs that plot individual events over a period of time. It is a method of monitoring the output of a process or system through the sample measurement of a selected characteristics and the analysis of its performance over time. The control chart below is a chart that plots the percentage of aggregate passing the 3/8" sieve in a gradation test. Each point is the average of two samples. The first thirty points are used to calculate upper and lower control limits and an overall average. The overall average, 41.89%, is plotted as a solid line labeled x. The control limits are plotted as horizontal dashed lines. There are formulas that are used to calculate these control limits. The five points above the upper control limit indicate a problem area, and the cause should be investigated. control charts are used to show trends, variation about an average, and whether a process has too much variation.



The seventh graphical display tool is the *Run Chart*. Run charts are line graphs that show a trend over time. They are similar to control charts, except that control limits are not shown, and the average is not necessarily shown. The example below shows the reduction in time required to install hardware and hang doors in an office building. The results were achieved as a result of a study of the process. A contractor can do the same thing for virtually any process. Simply plot the workhours per unit over a period of time. It can be workhours or equipment hours per cubic yard of excavation, a cubic yard of concrete, a square yard of asphalt, a square foot of drywall, etc. The value of the run chart is that it shows positive and negative trends, and provides a better visualization of the level of process performance.



Project Delivery Methods

Owners have a variety of project delivery systems to choose from in the construction industry. The delivery method refers to the Owner's approach to developing the project team throughout the entire design, procurement, construction and commissioning process. The three most common project delivery methods are the tradition form, the design-build form and the Construction Management approach. These project delivery methods and their variations are discussed below.

The most common traditional project delivery method is the *Fixed Price* or commonly referred to as the Lump Sum Contract. The Fixed Firm Price contract is primarily used for projects that are completely designed and the scope is clearly defined. A fixed price contract is a guarantee by the contractor to perform the work and provide the necessary labor, material and equipment in a timely manner, no matter what the actual costs incurred. All financial risks are borne entirely by the Contractor in a Lump Sum contract. The Owner agrees to pay the Contractor, normally on a monthly basis, payments based upon progress.

A second traditional project delivery method is the *Unit Price Contract*. The Unit Price contract provides the Contractor with a list of items and the estimated quantities to be installed. The Contractor guarantees to perform an estimated quantity of work at a specified unit price. Conversely, the Owner agrees to pay the Contractor the agreed upon unit price for the actual quantity of work installed at the job site. Hence, the total contract amount will vary depending on the actual quantities installed. However, the unit price for each particular item listed will not change throughout the contract, unless there is a major variation in a particular line item. Normally, the Unit Price contract contains a quantity adjustment clause for these major variances which states that "if the Quantities of an item of work installed varies from the estimated quantities by more than 20 percent, then the price will be adjusted." A unit price contract is primarily utilized on civil projects such as roads, bridges and massive excavation projects.

A third traditional project delivery method is the *Cost Plus Contract*. The Cost Plus contract is used for projects that contain a substantial amount of undefined design, undefined scope, complex procurement system, and unstable or uncertain labor, material and equipment prices. In the Cost Plus contract the Owner agrees to pay the Contractor for all actual direct costs of labor, materials and equipment incurred on the project, and a fee for the Contractor's services. There are numerous methods used to calculate the Contractor's fee on a Cost Plus contract such as the Cost Plus a Percentage of Project Costs, a Cost Plus a Fixed Fee, a Cost Plus Fixed Fee with a Target or Incentive Fee, and Cost Plus a Fixed Fee with a Guaranteed Maximum Price (GMP).

A fourth traditional project delivery method is the *Turn Key Contract*. The Turn key contract is used mostly by developers. The Contractor/Developer agrees to design the project or build the project according to your design. They will also purchase the property and finance the project. The Owner agrees to make monthly payments on a long term lease.

The *Design-Build* project delivery method sometimes referred to as Engineer-Construct project is a contract that the Owner enters into one contract with a company to provide all design, procurement and construction on the project. The Design-Build firm then enters into contracts with designers, contractors, subcontractors, vendors and suppliers to complete the project. One of the advantages for an Owner in selecting this method is from the better communication that can occur between the design professionals and the construction professionals during the early design phases of the project. This collaboration allows the project to be fast-tracked which can reduce the overall time of a project from schematic drawing to Owner occupancy. Fast-tracking is defined as the overlapping accomplishment of design, procurement, construction and commissioning of a project.

The *Construction Management* project delivery method the Owner hires both a design firm and a construction management firm during the pre design phase of a project. Under the traditional Construction Management Contract, the CM firm is hired as an Agent for the Owner similar to hiring the Architect/Engineer as an Agent. Under this traditional CM contract the Owner holds separate contracts with the A/E, the CM and each individual Trade Contractor. The CM's responsibility provides advice during the design phase and they provide overall scheduling, trade coordination, cost control and management services during construction of the project. The CM receives a management fee for their services similar to the A/E receiving a design fee for their services. This fee is called an agency fee and the two methods that an Agency CM may offer an Owner is a Fixed price Fee or a Guarantee Maximum Price Fee.

Finally, on long term construction projects prices can fluctuate substantially from the time for submitting the bid until the time for delivery and installation because of the risk of inflation. Therefore, if the Contractor is forced to provide a fixed price they will often include in their bid price a contingency for anticipated cost increases. These anticipated cost increases may or may not actually materialize. Therefore, for the Owner to avoid paying for something not received, the Owner should use an *escalation* clause. The escalation clause is used for price changes in labor rates and material prices only from regularly published indexes.

Contract Formation Principles
The contract formation principles outlined below are required to form an enforceable contract or subcontract. They are:

1. *Meeting of the Minds*. This is the signed Agreement between the parties. The Agreement must be provided to each prospective bidder during the bidding phase of the project. This allows the prospective bidders time to review the terms and conditions and determine any unusual risk involved before the Agreement is signed. The Agreement is Signed (executed) by both parties after the receipt of the Notice of Award. The agreement provides for the signing, or "execution of the contract." In construction, the Subcontract Agreements are written and signed by both parties after the signing of the Owner - Contractor Agreement. The major elements needed to form a valid contract are:

    A. *An offer is made*. Normally the Contractor is required to submit a bid proposal on the forms provided by the A/E firm. It is also a good practice to standardize the Subcontractor Bid Proposal form which includes a Bid Breakdown Section.

    B. *Acceptance of the Offer*. The contractor receives a Notice to Proceed which indicates that the site is free of any encumbrances, and that the contractor can occupy the site. The date of the Notice to Proceed establishes the reference date from which the beginning of the project is calculated. The Notice to Proceed allows the Contractor to perform certain functions for the project.

2. *Consideration is received*. In the prime contract, this is something that the contractor must lose of value. This is normally submitted with the offer such as a Bid Bond or certified check for a certain percentage of the total contract price. If the contractor decides not to sign the agreement then they will forfeit the value of their security to the owner. Consideration under the General-Subcontractor contract formation process must rely on the equitable doctrine of "promissory estoppel." This doctrine holds that if the prime contractor reasonably relies on the promise or price of the subcontractor to its detriment, then the subcontractor must be held to its promise in order to avoid harm to the prime contractor. To ensure that this promise isn't indefinite or unreasonable, the subcontractor provides a time limit for acceptance of their bid.

3. The Contract must be for a *Legal Purpose*.

4. The parties have the *legal capacity* to enter into a Contract. This means they must have the legal authority to sign the proposal being submitted. Under most types of ownership, the sole proprietor, the legal partners or the corporate officers have the legal authority. This becomes a problem when the estimator signs the proposal and is not recognized as a legal authority for the company.

Management, Legal Entities & Delivery Methods Exercise

1. The Owner wants to Fast-Track a construction project, Which type of contract best supports this process?

   - A. Cost Plus.
   - B. Unit Price.
   - C. Fixed Price.
   - D. Design-Build.

2. A clause in the contract states that "if the Quantities of an item of work varies from the estimated quantities by more than 20 percent, then the price will be adjusted.” Which type of contract will this clause be primarily used in?

   - A. Cost Plus.
   - B. Unit Price.
   - C. Fixed Price.
   - D. Design-Build.

3. A contract has been entered into whereby the Contractor agrees to design, build, purchase the land and finance the project. What is this type of contract called?

   - A. Cost Plus.
   - B. Turn Key.
   - C. Partnering.
   - D. Design-Build.

4. A contract is entered into whereby the design and scope are undefined and the Owner agrees to pay for all Direct Labor, Materials, Equipment plus some agreed upon allowance to the Contractor for their services. What is this type of contract called?

   - A. Cost Plus.
   - B. Partnering.
   - C. Design-Build.
   - D. Construction Management.

Management, Legal Entities & Delivery Methods Exercise

5. A contract is entered into whereby the Design, Scope and Bid quantities are established and payment for the work is to be made upon the basis of the actual quantity placed. What is this type of contract called?

- ○ A. Cost Plus.
- ○ B. Turn Key.
- ○ C. Unit Price.
- ○ D. Fixed Price.

6. A contract is entered into whereby the Design and Scope are partially undefined, the Owner holds a contract with the A/E, the Owner holds the contracts with each trade and the Owner also holds a contract with a management service company to perform the trade coordination, cost control and scheduling services. What is this type of contract called?

- ○ A. Cost Plus.
- ○ B. Joint Venture.
- ○ C. Design-Build.
- ○ D. Construction Management.

7. A contract is entered into whereby two Contractors agree to combine their resources to bid and build a specific project. What is this type of contract called?

- ○ A. Cost Plus.
- ○ B. Joint Venture.
- ○ C. Design-Build.
- ○ D. Construction Management.

8. What is the name of the clause that is sometimes used if the contract has the potential of an uncertainty in either labor or material prices?

- ○ A. Incentive.
- ○ B. Escalation.
- ○ C. Contingency.
- ○ D. Equitable Adjustment.

Management, Legal Entities & Delivery Methods Exercise

9. What are the two FEE methods that an Agency CM firm may offer an Owner?

- A. Incentive or Target.
- B. Unit Price or Alternate Prices.
- C. Fixed Price or Guaranteed Maximum Price.
- D. Cost-Plus a Percentage or Cost Plus Fixed Price.

10. Which legal entity is considered perpetual?

- A. Partnership.
- B. Corporation.
- C. Joint Venture.
- D. Sole Proprietorship.

11. Which legal entity affords an individual the most protection of individual assets from creditors of the business?

- A. Partnership.
- B. Corporation.
- C. Joint Venture.
- D. Sole Proprietorship.

12. Which legal entity exposes the personal assets of a person to pay for actions of other people involved in the business?

- A. Partnership.
- B. Corporation.
- C. Joint Venture.
- D. Sole Proprietorship.

13. Which legal entity makes it extremely difficult to generate new capital to expand the business?

- A. Partnership.
- B. Corporation.
- C. Sole Proprietorship.
- D. Subchapter S Corporation.

Management, Legal Entities & Delivery Methods Exercise

14. Which legal entity is taxed twice?

- A. Partnership.
- B. Corporation.
- C. Sole Proprietorship.
- D. Subchapter S Corporation.

15. Which type of legal entity allows the income and deductions of the corporation to flow through to the individual tax returns of the shareholders and it avoids federal taxes?

- A. Partnership.
- B. Corporation.
- C. Sole Proprietorship.
- D. Subchapter S Corporation.

16. Which type of legal entity requires a charter?

- A. Partnership.
- B. Corporation.
- C. Joint Venture.
- D. Sole Proprietorship.

17. Which law are corporations formed under?

- A. City.
- B. State.
- C. Federal.
- D. Municipal.

18. Which of the following contract formation principles are needed to form a valid contract?

- A. Offer, Acceptance, Meeting of the Minds and Consideration.
- B. Performance, Technical Specifications and Consideration.
- C. General Conditions, Supplementary Conditions and a Proposal.
- D. Plans, Technical Specifications, General and Supplementary Conditions.

Management, Legal Entities & Delivery Methods Exercise

19. The owner requests that you submit a proposal supplement titled, "Statement of Contractors' Qualifications - All Contracts" and under the officers/principals section it requests the names and titles of the vice president and the president. A proposal is submitted to the Owner with a bid bond, signed addenda, and the proposal form is attached and signed by the chief estimator. Have all of the contract formation principles been satisfied and your proposal would be considered responsive?

- ○ A. The principle of Consideration has been met, therefore, responsive bid.
- ○ B. The principle of Legal Capacity has been met, therefore, responsive bid.
- ○ C. The principle of the meeting of the minds has been met, therefore, responsive bid.
- ○ D. The principle of Legal Capacity has not been met, therefore, a non-responsive bid.

20. Which law establishes basic rules governing the sale of goods, used to establish a Purchase Order?

- ○ A. Davis Bacon Act.
- ○ B. Uniform Commercial Code.
- ○ C. National Labor Relations Act.
- ○ D. Uniform Transportation Code.

21. Which of the following Safety criteria that has the greatest potential for reducing the costs of accidents?

- ○ A. Experience.
- ○ B. Safety Meetings.
- ○ C. Traditional Safety Program.
- ○ D. Behavior-based Safety Process.

22. What management concept has as its primary goal to get commitment from top management of all project participants and stakeholders to develop open communications and cooperation on a project to?

- ○ A. Partnering.
- ○ B. Total Safety Management.
- ○ C. Statistical Process Control.
- ○ D. Total Quality Management.

Management, Legal Entities & Delivery Methods Exercise

23. What are the quality standards used internationally called?

- A. ISO 9000.
- B. Statistical Process Control.
- C. Total Quality Management.
- D. Baldrige Award of Excellence.

24, What management philosophy tries to maximize the competitiveness of an organization through continuous improvement?

- A. Partnering.
- B. Statistical Process Control.
- C. Total Quality Management.
- D. Baldrige Award of Excellence.

25. What is the name of the criteria that is utilized to improve an organization and evaluate their progress toward becoming the best in their field?

- A. Total Safety Management.
- B. Statistical Process Control.
- C. Total Quality Management.
- D. Baldrige Award of Excellence.

26. What management philosophy is defined as a performance and processed-oriented approach to safety and health that is improved continually and applies proven principles to maximize an organization's long-term competitiveness?

- A. Total Safety Management.
- B. Statistical Process Control.
- C. Total Quality Management.
- D. Baldrige Award of Excellence.

27. What makes TQM and TSM successful?

- A. Applying the partnering process to an organization.
- B. Applying the TQM and TSM principles to an organization.
- C. Adding more Quality Control and Safety Managers to oversee the workers.
- D. Eliminating the isolation problem and making quality and safety everybody's role.

Management, Legal Entities & Delivery Methods Exercise

28. What graphical measurement tool is a bar graph displaying a frequency distribution?

- A. Histogram.
- B. Pareto Chart.
- C. Control Chart.
- D. Fishbone Chart.

29. What graphical measurement tool is a pictorial representation of a process?

- A. Run Chart.
- B. Flow Chart.
- C. Control Chart.
- D. Scatter Diagram.

30. What graphical measurement tool displays the causes and effects on a diagram for analyzing problems?

- A. Histogram.
- B. Pareto Chart.
- C. Control Chart.
- D. Fishbone Chart.

31. What graphical measurement tool is a bar graph of identified causes shown in descending order of magnitude?

- A. Bar Chart
- B. Histogram.
- C. Gantt Chart.
- D. Pareto Chart.

32. What graphical measurement tool is a graph displaying the correlation of two characteristics?

- A. Run Chart.
- B. Flow Chart.
- C. Control Chart.
- D. Scatter Diagram.

Management, Legal Entities & Delivery Methods Exercise

33. What graphical display tool contain line graphs that show a trend over time such as the workhours per square yard of asphalt over a period of time?

- A. Bar Chart
- B. Run Chart.
- C. Flow Chart.
- D. Control Chart.

34. Which of the following principles of law states that if the prime contractor reasonably relies on the promise or price of the subcontractor to its detriment, then the subcontractor must be held to its promise in order to avoid harm to the prime contractor even though a signed contract between the contractor and subcontractor does not exist at the bidding phase of a project?

- A. Consideration.
- B. Legal Purpose.
- C. Promissory Estoppel.
- D. Equitable Adjustment.

35. At which point in time must the Agreement be provided to each prospective bidder?

- A. At the bid opening.
- B. During the bidding phase of the project.
- C. At the signing of the Owner- Contractor Agreement.
- D. Just before the signing of the Owner- Contractor Agreement.

36. Which document establishes the reference date from which the beginning of the project is calculated and that the contractor can occupy the site?

- A. Notice of Award.
- B. Notice to Proceed.
- C. Instructions to Bidders.
- D. Advertisement to Bidders.

Check Answers

Financial Statements
The three distinct financial statements are the Balance Sheet, the Income Statement and the Cash Flow Statement and each serves a specific function as described below.

Balance Sheet
The *Balance Sheet* is a summary of the existing conditions of the company and it follows the standardized format for classifying and ordering the Assets, Liabilities and, and Ownership interests in the business. The balance sheet accounts are subdivided into the following basic groups in the following order for presentation:

Assets are subdivided into these groups:
Current Assets
Fixed Assets or Long Term Property, Plant & Equipment
Other Assets

Liabilities are subdivided into these groups:
Current Liabilities
Long-term Liabilities
Owner's Equity

Each separate asset, liability, and owner's equity reported in a Balance Sheet is called an account and every account has a title and a dollar amount which is called its balance. The Balance Sheet is prepared at the close of business on the last day of the income statement period and lists the assets, liabilities and net worth. Assets minus Liabilities equals Net Worth. The balance sheet will always be in balance because Total Assets = Total Liabilities plus Net Worth.

Current assets are cash on hand, Accounts receivable, Inventories, Prepaid Expenses, and Other current assets that will be converted into cash during one operating cycle. The *Fixed assets* or Long-term assets are Land and Buildings, and Equipment. The cost of a fixed asset is reduced by the depreciable amount allocable over the period.

Current Liabilities or short-term liabilities are accounts that will come due within one year. The accounts are Accounts Payable, Notes payable, and Billings in excess of costs on uncompleted contracts. *Long-term Liabilities* are those that maturity dates are more than one year such as a long-term loan. The Net Worth or Stock holders' Equity accounts in the Balance sheet is comprised of Capital stock and Retained Earnings.

Working Capital is the net amount of current assets available. It is computed as follows. Working Capital = Current Assets minus Current liabilities

$3,415,807 - $1,546,107 = $1,869,700 at End of Year.

BALANCE SHEET

Assets	End of Year	Start of Year
Cash	$ 565,807.00	$ 750,000.00
Contracts Receivable	1,000,000.00	825,000.00
Inventory	1,690,000.00	1,250,000.00
Prepaid expenses	160,000.00	185,000.00
Total Current Assets	$3,415,807.00	$3,010,000.00
Property, Plant, Equipment	3,000,000.00	2,250,000.00
Accumulated Depreciation	(800,000.00)	(540,000.00)
Total Assets	$5,615,807.00	$4,720,000.00

Liabilities and Owners' Equity	End of Year	Start of Year
Accounts Payable - Inventory	$ 520,000.00	$ 450,000.00
Accounts Payable - Operating	120,000.00	85,000.00
Total Accounts Payable	$ 640,000.00	$ 535,000.00
Accrued Operating Expenses	$ 240,000.00	$ 185,000.00
Accrued Interest Payable	17,167.00	12,500.00
Total Accrued Expenses	$ 257,167.00	$ 197,500.00
Income Tax Payable	23,940.00	36,000.00
Short-Term Notes Payable	625,000.00	600,000.00
Total Current Liabilities	$1,546,107.00	$1,368,500.00
Long-Term Notes Payable	750,000.00	600,000.00
Total Liabilities	$2,296,107.00	$1,968,500.00
Capital Stock	775,000.00	725,000.00
Retained Earnings	2,544,700.00	2,026,500.00
Total Owners' Equity	$3,319,700.00	$2,751,500.00
Total Liabilities and	$5,615,807.00	$4,720,000.00

INCOME STATEMENT FOR THE YEAR

Contract Revenues	$10,400,000.00
Cost of Contracts Completed	6,760,000.00
Gross Margin	$ 3,640,000.00
Operating Expenses	2,080,000.00
Depreciation Expense	260,000.00
Operating Earnings	$ 1,300,000.00
Interest Expense	103,000.00
Earnings before Taxes	$ 1,197,000.00
Income Tax Expense	487,800.00
Net Income	$ 718,200.00

Financial Ratios and the Construction Industry Average Table

Ratio	Formula for Calculation	Industry Average
Liquidity: Current Ratio	current assets / current liabilities	2.5 times
Quick Assets or Acid test	current assets - inventory - prepaid expenses / current liabilities	1.0 times
Leverage: Debt to total assets - high	total liabilities / total assets	33 percent
Times interest earned - low	operating earnings / interest expenses	8.0 times
Fixed charge coverage	income available for meeting fixed charges / fixed charges	5.5 times
Activity: Inventory turnover	sales / inventory	9 times
Average collection period	receivables / sales per day	20 days
Fixed assets turnover	sales / fixed assets	5.0 times
Total assets turnover	sales / total assets	2 times
Profitability: Return on Sales	net income after taxes / sales	5 percent
Return on total assets	net income after taxes / total assets	8 percent
Return on Equity	net income after taxes / Owners Equity	15 percent
Break even	G&A Overhead / Gross Profit Percent	20 percent
Days of Cash	(Cash & Cash Equivalents) x 360 / Revenue	
Working Capital	Current Assets minus Current Liabilities	
Working Capital Turnover	Revenue / Working Capital	

Some of the *Balance Sheet Ratios* consists of the following. The *Current ratio* is expressed as Current assets to Current liabilities. The current ratio is always expressed as x to 1. The current ratio is:

$$\text{Current ratio} = \frac{\text{Current assets}}{\text{Current Liabilities}} = \frac{\$3{,}415{,}807}{\$1{,}546{,}107} = 2.21$$

This ratio is favored by loan officers and creditors as an indicator of financial health. Generally, a 2 to 1 Current ratio is considered the satisfactory minimum. According to the Summary of Financial Ratios and the Construction Industry Average Table, the Current ratio in the example is 2.21 and the construction industry average is 2.50. This is slightly below the average.

The *Quick assets ratio*, sometimes called the "*Acid test*" is expressed as Current assets without inventories or Prepaid Expenses to Current Liabilities. The Quick assets ratio is as follows:

($1,565,807 = Cash + Receivable)

$$\text{Acid Test} = \frac{\text{Current Assets - Inventories - Prepaid}}{\text{Current Liabilities}} = \frac{\$3{,}415{,}807 - 1{,}690{,}000 - \$160{,}000}{\$1{,}546{,}107} = 1.01$$

The acid test measures the immediate ability to pay current debts. This is a more conservative approach since inventories are not necessarily available and may not be readily available. Generally, a 1 to1 minimum is considered a healthy. The example shows a satisfactory ratio.

The *Debt to Total Assets Ratio* is an indicator of the companies Leverage. Leverage refers to using the equity capital base to raise additional capital from nonowner sources. The Debt to Total Assets ratio is calculated as follows:

($2,296,107)

$$\text{Debt to Total Assets Ratio} = \frac{\text{Total Liabilities}}{\text{Total Assets}} = \frac{\$1{,}546{,}107 + \$750{,}000}{\$5{,}615{,}807} = 40\%$$

According to the Construction Industry Average Table, the industry standard is 33 percent, The Debt to Total Assets Ratio in the example is 40% which is poor or high for this company.

The Debt to Equity Ratio is an indicator of whether a company is using debt prudently or are they overburdened with debt that may cause problems. The Debt to Equity ratio is as follows:

$$\text{Debt to Equity Ratio} = \frac{\text{Total Liabilities}}{\text{Total Owners Equity}} = \frac{\$2{,}296{,}107}{\$3{,}319{,}700} = .69 \text{ Debt to Equity Ratio}$$

This ratio says that the company is using $.69 of liabilities in addition to each $1.00 of Owners' Equity in the business. This business with its .69 to 1.00 debt to equity would be considered as moderately leveraged.

Income Statement
The *Income Statement* summarizes sales revenue and expenses for a period of time which is one year for the example. The ending date of that period is always the same as the closing date given on the balance sheet and the period covered is always specified on the top of the report. For example Income Statement for the Year ending December 31. The income statement is broken down into these accounts. The Sales revenue is the top line and it is the total amount of income from contact sales. The bottom line is called net income or net earnings. Net income is the final profit after all expenses are deducted from sales revenue.

The income statement is designed to be read in a step-down process. Each step down is a deduction fo one or more expenses. The first step deducts the cost of goods sold from the sales revenue of goods sold or completed contracts, which gives the *Gross Margin* sometimes called the gross profit.

Next, operating expenses and depreciation expenses are deducted, giving *Operating Earnings* before interest and income tax expenses are deducted. Operating earnings is also called “Earnings before Income Taxes and is abbreviated EBIT.

Next, Interest expenses on debt is deducted which results in *Earning before Income Taxes*. The last step is to deduct income tax expenses which results in *Net Income*. Publicly owned business corporations report Earnings per Share which is net income divided by the number of stock shares. Privately owned business do not have to report the Earnings per share.

In the example income statement, you see five different expenses identified, but you may find more expense lines in an income statement. Sales revenue and expenses reported in income statements generally follow accepted accounting practices, which are summarized below.

Completed Contract sales or Sales revenue is the total amount received or to be received from contract sales. Contract sales revenue is net.

Cost of Completed contracts or Cost of Goods Sold Expense is the total cost sold during the period.

Operating Expenses is a broad category of expenses such as Contract overhead, Selling expenses, General and Administrative expenses and depreciation. This category excludes Cost of Completed Contracts, Interest, and Income Tax.

Some of the *Income Statement Ratios* are as follows. The *Times Interest Earned Ratio* is used to test the ability to pay interest from earnings. It is calculated below:

$$\frac{\text{Operating Earnings}}{\text{Interest Expenses}} = \frac{\$1{,}300{,}000}{\$103{,}000} = 12.6 \text{ Times Interest Earned Ratio}$$

According to the construction industry, the low Time Interest Earned Ratio is 8.0 times, but the example indicates a 12.6 Times Interest Earned ratio which exceeds the average which is good.

The *Return on Sales Ratio* shows the margin of profit as a percentage. From the income statement, the company in this example earned $718,200 net income on its sales revenue of $10,400,000 for the year. The net income to contract sales is calculated as follows:

$$\frac{\text{Net Income}}{\text{Sales Revenue}} = \frac{\$718{,}200}{\$10{,}400{,}000} = 6.9\% \text{ Return on Sales Ratio}$$

According to the construction industry, the average percentage Return on Sales is 5 percent and the example indicates a 6.9 percent return on sales which is satisfactory.

The *Return on Equity Ratio (ROE)* shows this ratio as a percentage. It is calculated by dividing the annual net income from the Income Statement by the Owners' Equity from the Balance Sheet. The Return on Equity is calculated as follows:

$$\frac{\text{Net Income}}{\text{Owners' Equity}} = \frac{\$718{,}200}{\$3{,}319{,}700} = 21.6\% \text{ Return on Equity Ratio}$$

According to the construction industry, the average percentage Return on Equity is 15 percent and the examples indicates a 21.6% Return on equity which is good.

The *Return on Assets Ratio (ROA)* indicates what the business earned before interest and income tax expenses on the total assets employed during the year. The Return on Assets is calculated by dividing the Operating Earnings from the Income statement by the Total Assets from the Balance Sheet. The Return on Assets is calculated as follows:

$$\frac{\text{Operating Earnings}}{\text{Total Assets}} = \frac{\$1{,}300{,}000}{\$5{,}615{,}807} = 23.1\% \text{ Return on Assets}$$

The Return on Assets is compared to the annual interest rate on the company's borrowed money. According to the construction industry, the average percentage Return on Total Assets is 8 percent and the business earned 23.1 percent on the money borrowed, as a measure of Return of Assets. The difference between the two rates is a very favorable 15 percent.

The *Cash Flow Statement* is a summary of the sources of and uses of cash indicating where it came from and where it went to for the same period of time as the income statement. The cash flow statement example contains three sections. They are (1) Cash Flows from Operating Activities sometimes referred to as cash flow from profit, (2) Cash Flows from Investing Activities, and (3) Cash flows from Financing Activities.

From the Example Balance Sheet, if you compare the columns labeled End of Year and Start of Year, the result will be a change in assets, liabilities, and owner's equities. These increases and decreases from the balance sheet tie directly in with the cash flow statement. For example, the balance sheet Contracts Receivable line item indicates an increase of $175,000 and the heading Cash Flows from Operating Activities contains a line labeled Accounts Receivable and it shows a figure of ($175,000).

BALANCE SHEET

Assets	**End of Year**	**Start of Year**	Changes
Cash	$ 565,807.00	$ 750,000.00	($184,193.00)
Contracts Receivable	1,000,000.00	825,000.00	$175,000.00
Inventory	1,690,000.00	1,250,000.00	$440,000.00
Prepaid expenses	160,000.00	185,000.00	($25,000.00)
Total Current Assets	$3,415,807.00	$3,010,000.00	
Property, Plant, Equipment	3,000,000.00	2,250,000.00	$750,000.00
Accumulated Depreciation	(800,000.00)	(540,000.00)	($260,000)
Total Assets	$5,615,807.00	$4,720,000.00	

Liabilities and Owners' Equity	**End of Year**	**Start of Year**	
Accounts Payable - Inventory	$ 520,000.00	$ 450,000.00	
Accounts Payable - Operating	120,000.00	85,000.00	
Total Accounts Payable	$ 640,000.00	$ 535,000.00	$105,000.00
Accrued Operating Expenses	$ 240,000.00	$ 185,000.00	
Accrued Interest Payable	17,167.00	12,500.00	
Total Accrued Expenses	$ 257,167.00	$ 197,500.00	$59,667.00
Income Tax Payable	23,940.00	36,000.00	($12,060.00)
Short-Term Notes Payable	625,000.00	600,000.00	$25,000.00
Total Current Liabilities	$1,546,107.00	$1,368,500.00	
Long-Term Notes Payable	750,000.00	600,000.00	$150,000.00
Total Liabilities	$2,296,107.00	$1,968,500.00	
Capital Stock	775,000.00	725,000.00	$50,000.00
Retained Earnings	2,544,700.00	2,026,500.00	$518,000.00
Total Owners' Equity	$3,319,700.00	$2,751,500.00	
Total Liabilities and Owners' Equity	$5,615,807.00	$4,720,000.00	

Cash Flow Statement
The cash flow statement reveals increases and decreases or changes in funds and it is expressed as a change in the source and application of funds, and by the change in your working capital. In conclusion, a change in your cash flow is a result of a change in (1) Cash Flows from Operating Activities, (2) Cash flows from Investing, (3) and Cash flows from Financing Activities.

From the Cash Flow statement below, the business realized $540,807 from Operating Expenses for the year ended. The company spent $750,000 on capital expenditures. Its financing activities provided $$25,000 net of $200,000 cash dividends to stockholders. In summary, the three sources of income (1) Cash Flows from Operating Activities, (2) Cash flows from Investing Activities, (3) and Cash flows from Financing Activities, were less than the company's capital expenditures during the year. Therefore, the company's cash balance decreased by $184,193.

CASH FLOW STATEMENT FOR THE YEAR		
Cash Flows from Operating Activities		
Net Income from Income Statement		$718,200.00
Contracts Receivable Increase	($175,000.00)	
Inventory Increase	(440,000.00)	
Prepaid Expenses Decrease	25,000.00	
Depreciation Expense	260,000.00	
Accounts Payable Increase	105,000.00	
Accrued Expenses Increase	59,667.00	
Income Tax Payable Decrease	(12,060.00	
Cash Flow Adjustments to Net Income		($177,393.00)
Cash Flow from Operating Activities		$ 540,807.00
Cash Flows from Investing Activities		
Purchases of Property, Plant & Equipment		($750,000.00)
Cash Flows from Financing Activities		
Short-Term Debt Borrowing	$ 25,000.00	
Long-Term Debt Borrowing	150,000.00	
Capital Stock Issue	50,000.00	
Dividends Paid Stockholders	(200,000.00)	$ 25,000.00
Increase (Decrease in Cash during Year		($184,193.00)

Financial Analysis Exercise
Using the Balance Sheet, Income Statement and the Cash Flow Statement provided below and the Summary of Financial Ratios and the Construction Industry Average Table. Answer the following questions.

1. What is the Working Capital for this company at the End of the year?

- A. $0,176, 177
- B. $0,733,154
- C. $1,463,403
- D. $1,633,389

2. What is the Current ratio for this company at the end of the year?

- A. 0.47
- B. 1.97
- C. 2.07
- D. 4.36

3. What is the Acid Test Ratio for this company at the end of the year?

- A. 0.51
- B. 0.95
- C. 1.07
- D. 2.07

4. What is the Leverage Ratio of Total debt to total Assets for this company at the end of the year?

- A. 0.30
- B. 0.51
- C. 0.96
- D. 1.97

5. What is the Construction industry Average percentage for the leverage ratio?

- A. 5%
- B. 10%
- C. 20%
- D. 33%

Financial Analysis Exercise

6. What is the Debt to Equity Ratio for this company at the end of the year?

- A. 0.22
- B. 0.47
- C. 1.03
- D. 1.96

7. What is the Times Interest Earned Ratio for this company at the end of the year?

- A. 0.25
- B. 0.51
- C. 1.03
- D. 4.07

8. What is the Construction industry Average Times Interest Earned Ratio?

- A. 5.50 Times
- B. 8.00 Times
- C. 9.00 Times
- D. 33.0 Times

9. Assuming the Times Interest Earned Ratio fort his company was calculated to be 5.00, How does this compare to the Construction industry Average Times Interest Earned Ratio?

- A. This company exceeds the average.
- B. This company is equal to the average.
- C. This company is significantly below the average.
- D. Not enough information to make a comparison.

10. What is the return on Sales percentage for this company at the end of the year?

- A. 4.0%
- B. 6.2%
- C. 25.0%
- D. 37.1%

Check Answers

Financial Analysis Exercise Statements

BALANCE SHEET

Assets	**End of Year**	**Start of Year**
Cash	$ 260,631.00	$ 233,171.00
Contracts Receivable	423,731.00	385,259.00
Inventory	640,020.00	517,936.00
Prepaid expenses	91,433.00	85,559.00
Total Current Assets	$1,415,815.00	$1,221,925.00
Property, Plant, Equipment	2,317,500.00	2,089,336.00
Accumulated Depreciation	(753,917.00)	(764,900.00)
Cost Less Accumulated Depreciation	1,563,583.00	1,324,436.00
Total Assets	$2,979,398.00	$2,546,361.00

Liabilities and Owners' Equity	**End of Year**	**Start of Year**
Accounts Payable - Operating	281,915.00	242,294.00
Accrued Operating Expenses	142,246.00	126,264.00
Income Tax Payable	8,500.00	15,018.00
Short-Term Debt Payable	250,000.00	196,113.00
Total Current Liabilities	682,661.00	579,689.00
Long-Term Debt Payable	833,334.00	650,000.00
Total Liabilities	$1,515,995.00	$1,229,689.00
Capital Stock	509,722.00	489,167.00
Retained Earnings	953,681.00	827,505.00
Total Owners' Equity	$1,463,403.00	$1, 316,672.00
Total Liabilities & Owners' Equity	$2,979,398.00	$2,546,361.00

INCOME STATEMENT FOR THE YEAR

Contract Revenues	4,406,806.00
Cost of Contracts Completed	2,773,417.00
Gross Margin	1,633,389.00
Operating Expenses	1,263,032.00
Depreciation Expense	10,983.00
Operating Earnings	359,374.00
Interest Expense	88,333.00
Earnings before Taxes	271,041.00
Income Tax Expense	94,864.00
Net Income	176,177.00

Financial Analysis Exercise Statements

CASH FLOW STATEMENT FOR THE YEAR		
Cash Flows from Operating Activities		
Net Income from Income Statement		176,177.00
Contracts Receivable Increase	(38,472.00)	
Inventory Increase	(122,084.00)	
Prepaid Expenses Decrease	(5,874.00)	
Depreciation Expense	85,383.00	
Accounts Payable Increase	39,621.00	
Accrued Expenses Increase	15,982.00	
Income Tax Payable Decrease	(6,518.00)	
	(31,962.00)	
Cash Flow Adjustments to Net Income		
Cash Flow from Operating Activities		144,215.00
Cash Flows from Investing Activities		
Purchases of Property, Plant & Equipment		($354,028.00)
Proceeds from Disposals of Property, Plant & Equipment		29,498.00
Cash Used in Investing Activities		($324,530)
Cash Flows from Financing Activities		
Short-Term Debt Borrowing		53,887.00
Long-Term Debt Borrowing		183,334.00
Capital Stock Issue		20,554.00
Dividends Paid Stockholders		(50,000.00)
Cash from Financing Activities		207,775.00
Increase (Decrease)in Cash during Year		27,460.00

Depreciation Methods
Depreciation is an accounting charge that provides for recovery of the capital that purchased the physical asset. It is the process of allocating an amount of money over the recovery period (life) of a tangible capital asset. There are three methods that are approved by the U.S. Revenue Service (IRS). They are the straight-line, the double-declining balance or sum-of-the-year-digits.

Straight-line Example
Given the following information:

Purchase Price	= $20,000
Salvage Value	= $05,000
Service Life	= 5 Years.

The annual Depreciation Charge using the Straight Line is = $\frac{\$20{,}000 - \$5{,}000}{5 \text{ Years}} = \$3{,}000$

The table below indicates the depreciation annual expense over the full service life.

Year	Remaining Book Value	Yearly Depreciation	Book Value
0	$ 0	$ 0	$20,000
1	$20,000	$3,000	$17,000
2	$17,000	$3,000	$14,000
3	$14,000	$3,000	$11,000
4	$11,000	$3,000	$8,000
5	$8,000	$3,000	5,000

Declining Balance Example
The Declining Balance is also referred to as the double declining or 200% declining balance for new equipment and 150% declining balance for used equipment. This is a form of accelerated depreciation. In using this depreciation method, an item is depreciated until the estimated salvage value is reached.

The Declining Balance formula for equipment purchased new is = $2\,\frac{(\text{Remaining Book Value})}{\text{Service Life}}$

The Declining Balance formula for equipment purchased used is= $2\,\frac{(\text{Remaining Book Value})}{\text{Service Life}}$

Given the following information:

Purchase Price	= $20,000
Salvage Value	= $05,000
Service Life	= 5 Years.

Therefore, the first year depreciation using the Declining Balance is $2\,\frac{(\$20{,}000)}{5} = \$8{,}000$.

The table below indicates the depreciation annual expense over the full service life using the Double Declining Method until the salvage value is reached.

Year	Remaining Book Value	Yearly Depreciation	Book Value Beginning
0	$ 0	$ 0	$20,000
1	$20,000	2($20,000)/5 = $8,000	$12,000
2	$12,000	2($12,000)/5 = $4,800	$7,200
3	$7,200	2($7,200)/5 = $2,880 max ($2,200) =	$5,000
4			
5			

Sum-of-the-Year-Digits Example

Given the following information:	Purchase Price	= $20,000
	Salvage Value	= $05,000
	Service Life	= 5 Years.

The denominator for Sum of the Digits is $\underline{N}/2\,(N+1) = \underline{5/2}\,(5 + 1) = 15$ or $= 5 + 4 + 3 + 2 + 1$

The depreciable amount is $20,000 - $5,000 = $15,000. For the first year the numerator is 5, for the second year it is 4, and so forth.

The table below indicates the annual depreciation expense over the full service life using the Sum-of-the-Year-Digits method.

Year	Remaining Book Value	Yearly Depreciation	Book Value Beginning
0	$ 0	$ 0	$20,000
1	$20,000	5/15 ($15,000) = $5,000	$15,000
2	$15,000	4/15 ($15,000) = $4,000	$11,000
3	$11,000	3/15 ($15,000) = $5,000	$8,000
4	$8,000	2/15 ($15,000) = $2,000	$6,000
5	$6,000	1/15 ($15,000) = $1,000	5,000

Depreciation Methods Exercise

Given the following information:	Purchase Price	= $100,000
	Salvage Value	= $ 10,000
	Service Life	= 3 Years.

1. What is the depreciation amount at the end of year one using the Double Declining Method?

- A. $30,000
- B. $45,000
- C. $66,667
- D. $90,000

2. What is the depreciation amount at the end of year one using the Sum-of-the-Year-Digits method?

- A. $15,000
- B. $16,667
- C. $45,000
- D. $50,000

3. What is the remaining book value amount at the beginning of year two using the Sum-of-the-Year-Digits method?

- A. $10,000
- B. $45,000
- C. $50,000
- D. $55,000

4. What is the depreciation amount at the end of year one using the Straight line method?

- A. $30,000
- B. $33,333
- C. $45,000
- D. $90,000

Check Answers

Depreciation Methods and Formulas

Straight Line

$$SL\ dep\ rate = \frac{1}{N}(P - S)$$

$$BV\ @\ end\ of\ Jth\ Year = P - \frac{J}{N}(P - S)$$

Sum-of-Year Digits

$$SOYD \text{ in any year} = \frac{\text{Remaining Useful Life at Beginning of Year}}{\text{SOYD}}(P - S)$$

$$SOYD = \frac{N}{2}(N+1)$$

Double Declining Balance

$$DDB \text{ in any year} = \frac{2P}{N}\left(1 - \frac{2}{N}\right)^{n-1}$$

$$DDB \text{ i n any year} = \frac{2}{N}(BV)$$

$$Total\ DDB = P\left[1 - \left(1 - \frac{2}{N}\right)^{n}\right]$$

Book Value of an assest and end of n years

$$BV = P - Total\ DDB\ depreciation\ at\ end\ of\ n\ years$$

$$BV = P\left(1 - \frac{2}{N}\right)^{n}$$

Unit of Production

$$UOP = \frac{\text{Production for year}}{\text{Total Life Time Production}}(P - S)$$

Constructor's Code of Ethics

The Constructor is an individual who commits to serve the construction industry in a professional and ethical manner and engages in the continued development of skills and further education to meet increasing industry challenges and changes. The Constructor's Code of Ethics sets forth the principles of professional conduct and standards to be observed by holders of certification conferred by the AIC Constructor Certification Commission. Certificants shall, in their professional activities, sustain and advance the integrity, honor and prestige of the profession of Constructor and the construction industry.

The construction profession relies upon a system of ethical competence, management excellence, and fair dealing in undertaking complex works to serve the public with safety, efficiency, and economy. The AIC Constructor Certification Commission's, Constructor's Code of Ethics sets forth the principles of professional conduct and standards to be observed by holders of certification conferred by the AIC Constructor Certification Commission. Certificants shall, in their professional activities, sustain and advance the integrity, honor and prestige of the profession of the Constructor and the construction industry. The Constructor Code of Ethics principles and standards are stated below.

I. The Constructor shall maintain full regard to the public interest in fulfilling their professional responsibilities to the construction industry.

II. Constructor shall not engage in any deceptive practice, or in any practice that creates an unfair advantage for the Constructor or another.

III A Constructor shall not maliciously or recklessly injure or attempt to injure the professional reputation of others.

IV. A Constructor shall insure that when providing a service that includes advice, such advice shall be fair and unbiased.

V. A Constructor shall not divulge to any person, firm or company, information of a confidential nature acquired during the course of professional activities.

VI. A Constructor shall carry out responsibilities in accordance with current professional practice.

VII. A Constructor shall keep informed of new concepts and developments in the construction process relative to his or her responsibilities.

Ethics Exercise

These situations were adapted from the Column Mr. Ethics presented in previous issues of the American Institute of Constructors (AIC) Newsletter. Read the situations below and circle the best response to the situation.

1. Contractor "A" was low bidder on a general-contacted project which has an extensive number of alternative during bidding and negotiations. Contractor "A" received a standard contract from Mary, the lead Architect, a source of business for several years, Ed the Estimator at Contractor "A", discovers the contract value was erroneously issued at $365,000 instead of the $355,000. How should Ed handle this situation?

   - A. Ignore the error and sign the contract.
   - B. Call Mary, the lead architect, and inform her of your discovery.
   - C. Inform Mary, the lead architect, of the error but encourage them to leave the difference in the contract as a contingency.
   - D. Inform Mary, the lead, architect of the error and tell them to leave the amount in the contract to cover the potential errors in the numerous alternatives.

2. Constructor "Z" is building an addition to an existing pharmaceutical plant of approximately 20,000 square feet. There is space on the site for one more future addition. After installing foundations, Ed, the Constructors Superintendent, is verifying the dimensions with Jim the Bricklayer crew leader and they discover that the addition has been laid out 1' - 0" out of square. All work can still be performed with very minor field adjustments. The error will compound itself if the future addition ever takes place. Ed has worked on Mary the Architect's, projects for over twenty years but never for this owner. What should Ed do?

   - A. Ignore the error and tell no one.
   - B. Inform Mary, the architect only.
   - C. Inform the Owner and Mary the Architect.
   - D. Have Ed, the superintendent, and Jim, the Bricklayer adjust as required.

Ethics Exercise

3. A city electrical inspector makes the following statement after discovering that the new condominium building # 13 of 25 buildings has been drywalled without an electrical inspection. The inspector says to you, the superintendent, “Gee”! It will be pretty expensive to remove all of the drywall. I’d bet it will cost you at least $5, 000. I’d like to have that kind of money myself! (You suspect that the inspector is asking for a bribe).

- ○ A. Contact the building department supervisor and ask to have hidden areas removed
- ○ B. Instruct your workers to remove all of the drywall for the electrical inspection.
- ○ C. Pay the inspector because you don’t want to be bothered with the situation.
- ○ D. Contact the City Commissioners and the local newspaper and have the inspector relieved of his duties.

4. You as a Masonry Subcontractor recently submitted a bid of $450,000 to a General Contractor for the masonry portion of a new office building. You are invited to the General Contractor’s office to discuss the project. In the midst of negotiations, the General Contractors representative is called out of the room. In his absence, you notice the spread sheet listing all the bids received including yours. It is apparent from the spread sheet that you are $22,000 higher than the low bidder. The next highest bidder is $8,000 above you. What action should you take?

- ○ A. Lower your price by $25,000 upon the General Contractor’s return, giving the reason that you had a chance to re-examine your numbers.
- ○ B. Be concerned that the spread sheet may be a decoy with the intention of getting you to lower your price enough to become the lowest bidder.
- ○ C. Continue negotiating with the General Contractor over price upon the General Contractor’s return to the meeting. Always knowing you have the upper hand.
- ○ D. Maintain your original price quotation, extol the virtues of your company to be able to meet the schedule, the high quality of your work and your relationship.

Ethics Exercise

5. After a $15,000,000 bid on a new pump house. You are publicly regarded as the apparent second low bidder. The following day one of the subcontractors for a $4,500,000 portion of the project calls and asks how he compared with his competitors. He is the low bidder with you. What do you tell the subcontractor?

- A. Divulge all and hope to put your competitor at a negotiating disadvantage.
- B. Maintain your silence in respect for the other subcontractors who provided quotes.
- C. Provide the subcontractor a ball park idea where they stood, but don't be specific.
- D. Tell him that it is none of his business and hang up on him for bothering you.

6. According to the Constructor's Code of Ethics, The Constructor shall insure that when providing a service or advice such advice shall be to treat all parties in a fair and unbiased way. What is the best way for a Constructor to achieve this?

- A. Fire someone for being considered unethical.
- B. Review your mission and goal statement on ethical behavior.
- C. Follow the guidelines provided in your employment contract.
- D. Don't engage in any practice which creates an unfair advantage for one party.

7. According to the Constructor's Code of Ethics, The Constructor shall not maliciously or recklessly injure or attempt to injure the professional reputation of others. You have just been notified in writing that you have not met the minimum score required to pass the Level 2 Advanced Construction Applications Examinations even though you have over twenty years of experience. What is the Best way to proceed?

- A. Call the Commission office and criticize the poor quality of the examination.
- B. Submit a written request to the Commission, postmarked no later than thirty days after the notice of failure according to the Appeals Process procedures.
- C. Obtain the e-mail addresses of all members and send a letter criticizing the quality of the test questions and that certain portions of the examination were wrong.
- D. Call the Commission office and ask for hints on how close you were to passing and what questions should be appealed. Then provide a solid grounds for appeal.

Check Answers

CONSTRUCTION MATERIALS, METHODS AND PLAN READING

CSI MasterFormat Document Organization

In the early 1960s the need for a uniform system for organizing specifications was identified and resulted in the publishing of the "CSI MasterFormat", named after its author, the Construction Specifications Institute (CSI). The CSI MasterFormat introduced the seventeen division format associated with the ability to organize an infinite number of subject sections. In 1978, Construction Specifications Canada (CSC) joined with CSI to produce the first edition of MasterFormat.

The MasterFormat incorporates a complete organizational format for project manuals by including bidding requirements, contract forms, conditions of the contract and the General Requirements, in addition to the Technical Specifications Divisions 02 through 16. This document has been the construction industry's consensus standard for the organization of technical information. It is accepted by the U.S. federal agencies and most state and local governments. It was subsequently adopted by the McGraw-Hill Sweets Catalogs, the R.S. Means cost estimating books, and other organizations.

MasterFormat is intended to classify detailed construction information into a standard order or sequence by materials and methods. This is done by establishing a detailed master list of divisions, sections and parts. The MasterFormat facilitates construction communication, promotes standardization in the industry, and facilitates the retrieval of information. It is primarily used for the organization of project manuals, detailed construction cost estimates, and product data filing.

CSI MasterFormat Structure

The MasterFormat groups information into these areas:

- Bidding Requirements and Forms
- Contract Forms (Agreement)
- Conditions of the Contract (General and Supplementary)
- General Requirements (Division 01)
- Technical Specifications Division (02 through 16)

MasterFormat Numbering System

The MasterFormat number system categorizes the Bidding Requirements and Forms, Contract Forms and Conditions of the Contract into Division 0 - Bidding Requirements. Second, the MasterFormat uses a series of numbers associated with the sixteen divisions which address detailed construction specifications associated with products and systems. Division 1 - General Requirements outlines the specific administrative and procedural requirements that apply to all of the Technical Specification sections. Divisions 02 through 16 - Technical Specifications contain a written description of the specific requirements relating to a specific product or system. The Construction Specifications Institute (CSI) has developed the following Standard MasterFormat numbering system consisting of the following Documents and Divisions.

CSI MasterFormat Divisions

DIVISION 00 - BIDDING REQUIREMENTS
DIVISION 01 - GENERAL REQUIREMENTS
DIVISION 02 - SITE WORK
DIVISION 03 - CONCRETE
DIVISION 04 - MASONRY
DIVISION 05 - METALS
DIVISION 06 - WOOD AND PLASTICS
DIVISION 07 - THERMAL AND MOISTURE PROTECTION
DIVISION 08 - DOORS AND WINDOWS
DIVISION 09 - FINISHES
DIVISION 10 - SPECIALTIES
DIVISION 11 - EQUIPMENT
DIVISION 12 - FURNISHINGS
DIVISION 13 - SPECIAL CONSTRUCTION
DIVISION 14 - CONVEYING SYSTEMS
DIVISION 15 - MECHANICAL
DIVISION 16 - ELECTRICAL

CSI Masterformat Sections

The CSI Masterformat breaks down Divisions 02 - 16 into Sections using a three-digit numbering system. For example, in Division 02 - Sitework the Earthwork is under section number 200. Therefore, the complete Division and Section number is 02200.

Masterformat- Broadscope Section Titles

00010	PRE-BID INFORMATION
00100	INSTRUCTIONS TO BIDDERS
00200	INFORMATION AVAILABLE TO BIDDERS
00300	BID FORMS
00400	SUPPLEMENTS TO BID FORMS
00500	AGREEMENT FORMS
00600	BONDS AND CERTIFICATES
00700	GENERAL CONDITIONS
00800	DRAWINGS AND SCHEDULES
00900	ADDENDA AND MODIFICATIONS

Note: Since the items listed above are not specification sections, they are referred to as "Documents" in lieu of "Divisions or Sections" in the Master List of Section Titles, Numbers, and Broadscope Explanations.

DIVISION 1 - GENERAL REQUIREMENTS

01010	SUMMARY OF WORK
01020	ALLOWANCES
01025	MEASUREMENT AND PAYMENT
01030	ALTERNATES/ALTERNATIVES
01040	COORDINATION
01050	FIELD ENGINEERING
01060	REGULATORY REQUIREMENTS
01070	ABBREVIATIONS AND SYMBOLS
01080	IDENTIFICATION SYSTEMS
01090	REFERENCE STANDARDS
01100	SPECIAL PROJECT PROCEDURES
01200	PROJECT MEETINGS
01300	SUBMITTALS
01400	QUALITY CONTROL
01500	CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS
01600	MATERIALS AND EQUIPMENT
01700	CONTRACT CLOSEOUT
01800	MAINTENANCE

TECHNICAL SPECIFICATIONS

DIVISION 2 - SITEWORK

02010	SUBSURFACE INVESTIGATION
02050	DEMOLITION
02100	SITE PREPARATION
02140	DEWATERING
02150	SHORING AND UNDERPINNING
02160	EXCAVATION AND SUPPORT SYSTEMS
02170	COFFERDAMS
02200	EARTHWORK
02300	TUNNELING
02350	PILES AND CAISSONS
02450	RAILROAD WORK
02480	MARINE WORK
02500	PAVING AND SURFACING
02600	PIPED UTILITY MATERIALS
02660	WATER DISTRIBUTION
02680	FUEL DISTRIBUTION
02700	SEWERAGE AND DRAINAGE
02760	RESTORATION AND UNDERGROUND PIPELINES
02770	PONDS AND RESERVOIRS
02780	POWER AND COMMUNICATIONS
02800	SITE IMPROVEMENTS
02900	LANDSCAPING

DIVISION 3 - CONCRETE

03100	CONCRETE FORMWORK
03200	CONCRETE REINFORCEMENT
03250	CONCRETE ACCESSORIES
03300	CAST-IN-PLACE CONCRETE
03370	CONCRETE CURING
03400	PRECAST CONCRETE
03500	CEMENTITIOUS DECKS
03600	GROUT
03700	CONCRETE RESTORATION AND CLEANING
03800	MASS CONCRETE

DIVISION 4 - MASONRY

04100	MORTAR
04150	MASONRY ACCESSORIES
04200	UNIT MASONRY
04400	STONE
04500	MASONRY RESTORATION AND CLEANING
04550	REFRACTORIES
04600	CORROSION RESISTANT MASONRY

DIVISION 5 - METALS

05010	METAL MATERIALS
05030	METAL FINISHES
05050	METAL FASTENING
05100	STRUCTURAL METAL FRAMING
05200	METAL JOISTS
05300	METAL DECKING
05400	COLD-FORMED METAL FRAMING
05500	METAL FABRICATIONS
05580	SHEET METAL FABRICATIONS
05700	ORNAMENTAL METAL
05800	EXPANSION CONTROL
05900	HYDRAULIC STRUCTURES

DIVISION 6 - WOOD AND PLASTICS

06050	FASTENERS AND ADHESIVES
06100	ROUGH CARPENTRY
06130	HEAVY TIMBER CONSTRUCTION
06150	WOOD-METAL SYSTEMS
06170	PREFABRICATED STRUCTURAL WOOD
06200	FINISH CARPENTRY
06300	WOOD TREATMENT
06400	ARCHITECTURAL WOODWORK
06500	PREFABRICATED STRUCTURAL PLASTICS
06600	PLASTICS FABRICATIONS

DIVISION 7 - THERMAL AND MOISTURE PROTECTION

07100	WATERPROOFING
07150	DAMPROOFING
07190	VAPOR AND AIR RETARDERS
07200	INSULATION
07250	FIREPROOFING
07300	SHINGLES AND ROOFING TILES
07400	PREFORMED ROOFING AND CLADDING/ SIDING
07500	MEMBRANE ROOFING
07570	TRAFFIC TOPPING
07600	FLASHING AND SHEET METAL
07700	ROOF SPECIALTIES AND ACCESSORIES
07800	SKYLIGHTS
07900	JOINT SEALERS

DIVISION 8 - DOOR AND WINDOWS

08100	METAL DOORS AND FRAMES
08200	WOOD AND PLASTIC DOORS
08250	DOOR OPENING ASSEMBLIES
08300	SPECIAL DOORS
08400	ENTRANCES AND STOREFRONTS
08500	METAL WINDOWS
08600	WOOD AND PLASTIC WINDOWS
08650	SPECIAL WINDOWS
08700	HARDWARE
08800	GLAZING
08900	GLAZED CURTAIN WALLS

DIVISION 9 - FINISHES

09100 METAL SUPPORT SYSTEMS
09200 LATH AND PLASTER
09230 AGGREGATE COATINGS
09250 GYPSUM BOARD
09300 TILE
09400 TERRAZZO
09500 ACOUSTICAL TREATMENT
09540 SPECIAL SURFACES
09550 WOOD FLOORING
09600 STONE FLOORING
09630 UNIT MASONRY FLOORING
09650 RESILIENT FLOORING
09680 CARPET
09700 SPECIAL FLOORING
09780 FLOOR TREATMENT
09800 SPECIAL COATINGS
09900 PAINTING
09950 WALL COVERING

DIVISION 10 - SPECIALTIES

10100 CHALKBOARDS AND TACKBOARDS
10150 COMPARTMENTS AND CUBICLES
10200 LOUVERS AND VENTS
10240 GRILLES AND SCREENS
10250 SERVICE WALL SYSTEMS
10260 WALL AND CORNER GUARDS
10270 ACCESS FLOORING
10280 SPECIALTY MODULES
10290 PEST CONTROL
10300 FIREPLACES AND STOVES
10340 PREFABRICATED EXTERIOR SPECIALTIES
10350 FLAGPOLES
10400 IDENTIFYING DEVICES
10450 PEDESTRIAN CONTROL DEVICES
10500 LOCKERS
10520 FIRE PROTECTION SPECIALTIES
10530 PROTECTIVE COVERS
10550 POSTAL SPECIALTIES
10690 PARTITIONS
10650 OPERABLE PARTITIONS
10670 STORAGE SHELVING
10700 EXTERIOR SUN CONTROL DEVICES
10750 TELEPHONE SPECIALTIES
10800 TOILET AND BATH ACCESSORIES
10880 SCALES
10900 WARDROBE AND CLOSET SPECIALTIES

DIVISION 11 - EQUIPMENT

11010 MAINTENANCE EQUIPMENT
11020 SECURITY AND VAULT EQUIPMENT
11030 TELLER AND SERVICE EQUIPMENT
11040 ECCLESIASTICAL EQUIPMENT
11050 LIBRARY EQUIPMENT
11060 THEATER AND STAGE EQUIPMENT
11070 INSTRUMENTAL EQUIPMENT
11080 REGISTRATION EQUIPMENT
11090 CHECKROOM EQUIPMENT
11100 MERCANTILE EQUIPMENT
11110 COMMERCIAL LAUNDRY AND DRY CLEANING EQUIPMENT
11120 VENDING EQUIPMENT
11130 AUDIO-VISUAL EQUIPMENT
11140 SERVICE STATION EQUIPMENT
11150 PARKING CONTROL EQUIPMENT
11160 LOADING DOCK EQUIPMENT
11170 SOLID WASTE HANDLING EQUIPMENT
11190 DETENTION EQUIPMENT
11200 WATER SUPPLY AND TREATMENT EQUIPMENT
11280 HYDRAULIC GATES AND VALVES
11300 FLUID WASTE TREATMENT AND DISPOSAL EQUIPMENT
11400 FOOD SERVICE EQUIPMENT
11450 RESIDENTIAL EQUIPMENT
11460 UNIT KITCHENS
11470 DARKROOM EQUIPMENT
11480 ATHLETIC, RECREATIONAL AND THERAPEUTIC EQUIPMENT
11500 INDUSTRIAL AND PROCESS EQUIPMENT
11600 LABORATORY EQUIPMENT
11650 PLANETARIUM EQUIPMENT
11660 OBSERVATORY EQUIPMENT
11700 MEDICAL EQUIPMENT
11780 MORTUARY EQUIPMENT

11850 NAVIGATION EQUIPMENT

DIVISION 12 - FURNISHINGS

12050 FABRICS
12100 ARTWORK
12300 MANUFACTURED CASEWORK
12500 WINDOW TREATMENT
12600 FURNITURE AND ACCESSORIES
12670 RUGS AND MATS
12700 MULTIPLE SEATING
12800 INTERIOR PLANTS AND PLANTERS

DIVISION 13 - SPECIAL CONSTRUCTION

13010 AIR SUPPORTED STRUCTURES
13020 INTEGRATED ASSEMBLIES
13030 SPECIAL PURPOSE ROOMS
13080 SOUND, VIBRATION, AND SEISMIC CONTROL
13090 RADIATION PROTECTION
13100 NUCLEAR REACTORS
13120 PRE-ENGINEERED STRUCTURES
13150 POOLS
13160 ICE RINKS
13170 KENNELS AND ANIMAL SHELTERS
13180 SITE CONSTRUCTED INCINERATORS
13200 LIQUID AND GAS STORAGE TANKS
13220 FILTER UNDERDRAINS AND MEDIA
13230 DIGESTION TANK COVERS AND APPURTENANCES
13240 OXYGENATION SYSTEMS
13260 SLUDGE CONDITIONING SYSTEMS
13300 UTILITY CONTROL SYSTEMS
13400 INDUSTRIAL AND PROCESS CONTROL SYSTEMS
13500 RECORDING INSTRUMENTATION
13550 TRANSPORTATION CONTROL INSTRUMENTATION
13600 SOLAR ENERGY SYSTEMS
13700 WIND ENERGY SYSTEMS
13800 BUILDING AUTOMATION SYSTEMS
13900 FIRE SUPPRESSION AND SUPERVISORY SYSTEMS

DIVISION 14 - CONVEYING SYSTEMS

14100 DUMBWAITERS
14200 ELEVATORS
14300 MOVING STAIRS AND WALKS
14400 LIFTS
14500 MATERIAL HANDLING SYSTEMS
14600 HOISTS AND CRANES
14700 TURNTABLES
14800 SCAFFOLDING
14900 TRANSPORTATION SYSTEMS

DIVISION 15 - MECHANICAL

15050 BASIC MECHANICAL MATERIALS AND METHODS
15250 MECHANICAL INSULATION
15300 FIRE PROTECTION
15400 PLUMBING
15500 HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)
15550 HEAT GENERATION
15650 REFRIGERATION
15750 HEAT TRANSFER
15850 AIR HANDLING
15880 AIR DISTRIBUTION
15950 CONTROLS
15990 TESTING, ADJUSTING, AND BALANCING

DIVISION 16 - ELECTRICAL

16050 BASIC ELECTRICAL MATERIALS AND METHODS
16200 POWER GENERATION
16300 HIGH VOLTAGE DISTRIBUTION (ABOVE 600-VOLT)
16400 SERVICE AND DISTRIBUTION (600-VOLT AND BELOW)
16500 LIGHTING
16600 SPECIAL SYSTEMS
16700 COMMUNICATIONS
16850 ELECTRIC RESISTANCE HEATING
16900 CONTROLS
16950 TESTING

CSI MaterFormat Parts
Each technical Specification Section within a Division is further broken down into Parts. Part 1 is titled General. Part 2 is titled Products, and Part 3 is titled Execution. Part 1 contains these titles: Work Included, References, Quality Assurance, Submittals, Storage, and Environmental Requirements. Part 2 contains these titles: Acceptable Manufacturers, Types of Materials and Product Standards. Part 3 contains these titles: Preparation, Installation, Tolerances, Cleaning and Protection of the finished work. The discussion and example below will primarily focus on Part 1 titled General and the subsection titled Reference standards because it utilizes the law principle called Incorporated by Reference.

Part 1 generally contains a list of additional reference standards with complete designations and titles. It also identifies specific requirements for the submittal of shop drawings and product data sheets for each section. *Reference standards* are documents that are not physically attached with the Documents, but are referenced to in the documents may be part of the contract. The most common clause used to incorporate an item by reference is to state in the documents that the Reference Standards are "herewith made a part of the Specifications." This normally requires the Contractor to have these available at the job site. The specific Reference Standards that the Contractor must refer to are stated at the beginning of each Section of the Technical Specifications under Part 1. For example, Division 3 is Concrete and Section 200 is Concrete Reinforcement, PART 1.03 is Reference Standards and the A - J refers to the specific reference Standards required. Numerous CSI Division numbers, Section numbers with Part 1 Reference Standards and their abbreviations are shown below.

03100 Concrete Formwork
PART 1 GENERAL
1.03 Reference Standards
B. ACI SP-4 “Formwork for Concrete”
American Concrete Institute. Special Publication -4.
03200 Concrete Reinforcement
1.03 Reference Standards
I. CRSI 65 “Recommended Practice for Placing Bar Supports, Specifications and Nomenclature.” Concrete Reinforcing Steel Institute.

03300 Cast-in-Place Concrete
1.03 Reference Standards
N. ASTM C-94 “Specifications for Ready-mixed concrete.”
American Society for Testing Materials
02200 Excavation
1.06 Reference Standards
AASHTO - MI47-65 - Materials for Aggregate and Soil - Aggregate.
Am. Association of State Highway/Transportation Officials.

05120 Structural Steel
1.03 Reference Standards
AISC - Specification for the Design, Fabrication and Erection
American Institute of Steel Construction
AWS - D1.1 - Structural Welding Code
American Welding Society
SJI - Standard Specifications for Open Web Steel Joists
Steel Joist Institute

09250 Gypsum Board Systems
1.04 Reference Standards
ANSI/ASTM C36 - Gypsum Wallboard.
American National Standards Institute.
American Society for Testing Materials.

15050 Basic Mechanical Materials and Methods
1.06 Reference Standards
ASME B16 - Boiler and Pressure Vessel Code
American Society of Mechanical Engineers
ASHRAE 15 - Safety Code for Mechanical Refrigeration
American Society for Heating, Refrigerating, and Air Conditioning Engineers.
AWWA C601 - Standard Methods for the Examination of Water & Waste
American Water Works Association
UL 378 - Standard for Draft Equipment.
Underwriter Laboratories, Inc.
AMCA 99 - Standards Handbook.
Air Movement and Controls Association

15300 Fire Protection Piping
1.03 Quality Assurance
NFPA 13 - Sprinkler Systems
National Fire Protection Association.

15880 - Air Distribution
1.03 Reference Standards
SMACNA Symbols for Ventilation and Air Conditioning.
Sheet Metal and Air Conditioning Contractors' National Association.

16700 - Communications
1.03 Reference Standards
NEC - National Electrical Code
TIA - Telecommunication Industry Association.

CSI Master Format Exercise

1. What CSI Division contains technical information on Soil Compaction requirements?

- A. 01
- B. 02
- C. 04
- D. 16

2. What CSI Division contains technical information on Structural Steel?

- A. 01
- B. 03
- C. 05
- D. 15

3. What CSI Division contains technical information on Drywall?

- A. 06
- B. 09
- C. 10
- D. 14

4. What CSI Division contains technical information on Plumbing?

- A. 03
- B. 05
- C. 11
- D. 15

5. What CSI Division contains technical information on the Air Handling system?

- A. 11
- B. 13
- C. 14
- D. 15

CSI Master Format Exercise

6. What CSI Division contains technical information on the Conveyor System?

- A. 11
- B. 13
- C. 14
- D. 15

7. What CSI Division contains technical information on the Boiler System?

- A. 11
- B. 13
- C. 14
- D. 15

8. What CSI Division contains technical information on Painting?

- A. 02
- B. 06
- C. 09
- D. 16

9. What CSI Division contains technical information on Roofing?

- A. 04
- B. 06
- C. 07
- D. 10

10. What CSI Division contains technical information on Food Service Equipment?

- A. 10
- B. 11
- C. 13
- D. 15

CSI Master Format Exercise

11. According to CSI, What Division (s) are considered the Technical Specifications?

- ○ A. 00 - 01.
- ○ B. 01
- ○ C. 01 - 16.
- ○ D. 02 - 16.

12. What CSI Division applies to all contractors and subcontractors?

- ○ A. 01
- ○ B. 02
- ○ C. 09
- ○ D. 15

13. What CSI Division contains the Bid Requirements for a project?

- ○ A. 00
- ○ B. 01
- ○ C. 04
- ○ D. 16

14. What is the name of the legal principle for referring the contractor to other documents that are not contained in the documents provided?

- ○ A. Reference Standards.
- ○ B. Incorporated by Reference.
- ○ C. Standard General Conditions
- ○ D. General Conditions of the Contract.

15. What is the official name of the technical reference source that is mentioned in the documents to Design the Formwork and it is published by ACI?

- ○ A. Formwork Handbook.
- ○ B. Formwork for Concrete.
- ○ C. Formwork Design Manual.
- ○ D. Concrete Formwork Design Manual.

CSI Master Format Exercise

16. What is the official name of the technical reference source that is mentioned in the documents to Place the Slab Bolsters and it is published by CRSI?

- A. Steel Riggers Handbook.
- B. Steel Reinforcement Guide.
- C. Recommended Practice for Placing Bar Supports, Specifications & Nomenclature.
- D. Manual of Steel Erection Practices.

17. Your specifications reference this construction organization Acronym of ACI that publishes numerous Technical Reference Sources. What is the correct name of ACI?

- A. American Concrete Institute.
- B. Associated Contractors Institute.
- C. American Construction Institute.
- D. Associated Constructors Institute.

18. Your specifications reference this construction organization Acronym of CSI that publishes numerous Technical Reference Sources. What is the correct name of CSI?

- A. Cost System Information.
- B. Construction Standards Institute.
- C. Construction Standards Information.
- D. Construction Specifications Institute.

19. Your specifications reference this construction organization Acronym of CRSI that publishes numerous Technical Reference Sources. What is the correct name of CRSI?

- A. Concrete Reinforcing Steel Institute.
- B. Crane and Riggers Specification Institute.
- C. Concrete Reinforcement Standards Institute
- D. Concrete Reinforcement Specifications Institute.

20. Your specifications reference this construction organization Acronym of AISC that publishes numerous Technical Reference Sources. What is the correct name of AISC?

- A. American Institute of Steel Contractors.
- B. American Institute of Steel Constructors.
- C. American Institute of Steel Construction.
- D. American Institute of Structural Concrete.

CSI Master Format Exercise

21. Which CSI part number contains information on Reference Standards the contractor or subcontractor must consult?

- A. 1
- B. 2
- C. 3
- D. 4

22. Which CSI part number contains information on the installation procedures the contractor or subcontractors must consult?

- A. 1
- B. 2
- C. 3
- D. 4

23. Which Division and Section number contains technical information on the interior plumbing?

- A. 02660
- B. 02700
- C. 15300
- D. 15400

24. Which Division and Section number contains technical information on the exterior sewerage and drainage system?

- A. 02660
- B. 02700
- C. 15300
- D. 15400

25. Which Division and Section number contains technical information on the interior Electrical Service and Distribution system?

- A. 02600
- B. 02780
- C. 15950
- D. 16400

CSI Master Format Exercise

26. Which Division and Section number contains technical information on the communications systems?

- A. 02780
- B. 15950
- C. 16500
- D. 16700

27. Your specifications reference this construction organization Acronym of ASHRAE that publishes numerous Technical Reference Sources. What is the correct name of ASHRAE?

- A. American Steel Housing Rating Association of Engineers.
- B. Associated Structural Hoists Rating Association of Engineers.
- C. American Society for Heating, Refrigerating and Air Conditioning Engineers.
- D. Associated Society for Heating, Refrigerating and Air Conditioning Engineers.

28. Your specifications reference this construction organization Acronym of TIA that publishes numerous Technical Reference Sources. What is the correct name of TIA?

- A. Trade Industry Association.
- B. Testing Industry Association.
- C. Transportation Industry of America.
- D. Telecommunication Industry Association.

29. Your specifications reference this construction organization Acronym of UL that publishes numerous Technical Reference Sources. What is the correct name of UL?

- A. Union Laboratories.
- B. United Laboratories.
- C. Utility Laboratories.
- D. Underwriter Laboratories.

Check Answers

Construction Methods. Materials and Equipment

The contractor is responsible for the temporary shoring system selected and the design of the shoring system. These are not shown on the plans or described in any detail within the construction documents. The estimator is responsible for determining the number, size and cost for all temporary structures. These structures are normally utilized to restrain water, soil, existing structures, etc. Some of the more common temporary systems are described below.

Temporary Shoring Systems

The *Cofferdam* is a water tight rectangular structure built to restrain water and soil. It is utilized around the foundations of bridge piers or to have working space to place an item below grade. A cofferdam contains driven sheet piling (Uprights), wales(Walers) and Cross braces (Struts). To ensure structural soundness of the cofferdam, the sheet piles are driven beyond the bottom of the excavation at least two feet. This extension is called the *Toe*. The most common materials for construction of a cofferdam are wood timber and structural steel. If moderate ground water is encountered, Tongue & Groove sheeting is normally utilized to keep out the water. If considerable water is present, steel sheet piling is used.

Cribbing and Tie Backs shoring is a method of restraining a vertical wall of soil where it is impractical to slope the soil such as in a downtown area where the excavation and new substructure are below the street level. This system requires timbers called cribbing to be placed horizontally with rods (tiebacks) drilled through the cribbing at an angle back into the soil. This shoring system allows the contractor to maximize the open space.

Underpinning is the process of supporting an existing structure when the new excavation will be below the existing structures foundation. This requires temporary supports to support the structure while an extension to the existing foundation is being placed.

Dewatering is the process of removing water or in some cases lowering the water table to install an item below the existing water table. There are two dewatering methods. The first method is by utilizing a pump with a suction hose and discharge hose. The second method is to utilize wells points placed at specified intervals to lower the water table temporarily.

Equipment Mobilization is the process of loading off- road equipment, transporting it to the job site and assembling at the site. The assembly of a large lifting crane can require 7 -9 workers approximately three days if the crane requires the boom to be assembled and the cables to be run through the crane's jib. *Equipment Demobilization* is the process of disassembling equipment.

Excavation Shoring Systems

A *Support or Shoring System* is a structure such as a timber shoring system or hydraulic shoring system that supports the sides of an excavation and protects employees against cave-ins. According to the OSHA Excavation Safety Standards, anytime a worker enters a trench at least five (5) feet deep you must provide protection from cave-ins. After a qualified person has determined the type of soil, they have a few options. First, they can design a shoring system using the Shoring Designs provided in the Standards. The Second option is to design a support system using a Manufacturer's system. Finally, they can use a trench box. Below we will define the shoring options outlined in the excavation safety standards for shoring systems less than twenty feet deep. According to the OSHA Construction Standards, for excavations more than twenty (20) feet deep you must contact a Registered Professional Engineer (RPE) to design the protection system.

The *OSHA Standards for the Construction Industry 29 CFR Part 1926.650(b)* titled, Definitions applicable to subpart P - Excavations defines the following shoring terms.

The *Sheeting* means the individual members of a shoring system that are closely spaced together to retain the earth. Sheeting is also called Uprights or Sheet Piling. OSHA defines the term “Uprights”as the vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other (p 253).

The *Wales* means the horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system. They are set perpendicular to the sheeting. The *Crossbraces or Struts* are the horizontal members of the shoring system that span across the width of an excavation. They are installed perpendicular to the sides of the excavation and the ends are connected to either uprights or wales.

OSHA also defines *Tight Sheeting* as the use of specially-edged timber planks (e.g. Tongue and Groove) at least three inches thick. These are used when conditions are saturated or submerged in water as defined in the OSHA 1926.652(g). Also, *Close Sheeting* refers to the space between the timber planks not to exceed ½ inch when placed edge to edge according to OSHA 1926.652(g), titled Notes for all Tables in paragraph 2.

The *Shield or Trench Box* is a structure that normally does not prevent a cave-in but protects employees within the structure. Shields may be permanent structures or may be designed to be portable and moved along the trench. Shields used in trenches are usually referred to as "trench boxes" or "trench shields.”

Concrete Support Systems

Concrete Formwork is a temporary support system for restraining the compressive force from the concrete. The *OSHA Standards for the Construction Industry 29 CFR Part 1926.700(b)* titled, Definitions applicable to subpart Q - Concrete and Masonry Construction defines the following formwork terms. *Formwork* is the total system of support for freshly placed or partially cured concrete, including the sheeting that is in contact with the concrete as well as all supporting members including shores, reshores, hardware, braces, and related hardware. *Shoring* means a supporting member that resists a compressive force imposed by a load. *Reshoring* means the construction operation in which shoring equipment called reshores is placed, as the original forms and shores are removed, in order to support partially cured concrete and construction loads for elevated slab and beams. The *slip form system* is used to make a continuous vertical concrete pour which moves up on the freshly poured concrete at a constant speed.

Another temporary operation is called a *Lift-Slab or a jacking operation* which takes cured concrete slabs and lifts them vertically into placed using hydraulic jacks. An additional temporary system is called *tilt-up construction*. This system has the concrete poured on the ground into panels and after they are cured they are lifted or tilted up into place vertically. Finally, there is a formwork system called a *flying deck form system* which is a complete formwork support system that is repositioned using a crane for the next pour.

There are various methods for pouring the concrete such as direct chute, crane and bucket, concrete buggies, concrete pumping, tremie, shotcrete and sometimes by conveyor. The *Concrete bucket* is attached to the crane and a person pulls on a handle which opens the bottom of the bucket and pours concrete. This method is called the crane and bucket operation. There are two types of concrete buggies: Hand or Georgia buggies and the motorized buggies. The hand *Georgia buggy* has a very limited capacity of about 1.5 cubic feet, therefore, it is used to move small amounts of concrete. The *Motorized Concrete Buggy* is a small rubber tired vehicle with a dump box that carries up to 14 cubic feet. A *Concrete pump* is a truck mounted equipped with a placement boom or hose which pressurizes the hose system to pump the concrete to elevated locations or an inaccessible location. *Tremie* is the process of pouring concrete under water using a tube that is submerged into the fresh concrete at all times.

The Structural Engineering Institute (SEI) of the American Society of Civil Engineers (ASCE) insists that “more failures occur during construction than after completion”, therefore, they have developed a standard titled, *SEI/ASCE 37-02, Design Loads on Structures During Construction*. Another temporary area that fails during construction is the masonry wall bracing. Under the *Construction OSHA Standards Part 1926.700* titled *Masonry Construction* it states that temporary bracing should be provided for walls more than 8 feet high and the bracing shall not exceed 20 feet horizontally. Recently, the Masonry Institute has developed a temporary masonry bracing standard for construction.

Lifting Systems

The *Jin Pole* is a lifting system which utilizes a single pole or double pole above grade vertical lifting system with the intended purpose of lifting an unusually long horizontal piece of equipment into its permanent vertical position. The Jin poles are attached to a temporary foundation and the guy lines are attached to the top of each Jin pole and tied to deadmen buried in the ground.

Cranes are used to hoist and move loads from one location to another and it is necessary to know the lifting capacity and working range of a crane selected to perform a given service. Manufacturers and suppliers furnish this information in literature describing their products. When a crane lifts a load there is a tendency to tip the machine over. This introduces what is defined as the tipping condition. A machine is considered to be at the point of tipping when a balance is reached between the overturning moment of the load and the stabilizing moment of the machine when the crane is on a firm level supporting surface. A track mounted or a crawler mounted crane sets on a track base which rotates 360 degrees and the boom is attached at the base of the crane. A *rubber tired crane* is extremely mobile and it can be easily transported from one job site to another over the road. The crane *mat* is normally made of large square timbers tied together using cables threaded through the center of the timbers at specified spacings. It is best to place the crane on a mat to ensure that the load is distributed evenly.

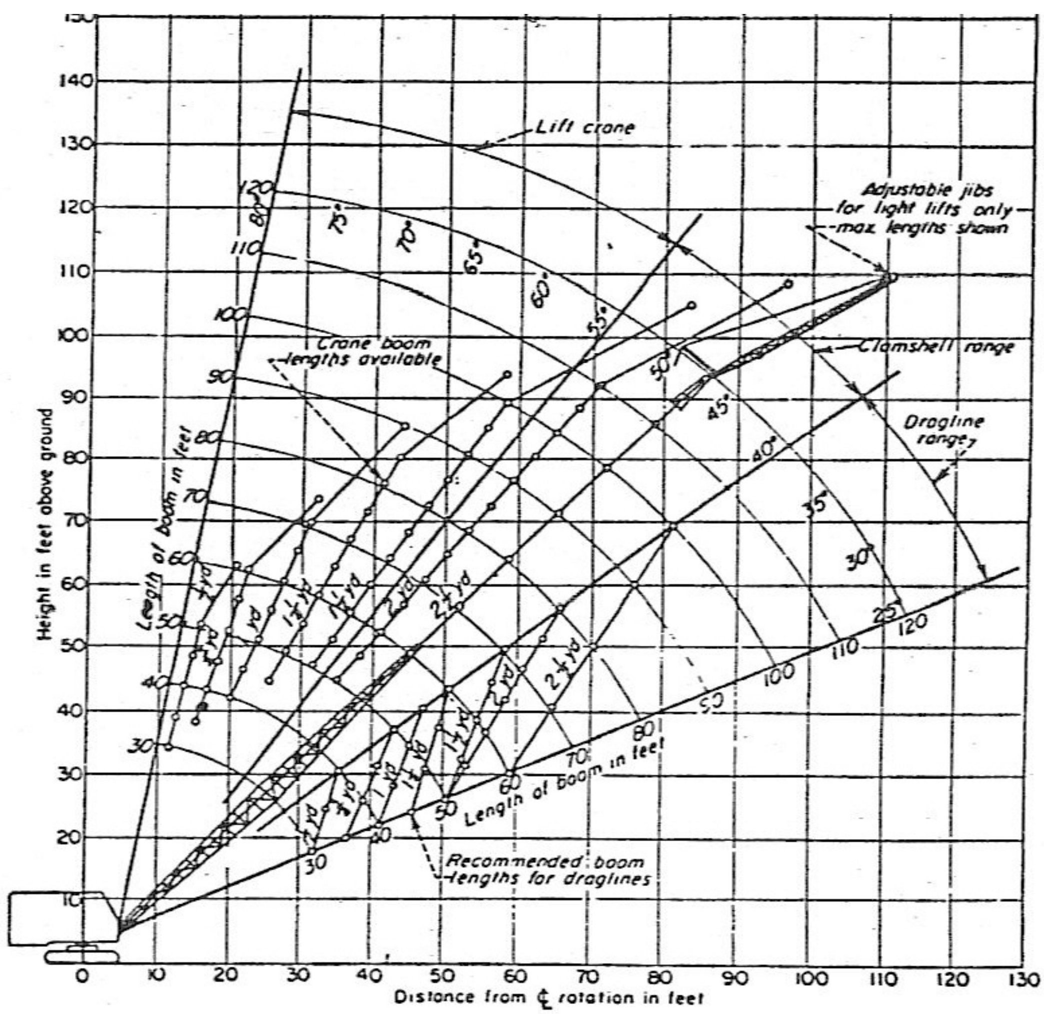
Tower Cranes are available as rail mounted units, stationary units, climbing units and mobile units. The rail mounted units can be equipped with fixed or slewing towers. Tower cranes generally have a larger area of coverage than climbing and stationary tower cranes. Tower cranes have their boom above the structure and it lifts the load vertically until it is above the structure, then it can move the load horizontally. A tower crane looks like an offset Tee.

A *Crane Load Capacity Chart* is provided with each crane by the crane manufacturer which indicates its safe lifting capacity under differing conditions. The major factor for safely lifting a load by a crane is its operating radius which is the horizontal distance from the center of the rotation to the hook. Some other factors which affect lifting capacity are the position of the crane in relationship to its base, the placement or use of outriggers and the soil conditions. Also, the boom angle for a crawler mounted lifting crane is normally between 55 degrees and 80 degrees.

Working Range of a Crane Chart

This crane table shows lifting ranges for a dragline, a clamshell and a lifting crane. From the crane table, the working range of a dragline is from 25 degrees to 39 degrees, the clamshell range is between 40 degrees and 54 degrees and the crane lifting range is between 55 degrees and 80 degrees. The crane chart also contains the distance from the center line rotation in feet along the horizontal axis and the height of a structure in feet such as a wall along the vertical structure. To utilize the chart, let’s assume that you are lifting an item over a vertical wall that is 45 feet above the ground and the horizontal distance from the centerline of the rotation is 60 feet.

The fist step is to find the working range for a lifting crane which is between 55 degrees and 80 degrees. Next, find the length of boom in feet required by determining if the rotation distance or the height above the ground is the controlling factor. In this example, using the height in feet above the ground of 45 feet and in the lifting crane range of 55 - 80 degrees the length of boom, the curved lines, needed is 50 feet. Now, using the center line rotation in feet of 60 feet and in the lifting crane range of 55 - 80 degrees the length of boom needed is 100 feet. This is found by entering the table along the horizontal axis at 60 feet and following the vertical line until it in within the lifting crane range and finding the intersection of the length of boom in feet curved line and the vertical (60 feet) line. The Crane Chart below indicates the working range of a crane.



Adapted from Peurifoy (1985). *Construction Planning, Equipment, and Methods*. Upper Saddle River, NJ: Prentice-Hall. (p 224).

Sling Angles are formed by the legs of the sling and the horizontal plane and the rated capacity of any sling depends on its size, its configuration and the angles. A sling with two legs that is used to lift a 1000 pound object will have a 500 pound load in each leg when the sling angle is 90 degrees. The load in each leg will increase as the angle is decreased and at 30 degrees the load will be 1000 pounds in each leg. Therefore, it is extremely important to keep the sling angles greater than 45 degrees. Hence, sling angles approaching 30 degrees should be considered extremely hazardous and avoided at all costs. Some load tables list sling angles as low as 15 degrees but the use of any sling at an angle less than 30 degrees is extremely dangerous. This is not only because of the high loads associated with them but because of the effect on the load of an error in sling angle measurement of as little as 5 degrees. It has been shown that an assumed sling angle of 15 degrees has an assumed load of 1,932 pounds per Leg but, if the actual angle is actually 10 degrees then the actual load is 2,880 pounds per leg. This illustrates how cautious you must be in ensuring that the angle is greater than 45 degrees and the importance of measuring the angle accurately.

The major types of *crane attachments* are the lift hook, the lifting beam and hook, the concrete bucket, the clamshell bucket, orange peel bucket, the pile driver, the auger or drilled attachment, and the dragline. Each attachment is described below. The *Lift Hook* has a sling or a configuration of slings connected to the hook on the crane. The *Lifting Beam* is utilized to lift long items such as beams for a bridge. The Beam has two lifting at each end with the crane hook connected to the center of the lifting beam. The *Clamshell bucket* opens and is dropped straight down into the soil being excavated and the jaws close toward each other. The Clamshell bucket is utilized to excavate inside the cofferdam after the sheet piles are driven. The *Orange Peel bucket* is similar to the Clamshell bucket but it opens and has straighter sides and it is dropped straight down into the soil being excavated and the jaws close toward each other. The *Pile Driver* can replace the boom or it can be attached to the boom via the hook and suspended from the crane. The *Auger or Drilled pile* is an attachment to the crane for drilling Caissons. These drill attachments have a mechanical device at the bottom of the caisson to form the bell.

Finally, the *Dragline* is used to excavate earth and load it into hauling units, such as trucks or tractor-pulled wagons, or to deposit it in levees, dams, and spoil banks near the pits from which it is excavated. A dragline usually does not have to go into a pit or hole in order to excavate. It may operate on natural ground while excavating material from a pit with its bucket. This will be very advantageous when earth is removed from a ditch, canal, or pit containing water. If the earth is hauled with trucks, they do not have to go into the pit and contend with mud. If the earth can be deposited along a canal or ditch or near a pit, it frequently is possible to use a dragline with a boom long enough to dispose of the earth in one operation, eliminating the need for hauling units, which will reduce the cost of handling the soil. A Dragline is an excellent unit for excavating trenches when an angle of repose can be utilized without shoring.

Excavation Equipment
Power Shovels are normally utilized in an area where the excavation is above the location of the machine. The shovel's bucket opens at the bottom to place the soil into trucks. They are capable of excavating all classes of earth, except solid rock, without prior loosening. They may be mounted on crawler tracks, in which case they are referred to as crawler-mounted. They may also be mounted on rubber-tired wheels. The non-self-propelled units mounted on the rear of trucks, which are refereed to as truck-mounted, have separate engines for operating them. The *Hydraulic Backhoe* is normally utilized in an area where the excavation is below the location of the machine. The bucket action of a Backhoe is to pull the excavated material toward the machine. *Front End Loaders* are used extensively to excavate earth, gravel or rock materials from a pile and place the material into a truck to be transported over a road and deposited at another location. There are basically two types of front-end-loaders, the crawler-tractor-mounted and the wheel-tractor-mounted. They may be further classified by the capacities of the buckets or the weights that the buckets can lift.

Scrapers are used to move large quantities of earth economically for relatively short haul distances. There are a number of different types of scrapers such as the crawler-type tractor, pulling a rubber-tired self-loading scraper. The high draw-bar pulls in loading a scraper, combined with good traction, even on poor haul roads, gives the crawler tractor an advantage for short hauls. However, as the haul distance is increased, the low speed of a crawler tractor is a disadvantage compared with a wheel tractor. Unless the loading operation is difficult, a crawler tractor can load a scraper without the aid of a bulldozer. However, if there are several scraper units on a job, the increased output resulting from using a bulldozer to help load the scrapers usually will justify the use of a bulldozer. Te wheel-tractor scrapers are for longer haul distances because of their higher speed. Also, a wheel type tractor-pulled self-loading scraper will permit it to move earth more economically than a crawler-type tractor. Although, the wheel-type tractor scraper lacks loading ability, the higher travel speed, which may exceed 30 mph for some models, will offset the disadvantage in loading when the haul distance is sufficiently long. The size of a scraper may be specified as the struck, or heaped, capacity of the bowl, expressed in cubic yards. The struck capacity is the volume of the material that a scraper will hold when the top of the material is struck off even with the top of the bowl. In specifying the heaped capacity of a scraper, some manufacturers specify the slope of the material above the sides of the bowl with the designation SAE which means the Society of Automotive Engineers. The SAE specifies a slope of 2:1, measured horizontally and vertically, respectively. Since, the slope will vary with the class of material being hauled, the heaped capacity is only an approximate value.

The *Bottom-dump Wagons* are to be used to haul materials, such as sand, gravel, reasonably dry earth, coal, etc., which flow easily, the use of bottom-dump wagons will reduce the time required to unload the units. Such units are particularly suitable for use where the materials are distributed in layers on a fill or are discharged through grizzlies into hoppers. The rapid rate of discharging the load gives these wagons a time advantage over rear-dump trucks.

Compaction Equipment

The Technical Specifications normally state the compaction method and the optimum moisture content range. The measurement testing method for determining if the desired compaction has be attained is the Modified Proctor Test or the Standard Proctor Test. For a contractor to attain the prescribed compaction, it must determine the number of passes for a roller with a specified unit pressure under the roller areas and the depth of each layer of soil to produce the desired compaction. Compaction is attained by applying energy to a soil by one or more of the following methods. The different methods to apply the energy is by a kneading or tamping action, a static weight, a vibrating action, or an impacting force. The common pieces of compaction methods are described below.

A kneading roller is the sheep's-foot type. This roller, which may be towed by a tractor or self-propelled, consists of a hollow steel drum on whose outer surface there are welded a number of projecting steel feet, which on different pieces of equipment may be of varying lengths and cross sections. A unit may consist of one or several drums mounted on one or more horizontal axles. The weight of a drum may be varied by adding water or sand to produce unit pressures under the feet up to 750 psi or more. As a sheep's foot roller moves over the surface, the feet penetrate the soil to produce a kneading action and a pressure to mix and compact the soil from the bottom to the top of the layer. With repeated passages of the roller over the surface, the penetration of the feet decreases until the roller is said to walk out of the fill. The *Sheep's-foot rollers* are quite effective in compacting clays and clay mixtures. However, they cannot compact granular soils such as sand and gravel. Also, the depth of a layer of soil to be compacted is limited too approximately the length of the feet.

Smooth-wheel Rollers may be classified by weight, which is usually stated in tons. A three-wheel two-axle roller. The front wheel is used for steering, while the two rear wheels are used for driving the unit. A two-wheel tandem roller of varying size is available. A three-wheel tandem roller differs from the two-wheel tandem unit in that it has three drums and three axles. This unit can be more effective than the two-wheel tandem or the three-wheel two-axle units in eliminating or reducing transverse surface roughness because of the concentration of pressure on the middle wheel when the unit passes over high spots in the surface being compacted. The rolls are steel drums, which may be ballasted with water or sand to increase the weights. If a roller is designated as 14-20 tons, it means that the minimum weight of the machine only is 14 tons and that it can be ballasted to give a maximum weight of 20 tons. These rollers are effective in compacting granular soils, such as sand, gravel, and crushed stone, and they are also effective in smoothing surfaces of soils that have been compacted by tamping rollers. Another type designates the weight per linear inch of roller, such as 300 lb. per inch of roller width. Specifying the minimum weight per linear inch of width is a more definitive method.

Pneumatic-tired Rollers are surface rollers which apply the principle of kneading action to affect compaction below the surface. They may be self-propelled or towed and they may be small or large-tired units. The small-tired units usually have two tandem axles with four to nine tires on each axle. The rear wheels are spaced to travel over the surfaces between the front wheels, which produces a complete coverage of the surface. The wheels may be mounted in a manner that will give them a wobbly-wheel effect to increase the kneading action on the soil. The Large-tired rollers are available in sizes varying from 15 to 200 tons gross weight. These units are frequently used to compact subgrade and base material on airfields and earth-fill dams.

The Manually Operated Vibratory Tamping Compactor is used in locations where larger units are not practical. These are self-propelled and they are called a vibrating plate for compacting sand or a vibrating sheepsfoot compactor for compacting clay.

The Manually Operated Rammer Compactor is normally gasoline-engine-driven rammer used for compacting cohesive or mixed soils in confined areas. these units range in impact from about 300 to 900 or more ft-lb per sec at an impact rate up to 850 per minute, depending on the specific model. Performance criteria include pounds per blow, area covered per hour, and depth of compaction (lift) in inches. Rammers are self-propelled in that each blow moves them ahead slightly to contact new soil.

Types of Equipment Suited for Compacting Different Types of Soils

Type compactor	Soil best suited for	Max. effect in loose, lift, in.	Density gained in lift	Max. Tons.
Sheep's foot	Clay, silty clay, gravel with clay binder	7 to 12	Nearly uniform	20
Steel tandem two-axle	Sandy silts, most granular material with some clay binder	4 to 8	Average*	16
Steel tandem three-axle	Same as above	4 to 8	Average*	20
Steel three-wheel	Granular or granular-plastic material	4 to 8	Average* to uniform	20
Pneumatic, small-tire	Sandy silts, sandy clays, gravelly sand and clays with few fines	4 to 8	Average* to uniform	12
Pneumatic large-tire	All types	? to 24	Uniform	50
Vibratory	Sand, silty sands, silty gravels	3 to 6	Uniform	30
Combinations	All	3 to 6	Uniform	20

* The density may decrease with depth

Temporary Material and Equipment Exercise

1. Which party is normally responsible for estimating and pricing the temporary structures?

- A. Owner.
- B. Vendor.
- C. Contractor.
- D. Architect/Engineer.

2. Which party is normally responsible for designing the temporary structures?

- A. Owner.
- B. Vendor.
- C. Contractor.
- D. Architect/Engineer.

3. Which of the following systems is designed to restrain horizontal temporary loads such as soil and water?

- A. Steel Piling.
- B. Sheet Piling.
- C. Wood Piling.
- D. Concrete Piling.

4. Which of the following systems is designed to carry the vertical load of the structure?

- A. Piling.
- B. Cofferdam.
- C. Timber Shoring.
- D. Cribbing and Tie-backs.

5. Which of the following systems is utilized for supporting an existing structure when the new excavation will be below the existing structures foundation while the extension to the existing foundation is being placed?

- A. Piling.
- B. Cofferdam.
- C. Underpinning.
- D. Cribbing and Tie-backs.

Temporary Material and Equipment Exercise

6. Which of the following systems is utilized for restraining a vertical wall of soil and other loads where it is impractical to slope the soil such as in a downtown area where the excavation and new substructure are below the street level?

- A. Piling.
- B. Cofferdam.
- C. Underpinning.
- D. Cribbing and Tie-backs.

7. Which of the following systems is designed as an enclosed structure to restrain soil and water, therefore, allowing workers to work inside safely?

- A. Caisson.
- B. Jin Poles.
- C. Cofferdam.
- D. Underpinning.

8. In construction, what is the proper terminology for transporting the off road equipment to the job site?

- A. Hauling.
- B. Mobilization.
- C. Militarization.
- D. Transportation.

9. What is the lifting system called which consists of two vertical towers with a cross beam on top with the intended purpose of lifting an unusually long piece of equipment which was transported horizontally and it is lifted into its permanent vertical position?

- A. Caisson.
- B. Jin Pole.
- C. Cofferdam.
- D. Tower Crane.

Temporary Material and Equipment Exercise

10. What are the components of a cofferdam or a support system?

- A. Sheeting, Wales, and Cross braces.
- B. Posts, Stringers, Joists and Pans.
- C. Posts, Stringers, Joists and Plyform.
- D. Wall forms, Wall Ties, Wales, Hairpins and Braces.

11. What is a toe in relationship to a Cofferdam?

- A. The Tie Back extension beyond the Cribbing at least 2 feet.
- B. The horizontal Wales which extends beyond the wall at least 2 feet.
- C. The braces set at a 45-degree angle and extended into the ground at least 2 feet.
- D. The vertical sheeting extended below the bottom of the excavation at least 2 feet.

12. According to the OSHA Construction Safety Standards, what is required for shoring systems more than 20 feet deep?

- A. The Architect shall design the protection system.
- B. The Project Engineer shall design the protection system.
- C. The designated Competent Person shall design the protection system.
- D. The Registered Professional Engineer shall design the protection system.

13. What is another name for Sheeting?

- A. Piles.
- B. Struts.
- C. Uprights.
- D. Caissons.

14. What does “close sheeting” mean in relationship to a shoring system?

- A. The span across the width of an excavation.
- B. The spacing between timber planks not to exceed ½ inch.
- C. Tongue and groove timber planks at least 3 inches thick.
- D. The use of a trench box or trench shield while working in the excavation.

Temporary Material and Equipment Exercise

15. Which piece of equipment and attachment would be the most efficient method to excavate inside a cofferdam?

- A. Shovel with a 3-CY bucket.
- B. Backhoe with a 3-CY bucket.
- C. Crane with an Auger Attachment.
- D. Crane with a Clamshell attachment.

16. Which piece of equipment sets below the excavation and the bucket pushes up?

- A. Power Shovel.
- B. Hydraulic Backhoe.
- C. Dragline.
- D. Wheel-tractor Scraper.

17. Which piece of equipment is used to excavate ponds or soil under water?

- A. Shovel.
- B. Backhoe.
- C. Dragline.
- D. Wheel-tractor Scraper.

18. Which piece of equipment has its boom above the structure and it lifts the load vertically until it is above the structure, then it can move the load horizontally?

- A. Shovel.
- B. Backhoe.
- C. Tower Crane.
- D. Track-mounted Crane.

19. Which piece of equipment is most efficient for compacting granular soils such as sand, gravel, and crushed stone?

- A. Backhoe.
- B. Sheepsfoot.
- C. Smooth-Wheel Roller.
- D. Wheel-tractor scraper.

Temporary Material and Equipment Exercise

20. Which of the following temporary systems is utilized to support freshly placed concrete which is poured continuously in a vertical direction?

- A. Slip form system.
- B. Tilt-up for system.
- C. Flying form system.
- D. Lift slab form system.

21. Which of the following temporary systems is utilized to support freshly placed concrete which is poured on the ground as a slab and lifted up to its final horizontal elevation using hydraulic jacks?

- A. Slip form system.
- B. Tilt-up for system.
- C. Flying form system.
- D. Lift slab form system.

22. What is the concrete pouring method called that is used to pour concrete under water?

- A. Tremie.
- B. Conveyor.
- C. Direct Chute.
- D. Underpinning.

23. Which organization has published a new design standard targeting loads on structures during construction?

- A. American Concrete Institute.
- B. Concrete Reinforcing Steel Institute.
- C. American Society for Testing Materials.
- D. Structural Engineering Institute of the American Society of Civil Engineers.

24. What is the primary cause for a masonry wall to collapse while under construction?

- A. Poor soil conditions.
- B. Lack of vertical reinforcement.
- C. Lack of horizontal reinforcement.
- D. Lack of masonry wall bracing and a change in wind conditions.

Temporary Material and Equipment Exercise

25. Which of the following sling angle ranges is best for lifting without making the lift extremely dangerous?

- A. 1 degree to 14 degrees.
- B. 15 degrees to 30 degrees.
- C. 31 degrees to 44 degrees.
- D. 45 degrees to 90 degrees.

26. You have an assumed sling angle of 24 degrees but the actual angel is 19 degrees. What effect does this have on the pounds per leg on the sling?

- A. The pounds per leg will decrease.
- B. The pounds per leg will increase.
- C. The pounds per leg stays constant.
- D. The pounds per leg does not matter since the cranes lifting capacity is not effected

Using the Working Range of a Crane Chart attached, answer questions 27 through 33.

27. What is the working range of a Clam Shell?

- A. 00 - 24 degrees
- B. 25 - 39 degrees
- C. 40 - 54 degrees
- D. 55 - 80 degrees

28. What is the working range of a Lift Crane?

- A. 00 - 24 degrees
- B. 25 - 39 degrees
- C. 40 - 54 degrees
- D. 55 - 80 degrees

29. What is the working range of a Dragline?

- A. 00 - 24 degrees
- B. 25 - 39 degrees
- C. 40 - 54 degrees
- D. 55 - 80 degrees

Temporary Material and Equipment Exercise

30. Assume you are lifting an item onto the roof. The Height of the exterior wall is 27 Feet above the ground and the horizontal distance from the centerline of the rotation is 40 feet. What is the minimum length of the boom required?

- A. 20 Feet.
- B. 50 Feet.
- C. 60 Feet.
- D. 70 Feet.

31. Assume you are lifting an item onto the bridge deck. The Deck is 27 feet above the ground and the horizontal distance from the centerline of the rotation is 40 feet. What is the minimum boom angle?

- A. 30 degrees.
- B. 40 degrees.
- C. 57 degrees.
- D. 72 degrees.

32. Assume you are lifting an item onto the bridge deck. The deck is 37 feet above the ground and the horizontal distance from the centerline of the rotation is 70 feet. What is the minimum length of the boom required?

- A. 70 Feet.
- B. 87 Feet.
- C. 110 Feet.
- D. 120 Feet.

33. Assume you are lifting an item onto the bridge deck. The deck is 37 feet above the ground and the horizontal distance from the centerline of the rotation is 70 feet. What is the minimum boom angle?

- A. 26 degrees.
- B. 40 degrees.
- C. 47 degrees.
- D. 57 degrees.

Check Answers

Schedules on Plans and in the Technical Specification
Many of the CSI Divisions utilize schedules to represent the work. Therefore, it is essential that a Constructor be able to identify and interpret information from various schedules as well as from the technical specifications and the plans. Some of the most common schedules, construction specifications and plans from various divisions will be discussed below.

Concrete Beam Schedule for Division 03 - Concrete
The Concrete Reinforcing Steel Institute (CRSI) defines reinforced concrete as a combination of both reinforcing steel and concrete using the best properties of each. They take into consideration the compression properties of the concrete and the tension strength of reinforcing steel.

The *Reinforcing Steel Bars* are also referred to as deformed bars. Reinforcing steel is most common in the form of deformed bars which contains ridges which makes a good bond with the concrete instead of smooth reinforcing. Each reinforcing bar contains identifying marks. The uppermost designation is usually a letter identifying the manufacturer, the next mark the bar size such as a #11. The bar numbers designate eighths of an inch beginning with a No. 3. The rebar diameter is determined by taking the bar # and dividing by eight. Therefore, a #3 bar is 3/8 inch in diameter. A #4 bar is 4/8 or ½ inch. The third mark down is type of steel used. Reinforcing bars are made of either new billet, axle, or rail steel. The fourth identifying mark may be shown on the bar is the tensile yield point. The tensile yield point indicates the minimum pounds per square inch (psi). A grade of 40 reinforcing bar has a minimum yield of 40,000 psi. Other grades are 50 and 60.

Welded Wire Fabric (WWF) is used in slabs-on-grade and highways. It is made of wire generally arranged to cross at right angles at each intersection. The welded wire fabric is made and delivered in rolls or as sheets. The designation is 6 x 6 - W1.4 x W1.4 (10 x 10). The 6 x 6 means that the spacing is 6 inches by 6 inches and the W1.4 xW1.4 is the wire (number) size for a 10-gauge material. The parenthesis indicates the old designation indicating the wire gauge.

Bar supports are normally incorporated by reference and they are not shown on the plans. It is the Contractors responsibility to ensure that they are placed properly. This requires the contractor to review the CRSI 65 *Recommended Practice for Placing Bar Supports, Specifications and Nomenclature*. Typically they are designed to raise the reinforcing bars to the required height above the bottom of the forms and to hold the bars in place. Many times bar supports are placed in the upper third of the slab and the lower third of the slab. This requires two sets of bar supports placed in a slab or beam. Normally these bar supports are called slab bolsters and beam bolsters and if their location is in the upper third of the slab or beam, then a U is placed at the end of the abbreviation. For example, BB means Beam Bolster and BBU means Beam Bolster Upper. The Concrete Reinforcing Steel Institute (CRSI) publication titled, *Manual of Standard Practice* and the adapted table titled Bar Support Designations is shown below.

The CSI Master Format has the bar supports under Division 03 CONCRETE, Section 200 REINFORCEMENT and Part 1.03 REFERENCE STANDARDS. A typical specification would indicate that the Contractor must be in compliance with CRSI 65 Recommended Practice for Placing Bar Supports, Specifications and Nomenclature. CRSI is an abbreviation for the Concrete Reinforcing Steel Institute. Some of the typical Types and Sizes of Wire Bar Support with their abbreviations, the type of support and the typical sizes are identified below.

SYMBOL	TYPE OF SUPPORT	TYPICAL HEIGHTS
SB	Slab Bolster	3/4, 1, 1-1/2, 2 inches
SBU	Slab Bolster Upper	Same as SB
BB	Beam Bolster	1,1-1/2, 2 to 5 inches in 1/4" increments
BBU	Beam Bolster Upper	Same as BB
BC	Individual Bar Chair	3/4, 1, 1-1/2 and 1-3/4 inches
JC	Joist Chair	3/4, 1, and 1-1/2 and 4, 5, 6 inches in widths
HC	Individual High Chair	2 to 15 inches in 1/4" increments
HCM	High Chair for Metal Decking	2 to 15 inches in 1/4" increments
CHC	Continuous High Chair	Same as HC
CHCU	Continuous High Chair Upper	Same as CHC
JCU	Joist Chair Upper	Heights -1 thru +3-1/2 in; 14 inch span

Adapted from the Concrete Reinforcing Steel Institute (March 2001). *Manual of Standard Practice*. Schaumburg, IL: author.

Column, Beam and Slab Schedules
Are utilized to provide the Constructor with detailed information for placing the reinforcing bars, the stirrups, and the bar supports. Reinforcing bars are designated as either straight bars or bar bends which are fabricated by the manufacturer in the shop and shipped to the job site.

Stirrups are also known as ties and they are used to wrap the around the horizontal or vertical bars at specified on center spacings. A Beam schedule is provided below as an exercise.

Concrete Beam Exercise

Given the Beam Schedule attached, and Using Mark 1B1. Answer the following questions.

1. What is the Size of the Beam?

- A. 12" wide x 24" deep.
- B. 12" wide x 33" deep.
- C. 24" wide x 12" deep.
- D. 24" wide x 10.5" deep.

2. How many total beams for Mark 1B1?

- A. 1
- B. 2
- C. 12
- D. 24

3. How many layers or mats of reinforcement are required for Mark 1B1?

- A. 1
- B. 2
- C. 12
- D. 24

4. What is the Reinforcing in the top mat?

- A. 4 Pieces - #6 bar, 20' 8 inches long.
- B. 12 Pieces - #6 bar - 20' 8 inches long.
- C. 2 Pieces - #6 bar - 15' 8 inches long.
- D. 2 Pieces - #6 bar - 15' 8 inches long and 4 pieces - #6 - 16' 0 inches long.

5. What is the size of the rebar in inches of the stirrups?

- A. 3/8"
- B. 4/6"
- C. 6/8"
- D. 36"

Concrete Beam Exercise

6. How are the stirrups labeled for Mark 1B1 at column #4?

- A. IB1
- B. 3A2
- C. 3A3
- D. 6A1

7. What is the on-center spacing of the stirrups for Mark 1B1 at column #4?

- A. 4" and 8"
- B. 6" and 8"
- C. 6" and 10"
- D. 8" and 12"

8. What are the quantity and length of the stirrup support bars for Mark 1B1?

- A. 2 each, 15' - 8" long
- B. 4 each, 16' - 0" long.
- C. 4 each, 20' - 8" long
- D. 5 each, 21' - 7" long

9. What are the size, and type of bar supports?

- A. 2 inch Slab Bolsters.
- B. 2 inch Beam Bolsters.
- C. 5 inch High Chairs.
- D. 5 inch Beam Bolsters.

10. What does the bar support abbreviation CHCU mean?

- A. Concrete High Chair Upper.
- B. Continuous High Chair Upper.
- C. Concrete High Chair Unidentified.
- D. Continuous High Chair Unidentified.

Concrete Beam Exercise

11. What does the bar support abbreviation BBU mean?

- A. Broad Beam Upper.
- B. Beam Bolster Upper.
- C. Bottom Bar Unidentified.
- D. Beam Bolster Unidentified.

12. What does the bar support abbreviation SB?

- A. Slab Bar.
- B. Slab Bolster.
- C. Slab Bottom.
- D. Beam Bolster.

13. Which of the following items are not shown or specified in the construction documents for a reinforced concrete structure?

- A. Rebar.
- B. Concrete.
- C. Bar Supports.
- D. Welded Wire Mesh.

14. What is the name of the organization which publishes a manual on the spacing requirements for bar supports?

- A. American Concrete Institute.
- B. Concrete Reinforcing Steel Institute.
- C. Concrete Reinforcement Standards Institute.
- D. Concrete Reinforcing Specifications Institute.

Check Answers

Concrete Beam Exercise - Schedule

Mark	No.	Beam Size (inches)		Reinforcing							#3 Stirrups							2" BB
				Bottom			Top				Total		Col. # O.C.			Support Bars		
		Width	Depth	No.	Size	Length	No.	Size	Length	Mark	No.	Mark	#	OC	OC	No.	L	
1B1	2	12	24	4	6	20'-8"	2 4	6 6	15' -8" 16' -0"	6A1	17 17	3A3 3A2	3 4	6" 6"	10" 8"	2 3	21' -7"	5
1B2	1	24	10.5	7	7	12'-8"	4 7	6 7	9' -4"	6A4	16 16	3A6 3A5		4" 4"	8" 8"	4	2' 0"	4
1B2A	1	24	10.5	7	7	12'-8"	4 7	6 7	11' -1"	6A4	16 16	3A6 3A5		4" 4"	8" 8"	4	2' 0"	4
1B3	6	24	10.5	6	7	17' -2"	8	7	11'- 1"		20 20	3A6 3A5		4" 4"	8" 8"	4	2' 0"	4
1B4	1	24	10.5	4	8	13' -4"	8	8	11' -1"		10 10	3A6 3A5		4" 4"	8" 8"	-----	-----	4
1B5	2	24	10.5	4	8	14' -3"	4	6		6A7	20 20	3A6 3A5		4" 4"	6" 8"	2	7' -0"	4
1B7	1	24	10.5	8	9	22' -9"	4 3	7 8	14' -6"	7A9	26 26	3A6 3A5		6" 6"	8" 8"	2	11' -0"	5
1B10	1	12	33	2	6	15' -2"	2	5	15' -8"		12 12	3A3 3A11		6"	12"	4	16' - 8"	4
1B12	2	12	18	3	6	13' -9"	2	5		5A15	8 8	3A3 3A16		8" 8"	12" 12"	----- -	------	4

Door and Window Exercise

Using the door schedule attached. Answer the following questions.

1. What is the location of Door number 104 B?

- A. Crib.
- B. Women.
- C. Nursing.
- D. Corridor.

2. What is the door size, type, door material, frame Material for Door No. 104 A?

- A. 3' - 6" x 7' -2" x 1-3/4", Type C Solid hollow metal door in a hollow metal frame.
- B. 3' - 0" x 7' -0" x 1-3/4", Type A Aluminum glass door in an aluminum frame.
- C. 3' - 0" x 7' - 2" x 1-3/4", Type D Wood door, w/sm. Window in a wood frame.
- D. 3' - 0" x 7' - 2" x 1-3/4", Type D Wood door w/sm. window, a hollow metal frame.

3. What does the Abbreviation HM stand for on the door schedule?

- A. Half Metal Frame
- B. Hallway Metal Frame
- C. Hollow Metal Frame.
- D. Halloway Metal Frame.

4. What is the door size, type door material frame material for Door 107?

- A. 3' -0" x 7'-2" x 1-3/4", Type D Wood w/sm window in a hollow metal frame.
- B. 3' -0" x 7' -0" x 1-3/4", Type A, Aluminum, in an aluminum frame.
- C. 3'-6" x 7'-2" x 1-3/4", Type C, Solid Wood door in a hollow metal frame.
- D. 3'-6"x 7'-2" x 1-3/4", Type C, Hollow metal door in a hollow metal frame.

5. What is the Fire rating of the door and the type of glass for Door No. 108B?

- A. No rating, standard glass.
- B. No rating, 1/4" Tempered
- C. 20 minute rating, 1/4" Wired Glass.
- D. 45 minute Rating, 1/4" Wired Glass.

Door and Window Exercise

6. What is the Fire rating of the door and the type of glass for Door No. 102?

- A. No rating, standard glass.
- B. No rating, 1/4" Tempered
- C. 20 minute rating, 1/4" Wired Glass.
- D. 45 minute Rating, 1/4" Wired Glass.

7. What is the Finish on the Frame for Door No. 111?

- A. Stain.
- B. Paint.
- C. Aluminum.
- D. Dark Bronze.

8. What is the Finish on the Door No. 108 B?

- A. Stain.
- B. Paint.
- C. Aluminum.
- D. Dark Bronze.

9. What is the Finish on the Door No. 108A?

- A. Stain.
- B. Paint.
- C. Aluminum.
- D. Dark Bronze.

10. How many sets of Hardware are needed for Door Number 106?

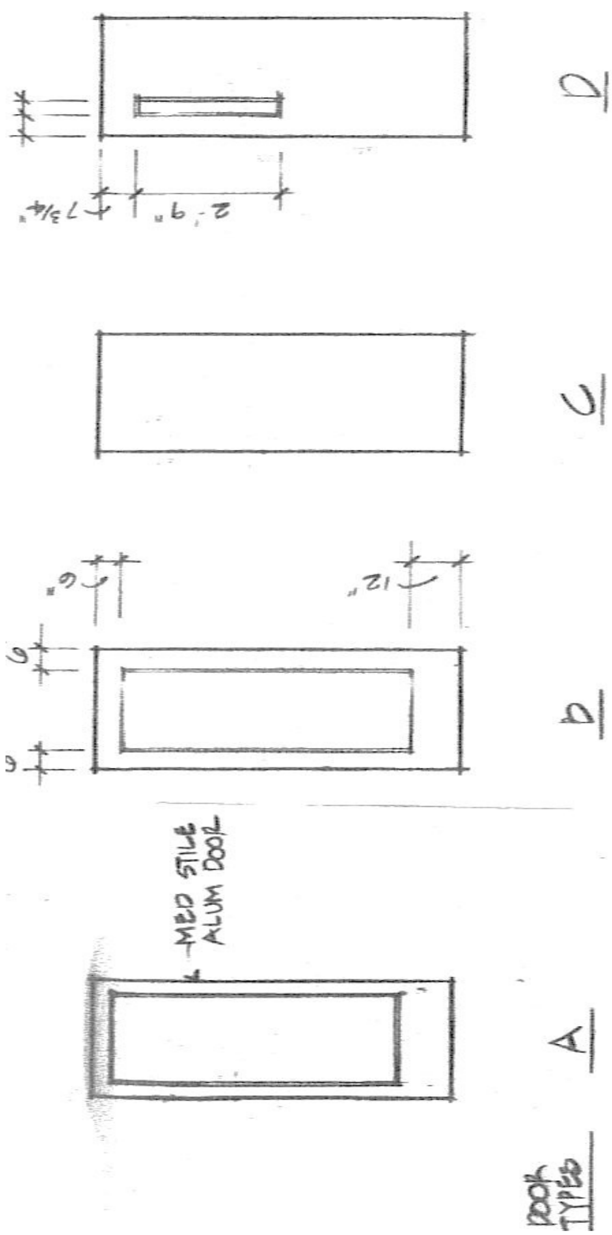
- A. 1
- B. 3
- C. 5
- D. 10

Check Answers

Door and Window Exercise - Door Schedule

Door No.	Location	Door				Frame		Label	Glass	Hrdwr Sets
		Size	Type	Material	Finish	Material	Finish			
101	Lower Narthex	3'x7'x1-3/4"(pr)	A	Alum	Dk Bronz	Alum	Dk Bronz	- - - -	1/4" Temp	1
102	Infants	3’x7’-2”x1-3/4”	D	Wood	Stain	HM	Paint	45 min	1/4" Wired	2
103	Crib	3’x7’-2”x1-3/4”	D	Wood	Stain	HM	Paint	- - - -	1/4" Temp	2
104A	Nursing	3’x7’-2”x1-3/4”	D	Wood	Stain	HM	Paint	20 min	1/4" Wired	2
104B	Nursing	3’x7’-2”x1-3/4”	D	Wood	Stain	HM	Paint	- - - - -	1/4" Temp	2
105	Women	3’x7’-2”x1-3/4”	C	Wood	Stain	HM	Paint	20 min	- - - - - - -	3
106	Men	3’x7’-2”x1-3/4”	C	Wood	Stain	HM	Paint	20 min	- - - - - - -	3
107	Mechanical	3’-6”x7’-2”x1-3/4”	C	HM	Paint	HM	Paint	20 min	- - - - - - -	5
108A	Corridor	2’-10”x7’-2”x1-3/4” (pr)	D	Wood	Stain	HM	Paint	45 min	1/4" Wired	10
108B	Corridor	3’x7’x1-3/4”	A	Alum	Dk. Bronz	Alum	Dk Bronz	- - - - -	1/4" Temp	1
109	Classroom	3’x7’-2”x1-3/4”	D	Wood	Stain	HM	Paint	20 min	1/4" Wired	2
111	Classroom	3’x7’-2”x1-3/4”	D	Wood	Stain	HM	Paint	20 min	1/4" Wired	2
112	Classroom	3’x7’-2”x1-3/4”	D	Wood	Stain	HM	Paint	20 min	1/4" Wired	2
113	Storage	3’x7’-2”x1-3/4”	C	Wood	Stain	HM	Paint	20 min	- - - - - - - -	5
114A	Stair	3’x7’-2”x1-3/4”	D	Wood	Stain	HM	Paint	1 hour	1/4" Wired	4

Door and Window Exercise - Diagrams



Finish and Paint Exercise

Using the Room Schedule attached, answer the following questions.

1. In room no. 105, which materials will be utilized on the floor?

   - A. Vinyl.
   - B. Concrete.
   - C. Carpet #1.
   - D. Carpet #2.

2. In Room No. 201, which material and finish will be on the W/NW Wall?

   - A. CMU and paint.
   - B. SF CMU, unpainted.
   - C. SF CMU/Wood, stain.
   - D. SF CMU/Wood, unpainted.

3. What does the abbreviation CMU on the Room Finish Schedule mean?

   - A. Cast Metal Unit.
   - B. Cabinet Metal Unit.
   - C. Corrugated Metal Unit.
   - D. Concrete Masonry Unit.

4. What is the height of the ceiling in room No. 107?

   - A. 8' - 0"
   - B. 9' - 0"
   - C. 10' - 3"
   - D. 13' - 0"

5. What are the ceiling material and finish in room No. 132?

   - A. ACT #1 and paint.
   - B. SF CMU and no paint.
   - C. ACT #1 and no paint.
   - D. Gypsum board and paint.

Finish and Paint Exercise

Using the Paint Specifications. Answer the following questions.

6. What types of paint are required on the interior gypsum board with a special finish?

- A. First coat stain, second coat sealer, third coat Satin finish varnish.
- B. First coat Vinyl primer-sealer, second coat Multicolored speckled paint.
- C. First coat Vinyl primer-sealer, second coat Latex eggshell or semigloss, third coat Latex eggshell or semigloss (deep accent colors).
- D. First coat stain, second coat Chemgard Sealer, Guardsman Chemical coatings, I, third coat Super Chemveer No. 20 Guardsman Chemical Coatings.4 coats.

7. Which room(s) require the special paint finish on gypsum board walls?

- A. Stairwell 2 room 132.
- B. 116, 117, 118, 119, 120, 121, 122, 123, 124, 208, 209, 210, 211, 214 and 132.
- C. 104, 107, 108, 109, 110, 111, 112, 113, 114, 115, 201, 205, 206, 207, and 132.
- D. 101, 102, 103, 105, 106, 130, 202, 203, 204, 212, 213, 215, 223, 227, and 127.

8. What is the second coat of paint on the natural finish wood?

- A. Sealer.
- B. Semigloss enamel.
- C. Alkyd flat enamel.
- D. Stain. Use stain filler for open grain wood.

9. What is the second coat of paint on the Exposed Piping, Hangers, Ductwork, and Equipment (Galvanized):?

- A. Alkyd flat enamel.
- B. Vinyl primer-sealer.
- C. Zinc-chromate primer (Federal Spc TTP-57a).
- D. Zinc-dust primer (Federal Spec. TTP641b, Type II).

10. What is the second coat on the aluminum jackets for the insulated piping?

- A. No paint.
- B. Epoxy paint.
- C. Alkyd flat enamel.
- D. Vinyl primer-sealer.

Check Answers

Finish and Paint Exercise - Room Finish Schedule												
Rm. No	Room Name	Floor		N/NE & S/SW		E/SE Wall		W/NW Wall		Ceiling		
		Material	Base	Material	Finish	Material	Finish	Material	Finish	Material	Finish	HT
101	Lower Narthex	Carpet #1	Carpet #1	CMU	Paint	CMU	Paint	CMU	Paint	ACT #1		9' -0"
102	Infants	Carpet #2	Carpet #2	CMU	Paint	CMU	Paint	CMU	Paint	ACT #2		8' -0"
103	Crib	Carpet #2	Carpet #2	CMU	Paint	CMU	Paint	CMU	Paint	ACT #2		8' -0"
104	Nursing	Carpet #2	Carpet #2	CMU	Paint	CMU	Paint	CMU	Paint	ACT #2		8' -0"
105	Women	Vinyl	Vinyl	CMU	Paint	CMU	Paint	CMU	Paint	Gyp Bd	Paint	8' -0"
106	Men	Vinyl	Vinyl	CMU	Paint	CMU	Paint	CMU	Paint	Gyp Bd	Paint	8' -0"
107	Mechanical	Concrete	- - - - - - -	CMU	Paint	CMU	Paint	CMU	Paint	Exposed	Paint	10'-3"
127	Stair	Carpet #1	Carpet #1	Glass	- - -- -	SP CMU	- - - -	Glass	- - -	ACT #1		- - - -
132	Stair	Carpet #1	Carpet #1	SF CMU	- - - - -	SF CMU	- - - -	SF CMU	- - -	ACT #1		8' -0"
201	Narthex A	Carpet #1	Carpet #1	Glass SF CMU	- -/ - -	SF CMU	- - - -	SF CMU/ Wood	- / Stain	ACT #1		13'-0"
206	Narthex B	Carpet #1	Carpet #1	SF CMU	- - - - -	SF CMU	- - - -	SF CMU	- - - -	ACT #1		13'-0"

Abbreviations

Acoustical Ceiling Tile	ACT	Concrete Masonry Unit	CMU	Gypsum Board	Gyp Bd
Split Face cmu	SF	Specified cmu	SP	Vinyl Composite Tile	VCT

Finish and Paint Exercise - Painting Specifications

09900 - PAINTING SPECIFICATIONS

PART 1 GENERAL

1.01 WORK INCLUDED

A. The term "paint" or "painting" as used in this section have reference to sealers, primers, stains, paints, varnishes, and the application of these materials.

B. Surface preparation.

C. Surface finish.

1.02 RELATED WORK

A. Division 3 - Concrete.

B. Section 04300 - Unit Masonry System.

C. Division 5 - Metals.

D. Division 6 - Carpentry.

E. Section 80111 - Standard Steel Doors and Frames.

F. Section 09260 - Gypsum Board System.

G. 10522 - Fire Extinguisher Cabinets.

H. Division 15 - Mechanical Equipment, Identification.

I. Division 16 - Electrical Equipment, Identification.

1.03 REFERENCES

A. ANSI/ASTM D16 - Definitions of terms Relating to Paint, Varnishes, Lacquer, and Related Products.

PART 3 EXECUTION

3.07 SCHEDULE - EXTERIOR SURFACES

A. Exterior Metal (Ungalvanized Ferrous):

1. First Coat: Zinc-chromate primer (Federal Spec TTP-57a).
2. Second Coat: Exterior latex enamel (semigloss or gloss).
3. Both coats in addition to any factory primer.

B. Exterior Metal (Galvanized):

1. Treat metal with Galva-prep, as manufactured by Am-chem, Inc.
2. First Coat: Zinc-dust primer (Federal Spec. TTP641b, Type II).
3. Second Coat: Exterior latex enamel (semigloss or gloss).

C. Exterior Metal (Aluminum):

1. Treat metal with Galva-prep, as manufactured by Am-chem, Inc.
2. First Coat: Zinc-chromate primer (Federal Spec TTP-57a).
3. Second Coat: Exterior latex enamel (semigloss or gloss).

Finish and Paint Exercise - Painting Specifications

3.08 SCHEDULE - INTERIOR SURFACES

A. Interior Gypsum Board (Standard Finish):
   1. First Coat: Vinyl primer-sealer.
   2. Second Coat: Latex eggshell or semigloss.
   3. Third Coat: Latex eggshell or semigloss (deep accent colors).

B. Interior Gypsum Board (Special Finish):
   1. First Coat: Vinyl primer sealer.
   2. Second Coat: Multicolored speckled paint.
   3. Apply per manufacturer's instructions.

C. Interior Block.
   1. First Coat: Clear Block Sealer.
   2. Spray finish.

D. Interior Roof Deck (Exposed Deck, Beams, and Joists).
   1. 1 coat of spray flat.

E. Interior Metal (Ungalvanized Ferrous):
   1. Both coast in Addition to any factory primer.
   2. First Coat: Zinc-chromate primer (Federal Spc TTP-57a) tinted
   3. Second Coat: Alkyd flat enamel.

F. Interior Metal (Galvanized):
   1. Treat metal with Galva-prep, as manufactured by Am-chem, Inc
   2. First Coat: Zinc-dust primer (Federal Spec. TTP641b, Type II).
   3. Second Coat: Alkyd flat enamel.

G. Interior Wood - Natural Finish:
   1. First Coat: Stain. Use stain filler for open grain wood.
   2. Second Coat: Sealer.
   3. Third Coat: Satin finish varnish.

   Or in lieu of the above, Contractor has the option of using:
   1. First Coat: Stain. Use stain filler for open grain wood.
   2. Second Coat: Chemgard Sealer, Guardsman Chemical Coatings, I
   3. Third Coat: Super Chemveer No. 20 Guardsman Chemical Coatings.

Finish and Paint Exercise - Painting Specifications

H. Interior Wood Painted:
   1. First Coat: Wood primer undercoater.
   2. Second Coat: Semigloss enamel.
   3. Third Coat: Semigloss enamel.

I. Exposed Piping, Hangers, and Equipment (Ungalvanized):
   1. First Coat: Zinc-chromate primer (Federal Spc TTP-57a)
   2. Second Coat: Alkyd flat enamel.
   3. Note: Cast iron pipe shall first be throughly cleaned with rags soaked in mineral spirits to remove oily film, then primed and finished as indicated above.

J. Exposed Piping, Hangers, Ductwork, and Equipment (Galvanized):
   1. Treat metal with Galva-prep, as manufactured by Am-chem, Inc
   2. First Coat: Zinc-dust primer (Federal Spec. TTP641b, Type II).
   3. Second Coat: Alkyd flat enamel.
   4. Note: Use epoxy paint for PVC pipe.

K. Covered (Insulated) Piping and Ductwork (Unprimed):
   1. First Coat: Vinyl primer-sealer.
   2. Second Coat: Alkyd flat enamel.
   3. Note: Aluminum jackets for insulated piping shall not be painted

L. Back Priming (Interior Millwork and Trim):
   1. 1 coat of white oil base primer for wood to receive paint finish.
   2. Clear sealer for wood to receive natural finish.
   3. Back prime interior millwork on unexposed areas as specified in Div.6.

M. Apply special paint finish on gypsum board walls in the following rooms: 101, 102, 103, 105, 106, 130, 202, 203, 204, 212, 213, 215, 223, 227, and 127 (stair 1). See Item B above.

N. Exposed piping, hangers, ductwork, and equipment shall be painted the same color as adjacent structure and deck.

END OF SECTION

Plumbing Schedule Exercise

1. The plumbing plans have the abbreviation DWV on them. What does the DWV mean?

- A. Drain Waste and Vent.
- B. Drain, Water and Vent.
- C. Domestic Waste Valve.
- D. Domestic Water Valve

2. The plumbing plans have the abbreviation DS on them. What does DS mean?

- A. Drain Spigot.
- B. Down Spout.
- C. Drain System.
- D. Domestic System.

3. What system is the DS connected to?

- A. Storm Sewer.
- B. Sanitary Sewer.
- C. Domestic Water.
- D. Sprinkler System.

4. The Site utility plans have the abbreviation I.E. on them. What does I.E. mean?

- A. Invert Elevation.
- B. Inside Elevation.
- C. Initial Elevation.
- D. Interior Elevations.

5. At what point is the I.E. calculate to:

- A. Top inside of the pipe.
- B. Top outside of the pipe.
- C. Bottom inside of the pipe.
- D. Bottom outside of the pipe.

Plumbing Schedule Exercise

6. What is the purpose of a water hammer arrestor?

- A. Reduce the pressure in the line.
- B. Reduce the vibration in the line.
- C. Maintain a constant flow in the line.
- D. Maintain a constant pressure in the line.

Given the Plumbing Pipe Size Schedule and the Natatorium Plumbing Plan, Answer the following questions.

7. What does the plumbing abbreviation VTR mean?

- A. Vent Thru Roof.
- B. Vent Top Return.
- C. Vertical Top of Roof.
- D. Vertical Transfer Run.

8. What system is the VTR connected to?

- A. Storm Sewer.
- B. Sanitary Sewer.
- C. Domestic Water.
- D. Sprinkler System.

9. What system is the CO connected to?

- A. Storm Sewer.
- B. Sanitary Sewer.
- C. Domestic Water.
- D. Sprinkler System.

10. What is the size of the connection to the HB?

- A. 0"
- B. ½"
- C. 3/4"
- D. 1"

Plumbing Schedule Exercise

11. What is the size of the Domestic hot water connection to the EWC?

- A. 0"
- B. ½"
- C. 3/4"
- D. 1"

12. What is the size of the waste line connection to the WC-2?

- A. 0"
- B. 1"
- C. 2"
- D. 4"

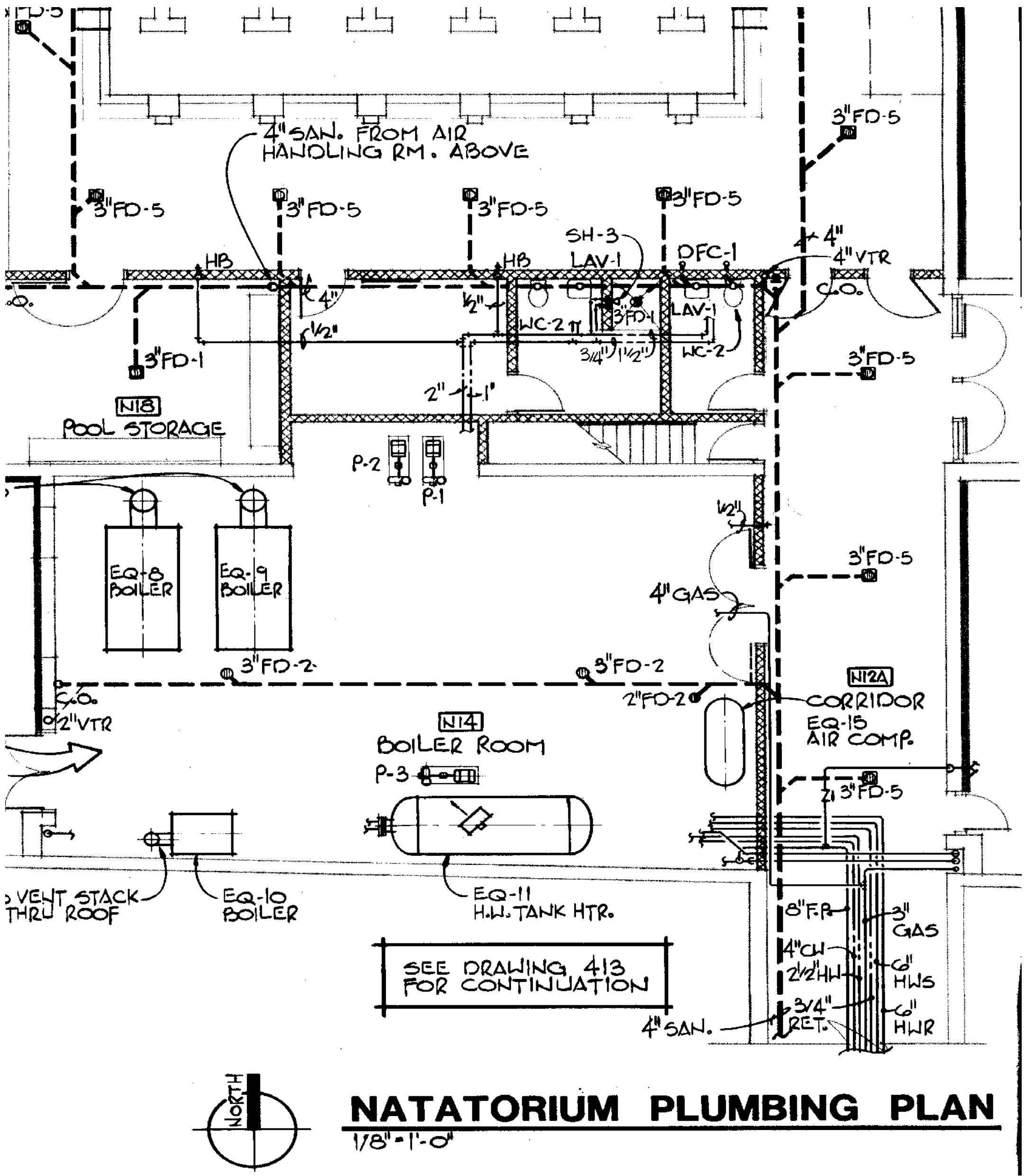
13. What is the size of the cold water connection to the LAV-1?

- A. 0"
- B. ½"
- C. 3/4"
- D. 1-1/2"

Check Answers

Plumbing Exercise - Pipe Size Schedule							
FIXTURE	COLD	HOT	WASTE	RE VENT	MAIN VENT	TRAP SIZE	REMARKS
WATER CLOSET	1"	- - -	4"	2"	3"	4"	FLUSH VALVE
URINAL	3/4"	- - -	2"	2"	2"	2"	WALL MTD.
LAVATORY	1/2"	1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/4"	
SINK	1/2"	1/2"	1-1/2"	1-1/2"	2"	1-1/2"	Or as Noted
ELECTRIC WATER COOLER	1/2"	- - -	1-1/4"	1-1/4"	- - -	1-1/4"	
HOSE BIB	3/4"	- - -	- - -	- - -	- - -	- - -	NON-FREEZE
FLOOR DRAIN	- - -	- - -	3"	2"	3"	3"	OR A NOTED
SERVICE SINK	3/4"	3/4"	3"	2"	2"	3"	

Plumbing Schedule Exercise - Natatorium Plans



Mechanical Equipment Exercise

Using the Mechanical Equipment tables provided, answer the following questions.

1. What does the mechanical abbreviation FT mean?

- ○ A. Fan Tube.
- ○ B. Fin Tube.
- ○ C. Fire Tube.
- ○ D. Furnace Tube.

2. What are the Depth and Height of FT-4?

- ○ A. 4" D, 5" Height.
- ○ B. 5" D, 12" Height.
- ○ C. 4" D, 14" Height.
- ○ D. 4" D, 12" Height.

3. What room does EF -3 service?

- ○ A. Toilet Room 105.
- ○ B. Toilet Room 125.
- ○ C. Toilet Room 209.
- ○ D. Prayer Room 205.

4. Where is AHU-1 located?

- ○ A. Narthex 201.
- ○ B. Prayer Room 205.
- ○ C. Sanctuary Room 202.
- ○ D. Mechanical Room 107.

5. Where is CC -1 located?

- ○ A. Inside B-1.
- ○ B. Inside AHU-1.
- ○ C. Inside CUH-1.
- ○ D. Inside RTU-1.

Mechanical Equipment Exercise

6. What service is P-3 connected to?

- A. B-1
- B. HC-1.
- C. Heating Loop.
- D. Chilled Water.

7. What does the mechanical abbreviation CUH mean?

- A. Cabinet Unit Heater.
- B. Chiller Unit Handler.
- C. Cooling Unit Handler.
- D. Convector Unit Heater.

8. What area does RTU-3 service?

- A. Narthex 201.
- C. Lower Level.
- D. Sanctuary 202.
- D. Prayer Room 205.

9. What service is L-2 connected to?

- A. AHU-1 INTAKE.
- B. EF-3 EXHAUST.
- C. AHU-1 EXHAUST.
- D. CEILING SUPPLY DIFFUSER.

10. What are the length and height in inches of L-1?

- A. 16" L and 16" H.
- B. 24" L and 18" H.
- C. 42" L and 84" H.
- D. 60" L and 84" H.

Check Answers

Mechanical Equipment Exercise - Fan and Fin Tube Schedules

FAN SCHEDULE										
Mark	Service	Model	CFM	S.P.	HP/AMPS.	RPM	T.S./O.V.	WHEEL DIA.	SONES	VOLTAGE
EF-1	TOILET 105,106	DB-8	825	½”	1/4	1000	2100	----	9.2	120v-1PH
EF-2	TOILET 125	360	125	1/8"	1.2	1200	0000	0000	2	120V-1PH
EF-3	PRAYER 205	GN-720	500	1/4"	1/4	1325	2200	0000	3.5	120V-1PH
EF-4	TOILET 208,209	GN-820	600	1/4"	1/4	700	1600	----	2.3	120v-1PH
1 Based on Cook 2 Based on Broan, Provide with wall cap										

FIN TUBE SCHEDULE									
MARK	LOCATION	ELEMENT	BTH/FT	FIN LENGTH	GPM	ROWS	ENCLOSURE		
							STYLE	D.	HT.
FT-1	SEE PLANS	3/4"C.-2 3/4"X3-48	720	SEE PLAN	SEE PLAN	1	FS-210	4"	14"
FT-2	SEE PLANS	3/4"C-2 3/4"X3-48	720	SEE PLAN	SEE PLAN	1	FS-210	4"	14"
FT-3	SEE PLANS	1"C.-3 1/4" -48	750	SEE PLAN	SEE PLAN	1	AA-1r2	4"	5"
FT-4	SEE PLANS	3/4"C.-2 3/4" X 4 1/4"	1050	SEE PLAN	SEE PLAN	1	DV4	5"	12"
1 BASED ON VULCAN, 180 * EWT, 160* LWT, 65* EAT 2 MOUNT INVERT AT 7'-6: A.F.F. 3 PROVIDE W/ 14GA PIPE ENCLOSURE AND PRESSURE CLIP FASTENERS AT LOCATIONS SHOWN ON PLANS									

Mechanical Equipment Exercise - Convector, Unit Heaters and Cabinet Unit Heater Schedules

CONVECTOR SCHEDULE										
MARK	MODEL	LOCATON	MBH	GPM	CABINET DIMENSIONS				CONTROL	REMARKS
					L	H	D	REC		
C-1	FWG-A-24	SEE PLANS	2.1	1.0	24"	24"	4"	4"	DAMPER	
1 BASED ON VULCAN, 180* EWT, 160* LWT, 65* EAT										

UNIT HEATER SCHEDULE									
MARK	SERVICE	MODEL	CFM	MBH	GPM	LAT	RPM	HP	REMARKS
UH-1	MECH RM 107	HV-24	350	15.6	2.0	98	1350	1/20	
1 BASED ON VULCAN, 180* EWT, 160* LWT, 65* EAT									

CABINET UNIT HEATER SCHEDULE												
MARK	MODEL	CFM	MBH	GPM	LAT	CABINET DIMENSIONS				RPM	HP	REMARKS
						L	H	D	REC.			
CUH-1	RWI-1130-06	630	38.4	3.0	125	59"	25'	9 ½"	6"	1050	1/10	1
1 BASED ON VULCAN, 180* EWT, 160* LWT, 65* EAT												

Mechanical Equipment Exercise - Air Handling, Cooling Coil and Heating Coil Schedules

AIR HANDLING UNIT SCHEDULE

MARK	LOCATION	SERVICE	MODEL	CFM	S.P.		O.V.	RPM	H.P.	REMARKS
					EXT.	TOTAL				
AHU-1	MECH RM 107	LOWER LEVEL	LML-122	10,100	1 1/4"	2 1/4"	1417	1291	7 ½	1,2

1 BASED ON McQUAY
2 PROVIDE 4" HIGH RAIL UNDER UNIT

COOLING COIL SCHEDULE

MK	Location	CFM	MBH TOT/ SEN	CHILLED WATER			AIR P.D.	WATER P.D.	EDB	EWB	LDB	LWB	COIL			
				GPM	LWT	EWT							ROWS	FPF	F.V.	
CC-1	AHU-1	10,100	340/282	78	55*	458	.56	15.9	80*	65*	55*	54*	5	144	478	1

1 BASED ON MCQUAY

HEATING COIL SCHEDULE

MK	Location	CFM	MBH	GPM	WATER P.D.	EWT	LWT	AIR P.D.	EAT	LAT	COIL				
											TYPE	ROWS	FPF	F.V.	
HC-1	AHU-1	10,100	403	39	11.7	140*	119*	.72	55*	90*	②	2	132	819	1

1 BASED ON McQUAY
2 MODEL #5WH1102C

Mechanical Equipment Exercise - Boiler and Pump Schedules

BOILER SCHEDULE							
MARK	MODEL	MBH		RECOVERY GPH	SUPPLY TEMP.	FULL SIZE	REMARKS
		INPUT	OUTPUT				
B-1	CHN0990	990	831	00	180*	10"	1,2,3

1 BASED ON LOCHINAR COPPER - FIN II
2 PROVIDE POWERED VENT CAP FOR SIDEWALL VENT & SEALED COMBUSTION
3 PROVIDE TEKMAR #254 4-STAGE BOILER CONTROL, INSTALLED & WIRED BY T.C.C.

PUMP SCHEDULE									
MARK	SERVICE	MODEL	GPM	FT. HEAD	RPM	IMPELLER DIA.	HP	VOLTAGE	REMARKS
P-1	HEATING LOOP	1510-2 ½"AB	65	45'	1750	7"	2	480V-3PH	1
P-2	HEATING LOOP	1510-2 ½"AB	65	45'	1750	7"	2	480V-3PH	1
P-3	HC-1	60-2"A	39	30'	1750	6 ½"	1	480V-3PH	1
P-4	CHILLED WATER	1510-2 ½"AB	78	45'	1750	7"	2	480V-3PH	1

1 BASED ON BELL & GOSSETT

Mechanical Equipment Exercise - Gas Fired Package Rooftop Unit Schedules

GAS FIRED PACKAGE ROOFTOP UNIT SCHEDULE													
MK	LOCATION	MODEL	CFM	EXT S.P.	SAF HP	SAF RPM	VOLTAGE	HTG. MBH IN/OUT	COOLING TOT/SEN	COMPRESSORS			Notes
										KW	RLA	LRA	
RTU-1	SANC. 202	558DE240	7500	1"	7 ½	1210	480v-3PH	270/216	235/173	20.6	31.4	223	1,2,3
RTU-2	SANC. 202	558DE240	7500	1"	7 ½	1210	480v-3PH	270/216	235/173	20.6	31.4	223	1,2,3
RTU-3	Narthex 201	558DE090	3000	3/4"	3	1470	480V-3PH	180/144	73/84	7.69	6.2	37.7	1,3

1 BASED ON BRYANT
2 PROVIDE W/INSULATED 24" HIGH ROOF CURB FOR SIDEWALL SUPPLY & RETURN
3 PROVIDE 2/100% ECONOMIZER

Mechanical Equipment Exercise - Louver, Diffuser, Register and Grille Schedules

LOUVER SCHEDULE								
MARK	SERVICE	DIMENSIONS		CFM	FREE AREA SQ. FT.	S.P. IN W.G.	AIR VELOCITY FPM	Notes
		LENGTH	HEIGHT					
L - 1	AHU -1 INTAKE	60"	84"	10,100	19.85	.05	510	1
L - 2	AHU -1 EXHAUST	42'	84"	9,100	13.69	.07	660	1
L - 3	EF - 3 EXHAUST	16"	16"	500	0.81	.06	620	1
L - 4	EF -4 EXHAUST	24"	18"	600	1.11	.05	540	1
1 Based on Rusken								

DIFFUSER, REGISTER AND GRILLE SCHEDULE					
MARK	SERVICE	MODEL	VOLUME DAMPER	FINISH	REMARKS
D -1	CEILING SUPPLY DIFFUSER	TDC -3	- - - - - - -	OFF-WHITE	1,2
D -2	CEILING SUPPLY DIFFUSER	TDC -1	- - - - - - -	OFF-WHITE	1
D -3	FLOOR SUPPLY DIFFUSER	CT - PP - 0	AG - 35	CLEAR ANODIZED	1, 3
R -1	SIDEWALL SUPPLY REGISTER	1700	AG - 15	OFF-WHITE	1
R -2	CEILING EXHAUST REGISTER	350FL	AG - 15	OFF-WHITE	1
G -1	CEILING RETURN GRILLE	50F	- - - - - - -	OFF-WHITE	1

Electrical Exercise

Using the Electrical Plans, Schedules provided below and the Mechanical Equipment Schedules previously attached, answer the following questions.

1. Using the One-line Diagram, what are the electrical power requirements to the Chiller?

- A. 3 #4, 1"C
- B. 3 #4/0, 2" C
- C. 4 #1/0, 2-1/2" C
- D. (4) #350 MCM & #2 Ground, 3" PVC

2. Using the One-line Diagram, what are the electrical power requirements from the Pad Mounted Transformer to the Main Switchboard?

- A. 3 #4, 1"C
- B. 3 #4/0, 2" C
- C. 4 #1/0, 2-1/2" C
- D. (4) #350 MCM & #2 Ground, 3" PVC

3. Using the One-line Diagram, what are the Feeders on the Main Switch Board going to?

- A. Panel “PP”, Panel “DP”.
- B. Panel “PP”, Panel “DP” and the Existing Service Panel.
- C. Panel DM, Panel “E”, Panel “F”, Panel “C” and Panel “D”
- D. Panel “PP”, Panel “DP”, Existing Service Panel, and the Chiller.

4. Using the One-line Diagram, what are the Feeders on the Distribution Panel going to?

- A. Panel “PP”, Panel “DP”.
- B. Panel DM, Panel “E”, Panel “F”, Panel “C” and Panel “D”
- C. Panel “PP”, Panel “DP”, Existing Service Panel, and the Chiller.
- D. Panel DM, Panel “E”, Panel “F”, Panel “C”, Panel “D”, Existing Service Panel.

5. Using the One-line Diagram, what phase motor is required for the Chiller?

- A. 1
- B. 3
- C. 4
- D. 17

Electrical Exercise

6. Using the Diagrams, you will see the symbol ● and the abbreviation's EF-4 and 17, F. What phase motor is required?

- A. 1
- B. 3
- C. 4
- D. 17

7. What does the abbreviation 17, F refer to?

- A. Fan #17.
- B. EF #17 on Panel F.
- C. Circuit # 17 on Panel F.
- D. Panel # 17 on Circuit F.

8. Which one of the following electrical receptacles is attached to 20, F?

- A. RTU-3, 201.
- B. Outlets Room 201.
- C. Outlets in Room 206.
- D. EF-3, Outlets in Room 205.

9. What is the horsepower for UH-1?

- A. 1/10
- B. 1/20
- C. 1.0
- D. 7-1/2

10. What is the voltage requirement for RTU-2?

- A. 120
- B. 208
- C. 240
- D. 480

Electrical Exercise

11. What phase motor is required for P-2?

- A. 1
- B. 2
- C. 3
- D. 480

12. What is the horse power required for P-3?

- A. 1/10
- B. 1.0
- C. 2.0
- D. 7-1/2

13. What size breaker in amperes is required for RTU-1?

- A. 1
- B. 3
- C. 20
- D. 50.

14. What is the mounting height of the outlet near the Narthex and on the south wall referred to as 18, F?

- A. 16 inches.
- B. 40 inches.
- C. 42 inches.
- D. 80 inches.

15. What is the mounting height of the Fire Alarm Smoke detector?

- A. 16 inches.
- B. 40 inches.
- C. 42 inches.
- D. 80 inches.

Electrical Exercise

16. Which of the following pieces of electrical equipment has a disconnect switch?

- A. EF-3
- B. CUH
- C EWC
- D. RTU-2.

17. What does the abbreviation GFI, WP mean?

- A. Ground Fixture Inside and Waterproof.
- B. Ground Fault Interrupter and Waterproof.
- C. Ground Fault Interrupter and Weatherproof.
- D. Ground Fluorescent Inside and Weatherproof.

18. What does the abbreviation EWC mean?

- A. Eye Wash Container.
- B. Electric Water Cooler.
- C. Exhaust Waste Convenience.
- D. Equalization Water Container.

19. Where are the lighting fixtures C 4 located?

- A. Narthex.
- B. Exterior.
- C. Bathrooms.
- D. Stairs and Entrances.

20. Which Fixture types are attached to a Photo-cell?

- A. A1 and EM1.
- B. B2. and K.
- C. E and EM1.
- D. M and N.

Electrical Exercise

21. What type of light is a B2 light?

- A. 2' x 2' Fluorescent Troffer with Prismatic lens.
- B. 2' x 4' Fluorescent Troffer with Prismatic lens.
- C. 2' x 4' Fluorescent Troffer with Prismatic lens with 3 lamps.
- D. 2' x 2' Fluorescent Troffer with Parabolic lens and 30K lamps.

22. How are the EM-2 lights mounted?

- A. Ceiling.
- B. Surface.
- C. Pendant.
- D. Recessed.

23. How many lamp(s) are in fixture A2?

- A. 1
- B. 2
- C. 3
- D. 4

24. What is the electrical symbol  with an E inside the circle mean?

- A. Exit Sign.
- B. Existing Sign.
- C. Electrical Fixture.
- D. Emergency Fixture.

25. Which of the following wire sizes has the greatest diameter?

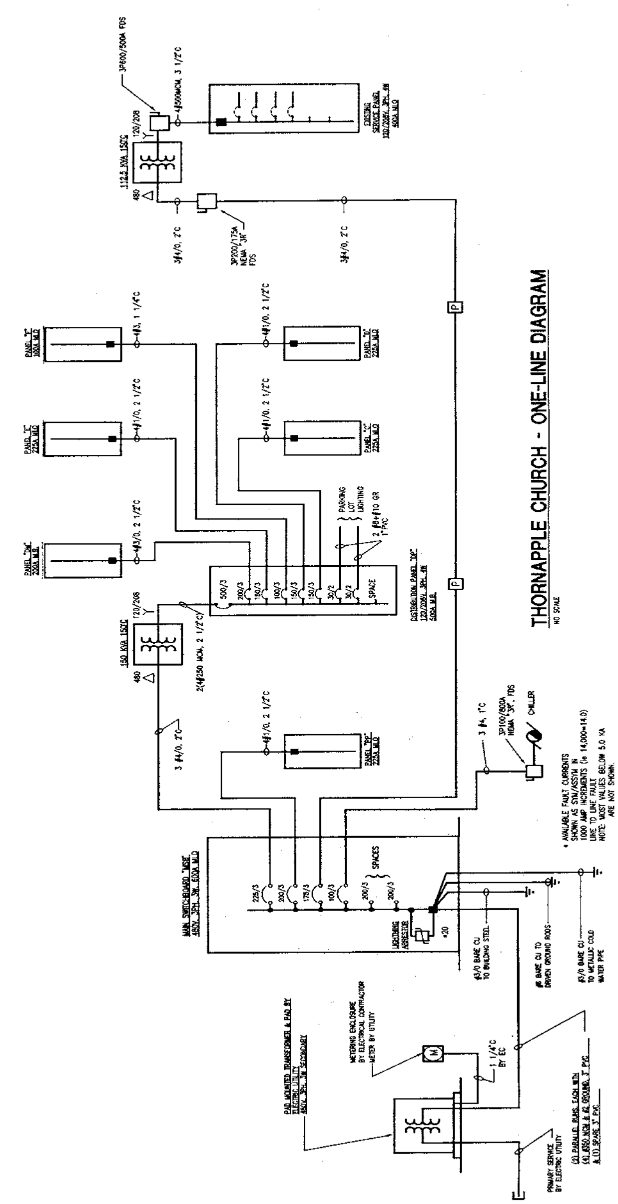
- A. #0
- B. #1
- C. #10
- D. #14.

Check Answers

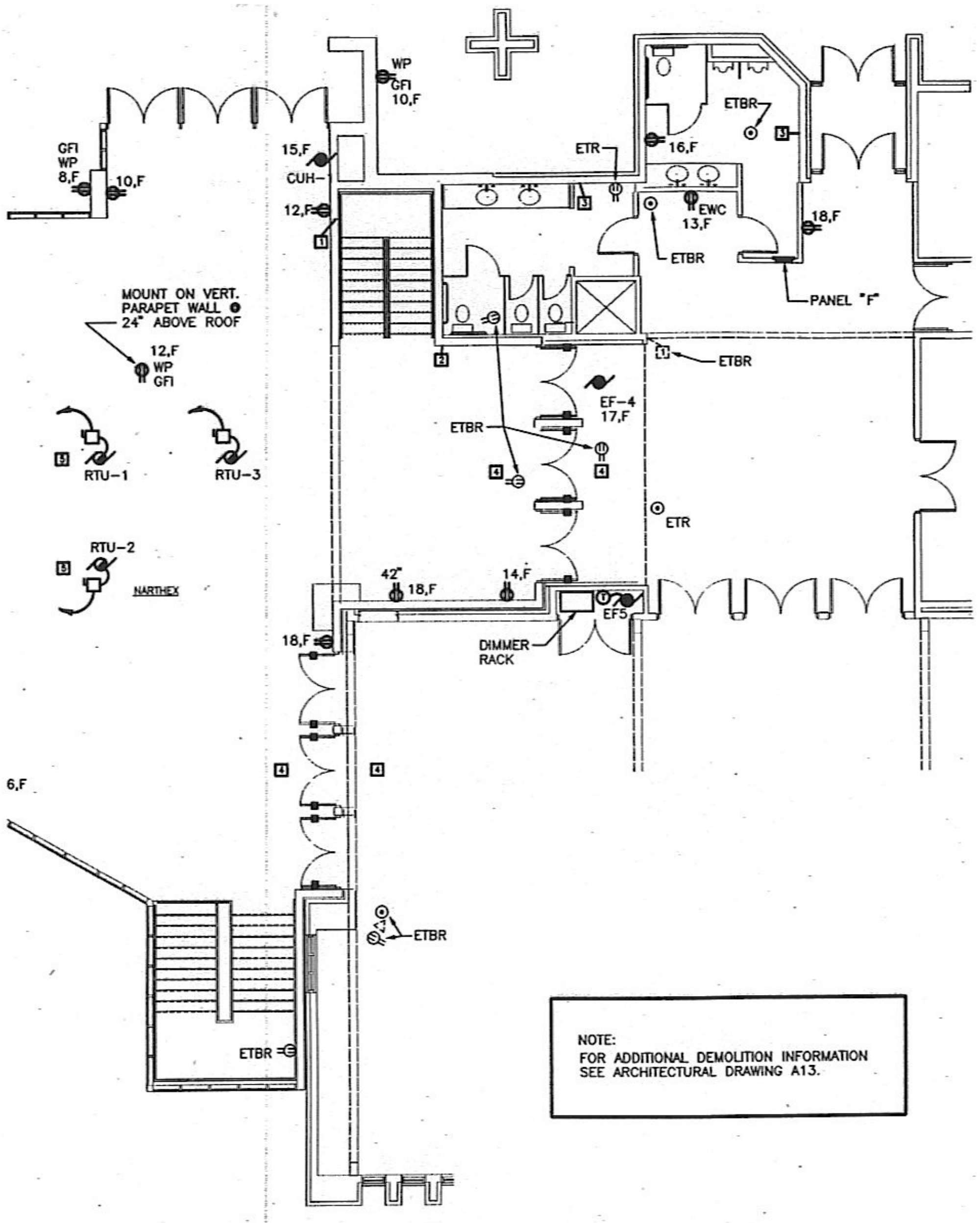
Electrical Exercise - Electrical Symbols Legend and Mounting Heights

ELECTRICAL SYMBOL LEGEND		
SYMBOL	**DESCRIPTION**	**MOUNTING HEIGHT**
S	SINGLE POLE SWITCH	
S3	THREE-WAY SWITCH	40"
$\boxed{D}$	DIMMER SWITCH	40"
O	CONVENIENCE OUTLET	40"
O GFI	CONVENIENCE OUTLET WITH GFI	16" OR AS NOTED
O WP	WEATHERPROOF OUTLET	16" OR AS NOTED
O	SAFETY CONVENIENCE OUTLET	16" OR AS NOTED
└□	DISCONNECT SWITCH	16" OR AS NOTED
●	SINGLE PHASE MOTOR	- - - -
⊖	3-PHASE MOTOR	- - - -
▬▬	BRANCH CIRCUIT PANEL BOARD	- - - -
▼	TELEPHONE OUTLET	- - - -
▿	DATA OUTLET	16" OR AS NOTED
■	MAGNETIC DOOR HOLDER	16" OR AS NOTED
$\boxed{J}$	JUNCTION BOX	- - - -
$\boxed{1}$	FIRE ALARM PULL STATION	- - - -
$\boxed{2}$	FIRE ALARM AUDIO/VISUAL DEVICE	40"
$\boxed{3}$	FIRE ALARM VISUAL DEVICE	80"
$\boxed{4}$	FIRE ALARM SMOKE DETECTOR	80"
$\boxed{5}$	FIRE ALARM DUCT SMOKE DETECTOR	- - - -
⊗		- - - -
●	RECESSED INCAND. OR FLUORESCENT	- - - -
¤	HID FIXTURE, SURFACE OR PENDANT	- - - -
⊗e	INCAND. FIXTURE, SURFACE OR PENDANT	- - - -
	EXIT SIGN	- - - -
|---------|	RECESSED FLUORESCENT TROFFER	- - - -
	STRIP FLUORESCENT FIXTURE	- - - -
▼■▼	SURFACE FLUORESCENT FIXTURE	- - - -
EM	BATTERY EMERGENCY FIXTURE	- - - -
ETR	EMERGENCY FIXTURE	- - - -
ETBR	EXISTING TO REMAIN	- - - -
	EXISTING TO BE REMOVED	- - - -
Note: All Mounting Heights are to Bottom.		

Electrical Exercise - One Line Diagram



Electrical Exercise - Power Plan Upper Level



POWER PLAN: UPPER LEVEL

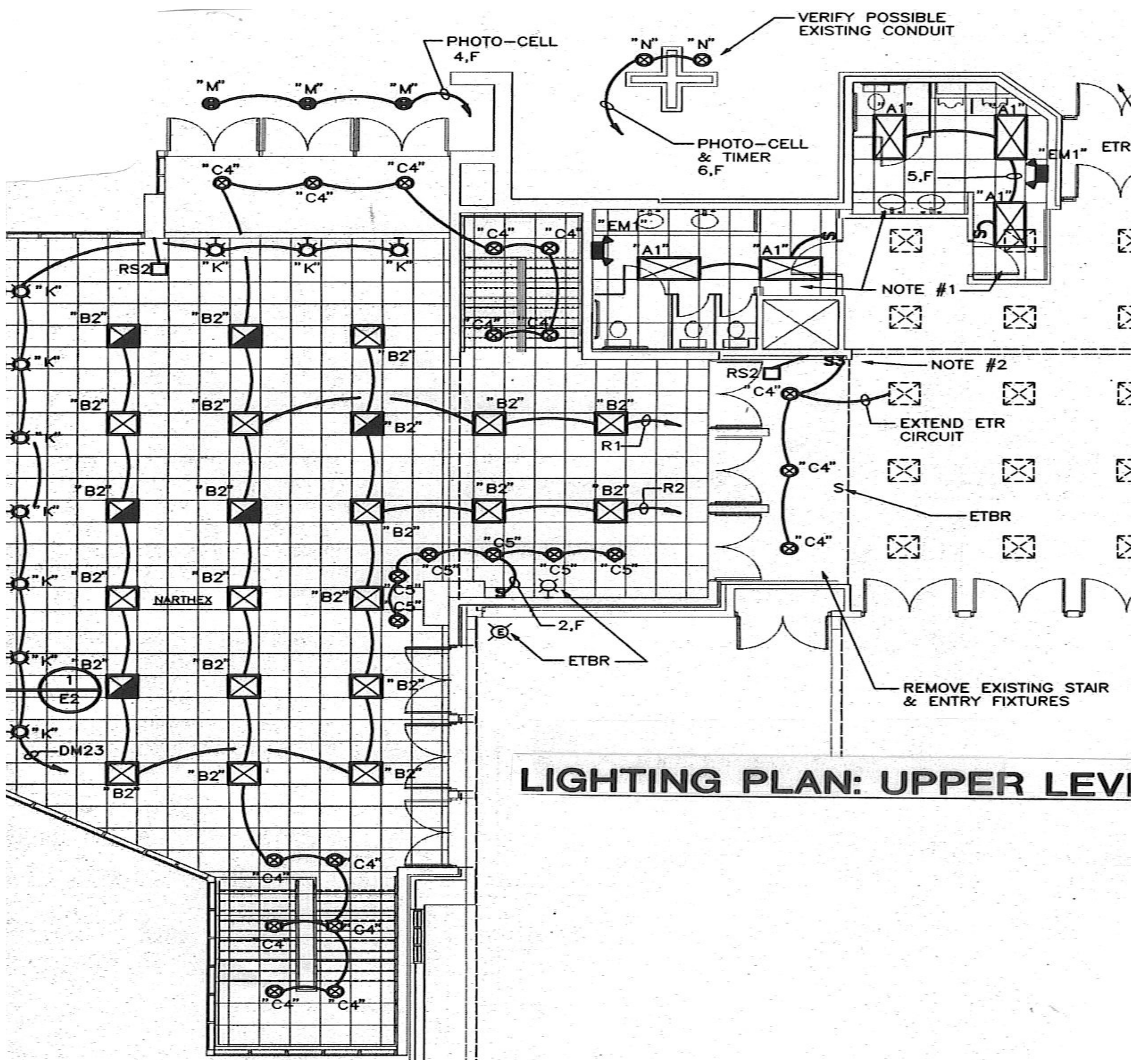
SCALE: 1/8" = 1'-0"

Electrical Exercise - Panel Board Load Sheet

PANEL: F	MOUNTING: RECESSED	MAINS: 3P100A MLD	PANEL LOCATION: 209
	VOLTAGE: 120/480 -3	FEEDER SIZE: 4#3, 1-1/4 C	FEEDER FROM: DP

LOCATION	LOAD IN VOLT AMPS			BKR		CKT		CKT	BKR		LOAD IN VOLT AMPS			LOCATION
	LIGHT	OUTLET	MOTOR	P	AMP	NO		NO	P	AMP	LIGHT	OUTLET	MOTOR	
RTU-1, 202				3	50	1		2						LIGHTING, 206
						3		4						P. CELL, 201A, B, C
LIGHTING, 209				1	20	5		6	1					OUTLET 201, P. CEL
RTU-2, 202				3	50	7		8	1					WP GFI, 202C
						9		10	1					OUTLET 201, WP GFI
EF -3, 205				1	20	11		12	1					WP GFI ROOF
EWC				1	20	13		14	1					OUTLET R 206, 202B
CUH				3	20	15		16	1					OUTLET ROOM 209
EF-4 208, 209				3	20	17		18	1					OUTLETS ROOM 206
OUTLETS 201				1	20	19		20	3	70				RTU-3
						21		22						
						23		24						
						25		26						
						27		28						
						29		30						

Electrical Exercise - Lighting Plan Upper Level



Electrical Exercise - Lighting Fixture Legend

	DESCRIPTION	MOUNTING	LAMPS	MANUFACTURER	
A1	2' X 4' FLUORESCENT TOFFER W/ PRISMATIC LENS	RECESSED	(2) F40CW/RS/WM	LITHONIA #2SPG-240	
A2	2' x 4' SIMILAR TO A1 EXCEPT W/ 3 LAMPS	RECESSED	(3) F40CW/RS/WM	LITHONIA #2SPG-340	
B1	2' X 2' FLUORESCENT TROFFER W/PRISMATIC LEN	RECESSED	(2) FB40CW/6	LITHONIA #2SPG-2U40	4
B2	SIMILAR TO B1 EXCEPT W/ PARABOLIC LENS & 30K LAMPS	RECESSED	(2) F40SPX30/U/6	LITHONIA #2PM3	6, 4
C1	INCANDESCENT DOWNLIGHT	RECESSED	(1)15ORFL120WM	KURT VERSEN #150	
C2	SIMILAR TO C1 EXCEPT W/ LAMP	RECESSED	(1)300RFL	KURT VERSEN #300	
C3	SIMILAR TO C1 EXCEPTW/ LAMP	RECESSED	(1)Q500 T4	KURT VERSEN #500	
C4	SIMILAR TO C1 EXCEPT W/ FLUORESCENT LAMP	RECESSED	(2)PLC26W/27	KURT VERSEN #120	12
C5	SIMILAR TO C1 EXCEPT WALLWASH	RECESSED	(2)PLC26W/27	KURT VERSEN #120	
D	PENDANT INCANDESCENT FIXTURE, ACRYLIC DIFFUSER	PENDANT	(8)N150	VISA #CB3616	13
K	INCANDESCENT UP/DOWN LIGHT	WALL PER DETAIL	(1)100A21/99	MANNING #DS89	10
M	HID DOWNLIGHT	RECESSED	(1)MS100BU/BDW	HALO #M6024	
N	HID WELL UPLIGHT	WELL IN GROUND	(1)MS100BU/BDW	HYDREL #9305	
EM 1	EMERGENCY BATTERY FIXTURE	SURFACE	PER UNIT	LITHONIA #ELM-H	
EM 2	SAME AS EM1 EXCEPT CEILING MOUNTED	CEILING	PER UNIT	LITHONIA #ELM-H	

Electrical Exercise - Lighting Fixture Notes

1. ALL BALLAST SHALL BE ENERGY SAVING TYPE, FLUORESCENT (T12) BALLAST.

2. HID LAMPS BY VENTURE, 'PL' LAMPS BY OSRAM AND ALL OTHER LAMPS BY G.E. WITH EQUAL BY SYLVANIA.

3. EXIT SIGNS ARE BATTERY POWERED LED TYPE.

4. PARTIALLY SHADED FIXTURES SHALL INCLUDE 1/3 OR ½ OF LAMPS ON BATTERY BACKUP EMERGENCY PACK SUCH FIXTURES ARE NORMALLY MANUALLY CONTROLLED AND AUTOMATICALLY LIGHT DURING LOSS OF POWER.

5. EQUAL FIXTURES BY LITHONIA, DAYBRITE, METALUX, HALO, AND CAPRI, ARE APPROVED. FIXTURE CUTS MUST BE SUBMITTED FOR SPECIFIC FIXTURES NOT LISTED ABOVE.

6. NOT THE USE OF 30K LAMPS FOR THE PARABOLIC 2 X 2 FIXTURES.

7. FIXTURES TYPE 'E1' & 'E2' SHALL MATCH 'D', INCLUDING THE BRASS RING AROUND THE UPPER PART OF THE FIXTURE. FIXTURE 'E2' IS ONLY 1/4 OF A SPHERE FOR CORNER MOUNTING, ACRYLIC OR MATCHING PAINT FINISH. FIXTURE TO SET OUT FROM WALL.

8. OF THE 18 TYPE 'F' FIXTURES, PROVIDING AT LEAST THREE (3) FIXTURES OF EACH BEAM TYPE CL, VNSP, NSP, MFL, & WFL. INCLUDE THREE (3) SETS OF SPARE LENS #S4PAR-LS. EQUAL FIXTURES BY STRAND SHALL BE APPROVED EQUALS. SEE ELEC. & ARCH DETAILS FOR INSTALLATION.

9. FIXTURE 'G' TO HAVE CLEAR LENS TO PREVENT COLLECTION OF DUST IN REFLECTOR. PROVIDE PHOTOMETRICS OF SIDE, FRONT & REAR WITH FIXTURE INVERTED PER DETAIL #7 ON DWG. E2.

10. UP/DOWN FIXTURE 'K' TO MOUNT DIRECTLY TO WALL PER DETAIL #1 ON DWG. E2.

11. FLOOD LIGHTING FIXTURE 'P' COLOR TO MATCH ROOF FINISH.

12. FIXTURE MUST BE 'IC' RATED.

13. 'D' FIXTURE BY VISA WITH WHITE PENDANT, LBZ RING & <u>NO</u> FINAL. 'D' FIXTURE BY MANNING WITH WHITE PENDANT 'DB' RING & NO FINAL.

BIDDING AND ESTIMATING

Document Relationships

The Construction Specifications Institute (CSI) has established a specific terminology to indicate the relationship among the documents. Each term is defined below.

The Basic Relationships Among the Various Documents

← **Construction Documents** →						
← **Bidding Documents** →						
← **Typical Project Manual** →						
Bidding Requirements	Contract Forms	Contract Conditions	Specifications	Plans Drawings	Addendum	Contract Modification
Bid Invitation Instructions Information Available Bid Forms and Attachments Bid Security Forms	Agreement Performance Bond Payment Bond (Labor/Mat) Certificates	General Conditions Supplementary Conditions	Division 01 General Requirements Division 2-16 Technical Specifications	Working Drawings Civil Architectural Structural Mechanical Electrical		Contract Change Orders Change Directives Minor Changes
	When Owner- Contractor Agreement is Signed, these become ← **CONTRACT DOCUMENTS** →					

The Construction Documents is the term utilized to refer to the inclusion of all seven categories. The *Bidding Document* is the term utilized to refer to the inclusion of six categories excluding the Contract Modification category.

The Project Manual is the term utilized to refer to the inclusion of the Bidding Requirements, Contract Forms, Contract Conditions and the Specifications. The *Contract Documents* is the term utilized to refer to the inclusion of the Contract Forms, Contract Conditions, Specifications, Working Drawings, Addendum and the Contract Modifications.

Project Manual Arrangement

Introductory Pages	00001	TITLE PAGE
	00003	TABLE OF CONTENTS
Bidding Requirements	00010	**PRE-BID INFORMATION**
	-030	Advertisement for Bids
	-040	Prequalification Forms
	00100	**INSTRUCTIONS TO BIDDERS**
	-120	Revisions to Instructions to Bidders
	-130	Pre-Bid Conference
	00200	**INFORMATION AVAILABLE TO BIDDERS**
	-210	Preliminary Schedules
	-220	Geotechnical Data - Geotechnical Report & Soil Boring Data
	-230	Existing Conditions - Existing Site, Existing Buildings & Property Survey
	-240	Project Financial Information
	00300	**BID FORMS**
	00400	**SUPPLEMENTS TO BID FORMS**
	-410	Bid Security Forms
	-430	Subcontractor List
	-440	Substitution List
	-460	Alternates/Alternatives
	-480	Noncollusive Affidavit
Contract Documents	00500	**AGREEMENT FORMS**
	00600	**BOND AND CERTIFICATES**
	00700	**GENERAL CONDITIONS**
	00800	**SUPPLEMENTARY CONDITIONS**
	-810	Modifications to General Conditions
	-820	Additional Articles - Equal Employment Opportunity Goals
	-830	Wage Determination Schedule
	00900	**ADDENDA AND MODIFICATIONS**
	01000	**GENERAL REQUIREMENTS**
	02-16	**TECHNICAL SPECIFICATIONS**

Adapted from Construction Specifications Institute's *Manual of Practice*.

Bidding Requirement Documents

The *Advertisement for Bids, Notice to Bidders or Invitation to Bid* is used to communicate to all prospective bidders the nature, intent, and location of the work and the authority under which it originates, together with the time, manner, and place in which bids are to be received. The Advertisement for Bids/Notice to Bidders is normally used on Public Project notices. An Invitation to Bid is normally used on Private projects.

The best sources for finding construction Advertisements for Bids are the Dodge Reports or your local Builders Exchange office. The Dodge Reports and the Builders Exchange are services that must be purchased by the Contractor but the Advertisements are updated daily and can be sent directly to the Contractor. These notices can also be found in newspapers and trade magazines. According to the Construction Specifications Institute's, Manual of Standard Practice they recommend that the following information be contained in the Instructions to Bidders.

A. Project Identification: Name, Project Number, Date, Name and Address of the Owners Representative.
B. Description of Work
C. Type of Bid
D. Time of Completion
E. Bid Opening
F. Examination and Procurement of Documents
G. Bid Security
H. Bidders' Qualifications
I. Owner's Right to Reject Bids
J. Laws and Regulations

Prepared by the Owners Representative (Architect or Engineer)
Sent to Dodge Reports, Newspapers, Magazines and Trade Publications.

The Contractor's Responsibility is to consult Dodge Reports, Builders Exchange and be informed through trade journals and magazines.

The *Prequalification* process is usually announced in the advertisement to bidders. The Contractors are asked to submit documents that establish the firm's expertise and capability in accomplishing similar types of work, before they can be issued bidding document & before they can submit their proposal. The purpose of prequalification is to allow the owner the opportunity to eliminate the incompetent, overextended, underfinanced, and inexperienced contractors from consideration. The American Institute of Architect and the Associated General Contractors recommend that the following information be contained in the Prequalification form.

A. Submittal Parties
B. Name of the Project
C. Type of Work Performed
D. Type of Organization
E. Licensing Information
F. Experience and Claims Record
G. Laws and Regulations
H. References: Trade, Banks and Surety
I. Financial Statement
J. Signatures and Notarized

This is Completed by the Contractor
Sent to the Owners Representative or State Highway Department.

The Contractor's Responsibility is to complete a prequalification questionnaire and/or other owner documents Prior to receiving the Bidding documents.

The *Instructions to Bidders* is normally found at the beginning of the Bid Requirements. These instructions review the requirements that the owner has set up for the form and content of the bids, and prescribes certain procedures with which the bidding contractors are required to conform. Conditions pertaining to the form of the bid, where and when it must be delivered, whether it is a public opening, proposal security required and information concerning late bids. Failure to comply with such instructions can result in a contractor's bid not being accepted. According to the Construction Specifications Institute's, Manual of Standard Practice they recommend that the following information be contained in the Instructions to Bidders.

1. Location of the Documents
2. Bid Submittal Procedures
3. Interpretation of the Construction Documents
4. Site Review Procedures
5. Bid Proposal Guarantees
6. Proposal Supplement Procedures
7. Time for Executing the Contract
8. Acceptance of Proposals
9. Erasure Procedures
10. Selection of Low Bidder
11. Bidder Qualifications
12. Withdrawal of Proposals
13. Selection of Alternates
14. Rejection of Proposals
15. Payment Form and Schedule of Values
16. Bid Authorization

This is prepared by the Owner or Owner's Representative
It is sent to the Contractor

The Contractor's Responsibility is to READ! Thoroughly

The *Prevailing Wage Rate Schedule* is normally found at the beginning of the Bid Requirements. On public construction projects the wage rates by craft may be established. This is sometimes referred to as the Davis-Bacon Act.

> Prepared by the Owner or Owner's Representative
> Sent to the Contractor
>
> Contractor's Responsibility is to use these rates as a minimum

The *Information Available to the Bidders* consists of preliminary schedules, Geotechnical data (Report), Soil Boring Information, existing conditions description, site maps, existing structures, existing substructure and property surveys for the contractor's review.

> Prepared by the Owner, Owner's Representative and/or Testing Company
>
> Sent to the Contractor with the bid package documents.
>
> The Contractor's Responsibility is to REVIEW THROUGHLY and COMPARE to Standard Table for Relative Density and Consistency. Also, most of the time these will indicate "For Bidding Purposes Only" which means that the Contractor shall review for bidding but they cannot utilize the documents for requesting a Contract Change Order.

The following questions can be utilized to determine whether the Information Available to the Bidders section is a Part of the Agreement. The Soil Reports and the Soil Borings may not be a part of the contract documents depending on their disclaimers. The A/E firms strongly suggest that these bidding requirement and forms be excluded from the contract. The general law principles are as follows:

QUESTIONS TO DETERMINE WHETHER INFORMATION IS PART OF THE AGREEMENT	Yes or No
Are these documents listed in the Owner/Contractor Agreement?	
Is the index listed in the Owner/Contractor Agreement?	
Is the Information Available listed in the Index?	
Is the report numbering continuous within a Division such as 02120 - 1, etc.?	

If you can answer yes to all of the questions then the information Available to the Bidders is included as a part of the Agreement.

Contractors Bid Submittal Documents

The *addenda* are used to communicate any changes, modifications, corrections or additions that arise BEFORE the Bids are opened. These will become a part of the bid package and they must be included in the Bid Price. This is the form the Owner or the Owners Representative uses to modify the scope and detail of the work prior to the bid opening.

> Prepared by the Owners Representative
> Sent to All Bidders at least five days' prior to bid opening
>
> The Contractor's Responsibility is to Sign all Addenda and Submit Acknowledgment with the Contractors Bid Submittal

The *Proposal Supplements* are used to request additional information concerning the Bid Proposal. Typically, the Architect will request the name of each major Subcontractors, the names of the major manufacturers and vendors. This information will be used to determine the reliability of the contractor and whether the project materials are in compliance with the Specifications.

> Prepared by the Contractor on the Form Provided in the Bid Package.
> Sent to the Owner with the Contractors Bid Submittal
>
> The Contractor's Responsibility is to obtain from the Subcontractors and Suppliers and Submit with the Bid Submittal.

Alternates are normally found in Division 01 of the General Requirements and they are used to request different methods of constructing a project. A Second purpose is to obtain bids on the basic contract and requesting additional alternatives on specific items that the owner may or may not decide to add or deduct form the Base bid. These Alternatives are requested during the bidding phase and they must be submitted by the contractor at the bid opening.

> Prepared by the Contractor on the Form Provided in the Bid Package.
> Sent to the Owner with the Contractors Bid Submittal
>
> The Contractor's Responsibility is to submit Addition or Deduction in Price with the Bid Submittal.

The *Bid Bond* also called a proposal security bond, is widely used for the purpose of bid security to the owner. Other forms of bid security that some owners may allow are a certified check or a cashier's check. This a guarantee to the owner that the successful bidder will enter into a contract with the owner for the amount of their bid and they will provide the contract bonds as required. A bond is a three-party instrument that protects one party from default on the part of a second party. In the event a default occurs, a third party is legally bound to offset any damages resulting from the default. In bonding terminology, the party in a position to be damaged by a default is called the OBLIGEE(Owner). The party who is in a position to default is the PRINCIPLE (Contractor). The third party offsetting the damages is the SURETY(Bonding Company). If the bond is invoked, the Surety will provide the Owner with the face value of the bid bond and they will in turn sue the contractor for the face value of the bid bond plus all additional expenses such as lawyer fees.

Prepared by the Surety (bonding company)
Sent to the Owner with the contractors bid submittal

The Contractor's Responsibility is to obtain from surety & properly submit with his bid submittal. The process of obtaining a Bonding Capacity normally requires the Contractor to Submit a Portfolios containing Financial Statements, Resumes of Key People, Type of Ownership, Long Range Plan, Types of Projects Completed and an Example of your Cost Control System.

The *Noncollusive Affidavit* is a sworn statement stating the bid submitted was arrived at without any agreement or cooperation with other prime bidders on the contract.

Prepared by the Contractor on the Form Provided and it will be Notarized.
Sent to the Owner with the Contractors Bid Submittal.

The Contractor's Responsibility is to have the form notarized and submit with bid submittal.

The *Proposal Form* is the written offer, tendered by the contractor to the owner, which stipulates the price for which the contractor agrees to perform the work described by the contract documents. It is an offer and by itself is not a formal contract. However, upon acceptance of the offer by the owner this results in a contractual relationship. The standardized proposal form, provided in the bid package, is desirable and necessary so that all bids will be presented and evaluated on the same basis. According to the Construction Specification Institute's Manual of Standard Practice, they recommend that the following information be contained on the Bid Form.

A. Project Identification
B. Name and Address of Party to Whom the Bid is Directed
C. Entity Submitting Bid
D. Acknowledgments
E. Amount of Time for the Bids to be Held Open
F. Identification of Addenda
G. Prices
H. Alternates
I. Allowances
J. Combined Bids
K. Completion Date
L. Liquidated Damages
M. Attachments
N. Closing with Signatures, Date and Corporate Seal

Prepared by the Contractor on the form provided in the Bid Package
Sent to the Owner with the Contractors Bid Submittal

The Contractor's Responsibility is to fill out and sign with correct prices in writing and in figures, sealed in an envelope that is addressed as directed by the instruction to bidders and clearly labeled as a proposal for the project being bid including the contractors return address. Failure to use the proposal form provided will result in disqualification of the bid.

The *Contractors Bid Breakdown Form for a Lump Sum Contract* is sometimes included in the bid package and the Contractor is required to submit their proposal broken down by certain divisions of work, as outlined in the Instructions to Bidders. Each division of work requested must include all labor, material, equipment, overhead, profit and subcontractor cost associated with performing the work. The contractor submits a lump sum price for each division. The owner uses the bid breakdown to compare contractor prices.

Prepared by the Contractor on the Form Provided in the Bid Package
Sent to the Owner with the Contractors Bid Submittal
Contractor's Responsibilities is to ensure all items are accounted for including overhead and profit. To ensure that no alterations or conditions are included in the bid submitted.

An example of a typical bid breakdown for a building is shown as follows

CSI DIV/SEC	MAJOR DIVISION	LUMP SUM AMOUNT ($)
01	GENERAL CONDITIONS	
02	EXCAVATION & GRADING	
03	CONCRETE	
04	MASONRY	
05	STRUCTURAL STEEL	
06	CARPENTRY	
07	ROOFING	
08	DOORS, WINDOWS, STOREFRONTS & GLAZING	
09250	DRYWALL	
09900	PAINTING	
15300	FIRE PROTECTION	
15400	PLUMBING	
15500	HEATING, VENTILATING, AIR CONDITIONING (HVAC)	
15550	BOILER	
16	ELECTRICAL	
16700	COMMUNICATIONS	
	TOTAL BID PRICE	

The *Contractor's Bid Form for a Unit Price Contract* is included as part of the bid package and the Contractor is required to submit a prince which includes all costs by the items requested on the Bid Item form as outlined in the Bid Instructions. Each item of work requested must include all labor, material, equipment, overhead, profit and subcontractor cost associated with performing the work. The contractor submits a unit price for each item and extends the price to determine the total estimated Amount. The owner uses the unit price breakdown to compare contractor prices.

Prepared by the Contractor on the Form Provided in the Bid Package
Sent to the Owner with the Contractors Bid Submittal
Contractor's Responsibility is to ensure all items are accounted for including overhead and profit. To ensure that no alterations or conditions are included in the bid submitted.

An example of a typical unit price bid for a Road and Flood Control Project is shown below.

NAME OF PROJECT: **NAME OF BIDDER**
ROAD AND FLOOD CONTROL PROJECT ________________________________
BIG SIOUX RIVER ________________________________
SIOUX CITY, IOWA AND SOUTH DAKOTA ________________________________
DATE: ____________________

TO: District Engineer

In compliance with the above dated advertisement for bids, the undersigned hereby proposes to perform all work for the Road and Flood Control Project, Stage I, Big Sioux River, Sioux City, Iowa and South Dakota in strict accordance with the Standard Specifications, Standard Plans, Bid documents and Supplementary Conditions. For the following amounts:

Item No.	Description	Quantity	Unit	Unit Price	Estimated Amount
1	Clearing and Grubbing	1	L.S.		
2	Type "A" Excavation	113,900	C.Y.		
3	TYPE "B" Excavation	25,000	C.Y.		
4	Compacted Embankment	196,600	C.Y.		
5	Riprap	42,300	Tons		
6	Seeding	60	Acres		
7	24" Dia CMP (12 Gage)	384	L.F.		
				TOTAL	

Typical Bidding Process Time Line

	Owner holds lowest 3 or 4 bidders			
Advertisement to bidder	Submittals provide Bid Bond	Obtain Contract Bonds and Insurances	If contractor can't provide these at the signing of contract the bid bond is Kept by Owner	
Approx 30 days	**30 days**	**14 days**	**must provide**	**Commence Work**
Bid Period Pick up Doc. Do Quantity Takeoff Select Subs	Review and Acceptance of Proposals and Selection by Owner		1)Performance Bond 2) Labor & Material Bond 3) Insurance Certificate	
	Bid Opening Date	Notice of Award	Sign/Execute Contract	Submit Shop Drawings Construction

Liquidated Damages is an assessment against the contractor for failure to complete the work within the time limit specified in the contract. The amount for liquidated damages is stated in a fixed sum per calendar day to cover the owners loss revenue. It must not be a penalty. If the dollar amount is not stated in the documents, then the Owner can charge the Contractor for actual damages incurred. *Retainage* is the amount withheld from the contractors progress payments until final completion and acceptance.

Conditions of the Contract

The *Agreement Between Owner and Contractor* is attached as a supplement to the Bid Requirements. The reason for providing the Agreement in the bid package is to allow the contractor the opportunity to review the terms and conditions prior to bidding the work.

Prepared by the Owner or Owner's Representative
Sent to the Contractor with the Bid package documents

Contractor’s Responsibility is to READ thoroughly!

The Signed Agreement and its terms and conditions which are included in the Agreement will rule over all other documents.

The *General Conditions* have been standardized by numerous associations. Below are two common forms of the General Conditions written by different associations. They are the American Institute of Architects (AIA) and the Engineers Joint Contract Document Committee. These are incorporated by reference.

The *General Conditions published by the American Institute of Architects* (AIA) defines the basic rights, responsibilities and relationships of all parties involved in the construction process. It also sets forth the manner and general Business procedures whereby the provisions of the contract are to be implemented according to accepted business practices in the construction industry. The AIA Standard General Conditions have been approved and endorsed by the AIA and the Associated General Contractors. The General Conditions describe the rights and responsibilities using the following article numbers.

1. General Provisions
2. Owners Responsibilities and Stop Work Procedures
3. Contractors Responsibilities and Shop Drawing Procedures
4. Architects Responsibilities and Claims Procedures
5. Subcontractors Responsibilities
6. Construction by the Owner or Separate Contractor's
7. Changes in the Work Procedures
8. Time and Time Extensions
9. Payment and Completion Procedures
10. Safety and Protection of People and Property
11. Insurance and Bond Descriptions
12. Uncovering and Correction of the Work
13. Governing Laws, Tests and Inspections
14. Termination or Suspension of the Contract Procedures

Each of the provisions has legal implications, and the word cannot be changed without careful consideration. The wording has evolved to establish a fair and equitable balance of protection for all parties concerned.

Prepared by the Owners Representative
Incorporated by Reference or sent to the Contractor

The Contractor's Responsibility is to become thoroughly familiar with the Standard General Condition forms. If the contractor finds considerable deviation from the STANDARD, They should consult their attorney or they may decline the opportunity to bid fearing costs of litigation in clarifying contractual problems.

There are numerous versions of the General Conditions and they are normally incorporated by reference, therefore, the Contractor must ensure that they are using the correct version for their project. Some previous editions of the AIA A 201 General Conditions are the 1997, 1987, 1976 and each edition is unique.

The *General Conditions published by Engineers Joint Contract Documents Committee* (EJCDC) defines the basic rights, responsibilities and relationships of all parties involved in the construction process. It also sets forth the manner and general Business procedures whereby the provisions of the contract are to be implemented according to accepted business practices in the construction industry. The EJCDC 1910-8 General Conditions have been issued and Published Jointly by the National Society of Professional Engineers (NSPE), the American Consulting Engineers Council (ACEC), the American Society of Civil Engineers (ASCE) and the Construction Specifications Institute (CSI). This document has been approved and endorsed by the Associated General Contractors. The Standard General Conditions describe the rights and responsibilities using the following article numbers:

1. Definitions
2. Preliminary Matters
3. Contract Documents: Intent, Amending, Reuse Procedures
4. Availability of Lands; Subsurface Physical Conditions;
5. Bonds and Insurance
6. Contractors' Responsibilities
7. Other Work
8. Owners' Responsibilities
9. Engineer's Status During Construction
10. Changes in the Work
11. Change of Contract Price
12. Change of Contract Time
13. Tests and Inspections; Correction, Removal or Acceptance of Defective Work
14. Payment to Contractor and Completion Procedures
15. Suspension of the Work and Termination Procedures
16. Dispute Resolution
17. Miscellaneous

Prepared by the Owners Representative
Incorporated by Reference or sent to the Contractor

The Contractor's Responsibility is to become thoroughly familiar with the Standard General Condition forms. If the contractor finds considerable deviation from the STANDARD, They should consult their attorney or they may decline the opportunity to bid fearing costs of litigation in clarifying contractual problems.

The EJCDC 1910-8 General Conditions has a 1990 and a 1996, etc. editions and each edition is unique.

The *Supplementary Conditions* contain provisions or clauses that are Written expressly for a GIVEN PROJECT. They reflect the peculiarities and special needs of a specific job. These Conditions use the same Article Numbers as the General Conditions and They Overrule the General Conditions. Items contained in Supplementary conditions are of two types:

1. Modifications to the basic Articles of the General Conditions in the form of additions, deletions, or substitutions.

2. Additional Articles of a contractual-legal nature which may be desirable or necessary for a particular project.

Typical provisions such as the duration of the project, commencement of work, owner-procured materials, format required for project progress reporting, amount of liquidated damages, special instructions requesting material substitutions, changes in insurance, etc.

Prepared by the Owner's Representative
Sent to the Contractor

The Contractor’s Responsibility is to READ THOROUGHLY!

The *Application and Certificate for Payment* is attached as a supplement to the Conditions of the Contract. The continuation Sheets are called the Schedule of Values.

Prepared by the Owner or Owner's Representative
Sent to the Contractor

The Contractor’s Responsibility is to complete within 10 days of acceptance. If not submitted prior to first payment request, the Contractor can have payment withheld.

Conditions of the Contract vs. Division 1 - General Requirements

CONDITIONS OF THE CONTRACT	DIVISION ONE
Are inherent part of the Agreement With the Agreement govern the content of the entire contract Contain contractual principles applicable to most projects with supplements for a particular project	An inherent part of the Specifications Administratively governs the specification sections contain specifics directly applicable to a particular project

GENERAL CONDITIONS	SUPPLEMENTARY CONDITIONS	SECTIONS OF DIVISION ONE
Are broad contractual conditions Contain the constants Relatively static content thus allowing the use of published standard documents	Modify the contractual conditions Modify the constants for a specific region or project Take precedence over general conditions Must be written separately for each project	Contain specific administrative and procedural requirements Contain variables directly applicable for specific project Must be written separately for each project

Adapted from the Construction Specification Institute's *Manual of Practice* (1992).

General Requirements - Division 01
Division 01 titled the *General Requirements* contains specific administrative and procedural requirements that apply to all of the Technical Specification sections. The General Requirements contain specifics directly applicable to a particular project and they are written separately for each project. These expand the broad administrative and procedural requirements stated in the General and Supplementary Conditions documents, but they apply to the work of ALL Technical Specification sections. This document also Summarizes the Scope of Work, use of the site, Owner Occupancy of building during construction, Phased construction activities, multiple prime contract requirements and exclusions and inclusions as they relate to the Plans. The General Requirements describe the Contractor's administrative, procedural and other activities that the Contractor must provide. The General Requirements contain the following categories.

Administrative

- 01010 Summary
- 01020 Allowances
- 01030 Alternates
- 01040 Coordination
- 01060 Regulatory Requirements
- 01080 Identification Systems
- 01090 References

Procedural

- 01025 Measurement and Payment
- 01035 Modification Procedures
- 01050 Field Engineering
- 01100 Special Project Procedures
- 01200 Project Meetings
- 01300 Submittals such as Construction Schedule, Logs
- 01400 Quality Control
- 01600 Material and Equipment
- 01650 Facility Startup/Commissioning
- 01700 Contract Closeout
- 01800 Maintenance

Temporary Activities

- 01500 Temporary Facilities

Prepared by the Owners Representative
Sent to the Contractor

The Contractor’s Responsibility is to include these items in Overhead.

Technical Specifications

Divisions 02 - 16 called the *Technical Specifications* contain the written description of the specific requirements relating to a specific product or system. The specification provisions define and establish the quality level procedures, standards of work and material standards. Each subsection defines the scope, technical requirements, performance requirements, material suppliers, and quality requirements. The Construction Specifications Institute (CSI) has developed the following standard MasterFormat numbering system consisting of the following Technical Specification Divisions.

CSI Technical Specification *Division Numbers*

Division 2 - Site Work
Division 3 - Concrete
Division 4 - Masonry
Division 5 - Metals
Division 6 - Wood and Plastics
Division 7 - Thermal and Moisture Protection
Division 8 - Doors and Windows
Division 9 - Finishes
Division 10 - Specialties
Division 11 - Equipment
Division 12 - Furnishings
Division 13 - Special Constriction
Division 14 - Conveying Systems
Division 15 - Mechanical
Division 16 - Electrical

The Construction Specification Institute (CSI) breaks down each Division into *Section Numbers* using three digits and a Standard Format. The following displays a portion of the section numbers for Division 02.

DIVISION 02 - SITE WORK

SECTION 02200	Earthwork
SECTION 02210	Grading
SECTION 02220	Excavating, Backfilling and Compacting
SECTION 02300	Tunneling

The CSI Technical Specification *Part Numbers* are contained in each Specification Section within a Division. Each Specification Section contains three PARTS in the following order.

SECTION 02210 GRADING

PART 1 - GENERAL

1.01 SECTIONS INCLUDES
- A. Subsoil and Topsoil materials

1.02 RELATED SECTIONS
- A. Section 02050 - Demolition
- B. Section 02100 - Site Preparation
- C. Section 02140 - Dewatering

1.03 REFERENCES
- A. ANSI/ASTM C136 - Method for Sieve Analysis of Aggregates.
- B. ASTM D2487 - Classification of Soils for Engineering Purposes.

1.04 SUBMITTALS
- A. Submit Cofferdam Design Drawings with engineer’s seal.
- B. Submit 10 pound sample of each type of soil in an air-tight container to test lab.

1.05 DELIVERY, STORAGE, AND HANDLING
- A. Store and protect materials under

PART 2 - PRODUCTS

2.01 MATERIALS

PART 3 - EXECUTION

3.01 INSTALLATION

END OF SECTION

Prepared by the Owners Representative
Sent to the Contractor

The Contractor’s Responsibility is to determine whether there appears to be any extraordinary or nonstandard aspects that will have an impact on cost, and should be studied carefully. Provide a copy to subcontractors and suppliers if requesting price quotations.

Plans or Drawings

Plans and Drawings are graphically portrays the physical aspects of the structure, showing the arrangement, dimensions, construction details, materials, and other information necessary for estimating and building the project. A job covered by drawings that are complete, intelligible, accurate, detailed, and well correlated can be priced much more realistically and claims for extra payment during construction are minimized, and the owner is likely to get a much better finished product at a lesser cost.

> Prepared by the Owners Representative
> Sent to the Contractor
>
> The Contractor's Responsibility is to examine & Study, Provide copy to subcontractors and suppliers if requesting price quotations.

Document Contradictions

When *Contradictions* exist between the Plans and the Technical Specifications the more specific or stringent item governs over the general item. The general principle of law described above is that the specific takes precedence over the general. Now, in the instance of *Plan Notes they take precedence over the Technical Specification* provisions because they are more specific than the Technical Specification because the specification provisions are frequently standardized. According to Bruce Jervis and Paul Levin in their book *Construction Law Principles and Practices (1989)* they state that *Drawings and Plan Notes must be customized* for each individual project. Therefore, in the event of a conflict between the Technical Specification and the Plans, it is logical to assume that the Plan or Plan notes more accurately reflect the intent of the A/E. It is for this reason that the old saying of specification rule over the plans is misleading and probably incorrect in most instances (p 87).

> Prepared by the Owners Representative
> Sent to the Contractor
>
> The Contractor's Responsibility according to the AIA General Conditions A201 (1987) Article 3.2, Review of Contract Documents is that if any errors, omissions, inconsistencies or contradictions are discovered by the Contractor or Subcontractor when comparing the documents, the Contractor shall inform the A/E in writing, normally using a Letter of Transmittal (p 8).

Bid Document Exercise

1. Which document is submitted to the Owner for bid consideration before the Contractor can receive the bidding documents?

   - A. Proposal Supplements.
   - B. Instructions to Bidders.
   - C. Noncollusive Affidavit.
   - D. Pre-qualification Forms.

2. Which document describes the duties and responsibilities of each party and the business procedures for administering the contract?

   - A. General Conditions.
   - B. General Requirements.
   - C. Instructions to Bidders.
   - D. Supplementary Conditions.

3. What is the name of the law principle for referring the Contractor to other documents that are not contained in the package provided?

   - A. Order of Precedence.
   - B. Incorporated by Reference.
   - C. Standardized General Conditions.
   - D. Shop Drawings and Reference Standards.

4. Which of the following documents is normally incorporated by reference?

   - A. General Conditions.
   - B. General Requirements.
   - C. Instructions to Bidders.
   - D. Supplementary Conditions.

5. Which document establishes the forms, content and procedures for submitting the bid proposals?

   - A. General Conditions.
   - B. General Requirements.
   - C. Instructions to Bidders.
   - D. Supplementary Conditions.

Bid Document Exercise

6. Which document makes changes, modifications and corrections prior to bid opening?

- A. Addenda.
- B. Change Directive.
- C. Proposal Supplements.
- D. Contract Change Order.

7. Which document issued by the Architect illustrates what is to be built?

- A. Plans.
- B. Shop Drawings.
- C. Product Data Sheets.
- D. Schematics Drawings.

8. Which document is submitted by each bidder stating that their bid was arrived at without any conferring with other prime bidders?

- A. Proposal Supplements
- B. Instructions to Bidders.
- C. Noncollusive Affidavit.
- D. Owner/Contractor Agreement.

9. Which document describes quality of work and the quality of the materials and the construction execution procedures?

- A. Agreement.
- B. General Requirements.
- C. Technical Specifications.
- D. Supplementary Conditions.

10. Which document applies to the Contractor and the Subcontractors and describes the administrative, procedural and temporary procedures on the job site?

- A. General Conditions.
- B. General Requirements.
- C. Instructions to Bidders.
- D. Supplementary Conditions.

Bid Document Exercise

11. Which document describes the business procedures for a specific project and they change the initial procedures?

- ○ A. General Conditions.
- ○ B. General Requirements.
- ○ C. Instructions to Bidders.
- ○ D. Supplementary Conditions.

12. Which document requests that additional information be submitted by the bidder within 48 hours of bid opening?

- ○ A. Proposal Supplements.
- ○ B. Instructions to Bidders.
- ○ C. Noncollusive Affidavit.
- ○ D. Pre-qualification Forms.

13. Which document establishes the labor rates on a project?

- ○ A. General Requirements.
- ○ B. Instructions to Bidders.
- ○ C. Proposal Supplements.
- ○ D. Prevailing Wage Rate Schedule.

14. What types of projects establish prevailing wage rates?

- ○ A. Union projects.
- ○ B. Merit Shop Projects.
- ○ C. Privately Funded Projects.
- ○ D. Federally Funded Projects.

15. Which document contains a description of the alternate(s)?

- ○ A. General Conditions.
- ○ B. General Requirements.
- ○ C. Instructions to Bidders.
- ○ D. Supplementary Conditions.

Bid Document Exercise

16. What is the term called which requires all Bidders to include in their bid a specified amount or unit price for a particular item?

- A. Plug.
- B. Alternate.
- C. Contingency.
- D. Cash Allowance.

17. Which document specifies the existing soil conditions?

- A. General Requirements.
- B. Technical Specifications.
- C. Supplementary Conditions.
- D. Information Available to Bidders.

18. Which document specifies the temporary facilities needed on a project?

- A. General Requirements.
- B. Technical Specifications.
- C. Supplementary Conditions.
- D. Information Available to Bidders.

19. Which document specifies the Regulations required such as soil erosion or minorities?

- A. General Requirements.
- B. Technical Specifications.
- C. Supplementary Conditions.
- D. Information Available to Bidders.

20. Which of the following documents are submitted by the Contractor at bid opening?

- A. Proposal Form, Bid Breakdown, Addendum, Bid Bond & Noncollusive Affidavit.
- B. Proposal Supplements, Performance Bond, Payment Bond & Insurance certificate.
- C. Prequalification Forms, Alternates, Cash Allowances, Prevailing Wages, Deposit.
- D. Agreement, Regulatory Requirements, Shop Drawings, Product Data & Samples.

Check Answers

Laws, Regulations, Codes and Specifications

The legal system in the United States has the following characteristics. First, it is a common law system. Second, There are more than fifty independent jurisdictions that are operating simultaneously. Third, in most cases the right to a jury trial exists but the right can be waived. Finally, it is based upon the belief that justice and truth shall prevail.

There are two types of legal systems that govern in the United States. They are the *Civil Law* systems and the *Common Law* systems. The *civil law system* is based primarily on codes and statues where judges and courts in the civil law system interpret the law and apply it to a case. However, the decision of the civil law judge is not law for subsequent cases. The *common law system*s also contain codes and statutes. In addition common law contains case law. In a common law system the decisions of appellate and supreme courts, excluding trial courts, are laws that apply to subsequent cases containing the same facts and issues. Other names for this type of law are case law, judicial decisions and common law.

The United States consists of fifty states or *jurisdictions* which operate independently of one another. In addition, to these fifty independent states, the federal government was formed to operate in certain areas such as national defense, interstate trade, international affairs and the national park system. The federal jurisdiction is independent of the state jurisdictions. In addition, there are other jurisdictions such as military jurisdictions and Native American jurisdictions. All state and the federal governments are divided into four areas. They are the legislative branch, the executive branch, the judicial branch and the administrative agencies. The legislative branch of each jurisdiction enacts laws which are called *statutes*. Also, many times the similar statutes are collected together into a code. For example, a state legislature might enact criminal statues, or mechanics' lien laws and they may collect all similar laws into the Criminal Law Code. The executive branch of each jurisdiction carries out the laws passed by the legislature and it controls the police power of that state. The governor is the head of the executive branch of a state government. The president of the United States is the head of the executive branch of the U.S.

Finally, because of the complexity of the government, both the state's and the federal government have established administrative agencies to carry out the laws passed by the legislature. These administrative agencies, such as the Occupational Safety and Health Administration (OSHA), the Department of Transportation(DOT) and the Equal Employment Opportunity Commission (EEOC), have been set up by the federal legislature to aid the executive branch in carrying out the laws enacted. Most administrative agencies have boards that resolve contractor disputes and the U.S. Government has established the Armed Services Board of Contract Appeals (ASBCA), the General Services Board of Contract Appeals GSBCA, the Board of Contract Appeals (BCA) and the Decisions of the Comptroller General, etc. to handle most disputes. These boards are sometimes referred to as the Federal Board of Contract Appeals.

The law can be divided into four *Types of Law*. They are constitutional, statutory, administrative regulation, and case law. Constitutional law is considered the law of the land and it is given respect by the courts and by the people of the United States. Constitutions are designed to be fairly difficult to change because it contains core principles. Constitutions outline the basic format of government operations and they define the basic rights the government cannot infringe upon, such as freedom of speech and freedom of the press. An example of constitutional law is Equality under the law shall not be denied because of sex, race, color, creed, or national origin.

Another type of law are statutes which are passed by the legislature. These can be changed more easily than constitutions. An example of a statute would be Workers Compensation rates are set by each state, therefore, this is a state statue. Also, the Davis-Bacon act applies to prevailing wages on federally funded projects. Therefore, this would be considered a federal statue. It should be noted that many states have enacted prevailing wage rate schedules on state public projects and this is sometimes referred to as the "Little Davis Bacon Act."

Administrative regulations are passed by administrative agencies such as the Occupational Safety and Health Administration (OSHA). For example, under 29 Code of Federal Regulations (CFR) Section 5. (a) reads that each employer –(1) shall furnish to each of their employees a place of employment which is free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees; . . This section is normally referred to as the "General Duty Clause."

Case law is made by appellate and supreme court judges. Case law is more specific and covers only the specific fact situation and issue raised in a particular case. Two well known judicial decisions utilized in the construction industry are the Spearin Doctrine and the Eichleay Formula. The Spearin Doctrine as interpreted by the courts has held that the owner gives the contractor an implied warranty that the plans and specifications are adequate to perform the project. The Eichleay was developed in the case of Eichleay Corp. versus Armed Services Board of Contract Appeals (ASBCA) 5183, 60-2 BCA ¶2688 (1960).

There are numerous *State Statues and Regulations* that are designed to regulate the construction industry. For example, many states have licensing laws, lien laws, building codes, school codes and soil erosion requirements that the contractor must be in compliance. Licensing laws establish the qualifications a person must possess to practice in the state as either an Architect or an Engineer. Licensing also establishes the qualifications for certain people to perform work as a Mechanical, Electrical or Plumbing Contractor. Mechanics' Lien Laws are another set of state statutes designed to apply specifically to the construction industry. The purpose of lien law is to allow someone who provides labor and/or materials for a construction project to obtain a lien attached to the real property for the value of the goods and services incorporated into the project. The lien is normally filed at the Register of Deeds office. But Mechanics' lien laws vary significantly from state to state.

Most states have enacted their own unique *Building Codes*, either by statues or regulations. A new International Building Code (IBC) has been developed by the International Code Council in an effort to standardize state and local codes.

Local Ordinances are laws set by municipalities. For example, there are zoning or building ordinances which specify the type of structure or the minimum size of the structure which can be placed on the piece of property. You can also have height restrictions so that a new structure cannot block the view of an existing structure. Most likely various permits are required on all types of construction such as new homes, commercial buildings, additions to buildings, garages, decks. Some of the permits are the building permit, a zoning permit, a health permit for the septic system, an electrical permit, a plumbing permit, a heating permit, a highway permit and a soil erosion permit. These permits are normally obtained at the local municipality but in some instances they are obtained at the state level.

There are also laws attached to the piece of property which are referred to as *Protective Covenants or Protective Restrictions*. These covenants are established so that the new owner must meet these restrictions to build in the area. These are sometimes referred to as Protective Restrictions. Many times a developer may what to establish the covenants, conditions, reservations and restrictions for the benefit of each owner of land in the development. These covenants are attached to each parcel within the development and they are filed with the Register of Deeds office in each County within a state. The Protective Covenants are given a Liber number and a page number.

The Uniform Commercial Code (UCC) involves the *Sales and Purchase of Goods*. This relationship is governed by the form of the UCC adopted by a particular jurisdiction. The UCC is a set of laws developed to make the law for the sale of goods consistent among various jurisdictions within the United States.

Law can be divided into two broad categories. They are *Criminal Law and Civil Law*. The purpose of criminal law is to prevent and punish certain acts against the public welfare that society has deemed unacceptable. Federal and State occupational Safety and Health laws have always contained criminal enforcement provisions but prosecutors and OSHA have just begun to use these provisions more frequently. According to some reports, criminal charges are becoming more common and in most cases' prosecutors are establishing criminal liability under general state criminal laws instead of under the state OSHA laws. Prosecutors in California, Illinois, Michigan, Ohio, Texas and Wisconsin have used general state criminal laws in connection with workplace accidents.

Civil Law Categories can be further divided into two broad categories. They are contracts and torts. Contract law upholds the duties that the parties have voluntarily agreed to in a contract or agreement. Tort law upholds the duties imposed by law between parties and it is not dependent on any contract between parties.

The Term *Tort* refers to wrongful acts done by one person to another, but only those for which the victim may demand legal redress. Torts may be committed intentionally or unintentionally and with or without force. A tort is distinguished from a crime in that a tort is a private injury upon which a suit may be brought, while a crime is an offense against the public for which retribution must be sought by the appropriate governmental authority. It is entirely possible for a single act to constitute at once a tort and a crime. The concept of due diligence was developed out of common law tort cases.

Due Diligence is define under criminal tort law as a person has a duty of care to the injured party. Most courts rely on the common traditions of tort cases to define torts (whether intentional or unintentional). The courts have defined torts as wrongful acts, breaches of duty of care to the injured, or willful or reckless indifference for the consequences of their actions. This duty of care to the injured party is applied to the managers and supervisors behavior to see if it conforms to a standard of reasonableness or “due diligence” in light of the known and recognized hazards to the injured. There are a number of elements that go into this “due diligence” measurement. First, there are the normal intellectual capacity and memory abilities. Second, are the minimum knowledge, skill and experience that are deemed common to everyone. Third, there is the superior knowledge, skill and experience the supervisor must possess. Finally, the physical traits and disabilities of the supervisor are assessed. In determining the proper standard of conduct or due diligence in a given situation, it is common to have testimony introduced concerning the general trade customs and the supervisor’s adherence to, or departure from, these practices. Therefore, a supervisor having responsibility over the safety of the employees must have employed due diligence to prevent its occurrence. Therefore, the supervisor must prove that they have employed due diligence in the area of safety, hence they must be able to prove the following. First, they have taken an active role in safety. Second, they promptly abated all known and recognized hazards. Third, they abated hazards that have caused harm previously to workers. Fourth, they corrected all violations immediately. Fifth, they obtained and maintain competent person designations. Sixth, they documented all decisions that they made about safety.

The Technical Specifications describe the type and quality of materials and equipment to be incorporated in the project. They detail the methods of fabrication, installation and erection along with these are code compliance requirements, the gauges of the materials and the recommended manufacturers.

Types of Specifications

There are numerous types of specifications and the responsibility and liability if the Architect, Contractor, and Subcontractor for the design of specific systems are defined in the contract documents. Some of the most common types of specifications and their associated liabilities are described below.

A *descriptive specification* also known as a *design specification* instructs the contractor on what to do and they explicitly state how the work is to be performed. Detailed design specifications contain an implied warranty that if they are followed, an acceptable result will be produced. The engineer is liable to the contractor for defective construction caused by a faulty design specification. The example below describes a descriptive or design specification.

> 03300 CAST-IN-PLACE CONCRETE
>
> PART 3 EXECUTION
>
> 3.04 Construction and Control Joints
>
> G. Provide a sealant at all construction joints and other joints in all walls above grade and where shown on the plans.

A *performance specification* tells the contractor the final performance of the system or the expected results of the work is to be but it leaves the methods up to the contractor. Performance may be expressed in numerous ways, depending upon the item. For example, the performance may be expressed in terms of operational capacity, functional qualities, appearance, finish, color, texture, structural tolerances, smoothness or cleanliness. The contractor is liable for defective construction. The example below describes a performance specification.

> 03100 CONCRETE FORMWORK
>
> 3.01 Concrete Formwork Installation
>
> G. Throughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and all other debris just prior to concrete placement. Retighten forms and bracing prior to concrete placement as required to prevent leakage of cement paste during concrete placement.

A *proprietary specification* states the exact manufacturer, make and model of the product or method to be used. Sometimes they may allow for an or-equal or approved substitution. The proprietary specification is a design specification, therefore, the Engineer is liable to the contractor for defective construction caused by a faulty design specification. However, if the contractor substitutes an or-equal or obtains an approved substitution, then the specification becomes a performance specification and the contractor is liable for its performance. Also, it should be noted that even though the designer has approved the or-equal, the contractor still has liability. The example below describes a proprietary specification.

13320 PROCESS CONTROL EQUIPMENT

PART 2 PRODUCTS

2.02 AIR AND EFFLUENT DISCHARGE FLOWMETERS

A. Meter shall be Hersey measurement Ramapo Mark V Target Meter.

A *combination specification* contains both a design specification and a performance specification. Determining liability for a defect related to a combination specification requires mediators, arbitrators, the judge and possibly a jury to determine whether the defect is related to a design or performance flaw. The example below describes a combination specification.

07900 JOINT SEALERS

PART 3 EXECUTION

3.03 INSTALLATION

C. Silicone rubber coating shall be applied in three separate and distinct coats.

Note: The word *applied* in 07900 3.03 C. above specifies a performance specification and the "*three separate" words* specify a design specification.

D. Materials shall be applied to horizontal surfaces in three coats of contrasting colors to ensure complete coverage.

Note: The word *three coats* in 07900 3.03 D above specifies the design specification and the words *complete coverage* specify the performance specification.

Laws, Regulations, Codes and Specifications Exercise

1. What are laws passed by a local government called?

- A. Statutes.
- B. Covenants.
- C. Ordinances.
- D. Judicial Decisions.

2. What are laws passed by the legislature called?

- A. Statutes.
- B. Covenants.
- C. Ordinances.
- D. Judicial Decisions.

3. Which type of law passes worker's compensation rates or mechanic's lien laws?

- A. Statutes.
- B. Covenants.
- C. Ordinances.
- D. Judicial Decisions.

4. Which type of law uses the Spearin Doctrine or the Eichleay Formula?

- A. Statutes.
- B. Covenants.
- C. Ordinances.
- D. Judicial Decisions.

5. Which type of law establishes restrictions or protective restrictions to a piece of property?

- A. Statutes.
- B. Covenants.
- C. Ordinances.
- D. Judicial Decisions.

Laws, Regulations, Codes and Specifications Exercise

6. Which type of law is the most difficult to change?

- A. Civil Law.
- B. Statute Law.
- C. Constitutional Law.
- D. Administrative Law.

7. How are most U.S. government contract disputes initially handled?

- A. U.S. Supreme Court.
- B. Federal District Court.
- C. Federal Circuit Court of Appeals.
- D. Armed Services Board of Contract Appeals.

8. Which type of law governs the sales and purchase of goods?

- A. Tort Law.
- B. Civil Law.
- C. Transportation Code.
- D. Uniform Commercial Code.

9. Which type of law governs agencies set up to carry out specific laws passed by the legislature?

- A. Civil Law.
- B. Statute Law.
- C. Constitutional Law.
- D. Administrative Law.

10. The Preamble to the OSHA Construction Safety Standards states that "the company representative must provide a place of employment free from known and recognized hazards." What is the name of this clause?

- A. OSHA Act
- B. Indemnification.
- C. Contractual Liability.
- D. General Duty Clause.

Laws, Regulations, Codes and Specifications Exercise

11. According to the Construction Safety Standards, what is the name of the wrongful act if a person who is informed of a wrongful act and they indicate that they understand the safety rules, but they proceed wrongfully anyway?

- ○ A. Disclaimer.
- ○ B. Due Diligence.
- ○ C. Wilful Violation.
- ○ D. Promissory Estoppel.

12. Which type of law case requires you to prove due diligence?

- ○ A, Civil case.
- ○ B. Criminal case.
- ○ C. Statutory case.
- ○ D. OSHA Administrative case.

13. In a court case that requires the person to prove "due Diligence." Which of the following would be an example of due diligence?

- ○ A. Report Violations.
- ○ B. Tell employees to be careful.
- ○ C. Correct hazards immediately.
- ○ D. Scream and threaten the workers.

14. Which party has all of the liability for a performance specification?

- ○ A. Owner.
- ○ B. Contractor.
- ○ C. Architect/Engineer.
- ○ D. Separate Contractor.

15. Which party has all of the liability for a descriptive specification?

- ○ A. Owner.
- ○ B. Contractor.
- ○ C. Architect/Engineer.
- ○ D. Separate Contractor.

Laws, Regulations, Codes and Specifications Exercise

16. Which party has liability for a proprietary specification if it does not perform as stated?

- A. Owner.
- B. Contractor.
- C. Architect/Engineer.
- D. Separate Contractor.

17. Which party has liability for a proprietary specification if an approved substitution does not perform?

- A. Owner.
- B. Contractor.
- C. Architect/Engineer.
- D. Separate Contractor.

18. A specification read as follows:
11305 STEP/STED SYSTEM EQUIPMENT

PART 2 PRODUCTS

2.05 STEP SYSTEM COMPONENTS

A. Screened Pump Vaults:
   1. For Low Profile Concrete Tank:
      a) 15 inches in diameter by 48 inches long with 4 inch flow inducer. Model SV1548Fi, as manufactured by Orenco.

What type of specification is this called?

- A. Proprietary Specification.
- B. Performance Specification.
- C. Combination Specification.
- D. Descriptive or Design Specification.

Laws, Regulations, Codes and Specifications Exercise

19. A specification reads as follows:
03200 CONCRETE REINFORCEMENT

PART 2 PRODUCTS

2.02 Reinforcing Steel

C. Provide deformed reinforcement prefabricated straight bars and bent bars according to the CRSI Manual of Standard Practice of not less than 10 feet with concrete coverage of at least 3 inches on exterior exposures and 2 inches elsewhere. Place bars at the on-center spacings shown on the plans.

What type of specification is this called?

- A. Proprietary Specification.
- B. Performance Specification.
- C. Combination Specification.
- D. Descriptive or Design Specification.

20. A specification reads as follows:
02140 DEWATERING

PART 3 EXECUTION

3.01 Dewatering

1. Furnish, install, operate, and maintain all necessary pumping equipment for dewatering the various parts of the work and for maintaining free of water the foundations and trenches as required for construction operations.

What type of specification is this called?

- A. Proprietary Specification.
- B. Performance Specification.
- C. Combination Specification.
- D. Descriptive or Design Specification.

Laws, Regulations, Codes and Specifications Exercise

21. A specification reads as follows:
10105 VISUAL DISPLAY BOARDS

PART 2 PRODUCTS

2.02 Marker Board Material
A. White LCS Writing surface or equal with 24-gauge porcelain enameled steel face on 3/8-inch foil-backed particle board.

What type of specification is this called?

- A. Proprietary Specification.
- B. Performance Specification.
- C. Combination Specification.
- D. Descriptive or Design Specification.

22. A specification reads as follows:
07530 ELASTOMERIC ROOFING - BOARD INSULATION

PART 3 EXECUTION

3.03 INSTALLATION - INSULATION
D. Pitch new roof surfaces to provide continuous drainage to roof drain locations. Set drains at 2 inches above deck level of the new roof. Gradually taper insulation at roof drains approximately 16 inch radius from roof drains using factory-tapered edge strips down to minimum 1 inch thick at drain rings.

What type of specification is this called?

- A. Proprietary Specification.
- B. Performance Specification.
- C. Combination Specification.
- D. Descriptive or Design Specification.

Check Answers

Types of Insurances

The Insurances are listed in the General Conditions and the dollar values are stated in the Supplementary Conditions. Normally, these are calculated as a percentage of direct costs. Below is a brief description of the types of insurance.

The *All Risk Builders Risk Insurance* protects against all risks of direct loss or damage to the project. This covers permanent materials installed or stored at the site that are damaged due to weather.

The *Contractor's Property Insurance* covers the contractor's temporary facilities such as field offices, storage sheds, concretes forms.

The *Floaters Insurance* covers the contractor's construction equipment regardless of location. This is a percentage of Construction Equipment Values on a project.

The *Contingent Liability Insurance* protects the owner from damages arising out of the operations of the General Contractor or its subcontractors.

The *Public Liability and Property Damage Insurance* protects the contractor from its legal liability for injuries to persons not in its employment and for damage to the property of others. This covers people passing by the job site.

The *Automobile or Fleet Insurance* protects the contractor against third-party claims of bodily injury or property damage involving the contractor's vehicles or rented vehicles.

The *Project Management Protective Liability* is defined in the AIA General Conditions as substitute liability for construction operations performed on behalf of the Contractor.

Sometimes the contractor must have specific coverages listed such as weather or else the damages are not covered. For instance, the *Weather* is a specific case in which you have coverage only for the items listed and the contractor's representative acted with due diligence. Some examples of *weather items listed are fire, hurricane, tornado, flood or soil erosion*.

In the example of Flood Insurance being listed, then the contractor has damage to the structure in the event of an storm such as up to a 200-year storm. However, If the structure lifts off of its foundation and flows down the river you must have Soil Erosion insurance to have coverage.

The *Fire Insurance* is in effect only if the Superintendent has performed their duties using due diligence. For example, if the supervisor allows someone to store flammable materials near an area where the cutting torches are being utilized, then there would be no coverage. This is considered a form of negligence. Therefore, the insurance company can sue the contractor and recover damages from the Contractor.

Another insurance consideration is the *Scope of the Contract, the Work Area or the Contract limits*. The courts have defined work as within the scope of the construction contract. For example, if the superintendent stored the materials in the existing portion of the building that does not contain any work. Then the contractor has the liability and the insurance company can recover all damages because you were storing materials outside the contract limits.

Unemployment Insurance is the second type of insurance coverage that most contractors find mandatory by law. The unemployment insurance program has its basis in both federal and state laws. In operation, the program is administered at the state level although backup funds for the state programs are maintained by the U.S. Treasury in accounts reserved for the individual states.

The employer makes the only premium payments for unemployment compensation except in Alabama, Alaska, and New Jersey where the employees are subject to a portion of the tax. There are two components to the premium. The first component is for payment of federal costs in connection with the program and for maintenance of a federal level loan fund used to back up the state funds in time of high regional unemployment. The second component of the premium goes into the state's account from which all benefits are withdrawn. This percentage is variable but will average between 3% and 9% of payroll wages. The percentage multiplier is an average considering all employers in the state. For a given employer, it can vary since employers are *experience rated*. In the long-run, employers' contributions must equal payments to former employees who have filed for and received unemployment benefits following release from the firm for lack of work. Thus, those with low layoff records pay less than those with high records. Rates also vary by states because benefits vary by states. A state can increase both the average rate and the ceiling if necessary to maintain adequate fund reserves. Rates are announced annually. Therefore, the estimator must be certain that the latest information for all states is available. It is difficult to project future contributions because they are dependent upon employer layoff experience. An estimator may logically assume that unemployment benefits will tend to increase with the overall cost of living and project future costs on the basis of present costs increased by expected inflation.

The nature of unemployment insurance contributions leads to a note of caution. It sometimes happens that an employer intending to fire an employee for cause will instead simply agree to release the employee as if work were no longer available so that the former employee will not lose unemployment benefits. The employer must realize that the firm will eventually pay for those benefits and thus add another overhead cost to the operation.

The *Worker's Compensation Insurance* is designed to provide protection to employees who are killed, injured, or suffer health problems due to job-related accidents or conditions. Each state has its own law covering workers' compensation (WC) insurance. Unfortunately, these laws, although similar in principle, are quite different in detail so that costs associated with this insurance program must be related to specific states. A feature of workers' compensation laws is that an employer, in carrying this insurance, is assuming liability without a fault. In return, an employee injured on the job cannot bring further suit against the employer for damages, although they can sue a fellow employee, another contractor on site, individual supervisors or business other than the employer that may have been involved.

Depending on the state, an employer may obtain Workers Compensation insurance from a commercial insurance company, or a state operated insurance fund, or the company may qualify for a self-insurance. Whatever the source of coverage, benefits included must be those established by state law. The rates paid by each contractor are a function of the **state** where the project is located. The **craft** being insured, the source of insurance coverage, the accident experience of the contractor and the loss tables are revised annually.

The *Experience Modification Rating* (EMR) is a multiplier that is calculated using the past workers compensation insurance experience or claims of the individual policy holder. The Experience Modification Rate (EMR) is applied to the workers compensation manual premium to reflect an employer's variation from the average of others with the same classification code or codes. The EMR is the ratio of actual losses to expected losses over a moving three-year period. The adjustment process will result in a multiplier to be applied to the base rates of the insurer. This multiplier will be greater than 1.0 for those firms with poor accident records and will be less than 1.0 for the firms with good records.

The cost implications of poor safety records cannot be overemphasized. For example, the worker's compensation base rate for structural steel workers in numerous states exceeds $30 per $100 of the payroll. A contractor in a state with a $30 base rate who has a good safety record may earn a multiplier of only 0.5 and pay only $15 per $100 of the payroll while a contractor with a poor record and a possible multiplier of 2.0 will pay $60 per $100 of the payroll. For example, if a contractor has an annual carpenter payroll of $100,000 and the insurance rate for carpenters are $24.50/$100, the annual insurance premium is $24,500 for that particular craft. A payroll includes base wages plus Overtime pay reduced to straight time pay for hours worked. A contractor operating in more than one state will be subject to more than one rate structure so estimators must insure that rates are for the proper state.

Another type of insurance is the *Medical Insurance*. It is quite common for employers to make group medical insurance plans available to their employees. An employer may pay the full cost of medical insurance for the employees or just a portion. Whatever the amount contributed by the employer, it is an added cost that must be accounted for. Since the contribution may vary from the employee to employee, an estimator would normally use an average contribution per employee in estimates since estimates do not identify individual workers. This is calculated as a percentage of the payroll.

Social Security is a federal program designed to bring eventual retirement, medical, survivor, and other benefits to employees or their beneficiaries. The program is funded jointly by employees and employers with each contributing an equal amount each pay period. Social security coverage is mandatory for employees of most businesses, including construction. Social security premium rates are established by law and are subject to annual adjustment. The rates are a combination of a percentage multiplier and an income ceiling.

The percentage multiplier is applied to all income up to the ceiling, with no premium on amounts over the ceiling. Assume that the current rate is 7.75% and the employee makes 35,000 per year and the ceiling is 55,000 per year. The annual social security premium would be 7.75% ($35,000) = $2,712.50. This amount would be paid by *both* the employer and the employee so that the total premium received by the federal government is $5425.00 for that employee. All payments made are credited to the employee's individual social security records in Washington. The estimator is concerned only with that part of the social security cost borne by the employer since that paid by the employee is deducted from base salary or wages.

Indemnification sometimes referred to as an indemnity or a hold harmless clause. It is common for the parties involved in a particular project to agree that one party, normally the contractor, will assume the legal liability of another for certain events or risks. The AIA and EJCDC General Conditions both contain an indemnification clause. These clauses can also be included in the subcontract agreement. There are three types of indemnification or hold harmless clauses that exist. They are limited form, intermediate form and broad form clauses. The *limited form indemnity clause* states that one party will pay only for damages it causes. The limited form indemnity clause is the easiest to acquire insurance coverage and it is standard in most comprehensive liability policies. The *intermediate form indemnity clause* states that one party will pay for all damages even if it is only partially responsible for the damage. This clause shifts the legal liability off one party and onto another if both are partially liable. The *broad form indemnity clause* states that one party will pay for all damages even if that one party has not caused any of the damages. Broad form indemnity clauses are unlawful in many jurisdictions. It should be noted that insurance does not automatically protect a party who accepts liability or risk under an intermediate or broad form indemnity clause. For a party to acquire insurance for intermediate or broad form indemnity, you must purchase an insurance rider which is not normally available or it is extremely expensive insurance. The courts disfavor these clauses.

Types of Bonds
There are three bonds that are described in the Instructions to Bidders and these are sometimes referred to as contract bonds. A bond provides a guarantee to the owner at a specific time and if the guarantee is not fulfilled by the contractor, then the bond will be invoked by the owner. Each bond is described below.

A *Bid Bond* guarantees to the owner that the contractor will enter into a contract with the owner after bid opening. The bid bond is also referred to as a proposal bond and it is submitted with the contractor's bid proposal. This is a guarantee that the successful contractor will enter into a contract with the owner for the amount of their bid. The Contractor will provide the contract bonds as required in the Instruction to Bidders. The Bid Bond percentage is stated in the Instructions to bidders and it is normally 5 percent of the bid proposal amount. This is called the face value of the bid bond. Assume that the contract submits a bid proposal for a project bid at $4,900,000. The contractor is the successful low bidder but they decide not to execute the contract, then the owner will invoke the bond and the surety will pay to the owner the face value of the bid bond of $245,000 which is 5% of $4,900,000. Then the Surety will sue the contractor for $245,000 plus surety administrative and attorney fees.

The *Performance Bond* guarantees to the owner that the contract will be performed and that the owner will receive his structure in compliance with the project specifications and with the terms of the contract. The performance bond is submitted to the owner at the signing of the Owner/Contractor Agreement and the bid bond is returned to the contractor. If the contractor fails to fulfill their contractual obligations, the surety must complete the contract and pay all costs up to the face amount of the bond. The performance bond percentage is normally found in the supplementary conditions and the face value of the performance bond is normally 100 percent of the contract amount. Assume that the successful contractor's bid was for $4,900,000 then the face value of the performance bond would be $4,900,000. If the bond was invoked, the costs over and above the face value of the bond will be paid by the contractor and the contractor is responsible to the surety for the face value of the bond plus all costs to complete including the sureties administrative and attorney fees.

The *Labor and Material Bond* guarantees to the owner that all third party liens against the property are paid. The labor and material bond is also known as a payment bond and it is submitted to the owner at the signing of the Owner/Contractor Agreement and the bid bond is returned to the contractor. If the contractor fails to pay the vendors and subcontractors, the surety must complete the contract and pay all costs up to the face amount of the bond. The payment bond percentage is normally found in the supplementary conditions and the face value of the payment bond is normally 50 to100 percent of the contract amount. Assume that the successful contractor's bid was for $4,900,000 then the face value of the labor and material bond at 50% would be $2,450,000.

A *bond is a three-party instrument* that protects one party from default on the part of a second party. In the event a default occurs, a third party is legally bound to offset any damages resulting from the default. In bonding terminology, the party in a position to be damaged by a default is called the OBLIGEE (Owner). The party who is in a position to default is the PRINCIPLE (Contractor). The third party off-setting the damages immediately is the SURETY (Bonding Company), but immediately after the Surety off sets the damages on behalf of the Contractor the Surety will take legal action against the Contractor to recover all damages plus any lawyer fees from the Contractor.

The *Bond Premium* is the amount the contractor is charged after award of the contract for submitting to the owner the face values of the three bonds. The bond premium is calculated using a graduated scale provided by the bonding (Surety) company or in an estimating guide such as Mean's Cost Data book. The example below uses the bond premium table below.

FIRST	$500,000		$6.00 PER M
NEXT	$2,000,000	$3,000 plus	$5.00 PER M
NEXT	$2,500,000	$13,000 plus	$4.10 PER M
NEXT	$2,500,000	$23,250 plus	$3.00 PER M

Assume the contractor's bid proposal was for $4,900,000. Then the price of the bond premium is:

$4,900,000	Proposal over $500,000	Yes
	Proposal over $2,500,000	Yes
	Proposal over $5,00,000	No
Then	$2,500,000 =	$13,000
Plus $4,900,000 - $2,500,000 =	$2,400,000 x $4.10/$1000 =	$9,840
	Total Bond Premium =	$22,840

Insurance and Bonds Exercise

1. Which type of insurance protects the Contractor's Off-road Construction Equipment?

- A. Floaters Insurance.
- B. Auto or Fleet Insurance.
- C. Builders Risk Insurance.
- D. Contractors Property Insurance.

2. Which document contains the coverage amounts for the insurances for the project?

- A. General Conditions.
- B. General Requirements.
- C. Instructions to Bidders.
- D. Supplementary Conditions.

3. Which type of insurance covers injuries to persons not employed at the site but get injured passing by the site?

- A. Floaters.
- B. Public Liability.
- C. Product Liability.
- D. Workers Compensation.

4. Which type of insurance covers workers being laid off from their job?

- A. Builders Risk.
- B. Unemployment.
- C. Public Liability.
- D. Worker's Compensation.

5. Which type of insurance covers injuries to workers employed at the job site?

- A. Floaters.
- B. Public Liability.
- C. Contractual Liability.
- D. Workers Compensation.

Insurance and Bonds Exercise

6. Which type of insurance is needed because the high winds blow down the 40 feet high concrete wall forms?

- A. Floaters.
- B. Builders Risk.
- C. Product Liability.
- D. Contractors Property.

7. Which type of insurance is needed because the high winds mangle the rebar inside the forms due to the high winds?

- A. Floaters.
- B. Builders Risk.
- C. Product Liability.
- D. Contractors Property.

8. Which type of insurance is needed because a 150-year rated rain storm has removed the structure from its foundation and it flows down the river?

- A. Flood.
- B. Floaters.
- C. Soil Erosion.
- D. Builders Risk.

9. Which type of insurance covers all parties and all risks under one unified insurance program and purchased by the Owner?

- A. Builders Risk.
- B. Wrap up policy.
- C. Umbrella Excessive Liability.
- D. Automobile General Liability.

10. Which type of insurance that covers the Contractor assuming the liability of another party through a hold harmless clause?

- A. Wrap-up Policy.
- B. Indemnification.
- C. Workers Compensation.
- D. Umbrella Excess Liability.

Insurance and Bonds Exercise

11. You have a Contract for a Dredging Project on Lake Michigan. Which of the following is required as an Insurance Rider?

- ○ 1. Builders Risk.
- ○ 2. Soil Erosion.
- ○ 3. Contractual Liability.
- ○ 4. Marine Workers Compensation.

12. Which of the following Insurance Coverage items are purchased as a Rider?

- ○ A. Builders Risk, Operations, Indemnify Limited, Contractual Liability
- ○ B. Broad Indemnify, Flood, Soil Erosion, Rail and Marine Workers Compensation.
- ○ C. Limited Indemnify, Umbrella Excessive and Wrap-up Insurance.
- ○ D. Comprehensive General Liability, Comprehensive Auto, and Workers Compensation

13. Assume that you are working on a three-story addition to an existing 3-story structure. You allow your subcontractor to store their material on the 3rd floor of the existing structure which does not contain any work. According to the legal system, WORK is defined by the Contract Documents and the Builders Risk Policy and it has a very specific trade meaning in Construction. Which of the following clearly Defines the word works according to the courts?

- ○ A. Storage of material in the existing structure.
- ○ B. Storage of materials in an offsite location.
- ○ C. Work within the contract limits of the new structure.
- ○ D. Work within the contract limits of the new and existing structures.

14. Assume that you are working on a three-story addition to an existing 3-story structure. You allow your subcontractor to store their material on the 3rd floor of the existing structure which does not contain any work. A fire burns down the 3rd floor of the existing structure. Does the Contractor have insurance coverage?

- ○ A. Yes. The Contractor is covered under their Property Insurance policy.
- ○ B. Yes. The Contractor is covered under their Builders Risk Insurance policy.
- ○ C. No. The Contractor is not covered and Insurance can recover under negligence.
- ○ D. Yes. The Contractor is covered under their Contractors Property Insurance policy.

Insurance and Bonds Exercise

15. What does the abbreviation EMR stand for?

- A. Employer Manual Rate.
- B. Estimated Manual Rate.
- C. Emergency Medical Rate.
- D. Experience Modification Rating.

16. What is the purpose of an EMR?

- A. Reduce Workers Compensations Rates.
- B. Cover Medical Costs and Lost Wages due to an injury.
- C. Adjust Workers Compensation Manual Rate to reflect a company.
- D. Compare Actual Occurrences of Accidents to Predicted Occurrences.

17. Which entity sets the worker's compensation manual rates?

- A. State.
- B. Federal.
- C. Contractor.
- D. Insurance Company.

18. Which period of time does the Bid Bond cover?

- A. bid submittal plus thirty days.
- B. bid advertising until bid submittal.
- C. bid submittal until the signing of the agreement
- D. signing the agreement through completion of construction

19. Which document specifies the Bid Bond Percentage?

- A. Instruction to Bidders
- B. General Requirements
- C. Advertisement to Bidders
- D. Supplementary Conditions

Insurance and Bonds Exercise

20. The Contractor submits a bid for $1,303,071 with the appropriate forms. They receive a Notice of Award letter indicating that their bid has been selected. The Contractor decides not to accept the contract. Will the Contractor lose anything?

- A. Yes, they will lose the amount of their Bond Premium.
- B. Yes, they will lose the amount of their Bid Bond Face Value.
- C. No, they will lose nothing, they will withdraw without ramifications.
- D. Yes, they will lose the amount of their Performance Bond Face Value.

21. Which document guarantees to the Owner that the successful Contractor will sign a contract?

- A. Bid Bond.
- B. Performance Bond.
- C. Labor/Material Bond.
- D. Insurance Certificates.

22. Which document guarantees to the Owner that all third parties will be paid or else the Bond will be invoked?

- A. Bid Bond.
- B. Performance Bond.
- C. Labor/Material Bond.
- D. Insurance Certificates.

23. Which document specifies the time frame for submitting the contract bonds & insurance?

- A. General Conditions.
- B. General Requirements.
- C. Instructions to Bidders.
- D. Supplementary Conditions.

24. Which documents must be submitted to the Owner from the Contractor at the signing of the Owner-Contractor Agreement?

- A. Bid Bond, Shop Drawings and Product Data Sheets.
- B. Bid Bond, Proposal Form and the Bid Breakdown Form.
- C. Performance Bond, Payment Bond and Insurance Certificates.
- D. .Estimate Summary Sheet, Project Overhead Sheet and the Unbalanced Bid Form.

Insurance and Bonds Exercise

25. Which party backs the face value of the Bonds?

- A. Surety.
- B. Owner.
- C. Architect.
- D. Contractor.

26. Which party invokes a bond?

- A. Surety.
- B. Owner.
- C. Architect.
- D. Contractor.

27. What does the Surety do if a bond is invoked?

- A. Sue the Owner for the loss to the Contractor.
- B. Sue the Subcontractors for their failure to follow the schedule.
- C. Nothing, their obligations were complete at the time of submittal.
- D. Pay the Owner the bond face value, then sues the contractor for face value plus.

28. What are the financial obligations of the Contractor if the Payment Bond is invoked?

- A. Nothing because they have already paid their Bond Premium.
- B. Nothing because they have already obtained the face value for the Payment Bond.
- C. Pay the Surety for the face value of the bond plus all other expenses incurred.
- D. Pay the Owner then the Contractor sues the Surety for all expenses incurred.

29. Given the bond premium table, What is the Bond Premium for a $2,755,000 Project?

First $ 500,000	$12.00 per M
Next $ 2,000,000	$6,000 plus $7.25 per M
Next $ 2,500,000	$20,500 plus $5.75 per M

- A. $19,974
- B. $21,966
- C. $25,974
- D. $36,341

Check Answers

Productivity and Labor Unit Cost

A construction cost estimate is only as good as the productivity information on which it is based. Currently, one of the most widely accepted standard numbering systems for collecting and organizing construction activities, their crew makeups and productivity data are the Construction Specifications Institute's (CSI) Master Format. Each activity has its own unique Composite Crew Makeup and Daily Output which establishes the productivity rate. For more Standard information on Composite Crews, Daily Outputs and Productivity Rates there are many reference guides available from R.S. Means, Dodge and Richardson. But, the best and most effective manner to gather productivity information is within your own company. Below are the definitions associated with determining productivity from R.S. Means Building *Construction Cost Data*.

CSI Master Format

Each construction activity is identified by a unique ten-digit number using the CSI Division, Subdivision, Major Classification coupled with an Individual Line Number.

CSI DIVISION	03	CONCRETE
CSI DIVISION & SECTION	03110	Concrete Formwork
CLASSIFICATION NUMBER	410	Forms in Place, Columns
LINE ITEM NUMBER	6500	24" x 24" Plyform Col. 1 Use

Composite Crew Makeup

The Composite Crew is established using the various skill levels within a craft such as Apprentice, Skilled Craft Workers (Journeyman) and Crew Leaders (Foreman) coupled with other Crafts such as Carpenters, Laborers, Brick Masons, Ironworkers, Sheet Metal Workers, Electricians, Plumbers, Pipefitters, Insulators, Riggers, Millwrights and Operators. The Composite Crew makeup for the CSI number 03110 410 6500 is shown below.

No.	CRAFT	Hours per Day	Total Workhours	Hourly Rate	Crew Cost per Day
3	Carpenters	x 8	24		
1	Building Laborer	x 8	8		
4	Total Per Day	x 8	32		

Crew Workhours Expended per Day (Workhours per Day) is the number of Hours the Crew expends in an 8-hour day. It is calculated by taking the Number of Workers per craft and multiplying by an 8-hour day. Then adding up the Workhours expended for each Craft. The Crew hours above indicate 24 hours expended for the Carpenters and 8 hours expended for the Laborer for a Total of 32 Workhours per Day for the Crew.

The *Daily Output and Unit of Measure* indicates the standard number of units that the Composite crew will complete in an 8-hour day. The Daily Output and Unit of Measure for CSI number 03110 410 6500 are shown below.

Daily Output =190 S.F.C.A.

Some of the *Unit of Measure Abbreviations* are S.F.C.A which means Square Feet of Contact Area. This indicates that the area calculated is in contact with concrete or the earth, etc. Another unusual abbreviation is V.L.F. which means Vertical Lineal Feet and it indicates direction. This is utilized for activities which are placed into the ground such as a catch basin or sheet piling. Some additional abbreviations which are very unusual and can become confusing are C.S.F. which means One-hundred (C) Square Feet, or the abbreviation C.L.F. which means One-hundred (C) Lineal Feet. The abbreviation C used alone means One-hundred units. The C placed in front of the other letters means one-hundred of those units. Another set of abbreviations is M.S.F. or M.L.F or M.S.Y. or M.B.F. The abbreviation M used alone means One-thousand units. The M placed in front of the other letters means One-thousand of those units. For example, M.B.F. means One-thousand Board Feet. Finally, the abbreviation Sq. means one-hundred square feet.

The *Productivity Rates* are expressed in Workhours per unit or Units per Workhours. The Productivity Rate expressed in *Workhours per Unit* is calculated by taking the Crew Workhours Expended and Dividing by the Daily Output. Using the CSI number 03110 410 6500, the Productivity Rate expressed in Workhours per Unit is:

$$\frac{\text{Crew Workhours Expended}}{\text{Daily Output}} = \frac{\text{32 Whr/day}}{\text{190 S.F.C.A./day}} = .168 \frac{\text{Workhours}}{\text{S.F.C.A.}}$$

The .168 Workhours represents the portion of an hour that it takes one worker to install a Square Foot of Contact Area. This is the method that Mean's uses to express productivity.

The Productivity Rate may also be expressed in *Units per Workhour*. This is calculated by taking the Daily Output and dividing by the Crew Workhours Expended. The Productivity Rate is:

$$\frac{\text{Daily Output}}{\text{Crew Workhours Expended}} = \frac{\text{190 S.F.C.A./day}}{\text{32 Whr/day}} = 5.94 \frac{\text{S.F.C.A.}}{\text{Workhour}}$$

The 5.94 Square Feet of Contact Area represents the amount of Square Feet that one Worker will complete per hour. This is another method for expressing productivity.

The *Total Workhours* is the amount of workhours required to complete a construction activity based upon the established productivity rate determined above. The Total Workhours is calculated by multiplying the Workhours per Unit by the Quantity from the Construction Issued Plans or the Quantity to be installed and it is expressed as follows:

Productivity Rate (Workhours per Unit) Times Plan Quantities = Total Workhours

Using the Productivity Rate expressed in Workhours per Unit from above, and the Plan Quantity of 1500 S.F.C.A. for CSI number 03110 410 6500, the Total Workhours are:

$$\text{Productivity Rate in (Workhours per Unit)} = .168\ \frac{\text{Workhours}}{\text{S.F.C.A.}}$$

Plan Quantities = install 1500 Square Feet of Contact Area Column Forms.

$$.168\ \frac{\text{Whr}}{\text{S.F.C.A.}} \times 1500\ \text{S.F.C.A.} = 252\ \text{Workhours}$$

The Total Workhours calculated above can be verified by taking the Number of Plan Quantities and dividing by the Productivity Rate in Units per Workhour

$$\frac{1500\ \text{S.F.C.A.}}{5.94\ \frac{\text{S.F.C.A.}}{\text{Workhour}}} = 252.52\ \text{Workhours}$$

The *Total Number of Crew Days* required to complete a construction activity is calculated by taking the Amount of Plan Quantity to be Installed and dividing by the Daily Output for the crew.

Using the Plan Quantity and the Daily Output for CSI number 03110 410 6500, the Total Number of Crew Days is:

$$\frac{\text{Plan Quantities}}{\text{Daily output}} = \frac{1500\ \text{S.F.C.A.}}{190\ \text{S.F.C.A./day}} = 7.89\ \text{days}$$

The Total Crew Days calculated above can be verified by taking the Total Workhours and dividing by the Crew Workhours expended per Day.

$$\frac{\text{Total Workhours}}{\text{Crew Workhours expended per Day}} = \frac{252\ \text{Workhours}}{32\ \text{Workhours per/day}}$$

The *Total Crew Cost per Day using Mean's Labor Rates* is shown below. The Total Crew costs per day are calculated by using the Composite Crew Makeup. This Makeup indicates the Number of similar craft workers, the various skill levels within a craft coupled with the various craft classifications. These Workhours per Craft Classification are then multiplied by the current hourly base wage or prevailing wage rate if on a public project. Using the Composite Crew makeup and the Means wage rates for the CSI number 031 142 6500, the Crew Cost per Day is shown below.

No.	CRAFT	Hours per Day	Total Workhours	Hourly Rate	Crew Cost per Day
3	Carpenters	x 8	24	$25.20	$604.80
1	Building Laborer	x 8	8	$19.80	$158.40
4	Total Per Day	x 8	32		$763.20

The *Labor Unit Cost using Mean's Labor Rates* is shown below. The Labor Unit Cost per unit of Measure is calculated by using the Crew Cost Per Day and dividing by the Daily Output. Using the Means Crew Costs per Day and the Daily Output per Day for the CSI number 031 142 6500, the Labor Cost per Unit is shown below.

$$\frac{\text{Crew Cost per Day}}{\text{Daily Output}} = \frac{\$763.20}{190 \text{ S.F.C.A.}} = \$4.02/\text{S.F.C.A.}$$

Another method for determining the Crew Cost per Day is by using a construction company's wage rates instead of Means. For example, using the composite crew makeup and the construction company's bare wage rates for the CSI number 03110 410 6500, the Crew Cost per Day is shown below.

No.	CRAFT	Hours per Day	Total Workhours	Hourly Rate	Crew Cost per Day
3	Carpenters	x 8	24	$22.00	$528.00
1	Building Laborer	x 8	8	$10.00	$ 80.00
4	Total Per Day	x 8	32		$608.00

Therefore, the Labor Unit Cost using Construction Company's Labor Rates is calculated as the Crew Cost per Day divided by the Daily Output. For example, the Labor Cost per Unit for the Construction Company using CSI number 03110 410 6500 is shown below.

$$\frac{\text{Crew Cost per Day}}{\text{Daily Output}} = \frac{\$608.00}{190 \text{ S.F.C.A.}} = \$3.20/\text{S.F.C.A.}$$

Productivity & Unit Cost Exercise

1. What does the Means book unit of measure abbreviation M.B.F. stand for?

- A. One-hundred Board Feet
- B. One-thousand Board Feet
- C. One-million Feet
- D. One-million Board Feet.

2. What does the Means book unit of measure abbreviation C.S.F. stand for?

- A. Cubic Square Feet.
- B. Contact Square Feet.
- C. One-hundred Square Feet.
- D. One-thousand Square Feet.

3. What does the Means Book unit of measure abbreviation S.F.C.A. stand for?

- A. Square Feet Continuous Area.
- B. Square Feet Cubic Area
- C. Square Feet Contact Area
- D. Square Feet Critical Area.

4. What does the Means Book unit of measure abbreviation Sq. stand for?

- A. Square inches.
- B. One Hundred Square Feet.
- C. One-hundred Square inches.
- D. One thousand Square Feet.

5. What does the Means Book unit of measure abbreviation V.L.F. stand for?

- A. Five Lineal Feet.
- B. Vertical Lineal Feet.
- C. Volume Lineal Feet.
- D. Vinyl Lineal Feet.

Productivity & Unit Cost Exercise

6. What does the Means Book unit of measure abbreviation C stand for?

- A. Ten.
- A. One hundred.
- B. One thousand.
- D. One Million.

Questions number 7 through 14 will utilize the information given below.

The plans call for the contractor to Drive, Pull and Salvage Steel Sheet Piling, 15 feet deep. The Estimated quantity is 12,000 Square Feet of Contact Area (S.F.C.A.).

CSI DIVISION & SECTION	02250	Shoring & Underpinning
CLASSIFICATION NUMBER	400	Sheet Piling
LINE ITEM NUMBER	1300	15' Deep exc., Drive, Extract & Salvage

Given the Crew Makeup and hourly rates based upon an 8-hour work day below and given the Crew Daily output and unit of measure are 545 S.F.C.A. per Day

No.	CRAFT	Hourly Rate
1	Crew Leader(s)	$27.20
4	Pile Drivers	$22.80
2	Crane Operators	$25.26
0.5	Oiler(s)	$18.00

7. How many total crew workhours are expended per day?

- A. 28
- B. 32
- C. 60
- D. 100

8. What is the Productivity Rate expressed in Workhours per Unit (Whr/Unit)?

- A. 00.059
- B. 00.110
- C. 09.083
- D. 17.031

Productivity & Unit Cost Exercise

9. How many total workhours are required to install 12,000 S.F.C.A.?

- A. 708
- B. 1,320
- C. 65, 400
- D. 108,996

10. How many days (whole) are required to install 12,000 S.F.C.A.?

- A. 9
- B. 22
- C. 200
- D. 1500

11. What is the Total Crew Cost per day?

- A. $ 746.08
- B. $1,423.36
- C. $2,071.36
- D. $5,595.60

12. What is the Labor Cost per S.F.C.A. ($L/S.F.C.A.)?

- A. $ 0.06
- B. $ 2.61
- C. $ 23.72
- D. $177.92

13. What is the Total Labor Cost for installing the 12,000 S.F.C.A.

- A. $ 720.00
- B. $ 1,440.00
- C. $ 31,320.00
- D. $284,640.00

Productivity & Unit Cost Exercise

14. What is the productivity rate in S.F.C.A. per Workhour?

- A. 0.045
- B. 0.110
- C. 9.083
- D. 68.130

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15. The plans call for you to **purchase** 4 x 4 - W2.9 x W 2.9 (6x6) of Welded Wire Fabric for a reinforced concrete bridge deck. The estimated quantity is 13,200 Square Feet (SF). The agreed upon purchase price is $18.30 per CSF. What is the Total Materials costs to purchase?

- A. $ 241.56
- B. $ 721.31
- C. $ 2,415.60
- D. $241,560.00

16. Given the information below and you are MASS EXCAVATING, WET SANDY LOAM using two- 21 CY self-propelled Scrapers, a 1/4 of a 300 HP Push Dozer and the haul distance to be 3000 feet. The Mass Excavation total quantity to be moved is 289,000 CY.

Given the Equipment and their rates below.

No.	CRAFT	Daily Cost per Piece
2	Self Propelled, Scraper, 21 CY	$2,400.00
0.25	Push Dozer	$250.00

Given the Daily output and unit of measure are 910 CY per Day.

What is the Equipment Cost per Cubic Yard ($Eq/CY)?

- A. $ 0.01
- B. $ 2.91
- C. $ 5.34
- D. $57.23

Check Answers

Wood Sheet Piling Material and Unit Cost Example

Rough Lumber Quantities are measured and sold by the board foot or by the thousand board feet which is expressed in M.B.F.. A board foot measures 1 inch thick by 12 inches long and 12 inches wide. For example, assume that you want to convert a 12-foot long 2" x 4" into board feet. The calculation would be $\left[\frac{2'' \times 4''}{12}\right] \times 12' = .67 \times 12 = 8$ board feet.

The Wood Sheet Piling Quantities and the materials cost for a Cofferdam that is 10 feet wide by forty-four feet long by nine feet deep enclosed with a three-foot toe is shown below. The Wales are placed at a Maximum Vertical Spacing of Four Feet. The Wale at the bottom must not exceed 1 foot. The Top Wale must be flush with the top of the upright. The Braces are 10' maximum on-center and along each line of wales with one for the starter within 2.5 feet of ends.

MATERIAL	COMPONENT SIZES	PRICES
Sheet Piling	3" x 14"	$390/MBF
Wales	6" x 8"	$390/MBF
Braces	10" x 10"	$390/MBF
Salvage	45%	
Waste Lumber	5%	

1. Determine the Square Feet of Contact Area (S.F.C.A.)

(10' + 44' + 10' + 44') = 108 LF x 12' deep =	1,296 S.F.C.A.

2. Determine the Total Vertical Lineal Feet (VLF) of Sheet Piling.

$\frac{108 \text{ LF}}{14''/12'' = 1.17'}$ = 93 PCS x 12' deep =	1,116 VLF

3. Determine the Total Board Feet (BF)

Piling	1,116 VLF x	$\frac{3'' \times 14''}{12}$	3,906
Wales 9'/4' = 2 +1 Starter = 3 lines	(10' + 44' + 10' + 44') = 108 LF x 3 = 324	$\frac{6'' \times 8''}{12}$	1,296
Braces 44'/10' OC = 5PCS/line	5 PCS/Line x 3 Lines x 10' Long = 150 LF	$\frac{10'' \text{ X } 10''}{12}$	1,250
	Subtotal		6,452
Waste 5%	5% x 6,452 =		323
		Total Board Feet	6,775

The Material Unit Costs would be calculated as shown below. Given the following Material Prices, Calculate the Total Material Costs for the Wood Sheet Piling system and Calculate the Material Unit costs.

MATERIAL	COMPONENT SIZES	PRICES
Cofferdam Lumber		$390/MBF
Nails	8Lbs/100 S.F.C.A..	$77 per 50 Lbs Box
Salvage	45%	
Transportation		$40/MBF
Sales Tax	4% of all Costs exclude Transportation	

3. Calculate the Total Lumber Cost and the Lumber Cost Allocated to this project.

Lumber	6,775 BF	$390/1000 BF	$2,642
Deduct Salvage	45%	$2,642	($1,189)
		Total Lumber Allocated to this Project	$1,453

4. Calculate the Pounds of Nails and the Total Cost of the nails.

Nails	8 Lbs/100 S.F.C.A. x 1,296 S.F.C.A. = 104 Lbs	50Lbs/Box = 3 Bx	$77/B	$231

5. Calculate the Costs for the remaining items.

Sales Tax	4% ($2,642 +$231) =	$115
Transportation	6,775 BF x $40/1000 BF =	$271

6. Calculate the Total Material Costs allocated to this project

Total Material Costs for this Project	$1,453 + $231 + $115 + $271 =	$2,070

7. Determine the Material Costs per Square Foot Contact Area ($M/S.F.C.A.)

$$\frac{\$2{,}070}{1{,}296 \text{ S.F.C.A.}} = \$1.60/\text{S.F.C.A.}$$

8. Determine the Material Costs per Vertical Lineal Feet ($M/VLF)

$$\frac{\$2{,}070}{1{,}116 \text{ VLF}} = \$1.85/\text{VLF}$$

Wood Sheet Piling Material and Unit Cost Exercise

Given the information below for a Cofferdam that is 60 feet wide by 100 feet long and 10 feet deep enclosed with a 3 foot toe. Answer the following questions.

Material	Size	Prices or Percentages
Sheet Piling (Toe = 3 feet)	3" x 13"	$550.MBF
Wales - 3 lines around the outside perimeter	6" x 8"	$550.MBF
Braces - 3 lines, 12 Pcs per line, each 60 feet long	6" x 6"	$550.MBF
Nails - 12 Lbs/100 Square Feet Contact Area		$35/Box, Box = 50 Lbs
Salvage Value		60%
Transportation & Shipping		$3.78/MBF
Sales Tax on Materials		4%
Timber Waste Factor	12%	

1. How many total square feet of contact area (S.F.C.A.) Is required for the sheet piling?

- A. 3,200
- B. 4,160
- C. 6,000
- D. 60,000

2. How many total vertical lineal feet (VLF) of sheet piling?

- A. 320
- B. 2,960
- C. 3,848
- D. 60,000

3. Approximately how many total board feet (BF) for all of the cofferdam components including the waste?

- A. 16
- B. 16,164
- C. 25,565
- D. 27,229

Wood Sheet Piling Material and Unit Cost Exercise

Given the information below and assume a Grand Total of 11,000 Board Feet, 3690 Square Feet of Contact Area, 5500 Vertical Lineal Feet includes the Piling, Wales, Braces and Waste for a Cofferdam. Answer the following questions.

Material	Size	Prices or Percentages
Sheet Piling (Toe = 3 feet)	3" x 13"	$550.MBF
Wales - 3 lines	6" x 8"	$550.MBF
Braces - 3 lines 12 Pcs per line. Each 9 feet long	6" x 6"	$550.MBF
Nails - 12 Lbs/100 Square Feet Contact Area		$35/Box, Box = 50 Lbs
Salvage Value		60%
Transportation & Shipping		$3.78/MBF
Sales Tax on Materials		4%
Timber Waste Factor	12%	

4. What is the Total Lumber Cost allocated to this project?

- A. $2,420
- B. $6,050
- C. $24,200
- D. $60,500

5. Approximately how many pounds of nails are required?

- A. 66
- B. 443
- C. 1,320
- D. 44,280

6. Assume the Total Material Costs for the Cofferdam above is $17,000 and using the information provided above. What is the Material Unit Costs per Vertical Lineal Feet ($M/VLF)?

- A. $0.65
- B. $1.55
- C. $3.09
- D. $4.61

Check Answers

Equipment Production and Unit Cost Examples

Hauling Production Example

Given that the 3 CY Hydraulic Backhoe will load at a rate of 150 CY/Hr and the Trucks will Haul 12 CY's per load to the Disposal Site 3 Miles Away. The Trucks will h Average 12 Miles per Hour (MPH) Loaded and 22 MPH Empty. Assume the truck Unload Time is 3 minutes.

1. Determine the truck round trip cycle time in hours (decimal of an hour).

Categories	Calculation	Time
Position	0 Minutes/60 minutes =	.000
Load	12 CY Truck/150 CY Backhoe =	.080
Haul Away	3 Miles Away/12.0 Miles Per hour Loaded	.250
Unload	3 minutes/ 60 minutes	.050
Return	3 Miles Away/22.0 MPH empty	.140
	Total Round Trip Time for 1 Truck	.520

2. Determine the Number of Round Trips/hour for one-truck

$$\frac{1}{.52/hr} = 1.92 \text{ trips/hour}$$

3. Determine the Number of Trucks needed to keep the Backhoe working efficiently.

$$\frac{\text{Backhoe Production}}{\text{Haul Unit Production}} = \frac{150 \text{ CY/hr}}{12 \text{ cy x } 1.92 \text{ Trips/hr}} = 6.5 \text{ use } 7$$

4. Verify the Production Rate by Back-checking.

$$\frac{7 \text{ trucks x } 1.92 \text{ Trips/hr x } 12\text{CY Truck capacity}}{\text{Backhoe capacity } 150 \text{ cy/hr}} = 1.07\text{hour or } 64.26 \text{ minutes.}$$

Hauling Equipment Unit Cost Example

Given that you must excavate 2,532 CY and the equipment production rates and hourly rates, mobilization, the crew size and hourly rates and the payroll burden.

No.	EQUIPMENT		Equipment Hourly Rate	Total Costs
1	Backhoe	2,532 CY / 150 CY/Hr = 16.88 hr x	$48.00 per hour	$810.24
	Backhoe Mobilization	$200/16.88 hr	$11.85 per hour	$200.00
			Total Backhoe Costs	$1,010.24
	Trucks		$13.10 pe hour	

No.	CRAFT		Hourly Rate	Total Hourly Costs
1	Crew Leader		$15.25 per hour	$15.25 per hour
1	Backhoe Operator		$12.45 pe hour	$12.45 pe hour
			Subtotal	$27.70 per hour
	Payroll Insurance	9.87% x $27.70		$2.74 per hour
	Payroll Taxes	14.55% x $27.70		$4.03 per hour
			Total Hourly Costs	$34.47 per hour

5. Determine the Backhoe Equipment Cost per Cubic Yard

$$\frac{\$1{,}010.24}{2{,}532\ \text{CY}} = \$0.40/\text{CY} \quad \text{or} \quad \frac{\$59.85\ \text{per hour}}{150\ \text{CY per hour}} = \$0.40/\text{CY}$$

6. Assume 7 trucks. Determine the Hauling Equipment Cost per Cubic Yard.

No.	EQUIPMENT	Equipment Hourly Rate	Total Hourly	CY per Hour	Cost per CY
7	12 CY Trucks	$13.10/hour	$91.70	/150.00	=.$0.61/CY

7. Determine the Labor Cost per Cubic Yard To Excavate.

$$\frac{\$34.47/\text{hour}}{150\ \text{CY/hour}} = \$0.23/\text{CY}$$

8. The rate includes burden. Determine the Labor Cost per Cubic Yard to Haul.

No.	CRAFT	Craft Hourly Rate	Total Hourly	CY/Hour	Cost per CY
7	Truck Drivers	$14.85/hour	$103.95	/150.00	=.$0.69/CY

Power Shovel Production Example

Given the Equipment Production Rates and Equipment Hourly Rates and the Labor Hourly Labor Rates below. Answer the following questions concerning the Backhoe Production.

No.	EQUIPMENT	Production Information	Equipment Hourly Rate	Craft Hourly Rate (Including Burden)
1	2.5 CY Shovel	36 Seconds	$55.00 per hour	$30.00 per hour
	Efficiency	50 minutes per hour		
	12 CY Trucks	2 Trips per hour	$37.50 per hour	$ 25.65 per hour

1. Determine the Bucket cycles per hour.

$$\frac{\text{60 seconds x 60 minutes}}{\text{36 seconds per cycle}} = \frac{\text{3600 seconds per hour}}{\text{36 seconds per cycle}} = \text{100 cycles/hour}$$

2. Determine the (Theoretical) Production Rate for the 2-1/2 C.Y. shovel in CY per hour.

$$\text{Bucket size/cycle x \#cycles/hour} = \frac{\text{2.5CY}}{\text{cycle}} \text{ x } \frac{\text{100 cycles}}{\text{hour}} = \text{250 cy/hour(Theoretical)}$$

3. Determine the true (Actual) output for the shovel in Cubic Yards per hour.

$$\frac{\text{50 minutes}}{\text{60 minutes}} = \text{83.3\% x 250 cy/hours} = \text{208 cy/hour}$$

4. Determine the number of trucks required to keep the Shovel working efficiently.

$$\frac{\text{Backhoe Production}}{\text{Haul Unit Production}} = \frac{\text{208 CY/hr}}{\text{12 CY x 2.00 Trips/hr}} = \text{8.66 use 9 Trucks}$$

5. Using 1 standby truck, Determine the Hauling Equipment Cost per Cubic Yard.

No.	EQUIPMENT	Equipment Hourly Rate	Total Hourly	CY per Hour	Cost per CY
10	12 CY Trucks	$37.50/hour	$375.00	/208.00	=.$1.80/CY

Steel Drum Roller Compaction Production Example

Given That you must compact 12,000 CY of Fill and the equipment production rates, the equipment hourly rates, mobilization and the crew size and hourly rates and the payroll burden for compacting are provided below. Answer these questions.

No.	EQUIPMENT	Production Information	Equipment Hourly Rate	
1	Vibrating Roller	10 Ton Roller, 5 feet wide	$12.00	
	Operating Costs		$1.50	
	Mobilization			$3,500

No.	CRAFT		Hourly Rate	Total Hourly Costs
2	Laborers		$12.00 per hour	$24.00 per hour
1	Roller Operator		$20.65 pe hour	$20.65 pe hour
			Subtotal	$44.65 per hour
	Payroll Insurance	9.87% x $44.65		$4.41 per hour
	Payroll Taxes	14.55% x $44.65		$6.50 per hour
			Total Hourly Costs	$55.56 per hour

Compaction Production Information

The Steel Drum Roller Compactor moves at 1.5 Miles per Hour working a 45 minute hour and 97% Proctor Density is developed after 6 passes for the 8 inch lifts.

1. Determine the true (Actual) Production rate in Cubic Yards per Hour.

$$\text{Compact} = \frac{[\text{width roller x prod speed mph x 5,280 feet per mile}]}{\text{\# passes x 27 CF/CY}} \text{ x lift x efficiency}$$

Note: The lift must be in a decimal of a foot

The efficiency must be in a decimal equivalency.

$$= \frac{[5' \text{ x 1.5 mph x 5280 feet per mile}]}{\text{6 passes x 27 cf/cy}} \text{ x} \frac{(8")}{(12")} \text{ x } \frac{(\text{45 minutes})}{(\text{60 minutes})}$$

$$= \frac{[39{,}600]}{162} \text{ x .67 x .75 = 122.83 CY per hour}$$

Steel Drum Roller Compaction Unit Cost Example

2. Determine the Equipment Cost per Cubic Yard ($EQ/CY) for the Steel Drum Roller.

No.	EQUIPMENT		Hourly Rate	Total Costs
1	Vibrating Roller	$\frac{12{,}000 \text{ CY}}{122.83 \text{ CY/ hr}}$ = 98 Hr	$12.00 per hour	$1,176.00
1	Operating Costs	= 98 Hr	$01.50 pe hour	$0,147.00
	Mobilization			$3,500.00
			Total Equipment $	$4,823.00

$\frac{\$4{,}823}{12{,}000 \text{ CY}}$ = $0.40/CY or	$\frac{\$13.50 \text{ per hour}}{122.83 \text{ CY/hour}}$ =	$0.11/CY
	$\frac{\$3{,}500}{12{,}000 \text{ CY}}$ =	$0.29/CY
		$0.40/CY

3. Determine the Labor Cost per Cubic Yard ($L/CY) for the Steel Drum Roller.

$$\frac{\$55.56/\text{hour}}{122.83 \text{ CY/hour}} = \$0.45/\text{CY}$$

Vibrating Plate Production and Equipment Unit Cost Example

Given That you must compact 12,000 CY of Fill and the equipment production rates and hourly rates, mobilization the crew size and hourly rates and the payroll burden for compacting are provided below. Answer these questions.

No.	EQUIPMENT	Production Information	Equipment Hourly Rate	
1	Vibrating Plate	21" wide and 24" long	$4.13	
	Operating Costs		$0.69	
		Total Equipment	$4.82	

No.	CRAFT		Hourly Rate	Total Hourly Costs
1	Laborer		$15.50 per hour	$15.50 per hour
	Payroll Insurance	9.87% x $15.50		$1.53 per hour
	Payroll Taxes	14.55% x $15.50		$2.26 per hour
			Total Hourly Costs	$19.29 per hour

Compaction Production Information

The vibrating plate moves at 50 feet per minute (FPM) working a 50 minute hour and 97% Modified Proctor Density is developed after 4 passes for the 8 inch lifts.

1. Calculate the production rate in Cubic Yards per hour for the vibrating plate.

$$= \frac{[21''/12'' \text{ plate width x } 50 \text{ FPM}]}{[4 \text{ Passes x}27 \text{ C.F. per C.Y}].} \text{ x } \frac{(8'')}{(12'')} \text{ lift x } 50 \text{ Minutes}$$

$$= \frac{1.75 \text{ x } 50}{108} = \frac{87.5}{108} = .81 \quad \text{x } 0.67 \text{ x } 50 = 27.14 \text{ CY/hour}$$

2. Determine the Equipment Cost per Cubic Yard ($EQ/CY) for the vibrating plate.

$$\frac{\$4.82/\text{hour}}{27.14 \text{ CY/hour}} = \$0.18/\text{CY}$$

3. Determine the Labor Cost per Cubic Yard ($L/CY) for the vibrating plate.

$$\frac{\$19.29}{27.14 \text{ CY/hour}} = \$0.71/\text{CY}$$

Equipment Production and Unit Cost Exercise

Given that you must excavate 7,255 CY. The equipment production rates, the equipment hourly rates, mobilization and the Crew, the Crew Hourly Rates and the Payroll Burden for Excavating are provided below. Answer the following.

No.	EQUIPMENT		Equipment Hourly Rate	Total Costs
1	Backhoe	80 CY per hour	$55.20 per hour	
	Backhoe Mobilization			$177
			Total Backhoe Costs	
	Trucks		$22.77 pe hour	

Excavation Crew

No.	CRAFT		Hourly Rate
1	Crew Leader		$12.35 per hour
1	Backhoe Operator		$11.85 per hour
1	Oiler		$10.15 per hour
			Subtotal
	Payroll Insurance	6.87%	
	Payroll Taxes	12.55%	
			Total Hourly Costs

Hauling Crew

No.	CRAFT		Hourly Rate
	Truck Drivers		$ 9.30 per hour

1. Given that the 1.5 CY Hydraulic Backhoe will load at rate of 80 CY/hr and the Trucks will Haul 10 CY per load to the Disposal Site 12 Miles Away. The Trucks will h Average 35 Miles per Hour (MPH) Loaded and 45 MPH Empty. Assume the truck Unload Time is 6 minutes. What is the truck round trip cycle time in hours (decimal of an hour)?

- A. 0.343
- B. 0.720
- C. 0.835
- D. 6.620

Equipment Production and Unit Cost Exercise

2. Assume that the round trip time is .266. How many Round Trips per hour for one-truck?

- A. 0.266
- B. 3.759
- C. 15.960
- D. 225.563

3. Assume that the round trips per hour for one truck is 1.197 Trips per hour. How many whole Trucks are needed to keep the Backhoe working efficiently?

- A. 2
- B. 7
- C. 8
- D. 16

4. What is the backhoe Equipment Cost per Cubic Yard?

- A. $ 0.01
- B. $ 0.71
- C. $ 0.97
- D. $36.80

5. Assume you are going to utilize 9 trucks. What is the Hauling Equipment Cost per Cubic Yard?

- A. $ 0.32
- B. $ 2.56
- C. $ 8.08
- D. 204.93

6. What is the Labor cost per CY ($L/CY) to EXCAVATE including Payroll Burden?

- A. $ 0.51
- B. $ 0.83
- C. $ 2.14
- D. $41.02

Equipment Production and Unit Cost Exercise

7. What is the Labor cost per CY ($L/CY) to HAUL using 6 trucks Drivers needed to keep the Backhoe productive including payroll burden.

- A. $ 0.12
- B. $ 0.83
- C. $ 1.20
- D. $66.63

8. Given the Backhoe Equipment Production Rates and Equipment Hourly Rates and the Labor Hourly Labor Rates below. Answer the following questions.

No.	EQUIPMENT	Production Information	Equipment Hourly Rate	
1	1.5 CY Backhoe	23 Seconds	$55.20 per hour	
	Efficiency	45 minutes per hour		
	10 CY Trucks	3 Trips per hour	$10.20 per hour	

How many Bucket cycles per hour can the backhoe complete?

- A. 0.006
- B. 0.383
- C. 2.610
- D. 156.5

9. What is the (Theoretical) Production Rate for the Backhoe in Cubic Yards per hour?

- A. 80.00
- B. 104.30
- C. 156.50
- D. 234.75

10. What is the true (Actual) output for the Backhoe in Cubic Yards per hour?

- A. 60.00
- B. 78.23
- C. 117.38
- D. 176.06

Equipment Production and Unit Cost Exercise

Given the Steel Drum Roller Compaction Production information and you must compact 7,500 CY of Fill. The equipment production rates, the equipment hourly rates, mobilization and the Crew, the Crew Hourly Rates and the Payroll Burden for compacting are provided below. Answer these questions.

No.	EQUIPMENT	Production Information	Equipment Hourly Rate	
1	Vibrating Roller	9 Ton Roller, 4 feet wide	$22.00	
	Operating Costs		$1.00	
	Mobilization			$3,000

No.	CRAFT		Hourly Rate
1	Roller Operator		$20.20 pe hour
			Subtotal
	Payroll Insurance	6.87%	
	Payroll Taxes	12.55%	

11. The Steel Drum Roller Compactor moves at 2 Miles per Hour working a 50 minute hour and 95% Proctor Density is developed after 8 passes for the 6 inch lifts. What is the true (Actual) Production rate in Cubic Yards per Hour?

- A. 0.017
- B. 1.832
- C. 81.480
- D. 21160.000

12. The Vibrating Plate is 24" wide and 26" long. The vibrating plate moves at 35 feet per minute (FPM) working a 45 minute hour and 95% modified Proctor Density is developed after 3 passes for the 6 inch lifts. What is the production rate in Cubic Yards per hour for the vibrating plate?

- A. 0.32
- B. 19.44
- C. 38.89
- D. 76,999.99

Check Answers

Excavation Quantity Takeoff

The process of ensuring a complete *Quantity Takeoff* requires the estimator to takeoff items by Division and Section number, Type of Work/Locations, Operations and sometimes type of operations. The following information will describe the process of identifying items while completing a quantity takeoff.

The *Divisions or Disciplines* are organized into basic groupings of related construction information. The Construction Specifications Institute's (CSI) Master Format uses Division 02 Sitework for site clearing and grubbing, dewatering, shoring and underpinning, cofferdams, earthwork, piles and caissons, paving and underground piping. The primary Division Sections this quantity takeoff will focus on are 02315 Excavation and Backfill, 02315 Trench Excavation and 02320 Hauling.

The *Types of Work Locations* are subsections within a Division or Major Discipline that indicate the type of work or the location of an activity to be installed. This is done because productivity and crew sizes differ by Type of work or Location. Some typical Type of Work Locations in the Excavation and Backfill Section are Building Excavation, or Trench Excavation. The *Operations* are the tasks performed for a particular Type of Work/Location such as Machine Excavate for the building. This process of completing a quantity takeoff indicating the Division and Section, the Type of Work/Location and the Operations for each Type of Work Location is a fundamental principle to ensure a complete item takeoff. The outline below identifies the Division and Section number and the Type of Work/Locations and Operations. For example, division 02 is Sitework and Section 200 Excavation Section the Type of Work locations and the Operations for 02200 would be as follows:

TYPE OF WORK LOCATIONS	OPERATIONS
TOPSOIL	MOBILIZE EQUIPMENT
SHEET PILING & COFFERDAMS	MACHINE EXCAVATE &
STRUCTURES-BUILDING EXCAVATION	DEWATER
PIERS OR CAISSON EXCAVATION	HAUL & TRAFFIC ADJUSTMENTS
TRENCH EXCAVATION	PURCHASE BACKFILL (MATERIAL $)
SITE EXCAVATION	BACKFILL
BORROW PIT EXCAVATION	COMPACT
ROAD EXCAVATION	SOIL ADJUSTMENT/ STABILIZE SOIL
PILING	DRIVE PILING OR SHORING
	PLACE PIPE AND MANHOLES

The *Topsoil Removal* can be performed with numerous arrangements of construction equipment and you have a couple of choices to make which are normally outlined in the Technical Specifications. The topsoil must be segregated from the structural fill and backfill materials. Therefore, you can remove the topsoil and haul it to another site or you may be instructed to stockpile on the site and reuse as landscaping materials after the construction is complete. The thickness for removal of topsoil can be found on the soil borings. Normally, the topsoil dimensions are either the entire site or the building area and parking areas. Sometimes the reports refer to topsoil as loam.

Assume that the site is 110' by 60 feet and the soil borings indicate an average of 6 inches to be removed. It is understood that all calculations are in decimals of a foot. Therefore, the total number of Cubic Yards of topsoil removal and stockpile for the entire site is

Description	Length	Width	Depth	Cubic Feet	Cubic Yards
Topsoil Removal	110'	60'	.5	3300CF/27 =	122.22 CY

Depth of the Excavation (Cut) for the Building Excavation
The Depth of the Cut for the Building goes down to the bottom of the fill under the Slab. This is an extremely important depth because it is utilized for the Building Excavation, the Working Space and the Angle of Repose calculations. For the Excavation and Concrete Plan and Detail Example attached, the depth of the cut is shown below.

$$[\![214.5' - .5']\!] - [\![204.00' - .33 - .42]\!] = 214.00 - 203.25' = 10.75' \text{ deep}$$

The rules for calculating the depth of the excavation are find the existing top elevation of the site (214.5') and then subtract the topsoil (6"/12") which has already been removed. Next, find the Finished Floor Elevation (204.00') and subtract the thickness of the concrete (4"/12") and also subtract the thickness of the compacted fill (5"/12") under the finished floor. Finally, subtract the Net Top Elevation (214.00') minus the Net Bottom Elevation (203.25') and the result will be the depth for the bulk building excavation.

Bulk Excavation
Bulk Excavation consists of the cubic yards of Building Excavation, Footing Excavation, Working Space, and Angle of Repose. These quantities of cubic yards added together is normally considered the bulk excavation.

Building excavation is calculated by using the outside wall dimensions and breaking the structure into recognizable shapes with dimensions to determine the areas. The areas are then multiplied by the Depth of the Excavation (cut) determined above. For the Excavation and Concrete Plan and Detail Example attached, the building excavation is shown below.

Description	Length	Width	Depth	Cubic Feet	Cubic Yards
Shape I	30'	45'	10.75'	14,512.5CF/27	537.50
Shape II	30'	30'	10.75'	9,675CF/27	358.33
Shape III	30'	15'	10.75'	4,837.5CF/27	179.17
Total Building Excavation in Cubic Yards					1,075.00

Footing Trench Excavation is along the outside perimeter and the depth is from the bottom of the Compacted area under the slab to the bottom of the footing. The trench width can be determined from the Trench Width Table attached at the end of this section. For the Excavation and Concrete Plan and Detail Example attached, the footing trench excavation is shown below. The length is the outside perimeter of the walls (90 + 15' + 30' + 15' + 30' + 15' + 30' + 45' = 270'. The width is from the Trench Width Table and for a 24' wide footing the trench with is 4.0 feet. Finally, the Depth of the Footing Trench is from the bottom of the Compacted area under the slab (203.25') to the bottom of the footing (198.00'). Therefore, the depth is 203.25 - 198.00 = 5.25'

Description	Length	Width	Depth	Cubic Feet	Cubic Yards
Footing Trench	270'	4'	5.25'	5,670CF/27	210

Working Space Excavation is the amount of space needed outside the structure to work placing footing forms, wall forms, drainage tiles and waterproofing the structure. The working space is normally estimated to be between 3 feet and 6 feet measured horizontally. The addition of the working space (12') to the wall perimeter (270') is called the Full Perimeter. For the Excavation and Concrete Plan and Detail Example attached, the working space excavation is shown below.

				Length	Width	Depth	Cubic Feet	Cubic Yards
a	90'	3	3	96'	3'	10.75'		
b	15'			16'	3'	10.75'		
c	30'			30'	3'	10.75'		
d	15'			15'	3'	10.75'		
e	30'			30'	3'	10.75'		
f	15'			15'	3'	10.75'		
g	30'			30'	3'	10.75'		
h	45'	3	3	51'	3'	10.75'		
	270	6	6	282'	3'	10.75'	9,094.5CF/27	336.83
	Wall	4 x 3 = W. S.		Full Perimeter				

Angle of Repose Excavation

The *Angle of Repose Excavation* is the amount of excavation need due to the type of soil being excavated. The type of soil that will be excavated can be determined from the soil borings. The OSHA Construction Safety Standards provide a guide based upon the Type of Soil classified as either Type A, Type B, or Type C and then the maximum allowable slopes are provided indicating the Run: Rise ratio. For our purposes, an Angle of Repose Table is provided for various types of soil classifications with their appropriate Run: Rise ratio.

Using the Excavation and Concrete Plan and Detail Example attached, and we are given a Firm Clay and we will use the 10.75' as the depth or vertical depth. Using the Angle of Repose Table for a Firm Clay, then the Run: Rise is found to be 2/3:1. For our example, this means that the vertical dimension is 10.75 feet and the horizontal dimension is 7.17 feet (.67' x 10.75'). For the Excavation and Concrete Plan and Detail Example attached, the angle of repose excavation is shown below.

Angle of Repose Building Exc = ½ (bh) x Full Perimeter

= ½ (10.75' x 7.17') x 282' = 10867.93CF/27 = 402.52 CY

Volume of the Corners Sloped Excavation is the amount of excavation needed because the corners are sloped. The volume of the sloped corners is short. The formula for the Volume of the Corners Short is:

$$V_{\text{SHORT in CF}} = \frac{(\text{Depth})^3}{12\ (n)^2}$$

n =Slope based on the type of soil and the run: rise ratio

Net Corners = Outside Corners - Inside Corners

$$\text{V total short CF} = \text{Net corners x V short each corner} = \text{Net Corners x } \frac{(\text{Depth})^3}{12\ (n)^2}$$

For the Excavation and Concrete Plan and Detail Example attached, the volume of the sloped corners excavation is shown below.

Net Corners = 6 Outside Corners - 2 Inside Corners = 4 Net

n = Firm Clay = 2/3: = .67

$$\text{V total short in CF} = \frac{4 \text{ net x } (10.75')^3}{12\ (.67)^2} = \frac{4 \text{ x } 1242.30}{12 \text{ x } .4489} = \underline{922.48\text{CF}/27} = 34.17 \text{ CY}$$

Total Excavation to be Hauled is the amount of excavation that must be hauled away which must be increased by a swell percentage of a particular soil. The amount to be hauled will consist of the cubic yards for the building excavation, the footing trench excavation, working space excavation, the angle of repose excavation and the sloped corners excavation. For the Excavation and Concrete Plan and Detail Example attached, the total excavation to be hauled for a Natural Bed Wet Clay is shown below.

$$\text{Swell \%} = \left(\frac{BCY}{LCY} - 1\right)100 \quad \text{Wet Clay} = \left(\frac{3400}{2800} - 1\right) 100 = (1.214 - 1) = 21.43\%$$

$$\text{Haul} = (\text{Building} + \text{Footing} + \text{Working Space} + \text{Angle of Repose} + V_{SHORT}) \times \text{Swell\%}$$

$$= (1{,}075.00 + 210.00 + 336.83 + 402.52 + 34.17) = 2{,}058.52 \times 21.43\%$$

$$\text{Total Haul} = 2{,}058.52 + 441.14 = 2{,}499.66 \text{ CY}$$

Compacted Fill

Compacted Backfill is the backfill around the structure. The type of fill is normally specified in CSI division and section number 02200. It normally states that backfill must be clean and free from debris, therefore, in many cases you must utilize a purchased structural grade fill. The backfill amount needed is increased by a shrinkage percentage. Backfill will consist of the cubic yards to be placed in the footing trench, the working space excavation, the angle of repose excavation and the corners short excavation. For the Excavation and Concrete Plan and Detail Example attached, the total compacted fill for a Damp Sand using the Modified Proctor method is shown below.

$$\text{Shrinkage \%} = \left(1 - \frac{BCY}{CCY}\right)100 \quad \text{Damp Sand} = \left(1 - \frac{3{,}130}{3{,}510}\right) 100 = (1 - .892) = 10.8\%$$

$$\text{Backfill} = (\text{Footing Trench} + \text{Working space} + \text{Angle of Repose} + V_{SHORT})\ \text{Sh\%}$$

$$= (210.00 + 336.83 + 402.52 + 34.17) = 983.52 \times 10.8\%$$

$$= 983.52 + 106.22 = 1{,}089.74$$

Trench Excavation
The *Sloped Utilities Trench Excavation* quantities are calculated based upon average depth of the trench. The technical specification's division and section number 02600 provide some of the slope information but many times the site plan will also provide the horizontal distances and the Invert elevations. The Invert elevation is the flow line of the pipe. The *Trench Average Depth* is calculated using depth at the start and the slope per foot to determine the depth at the other end. The average depth is an extremely important depth because it is used to determine the amount of trench excavation and the amount of the angle of repose excavation for the trench. For our example, assume that we have to place 75 feet of 30 inch diameter concrete pipe which is buried 6 feet at the building and the slope is 1/4 inch per foot. The average depth calculation is shown below.

Increase Other End = 75' x 1/4 per foot = 18.75"/12 = 1.56 Feet increase

Total Depth Other End = 6' + 1.56' = 7.56'

Average Depth = Start Depth + Total Other End Depth

= 6' + 7.56' = 13.56'/2 = 6.78'

Trench Excavation is the amount of cubic yards based upon the length of the trench, the width of the trench from the table and the average depth assuming the trench walls are vertical. Using our trench above the trench excavation is shown below.

Table TRENCH WIDTH BASED UPON PIPE DIAMETER 30" Diameter = 4.5' Trench Width

Description	Length	Width	Depth	Cubic Feet	Cubic Yards
Trench	75'	4.5'	6.78'	2,288,25CF/27	84.75

The Angle of Repose Excavation for the trench is based upon the type of soil to be excavated and the angle of repose is on both sides of the trench. We are given a Compacted Angular Gravel and we will use the 6.78' as the depth or vertical depth. Using the Angle of Repose Table for a Compacted Angular Gravel, then the Run: Rise is found to be 1/2:1. For our example, this means that the vertical dimension is 6.78 feet and the horizontal dimension is 3.39 feet (.50' x 6.78'). The angle of repose trench excavation is shown below.

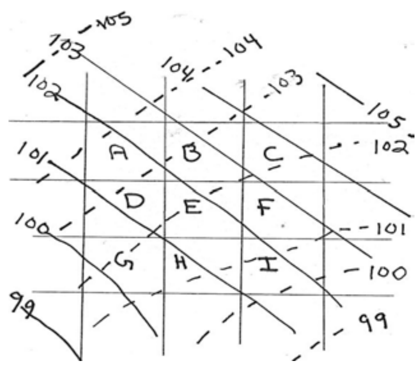
$$\text{Angle of Repose Trench} = \frac{\tfrac{1}{2}(bh) + \tfrac{1}{2}(bh) \times \text{trench length}}{27}$$

$$= \frac{\tfrac{1}{2}(6.78 \times 3.39) + \tfrac{1}{2}(6.78 \times 3.39) \times 75'}{27}$$

$$= 1{,}723.82/27 = 63.85\ \text{CY}$$

Cut Fill Excavation

The *Cut and Fill Method* uses the plot plan with the existing and proposed elevations shown and it establishes a grid system or square with a specified distance in each direction. Also, each grid has 4-points or corners each having an existing elevation and a proposed elevation. The corner of each grid starts in the northwest corner and moves counter clockwise. A grid can have all cuts, or all fills, or two cuts and two fills, or three cuts and one fill, or three fills and one cut. The example below utilizes a grid system of 100 feet but depending upon the variation in contours the grid system can change. Normally, if the elevation's change drastically you will utilize a smaller grid system. The Cut or Fill for Grid E are shown below.



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Grid = 100 Feet x 100 Feet
Existing Elevations - - - - - - - - - - - - - -
Proposed Elevations ________________

GRID NO.	TYPE OF ELEVATION	CORNERS 1	CORNERS 2	CORNERS 3	CORNERS 4	CUT VOLUME	FILL VOLUME
E	Existing	102.75	102.00	101.25	101.75		
	Proposed	101.75	102.75	101.75	101.00		
	Net Result	C - 1.00	F - 0.75	F - 0.50	C - 0.75	94.52	48.23

Using the information from Grid No. E above, the total volume for the cut and fill is:

$$V_c = \frac{L^2 \times (H_c)^2}{108 \times (H_c + H_f)} = \frac{100^2 \times 1.75^2}{108 \times [(1+0.75) + (0.75+0.50)]} = 94.52 \text{ CY}$$

$$V_f = \frac{L^2 \times (H_f)^2}{108 \times (H_c + H_f)} = \frac{100^2 \times 1.25^2}{108 \times [(1+0.75) + (0.75+0.50)]} = 48.23 \text{ CY}$$

Vc = Volume of cut in Cubic Yards (CY)	V_f = Volume of fill in Cubic Yards (CY)
Hc = Sum of cuts on four corners of grid.	Hf = Sum of fills on four corners of grid.
L = Length of side of grid Square in feet.	108 CY = 4 corners x 27CF per CY

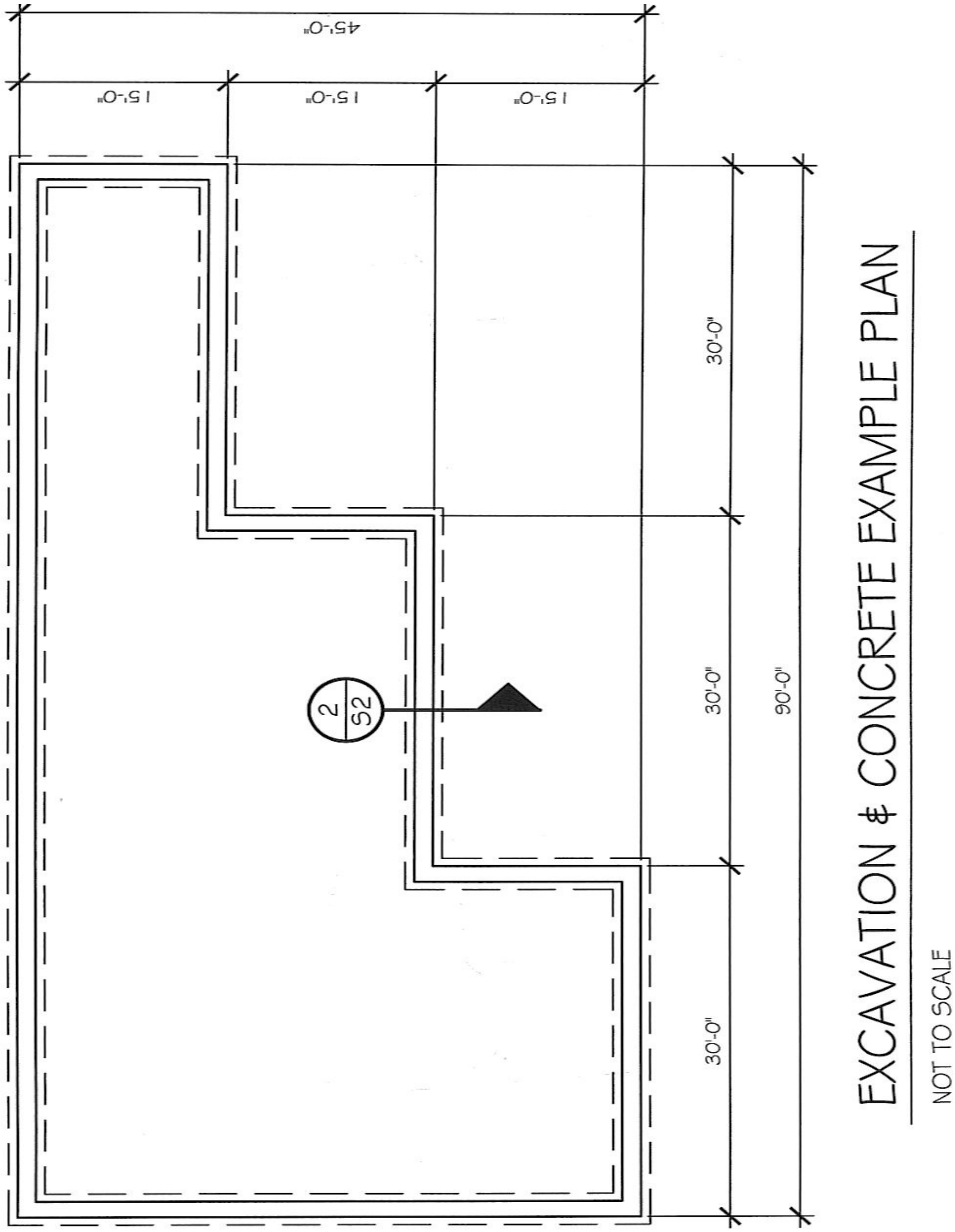
Caisson Auger and Bell Excavation

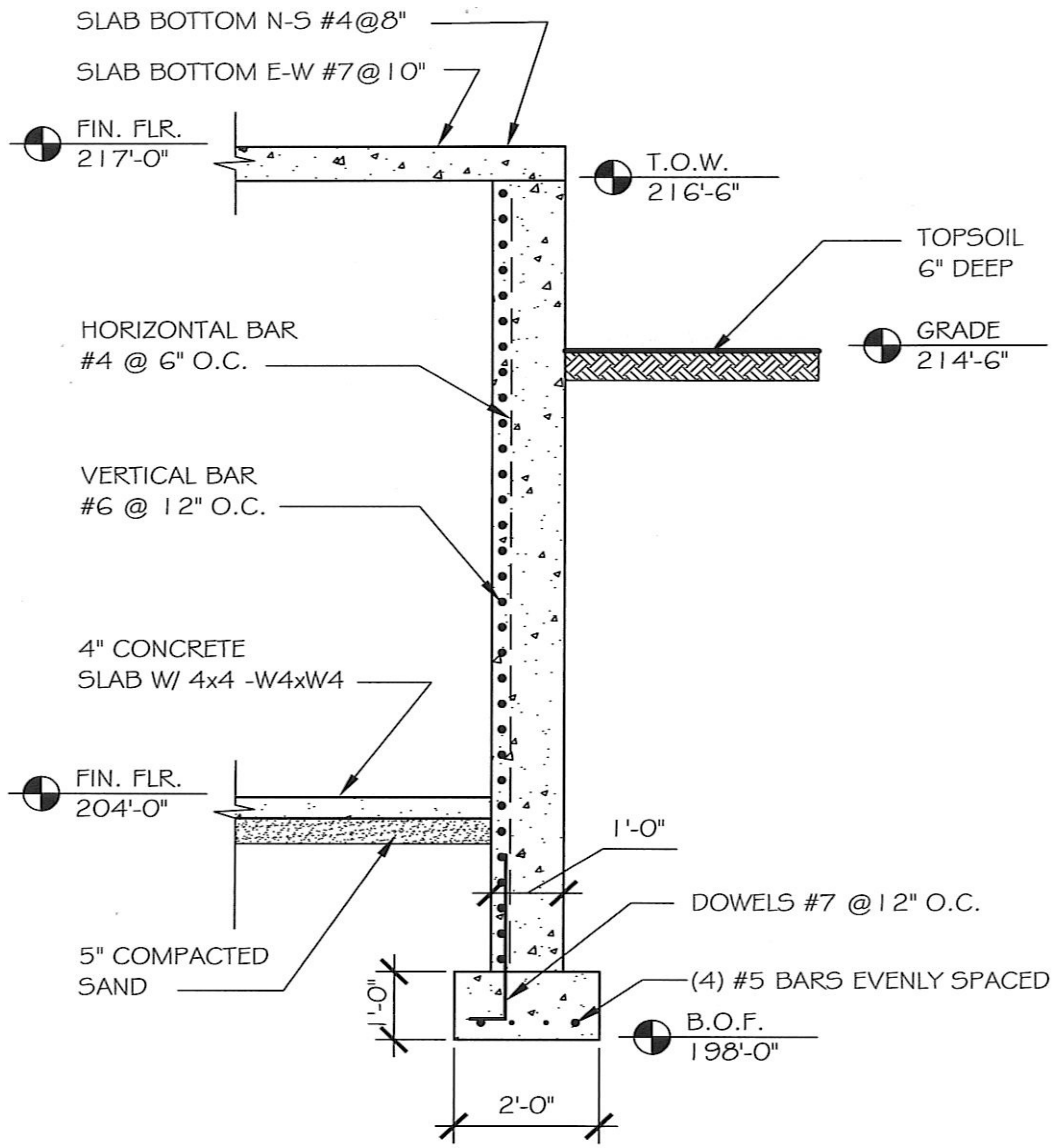
The *Caisson Auger Excavation and Bell Excavation* quantities requires you to calculate the Volume of the Shaft (V shaft) in cubic feet and determine the Volume Net in the Bell(V net bell) in cubic feet. Then add the Vshaft and the Vnet bell to determine the total Cubic Yards in the pier. The Vshaft = Π x r^2 x depth or 3.14 x r x depth + The Vnet bell (see Table) = Total Excavation

For example you are given a Round Pier or Caisson that is 18 feet deep, 2 foot diameter and the bell is 5 feet in diameter. The Vshaft = 3.14 x $(1')^2$ x 18' = 56.52 Cubic Feet (CF)

Using the Net Bell Volumes in Cubic Feet Table (p 140) from Daniel Atcheson's book *Estimating Earthwork Quantities* (1986), we find a value by using the Diameter of the Shaft in inches across the top of the table and using the Diameter of the bell along the side of the table in inches. The intersection of these two numbers determines the Vnet of the Bell in cubic feet. Using our example above, the Diameter of the Shaft is 24 inches and the Diameter of the bell is 60 inches. The intersection of these two values derives an additional Vnet of the Bell = 26.60 cubic feet. Therefore, the total volume of excavation is 56.52 CF + 26.6 CF = 83.12 CF/27 = 3.08 CY.

Dia. Bell	Atcheson's Table Net Bell Volumes (Cubic Feet) NET VOLUME IN THE BELL Diameter of Shaft												
	16"	18"	20"	22"	24"	26"	28"	30"	36"	42"	48"	54"	60"
24"	1.4	1.0	0.6	0.3									
28"	2.6	2.1	1.6	1.2									
30"	3.4	2.8	2.3	1.7	1.3	0.8	0.2						
32"	4.3	3.7	3.1	2.5	1.9	1.3	0.8						
36"	6.4	5.7	5.0	4.3	3.5	2.8	2.2	1.5					
42"	10.7	9.8	8.9	8.0	7.1	6.2	5.2	4.3	1.9				
44"	12.4	11.5	10.5	9.5	8.5	7.5	6.5	5.5	2.7	0.5			
48"	16.3	15.3	14.2	13.1	12.0	10.8	9.6	8.4	4.8	2.1			
54"	23.6	22.3	21.1	19.8	18.4	17.0	15.6	14.1	9.7	5.7	2.4		
60"	32.5	31.1	29.7	28.2	26.6	25.0	23.4	21.6	16.3	11.1	6.5	2.7	
64"		38.0	36.5	34.8	33.1	31.3	29.4	27.5	21.6	15.7	10.3	5.5	
68"		45.8	44.2	42.4	40.5	38.5	36.5	34.4	27.8	21.3	15.0	9.1	4.4
72"		54.6	52.8	50.8	48.8	46.7	44.5	42.2	35.1	27..7	20.5	13.8	8.0
84"		87.0	84.8	82.4	80.0	77.4	74.6	71.8	62.8	53.2	43.6	34.0	24.9


45'-0"
15'-0"
15'-0"
15'-0"
30'-0"
30'-0"
30'-0"
90'-0"
2
S2
EXCAVATION & CONCRETE EXAMPLE PLAN
NOT TO SCALE



EXCAVATION & CONCRETE EXAMPLE DETAIL

2
S2

N.T.S.

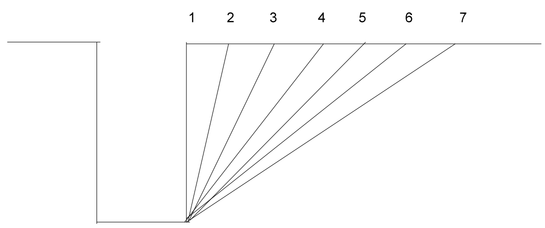
Excavation Tables
Average Soil Weights & Formulas

SOIL TYPE	LCY	BCY	CCY 100% STANDARD PROCTOR	CCY 100% MODIFIED PROCTOR	LOAD FACTOR
Clay - Dry	2050	2675	2835	3159	.81
Clay - Natural Bed Wet	2800	3400	3575	3959	.82
Sand - Dry	2420	2740	3362	3510	.85
Sand - Damp	2760	3130	3362	3510	.85
Gravel - Damp	2623	2980	3375	3645	.85
Common Earth - Dry	2185	2883	3375	3510	.80
Common Earth - Moist	2463	3160	3375	3510	.79
Loam	2100	2600	2835	3150	.81

Sw % $= \left(\frac{BCY}{LCY} - 1\right)100$	Load Factor (LF) $= \frac{100\%}{100\% + \%\ Swell}$
Sh % $= \left(1 - \frac{BCY}{CCY}\right)100$	LCY x LF = BCY
Shrinkage Factor (SF) $= \frac{CCY}{BCY}$	BCY x SF = CCY
Volume Cut (Vc) $= \frac{(L)^2\,(Hc)^2}{108\,(Hc + Hf)}$	$V_{Shaft} = \frac{\prod r^2 \times depth}{27}$
Volume Fill (Vh) $= \frac{(L)^2\,(Hf)^2}{108\,(Hf + Hc)}$	
Volume Mass Diagram $= \frac{\frac{A1 + A2}{2} \times Length}{27}$	V total short CF = Net Corners x $\frac{(Depth)^3}{12\,(n)^2}$
Roller Compaction $= \frac{[\text{width x mph x 5,280 feet per mile}] \text{ x lift x effic}}{\text{\# passes x 27 CF/CY}}$	Vibrating Plate $\frac{[\text{plate width x FPM}]}{[\text{\# Passes x27 CF/CY}]} \times \frac{\text{lift}}{(12")} \text{ x effic (min)}$

Excavation Allowable Slope or Angle of Repose

MAXIMUM ALLOWABLE SLOPE (ANGLE OF REPOSE) FOR THE SIDE OF AN EXCAVATION IN EXCESS OF 3' DEPTH



SLOPE (ANGLE OF REPOSE):

Slope (Angle of repose) RUN: RISE

1. Solid Rock Formation (90%)

2. Fractured Rock Formation
   1/4:1 (75°)

3. Stiff Clay with minimum 2.5 T.S.F.*
   1/2:1 (63°) or Compacted Angular Gravel

4. FIRM Clays with minimum 1.5 T.S.F.* 2/3:1 (56°)

5. Granular soil (dry) Dry Sand or Clay fill; dry sand and clay mixtures: medium clay with minimum of 1.0 T.S.F.* 1:1 (45°)

6. Granular soil (wet clay or silt seams), rubble or trash fill, firm or medium clays with running sand seams
   1 1/2:1 (34°) Compacted Sharp Sand

7. Saturated granular soil
   Soft Clays with less than 1.0 T.S.F.*
   2:1 (26°) Well Rounded Loose Sand

8. Running soil (Sand or Clay)
   3:1 (18°)

EXCAVATION - TRENCH WIDTH BASED UPON PIPE DIAMETER OR FOOTING WIDTH

Pipe Diameter	Minimum Trench Width at Bottom
8" and Under	2.5 Feet
10" -14"	3.0 Feet
15" - 20"	3.5 Feet
24"	4.0 Feet
30"	4.5 Feet
36"	5.0 Feet

Excavation Quantities Exercise

Given the information below for removal of topsoil from the entire site. Answer the following question.

GIVEN:
Assume the lot size is 60' X 75'
Topsoil is to be removed to a depth of 8"

1. How many Cubic Yards of topsoil must be excavated?

- A. 111.67
- B. 335.00
- C. 1,333.33
- D. 3, 015.00

2. Using the EXCAVATION TABLES. What is the swell percentage using a Loam?

- A. 08.3%
- B. 23.8%
- C. 31.9%
- D. 81.0%

3. What does Building Excavation mean?

- A. Excavation the entire site.
- B. Remove the topsoil from the entire site.
- C. Excavation to the bottom of the footing.
- D. Excavation to the bottom of the compacted fill under the floor.

Questions Number 3 through 7.
will use the 45 feet by 32 feet L-shaped EXCAVATION PROBLEM PLAN AND THE EXCAVATION PROBLEM DETAIL Attached.

4. What is the Total depth of the cut in Feet for the Building Excavation?

- A. 7.42
- B. 8.92
- C. 12.92
- D. 16.83

Excavation Quantities Exercise

5. How many Cubic Yards (CY) of Building Excavation must be excavated?

- A. 40.00
- B. 356.60
- C. 1,070.40
- D. 9,633,60

6. Assume that the working space is 4 feet. How many the Cubic Yards (CY) of Working Space Excavation must be excavated?

- A. 56.16
- B. 203.51
- C. 224.65
- D. 673.96

7. Assume that the excavation is **for a Compacted Sharp Sand Damp**. How many Cubic Yards (CY) of excavation for the Angle of repose?

- A. 125.24
- B. 250.49
- C. 480.88
- D. 751.15

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8. What is the swell percentage for a Compacted Sharp Sand Damp?

- A. 6.9
- B. 11.8
- C. 13.4
- D. 85.0

9. Using a Wet Sand and the Modified Proctor method, What is the shrinkage percentage?.

- A. 10.8
- B. 12.1
- C. 13.4
- D. 85.0

Excavation Quantities Exercise

10. Assume the depth of the excavation is 14' and the soil is a Firm Clay. What is the Run dimension in feet for the angle of repose?

- A. 3.00
- B. 9.33
- C. 14.00
- D. 21.00

11. Assume the depth of the excavation is 14' and the soil is a Compacted Angular Gravel. What is the Run dimension in feet for the angle of repose?

- A. 1.91
- B. 7.00
- C. 9.33
- D. 14.00

12. Assume the depth of the excavation is 14' and the soil is a Compacted Sharp Sand. What is the Run dimension in feet for the angle of repose?

- A. 7.00
- B. 9.33
- C. 14.00
- D. 21.00

Questions 13 through 16, utilizes the Trench information provided below.

13. The Trench is 224 Feet long and its starts 5 Feet below grade at the building and slopes 1/8 inch per Foot away from the building. The pipe is a 12 inch diameter Reinforced Concrete pipe. What is the Depth at the other end of the pipe in feet?

- A. 2.33
- B. 7.33
- C. 28.00
- D. 33.00

Excavation Quantities Exercise

14. What is the Average Depth of the Excavation?

- A. 1.17
- B. 3.67
- C. 6.17
- D. 7.33

15. Using the width of a trench for a 12 inch pipe is 3 feet. How many Cubic Yards of Trench Excavation with vertical walls must be excavated?

- A. 24.89
- B. 153.56
- C. 410.67
- D. 696.89

16. The Angle of repose is 9.25 feet (Run): 6.17 feet (rise). How many cubic yards of Trench excavation must be excavated for the Angle of Repose?

- A. 2.11
- B. 236.75
- C. 473.49
- D. 12,784.24

Questions 17 through 19 , refer to the Topography on the following page.

17. Looking at the existing elevations on the topography, which direction will the water flow towards?

- A. NE
- B. SE
- C. NW
- D. SW

18. What is the Net Result of the Cut/Fill in the South West corner?

- A. C - 0.5
- B. F - 0.5
- C. C - 1.5
- D. F - 1.5

Excavation Quantities Exercise

19. Given the Cut/fill Calculations for Grid Y below, What is the Fill Volume?

- A. 30.15
- B. 87.72
- C. 155.95
- D. 165.87
- E. 294.83

Check Answers

CUT AND FILL GRID CALCULATIONS

GRID NO.	TYPE OF ELEVATION	CORNERS				CUT VOLUME (CY)	FILL VOLUME (CY)
		NW	NE	SE	SW		
Y	Net Result	C - 1.5	F - 2.25	F - 3.25	C - 2.50		

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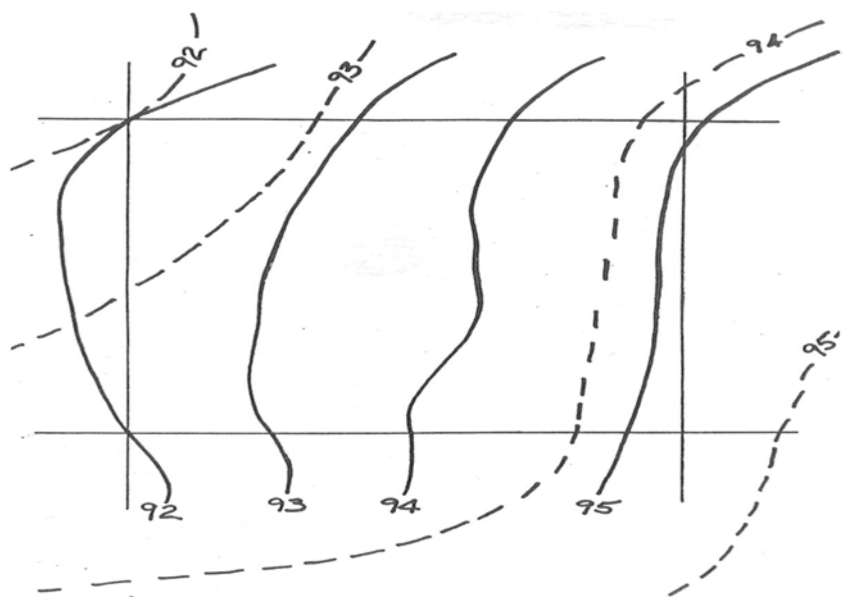
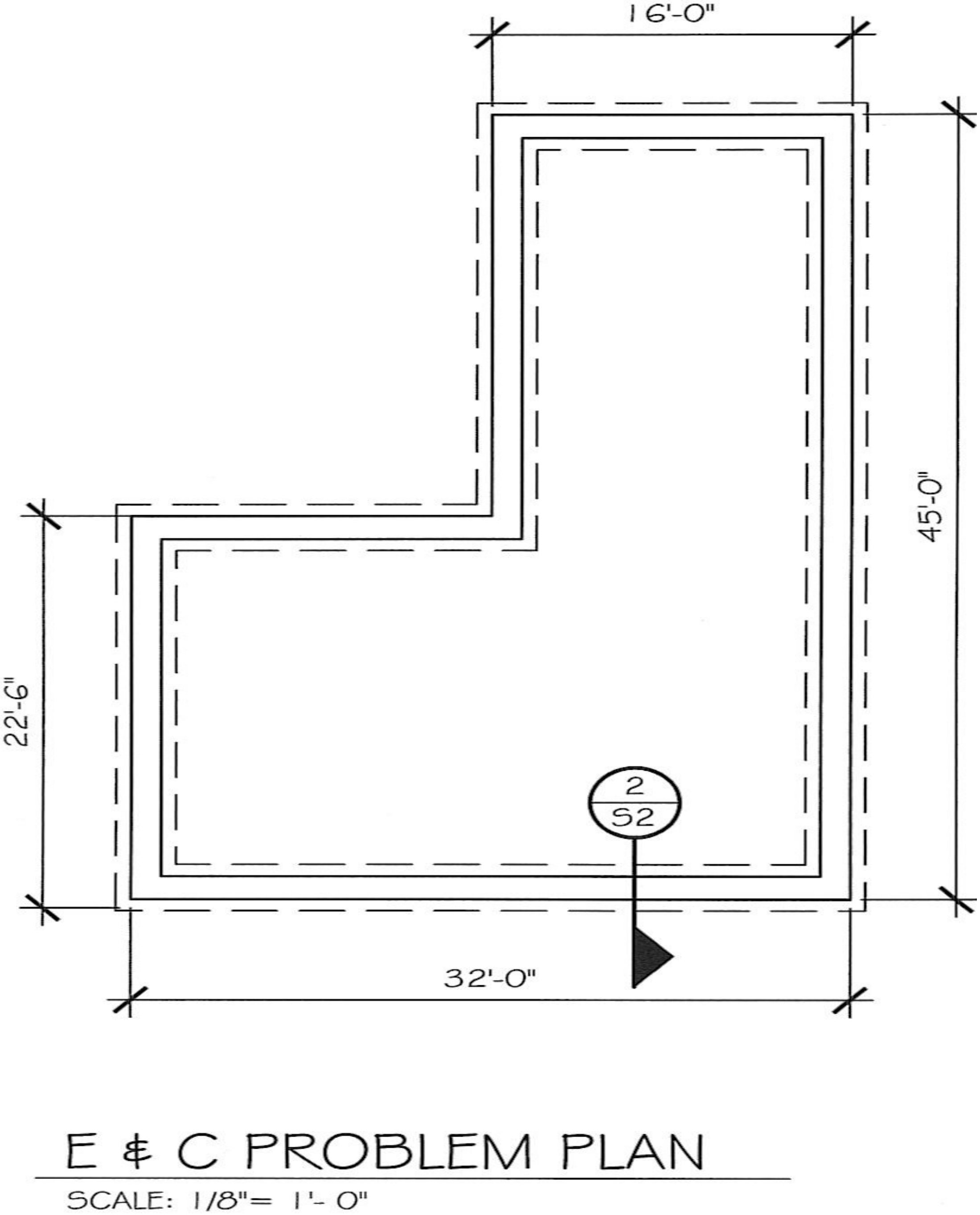


Grid = 75 Feet x 75 Feet

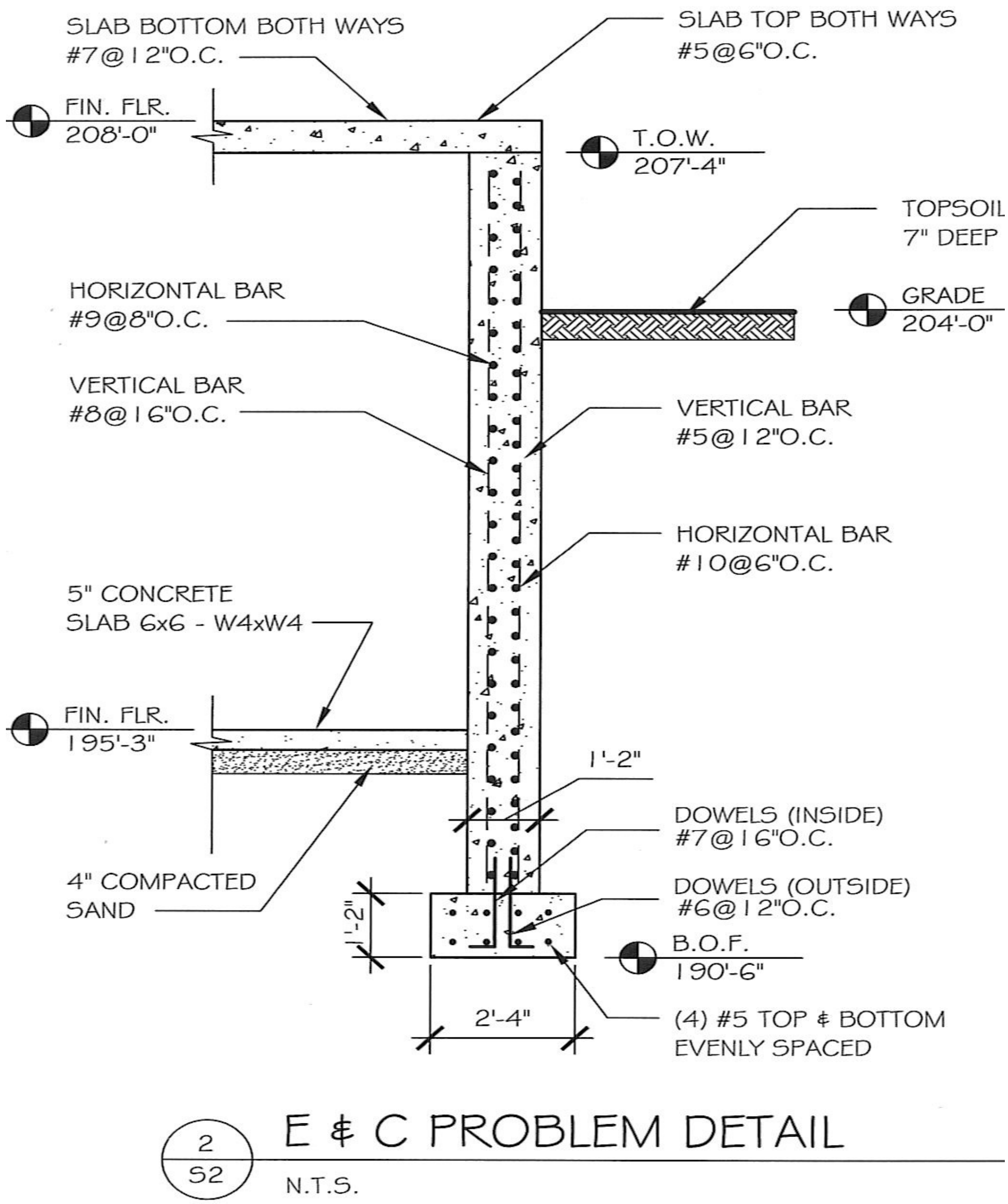
Existing Elevations - - - - - - - - -

Proposed Elevations ______________

Excavation Quantities Exercise

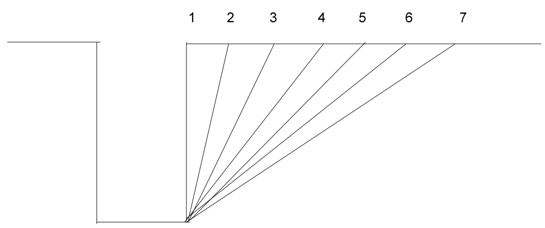


Excavation Quantities Exercise



Excavation Allowable Slope or Angle of Repose

MAXIMUM ALLOWABLE SLOPE (ANGLE OF REPOSE) FOR THE SIDE OF AN EXCAVATION IN EXCESS OF 3' DEPTH



SLOPE (ANGLE OF REPOSE):

Slope (Angle of repose) RUN: RISE

1. Solid Rock Formation (90%)
2. Fractured Rock Formation
   1/4:1 (75^{o})
3. Stiff Clay with minimum 2.5 T.S.F.*
   1/2:1 (63^{o}) or Compacted Angular Gravel
4. FIRM Clays with minimum 1.5 T.S.F.* 2/3:1 (56^{o})
5. Granular soil (dry) Dry Sand or Clay fill; dry sand and clay mixtures: medium clay with minimum of 1.0 T.S.F.* 1:1 (45^{o})
6. Granular soil (wet clay or silt seams), rubble or trash fill, firm or medium clays with running sand seams
   1 1/2:1 (34^{o}) Compacted Sharp Sand
7. Saturated granular soil
   Soft Clays with less than 1.0 T.S.F.*
   2:1 (26^{o}) Well Rounded Loose Sand
8. Running soil (Sand or Clay)
   3:1 (18^{o})

EXCAVATION - TRENCH WIDTH BASED UPON PIPE DIAMETER OR FOOTING WIDTH

Pipe Diameter	Minimum Trench Width at Bottom
8" and Under	2.5 Feet
10" -14"	3.0 Feet
15" - 20"	3.5 Feet
24"	4.0 Feet
30"	4.5 Feet
36"	5.0 Feet

Concrete Quantity Takeoff

The Construction Specifications Institute's (CSI) Master Format uses Division 03 Concrete for all activities related to the installation of concrete. The primary Division Sections this concrete quantity takeoff will focus on are 03100 Concrete Formwork, 03200 Concrete Reinforcement and 03300 Cast-in-Place Concrete.

Types of Work Locations are subsections within a Division and Section that indicate the type of work or the location of an activity to be installed. This is done because productivity and crew size differs by Type of work or Location. Some typical Type of Work Locations in the Concrete Division and Section are footings, walls and elevated slabs. The *Operations* are the tasks performed for a particular Type of Work/Location such as place forms, place rebar and place concrete for the building. This process of completing a quantity takeoff indicating the Division and Section, the Type of Work/Location and the Operations for each Type of Work Location is a fundamental principle to ensure a complete item takeoff. The outline below identifies the Division and section number and the Type of Work/Locations and Operations.

03100 Formwork, 03200 Concrete Reinforcement and 03300 Cast-in-Place Concrete

TYPE OF WORK LOCATIONS	OPERATIONS
PILE FOUNDATIONS OR CAPS	HAND EXCAVATE/BACKFILL
FOOTINGS	HAND COMPACT
MAT FOUNDATIONS	PLACE & STRIP FORMS
FOUNDATION WALLS	PLACE KEYWAY
FOUNDATION PIERS	PLACE WALL FORMS & BULK HEAD FORMS
GRADE BEAMS	PLACE WALL TIES
SLABS ON GRADE	PLACE REBAR
EQUIPMENT FOUNDATIONS	PLACE BOLSTERS
ELEVATED SLABS	PURCHASE CONCRETE - PSI
WALLS ABOVE GRADE	PLACE SCREEDS
COLUMNS	PLACE CONCRETE - METHODS
BEAMS AND GIRDERS	FINISH CONCRETE
STAIRS	ANCHOR BOLTS
	EXPANSION JOINT/WATER STOP

Concrete Formwork Systems
As shown above each Type of Work Location contains a set of Operations. The estimator must identify all of the individual components which make up the system to place concrete. Below is a brief description of the components which make up the various formwork and reinforcement systems. *The Footing Formwork System* operations are forms, stakes, nails and keyway. *The Footing Rebar System* operations are dowel bars, horizontal rebar in the top and bottom mats, tie wire, upper chairs and lower chairs, bar splicing and overlap requirements, and waste.

The *Wall Form System* operations are plyform with studs, wales, braces, chamfer strip, wall ties, tie clamps, nails, form oil, bulkheads and box outs. The *Wall Rebar System* operations are vertical rebar, horizontal rebar, tie wire, corner rebar, bar splicing and overlap requirements, and waste.

The *Column Form Systems* are either round or square columns and sometimes with capitals. The operations are plyform, capital forms, yokes or patented column clamps, bracing, chamfer strip, nails and form oil. The *Column Rebar System* operations are vertical bar, horizontal ties or a continuous spiral hoop bars, bar splicing and overlap requirements and waste.

The *Elevated Slab Form System* operations are edge forms, plyform, joists, stringers, posts, lacing, diagonal bracing and nails. There are numerous types of reinforced concrete floor systems. They are a solid slab supported by girders and columns, a flat slab with one way beams which uses pan forms, a flat slab with two way beams which also uses pan forms, a flat slab with drop panels and capitals, flat plates and a waffle flat plate which uses steel domes or pans. The *Elevated Slab Rebar System* operations are rebar in the top and bottom mats placed horizontally and vertically, upper slab bolsters, lower slab bolsters, tie wire, bar splicing and overlap requirements, and waste. The Elevated Beam System operations are plyform, joists, stringers, posts, lacing, diagonal bracing, chamfer strips and nails. These beam rest on the columns and they are sometimes an integral part of an elevated slab form system. The Elevated Beam Rebar System operations are rebar in the top and bottom placed horizontally, stirrups wrapped around, upper beam bolsters, lower beam bolsters, tie wire, bar splicing and overlap requirements, and waste.

The *Grade Beam System* is a horizontal beam which rests on footings or caissons spaced at specified intervals instead of resting on columns. The Grade Beam system operations are plyform, blocking, toe plates, ledgers, cross bracing and T-head shores. The Grade Beam Rebar System operations are rebar in the top and bottom placed horizontally, closed stirrups wrapped around, upper beam bolsters, lower beam bolsters, tie wire, bar splicing and overlap requirements, and waste.

The *Stair System* operations are stringer forms, riser forms beveled at the bottom and side forms.

Footing Formwork and Rebar Quantity Takeoff

Footing Forms are placed along the outside and the inside perimeter of the footing using the footing dimensions. The unit of measure for footing forms is Square Feet of Contact Area (S.F.C.A.) or Lineal Feet (L.F.). They are constructed of 2" lumber with the depth of the lumber being equal to the depth of the footing. Lumber can be purchased as 2 by 4", or 6", 8", 10", 12", 14" and 16" widths and stock lengths of 8', 10', 12', 14', 16', and 18'. An overlap of 2" at the corners is required along the outside perimeter. Also, lumber sizes are always referred to by its nominal dimensions. The footing forms for the Excavation and Concrete Plan and Detail Example attached is shown below.

Description		Wall	Extends	Extends	Total Length	Depth	SFCA
Forms Outside	A	90' +	.5' +	.5'	91'		
	B	15' +	.5' +	.5'	16'		
	C	30' +			30'		
	D	15' +			15'		
	E	30' +			30'		
	F	15' +			15'		
	G	30' +	.5' +	.5'	31'		
	H	45' +	.5' +	.5'	46'		
		270'	2	2	274'	1' =	274 SFCA
Forms Inside	A	91' -	2'	2'	87'		
	B	16' -	2'	2'	12'		
	C	30' -			30'		
	D	15' -			15'		
	E	30' -			30'		
	F	15' -			15'		
	G	31' -	2'	2'	27'		
	H	46' -	2'	2'	42'		
		274' -	8'	8'	258'	1' =	258 SFCA

Keyway is a trapezoidal shaped 2 inch deep material placed in the center of the concrete footing around the perimeter. It is beveled for ease in removing when the concrete has set up. For estimating purposes use the outside dimensions of the footing.

Keyway = 274'

Nails are ordered in 50# boxes using the table indicating the number of pounds per 100 S.F.C.A. of formwork. Normally 8d or 6d common double head nails are used for ease in removing formwork. Use the Nail Quantity Table provided for Footing Forms. The nails for the Excavation and Concrete Plan and Detail Example attached is shown below.

274 SFCA + 258 SFCA = 532 SFCA x 9 Lbs per100 SFCA = 47.88 pounds = 1 Box

Nail Quantity Needed for 100 Square Feet of Form Surface

Type of Form	Nails, Wire, Etc., Lb per 100 Square Feet of Contact Area (SFCA)
Footings and piers	9
Walls and partitions	8
Floors	8
Roofs	8
Columns	9
Beams and girders	12
Stairs	11

Note: Nails are purchased in 50 pound boxes.

Stakes are placed along the outside and the inside perimeter of the footing at three (3) to five (5) foot intervals. They are made of 2" by 4" lumber normally 18" to 28" in length.

Footing Rebar is placed inside the forms with a minimum cover of concrete from the sides of 1-1/2 inches. The footing rebar for a portion of the Excavation and Concrete Plan and Detail Example attached is shown below.

Description		Size	# Pieces	Length	Total LF	Lbs/ LF	Total Lbs
Footing Rebar	A	#5	4	90.75'	363'	1.043	378.61
	B	#5	4	15.75'	63'		
Inside 30' + 2' =	C	#5	4	31.75'	127'		
Inside 15' +2' =	D	#5	4	16.75'	67'		

Footing Rebar Lap Splices are needed whenever the length of a footing or wall is greater than 20 feet in length. This additional rebar known as lap splices must be added to the lineal feel of rebar. This requires the estimator to determine the number of laps and the length of the laps. Many times the splice lengths are specified as a certain number of bar diameters. The footing rebar for a portion of the Excavation and Concrete Plan and Detail Example attached is shown below. Using the 90.75 length on one side of a continuous footing, the standard rebar is 20 feet long, the splice length is specified as 24 bar diameter laps, and the plans call for #5 bar. From this information it can be determined that there are:

Lineal Feet of one side of footing is $= \dfrac{90.75 \text{ feet}}{20 \text{ feet}} \sim 5$ laps

Length of lap is = 24 x 5/8 inches = 24 x .625 inches = 15 inches or 1.25 feet per lap.

Lineal Feet of lap = 5 laps x 1.25 Feet = 6.25 feet per 90.75 feet. Therefore, the total lineal feet of lap for side A is 6.25 feet x 4 bars = 25 feet. Therefore, the total lineal feet of #5 reinforcement required for side A is 363 feet + 25 feet = 388 feet.

Wall Formwork and Rebar Quantity Takeoff

Height of the Wall

The height of the concrete wall is the distance in decimal of a foot from the top of the footing to the bottom of the elevated slab-finished floor. This is an extremely important height because it is utilized to calculate the wall forms, the reinforcement and the concrete. The height of the wall for the Excavation and Concrete Plan and Detail Example attached is shown below.

⟦216.5'⟧ - ⟦198.00' + 1.0'⟧ = 17.50'

Wall Forms are placed along the outside and the inside perimeter of the wall and the full height of the wall. The wall forms are calculated in Square Feet of Contract Area. The square feet of contact area for the wall forms for side A the 90' length of the Excavation and Concrete Plan and Detail Example attached is shown below.

Description		Length	Extends	Extends	Total LF	Height	SFCA
Wall Forms Outside	A	90'			90'	17.50'	1,575
Wall Forms Inside	A	90' -	1.0'	1.0'	88'	17.50'	1,540

Chamfer Strip is used to place a 45-degree angle on any exposed concrete corners such as outside corners, or exposed inside edges of square columns or exposed beams. This is to ensure that the aggregate is covered properly with cement paste. It is ordered in lineal feet.

Wall Rebars are placed opposite the force where the tensile force is greatest. In the Excavation and Concrete example the tensile force is the soil and the vertical and horizontal bars are placed approximately 1/3 the distance in from the interior concrete wall. Normally, the vertical and horizontal rebars are placed approximately 1/3 the distance in from each face. This is done if the forces are expected from both directions such as soil as a tensile force from outside and water as a tensile force from the inside. In this explanation, the rebars are placed on the inside and on the outside faces. The *horizontal wall rebar* for the Excavation and Concrete Plan and Detail Example attached is shown below. The plans call for the vertical bar attached to the dowels to be a #6 bar at 12 inches on-center with 2 inches of concrete cover. From this information, the calculations are as follows:

$$\text{\# sets Horizontal Bar} = \frac{17.5'}{.5'} = 35 \text{ spaces} + 1 \text{ starter} = 36 \text{ Pieces}$$

	Wall		Size	# Pieces	Length	Total LF	Lbs/ LF	Total Lbs
Horizontal Wall Rebar	90'	A	#4	36	89.75'	3,231.00		
	15'	B	#4	36	14.75'	531.00		
Inside 30' + 1'	31'	C	#4	36	30.75'	1,107.00		
Inside 15' + 1'	16'	D	#4	36	15.75'	567.00		
Inside 30' + 1'	31'	E	#4	36	30.75'	1,107.00		
Inside 15' + 1'	16'	F	#4	36	15.75'	567.00		
	30'	G	#4	36	29.75'	1,071.00		
	45'	H	#4	36	44.75'	1,611.00		
	274'			36 x	272	9,792		

Wall Rebar Lap Splices for the horizontal wall rebar is shown as follows. Using the standard rebar is 20 feet long, the splice length is specified as 30 bar diameter laps, and the plans call for the horizontal bar to be a #4 bar at 6 inches on-center with 1-1/2 inches of concrete cover.

$$\text{Lineal Feet of one side of footing is} = \frac{89.75 \text{ feet}}{20 \text{ feet}} \sim 5 \text{ laps}$$

Length of lap is = 30 x 4/8 inches = 30 x .500 inches = 15 inches or 1.25 feet per lap.
Lineal Feet of lap = 5 laps x 1.25 Feet = 6.25 feet for wall A (89.75 feet). Therefore, the total lineal feet of lap for side A is 6.25 feet x 36 bars = 225 feet. Hence, the total lineal feet of #4 horizontal reinforcement required for side A is 3,231 feet + 225 feet = 3,456 feet.

The Vertical Wall Rebar for the Excavation and Concrete Plan and Detail Example attached is shown below.

	Wall		Size	# Pieces	Length	Total LF	Lbs/ LF	Total Lbs
Horizontal Wall Rebar	90'	A	#6	90	17.50'	1,575.00		
	15'	B	#6	15	17.50'	262.50		
Inside 30' + 1'	31'	C	#6	31	17.50'	542.50		
Inside 15' + 1'	16'	D	#6	16	17.50'	280.00		
Inside 30' + 1'	31'	E	#6	31	17.50'	542.50		
Inside 15' + 1'	16'	F	#6	16	17.50'	280.00		
	30'	G	#6	30	17.50'	525.00		
	45'	H	#6	45	17.50'	787.50		
	274'			274	17.50'	4,795.00'		

Side A $\frac{89.75'}{1'}$ = 90 pieces

Side B $\frac{14.75'}{1'}$ = 15 pieces

The Concrete for the Walls uses the inside and the outside dimensions and it is calculated in Cubic Yards. The concrete for the Excavation and Concrete Plan and Detail Example attached is shown below.

				Length	Width	Depth	Cubic Feet	Cubic Yards
a	90'			90.00'	1.00'	17.50'		
b	15'	-1	-1	13.00'		17.50'		
c	30'			30.00'		17.50'		
d	15'			15.00'		17.50'		
e	30'			30.00'		17.50'		
f	15'			15.00'		17.50'		
g	30'			30.00'		17.50'		
h	45'	-1	-1	43.00'		17.50'		
	270	-2	-2	266.00'	1.00'	17.50'	4,655.00CF/27 =	172.41

Slab on Grade Rebar Quantity Takeoff

The *Welded Wire Fabric* (WWF) for the slab-on-grade is placed in the floor which uses the interior dimensions for the structure. The unit of measure for the WWF is in one-hundred Square Feet (C.S.F.). The welded wire mesh in hundred square feet for the Excavation and Concrete Plan and Detail Example attached is shown below.

Description	Length	Width	Square Feet	CSF
Shape I (inside)	28'	43'	1,204.00	12.04
Shape II (inside)	30'	28'	840.00	8.40
Shape III (inside)	30'	13'	390.00	3.90
			2,434.00	24.34

Elevated Slab Formwork Quantity Takeoff

The *Edge Forms* for a slab are placed around the outside perimeter. It is normally calculated in Lineal Feet (LF). The edge forms for the elevated slab for the Excavation and Concrete Plan and Detail Example attached is: 90' + 15' + 30' + 15' + 30' + 15' +30' + 45' = 270 Lineal Feet (L.F.). The *Slab Forms* for the elevated slab are placed under the slab on the inside of the walls. The slab forms are in Square Feet of Contact Area (S.F.C.A.). The slab forms for the Excavation and Concrete Plan and Detail Example would be 2,434 S.F.C.A.

Beam Rebar Quantity Takeoff

The *Beam Stirrups* for a beam are specified as an on-center spacing and usually the full length of the beam. The length of the rebar for each stirrup is the outside perimeter of the beam size minus the concrete cover. For our example below the concrete cover is 1-1/2 inches. Stirrups are calculated in lineal feet (LF). Therefore, the total lineal feet of stirrups is shown below.

Mark	No.	Beam Size (inches)		Reinforcing						#3 Stirrups			2" BB
				Bottom			Top				Support Bars		
		Width	Depth	No.	Size	Length	No.	Size	Length	O.C.	No.	L	
1B34	1	12	33	8	9	22' -9"	4	7	22' -9"	8"	2	11'	4

# of Stirrups = 22.75'/8" OC = 34 spaces + 1 starter = 35 pieces	
Length of a stirrup = 1' + 2.75' +1' + 2.75' = 7.5' - (4 x 0.125) = 7.0' per stirrup.	
Total Lineal Feet of stirrups = 35 pieces x 7 LF per Stirrup =	245.0
Lineal Feet of #3 Stirrup support bars 2 pieces x 11 feet =	22.0

Concrete and Rebar Quantities Exercise

Questions 1 through 10 refer to the E&C Problem Plan and the E&C Detail from the Excavation Quantities Exercise shown previously.

1. What is the height of the concrete wall?

- A. 12.83'
- B. 15.66'
- C. 16.80'
- D. 18.00'

2. How many total Square Feet of Contact Area (S.F.C.A.) for the Footing Forms?

- A. 114.67
- B. 185.08
- C. 298.64
- D. 348.41

3. How many total Square Feet of Contact Area (S.F.C.A.) for the Wall Forms?

- A. 154.00
- B. 2,411,64
- C. 4,676,70
- D. 5,226.20

4. How many total C.S.F.'s in the slab-on-grade?

- A. 0.91
- B. 9.05
- C. 14.40
- D. 905.50

5. How many cubic yards of concrete for the slab-on-grade?

- A. 14.09
- B. 39.41
- C. 377.21
- D. 1,064.17

Concrete and Rebar Quantities Exercise

6. How many Cubic Yards (CY) of Concrete for the Walls?

- A. 6.47
- B. 77.43
- C. 101.33
- D. 1,212.48

7. Assume that the cover is 1 inch. Assume that the bar is in 20 foot lengths and the bar laps are 28 bar diameters. How many total lineal feet of rebar in the elevated slab?

- A. 506.35
- B. 2,237,17
- C. 4,474.32
- D. 4,654.00

8. Assume that the cover is 2 inches. How many lineal feet of horizontal rebar is required for the walls excluding laps?

- A. 156.37
- B. 1,094.59
- C. 4,377.52
- D. 8,755.04

9. You are given the following beam information. Assume the cover is 2 inches.

Mark	No.	Beam Size (inches)		Reinforcing						#3 Stirrups			2" BB
				Bottom			Top				Support Bars		
		Width	Depth	No.	Size	Length	No.	Size	Length	O.C.	No.	L	
1B22	1	24	10.5	6	7	17' -2"	8	7	17' 2"	6"	4	10'	4

How many lineal feet of stirrups are required?

- A. 23.00
- B. 60.32
- C. 217.80
- D. 638.12

Concrete and Rebar Quantities Exercise

10. The Walls forms are job built for Wall A (45') which consists of 2"x 8" studs spaced 10 inches on-center with a top plate and a bottom plate and full height of the wall. How many board feet of lumber is required?

- A. 183.96
- B. 951.30
- C. 1,269.13
- D. 15,229.60

11. Where is the Keyway utilized in a forming system?

- A. Placed in the footing horizontally.
- B. Placed under a load-bearing wall.
- C. Place in the vertical concrete joint(s) between pours
- D. At the intersection of the concrete wall and the elevated slab.

12. Where is the chamfer strip utilized in a forming system?

- 1. Attached to the inside face of the formwork to form a texture.
- 2. Placed in the corners of exposed concrete to eliminate sharp edges.
- 3. Placed around the perimeter of an elevated slab to hold the concrete.
- 4. Placed in the exterior corners of the formwork to reinforce the walers.

13. On a Elevated Slab formwork system, Which dimensions do you use to calculate the amount of plyform for the elevated slab?

- A. The inside plan lengths and widths added together.
- B. The outside plan length and outside plan width added together.
- C. The outside plan length and outside plan width multiplied together.
- D. The height of the wall and the outside perimeter multiplied together.

14. On a Elevated Slab formwork system, Which dimensions are used to calculate the total Edge forms?

- A. The inside plan lengths and widths added together.
- B. The outside plan length and outside plan width added together.
- C. The outside plan length and outside plan width multiplied together.
- D. The height of the wall and the outside perimeter multiplied together.

Concrete and Rebar Quantities Exercise

Assume that you have to form and pour a concrete stair that is 4 feet wide with a top landing that is 4 feet by 4 feet. The total rise is 42 inches high and each step has a 7-inch rise and a 10-inch tread which is 6 inches thick and the slant distance is formed on the back side. The forms for the steps will consist of 5 stringers on the slant distance are made from 2' x 12 material and the risers for the front faces are made of 2 inch thick material. Answer the following questions about the stairs.

15. What is the horizontal distance in inches of the stairs?

- A. 6
- B. 42
- C. 50
- D. 65

16. What is the sloped distance for the stringers in feet?

- A. 1.02
- B. 3.50
- C. 4.17
- D. 5.44

17. How many board feet of formwork materials are needed for the front-face of the stairs?

- A. 20
- B. 44
- C. 72
- D. 864

18. How many cubic yards of concrete for the stairs including the landing?

- A. 0.91
- B. 8.82
- C. 24.66
- D. 238.11

Check Answers

Framing Quantity Takeoff

The Construction Specifications Institute's (CSI) Master Format uses Division 06 Wood and Plastics for all activities related to the installation of carpentry. The Division and Section Numbers are 06100 Rough Carpentry, 06200 Finish Carpentry and 06400 Architectural Woodwork.

Types of Work Locations are subsections within a Division and Section that indicate the type of work or the location of an activity to be installed. This is done because productivity and crew size differs by Type of work or Location. Some typical Type of Work Locations in the Rough Framing Division and Section are foundation walls, floors, walls and roofs. The *Operations* are the tasks performed for a particular Type of Work/Location such as place studs, place sheathing, and place the roof trusses for the building. This process of completing a quantity takeoff indicating the Division and Section, the Type of Work/Location and the Operations for each Type of Work Location is a fundamental principle to ensure a complete item takeoff. The outline below identifies the Type of Work/Locations and Operations for Division 06 and Section Number 06100 - Rough Carpentry

TYPE OF WORK LOCATIONS	OPERATIONS
FOUNDATION WALLS	PLACE STUDS
FLOORS	PLACE SILL PLATES
EXTERIOR WALLS	BUILD HEADERS, FRAME OPENINGS
INTERIOR WALLS	ATTACH SHEATHING, BRACING
ELEVATED WALLS	INSTALL WINDOWS, DOORS
CEILINGS	PLACE JOISTS
DOORS AND WINDOWS	SHINGLE
FINISH MILLWORK	INSTALL SIDING
FINISH HARDWARE	INSTALL SOFFIT
SIDING	BUILD STAIRS
ROOFING	WATERPROOF AND CAULKING
	PLACE INTERIOR TRIM
	INSTALL HARDWARE

Sub Flooring Framing Components

The sub floor system usually consists of the following components.

Beam or Girder	It is supported by the foundation wall to carry the load of the floor. This beam can be made of a solid wood beam, a steel beam or a built-up wood beam.
Columns	Are placed along the length of the Beam or Girder at specified intervals. These columns can be made of wood or steel.
Floor Joists	Are perpendicular to the beam and their size is governed by the floor load and the joist span.
Floor Trusses	Floor Trusses can also be used to replace the joists. These floor trusses are deeper but in return you can obtain longer spans and eliminate the center beam.
Sill Plate	This is placed on top of the foundation wall and secured to the wall using anchor bolts that have been placed in the concrete.
Rim Joists	Are nailed along on the ends of the joists.
Sub flooring	Placed perpendicular to the floor joists. Normally, consists of Tongue and Groove edges.
Termite Shield	Placed on top of the foundation wall to prevent termite damage.
Bridging	This is placed between the joist to prevent movement. In a Truss flooring system the bridging is along the bottom cord.
Floor Headers	Are headers placed perpendicular to the joists. They are normally doubled to carry the load. The short joists are called tail joists. These are placed in a floor opening for a stairs.
Trimmers	Are joists that have been doubled to carry the load. These are placed in a floor opening to accommodate the stairs.

Sub Flooring Quantity Takeoff

This is an L-Shaped structure with outside dimensions of 56 feet by 40 feet. The ends are 24 feet wide. The beam is placed in the center of the structure (12'). The Column Posts are placed 8' on-center. The Floor Joists are at least 12' long and they are placed 16" on-center.

DESCRIPTION	LENGTH	QUANTITIES
Beam or Girder	56 - 12 = 44 + 12 + 16 = 68' x 3=	204
Columns	44'/8' = 6+1 = 7,28/8' = 4+1 = 5	12 EA
Floor Joists	56'/1.33 = 42 + 1 = 43 x 2 = 86 16'/1.33 = 12 + 1 = 13 x 2 = 26 Under partition wall = 1	113 EA
Sill Plate	56' + 40' + 24 + 16 + 32 + 24 =	192 LF
Rim Joists	56' + 32 + 16 +16 =	120 LF
Subflooring	56' x 24' = 1344 16' x 24' = 0384 Total 1728 SF/ 32SF per Sheet	54 Sheets
Bridging		

Interior Wall Systems

Bottom Plate	This is a single plate used to secure the studs.
Top Plate	This is normally a Double Top Plate used to carry the roof load.
Interior Studs	Can be load bearing or non-load bearing. Spaced evenly.
Intersecting	Are vertical studs placed in the exterior wall to secure interior.
Headers	Are horizontal members used to carry the upper floor and roof.
Jambs	Are vertical studs used to provide support for the header.

Wall Framing Components

The Wall system can be for interior or exterior walls and they normally consist of the following components.

Exterior Wall System

Bottom Plate	This is a single plate used to secure the studs.
Double or Top Plate	This is normally a Double Top Plate used to carry the load of the roof. Also, the studs are secured to the plate.
Exterior Studs	Are normally load bearing and they are spaced evenly to carry the load of the upper floors and Roof.
Corner Studs	Are vertical studs in the corner of exterior walls to provide a smooth corner and nailing surface.
Headers/Lintels	Are horizontal members used to carry the upper floor and roof loads around a door or window opening.
Jambs	Are vertical studs used to provide support for the header.
Sills	Are horizontal members under a window sill.
Cripples	Are the vertical members under the window sill.
Wind Bracing	Is diagonal bracing placed in the exterior wall to provide stability and it used to resist horizontal wind loads.
Gable Ends	Are the vertical studs on the end of a Gable Roof.
Sheathing	Is the material placed on the exterior of the building to enclose the building, reduce air infiltration, brace the wall and provide a subbase for connecting the siding or masonry to the structure.

Wall Framing Quantity Takeoff
This is an L-Shaped structure with outside dimensions of 56 feet by 40 feet. The ends are 24 feet wide. Studs are 16" on-center. Gable Ends with 4/12 Slope.

DESCRIPTION	LENGTH	QUANTITIES
Bottom Plate	56 + 40 + 24 + 16 + 32 + 24 = 192	192 LF
Double Top Plate	192 x 2 = 384	383 LF
Exterior Studs	56/1.33=42+1=43 40/1.33=30+1=31 24/1.33=18+1=19 16/1.33=12+1=13 32/1.33=24+1=25 24/1.33=18+1=19	150 EA
Corner Studs	6 Corners x 2 studs =	012 EA
Headers/Lintels	2 doors x 2.92' wide x 3 headers 5 windows x 4.75' wide x 3 headers	
Jambs	5 windows x 2 per = 10 studs	
Sills	5 windows	
Cripples		
Wind Bracing		
Studs Gable Ends	24'/1.33=18 +1 = 19 x 2 sides	038 EA
Sheathing Gable Ends	192'/4' = 48 Sheets .5 (12' x 4') = 24SF x 4 =96/32 =3	51 EA

Types of Roofs

There are several common types of roof systems. They are the Shed Roof, the Gable Roof, Gambrel Roof, Hip Roof, Intersecting Roof, and the Mansard Roof. They are described below.

Shed Roof	The Shed Roof slopes in one direction.
Gable Roof	The Gable Roof Slopes in two directions.
Hip Roof	The Hip roof slopes in four directions.
Gambrel Roof	The Gambrel Roof has four slopes and it is made up of two separate sets of common rafters. This roof system is used to gain the use of the upper floor space. The upper set of rafters is relatively flat and the lower set is steep. This is a barn roof.
Intersecting Roof	The intersecting roof has four to six slopes depending on if the roof is two intersecting Gables or a Gable and a Hip.
Mansard Roof	The Mansard roof combines the Gambrel and Hip Roofs.

Roof Framing Components

The roof systems consist of the following components.

Common Rafters	The total length figures in the unit rise and the overhang.
Ridge Boards	Are at the peak of the roof.
Over hang	Is the horizontal projection beyond the exterior walls.
Hip Rafters	Are the longest rafters on a Hip roof.
Hip Jack Rafters	Are the shorter rafters on the ends of a Hip roof.
Valley Rafters	Are in the valley on both sides of an interesting roof.
Valley Jack Rafters	These are the short Rafters
Cripple Jack Rafters	Are between the Valley and the Hip in an intersecting roof.
Sloped Length	The top cord of the rafter. The increase in materials.
Roof Sheathing	Are placed perpendicular to the Rafters.
Fascia	Is attached to the tails of the rafters.
Barge board	Is the length of the common rafters at ends.

Roofing Terminology

These roofing terms are viewed as if you were looking at the cross section end (width) of a structure. These terms are utilized to determine various roof lengths. Therefore, the following terms and formulas are provided below.

The *Building Run* is considered one-half (½) of the Building Span.

The *Building Span* is the outside to outside width of the building.

The *Total Rafter Run* is considered one-half (½) of the Total Rafter Span.

The *Total Rafter Span* is the addition of the Building Span plus the Overhang distances.

The *Unit Run* is the horizontal run based upon 1 foot.

The *Unit Rise* is the Rise (height) for every 1 foot of Unit Run.

The *Slope* is the relationship of the Vertical Rise to the Horizontal Run.

The *Pitch* is the Vertical Rise divided by the Span. For Example, total roof rise is 4 feet and total span is 24 feet, therefore, the Pitch is 4/24 = 1/6 = 16.66%.

The *Unit Rafter Length* of a Common Rafter or *Rafter Constant*

$= \text{rise}^2 + \text{run}^2 = c^2$ or $c = \sqrt{\text{rise}^2 + \text{run}^2}$ = Unit Rafter Length

Assume a 7:12 roof slope, the Unit Rafter Length would be calculated as follows:

$c = \sqrt{(7)^2 + (12)^2} = \sqrt{193} = 13.89$ inches/12 = 1.1575 Rafter Constant

The *Total Length of the Common Rafter* is the Total run times the Unit Rafter Length

The *Hip and Valley Unit Rater Length* or Hip and Valley Constant

$= \text{common rafter}^2 + \text{run}^2 = c^2$ or $c = \sqrt{\text{common rafter}^2 + \text{run}^2}$ = Unit Hip Length

Assume the 7:12 roof slope from above. The hip and valley unit Length is:

$c = \sqrt{(13.89)^2 + (12)^2} = \sqrt{336.93} = 18.36$ inches/12 = 1.53 Rafter Constant

Gable Roof Quantity Takeoff Example
This is an L-Shaped structure with outside dimensions of 56 feet by 40 feet. The Gable ends are a total of 24 feet wide (Span), one side of the Gable has a 4/12 Unit rise: Unit run (slope) with a 14 foot Run. The other side of the Gable has a 3/12 Unit rise: Unit run (slope) with a 10' Run. The Overhang is 3 Feet. The Rafters are 16 inches on-center. Determine the Roof Rafter Constant(s).
Roof slope constant = $rise^2 + run^2 = c^2$ or $c = \sqrt{rise^2 + run^2}$

4/12 side $c = \sqrt{4^2 + 12^2} = \frac{12.65"}{12}$ / Foot = 1.05	3/12 side $c = 3^2 + 12^2 = \frac{12.37"}{12}$ / Foot = 1.03

The Total Rafter Run Length = Building Run plus the Overhang =

4/12 side = 14' + 3' = 17'	3/12 side = 10' + 3' = 13'

Total Length of the Common Rafter = Total Rafter Run x Roof Constant

4/12 side - 17' x 1.05 = 17.85'	3/12 side - 13' x 1.03 = 13.39'

Determine the Total Number of Common Rafters

DESCRIPTION	LENGTH	TOTAL	QUANTITIES
Common Rafters	Main 56'/1.33' = 42+1 =43 Extend 16'/1.33' = 12+1 =13 Total	112 EA	56 EA - 17.85' 56 EA - 13.39'

Determine the Hip and Valley Constant = Common Rafter^2 + Run^2 = c^2 or $c = \sqrt{CR^2 + Run^2}$

4/12 side $c = \sqrt{12.65^2 + 12^2} = \frac{17.44"}{12}$ / Foot = 1.45	3/12 side $c = 12.37^2 + 12^2 = \frac{17.23"}{12}$ / Foot = 1.44

Determine the length of the Valley and the Hip.

4/12 side - 17' x 1.45 = 24.65'	3/12 side - 13' x 1.44 = 18.72'

Ridge Boards	Main 56'+3'+3' - 13'=49' Intersecting 16'+17'+0 - 00=23 Total	82 LF	
Sheathing 4/12 3/12	17' x 33'=561 x 1.05=598 SF 17' x 32'=544 x 1.05=571 SF 13' x 46'=598 x 1.03=616 SF 13' x 47'=611 x 1.03=629 SF	2,414 SF	75 Sheets
Fascia	56'+3'+3'=62' 40'+3'+3'=46' 16'+0'+0'=16' 32'+0'+0'=32'	156 LF	
Barge board	17.85' x 2=35.70' 13.39' x 2=26.78'	62.48 LF	

Intersecting Gable Roof Quantity Takeoff Example
The main Gable roofs outside dimensions are 62 feet long and the Gable end is 28 feet wide. The Intersecting portion extends 20 feet beyond the 28-foot side and the intersecting portion is 28 feet wide. The overhang is 2 feet and the slope is 6:12. The Rafters are 16 inches on-center.

Determine the Roof Rafter Constant(s). Roof slope constant = $rise^2 + run^2 = c^2$ or $c = \sqrt{rise^2 + run^2}$

6/12 side $c = \sqrt{6^2 + 12^2} = \frac{13.42"}{12}$ / Foot = 1.12

The Total Rafter Run Length = Building Run plus the Overhang =

14' + 2' = 16 feet

Total Length of the Common Rafter = Total Rafter Run x Roof Constant

14' + 2' = 16 feet x 1.12 = 17.92 Feet use 18 Feet

Determine the Number of Common Rafters required.

DESCRIPTION	LENGTH		TOTAL
Common Rafters	Main Intersecting	62'/16" = 46.5 + 1 = 48 x 2 = 20'/16" = 15.0 + 1 = 16 x 2 =	128

Determine the Hip and Valley Constant = Common $Rafter^2 + Run^2 = c^2$ or $c = \sqrt{CR^2 + Run^2}$

6/12 side $c = \sqrt{13.42^2 + 12^2} = \frac{18.00"}{12}$ / Foot = 1.50

Determine the Total Length of the valley rafters = Total Rafter Run x Valley Constant.

14' + 2' = 16 feet x 1.50 = 24 Feet

Valley Rafters				2	2 - 24 Feet
Ridge Boards	Main Intersection	62' + 2' + 2' 20' + 14' + 2	= 66' = 36'	102'	
Roof Sheathing	Main Intersection	66' x 32' 20' x 32'	= 2,112 SF = 640 SF	2,752 SF	86 - 4' x 8' Sheets

Hip Roof Quantity Takeoff Example
This is an L-Shaped Hip Roof structure with outside dimensions of 56 feet by 40 feet. The ends are 24 feet wide. The slope is 3:12 with a 3-foot overhang. The rafters are 16 inches on-center.

Determine the Roof Rafter Constant(s). Roof slope constant = $rise^2 + run^2 = c^2$ or $c = \sqrt{rise^2 + run^2}$

3/12 side $c = 3^2 + 12^2 = \frac{12.37"}{12}$ / Foot = 1.03

The Total Rafter Run Length = Building Run plus the Overhang =

12' + 3' = 15 feet

Total Length of the Common Rafter = Total Rafter Run x Roof Constant

12' + 3' = 15 feet x 1.03 = 15.45 Feet use 16 Feet

Determine the Number of Common Rafters required.

DESCRIPTION	LENGTH		TOTAL
Common Rafters	Main L Shape	62'/16" = 46.5 + 1 = 48 x 2 = 16'/16" = 12.0 + 1 = 13 x 2 =	122

Determine the Hip and Valley Constant = Common Rafter^2 + Run^2 = c^2 or $c = \sqrt{CR^2 + Run^2}$

3/12 side $c = 12.37^2 + 12^2 = \frac{17.23"}{12}$ / Foot = 1.44

Determine the Total Length of the valley rafters = Total Rafter Run x Valley Constant

12' + 3' = 15 feet x 1.44 = 21.6 Feet

Determine the number of hips and valleys for the L-Shaped Hip roof.

Hips = 5 each 21.6 Feet long Valleys = 1 each 21.6 Feet long

Framing Quantity Takeoff Exercise

This structure is an intersecting hip roof with the main hip roof outside dimensions being 73 feet long and the width being 30 feet wide. The Intersecting portion extends 20 feet beyond the 30-foot side and the intersecting portion is 20 feet wide. The overhang is 2' - 6" and the slope is 5:12. The Rafters are 16 inches on-center.

1. What is the total length of the common rafters in lineal feet (LF)?

- A. 13.00
- B. 17.50
- C. 18.90
- D. 35.00

2. What is the total number of common rafters required for the roof?

- A. 55
- B. 72
- C. 112
- D. 144

3. What is the total length of the hip and valley rafters for the main roof in lineal feet (LF)?

- A. 15.00
- 2. 17.50
- C. 18.90
- D. 25.90

4. What is the total length of the hip/valley rafters for the intersecting roof in lineal feet?

- A. 12.50
- 2. 13.50
- C. 18.50
- D. 25.00

Framing Quantity Takeoff Exercise

5. What is the total number of hip rafters on the main portion of the roof?

- A. 2
- B. 4
- C. 6
- D. 8

6. What is the total number of hip and valley rafters on the intersecting portion of the roof?

- A. 4 hips
- B. 2 valleys
- C. 4 valleys
- D. 2 hips and 2 valleys

7. What is the total number of 4' x 8' sheathing required for the roof?

- A. 86
- B. 101
- C. 109
- D. 150

8. What is the hip and valley constant for an 8:12 sloped roof?

- A. 0.64
- B. 0.83
- C. 1.20
- D. 1.56

Check Answers

BUDGETING, COSTS, AND COST CONTROL

The Estimate and the Project Budget

The *estimate* is a static document at a specific point in time (Bid time). The estimate reflects what the project was bid for and the quantities and unit prices used.

The *project budget* continuously evolves until project completion. The project budget reflects the actual scope at the site and the actual quantities from construction issued drawings and a standard productivity rate. The project budget will always include change orders and extra work orders in terms of changed quantities and costs. These terms are important because the productivity and labor cost reports should reflect the project budget. Therefore, the project budget should reflect the actual quantities placed and a standard unit rate for each work activity.

This is considered the project budget. The project budget should be compared to the estimate but this comparison should only be made in the Project Cost Summary Report. This report compares the actual and projected quantities, workhours and costs for the project to the estimated costs. This reports the current status and the latest forecast of profit or loss by cost codes.

The Earned Workhour

An *Earned Workhour* is defined as the budgeted workhours earned for the quantity placed using the budgeted standard. The earned workhours for a work activity are calculated by multiplying the in place quantities (#units) by the budgeted standard workhours per unit rate (whr per unit).

$$EarnedWorkhour = Quantity\ placed\ (unit)\ x\ standard\ \frac{Whr}{unit} =$$

Determining the Budgeted Quantities

The budgeted quantities should reflect the actual project being built, therefore, these quantities should be calculated by someone in the office capable of determining the quantities for each work item from the construction issued drawings. These budgeted quantity takeoffs should be tabulated in enough detail for each work item that the field can easily identify the quantity. The quantity tabulation form should identify the take off by drawing numbers, revision numbers, area numbers, equipment item numbers, system numbers and elevation. These quantity tabulation sheets are sent to the field and they are used to show work completed.

There are three basic *Cost Control Reports*. They are the Earned Workhour Report, the Labor Cost Report and the Project Cost Summary Report. The purpose of the reports is to compare actual expenditures to the budgeted costs by the cost code established by the company and organized into a Work Breakdown Structure.

The Earned Workhour Report

This report is used by the superintendent to track productivity on each work activity. This report compares the actual workhour per unit rate to the budgeted workhour per unit rate on a daily or weekly basis for each activity. A budgeted Whr per unit rate is established for each work item (cost code) using the contractor's records for crew sizes and daily outputs. This budgeted Whr per unit rate is standardized throughout the company so that all superintendents are compared to the same workhour per unit rate for each work item. This budgeted standard unit rate may or may not be the rate used in the estimate, but for productivity purposes, all superintendents must be compared to the same rate. The budgeted standard unit rate is established by determining a base year, the standard crew size and daily output for each activity. The budgeted standard will never change, but the standard can be adjusted for each job due to working conditions, location and trade agreements.

The Earned Workhour Report is used to compare the actual workhours expended to the budgeted workhours and project the final workhours for each activity. The following discussion describes each column of the Earned Workhour Report and the procedure used to arrive at the answer.

1. *Cost Code*. The Cost Code in the Example is 035300.

2. *Activity Description*. The cost code and description are from the contractor's master code of accounts and all projects within the construction firm are assigned the same cost code with its respective activity description. The Activity Description in the example is Wall Forms 12".

QUANTITIES

3. *Budgeted quantities* are calculated from the plans and they reflect the actual quantities that must be placed. The Budgeted Quantity is found in the Estimate Ledger and it is

   1120 Square Feet of Contact Area.

4. *Weekly quantities* are the accumulated quantities that have been placed during the week. The Weekly Quantity is found in the Inplace Quantity Report and for the example it is

   60 Square Feet of Contact Area

5. *To Date quantities* are an accumulation of all previous weekly quantities. The Current Weekly Quantities are added to the To Date Quantity to arrive at the current To Date quantity placed. The To Date Quantity is found in the Inplace Quantity Report and for the example it is

   60 for Week + 64 (Previous Weeks) = 124 Square Feet of Contact Area.

6. *Unit* is the unit of measure used for that cost code. The Unit of measure in the example is SFCA which is an abbreviation for Square Feet of Contact Area..

EXPENDED WORKHOURS (Whr)

7. *Weekly workhours* are the accumulated workhours spent for the week. The Weekly workhours are found in the Weekly Labor Distribution and in the example it is 9 whr under the straight time (ST) column which are all hours worked.

8. *To Date Workhours* isare an accumulation of all previous weekly workhours. The Current Weekly Workhours are added to the To Date Workhours to arrive at the current To Date Workhours expended. The To Date Workhours is

   The current week of 9 workhours plus the previous workhours from the Detail Cost Ledger which is 15 workhours = 24 whr To Date.

EARNED WORKHOURS

9. *Earned Workhours* in this column are the total workhours earned to date using the budgeted workhour unit rate and the quantities placed To Date. The earned workhours are calculated by multiplying the To Date Quantities times the Budgeted Workhour/Unit. The Earned Workhours in the example are earned at the Budgeted unit Rate which is 192 Whr/1120 SF = .171 Whr/SF. Therefore, the total workhours earned is calculated as

Placed 124 SFCA x .171 Whr/SFCA = 21 Whr.

10. *Budgeted Workhours* are the total workhours estimated to perform this activity. The Budgeted Workhours are found in the Estimate Ledger and is 192 Whr.

UNIT WORKHOURS

11. *Budgeted Unit Workhour Rate* is expressed in Whr per unit (Whr/Uint). The budgeted standard rate is established company wide for each activity. The budgeted unit rate is calculated by taking the total Budgeted Workhours and dividing by the Budgeted Quantities. The Budgeted Workhours per unit rate in the example is

192 Whr/1120 SFCA = .171 Whr/SFCA

12. *Weekly Unit Workhour Rate* is expressed in Whr per unit (Whr/Uint). The weekly unit rate is calculated by taking the Weekly Expended Workhours and dividing by the Weekly Quantities placed. The Weekly Workhour per unit rate in the example is:

9 Whr/60 SFCA = .150 Whr/SFCA.

13. *To Date Unit Workhour Rate* expressed in Whr per unit (Whr/Uint). The To date unit rate is calculated by taking the To Date Expended Workhours and dividing by the To Date Quantities placed. The To Date Workhour per unit rate in the example is

24 Whr/124 SFCA = .194 Whr/SFCA.

PERCENTAGE these percentages are used to compare the total Earned to the Budgeted..

14. *Earned Percentage* is calculated by taking the total Earned Workhours and dividing by the total Budgeted Workhours. The Earned Percentage in the example is 21 Whr /192 Whr = 10.9%

15. *Expended Percentage* is calculated by taking the total Expended Workhours and dividing by the total Budgeted Workhours. The Expended Percentage in the example is 24 whr To Date expended/192 Whr Budgeted = 12.5%.

PROJECTED WORKHOURS

16. *Projected at Completion Workhours* is a forecast of the total Workhours to be spent when the estimated quantity is 100% complete. Using the *Straight Line projection* method, the projected workhours at completion is calculated by multiplying the to Date Workhour Unit Rate times the Total Budgeted Quantities. The Workhours Projected at Completion in the example is:

    1120 SF x .19 Whr/SFCA = 213 Whr. (Three decimals .194 Whr/SF = 217 Whr.)

17. *Projected Gain or (Loss)* is calculated by subtracting the Projected Workhours at Completion from the Total Budgeted Workhours and showing the net result. A (loss) is shown in parentheses. If the Projected Workhours at Completion is greater than the Total Budgeted Workhours, you will show a (LOSS) in this column. If the Projected Workhours at Completion is less than the Total Budgeted Workhours, you will show a GAIN in this column. The Projected Workhour Gain or (Loss) in the example is:

    Budgeted Whr = 192 Whr - 213 Projected = (21) a loss.

The completed Earned Workhour Report is shown on the following page.

Earned Workhour Report Example

PROJECT NAME: Jobsite USA

PROJECT NUMBER: 001

CODE	DESCRIPTION	QUANTITIES			UNIT	EXPENDED WORKHOURS		WORKHOURS		UNIT WORKHOURS			PERCENT		PROJECTED	
		BUDGET	WEEK	TO DATE		WEEK	TO DATE	EARNED	BUDGETED	BUDGET	WEEK	TO DATE	EARNED	EXPENDED	COMPLETION	GAIN/ LOSS
035300	Wall Forms	1120	60	124	SF	9	24	21	192	.17	.15	.19	10.9	12.5	213	(21)

		Estimate Ledger	Inplace Qty Current Week	Inplace Qty Current Week + Previou s Qty's 60 + 64		Labor Dist Current Week	Labor Dist Current Week + Detail cost 9+15	⇑ ⇑ ⇑ ⇑ ⇑ ⇑ ⇑ ⇑		Estimate Ledger	192 Whr 1120 Sf	9Whr 60 Sf	24 Whr 124 Sf	21 Whr 192 Whr	24 Whr 192 Whr	⇑ 192 ⇑ - 213 ⇑ (21) ⇑ ⇑ ⇑ ⇑ ⇑
				124	Sf	-------------------------------		X		-------------- -	.17 Whr Sf					
		1120 Sf	---					X		-- -			.19 Whr Sf	--		
									192		Minus				213	= (21)

Inplace Quantities Report for the Example

PROJECT NAME ____Jobsite USA___________

PROJECT NUMBER ______001____________

Cost Code	Description	Unit	M	T	W	T	F	Week Total	Previous Total	To Date Total
035300	Wall Forms	SFCA	0	0	0	0	60	60	64	124

Week 2 Labor Distribution Report for of the Example

PROJECT NAME___Jobsite U.S.A.__ PAYROLL ENDING August 5
PROJECT NUMBER _____001_______ PAYROLL NUMBER ______6_______

Cost Code	Craft	WORKHOURS							TOTAL		RATE		TOTAL	
		M	T	W	Th	F	S	S	PT	ST	PRM	REG	PRM	REG
035300	Carp					2/3			2	3	2.50	5.00	5.00	
	Cp					1/3			1	3	4.25	8.50	4.25	25.50
	Cp					/3				3		8.00		24.00
						3/9			3	9			9.25	64.50

Note: PT indicates Premium Time.
ST indicates Straight Time.

PRM means Premium or the Overtime Pay a person earns.
REG Means the Regular Pay a person earns.

Estimate Ledger for the Example

PROJECT NAME JOBSITE USA PROJECT NUMBER 001					COST CLASSIFICATION				
					1	2	4	5	
Cost Code	Description	Quantity	Unit	Workhours	Labor Cost	Material Cost	Equipment	Subcontract	Total
	Wall Form - Original	720		122.00	2310.00	400.00			2710.00
	C.C.O. #7	400	Sf	70.00	1285.00	504.00	300.00	207.00	2296.00
035300	Wall Forms 12"	1120	Sf	192 Whr	3595.00	904.00	300.00	207.00	5006.00

Detailed Cost Ledger for the Example

PROJECT NAME JOBSITE USA PROJECT NUMBER 001						COST CLASSIFICATIONS				
						1	2	4	5	
Cost Code	Date	Description	Ref	Quantity	Workhours	Labor Cost	Material Cost	Equipment	Subs Cost	Total Cost
035300	7/24	Wall Forms	PR5		15	105.45		421.00		526.45
	8/01		PO7				1141.00		220.00	1141.00
	8/01		SC 44						220.00	220.00
					15	105.45	1141.00	421.00		1887.45

The Labor Cost Report

This report is used to compare the actual labor costs to the budgeted labor costs and project the final cost for each activity. The budgeted labor costs are obtained from the estimate ledger which shows the revised estimated cost. The actual labor costs are obtained from the weekly labor distribution and balanced with the detail cost ledger. Finally, the Labor Cost Report could be called the Equipment Cost Report and the report could be used to determine the equipment cost per unit (equip $/unit) instead of labor cost per unit on construction projects that are equipment intensive.

1. *Cost Code*. The Cost Code in the Example is 035300.
2. *Activity Description*. The cost code and description from the contractor's master code of accounts assigned to each activity that must be performed on the project. The Activity Description in the example is Wall Forms 12".

3. *Budgeted quantities* are calculated from the plans and they reflect the actual quantities that must be placed. The Budgeted Quantity is found in the Estimate Ledger and for the example it is 1120 Square Feet of Contact Area..

4. *Weekly quantities* are the accumulated quantities that have been placed during the week. The Weekly Quantity is found in the Inplace Quantity Report and for the example it is 60 Square Feet of Contact Area..

5. *To Date quantities* are an accumulation of all previous weekly quantities. The Current Weekly Quantities are added to the To Date Quantity to arrive at the current To Date quantity placed. The To Date Quantity is found in the Inplace Quantity Report and for the example it is 60 for Week + 64 (Previous Weeks) = 124 Square Feet of Contact Area..

6. *Unit* is the unit of measure used for that cost code which is SFCA.

EXPENDED LABOR DOLLARS

7. *Weekly Expended Labor Costs* are obtained from the Weekly Labor Distribution by adding the Total Premium (PRM) costs plus the Total Regular (Reg) cost. The Weekly Expended Cost from the Labor Distribution Week 2 is

   $9.25 (PRM) + $64.50 (Reg) = $73.75.

8. *To Date Expended Labor Costs* are an accumulation of all previous weekly labor costs. The Current Weekly Labor Costs from the Weekly Labor Distribution are added to the To Date Labor Costs from the Detail Cost Ledger to arrive at the Current To Date Labor Cost. In the example, it is the $73.75 for the Week plus $105.45 from the Detail Cost Ledger = $179.00.

BUDGETED COST

9. ____*Total Budgeted Costs* are obtained from the Estimate Ledger. This figure is the original estimated labor cost plus or minus all approved contract change orders. The Total Budgeted Cost in the Estimate Ledger from the labor column is $3,595.00

UNIT COSTS

10. *Budgeted Unit Costs* are calculated by taking the total estimated labor costs and dividing by the Budgeted Quantities. The unit costs are always expressed in LABOR COSTS per unit ($L/unit). The Budgeted Labor Cost per unit in the example is:

$3,595/1120 SFCA = $3.21/SFCA

11. *Weekly Unit Costs* are calculated by taking the Weekly Expended Labor Costs and dividing by the Weekly Quantities placed. The example Weekly Labor Cost per unit is:

$73.75/60 SFCA = $1.21/SFCA

12. *To Date Unit Costs* are calculated by taking To Date Expended Labor Costs and dividing by the To Date Quantities placed. The To Date Labor Cost per unit in the example is:

$179.00/124 SFCA = 1.44/SFCA

PROJECTED LABOR COST

13. *Projected at Completion Labor Costs* is a forecast of the total labor cost to be spent when the estimated quantity is 100% complete. Using the Straight Line projection method, the projected labor cost at completion is calculated by multiplying the To Date Unit Cost ($/unit) times the Total Budgeted Quantities. The Projected Labor Cost at Completion is:

1120 SFCA x $1.44/SFCA = $1,613

14. *Projected Gain or (Loss)* is calculated by subtracting the Projected Labor Cost at Completion from the Total Budgeted cost and showing the net result. A (LOSS) is shown in parentheses. If the Project Labor Cost at Completion is greater than the Total Budgeted Cost, you will show a (LOSS) in this column. If the Projected Labor Cost at Completion is less than the Total Budgeted Cost, you will show a GAIN in this column. The Project Labor Cost Gain or (Loss) is:

$3595 Budgeted - $1,613 Projected = $1,982.

The completed Labor Cost Report is shown below.

Labor Cost Report for the Example

PROJECT NAME JOBSITE USA
PROJECT NUMBER __001__

CODE	DESCRIPTION	QUANTITIES				EXPENDED COST			UNIT COST			PROJECTED	
		BUDGET	WEEK	TO DATE	UNIT	WEEK	TO DATE	BUDGET TOTAL	BUDGET	WEEK	TO DATE	COMPLETION	GAIN/LOSS
035300	Wall Forms	1120	60	124	Sf	73.75	179	3595	$3.21/Sf	1.21/Sf	1.44/Sf	1613	1982

		Estimate Ledger Qty	Inplace Qty Current Week	Inplace Qty Current Week + Previous Qty's 60+64		Labor Dist. Current Week $73.75	Labor Dist. Current Week + Detail Cost $73.75 + 105.45	Estimate Ledger $	$\frac{\$3595}{1120Sf}$	$\frac{\$74}{60\ Sf}$	$\frac{\$179}{124\ Sf}$		
		1120 Sf					X				1.44/Sf		
						3595	minus					1613	

The Project Cost Summary Report
This report is the most valuable report in terms of the overall project because it sums up all actual and projected quantities, workhours and costs for the project by cost code and compares them to the budget by cost code. The projected cost compared to the estimated cost shows the latest prediction of a profit or loss for the overall project. This report forewarns management of specific work items that must be scrutinized closely to reduce losses to a minimum. If used properly, the project cost summary can be used to implement accurate decisions before the costs spiral out of control. The Projected Cost Summary Report is prepared from the budget and detail cost ledgers and balanced to the accounting ledgers. The following discussion describes each column of the Project Cost Summary Report and the procedure used to arrive at the correct answer.

1. *Cost Code*. The Cost code for the example is 035316.

2. *Activity Description*. The activity description associated with the cost code of 035316 is Wall Forms - 12".

3. *Item*. This Column summarizes the Budget, Actual Costs and Projected costs for each cost code by the following items.

CODE	ITEM
	Quantity
	Workhours
	Labor
	Material
	Equipment
	Subs
Sub Total Costs	

BUDGET INFORMATION from the Estimate Ledger

4. *Original Budgeted column* should reflect the quantities, workhours and cost classifications taken from the original column in the estimate ledger. The Original Budget in the example is 720 SFCA.

5. *Scope changes* are increases or decreases in quantities, workhours and cost classifications through approved contract change orders. The Scope changes are obtained from the estimate ledger. Also, internal shifts in the cost classifications from the original estimate to reflect the actual project being built called the budget are also recorded here, but they must be kept separated from the contract change orders. The Scope Changes in the example resulted in an additional 400 SFCA.

6. *Revised Budget* is the Accumulative total for the actual project budget. The revised budget is calculated by adding the Original Budgeted to the Scope Changes and showing the net increase or decrease in the Revised Budget column. The Revised Budget in the example is:

720 SFCA Original Budget + 400 SFCA Scope changes = 1120 SFCA

Expended Information from the Detail Cost Ledger

7. *Period Expended* column reflects the quantities, workhours and cost classifications that have been expended since the last report. Normally, the period consists of one month. The period items are obtained from the detail cost ledger. This is a stand-alone column it is for reference purposes only.

8. *Expended To Date*. This column reflects the quantities, workhours and cost classifications are an accumulation of previous period items expended. The Period items are added to the to Date Figure from the Previous report to arrive at the Current Expended To Date figure in this report. The To Date-Expended Column in the example indicates that:

	Expended To Date	Committed Cost	Expended Total Costs
Quantity	124 SFCA	0	124 SFCA
Workhours	24 Whr	0	24 Whr
Labor Costs	$179	0	$179
Material Costs	$800	$341	$1,141
Equipment Costs	$421	0	$421
Subcontract Costs	$100	$120	$220
Sub Total Costs for Cost Code 035316	$1,500	$461	$1,961

9. *Committed Costs* are shown separately from the To Date Expended costs to indicate that the contractor is contractually required to pay for an item but it has not actually been paid for yet. This column is used to put cost items that you have contracted for such as subcontracts and purchase orders immediately into the ledger system. The accounting system usually only reflects actual expended costs, therefore, to obtain the Expended Total Cost when the contract is 100% paid for it is placed into this column first. The Committed Costs in the Example are:

Material Costs	$341.00
Subcontract Costs	$120.00
Subtotal Costs	$461.00

10. *Expended Total* column is calculated by adding the Expended To Date Column to the Committed Costs column for each item. The Expended Totals in the example are:

Expended Total
124 SFCA
24 Whr
$179
$1,141
$421
$220
$1,961

Committed Cost Example

For example, assume that you have signed a subcontract Agreement with the Electrical contractor for $350,000. The contract calls for three monthly payments of $100,000 at the end of the first month with subsequent payments of $125,000 and $125,000. Upon signing the contract, the $350,000 would be placed into the Committed Cost column immediately and the Committed Cost would be added to the Expended To Date Costs, which is $0 in the first month. Therefore, the Expended Total Cost column would be $350,000.

Transaction Date	Expended To Date	Committed Cost	Expended Total Cost
Sub, Immediately	0	$350,000	$350,000

In the second month, the Expended To Date Costs would be $100,000 in the second month and $250,000 would be placed into the Committed Cost column and the Committed Cost would be added to the Expended To Date Costs of $100,000. Therefore, the Expended Total Cost column would still be $350,000.

Transaction Date	Expended To Date	Committed Cost	Expended Total Cost
Sub, Second	$100,000	$250,000	$350,000

The purchase orders, subcontracts and rental Equipment are recorded into the detail cost ledger as committed costs at the time they are written.

Projections by the Project Manager

11. *Current projection at Completion* is a prediction of the total to be spent when the item is 100% complete. There are three methods for projecting at completion.

Using the *Straight Line Projection Method* and projecting the At Completion (Forecast) number by multiplying the To Date Unit Cost ($/unit) times the Total Budgeted Quantities.

Using the *Expended Total Column* and projecting the Expended Total column as the projected at completion number.

Using the *Revised Budget Column* and projecting the Revised Budget as the projected at completion number.

The Current Projection in the example was made based upon the following methods.

	Current Projection	Projection Method
Quantity	1120 SFCA	Revised Budget
Workhours 24 Whr/124 SF = .19 x 1120 SF	213 Whr	Straight Line
Labor Costs $179/124 SF = $1.44/SF x 1120 SF	$1,613	Straight Line
Material Costs	$1,141	Expended
Equipment Costs	$421	Expended
Subcontract Costs	$220	Expended
Sub Total Costs for cost code 035316	$3,395	\\\\\\\\\\\\\\\\\\\\\\\\

12. *Projected Gain or (Loss)* is calculated by subtracting the Current Projection from the total Revised Budget and showing the net result: a gain or a (loss) shown in parentheses. If the Projected Labor Cost at Completion is greater than the Total Revised Budgeted Cost, you will show a **(loss)** in this column. If the Projected Labor Cost at Completion is less than the total Revised Budgeted Cost, you will show a gain in this column.

	Revised Budget	Current Projection	Gain/(Loss)
Quantity	1120 SFCA	1120 SFCA	0
Workhours	192 Whr	213 Whr	(21) Whr
Labor Costs	$3,595	$1,613	$1,982
Material Costs	$904	$1,141	($237)
Equipment Costs	$300	$421	($121)
Subcontract Costs	$207	$220	($13)
Sub Total Costs 035316	$5,006	$3,395	$1,611

The completed Project Cost Summary Report is shown on the following page.

Project Cost Summary Example

PROJECT NAME JOBSITE USA
PROJECT NUMBER __001__

CODE	ITEM	ORIGINAL BUDGET	SCOPE CHANGES	REVISED BUDGET	EXPENDED PERIOD	EXPENDED TO DATE	COMMITTED COST	EXPENDED TOTAL COST	CURRENT PROJECTED COST	PROJECTED GAIN/LOSS
035316	Wall Forms									
	Quantity	720Sf	400Sf	1120Sf	60Sf	124Sf		124Sf	1120Sf	0Sf
	Workhours	122Whr	70Whr	192Whr	9	24Whr		24Whr	213Whr	(21) Whr
	Labor	$2310	$1285	$3595		$179		$179	$1613	$1982
	Material	$400	504	904		800	341	1141	1141	(237)
	Equipment	-0-	300	300		$421		421	421	(121)
	Subcontracts	-0-	207	207		100	`120	220	220	(13)
Sub Total Costs		$2710	$2296	$5006		$1500	$461	$1961	$3395	+1611
		⇑___ + ⇑_____ = ⇑				⇑_____ + ⇑_____ = ⇑				

REVISED ESTIMATE 5006 MINUS CURRENT PROJECTION $ 3395 EQUALS PROJECTED GAIN(LOSS) BUDGET +1611

The Work Breakdown Structure

The *Work Breakdown Structure (WBS)* or the Master Code of Accounts should be developed by the contractor for use on all projects throughout the company. The master Work Breakdown Structure is a set of cost codes arranged into a hierarchy of recognizable categories used to compare all estimated and actual costs on a project. The work breakdown structure is the key element in a job cost control system. This portion of the cost control system is commonly overlooked and little or no attention has been paid to its importance. For a control system to be efficient, the work breakdown structure must follow a logical sequence of events and provide a hierarchy of management reports designed to meet the information requirements at different levels of management. The work breakdown structure is intended to provide a common basis for integrating accounting, cost control, scheduling and estimating information. Flexibility must be designed into the work breakdown structure to encompass all types of construction and it has the capability of segregating costs for the client's capital cost records.

An approach commonly used to develop a code of accounts is to arrange the construction items into the same categories and logical sequence the estimator uses when developing a quantity takeoff and cost estimate. These categories are called a "hierarchy" and they are used to provide management with reports that can be summarized at different levels. A typical Code of Accounts requires a minimum of seven digits to work effectively. The components of a typical code of accounts are shown below.

2	03	1	3	3	0

- *Size*
- *Type of Operations*
  Tube & Coupler
- *Operations* - Placing Scaffolding
- 1 _ _ _ ***Allocable Items*** or
  2 _ _ _ *Type of Work of Work Locations*
- *Major Discipline or Division* - Concrete Foundations
- *Cost Classification* - Materials, Permanent

Cost Reports Exercise

Using the Earned Workhour Report information provided, Answer the following questions.

1. What is the Budgeted Unit Workhours in Whr per Unit for the Column Forms?

- A. 0.045
- B. 0.171
- C. 0.241
- D. 5.838

2. What is the Weekly Unit Workhours in Whr per Unit for the Column Forms?

- A. 0.007
- B. 0.195
- C. 4.919
- D. 5.118

3. What is the To Date Unit Workhours in Whr per Unit for the Column Forms?

- A. 0.011
- B. 0.241
- C. 3.821
- D. 4.148

4. What are the Total Earned Workhours for the Column Forms?

- A. 19
- B. 27
- C. 465
- D. 2387

5. What is the Total Projected Workhours at Completion for the Column Forms?

- A. 27
- B. 104
- C. 602
- D. 2472

Cost Reports Exercise

6. What is the projected gain or loss in Workhours for the Column Forms?

- A. (174)
- B. 325
- C. 1897
- D. 2396

Using the Labor Cost Report attached, answer the following questions.

7. What is the Budgeted Labor Unit Cost in Dollars per unit for the Concrete Footings?

- A. 0.047
- B. 21.45
- C. 137.25
- D. 256.00

8. What is the Week Labor Unit Cost in Dollars per unit for the Concrete Footings?

- A. 0.70
- B. 1.43
- C. 3.14
- D. 14.60

9. What is the To Date Labor Unit Cost in Dollars per unit for the Concrete Footings?

- A. 0.32
- B. 3.14
- C. 20.12
- D. 5125.00

10. What is the Total Projected Labor costs at Completion for the Concrete Footings?

- A. 81.41
- B. 803.84
- C. 5150.72
- D. 10615.00

Cost Reports Exercise

11. What is the projected gain or loss in Labor Dollars for the Concrete Footings?

- A. (1.20)
- B. (4685.00)
- C. 338.00
- D. 5452.46

Using the Project Cost Summary Report attached and the Forecast information below, answer the following questions.

FORECAST the Current Projection column as follows:

QUANTITY - Project the REVISED ESTIMATE column
WORKHOURS - Project using the Straight Line Method
LABOR COST - Project using the Straight Line Method
MATERIAL COST - Project the REVISED ESTIMATE column
EQUIPMENT COST - Project the TOTAL EXPENDED column
SUBCONTRACT COST - Project the TOTAL EXPENDED column

12. What is current projection for the quantities in Vertical Lineal Feet (VLF)?

- A. 680
- B. 5300
- C. 5980
- D. 6700

13. What is the current projection for the Workhours at completion?

- A. 78
- B. 473
- C. 618
- D. 686

14. What is the current projection for the labor costs at completion?

- A. 11,960
- B. 13557
- C. 14917
- D. 16817

Cost Reports Exercise

15. What is the current projection for the material costs at completion?

- A. 7080
- B. 33470
- C. 40550
- D. 45225

16. What is the current projection for the Equipment costs at completion?

- A. 1400
- B. 14640
- C. 16040
- D. 16960

17. What is the current projection for the subcontract costs at completion?

- A. 0
- B. 7000
- C. 14000
- D. 21000

18. What is the current projection total costs at completion?

- A. 29957
- B. 70170
- C. 76470
- D. 85080

19. What are the projected workhours gain or loss?

- A. 0
- B. 67
- C. (134)
- D. (218)

Cost Reports Exercise

20. What is the projected labor cost gain or loss?

- A. (1900)
- B. 1900
- C. 2957
- D. 13557

21. What is the projected material cost gain or loss?

- A. 0
- B. 4675
- C. 7080
- D. 11755

22. What is the total projected gain or loss?

- A. (6363)
- B. (9843)
- C. 7975
- D. 14589

23. The estimated cost of a project if built today is $4,000,000 and the costs are expected to rise 3.5 percent for the next 5 years. What will be the estimated cost if the project is built five years from now?

- A. $4,700,000
- B. $4,750,745
- C. 17,936,133
- D. 24,213,779

24. The budget calls for 40,000 Lineal Feet of lumber and the labor is budgeted at $26,000. The work completed to date is 8,000 Lineal Feet of lumber and the labor cost is $6,000. What is the projected total labor cost savings or labor cost overrun at completion?

- A. $2,000 savings.
- B. $4,000 savings.
- C. $4,000 overrun.
- D. $10,000 savings.

Check Answers

Cost Reports Exercise - Earned Workhour Report Information

DESCRIPTION	QUANTITIES			UNIT	EXPENDED WORKHOURS		WORKHOURS		UNIT WORKHOURS			PROJECTED	
	BUDGET	WEEK	TO DATE		WEEK	TO DATE	EARNED	BUDGETED	BUDGET	WEEK	TO DATE	COMPLETION	GAIN/ LOSS
Col. Forms	2499	87	112	SFCA	17	27		428					
Concrete Ftg	256	25	40	CY	40	85		360					
Concrete Wa	453	30	34	CY	40	44		634					
Footing Frms	2417	210	410	SFCA	42	102		499					
Wall Forms	25,560	1880	3090	SFCA	364	664		5544					

Cost Reports Exercise - Labor Cost Report Information

CODE	DESCRIPTION	QUANTITIES				EXPENDED COST		TOTAL BUDGET $	UNIT COST			PROJECTED	
		BUDGET	WEEK	TO DATE	UNIT	WEEK $	TO DATE		BUDGET	WEEK	TO DATE	COMPLETION	GAIN/ LOSS
	Col. Forms	2499	87	112	SFCA	223	355	8022					
	Concrete Ftg	256	25	40	CY	365	805	5490					
	Concrete Walls	453	30	34	CY	394	431	9669					
	Footing Form	2417	210	410	SFCA	449	1038	8154					
	Wall Forms	25,560	1880	3090	SFCA	3812	6855	90370					

Cost Reports Exercise - Project Cost Summary Report Information

CODE	ITEM	ORIGINAL ESTIMATE	SCOPE CHANGE	REVISED ESTIMATE	EXPENDED WEEK	EXPENDED TO DATE	COMMITTED	TOTAL EXPEND	CURRENT PROJECTION	PROJECTED GAIN (LOSS)
035600	PILES									
	Quantity	6700 VLF	(720)	5980 VLF		680	0	680		
	Workhours	618 WHR	(67)	551 WHR		78	0	78		
	Labor	16817	(1900)	14917		1360	0	1360		
	Material	45225	(4675)	40550		10000	23470	33470		
	Equipment	16040	(1400)	14640		7600	9360	16960		
	Subcontract	0	0	0		7000	0	7000		
		78082	(7975)	70107		25960	32830	58790		

PLANNING, SCHEDULING, AND CONTROL

The Components of the Precedence Diagram Method

The *Precedence Diagram Method* is referred to as Activity on the Node and each Box represents an Activity. The Precedence Diagraming Method consists of the following parts.

A *Rectangular Box* represents a specific activity in the logic network. The *Activity Description* is placed in the center of the box. The *Activity Node Number* is placed in the top center box. Each activity is given a sequential non-consecutive number normally separated by 5 to 10.

The *Duration* is in Days and it is placed in the bottom center box. This Diagram Starts with Zero (0) as the duration. The *Activity Event Times* are placed in the four corner boxes of each activity for scheduling the project.

> The Earliest Start (ES) Time is placed in the top left hand box. This Diagram's Earliest Start (ES) Starts with Zero (0).
>
> The Earliest Finish (EF) Time is placed in top right hand boxes.
>
> The Latest Start (LS) Time is placed in the bottom left hand box
>
> .
>
> The Latest Finish (LF) Time is placed in the bottom right hand box

NODE NUMBER

ES	0	EF
	START	
LS	0	LF

DURATION

Precedence Diagram Abbreviations and Locations

The Project Activity Event Times
The Activity Event Times establish the Project Schedule. This step is dependent upon the logical sequence being correct. Computations are performed to determine the overall project completion date and the time requirements for each activity. To determine the project schedule, you must perform these network computations. First, calculate the *Forward Pass* to determine the earliest event times. The earliest event times calculations are described below.

The *Earliest Start* (ES) is placed in the top left hand portion of each activity. The ES is calculated at each Activity by completing the *Forward Pass* (Tail to head of the arrow). Start at the beginning of the project, use zero as the starting date and place in the top left hand portion of the first activity. Then add the duration to the Earliest Start of the activity(s) and place in the top right hand portion of the activity, called the Earliest Finish (EF).

To determine Earliest Start of the next activity(s) in the forward pass, select the Largest Early Finish from all preceding paths coming into the specific activity and place in the top left hand portion of the activity.

The *Earliest Finish* (EF) is placed in the top right hand portion of each activity. The EF is calculated at each Activity by completing the forward pass (Tail to head of the arrow) and taking the Earliest Start (ES) of that activity and adding the duration.

$$EF = ES + DURATION$$

Second, calculate the *Backward Pass* to determine the latest event times. The latest event time calculations are described below.

The *Latest Finish* (LF) is placed in the bottom right hand portion of each activity. The LF is calculated at each Activity by 1) completing the BACKWARD PASS (head to the tail of the arrow). Start at the completion of the project and select the largest number and place in the bottom right hand portion of the last activity or activities. Then, subtracting the duration from the Latest Finish of that activity(s) and place in the bottom left hand portion of the activity, called the Late Starts(LS).

To determine the Latest Finish of the next activity in the backward pass, select the smallest Latest Start (LS) from all paths (head to the tail of the arrow) going into the specific activity and place in the bottom right hand portion of the activity.

The *Latest Start* (LS) is placed in the bottom left hand portion of each activity. The LS is calculated by taking the LATEST FINISH (LF) of that activity and subtracting the DURATION.

$$LS = LF - DURATION$$

The *Total Float* (TF) is defined as the amount of slack or leeway through a path of activities and shared by all activities. Total Float is calculated by subtracting the Earliest Start (ES) from the Latest Start (LS) or by subtracting the Earliest Finish (EF) from the Latest Finish (LF).

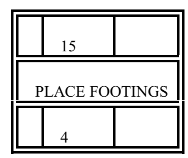
$$TF = LS - ES \quad \text{or} \quad TF = LF - EF$$

The *Free Float* (FF) is defined as the amount of slack or leeway within an activity. Free Float is calculated by subtracting the Earliest Finish (EF) of that activity from the Earliest Start of the next activity (ES(I)).

$$FF = ES(I) \text{ next activity} - EF \text{ that activity}$$

The *Critical Path* is defined as the longest continuous path or paths with zero float. This is the path the project manager must focus their attention upon because if time is added to any of these activities the project completion will be delayed. Also, to shorten the project schedule the durations of the critical activities must be shortened.

The Critical Path is identified using this criteria For the Precedence Method:



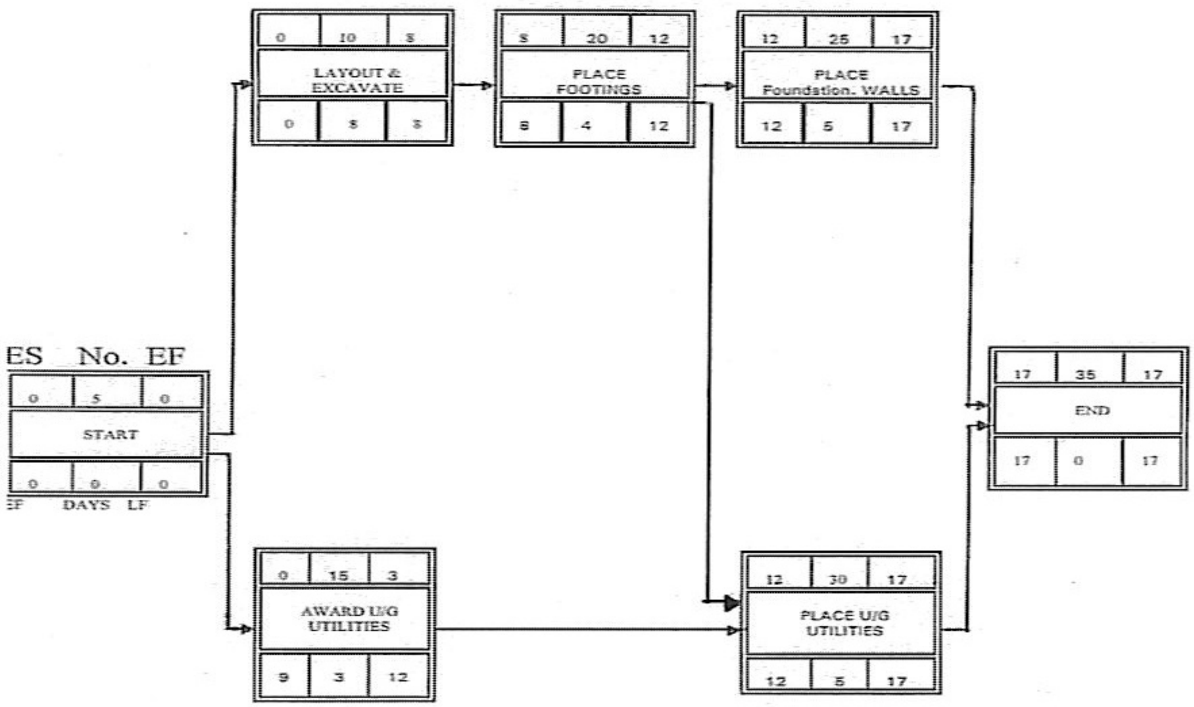
A. The Earliest Start (ES) is equal to the Latest Start (LS).
$$ES = LS$$

B. The Earliest Finish (EF) is equal to the Latest Finish (LF).
$$EF=LF$$

C. The Total Float (TF) and the Free Float (FF) are equal to Zero.
$$TF = 0 \text{ and } FF = 0.$$

The critical path(s) is normally indicated on the diagram using slashed lines /////// or a heavy dark line.

The Precedence Diagram Logic Network and Schedule Event Times Example



PRECEDENCE SCHEDULE EVENT TIME TABULATION SHEET
FOR THE PRECEDENCE DIAGRAM LOGIC

ACTIVITY	NODE	DAYS	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT	FREE FLOAT
START	15	0	0	0	0	0	0	0 *
LAYOUT & EXC	20	8	0	8	0	8	0	0*
AWARD U/G UT	25	3	0	3	9	12	9	12 -3 = 9
PLACE FOOTING	30-35	4	8	12	8	12	0	0*
	30-40							0*
PLACE WALL	35	5	12	17	12	17	0	12 - 12 = 0*
PLACE U/G UTIL	40	5	12	17	12	17	0	12 - 12 = 0*
END	45	0	17	17	17	17	0	0*

The Design Sequence for each Engineering Discipline

Each engineering discipline on a Design/Build Project must show the following design activities on the logic diagram prior to the procurement sequence of activities. The general design sequence of activities is shown below.

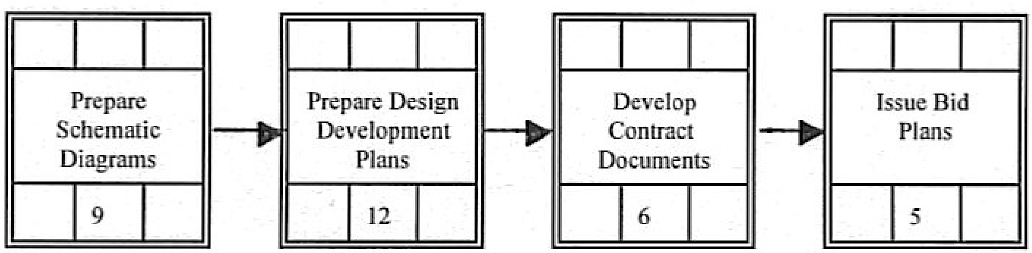
A. Prepare the Schematic or Process Diagrams.

B. Prepare the Design Development Drawing Packages.

C. Formalize the Final Design and Develop the Contract Documents.

D. Client Approves and Bid Plans Are Issued.

Each engineering discipline, such as civil engineering, structural engineering, processing piping engineering, chemical engineering, mechanical engineering, electrical engineering and plumbing design, will contain the following design sequence at the beginning of the logic diagram on a separate line for each discipline. The design sequence for each engineering discipline will be shown as follows.



The Procurement Sequence for each Discipline or Construction Trade

The Procurement Sequence (Material Leadtime) on a project is the amount of time required prior to the item being installed at the jobsite. The following activities must be analyzed to determine the total amount of leadtime required.

1. Prepare Bid package, Request price Quotations, Select and award the contract to the Vendor or Subcontractor.

2. Vendor prepares and submits shop drawings, Product Data or Samples as outlined in the Technical Specifications.

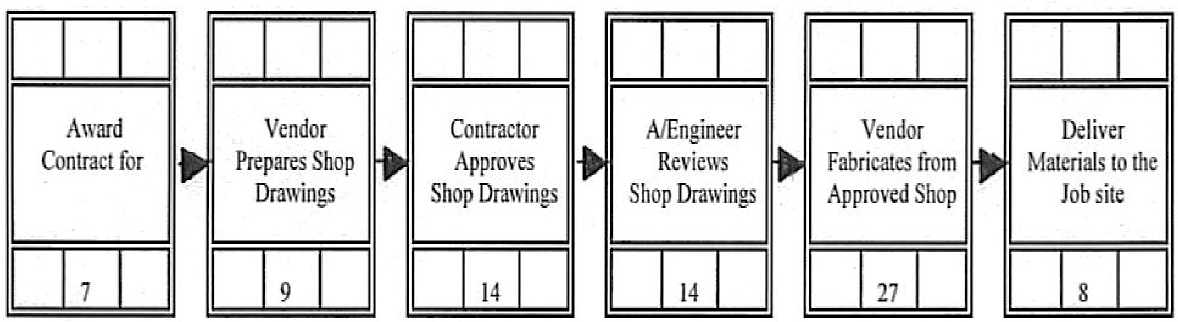
3. Contractor reviews & approves field measurements and field construction methods on the Shop Drawings.

4. Architect or engineer reviews all design criteria prior to the fabrication or erection of the item.

5. Vendor or Subcontractor schedules the contract into their fabrication schedule and shop fabricates the items according to the approved and revised drawings.

6. Vendor arranges for shipment and delivers the materials to the job site.

Each Construction Trade, such as concrete, rebar, equipment, structural steel, sheet metal, boilermaker, pipe fitter, instrumentation fitter, sprinkler fitter, insulator, electrical and plumbing, will contain the following procurement sequence at the beginning of the logic diagram on a separate line for each construction trade. The procurement sequence for each construction trade will be shown as follows.



The courts have established rules for allowing the schedule to admissible evidence in a case. The basic considerations are that the diagram method must show the interrelationships of activities. Also, the project schedule must contain the design sequence, the procurement sequence, the construction sequence, planned weather anticipated each month, inspections and testing, owner furnished items, separate contracts negotiated by the owner, closeout procedures, and commissioning activities. In addition the schedule must be updated regularly to show contract change order and all delays whether caused by the contractor, the owner, the subcontractors or a weather caused delay.

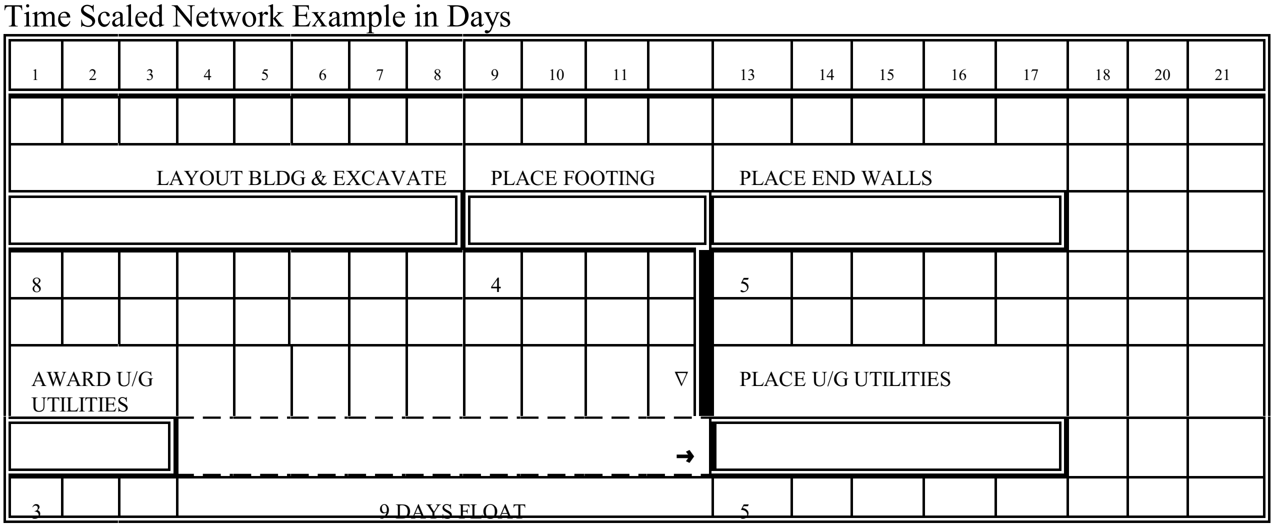
The Time Scaled Network Method
This method uses a graph with each column representing a duration, usually a day or week, and each activity is displayed on the chart based upon the relationships of the other starting and finishing activities. Also, described as a graphic display plotting the interrelationship of activities using the Early Starts (ES) and Late Finishes (LF). The Time Scaled Diagraming Method consists of the following parts.

The Activity is represented by an open bar.
The Length of Activity is represented by the length of the open bar. Stated in days.
The Activity Restraint is shown using a heavy vertical line with an arrow head.
The Activity Description is placed on the top of each bar.
The Duration is in Days. It is placed at the bottom left hand portion of each activity.
The Free Float is shown as a horizontal dotted line between each activity.

Given the Preceding and Following activities for the construction of a Basement Foundation.

Activity Description	Days	Preceding Activity	Following Activity
Layout & Excavate	8	None	Place Footing
Place Footing Forms	4	Layout & Excavation	Place Foundation Walls Place U/G Utilities
Award U/G Utilities	3	None	Place Utilities
Place U/G Utilities	5	Award U/G Utilities Place Footing Forms	None
Place Foundation Walls	5	Place Footing Forms	None

Time Scaled Network Example in Days

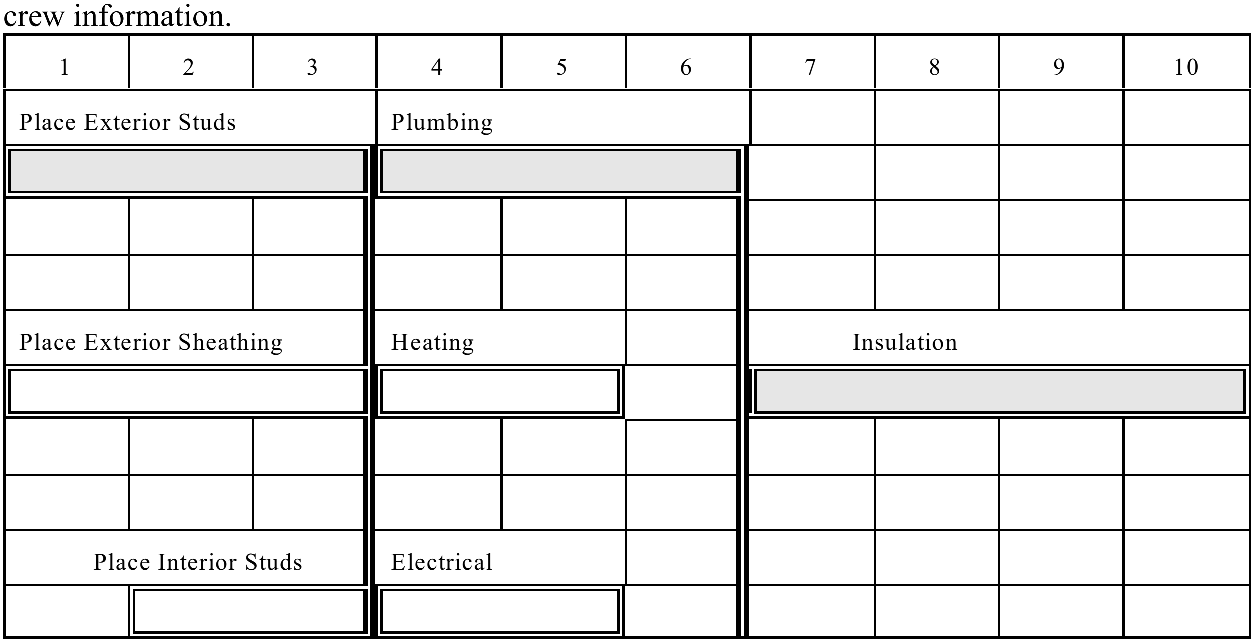


The Actual or the Effective Amount of Time

The *Multi-crew Effective Durations* is defined as the Actual or Effective amount of time expended because multiple crews are working on a sequence of activities simultaneously. This can be best shown using the following construction activities.

CSI DIV	ACTIVITY DESCRIPTION	CREW SIZE	DAILY OUTPUT	PLAN QTY	ACTIVITY DAYS	ACTUAL DAYS
06	EXT STUDS	4	100 LF	280 LF	2.80	3.00
	EXT SHEATH	4	1200 SF	3200 SF	2.67	
	INT STUDS	2	80 LF	160 LF	2.00	
15	PLUMBING	2	58 LF	150 LF	2.58	3.00
15	HEATING	2	170 LF	120 LF	.70	
16	ELECTRICAL	2	1300 LF	2600 LF	2.00	
07	INSULATION	3	1000 SF	3200 SF	3.20	4.00
	TOTALS	19				10.00

Using the Multi-crew Effective days from above, the Time-scaled Network & Crew Distribution Chart is shown below. N showing each day and using the Time Scaled Network for the Multi-crew information.



The Crew Distribution (Utilization) Chart and Graph

Completing a construction project efficiently requires the efficient scheduling and allocation of available resources, specifically the workers, equipment and materials available. Therefore, the allocation or distribution of the workers and equipment required over the length of the project provides you with the capability to determine if your planned schedule is feasible. This planned schedule can than be compared to the physical size of the project and the availability of workers and equipment within the area or within the company.

The crew distribution chart is developed using the Time Scaled Network and indicating the number of workers for each activity. Finally, you total the number of workers for each day at the bottom of the chart. This information is utilized to develop the crew utilization graph. This graph indicates the planned crew sizes and the maximum total number of workers by month.

1	2	3	4	5	6	7	8	9	10
Place Exterior Studs			Plumbing						
4	4	4	2	2	2				
Place Exterior Sheathing			Heating			Insulation			
4	4	4	2	2		3	3	3	3
Place Interior Studs			Electrical						
	2	2	2	2					
8	10	10	6	6	2	3	3	3	3
Total Number of Workers per Day									

To Develop a Crew Utilization Chart the following steps are involved.

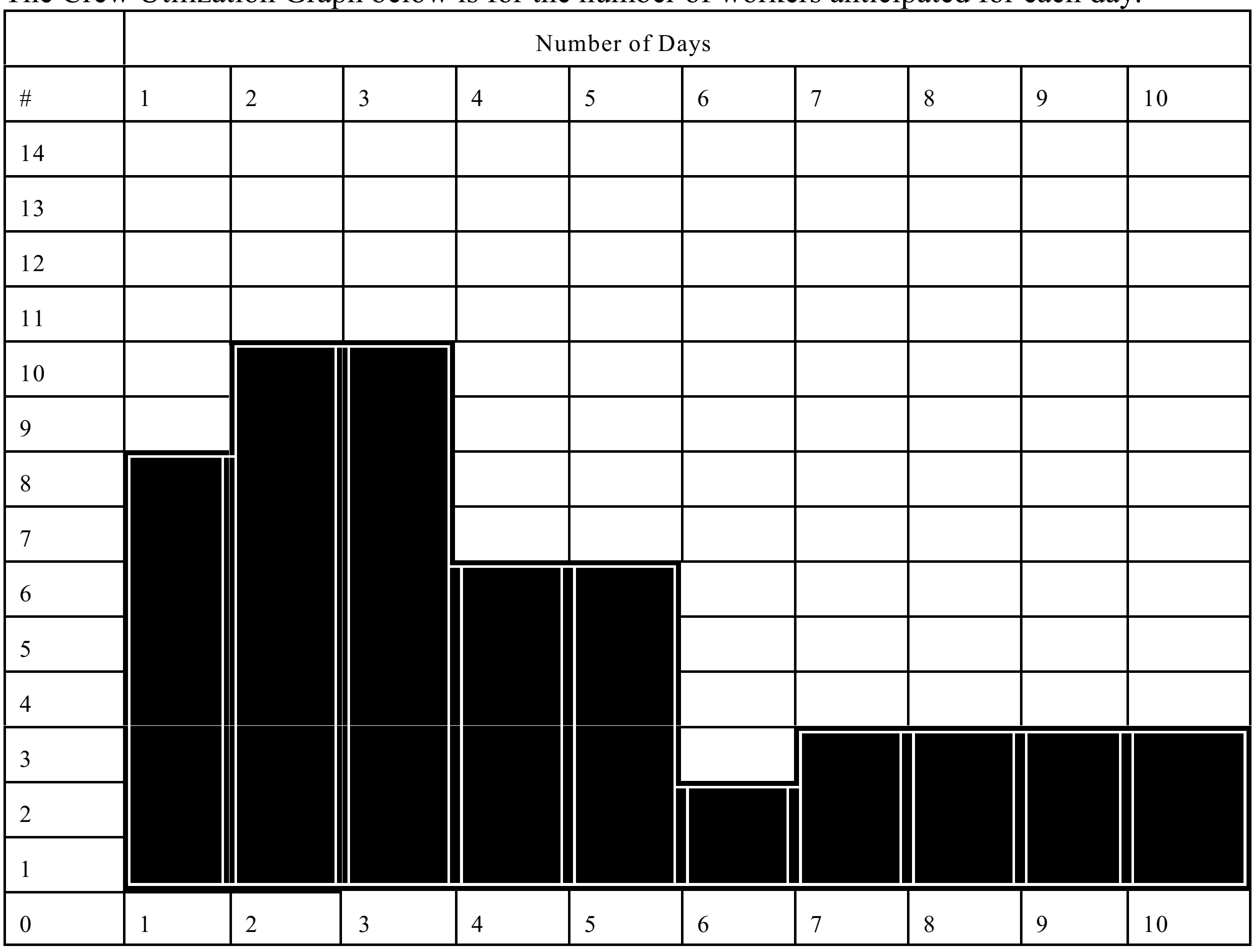
1. Time Scale the Project using Latest Starts (LS)

2. Determine the crew size for each activity and distribute for each activity. This can be taken from the original estimate or it must be estimated for the Subcontractors.

3. Total the number of workers required for each day.

4. Using the worker totals, Prepare the crew utilization graph.

The Crew Utilization Graph below is for the number of workers anticipated for each day.



Project Scheduling Definitions

A *Bar Chart* is a graph showing the list of items down the left hand side, the Time periods across the top, usually in months or weeks, and the time required to perform each activity is represented by a thick dark line. The major disadvantages of a bar chart are 1) it does not show the interrelationship of activities 2) it does not show the amount of float that may exist within the activities and 3) it cannot predict a new course of action in case of a delay. The bar chart is an extremely poor planning document for construction but it is an effective tool for displaying job progress. Also, a bar chart which does not show the interrelationship of activities and the amount of float available for each activity is not admissible evidence in court. But if the activities are represented in a Time Scaled Network Form, showing the interrelationships of activities and their available floats then it is admissible.

Fast Tracking is the overlapping accomplishment of Design, Procurement and Construction activities to complete a project faster.

Crashing is the shortening of the project schedule along the critical path using the activities on the critical path with the Least Cost. No activity can be crashed to a zero duration.

Resource Leveling is the shifting of activities within the schedule using the float times available. This shifting occurs due to a limited number of resources available such as workers available, equipment availability, material availability and subcontractors available.

Leadtime is the amount of time to procure the materials.

Activity Descriptions are extremely important because they convey to everyone using the logic diagram what the primary activities that are included in each description. The activity descriptions can be developed by reviewing the Technical Specifications Division and Section headings such as CSI number 02225 titled Excavating, Backfilling and Compacting for Trenching and 720 Storm Sewer System Piping. The two section from Division 02 Sitework can be combined to have a construction activity description which reads Excavate, Place Pipe, Backfill and Compact for the Storm Sewer System.

Activity Duration is the number of days required to install the quantity on a project. Using the crew size and the daily output for an activity, you can determine the number of days required. For example given the following crew size and daily output the number of days is calculated as follows:

No.	CRAFT	Hours per Day	Total Workhours	Hourly Rate
3	Carpenters	x 8	24	
1	Building Laborer	x 8	8	
4	Total Per Day	x 8	32	

Determine the Total Number of days to install the 1500 S.F.C.A.

$$\frac{\text{Plan Quantities}}{\text{Daily output}} = \frac{\text{1500 S.F.C.A.}}{\text{190 S.F.C.A./day}} = \text{7.89 days}$$

Activity Relationships

All logic diagrams require you to establish the interrelationship between activities by reading each activity Forward and Backwards to establish the logic network. This requires you to establish the interrelationship between activities using predecessors and successors. They are defined below.

Predecessors are activities that must logically occur before another activity can start.

Successors are activities that must logically occur after another activity is completed

Precedence Activity Relationships

The Precedence Diagraming method lets you establish a variety of relationships between activities. The Precedence Method allows you to establish these relationships. The Finish to Start relationship is the most common relationship for non-overlapping activities. Other relationships that can help you refine your schedule are the Start to Start and Finish to Finish relationships for overlapping activity relationships. Below is a description of the Finish to Start relationship

The *Finish-to-Start Relationship* is the most utilized relationship and the one that is utilized in establishing the initial relationships between activities. Finish-to-Start is a relationship in which the successor activity can only start when the predecessor is finished. In other words, this requires that the following activity (successor), cannot start until the preceding activity (predecessor) is 100 percent complete. In the Example logic network, the Activity 70 cannot start before the Client Review, Activity 10, is complete. In other words, the Design Process Diagram, Activity 70, cannot start until the Client Review, Activity 10, is complete.

Planning & Scheduling Exercise

1. Which of the following is the proper Design Activity Sequence that is used for every design discipline (such as mechanical, electrical and structural) on a Design/Build logic network according to acceptable legal practices.

- ○ A. Engineer, Design, and Build.
- ○ B. Design, Procurement, and Construction.
- ○ C. Prepare Schematic Diagrams, Prepare Preliminary Plans, Develop Contract Documents, and Issue Bid Plans.
- ○ D. Obtain Construction Contract, Request Plans, Receive Plans, Award Subcontracts, Procure materials, and Construct activities.

2. Which of the following is the proper Procurement Activity Sequence that is used for every Vendor or Supplier (such as Rebar, Structural Steel and Sheet Metal) on a Design/Build logic network according to acceptable legal practices.

- ○ A. Design, Procurement, and Construction.
- ○ B. Order and Deliver Materials, Place Forms, Place Rebar, Pour Concrete, and Strip Forms.
- ○ C. Award Vendor Contract, Vendor Prepares Shop Drawings, Contractor Reviews Shops, A/E Reviews Shops, Vendor Fabricates and Delivers.
- ○ D. Prepare Design Plans, Award Vendor Contract, A/E Approves Design, Order Materials, Fabricate, A/E Approves Shop Drawings, Contractor Approves Shop Drawings, Vendor Delivers Materials.

3. Many times the contractor must indicate a sequence of activities as consecutive because of crews or equipment available, What is the term for this sequence called?

- ○ A. Restraints.
- ○ B. Total Float.
- ○ C. Critical Path.
- ○ D. Project duration.

4. Leadtimes are used to determine the estimated time durations for what type of activities?

- ○ A. Design Activities.
- ○ B. Procurement Activities.
- ○ C. Construction Activities.
- ○ D. Project Closeout Activities.

Planning & Scheduling Exercise

Questions 5 and 6 are based on the following information. A list of sequential activities with a Finish to Start relationship and their estimated durations are provided below.

ACTIVITY DESCRIPTIONS	DAYS
Prepare the Reinforced Concrete Schematic drawings	28
Prepare the Preliminary Plans for the Reinforced Concrete Structure	32
Develop the Reinforced Concrete Bid and Contract Documents	12
Issue the Plans for Bidding and A/E Obtains bids	22
Award Rebar Vendor Contract	7
Vendor Prepares Rebar Shop Drawings	24
Contractor Reviews Rebar Shop Drawings	10
A/E Reviews Rebar Shop Drawings	10
Vendor Fabricates the Rebar according to Approved Shop Drawings	33
Deliver the Rebar to the Job Site	6
Contractor moves the Rebar from the storage area to the Placement Area (Rehandles)	1
Contractor installs the Rebar for the Footing Columns	3
Contractor calls for a Footing Inspection and the Inspector Inspects and Approves Rebar	2
Contractor Pours Concrete for the Columns	1
Contractor installs the Rebar for the Elevated Slab	6

5. What is the total estimated time in days for the Design of the Rebar?

- A. 60
- B. 94
- C. 184
- D. 197

6. What is the total estimated in days for the Rebar Leadtime?

- A. 90
- B. 94
- C. 103
- D. 197

Planning & Scheduling Exercise

7. How should the nodes on a logic network be numbered?

- A. Consecutively.
- B. Separated by a minimum of five numbers.
- C. The preceding node is greater than the following node
- D. The following node is greater than the concurrent node

8. How is Free float defined?

- A. The amount of slack in a node.
- B. The amount of slack within an activity.
- C. The amount of slack within a path (series) of activities.
- D. The amount of slack accumulated throughout the logic network.

9. What is the name of the term called for shortening a logic network?

- A. Crashing.
- B. Fast tracking.
- C. Resource Leveling.
- D. Timed scaled networking.

10. What types of activities are considered first when shortening the length of a project?

- A. Zero float and least cost.
- B. Zero float and highest costs.
- C. Highest floats and least cost.
- D. High floats and highest costs.

11. What is the primary reason that the courts disfavor a Bar Chart?

- A. It displays the activities time scaled.
- B. It does not show the activity descriptions.
- C. It displays the interrelationship of activities or the float within activities
- D. It does not display the interrelationship of activities or the activity floats.

Planning & Scheduling Exercise

12. How is the term fast tracking defined in construction?

- A. Planning and Scheduling the design
- B. Overlapping execution of the construction activities.
- C. Finalizing the design and procurement before construction begins.
- D. Overlapping execution of the design, procurement and construction.

13. What is the name of the term for shifting the activities within their available free floats in order to produce a uniform work force and reduce the maximum resource usage requirements?

- A. Crashing.
- B. Crew Utilization.
- C. Resource Leveling.
- D. Time scaled Networking.

14. What is the best source for developing the activity descriptions for the logic network and schedule?

- A. General Requirements.
- B. Technical Specifications.
- C. Financial Reports and the Balance Sheets.
- D. Estimate and the Earned Workhour report.

15. How is Total float defined?

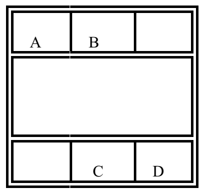
- A. The amount of slack in a node.
- B. The amount of slack within an activity.
- C. The amount of slack within a path (series) of activities.
- D. The amount of slack accumulated throughout the logic network.

16. For a Design-Build Schedule to be admissible evidence in court, it must contain the Design Activity Sequence, Procurement Activity Sequence and the Construction Activity sequence. Which of the following must also be on the preliminary schedule?

- A. A bar-chart with owner-furnished items and planned weather losses each month
- B. A time scaled with owner-furnished items and planned weather losses at the end.
- C. A bar-chart with planned versus as-built activities, sequence changes & all delays.
- D. A time scaled with owner-furnished items and planned weather losses each month

Planning & Scheduling Exercise

Questions 17 - 20 are based on the following diagram.



A letter has been placed at strategic locations within this diagraming method. Answer the following questions concerning the locations.

17. Using the diagram method above, What detail is displayed at Letter A?

- A. Late Start.
- B. Early Start.
- C. Early Finish.
- D. Activity Node.

18. Using the diagram method above, What detail is displayed at Letter B?

- A. Late Start.
- B. Late Finish.
- C. Activity Node.
- D. Activity Duration.

19. Using the diagram method above, What detail is displayed at Letter C?

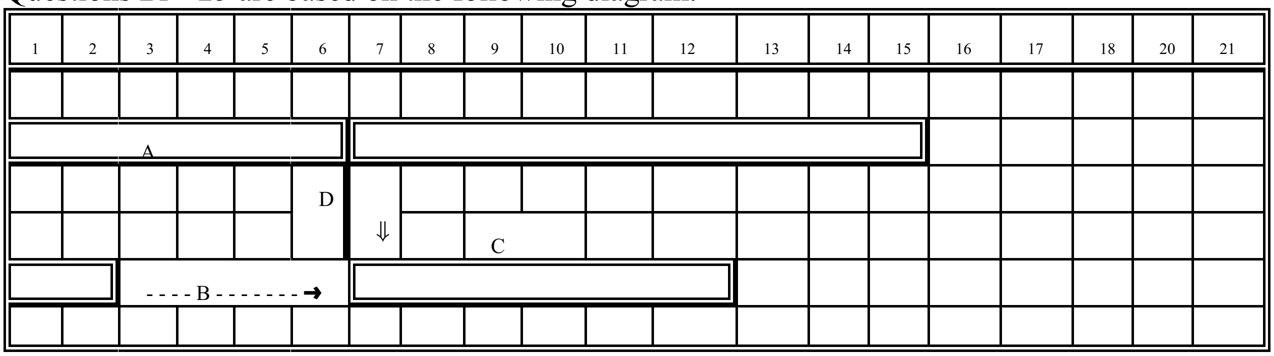
- A. Late Start.
- B. Early Finish.
- C. Activity Node.
- D. Activity Duration.

20. Using the diagram method above, What detail is displayed at Letter D?

- A. Late Start.
- B. Early Start.
- C. Late Finish.
- D. Activity Duration.

Planning & Scheduling Exercise

Questions 21 - 25 are based on the following diagram.



A letter has been placed at strategic locations within this diagraming method.

21. Using the Diagraming method above, What detail is displayed at letter A?

- A. Activity Duration.
- B. Activity Restraint.
- C. Activity Description.
- D. Consecutive Activity.

22. Using the Diagraming method above, What detail is displayed at letter C?

- A. Effective Days.
- B. Job Description.
- C. Activity Duration.
- D. Activity Description.

23. What does the Vertical line with arrowhead at D indicate?

- A. Float.
- B. Latest Start.
- C. Interrelationship.
- D. Activity Duration.

24. What is this diagraming method called?

- A. Arrow Diagraming Method.
- B. Bar Chart Diagraming method.
- C. Precedence Diagraming Method.
- D. Time-scaled Diagraming Method.

Planning & Scheduling Exercise

Questions 25 - 27 are based on the following Crew information table.

ACTIVITY	CREW SIZE	DAILY OUTPUT	PLAN QUANTITY	ACTIVITY DURATION	EFFECTIVE DAYS
EXTERIOR MASONRY	6	400 SF	3220 SF		
INTERIOR MASONRY	5	750 SF	8952 SF		
BOND BEAM LINTELS	5	280 LF	338 LF		
SAWING MASONRY	1	300 LF	2522 LF		
WALL REINFORCING	1	20 CLF	35 CLF		
WASH INTERIOR WALL	4	4000 SF	8952 SF		

Assume that the interior and the exterior walls both require bond beams lintels, joint reinforcement and sawing of masonry.

25. How many (whole) activity days are needed to complete the Interior Masonry?

- A. 1
- B. 8
- C. 12
- D. 34

26. Which activities can be going on concurrently?

- A. Interior Masonry and Wash Interior Walls.
- B. Exterior Masonry, Bond Beam, Sawing Masonry and Wall Reinforcement.
- C. Exterior and Interior Masonry, Bond Beams, Sawing Masonry and Reinforcement.
- D. Exterior and Interior Masonry, Bond Beams, Sawing, Reinforcement and Washing the Interior Walls.

27. How many (whole) effective days to complete this sequence of activities?

- A. 9
- B. 15
- C. 21
- D. 34

Planning & Scheduling Exercise

Questions 28 - 31 refer to the John Adams Logic Diagram Exhibit # 1776.

28. What is the total number of days to complete this sequence of activities?

- A. 13
- B. 14
- C. 18
- D. 31

29. What are the critical activities for this logic network?

- A. B, G
- B. A, C, F
- C. A, D, E, G
- D. A, C, F, G

30. What is the total float for activity B?

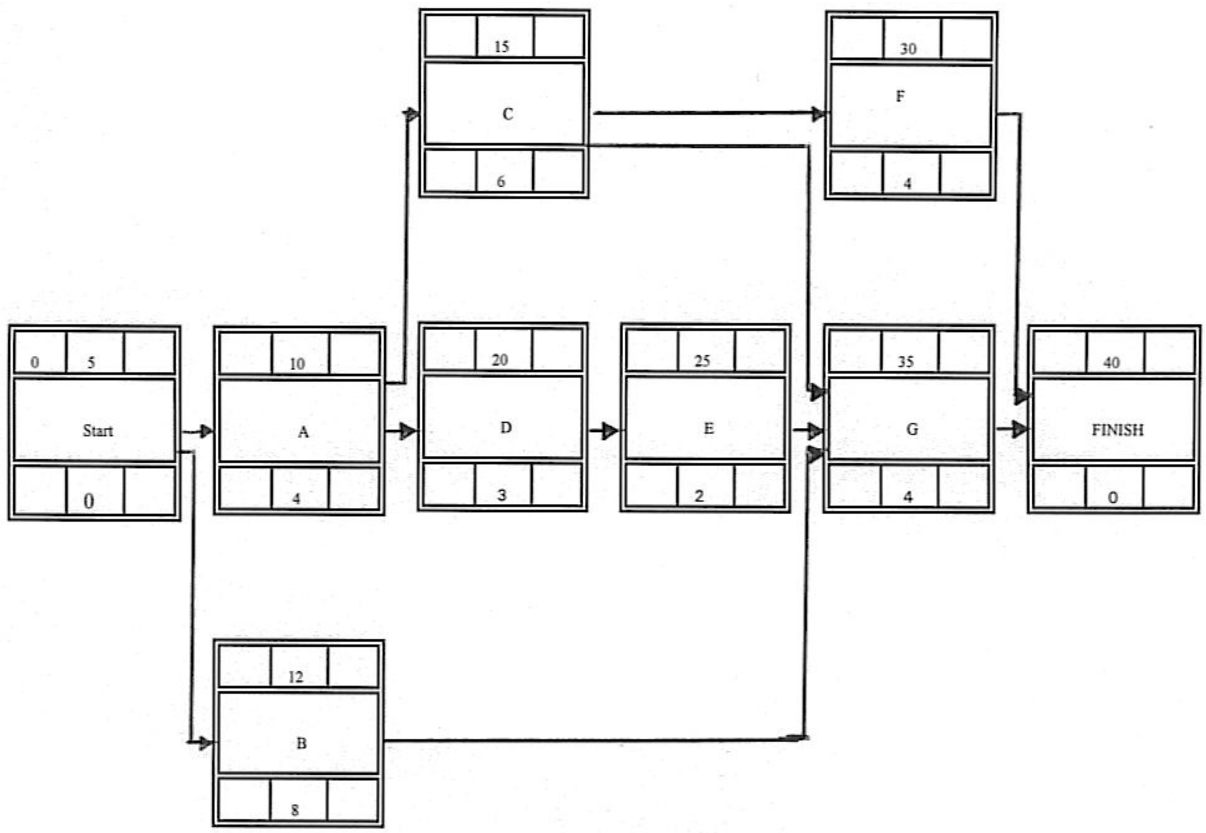
- A. 0
- B. 1
- C. 2
- D. 8

31. What is the free float between activity C and G?

- A. 0
- B. 1
- C. 10
- D. 20

Planning & Scheduling Exercise for the John Adams Logic Network

ACTIVITY	NODE	DAYS	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT	FREE FLOAT
Start		0						
B	12-35							
D								



John Adams Logic Network Exhibit # 1776

Planning & Scheduling Exercise

Questions 32 - 35 refer to the George Mason Logic Network Diagram Exhibit # 1777.

32. What is the total number of days to complete this sequence of activities?

- A. 14
- B. 15
- C. 18
- D. 32

33. What are the critical activities for this logic network?

- A. R, P
- B. M, Q, P
- C. M, O, P, Q
- D. M, N, O, P, Q

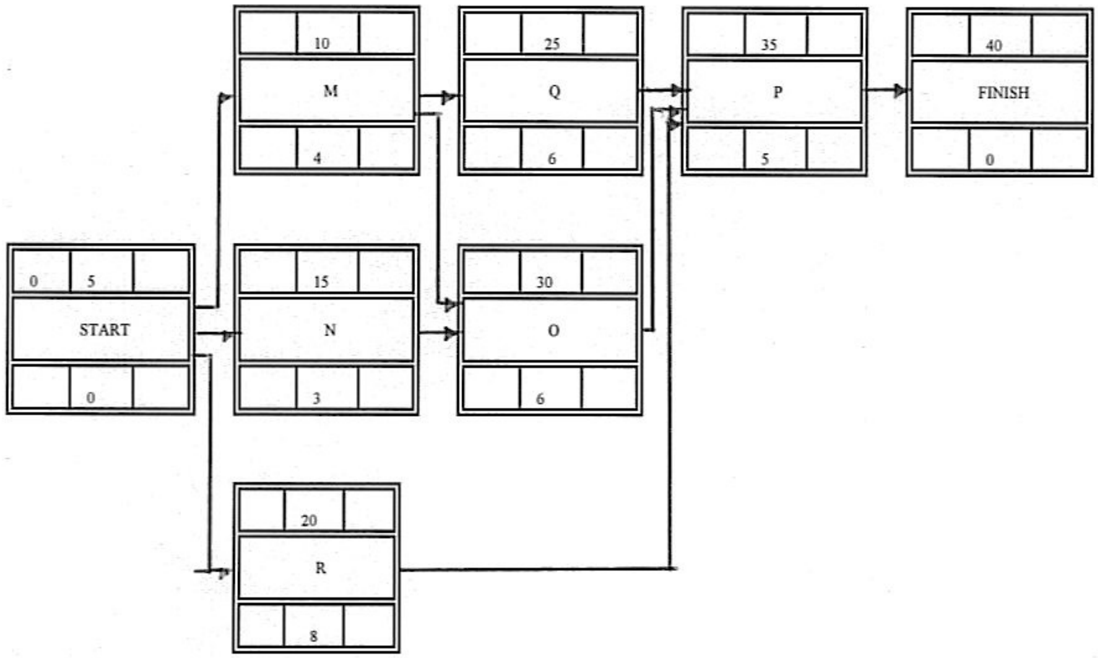
34. What is the total float for activity R?

- A. 0
- B. 1
- C. 2
- D. 8

35. What is the free float between activity N and 0?

- A. 0
- B. 1
- C. 10
- D. 20

Planning & Scheduling Exercise for the George Mason Logic Network



Activity	NODE	DAYS	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT	FREE FLOAT
START	5	0	0	0	0	0	0	0
M								
N								
O								
P								
Q								
R								

Planning & Scheduling Exercise

Questions 36 - 40 refer to the George Washington Logic Network Exhibit # 1787.

36. What is the total number of days to complete this sequence of activities?

- A. 21
- B. 25
- C. 37
- D. 93

37. What are the critical activities for this logic network?

- A. D, J, K.
- B. A, E, M
- C. D, G, M.
- D. D, H, J, K

38. What is the total float for Activity C?

- A. 0
- B. 15
- C. 17
- D. 20

39. What is the free float between activity F and K?

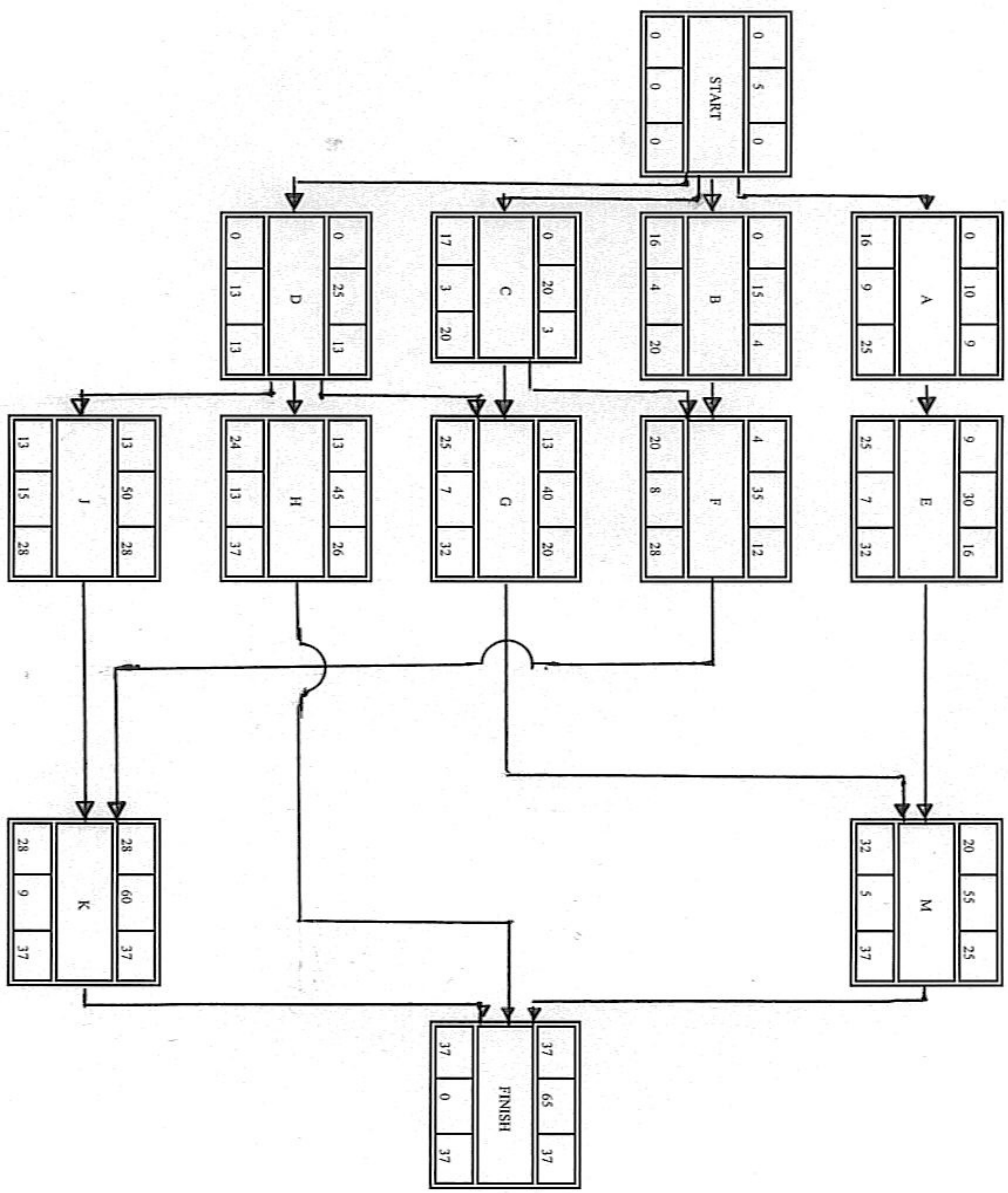
- A. 12
- B. 16
- C. 17
- D. 28

40. Reduce activities A, B, D and G each by two days. What is the length of the project?

- A. 21
- B. 29
- C. 35
- D. 85

Check Answers

Planning & Scheduling Exercise for the George Washington Logic



Planning & Scheduling Exercise Event Times Schedule Tabulation Sheet
for the George Washington Logic Network Exhibit # 1787

ACTIVITY	NODE	DAYS	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT	FREE FLOAT
START	5	0	0	0	0	0	0	0
A	10	9	0	9	16	25	16	0
B	15	4	0	4	16	20	16	0
C	20	3	0	3	17	20	17	1
D	25	13	0	13	0	13	0	0
E	30	7	9	16	25	32	16	4
F	35	8	4	12	20	28	16	16
G	40	7	13	20	25	32	12	0
H	45	13	13	26	24	37	11	11
J	50	15	13	28	13	28	0	0
K	60	9	28	37	28	37	0	0
M	55	5	20	25	32	37	12	12
FINISH	65	0	37	37	37	37	0	0

CONSTRUCTION SAFETY

The Code of Federal Regulations (CFR)

This is a codification of the general and permanent rules published in the Federal Register by the Executive departments and agencies of the Federal Government. The Code is divided into 50 titles which represent broad areas subject to Federal regulation. Each title is divided into chapters which usually bear the name of the issuing agency. Each chapter is further subdivided into parts covering specific regulatory areas. Based on this breakdown, the Occupational Safety and Health Administration is designated Title 29-Labor, and Chapter XVII is set aside for the Occupational Safety and Health Administration. Each volume of the Code is revised at least once each calendar year and issued on a quarterly basis. OSHA's regulations (Title 29) are therefore issued as of July 1. The approximate revision date is printed on the cover of each volume.

The Code of Federal Regulations is kept up to date by the individual issues of the *Federal Register*. These two publications (the CFR and the *Federal Register*) must be used together to determine the latest version of any given rule. To determine whether there have been any amendments since the revision date of the Code volume in which the user is interested, the following two lists must be consulted: the "Cumulative List of CFR Sections Affected" which is issued monthly and the "Cumulative List of Parts Affected" which appears daily in the *Federal Register*. These two lists refer the reader to the *Federal Register* page where the latest amendment of any given rule can be found. The pages in the *Federal Register* are numbered sequentially from January 1 to January 1 of the next year.

The Title 29, Chapter XVII, the regulations are further broken down into Parts. For example, Part 1926, is titled *Construction Safety Standards*. Some Parts are considered general because they apply to any employer in any industry. Other General Parts that are applicable to Construction are *Part 1903 titled OSHA Inspections*, *Part 1904 titled OSHA Record Keeping*, specific portions of *Part 1910 titled General Industry* such as fire protection is pertinent to construction, and the General Duty clause under Section 5(a) (1) are additional regulations that the contractor must comply with according to the Occupational Safety and Health Administration.

OSHA Paragraph Numbering

The paragraph numbering for the *Code of Federal Regulations and the Federal Register* is shown below. We will use this citation number to describe each portion of the citation.

29 CFR 1926.950(c)(1)(iii)

From this example, the first number 29 is the Title 29 for Labor. The second abbreviation is CFR which is the abbreviation for Code of Federal Regulations. The third number is the Part number which is 1926 the Construction Safety Standards. Next you see a period. Following the period is an arabic number which is the Section Number. This Section Number is also related to a Subpart

Letter and a Subpart Name. These subpart letters are used to organize the OSHA Compliance officers Field Manual developed by the OSHA Training Institute (OTI). The OTI has taken the major blocks of information in Part 1926 and broken them into subparts and categorized them as A - Z. The OTI Compliance Officers Field Manual contains compliance (CPL) directives. Also, it contains formal interpretations of an OSHA regulation using acronym STD for the standards. In this example the Subpart V is titled, Power Transmission and Distribution case, and under the Section .950 it is titled, General Requirements. Continuing the citation numbering system for Subpart V is titled, Power Transmission and Distribution case, and under the Section .950 which is titled, General Requirements.

29 CFR 1926.950(c)(1)(iii)

After the 1926.950, the next breakdown is by paragraphs. As you can see, the first tier of paragraphs beneath the Section level will be numbered in parentheses using lowercase alphabetical such as (a), (b), (c), (d), etc. as will all further designations, so that if you only had three major paragraphs of information under a section, they would be numbered .950(a), .950(b), and .950(c).

Using Section Number **.950 General Requirements**, Complete the Descriptions for each Paragraph Number is 1926.950 (a) is titled Application, 1926.950 (b) is titled, Initial inspections, tests, or determinations, 1926.950 (c) is titled, Clearances and 1926.950 (d) is titled, De-energizing line and equipment.

The second tier of paragraphs beneath the section level will be numbered in parentheses using arabic numbers. As an illustration, if there were three paragraphs of information between subheadings (c) and (d), they would be numbered (c)(1), (c)(2), and (c)(3). In the Example, 1926.950(c)(1) states that “No employee shall be permitted to approach or take any conductive object without an approved insulating handle close to exposed energized parts than shown in Table V-1, unless”:

(iii) reads “The Employee is isolated, insulated, or guarded from any other conductive object(s), as during live-line bare-hand work.” Also, 1926.950(c)(2) reads, The minimum working distances and minimum clear hot stick distances shall not be violated.

The third tier of paragraphs beneath the section level will be numbered in parentheses using lowercase roman numeral. An example would be between paragraphs (1) and (2). If there were five paragraphs of information pertaining too arabic (1) they would be numbered (1)(i), (1)(ii), (1)(iii), (1)(iv), and (1)(v). Finally, OSHA maintains a record of the most frequently cited Serious Violations. For example, the serious violations in Subpart V - Power and Transmission Distribution for a given year were 1926.950 (c)(1) Minimum Clearances for Working Near energized parts were violated, and 1926.950 (c)(1)(I) Employees was not insulated.

OSHA Recordkeeping
According to the Occupational Safety and Health Administration (OSHA) Title 29 CFR PART 1904 - Recording and Reporting Occupational Injuries and Illnesses and according to Section number 1904.15 it states that “Employers who had no more than ten (10) employees at any time during the calendar year immediately preceding the current calendar year need not comply with any of the requirements of this part except the following.”

(a) Obligation to report fatality or multiple hospitalization (3 or more employees, a catastrophe) incidents within 8 hours from a work-related incident; and

(b) Obligation to maintain a log of occupational injuries and illnesses and to complete an Occupational Injuries and Illnesses Survey requested in writing from the Bureau of Labor Statistics.

The regulation also states that an employer with eleven or more employees must maintain the following OSHA records.

1. *OSHA’s Log of Work-Related Injuries and Illnesses* (OSHA’s Form 300). This Log may be maintained at an alternate location if updates are sent to the specific job site within 6 days of any recordable or within 45 days of the previous update.

2. *OSHA’s Injury and Illness Incident Report* (OSHA’s Form 301). This record describes how the accident or illness exposure occurred, lists the objects or substances involved, and indicated the nature of the injury or illness and the part(s) of the body affected.

3. *OSHA’s Summary of Work-Related Injuries and Illnesses* (OSHA’s Form 300A). Each employer must post a copy of the company’s summary in a location visible to all employees. The summary will cover the previous calendar year and it shall be posted no later than February 1, and shall remain in place until March 1 each year.

OSHA has also established some rules to determine if a case is recordable or non recordable. Therefore, you must inquire about the following.

1. Determine whether a case occurred; that is, whether there was a death, illness, or injury;
2. Establish that the case was work related; that it resulted from an event or exposure in the work environment;
3. Decide whether the case is an injury or an illness; and
4. If the case is an illness, record it and check the appropriate illness category on the log; or
5. If the case is an injury, decide if it is recordable based on a finding of medical treatment, loss of consciousness, restriction of work or motion, or transfer to another job.

The first step in the decision making process is the determination of whether or not an injury or illness has occurred. Employers have nothing to record unless an employee has experienced a work-related injury or illness. In most instances, recognition of these injuries and illnesses is a fairly simple matter. However, two situations have troubled employers over the years. They are described below.

1. Hospitalization for observation. If an employee goes to or is sent to a hospital for a brief period of time for observation, it is not recordable, provided no medical treatment was given, or no illness was recognized. The determining factor is not that the employee went to the hospital, but whether the incident is recordable as a work-related illness or as an injury requiring medical treatment or involving loss of consciousness, restriction of work or motion, or transfer to another job.

2. Differentiating a new case from the recurrence of a previous injury or illness. Employers are required to make new entries on their OSHA forms for each new recordable injury or illness. However, recurrence of symptoms from previous case(s) is not recordable, and it is sometimes difficult to decide whether or not a situation is a new case or a recurrence. The guidelines below describe recurring injuries and illnesses and whether they are recordable.

   For instance, if a previous injury is aggravated, it almost always results from some new incident involving the employee such as a slip, a trip, a fall, or a sharp twist, etc. Consequently, when work related, these new incidents should be recorded as new cases.

   Another incident is an Illness. Generally, each occupational illness should be recorded with a separate entry. However, certain illnesses, such as silicosis, may have prolonged effects which recur over time. The recurrence of these symptoms should not be recorded as new cases on the OSHA forms. The recurrence of symptoms of previous illnesses may require adjustment of entries on the log for previously recorded illnesses to reflect possible changes of the particular case. Some occupational illnesses, such as dermatitis or respiratory conditions, may recur as the result of new exposures to sensitizing agents, and should be recorded as new cases.

A case is work related if it meets the following criteria. If an Injury or an illness results from an event or exposure in the employer's work areas of the premises, these are considered work related. Situations where the work area would not apply include the following. First, (1) When a worker is on the premises as a member of the general public and (2) when employees have symptoms that surface on the employer's premises, but is a result of a non work-related event. Also, the work premises excludes all employers controlled ball fields, tennis courts and other similar recreational facilities which are used by employees on voluntary basis for their own benefit. Finally, company parking lots are excluded as work premises.

Under the OSHA Record keeping regulations, all work-related illnesses must be recorded, while injuries are recordable only when they require medical treatment (other than first aid), or involve loss of consciousness, restriction of work or motion, or transfer to another job. The distinction between injuries and illnesses, therefore, has significant record keeping implications.

Whether a case involves an injury or illness is determined by the nature of the original event or exposure which caused the case, not by the resulting condition of the affected employee. Injuries are caused by instantaneous events in the work environment. Cases resulting from anything other than instantaneous events are considered illnesses. This concept of illnesses includes acute illnesses which result from exposures of relatively short duration.

Some conditions may be classified as either an injury or an illness (but not both), depending upon the nature of the event that produced the condition. For example, a loss of hearing resulting from an explosion (an instantaneous event) is classified as an injury; the same condition arising from exposure to industrial noise over a period of time would be classified as an occupational illness.

The OSHA record keeping regulations state that employers are required to record the occurrence of all occupational illnesses, which are defined in the instructions of the log and summary as:

> Any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to environmental factors associated with employment. It includes acute and chronic illnesses or diseases which may be caused by inhalation, absorption, ingestion, or direct contact.

The instructions also refer to recording illnesses which were"diagnosed or recognized." Illness exposures ultimately result in conditions of a chemical, physical, biological, or psychological nature. Occupational illnesses must be diagnosed to be recordable. However, they do not necessarily have to be diagnosed by a physician or other medical personnel.

A Recordable Work-related Injury under the OSHA regulations requires that all work-related deaths and illnesses be recorded, It also requires the recording of nonfactual injuries, but it is limited to certain specific types of cases such as those which require medical treatment; or involve the loss of consciousness; or a restriction of work or motion; or transfer to another job. Also, any minor injury which requires only first aid treatment is not recordable. The OSHA regulations also distinguish between medical treatment and first aid treatment since many work-related injuries are recordable only because medical treatment was given.

The regulations and the instructions on the back of the OSHA Log and Summary defines medical treatment as any treatment, other than first aid treatment, administered to injured employees. Essentially, medical treatment involves the provision of medical or surgical care for injuries that are not minor through the application of procedures or systematic therapeutic measures.

The regulations also specifically state that work-related injuries which involve only first aid treatment should not be recorded. First aid is commonly thought to mean emergency treatment of injuries before regular medical care is available. However, first aid treatment has a different meaning for OSHA record keeping purposes. The regulations define first aid treatment as:

> ...any one-time treatment, and any follow-up visit for the purpose of observation, of minor scratches, cuts, burns, splinters, and so forth, which do not ordinarily require medical care. Such one-time treatment, and follow-up visit for the purpose of observation, are considered first aid even though provided by a physician or registered professional personnel.

The distinction between medical treatment and first aid depends not only on the treatment provided, but also on the severity of the injury being treated. First aid is: (1) Limited to one-time treatment and subsequent observation; and (2) involves treatment of only minor injuries, not emergency treatment of serious injuries. Injuries are not minor if:

a. They must be treated only by a physician or licensed medical personnel;
b. They impair bodily function (i.e., normal use of senses, limbs, etc.);
c. They result in damage to the physical structure of a non superficial nature (e.g., fractures); or
d. They involve complications requiring follow-up medical treatment.

Physicians or registered medical professionals, working under the standing orders of a physician, routinely treat minor injuries, such treatment may constitute first aid. Also, some visits to a doctor do not involve treatment at all. For example, a visit to a doctor for an examination or other diagnostic procedure to determine whether the employee has an injury does not constitute medical treatment. Conversely, medical treatment can be provided to employees by lay person; i.e., someone other than a physician or registered medical personnel. The following procedures provide a guide for determining whether the injury is classified as medical treatment or first aid treatment.

Recordable Work-Related Medical Treatment

The following are generally considered medical treatment. These are Work-related injuries for which this type of treatment was provided or should have been provided. Medical Treatment cases are almost always recordable. The following items are considered medical treatment cases.

*Treatment of INFECTION

*Application of ANTISEPTICS during second or subsequent visit to medical personnel

*Treatment of SECOND OR THIRD DEGREE BURN(S)

*Application of SUTURES (stitches)

*Application of BUTTERFLY ADHESIVE DRESSINGS(S) OR STERI STRIP(S) in lieu of sutures

*Removal of FOREIGN BODIES EMBEDDED IN EYE

*Removal of FOREIGN BODIES FROM WOUND; if procedure is complicated because of depth of embedment, size, or location

*Use of PRESCRIPTION MEDICATIONS (except a single dose administered on first visit for minor injury or discomfort)

*Use of hot or cold SOAKING THERAPY during second or subsequent visit to medical personnel

*Application of hot or cold COMPRESS(ES) during second or subsequent visit to medical personnel

*CUTTING AWAY DEAD SKIN (surgical debridgement)

*Application of HEAT THERAPY during second or subsequent visit to medical personnel

*Use of WHIRLPOOL BATH THERAPY during second or subsequent visit to medical personnel

*POSITIVE X-RAY DIAGNOSIS(fractures, broken bones, etc.)

*ADMISSION TO A HOSPITAL or equivalent medical facility for treatment

Non-recordable Work-Related First Aid Treatment

The following are generally considered first aid treatment (e.g., one-time treatment and subsequent observation of minor injuries) and should not be recorded if the work-related injury does not involve loss of consciousness, restriction of work or motion, or transfer to another job:

*Application of ANTISEPTICS during first visit to medical personnel

*Treatment of FIRST DEGREE BURN(S)

*Application of BANDAGE(S) during any visit to medical personnel

*Use of ELASTIC BANDAGES(S)during first visit to medical personnel

*Removal of FOREIGN BODIES NOT EMBEDDED IN EYE if only irrigation is required

*Removal of FOREIGN BODIES FROM WOUND; if procedure is UNCOMPLICATED,

*SOAKING THERAPY on initial visit or removal of bandages by SOAKING

*Application of hot or cold COMPRESS(ES) during first visit to medical personnel

*Application of OINTMENTS to abrasions to prevent drying or cracking

*Application of HEAT THERAPY during first visit too medical

*Use of WHIRLPOOL BATH THERAPY during first visit to medical personnel
*NEGATIVE X-RAY DIAGNOSIS

*OBSERVATION of injury during visit to medical personnel.

The following procedure, by itself, is not considered medical treatment:
*Administration of TETANUS SHOT(S) or BOOSTER(S).

Other Nonfatal Criteria to Determine if an Injury is Recordable

Other nonfatal criteria utilized for determining if an injury is recordable or not are described below. First, if an employee loses consciousness as the result of a work-related injury, the case must be recorded no matter what type of treatment was provided. The rationale behind this recording requirement is that loss of consciousness is generally associated with the more serious injuries.

Second, is a restriction of work or motion. Restricted work activity occurs when the employee, because of the impact of a job-related injury, is physically or mentally unable to perform all or any part of his or her normal assignment during all or any part of the workday or shift. The emphasis is on the employee's ability to perform normal job duties. Restriction of work or motion may result in either a lost work time injury or a non-lost-work time injury, depending upon whether the restriction extended beyond the day of injury.

Third, is a transfer to another job. Injuries requiring transfer of the employee to another job are also considered serious enough to be recordable regardless of the type of treatment provided. Transfers are seldom the sole criterions for recordability because injury cases are almost always recordable on other grounds, primarily medical treatment or restriction of work or motion.

Once the employer decides that a recordable injury or illness has occurred, the case must be evaluated to determine its extent or outcome. There are three categories of *recordable cases*: They are fatalities, lost workday cases, and cases without lost workdays. Every recordable case must be placed in only one of these categories. A description of each category is provided below.

First, are Fatalities. All *Work-related Fatalities* must be recorded, regardless of the time between the injury and the death, or the length of the illness. Second, are *Lost Workday Cases*. These occur when the injured or ill employee experiences either days away from work, days of restricted work activity, or both. In these situations, the injured or ill employee is affected to such an extent that: (1) Days must be taken off from the job for medical treatment or recuperation; or (2) the employee is unable to perform his or her normal job duties over a normal work shift, even though the employee may be able to continue working.

Lost workday cases involving days away from work are cases resulting in days the employee would have worked but could not because of the job-related injury or illness. The focus of these cases is on the employee's inability, because of injury or illness, to be present in the work environment during their normal work shift. Lost workday cases involving days of restricted work activity are those cases where, because of injury or illness, (1) the employee was assigned to another job on a temporary basis, or (2) the employee worked at a permanent job less than full time, or (3) the employee worked at his or her permanently assigned job but could not perform all the duties normally connected with it. Restricted work activity occurs when the employee, because of the job-related injury or illness, is physically or mentally unable to perform all or any part of his or her normal job duties over all or any part of his or her normal workday or shift. The emphasis is on the employee's inability to perform normal job duties over a normal work shift. Injuries and illnesses are not considered lost workday cases unless they affect the employee beyond the day of injury or onset of the illness. When counting the number of days away from work or days of restricted work activity, do not include the initial day of the injury or onset of illness, or any days on which the employee would not have worked such as holidays, vacations, etc.

Third, is *Cases Not Resulting in Death or Lost Workdays*. These cases consist of the relatively less serious injuries and illnesses which satisfy the criteria for recordability but which do not result in death or require the affected employee to have days away from work or days of restricted work activity beyond the date of injury or onset of illness.

OSHA Record Keeping Exercise

Each multiple choice question in this examination will be followed by four choices for an answer. Only one of these four choices is the correct answer. Please circle the correct answer.

1. What is the correct name for the acronym OSHA mean?

   - A. Office of Safety and Health Administration.
   - B. Occupational Safety and Health Association.
   - C. Organizational Safety and Health Affiliation.
   - D. Occupational Safety and Health Administration.

2. What is the purpose of the OSHA law?

   - A. Protect companies from safety violations.
   - B. Prohibit safety violations against individuals.
   - C. Provide a place of employment free from safety hazards.
   - D. Prohibit safety violations against individuals with disabilities.

3. The Safety Standards utilize the abbreviation 29 CFR Part 1926, What does the acronym CFR stand for?

   - A. Code of Federal Register.
   - B. Code of Federal Regulations.
   - C. Construction Federal Register.
   - D. Construction Federal Regulations.

4. Which document is utilized to keep the CFR up to date?

   - A. Federal Register.
   - B. Federal Regulations.
   - C. Federal Compliance Standards.
   - D. Federal Safety and Health Violations.

5. Which Part of the OSHA Standards is designated for Recordkeeping?

   - A. 5(a)(1)
   - B. 1904
   - C. 1910
   - D. 1926

OSHA Record Keeping Exercise

6. Which Part of the OSHA Standards is designated for Inspections?

- A. 5(a)(1)
- B. 1903
- C. 1910
- D. 1926

7. Which Part of the OSHA Standards is designated for General Industry?

- A. 1903
- B. 1904
- C. 1910
- D. 1926

8. What does the safety acronym CPL stand for?

- A. Compliance.
- B. Code Personnel.
- C. Competent Personnel.
- D. Construction Personnel.

9. What does the safety acronym STD stand for?

- A. Standard.
- B. Short Term Directive.
- C. Safety Training Directive.
- D. Safety Training and Development.

10. What is the purpose of an STD?

- A. To provide a formal interpretation of an OSHA Regulation.
- B. To provide advice about an OSHA Regulation.
- C. To protect companies from safety violations.
- D. To prohibit companies from safety violations.

OSHA Record Keeping Exercise

11. What does the safety acronym MSDS stand for?

- A. Master Safety Data Sheet.
- B. Material Safety Data Sheet.
- C. Material Standard Data Sheet.
- D. Management Safety Designated Standard.

12 Which of the following activities is considered a Work related recordable?

- A. A worker employed by you, is on the premises to visit and gets injured.
- B. You get ill from the fumes while working in a certain area of the project.
- C. You are playing Racquetball at the employer owned courts on your break with another employee and you are injured.
- D. You are coming to work and you get injured in the parking lot as you exit the car.

13. Which of the following is considered a Work related recordable?

- A. Employee loses consciousness.
- B. Treatment of first degree burn(s).
- C. Application of bandage(s) during any visit to medical personnel.
- D. Application of Antiseptics during first visit to medical personnel.

14. Which of the following is considered a Work related recordable?

- A. Removal of foreign bodies embedded in the eye.
- B. Removal of foreign bodies not embedded in the eye.
- C. Removal of foreign bodies from uncomplicated wound.
- D. Application of hot or cold compress(es) during first visit to medical personnel.

15. Which of the following is described in STD 3-1.1 of an accident prevention program?

- A. A log of all previous safety violations for the company.
- B. Written job safety analysis that must be available for OSHA inspector.
- C. Guidelines for the minimum elements of an accident prevention program.
- D. Evaluation of their accident program by a Certified Safety Professional (CSP).

OSHA Record Keeping Exercise

16. Which of the following is true of the OSHA training regulations?

- A. Employer must train all employees annually.
- B. Employer must maintain a record of training with date, time, and subject.
- C. Employer must train all employees regularly in safety recognition and avoidance.
- D. Employer must have an OSHA Approved Certified Trainer to teach employees.

17. According to OSHA, which document must be filled out immediately after an accident by the supervisor describing the accident in detail?

- A. Insurance forms.
- B. OSHA's Summary of Work-Related Injuries and Illnesses (OSHA's 300A)
- C. OSHA's Log of Work-Related Injuries and Illnesses (OSHA's Form 300)
- D. OSHA's Injury and Illness Incident Report (OSHA's Form 301).

18 According to OSHA, which information must be posted at the job site and easily accessible to all employees at all times?

- A. Company Safety Policy, OSHA Common Violations, Injury Log.
- B. Variance Approval, Rights and Responsibilities Form, Citations.
- C. Worker Compensation rules, Compliance Sheet, Supplemental Record of Injury.
- D. Job Safety/ Health Regulations, Material Safety Data Sheet Notice, Emergency #.

19. When and Where must the OSHA Summary (OSHA 300A) be posted?

- A. All year long and easily accessible to all employees at the job site.
- B. All year long and in the Project Manager's office in the main office.
- C. February 1 - April 1 and accessible to all employees at the jobsite.
- D. February 1 - April 1 and in the office employees break room in the main office.

20. The OSHA Act states that "each employer shall furnish too each employee a place of employment which is free from recognized hazards that are causing or likely to cause death or serious physical harm to an employee." Which section is this stated in?

- A. 5(a)(1)
- B. 1910.10 (a)
- C. 1926.10(a)
- D. 1903.10 (a)

Check Answers

OSHA Inspection Process

Under Section 5(a) (1) of the General Duty Clause it states that, "Each employer (and its representatives) shall furnish to each of its employees, employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to an employee."

What elements are necessary to prove a violation under the general duty clause?
According to OSHA for a violation to exist under the General Duty Clause, the compliance officer must prove that the following four elements existed.

1. The employer failed to keep the workplace free of a hazard to which employees of that employer were exposed.

2. The hazard was recognized.

3. The hazard was causing or was likely to cause death or serious harm.

4. There was a feasible and useful method to correct the hazard.

Element 1 - A Hazard to which Employees Were Exposed:
A general duty violation must involve both a serious hazard and exposure to employees. A hazard is a danger which threatens physical harm to employees. It is not the lack of a particular abatement method nor a particular accident.

The hazard was reasonably foreseeable.
The hazard must affect the cited employer's employees.

Element 2 - The Hazard Must Be Recognized:
Recognition of a hazard can be established on the basis of industry recognition, employer recognition, or "common sense" recognition.

Element 3 - The Hazard Was Likely to Cause Death or Serious Physical Harm:
This element of a Section 5(a)(1) violation is similar to the substantial probability element of a serious violation under Section 17(k) of the Act (P.L. 91-596).

Element 4 - The Hazard Must Be Corrected by a Feasible and Useful Method.
To establish a violation under 5 (a) (1), a method which is feasible, available and likely to correct the hazard must be identified. The information must indicate that a recognized hazard, rather than a particular accident, is preventable.

OSHA Inspection Priorities

OSHA has established a system of inspection priorities based upon the following criteria:

Imminent Danger situations are given top priority. An imminent danger is any condition where there is reasonable certainty that a danger exists that can be expected to cause death or serious physical harm immediately or before the danger can be eliminated through normal enforcement procedures. If an imminent danger situation is found, the compliance officer will ask the employer to voluntarily abate the hazard and to remove endangered employees from exposure.

The second priority for an inspection is a *Fatal Accident or a Catastrophe* resulting in the hospitalization of three or more employees. The third inspection priority is *Formal Employee Complaints* of alleged violations of standards or of unsafe or unhealthful working conditions. The fourth inspection priority is *Programmed Inspections* which are aimed at specific high hazard industries. Industries are selected for inspection on the basis of factors such as the injury incidence rates, previous citation history, employee exposure to toxic substances, or random selection. The fifth inspection category is *Follow-up Inspections* to determine if previously cited violations have been corrected. If an employer has failed to abate a violation, the compliance officer informs the employer that they are subject to a "Failure to Abate" citation for the alleged violations and proposed additional daily penalties while such failure to abate or violation continues.

The OSHA regulation also identifies the *Safety Notices or Postings* that must be posted at the job site. You must have the following posters visible to all employees at the job site**.**

1. A safety poster titled "Safety and Health Protection on the Job."
2. An MSDS poster indicating the location of all Material Safety Data Sheets.
3. An Emergency Information poster. This poster provides the local phone numbers for Fire, Police, Ambulance, Hospital.

Also, the OSHA Officers' compliance manual describes the Job site Safety Inspection process that the Safety Compliance officer will follow when they arrive at the job site. First, they will determine who is in charge or the person that is designated as the safety site representative. Then the Safety Compliance Officer will present their credential. Finally, the Safety officer will conduct an opening conference and they will explain the purpose of the visit and describe the inspection is based on an immediate danger, fatal accident, employee complaint, programmed inspection, or follow-up inspection. They will ask the Supervisor if the employees have a representative. If there is not an authorized employee representative, then the compliance officer must consult with a reasonable member of employees about Safety and Health at the job site.

Next, they will ask the supervisor if there were any recordable injuries of their workers on that job site for the current year. Also, they will ask the Supervisor if there were 11 or more workers on the job site at any time during the past calendar year. If 11 or more employees, they will ask to see the OSHA No. 300 Form titled, Log and Summary of Occupational Injuries and Illnesses and OSHA No. 301 Form titled Supplemental Record of Occupational Injuries and Illnesses. Finally, they will verify the location of the safety poster and that it is prominently displayed on the site.

Another step in the safety officer's inspection is they will conduct a walk through inspection of the job site. The OSHA compliance officer will conduct an inspection of the work place with the supervisor and the employees' representative (if required). The route and duration of the inspection are determined by the compliance officer while talking with employees, and the compliance officer makes every effort to minimize any work interruptions. The compliance officer observes safety and health conditions and practices; consults with employees privately, and if necessary; they can take photographs and instrument readings; examine records, collect air samples, measures noise levels, and survey existing engineering controls; and monitor employee exposure to toxic fumes, gases, and dusts. Employees are consulted during the inspection tour. The compliance officer may stop and question workers, in private, about safety and health conditions and practices in their workplaces. Each employee is protected under the Act from discrimination by the employer for exercising his or her safety and health rights.

Finally, the safety compliance officer will conduct a closing conference. At the conclusion of an inspection, the compliance officer also will give the employer a copy of *Employer Rights and Responsibilities*. If necessary, the supervisor and the employees' representative have the right to separate closing conferences.

Also, at the closing conference the compliance officer discusses with the employer all unsafe or unhealthful conditions observed during the inspection and indicates all apparent violations for which a citation may be issued or recommended. It should be understood that the actual citations issued and the notices of the proposed penalties will be sent to the employer by certified mail.

The purpose of *Citations* is to inform the employer and employees of the regulations and standards alleged to have been violated and of the proposed length of time set for their abatement. The employer must post a copy of each citation at or near the place of violation for 3 working days or until the violation is abated, whichever is longer.

There are four factors that OSHA will use to determine if a violation exists. They are the: 1) Type of Hazard, 2) Type of Exposure, 3) Type of Violation and, 4) the Severity Factor. OSHA has three definitions of *Types of Hazards*. First, a Recognized Hazard is a hazard that requires common knowledge or general recognition in construction. Second, a Detectable Hazard is a hazard that is recognizable by means of the senses and by means of generally known and accepted tests for its existence.

Third, is a Serious physical harm hazard which is any hazard that may cause Serious Permanent or prolonged impairment of the body or could inhibit an internal bodily system as to shorten life.

OSHA classifies *Exposure*, when conducting an inspection or investigation, as the number of employees that are exposed to a particular hazard. This exposure is one of the factors that determines the cost of the penalty. OSHA views exposure in three different manners. First, is the *Past Exposure* that could be repeated may be a factor for potential exposure. Second, is the *Present Exposure* as observed by safety officer. Third, is the Potential Exposure inferred from the work patterns or the anticipated work requirements indicate a possibility of exposure.

The Types of OSHA Safety Violations

OSHA classifies the *Types of Violations* according to the following guidelines: First, the *Other-Than-Serious Violation* (OTS) which is a violation that has a direct relationship to job safety and health, but probably would not cause death or serious physical harm. A penalty of up to $7,000 for each violation is discretionary. Also, a penalty for an other-than-serious violation may be adjusted downward by as much as 95 percent depending on the employer's demonstrated efforts to comply with the regulations. This is called the good faith credit.

Second, is the *Serious Violation* (S) which is a violation where there is a substantial probability that death or serious physical harm could result and that the employer knew, or should have known, of the hazard. A mandatory penalty for a serious violation could be assessed from $1,500 to a maximum of $7,000 for each occurrence. A penalty for a serious violation may be adjusted downward, based on the employer's good faith, history of previous violations, the gravity of the alleged violation, and the size of the business.

Third, is the *Willful Violation* (W) which is a violation that the employer intentionally and knowingly commits. The employer is aware that a hazardous condition exists, knows that the condition violates a standard or other obligation of the Act, and makes no reasonable effort to eliminate it. Penalties of up to $70,000 may be proposed for each willful violation, with a minimum penalty of $5,000 for each violation.

Fourth, is the *Repeat Violation* (R) which is a violation of any standard, regulation, rule, or order where the original citation has become a final order, and upon reinspection, a substantially similar violation is found. Repeat violations can bring a fine of up to $70,000 for each such violation. You should be aware of the long-term ramifications of receiving a second safety violation citation concerning the same safety violation occurring within the company. OSHA can categorize the second violation as a wilful violation. In essence, OSHA is evaluating the company's complete history to establish the violation category. To calculate each repeat violation, the initial penalty is adjusted for the size and then multiplied by a factor of 2, 5, or 10 depending on the size of the employer.

Fifth, is the *Failure to Abate* (FA) prior violation which is defined as the failure to correct a prior violation. This may bring a civil penalty of up to $7,000 for each day that the violation continues beyond the prescribed abatement date.

Additional violations for which citations and proposed penalties may be issued as follows.

Falsifying records and reports can, upon conviction, bring a criminal fine of $10,000 or up to 6 months in jail, or both. A violation of the posting requirements may bring a civil penalty of up to $7,000. Finally, Assaulting or otherwise resisting, opposing, intimidating, or interfering with a compliance officer in the performance of their duties is a criminal offense and is subject to a fine up to $5,000 and imprisonment of up to 3 years.

OSHA has always taken the position that the penalty structure is not designed as a punishment for violations nor as a source of income. The fines are designed as an incentive toward correcting the violations voluntarily. Penalties are assessed on the basis of three factors. They are the: 1) the size of the business, 2) the seriousness of the violations and, 3) the employer's history of previous citations.

The *Gravity of the Violation* is the primary factor in determining penalty amounts. It shall be the basis for calculating the basic penalty for both serious and other violations. To determine the gravity of a violation the following two factors shall be considered. First, the *Severity* of the injury or illness which could result from the alleged violation. Second, the *Probability* that an injury or illness could occur as a result of the alleged violations. Finally, the size of the business and the history of previous violations shall be taken into account in deciding whether the gravity-based penalty shall be reduced.

The classification of the alleged violations as serious or other-than-serious, is based on the severity of the injury or illness which could result from the violation. This classification constitutes the first step in determining the gravity of the violation. The most serious type of injury or illness which is reasonably predictable as a result of the type of accident or health hazard exposure shall be assigned a *Severity Factor* in accordance with the following chart.

Injury and Illness Violations	Severity
Category I - Other-than-serious violations.	0
Category II - Injury and Illness violations *not* resulting in hospitalization or temporary, reversible illnesses requiring minor supportive treatment.	1 - 3
Category III - Injury and Illness violations resulting in hospitalization or temporary, reversible illnesses with a variable but limited period of disability.	4 - 7
Category IV - Injuries involving permanent disability or chronic, irreversible illnesses or death.	8 - 10

Categories II, III, and IV apply to serious violations.

The Supervisors Responsibilities under OSHA

The supervisor must provide, at the companies expense, personal protective equipment to employees when required by OSHA standards. If an employee requests, you must make available for them to inspect or copy any medical records that you have pertaining to that employee. Also, you must give an employee or an employee representative an opportunity to attend any meeting concerning a citation or disposition of a complaint. Third, you must permit a Compliance Officer to enter your workplace for the purpose of conducting an inspection.

During the Compliance Officer’s walk, you must allow an employee representative to accompany the Compliance Officer during an inspection or investigation or allow the investigator to consult with the employees’ representative and employees. Also, you cannot withhold wages or discriminate against any employee or their authorized representative for time spent participating in an inspection. After the Compliance Officer’s inspection, the employer must post a copy of each citation at or near the place of violation for 3 working days or until the violation is abated, whichever is longer. Also, you must provide a copy of any citation appeal to the affected employees. Finally, you must post the notice of OSHA's decision concerning an appeal.

All supervisors must maintain accurate records of work related to illnesses and injuries. They must maintain accurate records of any employee exposure to potentially toxic substances. Also, they must provide Hazardous Communication training to all employees. Finally, before starting an activity, all employees must be trained in the proper safety procedures for the activities they are performing. Finally, if a fatality or catastrophe happens you must notify the Department of Labor within 8 hours of a fatality or, a catastrophe. A catastrophe is defined as hospitalization of three or more employees suffering injuries or illness resulting from the same incident.

Multi-employer Work Site Citations

According to OSHA Compliance Directive (CPL 2.45B CH-3), on a *Multi-employer Work site*, both construction and non-construction citations normally shall be issued to employers whose employees are exposed to hazards. This is referred to as the Exposing Contractor. Prior to issuing citations to an *Exposing Employer*, it must first be determined whether the available facts indicate that the exposing employer has a legitimate defense to the citation, as set forth below.

First, the exposing employer did not create the hazard. Second, the exposing employer did not have the authority to have the hazard corrected. Third, the exposing employer did not have the ability to correct or remove the hazard. Fourth, the exposing employer can demonstrate that the creating, the controlling and/or the correcting employers have been notified of the hazards to which their employees are exposed and that the Exposing contractor made an effort to persuade the controlling contractor to correct the hazard.

Fifth, the exposing employer has instructed their employees to recognize the hazard and informed them of how to avoid the dangers when the hazard was known or with the exercise of reasonable due diligence could have been known. This requires where feasible, that an exposing employer must have taken appropriate alternative means of protecting employees from the hazard. Also, when extreme circumstances justify it, the exposing employer shall have removed their employees from the job to avoid citation. If an exposing employer meets all the conditions in 5 above, that employer shall not be cited. If all employers on a work site with employees exposed to a hazard meet these conditions, then the citation shall be issued only to the employers who are responsible for creating the hazard and/or who are in the best position to correct the hazard. In such circumstances, the controlling employer and/or the hazard-creating employer shall be cited. Penalties for such citations shall be calculated using the exposed employees of all employers as the number of employees for probability assessment. Finally, in the case of general duty clause violations, only employers whose own employees are exposed to the violation may be cited.

Other Contractor's can be cited on a Multi-Employer Job site, but prior to issuing citations to other employers, the Inspector must prove that each employer to be cited has knowledge of the hazardous condition or could have had such knowledge with the exercise of reasonable diligence. Under these conditions the following employers normally shall be cited, whether or not their own employees are exposed. First, the employer who actually creates the hazard, the *Creating Employer* can be cited for the same hazard. Second, the employer who is responsible by contract or through actual practice for safety and health conditions on the work site. This is the employer who has the authority for ensuring that the hazardous condition is corrected can be cited. This is referred to as the *Controlling Employer*. Third, the employer who has the responsibility for actually correcting the hazard can also be cited for the same safety violation. This is referred to as the *Correcting Employer*. In conclusion each violation will be evaluated on a multi-employer and the Exposing Contractor, the Creating Contractor, the Controlling Contractor and the Correcting Contractor can all be cited for the same violation.

A Supervisor can protect their company and themselves from citations and safety liability on a multi-employer job site, if you can show that you have taken all necessary actions to protect your employees. Depending upon the circumstances, you may not be liable for serious hazards that you neither created nor controlled. But, to protect yourself you must have attempted the following activities. First, you must have requested, in writing, that the controlling contractor correct the hazard. Second, instructed your employees to avoid the hazard, you must prove that you have enforced the instructions. Third, you instructed your employees on an alternative means of protecting them.

Finally, the Contractor can appeal any and all citations and this is highly recommended practice for the contractor to appeal or downgrade the citations. The contractor can request an informal hearing to discuss with the review office. The contractor should describe in detail how they have abated each violation and ask that the violations be downgraded. Second, the contractor can contest each violation within 15 days and they must post the letter of contest at the job site. Third, the contractor can submit a formal written appeal to the Administrative Law Judge. Fourth, the contractor can submit a written appeal to the OSHA Review Commission. Finally, the contractor can appeal the rulings to the U.S. Court of Appeals.

OSHA Inspection Exercise

1. According to OSHA violations, what is the name of the violation where the firm or designated person is aware that a hazardous condition exists, knows that the condition violates a standard and makes no effort to eliminate the safety hazard?

- A. Willful Violation.
- B. Serious Violation.
- C. De Minimis Violation.
- D. Other-Than-Serious Violation.

2. Which of the following would be an example of Due Diligence?

- A. Reports violations to OSHA.
- B. Tells employees to be careful.
- C. Corrects the hazard(s) immediately.
- D. Screams and threatens the workers to comply.

3. The compliance officer notices a potential hazard that is likely to cause serious physical harm but a regulation does not exist, under which provision can the contractor be cited?

- A. Federal Register.
- B. General Duty Clause.
- C. Construction Safety Act.
- D. Code of Federal Register.

4. What type of inspection is given top priority by OSHA?

- A. Imminent Danger.
- B. Employee Complaints.
- C. Catastrophe or Fatal Accident.
- D. Programmed inspections.

5. In construction, What is the minimum number of employees that an employer must have before they are required to maintain records of occupational injuries and illnesses?

- A. 2
- B. 11
- C. 20
- D. 100

6. What is the minimum number of days for posting the De Minimis Violation?

- A. 1
- B. 3
- C. 15
- D. 60

7. Which of the following is the definition of a work-related catastrophe?

- A. The death of two or more workers.
- B. An injury or illness that requires first aid treatment.
- C. An injury or illness that requires medical treatment.
- D. An injury or illness that requires hospitalization of 3 or more workers.

8. What is the maximum number of hours for reporting a Death or Catastrophe to OSHA?

- A. 4
- B. 8
- C. 24
- D. 48

9. What is the maximum number of days that an employer has to contest any citations?

- A. 1
- B. 15
- C. 30
- D. 60

10. The Pipefitting Subcontractor is required to lay pipe in a trench that is 10 feet deep and 3 feet wide with vertical walls and no sloping or other protection. The trench was dug by the Excavators. The General Contractor supervised the work, but had no employees in the trench. The Concrete Sub told the General contractor and Excavator that the trench needed to be sloped or shored before their employees could work in the trench. During the OSHA inspection, OSHA observed the General at the trench supervising the pipefitter in the trench. Which contractor(s) would receive a citation for an unsafe trench?

- A. Pipefitter only
- B. Pipefitter and excavator.
- C. Pipefitter, excavator, and general contractor
- D. Pipefitter, excavator, general contractor, and concrete contractor

Check Answers

Personal Protective Equipment

The Bureau of Labor Statistics reports indicates that 22 percent of all injuries occur to workers' eyes, and 7 percent to feet and toes. Many of these injuries can be avoided if you wear Personal Protective Equipment. Personal protective equipment (PPE) should be thought of as the "last thin line of defense" and it is required if there is a "reasonable probability of an injury."

According to the OSHA regulations, you are required to wear suitable eye and face protection where eye injuries may occur. Protection is needed where hazards of flying particles, liquids, welding, and radiation exist. Normally, you are required to wear Eye Protection on tasks such as Sawing, nailing, cutting bands, or wires, grinding, handling chemicals, using compressed air, welding. It is probably a good safety habit to wear eye protection all of the time.

If the tasks you are working on have the potential to cut, blister, burn, or irritate the skin you should wear gloves. There are numerous types of hand protection from which you can select effective and comfortable protection. Glove materials include canvas, latex, rubber, neoprene, vinyl-impregnated, leather, plastic-coated, and nylon.

You should select the appropriate glove for the task at hand such as when grouting you should use a rubber glove. Also, when lifting and carrying objects such as metal wood, glass or where sharp edges pose a hazard you should wear leather gloves may be required. Another potential hazard is where flame and heat are a factor, and various types of heat-resistant gloves should be worn.

Chemical hazards may require rubber, neoprene, or plastic gloves. Wrists and arms may require protection from high-temperature materials, solvents, or metal chips. Such protection is provided by arm protectors or gloves that extend over the wrist and lower arm.

Most job sites require a hard hat to be worn at all times. In a recent case two workers were told by the supervisor to put on their hard hats but they disregarded the instructions because they figured that 100 feet was far enough away from the overhead dangers. Five minutes later, a gust of wind lifted a piece of lumber off the fifth floor and it hit one of the workers in the head. Your hard hat must have an ANSI-APPROVED emblem on the inside. When wearing the hard hat you must leave at least a 1-1/4 inch clearance between your head and the shell.

TABLE E-1 - Eye and Face Protector Selection Guide

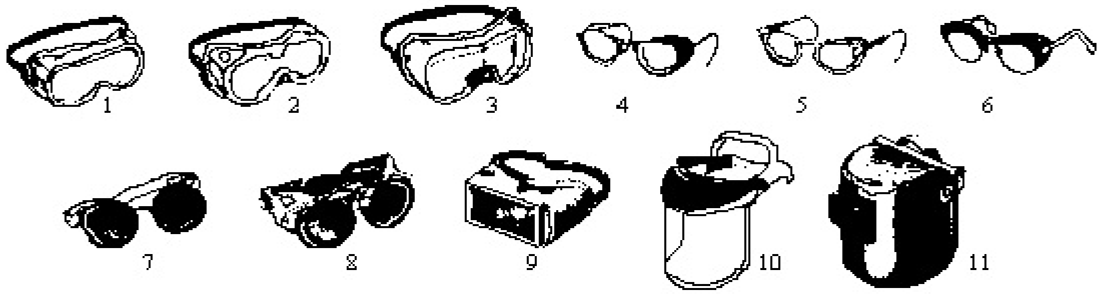


Table E-1 shall be used as a guide in the selection of face and eye protection for the hazards and operations identified below.

1. GOGGLES, Flexible Fitting - Regular Ventilation
2. GOGGLES, Flexible Fitting - Hooded Ventilation
3. GOGGLES, Cushioned Fitting - Rigid Body
4. SPECTACLES, Metal Frame, with Side shields (1)
5. SPECTACLES, Plastic Frame - with Side shields (1)
6. SPECTACLES, Metal-Plastic Frame - with Side shields (1)
7. WELDING GOGGLES, Eyecup Type - Tinted Lenses (2)

7A. CHIPPING GOGGLES, Eyecup Type - Clear Safety Lenses

8. WELDING GOGGLES, Coversepc Type - Tinted Lenses (2)

8A. CHIPPING GOGGLES, Coverspec Type - Clear Safety Lenses

9. WELDING GOGGLES, Coverspec Type - Tinted Plate Lens (2)
10. FACE SHIELD (Available with Plastic or Mesh Window)
11. WELDING HELMETS (2)

Footnote: (1) Non-side shield spectacles are available for limited hazard use requiring only frontal protection.

Footnote: (2) See Table E-2, in paragraph (b) of this section, Filter Lens Shade Numbers for Protection Against Radiant Energy.

Recommended Protectors based upon the Operation and the Hazards

Applications		
Operation	***Hazards***	***Recommended protectors: bold type numbers signify preferred protection***
Acetylene-Burning, Acetylene-Cutting, Acetylene-Welding	Sparks harmful rays, molten metal, flying particles.	7, 8, 9.
Chemical Handling	Splash, acid burns, fumes.	2,10 (For severe exposure add 10 over 2).
Chipping	Flying particles	1, 3, 4, 5, 6, 7A, 8A
Electric (arc) welding	Sparks, intense rays, molten metal	9, 11,(11 in combination 4, 5, 6 in tinted lenses, advisable
Furnace operations	Glare, heat, molten metal.	7, 8, 9 (For severe exposure add 10)
Grinding-Light	Flying particles	1, 3, 4, 5, 6, 10
Grinding-Heavy	Flying particles	1, 3, 7A, 8A (For severe exposure add 10)
Laboratory	Chemical splash glass breakage	2 (10 when in combination with 4, 5, 6)
Machining	Flying particles	1, 3, 4, 5, 6, 10.
Molten metals	Heat, glare, sparks, splash	7, 8, (10 in combination with 4, 5, 6, in tinted lenses
Spot welding	Flying particles, sparks.	1, 3, 4, 5, 6, 10

Respirators Nonmandatory Table

HAZARD	RESPIRATOR
Oxygen deficiency	Self-contained breathing apparatus (SCBA). Hose mask with blower. Combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.
Gas and vapor contaminants immediately dangerous to life and health.	Self-contained breathing apparatus (SCBA). Hose mask with blower. Air-purifying full face piece respirator with chemical canister. (Gas mask). Self rescue mouthpiece respirator (for escape only). Combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.
Not immediately dangerous to life and health	Air-line respirator. Hose mask without blower. Air-purifying, half-mask or mouthpiece respirator with chemical cartridge.
Particulate contaminants immediately dangerous to life and health (IDHL).	Self contained breathing apparatus (SCBA). Hose mask with blower. Air purifying, full face piece respirator with appropriate filter. Self-rescue mouthpiece respirator (for escape only). Combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.
Not immediately dangerous to life and health	Air-purifying, half-mask or mouthpiece respirator with filter pad or cartridge. Air-line respirator. Air-line abrasive-blasting respirator. Hose-mask without blower.
Combination gas, vapor, and particulate contaminants Immediately dangerous to life and health (IDLH).	Self-contained breathing apparatus (SCBA) . Hose mask with blower. Air-purifying, full face piece respirator with chemical canister and appropriate filter (gas mask with filter). Self-rescue mouthpiece respirator (for escape only), Combination air-line respirator with auxiliary self-contained air-supply or an air-storage receiver with alarm.
Not immediately dangerous to life and health.	Air-line respirator. Hose mask without blower. Air-purifying, half-mask or mouthpiece respirator with chemical cartridge and appropriate filter.

Personal Protection Equipment Exercise

Using the Eye and Face Protection Chart from the Construction Safety Standards, select the Recommended Protector for the Operation and Hazards described below.

1. You are Spot Welding, Which of the following types of Eye and Face Protection can be worn?

- ○ A. Welding Helmets.
- ○ B. Goggles, Flexible Fitting, Regular Ventilation
- ○ C. Goggles, Flexible Fitting, Hooded Ventilation.
- ○ D. Welding Goggles, Eyecup Type, Tinted Lenses.

2. You are Chipping, Which of the following types of Eye and Face Protection can be worn?

- ○ A. Welding Helmets.
- ○ B. Goggles, Cushion Fitting, Rigid Body.
- ○ C. Goggles, Flexible Fitting, Hooded Ventilation.
- ○ D. Welding Goggles, Eyecup Type, Tinted Lenses.

3. You are Handling Chemicals considered severe exposure. Which of the following types of Eye and Face Protection can be worn?

- ○ A. Spectacles, Plastic Frame, with Sideshields.
- ○ B. Goggles, Cushion Fitting, Rigid Body.
- ○ C. Goggles, Flexible Fitting, Hooded Ventilation.
- ○ D. Goggles, Flexible Fitting, Hooded Ventilation with Face Shield.

4. You are performing light Grinding, Which of the following types of Eye and Face Protection can be worn?

- ○ A. Spectacles with Sideshields.
- ○ B. Goggles, Flexible Fitting, Hooded Ventilation.
- ○ C. Welding Goggles, Coverspec Type, Clear Safety Lenses.
- ○ D. Chipping Goggles, Coverspec Type, Clear Safety Lenses.

Personal Protection Equipment Exercise

5. You are performing Heavy Grinding considered a severe exposure, Which of the following types of Eye and Face Protection can be worn?

- A. Spectacles with Sideshields.
- B. Goggles, Flexible Fitting, Hooded Ventilation.
- C. Chipping Goggles, Coverspec Type, Clear Safety Lenses.
- D. Chipping Goggles, Eyecup Type, Clear Safety Lenses with Face Shield.

Using the Respirator Chart, Select the Recommended Protector for the Operation and Hazards described below.

6. You need a Respirator for an Oxygen Deficient environment, Which of the following types of Respirators must be worn?

- A. Air-purifying Respirator.
- B. Supplied-air Respirator (SAR).
- C. Powered air-purifying Respirator (PAPR).
- D. Self-contained breathing apparatus (SCBA).

7. You need a Respirator for a combination gas ,vapor, and particulate contaminants not immediately dangerous to life, Which of the following types of Respirators must be worn?

- A. Air-purifying Respirator.
- B. Supplied-air Respirator (SAR).
- C. Powered air-purifying Respirator (PAPR).
- D. Self-contained breathing apparatus (SCBA).

Check Answers

Portable Fire Extinguishers

Portable fire extinguishers are classified to indicate their ability to control specific classes and sizes of fires using a specific symbol and color for each fire classification in accordance with the National Fire Protection Association (NFPA). Fire extinguishers are all labeled using a Letter and/or a pictograph, according to the type of material being extinguished. They are described below.

A	is for ordinary combustibles such as wood, paper, trash, cloth, rubber and many plastics. Old extinguishers can be identified by a GREEN TRIANGLE containing the letter A. The New Extinguisher can be identified by pictograph of a trash can and wood fire.
B	is for flammable liquids such as fuel oil, gasoline, liquids such as fuel oil, gasoline, paint, and grease solvents. This extinguisher can be identified by a RED SQUARE containing the letter B. The New Extinguisher can be identified by a gas can pictograph.
C	is for fires in electrical wiring, overheated fuse boxes, or electrical equipment. This extinguisher can be identified by a BLUE CIRCLE containing the letter C. The New extinguisher can be identified by an electrical plug and receptacle pictograph.
D	is for combustible metals such as aluminum or magnesium. This extinguisher can be identified by a YELLOW FIVE-POINTED STAR containing the letter D.

The latest development in portable fire extinguishers is an all-purpose extinguisher that is effective on Class A, B and C fires or a combination of Fires such as B-C. Also, on the new portable fire extinguishers the prohibited applications are displayed as a pictograph with the background in Black and the Slash is shown in Bright Red.

There are four elements that must be present to start a fire. They are *Fuel* in the form of a combustible material for the fire to consume. The next element is *Oxygen* which must be in a sufficient volume for the fire to feed upon, and the supply must be continuous for the fire to grow. This element is a component of the air around us. The third element is an *Ignition Source* in the form of heat are needed to ignite the fire. These can be invisible or visible. An invisible ignition source is normally called Spontaneous Combustion and it can occur in the form of oily rags or loosely packed organic materials such as turpentine or top soil. A visible ignition source is an open flame. This could be matches, welding sparks or a light bulb. Finally, these three elements combine to produce a *Chain Reaction*, which is called a fire pyramid.

OSHA Standards Requiring Fire Extinguisher in Construction

STANDARD	LOCATION	Type of Extinguisher	DISTANCE (feet)
150(c)(1)(i)	Building area	2A	100'
150(c)(1)(iv)	Each floor	2A	-------
150(c)(1)(iv)	Multistory	2A	adjacent to stairway
150(c)(1)(vi)	5 gallons of Flammable/combustible or 5 pounds of flammable gas	10B	50'
151(c)(6)	Open yard storage	2A or suitable for hazard	100'
152(d)(1)	Flammable liquid storage room	20B	10', Outside
152(d)(2)	Outside Flammable liquid storage area	20B	25'-75'
152(d)(4)	Vehicles	20B:C	On vehicle for dispensing or transporting flammable or combustible liquids
152(g)(11)	Service or Fuel area	20B:C	75'
153(1)	LPG storage	20B:C	---------
352(d)	Welding, cutting, or heating areas	Suitable	----------
550(a)(14)(i)	Crane cabs	5B:C	On crane
800(m)(8) 800 (m)(11)	Tunnel machinery not using fire-resistant hydraulic fluid Underground belt conveyors at head and tail pulley	4A:40B:C	----
902(i)	Vehicles used for transportation of explosives	10A:B:C	----

Fire Extinguishers Exercise

1. Which type of fire extinguisher Letter, Old Symbol, Color and the New Symbol would be used for extinguishing a fire caused by a combustible metals such as aluminum?

- ○ A. The old extinguishers can be identified by a Green Triangle around the letter A. The New Extinguisher pictograph is of a trash can and wood fire.
- ○ B. This extinguisher can be identified by a Red Square around the letter B. The New Extinguisher can be identified by a gas can pictograph.
- ○ C. This extinguisher can be identified by a Blue Circle around the letter C. The New extinguisher pictograph is an electrical plug and receptacle pictograph.
- ○ D. This extinguisher can be identified by a Yellow Five-pointed Star around letter D.

2. Which type of fire extinguisher Letter, Old Symbol, Color and the New Symbol would be used for extinguishing a fire caused by a flammable liquid?

- ○ A. The old extinguishers can be identified by a Green Triangle around the letter A. The New Extinguisher pictograph is of a trash can and wood fire.
- ○ B. This extinguisher can be identified by a Red Square around the letter B. The New Extinguisher can be identified by a gas can pictograph.
- ○ C. This extinguisher can be identified by a Blue Circle around the letter C. The New extinguisher pictograph is an electrical plug and receptacle pictograph.
- ○ D. This extinguisher can be identified by a Yellow Five-pointed Star around letter D.

3. Which type of fire extinguisher Letter, Old Symbol, Color and the New Symbol would be used for extinguishing a fire caused by electrical wiring?

- ○ A. The old extinguishers can be identified by a Green Triangle around the letter A. The New Extinguisher pictograph is of a trash can and wood fire.
- ○ B. This extinguisher can be identified by a Red Square around the letter B. The New Extinguisher can be identified by a gas can pictograph.
- ○ C. This extinguisher can be identified by a Blue Circle around the letter C. The New extinguisher pictograph is an electrical plug and receptacle pictograph.
- ○ D. This extinguisher can be identified by a Yellow Five-pointed Star around letter D.

Fire Extinguishers Exercise

4. On the new fire extinguishers, what are the Color and Pictograph Symbol used displayed on the fire extinguisher to indicate that a specific class of fire is prohibited?

- ○ A. The background is Green and a Slash is shown in Black.
- ○ B. The background is Bright Red and a Slash is shown in Black.
- ○ C. The background is Black and a Slash is shown in Bright Red.
- ○ D. The background is White and a Slash is shown in Bright Red.

5. What is the maximum horizontal travel distance to retrieve a fire extinguisher in a Building Area?

- ○ A. 10 Feet
- ○ B. 25 Feet.
- ○ C. 75 Feet
- ○ D. 100 Feet.

6. What is the maximum horizontal travel distance to retrieve a fire extinguisher in a Fuel Service Area?

- ○ A. 10 Feet
- ○ B. 25 Feet.
- ○ C. 75 Feet
- ○ D. 100 Feet.

7. What is the location of a Fired Extinguisher on a Multistory building?

- ○ A. On an Inside Wall.
- ○ B. On an outside Wall.
- ○ C. In the tool gang box.
- ○ D. Adjacent to Stairway.

Check Answers

Slings and Rigging Equipment

Slings require special attention because they are almost always subjected to severe wear, abrasion, impact loading, crushing, kinking and overloading. They also merit special attention because seemingly insignificant changes in sling angle drastically affect the loading. When using slings exercise extreme caution because you are going to be developing unknown loads, under less than ideal circumstances, in less than perfect equipment. Failure to provide blocking or protective pads will permit sharp corners to cut slings. Pulling slings from under loads will result in abrasion and kinking. Dropping loads on slings or running equipment over them will cause crushing. Also, sudden starts and stops when lifting loads will increase the stresses in them. The improper storage will result in deterioration of the sling. Finally, numerous errors can occur while using a sling such as an error in determining load weight, the effect of the hook angle and the effect of sling angles on the loading. Therefore, it is recommended that all safe working loads be based on a factor of safety.

Sling Materials

According to 1926.251 (b), (c), (d) and (e), the slings are grouped as alloy steel chain, wire rope, natural rope and synthetic fiber, and synthetic webbing. The *Chain Slings* are made for abrasion and high temperature resistance. The only chain suitable for lifting is fabricated from alloy steel and identified by a letter “A” or the number “8" or a combination of the two. The chain slings must be padded on sharp corners to prevent bending stresses in the links.

The use of *Wire Rope Slings* for lifting materials provides several advantages over other types of slings. While not as strong as a chain, it has good flexibility with minimum weight. Breaking outer wires warn of failure and allow time to react. Properly fabricated wire rope slings are very safe for general construction use. The Wire Rope Slings are called Improved Plow Steel Grade Rope with an Independent Wire Rope Core (IWRC), an Improved Plow Steel Grade Rope with a Fiber Core (FC) and a construction Galvanized Aircraft Grade Rope. The Wire Rope sling can also be made into a Braided Rope, a Cable Laid Rope, a Strand Laid Grommet, a Cable Laid Grommet, a Strand Laid Endless Sling and a Cable Laid Endless Sling. The *Braided Slings* are fabricated from usually 6 or 8 small diameter ropes braided together to form a single rope that provides a large bearing surface, tremendous strength and flexibility in all directions. They are very easy to handle and almost impossible to kink. The braided sling can be used in all the standard configurations and combinations but is especially useful for basket hitches where low bearing pressure is desirable or where the bend is extremely sharp. The *Endless Slings or Grommet Slings* are endless ropes that are made from one strand of a rope laid or twisted around itself on each successive loop. There is only one tuck in the entire circumference where the two ends enter the rope. These slings can be used in a number of configurations, as vertical hitches, basket hitches, choker hitches and all combinations of these basic configurations. They are very flexible but tend to wear and deteriorate more rapidly than the other slings because they are not normally equipped with fittings and thus are deformed when bent over hooks and bear against themselves.

The *Natural Rope and the Synthetic Fiber Rope* slings may be used in a temperature range from minus 20 degrees Fahrenheit to 180 degrees Fahrenheit without decreasing the working load limit. According to1926.251 (d) (6) The Natural Rope and the Synthetic Fiber Rope slings shall be immediately removed from service if any of the following conditions are present: (i) Abnormal wear; (ii) Powdered fiber between strands; (iii) Broken or cut fibers; (iv) Variations in the size or roundness of strands; or (v) Discoloration or rotting; and (vi) Distortion of hardware in the sling.

The *Synthetic Webbing Slings* are made of Nylon, Polyester and Polypropylene. According to 1926.251 (e) (6) (i)it states that the Nylon web slings shall not be used where fumes, vapors, sprays, mists or liquids of acids or phenolics are present. Also, under 1926.251 (e) (6) (ii) it states that the Polyester and polypropylene web slings shall not be used where fumes, vapors, sprays, mists or liquids of caustics are present. In addition, paragraph1926.251 (e) (6) (iii) it state that Web slings with aluminum fittings shall not be used where fumes, vapors, sprays, mists or liquids of caustics are present. Finally, under paragraph 1926,251 (e) (8) The Synthetic Web shall be immediately removed from service if any of the following conditions are present: (i) Acid or caustic burns; (ii) Melting or charring of any part of the sling surface; (iii) Snags, punctures, tears or cuts; (iv) Broken or worn stitches; or (v) Distortion of fittings.

Sling Configurations

The Sling Configuration and the sling angle are the most important considerations when deciding how to lift an object. The term “sling” includes a wide variety of configurations for all fiber ropes, wire ropes, chains and webs. The most commonly used *Sling Configurations* in construction rigging will be considered here because improper application can affect the safety of the lift.

The *Single Vertical Hitch* is a method of supporting a load by a single vertical part of leg of the sling. The total weight of the load is carried by a single leg, the angle of the lift is 90º and the weight of the load can equal the maximum safe working load of the sling and fittings. The end fittings of the sling can vary but thimbles should be used in the eyes. Also, the eye splices on wire ropes should be Mechanical-Flemish splices for best security. This sling configuration must not be used for lifting loose material, lengthy material or anything that will be difficult to balance. Use them only on items equipped with lifting eye bolts or shackles such as concrete buckets. They provide absolutely no control over the load because they permit rotation.

The *Bridle Hitch* is the use of two, three or four single hitches to form a bridle hitch for hoisting an object that has the necessary lifting lugs or attachments. They can be used with a wide assortment of end fittings. They provide excellent load stability when the load is distributed equally among the legs, when the hook is directly over the center of gravity of the load and the load is raised level. In order to distribute the load equally it may be necessary to adjust the leg lengths with turnbuckles. The use of a bridle sling requires that the sling angles be carefully determined to ensure that the individual legs are not overloaded. Unless the load is flexible, it is wrong to assume that a 3 or 4 leg hitch will safely lift a load equal to the safe load on one leg multiplied by the number of legs because there is no way of knowing that each leg is carrying its share of the load. With slings having more than 2 legs and a rigid load, it is possible for two of the legs to take practically the full load while the others only balance it.

The *Single Basket Hitch* is a method of supporting a load by hooking one end of a sling to a hook, wrapping it around the load and securing the other end to the hook. It cannot be used on any load that is difficult to balance because the load can tilt and slip out of the sling. On loads having inherent stabilizing characteristics the load on the sling will be automatically equalized with each leg supporting half the load. Ensure that the load dies not turn or slide along the rope during a lift because both the load and rope will become damaged.

The *Double Basket Hitch* consists of two single basket hitches passed under the load. They must be placed under the load so that it is properly balanced. The legs of the hitches must be kept far enough apart to provide balance but not so far apart that excessive angles are developed or to create a tendency for the legs to be pulled in toward the center. On smooth surfaces, both sides of the hitches should be snubbed against a step or change of contour to prevent the rope from slipping as load is applied. The angle between the load and the sling should be approximately 60º or greater to avoid slippage.

The *Double Wrap Basket Hitch* is a basket hitch that is wrapped completely around the load rather than just supporting as does the ordinary basket hitch. The double wrap basket hitch can be used in pairs like the double basket hitch. This method is excellent for handling loose material, pipe, rod or smooth cylindrical loads because the rope or chain exerts a full 360º contact with the load and tends to draw it together.

The *Single Choker Hitch* forms a noose in the rope that tightens as the load is lifted. It does not provide a full 360 degree contact with the load. Hence, it should not be used to lift loose bundles from which material can fall or loads that are difficult to balance. The single choker can also be doubled. When it is necessary to turn a load, the choker is made by placing both eyes of the sling on top of the load with the eyes pointing in the direction opposite the direction of the turn. The center of the sling is passed around the load, through both eyes and up to the hook. This hitch provides complete control over the load during the entire turning operation, and the load automatically equalizes between the two supporting legs of the slings. If, the choker is incorrectly made and the two eyes are placed on the crane hook and the supporting legs of the sling are not equal in length, the load may be imposed on one leg only.

The *Double Choker Hitch* consists of two single chokers attached to the load and spread to provide load stability. These like the single choker, do not completely grip the load but because the load is less likely to tip they are better suited for handling loose bundles of pipes or rods, etc.

The *Double Wrap Choker Hitch* is one in which the rope or chain is wrapped completely around the load before being hooked into the vertical part of the sling. This hitch is in full contact with the load and tends to draw it tightly together. It can be used either singly on short, easily balanced loads or in pairs on longer loads. The double wrap choker is made by placing both eyes of the sling on top of the load with the eyes pointing in the direction opposite to the direction of the turn. The center of the sling is passed around the load, through both eyes, and up to the hook. This hitch provides complete control over the load during the entire turning operation. The load automatically equalizes between the two supporting legs of the sling. Because the load is turned into a tight sling, there is no movement between the load and the sling. If the double wrap choker is incorrectly made, and the two eyes are placed on the crane hook, the supporting legs of the sling may not be equal in length and the load may be carried by one leg only.

Sling Inspection Requirements

According to Subpart H titled Materials Handling, Storage, Use, and Disposal and in section1926.251 titled Rigging Equipment Paragraph (a) titled *General* (1) it states that rigging equipment for material handling shall be inspected prior to use on each shift and as necessary during its use to ensure that it is safe. Also, under Paragraph1926.251 (a)(6) titled Inspections, it states that each day before being used, the sling and all fasteners and attachments shall be inspected by a competent person designated by the employer. Also, damaged or defective slings shall be immediately removed from service. Another paragraph under Subpart H 1926.251 (c) titled Wire Rope and subparagraph (4)(iv) it states that wire rope shall not be used if, in any length of eight diameters, the total number of visible broken wires exceeds 10 percent of the total number of wires, or if the rope shows other signs of excessive wear, corrosion, or defect.

Angle of the Hook and the Sling Hook Lifting Capacity

The Sling Hook condition can affect the lifting capacity. You must know what hardware to use, how to use it, and how its safe working loads (SWL) compare with the rope or chain used with it. All fittings must be of adequate strength for the application. Only forged alloy steel load-rated hardware should be used for overhead lifting. Load-rated hardware is stamped with its SWL. Inspect hardware regularly and before each lift. The signs to look for in the sling hook are any wear, cracks, severe corrosion, deformation or bends, any mismatched parts and obvious damage to the hook. The *Sling Hook Capacity is effected by the angle of the hook*. For example, the table below provides the reduction of the rated load due to the angle of the hook.

Effect of Eccentric Load on Hook Capacity	% of Rated Load
A Balanced load with the load distributed evenly through the Hook can carry	100%
An Eccentric load on the hook that is 1/4 Off Center can carry	86%
An Eccentric load on the hook that is ½ Off Center can carry	80%
An Eccentric load on the hook that is 3/4 Off Center can carry	70%
An Eccentric load on the hook that is carried by the end of the hook can carry	40%

Angle of the Sling and the Effect on the Lifting Capacity

The *Sling Angles also affect the rated capacity* of any sling. The rated capacity depends on its size, its configuration and the angles formed by the legs of the sling and the horizontal. A sling with two legs that is used to lift a 1000 pound object will have a 500-pound load in each leg when the sling angle is 90 degrees. The load in each leg will increase as the angle is decreased and at 30 degrees the load will be 1000 pounds in each leg. If at all possible, keep the sling angles greater than 45 degrees. Also, sling angles that are approaching 30 degrees should be considered extremely hazardous and avoided at all costs. Some load tables list sling angles as low as 15 degrees, but the use of any sling at an angle less than 30 degrees is extremely dangerous. This is not only because of the high loads associated with them but because of the effect on the load of an error in sling angle measurement of as little as 5 degrees. The following table illustrates the effect of a 5-degree error in sling angle measurement on the sling load.

EFFECT OF SLING ANGLE
MEASUREMENT ERROR ON LOADS

Assumed Sling Angle	Assumed Load (Pounds per Leg)	Actual Angle (is 5° Less Than Assumed Angle)	Actual Load (Pounds Per Leg)	Error %
90°	500	85°	502	0.4
75°	518	70°	532	2.8
60°	577	55°	610	5.7
45°	707	40°	778	9.1
30°	1,000	25°	1,183	18.3
15°	1,932	10°	2,880	49.0

As you can see that there is almost a 50% error in the assumed load at the 15-degree sling angle. This illustrates how cautious you must be in not only ensuring the angle is greater than 45 degrees, but the importance of measuring it accurately. The easiest and most accurate way to determine the angle is by measuring it with a large plywood measure graduated in degrees.

Rigging Equipment Exercise

1. How often does a sling have to be inspected?

- A. Yearly.
- B. Monthly.
- C. Once per day at the beginning of the shift.
- D. Each day before sling use and during sling use.

2. A wire rope is designated as a 1-3/4 inch, 6 x 37 - IWRC. What does the 6 indicate?

- A. Strands.
- B. Diameter.
- C. Rated Capacity.
- D. The number of wires per strand.

3. A wire rope is designated as a 3/4 inch, 6 x 19 - IWRC. What does the 19 indicate?

- A. Strands.
- B. Diameter.
- C. Rated Capacity.
- D. The number of wires per strand.

4. A wire rope is designated as a 3/4 inch, 6 x 19 - IWRC. What does the IWRC mean?

- A. Improved Wire Rope Core.
- B. Improved Wide Rope Core.
- C. Independent Wire Rope Core.
- D. Independent Wide Rope Core.

5. What are the total number of broken wires that can be visible in any eight diameter lengths given a 3/4 inch, 6 x 19 IWRC wire rope sling before it must be removed?

- A. 0
- B. 6
- C. 11
- D. 19

Rigging Equipment Exercise

6. Which type of material is suitable for a chain sling?

- ○ A. Carbon Steel 160.
- ○ B. Structural Steel Grade 60.
- ○ C. Improved Plow Steel Grade.
- ○ D. Alloy Steel and identified by a letter “A” or the number “8" or a combination.

7. Which type of sling material cannot be used where fumes, vapors, sprays, mists or liquids of acids or phenolics are present?

- ○ A. Chain Sling.
- ○ B. Wire Rope Sling.
- ○ C. Nylon Web Sling.
- ○ D. Natural Rope and Synthetic Fiber.

8. Which type of sling material is best for abrasion and high temperature resistance?

- ○ A. Chain Sling.
- ○ B. Wire Rope Sling.
- ○ C. Nylon Web Sling.
- ○ D. Natural Rope and Synthetic Fiber.

9. Which type of sling material may be used in a temperature range from minus 20 degrees Fahrenheit to 180 degrees Fahrenheit?

- ○ A. Chain Sling.
- ○ B. Wire Rope Sling.
- ○ C. Nylon Web Sling.
- ○ D. Natural Rope and Synthetic Fiber.

10. Which type of sling configuration is better suited for handling loose bundles of pipe or rebar?

- ○ A. Bridle Hitch.
- ○ B. Single Basket Hitch.
- ○ C. Single Choker Hitch.
- ○ D. Double Choker Hitch.

Rigging Equipment Exercise

11. What is the Rated Load Capacity for a hook that is ½ Off center?

- A. 70%
- B. 80%
- C. 86%
- D. 100%

12. Assume you are lifting 1000 pounds, What is the load on each leg of two legged sling if the horizontal sling angle is 45 degrees?

- A. 500 Pounds
- B. 577 Pounds
- C. 707 Pounds
- D. 1000 Pounds

Using the OSHA Sling Tables Attached answer the following questions.

13. Given a single leg sling that is 3/4 inch in diameter, 6 x 19 construction, IWRC, used in a choker hitch with a Mechanical Splice. What is the rated lifting capacity?

- A. 3.3 Tons
- B. 3.6 Tons
- C. 3.9 Tons
- D. 4.9 Tons

14. Given a load of 7500 pounds, you will lift using a Wire Rope Sling in a 2 legged Bridle Hitch in a 60 degree horizontal angle using a 6 x 19 Improved Plow Steel Grade Rope with Fiber Core, Hand Tucked. What is the minimum Wire Rope Diameter?

- A. 3/8. inches
- B. 7/16 inches
- C. 1/2 inches
- D. 9/16 inches

Rigging Equipment Exercise

15. Given a 3 legged Bridle Hitch in a 30 degree horizontal angle using a 3/4 inch 6 x 19 Construction Improved Plow Steel Grade Rope with an Independent Wire Rope Core (IWRC) and connected using a Hand Tucked. What is the Lifting capacity?

- A. 5.8 Tons
- B. 6.3 Tons
- C. 6.6 Tons
- D. 6.8 Tons
- E. 7.3 Tons
- F. 10. Tons
- G. 11. Tons
- H. 13. Tons

Check Answers

Rigging Equipment Exercise using Table H - 3. Rated Capacities for Single Leg Slings
6x19 and 6x37 Classification Improved Plow Steel Grade Rope With Fiber Core(FC)

Rope Diameter (Inches)	Construction	Rated Capacities, Tons (2,000 lb)								
		Vertical HT	Vertical MS	Vertical S	Choker HT	Choker MS	Choker S	Vertical Basket HT	Vertical Basket MS	Vertical Basket S
¼	6 x 19	0.49	0.51	0.55	0.37	0.38	0.41	0.99	1.0	1.1
5/16	6 x 19	0.76	0.79	0.85	0.57	0.59	0.64	1.5	1.6	1.7
3/8	6 x 19	1.1	1.1	1.2	0.80	0.85	0.91	2.1	2.2	2.4
7/16	6 x 19	1.4	1.5	1.6	1.1	1.1	1.2	2.9	3.0	3.3
½	6 x 19	1.8	2.0	2.1	1.4	1.5	1.6	3.7	3.9	4.3
9/16	6 x 19	2.3	2.5	2.7	1.7	1.9	2.0	4.6	5.0	5.4
5/8	6 x 19	2.8	3.1	3.3	2.1	2.3	2.5	5.6	6.2	6.7
¾	6 x 19	3.9	4.4	4.8	2.9	3.3	3.6	7.8	8.8	9.5
7/8	6 x 19	5.1	5.9	6.4	3.9	4.5	4.8	10.0	12.0	13.0
1	6 x 19	6.7	7.7	8.4	5.0	5.8	6.3	13.0	15.0	17.0
1 1/8	6 x 19	8.4	9.5	10.0	6.3	7.1	7.9	17.0	19.0	21.0
1 ¼	6 x 37	9.8	11.0	12.0	7.4	8.3	9.2	20.0	22.0	25.0
1 3/8	6 x 37	12.0	13.0	15.0	8.9	10.0	11.0	24.0	27.0	30.0
1 ½	6 x 37	14.0	16.0	17.0	10.0	12.0	13.0	28.0	32.0	35.0
1 5/8	6 x 37	16.0	18.0	21.0	12.0	14.0	15.0	33.0	37.0	41.0
1 ¾	6 x 37	19.0	21.0	24.0	14.0	16.0	18.0	38.0	43.0	48.0
2	6 x 37	25.0	28.0	31.0	18.0	21.0	23.0	49.0	55.0	62.0

Footnote(1) These values only apply when the D/d ratio for HT slings is 10 or greater, and for
MS and S Slings is 20 or greater where:
D=Diameter of curvature around which the body of the sling is bent; d=Diameter of rope.
HT = Hand Tucked Splice and Hidden Tuck Splice. For hidden tuck splice (IWRC) use values in HT columns.
MS = Mechanical Splice.
S = Swaged or Zinc Poured Socket.

Rigging Equipment Exercise using Table H - 4. Rated Capacities for Single Leg Slings
6x19 and 6x37 Classification Improved Plow Steel Grade Rope with Independent Wire Rope Core (IWRC)

Rope Diameter (Inches)	Construction	Rated Capacities, Tons (2,000 lb)								
		Vertical HT	Vertical MS	Vertical S	Choker HT	Choker MS	Choker S	Vertical Basket HT	Vertical Basket MS	Vertical Basket S
¼	6 x 19	0.53	0.56	0.59	0.40	0.42	0.44	1.0	1.1	1.2
5/16	6 x 19	0.81	0.87	0.92	0.61	0.65	0.69	1.6	1.7	1.8
3/8	6 x 19	1.1	1.2	1.3	0.86	0.93	0.98	2.3	2.5	2.6
7/16	6 x 19	1.5	1.7	1.8	1.2	1.3	1.3	3.1	3.4	3.5
½	6 x 19	2.0	2.2	2.3	1.5	1.6	1.7	3.9	4.4	4.6
9/16	6 x 19	2.5	2.7	2.9	1.8	2.1	2.2	4.9	5.5	5.8
5/8	6 x 19	3.0	3.4	3.6	2.2	2.5	2.7	6.0	6.8	7.2
¾	6 x 19	4.2	4.9	5.1	3.1	3.6	3.8	8.4	9.7	10.0
7/8	6 x 19	5.5	6.6	6.9	4.1	4.9	5.2	11.0	13.0	14.0
1	6 x 19	7.2	8.5	9.0	5.4	6.4	6.7	14.0	17.0	18.0
1 1/8	6 x 19	9.0	10.0	11.0	6.8	7.8	8.5	18.0	21.0	23.0
1 ¼	6 x 37	10.0	12.0	13.0	7.9	9.2	9.9	21.0	24.0	26.0
1 3/8	6 x 37	13.0	15.0	16.0	9.6	11.0	12.0	25.0	29.0	32.0
1 ½	6 x 37	15.0	17.0	19.0	11.0	13.0	14.0	30.0	35.0	38.0
1 5/8	6 x 37	18.0	20.0	22.0	13.0	15.0	17.0	35.0	41.0	44.0
1 ¾	6 x 37	20.0	24.0	26.0	15.0	18.0	19.0	41.0	47.0	51.0
2	6 x 37	26.0	30.0	33.0	20.0	23.0	25.0	53.0	61.0	66.0

Footnote(1) These values only apply when the D/d ratio for HT slings is 10 or greater, and for MS and S slings is 20 or greater where:
D=Diameter of curvature around which the body of the sling is bent; d=Diameter of rope.
HT = Hand Tucked Splice. For hidden tuck splice (IWRC) use Table H-3 values in HT column.
MS = Mechanical Splice.
S = Swaged or Zinc Poured Socket.

Rigging Equipment Exercise using Table H - 7. Rated Capacities for 2-leg and 3-leg Bridle Slings
6x19 and 6x37 Classification Improved Plow Steel Grade Rope with Fiber Core (FC)

Rope		Rated Capacities, Tons (2,000 lb)											
		2-leg bridle slings						3-leg bridle slings					
Dia (Inches)	Constr	30 deg (1) (60 deg) (2)		45 deg. Angle		60 deg (1) (30 deg) (2)		30 deg (1) (60 deg) (2)		45 deg. Angle		60 deg (1) (30 deg) (2)	
		HT	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*	*MS*
¼	6 x 19	0.85	0.88	0.70	0.72	0.49	0.51	1.3	1.3	1.0	1.1	0.74	0.7
5/16	6 x 19	1.3	1.4	1.1	1.1	0.76	0.79	2.0	2.0	1.6	1.7	1.1	1.2
3/8	6 x 19	1.8	1.9	1.5	1.6	1.1	1.1	2.8	2.9	2.3	2.4	1.6	1.7
7/16	6 x 19	2.5	2.6	2.0	2.2	1.4	1.5	3.7	4.0	3.0	3.2	2.1	2.3
½	6 x 19	3.2	3.4	2.6	2.8	1.8	2.0	4.8	5.1	3.9	4.2	2.8	3.0
9/16	6 x 19	4.0	4.3	3.2	3.5	2.3	2.5	6.0	6.5	4.9	5.3	3.4	3.7
5/8	6 x 19	4.8	5.3	4.0	4.4	2.8	3.1	7.3	8.0	5.9	6.5	4.2	4.6
¾	6 x 19	6.8	7.6	5.5	6.2	3.9	4.4	10.0	11.0	8.3	9.3	5.8	6.6
7/8	6 x 19	8.9	10.0	7.3	8.4	5.1	5.9	13.0	15.0	11.0	13.0	7.7	8.9
1	6 x 19	11.0	13.0	9.4	11.0	6.7	7.7	17.0	20.0	14.0	16.0	10.0	11.0
1 1/8	6 x 19	14.0	16.0	12.0	13.0	8.4	9.5	22.0	24.0	18.0	20.0	13.0	14.0
1 ¼	6 x 37	17.0	19.0	14.0	16.0	9.8	11.0	25.0	29.0	21.	23.0	15.0	17.0
1 3/8	6 x 37	20.0	23.0	17.0	19.0	12.0	13.	31.0	35.0	25.	28.0	18.0	20.0
1 ½	6 x 37	24.0	27.0	20.0	22.0	14.0	16.0	36.0	41.0	30.0	33.0	21.0	24.0
1 5/8	6 x 37	28.0	32.0	23.0	26.0	16.0	18.0	43.0	48.0	35.0	39.0	25.0	28.0
1 ¾	6 x 37	33.0	37.0	27.0	30.0	19.0	21.0	49.0	56.0	40.0	45.0	28.0	32.0
2	6 x 37	43.0	48.0	35.0	39.0	25.0	28.0	64.0	72.0	52.0	59.0	37.0	41.0

HT = Hand Tucked Splice.
MS = Mechanical Splice.
1 Vertical angles.
2 Horizontal angles.

Rigging Equipment Exercise using Table H - 8 Rated Capacities for 2-leg and 3-leg Bridle Slings
6x19 and 6x37 Classification Improved Plow Steel Grade Rope With Independent Wire Rope Core (IWRC)

Rope		Rated Capacities, Tons (2,000 lb)											
		2-leg bridle slings						3-leg bridle slings					
Dia (Inches)	Constr	30 deg (1) (60 deg) (2)		45 deg. Angle		60 deg (1) (30 deg) (2)		30 deg (1) (60 deg) (2)		45 deg. Angle		60 deg (1) (30 deg) (2)	
		HT	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*	*MS*
¼	6 x 19	0.92	0.97	0.75	0.79	0.53	0.56	1.4	1.4	1.1	1.2	0.79	0.84
5/16	6 x 19	1.4	1.5	1.1	1.2	1.81	0.87	2.1	2.3	1.7	1.8	1.2	1.3
3/8	6 x 19	2.0	2.1	1.6	1.8	1.1	1.2	3.0	3.2	2.4	2.6	1.7	1.9
7/16	6 x 19	2.7	2.9	2.2	2.4	1.5	1.7	4.0	4.4	3.3	3.6	2.3	2.5
½	6 x 19	3.4	3.8	2.8	3.1	2.0	2.2	5.1	5.7	4.2	4.6	3.0	3.3
9/16	6 x 19	4.3	4.8	3.5	3.9	2.5	2.7	6.4	7.1	5.2	5.8	3.7	4.1
5/8	6 x 19	5.2	5.9	4.2	4.8	3.0	3.4	7.8	8.8	6.4	7.2	4.5	5.1
¾	6 x 19	7.3	8.4	5.9	6.9	4.2	4.9	11.0	13.0	8.9	10.0	6.3	7.3
7/8	6 x 19	9.6	11.0	7.8	9.3	5.5	6.6	14.0	17.0	12.0	14.0	8.3	9.9
1	6 x 19	12.0	15.0	10.0	12.0	7.2	8.5	19.0	22.0	15.0	18.0	11.0	13.0
1 1/8	6 x 19	16.0	18.0	13.0	15.0	9.0	10.0	23.0	27.0	19.0	22.0	13.0	16.0
1 ¼	6 x 37	18.0	21.0	15.0	17.0	10.0	12.0	27.0	32.0	22.0	26.0	16.0	18.0
1 3/8	6 x 37	22.0	25.0	18.0	21.0	13.0	15.0	33.0	38.0	27.0	31.0	19.0	22.0
1 ½	6 x 37	26.0	30.0	21.0	25.0	15.0	17.0	39.0	45.0	32.0	37.0	23.0	26.0
1 5/8	6 x 37	31.0	35.0	25.0	29.0	18.0	20.0	46.0	53.0	38.0	43.0	27.0	31.0
1 ¾	6 x 37	35.0	41.0	29.0	33.0	20.0	24.0	53.0	61.0	43.0	50.0	31.0	35.0
2	6 x 37	46.0	53.0	37.0	43.0	26.0	30.0	68.0	79.0	56.0	65.0	40.0	46.0

HT = Hand Tucked Splice.
MS = Mechanical Splice.
1 Vertical angles.
2 Horizontal angles.

OSHA Scaffolding

Under Paragraph 1926.450 (b) it groups all types of scaffolds as either a "supported" or a "suspension" scaffold. OSHA believes that adding this information will make it easier for employers to identify the appropriate general requirements in 1926.451. In paragraph 1926.451 (a) it sets the minimum strength criteria for all scaffolding components and in paragraph 1926.451 (a) *Capacity*. (1) requires that each scaffolding and scaffold component shall be capable of supporting, without failure, its own weight and at least 4 times the maximum intended load applied or transmitted to it. Paragraphs (a)(2), (a) (3), (a) (4), (a) (5) and (g) of 1926.451 provide exceptions to this general rule. Also Paragraph1926.451 (a) (2) requires that direct connections to roofs and floors, and counterweights used to balance adjustable suspension scaffolds, shall be capable or resisting at least 4 times the tipping moment imposed by the scaffold operating at the rated load of the hoist, or 1.5 (minimum) times the tipping moment imposed by the scaffolding operating at the stall load of the hoist, whichever is greater. Also, 1626.451 (c) establishes the *Criteria for supported scaffolds* and 1926.451 (d) establishes the *Criteria for suspension scaffolds*.

According to Subpart L titled Scaffolding under Part 1926 and section number .452 describes the typical types of scaffolding that are available. The major types are (a) pole scaffolds which consist of single-pole scaffolds and independent pole scaffolds. Also, under 1926.452 (b) is tube and coupler scaffolds, (c) is titled fabricated frame scaffolds. Some of the specialized scaffolds include Plasterers', decorators', and large-area scaffolds; Bricklayers' square scaffolds; Horse scaffolds; Form scaffolds and carpenters' bracket scaffolds; Roof bracket scaffolds, Outrigger scaffolds; Pump jack scaffolds; Ladder jack scaffolds; Window jack scaffolds; Crawling boards (chicken ladders); Step, platform, and trestle ladder scaffolds; Single-point adjustable suspension scaffolds; Two-point adjustable suspension scaffolds; A multi-point adjustable suspension scaffold which includes Stone setters' multiple-point adjustable suspension scaffolds and Mason's multipoint adjustable suspension scaffolds; Float (ship) scaffolds; Interior hung scaffolds; Needle beam scaffolds; Multi-level suspended scaffolds; Mobile scaffolds, and under 1926.453 is title Aerial Lifts.

Subpart L Scaffolding under section 1926.454 also addresses *Training for Employees* working with scaffolds. This section supplements and clarifies the training requirements of the existing paragraph 1926.21 (b) (2) which applies to all construction work and requires employers to "instruct each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to their work environment to control or eliminate any hazards or other exposure to illness or injury." Section 1926.454 clarifies the types of hazards to be addresses in all training programs given to employees working on scaffolds and establishes a framework for training programs while allowing employers to tailor the program to fit their workplace. Section .454 Paragraph (a) addresses employees who are working on scaffolds and paragraph (b) address employees who are erecting, dismantling, inspecting and maintaining scaffolds.

The scaffolding safety standards also define a *Competent Person* under 1926.451 and it utilizes the word "a competent person" numerous times throughout the section. It also contains the word *Qualified Person* several times throughout the standard and it establishes that certain types of scaffolding shall be designed by an engineer experienced in or a *Registered Professional Engineer*. Finally, under the compliance Directive Number (CPL 2-1.23) it establishes the guidelines for evaluating the duties and responsibilities of the competent person or qualified person at the job site.

Subpart L Scaffolding provides a non-mandatory Appendices A - E. These are provided as guides to assist employers in the general guidelines for design loads and allowable spans. The non-mandatory guideline also contains specific guidelines and tables for pole scaffolds, tube and coupler scaffolds and fabricated frame scaffolds, and numerous other types of scaffolding. For instance, supported scaffolds such as pole scaffolds, tube and coupler and fabricated frame scaffolds are classified according to their loading capacity and there are three types of classifications.

A *Light-duty* can handle a maximum load of 25 pounds per square foot of platform surface. You must be particularly careful when working on this type of scaffold because it can be easily overloaded. A light-duty scaffold requires the supports to be spaced not more than 10 feet apart along the length of the scaffold. The *Medium-duty,* scaffold can handle a maximum of 50 pounds per square foot of working surface. A medium-duty scaffold requires the supports to be spaced not more than 8 feet apart along the length of the scaffold. Finally, the *Heavy-duty* scaffold can handle a 75-pound load per square foot. A heavy-duty scaffold requires the supports to be spaced not more than 6 feet apart along the length of the scaffold.

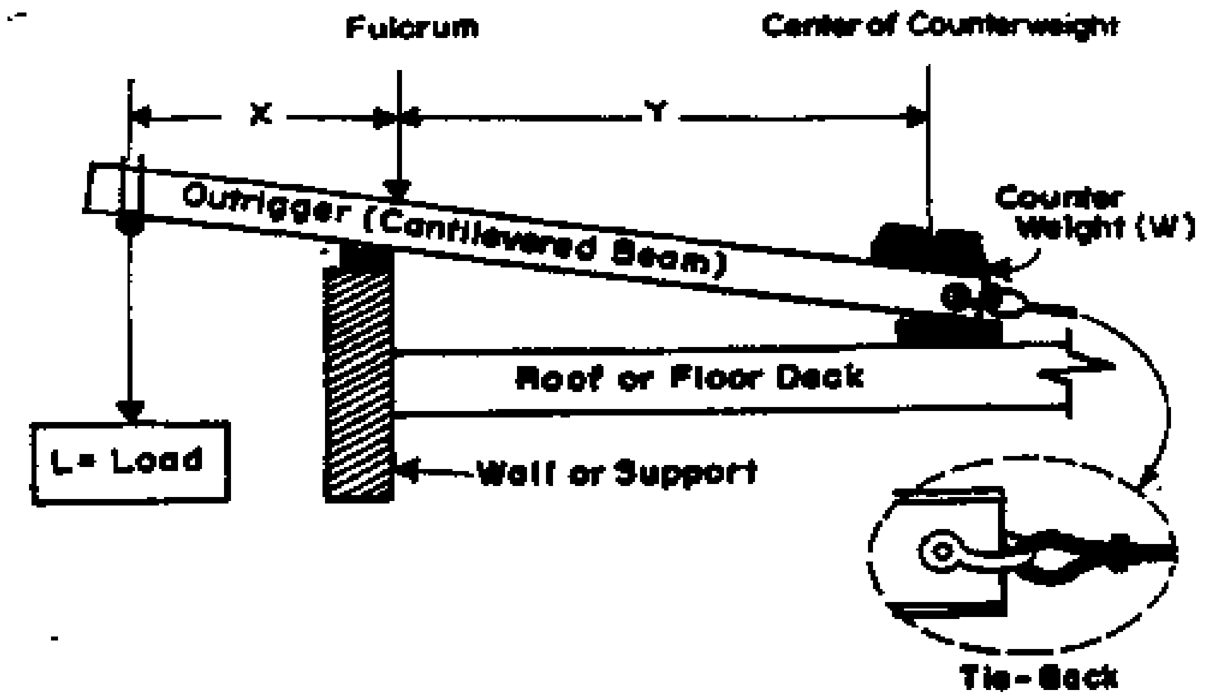
The maximum safe load of a scaffold is determined by measuring its platform area and multiplying the area by the platform's capacity per square foot. For example, if the platform of a medium-duty scaffold measures five feet by eight feet. To calculate the maximum loading capacity, you take the area 5' x 8' = 40 Square Feet x 50 pounds per square foot (medium-duty scaffold) = 2,000 pounds is the maximum loading capacity. However, this load must be evenly distributed and not concentrated in one area of the platform.

Mobile or Rolling Scaffolds also has some design limitations such as when it is moved, all tools, equipment, and workers must be secured or removed from the platform to prevent falling accidents. The floor should be level and free of obstructions. Also, overhead obstructions should be avoided. Once the scaffold has been positioned, the wheels must be locked to prevent any sudden movement of the scaffold. Rolling scaffolds must have design and construction features that will prevent their tipping. The height of the working platform must not exceed four times the smallest dimension of the base. For example, if the base of a rolling scaffold is eight feet by ten feet, the maximum height at which the scaffold can be used is 32 feet, which is four times the smallest dimension of the base. (4 x 8' = 32').

The *Suspension Scaffolds* are the two-point suspension scaffolds, sometimes called the swinging, or stage scaffold. The two-point suspension scaffold is suspended from the roof by roof hooks. Another suspension scaffold is the multiple-point suspension scaffold. This type is used for heavy-duty work and is designed to handle work loads of not more than 50 pounds per square foot. The work platform is supported by wire ropes suspended from overhead outrigger beams. The outrigger beam must be at least 15 feet long and should not extend more than six and one half feet beyond the bearing point. The outrigger beams must be made of structural metal, with the inside end anchored to the frame or floor system of the building by large U-bolts and anchor plates. Because suspension scaffolds can swing and move in the wind, the platform must be tied to the building while you are on it. All suspended scaffolds are hung from either fiber or wire ropes. These ropes must meet safety requirements. Any rope used for scaffold suspension must be able to support the weight of the scaffold, all workers and materials it carries.

The *rope requirements for a suspended scaffolding* supporting a swinging scaffold should not be less than 3/4 of an inch in diameter. They must be properly rigged into a set of six-inch blocks consisting of at least one double and one single block. If the scaffold is to be used with acids, torches, or open flames that will weaken manila rope, then wire rope, not less than 9/16 inch in diameter, must be used. Where wire rope is used, a hoisting mechanism must be provided on the end of the scaffold platform. The rope needs to be carefully checked for damage each time it is used. Otherwise, the damage will not be discovered until it is too late. Checking can be done by twisting the rope until the strands spread apart. If there are a powdery appearance or broken strands, the rope is damaged and must be thrown away. Knots and kinks cause damage to a rope and should be avoided. If usage requires that a rope be continuously twisted in one direction, compensating turns in the opposite direction should be made to avoid damage to the rope. When not in use, rope should be stored in dry, well-ventilated areas away from extreme temperatures, humidity, or dryness. A damp rope will rot, and a dry rope will become brittle, thus losing its strength and durability. As with any elevated working surface, the platform of a suspended scaffold must be equipped with a standard guardrail, toe board, and overhead protection where needed to protect you from being hit by falling objects.

Most suspended scaffolds are raised and lowered with some type of hoisting mechanism. This mechanism must be checked before each use to make certain it is operating safely. There should always be at least three turns of rope left on the hoisting drum, to reduce the force exerted on the rope where it connects with the drum. This measure will lessen the possibility of the rope slipping from the drum and breaking. Scaffold planks should be inspected before each use to ensure their safety. There are visible signs indicating that planks are unsafe. Some of the signs are large knots, excessive grain slope, and decay. Any plank that contains these or other defects should be discarded. Everyone on a suspended scaffold must wear a safety belt and lanyard. The lanyard must be fastened either to a substantial member of the structure to which the scaffold is suspended.



L = LOAD (IN POUNDS)
W = COUNTERWEIGHT (IN POUNDS),
X = LOAD LINE TO FULCRUM DISTANCE (IN FEET)
Y = CENTER OF COUNTERWEIGHT TO FULCRUM DISTANCE (IN FEET)
<u>FORMULAS</u>

LX - YW, BUT TO ADD 4 TO 1 SAFETY FACTOR, LX = 4 (YW)

$W = 4 \frac{(LX)}{Y}$, AND $Y = 4 \frac{(LX)}{W}$

<u>EXAMPLE #1</u>
L = 400 LBS., X = 2 FT., Y = 12 FT., W = ?
$W = 4 \frac{(400 X 2)}{12}$, $W = 4 \frac{(800)}{12}$, W = 4 (66.6), W = 266.6 LBS.

<u>EXAMPLE #2</u>
L = 300 LBS., X = 2 FT., W = 100 LBS., Y = ?
$Y = 4 \frac{(LX)}{W}$, $Y = \frac{(300 X 2)}{100}$, $Y = 4 \frac{(600)}{100}$, Y = 4 (6), Y = 24 FT

Scaffolding Exercise

1. A scaffold must be capable of supporting its own weight and what is the minimum factor that must be applied to the maximum intended load to determine the capacity?

- A. 0 times.
- B. 1 times.
- C. 2 times.
- D. 4 times.

2. OSHA has grouped all scaffolds into two groups and they have established certain criteria for each group. What are the two groups of scaffolds?

- A. Horizontal Scaffolds and Vertical Scaffolds.
- B. Supported Scaffolds and Suspended Scaffolds.
- C. Mandatory Scaffolds and Non-Mandatory Scaffolds.
- D. Required Scaffold Criteria and Not Required Scaffolds Criteria.

3. On scaffolds where platforms are overlapped to create a long platform, the lap shall occur only over supports. What is the minimum lap in inches if they are not nailed?

- A. 3 inches.
- B. 6 inches.
- C. 9 inches.
- D. 12 inches.

4. What is the minimum height to base ratio which requires guying, tying, bracing?

- A. 1:1
- B. 2:1
- C. 3:1
- D. 4:1

5. What is the maximum vertical tie-in distance range in feet for scaffolds that exceed the height to base ratio?

- A. 20 - 26 feet.
- B. 30 - 36 feet.
- C. 40 - 46 feet.
- D. 50 - 56 feet.

Scaffolding Exercise

6. What is the maximum horizontal tie-in distance in feet for scaffolds that exceed the height to base ratio?

- A. 30 feet.
- B. 35 feet.
- C. 50 feet.
- D. 75 feet.

7. What of the following scaffold descriptions describes an independent pole scaffolding?

- A. A supported scaffolding consisting of a platform(s) resting on bearers supported by ledgers and a double row of uprights without any support from any structure.
- B. A supported or suspended scaffold consisting of a platform(s) supported by tubing, erected by coupler devices connecting uprights, braces, bearers, & runners.
- C. A supported scaffolding of a platform resting on thrustouts projecting beyond the wall or face of the building or structure, the inboard ends are secured to inside the building or structure.
- D. A supported scaffolding consisting of a platform(s) resting on bearers, the outside bearers ends are supported on runners secured to a single row of uprights, and the inner bearer ends are supported on or in a structure or building wall.

8. At each end of a platform, what is the maximum extension range for extending the platform beyond its support?

- A. 12 - 18 inches.
- B. 19 - 24 inches.
- C. 25 - 31 inches.
- D. 32 - 36 inches.

9. What is the rated load capacity for a Medium-duty scaffold?

- A. 25 pounds per square foot applied uniformly over the entire span area.
- B. 50 pounds per square foot applied uniformly over the entire span area.
- C. 75 pounds per square foot applied uniformly over the entire span area.
- D. 250 pounds placed 18 inches to the left and right of the center of the span.

Questions 10 through 13 refer to the Non-Mandatory Appendix A in Subpart L, and the tables for various types of scaffolding.

10. Using an Independent Wood Pole Scaffold for a Medium Duty Rating. What is the size of the poles and the maximum on-center longitudinal pole spacing?

- A. 2 x 4 inches, spaced 6 feet on-center.
- B. 4 x 4 inches, spaced 8 feet on-center.
- C. 4 x 4 inches, spaced 10 feet on-center.
- D. Nominal 2 inch OD steel, spaced 4 feet x 7 feet.

11. Using an Independent Wood Pole Scaffold for a Medium Duty Rating. What is the maximum traverse pole spacing in feet?

- A. 5
- B. 6
- C. 8
- D. 10

12. Using an Independent Wood Pole Scaffold for a Medium Duty Rating. What is the maximum vertical spacing of the horizontal members?

- A. 5' - 0"
- B. 6' - 0"
- C. 6' - 6"
- D. 7' - 0"

13. Using an Independent Wood Pole Scaffold for a Light Duty Rating. What is the maximum post spacing using a nominal 2 inch OD?

- A. 4 feet x 7 feet.
- B. 4 feet x 10 feet.
- C. 6 feet x 6 feet.
- D. 8 feet x 8 feet.

14. What is the minimum ladder extension above the point of contact?

- A. 1
- B. 2
- C. 3
- D. 8

Scaffolding Exercise

15. What is the maximum height in feet before a pole scaffolds must be designed by a Registered Professional Engineer?

- A. 20
- B. 50
- C. 60
- D. 125

16. What is the maximum height in feet before a tube and coupler scaffolds must be designed by a Registered Professional Engineer?

- A. 25
- B. 50
- C. 75
- D. 125

17. What is the maximum height in feet before a fabricated frame scaffolds must be designed by a Registered Professional Engineer?

- A. 25
- B. 50
- C. 75
- D. 125

18. Given the following information concerning a Swing Stage Scaffold, the Load (L) is = 600 pounds, the load line to the fulcrum distance (X) = 2.5 feet, and the length of the outrigger from the counterweight to the fulcrum point (Y) is 16 feet. What is the weight (W) of the counter weight in pounds?

- A. 94
- B. 375
- C. 500
- D. 600

19. What is the maximum height in feet of a ladder jack platform?

- A. 20
- B. 30
- C. 60
- D. 125

Scaffolding Exercise

20. When free-standing mobile (manual rolling Scaffolding) scaffold towers are used, the height shall not exceed how many times the minimum base dimension?

- A. 2
- B. 9
- C. 45
- D. 60

21. A manual rolling scaffolding has a base of 7' x 9', What is the maximum height in feet?

- A. 14 Feet
- B. 30 Feet
- C. 60 Feet
- D. 125 Feet

22. Using the Non-Mandatory Appendix A in Subpart L, and the Allowable spans table. What is the minimum nominal size planking that can be used for scaffold planks?

- A. 2 x 6
- B. 2 x 8
- C. 2 x 10
- D. 2 x 12

23. Using a maximum loading for a medium duty scaffold, What is the maximum permissible span for a nominal plank 2 x 12?

- A. 4 feet
- B. 6 feet
- C. 8 feet
- D. 10 feet

24. The point of contact for your ladder is 16' above the ground, What is the proper horizontal distance from the wall?

- A. 03.33 Feet
- B. 04.00 Feet
- C. 12.00 Feet
- D. 16.00 Feet

Check Answers

Scaffolding Exercise for Single Wood Pole Scaffolds

	Light duty up to 20 feet high	Light duty up to 60 feet high	Medium duty up to 60 feet high	Heavy duty up to 60 feet high
Maximum intended load(lbs/sf	25	25	50	75
Poles or upright	2 x 4 in.	4 x 4 in.	4 x 4 in.	4 x 6 in.
Maximum pole spacing (longitudinal)	6 feet	10 feet	8 feet	6 feet
Maximum pole spacing (transverse)	5 feet	5 feet	5 feet	5 feet
Runners	1 x 4 in.	1 ¼ x 9 in.	2 x 10 in.	2 x 10 in.
Bearers and maximum spacing of bearers:				
3 feet	2 x 4 in.	2 x 4 in.	2 x 10 in. or 3 x 4 in.	2 x 10 in. or 3 x 5 in.
5 feet	2 x 6 in. or 3 x 4 in.	2 x 6 in. or 3 x 4 in. (rough)	2 x 10 in. or 3 x 4 in.	2 x 10 in. or 3 x 5 in.
6 feet	----	-----	2 x 10 in. or 3 x 4 in.	2 x 10 in. or 3 x 5 in.
8 feet	----	-----	2 x 10 in. or 3 x 4 in.	2 x 10 in. or 3 x 5 in.
Planking	1 ¼ x 9 in.	2 x 10 in.	2 x 10 in.	2 x 10 in.
Maximum vertical spacing of horizontal members	7 feet	9 feet	7 feet	6 ft. 6 in.
Bracing horizontal	1 x 4 in.	1 x 4 in.	1 x 6 in. or 1 ¼ x 4 in.	2 x 4 in.
Bracing diagonal	1 x 4 in.	1 x 4 in.	1 x 4 in.	2 x 4 in.
Tie-ins	1 x 4 in.	1 x 4 in.	1 x 4 in.	1 x 4 in.

Note: All members except planking are used on edge. All wood bearers shall be reinforced with 3/16 x 2 inch steel strip, or the equivalent, secured to the lower edges for the entire length of the bearer.

Scaffolding Exercise for Independent Wood Pole Scaffolds

	Light duty up to 20 feet high	Light duty up to 60 feet high	Medium duty up to 60 feet high	Heavy duty up to 60 feet high
Maximum intended load	25 lbs/ft (2)	25 lbs/ft (2)	50 lbs/ft (2)	75 lbs/ft (2)
Poles or uprights	2 x 4 in.	4 x 4 in.	4 x 4 in.	4 x 4 in.
Maximum pole spacing (longitudinal).	6 feet	10 feet	8 feet	6 feet
Maximum (transverse).	6 feet	10 feet	8 feet	8 feet
Runners	1 ¼ x 4 in.	1 ¼ x 9 in.	2 x 10 in.	2 x 10 in.
Bearers and maximum spacing of bearers:				
3 feet	2 x 4 in.	2 x 4 in.	2 x 10 in.	2 x 10 in (rough).
6 feet	2 x 6 in. or 3 x 4 in.	2 x 10 in. (rough) or 3 x 8 in.	2 x 10 in.	2 x 10 in. (rough).
8 feet	2 x 6 in. or 3 x 4 in.	2 x 10kn. (rough) or 3 x 8 in.	2 x 10 in	
10 feet	2 x 6 in. or 3 x 4 in.	2 x 10in. (rough) or 3 x 3 in.		
Planking	1 ¼ x 9 in.	2 x 10 in.	2 x 10 in.	2 x 10 in.
Maximum vertical spacing of horizontal members	7 feet	7 feet	6 feet	6 feet
Bracing horizontal	1 x 4 in	1 x 4 in.	1 x 6 in. or 1 ¼ x 4 in.	2 x 4 in.
Bracing diagonal	1 x 4 in.	1 x 4 in.	1 x 4 in.	2 x 4 in.
Tie-ins	1 x 4 in.	1 x 4 in.	1 x 4 in.	1 x 4 in.

Note: All members except planking are used on edge. All wood bearers shall be reinforced with 3/16 x 2 inch steel strip, or the equivalent, secured to the lower edges for the entire length of the bearer.

Scaffolding Exercise for Tube and Coupler Scaffolds

(b) MINIMUM SIZE OF MEMBERS

	Light duty	Medium duty	Heavy duty
Maximum intended load	25 lbs/ft (2)	50 lbs/ft (2)	75 lbs/ft (2).
Posts, runners and braces	Nominal 2 in. (1.90 inches) OD steel tube or pipe.	Nominal 2 in. (1.90 inches) OD steel tube or pipe.	Nominal 2 in. (1.90 inches) OD steel tube or pipe.
Bearers	Nominal 2 in. (1.90 inches) OD steel tube or pipe and a maximum post spacing of 4 ft. x 10 ft.	Nominal 2 in. (.190 inches) OD steel tube or pipe and a maximum post spacing of 4 ft x 7 ft. or Nominal 2 ½ in. (2.375 in.). OD steel tube or pipe and a maximum post spacing of 6 ft. x 8 ft.*	Nominal 2 ½ in. (2.375 in.). OD steel tube or pipe and a maximum post spacing of 6 ft. x 6 ft.
Maximum runner spacing vertically	6 ft. 6 in.	6 ft. 6 in.	6 ft. 6 in.

Footnote(*) Bearers shall be installed in the direction of the shorter dimension. Note: Longitudinal diagonal bracing shall be installed at an angle of 45 deg. (+/- 5).

Allowable spans for 2 x 10 inch (nominal) or 2 x 9 inch (rough) solid sawn wood planks as shown in the following table which is in compliance with the National Design Specification for Wood Construction published by the National Forest Products Association.

Maximum intended nominal load (lb/sf)	Maximum permissible span using full thickness undressed lumber (feet)	Maximum permissible span using nominal thickness lumber (feet)
25	10	8
50	8	6
75	6	------

OSHA Soil Classification System

The *Unconfined Compressive Strength* is the load per unit area at which soil will fail in compression. This measure can be determined by laboratory testing, or it can be estimated in the field using a pocket penetrometer, Torvane Soil Tester or a thumb penetration test. OSHA has established a *Soil Classification System* for categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the environmental conditions of the exposure. A *Type A Soil* is defined as a Cohesive soil with an unconfined compressive strength of 1.5 tons per square Foot (tsf) or Greater. Cohesive soil examples are clay, silty clay, sandy clay, clay loam. However *no soil is Type A if*:

1. The soil is fissured; or
2. The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or
3. The soil has been previously disturbed; or
4. The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or
5. The material is subject to other factors that would require it to be classified as a less stable material.

A *Type B Soil* means a cohesive soil with an unconfined compressive strength greater than 0 .5 tons per square foot but less than 1.5 tsf; or Granular Cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam. Also, a soil is a Type B if previously disturbed soil except those which would otherwise be classified as a Type C soil. Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or dry rock that is not stable; or material that is part of a sloped, layered systems where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

A *Type C soil* means a cohesive soil with an unconfined compressive strength of 0.5 tsf or less; or granular soils including gravel, sand and loamy sand; or submerged soil or soil from which water is freely seeping; or submerged Rock that is not Stable; or material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper. Also, OSHA defines the *Stable Rock* classification as natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Finally, according to the OSHA standards whenever you are classifying a soil and if any of the following characteristics are encountered, then the soil type must be dropped. For example, if the soil is: 1. Fissured or tension cracks on the surface or in the wall of the trench; 2. Vibrated from nearby traffic, equipment or blasting; 3. previously disturbed or excavated areas; 4. Water freely flowing into the trench; 5. sloped layers with a 4H: 1V or steeper; 6. excavation is below the water table; 7. a rock layer is above a weaker soil layer; or 8. Blasting occurs nearby then the soil type must be lowered. Below is a summary of the OSHA Soil Classification System.

SOIL TYPE	CHARACTERISTICS				
	Water Table	Visual	Tilted Soil Layers	Soil Layers	Unconfined Compressive Strength
TYPE A SOILS Intact Hard Soils *cohesive soils *unconfined compressive strength *Examples of Type A Soils clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam & sandy clay loam.	Above water table Not saturated	No fissures, cracks, or weak layers	No tilting layers dipping into the trench with a slope of 4H: 1V or steeper	No soil layers below bed rock layers	More than 1.5 tons per sq. ft.
TYPE B SOILS * cohesive soils *unconfined compressive strength Examples are: angular gravel; silt; silt loam; fissured or subject to vibration; dry unstable rock;	Above water table Not saturated	May have Fissures or Cracks	No tilting layers dipping into the trench with a slope of 4H:1V or steeper	No soil layers below bed rock layers	Between 0.5 - 1.5 tons per sq. ft.
TYPE C SOILS *cohesive soils *granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable.	May be within water table or Saturated	May not be able to stand on slope of 3H:1V without slumping	May contain layers tilting in at 4H:1V slope or greater		
Stable Rock					

Soil Classification Exercise

1. You have performed the following Visual inspection and manual tests. How would you classify a soil that has the following properties?

Visual Observations:	Trench 12 feet deep
Soil Observation:	Angular Gravel
Unconfined Compressive strength:	1.12 tsf
Surrounding Area & Trench Conditions:	an open field

- A. Type A soil
- B. Type B soil
- C. Type C soil
- D. Stable Rock

2. You have performed the following Visual inspection and manual tests. How would you classify a soil that has the following properties?

Visual Observations:	Trench 16 feet deep
Soil Observation:	Sand
Unconfined Compressive strength:	0.43 tsf
Surrounding Area & Trench Conditions:	an open field

- A. Type A soil
- B. Type B soil
- C. Type C soil
- D. Stable Rock

Soil Classification Exercise

3. You have performed the following Visual inspection and manual tests. How would you classify a soil that has the following properties?

Visual Observations:	Trench 6 feet deep
Soil Observation:	Clay
Unconfined Compressive strength:	1.73 tsf
Surrounding Area & Trench Conditions:	An open Field

- A. Type A soil
- B. Type B soil
- C. Type C soil
- D. Stable Rock

4. You have performed the following Visual inspection and manual tests. How would you classify a soil that has the following properties?

Visual Observations:	Trench 14 feet deep
Soil Observation:	Sandy Clay
Unconfined Compressive strength:	1.73 tsf
Surrounding Area & Trench Conditions:	water is freely seeping

- A. Type A soil
- B. Type B soil
- C. Type C soil
- D. Stable Rock

Soil Classification Exercise

5. You have performed the following Visual inspection and manual tests. How would you classify a soil that has the following properties?

Visual Observations:	Trench 9 feet deep
Soil Observation:	Silty Clay
Unconfined Compressive strength:	2.40 tsf
Surrounding Area & Trench Conditions:	Previously Disturbed Soil

- A. Type A soil
- B. Type B soil
- C. Type C soil
- D. Stable Rock

6. You have performed the following Visual inspection and manual tests. How would you classify a soil that has the following properties?

Visual Observations:	Trench 16 feet deep
Soil Observation:	Sandy Clay
Unconfined Compressive strength:	0.47 tsf
Surrounding Area & Trench Conditions:	Sloped Layered system with 4H:1V

- A. Type A soil
- B. Type B soil
- C. Type C soil
- D. Stable Rock

7. You have performed the following Visual inspection and manual tests. How would you classify a soil that has the following properties?

Visual Observations:	Trench 13 feet deep
Soil Observation:	Clay Loam
Unconfined Compressive strength:	1.56 tsf
Surrounding Area & Trench Conditions:	Vibration Nearby

- A. Type A soil
- B. Type B soil
- C. Type C soil
- D. Stable Rock

8. You have performed the following Visual inspection and manual tests. How would you classify a soil that has the following properties?

Visual Observations:	Trench 7 feet deep
Soil Observation:	Sandy Loam
Unconfined Compressive strength:	1.05 tsf
Surrounding Area & Trench Conditions:	Previously Disturbed

- A. Type A soil
- B. Type B soil
- C. Type C soil
- D. Stable Rock

9. What is the maximum lateral travel distance to a means of egress in a 5' deep trench?

- A. 25 feet
- B. 50 feet
- C. 75 feet
- D. 100 feet

Check Answers

OSHA Timber Shoring

A *Support System* is a structure such as a timber shoring system or hydraulic shoring system that supports the sides of an excavation and protects employees against cave-ins. According to the OSHA Excavation Safety Standards, anytime a worker enters a trench at least five (5) feet deep you must provide protection from cave-ins. After a qualified person has determined the type of soil, they have a few options. First, they can design a shoring system using the Shoring Designs provided in the Standards. The Second option is to design a support system using a Manufacturer's system. Finally, they can use a trench box. Below we will define the shoring options outlined in the excavation safety standards for shoring systems under twenty feet deep. According to the OSHA Construction Standards, for excavations over twenty (20) feet deep you must contact a Registered Professional Engineer (RPE) to design the protection system.

Subpart P titled Excavations under Paragraph1926.650, .651, .652 and Appendix C to Subpart P titled Timber Shoring for Trenches contain information that can be used to design timber shoring Systems or Aluminum Hydraulic Shoring. According to OSHA the Shoring Timber Tables are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations."

Shoring Tables Classified by Soil Type

OSHA has classified shoring tables as C for Timber shoring and D for Aluminum Hydraulic shoring. The Timber Shoring Tables C are further broken down by the type of material: Mixed Oak or Douglas Fir. The C-1.1, C-1.2 and C- 1.3 are based on using *Mixed Oak* with actual dimensions. Table C-1.1 is for a Type A soil. Table 1.2 is for a Type B soil. Table 1.3 is for a Type C soil. Another group of Timber Shoring Tables C-2.1, C-2.2 and C-2.3 are based on using *Douglas Fir* with nominal sizes (S4S). Table C-2.1 is for a Type A soil. Table 2.2 is for a Type B soil. Table 2.3 is for a Type C soil.

The *Aluminum Hydraulic Shoring* Tables D-1.1 through D-1.4 state the maximum vertical and horizontal spacings that may be used. Tables D 1.1 and D-1.2 are for vertical shores in Type A and Type B soils. Tables D-1.3 and D-1.4 are for a Horizontal Waler Systems in Type B and Type C soils. In conclusion, all of the tables are arranged by Soil Type and the data was developed to apply to the situations that are most commonly experienced in current trenching practice. Finally, all of the tables only apply to Timber and Hydraulic shoring systems that do not exceed 20 feet deep excavations.

Shoring Components

The *OSHA Standards for the Construction Industry 29 CFR Part 1926.650(b)* titled, Definitions applicable to subpart P - Excavations defines the following shoring terms. *Sheeting* means the individual members of a shoring system that are closely spaced together to retain the earth. Sheeting is also called Uprights or Sheet Piling. *Uprights* mean the vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other (p 253).

Wales are the horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or set perpendicular to the sheeting. *Crossbraces or Struts* are the horizontal members of the shoring system that span across the width of an excavation. They are installed perpendicular to the sides of the excavation and the ends are connected to either uprights or wales.

Tight Sheeting refers to the use of specially-edged timber planks (e.g. Tongue and Groove) at least three inches thick when conditions are saturated or submerged in water as defined in the OSHA 1926.652(g), titled Notes for all Tables, paragraph 2.. Steel sheet piling when driven must provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. According to 1926 Subpart P Appendix C (g) *Notes for all Tables.* 2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least 3 inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. According to 1926 Subpart P Appendix C (g) *Notes for all Tables.* 2. Close Sheeting refers to the placement fo planks side-by-side allowing as little space as possible between them. *Close Sheeting* refers to the space between the timber planks not to exceed ½ inch when placed edge to edge according to OSHA 1926.652(g), titled Notes for all Tables, paragraph 2.

Finally, under the Depth of Trench (Feet) column at the Over 20 (feet) row it says, See Note 1 and Note 1 under OSHA 1926.652(g), titled Notes for all Tables paragraph (1) states that members sizes at spacings other than indicated are to be determined as specified in 1926.652(c) titled, Design of Protective Systems. This section goes on to say that “designs of supports systems, shield systems and other protective systems shall be selected and constructed by the contractor or their designee and shall be in accordance with the paragraph (c) (1) titled, Option (1) - *Designs using Appendices A, C and D*. Another alternative in paragraph (c)(2) titled, Option (2) - *Designs Using Manufacturer’s Tabulated Data*. A third alternative in paragraph (c)(3) titled, Option (3) - *Designs using other tabulated data.* A fourth alternative in paragraph (c)(4) titled, Option (4) - *Design by a Registered Professional Engineer*.

Given the Soil type, the depth and width of the trench and the type of timber available, below is an example on how to utilize the timber tables to determine the size of the members and the on-center spacing of each component.

Soil Type	C
Depth	13 Feet
Width	5 Feet
Timber Species Available	Mixed Oak

From the information above, there are two acceptable arrangements from using the table selected.

Example of Timber Shoring Requirements for Arrangement #1

Type of Soil Identified	Type of Material Utilized	Shoring Table Number Selected
C	Mixed Oak	C - 1.3
MEMBERS	SIZE	ON-CENTER SPACING
Cross braces	8" x 8"	Horizontal _____6 Feet__ Vertical _____5 Feet__
Wales	10" x 12"	Vertical 5 Feet
Uprights	2" x 6"	Spacing Close

Arrangement #2

Type of Soil Identified	Type of Material Utilized	Shoring Table Number Selected
C	Mixed Oak	C - 1.3
MEMBERS	SIZE	ON-CENTER SPACING
Cross braces	8" x 10"	Horizontal ______8 Feet Vertical ______ 5 Feet
Wales	12 “ x 12"	Vertical 5 Feet
Uprights	2" x 6" Water Tight: Tongue & Groove	Spacing Close

OSHA Soil Classification System is outlined below. Type A is a cohesive soil with an unconfined compressive strength of 1.5 ton per square foot (Tsf) or Greater. *Cohesive soil* examples are clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, *No soil is classify as a Type A If:*

(1) The soil is fissured.

(2) The soil is subject to vibration from heavy traffic or pile driving.

(3) The soil has been previously disturbed soil.

(4) The soil is a part of a sloped, layered system where the layers dip into the Excavation on a slope of four horizontal to one vertical (4H:1V) or greater

E. The material is subject to other factors that would require it to be classified as a less stable material.

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Type B Cohesive Soil with an unconfined compressive strength greater than .5 tons per square foot but less than 1.5 tsf. *Granular Cohesionless soils* including angular gravel, silt, silt loam, sandy loam and in some cases silty clay loam and sandy clay loam. Also,

(1) Previously disturbed soils except those which would otherwise be classified as Type C soil.

(2) Soil that meets the unconfined compressive strength or cementation requirements of a Type A soil, but is fissured or subject to vibration.

(3) Dry rock that is not stable.

(4) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C Cohesive soil with an unconfined compressive strength of .5 Tsf or less. *Granular soils* include gravel, sand and loamy soil or

(1) Submerged soil or Soil from which water is freely seeping

(2) Submerged Rock that is not Stable.

(3) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.

OSHA Shoring Tables Exercise

1. What does the term Uprights from the timber shoring tables mean?

- A. The vertical supports that separate the wales.
- B. The vertical sheet piles that restrain the soil.
- C. The studs or braces that support the vertical shoring system.
- D. The posts or shores that support the horizontal shoring system.

2. What is the Difference between the C series and D series Tables?

- A. Table C is for Aluminum Hydraulic Shoring. and Table B is for Soil Type A.
- B. Table C is for Steel Sheeting and Table D is for Aluminum Hydraulic Shores.
- C. Table C is for Maximum Allowable Slopes and Table D is for Sloping.
- D. Table C is for Timber Shoring and Table D is for Aluminum Hydraulic.

3. What is the difference between Table C-1.1 and C-2.1?

- A. Table C-1.1 is for Mixed Oak and Table C-2.1 is for Douglas Fir.
- B. Table C-1.1 is for Douglas Fir and Table C-2.1 is for Mixed Oak.
- C. Table C-1.1 is for Soil Type A and Table C-2.1 is for Soil Type B.
- D. Table C-1.1 is for Steel Sheeting and Table C-2.1 is for Aluminum Hydraulic.

4. What is the difference between Table C-1.1 and C-1.2?

- A. Table C-1.1 is for Mixed Oak and Table C-1.2 is for Douglas Fir.
- B. Table C-1.1 is for Douglas Fir and Table C-1.2 is for Mixed Oak.
- C. Table C-1.1 is for Soil Type A and Table C-1.2 is for Soil Type B.
- D. Table C-1.1 is for Steel Sheeting and Table C-1.2 is for Aluminum Hydraulic.

5. What is the maximum depth that you can use shoring tables C and D?

- A. 20 Feet
- B. 60 Feet
- C. 100 Feet
- D. 125 Feet

OSHA Shoring Tables Exercise

Questions 6 and 7 refer to the Timber Shore Tables C & the Hydraulic Shore Tables D attached.

6. A trench is excavated in a Type A soil, 13 feet deep and 5 feet wide. The cross braces available are a 6" x 6" and the shoring available is a Mixed Oak. What is the horizontal and vertical spacing of the cross braces, the size and spacing of the wales and the size and spacing of the sheeting?

- A. Cross braces are spaced 6 feet horizontally and 5 feet vertically. The wales are 8" x 8" spaced 5 feet vertically, and the uprights are 2" x 6" spaced 2 feet horizontally.
- B. Cross braces are spaced 8 feet horizontally and 4 feet vertically. The wales are 6" x 8" spaced 4 feet vertically, and the uprights are 4" x 6" spaced 4 feet horizontally.
- C. Cross braces are spaced 10 feet horizontally and 4 feet vertically. The wales are 8" x 10" spaced 4 feet vertically, and the uprights are 2" x 6" spaced 5 feet horizontally.
- D. Cross braces are spaced 10 feet horizontally and 4 feet vertically. The wales are 8" x 8" spaced 4 feet vertically, and the uprights are 4" x 8" spaced 5 feet horizontally.

7. A trench is excavated in a Type B soil, 19 feet deep and 5 feet wide. The cross braces available are a 8" x 8" and the shoring available is a Douglas Fir. What is the horizontal and vertical spacing of the cross braces, the size and spacing of the wales and the size and spacing of the sheeting?

- A. Cross braces are spaced 6 feet horizontally and 5 feet vertically. The wales are 10" x 12" spaced 5 feet vertically, and the uprights are 3" x 6" spaced close horizontally.
- B. Cross braces are spaced 6 feet horizontally and 5 feet vertically. The wales are 6" x 8" spaced 4 feet vertically, and the uprights are 4" x 6" spaced close horizontally.
- C. Cross braces are spaced 10 feet horizontally and 4 feet vertically. The wales are 8" x 10" spaced 4 feet vertically, and the uprights are 3" x 6" spaced close horizontally.
- D. Cross braces are spaced 10 feet horizontally and 5 feet vertically. The wales are 12" x 12" spaced 5 feet vertically, and the uprights are 4" x 6" spaced close horizontally.

Check Answers

OSHA Shoring Tables Exercise using Table C-1.1 Timber Trench Shoring — Minimum Timber Requirements
Soil Type A $P_a = 25 \times H + 72$ PSF (2 FT Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	NOT REQ'D					2X6	
	UP TO 8	4X4	4X4	4X6	6X6	6X6	4	NOT REQ'D						2X8
	UP TO 10	4X6	4X6	4X6	6X6	6X6	4	8X8	4			2X6		
	UP TO 12	4X6	4X6	6X6	6X6	6X6	4	8X8	4				2X6	
10 TO 15	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	NOT REQ'D					3X8	
	UP TO 8	4X6	4X6	6X6	6X6	6X6	4	8X8	4		2X6			
	UP TO 10	6X6	6X6	6X6	6X8	6X8	4	8X10	4			2X6		
	UP TO 12	6X6	6X6	6X6	6X8	6X8	4	10X10	4				3X8	
15 TO 20	UP TO 6	6X6	6X6	6X6	6X8	6x8	4	6X8	4	3X6				
	UP TO 8	6X6	6X6	6X6	6X8	6X8	4	8X8	4	3X6				
	UP TO 10	8X8	8X8	8X8	8X8	8X10	4	8X10	4	3X6				
	UP TO 12	8X8	8X8	8X8	8X8	8X10	4	10X10	4	3X6				
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.

OSHA Shoring Tables Exercise using Table C-1.2 Timber Trench Shoring — Minimum Timber Requirements *
Soil Type B $P_a = 45 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3		
5 TO 10	UP TO 6	4X6	4X6	6x6	6X6	6X6	5	6x8	5			2x6		
	UP TO 8	6x6	6x6	6x6	6x8	6x8	5	8x10	5			2x6		
	UP TO 10	6x6	6x6	6x6	6x8	6x8	5	10x10	5			2X6		
	See Note 1													
10 TO 15	UP TO 6	6x6	6x6	6x6	6x8	6x8	5	8x8	5		2x6			
	UP TO 8	6x8	6x8	6x8	8x8	8x8	5	10x10	5		2x6			
	UP TO 10	8x8	8x8	8x8	8x8	8x10	5	10x12	5		2x6			
	See Note 1													
15 TO 20	UP TO 6	6x8	6x8	6x8	8x8	8x8	5	8x10	5	3X6				
	UP TO 8	8x8	8x8	8x8	8x8	8x10	5	10x12	5	3X6				
	UP TO 10	8x10	8x10	8x10	8x10	10x10	5	12x12	5	3X6				
	See Note 1													
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.

OSHA Shoring Tables Exercise using Table C-1.3 Timber Trench Shoring — Minimum Timber Requirements*

Soil Type C P_a - 80 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE				
5	UP TO 6	6x8	6x8	6x8	8x8	8x8	5	8x10	5	2x6				
TO	UP TO 8	8x8	8x8	8x8	8x8	8x10	5	10x12	5	2x6				
10	UP TO 10	8x10	8x10	8x10	8x10	10x10	5	12x12	5	2X6				
	See Note 1													
10	UP TO 6	8x8	8x8	8x8	8x8	8x10	5	10x12	5	2x6				
TO	UP TO 8	8x10	8x10	8x10	8x10	10x10	5	12x12	5	2x6				
15	See Note 1													
	See Note 1													
15	UP TO 6	8x10	8x10	8x10	8x10	10x10	5	12x12	5	3X6				
TO	See Note 1													
20	See Note 1													
	See Note 1													
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.

OSHA Shoring Tables Exercise using Table C-2.1 Timber Trench Shoring — Minimum Timber Requirements *
Soil Type A P_a = 25 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4X4	4X4	4X4	4X4	4X6	4	Not Req'd	Not Req'd				4x6	
	UP TO 8	4x4	4x4	4x4	4x6	4x6	4	Not Req'd	Not Req'd					4x6
	UP TO 10	4x6	4x6	4x6	6x6	6x6	4	8x8	4			4x6		
	UP TO 12	4x6	4x6	4x6	6x6	6x6	4	8x8	4				4x6	
10 TO 15	UP TO 6	4x4	4x4	4x4	6x6	6x6	4	Not Req'd	Not Req'd				4x10	
	UP TO 8	4x6	4x6	4x6	6x6	6x6	4	6x8	4		4x6			
	UP TO 10	6x6	6x6	6x6	6x6	6x6	4	8x8	4			4x8		
	UP TO 12	6x6	6x6	6x6	6x6	6x6	4	8x10	4		4x6		4x10	
15 TO 20	UP TO 6	6x6	6x6	6x6	6x6	6x6	4	6x8	4	3x6				
	UP TO 8	6x6	6x6	6x6	6x6	6x6	4	8x8	4	3x6	4x12			
	UP TO 10	6x6	6x6	6x6	6x6	6x8	4	8x10	4	3x6				
	UP TO 12	6x6	6x6	6x6	6x8	6x8	4	8x12	4	3x6	4x12			
OVER 20	SEE NOTE 1													

* Douglas Fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

OSHA Shoring Tables Exercise using Table C-2.2 Timber Trench Shoring — Minimum Timber Requirements *
Soil Type B $P_a = 45 X H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3	4	6
5 TO 10	UP TO 6	4X6	4X6	4x6	6X6	6X6	5	6x8	5			3 x 12 4 x 8		4 x 12
	UP TO 8	4x6	4x6	6x6	6x6	6x6	5	8x8	5		3 x 8		4 x 8	
	UP TO 10	4x6	4x6	6x6	6x6	6x8	5	8x10	5			4 x 8		
	See Note 1													
10 TO 15	UP TO 6	6x6	6x6	6x6	6x8	6x8	5	8x8	5	3 x 6	4 x 10			
	UP TO 8	6x8	6x8	6x8	8x8	8x8	5	10x10	5	3 x 6	4 x 10			
	UP TO 10	6x8	6x8	8x8	8x8	8x8	5	10x12	5	3 x 6	4 x 10			
	See Note 1													
15 TO 20	UP TO 6	6x8	6x8	6x8	6x8	8x8	5	8x10	5	4 X 6				
	UP TO 8	6x8	6x8	6x8	8x8	8x8	5	10x12	5	4 X 6				
	UP TO 10	8x8	8x8	8x8	8x8	8x8	5	12x12	5	4 X 6				
	See Note 1													
OVER 20	SEE NOTE 1													

*Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

OSHA Shoring Tables Exercise using Table C-2.3 Timber Trench Shoring — Minimum Timber Requirements *
Soil Type C P_a = 80 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE				
5	UP TO 6	6x6	6x6	6x6	6x6	8x8	5	8x8	5	3x6				
TO	UP TO 8	6x6	6x6	6x6	8x8	8x8	5	10x10	5	3x6				
10	UP TO 10	6x6	6x6	8x8	8x8	8x8	5	10x12	5	3x6				
	See Note 1													
10	UP TO 6	6x8	6x8	6x8	8x8	8x8	5	10x10	5	4x6				
TO	UP TO 8	8x8	8x8	8x8	8x8	8x8	5	12x12	5	4x6				
15	See Note 1													
	See Note 1													
15	UP TO 6	8x8	8x8	8x8	8x10	8x10	5	10x12	5	4x6				
TO	See Note 1													
20	See Note 1													
	See Note 1													
OVER 20	SEE NOTE 1													

*Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may by substituted for wood.

OSHA Shoring Tables Exercise using Table D - 1.1 Aluminum Hydraulic Shoring - Vertical Shores for Soil Type A

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 10 UP TO 15	8				
OVER 15 UP TO 20	7				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g) (1)
Note (2): See Appendix D, Item (g) (2)

OSHA Shoring Tables Exercise using Table D - 1.2 Aluminum Hydraulics Shoring - Vertical Shores for Soil Type B

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 10 UP TO 15	6.5				
OVER 15 UP TO 20	5.5				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g) (1)
Note (2): See Appendix D, Item (g) (2)

OSHA Shoring Tables Exercise using Table D - 1.3 Aluminum Hydraulic Shoring - Waler Systems for Soil Type B

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
	VERTICAL SPACING (FEET)	SECTION MODULUS (IN’)	WIDTH OF TRENCH (FEET)						MAX. HORIZ. SPACING (ON CENTER)		
			UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15		SOLID SHEET	2 FT	3 FT
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	8.0	2 IN	8.0	2 IN NOTE (2)	8.0	3 IN	---	---	3X12
		7.0	9.0	2 IN	9.0	2 IN NOTE (2)	9.0	3 IN			
		14.0	12.0	3 IN	12.0	3 IN	12.0	3 IN			
OVER 10 UP TO 15	4	3.5	6.0	2 IN	6.0	2 IN NOTE (2)	6.0	3 IN	---	3X12	---
		7.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 15 UP TO 20	4	3.5	5.5	2 IN	5.5	2 IN NOTE (2)	5.5	3 IN	3X12	---	---
		7.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
		14.0	9.0	3 IN	9.0	3 IN	9.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in appendix D, Item (g)

Notes: (1): See Appendix D. item (g) (1).

Notes: (2): See Appendix D. item (g) (2). *Consult manufacturer/Qualified engineer for Section Modulus of wales.

OSHA Shoring Tables Exercise using Table D - 1.4 Aluminum Hydraulic Shoring - Waler Systems for Soil Type C

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
	VERTICAL SPACING (FEET)	SECTION MODULUS (IN’)	WIDTH OF TRENCH (FEET)						MAX. HORIZ. SPACING (ON CENTER)		
			UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15		SOLID SHEET	2 FT	3 FT
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	6.0	2 IN	6.0	2 IN NOTE (2)	6.0	3 IN	3X12	---	---
		7.0	6.5	2 IN	6.5	2 IN NOTE (2)	6.5	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 10 UP TO 15	4	3.5	4.0	2 IN	4.0	2 IN NOTE (2)	4.0	3 IN	3X12	---	---
		7.0	5.5	3 IN	5.5	3 IN	5.5	3 IN			
		14.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
OVER 15 UP TO 20	4	3.5	3.5	2 IN	3.5	2 IN NOTE (2)	3.5	3 IN	3X12	---	---
		7.0	5.0	3 IN	5.0	3 IN	5.0	3 IN			
		14.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in appendix D, Item (g)

Notes: (1): See Appendix D. item (g) (1).

Notes: (2): See Appendix D. item (g) (2). *Consult manufacturer/Qualified engineer for Section Modulus of wales.

CONSTRUCTION SURVEYING AND PROJECT LAYOUT

Trigonometry Functions

This section is concerned with the ability to establish distances and elevations from established points, setup an instrument, layout the project, and interpret site information. Jack Roberts surveying book (1995) provides numerous examples on project layout, math and trigonometry. The three basic relationships in trigonometry, the sine, cosine, and tangent arise from the right triangle. The angles of the right triangle are related by trigonometry, and the sides of the right triangle are related by the Pythagorean theorem. For a right triangle the sides are related by:

$$a^2 + b^2 = c^2$$

Also, a right triangle has a standard relationship of 3 (a): 4 (b) : 5 (c). This allows you to determine the length of the third of a right triangle if you are given two side lengths. The trigonometry relationships are given by:

$$\text{SIN angle A} = \frac{\text{opposite side}}{\text{hypotenuse}} = \frac{a}{c}$$

$$\text{COS angle A} = \frac{\text{adjacent side}}{\text{hypotenuse}} = \frac{b}{c}$$

$$\text{TAN angle A} = \frac{\text{opposite side}}{\text{adjacent side}} = \frac{a}{b}$$

How to Find the Length of One Side of a Right Triangle Given Other Side & One Angle

A side walk 4 feet wide and 58 feet long must be laid out. The 58 foot long side (hypotenuse c) of the sidewalk intersects a street at an angle of 26 degrees (A). Find the length of side (b) street.

Select the formula which will give the length of side b, given the angle A and the length of the hypotenuse. The formula is c COS A will work. This means that you should multiple the length of c (58 feet) by the cosine COS (26 degrees) of angle A. The value for the COS 26 degrees from a Trigonometric Function Table is .89879. Now multiply 58 feet by .89879 which results in the length of side b of the right triangle being 52.13 feet.

Using the information for the sidewalk given above. You want to calculate the length of side a which is perpendicular to the street. The formula is c SIN A. This means that you should multiple the length of c (58 feet) by the sine SIN (26 degrees) of angle A. The value for the SIN 26 degrees from a Trigonometric Function Table is .43837. Now Multiply 58 feet by .43837 which results in the length of side a of the right triangle being 25.43 feet.

Elevations and Surveying Calculations

Surveys are usually done in the horizontal plane and they are keyed to a reference elevation. This reference elevation is referred to as the "datum elevation. These points on the survey are noted as being either at or a certain distance above or below the datum plane. The most common datum plane used is "mean sea level" or "MSL". The mean is given the elevation of 0'- 0". The federal and state government have determined the elevations of various inland points throughout the country in relationship to the elevation of 0'- 0". These points are called Benchmarks.

Job Benchmark Elevation = 100.00 feet.
Top of Footing (TOF) = 98.0 feet

BM	Benchmark.	HI	Height of the Instrument.
IP	Intermediate Point.	TP	Turning Point.
BS	Back sight.	FS	Foresight.
BOF	Bottom of Footing.	FF	Finish Floor.

Below are the Field Notes from a leveling operation.

IP	BM El.	BS Rod Reading	HI	FS Rod Reading	TP EL
#1	843.29'	4.68'	847.97'	5.91'	842.06
#2	842.06'	3.17'	845.23	3.94'	841.29
#3	841,29'	5.05'	846.34	4.72'	841.62
Math Check = - 1.67'		12.90'	minus	14.57'	
TP El. =	841.62				
BM El =	843.29'				
	-1.67'				

Jack Roberts (1995) states that the primary "principle to remember is to add the back sight and subtract the foresight"(p 85). This is expressed as

benchmark elevation + back sight - foresight = TP elevation
and also as benchmark + back sight = HI elevation.

Surveying and Layout Exercise

1. You are required to establish grade to the bottom of a footing (BOF) that is 1 foot thick. The elevation at the top of the footing(TOF) is 102.33'. The elevation of the existing grade 106.14'. The backsight (BS) of the instrument on the benchmark (BM) of 100.00' is 6.78'. What is the correct reading of the rod at the bottom of the footing?

- A. 0.64
- B. 3.81
- C. 4.45
- D. 5.45

2. Given a rectangular structure that is 60' - 9" long by 42' - 6" wide. What is the diagonal measurement in feet and inches for squaring up the structure during layout?

- A. 51' - 71/2"
- B. 74' - 13/4"
- C. 74' - 37/8"
- D. 103' - 3"

3. Using a right triangle, at the intersection point the slope distance or the hypotenuse is 310 feet long at a slope angle of 20 degrees 00' 00". What is the actual horizontal distance in feet?

- A. 106.02
- B. 112.84
- C. 291.09
- D. 851.73

4. What is the percentage grade for a slope ratio of 1:13 (rise:run)?

- A. 0.077
- B. 1.000
- C. 7.690
- D. 13.000

Surveying and Layout Exercise

5. A rod reading of 4.72' is taken on a BM whose elevation is 813.30. The finish floor (FF) is 809.00. The top of the batter board is set one foot above the Finish Floor. What rod reading is required to set the line for the top of the batter board?

- A. 4.30
- B. 5.30
- C. 8.02
- D. 9.02

6. We want to mark the grade points at elevation 668.00 for a ceiling grid systems using a rotating Lazer. When the inverted rod reading is placed on a BM with an elevation of 655.50 the receiver indicates a reading of 5.05 feet. At what reading on the inverted rod will the receiver be placed so that the ceiling grid will be at the correct elevation?

- A. 5.50
- B. 7.45
- C. 12.50
- D. 17.55

7. Using a right triangle, at the intersection point the slope distance or the hypotenuse is 240 feet long at a slope angle of 33 degrees 00' 00". What is the actual height distance?

- A. 130.70'
- B. 155.81'
- C. 201.29'
- D. 369.58'

8. What are the length ratios for a right triangle?

- A. 3:3:3
- B. 3:3:5
- C. 3:4:5
- D. 3:6:9

Surveying and Layout Exercise

9. Assume you have a right triangle which is 36 feet high and perpendicular from the baseline. What are the baseline distance and the diagonal distance?

- A. The baseline is 24 feet, the diagonal is 48 feet.
- B. The baseline is 27 feet, the diagonal is 45 feet.
- C. The baseline is 36 feet, the diagonal is 72 feet.
- D. The baseline is 48 feet, the diagonal is 60 feet.

10. The jobsite has a primary vertical control point with a reference (BM) of 100 feet. An instrument is set up with an HI of 5.42 above the BM. A grade stake is set at an elevation of 96.00'. What is the height reading on the rod for setting the receiver at?

- A. 1.42'
- B. 4.00'
- C. 5.42'
- D. 9.42'

11. Assume that you are looking at the cross section of a concrete lined dike which is 20 feet wide at the bottom and the sides are set at a 70 degree angle from the bottom (horizontal) of the dike, the depth of the water flow is 12 feet and the length of the dike is 166 feet. Using the cross sectional view, how many lineal feet of wetted cross section is there?

- A. 32.97
- B. 45.54
- C. 85.94
- D. 104.64

12. Assume that you have a concrete lined dike which is 20 feet wide at the bottom and the sides are sloped at a 70 degree angle from the bottom (horizontal) of the dike. Also, the depth of the water flow is 12 feet. Using the cross sectional view, how many square feet are in the wetted cross-sectional flow?

- A. 52.32
- B. 104.64
- C. 292.32
- D. 344.64

Surveying and Layout Exercise

13. What does the surveying abbreviation of TP mean?

- A. Tangent Point.
- B. Turning Point.
- C. Traverse Point.
- D. Terminal Point.

14. Which of the following situations would be most advantageous for using an inverted rod?

- A. Verifying a highway grid layout.
- B. Verifying a building footing layout.
- C. Verifying the elevation of a piece of equipment.
- D. Verifying the elevation of ceiling mounted duct work.

15. The federal and state governments have established elevations of various inland points throughout the country. What elevation are these points in relationship to?

- A. 0' - 0"
- B. 10' - 0"
- C. 100' - 0"
- D. 200' - 0"

Given the Back Sight and Fore Sight readings as follows.

IP	BM El.	BS Rod Reading	HI	FS Rod Reading	TP EL
#1	877.26	7.45		3.10	
#2		7.12		1.10	
#3		4.44		2.17	

16. What is the Benchmark elevation at IP #4?

- A. 864.62
- B. 889.90
- C. 896.27
- D. 902.64

Check Answers

PROJECT ADMINISTRATION

Vendors and Suppliers and The Uniform Commercial Code
The terms and conditions for *Vendor or Supplier Agreements* with contractors fall under the Uniform Commercial Conditions. According to numerous feature articles in *Construction Claims Monthly* (CCM, June 2000, May 1994, August 1987, & August 1984), edited by Bruce Jervis, Esq., the book by Bruce Jervis and Paul Levin (1987) titled *Construction Law Principles and Practices*, and an article by Kristin McLaughlin and Donald A. Jensen, Jr. (December 1997) titled: The UCC: It Effects Construction Contracts published in the *American Professional Constructor* state that different laws govern the sale of good. Also, Jervis in CCM (August 1987) says that the Contractor - Supplier (Vendor) relationship creates legal issues unique within the construction process (p 1). McLaughlin and Jensen (1997) state that "there are two types of contracts" and a different set of laws apply to each (p 12).

The *Sale of Goods and the Purchaser of Those Goods* are governed by the Uniform Commercial Code (UCC). Under UCC rules, the only thing agreed upon being the prices and the merchant warranty provided. Therefore, a purchase order should be utilized for materials only. According to Construction Claims Monthly (June 2000, August 1987) their article states "that a purchase order form should never be used for the procurement of construction services" (p 1). A purchase order does not meet the first element of a contract which is a meeting of the minds. The Uniform Commercial Code applies to the sale of goods and in the CCC (June 2000) the Editor, Jervis states that "there are several legal complications in this process, however. Which party submitted the "offer?" and which party submitted the "acceptance?" At what point, if ever, was an agreement reached? And if the various documents contain additional or conflicting terms, which provisions govern?" He goes on to state that "Conflicting terms and conditions are the most difficult ramifications of this "battle of the forms." Each party insists that its own preprinted "standard" conditions govern the transaction" (p 1). According to McLaughlin and Jensen (December 1977) they insist that a Purchase Order under "UCC Article 2-204(3) (1977) states that a contract will not fail due to lack of definite terms" (p 12). The feature article in CCM (June 200) titled *Supplier Relations: Which Terms Govern*? He states that "Section 2-207 of the UCC provides that acceptance of an offer can be binding even though the acceptance contains additional or different terms. The additional or deviating terms become part of the agreement unless: (1) the offer expressly required acceptance in accordance with the terms of the offer; (2) the additional terms materially alter the offer; or (3) the offeror gives a prompt objection to the additional terms" (p 1). The offering party accepts the differing terms unless they give 10 days notice of an objection. In conclusion, the only things agreed upon under UCC rules are (1) the prices and (2) the merchant warranty.

Jervis and Levin (1987) imply that under the UCC rules no meeting of the minds is necessary. In other words, **never put labor** on any form titled Purchase Order because the meeting of the mind's element of a contract is difficult to establish and a different set of laws applies. This becomes more apparent when the hybrid contract calls for the contracting party to provide a mix of goods and services under the Uniform Commercial Code (UCC). The courts will apply numerous tests if a hybrid contract is involved as discussed below.

McLaughlin and Jensen (December 1994) insist that many construction contracts are "actually *Hybrid Contracts* - a mix of goods and services" and recognizing that an agreement is a hybrid is important because "the resolution of a dispute over a contract will differ depending on the nature of the agreement" (p 12). They also state that how a court interprets a hybrid contract as either for labor services or one for goods will alter the outcome in court. They insist that "the appellate system applies various tests to determine if a contract is predominantly for services or for the sale of goods. The most commonly used is the *predominate thrust* test. They refer to the *Bonebrake v. Cox (1974)* which outlined the theory of the mixed contract test as follows.

. . . whether their predominate factor, their thrust, their purpose, reasonably stated, is the rendition of service, with goods incidentally involved . . .or is a transaction of sales with labor incidentally involved . . . (p 13).

The second test, predominate service, reviews the evidence regarding the intent of the parties to the contract, the purpose for creation of the contract by the parties and which of the hybrid transaction aspects, the services or goods, forms the basis of the bargain between the parties" (p 14). The third test is the goods supplied test. This test focuses on the definition of goods as it applies to the UCC. The fourth test is the policy test. This test the courts apply by considering the circumstances surrounding the making of the transaction as more important than the goods or services mix. The fifth test is the divisibility test is where the UCC code applies to only that part of the contract that focuses on goods and general contract law applies to the services portion of the transaction. The divisibility test is used infrequently. The sixth test is the contract language test. This test relies upon the verbiage in the contract such as utilizing the word's buyer and seller indicate a contract for the sale of goods, whereas, the word's Owner or Contractor and Subcontractor indicate a contract for services. Finally, McLaughlin and Jensen (December (1997) states that "the gravamen test focuses on the action at the center of the case. If the case is because of a mechanical failure then it is a goods contract. If it is because of a failure of workmanship, then it is a service contract" (p 14).

McLaughlin and Jensen (December 1997) conclude that the contractor must determine the direction of the agreement then the character of the agreement itself must provide much of the defense as to the contract being primarily a services contract or a sale of goods contract. They also state that "the court system most often uses the predominate thrust test, although it is subjective. Therefore, contractors should use additional tests to advance their argument; such as the language test and the divisibility test" (p 15).

The Procurement Process

This process begins with preparing a list of materials required for the project by reading the blueprints and specifications. This list of materials is sometimes called a want list. After the list of materials, showing quantities required and complete item descriptions, is prepared, it is used to request price quotations from the supplier (vendors) or the list is sometimes sent to the purchasing department requesting them to obtain price quotations. The form sent to purchasing department requesting price quotations is called a *Purchase Requisition*.

After requesting price quotations and detailed terms and conditions from the vendors (suppliers), either by telephone or in writing, a vendor is selected and a formal purchase order is prepared. The buyer (contractor) prepares the formal purchase order, sends the original to the vendor, and distributes copies to keep all parties well informed.

The next step in the procurement process is to ensure that the required submittals and materials arrive on the project at the exact time they are needed. This step requires someone from the contractor's firm to follow up the orders arranged by delivery date by calling and visiting the vendors' offices to verify that submittals of shop drawings, product data and fabrication schedules are on schedule and they meet the specification requirements. The process of following up orders to ensure compliance with the specifications and schedules is called *Expediting* and the person who performs these duties is sometimes called an expediter.

The next step requires the vendor to prepare a packing list of the quantity and description of the items being shipped and arranging for transportation, either by using their own trucks or by contracting with a freight company. The form used to contract with a freight company, common known as a Common Carrier for transportation of the items is called a *Bill of Lading*.

The final step in the procurement process is for the job site personnel to ensure that the proper quantity and materials have been received by counting the items, inspecting them for damage and comparing the packing list to the purchase order. The *Purchase Order* is under the Uniform Commercial Code (UCC) rules and the only thing agreed upon being the prices and a merchantability warranty. Therefore, a purchase order should be utilized for Materials only. When requesting quotations for a purchase order, the buyer must know the quantity required, item description, the name of the project, location of the project, project number, purchase order number, warranties required, delivery date, where the bill should be sent for payment, and the number of copies required. The buyer requests from the supplier unit prices, length of time the unit prices are good for, taxes, shipping terms, freight and insurance costs, and the accounting terms of the order.

Supplier Payment Request Form
An *Invoice* is a billing document from the supplier requesting payment for materials. The invoice will state the quantities, items and unit prices billed. It is the responsibility of the accounting department to verify the quantities with the receiving report and the unit prices with the purchase order.

Shipping Terms on the Purchase Order
The *Shipping Terms* are normally arranged by the vendor for the shipment of materials to the job site, but the buyer must thoroughly understand whether the price quotation includes the cost of insurance and freight, the form of transportation, the point at which ownership changes hands, and the party paying the shipping charges. The FOB terms indicate the point at which ownership transfers from the supplier to the buyer. FOB means *Freight on Board*. There are several FOB terms generally used. First, is the *FOB Factory* which means the vendor is only responsible for loading the order on the shipper's vehicle (a common carrier) at the factory and ownership transfers from the supplier to the buyer at the factory. Another term is *Fob Supplier's Sales Location* which means the vendor is responsible for loading your order on the shipper's vehicle at the sales location and ownership transfers from the supplier to the buy at the sales location. Finally, the *Fob Job Site* which means the vendor is responsible for shipment of the order and ownership transfers from the supplier to the buyer at the job site.

The FOB location becomes a very important factor in the shipment of materials because it establishes the point at which ownership transfers from the supplier to the buyer. This ownership transfer determines the contractual parties on the shipping document. The shipping document is known as a Bill of Lading. The *Bill of Lading* is a contractual agreement between a shipper and a common carrier to move the material from location A to location B for specified price. If the shipping terms are FOB Factory, the bill of lading is between the buyer and the common carrier. If damage occurs during shipment of the materials, the buyer must seek damages from the common carrier. If the shipping terms are FOB Job Site, the bill of lading is between the supplier and the common carrier. If damage occurs during shipment, the supplier must replace the damaged goods and seek damages from the common carrier.

When requesting a shipping quotation and the vendor quotes you the abbreviation CIF, they are indicating to the buyer that the supplier will act as an agent for the buyer in arranging for shipment and they will add to the cost of the items the additional costs for the Insurance and the Freight. If the supplier quotes the buyer shipping terms of collect on delivery (COD), they are indicating that the shipment costs will be paid by the buyer at the time of delivery.

The Accounting Terms on the Purchase Order

Accounting Terms are sometimes offered to the buyer from the vendor as a payment incentive called material discounts. These material discounts are offered to the buyer as an incentive that the buyer is able to reduce their payment to the vendor if the pay within a specified amount of time after either the invoice date or the receipt of goods (ROG) date. The following material discount terminology is commonly seen on purchase orders. First, there is the term shown as 1/10 NET 30. This means a 1% discount can be deducted from the purchase order amount if the contractor pays within 10 days of the invoice date. The full payment is due in 30 days.

Expediting Materials and Leadtime

The *Expediting of Materials* is defined as the process of following up on materials and vendor submittals to ensure that the proper materials and quantities are in compliance with the specifications and they arrive as scheduled. The person performing this function is sometimes called an expediter. To perform this function effectively, the expediter must be able to read and review all specifications and contract documents to ensure the vendor is in compliance. They must be able to compile a "material list" from the drawings and they must be able to follow up on shop drawings and product data submittals. Other responsibilities of the expediter are for them to review production schedules and delivery dates, maintain files by delivery dates, inform construction personnel on material status, follow up on purchase orders by calling and visiting vendors to verify work in progress to ensure deliveries arrive on time, communicate effectively to maintain good vendor relations, troubleshoot delivery problems and determine the amount of time, normally referred to as Leadtime, required to deliver the materials on time

Leadtime refers to the amount of time required by vendors to deliver materials to the job site. When determining the amount of time required to deliver materials, the following steps must be reviewed to determine the amount of Leadtime required for an item. The Leadtime process requires the Contractor to consult the contract documents and prepare a material bid package to request quotations from the vendors. Also, Leadtime requires the Contractor to mail the bid package to vendors requesting price quotations and delivery dates. It also contains time for the vendors to submit a price quotation (bids). After the vendors' proposals are submitted to the Contractor, they review the bids and they select a vendor. Then the Contractor issues a purchase order and mails it to the vendor. Leadtime also includes the time it takes for the Vendor to submit shop drawings and product data to the Contractor. When the shop drawing or product data sheets are received, it is the Contractors responsibility to review and approve shop drawings for field methods and means. After the Contractor's approval they stamp each shop drawing or product data sheet and forward them onto the Architect/engineer for approved. After the A/E reviews the shop drawings or make changes as noted, then the Contractor mails the approved drawings back to the vendor and request changes as noted. After all changes are made, the Vendor schedules the order into their fabrication schedule and the Vendor arranges a shipment of the materials to the job site.

Material Receiving Procedures

Material Receiving is the process of examining and verifying material deliveries at the job site prior to or during the unloading of the materials. It is generally seen as unimportant and often the deliveries are signed for before unloading. This type of procedure gives the suppliers an invitation to short delivery items and substitute unsatisfactory materials. To avoid this problem, a specific individual on each job site should be assigned the duties of examining and verifying all material orders and receiving procedures should be established. The following steps outline a good receiving procedure that all job sites should follow:

1. Count the quantities received and compare with the packing list or Bill of Lading for shortages or incorrect materials

2. Inspect all deliveries for damages. If visual damage occurs, have the driver sign for damaged cartons on the delivery receipt, contact the common carrier, request inspection before unpacking and file a claim immediately. If the damages are concealed, save the cartons and all packing material and contact the common carrier immediately.

3. Compare the packing list with the purchase order, noting the amount ordered versus the amount shipped.

4. Verify the items shipped meet the requirements outlined on the purchase order

5. Designate the lay down area where the materials are being stored

6. Prepare a receiving report indicating the condition of material, amount ordered and amount received and send copies to contractors' purchasing department. You should also notify them of any material shortages. Another copy should be sent to the contractor's accounting department for comparing the invoiced items to the items received. A third copy should be sent to the expediters, informing them that the order has been received. Finally, a copy should be sent to the field construction personnel, informing them where the order is located.

Stock Bins are utilized on large projects because certain materials are purchased in "bulk" quantities for use throughout the project or projects. To control the use of materials, a *stock requisition* is filled out by the person requesting the materials. This stock requisition identifies the quantities requested, item description, the name of the project and project number and the intended use. This document is then sent to the accounting department where a record of the costs charged to a specific work item are kept. This record becomes a part of the cost control system.

The Subcontract Agreement
There are a number of contract law principles that govern *Subcontractors* which are unique to the construction industry. For instance, it should be understood that the subcontractor is a separate legal entity which does not form a contract with the Owner of the project, but instead they submit a subcontract proposal to the Contractor for performing construction services which is utilize by the Contractor. Hence, the issues arising out of the relationship between the contractor and subcontractor and the formation of a subcontract is extremely different from the formation of the Owner - Contractor contracts. First, at the bidding phase of a prime contract, the subcontractor submits a subcontractor proposal to the Contractor which is considered an offer or promise. This promise to the Contractor is based upon the contractor utilizing the subcontractors bid and submitting its bid to the Owner. Also, it is understood that the Contractor cannot request additional money from the Owner if the subcontractor claims that a mistake has been made in their bid proposal. This rule or doctrine is called *Promissory Estoppel*.

Therefore, if a subcontractor claims a mistake in its proposal, the law will rely on the principle of promissory estoppel. It is defined as " a promise which the promisor (subcontractor) provides to the contractor and it induces the promisee (Contractor) to rely on that promise (Sub's Bid Proposal) in the Contractor's bid to the Owner. This doctrine holds that if the prime contractor reasonably relies on the promise or price of the subcontractor to its detriment, then the subcontractor must be held to its promise in order to avoid harm to the prime contractor. This promise is binding if the Contractor can prove that they relied on the offer and it caused harm to the Contractor. The drawback of this legal principle is that the subcontractor is obligated to the prime contractor, but the prime contractor is not obligated to the subcontractor. Therefore, once the prime contractor executes the prime contract, the contractor is not obligated to the subcontractor to sign a subcontract agreement. This practice of finding another subcontractor at a lower price is called *bid shopping*. The American Society of Professional Estimators (ASPE) brochure (2003) defines bid shopping as "when, after the award of the contract, a contractor contacts several subcontractors of the same discipline in an effort to reduce the previously quoted price" (p 1). Bid shopping is considered unethical.

ASPE also states that "*Bid peddling*, . . . occurs when a sub-bidder approach a general who has been awarded a project with the intent of voluntarily lowering the original price below the price level established on bid day. This action implies that the subcontractor's original was either padded or incorrect" (p 2). Bid peddling is also considered unethical under the American Society of Professional Estimators Code of Ethics.

A *subcontract agreement* is governed by the common law of contracts for labor services. Therefore, when contracting for labor services and to protect your rights under the common law contract formation principles, it is essential that you utilize a form of agreement that is titled Subcontract Agreement for all labor services. Under the contract formation principles in construction, the Subcontract Agreements are written and signed by both parties after the signing of the Owner - Contractor Agreement. The Subcontract Agreement must be provided to each prospective bidder during the bidding phase of the project. This allows the prospective bidders time to review the terms and conditions and determine any unusual risk involved before the Agreement is signed. This process of providing the subcontract agreement during the bidding phase of the project can reduce the risk of the subcontractor not understanding the terms and conditions and trying to withdraw before the execution of the subcontract.. The major elements needed to form a valid contract are:

1. *Meeting of the Minds*. This is the signed Subcontract Agreement between the parties. The Subcontract Agreements are written and signed by both parties after the signing of the Owner - Contractor Agreement.

   A. *An offer is made*. Normally the Contractor is required to submit a bid proposal on the forms provided by the A/E firm. It is also a good practice to standardize the Subcontractor Bid Proposal form which includes a Bid Breakdown Section.

   B. *Acceptance of the Offer*. The subcontractor receives a letter from the contractor indicating that they have been awarded the contract and they will be executing the subcontract agreement.

2. *Consideration is received*. Consideration under the General-Subcontractor contract formation process must rely on the equitable doctrine of "promissory estoppel." To ensure that this promise isn't indefinite or unreasonable, the subcontractor provides a time limit for acceptance of their bid.

A Subcontract agreement may contain numerous clauses which the subcontract and the contractor must understand throughly. These are sometimes called killer clauses. First, is the *flown down* clause. A flow down clause is a contract clause in the prime contract causing certain duties between the owner and the contractor to be explicitly stated that they will flow down to the subcontractor or the supplier/vendor. The typical flow down clause says:

> The Subcontractor agrees to be bound to the Contractor by the terms of the contract documents and assume toward the Contractor all of the obligations and responsibilities that the Contractor by aforesaid documents assumes toward the Owner.

Another killer clause is the *Pay when paid clause*. It states that the subcontractor will not be paid until the owner pays the contractor. The preceding clause makes payment by the owner a *condition precedent* to the contractor's obligation to pay the subcontractor. Some courts require the words condition precedent in the clause before it is enforceable. Finally, many contracts require the owner and the contractor to submit claims to binding arbitration. The arbitration clause can flow down to the subcontractors.

Vendor and Subcontractor Agreement Exercise

1. What is the primary difference in contract formation between a Subcontract Agreement and a Purchase Order?

- A. Meeting of the minds exists in a Subcontract but not in a Purchase Order.
- B. Consideration exists in a Subcontract but not in a Purchase Order.
- C. Legal purpose exists in a Subcontract but not in a Purchase Order.
- D. There are not any contract differences between a Subcontract & a Purchase Order.

2. Which law establishes basic rules governing the sale of goods used to establish a Purchase Order?

- A. Davis Bacon Act
- B. Uniform Commercial Code
- C. National Labor Relations Act
- D. Uniform Transportation Code

3. Which of the following items must never be agreed upon utilizing a form titled Purchase Order?

- A. Labor.
- B. Materials.
- C. Overhead.
- D. Rental Equipment.

4. Which test is most commonly used to determine if a contract is predominantly for services or for the sale of goods?

- A. Policy Test.
- B. Goods Supplied Test
- C. Predominate Thrust Test
- D. Predominate Service Test.

5. Which test focuses primarily on that part of the contract that UCC applies to goods and general contract law applies to the services portion of the transaction?

- A. Gravamen Test
- B. Divisibility Test.
- C. Predominate Thrust Test
- D. Contract Language Test.

Vendor and Subcontractor Agreement Exercise

6. Assume that you are utilizing the verbiage Purchaser and Supplier in the terms and conditions of the contract. How will the courts interpret this type of contract?

- A. Services contract.
- B. Agency Fee contract.
- C. Sale of Goods contract.
- D. Guaranteed Maximum Price contract.

7. Other than the most commonly utilized test, what other tests are suggested by McLaughlin and Jensen to prove your arguments for a specific type of contract?

- A. Language Test and the Divisibility Test.
- B. Policy Test and the Goods Supplied Test.
- C. Gravamen Test and the Predominate Service Test.
- D. Predominate Thrust Test and the Predominate Service Test.

8. The terms on the purchase order indicate F.O.B. Factory, at which point does the responsibility for the goods change?

- A. Passes at the invoice date
- B. Passes at the payment due date
- C. Passes at time of pickup by carrier
- D. Passes at time of receipt at the jobsite

9. If the Shipping terms are FOB JOBSITE, which parties is the Bill of Lading between?

- A. Vendor and the contractor.
- B. Common carrier and the vendor.
- C. Common carrier and the architect.
- D. Common carrier and the contractor.

10. If Damages should occur during shipment of construction materials and the terms on the Bill of Lading are FOB Factory, who would be required to recover the loss from the common carrier?

- A. Vendor
- B. Owner
- C. Architect
- D. Purchaser

Vendor and Subcontractor Agreement Exercise

11. Which of the following terms is used to refer to the process of following up on materials to ensure that the proper quantity and quality of materials arrive at the jobsite according to schedule?

- A. Leadtime
- B. Expediting
- C. Purchasing
- D. Procurement

12. Which of the following terms is used to refer to the complete process of obtaining materials?

- A. Leadtime
- B. Expediting
- C. Purchasing
- D. Procurement

13. Which document is used to request payment for materials?

- A. Invoice
- B. Bill of lading
- C. Purchase order
- D. Stock requisition

14. Which of the following documents is a contractual agreement used to move (ship) the goods from the vendor to the jobsite?

- A. Invoice
- B. Bill of lading
- C. Packaging list
- D. Purchase order.

15. Which of the following documents is used to request materials from the contractors storage bins?

- A. Purchase order
- B. Receiving report
- C. Stock requisition
- D. Purchase requisition.

Vendor and Subcontractor Agreement Exercise

16. The Vendor has quoted you a price of $9,270 CIF for an item. Which of the following is this price quote telling you?

- A. The $9,270 is the total to be paid and it includes freight and insurance.
- B. The $9,270 is the total item cost plus the freight and insurance will be added.
- C. The $9,270 will be collected on delivery and it includes freight and insurance .
- D. The $9,270 will be collected on delivery in cash or certified check.

17. Which of the following descriptions defines the term 2/10 Net 30?

- A. 2% Discount can be deducted if paid within 10 days of the arrival of goods. Full payment Due in thirty days.
- B. 2% discount can be deducted if paid within 10 days of the invoice date. Full payment due in thirty days.
- C. 2% discount is available for thirty days.
- D. 2% discount is available through the tenth of the month following the receipt of goods. Full payment due in thirty days.

18. Which of the following documents is used internally to request the contractor's purchasing department to obtain the prices for the materials needed for a project?

- A. Invoice.
- B. Purchase order.
- C. Stock Requisition.
- D. Purchase Requisition.

19. Which of the following are the best steps of a good material receiving procedure?

- A. Inspect delivery, note damages, count items and compare to the bill of lading.
- B. Inspect delivery, note damages, count items and compare to the accounting terms.
- C. Review specifications, follow up on materials orders and call for delivery date.
- D. Award contract, vendor prepare shop drawings, reviews, fabricate and deliver.

Vendor and Subcontractor Agreement Exercise

20. A clause in the Subcontract Agreement reads that “a Subcontractor binds themselves to the Contractor for the performance of the Subcontractor’s Work in the Same manner as the Contractor is bound to the Owner for such performance under Contractor’s contract with the Owner”. What is the name of this clause?

- A. Flow down.
- B. Arbitration.
- C. Pay when paid.
- D. Condition Precedent.

21. For labor services to be considered under the formation principles, which form shall they be placed on?

- A. Purchase Order.
- B. Vendor Agreement.
- C. Subcontract Agreement.
- D. Owner-Contractor Agreement.

22. Which of the clauses below is considered a Condition Precedent?

- A. Submit a claim within the time frame stated.
- B. The Sub will be paid when the Contractor is paid.
- C. Install street one-block at a time and only close the block.
- D. The Soil Report states “For Informational Purposes Only.”

23. What is the term called when a sub-bidder approaches a general who has been awarded a project with the intent of voluntarily lowering the original price below the price level established on bid day.

- A. Bid Peddling.
- B. Bid Shopping.
- C. Condition Precedent.
- D. Promissory Estoppel.

Vendor and Subcontractor Agreement Exercise

24. What is the name of the law principle that allows the Contractor to receive an oral or a printed quotation and then incorporate this price quotation into their bid proposal to the Owner and if awarded the prime contract they can hold the subcontractor to their quotation?

- A. Flow Down.
- B. Condition Precedent.
- C. Promissory Estoppel.
- D. Incorporated by Reference.

25. During what phase of a project must the Contractor provide the Subcontractor Agreement to the Subcontractor to avoid the subcontractor from refusing to sign an agreement that they have not seen?

- A. At the bid opening.
- B. During the bidding phase of the project.
- C. After the Owner-Contractor Agreement is signed.
- D. At the signing of the Contractor-Subcontractor Agreement.

26. A clause in the specifications states under 15333 1.3 A. Design and installation of an engineered fire detection and INERGEN total flooding, gaseous agent, fire suppression system shall be solely responsible for the performance of the fire suppression systems as specified and shall modify, add to, or alter the equipment as necessary, without any additional cost to Owner to provide satisfactory performance. Which party has the responsibility for the design of this system?

- A. Owner.
- B. Contractor.
- C. Subcontractor.
- D. Architect/Engineer.

27. What are the agreed upon terms and conditions on a purchase order?

- A. Freight and Insurance costs.
- B. Delivery date of the materials.
- C. Material prices and merchant warranty.
- D. Subcontracted labor and material prices.

Check Answers

Organization and Job Descriptions

An *Organizational Chart* is a pictorial form showing all positions and lines of communication. The horizontal Lines or positions indicate that these positions communicate with each other and the Vertical Lines or positions indicate that the lower position reports to the upper positions.

The Duties are the specifically assigned tasks and the Job Description is a complete list of specifically assigned duties for each position on the organizational chart. Many times the descriptions imply a certain amount of decision making. For example, a person may have a level of authority. Authority gives the person the ability to implement their decisions without the approval of superiors. Other times, a person may have a level of responsibility. Responsibility indicates that the person is burdened with the duties specified in the job description and they must answer for all causes and effects.

The Organizational Plan is a formalized analysis of the necessary tasks, how they relate to the company and it creates a clear understanding of the who, what, when and how. An organizational plan is intended to remove confusion, indecision, duplication of efforts and neglected duties.
An effective organizational plan should:

1. Be put in writing in the form of a procedure manual.
2. List all duties for each individual.
3. Include an organizational chart for the company and each project establishing the lines of communication.
4. Be discussed with everyone concerned.

The establishment of an effective operating organization requires the company to focus five (5) management functions. The following two management functions that *Establish the Team* through the process of *Organizing* which is the process of 1) determining what positions must be created 2) defining the responsibilities of each position and write job descriptions. 3) establishing the relationship between positions and draw an Organizational Chart.. *Staffing* is the process of selecting the right person for each position created.

The following three management functions that *Manage the Project* through *Planning* which is the process of determining what and how things will be done, and draw a construction logic network showing the interrelationship of the design, procurement and construction activities. *Directing* is the process of providing clear instructions and solving problems. *Controlling* is the process of monitoring the project through cost control and scheduling which compares the actual cost and schedule to the planned cost and schedule.

Project Management Team

The typical duties and responsibilities for specific construction positions are outlined below. The *Project Manager* has the authority and responsibility for the successful completion of the project(s) within the contract time and costs considerations. The project Manager devotes their energy and expertise to the overall management of the project. The essential skills of a Project Manager are:

1. Writes the subcontract agreements.

2. Write the purchase orders.

3. Develop the overall project plan and schedule including design, procurement, subcontracted and construction activities.

4. Develops the Schedule of Values for the project.

5. Produce the Progress Payment submittals.

6. Approve payments to suppliers and subcontractors.

7. Develops Contract Change Order Proposals.

8. Prepares and negotiates claims.

9. Manages safety.

10. Arranges for permits.

11. Travels between the home office and the job site.

The *Superintenden*t supervises and coordinates the daily activities of foremen. They plan and schedule the work force, the materials and equipment and they coordinate the subcontracts to promote an efficient construction of the structure at a profit. The essential skills of a Superintendent are:

1. Plans the sequence of daily construction operations.

2. Schedules daily labor, materials, equipment and tools required.

3. Interpret the plans and specifications.

4. Coordinates the subcontractors;

5. Maintains the Daily Job Diary and the Construction Reports.

6. Identifies and coordinates field changes.

7. Conducts safety inspections.

8. Conducts planning meetings on construction problems and solutions.

The *Crew Leaders or Supervisors* instructs the crew of skilled craftsmen and apprentices in the actual erection or fabrication of a structure. The Essential skills of a Crew Leader are:

1. Provides instructions to the crew about equipment and material needed.

2. Prepares the daily time cards.

3. Trains new personnel in proper safety and methods.

The *Field Engineer* or the *Project Engineer* assists the superintendent in solving engineering-related problems. The essential skills of a Project Engineer are:

1. Reviews and approves shop drawings from the subcontractors and vendors.

2. Performs surveying and dimensional layouts for the structure.

3. Performs design calculations for vertical and horizontal formwork, and slip forms.

4. Performs design calculations for temporary structures such as cofferdams and scaffolds.

The *Planning and Scheduling Engineer* collects the field material delivery information and they develop the look ahead schedule for design, procurement and construction activities on large complex construction projects. They verify that the materials have been received and coordinate the efforts for obtaining the materials. The essential skills of a Planning/Scheduling Engineer are:

1. Develops the project logic network.

2. Determines sequences for design, procurement & construction.

3. Develops project activity list for design, procurement and construction.

4. Calculates activity durations for design, procurement and construction activities.

The *Cost Engineer* collects field data and compares, analyzes and forecasts the final costs at completion. The essential skills of a Cost Engineer are:

1. Develops and analyzes the weekly cost and productivity reports.

2. Forecasts the productivity and costs at completion.

3. Produces the variance analysis report.

4. Maintains in-place quantity records.

The *Estimator* prices the contractor's portion of the estimate and develops the contractor's overhead costs and reviews and selects the subcontractor proposal bids to be incorporated into the Contractors' proposal. The essential skills of an Estimator are:

1. Develops labor, material & equipment unit costs.

2. Analyzes the costs forecast data and predicts the future costs of the project.

3. Utilizes cost adjustment factors to determining costs.

4. Develops the overhead costs.

5. Interprets the construction documents and sometimes performs quantity takeoffs.

6. Gathers, reviews and selects the subcontract bids.

Construction Crafts

The *Acoustical Tile Setter* performs the layout and assembles the acoustical tile suspension system and mounts the tile on the wall and ceilings to reduce the reflection of sound.

The *Insulators,* sometimes still referred to as the Asbestos Workers, pastes, staples, wires, tapes or sprays insulation to pipes, walls, ceilings and boilers.

The *Bricklayers* place brick, block and structural tile in walls, floors, partitions, fireplaces. They also install fire brick linings in industrial furnaces sometimes called boilers.

The *Stonemasons* cut and build stone walls using field stone, natural cut stone such as marble, granite and limestone or artificial stone.

The *Boilermakers* fabricates and assembles structural steel for boilers, tanks, vats and pressure vessels. In addition, they connect piping, valves, pumps, tubes and equipment inside the boiler.

The *Carpenters* layout, cut and erect concrete formwork for bridges, piers, tunnels, cofferdams and wood framework. They also install manufactured windows, doors and finish materials.

The *Cement Masons* or Finishers will screed and trowel exposed concrete surfaces for floors, highways, bridge decks and concrete sidewalks.

The *Communications Electrician* assembles, installs, connects and tests electronic communication equipment for low power data communications systems, intercom systems, sound systems, telephone systems, security systems and emergency signaling systems.

The *Drywallers* fasten drywall or gypsum board to the framework inside commercial buildings, houses and other structures.

The *Tapers* or Jointer seals the joints between gypsum board or other wall board normally in commercial buildings.

The *Electricians* assemble and install all fixtures, wiring, conduit, junction boxes and connect all wiring for the high power electrical and lighting systems.

The *Elevator Operators* assemble, install and align all frameworks, counterbalances, pumps and cylinders for electric elevators, hydraulic elevators and escalators.

The *Fireproofers* apply fire resistant materials to structural steel and they apply fire resistance refractory material to the inside of boilers and tanks.

The *Floor Covering Installers* install and replace carpet or resilient floor covering material such as vinyl tile, linoleum or vinyl flooring.

The *Glaziers* select, cut and install stationary pane glass, plastic materials or mirrors including all hardware used in curtain walls, window walls or store front windows.

The *Instrumentation Fitters* connect, mount and install all pressure and flow instruments, valves, tubing and panel boards associated with monitoring and controlling the process.

The *Ironworkers* shakeout and erect the structural steel framework, stairs, handrail and platforms on buildings, process plants, power plants and bridges.

The *Laborers* perform many activities such as air and power tool operator, a mason tender, concrete vibrator operator, carpenters assistant and they drive the motorized concrete buggies.

The *Lathers* fasten wooden, metal or rock board laths to walls and ceilings of buildings to provide supporting base for plaster, fireproofing or acoustical material.

The *Mechanics* repair and maintain the construction equipment.

The *Millwrights* assemble and align rotating machines and equipment such as shafts, conveyors, pumps and turbines.

The Oilers check the oil levels and lubricate the construction equipment.

The *Operators* run construction equipment such as air compressors, pumps, hoists, cranes, loaders, backhoes, power shovels, sheepsfoot rollers, rubber tired rollers, drag lines, bull dozers and concrete batching plants.

The *Painters* apply coats of paint, varnish and other finishes to interior and exterior surfaces.

The *Paperhangers* apply coverings to walls and ceilings made of fabric, vinyl or paper.

The *Pile Drivers* operates the pile driver mounted on skids or on the crane to drive permanent wood, steel or concrete piles. They also drive and extract sheet piles made of wood or steel.

The *Pipefitters*, sometimes referred to as the Fitters, lay out, cut, align and install all high pressure bolted and welded metallic piping on refineries, processing plants, water treatment plants and power plants.

The *Pipelayers* place and align underground pipe for sanitary sewer, storm sewer and water distribution systems outside the structure.

The *Plasterers* apply coats of plaster to interior walls and ceilings with many types of plaster materials that form fire resistant and sound proof surfaces. Also, they apply stucco to exterior surfaces.

The *Plumbers* fabricate and install domestic water, waste disposal and sanitary piping and fixtures such as bath tubs, sinks, water closets and dishwashers in residential, commercial and industrial buildings.

The *Riggers* assemble cranes, select and connect slings to the crane for lifting machinery, Structural steel and equipment. They also erect jin pole lifting systems designed to lift an unusually long piece of equipment which is shipped horizontally. The jin pole system allows the extremely long piece of equipment to be lifted into its permanent vertical position.

The *Rodbusters* fabricate and install reinforcing bars and wire mesh to reinforce concrete floors, columns, footings, beams and girders.

The *Roofers* apply various types of materials such as tar and gravel, rubber, asphalt or fiberglass shingles to commercial, residential and industrial projects.

The *Sheet Metal Workers'* layout, cut and install round and rectangular duct work for heating, ventilating, air conditioning, pollution control systems, kitchen equipment, and sheet metal work for roofs, siding, rain gutters, skylights and outdoor signs.

The *Sprinkler Fitters* layout, fabricate, assembles and installs all piping, sprinkler heads and equipment associated with the Fire protection System.

The *Teamsters* drive a variety of construction equipment such as dump trucks, low boys, flat bed trucks, transit mixers, tank trucks or pickup trucks to haul materials.

The *Terrazzo Workers* mix, pour, finish and polish mixture of cement, sand, pigment and marble chips for floors and stairs.

The *Tile Setters* cut, apply an adhesive base and install tiles to floors and walls.

The *Welders* adjoin together metal components for structural steel, process metal pipe, heavy rebar with cad welds, and heavy gage sheet metal using a variety of welding processes such as arc or gas. The welders are commonly associated with the following crafts 1) Ironworkers 2) Boilermakers and 3) Pipefitters and to a lesser degree Sheet Metal Welders and Rod Buster Welders. They will take on the name of the craft that they are affiliated with such as Boilermaker Welder, Pipefitter Welder, etc.

Traditionally within each craft listed above, there are at least four skill levels. The skill levels are described below. The *General Foreman* is normally described under a union agreement and a General Foremen is required after a specified number of Crew Leaders (Foreman) are on the job. The *Crew Leader* generally referred to as the Foreman provides instructions to the workers and many times they work with the craft worker. The *Skilled Trade Person* generally referred to as the Journeyman is a trained and skilled craft or trade person. Finally, the *Apprentice* is a specific craft or trade trainee.

Organization and Job Description Exercise

1. What do the horizontal lines on an organizational chart with various positions indicate?

- A. Communication
- B. Responsibility
- C. Promotion
- D. Authority

2. Which duties change as a person moves up an organizational chart?

- A. Analysis skills increase and their communication skills increase
- B. Technical skills increase and their negotiation skills decrease
- C. Administration skills decrease and their Technical skills increase.
- D. Communication skills decrease and their Administration skills decrease

3. Which position typically writes the subcontract agreements?

- A. Superintendent
- B. Project Engineer
- C. Project Manager
- D. Planning Engineer.

4. Which position typically forecasts the cost at completion for field activities?

- A. Estimator
- B. Cost Engineer
- D. Superintendent
- C. Project Engineer

5. Which position typically performs the Formwork design calculations?

- A. Superintendent
- B. Safety Engineer.
- C. Project Engineer.
- D. Project Manager.

Organization and Job Description Exercise

6. Which position typically draws the logical sequences and calculates the activity days?

- A. Cost Engineer
- B. Superintendent.
- C. Project Engineer
- D. Planning Engineer

7. Which position typically assigns the crews, maintains a job diary and schedules subcontractors?

- A. Cost Engineer
- B. Superintendent.
- C. Project Engineer
- D. Project Manager.

8. Which position typically completes the time card?

- A. Accountant
- B. Crew Leader
- C. Craft person
- D. Superintendent

9. Which party typically obtains the building permits?

- A. Owner.
- B. Subcontractor.
- C. Project Manager.
- D. Architect/Engineer.

10. Which position typically develops the overall project logic network and schedule?

- A. Estimator.
- B. Cost Engineer.
- C. Project Manager.
- D. Planning Engineer.

Organization and Job Description Exercise

11. Which of the following activities does a Millwright perform?

- ○ A. Cuts and installs trim and cabinets.
- ○ B. Assembles and aligns rotating equipment.
- ○ C. Fits and aligns high pressure process piping.
- ○ D. Fabricates and assembles sheet metal for duct work.

12. Which trade operates equipment to place the Steel Sheet Piling?

- ○ A. Rigger.
- ○ B. Excavator.
- ○ C. Ironworker.
- ○ D. Pile Driver.

13. Which trade assemblies and aligns the underground pipe outside the structure?

- ○ A. Plumber.
- ○ B. Pipe Fitter.
- ○ C. Pipe Layer.
- ○ D. Building Laborer.

14. Which trade applies stucco to the outside of the building?

- ○ A. Plasterer.
- ○ B. Insulator.
- ○ C. Carpenter.
- ○ D. Drywaller.

15. Which trade installs piping and equipment for the fire protection system?

- ○ A. Plumber.
- ○ B. Pipe Fitter.
- ○ C. Fireproofer.
- ○ D. Sprinkler Fitter.

Organization and Job Description Exercise

16. Which trade applies heat resistant materials to structural steel and sprays refractory material on the inside of steel Boilers and High Pressure Vessels or Tanks?

- A. Insulator.
- B. Fireproofer.
- C. Boilermaker.
- D. Asbestos Worker.

17. Which trade ties and places the rebar?

- A. Rigger
- B. Rod busters.
- C. Pile Driver.
- D. Iron worker.

18. Which of the following trades Fits, Aligns & Installs Drain, Waste and Vent Piping?

- A. Plumber.
- B. Pipe Fitter.
- C. Pipe layers.
- D. Sprinkler Fitter.

19. Which of the following trades Fabricates and Erects Air Distribution Duct work?

- A. Glaziers.
- B. Iron worker.
- C. Terrazzo workers.
- D. Sheet Metal Workers.

20. Which of the following trades installs and calibrates pressure and flow gauges?

- A. Plumber.
- B. Pipe Fitter.
- C. Sprinkler fitter
- D. Instrumentation Fitter.

Organization and Job Description Exercise

21. Which trade Installs low voltage intercom & security systems?

- A. Electrician.
- B. Instrumentation Fitter.
- C. Security Systems Engineer.
- D. Communications Electrician.

22. Which trade wraps the high pressure process piping and equipment?

- A. Insulator.
- B. Plasterer.
- C. Fireproofer.
- D. Boiler Maker.

23. Which trade erects jin poles for making heavy lifts, assembles cranes and attaches slings to the loads for the crane to lift?

- A. Rigger.
- B. Operator.
- C. Millwright.
- D. Ironworker.

24. Which trade Pours, finishes and polishes floors to bring out the marble chips?

- A. Tile Setter.
- B. Terrazzo Worker.
- C. Cement Finisher.
- D. Flooring Installer.

25. Which trade cuts and installs panes of glass in store fronts and glass curtain walls?

- A. Glazier.
- B. Lathers.
- C. Carpenter.
- D. Iron worker.

Organization and Job Description Exercise

26. Which trade seals the head and butt joints for the drywall on a commercial project?

- A. Taper.
- B. Lather.
- C. Plaster.
- D. Drywaller.

27. Which trade operates the motorized concrete buggies?

- A. Oiler.
- B. Laborer.
- C. Operator.
- D. Millwright.

28. Which trade welds the high pressure process piping?

- A. Plumber.
- B. Pipe Fitter Welder.
- C. Ironworker Welder.
- D. Sheet Metal Welder.

29. What are the components of a job-built boiler that the Boilermaker will assemble together?

- A. Assembles the turbine and fits and aligns the rotating equipment.
- B. Sets steel sheet piling, fabricates and assembles sheet metal and places piping.
- C. Sets structural steel sides, assembles piping, welds water tubes, and sets pumps.
- D. Assembles sheet metal, applies refractory material to boiler and paints the boiler.

30. The welders have associated themselves with numerous trades and they have taken on their trade name. Which of the following crafts are the welders are associated with?

- A. Millwrights, Pile Drivers and Operators.
- B. Ironworkers, Boilermakers and Pipe fitters.
- C. Plumbers, Sprinkler fitters and Pipe Layers.
- D. Instrumentation fitters, plumbers and Jointers.

Check Answers

Employment Laws and Regulations
There are numerous hiring information and employment law regulations that the supervisor must be in compliance with since they may be the first contact for the new employees. Therefore, your actions in labor matters can have a major effect on an employee's perception of the company and your concern for their well being. It is the supervisor's responsibility to abide by the labor laws and/or to abide by the collective bargaining agreements (union) negotiated by the contractor. This requires the supervisor to have a basic knowledge of the following labor laws.

Hiring Requirements
The *Fair Labor Standards (Wages and Hours Law)* act requires a poster to be posted in clear view for all employees. This poster must be posted at the job site at the employee bulletin board. This law regulates methods of wage payment and hours of work for all industries engaged in construction between two or more states. The law restricts the employment of children more than fourteen and less than sixteen to non construction jobs. Also, the employment of children under the age of 18 in hazardous construction jobs is prohibited. They can be employed in construction between sixteen and eighteen only in nonhazardous jobs. It is the contractor's responsibility to verify their age. The Fair Labor Standards law says that you cannot work nonexempt employees for more than forty hours per week unless you pay them at least time and a half their regular rate of pay for the overtime. Also, this Act specifies that you cannot use gender as basis for discriminating in wages, except where wages are based on a seniority system, a merit system, a piecework system, a commission or a bonus system. The law also specifies that you cannot simply lower the wage rate of any employee just to settle a wage disparity. The Fair Labor Standards Act does allow a manager to create a class of employees called exempt employees. This allows you not to pay overtime to some people if they work more than forty hours per week. This class normally consists of executives, managers, and first-line supervisors, and other employees whose jobs require making decisions and using personal judgment, creativity, or innovativeness but they are not classified as managers.

The *Illegal Immigration Reform and Immigrant Responsibility Act* requires that the supervisor ask for detailed proof of an applicant's eligibility to work in the United States. This is called the I-9 form requiring all non U.S. citizens employed in the United States to complete this form and it must be submitted to the federal government within three days of hiring. This form must be completed at the time of hiring. Penalties exist to supervisors and companies for a noncompliance. You can ask for proof of employment eligibility such as an alien registration card, U.S. passport, or a U.S. Social Security card. It is illegal for you to ask an applicant where they come from or which country they come from.

The *Employee Withholding Exemption Certificate* (W-4) for Federal and State Tax Withholdings requires that this form be completed at the time of hiring for each employee hired. This form requests the employee's name, address, social security number, marital status, the number of exemptions claimed and it is signed by the employee..

Employment Law Legislation

Employment law covers numerous situations where managers and supervisor's actions or inappropriate actions may have severe legal ramifications on the individual and the company. There are numerous possible actions which can be taken against an organization or its individuals if they do not take appropriate actions concerning employment issues. You or your company could face claims of breach of a contract for firing someone without just cause, retaliatory discharge for firing someone after they made a claim, slander or defamation of character for telling someone the reason for discharging an employee, sexual harassment for failure to take immediate action to remedy a hostile situation, wrongful discharge because you did not follow all of the progressive disciplinary steps and the list is extensive.

This section will focus on the daily activities concerning hiring, managing and discharging personnel. It will outline what activities you cannot do and what activities you can do concerning these numerous employment laws such as the civil rights laws, equal employment opportunity laws, Americans with disabilities laws, labor laws, safety liability law, sexual harassment, and due diligence under criminal law. The *Civil Rights legislation* was enacted in 1964 and it defined discrimination, but it still exists today and it is still illegal today. The primary reason for enacting numerous civil rights laws is prejudice against a group of people which cannot be erased by laws.

Prejudice means forming opinions or having feelings about a group of people on the basis of special characteristics, such as race, color, religion, ethnicity, sex, age, disability, or making a judgment in advance on the basis of stories, implications, or limited experience about people from a particular place or background. Ignorance in the form of what you don't know about people can also lead to prejudice. Ignorance and prejudice have prevented many productive groups of people from taking full advantage of economic employment opportunities. Therefore, laws have been enacted to protect people whose opportunities have been limited because they do not hold the "right" characteristics by people making the hiring decisions. These laws are designed to identify protected classes, or groups of people who have been identified as having suffered from economic discrimination in the past.

Employment legislation defines a protected class as a group of people distinguished by the special characteristic(s) that have inhibited their progress. These protected classes consist of race, color, ethnic identification, national origin, religion, sex, age, disability, and veteran status. Under the law, you cannot discriminate on the basis of a characteristic specific to any protected class, unless the characteristic is a bona fide occupational qualification. A bona fide occupational qualification is a trait that is integral or essential to the proper performance of the job. The federal government defines *discrimination* with respect to hiring practices, the decisions and actions that deny individuals in protected classes access to employment, advancement, benefits, training, and compensation permitted to other people in the organization.

Employment Law Discrimination
Employment Discrimination can take many forms in the workplace. Some examples are Sex Discrimination, Sexual harassment, Promotion discrimination, Hostile work environment, Improper termination, Racial harassment, Recruitment discrimination of women and minorities.

Under the Civil Rights Act, the Federal District Court for the Western District of Missouri has ruled that individual employees in a position of authority can be sued, held accountable for and required to pay punitive damages for acts of discrimination. Recent cases that Supervisors have been held liable for Intentional Infliction of Emotional Distress, Defamation Assault and Battery, Malicious Interference with employment, Invasion of Privacy and other common law theories. Also, the *Civil Rights Act of 1991, expanded employment discrimination* claims to allow for recovery of compensatory damages for Emotional Pain, Suffering, Inconvenience, Mental Anguish, and Loss of Enjoyment of Life. The act also allows for recovery of punitive damages if the jury finds that the employer acted with malice or reckless indifference. If compensatory and/ or punitive are awarded, they are not covered by business liability insurance. The 1991 act also provides for employee jury trial and it caps the compensatory and punitive damages.

A 1989 U.S. Supreme Court decision now allows plaintiffs to sue in court for an employer’s intent to discriminate in employment. The result has been that these cases can be tried by a jury where punitive damages and severe penalties can be assessed against the company and managers. The plaintiff is required only to show that the company’s or its representatives reckless disregard for the consequences of an action is sufficient to prove intent to discriminate intended to produce the outcomes. Therefore, the *Equal Employment Opportunity* (EEO) laws which are enforced by the Commission (EEOC) have identified guidelines for what a manager cannot do as follows.

1. Failure to hire or to discriminate against any person in a protected group.

2. Limit, segregate, or classify applicants which have an adverse effect on their status.

3. Failure to provide training because they are members of a protected group.

4. Retaliation against any person because they made a claim or participated in an action.

5. Print any employment notices that may adversely affect members of a protected group.

6. Discharge any person because they are members of a protected group.

7. Failure to maintain and post, in a conspicuous place, the contents of a civil rights law.

The *American with Disabilities Act* (ADA) of 1992 administered by the EEOC has expanded the list of ADA-covered disabilities. ADA defines disabled individuals as persons with a physical impairment, mental disorders, impaired or disabled person including individuals with AIDS, epilepsy, obesity or diabetes which may affect the human biological system creates a disability, alcoholics and drug abusers who have successfully undergone treatment. The ADA specifically excludes any employee or applicant who currently, knowingly uses a controlled substance. It also excludes homosexuals, bisexuals, transvestites, and persons whose sexual behaviors do not stem from physical impairments. Below is a list of things a manager cannot do to a qualified disabled person under the ADA guidelines.

1. Limit, segregate, or classify applicants solely on the basis of the person’s disability.

2. Participates in an arrangement with employment agencies, labor unions, benefit providers or training programs that subjects the qualified person to prohibited discrimination.

3. Uses criteria, or employment tests that are not bona fide occupational qualifications.

4. Excludes or denies equal employment or benefits to a qualified person solely because the qualified individual has a relationship with a disabled spouse.

5. Fails to make reasonable accommodations for a known physical or mental limitation.

6. Requires medical examinations or ask a person whether they have a disability.

The *Sexual Harassment Regulation* according to the Equal Employment Opportunity Commission’s (EEOC) policy it states that an employer is liable for sexual harassment if it knew or should have known upon reasonable diligent inquiry about a situation which created a hostile work environment. The policy also insists that each company must have policy that has been “clearly and regularly” communicated to all employees. Second, it must affirmatively raise the subject with all employees. Third, it must express strong disapproval and it must explain the consequences to all employees. Fourth, the company must have a sexual harassment complaint procedure that ensures confidentiality and provides effective remedies including protection of victims/witnesses. Fifth, the company must Investigate charges promptly and throughly. Sixth, it must take immediate and appropriate corrective action. Finally, the company must provide training on sexual harassment.

The courts have identified the situations below that created a *Hostile Work Environment* and they are things that supervisors cannot do. First, a hostile environment is created when a supervisor’s conduct had the purpose or effect of unreasonably interfering with the employee’s work performance. Second, evidence can be submitted that a supervisor had sexually harassed others. Third, evidence can be submitted of racial and sexual hostility created a hostile environment.

Fourth, a hostile environment is created by name calling or slurs. Fifth, offensive pictures or jokes create a hostile environment. Sixth, an invasion of privacy by a supervisor is a hostile environment. Seventh, a supervisor's intentional infliction of emotional distress creates a hostile environment. Supervisors can be held individually liable for sexual harassment claims and punitive damages for pain and suffering have been awarded.

Affirmative Action plans have been established to ensure equal employment opportunities on public projects. Many contracts with federal or state funds will establish goals and timetables for minority and female participation expressed in percentage terms for the Contractor's aggregate workforce in each trade on all construction work. The Contractor must comply by executing and submitting with their bid proposal, certifications relating to the following.

Minority Business Enterprises (MBE) on government projects require a dollar value or percentage as a goal of the contract to be supplied by a registered MBE. *Women Minority Business Enterprises* (WBE) on government projects require a dollar value or percentage goal of the contract to be supplied by a registered WBE. *Disadvantaged Business Enterprises* (DBE) on government projects require a dollar value or percentage overall goal of the contract to be supplied by a registered DBE. If these goals cannot be met, then the contractor must provide complete documentation of the names of the contacts with times and dates each MBE or WBE or DBE was contacted. Without proper documentation a Contractor can be considered a non-responsive bidder.

Another form of employment documentation is the *Disciplinary Memorandum*. It is imperative that all disciplinary memorandums contain three sections. They are the format, vocabulary, and the tone. Whenever you are required to write a disciplinary memo or letter, the memorandum should *never start or contain praise,* it sends a Contradictory Message to the Employee. When sending a Disciplinary memorandum, you must focus on three items. First, focus on the Format. Second, focus on the Vocabulary. Third, focus on the Tone. Below you will find some advice on the proper technique for writing each section of a disciplinary memorandum.

The Format section should contain these items: an introduction that should state what action is being taken and what caused the need for the disciplinary action; a supporting paragraph documenting the incident causing the action; a direct quotation from the company policy; a conclusion which focuses on the future; and the Format should include specific review periods and how they will be dealt within the future. The Vocabulary section should contain words that are easily understood. Finally, the Tone section should state the facts only and the Tone should not be harsh, exaggerated or judgmental. In summary, an improperly written disciplinary memo can send a contradictory message to an employee. Therefore, the writer must be aware of the format, vocabulary and tone.

Management and Union Labor Laws
There are numerous *Labor Laws* that apply to the construction industry which supervisor must be aware of to comply with the requirements. Also, these Labor Laws apply to all contractors' whether you are a union or merit shop contractor. Managers and supervisor's must be aware of these labor laws. For example, the Davis-Bacon Act, the Norris LaGuardia Act, the National Labor Relations Act, the Labor-Management Relations Act, the Fair Labor Standards Act, and the Labor-Management Reporting and Disclosure Act applies to all contractors. Each of these laws protects nonunion as well as union employees on the job and extends employees' rights to organize on their own behalf, including the right to form unions. These labor laws affect management practices with regard to pay including prevailing wages and overtime, concerted action, disciplinary procedures, and discharge policies. Therefore, they are defined below.

The *Davis-Bacon Act* was enacted in 1931, this act requires that in a contract for construction work for the United States government there shall be stated the wage rates and benefits for workers that the contractor and subcontractors must undertake to pay and they shall not be less than those prevailing in the locality. It established prevailing wage rates for each craft classification on all federally funded projects. This same act has been passed by many states and it establishes prevailing wage rates on state-funded projects. This form is normally provided in the Bidding Requirements section of the project. It identifies the name of the construction project site, the County, the Date Issued, and the basic hourly rate, the hourly fringe benefit rate, the total prevailing, and the overtime provisions. A contractor must ensure that all contractor employees and subcontractor employees are in compliance with this requirement.

The *Norris-LaGuardia Act* of 1932 (1) restricted the court's use of injunctions against union activities, (2) protected the right of workers to strike and picket peaceably, (3) prohibited Yellow Dog Contracts which is defined as a pre-hiring agreement requiring the job applicant not to join a union or to renounce their membership while employed.

The *National Labor Relations Act* of 1935 (NlRA) (Wagner Act) put into law protects employees' rights to take concerted action, that is, work together, to alter work conditions by (1) using bulletin boards that publish general community information, (2) holding meetings during work hours, with no loss pay or threat of retaliation, to discuss safety or other working conditions. It allows all workers to engage in other concerted activities for the purpose of collective bargaining through their own representatives. This includes forming, joining or assisting labor organizations, but at the same time, it prevents nonunion employees from being forced or coerced into joining a labor organization or engaging in collective bargaining except where membership in a labor organization is a condition of employment created by contract. The National Labor Relations Act created the National Labor Relations Board (NLRB) which is a decision making board established to resolve conflicts between management and employees.

The National Labor Relations Board also defined unfair labor practices by employers. It states that as a manager you cannot interfere with, restrain or coerce employees exercising their rights. Second, you cannot discriminate against an employee in order to encourage or discourage union membership. Third, you cannot discharge an employee because of membership or nonmembership. Fourth, you cannot refuse to bargain collectively with the employees' representatives and you must bargain in good faith. Fifth, you cannot enter into a Hot-Cargo Agreement. A *Hot Cargo Agreement* is where the employer agrees not to do business with or purchase the products of another employer. Sixth, you cannot discriminate in hiring or tenure on the basis of union or nonunion membership. The Wagner Act outlawed a closed shop. A *closed shop* is an agreement requiring a worker to be a member of the appropriate union at the time of hiring. Seventh, you cannot fire or otherwise discriminate against an employee for filing charges or giving testimony under this act.

The things below are activities you can do as a manager as long as you do not interfere with your employees' rights to take collective action or form a union. As a manager under the National Labor Relations Act you can freely express your own viewpoints, arguments, or opinions in writing, print, graphics, or visuals about unions or collective bargaining while ensuring that what you say does not threaten reprisal or force someone from forming or joining a collective bargaining unit or promise benefits for not forming or joining. Second, you can counter aggressive union recruiting tactics such as non-employee labor organizers. Third, you can hear employee grievances and adjust them without union representation.

The *Labor-Management Relations Act* of 1947 (Taft-Hartley Act) is primarily focused against unfair Union management Practices against its members or nonmembers while trying to organize. Under this amendment to the NLRA, a manager cannot conduct unwarranted or sudden lockouts against employees. Second, you cannot pay, lend, or deliver money or other assets to a union, union official, union welfare fund, or an employee involved in a labor dispute. The Labor Management Relations Act also included the following provisions against unions and union officials. It prohibits featherbedding. *Featherbedding* is defined as paying for services not performed. Second, it made secondary boycotts illegal. A *Secondary boycott* is a boycott using a third party to put pressure on one of the other parties to conform. The Labor Management Relations Act allows you the right to make every reasonable effort to reach an agreement with your employees on rates of pay, hours, and working conditions including notice of changes, and to arrange promptly to hold a conference to settle any differences. If the conference is unsuccessful, the law requires that both of you participate fully in meetings by the Federal Mediation Service.

The *Labor-Management Disclosure Act* of 1959 (Landrum-Griffin Act) has language similar to that used in the NRLA which says that you cannot interfere with employees' rights to work, to organize, to choose representatives, bargain collectively, or engage in concerted action for their mutual aid or protection. This act also requires the union officials to submit a personal financial statement and union financial statements to the government each year.

The *Collective Bargaining Agreement* established the terms and working conditions agreed upon between the contractor and the union are described in this document. These collective bargaining agreements are usually negotiated by a contractor association such as the Associated General Contractors (AGC) and they are signed by the contractor members. The supervisor should attain a copy of the local agreements in effect before starting or assigning work. Each trade and local have negotiated their own agreement.

The *Doctrine of "Separate Gates"* has established the rules for contractors to following in designating gates on a union construction project so that the owner's employees, the subcontractor's employees, the contractor's employees and the material deliveries are separated. Separate gates for each employer or each trade and they are in a different location from the job site deliveries. Also, the owner's employees entrance, and the owner's deliveries are usually away from the construction gates. Another clause is the *Subcontract Clause* which is under the Wagner Act in Section 8e and it states that Contractor's can agree to restrictions on subcontracting if the owner requests restrictions. Also, there are rules established for a construction company with a union arm and non-union arm. This is referred to as a *Double-breasted Operation*, but it must have separate management of the daily activities.

Another term unique to the construction industry is a *Merit Shop Contractor*. This term was coined by John Trimmer when nonunion firms were struggling for a market share with union contractors. John Trimmer was the executive vice president from 1952 until 1976 and later he was the assistant to the ABC president's. These are also referred to as Open Shop Contractors. Merit shop Contractor's have the right to establish the crew size, the right to select the trade that will perform each work activity and the right to select the installation methods for installing the materials. Many Merit shop contractors belong to the Associated Builders and Contractors (ABC).

Unions are under the Union Shops guidelines. A *Union Shop* requires employees to join within stipulated time after employment. A *Jurisdictional Dispute* is a disagreement of the work rules between two unions. Under a jurisdictional dispute the contractor must assign the work FIRST. If not resolved the contractor must:

1. File with the National Labor Relations Board in the Region.

2. NLRB schedules a hearing within 10 days. Seek an injunction to stop.

3. If not resolved within 10 days, NLRB has a hearing and assigns work.

4. If not obeyed, fined. Taft Hatley Act. Private parties can sue.

Common Situs Picketing is used on a multiple employer job site and it has established these rules.

1. Picketing is limited to working hours

2. Signs must indicate clearly

3. Picketing must be close to the work

Other labor law terms are a *Lockout*. A lockout is a contractor who withholds employment from the workers. Also, there are *Primary boycotts* which are legal and they are a dispute between the contractor and a specific union such as the painter. This dispute is primary if the painters' union strikes only the painting contractor. A *Secondary Boycott* which utilizes a third party to influence another party, such as the contractor or the union to settle a dispute, is illegal.

Work Preservation is a clause that the union can negotiate for in the labor agreement which bars the use of prefab products in construction. *Product Boycott* is a clause that the union can negotiate with an employer to prohibit the use of a product to preserve work. If the product is specified by the Architect or Engineer then it cannot be boycotted.

The *Grievance Procedure* is an internal step by step process up the organizational chart to resolve employee complaints. Below is the grievance procedure flow for an individual.

Step 1 (Immediate supervisor)

Within twenty (20) days of the time a grievance might reasonably be known to exist, the affected member of the bargaining unit shall present the grievance in writing to his or her immediate supervisor with a copy to HRD.

The immediate supervisor shall respond in writing to the grievant no later than ten (10) days after the grievance has been received. Any withdrawal of a grievance at this Step shall not constitute a binding precedent in the disposition of similar grievances.

Step 2 Department level, unless the department head is the immediate supervisor, then advance to Step 3. If the grievance is not resolved at step 1, it shall be presented in writing to the Department manager or, where appropriate, the equivalent supervisory level, with a copy to HRD, within seven (7) days after the response of the immediate supervisor or the date the response was due, whichever is sooner. The grievance shall state the reasons the step 1 response is unsatisfactory. The Department manager or appropriate supervisor shall meet with the grievant within seven (7) days and, if the grievant wishes, with a representative of the Association. A written response shall be made not later than seven (7) days after the meeting at which the grievance was discussed.

Step 3 (HRD level)

If the grievance is not resolved at the above steps, it shall be presented in writing to HRD within seven (7) days after the decision at step 1 or 2, whichever applies, or the date the response was due, whichever is sooner. The grievance must be signed by an authorized representative of the Association and shall be part of the original grievance form. It must include the reason the grievant considers the prior response unsatisfactory.

Following receipt, a meeting must be held between the representative of the Association and the Director of HRD, or his/her designee, within ten (10) days. The Director of HRD, or his/her designee, shall respond in writing within seven (7) days from the date of the meeting.

Step 4 (Arbitration)

If the Association is not satisfied with the response at step 3, the grievance may be submitted to arbitration by so notifying the Director of HRD in writing within two (2) weeks of the step 3 response, or the date such response was due, whichever is sooner.

Once notified, the University and the Association will agree to an arbitrator within two (2) weeks. If the parties cannot agree, the arbitrator shall be selected by alternately striking one name from the following list. Determination of who strikes the first name will be by a flip of a coin. The name remaining is selected as the arbitrator.

The American Institute of Architects (1997), General Conditions of the Contract A201-1997 edition has established a claims procedure which requires mediation before arbitration. *Mediation* is defined as a third party using their influence to force two parties to negotiate. Normally, the Contractor must conduct this dispute resolution method after they have perfected the claim and it has been rejected. The next step is Arbitration. *Arbitration* is defined as a third party establishing a binding decision as outlined in the contract. Finally, if the previous methods have been exhausted and there is a legal flaw within the case then either party can file a law suit called *Litigation* which is a court decision.

Employment Law Exercise

1. When hiring employees, Which form must they fill out requesting their marital status, number of exemptions and their social security number?

- A. I-9
- B. W-2
- C. W-4
- D. 1099

2. Which form must be completed by all non United States citizens?

- A. I-9
- B. W 2
- C. W 3
- D. W 4

3. According to the Federal government regulations, What is the maximum number of days that a company has to submit the non United States Citizens form to the federal government?

- A. 1
- B. 3
- C. 14
- D. 21

4. Which of the following posters describes the regulations for wage payment and hours of work for all industries and must be posted at the job site?

- A. Fair Labor Standards.
- B. Prevailing Wage Rates.
- C. Material Safety Data Sheet.
- D. Safety and Health Protection.

5. What is the correct name for the acronym EEOC?

- A. Enterprise of Equal Occupational Council
- B. Enterprise of Equal Opportunity Coalition
- C. Equal Employment Opportunity Companies.
- D. Equal Employment Opportunity Commission.

Employment Law Exercise

6. What is the purpose of the EEOC law?

- A. Prohibit discrimination against individuals with disabilities.
- B. Protect companies from discrimination from their employees.
- C. Prohibit discrimination against individuals due to race, sex, age.
- D. Protect individuals from discrimination from sexual harassment.

7. What is the correct name for the acronym ADA?

- A. American with Disabilities Act.
- B. Association of Disabled Americans.
- C. American with Disabilities Association.
- D. Association of Discriminatory Americans.

8. What is the purpose of the ADA law?

- A. Prohibit discrimination against individuals with disabilities.
- B. Protect companies from discrimination from their employees.
- C. Prohibit discrimination against individuals due to race, sex, age.
- D. Protect individuals from discrimination from sexual harassment.

9. What is the correct name for the acronym DBE?

- A. Disabled Business Enterprises.
- B. Department of Business Enterprises.
- C. Disadvantaged Business Enterprises.
- D. Department of Business Employment.

10. What do the EEO, ADA and DBE laws have in Common?

- A. Protection of unions from employment discrimination.
- B. Protection of individuals from employment discrimination.
- C. Protection of construction companies from discrimination.
- D. Protection of individuals from disciplinary action from employers.

Employment Law Exercise

11. What are the additional provisions that were **ADDED** by the 1991 Civil Rights Act to the existing employment discrimination law that allows employees to recover compensatory and punitive damages?

- A. ,MBE, DBE, WBE, and ADA discrimination.
- B. Disability, Gender, Sex changes, Veteran and Obesity.
- C. Race, Color, Ethnic identification, sexual orientation and Age Discrimination.
- D. Emotional Pain, suffering, inconvenience, mental anguish, and loss of enjoyment.

12. What can be recovered by an individual from the officers or Managers of a company under the Civil Rights Act of 1991 if a manager is found guilty?

- A. No damages can be recovered.
- B. Business insurance will cover the damages awarded.
- C. The company can be for awarded damages and lawyer fees.
- D. The manager can be held personally for awarded damages and lawyer fees.

13. Which of the following activities creates a hostile work environment under the Sexual Harassment provisions?

- A. Using humor in the work place.
- B. Consenting verbal flirtations with co-workers.
- C. Talking with co-workers about social activities.
- D. Conduct which interferes with work performance.

14. What are the content areas that a supervisor must take into consideration when writing a disciplinary memorandum?

- A. Format, Tone and Vocabulary.
- B. Praising Introduction, Body and Conclusions.
- C. Opening Question, Highlights, Specific Clauses and Recommendations.
- D. Topic, Purpose, Specific Objective, Executive Summary and Lead-in with praise.

Employment Law Exercise

15. In 1935 the Wagner act was enacted and the National Labor Relations Board (NLRB) was formed, What type of disputes is the NLRB empowered to resolve?

- A. Owner- Contractor disputes.
- B. Architect- Contractor disputes.
- C. Contractor- Subcontractor disputes
- D. Organized Labor-Contractor disputes.

16. In 1959 the Landrum-Griffin act was enacted, which party and what rules were enacted?

- A. Union officials must follow established rules for picketing a job site.
- B. Management must not coerce employees and they must bargain in good faith.
- C. Management must pay employees on federal projects the prevailing wage rate.
- D. Union officials must report organization activities and finances to congress yearly.

17. In 1947 the Taft-Hartley act was enacted, Which party were unfair practices established against?

- A. Union's management.
- B. Owner's management.
- C. Contractor's management.
- D. Subcontractor's management.

18. In 1932 the Norris-LaGuardia act was enacted, and it prohibited the use of a Yellow Dog Contract. What is a Yellow Dog contract?

- A. It outlawed secondary boycotts that required a contractor to put pressure on another party to conform under the agreement.
- B. It outlawed union-employer agreements that require the contractor to refrain from handling the products of another contractor or supplier.
- C. It outlawed the use of a pre-hiring agreement that requires employees to agree that they will not join a union while employed with the company.
- D. It prohibited the use of pre-hiring agreements requiring a job applicant not to join a union or to renounce their union membership while employed.

Employment Law Exercise

19. What is the name of the act that requires the contractor to pay prevailing wage rates on all federally funded projects?

- A. Wagner act.
- B. Taft-Hartley act.
- C. Davis-Bacon act.
- D. Norris-LaGuardia act.

20. In 1935 the Wagner Act was enacted and it made it unlawful to enter into a Hot-Cargo Agreement. What is a Hot-Cargo Agreement?

- A. It outlawed the practice that requires employees to agree that they will not join a union while employed.
- B. It outlawed the practice that requires a worker to be a member of the appropriate union at the time of hiring.
- C. It outlawed secondary boycotts that required a contractor to put pressure on another party to conform under the agreement.
- D. It outlawed union-employer agreement that requires the contractor to refrain from handling the products of another contractor or supplier.

21. The 1947 Taft-Hartley act prohibited Featherbedding. What is featherbedding?

- A. The practice of refusing to bargain in good faith.
- B. The practice of paying the union for services not performed.
- C. The practice of discharging an employee for union membership.
- D. The practice of requiring a job applicant to sign a pre-hiring agreement.

22. What is a court order called that prohibits a union or contractor to stop certain activities?

- A. Strike
- B. Lockout
- C. Directive
- D. Injunction

23. What is the name of the illegal dispute between a contractor and a union that causes the employees of a neutral party to exert pressure on the contractor to settle called?

- A. Lockout
- B. Primary boycott
- C. Secondary boycott
- D. Jurisdictional dispute

Employment Law Exercise

24. What is a dispute between two unions over work activities requiring the contractor to assign the work to one of the unions involved called?

- A. Primary boycott
- B. Secondary boycott
- C. Jurisdictional dispute
- D. Subcontractor dispute

25. What is a contractor referred to as that defends the concept of the right of each contractor to decide the crew size, the job activities assigned and established their wages according to each individual's ability and performance?

- A. Merit shop contractor
- B. Union shop contractor
- C. Agent shop contractor
- D. Closed shop contractor

26. What is the procedure established in the labor agreement that provides for meetings between successively higher levels of union-contractor management to resolve employee disputes without work stoppage called?

- A. Grievance procedure
- B. Mediation procedure
- C. Arbitration procedure
- D. Jurisdictional dispute

27. The EEO clause on a project states that "on this project a total of 13 percent of the contract award value shall be for DBE's." What is this DBE hiring percentage considered according to the law?

- A. Goal.
- B. Obligation.
- C. Minimum Requirement.
- D. Maximum Requirement.

Check Answers

Job Site Administration and the Contract Administration Documents

The *Notice of Award* is an acceptance of the contractor's offer from the owner. This notice is normally accomplished by a letter indicating their selection and directing the contractor to obtain necessary contract bonds, and insurance together with information concerning arrangements for the signing of the contract. The *Letter of Intent* is a slightly different version which indicates selection and acceptance of a proposal and states intent of entering into a suitable contract at a later date because of certain activities not being met at the notification time such as encumbrances at the site that have not been reconciled. The Notice of Award is prepared by the Owner and Sent to the Contractor. It is the contractor's responsibility to acknowledge receipt, keep copy and send an original back to the owner within the specified amount of time, obtain bonds. If the notification is a Letter of Intent you should determine how long you will guarantee prices and verify with your subcontractors before notifying the owner. The *Notice to Proceed* implies that the site is free of encumbrances and the contractor can occupy the site. The date of the notice to proceed establishes the reference date from which the beginning of the project is calculated. The Notice to Proceed is prepared by the Owner and sent to the Contractor. It is the contractor's responsibility to acknowledge by signing, keep copy, return original to the owner, commence work within the specified amount of time.

The *Stop Work Order* is a document prepared by the Owner and used to notify the contractor to stop work on the project for a variety of reasons such as Owner financial conditions, Owners changed needs, labor disputes, unsatisfied liens, failure to perform according to the specifications. Also, See the Termination clause in the General Conditions contains additional reasons for the owner to stop work.

The *Schedule of Value Forms are* normally bound into the documents and they require the Contractor to provide a cost breakdown for each category listed. These forms are normally required to be submitted by the Contractor within fourteen days after the Notice of Award as stated in the Instructions to Bidders. They are reviewed and accepted by the A/E firm prior to first payment request. The *Application and Certificate for Payment Forms* are the same form as the Schedule of Values which the Contractor has placed a Scheduled Value upon previously. This form is completed and submitted by the Contractor to request all progress payments and final payment. Also, *Lien Waivers* are submitted with each request for payment and attached to the Schedule of Values form. These must be attached from all vendors and subcontractors.

The *Construction Schedule* is normally required to be submitted within fourteen days of the Notice to Proceed and it is reviewed and accepted by the A/E firm prior to the first payment request. Normally, the Contractor is required to prepare and submit a logic diagram indicating the interrelationship of procurement and construction activities. Under a Design-Build contract the organization is also responsibility for the design sequence. Sometimes the Owner will specify a specific software package and the necessary schedule updates.

The *Permits* are typically obtained by the Project Manager after the signing of the agreement and before commencement of the work. The contractor is responsible for obtaining the building permit and the soil erosion permit. The mechanical, electrical and plumbing permits are normally obtained by the specific trade.

The *Soil erosion permit* is required whenever any excavation is going to be performed within 500 feet of anybody of water such as a creek, stream, wetland, a lake, a river or drainage easement. The Soil Erosion and Sedimentation Permit is required to be completed by anyone disturbing the existing soil. This is to ensure the public that all runoff water and soil will be captured before causing any harm to adjacent bodies of water. Some of the acts that the contractor shall be in compliance with are Act 347 - Soil Erosion and Sedimentation Act, Act 346 - Inland Lakes and Streams Act, Act 203 - Goemaere-Anderson Wetland Protection Act. This information is normally found in the General Requirements and Division 02 Site Work.

The *Stop Work Notice* is a document used to notify the owner that the work on the project is being stopped for non payment. The AIA General Conditions under the payments clause states that if the contractor is not paid within seven days after the date stated in the contract or within seven days after receipt of Application or Payment or Sworn Statement then the contractor may, upon seven additional days written notice to the owner, Stop the Work until payment is received. The Stop Work Notice is prepared by the General Contractor. It is the contractor's responsibility to Sign the form and sends it to the owner by certified or registered mail.

The *Certificate of Substantial Completion* is the substantial acceptance of the project which is implemented by a joint inspection on the part of the owner's representative and the contractor. The contractor and the owner's representative compile a list of items, called a "punch list"containing the corrections to be completed. The punch list becomes the basis for accepting the work as completed and releasing the final payment to the contractor. Substantial performance may be defined as an accomplishment by the contractor of all things essential to the fulfillment of the purpose of the contract, although there may be inconsequential deviations from certain terms. It is the contractor's responsibility to "walk the job" and compile a "punch list" for final acceptance of subcontractors work. A completion date should be set for correction of deficiencies by the prime contractor and subcontractors. An example of a punch list is shown below.

1. Caulking is required between the stucco and brick on the lower level
2. Streaks and cracking on stucco must be remedied.
3. Submit the Operation and Maintenance Manuals for the Mechanical Equipment
4. Install the Fire door stops in the Northeast end of corridor of hall #2
5. Balance the Air Conditioning System and submit records for the balancing.
6. Submit the "as built" construction drawings.

The *Certificate of Occupancy* involves the Fire Marshall, the Plumbing Inspector, the Heating or Mechanical Inspector, the Electrical Inspector and the Building Inspector. Each inspector must verify and sign off before owner occupancy. Finally, sometimes a *maintenance bond* is required to be submitted to the owner at a project closeout.

The *Requests for information* (RFI) are sent to the A/E for clarification of an item during construction. Some of these may become contract change orders.

Shop Drawings, Product Data Sheets and Reference Standards
The *Shop Drawings* are defined in the American Institute of Architects, General Conditions, A201-1997, as drawings or diagrams which illustrate the fabrication and erection procedures for some portion of the work. It continues and says that shop drawings, product data and samples must be submitted after the signing of the Agreement and prior to fabrication or erection of the item. In article 3.12.7 it states that the "Contractor shall perform no portion of the Work... requiring Submittals... until the submittals have been approved by the Architect" (p 8). It is the contractor's responsibility is to verify materials, field dimensions and field construction criteria with the requirements of the Contract Documents and Approve each Shop Drawing or Product Data Sheet by affixing a Professional Engineers stamp to each drawing. Furthermore, the Contractor must: 1.) Maintain a Submittal Schedule and 2.) Inform the Architect of any Deviations. 3.) Inform by specific reference using a Letter of Transmittal.

The Supplementary Conditions states that "the Contractor shall not be relieved of responsibility for any deviation, unless the Contractor has informed the Architect by specific reference in the accompanying Transmittal Letter of such deviation at the time of submission and the Architect has commented in writing on the specific deviation. The Contractor shall not be relieved from responsibility for errors or omissions in the Shop Drawings, Product Data, by the Architect's review thereof" (p SC-4). Under this clause the contractor must:

The *Letter of Transmittal* is a cover form addressed to the receiver and attached to each package of information being sent to inform the receiver what information is being sent. The letter of transmittal provides the reader with a complete list of the items being sent and instructions to the receiver outlining "what action is to be taken by the receiver." The letter of transmittal is prepared by anyone transmitting data such as the contractor, architect, engineer, owner or subcontractor.

The General Requirements states that "all Submittals shall be clearly identified with project Name and location, and manufacturers' name...and the Contractor shall indicate their approval by means of their stamp." Furthermore, the Contractor must submit a specific number of copies as of each submittal to the Architect/Engineer for their approval as stated in the General Requirements.

The specific Shop Drawings required are stated at the beginning of each Section within each Division of the Technical Specifications under Part 1. For example, Division 5 is Metals, Section 200 is Steel Joists, PART 1.04 is Submittals and the B refers to the Shop Drawings required to be submitted. The CSI number is shown below.

05200 JOISTS

PART 1 GENERAL
1.04 Submittals
B. Shop Drawings

The *Product Data* Sheets are defined as Performance Charts, Standard Schedules or Brochures which illustrate a Manufactured Material or Product that will be installed. The AIA General Conditions states that the Product Data must be submitted prior to installation of the item for Approval and Review by the Contractor and the Architect. The specific Product Data Sheets required are stated at the beginning of each Section within each Division of the Technical Specifications under Part 1. For example, Division 5 is Metals and Section 300 is Steel Roof Deck, PART 1.04 is Submittals and the C refers to the Product Data information required. The CSI number is shown below.

05300 STEEL ROOF DECK

PART 1 GENERAL
1.04 Submittals
C. Product Data

The Reference Standards are documents that are not physically attached with the Documents, but are referenced too in the documents and they may be part of the contract. This is the doctrine of Incorporation by Reference. The most common clause used to incorporate an item by reference is to state in the documents that the Reference Standards are "herewith made a part of the Specifications." This normally requires the Contractor to have these available at the job site. Some common construction reference manuals that are incorporated by reference and they should be at the job site is the Riggers Manual for selecting slings under various lifting configurations. Another reference standard is the Crane Lifting Tables showing the various angles, distances and their lifting capacity. The Formwork for Concrete reference standard for designing the concrete forms. Finally, the OSHA Construction Safety Standards are incorporated by reference.

The *Record (As-built) Drawings* must be maintained at the job site and marked currently to record field changes and selections made during construction. This record set is given to the owner upon completion. There should be only one master set where all changes are made.

Contract Changes

Change Orders or Contract Modifications are defined in the American Institute of Architects (AIA) General Conditions as a written order, prepared by the A/E, to the Contractor issued after execution of the Contract Agreement. It is signed in agreement by the Owner, Architect/Engineer and Contractor. A Contract Change Order authorizes a change in the scope of work and/or an adjustment in the Contract Sum and/or in the Contract Time. After a contract change order is issued, the contractor must notify 1) All vendors effected by issuing a Purchase Order Change Number and they must notify 2) All subcontractors effected by issuing a Subcontract Change Order Number.

Example Contract Change Order Form

PROJECT: JOBSITE, USA
OWNER: Owner, Inc
261 Wash Ave.
Houston, TX

CHANGE ORDER NO. _____________
DATE August 29,__
A/E PROJECT NO.: ____99-116_______

CONTRACT FOR: JOBSITE, USA_____

TO: Contractor, Inc.
345 Michigan Ave.
Houston, TX

The contract is changed as follows:

Not valid until signed by the Owner, A/E and Contractor

ORIGINAL CONTRACT SUM $ __________________________

NET CHANGE BY PREVIOUSLY AUTHORIZED CONTRACT CHANGES $ __________________________

CONTRACT SUM PRIOR TO THIS CHANGE ORDER $ __________________________

CONTRACT SUM WILL INCREASE/DECREASE BY THIS CHANGE ORDER $ __________________________

NEW CONTRACT SUM INCLUDING THIS CHANGE ORDER WILL BE $ __________________________

CHANGE IN CONTRACT TIME WILL BE ________(DAYS)

NEW DATE OF SUBSTANTIAL COMPLETION IS _______________

____________________	________________________________	__________________________
Owner's Signature	Architect's/Engineers Signature	Contractors Signature

Changes Ordered by the Architect/Engineer are called Extra Work Orders and they are frequently used to authorize the contractor's field personnel (superintendent) to proceed with a change immediately, with the sum and time extension to be settled later. The *Extra Work Order* is issued by the Architect/Engineer to the superintendent, indicating the work order number, a full description of the scope of work and the method for determining the total cost. It should be very clear that an Extra Work Order **does not** change the Contract Scope, Price or Time until it is converted to an executed Contract Change Order.

The *Extra Work Orders* place the contractor at an extreme disadvantage in settling the work order fairly because the work has already been completed. Therefore, it is required that the field personnel and subcontractors document all time, equipment and materials used daily by Extra Work activity. The field supervisor should also require the Architect/Engineer to approve these charges daily if possible. Immediately after completion of the extra work order, the contractor should prepare a change order proposal and submit it to the owner requesting that a contract change order be issued.

Extra Work Order

PROJECT: ______________________ EXTRA WORK ORDER NO. ______

OWNER: ________________________ DATE: ______________________

____

_____________________________________ A/E PROJECT NO: ____99-116______

____

TO CONTRACTOR: CONTRACT FOR: ________________

____

____

____

____

The scope is changed as follows: (Describe scope)

________________________________ ________________________________

Architect's/Engineer's Signature Superintendent's Signature

The Architect can issue a *Construction Change Directive* which is defined in the American Institute of Architects (AIA) General Conditions as a written order, prepared by the A/E, to the Contractor issued after execution of the Contract Agreement. It is signed in agreement by the Owner and Architect/Engineer authorizing a change in the scope of work and/or an adjustment in the Contract Sum and/or an adjustment in the Contract Time. If the contractor disagrees, they must:

1. Proceed with the directive
2. Maintain all cost records
3. Negotiate approval into change order or file a claim.

If the contractor agrees, they must:

1. Proceed with the directive
2. Sign and execute a contract change order

Construction Change Directive Form

PROJECT: JOBSITE, USA OWNER: Owner, Inc___________ 261 Wash Ave. Houston, TX TO: Contractor, Inc. 345 Michigan Ave. Houston, TX	DIRECTIVE NO. _____________ DATE August 22,__ A/E PROJECT NO.: _99-116_________ CONTRACT FOR: JOBSITE, USA_____

You are hereby directed to make the following change(s) in this Contract:

PROPOSAL ADJUSTMENTS

1. The proposed basis of adjustment to the Contract Sum is:

__ Lump Sum (increase) (Decrease) of $______________

__ Unit Price of $________ per ___________

2. The Contract Time is Proposed to be (an increase or decrease of: ___________ (days)

_____________________ _____________________________________ ____________________

Owner's Signature Architect's/Engineers Signature Contractors Signature

Signature indicates Contractor's Agreement

Another change form is the Minor Change in the Work request from the A/E. A *Minor Change* in the Work is defined in the American Institute of Architects (AIA) General Conditions as a written order of the Architects/Engineers' supplemental instructions to the Contractor and issued after execution of the Contract Agreement. It is signed in agreement by the Architect/Engineer authorizing a change in the scope of work but it indicates that there will be no modification and/or an adjustment in the Contract Sum and/or an adjustment in the Contract Time.

Minor Change in the Work Form

PROJECT: JOBSITE, USA OWNER:____Owner, Inc___________ 261 Wash Ave. Houston, TX	SUPPLEMENTAL INSTRUCTION NO. __8_ DATE SEPTEMBER 14 A/E PROJECT NO.: __99-116________
TO: Contractor, Inc. 345 Michigan Ave. Houston, TX	CONTRACT FOR: JOBSITE, USA_____ A/E FIRM: __________________________

The Work shall be carried out in accordance with the following supplemental instructions issued in accordance with the Contract Documents without change in Contract Sum or Contract Time. Prior to proceeding in accordance with these instructions, indicate your acceptance of these instructions for minor change to the Work as consistent with the Contract Documents and return a copy to the Architect/ Engineer.

Description:

As discussed in our telephone conversation at 10:15 A.M. on September 13, install Acme "Desert Beige" ceramic tile, mfg. #701, in lieu of Star "Chatum Tan" ceramic tile in the mens's and women's bathrooms.

You reported that Star Manufacturing Company's "Chatum Tan" ceramic tile is currently out of stock and unavailable for delivery.

Attachments:

Issued By ___________________________ Accepted By _________________________

Architect's/Engineer's Superintendent

There are only two parties that can request changes and they are the Owner and the Contractor since they are the names of the parties on the Agreement. The owner or the architect authorized by the owner, has the right to issue change order requests to the contractor for additions, deletions, or revisions in the scope with an appropriate change in contract price or contract time. Change requests may also be submitted by the contractor or the subcontractor through the general contractor to take advantage of more efficient construction methods or materials. Immediately after receiving a change request, the contractor should notify all parties who may be affected by the change, such as construction personnel, vendors and subcontractor. An example of a change request memo is shown below.

Change Order Request Memo

FROM: Owner, Inc.
261 Wash Ave.
Houston, TX
TO: Contractor, Inc.
345 Michigan Ave.
Houston, TX
PROJECT NAME: Jobsite, U.S.A., Houston, TX

CHANGE REQUEST
NUMBER 1

DATE July 25,

SUBJECT: Addition of Face brick

The enclosed drawing shows' the addition of face brick to the north exposed concrete block basement wall.

Please submit a detailed bid breakdown indicating the net price. To ensure that this change can be implemented, we must receive your quotation by July 28 so that a change order, if approved, can be issued.

REQUESTED BY: ____________________________
Authorized Signature

There are two types of Change Order Proposals that the Contractor can submit depending upon the circumstances of the Proposal. Upon receiving a change order request memo from the owner, the Contractor must first determine if the proposal is a New Change or a Net Change. A New Change Order Proposal requires the contractor to provide a Change Order Proposal Summary Cover Page indicating the Change in Scope, Price, Time and the Time Limit for Acceptance. Second, the Contractor must prepare and submit to the owner a Change Order Proposal Backup or Breakdown page showing a detailed cost breakdown, including all direct job costs, indirect job costs, overhead and profit. The New Change for the Change Request Memo #1 is shown below with a Summary Page and the Backup Page. The Supplementary Conditions will determine the direct and indirect cost items that can be included in the Proposal, the percentage for overhead and profit. The Prevailing Rate Table if they apply will specify the minimum wage rates and benefits that must be paid on federal projects. The AIA General Conditions indicates that the Contractor has 21 days from first occurrence to submit a Change Order Proposal.

FROM: Contractor, Inc.	CHANGE ORDER NUMBER
345 Michigan Ave.	CHANGE REQUEST (E.W.O) NUMBER 2
Houston, TX	CHANGE ORDER PROPOSAL NO. 47
TO: Owner, Inc.	
261 Wash Ave. , Houston TX	PROJECT NAME Jobsite, U.S.A., Houston, TX

SCOPE: We submit the following quotation to cover the addition of brown Chippewa brick 4" x 2-2/3" x 8" to the north exposed basement wall.

PRICE:	Direct Job Costs	
	Material	$113.50
	Labor	104.13
	Subcontracts	0.00
	Total direct costs	217.63
	Indirect costs	68.91
	Subtotal	286.54
	Main Office 7%	20.06
	Subtotal	306.60
	Profit 10%	30.66
	Total Price	337.26

TIME EXTENSION: We request a time extension of one (1) working day for this change.

ACCEPTANCE TIME: Please issue a contract change order if you wish to proceed with this change. We will not proceed without further written instructions. This change order proposal is good for three days from the date above.

A *Change Order Proposal Bid Breakdown Support Page* will be submitted as backup with the change order proposal summary page to the owner. The bid breakdown shows how the Direct Costs and Indirect Costs on the Change Order Proposal Summary page were arrived at by the contractor. This Change Order Proposal Backup or Breakdown page is for New Changes to the Scope and it must follow the Crew Sizes, Prevailing Wages established on public projects, Crew Costs per day, Total Costs for Materials, Labor and Equipment by Type of Work/Locations and Operations. The direct and indirect itemized costs that a Contractor can change on a Change Order Proposal are stated in the Supplementary Conditions and the

Change Order Proposal Breakdown

Example of Direct Costs by Type of Work/Locations And Operations
Masonry Face Brick

Material 500 Brick @ $227/1000	=	$113.50
Labor 2-2/3 hr. 3 BL 8.01 Whr x $9.00/hr		72.09
2-2/3 hr. 2 BLH 5.34 Whr x $6.00/hr		32.04
	JOB COSTS	$217.63

Example of Itemized Indirect Costs

Indirect Labor (1 hr.)		20.00
Insurance 1% Job Cost		2.18
Small Tool 1% Labor		1.00
Job Truck 1% Labor		1.00
Job Office 2% of Labor		2.00
Sales Tax 4% of Material		4.54
Taxes: FICA 6.5% of Labor		6.77
Unemployment 4.5% of Labor		4.69
Insurance: Workers Compensation $8.87/$100	Labor	9.23
Public Liability $.37/$100 Labor		.38
Property Damage $.30/$100 Labor		.30
Fringes: Health & Welfare $.60/hr. 13.35 hrs.		8.01
Pension $.65/hr. 13.35 hrs.		8.68
Apprentice .01/hr. 13.35 hrs.		.13
	TOTAL	$68.91

The Net Change Order Proposal is for an item that currently exists in the original estimate, and the change will result in either an increase or decrease in the contract price. The effect of the change request must be determined by the contractor by comparing the original estimated cost of the item with the new estimated cost of the item. This results in a net change in price. Normally, the contractor does not charge the owner for overhead items. A *Net Change* requires the contractor to provide a Change Order Proposal Summary Cover Page indicating the Change in Scope, Price, Time and the Time Limit for Acceptance. The net change should reflect the difference between the Original Direct Costs and the New Direct Costs. The Net change for the Change Request Memo #2 is shown below.

FROM: Contractor, Inc.	CHANGE ORDER NUMBER
345 Michigan Ave.	CHANGE REQUEST (E.W.O) NUMBER 2
Houston, TX	CHANGE ORDER PROPOSAL NO. 47
TO: Owner, Inc.	
261 Wash Ave. , Houston, TX.	Jobsite, U.S.A., Houston, TX

SCOPE: In reference to your change order request No. 2, we submit the following quotation to cover the relocation of the Domestic water line as shown on drawing DW001 Revision No. 4

PRICE:	Direct Job Cost - Original		
	Material		$1500
	Labor		$ 978
	Equipment		$ 0
	Subcontractor		$ 0
		Total	$2478
	Direct Job Costs - New		
	Material		$1000
	Labor		$ 652
	Equipment		$ 0
	Subcontractor		$ 0
		Total	$1652
	Net Change in Price		$(826) Decrease

TIME EXTENSION: We request a time extension of one (0) working day on this change.

ACCEPTANCE TIME: Please issue a contract change order if you wish to proceed with this change. We will not proceed without further written instructions. This change order proposal is good for three days from the date above.

Site Administration and Contract Documents Exercise

1. Which document informs the contractor that their proposal has been accepted?

   - A. Contract Bonds.
   - B. Notice of Award.
   - C. Notice to Proceed.
   - D. Contract Change Order.

2. Which document informs the owner that the work on a project will be stopped for failure of the owner to make a progress payment?

   - A. Stop Work Order.
   - B. Change Directive.
   - C. Stop Work Notice.
   - D. Contract Change Order.

3. Which document is used to allocate the estimated costs for the items listed and for requesting progress payments?

   - A. Schedule of Values.
   - B. Construction Schedule.
   - C. Contract Change Order.
   - D. Labor and Material Bond.

4. Which document is issued to the contractor for failure to perform according to the specifications?

   - A. Stop Work Order.
   - B. Change Directive.
   - C. Stop Work Notice.
   - D. Performance Bond.

5. Which document is signed in agreement by the Owner, A/E and the Contractor informing the contractor to modify the agreements terms and conditions?

   - A. Addenda.
   - B. Change Directive.
   - C. Contract Change Order.
   - D. Contract Change Order Proposal.

Site Administration and Contract Documents Exercise

6. Which document is signed in agreement by the Owner and the A/E and instructing the Contractor to make a change prior to agreeing on the adjustment in scope or price?

- A. Change Directive.
- B. Extra Work Order.
- C. Contract Change Order.
- D. Contract Change Order Proposal.

7. Which document establishes the actual start date from which the beginning of the project is calculated?

- A. Notice of Award
- B. Notice to Proceed
- C. Contractor's Proposal
- D. Supplementary Conditions

8. Which document terminates any liquidated damages from being assessed any further?

- A. Notice of Award.
- B. Stop Work Notice.
- C. Contract Change Order.
- D. Certificate of Substantial Completion.

9. According to the AIA documents, assume that the Owner through the A/E has rejected a claim that the Contractor has submitted. What action must the Contractor request in writing next?

- A. Lawsuit.
- B. Mediation.
- C. Arbitration.
- D. Negotiation.

10. When is the Certificate of Substantial Completion prepared?

- A. bid opening
- B. signing of the agreement
- C. end of the construction process
- D. beginning of the bidding process

Site Administration and Contract Documents Exercise

11. Which of the following items is contained in the Certificate of Substantial Completion?

- A. process payment schedule
- B. starting date of the project
- C. a list of items to be completed
- D. a list of contract documents to be submitted

12. What is an amount withheld from progress payments to ensure satisfactory completion of the work called?

- A. Lien
- B. Retainage.
- C. Cost Plus Expenses.
- D. Liquidated damages.

13. Assume that the Contractor has not been paid according to the contract payment due date. According to the contract documents, which document must the contractor complete and submit to the owner to inform them that they will be leaving the job site if the late progress payment is not received?

- A. Sworn Statement.
- B. Stop Work Order.
- C. Stop Work Notice.
- D. Schedule of Values.

14. According to the project documents, which document lists the itemized content required for submitting a Contract Change Order Proposal?

- A. General Conditions.
- B. General Requirements.
- C. Instructions to Bidders.
- D. Supplementary Conditions.

15. According to the project documents, after the signing of the Agreement which documents must be submitted by the contractor within fourteen days of executing the Agreement?

- A. Performance Bond and Labor/Material Bond.
- B. Extra Work Order and Contract Change Order.
- C. Construction Schedule and Schedule of Values.
- D. Stop Work Notice and Contract Change Order Proposal

Site Administration and Contract Documents Exercise

16. Which document lists the Contract Documents that shall be utilized to interpret the contract?

- A. General Conditions.
- B. Technical Specifications.
- C. Supplementary Conditions.
- D. Owner/Contractor Agreement.

17. According to the construction documents, What is the procedure and the name of the document that you must use to inform the Architect/Engineer of a change notation you would like to make to a shop drawing?

- A. Inform the A/E using a Contract Change Order.
- B. Inform the A/E using a Letter of Intent to change a shop drawing.
- C. Make the change on the shop drawing and Specify on the Change Directive.
- D. Make the change on the shop drawing and specify on the Letter of Transmittal.

18. Which position is typically responsible for verification of all materials, field measurements and field construction criteria on the shop drawings?

- A. Architect.
- B. Subcontractor.
- C. Project Engineer.
- D. Project Manager.

19. Which party is the primary developer of the shop drawings?

- A. Owner.
- B. Architect.
- C. Contractor.
- D. Subs and Vendors.

20. Which document explicitly tells the reader the specific shop drawings, product data, and reference standards required on a project?

- A. In Part 1 of each Section of the General Requirements.
- B. In Part 1 of each Section of a Technical Specification Division.
- C. In Part 2 of each Section of a Technical Specification Division.
- D. At the beginning of the first Section of each Technical Specification Division

Site Administration and Contract Documents Exercise

21. During what phase of the project are Shop drawings submitted and approved?

- A. during the bidding phase of the project.
- B. prior to fabrication or erection of the item.
- C. after erection of the item and after the punch list.
- D. after erection of the item and before project completion.

22. What is the name of the document that must be submitted which illustrates the Fabrication and Erection Procedures for some portion of the Work?

- A. Shop Drawings
- B. Specifications
- C. Working Drawings
- D. Product Data Sheets.

23. Which of the following words specifically distinguishes shop drawings from product data sheets?

- A. Schematic drawings.
- B. Schedules or Diagrams.
- C. Isometrics or Assembly plans.
- D. Architect/Engineer Working drawings.

24. Which of the following items that must be submitted show the Fabrication and Erection Process?

- A. Pella Windows, Kitchen Cabinets, Furniture and Pre-hung Doors.
- B. Structural Steel, Rebar, Formwork Design, Glazing and Frames for Store Fronts.
- C. Plumbing Fixtures, Heating Fixtures, Electrical Fixtures and Prepackaged Equip.
- D. Prepackaged Equipment, Brick Block, Roofing Membrane, and Kitchen Cabinets.

25. Which of the following items that must be submitted show the Fabrication and Erection Process?

- A. Sheet Metal Isometrics, Plumbing Isometrics, and Electrical Isometrics.
- B. Acoustical tile, Paint Colors, Plumbing Fixtures and Prepackaged Equipment.
- C. Kitchen Cabinets, Pella Windows, Prehung Doors and Interior Trim.
- D. Plumbing Fixtures, Heating Fixtures, Electrical Fixtures and Prepackaged Equipment, Piping Isometrics, Plumbing Isometrics, and Electrical Isometrics.

Site Administration and Contract Documents Exercise

26. Under what conditions are a Soil Erosion Permit Required?

- A. Whenever general permits are required on a project.
- B. If any excavation is within 500 feet of a body of water.
- C. Only if it is stated in the permit article number of the General Conditions.
- D. Only if it is stated in the permit article number of the General Requirements.

27. What are the names of the parties signing an Extra Work Order?

- A. Owner and Contractor
- B. Surety and the Owner
- C. Architect and the Subcontractor
- D. Architect and the Superintendent

28. Which item (s) is changed in the Contract Agreement using an Extra Work Order?

- A. Time
- B. Scope and Price
- C. All of the above
- D. None of the above

29. A Contract Change Order has been issued, Which parties may the Contractor have to issue changes to because of the contract change order being issued?

- A. Owner and the Architect
- B. Suppliers and the Architect
- C. Subcontractor and the Suppliers
- D. Subcontractor and the Architect

30. According to CSI and AIA, Which Document contains the definitions for Shop Drawings, Product Data and Samples?

- A. Instructions to Bidders
- B. General Conditions
- C. General Requirements
- D. Supplementary Conditions

Site Administration and Contract Documents Exercise

31. According to CSI and AIA, Which Document states the procedures for submitting Shop Drawings?

- A. Instructions to Bidders
- B. General Conditions
- C. General Requirements
- D. Supplementary Conditions

32. According to CSI and AIA, Which Document states the number of copies of the Shop Drawings and Product Data Sheets that must be submitted?

- A. Instructions to Bidders
- B. General Conditions
- C. General Requirements
- D. Supplementary Conditions

33. According to CSI and AIA, Which Document states the time frame for Submitting the Shop Drawings?

- A. Instructions to Bidders
- B. General Conditions
- C. General Requirements
- D. Supplementary Conditions.

34. According to CSI and AIA, Which document specifies the number of copies of Owner installation and operating manuals that must be submitted at a project closeout?

- A. Instructions to Bidders
- B. General Conditions
- C. General Requirements
- D. Supplementary Conditions

35. You are To price a New Contract Change Order Proposal, for a Road and Bridge Project, Which of the following items must be Consulted to properly price the proposal?

- A. General Conditions and General Requirements.
- B. Detailed Estimate and the Condensed Estimate Summary.
- C. Supplementary Conditions and Prevailing Wage Rate Table.
- D. Project Overhead Summary sheet and the Original Estimate.

Site Administration and Contract Documents Exercise

36. Which of the following parties issues the Certificate of Occupancy?

- A. Contractor, Architect and the Owner.
- B. Banker, Surety, and the Title company.
- C. Contractor, Mechanical Subcontractors, and the Electrical Subcontractor.
- D. Fire Marshall, Mechanical Inspector, Electrical Inspector and Building Inspector.

37. Which document do you extract the ORIGINAL PRICES from for calculating a NET CHANGE?

- A. Estimate
- B. Detail Cost Ledger
- C. Contract Change Order Proposal
- D. Project Overhead Summary Sheet

Given the following information, DETERMINE THE NET CHANGE AMOUNT that would be shown on the Change Order PROPOSAL for a change to an existing item on the project.

Original Costs		
	Material	$1000
	Labor	$2200
	Subcontract	$ 600
	SUB	$3800
New Costs		
	Material	$2000
	Labor	$1200
	Subcontract	0
	Subtotal	$3200
	Overhead	$ 900
Total		$4100

38. What is the correct Net Change Amount using the information provided above?

- A. $300 Increase
- B. $300 Decrease
- C. $600 Decrease
- D. $600 Increase

Check Answers

Project Documentation

Daily Job Diary

The *Daily Job Diary* is the primary source of information about the construction job site is the construction supervisor. Therefore, it is vitally important that the Supervisor/Foreman be aware of their responsibility to maintain an accurate and complete account of each days activities. The document used to record this information is called Daily Job Diary. The Daily Job Diary is used to record Conversations, Technical Problems/Solutions and Safety Recommendations with Subcontractors, Suppliers or the Architect. The content will describe information concerning arrival dates, material delivery dates, design and contract changes. The supervisor should maintain an accurate record of the material quantities and workhours spent. This information is very important because this is the basis for requesting contract changes in time and money. The Daily Job Diary Content is described in more detail below.

The *Conversations* describe any conversations or conflict concerning coordination with other crews and personal conversations, observations or conflicts within your own crew.

The *technical problems/solutions* describe changes in drawings, elevations or construction erection problems and how they were resolved. The *safety problems and solutions* describe all potential Hazards that you feel exist in the lab and your recommended Plan of Action. Identify, by NAME all individuals that are not wearing the proper safety Equipment such as heavy shoes, hard hat and safety glasses. Also, state the action that you took to resolve the unsafe practice such as asked employees to please put on their safety glasses. The *signature/title & date* of the person completing the report must be signed each day in ink.

An example of a completed Daily Job Diary is shown below.

Daily Job Diary Example

PROJECT JOBSITE, U.S.A. REPORT NO.: 262

JOB NO.: 001 DATE: AUGUST 5

CLIENT: OWNER, INC DAY: M TU W TH F S SU

CONTRACTOR: CONTRACTOR, INC. TEMPERATURE: 50 F A.M. 75 F P.M.

SUPERINTENDENT: JIM BOW

WEATHER:
BRIGHT SUN CLEAR OVER CAST FOG RAIN

SAFETY ENGINEER: JOHN CAP

INSPECTOR: KEN OVERTURE

WIND: STILL MODERATE HIGH

HUMIDITY: DRY MODERATE HUMID

CONVERSATIONS:
9:15 a.m. Mr. Lineman of L.A. Testing phoned and said that Walker hired him for mix designs and Walker told him that he had talked to the civil eng. Dept and was given the OK to use A Laguna Mix Design which contains Plastiment.

I disagreed with him because these specs allow only air entrained.

9:30 a.m. Phoned Mr. Blume to verify the concrete mix design criteria and he said that the Laguna Mix Design is not approved for this project and that the design must be based on Air Entrainment.

TECHNICAL PROBLEMS & SOLUTIONS: A waiver of continuous inspections at batch plant has been signed and approved by Blume and he will accept certificates instead, but we must call for occasional inspections.

SAFETY RECOMMENDATIONS: The state inspector approved the temporary Railing & False work which is required for us to redirect the Tubers to the East Side of the river to avoid injuring anyone from falling objects.

SIGNATURE ______________ TITLE ________________ DATE ________

Rules for Keeping a Job Diary or Daily Log

The general rules required for entering the job diary as court evidence is described below:

1. Use only a BOUND book such as used by surveyors for their note keeping.

2. Pages should be consecutively numbered in ink, and NO numbers should be skipped.

3. No erasures should be made. In case of error, simply cross out the incorrect information and enter the correct data next to it.

4. No pages should be torn out of the book at any time. If a page is to be voided, place a large "X" through the page, and mark "void."

5. Every day should be reported, and every calendar date should be accounted for. If there is no work performed on a given date, the date should be entered on the page followed by the words "no work" or similar wording. It is still desirable to record the weather on "no work" days, as it may have later bearing on WHY no work was performed in a case involving a claim for liquidated damages.

According to the legal system, admissible evidence must meet the following criteria:

1. All entries' must be made on the same day as they actually occurred. If notes are kept on separate scratch paper and later transcribed into the diary and this fact is disclosed during a trial, the credibility of the entire diary comes into question.

2. The documentation must have originated with the event. Therefore, you must record the event as near to the actual event as possible. Recording the time and date of the event may be extremely important.

3. The recording must be based upon direct knowledge of the event. Therefore, the diary cannot be written by someone else.

4. The diary must be maintained as a regular business record. This means that if you only record when you believe you are going to have a dispute the court will not allow the diary to be admissible evidence.

5. The diary must be detailed enough to permit reconstruction of all events.

The content of the diary or log is described below.

1. Telephone calls made or received, and a substantial outline of the nature of such calls, including any statements or commitments made during the call. Identify the parties calling.

2. Record any work or material in place that does not correspond with the drawings or specifications, as well as the action taken. List any other problems or abnormal occurrences that arose during each day, including notations of any particular lack of activity on the part of the contractor. Note corrective actions taken.

3. Record time and the name of the contractor's representative to whom field orders are delivered, and the nature of the contents of the field order.

4. Note unforeseen conditions observed by the inspector that may cause a slowdown by the contractor.

5. Where a contractor is performing extra work because of an unforeseen underground obstruction, make a careful field count of all personnel and equipment at the site and how they are occupied. Log the number and craft of each person idled by such work, as well as any idle equipment that would otherwise be capable of working.

6. Record the content of all substantive conversations held with the contractor at the site, as well as any tradeoffs, deals, or commitments made by either party.

7. Record all field errors made by any party at the site. Identify in detail and indicate probable effect.

8. Show the name of the job at the head of every page.

9. SIGN every diary entry and indicate job title immediately under the last line of entry on each day's report. This will preclude claims that additional wording was added later.

Daily Construction Report
The primary source of information about the construction activities being performed at the job site is the construction supervisor. Therefore, it is vitally important that the superintendent be aware of their responsibility to maintain an accurate and complete account of each days activities. The document used to record this information is called the Daily Construction Report.

The *Daily Construction Report* is a report sent to the contractor's home office describing the progress at the job site each day. This report contains the number of Workers Present, Weather conditions, Construction Activities Completed and In Progress, Quantities Placed, Materials Delivered, Construction Equipment, Visitors and meetings. The function and content are described below.

Report No. should be Numbered Consecutively. The *Workers Present* section records the number of workers present by craft and within each craft by craft classification. Each craft should also indicate whether there are any employees that were Absent, Hired or Terminated during the day. This section should include all of the contractor's employees and Subcontractor employees. The *Weather Conditions* section must record the Morning and Afternoon Conditions for the day. These could be used to verify your claim for a time extension. The *Construction Activities* describe the activities completed that day for your crew. You should reference exact locations. The *Materials Used* section should state the number of materials placed such as number of bricks, bags of mortar, cubic feet of Sand. The *Construction Equipment* used that day such as Masonry Saw, Fork Lifts, Saw Buck, Radial Arm, Power Hand Saw, Chisels, Hammers, Trowels, Mixers, Mixing Box. The *Visitors* section should indicate all visitors that arrived at the site such as the Architect, the Owner, material suppliers or an inspector. The *Meetings* section should describe any meetings that took place such as a tool box meeting, a crew meeting, a planning meeting or a safety meeting. An example of a Daily Construction Report is shown below.

Daily Construction Report Example

PROJECT	Jobsite, U.S.A.	REPORT NO.	262						
JOB NO.:	001	DATE	AUGUST 5						
CLIENT:	Owner, Inc.	DAY	M	T	**W**	T	F	S	S
CONTRACTOR	Contractor, Inc	DEGREES	50 F AM			75 F PM			
SUPERINTENDENT	Jim Bow	WEATHER AM/PM	SUNNY	PARTLY CLOUDY		OVERCAST	FOG/ RAIN		
SAFETY ENGINEER	John Cap	WIND SPEED	_5 MPH AM			20 MPH PM			
INSPECTOR	Ken Overature	HUMIDITY	DRY	MODERATE			HUMID		

	CONTRACTORS WORKERS				SUBCONTRACTORS WORKERS			
CRAFT	CREW LEADER	APPREN	JOURNEY	TOTAL	CREW LEADER	APPREN	JOURNEY	TOTAL
Boilermakers					1		2	3
Carpenters	1	3	4	8				
Electricians					1	2	2	5
Finishers								
Instrument Fitters								
Insulators								
Iron Workers	1	2	7	10				
Laborers	1	1	4	6				
Masons								
Operators					1	1	1	3
Pipe Fitters								
Plumbers					1	1	2	4
Riggers								
Rod Busters	1	1	3	5				
Sheet Metal								
Sprinkler Fitters								
Teamsters								
TOTALS	4	7	18	29	4	4	7	15

Daily Construction Report Example Continuation

CONSTRUCTION ACTIVITIES:
Prefabricated wall forms @ Col. Line D Tied column rebar for Col A & B @ Col. Line B-B; Placed Forms for Col C & D Stripped Wall Forms @ Col line B-B; Placed 100 Ft of 24" RCP Drainage Pipe from Manhole #30 to #31; Subcontractor Excavated and Hauled 400 Cy of Dirt south Lane of the Roadway from Sta 00 to Sta 1 + 01.

MATERIALS USED:
400 SF forms wall; 1.5 tons rebar columns; 100 lf reinforced concrete pipe; 400 PCS - 8" wall ties

MATERIALS RECEIVED:
10 tons rebar; 4000 LF electrical conduit.

CONST. EQUIPMENT AT SITE:
Cat D-7; Cat 955K; Cat D-3; Gradall; Manitowoc 3000B; 2 Front End Loaders H90 & 570A; 2 Clamshell Buckets; 2 Backhoes H2254 & Koring; 2 Sets of Cutting Torches; Generator; 1 Pump.

VISITORS TO THE SITE:
City Inspector; Architect Jim Shane; Inland Steel.

MEETINGS THAT TOOK PLACE:
Steel Fabrication Problems; Tool box Talk Monthly Safety Meeting; Progress Meeting.

Job Site Records

The *Field Records* are the vital link between the home office and the job site. These records are utilized to calculate the percentage complete, develop monthly progress payment requests, identify materials delivered to the site, determine productivity rates, estimate a change order proposal, calculate the payroll, compare actual progress to planned progress, establish a claim, and document problems or potential problems. The field supervisor is required to maintain some daily construction records pertaining to the job site activities. Some examples are a site storage location, delivery gates, site layout plan, a daily job diary, a daily construction report, a daily time card and a field one week look-ahead plan. Some additional records are the material delivery status report, purchase orders, stock bin requisitions, changes - Contract Change Order Proposals and Extra Work orders, construction equipment status report, subcontract agreements, collective bargaining agreements, permits, project schedule, standard references, emergency safety plan, OSHA safety manual, safety poster, Material Safety Data Sheet Location poster, Material Safety Data Sheets, emergency numbers, hiring records, progress inspections, progress payments, shop drawings, product data, samples, submittal log, planning meeting agendas and minutes, safety meeting agendas and minutes, training records and certificates, warranties, owner manuals, operating manuals, as-built drawings and certificate of occupancy.

Field correspondence can be a problem unless we have an effective and efficient method of dealing with the different types of correspondence. Time management suggests that correspondence accumulates for two reasons (1) we fail to make decisions about it immediately, and (2) we don't have a systematic process for handling all of the correspondence. One of the key concepts about correspondence and paperwork is that there are four things that we can do with it. We can dump it, delegate it, do it or delay it. Which option gets us in the most trouble?

Some of the best recommendations for handling paperwork are: First, handle only once. either do it, read it, trash it, or file it. Second, resist reading junk mail or junk e-mail and discard immediately. Third, write an answer on the bottom of the letter and return. Fourth, you may want to just telephone the person or e-mail them. Fifth, schedule a specific time for handling correspondence each day. Sixth, use an electronic reminder file too follow-up on time. Finally, always remember that many people find that at least eighty-percent of their mail and e-mail could be answered immediately when they read it.

One of the most efficient methods to organize the project records is to utilize the Construction Specifications Institutes Master Format. The Master Format facilitates construction communication, promotes standardization in the industry, and facilitates the retrieval of information. It is used for the organization of project manuals, detailed cost estimates, and product data filing. The Master Format with its Divisions and Sections is also an effective filing system for the field records listed above. Some of the best filing methods will be described below. Also, the complete Master Format is provided later.

The *Construction Reports* must be completed Daily. This should be filed under Division 01, Section 040 Coordination. Then file alphabetically within 01040 Coordination under Construction Report. Also, the Construction Reports inside the folder should be filed with the latest date on top. The *Job Diary*. This must be completed twice daily if it is going to become a legal document admissible in court. This should be filed under Division 01, Section 040 Coordination. Then file alphabetically within 01040 Coordination under Job Diary. The Job Diary is numbered consecutively, dated and signed. The *Time Cards* must be completed twice daily and the hours must be allocated by construction activities. This should be filed under Division 01, Section 040 Coordination. Then file alphabetically within 01040 Coordination under Time Cards. Time cards are dated and signed. Also, the Time Cards inside the folder should be filed with the latest date on top. To save writing time, it is advisable to preprint the time cards with the Activity Descriptions and their associated cost codes on the Time cards. This requires less writing and they can be easily reproduced requiring the field person too only have to identify the hours worked for each worker. You should have some blank spaces on the time card to allow for construction activities not listed or work that is identified as Extra work or a Contract Change Order.

The *Equipment Status Report* is an internal report identifying the construction equipment on the job site or the time and date it was returned. This should be filed under Division 01, Section 040 Coordination. Then file alphabetically within 01040 Coordination under Equipment Status Report. Also, the Equipment Status Reports inside the folder should be filed with the latest date on top. The *Material Delivery Status Report*. This is also an internal report identifying the materials delivered to the job site identifying the time, date it was delivered and any visible damage to the shipment. This should be filed under Division 01, Section 040 Coordination. Then file alphabetically within 01040 Coordination under Material Delivery Status Report. Also, the Material Delivery Status Reports inside the folder should be filed with the latest date on top. The *Field Purchase Orders*. This is also an internal report identifying items purchased at or near the job site. These should state the intended use of the items. This should be filed under Division 01, Section 040 Coordination. Then file alphabetically within 01040 Coordination under Field Purchase Orders. Also, the Orders inside the folder should be filed with the latest date on top.

The *Stock Requisition* is also an internal report which identifies the job number and quantity of materials taken out of the warehouse for a specific project. This should be filed under Division 01, Section 040 Coordination. Then file alphabetically within 01040 Coordination under Stock Requisitions. The Stock Requisitions inside the folder should be filed with the latest date on top. The *Look Ahead Plan* is another internal planning form. This is an internal form which identifies the planned daily output, crew size, materials needed, tools and equipment needed, technical information, safety plan, sequence plan, quality requirements, and sketches. This should be filed under Division 01, Section 040 Coordination. Then file alphabetically within 01040 under Look ahead Plans. Finally, the look-Ahead Plans inside the folder should be filed with the latest date on top.

Visitors Log. This for requires each person not assigned to this project to state the date and time of arrival, company name, their name printed, signatures and their departure time. This should be filed under Division 01, Section 040 Coordination. Then file alphabetically within 01040 under Visitors Log. Finally, the latest visitors log should be placed on top by date.

The *Permits, Prevailing Wages, Minority Hiring Procedures and Goals* can be filed under Division 01, Section 060 Regulatory Requirements and then, alphabetically within 01060 such as Minority, Permits - Building, Soil Erosion, Regulations - Prevailing Wages, Streams/Wetlands.

The *Union Collective Bargaining Agreements* can be filed under Division 01, Section 100 Special Project Procedures. Then file alphabetically within 01100 Special Project Procedures by Craft name. An alternative is to file under the Subcontractor Division and/or Section.

The *Project Meetings* consists of Working agendas and Meeting Minutes. This can be filed under Division 01, Section 200 Project Meetings. Then file alphabetically within 01200 Project Meetings by type of meeting such as Planning, Safety, etc. Also, place the latest date on top with the agendas on the left-hand side of the folder and the minutes of the meeting on the right.

The *Submittal Log or Time Table* can be filed under Division 01, Section 300 Submittals.

The *Contractor's Progress Payments* can be filed under Division 01, Section 025 Measurement and Payment.

The *Change Requests, Change Order Proposals, Approved Contract Change Orders* should be filed under Division 00, Section 900 Modifications. Then file alphabetically by Approved Contract Change Orders, Extra Work Orders, Proposals, and Requests and then within the folder place the latest item on top. The *Requests for information* (RFI) can also be filed under Division 00, Section 900 Modifications. Then file alphabetically by RFI and then within the folder place the latest number or date on top. Keep the A/E responses in the left side of the folder.

The *Formal Purchase Orders and Purchase Order Changes* can be filed under the Division and/or Section number that pertain to their portion of the work. Then file alphabetically by types of materials, then within the folder place the approved Purchase Change with the latest on top.

The *Subcontract Agreements and Subcontract Change Orders* can be filed under the Division and/or Section number that pertain to their portion of the work. Then file alphabetically within that Division/Section number. Then file Subcontract Agreement first and then within the folder place the approved Subcontract Change Orders with the latest on top. An alternative method is to have a separate folder for Subcontract Change Orders.

The *Subcontract Extra Work requests* can be filed under the Division and/or Section number that pertain to their portion of the work. Then file alphabetically within that Division/Section number. Also, the Progress Payment quantities inside the folder should be filed with latest on top.
The *Subcontractor Progress Payment Requests* can be filed under the Division and/or Section number that pertains to their portion of the work. Then file alphabetically within that Division/Section number. If you are collecting quantities for each subcontractor, then you might want to maintain a folder of quantities placed by month. Also, the Progress Payment quantities inside the folder should be filed with latest on top.

The *Shop Drawings, Product Data and Samples* can be filed under the Division and/or Section number that pertain to their portion of the work. Then file alphabetically within.

The *Owner Installation and Operating Manuals* can be filed under the Division and/or Section number that pertain to their portion of the work. Then file alphabetically within.

The Record (*As-Built) Drawings* must be maintained at the job site and marked currently to record field changes and selections made during construction. This record set is given to the owner upon completion. There should be only one master set where all changes are made.

The *Warranties* can be filed under the Division and/or Section number that pertains to their portion of the work. Then file alphabetically within that Division/Section number.

The *Certificate of Substantial Completion* can be filed under Division 01, Section 700 Contract Closeout. The *Certificate of Occupancy* can also be filed under Division 01, Section 700 Contract Closeout.

In Conclusion, assume you have received the following items for the Drywall: a Drywall Subcontract agreement, product data sheets, the Drywall Progress payment Requests, Change request, installation instructions, warranty, a record of the drywall quantities installed and the union Bargaining Agreement. The info is filed as follows: Division 09 Finishes and Section 250 Gypsum - Drywall and alphabetically as follows.

> Agreement with Approved Sub Changes, Change Requests, Quantities Installed Drywall, Owner Installation Manuals and Owner Operating Manuals, Progress Payment Request, Product Data, Shop Drawings, and Warranties.

Job Site Records Filed According to the CSI Master Format
The CSI Master Format number system categorizes the Bidding Requirements and Forms, Contract Forms and Conditions of the Contract into Division 0 - Bidding Requirements. Second, the MasterFormat uses a series of numbers associated with the sixteen divisions which address detailed construction specifications associated with products and systems. Division 1 - General Requirements outlines the specific administrative and procedural requirements that apply to all of the Technical Specification sections. Division's 02 through 16 - Technical Specifications contain a written description of the specific requirements relating to a specific product or system. The Construction Specifications Institute (CSI) has developed the following Standard Master Format numbering system consisting of the following Divisions.

CSI MASTER FORMAT DIVISIONS

DIVISION 00 - BIDDING REQUIREMENTS
DIVISION 01 - GENERAL REQUIREMENTS
DIVISION 02 - SITE WORK
DIVISION 0 3 - CONCRETE
DIVISION 04 - MASONRY
DIVISION 05 - METALS
DIVISION 06 - WOOD AND PLASTICS
DIVISION 07 - THERMAL AND MOISTURE PROTECTION
DIVISION 08 - DOORS AND WINDOWS
DIVISION 09 - FINISHES
DIVISION 10 - SPECIALTIES
DIVISION 11 - EQUIPMENT
DIVISION 12 - FURNISHINGS
DIVISION 13 - SPECIAL CONSTRICTION
DIVISION 14 - CONVEYING SYSTEMS
DIVISION 15 - MECHANICAL
DIVISION 16 - ELECTRICAL

MASTER FORMAT- Divisions & Sections

00010 PRE-BID INFORMATION
00100 INSTRUCTIONS TO BIDDERS
00200 INFORMATION AVAILABLE TO BIDDERS
00300 BID FORMS
00400 SUPPLEMENTS TO BID FORMS
00500 AGREEMENT FORMS
00600 BONDS AND CERTIFICATES
00700 GENERAL CONDITIONS
00800 DRAWINGS AND SCHEDULES
00900 ADDENDA AND MODIFICATIONS

DIVISION 0 1 - GENERAL REQUIREMENTS

01010 SUMMARY OF WORK
01020 ALLOWANCES
01025 MEASUREMENT AND PAYMENT
01030 ALTERNATES/ALTERNATIVES
01040 COORDINATION
01050 FIELD ENGINEERING
01060 REGULATORY REQUIREMENTS
01070 ABBREVIATIONS AND SYMBOLS
01080 IDENTIFICATION SYSTEMS
01090 REFERENCE STANDARDS
01100 SPECIAL PROJECT PROCEDURES
01200 PROJECT MEETINGS
01300 SUBMITTALS
01400 QUALITY CONTROL
01500 CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS
01600 MATERIALS AND EQUIPMENT
01700 CONTRACT CLOSEOUT
01800 MAINTENANCE

TECHNICAL SPECIFICATIONS

DIVISION 2 - SITEWORK

02010 SUBSURFACE INVESTIGATION
02050 DEMOLITION
02100 SITE PREPARATION
02140 DEWATERING
02150 SHORING AND UNDERPINNING
02160 EXCAVATION AND SUPPORT SYSTEMS
02170 COFFERDAMS
02200 EARTHWORK
02300 TUNNELING
02350 PILES AND CAISSONS
02450 RAILROAD WORK
02480 MARINE WORK
02500 PAVING AND SURFACING
02600 PIPED UTILITY MATERIALS
02660 WATER DISTRIBUTION
02680 FUEL DISTRIBUTION
02700 SEWERAGE AND DRAINAGE
02760 RESTORATION AND UNDERGROUND PIPELINES
02770 PONDS AND RESERVOIRS
02780 POWER AND COMMUNICATIONS
02800 SITE IMPROVEMENTS
02900 LANDSCAPING

DIVISION 3 - CONCRETE

03100 CONCRETE FORMWORK
03200 CONCRETE REINFORCEMENT
03250 CONCRETE ACCESSORIES
03300 CAST-IN-PLACE CONCRETE
03370 CONCRETE CURING
03400 PRECAST CONCRETE
03500 CEMENTITIOUS DECKS
03600 GROUT
03700 CONCRETE RESTORATION AND CLEANING
03800 MASS CONCRETE

DIVISION 4 - MASONRY
04100 MORTAR
04150 MASONRY ACCESSORIES
04200 UNIT MASONRY
04400 STONE
04500 MASONRY RESTORATION AND CLEANING
04550 REFRACTORIES
04600 CORROSION RESISTANT MASONRY

DIVISION 5 - METALS

05010 METAL MATERIALS
05030 METAL FINISHES
05050 METAL FASTENING
05100 STRUCTURAL METAL FRAMING
05200 METAL JOISTS
05300 METAL DECKING
05400 COLD-FORMED METAL FRAMING
05500 METAL FABRICATIONS
05580 SHEET METAL FABRICATIONS
05700 ORNAMENTAL METAL
05800 EXPANSION CONTROL
05900 HYDRAULIC STRUCTURES

DIVISION 6 - WOOD AND PLASTICS

06050 FASTENERS AND ADHESIVES
06100 ROUGH CARPENTRY
06130 HEAVY TIMBER CONSTRUCTION
06150 WOOD-METAL SYSTEMS
06170 PREFABRICATED STRUCTURAL WOOD
06200 FINISH CARPENTRY
06300 WOOD TREATMENT
06400 ARCHITECTURAL WOODWORK
06500 PREFABRICATED STRUCTURAL PLASTICS
06600 PLASTICS FABRICATIONS

DIVISION 7 - THERMAL AND MOISTURE PROTECTION
07100 WATERPROOFING
07150 DAMPPROOFING
07190 VAPOR AND AIR RETARDERS
07200 INSULATION
07250 FIREPROOFING
07300 SHINGLES AND ROOFING TILES
07400 PREFORMED ROOFING AND CLADDING/ SIDING
07500 MEMBRANE ROOFING
07570 TRAFFIC TOPPING
07600 FLASHING AND SHEET METAL
07700 ROOF SPECIALTIES AND ACCESSORIES
07800 SKYLIGHTS
07900 JOINT SEALERS

DIVISION 8 - DOOR AND WINDOWS
08100 METAL DOORS AND FRAMES
08200 WOOD AND PLASTIC DOORS
08250 DOOR OPENING ASSEMBLIES
08300 SPECIAL DOORS
08400 ENTRANCES AND STOREFRONTS
08500 METAL WINDOWS
08600 WOOD AND PLASTIC WINDOWS
08650 SPECIAL WINDOWS
08700 HARDWARE
08800 GLAZING
08900 GLAZED CURTAIN WALLS

DIVISION 9 - FINISHES
09100 METAL SUPPORT SYSTEMS
09200 LATH AND PLASTER
09230 AGGREGATE COATINGS
09250 GYPSUM BOARD
09300 TILE
09400 TERRAZZO
09500 ACOUSTICAL TREATMENT
09540 SPECIAL SURFACES
09550 WOOD FLOORING
09600 STONE FLOORING
09630 UNIT MASONRY FLOORING
09650 RESILIENT FLOORING
09680 CARPET
09700 SPECIAL FLOORING
09780 FLOOR TREATMENT
09800 SPECIAL COATINGS
09900 PAINTING
09950 WALL COVERING

MASTER FORMAT- CONTINUED

TECHNICAL SPECIFICATIONS

DIVISION 10 - SPECIALTIES

10100 CHALKBOARDS AND TACKBOARDS
10150 COMPARTMENTS AND CUBICLES
10200 LOUVERS AND VENTS
10240 GRILLES AND SCREENS
10250 SERVICE WALL SYSTEMS
10260 WALL AND CORNER GUARDS
10270 ACCESS FLOORING
10280 SPECIALTY MODULES
10290 PEST CONTROL
10300 FIREPLACES AND STOVES
10340 PREFABRICATED EXTERIOR SPECIALTIES
10350 FLAGPOLES
10400 IDENTIFYING DEVICES
10450 PEDESTRIAN CONTROL DEVICES
10500 LOCKERS
10520 FIRE PROTECTION SPECIALTIES
10530 PROTECTIVE COVERS
10550 POSTAL SPECIALTIES
10690 PARTITIONS
10650 OPERABLE PARTITIONS
10670 STORAGE SHELVING
10700 EXTERIOR SUN CONTROL DEVICES
10750 TELEPHONE SPECIALTIES
10800 TOILET AND BATH ACCESSORIES
10880 SCALES
10900 WARDROBE AND CLOSET SPECIALTIES

DIVISION 11 - EQUIPMENT
11010 MAINTENANCE EQUIPMENT
11020 SECURITY AND VAULT EQUIPMENT
11030 TELLER AND SERVICE EQUIPMENT
11040 ECCLESIASTICAL EQUIPMENT
11050 LIBRARY EQUIPMENT
11060 THEATER AND STAGE EQUIPMENT
11070 INSTRUMENTAL EQUIPMENT
11080 REGISTRATION EQUIPMENT
11090 CHECKROOM EQUIPMENT
11100 MERCANTILE EQUIPMENT
11110 COMMERCIAL LAUNDRY AND DRY CLEANING EQUIPMENT
11120 VENDING EQUIPMENT
11130 AUDIO-VISUAL EQUIPMENT
11140 SERVICE STATION EQUIPMENT
11150 PARKING CONTROL EQUIPMENT
11160 LOADING DOCK EQUIPMENT
11170 SOLID WASTE HANDLING EQUIPMENT
11190 DETENTION EQUIPMENT
11200 WATER SUPPLY AND TREATMENT EQUIPMENT
11280 HYDRAULIC GATES AND VALVES
11300 FLUID WASTE TREATMENT AND DISPOSAL EQUIPMENT
11400 FOOD SERVICE EQUIPMENT
11450 RESIDENTIAL EQUIPMENT
11460 UNIT KITCHENS
11470 DARKROOM EQUIPMENT
11480 ATHLETIC, RECREATIONAL AND THERAPEUTIC EQUIPMENT
11500 INDUSTRIAL AND PROCESS EQUIPMENT
11600 LABORATORY EQUIPMENT
11650 PLANETARIUM EQUIPMENT
11660 OBSERVATORY EQUIPMENT
11700 MEDICAL EQUIPMENT
11780 MORTUARY EQUIPMENT
11850 NAVIGATION EQUIPMENT

DIVISION 12 - FURNISHINGS

12050 FABRICS
12100 ARTWORK
12300 MANUFACTURED CASEWORK
12500 WINDOW TREATMENT
12600 FURNITURE AND ACCESSORIES
12670 RUGS AND MATS
12700 MULTIPLE SEATING
12800 INTERIOR PLANTS AND PLANTERS

DIVISION 13 - SPECIAL CONSTRUCTION

13010 AIR SUPPORTED STRUCTURES
13020 INTEGRATED ASSEMBLIES
13030 SPECIAL PURPOSE ROOMS
13080 SOUND, VIBRATION, AND SEISMIC CONTROL
13090 RADIATION PROTECTION
13100 NUCLEAR REACTORS
13120 PRE-ENGINEERED STRUCTURES
13150 POOLS
13160 ICE RINKS
13170 KENNELS AND ANIMAL SHELTERS
13180 SITE CONSTRUCTED INCINERATORS
13200 LIQUID AND GAS STORAGE TANKS
13220 FILTER UNDERDRAINS AND MEDIA
13230 DIGESTION TANK COVERS AND APPURTENANCES
13240 OXYGENATION SYSTEMS
13260 SLUDGE CONDITIONING SYSTEMS
13300 UTILITY CONTROL SYSTEMS
13400 INDUSTRIAL AND PROCESS CONTROL SYSTEMS
13500 RECORDING INSTRUMENTATION
13550 TRANSPORTATION CONTROL INSTRUMENTATION
13600 SOLAR ENERGY SYSTEMS
13700 WIND ENERGY SYSTEMS
13800 BUILDING AUTOMATION SYSTEMS
13900 FIRE SUPPRESSION AND SUPERVISORY SYSTEMS

DIVISION 14 - CONVEYING SYSTEMS

14100 DUMBWAITERS
14200 ELEVATORS
14300 MOVING STAIRS AND WALKS
14400 LIFTS
14500 MATERIAL HANDLING SYSTEMS
14600 HOISTS AND CRANES
14700 TURNTABLES
14800 SCAFFOLDING
14900 TRANSPORTATION SYSTEMS

DIVISION 15 - MECHANICAL

15050 BASIC MECHANICAL MATERIALS AND METHODS
15250 MECHANICAL INSULATION
15300 FIRE PROTECTION
15400 PLUMBING
15500 HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)
15550 HEAT GENERATION
15650 REFRIGERATION
15750 HEAT TRANSFER
15850 AIR HANDLING
15880 AIR DISTRIBUTION
15950 CONTROLS
15990 TESTING, ADJUSTING, AND BALANCING

DIVISION 16 - ELECTRICAL

16050 BASIC ELECTRICAL MATERIALS AND METHODS
16200 POWER GENERATION
16300 HIGH VOLTAGE DISTRIBUTION (ABOVE 600-VOLT)
16400 SERVICE AND DISTRIBUTION (600-VOLT AND BELOW)
16500 LIGHTING
16600 SPECIAL SYSTEMS
16700 COMMUNICATIONS
16850 ELECTRIC RESISTANCE HEATING
16900 CONTROLS
16950 TESTING

Project Documentation Exercise

1. What are the GENERAL RULES the courts require for considering the JOB DIARY to be considered Admissible evidence in a court of law?

- A. Place in a three-ring Binder, Completed closest to the event as possible by the home office, Place entries only when problems arise and Signed/Dated each day.
- B. Place in a Bound book, Pages Numbered randomly, Completed closest to the event as possible by the secretary, Erase entries that are wrong and make change.
- C. Place in a Bound book, Pages Numbered consecutively, Completed closest to the event as possible by Person with direct knowledge, and Signed/Dated each day.
- D. Place in a three-ring Binder, Pages Numbered consecutively, Completed closest to the event as possible by Person with direct knowledge Signed/Dated each day.

2. Which of the following statements would be considered admissible evidence?

- A. At 7:30 AM, Ed was drunk. He was coming from the bar.
- B. At 7:30 AM, Ed's breath smelled of alcohol and his clothes of marijuana.
- C. At 8:00 AM, Ed was carrying a bag of crack cocaine and he was swaying.
- D. At 8:00 AM, Ed was staggering and he arrived at the job site drunk again.

3. Which of the following descriptions provides the BEST example of how to report progress on the job site?

- A. Poured Concrete for the Columns
- B. Installed Rebar and Poured Concrete
- C. Poured 75 CY Concrete Placed Rebar, Stripped Forms for Columns D1 -D4.
- D. Poured 75 CY Concrete, Placed Rebar and Stripped Forms for the Building.

4. Which of the following items must be on an equipment time card for it to be admissible evidence in a court of law?

- A. Fuel Consumption and quantity moved.
- B. Estimated durations, weight of the materials and Idle Time.
- C. Total hours worked for each employee by day and their total hours for the week.
- D. Hours distributed by Work activities performed and Idle time and Extra Work.

Project Documentation Exercise

5. Which of the following Categories are contained in the Daily Construction Report?

- A. Weather Conditions, Construction Activities Completed and Conversations.
- B. Weather Conditions, Construction Activities Completed, Technical and Safety Problems/Solutions, Equipment on Site, Meetings at Site, and Visitors at Job Site.
- C. Weather Conditions, Construction Activities Completed, Equipment on Site, Meetings at Job Site, Workers Present, Visitors at Job Site, and Materials Placed.
- D. Weather Conditions, Construction Activities Completed, Technical and Safety Problems/Solutions, Equipment on Site, Meetings at Job Site, Conversations, Workers Present, Visitors at Job Site & Materials Placed.

6. Which of the following Categories are contained in the Daily Job Diary?

- A. Weather Conditions, Construction Activities Completed and Conversations.
- B. Weather Conditions, Meeting Agendas/Minutes and Time on activities.
- C. Weather Conditions, Time on activities and Extra Work Orders.
- D. Weather Conditions, Technical and Safety Problems/Solutions and Conversations.

7. How often should you distribute time to construction activities on the time cards to ensure admissible evidence in court?

- A. Daily.
- B. Hourly.
- C. Weekly.
- D. Twice per day.

8. How should conversations with solutions be recorded to ensure admissible evidence in court?

- A. Daily.
- B. Weekly.
- C. Hour and minutes of the event.
- D. Only when a controversial event occurs.

9. How often should you record the weather conditions to ensure proper evidence?

- A. Daily
- B. Hourly
- C. Weekly
- D. Twice per day

Project Documentation Exercise

10. Which of the following reports would be considered admissible evidence in a court of law?

- A. National Weather Station Report.
- B. Local Radio Station Weather Report.
- C. Contractor's Job Site Weather Report.
- D. Contractor's Home Office Weather Report.

11. Which of the following construction activities can be impacted by the wind?

- A. Drywall installation.
- B. Masonry wall placement.
- C. Quarry tile installation.
- D. Interior plumbing installation.

12. Which of the following construction activities can be impacted by the humidity?

- A. Drywall installation.
- B. Masonry wall placement.
- C. Quarry tile installation.
- D. Interior plumbing installation.

13. Which of the following items must be on a Time Card for it to be admissible evidence in a court of law?

- A. Total hours worked for each employee for each day.
- B. Hours worked for each employee by work activity description or EWO each day.
- C. Hours worked for each employee by cost code and completed at end of each week.
- D. Total hours worked for each employee for the week and completed at end of week

14. Which of the following items is contained in the Job Diary?

- A. Your observations and solutions.
- B. Your opinion about people and events.
- C. Conversations concerning coordination, technical problems and solutions.
- D. A record of workers present, construction activities, and materials placed.

Project Documentation Exercise

15. Which of the following diary entries is considered admissible evidence in a court of law?

- A. Make entries when you foresee a potential problem.
- B. Have your Assistant in the office record your site observations.
- C. Record the time and date of the conversation and make entries every day.
- D. Make entries concerning your opinion as certain problems arise at the site.

16. Which of the following documents has the primary purpose of recording progress at the job site?

- A. Job Diary.
- B. Memorandum.
- C. Construction Report.
- D. Formal Business Letter.

17. Which document specifies the conditions for requesting a weather time extension?

- A. General Conditions
- B. General Requirements
- C. Instructions to Bidders
- D. Supplementary Conditions

Questions 18 and 19 refer to the following information.

You are required to file the safety agenda for April 15 and Safety minutes for April 8 and the Planning Agenda for April 17 and Planning minutes for April 10.

18. What Division and Section number is these agendas and minutes filed under?

- A. 00700
- B. 01010
- C. 01040
- D. 01200

19. Within the Division and Section number how are the Safety Agenda, the Safety minutes, the Planning Agenda and the Planning minutes filed?

- A. In Alphabetical order with a Planning folder and Safety folder.
- B. The Safety agenda and minutes under 01060 and the planning under 01100.
- C. By Topic with the Safety agenda and minutes, then Planning agenda and minutes.
- D. By date with Safety minutes, and Planning minutes, Safety, and Planning agenda.

Project Documentation Exercise

20. Within a folder, How are the agendas and minutes filed?

- A. Latest on the Top, Agenda left side, Minutes Right Side.
- B. Latest on the bottom, Agenda left side, Minutes on Right Side.
- C. Latest on the Bottom, a folder for the Agenda and a folder for the minutes.
- D. Latest on the Top, a Safety & Planning agendas folder and a Minutes folder.

You are required to files these documents. Purchaser Order - Heat Exchanger dated 8/3, Shop Drawing - Heat Exchanger dated 8/5, Warranty - Heat Exchanger dated 8/6, Operating Manual - Heat Exchanger dated 9/2 and a Subcontract Agreement dated 8/1 for installation of the Heat Exchanger. Answer questions.

21. What Division & Section number is these heat exchanger documents filed under?

- A. 00800
- B. 01025
- C. 01300
- D. 15750

22. Using the Heat Exchanger documents provided above and a Division & Section number. State the order you would place these within a Division and Section Number?

- A. One folder with the latest date on top as Operate, Warranty, Shop, P.O., and Sub
- B. Separate folder for each item in this order Operate, P.O., Shop, Sub, & Warranty
- C. Separate folder for each item with latest date on top as Op, Wa, Sh, PO and Sub
- D. One folder with each item placed in alphabetical order as Op, PO, Sh, Sub, & Wa

23. You receive a Purchase Order Change for the Heat Exchanger. How should this be filed?

- A. Under 00900 label folder Purchase Order Changes - Heat Exchanger.
- B. Under 01010 label folder Purchase Order Changes - Heat Exchanger.
- C. Under 01030 label Folder Purchase Order Changes - Heat Exchanger.
- D. Under CSI number for Heat Exchanger in folder labeled P.O. on top of original

Project Documentation Exercise

24. You are required to file these documents. Job Diary, Construction Report, Time cards, Equipment Status Report, Material Delivery Status Report, Visitors Log, and Look Ahead Planning forms. What Division & Section number are all of these documents filed under?

- A. 00900
- B. 01040
- C. 01090
- D. 01900

25. You are required to file the Contractor's Progress Payment requests. What Division & Section number is this document filed under?

- A. 00500
- B. 01020
- C. 01025
- D. 01300

26. You are required to file the submittal log. What Division & Section number is this document filed under?

- A. 00600
- B. 00800
- C. 01040
- D. 01300

27. You are filing the Collective Bargaining Agreements for the Millwrights, Boilermakers, Pipefitters, Carpenters and Operators. How should these documents be filed?

- A. 00500 and each item in one folder and alphabetical order.
- B. 01040 and each item in separate folder and alphabetical order.
- C. 01060 and each item in separate folder and alphabetical order.
- D. 01100 and each item in separate folder and alphabetical order.

28. You are required to file the Prevailing Wage Rate Tables and Minority Contractors Affidavits for the project, How should these documents be filed?

- A. 01060 and one folder in alphabetical order.
- B. 01060 and each item in separate folder and alphabetical order.
- C. 01100 and one folder in alphabetical order.
- D. 01100 and each item in separate folder and alphabetical order.

Check Answers

Project Documentation Instructions for Project Documentation Situations

All of these case incidents utilize this general information concerning the Taggart Building project and the construction company. This is Project Number: 234

Client: Offices International	**Architect:** Pro Design	**Constructor**: Ruse Const.
Contact: Keith Corbeil	Mary Bockstahler	Ernest Meyer
676 Bell Street	775 Riverfront ST.	345 Michigan Avenue
Big Rapids. MI 49307	Cadillac, MI 49601	Mount Pleasant, MI 48858

The superintendent at the job site is Rick Fornsorg. The phone number at the Taggart job site is (517) 555-1213. The job site is located seventy-five miles from the home office.

ORGANIZATION - Four employees report directly to Ruse: Jeff Skala, Comptroller; Ernest Meyer, V.P., Sales/Estimating; Carol Pery, Office manager; and John Fryberger, General Superintendent.

OFFICERS - Bruce Ruse, President; Jeff Skala, Comptroller and Treasurer; Ernest Meyer, Vice President; Carol Percy, Office Manager and Secretary.

BOARD OF DIRECTORS - Bruce Ruse, Chairperson; Jeff Skala; Ernest Meyer; John Fryberger, Harley Wallace, Attorney; and Claude Cook, President of Commercial Bank.

PROPERTY - The company owns an office building located outside Manton, Michigan. Ruse Construction also owns a yard where all company equipment is stored. The yard is located across the street from the office. Finally, the company owns or leases considerable equipment including four office trailers for use by its field employees.

INSTRUCTIONS: The Crew Size Discrepancy Case and the Gimpy Case incidents occurred on the same day at the job site. Complete the requested documentation for each incident.

Project Documentation Instructions for the Crew Size Discrepancy Case

First Case:	Crew Size Discrepancy
Case Participants:	Rick Fornsorg, Job Superintendent
	Jim Agee, Plumbing Subcontractor Foreman
Your Position:	Job Superintendent - Rick Fornsorg

It's Wednesday, August 13 at 7:00 A.M. and you (Rick Fornsorg)have arrived. On the drive into work the current weather was 57 degrees and foggy. The forecast for the afternoon is for 87 degrees, humid and sunny and you are wondering how today's progress will turn out. At 7:30 A.M., the plumbing subcontractor foreman, Jim Agee, arrives on the job site three days after you had requested they start the mechanical rough-in. Furthermore, you noticed that the total crew consists of three plumbers and you scheduled the plumbers work based on a crew of eight and an output per day rate of 280 feet. Therefore, you ask, "Jim, how many plumbers will be on the job?" and he replies, "Just the three of us." Hence, you ask Jim how many days will it take your crew to complete the entire rough-in including an inspection and Jim replies, "three days." You reply, "Thank You," and then you instruct the plumbing crew leader where to start and you indicate the location of the materials.

At 7:30 A.M., these workers arrive at the job site. Roy Stokes, a laborer, Jon Adams, a Carpenter Apprentice, Stan Jackson, a Carpenter, and Mike Wards, the Carpenter Crew Leader, Hal Linsey, Rod Buster Apprentice, Ken Peters, Rod Buster, Paul Boon, Rod Buster Crew Leader, Shari Wes, a rigger, Lisa Wolverton, an Operator, Laura Stein, a rigger, and Janie Alton, the Rigger Crew Leader on the job site today. Dave Vaun, a rodbuster, and Ed Crace, a rigger are absent today. You've placed the interior wall forms on the north side (100 feet) and on the east side (75 feet) each wall is 18 feet high, the rebar is a #5 in the north wall at 9 inches on center horizontal, and 12-inches vertical. The riggers have been lifting the forms and rebar to the crews. You have received concrete tickets for six, 10CY pours, and you are missing three tickets for today's pours for the South and West Foundation Walls. In addition to the 50-ton crane, you have a welder and cutting torches. The Project Manager conducted the monthly planning meeting from 7 - 8 AM. with the Architect in attendance. An OSHA safety inspector unexpectedly stopped because of a routine inspection and the County inspector was there to see the concrete pours and LA Testing company was taking samples for the pours. Finally, at just about quitting time the Owner stopped by. You also, have 3 Bill of Ladings from the trucking company for 17 tons of rebar, 3 bundles of electrical conduit, 100 feet per bundle, and 14 Roof Vents.

1. The subcontractors were selected and the subcontract agreements were written by Ernest Meyer. This has been the policy since the company was formed.

2. The estimate called for __840__ total feet to be installed.

Daily Construction Report Exercise for the Crew Size Discrepancy Case

Correspondence Instructions: Given the Crew Size Discrepancy Case information provided, complete the Daily Construction Report provided below.

PROJECT		REPORT NO.	
JOB NO.:		DATE	
CLIENT:		DAY	M T W Th F S
CONTRACTOR		DEGREES	______ AM _____ PM
SUPERINTENDENT		WEATHER AM/PM	SUNNY CLOUDY OVERCAST RAIN/FOG
SAFETY ENGINEER		WIND SPEED AM/PM	STILL MODERATE HIGH
INSPECTOR		HUMIDITY AM/PM	DRY MODERATE HUMID

	CONTRACTORS WORKERS				SUBCONTRACTORS WORKERS			
CRAFT	CREW LEADER	APPREN	JOURNEY	TOTAL	CREW LEADER	APPREN	JOURNEY	TOTAL
Boilermakers								
Carpenters								
Electricians								
Finishers								
Instrument Fitters								
Insulators								
Iron Workers								
Laborers								
Masons								
Operators								
Pipe Fitters								
Plumbers								
Riggers								
Rod Busters								
Sheet Metal								
Sprinkler Fitters								
TOTALS								

Daily Construction Report Exercise for the Crew Size Discrepancy Case

CONSTRUCTION ACTIVITIES: ____

____

____

____

____

____

MATERIALS USED: ____

____

____

MATERIALS RECEIVED: ____

____

____

CONSTRUCTION EQUIPMENT AT THE SITE: ___________________________________

____

____

VISITORS TO THE SITE: ____

____

MEETINGS THAT TOOK PLACE: ____

____

Project Documentation Instructions for the Gimpy Case

Second Case:	Gimpy
Participants:	Roy Stokes, Laborer (Gimpy) Stan Jackson, Carpenter Mike Wards, Carpenter Foreman
Your Position:	Job Superintendent - Rick Fornsorg

Incident:
It’s Wednesday at 10:45 A.M. and everything had been going great until you heard the clatter of shattering glass. You ran to the door to see what had happened. Roy saw you just as you spotted him, and he slowly dropped his raised arm. But he knew you had seen him, and he know too that you hadn't missed noticing that the front window on the truck was smashed. You didn't even have to tell him to come to the trailer, but as he entered the door his first words were, "It's all Stan Jackson's fault." So you went back to the door and called Stan to come into the trailer.

Almost as soon as Jackson joined you and Roy Stokes, Roy launched into his tale of woe. "I just can't take it anymore, Rick. Sure, I threw the rock at Jackson, but a man can just take so much. Everybody's got a breaking point. He won’t leave me alone. Gimpy this, Gimpy that. Gotcha, Gimpy. Hey, Gimpy the eighth dwarf, where's Snow White? I mean, he just doesn't let up."

Before you could get a work out, Stan piped up with his side, "Hey, can't a guy kid a pal? He takes everything so seriously. He can't even take a joke. He's getting dangerous! Hell, if I got mad at everybody that kidded me, I'd . . . "

Additional Information:

1. Roy Stokes hurt his leg in an auto accident about two years ago and ever since has had a noticeable limp.

2. The above incident represents the first time company equipment has been broken as a result of a fight.

3. Neither Stokes nor Jackson has been involved in any fights on the job before.

4. The company has a written policy which says that employees who engage in fighting are subject to dismissal.

Daily Job Diary Exercise for the Gimpy Case

Correspondence: Given the Gimpy Case information provided, complete the Job Diary provided below. Briefly describe this incident in the daily log and indicate the decision(s) and the action that you have taken.

CASE NAME Gimpy

DAILY JOB DIARY

PROJECT NAME: __________________						
DATE:________________________						
M	T	W	Th	F	S	Su

PROJECT NUMBER:_______________
PAGE NUMBER _______________

WEATHER:	BRIGHT SUN	CLEAR	OVERCAST	FOG	RAIN	P.CLOUDY

TEMPERATURE:	AM	PM	COMMENTS

WIND:	STILL	MODERATE	HIGH

HUMIDITY:	DRY	MODERATE	HUMID

TIME: Describe the Conversation & State the Time and Your Solution

SIGNATURE ________________________________ Date ______________________

Title: ____

EXERCISE SOLUTIONS

Communication Skills Exercise **Solutions**

1. D
2. B
3. D
4. B
5. B
6. D
7. B
8. A
9. C
10. C
11. A
12. A
13. D
14. B
15. C

Communication Skills Exercise **Solution for the Memo**

Correspondence
Instructions: Given the Gimpy Case information provided, if anyone else must be informed about this incident, write a brief memo outlining the incident and what action you have taken.

CASE NAME ______Gimpy__

MEMO

TO:________John Fryberger___________ PROJECT NAME ____Taggart Building

FROM:_____Rick Fornsorg____________ PROJECT NUMBER _234____________

SUBJECT: __Windshield Damaged_______

DATE: ______August 13,____________

John:

There was a quarrel between Roy Stokes and Stan Jackson which resulted in Roy throwing a rock and the rock broke the front window on the pickup truck. Roy said that the rock throwing resulted from Stan constantly calling him "Gimpy" and "he can't take it anymore." Therefore, I have given Roy a written reprimand attached of the incident which is to be placed into his employment record. I filed an accident report for the broken windshield and possible submittal based upon your recommendation. Also, I gave Stan a written warning and we discussed in private about how you would feel if you were called names that may provide a reminder of other things that were out of your control. Stan agreed that he would stop calling Roy Gimpy and I indicated that if I hear the word "Gimpy" from him or any of his friends that it would result in another written reprimand and a one day suspension for him.

Communication Skills Exercise **Solution for the Business Letter**
August 13, 20_ _

Rick Fornsorg, Superintendent
Ruse Construction, LLC
345 Michigan Avenue
Mount Pleasant, MI 48858

Mary Bockstahler, Architect
775 Riverfront Street
Cadillac, MI 49601

RE: Taggart Building Project, Project Number 234

Dear Ms. Bockstahler:

There is an elevation change of at least ten feet from the driveway approach to the existing Michigan Department of Transportation (MDOT) business road. My initial review of the plans and specifications does not indicate a retaining wall. In a conversation with Mr. Nelson, at the regional office of MDOT in Rockford, MI on August 13, he indicated that MDOT requires a retaining wall designed to their standard details and approved by them. Also, the rebar would require approved shop drawings submitted to the Rockford office.

From the MDOT Standard Plan Details and the information available at the site, the retaining wall will be at least 12 feet high, 15 inches thick and 100 feet long with reinforcing horizontally and vertically. Ruse Construction is requesting that a change be issued before proceeding with this work. Upon receipt of the change instructions we will submit a proposal for the impact on the time and cost.

This retaining wall will result in the occupancy permit not being issued on August 18 unless we can find an acceptable alternative for the new residents to access the complex. I can be reached at the Taggart job site at (517) 555-1213, my cell (231) 250- 5555 and e-mail at rick@ruse.com. Also, Ernest Meyers our Estimator/Project Manager can be reached in our home office at (517) 485-8535. Please notify Ernest Meyers at the above address in writing within three calendar days of your acceptance of this change request.

Sincerely,
Rick Fornsorg, General Superintendent
cc: Ernest Meyers, V.P. Sales and Estimating
Keith Corbeil, Offices International
John Fryberger, General Superintendent

Engineering Materials Exercise **Solutions**

1. C
2. B
3. D
4. A
5. A
6. C
7. D
8. C
9. A
10. A
11. A
12. B
13. D
14. A
15. C
16. B
17. B
18. D
19. B
20. A
21. B
22. C
23. B
24. C
25. B
26. D
27. D
28. D
29. A
30. B
31. C
32. B
33. C
34. B
35. D
36. D
37. A
38. B
39. B
40. A
41. A
42. A
43. D
44. B
45. C
46. D
47. A
48. D
49. C
50. B
51. D
52. A
53. A
54. A
55. D
56. B
57. D
58. B
59. D
60. B
61. C
62. A
63. D
64. D
65. D
66. C
67. C
68. C
69. D
70. A
71. A
72. B
73. C
74. C
75. B (225-900)
76. C (225 x 12)

Formwork Design Exercise **Solutions**

1.	A	
2.	B	
3.	B	
4.	D	
5.	B	Rate of Pour in CF per hour = 375/8 = 46.875 CY/hr x 27 = 1265.625 CF/hr Plan Area = 151.33' x 1.33' = 201.72 Square Feet 1265.625/201.72 = 6.27 Feet per hour
6.	B	

Categories	Calculation	Minutes
Load	30 seconds/60 Seconds =	0.5000
Travel Up	55 Feet/ 80 Feet per minute	0.6875
Unload	4 minutes	4.0000
Travel Dn	55 Feet/ 100 Feet per minute	0.5500
	Total Round Trip Time for 1 Truck	5.7375

7.	D	60 minutes/7 minutes per round trip = 8.57 cycles/hour x 2.5CY/cycle = 21.43 CY

8.	B	151.33 feet x 16 feet x 1.33 feet = 3220 CF/27CF/CY = 119.27 CY

9.	B	119.27 CY/33 CY per hour = 3.61

10.	B	16 feet/2.25 hours = 7.11 Feet (vertical per hour)

11.	B	151.33 feet x 16 feet x 1.33 feet = 3220.30 CF/635CF/hour = 5.07 hours

Formwork Design Exercise **Solutions**

12.	B	$150 + \frac{9000(6)}{70} = 921$ psi
13.	A	$150 + \frac{43{,}400}{75} + \frac{2800}{75}(10) = 1102$ psi

14.	A	150 x h = 150 x 6 = 900 psi
15	B	150 x h = 150 x 15 feet = 2250 psi
16.	B	ACI Table 7-2, Right of double line is Long Term and parallel to grain column
17.	B	1102 psi x 10inches/12 inches = 918
18.	D	ACI Table 7-5.2, F’v = 225, 2" x 8" studs
19.	D	1000 plf x 36/12 = 3000 plf
20.	D	ACI Table 7-8.1, Right of the Double vertical line and F”v = 225 psi
21.	D	1102 psf x 36/12 x 45/12 = 12,398 pounds
22.	D	150/12 = 12.5 pounds per square soot x 10 inches = 125 psf

23.	C	
24.	A	
25.	B	
26.	A	

Soil Mechanics Exercise **Solutions**

1. C
2. D
3. C
4. C
5. C
6. D
7. B
8. B
9. C
10. A
11. C
12. D
13. B
14. D
15. B
16. D
17. C
18. A
19. B
20. C
21. C
22. D
23. A
24. A
25. C
26. D
27. D
28. A
29. D
30. B
31. C
32. A
33. D
34. D
35. B
36. C
37. A
38. B
39. D
40. A
41. B
42. B $Sw\% = \left(\frac{BCY}{LCY} - 1\right) 100 = \left(\frac{2600}{2100} - 1\right) 100 = 23.8\%$
43. A $Sh\% = \left(1 - \frac{BCY}{CCY}\right) 100 = \left(1 - \frac{3130}{3510}\right) 100 = 10.8\%$
44. B
45. B
46. A
47. A
48. C
49. D
50. B
51. C

Psychrometric Exercise **Solutions**

1. B
2. B
3. D
4. C
5. D
6. B
7. A
8. C
9. B
10. A

Management, Legal Entities & Delivery Methods Exercise **Solutions**

1.	D	21.	D
2.	B	22.	A
3.	B	23.	A
4.	A	24.	C
5.	C	25.	D
6.	D	26.	A
7.	B	27.	D
8.	B	28.	A
9.	C	29.	B
10.	B	30.	D
11.	B	31.	D
12.	A	32.	D
13.	C	33.	B
14.	B	34.	C
15.	D	35.	B
16.	B	36.	B
17.	B		
18.	A		
19.	D		
20.	B		

Financial Analysis Exercise **Solutions**

1.	B	1,415,815 - 682,661 = $733,154
2.	C	$\frac{\$1,415,815}{\$682,661}$ = 2.07
3.	C	$\frac{\$1,415,815 - \$640,020 - 91433}{\text{Current Liabilities}}$ = $\frac{\$684,362}{\$682,661}$ = 1.00
4.	B	$\frac{\$1,515,995}{\$2,979,398}$ = .51
5.	D	Construction average is 33%. See Summary of Financial ratio table
6.	C	$\frac{\$1,515,995}{\$1,463,403}$ = 1.03
7.	D	$\frac{\$359,374}{\$88,333}$ = 4.07
8.	B	Construction average is 8.00 Times. See the Summary of Financial ratio table
9	C	The assumption is 5 times. The Construction average is 8.00 Times
10.	A	$\frac{\$176,177}{\$4,406,806}$ = 4.00%

Depreciation Methods Exercise **Solutions**

Given the following information:

Purchase Price = $100.000
Salvage Value = $ 10,000
Service Life = 3 Years.

$\boxed{\text{1. C}}$ using the Double Declining Method

Year	Remaining Book Value	Yearly Depreciation	Book Value Beginning
0	$ 0	$ 0	$100,000
1	$100,000	2($100,000)/3 = $66,667	$33,333
2	$33,000	2($33,333)/3 = $22,222	$10,778
3		$778	$10,000

$\boxed{\text{2. C}}$ Sum-of-the-Year-Digits.. Sum = 3 + 2 + 1 = 6. $100,000 - $10,000 = $90,000

Year	Remaining Book Value	Yearly Depreciation	Book Value Beginning
0	$ 0	$ 0	$100,000
1	$100,000	3/6 ($90,000) = $45,000	$55,000
2	$55,000	2/6 ($90,000) = $30,000	$25,000
3	$25,000	1/6 ($90,000) = $15,000	$10,000

$\boxed{\text{3. D}}$

$\boxed{\text{4. A}}$ Straight line method. Yearly depreciation = $100,000 - $10,000/3 = $30,000

Year	Remaining Book Value	Yearly Depreciation	Book Value Beginning
0	$ 0	$ 0	$100,000
1	$100,000	$30,000	$70,000
2	$70,000	$30,000	$40,000
3	$40,000	$30,000	$10,000

Ethics Exercise **Solutions**

1. B
2. C
3. A
4. D
5. B
6. D
7. B

CSI Master Format Exercise **Solutions**

1. B
2. C
3. B
4. D
5. D
6. C
7. D
8. C
9. C
10. B
11. D
12. A
13. A
14. B
15. B
16. C
17. A
18. D
19. A
20. C
21. A
22. C
23. D
24. B
25. D
26. D
27. C
28. D
29. D

Temporary Material and Equipment Exercise **Solutions**

1.	C	U.	D
2.	C	V.	A
3.	B	W.	D
4.	A	X.	D
5.	C	Y.	D
6.	D	Z.	B
7.	C	AA.	C
8.	B	28.	D
9.	B	29.	B
10.	A	30.	D
11.	D	31.	C
12.	D	32.	D
13.	C	33.	D
14.	B		
15.	D		
16.	A		
17.	C		
18.	C		
19.	C		
T.	A		

Concrete Beam Schedule Exercise **Solutions**

1. A
2. B
3. B
4. D
5. A
6. B
7. B
8. D
9. B
10. B
11. B
12. B
13. C
14. B

Door and Window Schedule Exercise **Solutions**

1. C
2. D
3. C
4. D
5. B
6. D
7. B
8. D
9. A
10. B

Finish and Paint Schedule Exercise **Solutions**

1.	A	
2.	C	
3.	D	
4.	C	
5.	C	
6.	B	09900 3.08 B.2.
7.	D	09900 3.08 M.
8.	A	09900 3.08 G.2.
9.	A	09900 3.08 J.3.
10.	A	09900 3.08 K.3.

Plumbing and Mechanical Schedule Exercise **Solutions**

Plumbing Schedule Exercise

1. A
2. B
3. A
4. A
5. C
6. B
7. A
8. B
9. B
10. C
11. A
12. D
13. B

Mechanical Schedule Exercise

1. B
2. B
3. D
4. D
5. B
6. B
7. A
8. A
9. C
10. D

Electrical Schedule Exercise **Solutions**

1. A
2. D
3. D
4. B
5. B
6. A
7. C
8. A
9. B
10. D See the Mechanical Schedule for the Gas Fired Package Rooftop unit (RTU)
11. C
12. B
13. D
14. C as noted on the Power Plan: Upper Level
15. D
16. D
17. C
18. B
19. D
20. D
21. D
22. A
23. C
24. A
25. A

Bid Document Exercise **Solutions**

1. D
2. A
3. B
4. A
5. C
6. A
7. A
8. C
9. C
10. B
11. D
12. A
13. D
14. D
15. B
16. D
17. D
18. A
19. A
20. A

Laws, Regulations, Codes and Specifications Exercise **Solutions**

1.	C
2.	A
3.	A
4.	D
5.	B
6.	C
7.	D
8.	D
9.	D
10.	D
11.	C
12.	B
13.	C
14.	B
15.	C
16.	C
17.	B
18.	A
19.	D
20.	B
21.	A
22.	C

Insurance and Bonds Exercise **Solutions**

1.	A
2.	D
3.	B
4.	B
5.	D
6.	D
7.	B
8.	C
9.	B
10.	B
11.	D
12.	B
13.	C
14.	C
15.	D
16.	C
17.	A
18.	C
19.	A
20.	B
21.	A
22.	C
23.	C
24.	C
25.	A
26.	B
27.	D
28.	C
29.	B

Productivity & Labor Unit Cost Exercise **Solutions**

1. B
2. C
3. C
4. B
5. B
6. A
7. C = 1 x 8 + 4 x 8 + 2 x 8 + .5 x 8
8. B = 60 WHR/545 SFCA = .110
9. B = .110 X 12,000 SFCA = 1,320
10. B = 12,000 SFCA/545 SFCA = 22
11. B = 8 x 27.20 + 32 x 22.80 + 16 x 25.26 + 4 x 18.00
12. B = 1423.36/545 = $2.61
13. C = $2.61 x 12,000 = $31,320
14. C = 545 SFCA/60 Whr = 9.08
15. C = ($18.30/100) x 13,200 =$2,415.60
16. C = 2 x 2400 + .25 x $250 = $4862.50/910 CY

Wood Sheet Piling Material and Unit Cost Exercise **Solutions**

1. B	60 + 100 + 60 + 100 = 320 LF x 13 Feet = 4,160 SFCA
2. C	13"/12" = $\frac{320\text{ LF}}{1.083'}$ = 296 PCS x 13' long = 3848 VLF

3. C		
Component	Calculations	Board Feet
Piling	3848 VLF x $\frac{3" \times 13"}{12}$ (3.25 BF/VLF) =	12,506
Wales	3 lines x 320 Feet = 960 Lineal Feet x $\frac{6" \times 8"}{12}$ (4.0 BF/LF) =	3,840
Braces	3 lines x 12 PCS/line x 60' long =2,160 LF x $\frac{6" \times 6"}{12}$ (3 BF/LF)	6,480
	Subtotal Board Feet	22,826
Waste	12% x 17,318 BF =	2,739
	Total Board Feet	25,565

4. A		
Component	Calculations	Cost
Lumber	11,000 BF x $550/MBF (M= 1000) =	$ 6,050
Salvage	Deduct 60% x $6,050) =	($3,630)
	Total Allocated to this Project	$2,420

5. B	
Nails	12 Lbs/100 SFCA x 3,690 SF = $\frac{442.8\text{ Lbs}}{50\text{ Lbs/Bxs}}$ = 9 Bxs x $35/Bxs

6. C	$\frac{\$17,000}{5,500\text{ VLF}}$ $3.09/VLF

Equipment Production and Unit Cost Exercise **Solutions**

1. C		
Categories	Calculation	Decimal of an Hour
Position	0 Minutes/60 minutes =	.000
Load	10 CY Truck/80 CY Backhoe =	.125
Haul Away	12 Miles Away/35.0 Miles Per hour Loaded	.343
Unload	6 minutes/ 60 minutes	.100
Return	12 Miles Away/ 45.0 MPH empty	..267
	Total Round Trip Time for 1 Truck	.835

2. B	1 HOUR/.266 = 3.759 Trips per hour

3. B	<u>Backhoe Production</u> Haul Unit Production	= <u>80 CY per Hour</u> 10 CY x 1.197 Trips per hr.	= 6.72 Trucks USE 7 Trucks

4. B	7255CY/80CY/hour = 90.68 hour $177/90.68 hour = $1.95/hour mobilization $55.20 + 1.95 mobilization = <u>$57.15 per hour</u> 80 CY per hour = .714

5. B	<u>9 Trucks x $22.77 per hour</u> 80 CY per hour	= <u>$204.93 per hour</u> 80 CY per hour	= $2.56/CY

Equipment Production and Unit Cost Exercise **Solutions**

6.	A

No.	CRAFT		Hourly Rate	Total Hourly Costs
1	Crew Leader		$12.35 per hour	$12.35 per hour
1	Backhoe Operator		$11.85 pe hour	$11.85 pe hour
1	Oiler		$10.15 per hour	$10.15 per hour
			Subtotal	$34.35 per hour
	Payroll Insurance	6.87% x $34.35		$2.36 per hour
	Payroll Taxes	12.55% x $34.35		$4.31 per hour
			Total Hourly Costs	$41.02 per hour

Labor cost per CY ($L/CY) to EXCAVATE: $\dfrac{\text{\$41.02 per hour}}{\text{80 CY per hour}}$ = $0.51/CY

7.	B

No.	CRAFT		Hourly Rate	Total Hourly Costs
6	Truck Drivers		$9.30 per hour	$55.80 per hour
			Subtotal	$55.80 per hour
	Payroll Insurance	6.87% x $55.80		$03.83 per hour
	Payroll Taxes	12.55% x $55.80		$07.00 per hour
			Total Hourly Costs	$66.63 per hour

Labor cost per CY ($L/CY) to HAUL: $\dfrac{\text{\$66.63 per hour}}{\text{80 CY per hour}}$ = $0.83/CY

Equipment Production and Unit Cost Exercise **Solutions**

8. D	$\frac{\text{60 seconds x 60 minutes}}{\text{23 Seconds per Cycle}} = \frac{\text{3600 seconds}}{\text{23 Sec./Cycle}}$ = 156.5 Cycles per Hour
9. D	1.5 CY per Cycle x 156.5 Cycles per Hour = 234.75 CY/Hour
10. D	234.75 CY/Hour x $\frac{\text{45 Minutes}}{\text{60 Minutes}}$ = 176.06 CY/Hour
11. C	$\frac{\text{4 feet wide x 2 miles per hour x 5,280 Feet}}{\text{8 passes x 27 CF per Cubic Yard}} \times \frac{6''}{12''} \times \frac{\text{50 minutes}}{\text{(60 Minutes)}}$ = 81.48 CY/hr
12. B	$\frac{\text{[2 feet Wide x 35 FPM x 45 minutes/hour]}}{\text{[3 passes x 27 Cubic Feet per CY]}} \times \frac{\text{06 inches}}{\text{12 inches}}$ = 19.44 CY/Hour

Excavation Quantities Exercise **Solutions**

1. A					
ITEM	LENGTH	WIDTH	DEPTH	CUBIC FEET	CUBIC YARDS
SITE	60'	75'	.67'	3015CF/27CF/CY	111.67

2. B	Sw % $=\left(\frac{BCY}{LCY} - 1\right)100 = \left(\frac{2600}{2100} - 1\right) 100 = 23.8\%$
3. D	
4. B	204.00 - .58]- [195.25 - .42 - .33] = 8.92 Feet

5. B					
ITEM	LENGTH	WIDTH	DEPTH	CUBIC FEET	CUBIC YARDS
Shape I	45.0'	16.0'	8.92'	6,422.40	237.67
Shape II	22.5'	16.0'	8.92'	3,211.20	118.93
Total Building Excavation				9,633.60	356.60

6. C					
ITEM	LENGTH	WIDTH	DEPTH	CUBIC FEET	CUBIC YARDS
a	45' + 4' + 4' = 53'	4'	8.92'	1891.04	70.04
b	32' + 4' + 4' = 40'	4'	8.92'	1427.20	52.86
c	22.5'	4'	8.92'	802.80	29.73
d	16'	4'	8.92'	570.88	21.14
e	22.5'	4'	8.92'	802.80	29.74
f	16'	4'	8.92'	570.88	21.14
Full Perimeter = 170'		4'	8.92'	6,065.60	
Total CY of Excavation for the Working Space					224.65

Excavation Quantities Exercise **Solutions**

7.	C	Run = 1.5 x 8.92 Feet = 13.38' Rise = 8.92' Slope (Angle of Repose) = ½ (b x h) x Full Perimeter = ½ (8.92' x 13.38') 170' = 375.73 CY Total Slope Volume = 105.15 CY + 375.73 CY = 480.88 CY
8.	C	$Sw\ \% = (\frac{BCY}{LCY} - 1)100 = \frac{(3130)}{(2760)} - 1\ ]100 = 13.4\%$
9.	A	$Sh\ \% = (1 - \frac{BCY}{CCY})100 = (1 - \frac{3130}{3510)})\ 100 = 10.8\%$
10.	B	From the Slope (Angle of Repose Table a Firm Clay Slope (RUN: RISE) = 2/3:1 RISE = 14 Feet RUN = .6666666666 x 14 Feet = 9.33 Feet
11.	B	From the (Angle of Repose Table a Compacted Angular Gravel Slope = 1/2:1 RISE = 14 Feet RUN = .5 x 14 Feet = 7 Feet
12.	D	Slope (Angle of repose) RUN: RISE for a Compacted Sharp Sand Damp = 1.5:1.0 RISE = 14 Feet RUN = 1.5 X 14 = 21 Feet
13.	B	224 Feet x 1/8" per Foot = 28 inches/12 = 2.33 Feet + 5 Feet = 7.33 Feet
14.	C	$\frac{(5.00 \text{ Feet} + 7.33 \text{ Feet})}{2} = \frac{12.33 \text{ Feet}}{2} = 6.17 \text{ Feet}$
15.	B	224' x 3' x 6.17' = 4146.24 CF/27 = 153.56 CY
16.	C	½ (9.25' + 6.17') + ½ (9.25' + 6.17') x 224' = 12,784.24 CF/27 = 473.49 CY
17.	C	
18.	C	Corner 4 Existing Elevation 93.50 - 92.00 Proposed Elevation = C - 1.50 Feet
19.	D	$\frac{(L)^2\ (Hf)^2}{108\ (Hf + Hc)} = \frac{(75)^2\ (2.25 + 3.25)^2}{108\ (2.25 + 3.25 + 1.50 + 2.5)} = \frac{5626 \times 30.25}{108 \times 9.5} = 165.87$

Concrete Quantities Exercise **Solutions**

1. B	207.33' - 191.67 = 15.66'
2. D	

Description		Wall	Extends	Extends	Total Length	Depth	SFCA
Forms Outside	A	45' +	.58' +	.58'	46.16'		
	B	16' +	.58' +	.58'	17.16'		
	C	22.50' +			22.50'		
	D	16' +			16.00'		
	E	22.50' +	.58' +	.58'	23.66'		
	F	32 +	.58' +	.58'	33.16'		
		154	2.32	2.32	158.64	1.16666	185.08
Forms Inside	A	46.16' -	2.33'	2.33'	41.50'		
	B	17.16' -	2.33'	2.33'	12.50'		
	C	22.50' -			22.50'		
	D	16.00' -			16.00'		
	E	23.66' -	2.33'	2.33'	19.00'		
	F	33.16' -	2.33'	2.33'	28.50'		
		158.64	9.32	9.32	140'	1.16666	163.33
Footing Forms Total Square Feet Contact Area							348.41

Concrete Quantities Exercise **Solutions**

3.	C						
Description		Wall	Extends	Extends	Total Length	Wall Height	SFCA
Wall Forms (Out)	A	45.00' +			45.00' +	15.66'	
	B	16.00' +			16.00' +	15.66'	
	C	22.50' +			22.50' +	15.66'	
	D	16.00' +			16.00' +	15.66'	
	E	22.50' +			22.50' +	15.66'	
	F	32.00 +			32.00 +	15.66'	
		154.00'			154.00'	15.66'	2,411.64
Wall Forms (Inside	A	45.00' -	1.17'	1.17'	42.66'	15.66'	
	B	16.00' -	1.17'	1.17'	13.66'	15.66'	
	C	22.50' -			22.50'	15.66'	
	D	16.00' -			16.00'	15.66'	
	E	22.50' -	1.17'	1.17'	20.16'	15.66'	
	F	32.00 -	1.17'	1.17'	29.66'	15.66'	
		154.00' -	4.68'	4.68'	144.64	15.66'	2,265.06
Wall Forms Total Square Feet Contact Area							4,676.70

4.	B			
Description	Length	Width	Square Feet	CSF
Shape I (inside)	32 - 1.17' -1.17' = 29.67	22.5' - 1.17' - 1.17' = 20.16'	598.15	5.9815
Shape II (inside)	16 - 1.17-1.17 = 13.66	22.50'	307.35	3.0735
			905.50	9.0550

5.	A	
		905.50 SF x 0.42 depth/27CF/CY = 380.31 CF/27CF/CY= 14.09 CY

Concrete Quantities Exercise **Solutions**

6.	C

				Length	Width	Depth	Cubic Feet	Cubic Yards
A	45.00' -			45.00'	1.17'	15.66'		
B	16.00' -	1.17'	1.17'	13.66'	1.17'	15.66'		
C	22.50' -			22.50'	1.17'	15.66'		
D	16.00' -			16.00'	1.17'	15.66'		
E	22.50' -			22.50'	1.17'	15.66'		
F	32.00 -	1.17'	1.17'	29.66'	1.17'	15.66'		
	154.00'	2.34'	2.34'	149.32'	1.17'	15.66'	2,735.87CF/27CF/CY	101.33

7.	C

N-S = 32'/1' OC = 32 + 1 Starter = 33 E-W = 45'/1' OC = 45 +1 = 46

	Laps		Size	# Pieces	Length	Lineal Feet	Mats	Total LF
Top N-S Slab Rebar			#7	17	45'	765	2	1,530.00
Top N-S Slab Rebar			#7	16	22.5'	360	2	720.00
Top E-W Slab Rebar			#7	23	32	736	2	1,472.00
Top E-W Slab Rebar			#7	23	16	368	2	736.00
Splices N-S Slab Rebar	2	28	#7/8		2.04'	4.08	2	8.16
Splices N-S Slab Rebar	1	28	#7/8		2.04'	2.04	2	4.08
Splices E-W Slab Rebar	1	28	#7/8		2.04	2.04	2	4.08
Splices E-W Slab Rebar	0	28	#7/8		0	0	2	0
						2,237.16'		4,474.32

Concrete Quantities Exercise **Solutions**

8. D	Out = 15.66'/ .5' =						
	Wall		Size	# Pieces	Length	Total LF	Mat	
Horizontal Wall (Out)	45.0'	A	#10	32	45	1,440.00		
Horizontal Wall (In)	45.0	A	#9	24	45	1,080.00		
Horizontal Wall (Out)	16.0'	B	#10	32	16	512		
Horizontal Wall (In)	16.0	B	#9	24	16	384		
22.5 +1.17' Inside Cor	23.7	C	#10	32	23.67	757.44		
Inside Corner	23.7	C	#9	24	23.67	568.08		
16.0 + 1.17' Inside C	17.2	D	#10	32	17.17	549.44		
Inside Corner	17.2	D	#9	24	17.17	412.08		
Horizontal Wall (Out)	22.5	E	#10	32	22.5	720.00		
Horizontal Wall (In)	22.5	E	#9	24	22.5	540.00		
32rizontal Wall (Out)	32.0	F	#10	32	32	1,024.00		
Horizontal Wall (In)	32.0	F	#9	24	32	768.00		
						8,755.04		

9. C	
# of Stirrups = 17.17'/.5" OC = 34 spaces + 1 starter = 35 pieces	
Length of a stirrup = 2' +.875' + 2' + .875' = 5.75' - (4 x 0.167) = 5.08' per stirrup.	
Total Lineal Feet of stirrups = 35 pieces x 5.08 LF per Stirrup =	177.8
Lineal Feet of #3 Stirrup support bars 4 pieces x 10 feet =	40.0
Total Lineal Feet of Stirrups	217.8

10. C	45' + 45' + (55 x 15.66) = 951.30 x(2 x 8/12) = 1,269.13
11. A	
12. B	
13. A	
14. B	

Concrete Quantities Exercise **Solutions**

15.	C	42"/7" = 6 risers and 5 treads x 10" = 50"

16.	D	$C = \sqrt{(4.17)^2 + (3.5)^2} = 5.44'$

17.	C	5 stringers x 4' wide =	20' x (2" x 12"/12) = 40 Board Feet
		6 risers x 4' wide	24' x (2" x 8"/12) = 32 Board Feet
		Total Board Feet	72 Board Feet

18.	A	Back 5.44' x

Description	No.	b	H	Length	Width	Depth	Cubic Feet	Cubic Yards
Concrete Slant	1			5.44'	4.00'	0.50'	10.88	
Concrete Steps	0.5	0.58'	0.83'	6 Step	4.00		5.78	
Concrete Landing	1			4.00'	4.00'	0.50'	8.00	
Total Concrete for the Stairs							24.66CF/27	0.91

Framing Quantity Takeoff Exercise **Solutions**

A.	C	15' + 2.5' = 17.50' x 1.08 = 18.90'
2.	D	Main = 73'/1.333333' = 55 + 1 = 56 x 2 sides = 112 Extension = 20'/1.333333 = 15 + 1 = 16 x 2 sides = 32 Total = 144
3.	D	15' + 2.5' = 17.50' x 1.48 = 25.90'
4.	C	12.50' x 1.48 = 18.50'
5.	B	4 hips
6.	D	parallellogram
7.	D	main = 73 + 2.5 + 2.5 = 78 , 30 +2.5 + 2.5 = 35 78 x 35 = 2,730 SF x 1.48 = 4041 Ext = 20 (20 + 2.5 + 2.5) = 20 x 25 = 500 SF x 1.48 = 740 Total = 4781 4,781 SF/32 SF per sheet = 150 Sheets
8.	D	$c = \sqrt{8^2 + 12^2} = \sqrt{64 + 144} = \sqrt{208} = \frac{14.42''}{12}$ / Foot $c = \sqrt{14.42^2 + 12^2} = \sqrt{351.93} \quad \frac{18.76''}{12}$ / Foot = 1.563

Cost Reports Exercise **Solutions**

1. B
2. B
3. B
4. A
5. C
6. A
7. B
8. D
9. C
10. C
11. C
12. C
13. D
14. A
15. C
16. D
17. B
18. C
19. C
20. C
21. A
22. A
23. B
24. C

Earned Workhour Report Exercise **Solutions**

EARNED WORKHOUR REPORT

PROJECT NAME
PROJECT NUMBER _________

DESCRIPTION	QUANTITIES			UNIT	EXPENDED WORKHOURS		WORKHOURS		UNIT WORKHOURS			PROJECTED	
	BUDGET	WEEK	TO DATE		WEEK	TO DATE	EARNED	BUDGETED	BUDGET	WEEK	TO DATE	Completion	(gain/l(Losss)
Wall Forms	2499	87	112	SF	17	27	19.15	428	.171	.195	.241	602	(174)
Concrete Footings	256	25	40	CY	40	85	56.4	360	1.41	1.60	2.125	544	(184)
Concrete Walls	453	30	34	CY	40	44	47.6	634	1.40	1.33	1.29	586	+48
Footing Forms	2417	210	410	SFCA	42	102	84.5	499	.206	.200	.249	601	(102)
Wall Forms	25560	1880	3090	SFCA	364	664	670.53	5544	.217	.194	.215	5493	+51

Labor Cost Reports Exercise **Solutions**

PROJECT NAME
PROJECT NUMBER ________

LABOR COST REPORT

CODE	DESCRIPTION	QUANTITIES			UNIT	EXPENDED COST		TOT $	UNIT COST			PROJECTED	
		BUDGET	WEEK	TO DATE		WEEK	TO DATE	BUDGET $	BUDGET	WEEK	TO DATE	COMPLETION	GAIN/LOSS
	Wall Forms	2499	87	112	SF	$223	$355	$8022	$3.21/SF	$2.56/SF	$3.17/SF	$7921.83	$100.17
	Concrete Footings	256	25	40	CY	$364.60	$804.97	$5490	$21.45/CY	$14.58/CY	$20.12/CY	$5150.72	#339.28
	Concrete Walls	453	30	34	CY	$394.08	$430.54	$9669	$21.34/CY	$13.14/CY	$12.66/CY	$5734.98	$3934.02
	Footing Forms	2417	210	410	SFCA	$449.05	$1038.25	$8154	$3.37/	$2.14/	$2.53/	$6115.01	$2038.99
	Wall Forms	25560	1880	3090	SFCA	$3811.70	$6854.99	$90,370	$3.54.SF	$2.03/SF	2.22/SF	$56,743.02	$33626.98,

Project Cost Summary Reports Exercise **Solutions**

FORECAST the Current Projection column as follows:

QUANTITY - Project the REVISED ESTIMATE column
WORKHOURS - Project using the Straight Line Method
LABOR COST - Project using the Straight Line Method
MATERIAL COST - Project the REVISED ESTIMATE column
EQUIPMENT COST - Project the TOTAL EXPENDED column
SUBCONTRACT COST - Project the TOTAL EXPENDED column

ITEM	ORIGINAL ESTIMATE	SCOPE CHANGES	REVISED ESTIMATE	EXPENDED		COMMITT	TOTAL EXPENDED	CURRENT PROJECTION	PROJECTED GAIN/LOSS
				ERIOD	TO DATE				
Piles									
Quantity	6700 VLF	(720)	5980 VLF		680 VLF	0	680 VLF	5980 VLF	0
Workhours	618 WHR	(67)	551 WHR		78 WHR	0	78 WHR	686 WHR	(135) WHR
Labor	16817	(1900)	14917		1360	0	1360	$11960.00	$2957
Material	45225	(4675)	40550		10000	23470	33470	$40550.00	0
Equipment	16040	(1400)	14640		7600	9360	16960	$16960	($2320)
Subcontracts	0	0	0		7000	0	7000	$7000.00	($7000)
	78082	(7975)	70107		25960	32830	58790	$76470.00	($6363)

Planning & Scheduling Exercise **Solutions**

1.	C	21.	A	
2.	C	22.	D	
3.	A	23.	C	
4.	B	24.	D	
5.	B	25.	C	
6.	A	26.	C	
7.	B	27.	B	
8.	B	28.	B	
9.	A	29.	D	
10.	A	30.	C	10 - 8 or 2 - 0 = 2
11.	D	31.	A	ES next - EF that = 10 - 10 = 0
12.	D	32.	B	15
13.	C	33.	C	
14.	B	34.	C	
15.	C	35.	B	
16.	D	36.	C	
17.	B	37.	A	
18.	C	38.	C	17 - 0 or 20 - 3 = 17
19.	D	39.	B	28 - 12 = 16
20.	C	40.	C	Crash D (-2), J , K = 37-2 = 35

John Adams Logic Network Exercise **Solutions**
EXHIBIT #1776

ACTIVITY	NODE	DAYS	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT	FREE FLOAT
Start	5	0						
A	10-15	4	0	4	0	4	0	0 *
	10-20		0	4	0	4	0	0
B	12-35	8	0	8	2	10	2	10-8 = 2
C	15-30	6	4	10	4	10	0	0 *
	15-35		4	10	4	10	0	0
D	20	3	4	7	5	8	1	0
E	25	2	7	9	8	10	1	10-9 = 1
F	30	4	10	14	10	14	0	0 *
G	35	4	10	14	10	14	0	0 *

George Mason Network Logic Exercise **Solutions**
EXHIBIT #1777

EVENT TIME SCHEDULE TABULATION SHEET FOR THE
GEORGE MASON LOGIC NETWORK EXHIBIT # 1777.

Activity	NODE	DAYS	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT	FREE FLOAT
START	5	0	0	0	0	0	0	0
M	10	4	0	4	0	4	0	0*
N	15	3	0	3	1	4	1	1
O	30	6	4	10	4	10	0	0*
P	35	5	10	15	10	15	0	0*
Q	25	6	4	10	4	10	0	0*
R	20	8	0	8	2	10	2	2
FINISH	40	0	15	15	15	15	0	0

* Critical Activities are M, O, P, Q.

OSHA Recordkeeping and Inspections Exercise **Solutions**

OSHA Record Keeping Exercise

1. D
2. C
3. B
4. A
5. B
6. B
7. C
8. A
9. A
10. A
11. B
12. B
13. A
14. A
15. C
16. C
17. D
18. D
19. C
20. A

OSHA Inspection Exercise

1. A
2. C
3. B
4. A
5. B
6. B
7. D
8. B
9. B
10. C

OSHA Personal Protection Equipment and Fire Extinguishers Exercise **Solutions**

Personal Protection Exercise **Solutions**

1. B
2. B
3. D
4. A
5. D
6. D
7. A

Fire Extinguishers **Solutions**

1. D
2. B
3. C
4. C
5. D
6. C
7. D

OSHA Rigging Equipment Exercise **Solutions**

1.	D	
2.	A	
3.	D	
4.	C	
5.	C	See 1926.251(c)(iv) 10% (6 x 19) = 10% x 114 = 11.4 wires
6.	D	
7.	C	
8.	A	
9.	D	
10.	D	
11.	B	
12.	C	
13.	B	Table H-4 under MS
14.	D	
15.	B	

OSHA Scaffolding Exercise **Solutions**

1.	D	1926.451 (a) (1)
2.	B	
3.	D	1926.451 (b) (7)
4.	D	1926.451 (c)
5.	A	1926.451 (c) (1) (ii)
6.	A	1926.451 (c) (1) (iii)
7.	A	1926.450 (b)
8.	A	1926.451 (b) (5) (i) & (ii)
9.	B	
10.	B	
11.	C	
12.	B	
13.	B	
14.	C	
15.	C	1926.452 (a) (10)
16.	D	1926.452 (b) (10)
17.	D	1926.452 (c) (6)
18.	B	W = 4(600 x 2.5')/ 16' = 6000/16 = 375 Lbs
19.	A	
20.	A	1926.452(w)(6)(ii)
21.	A	2 times 7 feet = 14 feet
22.	C	
23.	B	See Allowable Span Table
24.	B	

OSHA Soil Classification and Shoring Tables Exercise **Solutions**

OSHA Soil Classification Exercise **Solutions**

1. B
2. C
3. A
4. C
5. B
6. C
7. B
8. B
9. A

OSHA Shoring Tables Exercise **Solutions**

1. B
2. D
3. A
4. C
5. A
6. C
7. D

Surveying and Layout Exercise **Solutions**

1.	D	5.45 = 106.78 -101.33
2.	B	74.14' = $a^2 + b^2 = c^2$, √ $(42.5)^2 + (60.75)^2$ = 74' - 1/34"
3.	C	291.09 = cos 20 Degrees (.9397) x 310
4.	C	7.69% = 1/13 x 100

5.	C	8.02 = 818.02 - 810; BM 813.30 + 4.72 = 818.02 HI, FF = 809.00 +1 = 810
6.	D	17.55' = 668.00 El - 655.50 BM = 12.50 +5.05
7.	A	130.70 = 240 x SIN 33 Degrees (.5446)
8.	C	3:4:5

9.	B	a: baseline is 3 x 9 = 27' , b: vertical height is 4 (36'/4) = 9, c: diagonal is 5 x 9 = 45'
10.	D	9.42 = 5.42 + 4.00
11.	B	TAN A = a/b; b= a/TAN A = 12/TAN 70 = 12/2.7475 = 4.36 hypotenuse c = √ $(12.0)^2 + (4.36)^2$ = √163.076 = 12.77 + 12.77 + 20 = 45.54 LF
12.	C	½(12 x 4.36) + ½(12 x 4.36) = 52.32 ; 12 x 20 = 240 + 52.32 = 292.32 SF

13.	B	

14.	D	

15.	A	

16.	B	877.26 + 19.01 (BS) - 6.37 (FS) = 889.90

Vendor and Subcontractor Exercise **Solutions**

1.	A	21.	C
2.	B	22.	B
3.	A	23.	A
4.	4	24.	C
5.	B	25.	B
6.	C	26.	C
7.	A	27.	C
8.	C		
9.	B		
10.	D		
11.	B		
12.	D		
13.	A		
14.	B		
15.	C		
16.	B		
17.	B		
18.	D		
19.	A		
20..	A		

Organization and Job Description Exercise **Solutions**

1.	A	21.	D
2.	A	22.	A
3.	C	23.	A
4.	B	24.	B
5.	C	25.	A
6.	D	26.	A
7.	B	27.	B
8.	B	28.	B
9.	C	29.	C
10.	C	30.	B
11.	B		
12.	D		
13.	C		
14.	A		
15.	D		
16.	B		
17.	B		
18.	A		
19.	D		
20.	D		

Employment Law Exercise **Solutions**

1. C
2. A
3. B
4. A
5. D
6. C
7. A
8. A
9. C
10. B
11. D
12. D
13. D
14. A
15. D
16. D
17. A
18. D
19. C
20. D
21. B
22. D
23. C
24. C
25. A
26. A
27. A

Site Administration and Contract Documents Exercise **Solutions**

1. B
2. C
3. A
4. A
5. C
6. A
7. B
8. D
9. B
10. C
11. C
12. B
13. C
14. D
15. C
16. D
17. D
18. C
19. D
20. B
21. B
22. A
23. C
24. B
25. A
26. B
27. D
28. D
29. C
30. B
31. D
32. C
33. B
34. C
35. C
36. D
37. A
38. C

Project Documentation Exercise **Solutions**

1. C
2. B
3. C
4. D
5. C
6. D
7. d
8. C
9. D
10. C
11. B
12. A
13. B
14. C
15. C
16. C
17. A
18. D
19. A
20. A
21. D
22. B
23. D
24. B
25. C
26. D
27. D
28. B

Project Documentation Exercise **Construction Report Solutions**

PROJECT	Taggart Building	REPORT NO.						
JOB NO.:	234	DATE	August 13					
CLIENT:	Offices International	DAY	M	T	W	Th	**F**	S
CONTRACTOR	Ruse Construction	DEGREES	57 AM		87 PM			
SUPERINTENDENT	Rick Fornsorg	WEATHER AM/PM	SUNNY **PM**	CLOUDY	OVERCAST	RAIN/FOG **AM**		
SAFETY ENGINEER		WIND SPEED AM/PM	**STILL**	**MODERATE**	HIGH			
INSPECTOR		HUMIDITY AM/PM	DRY	MODERATE	**HUMID**			

	CONTRACTORS WORKERS				SUBCONTRACTORS WORKERS			
CRAFT	CREW LEADER	APPREN	JOURNEY	TOTAL	CREW LEADER	APPREN	JOURNEY	TOTAL
Boilermakers								
Carpenters	1	1	1	3				
Electricians								
Finishers								
Instrument Fitters								
Insulators								
Iron Workers								
Laborers			1	1				
Masons								
Operators			1	1				
Pipe Fitters								
Plumbers					1		2	3
Riggers	1		2	3				
Rod Busters	1	1	1	3				
Sheet Metal								
Sprinkler Fitters								
TOTALS	3	2	6	11	1		2	3

Project Documentation Exercise **Construction Report Solution**s

CONSTRUCTION ACTIVITIES:
Placed the interior wall forms on the north side (100 feet) and on the east side (75 feet) each wall is 18 feet high, the rebar is a #5 in the north wall at 9 inches on center horizontal, and 12-inches vertical. The riggers have been lifting the forms and rebar to the crews.

MATERIALS USED:
Placed 100 Feet of the interior wall forms on the north side and 75 lineal feet on the east side for each of the 18 feet high walls. Placed, the #5 rebar on the north wall at 9 inches on center horizontal, and 12-inches vertical. The riggers lifted the forms and rebar to the crews. Placed 90 CY of Concrete for the walls on the South wall and West walls..

MATERIALS RECEIVED:
17 tons of rebar, 3 bundles of electrical conduit, 100 feet per bundle, and 14 Roof Vents.

CONSTRUCTION EQUIPMENT AT THE SITE:
50-ton crane, welding Unit and cutting torches.

VISITORS TO THE SITE:
Project Manager, the Architect, the OSHA safety inspector, the County inspector, LA Testing company and the Owner stopped by.

MEETINGS THAT TOOK PLACE: _7 - 8 AM.the Monthly planning meeting.

Project Documentation Exercise **Daily Job Diary Solutions**

CASE NAME _____Gimpy__

PROJECT NAME: Taggart Building						
DATE: August 13						
M	T	W	Th	F	S	Su

PROJECT NUMBER: 234
PAGE NUMBER 225

WEATHER:	[redacted]	CLEAR	OVERCAST	[redacted]	RAIN	P.CLOUDY
[redacted]			[redacted]			

TEMPERATURE:	[redacted]	COMMENTS

WIND:	[redacted]	MODERATE	HIGH

HUMIDITY:	DRY	MODERATE	[redacted]

TIME:	Describe the Conversation & State the Time and Your Solution
7:30 A	Jim Agee with the Plumbing subcontractor arrived today, 3 days late, with a crew of 3 workers.
	I anticipated a crew of 8 workers. Jim indicated that it would take the present crew 3 days to complete.
10:45 A	Roy threw a rock at Stan and broke the front window of truck #274. I had a conversation with Roy
	first and gave him a written reprimand to be placed into his file for throwing the rock in anger.
	Also, I has a conversation with Stan about calling people names and in this case calling Roy “Gimpy.”
	I also gave Stan a written reprimand for name calling names and teasing them. I tried to appeal to Stan
	How you would feel if you had been in an accident and the result was a permanent limp.

SIGNATURE ___Rick Fornsorg____________________________Date __August 13__________

Title ___Superintendent_____