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

<table>
<thead>
<tr>
<th>Construction Documents</th>
<th>Bidding Documents</th>
<th>Typical Project Manual</th>
<th>Plans Drawings</th>
<th>Addendum</th>
<th>Contract Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bid Invitation</td>
<td>Agreement</td>
<td>General Conditions</td>
<td>Division 01</td>
<td></td>
<td>Contract Change Orders</td>
</tr>
<tr>
<td>Instructions</td>
<td>Performance Bond</td>
<td>General Conditions</td>
<td>General</td>
<td></td>
<td>Change Directives</td>
</tr>
<tr>
<td>Information Available</td>
<td>Payment Bond</td>
<td>Supplementary Conditions</td>
<td>Requirements</td>
<td></td>
<td>Minor Changes</td>
</tr>
<tr>
<td>Bid Forms and</td>
<td></td>
<td></td>
<td>Division 2-16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Certificates</td>
<td></td>
<td></td>
<td>Technical</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Specifications</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Working</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Drawings</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Civil</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Architectural</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Structural</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mechanical</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Electrical</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Level</th>
<th>Section Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory Pages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00001</td>
<td>TITLE PAGE</td>
<td></td>
</tr>
<tr>
<td>00003</td>
<td>TABLE OF CONTENTS</td>
<td></td>
</tr>
<tr>
<td>00010</td>
<td>PRE-BID INFORMATION</td>
<td></td>
</tr>
<tr>
<td>-030</td>
<td>Advertisement for Bids</td>
<td></td>
</tr>
<tr>
<td>-040</td>
<td>Prequalification Forms</td>
<td></td>
</tr>
<tr>
<td>00100</td>
<td>INSTRUCTIONS TO BIDDERS</td>
<td></td>
</tr>
<tr>
<td>-120</td>
<td>Revisions to Instructions to Bidders</td>
<td></td>
</tr>
<tr>
<td>-130</td>
<td>Pre-Bid Conference</td>
<td></td>
</tr>
<tr>
<td>00200</td>
<td>INFORMATION AVAILABLE TO BIDDERS</td>
<td></td>
</tr>
<tr>
<td>-210</td>
<td>Preliminary Schedules</td>
<td></td>
</tr>
<tr>
<td>-220</td>
<td>Geotechnical Data - Geotechnical Report &amp; Soil Boring Data</td>
<td></td>
</tr>
<tr>
<td>-230</td>
<td>Existing Conditions - Existing Site, Existing Buildings &amp; Property Survey</td>
<td></td>
</tr>
<tr>
<td>-240</td>
<td>Project Financial Information</td>
<td></td>
</tr>
<tr>
<td>00300</td>
<td>BID FORMS</td>
<td></td>
</tr>
<tr>
<td>00400</td>
<td>SUPPLEMENTS TO BID FORMS</td>
<td></td>
</tr>
<tr>
<td>-410</td>
<td>Bid Security Forms</td>
<td></td>
</tr>
<tr>
<td>-430</td>
<td>Subcontractor List</td>
<td></td>
</tr>
<tr>
<td>-440</td>
<td>Substitution List</td>
<td></td>
</tr>
<tr>
<td>-460</td>
<td>Alternates/Alternatives</td>
<td></td>
</tr>
<tr>
<td>-480</td>
<td>Noncollusive Affidavit</td>
<td></td>
</tr>
<tr>
<td>00500</td>
<td>AGREEMENT FORMS</td>
<td></td>
</tr>
<tr>
<td>00600</td>
<td>BOND AND CERTIFICATES</td>
<td></td>
</tr>
<tr>
<td>00700</td>
<td>GENERAL CONDITIONS</td>
<td></td>
</tr>
<tr>
<td>00800</td>
<td>SUPPLEMENTARY CONDITIONS</td>
<td></td>
</tr>
<tr>
<td>-810</td>
<td>Modifications to General Conditions</td>
<td></td>
</tr>
<tr>
<td>-820</td>
<td>Additional Articles - Equal Employment Opportunity Goals</td>
<td></td>
</tr>
<tr>
<td>-830</td>
<td>Wage Determination Schedule</td>
<td></td>
</tr>
<tr>
<td>00900</td>
<td>ADDENDA AND MODIFICATIONS</td>
<td></td>
</tr>
<tr>
<td>01000</td>
<td>GENERAL REQUIREMENTS</td>
<td></td>
</tr>
<tr>
<td>02-16</td>
<td>TECHNICAL SPECIFICATIONS</td>
<td></td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>QUESTIONS TO DETERMINE WHETHER INFORMATION IS PART OF THE AGREEMENT</th>
<th>Yes or No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are these documents listed in the Owner/Contractor Agreement?</td>
<td></td>
</tr>
<tr>
<td>Is the index listed in the Owner/Contractor Agreement?</td>
<td></td>
</tr>
<tr>
<td>Is the Information Available listed in the Index?</td>
<td></td>
</tr>
<tr>
<td>Is the report numbering continuous within a Division such as 02120 - 1, etc.?</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>CSI DIV/SEC</th>
<th>MAJOR DIVISION</th>
<th>LUMP SUM AMOUNT ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>GENERAL CONDITIONS</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>EXCAVATION &amp; GRADING</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>CONCRETE</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>MASONRY</td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>STRUCTURAL STEEL</td>
<td></td>
</tr>
<tr>
<td>06</td>
<td>CARPENTRY</td>
<td></td>
</tr>
<tr>
<td>07</td>
<td>ROOFING</td>
<td></td>
</tr>
<tr>
<td>08</td>
<td>DOORS, WINDOWS, STOREFRONTS &amp; GLAZING</td>
<td></td>
</tr>
<tr>
<td>09250</td>
<td>DRYWALL</td>
<td></td>
</tr>
<tr>
<td>09900</td>
<td>PAINTING</td>
<td></td>
</tr>
<tr>
<td>15300</td>
<td>FIRE PROTECTION</td>
<td></td>
</tr>
<tr>
<td>15400</td>
<td>PLUMBING</td>
<td></td>
</tr>
<tr>
<td>15500</td>
<td>HEATING, VENTILATING, AIR CONDITIONING (HVAC)</td>
<td></td>
</tr>
<tr>
<td>15550</td>
<td>BOILER</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>ELECTRICAL</td>
<td></td>
</tr>
<tr>
<td>16700</td>
<td>COMMUNICATIONS</td>
<td></td>
</tr>
</tbody>
</table>

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 price 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.

<table>
<thead>
<tr>
<th>NAME OF PROJECT</th>
<th>NAME OF BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROAD AND FLOOD CONTROL PROJECT</td>
<td>_______________________________</td>
</tr>
<tr>
<td>BIG SIOUX RIVER</td>
<td>_______________________________</td>
</tr>
<tr>
<td>SIOUX CITY, IOWA AND SOUTH DAKOTA</td>
<td>_______________________________</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Estimated Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Clearing and Grubbing</td>
<td>1</td>
<td>L.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Type “A” Excavation</td>
<td>113,900</td>
<td>C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>TYPE “B” Excavation</td>
<td>25,000</td>
<td>C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Compacted Embankment</td>
<td>196,600</td>
<td>C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Riprap</td>
<td>42,300</td>
<td>Tons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Seeding</td>
<td>60</td>
<td>Acres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>24” Dia CMP (12 Gage)</td>
<td>384</td>
<td>L.F.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL
Typical Bidding Process Time Line

<table>
<thead>
<tr>
<th>Event</th>
<th>Duration</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner holds lowest 3 or 4 bidders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advertisement to bidder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submittals provide Bid Bond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtain Contract Bonds and Insurances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If contractor can’t provide theses at the signing of contract the bid bond is kept by Owner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approx 30 days</td>
<td>30 days</td>
<td>14 days</td>
</tr>
<tr>
<td>Commence Work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bid Period Pick up Doc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do Quantity Takeoff</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select Subs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review and Acceptance of Proposals and Selection by Owner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Performance Bond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Labor &amp; Material Bond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Insurance Certificate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bid Opening Date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notice of Award</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sign/Execute Contract</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submit Shop Drawings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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.

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  
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

<table>
<thead>
<tr>
<th>CONDITIONS OF THE CONTRACT</th>
<th>DIVISION ONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are inherent part of the Agreement</td>
<td>An inherent part of the Specifications</td>
</tr>
<tr>
<td>With the Agreement govern the content of the entire contract</td>
<td>Administratively governs the specification sections</td>
</tr>
<tr>
<td>Contain contractual principles applicable to most projects with supplements for a particular project</td>
<td>contain specifics directly applicable to a particular project</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GENERAL CONDITIONS</th>
<th>SUPPLEMENTARY CONDITIONS</th>
<th>SECTIONS OF DIVISION ONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are broad contractual conditions</td>
<td>Modify the contractual conditions</td>
<td>Contain specific administrative and procedural requirements</td>
</tr>
<tr>
<td>Contain the constants</td>
<td>Modify the constants for a specific region or project</td>
<td>Contain variables directly applicable for specific project</td>
</tr>
<tr>
<td>Relatively static content thus allowing the use of published standard documents</td>
<td>Take precedence over general conditions</td>
<td>Must be written separately for each project</td>
</tr>
<tr>
<td></td>
<td>Must be written separately for each project</td>
<td></td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>SECTION</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>02200</td>
<td>Earthwork</td>
</tr>
<tr>
<td>02210</td>
<td>Grading</td>
</tr>
<tr>
<td>02220</td>
<td>Excavating, Backfilling and Compacting</td>
</tr>
<tr>
<td>02300</td>
<td>Tunneling</td>
</tr>
</tbody>
</table>
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
   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.
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 statutes 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 systems 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 statutes, 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 statute. Also, the Davis-Bacon act applies to prevailing wages on federally funded projects. Therefore, this would be considered a federal statute. 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. Thoroughly 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.
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.
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, concrete 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 a 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 $35,000 \times 0.0775 = $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 to 100 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.

<table>
<thead>
<tr>
<th>FIRST</th>
<th>$500,000</th>
<th>$6.00 PER M</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEXT</td>
<td>$2,000,000</td>
<td>$3,000 plus</td>
</tr>
<tr>
<td>NEXT</td>
<td>$2,500,000</td>
<td>$13,000 plus</td>
</tr>
<tr>
<td>NEXT</td>
<td>$2,500,000</td>
<td>$23,250 plus</td>
</tr>
</tbody>
</table>

Assume the contractor’s bid proposal was for $4,900,000. Then the price of the bond premium is:

<table>
<thead>
<tr>
<th>$4,900,000</th>
<th>Proposal over $500,000</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proposal over $2,500,000</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Proposal over $5,000,000</td>
<td>No</td>
</tr>
<tr>
<td>Then</td>
<td>$2,500,000 = $13,000</td>
<td></td>
</tr>
<tr>
<td>Plus $4,900,000 - $2,500,000 =</td>
<td>$2,400,000 x $4.10/$1000 =</td>
<td>$9,840</td>
</tr>
<tr>
<td>Total Bond Premium =</td>
<td>$22,840</td>
<td></td>
</tr>
</tbody>
</table>
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?

   ☐ 2. Soil Erosion.
   ☐ 3. Contractual Liability.

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?
   - 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?

   O A. Yes, they will lose the amount of their Bond Premium.
   O B. Yes, they will lose the amount of their Bid Bond Face Value.
   O C. No, they will lose nothing, they will withdraw without ramifications.
   O 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?

   O A. Bid Bond.
   O B. Performance Bond.
   O C. Labor/Material Bond.
   O D. Insurance Certificates.

22. Which document guarantees to the Owner that all third parties will be paid or else the Bond will be invoked?

   O A. Bid Bond.
   O B. Performance Bond.
   O C. Labor/Material Bond.
   O D. Insurance Certificates.

23. Which document specifies the time frame for submitting the contract bonds & insurance?

   O A. General Conditions.
   O B. General Requirements.
   O C. Instructions to Bidders.
   O D. Supplementary Conditions.

24. Which documents must be submitted to the Owner from the Contractor at the signing of the Owner-Contractor Agreement?

   O A. Bid Bond, Shop Drawings and Product Data Sheets.
   O B. Bid Bond, Proposal Form and the Bid Breakdown Form.
   O C. Performance Bond, Payment Bond and Insurance Certificates.
   O 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
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 makeup 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.

<table>
<thead>
<tr>
<th>CSI DIVISION</th>
<th>03</th>
<th>CONCRETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSI DIVISION &amp; SECTION</td>
<td>03110</td>
<td>Concrete Formwork</td>
</tr>
<tr>
<td>CLASSIFICATION NUMBER</td>
<td>410</td>
<td>Forms in Place, Columns</td>
</tr>
<tr>
<td>LINE ITEM NUMBER</td>
<td>6500</td>
<td>24&quot; x 24&quot; Plyform Col. 1 Use</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Hours per Day</th>
<th>Total Workhours</th>
<th>Hourly Rate</th>
<th>Crew Cost per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Carpenters</td>
<td>x 8</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Building Laborer</td>
<td>x 8</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Total Per Day</td>
<td>x 8</td>
<td>32</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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:

\[
\frac{\text{Crew Workhours Expended}}{\text{Daily Output}} = \frac{32 \text{ Whr/day}}{190 \text{ S.F.C.A./day}} = 0.168 \text{ Workhours/S.F.C.A.}
\]

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:

\[
\frac{\text{Daily Output}}{\text{Crew Workhours Expended}} = \frac{190 \text{ S.F.C.A./day}}{32 \text{ Whr/day}} = 5.94 \text{ S.F.C.A./Workhour}
\]

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:

Productivity Rate in (Workhours per Unit) = .168 Workhours

S.F.C.A.

Plan Quantities = install 1500 Square Feet of Contact Area Column Forms.

.168 Whr x 1500 S.F.C.A. = 252 Workhours

S.F.C.A.

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

\[
\frac{1500 \text{ S.F.C.A.}}{5.94 \text{ S.F.C.A./day}} = 252.52 \text{ Workhours}
\]

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:

\[
\begin{align*}
\text{Plan Quantities} &= 1500 \text{ S.F.C.A.} = 7.89 \text{ days} \\
\text{Daily output} &= 190 \text{ S.F.C.A./day}
\end{align*}
\]

The Total Crew Days calculated above can be verified by taking the Total Workhours and dividing by the Crew Workhours expended per Day.

\[
\frac{\text{Total Workhours}}{\text{Crew Workhours expended per Day}} = 252 \text{ Workhours per/day}
\]

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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.

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Hours per Day</th>
<th>Total Workhours</th>
<th>Hourly Rate</th>
<th>Crew Cost per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Carpenters</td>
<td>x 8</td>
<td>24</td>
<td>$25.20</td>
<td>$604.80</td>
</tr>
<tr>
<td>1</td>
<td>Building Laborer</td>
<td>x 8</td>
<td>8</td>
<td>$19.80</td>
<td>$158.40</td>
</tr>
<tr>
<td>4</td>
<td>Total Per Day</td>
<td>x 8</td>
<td>32</td>
<td></td>
<td>$763.20</td>
</tr>
</tbody>
</table>

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.

\[
\text{Crew Cost per Day} \div \text{Daily Output} = \frac{\$763.20}{190 \text{ S.F.C.A.}} = \$4.02/\text{S.F.C.A.}
\]

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.

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Hours per Day</th>
<th>Total Workhours</th>
<th>Hourly Rate</th>
<th>Crew Cost per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Carpenters</td>
<td>x 8</td>
<td>24</td>
<td>$22.00</td>
<td>$528.00</td>
</tr>
<tr>
<td>1</td>
<td>Building Laborer</td>
<td>x 8</td>
<td>8</td>
<td>$10.00</td>
<td>$ 80.00</td>
</tr>
<tr>
<td>4</td>
<td>Total Per Day</td>
<td>x 8</td>
<td>32</td>
<td></td>
<td>$608.00</td>
</tr>
</tbody>
</table>

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.

\[
\text{Crew Cost per Day} \div \text{Daily Output} = \frac{\$608.00}{190 \text{ S.F.C.A.}} = \$3.20/\text{S.F.C.A.}
\]
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.).

<table>
<thead>
<tr>
<th>CSI DIVISION &amp; SECTION</th>
<th>02250</th>
<th>Shoring &amp; Underpinning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASSIFICATION NUMBER</td>
<td>400</td>
<td>Sheet Piling</td>
</tr>
<tr>
<td>LINE ITEM NUMBER</td>
<td>1300</td>
<td>15' Deep exc., Drive, Extract &amp; Salvage</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Hourly Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crew Leader(s)</td>
<td>$27.20</td>
</tr>
<tr>
<td>4</td>
<td>Pile Drivers</td>
<td>$22.80</td>
</tr>
<tr>
<td>2</td>
<td>Crane Operators</td>
<td>$25.26</td>
</tr>
<tr>
<td>0.5</td>
<td>Oiler(s)</td>
<td>$18.00</td>
</tr>
</tbody>
</table>

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

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.

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Daily Cost per Piece</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Self Propelled, Scraper, 21 CY</td>
<td>$2,400.00</td>
</tr>
<tr>
<td>0.25</td>
<td>Push Dozer</td>
<td>$250.00</td>
</tr>
</tbody>
</table>

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
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 \( \frac{2" \times 4"}{12} \times 12 = 8 \) 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.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>COMPONENT SIZES</th>
<th>PRICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet Piling</td>
<td>3&quot; x 14&quot;</td>
<td>$390/MBF</td>
</tr>
<tr>
<td>Wales</td>
<td>6&quot; x 8&quot;</td>
<td>$390/MBF</td>
</tr>
<tr>
<td>Braces</td>
<td>10&quot; x 10&quot;</td>
<td>$390/MBF</td>
</tr>
<tr>
<td>Salvage</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>Waste Lumber</td>
<td>5%</td>
<td></td>
</tr>
</tbody>
</table>

1. **Determine the Square Feet of Contact Area (S.F.C.A.)**

\[
(10' + 44' + 10' + 44') = 108 \text{ LF x 12' deep} = 1,296 \text{ S.F.C.A.}
\]

2. **Determine the Total Vertical Lineal Feet (VLF) of Sheet Piling.**

\[
\frac{108 \text{ LF}}{14''/12'' = 1.17'} = 93 \text{ PCS x 12' deep} = 1,116 \text{ VLF}
\]

3. **Determine the Total Board Feet (BF)**

<table>
<thead>
<tr>
<th>Piling</th>
<th>(1,116 \text{ VLF x} 3&quot; \times 14&quot;)</th>
<th>( \frac{3&quot; \times 14&quot;}{12} )</th>
<th>3,906</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wales 9'/4' = 2 +1 Starter = 3 lines</td>
<td>( (10' + 44' + 10' + 44') = 108 \text{ LF x 3} = 324 )</td>
<td>( \frac{6&quot; \times 8&quot;}{12} )</td>
<td>1,296</td>
</tr>
<tr>
<td>Braces 44'/10' OC = 5PCS/line</td>
<td>(5 \text{ PCS/Line x 3 Lines x 10' Long} = 150 \text{ LF} )</td>
<td>( \frac{10&quot; \times 10&quot;}{12} )</td>
<td>1,250</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td>6,452</td>
</tr>
<tr>
<td>Waste 5%</td>
<td>(5% \times 6,452 = )</td>
<td></td>
<td>323</td>
</tr>
<tr>
<td><strong>Total Board Feet</strong></td>
<td></td>
<td></td>
<td>6,775</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>COMPONENT SIZES</th>
<th>PRICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cofferdam Lumber</td>
<td></td>
<td>$390/MBF</td>
</tr>
<tr>
<td>Nails</td>
<td>8Lbs/100 S.F.C.A.</td>
<td>$77 per 50 Lbs Box</td>
</tr>
<tr>
<td>Salvage</td>
<td></td>
<td>45%</td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td>$40/MBF</td>
</tr>
<tr>
<td>Sales Tax</td>
<td></td>
<td>4% of all Costs exclude Transportation</td>
</tr>
</tbody>
</table>

3. Calculate the Total Lumber Cost and the Lumber Cost Allocated to this project.

<table>
<thead>
<tr>
<th></th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumber</td>
<td>6,775 BF</td>
<td>$390/1000 BF</td>
</tr>
<tr>
<td>Deduct Salvage</td>
<td>45%</td>
<td>$2,642</td>
</tr>
<tr>
<td></td>
<td></td>
<td>($1,189)</td>
</tr>
<tr>
<td>Total Lumber Allocated to this Project</td>
<td>$1,453</td>
<td></td>
</tr>
</tbody>
</table>

4. Calculate the Pounds of Nails and the Total Cost of the nails.

<table>
<thead>
<tr>
<th></th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nails</td>
<td>8 Lbs/100 S.F.C.A. x 1,296 S.F.C.A. = 104 Lbs</td>
<td>$77/B</td>
</tr>
<tr>
<td></td>
<td>50 Lbs/Box = 3 B x</td>
<td>$231</td>
</tr>
</tbody>
</table>

5. Calculate the Costs for the remaining items.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Tax</td>
<td>4% ($2,642 +$231) =</td>
<td>$115</td>
</tr>
<tr>
<td>Transportation</td>
<td>6,775 BF x $40/1000 BF =</td>
<td>$271</td>
</tr>
</tbody>
</table>

6. Calculate the Total Material Costs allocated to this project

<table>
<thead>
<tr>
<th>Total Material Costs for this Project</th>
<th>$1,453 + $231 + $115 + $271 =</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$2,070</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Material</th>
<th>Size</th>
<th>Prices or Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet Piling (Toe = 3 feet)</td>
<td>3” x 13”</td>
<td>$550.MBF</td>
</tr>
<tr>
<td>Wales - 3 lines around the outside perimeter</td>
<td>6” x 8”</td>
<td>$550.MBF</td>
</tr>
<tr>
<td>Braces - 3 lines, 12 Pcs per line, each 60 feet long</td>
<td>6” x 6”</td>
<td>$550.MBF</td>
</tr>
<tr>
<td>Nails - 12 Lbs/100 Square Feet Contact Area</td>
<td></td>
<td>$35/Box, Box = 50 Lbs</td>
</tr>
<tr>
<td>Salvage Value</td>
<td></td>
<td>60%</td>
</tr>
<tr>
<td>Transportation &amp; Shipping</td>
<td></td>
<td>$3.78/MBF</td>
</tr>
<tr>
<td>Sales Tax on Materials</td>
<td></td>
<td>4%</td>
</tr>
<tr>
<td>Timber Waste Factor</td>
<td></td>
<td>12%</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Material</th>
<th>Size</th>
<th>Prices or Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet Piling (Toe = 3 feet)</td>
<td>3&quot; x 13&quot;</td>
<td>$550.MBF</td>
</tr>
<tr>
<td>Wales - 3 lines</td>
<td>6&quot; x 8&quot;</td>
<td>$550.MBF</td>
</tr>
<tr>
<td>Braces - 3 lines 12 Pcs per line. Each 9 feet long</td>
<td>6&quot; x 6&quot;</td>
<td>$550.MBF</td>
</tr>
<tr>
<td>Nails - 12 Lbs/100 Square Feet Contact Area</td>
<td></td>
<td>$35/Box, Box = 50 Lbs</td>
</tr>
<tr>
<td>Salvage Value</td>
<td></td>
<td>60%</td>
</tr>
<tr>
<td>Transportation &amp; Shipping</td>
<td></td>
<td>$3.78/MBF</td>
</tr>
<tr>
<td>Sales Tax on Materials</td>
<td></td>
<td>4%</td>
</tr>
<tr>
<td>Timber Waste Factor</td>
<td></td>
<td>12%</td>
</tr>
</tbody>
</table>

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
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 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).

<table>
<thead>
<tr>
<th>Categories</th>
<th>Calculation</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position</td>
<td>0 Minutes/60 minutes =</td>
<td>.000</td>
</tr>
<tr>
<td>Load</td>
<td>12 CY Truck/150 CY Backhoe =</td>
<td>.080</td>
</tr>
<tr>
<td>Haul Away</td>
<td>3 Miles Away/12.0 Miles Per hour Loaded</td>
<td>.250</td>
</tr>
<tr>
<td>Unload</td>
<td>3 minutes/ 60 minutes</td>
<td>.050</td>
</tr>
<tr>
<td>Return</td>
<td>3 Miles Away/22.0 MPH empty</td>
<td>.140</td>
</tr>
<tr>
<td></td>
<td>Total Round Trip Time for 1 Truck</td>
<td>.520</td>
</tr>
</tbody>
</table>

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.

\[
\frac{150 \text{ CY/hr}}{12 \text{ cy x 1.92 Trips/hr}} = 6.5 \text{ use 7 trucks}
\]

4. Verify the Production Rate by Back-checking.

\[
7 \text{ trucks x 1.92 Trips/hr x 12CY Truck capacity} = 1.07 \text{hour or 64.26 minutes.}
\]

Backhoe capacity 150 cy/hr
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.

<table>
<thead>
<tr>
<th>No.</th>
<th>EQUIPMENT</th>
<th>Equipment Hourly Rate</th>
<th>Total Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Backhoe</td>
<td>16.88 hr x $48.00 per hour</td>
<td>$810.24</td>
</tr>
<tr>
<td></td>
<td>Backhoe Mobilization</td>
<td>$200/16.88 hr $11.85 per hour</td>
<td>$200.00</td>
</tr>
<tr>
<td></td>
<td>Total Backhoe Costs</td>
<td></td>
<td>$1,010.24</td>
</tr>
<tr>
<td></td>
<td>Trucks</td>
<td>$13.10 per hour</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Hourly Rate</th>
<th>Total Hourly Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crew Leader</td>
<td>$15.25 per hour</td>
<td>$15.25 per hour</td>
</tr>
<tr>
<td>1</td>
<td>Backhoe Operator</td>
<td>$12.45 per hour</td>
<td>$12.45 per hour</td>
</tr>
<tr>
<td></td>
<td>Subtotal</td>
<td>$27.70 per hour</td>
<td>$27.70 per hour</td>
</tr>
<tr>
<td></td>
<td>Payroll Insurance</td>
<td>9.87% x $27.70</td>
<td>$2.74 per hour</td>
</tr>
<tr>
<td></td>
<td>Payroll Taxes</td>
<td>14.55% x $27.70</td>
<td>$4.03 per hour</td>
</tr>
<tr>
<td></td>
<td>Total Hourly Costs</td>
<td></td>
<td>$34.47 per hour</td>
</tr>
</tbody>
</table>

5. Determine the Backhoe Equipment Cost per Cubic Yard

\[
\text{Cost per CY} = \frac{\text{Total Backhoe Costs}}{\text{Total CY}} = \frac{1,010.24}{2,532} = 0.40 \text{ CY per hour}
\]

6. Assume 7 trucks. Determine the Hauling Equipment Cost per Cubic Yard.

<table>
<thead>
<tr>
<th>No.</th>
<th>EQUIPMENT</th>
<th>Equipment Hourly Rate</th>
<th>Total Hourly Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>12 CY Trucks</td>
<td>$13.10/hour</td>
<td>$91.70 /150.00 =0.61/CY</td>
</tr>
</tbody>
</table>

7. Determine the Labor Cost per Cubic Yard To Excavate.

\[
\text{Cost per CY} = \frac{\text{Total Hourly Costs}}{150 \text{ CY/hour}} = \frac{34.47}{150} = 0.23 \text{ CY}
\]

8. The rate includes burden. Determine the Labor Cost per Cubic Yard to Haul.

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Craft Hourly Rate</th>
<th>Total Hourly Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Truck Drivers</td>
<td>$14.85/hour</td>
<td>$103.95 /150.00 =.69/CY</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>No.</th>
<th>EQUIPMENT</th>
<th>Production Information</th>
<th>Equipment Hourly Rate</th>
<th>Craft Hourly Rate (Including Burden)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.5 CY Shovel</td>
<td>36 Seconds</td>
<td>$55.00 per hour</td>
<td>$30.00 per hour</td>
</tr>
<tr>
<td></td>
<td>Efficiency</td>
<td>50 minutes per hour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>12 CY Trucks</td>
<td>2 Trips per hour</td>
<td>$37.50 per hour</td>
<td>$25.65 per hour</td>
</tr>
</tbody>
</table>

1. Determine the Bucket cycles per hour.

\[
\text{60 seconds x 60 minutes} = \frac{3600 \text{ seconds per hour}}{36 \text{ seconds per cycle}} = 100 \text{ cycles/hour}
\]

2. Determine the (Theoretical) Production Rate for the 2-1/2 C.Y. shovel in CY per hour.

\[
\text{Bucket size/cycle x #cycles/hour} = \frac{2.5 \text{ CY x 100 cycles}}{\text{cycle x hour}} = 250 \text{ cy/hour(Theoretical)}
\]

3. Determine the true (Actual) output for the shovel in Cubic Yards per hour.

\[
\frac{50 \text{ minutes}}{60 \text{ minutes}} = 83.3\% \times 250 \text{ cy/hours} = 208 \text{ cy/hour}
\]

4. Determine the number of trucks required to keep the Shovel working efficiently.

\[
\frac{\text{Backhoe Production}}{\text{Haul Unit Production}} = \frac{208 \text{ CY/hr}}{12 \text{ CY x 2.00 Trips/hr}} = 8.66 \text{ use 9 Trucks}
\]

5. Using 1 standby truck, Determine the Hauling Equipment Cost per Cubic Yard.

<table>
<thead>
<tr>
<th>No.</th>
<th>EQUIPMENT</th>
<th>Equipment Hourly Rate</th>
<th>Total Hourly</th>
<th>CY per Hour</th>
<th>Cost per CY</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>12 CY Trucks</td>
<td>$37.50/hour</td>
<td>$375.00</td>
<td>/208.00</td>
<td>= $.180/CY</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>No.</th>
<th>EQUIPMENT</th>
<th>Production Information</th>
<th>Equipment Hourly Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vibrating Roller</td>
<td>10 Ton Roller, 5 feet wide</td>
<td>$12.00</td>
</tr>
<tr>
<td></td>
<td>Operating Costs</td>
<td></td>
<td>$1.50</td>
</tr>
<tr>
<td></td>
<td>Mobilization</td>
<td></td>
<td>$3,500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Hourly Rate</th>
<th>Total Hourly Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Laborers</td>
<td>$12.00 per hour</td>
<td>$24.00 per hour</td>
</tr>
<tr>
<td>1</td>
<td>Roller Operator</td>
<td>$20.65 per hour</td>
<td>$20.65 per hour</td>
</tr>
<tr>
<td></td>
<td>Subtotal</td>
<td></td>
<td>$44.65 per hour</td>
</tr>
<tr>
<td></td>
<td>Payroll Insurance</td>
<td>9.87% x $44.65</td>
<td>$4.41 per hour</td>
</tr>
<tr>
<td></td>
<td>Payroll Taxes</td>
<td>14.55% x $44.65</td>
<td>$6.50 per hour</td>
</tr>
<tr>
<td></td>
<td>Total Hourly Costs</td>
<td></td>
<td>$55.56 per hour</td>
</tr>
</tbody>
</table>

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.

\[
\text{Compact} = \frac{\text{width roller} \times \text{prod speed mph} \times 5,280 \text{ feet per mile}}{\# \text{ passes} \times 27 \text{ CF/CY}} \times \text{lift} \times \text{efficiency} \\
\text{Note: The lift must be in a decimal of a foot} \\
\text{The efficiency must be in a decimal equivalency.}
\]

\[
= \frac{[5' \times 1.5 \text{ mph} \times 5280 \text{ feet per mile}]}{6 \text{ passes} \times 27 \text{ cf/cy}} \times (8'') \times (45 \text{ minutes}) \times (12'') \times (60 \text{ minutes})
\]

\[
= \frac{[39,600]}{162} \times .67 \times .75 = 122.83 \text{ CY per hour}
\]
Steel Drum Roller Compaction Unit Cost Example

2. Determine the Equipment Cost per Cubic Yard ($EQ/CY) for the Steel Drum Roller.

<table>
<thead>
<tr>
<th>No.</th>
<th>EQUIPMENT</th>
<th>Hours</th>
<th>Hourly Rate</th>
<th>Total Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vibrating Roller</td>
<td>12,000 CY = 98 Hr</td>
<td>$12.00 per hour</td>
<td>$1,176.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>122.83 CY/hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Operating Costs</td>
<td>98 Hr</td>
<td>$01.50 per hour</td>
<td>$0,147.00</td>
</tr>
<tr>
<td></td>
<td>Mobilization</td>
<td></td>
<td></td>
<td>$3,500.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total Equipment $</td>
</tr>
</tbody>
</table>

\[
\frac{12,000 \text{ CY}}{122.83 \text{ CY/hr}} = 0.40/\text{CY}
\]

3. Determine the Labor Cost per Cubic Yard ($L/CY) for the Steel Drum Roller.

\[
\frac{122.83 \text{ CY/hour}}{55.56/\text{hr}} = 0.45/\text{CY}
\]
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.

<table>
<thead>
<tr>
<th>No.</th>
<th>EQUIPMENT</th>
<th>Production Information</th>
<th>Equipment Hourly Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vibrating Plate</td>
<td>21” wide and 24” long</td>
<td>$4.13</td>
</tr>
<tr>
<td></td>
<td>Operating Costs</td>
<td></td>
<td>$0.69</td>
</tr>
</tbody>
</table>

Total Equipment $4.82

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Hourly Rate</th>
<th>Total Hourly Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Laborer</td>
<td>$15.50 per hour</td>
<td>$15.50 per hour</td>
</tr>
<tr>
<td></td>
<td>Payroll Insurance</td>
<td>9.87% x $15.50</td>
<td>$1.53 per hour</td>
</tr>
<tr>
<td></td>
<td>Payroll Taxes</td>
<td>14.55% x $15.50</td>
<td>$2.26 per hour</td>
</tr>
</tbody>
</table>

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.

\[
\text{Production Rate} = \frac{21”/12” \text{ plate width} \times 50 \text{ FPM}}{4 \text{ Passes} \times 27 \text{ C.F. per C.Y.}} \times \frac{(8”) \text{ lift}}{50 \text{ Minutes}} \times \frac{(12”)}{\text{27.14 CY/hour}}
\]

\[
= \frac{1.75 \times 50}{108} = \frac{87.5}{108} = .81 \times 0.67 \times 50 = \text{27.14 CY/hour}
\]

2. Determine the Equipment Cost per Cubic Yard ($EQ/CY) for the vibrating plate.

\[
\frac{$4.82/\text{hour}}{27.14 \text{ CY/hour}} = \frac{$0.18}{\text{CY}}
\]

3. Determine the Labor Cost per Cubic Yard ($L/CY) for the vibrating plate.

\[
\frac{$19.29}{27.14 \text{ CY/hour}} = \frac{$0.71}{\text{CY}}
\]
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.

<table>
<thead>
<tr>
<th>No.</th>
<th>EQUIPMENT</th>
<th>Equipment Hourly Rate</th>
<th>Total Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Backhoe</td>
<td>80 CY per hour</td>
<td>$55.20 per hour</td>
</tr>
<tr>
<td></td>
<td>Backhoe Mobilization</td>
<td></td>
<td>$177</td>
</tr>
<tr>
<td></td>
<td>Total Backhoe Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trucks</td>
<td></td>
<td>$22.77 pe hour</td>
</tr>
</tbody>
</table>

Excavation Crew

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Hourly Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crew Leader</td>
<td>$12.35 per hour</td>
</tr>
<tr>
<td>1</td>
<td>Backhoe Operator</td>
<td>$11.85 per hour</td>
</tr>
<tr>
<td>1</td>
<td>Oiler</td>
<td>$10.15 per hour</td>
</tr>
</tbody>
</table>

Subtotal

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Payroll Insurance</td>
<td>6.87%</td>
</tr>
<tr>
<td>Payroll Taxes</td>
<td>12.55%</td>
</tr>
</tbody>
</table>

Total Hourly Costs

Hauling Crew

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Hourly Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Truck Drivers</td>
<td>$ 9.30 per hour</td>
</tr>
</tbody>
</table>

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 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.

<table>
<thead>
<tr>
<th>No.</th>
<th>EQUIPMENT</th>
<th>Production Information</th>
<th>Equipment Hourly Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5 CY Backhoe</td>
<td>23 Seconds</td>
<td>$55.20 per hour</td>
</tr>
<tr>
<td></td>
<td>Efficiency</td>
<td>45 minutes per hour</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 CY Trucks</td>
<td>3 Trips per hour</td>
<td>$10.20 per hour</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>No.</th>
<th>EQUIPMENT</th>
<th>Production Information</th>
<th>Equipment Hourly Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vibrating Roller</td>
<td>9 Ton Roller, 4 feet wide</td>
<td>$22.00</td>
</tr>
<tr>
<td></td>
<td>Operating Costs</td>
<td></td>
<td>$1.00</td>
</tr>
<tr>
<td></td>
<td>Mobilization</td>
<td></td>
<td>$3,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>CRAFT</th>
<th>Hourly Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Roller Operator</td>
<td>$20.20 per hour</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>TYPE OF WORK LOCATIONS</th>
<th>OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOPSOIL</td>
<td>MOBILIZE EQUIPMENT</td>
</tr>
<tr>
<td>SHEET PILING &amp; COFFERDAMS</td>
<td>MACHINE EXCAVATE &amp;</td>
</tr>
<tr>
<td>STRUCTURES-BUILDING EXCAVATION</td>
<td>DEWATER</td>
</tr>
<tr>
<td>PIERS OR CAISSON EXCAVATION</td>
<td>HAUL &amp; TRAFFIC ADJUSTMENTS</td>
</tr>
<tr>
<td>TRENCH EXCAVATION</td>
<td>PURCHASE BACKFILL (MATERIAL $)</td>
</tr>
<tr>
<td>SITE EXCAVATION</td>
<td>BACKFILL</td>
</tr>
<tr>
<td>BORROW PIT EXCAVATION</td>
<td>COMPACT</td>
</tr>
<tr>
<td>ROAD EXCAVATION</td>
<td>SOIL ADJUSTMENT/STABILIZE SOIL</td>
</tr>
<tr>
<td>PILING</td>
<td>DRIVE PILING OR SHORING</td>
</tr>
<tr>
<td></td>
<td>PLACE PIPE AND MANHOLES</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Description</th>
<th>Length</th>
<th>Width</th>
<th>Depth</th>
<th>Cubic Feet</th>
<th>Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topsoil Removal</td>
<td>110'</td>
<td>60'</td>
<td>.5</td>
<td>3300CF/27 =</td>
<td>122.22 CY</td>
</tr>
</tbody>
</table>

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.

\[
214.5' - .5' - [204.00' - .33 - .42] = 214.00 - 203.25' = 10.75' deep
\]

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.
**Level 1 Construction Fundamentals Study Guide**

<table>
<thead>
<tr>
<th>Description</th>
<th>Length</th>
<th>Width</th>
<th>Depth</th>
<th>Cubic Feet</th>
<th>Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape I</td>
<td>30'</td>
<td>45'</td>
<td>10.75'</td>
<td>14,512.5CF/27</td>
<td>537.50</td>
</tr>
<tr>
<td>Shape II</td>
<td>30'</td>
<td>30'</td>
<td>10.75'</td>
<td>9,675CF/27</td>
<td>358.33</td>
</tr>
<tr>
<td>Shape III</td>
<td>30'</td>
<td>15'</td>
<td>10.75'</td>
<td>4,837.5CF/27</td>
<td>179.17</td>
</tr>
</tbody>
</table>

Total Building Excavation in Cubic Yards 1,075.00

*Footage 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 footiing 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'

<table>
<thead>
<tr>
<th>Description</th>
<th>Length</th>
<th>Width</th>
<th>Depth</th>
<th>Cubic Feet</th>
<th>Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footing Trench</td>
<td>270'</td>
<td>4'</td>
<td>5.25'</td>
<td>5,670CF/27</td>
<td>210</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Description</th>
<th>Length</th>
<th>Width</th>
<th>Depth</th>
<th>Cubic Feet</th>
<th>Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>90'</td>
<td>3</td>
<td>3</td>
<td>10.75'</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>15'</td>
<td>3</td>
<td>3</td>
<td>10.75'</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>30'</td>
<td>3</td>
<td>3</td>
<td>10.75'</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>15'</td>
<td>3</td>
<td>3</td>
<td>10.75'</td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>30'</td>
<td>3</td>
<td>3</td>
<td>10.75'</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>15'</td>
<td>3</td>
<td>3</td>
<td>10.75'</td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>30'</td>
<td>3</td>
<td>3</td>
<td>10.75'</td>
<td></td>
</tr>
<tr>
<td>h</td>
<td>45'</td>
<td>3</td>
<td>3</td>
<td>10.75'</td>
<td></td>
</tr>
<tr>
<td>Wall</td>
<td>4 x 3 = W. S.</td>
<td></td>
<td>282'</td>
<td>3'</td>
<td>10.75'</td>
</tr>
</tbody>
</table>

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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.

\[ \text{Angle of Repose Building Exc} = \frac{1}{2} (bh) \times \text{Full Perimeter} \]
\[ = \frac{1}{2} (10.75' \times 7.17') \times 282' = 10867.93\text{CF/27 = 402.52 CY} \]

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
V total short CF = Net corners \times V short each corner = Net Corners \times \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

\[ V_{\text{total short in CF}} = 4 \text{ net} \times (10.75')^3 = 4 \times 1242.30 = 922.48\text{CF/27 = 34.17 CY} \]

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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.

\[
\text{Swell} \% = \left( \frac{\text{BCY} - 1}{\text{LCY}} \right) 100
\]

\[
\text{Wet Clay} = \left( \frac{3400 - 1}{2800} \right) 100 = \left( \frac{1.214 - 1}{1} \right) = 21.43\%
\]

\[
\text{Haul} = (\text{Building } + \text{Footing } + \text{Working Space} + \text{Angle of Repose} + V_{\text{SHORT}}) \times \text{Swell}\%
\]

\[
= (1,075.00 + 210.00 + 336.83 + 402.52 + 34.17) \times 21.43\%
\]

\[
= 2,058.52 \times 21.43\% = 2,499.66 \text{ CY}
\]

Compacted Fill

Compact 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.

\[
\text{Shrinkage} \% = \left(1 - \frac{\text{BCY}}{\text{CCY}}\right) 100
\]

\[
\text{Damp Sand} = \left(1 - \frac{3,130}{3,510}\right) 100 = (1 - .892) = 10.8\%
\]

\[
\text{Backfill} = (\text{Footing Trench } + \text{Working space } + \text{Angle of Repose} + V_{\text{SHORT}}) \times \text{Sh}\%
\]

\[
= (210.00 + 336.83 + 402.52 + 34.17) \times 10.8\%
\]

\[
= 983.52 \times 106.22 = 1,089.74
\]
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.

\[
\text{Increase Other End} = 75' \times \frac{1}{4} \text{ per foot} = 18.75''/12 = 1.56 \text{ Feet increase}
\]

\[
\text{Total Depth Other End} = 6' + 1.56' = 7.56'
\]

\[
\text{Average Depth} = \text{Start Depth} + \text{Total Other End Depth}
\]

\[
= 6' + 7.56' = 13.56'/2 = 6.78'
\]

**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>
<thead>
<tr>
<th>Description</th>
<th>Length</th>
<th>Width</th>
<th>Depth</th>
<th>Cubic Feet</th>
<th>Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trench</td>
<td>75'</td>
<td>4.5'</td>
<td>6.78'</td>
<td>2,288,25CF/27</td>
<td>84.75</td>
</tr>
</tbody>
</table>

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.

\[
\text{Angle of Repose Trench} = \frac{1}{2} (bh) + \frac{1}{2} (bh) \times \text{trench length}
\]

\[
= \frac{1}{2}(6.78 \times 3.39) + \frac{1}{2}(6.78 \times 3.39) \times 75'
\]

\[
= 1,723.82/27 = 63.85 \text{ CY}
\]
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.

![Grid Diagram]

### Grid = 100 Feet x 100 Feet

Existing Elevations

<table>
<thead>
<tr>
<th>GRID</th>
<th>TYPE OF ELEVATION</th>
<th>CORNERS</th>
<th>CUT</th>
<th>FILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Existing</td>
<td>102.75 102.00</td>
<td>101.25</td>
<td>101.75</td>
</tr>
<tr>
<td></td>
<td>Proposed</td>
<td>101.75 102.75</td>
<td>101.75</td>
<td>101.00</td>
</tr>
<tr>
<td></td>
<td>Net Result</td>
<td>C - 1.00</td>
<td>F - 0.75</td>
<td>F - 0.50</td>
</tr>
</tbody>
</table>

Using the information from Grid No. E above, the total volume for the cut and fill is:

\[
V_c = \frac{L^2 \times (H_c)^2}{108 \times (H_c + H_f)} = \frac{100^2 \times 1.75^2}{108 \times [(1+0.75) + (0.75+0.50)]} = 94.52 \text{ CY}
\]

\[
V_f = \frac{L^2 \times (H_f)^2}{108 \times (H_c + H_f)} = \frac{100^2 \times 1.25^2}{108 \times [(1+0.75) + (0.75+0.50)]} = 48.23 \text{ CY}
\]

<table>
<thead>
<tr>
<th>Vc = Volume of cut in Cubic Yards (CY)</th>
<th>Vf = Volume of fill in Cubic Yards (CY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hc = Sum of cuts on four corners of grid.</td>
<td>Hf = Sum of fills on four corners of grid.</td>
</tr>
<tr>
<td>L = Length of side of grid Square in feet.</td>
<td>108 CY = 4 corners x 27CF per CY</td>
</tr>
</tbody>
</table>

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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 V shaft and the V net bell to determine the total Cubic Yards in the pier. The $V_{shaft} = \pi \times r^2 \times \text{depth} \text{ or } 3.14 \times r \times \text{depth} + \text{The Vnet bell (see Table)} = \text{Total Excavation}$

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 $V_{shaft} = 3.14 \times (1')^2 \times 18' = 56.52 \text{ Cubic Feet (CF)}$

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 V net 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 $V_{net}$ of the Bell $= 26.60 \text{ cubic feet. Therefore, the total volume of excavation is } 56.52 \text{ CF } + 26.6 \text{ CF } = 83.12 \text{ CF/27} = 3.08 \text{ CY.}$

<table>
<thead>
<tr>
<th>Dia. Bell</th>
<th>Atcheson’s Table Net Bell Volumes (Cubic Feet) NET VOLUME IN THE BELL Diameter of Shaft</th>
</tr>
</thead>
<tbody>
<tr>
<td>16&quot;</td>
<td>1.4 1.0 0.6 0.3 1.5 1.2 1.0 0.8 0.6 0.4</td>
</tr>
<tr>
<td>20&quot;</td>
<td>2.6 2.1 1.6 1.2 2.5 2.2 2.0 1.8 1.6 1.4</td>
</tr>
<tr>
<td>24&quot;</td>
<td>3.4 2.8 2.3 1.7 1.3 0.8 0.2 0.1 0.0 0.0</td>
</tr>
<tr>
<td>28&quot;</td>
<td>4.3 3.7 3.1 2.5 1.9 1.3 0.8 0.1 0.0 0.0</td>
</tr>
<tr>
<td>30&quot;</td>
<td>3.6 5.7 5.0 4.3 3.5 2.8 2.2 1.5 1.0 0.6</td>
</tr>
<tr>
<td>32&quot;</td>
<td>10.7 9.8 8.9 8.0 7.1 6.2 5.2 4.3 3.4 2.5</td>
</tr>
<tr>
<td>34&quot;</td>
<td>12.4 11.5 10.5 9.5 8.5 7.5 6.5 5.5 4.7 3.7</td>
</tr>
<tr>
<td>36&quot;</td>
<td>16.3 15.3 14.2 13.1 12.0 10.8 9.6 8.4 7.2 6.0</td>
</tr>
<tr>
<td>38&quot;</td>
<td>23.6 22.3 21.1 19.8 18.4 17.0 15.6 14.1 12.7 11.2</td>
</tr>
<tr>
<td>40&quot;</td>
<td>32.5 31.1 29.7 28.2 26.6 25.0 23.4 21.6 19.8 18.0</td>
</tr>
<tr>
<td>42&quot;</td>
<td>38.0 36.5 34.8 33.1 31.3 29.4 27.5 26.6 25.7 24.8</td>
</tr>
<tr>
<td>44&quot;</td>
<td>45.8 44.2 42.4 40.5 38.5 36.5 34.4 32.4 30.5 28.6</td>
</tr>
<tr>
<td>46&quot;</td>
<td>54.6 52.8 50.8 48.8 46.7 44.5 42.2 40.0 37.8 35.6</td>
</tr>
<tr>
<td>48&quot;</td>
<td>87.0 84.8 82.4 80.0 77.4 74.6 71.8 68.8 65.8 62.8</td>
</tr>
<tr>
<td>50&quot;</td>
<td>92.1 89.9 87.7 85.5 83.3 81.1 78.9 76.7 74.5 72.3</td>
</tr>
<tr>
<td>52&quot;</td>
<td>107.1 104.9 102.7 100.5 98.3 96.1 93.9 91.7 89.5 87.3</td>
</tr>
</tbody>
</table>

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EXCAVATION & CONCRETE EXAMPLE DETAIL

SLAB BOTTOM N-S #4@8"
SLAB BOTTOM E-W #7@10"
FIN. FLR. 217'-0"
T.O.W. 216'-6"
TOPSOIL 6" DEEP
GRADE 214'-6"
HORIZONTAL BAR
#4 @ 6" O.C.
VERTICAL BAR
#6 @ 12" O.C.
4" CONCRETE
SLAB W/ 4x4 -W4xW4
FIN. FLR. 204'-0"
5" COMPACTED SAND
1'-0"
DOWELS #7 @12" O.C.
(4) #5 BARS EVENLY SPACED
B.O.F. 198'-0"
2'-0"

2
52
N.T.S.
Excavation Tables
Average Soil Weights & Formulas

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

Sw % = \( \frac{(BCY - 1) \times 100}{LCY} \)

Load Factor (LF) = \( \frac{100\% + \% \text{ Swell}}{100\%} \)

Sh % = \( \frac{1-BCY \times 100}{CCY} \)

Shrinkage Factor (SF) = \( \frac{CCY}{BCY} \)

Volume Cut (Vc) = \( \frac{(L)^2 \times (Hc)^2}{108 \times (Hc + Hf)} \)

Volume Fill (Vh) = \( \frac{(L)^2 \times (HD)^2}{108 \times (Hf + Hc)} \)

Volume Mass Diagram = \( \frac{A1 + A2 \times \text{Length}}{2} \)

V total short CF = Net Corners x \( \frac{(Depth)^3}{12 \times (n)^2} \)

Roller Compaction = \[ \frac{\text{width} \times \text{mph} \times 5,280 \text{ feet per mile}}{\times \text{lift} \times \text{effic}} \times \# \text{passes} \times 27 \text{ CF/CY} \]

Vibrating Plate = \[ \frac{\text{plate width} \times \text{FPM}}{\times \text{lift} \times \text{effic (min)}} \times \# \text{Passes} \times 27 \text{ CF/CY} \]

x (12”)
Excavation Allowable Slope or Angle of Repose

MAXIMUM ALLOWABLE SLOPE (ANGLE OF REPOSE) FOR THE SIDE OF AN EXCAVATION IN EXCESS OF 3' DEPTH

<table>
<thead>
<tr>
<th>Slope (Angle of repose) RUN: RISE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Solid Rock Formation (90%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Fractured Rock Formation</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1/4:1 (75°)</td>
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<td></td>
</tr>
<tr>
<td>3. Stiff Clay with minimum 2.5 T.S.F.*</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1/2:1 (63°) or Compacted Angular Gravel</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. FIRM Clays with minimum 1.5 T.S.F.*</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2/3:1 (56°)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5. Granular soil (dry) Dry Sand or Clay fill; dry sand and clay mixtures: medium clay with minimum of 1.0 T.S.F.*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:1 (45°)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6. Granular soil (wet clay or silt seams), rubble or trash fill, firm or medium clays with running sand seams</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1/2:1 (34°) Compacted Sharp Sand</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>7. Saturated granular soil Soft Clays with less than 1.0 T.S.F.*</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:1 (26°) Well Rounded Loose Sand</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>8. Running soil (Sand or Clay)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:1 (18°)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

EXCAVATION - TRENCH WIDTH BASED UPON PIPE DIAMETER OR FOOTING WIDTH

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Minimum Trench Width at Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>8&quot; and Under</td>
<td>2.5 Feet</td>
</tr>
<tr>
<td>10&quot; - 14&quot;</td>
<td>3.0 Feet</td>
</tr>
<tr>
<td>15&quot; - 20&quot;</td>
<td>3.5 Feet</td>
</tr>
<tr>
<td>24&quot;</td>
<td>4.0 Feet</td>
</tr>
<tr>
<td>30&quot;</td>
<td>4.5 Feet</td>
</tr>
<tr>
<td>36&quot;</td>
<td>5.0 Feet</td>
</tr>
</tbody>
</table>
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

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

**CUT AND FILL GRID CALCULATIONS**

<table>
<thead>
<tr>
<th>GRID NO.</th>
<th>TYPE OF ELEVATION</th>
<th>CORNERS</th>
<th>CUT VOLUME (CY)</th>
<th>FILL VOLUME (CY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Net Result</td>
<td>NW</td>
<td>NE</td>
<td>SE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C - 1.5</td>
<td>F - 2.25</td>
<td>F - 3.25</td>
</tr>
</tbody>
</table>

Grid = 75 Feet x 75 Feet
Existing Elevations
Proposed Elevations

Check Answers
Excavation Quantities Exercise

E & C PROBLEM PLAN

SCALE: 1/8" = 1' - 0"
Excavation Quantities Exercise

Diagram of slab bottom both ways:
- #7 @ 12" O.C.
- FIN. FLR. 208'-0"
- SLAB BOTTOM BOTH WAYS
- HORIZONTAL BAR #9 @ 8" O.C.
- VERTICAL BAR #8 @ 16" O.C.
- 5' CONCRETE SLAB 6x6 - W4xW4
- FIN. FLR. 195'-3"

Diagram of slab top both ways:
- #5 @ 6" O.C.
- T.O.W. 207'-4"
- TOPSOIL 7" DEEP
- GRADE 204'-0"
- HORIZONTAL BAR #10 @ 6" O.C.
- VERTICAL BAR #5 @ 12" O.C.

Diagram of foundations:
- 4' COMPACTED SAND
- 1'-2"
- DOWELS (INSIDE) #7 @ 16" O.C.
- DOWELS (OUTSIDE) #6 @ 12" O.C.
- B.O.F. 190'-6"
- (4) #5 TOP & BOTTOM EVENLY SPACED

E & C PROBLEM DETAIL

N.T.S.

329
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):

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EXCAVATION - TRENCH WIDTH BASED UPON PIPE DIAMETER OR FOOTING WIDTH

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</tr>
<tr>
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</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>TYPE OF WORK LOCATIONS</th>
<th>OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PILE FOUNDATIONS OR CAPS</td>
<td>HAND EXCAVATE/BACKFILL</td>
</tr>
<tr>
<td>FOOTINGS</td>
<td>HAND COMPACT</td>
</tr>
<tr>
<td>MAT FOUNDATIONS</td>
<td>PLACE &amp; STRIP FORMS</td>
</tr>
<tr>
<td>FOUNDATION WALLS</td>
<td>PLACE KEYWAY</td>
</tr>
<tr>
<td>FOUNDATION PIERS</td>
<td>PLACE WALL FORMS &amp; BULK HEAD FORMS</td>
</tr>
<tr>
<td>GRADE BEAMS</td>
<td>PLACE WALL TIES</td>
</tr>
<tr>
<td>SLABS ON GRADE</td>
<td>PLACE REBAR</td>
</tr>
<tr>
<td>EQUIPMENT FOUNDATIONS</td>
<td>PLACE BOLSTERS</td>
</tr>
<tr>
<td>ELEVATED SLABS</td>
<td>PURCHASE CONCRETE - PSI</td>
</tr>
<tr>
<td>WALLS ABOVE GRADE</td>
<td>PLACE SCREEDS</td>
</tr>
<tr>
<td>COLUMNS</td>
<td>PLACE CONCRETE - METHODS</td>
</tr>
<tr>
<td>BEAMS AND GIRDERES</td>
<td>FINISH CONCRETE</td>
</tr>
<tr>
<td>STAIRS</td>
<td>ANCHOR BOLTS</td>
</tr>
<tr>
<td></td>
<td>EXPANSION JOINT/WATER STOP</td>
</tr>
</tbody>
</table>
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", 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.

<table>
<thead>
<tr>
<th>Description</th>
<th>Wall</th>
<th>Extends</th>
<th>Extends</th>
<th>Total Length</th>
<th>Depth</th>
<th>SFCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forms Outside</td>
<td>A 90’ +</td>
<td>.5’ +</td>
<td>.5’</td>
<td>91’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B 15’ +</td>
<td>.5’ +</td>
<td>.5’</td>
<td>16’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C 30’ +</td>
<td></td>
<td></td>
<td>30’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D 15’ +</td>
<td></td>
<td></td>
<td>15’</td>
<td></td>
<td></td>
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<td></td>
<td>E 30’ +</td>
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<td>30’</td>
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<td></td>
<td>F 15’ +</td>
<td></td>
<td></td>
<td>15’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G 30’ +</td>
<td>.5’ +</td>
<td>.5’</td>
<td>31’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H 45’ +</td>
<td>.5’ +</td>
<td>.5’</td>
<td>46’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>270’</td>
<td>2</td>
<td>2</td>
<td>274’</td>
<td>1’ = 274 SFCA</td>
</tr>
<tr>
<td>Forms Inside</td>
<td>A 91’ -</td>
<td>2’</td>
<td>2’</td>
<td>87’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B 16’ -</td>
<td>2’</td>
<td>2’</td>
<td>12’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C 30’ -</td>
<td></td>
<td></td>
<td>30’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D 15’ -</td>
<td></td>
<td></td>
<td>15’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E 30’ -</td>
<td></td>
<td></td>
<td>30’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F 15’ -</td>
<td></td>
<td></td>
<td>15’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G 31’ -</td>
<td>2’</td>
<td>2’</td>
<td>27’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H 46’ -</td>
<td>2’</td>
<td>2’</td>
<td>42’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>274’ -</td>
<td>8’</td>
<td>8’</td>
<td>258’</td>
<td>1’ = 258 SFCA</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Type of Form</th>
<th>Nails, Wire, Etc., Lb per 100 Square Feet of Contact Area (SFCA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footings and piers</td>
<td>9</td>
</tr>
<tr>
<td>Walls and partitions</td>
<td>8</td>
</tr>
<tr>
<td>Floors</td>
<td>8</td>
</tr>
<tr>
<td>Roofs</td>
<td>8</td>
</tr>
<tr>
<td>Columns</td>
<td>9</td>
</tr>
<tr>
<td>Beams and girders</td>
<td>12</td>
</tr>
<tr>
<td>Stairs</td>
<td>11</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Description</th>
<th>Size</th>
<th># Pieces</th>
<th>Length</th>
<th>Total LF</th>
<th>Lbs/ LF</th>
<th>Total Lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footing Rebar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>#5</td>
<td>4</td>
<td>90.75'</td>
<td>363'</td>
<td>1.043</td>
<td>378.61</td>
</tr>
<tr>
<td>B</td>
<td>#5</td>
<td>4</td>
<td>15.75'</td>
<td>63'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>#5</td>
<td>4</td>
<td>31.75'</td>
<td>127'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside 30'+2'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>#5</td>
<td>4</td>
<td>16.75'</td>
<td>67'</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**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:

\[
\text{Lineal Feet of one side of footing is } = \frac{90.75 \text{ feet}}{20 \text{ feet}} \sim 5 \text{ laps}
\]

Length of lap is \( = 24 \times \frac{5}{8} \text{ inches} = 24 \times 0.625 \text{ inches} = 15 \text{ inches or 1.25 feet per lap.} \)

Lineal Feet of lap \( = 5 \text{ laps} \times 1.25 \text{ Feet} = 6.25 \text{ feet per 90.75 feet.} \) Therefore, the total lineal feet of lap for side A is 6.25 feet \( \times 4 \text{ bars} = 25 \text{ feet.} \) 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.

<table>
<thead>
<tr>
<th>Description</th>
<th>Length</th>
<th>Extends</th>
<th>Extends</th>
<th>Total LF</th>
<th>Height</th>
<th>SFCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Forms Outside</td>
<td>A 90'</td>
<td></td>
<td></td>
<td>90'</td>
<td>17.50'</td>
<td>1,575</td>
</tr>
<tr>
<td>Wall Forms Inside</td>
<td>A 90' -</td>
<td>1.0'</td>
<td>1.0'</td>
<td>88'</td>
<td>17.50'</td>
<td>1,540</td>
</tr>
</tbody>
</table>

**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 rebar 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:

# sets Horizontal Bar = 17.5' = 35 spaces + 1 starter = 36 Pieces

<table>
<thead>
<tr>
<th>Wall</th>
<th>Size</th>
<th># Pieces</th>
<th>Length</th>
<th>Total LF</th>
<th>Lbs/ LF</th>
<th>Total Lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Wall Rebar 90' A</td>
<td>#4</td>
<td>36</td>
<td>89.75'</td>
<td>3,231.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15' B</td>
<td>#4</td>
<td>36</td>
<td>14.75'</td>
<td>531.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside 30' + 1' C</td>
<td>#4</td>
<td>36</td>
<td>30.75'</td>
<td>1,107.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside 15' + 1' D</td>
<td>#4</td>
<td>36</td>
<td>15.75'</td>
<td>567.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside 30' + 1' E</td>
<td>#4</td>
<td>36</td>
<td>30.75'</td>
<td>1,107.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside 15' + 1' F</td>
<td>#4</td>
<td>36</td>
<td>15.75'</td>
<td>567.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30' G</td>
<td>#4</td>
<td>36</td>
<td>29.75'</td>
<td>1,071.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45' H</td>
<td>#4</td>
<td>36</td>
<td>44.75'</td>
<td>1,611.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>274'</td>
<td>#4</td>
<td>36 x</td>
<td>272</td>
<td>9,792</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

Lineal Feet of one side of footing is = 89.75 feet ~ 5 laps
Length of lap = 89.75 feet / 5 laps = 17.95 feet

Therefore, the total lineal feet of lap for side A is 17.95 feet x 36 bars = 650.2 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.

<table>
<thead>
<tr>
<th>Wall</th>
<th>Size</th>
<th># Pieces</th>
<th>Length</th>
<th>Total LF</th>
<th>Lbs/ LF</th>
<th>Total Lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Wall Rebar</td>
<td>90'</td>
<td>A #6</td>
<td>90</td>
<td>17.50'</td>
<td>1,575.00</td>
<td></td>
</tr>
<tr>
<td>15'</td>
<td>B</td>
<td>15</td>
<td>17.50'</td>
<td>262.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside 30' + 1'</td>
<td>31'</td>
<td>C #6</td>
<td>31</td>
<td>17.50'</td>
<td>542.50</td>
<td></td>
</tr>
<tr>
<td>Inside 15' + 1'</td>
<td>16'</td>
<td>D #6</td>
<td>16</td>
<td>17.50'</td>
<td>280.00</td>
<td></td>
</tr>
<tr>
<td>Inside 30' + 1'</td>
<td>31'</td>
<td>E #6</td>
<td>31</td>
<td>17.50'</td>
<td>542.50</td>
<td></td>
</tr>
<tr>
<td>Inside 15' + 1'</td>
<td>16'</td>
<td>F #6</td>
<td>16</td>
<td>17.50'</td>
<td>280.00</td>
<td></td>
</tr>
<tr>
<td>30'</td>
<td>G</td>
<td>30</td>
<td>17.50'</td>
<td>525.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45'</td>
<td>H</td>
<td>#6</td>
<td>45</td>
<td>17.50'</td>
<td>787.50</td>
<td></td>
</tr>
<tr>
<td>274'</td>
<td></td>
<td>274</td>
<td>17.50'</td>
<td>4,795.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
<th>Depth</th>
<th>Cubic Feet</th>
<th>Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>90'</td>
<td>90.00'</td>
<td>1.00'</td>
<td>17.50'</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>15'</td>
<td>-1</td>
<td>-1</td>
<td>13.00'</td>
<td>17.50'</td>
</tr>
<tr>
<td>c</td>
<td>30'</td>
<td>30.00'</td>
<td></td>
<td>17.50'</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>15'</td>
<td>15.00'</td>
<td></td>
<td>17.50'</td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>30'</td>
<td>30.00'</td>
<td></td>
<td>17.50'</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>15'</td>
<td>15.00'</td>
<td></td>
<td>17.50'</td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>30'</td>
<td>30.00'</td>
<td></td>
<td>17.50'</td>
<td></td>
</tr>
<tr>
<td>h</td>
<td>45'</td>
<td>-1</td>
<td>-1</td>
<td>43.00'</td>
<td>17.50'</td>
</tr>
<tr>
<td>270</td>
<td>-2</td>
<td>-2</td>
<td>266.00'</td>
<td>17.50'</td>
<td>4,655.00CF/27 = 172.41</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Description</th>
<th>Length</th>
<th>Width</th>
<th>Square Feet</th>
<th>CSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape I (inside)</td>
<td>28'</td>
<td>43'</td>
<td>1,204.00</td>
<td>12.04</td>
</tr>
<tr>
<td>Shape II (inside)</td>
<td>30'</td>
<td>28'</td>
<td>840.00</td>
<td>8.40</td>
</tr>
<tr>
<td>Shape III (inside)</td>
<td>30'</td>
<td>13'</td>
<td>390.00</td>
<td>3.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>2,434.00</strong></td>
<td><strong>24.34</strong></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Mark</th>
<th>N o.</th>
<th>Beam Size (inches)</th>
<th>Reinforcing</th>
<th>#3 Stirrups</th>
<th>Support Bars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Width</td>
<td>Depth</td>
<td>Bottom No.</td>
<td>Size</td>
</tr>
<tr>
<td>BB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1B34</td>
<td>1</td>
<td>12</td>
<td>33</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

# 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.

<table>
<thead>
<tr>
<th>Mark</th>
<th>No.</th>
<th>Beam Size (inches)</th>
<th>Width</th>
<th>Depth</th>
<th>Bottom</th>
<th>Top</th>
<th>#3 Stirrups</th>
<th>Support Bars</th>
<th>2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SIze</td>
<td>No.</td>
<td>Size</td>
<td>Length</td>
<td>No.</td>
<td>Size</td>
<td>Length</td>
<td>O.C.</td>
</tr>
<tr>
<td>1B22</td>
<td>1</td>
<td>24 10.5</td>
<td>6</td>
<td>7</td>
<td>17' -2&quot;</td>
<td>8</td>
<td>7</td>
<td>17'2&quot;</td>
<td>6&quot;</td>
</tr>
</tbody>
</table>

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
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

<table>
<thead>
<tr>
<th>TYPE OF WORK LOCATIONS</th>
<th>OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOUNDATION WALLS</td>
<td>PLACE STUDS</td>
</tr>
<tr>
<td>FLOORS</td>
<td>PLACE SILL PLATES</td>
</tr>
<tr>
<td>EXTERIOR WALLS</td>
<td>BUILD HEADERS, FRAME OPENINGS</td>
</tr>
<tr>
<td>INTERIOR WALLS</td>
<td>ATTACH SHEATHING, BRACING</td>
</tr>
<tr>
<td>ELEVATED WALLS</td>
<td>INSTALL WINDOWS, DOORS</td>
</tr>
<tr>
<td>CEILINGS</td>
<td>PLACE JOISTS</td>
</tr>
<tr>
<td>DOORS AND WINDOWS</td>
<td>SHINGLE</td>
</tr>
<tr>
<td>FINISH MILLWORK</td>
<td>INSTALL SIDING</td>
</tr>
<tr>
<td>FINISH HARDWARE</td>
<td>INSTALL SOFFIT</td>
</tr>
<tr>
<td>SIDING</td>
<td>BUILD STAIRS</td>
</tr>
<tr>
<td>ROOFING</td>
<td>WATERPROOF AND CAULKING</td>
</tr>
<tr>
<td></td>
<td>PLACE INTERIOR TRIM</td>
</tr>
<tr>
<td></td>
<td>INSTALL HARDWARE</td>
</tr>
</tbody>
</table>
Sub Flooring Framing Components

The sub floor system usually consists of the following components.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam or Girder</td>
<td>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.</td>
</tr>
<tr>
<td>Columns</td>
<td>Are placed along the length of the Beam or Girder at specified intervals. These columns can be made of wood or steel.</td>
</tr>
<tr>
<td>Floor Joists</td>
<td>Are perpendicular to the beam and their size is governed by the floor load and the joist span.</td>
</tr>
<tr>
<td>Floor Trusses</td>
<td>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.</td>
</tr>
<tr>
<td>Sill Plate</td>
<td>This is placed on top of the foundation wall and secured to the wall using anchor bolts that have been placed in the concrete.</td>
</tr>
<tr>
<td>Rim Joists</td>
<td>Are nailed along on the ends of the joists.</td>
</tr>
<tr>
<td>Sub flooring</td>
<td>Placed perpendicular to the floor joists. Normally, consists of Tongue and Groove edges.</td>
</tr>
<tr>
<td>Termite Shield</td>
<td>Placed on top of the foundation wall to prevent termite damage.</td>
</tr>
<tr>
<td>Bridging</td>
<td>This is placed between the joist to prevent movement. In a Truss flooring system the bridging is along the bottom cord.</td>
</tr>
<tr>
<td>Floor Headers</td>
<td>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.</td>
</tr>
<tr>
<td>Trimmers</td>
<td>Are joists that have been doubled to carry the load. These are placed in a floor opening to accommodate the stairs.</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>LENGTH</th>
<th>QUANTITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam or Girder</td>
<td>56’ - 12 = 44 + 12 + 16 = 68’ x 3 =</td>
<td>204</td>
</tr>
<tr>
<td>Columns</td>
<td>44’/8’ = 6+1 = 7,28/8’ = 4+1 = 5</td>
<td>12 EA</td>
</tr>
<tr>
<td>Floor Joists</td>
<td>56’/1.33 = 42 + 1 = 43 x 2 = 86</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16’/1.33 = 12 + 1 = 13 x 2 = 26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Under partition wall = 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>113 EA</td>
</tr>
<tr>
<td>Sill Plate</td>
<td>56’ + 40’ + 24 + 16 + 32 + 24   =</td>
<td>192 LF</td>
</tr>
<tr>
<td>Rim Joists</td>
<td>56’ + 32 + 16 +16 =</td>
<td>120 LF</td>
</tr>
<tr>
<td>Subflooring</td>
<td>56’ x 24’ = 1344</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16’ x 24’ = 0384</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1728 SF/ 32SF per Sheet</td>
</tr>
<tr>
<td>Bridging</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Interior Wall Systems

<table>
<thead>
<tr>
<th>Bottom Plate</th>
<th>This is a single plate used to secure the studs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Plate</td>
<td>This is normally a Double Top Plate used to carry the roof load.</td>
</tr>
<tr>
<td>Interior Studs</td>
<td>Can be load bearing or non-load bearing. Spaced evenly.</td>
</tr>
<tr>
<td>Intersecting</td>
<td>Are vertical studs placed in the exterior wall to secure interior.</td>
</tr>
<tr>
<td>Headers</td>
<td>Are horizontal members used to carry the upper floor and roof.</td>
</tr>
<tr>
<td>Jambs</td>
<td>Are vertical studs used to provide support for the header.</td>
</tr>
</tbody>
</table>

345
Wall Framing Components
The Wall system can be for interior or exterior walls and they normally consist of the following components.

### Exterior Wall System

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom Plate</td>
<td>This is a single plate used to secure the studs.</td>
</tr>
<tr>
<td>Double or Top Plate</td>
<td>This is normally a Double Top Plate used to carry the load of the roof. Also, the studs are secured to the plate.</td>
</tr>
<tr>
<td>Exterior Studs</td>
<td>Are normally load bearing and they are spaced evenly to carry the load of the upper floors and Roof.</td>
</tr>
<tr>
<td>Corner Studs</td>
<td>Are vertical studs in the corner of exterior walls to provide a smooth corner and nailing surface.</td>
</tr>
<tr>
<td>Headers/Lintels</td>
<td>Are horizontal members used to carry the upper floor and roof loads around a door or window opening.</td>
</tr>
<tr>
<td>Jambs</td>
<td>Are vertical studs used to provide support for the header.</td>
</tr>
<tr>
<td>Sills</td>
<td>Are horizontal members under a window sill.</td>
</tr>
<tr>
<td>Cripples</td>
<td>Are the vertical members under the window sill.</td>
</tr>
<tr>
<td>Wind Bracing</td>
<td>Is diagonal bracing placed in the exterior wall to provide stability and it used to resist horizontal wind loads.</td>
</tr>
<tr>
<td>Gable Ends</td>
<td>Are the vertical studs on the end of a Gable Roof.</td>
</tr>
<tr>
<td>Sheathing</td>
<td>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.</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>LENGTH</th>
<th>QUANTITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom Plate</td>
<td>$56 + 40 + 24 + 16 + 32 + 24 = 192$</td>
<td>192 LF</td>
</tr>
<tr>
<td>Double Top Plate</td>
<td>$192 \times 2 = 384$</td>
<td>383 LF</td>
</tr>
<tr>
<td>Exterior Studs</td>
<td>$56/1.33=42+1=43, 40/1.33=30+1=31, 24/1.33=18+1=19, 16/1.33=12+1=13, 32/1.33=24+1=25, 24/1.33=18+1=19$</td>
<td>150 EA</td>
</tr>
<tr>
<td>Corner Studs</td>
<td>6 Corners x 2 studs =</td>
<td>012 EA</td>
</tr>
<tr>
<td>Headers/Lintels</td>
<td>2 doors x 2.92' wide x 3 headers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 windows x 4.75' wide x 3 headers</td>
<td></td>
</tr>
<tr>
<td>Jambs</td>
<td>5 windows x 2 per = 10 studs</td>
<td></td>
</tr>
<tr>
<td>Sills</td>
<td>5 windows</td>
<td></td>
</tr>
<tr>
<td>Cripples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Bracing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Studs Gable Ends</td>
<td>$24/1.33=18 +1 = 19 \times 2$ sides</td>
<td>038 EA</td>
</tr>
<tr>
<td>Sheathing Gable Ends</td>
<td>$192'/4' = 48$ $\times \frac{1}{2} (12' \times 4') = 24SF \times 4 = 96/32 = 3$</td>
<td>51 EA</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Roof Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shed Roof</td>
<td>The Shed Roof slopes in one direction.</td>
</tr>
<tr>
<td>Gable Roof</td>
<td>The Gable Roof slopes in two directions.</td>
</tr>
<tr>
<td>Hip Roof</td>
<td>The Hip roof slopes in four directions.</td>
</tr>
<tr>
<td>Gambrel Roof</td>
<td>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.</td>
</tr>
<tr>
<td>Intersecting Roof</td>
<td>The intersecting roof has four to six slopes depending on if the roof is two intersecting Gables or a Gable and a Hip.</td>
</tr>
<tr>
<td>Mansard Roof</td>
<td>The Mansard roof combines the Gambrel and Hip Roofs.</td>
</tr>
</tbody>
</table>

Roof Framing Components
The roof systems consist of the following components.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Rafters</td>
<td>The total length figures in the unit rise and the overhang.</td>
</tr>
<tr>
<td>Ridge Boards</td>
<td>Are at the peak of the roof.</td>
</tr>
<tr>
<td>Over hang</td>
<td>Is the horizontal projection beyond the exterior walls.</td>
</tr>
<tr>
<td>Hip Rafters</td>
<td>Are the longest rafters on a Hip roof.</td>
</tr>
<tr>
<td>Hip Jack Rafters</td>
<td>Are the shorter rafters on the ends of a Hip roof.</td>
</tr>
<tr>
<td>Valley Rafters</td>
<td>Are in the valley on both sides of an interesting roof.</td>
</tr>
<tr>
<td>Valley Jack Rafters</td>
<td>These are the short Rafters</td>
</tr>
<tr>
<td>Cripple Jack Rafters</td>
<td>Are between the Valley and the Hip in an intersecting roof.</td>
</tr>
<tr>
<td>Sloped Length</td>
<td>The top cord of the rafter. The increase in materials.</td>
</tr>
<tr>
<td>Roof Sheathing</td>
<td>Are placed perpendicular to the Rafters.</td>
</tr>
<tr>
<td>Fascia</td>
<td>Is attached to the tails of the rafters.</td>
</tr>
<tr>
<td>Barge board</td>
<td>Is the length of the common rafters at ends.</td>
</tr>
</tbody>
</table>
Level 1 Construction Fundamentals Study Guide

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 ($\frac{1}{2}$) of the Building Span.

The **Building Span** is the outside to outside width of the building.

The **Total Rafter Run** is considered one-half ($\frac{1}{2}$) 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 $\frac{4}{24} = \frac{1}{6} = 16.66\%$.

The **Unit Rafter Length** of a Common Rafter or **Rafter Constant**

\[ = \text{rise}^2 + \text{run}^2 = \text{c}^2 \text{ or } c = \sqrt{\text{rise}^2 + \text{run}^2} = \text{Unit Rafter Length} \]

Assume a 7:12 roof slope, the Unit Rafter Length would be calculated as follows:

\[
\begin{align*}
c &= \sqrt{(7)^2 + (12)^2} \\
&= \sqrt{193} \\
&= 13.89 \text{ inches}/12 = 1.1575 \text{ Rafter Constant}
\end{align*}
\]

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

\[ = \text{common rafter}^2 + \text{run}^2 = \text{c}^2 \text{ or } c = \sqrt{\text{common rafter}^2 + \text{run}^2} = \text{Unit Hip Length} \]

Assume the 7:12 roof slope from above. The hip and valley unit Length is:

\[
\begin{align*}
c &= \sqrt{(13.89)^2 + (12)^2} \\
&= \sqrt{336.93} \\
&= 18.36 \text{ inches}/12 = 1.53 \text{ Rafter Constant}
\end{align*}
\]
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 = \( \frac{\text{rise}}{\text{run}} = \frac{c}{c} \) or \( c = \sqrt{\frac{\text{rise}^2 + \text{run}^2}{12}} \)

\[
\begin{align*}
4/12 \text{ side } c &= \sqrt{\frac{4^2 + 12^2}{12}} = 12.65'' \text{ / Foot} = 1.05 \\
3/12 \text{ side } c &= \sqrt{\frac{3^2 + 12^2}{12}} = 12.37'' \text{ / Foot} = 1.03 \\
\end{align*}
\]

The Total Rafter Run Length = Building Run plus the Overhang =

\[
\begin{align*}
4/12 \text{ side } &= 14' + 3' = 17' \\
3/12 \text{ side } &= 10' + 3' = 13' \\
\end{align*}
\]

Total Length of the Common Rafter = Total Rafter Run x Roof Constant

\[
\begin{align*}
4/12 \text{ side } - 17' \times 1.05 &= 17.85' \\
3/12 \text{ side } - 13' \times 1.03 &= 13.39' \\
\end{align*}
\]

Determine the Total Number of Common Rafters

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>LENGTH</th>
<th>TOTAL</th>
<th>QUANTITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Rafters</td>
<td>Main 56'/1.33' = 42+1 =43</td>
<td>82 LF</td>
<td>56 EA - 17.85'</td>
</tr>
<tr>
<td></td>
<td>Extend 16'/1.33' = 12+1 =13</td>
<td></td>
<td>56 EA - 13.39'</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>112 EA</td>
</tr>
</tbody>
</table>

Determine the Hip and Valley Constant = Common Rafter\(^2 + \text{Run}^2 = c^2 \) or \( c = \sqrt{\text{CR}^2 + \text{Run}^2} \)

\[
\begin{align*}
4/12 \text{ side } c &= \sqrt{\frac{12.65^2 + 12^2}{12}} = 17.44'' \text{ / Foot} = 1.45 \\
3/12 \text{ side } c &= \sqrt{\frac{12.37^2 + 12^2}{12}} = 17.23'' \text{ / Foot} = 1.44 \\
\end{align*}
\]

Determine the length of the Valley and the Hip.

\[
\begin{align*}
4/12 \text{ side } - 17' \times 1.45 &= 24.65' \\
3/12 \text{ side } - 13' \times 1.44 &= 18.72' \\
\end{align*}
\]

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>LENGTH</th>
<th>TOTAL</th>
<th>QUANTITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridge Boards</td>
<td>Main 56'+3'+3' - 13'=49'</td>
<td>82 LF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intersecting 16'+17'+0 - 00=23</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheathing</td>
<td>4/12</td>
<td>17' x 33'=561 x 1.05=598 SF</td>
<td>2,414 SF</td>
</tr>
<tr>
<td></td>
<td>3/12</td>
<td>17' x 32'=544 x 1.05=571 SF</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13' x 46'=598 x 1.03=616 SF</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13' x 47'=611 x 1.03=629 SF</td>
<td></td>
</tr>
<tr>
<td>Fascia</td>
<td>56'+3'+3'=62'</td>
<td>156 LF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40'+3'+3'=46'</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16'+0'+0'=16'</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32'+0'+0'=32'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barge board</td>
<td>17.85' x 2=35.70'</td>
<td>62.48 LF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13.39' x 2=26.78'</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 = \( \frac{\text{rise}^2 + \text{run}^2}{\text{run}} = c \) or \( c = \sqrt{\frac{\text{rise}^2 + \text{run}^2}{\text{run}}} \)

\[
6/12 \text{ side } c = \sqrt{\frac{6^2 + 12^2}{12}} = 1.12 \text{ / Foot} = 1.12
\]

The Total Rafter Run Length = Building Run plus the Overhang =

\[
14' + 2' = 16 \text{ feet}
\]

Total Length of the Common Rafter = Total Rafter Run x Roof Constant

\[
14' + 2' = 16 \text{ feet} \times 1.12 = 17.92 \text{ Feet use 18 Feet}
\]

Determine the Number of Common Rafters required.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>LENGTH</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Rafters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main</td>
<td>62'/16&quot; = 46.5 + 1 = 48 x 2 =</td>
<td>128</td>
</tr>
<tr>
<td>Intersecting</td>
<td>20'/16&quot; = 15.0 + 1 = 16 x 2 =</td>
<td></td>
</tr>
</tbody>
</table>

Determine the Hip and Valley Constant = Common Rafter\(^2 + \text{Run}^2 = c^2\) or \(c = \sqrt{\text{CR}^2 + \text{Run}^2}\)

\[
6/12 \text{ side } c = \sqrt{\frac{13.42^2 + 12^2}{12}} = 1.50 \text{ / Foot} = 1.50
\]

Determine the Total Length of the valley rafters = Total Rafter Run x Valley Constant.

\[
14' + 2' = 16 \text{ feet} \times 1.50 = 24 \text{ Feet}
\]

<table>
<thead>
<tr>
<th>Valley Rafters</th>
<th>2</th>
<th>2 - 24 Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridge Boards</td>
<td>Main 62' + 2' + 2' = 66'</td>
<td>2</td>
</tr>
<tr>
<td>Intersection</td>
<td>20' + 14' + 2' = 36'</td>
<td>102'</td>
</tr>
<tr>
<td>Roof Sheathing</td>
<td>Main 66' x 32' = 2,112 SF</td>
<td>2</td>
</tr>
<tr>
<td>Intersection</td>
<td>20' x 32' = 640 SF</td>
<td>2,752 SF</td>
</tr>
</tbody>
</table>
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 = \( \frac{\text{rise}}{\text{run}} = c \) or \( c = \sqrt{\text{rise}^2 + \text{run}^2} \)

\[
3/12 \text{ side } c = \frac{3^2 + 12^2}{12} = \frac{12.37''}{\text{Foot}} = 1.03
\]

The Total Rafter Run Length = Building Run plus the Overhang =

\[
12' + 3' = 15 \text{ feet}
\]

Total Length of the Common Rafter = Total Rafter Run x Roof Constant

\[
12' + 3' = 15 \text{ feet} \times 1.03 = 15.45 \text{ Feet use 16 Feet}
\]

Determine the Number of Common Rafters required.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>LENGTH</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Rafters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main</td>
<td>( 62'/16'' = 46.5 + 1 = 48 \times 2 = )</td>
<td></td>
</tr>
<tr>
<td>L Shape</td>
<td>( 16'/16'' = 12.0 + 1 = 13 \times 2 = )</td>
<td>122</td>
</tr>
</tbody>
</table>

Determine the Hip and Valley Constant = Common Rafter \( ^2 + \text{Run}^2 = c^2 \) or \( c = \sqrt{\text{CR}^2 + \text{Run}^2} \)

\[
\frac{3/12 \text{ side } c = 12.37^2 + 12^2}{12} = \frac{17.23''}{\text{Foot}} = 1.44
\]

Determine the Total Length of the valley rafters = Total Rafter Run x Valley Constant

\[
12' + 3' = 15 \text{ feet} \times 1.44 = 21.6 \text{ Feet}
\]

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

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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
   - B. 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
   - B. 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