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U.S. MARINE CORPS **MCRP 3-40D.12**

CONSTRUCTION ESTIMATING

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CHANGE NOTIFICATION

1. PURPOSE. Change 1 to NTRP 4-04.2.3 (OCT 2021), Construction Estimating, is developed in accordance with NTRP 1-01 (JUN 2021), The Navy Warfare Library User Manual.

2. SUPERSEDURE. Change 1 supersedes NTRP 4-04.2.3 (OCT 2021), Construction Estimating.

3. CONTENTS OF CHANGE. This change replaces the original distribution statement on the front cover to publically releasable.

4. ENTRY OF CHANGE. This change is developed with the intent that the entire publication is to be reprinted and distributed in its entirety. Affected pages are identified in the List of Effective Pages. Changes throughout are identified by change bars and footers.

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FOREWORD

This publication has been prepared under our direction for use by our respective commands and other commands as appropriate.

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PREFACE

NTRP 4-04.2.3/TM 3-34.41/MCRP 3-40D.12 (OCT 2021), CONSTRUCTION ESTIMATING, is available in the Navy Warfare Library. It supersedes NTRP 4-04.2.3/TM 3-34.41/MCRP 3-40D.12 (DEC 2010), CONSTRUCTION ESTIMATING.

NTRP 4-04.2.3/TM 3-34.41/MCRP 3-40D.12, CONSTRUCTION ESTIMATING, is a reference for the preparation of construction project estimates for general engineering and contingency construction projects performed by military engineer units. Throughout this publication, references to other publications imply the effective edition. Unless otherwise stated, masculine nouns and pronouns do not refer exclusively to men.

INSTRUCTIONS FOR USE

This and other Navy Warfare Library (NWL) publications, including edition updates are available on the NWL portal (https://doctrine.navy.mil/ or https://doctrine.navy.smil.mil/). Printed copies may be ordered by following the directions included in Appendix A of NTRP 1-01.

Report urgent changes, routine changes, and administrative discrepancies by letter, general administrative message, or email to COMMANDER, NAVY WARFARE DEVELOPMENT COMMAND, ATTN: DOCTRINE, 1528 PIERSEY STREET, BLDG O-27, NORFOLK, VA 23511-2723. (Email: NWDC_NRFK_FLEET_PUBS@NAVY.MIL)

CHANGE BARS

Revised text is indicated by a black vertical line in the outside margin of the page, like the one printed next to this paragraph. The change bar indicates added or restated information. A change bar in the margin adjacent to the chapter number and title indicates a new or completely revised chapter.

WARNINGS, CAUTIONS, AND NOTES

The following definitions apply to warnings, cautions, and notes used in this manual:

WARNING

An operating procedure, practice, or condition that may result in injury or death if not carefully observed or followed.

CAUTION

An operating procedure, practice, or condition that may result in damage to equipment if not carefully observed or followed.

Note

An operating procedure, practice, or condition that requires emphasis.

WORDING

Word usage and intended meaning throughout this publication are as follows:

“Shall” and “must” indicate the application of a procedure is mandatory.

“Should” indicates the application of a procedure is recommended.

“May” and “need not” indicate the application of a procedure is optional.

“Will” indicates future time. It never indicates any degree of requirement for application of a procedure.

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CHAPTER 1
Introduction to Construction Estimating

1.1 INTRODUCTION

NTRP 4-04.2.3/TM 3-34.41/MCRP 3-40D.12, Construction Estimating, contains information for developing construction project estimates. Accurate construction estimates are critical for engineering forces to accomplish a mission. In today's operational environment, engineers are increasingly employed as joint forces, with multiple service engineers under a single commander. Additionally, one engineer unit may start a project and turn it over to an engineer unit from a different service for completion. Engineers from separate organizations need a way to reconcile various construction estimates to one another in order to avoid wasting time and effort. It is important to standardize procedures and data for estimating construction projects among service engineers.

1.1.1 Purpose

This multi-Service publication establishes uniform guidance to describe common methods, procedures, formats, and technical data for the preparation of construction project estimates for general engineering and contingency construction projects performed by military engineer units.

1.1.2 Scope

This unclassified publication provides technical reference information and data used to estimate construction projects performed by military engineer units. It provides information on estimating materiel quantities, equipment, and military labor requirements. It is designed for flexible application to projects of varying size, scope, and conditions. Estimates for materiels, equipment, and labor are discussed in Chapters 2, 3, and 4. Data and information for these estimates are provided in Chapter 5. Contingency estimate factors not contained in Chapter 5 are provided in Appendix A.

Standard units of issue listed in Appendix B and used throughout this publication conform to Department of Defense (DOD) (not commercial abbreviations) ordering requirements and are used for measurements and quantities to facilitate the ordering process.

Professional information useful to estimators is provided in the remaining appendices to this publication.

Data, as illustrated in figures throughout this publication, provides information for creating estimates. This data is not intended to establish production standards. The data must be used with sound judgment and modified as the user's experience and operational situation suggests. Man-hours/man-day figures are based upon direct labor and do not include allowances for indirect or overhead labor.

This publication is not a guide for project management; rather, it provides information and data for estimating construction projects only. Refer to NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/MCRP 3-40D.6, Construction Project Management, for a comprehensive guide of construction project management by military engineer operational units.

1.1.3 Applicability

This publication is intended for use by military engineer project crew leaders, but it is also useful to staff-level engineers serving as liaison officers and training and educational institutions. It applies to engineers, both active and reserve military and civilians from the United States Army (USA), United States Marine Corps (USMC), and United States Navy (USN).

Construction cost estimates for military construction program projects and projects intended for civilian contractors are developed by government engineering organizations and/or contracted private architect-engineer firms using Unified Facilities Criteria (UFC) guidance. The UFC documents provide planning, design, construction, sustainment, restoration, and modernization criteria and apply to military departments, defense agencies, and DOD field activities. The United States Army Corps of Engineers (USACE) and the Naval Facilities Engineering Systems Command (NAVFAC) are responsible for administration of the UFC system. Unified Facilities Criteria are distributed only in electronic media and effective upon issuance.

Refer to UFC 3-730-01, Programming Cost Estimates for Military Construction; UFC 3-701-01, DOD Facilities Pricing Guide; and UFC 3-740-05, Handbook: Construction Cost Estimating, for further information. For access to UFC documents, go to the Whole Building Design Guide Web site at http://www.wbdg.org/index.php and click on "Unified Facilities Criteria" under "Popular Links" on the left side of the web page.

While this publication is used by Marine Corps engineers as a reference to estimate general engineering projects, Marine air-ground task force (MAGTF) planners should reference NTTP 3-10.1M/MCTP 3-34D, Seabee Operations in the MAGTF, for information on the integration of Seabees into a MAGTF.

1.1.4 Implementation Plan

The following commands have primary responsibility for each respective service and will review this publication, validate the information, and incorporate it into service manuals and curricula.

1. The Army will incorporate these procedures into Army training and doctrine publications as directed by the United States Army Training and Doctrine Command.

2. The Navy will incorporate these procedures into Navy training and doctrine publications as directed by the Commander, Navy Warfare Development Command.

3. The Marine Corps will incorporate these procedures into Marine Corps training and doctrine publications by direction of the Commandant of the Marine Corps, Deputy Commandant for Combat Development and Integration.

1.1.5 Terminology

Terminology in this manual, as much as possible, is consistent with definitions found in JP 1-02, Department of Defense Dictionary of Military and Associated Terms; Army Doctrine Publication 1-02, Operational Terms and Graphics; MCRP 1-10.2, Marine Corps Supplement to the Department of Defense Dictionary of Military and Associated Terms; and NTRP 1-02, Navy Supplement to the DOD Dictionary of Military and Associated Terms. However, throughout this publication, some key terms used with industry standard definitions that specifically apply to construction are not consistent with joint and service dictionary definitions and are not intended for use in JP 1-02. This publication uses these terms in order to remain consistent across the services and with construction industry standards.

1.2 LEVELS OF ESTIMATES

Estimating is the process of determining the amount and type of work to be performed and the quantities of materiel, labor, and equipment needed. Figure 1-1 illustrates the relationship of the four levels of estimates used by military engineers for project planning and the method normally used to achieve an estimate. This publication is designed to provide data and information for conducting detailed estimates. These four levels of estimates are:

1. Order of magnitude estimates (also known as preliminary estimates) are made from limited information (e.g., general descriptions of projects, and preliminary plans and specifications with little or no detail). Preliminary estimates establish rough order of magnitude costs for budget purposes and to program labor requirements.

Level of Planning	Cognizant Organization	Level of Estimate	Method Used
Preliminary planning	USACE, NAVFAC	Order of magnitude	Adjusted historical data
		Budget/planning	Square foot, cubic foot; means, parametric
	Engineer unit higher headquarters	Definitive	Estimating software
Detailed planning	Engineer unit	Detailed	Manual materiel/quantity takeoff

Figure 1-1. Levels of Estimates

2. Budget/planning estimates are based on engineering parameters developed from historical databases, construction practices, and engineering/construction data. These parameters develop estimates for large scope projects (e.g., military construction program projects).

3. Definitive estimates, similar to detailed estimates, use automated software programs. These programs develop estimates used to award contract construction work.

4. Detailed estimates are the most accurate and take the most time to complete. Precise quantities of materiels, equipment, and labor required for a given project correctly quantify the requirements and ensure accuracy. Detailed estimates are done manually using the materiel/quantity takeoff method.

1.3 PROJECT PLANNING INTEGRATION

Project estimates are used to support construction project planning. Project managers/supervisors break a project down into logical, sequenced general areas of work known as master activities. Master activities are further divided into more specific work items known as construction activities, and these are further broken down into construction work elements. Estimators create detailed materiel, equipment, and labor estimates of each of these individual activities and then summarize them into an overall project estimate.

Project crewleaders use the information derived from materiel, equipment, and labor estimates to develop their project's construction activity summary sheets. These estimates also provide the basis for project schedule management, which includes materiel deliveries schedule, equipment schedule, and labor skill requirements. These topics fall into the category of project management. Discussion of project management is beyond the scope of this publication.

Refer to NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/MCRP 3-40D.6 for additional information on project management. Sections 1.3.1 through 1.3.4 describe the work element number, master activities, construction activities, and construction work elements.

1.3.1 Work Element Number

This publication uses the same numbering system as the current issuance of Construction Specifications Institute's MasterFormat to organize data presented in Chapter 5. This numbering system is also used by commercial manufacturers and publications (e.g., RSMeans Company) to present data and information. Use of this numbering system allows military engineers to easily search out and use data not contained in Chapter 5. Refer to 5.2.2 for conversion factors applied to commercial publications to adapt their data for use by military engineers. The data figures in Chapter 5 are not all inclusive. A complete list of the numbering system with title descriptions is available in Construction Specifications Institute's MasterFormat (current version) Update Numbers & Titles, available at http://csinet.org/Home-Page-Category/Formats/MasterFormat.aspx. Use of this numbering system also aligns and synchronizes estimating data, project specifications, and other project management requirements. It allows effective communication among the project personnel and provides easy tracking of essential project information.

Figure 1-2 illustrates the 12-digit work element number's components. The first two digits represent the master activity number, also known as the MasterFormat division (Level 1). The next two pairs of numbers represent Level 2 (10) and Level 3 (00). When additional detail is provided, an additional pair of digits (Level 4) is added following a decimal. The last four digits following a dash is a sequence number and provides the ability to assign a unique number to each identified work element. Numbers down to MasterFormat Level 4 are assigned by the MasterFormat system and align guide specifications with historical data information. Work element numbers are assigned by the user as required to present data in a publication or computer software program.

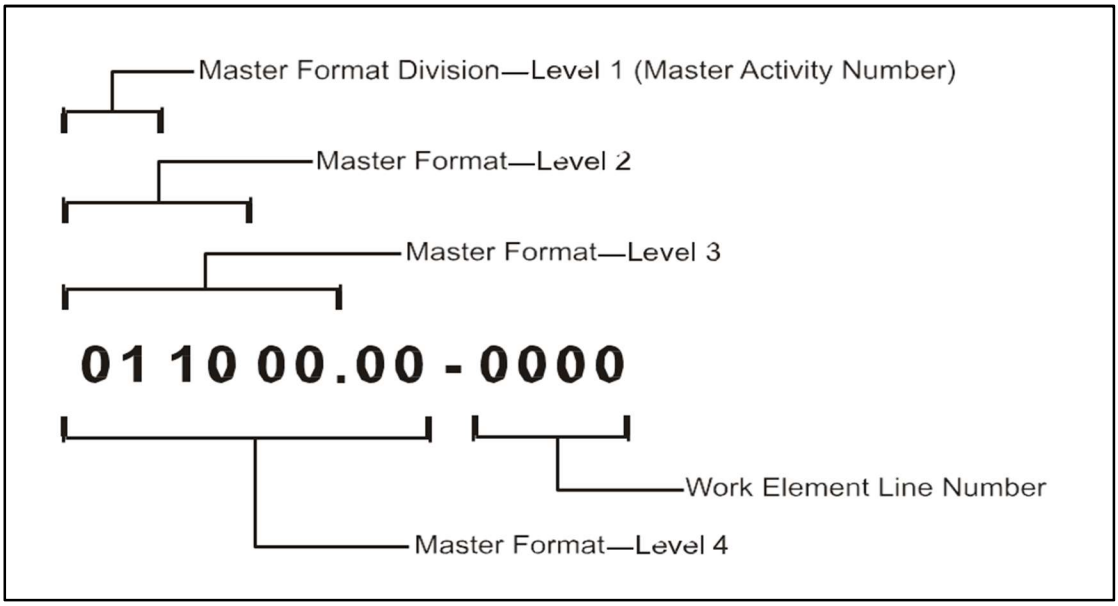

Figure 1-2. Work Element Number

Note

The work element number is used to organize data for estimating purposes only. It is not used for scheduling purposes. Use of master activity and construction activity numbers for scheduling purposes is discussed in NTRP 4-04.2.5/TM 3-34.42/ AFPAM 32-1020/MCRP 3-40D.6.

1.3.2 Master Activities

Master activities represent large, functional parts of a project and are based on divisions of the current version of MasterFormat, as established by the Construction Specifications Institute. This is a universal standard used throughout the private construction industry and the DOD. Figure 1-3 lists the standard master activities as assigned by the Construction Specifications Institute. The unit that initially plans the project assigns master activities, which remain with the project until completion. Estimators must obtain a master activity listing and a narrative description of the scope before starting a detailed estimate.

1.3.3 Construction Activities

Construction activities are subsets of the master activities and identify specific functional parts of the project. Project estimates are organized and formatted using these construction activities. Each construction activity description indicates a specific quantity of work, with clear, definite limitations or cut-off points readily understood by everyone concerned with the project. Refer to NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/ MCRP 3-40D.6 for information on construction activities.

Master Activity	Description	Master Activity	Description
00	Procurement and contracting	21	Fire suppression
01	General requirements	22	Plumbing
02	Existing conditions	23	Heating, ventilating, and air conditioning
03	Concrete	25	Integrated automation
04	Masonry	26	Electrical
05	Metals	27	Communications
06	Wood, plastics, and composites	28	Electronic safety and security
07	Thermal and moisture protection	31	Earthwork
08	Openings	32	Exterior improvements
09	Finishes	33	Utilities
10	Specialties	34	Transportation
11	Equipment	35	Waterway and marine construction
12	Furnishings	41	Materiel processing and handling equipment
13	Special construction	46	Water Treatment Equipment
14	Conveying systems		

Figure 1-3. Master Activities

1.3.4 Construction Work Elements

Detailed estimates use the smallest work element of a project to create the most accurate estimate. Construction work elements, also known as work items, are a construction activity further broken down into smaller parts when more detail is required for accuracy and completeness. A specific construction activity may have only one or several construction work elements. A work element is a definable item of work, usually consisting of a single trade or skill and expressed by a work rate. A work rate is a quantity of time per unit of measure. Selection of construction work elements should be taken from the data figures shown in Chapter 5. Placing a concrete grade beam, direct from chute, where the work rate is 0.480 man-hours per cubic yard of concrete is an example of a construction work element. Refer to data figures in Chapter 5 for more examples of work elements. In this publication, work element line numbers have been placed in the tables in Chapter 5 and indicated within parenthesis by each work element.

1.4 PROJECT ESTIMATE

Components of a project estimate are illustrated in Figure 1-4. A project estimate is developed using estimating procedures designed to yield a:

1. Materiel estimate (Chapter 2)

2. Equipment estimate (Chapter 3)

3. Labor estimate (Chapter 4).

Estimates initially incorporate a normal or ideal set of working conditions, unless specific limitations are known. Because all situations and production rates vary, the project crew will adjust factors from the original estimate for valid reasons as required. This is why estimators must note any assumptions and limitations about how the project is to be built to develop the estimate. This knowledge allows the project crew to adjust requirements as needed.

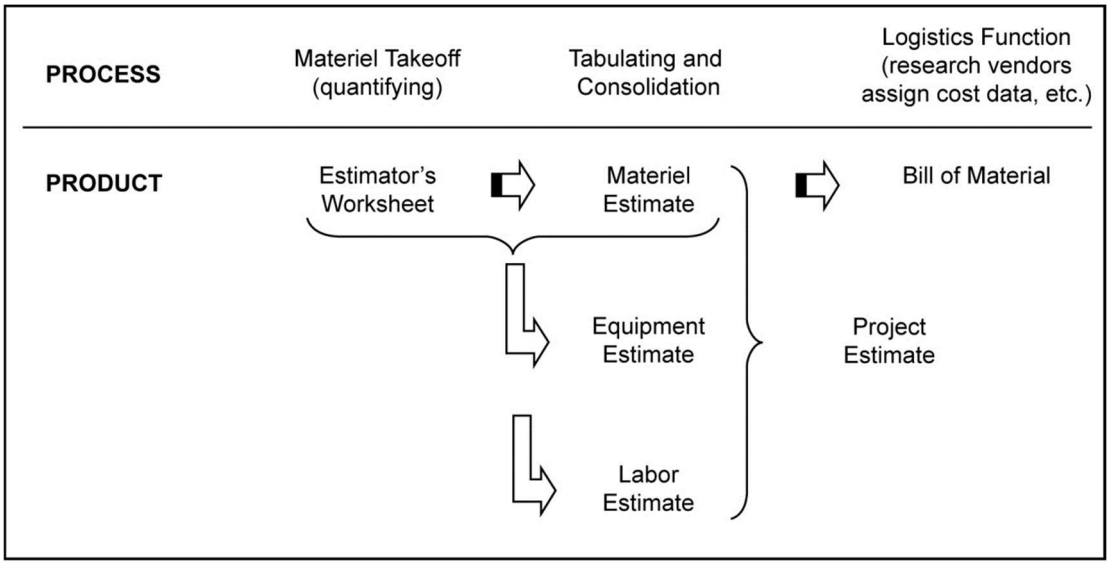

Figure 1-4. Project Estimate Process

Project estimates are developed by construction work element. The information in a project estimate is not arranged to help the actual management of a project, but to help ensure the minimum required resources of materiels, tools, equipment, and labor are identified so they can be resourced. Carelessly made estimates can jeopardize the successful completion of a project, cause uneconomical use of personnel, materiels, time, and equipment, and seriously jeopardize a tactical or strategic situation.

The major difference between project estimates done by private industry and a military engineer is that private industry's focus is on unit prices, whereas the military engineer's focus is on man-day quantity to determine labor. This does not mean that cost does not matter for the military engineer. Project crewleaders and supervisors must manage the financial aspects of a project. Man-days for the military engineer are comparable to labor costs for the private contractor. Refer to the NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/MCRP 3-40D.6 for additional information on project management.

1.4.1 Estimating by Construction Activity/Construction Work Element

Before estimators can create a detailed estimate, projects must be broken down into smaller parts so each part can be individually estimated. A clearly definable quantity of work is discussed in 1.3.4. A subset of materiel, equipment, and labor estimates is created for each construction work element.

For example to construct an 8-inch concrete masonry unit wall:

1. The materiel estimate identifies required quantities of sand, cement, lime, and 8-inch concrete masonry units. The quantity of concrete masonry units, together with information on worksheets (such as length and height of wall), is used to estimate the number of scaffold frames, scaffold boards, and special tools required.

2. The equipment estimate identifies that a mixer is required to mix the mortar.

3. The manpower estimate identifies the number of man-days required to perform the work.

1.4.2 Key Items to be Provided to Estimators

The following key items to be determined or completed at this stage in the project planning process must be provided to the estimator in order to create accurate estimates.

1. Drawings and specifications

2. Master and construction activity listing, and a narrative description of the project's scope

3. Project materiels and methods, or assumptions, noted

4. The amount and types of construction equipment available for use

5. Information about the location, local materiels, quarries, gravel pits, borrow pits, spoil areas, types of soil, haul roads and distances, foundation conditions, weather conditions to be expected during construction, and time allotted for completion

6. Availability of labor required.

1.4.3 Characteristics of a Good Estimator

The estimator must:

1. Visualize the separate operations of the job as the work would progress through the various stages of construction

2. Read, conceptualize, and obtain measurements from drawings

3. Have knowledge of mathematics, previous construction experience, and a working knowledge of all branches of construction

4. Have good judgment when determining what effect numerous factors and conditions will have on the construction of the project and what allowances should be made for each of them

5. Do accurate work and present it in a complete and organized format.

1.4.4 Standard Construction Skills

The military services have differing occupational specialties for their engineers to classify construction skills. The Navy's fleet rating system uses broad enlisted career fields to classify personnel similar to the Army's or Marine Corps' military occupational specialty (MOS) ratings. This publication uses the following broad skill categories (trade classification) and subordinate skill area terms in discussing labor estimates and crew sizes. These categories may not be all inclusive of the various service's MOSs. Refer to 5.2.3 for further information on crew and trade classification.

1. Builder. Includes the following skill areas:

   a. Bricklayer

   b. Carpenter

   c. Concrete finisher

   d. Mason

   e. Painter

   f. Plasterer

   g. Roofer.

2. Electrician. Responsible for power production and includes the following skill areas:

   a. Generators and power production

b. Power distribution

c. Interior wiring

d. Motors and control systems

e. Telephone systems.

3. Engineering services. Includes the following skill areas:

a. Draftsman

b. Surveyor

c. Quality assurance and materiel testing technician.

4. Equipment operator. Licensed operator of:

a. Automotive vehicles and trucks

b. Materiels handling equipment and weight-handling equipment

c. Pile-driving, drilling, and blasting equipment

d. Bulldozers, front-end loaders, excavators, and graders

e. Cranes

f. Rollers, graders, and asphalt paving equipment.

5. Steelworker. Includes the following skill areas:

a. Rigging and operation of special equipment used to move, hoist, and install materiels such as structural steel and structural shapes

b. Placing, fitting, welding, cutting, bolting, and riveting steel shapes and reinforcing construction materiels

c. Sheet metal work.

6. Utilitiesman. Includes the following skill areas:

a. Heating, ventilation, and air conditioning (HVAC) and refrigeration equipment

b. Compressed air

c. Water treatment and distribution systems.

CHAPTER 2
Materiel Estimates

2.1 INTRODUCTION

Materiel refers to items which physically become part of the structure and includes the supplies used to construct the project (e.g., lumber used for concrete forms). Accurate detailed materiel estimates are vital to the successful planning and execution of a project. Succeeding steps in creating equipment and labor estimates depend on the accuracy of the materiel estimate derived from a materiel takeoff, also known as a quantity takeoff. Materiel estimates are used for construction materiel procurement and as a check to determine if sufficient materiels are available to construct or complete a project.

2.2 MATERIEL ESTIMATE

The materiel estimate identifies all materiels required to construct the project and is derived using a procedure called a materiel takeoff to develop estimating worksheets for each construction work element or construction activity. Items identified by the materiel takeoff are consolidated, tabulated, and summarized as like materiel items by construction work element or construction activity, resulting in an overall materiel summary list, which becomes the materiel estimate for the project.

The materiel estimate and the estimator's worksheets are the basis for the equipment estimate and labor estimate. The materiel estimate is also used to develop the project's bill of materials (BOM). Refer to 2.4 for further information about the BOM.

2.2.1 Work Items and Materiel Items

Both work items and materiel items are identified during the development of the materiel estimate for each definable quantity of work. It is important at this stage to identify work items to allow for the application of labor estimates and/or unit prices. Definitions of the two categories are:

1. Work items are areas that require labor but do not have materiel directly tied to the labor, such as final grading or finishing concrete. These items may not appear on the plans but are still required to complete the project.

2. Materiel items are components that do have a materiel requirement or value. It is critical for the estimator to determine if English or metric system measurements will be used. This determination is based on the measurements used in the design plans and the source of materiel. If materiel is to be procured overseas and is of metric measurements, then the estimate should be developed using metric measurements.

2.2.2 The Estimating Worksheet

The estimating worksheet, as shown in Figure 2-1, is used to create the materiel takeoff and the materiel estimate. The worksheet lists the minimum data required and is a generic form used throughout the military services. UFC 3-740-05 contains standard estimating forms used by the military to present manually prepared construction cost estimates. Refer to UFC 3-740-05 for complete examples of these forms. These forms are not mandatory for use and are modified by each service based on specific requirements. Estimators should check unit standard operating procedures (SOPs) for specific guidance concerning use of forms.

Estimating worksheets are typically filled in with handwritten data. These worksheets are retained by the project crewleader for future use as a tool to ensure materiels are used as planned or to determine how the estimator arrived at a particular quantity.

Estimating Worksheet							Page___of ___
Project Location	Project Title		Project Number		BOM Number		Date Prepared
Project Section	Activity Number	Drawing Number	Prepared by			Checked by	
Description	Calculations		Quantity	Unit of Issue	Waste (%)	Total Quantity	Remarks (use, notes, local procedures, etc.)

Figure 2-1. Sample Estimating Worksheet

2.2.3 Materiel Estimate Process Steps

The following steps outline the materiel estimate process.

1. Determine the construction work elements. Study the plans and specifications, then select construction work elements. These work elements should align with the master/construction activities list provided by the project crewleader. Estimators must know or state assumptions of the resources available and methods to be used. Describe the method of construction, including sketches (as required), in the estimate to provide guidance for the project crewleader/supervisor. If the method of construction differs from the method the materiel estimate is based upon, project crewleaders will have to adjust the estimate for the difference in materiel requirement based on the different method.

2. Determine the materiels required for a given construction work element using the materiel takeoff method. Refer to 2.3 for guidelines on conducting a materiel takeoff.

3. Scale, count, and/or calculate the quantity of each item of materiel needed in the construction work element and record data on an estimating worksheet. Refer to 2.2.2 for further information on estimating worksheets. Refer to Chapter 5 for data on materiel weights and measures.

4. Determine waste allowance. Waste and loss considerations should be included, if appropriate, to each of the materiels required. Refer to 2.3, item 13, for further information on waste allowance application. Refer to Chapter 5 for data on waste allowance by materiel type. Combine the originally calculated quantity and the allowance for waste to give the total materiel required for that line item.

5. Consolidate, tabulate, and summarize materiel takeoff quantities of like materiel items by work activity to create the materiel estimate for the project.

6. Project supervisors use the completed materiel estimate to create an official BOM or conduct a BOM/materiel takeoff comparison if a BOM already exists. Refer to 2.4 for further information on materiel procurement and the BOM.

2.3 MATERIEL TAKEOFF GUIDELINES

Estimators follow guidelines that have been established for improving the speed, ease, and accuracy of the materiel takeoff process. Mistakes made in the materiel takeoff affect the reliability of the succeeding estimates. Best practice calls for two independent materiel takeoffs conducted by different estimators to be used as a check against each other. Estimators should perform the following.

1. Follow directions provided by the crewleader and project supervisor. Takeoffs must be clear and informative in order to prevent misinterpretation.

2. Thoroughly examine the drawings to ensure accurate estimates. Information found on drawings is the main basis used to define the required construction work elements and to measure quantities. All notes and references should be carefully read and all detail and reference drawings examined. Failure to read all notes and references on a drawing results in incomplete estimates. For example, an estimator may overlook a note stating that a component is symmetrical and thus compute only one-half the quantity.

3. Use specifications with the drawings to prepare the estimates for materiel, equipment, and quantity. The estimator must have working knowledge of all the requirements contained in specifications, such as unfamiliar work procedures or materiels, and the specific requirements for testing. The estimator may find it necessary to read the specifications several times to fix these requirements in mind. Notes made while reading the specifications prove helpful when the drawings are examined. Specifications often contain information required to prepare purchase requisitions. This should be used to prepare materiel lists. The wrong interpretation of a section of the specifications can cause errors in the estimate. If there is any doubt about the meaning of any portion of the specifications, the estimator should request an explanation.

4. Ensure estimating worksheets have sufficient detail and are self-explanatory. Examples of an estimating worksheet are illustrated in Figures 2-2 and 2-3; not to dictate how to record data, but to show the type and level of detail required when recording data. Estimating worksheets are typically filled in with handwritten data. Use symbols, sketches, and footnotes to clarify items. Symbols should be universally accepted construction drawing symbols or found in the legend. All computations should appear on the estimating worksheet to show how measurements were turned into materiel quantities. Any notes relative to the reuse of materiels must appear in the remarks column. It is important to be thorough and provide detailed information from plans and specifications describing the materiel item. Each line item of materiel must provide complete information necessary to procure it.

5. Identify items on a takeoff worksheet by location on the plans (i.e., sheet number and detail number/title). When items are listed on the worksheet, ensure the proper unit of issue is used. Refer to Appendix B for information on DOD standard units of issue for materiel quantities.

6. As discussed in 2.2.1, identify work items that require labor only. These items still need to have a unit of measure assigned. If a standard unit of measure does not apply, use lump sum to call attention that a cost or man-day quantity must be assigned to the work item.

7. When taking measurements, use a systematic procedure for working with plans. Consistency when working with plans is an estimator's most important consideration in creation of a materiel takeoff. A good approach is to follow the order of the actual field construction (e.g., moving from foundation to roof or moving clockwise around a drawing). Consistent practices help to avoid duplications, omissions, and errors.

8. Use checklists to help eliminate omissions from materiel estimates. The estimators should prepare a list for each individual project when examining the drawings, specifications, and construction activity/construction work elements. This is the practical way to prepare a list of the variety of materiels used in a project. The list applies only to the project for which it has been prepared. If no mistakes or omissions have been made in the checklist or estimate, the materiel estimate will contain a quantity for each item on the list. Refer to Appendix C for a comprehensive work item checklist to ensure all work items are considered during development of an estimate. Refer to Chapter 5 for estimating information and tips organized by MasterFormat division.

9. Confirm scale when taking off measurements from the plans, drawings, and details. Check for changes in scale, reduction errors caused by photocopied details, and not-to-scale details. Check for differences between specifications and drawings. Errors in scaling drawings generate incorrect quantities. Be sure that the correct measurements are recorded.

10. Use dimensions stated in the plans instead of measuring by scale, but check printed dimensions with a scale or by adding them up to identify errors. Always list dimensions in the same order (i.e., length, width, and depth or height). If it is necessary to scale dimensions, a scale rule should be used and the graphic scale on the drawings checked for expansion or shrinkage of the drawing. When there is disagreement between the plans, elevations, and details, the detail drawing is normally followed. When there is disagreement between the specifications and the drawings, the specifications are normally followed.

11. Use decimals instead of fractions. They are more precise and faster to calculate. Dimensions that are given in feet and inches are converted to decimal feet and tenths of a foot. Also, ensure consistent use of English or metric system numbers for measurements. This is especially important during overseas construction operations where the metric system is standard. Refer to Appendix D for conversion factors.

Estimating Worksheet — Page___of___

Project Location	Project Title		Project Number				BOM Number	Date Prepared
Project Section **Concrete**	Activity Number: **MA 03**	Drawing Number	Prepared by					Checked by
Description	Calculations		Quantity	Unit of Issue	Waste (%)	Total Quantity		Remarks (use, notes, local procedures, etc.)
Concrete,	Admin footings scaled from sheets S-2.1 & S-2.5:		195.19	CYD	10	215		1. Civil note from
ready-mix,	211 LF x 2.5 FT x 1.6 FT / 27 CF/CYD =	31.26 CYD						sheet C-1: All concrete
4000 psi,	Kennel footings scaled from sheets S-3.1 & S-3.5:							shall be "Type V" cement.
-3/4 inch	466 LF x 3 FT x 1.5 FT / 27 CF/CYD =	77.67 CYD						
aggregate,	Admin slab from sheet S-3.1:							2. Cast in place concrete
4 inch slump,	[(36.67 FT x 32.01 FT) + (14.67 FT x 20 FT)] x 0.417 FT / 27 CF/CYD =	22.67 CYD						S-1.1 Cement shall
0.45 water-	Kennel slab from sheets S-3.1:							be "Type II".
cement ratio	(52.67 FT x 33.34 FT) + (7.4 FT x 33.34 FT) + (52.67 FT x 16 FT) =							
	(1756.02 FT) + (246.72 FT) + (842.72 FT) =							3. Sheet S-2.1 slab note
	2845.46 x 0.417 FT / 27 CF/CYD =	43.95 CYD						Slab, 5 inches thick with
	Kennel thickened slab edge from sheets S-3.1, S-3.5, & A-28:							smooth trowel finish
	13 IN + 6 IN / 2 = 9.5 IN x 7 IN = 66.5 square inches / 144 square inches/SY =							
	0.462 SF: 0.462 x 52.5 FT x 2 / 27 CF/CYD =	1.80 CYD						4. Sheet S-3.1 slab note
	Kennel thickened edge for trench drains from sheets S-3.1 & S-3.5:							Slab, 5 inches thick with
	24 IN + 14 IN / 2 x 11 IN = 209 square inches / 144 square inches/SY =	1.45 SF;						textured trowel finish
	1.45 SF x 52.5 FT x 4 trenches / 27 CF/CYD =	11.28 CYD						
	Dog house slabs scaled from sheets S-3.1 & A-33:							
	[(2.5 FT x 0.67 FT) + (4.5 FT x 5.5 FT) x 0.67 FT x 10] / 27 CF/CYD =	6.56 CYD						

Legend: CF = cubic foot LF = linear foot
CYD = cubic yard SF = square foot
FT = foot SY = square yard
IN = inch

Figure 2-2. Sample Concrete Estimating Worksheet

Estimating Worksheet — Page___of ___

Project Location	Project Title		Project Number		BOM Number		Date Prepared	
Project Section **Sitework**	Activity Number **MA 32**	Drawing Number	Prepared by				Checked by	
Description	Calculations		Quantity	Unit of Issue	Waste (%)	Total Quantity	Remarks (use, notes, local procedures, etc.)
Asphalt concrete	Cut out Disposal asphalt concrete pavement to the extent of		699	TN	N/A	699	Requirement: Existing soil
disposal	sidewalk for administration building and 2 FT beyond kennel						subgrade under the
	perimeter fence.						foundations, slab, and
Sheet C-3	Admin = 44.5 FT x 57.5 FT =	2,558.75 SF					controlled fill shall be
	Obedience course = 154 FT x 154 FT =	23,716.00 SF					scarified to a depth of
	Kennel perimeter fence = 129 FT x 142 FT =	18,318.00 SF					6 inches and compacted
Sheet E-3, E-4	Electrical trench = duct "A" 80 FT (to fence) x 4 FT =	320.00 SF					to 95%.
	= duct "C" 15 FT x 3.29 FT =	49.35 SF					
Sheet C-3, C-9	Drainage trench = 70 FT of trench beyond perimeter fence cuts,						Sheet S-2.1, foundation
	width = 24 IN for 6 IN pipe + 6 IN on each side for asphalt repair						notes: cut/remove,
	= 70 FT x 3 FT =	210.00 SF					asphalt concrete
Sheet C-3, P-3, P-4	Sanitary trench = 122.5 FT x 3 FT =	367.50 SF					under structures and for
Sheet C-5, P-5, P-6	Water trench = 6 IN line = 25 FT x 3 FT =	75.00 SF					utility trenches.
	2-1/2 IN line = 38 FT x 1 FT wide trench + 6 IN each side for						
	asphalt repair = 38 FT x 2 FT =	76.00 SF					
	Total square feet of asphalt concrete to be removed =	**45,691.00 SF**					Asphalt concrete pavement
	Convert to CYD = 0.21 FT thick x 45,691 SF/27 CF/CYD =	355.37 CYD					spoils to be transported to
	Convert to tons of asphalt to be removed: 45,691 SF/9 SF/SY =	5076.78 SY					recycling plant 10 miles
	5076.78 SY x 2.5 IN thick x 110 LB/2000 LB/TN =	**698.06 tons**					from project site.

Legend: LB = pound
TN = ton

Figure 2-3. Sample Sitework Estimating Worksheet

12. Exercise judgment to ensure a reasonable degree of precision. Ballpark amounts are not acceptable for detailed estimates, but the estimate of materiel quantities does not have to be overly precise. Rounding to two decimal places is sufficient for most quantity takeoff purposes. Estimators develop rules consistent with measurement capabilities and learn the standards for each industry discipline. Also, some materiels are ordered in a different unit of issue than they are measured (e.g., lumber is ordered by board feet at standard commercial lengths and not in the linear quantity measured). Refer to Appendix E for information on how to calculate board foot (BF) measure and optimum lumber length requirements.

13. Add allowance for waste and loss to appropriate quantities. Allowances for waste and loss are added after the total requirement is determined. Before the waste allowance is made, the quantities are referred to as net quantities. After the waste allowance is made and added, quantities are considered gross quantities.

Failure to make the proper allowance for waste and loss of construction materiels results in incorrect estimates. Between the procurement of construction materiels and final installation, materiels are subject to waste and loss. Loss may occur during shipping, handling, or storage. Waste is inevitable where materiels are subject to cutting or final fitting prior to installation. Frequently, materiels such as lumber, conduit, or pipe have a standard issue length that is longer than required. Often, the excess is too short for use and ends as waste. Waste and loss (simply referred to as waste) factors vary, depending on the individual item, and must be checked against waste allowances.

The waste factor should reflect conditions at the work site, intended use of the materiel, and skill level of the troops working with the materiel. Waste allowance includes spillage, breakage, cutting waste, and spoilage. Refer to Chapter 5 for typical waste factors.

14. Systematically check all work, especially dimensions taken from the plans. The need for accuracy in quantity estimates requires that they be checked to eliminate as many errors as possible. One of the best ways to verify a quantity estimate is to have another person make an independent estimate and then compare the estimates after completion. Any differences should be checked and corrected.

Because of the widespread use of quantity estimates, accuracy during preparation is very important since errors tend to become larger. For example, if the estimator misreads a dimension for one side of a concrete slab as 30 feet instead of 300 feet and the other dimension was 100 feet, the quantity estimate would show 3,000 square feet instead of the actual 30,000 square feet. This quantity would then be used to order the required construction materiels (e.g., cement, sand, and reinforcing steel) and as the basis for equipment and manpower requirements. This one error would be the source of short estimates and future problems.

15. Use a standardized method of marking plans as items are taken off (e.g., use of colored pencils, highlighters, and symbols). Since most estimators have their own systems, it is a good idea to create a legend when teams of estimators are working the different drawing categories. Natural stopping points should be selected and clearly marked. Following these simple procedures will help avoid omissions and duplication.

16. Highlight and flag long lead items. Long lead items are those which are not readily available through the normal supply system, cannot be delivered to the job site in fewer than 60 days from the ordered date, or require special attention by the estimator to ensure delivery at the required time. Items that require long lead time are those which are not commercial off-the-shelf items or not available in the geographic area of the project (e.g., steam boilers, special doors, and window frames), items larger than the standard issue, and electrical transformers for power distribution systems. It is critical that these items be identified and ordered early.

2.4 MATERIEL PROCUREMENT

At this point, the effort transitions from an engineer function to a logistics function. Bills of materiels are developed from materiel, equipment, and labor estimates and represent a project's funding limits. They are the official record of line items ordered (including costs, vendors, national stock numbers if applicable, etc.) for a specific project and arranged by category (e.g., structural, electrical, and mechanical).

A BOM includes everything needed to complete the project: construction materiels, rental equipment, special tools and safety items not found in the unit's organic tools and equipment, and technical assistance or contracted services required (e.g., certification of a fire alarm system).

Project supervisors work with the unit's materiel liaison officer, in coordination with the unit's logistics officer (who manages the official project BOM), and use a variety of reports to track materiels status and project funds. The official project BOM and the reports are software program generated.

Refer to NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/MRCP 3-40D.6 for additional information on development of a BOM, conducting a BOM/materiel takeoff comparison, information on reports, and logistic procedures for materiel procurement.

CHAPTER 3
Equipment Estimates

3.1 INTRODUCTION

Construction equipment refers to the tools, instruments, machinery, civil engineering support equipment (CESE), and plant equipment required in the performance of construction work. Equipment is defined as items which are portable or mobile, ranging from small hand tools through CESE (e.g., tractors, cranes, and trucks). A construction plant is defined as a concrete batch plant, aggregate processing plant, conveying system, or any other processing plant that is erected in place at the job site and essentially stationary or fixed in place. For estimating purposes, plants and equipment are grouped together as equipment requirements. The initial equipment estimate is used to identify equipment and define labor requirements to accomplish the project. Labor estimates to support the equipment estimate are discussed in Chapter 4.

3.2 EQUIPMENT PRODUCTION ESTIMATE

An equipment production estimate is created using construction work elements, both work items and materiel items, identified in the project's materiel estimate, plus drawings, specifications, and information obtained from inspection of the site. Refer to 2.2.1 for information on work items and materiel items. The method of operation, types of equipment used, and the environmental conditions will affect the man-hours and machine-hours required to complete a given amount of work.

3.2.1 Method of Operation

The estimator needs to know what the intended method of operation is prior to selecting equipment to perform the required tasks. The project supervisor/crewleader should provide this information. If not, then the estimator must make and record assumptions. Refer to FM 5-434/MCRP 3-40D.9, Earthmoving Operations, for estimated production rates, characteristics, operation techniques, and soil considerations for earthmoving equipment.

3.2.2 Equipment Selection and Production Rate

The most important function for the estimator preparing an estimate is selecting the proper equipment to perform the required tasks. Each piece of equipment is specifically designed to perform certain mechanical tasks. Therefore, the estimator bases the equipment selection on efficient operation and availability.

The estimator should carefully consider number, size, and function of equipment to arrive at optimum equipment usage. The estimator must be familiar with construction equipment and job site conditions. The equipment selected should conform to project requirements and specifications and also be suitable for the materiels to be handled and conditions that will exist on the project.

After determining the type of equipment to be employed, the estimator selects the specific equipment size that has a production rate suited to efficient and economical performance of the work. Also known as work rate, production rate is critical in producing an accurate equipment estimate. Production rates are usually available from the manufacturer's data and/or historical military data for assigned equipment. Emphasis must be placed on the importance of establishing a reasonable production rate.

Production rate data is illustrated in various figures in Chapter 5, Division 31. Refer to FM 5-434/MCRP 3-40D.9 for additional production estimating information and samples for various types of CESE. This data may be adjusted based on the estimator's professional experience and conditions expected at the project location. In order to make this adjustment, the estimator should know on what basis the rate from the data figure was established. The production rates found in this publication apply to all construction equipment regardless of make or model. The equipment used in this publication are examples only. Information for production calculations should be

obtained from the operation and maintenance manuals for the make and model of the equipment being used. If the data illustrated in Chapter 5 is inadequate, consult other sources (e.g., other military manuals, civilian texts, experience, and unit records).

3.2.3 Environmental Conditions and Production Considerations

Equipment estimators must be familiar with the following environmental conditions and considerations that affect production:

1. Operator experience, certified training/licensing, and/or familiarity of equipment by operators must be considered when estimating equipment production. An experienced operator spreads a load of dirt with fewer passes than an inexperienced operator and does a better job of spreading. Also, inexperienced operators are more inclined to forget some of the required maintenance operations and tend to cause more equipment downtime.

2. Age and condition of equipment must be considered in estimating the number of days required to perform work. Old or poorly maintained equipment has more downtime than new equipment or equipment in good operating condition. Worn equipment also responds more slowly to the operator, has less power, and is generally less efficient. Downtime of equipment sometimes affects more than just its own operation. For example, if one of five trucks hauling dirt breaks down, it affects only its own operation, but if the equipment loading those five trucks breaks down, it stops all of the trucks, plus the equipment spreading and compacting the dirt being hauled.

3. Completion deadlines, magnitude of the job, and availability of space all drive production requirements. If crews must work extra hours, or if work must be performed under crowded conditions in order to complete the project within the allotted time, it is more efficient and productive to use smaller crews of two or more shifts per day. Remember, if CESE is worked two or more shifts per day, the equipment maintenance cycle will have to be adjusted to minimize CESE downtime.

4. Materiel consideration. The type of materiel to be handled changes the amount of time required for the work. For example, wet, sticky clay is slow to handle because it sticks to the bucket, pan, or truck bed and requires jarring and shaking to loosen and dump the load. Estimators must consider adjusting estimates for materiel weight, load factors, and soil properties (weight, loadability, moisture content, percentage of swell, and compactability). Refer to Chapter 5, Division 31, for further information.

5. Distances materiel must be moved, hauling restrictions, and permissible speeds influence the amount of time required for the work. Permissible speeds are established either by a governing authority, as in a highway or street speed limit, or by a command, such as in an operating limit on the equipment. In either case, the speed limits must be considered when estimating the average hauling speed which, in turn, determines the amount of materiel the equipment will move in 1 day. The estimator should not make the mistake of using the speed limit as the average speed at which equipment will be operated. Equipment speed usually averages 40 to 65 percent of speed limits, depending upon the condition of the road, number of intersections to be crossed, amount of traffic, and length of haul. Long hauls usually result in higher average speeds, other conditions being equal.

6. Site conditions and safety factors (e.g., congested work site, equipment capabilities, and steepness and direction of grades) limit the amount of work which can be produced with a piece of equipment. For example, although the manufacturer's crane rating may show it to be capable of lifting 40 tons with a 70-foot boom at a 45-degree angle, for reasons of safety the maximum lifting capacity of that crane may be limited to 85 percent of the manufacturer's rating. The crane can then lift only 34 tons with a 70-foot boom at a 45-degree angle. Also, certain pieces of equipment may have limited speed because of safety reasons which will reduce the rate of production.

7. Climate/weather has a considerable effect on production of equipment working outside. Rain slows down the work and frequently stops work for the remainder of the day, and sometimes for several days. In climates with considerable rainfall, equipment does not produce as much per hour or per week as in dry climates. Extremely cold weather slows down the operator and lowers the efficiency of the equipment, thus lowering production.

3.3 EQUIPMENT ESTIMATING PROCESS

Sections 3.3.1 and 3.3.2 show the process to create an equipment estimate.

3.3.1 The Estimating Worksheet

Estimators use worksheets to create the equipment estimate. The worksheet is not a standardized form with columns. It is a blank paper or engineer pad with a header listing minimum data required to organize and track the estimator's work as shown in Figure 3-1. Estimators should check the unit's SOPs for specific guidance concerning use of forms.

3.3.2 Equipment Estimate Process Steps

The following steps outline the equipment estimate process. Examples for some of the line items below are indicated by corresponding line item numbers on Figure 3-1.

1. Create a list of construction activities/construction work elements that require CESE, including both work items and materiel items identified during the materiel estimate. Study the plans and specifications to ensure familiarity with the project. Look for any work items that require CESE overlooked during the development of the materiel estimate.

2. Create an equipment estimating worksheet as described in 3.3.1 for each construction activity/construction work element.

3. Create a list of available resources and determine construction methods to be used. Remember to describe the method of construction, including sketches (as required), in the estimate to provide guidance for the project crewleader/supervisor. If the method of construction is different from the method the work rate is based upon, project crewleaders need to adjust the estimate for the new work rate.

4. Identify the task requirement quantity of materiel from the materiel estimate. This materiel estimate usually includes a waste factor. However, since the purpose here is to apply a work rate to the quantity of materiel handled, only the required amount of materiel to backfill the trench is used.

For example, if the work rate for backfilling a trench is given in terms of linear feet of trench per unit of time, and if extra fill materiel has been ordered as waste, the extra fill materiel should be omitted from this calculation. The amount of backfill to be placed in the trench is determined by the length and width of the trench rather than by the quantity of fill materiel ordered. Even if the waste allowance is used, it most likely will be used to replace lost fill materiel and thus not add to the linear feet of trench actually backfilled.

5. Select a work rate appropriate for the work item/materiel item being estimated. The work rate per day is estimated for each piece of CESE. Refer to 3.2.2 for information on how to determine work rate.

6. Divide the quantity of work by the production per day to determine how many days of equipment operation are required to perform the work. Some elements of work require several items of CESE to be used as a group rather than individually. In these cases, the days of operation should be shown as days of group operation. For example, if one front-end loader and five trucks are to be used for 10 days loading and hauling earth fill, they would be shown as one front-end loader and five trucks for 10 days, not as 10 days of front-end loading time and 50 days of truck time.

Sheet 1 __ of 2__

Estimated by: BROWN Date: 6/14/2008

Checked by: GREENE Date: 6/23/2008

EQUIPMENT ESTIMATE

Project Number: GM07-803 Project Title: CONSTRUCT BUILDING 101

Unit: NMCB FOUR Project Location: U.S. NAVAL MAGAZINE

Construction Activity Number and Description: 31 20 EARTH MOVING

Task requirement: Earth fill of 36,000 CYD loose measurement as identified in the materiel estimate. **(4)**

Assumptions based on project location and resources available: haul one way 2 1/2 miles; use a 2 1/2 CYD capacity front-end loader; and use 10 CYD capacity dump trucks.

Front-end loader work rate: 100 CYD per hour **(5)**

$$\frac{\text{36,000 CYD}}{\text{100 CYD per hour}} = \text{360 hours/8 hours per day = 45 eight-hour days } \textbf{(6)}$$

$$\frac{\text{100 CYD per hour}}{\text{10 CYD per dump truck}} = \text{10 dump trucks maximum loaded per hour}$$

Average hauling speed estimated at 15 miles per hour

Trip distance; 2 1/2 miles × 2 (both directions) = 5 miles round trip

$$\frac{\text{5 miles}}{\text{15 miles per hour}} \times \text{60 minutes per hour = 20 hauling minutes time per trip}$$

$$\frac{\text{60 minutes per hour}}{\text{10 trucks loaded per hour}} = \text{6 minutes loading time per truck}$$

Estimated dumping time per truck = 4 minutes

Total time round trip per truck: 30 minutes = 4 minutes dump time + 6 minutes load time + 20 minutes haul time

$$\frac{\text{60 minutes per hour}}{\text{30 minutes per truck round trip}} = \text{2 loads per hour per truck}$$

$$\frac{\text{10 trucks loaded per hour}}{\text{2 loads per hour per truck}} = \text{5 trucks required to keep front-end loader working at capacity}$$

100 CYD per hour × 8 hours = 800 CYD hauled per 8-hour workday

Initial equipment requirement:

One front-end loader (2 1/2 CYD capacity).
Five dump trucks (10 CYD capacity)
One bulldozer (work rate: spread 1,400 CYD daily)
One grader (to maintain haul road)
One tractor and tandem sheepfoot roller (work rate: compact 1,200 CYD daily)
One water distributor truck (for moisture control)
One rubber-tired wobbly wheel roller (on standby for compaction and sealing fill when rain is expected) (can be towed by above bulldozer or tractor)

Construction Work Element Number and Description: 31 23 01 EXCAVATION AND FILL—SITE PREPARATION

Legend: CYD = cubic yard
NMCB = naval mobile construction battalion

Figure 3-1. Sample Equipment Estimating Worksheet (Sheet 1 of 2)

Sheet 2__ of 2__

Estimated by: BROWN Date: 6/14/2008

Checked by: GREENE Date: 6/23/2008

EQUIPMENT ESTIMATE

Project Number: GM07-803 Project Title: CONSTRUCT BUILDING 101

Unit: NMCB FOUR Project Location: U.S. NAVAL MAGAZINE

Construction Activity Number and Description: 31 20 EARTH MOVING

Note: The initial requirement from page one must now be refined to accomplish a work schedule. Refinement of this estimate will also increase efficiency of equipment so it will be utilized close to full capacity. The work schedule requires completion of fill in an 18-day period. The weather at the project area is researched and an assumption is made that 3 days in every 17 working days will be lost due to rain. Therefore, 15 working days would be available for work. **(7)**

36,000 CYD = 2,400 CYD per day (The amount that must be hauled daily to complete the work on schedule)
15 working days

Task requirement: 2,400 CYD of earth fill will be hauled each day

2,400 CYD per day = 3 (This is three times the output of loading and hauling spread shown on page 1)
800 CYD hauled per 8 - hour day

Revised equipment requirement: (required to load and haul per a 15-day schedule)

Three	Front-end loaders (2 1/2 CYD capacity)
One	Bulldozer (to maintain borrow pit)
One	Grader (to maintain haul road)
15	Dump trucks (10 CYD capacity) (Recommend one or two extra trucks be added to assure that a truck will always be waiting to be loaded so that the front-end loader will work at full capacity or during breakdowns.)

2,400 CYD per day = 2 pieces of compacting equipment required.
1,200 CYD per day work rate

Two tractors and tandem sheepfoot rollers (for compaction of earth fill)

2,400 CYD per day = 2 pieces of spreading equipment required
1,400 CYD per day work rate

Two	Bulldozers (to spread earth fill)
One	Water distributor truck (for moisture control)
One	Rubber-tired wobbly wheel roller (on standby for compaction and sealing fill when rain is expected) (can be towed by above bulldozer or tractor).

Note: This refined estimate takes the work period from 45 days down to 15 days; one-third less time. Production has been tripled but equipment has not, with equipment working at or as close to capacity as possible.

Figure 3-1. Sample Equipment Estimating Worksheet (Sheet 2 of 2)

7. Consult the project schedule to find the time allotted for completion of the construction activity after determining the number of days of equipment operation required. In order to complete the work within the time scheduled, it may be necessary to work several pieces or groups of CESE at the same time. The result is a more efficient operation. Refer to Figure 3-1 (Sheet 2 of 2) for an example.

8. Develop a summation of the construction activity equipment estimates, providing a total CESE requirement for the duration of the project. Project crewleaders use the information from initial equipment estimates to develop project construction activity summary sheets, used in conjunction with equipment estimates to schedule or determine equipment, labor skill requirements, and CESE requirements and constraints. These topics fall into the category of project management. Discussion of project management is beyond the scope of this publication. Refer to NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/MCRP 3-40D.6 for additional information on project management.

3.4 MOBILIZATION AND DEMOBILIZATION CONSIDERATIONS

Estimators may need to consider time, materiel, and costs for mobilization and demobilization of equipment, especially plant equipment.

Mobilization costs for equipment include the loading cost at the point of origin; transportation costs from the point of origin to the construction site, including permits, unloading at the site, necessary assembly, and testing; and standby costs during mobilization and demobilization. Trucks capable of highway movement are usually driven to the site and are often used to transport minor items. All labor, equipment, and supply costs required to mobilize the equipment are also included in the mobilization costs. When the equipment's location is undetermined, the mobilization and demobilization distance should be based on a circular area around the project site, which will include a reasonable number of sources.

Demobilization costs should be based on that portion of equipment expected to be returned to the point of origin and may be expressed as a percentage of mobilization costs. All labor, equipment, and supply costs required for cleaning/prepping the equipment so that it is in the same condition as it was when it arrived at the site should also be included in the demobilization cost.

Mobilization and demobilization costs for plant equipment should be based on the delivered cost of the item, plus erection and dismantling costs, minus salvage value at the end of the project. Maintenance and repair are operating costs and should be distributed throughout work accomplishment.

3.5 UNIT ORGANIC EQUIPMENT LIST/SMALL TOOLS

Refer to unit organic equipment lists for specific information on the quantities and characteristics of CESE through small tools. Small power and hand tools and miscellaneous equipment and supplies not supported by a unit's organic equipment list must be identified and properly resourced.

Estimators should recognize that there may be additional equipment available at a construction site and that such equipment may be taken into consideration when making job estimates.

CHAPTER 4
Labor Estimates

4.1 INTRODUCTION

Detailed labor estimates are used to determine the number of direct labor man-days and trade skill requirements for a construction project. This initial labor estimate is a starting point for construction management and provides the minimum number of man-days and trade skills required. Man-day estimates also provide the basis to schedule labor in relation to construction progress. Only direct labor man-days are reflected in a project's labor estimate.

Project crewleaders use the information from initial labor estimates to develop a project's construction activity summary sheets. Construction activity summary sheets are used in conjunction with labor estimates to determine labor skill requirements, determine crew make-up, determine resource leveling, establish project duration, and develop Level I and Level II bar charts for scheduling purposes. A summation of construction activity labor estimates is developed providing a total labor requirement for the project. At the unit level, project man-day requirements are consolidated to provide unit tasking labor requirements. These topics fall into the category of construction management. Discussion of construction management is beyond the scope of this publication. Refer to NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/MCRP 3-40D.6 for additional information on construction management.

4.1.1 Types of Labor

It is important to distinguish between the three types of labor categories used by military engineers:

1. Direct labor. Includes all man-days expended directly on an assigned construction task, either in the field or in shops that contribute directly to the completion of the project. This does not include administrative time.

2. Indirect labor. Includes all labor required to support construction tasking that does not contribute directly to the completion of a project. An example of indirect labor is the time spent on construction management (e.g., coordinating with other crews and maintaining tools). Although necessary to the project, it does not directly contribute to the end product.

3. Overhead labor. Includes all labor not considered to be productive labor, since it does not contribute directly or indirectly to the project. It includes all labor that must be performed, regardless of the assigned mission (e.g., administrative).

4.1.2 Man-day Defined

A man-day is a unit of work performed by one person in 8 hours. It is critically important that the estimator understand this definition of a man-day. The man-day is a set standard and does not change. Man-day hours are not the same as workday hours. The number of hours for an assigned workday may change, but a man-day is always 8 hours.

4.2 LABOR ESTIMATE

The labor estimate is created using construction work elements, both work items and materiel items, identified in the project's materiel estimate. Refer to 2.2.1 for information on work items and materiel items.

Labor estimates may show only man-days for each construction activity or may be in sufficient detail to list the number of man-days of each labor category (e.g., builder, electrician, equipment operator, laborer, steelworker, and utilities worker) by each construction activity/construction work element.

Sections 4.2.1 and 4.2.2 provide information on the labor estimating process.

4.2.1 Labor Estimating Worksheet

Estimating worksheets are used to create the labor estimate. The worksheet is not a standardized form. It is a blank sheet of paper or engineer pad with a header listing minimum data required to organize and track the estimator's work, as shown in Figure 4-1. Estimators should check the unit's SOPs for specific guidance concerning use of forms. Estimating worksheets are typically filled in with handwritten data. These worksheets are retained by the project crewleader for future use as a tool to justify labor requirements.

4.2.2 Labor Estimate Process Steps

The following steps outline the labor estimate process. Examples for some of the line items below are indicated by corresponding line item numbers on Figure 4-1.

1. Direct labor requirements are broken into tasks of work. Since each task is usually performed by a labor crew (including equipment), the crew must be defined and a production rate established for the task. First, create a list of construction activities/construction work elements identified during the materiel and equipment estimates that require labor. Study the plans and specifications to ensure familiarity with the project. Look for any work items that require labor overlooked during the development of the materiel and equipment estimates.

2. Create a labor estimating worksheet as described in 4.2.1 for each construction activity and list subordinate construction work elements on the estimating worksheet. Consider available resources and methods of construction. Refer to the method of construction, including sketches, provided in the materiel and the equipment estimates. Remember, during construction, if the method of construction changes from the method the work rate is based upon, project crew leaders need to adjust the estimate with a new work rate.

3. Identify each construction activity's/construction work element's quantity of work (quantity of materiel) from the materiel and equipment estimates. Record this quantity of work and its associated unit of issue as indicated on Figure 4-1. A materiel estimate usually includes a waste factor. Since the purpose here is to apply a work rate to the quantity of materiel handled, accuracy in determining how much of the materiel will be used at the specified work rate is important. Normally, the waste factor quantity is not included in the quantity of materiel used to calculate the labor requirement.

4. Select a work rate appropriate for the work/materiel item being estimated. Refer to Chapter 5 to select, from the appropriate data figures, a work rate based on specific materiels and tasks. Work rates for labor in this publication are recorded as man-hours per unit of issue, where the unit of issue matches the quantity of work unit of issue and is based on a unit of issue of one (i.e., 0.007 man-hours/square foot), where square foot is equal to 1 square foot unless otherwise indicated. When a work rate is presented in any other form, the estimator should convert it to match the standard used in this publication. Record this work rate and indicate the source data reference as indicated on Figure 4-1. Refer to 4.3 for information on how to determine work rate and 4.4 for factors that impact labor production/work rate.

5. Convert each line item from man-hours to man-days by dividing by 8 man-hours per man-day. Record any deviations from this standard by noting changes in the column indicated on Figure 4-1. Refer to Figures 4-2 and 4-3 for fractional man-hours to decimal minute conversion data and man-day to man-hour conversion data.

6. Apply a multiplier as required to adjust production based on known circumstances. During the initial estimate a factor of one is normally used unless specifically noted in the Chapter 5 data figures and/or specific information is known about the project. Factors greater than one indicate less efficiency and add labor hours to a task; factors less than one indicate greater efficiency and provide fewer labor hours for a task.

Sheet __1__ of __1__

Estimated by: DAVIS — Date: 6/14/2008

Checked by: HOLZMAN — Date: 6/26/2008

Labor Estimate

Project Number: GM07-803 — Project Title: CONSTRUCT BUILDING 101

Unit: NMCB FOUR — Project Location: U.S. NAVAL MAGAZINE

Construction Activity Number and Description: 09 90 00 PAINTING AND COATINGS

Construction Work Element Number and Description: 09 91 13 EXTERIOR PAINTING

Construction Activity/Work Element **(2)** Number & Description (Chapter 5 Page # and Figure #)	Quantity of Work **(3)** & Unit of Issue		Man-hours **(4)** Per Unit (Work Rate)	Convert **(5)** Man-hours to Man-days		Table **(6)** Multiplier	Total **(7)** Man-days
09 97 13.23 Exterior spray painting, flat metal (Page 5-95, Figure 5-19.09-) **(4)**	6,000 SF	x	0.007 man-hours/SF	/8	x	1.0	5.25
09 91 13.62 Exterior brush painting, wood siding (Page 5-92, Figure 5-17.09-)	10,000 SF	x	0.013 man-hours/SF	/8	x	1.0	15.00
09 91 13.90 Exterior roller painting, masonry (Page 5-93, Figure 5-17.09)	100,000 SF	x	0.010 man-hours/SF	/8	x	1.0	125.00
TOTAL	116,000 SF						145.25

Figure 4-1. Sample Labor Estimating Worksheet

Fractional Man-hours	Minutes Equivalent	Fractional Man-hours	Minutes Equivalent
0.017	1	0.517	31
0.033	2	0.533	32
0.050	3	0.550	33
0.067	4	0.567	34
0.083	5	0.583	35
0.100	6	0.600	36
0.117	7	0.617	37
0.133	8	0.633	38
0.150	9	0.650	39
0.167	10	0.667	40
0.183	11	0.383	41
0.200	12	0.700	42
0.217	13	0.717	43
0.233	14	0.733	44
0.250	15	0.750	45
0.267	16	0.767	46
0.283	17	0.783	47
0.300	18	0.800	48
0.317	19	0.817	49
0.334	20	0.833	50
0.350	21	0.850	51
0.368	22	0.867	52
0.383	23	0.883	53
0.400	24	0.900	54
0.417	25	0.917	55
0.433	26	0.933	56
0.450	27	0.950	57
0.467	28	0.967	58
0.483	29	0.983	59
0.500	30	1.000	60

Figure 4-2. Fractional Man-hours to Decimal Minutes Conversion Data

Fractional Man-day	Man-hour Equivalent
0.1	0 hours 48 minutes
0.2	1 hour 36 minutes
0.3	2 hours 24 minutes
0.4	3 hours 12 minutes
0.5	4 hours 0 minutes
0.6	4 hours 48 minutes
0.7	5 hours 36 minutes
0.8	6 hours 24 minutes
0.9	7 hours 12 minutes
1.0	8 hours 0 minutes

Figure 4-3. Man-day to Man-hour Conversion Data

A multiplier must be applied to each construction activity/construction work element. A single multiplier cannot be applied to the entire job. Record this multiplier as indicated on Figure 4-1. Refer to 4.4 for factors that impact labor production/work rate and delay factors/multipliers.

7. Calculate the standard effort for each construction activity/construction work element using the following formula and record it as indicated on Figure 4-1. A summation of the construction activity labor estimates provides a total labor requirement for the project.

Note

Quantity of work divided by unit of issue size multiplied by work rate divided by 8 man-hour/man-day multiplied by multiplier equals standard effort (man-days).

4.3 PRODUCTION/WORK RATE DETERMINATION

A critical factor in producing an accurate labor estimate is determining the production/work rate. Estimating labor productivity is subject to many diverse and unpredictable factors. There is no substitute for the knowledge and experience of the estimator when estimating labor productivity. For some types of work, the task productivity of crewmembers (e.g., equipment operators) is determined by the productivity of the equipment. For some labor-based crews, the task productivity of craftsman (e.g., carpenters, steel workers, and masons) may be based on production rate data illustrated in various figures in Chapter 5.

This data may be adjusted based on the estimator's professional experience and on conditions expected at the project location. Refer to 4.4 for factors that impact labor production/work rate. In order to make this adjustment, the estimator should know how the rate from the data figure was calculated. The production rates found in this publication are based on averages of commercial manufacturers and government planning sources combined with, and adjusted to, military engineer productivity. If the data illustrated in Chapter 5 is inadequate, consult other sources (e.g., other military manuals, civilian texts, experience, and unit records). If using civilian estimating guides, refer to 5.2.2 to convert civilian production rates to an average military engineer production rate.

4.4 PRODUCTION CONSIDERATIONS

Estimators must be familiar with the following considerations and how they affect labor production/work rate. They may apply these considerations to an initial project estimate if they are aware of these specific conditions.

Often these considerations are applied to a project by the crewleader and planners during the project scheduling and crew determination process as a function of construction management. Refer to NTRP 4-04.2.5/TM 3-34.42/ AFPAM 32-1020/MCRP 3-40D.6 for additional information on construction management.

1. Workload. The time allotted for construction of the project has a definite bearing on the number of workers assigned to do the work. Rush jobs may require a crew to work long hours per day or multiple days without a day off. A worker's production per hour decreases sharply under these conditions. Sometimes it is better to increase the number of workers in a crew or work several shifts in order to complete a job quickly.

2. Project site area. The space for equipment maneuverability, storage of materiels, and job layout has a significant impact on the productivity of the crew. Site accessibility can affect labor requirements for a project. A hard-to-reach site may cause irregular delivery of materiels and time-consuming delays which use man-hours without producing results.

3. Labor. The number and size of each crew should be based on having sufficient workers to perform a task within the construction schedule and the limitations of workspace. This depends upon the skill and experience of the crewmembers performing the work, as well as certified training/licensing and/or familiarity of specific tasks by craft leaders/crewmembers. Once the crews have been developed, the task labor quantity can be determined based on the production rate of the crew.

4. Supervision. The skill and experience of the crewleader has a definitive bearing on how the crew performs.

5. Job conditions. Conditions on the job affect productivity. Low quality work requirements (e.g., rough surfaces and inexact cuts where visibility is not important) may allow for higher efficiency. Median quality requirements (e.g., temporary construction) may have average efficiency. High-visibility projects where the highest quality workmanship is required may have low efficiency production. Also, the types of materiel used may slow down the job progress significantly. Heavy wet clay is much more difficult to excavate than sandy loam or sand. Bulky or heavy materiels will require more time and equipment than light, prepackaged, easy-to-handle materiels.

6. Weather conditions. Weather conditions affect the number of man-hours required to do a job. Cold, damp climates, as well as hot, humid climates, reduce a worker's daily production and affect the output of construction equipment. Although time lost due to rain is not normally charged against a project, rain in the midst of a construction operation slows production and sometimes causes additional work, which increases the number of man-hours required to repair damages and to remove water from work areas before construction can resume. In colder climates, it is usually necessary to provide heat and protection for some parts of a project.

7. Equipment. The type of equipment available has a considerable effect on the amount of labor required to perform a certain task. Therefore, it is necessary for estimators to know what equipment will be used on a project before they can make an accurate estimate of manpower requirements.

8. Operational environment/location. An expeditionary operations project will be more labor intensive then a project in a benign, peaceful environment. Location of a job site will have tremendous impact on the progress of the project. A project in a remote location which has slow supply delivery and frequent tactical delays may rate low productivity. A project near the main camp with prompt deliveries and no tactical delay may rate high productivity.

CHAPTER 5
Estimating Data

5.1 INTRODUCTION

This chapter consists of annexes organized as divisions of work as listed in Figure 5-1. These divisions are based on the current version of MasterFormat, as discussed in 1.3.2. Each division provides estimating information and data for various construction tasks categorized in that division. Divisions having limited application for work normally performed by military engineers have been omitted. Refer to manufacturers' data or commercial publications (e.g., RSMeans Company) for further information on omitted topics. Refer to 5.2.2 for conversion factors applied to commercial publications to adapt their data for use by military engineers.

Master Activity	Description	Master Activity	Description
00	Procurement and contracting	21	Fire suppression
01	General requirements	22	Plumbing
02	Existing conditions	23	Heating, ventilating, and air conditioning
03	Concrete	25	Integrated automation
04	Masonry	26	Electrical
05	Metals	27	Communications
06	Wood, plastics, and composites	28	Electronic safety and security
07	Thermal and moisture protection	31	Earthwork
08	Openings	32	Exterior improvements
09	Finishes	33	Utilities
10	Specialties	34	Transportation
11	Equipment	35	Waterway and marine construction
12	Furnishings	41	Materiel processing and handling equipment
13	Special construction	46	Water treatment equipment
14	Conveying systems		

Figure 5-1. Divisions of Work

Data in this chapter supports general engineering operations. General engineering may be executed under combat conditions and in hostile operational environments. Data for support of combat engineering operations is beyond the scope of this publication. Refer to Appendix A for key resources and publications that also provide data for planning and estimating combat engineering operations.

5.2 HOW TO USE THE ESTIMATING DATA FIGURES

The following paragraphs discuss how to use data figures and information in this chapter to determine a reliable construction estimate. This includes instructions for the use of data figures, tips and relevant information on the circumstances under which data figures might be used, commercial data conversion factors, and information on crew sizes and trade classifications. Refer to Appendix C for an estimator's work item checklist to be used in conjunction with this chapter.

5.2.1 Figures and Data Information

Estimating data in the figures in this chapter is primarily based on information from RSMeans building construction cost data. This data was modified by military engineering subject matter experts using historical military engineering data to represent production under the range of conditions encountered in military engineering construction and at the level of training of military engineers. There are two basic categories of figures:

1. Weights and measures. Used to determine materiel quantities and equipment production factors as indicated in the appropriate figure.

2. Labor production. These figures are organized by construction work elements numbered using the current version of MasterFormat and synchronized with RSMeans (current version), Building Construction Cost Data. Labor is measured in man-hours (1 hour of labor per man) and converted to man-days as discussed in 4.1.2. The man-hour figure represents the number of man-hours required to accomplish one unit of work. The unit of work is based upon one unit of measure (e.g., 1 square foot or 1 foot). The unit of measure is indicated by an abbreviation as shown in Appendix B.

This data is not intended to establish production standards. The data must be used with sound judgment and modified as the user's experience and operational situation suggests. Man-hours/man-day figures are based upon direct labor and do not include allowances for indirect or overhead labor. Refer to 4.1.1 for information on the types of labor.

5.2.2 Commercial Data Conversion Factors

Materiel weight, measure, and equipment production figures from commercial publications may be directly applied by military engineers. Labor hours data from commercial publications may be applied for use by military engineers by using a multiplier to convert civilian labor production figures to reasonable production figures for military labor (man-hours/man-days).

Note

When civilian estimating guides are used, multiply the production rates by a factor of 1.33 through 2.00, depending on the complexity of the task in relation to the skill and training of military engineers, in order to convert to a reasonable military engineer production rate.

5.2.3 Crew and Trade Classifications Information

Minimum suggested crew size and trade classification information are provided in relevant figures. This information suggests a minimum number of personnel and skill types to safely and efficiently accomplish the work element task. Crew data in the figures in this chapter is primarily based on information from RSMeans. This data is not intended to be used as a rigid standard for crew determination. Rather, the data must be used with sound judgment and modified for the job, personnel availability, experience, training, and the operational situation. This publication uses two categories of labor:

1. Skilled. Skilled labor refers to a specific trade classification (e.g., builder, electrician, and welder). Refer to 1.4.4 for a description of trade classification/occupational construction skills used in this publication.

2. Laborer. This document uses the term laborer to refer to personnel that are unskilled within a specific occupational specialty and perform as general laborers or helpers.

CHAPTER 5 ANNEX A
Division 01
General Requirements

5.A.1 INTRODUCTION

Division 01, general requirements, is a mixture of performance and prescriptive specifications for items that do not apply directly to construction of the facility. Tasks are generally spread out over the entire project. These tasks are also referred to as project overhead, or job site overhead.

5.A.2 ESTIMATING INFORMATION AND TIPS

Estimators should review the Division 01 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable. Although Division 01 tasks are considered overhead labor, they must be planned for and resources set aside to accomplish them. Remember to account for funding of these items during BOM development.

5.A.3 ESTIMATING DATA

Figures 5-A-1 through 5-A-3 present data and guidelines for estimating items found in Division 01.

Work Element Description	Unit	Man-hours per Unit
01 51 13.80 0300 **Trailer Mounted Floodlight Set, 4 Light, Telescoping**	Each	.5
01 51 13.80 0400 **Jobsite Portolet**	Each	.5
01 54 23.70 **Scaffolding** (0010) Erect and dismantle tubular scaffold (including planks and leveling)	square foot of wall surface	0.040
Minimum suggested crew size: Scaffolding erection—three or four laborers, increase crew size for multiple tiers.		
Note: The first tier of scaffolding requires more time due to leveling and alignment procedures.		
01 54 36.00 0010 **CESE Mobilization or Demobilization**	Each	3.0
01 54 39.00 0010 **Tool Kit Inventory**	Kit	2.0
01 58 13.00 0010 **Project Sign**	Each	16.0

Figure 5-A-1. Project Mobilization and Scaffolding Production

Work Element Description	Unit	Man-hours per Unit
01 55 23.50		
Roads and Sidewalks		
(0010) Roads, gravel fill, no surfacing, 4-inch gravel depth	SY	0.090
(0020) 8-inch gravel depth	SY	0.104
(0030) Ramp, 3/4-inch plywood on 2- by 6-inch joists, 16 inches on center	SF	0.070
(0040) 2- by 10-inch joists, 16 inches on center	SF	0.077
01 56 23.10		
Barricades		
(0010) Fill and place sandbags	Each	0.0280
(0020) 5 feet high, 3 rail at 2 by 8 inches, fixed	LF	1.0640
(0030) Movable	LF	0.7090
(0040) Guardrail, wooden, 3 feet, 1 by 6 inches, on 2- by 4-inch posts	LF	0.1060
01 56 26.50		
Temporary Fencing		
(0010) Chain link, 11 gauge, 5 feet high	LF	0.053
(0020) 6 feet high	LF	0.070
(0030) Plywood, painted, 2- by 4-inch frame, 4 feet high	LF	0.237
(0040) Wire mesh on 4- by 4-inch posts, 4 feet high	LF	0.213
01 56 29.50		
Temporary Protective Walkways		
(0010) Sidewalks, 2- by 12-inch planks, two uses	SF	0.031
(0020) exterior plywood, two uses, 1/2 inch	SF	0.015
(0030) exterior plywood, two uses, 3/4 inch	SF	0.017
Minimum suggested crew size: two to four laborers.		
Legend: LF = linear foot SF = square foot SY = square yard		

Figure 5-A-2. Temporary Construction Items Production

Work Element Description	Unit	Man-hours per Unit
01 71 23		
Field Engineering		
Survey, conventional, topographical		
(0010) (level area)	SY	0.003
(0020) (hilly area)	SY	0.012
(0030) minimum	Acre	10.90
(0040) maximum	Acre	80.00
Lot location and lines, for large quantities,		
(0050) minimum	Acre	18.00
(0060) average	Acre	28.80
(0070) maximum, for small quantities	Acre	48.00
(0080) maximum, for small quantities	Each	3.750
(0090) Property lines, perimeter, cleared land	LF	0.036
(0100) Stake out clearing limits (roads/runways)	LF	0.005
Layout baseline with offset hubs at 100-foot intervals		
(0110) (level area)	Feet	0.005
(0120) (hilly area)	Feet	0.008
(0130) Set blue top at 25-foot interval	Feet	0.009
(0140) Layout bounds (building)	Each	4.50
(0150) Layout and grade pipe/culvert	Each	4.50
Minimum suggested crew size: One chief of party One instrument person One to two rodman/chainman		
Notes: 1. This data provides information needed to compute the time required to survey a parcel or to perform the layout for a construction project. 2. 1 acre = 43,560 SF.		

Figure 5-A-3. Field Engineering Data Production

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CHAPTER 5 ANNEX B
Division 02
Existing Conditions

5.B.1 INTRODUCTION

Division 02, existing conditions, includes site demolition and remediation, building relocation, site surveys, and geotechnical investigations. The scope of work included in demolition can range from the removal of a window to the complete dismantling and removal of existing structures.

5.B.2 ESTIMATING INFORMATION AND TIPS

Estimators must assess the particular project and determine if the takeoff should be performed by the piece, square foot, cubic foot, or whole unit. Review the Division 02 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable.

5.B.3 ESTIMATING DATA

Figures 5-B-1 through 5-B-3 present data and guidelines for estimating items found in Division 02.

Work Element Description	Unit	Man-hours per Unit
02 41 13.17 **Demolish, Remove Pavement and Curb**		
(0010) Pavement removal, bituminous roads, 4–6	SY	0.1260
(0020) Concrete to 6 inches thick, hydraulic hammer, mesh reinforced	SY	0.2090
(0030) Concrete to 6 inches thick, rod reinforced	SY	0.2660
(0040) Concrete, 7 to 24 inches thick, rod reinforced	CYD	2.2170
(0050) Curbs, concrete, plain	LF	0.0890
(0060) Curbs, concrete, reinforced	LF	0.1160
(0070) Curbs, bituminous	LF	0.0600
02 41 13.33 **Minor Site Demolition**		
(0010) Guiderail, corrugated steel, remove only	LF	0.320
(0020) Guiderail, corrugated steel, remove and reset	LF	0.800
(0030) Median barrier, precast concrete, remove and store	LF	0.150
(0040) Median barrier, precast concrete, remove and reset	LF	0.164
(0050) Railroad track removal, ties and track	LF	0.230
(0060) Ballast	CYD	0.128
(0070) remove and re-install, ties and track, new bolts and spikes	LF	1.277
(0080) Sidewalk removal, bituminous, 2 1/2 inches thick	SY	0.098
(0090) concrete, plain, 4 inches thick	SY	0.200
(0100) meshed reinforced	SY	0.213

Figure 5-B-1. Site Demolition (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
02 41 13.60	Foot	0.049
Fencing, Selective Demolish		
(0010) Fencing, barbed wire, 3 strand		
(0020) Fencing, barbed wire, 5 strand	LF	0.076
(0030) Chain link, posts and fabric, 8 to 10 feet high, remove only	LF	0.072
(0040) Chain link, posts and fabric, 8 to 10 feet high, remove and reset	LF	0.456

Figure 5-B-1. Site Demolition (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
02 41 16.17		
Building Demolition Footings and Foundations		
(0010) Concrete foundations	CYD	5.000
(0020) Concrete walls	CYD	6.000
(0030) Concrete slabs on grade with no reinforcing	CYD	4.000
(0040) Concrete slabs on grade with wire mesh reinforcing	CYD	4.000
(0050) Concrete slabs on grade with rebar and mesh reinforcing	CYD	6.000
02 41 19.16		
Selective Demolition, Cutout		
(0010) Ceilings, sheetrock	SF	0.024
(0020) Ceilings, suspended acoustic	SF	0.024
(0030) Doors and frames, wood 3 by 7 feet	Each	0.550
(0040) Doors and frames, steel 3 by 7 feet	Each	0.730
(0050) Flooring, ceramic or quarry tile	SF	0.050
(0060) Flooring, resilient tile	SF	0.040
(0070) Flooring, wood floor finish	SF	0.060
(0080) Flooring, wood subfloor	SF	0.030
(0090) Framing, steel	LF of wall	0.240
(0100) Framing, wood	LF of wall	0.072
(0110) Wallboard, gypsum	SF	0.030
(0120) Wallboard, plywood	SF	0.030
(0130) Roofing, corrugated	SF	0.030
(0140) Roofing, buildup five-ply	SF	0.030
(0150) Windows, metal	SF	0.096
(0160) Windows, wood	SF	0.100

Figure 5-B-2. Structure Demolition Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
02 41 19.23 B-1		
Selective Demolition, Rubbish Handling		
(0010) Chute, circular, prefabricated steel, 18-inch diameter	LF	0.798
(0020) 30-inch diameter	LF	1.064
(0030) Dust partition, 6 mil polyethylene, 2- by 4-inch frame (two builders)	SF	1.064
(0040) Rubbish disposal up to 5 miles	CYD	1.500
02 41 19.27		
Selective Demolition, Torch Cutting		
(0010) Steel, 1-inch-thick plate	LF	0.030
(0020) 1-inch-diameter bar	Each	0.050
Oxygen lance cutting, reinforced concrete walls,		
(0030) 12- to 16-inch-thick walls	LF	1.064
Crew sizes are dictated by safety, scope of the project, weight, and bulk of materiels handled.		
Notes: 1. Work includes removal of item and stacking or piling onsite for removal at ground level. 2. Second floor or upper story work includes dumping into rubbish chutes. 3. Concrete demolition is figured on using pneumatic tools with average crew of two tool operators and three to five laborers. 4. Work includes salvage of materiels (e.g., cleaning and pulling nails).		

Figure 5-B-2. Structure Demolition Production (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
02 58 13.10		
Snow Fencing System		
(0010) Snow fence on steel posts 10 feet on center, 4 feet high	LF	0.064

Figure 5-B-3. Snow Fencing Production

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CHAPTER 5 ANNEX C

Division 03

Concrete

5.C.1 INTRODUCTION

Division 03, concrete, includes formwork and accessories, reinforcing, cast-in-place, precast concrete, and concrete materiels and placement.

5.C.2 ESTIMATING INFORMATION AND TIPS

Be sure to review all drawing categories for use of concrete. Ensure alignment between specifications and drawings. Review the Division 03 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable. Refer to TM 3-34.44/FM 5-428/MCRP 3-40D.4, Concrete and Masonry, for further information on physical characteristics, properties, and ingredients of concrete; mixtures, design, and construction of forms; and reinforced concrete and field construction procedures. The following estimating tips are provided.

1. Labor for forming. Labor required for forming includes fabrication; handling into place; erection and oiling; installing form ties, tie wire, struts, chamfer strips, and screed guides; bracing and shoring; erecting runways and scaffolds; and checking forms during placement of concrete. Stripping includes removing, cleaning, and reconditioning forms. Forming is usually computed in square feet of contact surface, which is the area of concrete in direct contact with forms or in linear feet of form length required. Screed guides should be computed as the equivalent form length of an edge form.

2. Labor for reinforced concrete. Concrete is reinforced with steel bars or with welded steel wire mesh that is used for reinforcing slabs, gunite, and precast concrete. In some applications, wire mesh and bars are used in combination for reinforcing. Some tables show both bars and mesh, so that the appropriate man-hours per unit may be used. Reinforcing steel is computed in tons of bars. Reinforcing mesh is computed in square feet of the area. Labor for reinforcing steel includes handling into place, tying, supporting, and any cutting that becomes necessary at the site, such as cutting around embedded materiels or cutting stock lengths of straight bars to fit slab dimensions. Labor for wire mesh reinforcing includes handling into place, cutting to fit, tying at overlaps, and pulling up into position during placement of concrete.

3. Labor for mixing concrete. Sometimes, concrete must be mixed at the job site rather than being delivered in transit mix trucks. Labor for mixing concrete at the jobsite includes loading, measuring, wheeling, and dumping aggregates and cement into the mixer; bringing water to the mixer by truck, hose, pipe, or pump; and operating the mixer.

4. Labor for placing concrete. Handling from the mixer or transit mixer truck to the final position is included in placing concrete. This includes hoisting, spreading, vibrating, and screeding the concrete to grade.

5. Labor for finishing concrete. Concrete finishing includes floating, troweling, tooling slabs, and filling voids and honeycombs. Pointing and patching includes patching tie holes and removing fins.

6. Labor for curing concrete. The term curing includes covering surfaces with curing compound, sand, paper, tarpaulins, burlap, or straw, and keeping as wet as required.

7. Fine grading process. The process of fine grading includes bringing in fill or removing excess earth, spreading, leveling, compacting, and sprinkling when necessary.

8. Vapor barrier placement. The process of placing vapor barrier includes handling and placement, cutting to fit, smoothing as necessary, and sealing the joints.

9. Expansion joints. Placing premolded expansion joints includes handling into place, cutting to fit, placing, and fastening to hold in position until the concrete is placed. Labor for placing poured expansion joints includes cleaning the joints of foreign matter, handling materiel to the melting pot, melting, handling to the joints, pouring the joints, and dusting.

10. Cold weather protection. Several methods are available to provide cold weather protection for concrete. These include covering the concrete with sand, straw, or paper; heating the mixing water and aggregate; building enclosures; and operating heaters.

5.C.3 ESTIMATING DATA

Figures 5-C-1 through 5-C-15 present data and guidelines for estimating items found in Division 03.

Bar Number (Inches)	Nominal Weight		Diameter		Cross Sectional Area		Perimeter	
	Pounds per Foot	Kilograms per Meter	Inches	Millimeters	Square Inches	Square Centimeters	Inches	Millimeters
#3 (3/8)	0.376	0.560	0.375	9.52	0.11	0.71	1.178	29.9
#4 (1/2)	0.668	0.994	0.500	12.70	0.20	1.29	1.571	39.9
#5 (5/8)	1.043	1.552	0.625	15.88	0.31	2.00	1.963	49.9
#6 (3/4)	1.502	2.235	0.750	19.05	0.44	2.84	2.356	59.8
#7 (7/8)	2.044	3.042	0.875	22.22	0.60	3.87	2.749	69.8
#8 (1)	2.670	3.973	1.000	25.40	0.79	5.10	3.142	79.8
#9 (1 1/8)	3.400	5.059	1.128	28.65	1.00	6.45	3.544	90.0
#10 (1 1/4)	4.303	6.403	1.270	32.26	1.27	8.19	3.990	101.4
#11 (1 3/8)	5.313	7.906	1.410	35.81	1.56	10.06	4.430	112.5
#14 (1 3/4)	7.650	11.384	1.693	43.00	2.25	14.52	5.320	135.1
#18 (2 1/4)	13.600	20.238	2.257	57.33	4.00	25.81	7.090	180.1

Notes:
1. This figure provides specifications, sizes, and weights of reinforcing steel bars used for concrete reinforcement.
2. The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight per foot as the deformed bar.
3. Bar numbers are based on the number of eighths of an inch in the nominal diameter of the bars.
4. Refer to drawings and specifications for splicing requirements. If no guidance is given, use the following formula: splicing is equal to 32 times diameter, or a minimum of 24 inches per splice, or whichever is greater.

Figure 5-C-1. Reinforcing Steel Bars Weights and Measures

Type	New Designation	Steel Area per Foot				Weight		
	Spacing—Cross Section Area	Longitudinal		Transverse		Per 100 Square Feet		Kilograms per Square Meter
	(Inches—Square Inch 100)	Inches	Centimeters	Inches	Centimeters	Pounds	Kilograms	
Rolls	6 × 6—W1.4 × W1.4	0.028	0.071	0.028	0.071	21	9.53	1.026
	6 × 6—W2.0 × W2.0	0.040	0.102	0.040	0.102	29	13.15	1.466
	6 × 6—W2.9 × W2.9	0.058	0.147	0.053	0.147	42	19.05	2.053
	6 × 6—W4.0 × W4.0	0.080	0.203	0.080	0.203	58	26.31	2.834
	4 × 4—W1.4 × W1.4	0.042	0.107	0.042	0.107	31	14.06	1.515
	4 × 4—W2.0 × W2.0	0.060	0.152	0.060	0.152	43	19.50	2.150
	4 × 4—W2.9 × W2.9	0.087	0.221	0.087	0.221	62	28.12	2.981
	4 × 4—W4.0 × W4.0	0.120	0.305	0.120	0.305	85	38.56	4.154
Sheets	6 × 6—W2.9 × W2.9	0.058	0.147	0.058	0.147	42	19.05	2
	6 × 6—W4.0 × W4.0	0.080	0.203	0.080	0.203	58	26.31	2.73
	6 × 6—W5.5 × W5.5	0.110	0.279	0.110	0.279	80	36.36	3.72
	6 × 6—W4.0 × W4.0	0.120	0.305	0.120	0.305	85	38.63	3.59
Note: This figure provides specifications, sizes, and weights of welded wire fabric used for reinforcement.								

Figure 5-C-2. Reinforcing Steel Welded Wire Fabric Weights and Measures

Specified Compressive Strength	Maximum Absolute Permissible Water-Cement Ratio by Weight	
Pounds per Square Inch	Nonair-Entrained Concrete	Air-Entrained Concrete
2,500	0.67	0.54
3,000	0.58	0.46
3,500	0.51	0.40
4,000	0.44	0.35
4,500	0.38	see Note 2
5,000	see Note 2	see Note 2

Notes:

1. Specified compressive strength is designed to be achieved at 28 days. The water-cement ratios presented will provide average strengths that are greater than the specified strengths.
2. For strength above 4,500 pounds per square inch for nonair-entrained concrete, and 4,000 pounds per square inch for air-entrained concrete, proportions should be established by the trial-batch method. Refer to TM 3-34.44/FM 5-428/MCRP 3-40D.4 for further information.

Figure 5-C-3. Maximum Permissible Water-Cement Ratio for Concrete

Concrete (CYD)	Mix 1, 1:1:1-3/4			Mix 2, 1:2:2-1/4			Mix 3, 1:2-1/4:3			Mix 4, 1:3:4		
	Cement (94-LB Sack)	Sand (CYD)	Stone (CYD)	Cement (94-LB Sack)	Sand (CYD)	Stone (CYD)	Cement (94-LB Sack)	Sand (CYD)	Stone (CYD)	Cement (94-LB Sack)	Sand (CYD)	Stone (CYD)
1	10	0.37	0.63	7.75	0.56	0.65	6.25	0.52	0.70	5	0.56	0.74
2	20	0.74	1.26	15.50	1.12	1.30	12.50	1.04	1.40	10	1.12	1.48
3	30	1.11	1.89	23.25	1.68	1.95	18.75	1.56	2.10	15	1.68	2.22
4	40	1.48	2.52	31.00	2.24	2.60	25.00	2.08	2.80	20	2.24	2.96
5	50	1.85	3.15	38.75	2.80	3.25	31.25	2.60	3.50	25	2.80	3.70
6	60	2.22	3.78	46.50	3.36	3.90	37.50	3.12	4.20	30	3.36	4.44
7	70	2.59	4.41	54.25	3.92	4.55	43.75	3.64	4.90	35	3.92	5.18
8	80	2.96	5.04	62.00	4.48	5.20	50.00	4.16	5.60	40	4.48	5.92
9	90	3.33	5.67	69.75	5.04	5.85	56.25	4.68	6.30	45	5.04	6.66
10	100	3.70	6.30	77.50	5.60	6.50	62.50	5.20	7.00	50	5.60	7.40
20	200	7.40	12.60	155.00	11.20	13.00	125.00	10.40	14.00	100	11.20	14.80

Notes

1. The following notes are to be used for estimating quantities of materiel needed for concrete mixing. Refer to TM 3-34.44/FM 5-428/MCRP 3-40D.4 for further information on concrete designs and mixing procedures.
2. To calculate volumes of cement, sand, and gravel for mix design not presented; use the “Rule of 42.” To mix approximately 1 CYD of 1:2:4 concrete, add the numbers of the mix design together 1 + 2 + 4 = 7.

   Then divide 42 by the mix design summation of 7, which equals 6. This means it will take 6 parts per CF of materiel. For example:

   Cement 1 × 6 = 6 CF or 6 sacks of cement

   Sand 2 × 6 = 12 CF or 0.45 CYD of sand

   Stone 4 × 6 = 24 CF or 0.89 CYD of stone

   Total dry mix 42 CF will produce 1 CYD of concrete
3. “Rule of 42” is used when the size of the coarse aggregate is not over 2 1/2 inches. “Rule of 41” is used to calculate the quantities of materiel for concrete when the size of the coarse aggregate is not over 1 inch.
4. A waste factor is added in ordering materiels for jobs; 5 percent of materiels is added for jobs requiring 200 or more CDs of concrete, and 10 percent is added for smaller jobs.
5. The amount of water to be used is calculated by the specified water-cement ratio of numbered gallons of water to each bag of cement. A water-cement ratio is applied to a mix design to achieve a desired compressive strength and workability of the concrete. The amount of water (moisture content) of the sand and stone aggregates must be determined prior to adding water to ensure the water-cement ratio is accurate. The most important factor controlling the strength of concrete is the water-cement ratio, or the proportion of water to cement in the mix.

Legend: CF = cubic foot
CYD = cubic yard
LB = pound

Figure 5-C-4. Concrete Mix Design Materiel Quantities

Slab Thickness (Inches)	CF of Concrete Required per SF of Slab	Slab Area Coverage SF per CYD
2	0.167	162
3	0.250	108
4	0.333	81
5	0.417	65
6	0.500	54

Figure 5-C-5. Concrete Requirements for Slabs

Concrete Required per 100 SF of Given Thickness		
Thickness (Inches)	CF	CYD
4	33.3	1.24
6	50.0	1.85
8	66.7	2.47
10	83.3	3.90
12	100.0	3.70

Figure 5-C-6. Concrete Requirements for 100 Square Feet

Work Element Description	Unit	Man-hours per Unit			
		Fabricate	Erect and Strip	Clean and Move	Total Hours (1 Use)
03 11 13.20					
Beams and Girders, Forms in Place					
Exterior spandrel, plywood, one use					
(0010) 12-inch width	SF of contact surface	0.113	0.147	0.023	0.283
(0020) 18-inch width		0.102	0.133	0.020	0.255
(0030) 24-inch width		0.096	0.126	0.019	0.241
Interior beam, plywood, one use					
(0040) 12-inch width		0.085	0.111	0.017	0.213
(0050) 24-inch width		0.080	0.104	0.016	0.200
03 11 13.25					
Columns, Forms in Place					
Round fiber tube, recycled paper, one use					
(0010) 8-inch diameter	LF	*	0.274	*	0.274
(0020) 10-inch diameter	LF	*	0.274	*	0.274
(0030) 12-inch diameter	LF	*	0.283	*	0.283
(0040) 14-inch diameter	LF	*	0.294	*	0.294
(0050) 16-inch diameter	LF	*	0.304	*	0.304
Plywood (job-built), one use					
(0060) 8 by 8 inches	SF of contact surface	0.092	0.150	0.016	0.258
(0070) 12 by 12 inches		0.085	0.137	0.015	0.237
(0080) 16 by 16 inches		0.083	0.133	0.014	0.230
(0090) 24 by 24 inches		0.080	0.130	0.013	0.223
03 11 13.30 Culvert, Forms in Place	SF of contact surface				
(0010) 5 to 8 foot square or rectangular		*	*	*	0.250

Figure 5-C-7. Forms in Place for Concrete Production (Sheet 1 of 3)

Work Element Description	Unit	Man-hours per Unit			
		Fabricate	Erect and Strip	Clean and Move	Total Hours (1 Use)
03 11 13.35					
Elevated Slabs (Overhead)					
(0010) Flat plate, job-built, to 15 feet high	SF	0.049	0.087	0.020	0.156
(0020) Box out for slab openings	SF of contact surface	0.107	0.192	0.037	0.336
(0030) Bulkhead forms for slab	LF	0.041	0.072	0.014	0.127
(0040) Slab bulkhead form, 4 1/2 inches high	LF	0.011	0.021	0.004	0.036
(0050) Curb forms, wood, 6 to 12 inches high	SF of contact surface	0.076	0.135	0.026	0.237
(0060) Edge forms to 6 inches high	LF	0.027	0.049	0.009	0.085
(0070) Perimeter deck and rail	LF	0.151	0.270	0.052	0.473
03 11 13.45					
Footings, Forms in Place					
(0010) Continuous wall, plywood, one use	SF of contact surface	0.046	0.046	0.021	0.113
(0020) Dowel supports for footings or beams	LF	*	*	*	0.085
(0030) Keyway, tapered wood 2 by 4 inches	LF	*	*	*	0.020
(0040) Pile cap, square or rectangular, job built plywood, one use	SF of contact surface	*	*	*	0.146
(0050) Spread footing, job-built lumber	SF of contact surface	0.057	0.057	0.026	0.140
Support for dowels, plinths, or templates					
(0060) 2 by 2 feet, footing	Each	*	*	*	1.702
(0070) 4 by 4 feet, footing	Each	*	*	*	1.935
(0080) Plinths, job-built plywood	SF of contact surface	*	*	*	0.170
03 11 13.50					
Grade beam, Forms in Place	SF of contact surface	0.034	0.072	0.016	0.122
(0010) Job-built plywood, one use					
03 11 13.65					
Slab on grade, Forms in Place					
(0010) Bulkhead forms with keyway, wood, 6 inches high, one use	LF	0.025	0.051	0.008	0.084
(0020) Curb forms, wood 6 to 12 inches high, on grade, one use	SF of contact surface	0.263	0.119	0.020	0.402
(0030) Edge forms, wood, on grade to 6 inches high					
(0040) 7 to 12 inches high	LF	0.021	0.043	0.007	0.071
(0050) for depressed slabs, to 12 inches high	SF of contact surface	0.029	0.059	0.010	0.098
(0060) from 12 to 24 inches high					
	LF	0.043	0.085	0.014	0.142
	LF	0.073	0.146	0.024	0.243

Figure 5-C-7. Forms in Place for Concrete Production (Sheet 2 of 3)

Work Element Description	Unit	Man-hours Per Unit			
		Fabricate	Erect and Strip	Clean and Move	Total Hours (1 Use)
03 11 23.75 (0010) **Stairs, Forms in Place**	SF	----------0.55 Complete----------			
03 11 13.85 **Walls, Forms in Place**					
(0010) Wall, job-built plywood, to 8 feet	SF of contact surface	0.066	0.087	0.021	0.173
(0020) Wall, over 8 to 16 feet high		0.086	0.114	0.027	0.227
Minimum suggested crew size: Forming/stripping—five laborers. Forming/stripping (gang forms)—five laborers, two equipment operators.					
Notes: 1. The following notes are to be used for estimating labor to fabricate and erect forms. Refer to TM 3-34.44/FM 5-428/MCRP 3-40D.4 for information on concrete form design and materiel estimating procedures. 2. Concrete forming estimates are based on using form accessories, form ties, and steel column clamps. 3. Suspended slabs, beams, and girders are figures using 4- by 4-inch shores and wooden wedges. For adjustable shores, use a 0.9 multiplier. 4. Forming walls over 10 feet high and other high work will increase erection time. To compensate, use a 1.1–1.5 multiplier depending on job complexity.					

Figure 5-C-7. Forms in Place for Concrete Production (Sheet 3 of 3)

Application	Unit	Man-hours per Unit
03 15 05.02 **Anchor Bolts**		
J-type, plain, including nut and washer,		
(0010) 1/2-inch diameter 6 to 12 inches long, average	Each	0.125
(0020) 5/8-inch diameter 12 to 24 inches long, average	Each	0.154
(0030) 3/4-inch diameter 8 to 24 inches long, average	Each	0.173
(0040) 7/8-inch diameter 12 to 24 inches long, average	Each	0.219
03 15 05.12 **Chamfer Strips**		
(0010) Wood, 1/2 to 1 inch wide, average	LF	0.021
03 15 05.25 **Expansion Joints**		
(0010) Pre-molded, bituminous fiber, 1/2 by 6 inches	LF	0.028
(0020) 1 by 12 inches	LF	0.036
(0030) Polyethylene, backer rod, 3/8- to 1-inch diameter	LF	0.023
03 15 05.35 **Inserts**		
(0010) Slotted nut type for 3/4-inch bolts, up to 8 inches long also average for other types of inserts	Each	0.123
03 15 05.75 **Sleeves and Chases**		
(0010) Plastic, one use, 9 inches long, 2-inch diameter	Each	0.106
(0020) 4-inch diameter	Each	0.118
(0030) 6-inch diameter	Each	0.142
(0040) 12-inch diameter	Each	0.177

Figure 5-C-8. Placing Concrete Forming Accessories Production

Work Element Description	Unit	Man-hours per Unit
03 15 05.96		
Concrete Forming Accessories, Miscellaneous Items		
(0010) Acid wash (walls)	SF	0.02
(0020) Architectural concrete: patched, honed, sack rubbed	SF	0.08
(0030) Carborundum rub	SF	0.04
(0040) Ceiling inserts	Each	0.06
Concrete cutting		
(0050) Existing 2-inch-deep cut	LF	0.08
(0060) Existing 4-inch-deep cut	LF	0.12
(0070) Green 2-inch-deep cut	LF	0.05
(0080) Green 4-inch-deep cut	LF	0.08
Concrete core drilling		
(0090) Slab vertical - 3-inch diameter by 6 inches thick	Each	2.00
(0100) Wall horizontal - 4-inch diameter by 8 inches thick	Each	2.50
(0110) Curb angles	LF	0.16
(0120) Dovetail anchor slots	LF	0.023
(0130) Floor hardeners (magnesium fluosilicate) one coat	SF	0.01
(0140) Grout, nonshrink, under steel plate, 1 inch	SF	1.00
(0150) Patch tie holes (walls)	Each	0.05
(0160) Pickup and brace inserts	Each	0.064
(0170) Poured expansion joint 1/2 by 1/2 inch	Feet	0.04
(0180) Premolded expansion joint	Feet	0.04
(0190) Reglets (metal or polyvinyl chloride (PVC))	Feet	0.10
(0200) Silicon waterproofing	SF	0.01
(0210) Steel base plates 12 by 14 by 1/2 inches	Each	1.00
(0220) Vapor barrier, polyethylene	SF	.002
(0230) Water stops (PVC dumbbells or copper)	Feet	0.04
(0240) Gravel under floor slab 6" deep compacted	SF	.01

Notes:

1. Tables are for installation only and do not include fabrication time.
2. Premolded expansion joint figure is based on materiel 1/2-inch thick and of sufficient width to extend the required depth. Use a 1.15 multiplier for 1-inch materiel.
3. Concrete sawing is based on 4,000 feet-per-inch blade life, which reduces in proportion to depth.
4. Core drilling labor varies if slabs or walls are heavily reinforced with 3/4- to 1 1/2-inch rebar or if holes are widely spaced.

Figure 5-C-9. Concrete Forming Accessories Miscellaneous Items Production

Bar Size (# = Number)			By Hand	By Machine
	Hours/Bend	Hours/Hook	Hours/Bend	Hours/Hook
03 21 10.10 Reinforcing Steel Fabrication				
#4 or less	(0010) 0.04	(0020) 0.06	(0030) 0.015	(0040) 0.025
#5 to #7	(0050) 0.05	(0060) 0.08	(0070) 0.020	(0080) 0.030
#8 and #9	(0090) 0.06	(0100) 0.10	(0110) 0.025	(0120) 0.040
#10 to #14	(0130) 0.07	(0140) 0.12	(0150) 0.030	(0160) 0.050
Minimum suggested crew size: one skilled worker and one laborer.				
Notes: 1. This figure provides man-hours required for making one bend or hook in reinforcing steel bars. 2. Reinforcing steel fabrication includes cutting, banding, and tagging. Assembly and tying into mats and beams in the shop are also included.				

Figure 5-C-10. Reinforcing Steel Fabrication Production

Application	Unit	Man-hours per Unit
03 22 05.50 Welded Wire Fabric		
Sheets (0010) 58 pounds per 100 SF (0020) 85 pounds per 100 SF Slab on grade, concrete paving, precast roof panels, etc.	 SF SF	 0.008 0.009
Rolls (0030) Gunite reinforcement, beam and column wrap.	SF	0.033
Minimum suggested crew size: two skilled laborers.		
Notes: 1. Welded wire fabric is taken off by SF. It is manufactured in sheets and rolls. Rolls are 250 feet long by 5 feet wide, and flat sheets are 5 by 10 feet. Refer to Figure 5-C-2 for specifications, sizes, and weights of welded wire fabric. 2. The estimator should list separately the different sizes required. If specifications don't specify an overlap, add 10 percent for overlap and waste.		

Figure 5-C-11. Placing Reinforcing Steel Welded Wire Fabric Production

Application Reinforcing Bar Size (# = Number)	Unit	Man-hours per Unit
03 21 10.60 **Reinforcing in Place**		
Beams and girders		
(0010) #3 to #7	Ton	26.60
(0020) #8 to #18	Ton	15.76
Columns		
(0030) #3 to #7	Ton	28.37
(0040) #8 to #18	Ton	18.51
Footings		
(0050) #4 to #7	Ton	20.27
(0060) #8 to #18	Ton	11.82
Slab on grade (0070) #3 to #7	Ton	18.50
Walls		
(0080) #3 to #7	Ton	14.19
(0090) #8 to #18	Ton	10.64
Dowels		
(0100) 2 feet long, deformed, #3–#6	Each	0.041
(0110) 12 inches long, smooth, #3	Each	0.152
Minimum suggested crew size: four skilled laborers.		

Notes:

1. Reinforcing bar is taken off by LF and converted to pounds or, for large quantities, tons. Reinforcing bar is available in stock lengths of 20 feet. Refer to Figure 5-C-1 for sizes and weights of reinforcing bar.
2. The estimator should list separately each size (by bar designation) and shape required. If specifications and drawings don't specify an overlap, the bars should be lapped not fewer than 32 times the bar diameter, or not less than 24 inches. Add 10 percent for overlap and waste.
3. Placement of reinforcing steel includes handling into place, tying, supporting, and any cutting which becomes necessary at the site, such as cutting around imbedded items or cutting stock lengths of straight bars to fit slab dimensions.
4. Man-hour estimates are based on all reinforcing steel being shop fabricated (cut to length and bent ready to place in the structure).
5. If reinforcing steel is to be welded in place, use a 1.5 multiplier.
6. Order three 4-pound rolls of the wire for each ton of rebar (16-gauge black annealed wire).

Figure 5-C-12. Placing Reinforcing Steel Bars Production

Work Element Description	Unit	Man-hours per Unit
03 30 53.10		
Mixing Concrete		
Hand mixing onsite:		
(0010) two boards or boats	CYD	3.20
Machine mixing onsite:		
(0020) 16 CF capacity	CYD	1.60
(0030) 11 CF capacity	CYD	2.70
Tailor to 1 CF of capacity		
Transit mix truck (8 CYD capacity)	CYD	0.56
Minimum suggested crew size: Refer to the following notes.		

Notes:

1. This data provides information needed to compute the time required to survey a parcel or to perform the layout for a construction project.
2. Hand mixing using two boards eliminates waiting for a batch to be mixed before dry charging the mixing board, as the mixers alternate boards. With twelve men, the maximum output is about 8 CYD per day.
3. Warm weather (90 to 100 degrees) will slow mixing time and add 0.5 man-hours per CYD.
4. Labor to charge a mixer can be reduced by the use of a small front-end loader, but at least one man must remain on each aggregate stock pile to monitor bucket loading.
5. Transit mix man-hours are based on using four trucks, average haul of five miles, and four men operating a dry cement batching plant.
6. Large job man-day estimates are dependent on equipment used, as well as manufacturer's ratings and recommendations.

Figure 5-C-13. Mixing Concrete Production

Work Element Description	Unit	Direct from Chute	Wheeled	Pumped	Crane and Bucket
03 31 05.70 Placing Concrete					
Lintel or sill, 8 x 8, Cast in place, including forming	LF	*	(0005) 0.5	*	*
Beams, elevated	CYD	*	*	(0010) 1.60	(0020) 2.40
Columns, square or round					
12 inches thick	CYD	*	*	(0030) 1.60	(0040) 2.70
18 inches thick	CYD			(0050) 1.066	(0060) 1.963
24 inches thick	CYD			(0070) 1.044	(0080) 1.543
Elevated slabs					
less than 6 inches thick	CYD	*	*	(0090) 0.685	(0100) 1.137
6 to 10 inches thick	CYD			(0110) 0.60	(0120) 0.982
Footings, continuous					
Shallow	CYD	(0130) 0.600		(0140) 0.641	(0150) 1.200
deep	CYD	(0160) 0.514	*	(0170) 0.600	(0180) 0.982
Footings, spread					
under 1 CYD	CYD	(0190) 1.309		(0200) 1.477	(0210) 2.400
over 5 CYDs	CYD	(0220) 0.600		(0230) 0.641	(0240) 1.080
Grade beams	CYD	(0250) 0.480	*	(0260) 0.536	(0270) 0.900
Pile caps	CYD	(0280) 0.800	*	(0290) 0.873	(0300) 1.359
Slabs on grade					
up to 6 inches thick	CYD	(0310) 0.654	*	(0320) 0.738	(0330) 0.983
over 6 inches thick	CYD	(0340) 0.436		(0350) 0.520	(0360) 0.750
Walls					
8 inches thick	CYD	(0370) 0.800	*	(0380) 0.960	(0390) 1.350
12 inches thick	CYD	(0400) 0.720		(0410) 0.873	(0420) 1.200
1 inch thick	CYD	(0430) 0.700		(0440) 0.800	(0450) 1.137
Wheeled concrete dumping, add to placing time above, walking cart					
up to 50-foot haul, add	CYD	*	(0460) 0.422	*	*
up to 150-foot haul, add	CYD		(0470) 0.563		
up to 250-foot haul, add	CYD		(0480) 0.750		
Minimum suggested crew size: one crew leader, two skilled and six unskilled laborers, and two equipment operators.					

Notes:

1. This figure provides man-hours for labor and equipment to place and vibrate concrete.
2. For upper stories, add per story: placed by pump, use a 1.07 multiplier; placed by bucket or crane, use a 1.05 multiplier.
3. Construction that moves in and out of ramps, runways, or staging is not included. For moving and in and out, use 0.22 man-hours per linear foot.
4. Major considerations in planning concrete placement are: method of placement, accessibility, rate of placement in regard to form design, amount and frequency of delivery governed by the ability to screed, tamp, and finish.

Figure 5-C-14. Placing Concrete Production

Work Element Description	Unit	Man-hours per Unit
03 35 29.30		
Finishing Floors		
Manual screed finish	SF	
(0010) manual screed and bull float	SF	0.009
(0020) manual screed, bull float, manual float	SF	0.018
(0030) manual screed, bull float, manual float, broom finish	SF	0.020
(0040) manual screed, bull float, manual float, manual steel trowel	SF	0.028
(0050) manual screed, bull float, machine float, trowel (walk-behind)	SF	0.021
(0060) Power screed, bull float, machine float, trowel (walk-behind)	SF	0.015
(0070) Power screed, bull float, machine float, trowel (ride-on)	SF	0.009
(0080) Dustproofing, solvent-based, one coat	SF	0.006
(0090) Stair finish, float	SF	0.043
(0100) steel trowel finish	SF	0.060
(0110) silicon carbide finish, (0.25 pounds per SF)	SF	0.080
03 35 29.35		
Control Joints, Saw Cut		
(0010) Saw cut in green concrete, 1-inch up to 2-inch depth, average	LF	0.014
(0020) clean out control joint of debris	LF	0.002
joint sealant		
(0030) backer rod, polyethylene, 1/4-inch diameter	LF	0.026
(0040) 08081500 sealant polyethylene, 1/4-inch diameter	LF	0.045
03 35 29.60		
Finishing Walls		
(0010) Break ties and patch voids	SF	0.023
(0020) Burlap rub with grout	SF	0.027
(0030) Carborundum rub, dry	SF	0.045
(0040) wet	SF	0.070
(0050) Bush hammer, green concrete	SF	0.072
(0060) cured concrete	SF	0.111
(0070) Float finish, 1/16 inch thick	SF	0.041
(0080) Grind form fins flush	LF	0.017
03 39 13.50		
Water Curing		
(0010) Liquid spray, membrane, burlap, water spray	SF	0.004
03 39 23.13		
(0010) Sprayed membrane curing compound	SF	.0017
03 45 13.50		
Precast Wall Panels *	SF	0.0760
(0010) 20 ft x 10 ft x 6-inch thick		
Minimum suggested crew size: two builders and six laborers, depending on size of pour and type of finish. * Crew size, one equipment operator, six steelworkers		
Note: Refer to TM 3-34.44/FM 5-428/MCRP 3-40D.4 for further information on cold weather protection procedures.		

Figure 5-C-15. Finishing and Curing Concrete Production

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CHAPTER 5 ANNEX D

Division 04

Masonry

5.D.1 INTRODUCTION

Division 04, masonry, includes installing brick, concrete block, mortar-bound rubble, ceramic tile, quarry tile, structural tile (glazed or face), and lathing and plastering.

5.D.2 ESTIMATING INFORMATION AND TIPS

Ensure alignment between specifications and drawings. Review the Division 04 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable. Refer to TM 3-34.47/FM 5-426/MCRP 3-40D.3, Carpentry, for further information on mason's tools and equipment; physical characteristics and properties of concrete blocks, bricks, and structural clay tiles; and construction procedures and methods for these masonry units. The following estimating tips are provided.

1. Brick and concrete block. Labor for the installation of brick and concrete block includes mixing mortar, carrying materiels to the mason, hoisting materiels, and laying brick and block. It also includes tooling joints, erecting and dismantling scaffold, sawing block, and culling brick and block. Labor for this type of masonry includes cleaning brick and block in place.

2. Mortar-bound rubble. The installation of mortar-bound rubble includes labor for mixing mortar, rough-cutting stone, carrying mortar and rubble to the mason, hoisting materiels, and laying rubble. Installation also includes tooling and pointing joints, erecting and dismantling scaffold, and cleaning rubble in place.

3. Ceramic and quarry tile. The installation of ceramic and quarry tile includes mixing mortar for bed coat and joints, carrying mortar and tile to the tile setter, spreading bed coat, cutting tile, and setting tile. Labor estimates should also include slushing and finishing joints, cleaning tile in place, and erecting and dismantling scaffold.

4. Structural tile. The installation of structural face tile and glazed structural tile units includes mixing mortar, carrying mortar and tile to the mason, hoisting materiels, laying tile, tooling joints, erecting and dismantling scaffold, cutting tile, and cleaning tile in place.

5. Mortar. Mortar is a composition of water; fine aggregates (e.g., sand); Portland, hydraulic, or masonry cement; and lime. The purpose of mortar is to bond together individual units of brick, block, or stone.

6. Grout. Grout is a composition of Portland cement, sand, lime, and water mixed in similar proportions and strengths to mortar. Additional water is used to bring the consistency to a more fluid or plastic state, so the grout can be pumped or poured into the cells of set concrete block containing vertical or horizontal reinforcing.

5.D.3 ESTIMATING DATA

Figures 5-D-1 through 5-D-10 present data and guidelines for estimating items found in Division 04.

Mortar Type	Portland Cement	Hydrated Lime	Sand	Use
M	1	1/4	3 3/4	General use where high strength is required, especially good compressive strength; work that is below grade and in contact with earth.
S	1	1/2	4 1/2	Suitable for general use, but recommended where high resistance to lateral forces is required.
N	1	1	6	Suitable for general use in above grade, exposed masonry where high compressive and/or lateral strengths are not required.
O	1	2	9	Do not use when masonry is exposed to severe weathering; acceptable for non-load bearing walls of solid units and interior non-load bearing partitions of hollow units.

Notes:
1. This figure shows some common mortar types, mixing proportions, and their general uses.
2. The water used should be of the quality of drinking water. Use only as much as needed to bring the mix to a suitable plastic and workable state.
3. The sand should be damp and loose. A general rule for sand content is that it should not be less than 2 1/4 or more than 3 times the sum of the cement and lime volumes.

Figure 5-D-1. Masonry Mortar Mix Proportions

Mortar Type	Strength	Average Compressive Strength at 28 Days
M	High	2,500 pounds per square inch
S	High	1,800 pounds per square inch
N	Medium	750 pounds per square inch
O	Low	350 pounds per square inch

Figure 5-D-2. Compressive Strengths of Mortar

Number of Stretchers	Wall Length*	Number of Stretchers	Wall Length*
1.0	1 feet 4 inches	8.5	11 feet 4 inches
1.5	2 feet 0 IN	9.0	12 feet 0 IN
2.0	2 feet 8 inches	9.5	12 feet 8 inches
2.5	3 feet 4 inches	10.0	13 feet 4 inches
3.0	4 feet 0 IN	10.5	14 feet 0 IN
3.5	4 feet 8 inches	11.0	14 feet 8 inches
4.0	5 feet 4 inches	11.5	15 feet 4 inches
4.5	6 feet 0 IN	12.0	16 feet 0 IN
5.0	6 feet 8 inches	12.5	16 feet 8 inches
5.5	7 feet 4 inches	13.0	17 feet 4 inches
6.0	8 feet 0 IN	13.5	18 feet 0 IN
6.5	8 feet 8 inches	14.0	18 feet 8 inches
7.0	9 feet 4 inches	14.5	19 feet 4 inches
7.5	10 feet 0 IN	15.0	20 feet 0 IN
8.0	10 feet 8 inches	20.0	26 feet 8 inches
*Based on units 15 5/8 inches long and half units 7 5/8 inches long, with 3/8-inch-thick head joints.			

Figure 5-D-3. Length of Concrete Masonry Walls by Stretchers

Wall Height 3/8-inch Bed Joint					
No. of Courses	8-Inch Block (Height)	4-Inch Block (Height)	No. of Courses	8-Inch Block (Height)	4-Inch Block (Height)
1	8 inches	4 inches	10	6 feet 8 inches	3 feet 4 inches
2	1 feet 4 inches	8 inches	15	10 feet 0 IN	5 feet 0 IN
3	2 feet 0 IN	1 feet 0 IN	20	13 feet 4 inches	6 feet 8 inches
4	2 feet 8 inches	1 feet 4 inches	25	16 feet 8 inches	8 feet 4 inches
5	3 feet 4 inches	1 feet 8 inches	30	20 feet 0 IN	10 feet 0 IN
6	4 feet 0 IN	2 feet 0 IN	35	23 feet 4 inches	11 feet 8 inches
7	4 feet 8 inches	2 feet 4 inches	40	26 feet 8 inches	13 feet 4 inches
8	5 feet 4 inches	2 feet 8 inches	45	30 feet 0 IN	15 feet 0 IN
9	6 feet 0 IN	3 feet 0 IN	50	33 feet 4 inches	16 feet 8 inches

Figure 5-D-4. Height of Concrete Masonry Walls by Courses

Wall Thickness (Inches)	Spacing of Grouted Cores (Inches)	Grout, CYD for 100 SF Wall Area	Wall Area, SF for 1 CYD of Grout
6	All cores grouted	0.79	126
	16	0.40	250
	24	0.28	357
	32	0.22	450
	40	0.19	526
	48	0.17	588
8	All cores grouted	1.26	79
	16	0.74	135
	24	0.58	173
	32	0.49	204
	40	0.44	228
	48	0.39	257
12	All cores grouted	1.99	50
	16	1.18	85
	24	0.91	110
	32	0.76	132
	40	0.70	143
	48	0.64	156

Notes:
1. A 3 percent allowance has been included for waste and job conditions.
2. All quantities include grout for intermediate and top bond beams in addition to grout for cores.

Figure 5-D-5. Volume of Grout in Grouted Concrete Block Walls

Work Element Description	Unit	Man-hours per Unit
04 01 20.20		
Pointing Masonry		
(0010) Cut and repoint brick, hard mortar, running bond	SF	0.150
(0020) Repoint, mask, and grout method, running bond	SF	0.126
(0030) Scrub coat, sand grout on walls, minimum	SF	0.101
04 01 30.20		
Cleaning Masonry		
(0100) Chemical cleaning, new construction, brush and wash, average	SF	0.024
(0020) High-pressure water only, average	SF	0.041
(0030) Steam cleaning, average	SF	0.024
04 01 30.60		
Brick Washing		
(0010) Acid cleanser, smooth brick	SF	0.021
(0020) rough brick	SF	0.030
(0030) Stone, acid wash	SF	0.019
Minimum suggested crew size: one builder and laborer.		

Notes:

1. A multiplier of 1.5 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production.
2. Scaffolding is not included.
3. Clean-up is included.
4. A person can clean 50 SF per hour on smooth brick and 35 SF per hour on rough brick. Do not use acid solution until wall is at least 7 days old.
5. Recommend use of 1 gallon muriatic acid to 20 gallons of water for 1,000 SF.

Figure 5-D-6. Masonry Maintenance and Cleaning Production

Work Element Description	Unit	Man-hours per Unit
04 05 13.30		
Mortar		
(0010) Mixing	CF	0.083
04 05 16.30		
Grouting		
(0010) Bond beams and lintels, 8 inches deep, 6 inches thick, 0.15 CF per LF	LF	0.033
(0020) 8 inches thick, 0.2 CF per LF	LF	0.034
(0030) 10 inches thick, 0.25 CF per LF	LF	0.041
(0040) 12 inches thick, 0.3 CF per LF	LF	0.046
(0050) Concrete block cores, solid, 4 inches thick, by hand, 0.067 CF per SF of wall	SF	0.054
(0060) 6 inches thick, pumped, 0.175 CF per SF	SF	0.066
(0070) 8 inches thick, pumped, 0.258 CF per SF	SF	0.071
(0080) 10 inches thick, pumped, 0.340 CF per SF	SF	0.072
(0090) 12 inches thick, pumped, 0.422 CF per SF	SF	0.075
(0100) Cavity walls, 2-inch space, pumped, 0.167 CF per SF of wall	SF	0.028
(0110) 3-inch space, 0.250 CF per SF	SF	0.040
(0120) 4-inch space, 0.333 CF per SF	SF	0.042
(0130) 6-inch space, 0.500 CF per SF	SF	0.060
(0140) Door frames, 3- by 7-foot opening, 2.5 CF per opening	Each	0.800
(0150) 6- by 7-foot opening, 3.5 CF per opening	Each	1.070
(0160) Grout, for bond beams, lintels, and concrete masonry unit cores	CF	0.136
Minimum suggested crew size: one builder skilled and two laborers.		
Notes: A multiplier of 1.5 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production.		

Figure 5-D-7. Masonry Mortaring and Grouting Production

Work Element Description	Unit	Man-hours per Unit
04 05 19.05		
Anchor Bolts		
Hooked, with nut and washer		
(0010) 1/2-inch diameter, 8 and 12 inches long	Each	0.053
(0020) 5/8-inch diameter, 8 and 12 inches long	Each	0.058
(0030) 3/4-inch diameter, 8 and 12 inches long	Each	0.066
04 05 19.16		
Masonry Anchors		
(0010) Various types, average	HD	1.000
04 05 19.26		
Masonry Reinforcing Bars		
(0010) Steel bars, placed horizontal, #3 and #4 bars	LB	0.024
(0020) #5 and #6 bars	LB	0.013
(0030)Steel bars, placed vertical, #3 and #4 bars	LB	0.031
(0040) #5 and #6 bars	LB	0.016
(0050) Joint reinforcing, regular truss or cavity truss, to 6 inches wide	LF	0.004
(0060) to 12 inches wide	LF	0.005
04 05 23.13		
Control Joint		
(0010) for double Wythe 8-inch minimum wall (brick/concrete masonry unit) various types, average	LF	0.033
04 05 23.19		
Vent Box		
(0010) Extruded aluminum and stainless steel ventilators, various types, average	Each	0.400
04 05 23.95		
Wall Plugs (for nailing to brickwork)		
(0010) Galvanized, plain or wood-filled	HD	1.000

Figure 5-D-8. Masonry Anchorage, Reinforcing, and Accessories Production

Work Element Description	Unit	Man-hours per Unit
04 21 13.13		
Brick Veneer Masonry		
(0010) Common bond, standard, 4 by 2 2/3 by 8 inches (7.88 per SF)	SF	0.500
(0020) Stack bond, standard, (6.75 per SF)	SF	0.400
(0030) Backup, 4 inches, running bond, standard brick, (6.75 per SF)	SF	0.334
Note: Plan for 3 percent brick and 25 percent mortar waste		
04 21 26.10		
Glazed Structural Clay Masonry Tile		
(0010) Structural facing tile, (excluding scaffolding, grout, and reinforcing) various types, average	SF	0.250
Plan for 3 percent waste		
04 21 29.10		
Terra Cotta Masonry Components		
(0010) Coping, split type, not glazed, various types, average	LF	0.356
(0020) Partition or backup blocks, various types, average	SF	0.160
04 21 29.20		
Terra Cotta Tile		
(0010) On walls, dry set, 1/2 inch thick, various types, average	SF	0.118
Minimum suggested crew size: one builder and two laborers.		
Notes: A multiplier of 2.0 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production.		

Figure 5-D-9. Brick, Glazed Clay Tile, and Terra Cotta Masonry Production

Work Element Description	Unit	Man-hours per Unit
04 22 10.14		
Concrete Block, Back-up		
Normal weight, 8- by 16-inch units, tooled one side, not reinforced		
(0010) 8 inches thick	SF	0.200
Reinforced, alternate courses		
(0020) 4 inches thick	SF	0.178
(0030) 8 inches thick	SF	0.202
(0040) 12 inches thick	SF	0.320
04 22 10.16		
Concrete Block, Bond Beam		
Regular block, 8 inches high, including reinforcing (two #5 bars) and grout		
(0010) 8 inches thick	LF	0.266
(0020) 12 inches thick	LF	0.384

Figure 5-D-10. Concrete Unit Masonry Production (Sheet 1 of 3)

Work Element Description	Unit	Man-hours per Unit
04 22 10.18		
Concrete Block, Column or Pilaster		
Including vertical reinforcing (four #4 bars) and grout	vertical	
(0010) 1-piece unit, 16 by 16 inches	LF	1.230
(0020) 1-piece unit, 16 by 20 inches	LF	1.334
(0030) 2-piece unit, 16 by 20 inches	LF	1.454
04 22 10.24		
Concrete Block, Exterior		
(0010) Normal weight, tooled two sides, reinforced, alternate courses 8- by 16-inch units, 8 inches thick	SF	0.222
(0020) 12 inches thick	SF	0.384
04 22 10.26		
Concrete Block, Foundation Wall		
Normal weight, cut joints, horizontal joint reinforcing, no vertical reinforcing, hollow or solid		
(0010) 8- by 16-inch units, 8 inches thick	SF	0.188
(0020) 10 inches thick	SF	0.228
(0030) 12 inches thick	SF	0.320
04 22 10.30		
Concrete Block, Interlocking		
Not including reinforcing and grout		
(0010) 8- by 16-inch units, 8 inches thick	SF	0.130
(0020) 12 inches thick	SF	0.146
(0030) 16 inches thick	SF	0.172
Including reinforcing and grout		
(0040) 8- by 16-inch units, 8 inches thick	SF	0.262
(0050) 12 inches thick	SF	0.290
(0060) 16 inches thick	SF	0.346
04 22 10.32		
Concrete Block, Lintels		
Including horizontal reinforcing and grout		
(0010) 8- by 8-inch units, 8 inches thick, (one #4 bar)	LF	0.214
(0020) 8- by 8-inch units, 8 inches thick, (two #4 bars)	LF	0.216
(0030) 8- by 16-inch units, 8 inches thick, (one #4 bar)	LF	0.232
(0040) 8- by 16-inch units, 8 inches thick, (two #4 bars)	LF	0.238
(0050) 12- by 16-inch units, 8 inches thick, (one #4 bar)	LF	0.256

Figure 5-D-10. Concrete Unit Masonry Production (Sheet 2 of 3)

Work Element Description	Unit	Man-hours per Unit
04 22 10.19		
Concrete Block, Partitions		
Regular block, tooled joints, two sides, excludes scaffolding		
Hollow, not reinforced,		
(0010) 8- by 16-inch units, 4 inches thick	SF	0.186
(0020) 6 inches thick	SF	0.200
(0030) 8 inches thick	SF	0.214
(0040) 10 inches thick	SF	0.222
(0050) 12 inches thick	SF	0.282
Hollow, reinforced alternate courses		
(0060) 8- by 16-inch units, 4 inches thick	SF	0.188
(0070) 6 inches thick	SF	0.202
(0080) 8 inches thick	SF	0.216
(0090) 10 inches thick	SF	0.226
(0100) 12 inches thick	SF	0.286
04 22 10.19		
Concrete Block, Partitions		
Regular block, tooled joints, two sides, excludes scaffolding		
Solid, not reinforced,		
(0110) 8- by 16-inch units, 2 inches thick	SF	0.184
(0120) 4 inches thick	SF	0.192
(0130) 6 inches thick	SF	0.208
(0140) 8 inches thick	SF	0.222
(0150) 12 inches thick	SF	0.296
Solid, reinforced alternate courses		
(0160) 8- by 16-inch units, 4 inches thick	SF	0.190
(0170) 6 inches thick	SF	0.210
(0180) 8 inches thick	SF	0.226
(0190) 12 inches thick	SF	0.300
Minimum suggested crew size: one builder and two laborers.		

Notes:

1. A multiplier of 2.0 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production.
2. The masonry estimates are based on the following conditions:
   a. All joints are 3/8 inch.
   b. Units laid in running bond or stack bond.
   c. All mortar is mixed by machine.
3. All special blocks that require field cutting shall be ordered as full size blocks.

Figure 5-D-10. Concrete Unit Masonry Production (Sheet 3 of 3)

CHAPTER 5 ANNEX E

Division 05

Metals

5.E.1 INTRODUCTION

Division 05, metals, includes erection of structural and miscellaneous steel fabrications and erection of sheet metal.

5.E.2 ESTIMATING INFORMATION AND TIPS

Ensure alignment between specifications and drawings. Review the Division 05 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks if applicable. The following estimating tips are provided.

1. Erection of structural and miscellaneous steel. The labor for erection of structural steel includes unloading, erecting temporary bolting, plumbing, leveling, high-strength bolting, and/or welding. Miscellaneous steel erection includes unloading, setting in place, plumbing, leveling, and fastening (usually by bolting or welding).

2. Sheet metal. This includes the fabrication and erection of gutters, downspouts, ridges, valleys, flashings, and ducts. Fabrication is usually done in the sheet metal shop and includes making patterns, cutting, forming, seaming, soldering, attaching stiffeners, and hauling to the site. Erection includes unloading, storing onsite, handling into place, hanging, fastening, and soldering.

5.E.3 ESTIMATING DATA

Figures 5-E-1 through 5-E-17 present data and guidelines for estimating items found in Division 05.

Thickness (Inches)	Weight (LB per SF)	Thickness (Inches)	Weight (LB per SF)
3/16	7.6	3/4	30.6
1/4	10.2	7/8	35.7
5/16	12.7	1	40.8
3/8	15.3	1 1/4	51.0
7/16	17.8	1 1/2	61.2
1/2	20.4	1 3/4	71.4
5/8	25.5	2	81.6

Figure 5-E-1. Weights of Steel Plates in Pounds per Square Foot

Thickness (Inches)	Weight (LB per SF)	Thickness (Inches)	Weight (LB per SF)
1/8	8.0	5/16	13.7
3/16	8.7	3/8	16.2
1/4	11.2	1/2	21.5

Figure 5-E-2. Weights of Standard Diamond Steel Floor Plates

Black					Galvanized			
Description		Weight LB per SF			Description	Weight LB per SF		
United States (U.S.) Gage	Thickness	Flat	Corrugated		Thickness	Flat	Corrugated	
12	0.1046	4.3	4.7	5.0	0.1084	4.5	4.9	5.2
14	0.0747	3.1	3.4	3.6	0.0785	3.2	3.5	3.7
16	0.0598	2.5	2.7	2.8	0.0635	2.6	2.9	3.0
18	0.0478	2.0	2.1	2.3	0.0516	2.1	2.3	2.4
20	0.0359	1.5	1.6	1.7	0.0396	1.6	1.8	1.9
22	0.0299	1.2	1.3	1.4	0.0336	1.4	1.5	1.6
24	0.0239	1.0	1.0	1.1	0.0276	1.1	1.2	1.3
26	0.0179	0.75	0.8	0.8	0.0217	0.91	0.9	1.0
28	0.0149	0.6	0.6	0.7	0.0187	0.7	0.8	0.8
29	0.0135	0.5	0.6	0.6	0.0172	0.7	0.7	0.8
	Corrugations, inches		2 2/3 by 1/2	3 by 1/4	Corrugations, inches		2 2/3 by 1/2	3 by 1/4

Figure 5-E-3. Gage, Thickness, and Weight of Black and Galvanized Flat and Corrugated Sheets

Width of Bars						
Thickness (Inches)	**1 Inch**	**2 Inches**	**3 Inches**	**4 Inches**	**5 Inches**	**6 Inches**
3/16	0.64	1.28	1.91	2.55	3.19	3.83
1/4	0.85	1.70	2.55	3.40	4.25	5.10
5/16	1.06	2.12	3.19	4.25	5.31	6.38
3/8	1.28	2.55	3.83	5.10	6.38	7.65
7/16	1.49	2.98	4.46	5.95	7.44	8.95
1/2	1.70	3.40	5.10	6.80	8.50	10.20
9/16	1.92	3.83	5.74	7.65	9.57	11.48
5/8	2.12	4.25	6.38	8.50	10.63	12.75
11/16	2.34	4.67	7.02	9.35	11.69	14.03
3/4	2.55	5.10	7.65	10.20	12.75	15.30
13/16	2.76	5.53	8.29	11.05	13.81	16.58
7/8	2.98	5.95	8.93	11.90	14.87	17.85
15/16	3.19	6.38	9.57	12.75	15.94	19.13
1	3.40	6.80	10.20	13.60	17.00	20.40
1 1/16	3.61	7.22	10.84	14.45	18.06	21.68
1 1/8	3.83	7.65	11.48	15.30	19.13	22.95
1 3/16	4.04	8.08	12.12	16.15	20.19	24.23
1 1/4	4.25	8.50	12.75	17.00	21.25	25.50
1 5/16	4.46	8.93	13.39	17.85	22.32	26.78
1 3/8	4.67	9.35	14.03	18.70	23.38	28.05
1 7/16	4.89	9.78	14.66	19.55	24.44	29.33
1 1/2	5.10	10.20	15.30	20.40	25.50	30.60
1 9/16	5.32	10.63	15.94	21.25	26.57	31.88
1 5/8	5.52	11.05	16.58	22.10	27.63	33.15
1 11/16	5.74	11.47	17.22	22.95	28.69	34.43
1 3/4	5.95	11.90	17.85	23.80	29.75	35.70
1 13/16	6.16	12.33	18.49	24.65	30.81	36.98
1 7/8	6.38	12.75	19.13	25.50	31.87	38.25
1 15/16	6.59	13.18	19.77	26.35	32.94	38.53
2	6.80	13.60	20.40	27.20	34.00	40.80

Figure 5-E-4. Weights of Flat Steel Bars One Foot Long in Pounds

Thickness or Diameter in Inches	Weight of Square Bar	Weight of Round Bar	Thickness or Diameter in Inches	Weight of Square Bar	Weight of Round Bar
1/4	0.21	0.16	1 11/16	—	7.60
5/16	0.33	0.26	1 3/4	10.41	8.18
3/8	0.47	0.37	1 13/16	—	8.77
7/16	0.65	0.51	1 7/8	11.95	9.39
1/2	0.85	0.66	2	13.60	10.68
9/16	1.07	0.84	2 1/8	15.35	12.06
5/8	1.38	1.04	2 1/4	17.21	13.52
11/16	1.60	1.26	2 3/8	—	15.06
3/4	1.91	1.50	2 1/2	21.25	16.69
13/16	2.24	1.76	2 5/8	23.43	18.40
7/8	2.60	2.04	2 3/4	25.71	20.20
15/16	—	2.35	2 7/8	—	22.07
1	3.40	5.67	3	30.60	24.03
1 1/16	—	3.01	3 1/8	—	26.08
1 1/8	4.30	3.38	3 1/4	35.91	28.21
1 1/4	5.31	4.17	3 3/8	—	30.42
1 5/16	—	4.60	3 1/2	41.65	32.71
1 3/8	6.42	5.05	3 5/8	—	35.09
1 7/16	—	5.52	3 3/4	47.81	37.55
1 1/2	7.65	6.01	4	54.40	42.73
1 5/8	8.92	7.05			

Figure 5-E-5. Weights of Square and Round Bars One Foot Long in Pounds

Size In Inches	Weight per Foot (Pounds)	Size in Inches	Weight per Foot (Pounds)	Size in Inches	Weight per Foot (Pounds)
3 × 2 × 1/4	4.1	4 × 3 × 5/8	13.6	6 × 3 1/2 × 5/16	9.8
3 × 2 × 5/16	5.0	4 × 3 × 3/4	16.0	6 × 3 1/2 × 3/8	11.7
3 × 2 × 3/8	5.9			6 × 3 1/2 × 7/16	13.5
		4 × 3 1/2 × 1/4	6.2	6 × 3 1/2 × 1/2	15.3
3 × 2 1/2 × 1/4	4.5	4 × 3 1/2 × 5/16	7.7	6 × 3 1/2 × 5/8	18.9
3 × 2 1/2 × 5/16	5.6	4 × 3 1/2 × 3/8	9.1		
3 × 2 1/2 × 3/8	6.6	4 × 3 1/2 × 7/16	10.6	6 × 4 × 5/16	10.3
3 × 2 1/2 × 1/2	8.5	4 × 3 1/2 × 1/2	11.9	6 × 4 × 3/8	12.3
				6 × 4 × 7/16	14.3
3 × 3 × 1/4	4.9	4 × 4 × 1/4	6.6	6 × 4 × 1/2	16.2
3 × 3 × 5/16	6.1	4 × 4 × 5/16	8.2	6 × 4 × 9/16	18.1
3 × 3 × 3/8	7.2	4 × 4 × 3/8	9.8	6 × 4 × 5/8	20.0
3 × 3 × 7/16	8.3	4 × 4 × 7/16	11.3	6 × 4 × 3/4	23.6
3 × 3 × 1/2	9.4	4 × 4 × 1/2	12.8	6 × 4 × 7/8	27.2
3 × 3 × 5/8	11.5	4 × 4 × 5/8	15.7		
		4 × 4 × 3/4	18.5	6 × 6 × 3/8	14.9
3 1/2 × 2 1/2 × 1/4	4.9			6 × 6 × 7/16	17.2
3 1/2 × 2 1/2 × 5/16	6.1	4 1/2 × 3 × 3/8	9.1	6 × 6 × 1/2	19.6
3 1/2 × 2 1/2 × 3/8	7.2			6 × 6 × 9/16	21.9
3 1/2 × 2 1/2 × 1/2	9.4	5 × 3 × 5/16	8.2	6 × 6 × 5/8	24.2
3 1/2 × 2 1/2 × 5/8	11.5	5 × 3 × 3/8	9.8	6 × 6 × 3/4	28.7
		5 × 3 × 7/16	11.3	6 × 6 × 7/8	33.1
3 1/2 × 3 × 1/4	5.4	5 × 3 × 1/2	12.8	6 × 6 × 1	37.4
3 1/2 × 3 × 5/16	6.6	5 × 3 × 3/4	18.5		
3 1/2 × 3 × 3/8	7.9			7 × 3 1/2 × 3/8	13.0
3 1/2 × 3 × 1/2	10.2	5 × 3 1/2 × 5/16	8.7	7 × 3 1/2 × 7/16	15.0
		5 × 3 1/2 × 3/8	10.4	7 × 3 1/2 × 1/2	17.0
3 1/2 × 3 1/2 × 1/4	5.8	5 × 3 1/2 × 7/16	12.0	7 × 3 1/2 × 5/8	21.0
3 1/2 × 3 1/2 × 5/16	7.2	5 × 3 1/2 × 1/2	13.6		
3 1/2 × 3 1/2 × 3/8	8.5	5 × 3 1/2 × 5/8	16.8	8 × 3 1/2 × 1/2	18.7
3 1/2 × 3 1/2 × 7/16	9.8				
3 1/2 × 3 1/2 × 1/2	11.1	5 × 4 × 3/8	11.0	8 × 6 × 1/2	23.0
3 1/2 × 3 1/2 × 5/8	13.6	5 × 4 × 1/2	14.5	8 × 6 × 3/4	33.8
4 × 3 × 1/4	5.8	5 × 5 × 3/8	12.3	8 × 3 × 1/2	26.4
4 × 3 × 5/16	7.2	5 × 5 × 7/16	14.3	8 × 3 × 5/8	32.7
4 × 3 × 3/8	8.5	5 × 5 × 1/2	16.2	8 × 3 × 3/4	38.9
4 × 3 × 7/16	9.8	5 × 5 × 5/8	20.0	8 × 3 × 7/8	45.0
4 × 3 × 1/2	11.1	5 × 5 × 3/4	23.6	8 × 3 × 1	51.0
				8 × 3 × 11/8	56.9

Figure 5-E-6. Weights of Steel Angles

Depth of Channels (Inches)	Weight per Foot (Pounds)	Thickness of Web (Inches)	Width of Flange (Inches)	Depth of Channels (Inches)	Weight per Foot (Pounds)	Thickness of Web (Inches)	Width of Flange (Inches)
3	6.00	0.362	1.602	9	20.00	0.452	2.652
	5.00	0.264	1.504		15.00	0.288	2.488
	4.10	0.170	1.410		13.40	0.230	2.430
4	7.25	0.325	1.725	10	30.00	0.676	3.036
	5.40	0.180	1.580		25.00	0.529	2.889
5	9.00	0.330	1.890		20.00	0.382	2.742
	6.70	0.190	1.750		15.30	0.240	2.600
6	13.00	0.440	2.160	12	30.00	0.513	3.173
	10.50	0.318	2.038		25.00	0.390	3.050
	8.20	0.200	1.920		20.70	0.280	2.940
7	14.75	0.423	2.303	15	50.00	0.720	3.720
	12.25	0.318	2.198		40.00	0.524	3.524
	9.80	0.210	2.090		33.90	0.400	3.400
8	18.75	0.490	2.530				
	13.75	0.307	2.347				
	11.50	0.220	2.260				

Figure 5-E-7. Weights of Standard Channels

Size of Filet (Inches)	Pounds of Stick Electrode Required per Foot of Weld	Pounds of Wire Electrode Required per Foot of Weld
1/8	0.04	0.02
3/16	0.11	0.06
1/4	0.18	0.10
5/16	0.29	0.16
3/8	0.42	0.23
1/2	0.76	0.42
5/8	1.18	0.66
3/4	1.70	0.95
1	3.03	1.69

Figure 5-E-8. Electrode Wire Requirements for Horizontal Filet Weld

Joint Dimensions (Inches)			Pounds of Stick Electrode Required per Foot of Weld		Pounds of Wire Electrode Required per Foot of Weld	
Tee	Butt	Groove	Without Reinforcement	With Reinforcement	Without Reinforcement	With Reinforcement
1/4	0.207	1/16	0.1	0.2	0.80	0.14
5/16	0.311	3/32	0.3	0.4	0.17	0.25
3/8	0.414	1/8	0.5	0.7	0.28	0.39
1/2	0.558	1/8	0.8	1.1	0.48	0.64
5/8	0.702	1/8	1.3	1.6	0.75	0.94
3/4	0.847	1/8	1.9	2.3	1.08	1.32
1	1.138	1/8	3.4	4.0	1.93	2.24

Figure 5-E-9. Electrode/Wire Requirements for "V" Groove Butt Joint

Joint Dimensions (Inches)			Pounds of Stick Electrode Required per Foot of Weld		Pounds of Wire Electrode Required per Foot of Weld	
Tee	Butt	Groove	Without Reinforcement	With Reinforcement	Without Reinforcement	With Reinforcement
3/16	3/8		—	.16	—	.08
		1/16	.04	.20	.02	.10
1/4	7/16	1/16	.05	.23	.02	.12
		3/32	.07	.26	.03	.14
5/16	1/2	1/16	.06	.27	.03	.15
		3/32	.09	.30	.05	.17

Figure 5-E-10. Electrode/Wire Requirements for Square Groove Butt Joint

Work Element Description	Unit	Man-hours per Unit
05 05 21.10		
Cutting Steel		
Hand burning, includes preparation, torch cutting and grinding, no staging. Steel to:		
(0010) 1/2 inch thick	LF	0.033
(0020) 3/4 inch thick	LF	0.041
(0030) 1 inch thick	LF	0.050

Figure 5-E-11. Flame Cutting Structural Steel Production

Work Element Description	Unit	Man-hours per Unit
05 05 21.90		
Welding Steel, Structural		
Continuous fillet, stick welding, including equipment,		
Single pass,		
(0010) 1/8 inch thick, 0.1 LB per LF	LF	0.070
(0020) 3/16 inch thick, 0.2 LB per LF	LF	0.142
(0030) 1/4 inch thick, 0.3 LB per LF	LF	0.213
(0040) 5/16 inch thick, 0.4 LB per LF	LF	0.281
(0050) 3 passes, 3/8 inch thick, 0.5 LB per LF	LF	0.355
(0060) 4 passes, 1/2 inch thick, 0.7 LB per LF	LF	0.484
(0070) 5 to 6 passes, 3/4 inch thick, 1.3 LB per LF	LF	0.887
(0080) 8 to 11 passes, 1 inch thick, 2.4 LB per LF	LF	1.773
(0090) Cleaning and welding plates, bars, or rods to existing beams, columns, or trusses	LF	0.887
Notes: 1. For all position welding (e.g., overhead) multiply by: a. 1.20 minimum b. 3.00 maximum.		

Figure 5-E-12. Welding Structural Steel Production

Work Element Description	Unit	Man-hours per Unit
05 05 22 **Structural Steel Fabrication**		
(0010) Beams–Bolted connection	Ton	10.4
(0015) Beams–Welded connection	Ton	13.0
(0020) Columns–Bolted connection	Ton	16.0
(0025) Columns–Welded connection	Ton	20.0
(0030) Frames for openings–Bolted connection	Ton	2.8
(0035) Frames for Openings–Welded connection	Ton	3.5
(0040) Girders–Bolted connection	Ton	16.0
(0045) Girders–Welded connection	Ton	20.0
(0050) Platforms–Bolted connection	Ton	36.0
(0055) Platforms–Welded connection	Ton	45.0
(0060) Purlins: girts and struts–Bolted connection	Ton	12.8
(0065) Purlins; girts and struts–Welded connection	Ton	16.0
(0070) Railings (simple tube pipe)–Bolted connection	LF	1.6
(0075) Railings (simple tube pipe)–Welded connection	LF	2.0
(0080) Stairs–Bolted connection	Ton	28.0
(0085) Stairs–Welded connection	Ton	35.0
(0090) Structural frames–Bolted connection	Ton	16.0
(0095) Structural frames–Welded connection	Ton	20.0
(0100) Trusses–Bolted connection	Ton	8.0
(0105) Trusses–Welded connection	Ton	10.0

Notes:

1. Fabrication of structural steel includes cutting, riveting, burning, drilling, milling, fitting, assembling, welding, bolting, storing, loading, and hauling to the job site.
2. Man-hour units are based on bolted connection. If sections are to be welded, use 1.25 multiplier for welded joint preparation.

Figure 5-E-13. Structural Steel Fabrication Production

Work Element Description	Unit	Man-hours per Unit
05 12 23.00 **Structural Steel For Buildings**		
(0010) Beams	Ton	13.6
(0020) Bracing and tiers	Ton	17.9
(0030) Columns	Ton	13.6
(0040) Girders	Ton	9.0
(0050) Grating	SF	0.192
(0060) Light framing	Ton	23.8
(0070) Purlins: girts and struts	Ton	11.9
(0080) Trusses	Ton	17.0
(0090) Steel wire rope	LF	0.0030
Notes: 1. Erection of structural steel includes handling, erecting, temporary bolting, plumbing, leveling, high-strength bolting, and/or welding. 2. Man-hour figures are based on using new construction materiels. 3. For painting, refer to Division 09 97 13.23, Exterior Steel Coatings.		

Figure 5-E-14. Structural Steel Erection Production

Work Element Description	Unit	Man-hours per Unit
05 41 13.10 **Structural Metal Stud Framing Bridging**		
(0010) Solid between studs, 16 in OC, 16 GA 4 in wide	Each	0.0730
(0110) Solid between studs, 16 in OC, 16 GA 6 in wide	Each	0.0760
(0120) Solid between studs, 24 in OC, 16 GA 6 in wide	Each	0.0760
Legend: GA = gauge OC = on-center		

Figure 5-E-15. Structural Metal Stud Framing Bridging

Work Element Description	Unit	Man-hours per Unit
05 41 13.30 **Structural Metal Stud Framing Stud Walls**		
(0010) 10 feet high, Top and bottom track, no openings, 16 GA 3-5/8 inch studs at 16 inch OC	LF	0.242
(0210) 10 feet high, Top and bottom track, no openings, 16 GA 6 inch studs at 16 inch OC	LF	0.250
(0220) 10 feet high, Top and bottom track, no openings, 16 GA 6 inch studs at 24 inch OC	LF	0.182
(0410) 12 feet high, Top and bottom track, no openings, 16 GA 6 inch studs at 16 inch OC	LF	0.314
(0420) 12 feet high, Top and bottom track, no openings, 16 GA 6 inch studs at 24 inch OC	LF	0.229
(0450) 12 feet high, Top and bottom track, no openings, 14 GA 3-5/8 inch studs at 16 inch OC	LF	0.333
(0500) 20 feet high, Top and bottom track, no openings, 14 GA 3-5/8 inch studs at 16 inch OC	LF	0.391
(0510) 20 feet high, Top and bottom track, no openings, 14 GA 6 inch studs at 16 inch OC	LF	0.381

Figure 5-E-16. Structural Metal Stud Framing Stud Walls

Work Element Description	Unit	Man-hours per Unit
05 42 13.40 Cold Formed Metal Joist Framing		
(0010) Installation to band joists, beams, or headers, 18 GA x 6 inch x 2 inch flange	Each	0.145
05 42 23.05 Cold Formed Metal Roof Joist Framing Bracing		
(0010) Framing, Bracing 16 GA x 1 1/2 inch channel thru trusses or rafters 16 inch OC	LF	0.0178
05 42 23.10 Cold Formed Metal Roof Joist Framing Bridging		
(0100) Framing, Bridging, Solid between rafters, Rafters at 16 inch OC, 18 GA by 4 inch deep	Each	0.1333
05 42 23.60 Cold Formed Metal Roof Joist Framing Roof Rafters		
(0100) Boxed ridge beam, 18 GA, 6 inches deep	LF	0.1000
(0200) Rafters, 2 inch flange, 18 GA, 6 inches deep	Each	0.4570
05 42 23.70 Cold Formed Metal Roof Joist Framing Soffits and Canopies		
(0010) Continuous ledger track at wall, studs 16 inch OC, 18 GA x 6 inch wide	LF	0.3200
(0100) Horizontal soffit and canopy members, 18 GA 1 5/8 inch flange by 6 inch deep	Each	0.1450

Figure 5-E-17. Cold Formed Metal Work (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
05 44 13.60 **Cold Formed Metal Roof Trusses**		
(0010) Fabrication of trusses on ground, 5 to 12 to 8 to 12 pitch, 18 GA by 4 inch chord, 16 feet span	Each	1.6
(0020) Fabrication of trusses on ground, 5 to 12 to 8 to 12 pitch, 18 GA by 4 inch chord, 20 feet span	Each	1.7780
(0030) Fabrication of trusses on ground, 5 to 12 to 8 to 12 pitch, 18 GA by 4 inch chord, 40 feet span	Each	2.6670
(0040) Fabrication of trusses on ground, 5 to 12 to 8 to 12 pitch, 18 GA by 4 inch chord, 50 feet span	Each	3.2000
(0100) Erection only of roof trusses, 5 to 12 to 8 to 12 pitch, 16 feet span	Each	0.9520
(0110) Erection only of roof trusses, 5 to 12 to 8 to 12 pitch, 20 feet span	Each	1.000
(0120) Erection only of roof trusses, 5 to 12 to 8 to 12 pitch, 40 feet span	Each	1.3300
(0130) Erection only of roof trusses, 5 to 12 to 8 to 12 pitch, 50 feet span	Each	1.4290

Figure 5-E-17. Cold Formed Metal Work (Sheet 2 of 2)

CHAPTER 5 ANNEX F

Division 06

Wood, Plastics, and Composites

5.F.1 INTRODUCTION

Division 06, wood, plastics, and composites, includes structural/rough carpentry work, installation of subflooring and finish carpentry.

5.F.2 ESTIMATING INFORMATION AND TIPS

The search for carpentry items includes roofing sections, wall sections, and off-detail drawings. Temporary construction items should be accounted for under Division 01, general requirements, but may be listed under Division 06. Ensure items are not double counted. Review the Division 06 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable. Refer to TM 3-34.47/FM 5-426/MCRP 3-40D.3 for further information on techniques and procedures for frame construction, building layout, framing and finish carpentry, roof framing and coverings, and the materiels used for these operations. The following information is provided.

1. Rough carpentry. The term rough carpentry deals with structural members; it includes measuring, cutting, and installing wood framing, floor joists and sills, cross bridging, wall framing and plates, roof framing and rafters, and rough door bucks. It also includes the installation of wall and roof sheathing and siding.

2. Finish carpentry. The work of finish carpentry includes installing millwork, door and window frames, trim, kitchen cabinets, wooden stairs, closet units, and finish walls. Finish carpentry also includes installation of fastening devices such as plugs, expansion shields, and toggle bolts; blocking for leveling and plumbing; and scribing fillers and trim to walls and adjacent pieces.

5.F.3 ESTIMATING DATA

Figures 5-F-1 through 5-F-12 present data and guidelines for estimating items found in Division 06.

Partition, Floor Joist, and Ceiling Joist		
Distance on Center (Inches)	**Multiply Length of Partition by**	**Add (Each)**
12	1.00	1
16	0.75	1
24	0.50	1
Note: Add for top and bottom plates on stud walls. Add two full length studs for each opening.		

Figure 5-F-1. Number of Studs Required for Variable Spacing

Length in Feet									
Size (Inches)	8	10	12	14	16	18	20	22	24
1 × 2	1 1/3	1 2/3	2	2 1/3	2 2/3	3	3 1/3	3 2/3	4
1 × 4	2 2/3	3 1/3	4	4 2/3	5 1/3	6	6 2/3	7 1/3	8
1 × 6	4	5	6	7	8	9	10	11	12
1 × 8	5 1/3	6 2/3	8	9 1/3	10 2/3	12	13 1/3	14 2/3	16
1 × 10	6 2/3	8 1/3	10	11 2/3	13 1/3	15	16 2/3	18 1/3	20
1 × 12	8	10	12	4	16	18	20	22	24
5/4 × 4	3 1/3	4 1/6	5	5 5/6	6 2/3	7 1/2	8 1/3	9 1/6	10
5/4 × 6	5	6 1/4	7 1/2	8 3/4	10	11 1/4	12 1/2	13 3/4	15
2 × 4	5 1/3	6 2/3	8	9 1/3	10 2/3	12	13 1/3	14 2/3	16
2 × 6	8	10	12	14	16	18	20	22	24
2 × 8	10 2/3	13 1/3	16	18 2/3	21 1/3	24	26 2/3	29 1/3	32
2 × 10	13 1/3	16 2/3	20	23 1/3	26 2/3	30	33 1/3	36 2/3	40
2 × 12	16	20	24	28	32	36	40	44	48
3 × 4	8	10	12	14	16	18	20	22	24
3 × 6	12	15	18	21	24	27	30	33	36
3 × 8	16	20	24	28	32	36	40	44	48
3 × 10	20	25	30	35	40	45	50	55	60
3 × 12	24	30	36	42	48	54	60	66	72
3 × 14	28	35	42	49	56	63	70	77	84
3 × 16	32	40	48	56	64	72	80	88	96
4 × 4	10 2/3	13 1/3	16	18 2/3	21 1/3	24	26 2/3	29 1/3	32
4 × 6	16	20	24	28	32	36	40	44	48
4 × 8	21 1/3	26 2/3	32	37 1/3	42 2/3	48	53 1/3	58 2/3	64
4 × 10	26 2/3	33 1/3	40	46 2/3	53 1/3	60	66 2/3	73 1/3	80
4 × 12	32	40	48	56	64	72	80	88	96
4 × 14	37 1/3	46 2/3	56	65 1/3	74 2/3	84	93 1/3	102 2/3	112
4 × 16	42 2/3	53 1/3	64	74 2/3	85 1/3	96	106 2/3	117 1/3	128
6 × 6	24	30	36	42	48	54	60	66	72
6 × 8	32	40	48	56	64	72	80	88	96
6 × 10	40	50	60	70	80	90	100	110	120
6 × 12	48	60	72	84	96	108	120	132	144
6 × 14	56	70	84	98	112	126	140	154	168
6 × 16	64	80	96	112	128	144	160	176	192
8 × 8	42 2/3	53 1/3	64	74 2/3	85 1/3	96	106 2/3	117 1/3	128
8 × 10	53 1/3	66 2/3	80	93 1/3	106 2/3	120	133 1/3	146 2/3	160
8 × 12	64	80	96	112	128	144	160	176	192

Figure 5-F-2. Board Foot Content

Lengths of Common, Hip, and Valley Rafters per 12 Inches of Run			
1 Rise and Run or Cut	**2 Length in Inches Common Rafter per 12 Inches of Run**	**3 Length in Inches Hip or Valley Rafters**	**4 Conversion Factor**
2 and 12	12.165	17.088	1.014
3 and 12	12.369	17.233	1.031
4 and 12	12.649	17.433	1.054
5 and 12	13.000	17.692	1.083
6 and 12	13.417	18.000	1.118
7 and 12	13.892	18.358	1.158
8 and 12	14.422	18.762	1.202
9 and 12	15.000	19.209	1.250
10 and 12	15.620	19.698	1.302
11 and 12	16.279	20.224	1.357
12 and 12	16.971	20.785	1.413
13 and 12	17.692	21.378	1.474
14 and 12	18.439	22.000	1.537
15 and 12	19.210	22.649	1.601
16 and 12	20.000	23.324	1.667
17 and 12	20.809	24.021	1.734
18 and 12	21.633	24.739	1.803
19 and 12	22.500	25.475	1.875
20 and 12	23.375	26.230	1.948
21 and 12	24.125	27.000	2.010
22 and 12	25.000	27.785	2.083
23 and 12	26.000	28.583	2.167
24 and 12	26.875	29.394	2.240

Notes:

1. Count number of rafters. Includes common rafters, hip and valley rafters, ridge boards, and collar beams.
2. To obtain the SF of roof area for a given pitch, use the building SF of floor area and multiply it by the appropriate conversion factor in column 4 (include the overhang).

   Example: Building 10 by 10 feet with 2-foot overhang on all sides, using 6- and 12-inch cut.
   14 foot × 14 foot = 196 SF × 1.118 = 219.12 SF of roof area.

Figure 5-F-3. Materiel Required for Rafters

Pitch	Increase of Area Over Flat Roof (Percent)	Multiplication Factor
1/4	12	1.12
1/3	20	1.20
3/8	25	1.25
1/2	42	1.42
5/8	60	1.60
3/4	80	1.80
7/8	101	2.01

Figure 5-F-4. Roof Areas of Pitched Roofs

Application	Nail Spacing		
Plywood Thickness (Inches)	Nail Size and Type	Panel Edge (Inches)	Intermediate (Inches)
1/2	6d common	4	6
5/8	8d common	4	6
3/4	8d common	4	6

Figure 5-F-5. Nail Spacing Criteria for Plywood Roof Sheathing

			Nail Spacing		
Application	Thickness of Plywood (Inches)	Max Spacing of Supports Center to Center	Nail Size and Type	Panel Edge (Inches)	Intermediate (Inches)
Subflooring	1/2	16 inches	6d common	6	10
	5/8	20 inches	8d common	6	10
	3/4	24 inches	8d common	6	10
Underlayment	3/8 5/8		6d ring-shank or cement-coated 8d flathead	6	8 each way

Notes:
1. Provide blocking at panel edge for other than 25/32 inch thick strip flooring.
2. If strip flooring is perpendicular to supports, 1/2 inch thick strip flooring can be used on a 24-inch span.
3. If resilient flooring is to be applied without underlayment, set nails 1/16 inch below surface.
4. If supports are not well-seasoned, use ring-shank nails.

Figure 5-F-6. Nail Spacing Criteria for Plywood Flooring

Size	Length (Inches)	Common	Finish
2d	1.00	874	*
3d	1.25	574	*
4d	1.50	320	574
5d	1.75	254	*
6d	2.00	200	300
7d	2.25	154	*
8d	2.50	110	190
9d	2.75	90	*
10d	3.00	72	135
12d	3.25	60	*
16d	3.50	48	*
20d	4.00	30	*

Figure 5-F-7. Wire Nails: Length and Approximate Number per Pound

Work Element Description	Unit	Man-hours per Unit
06 10 53.00 Rough Carpentry		
(0010) Miscellaneous Rough Carpentry	LF	0.053
06 11 10.02		
Blocking		
Miscellaneous, to wood construction (0010) 2 by 4 inches	BF	0.062
(0020) Pneumatic nailed	BF	0.051
(0021) 2 by 6 inches	BF	0.041
(0022) Pneumatic nailed	BF	0.038
(0030) 2 by 8 inches	BF	0.038
(0040) Pneumatic nailed	BF	0.032
To steel construction		
(0050) 2 by 4 inches	BF	0.076
(0060) 2 by 8 inches	BF	0.051
06 11 10.04		
Wood Bracing		
(0010) Let-in, with 1- by 6-inch boards, studs 16 inches on center studs	LF	0.070
(0020) 24 inches on center	LF	0.046
06 11 10.06		
Bridging		
Wood, for joists 16 inches on center		
(0010) 1 by 3 inches	Pair	0.082
(0020) Pneumatic nailed	Pair	0.062
(0030) 2- by 3-inch bridging	Pair	0.083
(0040) Pneumatic nailed	Pair	0.062
Steel, galvanized, 18 gauge,		
(0050) for 2- by 10-inch joists at 12 inches on center	Pair	0.082
(0060) for 2- by 10-inch joists at 24 inches on center	Pair	0.076
(0070) for 2- by 14-inch joists at 16 inches on center	Pair	0.082
(0080) for 2- by 14-inch joists at 24 inches on center	Pair	0.076

Figure 5-F-8. Wood Framing Production (Sheet 1 of 7)

Work Element Description	Unit	Man-hours per Unit
06 11 10.10		
Beam and Girder Framing		
(0010) Single, 2 by 6 inches	BF	0.0310
(0020) Single, 2 by 6 inches pneumatic nailed	BF	0.0270
(0030) Single, 2 by 8 inches	BF	0.0240
(0040) Single, pneumatic nailed	BF	0.0210
(0050) Single, 2 by 10 inches	BF	0.0210
(0060) Single, 2 by 10 inches pneumatic nailed	BF	0.0180
(0070) 3 inches by 8- to 14-inch average	BF	0.0170
(0080) 4 inches by 8- to 14-inch average	BF	0.0160
(0090) Double, 2 by 6 inches	BF	0.0170
(0100) Double, 2 by 6 inches pneumatic nailed	BF	0.0150
(0110) Double, 2 by 8 inches	BF	0.0130
(0120) Double, 2 by 8 inches pneumatic nailed	BF	0.0120
(0130) Double, 2 by 10 inches	BF	0.0110
(0140) Double, 2 by 10 inches pneumatic nailed	BF	0.0090
(0150) Triple, 2 by 6 inches	BF	0.0120
(0160) Triple, 2 by 6 inches pneumatic nailed	BF	0.0110
(0170) Triple, 2 by 8 inches	BF	0.0090
(0180) Triple, 2 by 8 inches pneumatic nailed	BF	0.0080
(0190) Triple, 2 by 10 inches	BF	0.0080
(0200) Triple, 2 by 10 inches pneumatic nailed	BF	0.0070
06 11 10.12		
Ceiling Framing		
(0010) Suspended, 2 by 3 inches	BF	0.0430
(0020) Suspended, 2 by 4 inches	BF	0.0360
(0030) Suspended, 2 by 6 inches	BF	0.0270
(0040) Suspended, 2 by 8 inches	BF	0.0240
06 11 10.14		
Posts and Columns		
(0010) 4 by 4 inches	BF	0.0410
(0020) 4 by 6 inches	BF	0.0380
(0030) 6 by 6 inches	BF	0.0330
(0040) 6 by 10 inches	BF	0.0270

Figure 5-F-8. Wood Framing Production (Sheet 2 of 7)

Work Element Description	Unit	Man-hours per Unit
06 11 10.18 **Joist Framing**		
(0010) Joists, 2 by 4 inches	BF	0.0250
(0020) 2 by 4 inches, pneumatic nailed	BF	0.0230
(0030) 2 by 6 inches	BF	0.0170
(0040) 2 by 6 inches pneumatic nailed	BF	0.0150
(0050) 2 by 8 inches	BF	0.0150
(0060) 2 by 8 inches pneumatic nailed	BF	0.0120
(0070) 2 by 10 inches	BF	0.0150
(0080) 2 by 10 inches pneumatic nailed	BF	0.0120
(0090) 2 by 12- to 14-inch average	BF	0.0120
(0100) 2 by 12- to 14-inch average pneumatic nailed	BF	0.0110
(0110) 3 by 6 inches	BF	0.0160
(0120) 3 by 8- to 12-inch average	BF	0.0110
(0130) 4 by 6 inches	BF	0.0130
(0140) 4 by 8 inches	BF	0.0050
(0150) 4 inches by 10- to 12-inch average	BF	0.0110
06 11 10.24 **Miscellaneous Framing**		
(0010) Firestops, 2 by 4 inches	BF	0.0410
(0020) 2 by 4 inches pneumatic nailed	BF	0.0330
(0030) 2 by 6 inches	BF	0.0360
(0040) 2 by 6 inches pneumatic nailed	BF	0.0270
(0050) 2 by 8 inches	BF	0.0360
(0060) 2 by 12 inches	BF	0.0310
(0070) Nailers, treated, wood construction, 2 by 4 inches	BF	0.0400
(0080) 2 by 4 inches pneumatic nailed	BF	0.0330
(0090) 2 by 6 inches	BF	0.0270
(0100) 2 by 6 inches pneumatic nailed	BF	0.0240
(0110) 2 by 8 inches	BF	0.0240
(0120) 2 by 8 inches pneumatic nailed	BF	0.0190
(0130) Nailers, steel construction 2 by 4 inches	BF	0.0430
(0140) 2 by 6 inches	BF	0.0310
(0150) 2 by 8 inches	BF	0.0240
(0160) Rough bucks, treated, for doors or windows 2 by 6 inches	BF	0.0530
(0170) 2 by 6 inches pneumatic nailed	BF	0.0440
(0180) 2 by 8 inches	BF	0.0410
(0190) 2 by 8 inches pneumatic nailed	BF	0.0330
(0200) Stair stringers, 2 by 10 inches	BF	0.0970
(0210) 2 by 12 inches	BF	0.0810
(0220) 3 by 10 inches	BF	0.0690
(0230) 3 by 12 inches	BF	0.0560

Figure 5-F-8. Wood Framing Production (Sheet 3 of 7)

Work Element Description	Unit	Man-hours per Unit
06 11 10.26 **Partitions**		
Single bottom and double top plate,		
(0010) 2- by 4-inch studs, 8 feet high studs 16 inches on center	LF	0.2130
(0020) Pneumatic nailed	LF	0.1770
(0030) studs 24 inches on center	LF	0.1700
(0040) Pneumatic nailed	LF	0.1420
(0050) 2- by 4-inch studs, 12 feet high studs 16 inches on center	LF	0.2660
(0060) Pneumatic nailed	LF	0.2220
(0070) studs 24 inches on center	LF	0.2130
(0080) Pneumatic nailed	LF	0.1770
(0090) 2- by 6-inch studs, 8 feet high, studs 16 inches on center	LF	0.2370
(0100) Pneumatic nailed	LF	0.2000
(0110) studs 24 inches on center	LF	0.1850
(0120) Pneumatic nailed	LF	0.1540
06 11 10.30		
Roof Framing		
(0009) Fascia boards, 2 by 4 inches or 2 by 6 inches	BF	0.0700
(0010) 2 by 8 inches or 2 by 10 inches	BF	0.0700
(0020) Rafters, to 4 in 12 pitch, 2 by 6 inches	BF	0.0210
(0030) 2 by 8 inches	BF	0.0160
(0040) Hip and valley rafters, 2 by 6 inches	BF	0.0270
(0050) 2 by 8 inches	BF	0.0230
(0060) Hip and valley jacks, 2 by 6 inches	BF	0.0360
(0070) 2 by 8 inches	BF	0.0330
(0080) Rafter tie	BF	0.0780
Ridge board,		
(0090) 1 by 6 inches	BF	0.0700
(0100) 1 by 10 inches	BF	0.0510
(0110) 2 by 6 inches	BF	0.0420
(0120) 2 by 8 inches	BF	0.0360
(0130) 2 by 10 inches	BF	0.0330
For slopes steeper than 4 in 12, multiply by 1.30.		
For dormers or complex roofs, multiply by 1.50.		

Figure 5-F-8. Wood Framing Production (Sheet 4 of 7)

Work Element Description	Unit	Man-hours per Unit
06 11 10.32 **Sill and Ledger Framing**		
(0010) Sills, 2 by 4 inches	BF	0.0530
(0020) 2 by 6 inches	BF	0.0380
(0030) 2 by 8 inches	BF	0.0330
(0040) Sills, treated, 2 by 4 inches	BF	0.0580
(0050) 2 by 6 inches	BF	0.0430
(0060) 2 by 8 inches or 4 by 4 inches	BF	0.0360
(0070) Ledgers, nailed, 2 by 4 inches	BF	0.0430
(0080) 2 by 6 inches	BF	0.0360
(0090) Ledgers, bolted, not including bolts, 3 by 8 inches	BF	0.0330
(0100) 3 by 12 inches	BF	0.0310
06 11 10.34 **Sleepers**		
(0010) On concrete, treated, 1 by 2 inches	BF	0.0550
(0020) 1 by 3 inches	BF	0.0430
(0030) 2 by 4 inches	BF	0.0210
(0040) 2 by 6 inches	BF	0.0160
06 11 10.36 **Soffit and Canopy Framing**		
(0010) Soffit or canopy framing, 1 by 4 inches	BF	0.0700
(0020) 1 by 8 inches	BF	0.0430
(0030) 2 by 4 inches	BF	0.0520
(0040) 2 by 8 inches	BF	0.0330
(0050) 3 by 4 inches	BF	0.0430
(0060) 3 by 8 inches	BF	0.0360

Figure 5-F-8. Wood Framing Production (Sheet 5 of 7)

Work Element Description	Unit	Man-hours per Unit
06 11 10.40 Wall Framing		
(0010) Headers over openings, 2 by 6 inches	BF	0.0580
(0020) Pneumatic nailed	BF	0.0490
(0030) 2 by 8 inches	BF	0.0460
(0040) Pneumatic nailed	BF	0.0400
(0050) 2 by 10 inches	BF	0.0400
(0060) Pneumatic nailed	BF	0.0330
(0070) Plates, untreated, 2 by 4 inches	BF	0.0400
(0080) Pneumatic nailed	BF	0.0310
(0090) 2 by 6 inches	BF	0.0270
(0100) Pneumatic nailed	BF	0.0240
(0102) 2 by 8 inches	BF	0.0270
(0103) Pneumatic nailed	BF	0.0240
(0110) Studs, 8-foot-high wall, untreated, 2 by 4 inches	BF	0.0240
(0120) Pneumatic nailed	BF	0.0190
(0130) 2 by 6 inches	BF	0.0210
(0140) Pneumatic nailed	BF	0.0170
(0142) Studs, 10-foot-high wall, untreated, 2 by 4 inches	BF	0.0224
(0144) Pneumatic nailed	BF	0.0185
(0146) Studs, 10-foot-high wall, untreated, 2 by 6 inches	BF	0.0205
(0148) Pneumatic nailed	BF	0.0166
(0150) Studs, 12-foot-high wall, untreated, 2 by 4 inches	BF	0.0219
(0160) Pneumatic nailed	BF	0.0180
(0170) Studs, 12-foot-high wall, untreated, 2 by 6 inches	BF	0.0200
(0180) Pneumatic nailed	BF	0.0162
(0190) Studs, 6-foot-high wall, untreated, 2 by 4 inches	BF	0.0276
(0200) Pneumatic nailed	BF	0.0228
(0210) Studs, 6-foot-high wall, untreated, 2 by 6 inches	BF	0.0252
(0220) Pneumatic nailed	BF	0.0204
Notes: For stub wall, 2 feet high, multiply by 1.40. For second story and above, multiply by 1.05. For dormers and gables, multiply by 1.15.		

Figure 5-F-8. Wood Framing Production (Sheet 6 of 7)

Work Element Description	Unit	Man-hours per Unit
06 11 10.42		
Furring		
Wood strips, on walls, 1 by 2 inches or 1 by 3 inches		
(0010) on wood or masonry	LF	0.0210
(0020) on wood, pneumatic nailed	LF	0.0150
(0030) on concrete	LF	0.0430
On ceilings		
(0040) on wood or masonry	LF	0.0330
(0050) on wood, pneumatic nailed	LF	0.0240
(0060) on concrete	LF	0.0500
06 25 16.10		
Paneling, Plywood		
Plywood, prefinished, 1/4 inch thick, 4- by 8-foot sheets		
(0010) average	SF	0.050
(0020) maximum	SF	0.061
Plywood, prefinished, 3/4 inch thick, 4- by 8-foot sheets		
(0030) minimum	SF	0.066
(0040) maximum	SF	0.094
Minimum suggested crew size: two builders for each construction work element.		

Figure 5-F-8. Wood Framing Production (Sheet 7 of 7)

Work Element Description	Unit	Man-hours per Unit
06 13 23.10		
Heavy Framing		
(0010) Beams, single 6 by 10 inches	BF	0.0200
(0020) single 8 by 16 inches	BF	0.0170
(0030) Columns, structural grade, 4 by 4 inches	BF	0.0360
(0040) 6 by 6 inches	BF	0.0330
(0450) 8 by 8 inches	BF	0.0167
(0050) Floor planks, 2 by 6 inches	BF	0.0200
(0060) 2 by 10 inches	BF	0.0190
(0070) 3 by 6 inches	BF	0.0200
(0080) 3 by 10 inches	BF	0.0190
(0090) Girders, structural grade, 12 by 12 inches	BF	0.0270
(0100) 10 by 16 inches	BF	0.0210
(0110) Roof purlins, 4 inches thick, structural grade	BF	0.0200
(0120) Roof trusses	BF	0.0480
Minimum suggested crew size: two builders.		
Notes: 1. Scaffolding is not included. 2. Clean-up is included.		

Figure 5-F-9. Heavy Timber Construction Production

Work Element Description	Unit	Man-hours per Unit
06 16 23.10		
Subfloor		
(0010) Plywood, 1/2 inch thick	SF	0.0150
(0020) pneumatic nailed	SF	0.0120
(0030) Plywood, 5/8 inch thick	SF	0.0160
(0040) pneumatic nailed	SF	0.0130
(0050) Plywood, 3/4 inch thick	SF	0.0170
(0060) pneumatic nailed	SF	0.0130
With boards, 1 inch by 6 to 10 inches laid regular or diagonal, average	SF	0.0230
Subfloor adhesive, 3/8-inch bead	LF	0.0040
06 16 26.10		
Underlayment		
(0010) Plywood and particle board underlayment, average from 3/8 to 3/4 inch thick	SF	0.0150
(0020) pneumatic nailed	SF	0.0120
06 16 36.10		
Sheathing		
Roofs,		
(0010) Plywood, average from 5/16 to 3/4 inch thick	SF	0.0170
(0020) pneumatic nailed	SF	0.0150
(0030) with boards, 1 by 6 inches laid horizontal	SF	0.0310
(0040) laid diagonal	SF	0.0330
(0050) 1 by 8 inches laid horizontal	SF	0.0240
(0060) laid diagonal	SF	0.0310
For steep roofs, multiply by 1.40.		
For dormers, hips, and valleys, multiply by 1.50.		
Walls,		
(0070) Plywood and oriented strand board, average from 3/8 to 3/4 inch thick	SF	0.021
(0080) pneumatic nailed	SF	0.017
(0090) with boards, 1 by 6 inches laid	SF	0.036
(0100) horizontal laid diagonal	SF	0.033
(0110) by 8 inches laid horizontal	SF	0.027
(0120) laid diagonal	SF	0.033
(0130) Other miscellaneous materiel	SF	0.017
Minimum suggested crew size: two builders.		
Notes: 1. Scaffolding is not included. 2. Clean-up is included. 3. Refer to Figure 5-G-8 for siding.		

Figure 5-F-10. Sheathing Production

Work Element Description	Unit	Man-hours per Unit
06 22 13.40		
Moldings, Exterior		
(0010) Cornice, boards, 1 by 2 inches	LF	0.0310
(0020) 1 by 6 inches	LF	0.0430
(0030) 1 by 12 inches	LF	0.0590
(0040) Corner board, 1 by 4 inches and 1 by 6 inches	LF	0.0530
(0050) Fascia, 1 by 6 inches	LF	0.0430
(0060) 1 by 8 inches	LF	0.0480
(0070) Trim, back band, 11/16 by 2 1/16 inches,	LF	
and casing, crown, 11/16 by 4 1/4 inches	LF	0.0430
(0080) Verge board, 1 by 4 inches and 1 by 6 inches	LF	0.0530
(0090) 1 by 8 inches and 1 by 10 inches	LF	0.0640
06 22 13.45		
Moldings, Trim		
(0010) Average for astragal, chair rail, half round, lattice, quarter round	LF	0.0430
(0020) Wainscot moldings, 1 1/8 by 9/16 inches, 2 feet high, minimum	SF	0.1400
(0030) maximum	SF	0.1640
06 22 13.50		
Moldings, Window and Door		
(0010) Door trim set, one head and two sides, 2 1/2 inches wide	Opening	1.8030
(0020) 3 1/2 inches wide	Opening	2.0070
(0030) Threshold, 3 feet long, inside	Each	0.3320
(0040) outside	Each	0.6650
Window trim set, including casings, header, stops, stool and apron		
(0050) 2 1/2 inches wide, minimum	Opening	0.8180
(0060) average	Opening	1.0640
(0070) maximum	Opening	1.7730
06 22 13.60		
Moldings, Soffits		
(0010) Soffits, average from 1 by 4 inches to 1 by 12 inches	LF	0.0530
06 43 13		
Wood Stairs and Railings		
(0010) Box stairs, prefabricated, 3 feet wide treads, up to 14 risers	Riser	0.5450
(0020) 4-foot-wide treads, up to 14 risers	Riser	0.6813
(0030) Basement stairs, prefabricated, 3 feet wide, treads up to 14 risers	Riser	0.4100
(0040) Residential stairs, wood, prefabricated	Flight	14.1870
(0050) built in place	Flight	48.3640

Figure 5-F-11. Millwork and Stairs Production

Work Element Description	Unit	Man-hours per Unit
06 48 13.10		
Exterior Wood Door Frames and Accessories		
(0010) Exterior frame including exterior trim	LF	0.0610
(0020) Sills	LF	0.2130
Exterior, modern, plain trim 3-foot opening, in-swing,		
(0030) minimum	Each	0.8180
(0040) average	Each	0.8870
(0050) maximum	Each	0.9670
06 48 16.10		
Interior Wood Door Jamb and Frames		
(0010) Interior frame	LF	0.0610
(0020) Threshold	LF	0.1060
Minimum suggested crew size: two builders.		

Figure 5-F-12. Wood Frames Production

CHAPTER 5 ANNEX G

Division 07

Thermal and Moisture Protection

5.G.1 INTRODUCTION

Division 07, thermal and moisture protection, includes waterproofing, damp proofing, insulation, roofing, and siding work that protects structures from the elements.

5.G.2 ESTIMATING INFORMATION AND TIPS

Most of the work in this division can be found on the architectural drawings. Estimators should pay close attention to the plan sections and details for flashing, sheet metal, insulation, vapor barrier, and roof accessories. Review the Division 07 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable. Refer to TM 3-34.47/FM 5-426/MCRP 3-40D.3 for further information on techniques and procedures for waterproofing, insulation, roofing, siding work, and the materiels used for these operations.

Do not assume that specified items (e.g., sheet metal items) are off-the-shelf items. Gutters, downspouts, termite shields, gravel stops, expansion joints, and reglets may need to be shop fabricated.

5.G.3 ESTIMATING DATA

Figures 5-G-1 through 5-G-9 present data and guidelines for estimating items found in Division 07.

Density of Fill, LB per CF					
Thickness of Fill (Inches)	6 LB	7 LB	8 LB	9 LB	10 LB
	Area (SF) Covered per CF of Fill				
1	21.2	18.0	15.9	14.1	13.0
2	10.6	9.1	8.0	7.1	6.4
3	7.1	6.1	5.3	4.7	4.2
4	5.3	4.6	4.0	3.5	3.2

Figure 5-G-1. Loose Fill Insulation Requirements

Work Element Description	Unit	Man-hours per Unit
07 11 13.10		
Bituminous Asphalt Coating		
(0010) Brushed on, below grade, one coat	SF	0.0160
(0020) two coats	SF	0.0210
(0030) Sprayed on, below grade, one coat, 25.6 SF per gallon	SF	0.0130
(0040) two coats, 20.5 SF per gallon	SF	0.0210
(0050) Troweled on, asphalt, 1/16 inch thick	SF	0.0210
(0060) 1/8 inch thick	SF	0.0270
(0070) 1/2 inch thick	SF	0.0300
07 11 16.20		
Cementitious Damp Proofing		
(0010) Portland cement or waterproofed Portland cement, two coats, 1/2 inch thick	SF	0.0850
Minimum suggested crew size: one builder and one laborer.		

Figure 5-G-2. Damp Proofing Production

Work Element Description	Unit	Man-hours per Unit
07 12 13.20		
Membrane Waterproofing		
On slabs,		
(0010) one-ply, felt, mopped	SF	0.0140
(0020) one-ply, glass fiber fabric, mopped	SF	0.0360
(0030) two-ply, felt, mopped	SF	0.0290
(0040) two-ply, glass fiber fabric, mopped	SF	0.0450
(0050) Fiberglass fabric, 20/10 mesh	Square	0.1840
07 13 53.10		
Elastomeric Sheet Waterproofing		
(0010) Various materiels, e.g., neoprene, polyethylene, or rubberized sheets average	SF	0.0390
07 16 16.20		
Cementitious Waterproofing		
(0010) Sprayed on, 1/8-inch application	SF	0.0320
(0020) Cementitious/metallic slurry, troweled, two coats, 1/4 inch thick	SF	0.0430
(0030) three coats, 3/8 inch thick	SF	0.0570
(0040) four coats, 1/2 inch thick	SF	0.0890
07 19 19.10		
Silicone Bases Water Repellents		
(0010) Water based liquid, roller applied	SF	0.0030
(0020) Silicone or stearate, sprayed on concrete masonry units, one coat	SF	0.0030
(0030) two coats	SF	0.0040
Minimum suggested crew size: 1. For membrane waterproofing on slabs: one skilled leader, four skilled laborers, and two unskilled laborers. 2. For membrane waterproofing with fiberglass fabric and other work elements: one skilled laborer and one unskilled laborer. 3. For cementitious waterproofing sprayed on application: one skilled laborer and two unskilled laborers.		
Note: A square = 100 SF of area.		

Figure 5-G-3. Waterproofing Production

Work Element Description	Unit	Man-hours per Unit
07 21 13.10 **Rigid Insulation**		
Various materiels, e.g., fiberglass, unfaced or faced; Isocyanurate (4 by 8 sheet) foil faced both sides; perlite; etc.		
(0010) minimum	SF	0.0110
(0020) average	SF	0.0150
(0030) maximum	SF	0.0200
07 21 13.13 **Foam Board Insulation**		
(0010) Polystyrene, expanded, 1 or 2 inches thick	SF	0.0160
07 21 16.20 **Blanket Insulation for Walls**		
(0010) Batt insulation, kraft-faced fiberglass, various materiels, widths and thicknesses; average	SF	0.0090
07 21 23.10 **Poured Loose-Fill Insulation**		
(0010) Various materiels, e.g., cellulose fiber, perlite, fiberglass wool, mineral wool, polystyrene, etc., average	SF	0.0530
07 21 26.10 **Blown Insulation**		
Various materiels, i.e., cellulose, fiberglass, or mineral wool; average for thickness indicated		
(0010) 3 1/2 inches	SF	0.0070
(0020) 9 or 10 inches thick	SF	0.0190
(0030) 20 inches thick	SF	0.0350
Wall installation, includes drilling and patching from outside, two 1-inch-diameter holes at 16 inches on center, top and middle point of wall, add to above for:		
(0040) masonry	SF	0.0770
(0050) wood siding	SF	0.0390
(0060) stucco/plaster	SF	0.0480
07 21 29.10 **Sprayed-On Insulation**	SF	0.0160
(0010) Fibrous/cementitious, finished wall, 1 inch thick attic		
(0020) 5.2 inches thick attic	SF	0.0200
Closed cell, spray polyurethane foam, 2 pounds per CF density		
(0030) 1 inch thick	SF	0.0050
(0040) 4 inches thick	SF	0.0210
(0050) 6 inches thick	SF	0.0320

Figure 5-G-4. Thermal Insulation Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
07 22 16.10 **Roof Deck Insulation**		
Various materiels, e.g., fiberboard, fiberglass, perlite, extruded polystyrene, etc., based on thickness		
(0010) minimum	SF	0.0110
(0020) average	SF	0.0130
(0030) maximum	SF	0.0150
Minimum suggested crew size: one builder and one laborer.		
Notes: 1. The installation of insulation includes scaffolding when required, fastening insulation into place, and cut-outs in insulation, as required. 2. One hundred sixty staples are required per 100 SF.		

Figure 5-G-4. Thermal Insulation Production (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
07 26 10.10 **Vapor Retarders**		
(0010) Various materiels, e.g., aluminum and kraft, foil one side or two sides; asphalt felt sheathing paper; polyethylene vapor barrier, etc.	Square	0.2870
Minimum suggested crew size: one skilled laborer and one unskilled laborer.		
Note: A square = 100 SF of area.		

Figure 5-G-5. Vapor Retarders Production

Work Element Description	Unit	Man-hours per Unit
07 31 13.10 **Asphalt Roof Shingles**		
(0010) Standard strip shingles, inorganic, class A, 210–235 pounds per square	Square	1.9350
(0015) Pitch over 7 in 12	Square	2.9025
(0020) Pneumatic nailed	Square	1.5200
(0025) Pitch over 7 in 12, pneumatic nailed	Square	2.2800
(0030) Standard strip shingles, organic, class C, 235–240 pounds per square	Square	2.1280
(0035) Pitch over 7 in 12	Square	3.1920
(0040) Pneumatic nailed	Square	1.7020
(0045) Pitch over 7 in 12, pneumatic nailed	Square	2.5530
(0050) Standard, laminated multilayered, class A, 240–260 pounds per square	Square	2.3650
(0055) Pitch over 7 in 12	Square	3.5475
(0060) Pneumatic nailed	Square	1.8910
(0065) Pitch over 7 in 12, pneumatic nailed	Square	2.8365
(0070) Standard, laminated multilayered class C, 260–300 pounds per square	Square	2.6600
(0075) Pitch over 7 in 12	Square	3.9900
(0080) Pneumatic nailed	Square	2.1280
(0085) Pitch over 7 in 12, pneumatic nailed	Square	3.1920
(0090) Premium, laminated multilayered class A, 260–300 pounds per square	Square	3.0400
(0095) Pitch over 7 in 12	Square	4.5600
(0100) Pneumatic nailed	Square	2.4350
(0105) Pitch over 7 in 12, pneumatic nailed	Square	3.6525
(0110) Premium, laminated multilayered, organic class C, 300-385 pounds per square	Square	3.5740
(0115) Pitch over 7 in 12	Square	5.3205
(0120) Pneumatic nailed	Square	2.8370
(0125) Pitch over 7 in 12, pneumatic nailed	Square	4.2555
(0130) 15 pound felt underlayment	Square	0.1660
(0140) 30 pound felt underlayment	Square	0.1840
(0150) Self-adhering polyethylene and rubberized asphalt underlayment	Square	0.4840
(0160) Ridge shingles	LF	0.0320
(0170) Ridge shingles, pneumatic nailed	LF	0.0140
07 31 16.20 **Steel Shingles**		
(0010) Galvanized, 26 or 24 gauge	Square	4.8360
07 31 26.10 **Slate Roof Shingles**		
(0010) Various types, 3/16 to 1/4 inch thick	Square	6.0790

Figure 5-G-6. Shingles and Shakes Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
07 31 29.13		
Wood Shingles		
(0010) 16 inches, number 1 red cedar shingles, 5-inch exposure on roof	Square	4.2560
(0020) Pneumatic nailed	Square	3.2740
(0030) 16 inches, number 1 red cedar shingles, 7 1/2-inch exposure on walls	Square	5.1900
(0040) Pneumatic nailed	Square	3.9850
(0050) 15 pound organic felt underlayment on roof, one layer, add	Square	0.1660
(0060) two layers, add	Square	0.3320
07 31 29.16		
Wood Shakes (Hand-split red cedar shakes)		
(0010) 1/2 inch thick by 24 inches long 10-inch exposure on roof	Square	4.2560
(0020) Pneumatic nailed	Square	3.2740
(0030) 3/4 inch thick by 24 inches long, 10-inch exposure on roof	Square	7.7290
(0040) Pneumatic nailed	Square	3.6440
(0050) 1/2 to 3/4 inch thick by 24 inches long, 10 inch exposure on walls	Square	5.3200
(0060) Pneumatic nailed	Square	4.0920
(0070) Ridge shakes	LF	0.0300
Note: For steep roofs, 7 in 12 pitch or greater, multiply by 1.50. A square = 100 SF of area.		
Minimum suggested crew size: one builder and one laborer.		

Figure 5-G-6. Shingles and Shakes Production (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
07 32 13.10		
Clay Tiles		
(0010) Minimum, i.e., Spanish tile, 171 pieces per square	Square	5.9100
(0020) Average, i.e., Lanai tile or Classic tile, 158 pieces per square	Square	6.4480
(0030) Maximum, i.e., Mission tile, 192 pieces per square	Square	9.2530
(0040) 15 pound felt underlayment	Square	0.1660
(0050) 30 pound felt underlayment	Square	0.1840
(0060) Self-adhering polyethylene and rubberized asphalt underlayment	Square	0.4840
07 32 16.10		
Concrete Tiles		
(0010) Corrugated, 13 by 16 1/2 inches, 90 per square, 950 pounds per square	Square	7.8820
(0020) Shakes, 13 by 16 1/2 inches, 90 per square, 950 pounds per square	Square	7.0930

Figure 5-G-7. Roof Tiles and Panels Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
07 32 19.10		
Metal Roof Tiles		
(0010) Mission tile, accessories included, 0.032-inch-thick aluminum	Square	4.2560
(0020) Spanish tile, accessories included, 0.032-inch-thick aluminum	Square	3.5470
07 41 13.10	SF	0.0360
Aluminum Roof Panels		
(0010) Corrugated or ribbed, various thicknesses		
(0020) Corrugated or ribbed, various thicknesses for roofing on wood frame, deduct	SF	0.0090
(0030) Ridge cap	LF	0.0530
07 41 13.20	SF	0.0390
Steel Roofing Panels		
Corrugated or flat profile, on steel framing		
(0010) Minimum, i.e., 30 gauge		
(0020) Average, i.e., 24 gauge	SF	0.0450
(0030) Maximum, i.e., 22 gauge	SF	0.0480
(0040) Ridge, galvanized, 10 inches wide	LF	0.0530
(0050) Ridge, galvanized, 10 inches wide, minimum, i.e., 30 gauge	LF	0.0570
07 41 33.10	SF	0.0430
Fiberglass Panels		
(0010) Corrugated panels, roofing, various weights		
(0020) Corrugated panels, siding, and flat panels, various weights	SF	0.0480
07 61 13.10		
Standing Seam Sheet Metal Roofing		
Copper standing seam roofing, over 10 squares,		
(0010) Minimum, i.e., 16 ounces, 125 pounds per square	Square	8.1850
(0020) Average, i.e., 18 ounces, 140 pounds per square	Square	8.8670
(0030) Maximum, i.e., 20 ounces, 150 pounds per square	Square	9.6730
Also apply to batten seam and flat seam roofing materiels		
Minimum suggested crew size: one builder and one laborer.		

Notes:
1. A square = 100 SF of area.
2. Refer to RSMeans for information on built-up bituminous roofing and elastomeric membrane roofing. Remember to apply a conversion factor to convert civilian labor production figures to reasonable production figures for military labor (man-hours/man-days) as discussed in 5.2.2.

Figure 5-G-7. Roof Tiles and Panels Production (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
07 42 13.20		
Aluminum Siding Panels		
(0010) Corrugated on steel frame, various thicknesses,	SF	0.0540
(0020) Average for roofing on wood frame, deduct	SF	0.0150
07 42 13.30		
Steel Siding		
(0010) Galvanized, corrugated or ribbed, 30 to 20 gauge,	SF	0.0540
(0020) Average factory sandwich panel, 26 to 22 gauge, average	SF	0.1180
07 46 23.10		
Wood Board Siding		
Various types, e.g., wood, cedar bevel;		
(0010) Minimum, i.e., 4 to 6 inches wide	SF	0.0480
(0020) Average, i.e., 8 inches wide	SF	0.0320
(0030) Maximum, i.e., 10 inches wide	SF	0.0280
07 46 29.10		
Plywood Siding Option		
Various types;		
(0010) Minimum, i.e., 3/8 inch thick	SF	0.0280
(0020) Average, i.e., 1/2 or 5/8 inch thick	SF	0.0320
(0030) Maximum, i.e., 3/4 inch thick	SF	0.0330
07 46 33.10		
Vinyl Siding		
Various types;		
(0010) Minimum	SF	0.0400
(0020) Maximum	SF	0.0530
Minimum suggested crew size: one builder and one laborer.		

Figure 5-G-8. Siding Production

Work Element Description	Unit	Man-hours per Unit
07 65 10.10		
Sheet Metal Flashing and Counter Flashing		
(0010) Aluminum, various thicknesses	SF	0.0730
(0020) Copper, by weight of sheets in ounces, average	SF	0.0930
(0030) Stainless steel sheets, various thicknesses	SF	0.0690
07 65 23.10		
Rubber Sheet Flashing and Counter Flashing		
(0010) Rubber, butyl and neoprene, various thicknesses	SF	0.0370

Figure 5-G-9. Flashing and Roof Specialties Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
07 71 19.10		
Gravel Stop		
Various types, e.g., aluminum, galvanized steel, PVC, and stainless steel at		
(0010) 4-inch-face height	LF	0.0400
(0020) 6-inch-face height	LF	0.0780
(0030) 8-inch-face height	LF	0.0850
(0040) 12-inch-face height	LF	0.1060
07 71 23.10		
Downspouts		
Various types, e.g., aluminum, copper, steel, etc.		
(0010) Minimum, i.e., 2 by 6 inches, 28 gauge	LF	0.0560
(0020) Average, i.e., 3 by 4 inches, various thicknesses	LF	0.0400
(0030) Maximum, i.e., 6-inch diameter, 26 gauge	LF	0.1010
07 71 23.20		
Downspout Elbows		
(0010) Elbows, various types	Each	0.1060
07 71 23.30		
Gutters		
(0010) Aluminum, copper, galvanized and stainless steel of various thicknesses and widths, average	LF	0.0890
(0020) Vinyl, at various widths	LF	0.0970
(0030) Wood, clear treated cedar, fir or hemlock, 3 by 4 inches	LF	0.1060
07 71 26.10		
Reglets and Accessories		
(0010) Aluminum, copper, galvanized and stainless steel of various thicknesses, average	LF	0.0480
(0020) Counter flashing for above, 12 inches wide, at various thicknesses	LF	0.0700
07 72 23.10		
Roof Vents		
(0010) Mushroom shape, for built-up roofs, aluminum	Each	0.3550
(0020) Mushroom shape, for built-up roofs, PVC, 6 inches high	Each	0.3550
07 72 53.10		
Snow Guard		
(0010) Double rail pipe type	LF	0.082
07 92 10.10		
Caulking and Sealant Options		
Acrylic latex caulk, 11 ounce cartridge		
(0010) 1/4 by 1/2 inch and 1/2 by 1/2 inch	LF	0.0430
(0020) 3/4 by 3/4 inch	LF	0.0460
(0030) 3/4 by 1 inch	LF	0.0530
(0040) 1 by 1 inch	LF	0.0580
(0050) Backer rod, polyethylene, 1/4-inch through 1-inch diameter	LF	0.0230
Minimum suggested crew size: one builder and one laborer.		
Note: Installation includes unloading, storing onsite, handling into place, hanging, fastening, and sealing.		

Figure 5-G-9. Flashing and Roof Specialties Production (Sheet 2 of 2)

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CHAPTER 5 ANNEX H

Division 08

Openings

5.H.1 INTRODUCTION

Division 08, openings, includes doors, frames, windows, glass, and hardware.

5.H.2 ESTIMATING INFORMATION AND TIPS

Most architectural drawings or specifications include door, window, and hardware schedules that state types, sizes, materiels, and options. If these schedules are not available when the estimate is done, estimators should create a schedule to document assumptions made for each component. Review the Division 08 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks if applicable. Refer to TM 3-34.47/FM 5-426/MCRP 3-40D.3 for further information on techniques and procedures for doors, windows, and the materiels used for these items.

Remember doors, windows, and hardware (especially specialty items) may be long lead items.

5.H.3 ESTIMATING DATA

Figures 5-H-1 through 5-H-7 present data and guidelines for estimating items found in Division 08.

Work Element Description	Unit	Man-hours per Unit
08 05 05.10		
Selective Demolition Doors		
(0010) Doors, exterior, 1 3/4 inches thick, single, 3 feet by 7 feet high	Each	0.6650
(0020) Doors, exterior, 1 3/4 inches thick, double, 6 feet by 7 feet high	Each	0.8870
(0030) Frames, including trim, metal	Each	1.3300
(0040) Frames, including trim, wood	Each	0.6650
(0050) Overhead, commercial, 12 feet by 12 feet high	Each	5.3200
(0060) Roll-up grille	Each	4.2560
08 05 05.20		
Selective Demolition Windows		
Various materiels, including trim, e.g., aluminum, steel, wood, etc.		
(0010) Minimum, to 12 SF	Each	0.6650
(0020) Average, to 25 SF	Each	0.9670
(0030) Maximum, to 50 SF	Each	2.1280
(0040) Glass, minimum	SF	0.0530
(0050) Glass, maximum	SF	0.0700
(0060) Remove bay/bow window	Each	3.5470
(0070) Remove skylight, plastic domes	SF	0.1080
Minimum suggested crew size: one builder and one laborer.		
Note: The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for demolition.		

Figure 5-H-1. Selective Doors and Windows Demolition Production

Work Element Description	Unit	Man-hours per Unit
08 11 16.10		
Entrance Doors and Frames		
Aluminum, narrow stile, average by size opening		
(0010) 3- by 7-foot opening	Each	10.6400
(0020) 3-foot-6-inch by 10-foot opening, 3-foot-high transom	Each	11.8220
(0030) 6- by 7-foot opening	Each	16.3700
For non-standard size, multiply by 1.67.		
08 11 63.23		
Aluminum Screen and Storm Doors and Frames		
Combination storm and screen, various materiels, 6 feet 8 inches by		
(0010) 2 feet 6 inches wide	Each	1.4190
(0020) 2 feet 8 inches wide or 3 feet wide	Each	1.5200
For 7-foot-door height, multiply by 1.05.		
08 12 13.13		
Standard Hollow Metal Frames		
Average, up to 5 3/4-inch-jamb depth, standard height, various openings		
(0010) 3 feet wide, single	Each	1.3300
(0020) 4 feet wide, single	Each	1.4190
(0030) 6 feet wide, double	Each	1.5200
(0040) 8 feet wide, double	Each	1.7730
08 13 13.13		
Standard Hollow Metal Doors		
Various types of doors of standard size		
(0010) Minimum	Each	1.0640
(0020) Average	Each	1.2510
(0030) Maximum	Each	1.6370
08 14 16.09		
Smooth Wood Doors		
Various types of doors of standard size		
(0010) Minimum	Each	1.2510
(0020) Average	Each	1.4190
(0030) Maximum	Each	1.7730
08 31 13.10		
Access Doors and Frames		
(0510) Ceiling hatch 2 ft 6 in by 2 ft 6 in	Opening	2.9090
08 32 19.15		
Sliding Glass Vinyl-Clad Wood Doors		
(0010) Various, standard size	Opening	5.9850
Minimum suggested crew size: one builder and one laborer.		
Note: The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for door and frame installation.		

Figure 5-H-2. Doors and Frames Production

Work Element Description	Unit	Man-hours per Unit
08 34 16.10		
Aircraft Hanger Doors		
Bi-fold, overhead, 20 pounds per SF wind load, includes electronic operation		
(0010) 12 feet high by 40 feet wide	SF	0.0890
(0020) 16 feet high by 60 feet wide	SF	0.0930
(0030) 20 feet high by 80 feet wide	SF	0.0970
08 34 59.10		
Secure Storage Doors and Frames		
(0010) Various sizes and weights, average	Opening	18.6200
08 34 63.13		
Steel Detention Doors and Frames		
(0010) 3 feet by 7 feet, complete with hardware, single plate and double plate	Each	10.6400
08 36 13.10		
Overhead Commercial Doors		
Average, stock, sectional, wood, fiberglass, or aluminum, per size		
(0010) 8 feet by 8 feet high	Each	10.6400
(0020) 10 feet by 10 feet high	Each	11.8220
(0030) 12 feet by 12 feet high	Each	14.1870
(0040) 20 feet by 14 feet high	Each	30.4000
08 36 13.20		
Residential Garage Doors		
Average, overhead, sectional, including hardware, various types of doors		
(0010) Average	Each	3.5470
Minimum suggested crew size: one builder and one laborer.		
Note: The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for door and frame installation.		

Figure 5-H-3. Special Function Doors Production

Work Element Description	Unit	Man-hours per Unit
08 51 13.20		
Aluminum Windows		
Stock units, casement		
(0010) 3-foot-1-inch by 3-foot-2-inch opening	Each	2.1280
(0020) 3-foot-4-inch by 5-foot opening	Each	2.3650
(0030) 8- by 4-foot opening	Each	3.5470
08 52 10.30		
Wood Windows		
Double hung, sash, single lite		
(0010) 2 feet by 2 feet high	Each	0.5320
(0020) 2 feet 6 inches by 2 feet high	Each	0.5600
(0030) 2 feet 6 inches by 2 feet 6 inches high	Each	0.5900
(0040) 3 feet by 2 feet high	Each	0.6260
08 52 10.50		
Double Hung		
Solid vinyl, average quality, double insulated glass		
(0010) 2 feet by 3 feet	Each	1.0640
(0020) 3 feet by 4 feet	Each	1.1820
(0030) 4 feet by 4 feet 6 inches	Each	1.3300
08 52 66.10		
Wood Screens		
(0010) Over 3 SF, 3/4- and 1 1/8-inch frames	SF	0.0570
08 62 13.20		
Skylights		
Plastic domes, flush or curb mounted		
(0010) Normal size under 10 SF, double	SF	0.3270
(0020) Normal size under 10 SF, single	SF	0.2660
(0030) 10 SF to 20 SF, double	SF	0.1360
(0040) 10 SF to 20 SF, single	SF	0.1080
(0050) 20 SF to 30 SF, double	SF	0.1080
(0060) 20 SF to 30 SF, single	SF	0.0920
(0070) 30 SF to 65 SF, double	SF	0.0920
(0080) 30 SF to 65 SF, single	SF	0.0690
(0090) Ventilating insulated Plexiglas dome with curb mounting 36 by 36 inches and 52 by 52 inches	Each	3.5470
(0100) Ventilating insulated Plexiglas dome with curb mounting 28 by 52 inches and 36 by 52 inches	Each	4.2560
Does not include electric operating system		
Minimum suggested crew size: one builder and one laborer.		
Note: The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for window installation.		

Figure 5-H-4. Windows Production

Work Element Description	Unit	Man-hours per Unit
08 71 20.10 **Bolts, Flush**		
(0010) Standard, concealed	Each	1.5200
(0020) Automatic fire exit	Each	2.1280
(0030) For electric release, add	Each	3.5470
(0040) Barrel, brass, 2 to 6 inches long	Each	0.3270
08 71 20.30 **Door Closers**		
(0010) Various types, standard minimum	Each	1.6370
(0020) Maximum	Each	1.7730
08 71 20.35 **Panic Devices**		
(0010) Various types, minimum	Each	1.7730
(0020) Maximum	Each	2.1280
08 71 20.40 **Lockset**		
(0010) Various types, maximum	Each	1.0640
08 71 20.41 **Dead Locks**		
(0010) Various types, maximum	Each	1.1820
08 71 20.42 **Mortise Locksets**		
(0010) Commercial, wrought knobs and full escutcheon trim, various types, maximum	Each	1.5200
08 71 20.50 **Door Stops**		
(0010) Various types	Each	0.3320
08 71 20.55 **Push-Pull Plates**		
(0010) Push plate, 0.050 thick, 4- by 16-inch aluminum or bronze	Each	0.8870
(0020) Pull handle and push bar, aluminum	Each	0.9670
(0030) Pull handle and push bar, bronze	Each	1.0640
08 71 20.65 **Thresholds**	LF	0.2220
(0010) Threshold, 3-foot-long saddles, aluminum,		
(0020) Threshold, aluminum 8 inches wide by 1/2 inch thick	Each	0.8870
(0030) Threshold, bronze 8 inches wide by 1/2 inch thick	LF	0.1770
(0040) Bronze, panic threshold, 5 inches wide by 1/2 inch thick	Each	0.8870
(0050) Rubber, 5 1/2 inches wide by 1/2 inch thick	Each	0.5320

Figure 5-H-5. Door Hardware Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
08 71 20.95		
Kick Plates		
(0010) Various types and sizes, average	Each	0.7090
Minimum suggested crew size: one builder and one laborer.		
Note: Installation includes drilling for fasteners, expansion shields, installing plugs, toggle bolts, blocking, hinges, locks, and other hardware.		

Figure 5-H-5. Door Hardware Production (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
08 71 25.10		
Doors—Mechanical Seals, Weatherstripping		
(0010) Doors, wood frame, interlocking, for 3- by 7-foot door, zinc or bronze	Opening	3.5470
(0020) 6- by 7-foot opening, zinc or bronze	Opening	5.3200
(0030) Threshold weatherstripping, door sweep, flush mounted	Each	0.4260
(0040) Garage door bottom weatherstrip, 12-foot aluminum, rubber, etc.	Each	0.7600
08 75 30.10		
Windows—Mechanical Weather Seals		
(0010) Window, double hung, 3 by 5 feet, zinc or bronze	Opening	1.4780
(0020) heavy duty zinc or bronze	Opening	2.3130
Minimum suggested crew size: one builder and one laborer.		

Figure 5-H-6. Weather stripping Door and Window Production

Work Element Description	Unit	Man-hours per Unit
08 91 19.10		
Aluminum Louvers		
(0010) Aluminum with screen, residential, 8 by 8 inches, minimum	Each	0.2810
(0020) 24 by 30 inches, maximum	Each	0.7090
08 95 13.10		
Wall Louvers		
(0010) Soffit vent, continuous, 3 inches wide, aluminum	LF	0.0530
(0020) Under eaves vent, aluminum, 16 by 4 inches and 16 by 8 inches	Each	0.2220
08 95 16.10		
Louvers		
Redwood, 2-foot diameter, full circle and other shapes	Each	0.6650
Vinyl gable vent, 8 by 8 inches and 12 by 12 inches	Each	0.2810
12 by 18 inches	Each	0.3040
18 by 24 inches	Each	0.3550
Minimum suggested crew size: one builder and one laborer.		

Figure 5-H-7. Louvers and Vents Production

CHAPTER 5 ANNEX J

Division 09

Finishes

5.J.1 INTRODUCTION

Division 09, finishes, includes a variety of interior work items including gypsum board (also known as sheetrock or drywall), plaster construction, tile, acoustical ceilings, wood and resilient flooring, carpeting, and painting.

5.J.2 ESTIMATING INFORMATION AND TIPS

Most architectural drawings, including floor plans, elevations, and reflected ceiling plans or specifications, provide information to calculate quantities. Room finish schedules also provide critical information. If these schedules are not available when the estimate is done, estimators should create a schedule to document assumptions made for each component. Review the Division 09 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks if applicable. Refer to TM 3-34.47/FM 5-426/MCRP 3-40D.3 for further information on techniques and procedures for finishes, and the materiels used for these items.

5.J.3 ESTIMATING DATA

Figures 5-J-1 through 5-J-19 present data and guidelines for estimating items found in Division 09.

Materiels Required per 100 SF of Wall					
Thickness (Inches)	Mortar (CF)	Mortar: Mixture Ratio 1:2 1/2		Mortar: Mixture Ratio 1:3	
		Cement (Bags)	Sand (CF)	Cement (Bags)	Sand (CF)
1/4	2.08	0.84	2.08	0.73	2.20
3/8	3.13	1.26	3.14	1.10	3.30
1/2	4.17	1.68	4.19	1.47	4.40
5/8	5.21	2.09	5.23	1.83	5.50
3/4	6.25	2.51	6.28	2.20	6.60
1	8.33	3.35	8.37	2.93	8.80

Figure 5-J-1. Materiel Requirements for Cement, Stucco, and Plaster

Area to be Tiled (SF)	Waste Allowance (Percent)
1 to 50	14
51 to 100	10
101 to 200	8
201 to 500	7
501 to 1,000	5
Over 1,000	5

Figure 5-J-2. Floor Tile Waste Allowances

Type of Wallboard	Size of Panels (Inches)	Fastening Method	Nails Required per 100 SF
Gypsum	48×96	nailed to studs	1.00 LB
Perforated hardboard	48×96	nailed to studs	4.00 LB
Plant tongue and groove board	8×96	nailed to studs	2.00 LB
Plant tongue and groove board	12×96	nailed to studs	2.00 LB
Plywood panels	48×96	nailed to studs or wall	1.25 LB
Rock lath	16×96	nailed to studs	5.00 LB
Tempered tile board	48×96	nailed to studs	1.00 LB
Tempered tile board	48×96	adhesive applied to wall	1.50 LB (See Note 2)

Notes:
1. In the adhesive and nail-on method, gypsum board adhesive is applied to the joists and studs before each piece of wallboard is positioned and nailed. The adhesive is applied to the framing member from a caulking gun in about 3/8-inch-diameter bead. For each 1,000 SF of wallboard use eight quart-size tubes of adhesive.
2. Amount of adhesive required per gallon for 100 square feet.

Figure 5-J-3. Estimating Fastener Requirements for Wallboard

Materiel	Tough (Minutes)	Recoat (Hours)	Rub (Hours)
Lacquer	1 to 10 minutes	1.5 to 3 hours	16 to 24 hours
Lacquer sealer	1 to 10 minutes	0.50 to 0.75 hour	1 hour (sand)
Non-grain-raising stain	15 minutes	3 hours	N/A
Oil stain	60 minutes	24 hours	N/A
Paste wood filler	N/A	24 to 48 hours	N/A
Paste wood filler (quick dry)	N/A	3 to 4 hours	N/A
Pigment oil stain	60 minutes	12 hours	N/A
Pigment oil stain (quick dry)	60 minutes	3 hours	N/A
Shading stain	zero	zero	N/A
Shellac	15 minutes	2 hours	12 to 18 hours
Shellac (wash coat)	2 minutes	0.50 hour	N/A
Spirit stain	zero	0.167 hour	N/A
Stain (quick dry)	2 minutes	0.25 hour	N/A
Varnish	90 minutes	18 to 24 hours	24 to 48 hours
Varnish (quick dry, synthetic)	30 minutes	4 hours	12 to 24 hours
Water stain	60 minutes	12 hours	N/A

Note: Average drying time: Different products will vary.

Figure 5-J-4. Drying Times for Finishes

Items	Coat	One Gallon Covers (SF)		
		Brush	Roller	Spray
Paint wood siding	Prime	250	225	290
	Others	270	250	290
Paint exterior trim	Prime	400		
	First	475		
	Second	520		
Paint shingle siding	Prime	270	255	300
	Others	360	340	380
Stain shingle siding	First	180	170	200
	Second	270	250	290
Paint brick masonry	Prime	180	135	160
	First	270	225	290
	Second	340	305	360
Paint interior plaster drywall	Prime	400	380	495
	Others	450	425	495
Paint interior doors and windows	Prime	400		
	First	425		
	Second	450		
Note: For best results, refer to manufacturers' specifications and coverage figures.				

Figure 5-J-5. Paint Coverage

Type Construction	Surface Area (SF) per Ton	Coat	One Gallon Covers (SF)	
			Brush	Spray
Light structural	300 to 500	First	500	455
		Second	450	410
		Third	450	410
Medium	150 to 300	All	400	365
Heavy structural	50 to 150	All	400	365
Weighted average	225	All	400	365
Note: For best results, refer to manufacturers' specifications and coverage figures.				

Figure 5-J-6. Coating Coverage of Structural Steel

Work Element Description	Unit	Man-hours per Unit
09 21 16.33		
Partition Wall, Gypsum Board		
Stud wall, 8 to 12 feet high, interior, gypsum board, standard, tape and finish two sides		
1/2 inch thick on		
(0010) 2- by 4-inch or 6-inch wood studs, 16 inches on center	SF	0.0690
(0020) 3 5/8 inches wide, metal studs, non-load bearing, 16 inches on center	SF	0.0610
5/8 inch thick on		
(0030) 2- by 4-inch wood studs, 16 inches on center	SF	0.0710
(0040) 2- by 4-inch wood studs, 24 inches on center	SF	0.0640
(0050) 3 5/8 inches wide, metal studs, non-load bearing, 16 inches on center	SF	0.0620
09 22 13.13		
Metal Channel Furring		
(0010) Beams and columns, 7/8-inch channels galvanized, 16 inches on center	SF	0.0620
(0020) Ceilings, on steel, 7/8-inch channels, galvanized, 16 inches on center	SF	0.0370
(0030) Walls, 7/8-inch channels galvanized, 16 inches on center	SF	0.0400
09 22 16.13		
Metal Studs and Track		
(0010) 8 feet high, non-load bearing, galvanized, 3 5/8 inches wide, 16 inches on center	SF	0.017
(0020) 24 inches on center	SF	0.012
(0030) 10 feet high, non-load bearing, galvanized, 3 5/8 inches wide, 16 inches on center	SF	0.023
(0040) 24 inches on center	SF	0.015
(0050) 12 feet high, non-load bearing, galvanized, 3 5/8 inches wide, 16 inches on center	SF	0.027
(0060) 24 inches on center	SF	0.017
09 22 26.13		
Ceiling Suspension System		
Suspended ceiling, for gypsum board or plaster, 1 1/2- or 2-inch carriers		
(0010) 7/8-inch carrier channels, 16 inches on center	SF	0.052
(0020) 24 inches on center	SF	0.040
(0030) 1 5/8-inch carrier channels, 16 inches on center	SF	0.055
(0040) 24 inches on center	SF	0.041

Figure 5-J-7. Plaster and Gypsum Board Assemblies Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
09 22 36.13		
Gypsum Lath		
(0010) Plain or perforated, nailed, 3/8 inch thick	SY	0.1250
(0020) Plain or perforated, nailed, 1/2 inch thick	SY	0.1330
(0030) Clipped to steel studs, 3/8 inch thick	SY	0.1420
(0040) 1/2 inch thick	SY	0.1520
(0050) For ceiling installations, add	SY	0.0490
(0060) For columns and beams, add	SY	0.0620
09 22 36.23		
Metal Lath		
(0010) Mesh, nailed to wood, 1.8 pounds	SY	0.1770
(0020) Mesh, nailed to wood, 3.6 pounds	SY	0.1930
(0030) Wired to steel, 1.8 pounds	SY	0.2010
(0040) Wired to steel, 3.6 pounds	SY	0.2130
(0050)Hollow metal stud partitions, 3.4 pounds lath both sides, non-load bearing, various configurations, average	SY	0.5320
09 22 36.43		
Security Mesh		
Expanded metal, flat, screwed to framing, 3/4 inch, 1.76 pounds per SF		
(0010) on walls	SF	0.0150
(0020) on ceilings	SF	0.0160
09 22 36.83		
Accessories, Plaster		
(0010) Casing bead, expanded flange, galvanized	LF	0.0400
(0020) Corner bead, expanded bullnose	LF	0.0410
(0030) Expansion joint, 3/4-inch grounds, limited expansion, galvanized	LF	0.0400
Minimum suggested crew size: one builder and one laborer.		

Notes:
1. The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for plaster and gypsum board assemblies.
2. Fasteners are screws or blued, ring shank nails for wood framing and screws for metal framing.
3. Accessories are not included in plaster or stucco line items.

Figure 5-J-7. Plaster and Gypsum Board Assemblies Production (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
09 23 13.10		
Perlite or Vermiculite, (100 pound bags)		
(0010) two coats, no lath included, on walls	SY	0.5790
(0020) two coats, no lath included, on ceilings	SY	0.6730
(0030) three coats, no lath included, on walls	SY	0.7200
(0040) three coats, no lath included, on ceilings	SY	0.8450
09 23 20.10		
Gypsum Plaster on Walls and Ceilings, (80 pound bags)		
(0010) two coats, no lath included, on walls	SY	0.5070
(0020) two coats, no lath included, on ceilings	SY	0.5790
(0030) three coats, no lath included, on walls	SY	0.6120
(0040) three coats, no lath included, on ceilings	SY	0.6820
09 23 20.20		
Gauging Plaster, (100 pound bags)		
(0010) two coats, no lath included, on walls	SY	0.5070
(0020) two coats, no lath included, on ceilings	SY	0.5790
(0030) three coats, no lath included, on walls	SY	0.6120
(0040) three coats, no lath included, on ceilings	SY	0.6820
09 23 20.30		
Keenes Cement, (100 pound bags)		
(0010) Finish only, standard quality	SY	0.2470
(0020) Finish only, high quality	SY	0.3700
09 24 23.40		
Stucco, Portland Cement Plastering		
Exterior stucco, with bonding agent, three coats, no mesh included,		
(0010) walls	SY	0.2660
(0020) ceilings	SY	0.2950
(0030) beams	SY	0.6650
(0040) columns	SY	0.5320
Minimum suggested crew size: three builders and two laborers.		
Notes: 1. Lath not included, refer to Division 09 22 36.23 lath installation. 2. For irregular or curved surfaces, multiply by 1.30. 3. For irregular or curved surfaces, multiply by 1.50. 4. For soffits, multiply ceiling/overhead work by 1.40.		

Figure 5-J-8. Plastering and Stucco Production

Work Element Description	Unit	Man-hours per Unit
09 29 10.10		
Gypsum Board Ceilings		
Screwed to grid, channel, or joists, 1/2 or 5/8 inch thick		
(0010) standard, no finish	SF	0.0120
(0020) taped and finished (level 4 finish)	SF	0.0320
(0030) with compound skim coat (level 5 finish)	SF	0.0390
Over 8 feet high, multiply by 1.25.		
09 29 10.30		
Gypsum Board		
Walls, nailed or screwed to studs, various widths		
(0010) standard, no finish	SF	0.0120
(0020) taped and finished (level 4 finish)	SF	0.0230
(0030) with compound skim coat (level 5 finish)	SF	0.0320
On beams, columns, or soffits, various widths		
(0040) standard, no finish	SF	0.0360
(0050) taped and finished (level 4 finish)	SF	0.0510
(0060) with compound skim coat (level 5 finish)	SF	0.0630
09 29 15.10		
Accessories, Gypsum Board		
(0010) Casing bead, galvanized steel or vinyl	LF	0.0370
(0020) Corner bead, galvanized steel or vinyl, 1 by 1 inch	LF	0.0150
(0030) Corner bead, galvanized steel or vinyl, 1 1/4 by 1 1/4 inches	LF	0.0350
(0040) Furring channel, galvanized steel, 7/8 inch deep, standard	LF	0.0410
Minimum suggested crew size: two builders.		

Notes:

1. A multiplier of 1.5 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production.
2. For the adhesive and nail-on method, gypsum board adhesive is applied to the joists and studs before each piece of wall board is positioned and nailed. The adhesive is applied to the framing member from a caulking gun in about 3/8-inch-diameter bead. For each 1,000 SF of wallboard use eight quart-size tubes of adhesive.
3. Refer to Figure 5-J-3 for estimating fastener requirements for wallboard.
4. The industry standard levels of gypsum drywall finish are:
   a. Level 0: No taping, finishing, or accessories required.
   b. Level 1: All joints and interior angles shall have tape set in joint compound. Surface shall be free of excess joint compound. Tool marks and ridges are accepted.
   c. Level 2: All joints and interior angles shall have tape embedded in joint compound and wiped with a joint knife leaving a thin coating of joint compound over all joints and interior angles. Fastener heads and accessories shall be covered with a coat of joint compound. Surface shall be free of excess joint compound. Tool marks and ridges are accepted. Joint compound applied over the body of the tape at the time of tape embedment shall be considered a separate coat of joint compound and shall satisfy the conditions of this level.
   d. Level 3: All joints and interior angles shall have tape embedded in joint compound and one additional coat of joint compound applied over all joints and interior angles. Fastener heads and accessories shall be covered with two separate coats of joint compound. All joint compound shall be smooth and free of tool marks and ridges.
   e. Level 4: All joints and interior angles shall have tape embedded in joint compound and two separate coats of joint compound applied over all flat joints and one separate coat of joint compound applied over interior angles. Fastener heads and accessories shall be covered with three separate coats of joint compound. All joint compound shall be smooth and free of tool marks and ridges.
   f. Level 5: All joints and interior angles shall have tape embedded in joint compound and two separate coats of joint compound applied over all flat joints and one separate coat of joint compound applied over interior angles. Fastener heads and accessories shall be covered with three separate coats of joint compound. A thin skim coat of joint compound, or a materiel manufactured especially for this purpose, shall be applied to the entire surface. The surface shall be smooth and free of tool marks and ridges.

Figure 5-J-9. Gypsum Board Production

Work Element Description	Unit	Man-hours per Unit
09 30 13.10 **Ceramic Tile**		
(0010) Base, using 1- by 4-inch-high piece with 1- by 1-inch tiles, mud set	LF	0.2600
(0020) Base, using 1- by 4-inch-high piece with 1- by 1-inch tiles, thin set	LF	0.1660
(0030) Bullnose trim, 4 1/4 by 4 1/4 inches, mud set	Each	7.3380
(0040) Bullnose trim, 4 1/4 by 4 1/4 inches, mud set, thin set	LF	0.2600
(0050) Floors, random or uniform, thin set, 6 by 6 inches	LF	0.1660
(0060) Floors, random or uniform, 8 by 8 inches	SF	0.1160
(0070) Floors, random or uniform, 12 by 12 inches	SF	0.0850
(0080) Floors, random or uniform, 16 by 16 inches	SF	0.0650
(0090) Walls, interior, thin set, 4 1/4- by 4 1/4-inch tile	SF	0.0390
(0100) Various larger sizes decrease labor per unit	SF	0.1120
(0110) Exterior wall, frost proof, mud set, 4 1/4- by 4 1/4-inch tile	SF	0.2090
(0120) For epoxy grout, 1/16-inch joints, 4 1/4-inch tile, add	SF	0.0150
(0130) For tile set in Portland cement mortar, add	SF	0.0730
(0140) Regrout tile, 4 1/4 by 4 1/4 inches, or larger, wall or floor, add	SF	0.1060
09 30 16.10 **Quarry Tile**		
(0010) Base, cove or sanitary, mud set, to 5 inches high, 1/2 inch thick	LF	0.1930
(0020) Bullnose trim, 6 by 6 by 1/2 inches thick, mud set	LF	0.1770
(0030) 6 by 6 by 1/2 inches thick	LF	0.1930
(0040) Floors, mud set, 4 by 4 by 1/2 inches thick	SF	0.1770
(0050) Floors, mud set, 6 by 6 by 1/2 inches thick	SF	0.1520
(0060) Floors, mud set, 4 by 8 by 1/2 inches thick	SF	0.1640
(0070) Stair tread, 6 by 6 by 3/4 inches thick, plan or abrasive	SF	0.4520
(0080) Wainscot, 6 by 6 by 3/4 inches thick, thin set	SF	0.2020
(0090) Window sill, 6 inches wide, 3/4 inch thick	LF	0.2370
(0100) Window sill corners	Each	0.2660
Minimum suggested crew size: one builder and one laborer.		

Notes:

1. The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for tiling.
2. Tables are based on half of the crew experienced in the work.
3. A ratio of one helper to one tile setter.
4. Cutting tile masonry or tile saw.
5. Production will be affected by type and scope of work. Large open areas will go faster than small rooms with many corners.
6. Factors include: layout, centering, setting, grouting, and clean-up.

Figure 5-J-10. Tiling Production

Work Element Description	Unit	Man-hours per Unit
09 51 23.30		
Suspended Ceilings, Complete		
Including standard suspension system (not including carrier channels)		
Ceiling board, fiberglass or mineral fiber, on 15/16-inch suspension		
bar, various sizes		
(0010) minimum	SF	0.0210
(0020) maximum	SF	0.0430
09 51 53.10		
Ceiling Tile, Direct-Applied		
(0010) Stapled or cemented, 12 by 12 inches or 12 by 24 inches, various materiels, not including furring	SF	0.0360
Minimum suggested crew size: one builder and one laborer.		
Note: Refer to Division 09 22 26.13 for carrier channels for ceiling suspension systems.		

Figure 5-J-11. Ceilings Production

Work Element Description	Unit	Man-hours per Unit
09 64 23.10		
Wood Parquet		
(0010) Parquetry, standard, 5/16 inch thick, not including finish, minimum	SF	0.0670
(0020) Parquetry, standard, 5/16 inch thick, not including finish, maximum	SF	0.1060
(0030) Parquetry, custom, including finish, minimum	SF	0.1060
(0040) Parquetry, custom, including finish, maximum	SF	0.2130
09 64 29.10		
Wood		
(0010) Fir, vertical grain, 1 by 4 inches, not including finish	SF	0.0410
(0020) Maple, strip, 25/32 by 2 1/4 inches, not including finish	SF	0.0620
(0030) Yellow pine, 3/4 by 3 1/8 inches, tongue and groove, not including finish	SF	0.0530
(0040) Sanding and finishing, two coats polyurethane	SF	0.0360
Minimum suggested crew size: one builder and one laborer.		
Notes: 1. The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for wood flooring. 2. Refer to Division 06 16 23.10 for subfloor and Division 06 16 26.10 for underlayment.		

Figure 5-J-12. Wood Flooring Production

Work Element Description	Unit	Man-hours per Unit
09 65 10.10		
Latex Underlayment		
(0010) 1/8 inch thick, cementitious for resilient flooring, liquid	SF	0.0670
09 65 13.13		
Resilient Base		
(0010) Base, cove, rubber or vinyl, 2 1/2, 4, or 6 inches high	LF	0.0330
(0020) Corners, 2 1/2, 4, or 6 inches high	Each	0.0330
09 65 16.10		
Rubber and Vinyl Sheet Flooring		
(0010) Linoleum	SF	0.0290
(0020) Rubber, 36 inches wide, 0.125 inch thick	SF	0.0890
(0030) Rubber, 36 inches wide, 0.187 inch thick	SF	0.1060
(0040) Rubber, 36 inches wide, 0.250 inch thick	SF	0.1180
(0050) Vinyl, backed, 0.065 inch thick	SF	0.0430
(0060) Vinyl, backed, 0.080 inch thick	SF	0.0460
(0070) Vinyl, backed, 0.125 inch thick	SF	0.0530
09 65 19.10		
Miscellaneous Resilient Tile Flooring		
(0010) Rubber tile, various types, 12 by 12 inches, 1/8 inch thick	SF	0.0150
(0020) Synthetic turf, 3/8 inch thick	SF	0.1180
(0030) interlocking 2- by 2-foot squares, 1/2 inch thick, not cemented	SF	0.0630
(0040) Vinyl composition tile, various types and sizes, 12 by 12 inches, 1/16 inch thick	SF	0.0210
Minimum suggested crew size: one builder and one laborer.		

Notes:

1. The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for resilient flooring.
2. Adhesive cement, one gallon per 200 to 300 SF.
3. Asphalt primer, one gallon per 300 SF.
4. Emulsion, one gallon per 140 SF.

Figure 5-J-13. Resilient Flooring Production

Work Element Description	Unit	Man-hours per Unit
09 68 05.11 **Flooring Transition Strip**		
(0010) Clamp down brass divider, 12-foot strip, vinyl to carpet	Each	0.3400
09 68 10.10 **Commercial Grade Carpet Pad**		
(0010)Variety of types (e.g., sponge rubber, felt, and bonded urethane)	SY	0.0710
09 68 13.10 **Carpet Tile**		
(0010) Tufted nylon, 18 by 18 inches, hard back or cushion back, 20 ounce or 26 ounce	SY	0.0710
(0020) Tufted nylon, 24 by 24 inches, 24 ounce, 35 ounce, or 42 ounce	SY	0.1330
09 68 16.10 **Sheet Carpeting**		
(0010) Nylon, level loop, 26 ounce, light to medium traffic	SY	0.1420
(0020) Nylon, plush, 60 ounce, heavy traffic	SY	0.1520
For small rooms, less than 12 feet wide, multiply by 1.25.		
For large open areas (no cuts), multiply by 0.75.		
09 68 20.10 **Indoor Athletic Carpet**		
(0010) Nylon, level loop, 26 ounce, light to medium traffic	SF	0.0390
Minimum suggested crew size: one builder and one laborer.		
Note: The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for plaster and gypsum board assemblies.		

Figure 5-J-14. Carpeting Production

Work Element Description	Unit	Man-hours per Unit
09 69 13.10 **Access Floors**		
(0010) Access floor package including panel, pedestal, stringers, and laminate cover, (i.e., computer room)	SF	.0650
Minimum suggested crew size: four builders.		
Note: A multiplier of 1.5 was used to convert civilian production rates to military production rates in this figure.		

Figure 5-J-15. Access Flooring Production

Work Element Description	Unit	Man-hours per Unit
09 72 23.10 **Wallpaper**		
(0010) Average workmanship, solid pattern	SF	0.0170
(0020) Basic patterns, matching required	SF	0.0200
Minimum suggested crew size: one skilled paper hanger and one unskilled laborer.		
09 77 33.10 **Fiberglass Reinforced Plastic Panels**		
(0010) On walls, 0.090 inch thick, adhesive mounted	SF	0.0330
(0020) On walls, 0.090 inch thick, nylon rivet mounted, on drywall	SF	0.0440
(0030) On walls, 0.090 inch thick, nylon rivet mounted, on masonry	SF	0.0670
(0040) On walls, 0.090 inch thick, nylon rivet and adhesive mounted, on drywall	SF	0.0890
(0050) On walls, 0.090 inch thick, nylon rivet and adhesive mounted, on masonry	SF	0.1120
Minimum suggested crew size: one builder and one laborer.		
Notes: 1. The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for plaster and gypsum board assemblies. 2. A multiplier of 1.5 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production. 3. Refer to Division 09 29 10.30 for gypsum board installation.		

Figure 5-J-16. Wall Coverings Production

Work Element Description	Unit	Man-hours per Unit
09 91 03.30 **Exterior Surface Preparation** Average times for various surfaces, including steel		
(0010) scrape and sand	SF	0.0330
(0020) wire brush	SF	0.0150
(0030) power tool	SF	0.0150
(0040) pressure/power wash (2,800 to 6,000 SF per day)	SF	0.0020
(0050) steam cleaning (2,800 to 4,000 SF per day)	SF	0.0050
(0060) water blasting	SF	0.0040
(0070) masking with paper	SF	0.0130
(0080) volume cover up (drop cloths or plastic sheathing)	SF	0.0020
09 91 13.30 **Fences** Chain link or wire metal, picket, and stockade; one side, water base		
(0010) roll and brush, first coat	SF	0.0120
(0020) second coat	SF	0.0120
(0030) spray, first coat	SF	0.0050
(0040) second coat	SF	0.0040

Figure 5-J-17. Exterior Painting Production (Sheet 1 of 3)

Work Element Description	Unit	Man-hours per Unit
09 91 13.42		
Miscellaneous, Exterior		
(0010) Decking, wood, sealer or paint, brushwork, each coat	SF	0.0090
(0020) Railings, wood, 42 inches high, 2- by 2-inch verticals, 6 inches on center brushwork, stain, sand, seal, and varnish	LF	0.1180
(0030) Railings, wrought iron, 60 inches high, 1-inch rail, 1/2-inch-square verticals, 6 inches on center, brushwork, zinc chromate, each coat	LF	0.0820
(0040) Shutters or blinds, single panel, 2 by 4 feet, paint all sides, brushwork, each coat	Each	0.5320
(0050) Shutters or blinds, single panel, 2 by 4 feet, paint all sides, spray, each coat	Each	0.3050
(0060) Stair stringers, metal, roll and brush, zinc chromate, each coat	LF	0.0330
(0070) Stair stringers, wood, roll and brush, each coat	LF	0.0490
09 91 13.60		
Siding, Exterior		
(0010) Steel siding, oil based paint, brushwork, each coat	SF	0.0120
(0020) Steel siding, oil based paint, spray, each coat	SF	0.0050
(0030) Stucco, rough, oil based paint, brushwork, each coat	SF	0.0160
(0040) Stucco, rough, oil based paint, brushwork, roll, each coat	SF	0.0130
(0050) Stucco, rough, oil based paint, brushwork, spray, each coat	SF	0.0050
(0060) Texture 1-11, clapboard, or wood shingles, brushwork, each coat	SF	0.0160
(0070) Texture 1-11, clapboard, or wood shingles, spray, each coat	SF	0.0050
09 91 13.62		
Siding, Miscellaneous		
(0010) Aluminum siding, latex paint, brushwork, each coat	SF	0.0090
(0020) Mineral fiber shingles, brushwork, each coat	SF	0.0150
(0030) Mineral fiber shingles, roll, each coat	SF	0.0130
(0040) Mineral fiber shingles, spray, each coat	SF	0.0050
(0050) Rough wood, including shingles or shakes, brushwork, each coat	SF	0.0170
(0060) Rough wood, including shingles or shakes, roll, each coat	SF	0.0070
(0070) Rough wood, including shingles or shakes, spray, each coat	SF	0.0050
(0080) Smooth wood, including butt, tongue and groove, brushwork, each coat	SF	0.0090
(0090) Smooth wood, including butt, tongue and groove, roll, each coat	SF	0.0090
(0100) Smooth wood, including butt, tongue and groove, spray, each coat	SF	0.0050

Figure 5-J-17. Exterior Painting Production (Sheet 2 of 3)

Work Element Description	Unit	Man-hours per Unit
09 91 13.70		
Doors and Windows, Exterior		
(0010) Door frames and trim only, brushwork, each coat	LF	0.0210
(0020) Doors, flush, both sides, including frame and trim roll and brush, each coat	Each	1.0640
(0030) Doors, louvered, both sides, including frame and trim brushwork, each coat	Each	1.5200
(0040) Doors, panel, both sides, including frame and trim roll and brush, each coat	Each	1.7730
(0050) Windows, per exterior side, based on 15 SF, brushwork, 1 to 6 lite	Each	0.8180
(0060) Windows, per exterior side, based on 15 SF, brushwork, 7 to 10 lite	Each	0.9670
(0070) Windows, per exterior side, based on 15 SF, brushwork, 12 lite	Each	1.0640
09 91 13.80		
Trim, Exterior		
(0010) Fascia, latex paint, up to 1 by 12 inches, brushwork, each coat	LF	0.0170
(0020) Fascia, latex paint, up to 1 by 12 inches, roll, each coat	LF	0.0120
(0030) Fascia, latex paint, up to 1 by 12 inches, spray, each coat	LF	0.0050
(0040) Gutters and downspouts, metal, 4 or 5 inches, brushwork first coat	LF	0.0170
(0050) Gutters and downspouts, metal, 4 or 5 inches, brushwork second or third coat	LF	0.0120
(0060) Molding, exterior, up to 14 inches wide, brushwork, each coat	LF	0.0170
09 91 13.90		
Walls, Masonry, Concrete Masonry Unit, Exterior		
(0010) Concrete masonry unit, latex or waterproof sealer, brushwork, each coat	SF	0.0170
(0020) Concrete masonry unit, latex or waterproof sealer, roll, each coat	SF	0.0070
(0030) Concrete masonry unit, latex or waterproof sealer spray, each coat	SF	0.0050
Minimum suggested crew size: one builder and one laborer.		

Notes:

1. Surface preparation for exterior painting includes removing mill scale from metal surfaces with wire brushes or by sandblasting, removing dust with brush or cloth, removing oil and grease, masking and taping adjacent surfaces, and removing masking and taping. Sometimes it is necessary to lightly sand between coats, or size and fill porous materiels before painting, all of which is surface preparation.
2. Fence metal painting includes removing rust, scale, oil, grease, and dirt; and mixing and applying paint.
3. Labor for erection of scaffolding not included. Refer to Division 01 54 23.70 for scaffolding.
4. Refer to Division 09 97 13.23 for painting metals.
5. For work over 12 feet high, from pipe scaffolding, multiply by 1.15.
6. For work over 12 feet high, from extension ladder, multiply by 1.25.
7. For work over 12 feet high, from swing staging, multiply by 1.35.

Figure 5-J-17. Exterior Painting Production (Sheet 3 of 3)

Work Element Description	Unit	Man-hours per Unit
09 91 03.40		
Interior Surface Preparation		
Average times for various surfaces		
(0010) Scrape and sand	SF	0.0290
(0020) Wire brush	SF	0.0200
(0030) Wash walls	SF	0.0040
(0040) Masking with paper	SF	0.0160
(0050) Volume cover up (drop cloths or plastic sheathing)	SF	0.0030
09 91 23.20		
Cabinets and Casework		
(0010) Paint or stain, brushwork, each coat	SF	0.0160
09 91 23.35		
Doors and Windows, Interior		
Doors, flush, 3 by 7 feet, both sides, including frame and trim,		
(0010) roll and brush, each coat	Each	1.0640
(0020) spray, each coat	Each	0.5320
Doors, panel, or French, both sides, including frame and trim		
(0030) roll and brush, each coat	Each	1.7730
(0040) Doors, louvered, both sides, including frame and trim, brushwork,	Each	1.5200
(0050) Doors, louvered, both sides, including frame and trim, spray, each coat	Each	0.5320
Windows, per side, single lite type, brushwork		
(0060) 2 foot × 3 foot opening	Each	0.3220
(0070) 3 foot × 5 foot opening	Each	0.5320
(0080) 4 foot × 8 foot opening	Each	0.7600
09 91 23.40		
Floors, Interior		
Concrete or wood, oil base primer/sealer coat or latex		
(0010) brushwork, each coat	SF	0.0120
(0020) roll, each coat	SF	0.0040
(0030) spray, each coat	SF	0.0040
09 91 23.72		
Walls and Ceilings, Interior		
Drywall, concrete, masonry, or plaster, smooth finish, each coat		
(0010) brushwork, each coat	SF	0.0090
(0020) roll, each coat	SF	0.0080
(0030) spray, each coat	SF	0.0040
Minimum suggested crew size: one painter and one laborer.		

Notes:
1. The painting of interior surfaces includes surface preparation, mixing paint materiels, and application of paint to surface.
2. For ceiling installations, multiply by 1.25.
3. For work 8 feet to 15 feet high, multiply by 1.10.
4. For work over 15 feet high, multiply by 1.20.
5. For light textured surfaces, multiply by 1.10.
6. For heavy textured surfaces, multiply by 1.25.

Figure 5-J-18. Interior Painting Production

Work Element Description	Unit	Man-hours per Unit
09 97 13.23		
Exterior Steel Coatings		
(0010) Cold galvanizing, brush in field	SF	0.0090
Paints and protective coatings, sprayed in field		
(0020) alkyds	SF	0.0070
(0030) epoxy	SF	0.0080
(0040) latex	SF	0.0070
(0050) zinc-rich primers	SF	0.0120
Miscellaneous Iron and Steel, per coat		
Structural steel, per coat		
(0060) brush	Ton	3.0000
(0070) spray	Ton	2.0000
(0080) wire brush clean	Ton	4.0000
(0090) sandblasting	Ton	6.0000
Minimum suggested crew size: one painter and one laborer.		

Notes:

1. Structural steel painting includes removing rust, scale, oil, grease, and dirt; mixing and applying paint; and sanding between coats when required.
2. Refer to Division 09 91 03.30 for steel surface preparation treatments such as wire brushing, pressure washing, and steam cleaning.
3. Refer to Figure 5-J-6 for surface area (SF) coverage per ton of steel.
4. For work above one story, spray painting simple structures, multiply by 1.25.
5. For work involving intricate structures, multiply by 1.50.

Figure 5-J-19. Painting Structural and Miscellaneous Steel Production

CHAPTER 5 ANNEX K

Division 10, 11, 12

Specialties, Equipment, Furnishings

5.K.1 INTRODUCTION

The following three divisions are combined under the annex for Division 10 in this publication:

1. Division 10, specialties, includes prefinished, manufactured items that are usually installed at or near the end of a project. This division is often considered as a catch-all division, containing miscellaneous items that do not fit into other divisions.

2. Division 11, equipment, refers to items required for a particular project's type of construction. For example, equipment for a vehicle maintenance facility would include compressed air devices, tire balancing machine, vehicle lift, etc. The equipment listed in Division 11 is usually purchased directly by the facility owner.

3. Division 12, furnishings, refers to items brought into the facility for the occupants' use. Items include furniture, artwork, window treatments (e.g., blinds and curtains), mats, rugs, plants, etc. These items are normally supplied by the owner or are arranged for outside the scope of most construction-related projects.

5.K.2 ESTIMATING INFORMATION AND TIPS

Review specifications for Divisions 10, 11, and 12 items and then review all drawings, making a list of these items. If a schedule of specialty items, equipment, or furnishings is not available when the estimate is done, estimators should create a schedule to document assumptions made for each component. Review the Division 10 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable.

Items in these divisions, although they may not be directly part of the facility project, may require some type of support system that is part of the facility project. For example, it is much easier to install a behind-the-wall support system before the wall is in place. These divisions also include items not usually supplied with facility project items (e.g., support brackets, plates, and angles). Estimators must account for these items and add to the appropriate division.

5.K.3 ESTIMATING DATA

Figures 5-K-1 through 5-K-11 present data and guidelines for estimating items found in Divisions 10, 11, and 12.

Work Element Description	Unit	Man-hours per Unit
10 11 13.13		
Fixed Chalkboards		
Wall hung, aluminum or wood frame, by size		
(0010) 3 by 4 feet	Each	1.3300
(0020) 4 by 12 feet	Each	1.6370
10 11 23.10		
Fixed Tackboards		
(0010) Cork sheets or fabric faced	SF	0.0730
(0020) Prefabricated, case with single glass door, 3 by 3 feet	Each	1.7330
(0030) Horizontal sliding units, 4 by 12 feet	Each	4.2560
10 13 10.10		
Directory Boards		
(0010) Plastic, glass covered, 30 by 20 inches	Each	7.0920
(0020) Outdoor, weatherproofed, plastic, 36 by 36 inches	Each	14.1870
Minimum suggested crew size: one skilled laborer and one unskilled laborer.		
Note: Installation of specialties includes unloading, storing at site, handling into place, and installing fastening devices, including drilling, plugging, anchoring, and leveling as needed.		

Figure 5-K-1. Visual Display Surfaces Production

Work Element Description	Unit	Man-hours per Unit
10 21 13.13		
Metal Toilet Compartments		
(0010) Cubicles, ceiling hung, includes handicap units	Each	5.3200
(0020) Cubicles, floor and ceiling anchored, includes handicap units	Each	4.2560
(0030) Screens, entrance, floor mounted, 58 inches high, 48 inches wide	Each	1.4200
(0040) Urinal screen, 18 inches wide	Each	3.4610
10 21 16.10		
Partitions, Shower		
(0010) Cabinet, floor mounted, plumbing not included, 1-inch-thick walls, no door	Each	4.2560
(0020) with door	Each	4.7300
Minimum suggested crew size: one skilled laborer and one unskilled laborer.		
Note: Installation of specialties includes unloading, storing at site, handling into place, and installing fastening devices, including drilling, plugging, anchoring, and leveling as needed.		

Figure 5-K-2. Toilet and Shower Partitions Production

Work Element Description	Unit	Man-hours per Unit
10 22 13.10		
Partitions, Woven Wire		
Wall panels, 4 feet wide, for tool or stockroom enclosures, channel frame, 1 1/2-inch-diamond mesh, 10-gauge wire		
(0010) 7 feet high	Each	0.8510
(0020) 8 feet high	Each	0.9260
(0030) 10 feet high	Each	1.1820
For 5 foot wide panels, multiply by 1.05.		
(0040) Ceiling panels, 10 feet long, 2 feet wide	Each	0.8510
(0050) 4 feet wide	Each	1.4190
(0060) Panel with service window and shelf	Each	1.0640
(0070) Swinging doors, 3 feet wide, 7 feet high, 3-foot transom	Each	4.2560
10 22 16.10		
Security Gates		
(0010) Door gate, scissors type or folding steel gate, single, standard size	Opening	5.3200
(0020) double gate, standard size	Opening	8.5120
(0030) Window gates, 2 to 4 feet wide, 31 inches high	Opening	5.6750
10 22 23.13		
Wall Screens		
Divider panels, free standing, fiber core, fabric face straight, various types		
(0010) 3 feet long, 4 feet high	LF	0.2130
(0020) feet high	LF	0.2370
(0030) feet high	LF	0.2830
(0040) 6 feet long, 5 feet high	LF	0.1320
Minimum suggested crew size: one skilled laborer and one unskilled laborer.		
Notes: 1. The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for demolition. 2. Installation of partitions includes unloading, storing at site, handling into place, and installing fastening devices, including drilling, plugging, anchoring, and leveling as needed.		

Figure 5-K-3. Partitions Production

Work Element Description	Unit	Man-hours per Unit
10 28 13.13		
Commercial Toilet Accessories		
(0010) Dispenser unit, towel dispenser and waste receptacle	Each	1.1820
(0020) Grab bar, straight, various sizes	Each	0.4430
(0030) Hand dryer, surface mounted, electric, 115 volt, 20 amp	Each	2.6600
(0040) Mirror, with 5-inch shelf, 18 by 24 inches	Each	0.5320
(0050) Soap dispenser, surface mounted	Each	0.5320
(0060) Towel dispenser, surface mounted	Each	0.6650
Minimum suggested crew size: one skilled laborer.		
Note: Installation of toilet accessories includes unloading, storing at site, handling into place, and installing fastening devices, including drilling, plugging, anchoring, and leveling as needed.		

Figure 5-K-4. Commercial Toilet Accessories Production

Work Element Description	Unit	Man-hours per Unit
10 44 16.13		
Portable Fire Extinguishers		
(9400) Portable fire extinguisher, surface mount all types and sizes, nailable	Each	0.2627
(9420) Portable fire extinguisher, surface mount all types and sizes, on masonry	Each	0.5330
Minimum suggested crew size: one builder.		

Figure 5-K-5. Portable Fire Extinguishers

Work Element Description	Unit	Man-hours per Unit
10 51 13.10		
Lockers, steel		
(0010) Single tier box locker, 12 by 15 by 72 inches and two person, 18 by 15 by 72 inches	Each	1.3300
(0020) Double tier box locker, 12 by 15 by 36 inches	Each	0.5070
(0030) Five-tier box lockers, minimum	Opening	0.3550
(0040) maximum	Opening	0.4430
(0050) Wire meshed wardrobe, floor mounted, open front varsity type	Each	1.4190
(0060) Rack with 24 wire mesh baskets	SE	7.0930
10 56 13.10		
Shelving		
(0010) Metal, industrial, cross-braced, 3 feet wide by 12 inches deep	SF of shelf	0.0610
(0020) 3 feet wide 24 inches deep	SF of shelf	0.0320
(0030) 4 feet wide 12 inches deep	SF of shelf	0.0570
(0040) 4 feet wide 24 inches deep	SF of shelf	0.0280
(0050) Pallet racks, steel frame 5,000 pound capacity, 8 feet long by 36 inches deep	SF of shelf	0.0480
(0060) 42 or 48 inches deep	SF of shelf	0.0410
10 56 13.20		
Parts Bins		
Metal 6 feet 3 inches high, 3 feet wide		
(0010) twelve bins, 18 inches wide by 12 inches high by 12 inches deep, standard	Each	2.1280
(0020) and other various sizes, maximum	Each	2.6600
Minimum suggested crew size: one skilled laborer and one unskilled laborer.		
Notes: 1. The above options provide only a small sample of the myriad of possibilities. They provide a cross section of average labor times required for demolition. 2. Installation of storage items includes unloading, storing at site, handling into place, installing fastening devices, including drilling, plugging, anchoring, and leveling as needed.		

Figure 5-K-6. Storage Assemblies Production

Work Element Description	Unit	Man-hours per Unit
10 75 16.10 **Flagpoles**		
Ground set, not including base or foundation, various types, labor determined by height,		
(0010) 20 feet high, minimum	Each	10.6400
(0020) 40 feet high	Each	17.7320
(0030) 70 feet high, maximum	Each	26.6000
Foundations for flagpoles, including excavation and concrete,		
(0040) to 35 feet high	Each	4.2560
(0050) 36 to 50 feet high	Each	12.1600
(0060) over 50 feet high	Each	21.2800
10 75 23.10 **Flagpoles, Wall Mounted**		
Structure-mounted fiberglass or aluminum, vertical wall set,		
(0010) 19 feet 8 inches long, minimum	Each	14.1870
(0020) 29 feet 6 inches long, maximum	Each	21.2800
Minimum suggested crew size: one builder and one laborer.		
Note: Installation of specialties includes unloading, storing at site, handling into place, and installing fastening devices, including drilling, plugging, anchoring, and leveling as needed.		

Figure 5-K-7. Flagpole Production

11 11 26.00 **Vehicle Washing Equipment**		
(0010) Washrack equipment	Each	16.0000
Minimum suggested crew size: one utilitiesman and one laborer.		

Figure 5-K-8. Vehicle Washing Equipment

Work Element Description	Unit	Man-hours per Unit
11 30 13.23 **Residential Laundry Appliances**		
(0010) Washers residential, 4-cycle average	Each	3.5470
(0020) Dryers, gas fired, residential, 16 pound capacity, average	Each	3.5470
(0030) Electric, front loading	Each	7.0930
(0040) Vent kits for dryers	Each	1.1820
Minimum suggested crew size: one utilitiesman and one laborer.		
Note: Installation of specialties includes unloading, storing at site, handling into place, and installing fastening devices, including drilling, plugging, anchoring, and leveling as needed.		

Figure 5-K-9. Residential Appliances Production

Work Element Description	Unit	Man-hours per Unit
12 32 23.10		
Manufactured Wood Casework, Stock Units		
(0010) Built-in drawer units, 18 inches deep, 32 inches high, minimum	LF	0.4020
(0020) maximum	LF	0.5320
(0030) Kitchen base cabinets, not including counter tops		
various sizes, average	Each	0.9540
(0040) Range or sink base, two doors below, 30 inches wide	Each	0.9950
(0050) Kitchen wall cabinets, hardwood, 12 inches deep with two doors	Each	0.9380
Rule of thumb, kitchen cabinets not including appliances and counter top		
(0060) minimum	LF	0.7090
(0070) maximum	LF	0.8510
12 36 61.16		
Solid Surface Countertops		
(0010) Various materiels and sizes, average	LF	1.1820
Minimum suggested crew size: two builders.		
Note: Installation of casework units includes unloading, storing at site, handling into place, and installing fastening devices, including drilling, plugging, anchoring, and leveling as needed.		

Figure 5-K-10. Manufactured Wood Casework Production

Work Element Description	Unit	Man-hours per Unit
12 54 16.00		
Restaurant Furniture		
(0010) Folding chair setup	Each	0.0083
(0020) Folding table setup	Each	0.0333
12 59 16.00		
Office Furniture		
(0010) Desk assembly and setup	LF	1.0000
Minimum suggested crew size: two laborers.		

Figure 5-K-11. Furniture Production

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CHAPTER 5 ANNEX L
Division 13
Special Construction

5.L.1 INTRODUCTION

Division 13, special construction, includes tension fabric structures, pre-engineered steel buildings, fabricated steel buildings, steel towers, and antennas. These facilities (also known as pre-engineered structures) are some of the more common structures built by military engineers. There are many other special construction items not discussed here. Refer to manufacturers' data or commercial publications (e.g., RSMeans Company) for further information on these items.

5.L.2 ESTIMATING INFORMATION AND TIPS

Pre-engineered structures are commercially designed structures and fabricated to be erected in the shortest possible time. Each pre-engineered structure is shipped as a complete building kit, including all the necessary materiels and instructions to erect it. Various types of pre-engineered structures are available from numerous manufacturers. Normal takeoff procedures do not apply. Review plans and specifications to ensure interfaces, excavations, foundations, and electrical connections are accounted for. Make sure responsibility for unloading upon delivery of the facility assemblies is tasked and weight handling equipment is scheduled.

Estimators must also note if a specific fabrication machine and operator training are required.

5.L.3 ESTIMATING DATA

Figures 5-L-1 through 5-L-9 present data and guidelines for estimating items found in Division 13.

Work Element Description	Unit	Man-hours per Unit
13 00 00.00 **Weapons Clearing Facility**		
(0010) Install weapons clearing barrel.	Each	4.3100

Figure 5-L-1. Weapons Clearing Facility

Work Element Description	Unit	Man-hours per Unit
13 31 23.50 **Tension Fabric Structures**		
Fabric shell, 60-foot-clear span, not including foundation or floors		
(0010) 6,000 SF	SF Floor	0.0880
(0020) 12,000 SF	SF Floor	0.0800
Fabric shell, 80-foot-clear span, not including foundation or floors		
(0030) 20,800 SF	SF Floor	0.0720
Minimum suggested crew size: Structure installation: one steelworker (crew leader), four laborers, two equipment operators.		
Roll-up door (minimum)		
(0040) 12 by 14 feet	Each	20.0000
Minimum suggested crew size: Roll-up door: two builders.		
Notes: 1. These estimates are for frame and shell only. 2. Duckbill anchors furnished with basic tension fabric structures are for unpaved surfaces only. 3. For asphalt and concrete surfaces, use expansion-type anchors. 4. Refer to other divisions for estimates on footings, utilities, and other components of work. 5. Refer to manufacturers' specifications and installation instructions.		

Figure 5-L-2. Tension Fabric Structures Production

Work Element Description	Unit	Man-hours per Unit
13 31 33.00 **Framed Fabric Structures**		
(0010) MGPTS, Small, 18 by 18 feet, erect and strike	Each	1.8000
(0020) MGPTS, Medium, 18 by 36 feet, erect and strike	Each	2.4000
(0030) MGPTS, Large, 18 by 54 feet, erect	Each	4.4700
(0035) MGPTS, Large, 18 by 54 feet, strike	Each	3.0000
(0100) TEMPER, Small, 20 by 16 feet, erect	Each	1.5000
(0110) TEMPER, Medium, 20 by 32 feet, erect	Each	3.3300
(0120) TEMPER, Large, 20 by 48 feet, erect	Each	4.1000
(0150) ALASKA, United States Air Force (USAF), Small, 20 by 33 feet, erect and strike	Each	2.0000
(0160) ALASKA, AMEDD, Small, 20 by 20 feet, erect	Each	4.0000
(0170) ALASKA, AMEDD, Medium, 20 by 65 feet, erect	Each	4.0000
(0200) Airbeam TEMPER, Medium, 20 by 32 feet, erect	Each	1.0000
(0210) Expeditionary Shelter System, USMC, Medium, 18 by 25 feet, erect	Each	0.8000
Legend: AMEDD = Army Medical Department MGPTS = Modular general purpose tent system TEMPER = tent, expendable modular personnel		

Figure 5-L-3. Framed Fabric Structure Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
13 31 33.00 **Framed Fabric Structures (Continued)**		
(0250) Airbeam TEMPER, medium, 20 by 32 feet, erect, USN	Each	1.0000
(0255) Install interior 20 by 32 tent furnishings, F/12 PAX (people), USN	Each	2.0000
(0260) Airbeam shelter facility support, USN	Each	3.0000
(0300) Lightweight maintenance enclosure, USA, 25 by 32 feet, erect	Each	6.0000
(0310) Large area maintenance shelter (LAMS), USA, 75 by 190 feet	Each	432.0000
(0320) LAMS, USA, 65 by 122 feet, erect	Each	288.0000
(0400) Medium shelter, command post, USAF, 30 by 33 feet, erect	Each	12.0000
(0410) Medium shelter, maintenance, USAF, 30 by 52 feet, erect	Each	24.0000
(0420) Dome shelter, USAF, 70 by 121 feet, 2 big mouth ends, erect	Each	256.0000
(0430) Dome shelter, USAF, 70 by 116 feet, 2 gable ends, erect	Each	256.0000
(0440) Dome shelter, USAF, 70 by 89 feet, 1 gable end, 1 big mouth end, erect	Each	256.0000
(0450) Dome shelter, USAF, 70 by 135 feet, 2 big mouth ends, erect	Each	256.0000
(0460) LAMS, USA, 65 by 185 feet, Erect	Each	384.0000
(0490) Dome shelter, USAF, strike and repack	Each	208.0000
(0510) Erect BaseX 305 tent, USN, 18 x 25 feet with ECU	Each	8.0000
(0515) Install interior 18 x 25 tent furnishings, USN	Each	8.0000
(0520) Erect BaseX dome tent, USN, 31 x 37 feet with ECU	Each	20.0000
(0525) Install interior dome tent furnishings, USN	Each	20.0000
(0530) Erect BaseX 307 tent, USN, 18 x 35 feet with ECU	Each	8.0000
(0535) Install interior 18 x 35 tent furnishings	Each	8.0000
(0540) Erect BaseX 103 tent, USN, 9-1/2 x 15 feet with ECU	Each	8.0000
(0545) Install interior 9-1/2 x 15 tent furnishings	Each	8.0000
(0600) ASC, Type I, 35 by 35 feet, erect	Each	1.0000
(0610) ASC, Type II, 50 by 50 feet, erect	Each	2.0000
(0700) Camouflage net system, radar scattering, one system, complete, erect and strike	Each	1.5000
(0710) Camouflage net system, radar scattering, two systems, complete, erect and strike	Each	2.5000
(0720) Camouflage net system, radar scattering, three systems, complete, erect and strike	Each	3.5000
(0730) Camouflage net system, radar scattering, four systems, complete, erect and strike	Each	4.5000
Minimum suggested crew size varies in accordance with the facility being erected.		
Legend: ASC = advanced solar cover ECU = environmental control unit		

Figure 5-L-3. Framed Fabric Structure Production (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
13 36 13.00 **Steel Towers**		
(0010) Standard heights	Each	20
33 81 13.10 **Antenna, Radio Tower**		
(0010) Guyed, 50 feet high, 40 pound section, wind load 70 miles per hour	Each	22.0
(0020) Self-supporting, 60 feet high, wind load 70 miles per hour	Each	40.0
Minimum suggested crew size: two steelworkers, one equipment operator.		

Figure 5-L-4. Steel Towers and Antennas Production

Work Element Description	Unit	Man-hours per Unit
13 34 19.50 **Pre-engineered Steel Buildings**		
Clear span rigid frame, 26-gauge roofing and siding		
20-foot width		
(0010) 10-foot-eave height	SF Floor	0.1760
(0020) 14-foot-eave height	SF Floor	0.2130
30- to 40-foot width		
(0030) 10-foot-eave height	SF Floor	0.1400
(0040) 14-foot-eave height	SF Floor	0.1650
50- to 100-foot width		
(0050) 10-foot-eave height	SF Floor	0.0860
(0060) 14-foot-eave height	SF Floor	0.0970
Clear span tapered beam frame, 26-gauge roofing and siding	SF Floor	0.1400
30-foot width		
(0070) 10-foot-eave height		
(0080) 14-foot-eave height	SF Floor	0.1650
40-foot width	SF Floor	0.1240
(0090) 10-foot-eave height		
(0100) 14-foot-eave height	SF Floor	0.1460
50- to 80-foot width	SF Floor	0.0970
(0110) 10-foot-eave height		
(0120) 14-foot-eave height	SF Floor	0.1100
Minimum suggested crew size: one steelworker (crew leader), four laborers, and two equipment operators.		
Notes: 1. These estimates are for frame and shell only. Windows, doors, skylights, vents, gutters, and downspouts are not included. 2. Refer to manufacturers' specifications and installation instructions. 3. Standard bay length is 20 feet. To get square feet of floor, multiply width by length. Length is the number of bays. The true building length is equal to the number of 20-foot bays plus 6 inches; each end bay is 20 feet 3 inches.		

Figure 5-L-5. Pre-engineered Steel Building Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
Shelter, aluminum frame		
(0200) 3 feet by 9 feet by 8 feet high	Each	18.7
(0210) 3 feet by 12 feet by 8 feet high	Each	29.2
Minimum suggested crew size: one builder and one steelworker.		
Notes: 1. These estimates are for frame and shell only. Windows, doors, skylights, vents, gutters, and downspouts are not included. 2. Refer to manufacturers' specifications and installation instructions.		

Figure 5-L-5. Pre-engineered Steel Building Production (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
13 34 23.05 **Fabricated Structures (Fabrication)**		
P-Model (Straight sidewalls and arched roof. Optimizes useable space by raising the arch to above the sidewalls.) Typical ultimate building machine type. Unlimited length		
(0010) 14-foot width	SF	0.0130
(0020) 30-foot width	SF	0.0124
(0030) 14 foot width, end wall	SF	0.0140
(0035) 30 foot width, end wall	SF	0.0020
A-Model (high-pitched roof) unlimited length		
(0040) 20 foot width, high pitched roof	SF	0.0122
(0045) 40 foot width, high pitched roof	SF	0.0126
(0050) 20 foot width, end wall, high pitched roof	SF	0.0016
(0055) 40 foot width, end wall, high pitched roof	SF	0.0024
S-Model (high, straight sidewalls and curved arch roof) unlimited length		
(0060) 20-foot width	SF	0.0122
(0065) 40-foot width	SF	0.0126
(0070) 20-foot width, end wall	SF	0.0016
(0075) 40-foot width, end wall	SF	0.0024
Q-Model (Maximize usable interior space with no poles or beams), typical K-Span, arch style otherwise known as Quonset hut, unlimited length		
(0080) 50-foot width	SF	0.0144
(0085) 100-foot width	SF	0.0174

Figure 5-L-6. Fabricated Steel Building Production 1 of 3, Fabrication (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
(0090) 50 foot width, end wall	SF	0.0036
(0095) 100 foot width, end wall	SF	0.0025
Minimum suggested crew size: one steelworker (crew leader), four laborers, and two equipment operators.		
Notes: 1. These estimates are for frame and shell only. Windows, doors, skylights, vents, gutters, and downspouts are not included. 2. Refer to manufacturers' specifications and installation instructions. 3. Refer to other divisions for estimates on footings, utilities, and other components of work.		

Figure 5-L-6. Fabricated Steel Building Production 1 of 3, Fabrication (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
13 34 23.05 **Fabricated Structures (Seaming)**		
P-Model (Straight sidewalls and arched roof. Optimizes useable space by raising the arch to above the sidewalls.) Typical ultimate building machine type. Unlimited length.		
(0210) 14-foot width	SF	0.0022
(0220) 30-foot width	SF	0.0026
(0230) 14 foot width, end wall	SF	0.0011
(0235) 30 foot width, end wall	SF	0.0013
A-Model (high-pitched roof) unlimited length		
(0240) 20 foot width, high pitched roof	SF	0.0022
(0245) 40 foot width, high pitched roof	SF	0.0026
(0250) 20 foot width, end wall, high pitched roof	SF	0.0011
(0255) 40 foot width, end wall, high pitched roof	SF	0.0013
S-Model (high, straight sidewalls and curved arch roof) unlimited length		
(0260) 20-foot width	SF	0.0022
(0265) 40-foot width	SF	0.0026
(0270) 20-foot width, end wall	SF	0.0011
(0275) 40-foot width, end wall	SF	0.0013
Q-Model (Maximize usable interior space with no poles or beams), typical K-Span, arch style otherwise known as Quonset hut, unlimited length		
(0280) 50-foot width	SF	0.0024
(0285) 100-foot width	SF	0.0019

Figure 5-L-7. Fabricated Steel Building Production 2 of 3, Seaming (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
(0290) 50 foot width, end wall	SF	0.0014
(0295) 100 foot width, end wall	SF	0.0016
Minimum suggested crew size: one steelworker (crew leader), four laborers, and two equipment operators.		
Notes: 1. These estimates are for frame and shell only. Windows, doors, skylights, vents, gutters, and downspouts are not included. 2. Refer to manufacturers' specifications and installation instructions. 3. Refer to other divisions for estimates on footings, utilities, and other components of work.		

Figure 5-L-7. Fabricated Steel Building Production 2 of 3, Seaming (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
13 34 23.05 **Fabricated Structures (Erecting)**		
P-Model (Straight sidewalls and arched roof. Optimizes useable space by raising the arch to above the sidewalls.) Typical Ultimate Building Machine type. Unlimited length		
(0410) 14-foot width	SF	0.0139
(0420) 30-foot width	SF	0.0104
(0430) 14 foot width, end wall	SF	0.0207
(0435) 30 foot width, end wall	SF	0.0151
A-Model (high-pitched roof) unlimited length		
(0440) 20 foot width, high pitched roof	SF	0.0139
(0445) 40 foot width, high pitched roof	SF	0.0104
(0450) 20 foot width, end wall, high pitched roof	SF	0.0207
(0455) 40 foot width, end wall, high pitched roof	SF	0.0151
S-Model (high, straight sidewalls and curved arch roof) unlimited length		
(0460) 20-foot width	SF	0.0139
(0465) 40-foot width	SF	0.0104
(0470) 20-foot width, end wall	SF	0.0207
(0475) 40-foot width, end wall	SF	0.0151
Q-Model (Maximize usable interior space with no poles or beams), typical K-Span, arch style otherwise known as Quonset hut, unlimited length		
(0480) 50-foot width	SF	0.0108
(0485) 100-foot width	SF	0.0063

Figure 5-L-8. Fabricated Steel Building Production 3 of 3, Erection (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
(0490) 50 foot width, end wall	SF	0.0153
(0495) 100 foot width, end wall	SF	0.0143
Minimum suggested crew size: one steelworker (crew leader), four laborers, and two equipment operators.		
Notes: 1. These estimates are for frame and shell only. Windows, doors, skylights, vents, gutters, and downspouts are not included. 2. Refer to manufacturers' specifications and installation instructions. 3. Refer to other divisions for estimates on footings, utilities, and other components of work.		

Figure 5-L-8. Fabricated Steel Building Production 3 of 3, Erection (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
13 34 23.13 **Portable and Mobile Buildings**		
(0010) Containerized housing unit, ISO 20 feet x 8 feet	Each	5.0000
(0050) Containerized housing unit, collapsible, ISO 20 feet x 8 feet	Each	20.0000
(0060) Containerized housing unit, expandable, ISO 20 feet x 8 feet	Each	1.2500
(0100) Containerized storage, ISO 20 feet x 8 feet	Each	0.4000
(0110) Containerized storage, ISO 40 feet x 8 feet	Each	0.5000
(0140) Containerized storage, refrigerated, self-contained, ISO Type 5 Tricon	Each	0.5000
(0150) Containerized storage, refrigerated, self-contained, ISO 20 feet x 8 feet	Each	0.5000
(0160) Containerized storage, refrigerated, self-contained, ISO 40 feet x 8 feet	Each	0.6000
(0170) Containerized storage, refrigerated, externally powered, ISO 20 feet x 8 feet	Each	1.0000
(0180) Containerized storage, refrigerated, externally powered, ISO 40 feet x 8 feet	Each	1.1000
(0200) Containerized kitchen, ISO 20 feet x 8 feet	Each	3.2000
(0210) Mobile kitchen trailer	Each	3.4500
(0220) Expeditionary kitchen system, ISO Type 5 Tricon	Each	1.2500
(0230) Food sanitation center	Each	4.0000
(0310) Expeditionary latrine system, ISO Type 5 Tricon	Each	1.2500
(0315) Expeditionary 4 Head Green (FP) latrine system	Each	4.0000
(0320) Expeditionary shower system, ISO Type 5 Tricon	Each	1.2500
(0325) Shower system expeditionary Tricon 4-Head Green (force provider)	Each	6.0000
Legend: ISO = International Organization for Standardization		

Figure 5-L-9. Portable and Mobile Building Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
(0330) Expeditionary batch laundry system, ISO Type 5 Tricon	Each	1.5000
(0340) Expeditionary batch laundry system, ISO Tricon, USN	Each	1.7500
(0400) Guard tower, modular protective system, assembly	Each	5.0000
Minimum suggested crew size: Crew sizes vary in accordance with the facility being installed. Ensure enough personnel for the safe handling and movement of containers. Recommend builders, electricians, equipment operators and up to five laborers as needed.		

Figure 5-L-9. Portable and Mobile Building Production (Sheet 2 of 2)

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CHAPTER 5 ANNEX M

Division 21

Fire Suppression

5.M.1 INTRODUCTION

Division 21, fire suppression, includes the instrumentation, control, operation, maintenance, and commissioning of fire protection systems, including sprinkler and standpipe systems.

5.M.2 ESTIMATING INFORMATION AND TIPS

To perform this type of work, military engineers must be specifically trained and certified. Much of the work involving instrumentation and controls is performed by specialists; however, piping for fire protection systems is within the capability of military engineers. Piping for fire protection is covered in Division 22 11 13.

Ensure alignment between specifications and drawings. Always cross check work with local building codes, fire codes, and standards. Review the Division 21 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable.

5.M.3 ESTIMATING DATA

Figures 5-M-1 through 5-M-4 present data and guidelines for estimating items found in Division 21.

Work Element Description	Unit	Man-hours per Unit		
		4-inch Pipe	6-inch Pipe	8-inch Pipe
21 12 10.00 Fire Suppression Standpipe System				
Black steel pipe	LF	(0010) 0.5750	(0020) 0.8870	(0030) 1.1010
Pipe tee	Each	(0040) 5.3200	(0050) 7.9800	(0060) 10.6400
Pipe elbow	Each	(0070) 3.5470	(0080) 4.5610	(0090) 5.3200
Pipe nipple, 2 1/2 inches	Each	(0100) 1.3300	(0110) 1.3300	(0120) 1.3300
Hose valve, 2 1/2 inches	Each	(0130) 1.5160	(0140) 1.5160	(0150) 1.5160
Pressure restricting valve, 2 1/2 inches	Each	(0160) 1.5160	(0170) 1.5160	(0180) 1.5160
Check valve with ball drip	Each	(0190) 7.0930	(0200) 10.6400	(0210) 14.1870
Siamese inlet	Each	(0220) 4.2560	(0230) 4.6260	(0240) 4.6260
Roof manifold with valves	Each	(0250) 4.4330	(0260) 4.6260	(0270) 4.6260
21 12 13.00 Fire Suppression Standpipe System				
(0010) Fire Hose	LF	0.0070		
Note: Refer to Division 22 11 13 for further information on facility water distribution piping.				

Figure 5-M-1. Fire Suppression Standpipe System Production

Work Element Description	Unit	Man-hours per Unit
21 13 16.50 **Dry-pipe Sprinkler System Components**		
(0010) Alarm valve, 2 1/2-inch diameter	Each	7.0930
(0020) Alarm, water, motor, with gong	Each	2.6600
(0030) Fire alarm horn, electric	Each	0.4100
(0040) Air compressor, automatic, 200 gallon, sprinkler system 1/3 horsepower	Each	8.1850
(0050) Deluge system monitoring panel, 120 volt	Each	0.5910
(0060) Firecycle controls, with panel, batteries, valves, and switches	Each	42.5600
(0070) Firecycle package, check and flow control valves, trim 4-inch diameter	Each	21.2800
(0080) Heat detector	Each	0.6650
(0090) Thermostatic release	Each	0.5320
Pipe, black steel, threaded, schedule 40		
(0100) 4-inch diameter	LF	0.5750
(0110) 2 1/2-inch diameter	LF	0.4250
(0120) 2-inch diameter	LF	0.3320
(0130) 1 1/4-inch diameter	LF	0.2390
(0140) 1-inch diameter	LF	0.2010
Pipe, tee, 150 pound, black malleable		
(0150) 4-inch diameter	Each	5.3200
(0160) 2 1/2-inch diameter	Each	2.3650
(0170) 2-inch diameter	Each	1.9350
(0180) 1 1/4-inch diameter	Each	1.5200
(0190) 1-inch diameter	Each	1.3300
(0200) Pipe, elbow, 150 pound, black malleable, 1-inch diameter	Each	0.8180
(0210) Sprinkler head, 135 to 286 degrees, 1/2-inch diameter	Each	0.6650
(0220) Sprinkler head, dry pendent, 1-inch diameter	Each	0.7590
(0230) Valve, angle, bronze, thread end, 2-inch diameter	Each	0.9670
(0240) Valve gate, bronze, thread end, 1-inch diameter	Each	0.5600
(0250) Valve, gate, iron body, flanged, 125 pound, 4-inch diameter	Each	7.0930
(0260) Valve, swing check, with ball drip, flanged, 4-inch diameter	Each	7.0930
(0270) Valve, swing check, bronze, thread end, 2 1/2-inch diameter	Each	1.4200
(0280) Valve, dry pipe, with trim and gauges, 4-inch diameter	Each	21.2800
(0290) Valve, deluge, with trim and gauges, 4-inch diameter	Each	21.2800
Note: Refer to Division 22 11 13 for further information on facility water distribution piping.		

Figure 5-M-2. Automatic Sprinkler System Components Production

Work Element Description	Unit	Man-hours per Unit
21 22 16.50 **FM200 Fire Extinguishing System**		
(0010) Alarm, audio	Each	1.5880
(0020) Control panel, single zone	Each	10.6400
(0030) Control panel, multizone, four each	Each	21.2800
(0040) Discharge nozzle	Each	0.7580
(0050) Electro/mechanical release	Each	5.3200
FM200 system, filled, including mounting bracket		
(0060) 26 pound cylinder	Each	2.6600
(0070) 44 pound cylinder	Each	3.0400
(0080) 63 pound cylinder	Each	3.5470
(0090) 101 pound cylinder	Each	4.2560
(0100) 196 pound cylinder	Each	5.3200
(0110) Heat detector	Each	1.3300
(0120) Manual pull station	Each	1.7730
(0130) Pneumatic damper release	Each	1.3300
(0140) Smoke detector	Each	1.7160
0150) Standby power, battery	Each	3.7370
Minimum suggested crew size: two utilitiesmen.		
Note: Refer to Division 22 11 13 for further information on facility water distribution piping.		

Figure 5-M-3. Fire Extinguishing System Components Production

Work Element Description	Unit	Man-hours per Unit
21 31 13.50 **Electric-Drive Fire Pumps**		
Including controller, fittings, and relief valve		
(0010) 2-inch pump, 250 gallons per minute, 15 horsepower	Each	60.7800
(0020) 4-inch pump, 500 gallons per minute, 27 horsepower	Each	62.5900
(0030) 5-inch pump, 750 gallons per minute, 44 horsepower	Each	66.5000
(0040) 4-inch pump, 750 gallons per minute, 66 horsepower	Each	73.3790
21 31 16.50 **Diesel-Drive Fire Pumps**		
Including controller, fittings, and relief valve		
(0010) 4-inch pump, 500 gallons per minute, 27 horsepower	Each	66.5000
(0020) 5-inch pump, 750 gallons per minute, 44 horsepower	Each	70.9330
(0030) 4-inch pump, 1,000 gallons per minute, 89 horsepower	Each	76.0000
(0040) 6-inch pump, 2,000 gallons per minute, 167 horsepower	Each	125.1770
(0050) 10-inch pump, 3,500 gallons per minute, 300 horsepower	Each	176.9000
Minimum suggested crew size: three utilitiesmen and one laborer.		
Note: Refer to Division 09 22 26.13 for carrier channels for ceiling suspension systems.		

Figure 5-M-4. Centrifugal Fire Pumps Production

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CHAPTER 5 ANNEX N
Division 22
Plumbing

5.N.1 INTRODUCTION

Division 22, plumbing, includes piping and fixtures for potable water, domestic hot water, storm and sanitary waste, and interior gas piping systems. This division covers basic pipe and related materiels. These may be used by other divisions (i.e., fire suppression, HVAC, and utilities).

5.N.2 ESTIMATING INFORMATION AND TIPS

Plumbing work is shown by fixtures on drawings, riser diagrams, and schedules. Many details are not shown and are left to the estimator to include on the estimate based on personal knowledge and experience. Review the Division 22 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable.

Adjust labor hours using the following suggestions for various circumstances:

1. Adjust labor for elevated installation:
   a. 10 to 15 feet high, multiply by 2.00
   b. 15 to 20 feet high, multiply by 2.5
   c. 20 to 25 feet high, multiply by 3.00
2. Adjust labor for crawl space:
   a. 3 feet high, multiply by 2.00
   b. 4 feet high, multiply by 1.50
3. Adjust labor for the following miscellaneous situations:
   a. For cramped shaft, multiply by 1.50
   b. For congested area, multiply by 1.50
   c. For excessive heat or cold, multiply by 2.00.

5.N.3 ESTIMATING DATA

Figures 5-N-1 through 5-N-11 present data and guidelines for estimating items found in Division 22. Figures do not include provision for loading and hauling equipment and materiels to the project location.

Work Element Description	Unit	Man-hours per Unit							
		Pipe Diameter in Inches							
		1/8–1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
22 05 23.10									
Valves, Brass		(0010)	(0020)	(0030)	(0040)				
Gas cocks, threaded	Each	0.4430	0.4840	0.5600	0.7090				
22 05 23.20									
Valves, Bronze		(0010)	(0020)	(0030)	(0040)	(0050)	(0060)	(0070)	(0080)
Average time for the following valves:	Each	0.4430	0.5320	0.5600	0.7090	0.8180	0.9670	1.4200	1.6370
Angle									
Ball									
Check, swing									
Gate									
Globe									
			(0090)	(0100)	(0110)	(0120)	(0130)	(0140)	
Relief, pressure and temperature	Each		0.3800	0.4430	0.5320	0.5900	0.6650	0.7090	
		(0150)	(0160)	(0170)	(0180)	(0190)			
Reducing	Each	0.4430	0.5320	0.5600	0.7090	0.8180			
		(0200)							
Mixing	Each	1.3300							
22 05 23.60									
Valves, Plastic									
Average time for the following valves:									
		(0010)	(0020)	(0030)					
Angle, PVC,	Each	0.4100	0.4260	0.4630					
Ball, PVC or chlorinated polyvinyl chloride (plastic) (CPVC),	Each	(0040) 0.4100	(0050) 0.4260	(0060) 0.4630	(0070) 0.5070	(0080) 0.5320	(0090) 0.6260		
for PVC or CPVC, flanged, multiply by 1.15									
		(0100)	(0110)	(0120)	(0130)	(0140)			
Foot valve, PVC	Each	0.3130	0.3320	0.3800	0.3940	0.4100			
		(0150)	(0160)	(0170)	(0180)	(0190)			
Y sediment strainer, PVC	Each	0.4100	0.4430	0.4630	0.5070	0.5320			
Minimum suggested crew size: one utilitiesman and one laborer.									

Notes:

1. The installation of valves and fittings includes unloading, placing, caulking and leading, welding, and bolting flanges. It also includes installing gaskets, packing, hand wheels, and trim.
2. PVC solvent will not work with CPVC piping. Each materiel must have its own solvent cement.
3. Types of plastic pipe:
   a. PVC. Used with water, gas, and drainage systems, but not with hot water systems
   b. CPVC. Similar to PVC, but designed for piping water up to 180 degrees Fahrenheit.

Figure 5-N-1. General Duty Valves Installation Production

Work Element Description	Unit	Man-hours per Unit
22 07 19.00 Piping Insulation		
Fiberglass, with all-service jacket		
1-inch wall,		
(0010) 1/2-inch-iron pipe size	LF	0.0890
(0020) 1-inch-iron-pipe size	LF	0.0970
(0030) 2-inch-iron-pipe size	LF	0.1060
(0040) 3-inch-iron-pipe size	LF	0.1180
(0050) 4-inch-iron-pipe size	LF	0.1420
2-inch wall,		
(0060) 1/2-inch-iron pipe	LF	0.0970
(0070) 6-inch-iron-pipe size	LF	0.2130
(0080) 8-inch-iron-pipe	LF	0.2660
(0090) 10-inch-iron-pipe size	LF	0.3050
(0100) 12-inch-iron-pipe size	LF	0.3270
For fittings, add 3 LF for each fitting plus 4 LF for each flange of the fitting		
Finishes,		
(0110) for 0.010-inch or 0.016-inch-aluminum jacket, add	SF	0.1060
(0120) for 0.010-inch stainless steel, add	SF	0.1330
For single layer of felt or roofing paper, multiply by 1.10.		
Rubber tubing, flexible closed cell foam		
3/8-inch wall,		
(0130) 1/4-inch-iron-pipe size	LF	0.0890
(0140) 1/2-inch or 3/4-inch-iron-pipe size	LF	0.0930
(0150) 1-inch or 1 1/2-inch-iron-pipe size	LF	0.0970
1/2-inch, 3/4-inch or 1-inch wall		
(0160) 1/4-inch-iron-pipe size (1/2-inch wall only)	LF	0.1180
(0170) 1/2 or 3/4-inch-iron-pipe size	LF	0.1200
(0180) 1-inch-iron-pipe size	LF	0.1210
(0190) 1 1/4-inch-iron-pipe size (1-inch wall only)	LF	0.1300
(0200) 1 1/2-inch-iron-pipe	LF	0.1220
(0210) 2-inch-iron-pipe size	LF	0.1240
(0220) 2 1/2-inch-iron-pipe size (1-inch wall only)	LF	0.1330
(0230) 3-inch-iron-pipe size (1/2 and 3/4-inch wall only)	LF	0.1250
Minimum suggested crew size: two utilitiesmen.		

Figure 5-N-2. Piping Insulation Production

Work Element Description	Unit	Man-hours per Unit										
		Pipe Diameter in Inches										
		up to 1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	5	6	8
22 11 13.23 Copper Pipe												
Type K tubing	LF	(0010) 0.1610	(0020) 0.2660									
Type L tubing	LF	(0030) 0.1570	(0040) 0.1840	(0050) 0.2050	(0060) 0.2530	(0070) 0.3430	(0080) 0.3800	(0090) 0.4950	(0100) 0.5450	(0110) 0.6260	(0120) 0.7980	(0130) 0.8870
Type drain, waste, and vent (DWV) tubing	LF		(0140) 0.1770	(0150) 0.1970	(0160) 0.2420		(0170) 0.3670		(0180) 0.5320	(0190) 0.5900	(0200) 0.7590	
Minimum suggested crew size: one utilitiesman and one laborer.												

Notes:

1. Used for facility water distribution piping.
2. Use a 1.15 multiplier for silver solder joints (air conditioning and refrigeration only).
3. The installation of copper pipe includes cutting; cleaning and soldering joints; plumbing and grading pipe; and installing pipe hangers and straps.
4. Types of copper pipe:
   a. K—A thick-walled, flexible copper tubing. A thicker wall than type L and M. required for underground installations. Typical uses include water services, plumbing, heating, steam, gas, oil, oxygen, and other applications where thick-walled tubing is required. Can be used with sweat, flared, and compression fittings.
   b. L—Standard tubing used for interior, above ground plumbing. Uses include heating, air conditioning, steam, gas, oil, and underground drainage lines. Only sweat and flare fittings are legal for gas lines.
5. DWV. It is recommended for above ground use only and no pressure applications. Sweat fittings only.

Figure 5-N-3. Copper Pipe and Fittings Production

Work Element Description	Unit	Man-hours per Unit								
		Pipe Diameter in Inches								
		to 3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4
22 11 13.44 Steel Pipe, Threaded										
Schedule 40, with couplings, and clevis hanger assemblies sized for covering 10 feet on center	LF	(0010) 0.1740	(0020) 0.2010	(0030) 0.2390	(0040) 0.2660	(0050) 0.3320	(0060) 0.4260	(0070) 0.4950	(0080) 0.5320	(0090) 0.5900
Minimum suggested crew size: one utilitiesman and one laborer.										

Notes:

1. Used for facility water distribution piping.
2. The installation of galvanized-steel pipe vents and drains includes cutting and threading pipe, making joints and applying joint compound, plumbing and grading pipe, installing pipe hangers and straps, and installing fittings.

Figure 5-N-4. Threaded Steel Pipe and Fittings Production

Work Element Description	Unit	Man-hours per Unit								
		Pipe Diameter in Inches								
		1	2	3	4	5	6	8	10	12
22 11 13.44 Steel Pipe, Welded		(0100)	(0110)	(0120)	(0130)	(0140)	(0150)	(0160)	(0170)	(0180)
Schedule 40	LF	0.344	0.524	0.744	0.864	1.000	1.334	1.656	2.000	2.526
Minimum suggested crew size: one utilitiesman, one laborer, and one welder.										
Notes: 1. Used for facility water distribution piping. 2. Estimate includes use of yoke and roll hanger assemblies, sized for covering 10 feet on center. 3. A multiplier of 2.0 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production. 4. Use a 1.60 multiplier for schedule 80 pipe.										

Figure 5-N-5. Welded Steel Pipe Production

Work Element Description	Unit	Man-hours per Unit										
		Pipe Diameter in Inches										
		1	2	4	5	6	8	10	12	14	16	18
22 11 13.48 Steel, Grooved-joint Pipe, Fittings and Valves												
Elbows, reducers	Each	(0010) 0.16	(0020) 0.21	(0030) 0.42	(0040) 0.60	(0050) 0.62	(0060) 0.83	(0070) 0.96	(0080) 1.08	(0090) 1.37	(0100) 1.58	(0110) 1.79
Tees	Each	(0120) 0.23	(0130) 0.31	(0140) 0.62	(0150) 0.90	(0160) 0.94	(0170) 1.25	(0180) 1.44	(0190) 1.62	(0200) 2.03	(0210) 2.37	(0220) 2.68
Adapters	Each	(0230) 0.13	(0240) 0.16	(0250) 0.40	(0260) 0.59	(0270) 0.61	(0280) 0.66	(0290) 0.77	(0300) 0.98	(0310) 1.16	(0320) 1.34	(0330) 1.48
Crosses	Each	(0340) 0.29	(0350) 0.39	(0360) 0.80	(0370) 1.10	(0380) 1.19	(0390) 1.59	(0400) 1.84	(0410) 2.06	(0420) 2.59	(0430) 3.01	(0440) 3.39
Valves	Each	(0450) 0.16	(0460) 0.21	(0470) 0.42	(0480) 0.60	(0490) 0.63	(0500) 0.83	(0510) 0.96	(0520) 1.08	(0530) 1.29	(0540) 1.58	(0550) 1.79
Rigid couplings	Each	(0560) 0.08	(0570) 0.10	(0580) 0.21	(0590) 0.30	(0600) 0.31	(0610) 0.42	(0620) 0.48	(0630) 0.54	(0640) 0.68	(0650) 0.79	(0660) 0.89
Flexible couplings	Each	(0670) 0.06	(0680) 0.07	(0690) 0.16	(0700) 0.23	(0710) 0.24	(0720) 0.31	(0730) 0.36	(0740) 0.40	(0750) 0.51	(0760) 0.59	(0770) 0.66
Wyes	Each	(0780) 0.24	(0790) 0.35	(0800) 0.60	(0810) 0.88	(0820) 0.90	(0830) 1.19	(0840) 1.38	(0850) 1.51	(0860) 1.91	(0870) 2.21	(0880) 2.52
Minimum suggested crew size: one utilitiesman and one laborer.												
Notes: 1. Used for fire protection only! 2. Lifting equipment will be required on large-sized pipes (12 inches and above). 3. Time includes placing and leveling pipes.												

Figure 5-N-6. Steel Grooved Pipe and Fittings Production

Work Element Description	Unit	Man-hours per Unit									
		Pipe Diameter in Inches									
		1/2 & 3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	6
22 11 13.74 Plastic Pipe											
PVC, schedule 40, couplings 10 feet on center, clevis hanger assemblies, 3 per 10 feet	LF	(0010) 0.2090	(0020) 0.2310	(0030) 0.2530	(0040) 0.2950	(0050) 0.3600	(0060) 0.3800	(0070) 0.4020	(0080) 0.4430	(0090) 0.4950	(0100) 0.5450
Acrylonitrile-butadiene-styrene (plastic) (ABS) and PVC, for DWV, schedule 40, couplings 10 feet on center, clevis hanger assemblies, 3 per 10 feet	LF			(0110) 0.2530	(0120) 0.2950	(0130) 0.3600		(0140) 0.4020	(0150) 0.4430		(0160) 0.5450
CPVC, schedule 40, couplings 10 feet on center, clevis hanger assemblies, 3 per 10 feet	LF	(0170) 0.2090	(0180) 0.2310	(0190) 0.2530	(0200) 0.2950	(0210) 0.3600	(0220) 0.3800	(0230) 0.4020			
22 11 13.74 Plastic Pipe											
PVC, schedule 40, couplings 10 feet on center.	LF	(0310) 0.0752	(0320) 0.0832	(0330) 0.0911	(0340) 0.1564	(0350) 0.1908	(0360) 0.2014	(0370) 0.2131	(0380) 0.2348	(0390) 0.2624	(0400) 0.2889
ABS and PVC, for DWV, schedule 40, couplings 10 feet on center.	LF			(0410) 0.1265	(0420) 0.1475	(0430) 0.2016		(0440) 0.2251	(0450) 0.2481		(0460) 0.3052
CPVC, schedule 40, couplings 10 feet on center.	LF	(0470) 0.2090	(0480) 0.2310	(0490) 0.2530	(0500) 0.2950	(05210) 0.3600	(0520) 0.3800	(0530) 0.4020			
Minimum suggested crew size: one utilitiesman and one laborer.											

Notes:

1. Used for facility water distribution piping.
2. The installation of plastic water pipe includes cutting, cleaning, cementing, plumbing and grading pipe, and installing pipe hangers and straps.
3. PVC solvent will not work with CPVC piping. Each materiel must have its own solvent cement.
4. Types of plastic pipe:
   a. PVC. Used with water, gas, and drainage systems, but not with hot water system.
   b. CPVC. Similar to PVC, but designed for piping water at up 180 degrees Fahrenheit.
   c. ABS. Most common usage is for DWV pipes.

Figure 5-N-7. Plastic Pipe and Fittings Production

Work Element Description	Unit	Man-hours per Unit
22 11 19.64 **Water Piping Specialties** (0010) Yard hydrant, all types	Each	1.1430
22 13 29.14 **Sanitary Sewerage Pumps** (0160) Sewage ejector pump, 75 gallon, 12 gallons per minute	Each	6.6700
22 14 29.00 **Sump Pumps** (0010) Cellar drainer, pedestal, 1/3 horsepower, standard	Each	3.5470
Minimum suggested crew size: one utilitiesman and one laborer.		
Note: Installation of specialties includes unloading, storing at site, handling into place, and installing fastening devices, including drilling, plugging, anchoring, and leveling as needed.		

Figure 5-N-8. Fire Hydrant and Pump Production

Work Element Description	Unit	Man-hours per Unit					
		Pipe Diameter in Inches					
		2	3	4	6	8	12
22 13 16.20 **Cast Iron Pipe**							
Pipe, single hub, service weight, lead and oakum joints 10 feet on center	LF	(0010) 0.3380	(0020) 0.3550	(0030) 0.3870	(0040) 0.4380	(0050) 0.7210	(0060) 0.8870
lead for caulking,	pound	(0070) 0.1330					
oakum for caulking	pound	(0080) 0.5320					
No hub, couplings 10 feet on center	LF	(0090) 0.3180		(0100) 0.3670			
Bends	Each	(0110) 0.4200	(0120) 0.4900	(0130) 0.6300	(0140) 0.9500	(0150) 1.1900	(0160) 1.7500
Combination wyes, tees	Each	(0170) 0.8400	(0180) 0.9500	(0190) 1.2600	(0200) 1.8900	(0210) 2.3800	(0220) 2.4200
Reducing wyes, tees/combination	Each	(0230) 0.77	(0240) 0.84	(0250) 1.16	(0260) 1.75	(0270) 2.31	(0280) 2.73
1 1/4 to 1 1/2 to 2 tees, tapped	Each	(0290) 0.4200	(0300) 0.4900	(0310) 0.6300	(0320) 0.9500	(0330) 1.0000	(0340) 1.7500
Crosses, tapped	Each	(0350) 0.8400	(0360) 0.9500	(0370) 1.2600	(0380) 1.8900	(0390) 2.4200	(0400) 4.6900
Reducers	Each	(0410) 0.77	(0420) 0.84	(0430) 1.16	(0440) 1.68	(0450) 2.17	(0460) 4.59
Plugs, clean-out traps, closet Bends	Each	(0470) 0.4200	(0480) 0.4900	(0490) 0.6300	(0500) 0.9500	(0510) 1.1900	(0520) 1.7500
Minimum suggested crew size: one utilitiesman and one laborer.							
Notes: 1. Primarily used for facility sanitary waste and vent piping. 2. Lifting equipment will be required on larger sizes. 3. The installation of cast-iron drains includes caulking and leading joints, plumbing and grading pipe, installing pipe hangers and straps, cutting pipe, and installing fittings.							

Figure 5-N-9. Cast Iron Pipe and Fittings

Work Element Description	Unit	Man-hours per Unit
22 32 19.10		
Water Filters		
(0510) Diatomite filter, 660 gallons per hour, 1 inch pipe	Each	10.6667
22 32 33.00		
Water Heaters		
(0010) Electric or gas, 30 gallons	Each	4.2560
(0020) 80 gallons	Each	21.2800
Minimum suggested crew size: one utilitiesman and one laborer.		
Note: Installation of specialties includes unloading, storing at site, handling into place, and installing fastening devices, including drilling, plugging, anchoring, and leveling as needed.		

Figure 5-N-10. Domestic Water Appliance Production

Work Element Description	Unit	Man-hours per Unit	
		Rough-in	Finish
22 41 13.40			
Water Closets		(0010)	(0020)
Tank type, wall hung	Each	7.7950	4.0150
		(0030)	(0040)
Floor mounted, one piece	Each	6.9770	4.0150
		(0050)	(0060)
Bowl only, wall hung	Each	8.3120	3.6700
		(0070)	(0080)
Bowl only, floor mount	Each	7.4930	3.6700
		(0090)	(0100)
Water conserving type	Each	10.9720	3.9410
22 41 16.10			
Lavatories		(0010)	(0020)
Vanity top	Each	9.2570	3.3250
		(0030)	(0040)
Wall hung	Each	12.8210	2.6600
22 41 16.30			
Sinks		(0010)	(0020)
Corrosion resistant	Each	10.5340	4.4330
		(0030)	(0040)
Kitchen, countertop	Each	9.9480	4.4290
		(0050)	(0060)
Kitchen, raised deck	Each	11.5040	8.1850
Minimum suggested crew size: one utilitiesman and one laborer.			
Notes: 1. Rough-in includes supply, waste, and vent piping. 2. Work includes setting and connecting all supply piping, plumbing fixtures, and trim.			

Figure 5-N-11. Finished Plumbing (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit	
		Rough-in	Finish
22 41 19.10 **Bath Tubs**	Each	(0010) 10.2810	(0020) 4.8360
22 41 23.20 **Showers**	Each	(0010) 10.3740	(0020) 3.8690
22 41 36.10 **Laundry Sinks**	Each	(0010) 9.9480	(0020) 3.5470
22 42 13.30 **Urinals, Commercial**			
Wall hung	Each	(0010) 7.5140	(0020) 7.0930
Stall type	Each	(0025) 10.6930	(0026) 8.5120
22 42 16.40 **Service Sinks**			
Floor type	Each	(0010) 12.981	(0020) 4.841
Wall hung	Each	(0030) 16.3720	(0040) 5.3200
22 47 13.10 **Drinking Water Fountains**	Each	(0010) 5.8120	(0020) 3.3250
22 47 16.10 **Electric Water Coolers**	Each	(0010) 4.8150	(0020) 5.3200
Minimum suggested crew size: one utilitiesman and one laborer.			
Notes: 1. Rough-in includes supply, waste, and vent piping. 2. Work includes setting and connecting all supply piping, plumbing fixtures, and trim.			

Figure 5-N-11. Finished Plumbing (Sheet 2 of 2)

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CHAPTER 5 ANNEX P

Division 23

Heating, Ventilating, and Air Conditioning

5.P.1 INTRODUCTION

Division 23, heating, ventilating, and air conditioning, includes forced air heaters, boilers, electric heaters, ductwork, ventilation; hot water heating systems; and air conditioning systems.

5.P.2 ESTIMATING INFORMATION AND TIPS

Most of the work in this division can be found on the mechanical drawings. Estimators should pay close attention to riser diagrams and schedules. Ensure alignment between specifications and drawings. Many details are not shown and are left to the estimator to include on the estimate based on personal knowledge and experience.

Review the Division 23 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable.

5.P.3 ESTIMATING DATA

Figures 5-P-1 through 5-P-7 present data and guidelines for estimating items found in Division 23.

Work Element Description	Unit	Man-hours per Unit
23 05 00.00 **Common work for HVAC**		
23 05 23.30 **General duty valves for HVAC piping**		
(2280) Gate Valve 125 pound, nonrising stem flanged, 4 inch	Each	5.3300
Minimum suggested crew size: two utilitiesmen.		

Figure 5-P-1. Heating, Ventilation, and Air Conditioning Common Work

Work Element Description	Unit	Man-hours per Unit
23 09 00 **Instrumentation and Control for HVAC**		
23 09 53.10 **Pneumatic and Electric control for air conditioning units**		
(0010) Thermostat, manual	Each	1.0000
(0050) Thermostat, electric, low voltage 2 wire	Each	0.6150
(0060) Thermostat, electric, low voltage 3 wire	Each	0.8000
Minimum suggested crew size: one electrician.		

Figure 5-P-2. Install Heating, Ventilation, and Air Conditioning Controls

Work Element Description	Unit	Man-hours per Unit
23 31 13.00 **Metal Ducts**		
Fabricate Sheet Metal Duct		
(0010) 20- to 94-inch perimeter	LF	0.340
(0020) 96- to 126-inch perimeter	LF	0.650
(0030) 128- to 190-inch perimeter	LF	0.980
(0040) 192- to 240-inch perimeter	LF	1.220
(0050) 242- to 360-inch perimeter	LF	1.490
Minimum suggested crew size two steelworkers		
Install Sheet Metal Duct (rectangular)		
(0060) 20- to 94-inch perimeter	LF	0.420
(0070) 96- to 126-inch perimeter	LF	0.700
(0080) 128- to 190-inch perimeter	LF	1.440
(0090) 192- to 240-inch perimeter	LF	2.000
(0100) 242- to 360-inch perimeter	LF	2.640
Minimum suggested crew size three steelworkers		
Install Sheet Metal Duct (round)		
(0110) 20- to 94-inch perimeter	LF	0.525
(0120) 94- to 126-inch perimeter	LF	0.875
(0130) 127- to 190-inch perimeter	LF	1.800
(0140) 191- to 240-inch perimeter	LF	2.500
(0150) 241- to 360-inch perimeter	LF	3.300
Minimum suggested crew size two steelworkers		
(0160) Insulate Sheet Metal Duct	LF	0.060
23 33 00.00 **Air Duct Accessories**		
Install Fiber Duct for Slab Heating or Cooling System		
(0010) 6-inch inside diameter	LF	0.020
(0020) 8-inch inside diameter	LF	0.022
(0030) 10-inch inside diameter	LF	0.022
(0040) 12-inch inside diameter	LF	0.025
(0050)16-inch inside diameter	LF	0.032
(0060) 20-inch inside diameter	LF	0.042
(0070) 24-inch inside diameter	LF	0.060
(0080) Fabrication	LF	0.280
Installation includes hangers, but does not include grills and registers. **Minimum suggested crew size two steelworkers**		
Grills and Registers (Plaster Ground)		
(0090) 4 by 8 inches	Each	0.030
(0100) 6 by 12 inches	Each	0.090
(0110) 16 by 16 inches	Each	0.100
(0120) 20 by 36 inches	Each	0.130
Minimum suggested crew size two steelworkers		
Notes: 1. Fabrication is to be performed in the sheet metal shop. 2. Time for grills and registers will vary according to type of materiels used in ceilings and walls. 3. Installation of fiberglass duct will vary with manufacturer.		

Figure 5-P-3. Fabrication and Installation of Ductwork

Work Element Description	Unit	Man-hours per Unit
23 34 16.10 **Centrifugal HVAC Fans**		
Airfoil, motor and drive complete		
(0110) 1,000 CFM	Each	12.0000
(0120) 2,000 CFM	Each	15.0000
(0130) 4,000 CFM	Each	16.6665
(0140) 8,000 CFM	Each	21.4290
(0150) 12,000 CFM	Each	30.0000
Roof exhaust, direct drive		
(0410) 320 CFM	Each	4.2855
(0420) 600 CFM	Each	4.9995
(0430) 815 CFM	Each	6.0000
(0440) 1,450 CFM	Each	7.1430
(0450) 2,050 CFM	Each	7.5000
Install Sheet Metal Duct (round)		
See section 23 31 13.00		
23 34 23.10 **HVAC Power Circulators**		
Install circulators		
(0110) Propeller exhaust, wall shutter, direct drive, 375 CFM	Each	3.0000
(0120) Propeller exhaust, wall shutter, direct drive, 730 CFM	Each	3.3330
(0130) Propeller exhaust, wall shutter, direct drive, 1,000 CFM	Each	3.7500
(0140) Propeller exhaust, wall shutter, direct drive, 1,890 CFM	Each	4.2855
(0150) Propeller exhaust, wall shutter, direct drive, 3,275 CFM	Each	4.9995
(0160) Propeller exhaust, wall shutter, direct drive, 4,720 CFM	Each	6.0000
Minimum suggested crew size: one builder, one steelworker, one electrician		
23 38 13.10 **Hood and Ventilation Equipment**		
(0030) Vent hood, wall canopy with fire protection	LF	1.9995
(0040) Vent hood, wall canopy without fire protection	LF	1.8000
(0050) Vent hood, island canopy with fire protection	LF	2.5710
(0060) Vent hood, island canopy without fire protection	LF	2.2500
(0090) Range hood and carbon dioxide system	Each	8.0000
Minimum suggested crew size: one builder		
Legend: CFM = cubic feet per minute		

Figure 5-P-4. Install Exhaust Vents/Ducts and Motors

Work Element Description	Unit	Man-hours per Unit
23 52 13 **Boilers**		
Set and connect iron sectional boilers with insulating jacket and safety devices		
(0010) 95,000 British thermal unit (BTU)/hour and smaller	Each	21.0
(0020)100,000 to 250,000 BTU/hour	Each	29.0
(0030) 260,000 to 450,000 BTU/hour	Each	43.0
(0040) 500,000 to 750,000 BTU/hour	Each	60.0
(0050) 800,000 to 1,000,000 BTU/hour	Each	90.0
(0060) 1,050,000 to 1,500,000 BTU/hour	Each	127.0
Set and connect expansion tanks		
(0070) 50 gallons and smaller	Each	8.0
(0080) 55 to 100 gallons	Each	13.0
Install and plumb hot water storage tanks		
(0090) 80 gallons and smaller	Each	12.0
(0100) 81 to 150 gallons	Each	17.0
(0110) 151 to 300 gallons	Each	33.0
(0120) Steel above ground fuel tank 450 gallons	Each	5.9200
Minimum suggested crew size: one utilitiesman, one electrician, and one laborer.		

Figure 5-P-5. Install Heating Boilers

Work Element Description	Unit	Man-hours per Unit
23 54 00 **Furnaces**		
Set and connect forced air furnaces complete (less duct, diffusers, and hard wiring)		
(0010) 100,000 BTU and smaller	Each	17.0
(0020) 105,000 BTU to 145,000 BTU	Each	36.0
(0030) 145,000 BTU to 280,000 BTU	Each	56.0
(0040) 450,000 BTU to 750,000 BTU	Each	109.0
(0050) 1,000,000 BTU to 2,000,000 BTU	Each	159.0
Fuel oil storage tanks set on floor		
(0060) 275 to 500 gallons	Each	15.0
(0070) 1,000 to 2,000 gallons	Each	28.0
(0080) 5,000 gallons	Each	55.0
Minimum suggested crew size: one utilitiesman, one electrician, and one laborer.		
Notes: 1. Man-hour figures include the positioning and connecting of units complete with fans, filters, safety controls, and light oil burners. 2. Man-hour figures for installation of fuel storage tanks set on floors include supports, saddles, coatings, and fittings.		

Figure 5-P-6. Install Forced Air Furnaces

Work Element Description	Unit	Man-hours per Unit
23 74 00 **HVAC Equipment**		
Install Window Type Air Conditioners		
(0010) 1/2 to 3/4 ton	Each	3.0
(0020) 1 to 1 1/2 ton	Each	5.0
(0030) 2 ton	Each	7.0
Install Single Package Air Conditioning Units		
(0040) Up to 5 ton	Each	24.0
(0050) 6 to 12 ton	Each	32.0
(0060) 13 to 20 ton	Each	48.0
Install Split System Air Conditioning Units		
(0070) Up to 5 ton	Each	24.0
(0080) 6 to 12 ton	Each	32.0
(0090) 13 to 20 ton	Each	48.0
(0100) Set and connect dehumidifiers (per CF of space)	CF	0.0020
Testing—Contracted		
Note: Man-hour figures do not include the installation of piping or electric between various pieces of equipment, installation of ductwork or diffusers, curbs, or slabs.		
Minimum Suggested crew size: one utilitiesman, one electrician, one laborer		

Figure 5-P-7. Install Air Conditioners, Dehumidifiers, and Refrigerators

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CHAPTER 5 ANNEX Q

Division 26

Electrical

5.Q.1 INTRODUCTION

The electrical systems in building construction that were previously categorized in MasterFormat 1995, Division 16 are now covered in three different divisions of MasterFormat. These three divisions are combined under the annex of Division 26 in this publication.

1. Division 26—electrical

2. Division 27—communications

3. Division 28—electronic safety and security.

These divisions include construction of electrical distribution lines, outdoor lighting, underground power systems, installation of interior electrical services, transformers, and substation equipment.

5.Q.2 ESTIMATING INFORMATION AND TIPS

Most of the work in these divisions can be found on the electrical and mechanical drawings. Estimators should pay close attention to riser diagrams and schedules to ensure alignment between specifications and drawings. Many details are not shown and are left to the estimator to include on the estimate based on personal knowledge and experience. Review the Divisions 26, 27, and 28 estimating checklists shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable. The following estimating tips are provided.

1. Electrical line work. Labor includes unloading materiels, excavating, installing cross arms and insulators, setting poles, backfilling, and stringing and sagging wire. It also includes installing and connecting transformers, switches, breakers, capacitors, and regulators.

2. Outdoor lighting. Street lights, security lights, airfield lights, and athletic field lights are types of outdoor lighting. Labor for installation includes digging foundations, setting poles, backfilling, installing standards and light fixtures, stringing wire, laying buried cable, installing duct, encasing duct in concrete, and pulling cable. It also includes installing control devices, lamps, control vaults, and transformers.

3. Interior electrical rough-in. Roughing-in interior electric includes installing service mains, switches, panels, conduits, fittings, outlet boxes, nonmetallic cable, armored cable, transformers, and motor control centers. It also includes pulling cable through conduit and splicing in electrical boxes.

4. Interior electrical finish and trim. Finishing and trimming interior electric includes installing and connecting receptacles, switches, light fixtures, light-duty devices, heavy-duty utility devices, controls, and appliances. It also includes circuit testing.

5. Transformers and substation equipment. Installation of transformers and substation equipment includes unloading the equipment, moving it into position, leveling, plumbing, fastening, trimming, and connecting the equipment.

5.Q.3 ESTIMATING DATA

Figures 5-Q-1 through 5-Q-17 present data and guidelines for estimating items found in Division 26, 27, and 28.

Spacing in Inches Between Centers of Conduits for Under Slab Stub-ups													
Conduit Size	**1/2**	**3/4**	**1**	**1 1/4**	**1 1/2**	**2**	**2 1/2**	**3**	**3 1/2**	**4**	**4 1/2**	**5**	**6**
1/2	1 3/8	1 5/8											
3/4	1 1/2												
1	1 3/4	1 7/8	2										
1 1/4	2	2 1/8	2 1/4	2 1/2									
1 1/2	2 1/8	2 1/4	2 3/8	2 5/8	2 3/4								
2	2 3/8	2 1/2	2 3/4	3	3 1/8	3							
2 1/2	2 5/8	2 3/4	3	3 1/4	3 3/8	3 5/8	4						
3	3	3 1/8	3 3/8	3 5/8	3 3/4	4	4 3/8	4 3/4					
3 1/2	3 3/8	3 1/2	3 5/8	3 7/8	4	4 3/8	4 5/8	5	5 3/8				
4	3 3/4	3 7/8	4	4 1/4	4 3/8	4 3/4	5	5 3/8	5 5/8	6	6 1/2		
4 1/2	4	4 1/8	4 1/4	4 1/2	4 3/4	5	5 1/4	5 5/8	6	6 1/4		7 1/4	
5	4 3/8	4 1/2	4 5/8	4 7/8	5	5 3/8	5 5/8	6	6 1/4	6 5/8	7		
6	5	5 1/8	5 1/4	5 1/2	5 5/8	6	6 1/4	6 5/8	7	7 1/4	7 5/8	8	8 5/8

Figure 5-Q-1. Conduit Spacing

Work Element Description	Unit	Man-hours per Unit
26 05 00 **Common Work Results for Electrical**		
(0010) Construct H-frame and install three-phase transformer bank	Each	132.0
String Primary Conductors		
(0020) American Wire Gage (AWG) #6 to AWG #1 bare copper	LF	0.0160
(0030) AWG #0 to AWG #0000 bare copper	LF	0.0232
(0040) Larger than AWG #0000 bare copper	LF	0.0238
Install Transformer on Poles		
(0050) Single transformer 10 to 75 kilovolt-ampere (kVA)	Each	12.0
(0060) Three single-phase transformers 10 to 75 kVA	Bank	16.0
Install secondary racks	Each	2.4
Install Secondary Conductors and Service Drops		
(0080) AWG #4 and smaller: four-wire, weatherproof	LF	0.0530
(0090) AWG #2 to AWG # 0: four-wire, weatherproof	LF	0.0690
Install Voltage Regulators		
(0100) 25 kVA, single-phase, pole mounted	Each	17.60
(0110) 75 to 125 kVA, three-phase, slab mounted	Each	81.60
(0120) Capacitor units, pole mounted, factory preassembled, all kVA ratings	Each	16.80
Install Primary Protective Devices		
(0130) Pole top air break switches, three poles	Each	43.20
(0140) Enclosed-fused disconnect switch	Each	8.0
(0150) Open-fused disconnect switch	Each	8.0
Minimum suggested crew size: Capacitor units: two linemen and one ground man H-frame: six electricians Install primary protective devices: four electricians Install secondary conductors and service Drop #4 and smaller: two electricians Install secondary conductors and service Drop #2 to #0: two electricians, one equipment operator Install secondary racks: two electricians Install transformers on poles: three electricians, one equipment operator Install voltage regulators: three electricians Install wire guys: three electricians String primary conductors: ten electricians, one equipment operator Single cross assembly installation: two electricians.		
Notes: 1. Cross arm assembly figures are based on work being done before pole is set. If work must be done after pole is set, use 1.15 multiplier. 2. When using bucket truck, use 0.85 multiplier.		

Figure 5-Q-2. Overhead Primary and Secondary Conductors and Devices Production

Work Element Description	Unit	Man-hours per Unit
26 05 13.00 Medium-Voltage Cables		
Excavate trench for duct or direct burial of cable		
(0010) Hand excavating	CYD	13.60
(0020) Machine excavating	LF	0.0110
Install 4-inch-diameter conduit in trench, rigid galvanized steel		
(0030) One conduit without concrete (includes terminations and fittings)	LF	0.240
(0040) Underground duct bank	LF	0.1330
Install direct burial cable in trench		
(0050) Up to AWG #0 1/0—three conductors	LF	0.0860
(0060) AWG #00 2/0 to 500 MCM—three conductors	LF	0.1790
Pull cable into duct		
(0070) AWG #6—three conductors	LF	0.0580
(0080) AWG #2—three conductors	LF	0.110
(0090) AWG #0000 4/0—three conductors	LF	0.1950
(0100) 500 MCM—four conductors	LF	0.350
Pull cable into duct underground service to building		
(0110) AWG #2—four conductors	LF	0.1440
(0120) AWG #0—four conductors	LF	0.2240
Minimum suggested crew size: two electricians.		
Notes: 1. All excavating is figured on average soil conditions. 2. Duct man-hour figures allow for a normal number of bends, bells, and fittings, and installing pull line. 3. Direct burial cable in trench requires a sand bed. 4. Concrete encasement under roadway requires reinforcing steel. 5. When using mechanical cable-puller, use 0.85 multiplier.		
Legend: MCM = one thousand circular mils		

Figure 5-Q-3. Underground Power System Production

Work Element Description	Unit	Man-hours per Unit
26 05 19.00 Low Voltage Electrical Power Conductors and Cables		
Install Service Entrance, Four- Conductor		
(0010) 60 ampere	Each	11.2
(0020) 100 ampere	Each	13.8
(0030) 200 ampere	Each	15.2
(0040) 400 ampere	Each	19.2
Install Rigid Steel Conduit		
(0050) 1/2 to 3/4 inch	LF	0.16
(0060) 1 to 1 1/2 inches	LF	0.20
(0070) 2 to 3 inches	LF	0.3040
(0080) 3 1/2 to 4 inches	LF	0.3520
Install Thin Wall and Flexible Conduit		
(0090) 1/2 inch to 3/4 inch	LF	0.072
(0100) 1 to 1 1/2 inches	LF	0.096
(0110) 2 to 2 1/2 inches	LF	0.1360
(0120) 3 to 4 inches	LF	0.1920
Grounding and Bonding for Electrical Systems		
(0130) Install 8-foot ground rod and ground wire	Each	2.4
(0140) Install 10-foot ground rod and ground wire	Each	3.0
Install Type non-metallic cable		
(0150) AWG # 10/3 with ground and smaller	LF	0.0260
(0160) AWG # 8/2 with ground and larger	LF	0.0560
Install Boxes for non-metallic cable		
(0170) Boxes for non-metallic cable	Each	0.032
Install Pull Boxes		
(0180) 12 by 12 by 6 inches, National Electrical Manufacturers Association (NEMA) Type 1	Each	2.4
(0190) 16 by 20 by 8 inches, NEMA Type 1	Each	3.2
(0200) 24 by 36 by 8 inches, NEMA Type 1	Each	4.8
(0210) 6 by 6 by 6 inches, NEMA Type 3R and 4	Each	2.4
(0220) 10 by 6 by 6 inches, NEMA Type 3R and 4	Each	4.8
(0230) 16 by 16 by 6 inches, NEMA Type 3R and 4	Each	7.2
(0240) 24 by 18 by 8 inches, NEMA Type 3R and 4	Each	12

Figure 5-Q-4. Electrical Rough-in Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
Pull Wire in Conduit		
(0250) AWG #12	LF	0.0030
(0260) AWG #10	LF	0.0033
(0270) AWG #8	LF	0.0400
(0280) AWG #6	LF	0.0530
(0290) AWG #4	LF	0.0700
(0300) AWG #1	LF	0.1100
(0310) AWG #1/0	LF	0.1300
(0320) AWG #2/0	LF	0.1430
(0330) AWG #3/0	LF	0.1630
(0340) AWG #4/0	LF	0.1930
(0350) 350 MCM	LF	0.2600
(0360) 500 MCM	LF	0.3200
Minimum suggested crew: two electricians		
Cable Connectors **26 05 19.25**		
(0040) 600 volts, Non-metallic, AWG#10-3 wire to #14-4 and #12-4 wire	Each	0.0800
(0320) 600 volts, PVC jacket, AWG#0-3 wire	Each	0.7270
(0580) 15 kV armored, AWG#0 or #1	Each	2.0000
Cable Splicing **26 05 19.30**		2.5000
(0010) 15 kV, #1 stranded to 4/0 stranded	Each	
26 05 33.00 **Boxes for Electrical Systems**		
Outlet Boxes for Low Voltage Applications		
(0510) Install box, pressed steel, 4 inch square or octagon	Each	0.4000
(0520) Install box, pressed steel, 4 inch cover, blank or raised device	Each	0.1250
(0530) Install box, pressed steel, 1 gang handy or switch box	Each	0.2960
(0550) Install box, cast, 1 gang	Each	0.6670
(0555) Install box, cast, 2 gang	Each	0.8000
(0565) Install box, cast cover, 1 gang all types, including weatherproof	Each	0.1250
(0570) Install box, cast cover, 2 gang all types, including weatherproof	Each	0.1510
Install Pull Boxes		
(0080) 12 by 12 by 6 inches, NEMA Type 1	Each	2.4000
(0090) 16 by 20 by 8 inches, NEMA Type 1	Each	3.2000
(0100) 24 by 36 by 8 inches, NEMA Type 1	Each	4.8000
(0110) 6 by 6 by 6 inches, NEMA Type 3R and 4	Each	2.4000
(0120) 10 by 6 by 6 inches, NEMA Type 3R and 4	Each	4.8000
(0130) 16 by 16 by 6 inches, NEMA Type 3R and 4	Each	7.2000
(0140) 24 by 18 by 8 inches, NEMA Type 3R and 4	Each	12.000
Minimum suggested crew size: one electrician.		

Figure 5-Q-4. Electrical Rough-in Production (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
26 05 90.00 **Low Voltage Applications (Troop Housing)**		
Install Receptacles and Plates		
(0010) Duplex convenience outlets	Each	0.4000
(0020) Range and dryer receptacles	Each	1.6000
Install Standard Grade Toggle Switches and Plates		
(0030) Single pole	Each	0.3200
(0040) Three- or four-way	Each	0.4000
Install Incandescent Lighting Fixtures up to 150 Watts—Medium Base		
(0050) Surface-mounted	Each	1.6000
(0060) Flush-mounted	Each	1.6000
(0070) Porcelain lamp holder	Each	0.3200
(0080) Install fluorescent lighting fixtures	Each	2.4000
(0090) Install fluorescent tubes and diffusers	Each	1.6000
Connect Small Appliances		
(0100) Water heater (80 gallon capacity)	Each	3.2000
(0110) Space heater (2,000 watts)	Each	1.6000
(0120) Air conditioning units (up to 18,000 BTU)	Each	4.0000
(0130) Exhaust fans	Each	4.8000
Testing		
(0140) Receptacles, switches, lighting fixtures	Each	0.0800
(0150) Small appliances	Each	0.4000
Minimum suggested crew size: two electricians		
Install Tent Electrical		
(0600) Install tent light kit, ALASKA-MGPTS-TEMPER small	Each	0.3330
(0610) Install tent light kit, ALASKA-MGPTS-TEMPER medium	Each	0.6670
(0620) Install tent light kit, ALASKA-MGPTS-TEMPER large	Each	1.0000
(0650) Install tent receptacle kit, ALASKA-MGPTS-TEMPER small	Each	0.3330
(0660) Install tent receptacle kit, ALASKA-MGPTS-TEMPER medium	Each	0.6670
(0670) Install tent receptacle kit (M46),ALASKA-MGPTS-TEMPER large	Each	1.000
(0700) Install tent light and receptacle kit (M46), ALASKA-MGPTS-TEMPER small	Each	0.6670
(0710) Install tent light and receptacle kit (M46), ALASKA-MGPTS-TEMPER medium	Each	1.3330
(0720) Install tent light and receptacle kit (M46),ALASKA-MGPTS-TEMPER large	Each	2.0000
Minimum suggested crew size: two laborers.		
Note: Two or four tube, surface-, stem-, or chain-mounted on wood or masonry. Commercial industrial, residential: normal high output or power groove type.		

Figure 5-Q-5. Electrical Finish and Trim Production

Work Element Description	Unit	Man-hours per Unit
26 12 19.00 **Transformers and Switches**		
(0010) Install and wire complete dry transformer, 1 kVA	Each	4
Install and wire complete oil-filled transformer		
(0020) 300 kVA and smaller	Each	36.0
(0030) 500 kVA	Each	60.0
(0040) 750 kVA	Each	63.20
(0050) 1,000 kVA	Each	95.20
(0060) 2,000 kVA	Each	100.0
Install and wire complete three-phase dry-type air cooled transformer in vault or building	Each	24.8000
(0070) Up to 150 kVA	Each	24.80
(0080) 151 kVA and larger	Each	45.60
Medium Voltage Switchgear		
(0090) Install three-phase metal-clad switch gear unit	Each	16.0
Install oil circuit breakers	Each	8.4000
(0100) 100 to 600 ampere, single circuit	Each	8.40
(0110) 601 to 1200 ampere, single circuit	Each	24.0
Install open or enclosed disconnect switches	Each	8.8000
(0120) 100 ampere and smaller, single circuit	Each	8.80
(0130) 150 ampere and larger, single circuit	Each	12.80
Install air-break switches and components	Each	8.8000
(0140) 100 to 600 ampere, single pole, single throw	Each	8.80
(0150) 601 to 1,200 ampere, single pole, single throw	Each	12.80
Install capacitor bank with associated equipment		
(0160) 3 to 9 capacitor bank	Each	27.20
(0170) 12 to 24 capacitor bank	Each	42.40
26 13 16.00 Medium Voltage Lightning Arrester		
(0150) Lightning arrester, intermediate class or line Type 4, 8 kilovolt	Each	4.4445
(0160) Lightning arrester, intermediate class or line Type 13, 8 kilovolt	Each	6.0000
(0170) Lightning arrester, station class 4, 8 kilovolt	Each	4.4445
(0180) Lightning arrester, station class 13, 8 kilovolt	Each	6.0000
Minimum suggested crew size: two electricians.		

Figure 5-Q-6. Medium Voltage Electrical Distribution

Work Element Description	Unit	Man-hours per Unit
26 24 16.00 Panelboards		
Install safety switch, three poles, general or heavy duty		
(0010) 30 ampere	Each	2.40
(0020) 60 ampere	Each	3.20
(0030) 100 ampere	Each	4.0
(0040) 225 ampere	Each	7.20
(0050) 400 ampere	Each	11.20
(0060) 600 ampere	Each	17.60
Install circuit breakers, enclosed, NEMA type 1, 600 volt, three poles		
(0065) 20 ampere	Each	2.40
(0070) 30 ampere	Each	2.40
(0080) 60 ampere	Each	3.20
(0090) 100 ampere	Each	4.80
(0100) 225 ampere	Each	6.40
(0110) 400 ampere	Each	11.20
(0120) 600 ampere	Each	17.60
Install panel boards, lighting, and power four-wire, three-phase, 100 to 225 ampere main lugs		
(0130) 12 circuits or less	Each	9.60
(0140) 13 to 20 circuits	Each	16.0
(0150) 21 to 24 circuits	Each	17.60
(0160) 25 to 30 circuits	Each	20.0
(0170) 31 to 36 circuits	Each	23.20
(0180) 37 to 42 circuits	Each	26.40
Minimum suggested crew size: two electricians.		
Install Tactical Distribution Load Centers		
(0400) 40A, PDISE M40	Each	1.0
(0410) 60A, PDISE M60	Each	1.0
(0420) 100A, PDISE M100	Each	1.50
(0430) 200A, PDISE M200	Each	1.50
Minimum suggested crew size: two laborers.		
(0500) 5kW MEPDIS-R, USMC	Each	1.0
(0510) 15kW MEPDIS-R, USMC	Each	1.0
(0520) 30kW MEPDIS-R, USMC	Each	1.50
(0530) 100kW MEPDIS-R, USMC	Each	1.50
(0540) 300kW MEPDIS-R, USMC	Each	1.50
Minimum suggested crew size: one electrician, one operator.		
(0700) 200A, Power Distribution Box (PDB), USN	Each	1.0
(0710) 800A, PDB, USN	Each	1.0
Minimum suggested crew size: one electrician, one laborer.		
Notes: 1. For explosion-proof work, use 3.0 multiplier. 2. All work estimates based on surface mounting. 3. For aluminum cable trays, use 1.05 multiplier.		
Legend: MEPDIS-R = mobile electric power distribution system-replacement PDISE = power distribution illumination system, electrical		

Figure 5-Q-7. Panelboards Production

Work Element Description	Unit	Man-hours per Unit
26 24 19.40 **Motor Starters and Controllers**		
Connect light equipment (0010) (bench tools, table-mounted galley equipment)	Each	2.20
Connect heavy equipment (0020) (large floor-mounted machines and galley equipment)	Each	4.0
Motor starters and controls, magnetic full voltage non-reversing (FVNR) with heaters and enclosures		
(0030) 5 horsepower, size 0	Each	3.20
(0040) 10 horsepower, size 1	Each	5.60
(0050) 25 horsepower, size 2	Each	10.40
(0060) 50 horsepower, size 3	Each	12.80
(0070) 100 horsepower, size 4	Each	21.60
Combination starters, magnetic FVNR with circuit breaker or fused switch and heater		
(0080) 5 horsepower, size 0	Each	5.60
(0090) 10 horsepower, size 1	Each	8.0
(0100) 25 horsepower, size 2	Each	12.0
(0110) 50 horsepower, size 3	Each	15.20
(0120) 100 horsepower, size 4	Each	23.20
Control stations, heavy duty		
(0130) Start and stop	Each	0.80
(0140) Start, stop, and pilot light	Each	1.60
(0150) Hand, off, automatic	Each	1.60
(0160) Stop, start, and reverse	Each	1.60
(0170) Circuit testing and balance three-phase circuit	Each	1.60
Minimum suggested crew size: two electricians.		
Note: For combination reversing type controls, use 1.2 multiplier.		

Figure 5-Q-8. Motor Control Centers Production

Work Element Description	Unit	Man-hours per Unit
26 25 13 **Bus Duct/Busway and Fittings**		
Install wire way,		
5-foot length, screw cover with fittings and supports		
(0010) 4 by 4 inches	LF	0.320
(0020) 6 by 6 inches	LF	0.320
(0030) 8 by 8 inches	LF	0.480
Install cable trays,		
Ladder type, galvanized steel with fittings and supports		
(0040) 12 inches wide	LF	0.2480
(0050) 18 inches wide	LF	0.280
(0060) 24 inches wide	LF	0.320
Minimum suggested crew size: two electricians.		
Notes: 1. For explosion-proof work, use 3.0 multiplier. 2. All work estimates based on surface mounting. 3. For aluminum cable trays, use 1.05 multiplier.		

Figure 5-Q-9. Bus Duct/Busway and Fittings Production

Work Element Description	Unit	Man-hours per Unit
26 28 16.20 **Safety Switches**		
General Duty 240V, 3 Pole NEMA 1, fusible		
(0010) 30 amp	Each	3.0
(0020) 60 amp	Each	4.0
(0030) 100 amp	Each	4.750
(0040) 200 amp	Each	9.0
(0050) 400 amp	Each	12.0
Heavy Duty, 600V, 3 Pole NEMA 1, nonfusible		
(0210) 30 amp	Each	3.0
(0220) 60 amp	Each	4.0
(0230) 100 amp	Each	5.0
Heavy Duty, 240V, 3 Pole NEMA 3R, fusible		
(0310) 30 amp	Each	3.0
(0320) 60 amp	Each	4.50
Minimum suggested crew size: two electricians.		
Notes: 1. For explosion-proof work, use 3.0 multiplier. 2. All work estimates based on surface mounting. 3. For aluminum cable trays, use 1.05 multiplier.		

Figure 5-Q-10. Safety Switch Production

Work Element Description	Unit	Man-hours per Unit
26 32 13.13 Packaged Generator Assemblies		
Diesel Engine Driven Generator Sets		
(0010) 3 kW	Each	24.0000
(0020) 12 kW	Each	28.1600
(0030) 50 kW	Each	47.6000
(0040) 300 kW	Each	90.9000
(0050) 400 kW	Each	105.0000
(0060) 500 kW	Each	111.0000
Minimum suggested crew size: two electricians		
Tactical Generator Sets		
(0100) 2 kW	Each	0.2500
(0110) 3 kW	Each	0.2500
(0120) 5 kW	Each	0.5000
(0130) 10 kW	Each	0.6000
(0140) 15 kW	Each	0.7500
(0150) 30 kW	Each	0.8000
(0160) 60 kW	Each	1
(0170) 100 kW	Each	1
(0180) 200 kW	Each	1
Minimum suggested crew size: two laborers		
Tactical Generator Sets (USMC)		
(0220) 5 kW	Each	0.5000
(0230) 10 kW	Each	0.6000
(0240) 15 kW	Each	0.7500
(0250) 30 kW	Each	0.8000
(0260) 60 kW	Each	1
(0270) 100 kW	Each	1
(0280) 200 kW	Each	1
Minimum suggested crew size: one electrician, one operator		
Tactical Generator Sets (USN)		
(0300) 10 kW	Each	1.5000
(0310) 15 kW	Each	1.5000
(0320) 30 kW	Each	1.5000
(0330) 60 kW	Each	1.5000
(0340) 60 kW(2) with distribution, USN	Each	3.0000
Minimum suggested crew size: one electrician, one operator, one laborer electrician.		

Figure 5-Q-11. Packaged Generator Assembly Production

Work Element Description	Unit	Man-hours per Unit
26 36 13.10 Manual Transfer Switches		
(0100) Manual operated, NEMA 3R, 480 volt, 3 pole, 100 amp	Each	9.0000
(0020) Manual operated, NEMA 3R, 480 volt, 3 pole, 200 amp	Each	12.0000
(0030) Manual operated, NEMA 3R, 480 volt, 3 pole, 400 amp	Each	15.0000
Minimum suggested crew size: two electricians		
26 36 23.10 Automatic Transfer Switches		
(0100) Manual operated, NEMA 3R, 480 volt, 3 pole, 100 amp	Each	9.0000
(0020) Manual operated, NEMA 3R, 480 volt, 3 pole, 200 amp	Each	12.0000
(0030) Manual operated, NEMA 3R, 480 volt, 3 pole, 400 amp	Each	15.0000
Minimum suggested crew size: two electricians.		

Figure 5-Q-12. Transfer Switch Production

Work Element Description	Unit	Man-hours per Unit
26 56 00.00 Exterior Lighting		
(0010) Install foundations for metal standards (See Note 1)	Each	12.0
Install metal light standards (30 feet) (See Note 2)		
(0020) aluminum standard	Each	11.20
(0030) steel standard	Each	12.0
(0040) Install wooden pole with street light (See Notes 3, 4)	Each	9.60
(0050) Install wooden pole with two flood lights (See Notes 3, 4)	Each	11.20
(0055) Install precast concrete pole	Each	9.60
(0060)String one conductor for series lighting	LF	0.02
(0070) Connect streetlight/floodlight to power	Each	4.80
(0080) Install lighting transformer	Each	12.0
Install constant current regulator and control devices for street lighting		
(0090) Installed in vault	Each	6.40
(0100) installed on pole	Each	8.0
Minimum suggested crew size: two electricians and one equipment operator.		

Notes:

1. To install foundations for metal standards, increase crew size to include one builder.
2. Electrician's work includes approximately 10 feet of 2-inch rigid steel conduit and pull box.
3. Assembly and wiring are performed on the ground.
4. Work is the same as overhead power construction if light is to be added to existing pole.
5. Work is approximately the same as overhead power construction. Use 30 percent of primary conductor's man-hours for series circuits. Secondary installation of floodlights is the same as secondary conductors and service drops.
6. Refer to Division 31, earthwork, for excavating and Division 33, utilities, for man-hour figures for burial of power cables.
7. Work does not include installation of power source.

Figure 5-Q-13. Street and Security Lighting

Work Element Description	Unit	Man-hours per Unit
27 13 00.00 **Communications Cabling**		
Pull cable in conduit		
(0020) Polyethylene sheath, 100 pair	LF	0.4000
(0030) Install exposed interior cable, 26 pair	LF	0.3200
(0040) Install telephone terminal box	Each	2.4000
(0050) Install CAT 5 connector	Each	0.1000
(0060) Install polyethylene cable terminal, 26 pair	Each	1.6000
(0070) Connect terminal stub to cable, polyethylene sheath, 26 pair	Each	2.4000
(0080) Install telephone, complete, any style, one line	Each	3.2000
(0090) Splice telephone cable in building, vault, or manhole polyethylene sheath	Splice	5.6000
(0100) Testing	Each	0.4000
Minimum suggested crew size: one electrician and one laborer.		

Figure 5-Q-14. Division 27, Interior Telephone Service

Work Element Description	Unit	Man-hours per Unit
27 15 00.00 **Communications Horizontal Cabling**		
(0010) Install messenger suspension clamps	Each	0.1600
(0020) Attach messenger to suspension clamps	Feet	0.0320
(0030) Splicing overhead cable (straight splice) polyethylene sheath and insulation—100 pair	Splice	5.6000
(0040) Terminating cable at terminal box or main distribution frame (tag splice) polyethylene sheath and insulation—100 pair	Splice	8.0000
Minimum suggested crew size: one electrician and one helper.		
27 15 13.13 **Communications Copper Horizontal Cabling**		
(0010) Install CAT 6 cable	LF	0.0171
(0100) Install connector RJ45, CAT 5 or 6	Each	0.1500
(0120) Install jack RJ45, CAT 5 or 6	Each	0.1845
Minimum suggested crew size: one electrician.		

Figure 5-Q-15. Division 27, Overhead Telephone Line Construction

Work Element Description	Unit	Man-hours per Unit
27 51 00 **Audio-Video Communications Systems**		
Public address system conventional		
(0010) office	Each	2.4000
(0020) industrial	Each	4.0000
Sound system		
(0030) speakers, ceiling, or wall mounted	Each	1.6000
(0040) speakers	Each	3.2000
(0050) volume control	Each	1.6000
(0060) amplifier, 250 watt	Each	9.6000
(0070) cabinets	Each	9.6000
Intercom, master		
(0080) up to 25 station capacity	Each	9.6000
(0090) remote station	Each	1.6000
Emergency call system		
(0100) 12 zones, annunciator	Each	11.2000
(0110) bell	Each	1.6000
(0120) light or relay	Each	1.6000
(0130) transformer	Each	4.0000
(0170) Terminal box	Each	3.2000
(0180) Amplifier or power supply	Each	4.8000
(0190) Annunciator, master intercom, and amplifier	Each	1.0000
(0200) Testing and other devices	Each	0.1600
Minimum suggested crew size: one electrician and one helper.		

Figure 5-Q-16. Division 27, Installing Intercommunication System

Work Element Description	Unit	Man-hours per Unit
28 31 23.50 **Alarm Panels and Devices**		
Fire alarm control panel,		
(0010) 4 zones	Each	8.0000
(0020) 8 zones	Each	16.0000
(0030) 12 zones	Each	23.9880
(0035) Fire alarm actuating device	Each	1.0000
(0040) Battery and rack	Each	2.0000
(0050) Warning device, bell, strobe etc.	Each	2.0000
28 31 43.50 **Fire and Heat Detectors**		
(0010) Detector, rate of rise	Each	1.0000
28 31 46.50 **Smoke Detectors**		
(0010) Detector, smoke, ceiling type	Each	1.2900
(0020) Duct type	Each	2.5000
Minimum suggested crew size: one electrician.		

Figure 5-Q-17. Division 28, Fire Detection and Alarm Production

CHAPTER 5 ANNEX R
Division 31
Earthwork

5.R.1 INTRODUCTION

Division 31, earthwork, was previously categorized in MasterFormat 1995 Division 2 and covers earthwork-related items. The scope of work includes clearing and grubbing, tree and shrub removal, and soil stripping and stockpiling. Major earthwork items include grading, excavation, shoring, dewatering, backfill, compaction, hauling, erosion control, soil stabilization, shoring, and piles. Special categories include drilling, blasting, and ripping.

5.R.2 ESTIMATING INFORMATION AND TIPS

Most of the work in these divisions can be found on the civil drawings. Estimators should review all drawings for applicability to earthwork requirements. Ensure alignment between specifications and drawings. Review the Division 31 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable. Refer to FM 5-434/MCRP 3-3-40D.9 for further information on the process of estimating equipment production rates, characteristics, operation techniques, and soil considerations for earthmoving equipment. It provides information to help select the most economical and effective equipment for each individual operation.

5.R.3 ESTIMATING DATA

Figures 5-R-1 through 5-R-25 present data and guidelines for estimating items found in Division 31. Production rates found in this division apply to all construction equipment regardless of make or model. The equipment used in this division is generic examples only. Information for production calculations should be obtained from the operation and maintenance manuals for the make and model of the equipment being used.

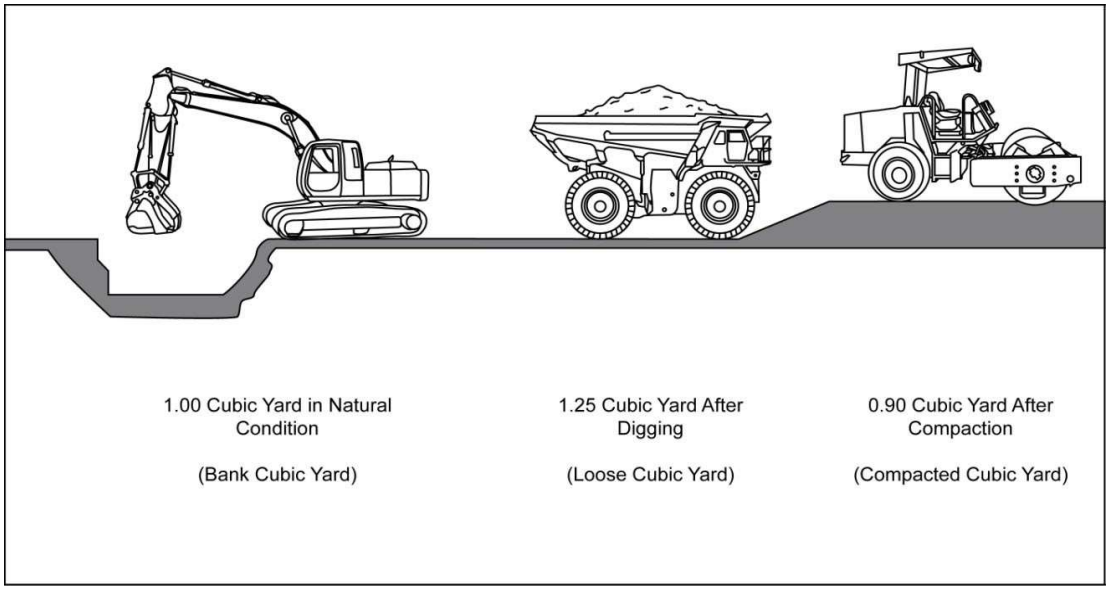

Figure 5-R-1. Materiel-volume Changes Caused by Construction Processes

Materiel Type	Converted From	Converted To		
		Bank	Loose	Compacted
Sand or gravel (soil Type C)	Bank		1.11	0.95
	Loose	0.90		0.86
	Compacted	1.05	1.17	
Loam (soil Type B)	Bank		1.25	0.90
	Loose	0.80		0.72
	Compacted	1.11	1.39	
Clay (soil Type A)	Bank		1.43	0.90
	Loose	0.70		0.63
	Compacted	1.11	1.59	
Rock (blasted)	Bank		1.50	1.30
	Loose	0.67		0.87
	Compacted	0.77	1.15	
Coral (comparable to lime rock)	Bank		1.50	1.30
	Loose	0.67		0.87
	Compacted	0.77	1.15	

Notes:
1. The cubic volume of fill (as compacted in place) times the multiplier equals the cubic volume of loose materiel required to be compacted fill.
2. Can also be applied as cubic volume in place times the multiplier equals the cubic volume of loose materiel to be moved.

Figure 5-R-2. Materiel/Soil Volume Conversion Factors

Materiel	Loose (Pounds per CYD)	Bank (Pounds per CYD)	Swell (%)	Load Factor
Cement, Portland	2,450	2,950	20	0.83
Clay, dry	2,100	2,650	26	0.79
Clay, wet	2,700	3,575	32	0.76
Clay and gravel, dry	2,400	2,800	17	0.85
Clay and gravel, wet	2,600	3,100	17	0.85
Concrete	2,650	3,700	40	0.72
Concrete, wet mix	3,600	3,600	40	0.72
Earth, loam, dry	2,215	2,850	29	0.78
Earth, loam, wet	2,750	3,380	23	0.81
Granite	2,800	4,560	65	0.60
Gravel, 1/4 to 2 inches, dry	2,780	3,140	13	0.88
Gravel, 1/4 to 2 inches, wet	3,090	3,620	17	0.85
Laterite	3,900	5,200	33	0.75
Limestone, blasted	2,500	4,250	69	0.59
Limestone, crushed	2,700	4,500	67	0.60
Limestone, marble	2,700	4,500	69	0.59
Mud, dry	2,100	2,550	21	0.82
Mud, wet	2,650	3,200	21	0.83
Sand, dry	2,900	3,250	12	0.89
Sand, wet	3,200	3,600	13	0.89
Sand and gravel, dry	2,900	3,250	12	0.89
Sand and gravel, wet	3,400	3,750	10	0.91
Sandstone, shot	2,700	4,250	58	0.64
Shale, riprap	2,100	2,800	33	0.75
Slate	3,600	4,700	30	0.77
Coral, class #2, soft	2,030	2,900	67	0.60
Coral, class #1, hard	2,440	4,075		

Notes:

1. The above numbers are averages for common materiels. Weights and load factors vary with such factors as grain size, moisture content, and degree of compaction. If an exact weight for a specific materiel must be determined, run a test on a sample of that particular materiel.
2. Percent of swell times the bank (in place) CYD equals the loose CYDs to be moved.
3. Load factor times the loose CYDs equals bank CYDs being moved.
4. Swell (%) = ((Weight per bank CYD/Weight per loose CYD) - 1) × 100.

Figure 5-R-3. Materiel Weights and Characteristics

Soil Type	Run/Rise Ratio	Slope Angle
Stable rock	Vertical	90
Type A	3/4:1	53
Type B	1:1	45
Type C	1 1/2:1	34
Type A (temporary)	1/2:1	63
Note: Figure 5-R-5 illustrates this content. This is just one sample; refer to USACE's Engineer Manual (EM) 385-1-1, Safety and Health Requirements Manual, for other sloping and bending configurations.		

Figure 5-R-4. Allowable Slopes

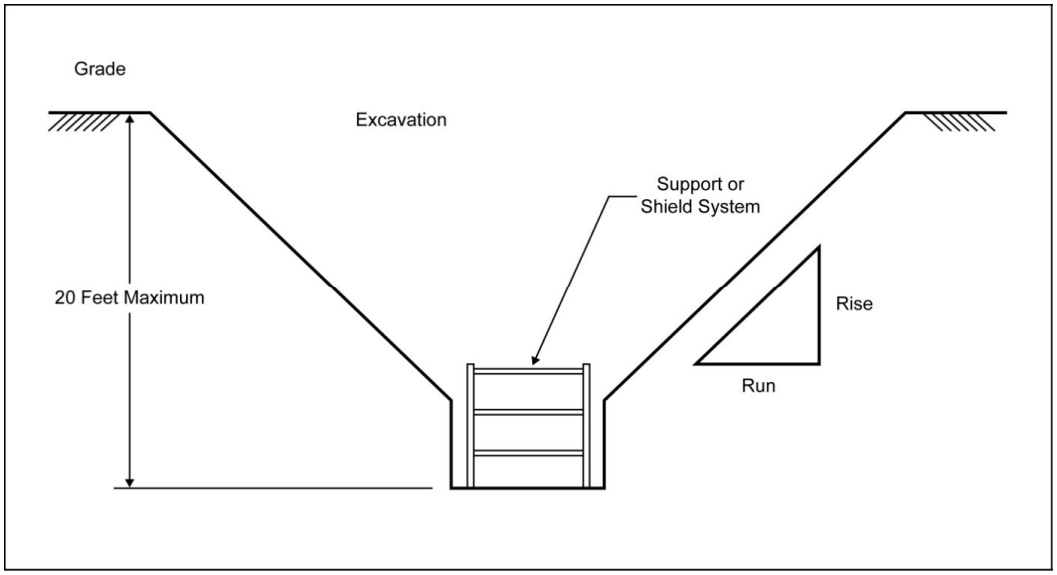

Figure 5-R-5. Sloping and Benching for Excavations

Trench Depth (Inches)	Trench Width (Inches)						
	12	18	24	30	36	42	48
	Content of Trench, CYD, per Foot of Length						
06	0.019	0.028	0.037	0.046	0.056	0.066	0.074
12	0.037	0.560	0.074	0.093	0.111	0.130	0.148
18	0.056	0.083	0.111	0.139	0.167	0.194	0.223
24	0.074	0.111	0.148	0.185	0.222	0.260	0.296
30	0.093	0.138	0.185	0.232	0.278	0.324	0.370
36	0.111	0.166	0.222	0.278	0.333	0.389	0.445
42	0.130	0.194	0.259	0.324	0.389	0.454	0.520
48	0.148	0.222	0.296	0.370	0.445	0.520	0.592
54	0.167	0.250	0.333	0.416	0.500	0.584	0.667
60	0.186	0.278	0.370	0.463	0.555	0.649	0.741

Figure 5-R-6. Trench Excavation Factors

Square Tracts of Land		
Acres	**Length of One Side of Square Track (feet)**	**Area (SF)**
1/10	66.0	4,356
1/8	73.8	5,445
1/6	85.2	7,260
1/4	104.4	10,890
1/3	120.5	14,520
1/2	147.6	21,780
3/4	180.8	32,670
1	208.7	43,560
1 1/2	255.6	63,340
2	295.2	87,120
2 1/2	330.0	108,900
3	361.5	130,680
5	466.7	217,800

Figure 5-R-7. Acreage and Areas

Depth in Inches or Feet	CYD to be Removed per SF of Area	Depth in Feet	CYD to be Removed per SF of Area
2.0 inches	0.006	4.5	0.167
4.0 inches	0.012	5.0	0.185
6.0 inches	0.018	5.5	0.204
8.0 inches	0.025	6.0	0.222
10.0 inches	0.031	6.5	0.241
1.0 feet	0.037	7.0	0.259
1.5 feet	0.056	7.5	0.278
2.0 feet	0.074	8.0	0.296
2.5 feet	0.093	8.5	0.314
3.0 feet	0.111	9.0	0.332
3.5 feet	0.130	9.5	0.350
4.0 feet	0.148	10.0	0.369
Example: Assume that excavation is 24 by 30 feet and 6 feet deep (24 × 30 = 720). In the table, the 6-foot depth has a factor of 0.222 (the number of CYD in an excavation 1 SF and 6 feet deep). Therefore, 720 × 0.222 = 159.84 CYD.			

Figure 5-R-8. General Excavation Factors

Work Element Description	Unit	Man-hours per Unit
31 11 10.10 Clear and Grub Site		
Cut and chip trees; 3 CYD crawler loader, brush chipper, and chain saws		
(0010) light trees to 6-inch diameter	Acre	64.0
(0020) grub stumps and remove	Acre	16.0
(0030) medium trees to 12-inch diameter	Acre	92.0
(0040) grub stumps and remove	Acre	32.0
(0050) heavy trees to 24-inch diameter	Acre	213.0
(0060) grub stumps and remove	Acre	64.0
Minimum suggested crew size: one equipment operator and one laborer.		
31 13 13.10 Selective Clearing		
(0010) Clearing brush with brush saw	Acre	42.6
(0020) by hand	Acre	88.7
(0030) with dozer, ball and chain, light clearing	Acre	10.6
(0040) medium clearing	Acre	14.2
(0050) with dozer, brush rake, light brush	Acre	2.1
(0060) medium brush to 4-inch diameter	Acre	2.7
(0070) heavy brush to 4-inch diameter	Acre	3.3
Brush mowing, tractor with rotary mower		
(0080) light density	Acre	5.3
(0090) medium density	Acre	7.2
(0100) heavy density	Acre	10.6
Minimum suggested crew size: one equipment operator and one laborer.		
31 13 13.20 Selective Tree Removal		
Remove selective trees, onsite using chain saws and chipper,		
(0010) not including stumps, up to 6-inch diameter	Each	3.547
(0020) 8- to 12-inch diameter	Each	5.320
(0030) 13- to 24-inch diameter	Each	6.384
(0040) 25- to 36-inch diameter	Each	7.980
Stump removal onsite by hydraulic backhoe, 1 1/2 CYD	Each	
(0050) 4- to 12-inch diameter	Each	0.967
(0060) 13- to 36-inch diameter	Each	1.995
Minimum suggested crew size: one equipment operators and one laborer.		
31 14 13.23 Topsoil Stripping and Stockpiling		
(0010 Loam or topsoil, remove and stockpile onsite, 6 inches deep, 200-foot haul	CYD	0.020
Minimum suggested crew size: one equipment operator and one laborer.		
Note: One acre = 43,560 SF or 4,840 SY		

Figure 5-R-9. Clearing and Grubbing Production

Motor Grader Production, Hour per Bank CYD	
31 22 16 **Fine Grading**	
Type of Operation	**Hour per Bank CYD**
(0010) Cut "V" ditch, easy (soil Type C)	0.0060
(0020) Cut "V" ditch, medium (soil Type B)	0.0100
(0030) Cut "V" ditch, hard (soil Type A)	0.0175
(0040) Trim and spread materiel	0.0133
Motor Grader Production, Hour per Square Foot	
Type of Operation (see Note 2)	**Hour per Square Foot**
(0110) Shape banks and slopes (large area)	0.0013
(0120) Shape banks and slopes (small area)	0.0026
(0130) Rough grade (large area)	0.0004
(0140) Rough grade (small area)	0.0008
(0150) Fine grade (blue top, large area)	0.0017
(0160) Fine grade (blue top, small area)	0.0034
Minimum suggested crew size: one equipment operator.	
Notes: 1. All figures are in bank CYD. 2. Small areas require additional directional changes and maneuvering.	

Figure 5-R-10. Motor Grader Production

Work Element Description	Unit	Man-hours per Unit
31 23 16.13 **Excavating, Trench, or continuous footing,**		
Common earth with no sheeting or dewatering included		
(0010) 1 to 4 feet deep, 3/8 CYD excavator	Bank CYD	0.142
(0020) 1/2 CYD excavator	Bank CYD	0.106
Loam and sandy clay with no sheeting or dewatering included		
(0030) 1 to 4 feet deep, 3/8 CYD tractor loader/backhoe	Bank CYD	0.132
(0040) 1/2 CYD excavator	Bank CYD	0.098
Sand and gravel with no sheeting or dewatering included		
(0050) 1 to 4 feet deep, 3/8 CYD excavator	Bank CYD	0.129
(0060) 1/2 CYD excavator	Bank CYD	0.097
Dense hard clay with no sheeting or dewatering included		
(0070) 1 to 4 feet deep, 3/8 CYD excavator	Bank CYD	0.161
(0080) 1/2 CYD excavator	Bank CYD	0.121
(0090) Backfill trench, front end loader, wheel mounted, 1 CYD, 100 foot haul	CYD	0.06

Figure 5-R-11. Trench and Footing Excavation Production (Sheet 1 of 2)

Work Element Description	Unit	Man-hours per Unit
31 23 16.14 Excavating, Utility Trench		
Common earth, chain trencher, 12 horsepower, operator walking		
(0010) 4-inch-wide trench, 12 to 24 inches deep	LF	0.015
(0020) 6-inch-wide trench, 12 to 24 inches deep	LF	0.020
(0030) 36 inches deep	LF	0.024
(0040) 8-inch-wide trench, 12 inches deep	LF	0.023
(0050) 18 inches deep	LF	0.027
(0060) 24 inches deep	LF	0.031
(0070) 36 inches deep	LF	0.036
Backfill by hand including compaction, add		
(0080) 4-inch-wide trench, 12 inches deep, minimum	LF	0.013
(0090) 8-inch-wide trench, 36 inches deep, maximum	LF	0.078
Chain trencher, 40 horsepower, operator riding		
(0100) 6-inch-wide trench and backfill, 12 inches deep	LF	0.009
(0110) 60 inches deep	LF	0.016
(0120) 16-inch-wide trench, 12 to 24 inches deep	LF	0.015
Hand excavation, trim for pipe bells		
(0130) 8-inch pipe	LF	0.069
(0140) 18-inch pipe	LF	0.082
31 23 16.16 Excavation for Minor Structures		
(0010) Hand digging, pits to 6 feet deep, sandy soil	Bank CYD	1.330
(0020) Hand digging, pits to 6 feet deep, heavy soil or clay	Bank CYD	2.660
(0030) Hand digging, pits 6 to 12 feet deep, sandy soil	Bank CYD	2.128
(0040) Hand digging, pits 6 to 12 feet deep, heavy soil or clay	Bank CYD	3.547
(0050) Hand digging, pits 12 to 18 feet deep, sandy soil	Bank CYD	2.660
(0060) Hand digging, pits 12 to 18 feet deep, heavy soil or clay	Bank CYD	5.320
(0070) Hand loading trucks from stock pile, heavy soil or clay	Bank CYD	1.330
(0080) Hand compact with pneumatic		0.8
(0090) Hand compact with vibratory		0.200
For wet or muck hand excavation, multiply by 1.50.		
Machine excavation, for spread footings and small building foundations		
(0100) Common earth, hydraulic backhoe, 1/2 CYD bucket	Bank CYD	0.387
(0110) 1 CYD bucket	Bank CYD	0.197
(0120) 2 CYD bucket	Bank CYD	0.106
(0130) Sand and gravel, 3/4 CYD bucket	Bank CYD	0.213
(0140) 1 CYD bucket	Bank CYD	1.769
(0150) 2 CYD bucket	Bank CYD	0.097
(0160) Clay, till, or blasted rock, 3/4 CYD bucket	Bank CYD	2.6600
(0170) 1 CYD bucket	Bank CYD	0.223
(0180) 2 CYD bucket	Bank CYD	0.121
(0190) Sandy clay and loam, hydraulic backhoe, 1/2 CYD bucket	Bank CYD	0.355
(0200) 1 CYD bucket	Bank CYD	0.184
(0210) 1 1/2 CYD bucket	Bank CYD	0.137
For loading onto trucks, multiply by 1.15.		
Minimum suggested crew size: one equipment operator and one laborer.		

Figure 5-R-11. Trench and Footing Excavation Production (Sheet 2 of 2)

Work Element Description	Unit	Man-hours per Unit
31 23 16.30 Drilling and Blasting Rock		
Drill Holes:		
(0010) Jackhammer, 2.5-inch diameter (medium)	Feet	0.20
(0020) Jackhammer, 2.5-inch diameter (hard)	Feet	0.30
(0030) Crawler-mounted rock drill, 2.5-inch diameter (medium)	Feet	0.09
(0040) Crawler-mounted rock drill, 2.5-inch diameter (hard)	Feet	0.14
(0050) Load and shoot holes	Each	0.50
Minimum suggested crew size: Jackhammer—one operator per drill Crawler-mounted rock drill—two operators per drill Load/shoot—minimum of four crew members.		
Note: Times may vary depending on type of rock, equipment, and/or explosives.		

Figure 5-R-12. Rock Drilling and Blasting Production

Excavation from Pit to Truck/Pile Hours per Loose CYD				
Bucket Size	**Haul Distance (Feet)**			
CYD	**50**	**100**	**150**	**200**
31 23 16.42 Excavating, Bulk Bank Measure				
1.25	(0010) 0.0256	(0020) 0.0357	(0030) 0.0476	(0040) 0.0588
2.50	(0050) 0.0081	(0060) 0.0109	(0070) 0.0133	(0080) 0.0161
5.00	(0090) 0.0047	(0100) 0.0062	(0110) 0.0075	(0120) 0.0091
Note: Figures are in loose CYD. Use Figure 5-R-2 to find the amount of bank (in place) CYD removed. Example: 2 1/2 CYD loader at 50-foot haul = 1/0.0081 = 124 loose CYD in 1 hour. 124 CYD × swell factor for earth, loam, dry = 124 × 0.81 = 100 bank CYD in 1 hour.				

Figure 5-R-13. Front-End Loaders Production

Clamshell Production—90-degree Swing Hour per Loose CYD (50-minute Hour)			
Work Element Description	**0.75 CYD**	**1.50 CYD**	**2.50 CYD**
31 23 16.42 Excavating, Bulk Bank Measure			
Loose sand/gravel	(0210) 0.0250	(0230) 0.0143	(0250) 0.0095
Pit excavation	(0220) 0.0294	(0240) 0.0167	(0260) 0.0111
Notes: 1. Figures are based on loose CYD. Refer to Figure 5-R-2 to find the amount of bank CYD. 2. Boom swing is for 90 degrees.			

Figure 5-R-14. Clamshell Production

Dragline Production—90-Degree Swing Hour per Bank CYD (50-Minute Hour)				
Bucket Size (CYD)	Optimum Digging Depth (feet)	Class of Materiel		
		Sand/Gravel	Common Earth	Dense Clay
31 23 16.42 Excavating, Bulk Bank Measure				
0.75	6.00	(0310) 0.0143	(0320) 0.0147	(0330) 0.0200
1.50	7.33	(0340) 0.0086	(0350) 0.0095	(0360) 0.0112
2.50	8.50	(0370) 0.0061	(0380) 0.0069	(0390) 0.0079
Note: Figures are in bank CYD. Refer to Figure 5-R-2 to find the amount of loose CYD.				

Figure 5-R-15. Draglines Production

Power Excavators Production Hour per Bank CYD (50-Minute Hour)		
Equipment Type	Bucket Size	Hour per Bank CYD
31 23 16.42 Excavating, Bulk Bank Measure		
Tractor-mounted backhoes	3/8 CYD	(0410) 0.1000
	1/2 CYD	(0420) 0.0769
Excavator, hydraulic hoes	3/4 CYD	(0430) 0.0250
	1 CYD	(0440) 0.0182
	1 1/2 CYD	(0450) 0.0139
Note: Figures are in bank CYD. Refer to Figure 5-R-2 to find the amount of loose CYD.		

Figure 5-R-16. Power Excavators Production

Loose CYD Age Production Hours per Loose CYD (50-Minute Hour)						
	Haul Distance (Feet)					
Dozer Size	50	100	150	200	300	400
31 23 16.46 Excavating, Bulk, Dozer						
Large	(0010)	(0015)	(0020)	(0025)	(0030)	(0035)
(Example: D-8)	0.0023	0.0035	0.0048	0.0059	0.008	0.0105
Medium	(0040)	(0045)	(0050)	(0055)	(0060)	(0065)
(Example: D-7/FD20)	0.0027	0.0049	0.0065	0.010	0.0135	0.0182
Small	(0070)	(0075)	(0080)	(0085)	(0090)	
(Example: D-5/1150)	0.0095	0.0154	0.0217	0.0294	0.0455	
Notes: 1. Figures are in loose CYD. Refer to Figure 5-R-2 to find the amount of bank CYD. 2. Production is based on slot dozing. If work is done without slots, use 0.75 multiplier.						

Figure 5-R-17. Bulldozer Production

Wheel Tractor Scraper Production Hour per Loose CYD					
Scraper Size	**One Way Haul Distance (feet)**				
	1,000	**2,000**	**3,000**	**4,000**	**5,000**
31 23 16.50 Excavation, Bulk, Scrapers					
14–28 loose CYD	(0010) 0.0082	(0020) 0.0116	(0030) 0.0159	(0040) 0.0200	(0050) 0.0233
21–31 loose CYD	(0060) 0.0038	(0070) 0.0061	(0080) 0.0083	(0090) 0.0105	(0100) 0.0123
Notes: 1. All figures in loose CYD. 2. Estimate figure is based on required size crawler tractor push loading.					

Figure 5-R-18. Wheel Tractor Scrapers Production

Work Element Description	Unit	Man-hours per Unit
31 23 23.13 Backfill		
(0010) Backfill by hand, light soil, no compaction	CYD	0.5710
(0020) Backfill by hand, 12 inch lifts w/hand tamp compaction, light soil	CYD	0.8060

Figure 5-R-19. Backfill Production

Dump Truck Production Hour per Loose CYD					
Average Speed	**Average Haul Distance One Way (Miles)**				
	1	**2**	**3**	**4**	**5**
31 23 23.20 Hauling	**5 Ton Dump Trucks**				
10 MPH	(0000) 0.0877	(0010) 0.1429	(0020) 0.2000	(0030) 0.2500	(0040) 0.3030
15 MPH	(0002) 0.0680	(0012) 0.1064	(0022) 0.1429	(0032) 0.1786	(0042) 0.2174
20 MPH	(0004) 0.0595	(0014) 0.0870	(0024) 0.1149	(0034) 0.1429	(0044) 0.1695
30 MPH	(0006) 0.0505	(0016) 0.0690	(0026) 0.0870	(0036) 0.1053	(0046) 0.1250
	20 Ton Dump Trucks				
10 MPH	(0050) 0.0092	(0060) 0.0476	(0070) 0.0667	(0080) 0.0833	(0090) 0.1010
15 MPH	(0052) 0.0227	(0062) 0.0355	(0072) 0.0476	(0082) 0.0595	(0092) 0.0725
20 MPH	(0054) 0.0198	(0064) 0.0290	(0074) 0.0383	(0084) 0.0476	(0094) 0.0565
30 MPH	(0056) 0.0168	(0066) 0.0230	(0076) 0.0290	(0086) 0.0351	(0096) 0.0417
Notes: 1. All figures are in loose CYD for 5 and 20-ton military dump trucks. 2. 2.5 CYD front-end loader required to load 5-ton trucks. 5 CYD front-end loader for 20-ton trucks. 3. Estimates based on loading time of 4 minutes and a dumping time of 3 minutes.					
Legend: MPH = miles per hour					

Figure 5-R-20. Dump Truck Production

Roller Production: Hour per Compacted CYD						
Type of Roller	Speed in MPH	Lift in Inches	Number of Passes			
			3	4	5	6
31 23 23.24 Compaction, Structural						
Towed grid	5	6	(0010) 0.0018	(0020) 0.0025	(0030) 0.0031	(0040) 0.0037
Vibratory	2	6	(0050) 0.0034	(0060) 0.0046	(0070) 0.0057	(0080) 0.0069
Smooth steel drums	1.5	3	(0110) 0.0093	(0120) 0.0122	(0130) 0.0154	(0140) 0.0185
Multi-tired pneumatic	2	3	(0150) 0.0079	(0160) 0.0105	(0170) 0.0132	(0180) 0.0156
High-speed tamping foot	6	6	(0210) 0.0011	(0220) 0.0015	(0230) 0.0019	(0240) 0.0023
			3 mile haul	6 mile haul	12 mile haul	
Water Truck, 3,000 gallon			(0300) 0.0080	(0310) 0.0110	(0320) 0.0160	
Water Truck, 6,000 gallon			(0330) 0.0040	(0340) 0.0050		

Notes:
1. All figures are in hours/compacted CYD.
2. Use Figure 5-R-2 to estimate loose CYD of fill requirements.
3. For small areas that require more directional changes and maneuvering, use 0.5 multiplier.
4. The number of machine passes required is dependent on soil type, moisture content, desired density, and machine compaction effort.
5. The number of passes can only be determined by testing the density of the compacted materiel onsite.

Figure 5-R-21. Rollers (Hourly Production)

Work Element Description	Unit	Man-hours per Unit
31 25 13.10 Erosion Control		
(0010) Place jute mesh, plastic netting, or polypropylene membrane	SY	0.0143
(0030) Place nylon, 3 dimensional geomatrix, 12 mil thick	SY	0.0470
(0110) Machine-place riprap materiel	CYD	0.0120
(0120) Hand-fill voids in riprap	SY	1.6000
Minimum suggested crew size: Place riprap—two operators for crane, using tongs/clamshell, with two crewmembers on tag lines placing rock.		
Note: Placing riprap should entail 120 man-hours if interlocked.		

Figure 5-R-22. Erosion Control Production

Work Element Description	Unit	Man-hours per Unit	
31 36 00.00 HESCO Concertainer Description (Install only, no fill)		**Bottom Layer**	**Upper Layer**
MIL 1, 54 in by 42 in by 32 ft 9 in, 9 cell, straight section	Each	(0010) 0.3333	(0020) 0.6667
MIL 1, 54 in by 42 in by 32 ft 9 in, 9 cell, corner section	Each	(0030) 0.4667	(0040) 0.9333
MIL 1, 108 in by 42 in by 10 ft 6 in, 3 cell, straight section	Each		(0045) 0.2000
MIL 2, 24 in by 24 in by 4 ft, 2 cell, straight section	Each	(0050) 0.0333	(0060) 0.0667
MIL 3, 39 in by 39 in by 32 ft, 10 cell, straight section	Each	(0090) 0.01333	(0100) 0.2667
MIL 3, 39 in by 39 in by 32 ft, 10 cell, corner section	Each	(0110) 0.2667	(0120) 0.5333
MIL 4, 39 in by 60 in by 32 ft, 10 cell, straight section	Each	(0130) 0.2000	(0140) 0.4000
MIL 4, 39 in by 60 in by 32 ft, 10 cell, corner section	Each	(0150) 0.4000	(0160) 0.8000
MIL 5, 24 in by 24 in by 10 ft, 5 cell, straight section	Each	(0170) 0.0667	(0180) 0.1333
MIL 5, 24 in by 24 in by 10 ft, 5 cell, corner section	Each	(0190) 0.1333	(0200) 0.2667
MIL 6, 66 in by 24 in by 10 ft, 5 cell, straight section	Each	(0210) 0.2000	(0220) 0.4000
MIL 7, 87 in by 84 in by 90 ft, 13 cell, straight section	Each	(0230) 1.5000	(0240) 3.0000
MIL 7, 87 in by 84 in by 90 ft, 13 cell, corner section	Each	(0250) 2.0000	(0260) 4.0000
MIL 8, 54 in by 48 in by 32 ft, 9 cell, straight section	Each	(0270) 0.3333	(0280) 0.6667
MIL 8, 54 in by 48 in by 32 ft, 9 cell, corner section	Each	(0290) 0.4667	(0300) 0.9333
MIL 9, 39 in by 30 in by 30 ft, 12 cell, straight section	Each	(0310) 0.1333	(0320) 0.2667
MIL 9, 39 in by 30 in by 30 ft, 12 cell, corner section	Each	(0330) 0.2667	(0340) 0.5333
MIL 10, 87 in by 60 in by 95 ft, 20 cell, straight section	Each	(0350) 1.500	(0360) 3.000
MIL 10, 87 in by 60 in by 95 ft, 20 cell, corner section	Each	(0370) 2.000	(0380) 4.000
EPW 1, 84 in by 42 in by 108 ft, 30 cell, straight section	Each	(0390) 1.000	(0400) 1.3333
Suggested crew size: two to six laborers			
Install fill in Consertainers	**Unit**	**Bottom Layer**	**Upper Layer**
Manual fill	CYD	(0900) 0.9333	(0910) 1.3253
Machine fill	CYD	(0920) 0.0489	(0930) 0.0575
Suggested crew size one equipment operator, four laborers			
Legend: EPW = enhanced protective wall ft = feet	in = inches		

Figure 5-R-23. Gabion Production

Work Element Description	Unit	Man-hours per Unit
31 41 16.10 **Sheet Piling Systems**		
(0005) Installation and removal of solid 2-inch sheeting for trenches 5 to 10 feet deep and 42 inches to 12 feet wide	SF of bank surface	0.1600
(0010) Sheet piling, no wales, 22 psf, 15 ft excavation, left in place	Ton	8.8800
(0020) Sheet piling, no wales, 22 psf, 15 ft excavation, drive, extract and salvage	Ton	16.0005
(0030) Sheet piling, no wales, 27 psf, 20 ft excavation, left in place	Ton	7.4130
(0040) Sheet piling, no wales, 27 psf, 20 ft excavation, drive, extract and salvage	Ton	14.6565
(0050) Sheet piling, no wales, 38 psf, 25 ft excavation, left in place	Ton	5.0520
(0060) Sheet piling, no wales, 38 psf, 25 ft excavation, drive, extract and salvage	Ton	9.1420
(0070) Sheet piling, no wales, 38 psf, 40 ft excavation, left in place	Ton	4.5285
(0080) Sheet piling, no wales, 38 psf, 40 ft excavation, drive, extract and salvage	Ton	7.8360
(0110) Sheet piling, no wales, 22 psf, 15 ft excavation, left in place	SF	0.0975
(0120) Sheet piling, no wales, 22 psf, 15 ft excavation, drive, extract and salvage	SF	0.1755
(0130) Sheet piling, no wales, 27 psf, 20 ft excavation, left in place	SF	0.1005
(0140) Sheet piling, no wales, 27 psf, 20 ft excavation, drive, extract and salvage	SF	0.1980
(0150) Sheet piling, no wales, 38 psf, 25 ft excavation, left in place	SF	0.0960
(0160) Sheet piling, no wales, 38 psf, 25 ft excavation, drive, extract and salvage	SF	0.1740
Minimum suggested crew size: three crane crew operators and five pile drivers		
Notes: 1. Work for typical unstable soil includes: solid sheeting; 4- by 6-inch stringers; 4-foot center-to-center hangers; cleats and 4- by 6-inch cross bracing spaced 7 feet center to center. 2. Design of shoring and sheeting will vary with soil conditions, width, and depth of trench, etc. 3. Installation should be in accordance with the EM 385-1-1.		
Legend: psf = pounds per square foot		

Figure 5-R-24. Sheeting and Shoring Excavations Production

Work Element Description	Unit	Man-hours per Unit
31 62 00 Driven Piles		
(0010) 25-foot wood piling	Each	3.000
(0020) 50-foot wood piling	Each	6.500
(0030) 75-foot wood piling	Each	9.600
(0040) 25-foot steel piling	Each	4.000
(0050) 50-foot steel piling	Each	7.200
(0060) 75-foot steel piling	Each	12.000
(0070) 40-foot precast concrete piling	Each	13.200
(0080) 60-foot precast concrete piling	Each	18.000
(0090) 80-foot precast concrete piling	Each	24.000
(0100) Steel sheet piling	SF	0.102
(0110) Assemble and rig leads and hammer	Each	48.000
(0120) Dismantle leads and hammer	Each	32.000
Minimum suggested crew size: three crane crew operators and five pile drivers.		
Notes: 1. Man-hour figures are preliminary estimate only. The many variables of this work require onsite determinations for accurate estimates. 2. Factors of importance are: design, soil, equipment and method used, tides, access to site, currents, materiels storage, etc. 3. Work included is preparation of pile, placing in leads, driving, and cutoff. 4. For concrete-filled, fluted, hollow steel piling and pipe piling for spudding pontoon, small craft, finger piers, use the steel bearing pile figures.		

Figure 5-R-25. Pile-Driving Production

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CHAPTER 5 ANNEX S

Division 32

Exterior Improvements

5.S.1 INTRODUCTION

Division 32, exterior improvements, was previously categorized in MasterFormat 1995 Division 2. The scope of work includes site improvement maintenance data (e.g., pavement maintenance, snow removal, and landscape maintenance); sidewalks, driveways, and patios; base course gravel and crushed stone; bituminous-stabilized base course; asphalt paving of roads and rigid concrete paving; and unit pavers, in addition to other paving specialties such as cast-in-place, precast, and bituminous concrete curbs. Site improvements include fencing, retaining walls, fabricated bridges, and landscaping.

5.S.2 ESTIMATING INFORMATION AND TIPS

Most of the work in this division can be found on the civil drawings. Ensure alignment between specifications and drawings. Review the Division 32 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks if applicable. Refer to TM 3-34.63/FM 5-436, Paving and Surfacing Operations, for further information for bituminous and concrete operations for roads and airfields. It contains information on construction materiels and equipment and the mix design, production, placement, and repair of concrete and bituminous pavements.

5.S.3 ESTIMATING DATA

Figures 5-S-1 through 5-S-8 present data and guidelines for estimating items found in Division 32.

Work Element Description	Equipment	Unit	Equipment Hours per Unit
32 01 11.00 Pavement Cleaning (Snow Removal)			
Roads and Airfields:			
Light snowfall (less than 2 inches)	(0010) Salt truck	Mile (15 feet width)	0.20
(salting and/or sanding)	(0020) Dump truck and shovels	Mile (10 feet width)	1.05
Medium snowfall (2 to 6 inches)	(0030) Dump truck with plow	Mile (6 feet width)	0.15
(plowing)	(0040) Plow grader	Mile (10 feet width)	0.18
Heavy snowfall (over 6 inches)	(0050) Dump truck with plow	Mile (6 feet width)	0.25
(plowing and blowing)	(0060) Heavy-duty blower	Mile (6 feet width)	0.15

Figure 5-S-1. Snow Removal Production (Sheet 1 of 2)

Work Element Description	Equipment	Unit	Equipment- Hours per Unit
32 01 11.00 Pavement Cleaning (Snow Removal)			
Sidewalks:			
Light snowfall (less than 2 inches)	(0110) Men (0120) Sidewalk tractor	1,000 LF	1.80 0.25
Medium snowfall (2 inches)	(0130) Men (0140) Sidewalk tractor	1,000 LF	2.00 0.2500
Medium snowfall (4 inches)	(0150) Men (0160) Sidewalk tractor	1,000 LF	3.00 0.3000
Medium snowfall (6 inches)	(0170) Men (0180) Sidewalk tractor	1,000 LF	4.00 0.3500
Heavy snowfall (over 6 inches)	(0190) Men (0200) Sidewalk tractor	1,000 LF	4.0 + 0.5 per inch over 6 inches 0.35 + 0.06 per inch over 6 inches
Note: Estimate does not include refueling, maintenance, time reloading, etc.			

Figure 5-S-1. Snow Removal Production (Sheet 2 of 2)

Work Element Description	Unit	Hours per Unit
32 01 29 Rigid Pavement Repair		
(0500) Polymer grout patch, 4 inches thick 15 to 40 SF	Each	8.00
(0510) Polymer grout patch, 4 inches thick 50 to 75 SF	Each	10.6670
(0520) Polymer grout patch, 4 inches thick 80 to 100 SF	Each	12.8000
Minimum suggested crew: One builder and two laborers.		

Figure 5-S-2. Pavement Repair Production

Work Element Description	Unit	Man-hours per Unit
32 11 13.66 Sealcoat		
(0010) Sealcoating, 2 coat, coal tar pitch emulsion, under 1,000 SY	SY	0.035
(0020) 1,000 to 10,000 SY	SY	0.007
(0030) over 10,000 SY	SY	0.004
(0040) Prepare and clean surface	SY	0.004
(0050) Hand seal asphalt curbing	LF	0.007
(0060) Asphalt surface treatment, single course, small area	SY	0.019
(0065) Road or large area	SY	0.009
(0070) Asphalt surface treatment, single course for shoulders	SY	0.014
Minimum suggested crew size: two equipment operators.		
Note: A multiplier of 1.5 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production.		

Figure 5-S-3. Sealcoat Production

Work Element Description	Unit	Man-hours per Unit
32 11 23.23		
Aggregate Base Courses		
(0010) Crushed 3/4 inch stone base, for roadways and large areas, compacted, 6 inch deep	SY	0.035
(0100) Prepare and roll subbase, large area over 2,500 cubic yards	SY	0.007
(0110) Prepare and roll subbase, for roadways	SY	0.004
(0300) Crushed 1-1/2 inch stone base, for airfield construction, compacted to 8 inch deep	SY	0.004
(0400) Crushed 1-1/2 inch stone base, for airfield construction, compacted to 12 inch deep		
Minimum suggested crew size: three equipment operators and one laborer.		

Figure 5-S-4. Aggregate Base Course Production

Work Element Description	Unit	Man-hours per Unit
32 12 16.13		
Plant-Mix Asphalt Paving		
(0010) Binder course, 1 1/2 inches thick	SY	0.017
(0020) 2 inches thick	SY	0.021
(0030) 4 inches thick	SY	0.032
(0040) Wearing course, 1 inch thick	SY	0.014
(0050) 2 inches thick	SY	0.023
(0060) 3 inches thick	SY	0.030
(0070) 4 inches thick	SY	0.035
(0300) Emulsion, prime coat, .30 gallons per SY	SY	0.01200
(0310) Emulsion. tack coat, .10 gallons per SY	SY	0.01200
32 12 16.14		
Asphaltic Paving, Parking Lots, and Driveways		
(0010) Binder course, 1 1/2 inches thick	SF	0.002
(0020) 2 inches thick	SF	0.003
(0030) 4 inches thick	SF	0.006
(0040) Sand finish course, 3/4 or 1 inch thick	SF	0.002
(0050) Fill pot holes, hot mix, 2 inches thick	SF	0.012
(0060) 4 inches thick	SF	0.013
(0070) 6 inches thick	SF	0.015
(0080) Cold patch, 2 inches thick	SF	0.024
(0090) 4 inches thick	SF	0.027
(0100) 6 inches thick	SF	0.038
Minimum suggested crew size: four equipment operators and six laborers.		
Notes: 1. A multiplier of 1.5 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production. 2. Estimate does not include hauling. Refer to Division 31 23 23.20 for hauling production times.		

Figure 5-S-5. Asphalt Paving Production

Work Element Description	Unit	Man-hours per Unit
32 31 00.00 **Fences and Gates**		
(0010) Install wood fence 4 feet high	SF	0.054
(0020) Install metal fence 5-foot-high chain link	Feet	0.219
(0030) Install metal fence 7 to 8-foot-high chain link	Feet	0.244
(0031) Install metal fence 7 to 8-foot-high chain link, braced or corner panel	Feet	0.244
(0035) Install metal fence 10 to 12-foot-high chain link	Feet	0.310
(0036) Install metal fence 10 to 12-foot-high chain link, braced or corner panel	Feet	0.310
(0040) Hang single gates	Each	8.0
(0041) Hang double gates	Each	16.0
(0050) Install barbed wire	LF	0.0105
(0055) Install barbed wire, tactical cattle fence (per strand)	LF	0.0060
(0060) Install single strand concertina	LF	0.0100
(0070) Install triple strand concertina	LF	0.0300
(0080) Install single strand concertina, fence top	LF	0.0200
(0090) Install single extension arm, 3 strand barbed wire	Each	0.1680
(0095) Install double extension arm, 3 or 6 strand barbed wire	Each	0.2010
(0100) Install post, metal, U-shaped picket, 8 ft	Each	0.1300
(0130) Install post, wood, 4 in diameter, 8 ft	Each	0.2250
(0215) Install wire fence, 5-foot high barbed wire, wood or metal post, braced or corner panel	Each	1.9350
(0310) Hang gates, barbed wire, single leaf	Each	3.870
(0315) Hang gates, barbed wire, double leaf	Each	4.0
(0320) Install drop gate, 5-foot high barbed wire, wood or metal post	Each	3.870
Minimum suggested crew size: one equipment operator and two laborers.		
Notes: 1. Fence installation includes: digging holes; auger truck; unloading and distributing materiels; setting, plumbing, aligning, and concreting posts; installing braces; stretching and fastening fence fabric; installing caps or brackets on posts; and stringing lone and barbed wire. 2. Estimate of hanging gates includes installation of hardware.		

Figure 5-S-6. Fences and Gates Production

Work Element Description	Unit	Man-hours per Unit
32 32 23.00 **Retaining Walls**		
(0040) 12 feet high, 7 feet 7 inches deep, backfill not included	SF	0.1060
(0050) 16 feet high, 7 feet 7 inches deep, backfill not included	SY	0.1090
Minimum suggested crew size: one equipment operator and five laborers.		

Figure 5-S-7. Metal Retaining Wall Production

Work Element Description	Unit	Man-hours per Unit
32 92 00 **Turf and Grasses**		
(0010) Spread topsoil with machine	CYD	0.220
(0020) Top dress by hand (rake and clean)	SY	0.079
(0030) Seed and fertilize by hand	SY	0.105
(0040) Hydro-mulch	SY	0.013
(0050) Plant shrubs, 1-gallon size	Each	0.500
Minimum suggested crew size: one equipment operator and one laborer.		
Note: Hydro-mulch figure based on 1,000-gallon-capacity machine and includes charging time.		

Figure 5-S-8. Landscape Production

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CHAPTER 5 ANNEX T

Division 33

Utilities

5.T.1 INTRODUCTION

Division 33, utilities, includes underground water distribution systems, sanitary sewage systems, storm drainage systems, electrical underground utilities, and accessories.

5.T.2 ESTIMATING INFORMATION AND TIPS

Most of the work in this division can be found on the civil, electrical, and mechanical drawings. Ensure alignment between specifications and drawings. Review the Division 33 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable.

5.T.3 ESTIMATING DATA

Figures 5-T-1 through 5-T-16 present data and guidelines for estimating items found in Division 33.

Work Element Description	Unit	Man-hours per Unit
33 11 13.00 **Water Supply Tactical Hoseline**		
(0010) Install tactical water distribution system, 10 miles	Each	180
33 11 13.05 **Water Supply Miscellaneous**		
(0010) Flush, chlorinate and test distribution mains	LF	0.0040
33 11 13.06 **Tactical Water Distribution System**		
(0010) Install expeditionary water distribution	Each	1.50
33 11 13.25 **Water Supply PVC Pipe**		
(0010) Pressure pipe, Class 150, SDR 18, AWWA C900, 4 inch diameter	LF	0.0840
(0020) Pressure pipe, Class 150, SDR 18, AWWA C900, 6 inch diameter	LF	0.1010
Minimum suggested crew size: one utilitiesman, one laborer.		
Legend: AWWA = American Water Works Association SDR = standard dimension ratio		

Figure 5-T-1. Tactical Water Distribution Production

Work Element Description	Unit	Man-hours per Unit
33 12 19.10 Fire Hydrants		
(0010) 5-1/4 in valve size, 2 ft depth	Each	4.20
(0020) 5-1/4 in valve size, 4 ft depth	Each	4.6665
(0030) 5-1/4 in valve size, 6 ft depth	Each	6.0
Minimum suggested crew size: one utilitiesman, one equipment operator, two laborers		

Figure 5-T-2. Fire Hydrant Production

Work Element Description	Unit	Man-hours per Unit
33 16 13.13 Steel Water Storage Tanks		
(0010) 100 barrel tank	Each	55
(0020) 250 barrel tank	Each	130
(0030) 500 barrel tank	Each	220
(0040) 1,000 barrel tank	Each	440
(0050) 3,000 barrel tank	Each	750
(0060) 10,000 barrel tank	Each	1,600
(0070) 50,000 barrel tank	Each	6,660
Minimum suggested crew size: six steelworkers.		
Note: Basis: tank erection only; does not include site preparation or uncrating.		

Figure 5-T-3. Bolted Steel Tank Production

Work Element Description	Unit	Man-hours per Unit
33 16 13.23 Fabric Pillow Water Storage Tanks		
(0010) 500 gallon drum	Each	1.0
(0020) 3,000 gallon tank	Each	3.0
(0030) 5,000 gallon tank	Each	6.0
(0040) 10,000 gallon tank	Each	12.0
(0050) 20,000 gallon tank	Each	24.0
(0060) 50,000 Gallon tank	Each	42.6670
Minimum suggested crew size: one equipment operator and two to eight laborers.		

Figure 5-T-4. Pillow Storage Tank Production

Work Element Description	Unit	Man-hours per Unit
33 31 13.20 Plastic Sewage Pipe (No excavation)		
(0010) Schedule 40 ABS 4 inch	LF	0.0640
(0020) 6 inch	LF	0.0690
(0022) 8 inch	LF	0.0720
(0024) 10 inch	LF	0.0850
(0030) Schedule 40 ABS 4 inch coupling	Each	0.3333
(0040) 6 inch	Each	0.5
(0042) 8 inch	Each	0.6000
(0044) 10 inch	Each	0.6500
Minimum suggested crew size: one utilitiesman and one laborer.		

Figure 5-T-5. Sewage Collection Pipe Production

Work Element Description		Unit	Man-hours per Unit
33 41 13.60 Concrete Pipe, Sewage/Drainage Collection			
Install concrete pipe	Laying lengths		
(0010) 15- to 18-inch inside diameter	3 feet	LF	0.48
(0020) 18- to 24-inch inside diameter	4 feet	LF	0.64
(0030) 30- to 48-inch inside diameter	5 feet	LF	0.88
(0040) 48- to 72-inch inside diameter	5 feet	LF	1.12
(0050) Waste water treatment system		Each	21.70
Minimum suggested crew size: one builder, two laborers, and one equipment operator.			

Notes:
1. Work includes handling, placing, caulking, grouting, and bedding pipe.
2. Adjust man-hour figures for laying lengths other than those indicated in table.
3. For gaskets of spediseal-type joints, use 0.8 multiplier.
4. For headways, drop inlets, catch basins, and other drainage structures, refer to Division 03, concrete.
5. For excavation and backfill, refer to Division 31, earthwork.
6. For sheeting and shoring of banks of excavations, refer to Division 31, earthwork.

Figure 5-T-6. Concrete Drain Pipe Production

Work Element Description	Unit	Man-hours per Unit
33 42 16.15 Oval Arch Culverts		
Install galvanized pipe culverts		
(0010) 12 to 24 inches	LF	0.32
(0020) 26 to 45 inches	LF	0.50
(0030) 48 to 72 inches	LF	0.72
Install galvanized culvert (bolted)		
(0040) 12 to 24 inches	LF	0.48
(0050) 26 to 45 inches	LF	0.65
(0060) 48 to 72 inches	LF	0.88
Minimum suggested crew size: three builders and one equipment operator.		
Notes: 1. Installation of galvanized culvert includes unloading, fine grading, placing, caulking, and installing joint clamps. 2. Installation of galvanized culvert (bolted) includes bolting together of sections, unloading, fine grading, and placement. 3. Man-hour estimates for galvanized culvert (bolted) are based on sections being bolted into desired lengths in a prefabrication yard. 4. When installing culverts over 48 inches in diameter, it is recommended that cross bridging be used to prevent culverts from being bent or twisted during hauling or installation. Cross bridging can easily be removed upon completion of backfilling and compaction.		

Figure 5-T-7. Galvanized Pipe Culvert Production

Work Element Description	Unit	Man-hours per Unit
33 42 26.00 Tactical Culvert Denial		
(0010) Install culvert denial, Type I, 18 inch and smaller	Each	0.5000
(0012) Install anchor, Type I, 18 inch and smaller	Each	0.2000
(0015) Install culvert denial, Type I, 21 inch and larger	Each	0.6000
(0017) Install anchor, Type I, 21 inch and larger	Each	0.2500
(0020) Install culvert denial, Type II	Each	1.1850
(0030) Install culvert denial, Type III	Each	1.3200
(0032) Install anchor, Type II and III	Each	0.2500
(0040) Install culvert denial, Type IIIM	Each	1.9500
(0042) Install anchor, Type IIIM	Each	0.3000
Minimum suggested crew size: one equipment operator and one to two laborers.		

Figure 5-T-8. Tactical Culvert Denial System Production

Work Element Description	Unit	Man-hours per Unit
33 49 13.10 **Storm Drainage Manholes, Frames, Covers**		
(0110) Install precast 48 inch ID x 48 inches deep	Each	10.0
(0120) Install precast 48 inch ID x 72 inches deep	Each	12.0
(0130) Install precast 48 inch ID x 96 inches deep	Each	15.0
(0300) Slab top, precast, 8 inch thick, with casting	Each	3.0
(0400) Steps, heavyweight cast iron 7 inches x 9 inches	Each	0.2000
Minimum suggested crew size: one builder, one equipment operator and one laborer.		
Legend: ID = inside diameter		

Figure 5-T-9. Storm Drainage Manhole Production

Work Element Description	Unit	Man-hours per Unit
33 52 00.00 **Bulk Fuel Receiving and Dispensing**		
(0110) Install tactical petroleum terminal (TPT) fuel unit Crew size: one equipment operator, 29 laborers	Each	1080.0
(0120) Install pipeline connection assembly Crew size: one equipment operator, nine laborers	Each	200.0
(0130) Petroleum, oil, lubricant (POL) Pipeline, pipeline support equipment Crew size: one equipment operator, one laborer	Each	2.0
(0140) POL pipeline, pump station Crew size: two equipment operator, eight laborers	Each	40.0
(0150) POL pipeline, five mile pipeline set Crew size: 25 equipment operators, six laborers	Each	720.0
(0170) POL pipeline, pressure reducing station Crew size: one equipment operator, one laborer	Each	2.0
(0180) POL pipeline, suspension bridge, 100-foot span Crew size: one equipment operator, nine laborers	Each	80.0
(0181) POL pipeline, suspension bridge, 200-foot span Crew size: one equipment operator, nine laborers	Each	90.0
(0182) POL pipeline, suspension bridge, 400-foot span Crew size: one equipment operator, nine laborers	Each	100.0
33 52 16.13 **Gasoline Distribution**		
(0010) Install portable 50 gallons per minute pump, tactical Crew size: 2 laborers	Each	1.0

Figure 5-T-10. Bulk Fuel Receiving and Dispensing Equipment Production

Work Element Description	Unit	Man-hours per Unit
33 52 19.00 **Diesel Fuel Distribution**		
(0010) Install assault hoseline system, 2-1/2 miles Minimum suggested crew size: six laborers	Each	24.0
(0020) Install forward area refueling equipment Minimum suggested crew size: four laborers	Each	1.0
(0030) Install advanced aviation forward area refueling system Minimum suggested crew size: four laborers	Each	1.3330
(0040) Install HEMTT tanker aviation refueling system Minimum suggested crew size: two laborers	Each	1.0
(0050) Install fuel distribution system with 1,000 gallon bag Minimum suggested crew size: one laborer	Each	2.0
(0100) Filter separator, 350 GPM Minimum suggested crew size: two laborers	Each	0.50
(0200) Install 120K fuel system supply point (FSSP) (0210) Install 300K FSSP (0220) Install 800K FSSP	Each Each Each	172.0 284.0 748.0
Minimum suggested crew size: two equipment operators, 28 laborers		
(0600) Assemble and install fuel valve manifold, USN Minimum suggested crew size: one laborer.	Each	0.7500
Legend: HEMTT = heavy expanded mobility tactical truck K = thousand		

Figure 5-T-11. Diesel Fuel Distribution Production

Work Element Description	Unit	Man-hours per Unit
33 56 00.00 **Plastic Coated, Fabric, Pillow Fuel Tanks**		
(0005) 250 gallon drum, USN	Each	0.7500
(0010) 500 gallon drum	Each	1.0
(0020) 20,000 gallon tank	Each	24.0
(0030) 50,000 gallon tank	Each	42.6670
(0040) 210,000 gallon tank	Each	180.0
Minimum suggested crew size: one equipment operator and one to nine laborers.		

Figure 5-T-12. Pillow Fuel Tank Production

33 71 16.33 Set Wood Electrical Utility Poles				
Pole Length in Feet	**Unit**	**Line Truck Man-hours**	**Crane Man-hours**	**Pike-Method Man-hours**
20 to 35	Each	(0001) 3.2	(0001) 3.2	(0002) 6.4
40 to 60	Each	(0003) 4.0	(0003) 4.0	
65 to 80	Each	(0004) 6.3	(0005) 4.8	
Work Element Description			**Unit**	**Man-hours per Unit**
Pole Mounted Insulators				
(0007) Single phase			Each	1.0
(0008) Three phase			Each	2.0
Cross Assembly (standard 8-foot arm)			Each	4.0
(0010) Single arm			Each	4.0
(0020) Double arm			Each	5.6
Install Guys (common grade seven strand)				
(0030) Down guys			Each	4.0
(0040) Head guys			Each	4.0
(0300) Attach grounding plate to bottom of pole			Each	0.50
Minimum suggested crew size: one electrician, one equipment operator and one laborer.				
Notes: 1. Time for setting poles includes backfilling and tamping. 2. Man-hours are based on normal working conditions and average terrain. 3. Use 1.1 multiplier for framing.				

Figure 5-T-13. Electrical Line Work: Setting Poles Production

Pole Holes Depth in Feet	**Hand Digging Man-hours per Hole**	**Hand Digging Man-hours per Hole**	**Machine Digging Man-hours per Hole**	**Machine Digging Man-hours per Hole**
33 71 16.33 Wood Electrical Utility Poles				
	In Soil	**In Rock**	**In Soil**	**In Rock**
4	(0100) 0.8	(0105) 4.0	(0110) 0.5	(0115) 1.0
5	(0120) 0.8	(0125) 4.8	(0130) 0.5	(0135) 1.0
6	(0140) 1.6	(0145) 5.6	(0150) 0.5	(0155) 1.2
7	(0160) 1.6	(0165) 6.4	(0170) 0.6	(0175) 1.2
8	(0180) 1.6	(0185) 7.2	(0190) 0.6	(0195) 1.6
Anchor Holes Depth in Feet	**In Soil**	**In Rock**	**In Soil**	**In Rock**
4	(0200) 0.8	(0205) 4.0	(0210) 0.5	(0215) 1.0
6	(0220) 1.6	(0225) 5.6	(0230) 0.5	(0235) 1.2
8	(0240) 1.6	(0245) 7.2	(0250) 0.5	(0255) 1.6
Minimum suggested crew size: one laborer and one equipment operator.				
Notes: 1. Times for anchor holes include backfill, tamping, and securing tail of guy line. 2. Times for machine digging include setting up machine. 3. When using power-installed screw anchor machines, use 0.5 multiplier. 4. Pole hole depth is determined by: length of pole in feet, divided by 10; plus 1 foot for rock or 2 feet for dirt.				

Figure 5-T-14. Digging Pole and Anchor Holes Production

Work Element Description	Unit	Man-hours per Unit
33 71 19.17 **Electrical and Telephone Underground**		
Hand holes, precast concrete, with concrete cover		
(0010) 2 feet by 2 feet by 3 feet deep	Each	11.080
(0020) 4 feet by 4 feet by 4 feet deep	Each	19.000
Manholes, precast concrete, with iron racks and pulling irons, and cast iron cover		
(0050) 4 feet by 6 feet by 7 feet deep	Each	37.240
(0060) 6 feet by 8 feet by 7 feet deep	Each	39.200
Underground duct, banks ready for concrete fill		
(0100) PVC, two each at 4-inch diameter	LF	0.133
(0110) PVC, four each at 4-inch diameter	LF	0.266
(0120) Rigid galvanized steel, two each at 4-inch diameter	LF	0.305
(0130) Rigid galvanized steel, four each at 4-inch diameter	LF	0.626
Minimum suggested crew size: one electrician and one laborer.		
Note: Not including excavation, backfill and cast in place concrete. Refer to Division 03, concrete, and Division 31, earthwork.		

Figure 5-T-15. Electric and Telephone Underground Construction

Work Element Description	Unit	Man-hours per Unit
33 81 13.10 **Radio Antenna Tower**		
Erect antenna tower		
(0010) Guyed, 50 feet high, 40 pound section, wind load 70 miles per hour	Each	22
(0020) Self-supporting, 60 feet high, wind load 70 miles per hour	Each	40
Minimum suggested crew size: two steelworkers and one equipment operator.		

Figure 5-T-16. Antenna Tower Production

CHAPTER 5 ANNEX U

Division 34

Transportation

5.U.1 INTRODUCTION

Division 34, transportation, addresses transportation-related items which were previously categorized in MasterFormat 1995 Division 2. The scope of work includes: operations and maintenance of railroads; railroad construction and related items; traffic signal systems; airfield signaling; and roadway construction.

5.U.2 ESTIMATING INFORMATION AND TIPS

Ensure alignment between specifications and drawings. Review the Division 34 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable.

5.U.3 ESTIMATING DATA

Figures 5-U-1 through 5-U-6 present data and guidelines for estimating items found in Division 34.

Work Element Description	Unit	Man-hours per Unit
34 11 33.13		
Concrete Track Cross Ties		
(0010) Concrete, 8 feet 6 inches long, 30 inches on center	Each	0.900
34 11 33.16		
Timber Track Cross Ties		
(0010) Wood, pressure treated, 6 inches by 8 inches by 8 feet 6 inches	Each	0.780
(0020) heavy duty, 7 inches by 9 inches by 8 feet 6 inches	Each	1.030
Minimum suggested crew size: one equipment operator and five laborers.		
Note: A multiplier of 1.5 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production.		

Figure 5-U-1. Track Rails Production

Work Element Description	Unit	Man-hours per Unit
34 17 23.13 **Pavement Marking**		
(1100) Pavement marking, with or without reflective beads	SF	0.020
Minimum suggested crew size: two equipment operators and one laborer.		

Figure 5-U-2. Pavement Marking Production

Work Element Description	Unit	Man-hours per Unit
34 41 13.10 **Traffic Signal Systems**		
(0010) Security gate traffic signal, light-emitting diode, mast, no lane control	Each	56.0
Minimum suggested crew size: four electricians, one equipment operator and one laborer.		

Figure 5-U-3. Traffic Signal Production

Work Element Description	Unit	Man-hours per Unit
34 43 23.16 **Airfield Wind Cones**		
(0010) Wind cone, 12 feet lighted assembly, rigid with obstruction light	Each	24.1180
(0040) Wind cone, 12 feet unlighted assembly, rigid with obstruction light	Each	19.5240
(0060) Wind cone, slip fitter 2 1/2 inch pipe	Each	3.0
(0070) Wind cone, sock 12 feet x 3 feet	Each	2.0
34 43 23.18 **Runway and Taxiway Lighting Systems**		
(0010) Install precision approach path indicator (PAPI) foundation only L-849i(L)	Each	28
(0020) Install PAPI foundation only L-849i(L)	Each	80
(0030) Light, elevated airfield light on L-867 base	Each	18.0
(0040) Install pull box, 36 by 36 by 36 inches	Each	18.0
(0050) Install permanent visual landing zone marker panel (VLZMP)	Each	32.0
(0060) Install temporary VLZMP	Each	0.1670
(0070) Install airfield lighting vault	Each	104.0
(0080) Install portable airfield lighting kit, 3,500 foot runway	Each	11.50
(0090) Install portable airfield lighting kit, 5,000 foot runway	Each	15.50
Minimum suggested crew size: two to six electricians, one equipment operator and two laborers.		

Figure 5-U-4. Airfield Signaling and Control Systems Production

Work Element Description	Unit	Man-hours per Unit
34 71 13.16		
Vehicle Crash Barriers		
(0005) Portable wedge barrier, towable	Each	0.50
(0010) Jersey concrete barrier, 10 feet long, 2 feet by 6 inches wide by 30 inches high; average time for various sizes	Each	0.210
(0011) Tall concrete barriers, 6 ft to 8 ft long, 3 ft to 4 ft wide by 10 ft high; average time	Each	0.420
(0012) Panel and base concrete barrier, 8 ft long, 4 ft 5 in wide by 5 ft high; average time	Each	0.310
(0020) Pipe bollards, steel, concrete filled, painted, 8-foot length by 4-foot-deep hole, 8-inch diameter	Each	2.40
(0030) Bollards, wood, 8-foot length by 4-foot-deep hole, 12-inch diameter	Each	1.60
(0040) Move and place barrier, up to 100 pounds	Each	0.040
34 71 13.26		
Vehicle Guide Rails		
(0010) Corrugated steel, galvanized, posts, 6 feet 3 inches on center	LF	0.057
(0020) End sections, galvanized, flared	Each	0.960
(0030) Guide rail, steel box beam, 6 by 6 inches	LF	0.400
(0040) Concrete posts, individual, 6-foot-5-inch square	Each	0.436
Minimum suggested crew size: one auger truck or crane operator, one flatbed truck operator, and two laborers.		
Note: A multiplier of 1.5 was used to convert civilian production rates to military production rates in this figure. No further adjustment required for military production.		

Figure 5-U-5. Vehicle Barriers

Work Element Description	Unit	Man-hours per Unit
34 73 26.00 Manufactured Helipads		
(0010) AM2 matting, placement	SF	0.0035
Suggested crew size: one equipment operator, nine laborers		
(0020) AM2 matting, anchoring, 10 foot spacing	Each	0.70
Suggested crew size: one equipment operator, four laborers		
(0030) AM2 matting, recovery	SF	0.0004
Suggested crew size: one equipment operator, nine laborers		
(0040) AM2 matting, anchor removal	Each	0.10
(0050) AM2 matting, keylock installation	Each	0.050
(0060) AM2 matting, aircraft tie down installation	Each	0.670
(0110) Fabric helipad, placement	SF	0.0008
(0120) Fabric helipad, anchoring	Each	0.80
(0130) Fabric helipad, recovery	LF	0.400
(0140) Fabric helipad, anchor removal	Each	0.030
Suggested crew size: one equipment operator, up to eight laborers		

Figure 5-U-6. Manufactured Helipads

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CHAPTER 5 ANNEX V

Division 35

Waterway and Marine Construction

5.V.1 INTRODUCTION

Division 35, waterway and marine construction, includes signaling and control equipment; construction and control equipment; coastal construction; waterway construction and equipment; marine construction and equipment; and dam construction and equipment.

5.V.2 ESTIMATING INFORMATION AND TIPS

Review the Division 35 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable. Refer to TM 3-34.73/FM 5-480, Port Construction and Repair, for further information on port planning and layout; construction of freed and floating wharves to support both conventional and container ships; and the special problems of expedient construction of ports and railways on wharves and piers. Refer to NTRP 4-04.2.8, Conventional Underwater Construction and Repair Techniques, for further information on project preparation and documentation; tool selection, technical references, and sources of related equipment and materiels; and field construction procedures.

5.V.3 ESTIMATING DATA

Figures 5-V-1 through 5-V-5 present data and guidelines for estimating items found in Division 35.

Work Element Description	Unit	Man-hours per Unit
35 51 00		
Floating Construction		
(0010) Stringers	BF	0.024
(0020) Bridging	Feet	0.144
(0030) Decking (4 inches thick)	Feet	0.056
(0040) Wearing surface (2 inches thick)	Feet	0.032
(0050) Bull rail	Feet	0.320
(0060) Bumpers	Feet	0.288
For quick estimates:		
(0070) Pier framing complete (less piles, capping, bracing)	SF	0.176
Minimum suggested crew size: two equipment operators and six builders.		
Note: Estimates include precutting, bolting, or drifting members in place		

Figure 5-V-1. Pier Framing

Work Element Description	Unit	Man-hours per Unit
35 59 13		
Marine Fenders		
(0010) Place in leads and drive	Each	0.800
(0020) Lash with wire rope	Each	0.750
(0030) Install fenders	Each	0.600
(0040) Fender pile	Each	0.750
Minimum suggested crew size: two equipment operators, two engineering aides, and six builders.		
Note: Based on 50-foot piles.		

Figure 5-V-2. Marine Fender Production

Work Element Description	Unit	Man-hours per Unit
35 59 33		
Marine Bollards and Cleats		
(0010) Bits	Each	13.00
(0020) Bollards	Each	16.00
(0030) Chocks	Each	13.00
(0040) Cleats	Each	11.00
(0050) Pad eyes	Each	2.50
Minimum suggested crew size: one equipment operator and two builders.		

Figure 5-V-3. Marine Bollards and Cleats

Work Element Description	Unit	Man-hours per Unit
35 59 53.01 **Underwater Structures Construction (Surveys)**		
(0010) Bathometric survey	SM	0.00014
(0020) Side scan survey	SM	0.00014
Minimum suggested crew for above elements 3 divers.		
(0030) Post process of bathometric/side scan survey	SM	0.00014
(0040) Rapid penetration test soil density test includes drive and extraction (18 inch rod)	Each	1.57
(0050) Shear-vain test (soil density test)	Each	0.3
(0060) Remote operated vehicles inspection of chain/cable	LF	0.2
Note: Sea state of 2 or less, no current, minimum visibility of 5 feet, average water depth of 45 feet, water temperature above 60 degrees Fahrenheit.		
Minimum suggested crew size of six second class divers and one first class diver		
Legend: SM = square meters		

Figure 5-V-4. Marine Underwater Structures Production (Surveys)

Work Element Description	Unit	Man-hours per Unit
35 59 53.02 **Underwater Structures Construction (Cabling)**		
(0010) Install sea floor cable	Meter	0.224
(0020) Inspect sea floor cable	Meter	0.18
(0030) Repair sea floor cable	Each	50
(0040) Stabilize and protect sea floor cable split pipe	Feet	1.68
(0050) Stabilize and protect sea floor cable concrete bags	Feet	0.40
Note: Sea state of 2 or less, no current, minimum visibility of 5 feet, average water depth of 45 feet, water temperature above 60 degrees Fahrenheit.		
Minimum suggested crew size of six second class divers and one first class diver		

Figure 5-V-5. Marine Underwater Structures Production (Cabling)

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CHAPTER 5 ANNEX W

Division 41

Materiel Processing and Handling Equipment

5.W.1 INTRODUCTION

Division 41, materiel processing and handling equipment, includes bulk materiel processing equipment; piece materiel handling equipment; manufacturing equipment; container processing and packaging; materiel storage; and mobile plant equipment.

5.W.2 ESTIMATING INFORMATION AND TIPS

Review the Division 41 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable. Refer to the manufacturer's data for the specific equipment being used for production information.

5.W.3 ESTIMATING DATA

Figures 5-W-1 through 5-W-3 present data and guidelines for estimating items found in Division 41.

Work Element Description	Unit	Man-hours per Unit
41 11 00 **Bulk Materiel Sizing Equipment**		
(0010) Setup and dismantle	Each	320.000
(0020) Operate crushing plant	CYD	0.160
(0030) Stockpile crushed materiel	CYD	0.024
(0040) Haul crushed materiel to job	CYD	0.048
Minimum suggested crew size: Setup and dismantle plant—seven equipment operators, one electrician, one steelworker, and one mechanic. Plant operation and maintenance—two equipment operators, one electrician, one steelworker, and one mechanic. Stockpile crushed materiel—four equipment operators.		
Notes: 1. The production figure is based upon 75 tons per hour, plant operating at 50 percent of rated capacity crushing granite at 3,000 pounds per CYD. For plants of other sizes use 50 percent of rated capacity and the size of your crew for calculations. 2. Production figures may have to be adjusted in accordance with the type of materiel being processed and with other varying circumstances. For example: Coral weights (approximately 2,000 pounds per loose CYD).		

Figure 5-W-1. Rock Crushing Plant Operation

Work Element Description	Unit	Man-hours per Unit
41 14 00 **Batching Equipment**		
(0010) Setup and dismantle plant	Each	120.000
(0020) Operation of asphalt plant	Ton	0.080
(0030) Haul asphalt to job	Ton per mile	0.048
Minimum suggested crew size: Setup and dismantle plant—five equipment operators, one electrician, one steelworker, and one mechanic. Asphalt plant operation and maintenance—two equipment operators, one electrician, and one mechanic.		
Notes: 1. Figures are based on drum mix plant, 70 tons per hour. 2. Site preparation and concrete curing time not included in table.		

Figure 5-W-2. Asphalt Plant Operation

Work Element Description	Unit	Man-hours per Unit
41 22 23.10 **Hoisting Equipment**		
(0100) Setup overhead crane 5T	Each	34.0
Minimum suggested crew size: Setup hoist—seven equipment operators, one electrician, one steelworker		

Figure 5-W-3. Hoisting Equipment Production

CHAPTER 5 ANNEX X

Division 46

Water Treatment Equipment

5.X.1 INTRODUCTION

Division 46, water treatment equipment, includes packaged water treatment and waste water treatment equipment.

5.X.2 ESTIMATING INFORMATION AND TIPS

Review the Division 46 estimating checklist shown in Appendix C and identify labor, materiel, and equipment requirements to accomplish these tasks, if applicable. Refer to the manufacturer's data for the specific equipment being used for production information.

5.X.3 ESTIMATING DATA

Figure 5-X-1 presents data and guidelines for estimating items found in Division 46.

Work Element Description	Unit	Man-hours per Unit
46 07 00.00 **Water Treatment Equipment**		
(0400) ROWPU, tactical, 3,000 gallons per hour	Each	3.0
(0410) ROWPU, tactical, 1,500 tactical water purification system	Each	3.0
(0420) ROWPU, tactical, 125 lightweight water purifier system	Each	4.0
(0430) ROWPU, tactical, 600 ROWPU	Each	3.0
(0490) Expeditionary shower water reuse system, ISO Type 5 Tricon	Each	0.750
(0500) ROWPU, commercial, 45,000 gallons per day	Each	32.0
Minimum suggested crew size: Setup hoist—seven equipment operators, one electrician, one steelworker		
Legend: ROWPU = reverse osmosis water purification unit		

Figure 5-X-1. Water Treatment Equipment Production

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APPENDIX A
Contingency Estimating

A.1 INTRODUCTION

Military engineers frequently conduct short-fused contingency missions both domestically and in expeditionary environments across the range of military operations. These contingency missions do not always allow time for the detailed estimating normally done for a construction project. This appendix provides military engineers with key reference publications, engineer reachback points of contact, and automated construction systems used for developing contingency construction estimates. This construction estimate does not eliminate the need for contingency mission planning considerations. Refer to JP 3-34, Joint Engineer Operations, for further information on the definitions and discussions of the engineer functions in support of the range of military operations.

A.2 REFERENCES FOR ENGINEER ESTIMATES

The following publications are source documents that provide specific data useful for developing project estimates for various engineer missions. The engineering data contained in these publications may be applied to general engineering functions or combat engineering functions, as appropriate.

1. United States Central Command Regulation Number 415-1, Construction and Base Camp Development in the United States Central Command Area of Responsibility: The Sand Book. This publication provides guidance, responsibilities, and procedures for military construction and the planning and development of contingency and permanent base camps that support associated missions in Commander, United States Central Command's area of responsibility. It establishes consistent standards for the service components program and use regarding infrastructure development, security, sustainment, survivability, safety, and affordable working and living environments for personnel.

2. ATP 3-34.40/FM 3-34.400/MCWP 3-17.7, General Engineering. This publication's focus is general engineering. It provides an array of planning considerations, equipment, and materiel estimating data covering topics such as seaport facilities, airfields, heliports, roads, railroads, bridging, force protection, sustainment facilities, power generation, power distribution, water supply, and well drilling. Appendix E to ATP 3-34.40/FM 3-34.400/MCWP 3-17.7 provides a robust planning tool for base camp estimating and planning.

3. FM 3-05.230, Special Forces Tactical Facilities. This publication's focus is the establishment, improvement, operations, and security of special forces' tactical facilities. It provides applicable data for use by military engineers who build forward operations bases. It details the three phases of construction (initial, temporary, and permanent) and sequentially discusses planning, design, and construction.

4. TM 3-34.85/MCRP 3-34.1, Engineer Field Data. This publication focuses on combat engineering but has significant relevance for general engineering under combat conditions. It provides an array of equipment and materiel estimating data, covering topics such as engineer reconnaissance, mobility (breaching and minefields), obstacles, survivability considerations, demolitions, bridging, roads, and airfields.

5. FM 5-430.00.1/AFJPAM 32-8013/MCRP 3-40D.1, Volume I, Planning and Design of Roads, Airfields and Heliports in the Theater of Operations—Road Design. This volume is a stand-alone volume for the design of theater of operations roads. It also serves as a detailed description of information common to both roads and airfields, such as site selection, survey and earthwork, clearing and grubbing, base and subbase courses, and drainage.

6. FM 5-430.00.2/AFJPAM 32-8013/MCRP 3-40D.2, Volume II, Planning and Design of Roads, Airfields and Heliports in the Theater of Operations—Airfield and Heliport Design. This volume discusses the complete process of airfield and heliport construction from the preliminary investigations, through design

criteria, to the final project layout and construction techniques. It is not a stand-alone volume, as FM 5-430.00.1/AFJPAM 32-8013/MCRP 3-40D.1, Volume I, contains much of the information required to design the substructure of an airfield or a heliport.

7. Graphic Training Aid 90-01-011, Deployed Forces Protection Handbook (JFOB). This publication addresses force protection at joint forward operations in the Iraqi theater of operations. The focus is on defense against rockets, artillery, mortars, and vehicle-borne improvised explosive devices. It describes best practices for planning and construction design to defeat these threats. It is geared towards engineer and force protection specialists to assist with operational level force protection planning.

8. Marine Air-Ground Task Force Staff Training Program Pamphlet 5-0.3, MAGTF Planner's Reference Manual. This publication provides planning factors for bridging, breaching, obstacles, survivability considerations, bulk fuel, expeditionary airfield, and water storage/production.

9. UFC guidance provides planning, design, construction, sustainment, restoration, and modernization criteria as discussed in 1.1.3.

A.3 ENGINEER REACHBACK CAPABILITIES

Planners and estimators can access professional engineers through reachback capabilities that provide a full spectrum of engineering expertise to support worldwide engineer operations. The following reachback resources are available.

1. Army tools and resources are available from the USACE Reachback Operations Center (UROC). The UROC provides a reachback engineering capability that allows DOD personnel deployed worldwide to talk directly with experts in the United States when a problem in the field needs quick resolution. The USACE reachback operations center may be contacted via email at UROC@usace.army.mil

Fax (non-secure): (601) 634-2764
Telephone: (601) 634-2439/3485; DSN (312) 446-2439/3485

2. The Navy tools include resources from NAVFAC in addition to the Navy Expeditionary Combat Command, naval construction groups, and subordinate naval construction regiments. The contingency engineer manager at Naval Facilities Engineering Systems Command, Atlantic (NAVFACLANT) and Naval Facilities Engineering Systems Command Pacific (NAVFACPAC) provides contracting and engineering support to operating forces. The contingency engineer at NAVFACLANT and NAVFACPAC may be contacted at:

NAVFACLANT
Attention: Contingency Engineering Business Line Manager
6506 Hampton Blvd., Norfolk, VA 23508-1278
Telephone: (757) 322-8302

NAVFACPAC
Attention: Contingency Engineering Business Line Manager
258 Makalapa Drive, Suite 100, Pearl Harbor, HI 96860-3134
Telephone: (808) 472-1162

A.4 JOINT CONSTRUCTION MANAGEMENT SYSTEM

The Joint Construction Management System (JCMS) is the latest tool (computer software) that allows users to access Army Facilities Components System (AFCS) design, logistics, and planning data for initial, temporary, and semipermanent construction. The JCMS is an interactive, unclassified system which allows planners to roll-up facilities, BOMs, and construction man-hours for each construction mission. It can be used to ease the selection of facilities component system and base camps while considering theater priorities, standards of construction, resource constraints, and climate.

The AFCS is the Army repository of standardized contingency facilities and installation designs and the associated construction data used for Armed Services Component Command war planning and Army Force modeling as directed by Army Regulation 415-16. The system provides users an automated tool that supports the logistical and engineer planning of contingency bases and the execution of construction activities. The AFCS will be used as the baseline platform for the JCMS to support the joint engineer community.

The AFCS manages the construction (designs, bills of materiels, schedules, labor and equipment estimates, and specifications) and the platforms (Data Management System database and JCSM software) for the joint engineer to expeditiously and efficiently provide design and construction services independent of the environment.

The AFCS has incorporated Navy facility designs from the Naval Facilities Engineering Command Publication 437, Volume II, Facility Planning Guide, into the AFCS standardize design portfolio for additional capability.

A.4.1 Joint Construction Management System Availability and Key Features

Distribution of JCMS is available upon request to all U.S. military engineer units including all active components, Army Reserve, and Army National Guard. This includes requests from all other service engineers. Key features of JCMS include:

1. Planning. Users are able to develop facility and installation plans to satisfy mission construction requirements using the JCMS computer routines. The system determines personnel and materiel requirements, as well as cost, weight, and volume of materiels needed for a specific project.

2. Design. The system provides standard designs for base camp development, utilities, and airfields. The AFCS provides over 600 individually standardized, UFC (life, health and safety) and doctrinally compliant, initial and temporary facility designs. Through JCMS, the designs are available to the warfighter in both networked and limited communications environments. The AFCS also provides over 80 component designs (clusters of several facilities with appropriate functional and special layouts) to support the design of outpost; base camp; reception, staging, onward-movement integration; and logistics operations. The AFCS manages nearly 5,000 national stock numbers and over 2,800 construction activities that support these designs.

3. Management. Users are able to set up and manage the construction progress and the construction resource allocation and utilization throughout the construction time frame.

4. Reporting/Communication. The JCMS develops and transmits the necessary reports following the engineer chain of command to facilitate the decision-making process using intercomputer electronic and direct entry.

The AFCS provides readily accessible, current, standardized, adaptable, and scalable base camp component and facility designs. Army Regulation 415-16 establishes policy and procedures for the development, maintenance, use, and governance of the AFCS program of record. The proponent agency of this regulation is Headquarters Department of the Army, Office of the Chief of Engineers.

For additional information, please visit the AFCS Reachback Engineer Data Integration (REDi) web portal at https://uroc-redi.usace.army.mil/sites/afcs/default.aspx or call toll free 1-877-ARMY-ENG (1-877-277-9364), commercial 601-634-2439, or DSN 312-446-2439. The AFCS REDi web portal hosts a variety of reachback and support services, including JCMS desktop software, JCMS View, JCMS Training, Report a Problem, Report a Data Correction, or Suggest a New Feature or Design.

A.4.2 Joint Construction Management System Facilities Samples

The following list contains examples of facilities found in JCMS. Refer to the JCMS Training Manual and User Guide, on the REDi portal https://uroc-redi.usace.army.mil/sites/afcs/default.aspx for further information.

1. HELIPAD, large, pallet and mat assembly, 100 by 100 feet

2. K-SPAN, general storage, temporary standard, concrete floor, 50 by 90 feet

3. ROAD REPAIR, Class B, 20 feet wide by 0.1 mile, initial construction, gravel

4. SEAHUT, wood frame building, 16 by 48 feet

5. ELECTRIC POWER PLANT, 2-60 kilowatt generator sets and a pillow tank.

A.5 GEOSPATIAL EXPEDITIONARY PLANNING TOOL

The Air Force's Geospatial Expeditionary Planning Tool is a personal, computer-based, automated geographic information system application. Its primary purpose is to allow civil engineer planners to quickly and accurately achieve an 85 percent bed-down solution. Scenario planning operations are automated and interactive, using the appropriate Air Force standards to determine aircraft parking requirements, place deployable facility and utility assets, provide automatic constraint checks; manage airfield damage, and generate a variety of reports and timelines. This program has the capability to:

1. Spatially visualize a layout plan for the facilities and equipment identified as part of any scenario.

2. Interactively change the spatial plan based on user knowledge.

3. Interface with other modules that provide critical information and/or spatial configurations for facilities and equipment to be included in the layout plan.

APPENDIX B
Standard Units of Issue

B.1 INTRODUCTION

This appendix provides names and definitions of common DOD codes for standard units of issue used on military standard requisitioning and issue procedure requisitions. The unit of issue is a two-letter abbreviation of the types of units under which materiel is ordered/issued. Unit of issue codes are sourced by the Defense Logistics Management System. Estimators must be familiar with these codes to ensure that the quantity of materiel ordered is equal to or greater than what is estimated.

Figure B-1 illustrates DOD codes effective as of 27 August 2008. Refer to DOD 4000.25-M, Defense Logistics Management Standards, or the Defense Logistics Management Standards Office Web site at http://www.dla.mil for additional codes and information.

Code	Description	Code	Description	Code	Description
AM	Ampoule	CS	Case	PK	Pack
AT	Assortment	CT	Carton	PR	Pair
AY	Assembly	CY	Cylinder	PT	Pint
BA	Ball	CZ	Cubic Meter	QT	Quart
BD	Bundle	DR	Drum	RL	Reel
BE	Bale	DZ	Dozen	RM	Ream
BF	Board Foot	ea	Each	RO	Roll
BG	Bag	FT	Foot	SD	Skid
BK	Book	GL	Gallon	SE	Set
BL	Barrel	GP	Group	SF	Square Foot
BO	Bolt	GR	Gross	SH	Sheet
BR	Bar	HD	Hundred	SL	Spool
BT	Bottle	IN	Inch	SO	Shot
BX	Box	KT	Kit	SP	Strip
CA	Cartridge	LB	Pound	SX	Stick
CYD	Cubic Yard	LF	Linear Foot	SY	Square Yard
CE	Cone	LG	Length	TI	Tin
CF	Cubic Foot	LI	Liter	TN	Ton
CL	Coil	OZ	Ounce	TU	Tube
CN	Can	PD	Pad	VI	Vial
CO	Container	PG	Page	YD	Yard

Figure B-1. Standard Unit of Issue Terms and Abbreviations

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APPENDIX C
Estimating Checklist

C.1 INTRODUCTION

This appendix provides estimators with a comprehensive work item checklist to ensure all work items are considered during development of an estimate. Figures C-1 through C-21 illustrate checklists organized by the Construction Specification Institute's MasterFormat divisions. Divisions having limited application for work normally performed by military engineers have been omitted. These checklists are not timeline sequenced but are to be used by estimators as estimates are developed or as a final review checklist.

Division 01—General Requirements			
Number	**Description**	**Number**	**Description**
01 00 00	**General Requirements**		Project management and coordination
	Work restrictions		Pumping/drainage
01 30 00	**Administrative Requirements**		Repair/restore area
	Blueprint machine		Scaffolding
	Cleanup and waste management (regular)		Set-up and removal
	Cleanup (final)		Signs project and site info
	Coffee maker		Submittals
	Computers/software		Supplies, consumable
	Copy machine		Surveying
	Dust control		Tools and equipment
	Fax machine		Vehicles
	Furnishings/equipment	**01 40 00**	**Quality Requirements**
	Licenses		Concrete testing
	Lifting/hoisting		Regulatory requirements
	Permits		Soils testing
	Photographs		Structural testing
	Printer		

Figure C-1. Estimating Checklist—Division 01 (Sheet 1 of 2)

Division 01—General Requirements			
Number	**Description**	**Number**	**Description**
01 50 00	**Temporary Facilities and Controls**		Vehicular access and parking
	Temporary utilities		Temporary barriers and enclosures
	Electricity		Barricades
	Fire protection		Dust barriers
	Fuel (oil, natural gas, etc.)		Fencing
	HVAC		Noise barriers
	Lighting		Protective walkways/enclosures
	Telecommunications/internet		Temporary controls
	Water		Environmental controls
	Construction facilities		Erosion and sediment controls
	Field office		Pest controls
	First aid facilities		Storm water pollution controls
	Sanitary facilities (toilets)		Project identification
	Storage boxes/sheds/trailers		Temporary project signs
	Temporary construction		Temporary interior/site signage
	Bridges and ramps	**01 60 00**	**Product Requirements**
	Decking		Hazardous materiels storage and handling
	Construction aids		Toxic materiels storage and handling
	Scaffolding and platforms		

Figure C-1. Estimating Checklist—Division 01 (Sheet 2 of 2)

Division 02—Existing Conditions			
Number	**Description**	**Number**	**Description**
02 40 00	**Demolition**	**02 80 00**	**Facility Remediation**
	Demolition of structure		Transportation and disposal of hazardous materiels
	Rubbish disposal		Asbestos removal/encapsulation
	Remove from site		Lead paint removal/encapsulation
	Disassembly		Polychlorinate biphenyl remediation
			Mold remediation
			Hazardous waste drum handling

Figure C-2. Estimating Checklist—Division 02

Division 03—Concrete			
Number	**Description**	**Number**	**Description**
03 00 00	**Applications**		Retention walls
	Aprons		Sills
	Architectural concrete		Oil
	Bases		Slab-on-grade
	Flagpole		Stair fill
	Light		Stairs
	Sign		On grade
	Beams		Planters
	Cant strips		Sump Pits
	Columns		Toppings
	Copings		Walks
	Curbs	**03 10 00**	**Concrete**
	Drivers		Aggregate
	Elevated slabs, includes on metal deck		Air entraining agent
	Embedded items		Cement
	Equipment pads		Color
	Exterior walls		Compressive strength
	Footings		Enhancer
	Column		Hardeners
	Spread		Heated
	Strip (wall)		Mix design
	Grade beams		Other admixtures
	Pile caps		Retarder
	Foundation mats		Sand
	Foundation walls		Water
	Girders		
	Gutters		
	Panels		
	Piers		
	Platforms		
	Ramps		

Figure C-3. Estimating Checklist—Division 03 (Sheet 1 of 3)

Division 03—Concrete			
Number	**Description**	**Number**	**Description**
03 11 00	**Formwork**		Forms, slab
	Block-outs		Forms, stair
	Bracing		Forms, wall
	Chamfer strips		Joints
	Clamps		Expansion
	Clean		Construction
	Erection	**03 20 00**	**Concrete Reinforcing**
	Expansion joints		Bars
	Inserts		Grade of steel
	Release agent		Galvanized
	Removal		Epoxy coating
	Repair		Keyways
	Scaffolding		Liners
	Shoring		Accessories
	Storage		Cutting
	Ties		Chairs
	Transportation		Bolsters
	Vapor barrier	**03 30 00**	**Ready-Mix Concrete**
	Forms, beam		Transporting
	Forms, column		Mixer truck
	Forms, curb		Hand or power buggies
	Domes		Conveyer
	Forms, edge		Placing
	Forms, fuel pump		Direct chute
	Forms, gutter		Crane and bucket
	Pans		Pump truck
	Forms, ramp		Consolidating

Figure C-3. Estimating Checklist—Division 03 (Sheet 2 of 3)

Division 03—Concrete			
Number	**Description**	**Number**	**Description**
03 35 00	**Finish**	**03 40 00**	**Precast Concrete**
	Broom		Architectural
	Caulk		Beams
	Darby		Ts
	Fill		Ls
	Float		Columns
	Grind		Floor slabs
	Patch		Slabs
	Wire mesh		Planks
	Galvanized		Hollow core
	Epoxy coating		Tees
	Fiber reinforcing		Double tees
	Forming		Multiple tees
	Ties and stirrups		Joists
03 39 00	**Curing and Protection**		Lift slaps
	Admixtures		Lintels
	Sprays		Lightweight
	Straw		Stairs
	Blankets		Wall panels
	Heating		Tilt-ups
	Canvas		Precast
	Plastic sheeting		Architectural
			Rub
			Sandblast
			Screed
			Trowel

Figure C-3. Estimating Checklist—Division 03 (Sheet 3 of 3)

Division 04—Masonry			
Number	**Description**	**Number**	**Description**
04 00 00	**Applications**		Flemish
	Exterior walls		Stack
	Load bearing		Reinforcing
	Non-load bearing		Grouting/fill
	Interior walls	**04 21 29**	**Terra Cotta**
	Load bearing	**04 22 00**	**Concrete Block**
	Non-load bearing		Exterior
	Solid walls		Interior
	Cavity walls		Regular
	Veneer walls		Lightweight
	Flooring		Solid
04 21 00	**Brick**		Hollow core
	Common		Finish
	Face		One side
	Cement		Two sides
	Fire		Ribbed
	Color		Fluted
	Special color		Split face
	Glazed		Ground
	Special finish		Colored
	Size		Glazed
	Standard		Bond beams
	Jumbo		Lintels
	Norman		Pilasters
	Roman		Grouting/fill
	Engineer		Reinforcing
	Double		Bars
	Bond pattern		Wall reinforcing (truss type)
	Common		Wall ties
	Running		Anchor bolts and templates
	English	**04 23 00**	**Glass Block**

Figure C-4. Estimating Checklist—Division 04 (Sheet 1 of 2)

Division 04—Masonry			
Number	**Description**	**Number**	**Description**
04 40 00	**Stone**		Weathered
	Ashlar		Stripped
	Rubble		**Cleaning Masonry**
	Cut stone		Sandblasting
	Bases		Steam clean
	Curbs		Acid wash
	Wall ties		Power wash
	Flooring		Final clean
	Soffits		Facing panels
	Simulated stone		**Miscellaneous**
	Showers		Anchors
	Stairs		Bolts
	Stair treads		Control joints
	Thresholds		Copings
	Window sills		Dowels
	Window stools		Expansion joints
	Mortar		Flashings
	Type		Insulation
	K		Insets
	O		Reglets
	N		Pointing
	S		Waterproofing
	M		Weep holes
	Color		Window sills
	Admixtures		Window stools
	Joints		Vents
	Concave		
	Struck		
	Flush		
	Raked		

Figure C-4. Estimating Checklist—Division 04 (Sheet 2 of 2)

Division 05—Metals			
Number	**Description**	**Number**	**Description**
05 12 00	**Structural Steel Framing**		**Fastening**
	Anchor bolts		Welding
	Angles		Bolts
	Base plates		Expansion anchors
	Beams		Epoxy anchors
	Bridging		Machinery anchors
	Channels		Weld studs
	Clip angles		Shear connectors
	Columns		Rivets
	Connectors		Timber connectors
	Cross bracing		Machine screws
	Girders		**Painting**
	Girts		Shop
	Hanger rods		Field
	Joists		Finish
	Leveling plates		**Seismic Considerations**
	Wind bracing and wire rope assemblies		**Other Miscellaneous Considerations**
05 20 00	**Metal Joists**		Bumper posts
05 30 00	**Metal Decking**		Corner guards
	Roof		Crane rails
	Floor		Curb angles
05 40 00	**Cold-Formed Metal Framing**		Expansion joints and covers
	Roof frames		Lintels
	Load-bearing studs, joists, rafters, and trusses		Metal cleaning
	Equipment support framing		Pipe supports
	Light gauge framing		Trench covers
	Miscellaneous		Window guards
05 50 00	**Metal Fabrications**		Wire products
	Stairs and railings	**05 70 00**	**Decorative Metal**
	Fire escapes		Gratings
	Ladders		Treads and nosings
	Catwalks		Castings, fabrications, and specialties

Figure C-5. Estimating Checklist—Division 05

Division 06—Wood, Plastics, and Composites			
Number	**Description**	**Number**	**Description**
06 10 00	**Structural (Rough Carpentry)**		Sheathing
	Beams		Hardboard
	Box		Particleboard
	Laminated		Plywood
	Blocking and bridging		Shelving
	Bracing		Siding
	Columns		Sills
	Fire stopping		Soffits
	Floor planking		Stairs
	Joists		Subflooring
	Posts and girts		Thresholds
	Purlins		Underlayment
	Rafters		Wainscoting
	Roof carpentry		Wall framing
	Cants		Studs
	Decking		Plates
	Sheathing		Sills
	Trusses	**06 40 00**	**Architectural Woodwork**
06 20 00	**Finish Carpentry**		Ceiling beams, decorative
	Cabinets		Chair rails
	Casings		Cupolas
	Closets		Ornamental
	Cornices		Stairs and railings
	Countertops		Trim
	Door bucks		Wood frames
	Molding and trim		Wood screens and exterior wood shutters
	Nailer plates	**06 50 00**	**Structural Plastic**
	Paneling	**06 60 00**	**Plastic Fabrications**
	Railings	**06 70 00**	**Structural Composites**
		06 80 00	**Composite Fabrications**

Figure C-6. Estimating Checklist—Division 06

Division 07—Thermal and Moisture Protection			
Number	**Description**	**Number**	**Description**
07 10 00	**Damp Proofing and Waterproofing**	**07 70 00**	**Roof Accessories**
07 20 00	**Thermal Protection**		Downspouts
	Exterior insulation and finish systems		Gutters
	Roof and deck insulation		Expansion joints
	Thermal insulation		Fascia
07 25 00	**Weather Barriers**		Flashing
07 30 00	**Steep Slope Roofing**		Gravel stop
07 40 00	**Roofing and Siding Panels**		Louvers
	Aluminum siding		Reglet
	Steel siding		Roof drains
	Wood siding		Soffit
	Hardboard siding		Hatches
	Plywood siding		Roof
	Plastic siding		Smoke vents
	Composition siding		Sky roof
	Mineral-fiber cement siding		Ventilators
	Fabrication panel assemblies with siding		Walkways
07 50 00	**Membrane Roofing**	**07 81 00**	**Fireproofing**
	Built-up roofing		Beams
	Membrane roofing		Columns
	Fluid applied roofing		Decking
	Coated foamed roofing	**07 84 00**	**Firestopping**
	Roll roofing	**07 90 00**	**Joint Protection**
07 60 00	**Flashing and Sheet Metal**		Preformed joint seals
			Joint sealants
			Expansion control

Figure C-7. Estimating Checklist—Division 07

Division 08—Openings			
Number	**Description**	**Number**	**Description**
08 10 00	**Doors and Frames**	**08 50 00**	**Windows**
	Accordion		Ballistic/hurricane
	Acoustical		Casement
	Aluminum		Double-hung
	Ballistic		Picture
	Bi-parting		Projected
	Blast		Screens
	Cold storage		Security
	Fire rated		Single-hung
	Folding		Sliding
	Garage	**08 60 00**	**Roof Windows and Skylights**
	Glass	**08 70 00**	**Hardware**
	Sliding		Automatic
	Swing		Handicapped
	Grilles		Security
	Rolling	**08 80 00**	**Glazing/Glass**
	Handicapped		Acoustical
	Hollow metal		Allowance for broken glass replacement
	Overhead		Allowance for temporary glass
	Pressure		Ballistic
	Revolving		Faceted
	Rolling		Fire glass
	Security		Insulated
	Service		Laminated
	Sliding		Plexiglass
	Tin-clad		Reflective
	Vault		Spandrel
	Wood		Stained
08 30 00	**Specialty Doors and Frames**		Window films
08 40 00	**Entrances, Storefronts, and Curtain Walls**		Wire
		08 90 00	**Louvers and Vents**

Figure C-8. Estimating Checklist—Division 08

Division 09—Finishes			
Number	**Description**	**Number**	**Description**
09 20 00	**Plaster and Gypsum Board**	**09 70 00**	**Wall Finishes**
09 30 00	**Tiling**		Ceramic tile
	Chemical-resistant tiling		Metal tile
	Conductive tiling		Mosaic tile
	Mortar-bed tiling		Paint
	Thin-set tiling		Paneling
	Waterproofing-membrane tiling		Planking
09 50 00	**Ceilings**		Plaster
	Acoustical		Plastic tile
	Dropped		Quarry tile
	Drywall		Stucco
	Insulation		Wainscoting
	Thermal		Wall coverings
	Acoustic		Cloth
	Plaster		Paper
	Suspension system		Vinyl
09 60 00	**Flooring**	**09 90 00**	**Painting and Coatings**
	Access/raised flooring		
	Carpeting		
	Fluid-applied		
	Masonry		
	Resilient		
	Specialty		
	Terrazzo		
	Wood		

Figure C-9. Estimating Checklist—Division 09

Division 10—Specialties			
Number	**Description**	**Number**	**Description**
10 10 00	**Information Specialties**	**10 30 00**	**Fireplaces and Stoves**
	Display cases	**10 40 00**	**Safety Specialties**
	Signage	**10 50 00**	**Storage Specialties**
	Visual displays		Lockers
	Chalkboards, etc.		Postal specialties
10 20 00	**Interior Specialties**		Storage assemblies (shelving)
	Compartments and cubicles		Wardrobe and closet specialties
	Toilet compartments	**10 70 00**	**Exterior Specialties**
	Shower and dressing compartments		Exterior protection (sun and storm)
	Dispenser units		Flagpoles
	Paper towel		Manufactured exterior specialties
	Napkin		Protective covers
	Soap	**10 80 00**	**Other Specialties**
	Toilet paper		Flags and banners
	Toilet seat cover		Grilles and screens
	Grab bars		Pest control devices
	Hand dryers		Security mirrors and domes
	Handicapped bars		
	Hat/coat rack		
	Medicine chests		
	Mirrors		
	Mop holder		
	Partitions		
	Robe hook		
	Shelving		
	Toilet accessories		
	Towel bars		
	Towel shelf		
	Waste receptacles		

Figure C-10. Estimating Checklist—Division 10

Division 21—Fire Suppression			
Number	**Description**	**Number**	**Description**
21 10 00	**Water-Based Fire-Suppression Systems**	**21 20 00**	**Fire-Extinguishing Systems**
	Hydrants and fire department connections		Carbon dioxide
	Standpipes		Clean agent
	Hoses and nozzles		Wet chemical
	Reels		Dry chemical
	Racks	**21 30 00**	**Fire Pumps**
	Valves		Centrifugal
	Cabinets		Vertical-turbine
	Sprinkler systems		Positive-displacement
	Wet pipe	**21 40 00**	**Fire-Suppression Water Storage (Tanks)**
	Dry pipe		
	Pre-action		
	Deluge		

Figure C-11. Estimating Checklist—Division 21

Division 22—Plumbing			
Number	**Description**	**Number**	**Description**
22 10 00	**Plumbing Piping and Pumps**	**22 15 00**	**Compressed-Air Systems**
	Air chambers	**22 30 00**	**Plumbing Equipment**
	Concrete encasement		Water softeners
	Escutcheons		Filtration equipment
	Expansion joints		Water heaters
	Excavation for piping		Electric
	Fittings		Fuel-fired
	Hangers		Water heat exchangers
	Insulation	**22 40 00**	**Plumbing Fixtures**
	Shock absorbers		Bathtubs
22 12 00	**Facility Potable-Water Storage Tanks**		Drinking fountains
	Elevated/roof-mounted		Hose bibs
	Ground-mounted		Lavatories
	Indoor storage tank		Showers
	Pressure		Sinks
	Nonpressure		Bar
22 13 00	**Facility Sanitary Sewerage**		Janitor
	Facility septic tanks		Kitchen
	Interceptors		Laundry
	Pumps		Toilets
	Sanitary waste piping specialties		Urinals
	Air-admittance valves		Wash centers/fountains
	Fats, oils, and grease disposal systems		Water closets
	Grease removal		Water coolers
	Sanitary drains	**22 50 00**	**Pool and Fountain Plumbing Systems**
	Separators		Piping
	Waste and vent piping		Pumps
22 14 00	**Facility Storm Drainage**		Water treatment equipment
	Piping		Controls
	Leaders and drains	**22 60 00**	**Gas and Vacuum Systems for Laboratory and Healthcare Facilities**
	Sump pumps		

Figure C-12. Estimating Checklist—Division 22

Division 23—Heating, Ventilating and Air Conditioning			
Number	**Description**	**Number**	**Description**
23 10 00	**Facility Fuel System**	**23 60 00**	**Central Cooling Equipment**
	Fuel piping		Cooling towers
	Fuel pumps		Packaged compressor and condenser units
	Fuel storage tanks		Packaged water chillers
	Underground		Refrigerant compressors
	Above ground		Refrigerant condensers
23 20 00	**HVAC Piping and Pumps**	**23 70 00**	**Central HVAC Equipment**
	HVAC water treatment		Air-to-air energy recovery equipment
	Hydronic piping and pumps		Custom-packaged outdoor HVAC equipment
	Internal-combustion engine piping		Evaporative air-cooling equipment
	Refrigerant piping		Indoor central-station air-handling units
	Steam and condensate piping and pumps		Packaged outdoor HVAC equipment
23 30 00	**HVAC Air Distribution**		Thermal storage (hot and cold)
	Air duct accessories (volume dampers)	**23 80 00**	**Decentralized HVAC Equipment**
	Air outlets and inlets (diffusers, grilles, etc.)		Convection heating and cooling units
	Air plenums and chases		Humidity control equipment
	Air terminal units		Packaged units
	Ducts and casings		Radiant heating units
	Fans (exhaust and return)		**Temperature Control Systems**
	Special exhaust systems		**Insulation**
	Ventilation hoods		Duct and piping
23 40 00	**HVAC Air Cleaning Device**		Water heaters
	Electronic air cleaners		**Piping**
	Gas-phase air filtration		Air chambers
	Particulate air filtration		Concrete encasement
23 50 00	**Central Heating Equipment**		Escutcheons
	Breechings, chimneys, and stacks		Expansion joints
	Feedwater pumps and deaerators		Excavation for piping
	Fuel-fired heaters		Fittings
	Heat exchangers for HVAC		Hangers
	Heating boilers or furnaces		Shock absorbers

Figure C-13. Estimating Checklist—Division 23

Division 26, 27, And 28—Electrical, Communications, and Security			
Number	**Description**	**Number**	**Description**
26 10 00	**Medium-Voltage Electrical Distribution**		**Fixtures**
	Substations		Area lighting
	Transformers		Exit lights
	Switchgear		Floodlighting
	Circuit protection devices		Fluorescent
26 20 00	**Low-Voltage Electrical Distribution**		Fountain lighting
	Overhead electrical power systems		High-intensity discharge
	Transformers		High-pressure sodium
	Switchgear		Incandescent
	Switchboards and panel boards		Metal halide
	Enclosed bus assemblies		Site lighting
	Power distribution units		Step lighting
	Distribution equipment		**Devices**
	Circuit protection devices		Bollards
	Controllers and control devices		Boxes for outlets, receptacles, light switches, and dimmers
26 30 00	**Facility Electrical Power Generating and Storing Equipment**		Cover plates
	Packaged generator assemblies		Dimmers
	Battery equipment		Lighting control switches
	Power filters and conditioners		Motor control centers
	Transfer switches		Motors
26 40 00	**Electrical and Cathodic Protection**		Outlets
	Facility lighting protection		Poles
	Cathodic protection		Receptacles
	Transient voltage suppression		Safety devices
26 50 00	**Lighting**		
	Interior		
	Emergency		
	Exit signs		
	Special purpose		
	Exterior		

Figure C-14. Estimating Checklist—Division 26, 27, and 28 (Sheet 1 of 2)

Division 26, 27, And 28—Electrical, Communications, and Security			
Number	**Description**	**Number**	**Description**
	Incoming Service		Pull boxes
	Connection to power company system		Raceways
	Overhead		Supports
	Underground		Undercarpet cabling/wiring systems
	Primary		Underfloor cabling system
	Secondary		Wire
	Service feeds		**Emergency Systems**
	Main transformer		Area protection relay system
	Unit substation		Exit lighting
	Feeder		Battery emergency lighting
	Manholes		Generator
	Primary		Lighting
	Secondary		Power
	Meters		Power connection to second service entrance
	Wiring		Transfer switch
	Cable	**27 20 00**	**Data Communications**
	Armored	**27 30 00**	**Voice Communications**
	Coaxial	**27 40 00**	**Audio-Video Communications**
	Ethernet		Paging systems
	Insulated		Public address systems
	Metallic		Sound systems
	Nonmetallic		Television systems
	Optical fiber		Antennae
	Shielded		Cables
	Connections		Cameras
	Equipment connections		Satellite dishes
	Grounding	**28 10 00**	**Electronic Access Control and Intrusion Detection**
	Junction boxes		

Figure C-14. Estimating Checklist—Division 26, 27, and 28 (Sheet 2 of 2)

Division 31—Earthwork			
Number	**Description**	**Number**	**Description**
31 10 00	**Site Clearing**		Concrete raising
	Clearing and grubbing		Pressure grouting
	Selective clearing		Compaction grouting
	Tree and shrub removal		Mechanical jacking
	Stripping and stockpiling		Vibroflotation and densification
31 20 00	**Earthmoving**		Needle beams
	Off-gassing mitigation		Underpinning
	Grading	**31 50 00**	**Excavation Support and Protection**
	Excavation and fill		Anchor tiebacks
	Mass		Cofferdams
	Trench		Cribbing and whalers
	Embankments		Ground freezing
	Erosion and sedimentation controls		Slurry walls
31 30 00	**Earthwork Methods**	**31 60 00**	**Special Foundations and Load-Bearing Elements**
	Soil treatment		Driven piles
	Rodent control		Pressure-injected footings
	Termite control		Bored piles
	Vegetation control		Caissons
	Soil stabilization		Special foundations
	Rock stabilization		Foundation anchors
	Soil reinforcement	**31 70 00**	**Tunneling and Mining**
	Slope protection		**Blasting**
	Gabions		
	Riprap		
31 40 00	**Shoring and Underpinning**		
	Shoring		
	Timber		
	Sheet piling		
	Metal hydraulic shoring		
	Pneumatic shoring		
	Trench shielding		

Figure C-15. Estimating Checklist—Division 31 (Sheet 1 of 2)

Division 31—Earthwork			
Number	**Description**	**Number**	**Description**
	Borrow Pit		**Compaction**
	Groundwater expected		Hand
	None		Mechanical
	Pump		**Water Control**
	Wellpoint system		Dams
	Trench away from excavation		Ditching
	Sheeting/shoring		Pumping
	Disposal		Wellpoint system
	Off site		
	Onsite		
	Use for fill		
	Backfill		
	Mass		
	Trench		
	Berms		
	Topsoil		
	Gravel		
	Stone		
	Source		
	Borrow pit		
	Commercial pit		
	Onsite		

Figure C-15. Estimating Checklist—Division 31 (Sheet 2 of 2)

Division 32—Exterior Improvements			
Number	**Description**	**Number**	**Description**
32 10 00	**Bases, Ballasts, and Paving**	**32 30 00**	**Site Improvements**
32 11 00	**Base Courses**		Fencing and gates
32 12 00	**Flexible Paving**		Retaining walls
	Preparatory coats		Fabricated bridges
	Tack coat		Screening devises
	Asphaltic tack coats	**32 70 00**	**Wetlands**
	Prime coats	**32 80 00**	**Irrigation**
	Asphaltic prime coats	**32 90 00**	**Planting**
	Asphalt paving		Planting preparation
	Hot mix		Lawn
	Cold mix		Seeding
	Asphalt paving		Sodding
	Flexible paving surface treatments		Trees
	Asphaltic seal and fog coats		Bushes
	Coal tar seal coats		Shrubs
	Fuel-resistant sealers		Plantings
	Joint sealants		Ground cover
32 13 00	**Rigid Paving (concrete)**		Mulch
32 14 00	**Unit Paving, precast**		Edgings
	Brick unit		Maintenance agreements
	Asphalt unit		Plants
	Stone unit		Planting accessories
32 15 00	**Aggregate Surfacing**		Edging
	Cinder		Tree guying
	Crushed stone		Transplanting
32 16 00	**Curbs and Gutters**		Special considerations
32 17 00	**Paving Specialties**		**Other Considerations**
	Bumpers, parking		Driveways
	Markings, pavement		Patios
32 18 00	**Athletic and Recreational Surfacing**		Steps
			Walks

Figure C-16. Estimating Checklist—Division 32

Division 33—Utilities			
Number	**Description**	**Number**	**Description**
33 05 23	**Trenchless Utility**	**33 60 00**	**Hydronic and Steam Energy Distribution**
	Microtunneling		Hydronic distribution
	Horizontal boring		Steam distribution
33 10 00	**Water Utilities**	**33 70 00**	**Electrical Utilities**
	Piping		Electrical utility transmission and distribution
	Equipment		Substations
	Tanks		Transformers
33 20 00	**Wells**		Overhead wiring
33 30 00	**Sanitary Sewer Utilities**		High-voltage switchgear
	Piping		Medium-voltage switchgear
	Equipment		Grounding
	Pumping station	**33 80 00**	**Communications Utilities**
	Force mains		Structures
	Septic systems		Distribution
	Structures		Communications distribution
33 40 00	**Storm Drainage Utility**		Copper cabling
	Piping		Optical fiber cabling
	Culverts (head and wing walls)		Coaxial cabling
	Drains		Grounding and bonding
	Structures (e.g., catch basins)		Wireless communications distribution
33 51 00	**Natural Gas Distribution**		Laser
	Piping		Microwave
	Watering		Infrared
33 52 00	**Liquid Fuel Distribution**		Ultrahigh frequency/very high frequency
	Piping		**Valve and Valve Boxes**
	Pumps		
33 56 00	**Fuel Storage Tanks**		
	Above ground		
	Underground		
	Aviation fuel		
	Compressed gas		

Figure C-17. Estimating Checklist—Division 33

Division 34—Transportation			
Number	**Description**	**Number**	**Description**
34 10 00	**Rail Tracks**	**34 43 00**	**Airfields**
	Rails		Runway signals and lights
	Cross ties		Landing equipment
	Signal and control equipment		Control tower equipment
	Track accessories		Weather observation equipment
34 40 00	**Roadways**	**34 80 00**	**Bridges**
	Signals		Bridge machinery
	Controls		Bridge specialties
	Monitoring equipment		
	Vehicle barriers		
	Guard rails and guide rails		
	Vehicle delineators		
	Fare collection equipment		

Figure C-18. Estimating Checklist—Division 34

Division 35—Waterway and Marine Construction			
Number	**Description**	**Number**	**Description**
35 10 00	**Signaling and Control Equipment**	**35 50 00**	**Marine Construction and Equipment**
35 20 00	**Construction and Control Equipment**		Floating construction
	Hydraulic fabrications		Offshore platform construction
	Hydraulic gates		Underwater construction
	Hydraulic valves		Harbor deepening
	Dredging		Pipeline construction
35 30 00	**Coastal Construction**		Foundation construction
	Shoreline protection		Structures construction
	Seawalls		Waterproofing
	Revetments		Marine specialties
	Breakwaters		Marine fenders
	Jetties		Buoys
	Groins		Mooring devices
	Artificial reefs		Marine bollards and cleats
35 40 00	**Waterway Construction and Equipment**		Marine chain and accessories
	Levees	**35 70 00**	**Dam Construction and Equipment**
	Bank protection		
	Scour protection		
	Waterway structures		

Figure C-19. Estimating Checklist—Division 35

Division 41—Materiel Processing and Handling Equipment			
Number	**Description**	**Number**	**Description**
41 10 00	**Bulk Materiel Processing Equipment**		Lifting devices
	Sizing equipment		Specialty materiel handling equipment
	Conveying equipment	**41 30 00**	**Manufacturing Equipment**
	Feeders	**41 40 00**	**Container Processing and Packaging**
	Batching equipment	**41 50 00**	**Materiel Storage**
41 20 00	**Piece Materiel Handling Equipment**	**41 60 00**	**Mobile Plant Equipment**
	Conveyors		
	Cranes and hoists		

Figure C-20. Estimating Checklist—Division 41

Division 46—Water Treatment Equipment	
Number	**Description**
46 07 00	**Water Treatment Equipment**
	Packaged water treatment
	General water treatment equipment
	Water filtration equipment
	Water treatment chemical systems equipment
	Water treatment biological systems equipment
	Sludge treatment and handling equipment for water treatment system

Figure C-21. Estimating Checklist—Division 46

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APPENDIX D
Conversion Factors

D.1 INTRODUCTION

This appendix provides unit of measure conversion factors. Many are provided to convert between the English system of measure and the metric system of measure. Figure D-1 lists these conversion factors. For additional weights and measures of materiels, and conversion factors refer to http:www.convert-me.com.

Multiply	By	To Obtain	Multiply	By	To Obtain
Area					
Acres	43560	Square feet	Square kilometers	0.3861	Square miles
Acres	0.004047	Square kilometers	Square meters	10.76	Square feet
Acres	4046.9	Square meters	Square meters	1.196	Square yards
Acres	0.0015625	Square miles	Square miles	2.590	Square kilometers
Acres	4840	Square yards	Square miles	3097600	Square yards
Square centimeters	0.1550	Square inches	Square yards	1296.0	Square inches
Square feet	0.0929	Square meters	Square yards	9.0	Square feet
Square inches	6.45	Square centimeters	Square yards	0.836	Square meters
Linear Measure					
Centimeters	0.394	Inches	Kilometers	0.540	Miles (nautical)
Degrees (angle)	0.01745	Radians	Kilometers	0.621	Miles (statute)
Feet	0.305	Meters	Meters	3.281	Feet
Feet per minute	0.5080	Centimeters per second	Meters	1.094	Yards
Feet per minute	0.01136	Miles per hour	Miles (nautical)	1.152	Miles (statute)
Feet per second	1.097	Kilograms per hour	Miles (statute)	1.6093	Kilometers
Inches	2.540	Centimeters	Millimeters	0.039	Inches
Inches	25.40	Millimeters	Radians	57.3	Degrees (angle)
Kilometers	3281	Feet	Yards	0.9144	Meters

Figure D-1. Conversion Factors (Sheet 1 of 2)

Multiply	By	To Obtain	Multiply	By	To Obtain
Volume					
Cubic feet	0.037037	CYDs	Gallons (U.S. liquid)	3.79	Liters
Cubic feet	0.028317	Cubic meters	Gallons (U.S. liquid)	0.003785	Cubic meters
Cubic feet	7.481	Gallon	Gallons (U.S. liquid)	0.1336806	Cubic feet
Cubic meters	35.30	Cubic feet	Liters	1.057	Quarts (U.S. liquid)
Cubic meters	1.308	CYDs	Liters	0.264	Gallons (U.S. liquid)
Cubic meters	264.2	Gallons (U.S. liquid)	Milliliters	0.0338	Ounces (U.S. liquid)
CYDs	27.0	Cubic feet	Ounces (U.S. liquid)	29.6	Milliliters
CYDs	0.76455	Cubic meters	Quarts (U.S. liquid)	0.946	Liters
Miscellaneous Measure					
Atmospheres	14.70	Pounds per square inch	Joules	0.0009486	British thermal units
Centimeters of mercury	0.01316	Atmospheres	Kilograms per square meter	0.00009678	Atmospheres
Centimeters of mercury	0.1934	Pounds per square inch	Kilograms-calories	3.968	British thermal units
Grams- calories	0.003968	British thermal units	Kilograms per meter	0.009302	British thermal units
Horsepower	42.44	British thermal units per minute	Miles per hour	1.467	Feet per second
Horsepower	745.7	Watts	Pounds per square inch	0.06804	Atmospheres
Inches of water	0.002458	Atmospheres	Watts	0.05692	British thermal units per minute
Temperature					
Temperature (Celsius)	Add 17.8 and multiply by 1.80	Temperature (Fahrenheit)	Temperature (Fahrenheit)	Subtract 32 and multiply by 0.5556	Temperature (degrees Celsius)
Weight					
Pounds	0.454	Kilograms	Metric tons	0.984	Long tons
Grams	0.0353	Ounces	Metric tons	1.102	Short tons
Grams	0.002205	Pounds	Ounces	28.35	Grams
Kilograms	2.20	Pounds	Ounces	0.0625	Pounds
Kilograms	0.001102	Short tons	Short tons	907.18	Kilograms
Long tons	1016.0	Kilograms	Short tons	0.8929	Long tons
Long tons	1.12	Short tons	Short tons	0.907	Metric tons
Long tons	1.016	Metric tons	Short tons	2000	Pounds

Figure D-1. Conversion Factors (Sheet 2 of 2)

APPENDIX E
Lumber Length Calculations

E.1 INTRODUCTION

This appendix provides estimators with calculations for estimating BF measure and the optimum lumber length requirements. Lumber is ordered by board feet at standard commercial lengths. The lengths available in DOD logistic depots range from 8 to 20 feet, in 2-foot increments.

E.2 BOARD FOOT MEASURE

Lumber is quantified using a system of measure called BF measure. It allows an estimator to quantify lumber of varying dimensional sizes to a common unit of measure for pricing and comparisons. It is a measure of wood volume. One BF is equal to the volume of a piece of lumber 1 inch thick by 1 foot square. The following formula is used to calculate BF/board feet of lumber:

$$BF = \frac{t \times w \times l}{12}(n)$$

where:

1. t = nominal thickness in inches
2. w = nominal width in inches
3. l = length in feet of the individual piece of lumber
4. n = number of like pieces of lumber.

For example: How many board feet are in a 2- by 8-inch piece of lumber 18 feet long?

$$BF \quad \frac{2 \times 8 \times 18}{12}(1) = 24 \text{ board feet}$$

E.3 BOARD MEASURE

Board measure is an informal hybrid unit of measure for lumber. It is the sum of the board feet and square feet in an assembly of lumber. If all of the wood in an assembly is measured in board feet (and none in square feet), then the number of board measure in that assembly equals the number of board feet.

For example, if 1 square foot of formwork contains 1 square foot of plywood and 1.24 board feet of framing lumber; then there is a total of 2.24 board measures in that 1 square foot of formwork.

1 square foot + 1.24 BF = 2.24 board measure

E.4 LENGTH CALCULATIONS

In many parts of a facility/building, it is obvious what commercial lengths should be ordered. For example, if the joists and girders are 10 feet, 0 inches long, 10-foot commercial lengths are obviously needed. There are situations, however, where it is not quite as evident what length should be ordered. The manager must then calculate the most economical standard length with the least waste.

The procedure for this is as follows:

1. Number pieces/standard lengths. Calculate the number of pieces per standard length for each of the three standard lengths (8, 10, and 12). If this number is not an integer, round down.

$$\text{number of pieces per standard length} = \frac{\text{one standard length (inches)}}{\text{length of one piece (inches)}}$$

2. Number standard lengths required. Find the number of standard lengths required for each of the three alternatives. If this number is not an integer, round up.

$$\text{number of standard lengths} = \frac{\text{one standard length (inches)}}{\text{length of one piece (inches)}}$$

3. Total linear feet required. Calculate the total linear feet required for each of the three standard lengths and use the least.

linear feet = one standard length (feet) × number of standard lengths

E.5 SAMPLE LENGTH CALCULATION PROBLEM

The following sample problem is provided: 50 pieces of 2- by 4-inch lumber, 27 inches long, are required. Find the most economical length and the number of pieces to be ordered. There are three standard lengths which can be ordered: 8 feet, 10 feet, or 12 feet.

The following analysis examines each:

1. Number pieces/standard lengths

   08 feet = 096 inches — 96/27 = 3+
   10 feet = 120 inches — 120/27 = 4+
   12 feet = 144 inches — 144/27 = 5+

   Thus, each 96-inch length yields three pieces; each 120-inch length yields four pieces; and each 144-inch length yields five pieces.

2. Number standard lengths required

   08 feet — 50/3 = 16+
   10 feet — 50/4 = 12+
   12 feet — 50/5 = 10

3. Total linear feet required.

   08 feet — 17 × 08 feet = 136 linear feet
   10 feet — 13 × 10 feet = 130 linear feet
   12 feet — 10 × 12 feet = 120 linear feet

Twelve-foot standard lengths result in the minimum amount of lumber required, and 10 of these 12-foot lengths should be ordered.

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GLOSSARY

capability. The ability to execute a specified course of action. (A capability may or may not be accompanied by an intention.) (NTRP 1-02)

combat engineering. Engineering capabilities and activities that directly support the maneuver of land combat forces that require close and integrated support. (DOD Dictionary)

component. 1. One of the subordinate organizations that constitute a joint force. (JP 1) 2. In logistics, a part or combination of parts having a specific function, which can be installed or replaced only as an entity. (DOD Dictionary)

contingency. A situation requiring military operations in response to natural disasters, terrorists, subversives, or as otherwise directed by appropriate authority to protect United States interests. (DOD Dictionary)

doctrine. Navy doctrine conveys fundamental principles and overarching guidance in warfare and other operations. It is authoritative, but requires judgment in its application. Navy doctrine is organized hierarchically and is divided into six series: General/reference, intelligence, operations, logistics, planning, and communications. (NTRP 1-02)

engineer reconnaissance. The gathering of specific, detailed, technical information required by supporting engineer forces to prepare for and accomplish assigned missions. (NTRP 1-02)

facility. A real property entity consisting of one or more of the following: a building, a structure, a utility system, pavement, and underlying land. (DOD Dictionary)

general engineering (GE). Those engineering capabilities and activities, other than combat engineering, that provide infrastructure and modify, maintain, or protect the physical environment. (DOD Dictionary)

joint. Connotes activities, operations, organizations, etc., in which elements of two or more Military Departments participate. (DOD Dictionary)

joint publication (JP). A compilation of agreed-to fundamental principles, considerations, and guidance on a particular topic, approved by the Chairman of the Joint Chiefs of Staff or authorized designee, that guides the employment of a joint force toward a common objective. (DOD Dictionary)

liaison. Contact or intercommunication maintained between elements of military forces or other agencies to ensure mutual understanding and unity of purpose and action. (NTRP 1-02)

logistics. Planning and executing the movement and support of forces. (DOD Dictionary)

Marine air-ground task force (MAGTF). The Marine Corps' principal organization for all missions across a range of military operations, composed of forces task-organized under a single commander capable of responding rapidly to a contingency anywhere in the world. The types of forces in the Marine air-ground task force are functionally grouped into four core elements: a command element, an aviation combat element, a ground combat element, and a logistics combat element. The four core elements are categories of forces, not formal commands. The basic structure of the Marine air-ground task force never varies, though the number, size, and type of Marine Corps units comprising each of its four elements will always be mission dependent. The flexibility of the organizational structure allows for one or more subordinate Marine air-ground task forces to be assigned. In a joint or multinational environment, other Service or multinational forces may be assigned or attached. (NTRP 1-02)

materiel. All items necessary to equip, operate, maintain, and support military activities without distinction as to its application for administrative or combat purposes. (DOD Dictionary)

mission. 1. The task, together with the purpose, that clearly indicates the action to be taken and the reason therefore. (JP 3-0) 2. In common usage, especially when applied to lower military units, a duty assigned to an individual or unit; a task. (JP 3-0) 3. The dispatching of one or more aircraft to accomplish one particular task. (DOD Dictionary)

operation. 1. A sequence of tactical actions with a common purpose or unifying theme. (JP 1) 2. A military action or the carrying out of a strategic, operational, tactical, service, training, or administrative military mission. (DOD Dictionary)

organic. Assigned to and forming an essential part of a military organization as listed in its table of organization for the Army, Air Force, and Marine Corps, and are assigned to the operating forces for the Navy. (DOD Dictionary)

support. The action of a force that aids, protects, complements, or sustains another force in accordance with a directive requiring such action. 2. A unit that helps another unit in battle. 3. An element of a command that assists, protects, or supplies other forces in combat. (DOD Dictionary)

sustainment. The provision of logistics and personnel services required to maintain and prolong operations until successful mission accomplishment. (DOD Dictionary)

theater. The geographical area for which a commander of a geographic combatant command has been assigned responsibility. (DOD Dictionary)

LIST OF ACRONYMS AND ABBREVIATIONS

ABS	acrylonitrile-butadiene-styrene (plastic)
AFCS	Army Facilities Components System
AFJPAM	Air Force joint pamphlet
AFPAM	Air Force pamphlet
AWG	American wire gage
BF	board foot
BOM	bill of materials
BTU	British thermal unit
CESE	civil engineering support equipment
CPVC	chlorinated polyvinyl chloride (plastic)
DOD	Department of Defense
DWV	drain, waste, and vent
EM	engineer manual
FM	field manual (USA)
FSSP	fuel system supply point
FVNR	full voltage non-reversing
HD	hundred
HVAC	heating, ventilation, and air conditioning
JCMS	Joint Construction Management System
JP	joint publication
kVA	kilovolt-ampere
LAMS	large area maintenance shelter
MAGTF	Marine air-ground task force
MCRP	Marine Corps reference publication
MCWP	Marine Corps warfighting publication
MOS	military occupational specialty
NAVFAC	Naval Facilities Engineering Systems Command
NAVFACLANT	Naval Facilities Engineering Systems Command, Atlantic
NAVFACPAC	Naval Facilities Engineering Systems Command, Pacific
NEMA	National Electrical Manufacturers Association
NTRP	Navy tactical reference publication
NTTP	Navy tactics, techniques, and procedures
PAPI	precision approach path indicator
PDB	power distribution box
POL	petroleum, oil, lubricant
PVC	polyvinyl chloride
REDi	Reachback Engineer Data Integration
SOP	standard operating procedure
TM	technical manual

TPT	tactical petroleum terminal
U.S.	United States
UFC	Unified Facilities Criteria
UROC	USACE Reachback Operations Center
USA	United States Army
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy
VLZMP	visual landing zone marker panel

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