UNITED STATES MARINE CORPS
ENGINEER INSTRUCTION COMPANY
MARINE CORPS DETACHMENT
14183 EAST 8TH ST
FORT LEONARD WOOD, MO 65473-8963

LESSON PLAN

COMPUTE BILL OF MATERIALS

EAC-B01

ENGINEER ASSISTANT CHIEF COURSE

A16EAV1

REVISED 08/01/2014

APPROVED BY _____ **DATE** _____

(On CS #1)

INTRODUCTION **(10 Min)**

1. **GAIN ATTENTION**: Once the design phase for a project has been completed and the drawings have been developed, the materials estimate for the project can be compiled.

(On CS #2)

2. **OVERVIEW**: Good morning/afternoon my name is _____. The purpose of this lesson is to provide you with the knowledge to estimate the material requirements for a vertical construction project. I will do this by discussing: principles of estimating, material takeoff lists, materials estimates, and mathematical computations used for estimating materials.

(On CS #3-5)

3. **LEARNING OBJECTIVES**

INSTRUCTORS NOTE
Introduce the learning objectives by having the students read them from the Student Outline or presentation.

a. **TERMINAL LEARNING OBJECTIVE**. Provided a vertical construction mission, a scientific calculator, a computer, software applications, and references, compute a project bill of materials accounting for all Class IV quantities. (1361-SRVY-2004)

b. **ENABLING LEARNING OBJECTIVES**

(1). Provided written project specifications, design drawings, a scientific calculator, a blank material takeoff sheets, and references, calculate concrete requirements per the MCRP 3-17.7D. (1361-SRVY-2004a)

(2). Provided written project specifications, design drawings, a scientific calculator, a blank material takeoff sheets, and references, calculate masonry requirements per the MCRP 3-17.7D. (1361-SRVY-2004b)

(3). Provided written project specifications, design drawings, a scientific calculator, a blank material takeoff sheets, and references, calculate lumber/plywood requirements per the MCRP 3-17.7C. (1361-SRVY-2004c)

(4). Provided written project specifications, design drawings, a scientific calculator, a blank material takeoff sheets, and references, calculate finish material requirements per the MCRP 3-17.7C. (1361-SRVY-2004d)

(5). Provided written project specifications, design drawings, a scientific calculator, a completed lumber/plywood consolidations, blank material estimate sheets, and references, estimate construction hardware quantities per the MCRP 3-17.7C. (1361-SRVY-2004e)

(6). Provided written project specifications, design drawings, a scientific calculator, a completed material takeoff sheets, and references, compile bill of materials (BOM) per the MCRP 3-17.7C. (1361-SRVY-2004f)

(On CS #6)

4. **METHOD/MEDIA**: This lesson will be presented by lecture, demonstration, and practical application. I will be aided by computer supported instruction, and the dry erase board. During the demonstrations, you will follow the procedures as I demonstrate them.

(On CS #7)

5. **EVALUATION**: A performance examination, covering the material in this lesson, will be administered at the end of this period of instruction as noted on your training schedule.

INSTRUCTORS NOTE
Explain lesson critique forms to students.

(On CS #8)

6. **SAFETY/CEASE TRAINING (CT) BRIEF**. If at any time you the student see anything that is unsafe or are told by an instructor to stop, STOP IMMEDIATELY. In the event of fire, we will consolidate outside where the pavilion is located at and account for everyone. In the event of a tornado, the passageway on the first deck of Brown Hall will be our consolidation area. Safety at this course is paramount.

INSTRUCTORS NOTE
Read ORA worksheet to the students.

(On CS #9)
TRANSITION: Are there any questions on what we will be covering, or how you will be evaluated? We will begin by discussing the principles of estimating.

BODY **(16 HRS 50 MIN)**

(On CS #10)

1. **PRINCIPLES OF ESTIMATING**: **(20 Min)** Estimating is the calculation of the approximate amount of material and/or labor requirements to build a construction project. Estimates are prepared from finished working drawings and project specifications.

(On CS #11)

a. **Qualifications**: The estimator needs to have the following basic qualifications to compile a reliable project estimate.

(1) Be able to read and scale drawings

(2) Possess a good working knowledge of math.

(3) Be able to mentally visualize the work required.

(4) Working knowledge of construction methods and construction materials.

(5) Knowledge and ability to assemble materials into working units.

(On CS #12)

b. **Calculations**: There are two basic calculations involved in the estimating process.

(1) Measurement: Measuring work consists of three parts:

(a) Descriptions of materials, and items of work.

(b) Dimensions of items of work, and materials required.

(c) Calculating the quantities of materials, and items of work.

(2) Pricing: Simple arithmetic used to determine the cost of an item by applying unit prices to measured quantities, to determine material costs.

(On CS #13)

TRANSITION: Do I have any questions concerning the principles of estimating?

OPPORTUNITY FOR QUESTIONS

1. **QUESTIONS FROM THE CLASS**: (Answer student's questions.)

2. **QUESTIONS TO THE CLASS**:

a. **QUESTION**: Name some of the qualifications an estimator need to have in order to compile accurate estimates.

ANSWER: Able to read and scale drawings. Good knowledge of math. Mentally visualize work required. Knowledge of construction methods/materials.

(5) Knowledge and ability to assemble materials into working units.

b. **QUESTION**: What are the two basic calculations involved in construction project estimations?

ANSWER: Measurement and Pricing.

TRANSITION: Now we will discuss basic Mathematical Equations.

(On CS #14)

2. **MATHEMATICAL EQUATIONS**: **(120 Min)** The application of basic mathematical computations is all that is necessary to compile an accurate project estimate of materials and/or labor. There are three fundamental conversion formulas used to estimate material requirements:

(On CS #15)

a. **Linear Conversion**: Linear dimensions are converted to a specific unit of measure to aid in determining such items of

work as the number of required rafters, joists, studs, etc.. Linear values are expressed in feet, inches, and fractions of an inch, or they are expressed in feet and decimal parts of a foot.

(1) Feet x 12 = Inches.

Example: **3' x 12" = 36"**

(2) Inches ÷ 12 = Decimal feet.

Example: **36" ÷ 12 = 3.00'**

(3) Fraction numerator ÷ Denominator = Decimal parts of an inch (in).

Example: ¾" is **3 ÷ 4 = 0.75″**

(4) Decimal parts of an inch ÷ 12 = Decimal parts of a foot (ft).

Example: **0.5" ÷ 12 = 0.04167′**

(5) NOTE: 12 inches, equals 1 linear foot.

INTERIM TRANSITION: Do you questions for me? Now let's move on to a quick demonstration of additional Linear Conversions.

(On CS #16)

INSTRUCTORS NOTE

Introduce guided demonstration. Solve three problems each on the dry erase board to demonstrate linear conversion calculations.

DEMONSTRATION. (15 Min) Gather the students' attention on the dry-erase board for additional Linear Conversion calculations.

STUDENT ROLE: Active participation in answering proving questions from the instructor on linear Conversion calculations.

INSTRUCTOR(s) ROLE: Using the dry-erase board, write out additional examples of:

Feet x 12 = Inches

1) 12′ x 12 = **144″**
2) 9′ x 12 = **108″**
3) 13′-6″ x 12 = **150″**

Inches ÷ 12 = Decimal feet
1) 44″ ÷ 12 = **3.67′**
2) 12″ ÷ 12 = **1.00′**
3) 33″ ÷ 12 = **2.75″**

Fraction numerator ÷ Denominator = Decimal parts of an inch (in)
1) 7/8″ is 7 ÷ 8 = **0.88″**
2) 3/8″ is 3 ÷ 8 = **0.38″**
3) 5/8″ is 5 ÷ 8 = **0.62″**

Decimal parts of an inch ÷ 12 = Decimal parts of a foot (ft).
1) 0.75″ ÷ 12 = **0.06′**
2) 0.875″ ÷ 12 = **0.07′**
3) 0.625″ ÷ 12 = 0.05′

1. SAFETY BRIEF: No safety concerns with this class.

2. SUPERVISION & GUIDANCE: Ensure all students actively participate in verification of the above numbers and calculations.

DEBRIEF: What you have just seen are examples of linear conversion calculations. Keep these in mind when you are producing project materials estimations for Bill of Materials.

INTERIM TRANSITION: Do you have any questions on linear conversion calculations? Answer questions students may have. Let's move on to Area Conversions.

(On CS #17)

b. **Area Conversion**: The area of a surface is calculated to determine such things as plywood, paint, siding, shingles, and concrete block requirements. Surface areas are expressed as square feet (sqft, or sf).

(1) Rectangles:

(a) Walls:

Length (ft) x Height (ft) = Area (sqft/sf)

Example: **10' x 8' = 80 sqft/sf**

(b) Floors, Ceilings, and Roofs:

Length (ft) x Width (ft) = Area (sqft/sf)

Example: **20' x 10' = 200 sqft/sf**

(2) Triangles:

$$\frac{\text{Base (ft) x Height (ft)}}{2} = \text{Area (sqft/ft)}$$

Example: $\frac{\textbf{10' x 5'}}{2}$ **= 25 sqft/sf**

(3) Trapezoids:

Height (ft) x Half the sum of the parallel sides (ft) = Area (sqft/sf).

Example: **10' H x [(20' A + 40' B) ÷ 2] = 300 sqft/sf**

INTERIM TRANSITION: Do you questions for me? Now let's move on to a quick demonstration of additional Area Conversion calculations.

(On CS #18)

INSTRUCTORS NOTE

Introduce guided demonstration. Solve two problems each on the dry erase board to demonstrate Area Conversion calculations.

DEMONSTRATION. (15 Min) Gather the students' attention on the dry-erase board for additional Area Conversion calculations.

STUDENT ROLE: Active participation in answering proving questions from the instructor on Area Conversion calculations.

INSTRUCTOR(s) ROLE: Using the dry-erase board, along with graphical representations, write out additional examples of:

Rectangular (Wall, Flooring, Roof, Ceiling, etc.)

1) 12'-6" H x 24'-6" L = **306'-3"sqft or 306.25sf**
2) 9' L x 12' W = **108sqft or 108sf**

Triangles (Gable Roof end, etc.)

1) $\frac{\text{44' B x 12' H}}{2}$ = **264sqft or 264sf**

2) $\frac{\text{12' B x 12' H}}{2}$ = **72sqft or 72sf**

Trapezoids
1) ([7′ A + 8′ B] ÷ 2) x 8′ H = **60sqft or 60sf**
2) ([3′ A + 8′ B] ÷ 2) x 4′ H = **22sqft or 22sf**

1. SAFETY BRIEF: No safety concerns with this class.

2. SUPERVISION & GUIDANCE: Ensure all students actively participate in verification of the above calculations and results.

DEBRIEF: What you have just seen are examples of Area Conversion calculations of different shapes you may encounter. Keep these in mind when you are producing project materials estimations for Bill of Materials.

INTERIM TRANSITION: Do you have any questions on Area Conversion calculations? Answer questions students may have. Let's move on to Volume Conversions.

(On CS #19)

c. **Volume Conversion:** Volume is expressed in cubic feet (cuft, or cf) or in cubic yards (cuyd, or cy). These calculations are used to determine concrete, sand, aggregate, and mortar requirements.

(1) Length (ft) x Width (ft) x Height (ft) = Volume (cuft/cf).

Example: **10' x 10' x 8' = 800 cuft/cf**

(2) Volume (cf) ÷ 27 = Volume (cuyd/cy).

Example: **800 cuft ÷ 27 = 29.63 cuyd/cy**

(3) Volume (cy) x 27 = Volume (cuft/cf).

Example: **29.63 cuyd x 27 = 800 cuft/cf**

(a) NOTE: 27 cubic feet, equals 1 cubic yard.

INTERIM TRANSITION: Do you questions for me? Now let's move on to a quick demonstration of additional Volume Calculations.

INSTRUCTORS NOTE
Introduce guided demonstration. Solve two problems each on the

dry erase board to demonstrate Volume Conversion calculations.

DEMONSTRATION. (15 Min) Gather the students' attention on the dry-erase board for additional Volume Conversion calculations.

STUDENT ROLE: Active participation in answering proving questions from the instructor on Volume Conversion calculations.

INSTRUCTOR(s) ROLE: Using the dry-erase board, along with graphical representations, write out additional examples of:

Rectangular (Foundation, Footer, Slab, etc.)

1) 12'-6" W x 24'-6" L = 306'-3"sqft or 306.25sf
   8" (8" ÷ 12 = 0.67') Depth
   288.25sf x 0.67' = **205.19cuft or 205.19cf**

Convert the above cubic feet to cubic yards:

1) 205.19 ÷ 27 = **7.60cuyd or 7.60cy**

Trapezoidal Shape (Berm, etc.)

1) ([7' A + 8' B] ÷ 2) x 8' H = **60sqft or 60sf**
   50' Length of the berm
   60sqft x 50' = **3000cuft or 3000cf**

Convert the above cubic feet to cubic yards:

1) 3000cf ÷ 27 = **111.11cuyd or 111.11cy**

1. **SAFETY BRIEF**: No safety concerns with this class.

2. **SUPERVISION & GUIDANCE**: Ensure all students actively participate in verification of the above calculations and results.

DEBRIEF: What you have just seen are examples of Area Conversion calculations of different shapes you may encounter. Keep these in mind when you are producing project materials estimations or Bill of Materials.

INTERIM TRANSITION: Do you have any questions on Volume Conversion calculations? Answer questions students may have. Let's move on to the "Perimeter Rule" calculation.

(On CS #21)

d. **"Perimeter Rule"**: The "Perimeter Rule" is a progressive calculation which allows you to compute areas and volumes more rapidly. This is done by first calculating the total perimeter linear footage (ft) of the structure being estimated for. There are two formulas for calculating perimeter length based on the shape of the structure.

(1) Rectangular Shaped: Footing dimensions: 32.67' x 16.67', Height: 0.67', Depth: 1.33'.

1 (Outside length (ft) + Inside Width (ft)) x 2 = Total Perimeter Length (ft).

Example: **(32.67' + 14.01') x 2 = 93.36'**

2 Total perimeter length (ft) x Height (ft) = Area (sqft/sf).

Example: **93.36' x 0.67' = 62.55 sqft**

3 Area (sf) x Depth (ft) = Volume (cuft/cf).

Example: **62.55 sqft x 1.33' = 83.19 cuft**

(On CS #22)

(2) Irregular Shaped: Example: Pentagon: Footing Length (one side): 20.48', Height: 0.67', Depth: 1.33'. Total outside perimeter length is 102.4'. Total inside perimeter length is 95.75'.

1 (Total outside perimeter length (ft) + Total inside perimeter length (ft)) ÷ 2 = total perimeter length (ft).

Example: **(102.4' + 95.75') ÷ 2 = 99.08'**

2 Total perimeter length (ft) x Height (ft) = Area (sqft/sf).

Example: **99.08' x 0.67' = 66.38 sqft/sf**

3 Area (sf) x Depth (ft) = Volume (cuft/cf).

Example: **66.38 sqft x 1.33' = 88.28cuft**

INTERIM TRANSITION: Do you questions for me? Now let's move on to a quick demonstration of additional "Perimeter Rule" Calculations.

(On CS #23)

INSTRUCTORS NOTE

Introduce guided demonstration. Solve one problem on the dry erase board to demonstrate "Perimeter Rule" calculations.

DEMONSTRATION. (15 Min) Gather the students attention on the dry-erase board for additional "Perimeter Rule" calculations of a 20' x 40' footer/foundation wall dimension of a vertical construction.

STUDENT ROLE: Active participation in answering proving questions from the instructor on "Perimeter Rule" calculations.

INSTRUCTOR(s) ROLE: Using the dry-erase board, along with graphical representations, write out an example of:

Rectangular Shape (Foundation/Footer Wall, etc.)

1) 20' x 40' with 8" (0.67') Height and 16" (1.33) Depth

Calculate Total Perimeter Length:
(17.34' + 40') x 2 = **114.68'**

Calculate Area:
114.68' x 0.67' = **76.84sqft or 76.84sf**

Calculate Volume:
76.84sf x 1.33' = **102.19cuft or 102.19cf**

Convert the above cubic feet to cubic yards:
102.19 ÷ 27 = **3.78cuyd or 3.78cy**

Irregular Shape (Octagon, etc.)

1) Footing Length (one side): 18.50', Height: 0.67', Depth: 1.33'. Total outside perimeter length is 148.00'. Total inside perimeter length is 137.36'. 8 Sides * 1.33=10.64

Calculate Total Perimeter Length:
(148.00' + 137.36') ÷ 2 = **142.68'**

Calculate Area:
142.68' x 0.67' = **95.60sqft or 95.60sf**

Calculate Volume:
95.60sf x 1.33′ = **127.14cuft or 127.14cf**

Convert the above cubic feet to cubic yards:
127.14 ÷ 27 = **4.71cuyd or 4.71cy**

1. **SAFETY BRIEF**: No safety concerns with this class.

2. **SUPERVISION & GUIDANCE**: Ensure all students actively participate in verification of the above calculations and results.

DEBRIEF: What you have just seen is a demonstration of "perimeter rule". Keep these in mind when you are producing project materials estimations or Bill of Materials.

INTERIM TRANSITION: Do you have any questions on "Perimeter Rule" calculation? Answer questions students may have. Let's move on to the Standard Lumber Length.

(On CS #24)

e. **Standard Lumber Length**: To reduce the amount of waste that is left over after cutting, the standard length of lumber to be used is calculated to determine the optimum standard length of lumber to use for the specific item of work. This calculation is used to determine such things as the number of pieces of floor bridging or wall fire blocking that can be cut from a standard length of lumber. The following sequence is used to determine standard length requirements:

(On CS #25)

(1) Length In Place (LIP) Measurement (in): This is the first step, and is determined by measuring the actual length of one piece of the material from the drawings and converting it to inches.

(2) Quantity of LIP Requirements (ea): This is taken off of the drawings by "counting" or mathematical computation.

(3) Convert Standard Lengths (in): Standard lengths of commercial lumber come in lengths of 8′, 10′, 12′, 14′, and 16′. Each standard length must be converted to inches.

(On CS #26)

(4) Number of LIP Pieces (ea): Determine the number of LIP pieces that can be cut from one standard length of lumber by dividing each converted standard length by the individual LIP measurement. The answer must be **rounded down**.

(5) Number of Standard Lengths (ea): Determine the number of standard lengths required to cut all LIP pieces by dividing the **quantity** of LIP requirements by the **number** of LIP pieces that can be cut from each standard length of lumber. The answer must be **rounded up**.

(On CS #27)

(6) Standard Length to Use (ea): This is the final step, and is determined by multiplying each standard length in feet (ft) by the number of LIP pieces that can be cut from that standard length. The result will be the total linear feet of standard lumber length. Compare each computed value and select the **lowest value**. This will be the standard length of lumber to be used to cut all LIP pieces with the least amount of waste left over.

(On CS #28)

Example: You have determined that 13 pieces of floor bridging is needed to stiffen the floor joists. The LIP measurement of one piece of bridging is 1'-9" in length.

Converted Standard Length	LIP pieces cut from std lgth	Number of std lgth	Standard lgth to use
8' x 12" = 96"	96" ÷ 21" = 4	13 ÷ 4 = 4	8' x 4 =32'
10' x 12" = 120"	120" ÷ 21" = 5	13 ÷ 5 = 3	10' x 3 = 30'
12' x 12" = 144"	144" ÷ 21" = 6	13 ÷ 6 = 3	12' x 3 = 36'
14' x 12" = 168"	168" ÷ 21" = 8	13 ÷ 8 = 2	**14' x 2 = 28'**
16' x 12" = 192"	192" ÷ 21" = 9	13 ÷ 9 = 2	16' x 2 = 32'

INTERIM TRANSITION: Do you have any questions on Length in Place (LIP) estimations? Answer questions students may have. Let's take a ten minute break and then you will move on to your practical exercises.

(On CS #29)

(BREAK 10 Min)

INTERIM TRANSITION: Do you have any more questions before you move on to your practical exercises.

(On CS #30)

INSTRUCTORS NOTE
Introduce Practical Application. Hand out practice sheets.

PRACTICAL APPLICATION: (1.0 Hrs) This PA is designed to test your knowledge on all of the items covered so far. This PA should take about 1 hour to complete. Any practical problems that you do not finish will be completed as homework and turned in before class resumes the following day.

PRACTICE: Do as assigned by the instructor.

PROVIDE-HELP: Walk around the classroom and assist all students.

SAFETY BRIEF: No safety concerns with this class.

SUPERVISION & GUIDANCE: Be sure to follow the step by step directions covered in your student outline and from the demonstration presented earlier. Answer any questions.

DEBRIEF: After the PA, ask the students if there are any questions.

TRANSITION: Do you have any questions concerning the procedures of estimating or mathematical equations?

(On CS #31)

OPPORTUNITY FOR QUESTIONS

1. **QUESTIONS FROM THE CLASS**: (Answer student's questions.)

2. **QUESTIONS TO THE CLASS**:

a. **QUESTION**: Why would you want to select the lowest value of your LIP calculations off of the standard lumber length?

ANSWER: Because the least value is related to the least amount of waste.

b. **QUESTION**: What are the three fundamental conversion formulas that are used to estimate material requirements?

ANSWER: Linear, area, and volume conversions.

(BREAK 10 min)

TRANSITION: During the last 4 hours we have discussed the principles of estimating and the mathematical equations that are used. We will now discuss material takeoff lists.

(On CS #32)

3. **MATERIAL TAKEOFF LISTS**: **(120 Min)** The Materials Takeoff List (MTO) is the first step in the estimating process. The MTO is broken down into three types:

- Concrete and Masonry

- Lumber

- Finished Materials

MTOs are a listing of all items of work, dimensions (sizes), quantities of work, and units of measure conversions. The information for completing the MTO is extracted from project specifications and working drawings. To ensure an estimate's completeness, follow the basic rules for compiling takeoff lists:

a. Study the entire set of drawings, including notes and written specifications.

b. Measure everything as it is shown.

c. Measure everything that you can see.

(On CS #33)

d. Time savers: "Tricks of the trade" are used by most estimators. A partial list follows, the rest are learned by experience.

(1) Never use long words if short ones will describe an item of work.

(2) Abbreviate words as necessary to simplify descriptions.

(3) Keep all dimensions, figures, and notes that might be useful later.

(4) Always start in the same place on each drawing, and progress around the structure in the same direction.

(5) Check (mark up) the drawing as you take off items of work.

(6) Take advantage of duplication of design.

(On CS #34)

e. Precedence. If a work item is different, list it separately on the MTO. The items of work are estimated in a logical sequence using the following order of precedence:

(On CS #35)

(1) Excavation: Excavation is measured by the **cubic yard** on the MTO. When calculating the amount of excavation to be done, use the dimension measurements for the outside face of the footings and not the dimensions of the outside face of the walls.

(2) Concrete: Concrete is measured by the **cubic foot** on the MTO. Concrete may be ready-mix, or mixed on the job site. When estimating concrete for footings, walls, piers, slabs, and sidewalks, the compressive strength (psi) must be annotated in its description.

(a) Ready mix or Truck mix concrete is mixed at a local concrete mix plant and then delivered to the project site. The total volume for ready-mix is taken off as **cubic feet** on the MTO.

(b) Batch mix concrete is mixed on, or near the job site. This type of concrete is a mix of Portland cement, sand, aggregate, and water. The total volume for a batch mix is taken off as **cubic feet** on the MTO. Water is not included or considered in the takeoff list, but the mix ratio must be noted in the description of work.

(c) Reinforcement bar (Rebar) is taken off by the **lineal foot** on the MTO. The standard length for rebar is 20', and an allowance of twelve inches must be made in the takeoff for lap splices.

(d) Wire Mesh is taken off by the **square foot** on the MTO. The square footage of a concrete slab is used to takeoff wire mesh requirements. The lap requirement must be added to the computed area, and annotated in the takeoff description.

(e) Polyethylene vapor barrier material is taken off by the **square foot**. Rolls of vapor barrier come in widths of 3', 4', 6', 8', 12', 16', and 20' feet, and are 100' in length.

(f) Expansion joint filler is taken off by the **lineal foot** on the MTO. They come in thickness' of 1/4", 3/8", 1/2", 3/4", and 1". Common widths are from 2" to 8", and in lengths of 10'.

(g) Base course material is taken off as **cubic feet** on the MTO. A detailed description of the material must be annotated in the item of work description.

(3) Masonry (i.e. CMU)

(a) Masonry wall requirements are taken off on the MTO as the **square footage** of wall surface area to be constructed.

(b) Masonry wall reinforcement is taken off as **lineal feet** on the MTO, for both vertical and horizontal reinforcement.

(On CS #36)

(4) Lumber: Lumber is taken off as the number of **standard lengths**, plywood and siding is taken off by the **square footage** of area to be covered, and finish trim work is taken off by the **lineal foot**. Sizes and grades of lumber and plywood, and trim styles must be noted in the takeoff lists. Lumber is broken down into two separate categories on a lumber MTO.

(a) Rough carpentry:

1 Floor framing (lumber and plywood)

2 Wall framing (lumber and plywood)

3 Roof framing (lumber and plywood)

4 Wooden concrete forms (lumber and plywood)

(b) Finish carpentry:

1 Siding

2 Trim work

(On CS #37)

(5) Finish Materials: Finish materials are those items needed to "finish" the exterior and interior of the structure.

(a) Doors and windows are taken off as **each,** on the MTO.

(b) Shingles are taken off on the MTO by the **square footage** of the area to be covered.

(c) Drywall is taken off on the MTO by the **square footage** of the area to be covered.

(d) Paint is taken off on the MTO by the **square footage** of the area to be covered.

(e) Insulation is taken off on the MTO by the **square footage** of the area to be covered.

INTERIM TRANSITION: Do you have questions for me? Now let's move on to the Materials Takeoff (MTO) demonstration.

(On CS #38)

INSTRUCTORS NOTE

Conduct demonstration using the master answer keys and support drawings to clarify the calculations and procedures to develop concrete/masonry and lumber MTO's.

DEMONSTRATION. (60 Min) Gather the students attention on the dry-erase board, presentation slides and the desk with supporting drawing plans for demonstration of Materials Takeoff (MTO) calculations and production.

STUDENT ROLE: Active participation in answering proving questions from the instructor on MTO calculations.

INSTRUCTOR(s) ROLE: Using the dry-erase board, along with supporting drawing plans on the computer slides and MTO sheets, demonstrate MTO calculations.

Concrete and Masonry Material Takeoff Sheet				
Item of Work	**Dimensions**	**Qty Required**	**Concrete Volume (L x W x H)**	**Masonry Area (L x H)**
Concrete Footing	**(32.00' + 14.67') x 2 = 93.34**			
	93.34' x 1.33' x 0.67' = 83.18	**1**	**83.18 cuft**	**----------**
Concrete Pilaster Footings	**2.0' x 0.67' x 0.67' = 0.90**	**2**	**1.80 cuft**	**----------**
Concrete Piers	**2.0' x 2.0' x 1.0' = 4.0**	**2**	**8.00 cuft**	**----------**
CMU Foundation Wall	**(32.0' + 14.67') x 2 = 93.34**			
	93.34' x 3.33' = 310.82	**1**	**----------**	**310.82 sqft**
CMU Pilasters	**1.33' x 2.67' = 3.55**	**2**	**----------**	**7.10 sqft**
CMU Columns	**1.33' x 2.67' = 3.55**	**2**	**----------**	**7.10 sqft**

Project: MTO Demo	Total Volume of Concrete =	**92.98** cuft	
Estimator: GySgt Thomas	Total Surface Area of Masonry Units =		**325.02** sqft

Lumber Material Takeoff List

DESCRIPTIVE ITEM OF WORK	ITEM U/M	LIP MEASURE	LIP QUANTITY	STD. LGTH TO USE	STD. LGTH QUANTITY	LIP PCS/ STD. LGTH
2 x 6 Sill (treated)	ea	**94.16'**	**N/A**	**16'**	**6**	**N/A**
2 x 8 Header Joists	ea	**32.0'**	**2**	**16'**	**4**	**N/A**
2 x 8 End Joists	ea	**15.75'**	**2**	**16'**	**2**	**N/A**
2 x 8 Floor Joists	ea	**15.75'**	**15**	**16'**	**15**	**N/A**
2 x 8 Solid Floor Bridging	ea	**22.5"**	**32**	**8'**	**8**	**4**
				16'	**4**	**8**
2 x 10 Built-up Girder	ea	**30.67'**	**3**	**16'**	**6**	**N/A**
3/4" Plywood Subfloor	ea	**512 sqft**	**N/A**	**32 sqft**	**16**	**N/A**

Bridging Calculation: LIP

8' x 12" = 96"	96" ÷ 22.5" = 4	32 ÷ 4 = 8	8' x 8 = 64	Use due to ease of handling.
10' x 12" = 120"	120" ÷ 22.5" = 5	32 ÷ 5 = 7	10' x 7 = 70	
12' x 12" = 144"	144" ÷ 22.5" = 6	32 ÷ 6 = 6	12' x 6 = 72	
14' x 12" = 168"	168" ÷ 22.5" = 7	32 ÷ 7 = 5	14' x 5 = 70	
16' x 12" = 192"	192" ÷ 22.5" = 8	32 ÷ 8 = 4	16' x 4 = 64	Use 16' due to ease of ordering.

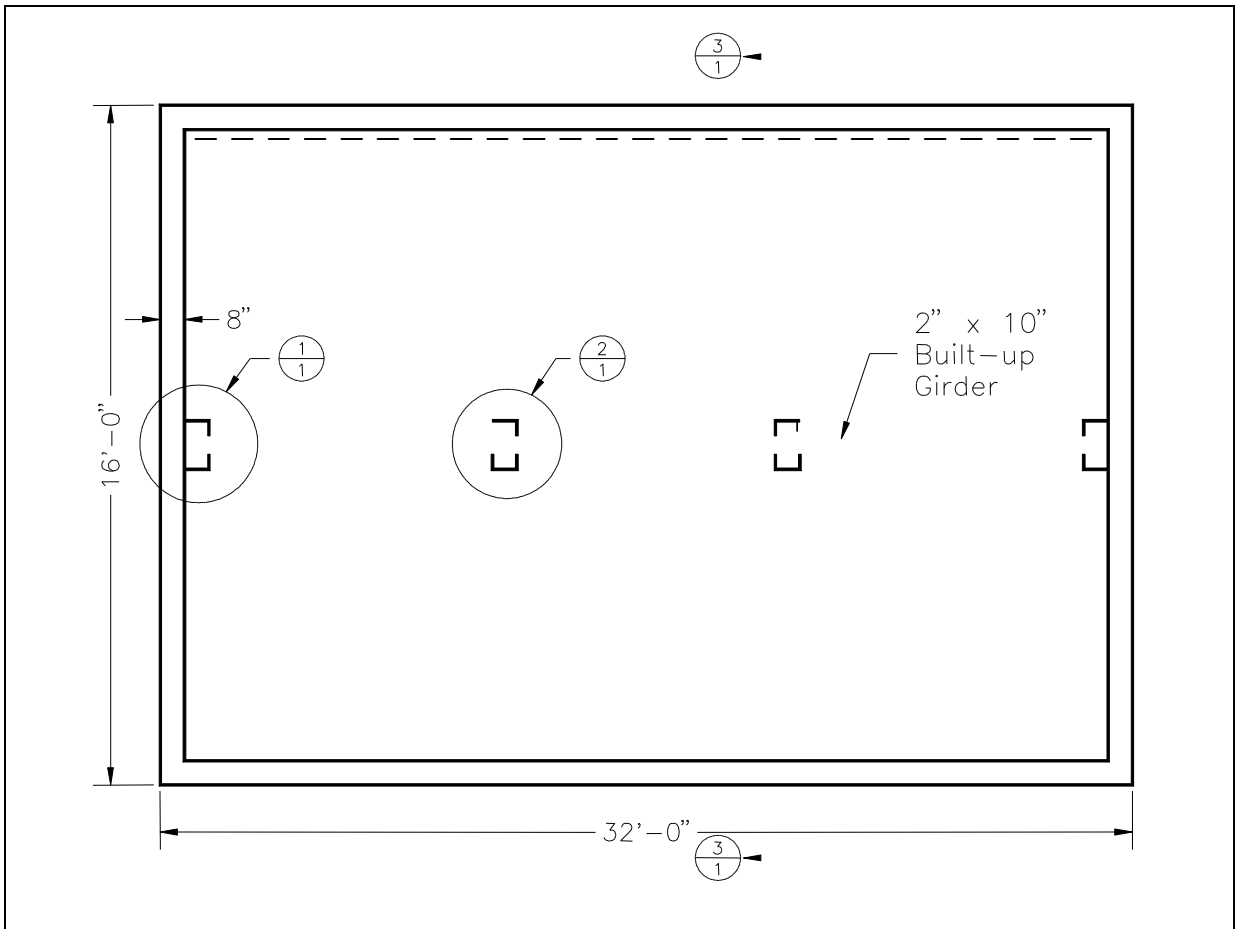
Project: MTO Demo	Date: 140801
	Sheet of

1. **SAFETY BRIEF**: No safety concerns with this class.

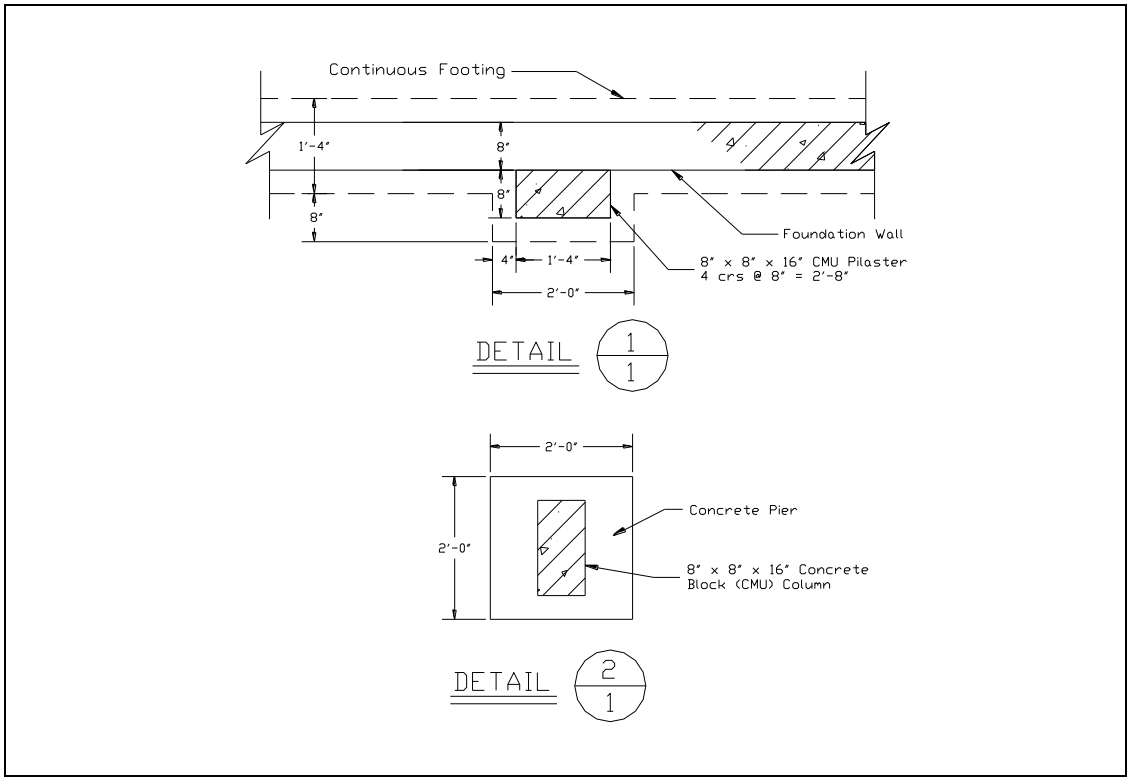
2. <u>SUPERVISION & GUIDANCE</u>: Ensure all students actively participate in verification of the above calculations and results.

<u>DEBRIEF:</u> What you have just seen is a demonstration of a materials estimations using MTO calculations. Keep these in mind when you are producing project estimations for Bill of Materials.

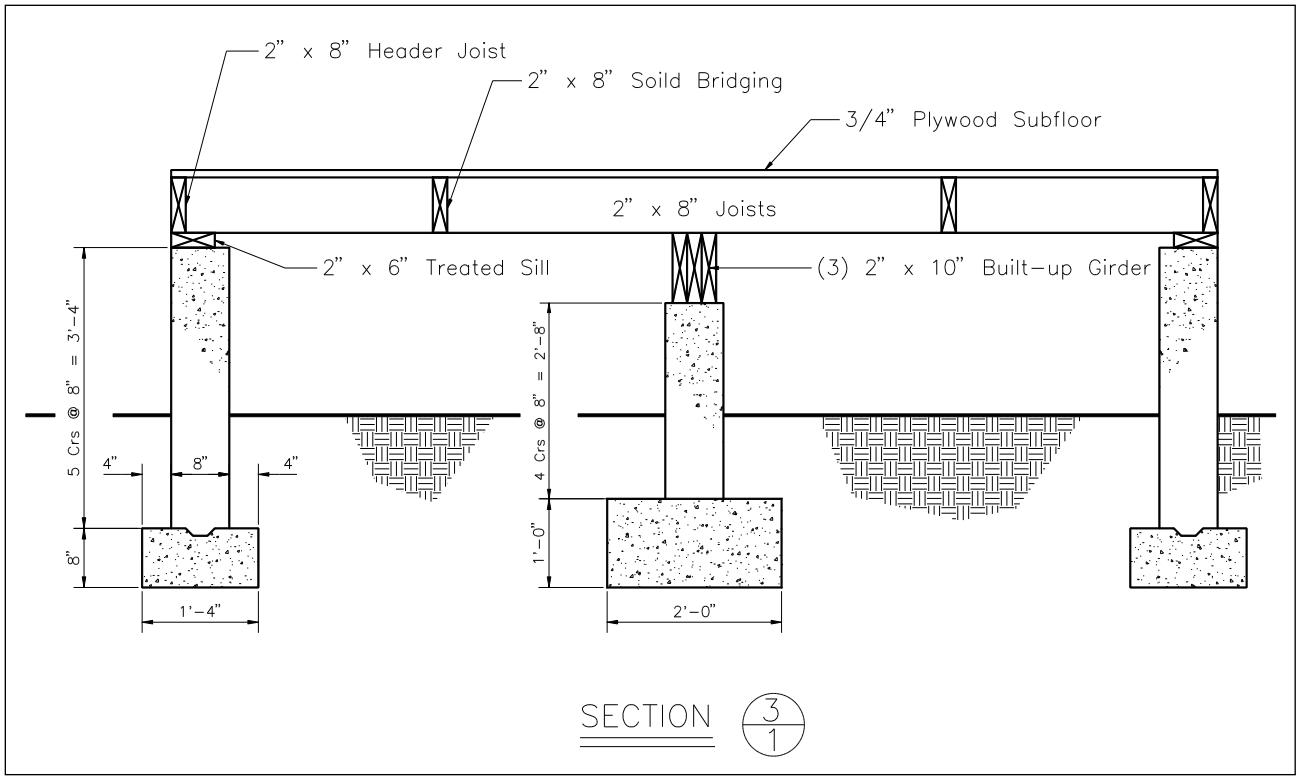
(On CS #39)



(On CS #40)


Continuous Footing
1'-4"
8"
8"
8"
Foundation Wall
4"
1'-4"
8" x 8" x 16" CMU Pilaster
4 crs @ 8" = 2'-8"
2'-0"
DETAIL 1/1
2'-0"
2'-0"
Concrete Pier
8" x 8" x 16" Concrete
Block (CMU) Column
DETAIL 2/1

(On CS #41)

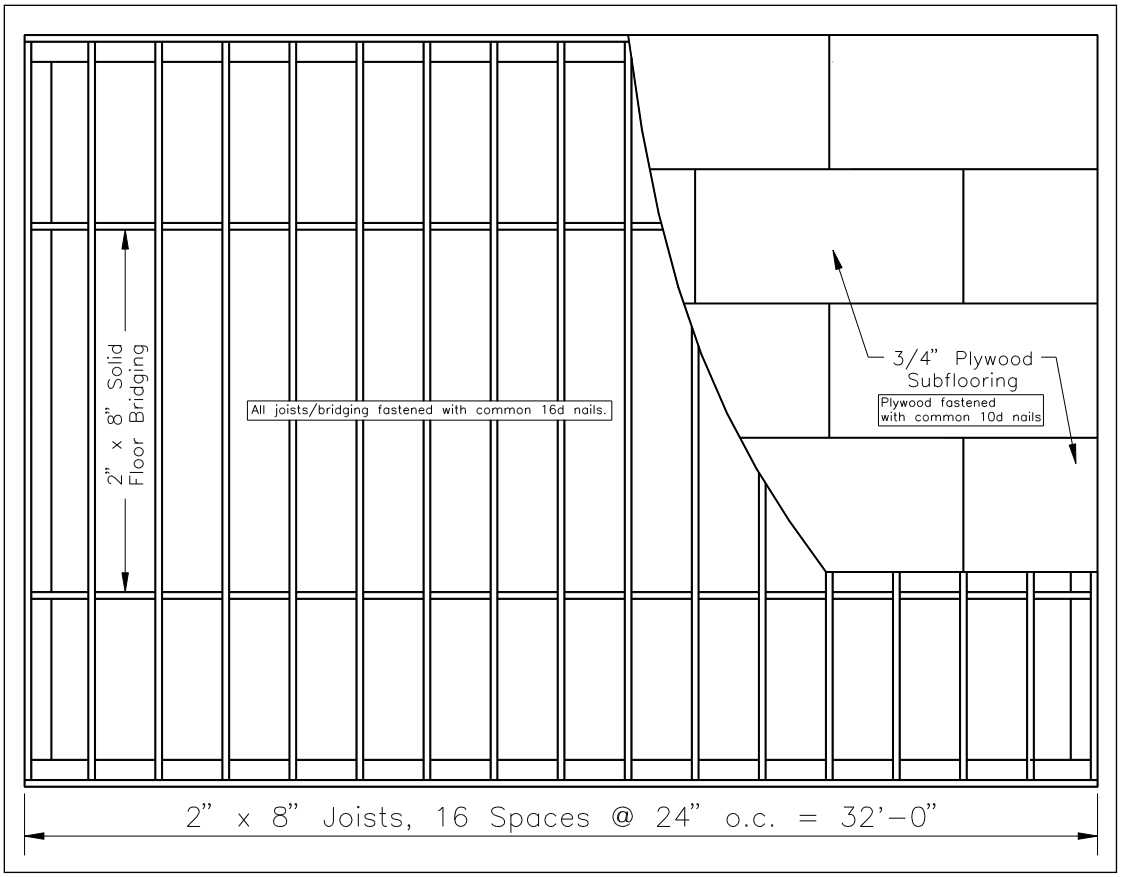


(On CS #42)

Concrete and Masonry Material Takeoff Sheet				
Item of Work	**Dimensions**	**Quantity Required**	**Concrete Volume (L x W x H)**	**Masonry Area (L x H)**

Project:	Total Volume of Concrete =			
Estimator:	Total Surface Area of Masonry Units =			

(On CS #43)



(On CS #44)

Lumber Material Takeoff List						
DESCRIPTIVE ITEM OF WORK	**ITEM U/M**	**LIP MEASURE**	**LIP QUANTITY**	**STD. LGTH TO USE**	**STD. LGTH QUANTITY**	**LIP PCS/ STD. LGTH**
Bridging Calculation: LIP						

Converted Standard Length	LIP pieces cut from std lgth	Number of std lgth	Standard lgth to use			
8' x 12" = 96"						
10' x 12" = 120"						
12' x 12" = 144"						
14' x 12" = 168"						
16' x 12" = 192"						
Project:					Date:	
Estimator:					Sheet of	

INTERIM TRANSITION: Do you have any questions on MTO calculations? Answer questions students may have. Let's take a ten minute break and then we will move on to your practical exercises.

(On CS #45)

(BREAK 10 Min)

INTERIM TRANSITION: Are there additional questions you may have thought of during the break before we move on to your MTO Practical Application?

(On CS #46)

INSTRUCTORS NOTE
Introduce Practical Application. Hand out practice sheets.

PRACTICAL APPLICATION: (3.5 Hrs) This PA is designed to test your knowledge on all of the items covered during the Material Takeoff portion of this lesson. This PA should take about 2.5 hours to complete.

PRACTICE: Do as assigned by the instructor. Complete MTO only for Part #.

PROVIDE-HELP: Walk around the classroom and assist all students.

SAFETY BRIEF: No safety concerns with this class.

SUPERVISION & GUIDANCE: Be sure to follow the step by step directions covered in your student outline and from the demonstration presented earlier. Answer any questions.

DEBRIEF: After the PA, ask the students if there are any questions.

TRANSITION: Do you have any questions concerning material takeoff sheets?

(On CS #47)

OPPORTUNITY FOR QUESTIONS

1. **QUESTIONS FROM THE CLASS**: Answer students' questions.

2. **QUESTIONS TO THE CLASS**:

   a. **QUESTION**: What is a materials takeoff sheet used for?

   ANSWER: The MTO is a listing of all items of work, dimensions (sizes), quantities of work, and units of measure conversions.

   b. **QUESTION**: Where does the information come from to create a MTO?

   ANSWER: It is extracted from project specifications and working drawings.

(On CS #48)

(BREAK 10 Min)

TRANSITION: During the last period of instruction we discussed material takeoff procedures. We will now discuss creating a materials estimate.

(On CS #49)

4. **MATERIAL ESTIMATES: (90 Min)** Once the takeoff lists have been completed, the next step in the estimating process is the creation of the Materials Estimate.

a. The materials estimate puts the information contained in the material takeoff lists into a more detailed form showing:

(1) Description of work.

(2) Detailed description of materials.

(3) Unit of measure (unit of issue) for materials.

(4) Quantities of "dissimilar" (different) materials.

(5) Quantities of consolidated "like" (similar) materials.

(6) Waste factor allowances.

(7) Total material quantities after waste has been included.

INSTRUCTORS NOTE
Refer students to waste factor chart in outline to clarify understanding.

STANDARD WASTE FACTORS

MATERIAL	**WASTE**		**MATERIAL**	**WASTE**
CONCRETE (Ready Mix)	10%		DIMENSION LUMBER	10%
SAND	10%		TIMBER	5%
GRAVEL	10%		PLYWOOD	15%
CEMENT	5%		TRUSS'S	2%
CONCRETE BLOCK	2%		DRYWALL	15%
REINFORCEMENT BAR	10%		NAILS	10%
WELDED WIRE	10%		SCREWS	5%
CRUSHED ROCK	10%		ANCHOR BOLTS	5%
POLY VAPOR BARRIER	15%		BOLTS	5%
FILL DIRT	15%		DRYWALL SCREWS	10%
BATT INSULATION	5%		DRYWALL TAPE	10%
PAINT	10%		DRYWALL COMPOUND	10%
HINGES	2%		LAP SIDING	10%
INSECT SCREEN	10%		T-111 SIDING	10%

ROOFING FELT	20%		CORRUGATED ROOFING	10%
ROLL ROOFING	20%		ASPHALT SHINGLES	5%
DOORS	N/A		WINDOWS	N/A
ELECTRICAL WIRE	20%		ELECTRICAL OUTLETS	2%
ELECTRICAL SWITCHES	2%		LIGHTING	N/A
ELECTRICAL CONDUIT	15%		JUNCTION BOXES	2%
SERVICE HEAD	N/A		CONDUIT CONNECTORS	15%
PLUMBING FIXTURES	N/A		PLUMBING PIPE	15%
PIPE COUPLINGS	15%		FORM TIE WIRE	15%

b. Information is compiled from the MTO sheets and project specifications. Further mathematical calculations are required to consolidate the material requirements into their respective units of measure, and determine total quantities.

(On CS #50)

(1) Ready-Mix or Truck-Mix Concrete: Volumes are extracted from the concrete and masonry MTO and converted to **cubic yards**. The appropriate waste factor is then added to the consolidated quantity to compute the total ready-mix concrete requirements to be listed on the material estimate sheet. Round up.

(a) NOTE: Ready-mix concrete is estimated to the nearest **whole cubic yard (cy)**.

(On CS #51)

(2) Batch Mix Concrete: Water is not figured into the estimate, nor is it a proportion in the calculations. A standard mix ratio of 1 part Portland cement, 2 parts sand, and 3 parts gravel (1:2:3) will create a concrete mix that has a compressive strength of 2000 psi at 28 days. The following steps are used to calculate batch mix requirements.

(On CS #52)

(a) Total concrete volume from MTO (cf) x 1.5 (3/2 rule) = Concrete Proportion Ratio (CPR).

(b) Apply CPR ratio to mix ratio (1:2:3). Ratio proportions when added together equal 6 parts (1/6 Portland cement, 2/6 Sand, and 3/6 Gravel).

1 (1/6 x CPR) + Waste factor = Total number of bags of Portland cement (bg). Round up to the nearest whole bag.

a NOTE: 1 bag of Portland contains 1 cubic foot of cement. Portland cement is estimated to the nearest **whole bag (bg).**

2 ((2/6 x CPR) ÷ 27) + Waste factor = Total Sand (cy). Round up to nearest half cubic yard.

a NOTE: Sand is estimated to the nearest **half cubic yard (cy).**

3 ((3/6 x CPR) ÷ 27) + Waste factor = Total Gravel (cy). Round up to nearest whole cubic yard.

a NOTE: Gravel is estimated to the nearest **cubic yard (cy).**

(On CS #53)

(3) Concrete Masonry Units (CMU): Concrete blocks (CMU) are manufactured in numerous styles, but come in standardized full and half lengths. One concrete block has a surface area of 0.89 square feet, using the nominal dimensions of the length and height of the block. The nominal dimensions of a full CMU block are 16" x 8" x 8", and the actual dimensions of a full block are 15 5/8 x 7 5/8" x 7 5/8". To calculate the CMU block requirements to be listed on the material estimate sheet use the following computations:
(On CS #54)

(a) Total masonry surface area from MTO (sf) ÷ 0.89 (sf) = Number of CMU blocks (ea).

(b) Number of CMU blocks + Waste factor = Total CMU blocks (ea). Round up to nearest whole block.

1 NOTE: CMU block is estimated to the nearest **whole block (ea).**

(On CS #55)

(4) Mortar: Mortar is used to bond CMU blocks together. Mortar is a batch mix of proportional parts of Portland cement, masonry cement, and sand respectively. Water

is not figured into the estimate, nor is it a proportion in the calculations. A standard mix ratio of 1 part Portland cement, 1 part masonry cement, and 6 parts sand (1:1:6) will create a mortar batch mix that has a compressive strength of 2000 psi at 28 days. Concrete blocks are bonded together with a 3/8" mortar head joint which will bond 0.054 cubic feet of block area. The following steps are used to calculate batch mix requirements:

(On CS #56)

(a) Total estimated CMU blocks (ea) x 0.054 (cf) = Total amount of mortar to bond all blocks (cf).

(b) Apply the total amount of mortar to mix ratio (1:1:6). Ratio proportions when added together equal 8 parts (1/8 Portland cement, 1/8 Masonry cement, and 6/8 Sand).

1 (1/8 x Mortar total) + Waste factor = Total number of bags of Portland cement (bg). Round up to the nearest whole bag.

a NOTE: 1 bag of Portland contains 1 cubic foot of cement. Portland cement is estimated to the nearest **whole bag (bg).**

2 (1/8 x Mortar total) + Waste factor = Total number of bags of Masonry cement (bg). Round up to nearest whole bag.

a NOTE: 1 bag of Masonry cement contains 1 cubic foot of cement. Masonry cement is estimated to the nearest **whole bag (bg).**

3 ((6/8 x Mortar total) ÷ 27) + Waste factor = Total Sand (cy). Round up to nearest half cubic yard.

a NOTE: Sand is estimated to the nearest **half cubic yard (cy).**

(On CS #57)

(5) Boards/Lumber/Timber/Plywood: The unit of measure used to estimate board, lumber, and timber requirements is the **board foot** (bf), and the unit of measure for plywood is the **sheet** (sh). A board foot is a piece of wood having an end area of 12 square inches, and a length of 1 foot.

(a) NOTE: One sheet of plywood has a surface area of 32 square feet. The following sequence is used to compute the lumber requirements to be listed on the materials estimate sheet.

(On CS #58)

(a) Consolidate and total all "like" (similar) wood sizes and grades. Calculate board footage using: ((Thickness (in) x Width (in) x Length (ft) x Quantity) ÷ 12) + Waste factor = Total board feet (bf).

(b) Total all "dissimilar" (different) wood sizes and grades. Calculate board footage using: ((Thickness (in) x Width (in) x Length (ft) x Quantity) ÷ 12) + Waste factor = Total board feet (bf).

(On CS #59)

(c) Consolidate and total all "like" (similar) plywood sizes and veneer grades. Calculate plywood totals using: (Total surface area to be covered from MTO (sf) ÷ 32 (sf)) + Waste factor = Total sheets of plywood (sh).

(d) Total all "dissimilar" (different) plywood sizes and veneer grades. Calculate plywood totals using: (Total surface area to be covered from MTO (sf) ÷ 32 (sf)) + Waste factor = Total sheets of plywood (sh).

1 NOTE: Boards, lumber, and timber are estimated to the nearest **board foot**. Plywood is estimated to the nearest **whole sheet**.

(On CS #60)

(6) Nail Fasteners: The unit of measure for nail requirements is the **pound** (lb). There are three separate formulas (based on nail size) which are used to calculate the estimated amount of nails required to fasten boards, lumber, timber, and plywood.

(a) Nail sizes 2d to 12d: ((Nail size x Total board footage (bf) of lumber to be fastened) ÷ 400) + Waste factor = Total Nails (lb). Round up to the nearest pound (lb).

1 NOTE: The number 400 is a pre-designed constant for estimating these nail sizes. Nails are estimated to the nearest **whole pound.**

(On CS #61)

(b) Nail sizes over 12d to 60d: ((Nail size x Total board footage (bf) of lumber to be fastened) ÷ 600) + Waste factor = Total Nails (lb). Round up to the nearest pound (lb).

(c) Nail sizes 2d to 12d for plywood: ((32 (sf) x Total number of sheets (sh) to be fastened) ÷ 400) + Waste factor = Total Nails (lb).

(On CS #62)

MATERIAL ESTIMATE SHEET

WORK DESCRIPTION	DETAILED MATERIAL DESCRIPTION	MATERIAL U/I	MATERIAL QUANTITY	WASTE FACTOR	TOTAL QUANTITY
Concrete					
Masonry					
Rough Carpentry					

Project:				Date:	
Estimator:				Sheet of	

INTERIM TRANSITION: Do you questions for me? Now let's move on to the demonstration of Materials Estimation Sheet (MES) development.

(On CS #63)

INSTRUCTORS NOTE

Conduct demonstration to clarify the calculations and procedures to develop an Material Estimation Sheet.

DEMONSTRATION. (60 Min) Gather the students attention on the dry-erase board and the desk with supporting drawing plans, Materials Takeoff (MTO) sheet, for a demonstration of the Material Estimation Sheet (MES).

STUDENT ROLE: Active participation in answering proving questions from the instructor on MES.

INSTRUCTOR(s) ROLE: Using the dry-erase board, along with supporting drawing plans and completed MTO sheet, demonstrate MES calculations.

MATERIAL ESTIMATE SHEET

WORK DESCRIPTION	DETAILED MATERIAL DESCRIPTION	MATERIAL U/I	MATERIAL QTY	WASTE FACTOR	TOTAL QUANTITY
Concrete					
92.98 ÷ 27 = 3.44	Ready-mix, 2,000 psi	cuyd	**3.44**	10%	**4.0**
92.98 x 1.5 = 139.47	Batch-mix (1:2:3 ratio)				
1/6 x 139.47 = 23.25	Portland Cement	bg	**23.25**	5%	**25.0**
(2/6 x 139.47) ÷ 27 = 1.72	Sand	cuyd	**1.72**	10%	**2.0**
(3/6 x 139.47) ÷ 27 = 2.58	Gravel	cuyd	**2.58**	10%	**3.0**

Masonry					
325.02 ÷ 0.89 = 365.19	Light Weight, 8" x 8" x 16"	ea	**365.19**	2%	**373.0**
373 x 0.054 = 20.14	Batch-mix Mortar(1:1:6)				
1/8 x 20.14 = 2.52	Masonry Cement	bg	**2.52**	5%	**3.0**
(6/8 x 20.14) ÷ 27 = 0.56	Sand	cuyd	**0.56**	10%	**1.0**
Rough Carpentry					
(2 x 6 x 16 x 6) ÷ 12 =	2" x 6" x 16' Press Treated	bf	**96.0**	10%	**106.0**
(2 x 8 x 16 x 25) ÷ 12 =	2" x 8" x 16' #2 Common Southern Yellow Pine	bf	**533.33**	10%	**587.0**

WORK DESCRIPTION	DETAILED MATERIAL DESCRIPTION	MATERIAL U/I	MATERIAL QTY	WASTE FACTOR	TOTAL QUANTITY
(2 x 8 x 16 x 21) ÷ 12 =	2" x 8" x 16' #2 Common Southern Yellow Pine	bf	**448.0**	10%	**493.0**
(2 x 8 x 8 x 8) ÷ 12 =	2" x 8" x 8' #2 Common Southern Yellow Pine	bf	**85.33**	10%	**94.0**
(2 x 10 x 16 x 6) ÷ 12 =	2" x 10" x 16' #2 Common Southern Yellow Pine	bf	**160.0**	10%	**176.0**
512 ÷ 32 =	Interior	sh	**16**	15%	**19.0**

1. **SAFETY BRIEF**: No safety concerns with this class.

2. **SUPERVISION & GUIDANCE**: Ensure all students actively participate in verification of the above calculations and results.

DEBRIEF: What you have just seen is a demonstration of a materials estimations off of the MTO product. Keep these in mind when you are producing Bill of Materials for a particular construction project.

INTERIM TRANSITION: Do you have any questions on MES calculations? Answer questions students may have. Let's take a 10 minute break and then we will move on to your practical exercises.

(On CS #64)

(BREAK 10 Min)

INTERIM TRANSITION: Are there additional questions you may have thought of during the break before we move on to your MES Practical Application?

(On CS #65)

INSTRUCTORS NOTE

Introduce Practical Application. Hand out practice sheets.

PRACTICAL APPLICATION: (3.5 Hrs) This PA is designed to test your knowledge on all of the items covered during the Material Takeoff portion of this lesson. This PA should take about 2.5 hours to complete. Any practical problems that you do not finish will be completed as homework and turned in before class resumes the following day.

PRACTICE: Do as assigned by the instructor. Complete MES for Part #1 and MTO and MES for Part #2.

PROVIDE-HELP: Walk around the classroom and assist all students.

SAFETY BRIEF: No safety concerns with this class.

SUPERVISION & GUIDANCE: Be sure to follow the step by step directions covered in your student outline and from the demonstration presented earlier. Answer any questions.

DEBRIEF: After the PA, ask the students if there are any questions.

TRANSITION: Do you have any questions concerning MES calculations?

(On CS #66)

OPPORTUNITY FOR QUESTIONS

1. **QUESTIONS FROM THE CLASS:** (Answer students' questions.)

2. **QUESTIONS TO THE CLASS:**

   a. **QUESTION:** What is the purpose of a materials estimate sheet?

      ANSWER: Materials estimates put the information contained in the material takeoff lists into a more detailed form.

   b. **QUESTION:** What is a "board foot"?

ANSWER: A board foot is a piece of wood having an end area of 12 square inches, and a length of 1 foot.

(On CS #67)

(BREAK 10 Min)

TRANSITION: During the last period of instruction we discussed material estimate procedures. We will now discuss creating the bill of materials.

(On CS #68)

5. **BILL OF MATERIALS: (30 Min)** The creation of the bill of materials is the final step in the estimating process. The bill of materials is a consolidated listing of all material descriptions, quantities, NSN's, units of issue, unit costs, total cost of the individual items, and the total cost of all materials required for the project.

a. The finalized bill of materials listing is the source document that is used for the procurement of all the materials that are necessary for the construction of the project.

b. In addition to the required information listed previously, it is necessary to annotate the source of where the material is to be procured, and any substitute materials that are acceptable in the event the estimated item is not available.

c. Upon completion of the bill of materials, copies of all estimating documents and calculations are placed in the project files for future reference in the event a similar project requires construction in the future. This will prevent duplication of estimating effort.

(On CS #69)

STANDARD UNITS OF MEASURE

MATERIAL	U/M		MATERIAL	U/M
CONCRETE (Ready Mix)	cuyd		DIMENSION LUMBER	bf
SAND	1/2 cuyd		TIMBER	bf
GRAVEL	1/2 cuyd		PLYWOOD	sh
CEMENT	bg		TRUSS'S	ea
CONCRETE BLOCK	ea		DRYWALL	sh
REINFORCEMENT BAR	ft		NAILS	lb
WELDED WIRE	ro		SCREWS	bx

CRUSHED ROCK	cuyd		ANCHOR BOLTS	ea
POLY VAPOR BARRIER	ro		BOLTS	ea
FILL DIRT	cuyd		DRYWALL SCREWS	bx
BATT INSULATION	ro		DRYWALL TAPE	ro
PAINT	ga		DRYWALL COMPOUND	ga
HINGES	ea		LAP SIDING	sq
INSECT SCREEN	ro		T-111 SIDING	sh
ROOFING FELT	ro		CORRUGATED ROOFING	sh
ROLL ROOFING	ro		ASPHALT SHINGLES	sq
DOORS	ea		WINDOWS	ea
ELECTRICAL WIRE	ft		ELECTRICAL OUTLETS	ea
ELECTRICAL SWITCHES	ea		LIGHTING	ea
ELECTRICAL CONDUIT	ft		JUNCTION BOXES	ea
SERVICE HEAD	ea		CONDUIT CONNECTORS	ea
PLUMBING FIXTURES	ea		PLUMBING PIPE	ft
PIPE COUPLINGS	ea		FORM TIE WIRE	ft

(On CS #70)

BILL OF MATERIALS						
Detailed Nomenclature Description	**NSN**	**U/I**	**Unit Cost**	**Quantity Required**	**Total Cost**	**Source/ Substitute**

Project:		**Total Project Material Cost:**				
Estimator:		Date:			Sheet of	

(On CS #71)

TRANSITION: Do you have additional questions before we finish our class on Compute Project Bill of Materials?

1. **QUESTIONS FROM THE CLASS**: Do you have any questions concerning bills of materials? (Answer students' questions.)

2. **QUESTIONS TO THE CLASS**

a. **Question**: What is a bill of materials?

ANSWER: A bill of materials is an detailed listing of all material descriptions, quantities, NSN's, units of issue, unit costs, total cost of the item, and the total cost of all the materials required for the project.

b. **Question**: What is a bill of materials used for?

ANSWER: It is the source document which is used to procure all required project materials.

(On CS #72)

SUMMARY: **(5 Min)**

During this lesson you have learned how to create material takeoff lists, develop a materials estimate, and produce a consolidated bill of materials. The estimating of project materials cannot be overlooked, or taken lightly. Haphazard estimating will result in insufficient quantities of needed project materials, or extreme amounts of excess materials.

(BREAK-10 min)

REFERENCES

Carpentry	MCRP 3-17.7C
Concrete and Masonry	MCRP 3-17.7D
Construction Drafting	TM 5-581B
Construction Print Reading in the Field	TM 5-704
Project Management	MCRP 3-17.7F
Seabee Planner's and Estimator's Handbook	NAVFAC P-405