Module: Fundamental Construction Math

Overview:

A background review of fundamental math principles, concepts, and calculation used in common construction activities including estimating, load calculations, and building layout.

Concepts:

Plane/solid geometry, manual and calculator math computations, sketch, perimeter, area, volume, length, computations, area and volume unit conversations, inches to decimal feet conversions, rise to run calculations, significant digits, order of magnitude.

Responsibility: (4.5 hours)	
30 minutes	read definitions Construction Math File
30 minutes	sketch to visualize shapes - assignment
2.0 hour	work math problems (use both paper & calculator)
2.5 hours	complete construction quantification & conversion calculations.

Assignments:

1. Sketch shapes,
2. Develop algorithms/formulas,
3. Calculate various basic construction mathematical resultants.
4. Convert to purchase units.

Basic Construction Math

(Adapted from Kevin Miller BYU - http://cmfac.groups.et.byu.net/miller/cfm105/notes15/math/math.php)

Most construction math uses basic multiplication, division, addition and subtraction and some trigonometry to calculate Counts (EA), Linear Feet (LF), Area (SF), Weight (tons), or Volume (CY), Angles and relies on conversion of units of material and the feet and inch system. Below is a table of common units used in construction.

Unit of Measure (UOM)	Examples	Calculation Method
Count Ea - Each	 Fire Extinguishers, Chalkboards, Doors	
Linear Units LF - Lineal Feet:	Inches to Feet Flashing & sheet metal, wall base, handrail, trim, pipe, water-stop,	1'- 4" = 1.33'; (inch/12 = decimal equiv.); Use +/- .08'/ft. e.g., 6"=.5', 7"=.58', 5"=.42'
Area SF - Square Feet: SY - Square Yard: SQ - Square SFCA - Square Feet of Contact Area: ACRE -	 Carpet, Asphalt, concrete finishing, Roofing, Asphalt, Carpet, Roofing 100 SF: Asphalt, Roofing Concrete Forming Spread/Spot Footings Form all 4 sides; <u>Continuous footings</u> only form the 2 long sides Site Clearing	 Length*Width SF / 9 SF / 100 43,560 SF =1 acre
Volume CY - Cubic Yard:	 Concrete, Earth	 CF / 27
Weight LB - Pound: Ton:	 Rebar, steel Steel	 1 ton = 2000 LB
Misc Units BDFT or BF: - Board Feet LS - Lump Sum:	 Volume of lumber One time Unique items	
Time WK - Week: MH - Man hour: MN - Month: CH - Crew Hour:	 Supervisory Labor Direct Labor Project Management Labor Direct Labor	 12 Months /52 weeks

Watch your units

Most calculations mistakes occur when dissimilar units are added, multiplied etc. For example, inches multiplied by feet equals inch feet, not square feet. To illustrate this, 3 feet multiple by 6 inches is 1 foot 6 inches, 3 feet * 6 inches /12, not 18 square feet. To convert from inches to feet divide the inches by 12 because 12 inches equals 1 foot. 1'- 4" = 1.33'; (inch/12 = decimal equiv.);
Use +/- .08'/ft. e.g., 6" =.5', 7"=.58', 5"=.42'. Learn the decimal equivalents.

Construction Specific Math

Square Feet

SF = Length' * Width' or for other shapes use one of the formulas above. Remember that all lengths should be in the UOM of feet.

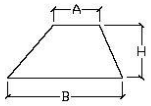
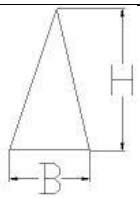
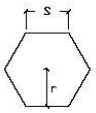
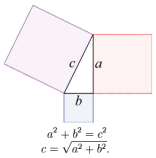
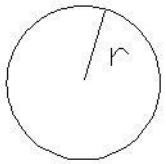
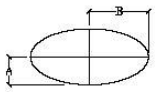
Square Feet of Contact Area)(SFCA)
SFCA is used to measure the area where concrete contacts the forms. This is calculated by measuring the LF of forming and multiplying it by the height of the forms. Remember that if the forms are 18" in height, for the calculation use 1.5' instead of 18" so the UOM is correct.

Square Yard (SY) ---- SY = (Length' * Width') / 9 sf
Cubic Feet (CF) ---- CF = Length' * Width' * Height'
Cubic Yard (CY) ---- CY = (Length' * Width' * Height') /27 cf
Board Feet (BF) ---- BF = (Lumber thickness" * Lumber Width" * Lumber Length')/12
Pounds (LB) ---- LB = Length' * Conversion Factor LB/LF
Lineal Feet (LF) ---- Typically this is a straight addition. Be sure that the units are similar that are being added. For example, you cannot add 5' and 10" to get 15'.
Slope or Pitch ---- Rise:Run (2:1) or Rise/Run (5/12). Used in earthwork and roof or stair framing.

If you are working with reduced size drawing sets, you may need to find a conversion factor to take measurements off the drawings. For example, if a dimension line states that a length is 250', however when you measure it, the length is 100', the discrepancy comes from a drawing size reduction. The best way to measure is to use the called dimension (250').If you are scaling from a drawing take the length from the dimensioned line and divide it by the scaled length. When you do this, you find that the scale factor is 250/100=2.5. This means that anything you measure on the drawing with your scale, you would multiply the length by 2.5. Taking this a step further, if the scale shown on the drawings was 1/8" =1' and the scale factor was 2.5, you could use the 1/20 scale. Why, because 8 *2.5 = 20, therefore, you could you the 1/20 scale on the reduced set of plans.

How to Calculate
Linear Feet
If you are working a straight line, just use a scale to measure the line to get linear feet. If you are working with a circle, the circumference needs to be found. The circumference or perimeter of a circle is found by the following formula. 2 * Pi * radius. **Pi = 3.141592654**, usually 3.14 will be close enough for most calculations. Radius is half the distance across a circle.

Area (SF)

Area for Typical Shapes		Other Shapes
	**Squares / Rectangles:** The area of a square or rectangle is calculated by taking the Length multiplied by the Width.	Trapezoid  $AREA = 5 * H(A + B)$
	**Triangles** The area of a triangles is calculated by the formula .5 * B * H. Length of side using trig or Pythagoras Theory, see other shapes.	Polygon  $AREA = (nsr)/2$ n = number of sides  $a^2 + b^2 = c^2$ $c = \sqrt{a^2 + b^2}.$
	**Circles** To calculate the area of a circle the formula is pi* radius * radius , (πr^2) remember use pi = 3.14	Ellipse  $AREA = \pi * A * B$

Volume
To calculate volume on any of the shapes above, multiply the area by the height. Remember to use the same units of measure when multiplying the height by the area.

Problems: Sketch, dimension, and write out the formula algorithm**.**

1. A continuous footing is 100’ long, 12" thick and 24" wide, how many CY of concrete is needed?

2. From the above problem, how many SFCA is needed for the forms?

3. A circular column is 10' high with a diameter of 24" is how many CY of concrete are required?

4. An 9’x9x4” slab is being placed in a back yard.
    a. How many LF of edge form is required?

    b. How much surface area must be finished?

    c. How much concrete is required?

Lab Activity – M1 Construction Math
Sketch shapes on the provided graphs. Show all steps and processes used to arrive at your answer.
Construction Math: Note that not all calculators will calculate in the same computational sequence.

Area Calculation and Conversion: Square Feet (SF) to Square Yards (SY)

A-1. Suppose you have a commercial project with a parking lot measuring 100' by 300', how many square yards are in this parking lot? *(Round up to nearest whole number)*

Answer	Unit

B-1. Suppose you have a commercial project with a parking lot measuring 150' - 4'' by 300' - 10'', how many square yards are in this parking lot? *(Round up to nearest whole number)*

Answer	Unit

Question 2 - Conversion of Inches into a Decimal Equivalency

A-2. What is the decimal equivalency of 8" in feet? *(Round up to nearest hundredths)*

Answer	Unit

B-2. What is the decimal equivalency of 5" in feet? *(Round up to nearest hundredths)*

Answer	Unit

Lab Activity – M1 Construction Math

Sketch shapes on the provided graphs. Show all steps and processes used to arrive at your answer.

Construction Math: Note that not all calculators will calculate in the same computational sequence.

Question 3 - Volume in Cubic Yards

A-3. Suppose that same parking lot in question A1 had a paving thickness of 5", how many cubic yards of paving material are in this parking lot? *(Round up to nearest whole number)*

Answer	Unit

B-3. Suppose that same parking lot in question A1 had a paving thickness of 8", how many cubic yards of paving material are in this parking lot? *(Round up to nearest whole number)*

Answer	Unit

Question 4 – Trench volume excavation in Cubic Yards (CY) with a side slope

A-4. Suppose you are excavating a ditch required for the installation of (1) 12" water line. The ditch depth is 5' high and the width at the bottom is 3'. The ditch requires side slopes of 2:1 *(*a ratio know as *Rise: Run)* for worker safety to protect against cave-in. What is the overall volume of soil excavated per linear foot (LF) in cubic yards (CY)? *(Round up to nearest hundredths)*

Answer	Unit

B-4. Suppose you are excavating a ditch required for the installation of (2) 6" water line. The ditch depth is 6' and width at the bottom is 4'. The ditch requires side slopes of 2:1 ratio *(*a ratio know as *Rise: Run)* for worker safety to protect against cave-in. What is the overall volume of soil excavated from the ditch per linear foot (LF) in cubic yards? *(Round up to nearest hundredths)*

Answer	Unit

Question 5 – Concrete pour volume in Cubic Yards (CY) along with formwork area (SFCA)

Lab Activity – M1 Construction Math

Sketch shapes on the provided graphs. Show all steps and processes used to arrive at your answer.

Construction Math: Note that not all calculators will calculate in the same computational sequence.

A-5. Suppose you are determining how much concrete will be needed for a new sidewalk from the street and a new slab-on-grade patio addition next to an existing building. The new sidewalk is 20' in length and 5' in width, and creates a T – shape where it connects to the 35' long (against the existing building) by 15' wide slab. The slab-on-grade will connect to an existing warehouse 75' in length. Assume the new sidewalk and slab-on-grade are 4'' thick. How many cubic yards (CY) of concrete will be needed? *(Round up to nearest hundredths)*

Answer	Unit

B-5. Suppose the owner decided to add (2) 45 degree triangles x 4'' thick slabs-on-grade with one triangle piece on each end of the new slab-on-grade. How many cubic yards (CY) of concrete will be needed for each triangle? *(Round up to nearest hundredths)*

Answer	Unit

C-5. What is the total cubic yards (CY) needed for the sidewalk, slab, and triangles? How much formwork is required? (*Round up to nearest hundredths)*

Answer	Unit