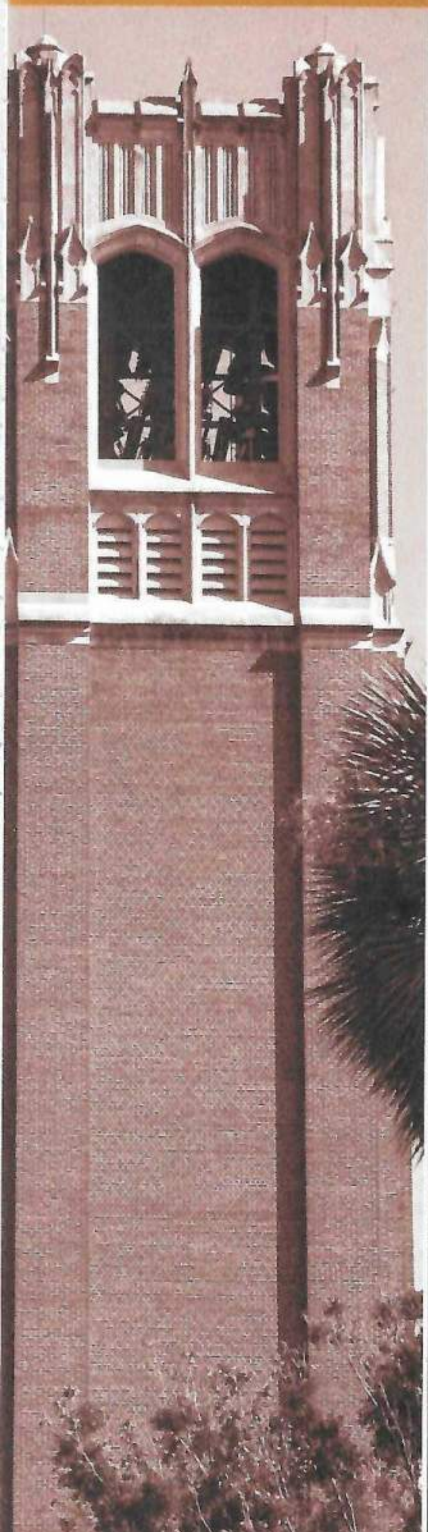
28103-13

Measurements, Drawings, and Specifications



Overview

This module covers math tools commonly used by masons. It includes concepts used for calculations, reading plans and drawings, and reading and meeting specifications. From understanding a set of drawings, to measuring and mixing mortar, math skills are needed at every step. A mason who has mastered math skills will save time, energy, materials, and money on the job.

Module Four

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28103-13
Measurements, Drawings, and Specifications

Objectives

When you have completed this module, you will be able to do the following:

1. Recognize the mathematical concepts used in masonry.
   a. Explain how to read a six-foot rule.
   b. Explain how to read other measuring devices.
   c. Explain how to read mason's rules.
   d. Recognize modular increments.
   e. Describe how to determine areas and circumferences.
   f. Explain how to use the 3-4-5 ratio to square a corner.
2. Identify the basic parts of a set of drawings and list the information found on each type.
   a. Identify lines, symbols, and abbreviations used on drawings.
   b. Identify scales and dimensions used on drawings.
   c. Identify types of construction drawings.
3. Identify the purpose of specifications, standards, and codes used in the building industry and the sections that pertain to masonry.
   a. Explain the purpose of specifications, standards, and codes.
   b. Describe the purpose of inspections and testing.

Performance Tasks

Under the supervision of your instructor, you should be able to do the following:

1. Use a mason's rule to measure a space and verify its squareness.
2. Use a rule to measure fractional dimensions.
3. Locate information on construction drawings.

Trade Terms

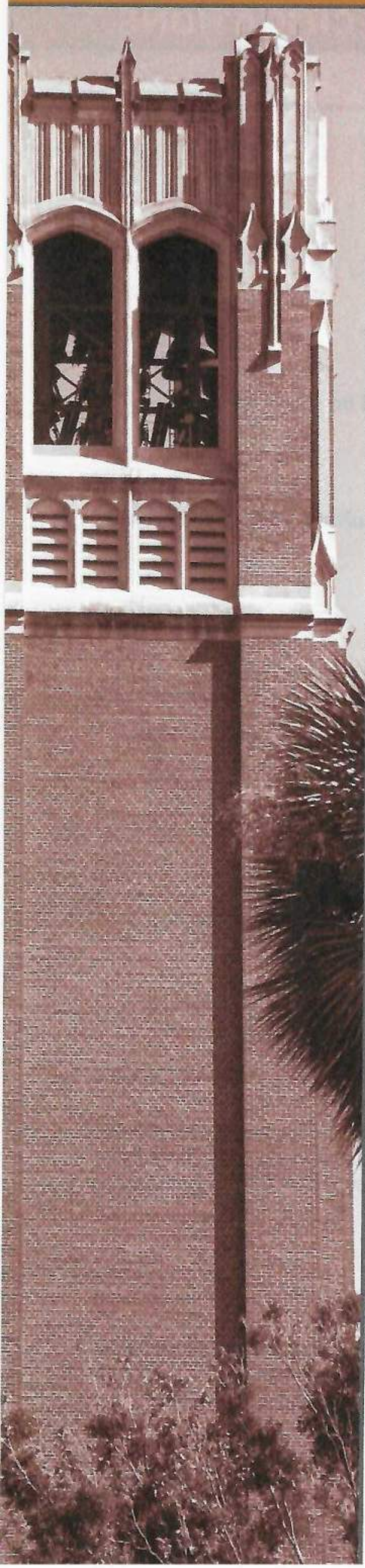
Converting
Legend
MasterFormat™
Nominal dimension

Industry-Recognized Credentials

If you're training through an NCCER-accredited sponsor, you may be eligible for credentials from NCCER's Registry. The ID number for this module is 28103-13. Note that this module may have been used in other NCCER curricula and may apply to other level completions. Contact NCCER's Registry at 888.622.3720 or go to **www.nccer.org** for more information.

Code Note

Codes vary among jurisdictions. Because of the variations in code, consult the applicable code whenever regulations are in question. Referring to an incorrect set of codes can cause as much trouble as failing to reference codes altogether. Obtain, review, and familiarize yourself with your local adopted code.



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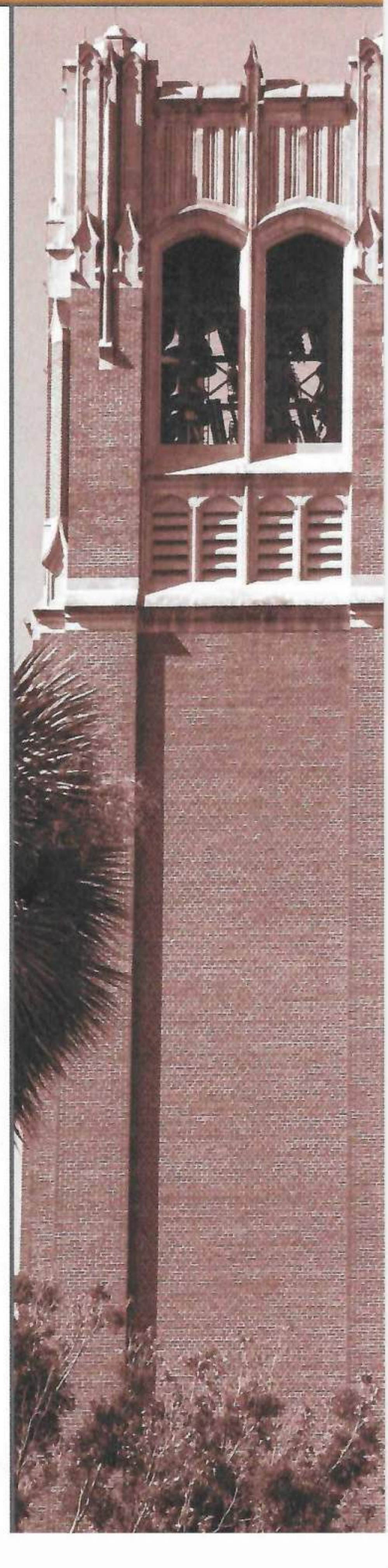

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Section One

1.0.0 Masonry Math

Objective

Recognize the mathematical concepts used in masonry.

a. Explain how to read a six-foot rule.
b. Explain how to read other measuring devices.
c. Explain how to read mason's rules.
d. Recognize modular increments.
e. Describe how to determine areas and circumferences.
f. Explain how to use the 3-4-5 ratio to square a corner.

Performance Tasks 1 and 2

Use a mason's rule to measure a space and verify its squareness.

Use a rule to measure fractional dimensions.

Trade Terms

Converting: The process of changing from one form of measure to another; for example, from feet to inches or from inches to feet.

Nominal dimension: The size of the masonry unit plus the thickness of one standard (⅜ to ½ inch) mortar joint, used in laying out courses.

In the United States, masonry measurements are made in inches, feet, pounds, and gallons. You can only add and subtract numbers with the same units. When you are finished doing the arithmetic, you may need to convert smaller units into larger ones. The process of changing from one form of measure to another, say from feet to inches or from inches to feet, is called **converting**. The process of converting feet to inches is similar to the process of carrying in addition, as shown in *Figure 1*.

Masons use two numbering systems of their own: the course system and the modular system. As noted in the *Masonry Tools and Equipment* module, masons have two kinds of rules for these measures. When working with these rules (or any measuring tools), it is important to do the following:

- Familiarize yourself with the scale.
- Take readings carefully, and take them again to avoid making costly mistakes.

The old carpentry rule "measure twice and cut once" applies here.

1.1.0 Reading a Six-Foot Rule

Masons use rules to make accurate measurements. One of the most commonly used rules is the six-foot folding rule (*Figure 2*). The markings on the front of a standard six-foot rule are in inches and feet. Some rules have metric markings on the other side. A standard ruler is divided into whole inches and then halves, fourths, eighths, and sixteenths (*Figure 3*). Some rules also include thirty-seconds and sixty-fourths. The most common fractions that masons will encounter on the job are ⅜ and ⅝. You need to pay close attention when measuring. Your projects are only as accurate as your measurements.

In this section, you will learn how to add, subtract, multiply, and divide using the inch and foot measurements on a six-foot rule. Take the time to learn how to measure accurately. The quality of your work depends on accurate measurements.

1.1.1 Addition

This section shows the steps for solving an addition problem using a six-foot rule.

Add these measurements:

```
    2 feet  9 inches
+   2 feet  5 inches
--------------------
```

Step 1 Add the inches.

```
    2 feet  9 inches
+   2 feet  5 inches
--------------------
           14 inches
```

Step 2 There are 12 inches in a foot. When the inch column is 12 or greater, carry 1 foot to the foot column. The rule is to convert inches to feet when the number of inches is greater than 12.

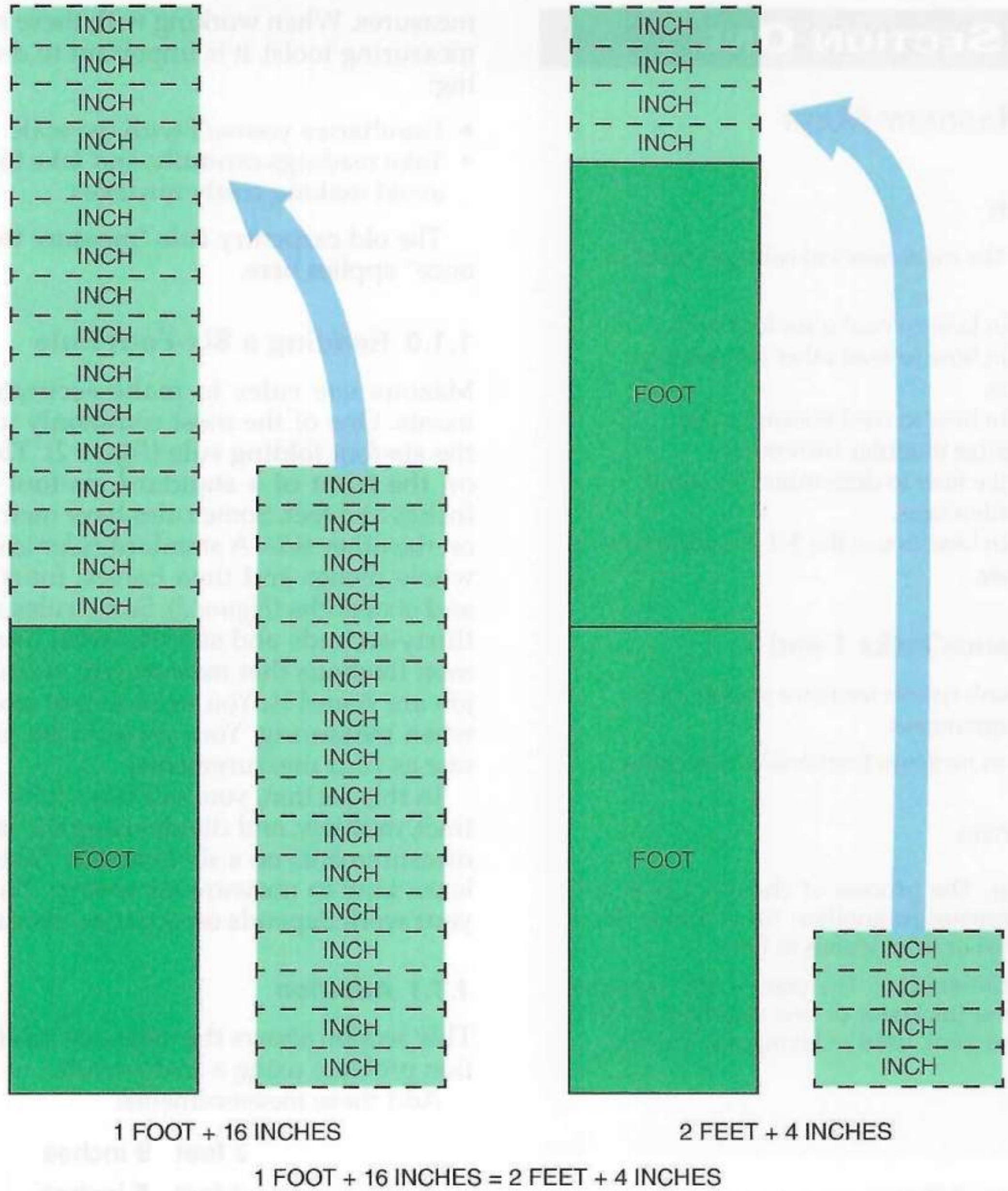

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Figure 1 Converting units.

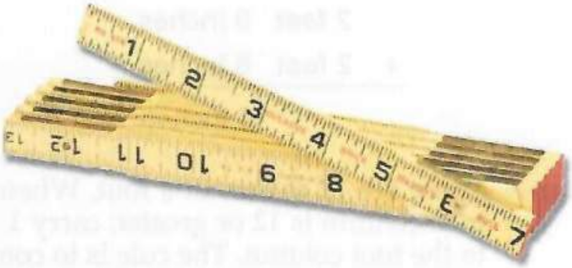

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Figure 2 Six-foot folding rule.

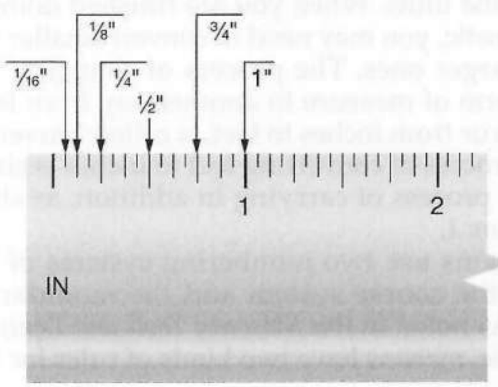

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Figure 3 Reading rules accurately.

Step 3 Add the foot column, and subtract 12 from the inches column to account for the carry to the foot column.

	1 foot	
	2 feet	9 inches
+	2 feet	5 inches
	5 feet	14 inches
–		12 inches
	5 feet	**2 inches**

The sum of the two measurements is 5 feet 2 inches.

> **NOTE**
> Inches must be converted to feet when they exceed 12.

1.1.2 Addition Practice Exercises

This exercise will give you practice in adding measurements using a six-foot rule. You can check your work by looking up the answers in *Appendix A*.

1.		1 foot	10 inches
	+	2 feet	5 inches
2.		2 feet	9 inches
	+	2 feet	4 inches
3.		2 feet	7 inches
	+	1 foot	6 inches
4.		1 foot	9 inches
	+	1 foot	7 inches

1.1.3 Subtraction

Subtraction problems call for similar conversions. In subtraction, remember that borrowing does not give the 10 units that you get working with ordinary numbers. The borrowed amount depends on the measure you are converting (*Figure 4*).

The following section shows the steps for solving a subtraction problem with measurements. Subtract these measurements:

	4 feet	7 inches
–	2 feet	8 inches

Step 1 Subtract the inches. Since 7 is less than 8, borrow 12 inches from the foot column, leaving 3 feet. Add 12 inches to 7 inches to get 19 inches. Now subtract 8 inches from 19 inches.

		(12 + 7) =
	3 feet	19 inches
	~~4 feet~~	~~7 inches~~
–	2 feet	8 inches
		11 inches

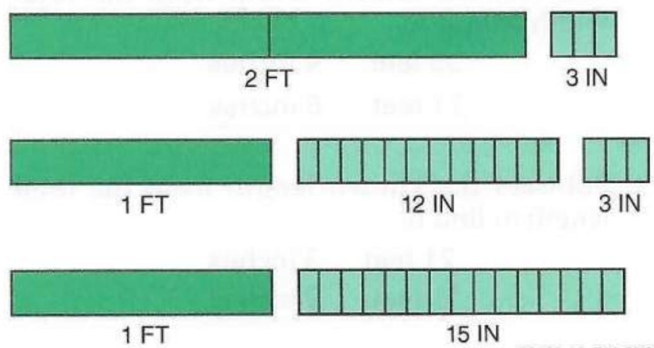

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Figure 4 Borrowing units.

Rule of Thumb

Before tape measures, people used their bodies as a gauge. A small length was measured using the thumb. Larger distances were measured in feet or paces. You can still use your body to estimate distances:

- 1 inch = the width of your thumb
- 10 inches = the length of your foot
- 5 feet = a pace (two steps)
- 1 yard = the distance from your nose to your fingertips

You might wish to see how closely these "rules of thumb" apply to you.

Step 2 Subtract the foot column.

3 feet	19 inches
– 2 feet	8 inches
1 foot	11 inches

The difference between the two measurements is 1 foot 11 inches.

1.1.4 Subtraction Practice Exercises

This exercise will give you practice in subtracting measurements. You can check your work by looking up the answers in *Appendix A*.

1.
2 feet	6 inches
– 1 foot	8 inches

2.
2 feet	5 inches
– 2 feet	7 inches

Sometimes, plans will not give all of the dimensions used. Find the missing dimensions in *Figure 5* using Questions 3 and 4.

3. Subtract the known width from the total width to find A.

35 feet	4 inches
– 21 feet	6 inches

4. Subtract the known length from the total length to find B.

21 feet	3 inches
– 11 feet	9 inches

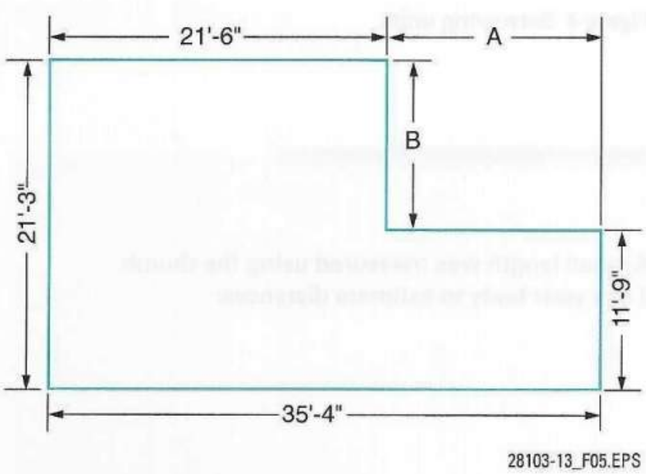

Figure 5 Find missing dimensions.

1.1.5 Other Measures

Measurements commonly used in the United States are listed in *Table 1*.

1.1.6 Fractions

Masons often use fractions in measuring and mixing. A fraction divides whole units into parts. They are usually written as two numbers, such as ¼, ½, or ⅝. The bottom number is the denominator. The upper number is the numerator. This section will review how to add, subtract, divide, and multiply fractions. As noted elsewhere in this module, the most common fractions that masons will encounter on the job are ⅜ and ⅝.

As with measurements: you must have the same units in order to perform mathematical operations on fractions. You cannot simply add ⅝ and ¾. The denominators (the bottom numbers) must be the same. The fractions must be converted before they are added together. The conversion process is known as finding a common denominator. The lowest common denominator is the smallest number that the denominators can be evenly divided into.

To find the lowest common denominator, follow these steps:

Step 1 Reduce each fraction to its lowest terms.

Step 2 Find the lowest common multiple of the denominators. Sometimes it is simple; one number is a multiple of the other and the larger is the lowest common denomi-

Table 1 Common Measures

WEIGHT UNITS
1 ton = 2,000 pounds
1 pound = 16 dry ounces
LENGTH UNITS
1 yard = 3 feet
1 foot = 12 inches
VOLUME UNITS
1 cubic yard = 27 cubic feet
1 cubic foot = 1,728 cubic inches
1 gallon = 4 quarts
1 quart = 2 pints
1 pint = 2 cups
1 cup = 8 fluid ounces
AREA UNITS
1 square yard = 9 square feet
1 square foot = 144 square inches

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nator. That means you can multiply by a whole number to get the larger number. If this is the case, all you have to do is find the equivalent fraction for the fraction with the smaller denominator.

Step 3 If neither of the denominators is a multiple of the other, you must multiply the two together to get a common denominator.

The following example will walk you through the steps to find the lowest common denominator between $\frac{1}{4}$ and $\frac{1}{3}$:

Step 1 Looking at the denominators, you see that 12 is a multiple of both 4 and 3. You need to find the equivalent fractions for $\frac{1}{4}$ and $\frac{1}{3}$ that have a denominator of 12. Because 4 goes into 12 three times, multiply the numerator in the fraction $\frac{1}{4}$ by 3. Because 3 goes into 12 four times, multiply the numerator in the fraction $\frac{1}{3}$ by 4:

$$\frac{1}{4} = \frac{3}{12}$$

$$\frac{1}{3} = \frac{4}{12}$$

Step 2 Add the two fractions together:

$$\frac{3}{12} + \frac{4}{12} = \frac{7}{12}$$

In this example, since $\frac{7}{12}$ can't be reduced, 12 is the lowest common denominator of the fractions $\frac{1}{4}$ and $\frac{1}{3}$.

1.1.7 Adding Fractions

How many inches will you have if you add $\frac{3}{4}$ of an inch and $\frac{7}{16}$ of an inch? To answer this question, you will have to add the fractions using the following steps:

Step 1 Find the lowest common denominator for the two fractions. Since 4 is a multiple of 16, the lowest common denominator is 16.

Step 2 Convert the fractions to equivalent fractions with the same denominator.

$$\frac{3}{4} \times \frac{4}{4} = \frac{12}{16}$$

Step 3 Add the numerators of the fractions.

$$\frac{12}{16} + \frac{7}{16} = \frac{19}{16}$$

Step 4 Reduce the fraction to its lowest terms. If the numerator is larger than the denominator, the answer is greater than 1.

$$\frac{19}{16} = \frac{16}{16} + \frac{3}{16} = 1\frac{3}{16}$$

1.1.8 Subtracting Fractions

You follow the same steps to subtract fractions. Say you have $\frac{3}{4}$ of a bag of mortar mix. You need $\frac{1}{2}$ a bag for a small batch of mortar. How much mortar mix will you have left?

Step 1 Find the common denominator. In this case, it is 4.

$$\frac{3}{4} - \frac{1}{2}$$

Step 2 Multiply to convert the fractions to equivalent fractions.

$$\frac{1}{2} \times \frac{2}{2} = \frac{2}{4}$$

Step 3 Subtract the numerators.

$$\frac{3}{4} - \frac{2}{4} = \frac{1}{4}$$

How Many Gallons?

The traditional volume units are the names of standard containers. Until the 18th century, it was very difficult to measure the capacity of a container. Standard containers were defined by the weight of a particular item, such as wheat or beer, that they could carry. This custom led to several standard units. These included the barrel, the hogshead, and the peck. The gallon was originally the volume of eight pounds of wheat.

The situation was still confused during the American colonial period. The Americans chose two of the many gallons. These two were the most common. For dry commodities, the Americans were familiar with the Winchester bushel. The corresponding gallon is one-eighth of this bushel.

For liquids, Americans used the traditional British wine gallon. As a result, the US volume system includes both dry and fluid units. The dry units are about one-sixth larger than the corresponding liquid units.

In 1824, the British established a new system based on the Imperial gallon. The Imperial gallon was designed to hold exactly 10 pounds of water. Unfortunately, Americans did not adopt this new, larger gallon. So the traditional English system actually includes three different gallons: US liquid, US dry, and British Imperial.

1.1.9 Multiplying Fractions

Multiplying and dividing fractions is very different from adding and subtracting fractions. You do not need to find a common denominator. Say you have ¾ of a bag of mortar mix. You need to make three even batches. How much mix is in each batch? You want to know how much is ⅓ of ¾. The word *of* lets you know to multiply.

Step 1 Multiply the numerators together to get a new numerator. Multiply the denominators together to get a new denominator.

$$3/4 \times 1/3 = 3/12$$

Step 2 Reduce the fraction to its lowest terms.

$$3/12 = 1/4$$

1.1.10 Dividing Fractions

Dividing fractions is similar to multiplying fractions with one added step. You must invert or flip the fraction you are dividing by. Use ½ ÷ ¾.

Step 1 Invert the fraction you are dividing by.

$$3/4 \text{ becomes } 4/3$$

Step 2 Change the division sign to a multiplication sign. Multiply as instructed earlier.

$$1/2 \div 3/4 \text{ becomes}$$

$$1/2 \times 4/3 = 4/6$$

Step 3 Reduce the fraction to its lowest terms.

$$4/6 = 2/3$$

1.2.0 Reading Other Measuring Devices

In addition to the six-foot folding rule, masons may be called on to use other types of measuring devices in the field. These may include measuring tapes, ranging from 25 to 200 feet in length, and engineer's rules. It is important that masons are able to recognize and to use these measuring devices as skillfully as they use folding rules. Measuring tapes (*Figure 6*) are similar in appearance to retractable steel tapes, which you were introduced to in the module *Masonry Tools and Equipment.* Measuring tapes are used for laying out buildings and other large structures.

Use the following steps to read a measuring tape:

Step 1 Place the end of the tape at the starting point.

Step 2 Reading from the starting end of the tape, measure the distance to the point being measured. Notice that the measuring tape includes the foot measurement as a smaller number between the inch increments. This is to help you keep track of the distance without having to go back to the last foot increment.

Step 3 Read the feet, inches, and fractions of an inch just as you would for a steel tape or folding rule.

The tape in *Figure 7* illustrates a measurement of 17 feet, 2½ inches from the first reference point (the starting end of the tape) to the second reference point (the point being measured). You can see that the foot measurements in between the inch increments make it easier to read the distance being measured.

The graduations in an engineer's rule are different from those used in other types of rulers. Instead of being based on fractions of an inch, they are divided by tenths of a foot (*Figure 8*). On an engineer's rule, 10 hundredths equal 1/10 of a foot, and 10 tenths equals 1 foot. Likewise, 25 hundredths (0.25) is the same as ¼ foot or 3 inches, and 50 hundredths (0.50) is the same as ½ foot or 6 inches.

Use the following steps to read an engineer's rule:

Step 1 Place the end of the tape at the starting point.

> **Think About It**
> **Dividing Fractions**
>
> You want to divide two-thirds of a bag of cement mix in half. What is the mathematical equation and correct answer?

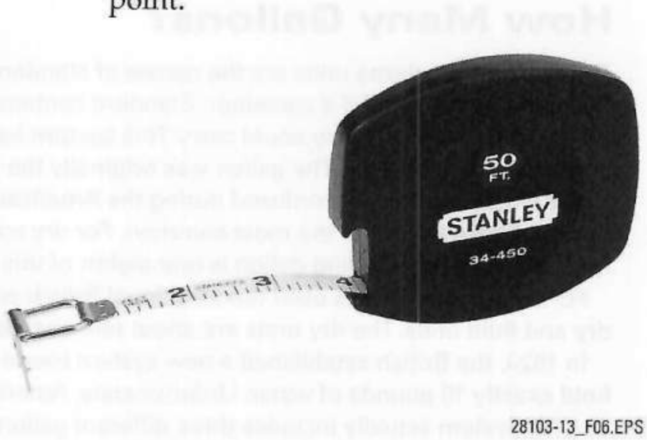

Figure 6 Measuring tape.

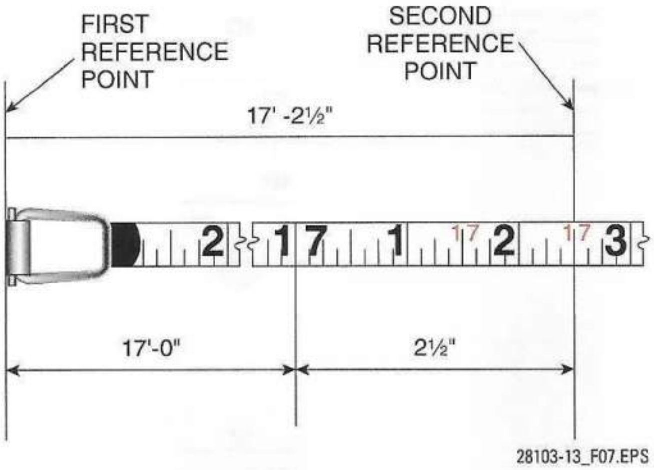

Figure 7 Reading a measuring tape.

Step 2 Reading from the starting end of the rule, measure the distance to the point being measured. Determine the number of whole units between the starting point and the point being measured. Remember, these are in tenths of a foot, not fractions of an inch.

Step 3 Use the inch and increments of tenths of an inch to determine the distance. If necessary, use a conversion table or your calculator to convert decimal units into fractions of an inch.

1.3.0 Reading Mason's Rules

On the back of mason's rules are measures that masons use to determine the distances between brick courses. The course system, also called the brick spacing rule or brick spacing system, predates the modular system of measurement. The standard brick spacing rule numbers the courses of different sizes of brick that will fill a vertical space (*Figure 9*). Standard and oversize rules are used to lay out and space standard brick courses to nonmodular dimensions. The rule has inches on the other side, marked in sixteenths of an inch.

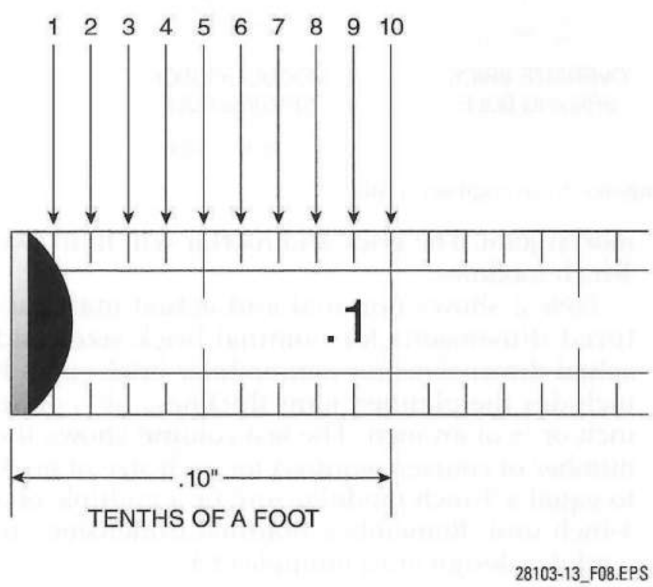

Figure 8 Reading an engineer's rule.

Figure 9 shows the standard, oversize, and modular brick spacing rules that masons commonly use on the job. The standard brick spacing rule has a gauge at the beginning that measures the size of one brick. It is used to identify the size of the brick so you will know which scale to read. On the standard brick spacing rule, all the reference measures fall between 2⅜ and 3 inches. For larger brick, you need to use the oversize brick spacing rule.

The large figures on the rule are references for the nominal sizes of standard brick and mortar thickness. The small figures at right angles to the size references count the number of courses for that size brick. The number of courses is marked for reference in *Figure 10*. On many rules, the large and small figures are shown in different colors to help you distinguish between them.

The number of courses refers to the number of times the block will need to be set in order to establish the correct height of the wall. If you are told to erect a 10-foot tall wall using nominal 8 inch × 8 inch × 16 inch concrete block, for example, the wall would be 15 courses:

10 feet × 12 inches (the number of inches in a foot) = 120 inches

Nominal block height = 8 inches

Height of wall (120 inches) ÷ Nominal height of block (8 inches) = 15

Number of courses = 15

Use the standard spacing rule to adjust course height or bed joints to meet benchmarks. Then transfer the correct markings from the spacing rule to the corner pole.

Oversize brick spacing rules have scales to measure nonmodular brick spacing. Instead of numbers, oversize brick spacing rules use letters (*A* through *K*) to indicate the number of courses. You will learn more about how to use mason's rules in later levels of the *Masonry* curriculum.

1.4.0 Recognizing Modular Increments

Today, brick is made for use on the modular grid system. The dimensions are based on a 4-inch unit called a module. The grid system makes it easier to combine different materials in a con-

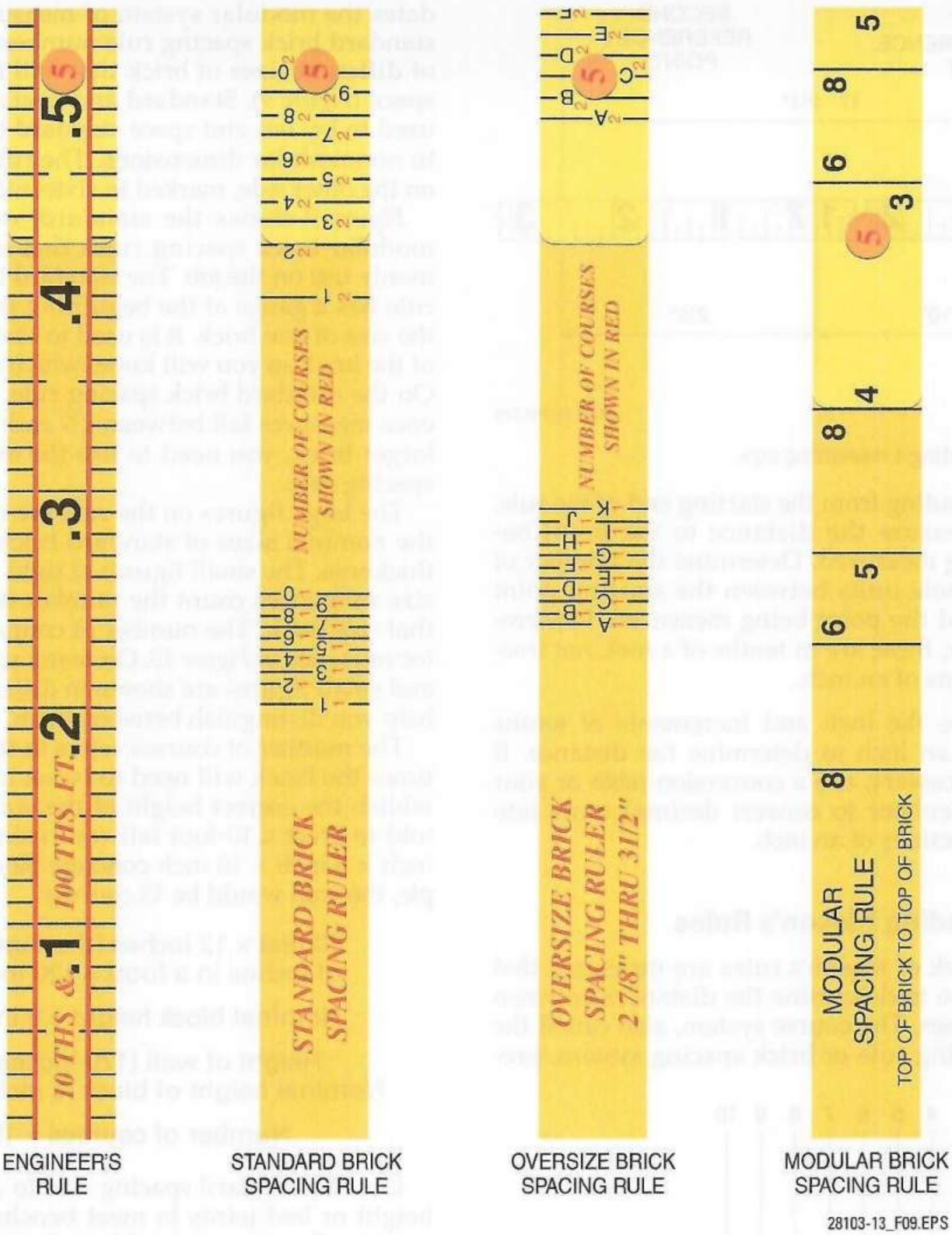

Figure 9 Standard, oversize, and modular brick spacing rules compared to an engineer's rule.

struction job. It creates a standard measurement, so different materials can be easily measured or calculated.

In modular design, the **nominal dimension** of a masonry unit is the manufactured dimension plus the thickness of the mortar joint. The nominal dimension is a multiple of 4 inches. A modular brick with a nominal length of 8 inches will have a manufactured dimension of 7½ inches if it is designed to be laid with a ½-inch mortar joint. It will have a manufactured dimension of 7⅝ inches if it is designed to be laid with a ⅜-inch mortar joint. The brick and mortar will fit in two 4-inch modules.

Table 2 shows nominal and actual manufactured dimensions for nominal brick sizes and actual dimensions for nonmodular brick sizes. It includes the planned joint thickness of ⅜ of an inch or ½ of an inch. The last column shows the number of courses required for each size of brick to equal a 4-inch modular unit or a multiple of a 4-inch unit. Remember, nominal dimensions in modular design are a multiple of 4.

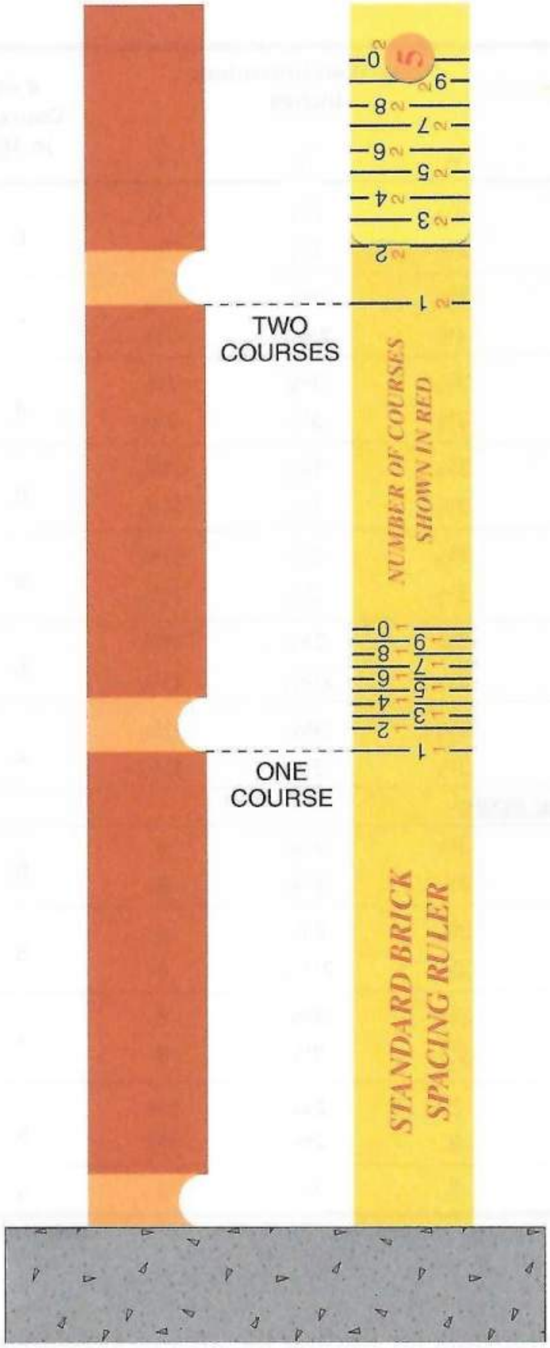

Figure 10 Reading the standard brick spacing rule.

Most masonry materials will tie and level off at a height of 16 inches vertically. Two courses of block with mortar will be 16 inches high. Six courses of modular brick with mortar will also be 16 inches vertically. As a result, the wythes can be tied together at 16-inch intervals or at multiples of 16 inches.

The modular spacing rule (*Figure 11*) has a modular scale on one side and inches marked into sixteenths on the other side.

The black figures are the references for the nominal sizes of modular brick and block. The modular markings give course numbers for different sizes. Scale 2 is for regular block or any brick with two courses equal to 16 inches in height. Scale 3 measures three courses in 16 inches and so on. Again, the specifications are the place to find the brick size or planned course height.

1.4.1 Determining the Number of Modular Brick Courses

The following example will show you how to determine how many courses of brick are needed to build a wall 8 feet high using modular brick.

Step 1 Determine the number of 16-inch sections.

$$8 \text{ ft} \times 12 \text{ in/ft} = 96 \text{ in}$$

$$96 \text{ in} \div 16 \text{ in} = 6 \text{ (16-inch sections)}$$

Step 2 Use *Table 2* to find the number of courses in a 16-inch section for modular brick.

Step 3 Multiply the number of courses per 16-inch section by the number of sections to find the total number of courses.

$$6 \times 6 = 36 \text{ courses}$$

1.4.2 Modular Brick Course Practice Exercises

You are building a wall 6 feet high. How many courses will you need for each type of brick? Refer to *Table 2*. You can check your work by looking up the answers in *Appendix A*.

1. Modular brick __________
2. Roman brick __________
3. Utility brick __________
4. Norman brick __________

1.5.0 Determining Areas and Circumferences

Knowledge of geometry is useful on a construction site. For example, if a wall is to have two windows in it, it will not need brick in these areas. Geometry allows the mason to calculate how much brick will be needed. This knowledge saves time and money when ordering materials. It can also be used to save steps when carrying brick to the workstation.

The next sections review the steps for calculating the areas of common geometric shapes. The

Table 2 Sizes of Brick

Unit Designation	Nominal Dimenions Inches w	h	l	Joint Thickness Inches	Specified Dimenions Inches w	h	l	# of Courses in 16"
Modular	4	2⅔	8	⅜	3⅝	2¼	7⅝	6
				½	3½	2¼	7½	
Engineer Modular	4	3⅕	8	⅜	3⅝	2¾	7⅝	5
				½	3½	2 13/16	7½	
Closure Modular	4	4	8	⅜	3⅝	3⅝	7⅝	4
				½	3½	3½	7½	
Roman	4	2	12	⅜	3⅝	1⅝	11⅝	8
				½	3½	1½	11½	
Norman	4	2⅔	12	⅜	3⅝	2¼	11⅝	6
				½	3½	2¼	11½	
Engineer Norman	4	3⅕	12	⅜	3⅝	2¾	11⅝	5
				½	3½	2 13/16	11½	
Utility	4	4	12	⅜	3⅝	3⅝	11⅝	4
				½	3½	3½	11½	
NONMODULAR BRICK SIZES								
Standard				⅜	3⅝	2¼	8	6
				½	3½	2¼	8	
Engineer Standard				⅜	3⅝	2¾	8	5
				½	3½	2 13/16	8	
Closure Standard				⅜	3⅝	3⅝	8	4
				½	3½	3½	8	
King				⅜	3	2¾	9⅝	5
					3	2⅝	9⅝	
Queen				⅜	3	2¾	8	5

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measurements of these shapes are typically in square feet. Plane figures are figures drawn in only two dimensions. Rectangles, triangles, and circles are common plane figures. The area of a plane figure is expressed in square units of the appropriate denomination.

1.5.1 Four-Sided Figures

Squares, rectangles, and parallelograms are four-sided regular polygons (*Figure 12*). They are figures with opposite parallel sides of the same length.

A rectangle is a polygon that has four sides of two different lengths that meet at right angles. The formula for finding the area of a rectangle is length × width, or:

$$A = lw$$

A square has four sides of the same length that meet at right angles. The formula for finding the area of a square is also length × width, simply expressed as *side times side*, or:

$$A = s^2 \text{ or } A = ss$$

A parallelogram has four sides that do not meet at right angles. The formula for finding the area of a parallelogram is base × height. The base (b) is the longest side, and the height (h) is the shortest

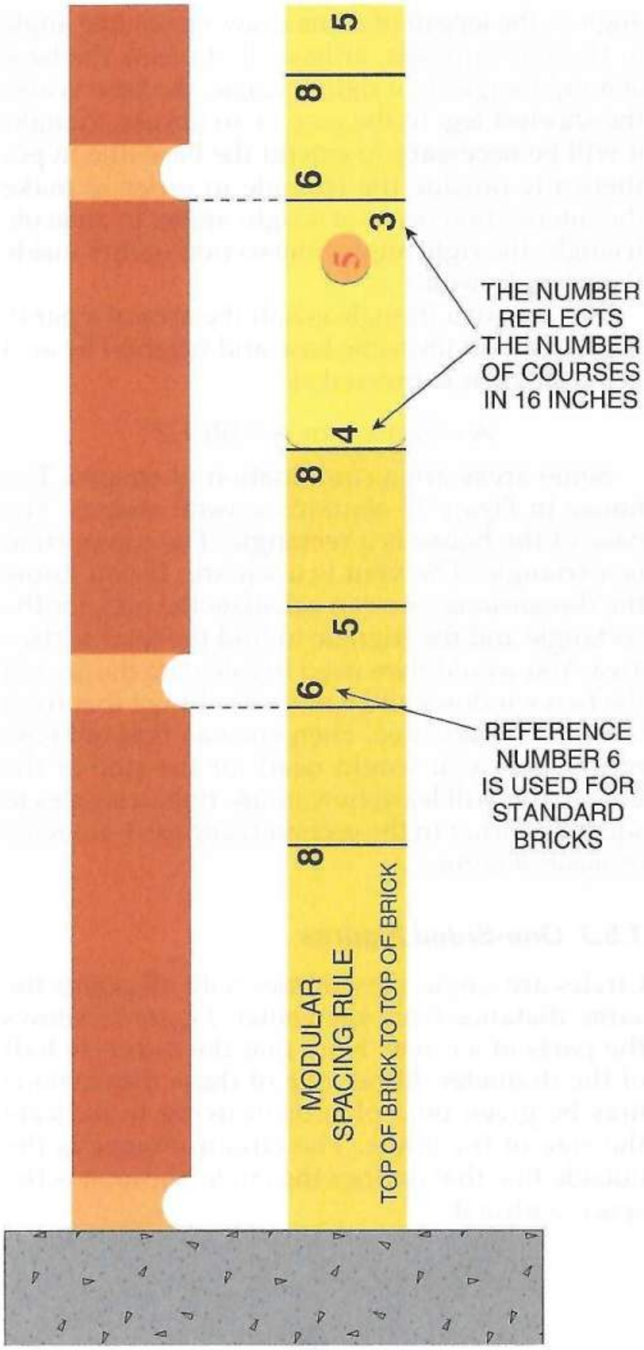

Figure 11 Reading the modular spacing rule.

distance between the upper and lower bases. This formula is expressed as:

$$A = bh$$

For example, a drawing shows a wall to be built that is 4 feet high and 10 feet long. What is the surface area of the wall?

Step 1 Find the formula for the calculation. The wall is a rectangle. The formula for the surface area of a rectangle is A = lw.

Step 2 Calculate the answer using the data from the drawing.

$$A = lw$$

$$A = 4 \text{ feet} \times 10 \text{ feet}$$
$$A = 40 \text{ square feet}$$

> **NOTE**
> Before performing a calculation, make sure that the two numbers have the same units. If the units are different, you must convert them to the same units.

1.5.2 Three-Sided Figures

Triangles are three-sided figures. They take many shapes. In all triangles, the three internal angles add up to 180 degrees. This is useful to know. If you know two of the angles, you can calculate the third. For example, if two angles of a triangle are 25 degrees and 75 degrees, the unknown angle is 80 degrees:

$$180 \text{ degrees} - 25 \text{ degrees} - 75 \text{ degrees} = 80 \text{ degrees}$$

Triangles can be identified by the relationships of the sides. Three examples are shown in *Figure 13*. All three sides of an equilateral triangle are the same size. Only two sides of an isosceles triangle are the same size. None of the sides of a scalene triangle are the same size.

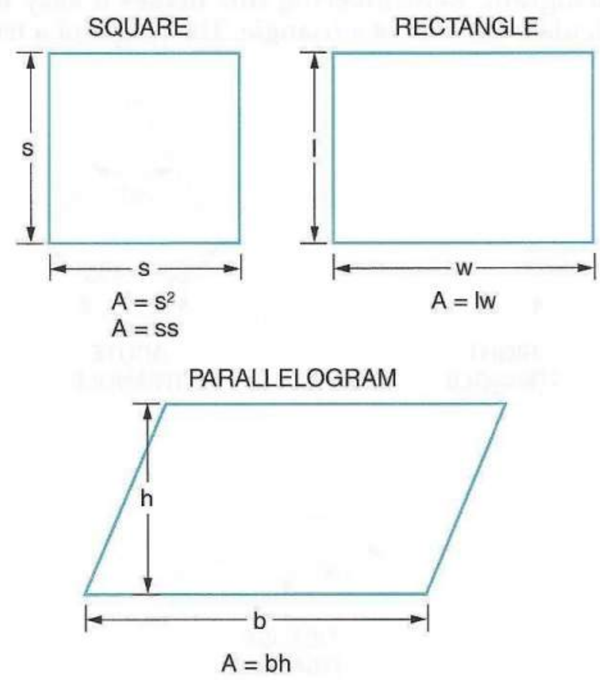

Figure 12 Four-sided figures.

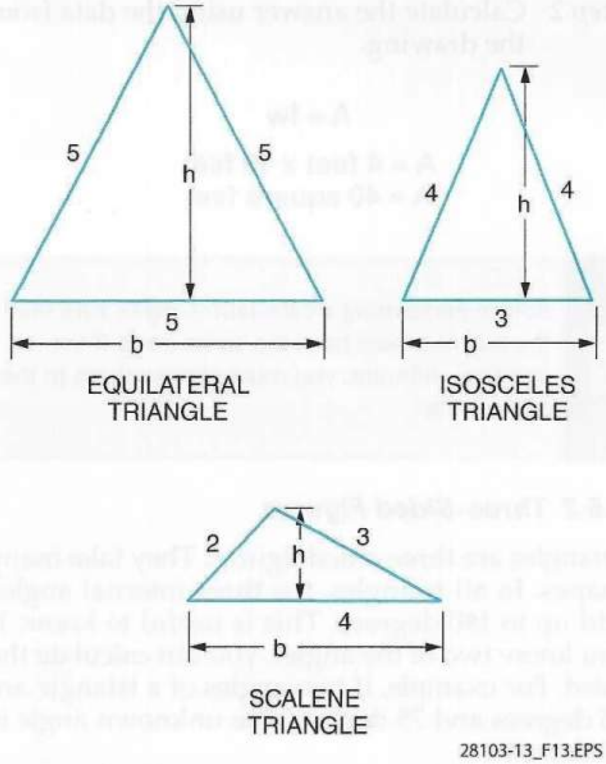

Figure 13 Triangles named by sides.

Triangles are also classified according to their interior angles (*Figure 14*). If one of the angles is 90 degrees, it is called a right triangle. If one of the angles is greater than 90 degrees, it is called an obtuse triangle. If each of the interior angles is less than 90 degrees, it is called an acute triangle.

Every triangle is really an exact half of a parallelogram. Remembering this makes it easy to calculate the area of a triangle. The height of a triangle is the length of a line drawn from one angle to the side opposite, or base, that meets the base at a right angle. In a right triangle, the base is also the shortest leg. In the case of an obtuse triangle, it will be necessary to extend the base line hypothetically outside the triangle in order to make the intersection occur at a right angle. In an acute triangle, the right angle intersection occurs inside the triangle itself.

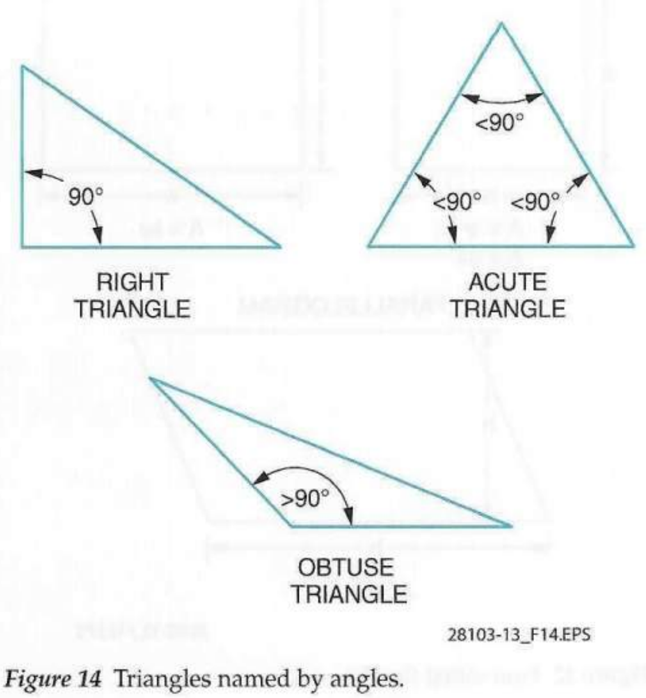

Figure 14 Triangles named by angles.

The area of a triangle is half the area of a parallelogram with the same base and height. The area of a triangle is expressed as:

$$A = \frac{1}{2}\, b \times h \text{ or } A = bh \div 2$$

Some areas are a combination of shapes. The house in *Figure 15* contains several shapes. The base of the house is a rectangle. The top portion is a triangle. The vent is a square. If you know the dimensions, you can calculate the area for the rectangle and the triangle to find the total surface area. You would then need to calculate the area of the two windows and vent and subtract that from the total surface area. Then you can find out how much brick you would need for the side of the house. You will learn how to use right triangles to square a corner in the section *Using the 3-4-5 Ratio to Square a Corner.*

1.5.3 One-Sided Figures

Circles are single, closed lines with all points the same distance from the center. *Figure 16* shows the parts of a circle. Note that the radius is half of the diameter. Either one of these dimensions may be given on a plan or drawing to indicate the size of the circle. The circumference is the outside line that defines the circle; the area is the space within it.

Figure 15 Divide figures to find the area.

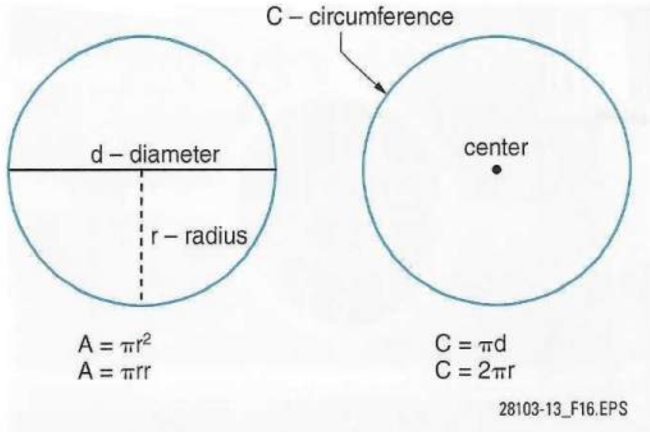

Figure 16 Parts of a circle.

> **NOTE**
> Remember to include the units, such as feet or inches, in your calculations.

If you are building a circular garden wall, you will need to know its circumference to figure out how much material will be needed. The circumference of a circle is its diameter (d) times the constant pi (π), or twice its radius (r) times the constant π. The rounded value of π is 3.14, or 22⁄7. The formula for the circumference of a circle is expressed as:

$$C = \pi d \text{ or } C = 2\pi r$$

You may need to know the area of a circular patio to be paved with brick. The area of a circle is expressed in square units. The formula for the area of a circle is expressed as:

$$A = \pi r^2 \text{ or } A = \pi rr$$

1.5.4 Many-Sided Figures

Many-sided figures with all sides the same size and the same distance from the center are called regular polygons. They are also named after their number of sides. A five-sided figure is a pentagon, a six-sided figure is a hexagon, and an eight-sided figure is an octagon. *Figure 17* shows some regular polygons.

Occasionally, a plan will incorporate a hexagonal window over a door or an octagon in a bathroom. Sometimes a structure will be in the shape

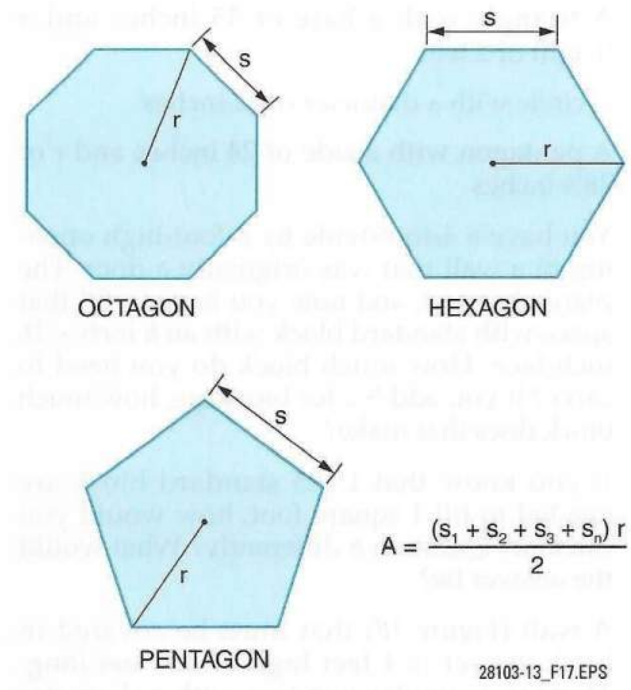

Figure 17 Regular polygons.

of an octagon instead of a square. To calculate the circumference of any regular polygon, you need to know the number and the length of each side.

The formula for the area of a regular polygon is the sum of the lengths of the sides divided by 2 then multiplied by r. The r is the distance from the center to any one angle. You may have to use your ruler on the plan to approximate that distance. The formula for the area of a regular polygon is written as:

$$A = (S_1 + S_2 + S_3 + S_n)\ r/2$$

The small n indicates that the sides continue to the required number.

1.5.5 Area and Circumference Practice Exercises

Calculate the areas of the following plane figures. You can check your work by looking up the answers in *Appendix A*.

1. A square with a height of 3 feet
2. A rectangle twice as wide as it is high, with a height of 3 feet, 8 inches

theorem, because it was first explained by the ancient Greek mathematician Pythagoras. It states that the square of the hypotenuse is equal to the sum of the squares of the remaining two sides. Expressed mathematically:

$$c^2 = a^2 + b^2$$

where c is the length of the hypotenuse and a and b are the lengths of the other two sides.

You may rearrange the equation to solve for the unknown side as follows:

$$a = \sqrt{(c^2 - b^2)}$$
$$b = \sqrt{(c^2 - a^2)}$$
$$c = \sqrt{(a^2 - b^2)}$$

For example, say you are trying to determine how long of a ladder to use to reach the top of a brick wall (*Figure 20*). If you know the height of the wall and the distance from the wall where the ladder will be placed, you can easily calculate the length of the ladder required using the Pythagorean theorem. In this example, the ladder is the hypotenuse of the right triangle formed by the wall and the level ground.

In the construction trades, the Pythagorean theorem is also called the 3-4-5 ratio. That's because whenever the longest leg of a triangle is 5 feet and the shorter legs are 3 feet and 4 feet, respectively, then the triangle is always a right triangle and contains a 90-degree angle. This is true for any triangle that has sides with a 3-4-5 ratio.

This theorem also applies if you multiply each number in the ratio (3, 4, and 5) by the same number. For example, if multiplied by the constant 3, it becomes a 9-12-15 triangle. For most construction layout and checking, right triangles that are multiples of the 3-4-5 ratio are used (such as 9-12-15, 12-16-20, 15-20-25, and 30-40-50). The specific multiple used is determined mainly by the relative distances involved in the job being laid out or checked. It is best to use the highest multiple that is practical because when smaller multiples are used, any error made in measurement will result in a much greater angular error.

So how does this work in practical terms? Let's say that C = 5 feet, A = 3 feet, and B = 4 feet. Plug these numbers into the formula as follows:

$$5^2 = 3^2 + 4^2$$
$$25 = 9 + 16$$

In practice, you can use the 3-4-5 ratio to verify that a building corner is square. To do this, follow these steps:

Step 1 Measure from the corner 3 feet along one wall, and place a mark at that point. Measure 4 feet along the other wall and mark that point.

Step 2 Use a ruler to measure the straight-line distance between the two points. If that distance is 5 feet, the corner is square. See *Figure 21.*

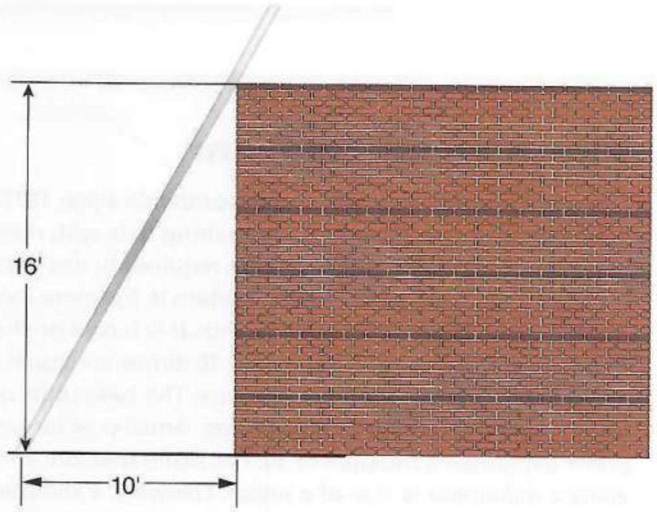

Figure 20 Brick wall and ladder.

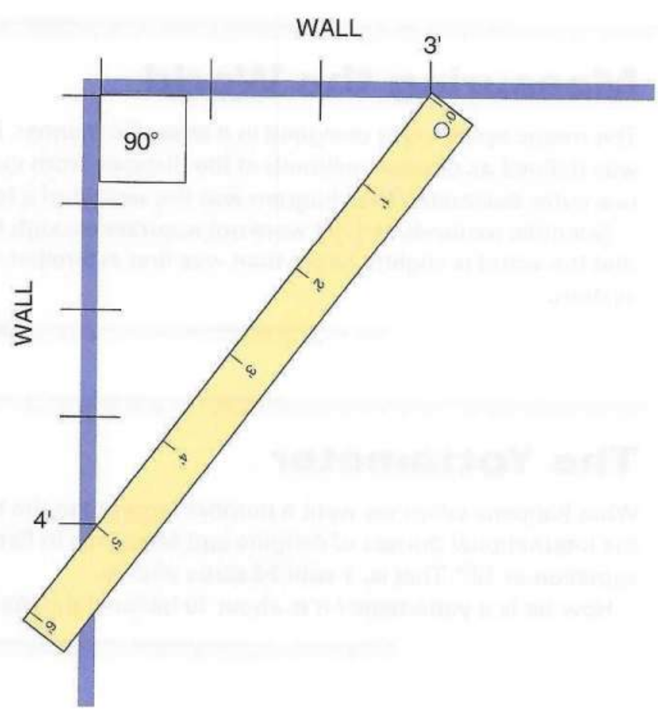

Figure 21 Checking the squareness of a corner.

Another Way to Think about Square Numbers

You know that the word square refers to shape, but in mathematical terms, it also refers to the product of a number multiplied by itself. For example, 25 is the square of 5, and 16 is the square of 4. Another way to say this is that 25 is 5 squared, or 5 times itself, and 16 is 4 squared, or 4 times itself.

In a mathematical equation this might appear as $5^2 = 25$ or $4^2 = 16$. In these examples, the numbers 5 and 4 are called the square roots, because you have to square them—or multiply them by themselves—to arrive at the squares.

The Metric System

The metric system has been used worldwide since 1875. The General Services Administration, which oversees all federal building projects, began requiring bids with metric specifications. In September 1996, all federally assisted highway construction projects were required to use metric standards.

The official name of the metric system is *Système International d'Unités* (SI). SI is a very convenient and logical system of measurements and weights. It is based on the number 10. This is similar to our system of currency: 10 pennies are equal to a dime, and 10 dimes are equal to a dollar. Terms such as kilometer, centimeter, and millimeter are units of metric measure. The base units of measure include the meter for length, the gram for weight, and the liter for liquid volume. Smaller or larger units are noted by adding a prefix to the base unit. The prefix expresses a multiple of 10. The same prefixes are used with all base units. A kilometer is 1,000 meters, while a millimeter is $\frac{1}{1,000}$ of a meter. Likewise, a kilogram is 1,000 grams, while a milligram is $\frac{1}{1,000}$ of a gram. This makes the metric system very easy to use. Refer to *Appendix B* for a list of the common SI prefixes, common metric measurements, and common US-to-metric and metric-to-US conversions,

Measuring the World

The metric system was designed in a scientific manner. Earth itself was selected as the measuring stick. The meter was defined as one ten-millionth of the distance from the equator to the North Pole. The liter was the volume of one cubic decimeter. The kilogram was the weight of a liter of pure water.

Scientific methods in 1795 were not accurate enough to measure the world. Modern measurements have shown that the world is slightly larger than was first estimated. However, the difference does not change the basic metric system.

The Yottameter

What happens when we want a number larger than the largest prefix? Every so often, new prefixes are added by the International Bureau of Weights and Measures in Paris. Added in 1991, the largest prefix is the yotta. It is one septillion or 10^{24}. That is, 1 with 24 zeros after it.

How far is a yottameter? It is about 10 billion light-years. Only the Hubble Space Telescope can see that far.

Additional Resources

Bricklaying: Brick and Block Masonry. 1988. Reston, VA: The Brick Institute of America.

Bricklaying Curriculum: Advanced Bricklaying Techniques. 1992. Raymond J. Turcotte and Laborn J. Hendrix. Stillwater, OK: Oklahoma Department of Vocational and Technical Education.

Building Block Walls: A Basic Guide for Students in Masonry Vocational Training. 1988. Herndon, VA: National Concrete Masonry Association.

1.0.0 Section Review

1. The two numbering systems that masons use, for which they have two kinds of rulers, are _____.
   a. the standard and metric systems
   b. the decimals and fraction systems
   c. the course and modular systems
   d. the standard and engineer's rules

2. The graduations in an engineer's rule are divided into _____.
   a. the letters *A* through *K*
   b. fractions of an inch
   c. percentages of a foot
   d. tenths of a foot

3. The three types of spacing rules commonly used by masons are _____.
   a. small, medium, and large
   b. residential, commercial, and specialty
   c. standard, oversize, and modular
   d. brick, block, and CMU

4. In modular design, the nominal dimension of a masonry unit is a multiple of _____.
   a. 4 inches
   b. 8 inches
   c. 16 inches
   d. 20 inches

5. A polygon that has four sides of two different lengths that meet at right angles is called a(n) _____.
   a. triangle
   b. rectangle
   c. tetrahedron
   d. pentagon

6. The formula for the Pythagorean theorem is _____.
   a. $c^2 = a^2 \times b^2$
   b. $c^2 = a^2 \div b^2$
   c. $c^2 = a^2 - b^2$
   d. $c^2 = a^2 + b^2$

SECTION TWO

2.0.0 MASONRY DRAWINGS

Objective

Identify the basic parts of a set of drawings and list the information found on each type.

a. Identify lines, symbols, and abbreviations used on drawings.
b. Identify scales and dimensions used on drawings.
c. Identify types of construction drawings.

Performance Task 3

Locate information on construction drawings.

Trade Term

Legend: A table, list, or chart used in construction drawings to explain the meanings of the various lines, symbols, and abbreviations used in that particular set of drawings.

Construction drawings are always part of a project's documentation. Along with the specifications, they form the written guidelines for the builder. In order to do well in your work, you must be able to read and understand the information on the project drawings.

This section is a review of construction drawing material introduced in the *Core Curriculum*. It also presents some additional information that is relevant to masons about drawings, their organization, and the symbols for construction materials.

2.1.0 Identifying Lines, Symbols, and Abbreviations Used on Drawings

In order to read drawings, you have to recognize the various lines, symbols, and abbreviations used in their preparation. *Figure 22* shows typical details from construction drawings, showing a variety of brick masonry walls. You will encounter many drawings like this on the job. This section reviews the keys to lines, symbols, and scales and the information they carry. Because lines, symbols, and abbreviations can vary from drawing to drawing, you should always consult the **legend**, which explains the meanings of the various lines, symbols, and abbreviations used in that particular set of drawings. You should always consult the legend before attempting to read a set of drawings.

Each line symbol used on drawings means something different. *Figure 23* shows the most common types of lines. However, these lines can vary. Always consult the legend or symbol list when referring to any drawing. *Figure 24* shows an example of a construction drawing using several different types of lines.

The drafting lines shown in *Figure 23* are used as follows:

- *Light full line* – This line is used for section lines, building background (outlines), and similar uses where the object to be drawn is secondary to the system being shown, such as heating, ventilating, and air conditioning (HVAC) or electrical.
- *Medium full line* – This type of line is frequently used for hand lettering on drawings. It is further used for some drawing symbols and circuit lines.
- *Heavy full line* – This line is used for borders around title block, schedules, and for hand-lettering drawing titles. Some types of symbols are frequently drawn with a heavy full line.
- *Center line* – A center line is a broken line made up of alternately spaced long and short dashes. It indicates the centers of objects, such as holes, pillars, or fixtures. Sometimes, the center line indicates the dimensions of a finished floor.
- *Hidden line* – A hidden line consists of a series of short dashes that are closely and evenly spaced. It shows the edges of objects that are not visible in a particular view. The object outlined by hidden lines in one drawing is often fully pictured in another drawing.
- *Dimension line* – These are thin lines used to show the extent and direction of dimensions. Dimension lines have three parts: a line, a dimension, and a termination symbol. The dimension is usually placed in a break inside the dimension lines. Normal practice is to place the dimension lines outside the object's outline. However, it may sometimes be necessary to draw the dimensions inside the outline depending on the available room. *Figure 25* shows some common dimension line styles.

Other uses of the lines just mentioned include the following:

- *Extension lines* – Extension lines are lightweight lines that start about 1/16 inch away from the edge of an object and extend out. A common use of extension lines is to create a boundary for dimension lines. Dimension lines meet extension lines with arrowheads, slashes, or dots.

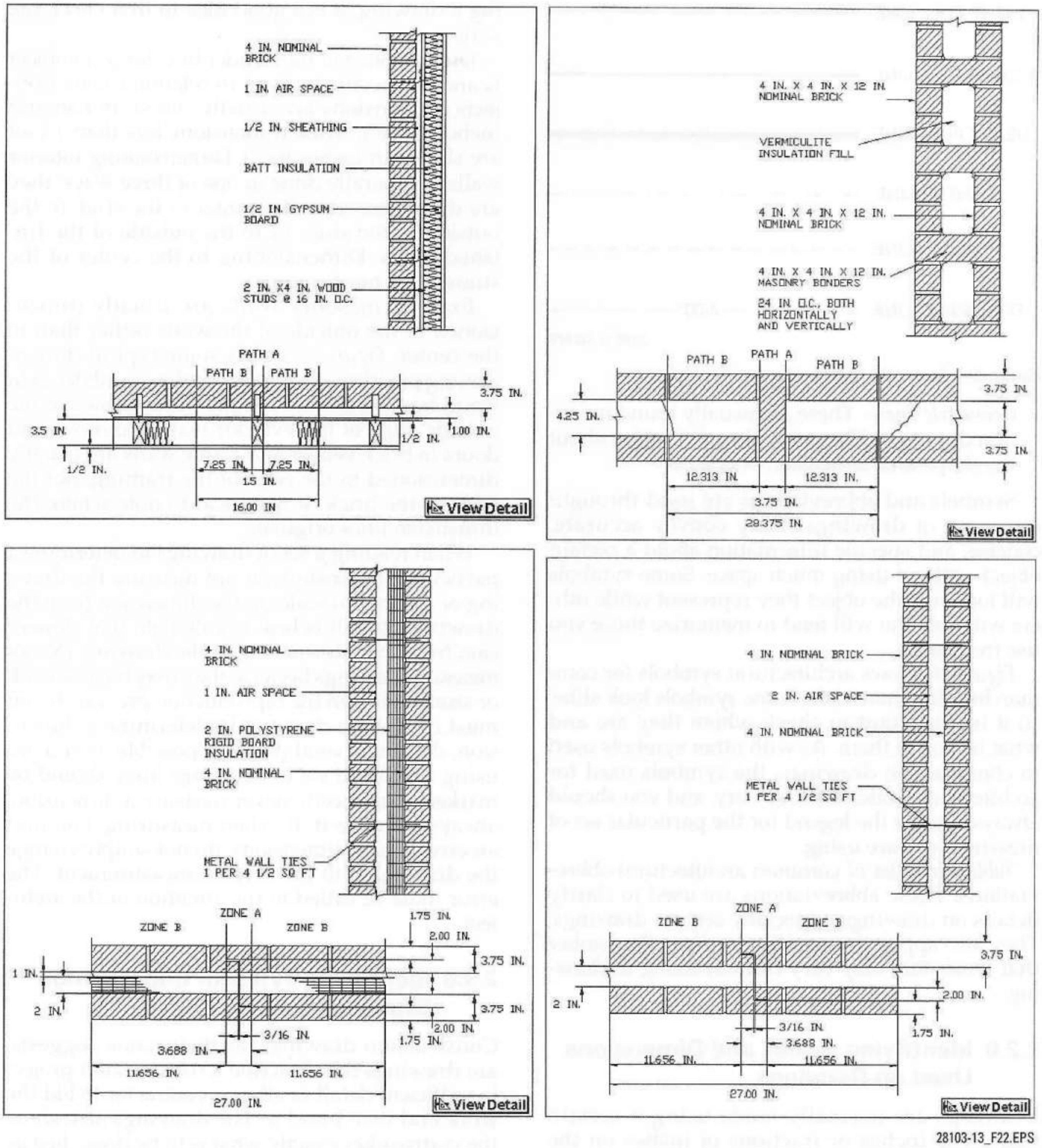

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Figure 22 Details from construction drawings showing brick masonry walls.

Extension lines that point from a note or other reference to a particular feature on a drawing are called leaders. They usually end in either an arrowhead or a dot and may include an explanatory note at the end.

- *Section lines* – These are often referred to as crosshatch lines. Drawn at a 45-degree angle, these lines show where an object has been cut away to reveal the inside.
- *Phantom lines* – Phantom lines are solid, light lines that show where an object will be installed. A future door opening or a future piece of equipment can be shown with phantom lines.

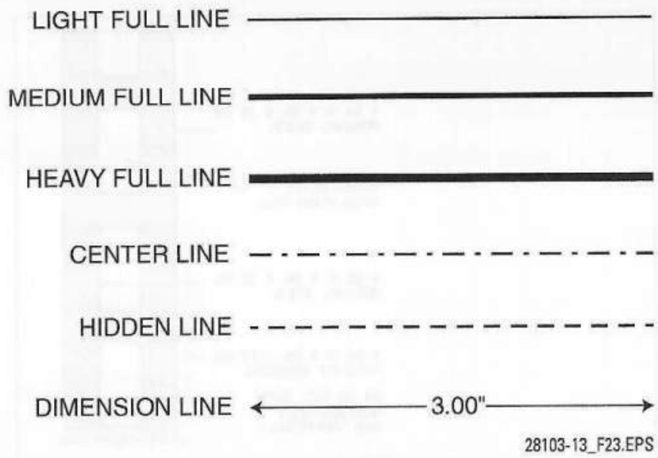


Figure 23 Lines used for construction drawings.

- *Geometric lines* – These are usually found in section drawings. They provide information about the shape and dimension of objects.

Symbols and abbreviations are used throughout a set of drawings. They convey accurate, concise, and specific information about a certain object without using much space. Some symbols will look like the object they represent while others will not. You will tend to memorize those you use frequently.

Figure 26 shows architectural symbols for common building materials. Some symbols look alike, so it is important to check where they are and what is next to them. As with other symbols used in construction drawings, the symbols used for architectural materials may vary, and you should always consult the legend for the particular set of drawings you are using.

Table 3 is a list of common architectural abbreviations. These abbreviations are used to clarify details on drawings, especially section drawings. They also appear in specification lists. Remember that these, too, may vary from drawing to drawing.

2.2.0 Identifying Scales and Dimensions Used on Drawings

Drawings are normally made using a certain scale. The inches or fractions of inches on the drawing represent real distances on the project. For residential drawings, the scale is usually ¼ of an inch equals 1 foot (1/4" = 1'-0"). This means that ¼ of an inch on the drawing equals 1 foot on the ground. For larger commercial projects, a smaller scale of ⅛ of an inch to 1 foot is normally used. For detail or sectional drawings, a larger scale is used. Commonly, these detail scales are ½ inch to 1 foot, or 1 inch to 1 foot. These scales are referred to as the ¼-, ⅛-, ½-, and 1-inch scales. When reading a drawing, it is a good idea to first check the scale.

Dimensions tell the builder how large an object is and its specific location in relation to other objects. Dimensions are usually shown in feet and inches (12'-6"), while dimensions less than 1 foot are shown in inches (6½"). Dimensioning interior walls is generally done in one of three ways: they are dimensioned to the center of the stud, to the outside of the stud, or to the outside of the finished walls. Dimensioning to the center of the studs is the most common.

Exterior masonry walls are usually dimensioned to the outside of the walls rather than to the center. *Figure 27* shows some typical dimensioning practices. Note that windows and doors in wood frame walls are usually dimensioned to the outside edge of the exterior wall. Windows and doors in brick veneer and frame walls are usually dimensioned to the edge of the framing, not the edge of the brick. It is critical to note where the dimension lines originate.

When reading a set of drawings to determine a particular dimension, do not measure the drawing or attempt to scale up the dimension from the drawing itself. It is best to calculate that dimension from the information on the drawing. Do not measure drawings because they may have shrunk or stretched from the reproduction process. If you must measure a drawing to determine a dimension, do it in several places if possible. If you are using a reduced set of drawings (they should be marked as reduced), never measure a dimension, always calculate it. If, when measuring, you find an error in the dimensions, do not simply change the drawing with the revised measurement. The error must be called to the attention of the architect.

2.3.0 Identifying Types of Construction Drawings

Construction drawings, as their name suggests, are drawings that describe a construction project in sufficient detail to allow a contractor to bid the work and then build it. The drawings also show the craftworker exactly what is to be done. Just as a mason always uses a level to check for plumb, a mason always uses a drawing to check for detail, location, and measurements. These drawings are usually bound together in a package. The package contains a cover page, a table-of-contents page, and sheets showing the technical details of the project. Depending on the complexity of the project, the specifications may also be included as part of the construction drawings. The title block

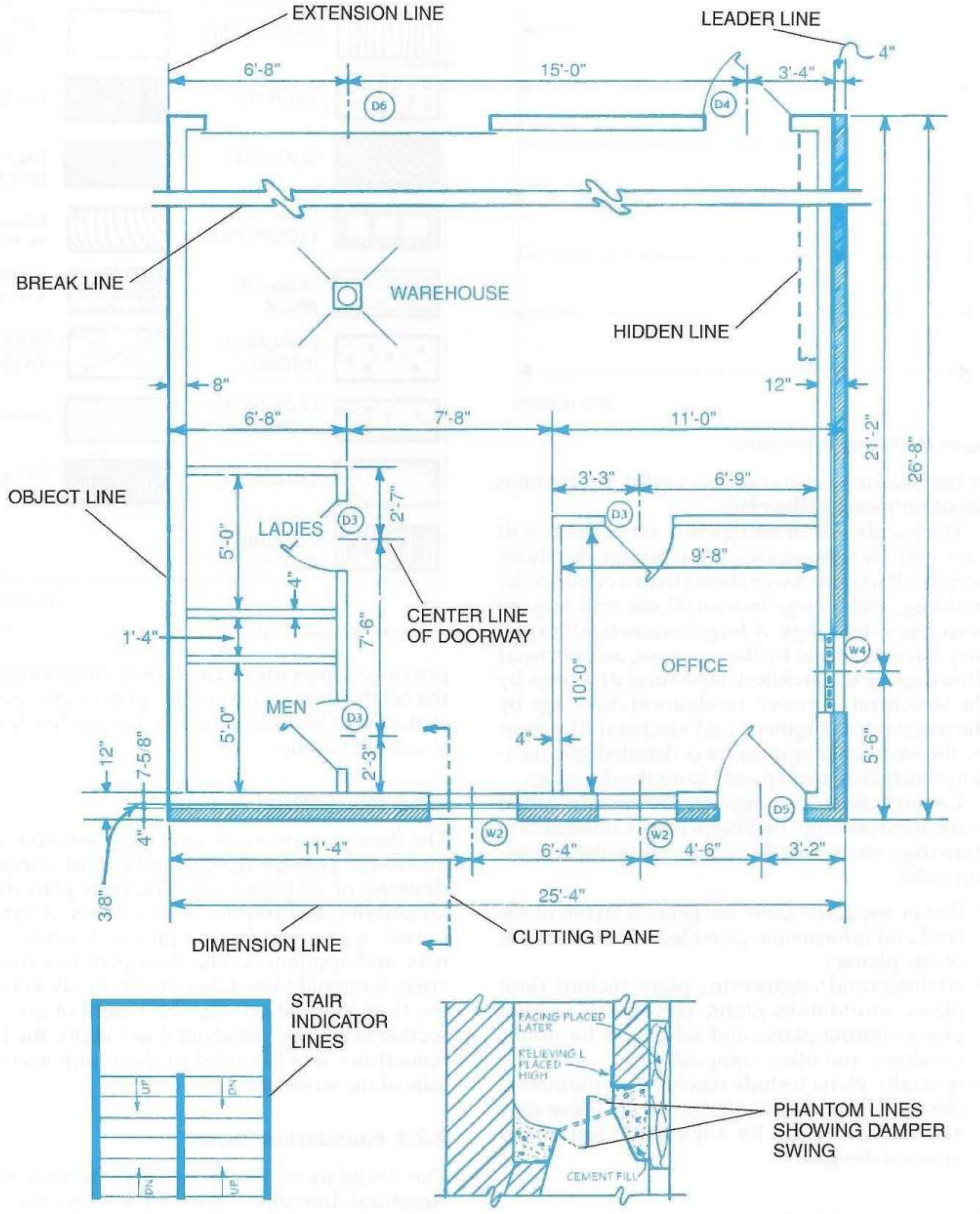
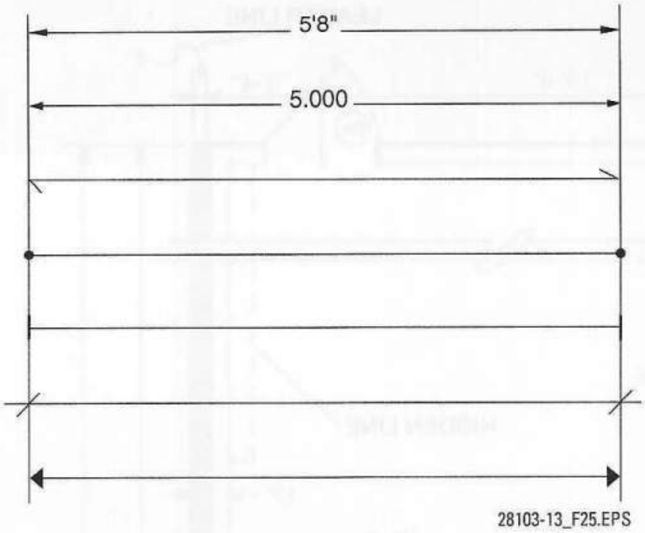
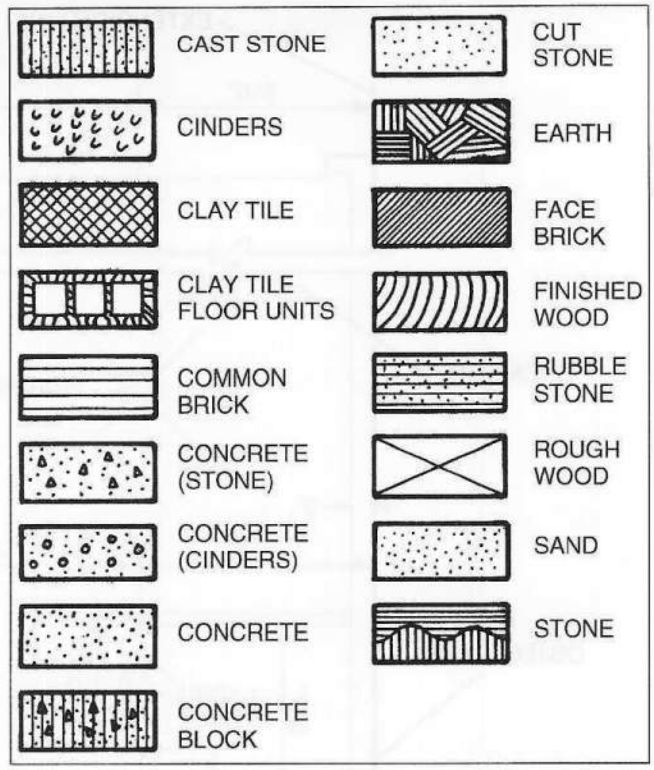


Figure 24 Sample construction drawing showing a variety of lines.



28103-13_F25.EPS

Figure 25 Dimension line styles.



28103-13_F26.EPS

Figure 26 Architectural material symbols.

of the drawings also contains useful information about revisions to the plans.

The number of drawings in a set of plans will vary with the complexity of the project. A private home will require fewer sheets than a commercial building, and a large industrial site will require even more drawings. A large commercial project may have site plans by the surveyor, architectural drawings by the architect, structural drawings by the structural engineer, mechanical drawings by the mechanical engineer, and electrical drawings by the electrical engineer, plus detailed specification sheets that are separate from the drawings.

Construction drawings are frequently called working drawings or blueprints. Construction drawings are normally organized in the following order:

- Plot or site plans show the general layout of the land and information provided by the surveyor or site planner.
- Architectural/engineering plans include floor plans, foundation plans, elevations, section plans, roofing plans, and schedules for doors, windows, and other equipment.
- Specialty plans include mechanical, plumbing, electrical, and ductwork drawings. These may also include details for any custom features or unusual designs.

2.3.1 Plot or Site Plans

The plot or site plan shows the location of the building in relation to the property lines. It may show utilities and utility easements, contour lines, site dimensions, other buildings on the property, walks, drives, and retaining walls (*Figure 28*). This plan also shows the finished floor elevation(s) and the north direction arrow. Site plans were covered in the *Core Curriculum* module *Introduction to Construction Drawings*.

2.3.2 Floor Plans

The floor plan provides the largest amount of information, perhaps making it the most important drawing of all (*Figure 29*). The floor plan shows all exterior and interior walls, doors, windows, patios, walks, decks, fireplaces, built-in cabinets, and appliances. The floor plan is actually a cross-sectional view taken horizontally between the floor and the ceiling. The height of the cross section is usually cut about 4 feet above the floor. Sometimes this is varied to show important details of the structure.

2.3.3 Foundation Plans

The foundation plan is usually the first of the structural drawings (*Figure 30*). It shows the foundation size and materials. It shows details about excavation, waterproofing, and supporting structures, such as footings or piles. It can have sections of the footings and foundation walls. When a building has a basement, it is included here as well.

Table 3 Architectural Abbreviations

ABBREVIATIONS					
AB	ANCHOR BOLT	FDN	FOUNDATION	RM	ROOM
ADD'L	ADDITIONAL	FIN.	FINISH	SCHED	SCHEDULE
ADJ	ADJACENT	FLR	FLOOR	SECT.	SECTION
AISC	AMERICAN INSTITUTE OF	FOB	FACE OF BRICK	SHT	SHEET
	STEEL CONSTRUCTION	F.O.CONC	FACE OF CONCRETE	SIM	SIMILAR
ALT.	ALTERNATE	FOW	FACE OF WALL	SLV	SHORT LEG VERTICAL
ARCH.	ARCHITECTURAL	FS	FLAT SLAB	SPC	SPACE
ASTM	AMERICAN SOCIETY FOR	FT	FOOT	SPEC	SPECIFICATION
	TESTING & MATERIALS	FTG	FOOTING	SQ	SQUARE
BLDG	BUILDING	FW	FILLET WELD	STD	STANDARD
BM	BEAM	GA	GAUGE	STIFF	STIFFENER
B.O.	BOTTOM OF	GAL.	GALVANIZED	STL	STEEL
BOT	BOTTOM	GL	GLULAM BEAM	STOR	STORAGE
BSMT	BASEMENT	GR	GRADE	SYM	SYMMETRICAL
BTWN	BETWEEN	GR BM	GRADE BEAM	T&B	TOP AND BOTTOM
CANT.	CANTILEVER	H.A.S.	HEADED ANCHOR STUD	THK	THICKNESS
CB	CARDBOARD	HORIZ	HORIZONTAL	T.O.	TOP OF
CH	CHAMFER	HSB	HIGH-STRENGTH BOLT	TYP	TYPICAL
CJ	CONTROL/CONSTRUCTION JOINT	ID	INSIDE DIAMETER	U.N.O.	UNLESS NOTED OTHERWISE
CLR	CLEAR, CLEARANCE	IN.	INCH	VAR	VARIES
CMU	CONCRETE MASONRY UNIT	INT	INTERIOR	VERT	VERTICAL
COL	COLUMN	JNT	JOINT	VIF	VERIFY IN FIELD
CONC	CONCRETE	LB	POUND	WT	WEIGHT
CONN	CONNECTION	LIN FT	LINEAL FEET		
CONST	CONSTRUCTION	LLV	LONG LEG VERTICAL		**SYMBOLS**
CONT	CONTINUOUS	MAT'L	MATERIAL		
CONTR	CONTRACTOR	MAX.	MAXIMUM	℄	CENTER LINE
CTRD	CENTERED	MECH	MECHANICAL		
DET	DETAIL	MID.	MIDDLE	ϕ	DIAMETER
DIAG	DIAGONAL	MIN	MINIMUM		ELEVATION
DIAM	DIAMETER	MISC	MISCELLANEOUS		
DIM.	DIMENSION	MTL	METAL	&	AND
DISCONT	DISCONTINUOUS	NIC	NOT IN CONTRACT		
DWG	DRAWING	NO.	NUMBER	W/	WITH
EA	EACH	NOM	NOMINAL		
EF	EACH FACE	NTS	NOT TO SCALE	PL	PLATE
EL.	ELEVATION	OC	ON CENTER	X	BY
ELECT.	ELECTRICAL	OD	OUTSIDE DIAMETER		
ELEV	ELEVATOR	O.H.	OPPOSITE HAND	#	NUMBER
EQ	EQUAL	OPNG	OPENING		
EWB	END WALL BARS		PLATE	@	AT
EW	EACH WAY	PSF	POUND PER SQUARE FOOT	◫	SQUARE
EXIST.	EXISTING	PSI	POUND PER SQUARE INCH		
EXP JNT	EXPANSION JOINT	R	RADIUS	L	ANGLE
EXT	EXTERIOR	REINF	REINFORCEMENT		
FD	FLOOR DRAIN	REQ'D	REQUIRED		

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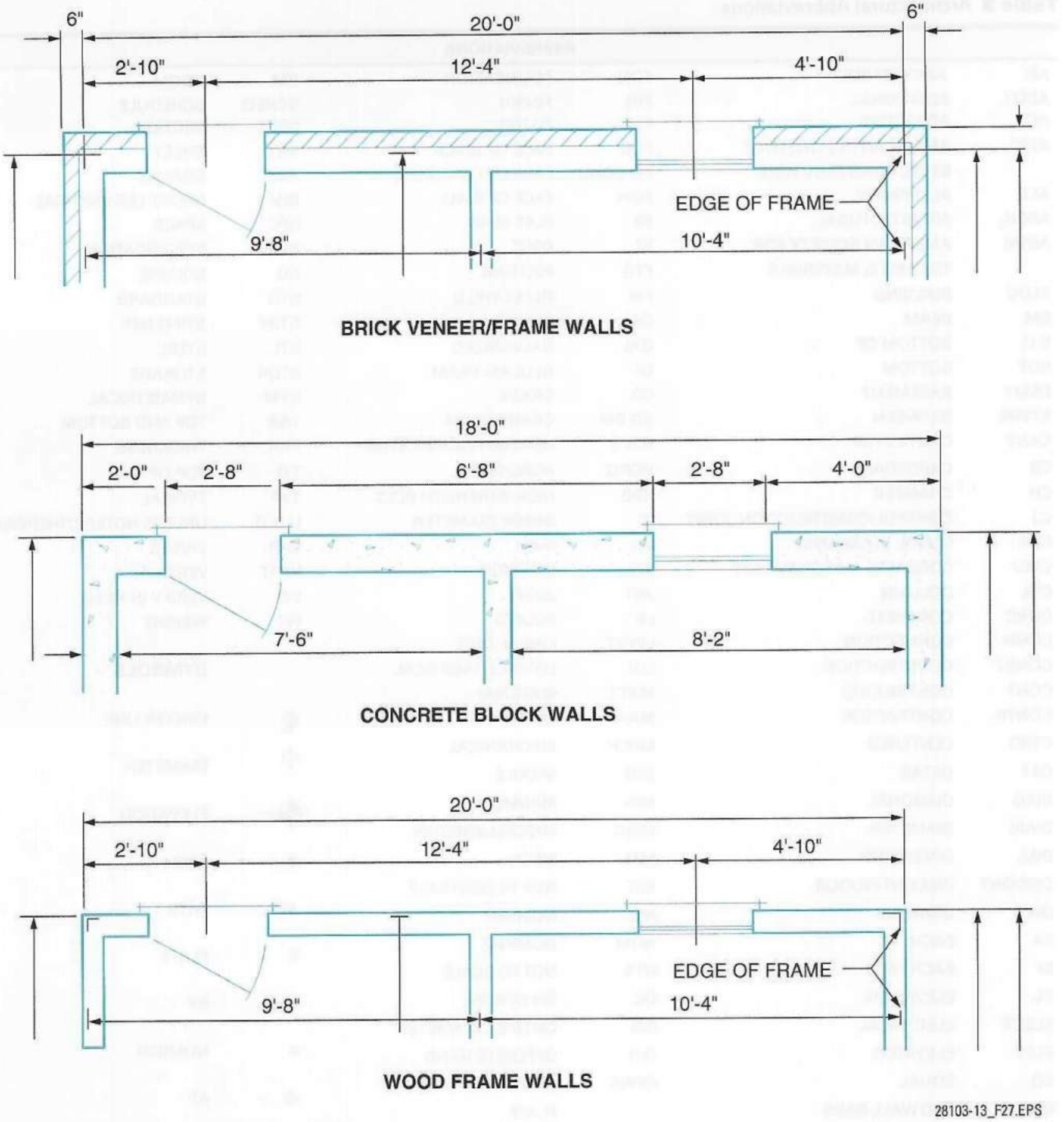
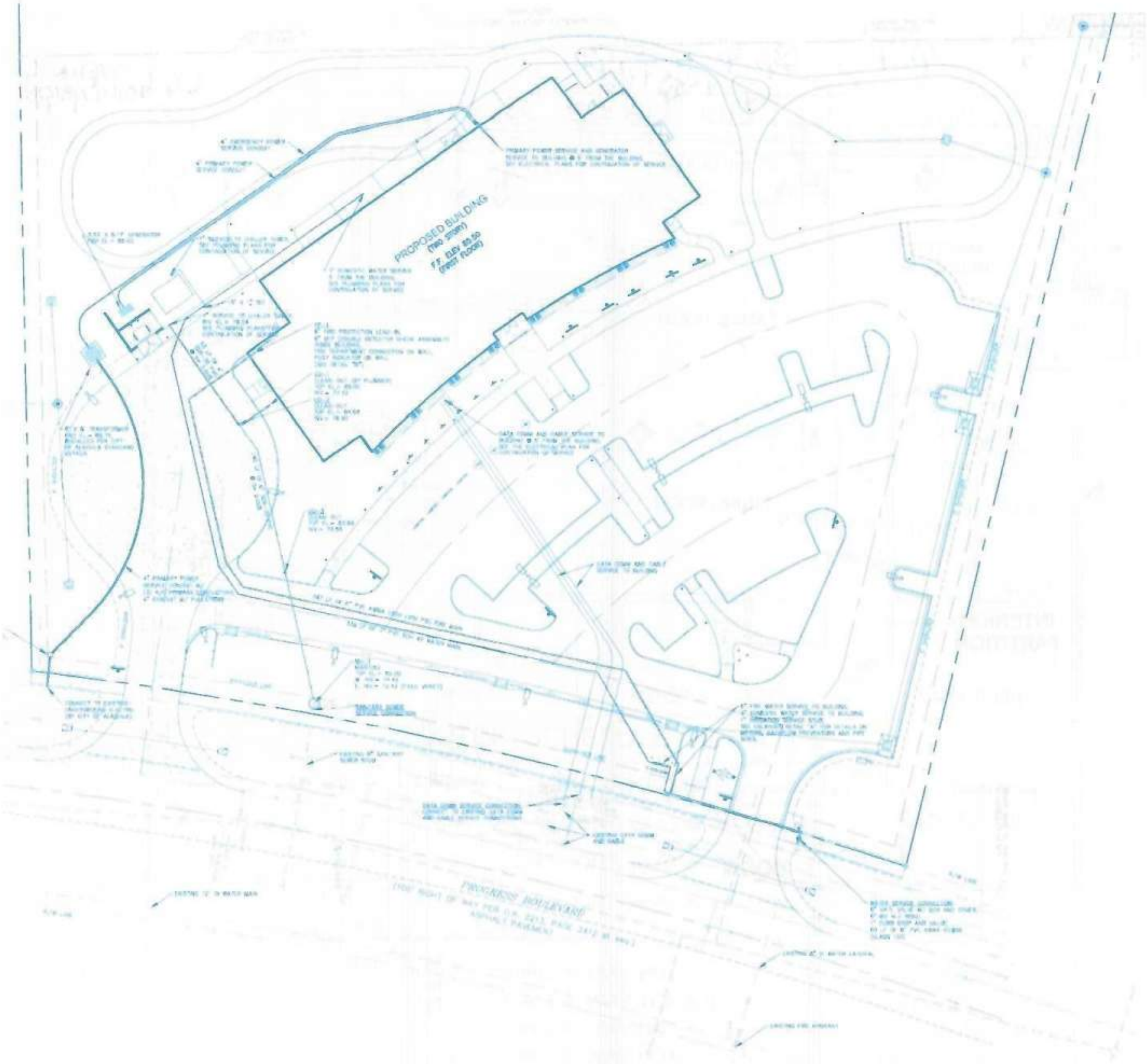


Figure 27 Dimension lines for different wall types.

Note that this detail contains alphanumeric bubble references to several construction details and section drawings that provide detailed information about the methods of construction.

2.3.4 Elevation Drawings

Elevation drawings are views of the exterior features of the building (*Figure 31*). They usually show all four sides of a building. Sometimes, for



28103-13_F28.EPS

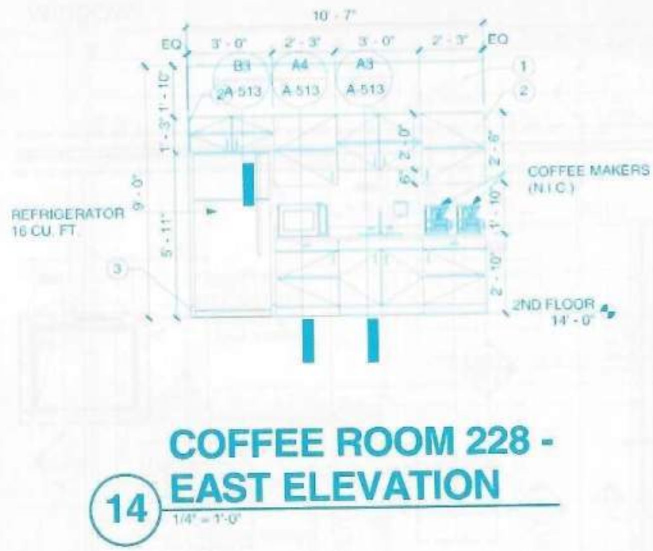
Figure 28 Plot plan.

a building of unusual design, more than four elevations may be needed. The elevation drawings show outside features, such as placement and height of windows, doors, chimneys, and roof lines. Exterior materials are indicated, as well as important vertical dimensions.

Interior elevation drawings show in greater detail the various cabinets, bookshelves, fireplaces, and other important interior features. These are sometimes called detail drawings.

2.3.5 Section Drawings

Section drawings give information about the construction of walls, stairs, or other items that cannot be easily given on the elevation or floor plan drawings (*Figure 32*). These drawings are usually drawn to a scale large enough to show the details without cluttering the drawing. A section taken through the narrow width of a building is known as a transverse section. A section taken through the entire length is known as a longitudinal section.



28103-13_F31.EPS

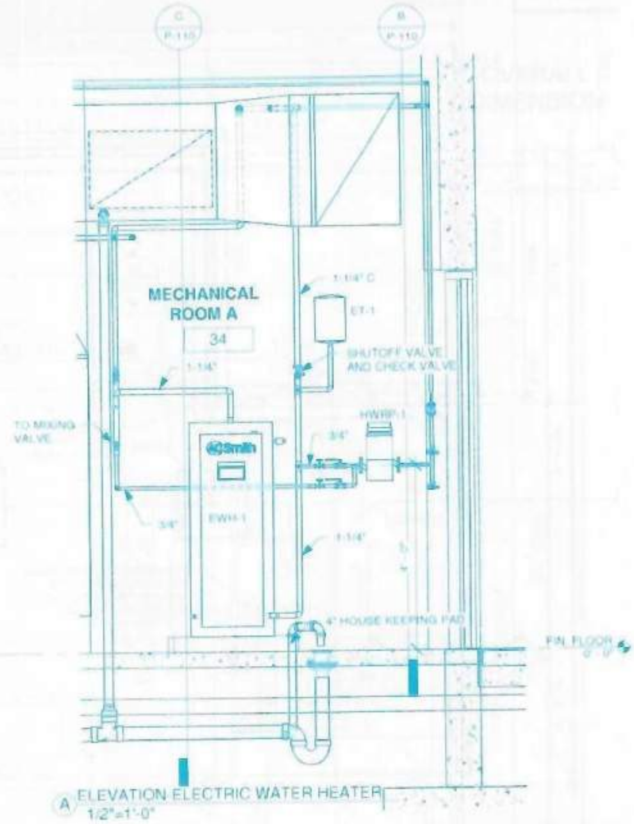
Figure 31 Detail of an elevation drawing.

When there are only a few sections, they are often incorporated onto one of the other drawings instead of a separate section drawing. The section drawings show the building from the foundation footings to the roof.

The working mason should be able to read section plans and answer questions about the work. What is the foundation wall made of? What is the distance between the brick veneer and the backing walls? How frequently is the veneer tied to the backing? What is the distance between weepholes?

2.3.6 Schedules

Schedules are an important tool in a set of plans. Although they are tables, not drawings, they give specific information that would be impractical to include on the documents. They also make it convenient for ordering material by collecting this detailed information in one place.

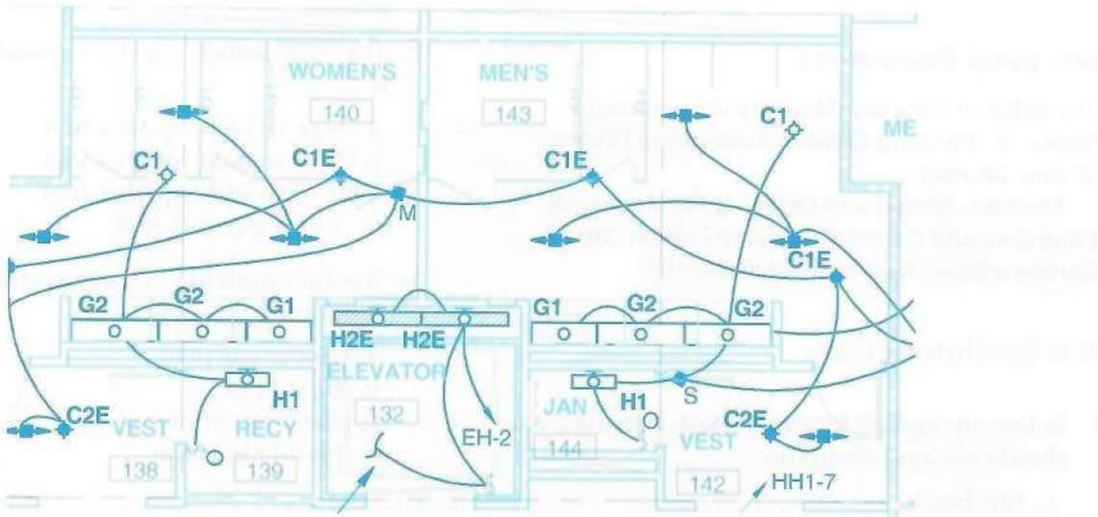


28103-13_F32.EPS

Figure 32 Section drawing.

2.3.7 Specialty Plans

Specialty plans give details about plumbing, electrical, and duct work (*Figure 33*). It might seem that a mason does not have to know about these things, but this is not the case. Masons are only one of the many kinds of craftworkers on the job. For example, masons have to cut around plumbing pipe, electrical boxes, and wall penetrations. Understanding what other workers are doing and how they affect your work is important. This information is on the drawings. Use them to help you work smarter.



NCCER LUMINAIRE SCHEDULE

TYPE	MFG	CATALOG NO.	DESCRIPTION	LAMPS Qty	LAMPS Watts	LAMPS Desc	FIXTURE INPUT WATTS	VOLTS	MTG	REMARKS
INTERIOR										
A1	METALUX	AC	2x2 DUAL BASKET LINEAR FACETED ACRYLIC REFLECTOR	2	17	T8	46	277	GRID	
A2	METALUX	AC	2x4 DUAL BASKET LINEAR FACETED ACRYLIC REFLECTOR	2	32	T8	76	277	GRID	
A3	METALUX	RDI	2x2 DIRECT/INDIRECT SINGLE BASKET LINEAR FACETED ACRYLIC REFLECTOR	3	17	T8	72	277	GRID	
A4	METALUX	RDI	2x4 DIRECT/INDIRECT SINGLE BASKET LINEAR FACETED ACRYLIC REFLECTOR	3	32	T8	114	277	GRID	
B1	METALUX	GR8	2x2 LENSED A12 125	2	17	T8	46	277	GRID	
B2	METALUX	GR8	2x4 LENSED A12 125	2	32	T8	76	277	GRID	
C1	COOPER	PD6	6" DOWNLIGHT CLEAR SPECULAR REFLECTOR	1	26	TRT	28	277	GRID	
C2	COOPER	PD6	6" DOWNLIGHT CLEAR SPECULAR REFLECTOR	1	32	TRT	36	277	GRID	
C3	COOPER	PD6	6" DOWNLIGHT CLEAR SEMI-SPECULAR REFLECTOR WITH WHITE SPLAY FRESNEL LENS	1	18	TRT	22	277	GRID	WET LOCATION
C4	SPECTRUM LIGHTING	SPC0812CF	8" PENDANT CLEAR SPECULAR REFLECTOR COLOR BLACK	1	26	TRT	28	277	PENDANT	
C5	SPECTRUM LIGHTING	PROCT22	22" PENDANT HALF REFLECTOR/HALF OPAL DIFFUSER	8	42	CFL	384	277	PENDANT	
C6	SPECTRUM LIGHTING	SPC0611CF	6" PENDANT CLEAR SPECULAR REFLECTOR COLOR BLACK	1	32	TRT	36	277	PENDANT	
D1	METALUX	WN	SQUARE BASKET WRAPAROUND	2	32	T8	70	277	CHAIN	
D2	SPECTRUM LIGHTING	STPT3LED	3" LED TRACK LIGHT WITH 48" TRACK COLOR BLACK	2	15	LED (INCLUDED)	30	277	CEILING	
D3	SPECTRUM LIGHTING	STPT3LED	3" LED TRACK LIGHT WITH 72" TRACK COLOR BLACK	3	15	LED (INCLUDED)	45	277	PENDANT	
D4	SPECTRUM LIGHTING	STPT2LED	3" LED TRACK LIGHT WITH 72" TRACK COLOR BLACK	4	15	LED (INCLUDED)	60	277	PENDANT	
F1	INCON LIGHTING	544	WIDE BAND VANITY WITH CHOME ACCENTS	2	17	T8	48	277	WALL	
G1	METALUX	SSL	STAGGERED STRIP W/ SPECULAR ASYMMETRIC REFLECTOR (3)	1	25	T8	33	277	SURFACE	
G2	METALUX	SSL	STAGGERED STRIP W/ SPECULAR ASYMMETRIC REFLECTOR (4)	1	32	T8	38	277	SURFACE	
H1	LSI INDUSTRIES	VL	2' ENCLOSED LINEAR POLYCARBONATE DIFFUSER	1	17	T8	24	277	WALL	<1>
H2	LSI INDUSTRIES	VL	4' ENCLOSED LINEAR POLYCARBONATE DIFFUSER	2	32	T8	76	277	WALL	<1>
X1	THOMAS & BETTS	LXN	EXIT SIGN EDGE LIT LED RED LETTER STENCIL ON MIRROR ACRYLIC PANEL EXTRUDED AL FINISH HOUSING	1		LED (INCLUDED)				MOUNTING TYPE SEE LIGHTING PLANS
X2	THOMAS & BETTS	ELXN400	EXIT SIGN LED RED LETTER STENCIL WHITE THERMOPLASTIC HOUSING	1		LED (INCLUDED)				MOUNTING TYPE SEE LIGHTING PLANS

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Figure 33 Detail of an electrical drawing and schedule.

Additional Resources

The ABCs of Concrete Masonry Construction. Skokie, IL: Portland Cement Association (Video, 13 min. 34 sec.).

Masonry Design and Detailing For Architects, Engineers and Contractors, Sixth Edition. 2012. Christine Beall. New York: McGraw-Hill.

2.0.0 Section Review

1. Before attempting to read a set of drawings, you should always consult the _____.
   a. title block
   b. legend
   c. ANSI specifications
   d. plot or site plans

2. The scale usually used for residential drawings is _____.
   a. ⅛ of an inch equals 1 foot
   b. ¼ of an inch equals 1 foot
   c. ½ of an inch equals 1 foot
   d. 1 inch equals 1 foot

3. The first drawing in a set of structural plans is usually the _____.
   a. plot or site plan
   b. floor plan
   c. elevation drawing
   d. foundation plan

SECTION THREE

3.0.0 MASONRY SPECIFICATIONS, STANDARDS, AND CODES

Objective

Identify the purpose of specifications, standards, and codes used in the building industry and the sections that pertain to masonry.

a. Explain the purpose of specifications, standards, and codes.
b. Describe the purpose of inspections and testing.

Trade Term

MasterFormat™: A standard indexing system for construction specifications in the United States and Canada, developed by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC) and used by project planners to prepare project specifications.

A mason must follow certain rules in addition to the building plans. These include specifications, standards, and codes. Specifications provide additional detail that is often not available on the plans. Standards provide detailed information and guidance on a single topic and are followed across the industry and even internationally. Codes are legal documents adopted by a jurisdiction that establish the minimum acceptable standards, rules, and regulations for all materials, practices, and installations used in buildings and building systems. Codes are adopted to ensure that contractors perform their work according to recognized standards. In this section, you will learn about specifications, standards, and codes, and how they apply to masonry. You will also learn about how specifications, standards, and codes govern inspections and testing, and why these activities are important for ensuring that safe construction practices are followed.

3.1.0 Understanding Specifications, Standards, and Codes

Construction plans or drawings usually include specifications. These are known as *specs*. They are written instructions or information needed to complete the work. Specs contain information not found on the drawings. The architect, the engineer, or the owner can give direction on how the job must be done. In fact, such specifications are part of the building contract. The plans cannot show all the necessary information for the mason to complete the work. Specifications add the details. These include the following:

- Quality of materials
- Quality of workmanship (minimum tolerance)
- Procedures or techniques to be used during construction
- Various responsibilities of each subcontractor

Generally, specifications are divided into two major areas: general conditions and technical specifications. The general conditions cover such legal items as insurance, permit responsibilities, and payment schedules. The mason will have little contact with these general conditions. Masons do need to read the technical specifications, though, to do their work properly.

Specifications are prepared for specific projects. They reflect the special conditions of that project. Standards apply to all projects. They describe the best practices or minimum requirements for doing certain tasks. Standards are referenced by specifications and by codes.

As explained previously, codes are legal requirements for building and construction. Model codes are set by national organizations and are adopted by local governments, which may modify them. Local codes have the force of the law, and they are enforced by building inspectors.

3.1.1 Specifications

Technical specifications directly affect the mason's work. They list how the job is to be completed. Each section includes information for the work of a single subcontractor. On every project, there will be a set of technical specifications for the masonry work.

Technical specifications are legal documents because they are part of a contract. The mason must use both the drawings and the specifications to construct the project. If there is a discrepancy between the two, the specifications have priority. The architect will address conflicts that occur during construction, such as an electrical conduit that is supposed to be positioned where a drainpipe is to be located.

In 1995, the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC) jointly developed a standard indexing system for construction specifications in the United States and Canada called **MasterFormat™**. Project planners follow the MasterFormat™ system when preparing project specifications because it makes organizing and finding information much simpler. Today, MasterFormat™ is divided into more than 50 divisions, each of which refers to a specific trade, specialty, or area of technical expertise. Masonry is covered in Division 4 of the MasterFormat™. *Figure 34* lists the sections under Division 4 that are used to organize masonry specifications on a project.

Highly detailed technical specifications spell out not only the materials, but how they are to be assembled and finished. This ensures the long-term performance of the materials. It is based on engineering studies about the properties of masonry construction.

Specifications take advantage of these engineering studies. They do this by referencing existing standards and codes. By referencing them, the specifications incorporate the provisions of the standards and codes.

Almost every type of building material has a multitude of size and performance standards and codes for it. The standards and codes guide and regulate manufacturers, designers, and builders. There are voluntary standards, national standards, international standards, national codes, local building codes, and model codes. The next sections discuss standards and codes in greater detail.

3.1.2 Standards

When you look at technical specifications, you will find items like "work to meet *ASTM C144-96*" or "as defined by *CSA A165.2*." These phrases refer to studies by the American Society for Testing and Materials (ASTM) International or the Canadian Standards Association (CSA). These are known as standards.

A standard usually has a single subject. It defines one aspect of the subject. The standards are based on studies, research, and advances in materials and construction techniques. Typical standards include the following:

- *ASTM C1072, Method for Measurement of Masonry Flexural Bond Strength*
- *ASTM C315, Specification for Clay Flue Linings*

Appendix C lists ASTM standards for masonry construction. Read through the list of titles in *Appendix C*. You can see how much study has gone into modern masonry materials and practices.

The ASTM and CSA are only two of the organizations publishing standards for the masonry industry. Consensus standards and codes are developed by other independent organizations, including the following:

- The American Society of Civil Engineers (ASCE)
- The American Institute of Steel Construction (AISC)
- The Masonry Society (TMS)
- The American Concrete Institute (ACI)

Standards are usually updated on a three-year cycle. ASTM and the other organizations gather data on new materials and techniques and include them in the standards. For ASTM publications, the year of publication follows a dash after the title number. Always make sure you are using the most current standard as adopted by your local jurisdiction.

DIVISION 04—MASONRY

- 04 00 00 - MASONRY
- 04 10 00 - *UNASSIGNED*
- 04 20 00 - UNIT MASONRY
- 04 30 00 - *UNASSIGNED*
- 04 40 00 - STONE ASSEMBLIES
- 04 50 00 - REFRACTORY MASONRY
- 04 60 00 - CORROSION-RESISTANT MASONRY
- 04 70 00 - MANUFACTURED MASONRY
- 04 80 00 - *UNASSIGNED*
- 04 90 00 - *UNASSIGNED*

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Figure 34 CSI MasterFormat™ specification divisions for masonry.

3.1.3 Codes

Building codes are enforceable standards. They include all aspects of building construction. Their primary purpose is to protect the public. Safety is included in all aspects of building construction. Some areas have special concerns, like earthquakes. The local codes in these areas include special conditions for local hazards. Local codes can also include local requirements, such as conformance with a zoning plan, or lot setbacks. Codes establish minimum requirements for all aspects of masonry units and masonry work. Masonry work will meet or exceed code standards.

You may have heard of the *International Building Code®*. Throughout the years, organizations have worked together to establish model building codes. Model codes are technical documents written by an organization. They are based on or incorporate standards published by ASTM and other organizations. Local communities or states can adopt a model code. The model code then becomes a local code or law. This provides communities with sound laws without the expense of research and investigation.

ACI 530/ASCE 5/TMS 402 Building Code Requirements for Masonry Structures, consolidates several masonry codes. As its title suggests, it is published jointly by the ACI, ASCE, and TMS. *Figure 35* is an outline of the 2011 edition of *Building Code Requirements for Masonry Structures.* Each of these topics refers to many standards. It reflects many years of testing and research.

Specifications for commercial and industrial projects are based on local codes. Unlike residential projects, commercial and industrial projects are always designed and managed by architects and engineers registered by the state. They must make sure that the project complies with all local codes. Codes for commercial projects are usually more detailed. They are more stringent about fire protection, loadbearing, and parking spaces than codes for residential buildings.

3.2.0 Understanding Inspections and Testing

Every construction contract has specifications to cover inspection and acceptance of the finished work. ASTM has published many specifications about testing. Acceptance of the finished product depends on the inspection and test results.

For residential projects, inspection and testing are usually done by the local building inspector. This inspector will be looking for compliance with the local building code. The inspector works closely with the contractor to coordinate inspections with the completion of critical phases of the work. Work cannot progress on the next phase until this inspection has been made and the inspector signs off on the work. For this reason, you may see an inspector's checkoff sheet posted on the job site with the inspector's comments and signature for each phase. This may be in the job superintendent's office, or it may be posted at the next place the inspector is due to visit.

For residential projects, testing is usually limited to looking at the material tags and manufacturer's documents that come with the materials. For this reason, you should not throw these documents away until the inspector visits the site and signs off on the work.

On some projects, the architect will also inspect the work as it progresses. The architect will be looking for compliance with the drawings and specifications and will not worry about the building code. On some projects, a representative of the owner may check the craftsmanship of the work accomplished every day. Work that does not meet standards, drawings, specifications, or local codes must be done again. This can be very costly, so it is important to do it right the first time.

Inspection and testing on commercial and industrial projects is much more involved, and depending on the project size, will require a full-time staff hired by the owner. The representatives of the owner and/or architect will look for quality and compliance with the plan and specifications. The building inspector will look for compliance with the code. The contractor must pay to take out and replace work that is not up to specifications or code, just as with residential projects.

Earliest Building Code

The earliest building code was the Code of Hammurabi. The king of the Babylonian empire adopted this code in 2200 BC. It assessed severe penalties, including death, if a building was not constructed safely.

A Brief History of Codes

Prior to 2000, there were three model codes used throughout the United States:

- The *Southern Standard Building Code,* published by the Southern Building Code Congress International (SBCCI), typically used throughout the Southeast
- The *National Building Code,* published by the Building Officials and Code Administrators (BOCA) International, adopted mostly in the northeast and central states
- The *Uniform Building Code,* published by the International Conference of Building Officials (ICBO), used throughout the West

In 2000, these three organizations merged into the International Code Council. They issued the *International Building Code®* (IBC). This model code has been adopted and is now law throughout most of the United States. The National Fire Protection Association also issued a model code called *NFPA 5000®*. It is used in a few communities and has been adopted by the state of California.

Building Code Requirements for Masonry Structures (TMS 402-11/ACI 530-11/ASCE 5-11)

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Additional Resources

ACI 530/ASCE 5/TMS 402, Building Code Requirements for Masonry Structures. Latest edition. Reston, VA: American Society of Civil Engineers.

International Building Code® Latest edition. Falls Church, VA: International Code Council.

A Manual of Construction Documentation: An Illustrated Guide to Preparing Construction Drawings. 1989. Glenn E. Wiggins. New York: Whitney Library of Design.

3.0.0 Section Review

1. *Building Code Requirements for Masonry Structures*, is published jointly by _____.
   - a. OSHA, EPA, and DOL
   - b. NCMA, BIA, and MCAA
   - c. ACI, ASCE, and TMS
   - d. SBCC, BOCA, and ICBO

2. For residential projects, inspection and testing are usually done by _____.
   - a. the project manager
   - b. the architect
   - c. the site inspector
   - d. the local building inspector

SUMMARY

This module covered three topics: math, drawings, and specifications. Math skills are useful for calculating materials and supplies. They are also needed to interpret project drawings. Masons need to know how to convert fractions and measurements. They must be able to calculate areas and volumes of common geometric figures. They also need to read mason's rules.

Project drawings include several categories. A project drawing package will include plot plans, floor plans, elevations, sections, materials schedules, and structural, electrical, and mechanical drawings. They provide details by using lines, symbols, and measurement notations.

Specifications provide detail not available on the plans. Technical specifications refer to and include standards and codes. Standards are single-topic, nationally published, detailed guidelines. Model codes include references to many standards. Local codes are often based on model codes and include local matters, such as zoning.

Review Questions

1. On the job, the most common fractions a mason will deal with are ⅜ inch and _____.
   a. ¼ inch
   b. ½ inch
   c. ⅝ inch
   d. ⅞ inch
2. The common denominator of ⅔ and ¾ is _____.
   a. 3
   b. 4
   c. 6
   d. 12
3. On a six-foot folding rule, each inch is usually divided into _____.
   a. 6 parts
   b. 10 parts
   c. 16 parts
   d. 24 parts
4. A 10-foot wall built with 8 inch × 8 inch × 16 inch concrete block would be _____.
   a. 11 courses
   b. 13 courses
   c. 15 courses
   d. 17 courses
5. To find the circumference of a circle, multiply the diameter by _____.
   a. 2.25
   b. 3.14
   c. 3.66
   d. 4.12
6. A three-sided figure with an interior angle greater than 90 degrees is a(n) _____.
   a. acute triangle
   b. equilateral triangle
   c. obtuse triangle
   d. scalene triangle
7. The shortest leg of a right triangle is the _____.
   a. base
   b. orthogonal
   c. hypotenuse
   d. riser
8. The symbol shown in *Review Question Figure 1* is used on construction drawings to indicate _____.
   a. stone
   b. face brick
   c. common brick
   d. clay tile

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Figure 1

9. If the scale on a construction drawing reads 1/4" = 1'-0" and a dimension on the drawing is 2" long, the actual length of that dimension is _____.
   a. 8'
   b. 6'
   c. 4'
   d. 2'
10. Floor plans, foundation plans, and elevations are all considered _____.
    a. specialty plans
    b. mechanical drawings
    c. architectural/engineering plans
    d. plot or site plans
11. A floor plan represents a cross section of the building, generally _____.
    a. at floor level
    b. 4 feet above the floor
    c. at ceiling level
    d. 2 feet below the top plate
12. Construction drawings show the edges of objects that are not visible in a particular view by using a(n) _____.
    a. phantom line
    b. extension line
    c. light full line
    d. hidden line

13. Details such as quality of materials and quality of workmanship are covered _____.
    a. in specifications
    b. by national standards
    c. as part of local building codes
    d. in OSHA regulations

14. If there is a discrepancy between construction drawings and specifications, _____.
    a. the building inspector must be informed
    b. drawings have priority
    c. specifications have priority
    d. the mason can choose which to follow

15. The abbreviation ASTM stands for _____.
    a. Allied School of Technical Masonry
    b. American Society for Testing and Materials
    c. Annual Survey of Testing Methods
    d. American Society of Training Managers

Trade Terms Quiz

Fill in the blank with the correct trade term that you learned from your study of this module.

1. A table, list, or chart used in construction drawings to explain the meanings of the various lines, symbols, and abbreviations used in that particular set of drawings is called a _______.

2. The _______ is the size of the masonry unit plus the thickness of one standard mortar joint, used in laying out courses.

3. The process of changing from one form of measure to another is called _______.

4. _______ is the CSI's standard indexing system for construction specifications in the United States and Canada.

Trade Terms:

Converting
Legend
MasterFormat™
Nominal dimension

Steven Fechino

Engineering and Construction Manager
Mortar Net Solution

Training has been an important part of Steven Fechino's career in masonry, ever since he learned valuable skills as an apprentice. Today, as an instructor, he helps young apprentices learn the same values of craftsmanship and skill that helped make his career rewarding.

How did you get started in the construction industry?
My father and all of his friends were in the industry, and so I never even considered another career path. My father was in construction product sales, and I grew up walking on job sites with my father, measuring projects for his customers. I held the dumb end of the tape measure; I have never understood why.

What do you enjoy most about your career?
I enjoy projects that are difficult when they under construction, but that are simple to explain once they are completed!

Why do you think training and education are important in construction?
Training is the most important part of my job. I believe that training comes from everyone you meet in the industry. People I have worked with have influenced me even if they did not show me a specific trade skill. Special people have taught me to talk respectfully to customers, to ask better questions, and to listen to their requirements better. True professionals never complete their craft training.

Why do you think credentials are important in construction?
Credentials are important because you must be able to show where you have been, so that clients can decide whether they want to follow you to the next destination.

How has training/construction impacted your life and career?
Training has been a big part of my career, as I have had many mentors. The range of skills that I have developed has allowed me to support my family through this economic downturn by performing many different tasks.

Would you recommend construction as a career to others?
Yes, without a doubt! It has been a fulfilling career that has offered many challenges with exciting results.

What does craftsmanship mean to you?
Craftsmanship is your reward for hard work. It is the skill that allows you to get a job, maintain a job, and win out over another person for a job. It is what you bring to the table; it is where you leave your mark.

Trade Terms Introduced in This Module

Converting: The process of changing from one form of measure to another, for example, from feet to inches or from inches to feet.

Legend: A table, list, or chart used in construction drawings to explain the meanings of the various lines, symbols, and abbreviations used in that particular set of drawings.

MasterFormat™: A standard indexing system for construction specifications in the United States and Canada, developed by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC) and used by project planners to prepare project specifications.

Nominal dimension: The size of the masonry unit plus the thickness of one standard (⅜ to ½ inch) mortar joint, used in laying out courses.

Appendix A

Answers to Practice Exercises

Answers to 1.1.2 Addition Practice Exercises

1. 1 foot 10 inches + 2 feet 5 inches = 3 feet 15 inches = 4 feet 3 inches
2. 2 feet 9 inches + 2 feet 4 inches = 4 feet 13 inches = 5 feet 1 inch
3. 2 feet 7 inches + 1 foot 6 inches = 3 feet 13 inches = 4 feet 1 inch
4. 1 foot 9 inches + 1 foot 7 inches = 2 feet 16 inches = 3 feet 4 inches

Answers to 1.1.4 Subtraction Practice Exercises

1. 2 feet 6 inches – 1 foot 8 inches = 1 foot 18 inches – 1 foot 8 inches = 10 inches
2. 2 feet 5 inches – 2 feet 7 inches = –2 inches
3. 35 feet 4 inches – 21 feet 6 inches = 34 feet 16 inches – 21 feet 6 inches = 13 feet 10 inches
4. 21 feet 3 inches – 11 feet 9 inches = 20 feet 15 inches – 11 feet 9 inches = 9 feet 6 inches

Answers to 1.4.2 Modular Brick Course Practice Exercises

6 ft × 12 in/ft = 72 in   72 in ÷ 16 in = 4.5 (16 inch sections)

1. Modular brick: 6 × 4.5 = 27 courses
2. Roman brick: 8 × 4.5 = 36 courses
3. Utility brick: 4 × 4.5 = 18 courses
4. Norman brick: 6 × 4.5 = 27 courses

Answers to 1.5.5 Area and Circumference Practice Exercises

1. $A = s^2$
   $A = (3 \text{ feet})^2$
   A = 9 square feet
2. A = lw
   w = 3 feet 8 inches = 36 inches + 8 inches = 44 inches
   l = 2w = 2(44 inches) = 88 inches
   A = (44 inches)(88 inches)
   A = 3,872 square inches ÷ 144 square inches per square foot
   A = 26.89 square feet

3. $A = bh \div 2$

   $A = (35 \text{ inches})(24 \text{ inches}) \div 2$

   $A = 840 \text{ square inches} \div 2$

   $A = 420 \text{ square inches}$

4. $A = \pi r^2$

   $r = d \div 2 = 52 \text{ inches} \div 2 = 26 \text{ inches}$

   $A = 3.14 \times (26 \text{ inches})^2$

   $A = 3.14 \times 676 \text{ square inches}$

   $A = 2{,}122.6 \text{ square inches}$

5. $A = (S_1 + S_2 + S_3 + S_4 + S_5)\ r \div 2$

   $A = (24 + 24 + 24 + 24 + 24)\ 28.5 \text{ inches} \div 2$

   $A = (120 \text{ inches})\ 28.5 \text{ inches} \div 2$

   $A = 3{,}420 \text{ square inches} \div 2$

   $A = 1{,}710 \text{ square inches} \div 144 \text{ square inches per square foot}$

   $A = 11.875 \text{ square feet}$

6. $A = lw$

   Area of hole = 4 feet × 8 feet = 32 square feet

   8 inches ÷ 12 inches per foot = 0.667 feet

   16 inches ÷ 12 inches per foot = 1.333 feet

   Area of block face = 0.667 feet × 1.333 feet = 0.889 square feet

   # brick = area of hole ÷ area of brick

   # brick = 32 square feet ÷ 0.889 square feet

   # brick = 35.99 brick, round up to 36 brick

   # brick + 5% = 37.8 brick, round up to 38 brick

7. # brick = 18 square feet × 1.25 brick per square foot

   # brick = 20.25 brick, round up to 21 brick

8. Area of wall = total area of wall – area of window

   Total area of wall = lw

   Total area of wall = 4 feet × 6 feet = 24 square feet

   Area of window = πr^2

   $r = d \div 2 = 1 \text{ foot} \div 2 = 6 \text{ inches}$

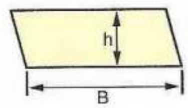
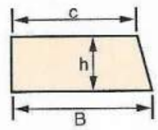
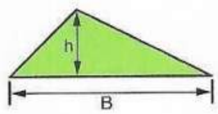
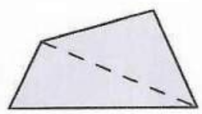
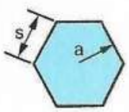
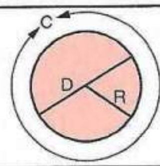
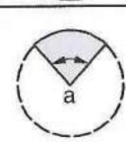
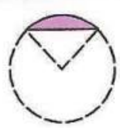
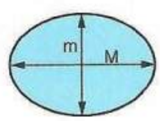
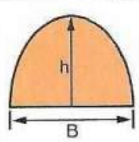
   Area of window = $\pi r^2 = 3.14 \times (6 \text{ inches})^2 = 3.14 \times 36$ square inches = 113.03 square inches = 0.785 square feet (113.03 square inches ÷ 144 square inches per square foot)

   Area of wall = 24 square feet – 0.785 square feet = 23.215 square feet

Appendix B

METRIC PREFIXES, MEASURES, AND CONVERSIONS

AREAS OF PLANE FIGURES

NAME FORMULA	SHAPE
(A = Area) Parallelogram $A = B \times h$	
Trapezoid $A = \frac{B + C}{2} \times h$	
Triangle $A = \frac{B \times h}{2}$	
Trapezium (Divide into 2 triangles) A = Sum of the 2 triangles (See above)	
Regular Polygon $A = \frac{aP}{2}$ Where a is the length of the *apothem* (perpendicular distance from center to a side) P is the *perimeter* (sum of the sides, s)	
Circle $\pi = 3.14$ (1) πR^2 A = (2) $.7854 \times D^2$	
Sector (1) $\frac{a^\circ}{360^\circ} \times \pi R^2$ A = (2) Length of arc $\times \frac{R}{2}$ ($\pi = 3.14$, a = angle of sector)	
Segment A = Area of sector minus triangle (see above)	
Ellipse $A = M \times m \times .7854$	
Parabola $A = B \times \frac{2h}{3}$	

VOLUMES OF SOLID FIGURES

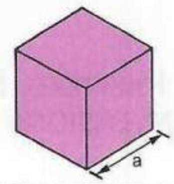
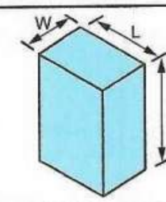
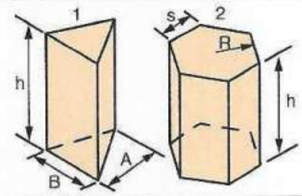
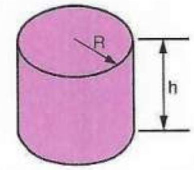
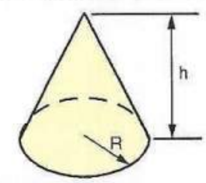
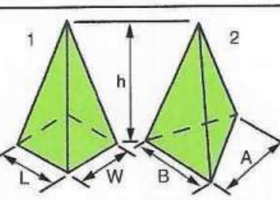
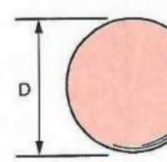
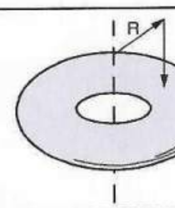
NAME FORMULA	SHAPE
(V - volume) Cube $V = a^3$ (in cubic units)	
Rectangular Solids $V = L \times W \times h$	
Prisms $V(1) = \frac{B \times A}{2} \times h$ $V(2) = \frac{s \times R}{2} \times n \times h$ V = Area of end × h n = Number of sides.	
Cylinder $V = \pi R^2 \times h$ ($\pi = 3.14$)	
Cone $V = \frac{\pi R^2 \times h}{3}$ ($\pi = 3.14$)	
Pyramids $V(1) = L \times W \times \frac{h}{3}$ $V(2) = \frac{B \times A}{2} \times \frac{h}{3}$ V = Area of Base $\times \frac{h}{3}$	
Sphere $V(1) = \frac{1}{6} \pi D^3$ $V(2) = \frac{4}{3} \pi R^3$	
Circular Ring (Torus) $V = 2\pi^2 \times Rr^2$ V = Area of section $\times 2\pi R$ R = radius of the ring at its center, i.e., (OD – ID)/2 + ½ID; r = radius of the cross section of the ring at R.	

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Figure A-1

Table A-1 Common SI Prefixes

PREFIX	SYMBOL	NUMBER	MULTIPLICATION FACTOR
giga	G	billion	$1,000,000,000 = 10^9$
mega	M	million	$1,000,000 = 10^6$
kilo	k	thousand	$1,000 = 10^3$
hecto	h	hundred	$100 = 10^2$
deka	da	ten	$10 = 10^1$
			BASE UNITS $1 = 10^0$
deci	d	tenth	$0.1 = 10^{-1}$
centi	c	hundredth	$0.01 = 10^{-2}$
milli	m	thousandth	$0.001 = 10^{-3}$
micro	μ	millionth	$0.000001 = 10^{-6}$
nano	n	billionth	$0.000000001 = 10^{-9}$

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Table A-2 Common Metric Measures

WEIGHT UNITS		
1 kilogram	=	1,000 grams
1 hectogram	=	100 grams
1 dekagram	=	10 grams
1 gram	=	1 gram
1 decigram	=	0.1 gram
1 centigram	=	0.01 gram
1 milligram	=	0.001 gram
LENGTH UNITS		
1 kilometer	=	1,000 meters
1 hectometer	=	100 meters
1 dekameter	=	10 meters
1 meter	=	1 meter
1 decimeter	=	0.1 meter
1 centimeter	=	0.01 meter
1 millimeter	=	0.001 meter
LIQUID VOLUME UNITS		
1 kiloliter	=	1,000 liters
1 hectoliter	=	100 liters
1 dekaliter	=	10 liters
1 liter	=	1 liter
1 deciliter	=	0.1 liter
1 centiliter	=	0.01 liter
1 milliliter	=	0.001 liter

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Table A-3 US Customary to SI Metric Conversions

U.S. CUSTOMARY		SI METRIC
WEIGHTS		
1 ounce (oz)	=	28.35 grams
1 pound (lb)	=	435.6 grams or 0.4536 kilograms
1 (short) ton	=	907.2 kilograms
LENGTHS		
1 inch (in)	=	2.540 centimeters
1 foot (ft)	=	30.48 centimeters
1 yard (yd)	=	91.44 centimeters or 0.9144 meters
1 mile	=	1.609 kilometers
AREAS		
1 square inch (in^2)	=	6.452 square centimeters
1 square foot (ft^2)	=	929.0 square centimeters or 0.0929 square meters
1 square yard (yd^2)	=	0.8361 square meters
VOLUMES		
1 cubic inch (in^3)	=	16.39 cubic centimeters
1 cubic foot (ft^3)	=	0.02832 cubic meter
1 cubic yard (yd^3)	=	0.7646 cubic meter
LIQUID MEASUREMENTS		
1 (fluid) ounce (fl oz)	=	0.095 liter or 28.35 grams
1 pint (pt)	=	473.2 cubic centimeters
1 quart (qt)	=	0.9263 liter
1 (US) gallon (gal)	=	3,785 cubic centimeters or 3.785 liters

TEMPERATURE MEASUREMENTS

To convert degrees Fahrenheit to degrees Celsius, use the following formula: C = 5/9 × (F – 32).

28103-13_TA03.EPS

Table A-4 SI Metric to US Customary Conversions

SI METRIC		U.S. CUSTOMARY
WEIGHTS		
1 gram (G)	=	0.03527 ounces
1 kilogram (kg)	=	2.205 pounds
1 metric ton	=	2,205 pounds
LENGTHS		
1 millimeter (mm)	=	0.03937 inches
1 centimeter (cm)	=	0.3937 inches
1 meter (m)	=	3.281 feet or 1.0937 yards
1 kilometer (km)	=	0.6214 miles
AREAS		
1 square millimeter	=	0.00155 square inches
1 square centimeter	=	0.155 square inches
1 square meter	=	10.76 square feet or 1.196 square yards
VOLUMES		
1 cubic centimeter	=	0.06102 cubic inches
1 cubic meter	=	35.31 cubic feet or 1.308 cubic yards
LIQUID MEASUREMENTS		
1 cubic centimeter (cm^3)	=	0.06102 cubic inches
1 liter (1,000 cm^3)	=	1.057 quarts, 2.113 pints, or 61.02 cubic inches

TEMPERATURE MEASUREMENTS

To convert degrees Celsius to degrees Fahrenheit, use the following formula: F = (9/5 × C) + 32.

28103-13_TA04.EPS

Appendix C

ASTM Standards for Masonry Construction

Brick

ASTM C27, Standard Classification of Fireclay and High-Alumina Refractory Brick
ASTM C32, Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C34, Standard Specification for Structural Clay Load-Bearing Wall Tile
ASTM C43, Standard Terminology of Structural Clay Products (note: withdrawn 2009)
ASTM C56, Standard Specification for Structural Clay Nonloadbearing Tile
ASTM C62, Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C106, Specification for Refractories and Incinerators (note: withdrawn 1972)
ASTM C126, Standard Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
ASTM C155, Standard Classification of Insulating Firebrick
ASTM C212, Standard Specification for Structural Clay Facing Tile
ASTM C216, Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C279, Standard Specification for Chemical-Resistant Masonry Units
ASTM C315, Standard Specification for Clay Flue Liners and Chimney Pots
ASTM C410, Standard Specification for Industrial Floor Brick
ASTM C416, Standard Classification of Silica Refractory Brick
ASTM C530, Standard Specification for Structural Clay Nonloadbearing Screen Tile
ASTM C652, Standard Specification for Hollow Brick (Hollow Masonry Units Made from Clay or Shale)
ASTM C902, Standard Specification for Pedestrian and Light Traffic Paving Brick
ASTM C1261, Standard Specification for Firebox Brick for Residential Fireplaces
ASTM C1272, Standard Specification for Heavy Vehicular Paving Brick

Concrete Masonry Units

ASTM C55, Standard Specification for Concrete Building Brick
ASTM C73, Standard Specification for Calcium Silicate Brick (Sand-Lime Brick)
ASTM C90, Standard Specification for Loadbearing Concrete Masonry Units
ASTM C129, Standard Specification for Nonloadbearing Concrete Masonry Units
ASTM C139, Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C744, Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units
ASTM C936, Standard Specification for Solid Concrete Interlocking Paving Units
ASTM C1319, Standard Specification for Concrete Grid Paving Units

Natural Stone

ASTM C119, Standard Terminology Relating to Dimension Stone
ASTM C503, Standard Specification for Marble Dimension Stone
ASTM C568, Standard Specification for Limestone Dimension Stone
ASTM C615, Standard Specification for Granite Dimension Stone
ASTM C616, Standard Specification for Quartz-Based Dimension Stone
ASTM C629, Standard Specification for Slate Dimension Stone

Mortar and Grout

ASTM C5, Standard Specification for Quicklime for Structural Purposes
ASTM C33, Standard Specification for Concrete Aggregates
ASTM C91, Standard Specification for Masonry Cement
ASTM C144, Standard Specification for Aggregate for Masonry Mortar
ASTM C150, Standard Specification for Portland Cement
ASTM C199, Standard Test Method for Pier Test for Refractory Mortars
ASTM C207, Standard Specification for Hydrated Lime for Masonry Purposes
ASTM C270, Standard Specification for Mortar for Unit Masonry
ASTM C330, Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C331, Standard Specification for Lightweight Aggregates for Concrete Masonry Units
ASTM C404, Standard Specification for Aggregates for Masonry Grout
ASTM C476, Standard Specification for Grout for Masonry
ASTM C658, Standard Specification for Chemical-Resistant Resin Grouts for Brick or Tile
ASTM C887, Standard Specification for Packaged, Dry, Combined Materials for Surface Bonding Mortar
ASTM C1142, Standard Specification for Extended Life Mortar for Unit Masonry
ASTM C1329, Standard Specification for Mortar Cement

Reinforcement and Accessories

ASTM A82, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A185, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A496, Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A641, Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A951, Standard Specification for Steel Wire for Masonry Joint Reinforcement
ASTM B227, Standard Specification for Hard-Drawn Copper-Clad Steel Wire
ASTM B766, Standard Specification for Electrodeposited Coatings of Cadmium
ASTM C915, Standard Specification for Precast Reinforced Concrete Crib Wall Members
ASTM C1089, Standard Specification for Spun Cast Prestressed Concrete Poles
ASTM C1242, Standard Guide for Selection, Design, and Installation of Dimension Stone Attachment Systems

Sampling and Testing

ASTM C67, Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM C97, Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone
ASTM C109, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 in. or [50 mm] Cube Specimens)
ASTM C140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
ASTM C170, Standard Test Method for Compressive Strength of Dimension Stone
ASTM C241, Standard Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic
ASTM C267, Standard Test Methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes
ASTM C426, Standard Test Method for Linear Drying Shrinkage of Concrete Masonry Units
ASTM C780, Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
ASTM C880, Standard Test Method for Flexural Strength of Dimension Stone
ASTM C952, Standard Test Method for Bond Strength of Mortar to Masonry Units
ASTM C1006, Standard Test Method for Splitting Tensile Strength of Masonry Units
ASTM C1019, Standard Test Method for Sampling and Testing Grout
ASTM C1072, Standard Test Methods for Measurement of Masonry Flexural Bond Strength
ASTM C1093, Standard Practice for Accreditation of Testing Agencies for Masonry
ASTM C1148, Standard Test Method for Measuring the Drying Shrinkage of Masonry Mortar
ASTM C1194, Standard Test Method for Compressive Strength of Architectural Cast Stone
ASTM C1195, Standard Test Method for Absorption of Architectural Cast Stone
ASTM C1196, Standard Test Methods for In Situ Compressive Stress Within Solid Unit Masonry Estimated Using Flatjack Measurements
ASTM C1197, Standard Test Method for In Situ Measurement of Masonry Deformability Using the Flatjack Method
ASTM C1262, Standard Test Method for Evaluating the Freeze-Thaw Durability of Dry-Cast Segmental Retaining Wall Units and Related Concrete Units
ASTM C1314, Standard Test Method for Compressive Strength of Masonry Prisms
ASTM C1324, Standard Test Method for Examination and Analysis of Hardened Masonry Mortar
ASTM D75, Standard Practice for Sampling Aggregates
ASTM E72, Standard Test Methods of Conducting Strength Tests of Panels for Building Construction
ASTM E447, Test Methods for Compressive Strength of Laboratory Constructed Masonry Prisms (note: withdrawn 1988)
ASTM E488, Standard Test Methods for Strength of Anchors in Concrete Elements
ASTM E514, Standard Test Method for Water Penetration and Leakage Through Masonry
ASTM E518, Standard Test Methods for Flexural Bond Strength of Masonry
ASTM E519, Standard Test Method for Diagonal Tension (Shear) in Masonry Assemblages
ASTM E754, Standard Test Method for Pullout Resistance of Ties and Anchors Embedded in Masonry Mortar Joints

Assemblages

ASTM C901, Standard Specification for Prefabricated Masonry Panels
ASTM C946, Standard Practice for Construction of Dry-Stacked, Surface-Bonded Walls
ASTM E835, Standard Guide for Modular Coordination of Clay and Concrete Masonry Units (note: withdrawn 2011)
ASTM C1283, Standard Practice for Installing Clay Flue Lining
ASTM E1602, Standard Guide for Construction of Solid Fuel Burning Masonry Heaters

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

The ABC's of Concrete Masonry Construction, Video. Skokie, IL: Portland Cement Association.

ACI 530/ASCE 5/TMS 402, *Building Code Requirements for Masonry Structures*. Latest edition. Reston, VA: American Society of Civil Engineers.

Bricklaying: Brick and Block Masonry. Reston, VA: The Brick Institute of America.

Bricklaying Curriculum: Advanced Bricklaying Techniques. 1992. Raymond J. Turcotte and Laborn J. Hendrix. Stillwater, OK: Oklahoma Department of Vocational and Technical Education.

Building Block Walls: A Basic Guide for Students in Masonry Vocational Training. 1988. Herndon, VA: National Concrete Masonry Association.

International Building Code®. Latest edition. Falls Church, VA: International Code Council.

A Manual of Construction Documentation: An Illustrated Guide to Preparing Construction Drawings. 1989. Glenn E. Wiggins. New York: Whitney Library of Design.

Masonry Design and Detailing For Architects, Engineers and Contractors, Sixth Edition. 2012. Christine Beall. New York: McGraw-Hill.

Figure Credits

Bon Tool Company, Figure 2

Courtesy of Stanley Black + Decker, Inc., Figure 6

Courtesy of Dennis Neal, FMA&EF, Figure 15

Courtesy of the Brick Industry Association, Figure 22

Courtesy of Haskell, Figure 28, Figure 30, Figure 31, Figure 32, Figure 33

Courtesy of The Masonry Society (TMS), Figure 35

Section Review Answer Key

Answer	Section Reference	Objective
Section One		
1. c	1.0.0	1a
2. d	1.2.0	1b
3. c	1.3.0	1c
4. a	1.4.0	1d
5. b	1.5.1	1e
6. d	1.6.0	1f
Section Two		
1. b	2.1.0	2a
2. b	2.2.0	2b
3. d	2.3.3	2c
Section Three		
1. c	3.1.3	3a
2. d	3.2.0	3b

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