MODULE 3 - AREA MEASUREMENTS

Slide 1 WELCOME

Welcome to the Final Estimates Level 1 course, Module 3 – Area Measurements, offered through the Construction Training Qualification Program. This Final Estimates training course consists of 8 modules and covers the preparation of final estimates by field personnel. This training contains interactive elements. An alternate transcript version is available. To begin, select the start button or press Shift+N on your keyboard.

Slide 2 INTRODUCTION

Many pay items are computed based on area measurements. These items can include roadway base, sidewalks, ditch pavement, slope pavement, and performance turf. This module will describe methods for performing these calculations and provide example problems to illustrate documentation for final estimates.

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Chapter Eight of the Construction Math CBT training course is entirely devoted to basic information on area measurements and area calculations. If you have trouble with the information covered in this module, review Chapter Eight of the Construction Math course again.

Slide 4 METHODS FOR COMPUTING AREAS

Three methods for computing areas are described in this module:

- geometric formulas (including applications of trigonometry)
- latitudes and departures
- computer programs

We will study all three methods, but first let's review a few basic points about units of measurement.

Slide 5 UNITS OF MEASUREMENT

Areas are usually measured in terms of square feet (SF), square yards (SY), or acres (AC). Sometimes the field measurements and the computations are in units different from those specified for the pay items, and it is necessary to convert answers from one unit to another. For example, since most field measurements are recorded in linear feet, it is convenient to calculate areas in square feet. But a conversion must be made when the pay item is in acres or square yards.

Just keep in mind these relationships:

1 AC = 43,560 SF
144 $in.^2$ = 1 SF
9 SF = 1 SY

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Another thing to keep in mind is if you don't get the same answer the difference is probably due to rounding. In practical applications, answers are computed by using the full capacity of a calculator. In this course, however, we will use the following rules of rounding:

Item	No. Of Decimal Places
Pi () will be rounded to	3.1416
Converted inches to feet will be rounded to	4 decimal places
Radians will be rounded to	7 decimal places
And Trigonometric Functions	4 decimal places

Now let's get into the area computation methods, beginning with geometric formulas.

Slide 7 GEOMETRIC FORMULAS

Nearly all areas - even irregular shapes - can be computed by a mathematical formula or a combination of several formulas. This method is not always the easiest way to determine areas - but if we understand this first, it will help us to understand other methods.

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In studying geometric formulas, we will divide our discussion into:

- rectangles, parallelograms, trapezoids;
- triangles (including trigonometric relationships);
- circles (including radians); and
- combinations of shapes.

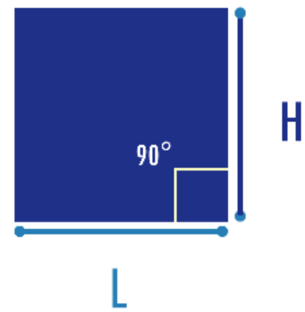
Slide 9 ***Rectangles, Parallelograms, Trapezoids***

These are the simplest area computations and are applicable to many highway features. The basic formula is:

Area = Length x Height (A = L x H)

. . . but there are a few special points to remember.

Rectangles are four-sided figures with opposite sides parallel and four 90° angles. A square is a special type of rectangle with all sides of equal length.



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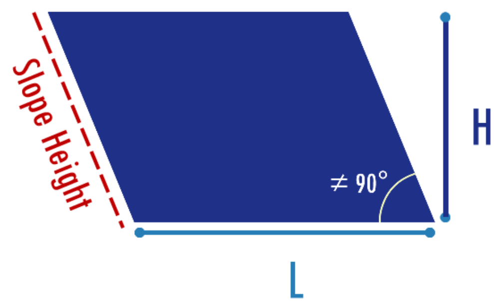
Parallelograms also have parallel opposite sides, but the angles are larger or smaller than 90°.For these figures, the height (H) is always measured perpendicular to the base side. Do not use the slope height for computations.



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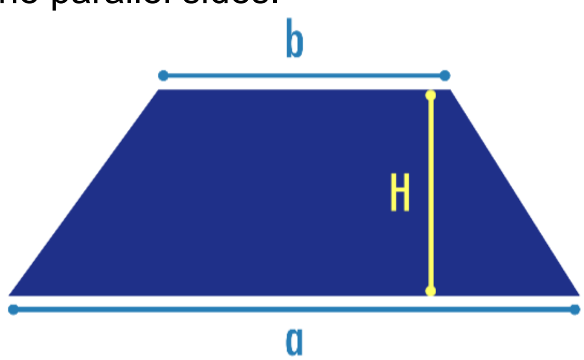
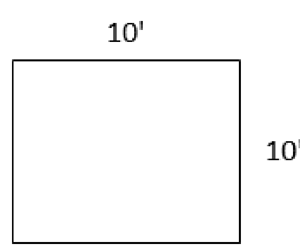
Trapezoids have only two parallel sides. The length used for computation of areas is the average of the lengths of the parallel sides.



Slide 12 Square Area Example

Calculate the area for the square shown.
Each side equals 10 ft.
Answer to the nearest Square Foot.



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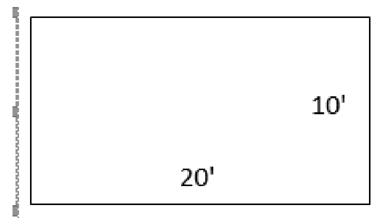
Solution: Area for a square equals length x height, which in this example equals 10 feet times 10 feet. This makes the area of this square 100 square feet.

Area = Length x Height = 10 ft. x 10 ft. = 100 SF

Slide 14 Rectangle Area Example

Calculate the area of the rectangle shown.
Answer to the nearest Square Yard.



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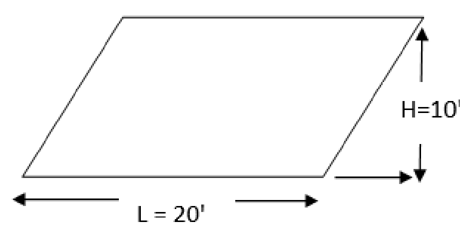
Solution: Area for a rectangle equals length x height, which in this example equals 20 feet x 10 feet. This makes the area of this rectangle 200 square feet. However, the problem asks for the solution to be given in square yards. Remember that the way to convert square feet to square yards is to divide by 9. 200 divided by 9 equals 22.22. The problem also asks that we give our answer in the nearest square yard. We should round our answer, which gives a final answer as 22 square yards.

Area = L x H = 20 ft. x 10 ft. = 200 SF

$$= \frac{200\ SF}{9\frac{SF}{SY}} = 22.22\ SY = 22\ SY$$

Slide 16 Parallelogram Area Example

Calculate the area of the Parallelogram shown.
Answer to the nearest Square Foot.



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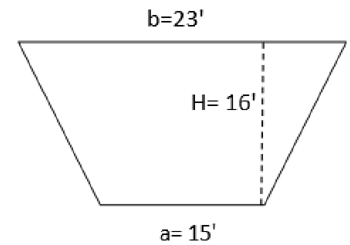
Solution: Area for a parallelogram equals length x height. In the case of a parallelogram, we need to remember to determine the height based on the perpendicular measurement to the base side. In this example, the area would be 20 feet x 10 feet, making the area 200 square feet.

Area = L x H = 20 ft. x 10 ft. = 200 SF

Slide 18 Trapezoid Area Example

Calculate the area of the Trapezoid shown.
Answer to the nearest Square Yard.



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Solution: Area for a trapezoid is the average of the two parallel sides or bases, times the height. The height is determined in the same way for a trapezoid as a parallelogram – perpendicular to the base. In this example, add the two bases 15 ft. and 23 ft. which equals 38. Divide 38 by 2 to get 19 - the average of the two bases. Then multiple by the height or 16 ft. 19 times 16 equals 304 square feet.

Remember the problem asked for the answer in square yards. Divide 304 by 9 to get 33.78 square yards. Round to the nearest square yard, which gives us a final answer of 34 square yards.

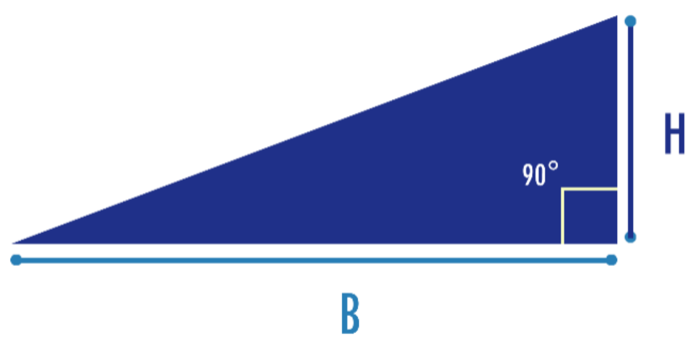
$$\text{Area} = \left(\frac{a + b}{2}\right)H = \left(\frac{15\text{ ft.} + 23\text{ ft.}}{2}\right)16\text{ ft.} = \left(\frac{38\text{ ft.}}{2}\right)16\text{ ft.} = (19)16\text{ ft.} = 304\text{ SF}$$

$$\text{Area} = \left(\frac{304\text{ SF}}{9\text{ SF/SY}}\right) = 33.78\text{ SY} = 34\text{ SY}$$

Slide 20 *Triangles*

Any triangle can be treated as one-half of a rectangle or parallelogram. The area, then, is one-half of the product of the base (B) times the height (H).

$$A = \frac{BH}{2}$$



Remember, H is measured perpendicular to the base of the triangle not along the slope.

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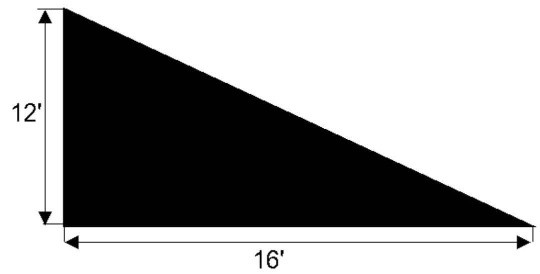
Let's find the area of the triangle shown. We will answer to the nearest square foot. Height = 12 inches and Base = 16 inches. Because H is perpendicular to the base B, we can use the equation ***A= BH/2.***



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So, the area would be 16 inches (base) times 12 inches (height), divided by 2. This equals 96 square inches.

$$A = \frac{16 \text{ in.} \times 12 \text{ in.}}{2} = 96 \text{ in.}^2$$

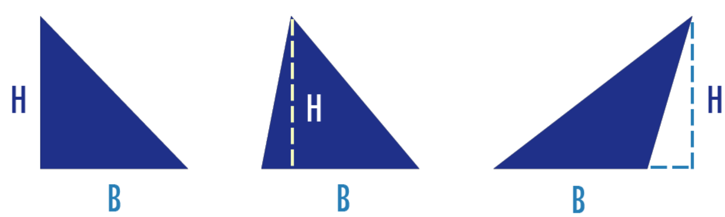
Slide 23

However, the answer needs to be to the nearest Square Foot. Remember that you can find square feet by dividing any value of square inches by 144. 96 divided by 144 equals 0.667 square feet. The problem asks for an answer in the nearest square foot, so we will round our answer to 1 square foot.

$$A = \frac{96 \text{ in.}^2}{144 \text{ in.}^2/\text{ft.}^2} = 0.667 \text{ SF} = 1 \text{ SF}$$

Slide 24

Here are three examples of triangles that would include the height.



To use the Area = Base times Height divided by 2 formula, you must know the height.

But what if we don't know the height? Well, if we know the lengths of all three sides we can compute the area using this formula:

$$\text{Area} = \sqrt{s(s-a)(s-b)(s-c)}$$

$$S=0.5(a+b+c)$$

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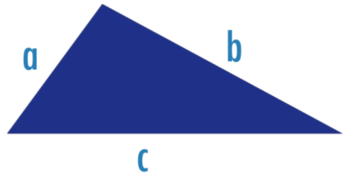
The square root of S times S minus A times S minus B times S minus C, where S equals half of the total sum of all three sides. Simply put, one half times a+b+c, where a, b, and c represent the length of the sides of the triangle.



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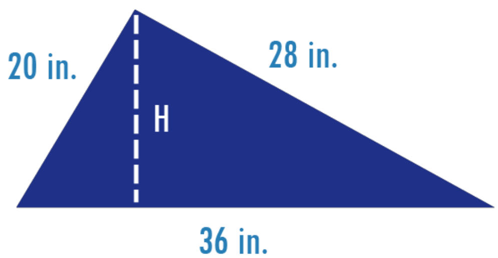
Here is an example of a triangle where height is unknown and where the length of all sides is known:

The values for this triangle are a=20 inches, b=28 inches, and c=36 inches. Let's find the area to the nearest square foot.



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First, we need to calulate the variable for "s". Because we know all three sides, we can add these values and multiply by 0.5. The sum of a, b and c or 20 + 28 + 36 equals 84. One-half of 84 equals 42. Now we have a value for s; s equals 42.

$$S = 0.5(a + b + c) = 0.5(20 \text{ in.} + 28 \text{ in.} + 36 \text{ in.}) = 0.5(84 \text{ in.}) = 42 \text{ in.}$$

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Based on our equation, we now plug in the values for s, a, b, and c. Next we will use order of operations to solve the equation. According to the order of operations, we must first address the items in parantheses, subtracting each side from s. 42 minus 20 equals 22. 42 minus 28 equals 14. 42 minus 36 equals 6. This leaves us with the square root of 42 times 22 times 14 times 6.

$$\text{Area} = \sqrt{s(s\text{-}a)(s\text{-}b)(s\text{-}c)}$$

$$\text{Area} = \sqrt{42(42\text{-}20)(42\text{-}28)(42\text{-}36)}$$

$$\text{Area} = \sqrt{42(22)(14)(6)}$$

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Again, the order of operations dictates that we must perform our multiplication before we can use the square root. So, we will multiply these 4 values to arrive at 77,616. The square root of 77,616 rounded to the second decimal place is 278.60 square inches.

The problem asks us to provide our answer in square feet. Using our conversion table, we know to divide square inches by 144 to calculate square feet. The area of the triangle is 1.93 square feet. The problem also asked that we round to the nearest foot. Our final answer is 2 square feet.

$$\text{Area} = \sqrt{77{,}616}$$

$$\text{Area} = 278.60 \text{ Square inches}$$

$$\text{Area} = \frac{278.60 \text{ in.2}}{144 \text{ in.}^2/\text{ft.2}}$$

$$\text{Area} = 1.93 = 2 \text{ SF}$$

Slide 30 KNOWLEDGE CHECK

Now let's test your knowledge of calculating areas of various shapes.

1) The unit of measurement for Pay Item No. 285-7 – Optional Base is Square Yards. Which of the following is the area of a 25-foot wide base, constructed between Station 234+20 and Station 295+31, to the nearest square yard?

A. 16,975 SY
B. 152,775 SY
C. 16,974.55 SY
D. 152,774.90 SY

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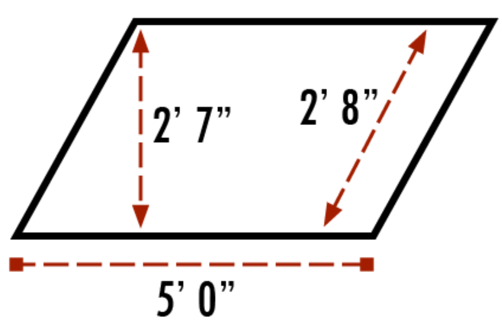
2) The area of the parallelogram shown is 21.55 square feet.

A. True
B. False



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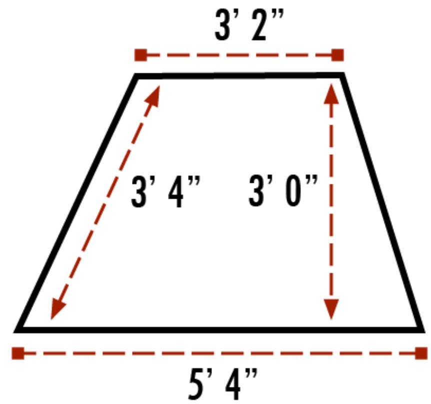
3) The area of the Trapezoid shown is 12.75 square feet.

A. True

B. False

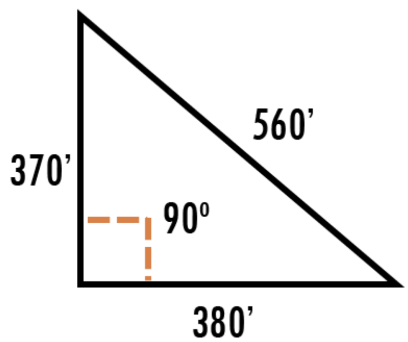


Slide 33

4) The area of the Triangle shown is 70,300 square feet.

A. True

B. False



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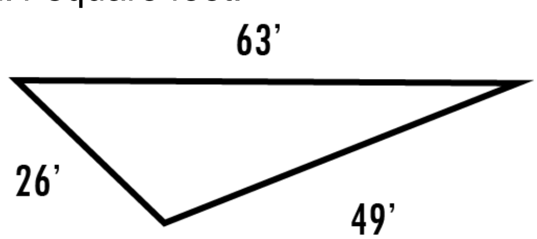
5) The area of the Triangle shown is 492.1 square feet.

A. True

B. False



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6) If an acre has 43,560 square feet, how many feet are in 2 and two-tenths acres?

A. 65,322 SF

B. 95,832 SF

C. 19, 800 SF

D. 91,476 SF

Slide 36 ***Trigonometric Relationships***

Sometimes it is necessary to use trigonometric relationships to calculate dimensions, when all sides aren't known. Let's review a few of the relationships that can be helpful.

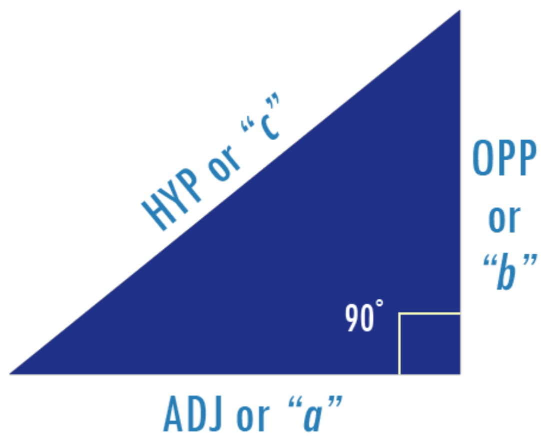
In the case of a right triangle (where one angle is 90°) we can find the length of any side if we know the length of the other two sides. The known relationship is that the square of the hypotenuse (side opposite the 90° angle) is always equal to the sum of the squares of the other two sides ("adjacent" and "opposite" sides). This is known as the Pythagorean Theorem.

For example:

If we know the length of sides a and b, then:
$c = \sqrt{a^2 + b^2}$

If we know a and c, then:
$b = \sqrt{c^2 - a^2}$

If we b and c, then:
$a = \sqrt{c^2 - b^2}$

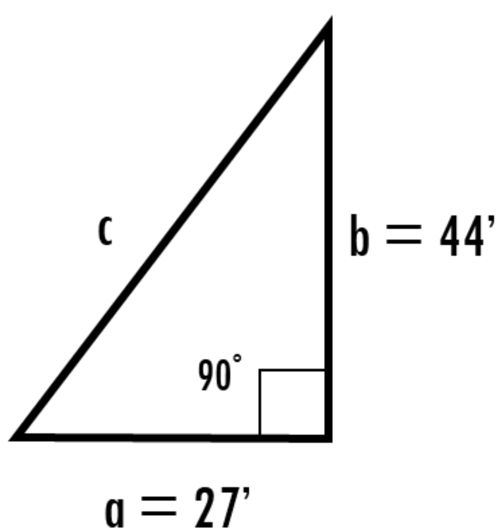


Slide 37 **KNOWLEDGE CHECK**

Now let's test your knowledge of calculating triangular lengths and areas.

1) Calculate the length of side c in the triangle below to the nearest foot.

A. 51 ft.
B. 71 ft.
C. 52 ft.
D. 75 ft.



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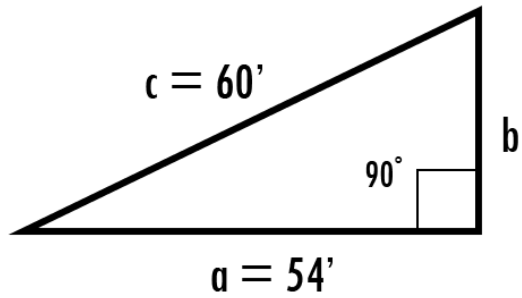
2) Determine which of the following is the length of side b (to the hundredths of a Foot) and the area (to the nearest Square Foot) of the triangle shown.

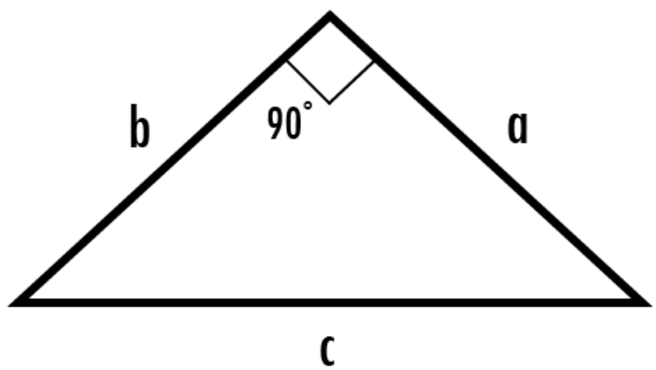
A. Length b = 28.83 ft. and Area = 778 SF
B. Length b = 26.15 ft. and Area = 706 SF
C. Length b = 27.46 ft. and Area = 741 SF
D. Length b = 30.27 ft. and Area = 817 SF
E. None of the above.



Slide 39

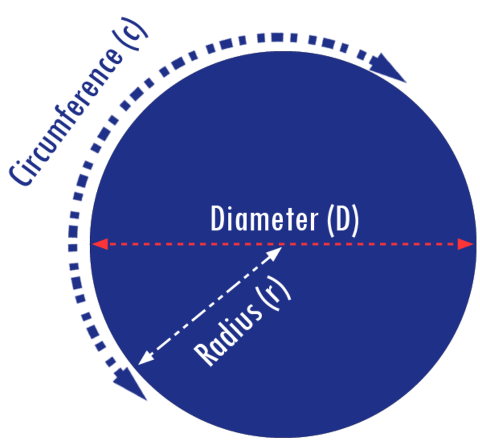
3) Determine which of the following is the length of side c (to the nearest square foot) and the area (to the nearest square foot) of the triangle shown Note: a = b = 17 ft.

A. c = 24 ft.; Area = 145 SF
B. c = 21 ft.; Area = 355 SF
C. c = 22 ft.; Area = 560 SF
D. c = 29 ft.; Area = 155 SF



Slide 40 ***Circles***

Circles are entirely symmetrical in shape. Each circle contains a circumference, diameter and a single radius. Because the radius of a circle starts at the center, it is always half of the diameter. Therefore, the diameter is 2 times the radius.



$$\text{Diameter(D)} = 2 \times \text{Radius(r)}$$

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The circumference is the length around the perimeter of the circle and can be calculated as Pi times the Diameter of the circle. Remember π (Pi) equals 3.1416 (for this course).

$$\text{Circumference(c)} = \pi \times \text{Diameter(D)}$$

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The area of a circle can be described by the formula: (Pi) times the radius squared.

$$\text{Circle Area} = \pi \times r^2$$

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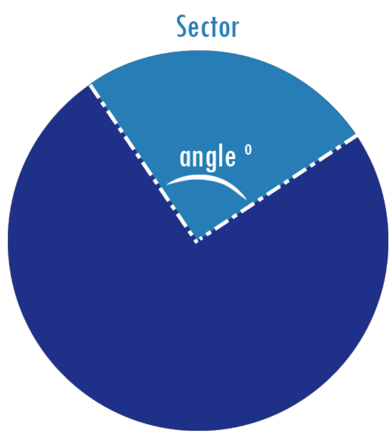
To find the area of any sector of a circle, multiply the area of an entire circle by the ratio of the intersected area. This equation will be Pi multiplied by the radius squared multiplied by the angle divided by 360 degrees.



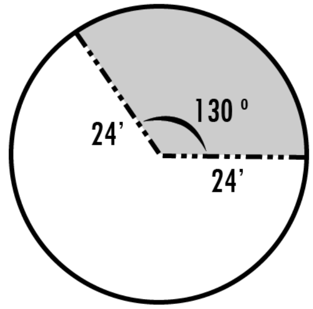
$$\text{Area of Sector} = \pi r^2 \times \frac{\text{angle}°}{360°}$$

Slide 44   KNOWLEDGE CHECK

Now let's calculate the area of a sector.

1) Which of the following is the area of the sector in the circle shown to the nearest tenth of a square foot? Remember to use the rounded value for Pi as 3.1416.

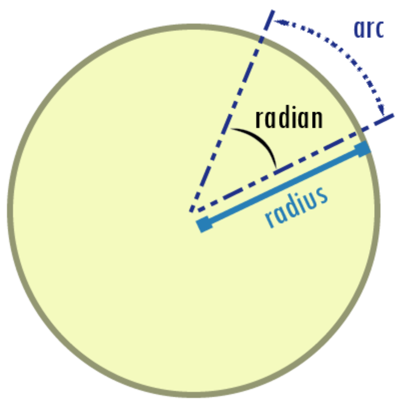
A. **653.5 SF**
B. 65.3 SF
C. 208.0 SF
D. 27.2 SF



Slide 45 Curvature Lengths and Areas

Usually, a central angle formed between two radii is measured in degrees. However, radians are another way to describe angles, instead of degrees.

What is a radian? It's simply the ratio of the length of an arc of a circle to the length of the radius and it serves as the measurement of the central angle between the two radii.



$$\text{Radians} = \frac{\text{Arc}}{\text{Radius}}$$

This means that if the arc of a sector is equal to the radius, that angle has a measurement of one radian.

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How many radians are there in a circle? Remember that a radian is the length of the arc divided by the length of radius; and for an entire circle the length of the arc would be equal to the circumference. Once this equation is simplified, we discover there are 2π radians in a circle. This is also equal to 6.2832 radians.

$$\text{Radians in an Entire Circle} = \frac{\text{Arc}}{\text{Radius}} = \frac{\text{Circumference}}{\text{Radius}}$$

$$= \frac{(2\pi)(\text{Radius})}{\text{Radius}} = 2\pi = 6.2832 \text{ radians}$$

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Why is this information important? It can be useful in calculating lengths and areas within construction projects. For example, an engineer can calculate the length of striping on a curve using the following formula. This relationship can be converted to the following formula to be used to calculate centerline lengths.

$$\text{Centerline Length} = \frac{(\text{Sector Angle}°)(\pi)(r)}{180°}$$

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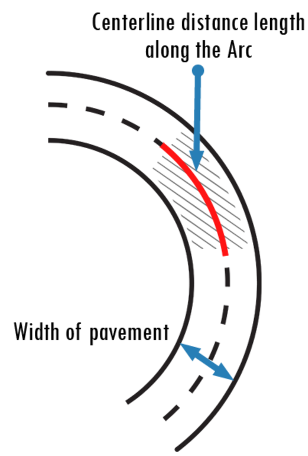
For example, to find the striped surface area in the figure at the right, the area will be the centerline distance along the arc times the width of pavement. First, let's calculate the centerline length along the arc. This can be found using the equation:

$$\text{Centerline Length} = \frac{(\text{Sector Angle}°)(\pi)(r)}{180°}$$



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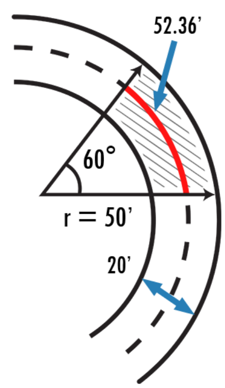
From the illustration, we learn the angle of sector is 60° and the radius is 50'. When these quantities are input in the equation, we calculate a centerline length of 52.36 feet.

$$\text{Centerline Length} = \frac{(60°)(3.1416)(50')}{180°}$$
$$= 52.36 \text{ ft.}$$



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Now, to calculate the area shaded we must use the centerline length and multiply by the width of the road which is 20 feet.

$$\text{Area} = \text{Centerline Length x Width}$$

= 52.36 ft. x 20 ft.

= 1,047.2 SF

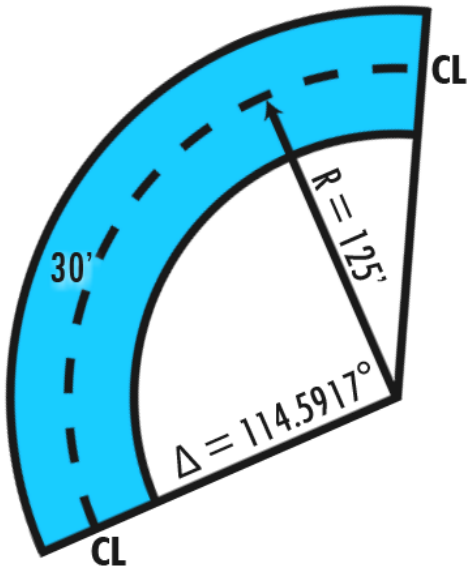
Our area is 1,047.2 SF.

Slide 51 KNOWLEDGE CHECK

Now let's test your knowledge of calculating centerline lengths and areas.

1) In constructing a circular curve for a driveway as outlined, the center line radius is 125 ft., the delta of the curve is 114.5917 degrees, and the roadway width is 30 ft. With these dimensions, which of the following is the length of the center line to the nearest foot?

A. 2,000 feet
B. 250 feet
C. 289 feet
D. 350 feet



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In constructing a circular curve for a driveway as outlined, the center line radius is 125 ft., the delta of the curve is 114.5917 degrees, and the roadway width is 30 ft. With these dimensions, what is the area of the pavement's surface to the nearest square yard?

A. 242 SY
B. 7500 SY
C. 416 SY
D. 833 SY

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3) In constructing a circular curve for a driveway as outlined below, the center line radius is 125 ft. delta of the curve is 114.5917 degrees, and the roadway width is 30 ft. With these dimensions, the pavement's surface area is 833.34 Square yards. (To the nearest hundredth of a square yard).

A. True
B. False

Slide 54 ***Curvature Corrections***

In the previous examples, we solved for roadway areas using centerline lengths. However, if the survey information is not along the centerline, a curvature correction must be made. Corrections for curvature must be made when:

- measurements are determined from a surveyed based line,
- that base line is not the centerline of the area to be measured, and
- the surveyed base line follows a curve.

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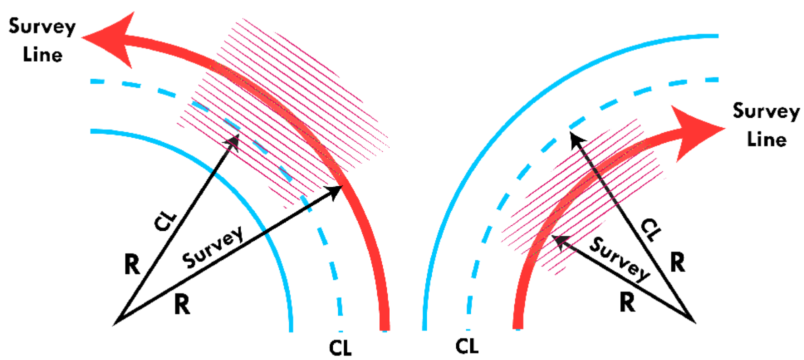
For example, when computing the area of a two-lane pavement surface, no correction factor is needed when the survey line is the center of the highway. The area is found simply by multiplying the stationing length by the surface width. This works on both tangents (straight) and curved sections. But what happens if the survey line is along the shoulder or the curb line? On tangent sections it makes no difference -- but on a curve the stationing length no longer serves as an accurate basis for computing areas. To get the area at the roadway centerline, the area calculated will need to be adjusted appropriately for the differing radii. We illustrate this here.



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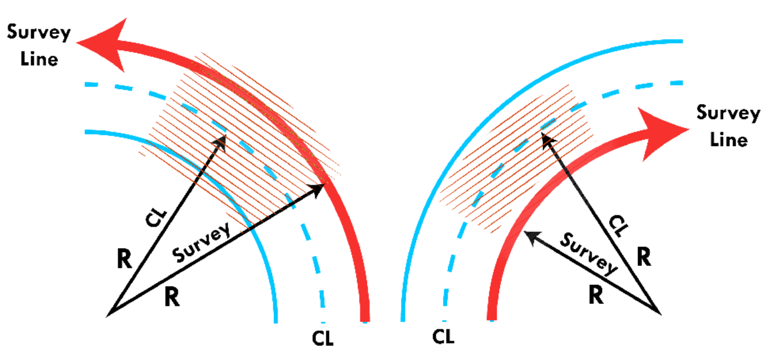
In the case of the right curve below, the computed area will be <u>less</u> than the actual area if the survey line is used for length measurement. But when the left curve is considered, the computed area will be greater than the actual area.



Slide 57

In other words, when the base line or survey line is on the <u>outside</u> of the area with respect to the center of the curve, the computed area will be greater than the actual area. When the base line is on the <u>inside</u>, the computed area will be less than the actual area.

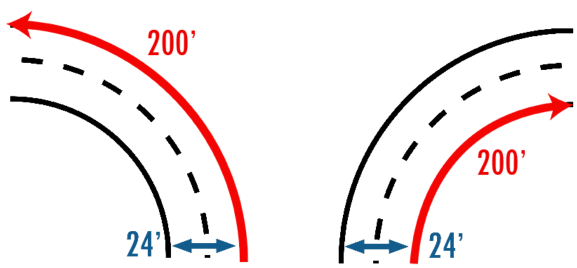
Slide 58

So, what do we do? We introduce a correction factor based on the relationships between the two radii to adjust the calculated area proportionately:

$$\text{Correction Factor} = \frac{\text{Centerline Radius}}{\text{Survey line Radius}}$$

Slide 59

The correction factor should be rounded to the nearest thousandth. Let's solve the correction factors for an example. Suppose that both curves shown had centerline survey radii of 200 feet, and that the roadway had a 24-foot width. First determine the two radii:



Inside Curve Radius = 200' – ½ (24') = 188 ft.

Outside Curve Radius = 200' + ½ (24') = 212 ft.

Slide 60

Next, determine the curve correction factors:

$$\text{Inside curve correction factor} = \frac{188'}{200'} = 0.94$$

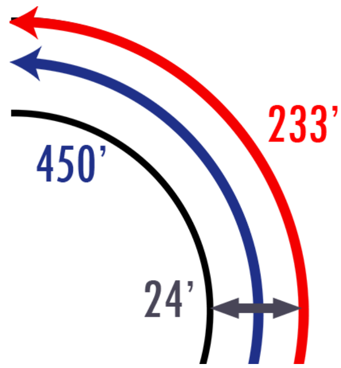
$$\text{Outside curve correction factor} = \frac{212'}{200'} = 1.06$$

The computed area between the beginning and end of each curve -- based on survey stationing -- would be multiplied by the appropriate correction factor to determine actual surface area.

Slide 61

Let’s look at another example. Suppose that the outside edge of pavement of a left curve had survey line radii of 233 feet, the roadway length was 450 feet and the width was 24 feet. What would be the actual surface area of the curve?

First, to find the centerline radii, subtract 12 ft from the survey radii of the outside edge of pavement.



233’ – 12’ = 221’

Slide 62

To find the curve correction factor, divide the centerline radii by the outside curve radii.

$$\text{Correction Factor} = \frac{\text{Centerline Radius}}{\text{Survey line Radius}} = \frac{221'}{233'} = 0.95$$

Slide 63

Determine the area by multiplying the roadway length by the roadway width by the curve correction factor:

Area = (Roadway Length) x (Width) x (Curve Correction Factor)

= 450 ft. x 24 ft. x 0.95

= 10,244 SF

The area of this curve is 10,244 square feet. Now, let’s assume the same length for the curve of the inside edge of pavement and determine the area.

Slide 64

First, find the inside curve radii by subtracting 24 ft from the outside curve survey radii

233’ – 24’ = 209’

Then, find the curve correction factor by dividing the centerline radii by the radii of the inside curve

$$\text{Inside curve correction factor} = \frac{221'}{209'} = 1.06$$

Slide 65

Determine the area by multiplying the roadway length by the roadway width by the curve correction factor:

Area = (Roadway Length) x (Width) x (Curve Correction Factor)

= 450 ft. x 24 ft. x 1.06

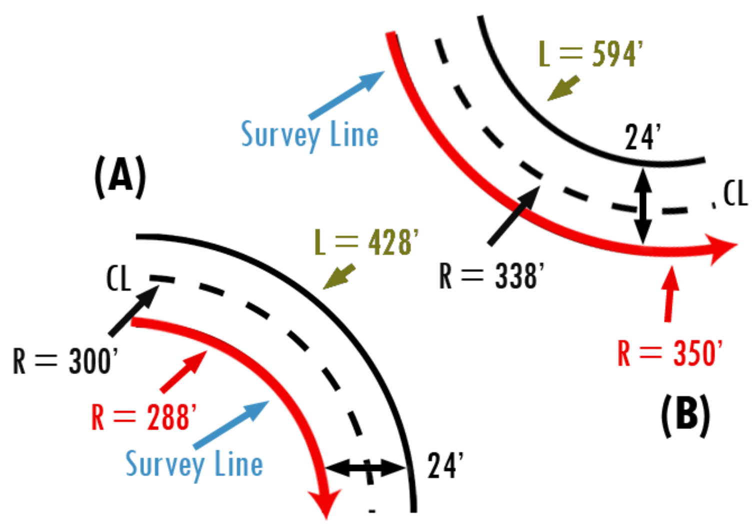
= 11,420 sq. ft.

The area of this curve is 11,420 square feet. Now let's test your knowledge.

Slide 66 KNOWLEDGE CHECK

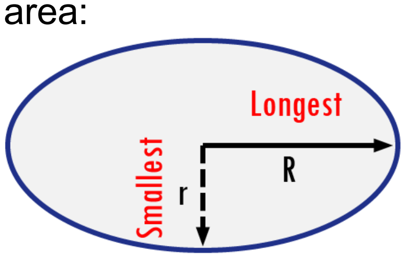
1) The areas of the curved sections of roadway (A) and (B) are [1,187 Square yards] and [1,530 Square Yards] respectively to the nearest square yards.

A. True
B. False



Slide 67 ***Ellipses***

Ellipses are similar to circles, but are oblong – or egg shaped. A slightly different formula is used to compute the area:



$A = \pi(R)(r)$

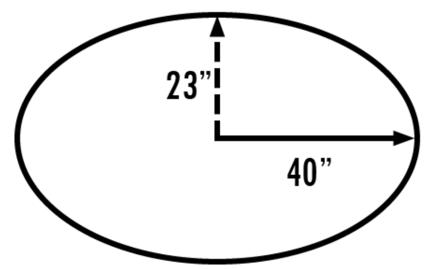
Area of an ellipse is equal to Pi times the two radii of the ellipse. Pi equals 3.1416 for this course. Unlike a circle, the line from the center of an ellipse to the edge is not always the same depending on which end you use. Notice the diagram lists a capital R which is the longest radius. The lower case r represents the smallest radius.

Slide 68 KNOWLEDGE CHECK

Now let's demonstrate your understanding on how to calculate the area of an ellipse.

1) The area of the ellipse shown is 2,890 Square Inches to the nearest Square Inch.

A. True
B. False

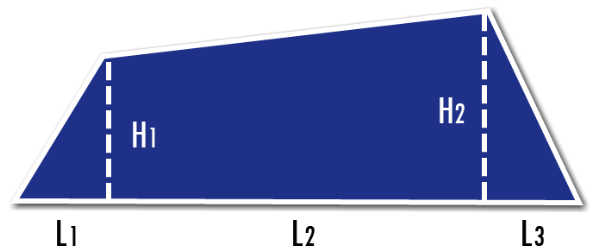


Slide 69 *Combinations of Shapes*

Many irregular areas can be measured readily by breaking the shapes into several component areas, each of which can be computed by a formula. The total area is then found by adding the individual areas -- or sometimes by subtracting one area from another.

Slide 70

For example, the area of a four-sided figure with no sides parallel can be determined by dividing the shape into two triangles and a trapezoid, as shown:



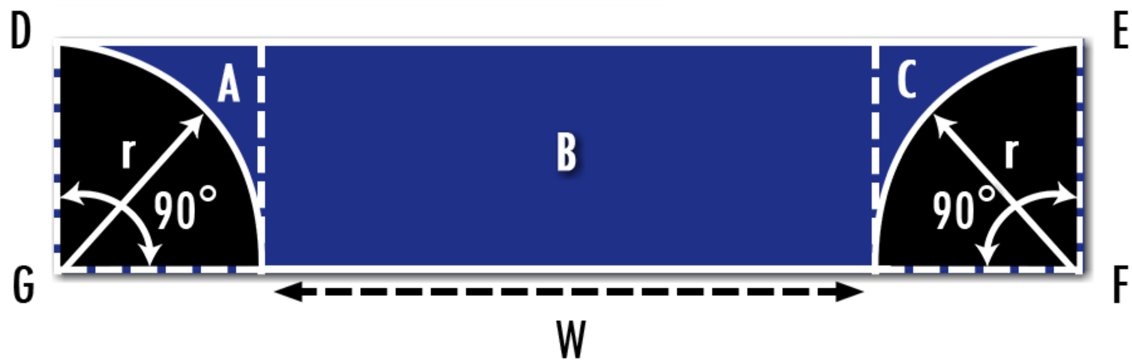
$$A = \frac{L_1 \times H_1}{2} + (L_2)\left(\frac{H_1 \times H_2}{2}\right) + \frac{L_3 \times H_2}{2}$$

Using the formulas for triangles and trapezoids, the total area is:

Area equals L1 times H1 divided by 2 plus L2 times H1 plus H2 divided by 2 plus L3 times H2 divided by 2.

Slide 71

Let's look at another sample scenario. The area of a driveway entrance can be calculated by summing A, B and C, where:



$A = r^2 - \frac{\pi r^2}{4}$ $B = Wr$ $C = r^2 - \frac{\pi r^2}{4}$

Slide 72

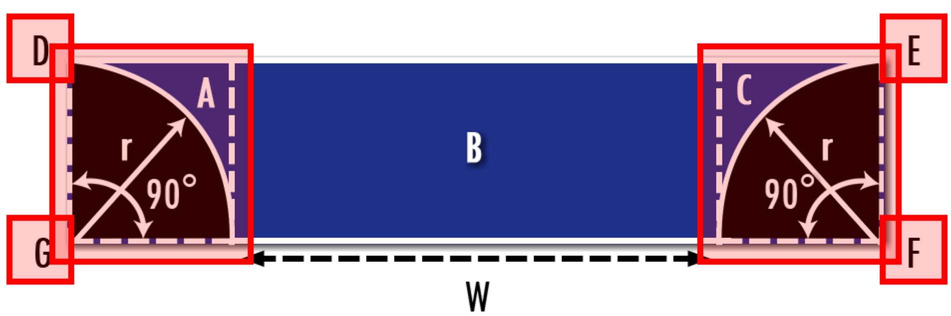
The area of A equals radius squared minus Pi radius squared divided by four. B equals W times radius. And C equals radius squared minus Pi radius squared divided by four or simplified to be:

$$[W \times r + 2(\pi r^2 / 4)]$$

Taking the area of B, which is W times r, and adding 2 times Pi radius squared divided by four.

Slide 73

Another approach would be to consider the driveway entrance one rectangle (DEFG) from which the areas of the two quarter-circles (one semi-circle) must be subtracted, which simplifies to be:



$$[L \times H - 2(\pi r^2 / 4)]$$

Taking the area of a rectangle as Length x Height and subtracting 2 times Pi radius squared divided by four.

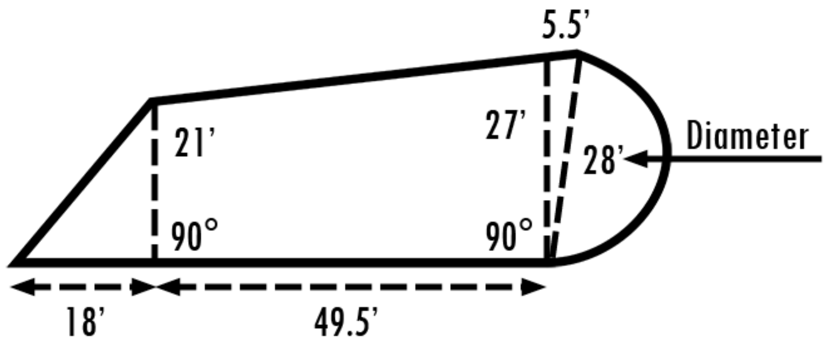
Slide 74 KNOWLEDGE CHECK

Now let's test your knowledge using an irregular shape.

1) By using the combination-of-shapes method, the total area of the irregular shape shown is 1,759.0 Square Foot (calculate to the tenth of a square foot).

   (Note: Add up all the following: Area of ½ Circle, Area of Triangle, Area of Trapezoid and Area of Triangle).

   A. True
   B. False



Slide 75 COMPUTER PROGRAMS

Many area computations are relatively simple and can be calculated easily with a calculator. However, if field revisions or the plan errors are significant throughout the project, we should consider using a computer program. Sometimes manual computations can become difficult because of either the complexity or the large number of calculations. For these situations, the FDOT Quantity Programs are available from the Department to help with computing and documenting Final Estimate quantities. These programs are located on the FDOT Construction Website.

Slide 76 LATITUDES AND DEPARTURES

Latitude and Departure is a method of measurement utilizing offset points to calculate areas. These offset points are referenced to a surveyed baseline or centerline of construction. If the area is on a curve, then the baseline follows the curve. This method averages the widths of each station multiplied by the length between stations to calculate the area. Calculations can be performed manually or by the FDOT Quantity Programs. All Latitude and Departure measurements are required to be recorded on the Department's "Final Measurements" Site Source Record (Form 700-050-53) or on the Final Measurement "Miscellaneous" (Form 700-050-61).

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Latitude and Departure measurements are to be taken in the direction of the stationing. The first measurement is taken at the lowest station and the following measurements are taken with the stationing in ascending order. For example, measurements may begin at Station 10+00 and continue to 10+50, 11+00 and 11+50.

Slide 78

This does not mean that measurements have to be recalculated when areas are skipped over during different phases of construction and then returned to at a later date for completion. If an area is skipped, the measurements from a later date would be recorded after the last entry from the previous phase. These new measurements would be made on the form starting with the lowest station and proceeding forward to the end of that area.

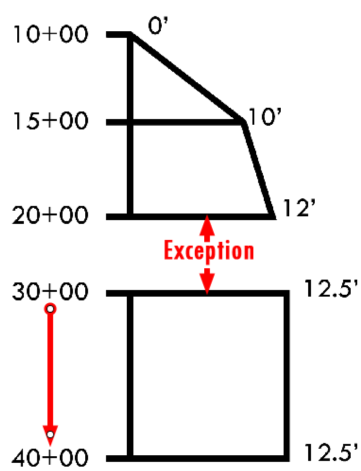
Slide 79

A width measurement must be taken every time the width changes. When widths vary, as with a roadway taper or in curves, more frequent measurements should be taken for accuracy. Be aware of exceptions and station equations. If not noted properly, the area will not be calculated accurately. Sketches are helpful in documenting measurements of atypical or odd shapes.

Slide 80

The following examples will show you how to record measurements on the Latitude and Departure forms.

In this example, there is a plan error in the Performance Turf pay item quantity. The designer overlooked an area when calculating quantities during design and now construction personnel must calculate the affected area.



The measurements will begin at Station 10+00 and stop at Station 20+00. An exception exists from Station 20+00 to Station 30+00. No measurements are taken within the limits of an exception; therefore, no measurement is taken until the end of the exception at Station 30+00 where measurements will resume and continue forward.

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This is how this example would be recorded on the Final Measurement form.

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FINAL MEASUREMENTS
SITE SOURCE RECORD

700-050-53
CONSTRUCTION
06/17

CONTRACT #: T1234
FINANCIAL PROJECT ID: 123456-1-52-01
PAY ITEM #: 570-1
PAY ITEM DESCRIPTION: Performance Turf (Sod)

NAME OF PERSON(S) TAKING MEASUREMENT: J.M. Bill
DATE: 07/31/2018

STATIONS BKE AND AHD EQUATIONS	BKE	AHD	OFFSET	REMARKS
10+00	0.0	0.0		Begin Performance Turf (Sod)
15+00	0.0	10.0		[(0+10.0)/2] 500 = 2,500.0 SF
20+00	12.0	0.0		[(10+12)/2] 500 = 5,500.0 SF
Exception				Exception Sta.20+00 to Sta. 30+00
30+00	0.0	12.5		(12.5 x 1,000) = 12,500.0 sf
40+00	12.5	0.0		
				End Performance Turf (Sod)
				Total = 20,500/9 = 2,277.78 = 2,278 SY

Measurements entered into the FDOT Quantity Programs do not require calculations in the remarks column. The remarks column should be used to make notations of beginning and ending measurements, intersecting streets, other exceptions or obstructions, and any other pertinent information concerning the measurements.

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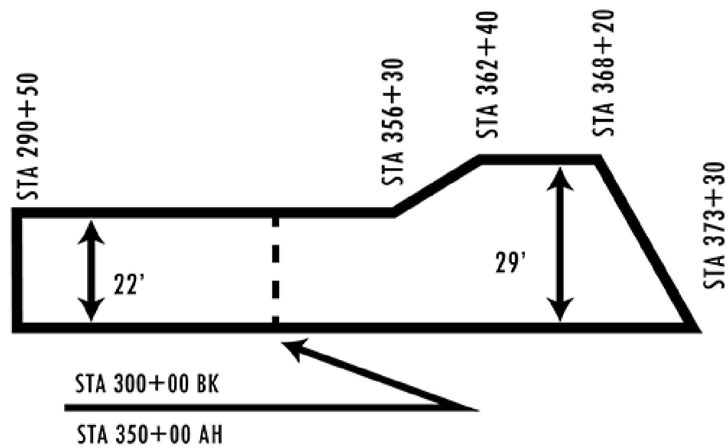
Area 1 and Area 2 are calculated from Station 10+00 to 20+00. However, Area 3 is calculated from Station 30+00 to 40+00. It is very important to be sure to calculate these properly, otherwise a substantial error could be made. Always stop the stationing at the back station and restart with the ahead station.

Slide 83 KNOWLEDGE CHECK

Now let's test your knowledge.

1) In the next example, there is another plan error in the Performance Turf pay item quantity and construction personnel must calculate the affected area. Which of the following is the area of the Performance Turf to the nearest square yard, using the latitude and departure method?

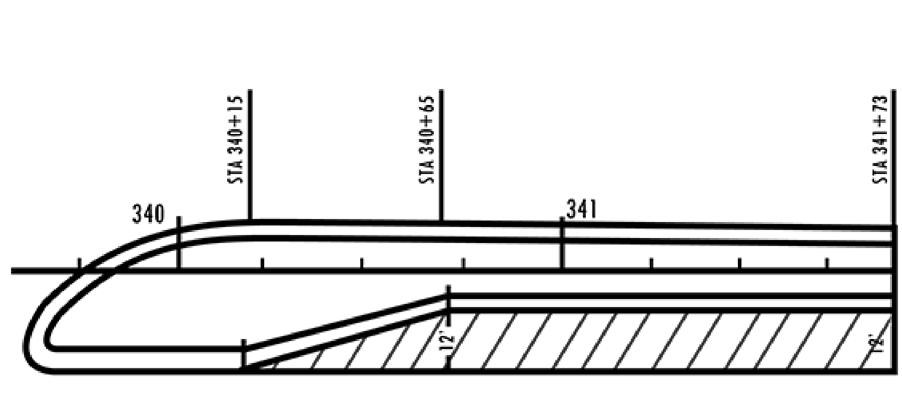
A. 8,350 SY
B. 9,345 SY
C. 7,344 SY
D. 8,279 SY



Slide 84

2) Using the Latitude and Departure method, the hashed area shows 3.5 inches milling that was left out from the plans. What is the measurement of the hashed area to the nearest square yard?

A. 210.7 SY
B. 177 SY
C. 177.3 SY
D. 211 SY



Slide 85

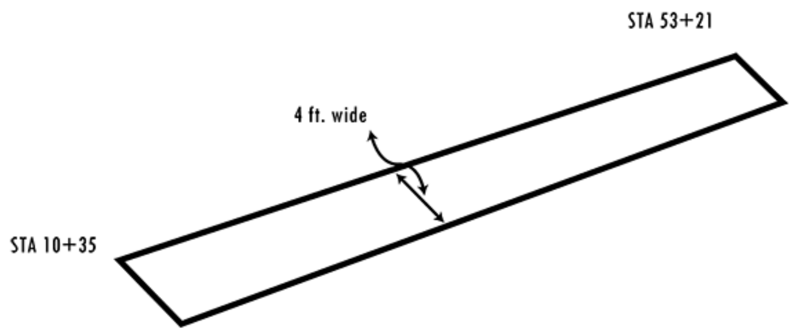
3) Field revisions or plan errors on a Performance Turf (Sod) pay item are often measured by latitude and departures.

A. True
B. False

Slide 86

4) A plan error was noted on a project. The 4-foot sidewalk was not calculated by the designer. Field personnel measured the sidewalk as shown below. Calculate the area from station 10+35 to station 53+21. Rounding your answer to the nearest square yard, which of the following is the missing area?

A. 4,286 SY
B. 1,905 SY
C. 4,300 SY
D. 480 SY



Slide 87 SUMMARY

Let's review a few of the things you learned about area computations:

- All field measurements should be clearly recorded (odd areas with sketches) on site source records (such as Department Forms).
- If any area changes in the field can be determined from simple area calculations, site source records are sufficient documentation.

Slide 88

- When area computations are more complex, measurements should be documented on site source records, calculations should be performed by computer programs and quantities should be summarized on the Plan Summary Boxes/Tabulation Sheets in the Final As-Built Plans, pertaining to the appropriate pay item.
- Some irregular areas can be computed by breaking them into several geometric shapes, each of which can be calculated with established geometric formulas.
- The method of latitude and departure can be used to compute the areas of irregular shapes.

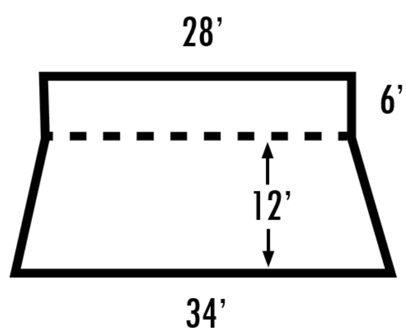
Slide 89

- Available computer programs can help reduce the amount of routine manual calculations, improve accuracy and provide reliable documentation of final quantities.

- Remember, before final payments can be made, all computations must be checked regardless of which technique is used; Plan Summary Boxes and the Tabulation of Quantity Sheets in the Final As-Built Plans and backup documentations must give a complete picture of how the quantities were determined. Some of the back-up documentation may refer you (under Remarks, in the plans) to certain Site Source Records, such as Final Measurement Forms, for further calculations and documentations.

Slide 90

1) The area of the driveway shown is 60 Square Yards.



A. True
B. False

Slide 91

2) The area of irregular shapes can be computed by the method of Latitude and departure.

A. True
B. False

Slide 92

3) All field measurements for odd areas should be clearly recorded:

A. In the Miscellaneous Construction Programs Manual.
B. With sketches on a piece of paper
C. With sketches in the field records and referenced to the Final As-Built Plans Summary Sheet pertaining to the pay item.
D. All the above.
E. None of the above.

Slide 93 Conclusion

This is the end of Module 3. Thank you for your time and attention.