Site Analysis and Planning

Lecture 6

Welcome to UGC lecture series, today's topic is Site Analysis and Planning. Subject code - AR 6512. Unit 2 - Site drawings, Lecture 06.

Presentation outline - presentation has been divided into Introduction, Computation of Areas, Geometrical shapes and Irregular area calculation. In this presentation, we are going to summarize how area can be determined for regular and irregular shapes and what are the different techniques a surveyor can use to determine the area for a given site or a given piece of land.

Computation of Area

One of the primary objects of land surveying is to determine the area of the land surveyed. Areas may be determined by - computation from field notes, it can be done in two ways. Calculation of the area of the skeleton of the survey and calculation of the area enclosed between survey lines of skeleton and boundaries. Computation of areas is a very preliminary information about any site. Whenever you look at the site, the first question any architect asks is the area of the site. In order to determine this, we need to understand how different methods are being worked out or how different methods can be used to find area of a piece of a land. This can be done in two ways, one is by calculation of area of skeleton of survey or by calculation of survey enclosed between survey lines of skeleton and boundaries.

Area of Skeleton - one is by Geometry which means your area is of perfect shape. If it is a square, all you need to do is, s2, s x s and parallelogram is area x b x h and for triangle it is 1/2 bh and for Trapezoid, the area is (b1 + b2)/2) x h. The average of b1 and b2 is calculated and multiplied into the height. This is when your site is completely in geometry. This is coordinates. When your site is in a different shape, summation of different geometries, what you can do is, you can find out by co-ordinates. This is by finding out grid system. Usually finding out by co-ordinates is when it is usually determined for larger spaces for a country or for a state, when you need to survey or when you need to find area for a huge piece of land such as for a country or a state, this method is used. As we saw in our earlier presentation in unit 1, how the whole of UK has been divided into grids and how the measurement survey is conducted, this is similar to that type of surveying method.

By Geometry - area of triangle forming skeleton. Area is under route s(s-a) (s-b) (s-c) where a,b,c are the sides of a triangle and semi perimeter, s = a + b + c/2. When you are going to find out the area of a triangle this is the method. When you need to find out the perimeter, s= a+b+c/2. a,b,c are the length of the sides that form the triangle.

Area = 1/2 x base x height. Area of a rectangle is length x breadth. Area of a square = a x a. Area of Trapezium = 1/2 (sum of parallel sides) x distance between them = 1/2 (a+b)xh. It is the similar explanation of what we saw in the previous slide.

The area may be calculated in the following 2 ways; case 1 - Graphical method. Case 2 = Instrumental method. Graphical method - the graphical methods are those in which the required data obtained from measurements of plan. In this case, the area of figure is found as a whole, or the areas of the skeleton and the irregular strips are found separately. This is the method in which the whole area has been found as one or if this area is much bigger, it can be divided into smaller sections and a summation of all these small areas can be added together to find out the area of the entire plot. This is one method that is called Graphical method. Considering entire area by division into triangles.

When you have a huge plot of land, you need to find out the area and it is not in a regular shape, what you can do is, split into smaller triangles and find out the area of each triangle and add up all the areas you have got. The most convenient method is to divide the figure into a number of triangles. The base and altitude of each triangle are scaled and its area is found. As I said earlier, the huge site is divided into smaller triangles and the area of smaller triangles is being discovered, calculated separately.

By division into squares - in this method a piece of tracing paper ruled out into squares, each responding a definite number of square meter or square centimeter is placed over the drawing. The number of whole square is measured and area is found. The portions of broken square are estimated in terms of whole square and broken squares. This is the method in which you can break an entire piece of land using grid system or using smaller squares. The first one is breaking the whole site into triangles, the second method is breaking the whole site into squares. These are two methods in which area of separate broken pieces can be calculated and everything can be added together. By division into trapezoids or by drawing parallel lines and converting them into rectangles. By placing the tracing paper over the plan the length of the rectangles are obtained and the area is calculated as - Required area = (length of rectangles) x (constant distance common breadth). This is how you need to calculate the area of the trapezoid. Area is the average of two parallel lines i.e b1 and b2 which are being added and divided by 2 and multiplied by height which is the difference between the two parallel lines b1 and b2. Say if this is like a site, you can draw parallel lines and make each of these areas into a smaller trapezoid. The area is then found out for each trapezoid and all these areas will be added together in order to find out the accurate area for this shape.

Instrumental method - When you have an irregular shape, you need to find the area of such a kind of shape. Say for example, if you have a golf course or a huge pond, this is the one of the methods which uses a Planimeter. This method consists of determining the area of a given map with the uses of a planimeter. It is the best and most expeditious method and gives accurate results when compared to other methods. This is very accurate when compared to other methods which is very convenient to predict the area of an irregular shape.

Methods for Calculating the Area

Different methods for the calculation of areas in the field of surveying - Here are five important rules or methods used for the calculation of areas in surveying. First is, Midpoint ordinate rule, Average ordinate rule, Simpson's rule, Trapezoidal rule and Graphical rule. When you have complex shades or complex layouts for which you need to find the area. There are many more types of rules or methods that can be followed. these are the five types of rules and methods that can be followed to find out the accurate area. Let's look into each one in detail. First one is mid-point ordinate rule - the sum of all the ordinates taken at midpoints of each division multiplied by the length of the baseline having the ordinates. In this, baseline AB is divided into equal parts and the ordinates are measured in the midpoints of each division. As you see there are the points A and B, the baseline has been divided into equal parts. The distance between each point is equal. You need to divide the length into a number of divisions and you need to mark it. This forms a trapezoid, we use the calculation of area of a trapezoid. The same calculation is being used to find out the area. The height is taken from the midpoint, the line is being projected, the intersected line from this side to the baseline i.e the average height is being taken. Area = ([O1 + O2 + O3 +.... On]xL)/n

L = length of the baseline.
n = number of equal parts, the baseline is divided
d = common distance between the ordinates.

This is how the midpoint coordinate rule system is adopted.

Next is, the Average Ordinate Rule. The rule states that to the average of all ordinates taken at each of the division of equal length multiplies by baseline length divided by number of ordinates. This is another method in which you can find out the area, this rule states the average of all ordinates taken at each of the division, equal length multiplied by the baseline length divided by the number o ordinates. We need to make sure all these points are made into equal distance.

01, 02, 03, 04; ordinate taken at each division, these are the different areas. l is the length of the baseline, n is the number of equal parts and d is the common distance.

Area = ([O1+O2+O3.... +On) xL] / (n+1)

This is the average ordinate rule. Next is the Simpson's rule.

It states that sum of first and last ordinates have to be done. Add twice the sum of remaining odd ordinates and four times the sum of the remaining even ordinates. Multiply to this total sum by 1/3rd of the common distance between the ordinates which give the required area.

Where O1, O2, O3... On are the lengths of the ordinates. d is the common distance and n denotes the number of divisions. It is very similar to what we saw earlier.

Now, let's look into Trapezoidal rule. While applying the trapezoidal rule, boundaries between the ends of the ordinates are assumed to be straight. Thus, the areas enclosed between the base line and the irregular boundary line are considered as trapezoids. When you are connecting the lines, the distance between the baseline and the topline, you consider all the smaller pieces of trapezoids. Let O1, O2,.... On = ordinate at equal intervals and d = common distance between two ordinates. To the sum of the first and last ordinate, twice the sum of the intermediate ordinates are added. You need to sum the first ordinate and the last ordinate, you need to calculate twice the sum of the intermediate ordinates and it is added to it. Thus, this total sum is multiplied by the common distance. What you find as the total area has to be multiplied with the total distance. Half of this product is the required area. Whatever you find has to be divided by 2 and this is how area is found using trapezoidal rule.

A common problem for a surveyor is the calculation of the surface area of a field. The fields are often irregular which make direct calculation of areas difficult. Often surveyors face the problem of irregular shaped plots. Mostly they are very irregular in shape or have curved spots, how do you find the area if there are irregular spots? Let's discuss this further.

In such cases, fields are divided into a number of regular areas (triangles, rectangles, etc) of which the surfaces can be calculated with simple formulas. First, even if it is an irregular plot, it can be divided into smaller geometry or smaller regular shapes and then the areas can be found for these smaller divided geometrical patterns and everything can be added together to find the area of the irregular shape.

All areas are calculated separately and the sum of these areas give the total area of the field. As you see, these are completely irregular figures and these are further divided into smaller triangles. All these triangles can be found using area calculations. Area of this entire plot can be calculated by adding the area of this triangle, area of this and this. When you add the area of all these five triangles, this gives an entire area of the site.

Field of Irregular Shape

What happens when I feel this irregular shape? When it is completely irregular, what do you do?

The procedure to follow is - Step 1: Make a rough sketch of the field. As you see in this figure, this is a rough sketch indicating the corners of the field i.e point A, point A, point C, point D and point E. In addition, some major landmarks are indicated. As you see here, some of the additional landmarks are roads, ditches, houses, trees, etc, that may help to locate the field. These landmarks actually help ensure that your site is plotted correctly. Then, divide the field as indicated on the sketch into areas with regular shapes. In this example, the field can be divided into three triangles; ABC (base AC and height BB); AEC (base AC and height EE); and CDE (base EC and height DD1). There are three triangles here that form the entire site. There is one triangle and there is this one more triangle.

Step 3 - Mark on the field,the corners A, B, C, D and E with pegs. First you need to mark these five points with a peg so that your points are not going to get disturbed.

Step 4 - Set out ranging poles on lines AC (base of triangles ABC and AEC) and EC (base of triangle EDC). As you see in this figure, the baseline is set and then the measure between the distances AC and EC.

Step 5 - Set out line BB(height of triangle ABC) perpendicular to the baseline AC using one of the methods described in the earlier chapter 4. Measure the distance BB.

Step 6 - In the same way, the height EE of triangle AEC and the height DD of triangle CDE are set out and measured. Using the same method, you are finding the right angle from the baseline AC and we are finding a right angle from this line EC.

Step 7 - The base and the height of the three triangles have been measured. The final calculation can be done as follows -

As you measure, there is triangle ABC, base = AC = 130m and height = BB1 = 55m. This can be measured using the steel tape, this is an example that is existing. These are the figures that we

already know. For triangle ACE, the base length is 130m and the height EE1 = 37m. For triangle CDE, base EC = 56m, height DD1 = 55m. Answer is, you need to multiply half of the base x height which gives you the area. You need to find out the area of each triangle. For the whole field ABCDE, area of triangle of ABC is calculated, the area of triangle ACE is calculated and area of triangle CDE is calculated, then the total area is just the summation of all these three triangles, which gives 0.752 ha.

Next is, Exercise for students - the surface area of the field shown in figure has to be determined at a time that the field is covered by a tall crop, eg; maize or sugarcane. This is the existing field, almost in trapezoidal shape. You need to find the area of this site. This length is 90m and this length is 77m and this is 102m and this is 67m. Students can try to find out the area for this site.

Next is Irregularly-shaped area. Method 1 - Determination of a very irregularly shaped area can be obtained by establishing the longest line possible lengthwise through the centre of the area. Numerous lines are then established perpendicular to this centre line. The total number of lines will depend upon how irregular the shape of the area may be. The more irregular it is, the more lines should be drawn. From the average length of all these lines, the width of the area is determined and the area is calculated as a rectangle. When it is completely irregular, what you need to do is, you need to find the centre point and you need to draw lines to the outer edge. If it is more irregular, you need to draw more lines closer to each other and you need to find out the lengths that are connecting the centre point to the outer edge. All the lengths have been calculated and the average length is taken. The length is used, we then convert and apply the area of a triangle to find out the area of the irregular plot. This is much more simpler line as you can see. This is the baseline creating two extreme points. We are introducing smaller lines in between and we calculate the distance between these lines and as you can see, the distance being marked here and what we do is, we add the total distance and find out the average length which is being used to find out the area of this irregular plot using the area of a rectangle.

Formula A = a x b, where a = distance between A and B, and b = average of all lengths a' to j' (lines are drawn perpendicular to a). The formula to determine the area of this irregular plot is the distance between point A and point B x multiplying the average length of total length.

Example - as you can see, different lengths have been given for different points. We add everything together. We already know the distance between a and A is 128 ft and h' = 20ft and b = 18.6 ft. i' = 15ft. We are having different measurements. What we are doing is, 18.6 ft is calculated by adding up all the lengths and finding out the average of this.

Method II is another method for determining the size of an irregularly-shaped area, a golf green for example, is to establish a point as near to the centre of the area as can be estimated. From this point, as with a compass, distances for each 10-degree increment are measured to the edge of the irregularly shaped green. As you see, for an irregular golf green, you need to find the centre point and you need to find an angle using theodolite instrument. For each 10 degrees, you need to draw a line to the outer edge. Then, the 36 measurements taken completely around the central point are averaged. The idea is to obtain an average measurement and that measurement becomes the radius of the circle. The diameter d of the circle is found by multiplying its radius by 2. The average of all this length is added and then we are finding out the rough radius of this entire irregular shaped plot and then we are multiplying the radius by 2 by which we are finding out the diameter. The area is then computed using the formula for a circle which is **π** r square.

As you can see, this is an irregular circular plot, what we are doing is, drawing lines to the outer edge from the centre point at a 10 degree distance. Formula - A = 0.7854 x d x d where d = average r x 2. Example - distance between the first r1, the distance is 54.8. As you can see these are different distances until 360. What we are doing is, we are adding all these distances and finding the average. The total is 1980 and we divided it by 6, by which we find out the radius to be 55. The diameter is 110. The overall area is 0.7854 x 110 x 110 = 9503.34 sq ft.

Let's summarize what we have learnt from the entire presentation as learning outcomes - Computation of area on site. We studied how important was studying of an area on the site. The second is Calculation of area for geometrical shapes. If it is properly shaped or follows a proper geometrical shape, there are different formulas from which the area can be calculated. Then, different methods for the calculation of areas in the field of surveying. Different methods like coordinate land surveying, etc. Two methods for calculating area of irregular sites. These two methods average how the plot has been divided into parallel lines and how the plot is being marked with radial lines. These are the two methods through which you can find out the area for irregular shaped sites.

Questions - What does computation of area mean? And why is it important? How to calculate area for a site? What is instrumental method of calculating area in surveying? How to calculate area for irregular shaped plots? How to calculate area for a golf course? Thank you!