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CHAPTER FIVE:
CROSS SECTIONS

Cross sections are necessary for measurement of earthwork volumes in roadway construction. They are profile views of the ground, perpendicular to the centerline or base line, and indicate ground elevations at points of change in the ground slope. (Figure 5-1)

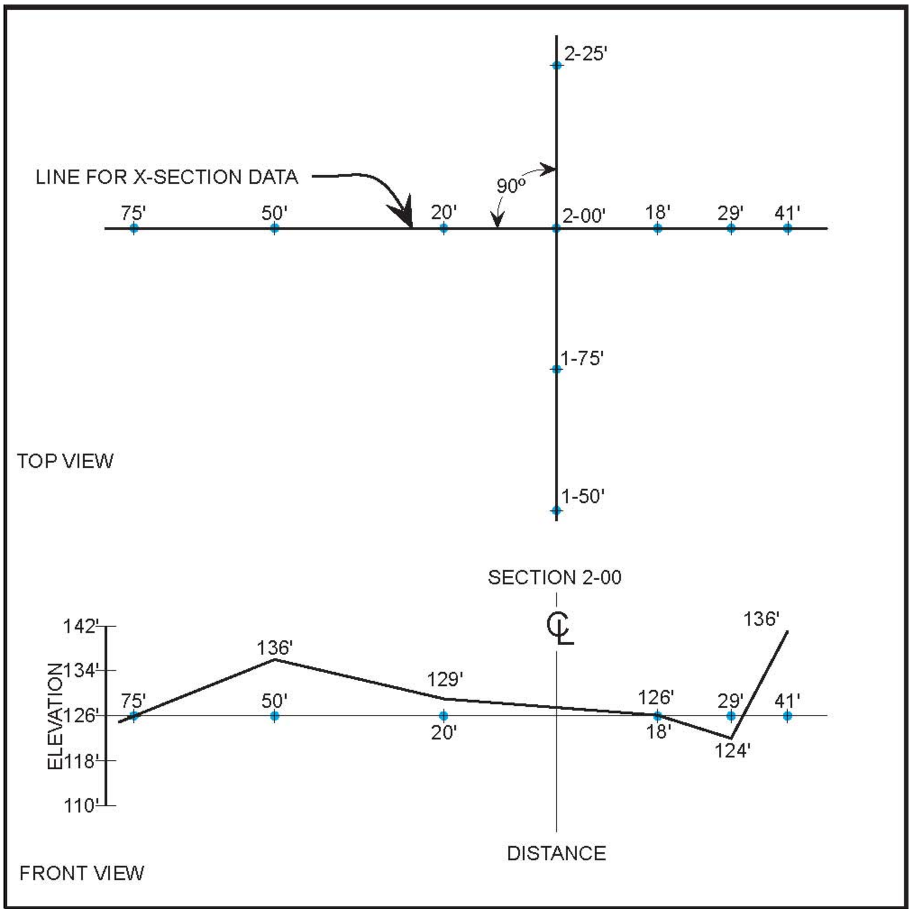


Figure 5-1. Cross Section

Sections are usually taken at pre-determined intervals, normally at 50 ft or 100 ft along the centerline or baseline.

An elevation is taken at the centerline and at intervals right and left of the centerline, normally 25 or 50 ft. Sometimes, elevations are taken at points other than the normal interval, depending on the terrain (i.e. locations of changes in the slope of the ground).

SIDE SLOPES

Side slope (Figure 5-2) is defined as the slope of the cut or fill expressed as the ratio of horizontal distance to vertical distance.

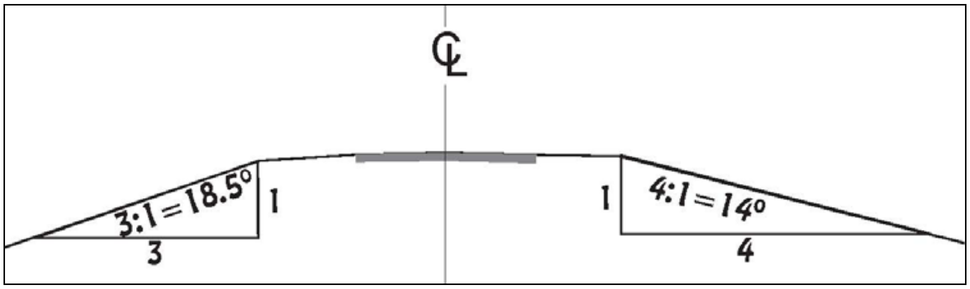
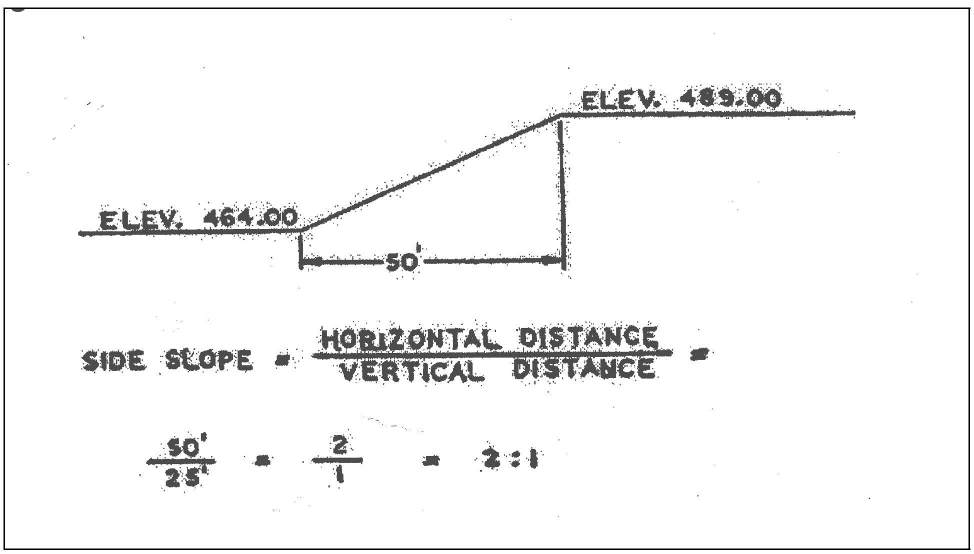


Figure 5-2. Side Slope

Example:

A 2:1 side slope indicates that for every horizontal distance of 2 ft, the corresponding vertical distance is 1 ft as indicated in the following diagram:



FIELD NOTES

Field notes (Figures 5-3 and 5-4) are recorded in the field books. Reference notes, such as EP (edge of pavement), CL (centerline), TS (toe of slope), TB (top of bank), OG (original ground), and where each shot (elevation) is taken are recorded.

The accuracy of the readings taken are required to be 0.1 ft on the ground and 0.01 ft on the pavement.

ORIGINAL CROSS SECTIONS

Original cross sections indicate the profile of the original ground before the ground is disturbed. These measurements may be used for primary design, estimating volumes, etc. Borrow pit original cross sections (Figures 5-3 and 5-4) are taken after stripping has occurred.

Before beginning a contract, the original sections is checked every 500 ft and compared to the sections shown on the plans. If these check sections vary consistently by more than 0.2 ft, the original sections may have to be retaken.

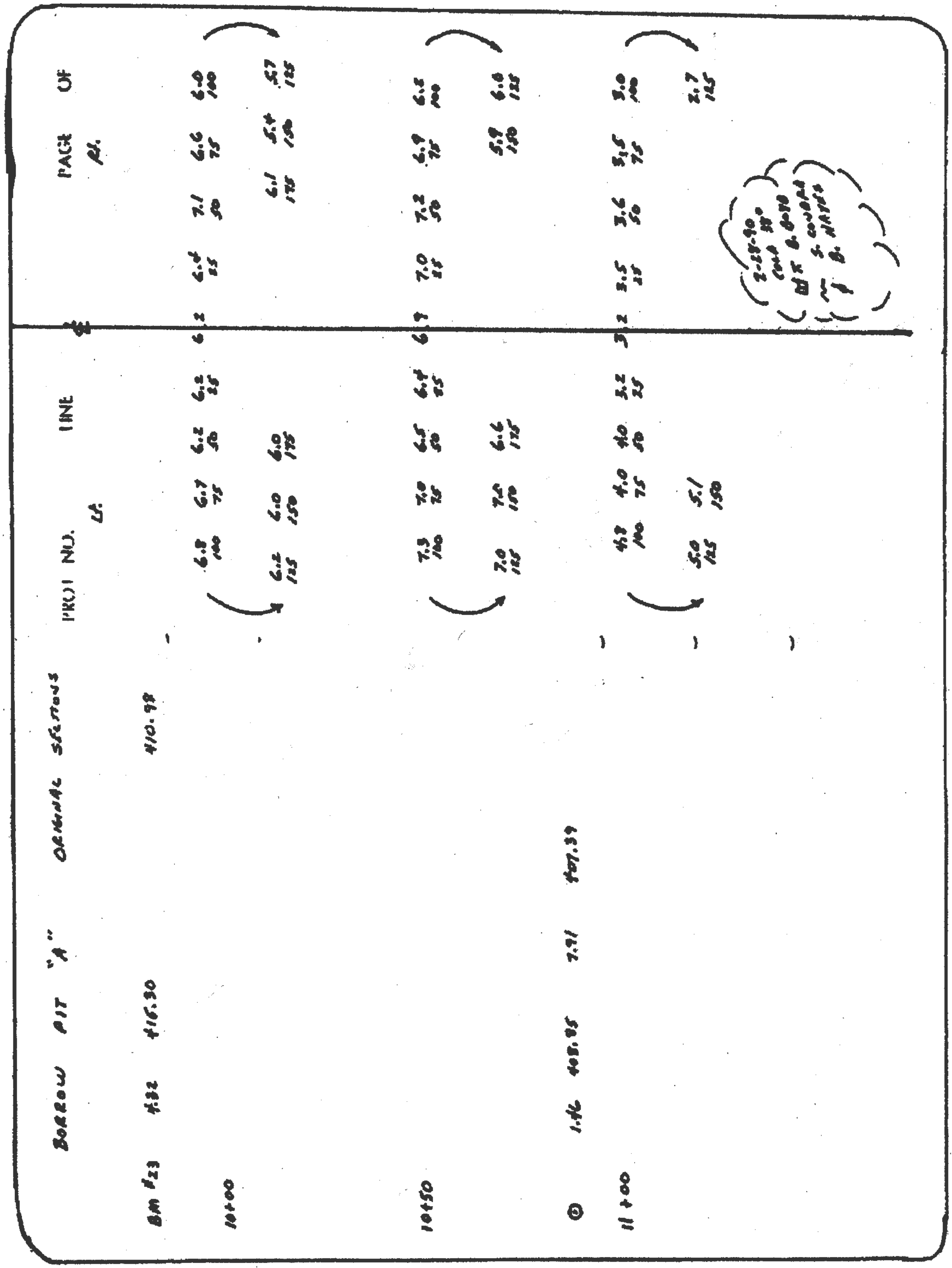


Figure 5-3. Field Notes – Original Section

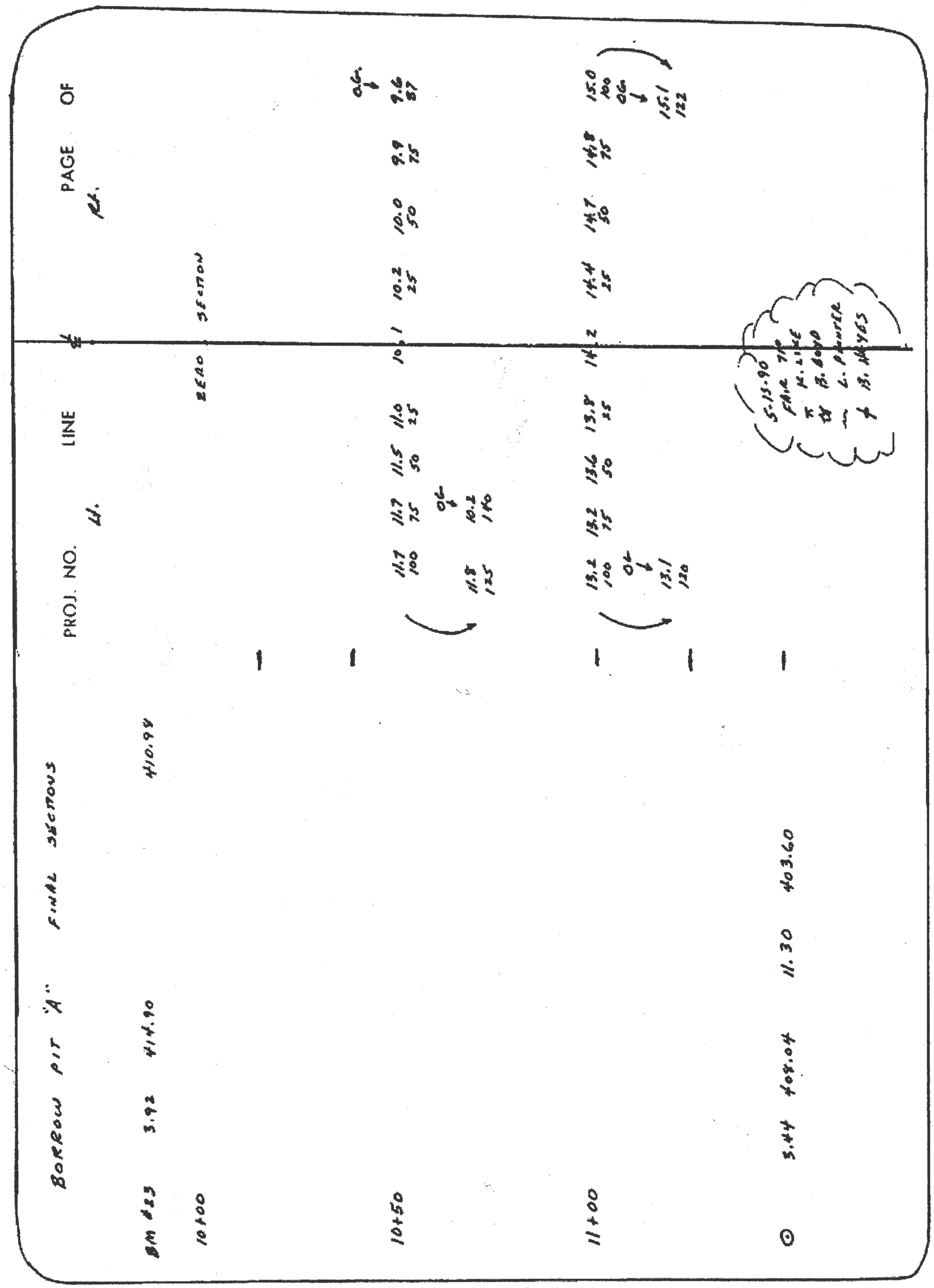


Figure 5-4. Field Notes – Final Section

PROFILES

Profiles indicate a vertical cross section or side view of the surface of the earth. They are necessary for the design and construction of the roads, curbs, sidewalks, drainage systems, etc.

The plotting of profiles is generally a graph of elevations plotted on the vertical axis as a function of horizontal distance (situations).

The vertical scale is usually exaggerated in comparison to the horizontal scale, making the shape of the ground easily visible. This procedure is especially helpful when plotting profile grades at intersections, railroad crossings, bridge approaches, wedge levels, etc.

Cross sections are plotted on special grid or cross section paper (Figure 5-5) which is printed in various grid sizes.

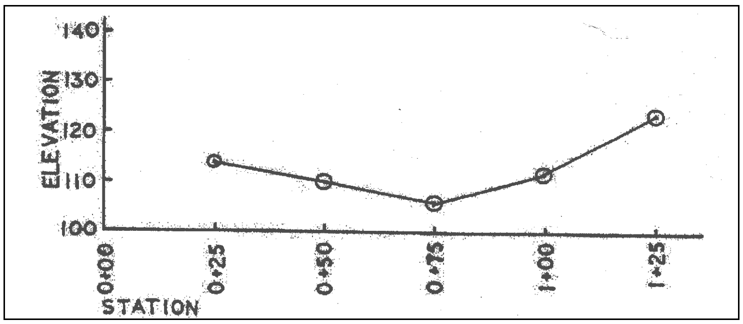


Figure 5-5. Profile

VERTICAL SECTIONS

Vertical sections (Figure 5-6) are straight up and down or 90° from horizontal. There are two shots taken at the same distance or station when a vertical section is taken.

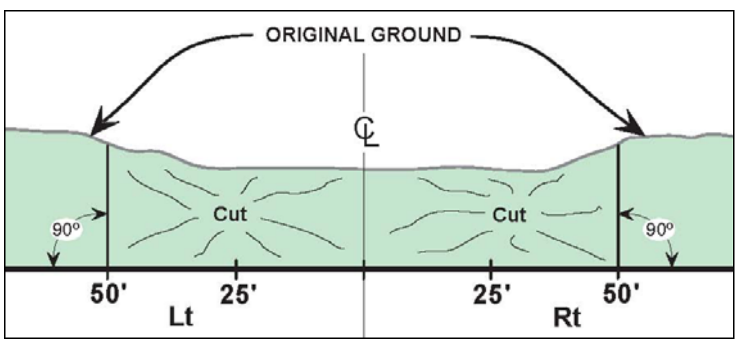


Figure 5-6. Vertical Section

ZERO SECTION

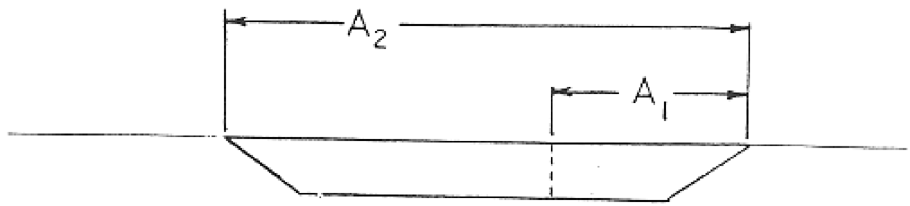
A zero section is a section at which no earthwork was done. These usually occur at the beginning and ending of contracts.

SPLIT SECTION

A split section sometimes is necessary so that earth quantities are not overestimated. They consist of two sets of cross sections taken at the same station.

Example:

Two sections would be required at station 5+50, one labeled 5+50 back and one labeled 5+50 ahead. Not splitting the section into back and ahead sections would result in an erroneous quantity.



SECTION AT 5+50
A1 = Area to be used for 5+50 back
A2 = Area to be used for 5+50 ahead

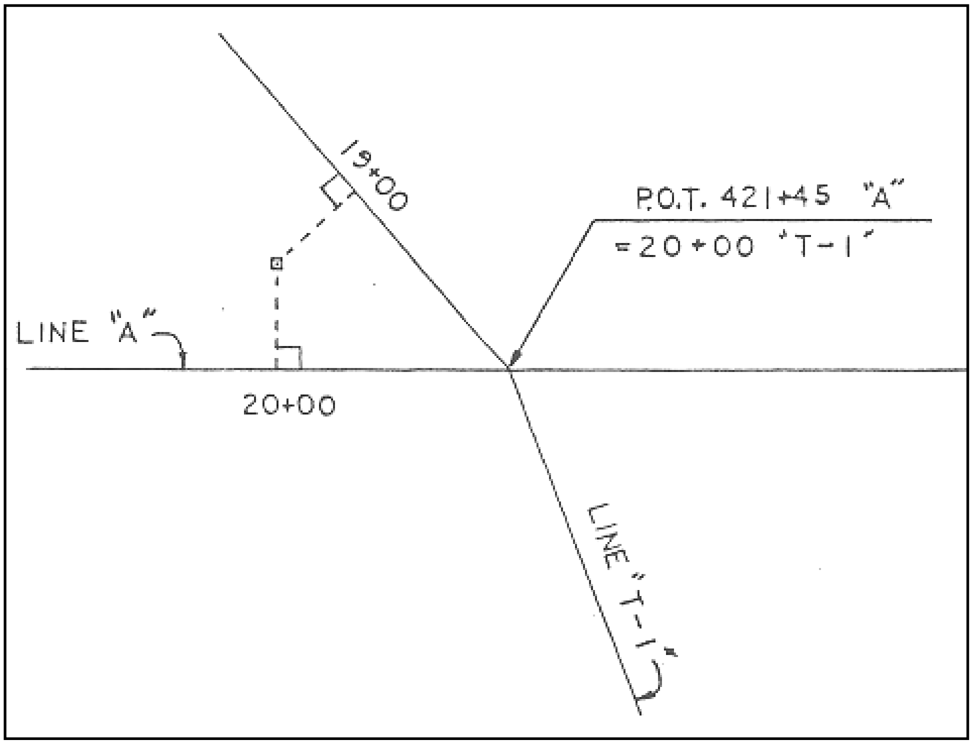
Splitting the section in this manner would require that a break be made in the earthwork computations.

MATCH LINES

Match lines occur when two sections from two separate baselines intersect at a point common to both baselines. Match lines are also those lines made when there is not enough cross section paper to accommodate the entire section.

Example:

Point "A" in the following section would be the point where the match line would occur and the two sections intersect. There probably is a vertical section at this point, if this point is not the original ground.



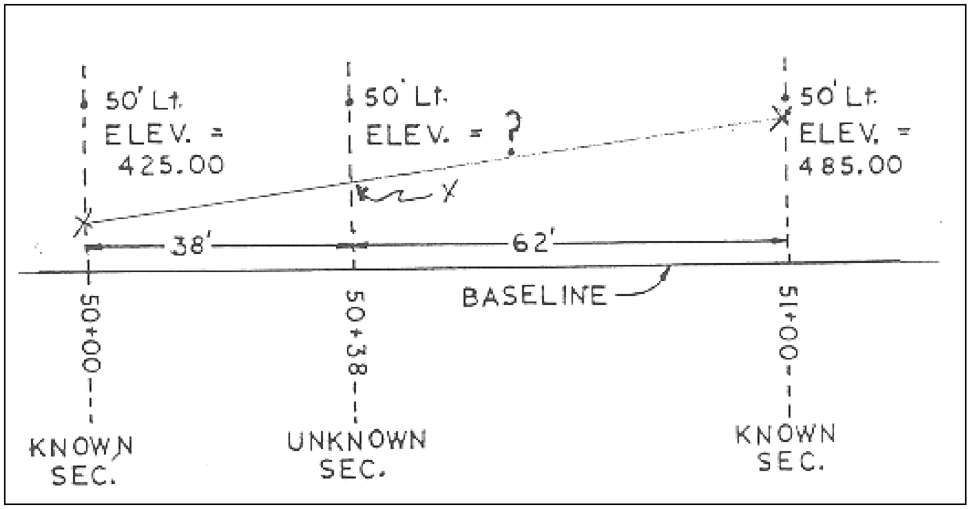
INTERPOLATION

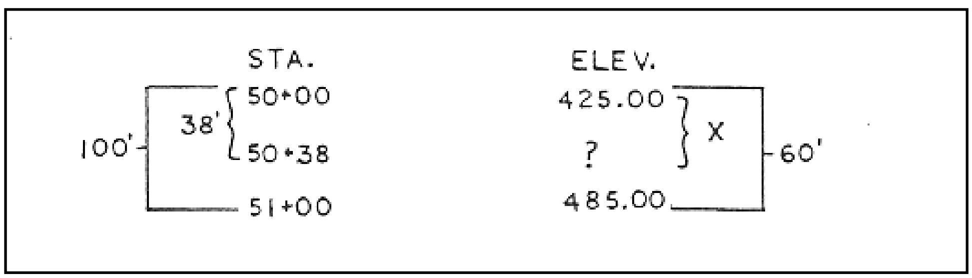
The estimation of an unknown section from two known adjacent sections is called interpolating that section. Usually, an original section requires to be interpolated since the original conditions no longer exist. The number of required interpolated sections varies depending on the number of changes in ground elevation between the two known sections.

To interpolate, assume that the ground is on a straight grade between the known sections. Points that are equidistant from the baseline for the known sections are selected. This distance is figured for the unknown section.

Example:

To figure the elevation of a point 50 ft left of a baseline at station 50+38, the following illustration explains the procedure:





x = the difference in elevation from station 50+00 to station 50+38.

Note that the ground elevation from station 50+00 to 51+00 is rising. This means that the elevation at station 50+38 is greater than the elevation at station 50+00. Therefore, 22.8 ft is added to 425.00 to obtain the elevation at station 50+38.

Elevation at Station 50+38 = 425.00 + 22.80 = 447.80 ft

EARTHWORK QUANTITIES

Earthwork quantities are usually measured in cubic yards and may be a cut or fill. The volumes are computed as the product of an area and a distance.

The methods for determining areas include:

1) Picking or stripping

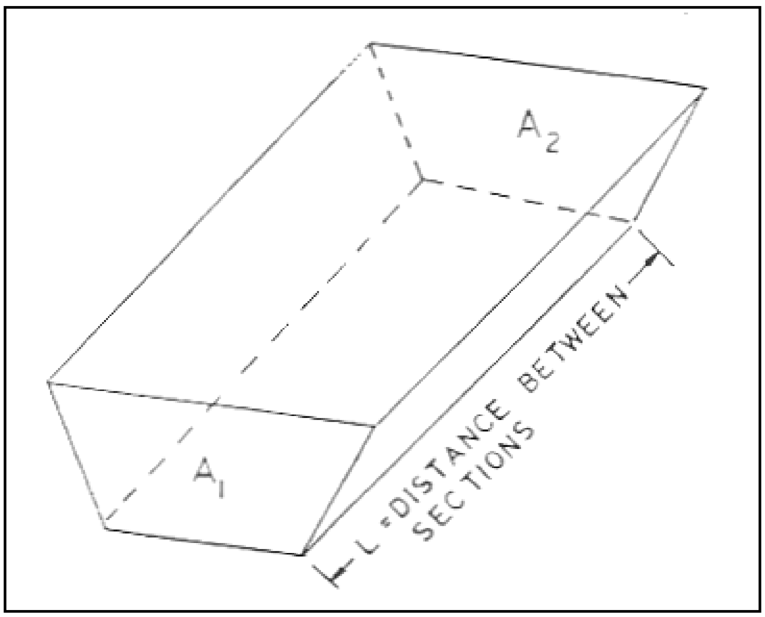
2) Plane geometry

3) Planimeter

4) Coordinates

Plane geometry, the most commonly used method by INDOT, requires dividing the section into regular shapes such as triangles and trapezoids. Dimensions may be determined by scaling or from field data. Areas are computed from basic geometric formulas.

Once the areas of the sections are determined, the volume between two adjacent sections may be computed by using the Average End Area Method (Figures 5-7).



$$\text{Volume (yd}^3\text{)} = \left(\frac{A_1 + A_2}{2}\right)(L)\left(\frac{1}{27}\right)$$

$$= \frac{(A_1 + A_2)(L)}{(2)(27)}$$

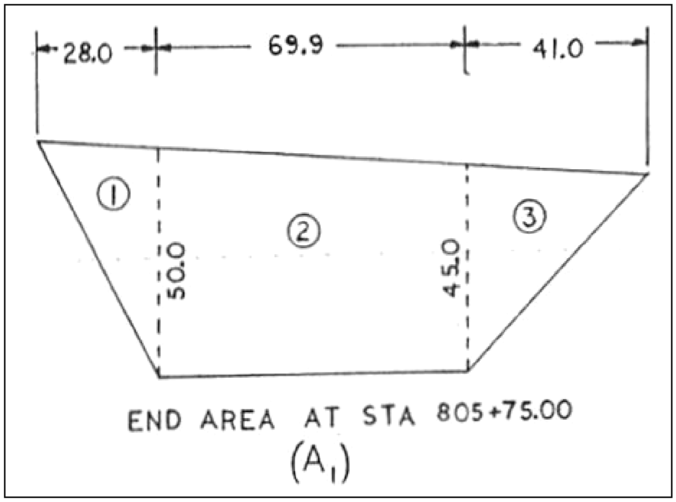
where:

A_1 = End Area in ft^2
A_2 = End Area in ft^2
L = Distance between stations in ft

Figure 5-7. Average End Area Method

Example:

Given the end sections as follows, determine the quantity of earthwork.



<u>Area 1</u>

$Area_1 = ½ (28.0 ft) (50.0 ft)$

$= 700.0 ft^2$

<u>Area 2</u>

$$Area_2 = \left(\frac{50.0ft + 45.0ft}{2}\right) (69.9)$$

$= 3320.0 ft^2$

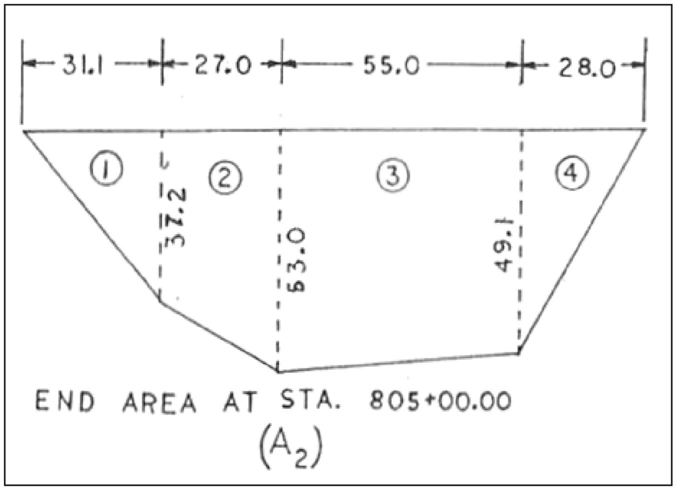
<u>Area 3</u>

$Area_3 = ½ (41.0 ft) (45.0 ft)$

$= 922.5 ft$

Total Area $A_1 = 700.0 ft^2 + 3320.3 ft^2 + 922.5 ft^2$

$= 4942.8 ft^2$



<u>Area 1</u>

$$\text{Area}_1 = \tfrac{1}{2}\,(37.2\text{ ft})\,(31.1\text{ ft})$$

$$= 578.5\text{ ft}^2$$

<u>Area 2</u>

$$\text{Area}_2 = \left(\frac{37.2\text{ft} + 53.0\text{ft}}{2}\right)(27.0)$$

$$= 1217.7\text{ ft}^2$$

<u>Area 3</u>

$$\text{Area}_3 = \left(\frac{53.0\text{ft} + 49.1\text{ft}}{2}\right)(55.0\text{ft})$$

$$=2807.8\text{ ft}^2$$

<u>Area 4</u>

$$\text{Area}_4 = \tfrac{1}{2}\,(28.0\text{ ft})\,(49.1\text{ ft})$$

$$= 687.4\text{ ft}^2$$

$$\text{Total Area } A_2 = 578.5\text{ ft}^2 + 1217.7\text{ ft}^2 + 2807.8\text{ ft}^2 + 687.4\text{ ft}^2$$

$$= 5291.4\text{ ft}^2$$

$$\text{Total Volume} = \frac{(A_1 + A_2)\,(L)}{(2)(27)}$$

$$= \frac{(5291.4\text{ ft}^2 + 4942.8\text{ ft}^2)\,(75.0\text{ ft})}{(2)(27)}$$

$$= 14{,}214.0\text{ yd}^3$$