

of the table, since in general the points, (intersections) used in the diagram will lie not far from the curve of level section.

Use of Diagram.

Find the diagonal line corresponding to the given value of C ; follow this up until the vertical line representing the given value of D is reached, and this intersection found. Then read off the value of S corresponding to this intersection.

Example.

Notes	Sta 1	$\frac{13.0}{-4.0}$	-3.7	$\frac{12.4}{-3.6}$	136.
	Sta 0	$\frac{10.6}{-2.4}$	-2.5	$\frac{10.3}{-2.2}$	78.
					214.

For Sta 1 $C = 3.7$ $D = 25.4$

$C = 3.7$ is the middle of the space between 3.6 and 3.8 - follow this up until the vertical line 25.4 is reached.

The intersection lies upon the line $S = 136$.

Enter this above opposite Sta 1.

For Sta 0 $C = 2.5$ $D = 20.9$

$C = 2.5$ is the middle of space between 2.4 and 2.6 - follow this up until the middle of space between 20.8 and 21.0 is reached.

The intersection lies just above the line
 $S_0 = 78$. Enter this opposite Sta 0

$$S'_{100} = S_0 + S_1 \\ = 136 + 78 = 214 \text{ cu. yds.}$$

The prismatical correction may be applied if desired.

It should be noticed that in each case the intersection was quite close to the "curve of level section"

Diagrams may be constructed in this way, that will give results to a greater degree of precision than is warranted by the precision reached in taking the measurements on the ground.

In point of rapidity diagrams are much more rapid than tables for the computation of "Three Level Sections" for "Triangular Prisms" and for "Prismatical" Correction, the diagrams are somewhat more rapid.

For "Level Sections" the Puller and Chandler tables are at least equally rapid.

A book "Computation from Diagrams of Railway Earthwork" by Arthur M. Wellington, published by D. Appleton & Co. N.Y.

Explains the application and construction of certain other tables in addition to those given here. "Wellington's Diagrams" as they published are upon a scale differing from that used here, and they do not allow of as great precision, but are in the contrary arranged to cover a large number of tables differing some as to base and slope.

The use of approximate methods for applying the prismatical correction to irregular sections (p. 152-153) will be rendered practicable by the use of these "Diagrams for Three Level Sections".

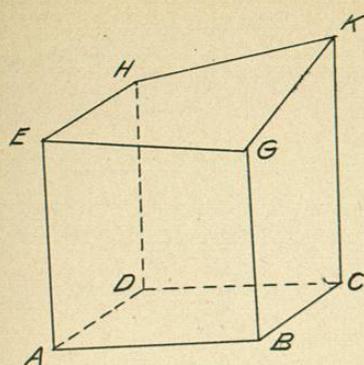
Method 1. - No use of diagrams is necessary.
 Method 2. - Having found for any irregular section (by triangular prisms or any other method) the solidity for 50 ft in length - S , find upon the Diagram the line corresponding to this value of S - follow this line to the curve of level section and read off the value of C (for a level section) which corresponds, and also the value of D for the same section.

Method 3. Having found in any way the value of S ; if c is given, find the value of D to correspond; if D is given find the value of c to correspond.

Method 4- The use of diagrams is not needed.

Borrow Pits.

In addition to the ordinary work of excavation and Embankment for railroads, earth is often "borrowed" from outside the limits of the work proper, and in such excavations, called "borrow-pits", it is common to prepare the work by dividing the surface into squares, rectangles, or triangles; taking levels at every corner upon the original surface; and again after the excavation of the borrow-pit is completed, the prints are reproduced and levels again taken. The excavation is thus divided into a series of vertical prisms, having square, rectangular or triangular cross-sections. These prisms are commonly truncated top and bottom, the lengths or altitudes of the vertical edges of these prisms are given by the difference in levels taken 1st on the original surface and 2nd after the excavation is completed. This method of measurements is very generally used ^{and} for many purposes.

Truncated Rectangular Prism.

Let A = area of right section
 $ABCD$ of a rectangular
 prism truncated on top
 (base is $ABCD$)

h_1 = height AE

h_2 = " BG

h_3 = " KC

h_4 = " HD

S' = Solidity of prism

b = $AD = BC$

a = $AB = DC$

Then using method of End areas

$$S' = \frac{AEHD + BGKC}{2} \times a$$

$$= \frac{b \frac{h_1 + h_4}{2} + b \frac{h_2 + h_3}{2}}{2} \times a$$

$$= ab \frac{h_1 + h_2 + h_3 + h_4}{4}$$

$$S' = A \frac{h_1 + h_2 + h_3 + h_4}{4} \text{ (cu. ft.) (173)}$$

$$S' = \frac{A}{27} \frac{h_1 + h_2 + h_3 + h_4}{4} \text{ (cu. yds.) (174)}$$

We may find S' correct by the Prismoïdal formula if we apply the prismoïdal correction.

The prismoïdal correction $C = 0$ since

$D_0 - D_1 = 0$ (or in this case $AD - BC = 0$)

The formula therefore remains unchanged.

It is evident from this then that the solution holds good and the formula is

Correct, not only when the surface EHKG is a plane, but also when it is a warped surface, generated by a right line moving always parallel to the plane ADHE and upon EG and HK as directrices.

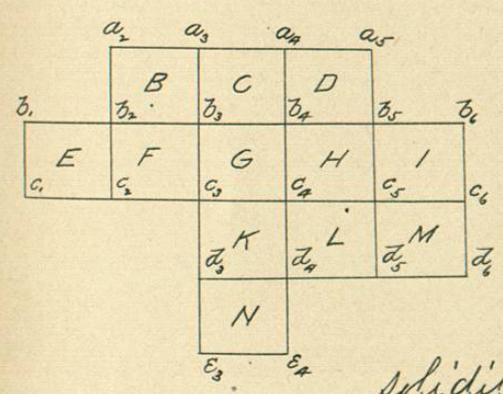
Some engineers prefer to cross section in rectangles of base 15' x 18'. In this case

$$S = \frac{15' \times 18'}{27} \cdot \frac{w_1 + w_2 + w_3 + w_4}{4} \text{ (cu. yds.)}$$

$$= 10 \frac{w_1 + w_2 + w_3 + w_4}{4} \text{ (cu. yds.) (175.)}$$

Other convenient dimensions will suggest themselves, as 10' x 13.5' or 20' x 13.5' or 20' x 27'

Assembled Prisms.



In the case of an assembly of prisms of equal base, it is not necessary to separately calculate each prism but the

solidity of a number of prisms may be calculated in one operation.

In the prism B - $S'_B = A \frac{a_2 + a_3 + b_3 + b_2}{4}$
 $S'_C = A \frac{a_3 + a_4 + b_4 + b_3}{4}$ etc

From inspection it will be seen, taking

A as the common area of base of a single prism, and taking the sum of the solidities, that the heights $a_2 - a_5$ enter into the calculation of one prism only; $a_3 - a_4$ into two prisms each; $b_1 - b_6$ one only; $b_2 - b_5$ into three prisms; $b_3 - b_4$ into four prisms; and similarly throughout.

Let $t_1 =$ sum of hts. common to one prism.
 $t_2 =$ " " " " " two prisms.
 $t_3 =$ " " " " " three "
 $t_4 =$ " " " " " four "

Then the total solidity

$$S'_6 = A \frac{t_1 + 2t_2 + 3t_3 + 4t_4}{4} \text{ (cu.ft.) (176.)}$$

$$S'_6 = \frac{A}{27} \frac{t_1 + 2t_2 + 3t_3 + 4t_4}{4} \text{ (cu.yds.) (177.)}$$

Haul.

When material from Excavation is hauled to be placed in Embankment, it is customary to pay to the contractor a certain sum for every cubic yard hauled. Oftentimes it is provided that no payment shall be made for material hauled less than a specified distance. In the East a common limit of "free haul" is 1000 feet. Often in the West 100 feet is the limit of "free haul".

A common custom is to make the unit for payment of haul, one yard hauled 100 feet; the price paid will often be from 1 to 2 cents per cubic yard hauled 100 feet.

The price paid for "haul" is small, and therefore the standard of precision in calculation need not be quite as fine as in the calculation of the quantities of Earthwork.

The total "haul" will be the product of (1.) the total amount of Excavation hauled, and (2.) the average length of haul.

The average length of haul is the distance between the center of gravity of the material as found in Excavation, and the center of gravity as deposited. It would in general not be simple to find the center of gravity