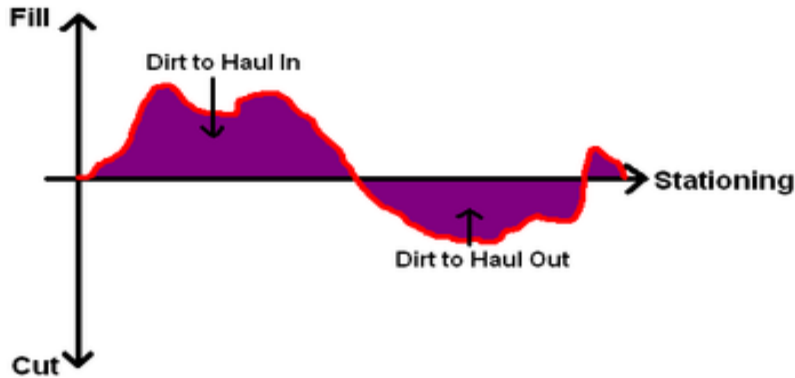


Excavation and embankment (cut and fill)

Excavation = the removal of soil or rock from its natural location.

Embankment = the placement and compaction of layers of earth or rock to form a roadbed of the planned shape, density, and profile grade.

Various sections of a roadway design will require bringing in earth. Other sections will require earth to be removed. Earth that is brought in is considered **Fill** while earth that is removed is considered **Cut**. Generally, designers generate drawings called Cut and Fill Diagrams, which illustrate the cut or fill present at any given site. This drawing is quite standard, being no more than a graph with site location on the X-axis and fill being the positive range of the Y-axis while cut is the negative range of the Y-axis.



For the PE exam - cut-fill problems are really simple. There are two types of problems that could be asked.

1. What is the volume of the cut/fill area for a road between two stations
2. What is the volume of the cut/fill area for a road between multiple stations

In real life, mostly these problems are solved using computer programs. However, you don't have the luxury doing the PE Exam so you need to know a few things,

The only things you need to know are

1. How to find the Area of the cross section
 - Usually given
 - Use Geometry
2. How to find the volume using the different techniques

Average end area Method

$$V = \frac{A_1 + A_2}{2}L$$

Volume cut/fill Formulas Legend required

L=distance between stations

A = Area of cut/fill

A_m = Area of a plane surface midway between the two cross sections

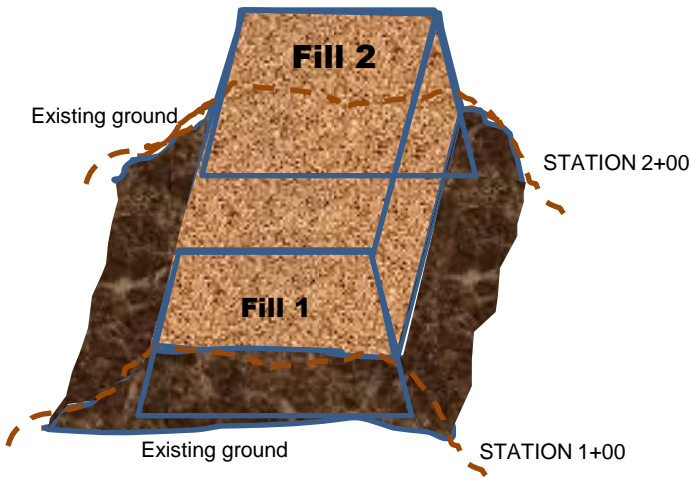
Prismoidal Method – This is a more accurate formula, which takes out most of the error accrued by the average end area method.

$$V_p = \frac{L(A_1 + 4A_m + A_2)}{6}$$

Pyramid Method - If one end area has a value of zero, the earthwork volume can be considered a pyramid and the correct formula would be:

$$V = \frac{AL}{3}$$

Cut and Fill between two Stations



To figure out what is the total net fill between station 1+00 and 2+00.

Step 1: figure out total fill area per station. The area is usually given.

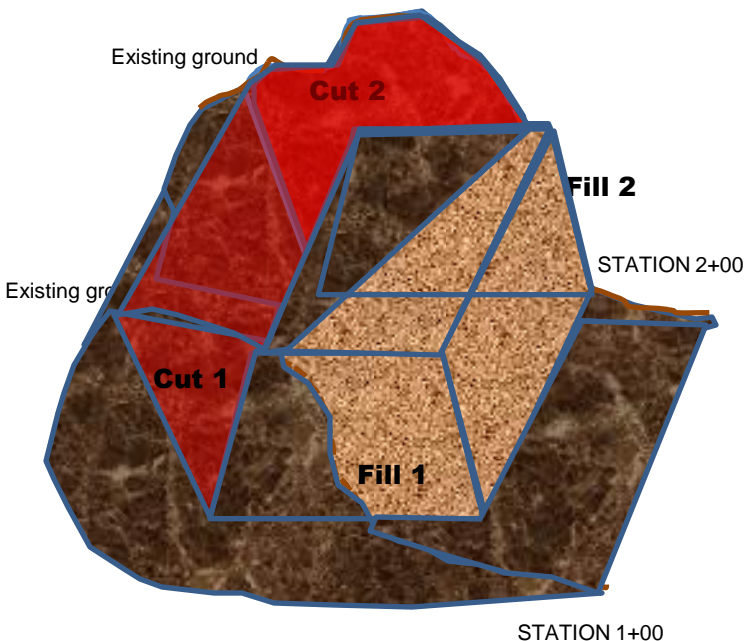
- STA 1+00 = Fill 1 area = 100ft²
- STA 2+00 = Fill 2 area = 40ft²

Step 2: Use formula to calculate the fill volume between stations

- Volume fill = $(100\text{ft}^2 + 40\text{ft}^2) / 2 \times 100\text{ft} = 7000 \text{ft}^3$

Step 3: Convert Cubic Feet to Cubic Yards

- CY soil = $\text{CF soil} / 27 = 7000 \text{ft}^3 / 27 = 260 \text{CY Fill}$



To figure out what is the total net cut/fill between station 1+00 and 2+00.

Step 1: figure out total cut/fill area per station. This is usually given.

- STA 1+00 = Cut 1 area = 85ft², Fill 1 area = 100ft²
- STA 2+00 = Cut 2 area = 140ft², Fill 2 area = 20ft²

Step 2: Use above formula to calculate the cut/fill volume between stations

- Volume cut = $(85\text{ft}^2 + 140\text{ft}^2) / 2 \times 100\text{ft} = 11250 \text{ft}^3$
- Volume fill = $(100\text{ft}^2 + 20\text{ft}^2) / 2 \times 100\text{ft} = 6000 \text{ft}^3$

Step 3: Find total net cut or fill between stations

- Total cut or fill = Volume cut – Volume fill
- Total cut = $11250\text{ft}^3 - 6000\text{ft}^3 = 5250 \text{ft}^3 \text{ Cut}$

Step 4: Convert Cubic Feet to Cubic Yards

- CY soil = $\text{CF soil} / 27 = 5250 \text{ft}^3 / 27 = 194.44\text{CY Cut}$

Cut and Fill between multiple Stations

To figure out what is the total net cut/fill between stations 1+00 and 3+00.
Columns Station #, Cut Area, and fill area will be given

Step 1: Complete "Cut Vol"

Step 2: Complete the "Fill Vol"

Step 3: Complete the "Net Cut"

Step 4: Complete the Cum Cut

Station #	Cut Area	Fill Area	Cut Vol	Fill Vol	Net Vol	Cum Cut
0+00	175	125	7300	6200	1100	1100
0+50	117	123				
1+00	238	250	8875	9325	-450	650
1+50	211	240	11225	12250	-1025	-375
2+00	198	180	10225	10500	-275	-650
2+50	140	141	8450	8025	425	-225
3+00	258	200	9950	8525	1425	1200