Online Surveying FE 208
Lecture 5

Survey Measurements – Horizontal and Vertical Distance

Learning Objectives for this Lecture

1. **Understand the difference between horizontal and slope distances**
2. **Know the conversion for horizontal distance from slope distance**
3. **Know the conversion for slope distance from horizontal distance**
4. **Know the concept of breaking chain**
5. **Know the format for field book notation of horizontal distance**
6. **Know the field book notation for distances in road layout format**
7. **Know the calculation for vertical distance from percent slope angle**
8. **Give examples of when a slope distance might be desired over a horizontal distance**

Horizontal Distance

One of the most basic operations in surveying is the determination of horizontal distance between two points.

Horizontal distance vs. slope distance

We can measure all distances as slope distance but we must reduce them to horizontal distance

Horizontal distance is also known as *plane distance* and is either measured directly with the measuring tape held so that the slope is zero or is calculated from the slope distance. The slope distance is that distance measured parallel to the ground accounting for differences in elevation
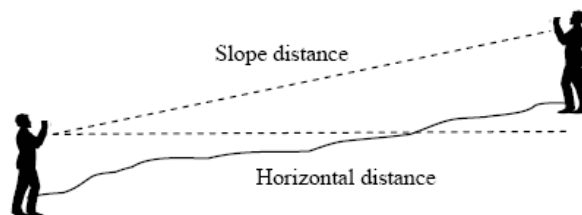
When measuring the slope angle in percent;

$$HD = ((\tan^{-1}) \times (\text{slope angle in percent})) \cos) \times SD$$

Note that a slope angle of 45% is input into the equation as 0.45

Example;

Slope angle of 30% and a slope distance of 212.5'
$$HD = ((\tan^{-1}) \times (0.30)) \cos) \times 212.5' = 203.5'$$

Measurement of horizontal distances can be accomplished by a number of methods including pacing, taping, stadia, and electronic distance measurement (EDM) devices. The choice of measurement device usually is determined by the accuracy required.

Each point along a surveyed line is called a ***station***. Stations are usually designated by a point reference number. In the case of an open traverse such as a road, for example, the stations will be designated by their horizontal distance from the beginning point in the format XX + YY.ZZ where X = hundreds of feet (or meters), Y = ones of feet (or meters), and Z = fractions of feet (or meters). For example, a station 1880.59 feet from the beginning would be designated as **18 + 80.59**.

Breaking Chain

It is often the case that a long horizontal distance will have a number of slope angle changes. In addition, the distance may be greater than the total length of the tape and it will be necessary to measure the distance in sections. This is called "***breaking chain***". Think of it as breaking up the total distance into more easily managed sections. For example, we would measure the sections of a line by separating out the sections that are of a different slope angle. En example of this is shown below. The line runs up and over a hillside and down the other side. It has been broken into three separate slope angle sections. Stations are designated as A, B, C, and D.
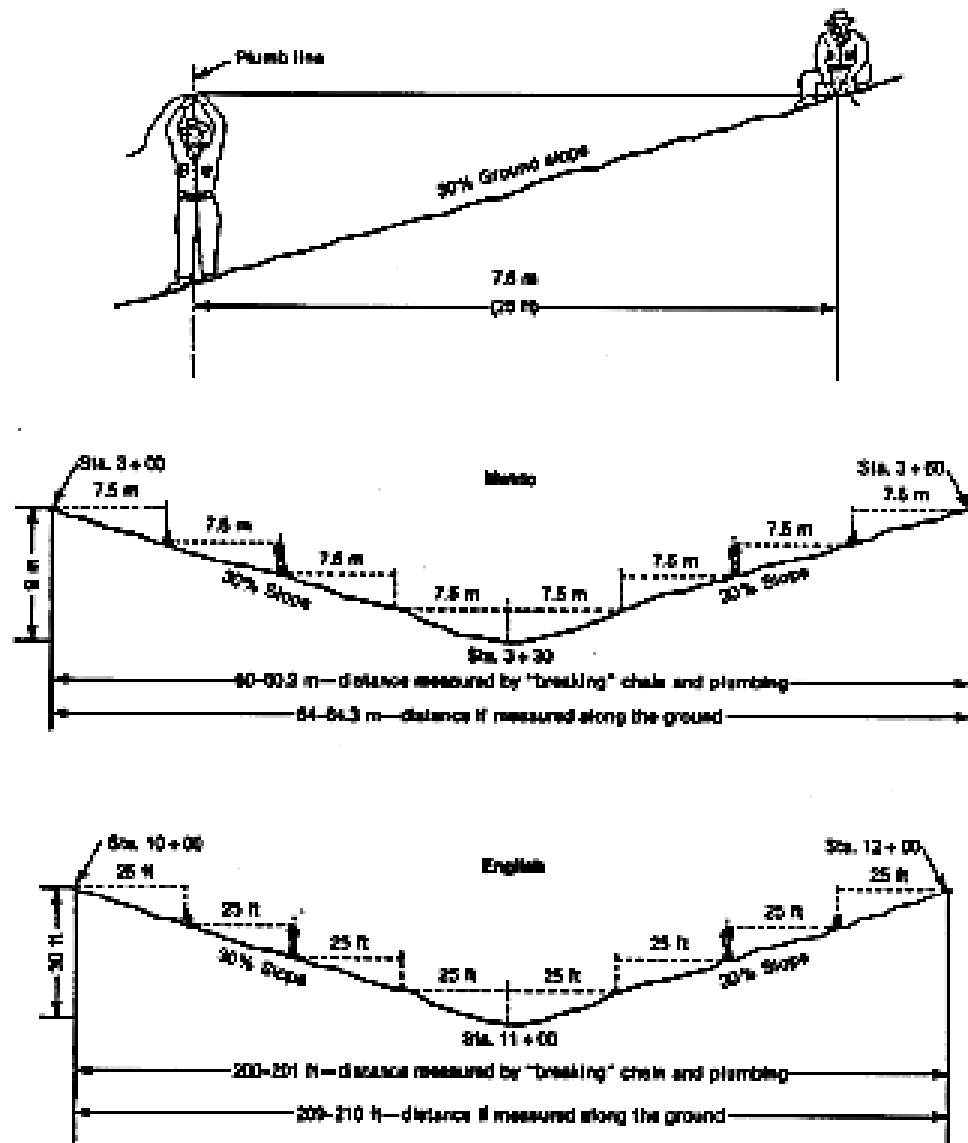
Breaking chain. These diagrams illustrate the methods for breaking chain to obtain horizontal measurements on sloping ground.

Field Book Notation

At this point, it is a good time to talk about field book notation with regard to decimals. A small decimal point written in a field book or on a field stake can be easily missed, particularly where the field book has become dirty, wet, or heavily used. However, missing a decimal point can be a critical mistake. For example, mistaking 150.2' for 1502'. A convention

used by many surveyors and particularly by construction surveyors is the use of the following convention. Whole numbers are written as normal while decimals are written as a superscript with a line underneath. For the example above, 150.2 would be written as
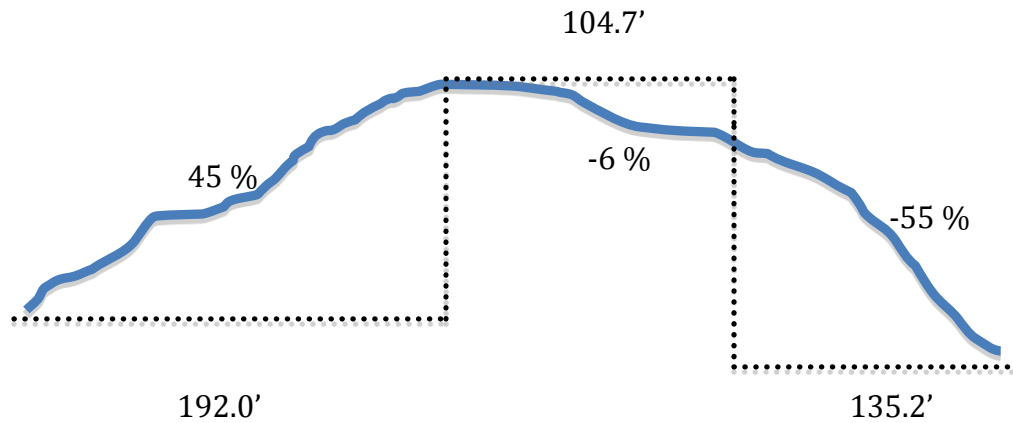
$$150^{\underline{2}}$$

Example of breaking chain and field book format
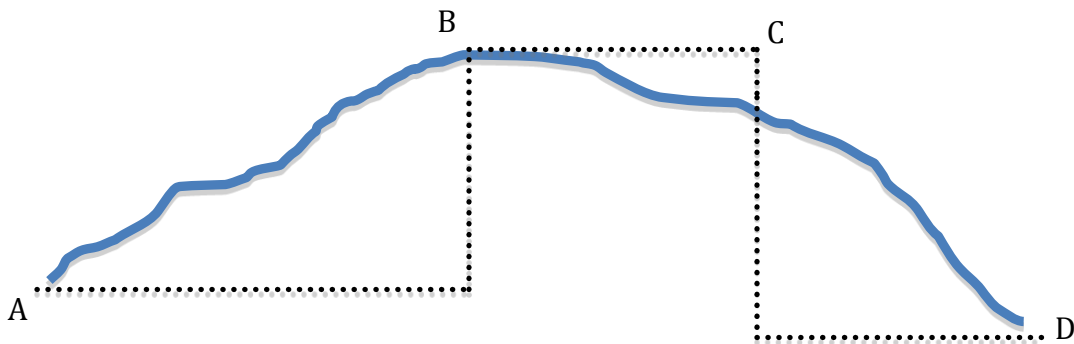
STA	SD	%	HD
A			
	$210^{\underline{5}}$	45	$192^{\underline{0}}$
B			
	$104^{\underline{9}}$	-6	$104^{\underline{7}}$
C			
	$154^{\underline{3}}$	-55	$135^{\underline{2}}$
	$(431^{\underline{9}})$		
D			

Note also in this example, that because this was a single straight line distance that has been broken up into segments, the overall horizontal distance is recorded in parentheses at the last station.
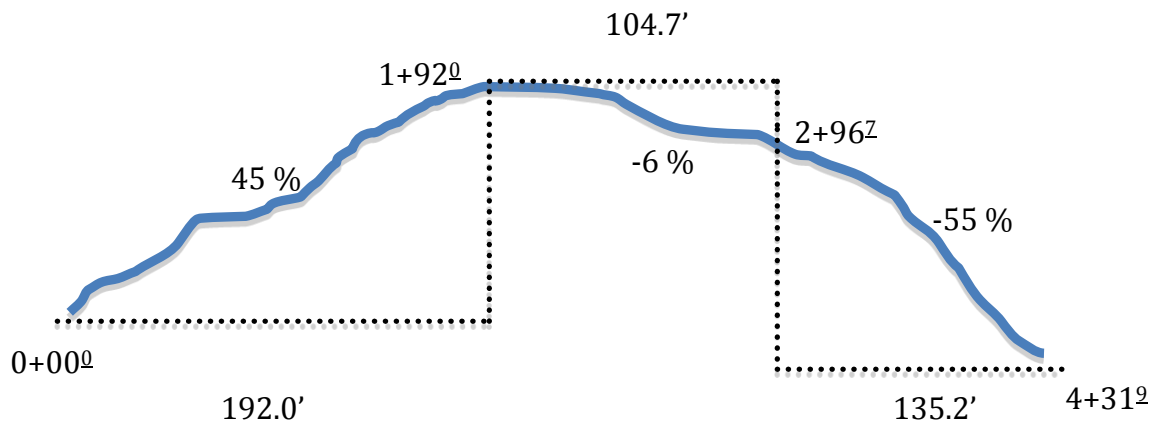
104.7'

45 %   -6 %   -55 %

192.0'   135.2'

A-B HD = ((tan-1)(0.45) cos * 210.5 = 192.0

B-C HD = ((tan-1)(-0.06) cos * 104.9 = 104.7'

C-D HD = ((tan-1)(0.55) cos * 154.3 = 135.2'

Note the stationing for the same example above, if we had used the format that is typical for road layout. Also, note that the stationing is a cumulative of the horizontal distance. A final note on this, the stationing for the road format is reversed and progresses from the bottom of the page to the top. This is explained later in more detail.

STA	SD	%	HD
4+31[9]			
	154[3]	-55	135[2]
2+96[7]			
	104[9]	-6	104[7]
1+92[0]			
	210[5]	45	192[0]
0+00[0]			

104.7'

1+92$_0$

45 %

-6 %

2+96$_7$

-55 %

0+00$_0$

192.0'

135.2'

4+31$_9$

Vertical Distance

Since % slope is defined as rise/run

= Vertical Distance/Horizontal Distance

= Elevation Difference/Horizontal Distance

Therefore;

VD = percent slope X HD

A-B 0.45 * 192.0 = +86.4'

B-C -0.06 * 104.7' = -6.3'

C-D -0.55 * 135.2' = -74.4'

Suppose that in the field you have measured a % slope of –26% between two points and the calculated horizontal distance is 229.7 feet (70 meters) and the elevation of point A is 549.9 feet (167.6 meters). You need to know the elevation of point B.

Vertical distance from point B to A =

229.7 feet x -0.26 = 59.7 feet

The elevation of point B = 549.9 feet + -59.7 feet

= 544.20 feet

Using the previous example from a set of field notes:

If we started at an elevation of 535.5' for point A;

STA	SD	%	HD	VD	Elev
A					535.5
	210.5	45	192.0	+86.4	
B					621.9
	104.9	-6	104.7	-0.63	
C					615.6
	154.3	-55	135.2	-74.4	
D					541.2

Reading for this Section
Moffitt and Bossler, pages 15-60
Kiser, pages 43-52, 61-62