Measuring and Calculating Slopes

Roadway Slopes

Roadway grade and travel way, shoulder, and ditch line slopes affect the removal of a road's greatest enemy: WATER. Some slope enables water to flow away from the roadway, but too much creates erosion.

Table 1 contains the recommended slopes for roads cross section, shoulders, and ditches for paved and unpaved roads. Slopes are described by the vertical rise or fall per unit of horizontal distance. For example, the recommended slope for a paved road cross section is a ¼ inch rise from shoulder to crown for each foot of horizontal road width. This is expressed as "¼ inch to 1" or "2 percent." Steeper slopes are usually expressed as a proportion. For example, a 1:4 slope, pronounced "1 to 4," has a 1 foot rise (or fall) for every 4 feet of horizontal distance.

Table 1	
Recommended Slopes for Gravel Roads	
Road Cross Section	½ - ¾" to 1, 4 to 6%
Shoulder	¾-1" to 1, 6 to 8%
Ditch Front Slope	1:4 minimum, 1:2 max.
Ditch Back Slope	1:2
Recommended Slopes for Paved Roads	
Road Cross Section	¼" to 1, 2%
Shoulder	½-3/4" to 1, 4 to 6%
Ditch Front Slope	1:4 minimum, 1:2 max.
Ditch Back Slope	1:2

The Pop-level

The most accurate instruments for measuring slope are theodolites and transits. A "pop" or hand level is accurate enough for most maintenance work. Figure 1 shows the elements of a typical eye level. The operator holds the instrument in his/her hand, and steadies it against a temporary, non-bending pole. Another person is needed to help measure vertical and horizontal distance. A leveling rod works well for vertical distance.

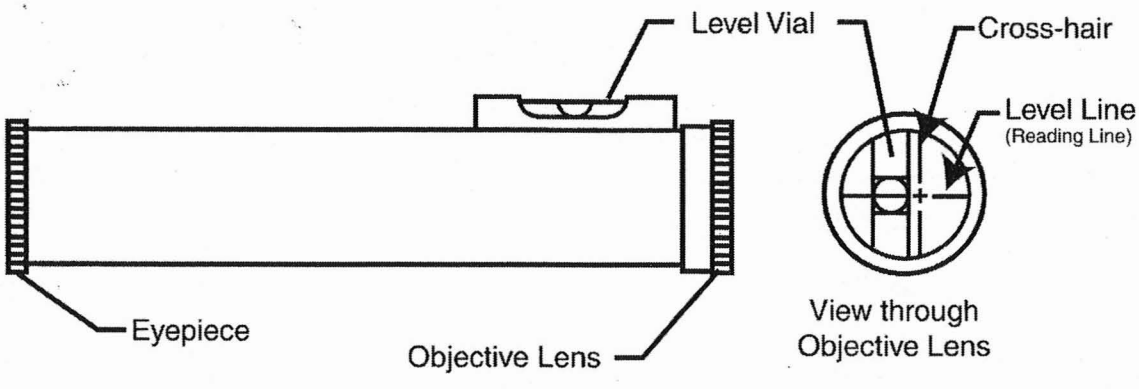


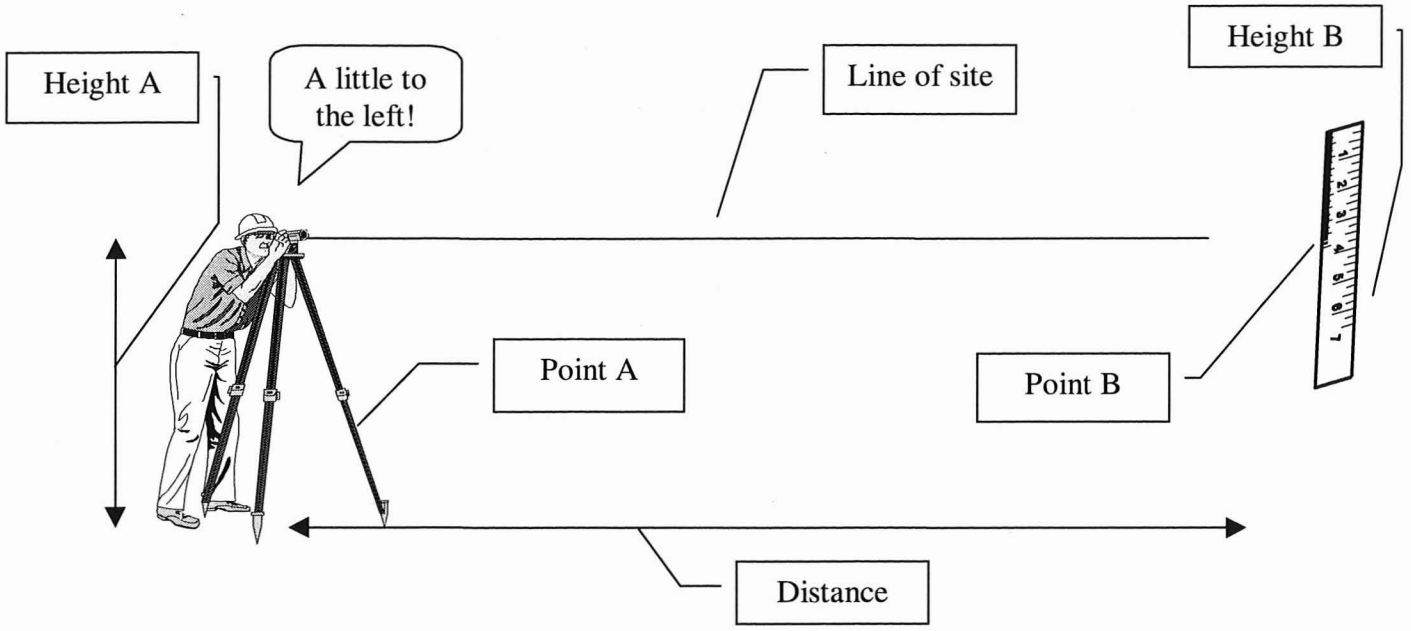
Figure 1

Determining the Slope

The slope is the incline or decline between two points. It is the usual practice to call these points "A" and "B." The procedure begins with positioning the eye level (or theodolite or transit) where the operator can read the level rod at each of the two points. The operator then reads the elevation of each point on the

level rod, and subtracts the values. This is the difference in elevation between points "A" and "B." The crew then measures the horizontal distance between the two points.

It is sometimes convenient to position the instrument at one of the points. In Figure 2, the instrument is placed over Point A. One measures the height of the transit or eye level as the elevation of Point A.



The slope is calculated by the dividing the elevation difference by the horizontal distance. The following examples illustrate slope calculation. Note the need to carefully consider the units of measure.

Cross Section Slope

Elevation of Shoulder	4 feet-11inches
Elevation of Crown	4 feet-8 inches
Difference in Elevation	0 feet-3 inches
Horizontal Distance	12 feet

Slope expressed as inches per foot:

3 inches/12 feet = ¼" per foot

Slope expressed as a percent:

[3 inches/(12 feet x 12 inches/foot)]x100%

= [3 inches/144 inches]x100% = 2%

Ditch Front Slope

Elevation of Slope Top	4 feet-11inches
Elevation of Ditch Bottom	5 feet-5 inches
Difference in Elevation	1 foot-6 inches
Horizontal Distance	6 feet

To express as a proportion, both measure must be the same units.

1 foot-6 inches = 1.5 feet or 18 inches

6 feet = 72 inches

1.5 feet:6 feet = 1:4 or 18 inches:72 inches = 1:4

Comparing these results to Table 1 shows that the cross section would be adequate if the road was paved, but too low for a gravel road. The 1:4 ditch slope is a minimum slope for either type road. Knowing how to calculate roadway slopes helps municipal road crews effectively remove water without incurring erosion from water run-off. Whether using a transit or pop level, crews can determine if slopes are sufficient to carry water away from the road but not so great that water will erode road surfaces and road sides.