LECTURE A5 – VERTICAL ALIGNMENT – SIGHT DISTANCE & CURVES

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INTRODUCTION

As in the case of the horizontal alignment, the vertical alignment is a sequence of tangents and curves. Tangents are referred to as *"grades"* and the value of the slope at which they occur is the *"gradient"*. Curves can be circular as in European practice or elliptical although the parabola is preferred in the United States. South African practice derives principally from American precedents; hence the local preference is also for the parabola.

In practice, there is little to choose between the circular and the parabolic curve because with a given curve length and specified gradients on either side of it, the difference in levels achieved by using the one in preference to the other are almost unplottable.

INTRODUCTION

Furthermore, once the levels have been calculated with painstaking accuracy to the nearest micromillimetre, the man, responsible for assuring that they get transferred to the base course, is sitting on a grader and, consequently, has an eye height closer to three metres than to two. He will positively guarantee that any differences between the circular curve and the parabola are totally undetectable.

A particular case where the circular vertical curve must be used is where an incrementally launched bridge is to be constructed on a vertical curve. Because each segment of the bridge is cast in a fixed casting yard before being launched, it can only be pushed out on a circular path.

THE SHAPE OF THE VERTICAL CURVE

In theory, the parabola is vastly to be preferred over the circular curve. The horizontal circular curve treats the driver to a constant rate of change of bearing and the parabola provides a constant rate of change of gradient, ie:

The rate of change in gradient is constant. This gives rise to the formula K = L/A, the length of curve divided by the unit change in gradient, or *sharpness* of curve, or

L = K x A, the length of curve required for specified K and relevant A.

THE SHAPE OF THE VERTICAL CURVE

"A" being the algebraic difference in gradients, or the total change in gradient across the length of the vertical curve and K being equal to L/A.

K, described in words, is the distance required for a unit change of gradient.

It does not matter how the gradient is described; whether as a percentage or as a slope of 1 in x. The length of the curve will be in the same unit as that adopted for K.

Percentage gradients, being the height difference (in metres) achieved across a horizontal distance of 100 metres, are the most convenient to work with.

THE CALCULATION OF VERTICAL CURVES

With the advent of modern computers and road design software packages, the designer is no longer required to manually calculate design elevations along the vertical alignment. It is however useful to have some idea of how one should set about carrying out the exercise.

There are two fundamental forms of calculation to be considered. These are the Offset Method and the other the Gradient Method. The Offset Method calculates a level on the extension of the first grade beyond the start of the vertical curve, the BVC, and then goes on to calculate the height difference between this point and the alignment to finally achieve the gradeline level required.

THE CALCULATION OF VERTICAL CURVES

The attraction of this method is that it is possible to very easily calculate a gradeline level at any point on the curve as opposed to being locked into calculating levels at fixed intervals along the road. This is the method that modern computers use.

The principal attraction of the Gradient Method is that it is self-checking. It involves two distinct steps. The first step is calculation of the gradient between all the successive pairs of points on the road and is checked by the fact that the gradient at the end of curve (EVC) is in fact equal to the gradient selected for that grade. The next step uses the height of the preceding point and the gradient to the succeeding point to establish its height, and so on along the full length of the curve.

PLOTTING OF VERTICAL CURVES

As with the calculation of the vertical curve, modern computing packages and plotters has resulted in the old-fashioned manual method of plotting and drawing vertical curves becoming redundant.

The vertical alignment is usually drawn to a distorted scale of 1:10 between the vertical and the horizontal. The scale factor is simply a matter of convenience because gradients are small, typically less than 5 %, and differences in successive gradients not easy to see when drawn to a natural scale.

SIGHT DISTANCE AND CURVATURE

The minimum curvature that may be adopted is based on stopping sight distance for the selected design speed of the road in the case of a crest curve. Reference here is to a grazing ray from an eye height of 1,05 m to an object height of 0,15 m. Minimum curvature in the case of a sag curve is based on headlight illumination distance where the assumption is that the headlight is mounted at a height of 0,6 m above the centreline of the road, and the spread of useful light has a divergence angle of 1° above the horizontal.

SIGHT DISTANCE AND CURVATURE

Minimum K-values compatible with stopping sight distance (as discussed in Lecture T4) are given in the relevant design guidelines. The table hereafter is that given in TRH 17.

SIGHT DISTANCE AND CURVATURE

Table A5.1: Minimum values of k for vertical curves

Design speed (km/h)	Crest curves	Sag curves
40	6	8
50	11	12
60	16	16
70	23	20
80	33	25
90	46	31
100	60	36
110	81	43
120	110	52
130	33	57
140	163	64