Press Release 2009.1

Optimization of Vertical Profile to get most economic Roadway Design

Optimization is a special technology which can be effectively used in highway project planning. It enables to consider several alternate alignments and choose the economically best by the process of optimization. Experience in developed countries indicates that the use of optimization technology can make considerable savings and large reductions in construction costs. In a developing country, where roadways are a major mode of transportation, optimization of the highway alignment would result in construction at a significantly reduced cost.

In HEADS we shall study here to know how the optimization of vertical alignment could result in savings in highway construction costs. The design horizontal alignment can have innumerable combinations of vertical alignment with varying gradients and vertical curves. The profile which can be considered as the best is the one with minimum depth of cut and height of fill and with the lowest volume of earthworks. It is a tedious process to work out the best combination manually and it was found that the optimum vertical profile can be decided more efficiently using software technology. Reducing the cost of construction would enable the Govt. to go for more development in the transportation network in the country as the savings accrued can be invested in other highway developmental activities.

Problem Definition

Two types of optimization are done by HEADS, these are Earthwork Optimization and Bituminous Overlay optimization.

In earthwork optimization there will be Cut & Fill in the Optimized profile and will tend to balance the quantities.

In Bituminous Overlay Optimization the design profile will be mostly in Fill which is close to the user defined thickness.

The job is to divide the road into different sections and is termed as Horizontal Increment (HIN). The formation level at the beginning of the road section is to be specified. The end point along the alignment of a section is attained as the ground is reached and not exceeding the maximum gradient (MAX), done by a set of vertical steps defined by the Vertical increment (VIN). The end point of any section serve as the starting point for the next section and the points along the vertical alignment had thus to be generated.

The main area where reduction in costs was aimed to be achieved was either in earthwork or in Bituminous Overlay; the vertical alignment had to be so chosen that it involved minimum quantity of CUT/FILL. The alignment thus depends on the natural ground profile involving the permissible gradients. Commonly in Plain Terrain, the gradient is limited to a maximum of 3.33 per cent which is the ruling gradient.

Two main arrays, one listing the ground levels at an interval equal to the HIN and the other listing the formation levels were created following the VIN & maximum Gradient MAX. The initial earthwork calculations for each possible vertical alignment were made and the total amount of earthwork involved in each case was stored.

The above analysis was conducted in stages. The formation level obtained at the end of one stage served as the initial formation level for the succeeding stage. The process continued until the end of the alignment was reached.

Comparison of Alternate Vertical Alignments

In the present example Horizontal grids of 150 m length have been considered for HIN, For vertical alignment optimization 0.10 m increments have been considered for VIN. The description of grid is shown in fig.1. The gradient was limited to a maximum of 1 in 30 for each grid. The user input for HIN, VIN & MAX is flexible and the grid size & gradient can be varied, if necessary.

The working of the program for connecting two points A and B by a roadway with an optimal vertical alignment is as follows:

Suppose referring to Fig. 2, if the distance between A and B is 600 m. Since, the Horizontal length of each grid has been taken as 150 m number of stages in the analysis is four. Each stage is considered one after the other.

The first stage is connecting two extremities of the current section. There are eleven possible ways at the rate of 0.10 m vertical increment in which this can be done. The connection giving the least volume of FILL and consequently minimum FILL cost is considered to be optimum. Once this connection is established, the subsequent connection is worked out.

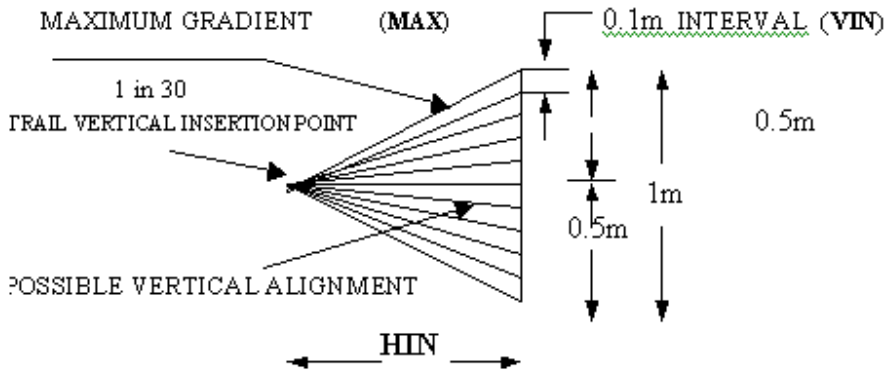

Fig. 1: Description of the grid

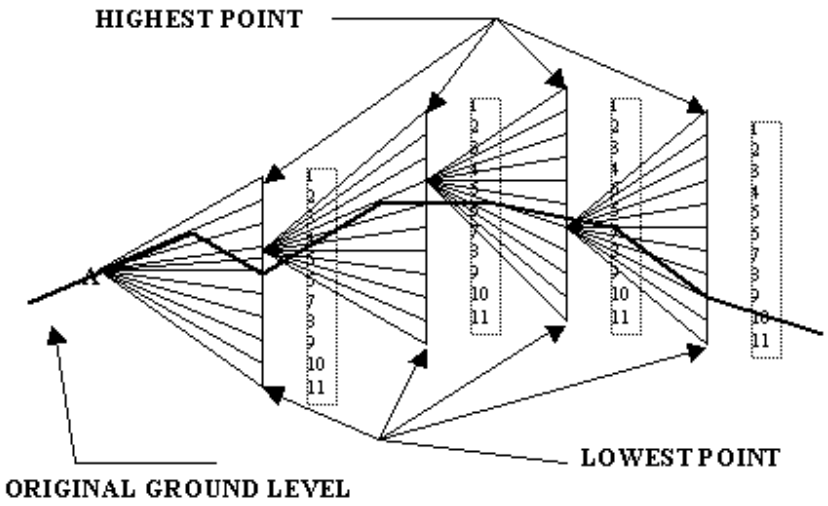

Fig. 2: Optimum road link design

The following example User Input data format is as given below, this performs following task:

This follows the profile of the reference Model/String and creates the Input data with VIPs for a proposed profile having minimum quantity for Earthwork in Fill.

330,VIP option reads a reference string from the Model file and writes formatted output data in VALIGN.DAT file, which may be used as input data required for running Major option 300,VALIGNMENT as explained in example 300.1 above.

Example 300.3.1

Data below is for Optimization of Earthwork in Cut & Fill, here the value of Horizontal increment HIN=150.0m, Vertical Curve Length VCL=150.0m, value of Vertical increment VIN=0.10m, Formation thickness FORM=0m and Maximum Gradient MAX=0.0333 ie, 3.33%

```
PROHEADS
300,PROVALIGN
330,VIP
331,MODEL=DESIGN,STRING=E001
332,MODEL=DESIGN,STRING=E002
333,SC=0.0,IN=25.0,EC=3000.0,VCL=150.0
334,HIN=150.0,VIN=0.1,FORM=0.0,MAX=0.0333
FINISH
```

Example 300.3.2

Data below is for Optimization of Bituminous Overlay, here the value of Horizontal increment HIN=50.0m, value of Vertical increment VIN=0.10m, Vertical Curve Length VCL=50.0m, Formation thickness FORM=0.03m and Maximum Gradient MAX=0.0333 ie, 3.33%

```
PROHEADS
300,PROVALIGN
330,VIP
331,MODEL=DESIGN,STRING=M001
332,MODEL=DESIGN,STRING=M002
333,SC=0.0,IN=25.0,EC=3000.0,VCL=50.0
334,HIN=50.0,VIN=0.1,FORM=0.03,MAX=0.0333
FINISH
```

The Output is written in file VALIGN.TXT, which may be selected using Heads menu option ‘File_open’ and run using Heads menu option ‘Geometrics_300 Valignment’. This will create vertical profile of the design alignment in the model files MODEL.FIL & MODEL.LST, design database file VALIGN.FIL and will write a report VALIGNMENT.REP.