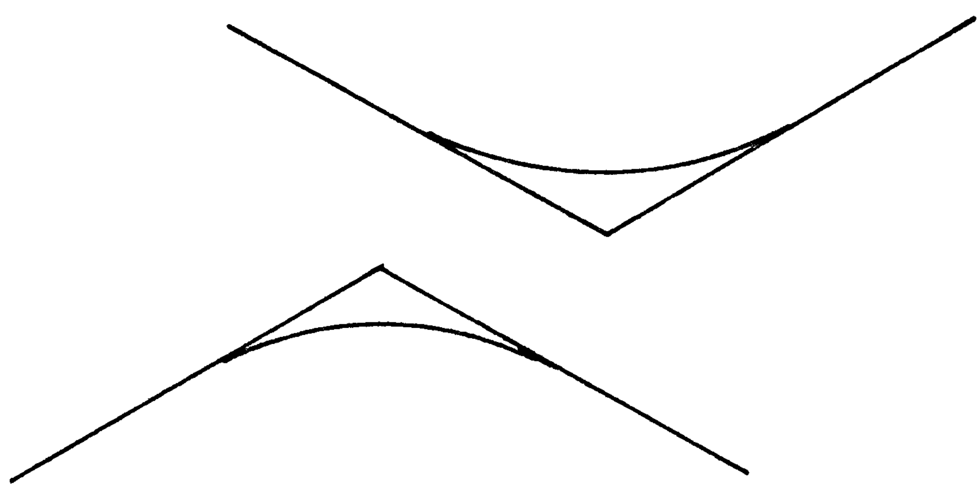
DESIGN FOR VERTICAL CONTROL POINTS

Consider, first, taking the left hand branch of the ROAD DESIGN FLOW DIAGRAM. That is where vertical control points will control the design of this zone of the project. Construction limitations such as full bench sections, or full fill sections are not always control points.

I. Draw a grade line between the vertical control points. Keep in mind that on the sag curve, the roadway actually passes above the grade line. Similarly, on the crest curve, the roadway passes below the grade line.



Do not be concerned with trying to balance the cut and fill at this time. The profile is not a reliable indicator of the earthwork that will be involved. The grade line that is selected should satisfy the criteria specified for the class of road, its use and its users.

There are occasions where a designer should consider exceeding the specified grade in the essence of good engineering. For example, a short pitch of grade in excess of that specified may allow the road to reach a bench, a saddle, ridge or other desirable terrain. The effect is often to shorten the total road, provide for a better side slope condition, or eliminate earthwork. The designer should be ready and willing to consider non-traditional solutions to the road design problems. As part of this consideration, the designer must be ready to document the reasoning and engineering behind his or her decision to utilize the non-standard design technique.

Connect the profile grade lines with vertical curves. The vertical curve can be one of the designer's most valuable tools. The length of a curve can be adjusted to provide a particular elevation at a sag or crest point. Even more flexibility is available to the designer who wishes to apply unbalanced or unsymmetrical vertical curves to the design. These curves provide a great deal of ability to control the earthwork along the alignment by controlling the cut or fill through the change in grades. Refer to the appendix discussion on vertical curves for more detail.

Design philosophies often state that a roadway should not have a vertical curve located on a horizontal curve. For arterial roads and forest highways, this is a reasonable goal. Often the designer is unable to satisfy this criteria on the end-of-system haul road and on occasion on the collector roads. Due to the relatively low volume and low speed of these roads, it is reasonable to allow the superposition of the horizontal and vertical curves. Each case must be considered individually.

II. The designer must always be considering the effects on the entire design of any one design action or decision. At this time the designer should be considering what effect the vertical grade will have on possible horizontal alignments. The individual cross sections covered by the grade line should be examined. Can this grade line be constructed to the right or left of the established "P" line location? Will this result in a horizontal control point?

III. Turnouts should also be considered at this time. Study the horizontal "P" line alignment to establish the turnout locations that appear to be needed.

Refer to the design standards and specifications for the road classification to determine the characteristics of the turnouts. Study the vertical "P" line alignment to establish turnout locations needed for crest curve safety considerations. Finally, the designer must consider the interaction of the horizontal and vertical alignments to determine if turnouts are needed as a result of the combination of the two alignments.

When the designer is considering the cross sections, he or she should recall that the turnout results in a considerable widening of the roadway. In a similar fashion, extra widening may be needed for curves and for slough widening on fill sections.

Where long adverse grades are encountered, the designer should consider the need for a double track typical section. This, in effect, provides a passing lane. (The length of this double track must be considered in terms of the passing sight distance.)

IV. Drainage must be given a preliminary consideration at this time. Tentative location for all culverts and drainage structures must be determined.

V. Refer to the ROAD DESIGN FORM. Record on the form the "P" line stations where cross sections were taken. See item A. Using the "P" line profile, determine the elevation of the grade at each "P" line station. Record this information on the ROAD DESIGN FORM. See item B. This is the elevation of the proposed grade, not the ground line elevation. This same grade elevation should be plotted on the cross section. Utilize a short horizontal line drawn at the "P" line centerline to denote this elevation.

VI. A balanced roadway prism is desired. Using a template on the cross section, slide the template to the left or right until a balanced cross section is achieved. A balanced section is one where the amount of material to be cut or excavated (represented by the cut area) equals the amount of material to be filled (represented by the fill area). This is also referred to as a side-cast section. The designer must allow for the extra width that may be involved with turnouts, slough widening, and curve widening. In addition, allowance must be made for material that will be lost or gained as a result of the shrinkage or swell factor. When the template has been located at the balanced section location, the centerline of the roadway should be marked on the cross section with a short vertical line. The distance from the "P" line centerline to the proposed or "L" line centerline should be scaled off of the cross section sheet and recorded on the ROAD DESIGN FORM under the heading of TRIAL OFFSET. See item C. Note on the form

ROAD DESIGN FORM

oject Manual No. ______ Section ______ Class ______ Page ______

est ______ Designed by RH Date october 19 79

' Line	Trial Grade Elev.	Trial Offset Lt.	Trial Offset Rt.	"L" Line	Offset Lt.	Offset Rt.	Ground Elev. Projtd. Line	% Grade	Tangent Grade El.	Vertical Curve Dist.	Vertical Curve Ord.	Vertical Curve Elev.	Remarks
(A)	(B)	(C)	(C)	(D)	(E)	(E)	(F)		(G)	(H)		(I)	
-00	805	10		0+00	8		800	-4%	805				
-27	804	5		0+26	4		797	-4%	804				
+52	803	—		0+49		1	795	-4%	803				
+02	801		6	1+00		7	793	-4%	801				
+50 -75	VPC(799) 798		12	1+74		12	790	-4%	799 798	0 25		799 799-	
+00 +10	VPI(797) 797+		8	2+12		9	792	+5%	797	50 60		798 799-	
+50 +80	VPT(799) 801		4	2+84		5	796	+5%	799 801	100		799	
+25	805	—		3+30		2	801	+5%	805				

those cross sections where the ground line slope is steeper than the design fill slope. Those locations will require full bench sections design.

VII. Refer to the horizontal plan of the "P" line and the ROAD DESIGN FORM. Use the offsets recorded in the column TRIAL OFFSETS and plot these distances on the cross section lines on the plan drawing. When this is completed, if these points were connected, a minimum earthwork roadway would have been aligned. It is unlikely, however, that such an alignment would result in a smooth continuous curve or in any tangents.

A horizontal alignment that will fit both the offsets and the design criteria can now be designed. The horizontal alignment of a roadway should, of course, provide as direct a route as possible. The design should also provide for an alignment that fits the contours of the terrain as much as possible to eliminate earthwork.

The designer is often cautioned to avoid the use of the tightest curve for a given design speed, i.e., the maximum degree of curvature, or the minimum radius of curvature, avoid broken back curves, compound curves, reverse curves, and abrupt changes in the alignment. These considerations are both correct and valuable. However, for the low volume, low standard roadway, these considerations often must give way to the more pragmatic considerations of limited impact, and minimum cost. The designer's judgment is stretched to the limit, at times, in the decision making process.

The horizontal design must taken into consideration termainals, future expansion, intersections, the logging and transportation plans, and the vertical alignment.

Using a compass, radius guide, circle template, and a straight edge, lay in an alignment that satisfies the specified criteria for the horizontal alignment design. Along this alignment take into account the location of turnouts, culverts and drainage installations, both surface and subsurface, and all existing horizontal control points. One method for expediting the horizontal layout procedure is to draw straight line through the various tangent sections that exist on the plan. The points where these tangents intersect become the "PI's" for the "L" line. The exact location of these PI's can be either scaled off of the plan or designated at the nearest 10 foot coordinate line.

VIII. To insure that the horizontal and vertical alignments are well coordinated, it is advisable at this stage to prepare a profile of the proposed or "Trial" alignment or "L" line. Since the proposed alignment has been moved off of the "P" line, that profile is no longer valid.

In order to prepare the trial "L" line profile, it is necessary to determine the new stationing of the "L" line. Because the cross sections are the only source of the profile information, the designer must determine the "L" line station at each "P" line cross section.

Starting at the beginning of the design zone, scale along the center-line to determine the stationing of the "L" line. Because of the trial nature of the design at this point, it is acceptable to simply scale around the curves to determine the stationing.

Where the "L" line intersects a cross section, the "L" line stationing should be recorded, in pencil, on the ROAD DESIGN FORM opposite the "P" line stationing for that cross section. See item D on the form.

Although the offset from the "P" line to a possible "L" line was recorded earlier, it may no longer be valid. If the proposed "L" line alignment passes through the tic mark set off from the "P" line, the distance recorded in the column titled TRIAL OFFSET can be re-recorded in the column titled OFFSET. See item E. If, on the other hand, the proposed line does not go through the tic mark scale, the new offset distance from the "P" line and record that distance in the OFFSET column.

Referring to the cross section sheets, determine the ground line elevation under the "L" line centerline mark. Record this elevation under the appropriate column on the ROAD DESIGN FORM. See item F.

Using the "L" line stations and the ground line information, plot the "L" line profile. Since this line may be subject to adjustments, it should be drawn in pencil.

The designer now must superimpose the trial design grade and the vertical alignment upon the revised "L" line profile to determine if the horizontal adjustments that were made have a significant effect on the design. If significant problems have been introduced as a result of the trial design, the designer must attempt another trial design over the zone in question. Experience has shown that most neophyte designers complete a satisfactory design in no more than two cycles. Experienced designers usually have completed the vertical alignment at this stage.

If no significant problems have been introduced into the design, the designer is ready to prepare preliminary earthwork computations and a trial mass diagram. We will return to these topics after reviewing the other alternative to vertical control.