VERTICAL CURVES

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SUBJECT. A practical and quick way to design lengths of crest vertical curves and sag vertical curves.

I. Length of Crest Vertical Curves.

A- When S<L.

According to Thomas F. Hickerson, when we are in stopping conditions :

$$L = \frac{S^2 A}{1400} = \frac{160^2 A}{1400} = 18.29\,A \quad 18.3\,A$$

Assume :

- Design speed = 25 MPH
- Perception - reaction time = 2.5 sec.
- Height of driver's eye = 3.75 ft.
- Height of roadway obstruction = 0.5 ft.
- Coefficien of friction f = 0.35
- Safe stopping distance = 160 ft.
- Level ground

When L = 160 ft. A = 8.74%
When A = 44% L = 805.2 ft.

From those limits we can draw diagram BC for length of crest vertical curve when S<L. Fig (1).

L = Length of crest vertical curve
A = Algebraic difference in grades in percent, absolute value

B- When S>L.

According to Thomas F. Hickerson, when we ara in stopping conditions

$$L = 2S - \frac{1400}{A}$$

Using the same assumption as in part (a) S = 160 ft, we have :

$$L = 320 - \frac{1400}{A} \quad (2)$$

When A = 4.38% A = 8.75%
L = 0 L = 160 ft

From equation (2), we draw a "diagram" DB for length of crest vertical curve S>L. Now we have a complete diagram of length of crest vertical via A: Algebraic difference in grades in percent % (absolute value) on Fig,

* Now it's the quick way to find the length of the crest vertical curve

Example. We have a section of street of having a profile with a grade break with algebraic difference A = 15%, find the length of the appropriate crest vertical curve.

From A = 15 draw a vertical line to meet the diagram at point I, from I draw a horizontal line to meet ordinate L = length of crest vertical curve.
L = 274.5 ft. $\simeq$ 280. ft.
We usually round the length of vertical curb up to the nearest ten for practical point of view of road construction.
One of the advantages of this method of design is when we get an algebraic difference of grades A, we use the diagram to find directly the length of of vertical curve, and we don't need to check back and compare with the length of stopping sight distance. That means we save a lot of time especially for a big project involving a lot of grade breaks and vertical curves.

II. Length of Sag Vertical Curve.

A- When S<L.

The head light is assumed 2.0 ft. above the roadway and the light beam has an upward angle of 1° with the horizontal.

According to Thomas Hickerson :

$$L = \frac{S^2 A}{400 + 3.5\,S}$$

With S = 160 ft. $L = 26.67\,A \cong 26.7\,A$ (3)

When A = 6% L = 160 ft.

A = 44% L = 1174.8 ft.

From those two limit values we draw the chart BC for the sag vertical curve when S<L. Fig. (2).

B- When S>L.

$$L = 2S - \frac{400 + 3.5\,S}{A}$$

For S = 160 ft. $L = 320 - \frac{960}{A}$ (4)

When A = 3% L = 0

A = 6% L = 160 ft.

From equation (4) we draw the chart DB for the sag vertical curve when S>L. Fig. (2).

C- The Comfort Sag Vertical Curve.

The comfort effect of change in vertical direction is more pronounced in "sag" than in "crest" vertical curve because gravitational and centrifugal forces are combining forces in this case - AASHTO states that riding is comfortable on sag vertical curves when the centripetal acceleration does'nt exceed 1.ft/sec^2.

According to Thomas Hickerson : $L = \frac{V^2 A}{46.5}$ V = 25 MPH

$L = 13.44\,A \cong 13.5\,A$ (5)

This is the lower limit length of sag vertical curve which should be used whenever we have constraints in design and existing conditions of the terrain that do not allow us to obtain the correct lengths of sag vertical curves in (a) and (b).

For a small grade break such as A = 3%

L = 13.5 X 3 = 40.5 ft. Take L = 40 ft.

M.O. = LA/800 = 40 X 3/800 = 0.15<0.2 not good.

A = 3.5% L = 13.5 X 3.5 = 47.25 ft. Take L = 50 ft.

M.O. = 50 X 3.5/800 = 0.22>0.2 OK.

A = 44% L = 594 ft.

From equation (5) we can draw diagram EF for the comfort sag vertical curve. Fig.

Now it is the quick way to find the length of sag vertical curve.

Example. We have a section of street having a profile with a grade break that its algebraic difference A = 20%, find the length of the appropriate vertical sag vertical curve.

From A = 20, draw a vertical line to meet the diagram DBC Fig. 2 at point I, from I draw a horizontal line to meet the ordinate at L = 534 ft. Take L = 540 ft. = length of sag vertical curve.

If the existing terrain condition does not permit us to build 540 ft. sag vertical curve, we will use "comfort sag vertical curve" diagram and L = 268 ft. Take L = 270 ft. (or L 270 ft.) wherever possible.

Comment. From equation (3) and (5) which are $L_1 = 26.7\,A$ and $L_2 = 13.5\,A$

$L_1/L_2 = 26.7/13.5 = 1.98 \cong 2$. $L_1 \cong 2L_2$

So when S<L (A≥6%) the comfort sag vertical curve is equal to one half of the normal sag vertical curve.

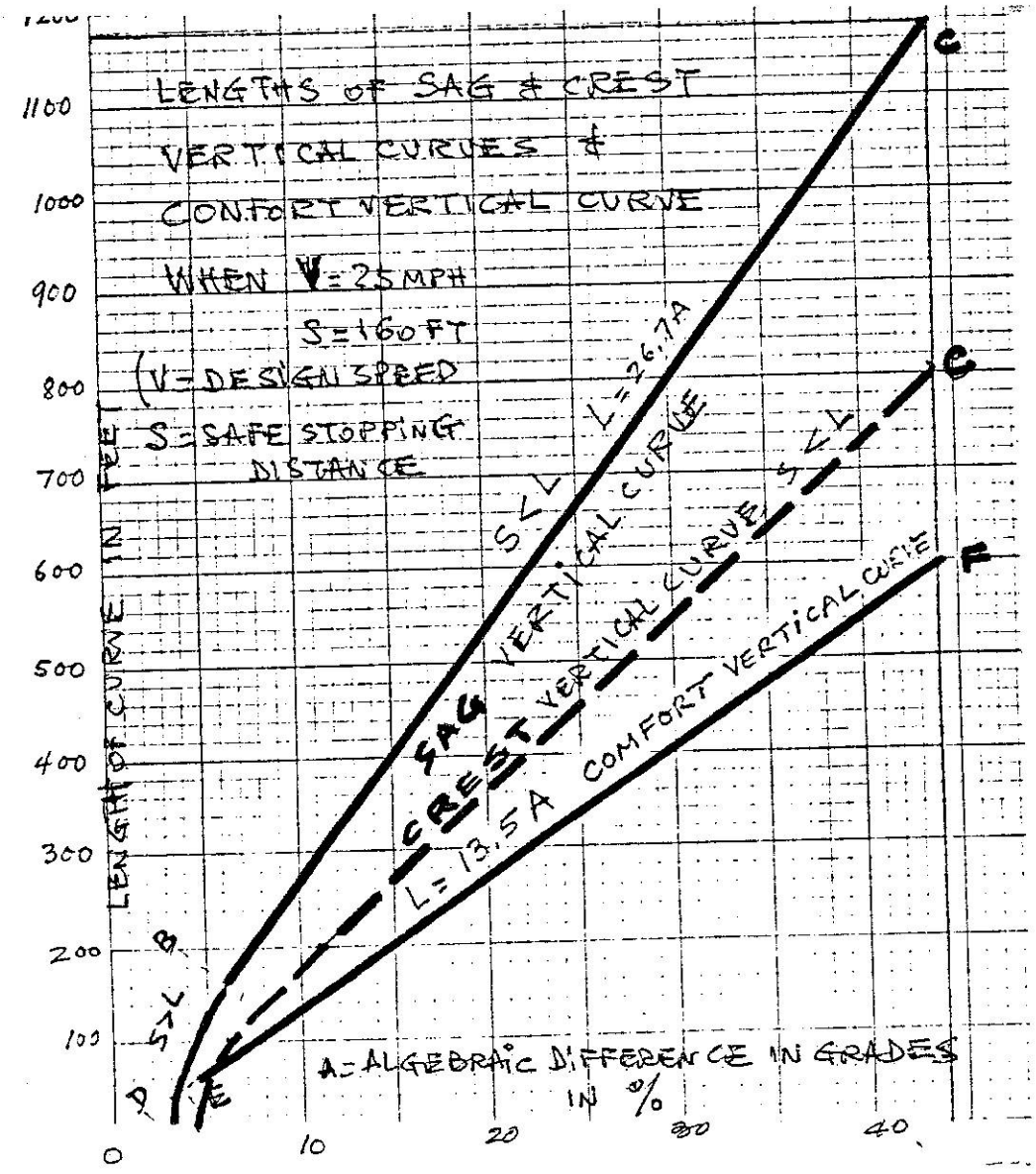
Using the same method, we can develop the diagrams for lengths of

vertical curves on roads with different design speeds and different safe stopping distances.

But there are some exceptions that the designer ought to know when determining the vertical curve lengths are :

- The above procedure shall not apply when designing curb returns, cul-de-sacs or where the profile does not represent the primary roadway alignment.
- No vertical curve shall be designed to yield a middle ordinate of less than 0.2 ft. for practical point of view of road construction.

We hope that those figures will help the designers of the City to save time, energy and feel more confident when designing the vertical curves.



TIN TAI NẠN.

Chúng tôi vừa được tin Anh TRẦN-HỮU-LAI (Saigon T.C.) đã bị tai nạn xe hỏi trong lúc đang lái xe trên xa-lộ ở Los Angeles, vào khoảng trưng tuần tháng 10 vừa qua.

Sau khi xảy ra tai nạn, xe bị lật và bốc cháy, cửa xe bị kẹt không mở được, nhờ có 1 người Mỹ dừng lại đập bể kiếng cứu anh cùng 3 đứa con ra khỏi xe. Hiện cả 4 cha con Anh Lai đang điều-trị tại phòng cấp cứu bệnh viện vì phỏng nặng trên 50%. Chị Lại ở nhà và đang ở trong tình trạng bấn loạn tinh thần.

Cầu chúc Anh Lai và 3 cháu sớm bình phục. Mong các bạn AHCC ở vùng Los-Angeles theo dõi giúp đỡ Chi Lai và thông-báo tin tức cho LTAHCC. (XEM TIẾP TRANG 94)