Horizontal Sight Distance Considerations in Freeway and Interchange Reconstruction

JOEL P. LEISCH

With improvements being made to freeways and expressways, the problem of inadequate stopping sight distance on curves accompanying installation of a concrete barrier may arise. This could also occur when lanes are added in the median of a freeway or expressway and a narrow median results. It also may become a problem on curved ramps on structures where the parapet may not be offset sufficiently from the traveled-way. One solution to the problem for freeway medians is to provide a wider shoulder (greater offset to barrier) for the traveled-way turning to the left. Where a constant median width exists, the left shoulder for the opposing direction is, of course, narrowed. When a ramp is on a structure (bridge or retaining wall) and there is a curve to the left, the traveled-way can be shifted to the right, providing a wider left shoulder for sight distance and breakdown. The right shoulder would then be narrowed, preferably to not less than 4 ft. It must be kept in mind that stopping sight distance is only one of many design and operational considerations in planning an improvement. There certainly can be trade-offs with other features and the potential influence on accident experience. Further study is needed to ascertain the optimum dimensions of all cross-sectional elements to best satisfy safety, operational, and design requirements.

As improvements are made to freeways and expressways, the problem of inadequate stopping sight distance on curves accompanying the installation of a concrete barrier may arise. This could also occur when lanes are added in the median of a freeway or expressway and a narrow median results. It also may become a problem on curved ramps on structures where the parapet may not be offset sufficiently from the traveled-way.

Many designers are not aware of these possible situations (combination of curvature and shoulder width), which may not only occur where shoulder width is less than 10 ft but in some cases can become a problem when a full shoulder is provided. Figure 1 [taken from Figure III-25A of AASHTO's 1984 Green Book (*1*)] clearly shows that when the curvature exceeds approximately 50–70 percent of the maximum curve for a specific design speed and there is a 10-ft shoulder, stopping sight distance for that design speed is not provided. This also holds true for a curve to the right where a barrier or parapet is placed adjacent to the right shoulder.

How can a designer deal with these situations or with the preparation of a design with constrained conditions? Presented here are examples of the situations mentioned above

Jack E. Leisch & Associates, 1603 Orrington Ave., Suite 1200, Evanston, Ill. 60201.

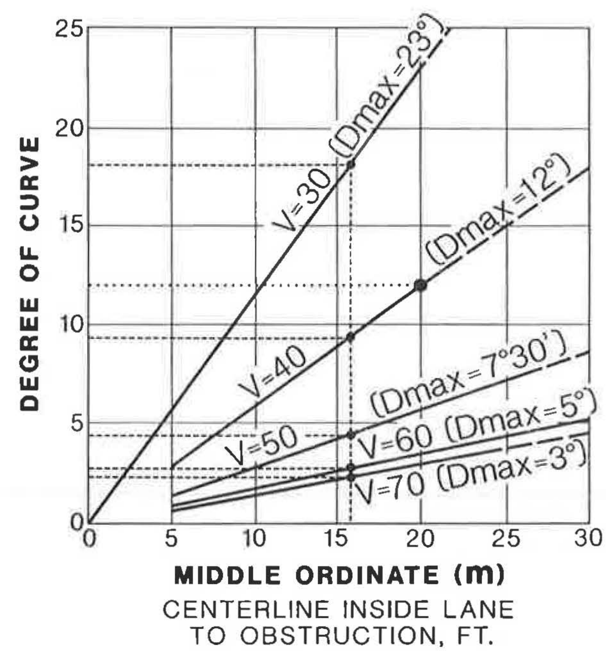


FIGURE 1 Curvature and middle ordinate relationships for lower values of stopping sight distance.

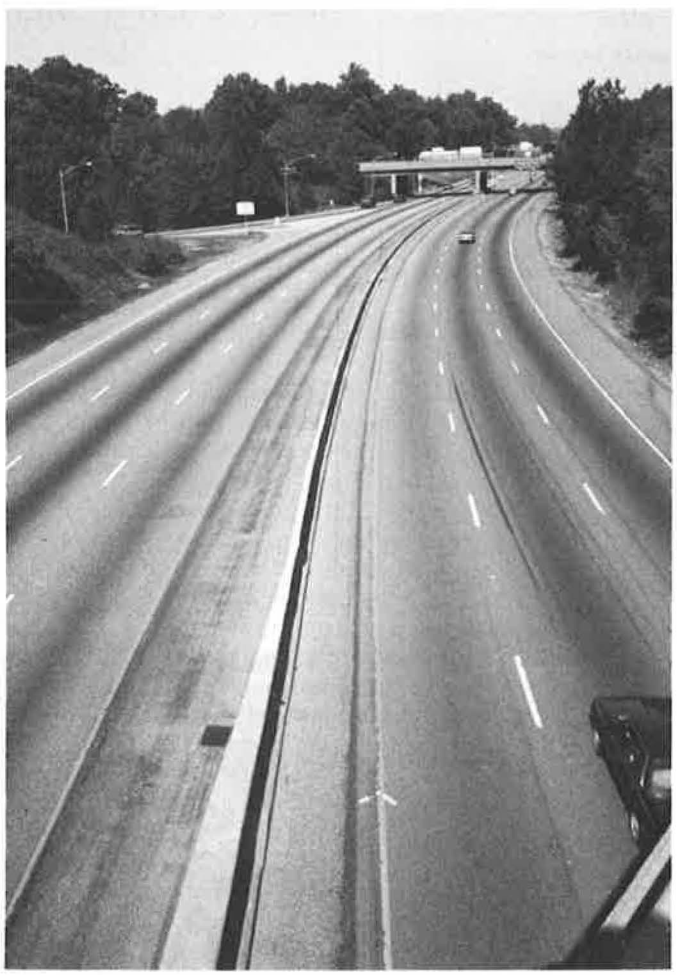
and sample solutions. In addition, two examples from the field are shown and the applied solutions described.

FREEWAY MEDIAN

The median barrier often restricts sight distance, as previously mentioned, even when a 10-ft shoulder is provided where the curve exceeds 2 degrees for a 70 mph design and 2.5 degrees for a 60 mph design. The maximum curvatures are approximately 3 degrees and 5 degrees, respectively, for 70 mph and 60 mph design speeds using a .08 ft/ft maximum superelevation. Consequently, numerous situations may already exist in urban areas where there is inadequate stopping sight distance. Where medians are narrower than 22–24 ft, the problem may occur more frequently.

One solution to this potential problem is to provide a wider shoulder (greater offset to barrier) for the traveled-way turning to the left. Where a constant median width exists, the left shoulder for the opposing direction is, of course, narrowed. It would not, however, be advisable to reduce this shoulder to less than 6 ft. Figure 2 shows this solution.

SHIFTED MEDIAN
BARRIER—FROM
DRIVER'S
PERSPECTIVE



SHIFTED MEDIAN
BARRIER AT THE
END OF THE CURVE
FROM ABOVE

FIGURE 2 Shifted median barrier—two views.

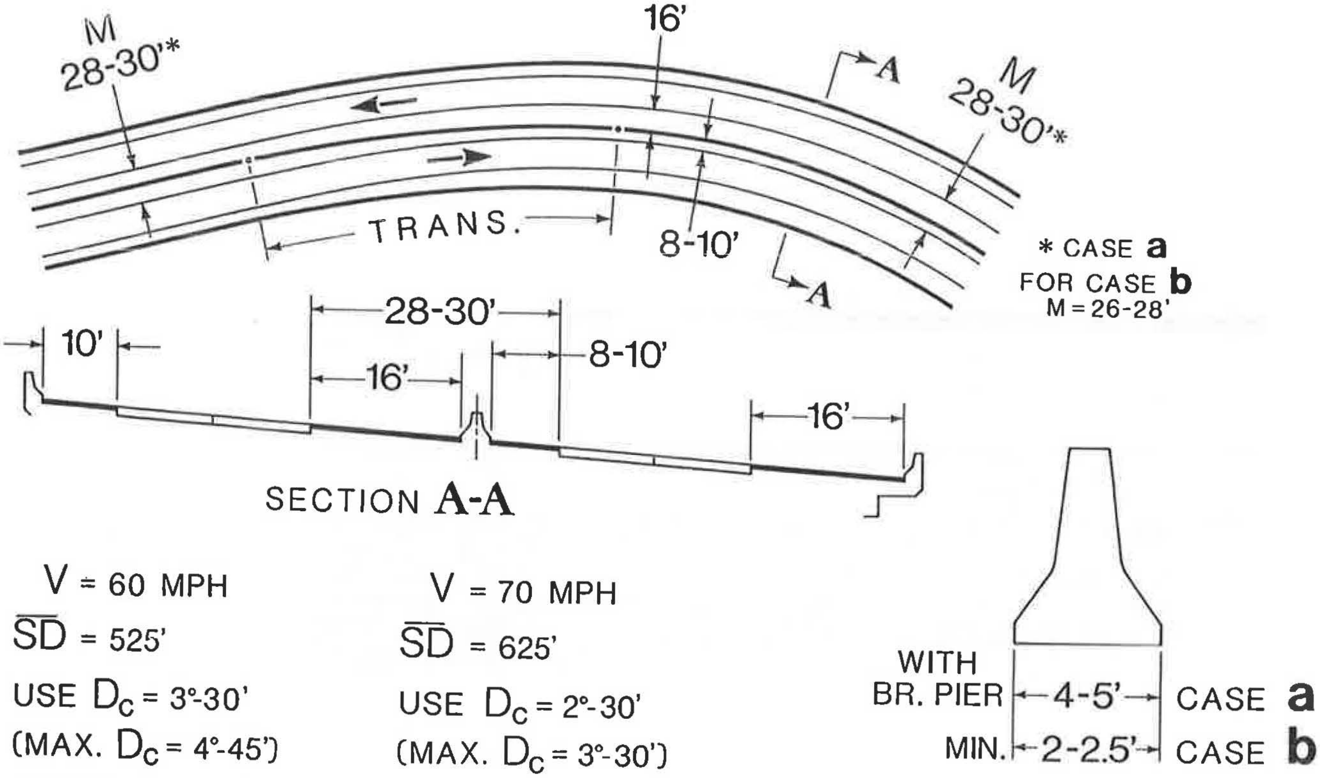


FIGURE 3 An example of freeway sight distance with a median barrier.

This design resulted from the addition of a median-side lane in each direction of travel. The median became 20 ft in width as a result of the widening. Through this curve (shown in Figure 2) the shoulder is 11 ft for the traveled-way curving to the left, and a 7-ft shoulder is provided for the opposing roadway. This solution provides adequate stopping sight distance for the critical direction of travel. The 7-ft shoulder for the opposing direction, while not a full shoulder, would provide a partial refuge for a stalled vehicle with minimal influence on vehicles operating in the left lane.

Utilizing the concept as implemented in the field and described above, two examples are presented below. These examples fully comply with the guidelines for sight distance and shoulder width presented in the AASHTO Policy for new design or major reconstruction projects (refer to Figure 3).

Both examples are for median widths of 26 to 30 ft. One is for a design speed of 60 mph and a curvature of 3.5 degrees and the other is for a design speed of 70 mph and a curvature of 2.5 degrees. The required offset to the face of the barrier from the edge of the traveled-way is 16 ft in both cases. Note that in the figure the barrier has been transitioned upon entry into the curve from its center position in the median to the necessary 16-ft offset through the curve. The resultant shoulder for the opposing traveled-way is 8 to 10 ft, depending on median and barrier width. It is also possible that stopping sight distance restrictions may occur on the right side of the freeway traveled-way on curves to the right when a barrier, parapet, or retaining wall is adjacent to the shoulder. This is also shown in Figure 3. As can be seen in the cross-section and plan view, the critical shoulder has been widened to 16 ft through the curve to provide for safe stopping sight distance.

RAMPS ON A STRUCTURE OR RETAINING WALL

Ramps can also have sight distance problems on curves when the ramp is on a bridge or adjacent to a retaining wall. As with the mainline traveled-way, this can occur on curves both to the left and to the right.

Referring to Figure 1, it can be seen that for a ramp with a 40 mph design speed and a maximum curvature of 12 degrees, a midordinate offset to the barrier is 20 ft from the center of the lane. Using a 10-ft ramp traveled-way, the offset from the edge of traveled-way to obstruction, barrier, or retaining wall is 12 ft. Most agencies presently use a 10-ft right shoulder on the right—this is inadequate for the conditions described above for a curve to the right. The 10-ft shoulder would be adequate for an 11 degree curve and a 40 mph design speed.

With a curve to the left (40 mph design speed), the typical 2-ft, 4-ft, or 6-ft left shoulder on a ramp would permit curves of approximately 6, 7, and 8 degrees, respectively, to provide for stopping sight distance. The left curve and the narrower left shoulder would apparently become critical in more cases than the right-curve, right-shoulder condition. With existing ramps or ramps to be constructed where this sight distance restriction already exists or might occur, a relatively simple solution may be effective. Shifting the ramp traveled-way to the left or right within the total pavement width could produce

FIGURE 4 Curve to the left and ramp traveled-way shifted right.

the desired offset to the obstruction, parapet, or retaining wall. An example of this is shown in Figure 4. In this actual situation, the 28-ft parapet-to-parapet width has been used to achieve safe stopping sight for this left-turning ramp onto a bridge. As can be seen, the left shoulder is 10 ft and the right shoulder is 2 ft. This was accomplished by restriping the pavement edges through the curve to produce the adequate offset to the parapet. An important feature of the design solution is that a shoulder or refuge area is still provided. This solution can be easily accomplished on existing ramps with adequate total width and can be considered on new interchange ramps as well.

Figures 5 and 6 show possible solutions for curves to the left and right. The first of these (curve to the left) is a ramp with a 40 mph design and a total width of 30 ft. The left curve is 9.5 degrees, resulting in an 8-ft offset to the parapet. As can be seen, the 16-ft traveled-way is transitioned 4 ft to the right to provide this offset.

Figure 6 illustrates a curve to the right where the ramp, with a 40 mph design speed and a 12 degree curve, requires a 12-ft shoulder or offset to the parapet or barrier. In this case, the traveled-way is transitioned 2 ft left upon entering the curve to produce the desired offset.

The above solutions, as in the actual cases illustrated, are simple to accomplish. Other types of solutions are also possible, which may include widening the total pavement and bridge width if full shoulders are to be maintained both left and right. The conditions, however, should be analyzed, and in each case an appropriate design should be selected.

OTHER CONSIDERATIONS

It must be kept in mind that stopping sight distance is only one of many design and operational considerations in planning an improvement. There certainly can be trade-offs with other features and the potential influence on accident experience.

One geometric consideration that has not been fully investigated relates to sight distance over the concrete barrier in a sag vertical curve in combination with a horizontal curve. There are instances where the driver is afforded safe stopping sight distance, depending on the combination and coordination of horizontal and vertical curvature.

In the areas of operations and safety, there are several matters that should be explored. The first of these relates to the narrowing of the left shoulder on the median side of the freeway on the outside of the curve. This has several potential safety ramifications. One is perhaps an inadequate breakdown area; the second is associated with the reduced lateral clearance to the barrier on the outside of the curve. There may be an optimum dimension that could provide stopping sight distance and not sacrifice other safety features.

It is also appropriate to consider the reduction of the right shoulder on a ramp and the increase in left shoulder width for a curve to the left. A breakdown (disabled vehicle) normally moves to the right shoulder on a ramp. In the case cited above, the left shoulder would provide refuge. Nevertheless, it is the total ramp width (parapet to parapet) that is important in allowing a vehicle to pass a stalled vehicle. Research would be helpful in resolving this issue.

SUMMARY

The highway designer must be made aware of the potential sight distance restrictions on curves of freeways and ramps where a barrier or parapet is present. For many existing situations and for new configurations currently being designed, the solution may be simple. Additional alternatives could be

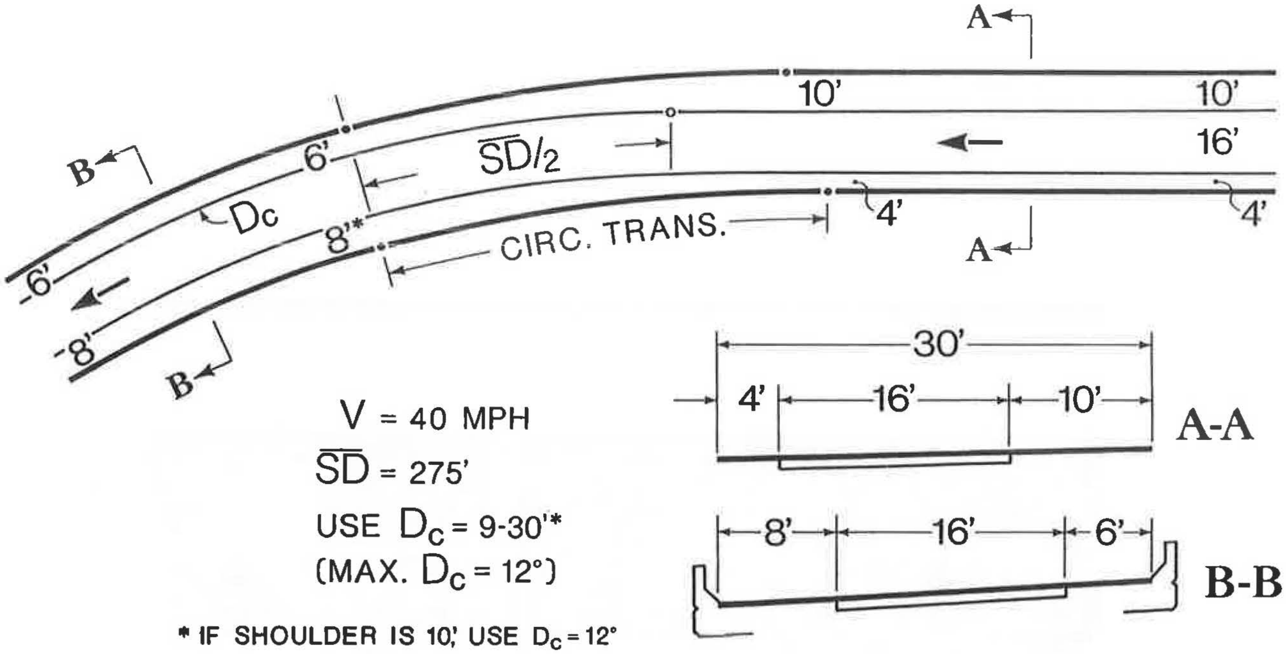


FIGURE 5 An example of provision for sight distance on a ramp with a barrier and a curve left.

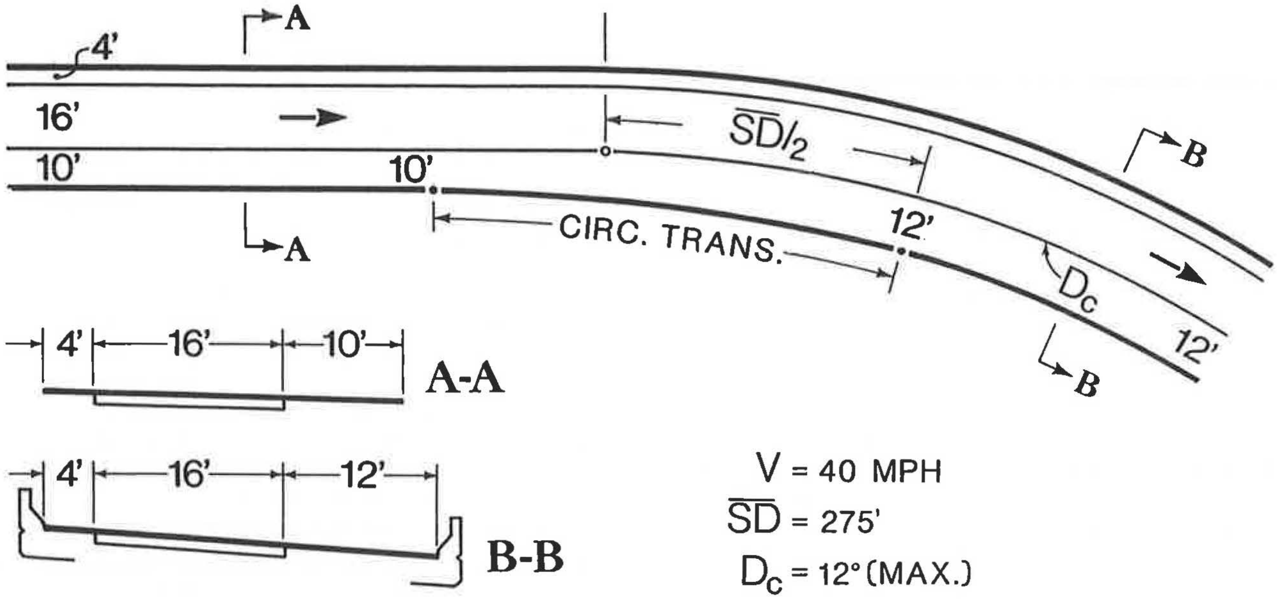


FIGURE 6 An example of provision for sight distance on a ramp with a barrier and a curve right.

developed and analyzed for specific site conditions. Some example solutions for the freeway proper and freeway ramps are presented here for consideration. Other solutions should be documented, based on experience, to assist the engineer in achieving the most cost-effective design for a given set of conditions. Additional research may be required to provide the designer with adequate information concerning trade-offs in design and operational criteria to assure that the optimum design is being achieved.

REFERENCE

1. *A Policy on Geometric Design of Highways and Streets.* AASHTO, Washington, D. C., 1984.

Publication of this paper sponsored by Committee on Geometric Design and Committee on Operational Effects of Geometrics.