Treatment of Roadside Hazards—Decision and Design

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An attempt is made to systematize the identification, priority ranking, and treatment of roadside hazards, those side-of-the-road features and appurtenances that by nature and location make the severity of collisions higher than necessary. A consideration of the effect of roadway geometrics and the nature and location of the hazard permits the identification of objects as hazards to be made in a straightforward manner. A priority-of-treatment rating system is introduced, and it too is based on the relative importance ascribed to each of the characteritics relating to the hazard. A number of typical designs are included, based on materials and devices currently available, for the treatment of hazard conditions on urban expressways.

•THE HANDBOOK of Highway Safety Design and Operating Practices recently released by the U. S. Department of Transportation (1) does not go far enough to be of use to the highway designer or the traffic engineer. Engineers apply science, and the material of science must be in a form for ready application. This handbook provides little but photographs and dimensionless sketches. Although it may be true that supervisory engineers are capable of exercising the judgment that the handbook requires, it is not usually the supervising engineer who designs and prepares drawings of the protective measures. What is needed in this area, which includes the upgrading of existing highways and the application of safety design principles to those not yet built, is an overall point of view and a systematic method.

If it is assumed that the roadside object need be there in the first place, we may start from the point of view of protecting the motorist from the effects of a one-car collision (in the past, formidable installations, still extant, have been used to protect a lamppost or a sign support). In the highway's design stage, of course, the viewpoint should be directed toward reducing the number of fixed objects and removing them from the vicinity of the traveled way as follows:

1. Reduce the number of fixed objects
   a. Place signs that must be in the median back-to-back wherever possible.
   b. Consolidate signs and remove unnecessary signposts.
   c. Combine signs and light poles where possible.
   d. Utilize existing structures for posting signs.
   e. Use sign bridges where possible rather than gore signs.
2. Reduce exposure to fixed objects
   a. Reduce exposure to total traffic by placing signs and light poles on the right side of pavements rather than in the median or gore areas if feasible.
   b. Use sign bridges where possible rather than gore signs.

On the other hand, if fixed objects are to remain or be placed by necessity where they constitute hazards, then their hazards should be minimized as follows:

3. Minimize the hazards of fixed objects
   a. Provide guardrail in front of those objects.
   b. Use other devices such as prows and energy-absorbing devices wherever guardrail is not suitable.
   c. Use breakaway sign supports and light poles.

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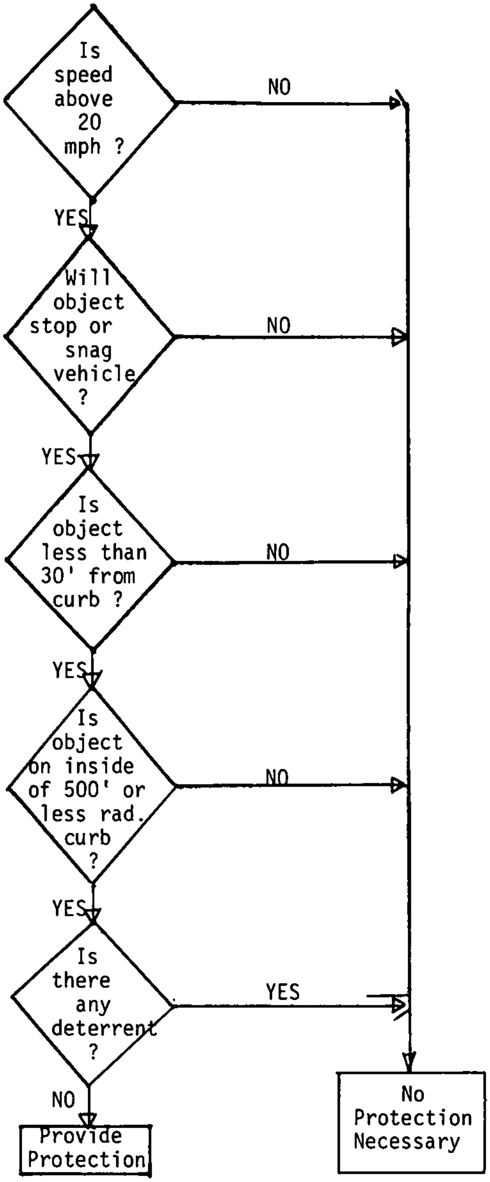

Figure 1. Process to determine whether protection should be provided for roadside hazards.

But what constitutes a hazard? We need to consider the following:

1. Speed of vehicle. Protection of vehicles and drivers should be provided against all roadside objects when the criteria discussed in later sections are met and where speed of travel is greater than 20 mph. If the vehicle is traveling faster than 20 mph and strikes a rigid object, it will be considered to have been in a serious accident (2).

2. Features of the roadside objects. Concrete piers or abutments, ends of walls, heavy sign supports and foundations, light towers, large trees, rock outcroppings, or any other rigid object that would cause a vehicle striking the object to be stopped or snagged are considered to be hazardous. Some objects, such as breakaway sign supports and aluminum lampposts (unless set in a high concrete base), do not warrant protection because studies have shown that protecting vehicles from these devices does not reduce accident severity.

3. Location of the roadside object. Any object 30 ft behind the curb line is not considered to be hazardous. This can be reduced to the distance necessary to provide one second of perception-reaction time, based on roadway speed and the maximum angle of impact for the road condition. This distance should permit about 80 percent recovery by drivers of vehicles out of control (1). On tangent alignment, objects on either side of the road are considered to be equally hazardous. When a motorist is negotiating a curve, objects on the outside of the curve are more hazardous than those on the inside of the curve, because there is a greater possibility of undercorrecting with the steering wheel than of overcorrecting and because of the possibility of skidding (3). A radius of 500 ft or less is considered sharp enough so that any object on the inside of the curve does not require protection. (This only applies to objects more than 100 ft past the point of curvature.) The 500-ft radius is chosen because it is recommended by the American Association of State Highway Officials as being the minimum radius for which pavement widening is not required.

4. Deterrents. Deterrents include natural topography of the ground as the object is approached; walls such as abutments and piers that are continuous and do not expose any sharp corners to passing vehicles; and any object near the roadside hazard, such as light poles and signposts, that will be hit before the out-of-control vehicle hits the roadside hazard, will break away, and will reduce the speed of the vehicle. Whether or not any deterrent eliminates the necessity for protective measurements should be based on sound engineering judgment.

A summary of these considerations is shown in Figure 1.

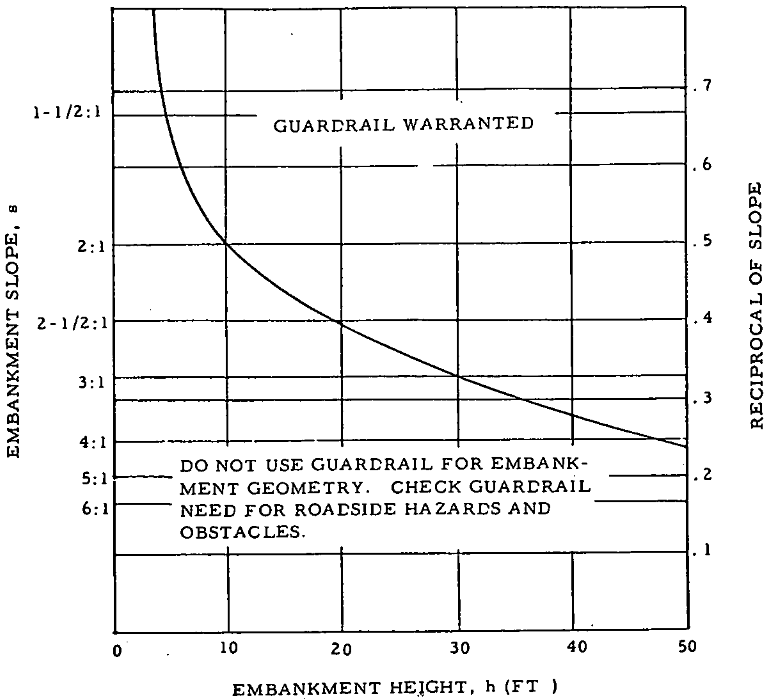

Figure 2. Guardrail requirements based on embankment geometry.

There has been no mention of two hazards—roadways on embankment and divided highways with narrow medians—because these conditions have been covered elsewhere (4, 5). Figure 2 shows guardrail requirements in relationship to embankment geometry (4, p. 3). Guardrails used in medians fall into two classifications: roads with constant-width median and roads with independent alignment. On roads with independent alignment the warrants for guardrails in the median are the same for guardrails on the right side of the roadway. Where the median is of a relatively constant width, the warrants are based on traffic volumes and median width. Table 1 gives the minimum and desirable standards for use in determining when a guardrail or other median dividers are required (5, p. 27).

Because money, time, and effort must be directed toward the worst conditions first, a method for determining priorities would be of value. Obviously, proper protection or further improvements would be undertaken first at those locations with high accident occurrence rates.

TABLE 1

STANDARDS FOR DETERMINING WHEN MEDIAN BARRIER IS NEEDED BASED ON ADT AND MEDIAN BARRIER WIDTH

Standard	ADT, thousands, for Median Width of			
	10 ft	20 ft	30 ft	40 ft[a]
Desirable				
Unfavorable conditions	10	20	30	—
Favorable conditions	15	30	45	—
Minimum	20	40	60	60

[a]Median barrier normally omitted when median width is 40 ft.

RATING METHODS FOR PRIORITY

The possibility of accidents involving roadside objects and the severity of such accidents are related to traffic volume, vehicle speed, distance from curb to object, alignment of the roadway, type of object, and deterrents such as topography between vehicle and object or such as another object that will break away, reduce the speed of the crashing vehicle, or reduce damage

TABLE 2

POINT SYSTEM

Points	Speed (mph)	Distance (ft)	ADT (thousands)	Horizontal Alignment (radius in ft)	Vertical Alignment (percent)
9	Over 60	0 to 3	Over 35	Over 1,100[a]	-8 or under
8	55 to 60	3 to 6	30 to 35	Over 1,100[a]	-6
7	50 to 55	6 to 9	25 to 30	Over 1,100[a]	-4
6	45 to 50	9 to 12	20 to 25	1,000 to 1,100[b]	-2
5	40 to 45	12 to 15	15 to 20	900 to 1,000[b]	0
4	35 to 40	15 to 18	10 to 15	800 to 900[b]	+2
3	30 to 35	18 to 21	5 to 10	700 to 800[b]	+4
2	25 to 30	21 to 24	2.5 to 5	600 to 700[b]	+6
1	20 to 25	Over 24	Under 2.5	500 to 600[b]	+8 or over

[a]8 points for all curvatures over 1,100 or for hazards outside this curvature.
[b]For hazards inside this curvature.

or injury. It is impractical to measure the degree of effect and the relative importance these factors have on the possibility and the severity of accidents. If arbitrary points are assigned to each class of factors, however, roadside objects can be rated according to the relative urgency for protection from them. The priority number indicates only that an object with a higher number is located in a relatively higher speed zone, is closer to the curb line, is on a flatter alignment or flatter area, and is exposed to more traffic. Because vehicle speed, traffic volume, and the location of hazard have been proved to some degree to be related directly to the frequency and severity of accidents (3), the point system for those three factors is assumed to be valid to a certain degree. Very little is known of the effect of horizontal and vertical alignments. The point method will at least differentiate some of the extreme conditions; however, it will not drastically change the effect of presumably important factors such as speed and exposed traffic volume because, for example, a 50-mph roadway usually does not have a 500-ft radius or an 8 percent grade.

Climatic conditions might also have some effect on the frequency and severity of accidents involving roadside hazards. However, it is not necessary to incorporate climatic conditions into the point system because the point system will be used to determine priorities for providing protection from roadside hazards within a limited area where climatic conditions are similar. The effect of an existing deterrent, man-made or natural, is not considered because there are too many different possible conditions. These effects can be judged by field engineers who are familiar with the conditions.

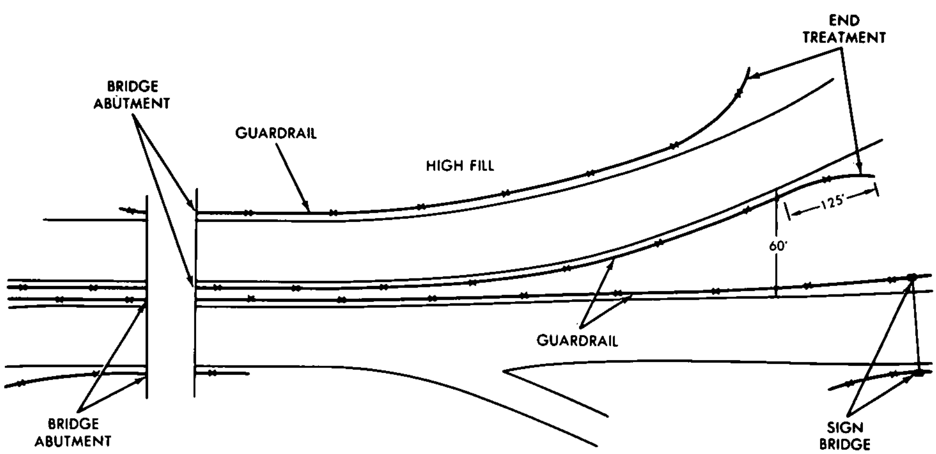

Figure 3. Typical guardrail installations.

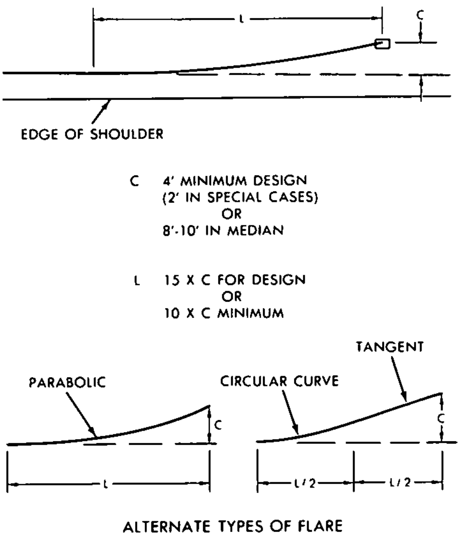

Figure 4. Standard introduction of guardrail, plan view.

If additional information were obtained, a cost-benefit index for the improvement could be developed and included in the point system. Table 2 gives the points for combinations of the factors included. The following example shows how the point system is used. An object, a concrete pier, is located 10 ft away from the curb in a 50-mph speed zone on a straight roadway with a 2 percent downgrade and an ADT of 27,000:

Factor	Points
Speed	7
Distance	6
Volume	7
Horizontal alignment	8
Vertical alignment	6
Total	34

Once it has been decided that protection is necessary, the proper kind of protective device should be chosen. These are discussed in the next section.

INTRODUCTION OF GUARDRAIL

A typical guardrail installation is shown in Figure 3. The guardrail should begin in such a manner that the end facing approaching traffic is not a hazard. The end should be flared to offset it further from the roadway as shown in Figure 4. The end

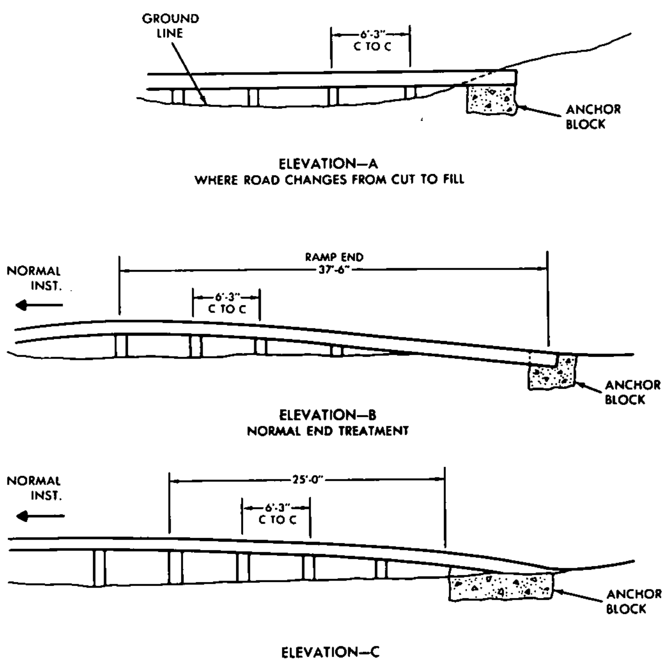

Figure 5. Standard introduction of guardrail, elevation view.

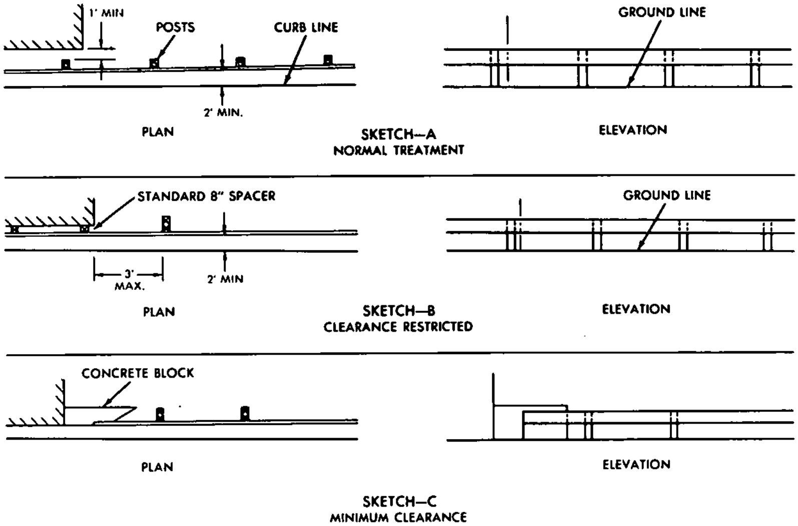

Figure 6. Guardrail installation at abutments and piers.

sections should also be sloped to provide additional safety to vehicles striking it and anchored to give stability to the adjoining sections. The guardrail should begin 125 ft in advance of the point where it is needed. In special cases where speeds are low, this can be reduced to 75 ft.

The end of the rail should be anchored and buried. In Figure 5, elevation A shows the treatment when the natural ground slope permits the rail to have continuous vertical alignment. Under normal conditions, elevation B would be the desired end treatment. Elevation C shows the treatment when excavation would be difficult. This is basically the same as elevation B, except that C requires a shallower excavation.

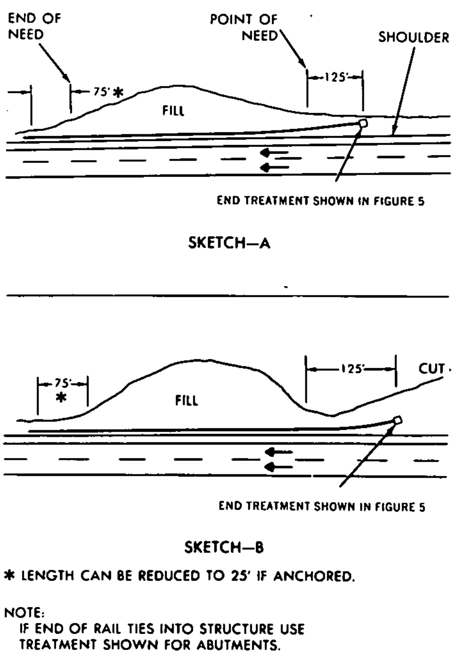

Figure 7. Guardrail installation at fills.

ABUTMENTS AND PIERS

The need for protection at bridge abutments is apparent. If bridge abutments and piers are far enough from the roadway, the most desirable treatment is to run the guardrail past the abutment or pier, keeping the back of the post at least 1 ft from it, as shown in sketch A of Figure 6. In areas where this is not possible, the next most desirable treatment is to anchor the spacers to the abutment wall as shown in sketch B. The spacers are needed to keep a vehicle from contacting the face of the abutment. In areas where the clearance does not permit carrying the rail with spacers past the face of the abutment, it is necessary to install a concrete block shaped to direct vehicles away from the wall as shown in sketch C.

FILLS

The need for a guardrail at fills is based on the nomograph in Figure 2. The guardrail

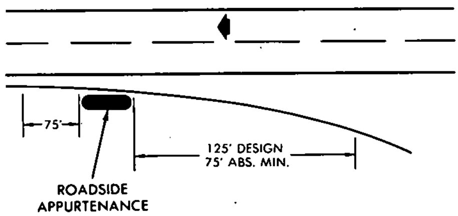

Figure 8. Guardrail between road and roadside appurtenances.

should begin 125 ft in advance of the point where it is first required and should extend at least 50 ft (preferably 75) past the point where it is no longer needed. This can be reduced to 25 ft if the end of the rail is anchored. Figure 7 shows typical installations. Sketch A shows the recommended treatment when the guardrail goes from a level section or low fill to a high fill where a guardrail is required. The treatment shown in sketch B is recommended when the transition is from a cut to a high fill.

ROADSIDE APPURTENANCES

Roadside appurtenances such as sign supports, light towers, or other objects that could be a hazard to out-of-control vehicles should be insulated from the active roadway. Figure 8 shows a typical guardrail installation for which the same standards apply as those at installations previously discussed.

ADDITIONAL DEVICES

Prows and Energy-Absorbing Devices

In addition to guardrail installations, a device is needed at nosings or points of divergence of two roadways. A protective device at such a location is warranted, however, only if the alternative is that a vehicle will strike a wall, or if there is a pronounced difference in elevation between the two diverging roadways. A prow should never be installed if there is an open area behind the nosing. In such a case, there is no justification for the existence of a sign, light standard, or any other installation at the point. Generally, prows are used where installation of guardrails is not feasible. The principle function of the prow is to deflect vehicles leaving roadways back to the roadways or to stop vehicles without severe damage or injury before they strike the roadside appurtenance. Some of the various types of energy-absorbing devices now being developed and tested may prove to be effective. Again, prows should never be

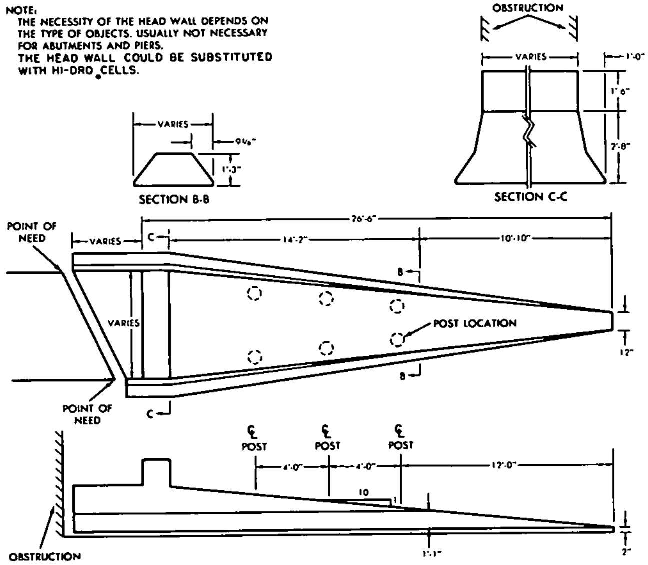

Figure 9. Standard prow.

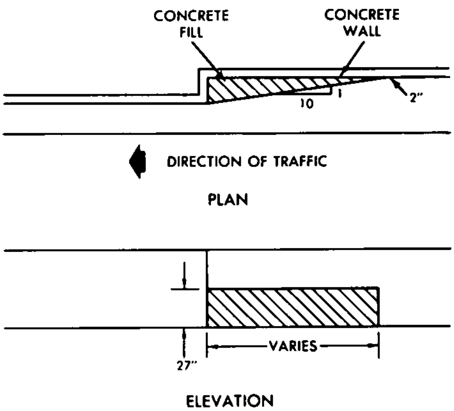

Figure 10. Typical installation of concrete fill.

designed to protect roadside appurtenances from colliding vehicles. The standard prow shown in Figure 9 can be modified for local field conditions in practical applications. Provision is made for the emplacement of energy-absorbing posts, whether wood, rubber, or metal.

Concrete Fill

Concrete fill is used to eliminate small openings or projections along concrete walls. A typical installation is shown in Figure 10.

SUMMARY

The need to avoid the mistakes of the past in highway design and the need for a thorough inspection of existing highway installations with a view to the elimination of dangerous or potentially dangerous situations are now recognized by highway engineers, governmental leaders, and the public. What is further needed is a systematic method for evaluating the potential danger, rating its need for correction, and applying the correct treatment. This paper attempts to take the first steps in meeting that need. After implementation, all of those recommended measures should be constantly evaluated and upgraded as accident records are studied and as new methods and materials are developed.

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