



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: April 21, 2004

In reply refer to: H-04-17

Mr. John Horsley
Executive Director
American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, DC 20001

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation, which addresses barrier design, is derived from the Safety Board's investigation of an April 4, 2002, accident involving a child care van in Memphis, Tennessee,¹ and is consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has reiterated 1 past recommendation and issued 10 new safety recommendations, 1 of which is addressed to the American Association of State Highway and Transportation Officials. Information supporting this recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendation.

On April 4, 2002, about 8:19 a.m., a 15-passenger Ford E-350 van, driven by a 27-year-old driver and transporting six children to school, was southbound in the left lane of Interstate 240 in Memphis, Tennessee. The van was owned and operated by Tippy Toes Learning Academy, a private child care center. A witness driving behind the van stated that the vehicle was traveling about 65 mph when it drifted from the left lane, across two other lanes, and off the right side of the roadway. She said that she did not see any brake lights. The van then overrode the guardrail and continued to travel along the dirt and grass embankment until the front of the van collided with the back of the guardrail and a light pole. The rear of the van rotated counterclockwise and the front and right side of the van struck the bridge abutment at the Person Avenue overpass before coming to rest. The driver was ejected through the windshield and sustained fatal injuries. Four of the children sustained fatal injuries, and two were seriously injured.

¹ For more information, read National Transportation Safety Board, *Fifteen-Passenger Child Care Van Run-off-Road Accident, Memphis, Tennessee, April 4, 2002*, Highway Accident Report NTSB/HAR-04/02 (Washington, DC: NTSB, 2004).

The Safety Board determined that the probable cause of this accident was the absence of oversight by Tippy Toes Learning Academy and the driver's inability to maintain control of his vehicle because he fell asleep, quite likely due to an undiagnosed sleep disorder; the driver's marijuana use may also have had a role in the accident. Contributing to the accident was the Tennessee Department of Human Services's lack of oversight of child care transportation. Contributing to the severity of the injuries were the use of a 15-passenger van to transport pupils, the nonuse of appropriate restraints, and the design of the roadside barrier system.

As the van departed the roadway in this accident, it drove over the top of the guardrail terminal and became trapped behind the guardrail. Because of the backslope, the guardrail at the accident location varied in height from 5 inches at the anchored-in-backslope terminal to 26 inches above ground 57 feet beyond the terminal. Yet, because of the backslope, the guardrail remained level to the pavement surface. This allowed the van to encroach on the barrier and easily mount it at its anchor point, ride over it, and continue along and behind the length of the barrier. The use of such a design resulted in a terminal configuration similar to a turned-down terminal, because of the reduction from the full barrier height to ground level. The Safety Board concludes that had the barrier system in place at the accident location not tapered into the backslope and had another type of barrier terminal been used, the van would not have been able to ride over the top of the barrier's longitudinal guardrail and would probably have been prevented from becoming trapped behind the guardrail and striking the bridge abutment.

While an anchored-in-backslope design can be effective, it is not a safe design for locations where design hazards exist along a steep backslope or a horizontal curve, as was true at the accident location. There, the anchored-in-backslope terminal essentially becomes a flared turned-down design, which is unsafe and no longer permitted because the turned-down design provides no protection to errant vehicles. As a result of these findings, the Safety Board is recommending that State Departments of Transportation identify guardrails with anchored-in-backslope terminals and eliminate any that create a situation similar to a turned-down terminal.

The roadside barrier at the accident site extended 160 feet from the bridge abutment. Based on a plot of the accident site, using the 21-foot clear zone and the 360-foot runout length recommended by AASHTO for design speeds of 55 mph,² the barrier's calculated length of need is 79 feet. As can be seen in figure 1, when the runout length is plotted, it actually intersects the roadway only 227 feet from the bridge abutment because of the roadway's curvature, so that the full 360 feet is not available for errant drivers to recover.

² American Association of State Highway and Transportation Officials, *Roadside Design Guide*, (Washington, DC: AASHTO, 1989), page 5-33.

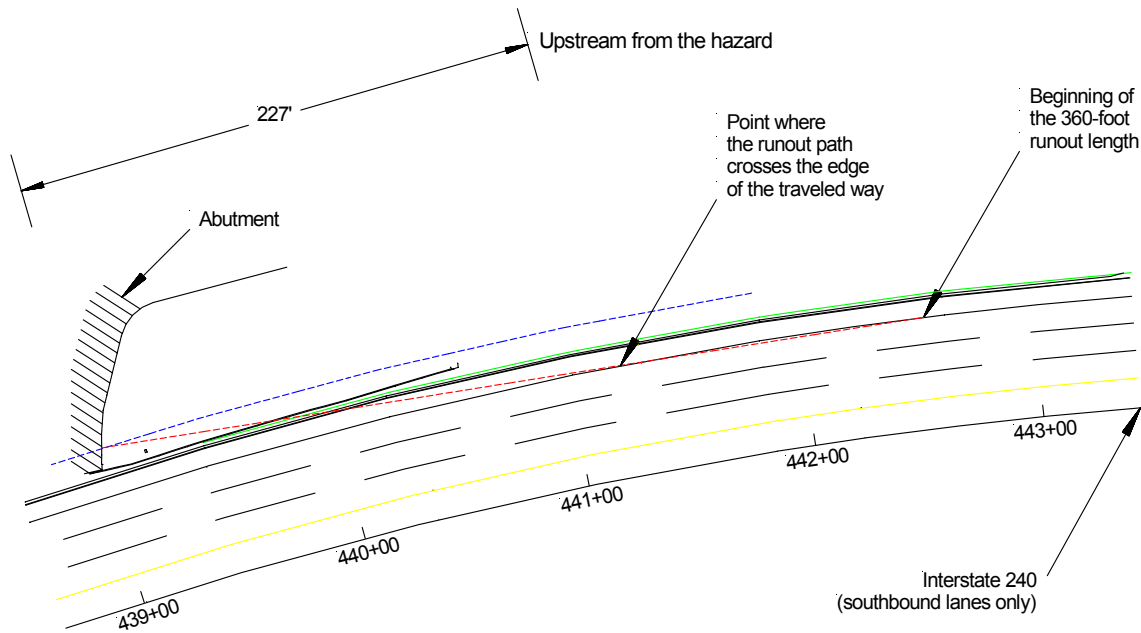


Figure 1. True runout length on curve.

Because of the horizontal curve before the bridge abutment, the length of need of the guardrail should be calculated to account for vehicles that leave the roadway tangent to the curve, as the accident vehicle did. Your organization states in one of its design examples³ that when a vehicle leaves the road on the outside of the curve (as in this accident), it generally follows a tangential path. In such cases, the tangent line from the curve to the clear zone or outside edge of the hazard should be used instead of the theoretical runout length.

Because of the curvature of the roadway, a vehicle can depart the roadway at a distance further from the hazard than that predicted by AASHTO's recommended runout length. When a vehicle "straightens out" the curve, it departs the roadway further from the hazard but still needs to be redirected or provide room to stop. When this occurs, the vehicle can completely miss the barrier system designed to protect against the hazard, as was the case in this accident and others. Memphis Police Department records indicate three fatal (including this accident) and two property damage accidents at the accident location between 1997 and 2002 in which vehicles became trapped behind the guardrail.

The steep grade of the backslope and the wall of the bridge abutment, when combined with the barrier, created a trap. Once trapped behind the barrier, even had the driver tried to steer to avoid striking the abutment, he would not have been able to return to the roadway because the van was trapped between the guardrail and the backslope, effectively directing the van into the bridge abutment. However, with sufficient stopping distance, a vehicle could stop before striking the bridge abutment. Thus, the runout length of the barrier also needs to take into consideration situations in which no clear zone is available to a driver who gets trapped behind the barrier.

³ AASHTO, *Roadside Design Guide*, page 5-39.

In the Safety Board's simulation of this accident, the driver would have had 1.8 seconds to try to bring the vehicle under control from the time he departed the roadway. This is insufficient time to stop a vehicle, and the slope does not allow the driver to steer away from the barrier. The simulation further predicted that a vehicle traveling at 65 mph in the left lane and continuing in a straight path tangent to the curve, instead of following the curvature of the roadway, would need at least 40 more feet of guardrail with the same end treatment, or 10 feet more with a different end treatment, to redirect the vehicle onto the roadway.

Using AASHTO's formulas and a runout length of 480 feet (based on the 85th percentile speed of 70 mph) and plotting the trajectory of a vehicle that leaves the roadway tangential to the curve, the barrier system's length of need is 293 feet, exceeding the existing barrier's length by 133 feet, not including the end treatment. (See figure 2.) By extending the barrier, the likelihood of an errant vehicle impacting the barrier system and being redirected away from the bridge abutment increases. For a driver trapped behind the barrier, the additional length would provide the opportunity to stop before colliding with the bridge abutment.

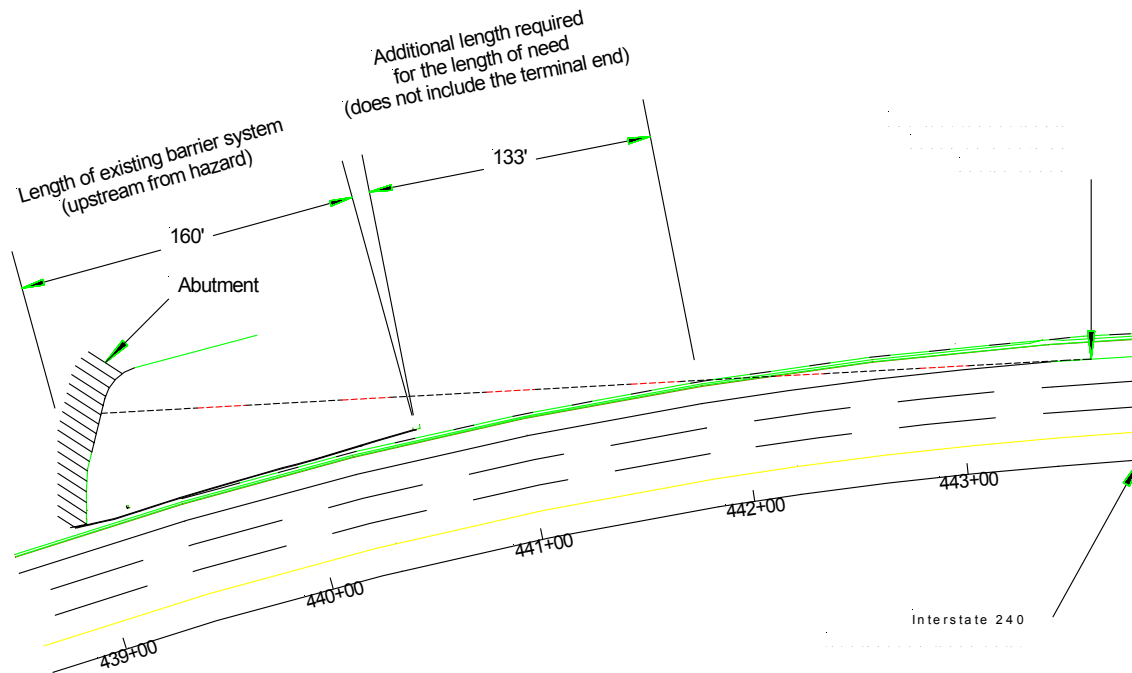


Figure 2. Length of need based on speed and roadway curvature.

The Safety Board concludes that given the roadway curvature and the lack of a clear zone, the barrier at the accident site was not long enough to prevent a vehicle that departed the roadway from going behind the barrier or to allow an errant vehicle to recover before striking the bridge abutment. AASHTO's *Roadside Design Guide* does not specifically address these types of situations or direct the highway designer to examine the need for longer runout lengths if the conditions could contribute to a vehicle becoming trapped behind the barrier or if the roadway curves.

The National Transportation Safety Board therefore recommends that the American Association of State Highway and Transportation Officials:

Modify the guidance contained in the *Roadside Design Guide* to clearly provide designers with information on the design of roadway barrier systems in situations where the roadway curves or where the terrain, hazards, and barrier system could trap an errant vehicle behind the barrier system. (H-04-17)

In addition, the Safety Board will ask AASHTO to inform its members of the circumstances of this accident and of the importance of considering roadway curvature and terrain configurations in the design of barrier systems.

The Safety Board also issued safety recommendations to the State and District of Columbia Departments of Transportation, the State and District of Columbia child care transportation oversight agencies, and the National Association for the Education of Young Children. In addition, the Safety Board reiterated a past recommendation to 39 States and the District of Columbia.

Please refer to Safety Recommendation H-04-17 in your reply. If you need additional information, you may call (202) 314-6177.

Chairman ENGLEMAN CONNERS, Vice Chairman ROSENKER, and Members GOGLIA, CARMODY, and HEALING concurred in this recommendation.

By: Ellen Engleman Connors
Chairman