Full-Scale Arrester Bed Testing Leads to More Cost-Effective Design

Truck escape ramps, or arrester beds, are a common vehicle safety feature on steep, sustained grades. Unfortunately, arrester beds are located typically in mountainous areas where construction is costly and site selection difficult.

Problem

The most common form of truck escape ramp is the gravel arrester bed, which slows vehicles by displacing the aggregate or gravel in the bed. The gravel imparts a rolling resistance to the vehicle motion, allowing a controlled deceleration and shorter stopping distance.

The effectiveness of an arrester bed depends principally on its geometry and aggregate characteristics. The main design considerations are the length and depth of the bed and the gradation and shape of the aggregate. Shape is important: the aggregate should be well rounded so that it can displace easily, allowing a vehicle to sink into the bed. Highly fractured aggregate tends to sustain a vehicle's weight, resulting in a lower rolling resistance.

Arrester beds are typically situated at locations where construction costs are high; thus, it is desirable to use aggregate with a very high rolling resistance to allow shorter bed lengths--which provides for sizable cost savings in areas where rock excavation or fills are required for construction.

The day-to-day maintenance of arrester beds may also affect their performance. The environment and traffic cause some arrester

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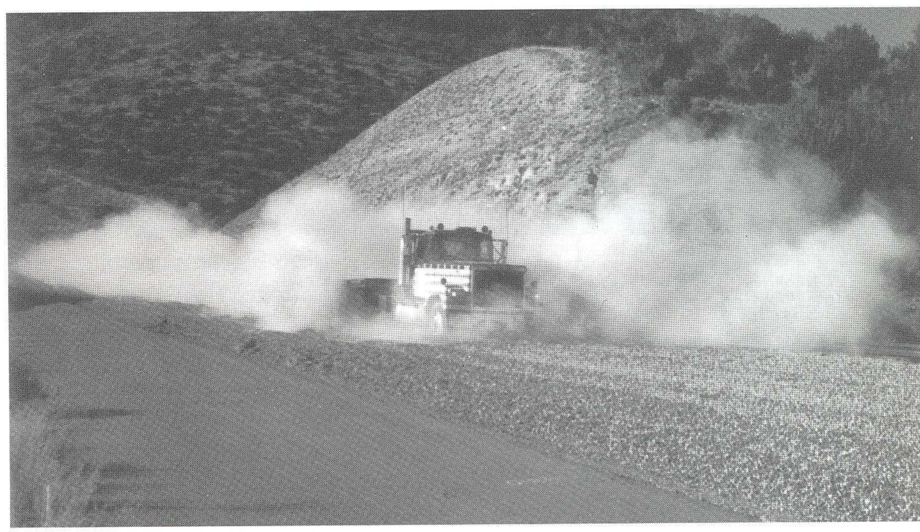

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Truck entering arrester bed produces dust plume.

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The Arizona Department of Transportation (ADOT) sponsored research to conduct inservice testing at four of its seven arrester beds. The testing was performed to verify the rolling resistance of the aggregate and to evaluate several maintenance techniques. ADOT had recently changed its aggregate gradation and specifications when it began the study. The new grading was more expensive to produce, but it was hoped that it would afford a higher rolling resistance than the gradation that had been used.

To evaluate the in-place aggregate rolling resistance, 102 entries were performed with an unloaded single-trailer truck with five axles. The truck entered each of the four arrester beds at two speeds: 45 and 65 mph (Figure 1). A radar unit was positioned to measure the change in vehicle velocity at 1/20-second intervals. These values allowed for backcalculation of the rolling resistance.

using the three techniques. The effect on the stopping distance was then analyzed. A fourth condition was also evaluated to determine if vehicles that entered an arrester bed in the tracks left by a previous vehicle traveled farther into the bed.

Application

The results of the research indicated that the revised aggregate specification exhibited an effective rolling resistance of 0.3; the design rolling resistance at the time of the study was 0.25. Using the effective rolling resistance allows the arrester bed to be reduced 180 feet in length.

Because all four arrester beds evaluated were designed with different grades, transitions, and depths of aggregate, it was difficult to quantify precisely the effect of aggregate depth. It was determined, however, that the depth of the aggregate could be reduced from

48 to 36 inches. ADOT is evaluating the possibility of further reducing the depth to 30 inches.

The results of this study demonstrated that entry speed, bed preparation, and tracking significantly affect the distance that a truck travels into an arrester bed. When trucks follow in the tracks of a previous vehicle, their stopping distance may increase by 15 to 20 percent. Removing these tracks by scarification was recommended; the method to be used is not significant.

Benefits

Using the effective aggregate rolling resistance and reducing the thickness of the arrester bed have resulted in a construction savings of about $30,000 per site. The savings can be much higher (in the hundreds of thousands of dollars) at locations where rock cuts or high fills are required. The higher rolling resistance allows the length of an arrester bed to be reduced by 15 percent.

Not only were construction costs saved, but the need to replace the aggregate in one of the beds was eliminated. Before the testing, there was concern about the adequacy of the only bed with the "old" aggregate gradation. Test results indicated that the bed performed satisfactorily and could remain.

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Readers interested in further information on arrester beds are referred to *NCHRP Synthesis 178: Truck Escape Ramps.* The report is available (price: $9.00; $6.75 for TRB affiliates) from the Transportation Research Board, Box 289, Washington, D.C. 20055 (telephone 202-334-3213 or 3214).

Suggestions for "Research Pays Off" topics are welcome. Contact Crawford F. Jencks, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 (telephone 202-334-2379).

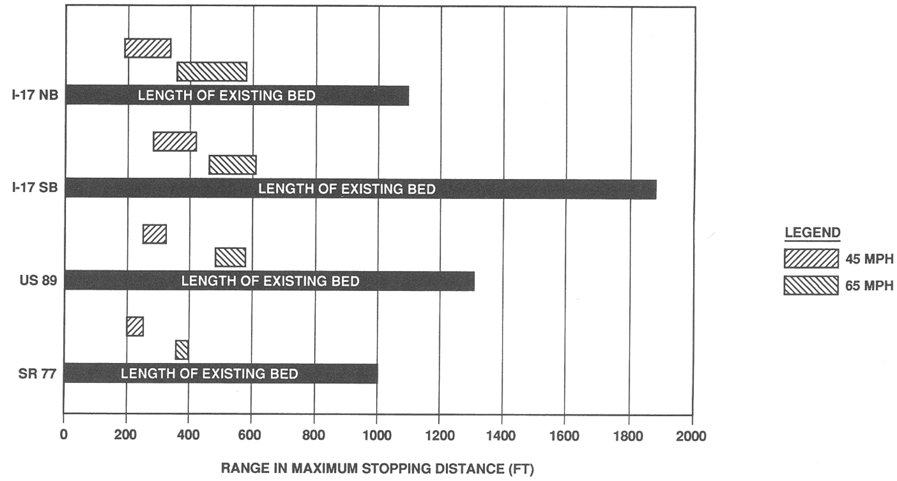

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FIGURE 1 Ranges of maximum stopping distances at four locations of arrester bed testing.

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Arrester bed entry shows truck, pilot vehicle behind, and extraction vehicle to right.

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Aggregate sprays as arrester bed slows truck.