EVALUATION OF A NEW GUARDRAIL TERMINAL

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ABRIDGMENT

•UPSTREAM guardrail terminals have been identified as roadside hazards. Ramped terminals have launched errant vehicles while beams terminated with straight sections have speared passenger compartments.

A promising guardrail terminal (Fig. 1) for the G4S or G4W (1) barrier was evaluated by full-scale crash tests. This terminal develops effective redirective properties of the barrier for angle impacts occurring downstream from the end span, yet it will safely break away for direct impact. Principal features of the concept are the (a) anchor-cable-to-end post detail and (b) beam end design. As shown in Figure 1, the cable, which develops adequate beam tensile strength, is attached through a hole in the end post, which is set in concrete. This hole, located near grade level, weakens the post in flexure and shear for forces applied above the hole. Hence, when a vehicle strikes the post, it breaks at the hole; this releases the cable and thus greatly diminishes spearing forces that can develop in the beam. In addition, the beam is ended by a special 11-in. radius bend that is stiffened with a steel diaphragm or lighweight concrete and that serves as a "load spreader" to further reduce the possibility of beam-spearing during direct-on hits. For downstream impacts, forces are introduced to the end post via the anchor cable. For these cases, the hole has no adverse effect on the post strength, and the cable forces are transmitted through the post to the foundation. Principles of the concept and component functions are summarized in Table 1.

In the test program, three full-scale crash tests were conducted. All guardrail installations were basically the G4W system anchored by the breakaway cable terminal. The test series is summarized in Table 2; sequential test events are shown in Figure 2.

Test results are compared to terminal design purpose and service requirements in Table 3. In general, the design was considered to be quite promising. Terminal performance for end-on impacts indicated a need for "softening" the longitudinal stiffness of the beam. With this single improvement, the breakaway cable terminal should prove to be a safe, economical solution to the W-beam guardrail terminal problem.

ACKNOWLEDGMENT

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REFERENCE

1. Michie, J. D., and Bronstad, M. E. Location, Selection, and Maintenance of Highway Traffic Barriers. NCHRP Rept. 118, 1971.

Sponsored by Committee on Traffic Safety Barriers and Sign, Signal and Lighting Supports.

Figure 1. Breakaway cable terminal details.

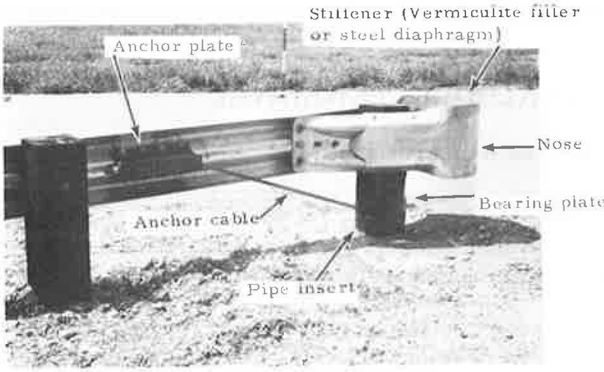

Figure 2. Test series sequence of events.

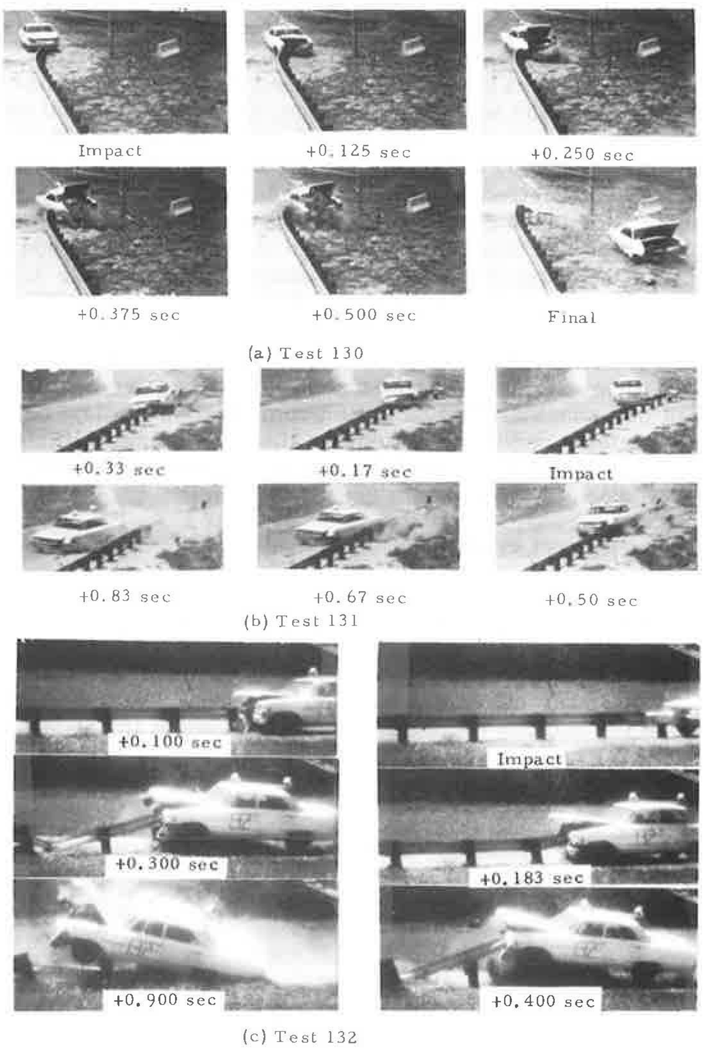

Table 1. Breakaway cable terminal.

Component	Design Function: End-On Impacts	Design Function: Downstream Impacts
End post	Post breaks away at bored hole, releasing cable, thus minimizing spearing forces.	Post is designed to transfer breaking strength of cable to the concrete footing.
Pipe insert	No function.	Distributes forces due to vertical component of cable to the post. Size was determined from bearing strength of southern pine.
Bearing plate	No function.	Distributes horizontal forces from cable to post. Size was determined from bearing strength of southern pine.
End nose	Large nose is stiffened by vermiculite concrete (Tests 130 and 131) or steel diaphragms (Test 132) to distribute loads over a large area, thus reducing chances of rail penetration into passenger compartment.	No function.
Anchor cable	The cable does not perform for end-on impacts, but it is essential that it does not develop spearing forces in the W-beam.	Cable transfers tensile forces from beam to end post. Proper anchorage is essential for angle impacts downstream from the end.
Concrete footing	No function.	Distributes loads from end post to soil.
End flare	For Tests 130 and 131, a horizontal flare was installed to introduce eccentric loads for end-on impacts, thus bending beam away from car.	No function.

Table 2. Summary of guardrail terminal tests.

Test Number	Purpose	Vehicle Weight (lb)	Vehicle Speed (mph)	Impact Angle (deg)	Maximum Average Deceleration: Longitudinal (g)	Maximum Average Deceleration: Lateral (g)	Remarks
130	End-on impact (with flare)	4,138	61.0	0	10.8[a] 2.5[b]	1.7[a]	Vehicle was redirected behind the rail; vehicle stability was good throughout.
131	Test anchorage for downstream impact	4,000	59.4	15	4.6[a]	4.6[a]	Vehicle was redirected at large exit angle. No sign of anchorage failure.
132	End-on impact (without flare)	4,100	58.5	0	8.6[a] 3.4[b]	1.2[a]	Vehicle was redirected behind rail; considerable upward pitch of the vehicle noted.

[a]Highest 50-msec average. [b]Based on stopping distance.

Table 3. Critique of terminal performance.

Design Purpose and Service Requirements	Test Results
Develop structural effectiveness of "length-of-need" section.	Test 131 demonstrated anchor effectiveness.
Provide degree of protection for terminal section impacts consistent with "length-of-need" impacts.	Deceleration levels for end-on impacts were well within limits specified for crash cushions.
Develop tensile and/or flexural strength necessary to ensure desirable redirection performance of the "length-of-need" section.	Test 131 demonstrated the anchor effectiveness.
Either by redirection, containment, or controlled penetration, minimize vehicle and occupant decelerations for terminal section impacts. (In some cases end-on impacts can be eliminated, e.g., extending rail end into back slope.)	Vehicle was redirected for angular impact near the end (Test 131) and was redirected behind the rail for the two end-on tests (130 and 132). Decelerations were within limits specified for crash cushions.
Not launch, roll, or pocket an impacting vehicle.	Vehicle stability was good in Tests 130 and 131, with no pocketing for angular impact. Undesirable vehicle instability occurred in Test 132.
Be designed so that possible penetration of vehicle passenger compartment by system component is minimized.	No penetration of passenger compartment occurred in any of the tests.
Be economical in construction, damage repair, and maintenance.	Terminal construction costs are in-line with existing standards. Damage to terminal was not excessive for end-on tests. Several components were reusable.
Have a pleasing and functional appearance.	Terminal design fulfills this requirement.
Minimize vehicle damage.	Damage to the vehicle front end was severe for the end-on impacts; however, the passenger compartment integrity was not violated.