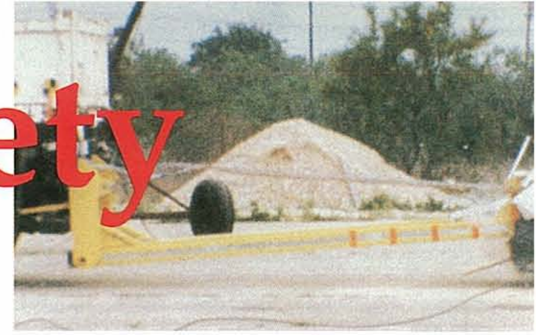
Roadside Safety



Drivers benefit from Institute research on impact attenuators

by John W. Strybos, P.E.

As economic and environmental concerns have encouraged the use of smaller, lighter weight passenger cars and sport utility vehicles, a need has arisen for changes to roadside safety devices to accommodate the new fleet of cars on the road.

To address this need and others, the U.S. Congress enacted the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991.[1] The act includes a provision for revised guidelines and standards for acceptable roadside barriers and other safety devices.

In response to this legislation, the National Cooperative Highway Research Program (NCHRP) prepared Report 350,[2] which was in turn adopted by the Federal Highway Administration (FHWA). Report 350 includes revised standards for full-scale crash testing of roadside safety devices, many of which must be tested for compliance with today's minivans, sport utility vehicles, and lightweight passenger sedans.

Roadside safety devices include crash cushions, median barriers, and bridge railings intended to prevent errant vehicles from impacting fixed objects. These devices are an integral part of safe roadway design under the "clear zone" concept. The clear zone is an unobstructed area that extends 30 feet beyond the edge of the driving lane. Studies have shown that approximately 80 percent of vehicles leaving a roadway out of control can be brought safely under control within the 30-foot zone. To develop a safe clear zone, obstacles are removed, relocated, redesigned, or shielded by traffic barriers or crash cushions.

Southwest Research Institute has been a recognized leader in the development of roadside safety hardware for more than 30 years. Institute engineers and scientists have patented innovative designs and have authored several standards used by highway research engineers [*see box at end of article*].

To study the dynamic behavior of barriers, barrier components, vehicles, and highway appurtenances such as sign supports, motorist call boxes, and other breakaway devices, the Institute conducts both pendulum and full-scale vehicle impact tests, using equipment and procedures based on FHWA test requirements.

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Pendulum impact tests are conducted primarily to evaluate materials, structures, and vehicular components at impact velocities up to 40 feet per second. The impacting structure is a steel-reinforced, concrete mass with either a hard, unyielding impact nose or a staged, aluminum honeycomb nose that crushes to simulate vehicle deformation. Accelerometers mounted on the rear of the impacting structure are monitored continuously using high-speed magnetic recorders. High-speed cameras that record up to 10,000 frames per second provide visual documentation of tests.

Two crash test facilities permit experimental studies of vehicle dynamic behavior during impact. Unmanned test vehicles are guided into various highway appurtenances at SwRI on two 12-foot wide, 1,500-foot long paved runways that provide adequate acceleration distances for vehicles that are either self-powered or towed. A second test facility at Brooks Air Force Base in San Antonio provides a longer runway required to test larger vehicles.

In response to the recent legislation governing development and evaluation of roadside safety devices, Institute facilities and expertise were employed to test two impact attenuator systems.

Crash Cushion Attenuating Terminal

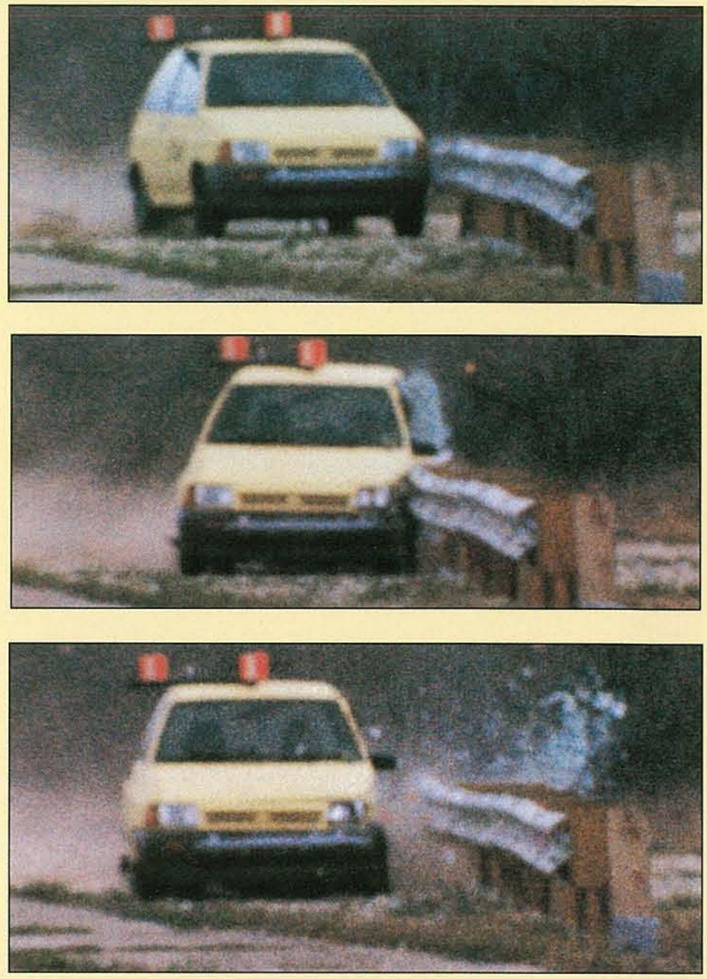
In 1982, SwRI was contracted by the FHWA to develop an energy absorbing guardrail terminal that would attach to a conventional guardrail, thus eliminating costly replacement of complete guardrails. Institute engineers developed the crash cushion attenuating terminal (CAT®). The system absorbs a vehicle's kinetic energy while bringing it to a controlled stop or redirects the forward motion of the vehicle, thus preventing the disastrous consequences of spearing, vaulting, or rollover. The promising CAT prototype was further developed by SwRI under contract to Syro, Inc., which now manufactures and sells the system.

CAT had been tested successfully with a 4,500-pound passenger sedan, but the 1991 ISTEA called for the system to be qualified for lighter weight passenger vehicles and pickup trucks. Although of comparable weight, pickup trucks have higher centers of gravity and thus perform differently than sedans. SwRI conducted several full-scale

Truck-mounted attenuators are affixed to dump trucks and other 'shadow' vehicles that closely follow road maintenance vehicles, to protect the latter from rear-end collisions. In this test of the MPS-350® attenuator, an 1,800-pound passenger vehicle impacts a dump truck at 41 miles per hour.

crash tests of the three-stage CAT system using an 1,800-pound passenger sedan and a 4,500-pound pickup truck. In these tests, impact occurred at 62 mph at varying impact angles.

The most important result from these tests is the occupant ride-down acceleration (Gs), because acceleration that is too high can result in severe injuries or death. NCHRP Report 350 established acceptable acceleration at not more than 20 Gs, with 15 Gs preferred. The results of the most recent series of CAT tests were well below 15 Gs. The highest acceleration, 13.2 Gs, occurred when a 4,500-pound pickup truck impacted CAT at an angle of 20 degrees and a speed of 62 mph.[3]



The crash cushion attenuating terminal, or CAT®, is a three-stage system that uses energy absorbing beam elements, breakaway wooden posts, and a cable anchorage system to prevent out-of-control vehicles from impacting fixed objects. This high-speed camera sequence — taken at 0, 0.2, and 0.4 seconds after impact — shows an 1,800-pound vehicle traveling at 62 mph as it strikes a CAT-equipped guardrail at a 15-degree angle. The energy absorbing system effectively cushions the crash and redirects the vehicle.

Truck-mounted Attenuator

Road work zones are potentially hazardous areas because of the vehicles, equipment, and materials used for maintenance and construction. To prevent rear-end collisions of passenger vehicles with slower moving maintenance vehicles, the maintenance vehicle is often followed closely, or shadowed, by a protective vehicle such as a dump truck equipped with a rear-mounted impact attenuator.

The MPS-350®, manufactured by Syro, Inc., is a truck-mounted attenuator that absorbs the kinetic energy of an impacting vehicle while bringing the vehicle to a controlled stop. The attenuator consists of a bracket and a frame made up of two main beams connected by an impact face and a series of cross braces. Each beam contains two steel channels oriented horizontally.

During impact, load is transferred through the beams and into the bracket in a way that causes the bracket supports to release. As the frame slides forward, the metal plates on the outside of each beam are split apart by a ripper assembly, and the impacting vehicle is brought to a stop.

The Institute has performed several full-scale crash tests for Syro to evaluate the MPS-350 with an 1,800-pound sedan and a 4,500-pound pickup truck. All test results showed occupant ride-down accelerations below the maximum limit.[4] In a test of an 1,800-pound passenger sedan traveling at 41 mph and impacting at 0 degrees, the maximum ride-down acceleration was 19.6 Gs, while a test of a 4,500-pound pickup traveling at 62 mph and impacting at 0 degrees had a maximum acceleration of 16.4 Gs.

Conclusions

As a result of the recent successful tests of CAT and its previous performance with heavier passenger vehicles, the crash cushion terminal has been installed on highways and roads nationwide. Marketing of the MPS-350 began last summer, and units have been purchased by several state highway departments. The device has also been purchased for use abroad.

The Institute continues to test highway safety hardware for both private industry and state highway departments and was recently awarded three contracts by the FHWA to perform full-scale crash tests of guardrail terminals and guardrail-to-bridgerail transitions. ❖

References

1. Intermodal Surface Transportation Efficiency Act: Public Law 102-240, *United States Statutes at Large*, Vol. 105, Part 3, U.S. Government Printing Office, 1991.

2. H. Ross, D. Sicking, R. Zimmer, and J.D. Michie, "Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances," National Cooperative Highway Research Program Report 350, Washington, D.C., 1993.

3. J.W. Strybos and J. Mayer, "Full-Scale Crash Evaluation of the CAT® System," SwRI Final Report Project 06-4995, July 1995.

4. J.W. Strybos and J. Mayer, "Full-Scale Crash Evaluation of a Truck-Mounted Attenuator," SwRI Final Report Project 06-4995, May 1996.

SwRI Roadside Safety Device Patents and Standards

U.S. Patent No. 4,655,434, "Energy Absorbing Guardrail Terminal" (M.E. Bronstad, inventor)

U.S. Patent No. 4,678,166, "Eccentric Loader Guardrail Terminal" (M.E. Bronstad, J.H. Hatton, and L.C. Meczkowski, inventors)

U.S. Patent No. 5,490,661, "Quick Release System for Guardrail Terminals" (K.A. Marchand, D.J. Stevens, and J.B. Mayer, inventors)

"Location, Selection and Maintenance of Highway Traffic Barriers," NCHRP Report 118 (J.D. Michie and M.E. Bronstad, authors)

"Guardrail Performance and Design," NCHRP Report 115 (J.D. Michie, L.R. Calcote, and M.E. Bronstad, authors)

"Guardrail Crash Test Evaluation — New Concepts and End Designs," NCHRP Report 129 (J.D. Michie and M.E. Bronstad, authors)

"Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances," NCHRP Report 153 (M.E. Bronstad and J.D. Michie, authors)

The Institute also received an R&D 100 Award in 1981 from *R&D Magazine* for the "Self Restoring Traffic Barrier," invented by M.E. Bronstad.