TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM

Project Summary Report 1792-S
Project 0-1792: Roadside Safety Hardware for Traffic Control Devices

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PROJECT SUMMARY REPORT

Safety Evaluation of Traffic Control Devices and Breakaway Supports

Through its research program, the Texas Department of Transportation (TxDOT) continues to be proactive in providing safer roadsides for the traveling public. TxDOT-sponsored projects have resulted in the development of many crashworthy breakaway supports for signs, flashing beacons, and mailboxes. These devices reduce the probability of injury when they are impacted by an errant vehicle. Safety of work zones is also a major concern to TxDOT. The proper use of traffic control devices is an essential aspect of work zone safety. However, traffic control devices themselves may pose a safety hazard to workers or vehicle occupants when impacted by errant vehicles. The impact performance of these devices must, therefore, be evaluated.

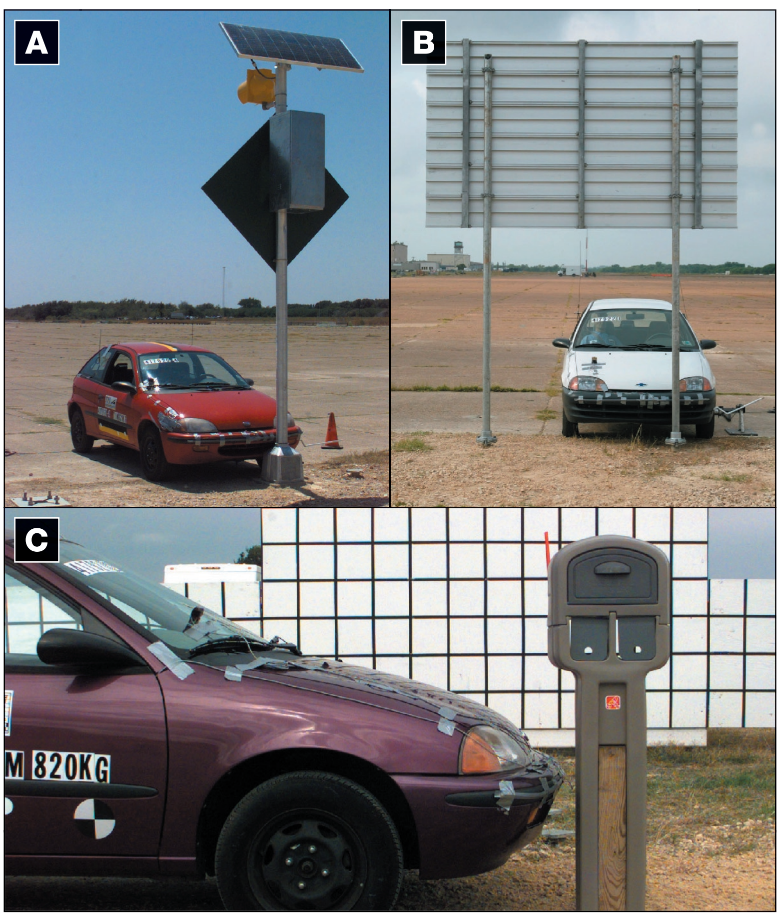

Figure 1. a) Tests in this project combined solar-powered units with flashing beacon assemblies; b) Properly installed dual slip-base sign supports serve as a safe, cost-effective system; c) In all three tests performed, molded plastic mailbox units satisfied evaluation criteria.

What We Did . . .

TxDOT uses the results of in-service performance evaluations and feedback from field crews, district personnel, and contractors to continually assess the performance of roadside safety devices. These evaluations allow TxDOT to identify areas in which design improvements can be realized in terms of cost, maintenance, and/or impact behavior. With this input and guidance from TxDOT, Texas Transportation Institute (TTI) researchers designed, tested, and evaluated several types of roadside safety hardware. Crash tests were conducted in accordance with the procedures specified in *National Cooperative Highway Research Program (NCHRP) Report 350*. Devices included in the investigation were:

- screw-in foundations for pedestal base supports,
- solar-powered flashing beacon assemblies,
- single and dual slip-base sign supports,
- molded plastic mailboxes,
- flexible delineators, and
- various work zone traffic control devices.

What We Found . . .

Work Zone Traffic Control Devices

TTI researchers conducted a total of 24 crash tests on work zone traffic control devices including:

- various Type I and Type III barricades,
- short-term portable sign supports,
- intermediate/long-term portable and ground-mounted sign supports,
- chevron supports, and
- a temporary barrel-mounted mailbox.

Devices that failed to meet the required evaluation criteria of *NCHRP Report 350* were either modified and retested or abandoned in favor of new designs with improved impact performance that satisfy the same functional requirements as the failed devices. During the redesign process, the researchers received input from TxDOT personnel, contractors, and manufacturers to help ensure that the improved devices met the needs of the department and were functional, durable, and cost effective. The work zone devices that were implemented based on the results of this project are summarized in Figure 2.

Type I Barricades
- Plastic A-frame barricade (Fender Enterprises)—42 inch (1067 mm) height
- Steel tube skid-mount barricade with wood panel
- Hollow profile plastic skid-mount barricade with wood panel and skids
- Hollow profile plastic folding A-frame barricade with wood panels
- Wood fixed A-frame barricade

Type III Barricades
- Barricade with fiber-reinforced polymer (FRP) supports in dual-purpose base
- Perforated steel tube barricade with plastic panels
- Barricade with hollow profile plastic supports not bolted to skids

Intermediate/Long-Term Portable Sign Supports
- Single FRP sign support in dual-purpose base with plywood panel at 7 ft (2.1 m)
- Wood sign support in H-leg base with plywood panel at 7 ft (2.1 m)

Intermediate Long-Term Ground-Mounted Sign Supports
- Ground-mounted dual FRP sign support

Short-Term Portable Sign Supports
- Roll-up sign on FRP support in dual-purpose base
- Polyvinyl chloride (PVC) easel support and fiberglass sign panel
- Hollow profile plastic sign support in H-leg base with 3x3 ft (0.9x0.9 m) plywood panel at 1 ft (0.3 m) mounting height
- Single hollow profile plastic sign support with wooden T-leg base with a 48x48x0.4 inch (1220x1220x11 mm) corrugated plastic sign panel mounted at 2 ft (0.6 m)

Temporary Mailbox Support
- Mailbox mounted on plastic channelizing drum using standard TxDOT hardware

Figure 2. Work zone devices implemented as a part of the project.

Alternative Anchorage for Pedestal Base Supports

Several TxDOT districts expressed interest in using helical, screw-in foundation anchors for pedestal-style cast aluminum base support structures in lieu of traditional concrete footings. Screw-in foundation anchors can significantly reduce installation cost and time. A sign crew with an auger truck can install a helical anchor and complete the installation of a pedestal base support in a single trip.

A pedestal base sign installation attached to a helical type, screw-in foundation anchor was evaluated through full-scale crash testing. The support structure consisted of a 4.5 inch (114 mm) outside diameter (O.D.) spun-aluminum pole connected to a cast-aluminum traffic signal base. A flashing yellow signal beacon was mounted directly above and below a plywood sign panel.

Self-Contained Solar-Powered Flashing Beacon Assembly

Previous testing has demonstrated the crashworthiness of support structures with warning signs and flashing beacons attached to pedestal-style cast-aluminum breakaway bases. The solar panel and batteries that power the beacons are typically mounted on a separate support structure located near the right-of-way. Some TxDOT districts expressed interest in combining all of the hardware for a solar-powered beacon assembly onto a single support structure. Elimination of the second support structure, its foundation, and conduit between the two would result in a reduction of installation cost and time. However, the support structure must be properly configured to prevent the battery control cabinet or other components from penetrating into the occupant compartment of a vehicle when the breakaway base is impacted and the support pole released.

An engineering model based on conservation of energy and linear and angular momentum principles was used to estimate post-impact trajectory of a pedestal-base sign installation with solar voltaic equipment and determine a safe location for the battery cabinet. The recommended system consists of a 4.5 inch (114 mm) O.D. spun aluminum pole connected to a cast-aluminum traffic signal base. A flashing yellow signal beacon was mounted directly above a plywood sign panel. A solar panel was attached to the top of the support pole, and the battery cabinet for the panel was mounted behind the sign panel.

Small Slip-Base Sign Supports

Researchers investigated several independent issues related to the performance of small slip-base sign supports. These issues included:

- the effect of bolt torque on the impact performance of slip-base sign supports,
- the effect of sign panel configuration on the trajectory and impact performance of slip-base sign supports, and
- an evaluation of methods for retrofitting slip-base stubs that incorporate a lifting ramp or cone.

Some TxDOT districts have reported slip-base sign installations blowing down in regions subject to high winds. This occurrence is probably due to the cyclical loading applied to the slip base, which varies the tension in the slip bolts and permits them to "walk" out of their slots. If adequate safety performance is maintained, a higher bolt torque could help alleviate incidences of signs blowing down. Based on the results of pendulum and full-scale crash tests conducted under this project, small slip-base sign supports using slip-bolt torques in the range of 80 ft•lb (109 N•m) to 100 ft•lb (136 N•m) were determined to be in compliance with *NCHRP Report 350* and suitable for implementation. Any higher value of bolt torque could result in the kinking or collapsing of the schedule 10 support, which would hinder activation of the slip-base mechanism.

Previous TxDOT slip-base designs incorporated a lifting device on the lower base plate to help propel the sign support upward during impact and eliminate or reduce the severity of any secondary impacts of the support with the windshield or roof of the vehicle. However, previous TxDOT research determined that the lifting cone was not needed and, in some instances, was detrimental to overall impact performance. The lifting cone was, therefore, removed from the current slip-base design. This change in design created a need to develop a retrofit concept to enable existing slip-base foundations with lifting devices to be repaired or upgraded with the new slip-base system. A triangular polycarbonate spacer cap proved to be the best alternative of the retrofit concepts investigated. In a dynamic pendulum test, the triangular spacer cap for retrofitting existing slip-base foundations complied with *NCHRP Report 350* performance criteria and is considered suitable for implementation when circumstances warrant during upgrade and repair operations. The plastic spacer ring provides the required separation between the slip plates to accommodate an existing lifting cone and does not impede the breakaway performance of the small sign support.

Molded Plastic Mailboxes

Crash tests evaluated the performance of molded plastic mailboxes on three different types of support posts:

- 4x4 wood,
- 2 lb/ft U-channel, and
- 3-inch diameter schedule 40 pipe.

In all three tests, the molded plastic mailbox units satisfied *NCHRP Report 350* evaluation criteria. However, performance associated with the different support posts varied. From both a functional and impact performance standpoint, the 4x4 timber support post appears to be the best alternative from among the three support posts investigated. The mailbox installation mounted on the 4x4 timber support post resulted in the least amount of windshield damage to the test vehicle.

Delineators

The researchers evaluated recycled plastic delineators manufactured by Environmental Transportation. The delineators were installed in a standard TxDOT driveable thin wall wedge anchor. The height to the top of the delineators was 48 inches (1225 mm). The metal wedge used to secure the delineators in the socket extended 4 inches (102 mm) above the top of the socket.

The recycled plastic delineators performed acceptably as non-reusable delineators when impacted by an 1800 lb (820 kg) passenger vehicle.

Dual Slip-Base Sign Supports

Large signs have long used extruded aluminum panels as a signage substrate. The aluminum panels are extruded with wind beams integral to the sign panel and have typically been mounted on hot-rolled W-shape supports with 4-bolt uni-directional slip bases. The supports incorporate fuse plates just below the sign panel that serve as hinge points when errant vehicles impact the supports.

One of TxDOT's districts proposed supporting the extruded aluminum panels with schedule 80 pipe supports with triangular slip bases. These pipe supports are commonly used on a wide range of small signs, and such a system would provide a cost-effective solution for dual-support sign installations with sign panels up to 60 ft^2 (5.6 m^2). Since the pipe support does not have a hinge point, the impact performance of this type of installation was unknown and full-scale testing was deemed necessary.

The Researchers Recommend . . .

Product	Implementation Recommendation
Alternative Anchorage for Pedestal Base Supports	Suitable.
Self-Contained Solar-Powered Flashing Beacon Assembly	Suitable. Installations that deviate from recommended system may require additional testing. Lowering battery mounting height may alter impact performance.
Small Slip-Base Sign Supports	Suitable. Recommend slip-bolt torques near 80 ft•lb (109 N•m).
Molded Plastic Mailboxes	Suitable. Recommend 4x4 wood support post.
Delineators	Suitable.
Dual Slip-Base Sign Supports	Suitable. Recommend four universal pipe clamps, two per support.

For More Details . . .

The research conducted under this project is documented in the following reports:
Report 1792-1: *NCHRP Report 350 Evaluation of the Temporary Barrier Barrel-Mounted Guard Fence (TB(BMGF)-92)*
Report 1792-2: *Impact Performance Evaluation of Work Zone Traffic Control Devices*
Report 1792-3: *Testing and Evaluation of a Pedestal Base Sign Support*
Report 1792-4: *Testing and Evaluation of the Solar Panel Sign Support System*
Report 1792-5: *Testing and Evaluation of Slip Base Sign Supports*
Report 1792-6: *Testing and Evaluation of Molded Plastic Mailboxes*
Report 1792-7: *Crash Test of the Environmental Transportation's Delineators (DRAFT)*
Report 1792-8: *Evaluation of Dual Support, Triangular Slip Base Sign Installations*

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TxDOT Implementation Status
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This research examined the development of crashworthy low-cost, generic traffic control devices in construction work zones. Full-scale crash tests were conducted on various work zone traffic control devices, and the results of these crash tests were evaluated for performance. As a result of this research, approved generic crashworthy traffic control devices have been incorporated into construction work zones on Texas highways. In addition, the "Compliant Work Zone Traffic Control Devices" manual was developed for TxDOT personnel, contractors and vendors. The continued use of crashworthy generic work zone traffic control devices will save TxDOT money and save lives.

For more information, please contact: Wade Odell, P.E., Research Engineer, Research and Technology Implementation Office, (512) 465-7403.

YOUR INVOLVEMENT IS WELCOME!

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