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16. Abstract

Two full-scale crash tests were conducted on the Louisiana two-post, inclined, slip-base sign assembly with cluster sign attachment. These two tests were performed and evaluated in accordance with guidelines under NCHRP Report 230 and standards established in the 1985 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

The sign supports broke away readily in both the low-speed and the high-speed tests through activation of the slip-base breakaway mechanism. The sign panel did slap the rear of the roof of the vehicle and the support posts contacted the rear of the vehicle in the low-speed test, but the impact was very minor with little resulting damage to the vehicle, and there was no penetration of the test object into the passenger compartment. The vehicle sustained minor to moderate damage in the two tests and was stable throughout the collision without exhibiting any tendency of rollover or instability. Neither the vehicle nor the sign installation presented any undue hazard to other traffic after the impact in either test. The occupant impact velocities and ridedown accelerations for both tests were well below the limits recommended in NCHRP Report 230.

The Louisiana two-post, inclined, slip-base sign assembly with cluster sign attachment as tested in this study conformed to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO standards. There is no indication that the attachment of sign clusters to the support posts poses any potential adverse effect on the impact performance of the slip-base breakaway design.

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ABSTRACT

Two full-scale crash tests were conducted on the Louisiana two-post, inclined, slip-base sign assembly with cluster sign attachment. These two tests were performed and evaluated in accordance with guidelines under NCHRP Report 230 and standards established in the 1985 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

The sign supports broke away readily in both the low-speed and the high-speed tests through activation of the slip-base breakaway mechanism. The upper hinge connections did not play a major role in the breakaway sequence since the vehicle impact both sign support posts simultaneously and the entire sign assembly was dislodged from its bases and displaced by the impacting vehicle. The sign panel did slap the rear of the roof of the vehicle and the support posts contacted the rear of the vehicle in the low-speed test, but the impact was very minor with little resulting damage to the vehicle, and there was no penetration of the test object into the passenger compartment. The vehicle sustained minor to moderate damages in the two tests and was stable throughout the collision without exhibiting any tendency for rollover or instability. Neither the vehicle nor the sign installation presented any undue hazard to other traffic after the impact in either test. The occupant impact velocities and ridedown accelerations for both tests were well below the limits recommended in NCHRP Report 230.

The Louisiana two-post, inclined, slip-base sign assembly with cluster sign attachment as tested in this study conformed to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO standards. There is no indication that the attachment of sign clusters to the support posts poses any potential adverse effect on the impact performance of the slip-base breakaway design.

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INTRODUCTION

The Louisiana Department of Transportation and Development (LADOTD), in cooperation with the Federal Highway Administration (FHWA), contracted with the Texas Transportation Institute (TTI) to crash test and evaluate the impact performance of a two-post, slip-base sign installation with sign clusters attached to the post. The objective of the study was to assess if the attachment of sign clusters to the posts of slip-base sign supports, which is the current practice in the state of Louisiana, poses any potential adverse effect on the impact performance of the slip-base breakaway design.

The scope of the project included the construction of the sign installation in accordance with LADOTD design standards, performance of two crash tests in accordance with standards established in AASHTO (American Association of State Highway and Transportation Officials) Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals and NCHRP (National Cooperative Highway Research Program) Report 230, and evaluation of the crash test results.

General descriptions of the study approach, including those of the sign installation and the crash test and data analysis procedures, are presented in the Methodology section of this report. Data and evaluation results of the two crash tests are described in the Discussion of Results section and a summary of findings and conclusions is presented in the last section of this report.

OBJECTIVE

The objective of the study was to assess if the attachment of sign clusters to the posts of slip-base sign supports, which is the current practice in the state of Louisiana, poses any potential adverse effect on the impact performance of the slip-base breakaway design.

SCOPE

The scope of the project included the construction of the sign installation in accordance with LADOTD design standards, performance of two crash tests in accordance with standards established in AASHTO (American Association of State Highway and Transportation Officials) Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals and NCHRP (National Cooperative Highway Research Program) Report 230, and evaluation of the crash test results.

METHODOLOGY

DESCRIPTION OF TEST INSTALLATION

The sign installation used in this test consisted of a 114-inch wide by 53-inch high aluminum sign panel attached to two W8x18 steel posts mounted atop inclined slip bases. The spacing between the two posts was set at 40 inches center to center, or 43 inches from outside of post to outside of post, so that both posts could be impacted simultaneously by an 1,800-pound passenger car with sufficient clearance for the tires of the impacting vehicle to clear the posts. The distance from inside to inside of tires for the test vehicle was 47.5 inches. The bases were set into reinforced concrete footings 5 feet deep and 2 feet in diameter and extended 3.5 inches above the ground. The concrete footings were placed in a crushed limestone pit (NCHRP Report 230 Strong Soil).

The length of the main support posts was 169 inches, with 46 inches above the upper hinge connection. The bottom of the sign panel was approximately even with the upper hinge connection and 125 inches above ground level. A sign cluster, consisting of two route marker assemblies and six sign panels mounted on an aluminum frame, was bolted to the front flange of the left sign support post. The sign cluster attachment had an overall dimension of 57 inches wide and 53 inches high, and the bottom of the sign cluster attachment was 66 inches above ground level.

The bolts in the inclined slip bases were torqued to 660 inch-pounds (55 foot-pounds) for the crash tests. LADOTD specifications allow for a range of torque for the bolts from 450 to 680 inch-pounds (37.5 to 56.7 foot-pounds). A round number near the upper limit of the specified torque range was selected since it would represent a more critical condition from the standpoint of activation of the breakaway mechanism and impact performance. The bolts in the upper hinge connection were tightened snug plus one-quarter turn in accordance with LADOTD specifications. A drawing of the test sign installation is shown in Figure 1, and photographs of the completed installation are shown in Figures 2 through 4.

DESCRIPTION OF CRASH TEST PROCEDURES

According to NCHRP Report 230 guidelines, two crash tests are recommended for the evaluation of a sign support installation, as follows:

1. Test Designation 62. 1,800-pound vehicle impacting the sign

2. Test Designation 63. 1,800-pound vehicle impacting the sign supports at a speed of 60 miles per hour.

The center of the vehicle was aligned with the center of the sign installation in both tests. As mentioned previously, the two sign supports were spaced 40 inches apart so that both sign supports would be impacted by the test vehicle simultaneously while providing sufficient clearance for the tires of the vehicle to clear the bases of the sign supports.

The crash test procedures were in accordance with guidelines presented in NCHRP Report 230. The test vehicles were instrumented with three rate transducers to measure roll, pitch, and yaw rates and a triaxial accelerometer near the vehicle center of gravity to measure acceleration levels. The electronic signals from the accelerometers and transducers were telemetered to a base station for recording on magnetic tape and for display on a real-time strip chart. A provision was made for the transmission of calibration signals both before and after the test, and an accurate time reference signal was simultaneously recorded with the data. Contact switches on the bumper were actuated just prior to impact by wooden dowels to indicate the elapsed time over a known distance to provide a measurement of impact velocity. The initial contact also produced an "event" mark on the data record to establish the exact instant of impact.

In accordance with guidelines presented in NCHRP Report 230, an unrestrained, uninstrumented, 50th percentile male anthropomorphic dummy was positioned in the driver seat of the test vehicle for both tests. This dummy was used to evaluate typical unsymmetrical vehicle mass distribution and its effect on vehicle stability during impact.

Photographic coverage of the tests included two high-speed cameras, one perpendicular to the sign installation and the other located downstream from the point of impact at an angle of approximately 45 degrees to the vehicle path. The films from these high-speed cameras were used to observe phenomena occurring during collision and to obtain time-event, displacement and angular data. A 3/4-inch videotape and still cameras were also be used for documentary purposes.

DATA ANALYSIS PROCEDURES

The data analysis procedures were in accordance with guidelines presented in NCHRP Report 230. The analog data from the accelerometers and transducers were digitized with a microcomputer for analysis and evaluation of performance. The digitized data were then analyzed using a number of computer programs:

GITIZE, PLOTANGLE and commercially available LOTUS software. Brief scriptions on each these computer programs are provided as follows.

The DIGITIZE program uses digitized data from vehicle-mounted linear celerometers to compute occupant/compartment impact velocities, time of cupant/compartment impact after vehicle impact, final occupant displacement, d the highest 0.010-second average ridedown accelerations. In addition, the ogram also calculates the vehicle impact velocity, the change in vehicle elocity at the end of a given impulse period, and maximum average accelerations ver 0.050-second intervals for the longitudinal, lateral and vertical irections.

The PLOTANGLE program uses the digitized data from the yaw, pitch, and roll ate charts to compute angular displacement in degrees at 0.001-second intervals nd then instructs a plotter to draw a reproducible plot: yaw, pitch, and roll ersus time. It should be noted that these angular displacements are sequence-dependent with the sequence being yaw-pitch-roll for the data presented in this report. These displacements are in reference to the vehicle-fixed coordinate system with the initial position and orientation of the vehicle-fixed coordinate system being that which existed at initial impact.

The LOTUS program plots acceleration versus time curves for the longitudinal, lateral, and vertical directions using digitized data from the vehicle mounted linear accelerometers.

DISCUSSION OF RESULTS

As mentioned previously, two crash tests recommended by NCHRP Report 230 were conducted on the test sign installation:

1. Test Designation 62. 1,800-pound vehicle impacting the sign supports at a speed of 20 miles per hour.
2. Test Designation 63. 1,800-pound vehicle impacting the sign supports at a speed of 60 miles per hour.

TEST NUMBER 1

A 1982 Honda Civic (shown in Figures 5 and 6) impacted the sign installation at 20.2 miles per hour (32.5 km/h) using a cable-reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 pounds (817 kg) and its gross static mass was 1,970 pounds (894 kg). The height to the lower edge of the vehicle bumper was 14.5 inches (36.8 cm) and 20.0 inches (50.8 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 7.

The vehicle was freewheeling and unrestrained just prior to impact. Upon impact, the slip-base breakaway mechanism was activated and the sign support posts separated from the bases as the sign assembly was pushed forward by the impacting vehicle. The vehicle lost contact with the sign support posts at 0.08 second after initial impact. As the vehicle continued forward, the sign support posts continued to rise, allowing the vehicle to pass beneath the sign assembly. At 0.765 second, the sign assembly impacted the vehicle in the hatchback area. As the top of the sign assembly hit the ground, the upper hinge connection was bent. The posts of the sign assembly then impacted both sides of the rear of the vehicle at 1.127 seconds after initial impact. Shortly thereafter, the brakes were applied and the vehicle came to rest 65 feet (19.8 m) from the point of initial impact. Sequential photographs of the test are shown in Figure 8.

The slip-base breakaway mechanism functioned as designed and yielded to the impacting vehicle. The upper hinge connections were not activated by the vehicular impact. This is to be expected since the vehicle impacted both sign support posts simultaneously and the entire sign assembly was dislodged from its bases and displaced by the impacting vehicle. This is different from the typical impact in which only one of the two support posts would be struck. The upper hinge connection would then allow the impacted sign support post to rotate around the upper hinge and move out of the way of the impacting vehicle. Th...

assembly remained intact and there were no detached elements or debris. The sign assembly received only minor damage (see Figure 9) and was re-used in the 60 mi/h test.

The vehicle sustained minor damage to the bumper, grill, headlights, roof and hatchback, as shown in Figure 10. Maximum vehicle crush was 2 inches (5.1 cm) at the right front corner at bumper height.

A summary of the test results and other information pertinent to this test is given in Figure 11. The data presented for change in vehicle velocity and momentum represents the conditions present at the time the vehicle initially lost contact with the sign assembly. The maximum 0.050-second average acceleration experienced by the vehicle was -4.1 g in the longitudinal direction and -0.7 g in the lateral direction. Vehicle angular displacements are plotted in Figure 12 and vehicle accelerometer traces are displayed in Figures 13 through 15. Occupant impact velocity in the longitudinal direction was 11.2 feet per second (3.4 m/s) and 5.7 feet per second (1.7 m/s) in the lateral direction. The highest 0.10-second average occupant ridedown accelerations were -1.2 g (longitudinal) and -0.8 g (lateral). At 0.080 second after impact, i.e., the time at which the vehicle lost contact with the sign support posts, the change in velocity was 3.3 mi/h (5.3 km/h) and the change in momentum was 270 lb-s.

In summary, the sign installation yielded to the impacting vehicle by activating the slip-base breakaway mechanism. The vehicle sustained very minor damages and was stable throughout the collision without exhibiting any tendency for rollover or instability. Neither the vehicle nor the sign installation presented any undue hazard to other traffic after the impact. The occupant impact velocity was well below the NCHRP Report 230 recommended limit of 15 feet per second and the change in momentum was substantially under the recommended limit of 750 lb-sec.

TEST NUMBER 2

The same 1982 Honda Civic (see Figure 16) used in the low-speed test (Test Number 1) was used in this high-speed test (Test Number 2). The vehicle impacted the sign installation at 62.9 miles per hour (101.2 km/h) using a cable reverse tow and guidance system. The vehicle properties, including the test inertia mass, the gross static mass, the vehicle bumper heights, and other dimensions and information on the vehicle are the same as for Test Number 1 and will not be repeated here.

The vehicle was freewheeling and unrestrained just prior to impact. Upon impact, the slip-base breakaway mechanism was activated and the sign support posts separated from the bases as the sign assembly was pushed forward by the impacting vehicle. The upper hinge connections began to bend at 0.018 second after impact. The vehicle lost contact with the sign support posts at 0.078 second after impact. As the vehicle continued forward, the sign support posts continued to rise, allowing the vehicle to pass beneath the sign assembly. The sign assembly rotated a full 360 degrees, and as the right support post contacted the ground, the sign panel began to separate from the right support post. Shortly thereafter, the sign panel also separated from the left support post. After the vehicle cleared the sign assembly, the brakes were applied and the vehicle subsequently came to rest 230 feet (70.1 m) from the point of impact. Sequential photographs of the test are shown in Figure 17.

The slip-base breakaway mechanism functioned as designed and yielded to the impacting vehicle. The upper hinge connections were only slightly bent, which was expected since the vehicle impacted both sign support posts simultaneously and the entire sign assembly was dislodged from its bases and displaced by the impacting vehicle, as discussed previously under Test Number 1. The sign panel was separated from the sign assembly. However, the detached elements remained in the same general area and did not present any undue hazard to other traffic. Overall, the sign assembly received moderate damage (as shown in Figures 18 and 19) and was repairable.

The vehicle sustained moderate damage to the bumper, grill, radiator, hood, headlights, and the right and left front quarter panels as shown in Figure 20. Vehicle crush at bumper height was 9 inches (22.9 cm) at the right front corner and 12 inches (30.5 cm) at the left front corner.

A summary of the test results and other information pertinent to this test are given in Figure 21. The data presented for change in vehicle velocity and momentum represents the conditions present at the time the vehicle initially lost contact with the sign assembly. The maximum 0.050-second average acceleration experienced by the vehicle was -7.3 g in the longitudinal direction and -1.5 g in the lateral direction. Vehicle angular displacements are plotted in Figure 22 and vehicle accelerometer traces are displayed in Figures 23 through 25. Occupant impact velocity in the longitudinal direction was 14.2 feet per second (4.3 m/s) and 6.7 feet per second (2.0 m/s) in the lateral direction. The highest 0.10-second average occupant ridedown acceleration was -1.2 g (longitudinal) and 1.3 g (lateral). At 0.078 second after impact, i.e., the time at which the vehicle lost contact with the sign support posts, the change in velocity was 8.1 mi/h (13.0 km/h) and the change in momentum was 664 lb-s.

In summary, the sign installation yielded to the impacting vehicle by activating the slip-base breakaway mechanism. The vehicle sustained moderate damage and was stable throughout the collision without exhibiting any tendency of rollover or instability. Neither the vehicle nor the sign installation presented any undue hazard to other traffic after the impact. The occupant impact velocity was below the NCHRP Report 230 recommended limit of 15 feet per second, and the change in momentum was under the recommended limit of 750 lb-sec.

FINDINGS AND CONCLUSIONS

Results of the two crash tests indicate that the Louisiana two-post, inclined, slip-base sign assembly with cluster sign attachment meets with the guidelines set forth in NCHRP Report 230 and AASHTO standards.

The sign supports broke away readily in both the low-speed and the high-speed tests through activation of the slip-base breakaway mechanism. The upper hinge connections did not play a major role in the breakaway sequence since the vehicle impacted both sign support posts simultaneously and the entire sign assembly was dislodged from its bases and displaced by the impacting vehicle.

The sign panel did slap the rear of the roof of the vehicle and the support posts contacted the rear of the vehicle in the low-speed test, but the impact was very minor with little resulting damages to the vehicle and there was no penetration of the test object into the passenger compartment. The vehicle sustained minor to moderate damages in the two tests and was stable throughout the collision without exhibiting any tendency for rollover or instability. Neither the vehicle nor the sign installation presented any undue hazard to other traffic after the impact in both tests.

The occupant impact velocity was 11.2 feet per second for the low-speed test and 14.2 feet per second for the high-speed test, both well below the limit of 15 feet per second as recommended in NCHRP Report 230. The change in momentum was under the desirable limit of 750 lb-sec in both tests (270 and 664 lb-sec).

In summary, the Louisiana two-post inclined slip-base sign assembly with cluster sign attachment as tested in this study conformed to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO standards. There is no indication that the attachment of sign clusters to the support posts poses any potential adverse effect on the impact performance of the slip-base breakaway design.