Minnesota Swing-Away Mailbox Support

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A swing-away mailbox support was designed by the Minnesota Department of Transportation (MnDOT) for use in locales where snow and ice removal during the winter presents a problem. The Minnesota swing-away mailbox support design uses a cantilevered arm for attachment of the mailbox assembly. The cantilever arm design is intended to allow for more efficient snow plowing operation without damaging the mailbox support, which presents a maintenance problem. The design allows complete snow removal beyond the shoulder or curbline, thus reducing snow-drifting on the roadway. It is easily installed with existing highway agency equipment, can be salvaged and reinstalled, and costs considerably less than current mailbox designs approved by MnDOT. The results of four full-scale crash tests conducted on this Minnesota swing-away mailbox support and the evaluation of its impact performance are presented. The mailbox support with a single mailbox assembly was judged to have successfully met all evaluation criteria outlined in *NCHRP Report 350* and the 1985 AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*. However, the mailbox support with a triple mailbox assembly was judged to have failed to meet the evaluation criteria.

The Minnesota Department of Transportation (MnDOT) has designed a swing-away mailbox support suitable for use in locales where snow and ice removal during the winter presents a problem. The Minnesota swing-away mailbox support design uses a cantilevered arm for attachment of the mailbox assembly. The cantilever design is intended to allow for snow plowing operation without damaging the mailbox support, which presents a maintenance problem. The design allows complete snow removal beyond the shoulder or curbline, thus reducing snow-drifting on the roadway. It is easily installed with existing highway agency equipment, can be salvaged and reinstalled, and costs considerably less than current mailbox designs approved by MnDOT. This paper presents the results of four full-scale crash tests conducted on this Minnesota swing-away mailbox support and the evaluation of its impact performance. Testing and evaluation were performed in accordance with guidelines outlined in *NCHRP Report 350* (*1*) and the 1985 AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals* (*2*).

MINNESOTA SWING-AWAY MAILBOX SUPPORT DESIGN

The Minnesota swing-away mailbox support, a schematic diagram of which is shown in Figure 1, consists of four major components:

1. U-channel base post. A 3-lb/ft (4.46-kg/m), 60,000-lb/in^2 (413,685-kN/m^2) U-channel sign post is driven into the ground as a base post, leaving a stub height of approximately 18 in. (0.46 m) above ground level. The minimum specified embedment depth of the post is 4 ft (1.22 m) so that either a 6-ft (1.83-m)-long or a 7-ft (2.13-m)-long post may be used with the installation. A 7-ft (2.13-m)-long post was used in the crash tests since it was considered to be a more critical condition from a base bending standpoint. Note that the strong axis of the U-channel post is aligned with the direction of vehicle travel.

2. Vertical support. A vertical support, made from 1.66-in. (42-mm)-outsider-diameter, 1.38-in. (35-mm)-inside-diameter standard-weight pipe, is bolted to the post stub with two 3/8-in. × 2.5-in. (9.5-mm × 64-mm) bolts spaced 12 in. (0.31 m) apart. The locations of the bolts are adjustable so that the height of the mailbox above the roadway surface is between 38 and 42 in. (0.97 and 1.07 m). A midrange mailbox height of 40 in. (1.02 m) was used in the crash tests. The top 12 in. (0.31 m) of the pipe is bent at a 45-degree angle. A 16-in. (0.41-m)-long, 1.315-in. (33-mm)-outside-diameter, 1.049-in. (27-mm)-inside-diameter standard-weight pipe is inserted into the bent end of the vertical support and is welded in place. The insert pipe extends 8 in. (203 mm) beyond the end of the vertical support for attachment of the cantilever arm. A groove, 1/2 in. (13 mm) wide and 1/8 in. (3.2 mm) deep, is cut into the insert pipe 3 in. (76 mm) above the end of the vertical support for use with a 1/4-in. (6.4-mm)-diameter set screw to attach the cantilever arm. The set screw and groove configuration renders removal of the cantilever arm more difficult, to discourage vandalism, although it still allows the cantilever arm to rotate freely about the insert pipe and to separate readily from the vertical support on impact.

3. Cantilever arm. A cantilever arm, also made from 1.66-in. (42-mm)-outside-diameter, 1.38-in. (35-mm)-inside-diameter standard-weight pipe, connects the vertical support to the mailbox assembly. The cantilever arm is 48 in. (1.22 m) in length, 12 in. (0.31 m) of which is bent at 45 degrees for attachment to the insert pipe. Two 1/8-in. (3.2-mm)-thick, 5-in. (127-mm)-long, 1-in. (25-mm)-wide metal straps, one at the end of the cantilever arm and the other spaced 12 in. (0.31 m) apart, are welded to the top of the pipe. Two 5/16-in. (7.9-mm) holes, spaced 4 in. (102 mm) center to center, are drilled in the straps for attachment of the mailbox assembly to the cantilever arm. An alternative design shortens the metal strap to only 2.5 in. (64 mm) in length with a single 5/16-in. (7.9-mm)-diameter hole drilled through the center of the pipe and strap. The purpose of the shorter strap is to minimize the potential of the straps penetrating the windshield if they should become exposed during an impact. It was decided to use the longer metal strap attachments for the test installation since that would be the more critical design from a safety standpoint.

For the triple mailbox assembly, the cantilever arm consists of standard-weight pipe for the bent portion of the arm that attaches to the insert arm and the first 5 in. (127 mm) of the horizontal arm. The remainder of the horizontal arm is constructed of thin-wall pipe (such as muffler pipe) welded to the standard-weight pipe to reduce the weight of the cantilever arm. The horizontal arm forks out into three branches, spaced 12 in. (0.31 m) apart, one for each of the three mailbox assemblies.

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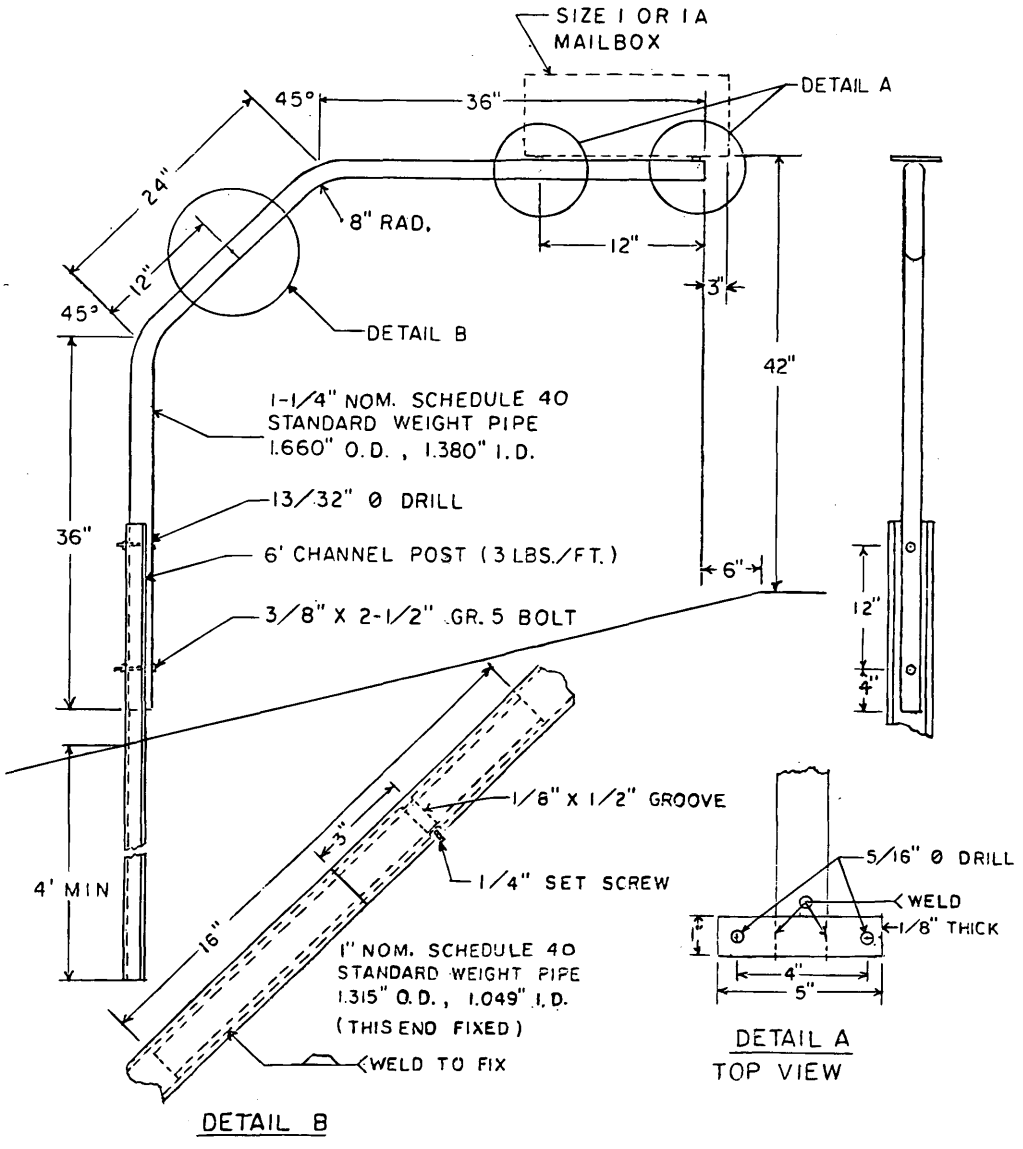


FIGURE 1 Minnesota swing-away mailbox support design.

4. Mailbox assembly. A 16-in. (0.41-m)-long, 8-in. (203-mm)-wide (nominal), 1-in. (25-mm)-thick (nominal) wood board is bolted to the straps on the cantilever arm with four ¼-in. (6.4-mm)-diameter, 1.5-in. (38-mm)-long carriage bolts. A size 1A mailbox is attached to the wood board with drywall (sheetrock) screws.

A standard plastic newspaper tube is also attached to one side of the mailbox assembly with a 16-gage metal bracket. The plastic newspaper tube is attached to the metal bracket with two ¼-in. × ½-in. (6.4-mm × 13-mm) bolts, and the metal bracket is attached to the bottom of the wood board with four 1-in. (25-mm) drywall screws. This attachment configuration has been approved by the U.S. Postal Service.

The attachment of the mailboxes to the cantilever arm for the triple mailbox assembly was similar to that of the single mailbox assembly. For each mailbox assembly, a wood board was bolted to the cantilever arm and the mailbox was attached to the wood board with drywall screws. A single plastic newspaper tube was attached to one end (nonimpact end) of the triple mailbox assembly.

Photographs of the mailbox test installation and details of the mounting bracket and the post attachment are shown in Figures 2 and 3, respectively.

CRASH TEST MATRIX

Four full-scale crash tests were conducted to evaluate the impact performance of the Minnesota swing-away mailbox support:

1. *NCHRP Report 350* (*1*) Test Designation 3-60 (Test 7147-11). An 820-kg (1,808-lb) passenger car struck the vertical mailbox support head-on at a nominal speed of 35 km/hr (21.7 mph) and 0 degrees. The mailbox support was aligned with the right front quarter point of the vehicle.
2. *NCHRP Report 350* (*1*) Test Designation 3-61 (Test 7147-12). An 820-kg (1,808-lb) passenger car struck the mailbox support head-on at a nominal speed of 100 km/hr (62.1 mph) and 0 degrees.

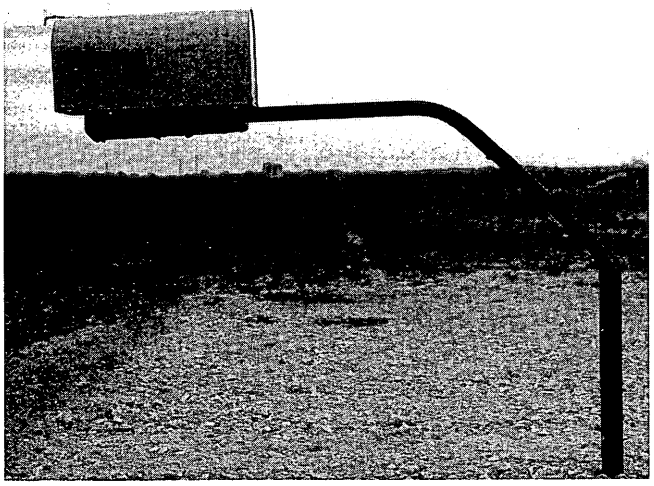


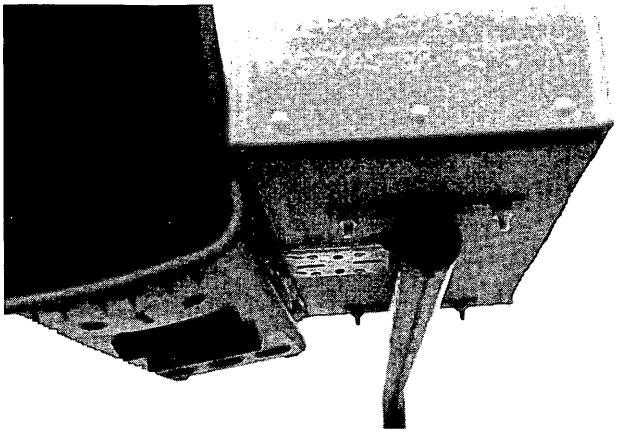
FIGURE 2 Minnesota swing-away mailbox installation.

The mailbox support was aligned with the right front quarter point of the vehicle.

3. Test 7147-13. An 820-kg (1,808-lb) passenger car struck a single mailbox assembly head-on at a nominal speed of 100 km/hr (62.1 mph) and 0 degrees. The centerline of the mailbox assembly was aligned with the centerline of the vehicle.

4. Test 7147-14. This test was identical to Test 7147-13 except for the mailbox assembly, to which three mailboxes instead of a single mailbox were attached.

In accordance with the crash test matrix for support structures outlined in *NCHRP Report 350* (*1*), two crash tests are required for evaluation of the mailbox support, which are Tests 3-60 and 3-61.



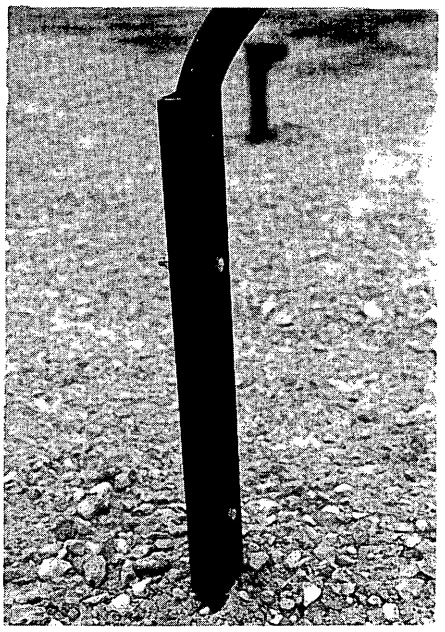


FIGURE 3 Mounting bracket and post attachment.

The objective of the low-speed test (Test 3-60) is to evaluate the breakaway, fracture, or yielding mechanism of the support, whereas the objective of the high-speed test (Test 3-61) is to evaluate the vehicle and test article trajectory. The right front quarter point of the vehicle was selected as the point of impact so that the interaction between the cantilevered arm and the mailbox assembly with the windshield of the vehicle can be evaluated.

The third (Test 7147-13) and fourth (Test 7147-14) tests in which the mailbox assembly directly impacts the windshield of the vehicle are not specifically required according to guidelines set forth in *NCHRP Report 350* (*1*) but they are included because of the cantilever design of the mailbox support. Previous crash tests have shown that the mailbox assembly has the potential of striking the windshield and intruding into the passenger compartment. This potential is minimized by designing the support structure so that the front of the vehicle will contact and engage the support structure first. This allows the mailbox assembly to be pushed forward and downward or thrown up and over the vehicle, thus avoiding impact of the mailbox assembly with the windshield.

In the case of the Minnesota swing-away mailbox support, the mailbox assembly is attached to a cantilevered arm so that the mailbox assembly could impact the windshield of the vehicle without the front of the vehicle impacting the support. Since the mailbox assembly has the potential of directly impacting the windshield of the vehicle, Crash Tests 3 and 4 were included in the crash test matrix to evaluate the potential of the mailbox assembly penetrating or intruding into the occupant compartment.

RESULTS OF CRASH TESTS

All crash tests and data analysis were conducted in accordance with guidelines contained in *NCHRP Report 350* (*1*). All four crash tests were conducted with 820-kg (1,808-lb) passenger cars at a test weight of 895 kg (1,971 lb), including an uninstrumented 50th percentile male anthropometric dummy placed in the driver's seat. Photographs of a typical test vehicle are shown in Figure 4. The vehicles were directed into the test installation using the cable reverse tow and guidance system, and was released to be free-wheeling and unrestrained just before impact. Brief descriptions of the crash test and data analysis procedures are presented as follows.

FIGURE 4 Test vehicle.

Test 7147-11

A 1986 Yugo GV was used for the first crash test. The vehicle struck the mailbox support at a speed of 35.1 km/hr (21.8 mph). On impact the vertical support and the U-channel base post began to lean forward and the cantilever arm and mailbox assembly began to rotate toward the vehicle. The cantilever arm then separated from the vertical support. The vehicle lost contact with the cantilever arm and mailbox assembly traveling at a speed of 25.9 km/hr (16.1 mph). However, the vertical support remained in contact with the undercarriage of the vehicle until the vehicle cleared the vertical support. The brakes on the vehicle were then applied, and the vehicle subsequently came to rest approximately 24 m (80 ft) downstream from the point of impact.

The cantilever arm and mailbox assembly came to rest approximately 17 m (55 ft) downstream and 5 m (15 ft) to the right of the impact point. The cantilever arm was only scraped, and the mailbox assembly was deformed, as shown in Figure 5. The vertical support was scraped, and the U-channel base post was bent and pushed back 180 mm (7 in.) at ground level.

The vehicle (also shown in Figure 5) sustained minimal damage. There was 80 mm (3.2 in.) of permanent deformation to the bumper where contact with the vertical support and U-channel base post occurred. There were dents in the oil pan and gas tank and scrape marks along the floor pan on the right side caused by contact with the vertical support of the mailbox test installation.

FIGURE 5 Mailbox installation (*top*) and vehicle (*bottom*) after Test 7147-11.

A summary of the test results is presented in Table 1. In the longitudinal direction, occupant impact velocity was 1.9 m/sec (6.1 ft/sec), and the highest 10-msec average ridedown acceleration was 0.9 *g*. No occupant contact occurred in the lateral direction. The change in vehicle velocity at the loss of contact was 9.2 km/hr (5.7 mph).

Test 7147-12

The 1986 Yugo GV used in the first test (Test 7147-11) was repaired and used for the second crash test. The vehicle struck the mailbox vertical support at a speed of 104.9 km/hr (65.2 mph). On impact the vertical support and the U-channel base post began to lean forward and the cantilever arm and mailbox assembly began to rotate toward the vehicle. The mailbox also began to separate from the wood board that was attached to the cantilever arm. The mailbox became completely detached from the wood board, and the mailbox struck the A-pillar on the driver's side of the vehicle. The mailbox lost contact with the vehicle while the vehicle was traveling at 98.0 km/hr (60.9 mph). The vertical support and U-channel base post remained in contact with the undercarriage of the vehicle until the vehicle cleared the vertical support. The brakes on the vehicle were then applied, and the vehicle subsequently came to rest 134 m (441 ft) downstream from the point of impact.

The mailbox installation separated into several pieces as shown in Figure 6. The plastic newspaper tube landed 15 m (48 ft) downstream and 8 m (25 ft) to the left of the point of impact. The deformed mailbox landed 18 m (60 ft) downstream and 5 m (18 ft) to the left of the point of impact. The cantilever arm and wood board were found 22 m (72 ft) downstream and 12 m (38 ft) to the left of the point of impact. The vertical support arm was only scraped, and the U-channel base post was bent and pushed back 150 mm (6 in.) at ground level.

The vehicle sustained minimal damage, as shown in Figure 6. There was 120 mm (4.8 in.) of permanent deformation to the bumper where contact with the vertical support and the U-channel base post occurred. The A-pillar on the driver's side was deformed from impact by the mailbox, and the windshield was cracked around the point of impact. The door post on the driver side was bent and the glass was broken out. There was also damage to the hood and grill and the right rear tire and rim. There was a dent in the gas tank, and there were scrape marks and a dent along the floor pan on the right side of the undercarriage caused by contact with the vertical support.

A summary of the test results is presented in Table 1. In the longitudinal direction, occupant impact velocity was 1.3 m/sec (4.3 ft/sec), and the highest 10-msec average ridedown acceleration was − 2.7 *g*. In the lateral direction, occupant impact velocity was 1.4 m/sec (4.5 ft/sec), and the highest 10-msec average ridedown acceleration was 4.6 *g*. The change in vehicle velocity at the loss of contact was 6.9 km/hr (4.3 mph).

Test 7147-13

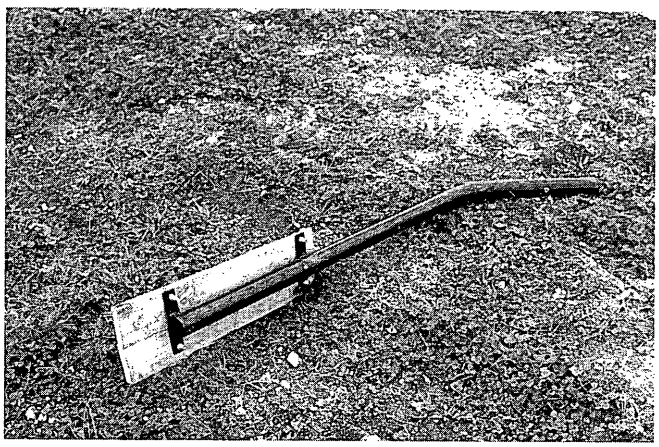
The 1986 Yugo GV used in the first two tests was repaired and used for the third crash test. The vehicle struck the mailbox assembly at a speed of 103 km/hr (64.0 mph). On impact the mailbox shattered the windshield. The cantilever arm contacted the A-pillar on the passenger's side of the vehicle, and the mailbox assembly started to rotate away from the windshield and then separated from the vertical support. The mailbox assembly and the cantilever arm then went up and over the vehicle. The vehicle was traveling at 99.6 km/hr (61.9 mph) as it lost contact with the mailbox assembly. The windshield, which was held in place by a rubber grommet, separated from the vehicle. The detached windshield first went outward and upward, contacted the roof of the vehicle, and was partially on the roof of the vehicle before eventually sliding back inside the occupant compartment after the brakes on the vehicle were applied. The vehicle subsequently came to rest 100 m (327 ft) downstream from the point of impact.

The mailbox installation separated into several pieces, as shown in Figure 7. The cantilever arm and part of the wood board landed 54 m (177 ft) downstream and 1.4 m (4.5 ft) to the right of the point of impact. The severely deformed mailbox, part of the wood board, and the plastic newspaper tube came to rest 55 m (182 ft) downstream and 0.3 m (1 ft) to the left of the point of impact. The vertical support was only scraped, and the U-channel base post was not damaged or pushed back.

The vehicle (also shown in Figure 7) sustained moderate damage. There was 30 mm (1.2 in.) of permanent deformation to the A-pillar on the passenger's side of the vehicle, and the door post on the passenger's side was deformed at the location where the cantilever arm made contact. There was also a scratch located on the left rear section of the roof from contact by the detached cantilever arm as it went over the vehicle. The windshield was broken out and was lying on the floorboard of the vehicle. However, it should be noted that the windshield actually went outward and upward after separation from the vehicle and was partially on the roof of the vehicle before falling back into the occupant compartment. The detachment of the windshield from the vehicle could be partially attributed to the poor design of the windshield, which was held in place only with a rubber grommet. Most other vehicles have a more positive

TABLE 1 Crash Test Results

Test No.	Impact Speed, km/h (mph)	Occupant Impact Velocity, m/s (ft/s)		Ridedown Acceleration, g's		Comments
		Long.	Lateral	Long.	Lateral	
7147-11	35.1 (21.8)	1.9 (6.1)	No Contact	0.9	No Contact	
7147-12	104.9 (65.2)	1.3 (4.3)	1.4 (4.5)	-2.7	4.6	
7147-13	103.0 (64.0)	No Contact	1.2 (3.9)	No Contact	1.0	Windshield cracked and separated from vehicle
7147-14	101.0 (62.8)	0.9 (2.8)	No Contact	-0.3	No Contact	Windshield penetrated by mailbox assembly



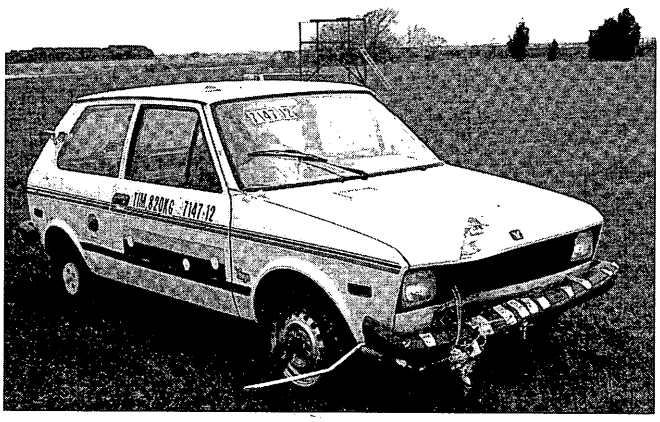


FIGURE 6 Mailbox installation (*top* and *middle*) and vehicle (*bottom*) after Test 7147-12.

mechanism for attaching the windshield to the vehicle. In additions previous crash tests caused damage to the A-pillar, which might have further weakened the attachment mechanism.

A summary of the test results is presented in Table 1. No occupant contact occurred in the longitudinal direction. In the lateral

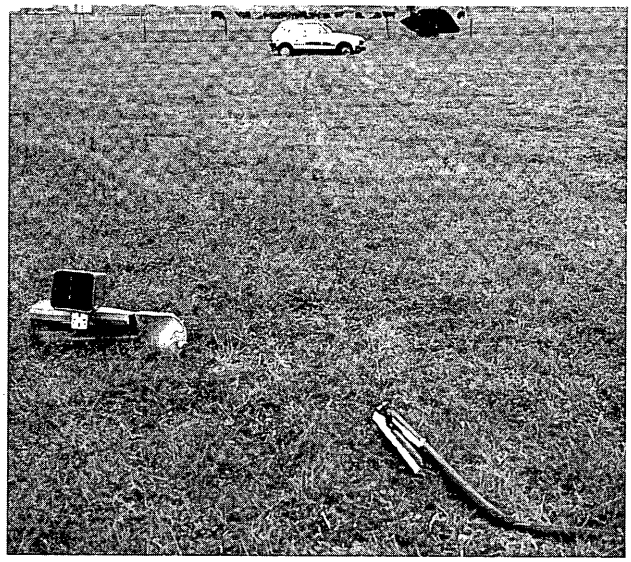


FIGURE 7 Mailbox installation (*top*) and vehicle (*bottom*) after Test 7147-13.

direction, occupant impact velocity was 1.2 m/sec (3.9 ft/sec), and the highest 10-msec average ridedown acceleration was 1.0 *g*. The change in vehicle velocity at the loss of contact was 3.4 km/hr (2.1 mph).

Test 7147-14

A 1989 Yugo GVL was used for the fourth crash test. The vehicle struck the triple mailbox assembly at a speed of 101 km/hr (62.8 mph). On impact the mailbox assembly shattered the windshield, and the first mailbox bounced up and struck the edge of the roof just above the windshield. The cantilever arm then contacted the A-pillar on the passenger's side of the vehicle, and the cantilever arm and mailbox assembly separated from the vertical support at 41 m/sec after impact. The cantilever arm and mailbox assembly intruded into the occupant compartment of the vehicle and rode along partially in the compartment and partially on the hood of the vehicle. The brakes on the vehicle were applied, and the vehicle subsequently came to rest 121 m (397 ft) downstream from the point of impact.

The test site and components of the mailbox test installation after the test are shown in Figure 8. The mailbox assembly was de-

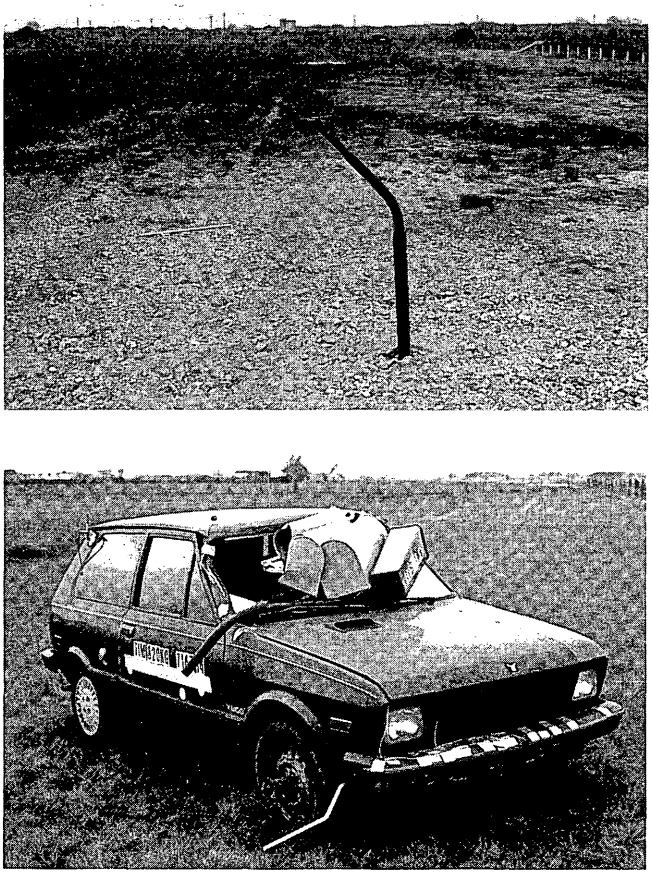


FIGURE 8 Mailbox installation (*top*) and vehicle (*bottom*) after Test 7147-14.

formed, but it remained attached to the cantilever arm and remained with the vehicle through final rest. The vertical support was only scraped, and the U-channel base post was bent slightly.

The vehicle sustained moderate damage around the windshield area, as shown in Figure 8. The mailbox assembly intruded into the occupant compartment through the windshield and remained partially in the compartment throughout the test period. The roof of the vehicle was deformed upward from the inside of the vehicle approximately 50 mm (2 in.). The passenger's side door was pushed out 40 mm (1.6 in.), and the glass was shattered. The A-pillar and door post on the passenger's side was also deformed.

In the longitudinal direction, occupant impact velocity was 0.9 m/sec (2.8 ft/sec), and the highest 10-msec average ridedown acceleration was −0.3 *g*. No occupant contact occurred in the lateral direction. The change in velocity at the loss of contact was not applicable since the mailbox assembly and the cantilever arm remained in contact with the vehicle throughout the test period.

SUMMARY OF FINDINGS AND DISCUSSION OF RESULTS

The Minnesota swing-away mailbox support with a single mailbox assembly was judged to have successfully met all evaluation criteria set forth in *NCHRP Report 350* (*1*) and the 1985 AASHTO *Standard Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals* (*2*).

The first two crash tests (Tests 7147-11 and 7147-12) involving impacts with the vertical supports of the mailbox installations with single mailbox assemblies showed occupant impact velocities and ridedown accelerations that were well below the preferred limiting values of 3 m/sec (11.8 ft/sec) and 15 *g*, respectively. No penetration or intrusion into the occupant compartment occurred. Debris from the test installation, which consisted of the cantilever arm and the mailbox assembly, remained close to the approximate path of the vehicle and did not pose any potential hazard to adjacent traffic. The vehicle remained stable during and after the impact sequence.

The third crash test (Test 7147-13) with the single mailbox assembly directly struck and damaged the windshield, but the windshield kept the mailbox assembly from intruding or penetrating into the occupant compartment. Damage to the windshield is normally not considered a desirable behavior since it could obstruct the driver's vision or otherwise cause the driver to lose control of the vehicle. However, given the need for a cantilever design because of the snow-plowing operation, damage to the windshield is considered an acceptable trade-off provided that there was no intrusion or penetration into the occupant compartment. It is recommended that the maximum size of mailbox used with the support be limited to size 1A or smaller.

The fourth crash test (Test 7147-14) with triple mailbox assembly was judged to have failed to meet the evaluation criteria set forth in *NCHRP Report 350* (*1*). The mailbox assembly shattered the windshield and substantially intruded and penetrated into the occupant compartment, which was judged to be unacceptable. It appeared that two factors contributed to the unsatisfactory performance: (*a*) the combined weight of the triple mailbox assembly and the cantilever arm was 19 kg (42 lb), which was more than double the weight of 8.8 kg (19.5 lb) for the single mailbox assembly, and (*b*) the width of the triple mailbox assembly allowed the mailbox assembly to impact and penetrate the windshield before the cantilever arm struck the A-pillar of the vehicle, which would have partially counteracted against the force of the mailbox assembly into the windshield. In light of the unsatisfactory performance of the triple mailbox assembly, the use of the swing-away mailbox support design should be limited to only a single mailbox assembly. At locations where multiple mailboxes are to be installed, it is recommended that each mailbox be installed on its own support and that they be spaced at least 36 in. (0.91 m) apart to allow for unrestricted functioning of the cantilever arm.

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2. *Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals*. AASHTO, Washington, D.C., 1985.