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TEXAS HIGHWAY DEPARTMENT

COOPERATIVE RESEARCH

CRASH TESTS AND EVALUATION OF SINGLE POST HIGHWAY SIGNS

in cooperation with the
Department of Transportation
Federal Highway Administration

RESEARCH REPORT 146-11
STUDY 2-10-68-146
ADAPTATION OF ATTENUATION SYSTEMS

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16. Abstract

Seventeen full-scale vehicle crash tests were conducted to evaluate single post roadside signs such as Mile Post Markers, Route Marker, Destination, Stop, and One Way Signs. Some of the signs were equipped with breakaway devices such as threaded pipe couplings and multi-directional slip bases. Other signs were mounted on delineator posts and small diameter pipe which bent down on vehicle impact.

The test vehicles were 1965 Ford sedans weighing approximately 4000 lb. The vehicles were towed into the signs at nominal impact speeds of 30, 45 and 60 mph. Highspeed photography was used as the primary source of data aquisition. The initial vehicle impact with all signs was relatively minor with change in vehicle speeds ranging from 0.5 mph to 2.6 mph. Some potentially hazardous secondary collisions of the signs with the vehicle's windshield and roof were found. Recommendations to minimize or eliminate this secondary collision were set forth.

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CRASH TESTS AND EVALUATION OF SINGLE POST HIGHWAY SIGNS

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Research Report Number 146-11
Studies of Field Adaptation of Impact Attenuation Systems
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Sponsored by
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ABSTRACT

Seventeen full-scale vehicle crash tests were conducted to evaluate single post roadside signs such as Mile Post Markers, Route Marker, Destination, Stop, and One Way Signs. Some of the signs were equipped with breakaway devices such as threaded pipe couplings and multi-directional slip bases. Other signs were mounted on delineator posts and small diameter pipe which bent down on vehicle impact.

The test vehicles were 1965 Ford sedans weighing approximately 4000 lb. The vehicles were towed into the signs at nominal impact speeds of 30, 45 and 60 mph. Highspeed photography was used as the primary source of data aquisition. The initial vehicle impact with all signs was relatively minor with change in vehicle speeds ranging from 0.5 mph to 2.6 mph. Some potentially hazardous secondary collisions of the signs with the vehicle's windshield and roof were found. Recommendations to minimize or eliminate this secondary collision were set forth.

Key Words: Highway Safety, Safer Sign Supports, Full-Scale Crash Testing, Breakaway Signs.

SUMMARY

Seventeen full-scale vehicle crash tests were conducted to evaluate single post roadside signs such as Mile Post Markers, Route Marker, Destination, Stop, and One Way Signs. Some of the signs were equipped with breakaway devices such as threaded pipe couplings and multi-directional slip bases. Other signs were mounted on delineator posts and small diameter pipe which bent down on vehicle impact.

The test vehicles were 1964 Ford sedans weighing approximately 4000 lb. The vehicles were towed into the signs at nominal impact speeds of 30, 45 and 60 mph. Highspeed photography was used as the primary source of data aquisition. The initial vehicle impact with all signs was relatively minor with change in vehicle speeds ranging from 0.5 mph to 2.6 mph. Some potentially hazardous secondary collisions of the signs with the vehicle's windshield and roof were found. Recommendations to minimize or eliminate this secondary collision were set forth.

The following conclusions and recommendations were developed from the vehicle crash tests results presented.

MILE POST MARKER SIGNS

1. The standard Texas Mile Post Marker sign mounted on delineator post (which does not conform to the new MUTCD standard) was less hazardous to the impacting vehicle. In collisions at speeds from 28 mph to 61 mph, the change in vehicle speed ranged from 0.5 mph to 0.9 mph respectively. The sign bent down in low to medium speed impacts

and hooked on the hood at high speeds. No secondary collisions occurred.

2. The standard MUTCD Mile Post Marker panel mounted on a 1.25 in. diam. pipe driven into the soil was the next less hazardous to the impacting vehicle. In collisions at speed ranging from 31 mph to 59 mph, the change in vehicle speed ranged from 1.4 mph to 0.5 mph respectively. The sign bent down at low speed and pulled out and hooked over the vehicle hood at medium and high speeds. No secondary collisions occurred.

3. The standard MUTCD Mile Post Marker panel mounted on a 1.25 in. diam. pipe cast in an 8 in. diam. concrete shaft 2 ft - 6 in. deep was the next less hazardous to the impacting vehicle. In collisions at speeds ranging from 38 mph to 57 mph, the change in vehicle speed ranged from 1.3 mph to 0.9 mph respectively. The sign post bent down in all cases. At high speed the aluminum sign panel came off and struck the windshield, cracking it. The panel to post connection can be strengthened.

4. The standard MUTCD Mile Post Marker panel mounted on a 2 in. diam. pipe with threaded coupling at the base as a breakaway feature was the most hazardous. In Test S-1 with no pipe insert, the sign pulled out of the coupling and struck and penetrated the vehicle windshield. In Test S-7 with a 1.5 in. diam. pipe insert the secondary collision was prevented, however, the vehicle change in speed was 2.6 mph for the 47.5 mph impact.

STOP SIGN

5. The standard Texas Highway Department Stop Sign mounted on a 2.5 in. diam. pipe with a threaded coupling at the base as a "breakaway" feature was satisfactory. The change in speed at 45 mph was 1.7 mph. The pipe pulled out of the coupling and rotated and struck the rear roof of the car.

ONE WAY SIGN

6. The standard Texas Highway Department One Way Sign mounted on a 2.5 in. diam. pipe with a threaded coupling at the base as a breakaway feature was satisfactory. However, the connection of the sign panel to the pipe support needs strengthening to prevent the panel from coming off during vehicle impact and striking the vehicle. In collisions of speeds ranging from 30 mph to 58 mph the change in vehicle speed ranged from 2.3 mph to 1.3 mph respectively. The post pulled out of the threaded coupling and hooked on the vehicle hood in all cases.

ROUTE MARKER SIGN

7. The typical Texas Highway Department Route Marker mounted on a 3 in. diam. pipe with a multi-direction slip base as a breakaway feature behaved satisfactory. In collisions at speeds ranging from 31 mph to 46 mph, the change in vehicle speed was 0.9 mph to 0.8 mph respectively. In all cases the slip base activated, the sign post

rotated 180° and struck the trailing end of the vehicle's trunk.

DESTINATION SIGN

8. The typical Texas Highway Department Destination Sign mounted on a 5 in. diam. pipe with a multi-directional slip base as a breakaway feature is adequate. Adding riser plates to the slip base to propel the sign upward on impact could reduce or eliminate the secondary impact with the vehicle roof. When impacted at 45 mph, the change in vehicle speed ranged from 1.4 to 1.7 mph. The slip base activated and the sign post rotated about 110° and struck the roof of the vehicle.

IMPLEMENTATION STATEMENT

These crash tests were conducted at the request of Texas Highway Department engineers who were in the process of revising the State Standard Designs for small single post guide signs and route markers. The tests were conducted to evaluate existing designs and proposed new designs. By the time the report is published, many of the significant findings will have been incorporated in the revised standard designs drawings.

ACKNOWLEDGMENTS

Information contained in this report was developed on a cooperative research study sponsored jointly by the Texas Highway Department and the Federal Highway Administration. Liaison was maintained through Mr. John Nixon of the Texas Highway Department in Austin.

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INTRODUCTION

In October of 1972, a full-scale vehicle crash test (S-1) was conducted for the Texas Highway Department on a proposed mile post marker, with a 2 in. diam. pipe support mounted in a threaded pipe coupling (1). The vehicle was a sedan weighing 3400 lb and was towed into the mile post marker at 43.9 mph. The mile post marker, proposed for use on interstate highways, consisted of a 1 ft by 4 ft sign panel mounted on a 2 in. standard pipe 8 ft high with a threaded coupling as a breakaway feature.

The standard threaded coupling breakaway feature resulted in only 1.6 mph change in vehicle velocity during impact. However, the behavior of the sign panel and post, which struck the windshield, was considered undesirable. Penetration through the windshield was estimated to have been about 3 in. and was reduced by the sign's contact with the vehicle's cowling, windshield, wiper assembly and top of dash.

Modifications to the proposed mile post marker were indicated in order to minimize the probability of a secondary impact into the windshield and interior of the passenger compartment.

As a result of this test, the Texas Highway Department decided to conduct additional crash tests to evaluate various alternative designs for the mile post marker signs. In addition, tests were conducted to evaluate other single post roadside signs such as Route Marker, Destination, Stop, and One Way Signs.

In March and April of 1973, seventeen full-scale vehicle crash tests were conducted on the signs in question. The results of these tests are reported herein.

BRIEF DESCRIPTION OF TESTS

Full-scale vehicle crash tests were conducted in March and April of 1973 on various single post highway signs at different speeds in order to evaluate them from a safety standpoint.

The test vehicles used were two 1965 Ford sedans. The first vehicle, weighing 3970 lb, was used in Tests S-2 through S-11. The second vehicle weighing 4170 lb was used in test S-12 through S-18. The vehicles were towed into the signs with nominal impact speeds of 30, 45, and 60 mph employing a cable and pulley arrangement. A release mechanism was incorporated to release the vehicle immediately prior to impact. A cable stretched alongside the vehicle path and threaded through an attachment to the left front spindle of the test vehicle wheel provided directional control.

Two high speed motion picture cameras placed perpendicular to the vehicle path and operating at 400 frames per second were used to obtain time-displacement data of the vehicle. A stadia board mounted on the side of the vehicle was used to ascertain distances on the film. A tape switch fixed to the front bumper of the vehicle actuated a flash bulb that indicated the time of impact. A third camera was used to record the entire scene for an overall documentary.

Table 1 and Figure 1 present a brief summary of the test results and pertinent dimensions of the single post roadside signs tested. More detailed drawings and photographs of each sign and a discussion of the test results are presented in the body of this report. Sequence photographs of each test and detailed technical data are presented in the appendix.

TABLE 1. SUMMARY OF TEST RESULTS ON SINGLE POST ROADSIDE SIGNS
Vehicle 1965 Ford 4 door sedan (3970 lb - 4170 lb)

Test No.	Type Sign	Panel Size w	Panel Size h	Pipe Support Diam.	Pipe Support H	Embed-ment d	Breakaway Feature	Test Initial Speed	Test Change Speed	Remarks
S-2	Mile Marker	1'	4'	1.25"	8'	2'-6"	8" diam. conc.	38.2 mph	1.3 mph	sign bent down
S-12	"	"	"	"	"	"	"	56.9 mph	0.9 mph	sign bent down, panel came off hit windshield
S-3	Mile Marker	1'	4'	1.25"	8'	2'-6"	Driven in Soil	31.0 mph	1.4 mph	sign bent down
S-5	"	"	"	"	"	"	"	44.9 mph	0.8 mph	sign pulled out, hooked over hood
S-4	"	"	"	"	"	"	"	59.4 mph	0.5 mph	sign pulled out, hooked over hood
S-1	Mile Marker	1*	4'	2"	8'	2'-6"	2" cou-pling	43.9 mph	1.6 mph	sign pulled out of coupling, struck and penetrated wind-shield
S-7	"	"	"	"	"	4'	2" cou-pling w/1 1/2" insert	47.5 mph	2.6 mph	sign pulled out of coupling, hooked over hood
S-15	Tex. Mile Marker	1'	2'-8"	2.2* lb/ft	6'	2'	Driven in Soil	28.1 mph	0.5 mph	sign bent down
S-9	"	"	"	"	"	"	"	45.2 mph	0.9 mph	sign bent down
S-6	"	"	"	"	"	"	"	61.3 mph	0.9 mph	sign pulled out, bent over hood

* Delineator Post

TABLE 1. CONTINUED

	Test No.	Type Sign	Panel Size w	Panel Size h	Pipe Diam.	Support H	Embedment d	Breakaway Feature	Test Initial Speed	Test Change Speed	Remarks
	S-14	One Way	4'	1'-4"	2.5"	8'-4"	4'	2.5" coupling	30.2 mph	2.3 mph	sign pulled out, hooked over hood
6.	S-13	"	"	"	"	"	"	"	44.2 mph	1.5 mph	sign pulled out, hooked on hood, panel came off hit roof
	S-16	"	"	"	"	"	"	"	58.4 mph	1.3 mph	" " "
7.	S-10	Stop Sign	2.5'	2.5'	2.5"	9'-6"	4'	2.5" coupling	45.5 mph	1.7 mph	sign flipped over, hit roof of car
	S-17	Destination	8'6"	2'	5"	9'	4'	Multi-Dir. Slip Base	45.5 mph	1.7 mph	sign flipped over, hit roof of car
8.	S-11	"	"	"	"	"	"	"	44.5 mph	1.4 mph	" " "
	S-18	Route Marker	1'-6"	7'-10"	3"	14'10"	4'	Multi-Dir Slip	31.3 mph	0.9 mph	sign flipped over, hit trunk of car
9.	S-8	"	"	"	"	"	"	"	46.0 mph	0.8 mph	" " "

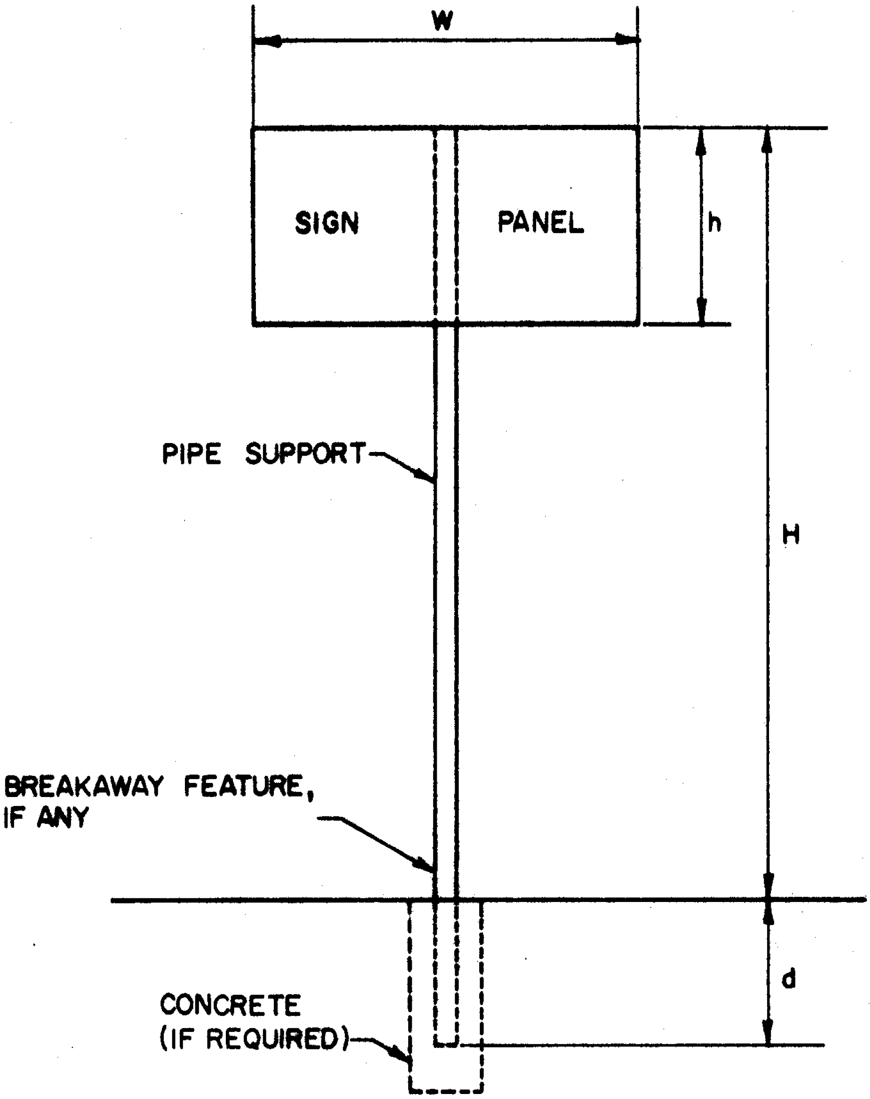


FIG. I PERTINENT DIMENSIONS OF SINGLE POST ROADSIDE SIGNS TESTED

MILE POST MARKER SIGNS

2" PIPE WITH COUPLING. The new MUTCD standard for Mile Post Marker signs requires a panel 1 ft wide by 4 ft high mounted 4 ft clear of the ground line. To meet AASHO design requirements for wind loads a 2 in. diam. pipe is required to support this panel if threaded pipe and coupling are used as a breakaway feature. Research Report 146-8 "Crash Test of Mile Post Marker" and the Introduction of this report discussed the undesirable behavior of this sign configuration (Test S-1).

Figures 2 and 3 show a similar Mile Post Marker design with a 1.5 in. diam. pipe insert placed inside the 2 in. pipe. The function of the pipe insert was to delay the rotation of the sign post after "breakaway" on impact to avoid a secondary impact of the sign post into the windshield area. The 3970 lb vehicle impacted the sign head-on at 47.5 mph and sustained a speed change of 2.6 mph. The sign behaved as intended. The pipe hooked on the car hood after "breakaway" rode with the car and no secondary collision occurred. The impact force and damage to the vehicle front end (see Figure 5) was more severe than that obtained from other designs tested.

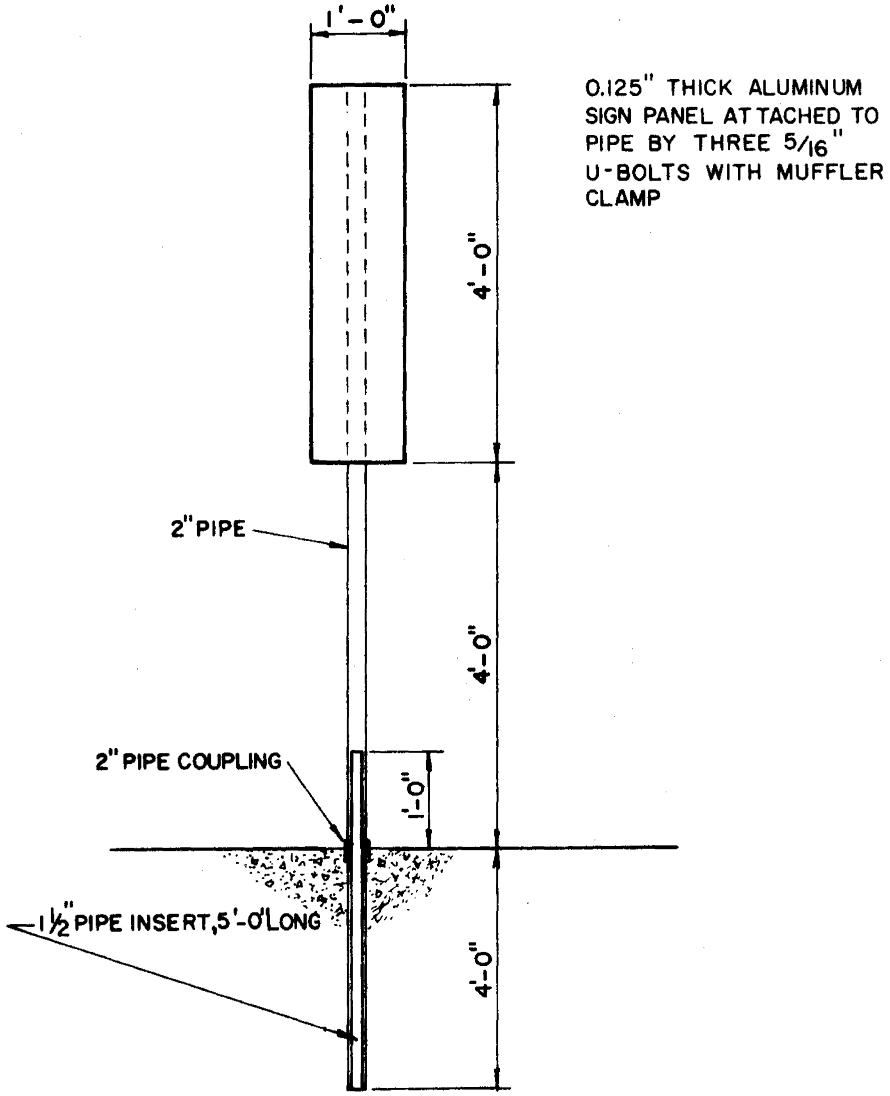


Figure 2. Mile Post Marker with pipe insert.
Test S-7, 47.5 mph, ΔV = 2.6 mph.

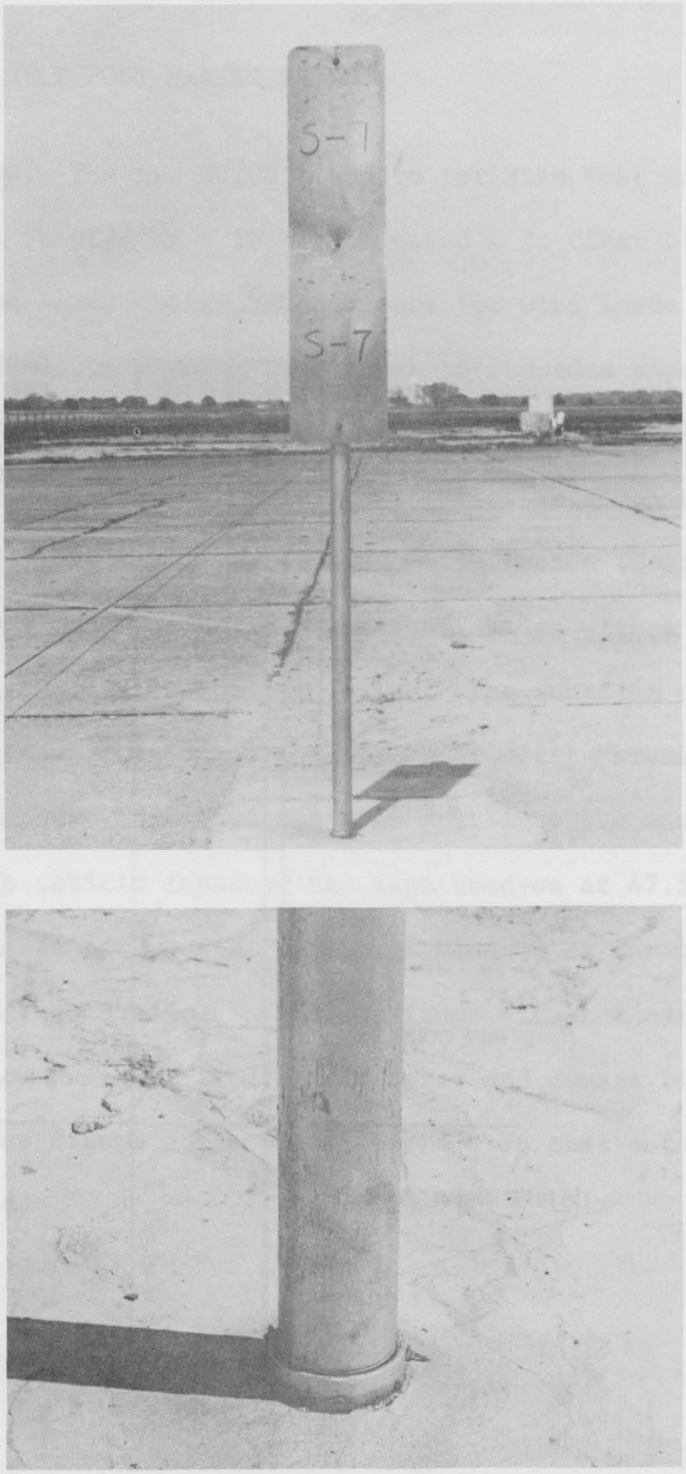
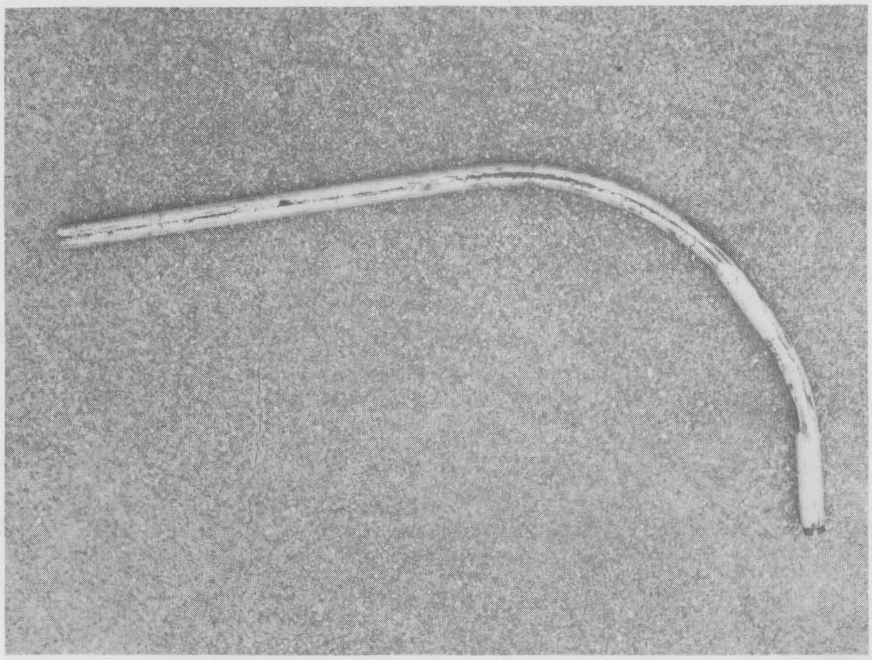


Figure 3. Mile Post Marker on 2" pipe post in threaded coupling with 1 1/2" pipe insert, Test S-7.



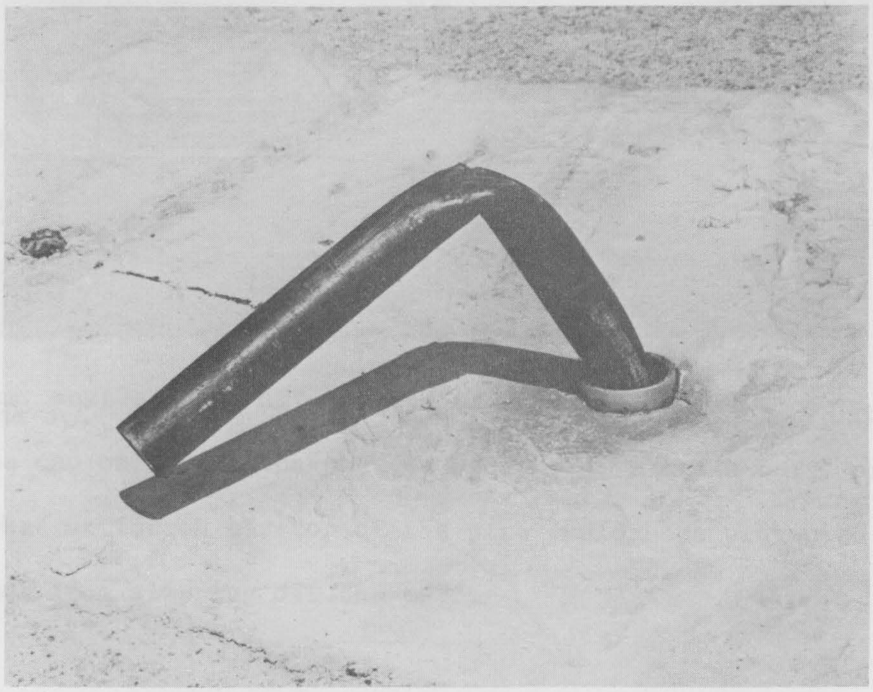


Figure 4. 2" pipe post and 1.5" pipe insert after crash.
Test S-7, 47.5 mph, ΔV = 2.6 mph.

Figure 5. Vehicle after Test S-7, 47.5 mph, ΔV = 2.6 mph.

1.25" PIPE EMBEDDED IN 8" DIAM. CONCRETE SHAFT. Figure 6 shows an alternative mile post marker sign supported by 1.25 in. diam. pipe embedded in an 8 in. diam. concrete shaft 2 ft - 6 in. deep. This design has no "breakaway" feature. It is anticipated that the small diameter pipe will bend down upon vehicle impact.

In Test S-2, this sign was impacted head-on at 38.2 mph. The post bent down as intended and the panel was stripped from the post by the undercarriage of the vehicle as shown by Figure 7. The velocity change of the vehicle was 1.3 mph and little damage was sustained (see Figure 8).

In Test S-12, the sign was impacted head-on at 56.9 mph. The post bent down as intended, however, the sign panel came off the post and hit the windshield of the vehicle (see Figures 9 and 10). The velocity change of the vehicle was 0.9 mph and it sustained a cracked windshield.

The U-bolts holding the 0.125 in. thick aluminum sign panel to the 1.25 in. diam. post slipped off the end of the pipe during impact. A threaded pipe cap on top of the post, a spot weld, a cross bolt or some other obstruction on the top of the pipe could have prevented the sign panel from slipping off the post.

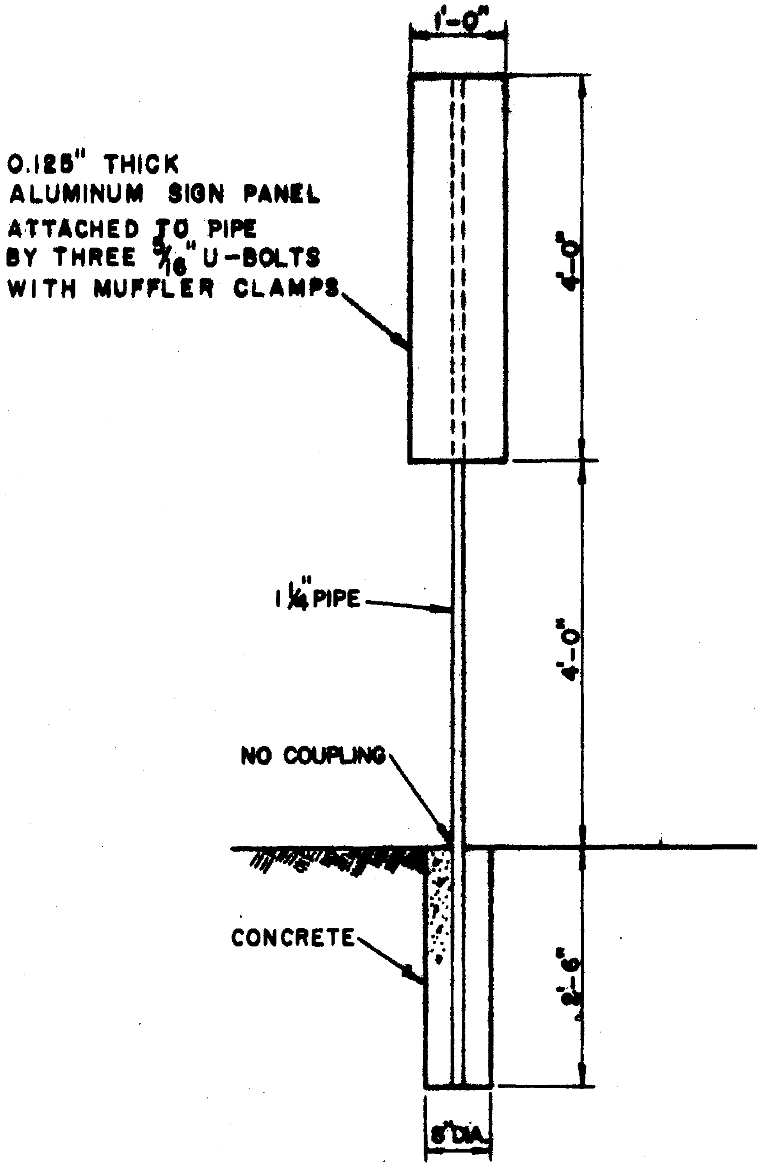
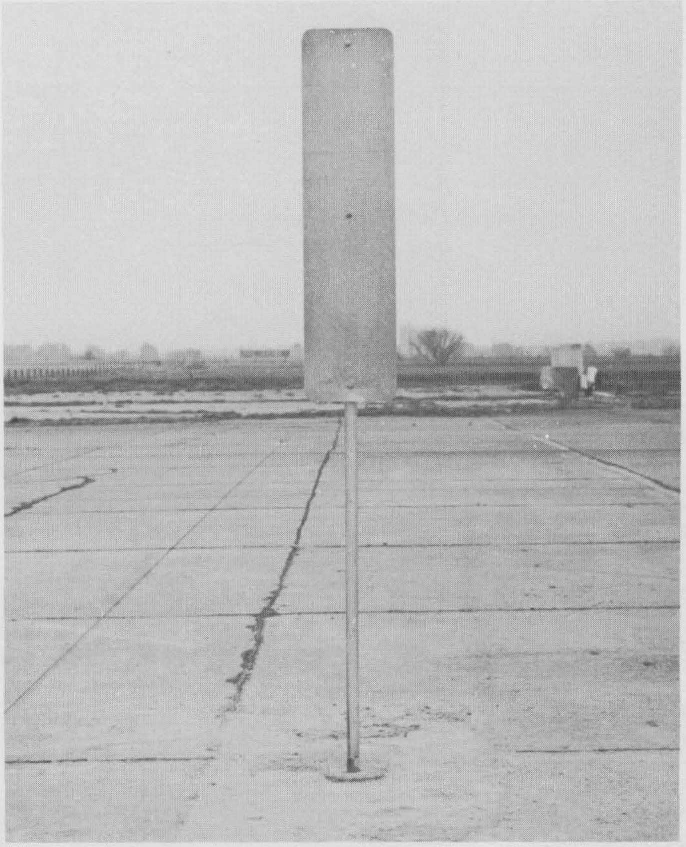


Figure 6. Mile Post Marker in concrete footing.
Tests S-2 and S-12.



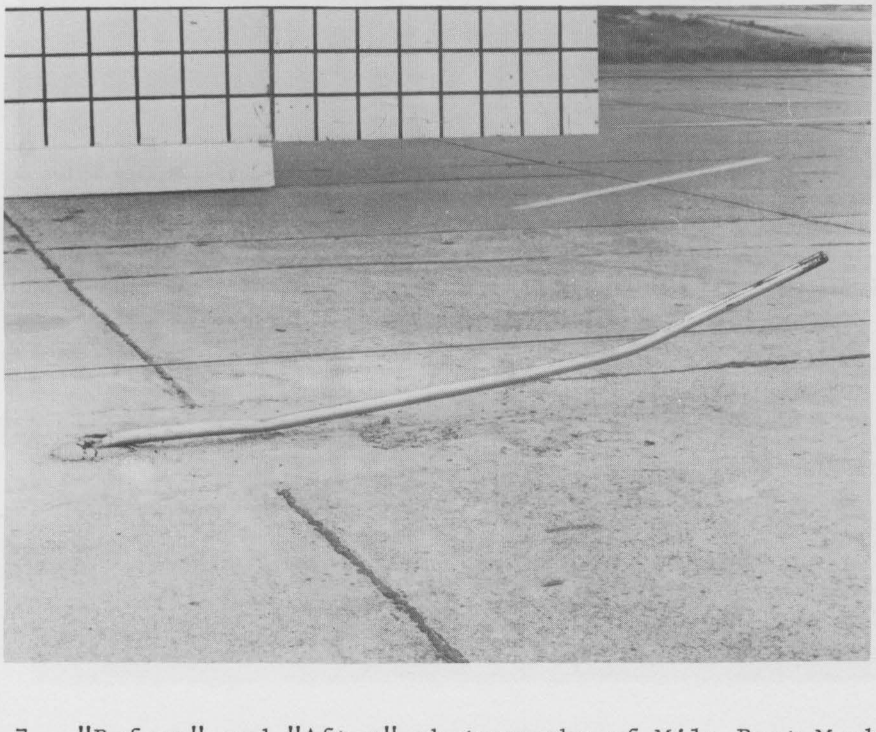


Figure 7. "Before" and "After" photographs of Mile Post Marker mounted on 1.25" pipe embedded in 8" diam. concrete shaft. Test S-2, 38.2 mph, $\Delta V \approx 1.3$ mph.

Figure 8. Vehicle after Test S-2, 38.2 mph, ΔV = 1.3 mph.

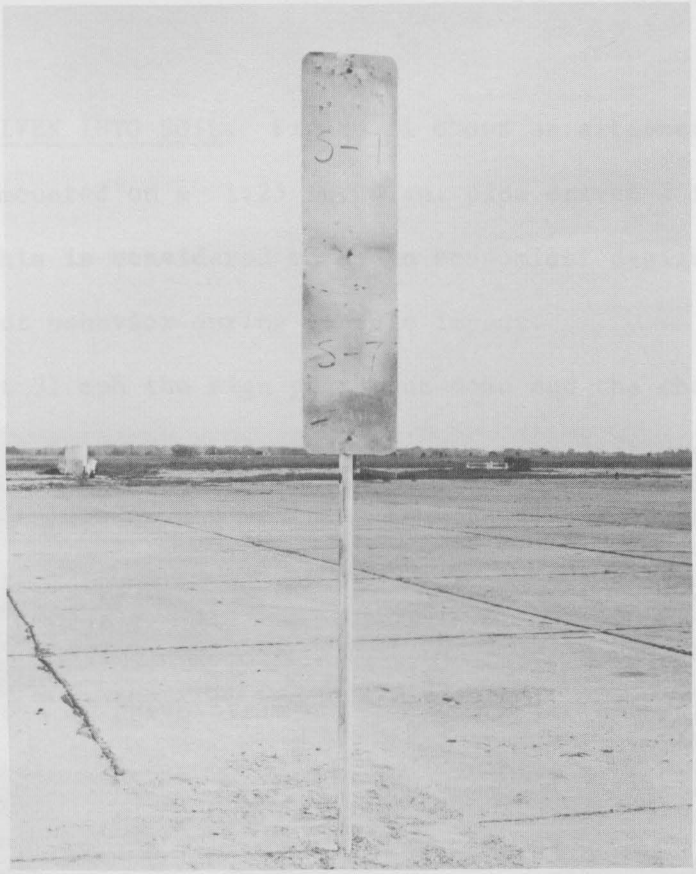


Figure 9. "Before" and "After" photographs of Mile Post Marker mounted on 1.25" pipe embedded in 8" diam. concrete shaft. Test S-12, 56.9 mph.

Figure 10. Vehicle after Test S-12. (Note cracked windshield)
56.9 mph, $\Delta V = 0.9$ mph.

1.25" PIPE DRIVEN INTO SOIL. Figure 11 shows an alternative Mile Post Marker sign mounted on a 1.25 in. diam. pipe driven 2 ft - 6 in. into the soil. This is considered to be an economical design which exhibited excellent behavior during vehicle impact.

In Test S-3 at 31 mph the sign post bent down and the change in vehicle speed was 1.4 mph (see Figure 12). The sign panel was stripped off by the undercarriage of the vehicle. No damage was sustained by the vehicle (see Figure 13).

In Test S-5 at 44.9 mph the sign post pulled out of the soil and hooked over the hood of the vehicle and rode with it (see Figure 14). The change in vehicle speed was 0.8 mph and little damage was sustained (see Figure 15).

In Test S-4 at 59.4 mph the sign post pulled out of the soil and hooked over the hood of the vehicle and rode with it (see Figure 16). The change in vehicle speed was 0.5 mph and little damage was sustained (see Figure 17).

The behavior of this design was considered excellent because the vehicle underwent small changes in velocity, sustained little damage, and there appeared to be little to no possibility of a secondary impact into the windshield or vehicle roof.

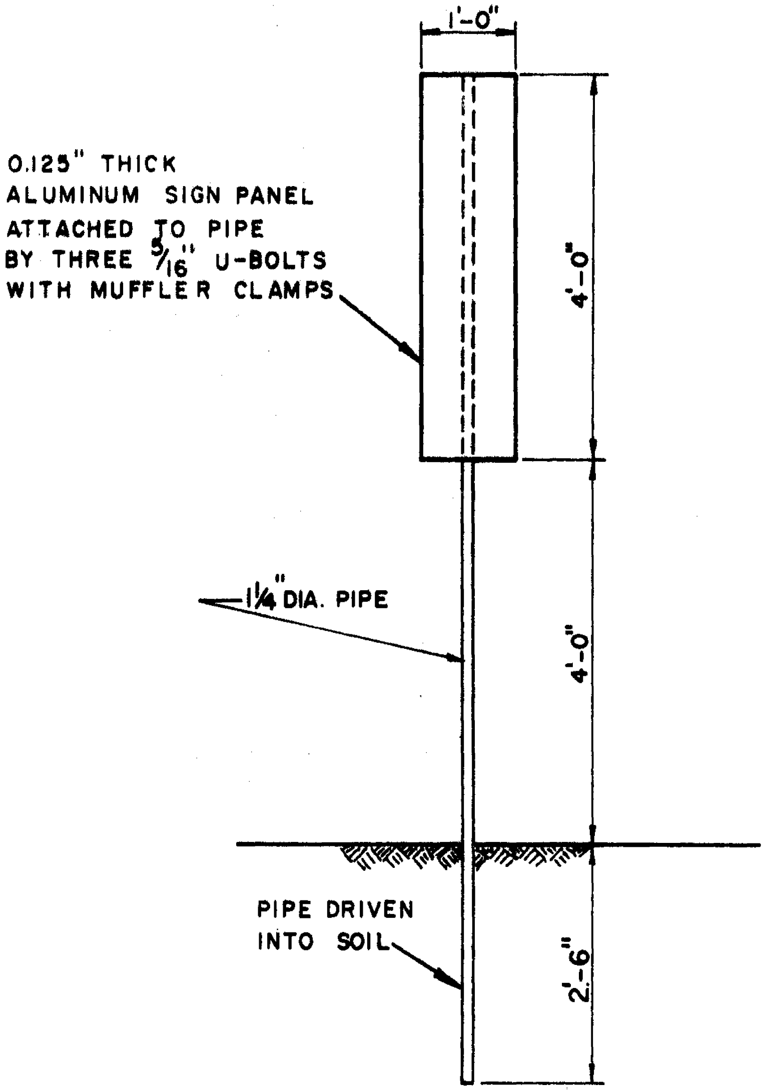


Figure 11. Mile Post Marker driven into soil.
Tests S-3, S-4, and S-5.

Figure 12. "Before" and "After" photographs of Mile Post Marker mounted on 1.25" pipe driven into soil.
Test S-3, 31 mph, ΔV = 1.4 mph.

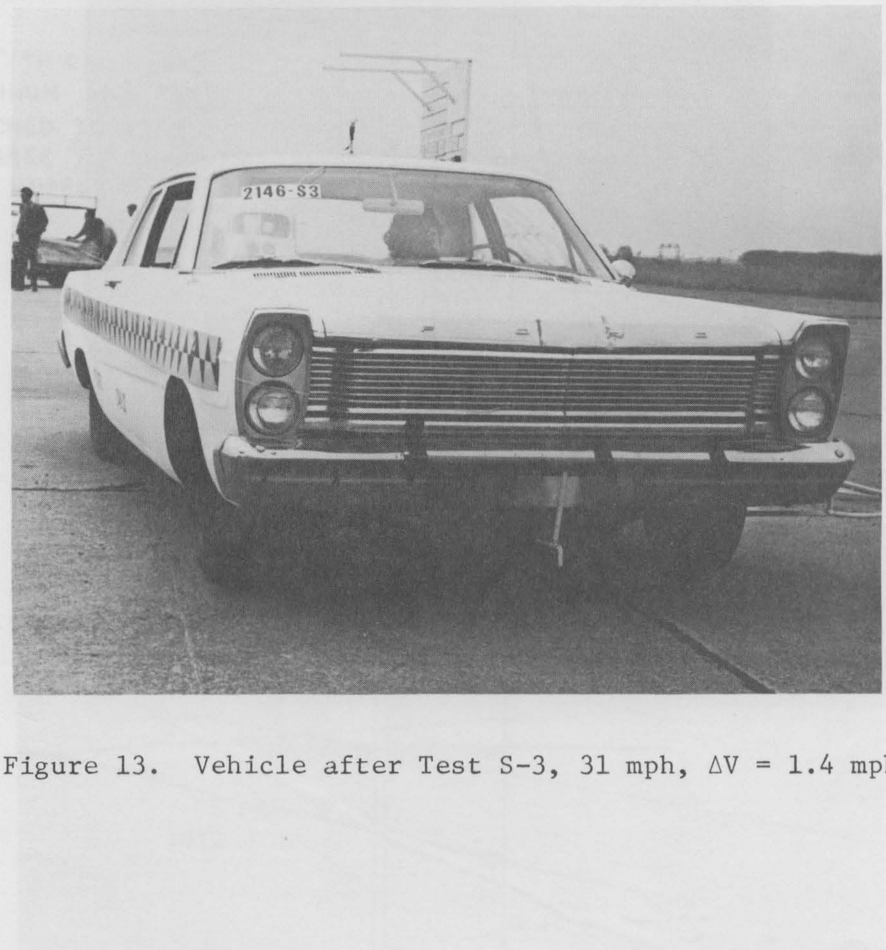
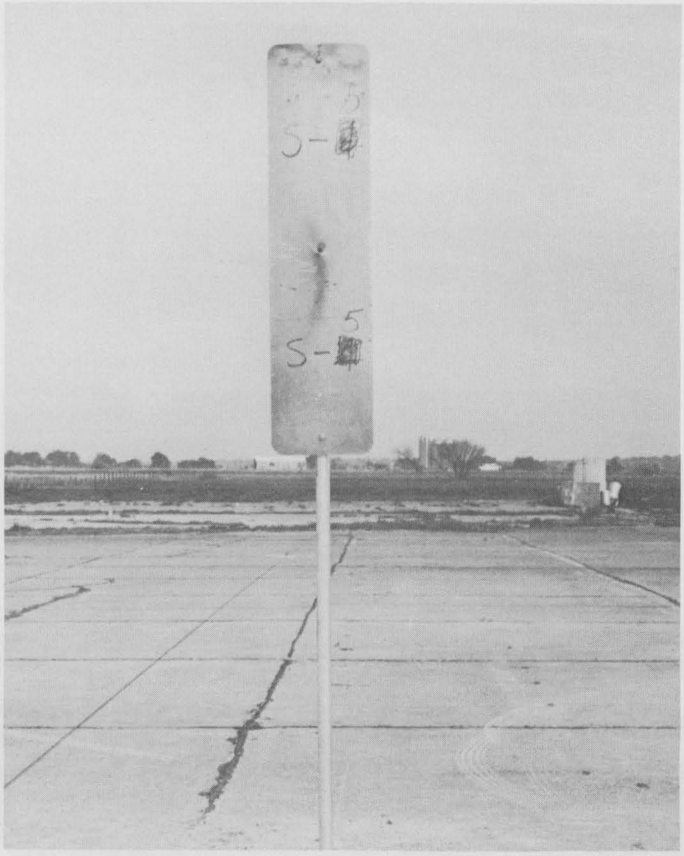


Figure 13. Vehicle after Test S-3, 31 mph, ΔV = 1.4 mph.



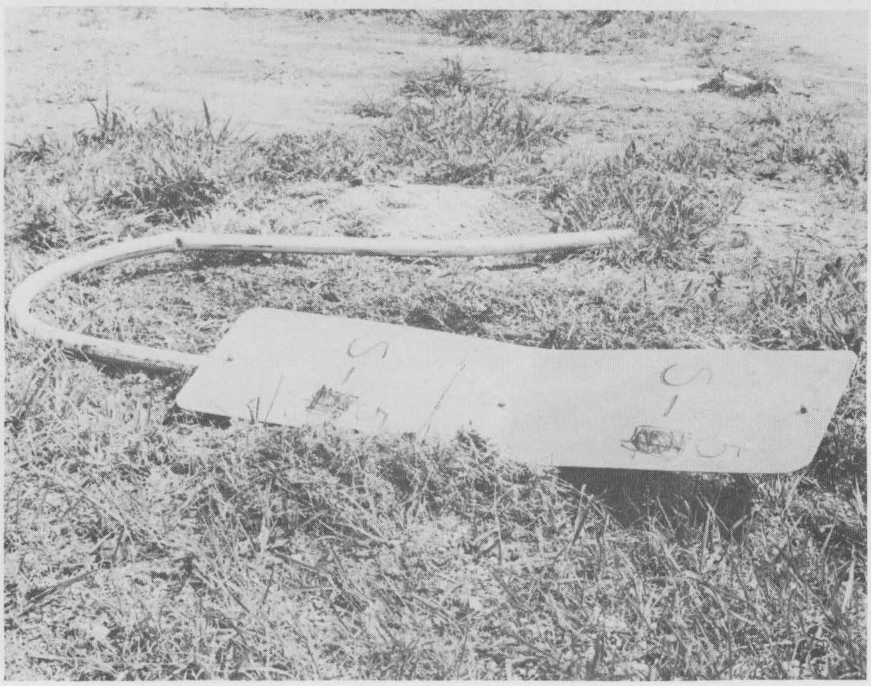


Figure 14. "Before" and "After" photographs of Mile Post Marker mounted on 1.25" pipe driven into soil.
Test S-5, 44.9 mph, $\Delta V = 0.8$ mph.

Figure 15. Vehicle after Test S-5, 44.9 mph, ΔV = 0.8 mph.

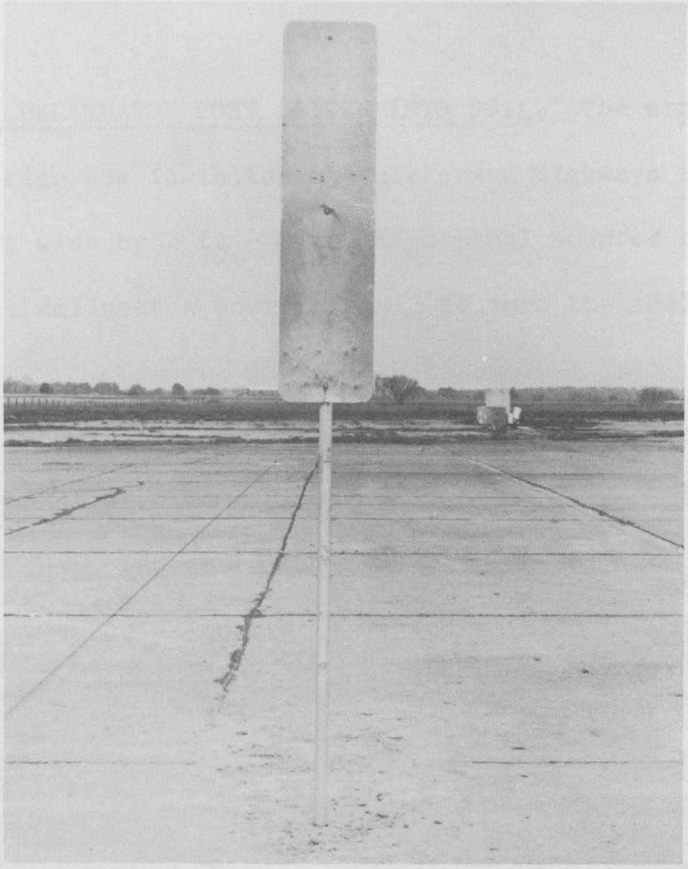


Figure 16. "Before" and "After" photographs of Mile Post Marker mounted on 1.25" pipe driven into soil. Test S-4, 59.4 mph, ΔV = 0.5 mph.

Figure 17. Vehicle after Test S-4, 59.4 mph, ΔV = 0.5 mph.

2.2 lb per ft DELINEATOR POST DRIVEN INTO SOIL. The standard Texas Mile Post Marker sign now installed on Interstate Highways in Texas consists of a 1 ft wide by 2 ft - 8 in. high panel mounted on a 6 ft high 2.2 lb per ft delineator post driven 2 ft into the soil (see Figure 18).

In Test S-15 the sign was impacted head-on at 28.1 mph and it bent down as intended by the design (see Figure 19). The speed change of the vehicle was 0.5 mph and the vehicle sustained little damage.

In Test S-9 the vehicle impacted the sign at 45.2 mph and again the sign bent down (see Figure 20). The speed change of the vehicle was 0.9 mph.

In Test S-6 the vehicle impacted the sign at 61.3 mph and the sign post pulled out of the soil and hooked over the hood of the vehicle and rode with it (see Figure 21). The speed change of the vehicle was 0.9 mph. The slight damage to the vehicle after all three tests is shown by Figure 22.

The behavior of this design was considered excellent because the vehicle underwent small changes in speed, it sustained little damage and there appeared to be little to no possibility of a secondary impact into the vehicle windshield or roof.

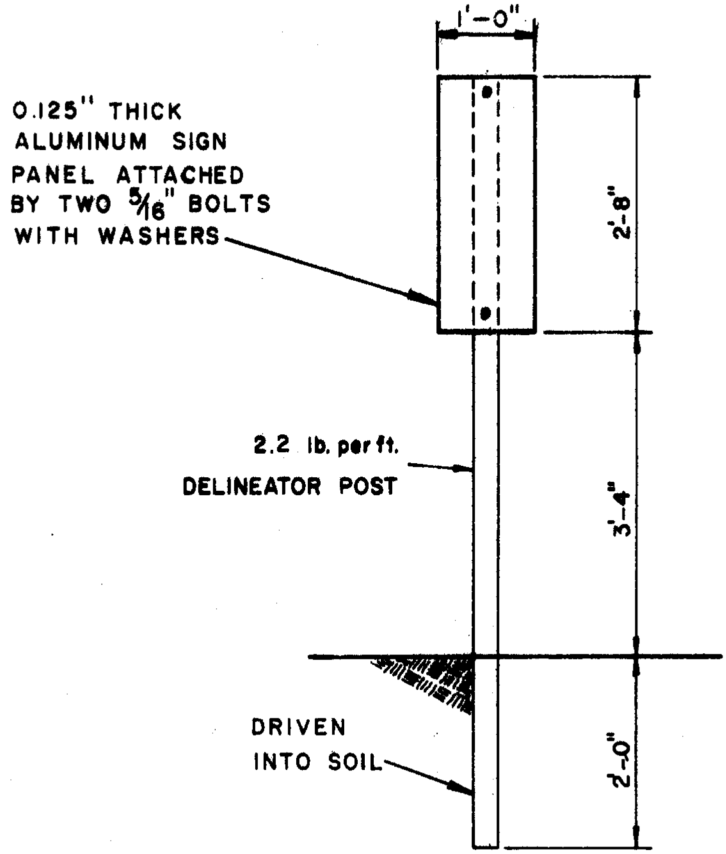


Figure 18. Texas Mile Post Marker mounted on delineator post driven into soil. Tests S-6, S-9, and S-15.

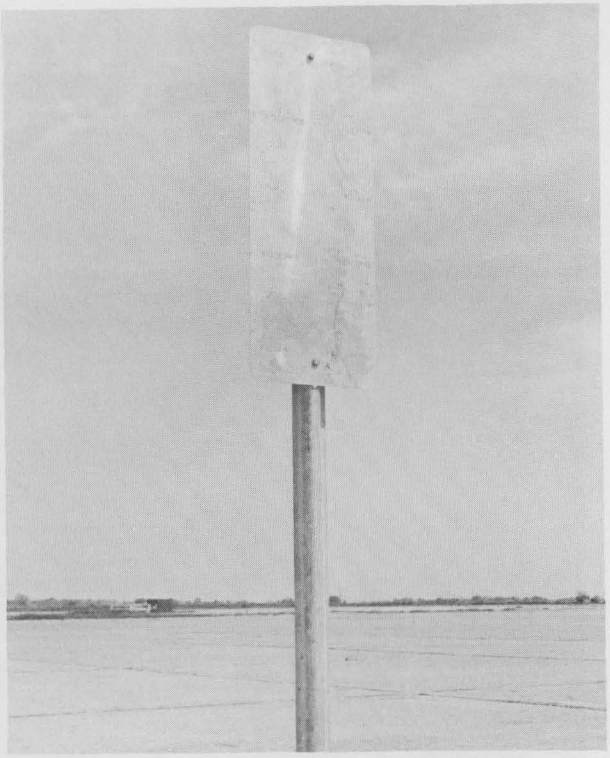


Figure 19. "Before" and "After" photographs of Texas Mile Post Marker mounted on delineator post driven into soil.
Test S-15, 28.1 mph, ΔV = 0.5 mph.

Figure 20. "Before" and "After" photographs of Texas Mile Marker mounted on delineator post driven into soil. Test S-9, 45.2 mph, ΔV = 0.9 mph.

Figure 21. "Before" and "After" photographs of Texas Mile Post Marker mounted on delineator post driven into soil. Test S-6, 61.3 mph, $\Delta V = 0.9$ mph.

Figure 22. Vehicle after Test S-6, 61.3 mph, Δ = 0.9 mph.

STOP SIGN

The standard Texas Highway Department Stop Sign is mounted on a 2.5 in. diam. pipe with a threaded coupling at the base as a breakaway feature (see Figure 23). In Test S-10 the sign was impacted head-on at 45.5 mph. The pipe pulled out of the coupling (as intended), rotated and struck the rear roof of the car. The sign panel came off the post as it hit the ground (see Figure 24). The change in vehicle speed was 1.7 mph. The behavior of this sign is considered satisfactory, since the height and geometry of the sign is such that the secondary impact of the pole will be in the roof area of a standard passenger car.

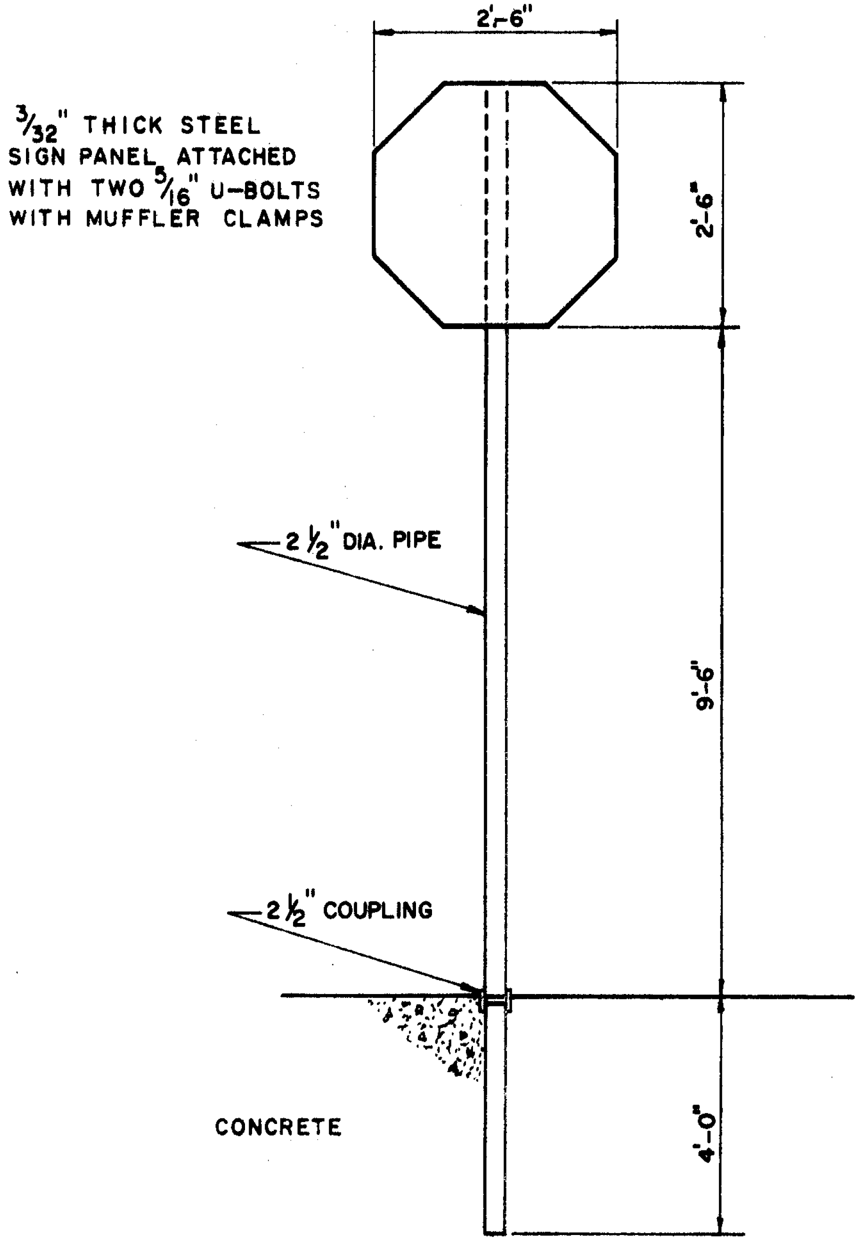


Figure 23. Stop Sign.
Test S-10, 45.5 mph, ΔV = 1.7 mph.

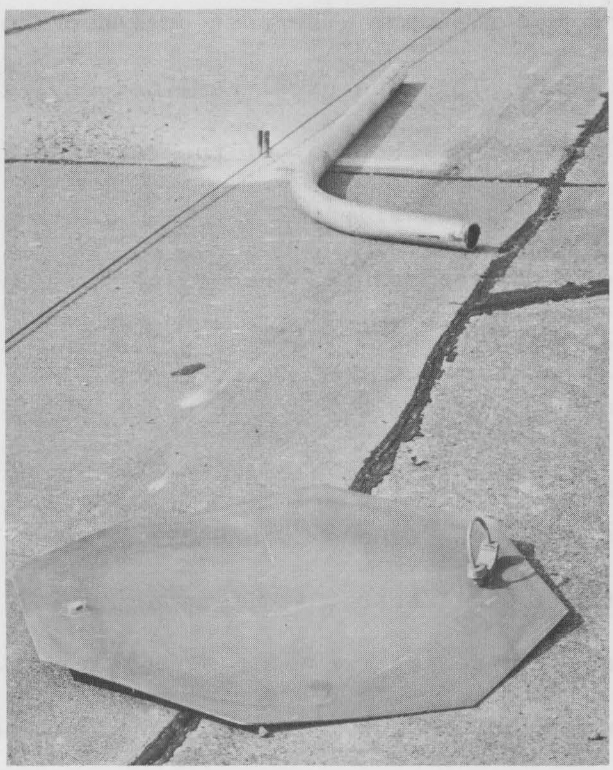


Figure 24. "Before" and "After" photographs of Stop Sign mounted on 2.5" pipe with threaded coupling as breakaway feature. Test S-10, 45.5 mph, ΔV = 1.7 mph.

ONE WAY SIGN

The standard Texas Highway Department One Way Sign is mounted on a 2.5 in. diameter pipe with a threaded coupling at the base as a breakaway feature (see Figure 25).

In Test S-14 the sign was impacted head-on at 30.2 mph and the vehicle change in speed was 2.3 mph. The post pulled out of the coupling and hooked over the hood. As the vehicle moved on, the post slid under the car and was dragged (see Figure 26 and 27). The sign panel slipped off the pipe as the sign was dragged.

In Test S-13 the sign was impacted head-on at 44.2 mph and the vehicle change in speed was 1.5 mph. The post pulled out of the coupling and hooked over the hood. The sign panel came off during impact and passed over and lightly struck the roof of the car (see Figures 28 and 29). Damage to the vehicle was slight.

In Test S-16 the sign was impacted head-on at 58.4 mph and the vehicle change in speed was 1.3 mph. The post pulled out of the coupling and hooked on the hood of the car. The sign panel came off, passed over the top of the car, and fell to the ground on the threaded coupling embedded in the concrete (see Figures 30 and 31).

As a result of these three tests, it is apparent that the connection of the sign panel to the pipe support needs strengthening. The two 5/16 in. U-bolts should be increased to four. In addition, threaded caps or some other stop device should be placed on top of the pipe to prevent the U-bolts from slipping off. Overall the One Way Sign behaved in an adequate manner.

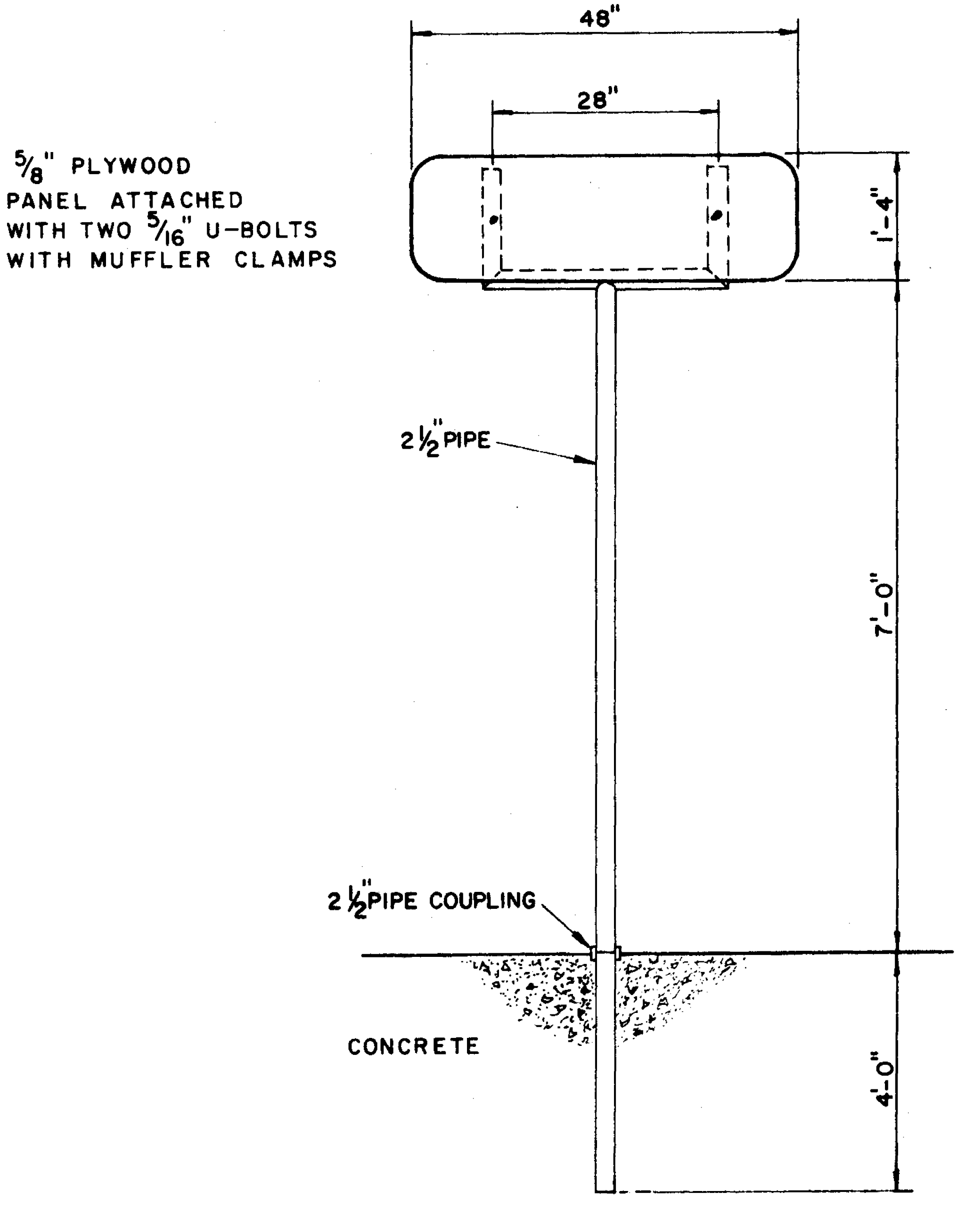


Figure 25. One Way Sign.
Tests S-13, S-14, and S-16.

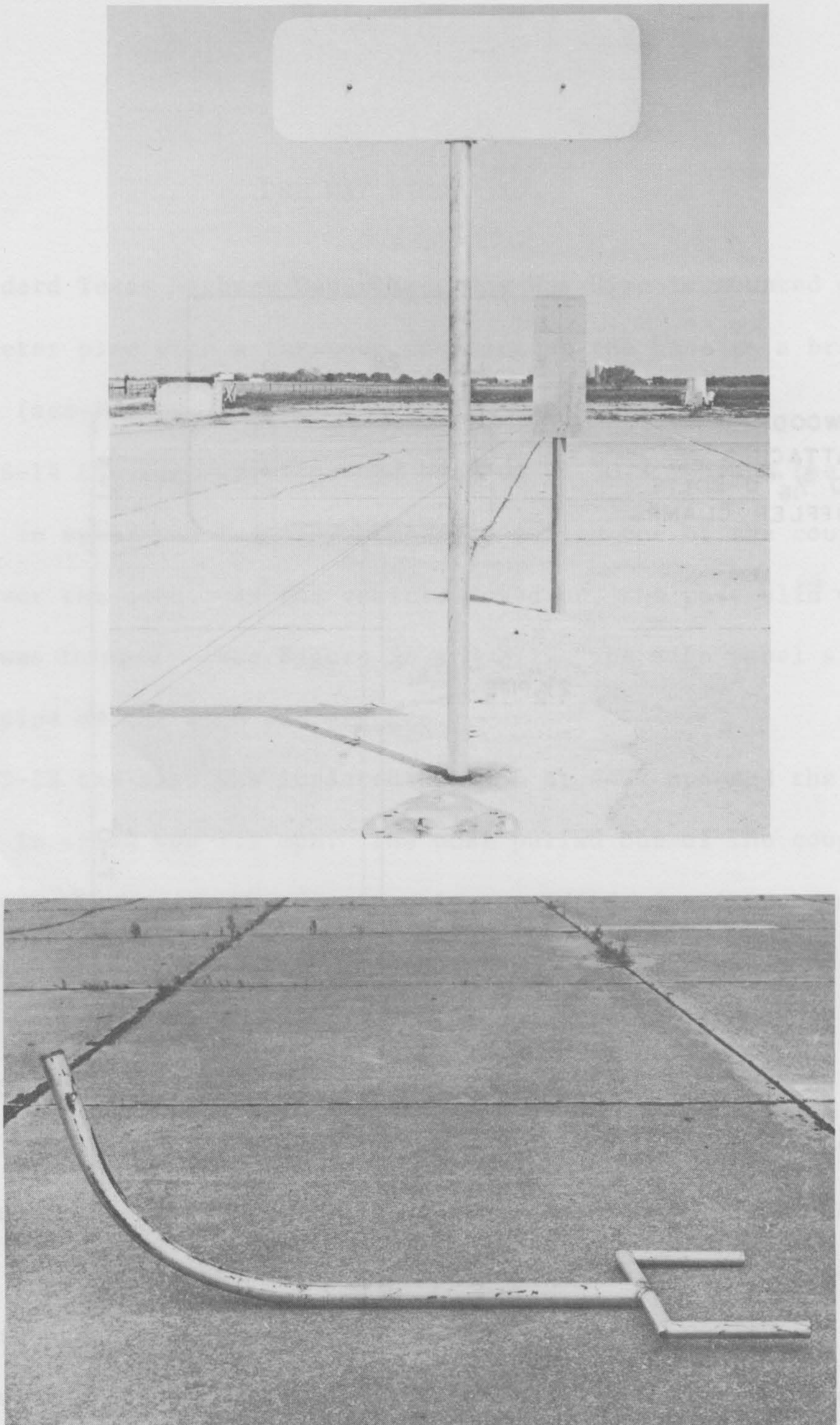


Figure 26. "Before" and "After" photographs of One Way Sign mounted on 2.5" pipe with threaded coupling as breakaway feature. Test S-14, 30.2 mph, ΔV = 2.3 mph.

Figure 27. Vehicle after Tests S-14.
Windshield was cracked in Test S-12.

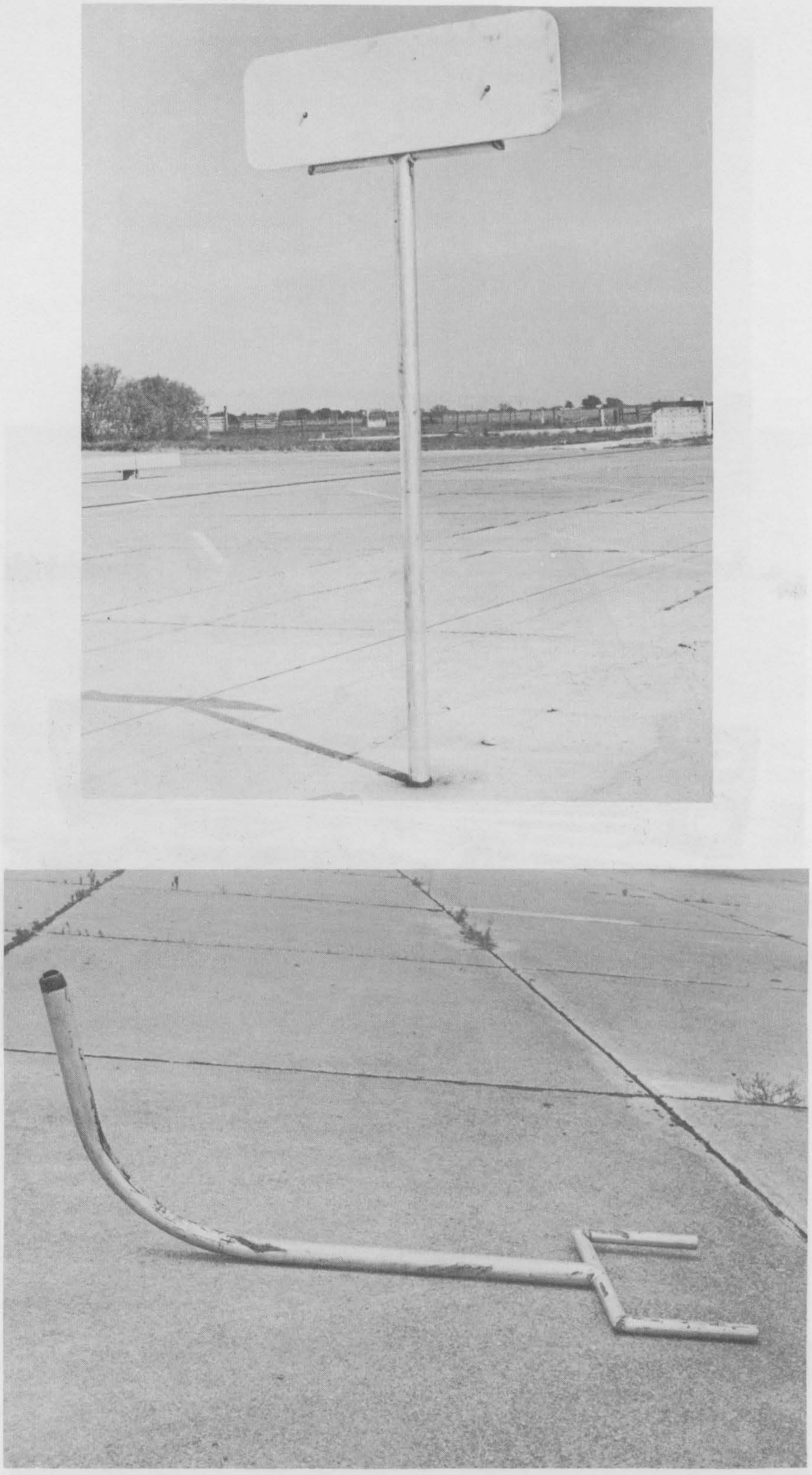


Figure 28. "Before" and "After" photographs of One Way Sign mounted on 2.5" pipe with threaded coupling as breakaway feature. Test S-13, 44.2 mph, $\Delta V = 1.5$ mph.

Figure 29.. Vehicle after Test S-13.
Windshield was cracked in Test S-12.

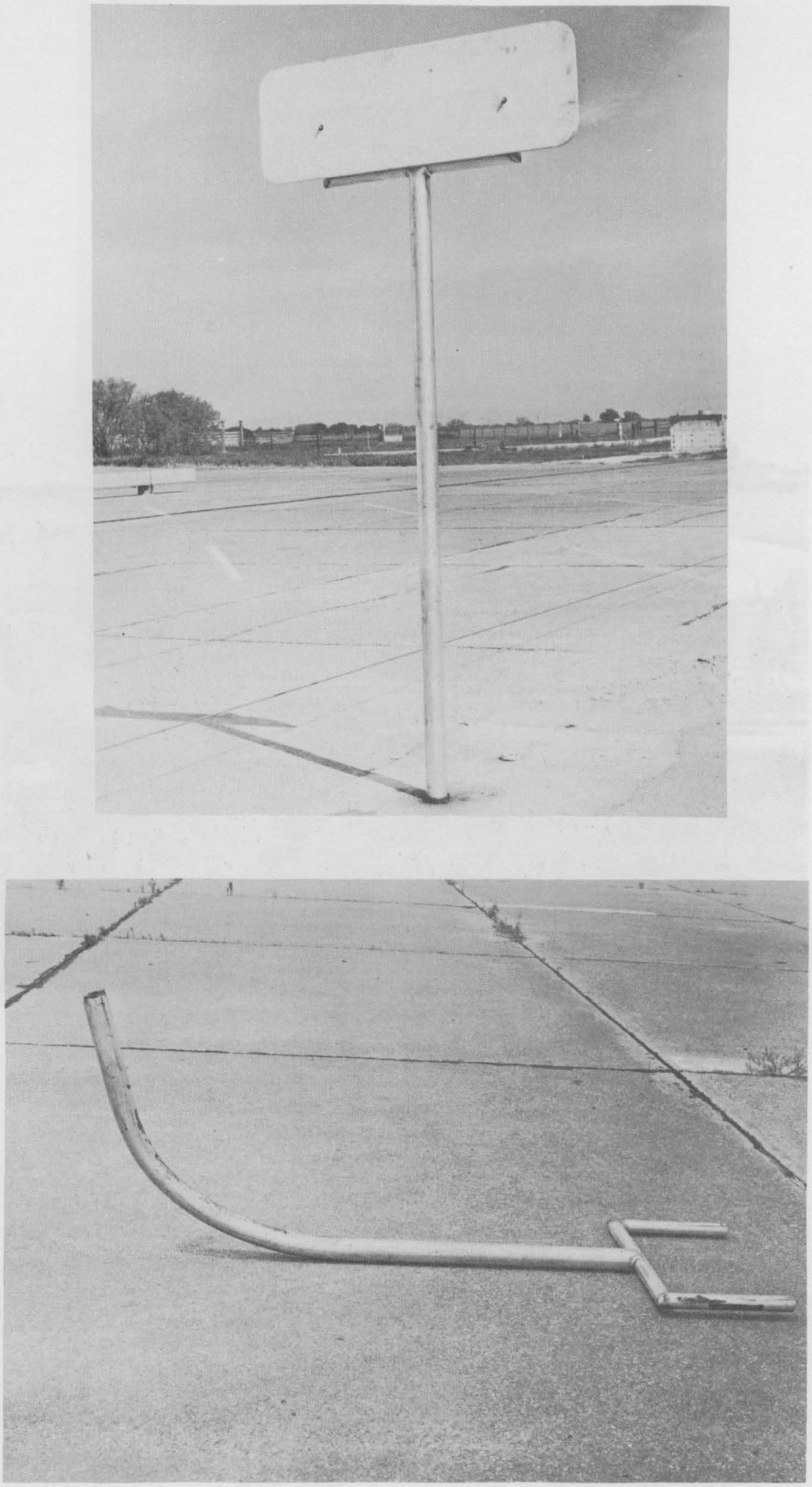


Figure 30. "Before" and "After" photographs for One Way Sign, mounted on 2.5" pipe with threaded coupling as breakaway feature. Test S-16, 58.4 mph, Δ = 1.3 mph.

Figure 31. Vehicle after Test S-16.
Windshield was cracked in Test S-12.

ROUTE MARKER SIGN

The Route Marker sign shown in Figures 32 and 33 is typically used on main lanes and frontage roads of Interstate Highways in Texas. The 3 in. diam. pipe mount is used to support a 36 in. Interstate Route Marker with a 24 in. Route Marker. For pipe supports 3 in. in diam. or larger, the multi-directional slip base is used (see Appendix A for details).

In Test S-18 the Route Marker was impacted head-on at 31.3 mph and the change in speed of the vehicle was 0.9 mph. The slip base activated, the sign post rotated 180° and barely struck the trailing end of the vehicle's trunk. The behavior was satisfactory and as anticipated (see Figure 34).

In Test S-8 the Route Marker was impacted head-on at 46 mph and the change in speed of the vehicle was 0.8 mph. The slip base activated, the sign post rotated 180° and again struck the trailing end of the vehicle trunk (see Figure 35).

The overall behavior of this sign structure was considered satisfactory.

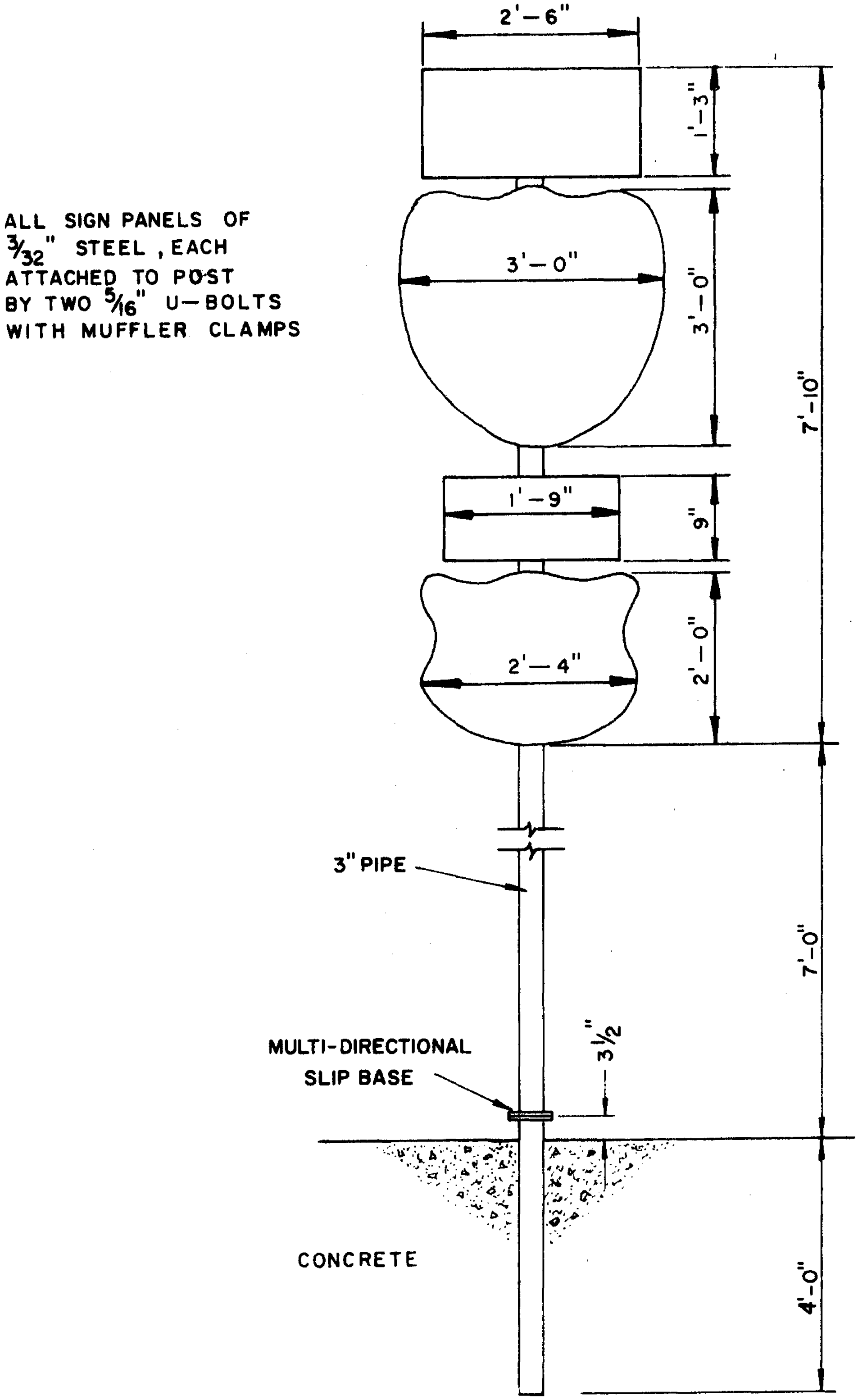


Figure 32. Route Marker with multi-direction slip base. Tests S-8 and S-18.

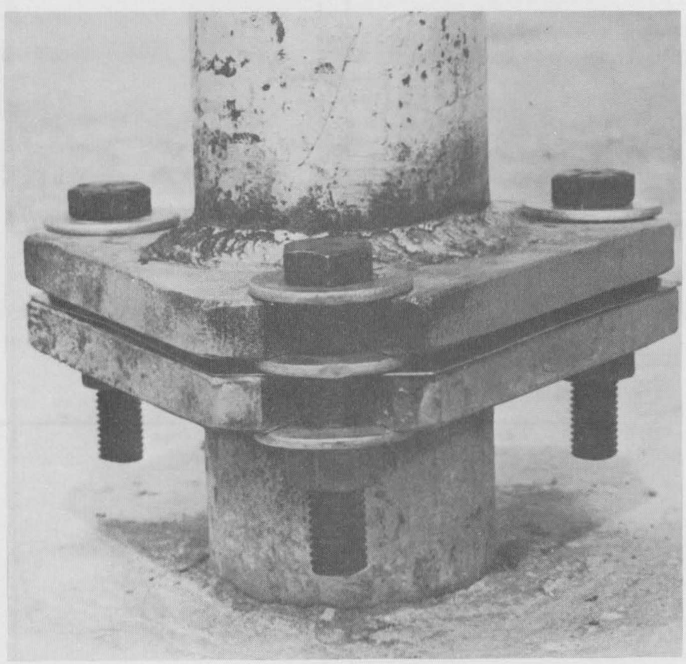


Figure 33. Route Marker supported on 3 in. pipe with multi-directional slip base.
Test S-8 and Test S-18.

Figure 34. Route Marker after crash.
Test S-18, 31.3 mph, ΔV = 0.9 mph.

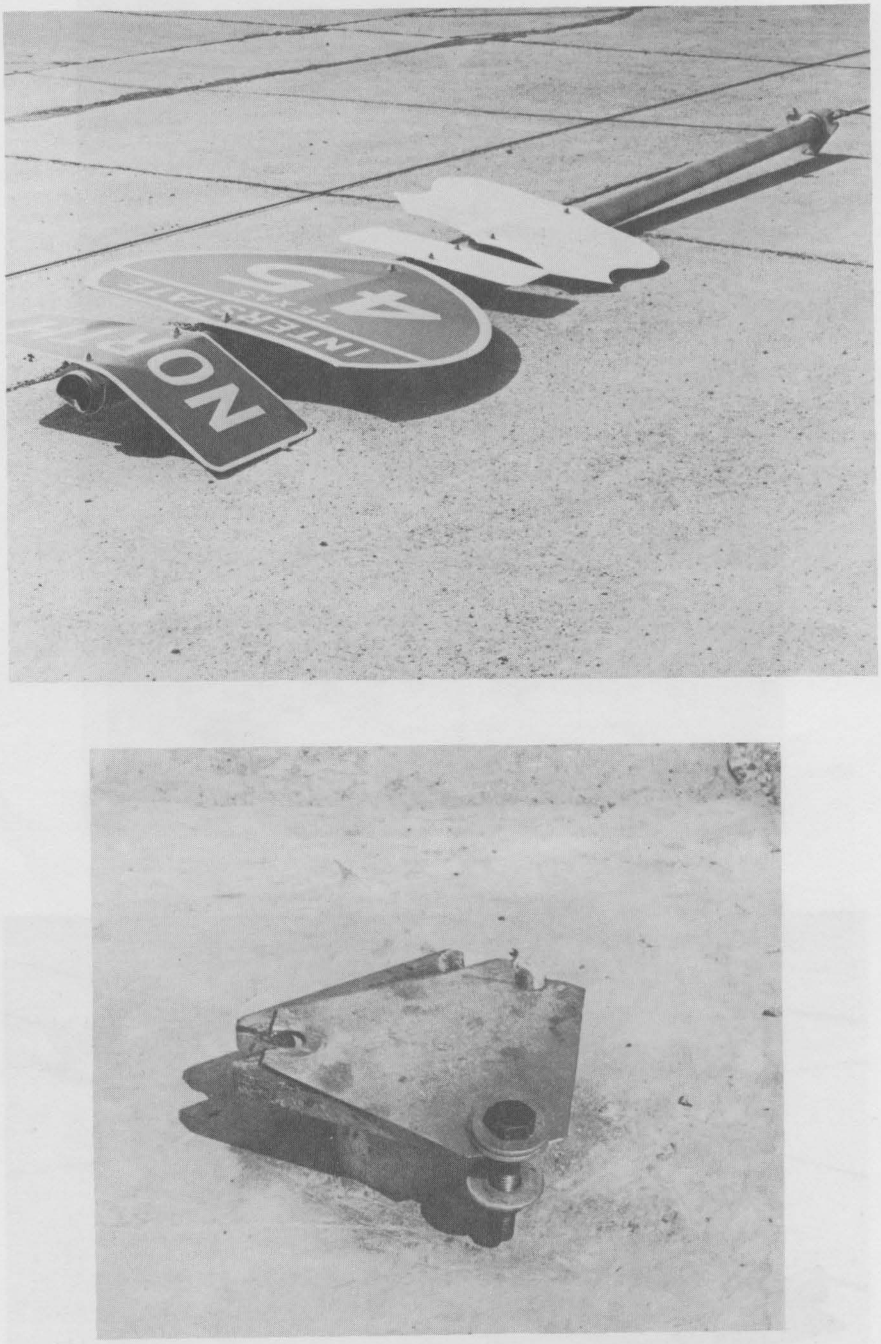


Figure 35. Route Marker and base after crash.
Test S-8, 46 mph, ΔV = 0.8 mph.

Figure 36. Vehicle after crash.
Test S-8.

DESTINATION SIGN

The Destination Sign with multi-directional slip base shown by Figure 37 and 38 is typical of this type sign now used in Texas.

In Test S-11 the sign was impacted head-on at a speed of 44.5 mph and the change in speed of the vehicle was 1.4 mph. The slip base activated and the sign rotated about 110° and struck the roof of the vehicle rather hard over the front passenger compartment. Damage to the front of the vehicle was significant as shown by Figure 40. Figure 39 shows the final position of the sign structure.

In an attempt to minimize the secondary collision of the sign with the roof of the car, the multi-directional slip base was modified to include riser plates as shown in Figure 42. The function of the riser plates is to impart an upward velocity to the sign post on vehicle impact. This upward velocity should raise the sign higher into the air and allow the vehicle to pass underneath and avoid a secondary collision with the roof of the car.

In Test S-17 the sign was impacted head-on at a speed of 45.5 mph and the change in speed of the vehicle was 1.7 mph. The slip base activated and the sign rotated about 120° and struck the roof of the vehicle over the rear passenger compartment. The sign raised about 2 ft higher into the air than in Test S-11, however, the secondary collision still occurred. Figures 43 and 44 show the sign and vehicle, respectively, after the test.

The modified slip base with riser shown in Figure 43 was considered partially successful. The recommended slip base with riser shown in Figure 45 is believed to be a better design which will impart a higher upward velocity to the sign post.

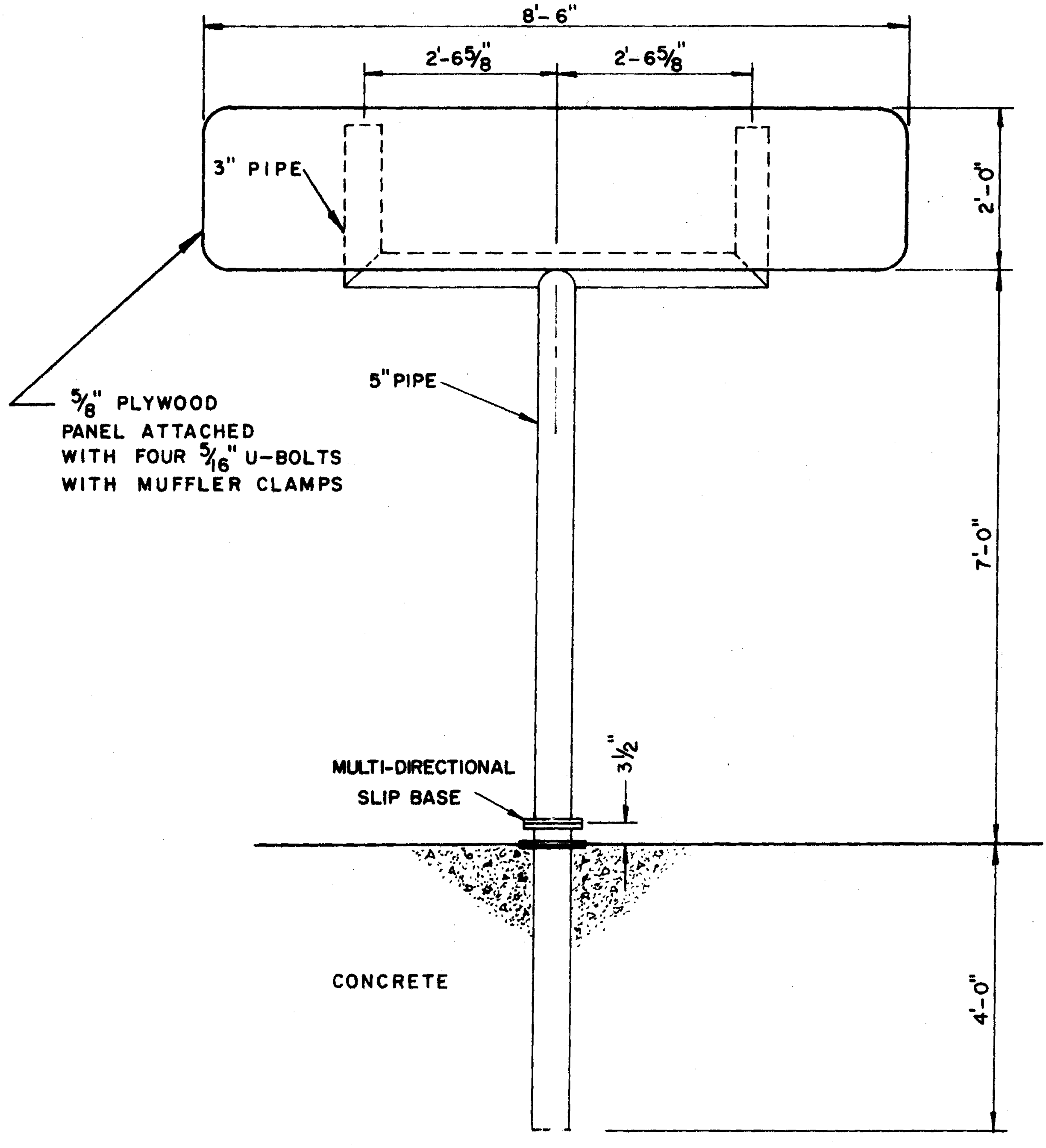


Figure 37. Destination Sign with multi-directional slip base. Test S-11 and S-17.

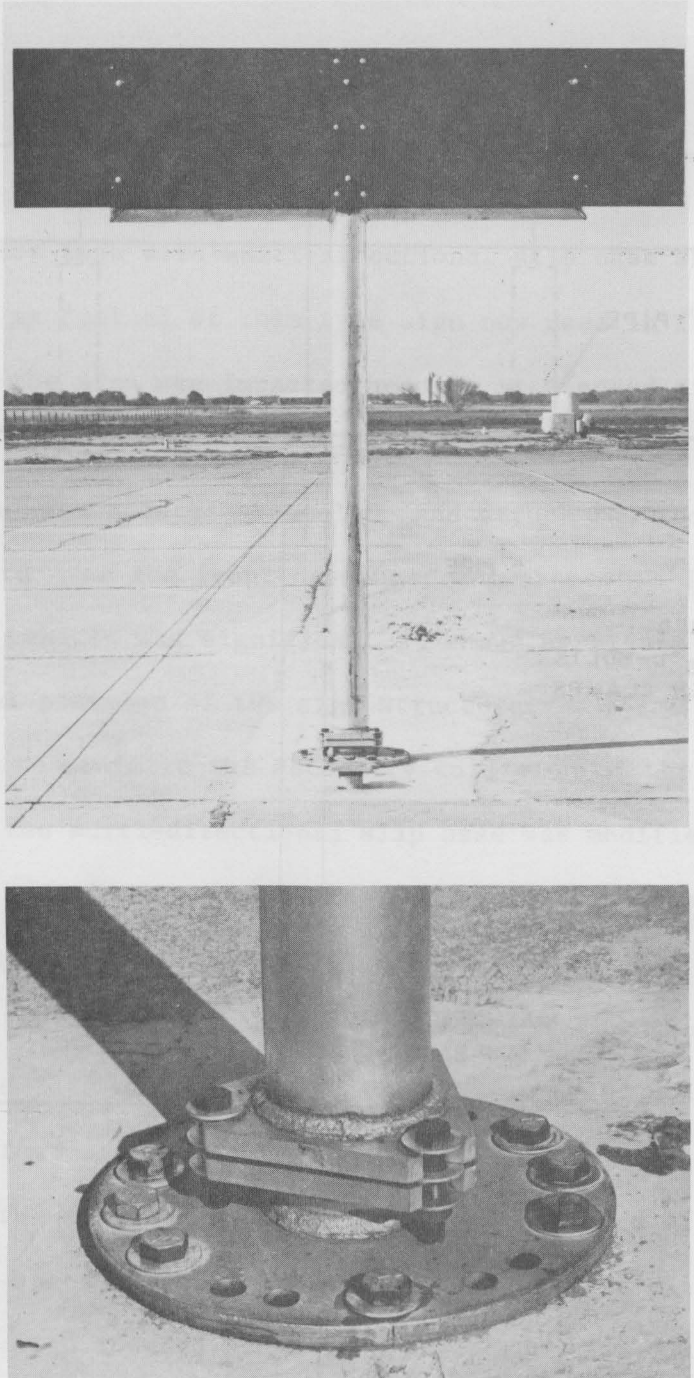


Figure 38. Destination Sign mounted on 5" pipe with multi-directional slip base. Test S-11. 44.5 mph, ΔV = 1.4 mph.

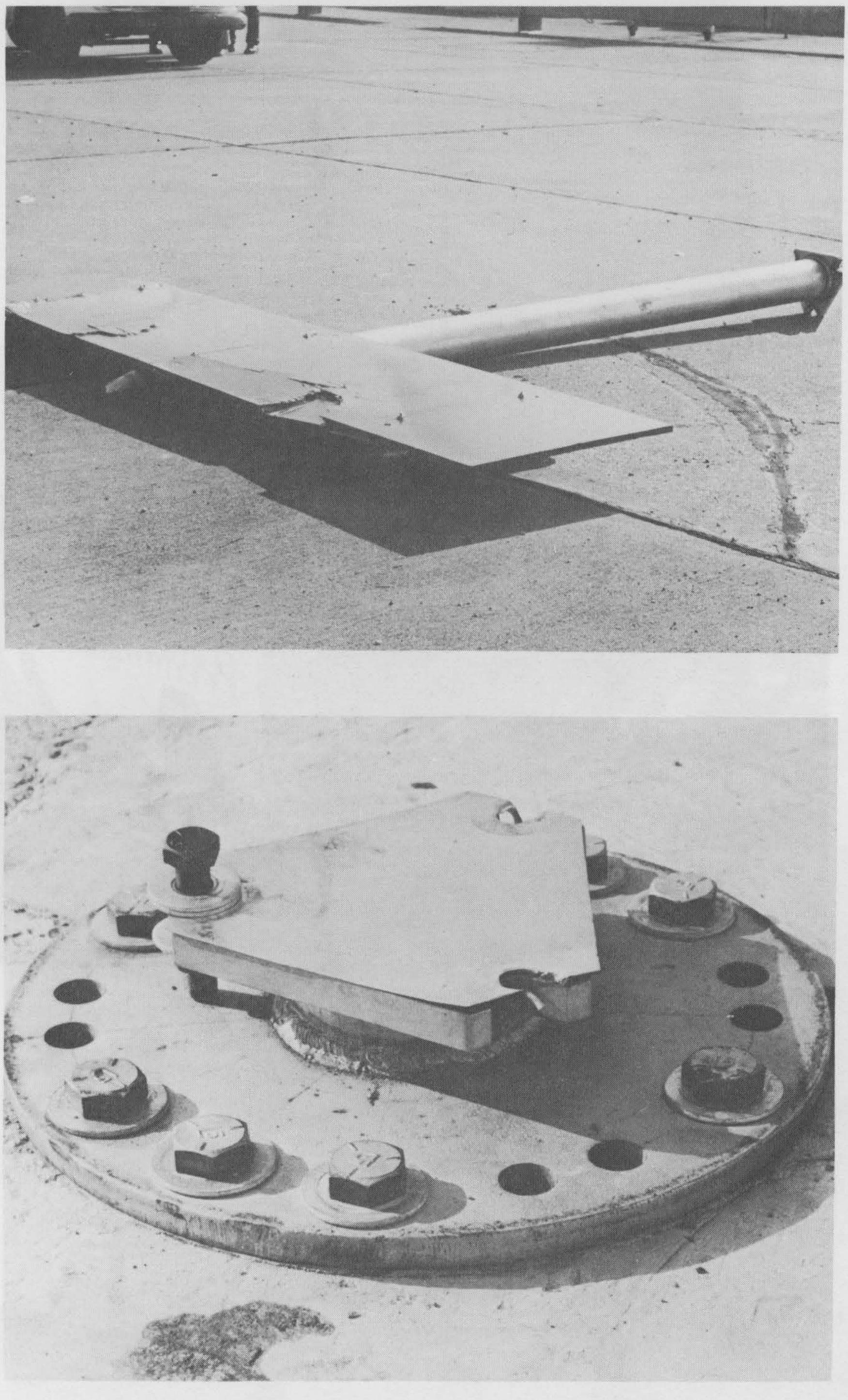


Figure 39. Destinations Sign and base after crash.
Test S-11, 44.5 mph, $\Delta V = 1.4$ mph.

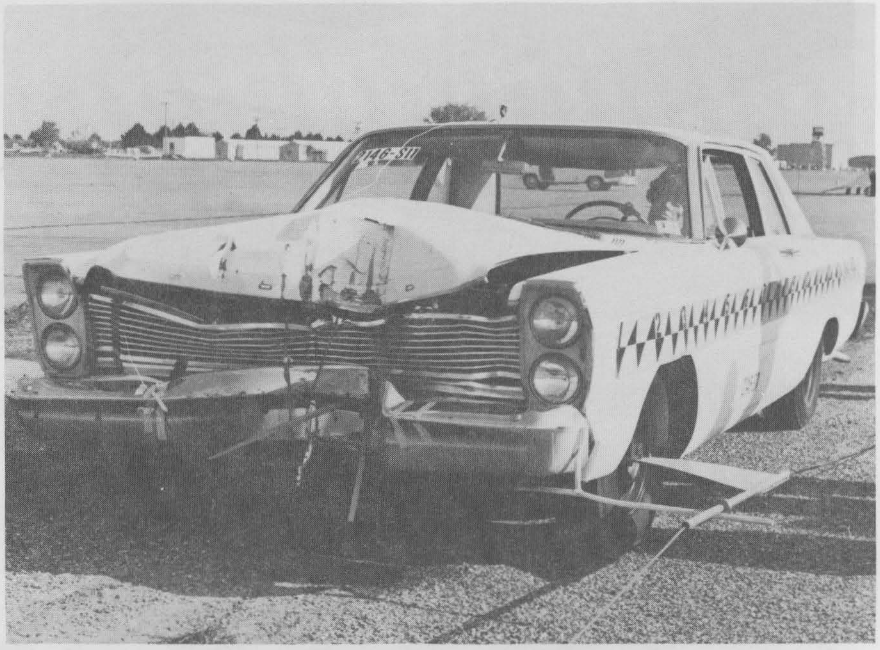
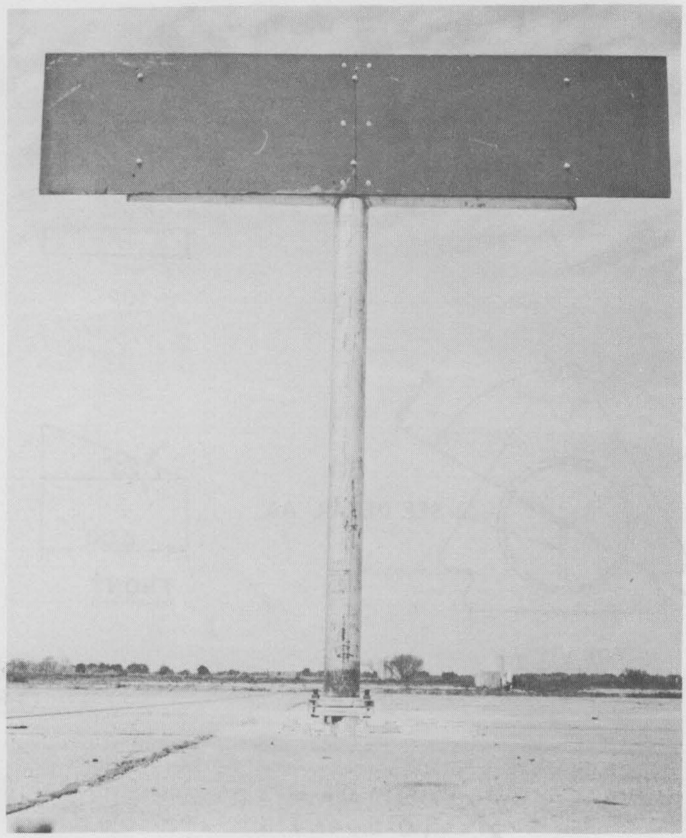


Figure 40. Vehicle after Test S-11.



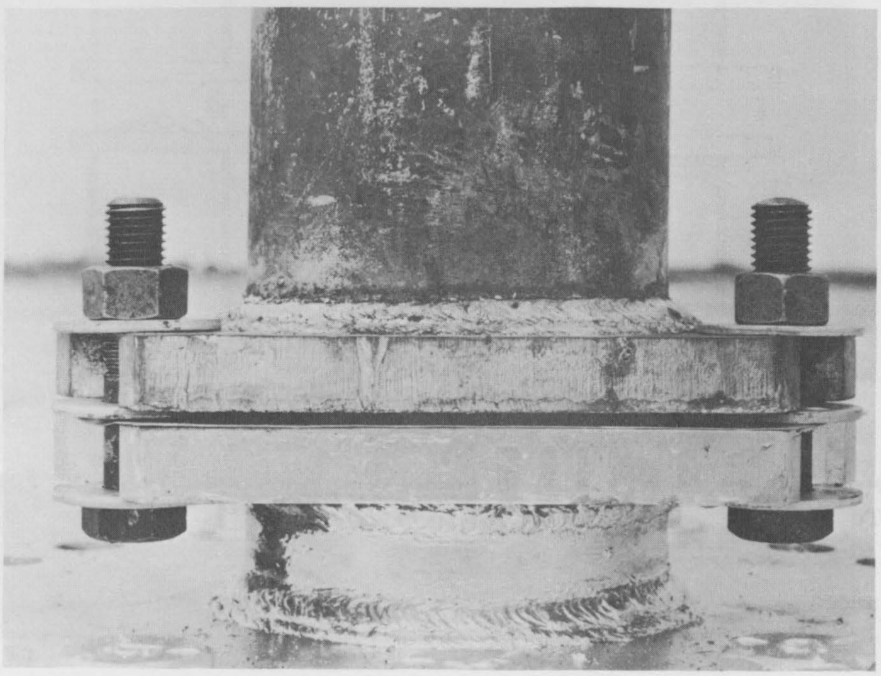


Figure 41. Destination Sign mounted on 5" pipe with multi-directional slip base with riser modifications. Test S-17, 45.5 mph, ΔV = 1.7 mph.

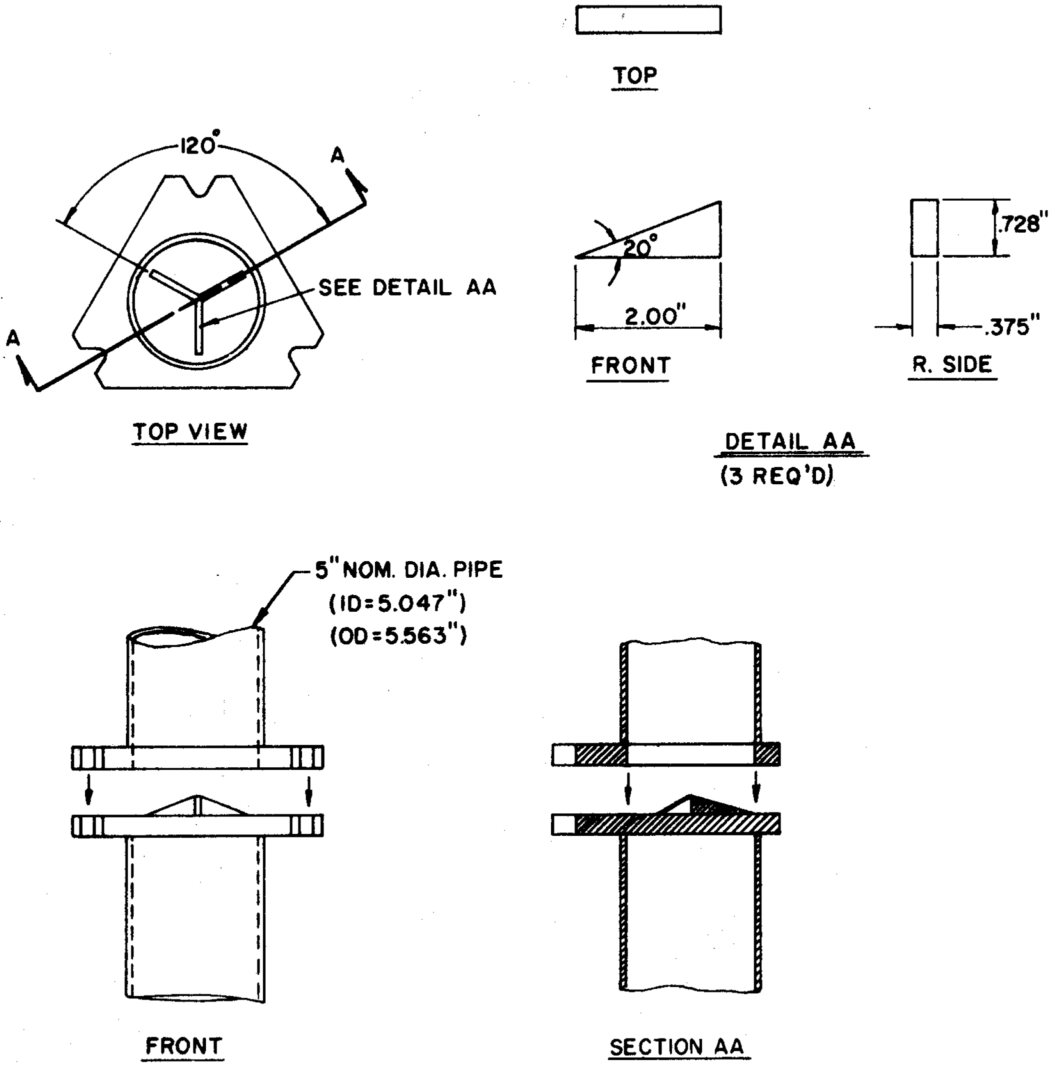


Figure 42. Multi-directional slip base with riser modification for 5" pipe support. Test S-17.

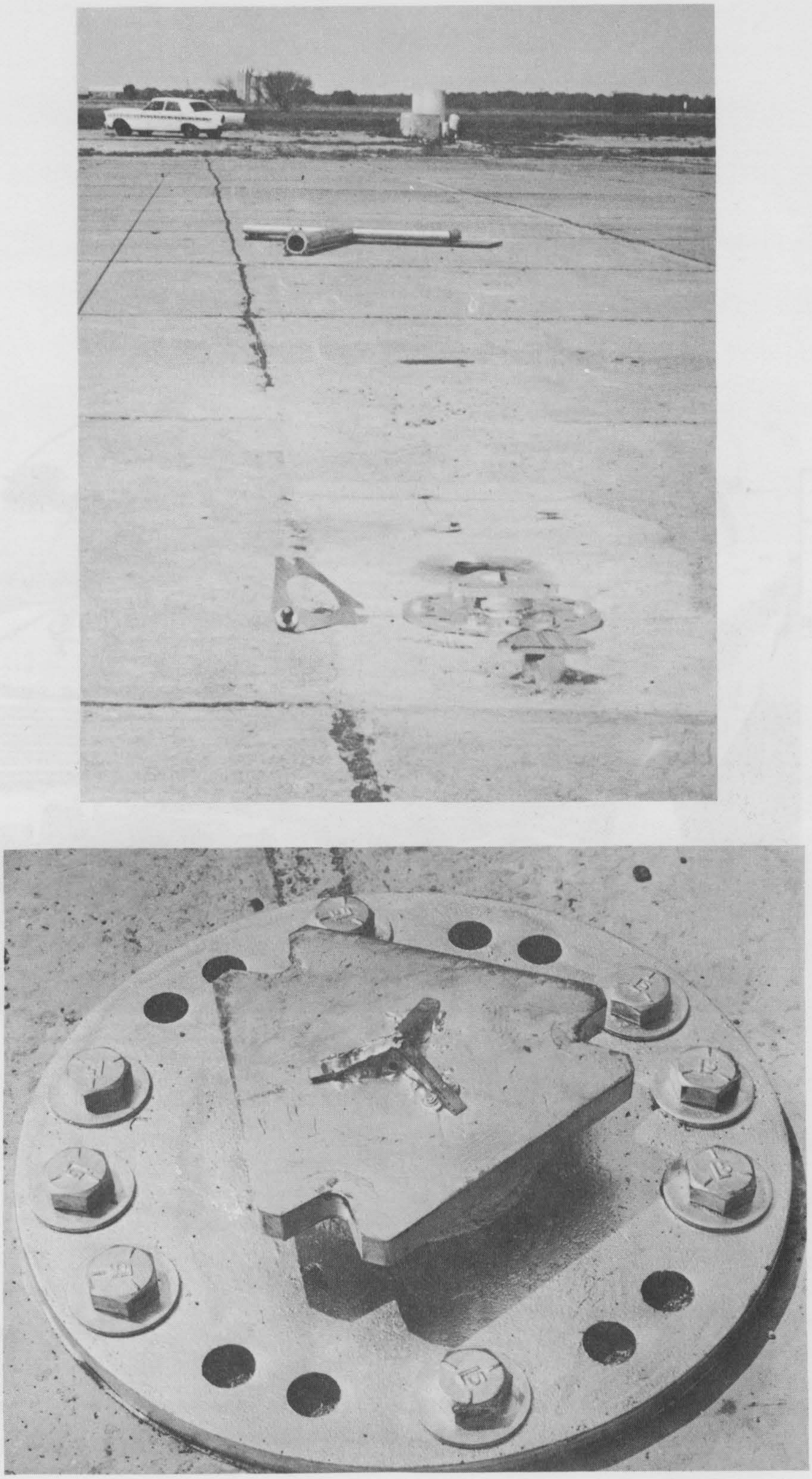


Figure 43. Destination Sign and base after testing, note modification on base for raising sign post during impact. Test S-17, 45.5 mph, ΔV = 1.7 mph.

Figure 44. Vehicle after Test S-17.

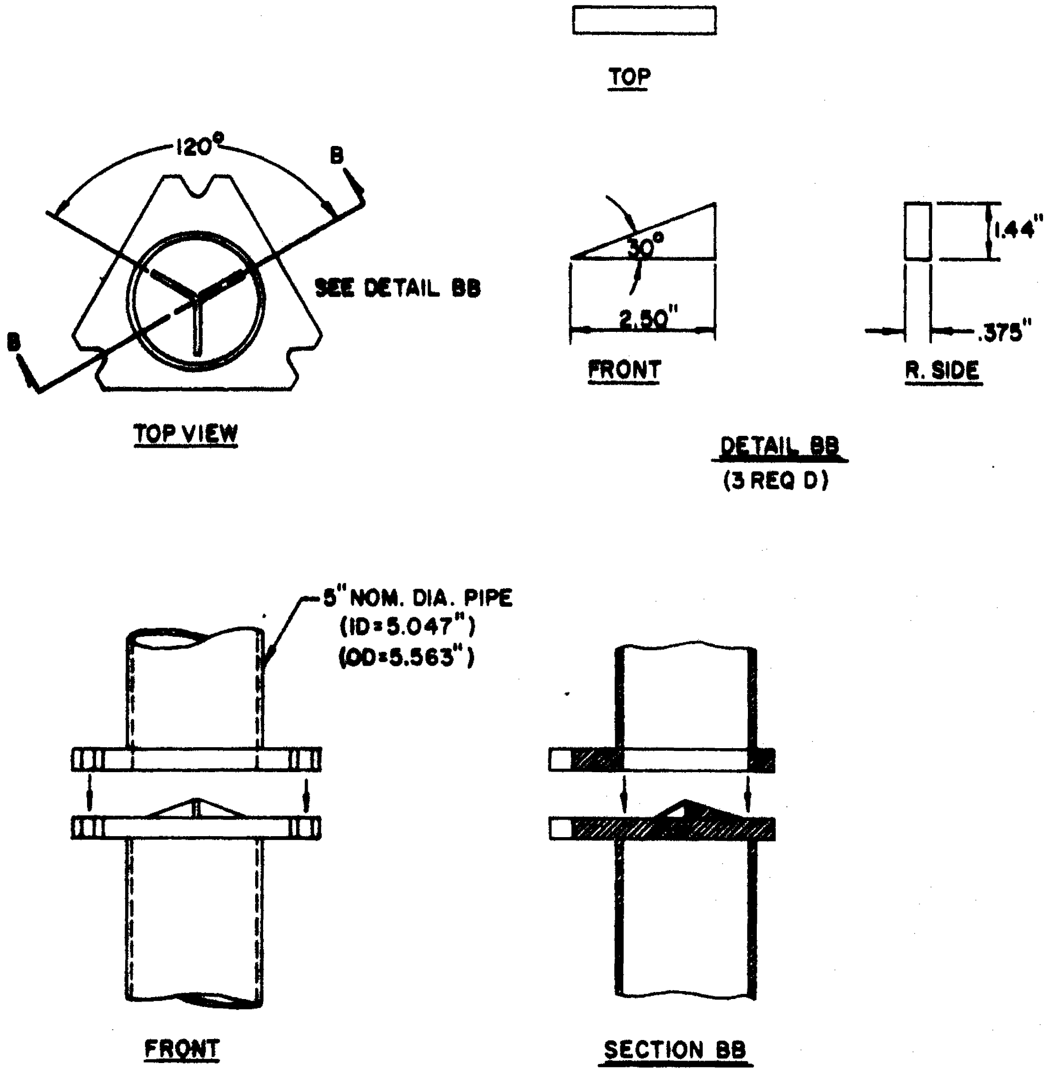


Figure 45. Recommended multi-directional slip base with riser modification for 5 in. pipe support.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations were developed from the vehicle crash tests results presented.

MILE POST MARKER SIGNS

1. The standard Texas Mile Post Marker sign (which does not conform to the new MUTCD standard) was less hazardous to the impacting vehicle than the other signs tested. In collision at speeds from 28 mph to 61 mph, the change in vehicle speed ranged from 0.5 mph to 0.9 mph respectively. The sign bent down in low to medium speed impacts and hooked on the hood at high speeds. No secondary collisions occurred.

2. The standard MUTCD Mile Post Marker panel mounted on a 1.25 in. diam. pipe driven into the soil was the next less hazardous to the impacting vehicle. In collisions at speed ranging from 31 mph to 59 mph, the change in vehicle speed ranged from 1.4 mph to 0.5 mph respectively. The sign bent down at low speed and pulled out and hooked over the vehicle hood at medium and high speeds. No secondary collisions occurred.

3. The standard MUTCD Mile Post Marker panel mounted on a 1.25 in. diam. pipe cast in an 8 in. diam. concrete shaft 2 ft - 6 in. deep was the next less hazardous to the impacting vehicle. In collisions at speeds ranging from 38 mph to 57 mph, the change in vehicle speed ranged from 1.3 mph to 0.9 mph respectively. The sign post bent down in all cases. At high speed the aluminium sign panel came off and

struck the windshield, cracking it. The panel to post connection can be strengthened.

4. The standard MUTCD Mile Post Marker panel mounted on a 2 in. diam. pipe with threaded coupling at the base as a breakaway feature was the most hazardous. In Test S-1 with no pipe insert, the sign pulled out of the coupling and struck and penetrated the vehicle windshield. In Test S-7 with a 1.5 in. diam. pipe insert the secondary collision was prevented, however, the vehicle change in speed was 2.6 mph for the 47.5 mph impact.

STOP SIGN

5. The standard Texas Highway Department Stop Sign mounted on a 2.5 in. diam. pipe with a threaded coupling at the base as a "breakaway" feature was satisfactory. The change in speed at 45 mph was 1.7 mph. The pipe pulled out of the coupling and rotated and struck the rear roof of the car.

ONE WAY SIGN

6. The standard Texas Highway Department One Way Sign mounted on a 2.5 in. diam. pipe with a threaded coupling at the base as a breakaway feature was satisfactory. However, the connection of the sign panel to the pipe support needs strengthening to prevent the panel from coming off during vehicle impact and striking the vehicle. In collisions at speeds ranging from 30 mph to 58 mph the change in vehicle speed ranged from 2.3 mph to 1.3 mph respectively. The post

pulled out of the threaded coupling and hooked on the vehicle hood in all cases.

ROUTE MARKER SIGN

7. The typical Texas Highway Department Route Marker Sign mounted on a 3 in. diam. pipe with a multi-direction slip base as a breakaway feature behaved satisfactory. In collisions at speeds ranging from 31 mph to 46 mph the change in vehicle speed was 0.9 mph to 0.8 mph respectively. In all cases the slip base activated, the sign post rotated 180° and struck the trailing end of the vehicle's trunk.

DESTINATION SIGN

8. The typical Texas Highway Department Destination Sign mounted on a 5 in. diam. pipe with a multi-directional slip base as a breakaway feature is adequate. Adding riser plates to the slip base to propel the sign upward on impact, could reduce or eliminate the secondary impact with the vehicle roof. When impacted at 45 mph the change in vehicle speed ranged from 1.4 to 1.7 mph. The slip base activated and the sign rotated about 110° and struck the roof of the vehicle.

REFERENCES

1. Hirsch, T. J., and Buth, C. E., "Crash Test of Mile Post Marker," Research Report No. 146-7, Texas Transportation Institute, Texas A&M University, January, 1973.

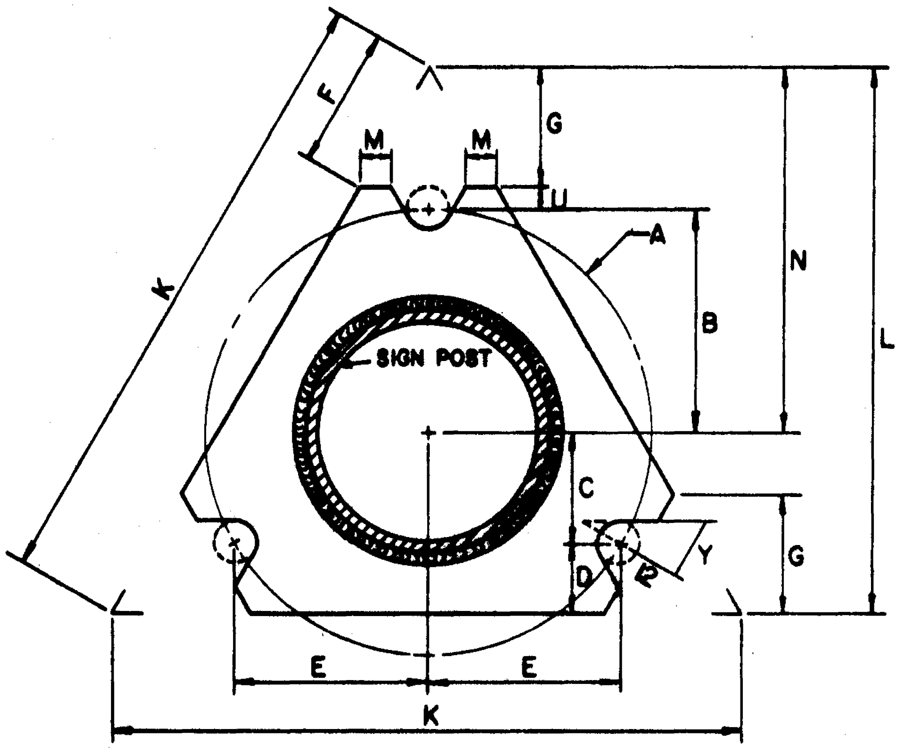
2. Martinez, J. E. and Hairston, D. E., "An Evaluation of the Impact Response of Various Motorist-Aid Call Systems," Highway Research Record No. 386, 1972, p. 73.

Appendix A

Details of Multi-directional Slip Base,
Threaded Coupling Breakaway Feature

and

Soil Characteristics



DIMENSIONS NOMINAL PIPE SIZES	BOLT SIZE & TORQUE	WELD SIZE	t	Y	A	B	C	D	E	F	G	K	L	M	U	N
3" DIA. 3½" DIA.	5/8" ⌀ x 3¼" T = 450	3/8"	5/8"	7"	7"	3½"	1¾"	1¼"	3"	2 5/16"	2"	10⅜"	9"	½"	½"	6"
4" DIA. 5" DIA.	¾" ⌀ x 3¾" T = 750	7/16"	⅞"	8 9/16"	9"	4½"	2¼"	1½"	3⅞"	2⅞"	2½"	13"	1¼"	⅝"	½"	7½"

Figure A1. Details of multi-directional slip base.

WHEN VEHICLE IMPACTS PIPE THREADS WILL PULL OUT OF COUPLING CAST IN CONCRETE. IF COUPLING THREADS ARE DAMAGED, COUPLING CAN BE UNSCREWED FROM LOWER PIPE AND REPLACED.

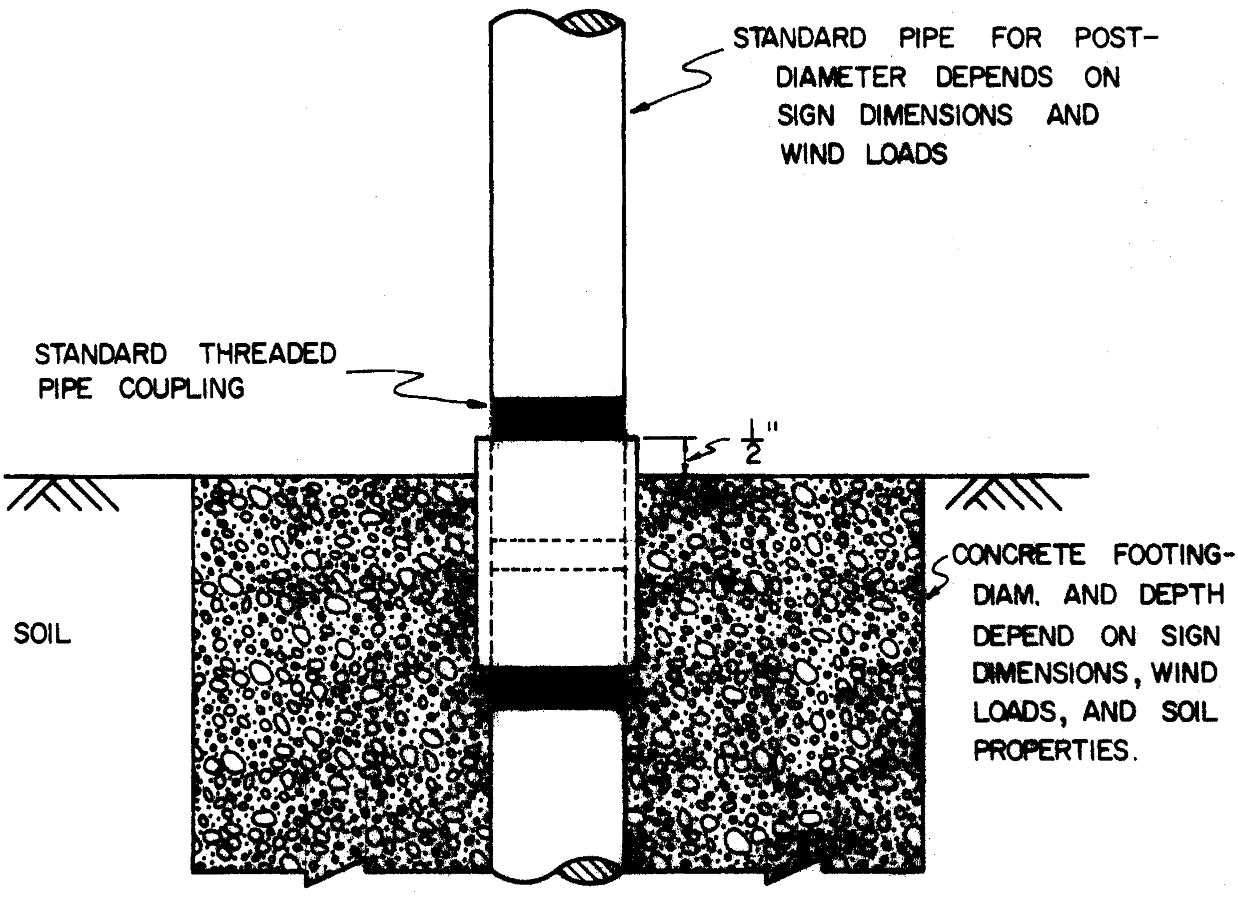


FIGURE A2. THREADED COUPLING BREAKAWAY FEATURE

TABLE A1

SOIL CHARACTERISTICS

Soil Depth	0 - 14 inches	14 - 30 inches
Description of Soil	Fill Soil: Yellow-Gray Sandy Clay Compacted with Pneumatic Tamper	Typical Brazos River Bottomland Black Sandy Clay
Moisture Content	33%	21%
Avg. Density	110 pcf	128 pcf
Avg. Load Bearing Capacity *	0 - 8": 3.0 tsf 8 - 14": 2.5 tsf	2.3 tsf

* From Pocket Penetrometer

Appendix B

"Before" and "After" photographs

of Test Vehicles

Figure B1. This vehicle was used in Tests S-2 through S-11.
1965 Ford sedan, weight 3970 lb.

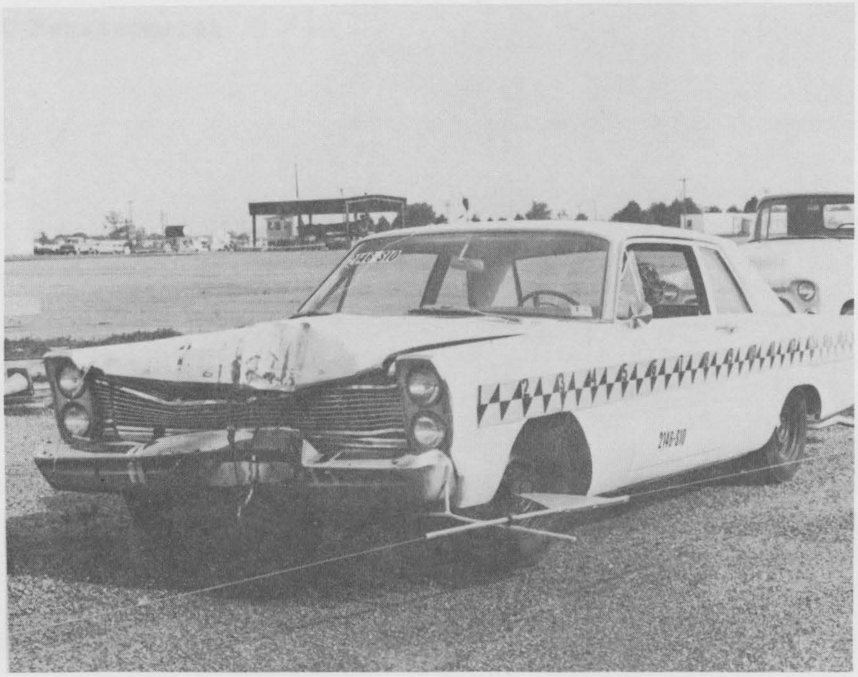


Figure B2. Vehicle after Test S-10.

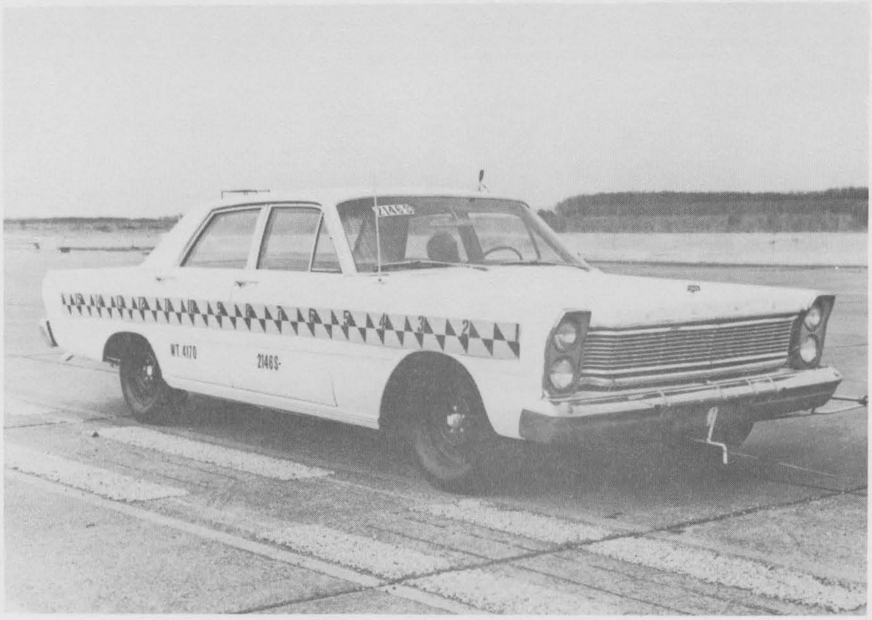


Figure B3. This vehicle was used in Tests S-12 through S-18. 1965 Ford sedan, weight 4170 lb.

Figure B4. Vehicle after Test S-18.

Appendix C

Summary of Crash Test Data

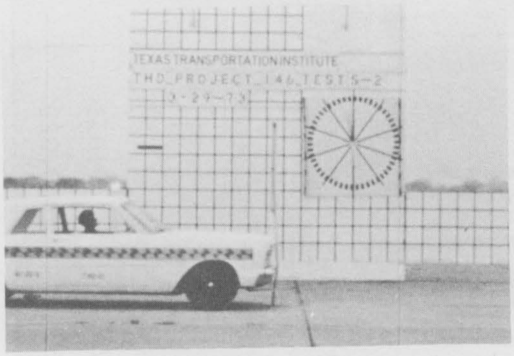
and

Sequence photographs of Tests S-2 through S-18

TABLE C-1

EXPERIMENTAL DATA

TEST NO.	VEHICLE DATA	FILM DATA							
	1965 Ford weight lb	Initial Velocity fps	Initial Velocity mph	Final Velocity fps	Final Velocity mph	Velocity Change mph	Change in Momentum lb-sec	Collision Duration sec	Avg. Decel. g's
S-2	3970	56.1	38.2	54.1	36.9	1.3	246	0.119	0.5
S-3	3970	45.5	31.0	43.4	29.6	1.4	259	0.134	0.5
S-4	3970	87.2	59.4	86.4	58.9	0.5	99	0.056	0.4
S-5	3970	65.8	44.9	64.6	44.1	0.8	148	0.066	0.6
S-6	3970	89.9	61.3	88.6	60.4	0.9	160	0.036	1.1
S-7	3970	69.6	47.5	65.9	44.9	2.6	456	0.046	2.5
S-8	3970	67.4	46.0	66.3	45.2	0.8	136	0.020	1.7
S-9	3970	66.3	45.2	65.0	44.3	0.9	160	0.080	0.5
S-10	3970	66.7	45.5	64.3	43.8	1.7	296	0.031	2.4
S-11	3970	65.3	44.5	63.2	43.1	1.4	259	0.031	2.1
S-12	4170	83.4	56.9	82.2	56.0	0.5	155	0.077	0.5
S-13	4170	64.9	44.2	62.7	42.7	1.5	285	0.046	1.5
S-14	4170	44.3	30.2	40.8	27.9	2.3	453	0.076	1.4
S-15	4170	41.2	28.1	40.5	27.6	0.5	91	0.101	0.2
S-16	4170	85.7	58.4	83.8	57.1	1.3	246	0.046	1.3
S-17	4170	66.7	45.5	64.2	43.8	1.7	324	0.015	5.2
S-18	4170	45.9	31.3	44.6	30.4	0.9	168	0.020	2.0



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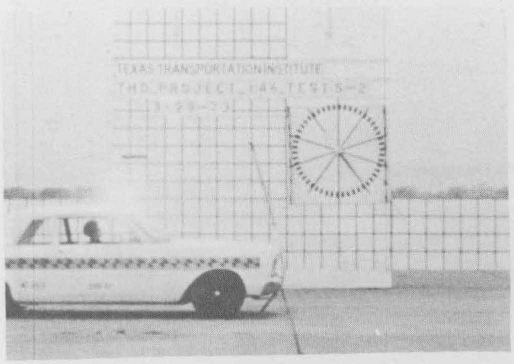

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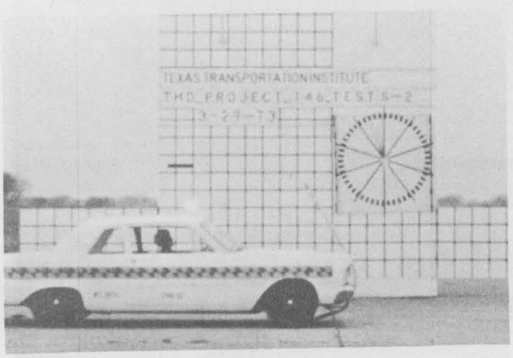

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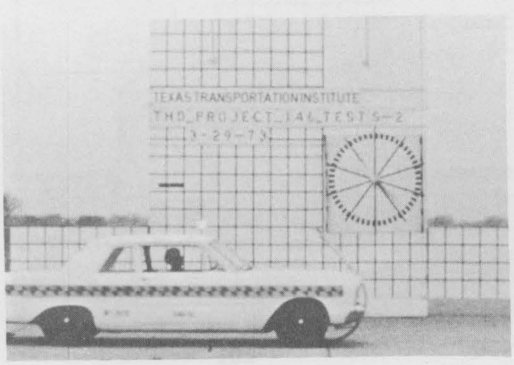

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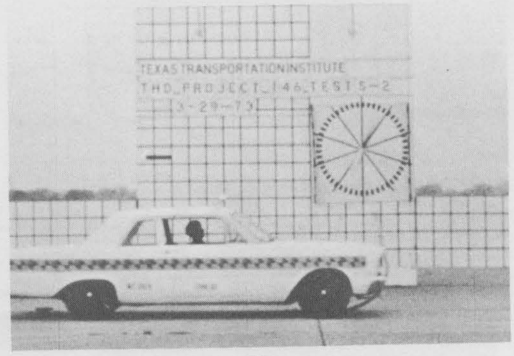

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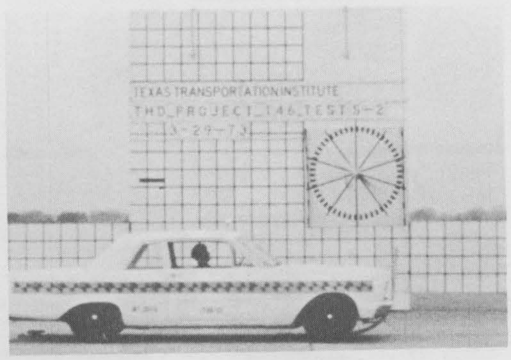

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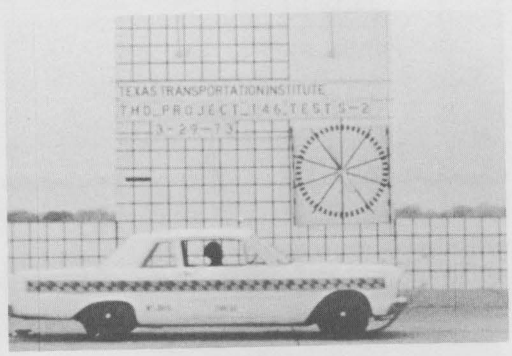

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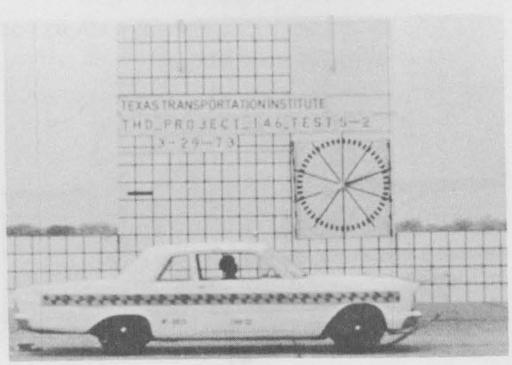
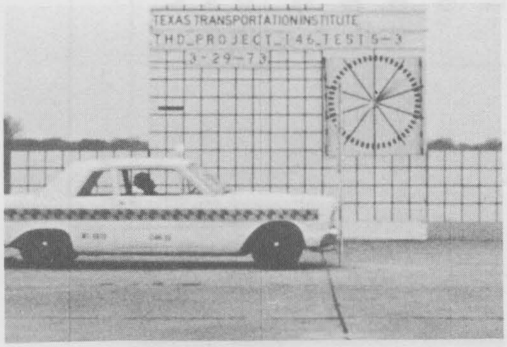


119

Figure C1. Sequential Photographs.
Test S-2, 38.2 mph, ΔV = 1.3 mph.



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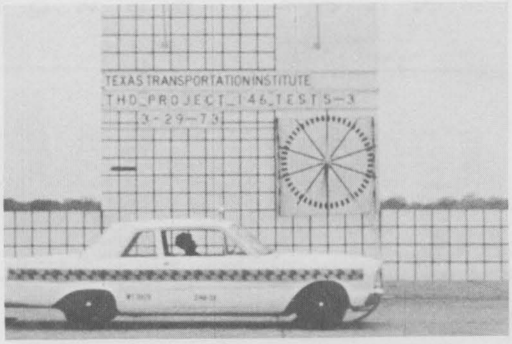

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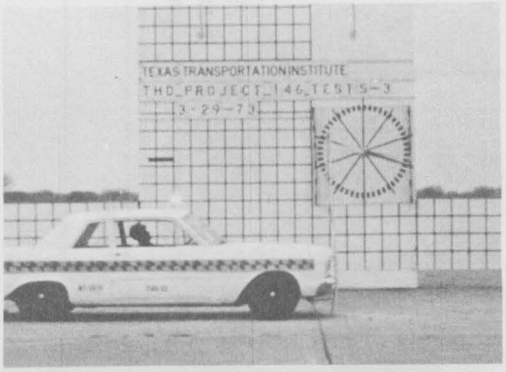

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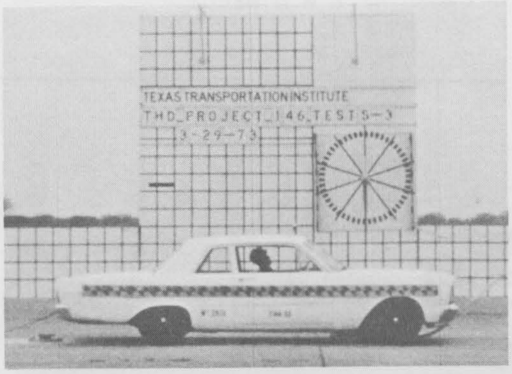

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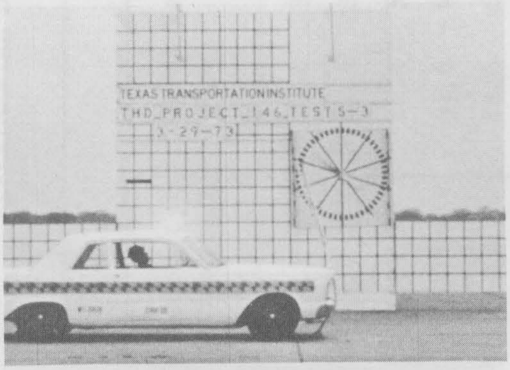

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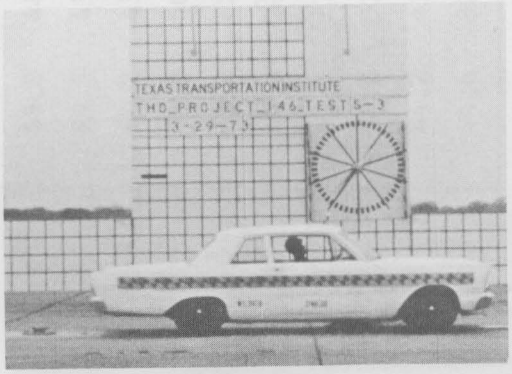

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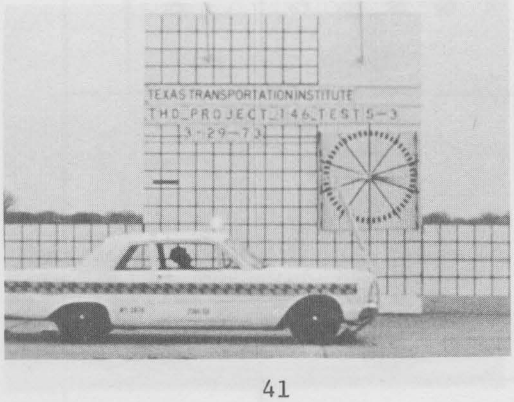

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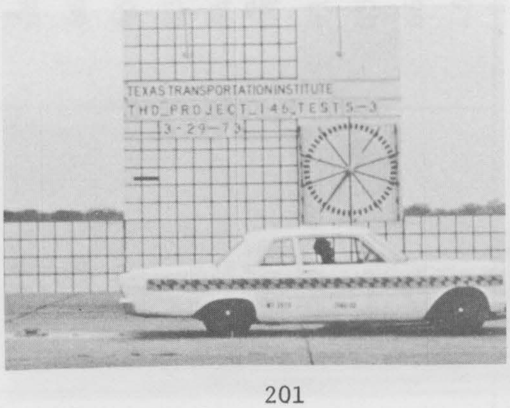


201

Figure C2. Sequential Photographs.
Test S-3, 31 mph, ΔV = 1.4 mph.

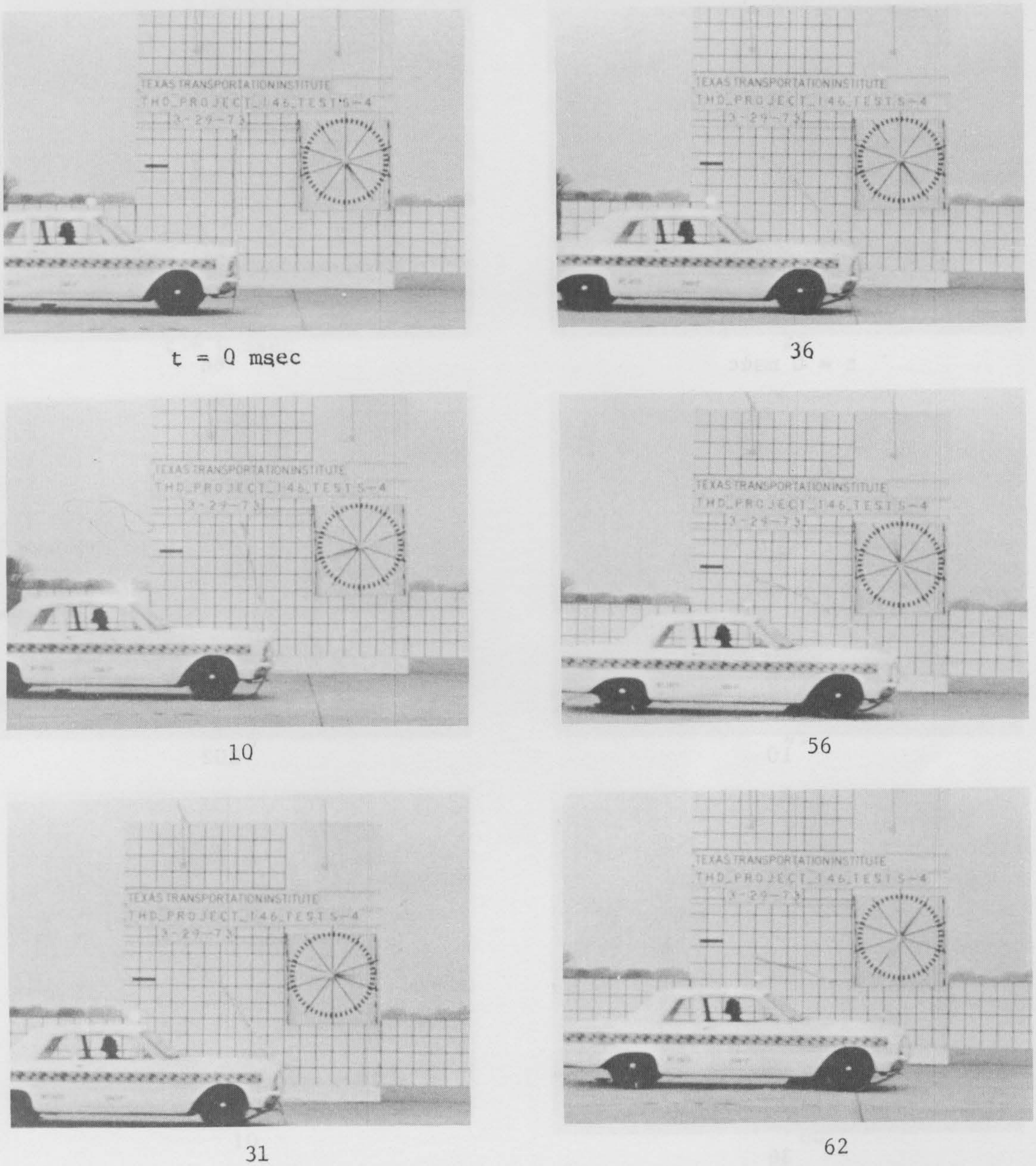
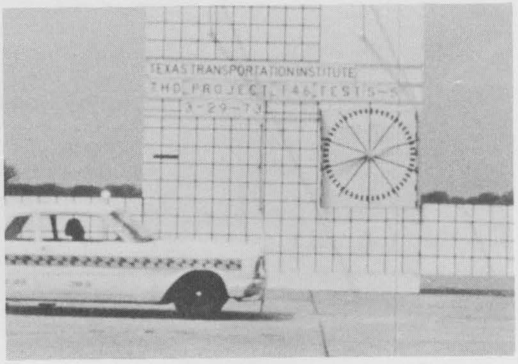


Figure C3. Sequential Photographs.
Test S-4, 59.4 mph, ΔV = 0.5 mph.



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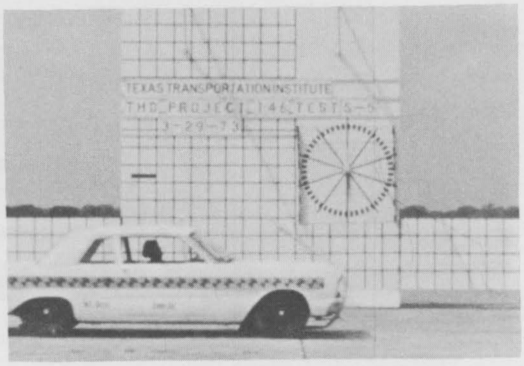

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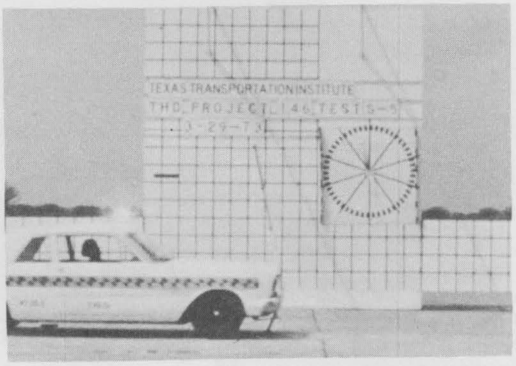
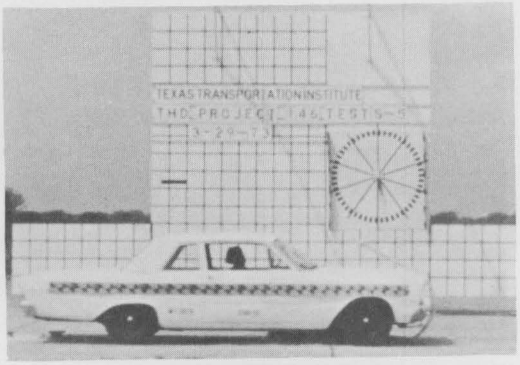
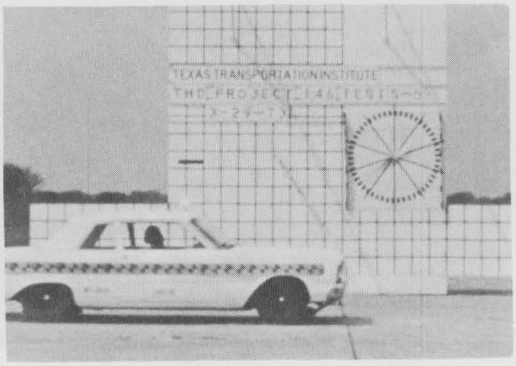


10

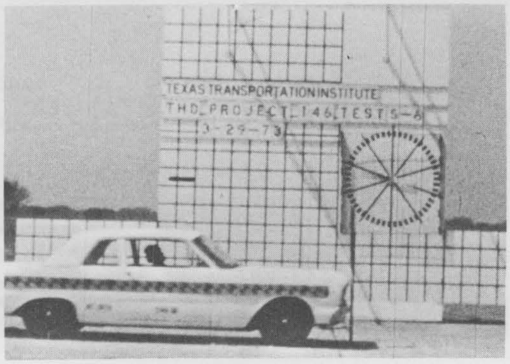


102

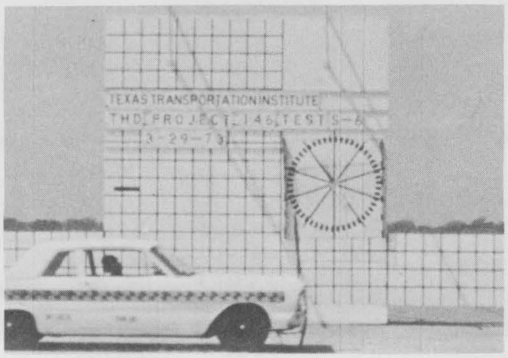


36

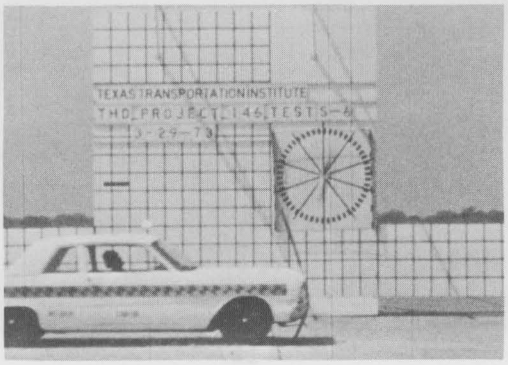
Figure C4. Sequential Photographs.
Test S-5, 44.9 mph, ΔV = 0.8 mph.



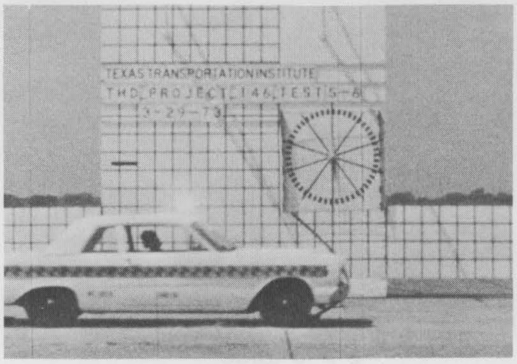
t = 0 msec



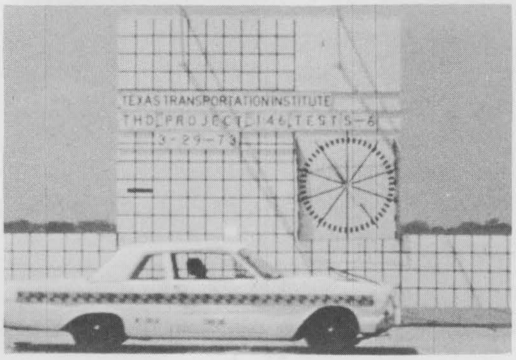
5



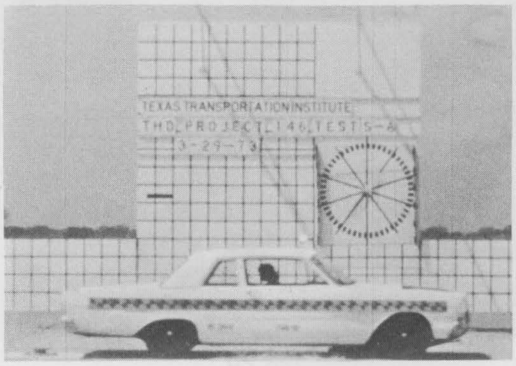
10



25



41



66

Figure C5. Sequential Photographs.
Test S-6, 61.3 mph, ΔV = 0.9 mph.

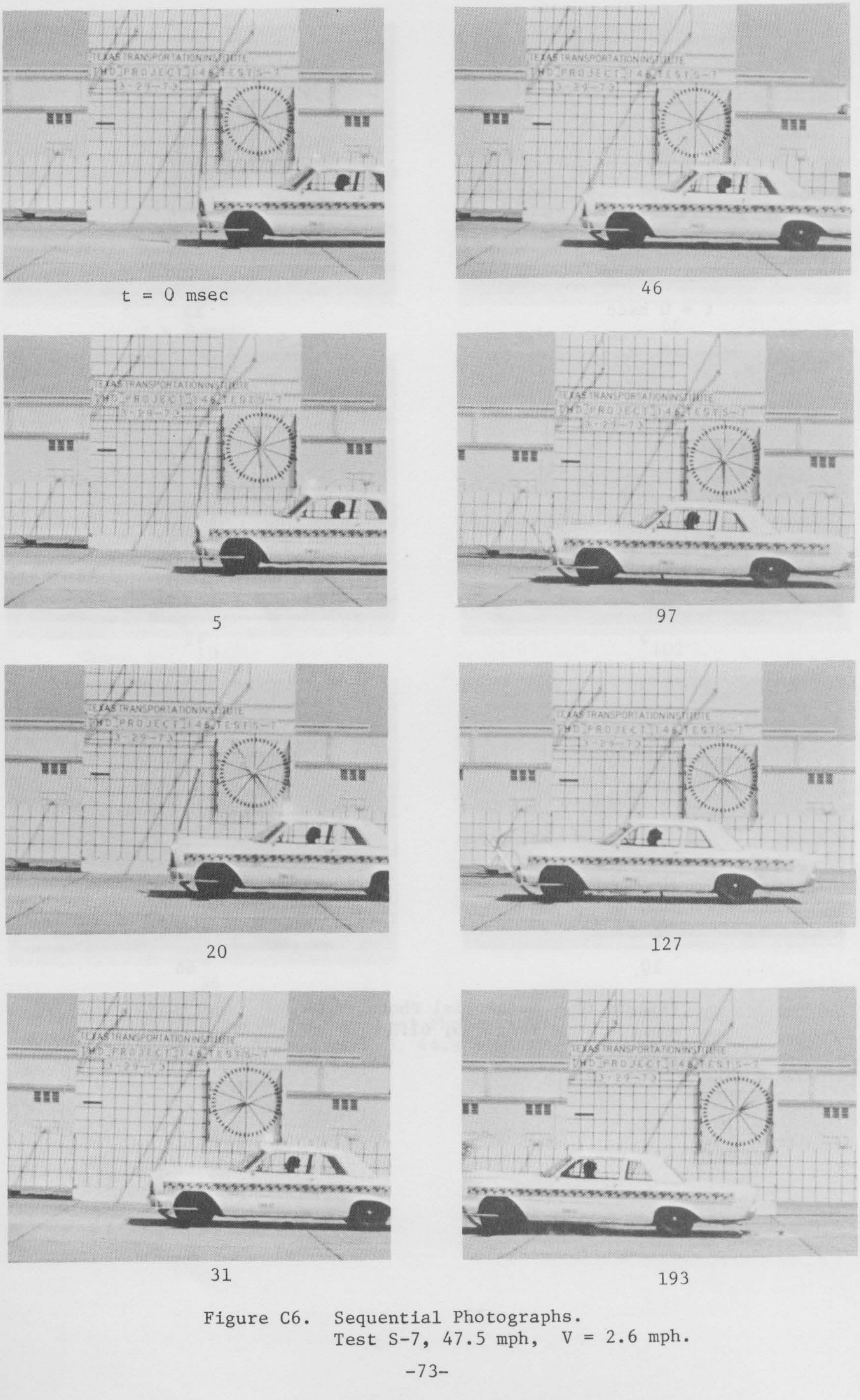
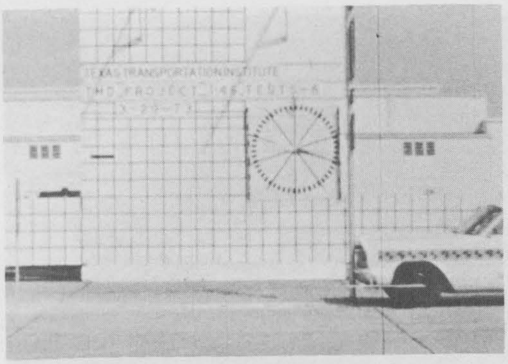
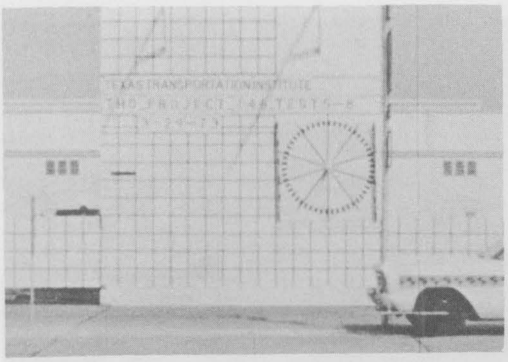


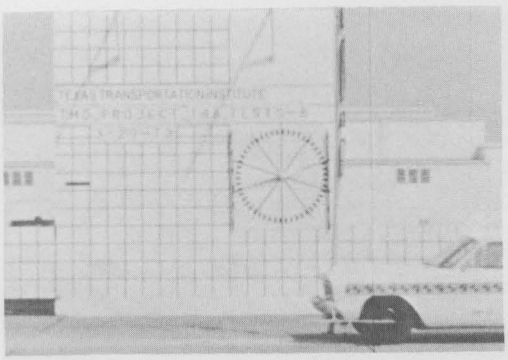
Figure C6. Sequential Photographs.
Test S-7, 47.5 mph, V = 2.6 mph.



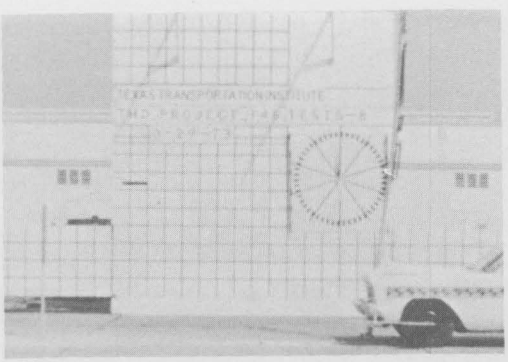
t = 0 msec



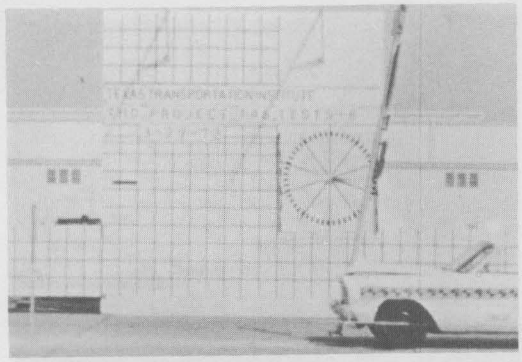
10



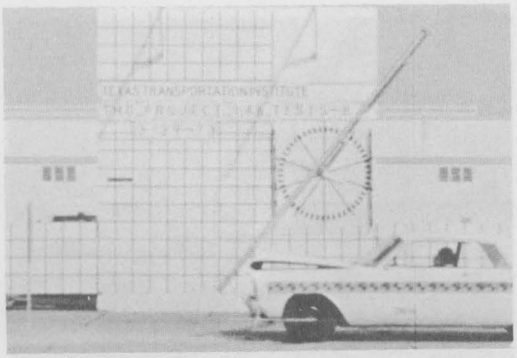
15



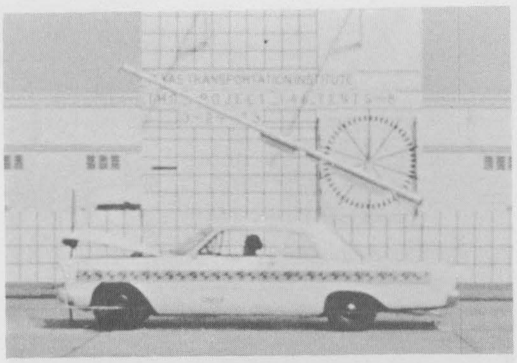
25



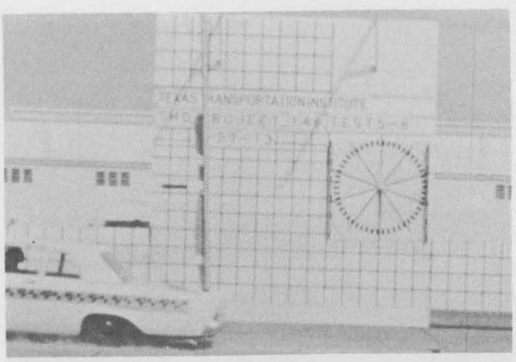
36



91

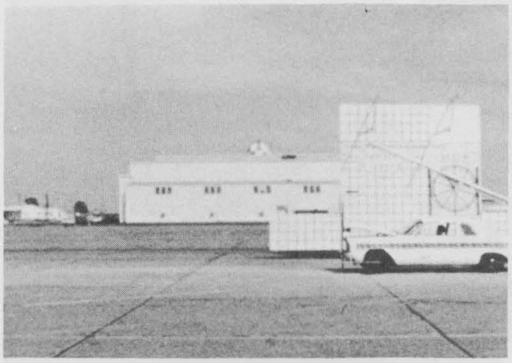


244

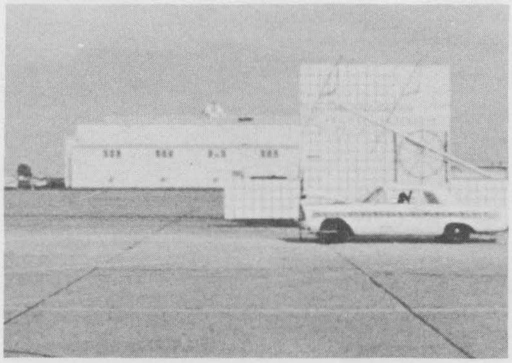


407

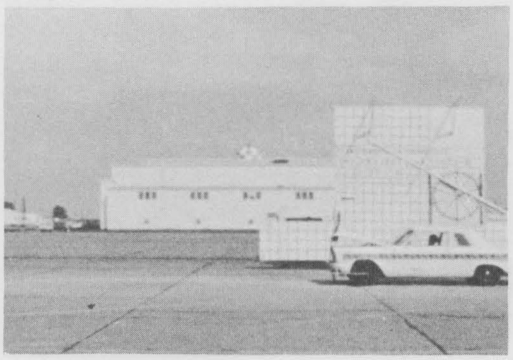
Figure C7. Sequential Photographs.
Test S-8, 46 mph, ΔV = 0.8 mph.



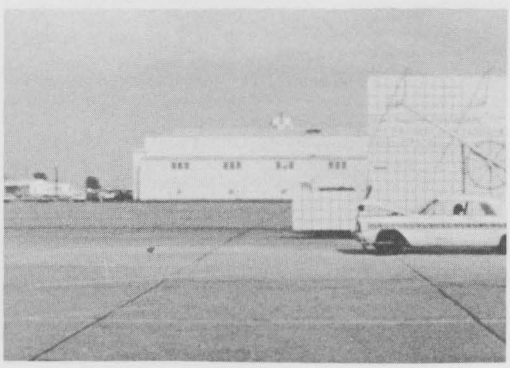
t = 0 msec



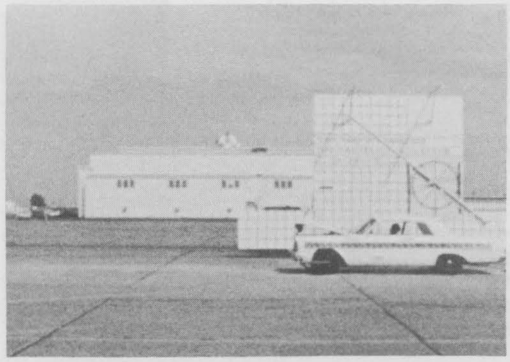
5



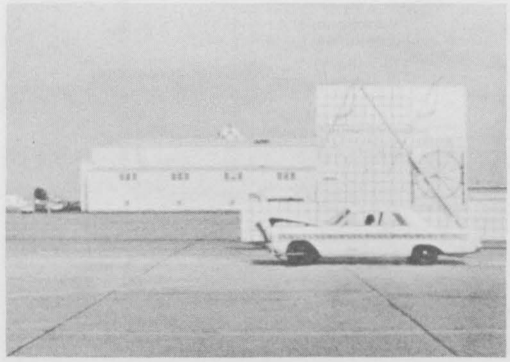
10



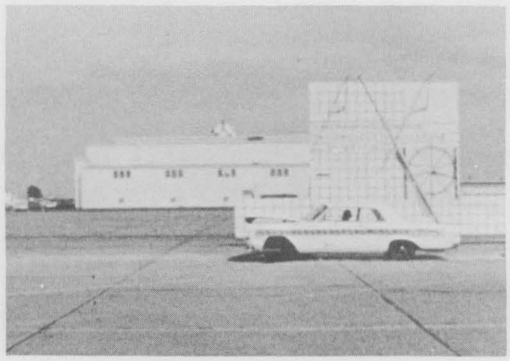
20



30

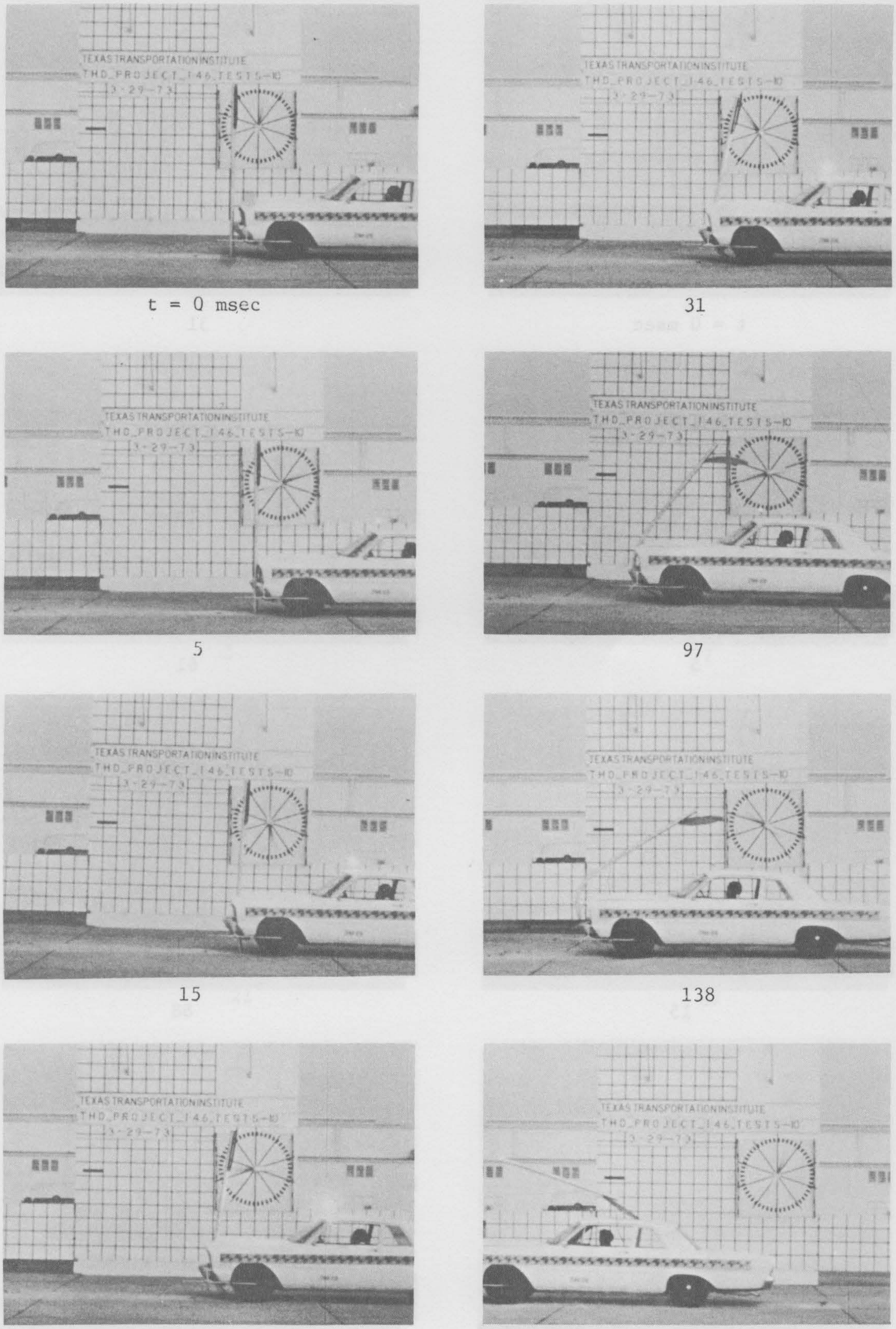


65



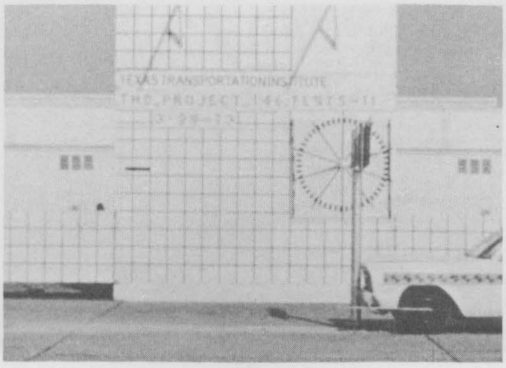
85

Figure C8. Sequential Photographs.
Test S-9, 45.2 mph, ΔV = 0.9 mph.

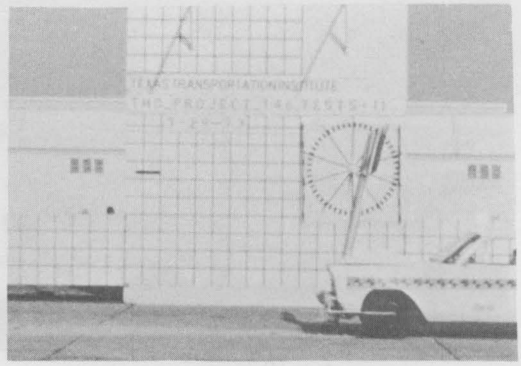


t = 0 msec, 31, 5, 97, 15, 138, 25, 255

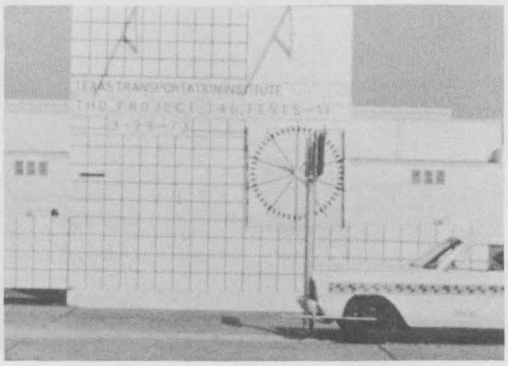
Figure C9. Sequential Photographs.
Test S-10, 45.5 mph, ΔV = 1.7 mph.



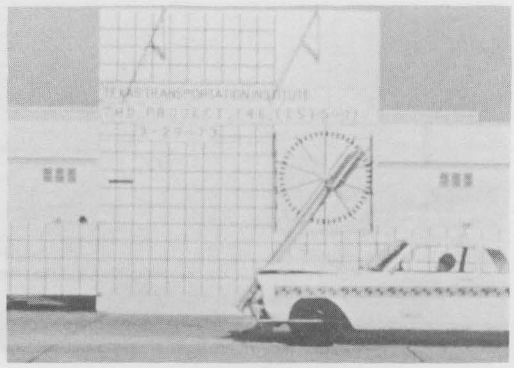
t = 0 msec



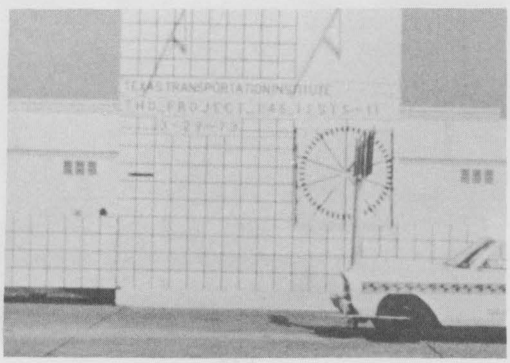
31



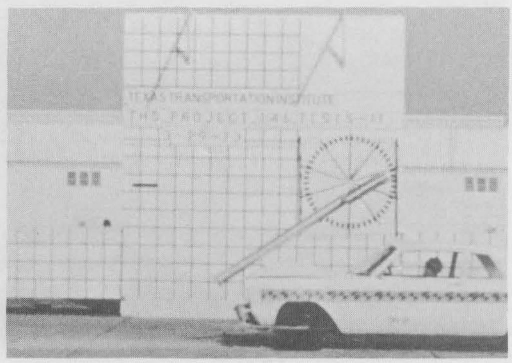
5



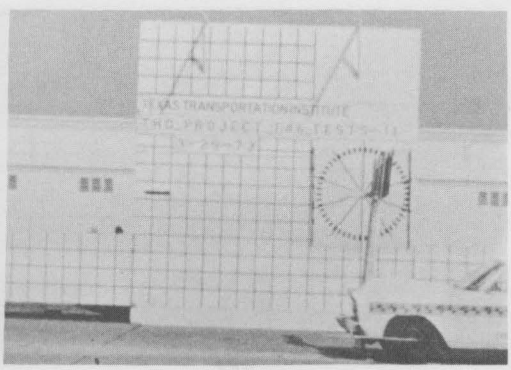
61



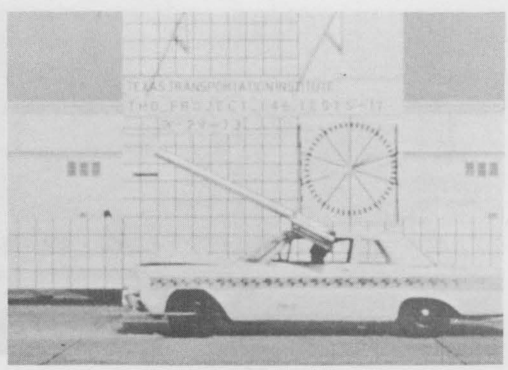
15



88

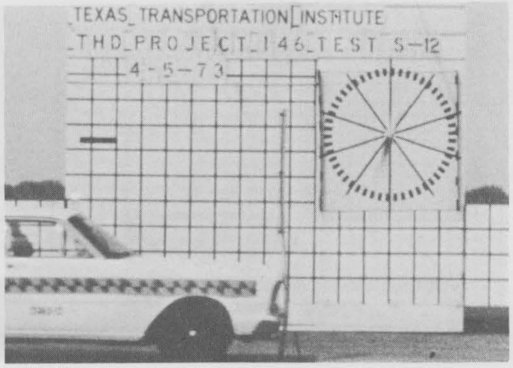


20

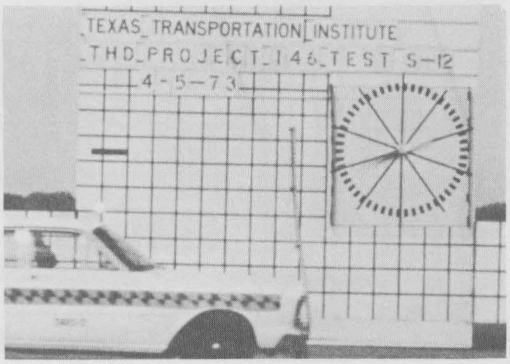


148

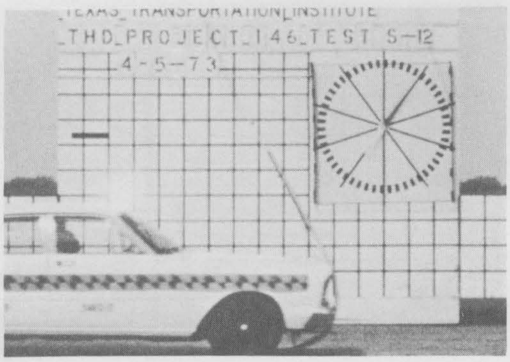
Figure C10. Sequential Photographs.
Test S-11, 44.5 mph, ΔV = 1.4 mph.



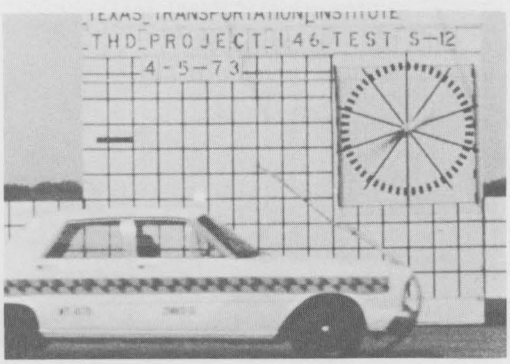
t = 0 msec



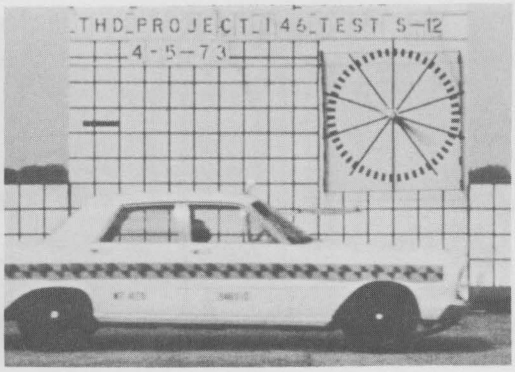
5



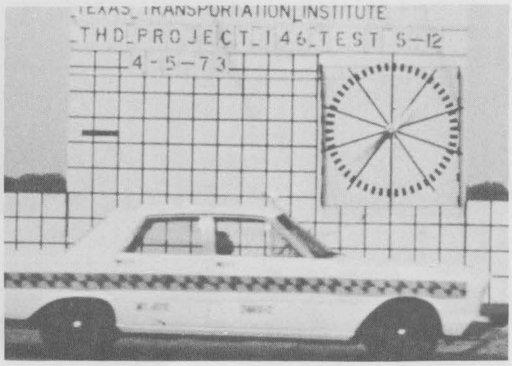
21



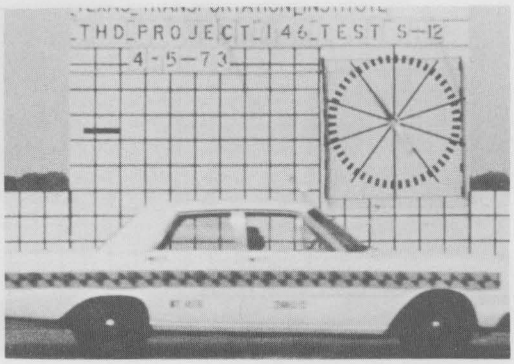
41



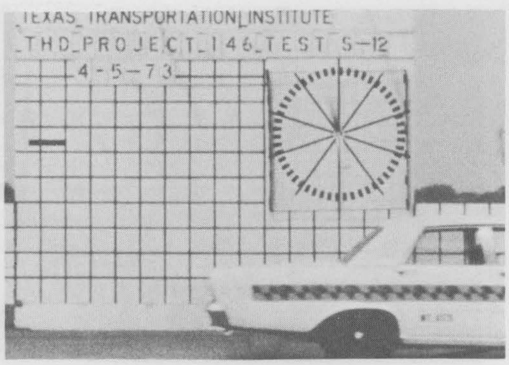
67



77



87



200

Figure C11. Sequential Photographs.
Test S-12, 56.9 mph, ΔV = 0.9 mph.

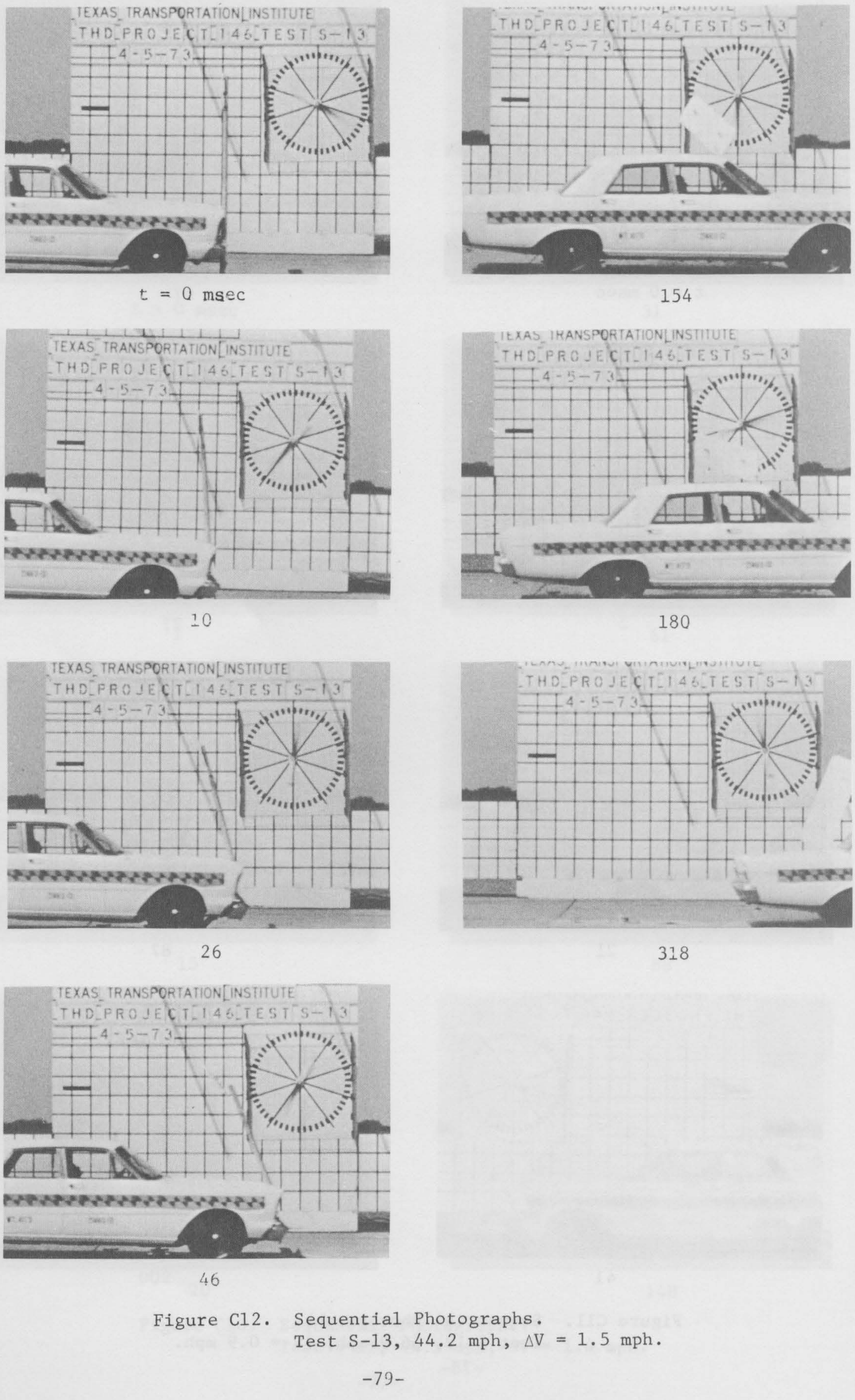
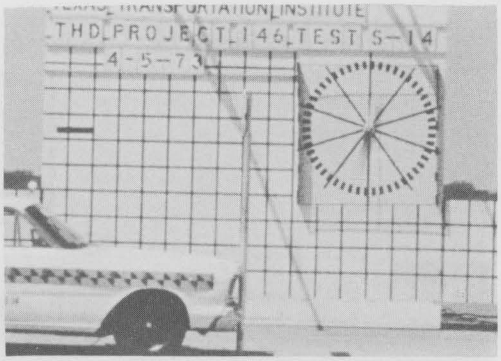
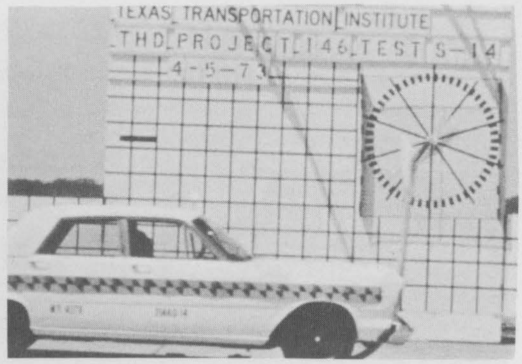


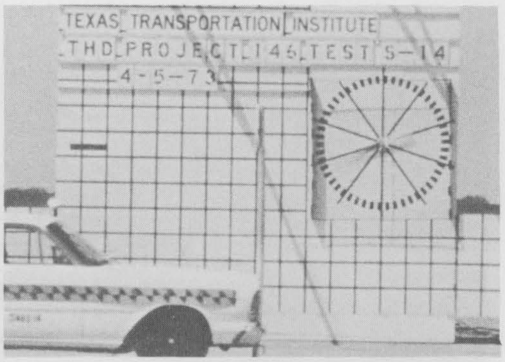
Figure C12. Sequential Photographs.
Test S-13, 44.2 mph, ΔV = 1.5 mph.



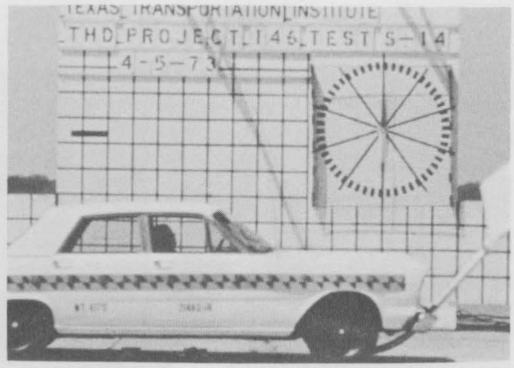
t = 0 msec



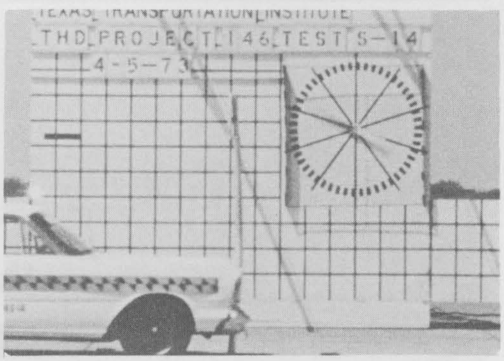
76



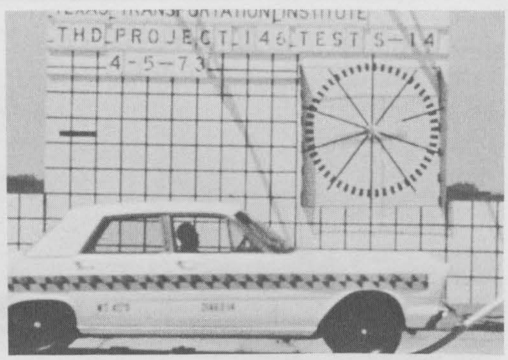
5



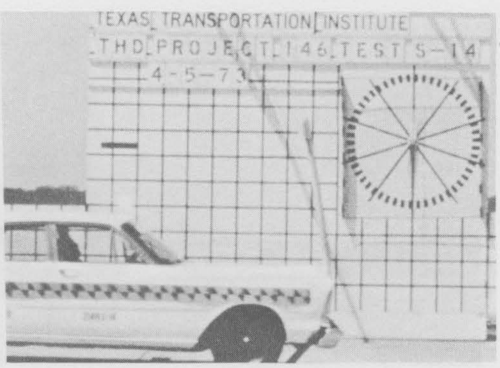
127



10

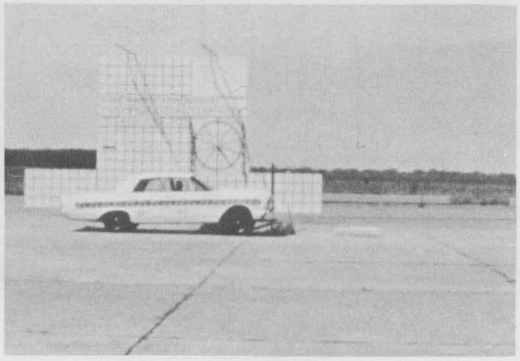


153

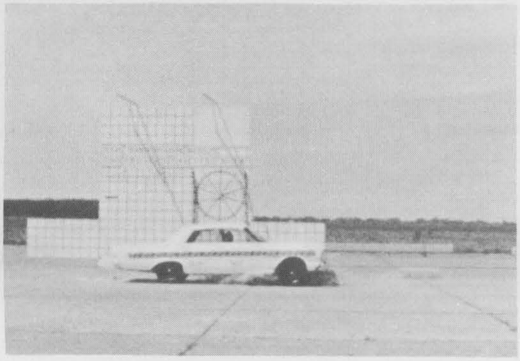


36

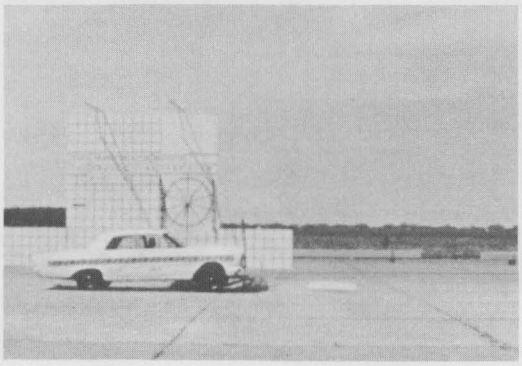
Figure C13. Sequential Photographs.
Test S-14, 30.2 mph, ΔV = 2.3 mph.



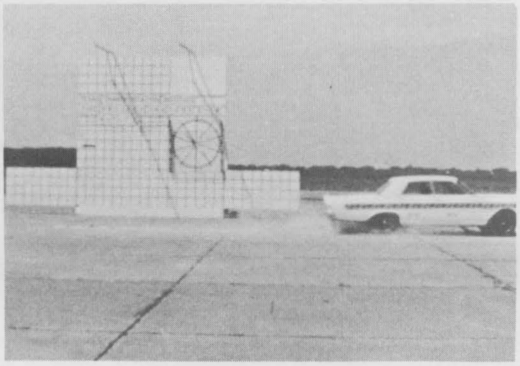
t = 0 msec



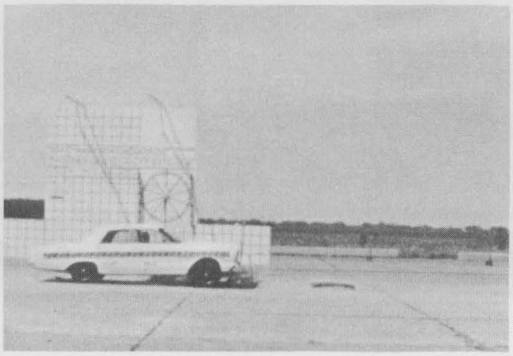
101



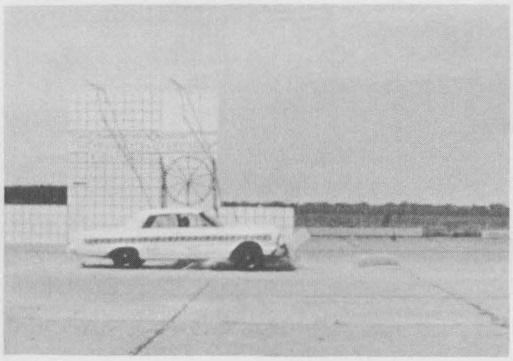
5



589

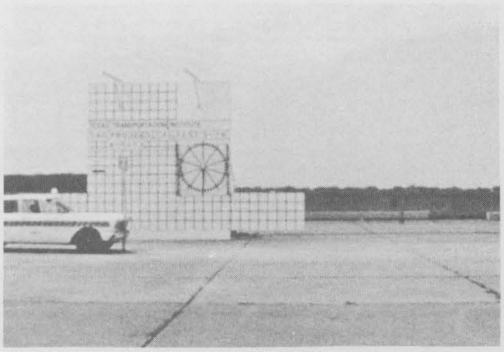


40

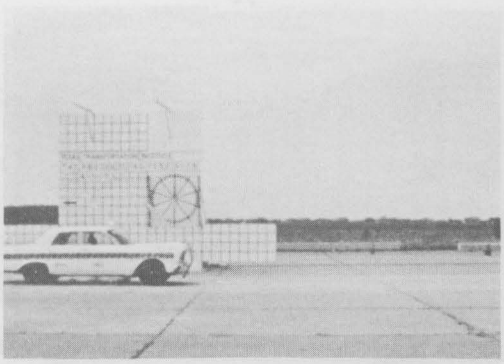


75

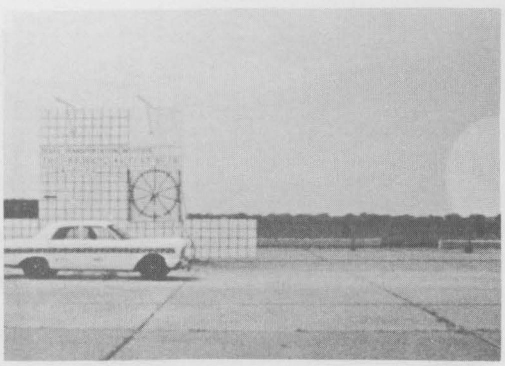
Figure C14. Sequential Photographs.
Test S-15, 28.1 mph, ΔV = 0.5 mph.



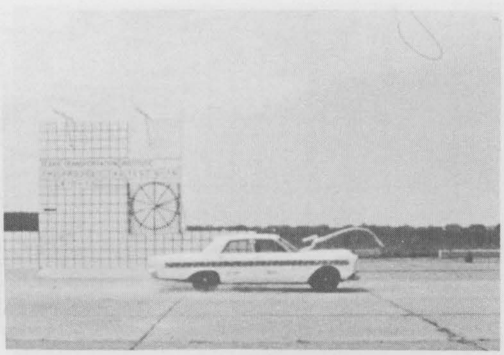
t = 0 msec



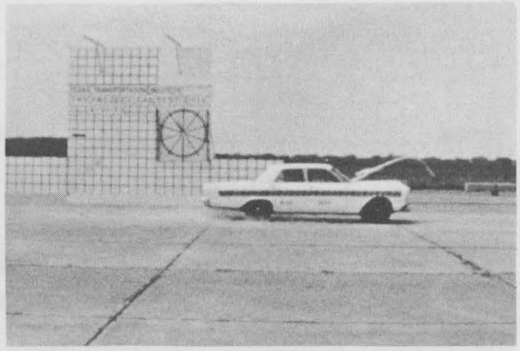
91



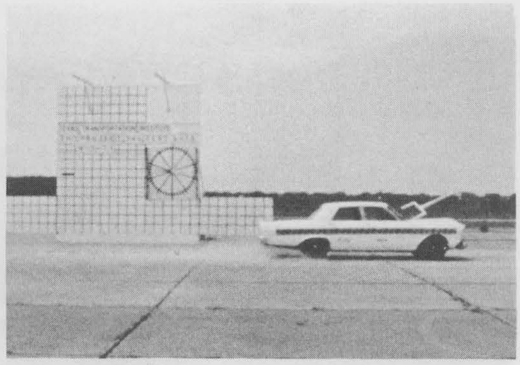
111



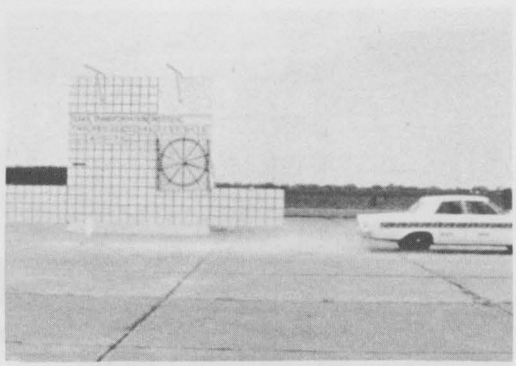
277



302

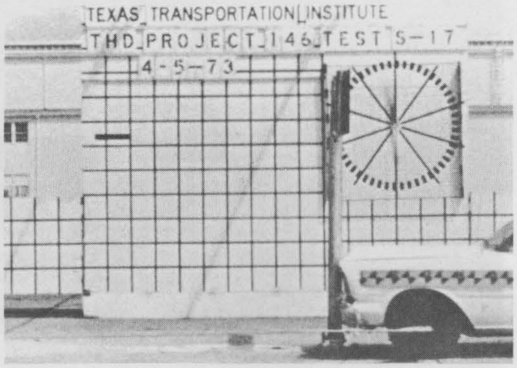


367

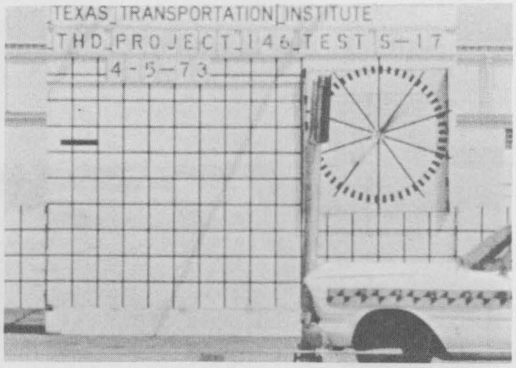


458

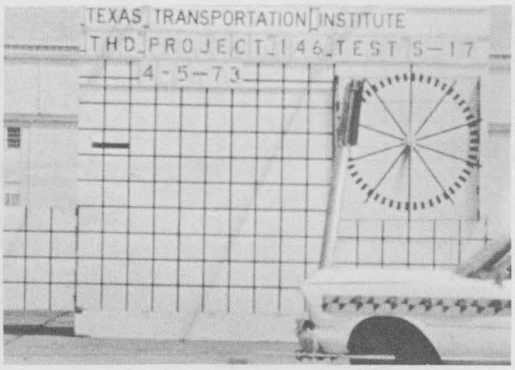
Figure C15. Sequential Photographs.
Test S-16, 58.4 mph, ΔV = 1.3 mph.



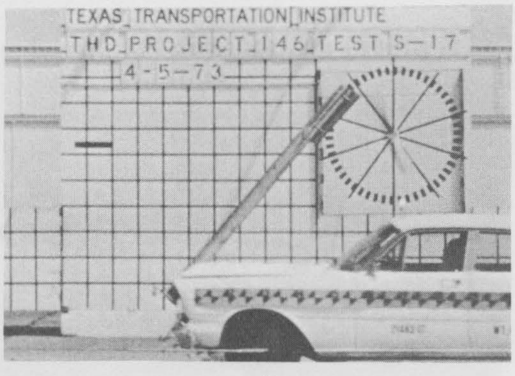
t = 0 msec



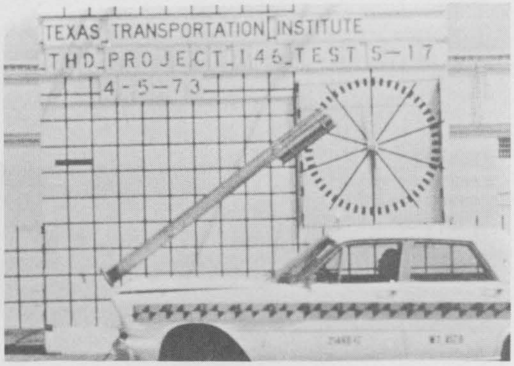
5



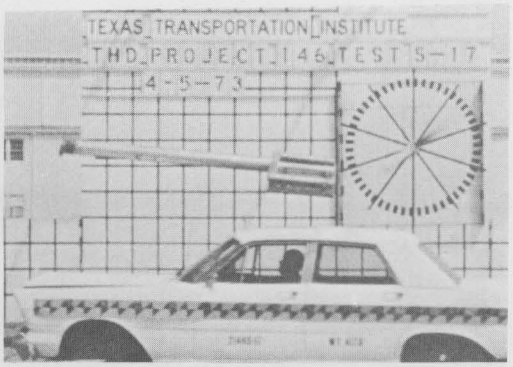
20



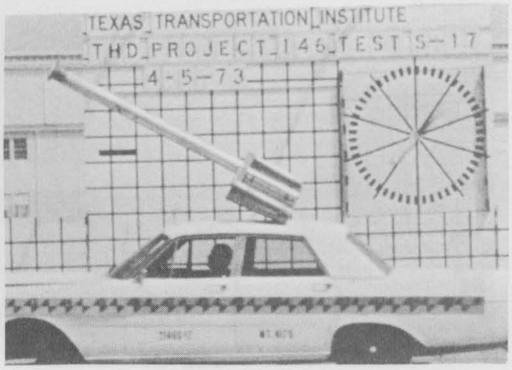
71



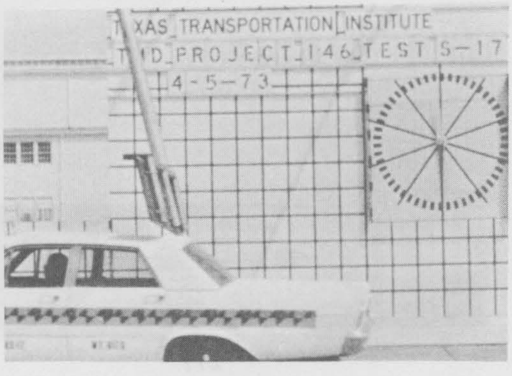
92



153

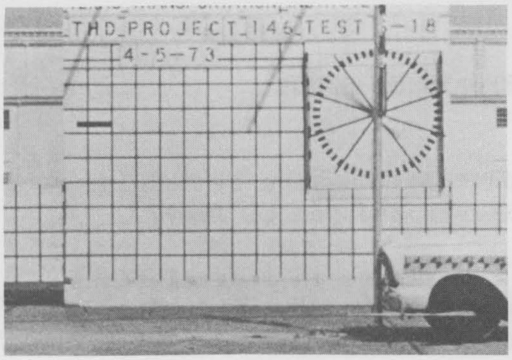


189

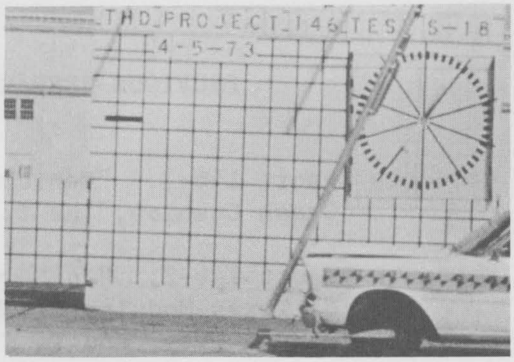


276

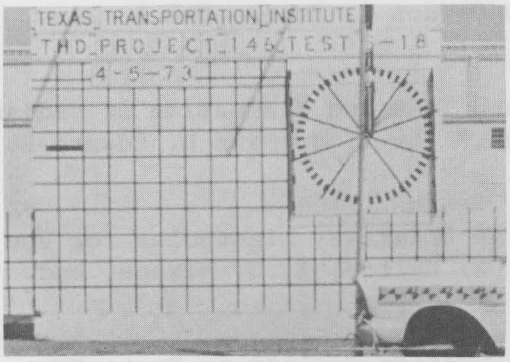
Figure C16. Sequential Photographs.
Test S-17, 45.5 mph, ΔV = 1.7 mph.



t = 0 msec



81



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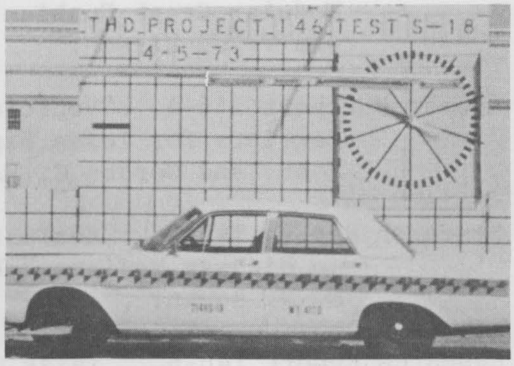

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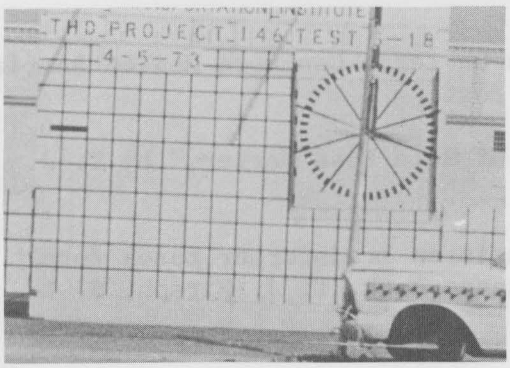

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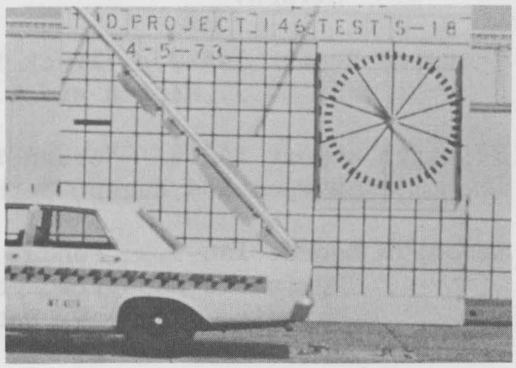

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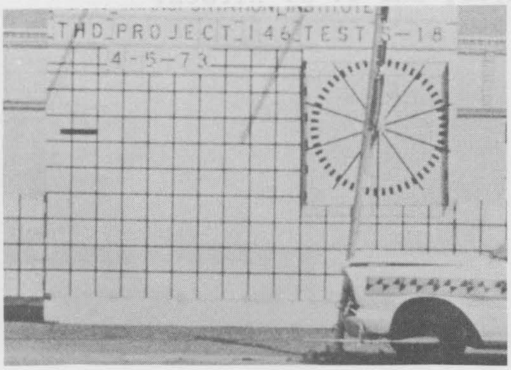

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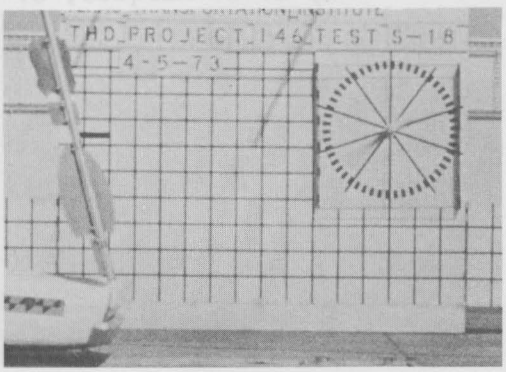

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Figure C17. Sequential Photographs.
Test S-18, 31.3 mph, ΔV = 0.9 mph.

PREVIOUS RESEARCH REPORTS OF STUDY

Research Report 146-1. "Vehicle Impact Attenuation by Modular Crash Cushion," by T. J. Hirsch and Don L. Ivey.

Research Report 146-2. "In-Service Experience on Installations of Texas Modular Crash Cushions," by Monroe C. White, Don L. Ivey, and T. J. Hirsch.

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Research Report 146-4. "Vehicle Crash Test and Evaluation of Median Barriers for Texas Highways," by T. J. Hirsch, Edward R. Post, and Gordon G. Hayes.

Research Report 146-5. "Evaluation of Breakaway Lightpoles for Use in Highway Medians," by N. E. Walton, T. J. Hirsch, and N. J. Rowan.

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Research Report 146-9. "Pendulum Tests on Transformer Bases for Luminaire Supports," by Eugene Buth, T. J. Hirsch, E. L. Marquis, and J. W. Button.

Research Report 146-10. "Chain Link Fence Vehicle Arresting System," by E. L. Marquis, G. G. Hayes, and T. J. Hirsch.