Safety Performance Evaluation of

a Modified Perforated Tension Fuse Plate

for Dual Support Breakaway Signs

by

Brian G. Pfeifer
Research Associate Engineer

Midwest Roadside Safety Facility
Civil Engineering Department
1901 "Y" St., Bldg. 'C'
P.O. Box 880601
University of Nebraska-Lincoln
Lincoln, NE 68588-0601
(402) 472-9198

submitted to

Dan Davidson
Design Division
Missouri Highway Transportation Department
P.O. Box 270
Jefferson City, MO 65102

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ABSTRACT

The Missouri Highway and Transportation Department (MHTD) has been using dual leg breakaway supports for highway signs which include a perforated tension fuse plate developed by the Texas Transportation Institute in 1984. The perforated tension fuse plate is designed to fail in tension, allowing a plastic hinge to form during a vehicular impact. Hinge formation decreases the impact forces applied to a vehicle and reduces the damage to the sign structure. The MHTD found that in some cases the perforated tension fuse plate did not fail when impacted in the field, so the hinge would not activate. The MHTD Engineers redesigned this fuse plate by reducing its thickness so that it would fail upon impact and allow better hinge formation.

At the request of the MHTD, two full-scale 1800-lb vehicle crash tests were performed to evaluate the safety performance of the modified fuse plate. The performance of the dual support breakaway sign with a modified tension fuse plate was determined to be acceptable according to criteria set forth in the National Cooperative Highway Research Program Report 230, AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, and Volume 54 of the Federal Register.

However, design calculations showed that the fuse plate with reduced cross-sectional area is unable to develop the full capacity of the sign post for carrying windloads. Therefore, an alternate fuse plate design was developed and is presented that should provide both improved impact performance and develop the full wind load capacity of MHTD standard structural supports.

DISCLAIMER STATEMENT

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Missouri Highway and Transportation Department nor the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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1 INTRODUCTION

1.1 Problem Statement

The Missouri Highway Transportation Department (MHTD) has been using the design for a dual support breakaway roadside sign which was developed and tested by the Texas Transportation Institute in 1984 (1). This system was designed in such a way that during vehicle impact, the base slipped and a hinge formed 6 in. below the sign, allowing the post to rotate up and out of the way of the errant vehicle. The design utilizes a perforated tension fuse plate to develop the plastic hinge. The MHTD found that, in some cases, this fuse plate does not fail during impacts and, as a result, the hinge fails to activate.

1.2 Background

A very important feature of the dual support breakaway sign is the ability of the support to swing up and out of the way when impacted by an errant vehicle. Not only must the support break away easily at the base, it must also swing away without becoming a projectile, impacting the vehicle a second time, or produce high accelerations on impacting vehicles. The most common structural supports for this type of sign are made of steel W-shapes with a 4-bolt slip base and a plastic hinge located just under the sign. This system was first developed and tested by the Texas Transportation Institute (TTI) in the mid-1960s (2). The following is a brief summary of the evolution of this system.

During the first design iteration of the hinge mechanism, the W-shape was cut through the web and both flanges; the front and back flanges were then reconnected with cast iron plates. When this system was impacted during full-scale vehicle crash tests, both cast iron plates fractured, and the post support completely disengaged from the sign. As a result, the support fell on the test vehicle as it passed under the sign, breaking the windshield and deforming the roof of the vehicle. This test clearly demonstrated the need for a yielding hinge mechanism.

In order to produce a yielding hinge, the support was cut through the front flange and web of the support, while leaving the back flange intact. A cast-iron plate bolted to the front face provided support against static wind loads, but fractured when impacted by a vehicle. When this cast-iron plate fractured, the back flange acted as a hinge and the post swung free of the vehicle but remained attached to the sign. Crash tests on this design were successful (2), but difficulties in casting, handling, bolting and maintaining cast-iron fuse plates led researchers to consider other alternatives.

In the next iteration, a standard ⅜-in. plate of ASTM A441 steel was cut with the bottom two holes notched so the plate would slip under impact. Several static tensile load tests were performed on the steel slip plate to verify that it would withstand design wind loads (3). Both the static tests and the full-scale vehicle crash tests were successful, and this modified design was approved for installation along highways.

In 1984, after numerous reports of the bolted, slotted, friction fuse plates loosening and giving away, an alternate fuse plate was developed (1). Nine static tensile tests were performed on perforated tension fuse plates to determine the proper material and dimensions. Upon completion of these static tests, one full-scale vehicle crash test was conducted with an 1800-lb vehicle at 20 mph to verify the impact performance of the design. The hinge did not activate, but both the lower and middle wind clamps (post-to-sign connections) pulled out and the post rotated about the upper wind clamp. This performance was considered satisfactory, since it did meet the criteria required by NCHRP 230 (4). The design was then approved for highway use, even though the hinge did not activate.

The Missouri Highway Transportation Department (MHTD) installed this system along its highways from 1985 through 1989 and had a few reports of the hinge failing to activate when impacted. In January of 1990 the MHTD reduced the thickness of the fuse plates so that a smaller force would be required to activate the hinge.

The MHTD requested that the Midwest Roadside Safety Facility evaluate the performance of this modified design by conducting two full-scale vehicle crash tests according to the guidelines set forth by NCHRP 230 (4), AASHTO (5), and the Federal Register (6).

1.3 Test Installation

A plan drawing of the dual support system tested is shown in Figure 1. Photographs of the actual installation are shown in Figure 2. The tested system consisted of a 6-ft wide by 5-ft high sign mounted on two Design No. 1 (W6×9) supports. This system was selected because it is the size required for interstate exit signs, which are the most frequently hit signs in the State of Missouri. The hinge mechanism was located 6 inches below the sign. The bottom of the sign was mounted 7-ft 9-in. above the ground surface. The center-to-center spacing of the supports was 3-ft 6-in.

Each support was mounted on the permanent lower slipbase assembly by four 5/8 in. diameter bolts torqued to 345 in.-lbs. These bolts were held in place by a bolt retainer made from 30 gauge galvanized sheet metal. The height of the permanent lower slipbase assembly was 4 in. A drawing of the fuse plate which was used in the safety evaluation is shown in Figure 3 and photographs of this plate on the installation are shown in Figure 4.

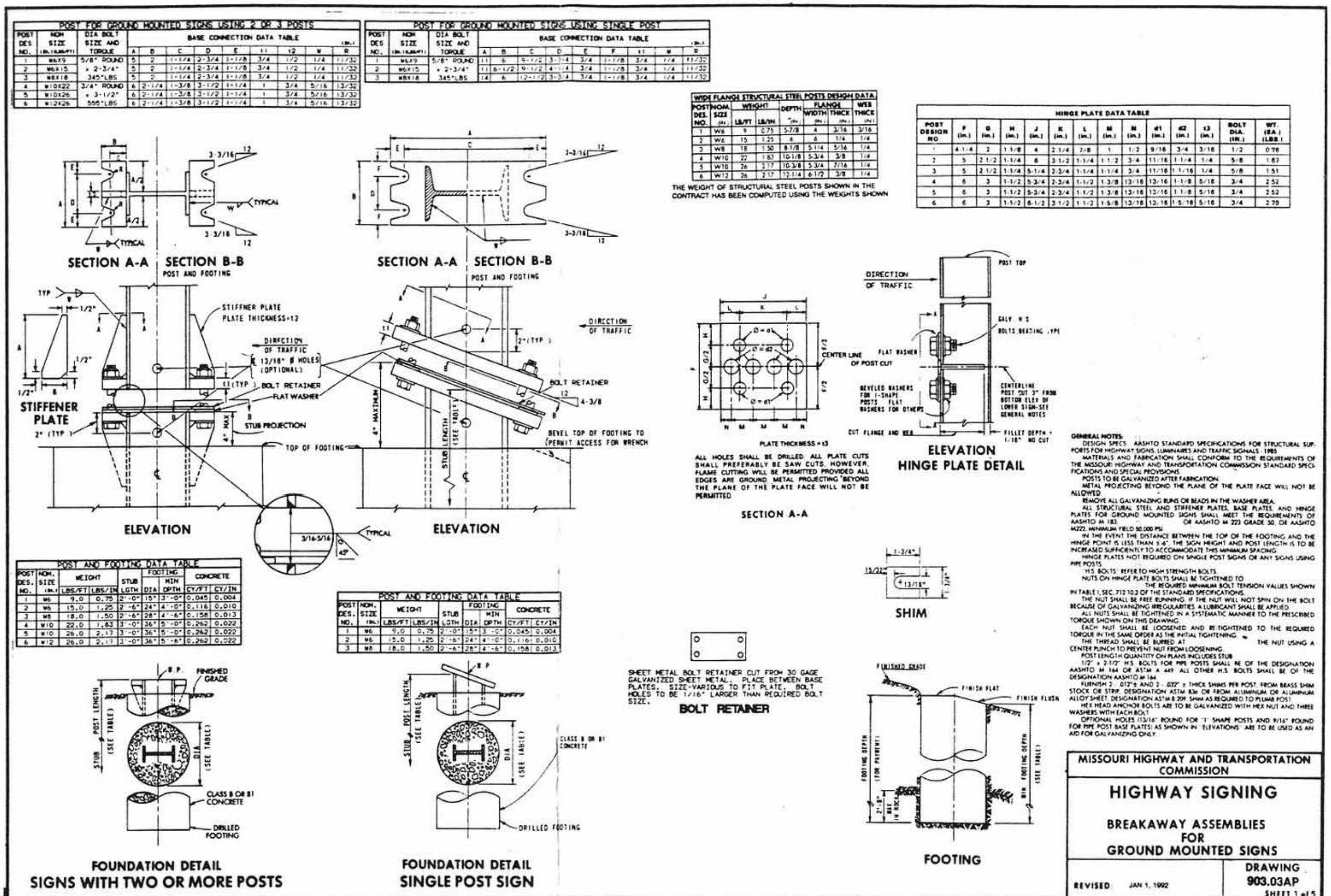


FIGURE 1. Plan drawing of the dual support breakaway system

FIGURE 2. Photographs of the dual support breakaway system

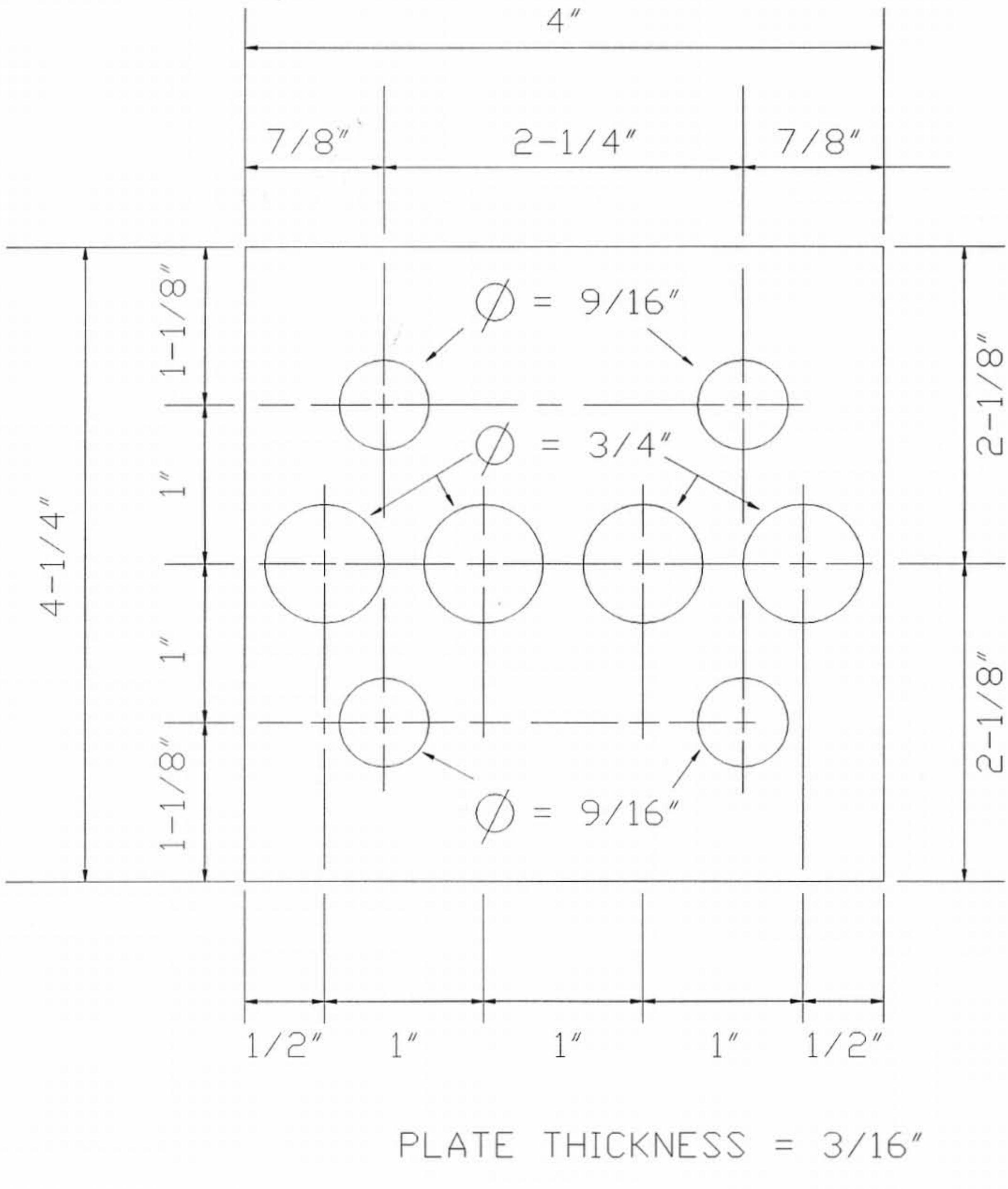


FIGURE 3. Details of the modified perforated tension fuse plate

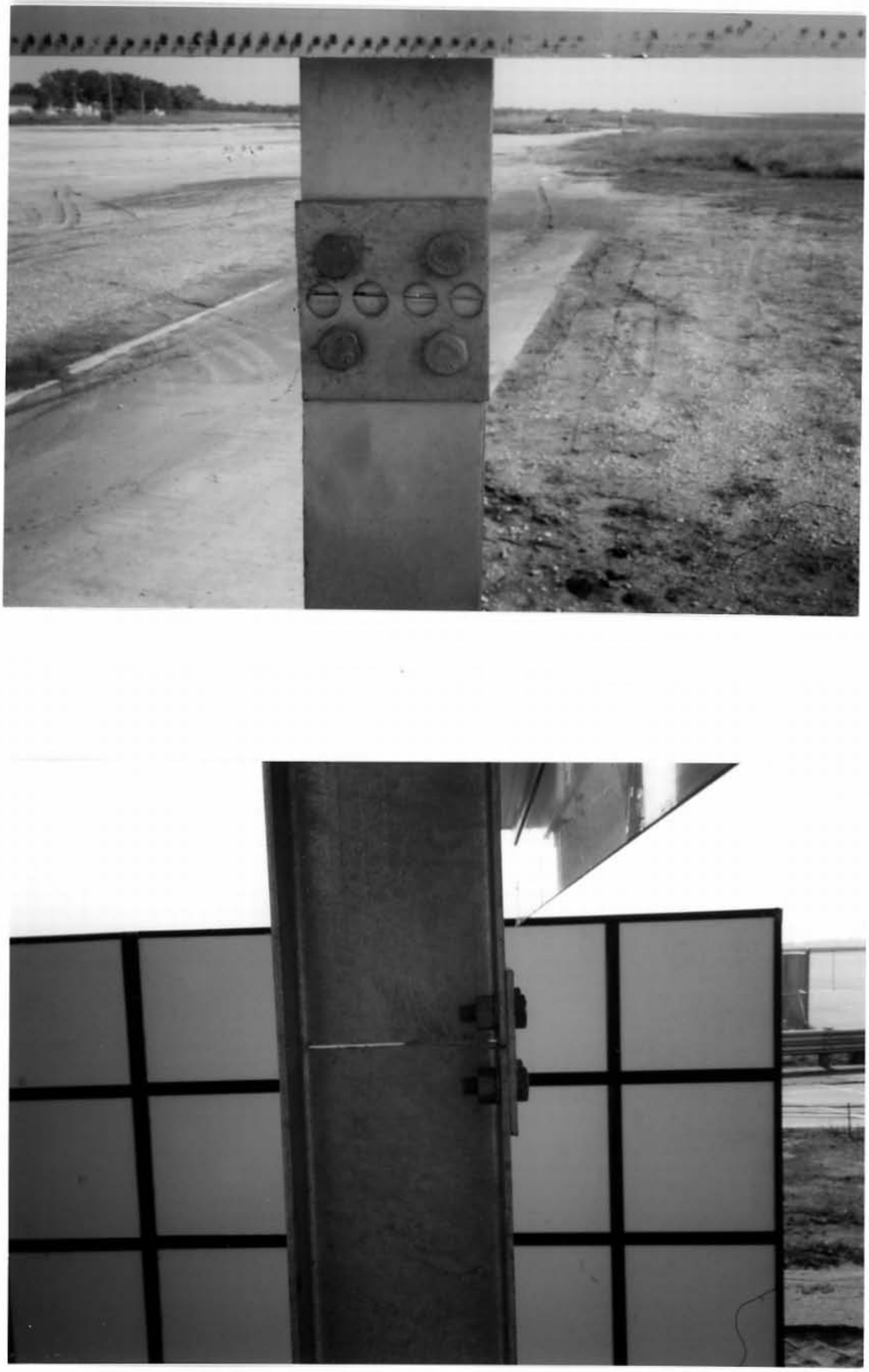


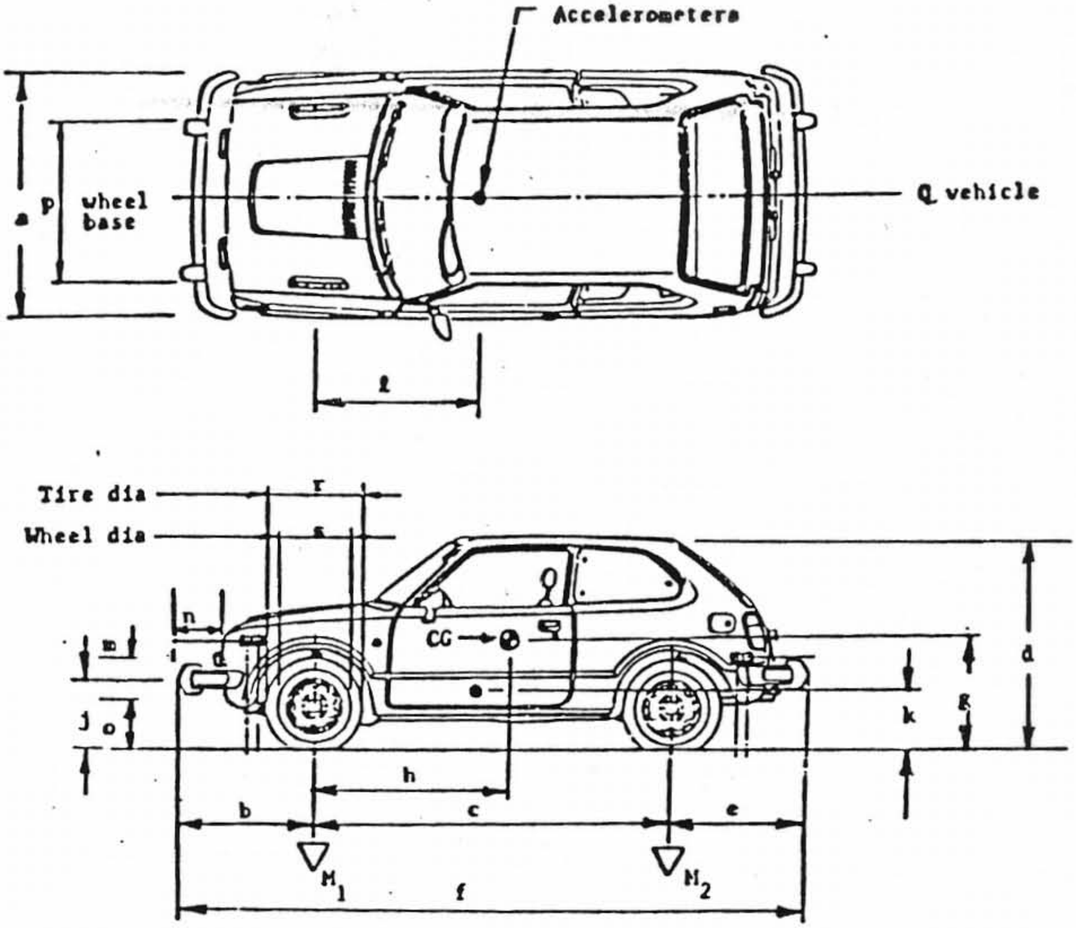
FIGURE 4. Photographs of the modified perforated tension fuse plate

2 TEST CONDITIONS

2.1 Test Vehicle

An 1810-lb 1979 Volkswagen Rabbit, shown in Figure 5, was used as a test vehicle in Tests MOBS-1 and MOBS-2. Dimensions and axle weights of the test vehicle are shown in Figure 6. Black and white-checkered targets were placed on the vehicle for high-speed film analysis. Two targets were located on the center of gravity, one on the top and one on the driver's side of the test vehicle. Additional targets were located for reference so that they could be viewed from all cameras. The front wheels of the test vehicle were aligned for camber, caster, and toe-in values of zero so that the vehicle would track properly along the guide cable. Two 5B flash bulbs, fired by a pressure tape switch on the front bumper, were mounted on the roof of the vehicle to establish the time of impact on the high-speed film.

FIGURE 5. Photographs of test vehicle



Geometry - in.

a 57.25	d --	j 18.5	m 4.0	p 55.0
b 32.0	e 27.5	k 21.6	n 5.0	r 22.5
c 94.0	f 153.5	l 32.3	o 16.5	s 14.5

Mass - lb	Curb	Test Inertial*	Gross Static**
M_1	1290	1200	1200
M_2	680	610	610
M_T	1970	1810	1810
h - in.		32.3	
g - in.		21.6	

FIGURE 6. Test vehicle data sheet

2.2 Data Acquisition Systems

2.2.1 Accelerometers

Two triaxial piezoresistive accelerometer systems with a range of ± 200 g's (Endevco Model 7264) were used to measure vehicle accelerations. The accelerometers were rigidly attached to a metal block mounted near the vehicle's center of gravity. Accelerometer signals were received and conditioned by an onboard Series 300 Multiplexed FM Data System built by Metraplex Corporation. The multiplexed signal was then transmitted to a Honeywell 101 Analog Tape Recorder. "Computerscope" computer software was used to digitize accelerometer data and transfer it to a Cyclone 386/16 Mhz computer with a high-speed data acquisition board. The "DSP" program was then used on a 486/33 Mhz computer to analyze and plot the data.

2.2.2 High Speed Photography

Three high-speed 16-mm cameras, with operating speeds of approximately 500 frames/sec, were used to film the crash tests. The camera locations are shown in Figure 7. One of the perpendicular cameras was a Red Lake Locam with a wide-angle 12.5-mm lens. The other perpendicular camera was a Photec IV with a 55-mm lens. The third high-speed camera was a Photec IV with an 80-mm lens. An 8-ft high by 12-ft long backboard with a 2 ft grid was located 10 ft behind the impacted post. The grid was used to provide a visible reference system which could be used in the analysis of the perpendicular high-speed film. The film was analyzed using a Vanguard Motion Analyzer. Actual camera speed and camera divergence factors were considered in the analysis of the high-speed film.

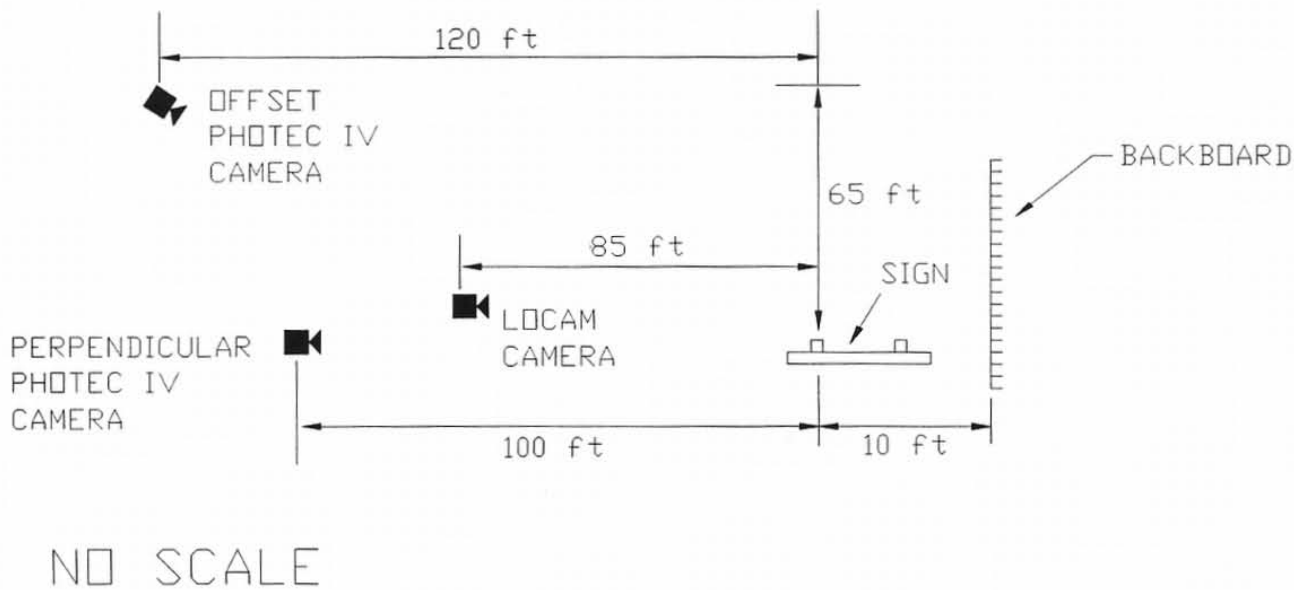


FIGURE 7. Schematic of camera locations

2.2.3 Speed Trap

Seven pressure tape switches spaced at 5-ft intervals were used to determine the speed of the vehicle before and after impact. Each tape switch fired a strobe light and sent an electronic timing mark to the data acquisition system as the left front tire of the test vehicle passed over it. Test vehicle speeds were determined from electronic timing mark data recorded on "Computerscope" software. Strobe lights and high speed film analysis are used only as a backup in the event that vehicle speeds cannot be determined from the electronic data.

3 TEST RESULTS

3.1 Test MOBS-1 (1810 lbs, 20.6 mph, 0 deg)

In Test MOBS-1, the 1979 Volkswagen Rabbit impacted the sign structure head on at a speed of 20.6 mph. A summary of the test results is shown in Figure 8. The target impact point was the center of the front bumper, but the actual impact was offset 5.5 in. toward the passenger side of the vehicle. A maximum crush depth of 9.75 in. was measured on the front bumper of the test vehicle. The damage to the test vehicle is shown in Figure 9. Damage to the sign support consisted only of destruction of the perforated tension fuse plate and the impacted support. Damage to the installation is shown in Figure 10.

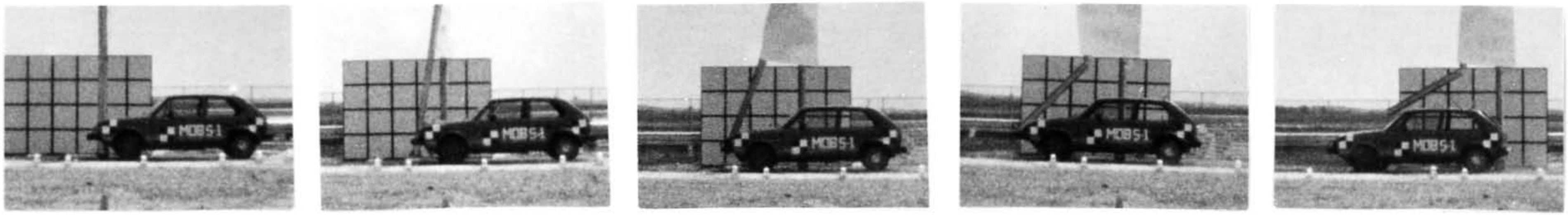
3.1.1 Results of Film Analysis

Sequential photographs taken from the high speed 16-mm film are shown in Figure 8. At the time of impact with the sign support, the front bumper of the test vehicle crushed inward for a period of approximately 42 ms, after which the slip base began to activate. By 62 ms after impact, the slip base had completely activated, and the support was free of the base. At 92 ms, the post momentarily lost contact with the vehicle, and a noticeable twist was developed in the sign. At 160 ms after impact, the vehicle regained contact with the post, and at 238 ms the hinge mechanism began to activate. As the perforated tension fuse plate failed, the support swung up and away from the vehicle, losing contact with the vehicle 310 ms after impact. As shown in the sequential photos (Figure 8), a combination of the upward motion of the support and the twisting of the sign allowed the test vehicle to pass under the support.

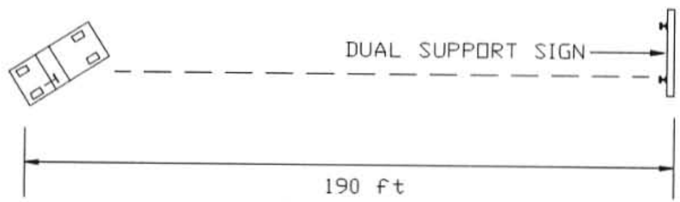
3.1.2 Results of Accelerometer Analysis

The analysis of the accelerometer data showed that the performance of the breakaway support passed the occupant risk criteria presented by NCHRP 230 (4). The occupant impact velocity was 8.7 fps, well below the limit of 15 fps. The vehicle change in speed was determined to be 8.7 fps, which is below the required limit of 16 fps. The maximum ridedown acceleration of 1.0 g was well below the specified limit of 15 g's.

Plots of the accelerometer data from Test MOBS-1 can be found in Appendix A. A summary of the safety performance results is given in Table 1.



42 ms 92 ms 239 ms 311 ms 541 ms



Test Number	MOBS-1
Date	5/29/92
Installation	Dual Steel Support Breakaway Sign
Sign size	5 ft × 6 ft
Sign mounting height	7 ft - 9 in.
Support size	W6×9
Post Spacing	3 ft - 6 in.
Perforated Tension Fuse Plate	
Location	6 in. below sign
Plate thickness	3/16 in.
Effective cross sectional area	0.1875 in.^{2}
Permanent lower slipbase assembly	
Slip Bolt size	5/8 in.
Bolt torque	345 in.-lb
Stub height	4 in.

Vehicle Model	1979 Volkswagen Rabbit
Vehicle Weight	
Curb	1970 lbs
Test Inertial	1810 lbs
Gross Static	1975 lbs
Vehicle Impact Speed	20.6 mph
Vehicle Impact Angle	0 deg
Vehicle Impact Location	5.5 in. right of center
Vehicle Snagging	None
Vehicle Stability	Satisfactory
Occupant Impact Velocity	8.7 fps
Occupant Ridedown Acceleration	1.0 g
Vehicle Change in Speed	8.7 fps
Vehicle Damage	Minimal
TAD	12-FC-3
VDI	12FCEN1
Vehicle Front-end Crush	9.75 in.
Vehicle Stopping Distance	190 ft

FIGURE 8. Summary of Test MOBS-1

FIGURE 9. Vehicle damage, Test MOBS-1

FIGURE 10. Sign support damage, Test MOBS-1

3.2 Test MOBS-2 (1810 lbs, 59.3 mph, 0 deg)

In Test MOBS-2, the 1979 Volkswagen Rabbit impacted the sign structure head on at a speed of 59.3 mph. A summary of the test results is shown in Figure 11. The target impact point was the center of the front bumper, but the actual impact occurred 6.25 in. from the center point toward the driver side of the vehicle. The damage to the test vehicle is shown in Figure 12, and damage to the test installation is shown in Figure 13. The impacted support and corresponding fuse plate were destroyed shortly after impact when the hinge mechanism activated. The other support was deformed as the sign system rotated around clockwise. One of the flanges from the stub of the non-impacted support was torn off as the support was rotated around. Damage to the sign was minimal, but one of the support beams was partially separated from the back of the sign.

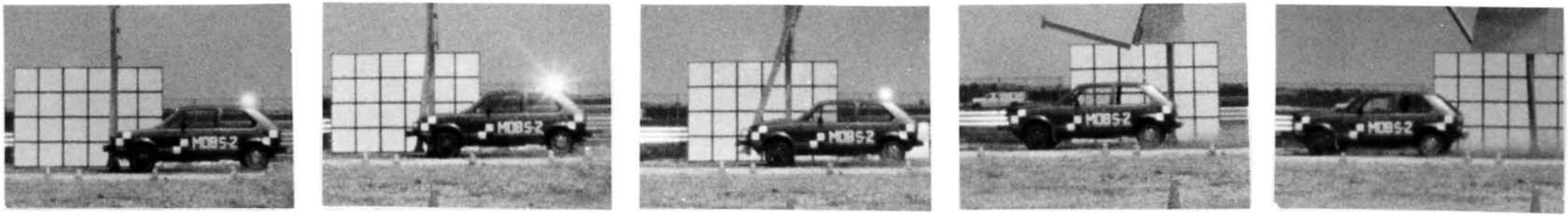
3.2.1 Results of Film Analysis

Sequential photographs taken from the high speed 16-mm film are shown in Figure 13. At the time of impact with the sign support, the front bumper of the test vehicle began to crush inward. At 8 ms after impact, the slip base began to activate, and the support had slipped completely off the base by 18 ms. The vehicle continued to push the support back and twist the sign until 60 ms after impact when the hinge mechanism began to activate. At the same time, the support lost contact with the vehicle and swung up and away from the vehicle. The support continued to swing upward, and the system was rotated around. The bolt retainer was projected 75 feet behind the sign, but this was not considered to be a hazard due to the low mass of the 30 gage sheet. The entire sign rotated clockwise and landed as shown in Figure 14.

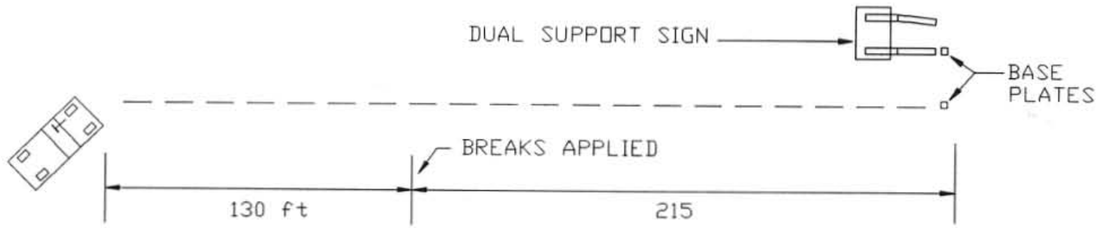
3.2.2 Results of Accelerometer Analysis

The analysis of the accelerometer data showed that the performance of the breakaway support easily passed the occupant risk criteria presented by NCHRP 230 (4). The occupant impact velocity was 6.7 fps, well below the limit of 15 fps. The vehicle change in speed was determined to be 4.3 fps, which is below the required limit of 16 fps. The maximum ridedown acceleration of 1.4 g's was well below the specified limit of 15 g's.

Plots of the accelerometer data from Test MOBS-2 can be found in Appendix A. A summary of the safety performance results is given in Table 1.



18 ms 41 ms 60 ms 208 ms 378 ms



Test Number	MOBS-2
Date	5/29/92
Installation	Dual Steel Support Breakaway Sign
Sign size	5 ft × 6 ft
Sign mounting height	7 ft - 9 in.
Support size	W6×9
Post Spacing	3 ft - 6 in.
Perforated Tension Fuse Plate	
Location	6 in. below sign
Plate thickness	3/16 in.
Effective cross sectional area	0.1875 in.^{2}
Permanent lower slipbase assembly	
Slip Bolt size	5/8 in.
Bolt torque	345 in.-lb
Stub height	4 in.

Vehicle Model	1979 Volkswagen Rabbit
Vehicle Weight	
Curb	1970 lbs
Test Inertial	1810 lbs
Gross Static	1975 lbs
Vehicle Impact Speed	59.3 mph
Vehicle Impact Angle	0 deg
Vehicle Impact Location	6.25 in. left of center
Vehicle Snagging	None
Vehicle Stability	Satisfactory
Occupant Impact Velocity	6.7 fps
Occupant Ridedown Acceleration	1.4 g
Vehicle Change in Speed	4.3 fps
Vehicle Damage	Minimal
TAD	12-FC-3
VDI	12FCEN1
Vehicle Front-end Crush	9.5 in.
Vehicle Stopping Distance	345 ft

FIGURE 11. Summary of Test MOBS-2

FIGURE 12. Vehicle damage, Test MOBS-2

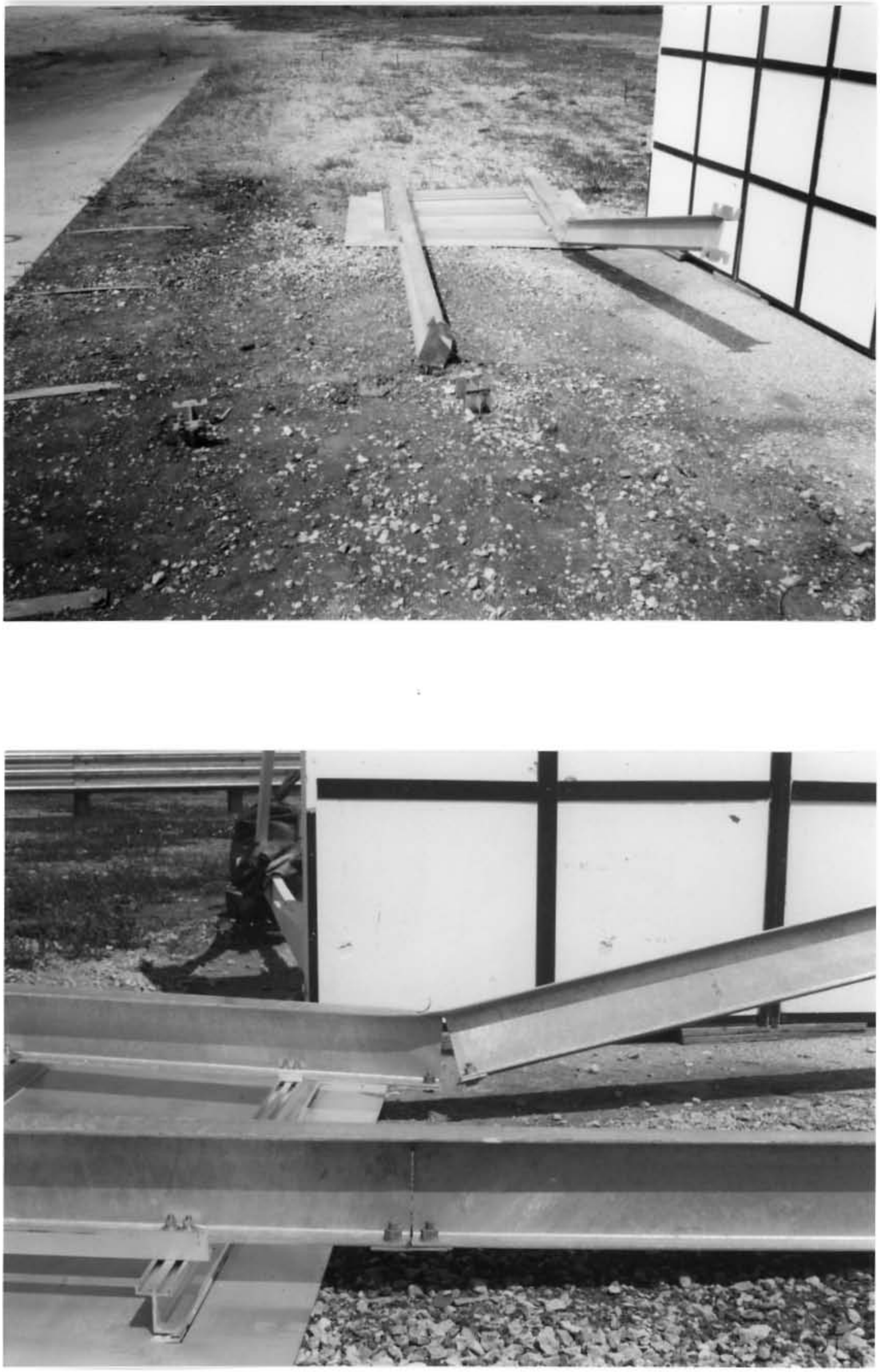


FIGURE 13. Sign support damage, Test MOBS-2

Table 1. Performance Evaluation Results

Evaluation Factors	Evaluation Criteria	Test MOBS-1			Test MOBS-2		
		NCHRP 230 (4)	AASHTO (5)	FHWA (6)	NCHRP 230 (4)	AASHTO (5)	FHWA (6)
Structural Adequacy	1. The test article shall readily activate in a predictable manner by breaking away or yielding.	S	S	S	S	S	S
	2. Detached elements, fragments or other debris from the test article shall not penetrate or show potential for penetrating the passenger compartment or present undue hazard to other traffic.	S	S	S	S	S	S
Occupant Risk	3. The vehicle shall remain upright during and after collision although moderate roll, pitching and yawing are acceptable. Integrity of the passenger compartment must be maintained with essentially no deformation or intrusion.	S	S	S	S	S	S
	4. Longitudinal Occupant Impact Velocity (fps).	8.7<15	8.7<15	8.7<15	6.7<15	6.7<15	6.7<15
	5. Long. Occupant Ridedown Decelerations (g).	1.0<15	1.0<15	1.0<15	1.4<15	1.4<15	1.4<15
	6. Vehicle Change in Velocity (fps).	NA	8.7<15	8.7<16	NA	4.3<15	4.3<16
Vehicle Trajectory	7. After collision, the vehicle trajectory and final stopping position shall intrude a minimum distance, if at all, into adjacent traffic lanes.	S	S	S	S	S	S
	8. Vehicle trajectory behind the test article is acceptable.	S	S	S	S	S	S

S Satisfactory M Marginal
U Unsatisfactory NA Not Applicable

4 DISCUSSION AND RECOMMENDATIONS

The original scope of this project was to perform a safety evaluation on the modified perforated tension fuse plate to verify that it met the safety requirements set forth by NCHRP Report 230 (4). The testing indicated that the system easily passed all of the safety criteria. However, when a wind load analysis was performed on the system, it was found that the fuse plate was underdesigned for many of the sign sizes specified in the MHTD Design Guide (8). A sample wind load calculation is shown in Appendix B. The extent of the underdesign of this system is represented in Table 2. In this table the maximum sign panel height allowed by the modified perforated tension fuse plate is compared to that allowed by other systems which have been used in the past. In many cases it can be seen that the maximum allowable sign size is less than that specified in the MHTD Design Guide (8).

A number of static bend tests were performed on the existing design as shown in Appendix C. It was determined that a potential solution to this problem involves specifying a free machining steel to be used for the fuse plate. This type of steel contains inclusions which cause the dynamic strength of the plate to be reduced by approximately 50% in the direction perpendicular to rolling. When the perforation holes are drilled in a line parallel to the roll direction, the static strength of the plate remains the same, but the plate will fail in a dynamic loading situation such as a collision. A suggested material for this plate is AISI 8620 (Yield Strength = 65 ksi, Ultimate Tensile Strength = 89 ksi, % elongation at failure = 25%). The cost of this material is about 70% higher than that of the A36 material which is currently being used, but because of the relatively small size of the fuse plate, this would represent an increase of only approximately $25 per system. If this material was to be used, the geometry of the fuse plate could remain the same except for those changes indicated in Table 3.

It is suggested that further testing and analysis be performed with this proposed material before it is placed in service. Static and dynamic tests of the fuse plate components may be sufficient to ascertain the performance of the proposed new designs.

TABLE 2. ALLOWABLE SIGN PANEL HEIGHTS ASSOCIATED WITH DIFFERENT FUSE PLATES

Clear Height and No. of Supports	Sign Support Size	Maximum Allowable Based on Strength of Post Only (MHTD Design Guide) (ft) (8)	TTI's Perforated Tension Fuse Plate (ft) (1)	Missouri's Perforated Tension Fuse Plate (ft)	Friction Fuse Plate (ft) (2,3)
8 ft clear height 2 supports	W6×9	10.5	10.5	10.5	10.5
	W8×18	18.75	18.75	< 8.25	18.75
	W10×26	20	20	< 13	< 13
8 ft clear height 3 supports	W6×9	13.5	13.5	12	13.5
	W8×18	20	18.5	< 11.25	20
	W10×26	20	20	< 15.7	< 15.7
12 ft clear height 2 supports	W6×9	7.4	7.4	7.4	7.4
	W8×18	17	17	11.75	17
	W10×26	20	20	14.5	20
12 ft clear height 3 supports	W6×9	10.5	10.5	10.5	10.5
	W8×18	20	20	13	20
	W10×26	20	20	14.75	20
16 ft clear height 2 supports	W6×9	6.25	6.25	6.25	6.25
	W8×18	14.25	14.25	14.25	14.25
	W10×26	20	20	19.75	20
16 ft clear height 3 supports	W6×9	9	9	9	9
	W8×18	19.5	19.5	18	19.5
	W10×26	20	20	19.8	20

[1] Design wind load of 70 mph

[2] The '<' sign indicates that the maximum allowable height was less than the lowest height on the MHTD design charts.

TABLE 3. Recommended fuse plate design changes

AISI 8620		
Post Design Number	Perforation Hole Diameter (in.)	Fuse Plate Thickness (in.)
1	3/4	3/16
2	1 ¼	5/16
3	15/16	5/16
4	1	5/16
5	15/16	5/16
6	1	5/16

5 CONCLUSIONS

The safety performance of the modified perforated tension fuse plate was evaluated according to the criteria presented in NCHRP Report 230 (4), AASHTO (5), and the Federal Register (6). It easily passed all of the safety criteria. Unlike the original perforated tension fuse plate developed by TTI, this system performed as designed, with the fuse plate failing under impact.

A wind load analysis on the revised system revealed that the modification to the perforated tension fuse plate resulted in a large reduction in post strength. In many cases this reduction is large enough to result in wind load failures at moderate wind speeds. It is recommended that the MHTD consider further investigation of the fuse plate design changes suggested in this report.

6 REFERENCES

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7 APPENDIX A - ACCELEROMETER DATA ANALYSIS

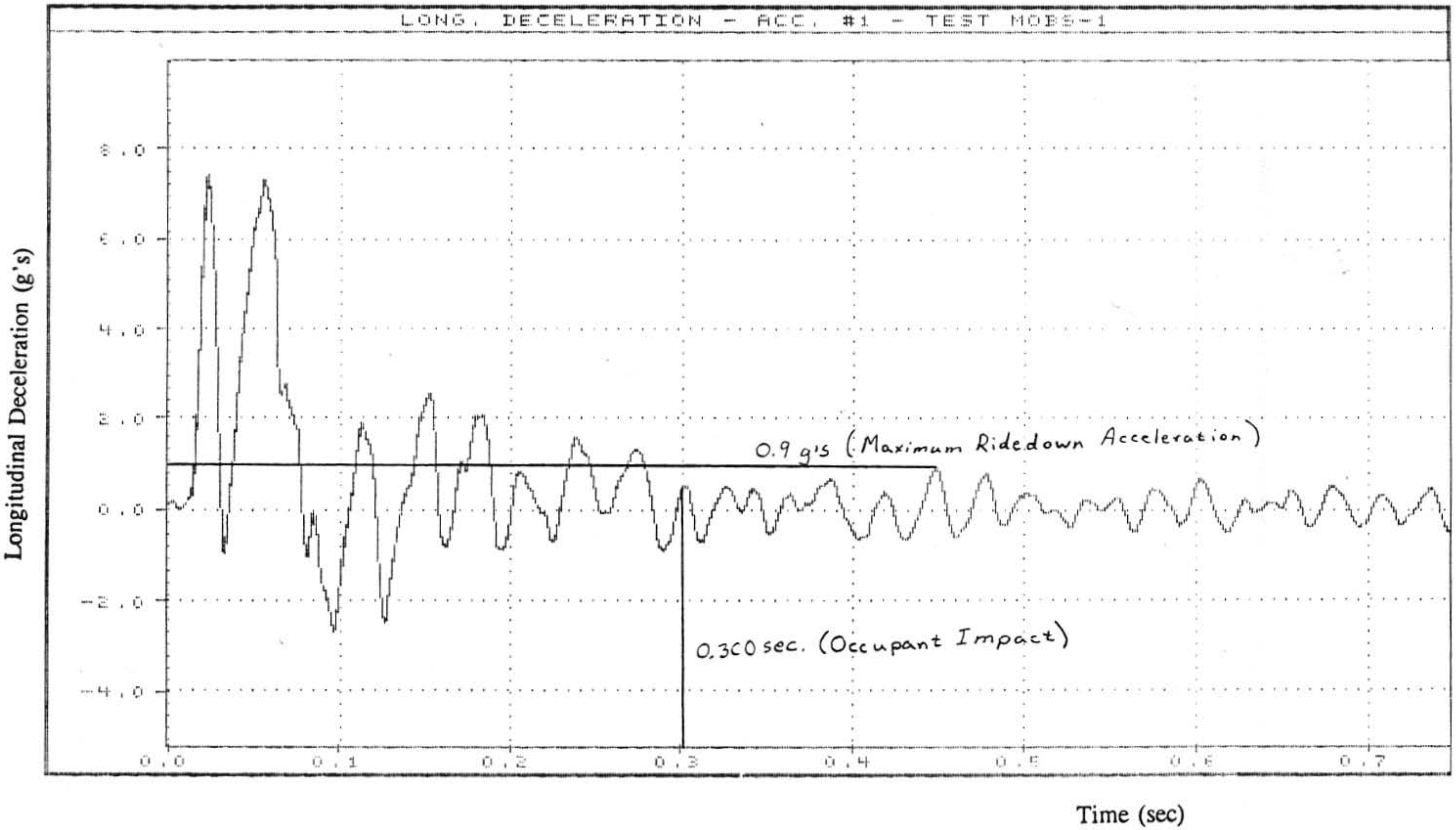

Figure A-1. Graph of Longitudinal Deceleration, Test MOBS-1

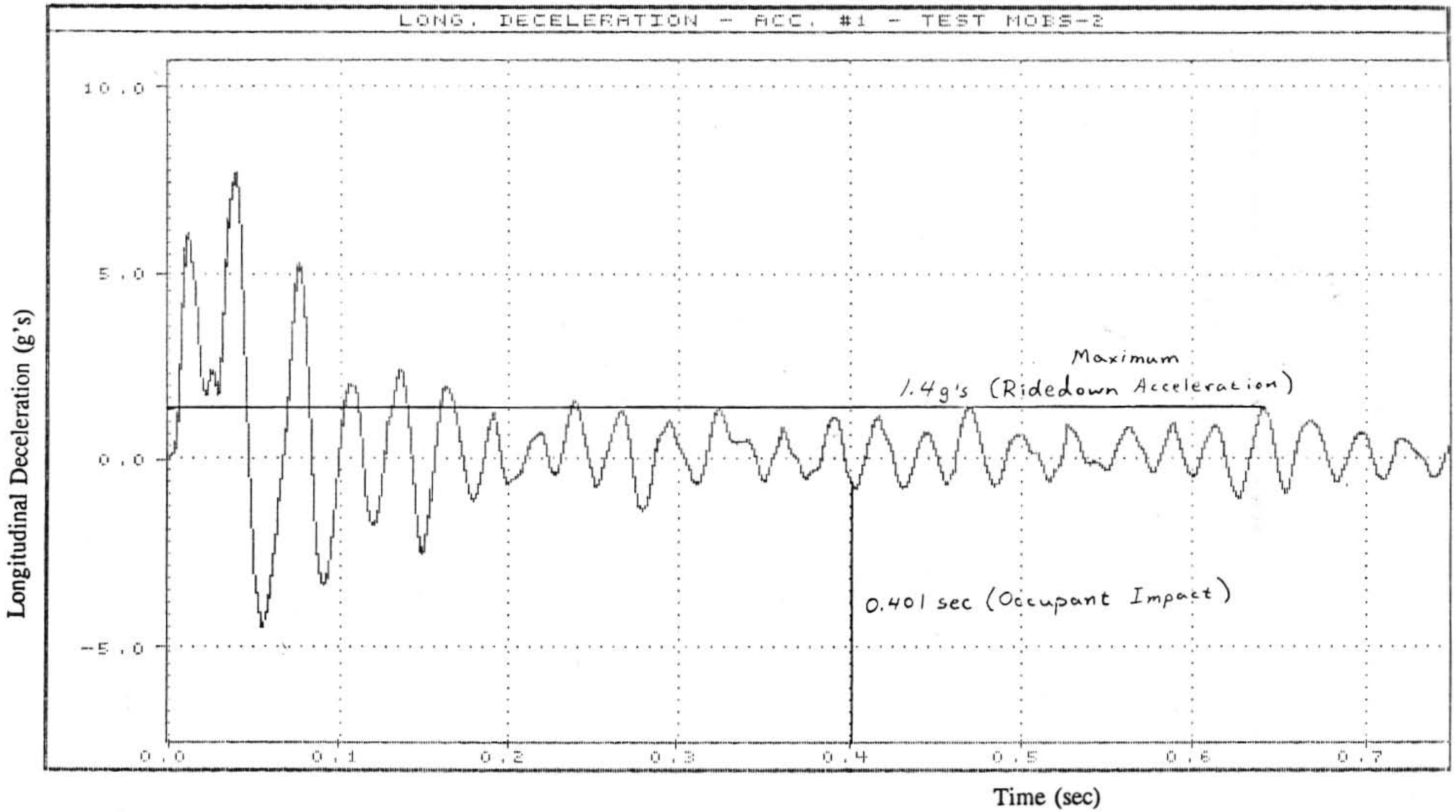

Figure A-2. Graph of Longitudinal Deceleration, Test MOBS-2

8 APPENDIX B - WIND LOAD DESIGN CALCULATIONS

Calculations were performed to determine if the modified perforated tension fuse plate had the strength to resist wind loads. As described in the main body of this report, it was found that the modified fuse plate was underdesigned for a number of sign sizes used by the MHTD. The following is an example calculation which demonstrates the method used to determine the wind induced stress levels in the fuse plate.

The method used to determine the wind load on the sign is described in *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 1985* (5). According to this specification, the pressure exerted on a sign by the wind can be computed using the following formula:

$$P = 0.00256\ (1.3V)^2 C_d C_h$$

where:

P = wind pressure (lb/ft^2)

V = wind speed from map (mph), n-year mean recurrence interval (the factor of 1.3 accommodates for wind gusts of 30%)

C_h = coefficient for height above ground measured to the centroid of the corresponding limits of the loaded area

C_d = drag coefficient

According to the MHTD Design Guide (8), an allowable sign size for a Type 3 (W8×18) post is 14.5 ft high by 12 ft wide. According to AASHTO (5), the maximum wind speed across most of the United States is 70 mph, so this value was used in the calculations. The values of $C_d = 1.12$ and $C_h = 1.00$ were obtained from AASHTO (5).

The pressure applied to the sign by a 70 mph wind was calculated to be 23.74 lb/ft^2. For a sign with a 174 ft^2 surface area, the total wind force was 4,132 lbs, or 2,066 lbs per support.

The resulting forces on the sign are shown in Figure B-1 and the calculations are shown below:

$$(2{,}066lbs)(93in.) = (F)(8.1in.)$$

$$F = 23{,}721lbs.$$

$$\sigma = \frac{F}{A} = \frac{23{,}721lbs}{0.25in.^2} = 94{,}883psi$$

As can be seen, when the moments were summed about the hinge, it was found that the stress in the perforated tension fuse plate was approximately 94.9 ksi. The material used for the fuse plate had a minimum yield strength of 36 ksi, so it is evident that this fuse plate would fail under high wind loads.

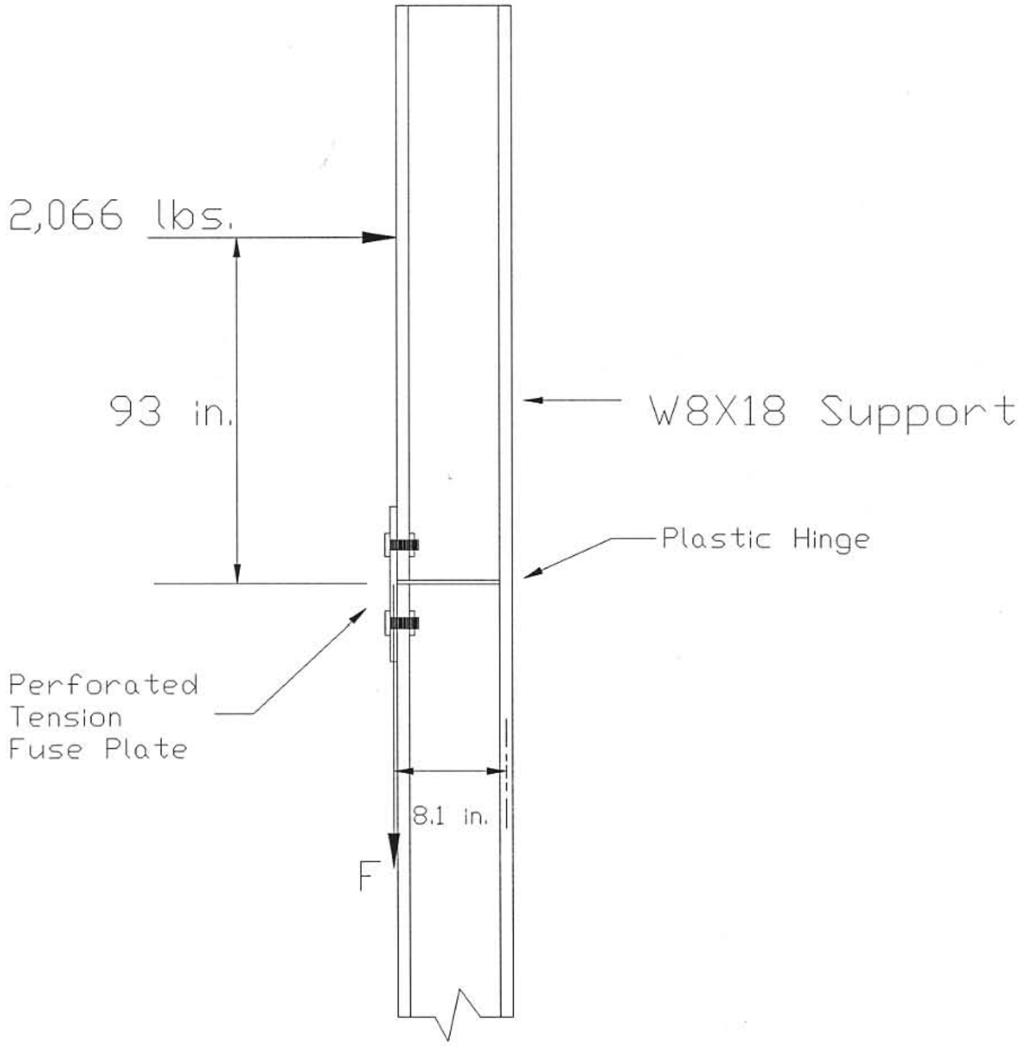

FIGURE B-1. Forces applied to sign as a result of wind loads.

9 APPENDIX C - RESULTS OF STATIC BEND TESTS

In order to better understand the operation of the mechanical hinge, a series of static bend tests was conducted to obtain a set of force vs. deflection curves. In these tests the post was secured below the fuse plate and a load was applied 69 inches above the hinge. The load vs. deflection curves for these tests are presented Figure C-1.

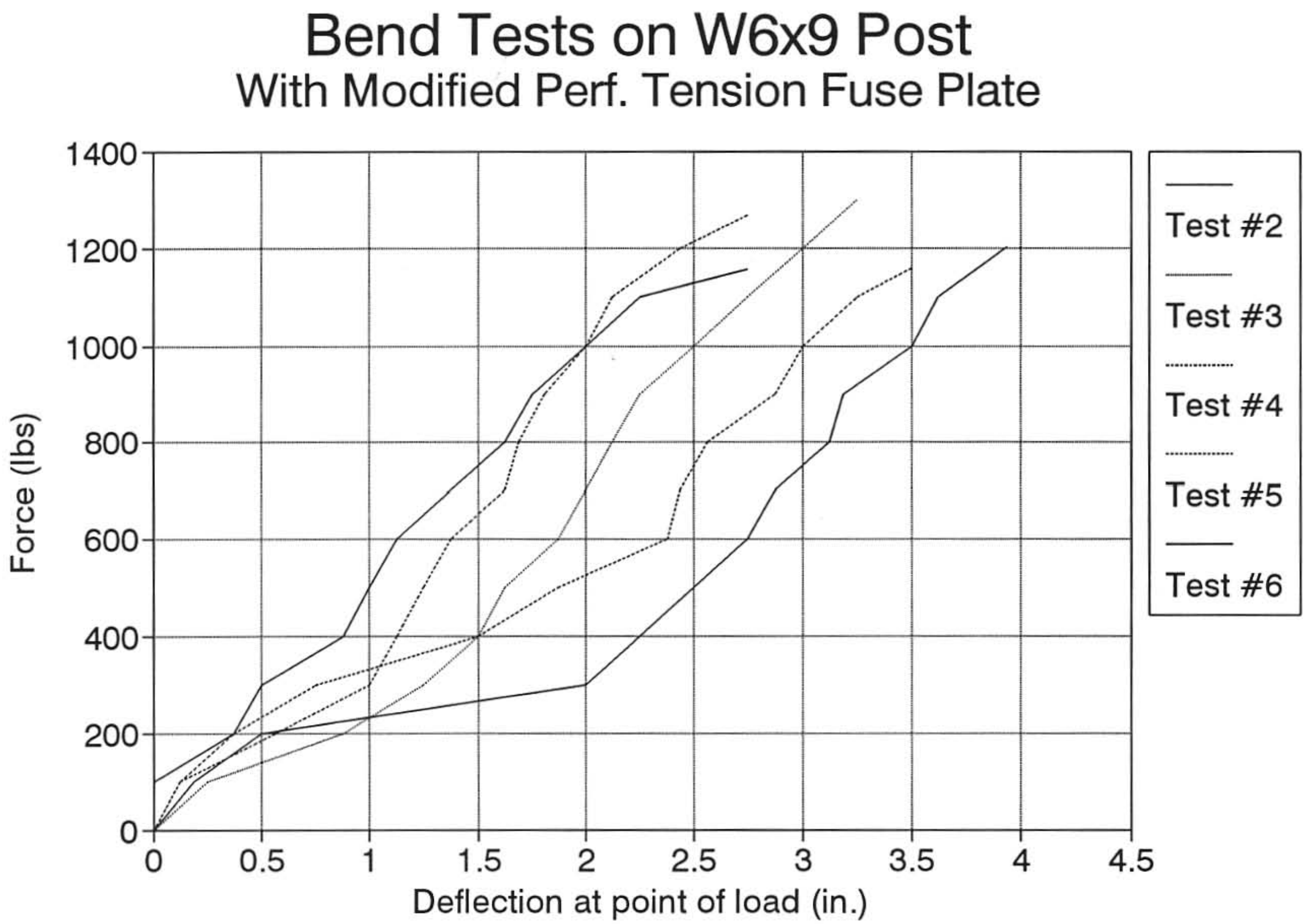

FIGURE C-1. Results of Static Bend Tests