"REPORT ON THE STATIC AND DYNAMIC TESTING OF FRANKLIN'S U-POST AND EZE-ERECT CONNECTION"

by

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Research Report 3491-1F

Final Report
on
Project RF 3491

June 1977

Revised December 1977

Texas A & M Research Foundation
Texas Transportation Institute
Texas A&M University
College Station, Texas 77843

Submitted to

Franklin Steel Company
Franklin, Pennsylvania

ACKNOWLEDGEMENTS

The authors wish to thank Sheila Darsie for typing the report, Michael Byrd and Benito Jackson for drafting the figures, and the technical support personnel at Texas A&M University Research Annex for their assistance in performing the tests. Thanks should also be extended to Mr. Larry Sweeney of Franklin Steel for his technical assistance and cooperation during the study.

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INTRODUCTION

The steel U-post is a widely used highway sign support. It has been common practice to drive the full-length U-post into the ground and then mount the sign panel. Driving the post in this manner can be awkward and hazardous to the installation crew since the post may be up to 16 feet in length, or possibly even longer. Equipment, in the form of a ladder, lift truck, etc., is necessary for the installation.

To simplify the installation procedure for the U-post, the Franklin Steel Company developed the Eze-Erect connection. Initially, a stub post, about 3-1/2 feet in length, is driven into the ground. Then the sign post, with sign panel attached, is attached to the stub post with the Eze-Erect bolted connection. A retainer-spacer strap is used in the connection to help control the impact trajectory of the sign post resulting from a vehicle collision and to provide a close fit at the post-to-stub connection during normal loading conditions.

Static load tests and full-scale vehicle crash tests were conducted to evaluate the Eze-Erect connection. The crash tests were conducted in accordance with current standards and guidelines.[1,2] This report describes these tests and the results obtained therefrom.

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[1] Bronstad, M. E. and Michie, J. D., "Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances", NCHRP Report 153, Transportation Research Board, Washington, D.C., 1974.

[2] "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals", American Association of State Highway and Transportation Officials, Washington, D.C., 1975.

STATIC LOADING TESTS

TEST ARTICLES

The Eze-Erect connection consists of bolts and a retainer-spacer strap that connect the signpost to the base. Details are shown in Figure 1. The reatiner-spacer strap is designed to provide a snug fit between the base post and the signpost. It is also designed to help retain the signpost after vehicle impact, at least for low speed impacts.

Two design configurations were static tested. In Configuration I, the assembly consisted of a 2.75 lb/ft base post 3 feet in length and a 2 lb/ft signpost 8.5 feet in length. In Configuration II, the assembly consisted of a 3 lb/ft base post, 3 feet in length and a 3 lb/ft signpost 8 feet in length. The Configuration I strap was 16 inches long, 1.0 inches wide and 0.25 inches thick. In Configuration II, the strap was 16 inches long, 1.12 inches wide and 0.25 inches thick. In each case the strap was slotted 9 inches at one end and 1.25 inches at the other end.

The signpost and base post were bolted together with a 6 inch overlap. Two grade 5, 5/16-18 bolts with washers as shown in Figure 1 were used for connecting the retainer strap to the base post and for bolting the retainer strap to the signpost. In the overlapping region, two grade 5, 5/16-18 x 1½" bolts spaced 5 inches apart, were used to attach the signpost to the base post.

TEST APPARATUS

Figure 2 shows the cantilevered test arrangement used to load the Eze-Erect assembly. A photo of the test setup is shown in Figure 3.

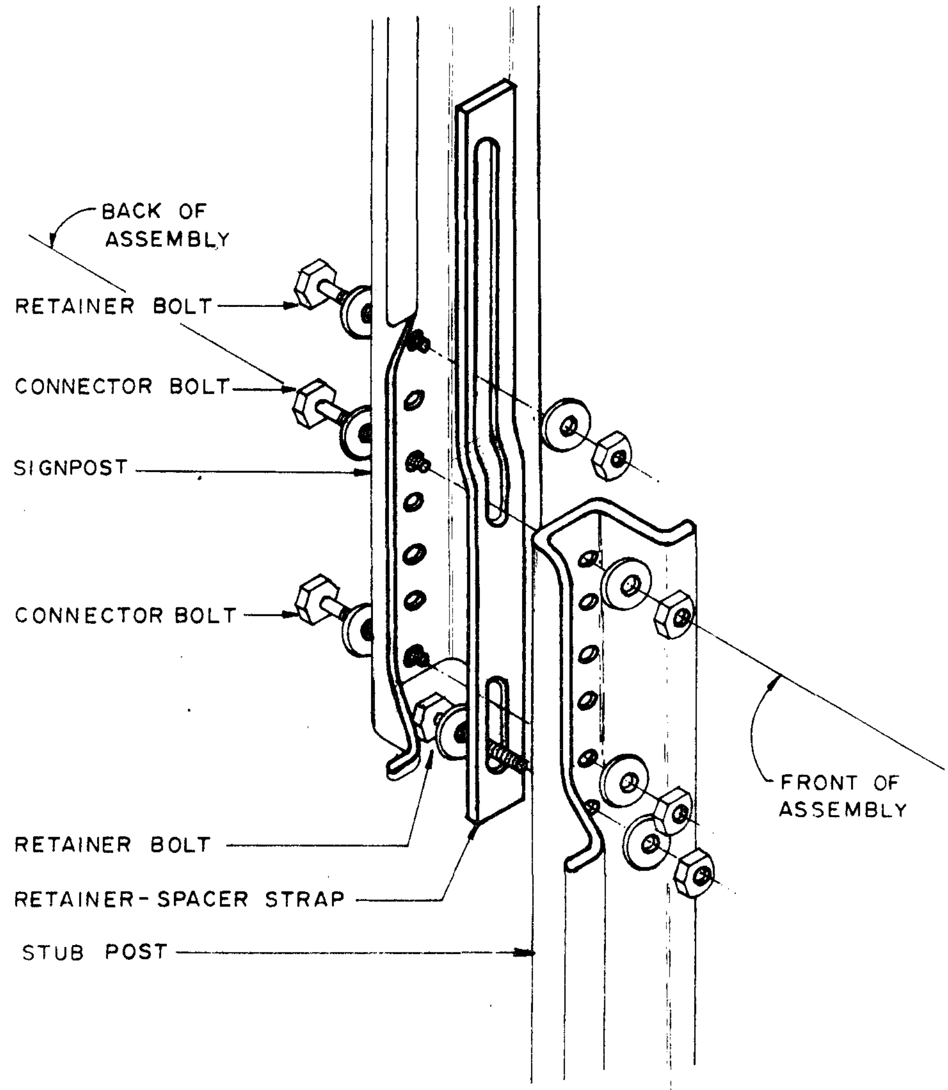


FIGURE 1. EZE-ERECT SIGNPOST ASSEMBLY

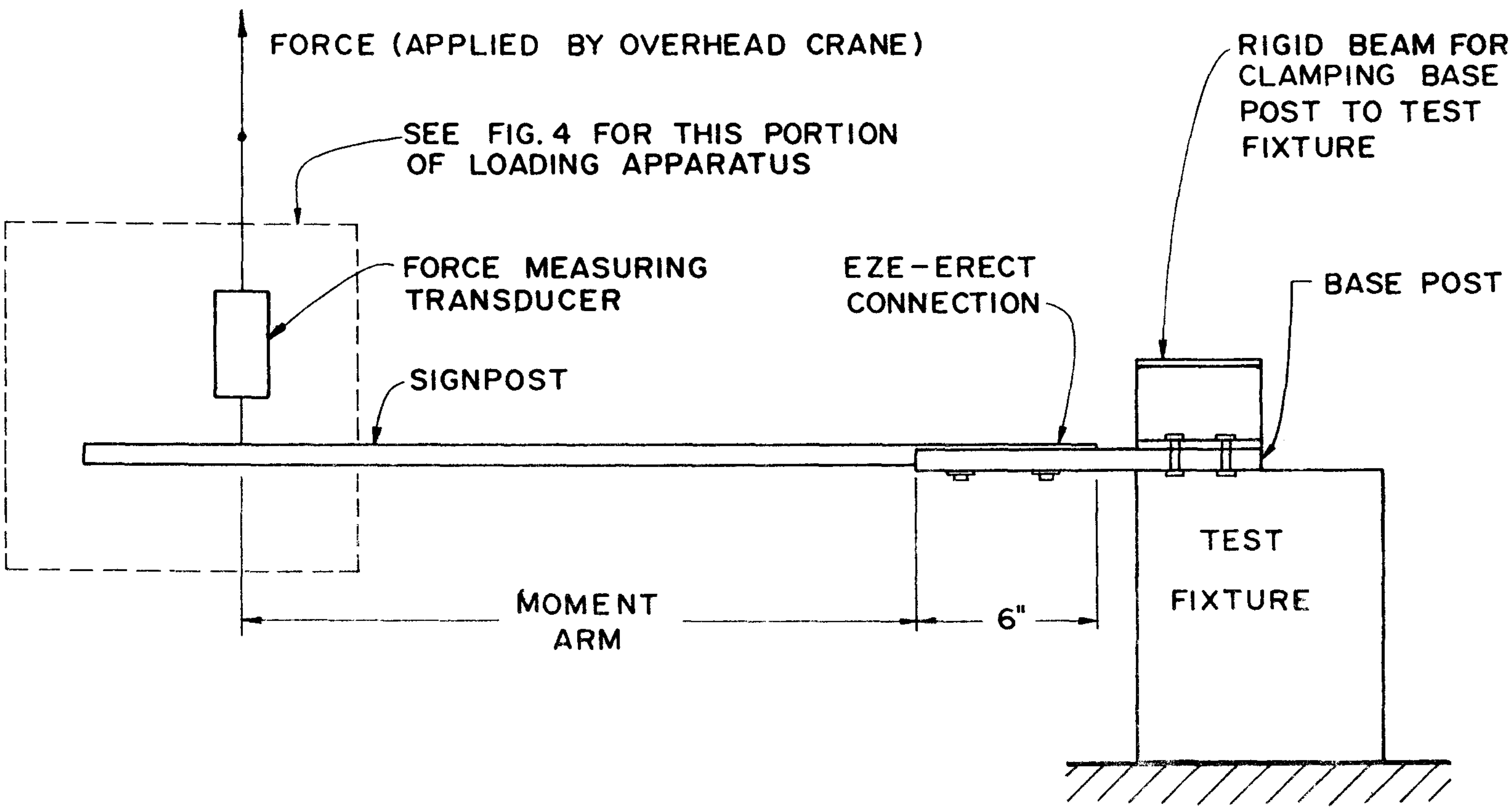


FIGURE 2. STATIC TEST ARRANGEMENT.

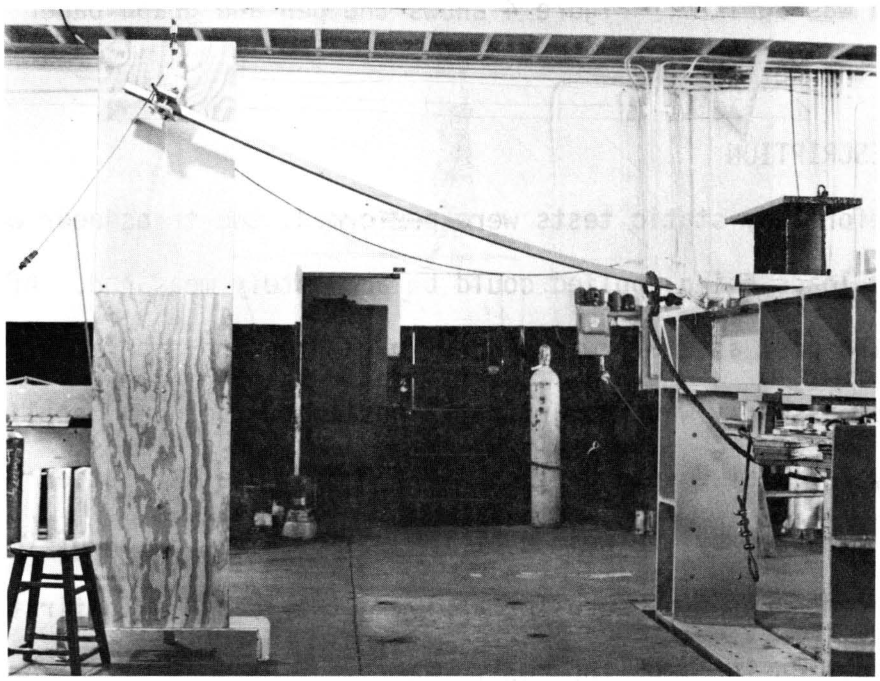


FIGURE 3. STATIC TESTING APPARATUS.

An overhead crane was used to apply force to the signpost. A calibrated force transducer provided a digital reading of the force applied. The signpost-to-transducer connection is shown in Figure 4. A pen was placed on the clamping device to record deflection of the post as load was applied. Figure 4 shows the pen and graph paper used to record the deflection.

TEST DESCRIPTION

Before any static tests were performed, the transducer was calibrated so that loads being applied could be accurately measured. After calibration, the post assembly was placed in the testing apparatus. Then, since the post assembly was in horizontal position, the crane applied a previously calculated load vertically to remove the deflection in the post assembly caused by the weight of the post. Now loading of the post could be started. The procedure for applying the load was to first place 50% of the design load[3] on the post, recording the deflections on graph paper, and then to remove the load completely. Deflection, if any, was measured at the no load configuration. Then, repeating this procedure, the load was increased by 10% increments until the design load was reached. Then the assembly was turned over and the same loading procedure was done.

After the post had been tested under full design load in each of the two directions, it was loaded beyond the design load by applying load increments of 10% of design load until failure or yielding occurred in the direction normal to the front of the Eze-Erect post assembly. All deflections and permanent sets were recorded for every loading. This procedure was used for both sign assemblies.

[3] Design load determined by Franklin Steel Company.

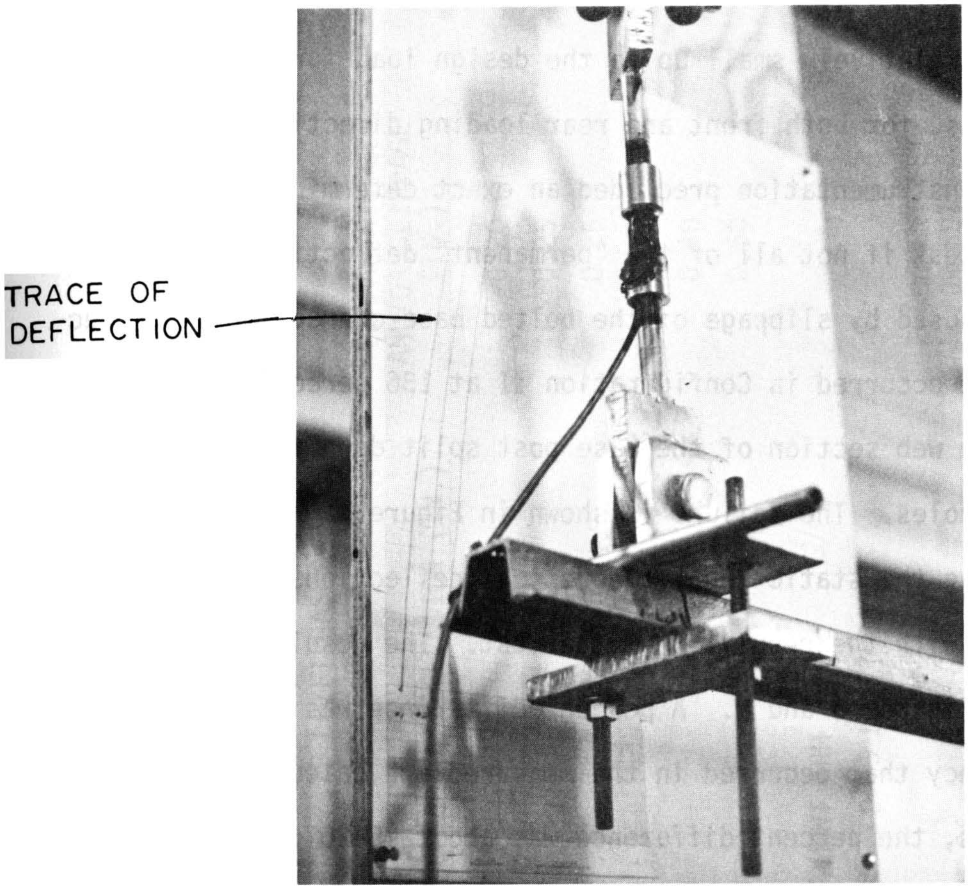


FIGURE 4. CLAMPING MECHANISM.

RESULTS OF THE TESTING

Results of the static load tests are given in Tables 1 and 2 and Figures 5 and 6. It can be seen that the amount of permanent set and/or slippage was relatively small up to the design load for both loading configurations, for both front and rear loading directions. Although the limited instrumentation precluded an exact determination, it is likely that most if not all of the "permanent" deflections, up to design load, were caused by slippage of the bolted base connection. A structural failure occurred in Configuration II at 136 percent of the design load when the web section of the base post split down the center line of the punched holes. The failure is shown in Figure 7.

Following the static test, theoretical deflections were calculated and compared with the results from the test. The results are shown in Table 3 and Figures 8 and 9. A percent difference was calculated for the discrepancy that occurred in the measured and calculated deflections. In most cases, the percent difference was about 15-20%.

At least five factors could have contributed to the difference:

(1) Moment of inertia values are for a solid cross-section. The 3/8 inch holes on 1 inch centers reduce these values. For example, I at a solid section of 2 lb/ft post is about 1.2 times larger than at a section with a hole. The ratio is about 1.1 for the 3 lb/ft post.

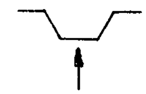
(2) As the load increases, the cross-section tends to flatten out more and more. As a result, the moment of inertia changes with load.

TABLE 1. CONFIGURATION I RESULTS,
DESIGN LOAD = 141 LB

8.0 FT MOMENT ARM

2.0 LB/FT SIGNPOST 2.75 LB/FT BASE

Direction of Load



TEST NO.	LOAD (LB)	PERCENT OF DESIGN LOAD	DEFLECTION (IN.)	PERMANENT SET AND/OR SLIPPAGE (IN.)
1	70	50	4.75	0.20
2	84	60	5.55	0.25
3	99	70	6.55	0.25
4	113	80	7.60	0.30
5	127	90	8.80	0.40
6	141	100	9.75	0.60

8.0 FT MOMENT ARM

2.0 LB/FT SIGNPOST 2.75 LB/FT BASE

Direction of Load

TEST NO.	LOAD (LB)	PERCENT OF DESIGN LOAD	DEFLECTION (IN.)	PERMANENT SET AND/OR SLIPPAGE (IN.)
7	70	50	4.60	0.00
8	84	60	5.65	0.00
9	99	70	6.50	0.05
10	113	80	7.65	0.10
11	127	90	8.55	0.15
12	141	100	9.50	0.20

TABLE 1. CONFIGURATION I RESULTS,

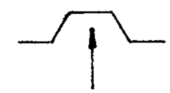
DESIGN LOAD = 141 LB

(CONTINUED)

8.0 FT MOMENT ARM

2.0 LB/FT SIGNPOST 2.75 LB/FT BASE

Direction of Load



TEST NO.	LOAD (LB)	PERCENT OF DESIGN LOAD	DEFLECTION (IN.)	PERMANENT SET AND/OR SLIPPAGE (IN.)
13	155	100	10.60	0.50
14	169	120	11.20	0.65
15	183	130	12.25	0.85
16	197	140	13.15	1.00
17	239	170	16.85	1.85
18	267	190	19.40	3.10
19	281 (yield)	200	25.20	EXCESSIVE

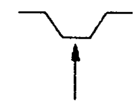
TABLE 2. CONFIGURATION II RESULTS,

DESIGN LOAD = 270 LB

7.5 MOMENT ARM

3 LB/FT SIGNPOST 3 LB/FT BASE

Direction of Load

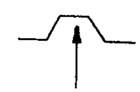


TEST NO.	LOAD (LB)	PERCENT OF DESIGN LOAD	DEFLECTION (IN.)	PERMANENT SET AND/OR SLIPPAGE (IN.)
20	135	50	4.45	0.15
21	162	60	5.40	0.20
22	189	70	6.35	0.20
23	216	80	7.40	0.40
24	243	90	8.30	0.45
25	270	100	9.40	0.60

7.5 FT MOMENT ARM

3 LB/FT SIGNPOST 3 LB/FT BASE

Direction of Load



TEST NO.	LOAD (LB)	PERCENT OF DESIGN LOAD	DEFLECTION (IN.)	PERMANENT SET AND/OR SLIPPAGE (IN.)
26	135	50	3.85	0.50
27	162	60	5.20	0.85
28	189	70	6.15	0.90
29	216	80	7.40	1.20
30	243	90	8.75	1.65
31	270	100	10.15	2.15

TABLE 2. CONFIGURATION II RESULTS,
DESIGN LOAD = 270 LB
(CONTINUED)

7.5 FT MOMENT ARM

3 LB/FT SIGNPOST 3 LB/FT BASE

Direction of Load

TEST NO.	LOAD (LB)	PERCENT OF DESIGN LOAD	DEFLECTION (IN.)	PERMANENT SET AND/OR SLIPPAGE (IN.)
32	324	120	13.20	1.65
33	358	130	13.60	1.05
34	378 Failed at 368	140 Failed at 136.4	14.50	FAILURE

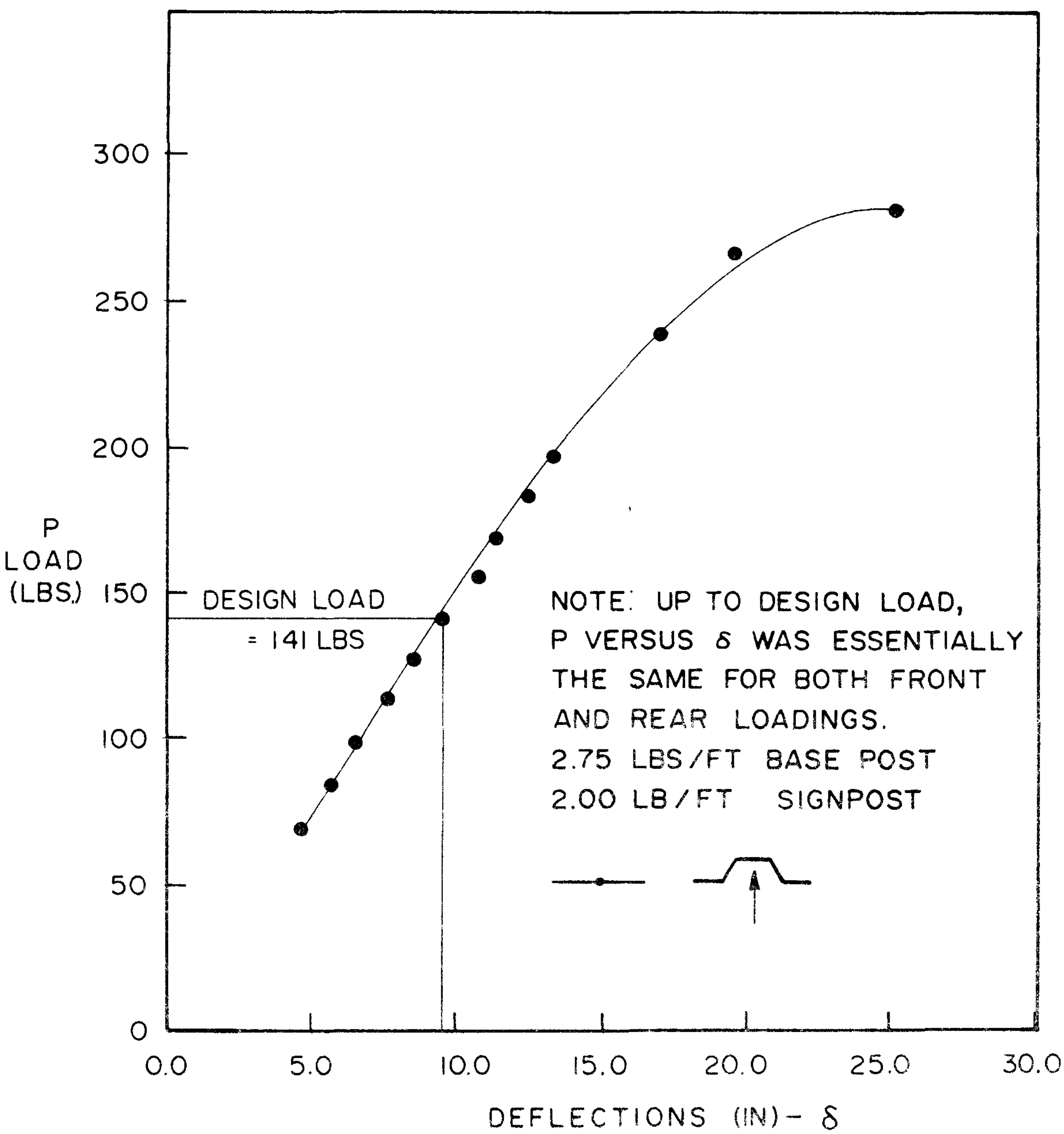


FIGURE 5. LOAD-DEFLECTION CURVE, DESIGN LOAD = 141 LBS.

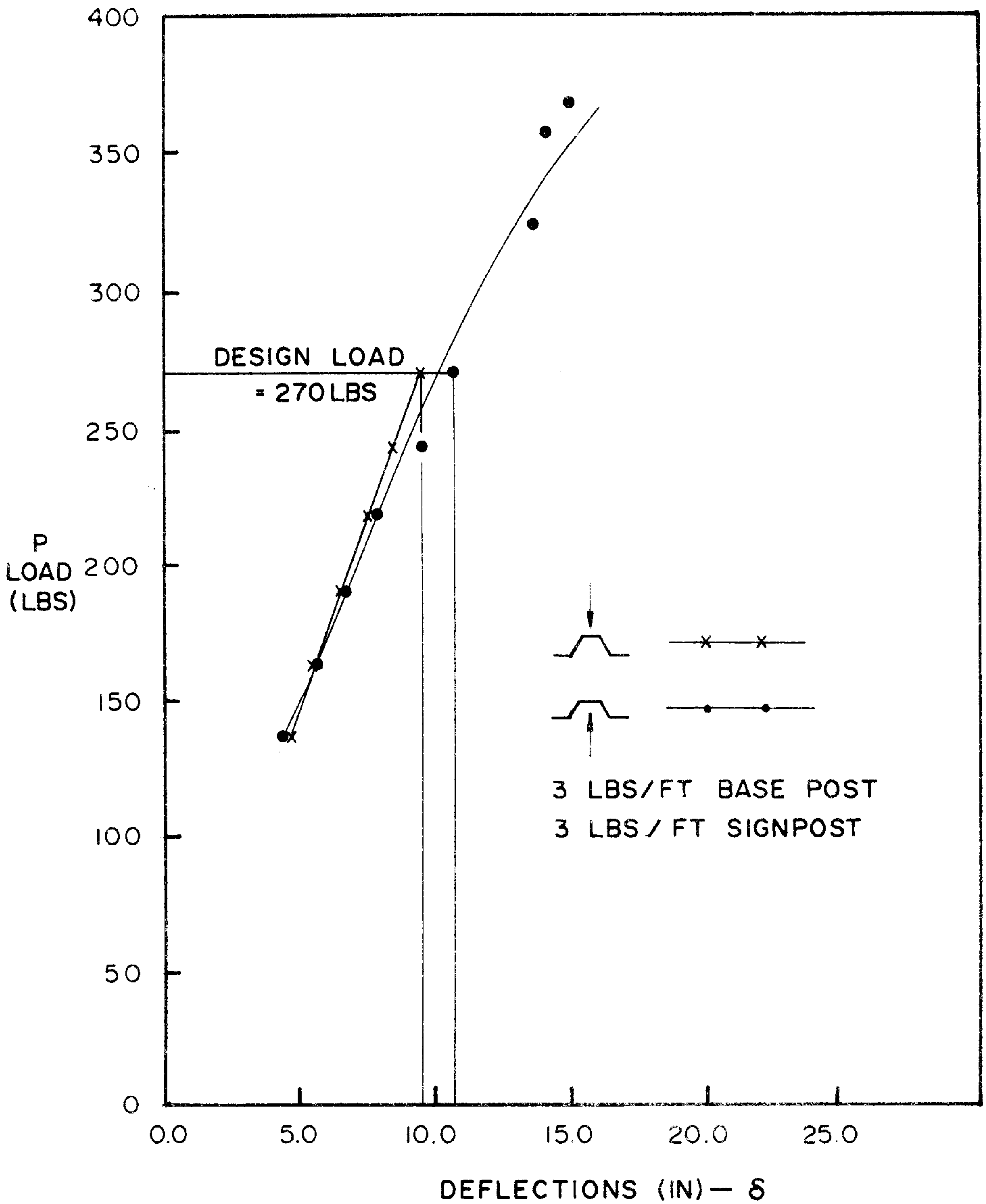


FIGURE 6. LOAD-DEFLECTION CURVE, DESIGN LOAD = 270 LBS.

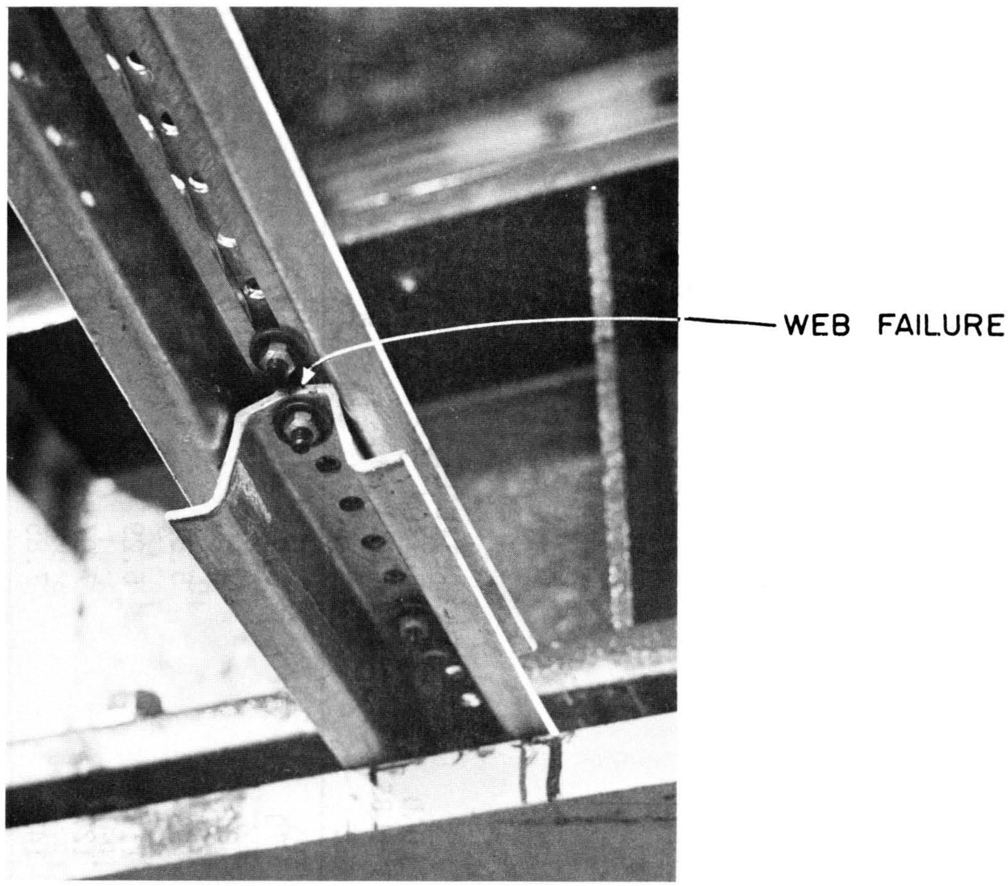
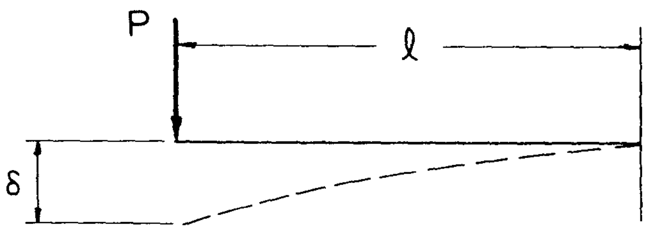


FIGURE 7. FAILURE OF WEB SECTION.

TABLE 3. THEORETICAL VERSUS MEASURED LOAD-DEFLECTION DATA



DEFLECTION AT FREE END

$$\delta = \frac{P\ell^3}{3EI} \qquad E = 29.6 \times 10^6 \text{ PSI (ASSUMED)}$$

FOR $2^{\#}$/FT. $I^A = .179 \text{ in}^4$

FOR $3^{\#}$/FT. $I^A = .372 \text{ in}^4$

	TEST NO.	LENGTH ℓ (IN.)	I (IN.^{4})	LOAD P (LBS)	THEORETICAL DEFLECTION δ_T (IN.)	MEASURED DEFLECTION δ_M (IN.)	% DIFF. $\frac{\delta_M - \delta_T}{\delta_M} \times 100$
CONFIGURATION I	1	96	.179	70	3.9	4.75	17.9
	2			84	4.68	5.55	15.7
	3			99	5.51	6.55	15.9
	4			113	6.29	7.6	17.2
	5			127	7.07	8.8	19.7
	6			141	7.85	9.75	19.5
	7			70	3.9	4.6	15.2
	8			84	4.68	5.65	17.2
	9			99	5.51	6.5	15.2
	10			113	6.29	7.65	17.8
	11			127	7.07	8.55	17.3
	12			141	7.85	9.5	17.4

TABLE 3. THEORETICAL VERSUS MEASURED LOAD-DEFLECTION DATA (CONTINUED)

	TEST NO.	LENGTH ℓ (IN.)	I (IN.^{4})	LOAD P (LBS)	THEORETICAL DEFLECTION δ_T (IN.)	MEASURED DEFLECTION δ_M (IN.)	% DIFF. $\frac{\delta_M - \delta_T}{\delta_M} \times 100$
CONFIGURATION I	13	96	.179	155	8.63	10.6	18.6
	14			169	9.41	11.2	16
	15			183	10.19	12.25	16.8
	16			197	10.97	13.15	16.6
	17			239	13.30	16.85	21.1
	18			267	14.86	19.4	23.4
	19			281	15.64	25.2	37.9
CONFIGURATION II	20	93	.372	135	3.29	4.45	26.1
	21			162	3.94	5.4	27
	22			189	4.6	6.35	27.6
	23			216	5.26	7.4	28.9
	24			243	5.92	8.3	28.7
	25			270	6.57	9.4	30.1
	26	90		135	2.98	3.85	23.4
	27			162	3.58	5.2	31.2
	28			189	4.17	6.15	32.3
	29			216	4.77	7.4	35.5
	30			243	5.36	8.75	38.7

TABLE 3. THEORETICAL VERSUS MEASURED LOAD-DEFLECTION DATA (CONTINUED)

	TEST NO.	LENGTH ℓ (IN.)	I (IN.^{4})	LOAD P (LBS)	THEORETICAL DEFLECTION δ_T (IN.)	MEASURED DEFLECTION δ_M (IN.)	% DIFF. $\frac{\delta_M - \delta_T}{\delta_M} \times 100$
CONFIGURATION II	31	90	.372	270	5.96	10.15	41.3
	32	↓	↓	324	7.15	13.2	47
	33	↓	↓	358	7.90	13.6	41.9
	34	↓	↓	368	8.12	14.5	44

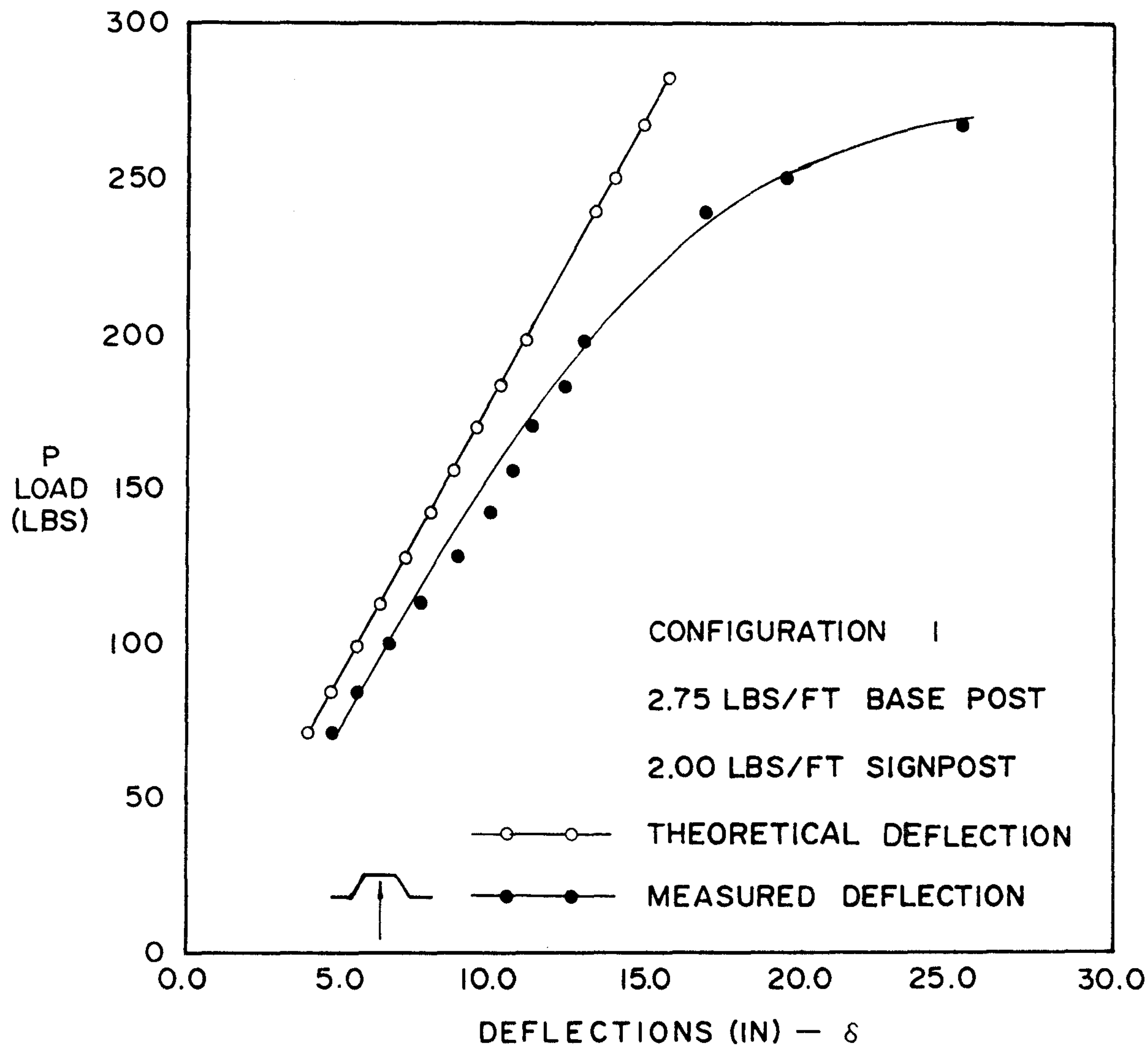


FIGURE 8. THEORETICAL VS. MEASURED DEFLECTIONS, DESIGN LOAD = 141 LBS.

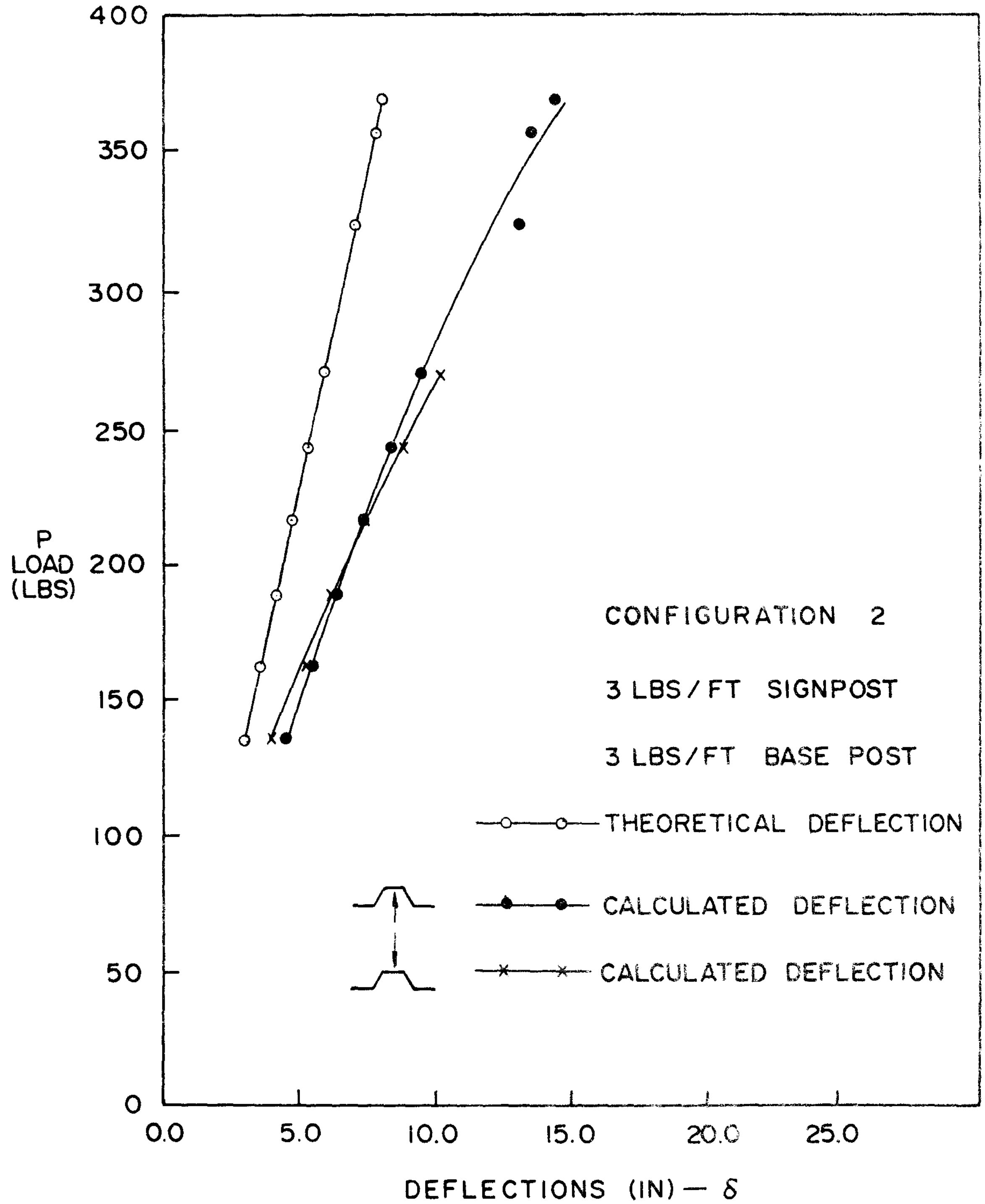


FIGURE 9. THEORETICAL VS. MEASURED DEFLECTION, DESIGN LOAD = 270 LBS.

(3) The modulus of elasticity, although believed to be accurate, may not be exact.

(4) There was some slippage in the bolted connection.

(5) From Figure 5, some yielding took place above a load of about 200 lb. The theoretical values are based on a linear elastic material.

FULL-SCALE CRASH TESTS

TEST DESCRIPTION

Four full-scale crash tests were conducted on the Franklin Eze-Erect post assemblies as shown in Table 4. Two 1971 Vega automobiles were used in the tests, one for Tests 1 and 2 and another for Tests 3 and 4. The test vehicles were released from the reverse tow and guidance system just prior to impact into the post assembly. Figures 10 and 11 show the tow and guidance system.

In Tests 1 and 3, the impact point was approximately 15 inches to the left of the vehicle's centerline (fore and aft direction). In Test 2 the impact point was approximately 15 inches to the right of the centerline. In Test 4 the impact was about 25 inches to the right of the centerline.

The tests were conducted in accordance with recommended guidelines established by NCHRP.[4]

TEST ARTICLE

On each test, the test article was an Eze-Erect Franklin post assembly supporting a 24 x 30 inch 7.5 pound aluminum "keep right" sign. Each test assembly consisted of a 3 lb/ft base post 3.5 feet long, driven in the ground 37 inches, with 5 inches remaining above the ground, as is shown in Figures 12 and 13. A 3 lb/ft signpost, 8.5 feet long, was attached to the base. The signpost was bolted to the base post the same way as described in the section on test articles for the static test.

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[4]Bronstad, M. E. and Michie, J. D., NCHRP Report 153.

TABLE 4. TEST MATRIX

TEST NO.	VEHICLE WEIGHT (LB)	VEHICLE SPEED (MPH)	BASE EMBEDMENT DEPTH (IN.)	SIGN PANEL MOUNTING HEIGHT[a] (FT)	SIGNPOST CONFIGURATION AT IMPACT
1	2280	20	37	6	
2	2280	60	37	6	
3	2280	20	37	6	
4	2280	20	37	6	

[a]Distance from bottom of panel to groundline.

FIGURE 10. TOW SYSTEM.

FIGURE 11. CAR GUIDANCE SYSTEM.

FIGURE 12. DRIVING BASE POST WITH DRIVING CAP.

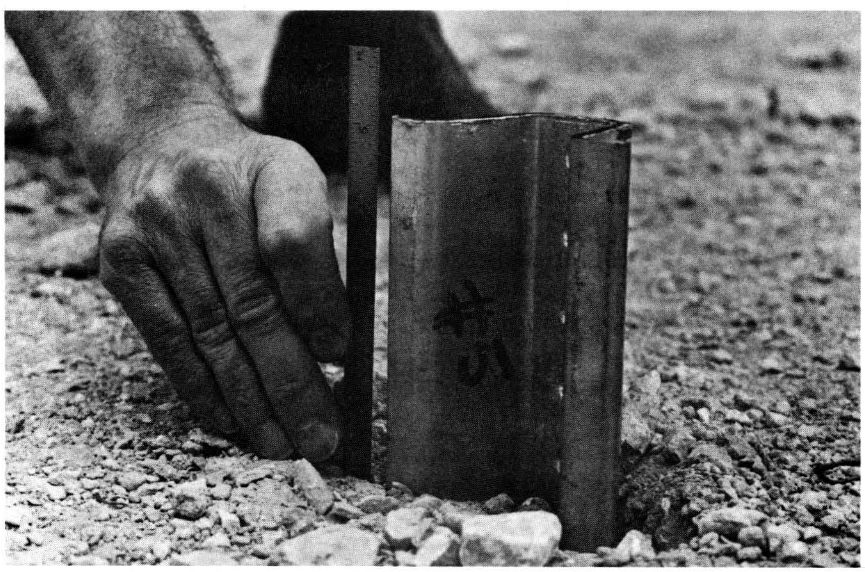

FIGURE 13. BASE POST DRIVEN 5 INCHES ABOVE THE GROUND.

The sign was bolted to the U-post with two Grade 5 5/16-18 bolts with 2 flat washers that went between the head of the bolt and the sign, and the U-post and the nut with a 1.5 x 4.5 inch aluminum plate between the sign and the U-post, as shown in Figure 14.

PHOTOGRAPHIC INSTRUMENTATION

Two high-speed motion picture cameras were used to obtain time-displacement data and a third camera was used for making a documentary film of the tests. Of the two high-speed cameras, one used a long focal lens to obtain a close-up of the impact, with a field of view of ±15 feet. The field of view of the second camera encompassed a horizontal distance of 10 feet in front of impact point to 40 feet beyond the point of impact. The high-speed cameras are shown in Figure 15.

ELECTRONIC INSTRUMENTATION

A strain gage accelerometer was placed on each longitudinal frame member and lateral frame member of the test vehicle to measure accelerations in the longitudinal and lateral directions. The signals from these accelerometers were telemetered to a base receiver station and recorded on magnetic tape for permanent record. Analog traces with the signal pasing through a 80 Hz max flat filter were produced for analysis. Instrumentation on board a test vehicle is shown in Figure 16.

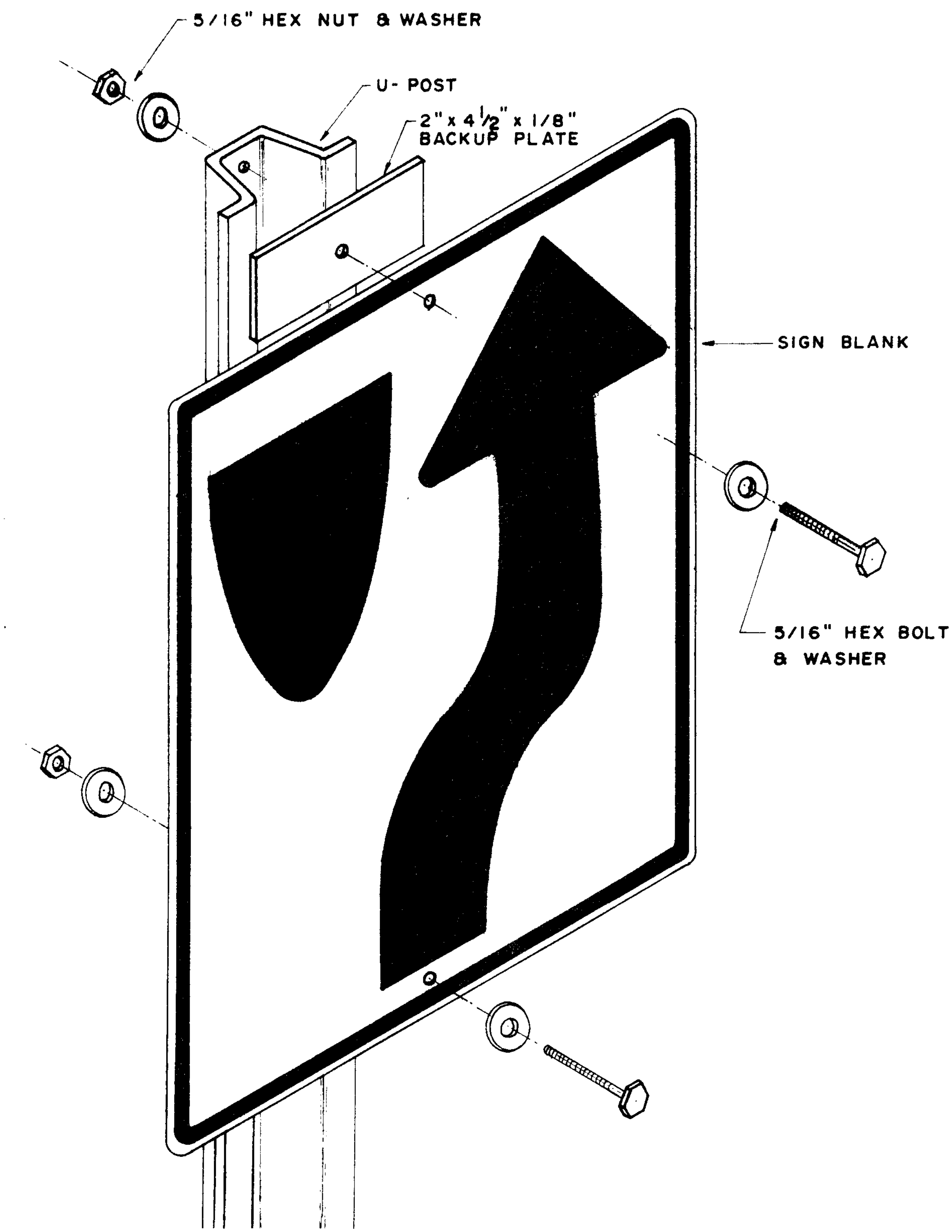

FIGURE 14. FASTENING SIGN TO SIGNPOST.

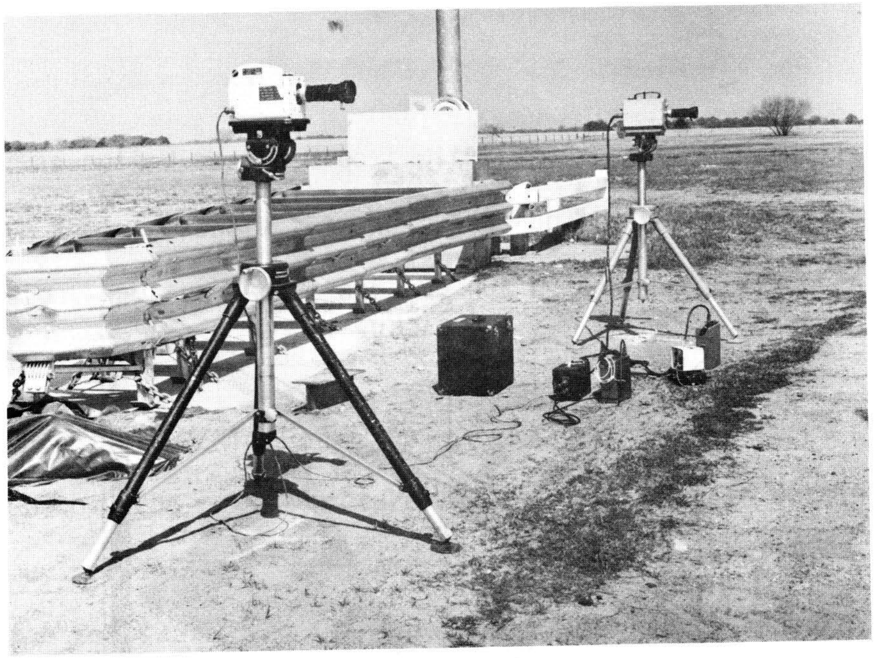

FIGURE 15. HIGH SPEED CAMERAS.

FIGURE 16. ON-BOARD INSTRUMENTATION.

TEST RESULTS

The results of the four tests are compiled and presented in the discussion below. The data were obtained from the high-speed film and accelerometer traces. Change in momentum values for all four tests were significantly below the limiting value of 1100 lb-sec and the preferred maximum value of 750 lb-sec specified by AASHTO.[5]

TEST 1

The first test was a 20 mph impact with the car towed perpendicular to the front of the sign (Figure 17). Results of the first test are summarized in Table 5. Change in momentum of the test vehicle computed over the duration of initial contact (0.089 sec) was 181 lb-sec for the high-speed film and 145 and 235 lb-sec for the left and right side accelerometers, respectively. Accelerations are shown in Figure 18 and the change in momentum, calculated by time integration from the accelerometer traces, is shown in Figure 19. The peak decelerations measured by the two accelerometers were 4.8 and 4.1 g's. The time of initial contact was used in calculating the change in momentum because it is less than the free missile travel time (Figure 20).[6] The 50 millisecond average acceleration and the force exerted on the car by the sign are shown in Figures 21 and 22.

Sequential photographs of the test from the high-speed film are given in Figure 23. Upon impact, the bolts connecting the base post and the signpost in the Eze-Erect connection broke, with some tearing

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[5] "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals", AASHTO, 1975.

[6] Bronstad, M. E. and Michie, J. E., <u>NCHRP Report 153</u>.

FIGURE 17. DIRECTION OF IMPACT - TEST 1.

TABLE 5. SUMMARY OF RESULTS, TEST 3491-1

VEHICLE		
Make	Chevrolet	
Model	Vega	
Year	1971	
Weight	2280 lbs	
FILM DATA		
Impact Velocity	33.3 ft/sec (22.7 mph)	
Final Velocity	30.7 ft/sec (21.0 mph)	
Time of Contact	0.089 sec	
Free Missile Time	*	
Change in Momentum Over Time of Contact	181 lb-sec	
ACCELEROMETER DATA - 80 Hz Max Flat Filter		
	Left Long.	Right Long.
Peak Deceleration at Time	4.8 g 0.024 sec	4.1 g 0.042 sec
Max .050 sec Average Deceleration	1.21 g	1.79 g
Change in Momentum Over Time of Contact	145 lb-sec	235 lb-sec
Peak Force at Time	10.79 K .024 sec	9.16 K .042 sec
DAMAGE CLASSIFICATION		
TAD	FL-1	
SAE	12FLEN1	

*Free missile time greater than 0.089 sec.

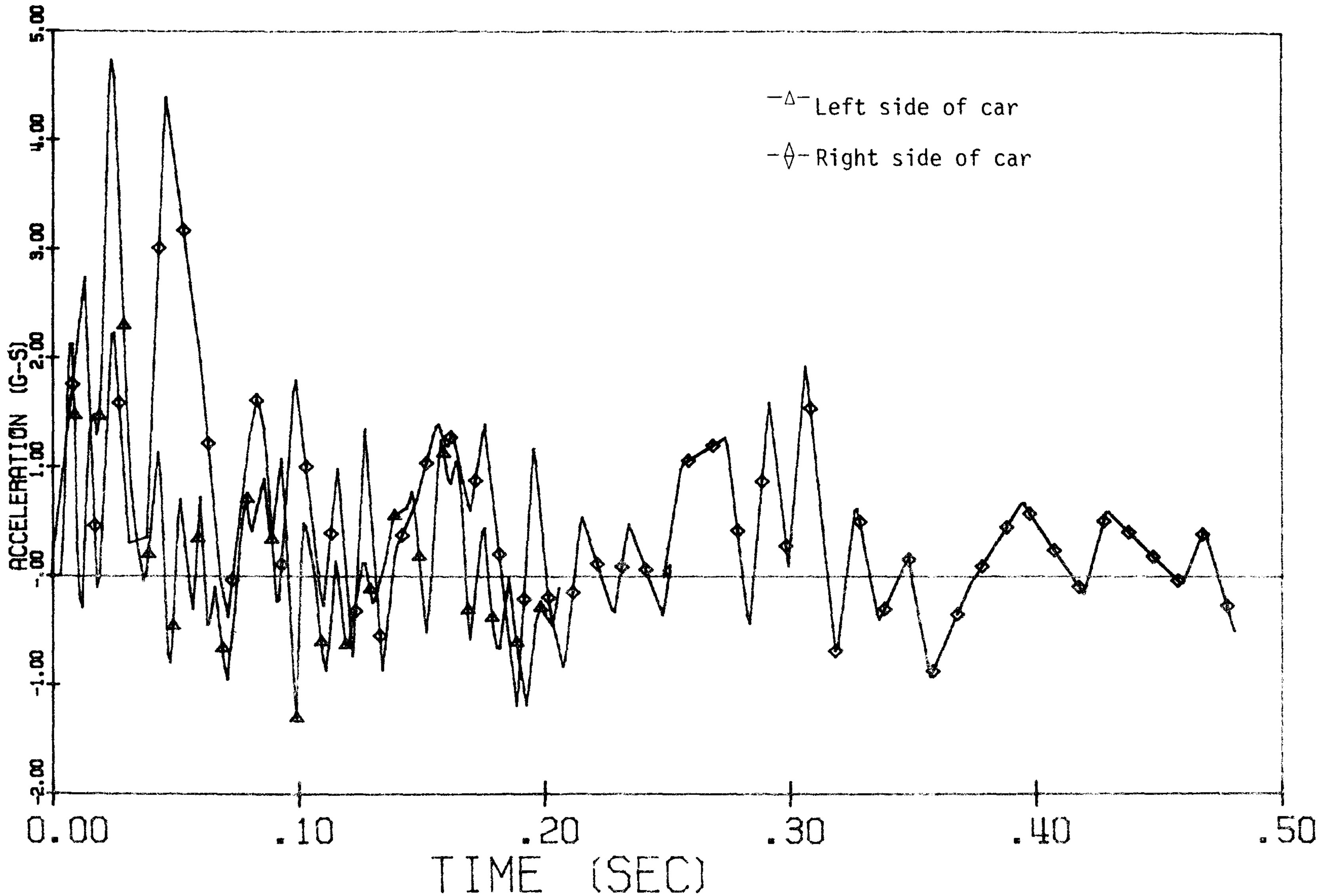


FIGURE 18. ACCELERATION VS. TIME FOR TEST 1.

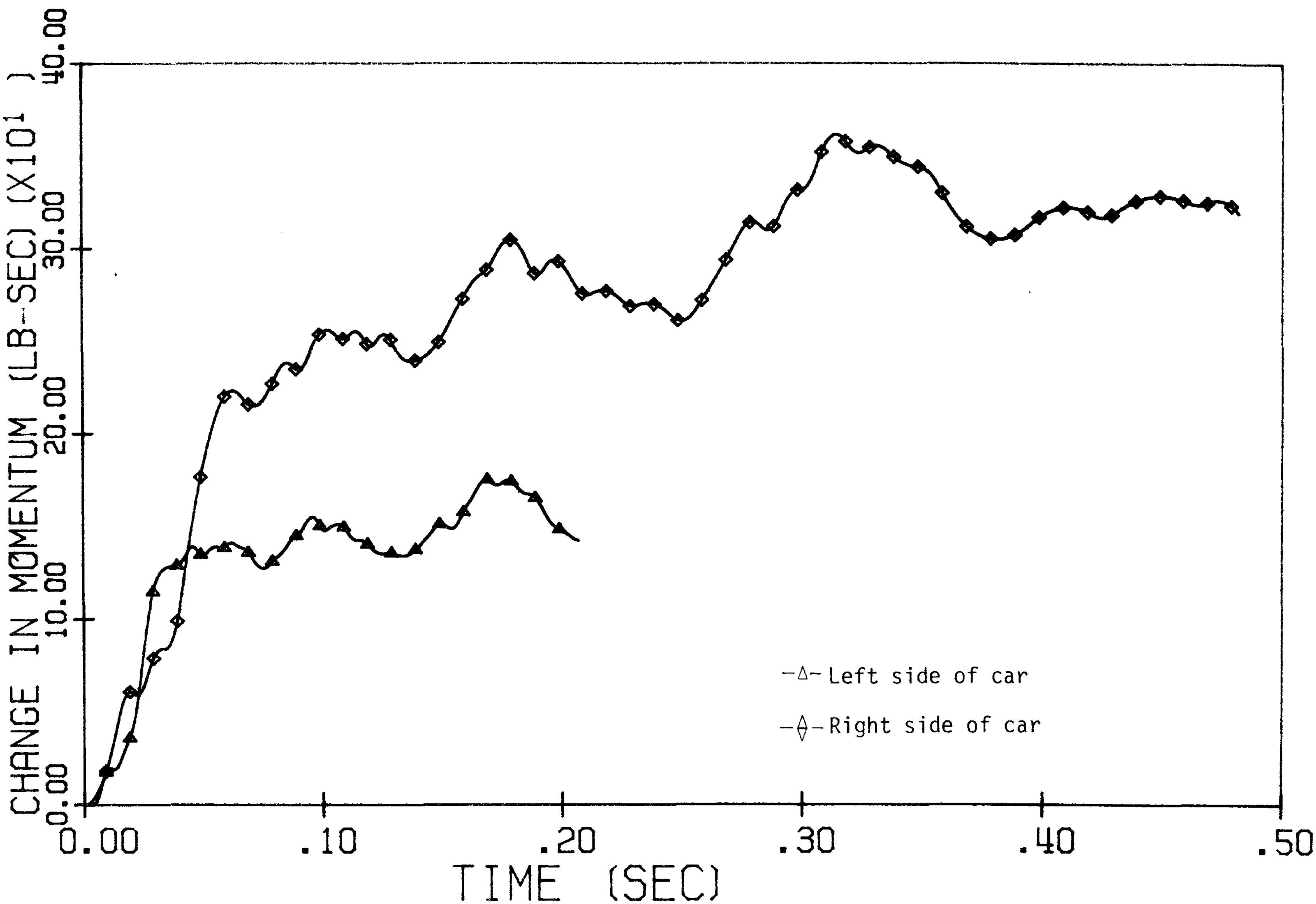


FIGURE 19. CHANGE IN MOMENTUM VS. TIME FOR TEST 1.

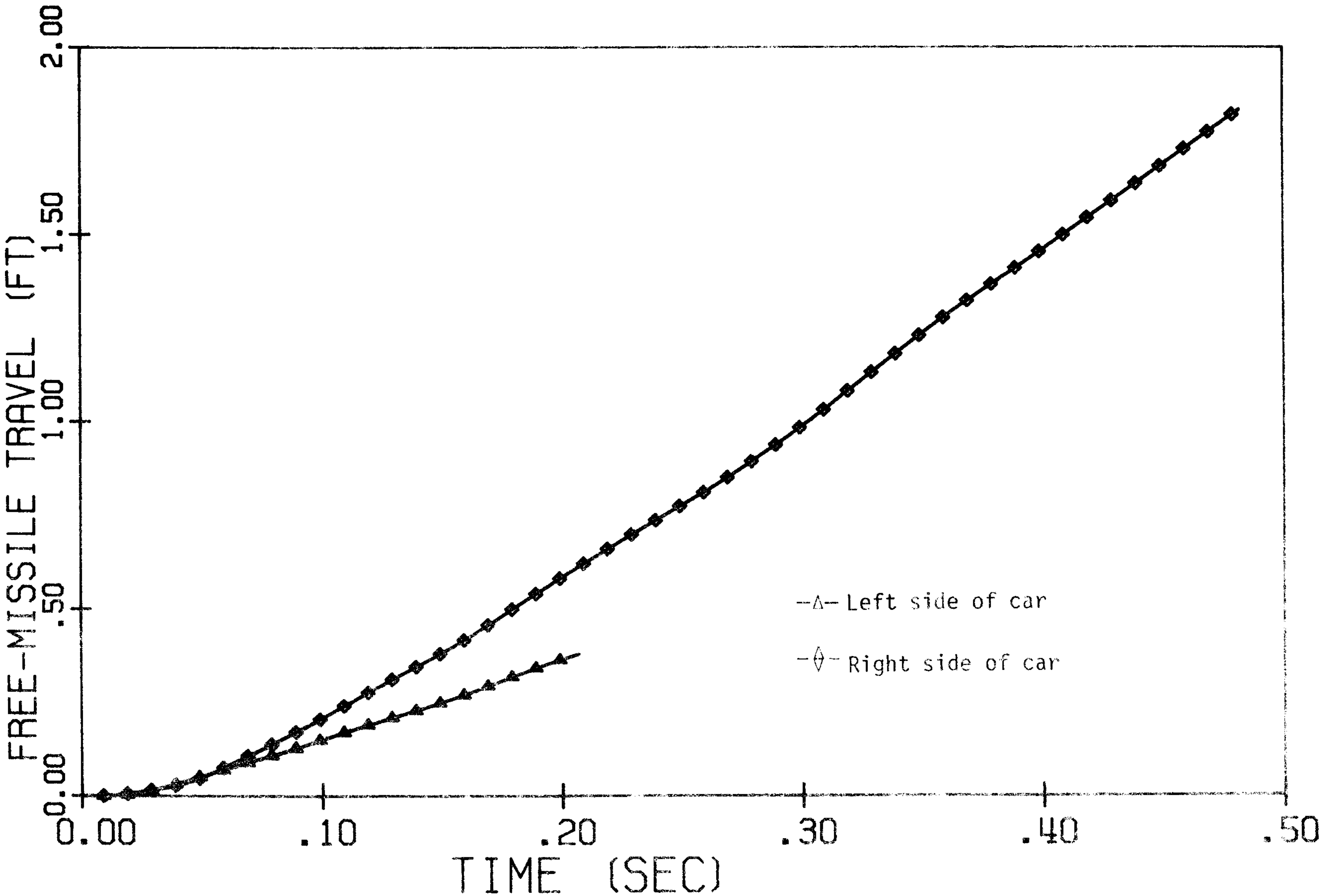


FIGURE 20. FREE-MISSILE TRAVEL VS. TIME FOR TEST 1.

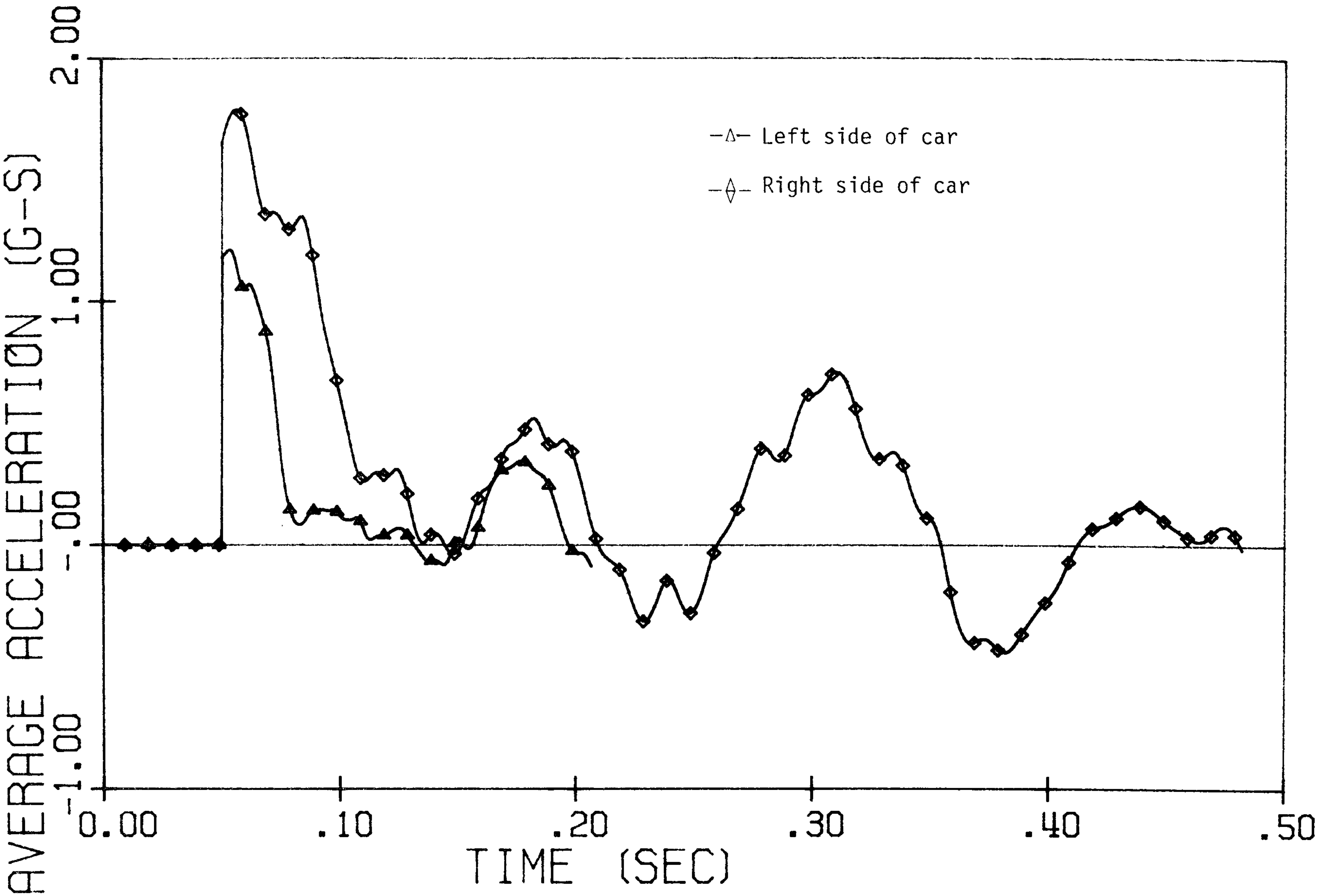


FIGURE 21. 50 MILLISECOND AVERAGE ACCELERATION FOR TEST 1.

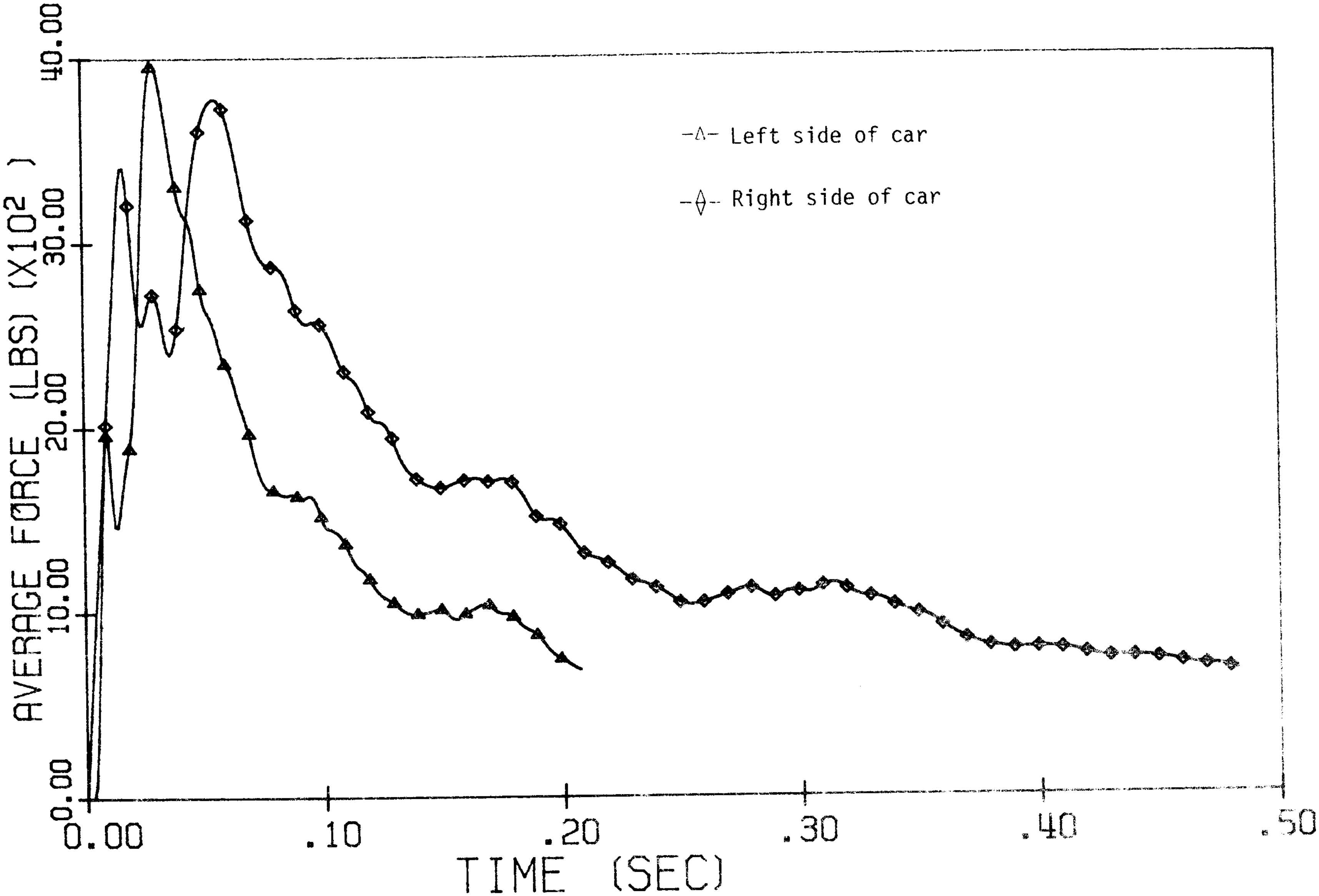
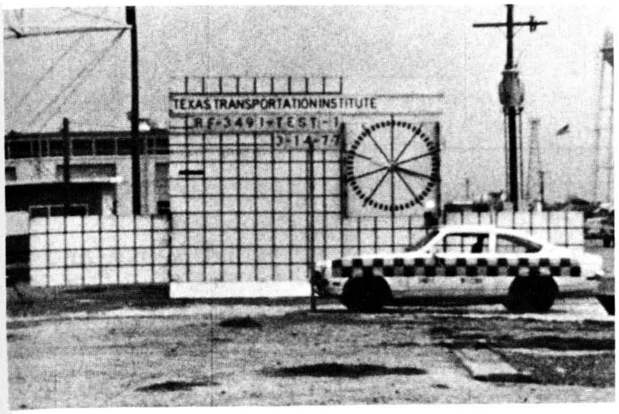
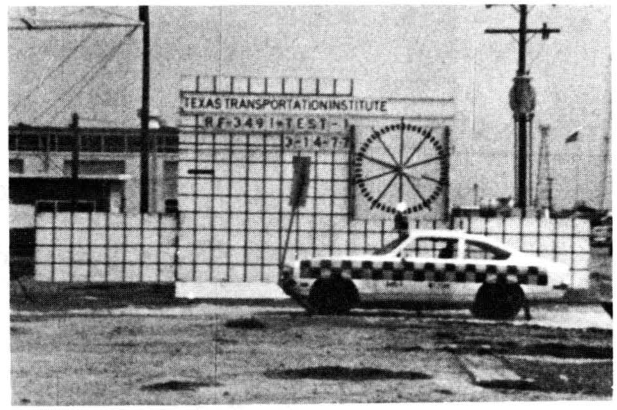


FIGURE 22. SIGN FORCE ON CAR VS. TIME FOR TEST 1.



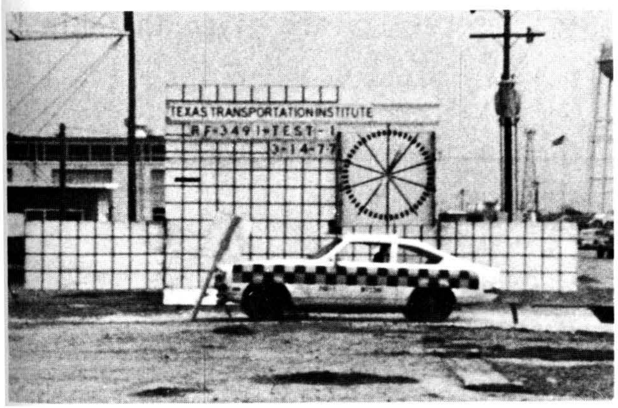
0.000 sec



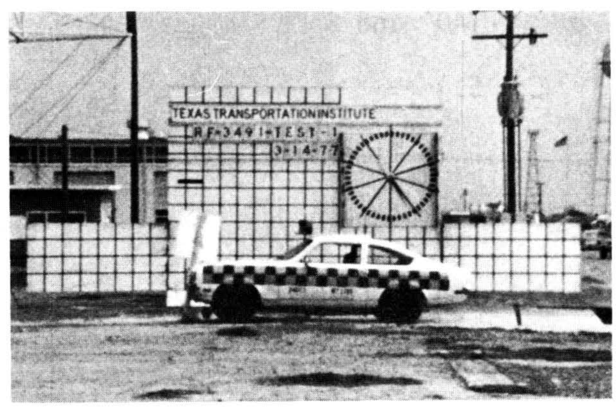
0.0568 sec

0.0893 sec

0.1109 sec



0.1434 sec



0.1975 sec

FIGURE 23. SEQUENTIAL PHOTOGRAPHS OF TEST 1.

of the web section in the base post. The signpost broke also at the bumper height (20 in.) of the car upon impact. The upper part of the signpost with the sign attached flew forward after it broke loose and was rehit by the car.

The web section of the base post was torn out where the top bolt connects the base post to the signpost. The signpost was twisted and broken at the bumper height of the car. Both the signpost and the base post would have to be replaced for the reinstallation of the sign. The sign itself was undamaged and was reusable. Damage to the installation is shown in Figures 24 and 25.

Before and after photographs of the car are shown in Figures 26 through 29. Permanent deformation of the car was minor with the bumper being displaced into the grill and the metal above the front grill being slightly damaged. Damage to the vehicle was assessed using the TAD[7] and SAE[8] damage rating scales and the results are given in Table 5.

Time-displacement information for the test vehicle, obtained from the high-speed film, is given in Table 6.

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[7] "Vehicle Damage Scale for Traffic Accident Investigators", National Safety Council, Chicago, Illinois, 1968.

[8] Collision Deformation Classification - SAE J224a, SAE Recommended Practice, 1972, p. 1258.

FIGURE 24. EZE-ERECT CONNECTION AFTER TEST 1.

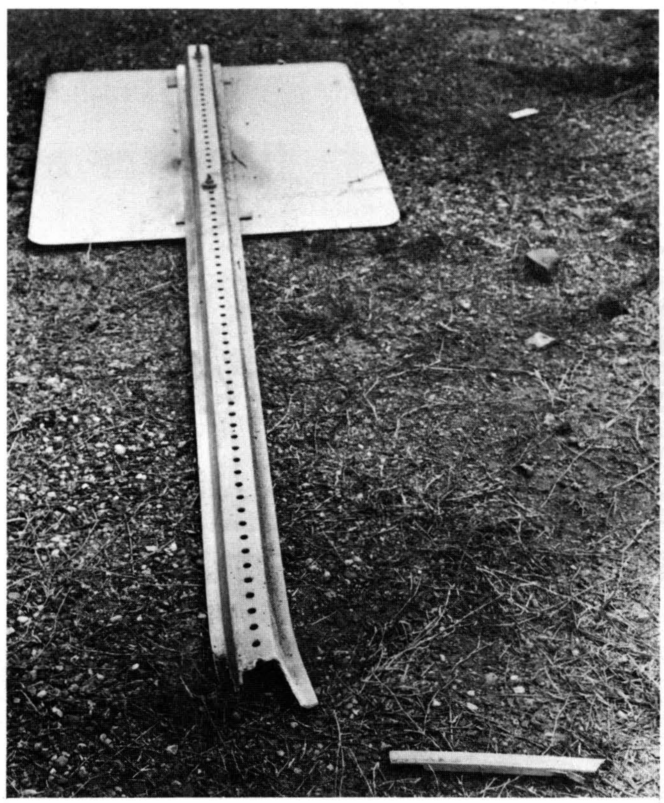

FIGURE 25. SIGNPOST AFTER TEST 1.

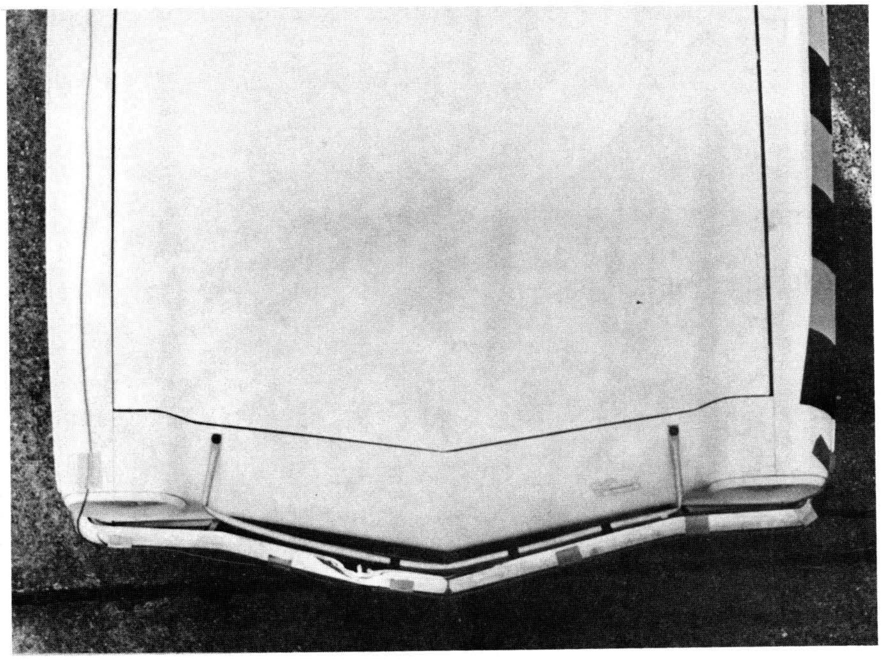

FIGURE 26. TOP VIEW OF CAR BEFORE TEST 1.

FIGURE 27. FRONT VIEW OF CAR BEFORE TEST 1.

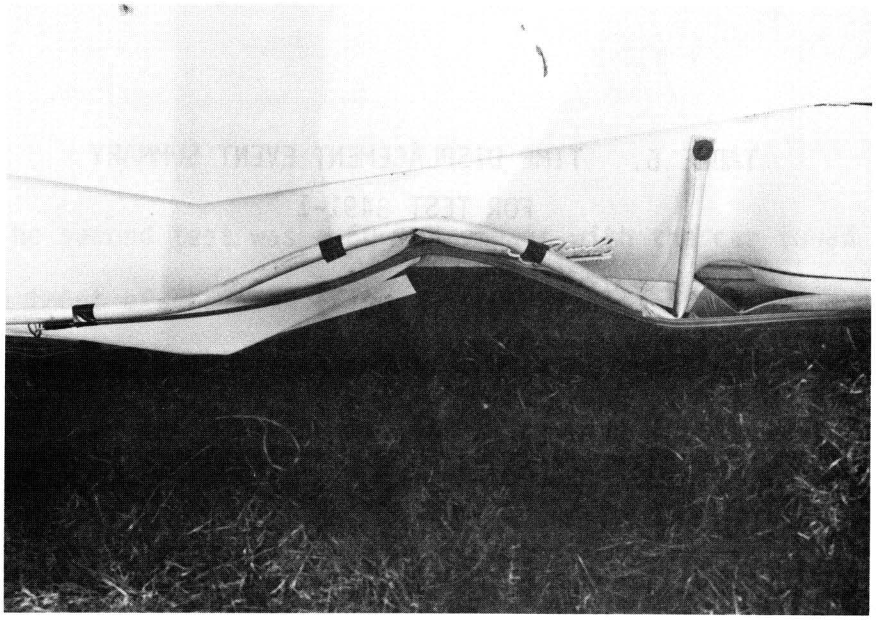

FIGURE 28. TOP VIEW OF CAR AFTER TEST 1.

FIGURE 29. FRONT VIEW OF CAR AFTER TEST 1.

TABLE 6. TIME DISPLACEMENT EVENT SUMMARY FOR TEST 3491-1

TIME (sec)	NOMINAL VEHICLE DISPLACEMENT (ft)	EVENT
0.0000	0.00	Impact
0.0568	1.84	Signpost breaks
0.0893	2.78	Loss of contact
0.1109	3.45	
0.1434	4.44	Car hits post again

TEST 2

The second test was a 60 mph impact with the car towed perpendicular to the front of the sign (Figure 30). Results of the second test are summarized in Table 7. Change in momentum from the film was 201 lb-sec computed over the duration of initial contact (0.089 sec) and the change in momentum (Figure 31) for the accelerometer traces was 147 and 210 lb-sec for the left and right accelerometers respectively for the same time period. Accelerations are shown in Figure 32. The peak decelerations were 5.1 g's at 0.014 sec after contact and 7.4 g's at 0.011 sec after contact for the left and right accelerometers respectively. The time of initial contact was used in calculating the change in momentum because it is less than the free missile travel time (Figure 33).[9] The 50 millisecond average acceleration and the force exerted on the car by the sign are shown in Figures 34 and 35.

In Figure 36, sequential photographs from the high-speed film are shown. Upon impact, the signpost was bent by the bumper. Then the signpost and strap broke free from the base post. After the signpost was free, the post flew above the vehicle hitting the top of the car above the windshield but did not crack the glass.

The web section of the base post was torn out as in Test 1 (Figure 37). The bumper of the car hit the signpost causing it to bend approximately 20 inches from the bottom of the post (Figure 38). The sign

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[9] Bronstad, M. E. and Michie, J. D., NCHRP Report 153.

FIGURE 30. DIRECTION OF IMPACT - TEST 2.

TABLE 7. SUMMARY OF RESULTS, TEST 3491-2

VEHICLE		
Make	Chevrolet	
Model	Vega	
Year	1971	
Weight	2280 lbs	
FILM DATA		
Impact Velocity	87.4 ft/sec (59.6 mph)	
Final Velocity	84.6 ft/sec (57.7 mph)	
Time of Contact	0.089 sec	
Free Missile Time	*	
Change in Momentum Over Time of Contact	201 lb-sec	
ACCELEROMETER DATA - 80 Hz Max Flat Filter		
	Left Long.	Right Long.
Peak Deceleration	5.1 g	7.4 g
at Time	0.014 sec	0.011 sec
Max .050 sec Average Deceleration	1.20 g	1.54 g
Change in Momentum Over Time of Contact	147 lb-sec	210 lb-sec
Peak Force	11.23 K	15.66 K
at Time	0.013 sec	0.011 sec
DAMAGE CLASSIFICATION		
TAD	FR-1	
SAE	12FREN1	

*Free missile time greater than 0.089 sec.

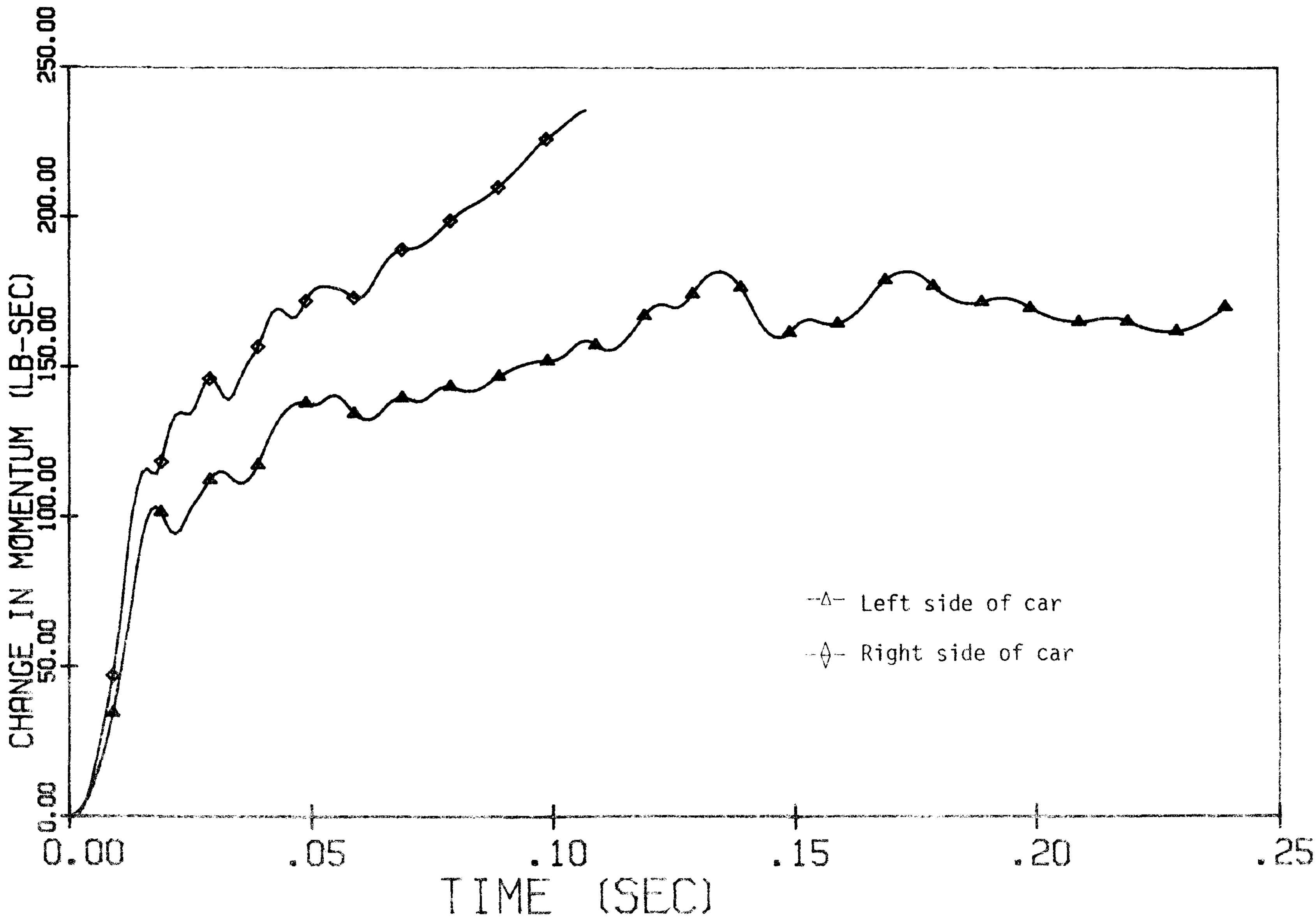


FIGURE 31. CHANGE IN MOMENTUM VS. TIME FOR TEST 2.

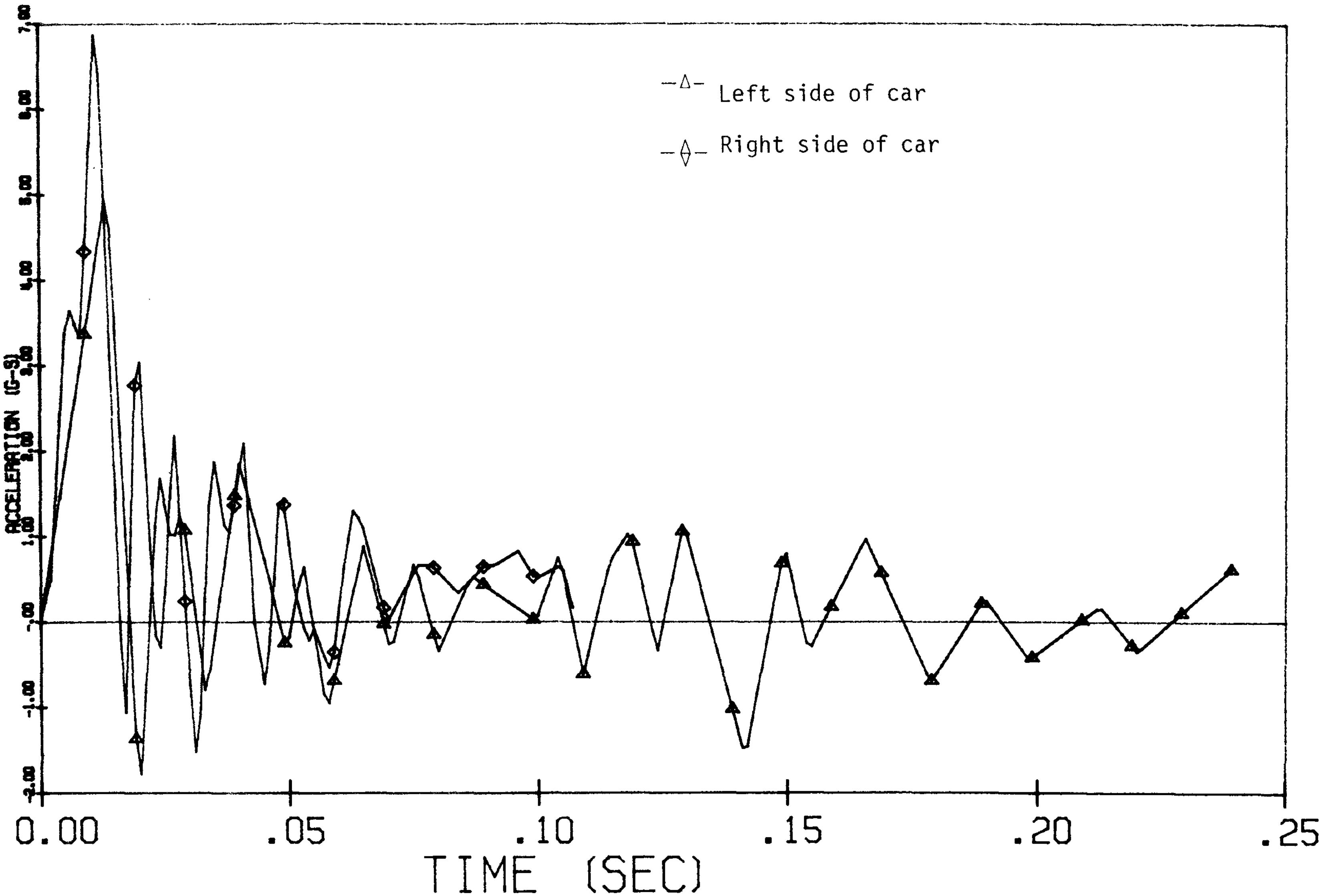


FIGURE 32. ACCELERATION VS. TIME FOR TEST 2.

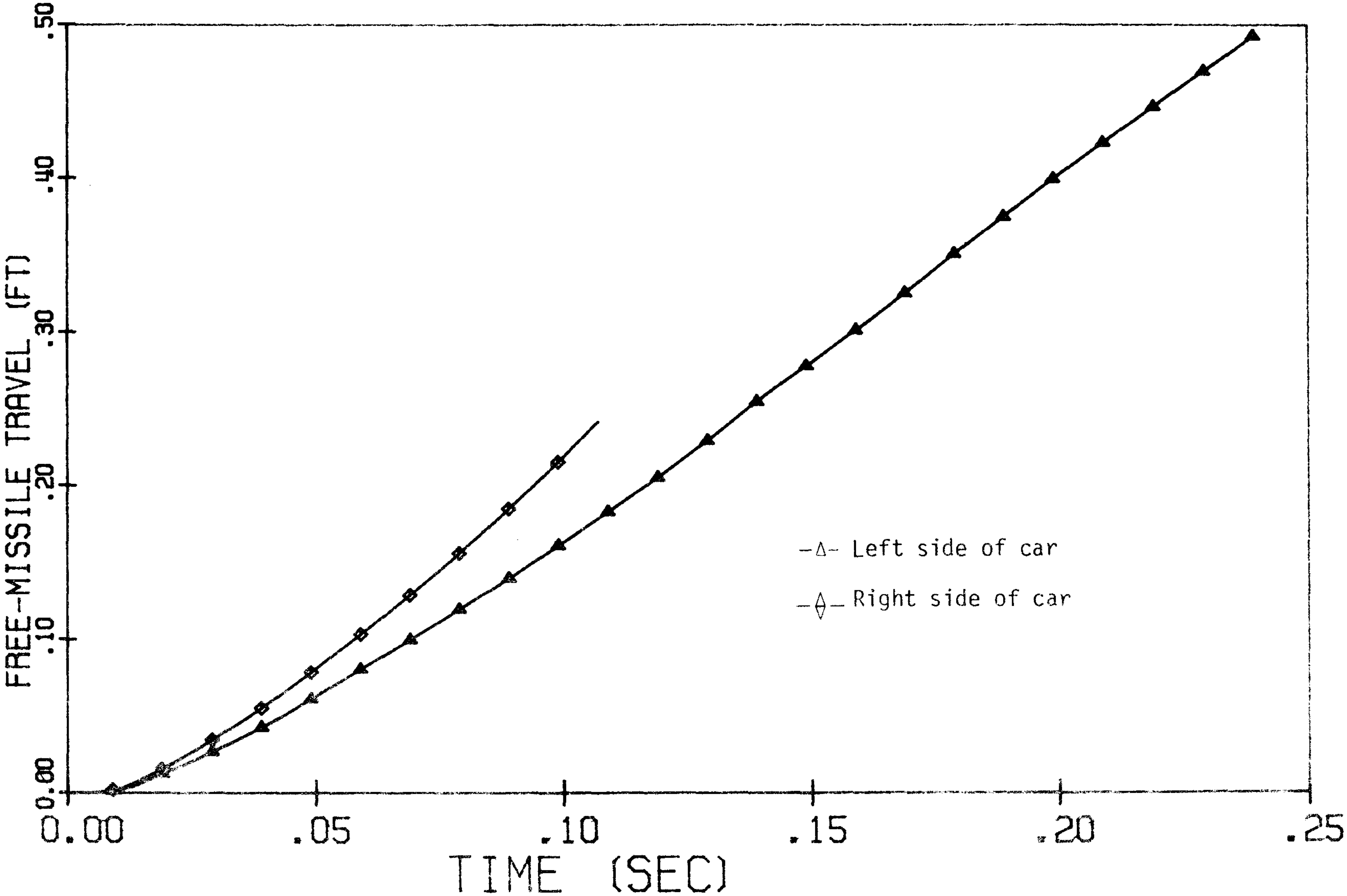


FIGURE 33. FREE-MISSILE TRAVEL VS. TIME FOR TEST 2.

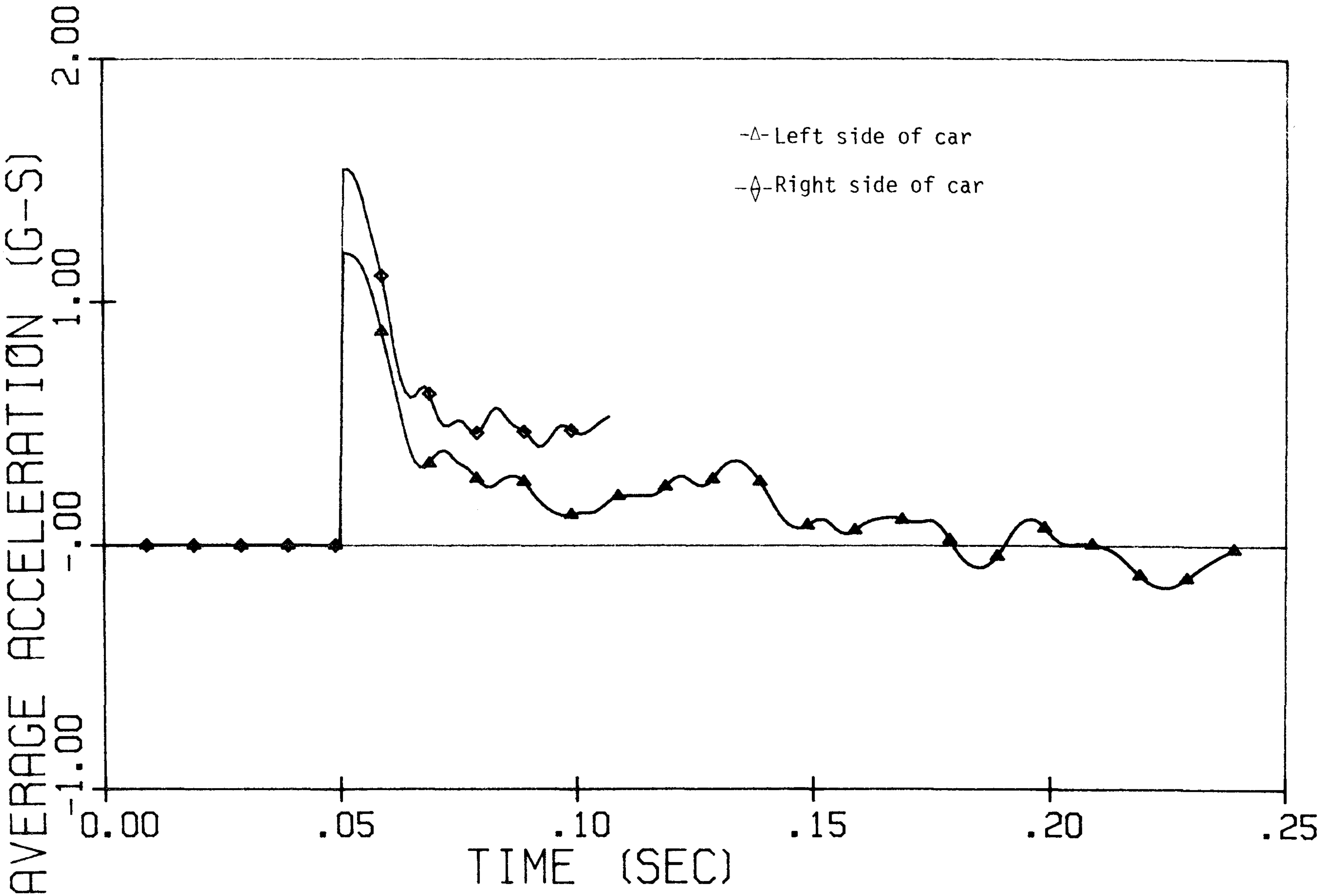


FIGURE 34. 50 MILLISECOND AVERAGE ACCELERATION FOR TEST 2.

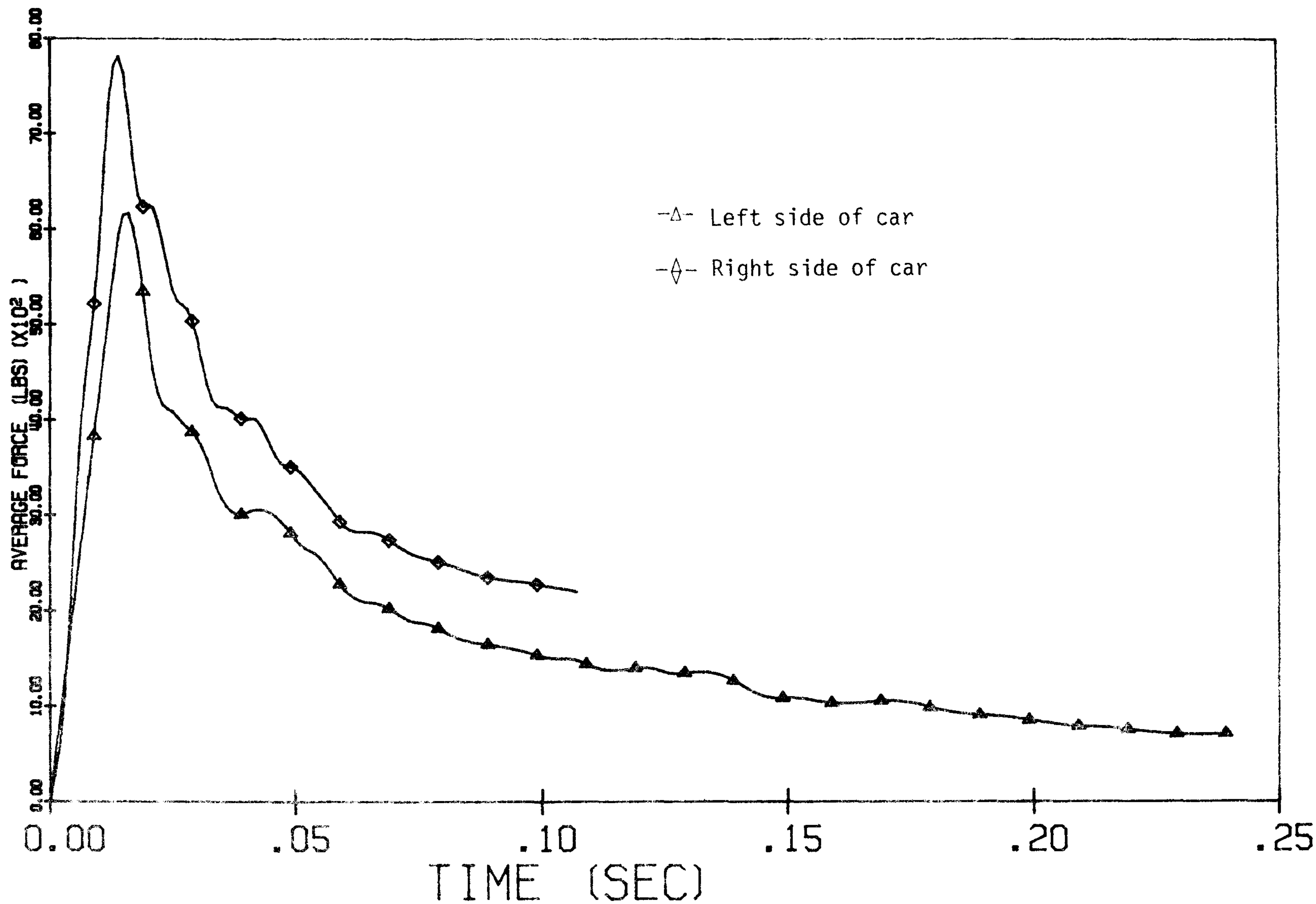
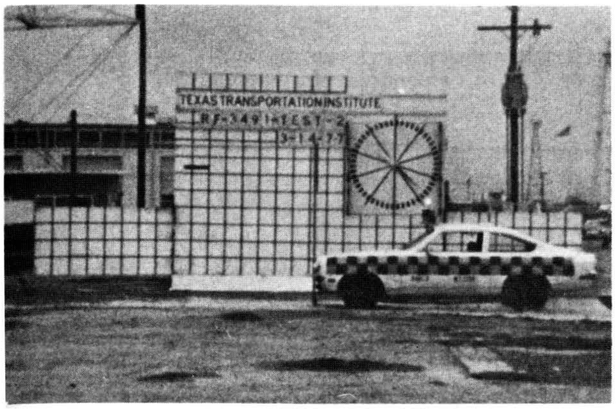
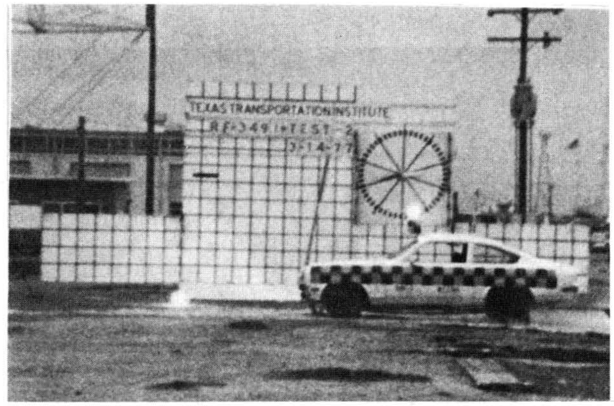


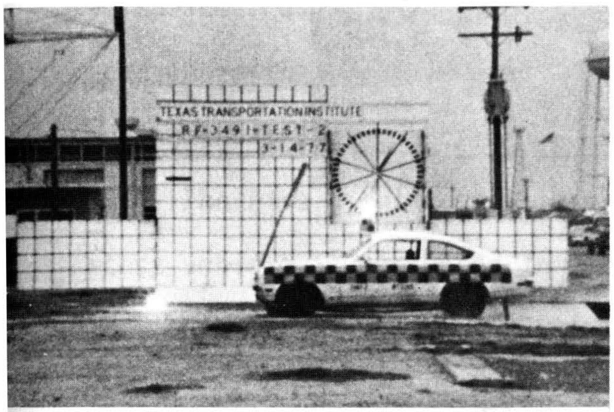
FIGURE 35. SIGN FORCE ON CAR VS. TIME FOR TEST 2.



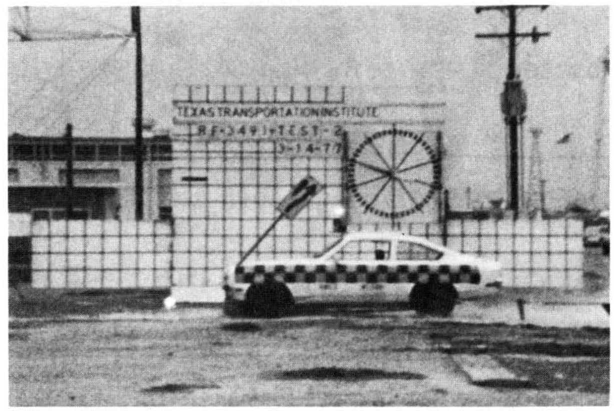
0.000 sec



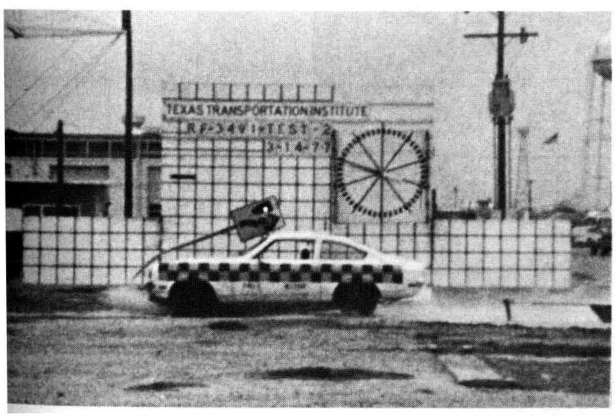
0.0131 sec



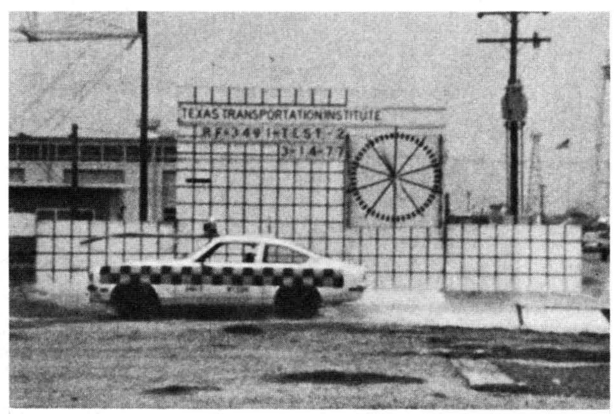
0.0262 sec



0.0525 sec



0.0892 sec



0.1312 sec

FIGURE 36. SEQUENTIAL PHOTOGRAPHS OF TEST 2.

FIGURE 37. BASE POST.

FIGURE 38. SIGNPOST.

POST ASSEMBLY AFTER TEST 2

panel was damaged when it came in contact with the top of the car. For reinstallation, the base post, signpost, and sign panel would have to be replaced.

The before and after damage to the car is shown in Figures 39 and 40, with the damage for this test being on the left portion of the vehicle. The permanent deformation was minor with the bumper being displaced, damaging the metal section above the grill. The top of the car above the windshield was dented. Damage to the vehicle was assessed using the TAD and SAE systems and is presented in Table 7.

The time-displacement information from the high-speed film of the test vehicle is presented in Table 8.

FIGURE 39. CAR BEFORE TEST 2.

FIGURE 40. CAR AFTER TEST 2.

TABLE 8. TIME DISPLACEMENT EVENT SUMMARY FOR TEST 3491-2

TIME (sec)	NOMINAL VEHICLE DISPLACEMENT (ft)	EVENT
0.0000	0.00	Impact
0.0131	1.14	Sign has broken from base
0.0262	2.27	Sign continues to perform
0.0525	4.52	
0.0892	7.63	Loss of contact
0.1312	11.18	Sign falling to right side of test vehicle
0.2231	18.77	

TEST 3

The third test was a 20 mph impact with the car towed perpendicular to the back of the sign (Figure 41). The results of this test are summarized in Table 9. The change in momentum of the vehicle computed over the initial time of contact (0.245 sec) was 300 lb-sec for the high-speed film. The maximum change in momentum (Figure 42) during time of contact was 359 lb-sec for the left accelerometer and 376 lb-sec for the right accelerometer. The accelerations are shown in Figure 43. The peak decelerations measured by the two accelerometers were 3.9 g's and 4.3 g's. The time of initial contact was used in calculating the change in momentum because it is less than the free missile travel time (Figure 44).[10] The 50 millisecond average acceleration and the force exerted on the car by the sign are shown in Figures 45 and 46.

Sequential photographs from the high-speed film are given in Figure 47. Upon impact, the base post fractured approximately 5 inches below the ground (Figure 48). After the base post broke, the signpost with sign panel attached first flew, then slid along the ground in front of the car.

The base post would have to be replaced but the signpost could probably be reused if the slight bend was straightened out (Figure 49). The sign was scratched up but could probably be reused after rescreening.

Photographs of the car, before and after the test, are shown in Figures 50 and 51. The permanent deformation to the car was minor with the bumper pushed into the grill of the car and the metal above the

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[10] Bronstad, M. E. and Michie, J. D., NCHRP Report 153.

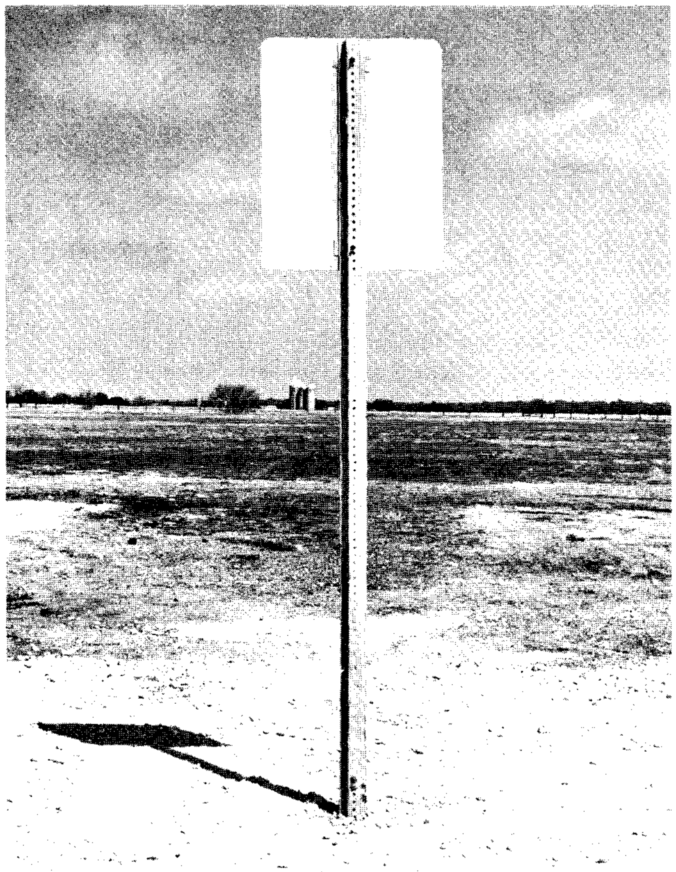


FIGURE 41. DIRECTION OF IMPACT - TEST 3.

TABLE 9. SUMMARY OF RESULTS, TEST 3491-3

VEHICLE		
Make	Chevrolet	
Model	Vega	
Year	1971	
Weight	2280 lbs	
FILM DATA		
Impact Velocity	25.2 ft/sec (17.2 mph)	
Final Velocity	21.0 ft/sec (14.3 mph)	
Time of Contact	0.245 sec	
Free Missile Time	*	
Change in Momentum Over Time of Contact	300 lb-sec	
ACCELEROMETER DATA - 80 Hz Max Flat Filter		
	Left Long.	Right Long.
Peak Deceleration at Time	3.9 g 0.041 sec	4.3 g 0.038 sec
Max .050 sec Average Deceleration	1.71 g	1.77 g
Change in Momentum Over Time of Contact	359 lb-sec	376 lb-sec
Peak Force at Time	8.61 K 0.041 sec	9.51 K 0.038 sec
DAMAGE CLASSIFICATION		
TAD	FL-1	
SAE	12FLEN1	

*Free missile time greater than 0.245 sec.

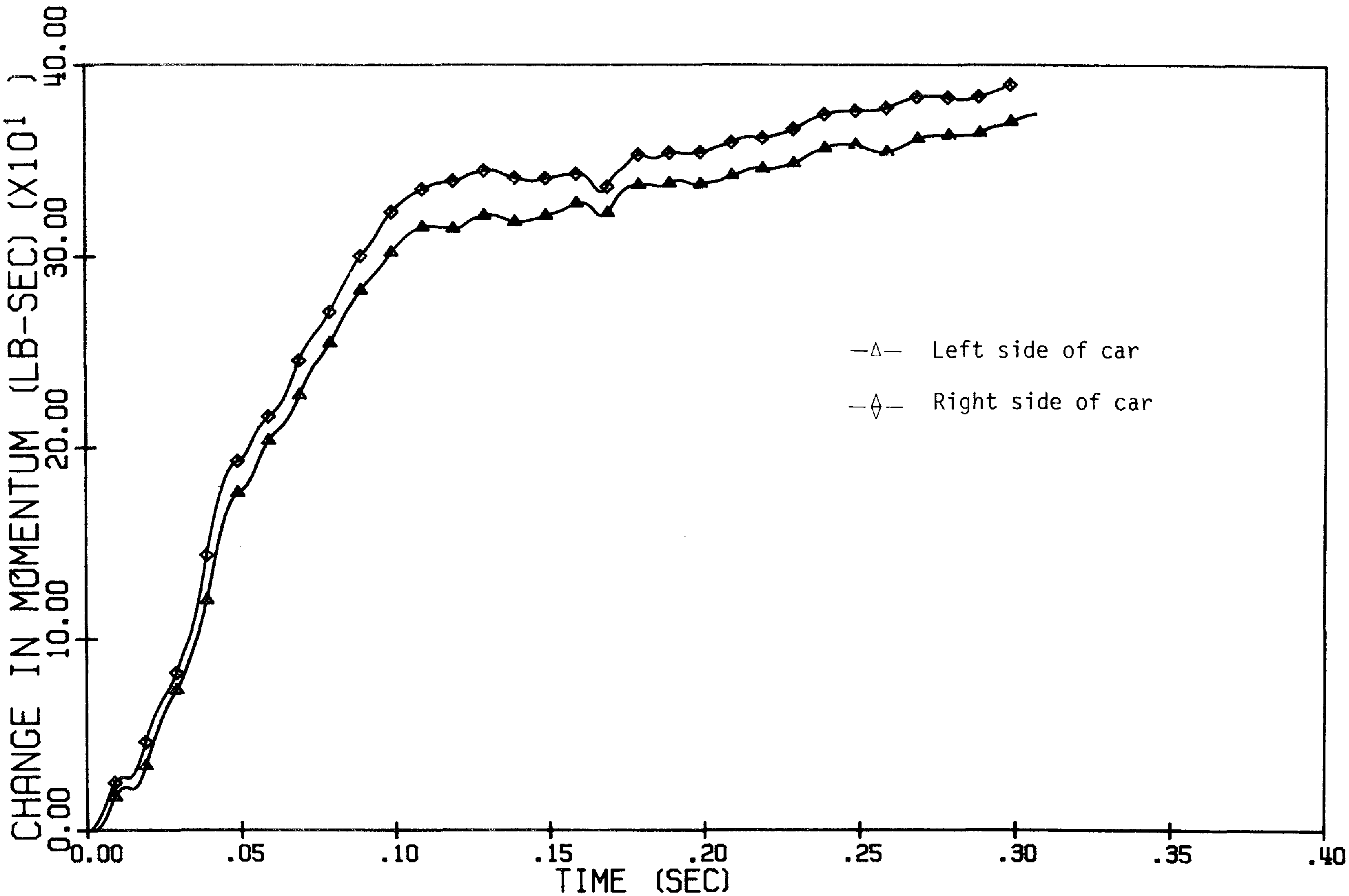


FIGURE 42. CHANGE IN MOMENTUM VS. TIME FOR TEST 3.

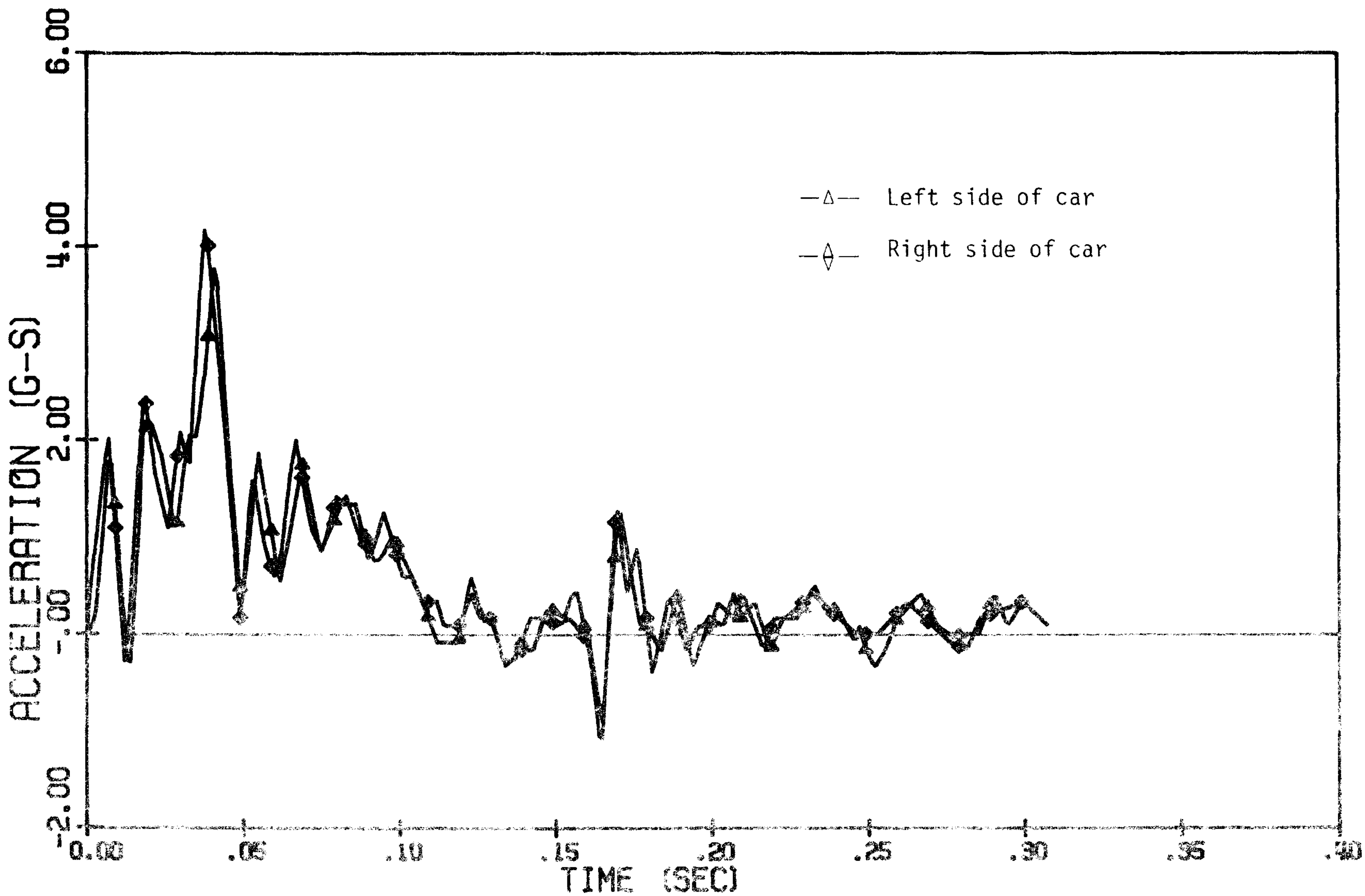


FIGURE 43. ACCELERATION VS. TIME FOR TEST 3.

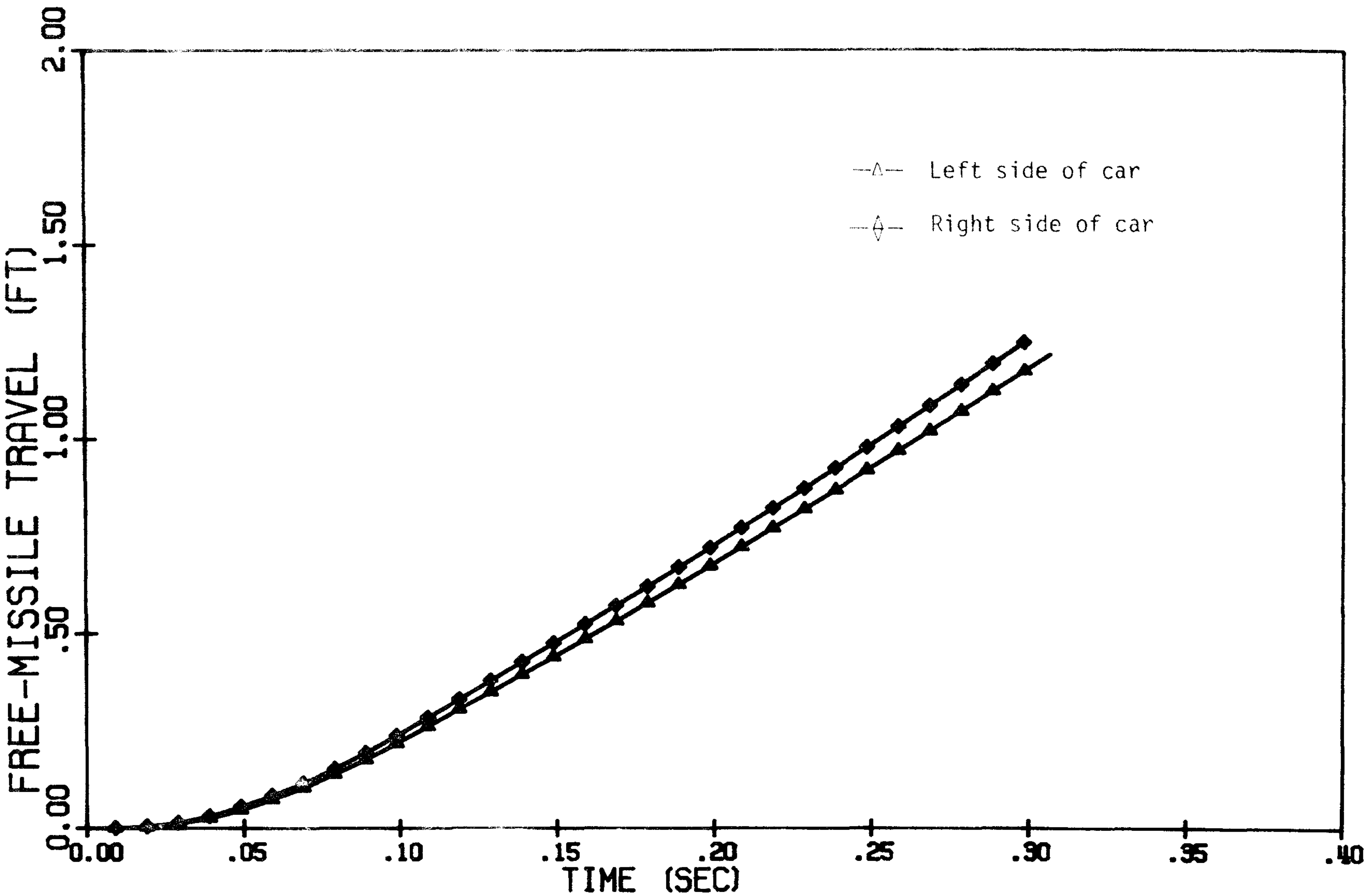


FIGURE 44. FREE-MISSILE TRAVEL VS. TIME FOR TEST 3.

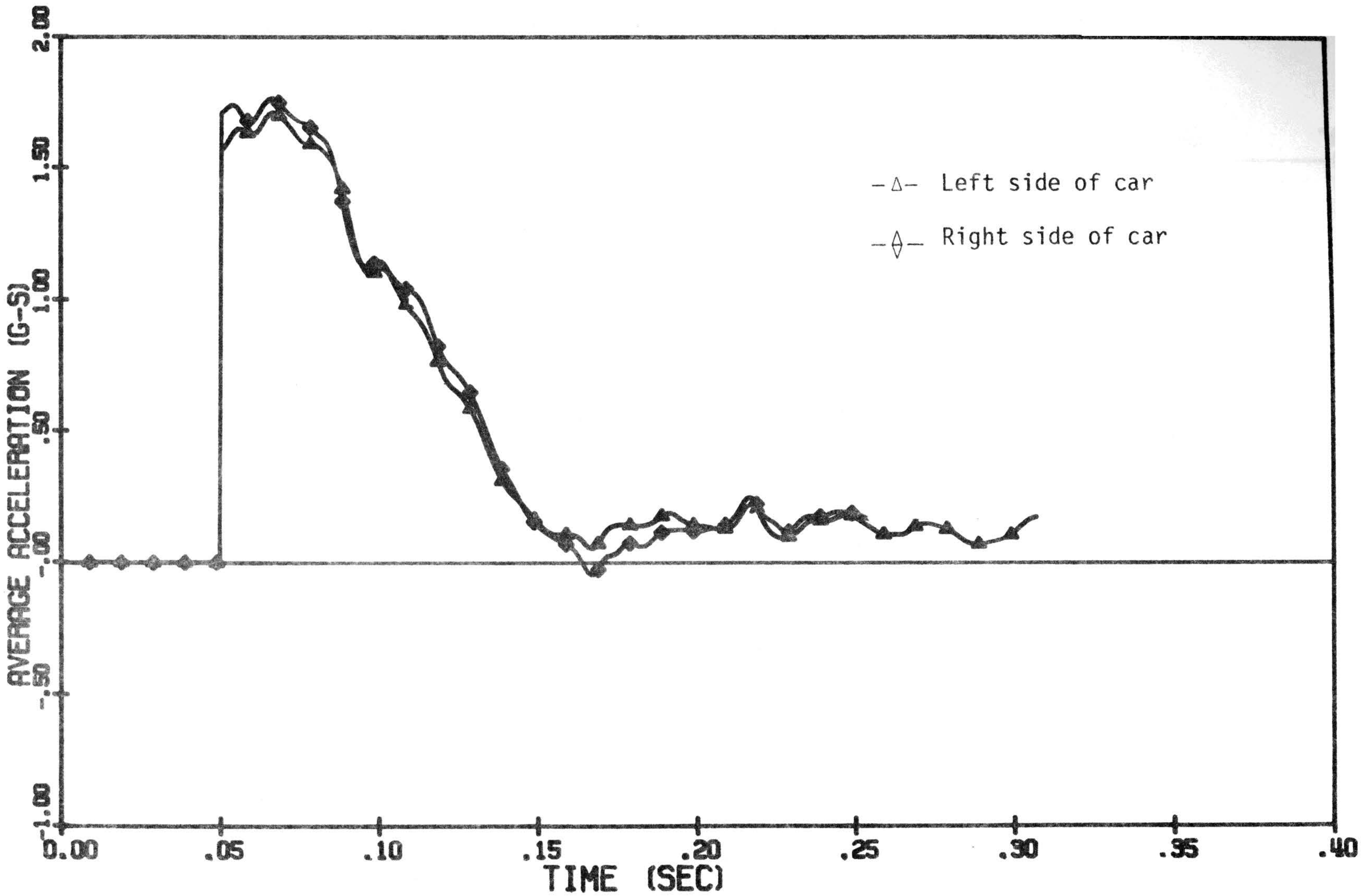


FIGURE 45. 50 MILLISECOND AVERAGE ACCELERATION FOR TEST 3.

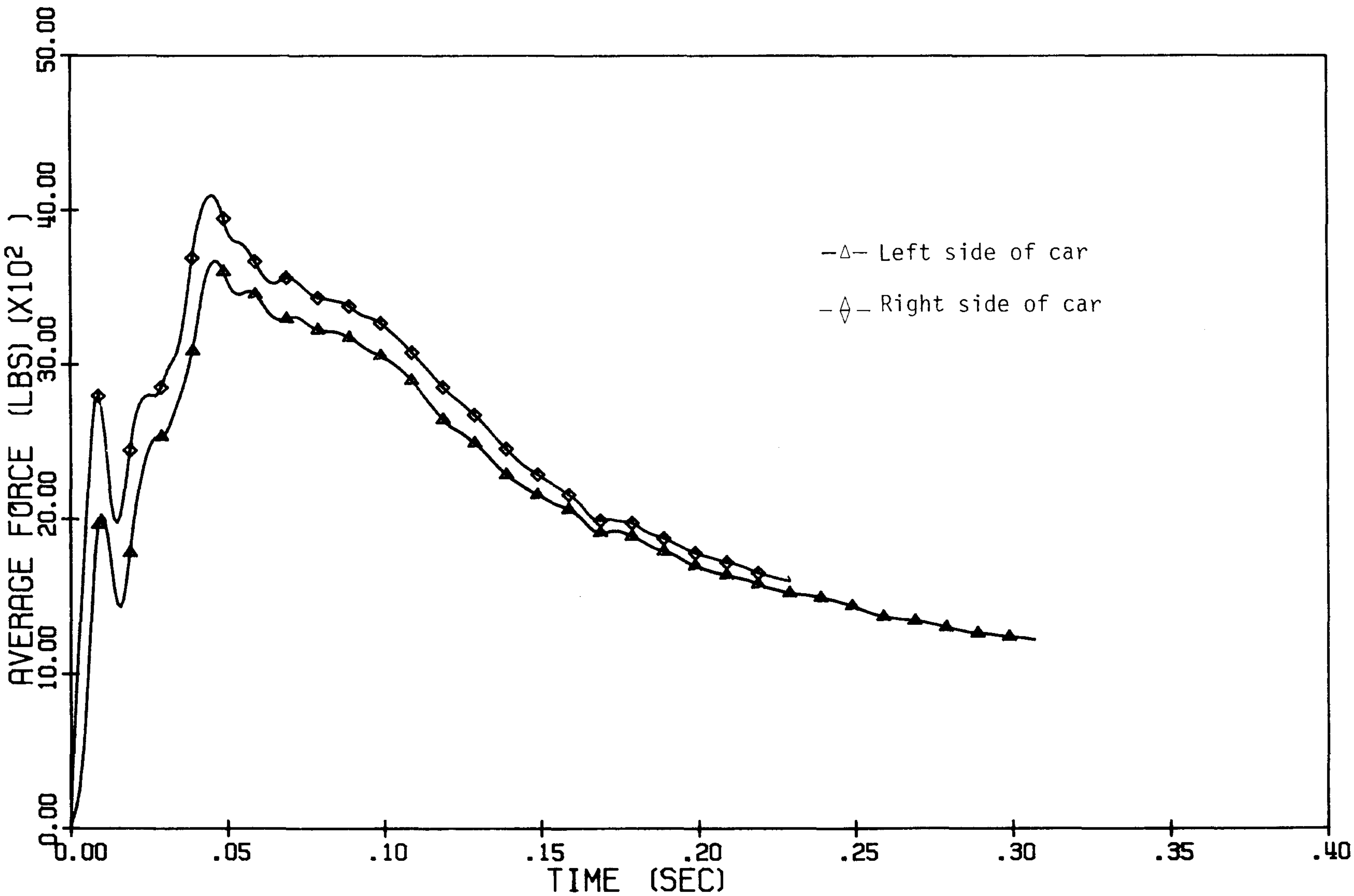
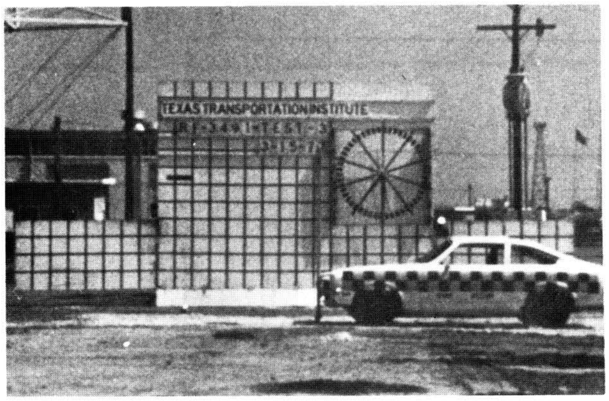
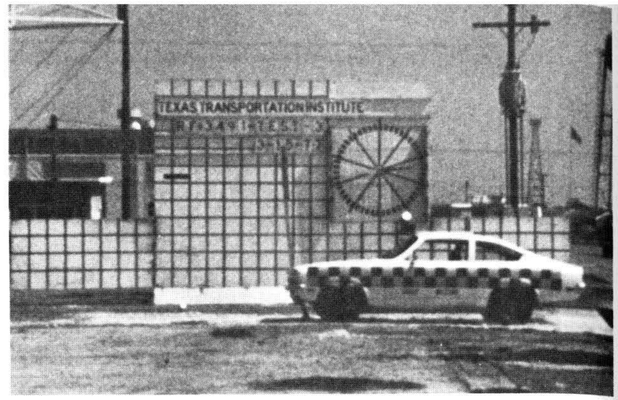


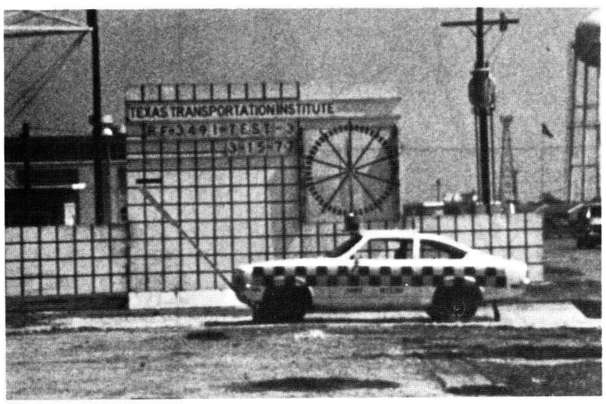
FIGURE 46. SIGN FORCE ON CAR VS. TIME FOR TEST 3.



0.000 sec



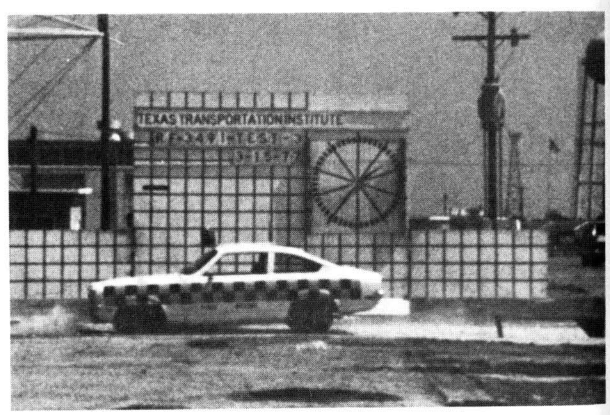
0.065 sec



0.129 sec

0.245 sec

0.261 sec



0.467 sec

FIGURE 47. SEQUENTIAL PHOTOGRAPHS OF TEST 3.

FIGURE 48. BASE POST BROKEN IN GROUND IN TEST 3.

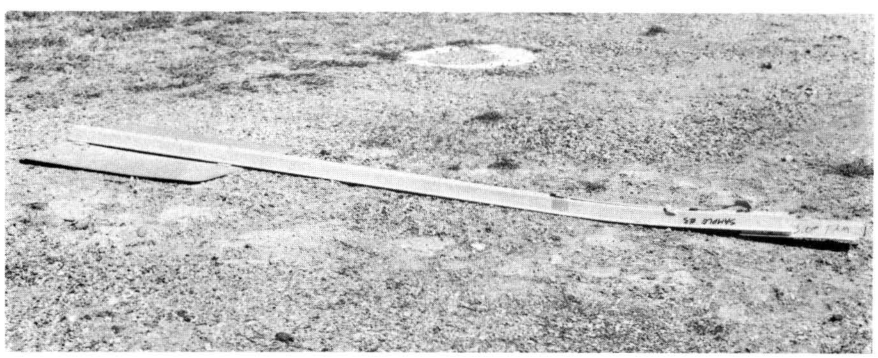


FIGURE 49. SIGNPOST AFTER TEST 3.

FIGURE 50. CAR BEFORE TEST 3.

FIGURE 51. CAR AFTER TEST 3.

grill deformed. The damage to the car was assessed as in previous tests by the TAD and SAE systems. The results are given in Table 9.

In Table 10, the time-displacement information of the test vehicle taken from the high-speed film is shown.

TABLE 10. TIME DISPLACEMENT EVENT SUMMARY FOR TEST 3491-3

TIME (sec)	NOMINAL VEHICLE DISPLACEMENT (ft)	EVENT
0.000	0.00	Impact
0.065	1.52	Post bending
0.129	2.85	Post bending
0.245	5.25	Visual separation
0.261	5.59	Sign hits ground
0.467	9.96	

TEST 4

In Test 4, the car was towed at a speed of 20 mph into the side of the signpost assembly (Figure 52). Results of Test 4 are summarized in Table 11. Change in momentum of the test vehicle computed over the time of initial contact (.20 sec) was 370 lb-sec for the high-speed film and 378 and 337 lb-sec for the left and right side accelerometers, respectively. Figures 54 and 54 show the change in momentum and accelerations of the vehicle taken from the accelerometer traces. The peak measured deceleration by the two accelerometers were 2.4 and 2.7 g's. The time of initial contact was used in calculating the change in momentum because it is less than the free missile travel time (Figure 55).[11] The 50 millisecond average acceleration and the force exerted on the car by the sign are shown in Figures 56 and 57.

Sequential photographs from the high-speed cameras are given in Figure 58. After impact, the bending and twisting action of the signpost caused the bolts in the Eze-Erect connection to fail. However, the retainer strap kept the signpost from further travel and the signpost fell to the ground in front of the car. The right front tire contacted the base post causing the car to veer off to the right.

The base post was twisted and bent above the ground and the signpost was twisted on the bottom two and a half feet. The sign panel was scratched and bent. (Figures 59 and 60) For reinstallation, the entire assembly would need replacing.

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[11] Bronstad, M. E. and Michie, J. D., NCHRP Report 153.

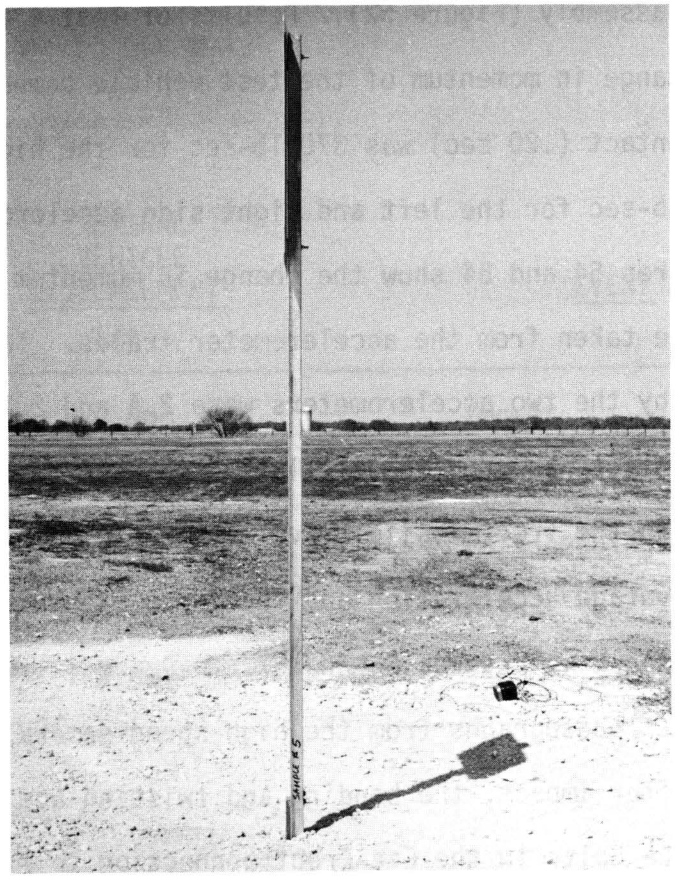


FIGURE 52. DIRECTION OF IMPACT - TEST 4

TABLE 11. SUMMARY OF RESULTS, TEST 3491-4

VEHICLE		
Make	Chevrolet	
Model	Vega	
Year	1971	
Weight	2280 lbs	
FILM DATA		
Impact Velocity	24.4 ft/sec (16.6 mph)	
Final Velocity	19.1 ft/sec (13.0 mph)	
Time of Contact	0.200 sec	
Free Missile Time	*	
Change in Momentum Over Time of Contact	370 lb-sec	
ACCELEROMETER DATA - 80 Hz Max Flat Filter		
	Left Long.	Right Long.
Peak Deceleration at Time	2.4 g 0.047 sec	2.7 g 0.032 sec
Max .050 sec Average Deceleration	1.52 g	1.65 g
Change in Momentum Over Time of Contact	378 lb-sec	337 lb-sec
Peak Force at Time	5.46 K 0.047 sec	6.04 K 0.032 sec
DAMAGE CLASSIFICATION		
TAD	FR-2	
SAE	12FREN1	

*Free missile time greater than 0.200 sec.

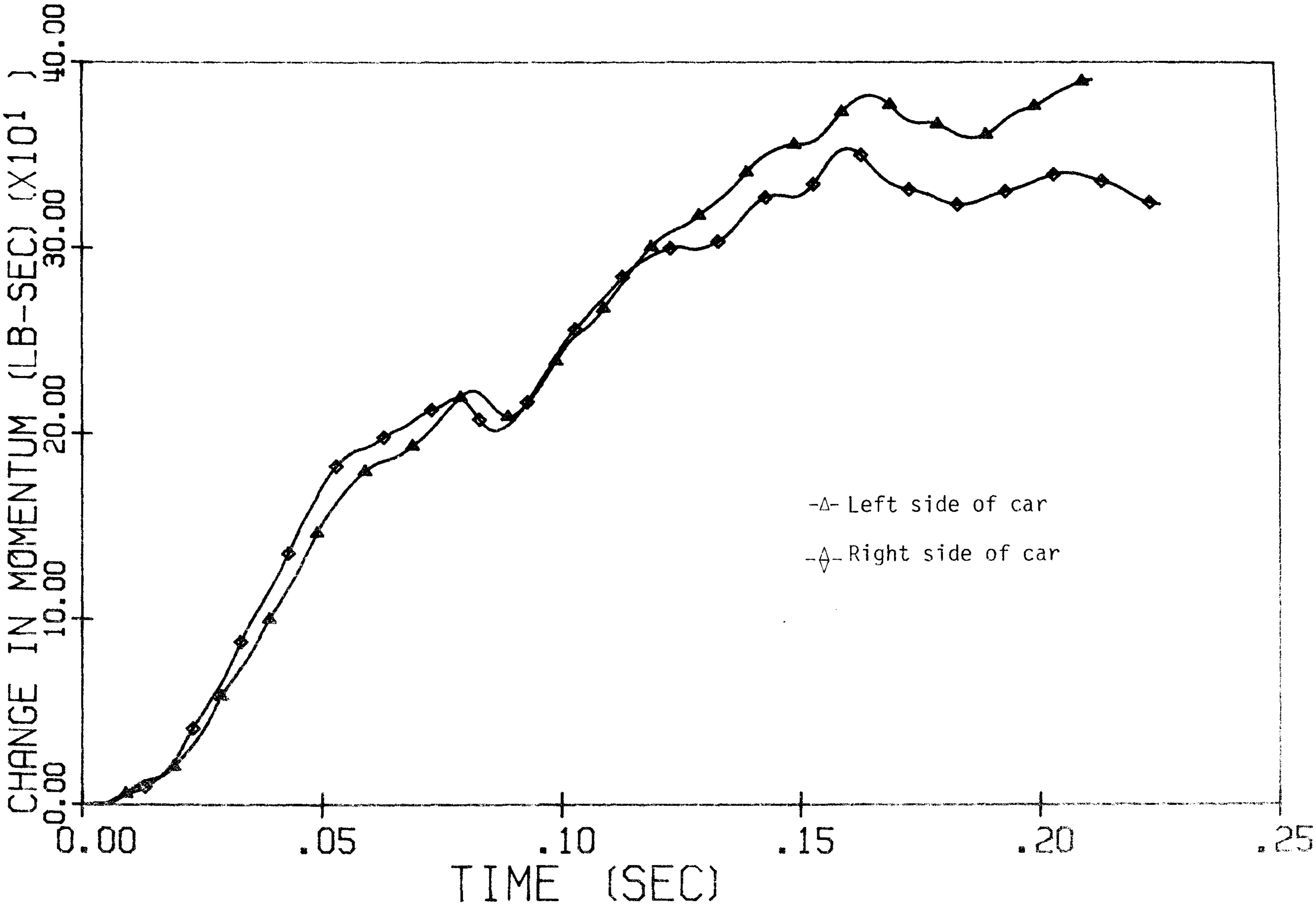


FIGURE 53. CHANGE IN MOMENTUM VS. TIME FOR TEST 4.

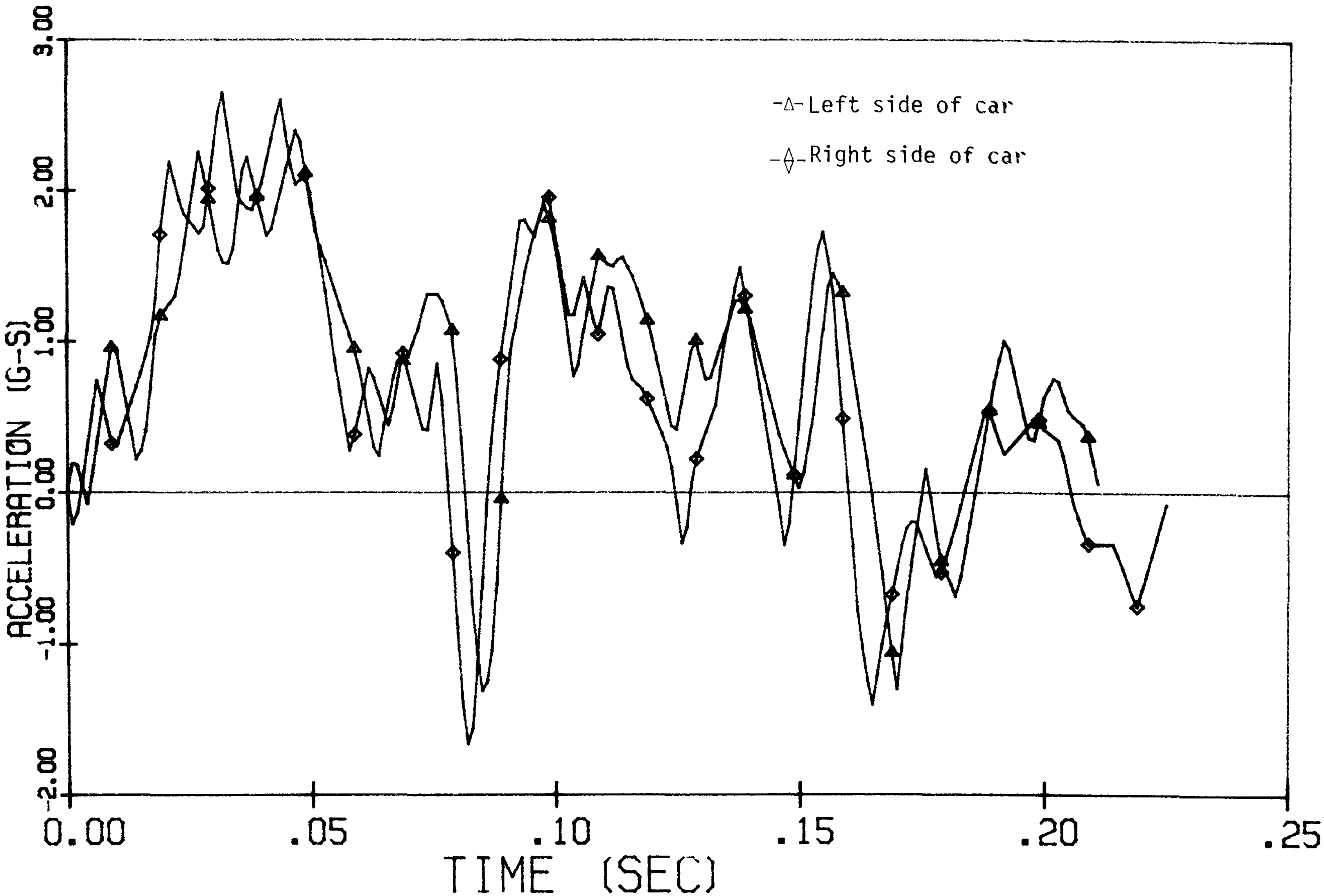


FIGURE 54. ACCELERATION VS. TIME FOR TEST 4.

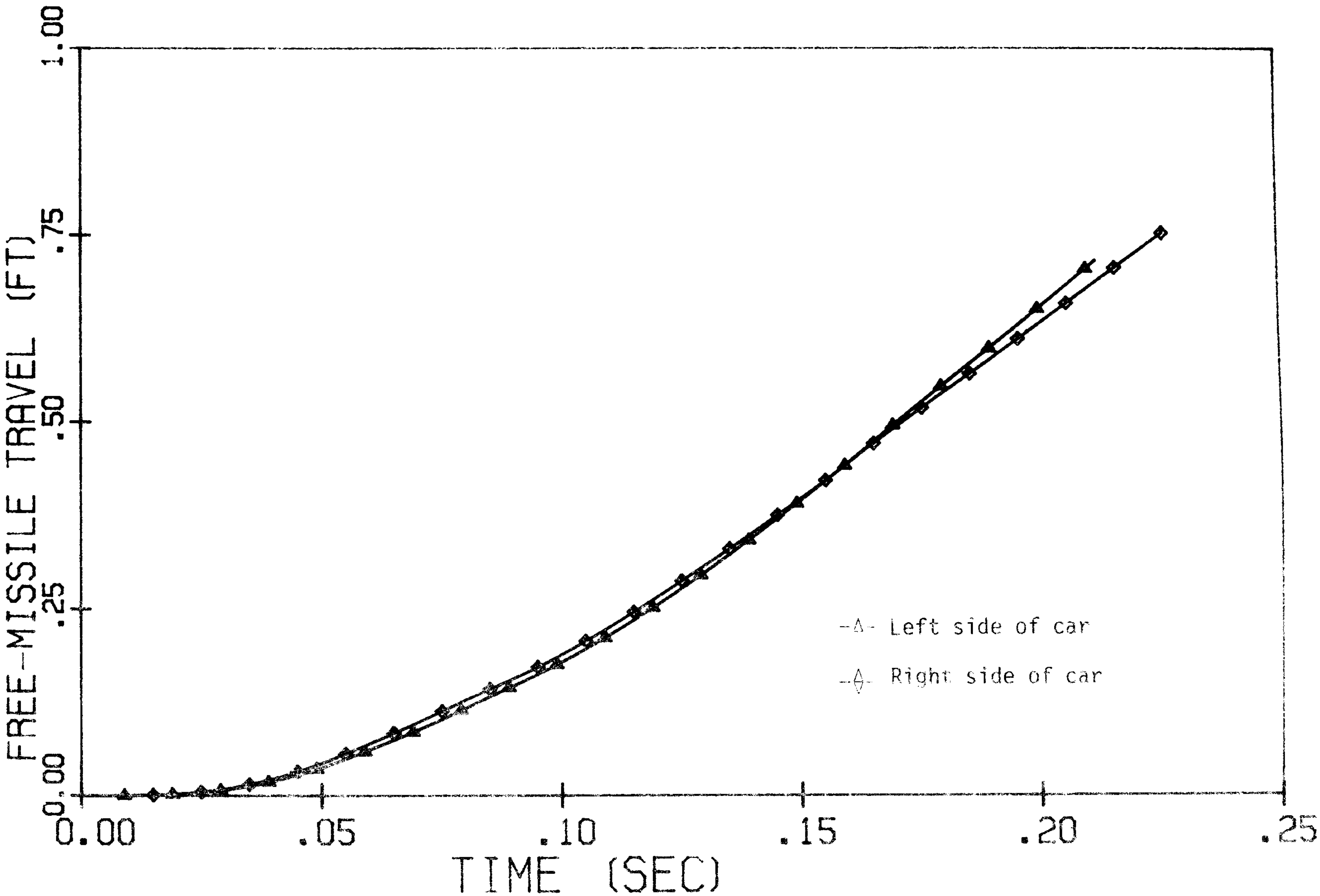


FIGURE 55. FREE-MISSILE TRAVEL VS. TIME FOR TEST 4.

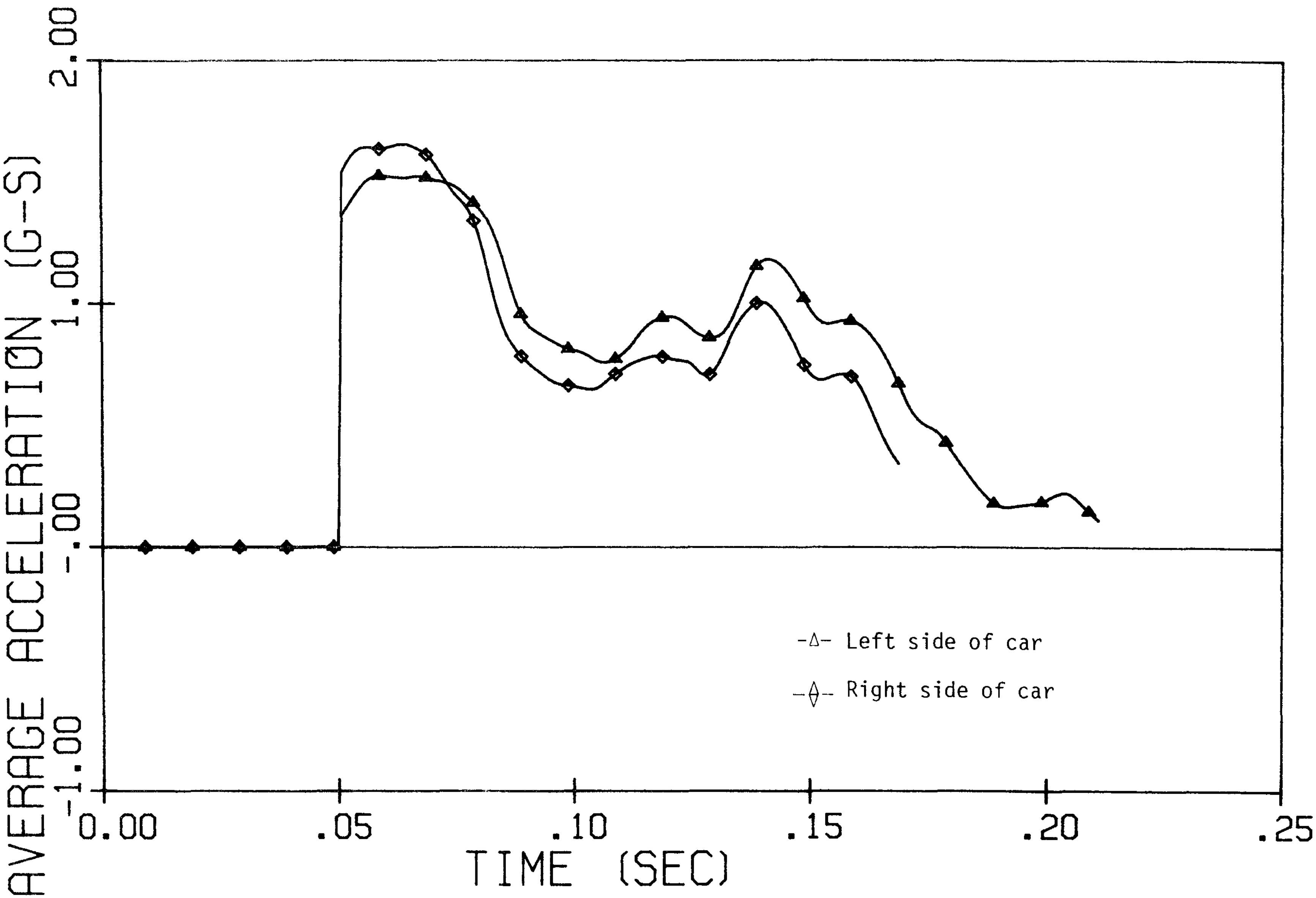


FIGURE 56. 50 MILLISECOND AVERAGE ACCELERATION FOR TEST 4.

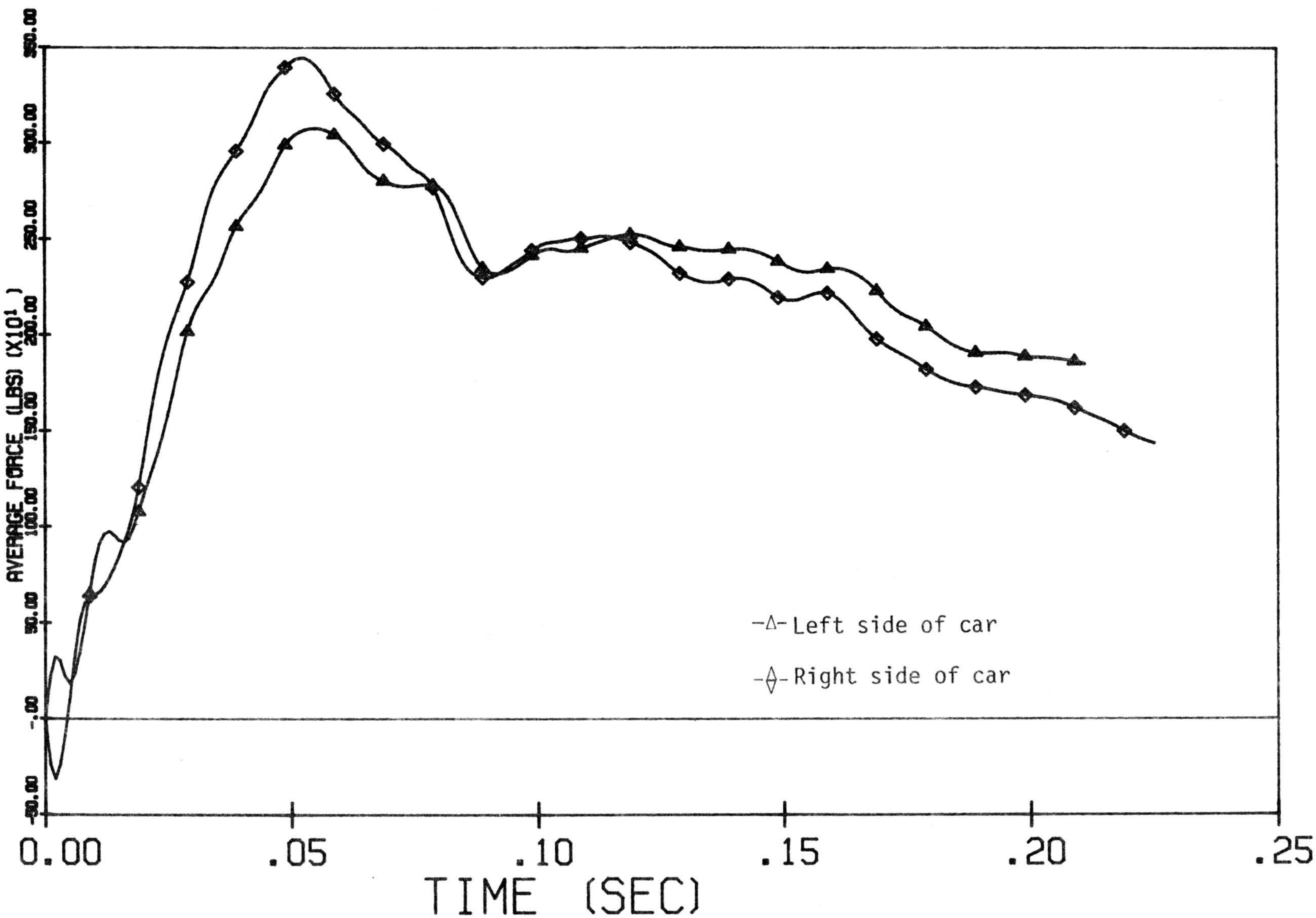
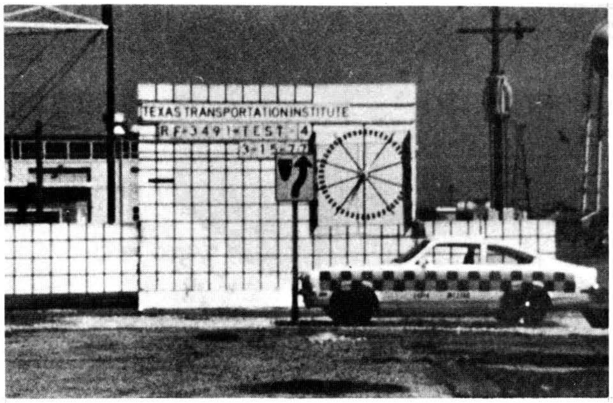
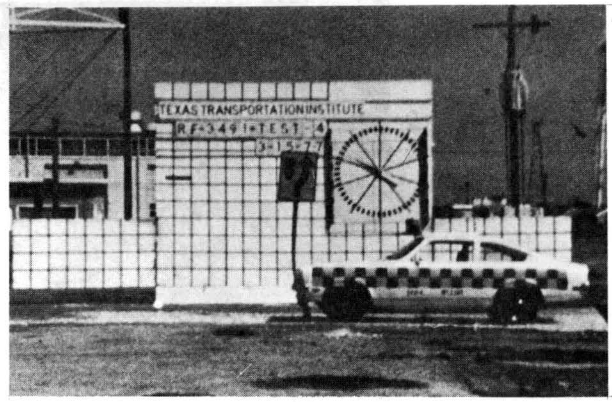


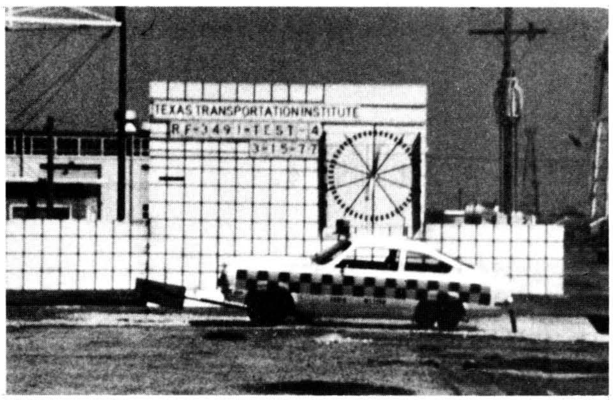
FIGURE 57. SIGN FORCE ON CAR VS. TIME FOR TEST 4.



0.000 sec



0.046 sec



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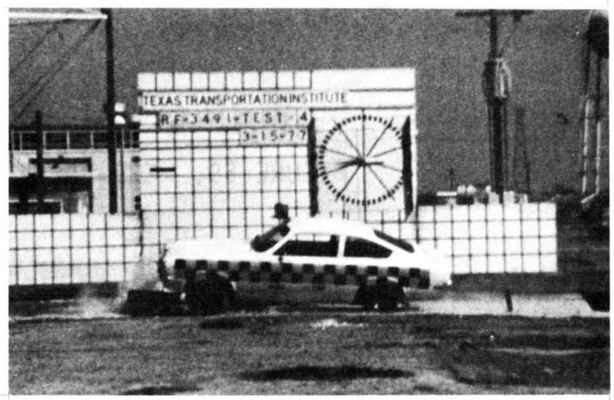
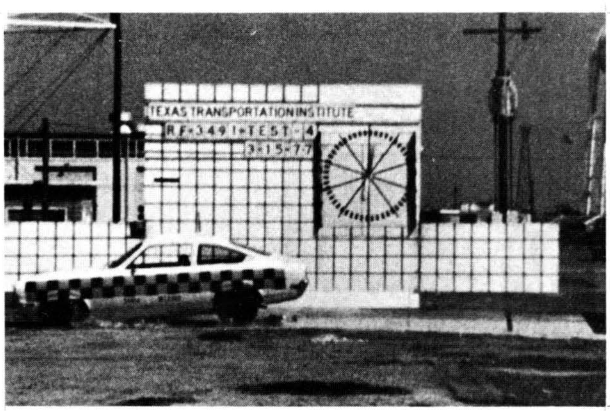
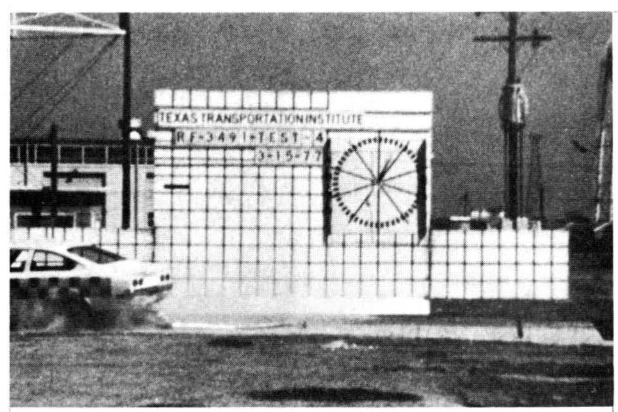


0.336 sec



0.714 sec



1.266 sec

FIGURE 58. SEQUENTIAL PHOTOGRAPHS OF TEST 4.

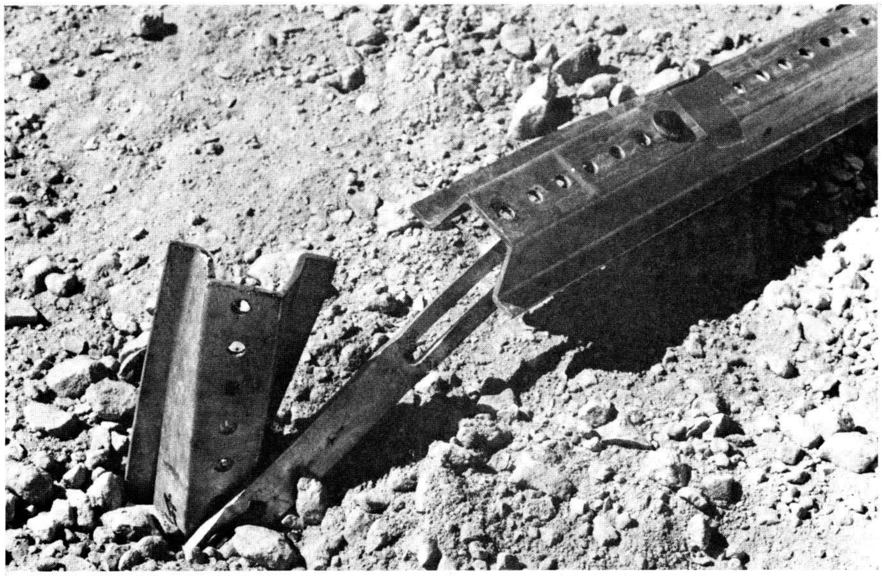


FIGURE 59. EZE-ERECT CONNECTION AFTER TEST 4.

FIGURE 60. POST ASSEMBLY AFTER TEST 4.

Figures 61 and 62 show the before and after photographs of the car. The front right end of the car was pushed up against the tire damaging the area between the headlight and the right front tire. The TAD and SAE systems were used to assess the damage to the car and are presented in Table 11.

The time-displacement information for the test vehicle obtained from the high-speed film is given in Table 12.

FIGURE 61. CAR BEFORE TEST 4.

FIGURE 62. CAR AFTER TEST 4.

TABLE 12. TIME DISPLACEMENT EVENT SUMMARY
FOR TEST 3491-4

TIME (sec)	NOMINAL VEHICLE DISPLACEMENT (ft)	EVENT
0.000	0.00	Impact
0.046	1.09	Post bending
0.200	4.24	Visual separation
0.336	6.84	Vehicle hits sign
0.714	13.81	Vehicle turning to right
1.266	22.02	Loss of contact

SUMMARY AND CONCLUSIONS

Both static and dynamic tests were performed on the Franklin Steel Eze-Erect sign support system. A summary of the results of these tests follows:

STATIC TESTS

Static load tests were conducted on two different signpost-to-base post configurations. Configuration I was a 2 lb/ft signpost attached to a 2.75 lb/ft base post and Configuration II was a 3 lb/ft signpost attached to a 3 lb/ft base post. Design loads (as determined by Franklin Steel) were reached in both configurations without failure and without appreciable yielding or permanent set. Configuration I was loaded to 200 percent of the design load without failure, but with appreciable yielding. Configuration II failed at a load of about 136 percent of the design load. Failure occurred when the web section of the base post split down the center line from the top of the post to the first punched hole.

FULL-SCALE IMPACT TESTS

Four full-scale vehicle tests were conducted to determine the impact performance of the Eze-Erect system. Head-on impact tests were conducted at 20 mph and at 60 mph. Side and rear (with respect to sign orientation) impact tests were conducted at 20 mph. In each test, a 1971 Vega automobile, weighing 2280 lbs, was used. A 3 lb/ft signpost with a 3 lb/ft base post was used in each test.

Change in vehicle momentum values in each test were well below recommended maximums.* In no case did the test articles (sign panel, signpost, bolts, nuts, etc.) penetrate the occupant compartment of the test vehicles.

CONCLUSIONS

A simple and effective method has been developed to install the steel channel signpost. Use of the stub-signpost system described in this paper will reduce the hazard associated with driving full-length posts. Special equipment such as a lift truck or other devices needed to obtain the required heights for driving will not be needed. The sign panel can be mounted to the signpost prior to erection of the post.

Crash tests, for a full range of impact speeds and orientations, have shown that a 3 lb/ft stub-signpost system presents no significant hazard to a motorist. Change in momentum values were well below AASHTO limits.

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*AASHTO Specifications.