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16. Abstract

Small sign systems include everything from stop signs and delineator posts to signs up to about 25 square feet. In some cases, multiple small sign support systems are used to support much larger signs (40-50 square feet). This broad class of sign has been and is currently being used along Texas highways.

To insure the safety of vehicle occupants, there have been a series of specifications, guidelines and recommendations which define acceptable vehicle impact performance criteria. Most small sign systems have been tested with vehicles larger than the current standard 1800 pound car. As a result, the first phase of this study was to undertake a series of recertification tests for those systems currently being used in Texas An analytical model also was developed to aid in the evaluation of data from previous crash tests. Although certification was achieved through crash testing, this analytical model proved to be an accurate predictor of impact performance with the smaller 1800 pound vehicle. The crash tests demonstrated satisfactory impact performance for U-post, triangular slip base, and 2-1/2 inch standard pipe with threaded coupler supports, which are all used extensively in Texas. Other currently used systems were not tested because of prior acceptance by FHWA.

The second phase of this study consisted of the development and testing of a generic small sign support system. The resulting generic ground anchor system can be used with any tubular sign post. This system has proven satisfactory in both "strong" and "weak" soils (as defined by NCHRP Report 230) both from the standpoint of driveability and impact performance.

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GENERIC SMALL SIGN SUPPORT SYSTEM

AND

VALIDATION OF ACCEPTABLE SUPPORT PERFORMANCE

by

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Research Report 1122-1F

Sponsored by
Texas State Department of Highways and Public Transportation

in cooperation with
The United States Department of Transportation
Federal Highway Administration

April, 1990

Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843-3135

METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
AREA				
in²	square inches	645.2	millimetres squared	mm²
ft²	square feet	0.0929	metres squared	m²
yd²	square yards	0.836	metres squared	m²
mi²	square miles	2.59	kilometres squared	km²
ac	acres	0.395	hectares	ha
MASS (weight)				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
VOLUME				
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft³	cubic feet	0.0328	metres cubed	m³
yd³	cubic yards	0.0765	metres cubed	m³

NOTE: Volumes greater than 1000 L shall be shown in m³.

TEMPERATURE (exact)

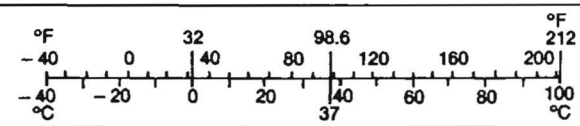
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
AREA				
mm²	millimetres squared	0.0016	square inches	in²
m²	metres squared	10.764	square feet	ft²
km²	kilometres squared	0.39	square miles	mi²
ha	hectores (10 000 m²)	2.53	acres	ac
MASS (weight)				
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
VOLUME				
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m³	metres cubed	35.315	cubic feet	ft³
m³	metres cubed	1.308	cubic yards	yd³

TEMPERATURE (exact)

°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

ABSTRACT

Small sign systems include everything from stop signs and delineator posts to signs up to about 25 square feet. In some cases, multiple small sign support systems are used to support much larger signs (40 - 50 square feet). This broad class of sign has been and is currently being used along Texas highways.

To insure the safety of vehicle occupants, there have been a series of specifications, guidelines and recommendations which define acceptable vehicle impact performance criteria. Most small sign systems have been tested with vehicles larger than the current standard 1800 pound car. As a result, the first phase of this study was to undertake a series of recertification tests for those systems currently being used in Texas. An analytical model also was developed to aid in the evaluation of data from previous crash tests. Although certification was achieved through crash testing, this analytical model proved to be an accurate predictor of impact performance with the smaller 1800 pound vehicle. Crash tests were performed on several small sign support systems, including U-post, triangular slip base, and 2-1/2 inch standard pipe with threaded coupler supports. Each of these systems demonstrated satisfactory impact performance in "strong" soil (see test descriptions for specific test configurations). These systems currently are used extensively and maintained in Texas. Other systems were not tested because of prior acceptance by FHWA or obsolescence.

The second phase of this study consisted of the development and testing of a generic small sign support system. The resulting generic ground anchor system can be used with any tubular sign post. For single post installations, this system has proven satisfactory in both "strong" and "weak" soils (as defined by NCHRP Report 230) both from the standpoint of driveability and impact performance. Further development and testing could extend the application of the generic anchor system to dual-post installations.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Texas State Department of Highways and Public Transportation. This report does not constitute a standard, specification, or regulation.

KEY WORDS

Sign Supports, Crash Testing, Ground Anchors, Impact Performance, Breakaway, Break-Away, Frangible

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IMPLEMENTATION STATEMENT

Results of this study are available for immediate implementation by the Texas State Department of Highways and Public Transportation. As a result, the generic system can be used in any single post application. With additional development and testing, the generic system could be extended to include dual post installations. Other states may want to realize benefits from this study.

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INTRODUCTION

Small sign systems include everything from stop signs and delineator posts to signs up to about 25 square feet. In some cases, multiple small sign support systems are used to support much larger signs (40 - 50 square feet). This broad class of signs has been and is currently being used all along Texas highways.

To insure the safety of vehicle occupants, a series of specifications, guidelines and recommendations have been written that define acceptable vehicle performance criteria (References 1 & 2). In 1981 the NCHRP Report 230 (Reference 3) became the standard for measuring crash worthiness. The NCHRP Report with modifications from AASHTO 1985 (Reference 4) is the current standard with which the state of Texas must comply.

Previously, small sign systems in Texas had been tested and approved under the TRB specification (Reference 2) using a 2250 lb. vehicle. However, more recent specifications including NCHRP Report 230 (Reference 3) and AASHTO 1985 (Reference 4) require the use of an 1800 lb. vehicle tested at 20 and 60 mph. These specifications require the Texas State Department of Highways and Public Transportation (SDHPT) to recertify its sign systems.

This project was funded to complete the necessary recertification process. This process was conducted with existing crash test data through analytical means where possible and supplemented with new crash tests when required. In addition, it was anticipated that the Texas Transportation Institute (TTI) would develop and test generic sign systems for the state. Furthermore, the generic system produced as a part of this study should be applicable for both strong and weak soil installations.

EXISTING SIGN SYSTEMS - PHASE ONE

ANALYSIS

The primary focus of the specifications has been the changes in velocity during impact and the integrity of the occupant compartment. The current standard addresses these areas as follows. First, the change in velocity of an unrestrained occupant should not exceed 15 feet per second (extended to 16 feet per second by Reference 13) during the impact. Second, there can be no penetration of the occupant compartment. The report includes other test specifications, but for a given sign system, it is generally these two criteria that determine the acceptability of a sign installation for crash performance.

The most significant difference between the 1800 lb. and 2250 lb. cars has been the change in velocities. Vehicle stability and occupant compartment integrity are also major consideration, but these are usually linked to the change in velocity. Unfortunately, there has been no acceptable method for comparing or predicting the crash performance of the 1800 lb. car versus the 2250 lb. car. To complicate the problem, many of the previous tests included cars of weights other than 2250 lb., various impact speeds, different crush characteristics, and test matrices with multiple posts as well as single post sign systems.

The first effort in the project was to devise a rational that could predict impact performance for sign installations that had been tested previously with a different size and class of vehicles.

DATA COLLECTION

The analysis task began with the compilation of recent crash test data for sign systems similar to the small sign supports currently used by the Texas State Department of Highways and Public Transportation. It soon became obvious the data that could be classified as recent was very limited in quantity. Therefore, the data search was expanded to include all previous crash tests for which the vehicle weight, impact speed and change in velocity were accurately known; and the sign installation was well defined. The data collected is listed in Table 1 (References 5 - 12) by sign classification.

Each crash test supplied three data points:

(a) The vehicle mass ----- M_1

(b) The impact velocity --- V_1

(c) The change in velocity - ΔV_1

TABLE 1 - Crash Data

Test Number	Vehicle Weight (lb)	Impact Velocity (mph)	Change Velocity (ft/s)	Change[1] Momentum (lb-sec)	Change Kin. Energy (ft-lb)
3 lb/ft U-Post Ground Splice (Rail Steel Post)					
3491-1	2250	22.7	2.7	190	6070
3491-2	2250	59.6	2.5	179	15420
3491-3	2250	17.2	5.2	368	8323
3491-4	2250	16.6	5.1	358	7807
3 lb/ft U-Post High Splice (100 ksi) -Single Post					
7024-7	1800	60.5	3.1	169	14740
7024-8	1800	19.9	6.0	339	8866
Three Posts					
7024-9	1800	59.3	10.6	197	16067
7024-10	1800	19.4	23.9	445	7348
3 lb/ft U-Post High Splice (80 ksi) Three Posts					
7024-16	1800	20.0	27.9	511	7983
7024-17	1800	62.0	18.9	353	28732
7024-18	1800	19.5	24.9	465	7496
7024-21	1800	61.5	22.9	412	32585
Two Posts					
7024-22	1800	20.0	9.4	267	6557
7024-23	1800	62.8	11.7	334	28768
3 lb/ft U-Post Ground Splice (Three High Carbon Billet Post)					
7024-26	1800	21.7	12.6	235	5998
7024-27	1800	61.6	9.1	169	14530
4 lb/ft U-Post High Splice (High Carbon Billet Post) -Two Posts					
7024-11	1800	20.2	12.5	327	7766
7024-12	1800	60.9	10.3	295	24753
-Single Post					
7024-13	1800	61.3	6.3	352	30539

[1]NOTE: All values for Change in Momentum or Kinetic Energy are given for a single post and obtained by linear interpolation.

TABLE 1 - Crash Data (Cont.)

Test Number	Vehicle Weight (lb)	Impact Velocity (mph)	Change Velocity (ft/s)	Change Momentum (lb-sec)	Change Kin. Energy (ft-lb)
4 lb/ft U-Post Ground Splice (Three Rail Steel Post)					
7024-24	1800	20.6	28.0	522	8460
7024-25	1800	62.6	13.2	246	20962
8 lb/ft U-Post					
1817-4	3500	37	16.6	1810	30664
1817-25	3600	31.5	16.9	1890	71343
1817-29	3550	24	15.4	1700	46733
1817-31	3900	36	14.9	1810	82043
2466-1	4100	29.3	9.3	1180	45241
2466-2	4100	43.7	12.6	1610	93011
2466-3	4400	43.9	12.4	1700	98883
2466-4	4400	30.4	15.0	2050	76025
2466-5	3880	45.8	14.8	1780	106421
2466-6	3750	49.5	13.5	1570	103399
2466-7	3850	31.7	16.7	2000	76259
2466-8	3850	45.6	18.1	2170	125438
2466-9	3800	47.8	15.0	1770	110815
2-1/2 inch Pipe w/Frangible Connector					
3254-14	2250	20.3	11.4	802	19316
3254-15	2250	63.3	5.4	379	34167
3254-16	2250	19.2	9.1	638	15079
0941-3	2270	29.2	7.3	514	20139
2 x 2 inch Square Perforated Steel Tube -Single Post					
7024-3	1800	20.0	3.5	193	5328
7024-4	1800	56.8	8.5	468	37028
-Two Posts					
7024-5	1800	19.7	20.7	575	10699
7024-19	1800	18.9	14.7	413	8391
7024-20	1800	57.5	17.9	503	37860
-Three Posts					
7024-6	1800	59.3	26.3	486	35951
3 inch Pipe on Triangular Slip Base					
0941-1	2270	60.8	5.5	386	33364
0941-4	2270	45.4	3.0	209	13637
S-8	3970	46.0	1.1	136	9100
S-18	4170	31.3	1.3	168	7603

The direct comparison of the changes in velocity for a particular sign installation type showed no apparent trend. The only general tendency was a decrease in the change in velocity for a corresponding increase in impact velocity. This data confirmed the observation that the actual failure mechanism varied for different impact speeds. At this point two different methods, Conservation of Energy and Impulse and Momentum, were incorporated to further reduce the data in hope of finding a relationship that overrides the physical differences.

DATA REDUCTION

In review, the mass (weight) of the vehicle, impact speed, and change in velocity (ΔV) during impact are all known for specific tests. However, the challenge is to predict the change in velocity for a vehicle of any mass, M_1^*, impacting at any velocity, V_1^*, in a future impact.

The first approach is to use the principle of Impulse and Momentum. Simply stated, the principle on Impulse and Momentum can be expressed as:

$$(M_1)V_1 + (M_2)V_2 - \int F\,dt = (M_1)V_1' + (M_2)V_2'$$

Where M_1= mass of automobile, $V_\#$= initial velocity (V_i), M_2= mass of sign system, $V_\#'$ = final velocity (V_f) and $\int F\,dt$ = Impulse or impact force. Assuming M_2 is negligible compared to M_1 gives:

$$(M_1)(V_i) - \int F\,dt = (M_1)(V_f) \qquad \text{(Eq. 1)}$$

or, $\int F\,dt = (M_{CAR})*(\Delta V)$ = change in Momentum. This is the formulation used to calculate change in Momentum from the ΔV supplied from the crash test.

Then, for a known change in Momentum with a new car mass and/or a new impact velocity, the equation can be written:

$$(M_1^*)(V_i^*) - \int F\,dt = (M_1^*)(V_f)$$

or

$$V_f = (1/M_1^*)[(M_1^*)V_i^* - \int F\,dt]. \qquad \text{(Eq.2)}$$

This is the formulation that is used to predict final velocity and change in velocity for a sign system with a known change in Momentum.

The next approach was to enforce Conservation of Energy. The total energy is expressed as the sum of the Kinetic Energy (T) and the Potential Energy (V). Energy is conserved when the change in the total energy of a system, represented by the prefix Δ, is equal to zero. This can be shown as: $\Delta T + \Delta V_g + \Delta V_e = 0$. Note the change in Potential Energy is subdivided into gravitational and elastic potential designated by the subscripts g and e, respectively.

Again, assuming the mass of the sign system is negligible compared to the

automobile's mass greatly simplifies the energy expression. The only term contributing an appreciable amount is the change in Kinetic Energy of the car. This term is written:

$$\Delta T = 1/2\ (M_{CAR})\ [V_f^2 - V_i^2] = \Delta KE \qquad \text{(Eq. 3)}$$

This equation is used to calculate the change in Kinetic Energy (ΔKE) from the crash test data.

Then, for a known change in Kinetic Energy with a new car mass and/or a new impact velocity, the equation can be written:

$$V_f = [V_i^2 - 2(\Delta KE)/M_{CAR}]^{1/2}. \qquad \text{(Eq. 4)}$$

Therefore, if the change in Kinetic Energy is known for a particular sign system, a prediction of the car's final velocity and its change in velocity can be made.

As noted in the footnote, many of the tests involved multiple post installations. Once the change in Momentum or Kinetic Energy was calculated as described above, the values were divided by the corresponding number of posts to obtain an extrapolated value for a single post installation.

Momentum -vs- Kinetic Energy

Basic engineering mechanics provides two equations that can be used to predict the vehicle's final velocity. The question remains as to what values for change in either Momentum or Kinetic Energy should be used and if either equation is appropriate.

Noting the previous trend that the ΔV seemed to vary with impact velocity, both the changes in Momentum and Kinetic Energy were plotted versus velocity. To find a general trend for all breakaway systems, all the data points were lumped together as shown in Figures 1 and 2. The plot using Momentum showed too much scatter to detect any general trend. On the other hand, the plot using Kinetic Energy did show a generally increasing trend. To qualify this trend, a least squares fit for a linear line was done and the corresponding equation and line is listed on the graph.

The comparison between the two approaches was then narrowed down to a single class of small sign support system, the 3 lb/ft U-Post that used breakaway mechanisms. Again, a least squares fit was done, Figure 3, and the results compared with Momentum in Figure 4. The data from a particular system fit a linear line very well. After these two comparisons, it was decided that the best approach would be the use of Kinetic Energy for prediction of change in velocities. Although this model neglects many variables (vehicle crush,

etc.), when limited to systems with similar strength and breakaway characteristics it shows good correlation with experimental data.

The 3 lb/ft nonbreakaway U-Posts, Figure 5, and the sets of 4 lb/ft U-Posts, Figures 6 & 7 also exhibit similar linear behavior (Note: the diamond data points were not used in obtaining the "best fit" line shown on Figures 6, 7, 9, 11 and 12) . It was noted that the line for the nonbreakaway posts was generally steeper than the breakaway systems. This greater slope corresponded to the greater stiffness of the nonbreakaway systems.

In doing the data search, many data points were found for 8 lb/ft U- Post systems. Even though this system is no longer used, it was plotted in Figure 8 because of the number of data points and the large variety of impact speeds. This figure clearly illustrates the linear relationship between Impact Velocity and change in Kinetic Energy. Two additional graphs are included with linear relationships. The 2-1/2 inch pipe with frangible connectors, Figure 9, and the 2x2 square perforated steel tube, Figure 10, exhibit good correlation to a linear relationship.

One other system, 3 inch pipe on triangular slip base, is shown in Figure 11. While this is certainly a breakaway system, it differs from all the others considered in its failure mechanism. This system uses friction to facilitate the break-away capability. Such a difference could mean that the relationship for velocity and Kinetic Energy is not linear but perhaps cubic,as shown in Figure 12. Considering the limited number of data points available, it would be inappropriate to use any "recommended" best fit curve for this system.

Predicting Change in Velocity

Although many things, vehicle crush, post impact stability, size of sign, mounting height, variability in material properties, etc., influence the behavior of breakaway sign support systems, a significant feature is the change in kinetic energy of the vehicle. While it is a great simplification to ignore all other effects, the kinetic energy analyses show good agreement with experimental data.

The least squares fit of the data (square data points only) as shown on each of the graphs now provides a value for the change in Kinetic Energy for any impact velocity. One would expect the curves to tend toward zero, as is the case in all curves presented. However, these curves are valid only for systems (and impact speeds) for which a breakaway will occur. Obviously, as the impact speed decreases, at some point there will not be enough energy for

a breakaway to occur. This information taken from previous crash tests can then be used to estimate the final velocity of a car of any mass and any impact velocity using Equation 4. The difference in the final velocity and initial velocity is the change in velocity of the vehicle during impact provided that a breakaway of the sign support does indeed occur.

This approach can be extended from single post to multiple posts by assuming linear interpolation. That is, the ΔKE taken from the graph is simply multiplied by the number of posts. The product is then plugged into Equation 4 as the ΔKE.

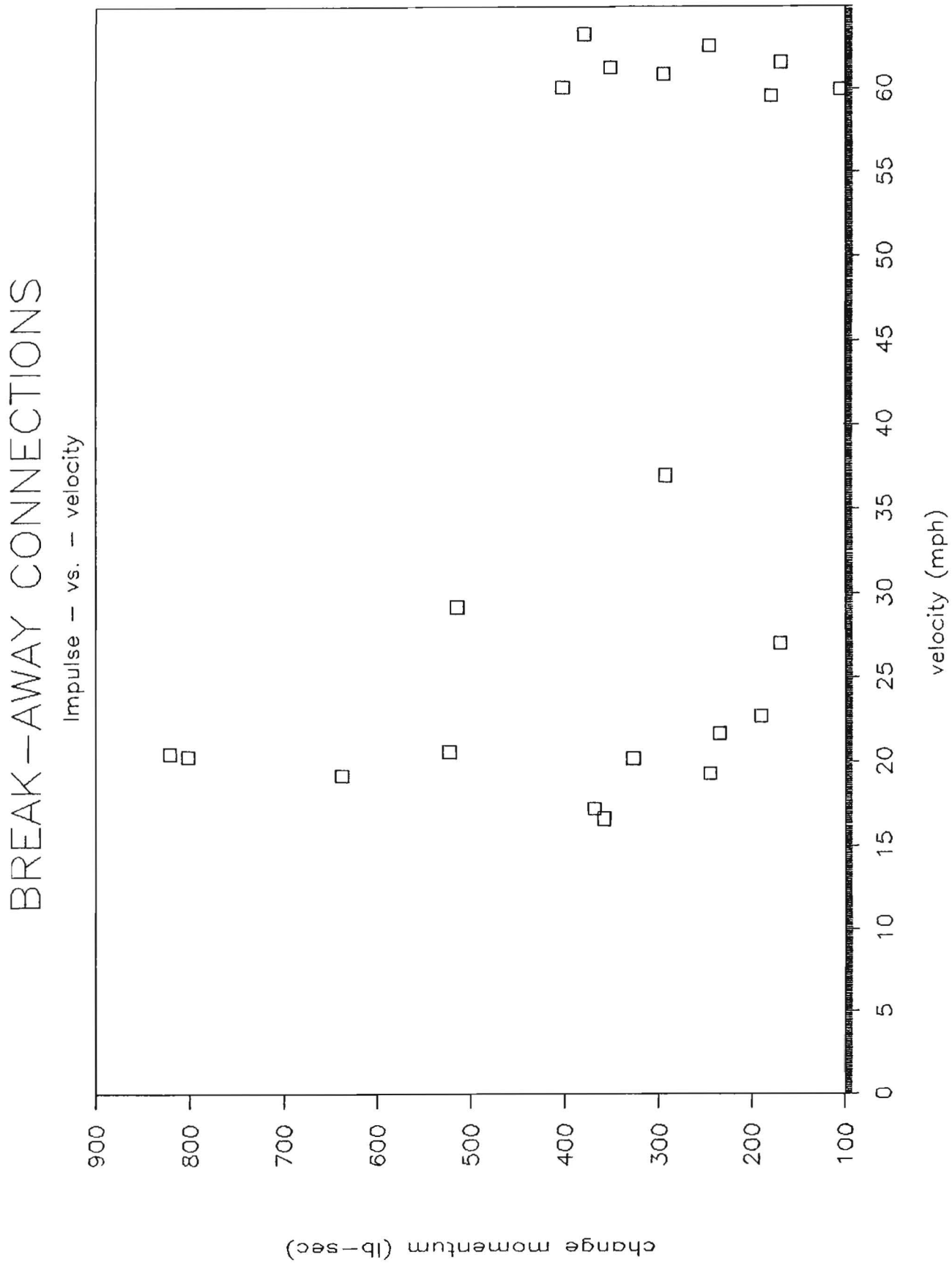


Figure 1. Breakaway connections -- Momentum.

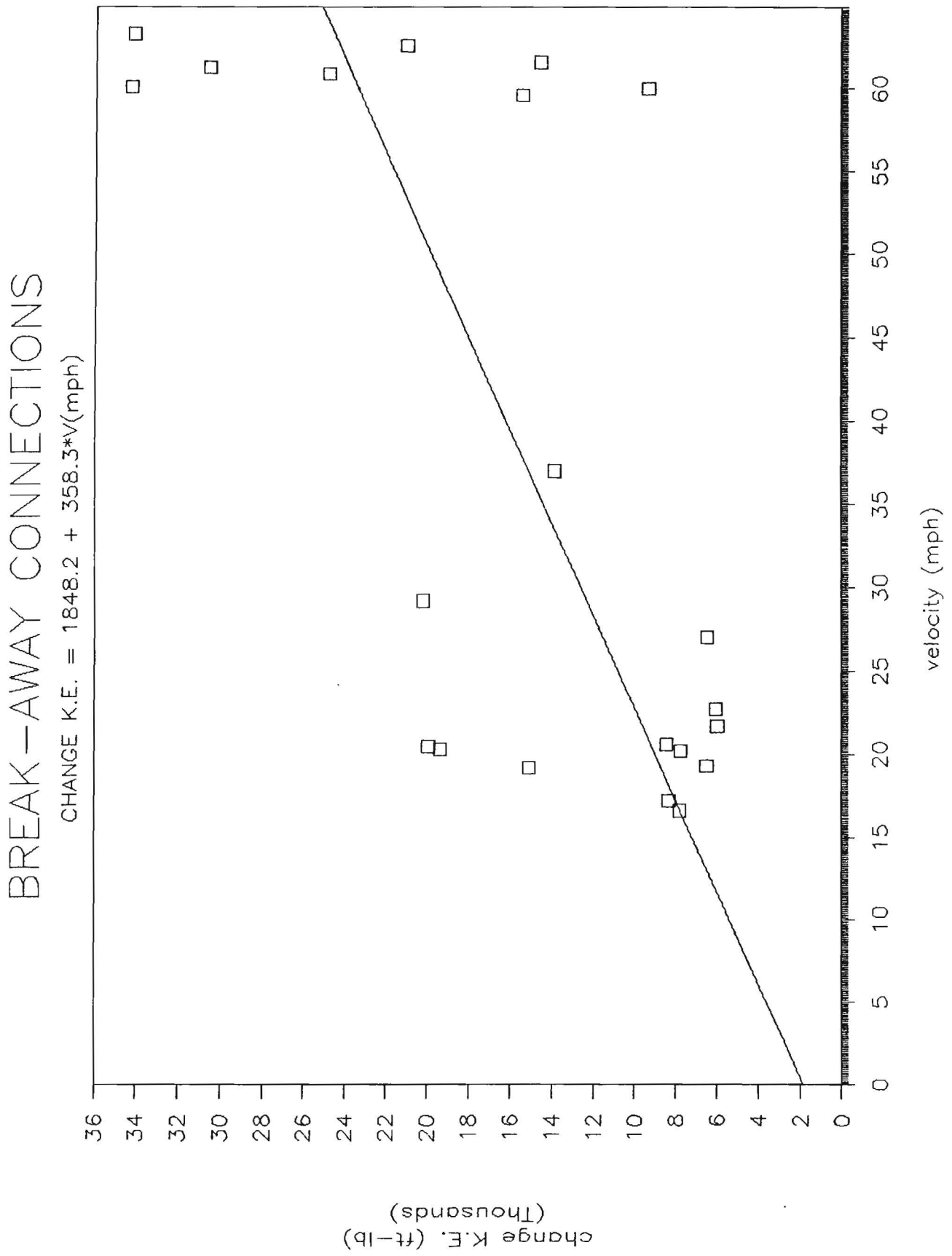


Figure 2. Breakaway connections - Kinetic Energy.

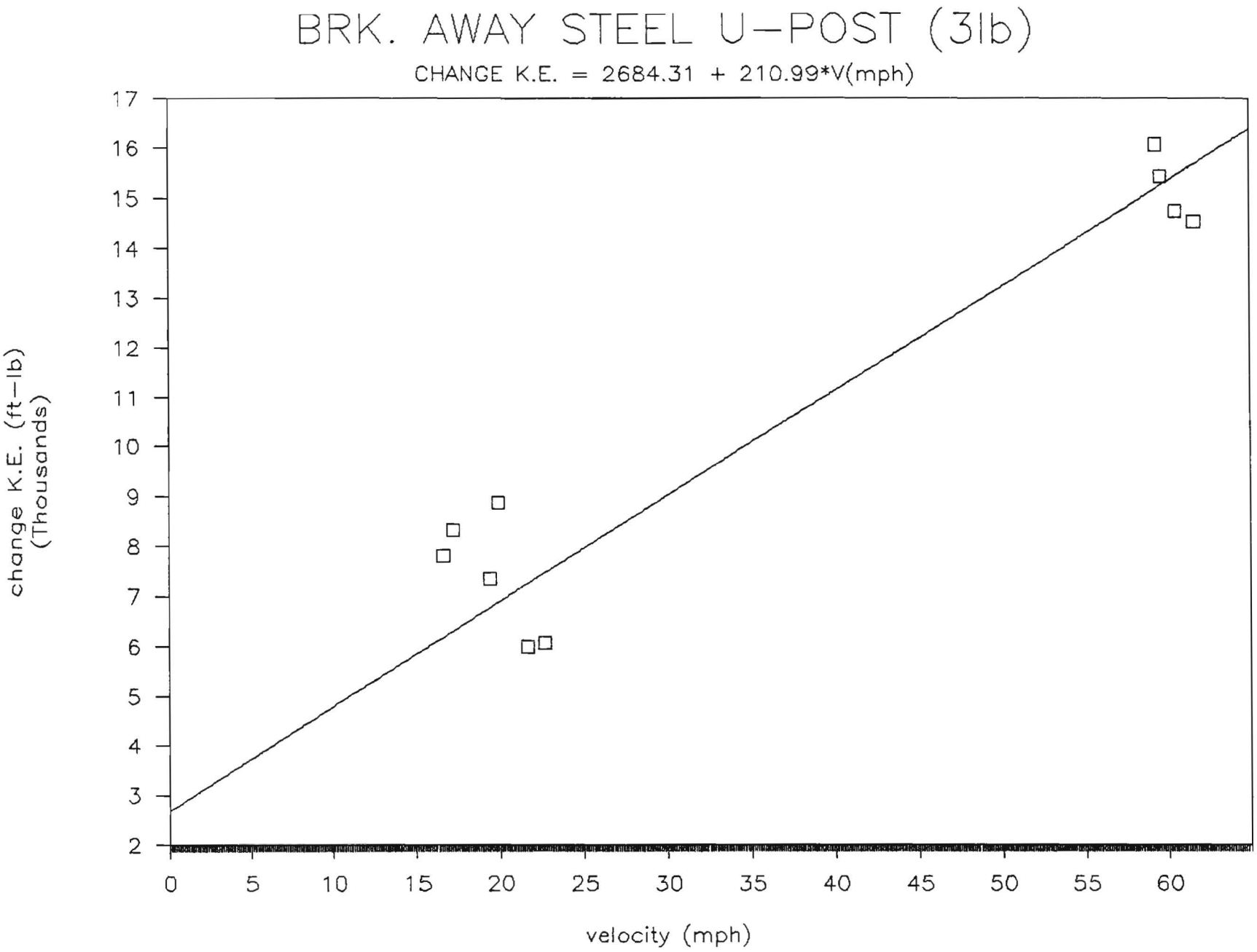


Figure 3. 3 lb/ft U-Post - Kinetic Energy.

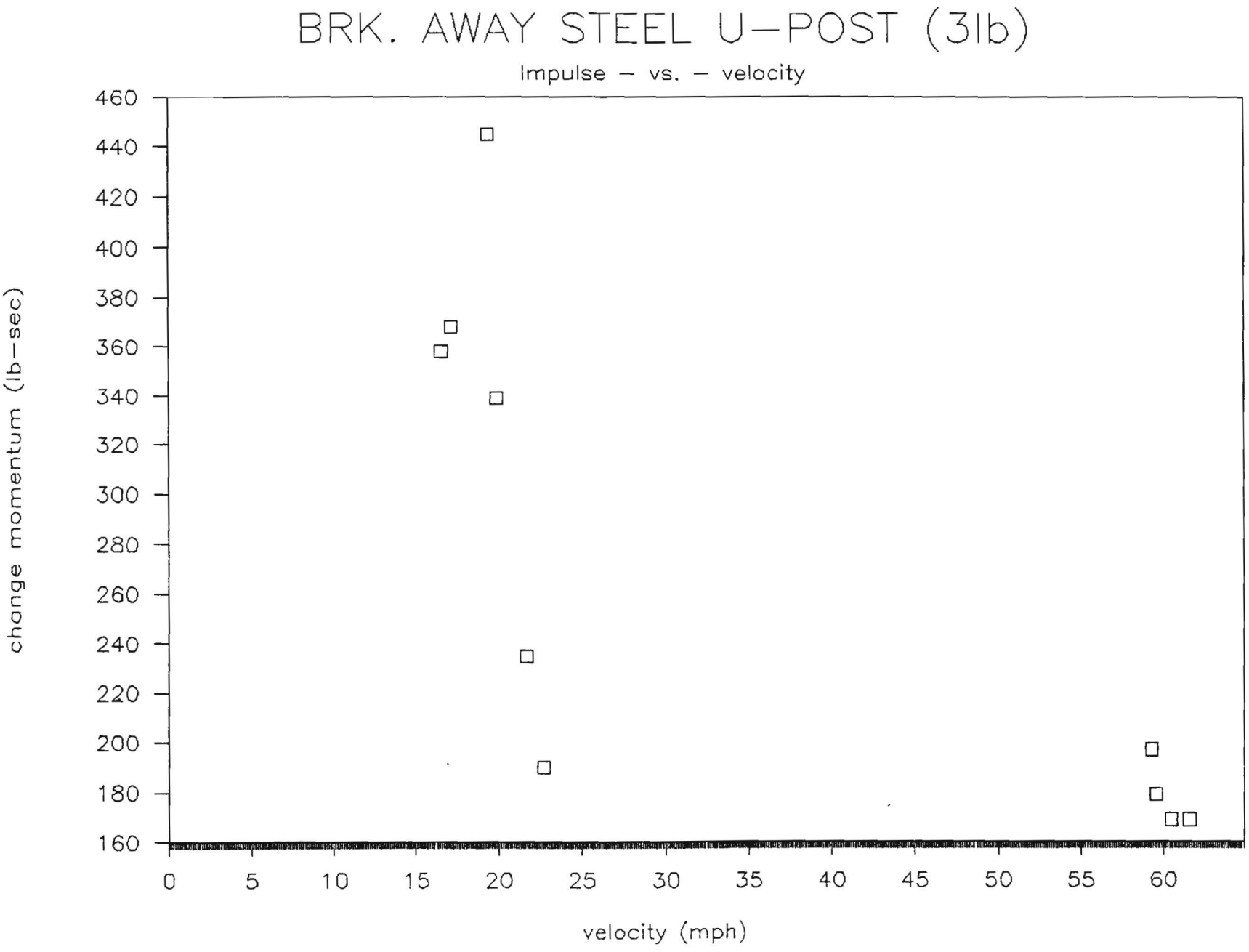


Figure 4. 3 lb/ft U-Post - Momentum.

Figure 5. 3 lb/ft U-Post - Nonbreakaway.

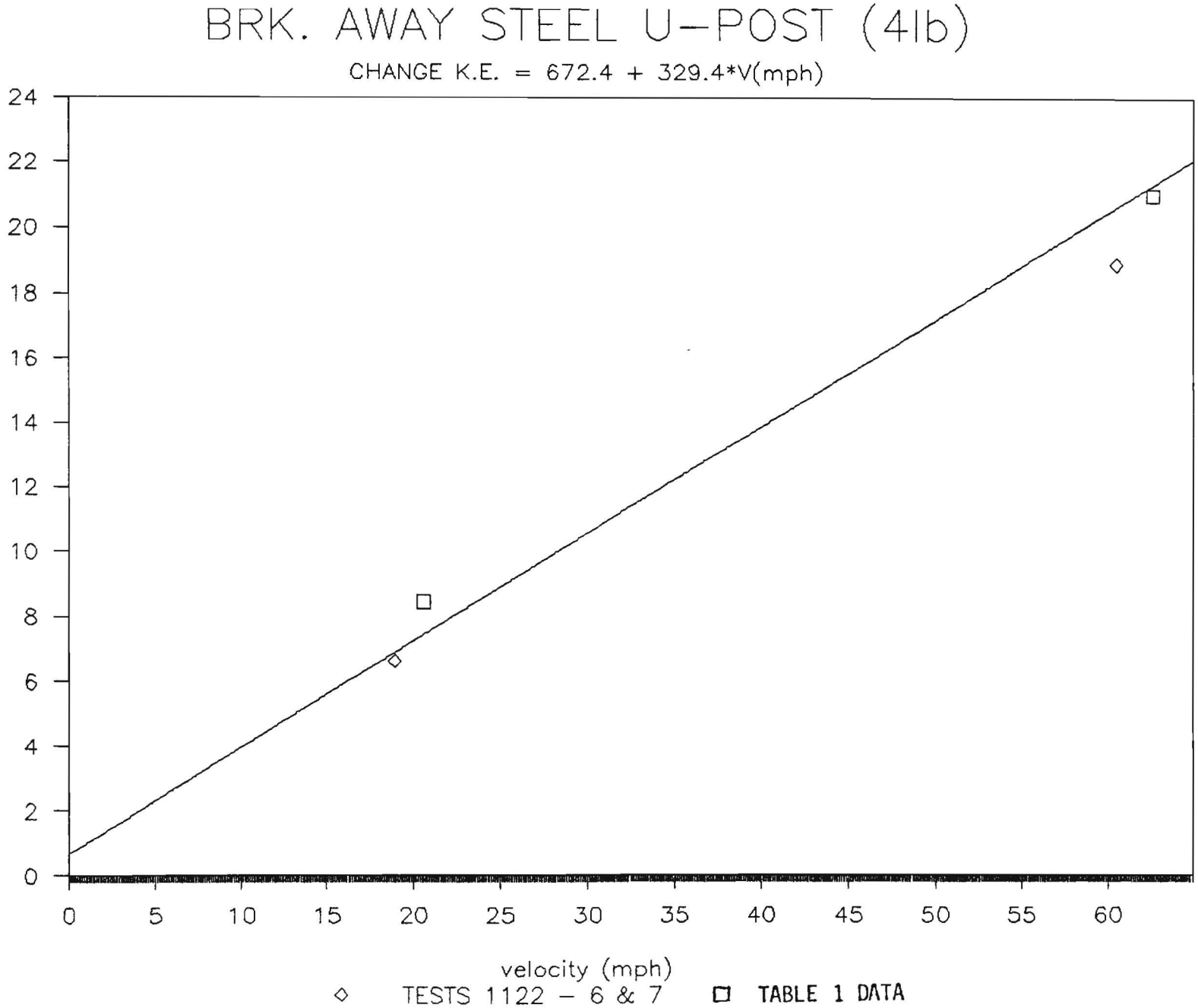


Figure 6. 4 lb/ft U-Post - Breakaway.

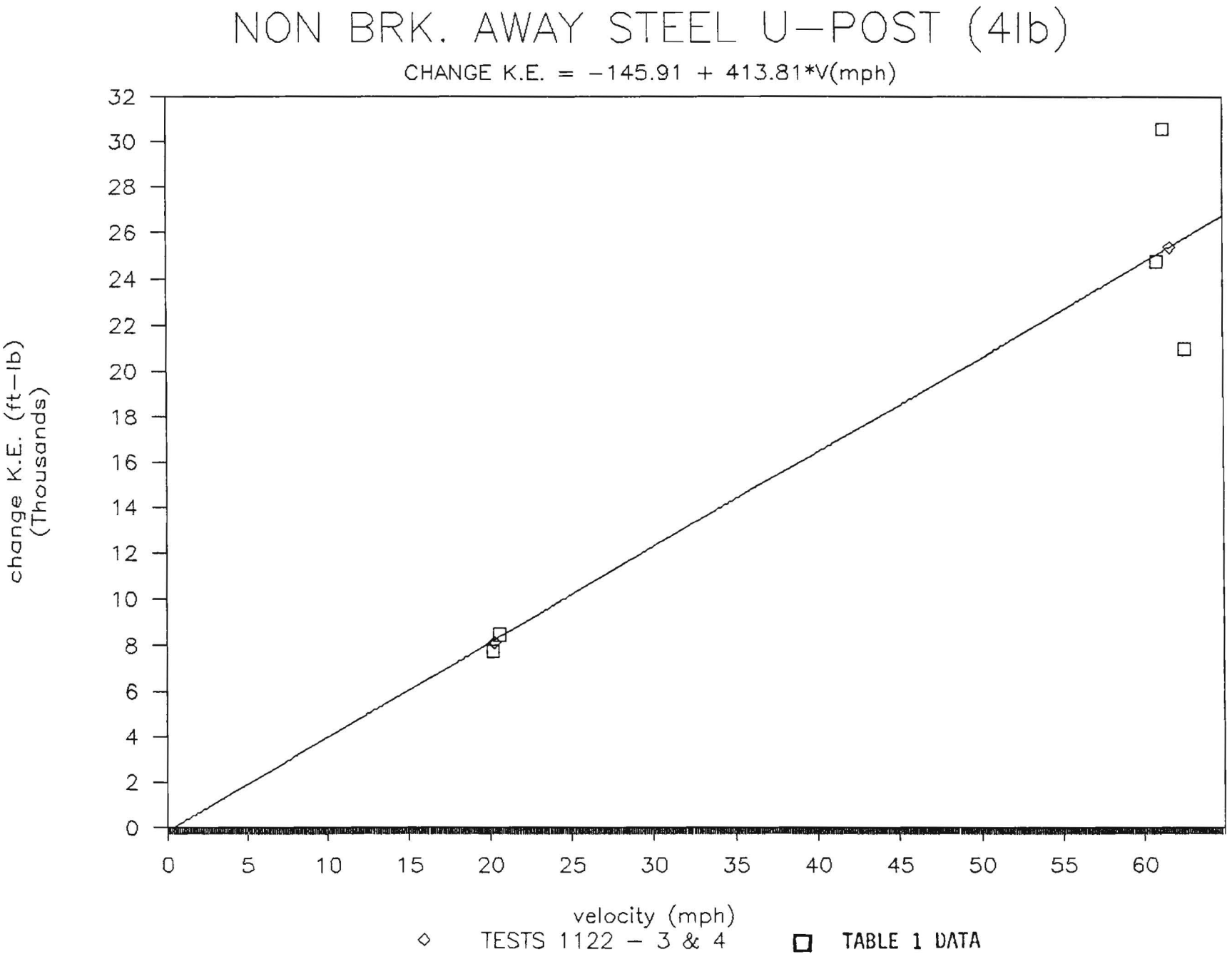


Figure 7. 4 lb/ft U-Post - Nonbreakaway.

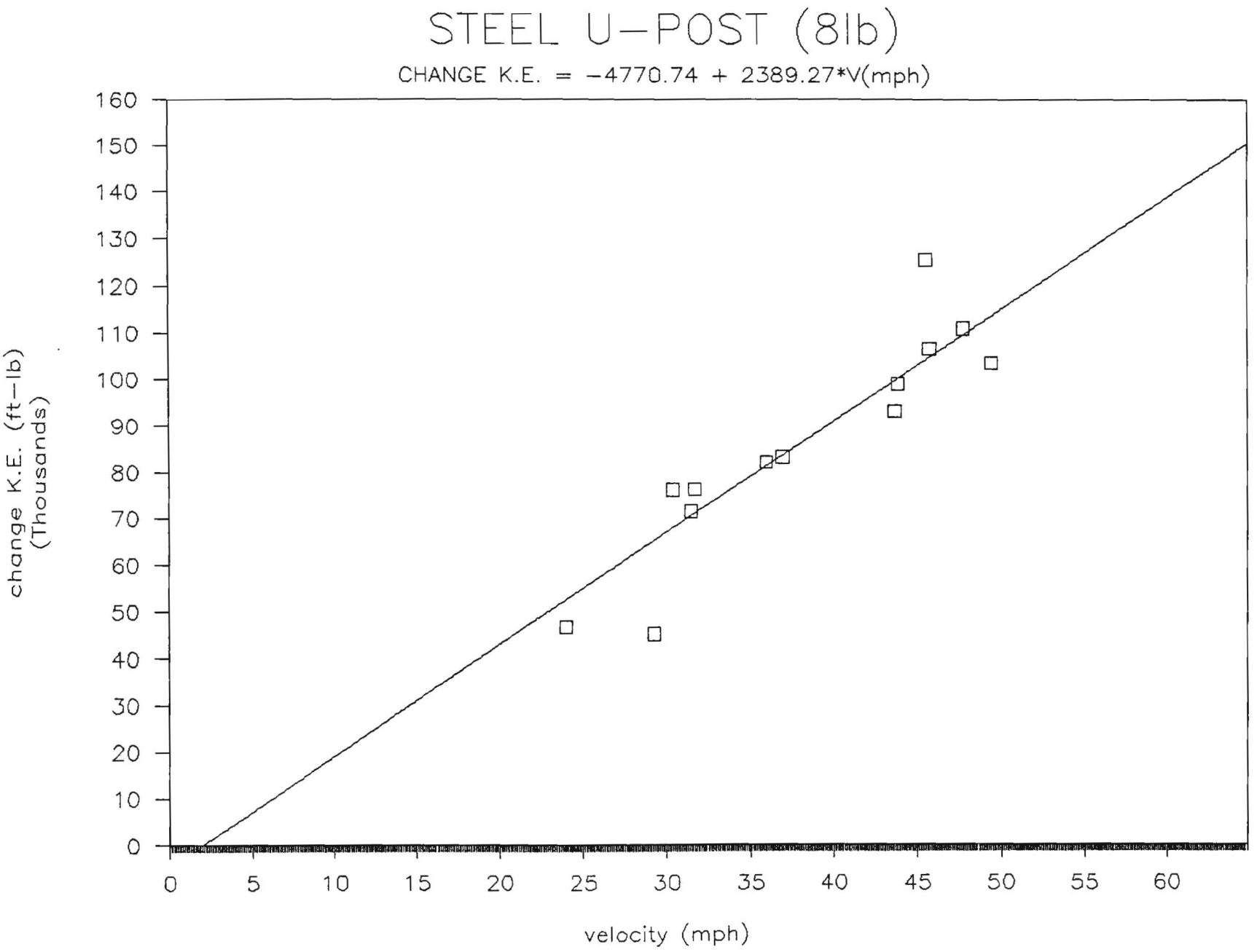


Figure 8. 8 lb/ft U-Post.

Figure 9. 2-1/2 inch standard steel pipe.

Figure 10. 2 inch unistrut post.

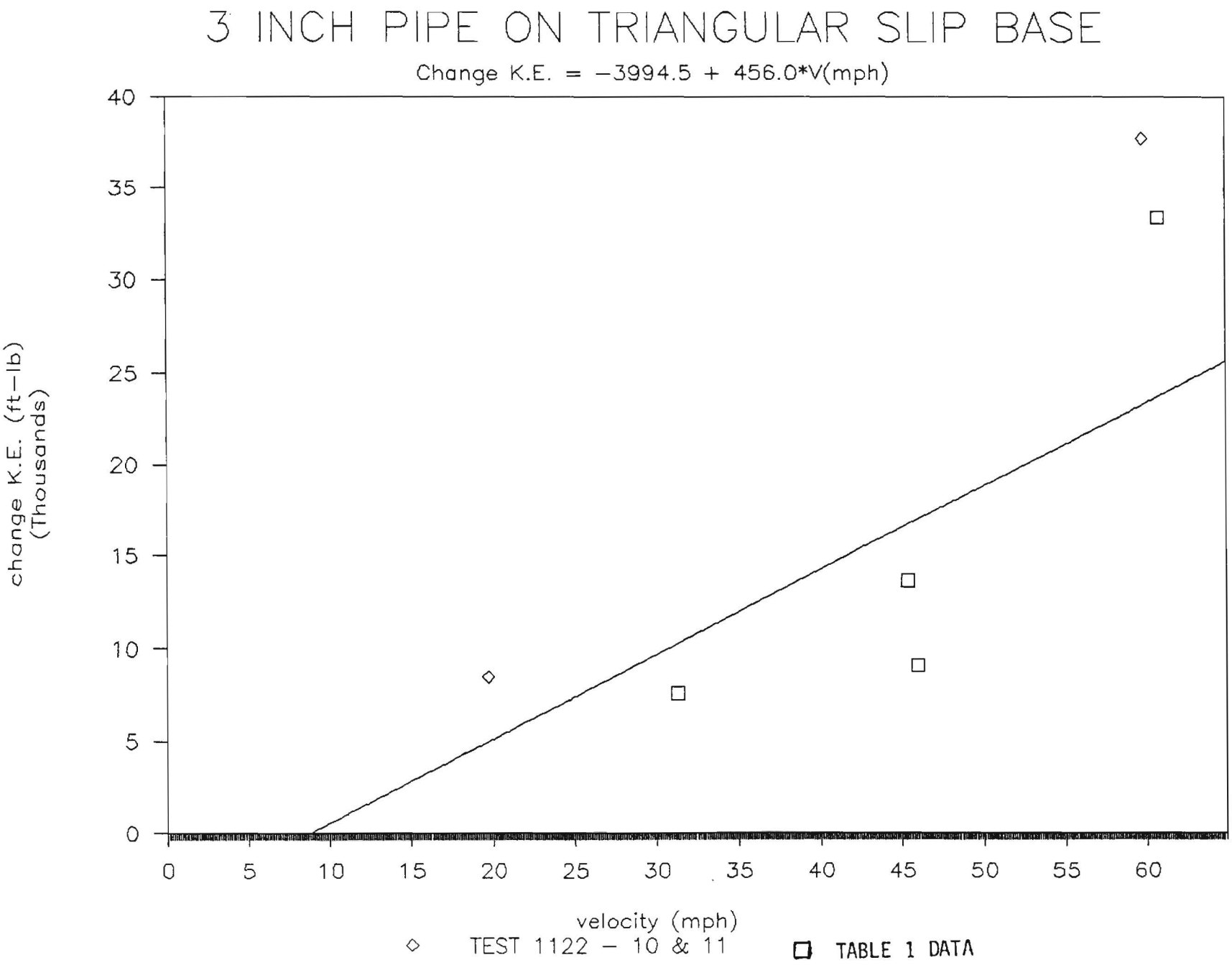


Figure 11. 3 inch pipe on triangular slip base - linear.

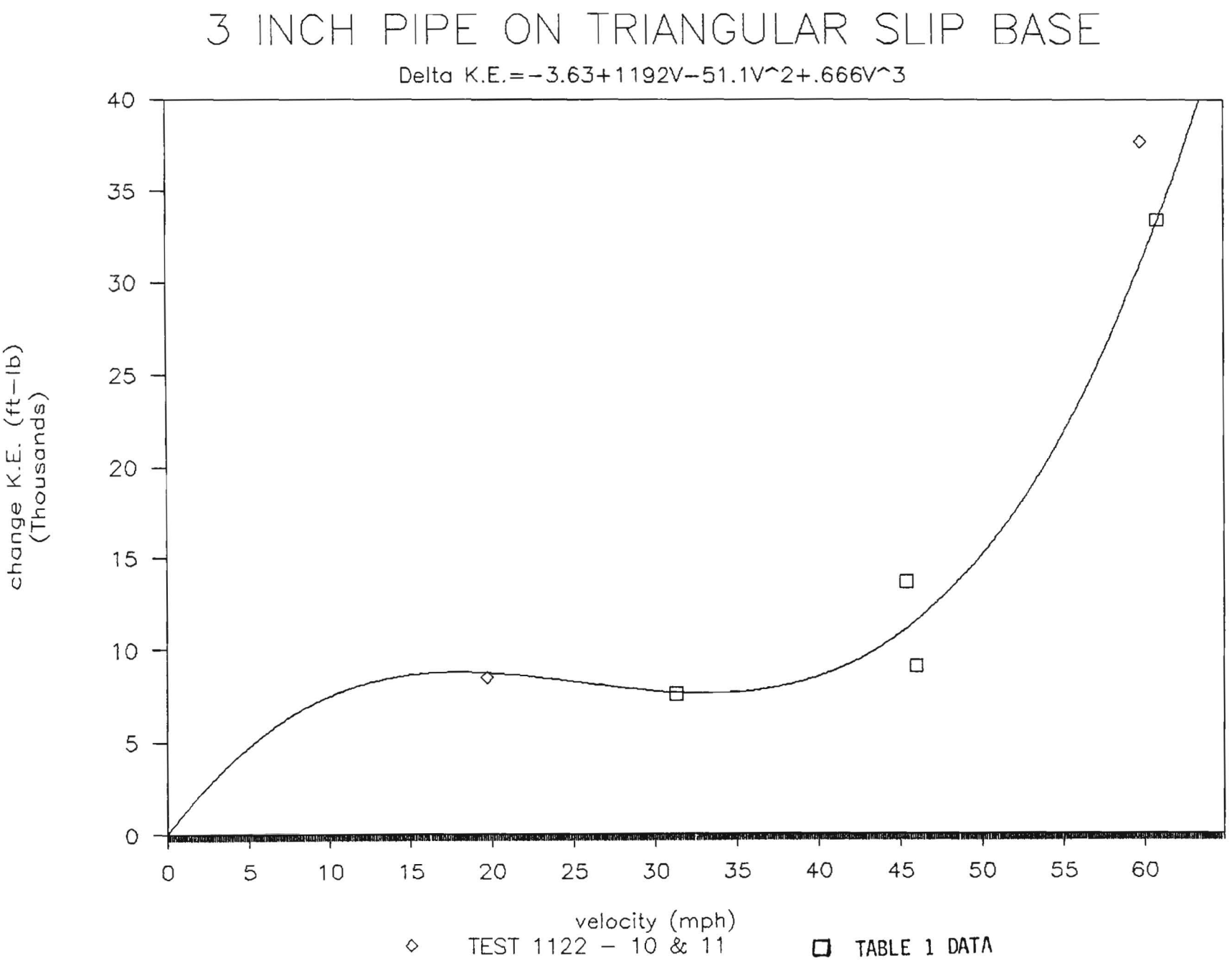


Figure 12. 3 inch pipe on triangular slip base - cubic.

RECOMMENDATIONS FROM ANALYSIS

This analysis was then used to make a recommendation to the state on which of its existing sign systems should be retested. Since there were no crash tests to verify the new prediction model, it was felt a worst case scenario would be appropriate.

The largest vertical error was calculated between the existing crash data and the best fit line for each sign system. This value was used as an offset for a line parallel to each calculated best fit line. Since the offset represented the largest error, the parallel line was used as an upper bound estimate for the change in Kinetic Energy.

The expected changes in velocities, including upper bounds, were then calculated and presented in a technical memorandum to Texas SDHPT and FHWA. The results appeared as follows:

1. **U - channel supports with bolted lap splice at ground level**
   - **FOR A SINGLE 3 LB/FT BILLET OR RAIL STEEL POST** (Figure 3)
     Test Vehicle: 1800 lb
     Impact Speed: 20 and 60 mph
     Expected ΔV: 3.7 and 3.2 fps respectively
     Upper Bound ΔV: 6.1 and 3.9 fps respectively

2. **Pipe supports with threaded coupler at ground level**
   - **FOR A SINGLE 2-1/2 INCH OR SMALLER STANDARD STEEL PIPE** (Figure 9)
     Test Vehicle: 1800 lb
     Impact Speed: 20 and 60 mph
     Expected ΔV: 9.4 and 7.6 fps respectively
     Upper Bound ΔV: 16.1 and 9.0 fps respectively

3. **Posts on multi-directional (triangular) slip bases**
   - **FOR A SINGLE 3-1/2 INCH OR SMALLER STANDARD STEEL PIPE** (Figure 11)
     Test Vehicle: 1800 lb
     Impact Speed: 20 and 60 mph
     Expected ΔV: 4.6 and 4.7 fps respectively
     Upper Bound ΔV: 13.8 and 7.0 fps respectively

Results for rectangular slip bases also were presented, but they were later found to be outside the scope of this project.

Using the results listed, it was recommended that:

1. Up to three 80 ksi, 3 lb/ft U-channel supports with bolted lap splice at ground level would pass (using linear extrapolation).

2. A single standard steel pipe, 2-1/2 inch or smaller schedule 40, with a threaded coupler at ground level would pass.

3. A steel post 3-1/2 inch or larger mounted on a multi-directional slip base should pass, but the breakaway behavior was not clear.

It was noted that the 20 mph test for the 2-1/2 inch pipe with a threaded coupler had an upper bound value at the limit; therefore, a crash test may be justified. In addition to these recommendations, a new list from FHWA of Sign Support Systems in Compliance with 1985 AASHTO Specifications was included. This list included some of the sign systems in question for the State of Texas.

After reviewing the technical memorandum and corresponding with FHWA, the State decided that while the data looked convincing, it would be best if the sign systems were validated with actual crash tests. These crash tests were conducted at the TTI Crash Test Facility located at the Riverside Campus of Texas A&M University.

CRASH TESTS

The objective of these tests was to determine the impact characteristics of a variety of current small sign installations when impacted by an 1,800 lb vehicle at 20.0 and 60.0 mi/h. Standards established in AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals" and NCHRP Report 230 were used for analyses and evaluation of this test.

STUDY APPROACH

Description of Crash Test Procedures

The crash test procedures were in accordance with guidelines presented in NCHRP Report 230. The test vehicle was instrumented with three rate transducers to measure roll, pitch, and yaw rates and a triaxial accelerometer near the vehicle center of gravity to measure acceleration levels.

The electronic signals from the accelerometers and transducers were telemetered to a base station for recording on magnetic tape and for display on a real-time strip chart. Provision was made for transmission of calibration signals before and after the test, and accurate time reference signal was simultaneously recorded with the data. Contact switches on the bumper were actuated just prior to impact by wooden dowels to indicate the elapsed time over a known distance to provide a measurement of impact velocity. The initial contact also produced an "event" mark on the data record to establish the exact instant of impact.

In accordance with NCHRP 230, an unrestrained, uninstrumented special purpose 50th percentile anthropomorphic test dummy was positioned in the front seat of the test vehicle. This dummy was used to evaluate typical unsymmetrical vehicle mass distribution and its effect on vehicle stability during impact.

Photographic coverage of the tests included two high-speed cameras, one perpendicular to the sign installation and another located downstream 45 degrees from the point of impact. The films from these high-speed cameras were used to observe phenomena occurring during collision and to obtain time-event, displacement and angular data. A 16-mm movie camera, a 3/4-inch videotape, and still cameras were also be used for documentary purposes.

Data Analysis Procedures

The analog data from the accelerometers and transducers were digitized, using a microcomputer, for analysis and evaluation of performance. The digitized data were then analyzed using a number of computer programs: DIGITIZE, VEHICLE,

and PLOTANGLE. Brief descriptions on each of these computer programs are provided as follows.

The DIGITIZE program uses digitized data from vehicle-mounted linear accelerometers to compute occupant/compartment impact velocities, time of occupant/compartment impact after vehicle impact, final occupant displacement, highest 0.010-second average. The DIGITIZE program also calculates a vehicle impact velocity and the change in vehicle velocity at the end of a given impulse period.

The VEHICLE program also uses digitized data from vehicle-mounted linear accelerometers to compute vehicle accelerations, areas enclosed by acceleration-time curves, changes in velocity, changes in momentum, instantaneous forces, average forces, and maximum average accelerations over 0.050-second intervals in each of three directions. The VEHICLE program plots acceleration versus time curves for the longitudinal, lateral, and vertical directions.

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

DESCRIPTION OF TEST INSTALLATION FOR 1122-3 & 4

The sign installation used in these tests consisted of a 6 ft-0 in wide x 5 ft-0 in high plywood sign panel mounted on three Franklin 4.0 lb-ft steel supports. These supports were attached to three 60 inch stubs which had been driven into crushed limestone (NCHRP Report 230 "strong" soil) at 21 inches on center spacing. The supports were attached to the stubs in a nested splice (stubs in front of sign supports) with 1/2 inch spacers and 5/16 inch grade 9 bolts, nuts and washers. The bottom of sign mounting height was 5 ft. Details of the sign installation are shown in Figures 13 and 14.

TEST REPORT 1122-3

VEHICLE: 1980 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,963 lbs.

TEST ARTICLE: Multi-Leg Sign Installation
Support: Three Franklin
4.0 lb-ft supports

IMPACT CONDITIONS: 20.3 mi/h
Center (impact all three
legs of sign)

Crash Test Results

A 1980 Honda Civic (shown in Figure 15) impacted the sign installation at 20.3 miles per hour (32.6 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,963 lb (890 kg). The height to the lower edge of the vehicle bumper was 14.0 inches (35.6 cm) and 19.5 inches (49.5 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 16.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the center of the vehicle. Upon impact, the sign supports began to deform and the vehicle started climbing the sign installation. At approximately 0.138 seconds, the front wheels were clear of the ground and the sign support bolts had fractured. At approximately 0.188 seconds, the vehicle lost contact with the sign installation, as the vehicle ceased forward motion and the sign installation yielded. As the front of the vehicle came into contact with the ground, the brakes were applied and the vehicle came to rest over the installation stubs at the point of impact. Sequential photographs of the test are shown in Figure 17.

The sign installation stubs were pushed rearward 4.0 in (10.16 cm) and the three sign supports were bent 19.0 in (48.3 cm) to 23.0 in (54.4 cm) above their original ground mounting height. In addition, the end of the sign supports came to rest 22.0 in (55.9 cm) from the front of the vehicle (see Figure 18). The vehicle sustained minor damage to the bumper and windshield as shown in Figure 19.

A summary of the test results and other information pertinent to this test are given in Figure 20. The maximum 0.050 second average acceleration experienced by the vehicle was -8.3 g in the longitudinal direction and -1.0 g in the lateral direction. Vehicle angular displacements are plotted in Figure 21 and vehicle accelerometer traces are displayed in Figure 22 through 24. Occupant impact velocity in the longitudinal direction was 28.2 feet per second (8.6 m/s) and no occupant impact velocity existed in the lateral direction. The highest 0.10 second occupant ridedown acceleration was -2.1 g (longitudinal). Change in velocity was 21.8 mi/h (35.0 km/h) and change in momentum was 1785 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. However, the occupant impact velocity was high (NCHRP Report 230 limit is 15 ft/s) and change in momentum was over the recommended limit of 1100 lb-s. This sign installation in "strong" soil is not acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

TEST REPORT 1122-4

VEHICLE: 1980 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,963 lbs.

TEST ARTICLE: Multi-Leg Sign Installation
Support: Three Franklin
4 lb-ft supports

IMPACT CONDITIONS: 61.7 mi/h
Center (impact all three
legs of sign)

Crash Test Results

A 1980 Honda Civic (shown in Figure 25) impacted the sign installation at 61.7 miles per hour (99.2 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,963 lb (890 kg). The height to the lower edge of the vehicle bumper was

14.0 inches (35.6 cm) and 19.5 inches (49.5 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 26.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the center of the vehicle. Upon impact, the sign supports began to deform and by approximately 0.018 second the sign support bolts had fractured. At approximately 0.173 second, as the sign installation yielded, the face of the sign slapped the roof of the vehicle. As the vehicle lost contact with the sign installation, at approximately 0.228 second, the brakes were applied and the vehicle came to rest approximately 261.0 ft (79.6 m) from the point of impact. Sequential photographs of the test are shown in Figure 27.

The left sign support stub was pushed rearward 1.0 in (2.5 cm), the center support 4.0 in (10.2 cm), and the right sign support 2.0 in (5.1 cm). After impact, the sign installation came to rest 42 ft (12.8 m) from the impact site. The vehicle sustained minor damage to the bumper and windshield, as shown in Figure 29.

A summary of the test results and other information pertinent to this test are given in Figure 30. The maximum 0.050 second average acceleration experienced by the vehicle was -8.7 g in the longitudinal direction and 1.3 g in the lateral direction. Vehicle angular displacements are plotted in Figure 31 and vehicle accelerometer traces are displayed in Figure 32 through 34. Occupant impact velocity in the longitudinal direction was 15.5 feet per second (4.7 m/s) and no occupant impact velocity existed in the lateral direction. The highest 0.10 second occupant ridedown acceleration was -3.4 g (longitudinal). Change in velocity was 11.8 mi/h (18.9 km/h) and change in momentum was 963 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. The occupant impact velocity was marginally above the recommended NCHRP Report 230 limit of 15 ft/s. However, the change in momentum was under the recommended limit of 1100 lb-s. This sign installation would be acceptable in "strong" soil according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards, however, it failed to meet these criteria at 20 mph.

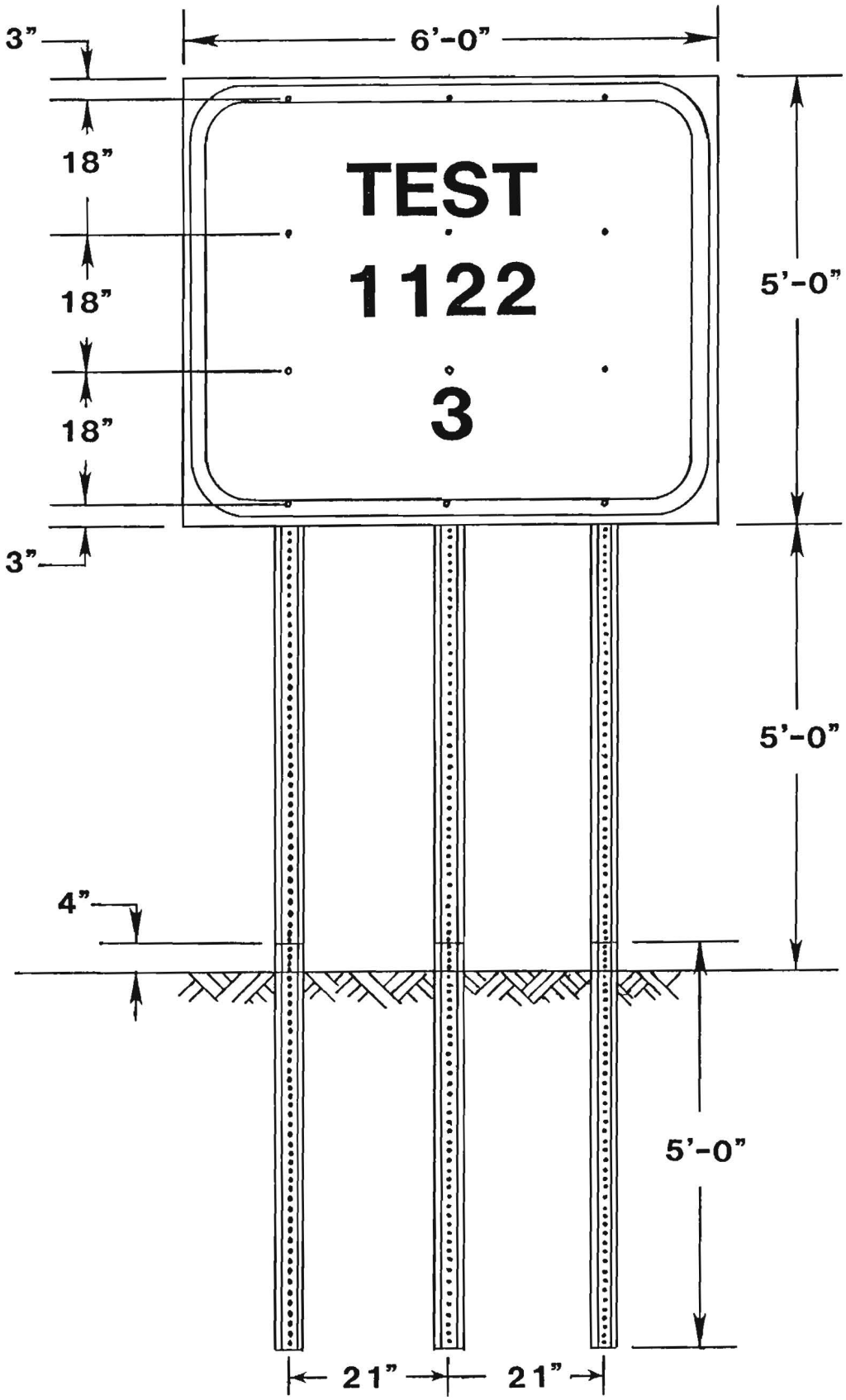


Figure 13. Details of sign installation for test 1122-3.

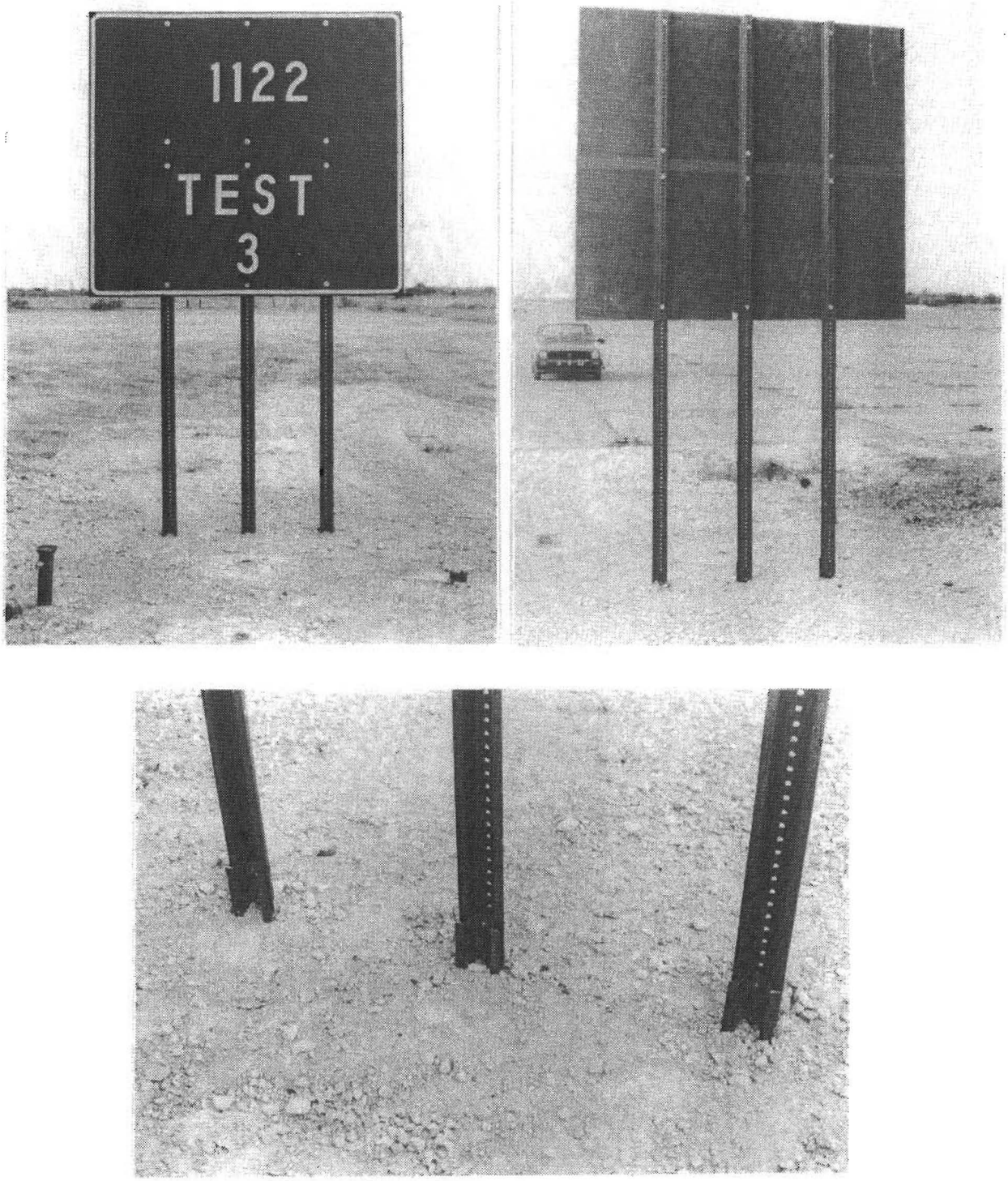


Figure 14. Sign installation before test 1122-3.

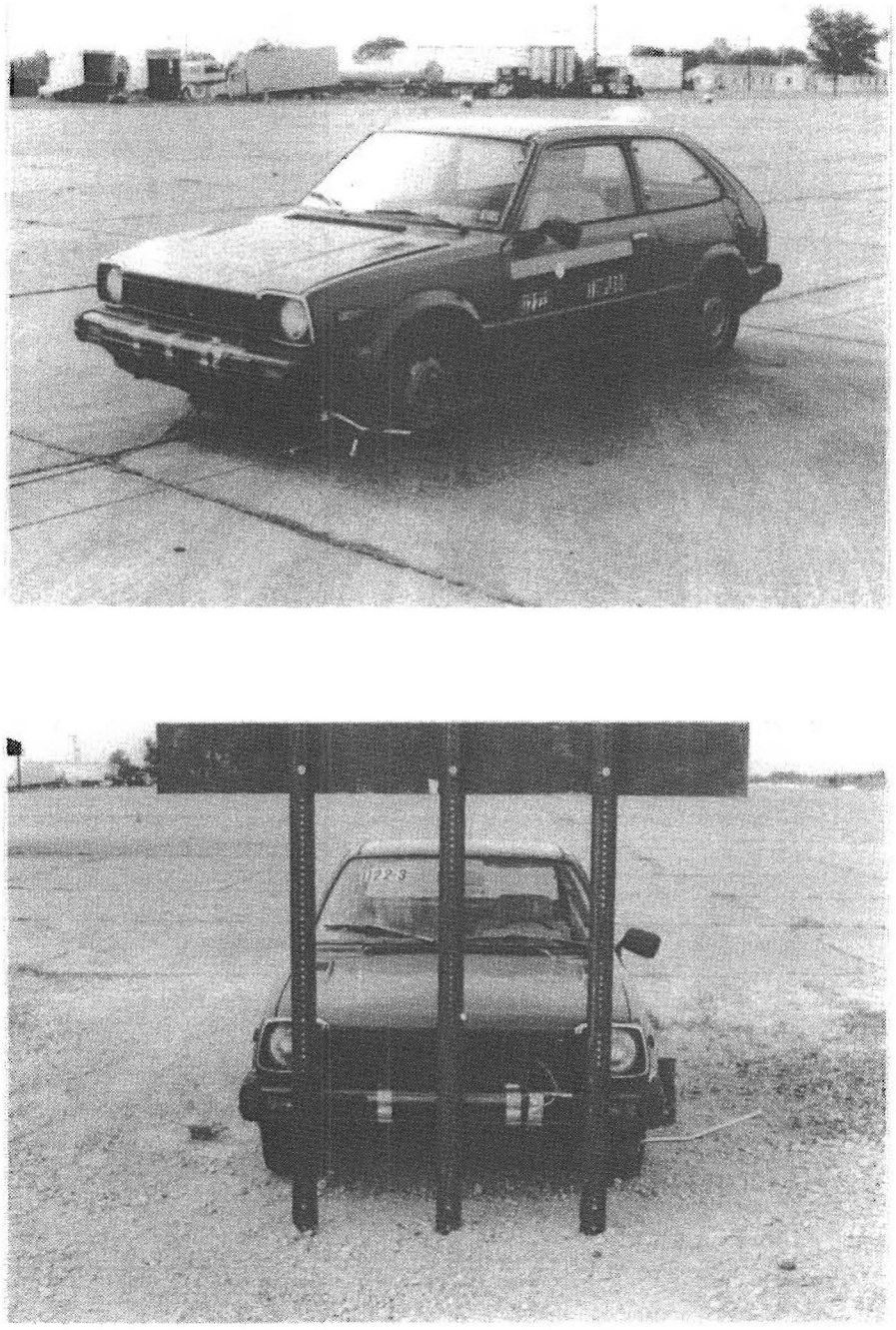
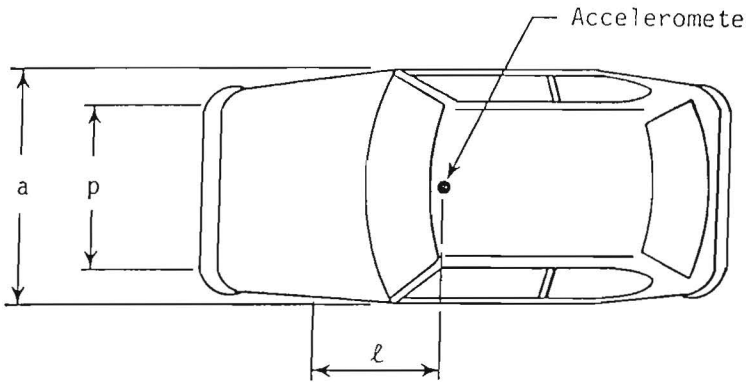


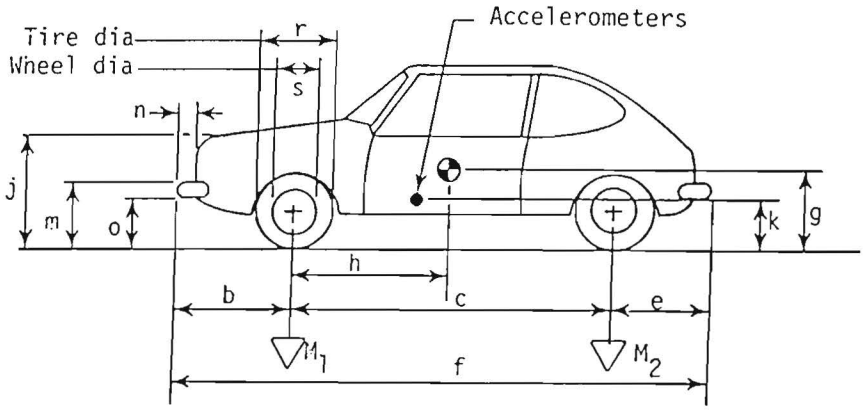
Figure 15. Vehicle before test 1122-3.

Date: 7-19-88 Test No.: 1122/3-4 VIN: SLC1011257

Make: Honda Model: Civic Year: 1980 Odometer: 050548

Tire Size: 155 SR-12 Ply Rating: 2 Bias Ply: ___ Belted: ___ Radial: X





4-wheel weight for c.g. det. ℓf 578 rf 573 ℓr 312 rr 337

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1123	1151	1228
M_2	617	649	735
M_T	1740	1800	1963

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Tire Condition: good ___
fair X
badly worn ___

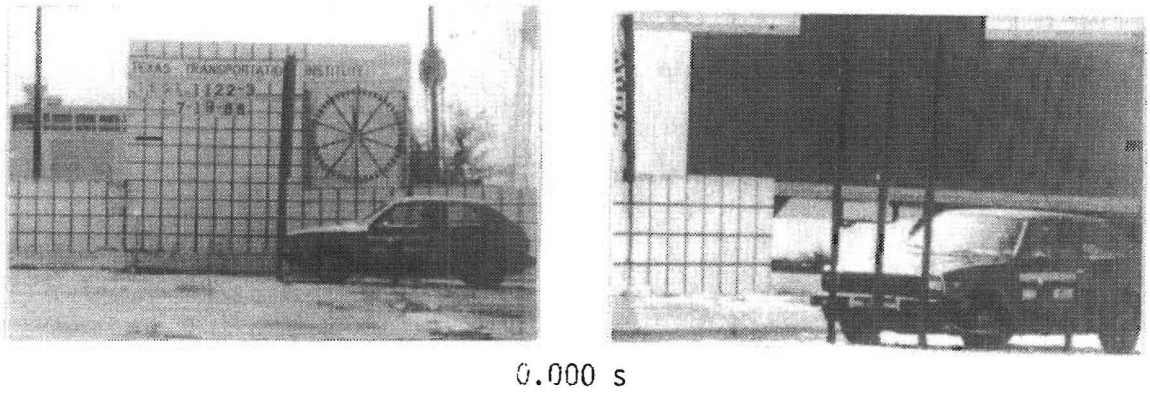
Vehicle Geometry - inches

a	62	b	28
c	88 1/4	d*	52
e	28 1/2	f	
g		h	31.8
i	----	j	29 1/2
k	16 1/2	ℓ	26
m	19 1/2	n	5
o	14	p	53 1/2
r	21	s	13 1/4

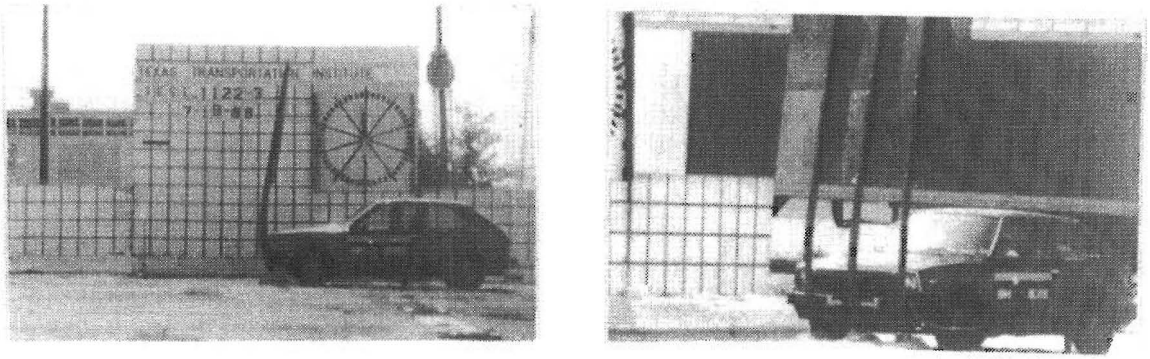
Engine Type: 4 cyl
Engine CID: ___
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD
Body Type: Hatch
Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

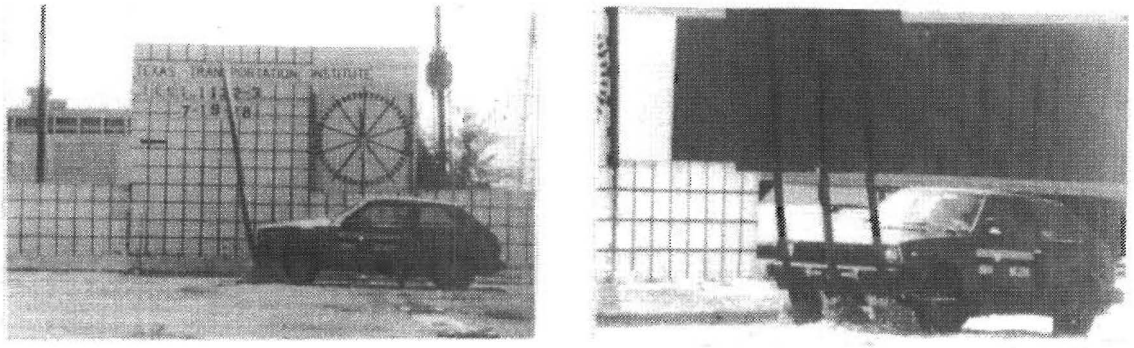
Figure 16. Test vehicle properties (1122-3).



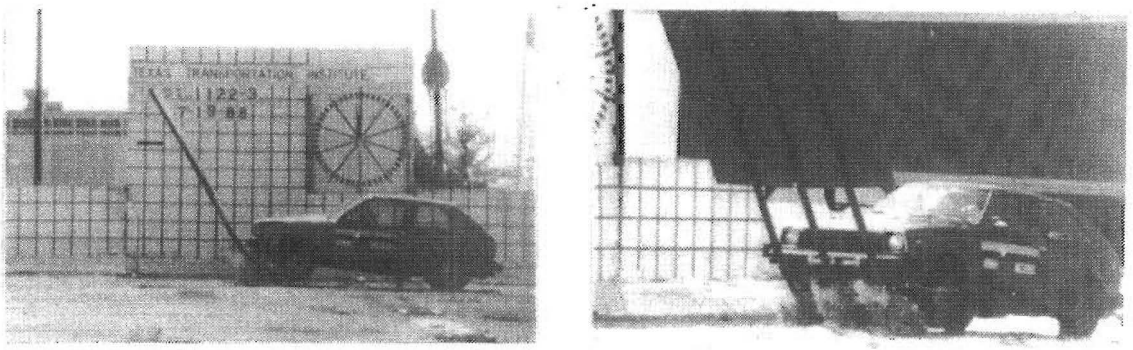
0.000 s



0.068 s

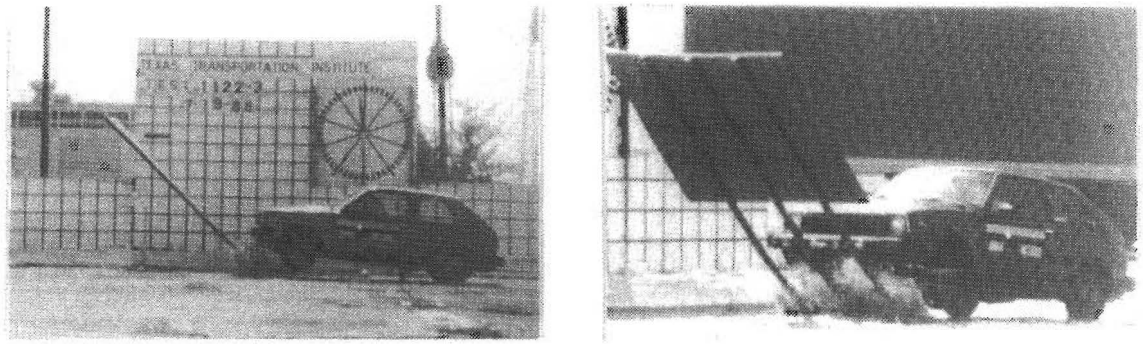


0.135 s

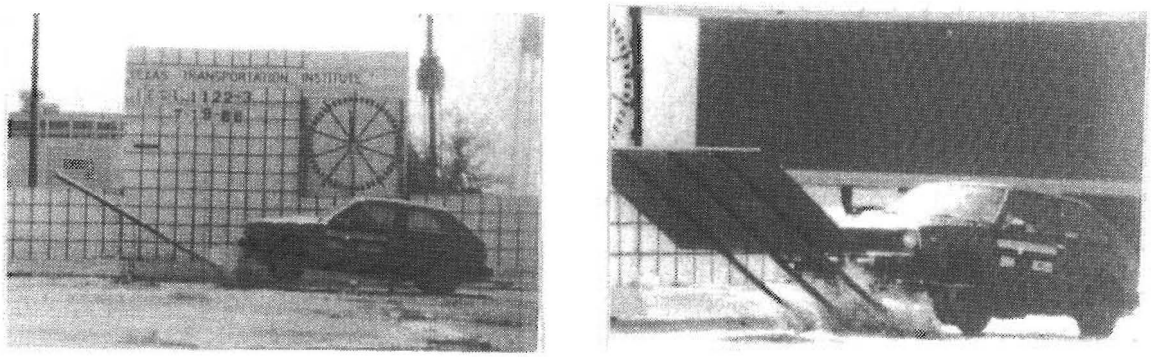


0.203 s

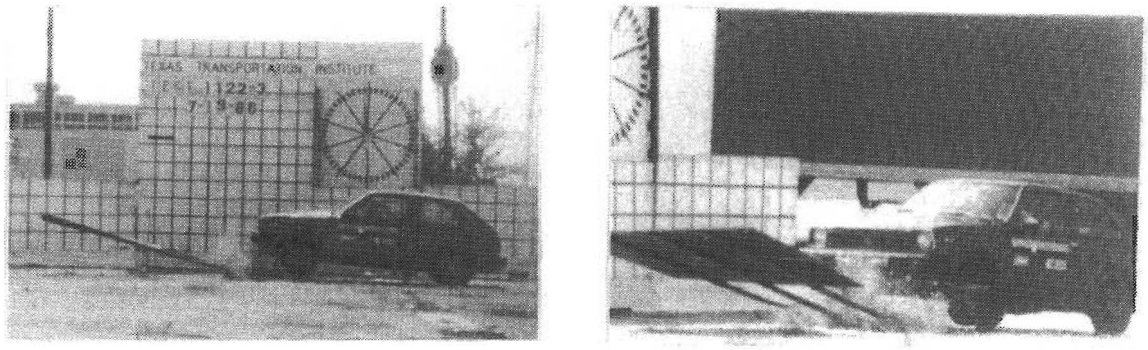
Figure 17. Sequential photographs for test 1122-3.



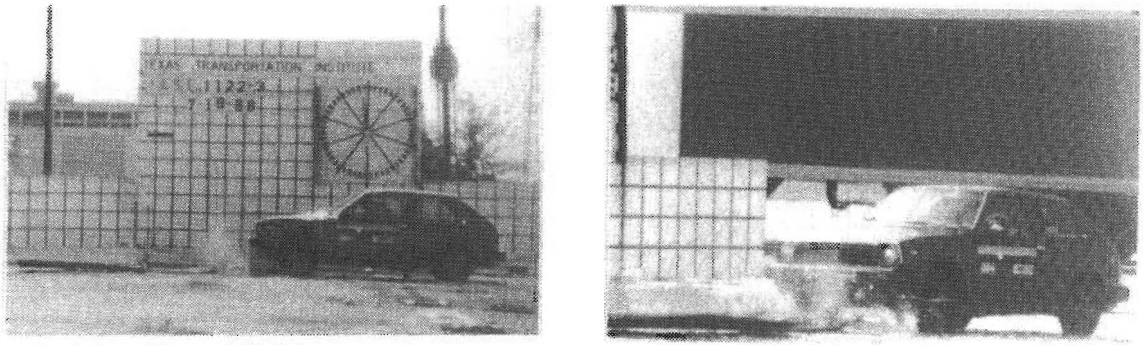
0.270 s



0.338 s



0.406 s



0.473 s

Figure 17. Sequential photographs for test 1122-3. (Continued)

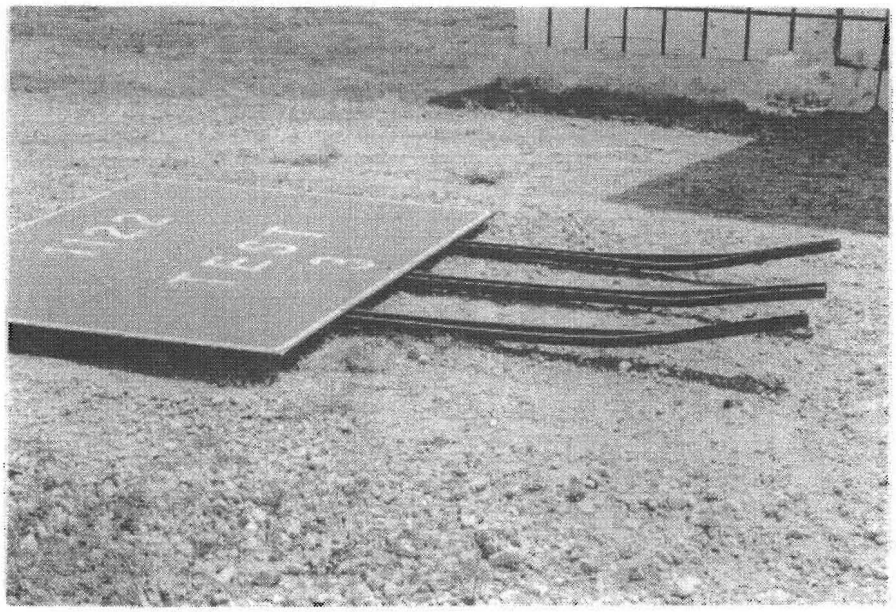
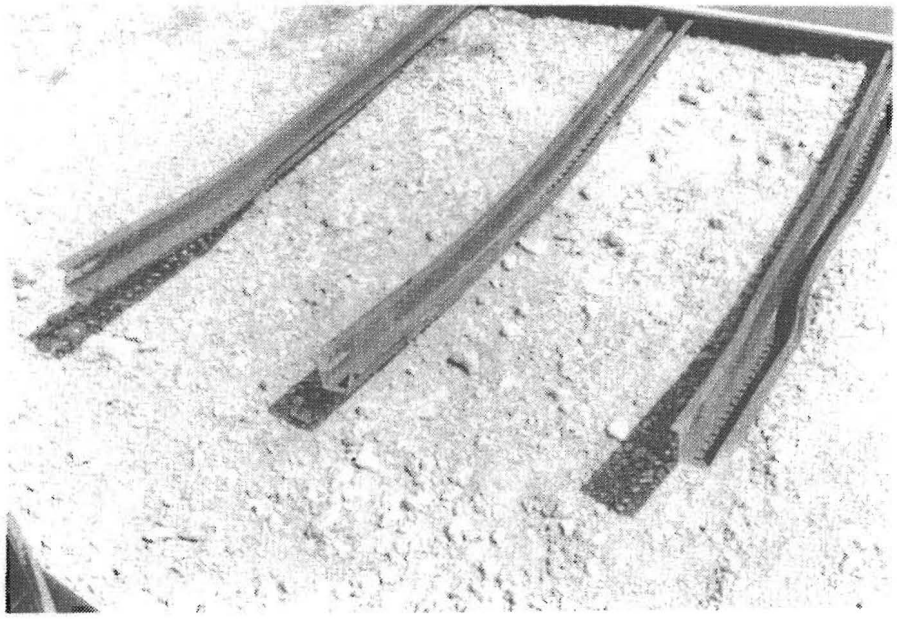


Figure 18. Sign installation after test 1122-3.



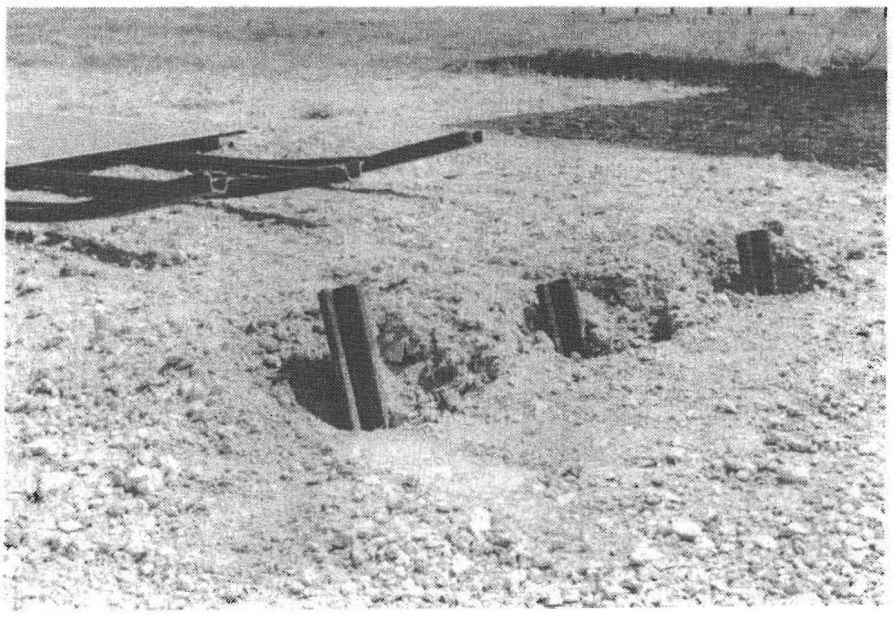


Figure 18. Sign installation after test 1122-3.
(Continued)

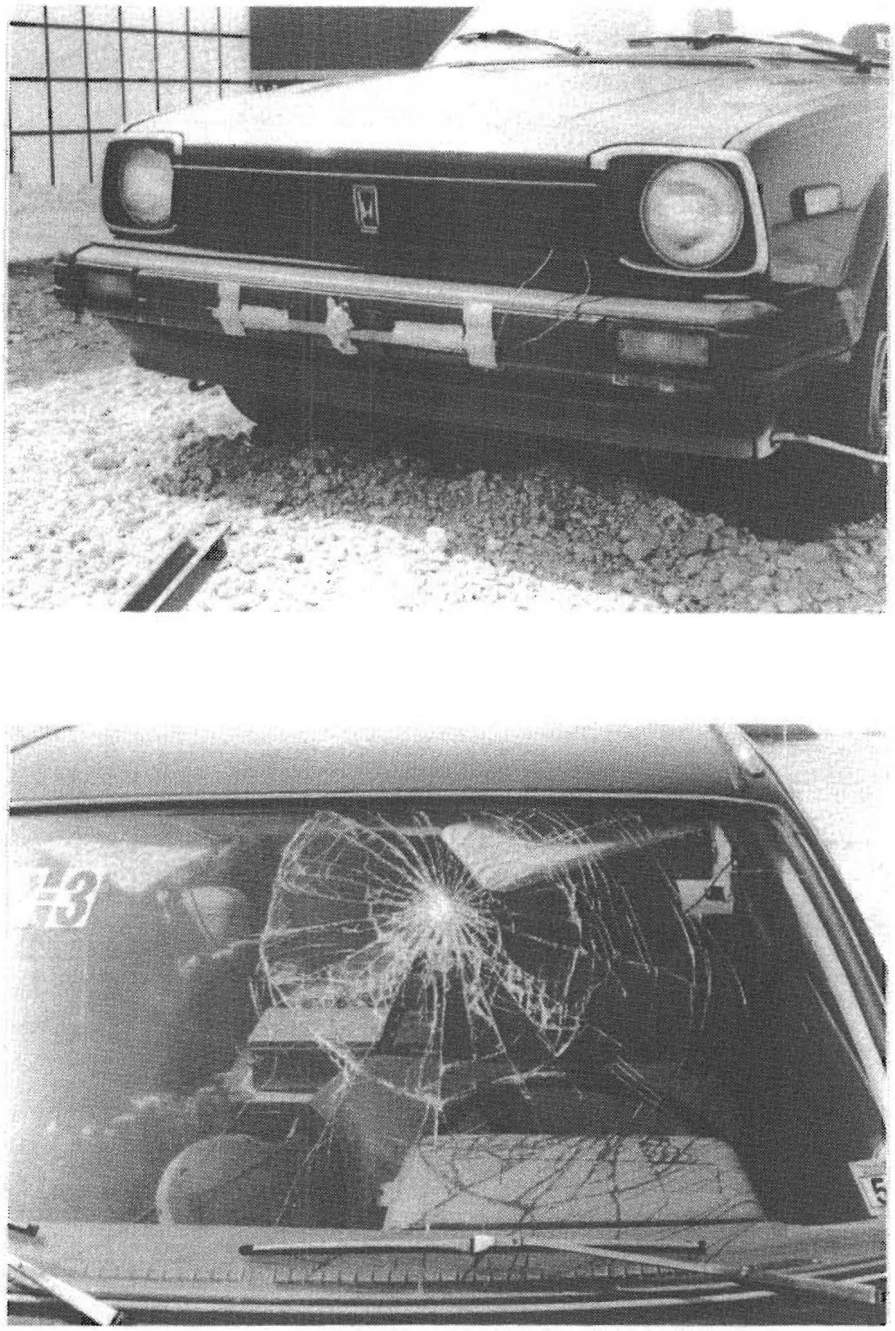
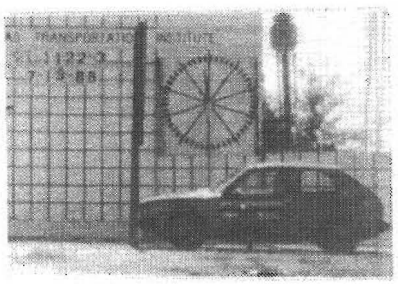
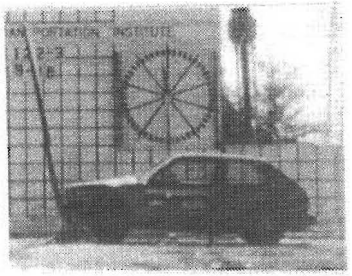


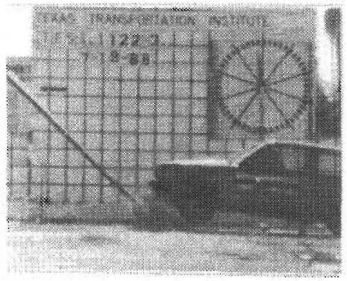
Figure 19. Vehicle after test 1122-3.



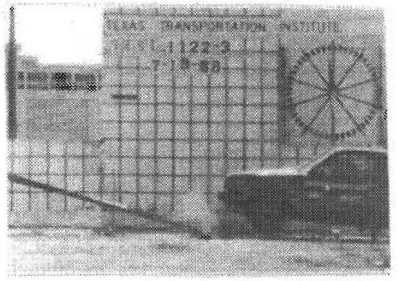
0.000 s



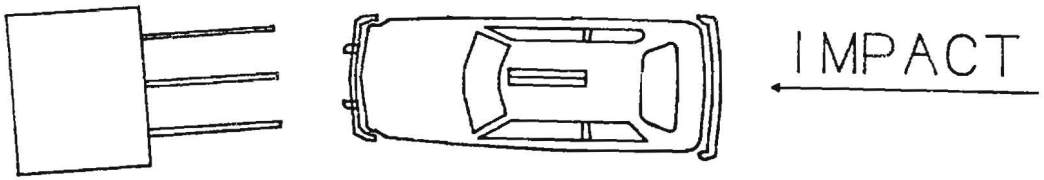
0.135 s



0.270 s



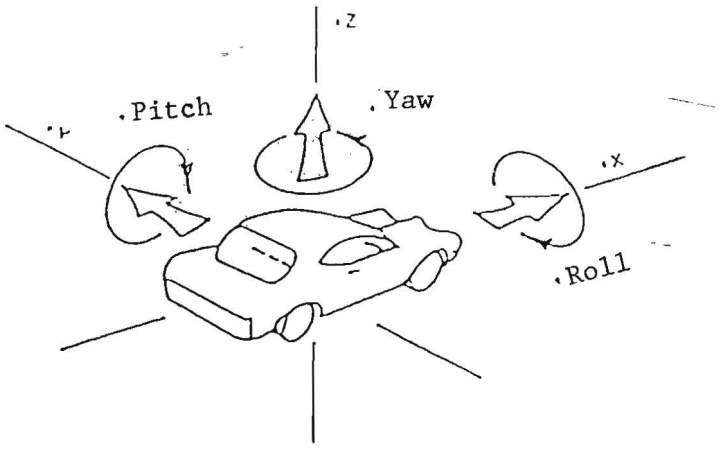
0.406 s



Test No.	1122-3
Date	7/19/88
Test Article	Sign Installation
Support	Three Franklin 4.0 lb-ft Supports
Vehicle	1980 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,963 lb (890 kg)
Vehicle Damage Classification	
TAD	12FD1
SAE	12FDLW1

Impact Speed.	20.3 mi/h (32.6 km/h)
Change in Velocity . . .	21.8 mi/h (35.0 km/h)
Change in Momentum. . . .	1,785 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-8.3 g
Lateral	-1.0 g
Occupant Impact Velocity	
Longitudinal.	28.2 ft/s (8.6 m/s)
Lateral	None
Occupant Ridedown Accelerations	
Longitudinal	-2.1 g
Lateral	No Contact

Figure 20. Summary of results for test 1122-3.



Axes are vehicle fixed.
Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

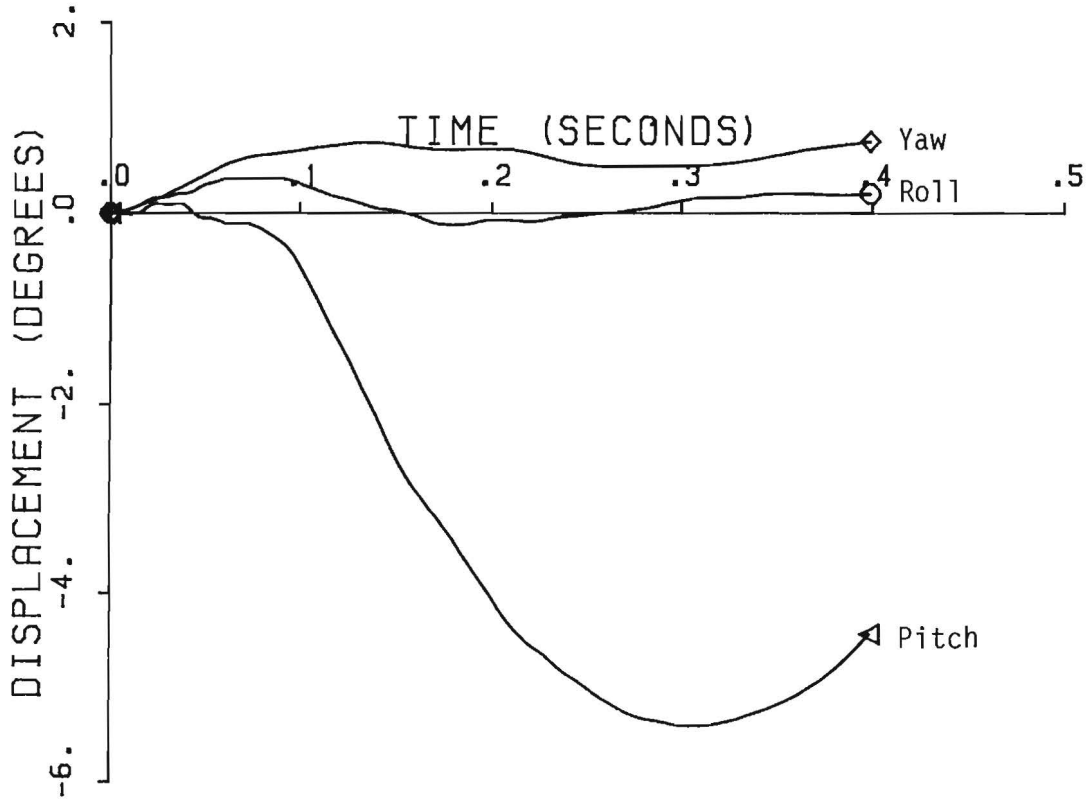


Figure 21. Vehicle angular displacements for test 1122-3.

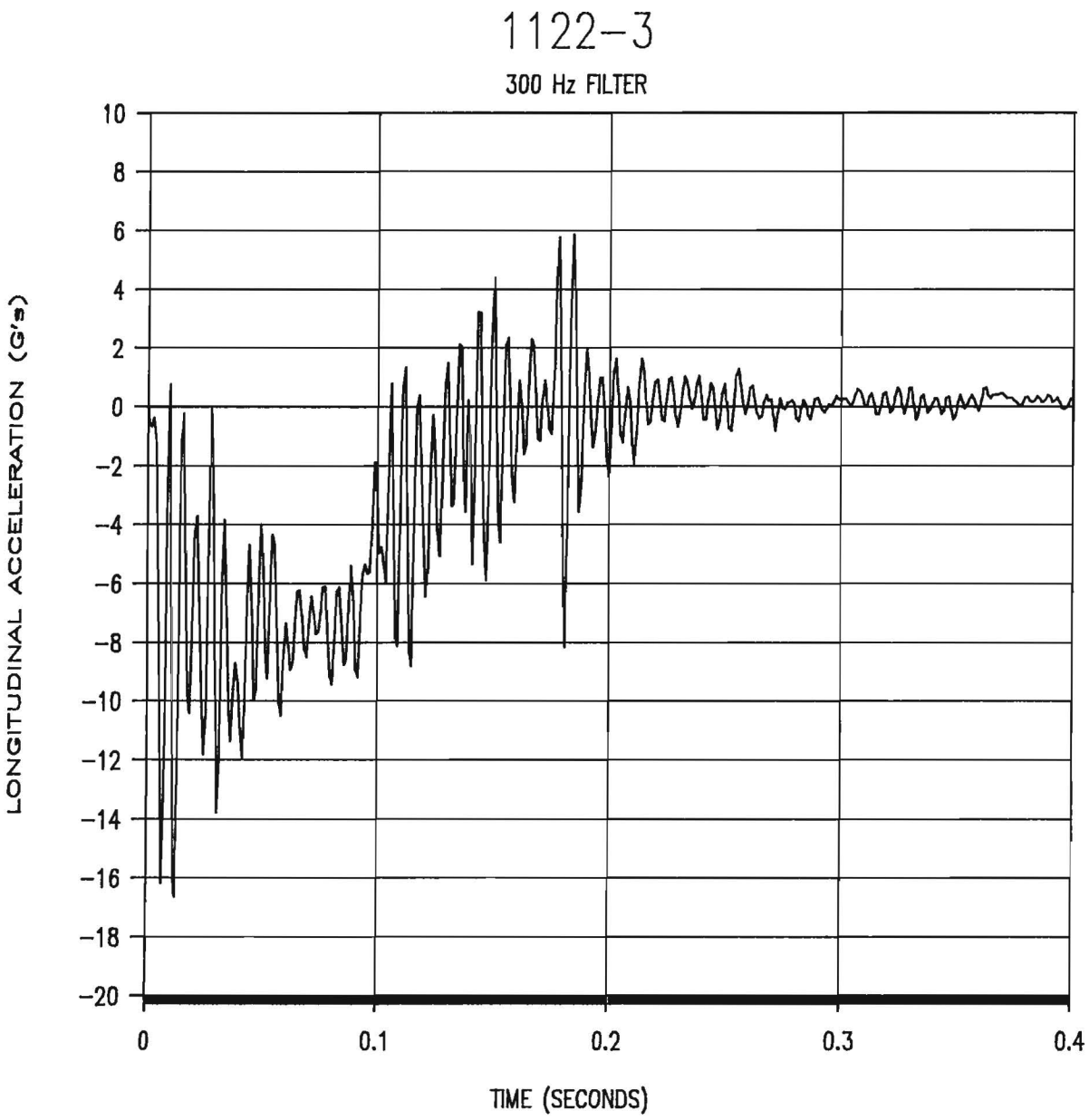


Figure 22. Longitudinal accelerometer trace for test 1122-3.

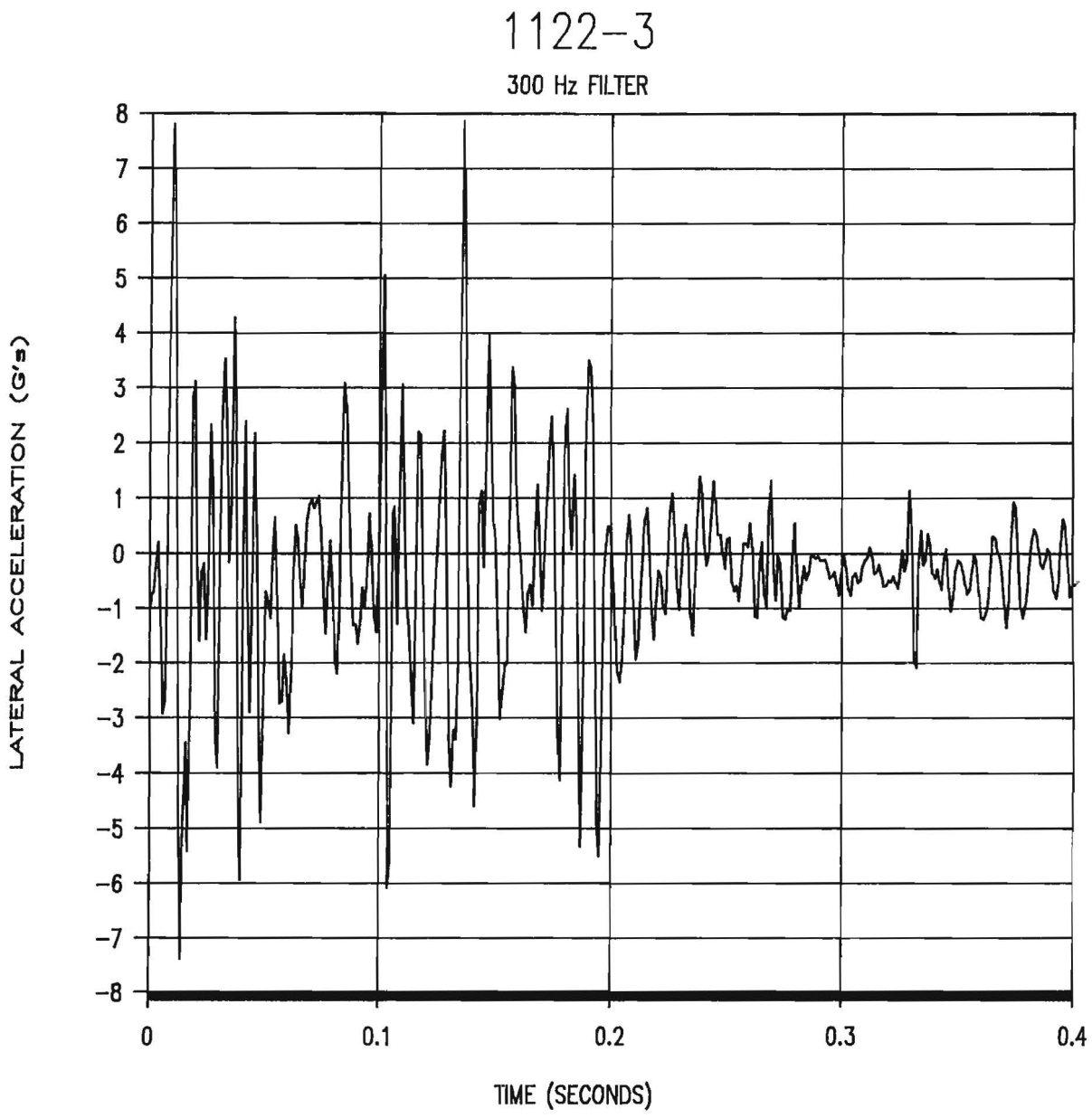


Figure 23. Lateral accelerometer trace for test 1122-3.

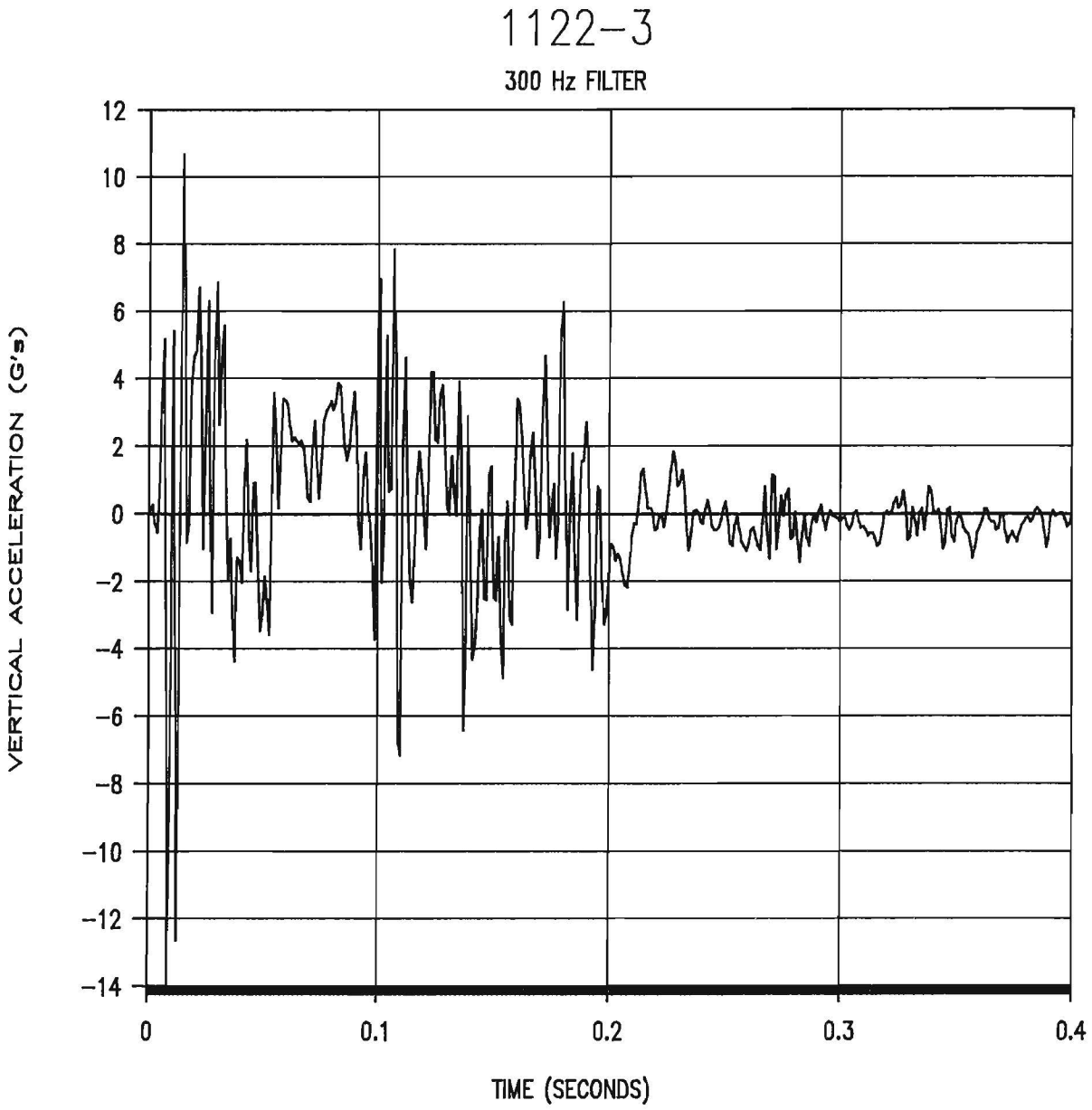


Figure 24. Vertical accelerometer trace for test 1122-3.

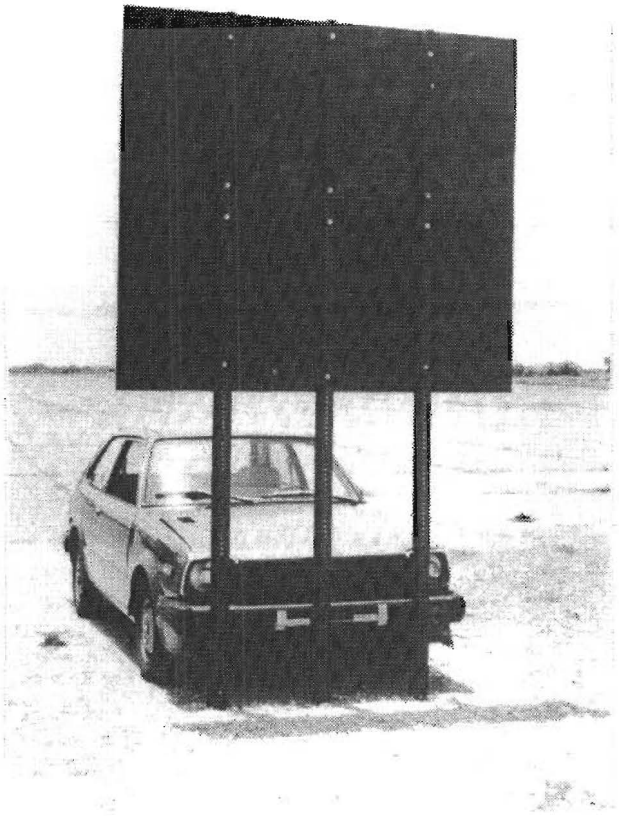
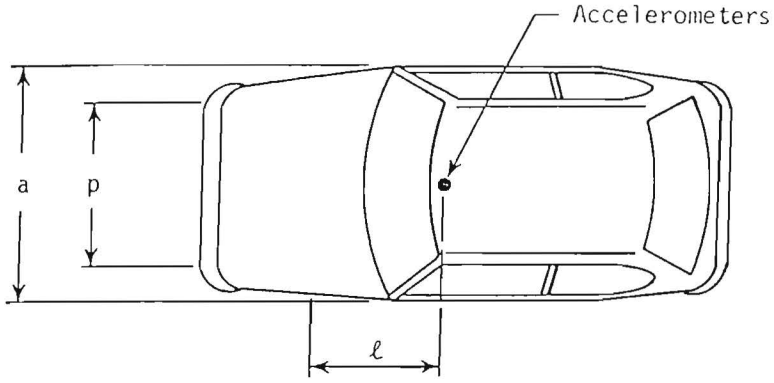


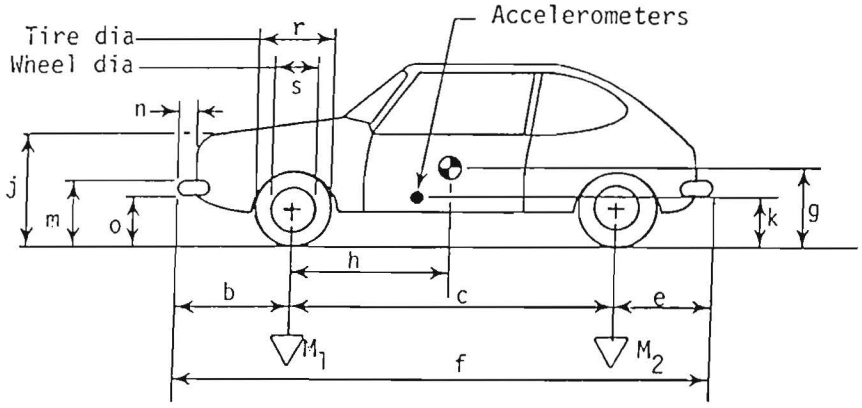
Figure 25. Vehicle before test 1122-4.

Date: 7/19/88 Test No.: 1122/3-4 VIN: SLC1011257

Make: Honda Model: Civic Year: 1980 Odometer: 05048

Tire Size: 155 SR-12 Ply Rating: 2 Bias Ply: ___ Belted: ___ Radial: X





4-wheel weight for c.g. det. ℓf 578 rf 573 ℓr 312 rr 337

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1123	1151	1228
M_2	617	649	735
M_T	1740	1800	1963

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Tire Condition: good ___
fair X
badly worn ___

Vehicle Geometry - inches

a	62	b	28
c	88 1/4	d*	52
e	28 1/2	f	
g		h	31.8
i	----	j	29 1/2
k	16 1/2	ℓ	26
m	19 1/2	n	5
o	14	p	53 1/2
r	21	s	13 1/4

Engine Type: 4 cyl

Engine CID:

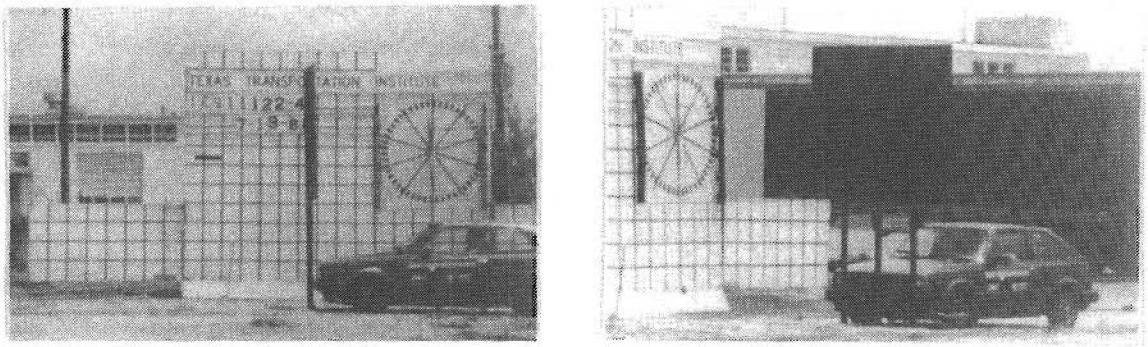
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD

Body Type: Hatch

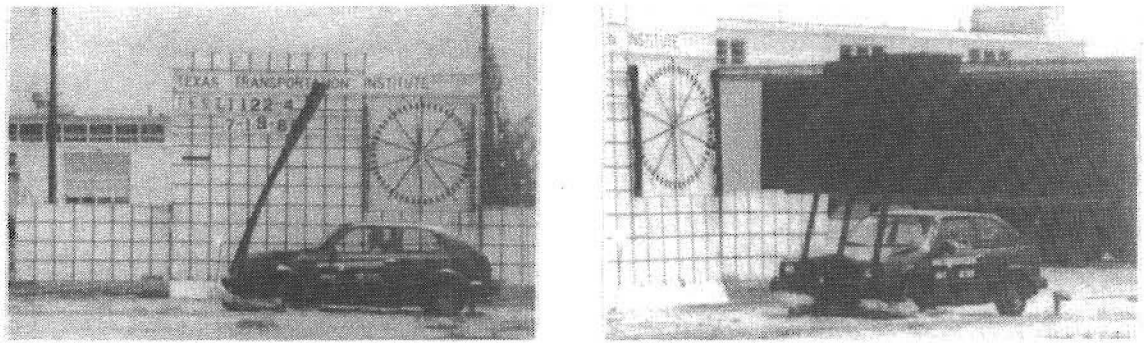
Steering Column Collapse Mechanism:
___ Behind wheel units
___ Convoluted tube
___ Cylindrical mesh units
___ Embedded ball
___ NOT collapsible
___ Other energy absorption
___ Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

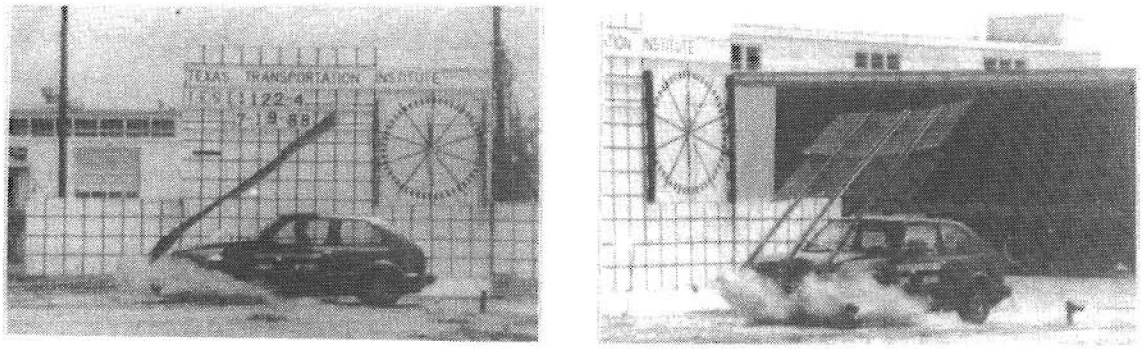
Figure 26. Test vehicle properties (1122-4).



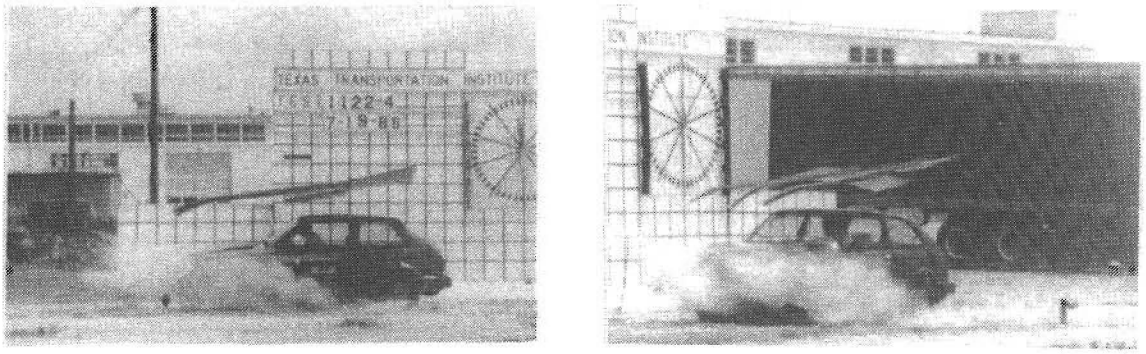
0.000 s



0.043 s

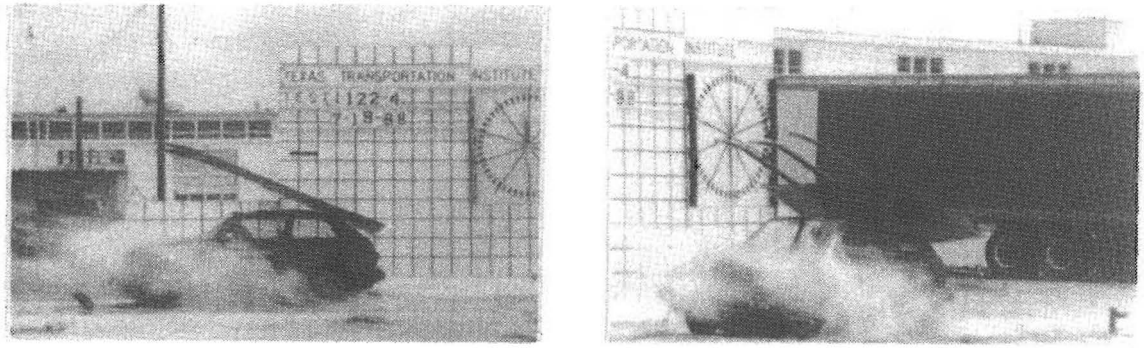


0.085 s

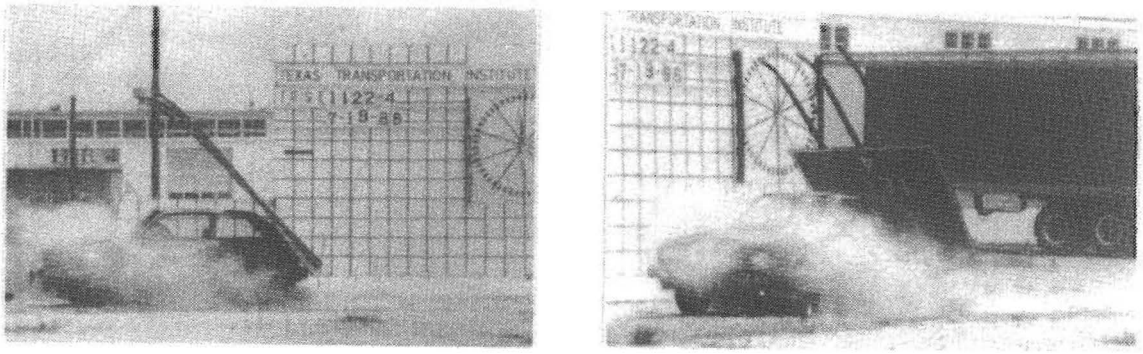


0.128 s

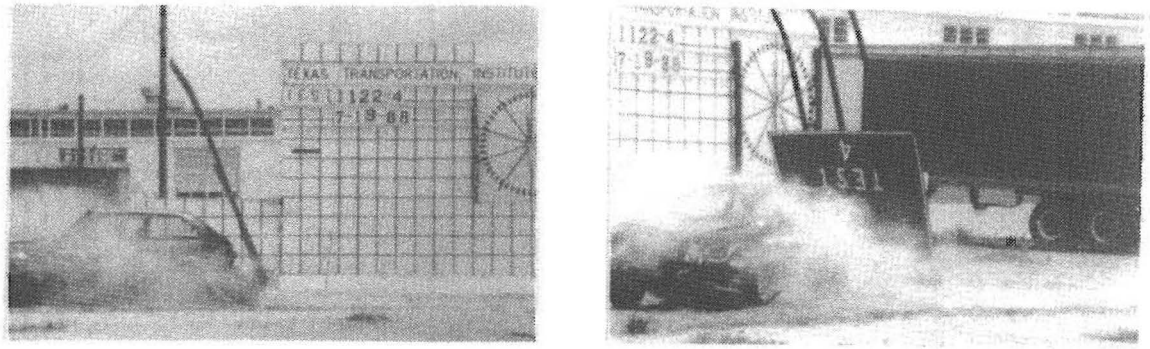
Figure 27. Sequential photographs for test 1122-4.



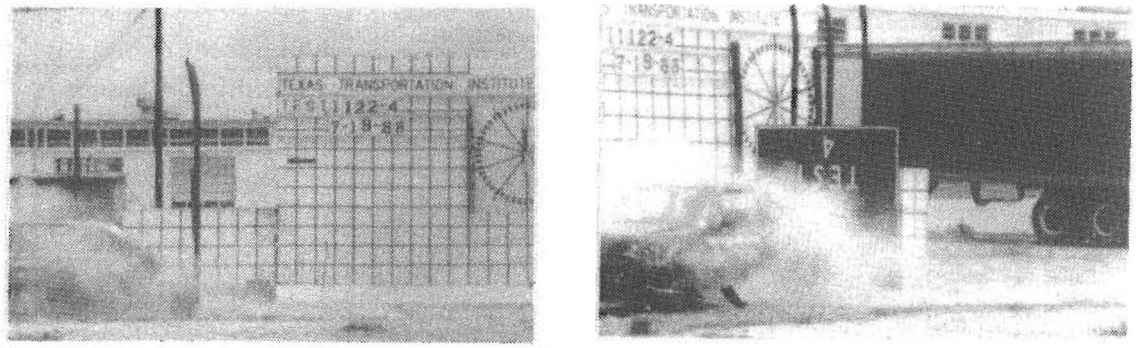
0.171 s



0.213 s

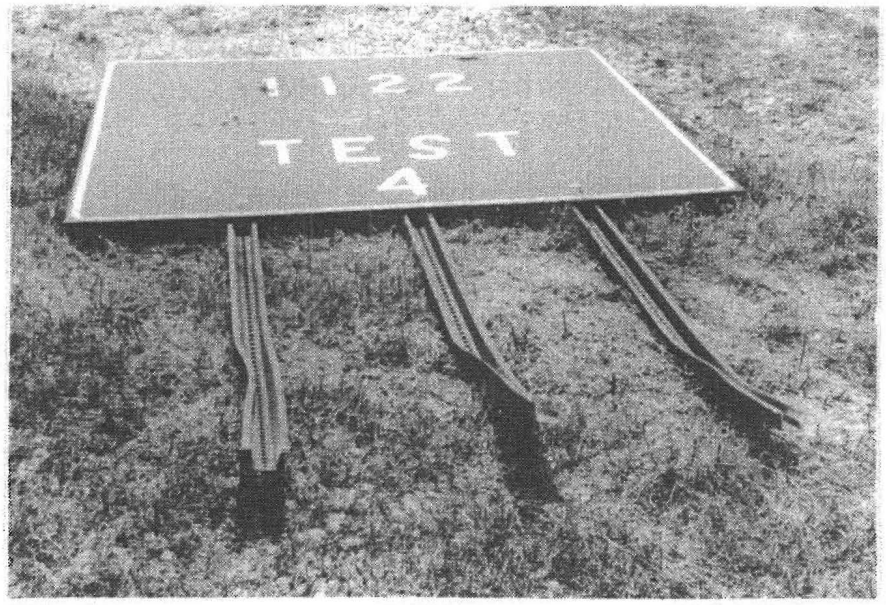


0.256 s



0.299 s

Figure 27. Sequential photographs for test 1122-4. (Continued)



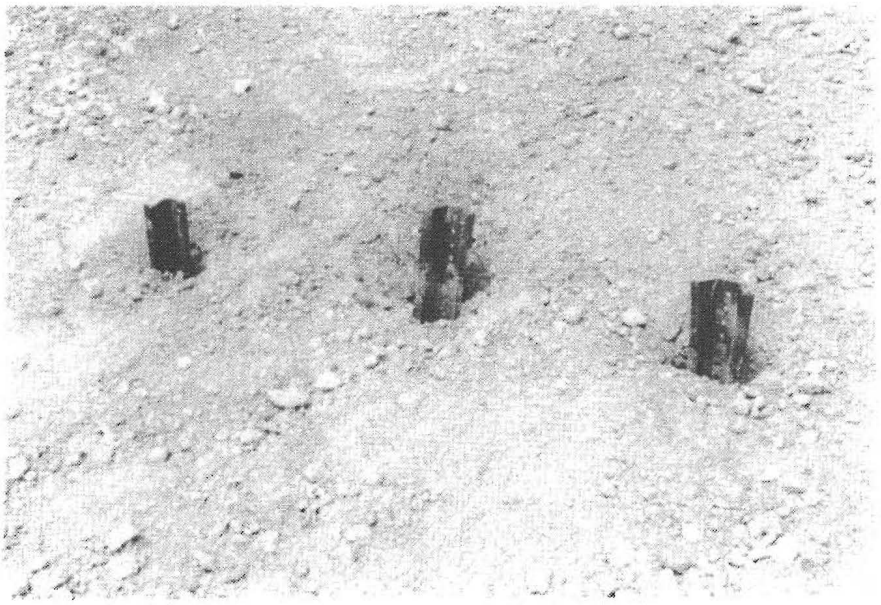


Figure 28. Sign installation after test 1122-4.

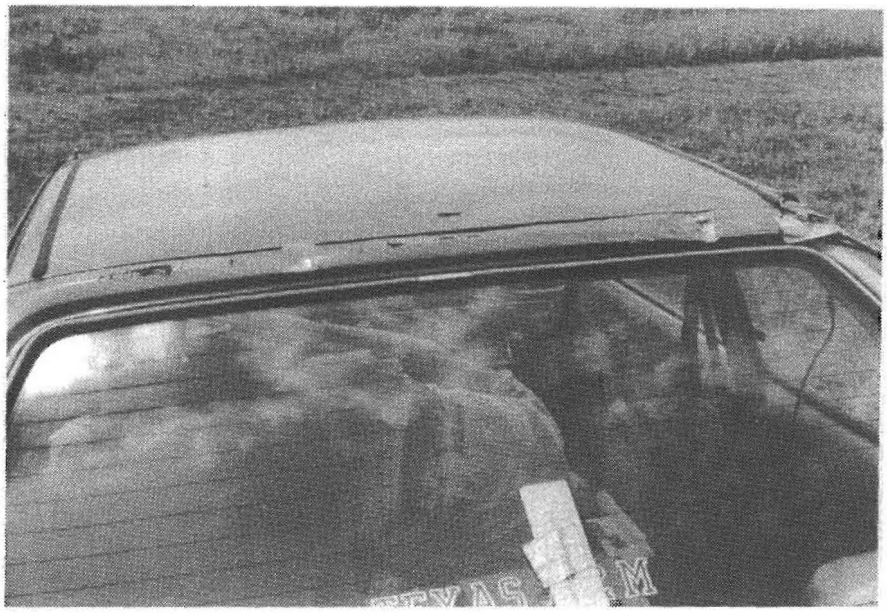
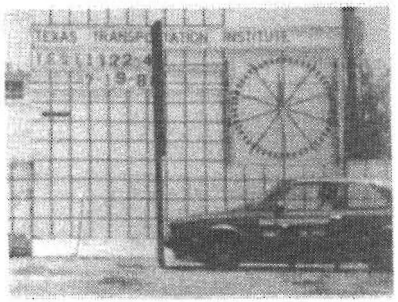
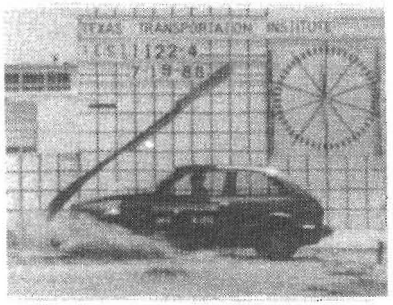


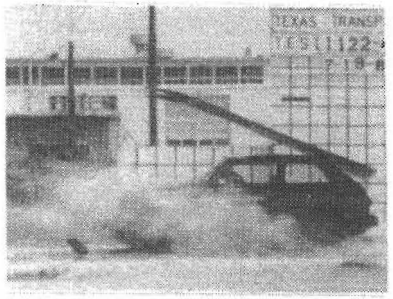
Figure 29. Vehicle after test 1122-4.



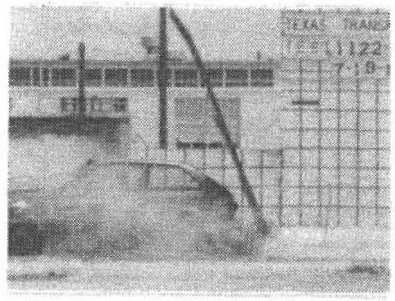
0.000 s



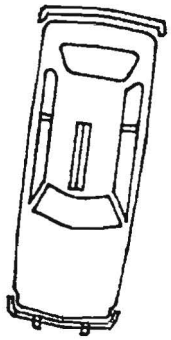
0.085 s

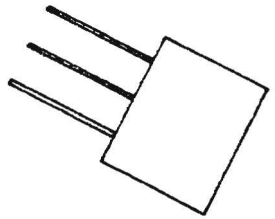


0.171 s



0.256 s





Test No.	1122-4
Date	7/19/88
Test Article	Sign Installation
Support	Three Franklin 4.0 lb-ft Supports
Vehicle	1980 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,963 lb (890 kg)
Vehicle Damage Classification	
TAD	12FD1
SAE	12FDEW 1

Impact Speed.	61.7 mi/h (99.2 km/h)
Change in Velocity . . .	11.8 mi/h (18.9 km/h)
Change in Momentum. . . .	963 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-8.7 g
Lateral	1.3 g
Occupant Impact Velocity	
Longitudinal.	15.5 ft/s (4.7 m/s)
Lateral	None
Occupant Ridedown Accelerations	
Longitudinal	-3.4 g
Lateral	No Contact

Figure 30. Summary of results for test 1122-4.

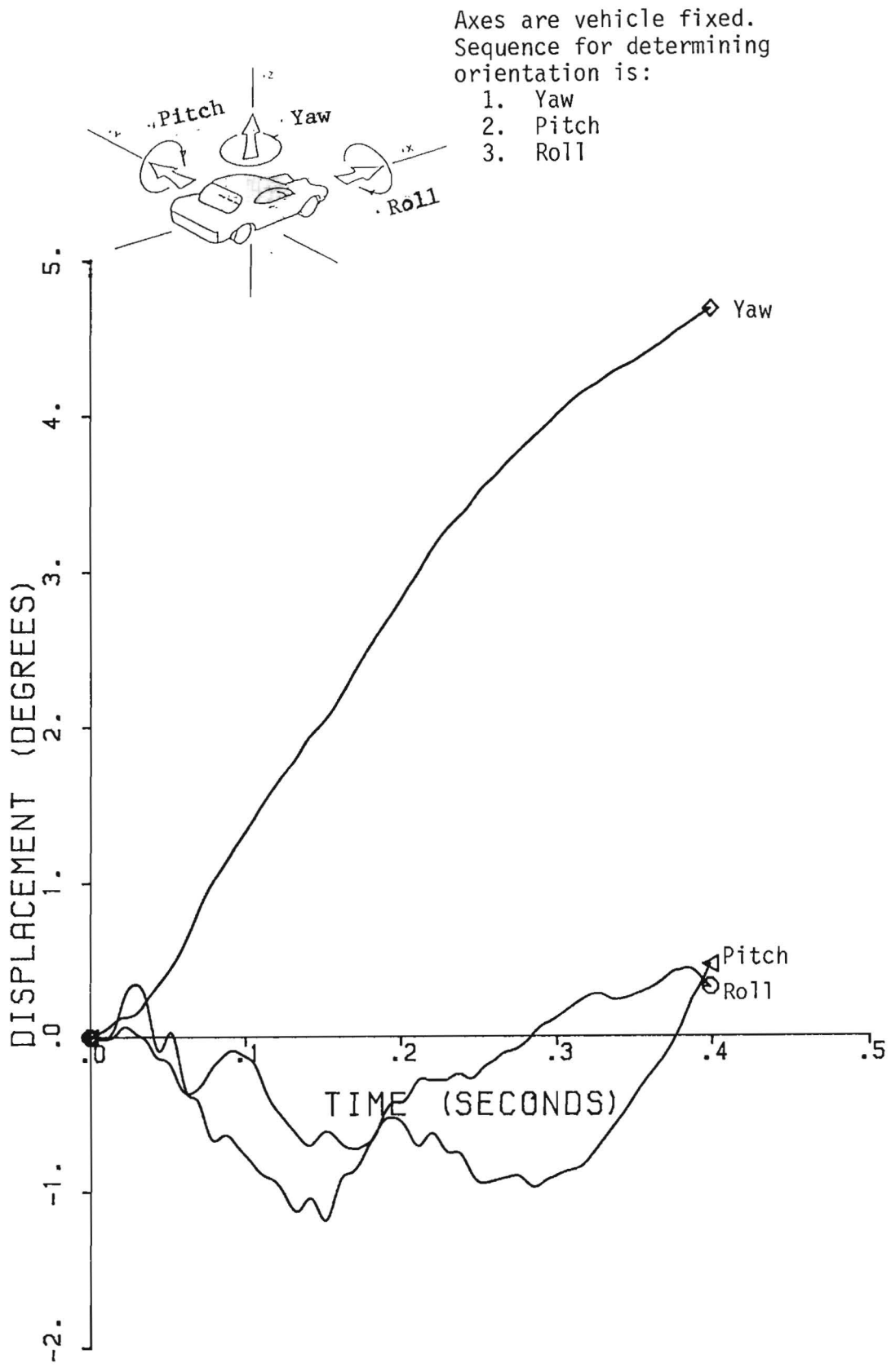


Figure 31. Vehicle angular displacements for test 1122-4.

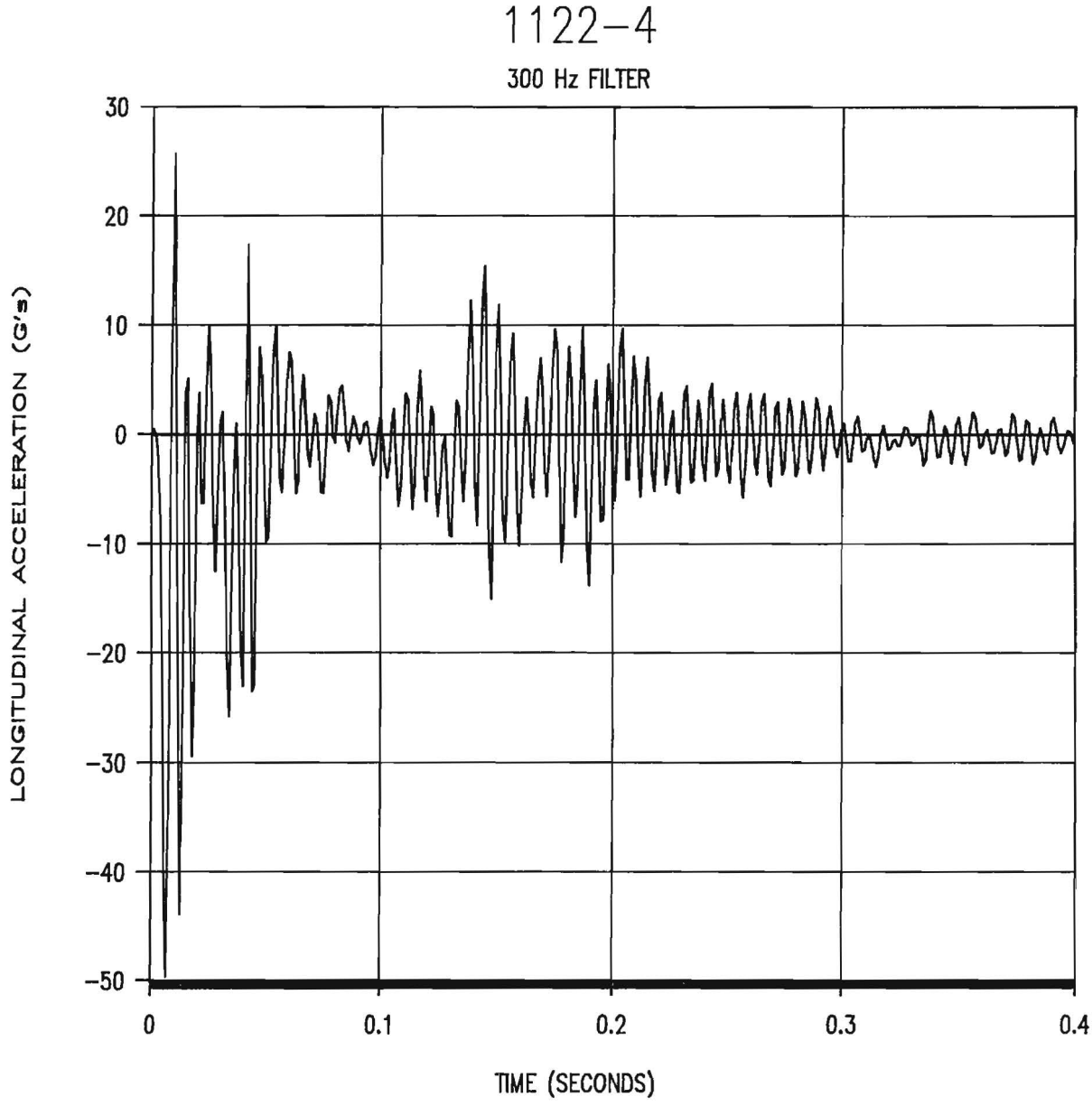


Figure 32. Longitudinal accelerometer trace for test 1122-4.

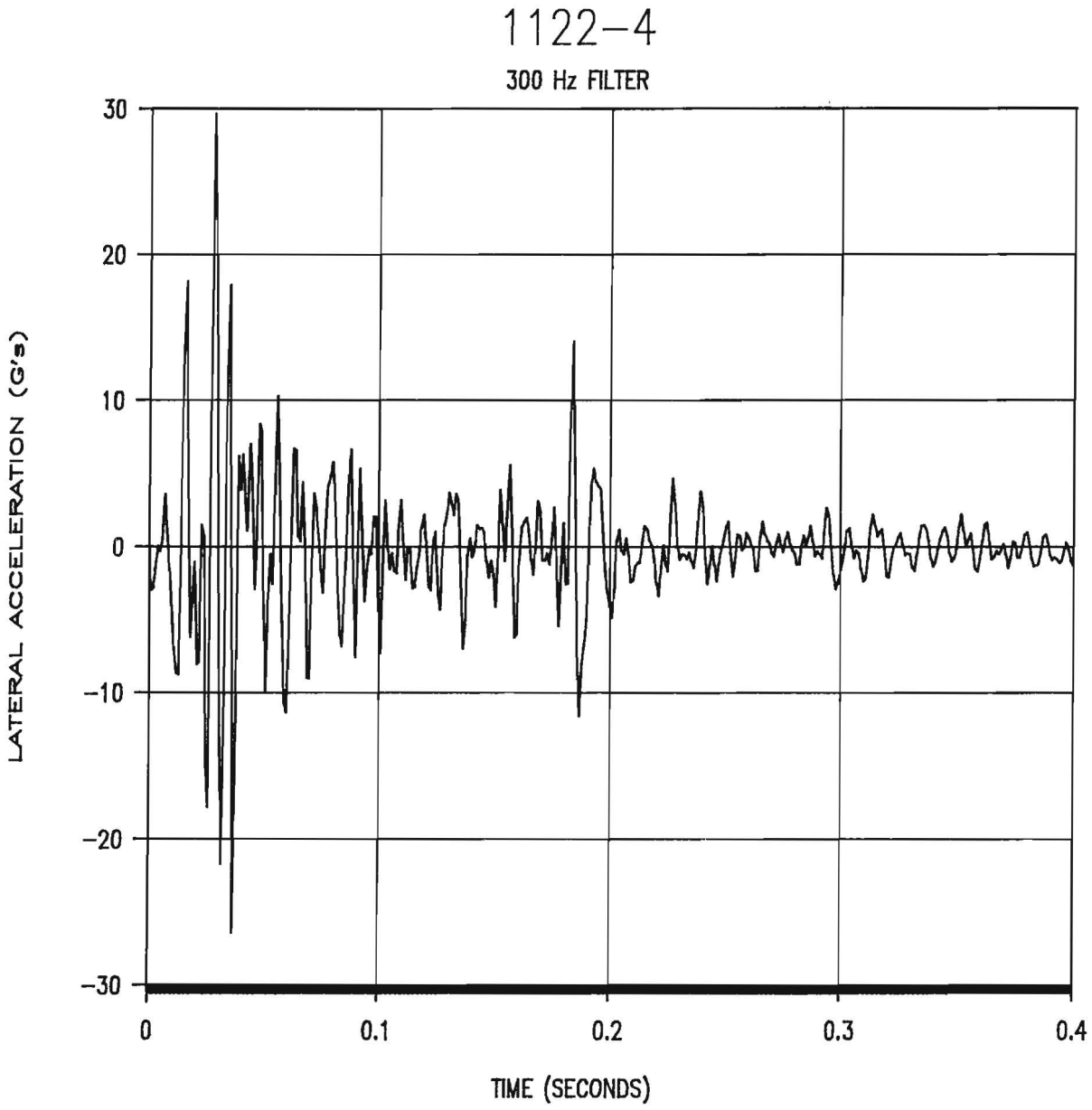


Figure 33. Lateral accelerometer trace for test 1122-4.

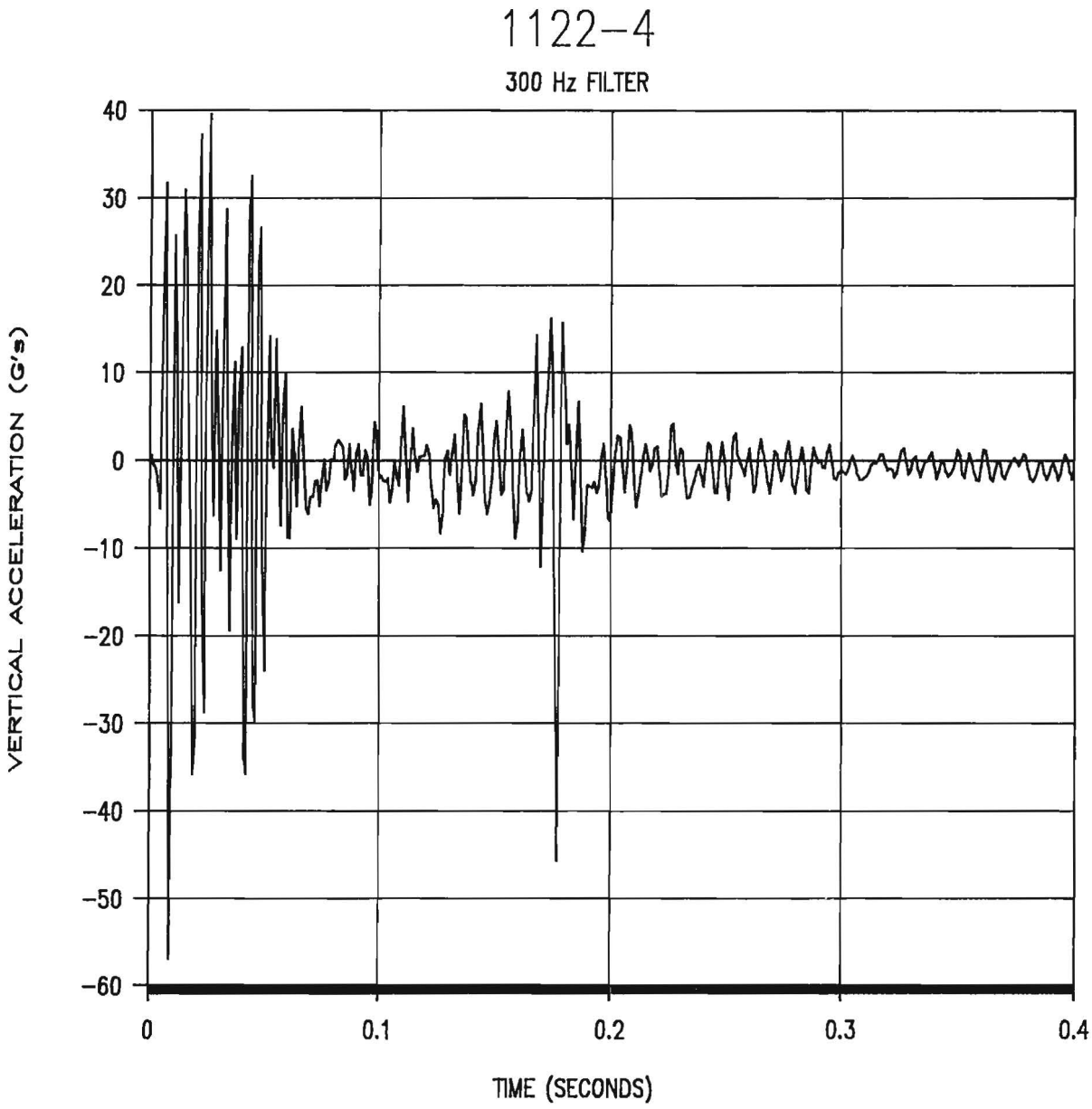


Figure 34. Vertical accelerometer trace for test 1122-4.

DESCRIPTION OF TEST INSTALLATION FOR 1122-5

The sign installation used in this test consisted of a 6 ft-0 in wide x 5 ft-0 in high plywood sign panel mounted on three Marion 3.0 lb-ft steel supports. These supports were attached to three 60 inch stubs which had been driven into crushed limestone (NCHRP Report 230 Strong Soil) at 21 inches on center spacing. The supports were attached to the stubs in a nested splice (stubs in front of sign supports) with 1/2 inch spacers and 5/16 inch grade 9 bolts, nuts and washers. The bottom of sign mounting height was 5 ft. Details of the sign installation are shown in Figures 35 and 36.

TEST REPORT 1122-5

VEHICLE: 1982 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,970 lbs.

TEST ARTICLE: Multi-Leg Sign Installation
Support: Three Marion
3 lb-ft supports

IMPACT CONDITIONS: 19.5 mi/h
Center (impact all three
legs of sign)

Crash Test Results

A 1982 Honda Civic (shown in Figure 37) impacted the sign installation at 19.5 miles per hour (31.4 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,970 lb (894 kg). The height to the lower edge of the vehicle bumper was 13.8 inches (34.9 cm) and 19.5 inches (49.5 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 38.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the center of the vehicle. Upon impact, the sign supports began to deform and by approximately 0.078 second, the left sign support had fractured at bumper height. The center sign support had fractured partially prior to the splice joint bolts yielding. At approximately 0.098 second, the right sign support yielded by fracturing the splice joint bolts. As the sign installation yielded and the vehicle lost contact, at approximately 0.349 seconds, the brakes were applied and the rear of the vehicle came to rest directly behind the point of impact. Sequential photographs of the test are shown in Figure 39.

The left sign support was fractured and the center support partially fractured 22.0 inches (55.88 cm) above ground level. The right support stub was pushed rearward 9.0 inches (22.86 cm). After impact, the sign installation came to rest 21 ft (6.4 m) from the impact site. The vehicle sustained minor damage to the bumper and windshield as shown in Figure 41.

A summary of the test results and other information pertinent to this test are given in Figure 42. The maximum 0.050 second average acceleration experienced by the vehicle was -6.5 g in the longitudinal direction and -0.9 g in the lateral direction. Vehicle angular displacements are plotted in Figure 43 and vehicle accelerometer traces are displayed in Figure 44 through 46. Occupant impact velocity in the longitudinal direction was 21.1 feet per second (6.4 m/s) and no occupant impact velocity existed in the lateral direction. The highest 0.10 second occupant ridedown acceleration was -2.7 g (longitudinal). Change in velocity was 18.4 mi/h (29.6 km/h) and change in momentum was 1,509 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. The occupant impact velocity was high (NCHRP Report 230 limit is 15 ft/s). In addition, the change in momentum was over the recommended limit of 1100 lb-s. This sign installation in "strong" soil is unacceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

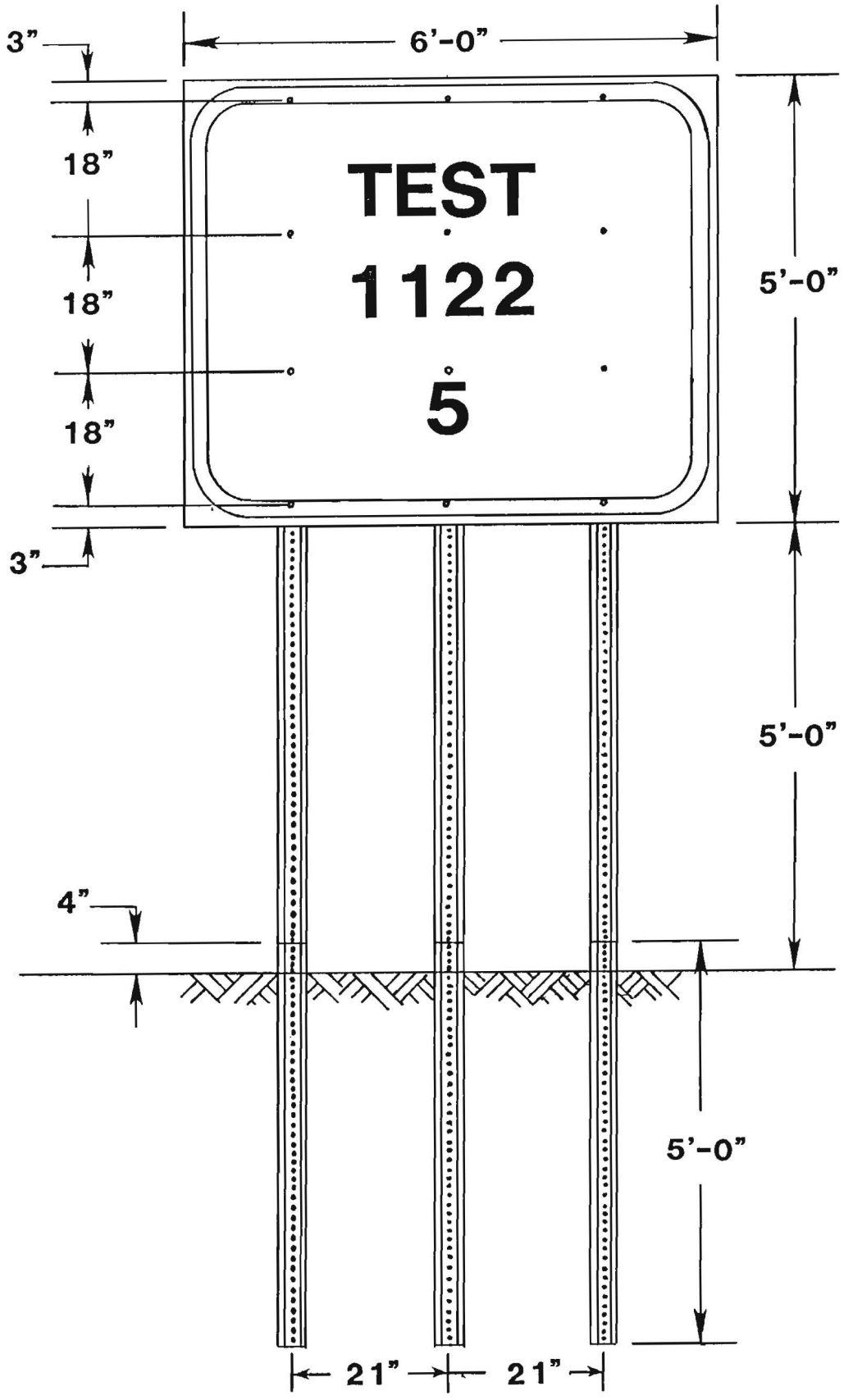


Figure 35. Details of sign installation for test 1122-5.

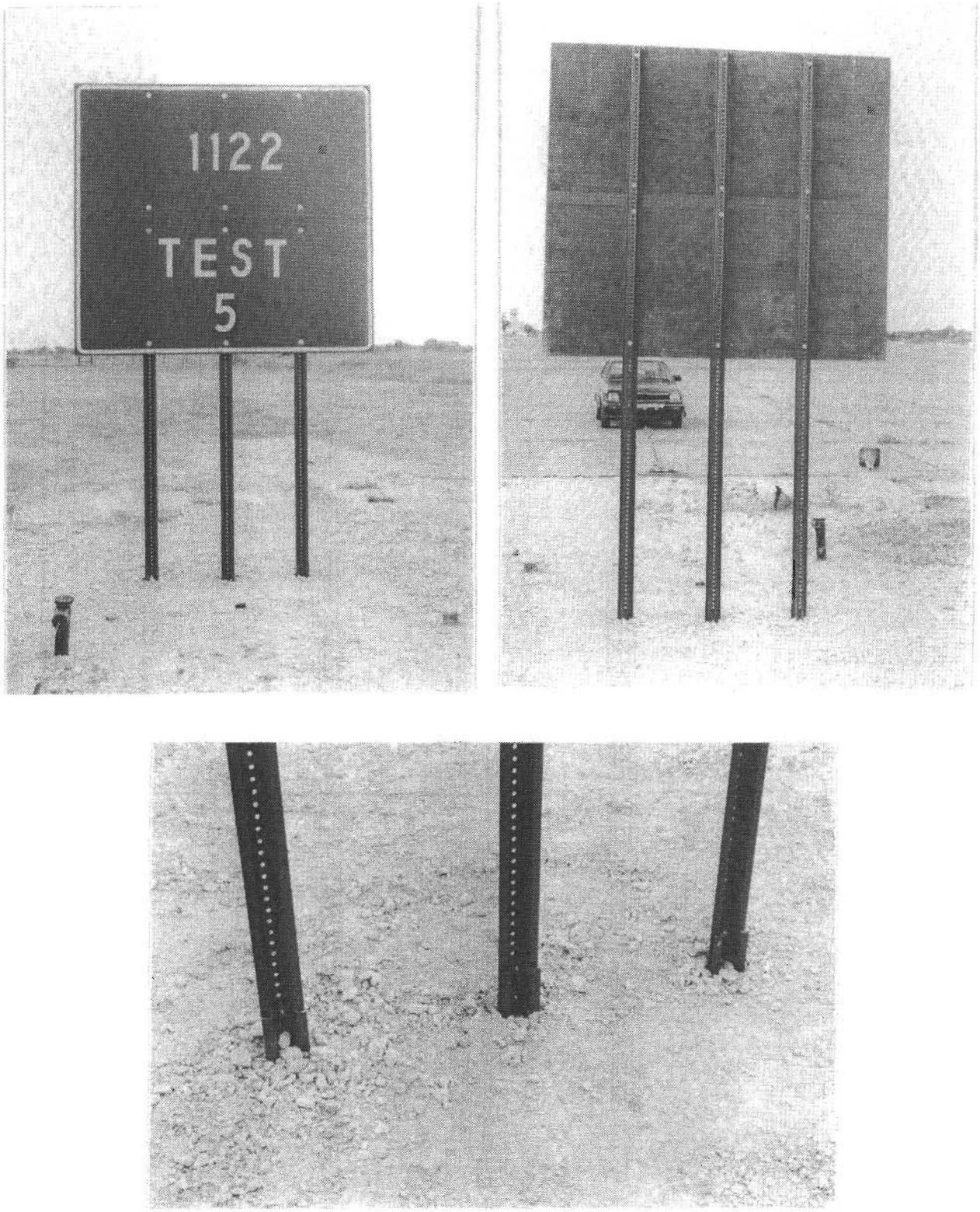


Figure 36. Sign installation before test 1122-5.

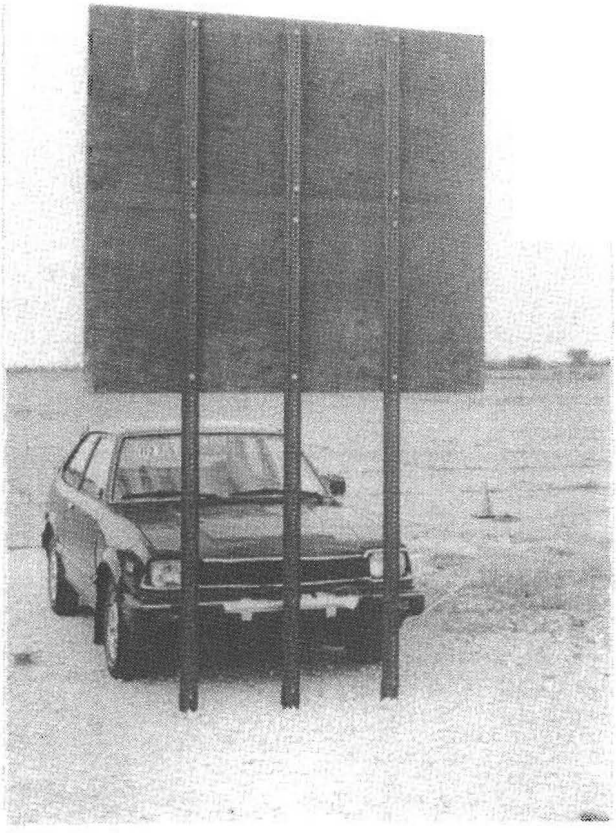
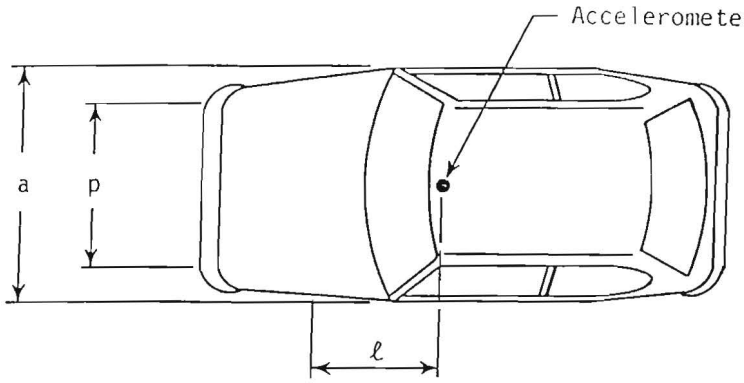


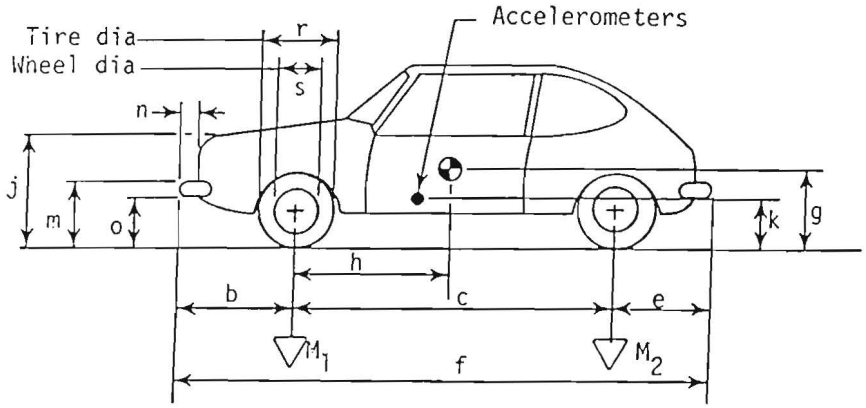
Figure 37. Vehicle before test 1122-5.

Date: 7-28-88 Test No. 1122-5 VIN: JHMSL5327CS012650

Make: Honda Model: Civic Year: 1982 Odometer: 110007

Tire Size: 155 SR13 Ply Rating: 1 Bias Ply: ___ Belted: ___ Radial: X





4-wheel weight for c.g. det. ℓf 600 rf 532 ℓr 329 rr 339

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1159	1132	1216
M_2	639	668	754
M_T	1798	1800	1970

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Tire Condition: good ___
fair X
badly worn ___

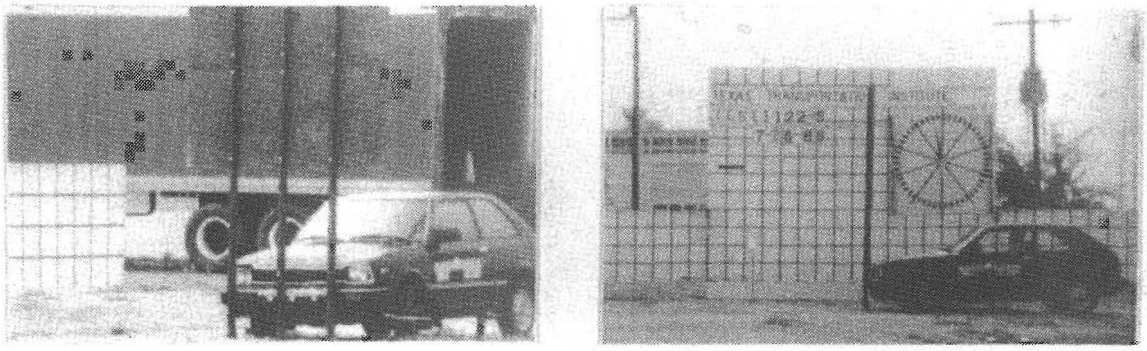
Vehicle Geometry - inches

a	62 3/4	b	30
c	88	d*	52 3/4
e	28	f	146
g	___	h	32.7
i	----	j	30
k	16 1/2	ℓ	28 1/2
m	19 1/2	n	4
o	13 3/4	p	54
r	21 3/4	s	14 1/4

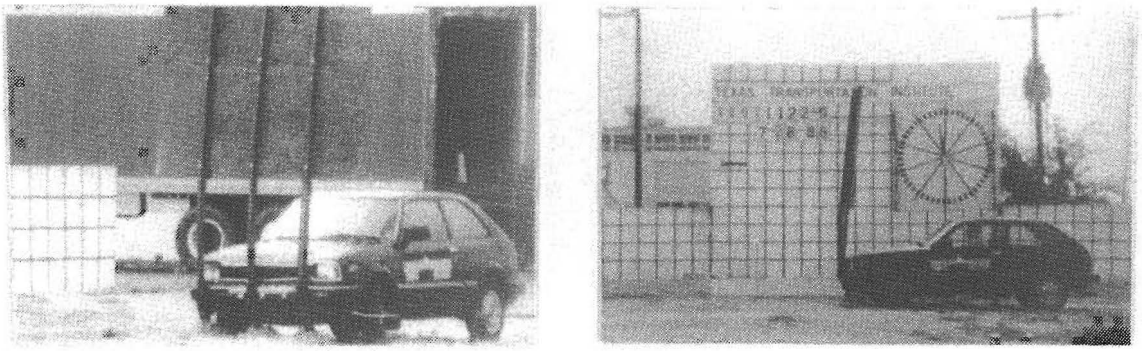
Engine Type: 4 cyl
Engine CID: ___
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD
Body Type: Hatch
Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

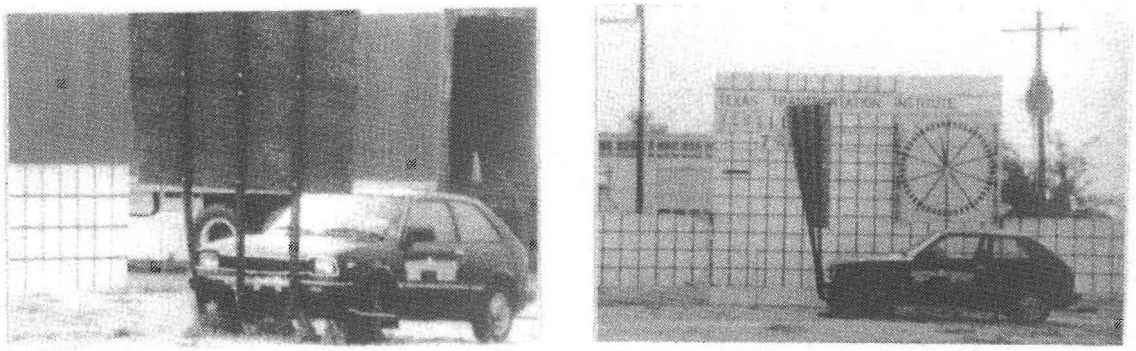
Figure 38. Test vehicle properties (1122-5).



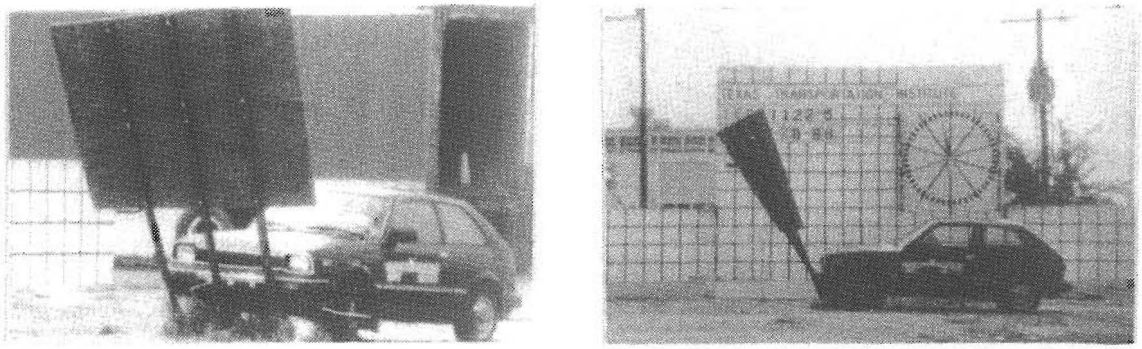
0.000 s



0.080 s

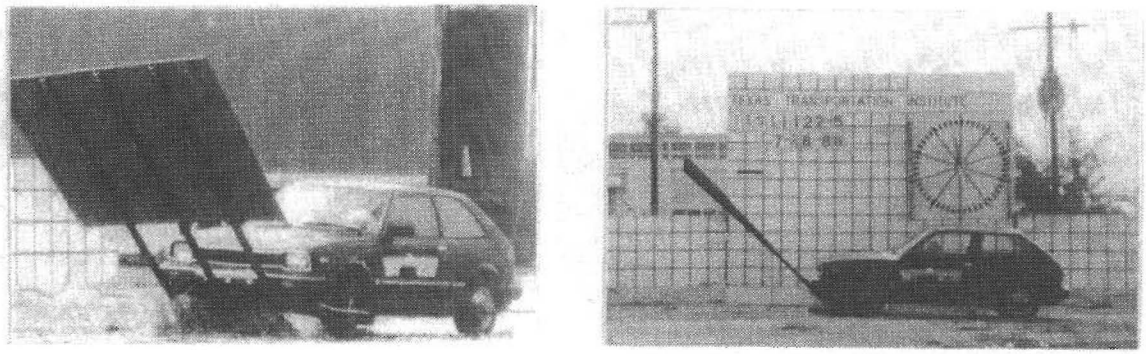


0.160 s

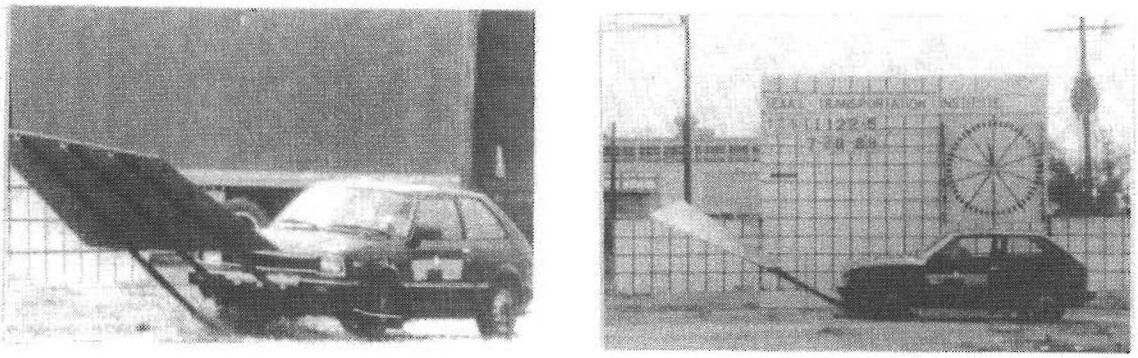


0.239 s

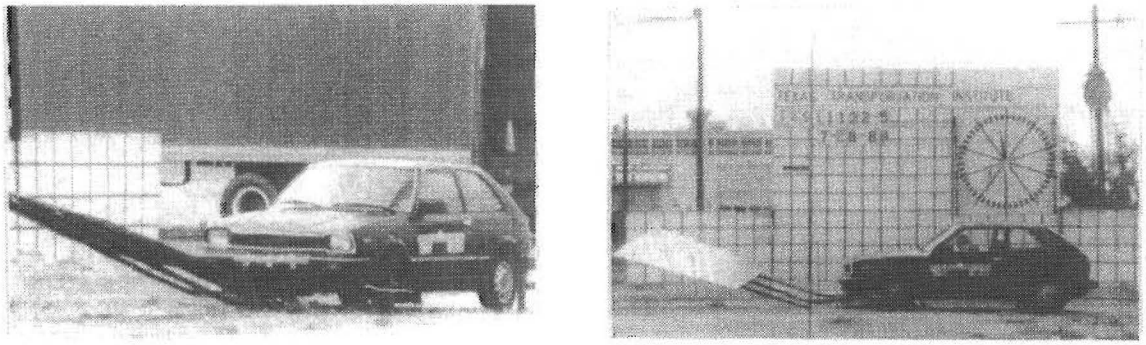
Figure 39. Sequential photographs for test 1122-5.



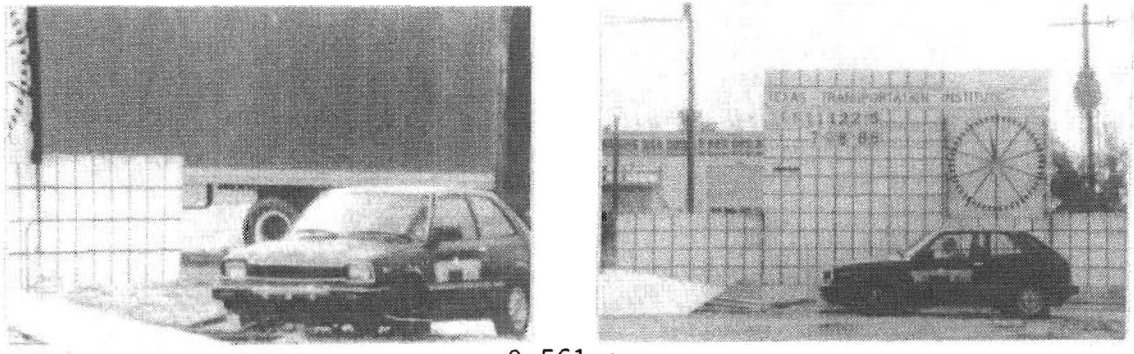
0.319 s



0.399 s



0.479 s



0.561 s

Figure 39. Sequential photographs for test 1122-5. (Continued)

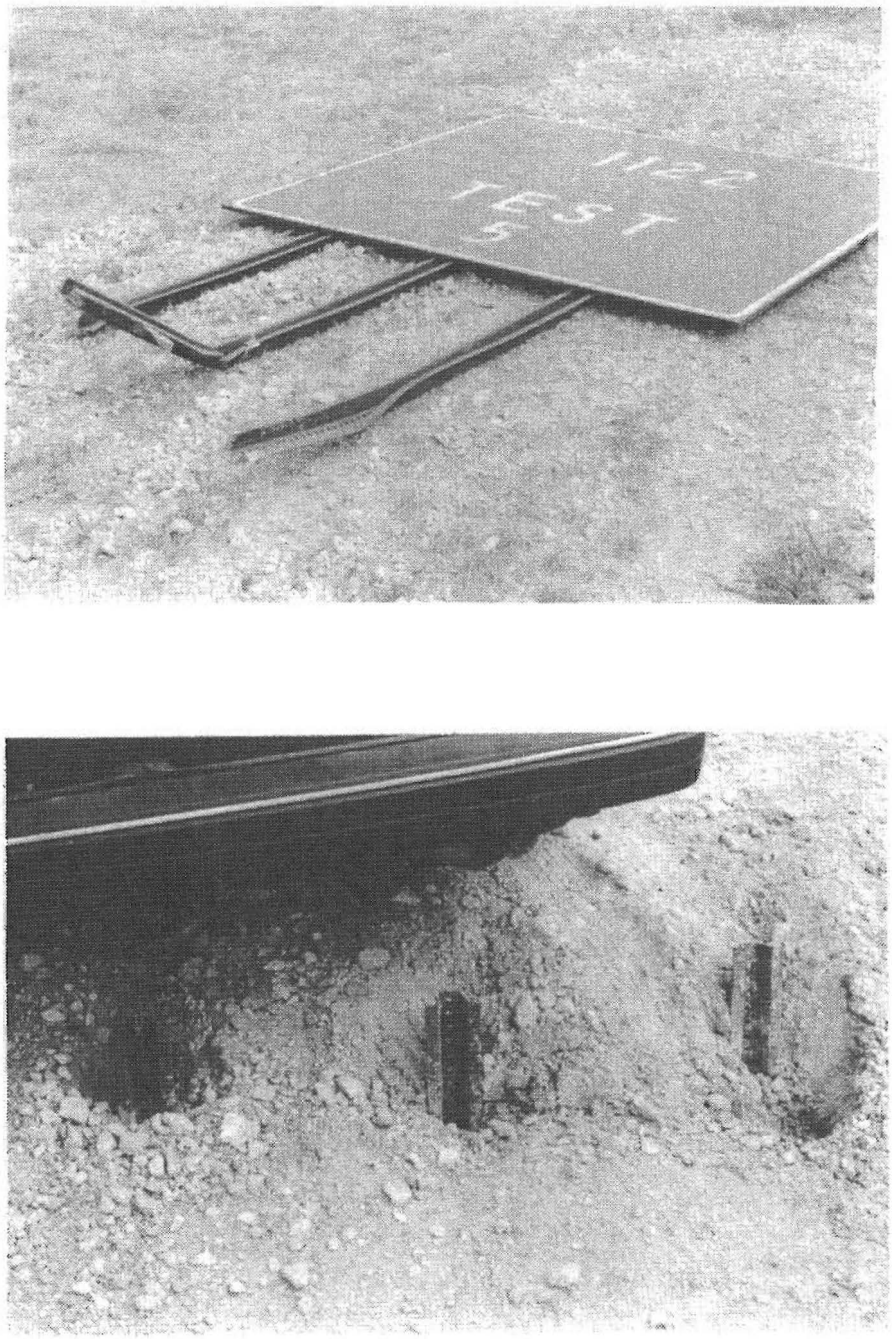
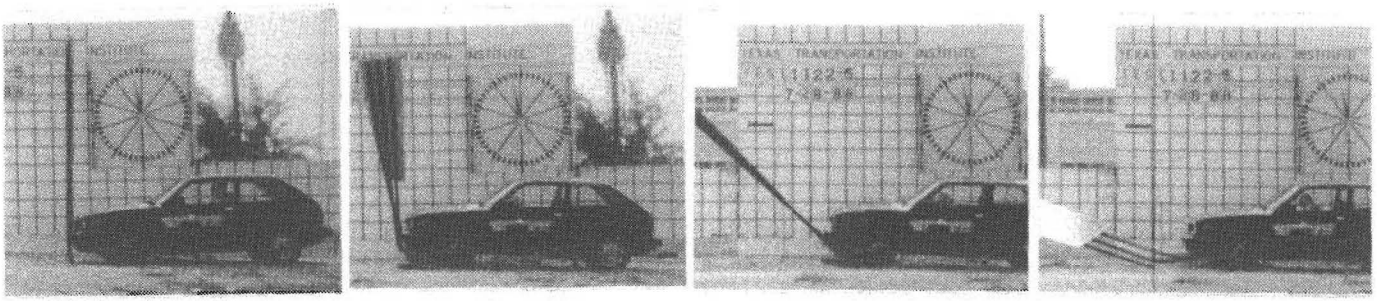
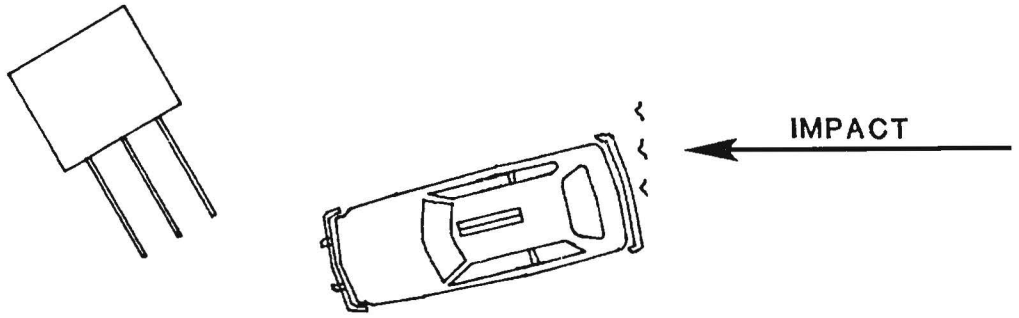


Figure 40. Sign installation after test 1122-5.

Figure 41. Vehicle after test 1122-5.



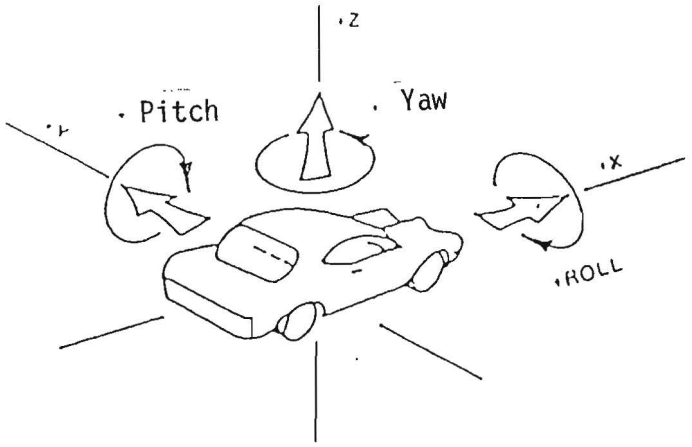
0.000 s 0.160 s 0.319 s 0.479 s



Test No.	1122-5
Date	07/28/88
Test Article	Sign Installation
Support	Three Marion 3.0 lb-ft Supports
Vehicle	1982 Honda
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,970 lb (894 kg)
Vehicle Damage Classification	
TAD	12FD1
SAE	12FDEW1

Impact Speed.	19.5 mi/h (31.4 km/h)
Change in Velocity . . .	18.4 mi/h (29.6 km/h)
Change in Momentum. . . .	1,509 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-6.5 g
Lateral	-0.9 g
Occupant Impact Velocity	
Longitudinal.	21.1 ft/s (6.4 m/s)
Lateral	N/A
Occupant Ridedown Accelerations	
Longitudinal	-2.7 g
Lateral	No Contact

Figure 42. Summary of results for test 1122-5.



Axes are vehicle fixed.
Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

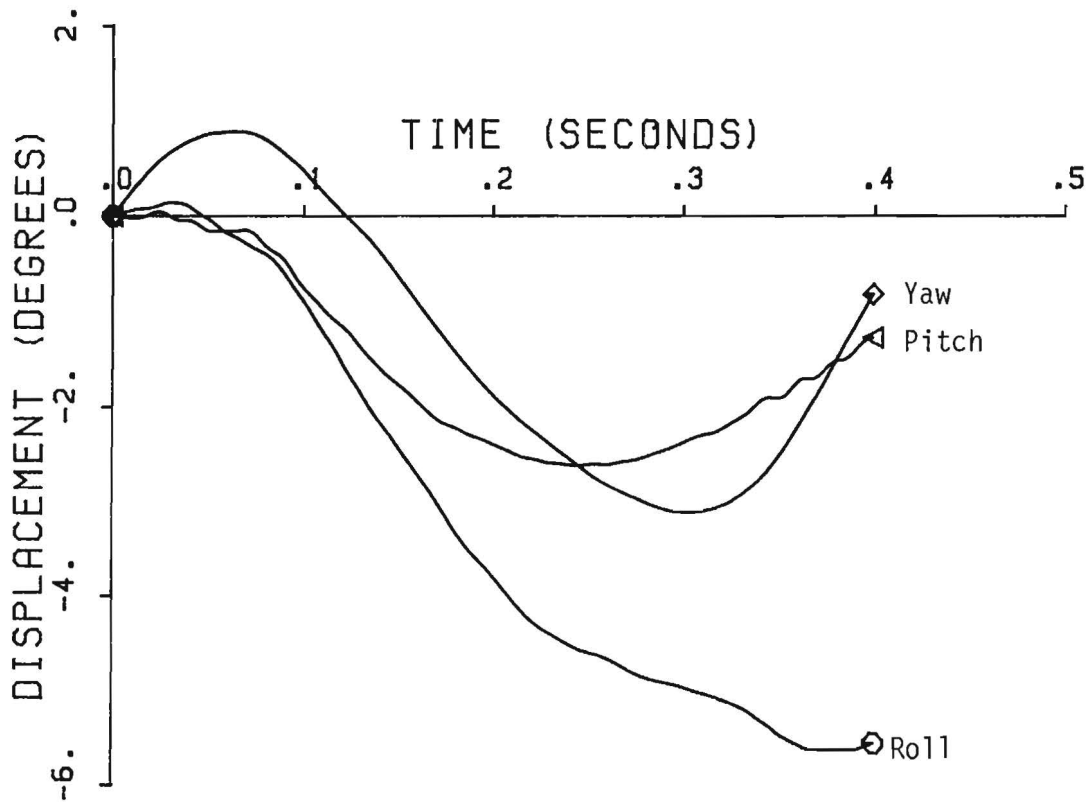


Figure 43. Vehicle angular displacements for test 1122-5.

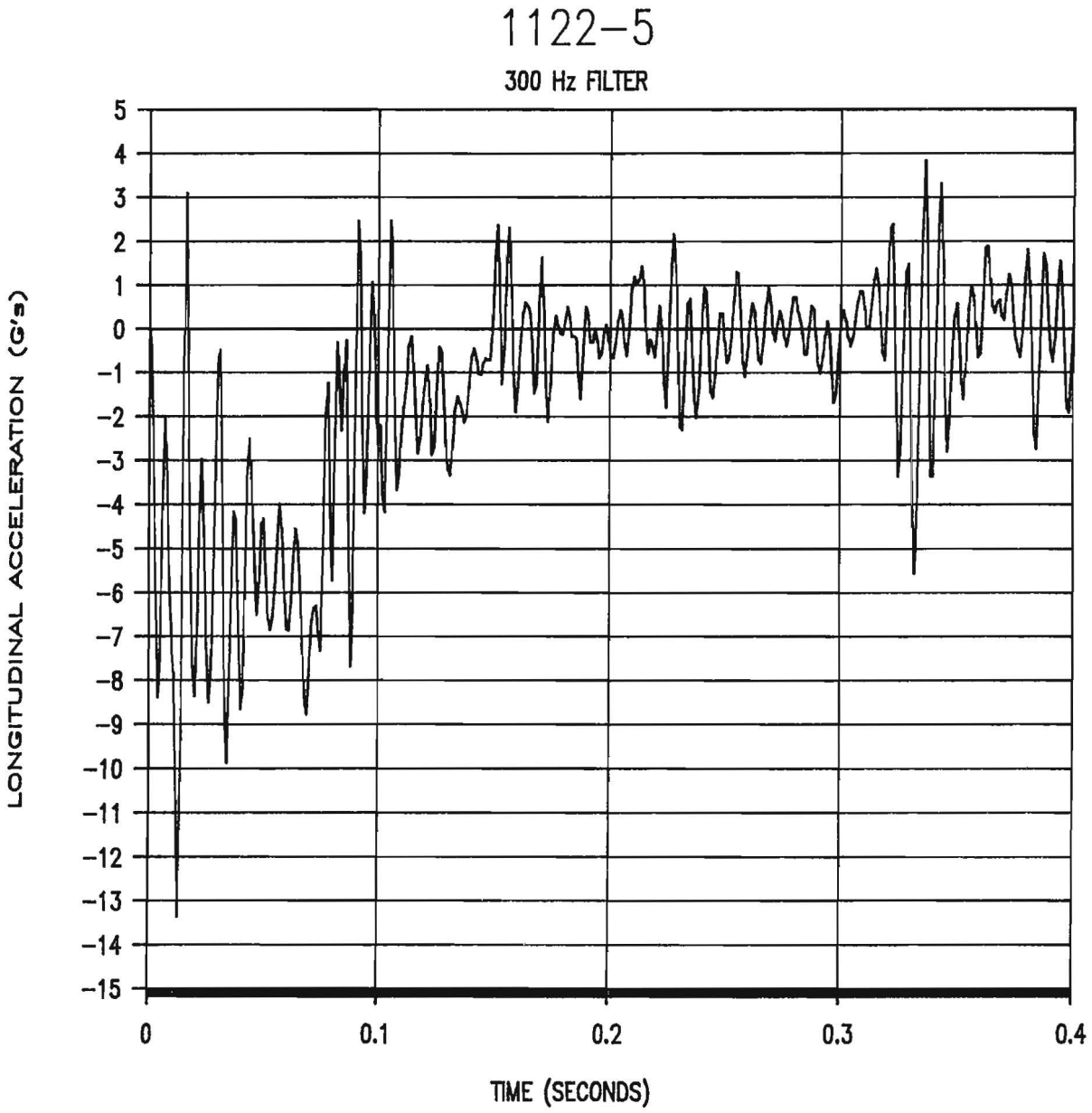


Figure 44. Longitudinal accelerometer trace for test 1122-5.

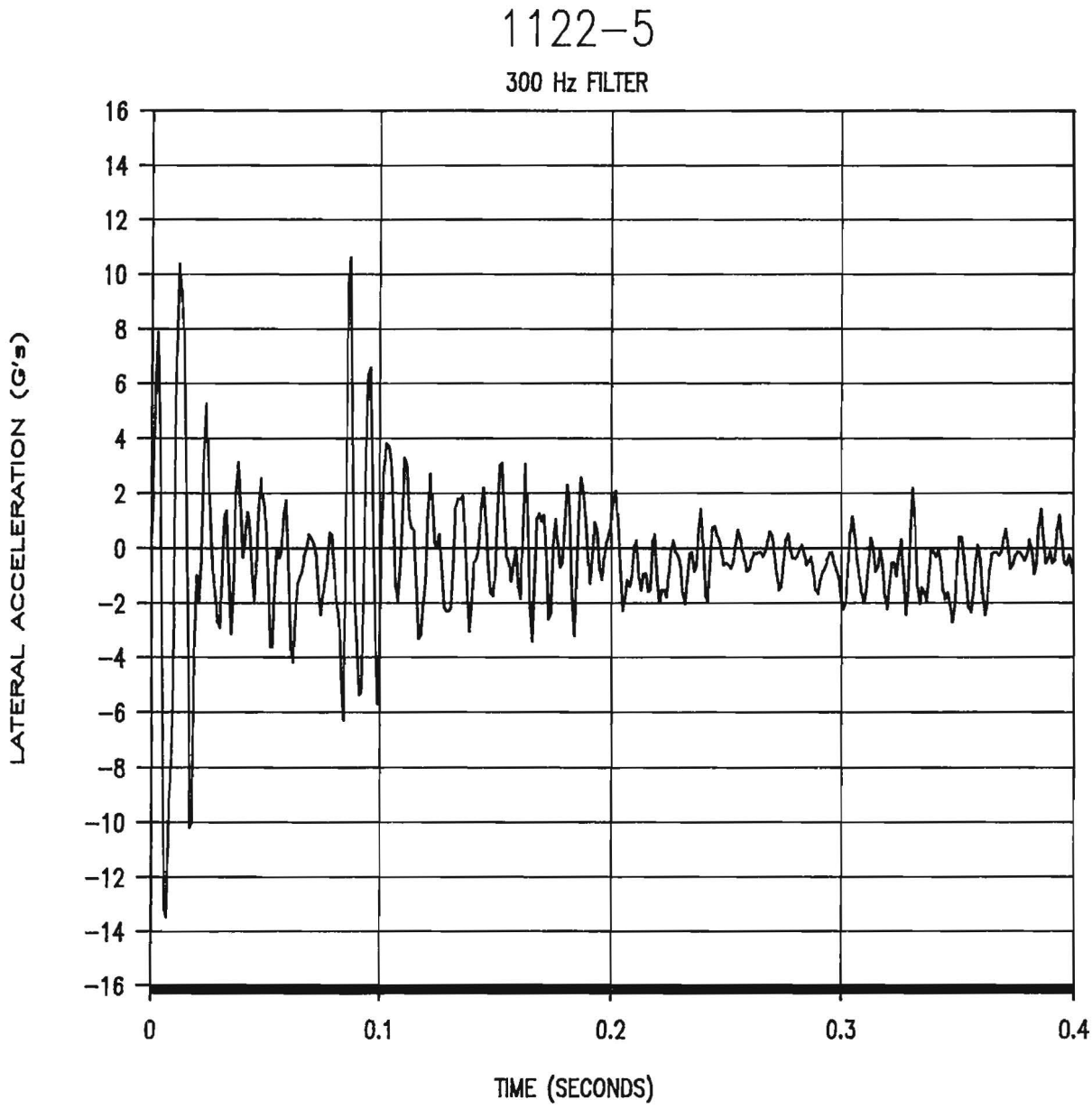


Figure 45. Lateral accelerometer trace for test 1122-5.

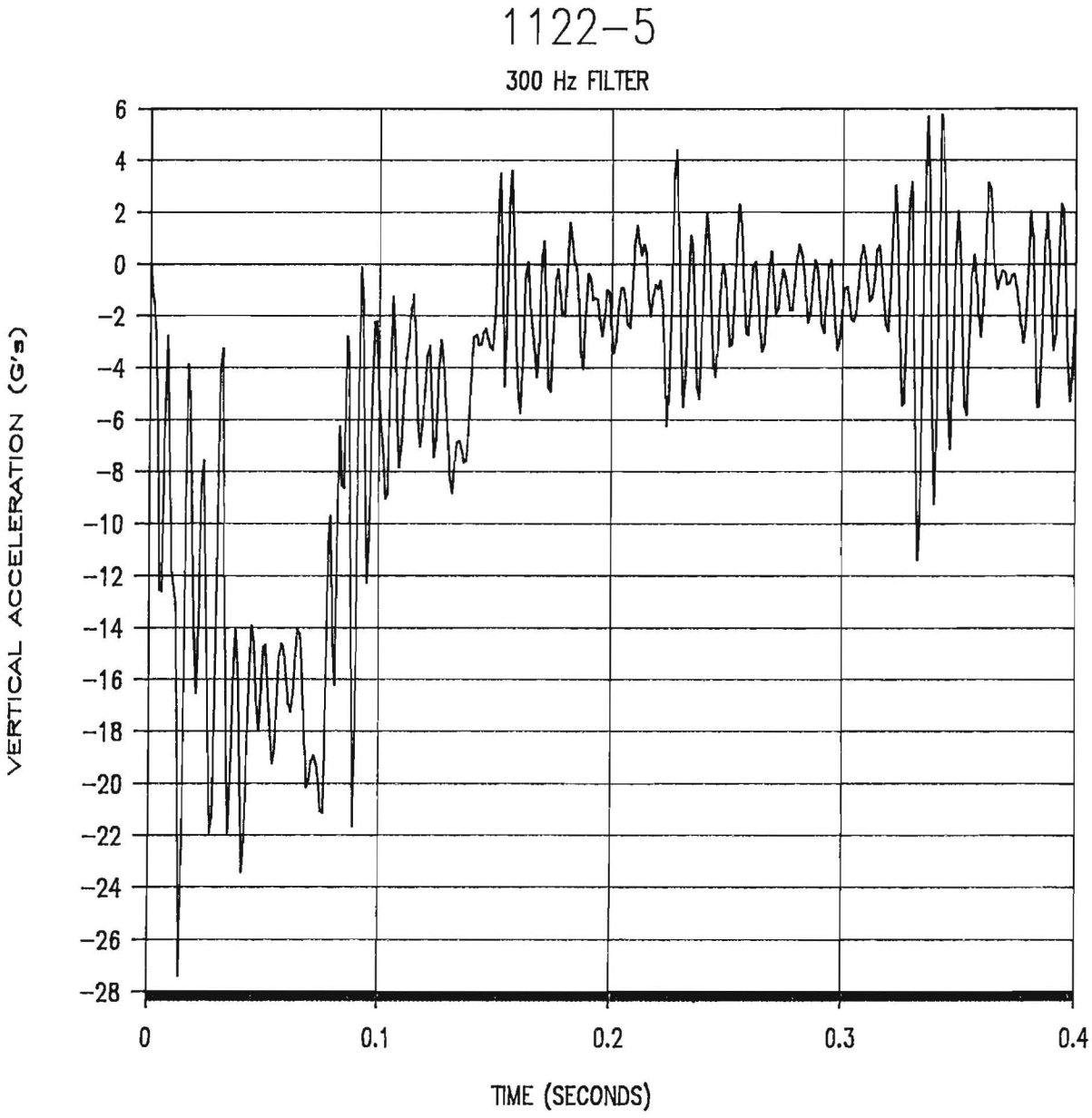


Figure 46. Vertical accelerometer trace for test 1122-5.

DESCRIPTION OF TEST INSTALLATION FOR 1122-6, 6A & 7

The sign installation used in these tests consisted of a 4 ft-0 in wide x 6 ft-0 in high plywood sign panel mounted on two Franklin 4.0 lb-ft steel supports. These supports were attached to two 40 inch stubs which had been driven into crushed limestone at 36 inches on center spacing. The supports were attached to the stubs in a 3.0 inch nested splice (stubs in front of sign supports) with 1/2 inch spacers and 5/16 inch grade 9 bolts, nuts and washers. The bottom of sign mounting height was 5 ft. Details of the sign installation are shown in Figures 47 and 48.

TEST REPORT 1122-6

VEHICLE: 1983 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,970 lbs.

TEST ARTICLE: Multi-Leg Sign Installation
Support: Two Franklin
4.0 lb-ft supports

IMPACT CONDITIONS: 18.6 mi/h
Center (impact both
legs of sign)

Crash Test Results

A 1983 Honda Civic (shown in Figure 49) impacted the sign installation at 18.6 miles per hour (29.9 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,970 lb (894 kg). The height to the lower edge of the vehicle bumper was 14.5 inches (36.8 cm) and 20.0 inches (50.8 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 50.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the center of the vehicle. Upon impact, the sign supports began to deform and by 0.100 seconds the splice joint bolts had fractured. At approximately 0.301 seconds, the vehicle lost contact with the sign installation, the brakes were applied and the vehicle came to rest 21 ft (6.4 m) from the point of impact. Sequential photographs of the test are shown in Figure 51.

The sign installation stubs were pushed rearward 3.0 in (7.6 cm) and the two sign supports were bent and scraped up to 28.0 in (71.1 cm) above ground level. In addition, the lower 15.0 in (38.1 cm) of the right support was completely detached. The sign installation came to rest 26.0 ft (7.9 m) from the

point of impact. The vehicle sustained minor damage to the bumper and windshield as shown in Figure 53

A summary of the test results and other information pertinent to this test are given in Figure 54. The maximum 0.050 second average acceleration experienced by the vehicle was -5.8 g in the longitudinal direction and -1.1 g in the lateral direction. Vehicle angular displacements are plotted in Figure 55 and vehicle accelerometer traces are displayed in Figure 56 through 58. Occupant impact velocity in the longitudinal direction was 20.1 feet per second (6.1 m/s) and no occupant impact velocity existed in the lateral direction. The highest 0.10 second occupant ridedown acceleration was -0.8 g (longitudinal). Change in velocity was 14.9 mi/h (23.9 km/h) and change in momentum was 1218 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. However, the occupant impact velocity and the change in momentum were over the recommended limits. While not acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards, test conditions did not represent "strong" soil because of improper compaction.

TEST REPORT 1122-6A

VEHICLE: 1981 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,967 lbs.

TEST ARTICLE: Multi-Leg Sign Installation
Support: Two Franklin
4.0 lb-ft supports

IMPACT CONDITIONS: 18.9 mi/h
Center (impact both
legs of sign)

Crash Test Results

A 1981 Honda Civic (shown in Figure 59) impacted the sign installation at 18.9 miles per hour (30.4 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,967 lb (892 kg). The height to the lower edge of the vehicle bumper was 13.5 inches (34.3 cm) and 19.5 inches (49.5 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 60.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the center of the vehicle.

Upon impact, the sign supports began to deform and by 0.023 second the splice joint bolts had fractured. At approximately 1.33 seconds, as the sign yielded, the face of the sign struck the roof of the vehicle. Shortly thereafter, the vehicle lost contact with the installation, the brakes were applied and the vehicle came to rest 42 ft (12.8 m) from the point of impact. Sequential photographs of the test are shown in Figure 61.

The sign installation stubs were pushed rearward 1.0 in (2.5 cm) and the two sign supports were bent and scraped up to 28.0 in (71.1 cm) above ground level. The sign installation came to rest 36.0 ft (11.0 m) from the point of impact. The vehicle sustained minor damage to the bumper, hood and right front fender as shown in Figure 63.

A summary of the test results and other information pertinent to this test are given in Figure 64. The maximum 0.050 second average acceleration experienced by the vehicle was -3.6 g in the longitudinal direction and -1.0 g in the lateral direction. Vehicle angular displacements are plotted in Figure 65 and vehicle accelerometer traces are displayed in Figure 66 through 68. Occupant impact velocity in the longitudinal direction was 10.2 feet per second (3.1 m/s) and no occupant impact velocity existed in the lateral direction. The highest 0.10 second occupant ridedown acceleration was -0.6 g (longitudinal). Change in velocity was 7.2 mi/h (11.6 km/h) and change in momentum was 590 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. The occupant impact velocity was below the NCHRP Report 230 recommended limit of 15 ft/s. In addition, the change in momentum was also below the recommended limit of 1100 lb-s. This sign installation in "strong" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

TEST REPORT 1122-7

VEHICLE: 1983 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,970 lbs.

TEST ARTICLE: Multi-Leg Sign Installation
Support: Two Franklin
4.0 lb-ft supports

IMPACT CONDITIONS: 60.5 mi/h
Center (impact both
legs of sign)

Crash Test Results

A 1983 Honda Civic (shown in Figure 69) impacted the sign installation at 60.5 miles per hour (97.3 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,970 lb (894 kg). The height to the lower edge of the vehicle bumper was 14.5 inches (36.8 cm) and 20.0 inches (50.8 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 70.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the center of the vehicle. Upon impact, the sign supports began to deform and by 0.013 seconds the splice joint bolts had fractured. At approximately 0.156 seconds, as the sign yielded and the test vehicle passed beneath, the face of the sign slapped the roof of the vehicle. At approximately 0.201 seconds, the vehicle lost contact with the sign installation, the brakes were applied and the vehicle came to rest 180 ft (54.9 m) from the point of impact. Sequential photographs of the test are shown in Figure 71.

The sign installation stubs were pushed rearward 1.0 in (2.5 cm) and the two sign supports were bent and scraped. In addition, the right support became completely detached from the sign panel. The sign installation came to rest 27.0 ft (8.2 m) from the point of impact. The vehicle sustained minor damage to the bumper, hood and roof as shown in Figure 73.

A summary of the test results and other information pertinent to this test are given in Figure 74. The maximum 0.050 second average acceleration experienced by the vehicle was -3.1 g in the longitudinal direction and -0.7 g in the lateral direction. Vehicle angular displacements are plotted in Figure 75 and vehicle accelerometer traces are displayed in Figure 76 through 78. No contact by the anthropomorphic dummy was made. Therefore, no occupant impact velocity or ridedown accelerations were recorded in the longitudinal or lateral direction. Change in velocity was 5.4 mi/h (8.7 km/h) and change in momentum was 445 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. No occupant impact velocity or ridedown accelerations were recorded. The change in momentum was considerably under the recommended limit of 1100 lb-s. This sign installation in "strong" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

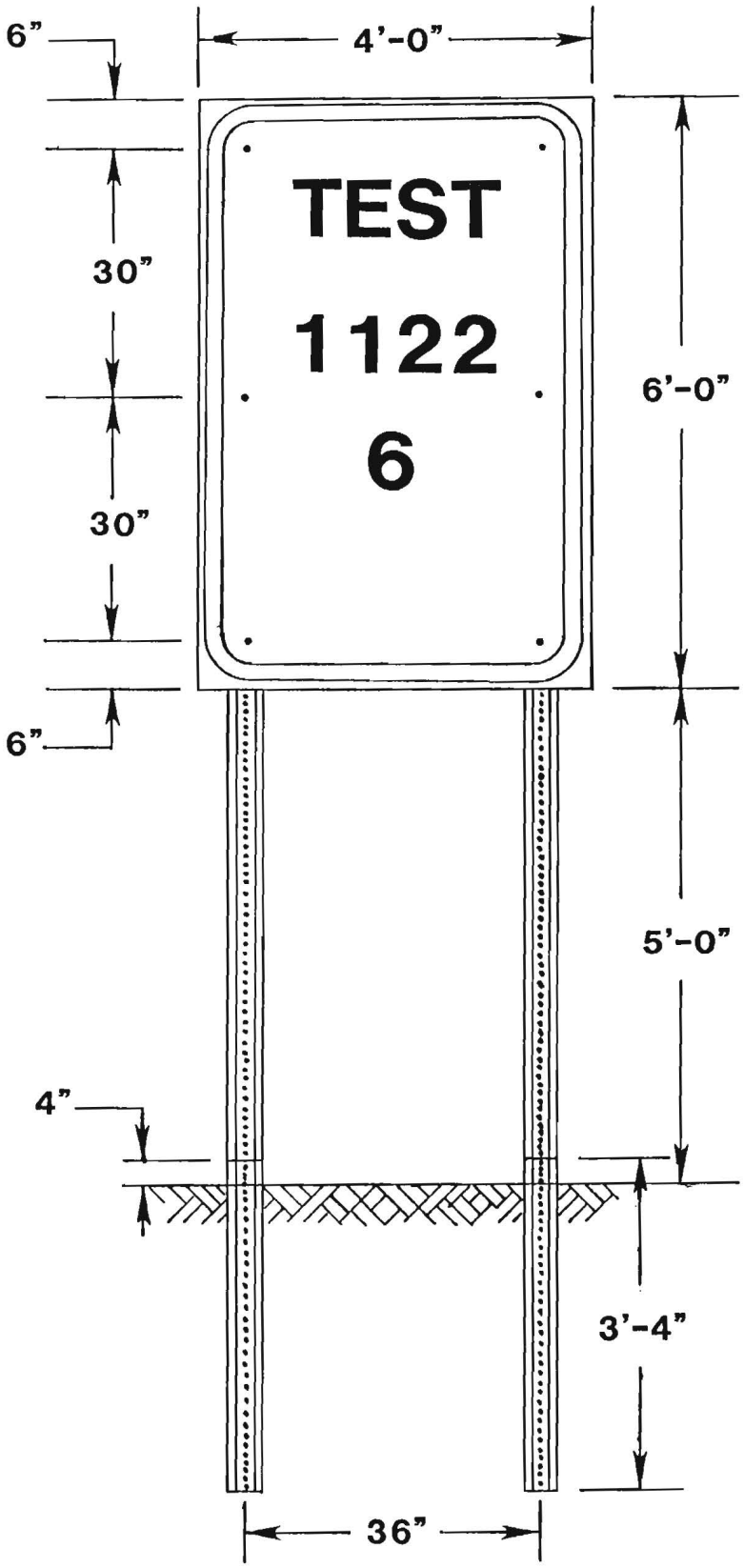


Figure 47. Details of sign installation for test 1122-6.

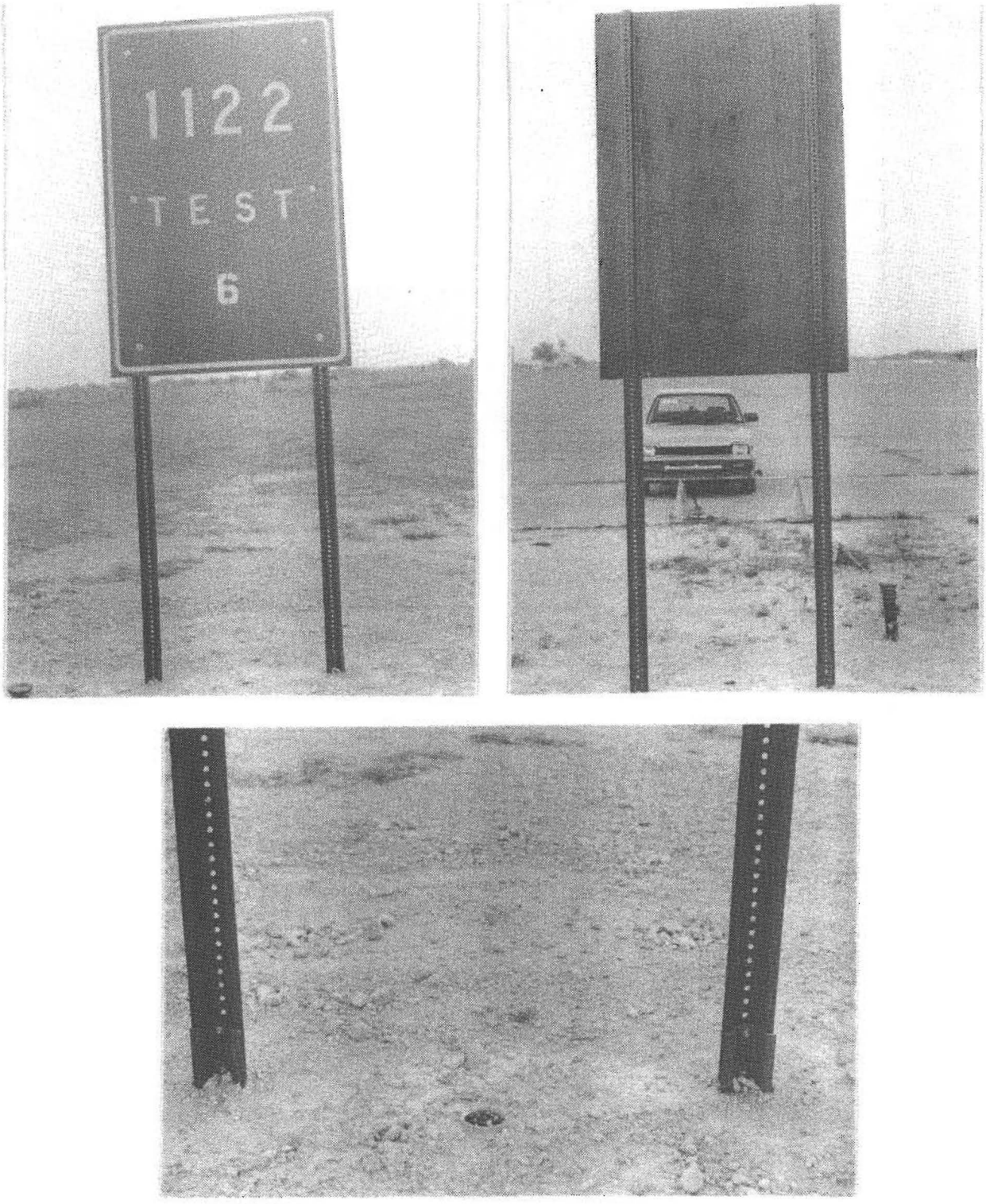


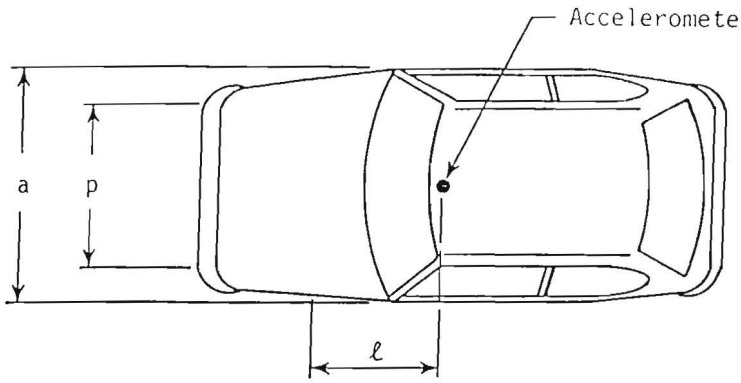
Figure 48. Sign installation before test 1122-6.

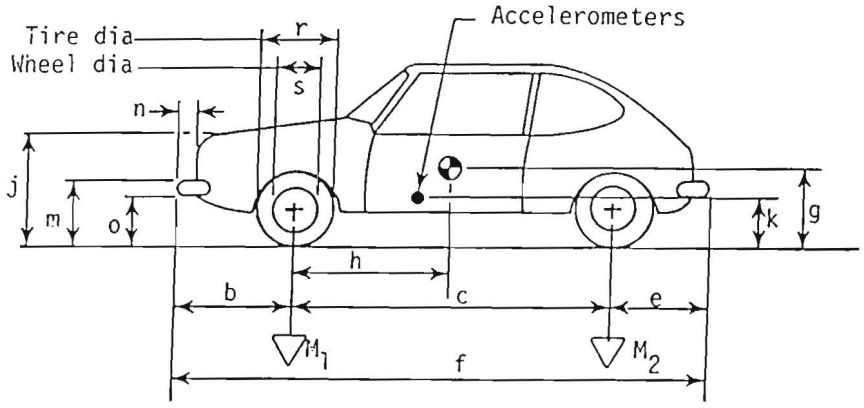
Date: 8/9/88 Test No.: 1122-6 VIN: JHMSL5327DS021592

Make: Honda Model: Civic Year: 1983 Odometer: 67360

Tire Size: P165/80R13 Ply Rating: 3 Bias Ply: ___ Belted: ___ Radial: X

Tire Condition: good X
fair ___
badly worn ___





4-wheel weight for c.g. det. ℓf 599 rf 568 ℓr 308 rr 325

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1164	1167	1246
M_2	640	633	724
M_T	1804	1800	1970

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Vehicle Geometry - inches

a	62 1/2	b	30
c	88	d*	53
e	29 1/2	f	147.5
g		h	30.9
i	----	j	28 1/2
k	16 3/4	ℓ	28 1/2
m	20	n	4
o	14 1/2	p	53 1/4
r	22 1/2	s	14 1/4

Engine Type: 4 cyl

Engine CID: ___

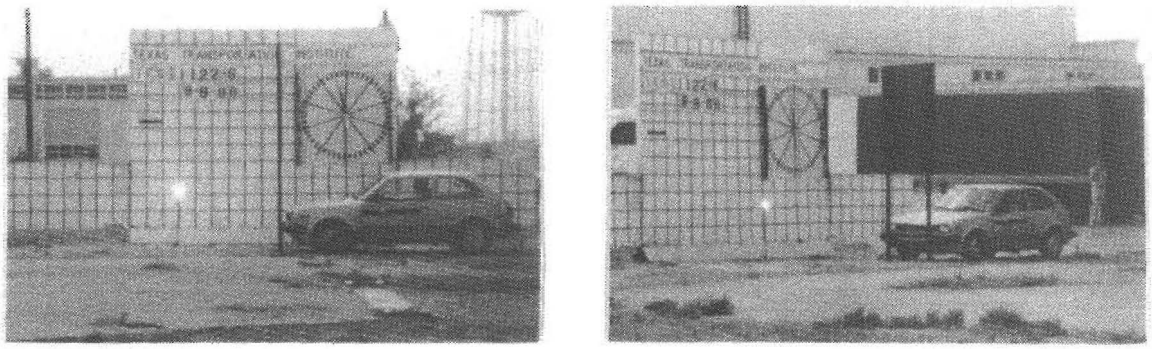
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD

Body Type: Hatch

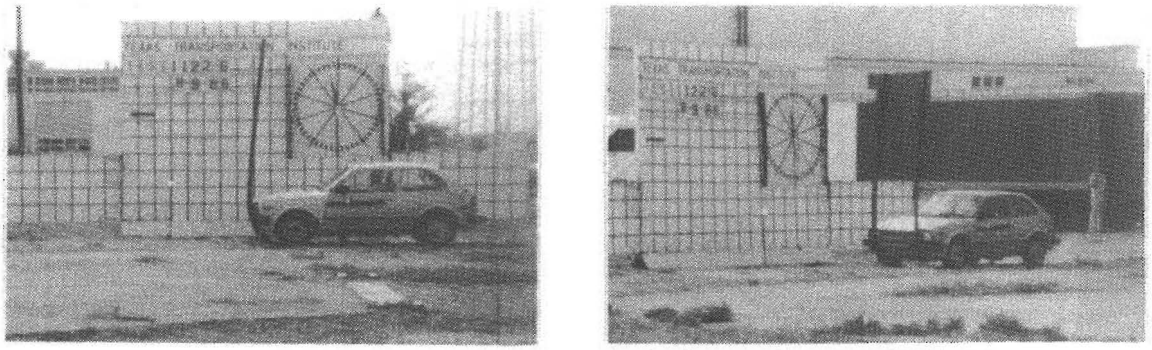
Steering Column Collapse Mechanism:
___ Behind wheel units
___ Convoluted tube
___ Cylindrical mesh units
___ Embedded ball
___ NOT collapsible
___ Other energy absorption
___ Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

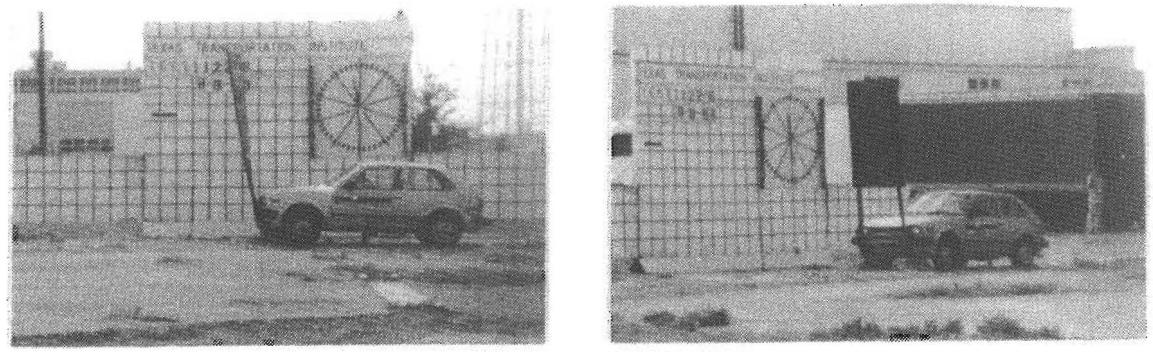
Figure 50. Test vehicle properties (1122-6).



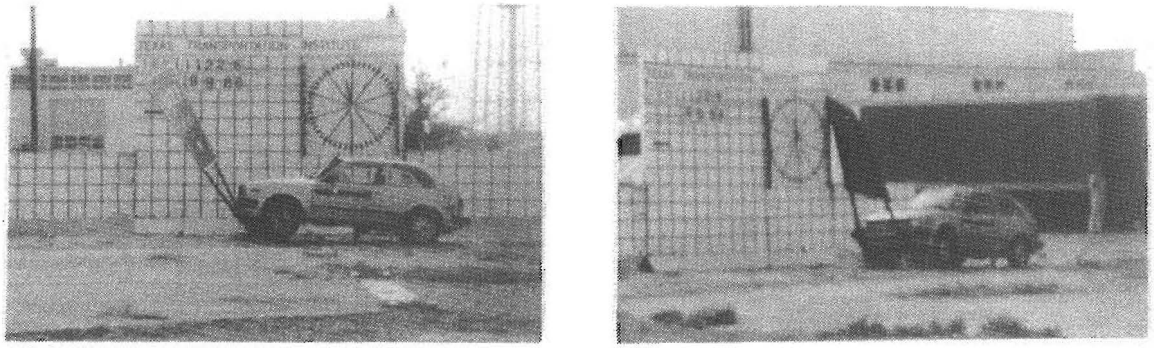
0.000 s



0.070 s

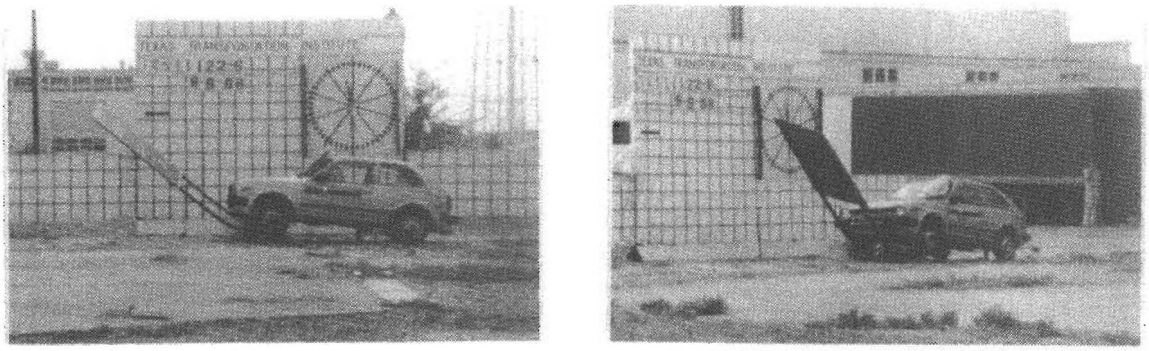


0.140 s

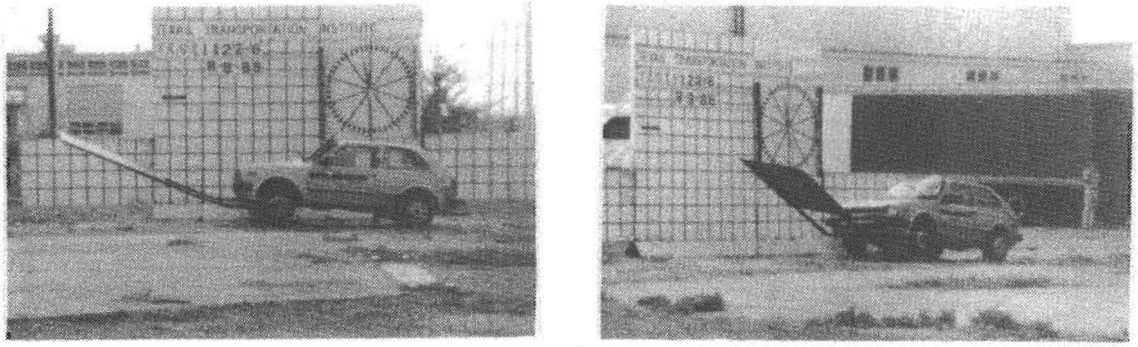


0.213 s

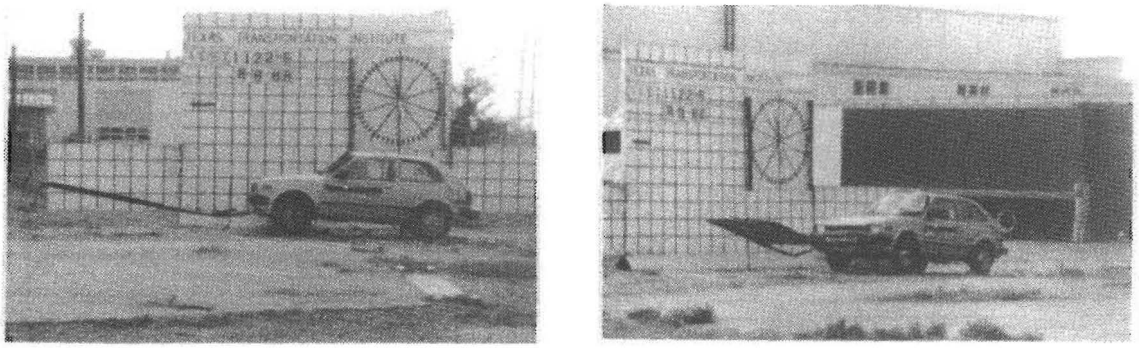
Figure 51. Sequential photographs for test 1122-6.



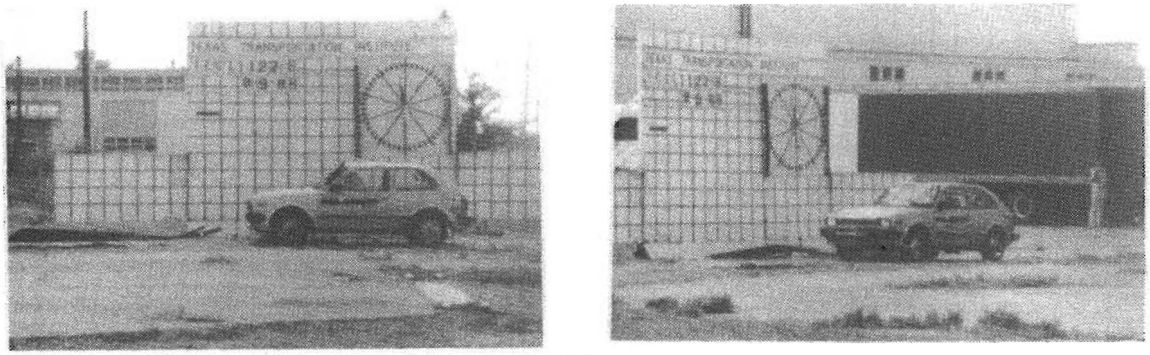
0.286 s



0.359 s



0.431 s



0.502 s

Figure 51. Sequential photogrpahs for test 1122-6. (Continued)

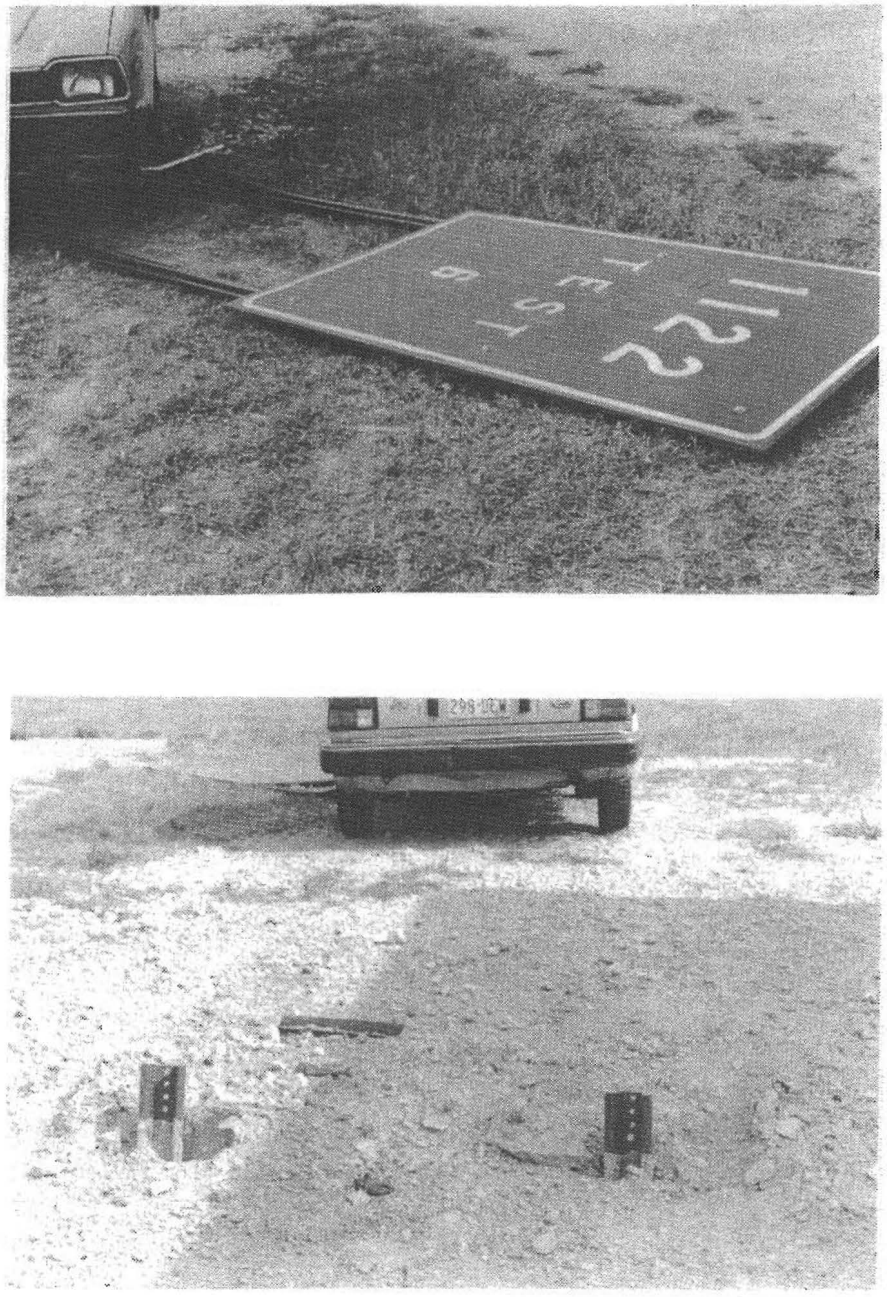


Figure 52. Sign installation after test 1122-6.

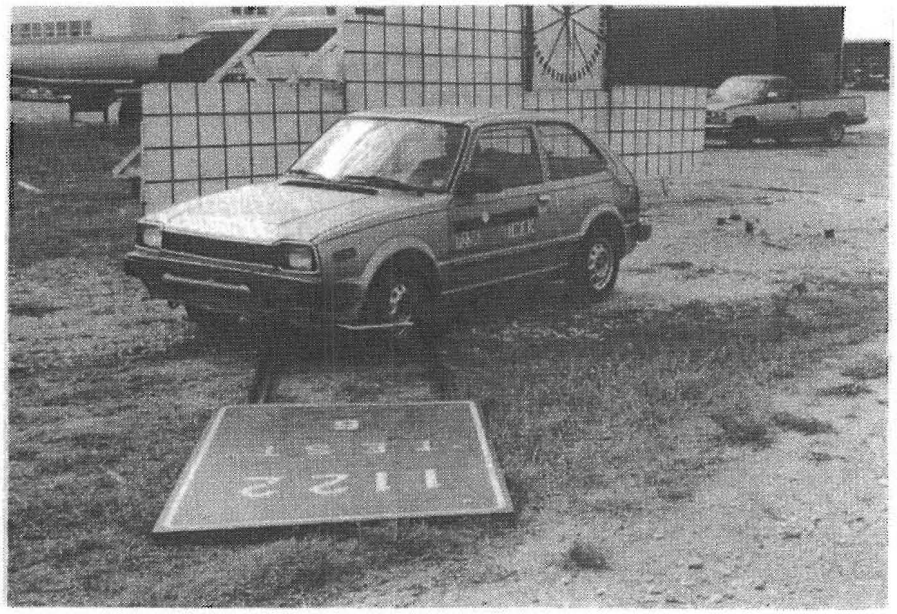
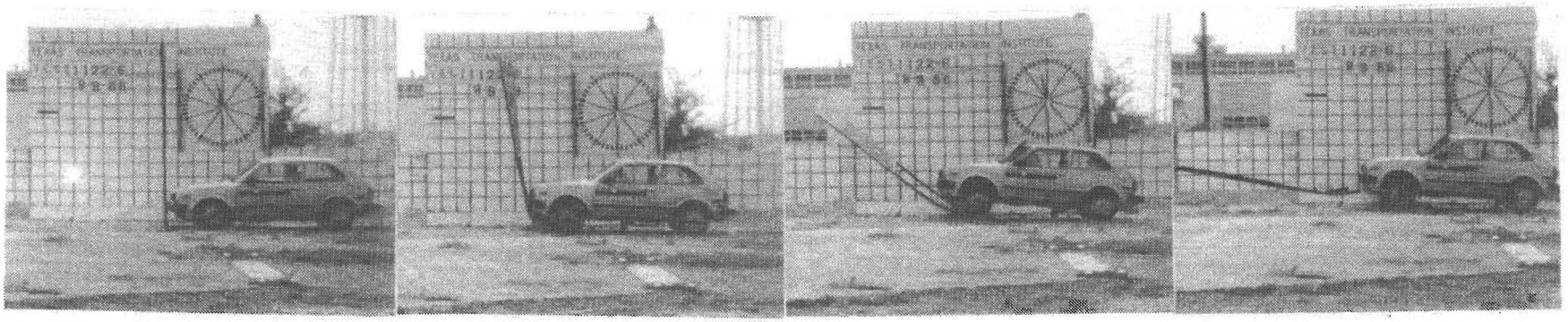
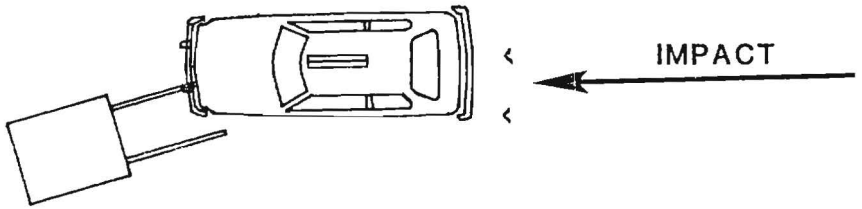


Figure 53. Vehicle after test 1122-6.



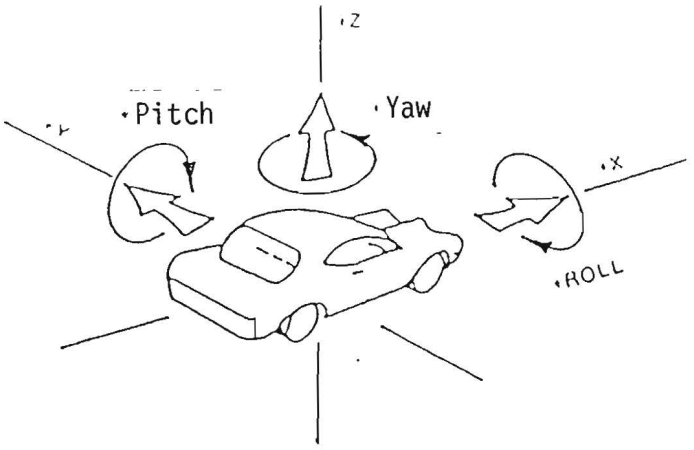
0.000 s 0.140 s 0.286 s 0.431 s



Test No.	1122-6
Date	08/09/88
Test Article	Sign Installation
Support	Two Franklin 4 lb-ft Supports
Vehicle	1983 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,970 lb (894 kg)
Vehicle Damage Classification	
TAD	12FD1
SAE	12FDEW1

Impact Speed.	18.6 mi/h (29.9 km/h)
Change in Velocity . . .	14.9 mi/h (23.9 km/h)
Change in Momentum. . . .	1,218 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-5.8 g
Lateral	1.1 g
Occupant Impact Velocity	
Longitudinal.	20.1 ft/s (6.1 m/s)
Lateral	None
Occupant Ridedown Accelerations	
Longitudinal	-0.8 g
Lateral	No Contact

Figure 54. Summary of results for test 1122-6.



Axes are vehicle fixed. Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

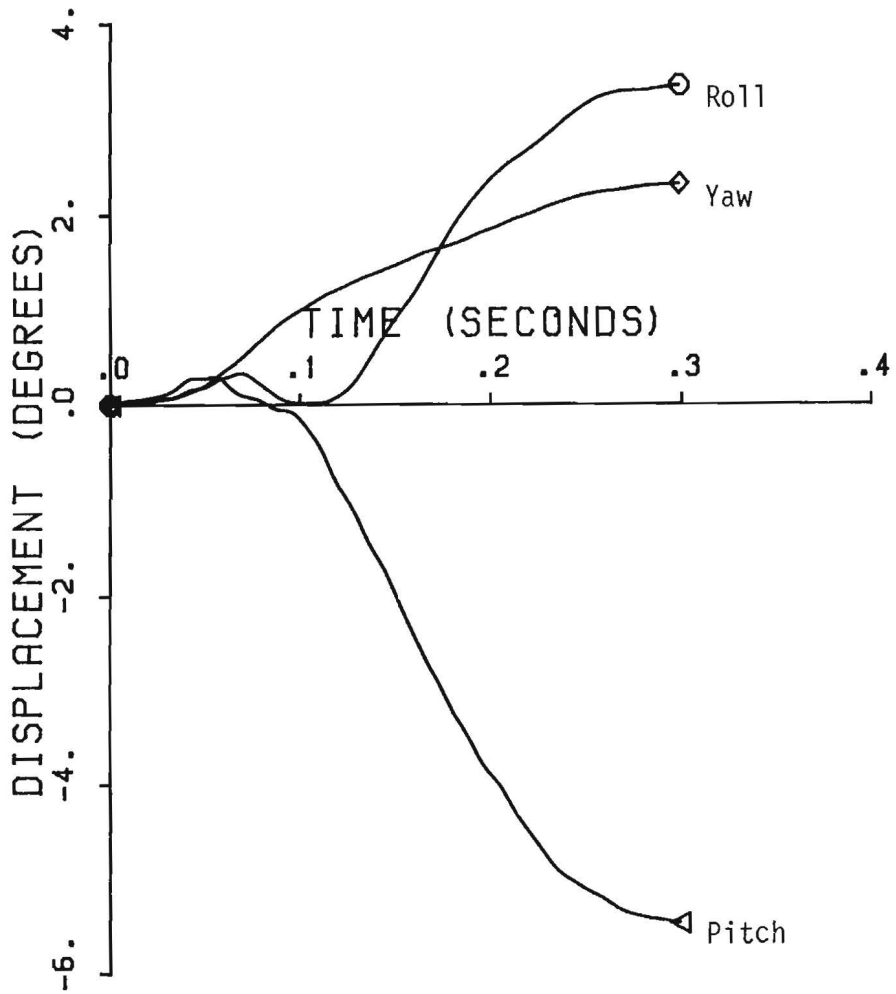


Figure 55. Vehicle angular displacements for test 1122-6.

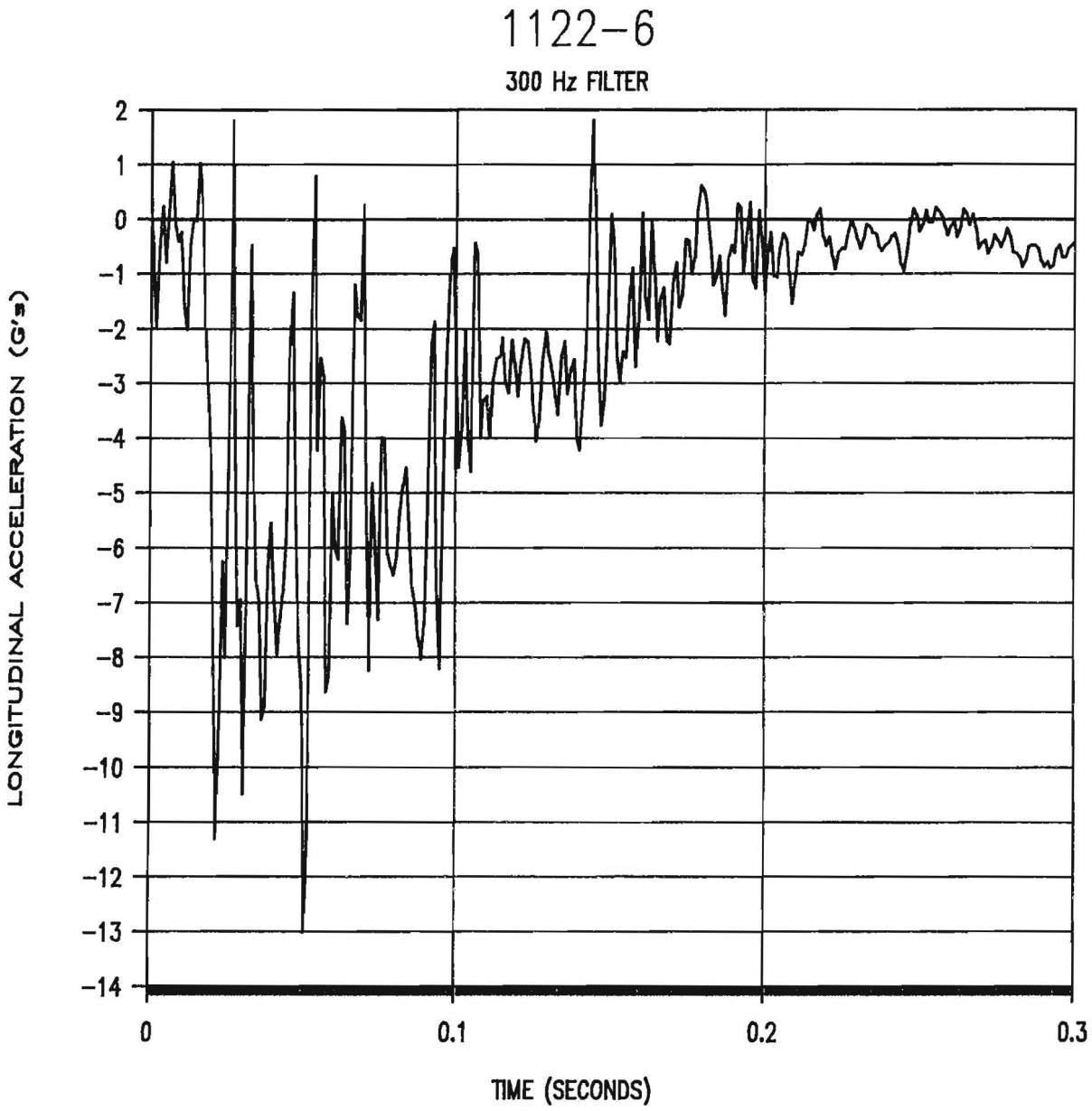


Figure 56. Longitudinal accelerometer trace for test 1122-6.

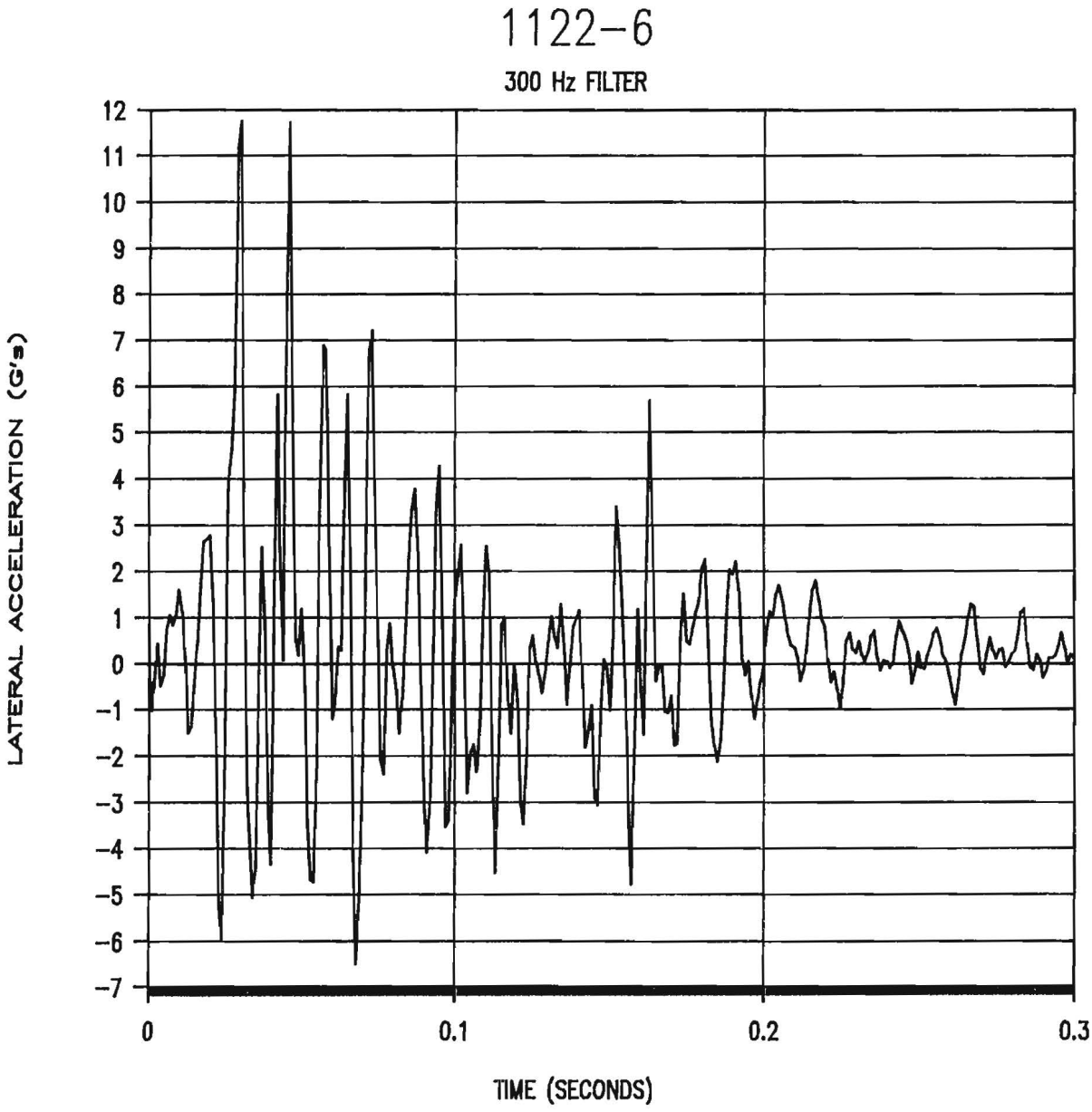


Figure 57. Lateral accelerometer trace for test 1122-6.

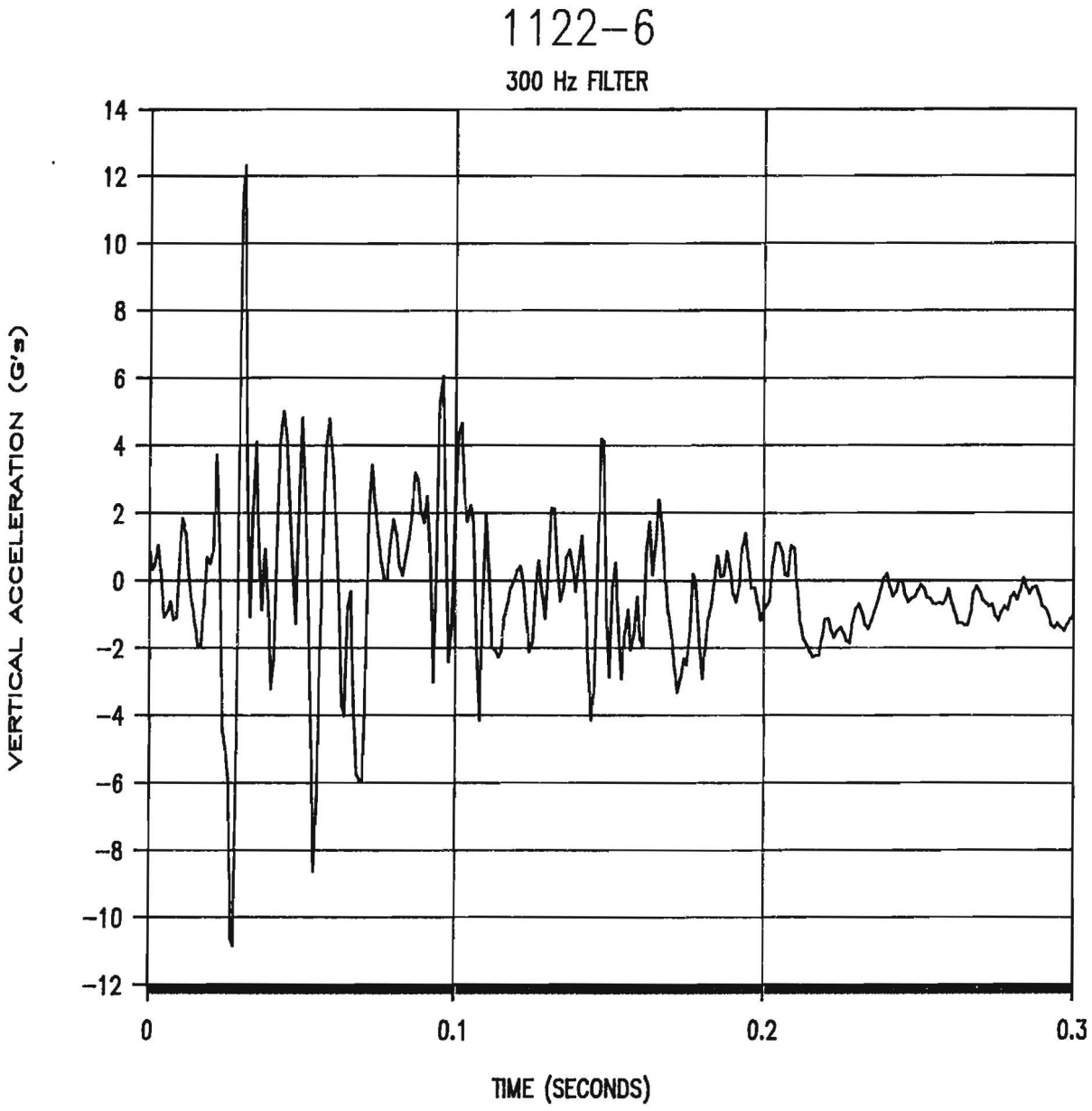


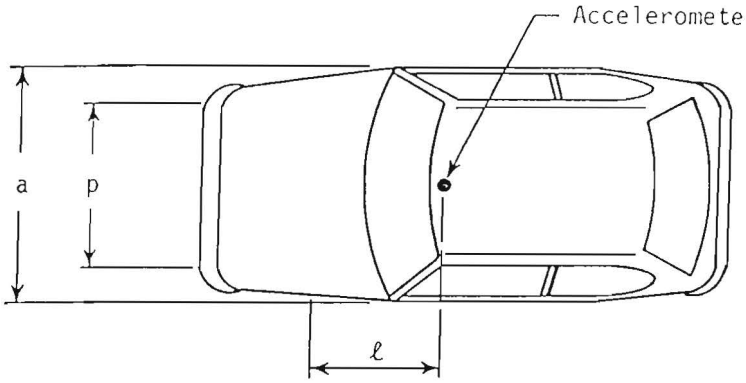
Figure 58. Vertical accelerometer trace for test 1122-6.

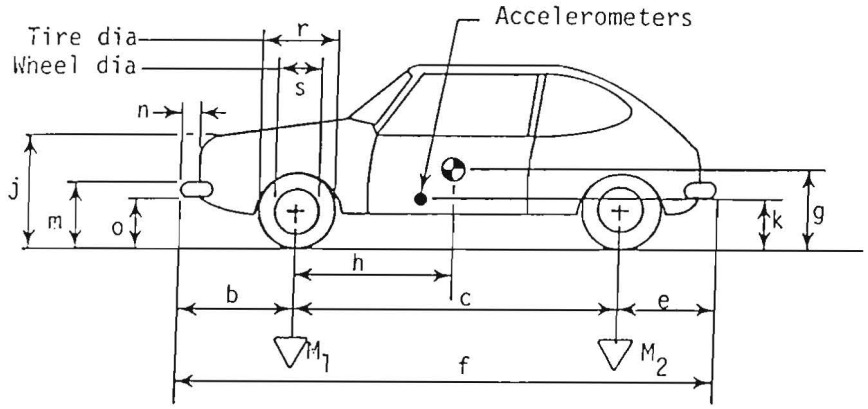
Figure 59. Vehicle before test 1122-6A.

Date: 8/26/88 Test No. 1122-6A VIN. JHMSL4312BS027072

Make: Honda Model: Civic Year: 1981 Odometer: 873645

Tire Size: 155/SR12 Ply Rating: 2 Bias Ply: X Belted: ___ Radial: ___





4-wheel weight for c.g. det. ℓf 582 rf 550 ℓr 330 rr 338

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1139	1132	1214
M_2	669	668	753
M_T	1808	1800	1967

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Tire Condition: good ___
fair X
badly worn ___

Vehicle Geometry - inches

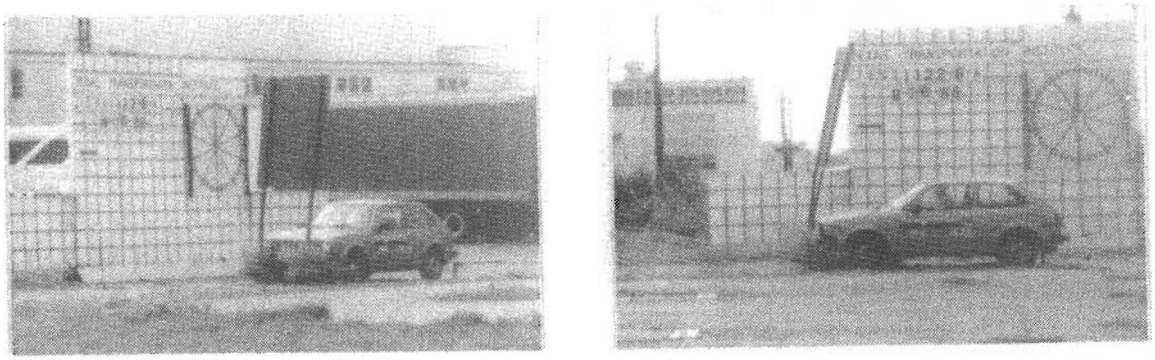
a	62 1/4	b	29 1/4
c	88	d*	52
e	29 1/2	f	
g		h	32.7
i	----	j	30
k	16 1/2	ℓ	26
m	19 1/2	n	4 1/2
o	13 1/2	p	54
r	21 1/2	s	13 1/4

Engine Type: 4 cyl
Engine CID: ___
Transmission Type:
Automatic or Manual
FWD or RWD or 4WD
Body Type: Hatch
Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

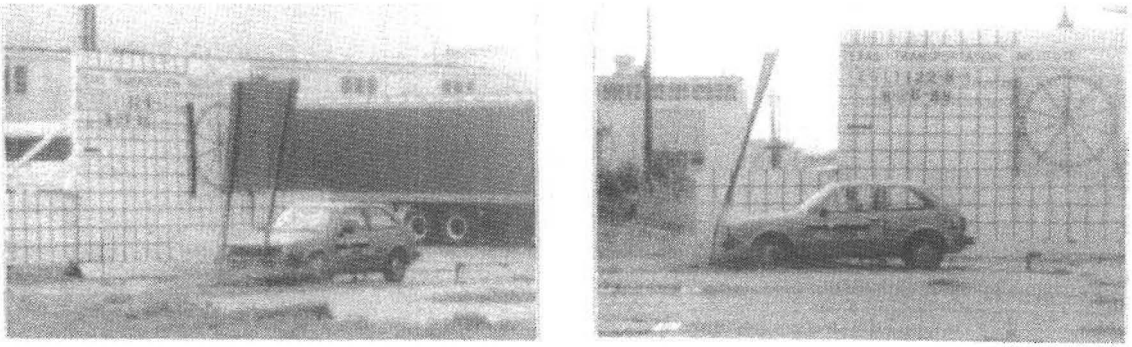
Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

Figure 60. Test vehicle properties (1122-6A).

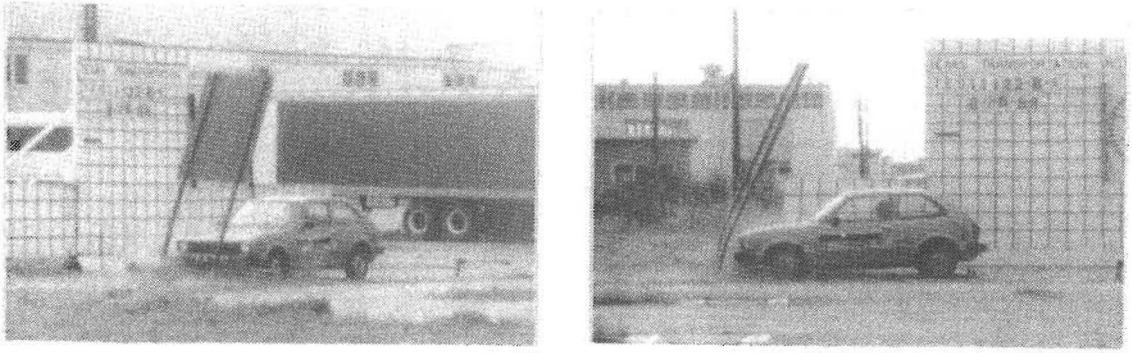
0.000 s



0.195 s

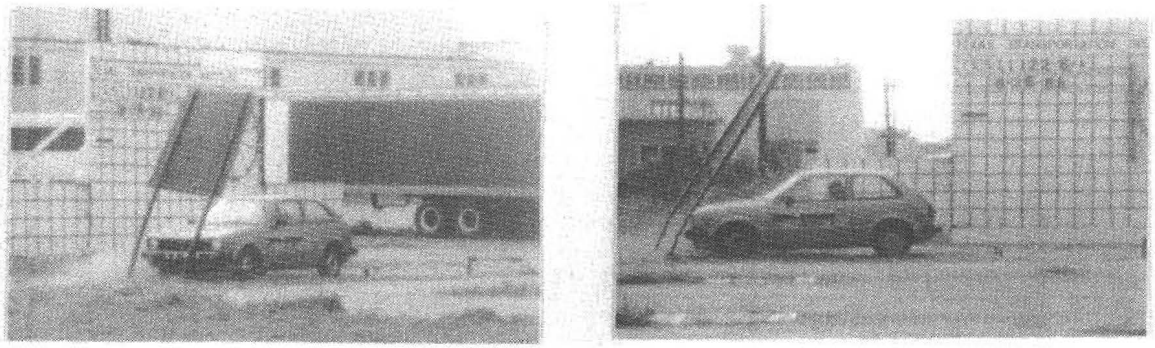


0.391 s

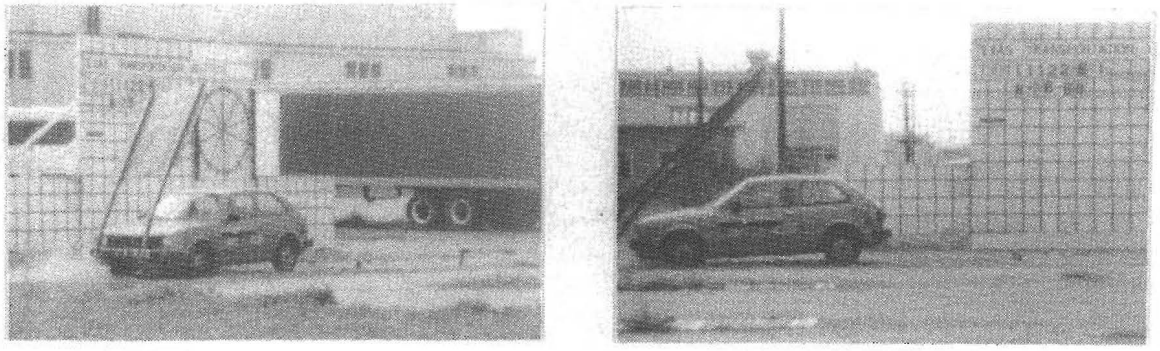


0.586 s

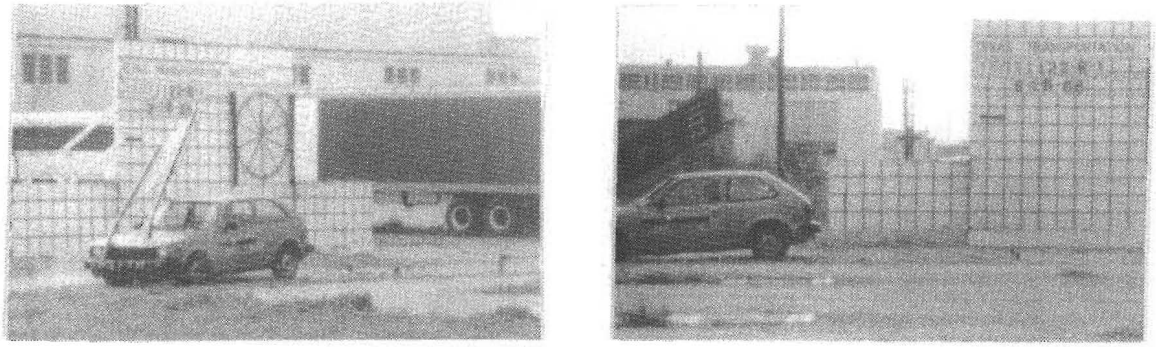
Figure 61. Sequential photographs for test 1122-6A.



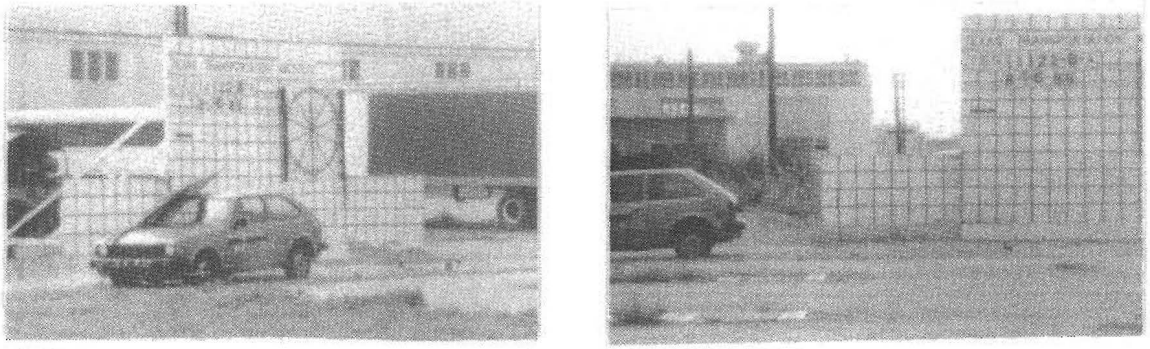
0.782 s



0.977 s



1.173 s



1.368 s

Figure 61. Sequential photographs for test 1122-6A. (Continued)

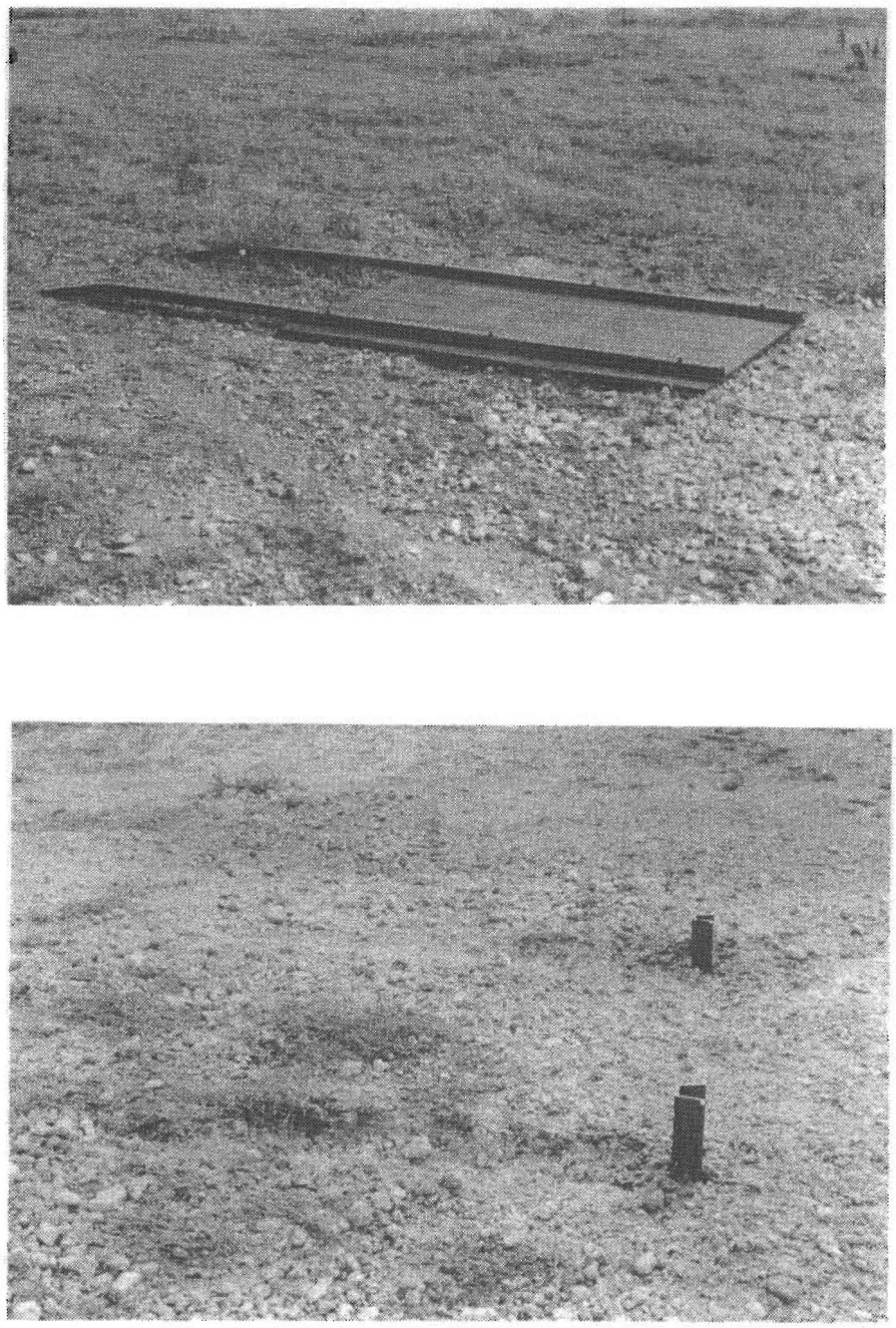
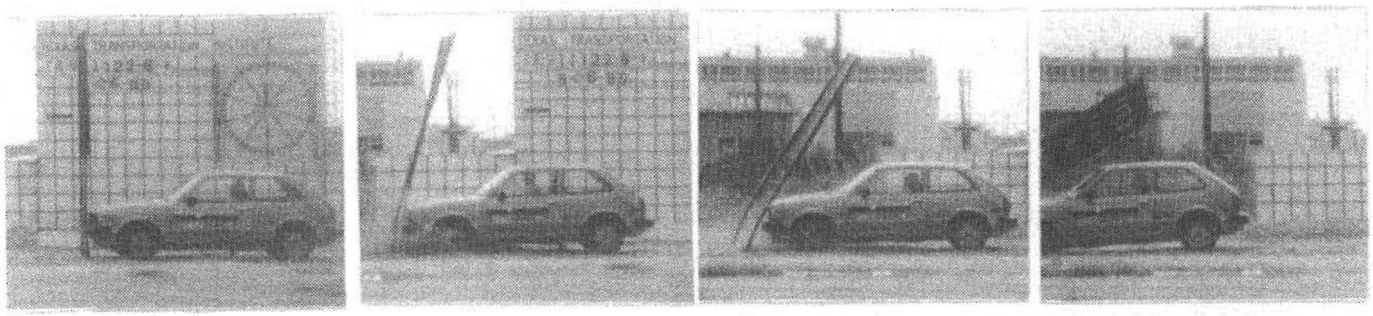
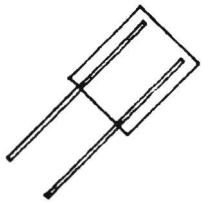


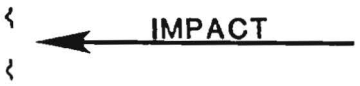
Figure 62. Sign installation after test 1122-6A.

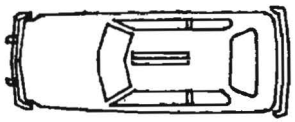
Figure 63. Vehicle after test 1122-6A.



0.000 s 0.391 s 0.782 s 1.173 s

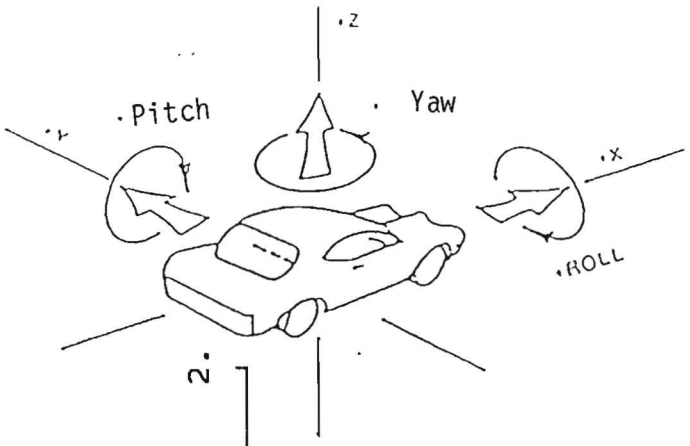






Test No.	1122-6A	Impact Speed	18.9 mi/h (30.4 km/h)
Date	08/26/88	Change in Velocity	7.2 mi/h (11.6 km/h)
Test Article	Sign Installation	Change in Momentum	590 lb-s
Support	Two Franklin 4 lb-ft Supports	Vehicle Accelerations (Max. 0.050-sec Avg)	
Vehicle	1981 Honda Civic	Longitudinal	-3.6 g
Vehicle Weight		Lateral	-1.0 g
Test Inertia	1,800 lb (817 kg)	Occupant Impact Velocity	
Gross Static	1,967 lb (892 kg)	Longitudinal	10.2 ft/s (3.1 m/s)
Vehicle Damage Classification		Lateral	None
TAD	12FD1	Occupant Ridedown Accelerations	
SAE	12FDEW1	Longitudinal	-0.6 g
		Lateral	No Contact

Figure 64. Summary of results for test 1122-6A.



Axes are vehicle fixed.
Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

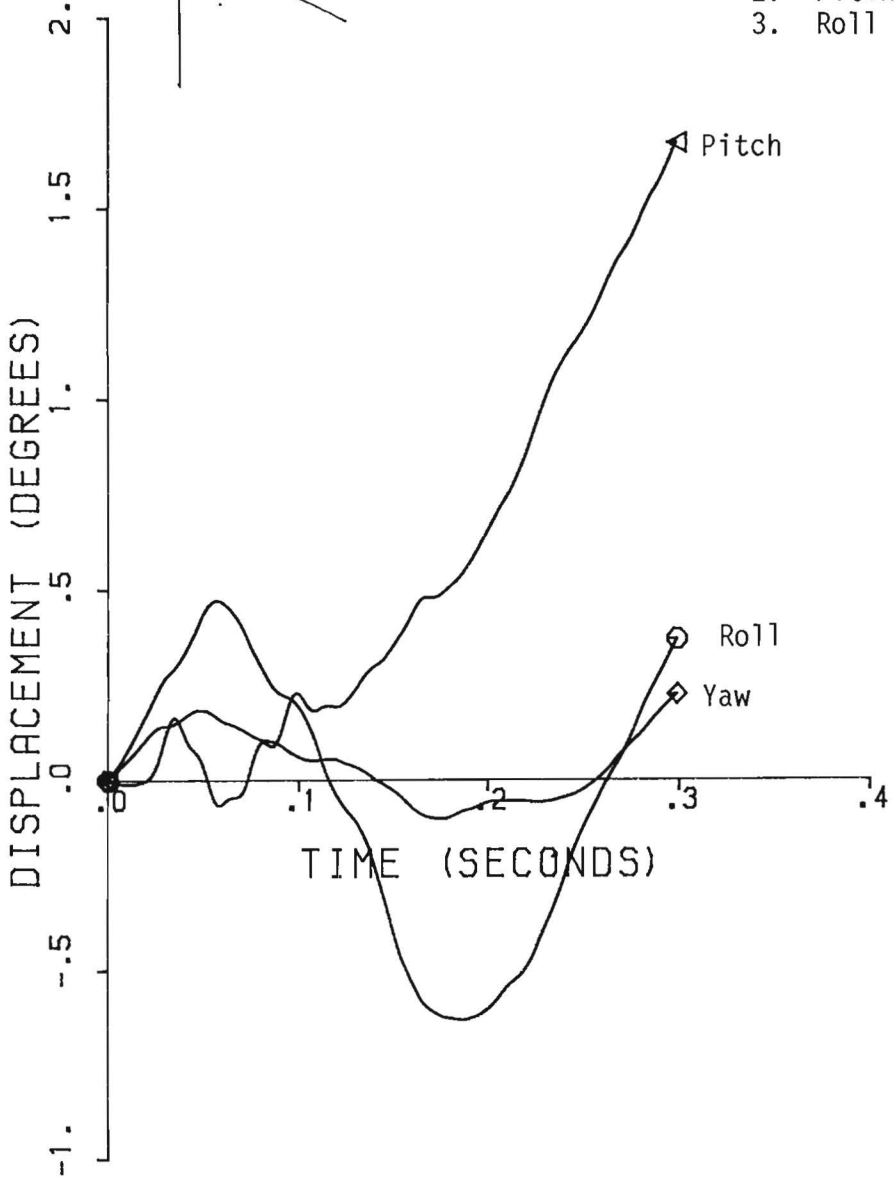


Figure 65. Vehicle angular displacements for test 1122-6A.

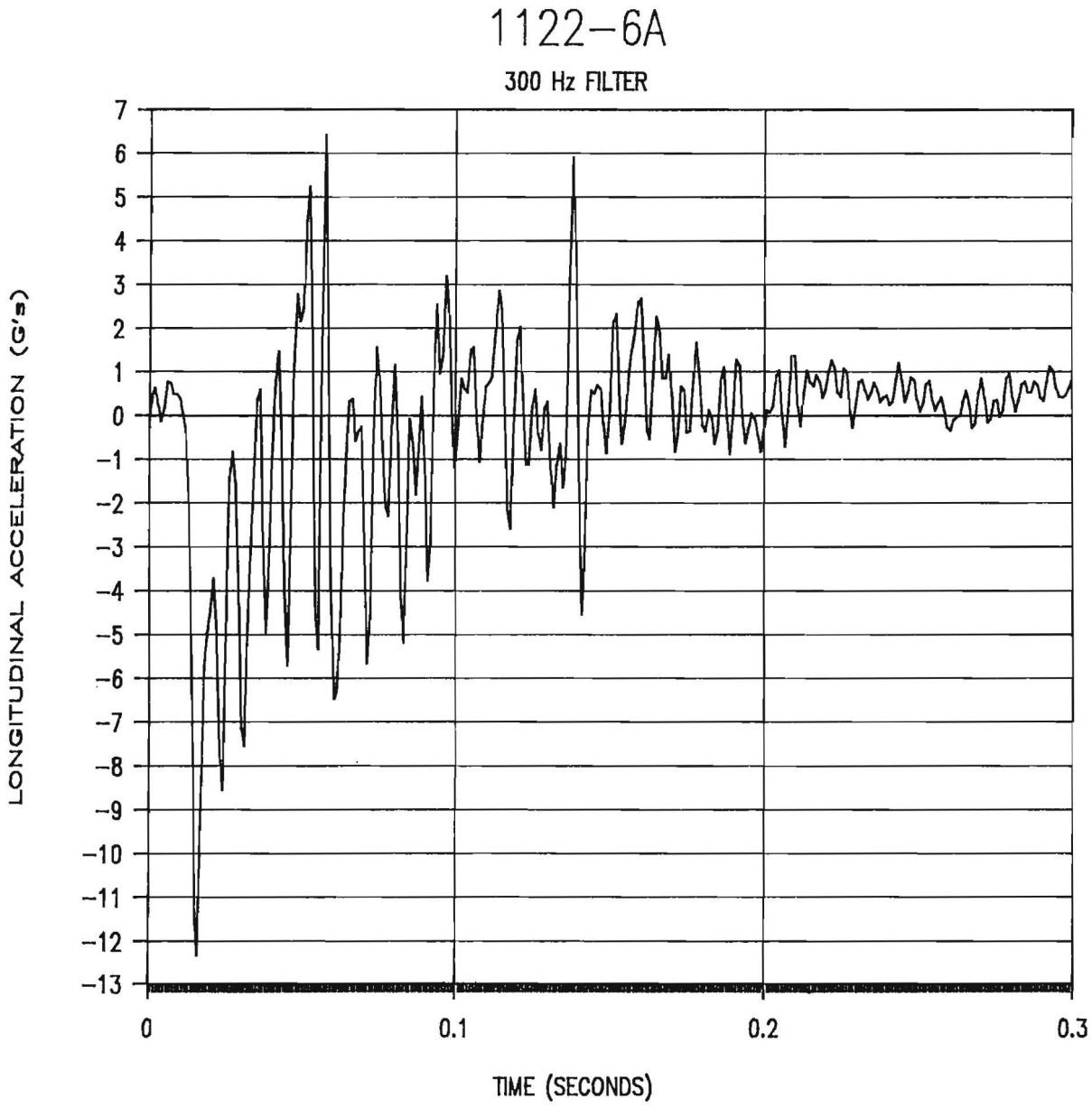


Figure 66. Longitudinal accelerometer trace for test 1122-6A.

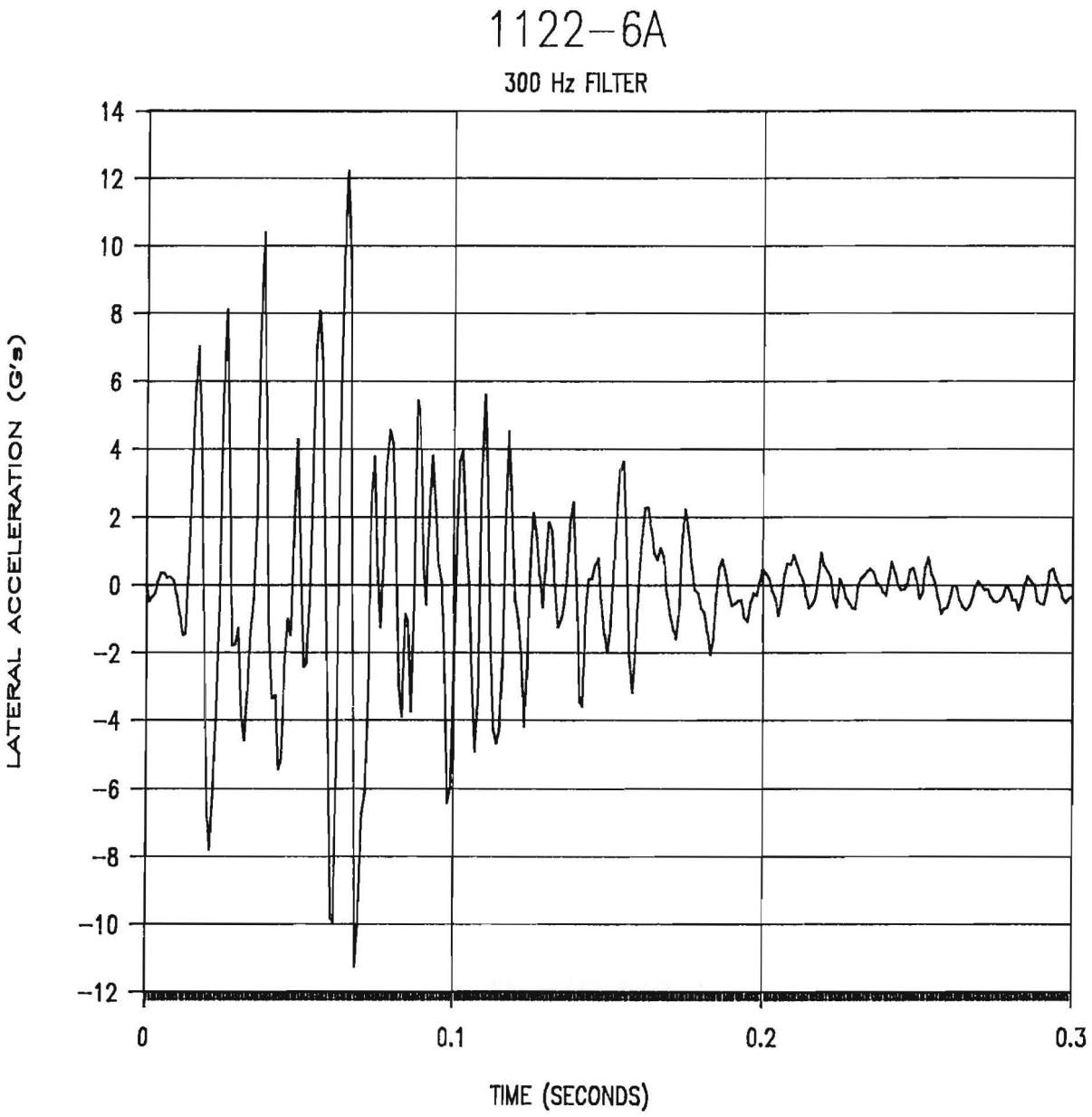


Figure 67. Lateral accelerometer trace for test 1122-6A.

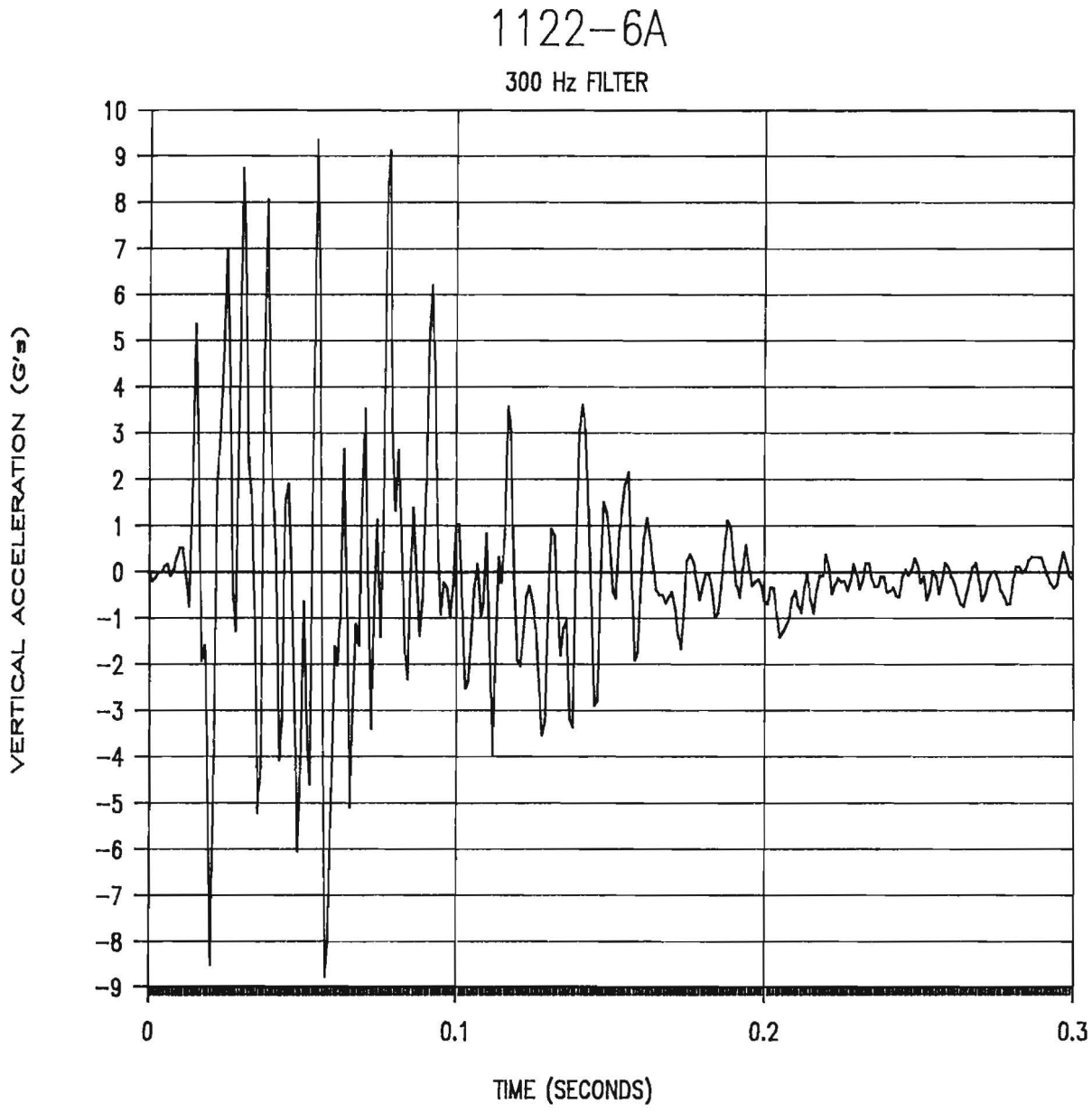


Figure 68. Vertical accelerometer trace for test 1122-6A.

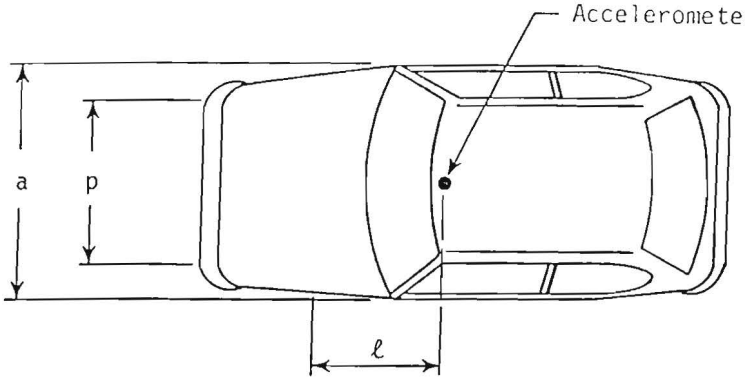
Figure 69. Vehicle before test 1122-7.

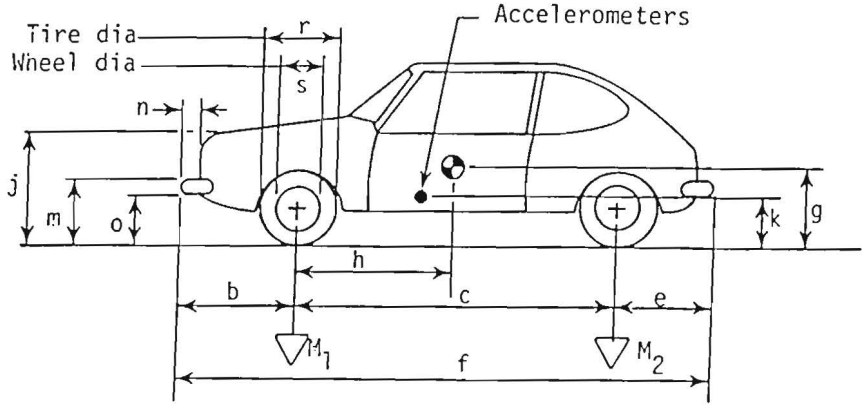
Date: 8/9/88 Test No.: 1122-7 VIN: JHMSL5327DS021592

Make: Honda Model: Civic Year: 1983 Odometer: 67360

Tire Size: P165/80R13 Ply Rating: 3 Bias Ply: ___ Belted: ___ Radial: X

Tire Condition: good X
fair ___
badly worn ___





4-wheel weight for c.g. det. ℓf 599 rf 568 ℓr 308 rr 325

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1164	1167	1246
M_2	640	633	724
M_T	1804	1800	1970

Note any damage to vehicle prior to test:

*d = overall height of vehicle

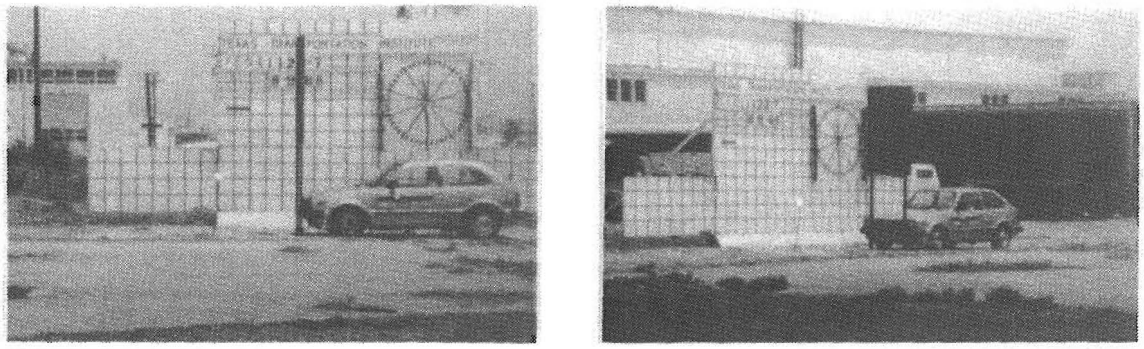
Vehicle Geometry - inches

a	62 1/2	b	30
c	88	d*	53
e	29 1/2	f	147.5
g		h	30.9
i	----	j	28 1/2
k	16 3/4	ℓ	28 1/2
m	20	n	4
o	14 1/2	p	53 1/4
r	22 1/2	s	14 1/4

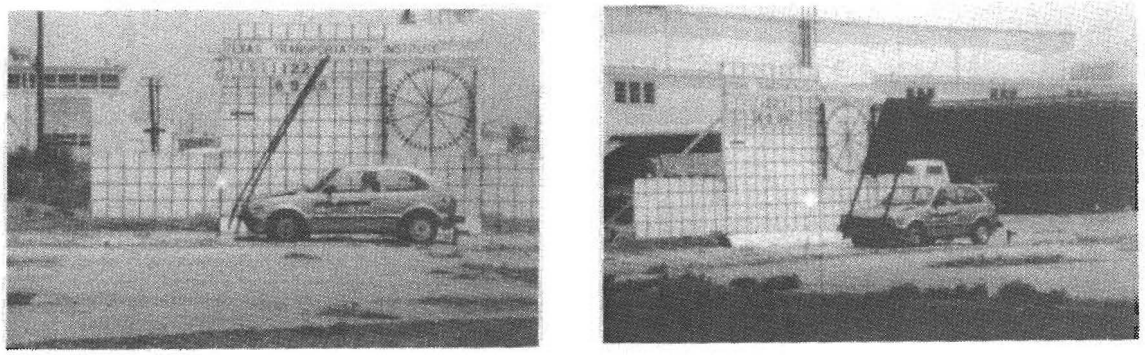
Engine Type: 4 cyl
Engine CID: ___
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD
Body Type: Hatch
Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

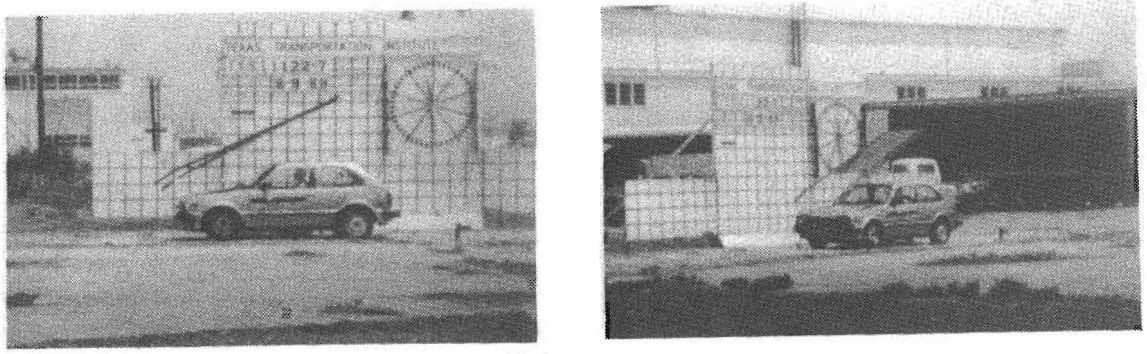
Figure 70. Test vehicle properties (1122-7).



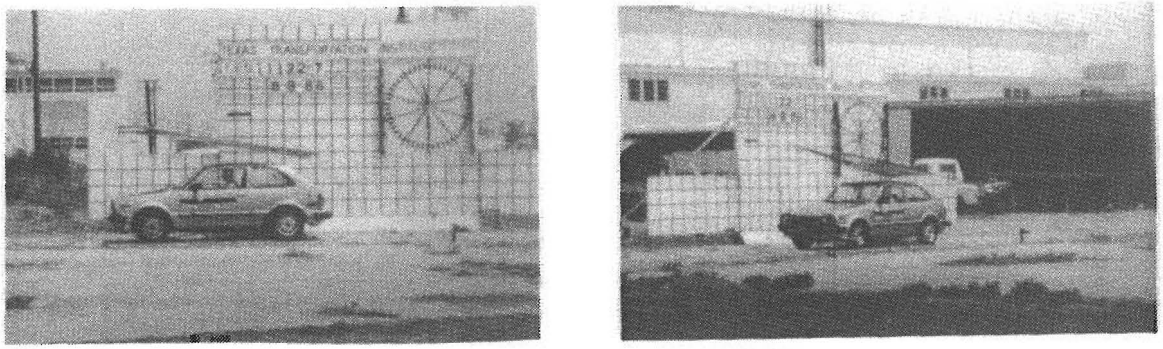
0.000 s



0.043 s

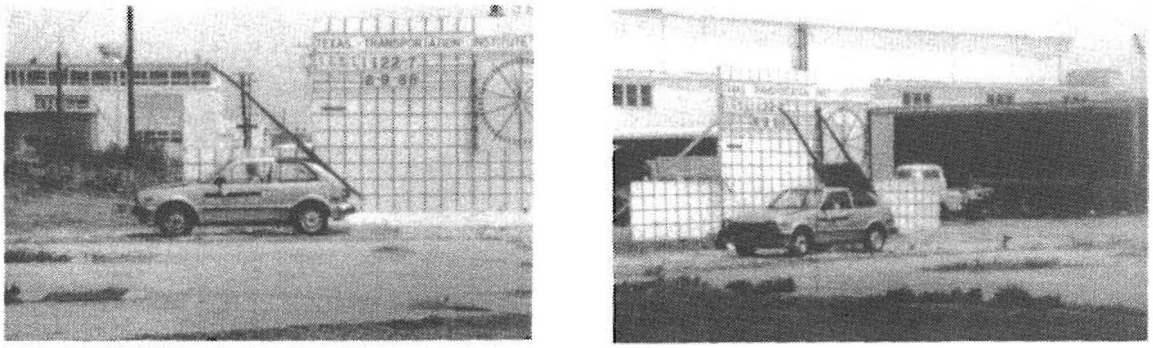


0.086 s

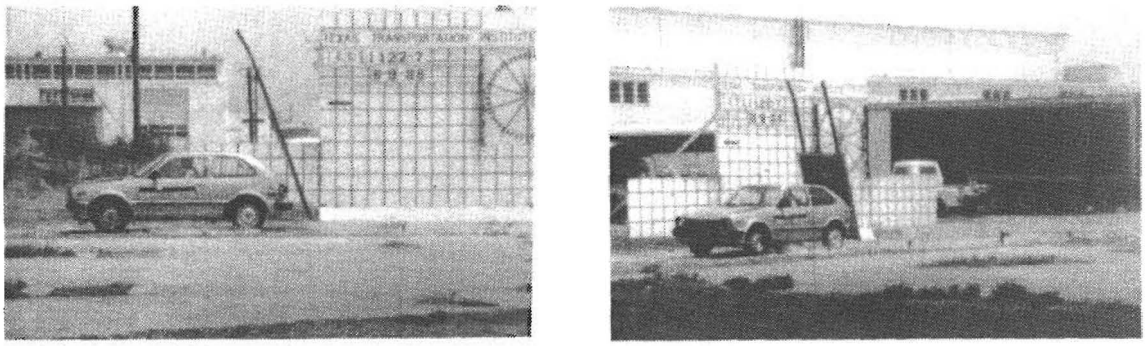


0.128 s

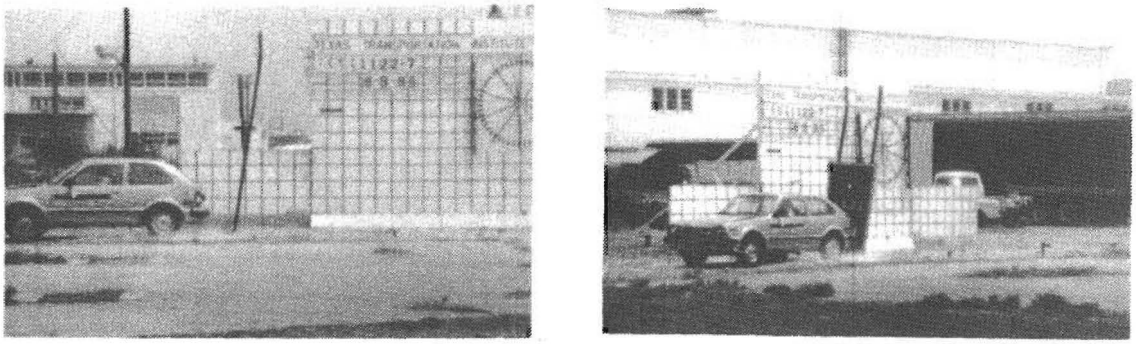
Figure 71. Sequential photographs for test for test 1122-7.



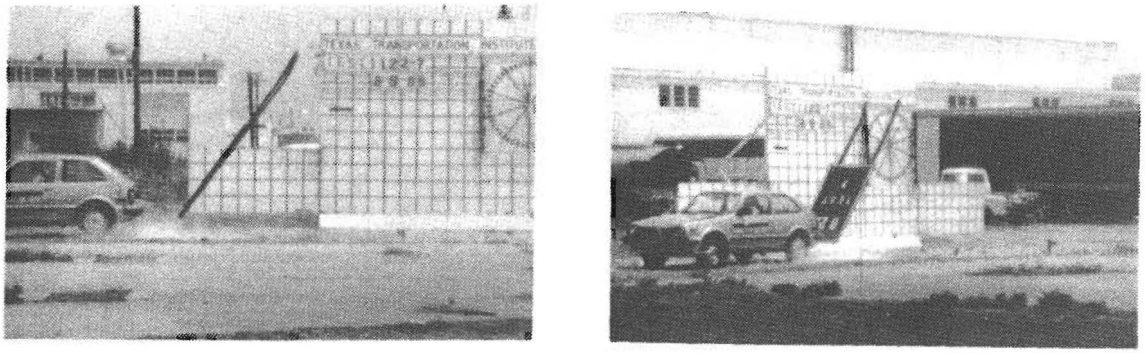
0.174 s



0.219 s

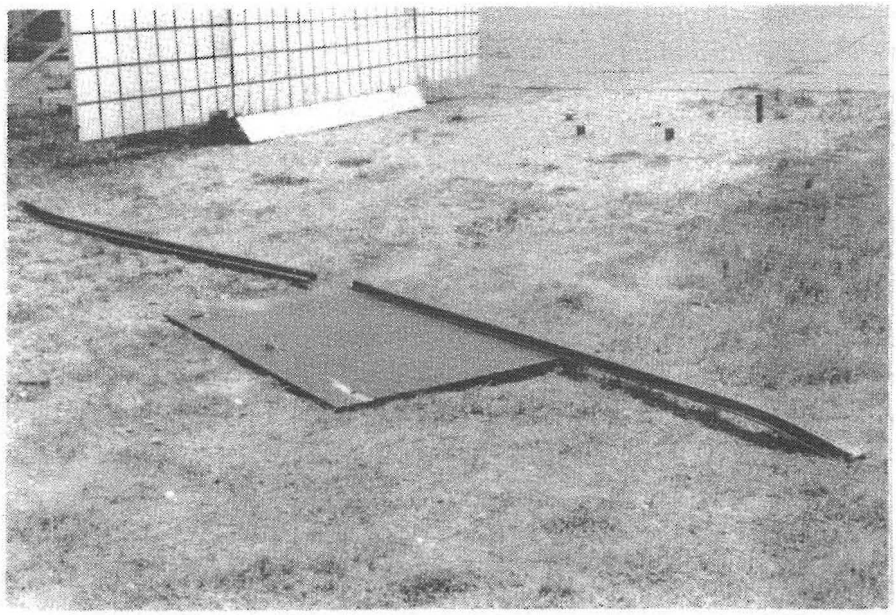


0.267 s



0.314 s

Figure 71. Sequential photographs for test 1122-7. (Continued)



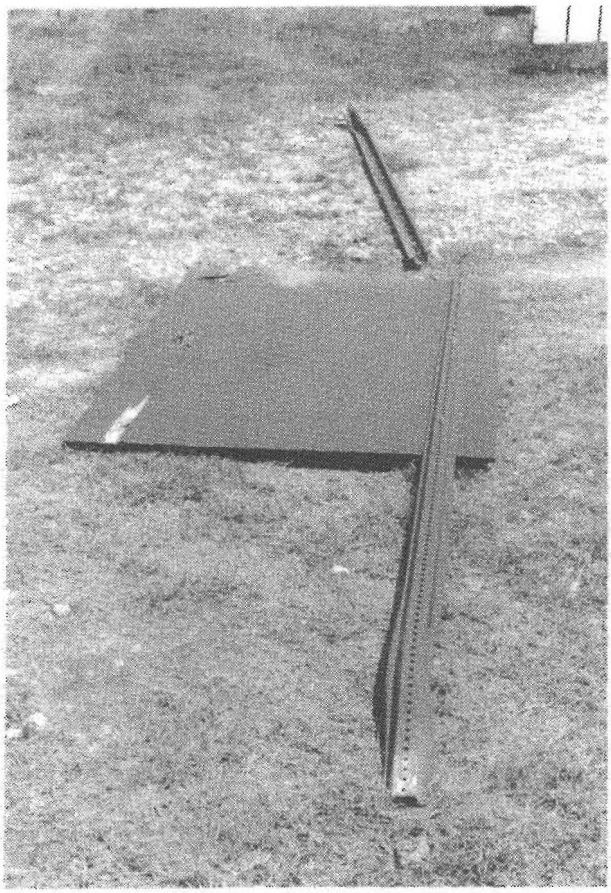
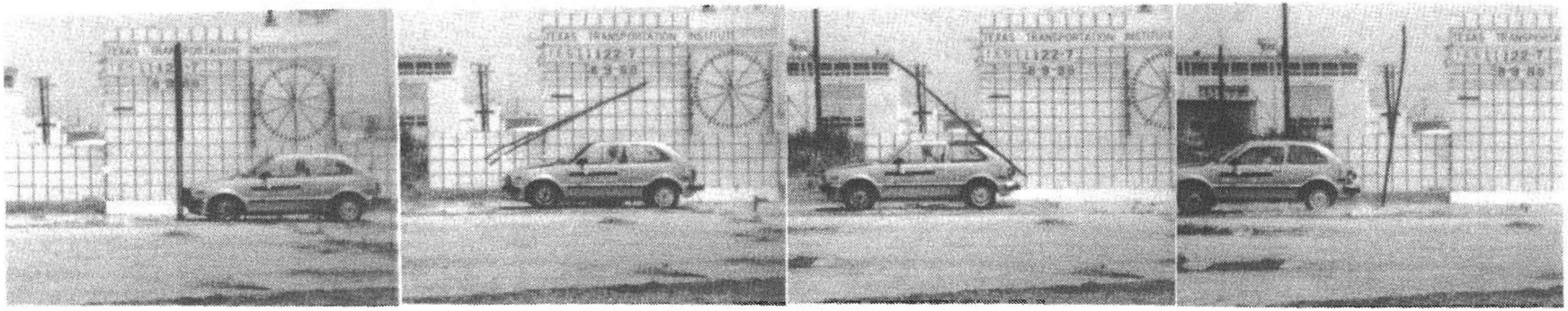
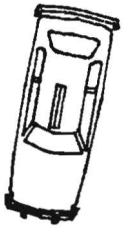


Figure 72. Sign installation after test 1122-7.

Figure 73. Vehicle after test 1122-7.



0.000 s 0.086 s 0.174 s 0.267 s



Test No.	1122-7
Date	08/09/88
Test Article	Sign Installation
Support	Two Franklin 4 lb-ft Supports
Vehicle	1983 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,970 lb (894 kg)
Vehicle Damage Classification	
TAD	12FD1
SAE	12FDEW1

Impact Speed.	60.5 mi/h (97.3 km/h)
Change in Velocity . . .	5.4 mi/h (8.7 km/h)
Change in Momentum. . . .	445 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-3.1 g
Lateral	-0.7 g
Occupant Impact Velocity	
Longitudinal.	None
Lateral	None
Occupant Ridedown Accelerations	
Longitudinal	No Contact
Lateral	No Contact

Figure 74. Summary of results for test 1122-7.

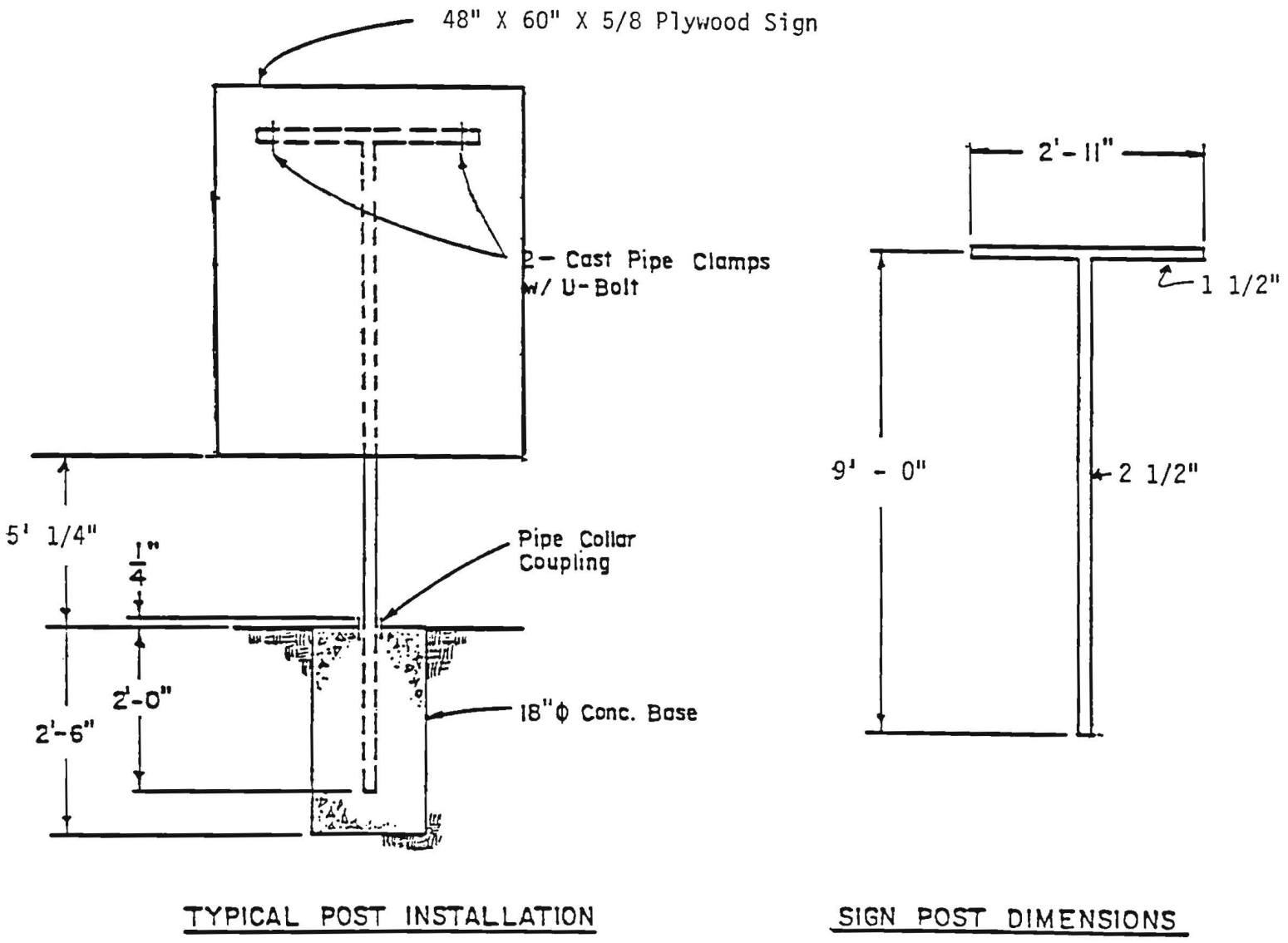
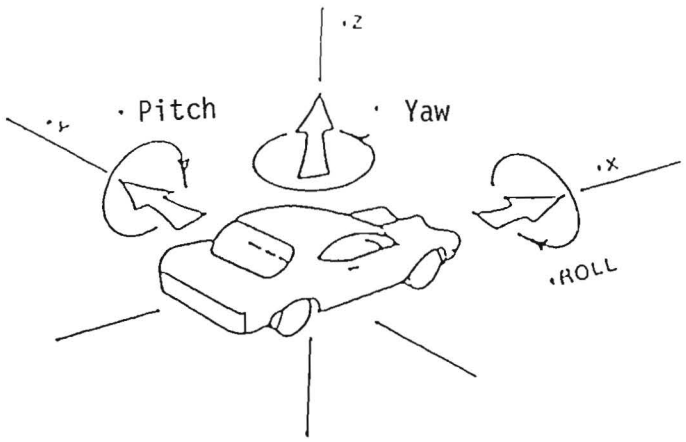


Figure 79. Signpost installation details for test 1122-8.



Axes are vehicle fixed.
Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

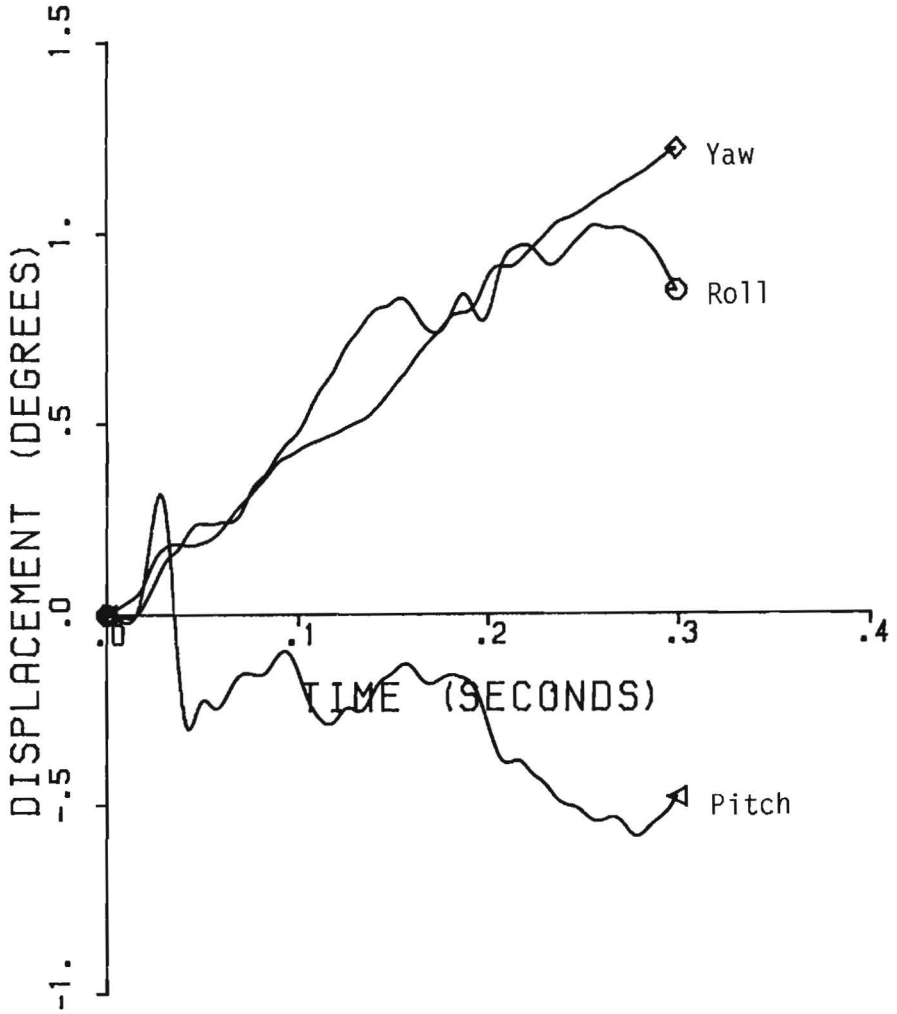


Figure 75. Vehicle angular displacements for test 1122-7.

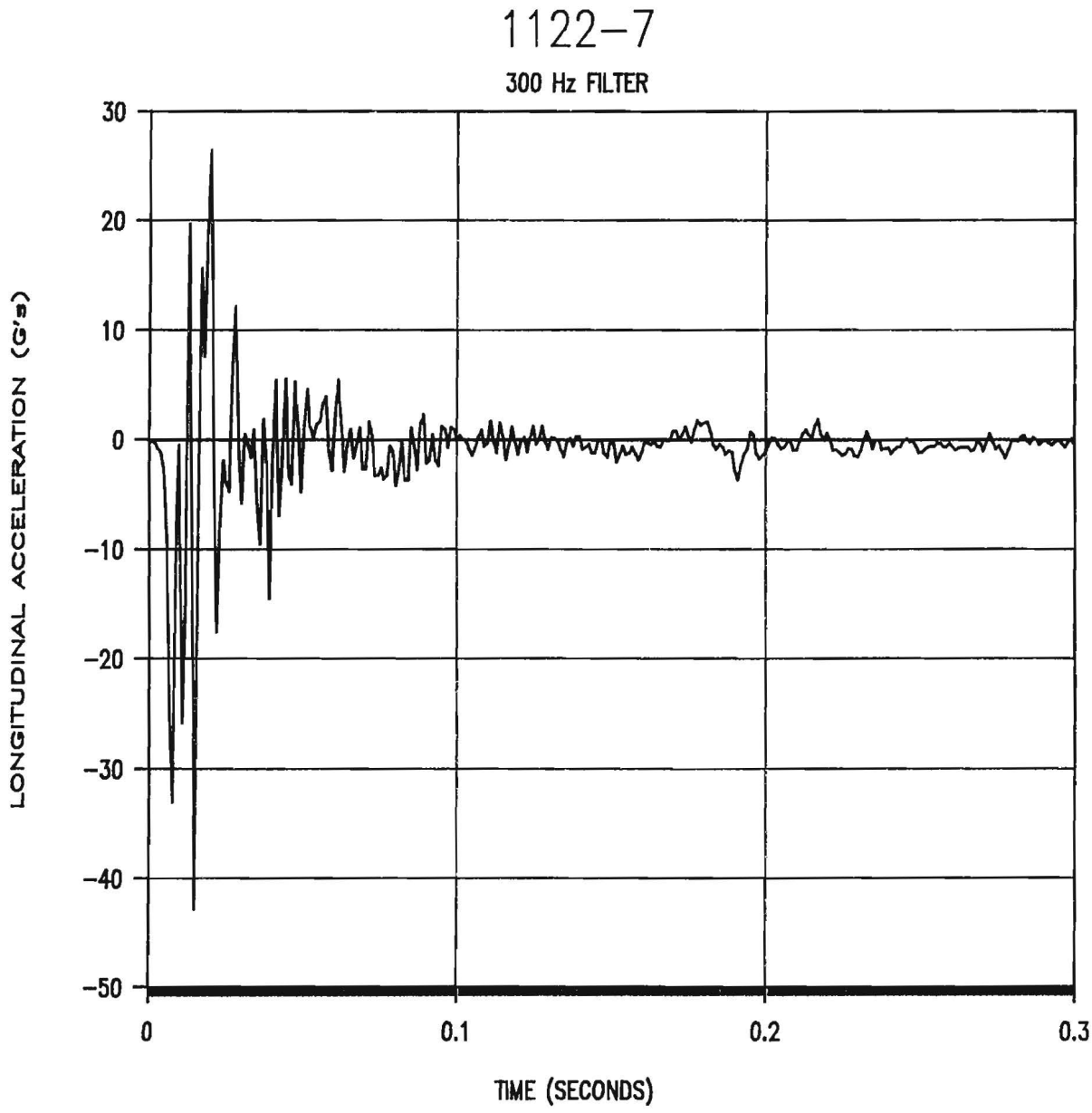


Figure 76. Longitudinal accelerometer trace for test 1122-7.

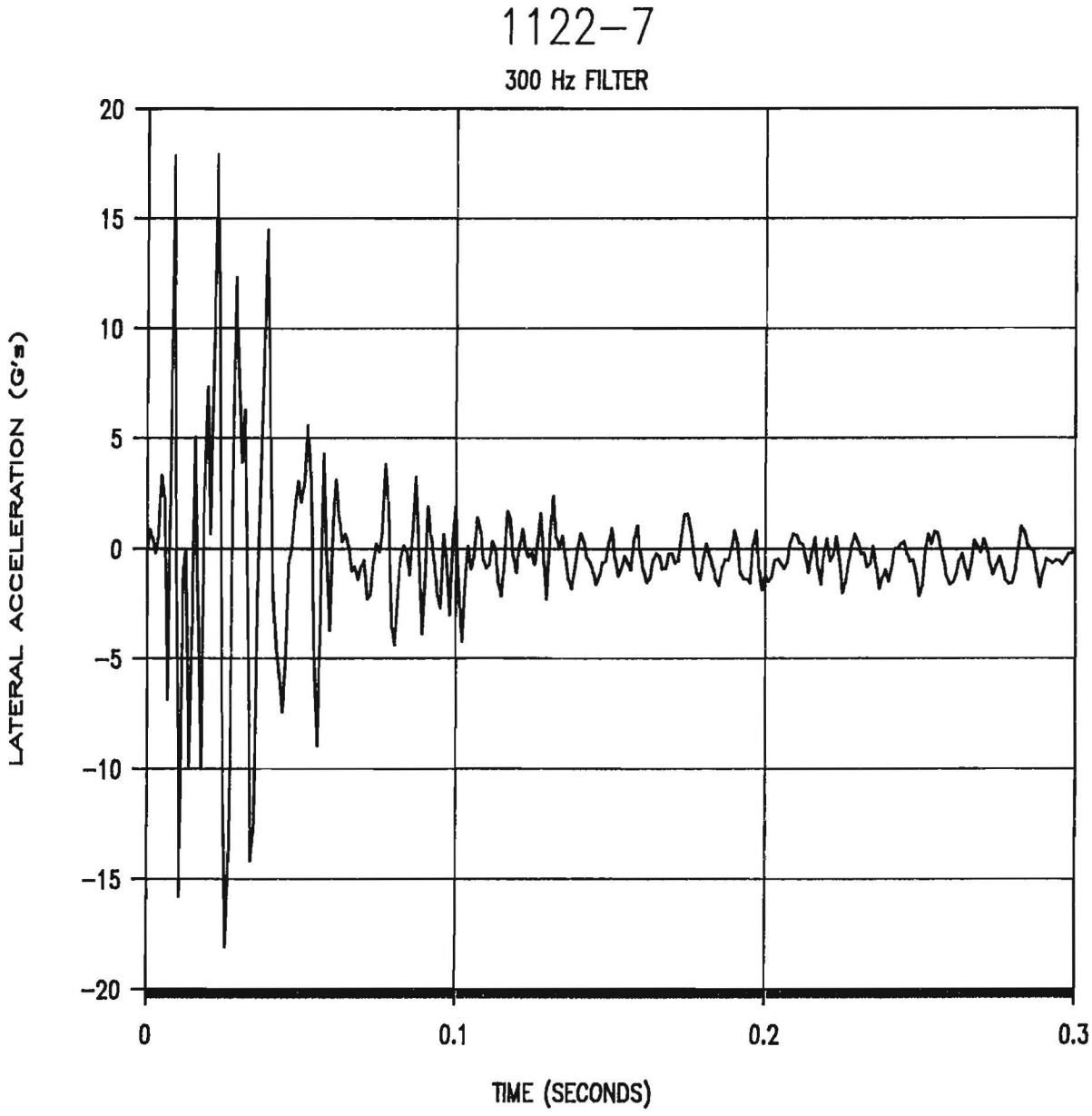


Figure 77. Lateral accelerometer trace for test 1122-7.

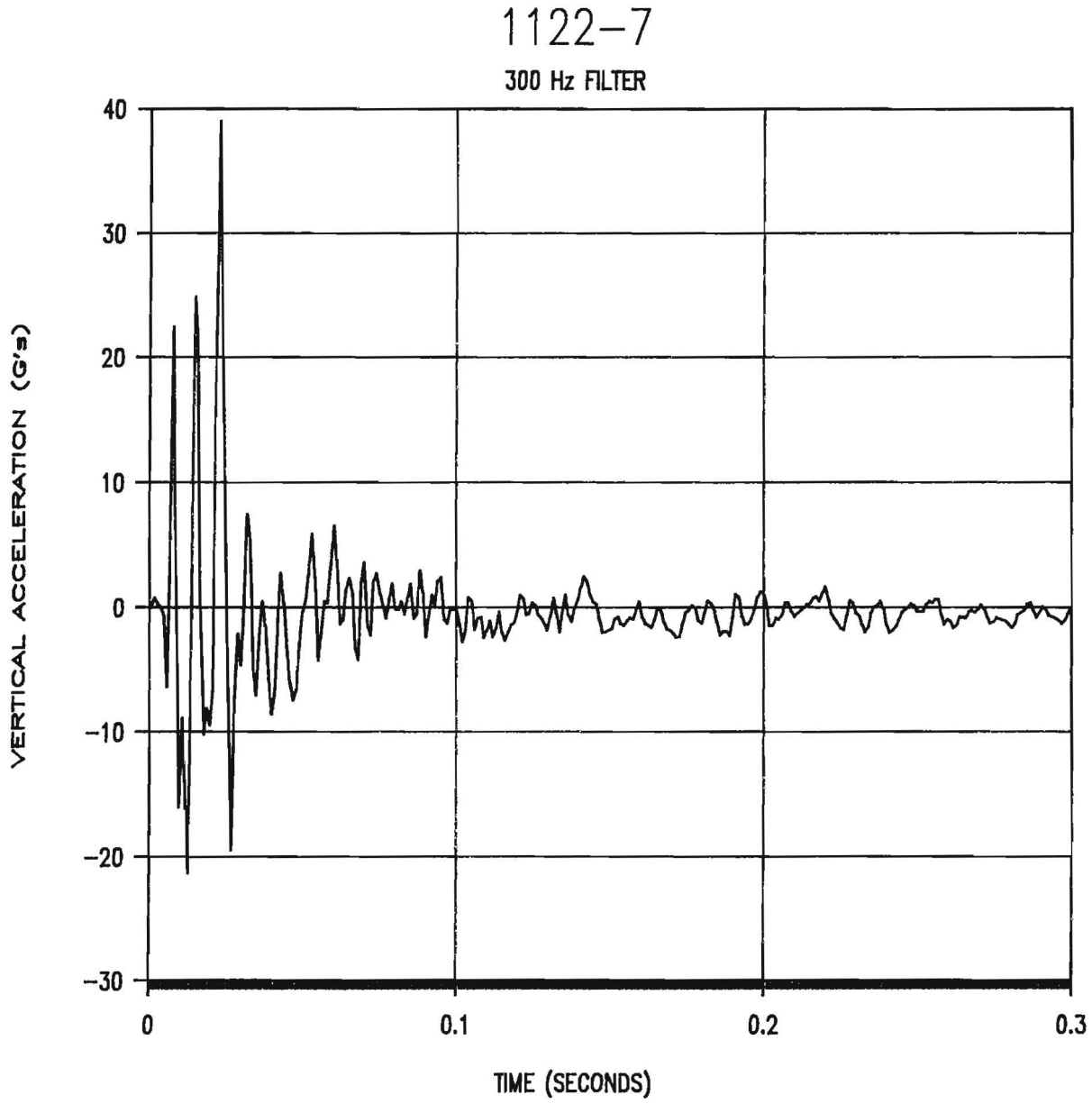


Figure 78. Vertical accelerometer trace for test 1122-7.

DESCRIPTION OF TEST INSTALLATION FOR 1122-8, 9 & 9A

The sign installation used in these tests consisted of a 4 ft-0 in wide x 5 ft-0 in high plywood sign panel mounted with three cast U-Bolts to a single 2-1/2 inch steel pipe T-support. A 2-1/2 inch x 24.0 inch steel pipe was embedded in a concrete footing 18.0 inches in diameter x 30.0 inches long for attachment purposes. The concrete footing was placed in crushed limestone (NCHRP Report 230 "strong" soil). The sign support was then attached to the footing using a pipe collar coupling. The bottom of sign mounting height was 5 ft-1/4 in. Details of the sign installation are shown in Figures 79 and 80.

TEST REPORT 1122-8

VEHICLE: 1982 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,970 lbs.

TEST ARTICLE: Single Support Sign Installation
Support: 2-1/2 inch Pipe
and Pipe Collar Coupling

IMPACT CONDITIONS: 20.6 mi/h
Quarter point (on passenger side of vehicle)

Crash Test Results

A 1982 Honda Civic (shown in Figure 81) impacted the sign installation at 20.6 miles per hour (33.1 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,970 lb (894 kg). The height to the lower edge of the vehicle bumper was 13.8 inches (34.9 cm) and 19.5 inches (49.5 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 82.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the quarter point on the passenger side of the vehicle. Upon impact, the sign support began to deform and the vehicle started to climb the post. At approximately 0.118 second, the right front wheel became airborne. Shortly thereafter, at 0.138 second the sign support pulled from the pipe collar coupling. As the sign installation yielded, the brakes were applied and the vehicle came to rest 10 ft (3.0 m) from the point of impact. Sequential photographs of the test are shown in Figure 83.

The sign support and panel came to rest directly beneath the test vehicle. The support anchor received only minor damages and could be placed back into

service. The vehicle sustained minor damage to the bumper, hood, fender, right front control arm and strut assembly, as shown in Figure 85.

A summary of the test results and other information pertinent to this test are given in Figure 86. The maximum 0.050 second average acceleration experienced by the vehicle was -4.6 g in the longitudinal direction and -1.2 g in the lateral direction. Vehicle angular displacements are plotted in Figure 87 and vehicle accelerometer traces are displayed in Figure 88 through 90. Occupant impact velocity in the longitudinal direction was 15.2 feet per second (4.6 m/s) and no occupant impact velocity existed in the lateral direction. The highest 0.10 second occupant ridedown acceleration was -0.5 g (longitudinal). Change in velocity was 11.0 mi/h (17.7 km/h) and change in momentum was 904 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. The occupant impact velocity was acceptable (NCHRP Report 230 limit is 15 ft/s). In addition, the change in momentum was under the recommended limit of 1100 lb-s. This sign installation in "strong" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

TEST REPORT 1122-9

VEHICLE: 1982 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,970 lbs.

TEST ARTICLE: Single Support Sign Installation
Support: 2-1/2 inch Pipe
and Pipe Collar Coupling

IMPACT CONDITIONS: 60.7 mi/h
Quarter point (on passenger
side of vehicle)

Crash Test Results

A 1982 Honda Civic (shown in Figure 91) impacted the sign installation at 60.0 miles per hour (97.7 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,970 lb (894 kg). The height to the lower edge of the vehicle bumper was 13.8 inches (34.9 cm) and 19.5 inches (49.5 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 92.

The vehicle was freewheeling and unrestrained just prior to impact. In addition, prior to impact the guidance system malfunctioned. Therefore, the point of impact was the center line of the sign with the front edge of the left

fender and guide plate attached to the vehicle. Upon impact, the sign support began to deform and at approximately 0.045 second, the sign support became detached from the pipe collar coupling. As the sign installation yielded and the vehicle lost contact, at approximately 0.151 second, the brakes were applied and the vehicle came to rest 210 ft (64.0 m) from the point of impact. Sequential photographs of the test are shown in Figure 93.

The sign support and panel came to rest directly behind the point of impact. The support anchor received only minor damages and could possibly be placed back into service. The vehicle sustained minor damage to the bumper, fender, left front tire, control arm, and strut assembly, as shown in Figure 95.

A summary of the test results and other information pertinent to this test are given in Figure 96. The maximum 0.050 second average acceleration experienced by the vehicle was -3.5 g in the longitudinal direction and -2.0 g in the lateral direction. Vehicle angular displacements are plotted in Figure 97 and vehicle accelerometer traces are displayed in Figure 98 through 100. Occupant impact velocity in the longitudinal direction was 10.7 feet per second (3.3 m/s) and no occupant impact velocity existed in the lateral direction. The highest 0.10 second occupant ridedown acceleration was -1.4 g (longitudinal). Change in velocity was 10.6 mi/h (17.1 km/h) and change in momentum was 868 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. The occupant impact velocity was below the NCHRP Report 230 recommended limit of 15 ft/s. In addition, the change in momentum was under the recommended limit of 1100 lb-s. This sign installation in "strong" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards. However, the test conditions presented herein do not represent a valid test matrix under NCHRP Report 230 guidelines.

TEST REPORT 1122-9A

VEHICLE: 1981 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,967 lbs.

TEST ARTICLE: Single Support Sign Installation
Support: 2-1/2 inch Pipe
and Pipe Collar Coupling

IMPACT CONDITIONS: 61.0 mi/h
Quarter point (on passenger
side of vehicle)

Crash Test Results

A 1981 Honda Civic (shown in Figure 101) impacted the sign installation at 61.0 miles per hour (98.2 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,967 lb (892 kg). The height to the lower edge of the vehicle bumper was 13.5 inches (34.3 cm) and 19.5 inches (49.5 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 102.

The vehicle was freewheeling and unrestrained just prior to impact. Upon impact, the sign support began to deform and the sign face began to separate from the support. At approximately 0.020 second, the sign support became detached from the pipe collar coupling. Shortly thereafter, as the vehicle passed beneath the installation, the sign struck the roof of the vehicle. At 0.505 second, the vehicle lost contact with the installation, the brakes were applied and the vehicle came to rest 185 ft (56.4 m) from the point of impact. Sequential photographs of the test are shown in Figure 103.

The sign support came to rest 52.0 ft (15.9 ft) from the point of impact. The support anchor received only minor damages and could possibly be placed back into service. The vehicle sustained minor damage to the bumper, hood, and roof as shown in Figure 105.

A summary of the test results and other information pertinent to this test are given in Figure 106. The maximum 0.050 second average acceleration experienced by the vehicle was -4.2 g in the longitudinal direction and -1.8 g in the lateral direction. Vehicle angular displacements are plotted in Figure 107 and vehicle accelerometer traces are displayed in Figure 108 through 110. No contact by the anthropomorphic dummy was made. Therefore, no occupant impact velocity or ridedown accelerations were recorded in the longitudinal or lateral direction. Change in velocity was 6.7 mi/h (10.7 km/h) and change in momentum was 545lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. No occupant impact velocity or ridedown accelerations were recorded. The change in momentum was considerably under the recommended limit of 1100 lb-s. This sign installation in "strong" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

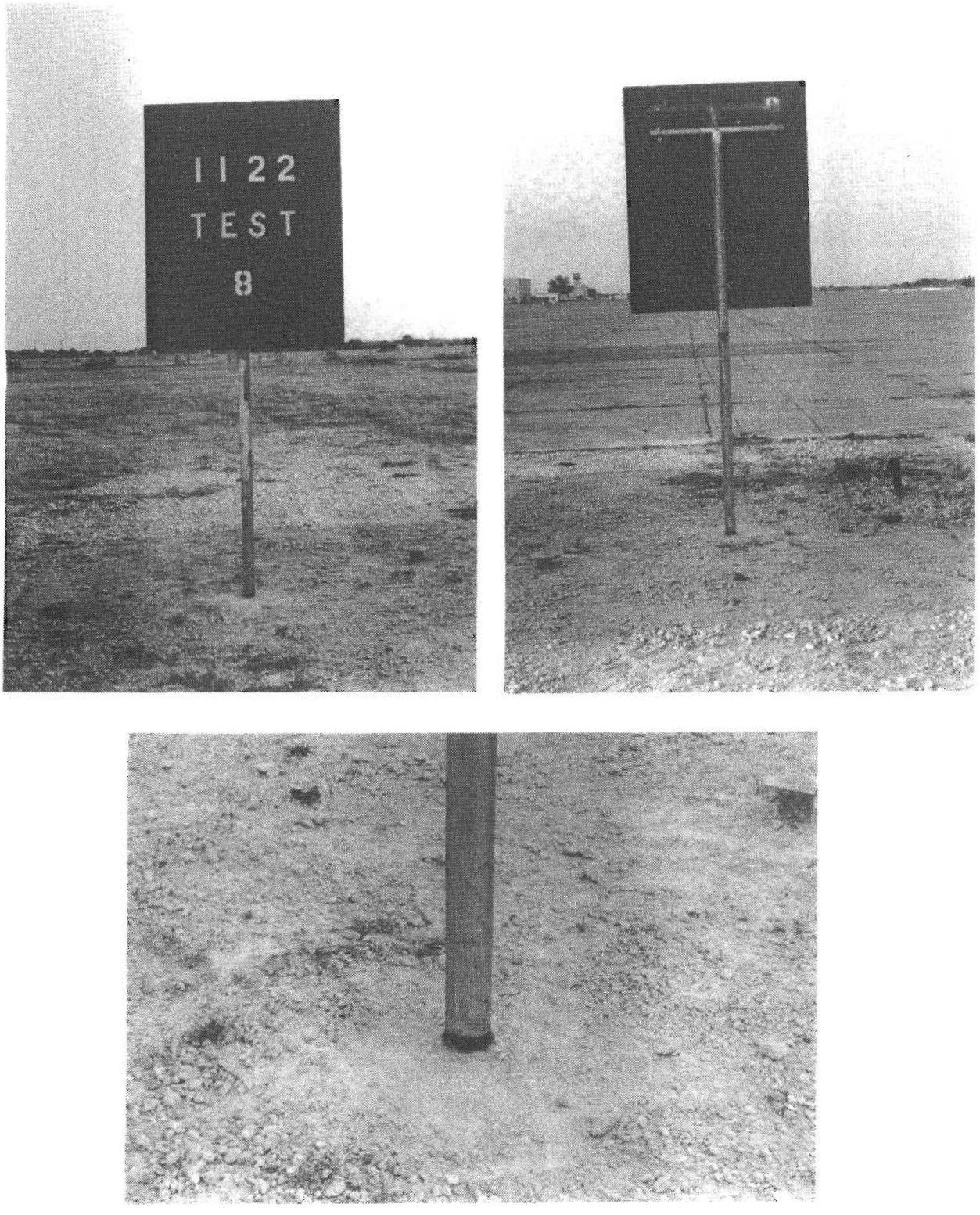


Figure 80. Sign installation before 1122-8.

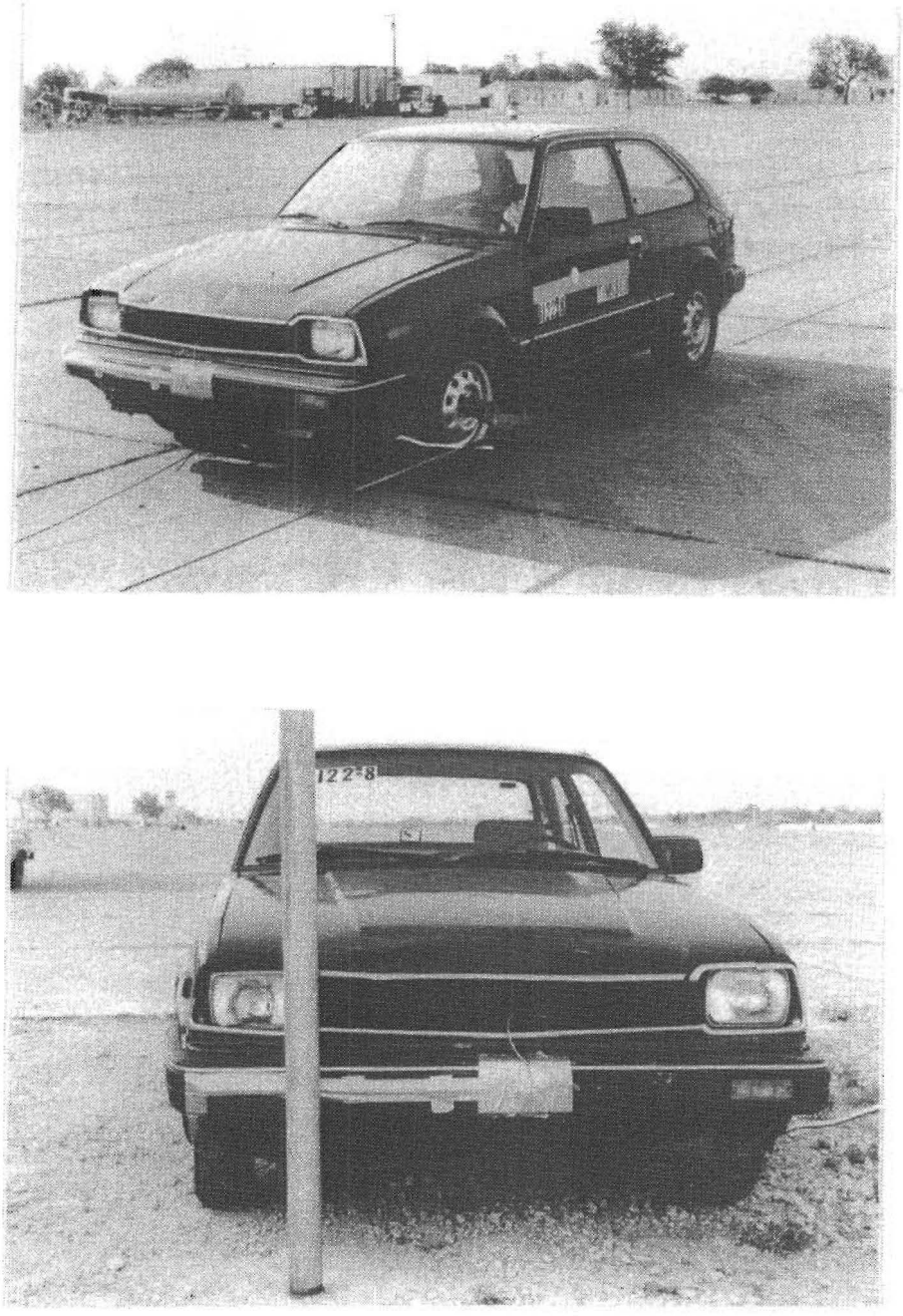
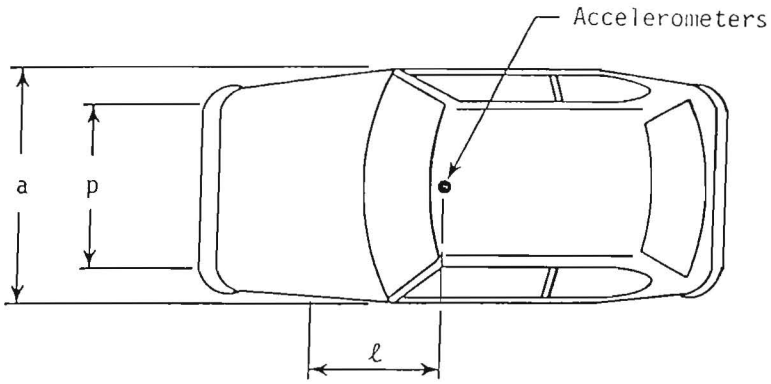


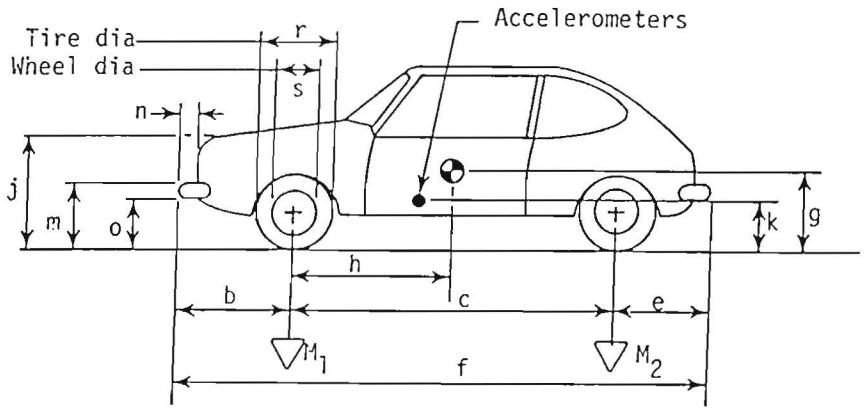
Figure 81. Vehicle before test 1122-8.

Date: 8-16-88 Test No.: 1122-8 VIN: JHMSL5327CS012650

Make: Honda Model: Civic Year: 1982 Odometer: 110007

Tire Size: 155 SR13 Ply Rating: ____ Bias Ply: ___ Belted: ___ Radial: X





4-wheel weight for c.g. det. ℓf 600 rf 532 ℓr 329 rr 339

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1159	1132	1216
M_2	639	668	754
M_T	1798	1800	1970

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Tire Condition: good ___
fair X
badly worn ___

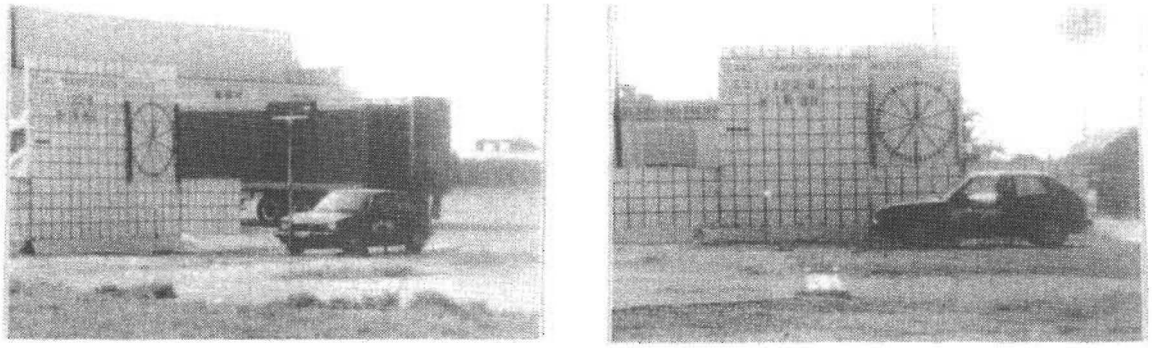
Vehicle Geometry - inches

a	62 3/4	b	30
c	88	d*	52 3/4
e	28"	f	146
g	---	h	32.7
i	----	j	30"
k	16 1/2	ℓ	28 1/2
m	19 1/2	n	4
o	13 3/4	p	54
r	21 3/4	s	14 1/4

Engine Type: 4 cyld
Engine CID: ____
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD
Body Type: Hatch
Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

Figure 82. Test vehicle properties (1122-8).



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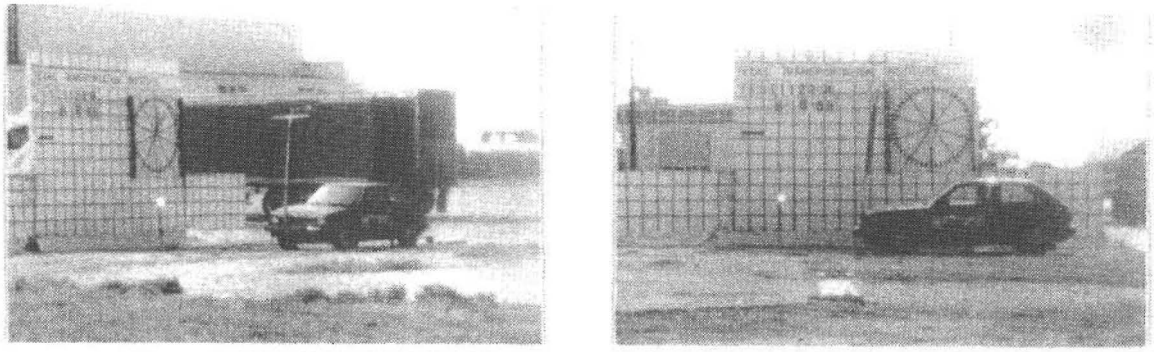
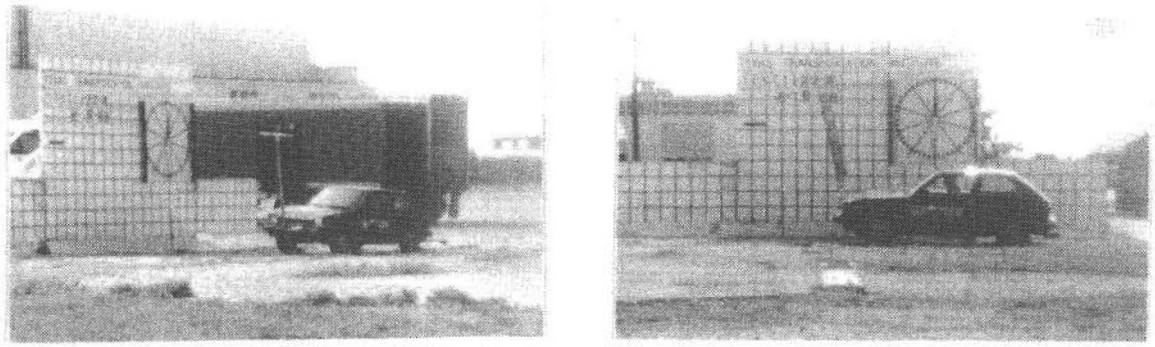
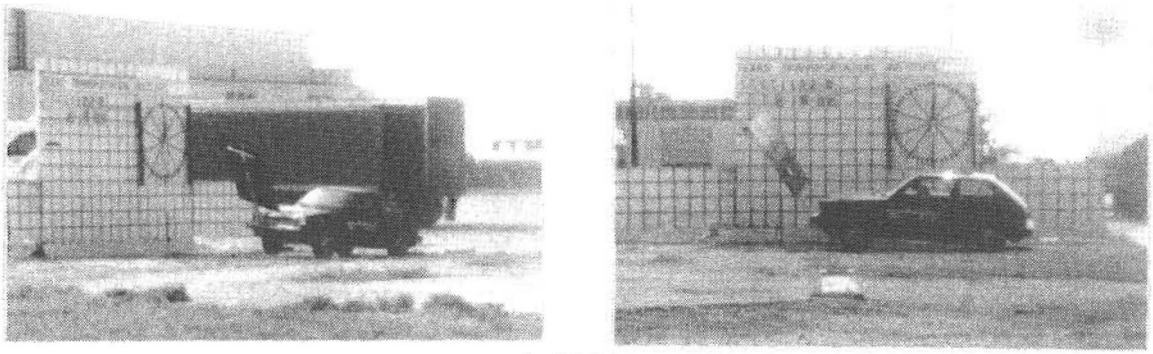


0.065 s

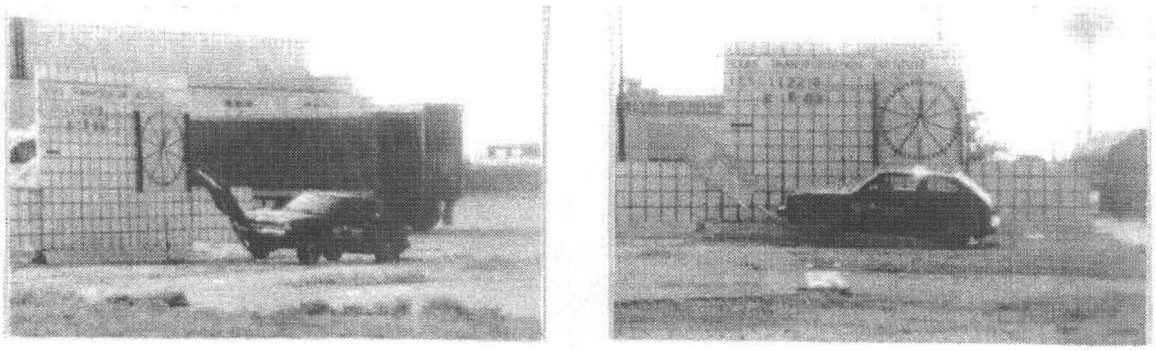


0.131 s

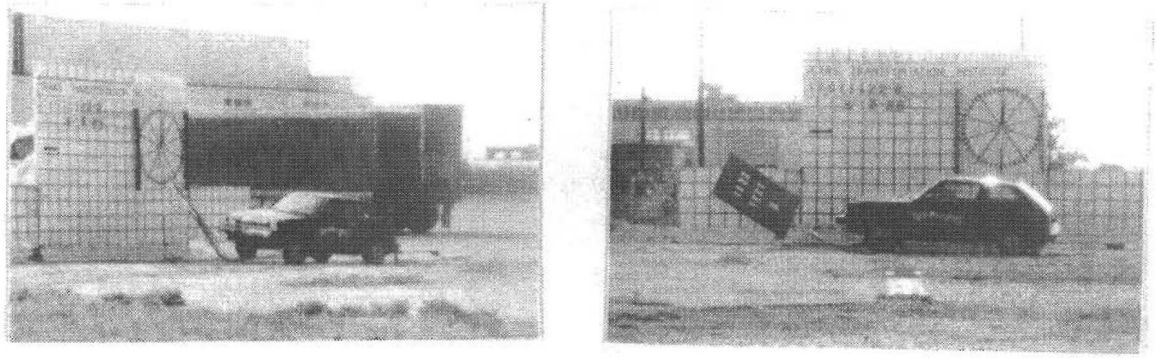


0.196 s

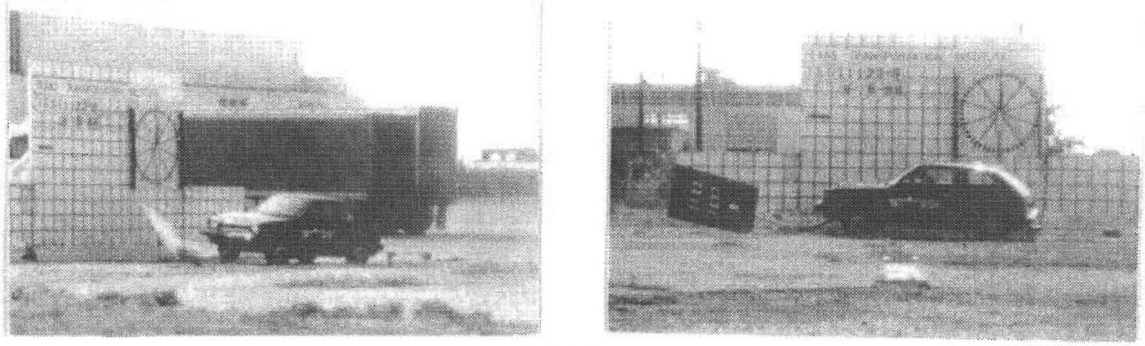
Figure 83. Sequential photographs for test 1122-8.



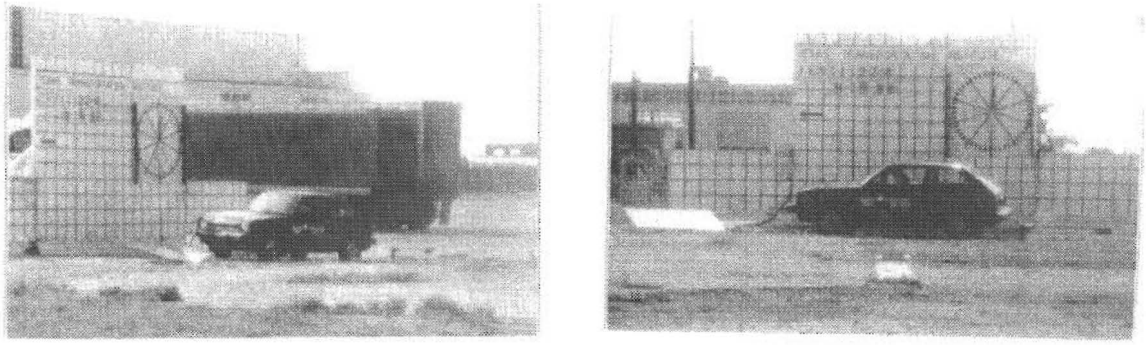
0.262 s



0.327 s



0.393 s



0.458 s

Figure 83. Sequential photographs for test 1122-8. (Continued)

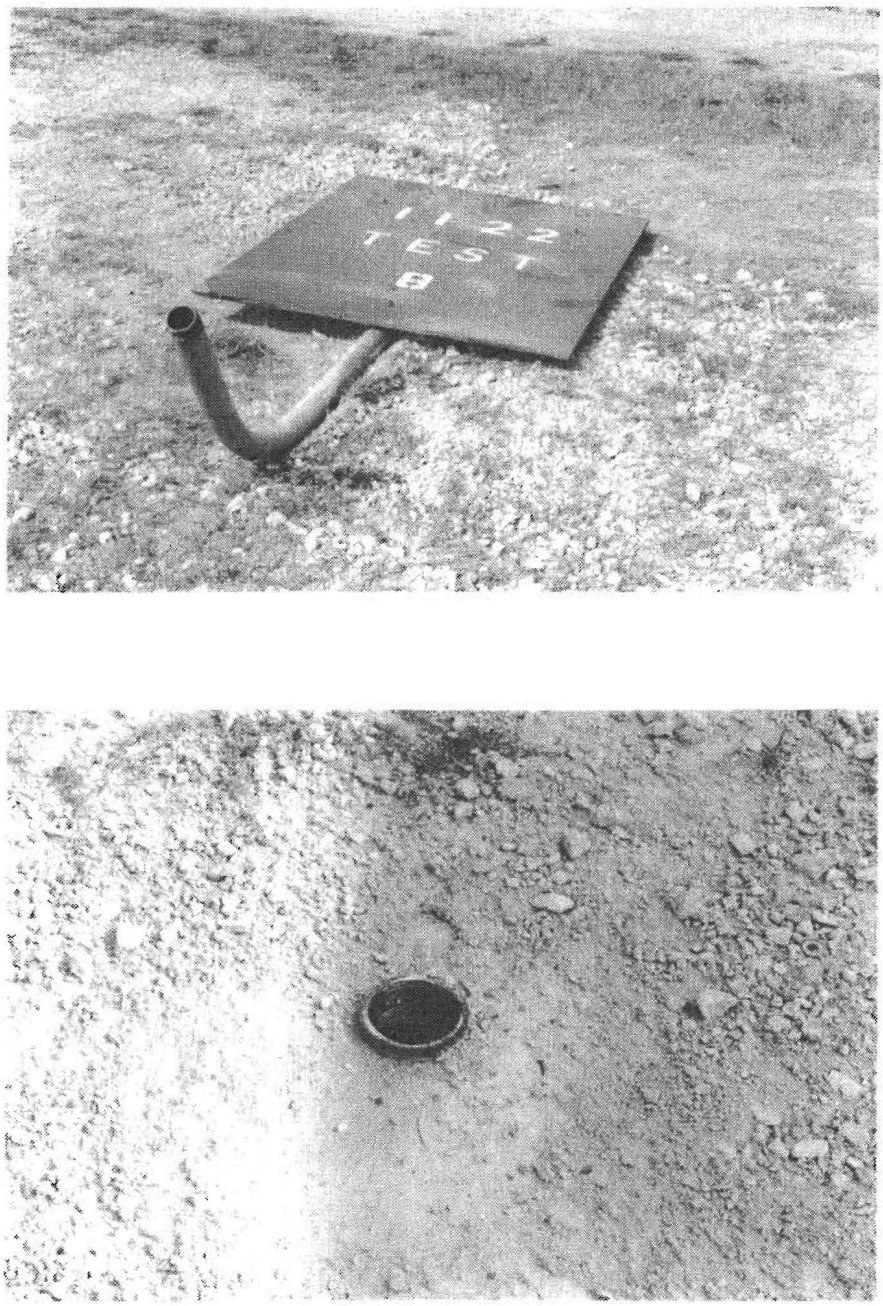
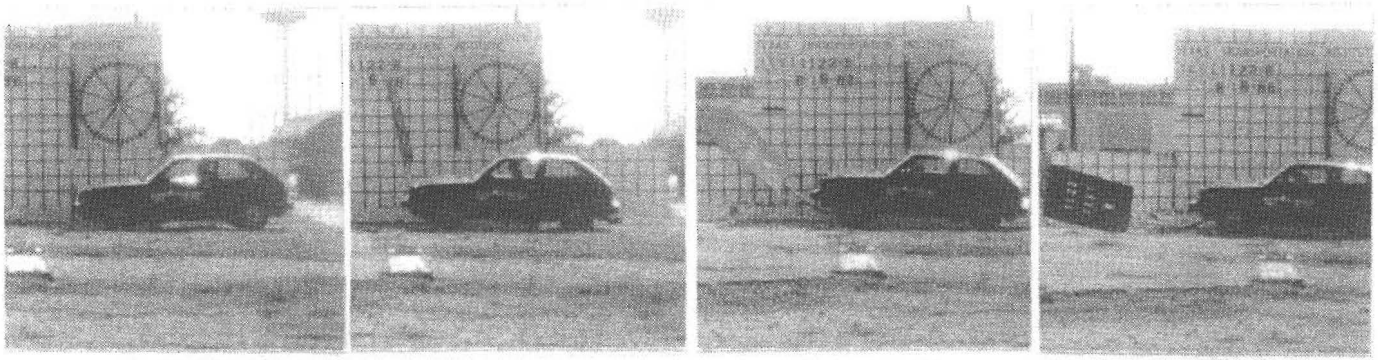
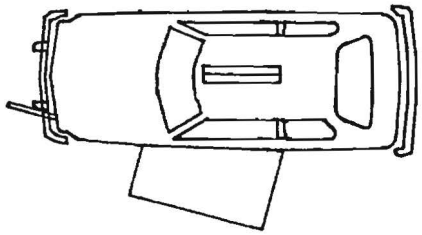


Figure 84. Sign installation after test 1122-8.

Figure 85. Vehicle after test 1122-8.



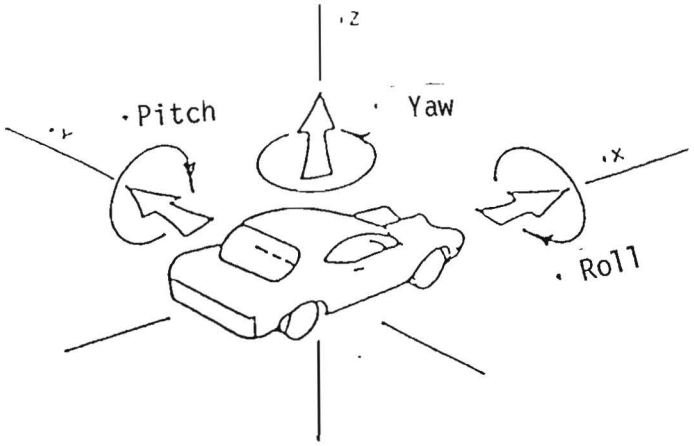
0.000 s 0.131 s 0.262 s 0.393 s



Test No.	1122-8
Date	08/16/88
Test Article	Sign Installation
Support	2 1/2" Pipe & Pipe Coupling Support
Vehicle	1982 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,970 lb (894 kg)
Vehicle Damage Classification	
TAD	12FR1
SAE	12FRE1 & 00TDGN1

Impact Speed.	20.6 mi/h (33.1 km/h)
Change in Velocity . . .	11.0 mi/h (17.7 km/h)
Change in Momentum. . . .	904 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-4.6 g
Lateral	-1.2 g
Occupant Impact Velocity	
Longitudinal.	15.2 ft/s (4.6 m/s)
Lateral	None
Occupant Ridedown Accelerations	
Longitudinal	-0.5 g
Lateral	No Contact

Figure 86. Summary of results for test 1122-8.



Axes are vehicle fixed. Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

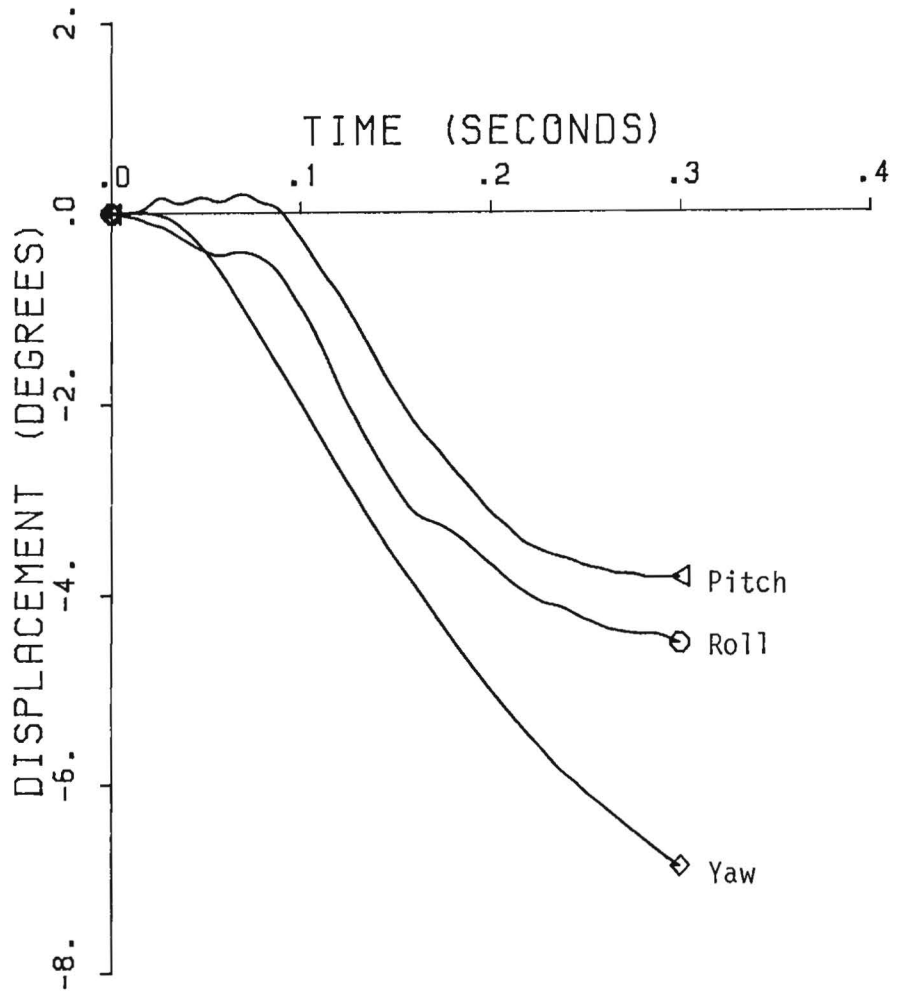


Figure 87. Vehicle angular displacements for test 1122-8.

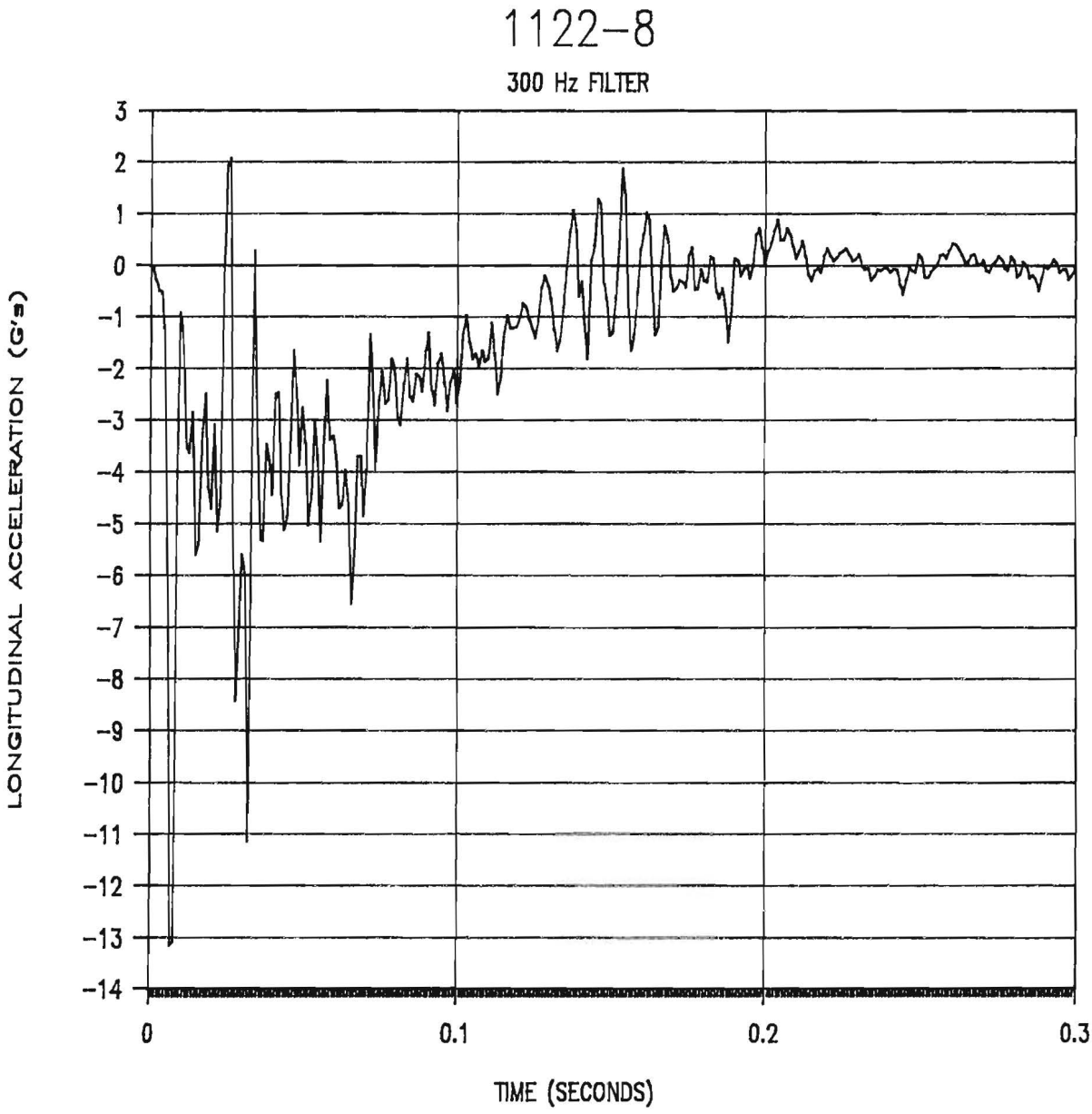


Figure 88. Longitudinal accelerometer trace for test 1122-8.

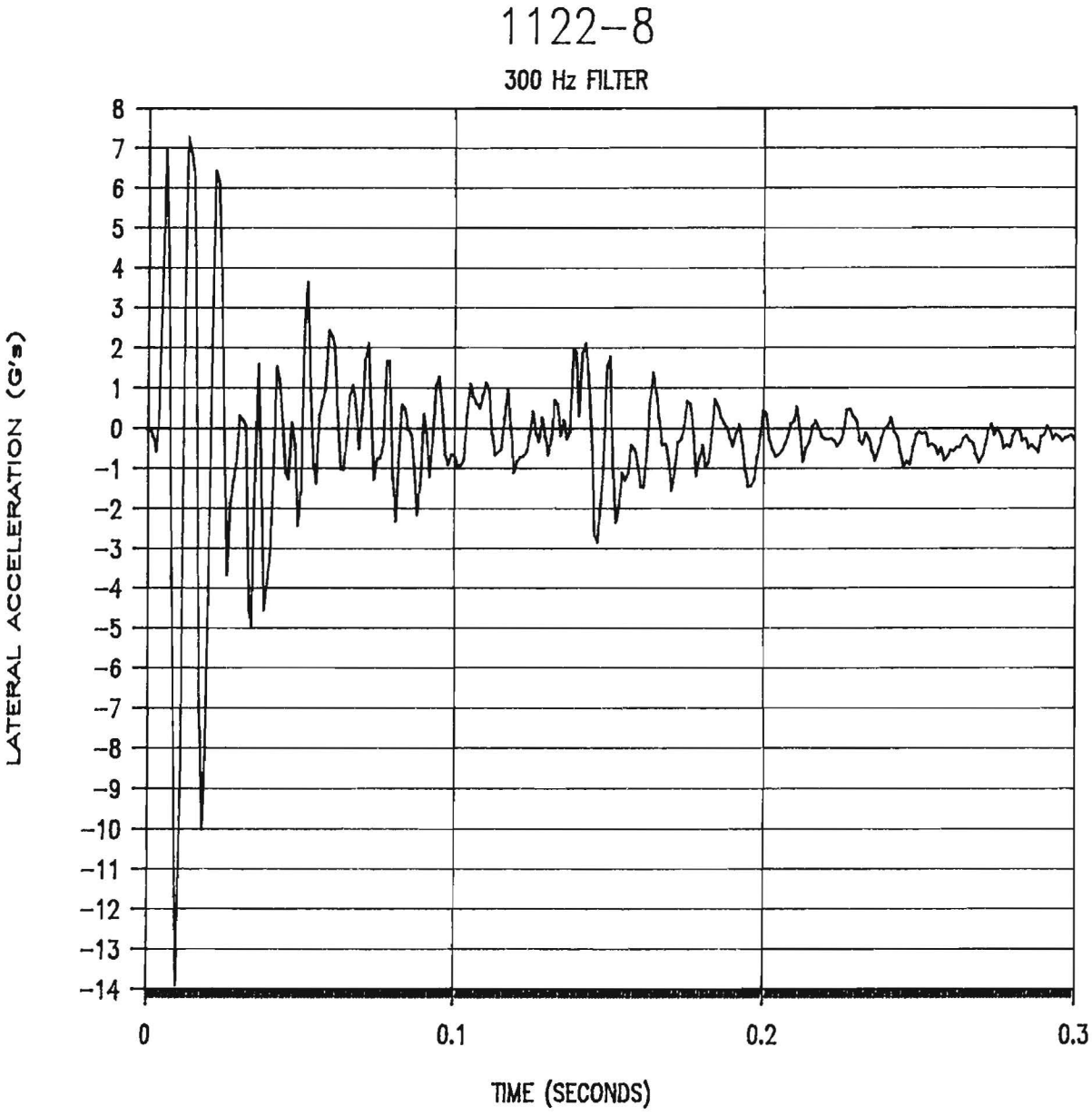


Figure 89. Lateral accelerometer trace for test 1122-8.

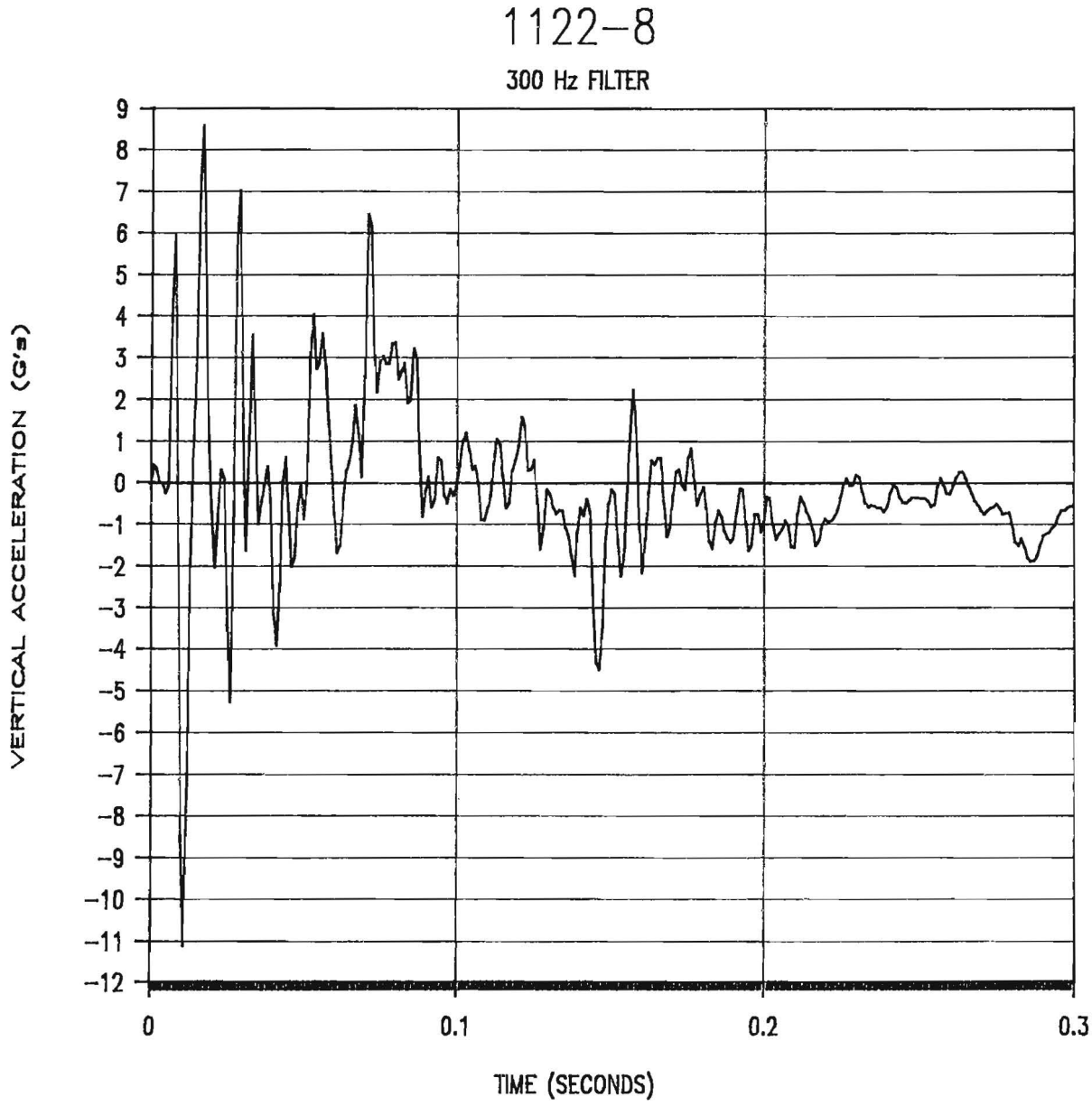


Figure 90. Vertical accelerometer trace for test 1122-8.

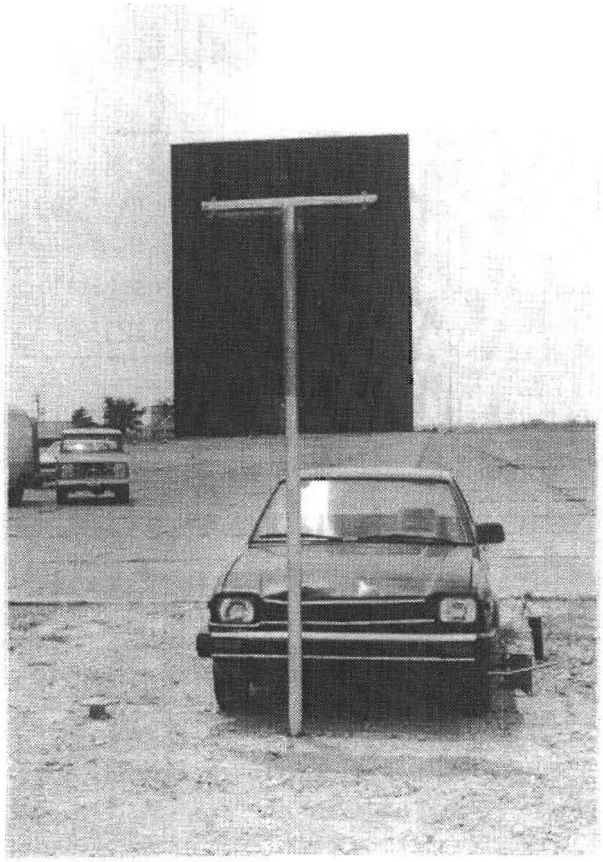


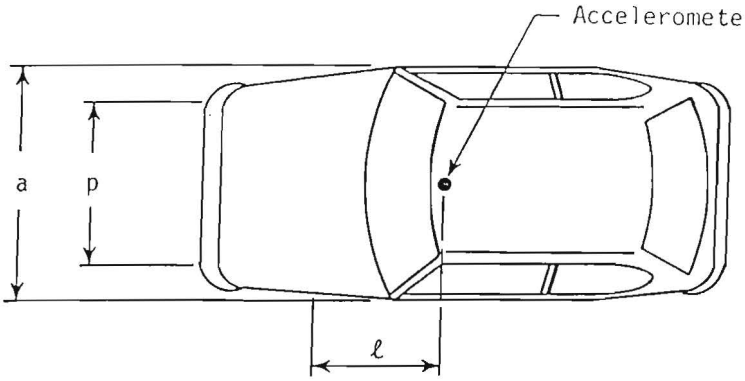
Figure 91. Vehicle before test 1122-9.

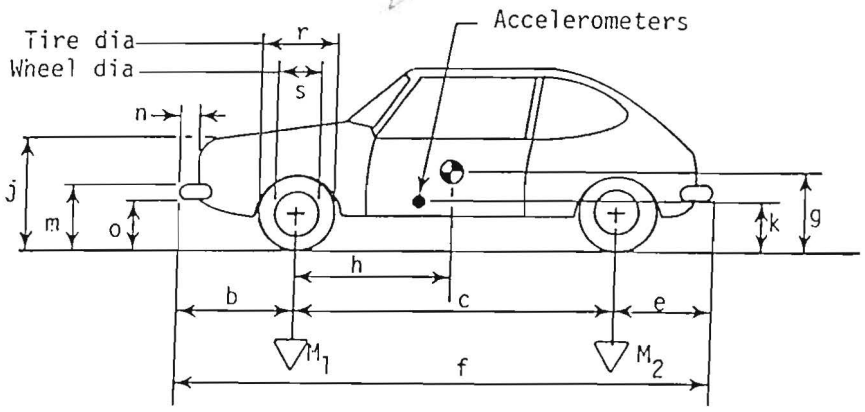
Date: 8/16/88 Test No.: 1122-9 VIN: JHMSL5327CS012650

Make: Honda Model: Civic Year: 1982 Odometer: 110007

Tire Size: 155 SR13 Ply Rating: _____ Bias Ply: ___ Belted: ___ Radial: X

Tire Condition: good ___
fair X
badly worn ___





4-wheel weight for c.g. det. ℓf 600 rf 532 ℓr 329 rr 339

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1159	1132	1216
M_2	639	668	754
M_T	1798	1800	1970

Note any damage to vehicle prior to test:

_____

_____

*d = overall height of vehicle

Vehicle Geometry - inches

a	62 3/4	b	30
c	88	d*	52 3/4
e	28	f	146
g	_____	h	32.7
i	----	j	30
k	16 1/2	ℓ	28 1/2
m	19 1/2	n	4
o	13 3/4	p	54
r	21 3/4	s	14 1/4

Engine Type: 4 cyld

Engine CID: _____

Transmission Type:

Automatic or (Manual)

(FWD) or RWD or 4WD

Body Type: Hatch

Steering Column Collapse Mechanism:

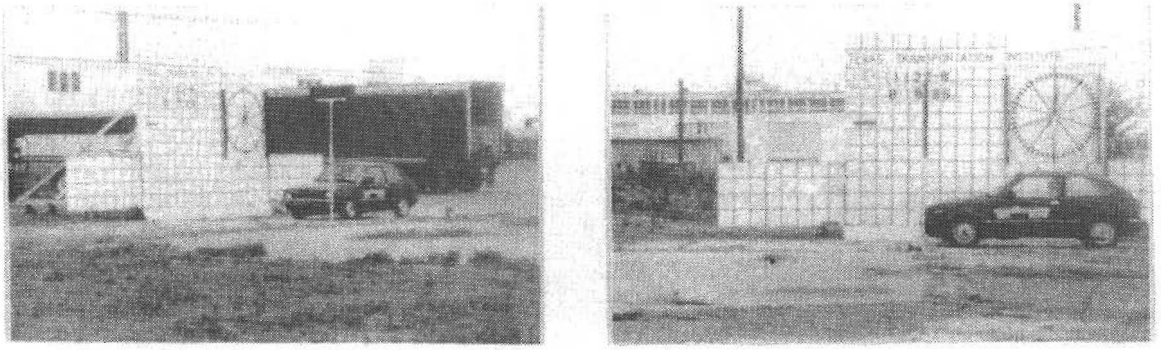
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:

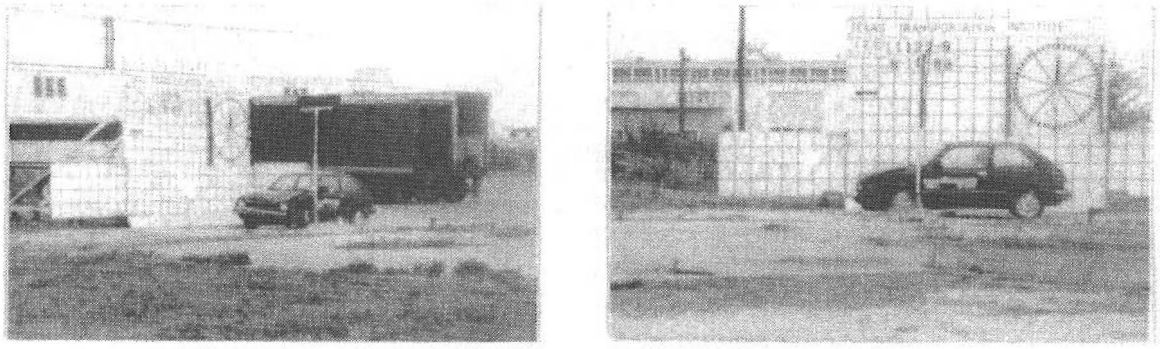
Front: disc X drum ___

Rear: disc ___ drum X

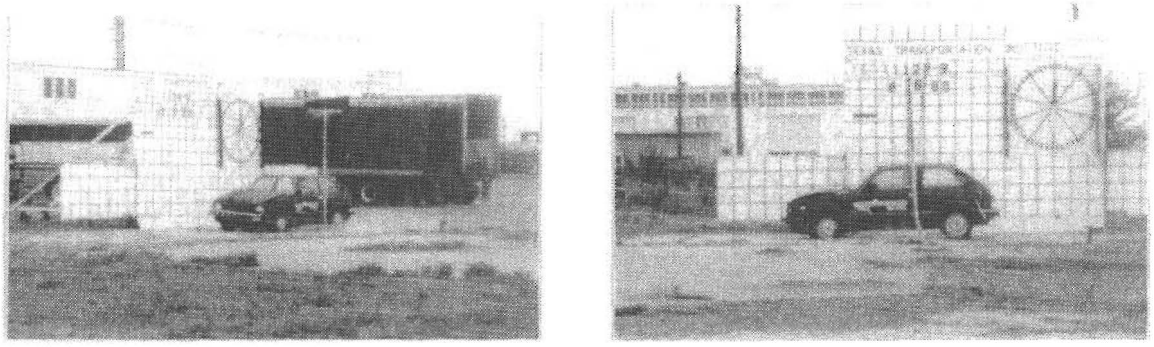
Figure 92. Test vehicle properties (1122-9).



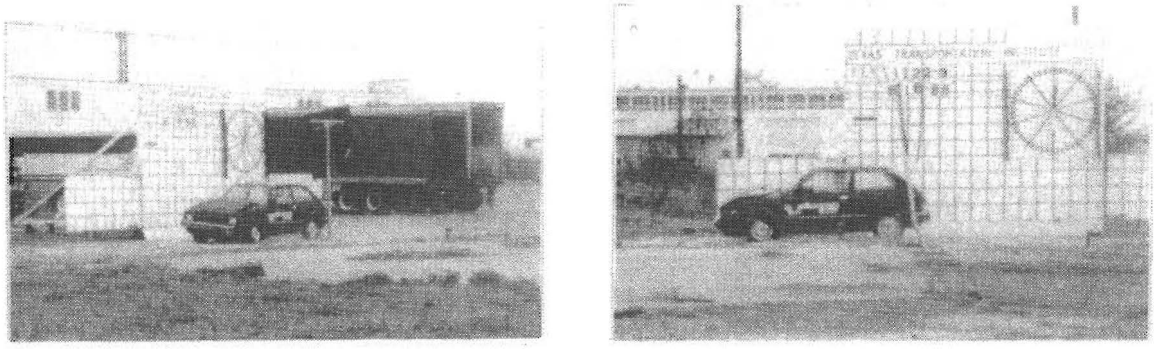
0.000 s



0.045 s

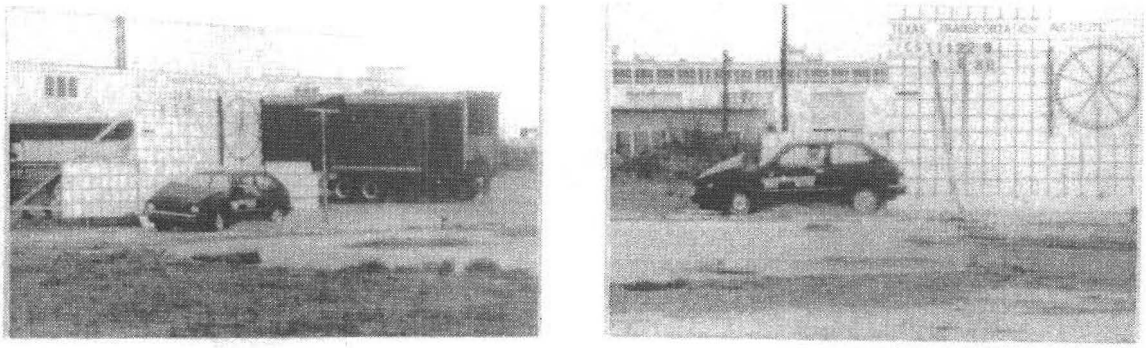


0.091 s

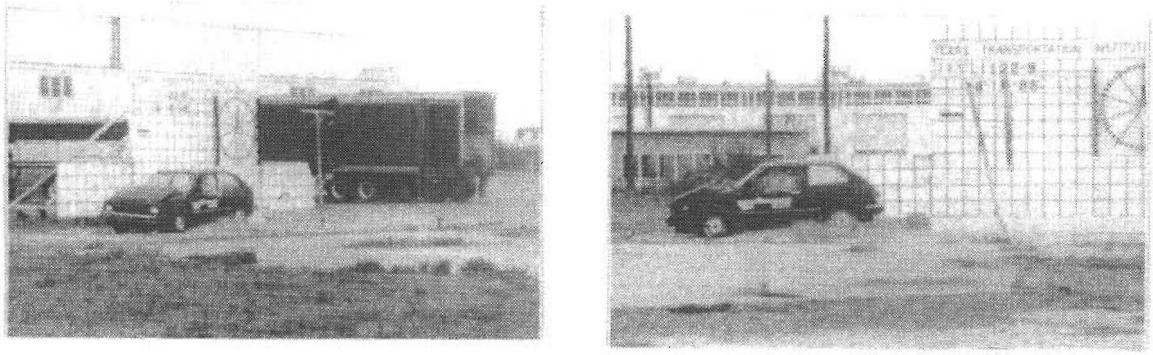


0.136 s

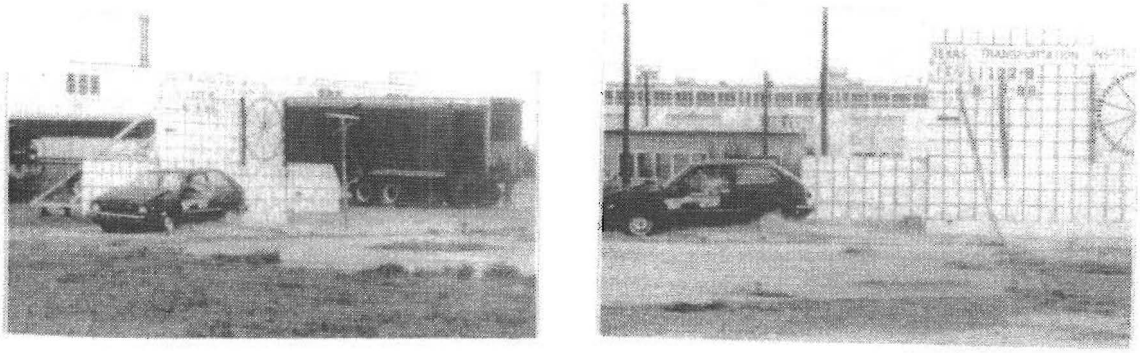
Figure 93. Sequential photographs for test 1122-9.



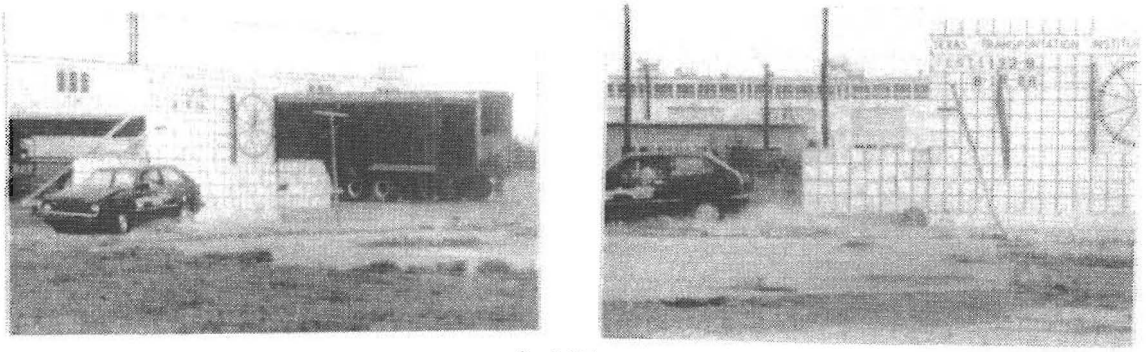
0.181 s



0.227 s



0.272 s



0.317 s

Figure 93. Sequential photographs for test 1122-9. (Continued)

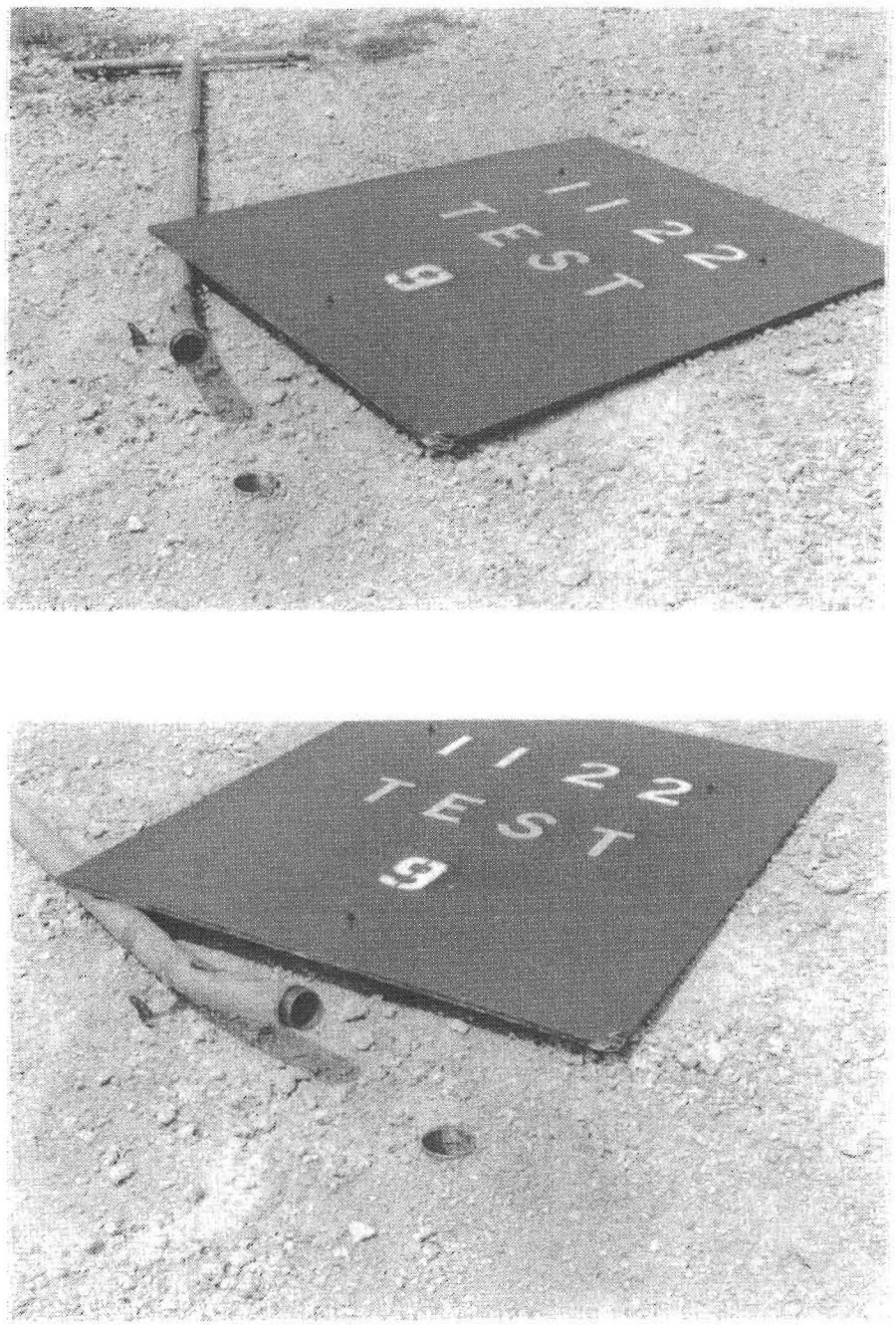
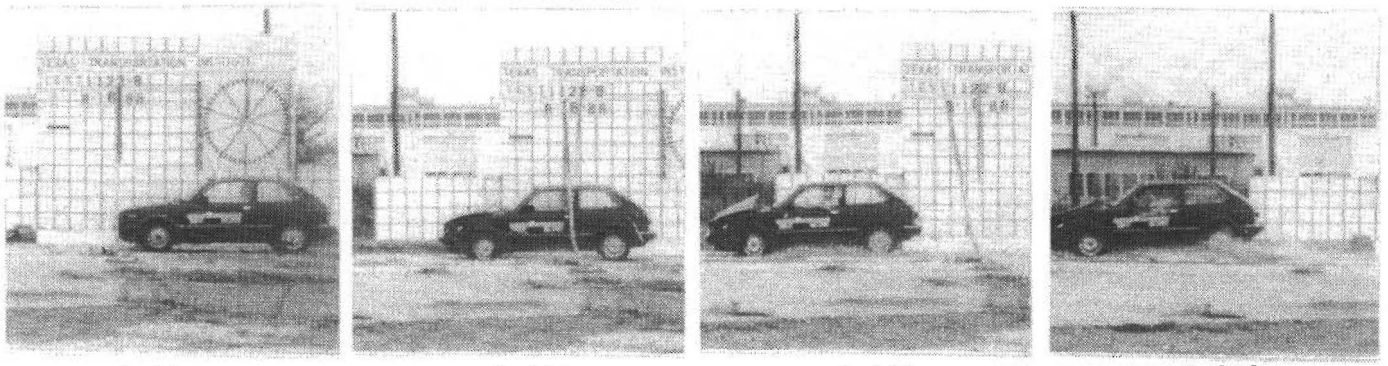
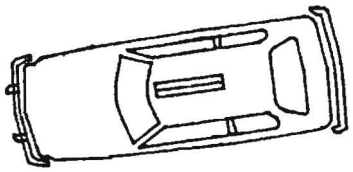


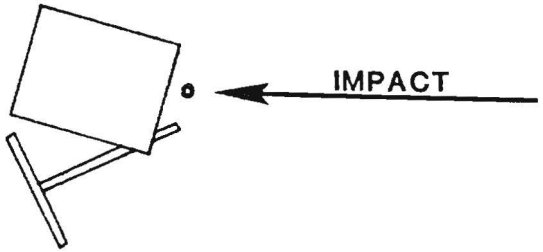
Figure 94. Sign installation after test 1122-9.

Figure 95. Vehicle after test 1122-9.



0.000 s 0.091 s 0.181 s 0.272 s

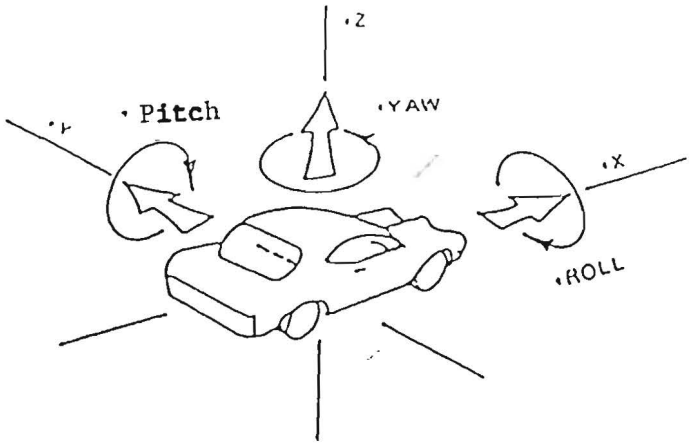




Test No.	1122-9
Date	08/16/88
Test Article	Sign Installation
Support	2 1/2" Pipe & Pipe Collar Coupling Support
Vehicle	1982 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,970 lb (894 kg)
Vehicle Damage Classification	
TAD	12FL1
SAE	12FFEN4

Impact Speed.	60.7 mi/h (97.7 km/h)
Change in Velocity . . .	10.6 mi/h (17.1 km/h)
Change in Momentum. . . .	868 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-3.5 g
Lateral	-2.0 g
Occupant Impact Velocity	
Longitudinal.	10.7 ft/s (3.3 m/s)
Lateral	None
Occupant Ridedown Accelerations	
Longitudinal	-1.4 g
Lateral	No Contact

Figure 96. Summary of results for test 1122-9.



Axes are vehicle fixed.
Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

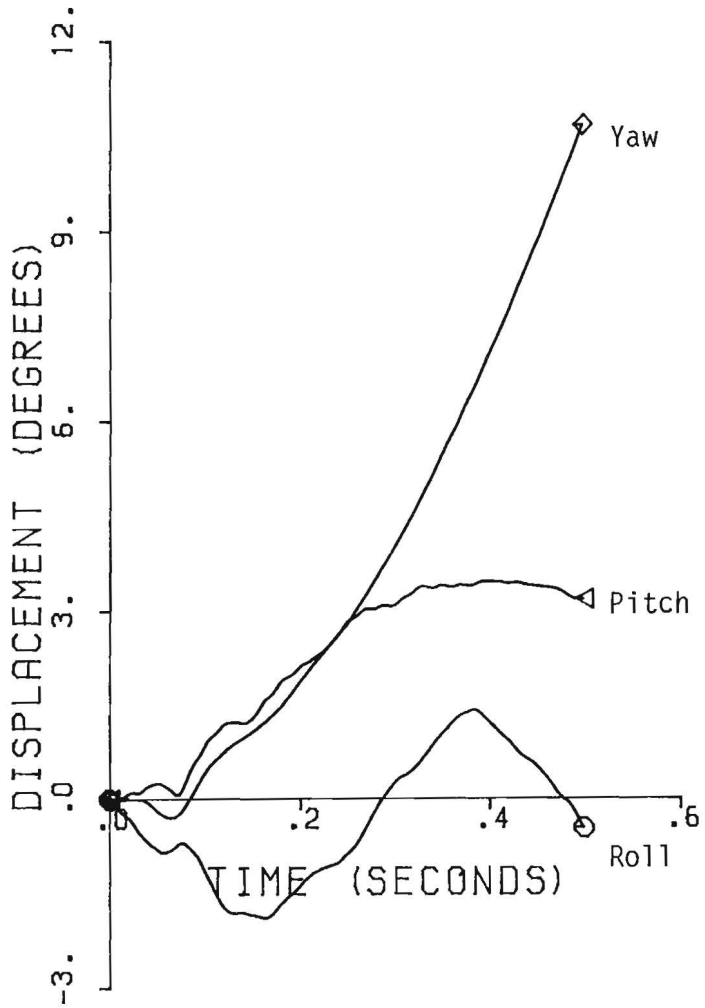


Figure 97. Vehicle angular displacements for test 1122-9.

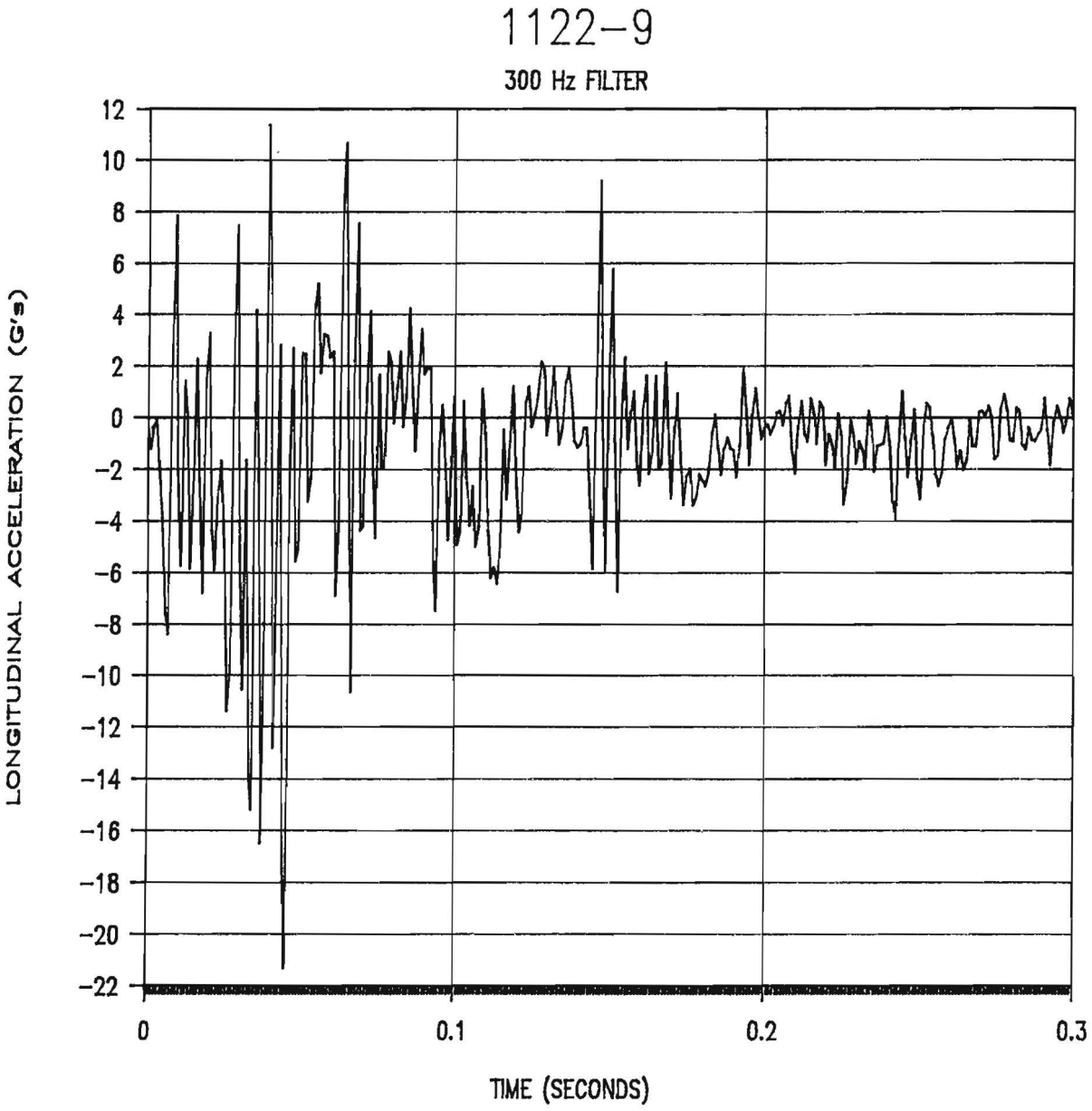


Figure 98. Longitudinal accelerometer trace for test 1122-9.

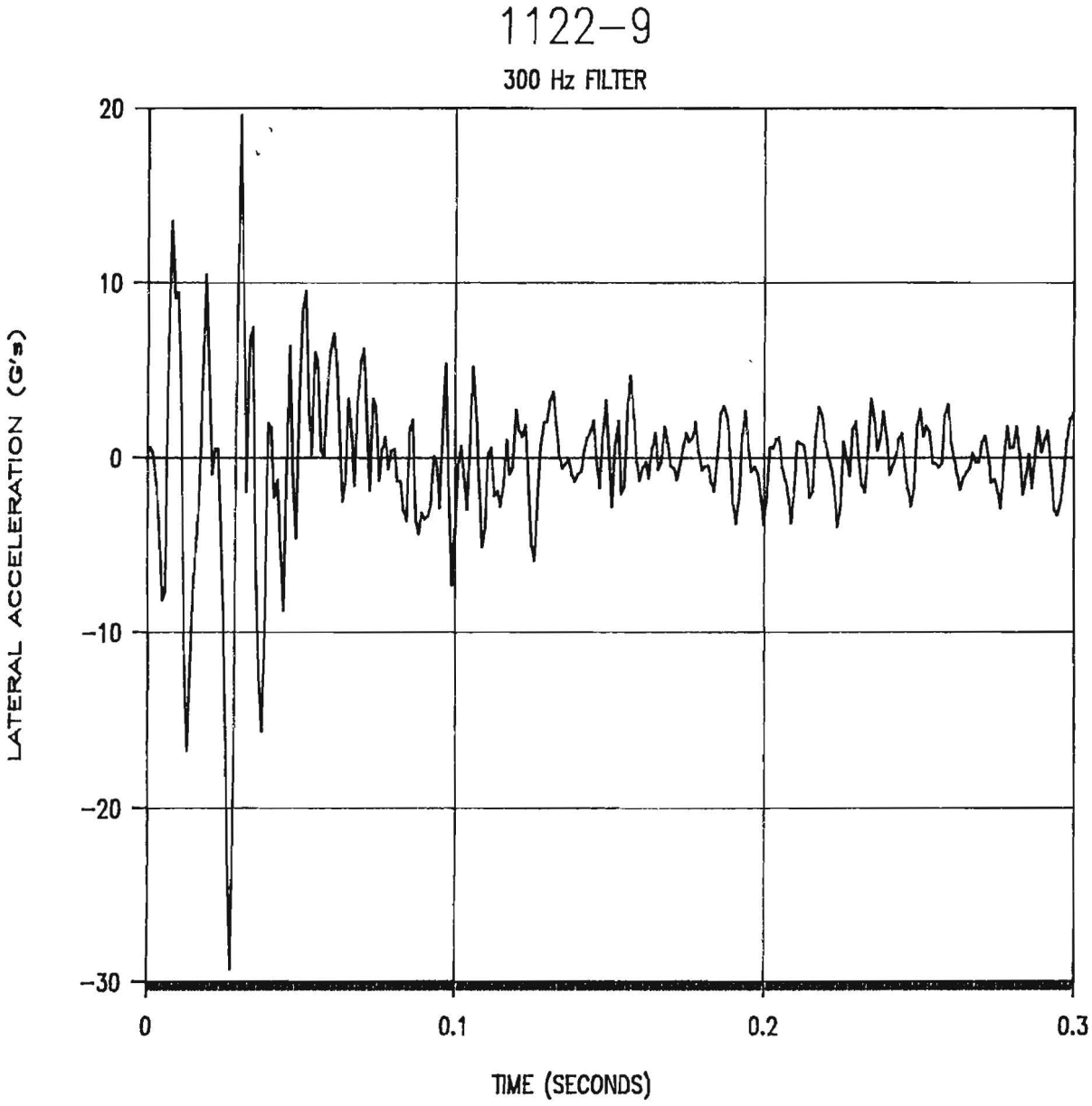


Figure 99. Lateral accelerometer trace for test 1122-9.

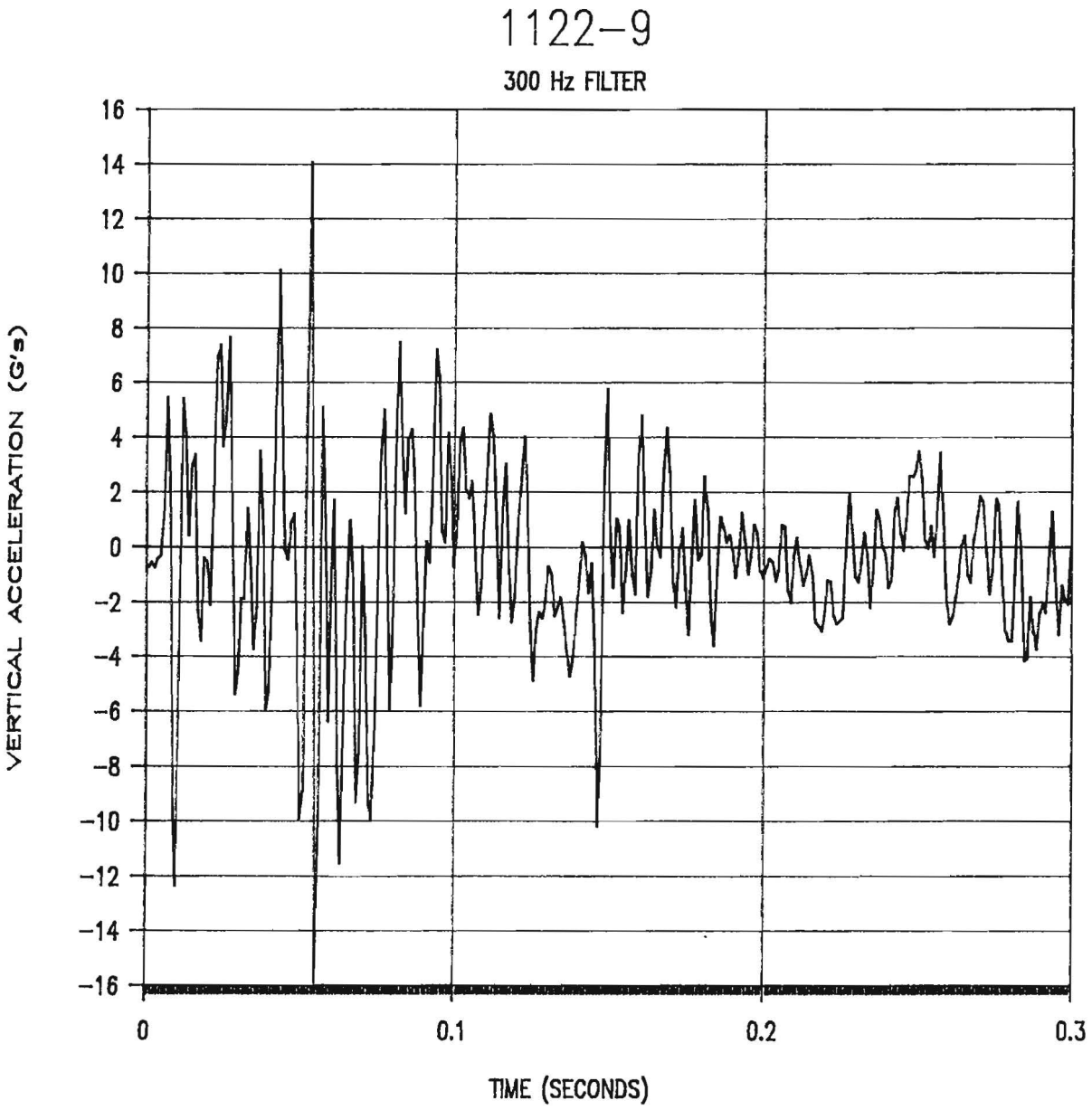


Figure 100. Vertical accelerometer trace for test 1122-9.

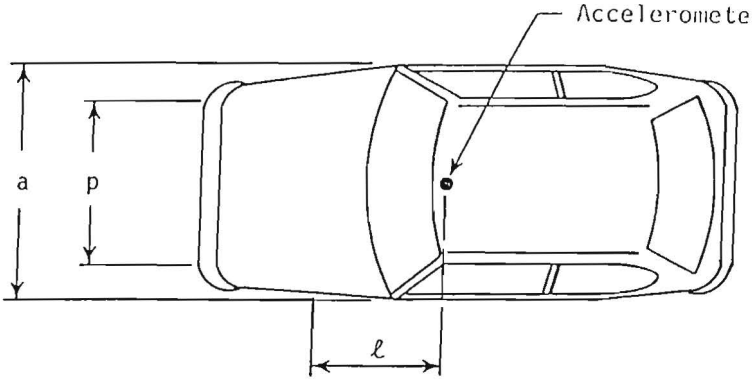
Figure 101. Vehicle before test 1122-9A.

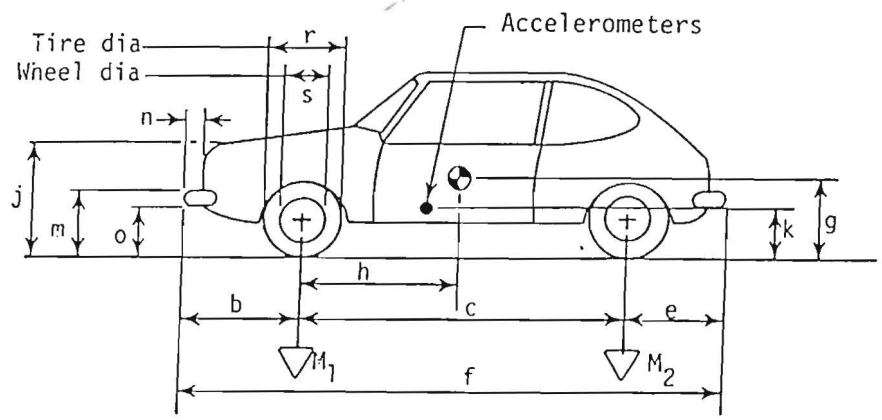
Date: 8/26/88 Test No.: 1122-9A VIN: JHMSL4312BS027072

Make: Honda Model: Civic Year: 1981 Odometer: 873645

Tire Size: 155/SR12 Ply Rating: 2 Bias Ply: X Belted: ___ Radial: ___

Tire Condition: good ___
fair X
badly worn ___





4-wheel weight for c.g. det. ℓf 582 rf 550 ℓr 330 rr 338

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1139	1132	1214
M_2	669	668	753
M_T	1808	1800	1967

Note any damage to vehicle prior to test:

_____

_____

*d = overall height of vehicle

Vehicle Geometry - inches

a	62 1/4	b	29 1/4
c	88	d*	52
e	29 1/4	f	
g		h	32.7
i	----	j	30
k	16 1/2	ℓ	29
m	19 1/2	n	4 1/2
o	13 1/2	p	54
r	21 1/2	s	13 1/4

Engine Type: 4 cyl

Engine CID: _____

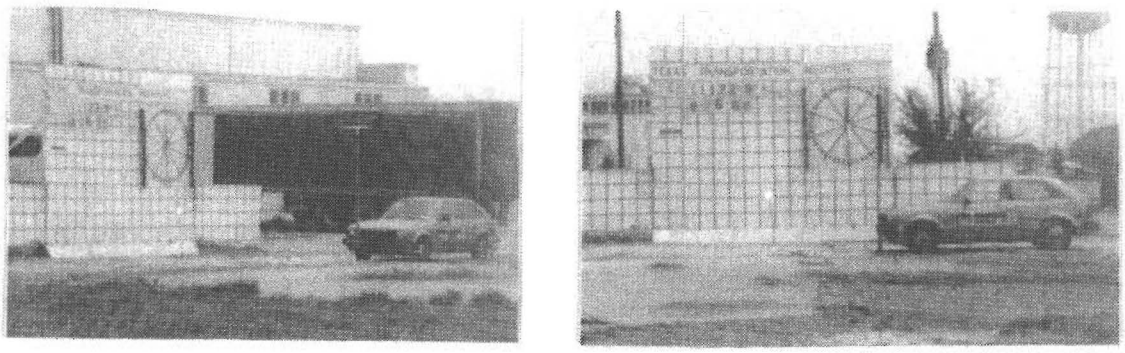
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD

Body Type: Hatch

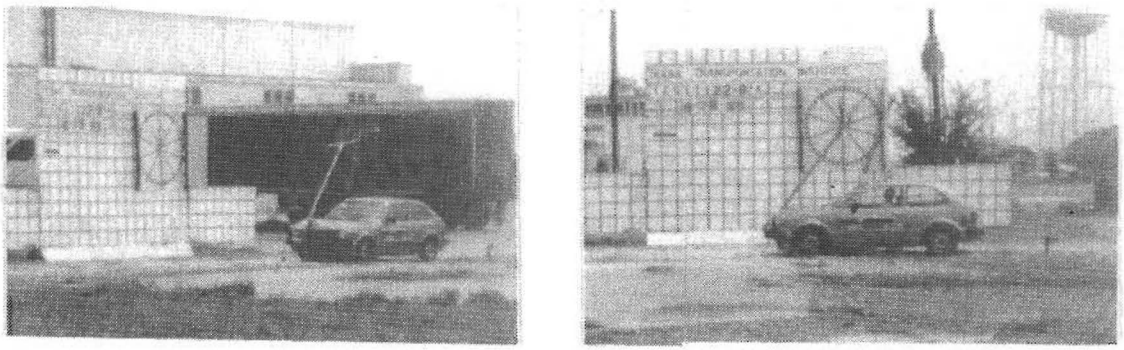
Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

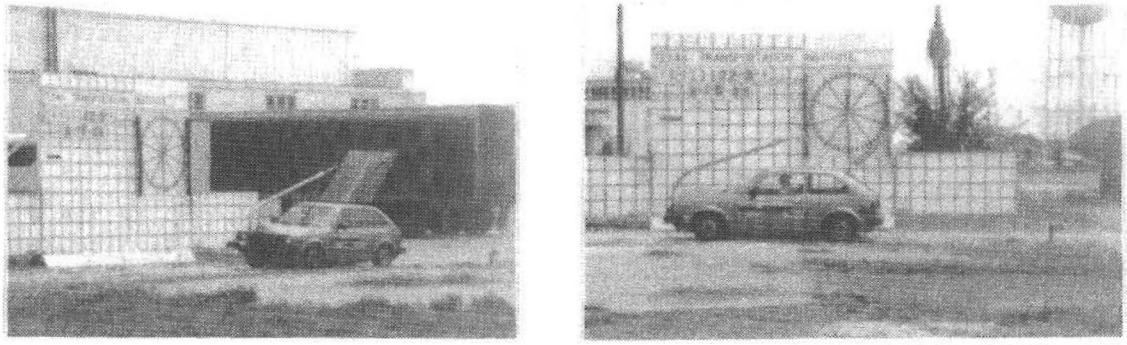
Figure 102. Test vehicle properties (1122-9A).



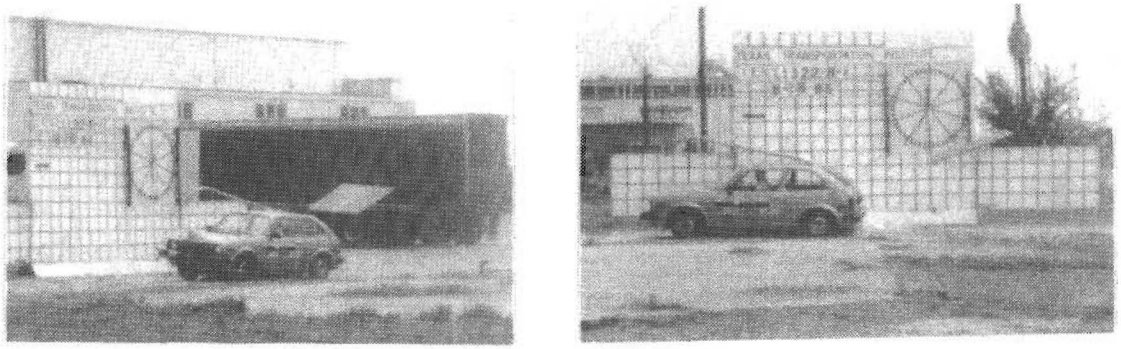
0.000 s



0.071 s

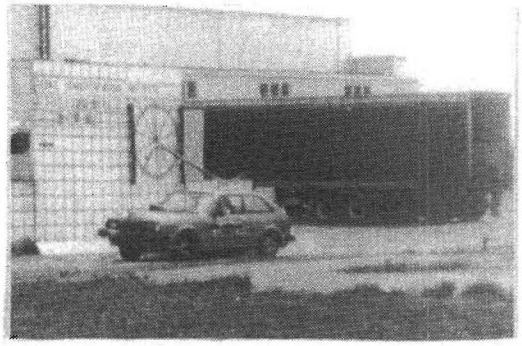
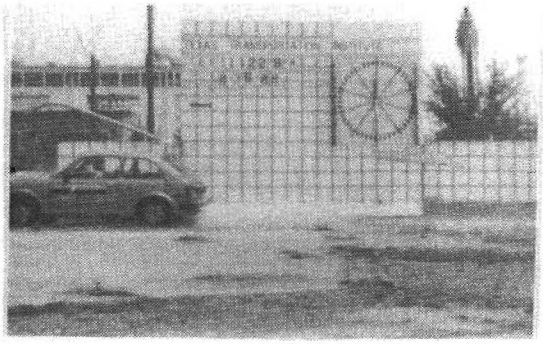


0.141 s

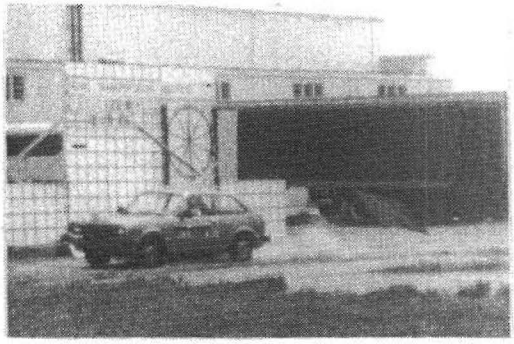
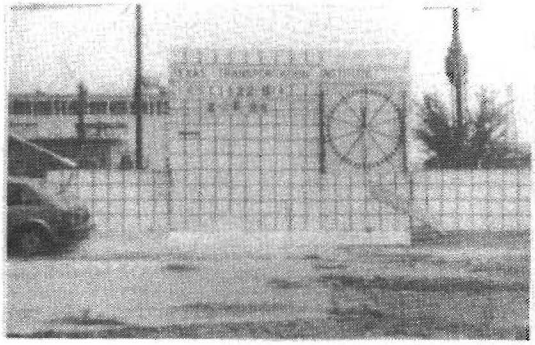


0.212 s

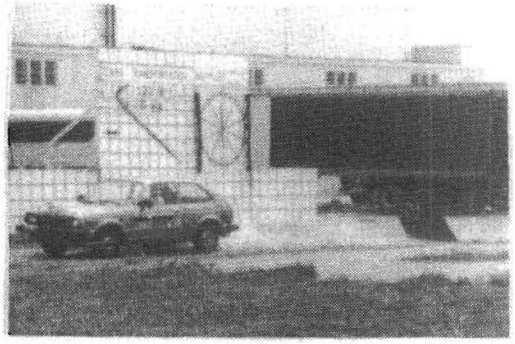
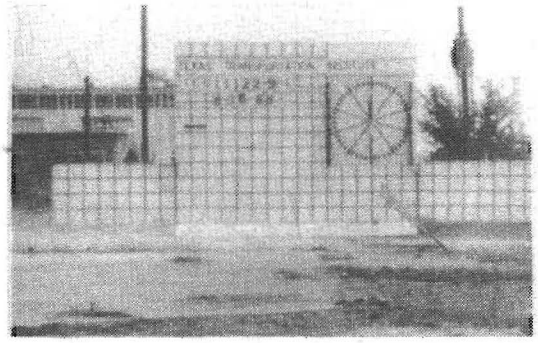
Figure 103. Sequential photographs for test 1122-9A.

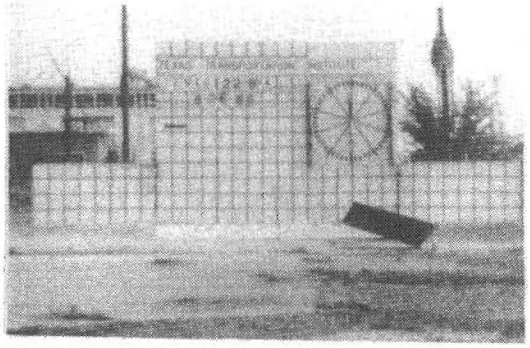
0.285 s

0.359 s

0.432 s



0.505 s

Figure 103. Sequential photographs for test 1122-9A. (Continued)

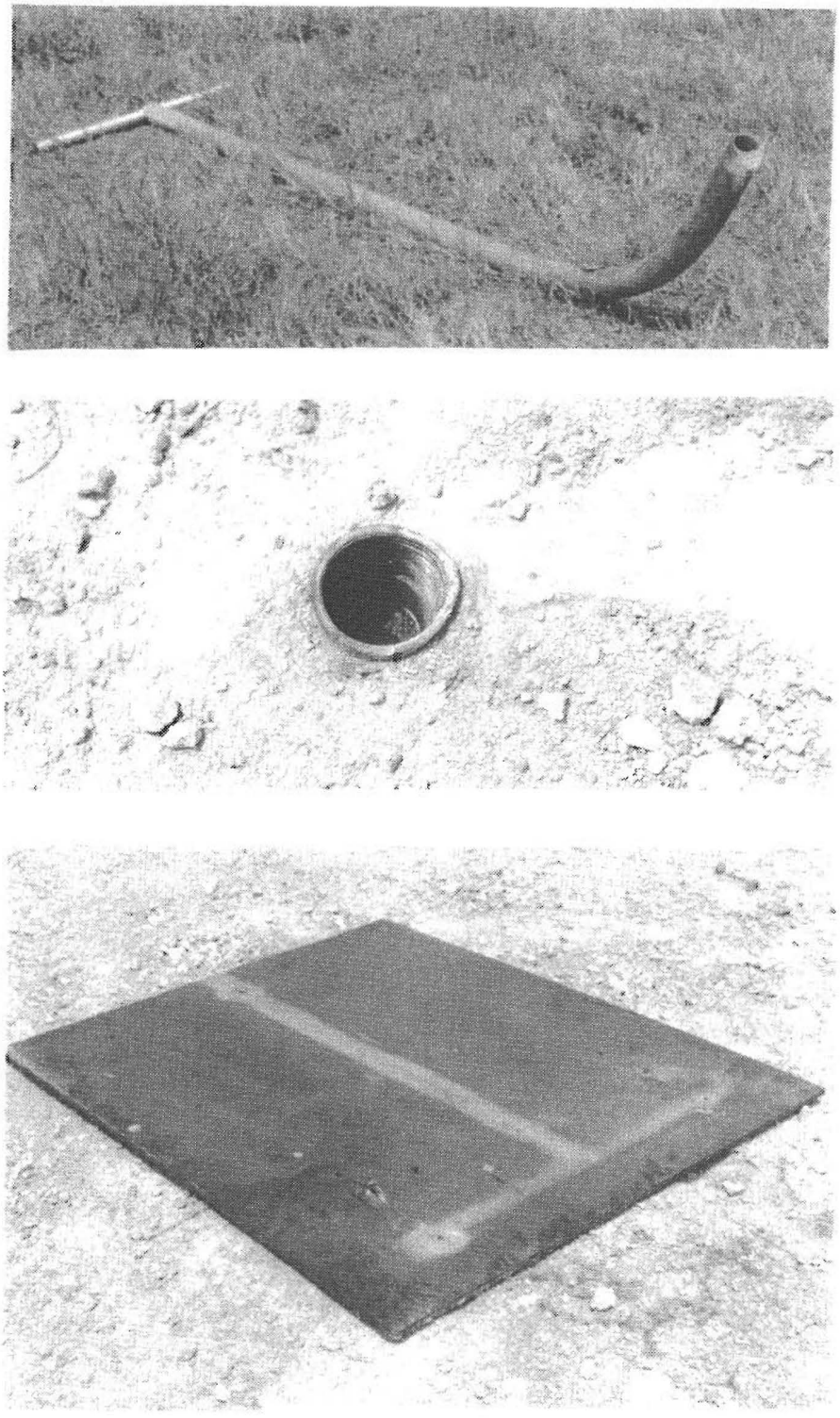
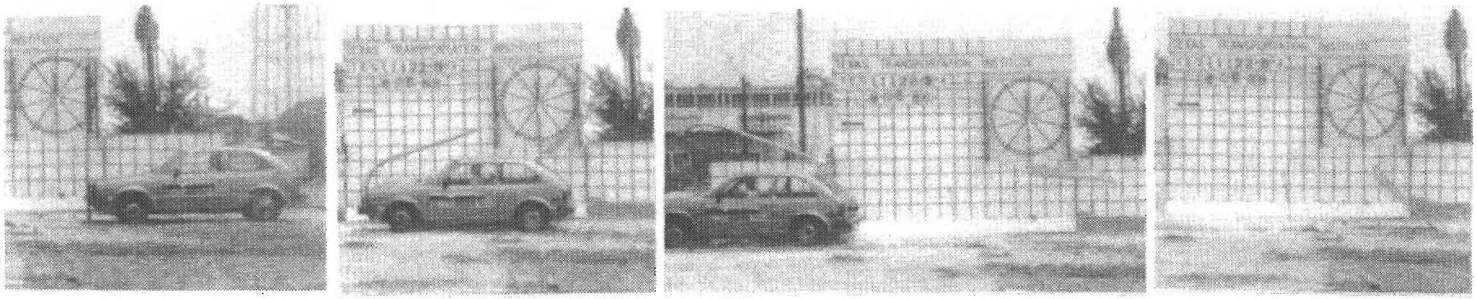
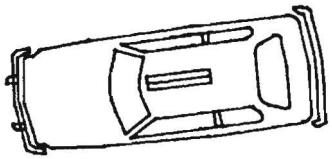


Figure 104. Sign installation after test 1122-9A.

Figure 105. Vehicle after test 1122-9A.



0.000 s 0.141 s 0.285 s 0.432 s



Test No.	1122-9A
Date	08/26/88
Test Article	Sign Installation
Support	2 1/2" Pipe & Pipe Collar Coupling Support
Vehicle	1981 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,967 lb (892 kg)
Vehicle Damage Classification	
TAD	12FC2
SAE	12FREN1

Impact Speed.	61.0 mi/h (98.2 km/h)
Change in Velocity . . .	6.7 mi/h (10.7 km/h)
Change in Momentum. . . .	545 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-4.2 g
Lateral	-1.8 g
Occupant Impact Velocity	
Longitudinal.	None
Lateral	None
Occupant Ridedown Accelerations	
Longitudinal	No Contact
Lateral	No Contact

Figure 106. Summary of results for test 1122-9A.

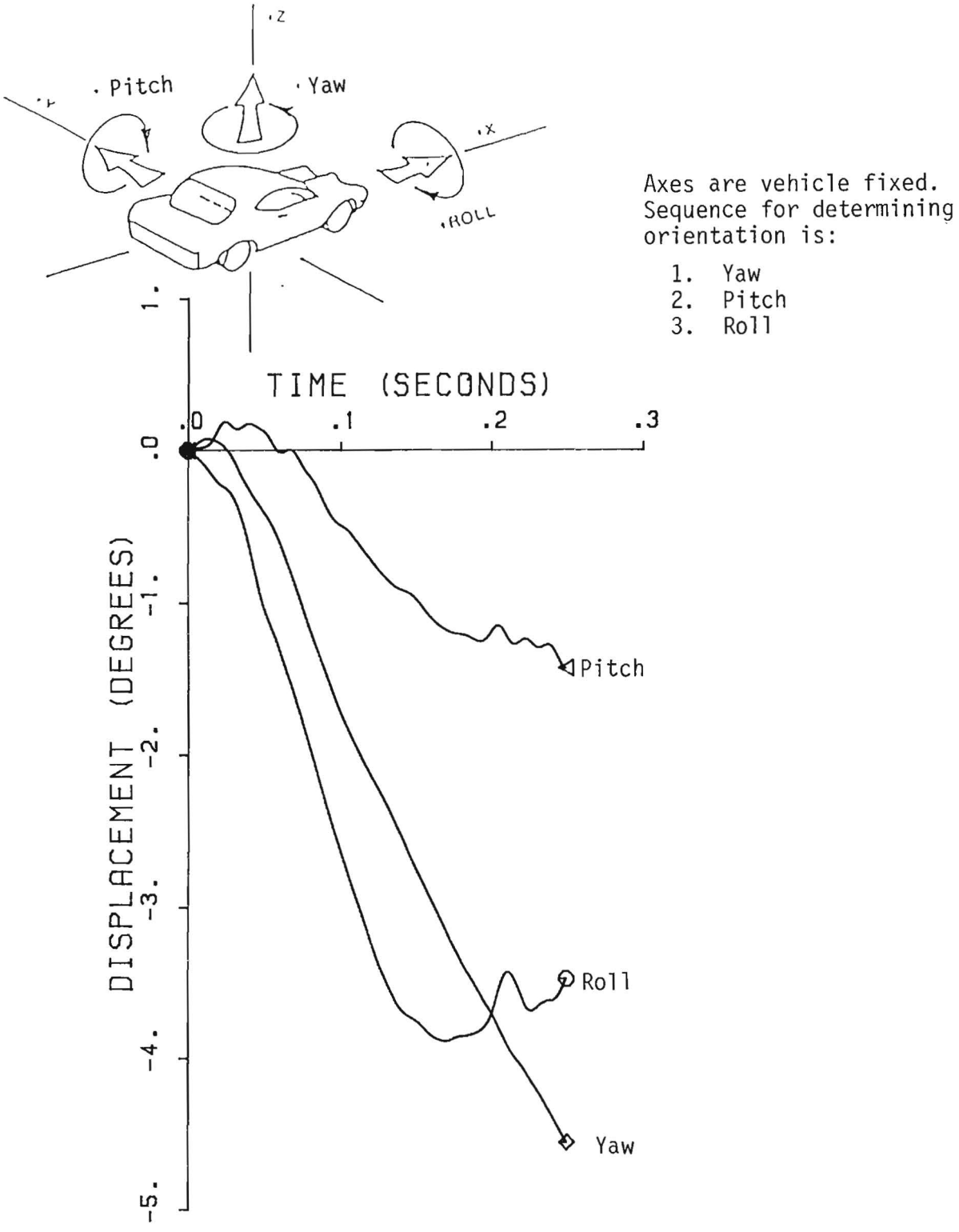


Figure 107. Vehicle angular displacements for test 1122-9A.

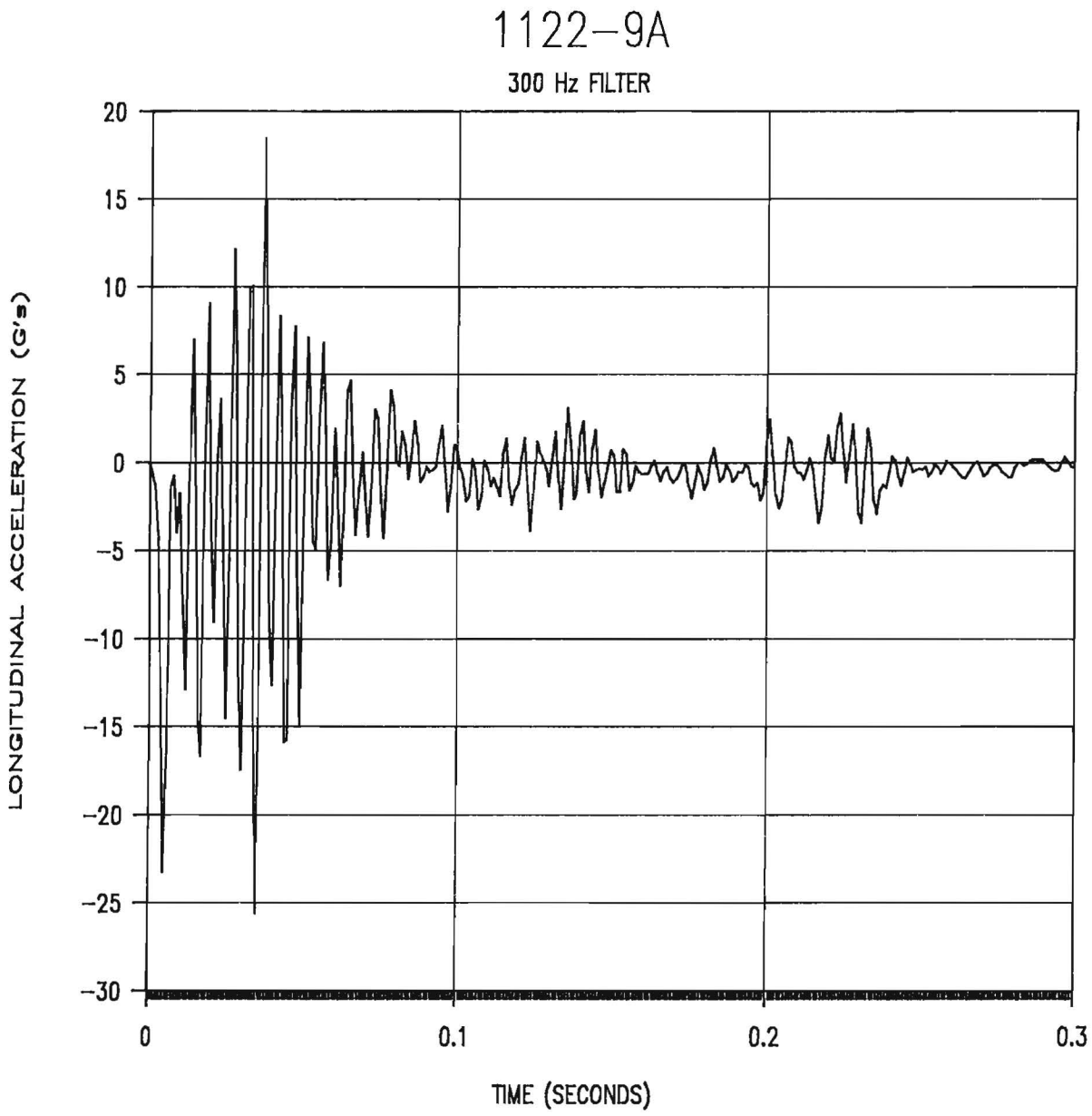


Figure 108. Longitudinal accelerometer trace for test 1122-9A.

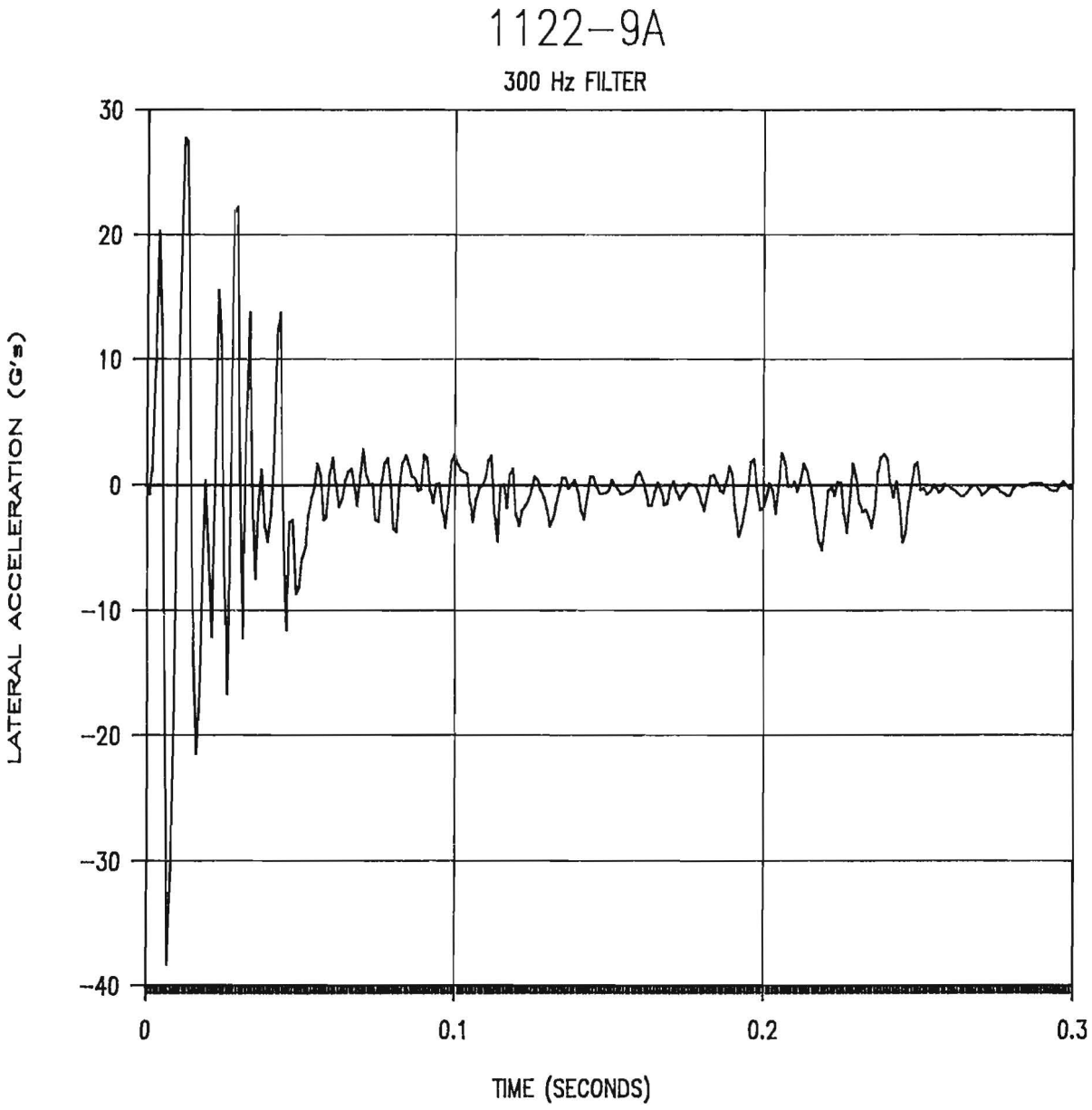


Figure 109. Lateral accelerometer trace for test 1122-9A.

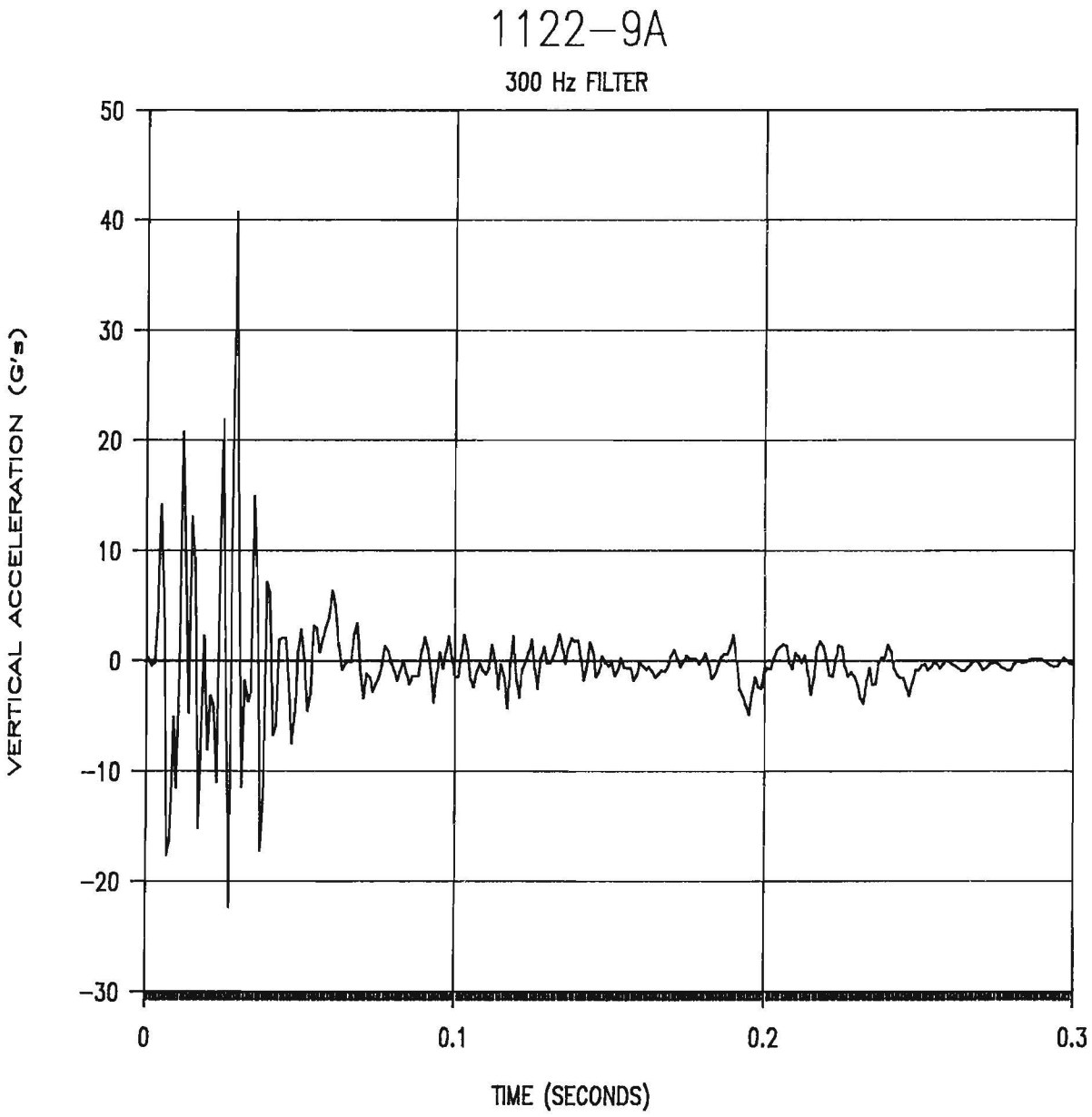


Figure 110. Vertical accelerometer trace for test 1122-9A.

DESCRIPTION OF TEST INSTALLATION FOR 1122-10 & 11

The sign installation used in these tests consisted of a U-frame constructed of 2.0 inch diameter steel pipe welded to a 3.0 inch diameter steel pipe support. The U-frame dimensions were 9 ft-1 1/2 in on one side and 4 ft-6 in on the other. The spacing between the U-frame uprights was 2 ft-8 1/2 in. This was welded to a 4 ft-10 long steel pipe support equipped with a triangular slip base. A 3.0 inch x 36.0 inch steel pipe with triangular slip base and lifting ramp was embedded in a concrete footing 18.0 inches in diameter x 42.0 inches long for attachment purposes. The concrete footing was placed in crushed limestone (NCHRP Report 230 Strong Soil). The sign support base was then attached to the footing base using 5/8 in x 2-1/2 in H.S. Hex bolts, washers, and nuts. All signs were attached using 2 cast pipe clamps per sign with U-bolts. The bottom of sign mounting height was 5 ft-0 in. Details of the sign installation are shown in Figures 111 and 112.

TEST REPORT 1122-10

VEHICLE: 1980 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,972 lbs.

TEST ARTICLE: Single Support Sign Installation
Support: 3.0 inch Pipe Support
with Triangular Slip Base

IMPACT CONDITIONS: 19.7 mi/h
Quarter point (on passenger
side of vehicle)

Crash Test Results

A 1980 Honda Civic (shown in Figure 113) impacted the sign installation at 19.7 miles per hour (31.7 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,972 lb (894 kg). The height to the lower edge of the vehicle bumper was 11.6 inches (29.5 cm) and 20.0 inches (50.8 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 114.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the quarter point on the passenger side of the vehicle. Upon impact, the sign support began to slip. At approximately 0.020 second, the support had completely detached from the anchored slip base. As the vehicle passed beneath the installation, the face of the sign impacted the rear of the vehicle at 0.640 second. In addition, at 1.110 seconds,

the base of the sign support came down into the vehicle's rear hatch window. Shortly thereafter, the brakes were applied and the vehicle came to rest 110 ft (33.5 m) from the point of impact. Sequential photographs of the test are shown in Figure 115.

The sign installation came to rest directly on the rear of the test vehicle. The sign installation received only minor damages. The vehicle sustained minor damage to the bumper and rear hatch door as shown in Figure 117.

A summary of the test results and other information pertinent to this test are given in Figure 118. The maximum 0.050 second average acceleration experienced by the vehicle was -1.8 g in the longitudinal direction and -0.6 g in the lateral direction. Vehicle angular displacements are plotted in Figure 119 and vehicle accelerometer traces are displayed in Figure 120 through 122. No contact by the anthropomorphic dummy was made. Therefore, no occupant impact velocity or ridedown accelerations were recorded in the longitudinal or lateral direction. Change in velocity was 4.0 mi/h (6.4 km/h) and change in momentum was 328 lb-s.

In summary, the sign installation yielded to the vehicle and the vehicle sustained very minor damage. Although, the base of the sign support came down into the vehicle's rear hatch window, it did not present undue hazard to the occupants or to other traffic. No occupant impact velocity or ridedown accelerations were recorded. The change in momentum was considerably under the recommended limit of 1100 lb-s. This sign installation in "strong" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

TEST REPORT 1122-11

VEHICLE: 1980 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,972 lbs.

TEST ARTICLE: Single Support Sign Installation
Support: 3.0 inch Pipe Support
with Triangular Slip Base

IMPACT CONDITIONS: 59.8 mi/h
Quarter point (on passenger
side of vehicle)

Crash Test Results

A 1980 Honda Civic (shown in Figure 123) impacted the sign installation at 59.8 miles per hour (96.2 km/h) using a cable reverse tow and guidance system.

Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,972 lb (894 kg). The height to the lower edge of the vehicle bumper was 11.6 inches (29.5 cm) and 20.0 inches (50.8 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 124.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign, with the quarter point on the passenger side of the vehicle. Upon impact, the sign support began to slip. At approximately 0.013 second, the support had completely detached from the anchored slip base. As the sign installation yielded, the test vehicle passed beneath. At approximately 0.078 second, the vehicle lost complete contact with the installation. Shortly thereafter, the brakes were applied and the vehicle came to rest 185 ft (56.4 m) from the point of impact. Sequential photographs of the test are shown in Figure 125.

The sign installation came to rest 24 ft from the point of impact. The sign installation received only minor damages. The vehicle sustained minor damage to the bumper and hood as shown in Figure 127.

A summary of the test results and other information pertinent to this test are given in Figure 128. The maximum 0.050 second average acceleration experienced by the vehicle was -3.3 g in the longitudinal direction and -0.9 g in the lateral direction. Vehicle angular displacements are plotted in Figure 129 and vehicle accelerometer traces are displayed in Figure 130 through 132. No contact by the anthropomorphic dummy was made. Therefore, no occupant impact velocity or ridedown accelerations were recorded in the longitudinal or lateral direction. Change in velocity was 5.5 mi/h (8.9 km/h) and change in momentum was 451 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. No occupant impact velocity or ridedown accelerations were recorded. The change in momentum was considerably under the recommended limit of 1100 lb-s. This sign installation in "strong" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

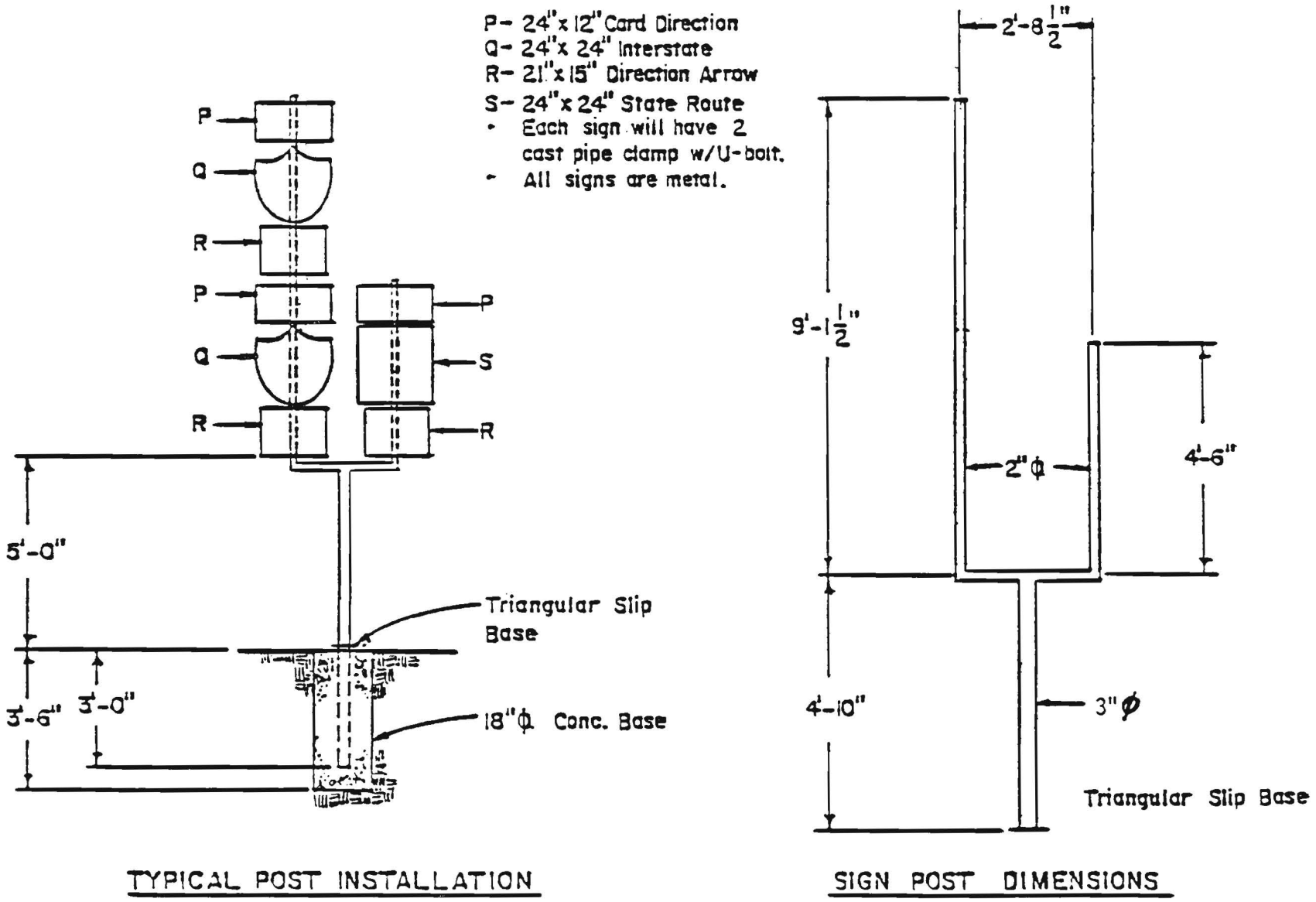
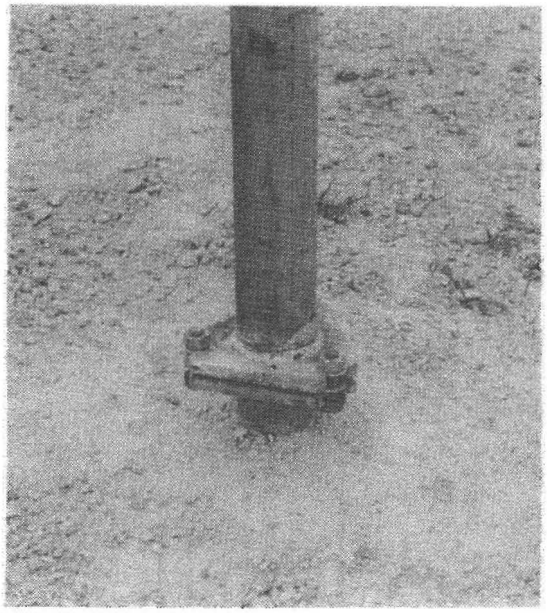


Figure 111. Signpost installation details for test 1122-10.



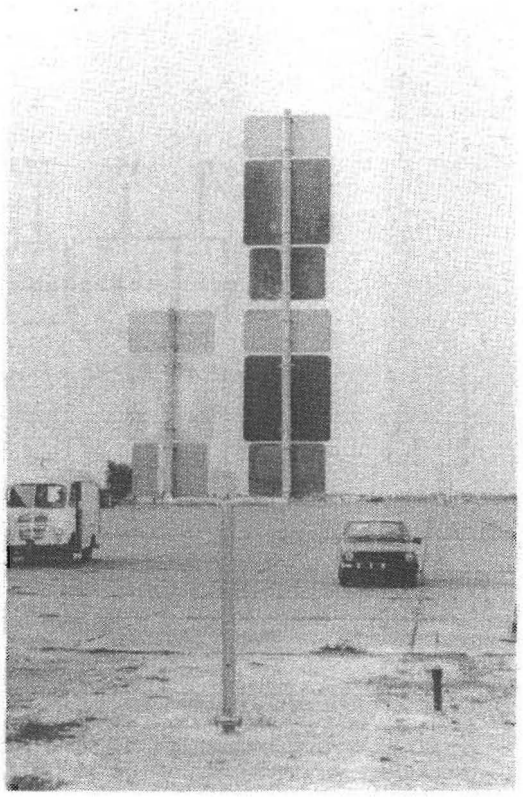


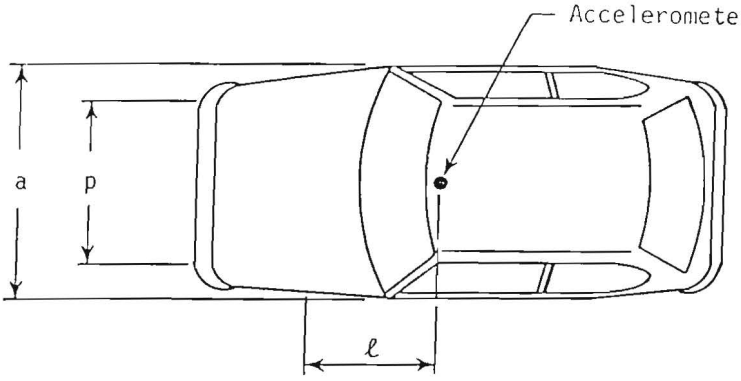
Figure 112. Sign installation before test 1122-10.

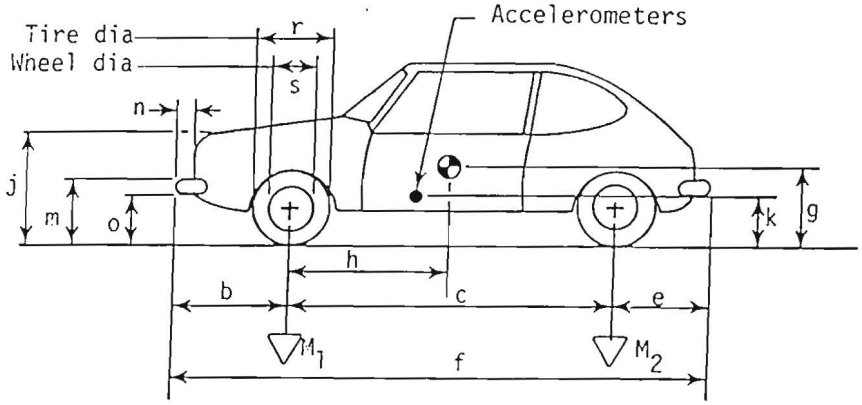
Figure 113. Vehicle before test 1122-10.

Date: 8/18/88 Test ... 1122-10 VIN: SLC1014433

Make: Honda Model: Civic Year: 1980 Odometer: 813201

Tire Size: P155/80R12 Ply Rating: _____ Bias Ply: ___ Belted: ___ Radial: X





4-wheel weight for c.g. det. ℓf 592 rf 536 ℓr 314 rr 358

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1137	1128	1210
M_2	647	672	762
M_T	1784	1800	1972

Note any damage to vehicle prior to test:

_____

_____

*d = overall height of vehicle

Tire Condition: good ___
fair X
badly worn ___

Vehicle Geometry - inches

a	61 1/2	b	30
c	88 1/2	d*	51 7/8
e	28 3/4	f	
g		h	33.0
i	----	j	29 1/4
k	14 1/4	ℓ	27 1/2
m	20	n	3 1/2
o	11 5/8	p	53 3/4
r	21 1/4	s	13 1/4

Engine Type: 4 cyl

Engine CID: _____

Transmission Type:
Automatic or (Manual)

(FWD) or RWD or 4WD

Body Type: 2-DR/Hatch

Steering Column Collapse Mechanism:

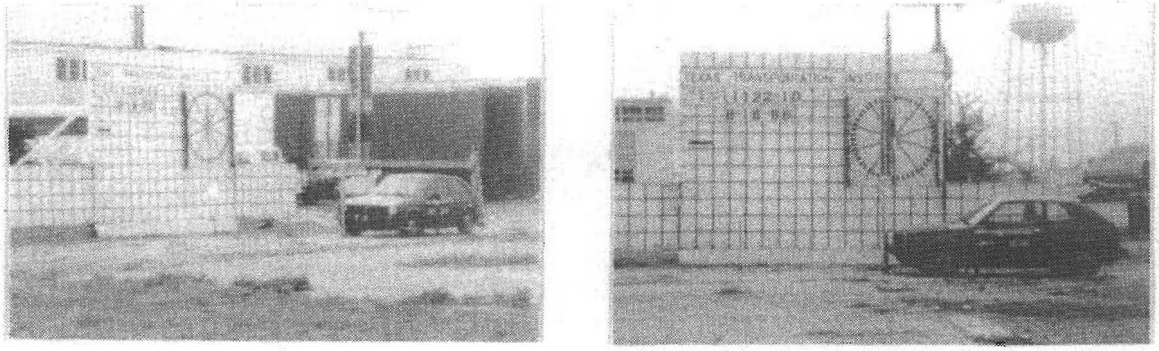
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:

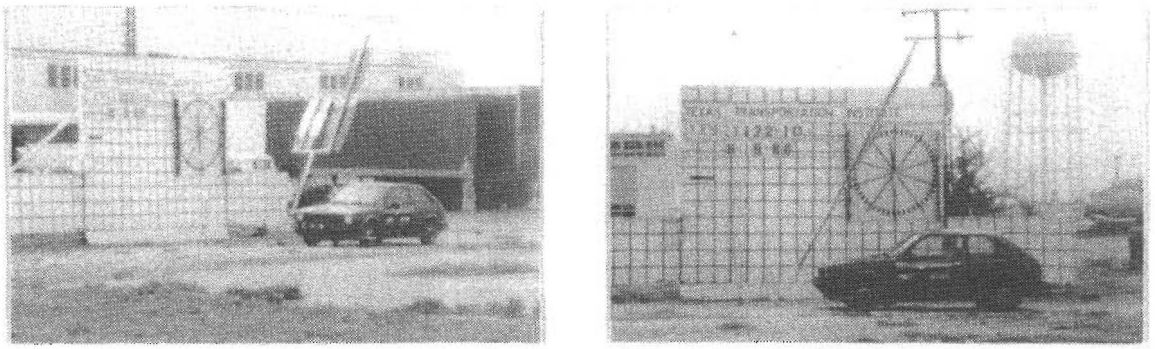
Front: disc X drum ___

Rear: disc ___ drum X

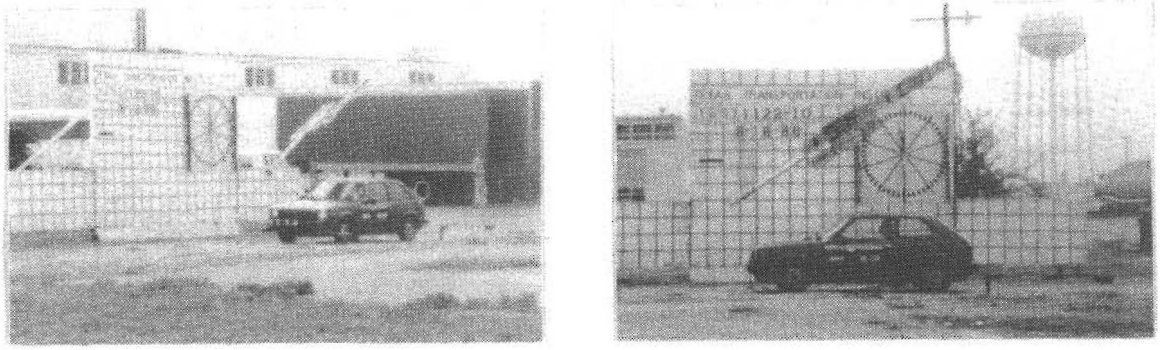
Figure 114. Test vehicle properties (1122-10).



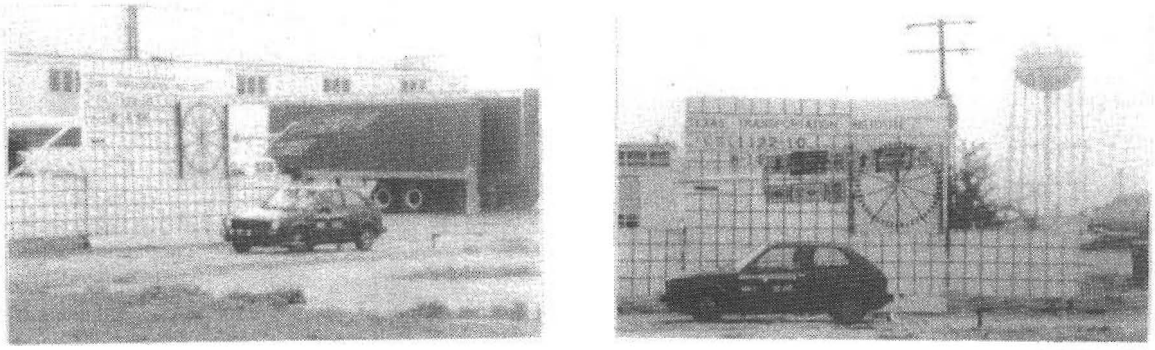
0.000 s



0.161 s

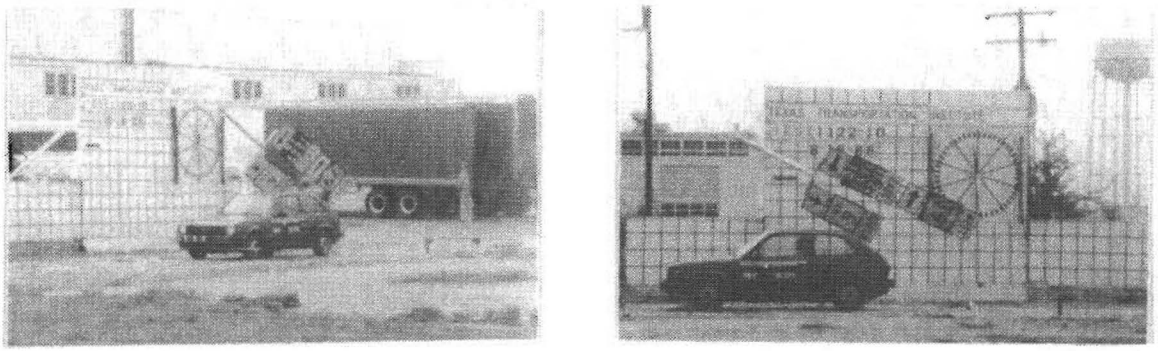


0.321 s

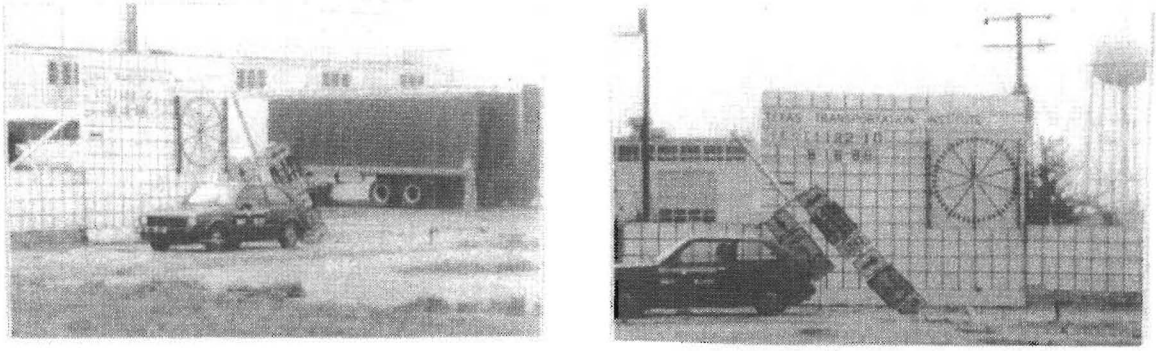


0.482 s

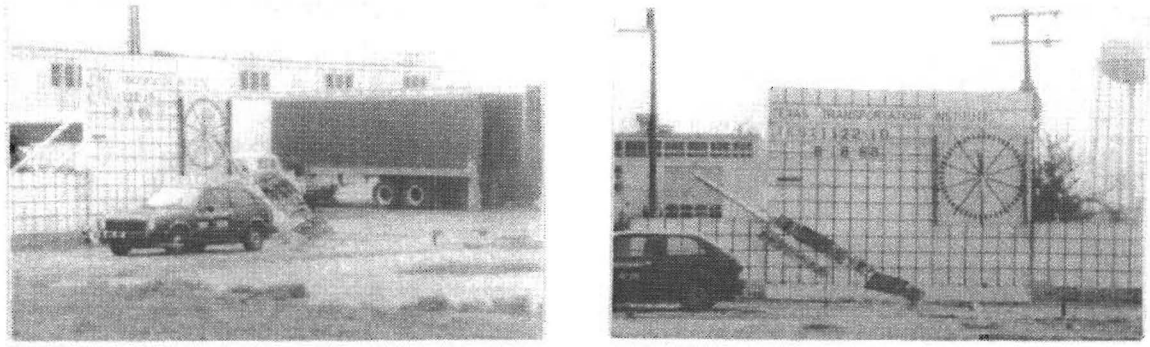
Figure 115. Sequential photographs for test 1122-10.



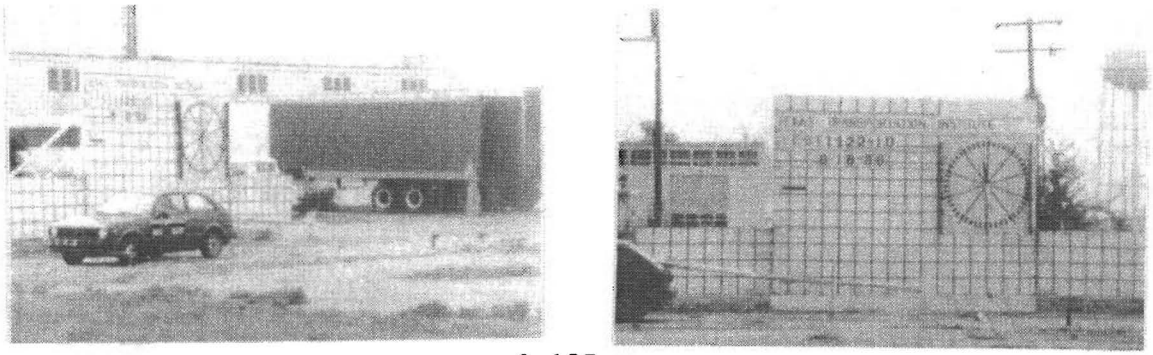
0.643 s



0.803 s



0.964 s



1.125 s

Figure 115. Sequential photogrpahs for test 1122-10. (Continued)

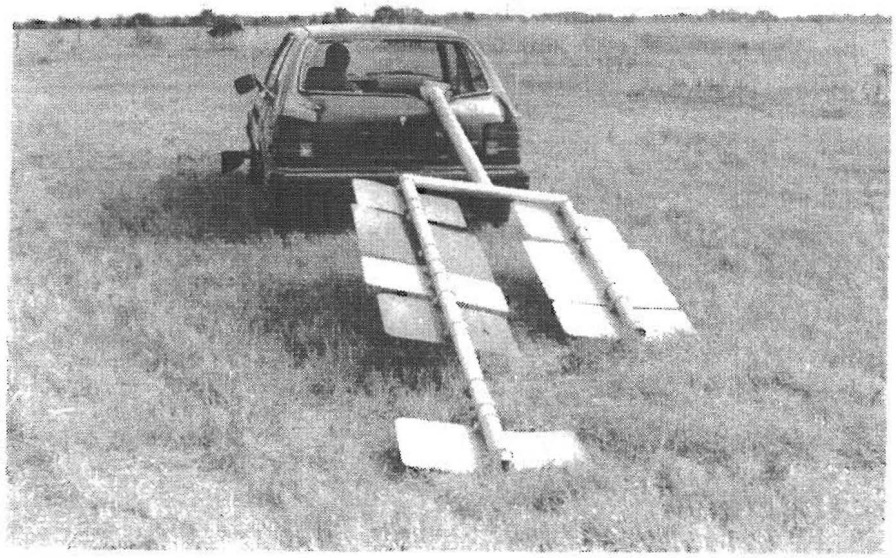
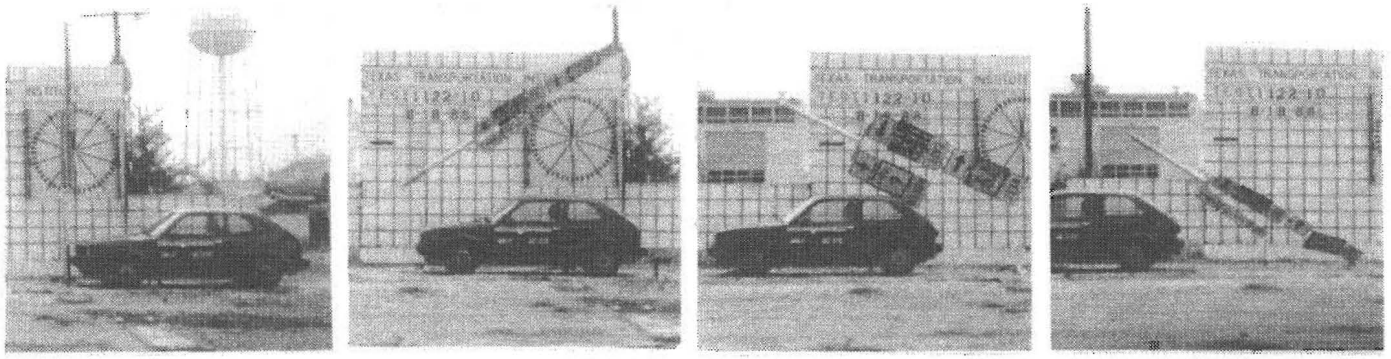


Figure 116. Sign installation after test 1122-10.

Figure 117. Vehicle after test 1122-10.

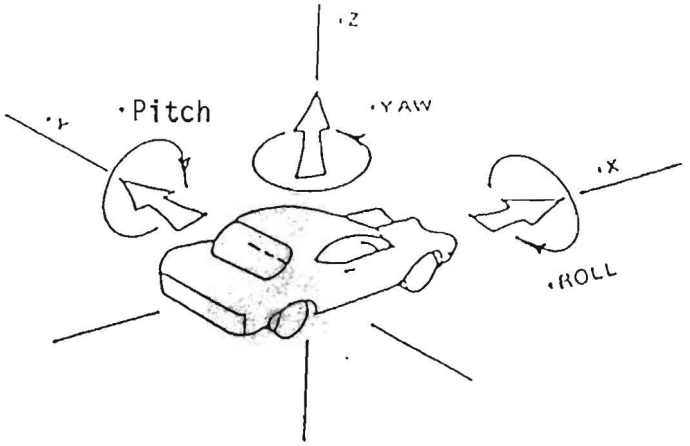


0.000 s 0.321 s 0.643 s 0.964 s

Test No.	1122-10
Date	08/18/88
Test Article	Sign Installation
Support	3" Pipe Support with Triangular Slip Base
Vehicle	1980 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,972 lb (894 kg)
Vehicle Damage Classification	
TAD	12FR1
SAE	12FRLN1

Impact Speed.	19.7 mi/h (31.7 km/h)
Change in Velocity . . .	4.0 mi/h (6.4 km/h)
Change in Momentum. . . .	328 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-1.8 g
Lateral	-0.6 g
Occupant Impact Velocity	
Longitudinal.	None
Lateral	None
Occupant Ridedown Accelerations	
Longitudinal	No Contact
Lateral	No Contact

Figure 118. Summary of results for test 1122-10.



Axes are vehicle fixed.
Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

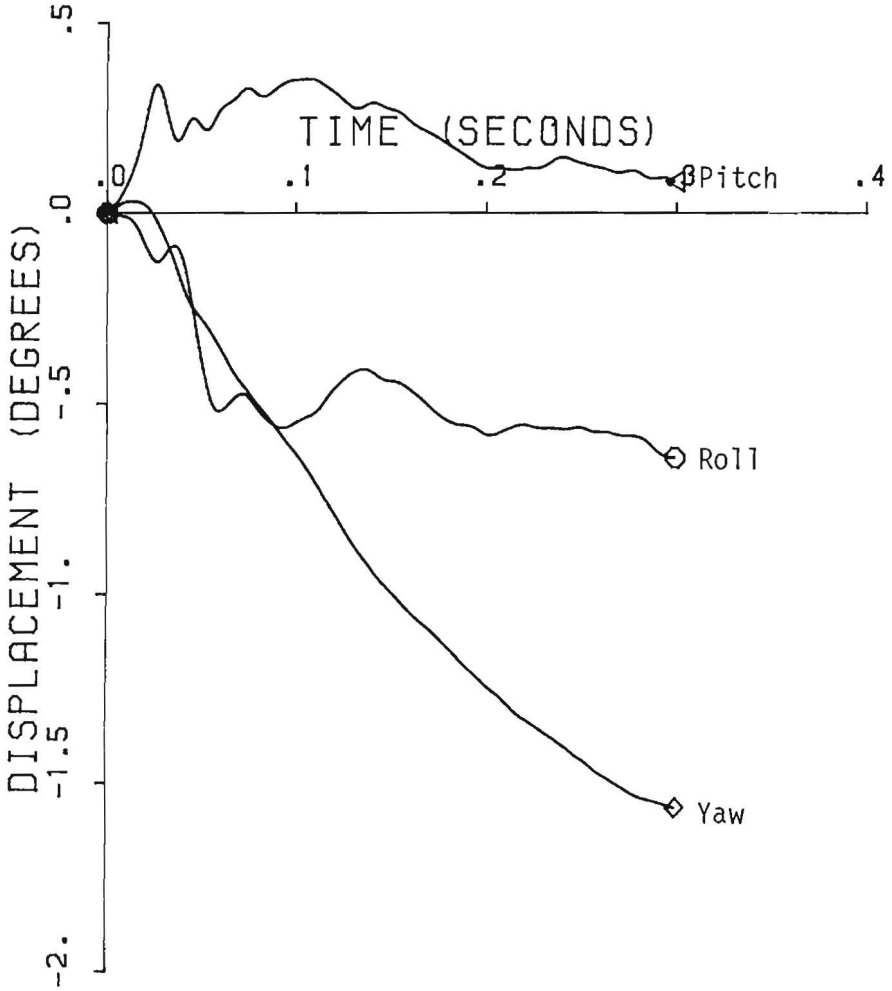


Figure 119. Vehicle angular displacements for test 1122-10.

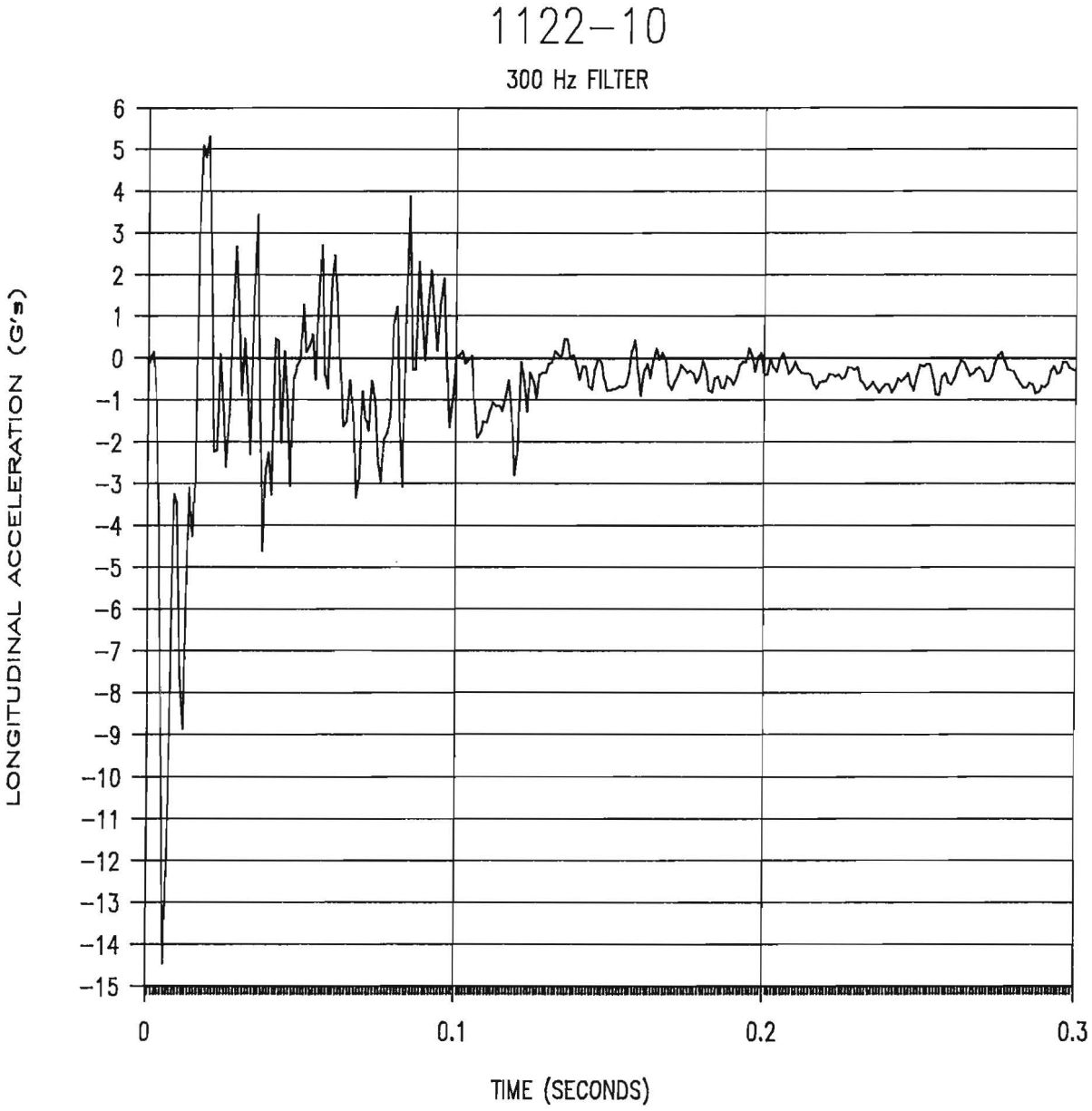


Figure 120. Longitudinal accelerometer trace for test 1122-10.

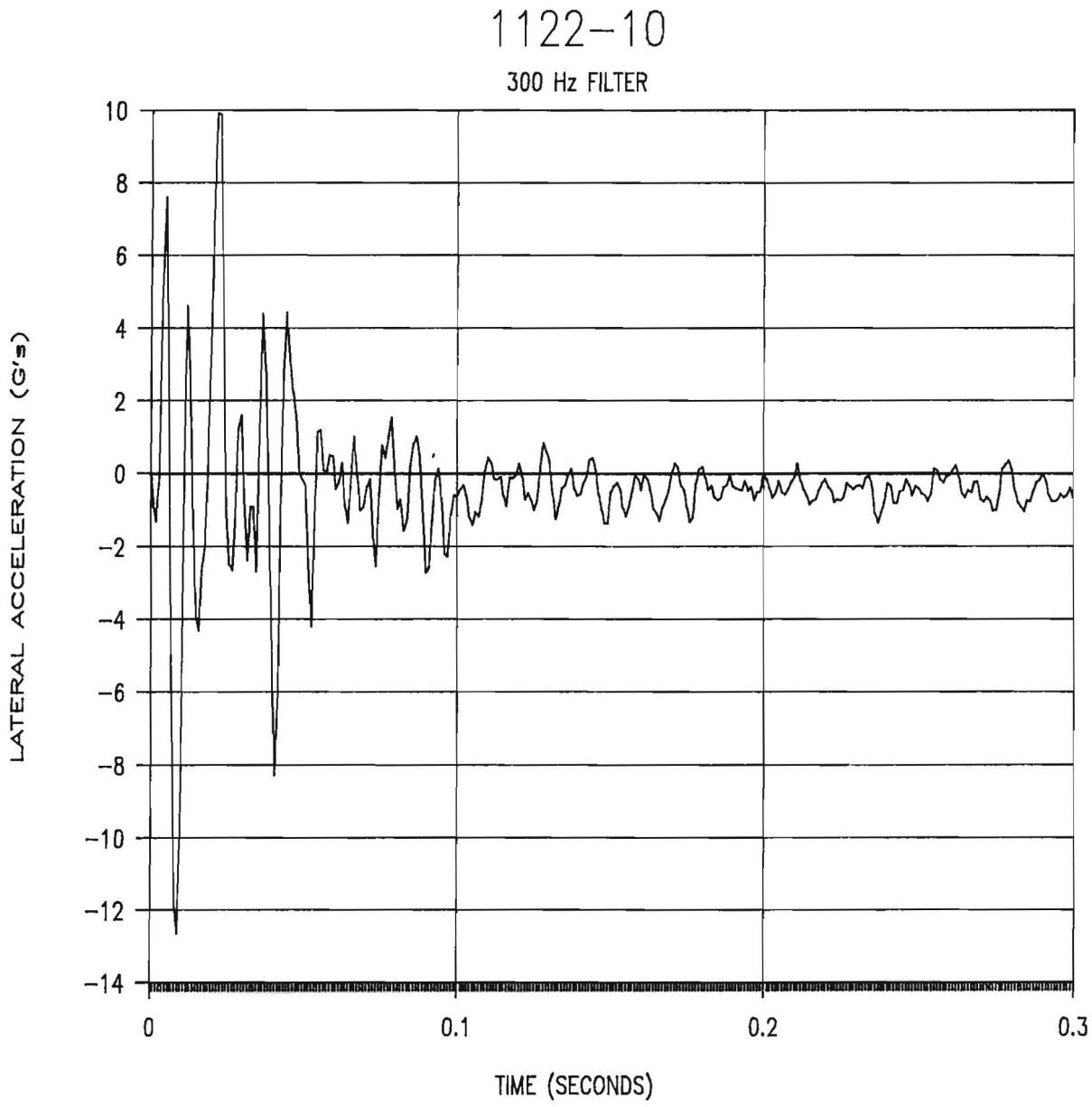


Figure 121. Lateral accelerometer trace for test 1122-10.

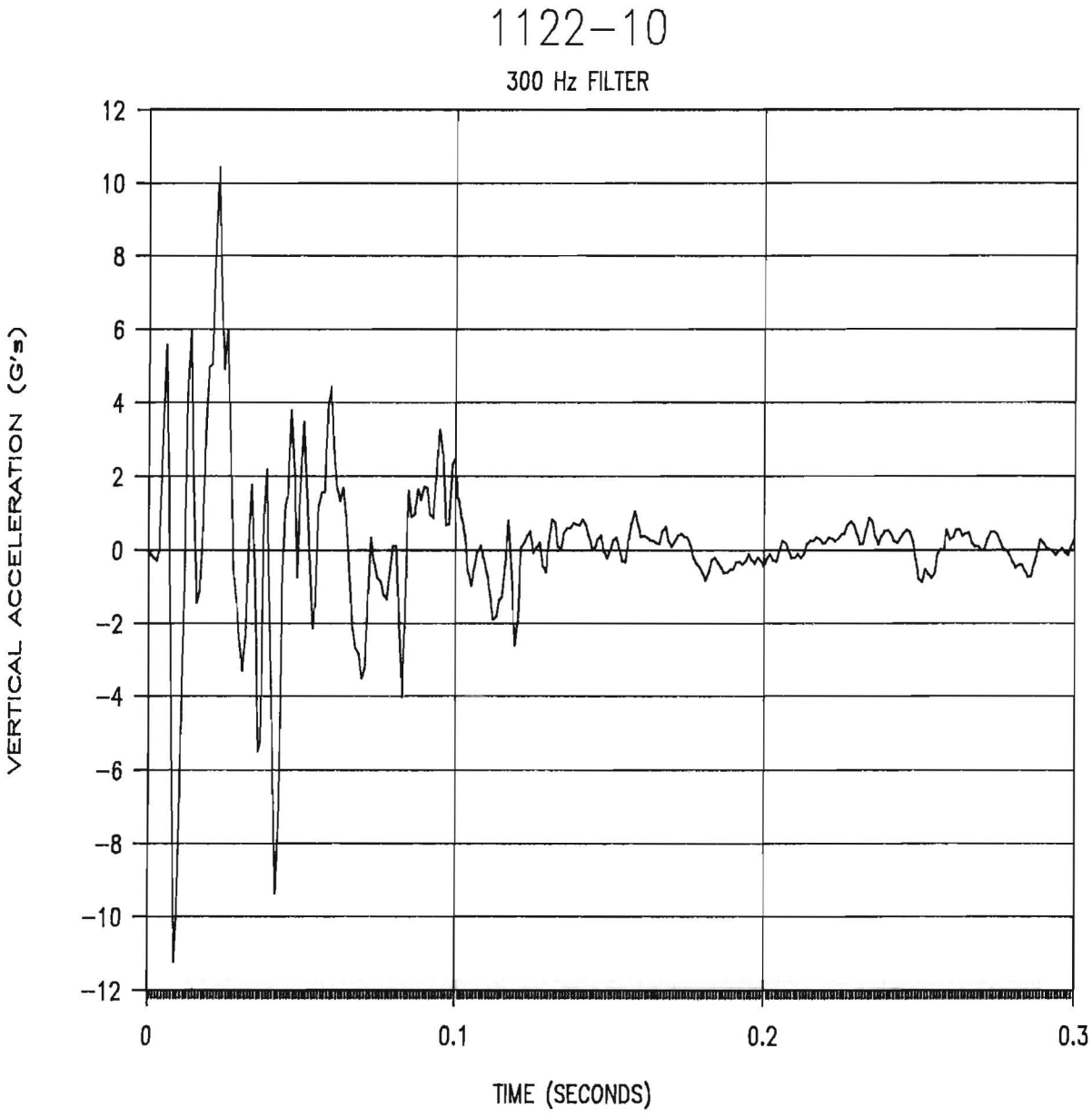


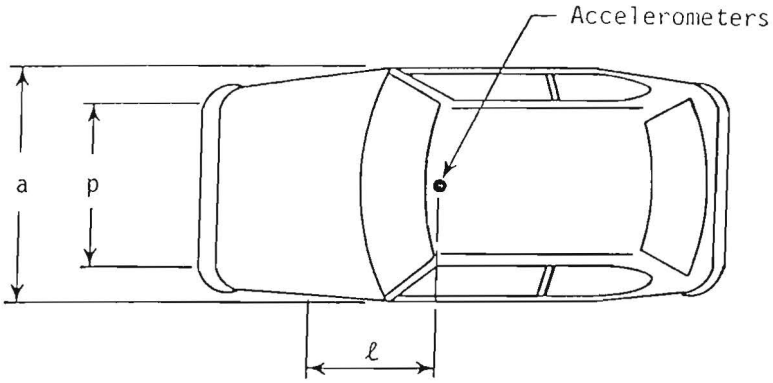
Figure 122. Vertical accelerometer trace for test 1122-10.

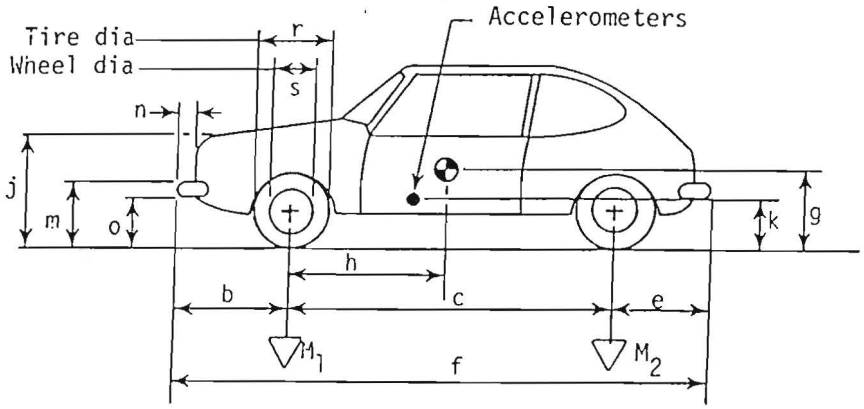
Figure 123. Vehicle before test 1122-11.

Date: 8/18/88 Test No. 1122-11 VIN: SLC1014433

Make: Honda Model: Civic Year: 1980 Odometer: 813201

Tire Size: P155/80R12 Ply Rating: _____ Bias Ply: ___ Belted: ___ Radial: X





4-wheel weight for c.g. det. ℓf 592 rf 536 ℓr 314 rr 358

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1137	1128	1210
M_2	647	672	762
M_T	1784	1800	1972

Note any damage to vehicle prior to test:

_____

_____

*d = overall height of vehicle

Tire Condition: good ___
fair X
badly worn ___

Vehicle Geometry - inches

a	61 1/2	b	30
c	88 1/2	d*	51 7/8
e	28 3/4	f	
g		h	33.0
i	----	j	29 1/4
k	14 1/4	ℓ	27 1/2
m	20	n	3 1/2
o	11 5/8	p	53 3/4
r	21 1/4	s	13 1/4

Engine Type: 4 cyl

Engine CID: _____

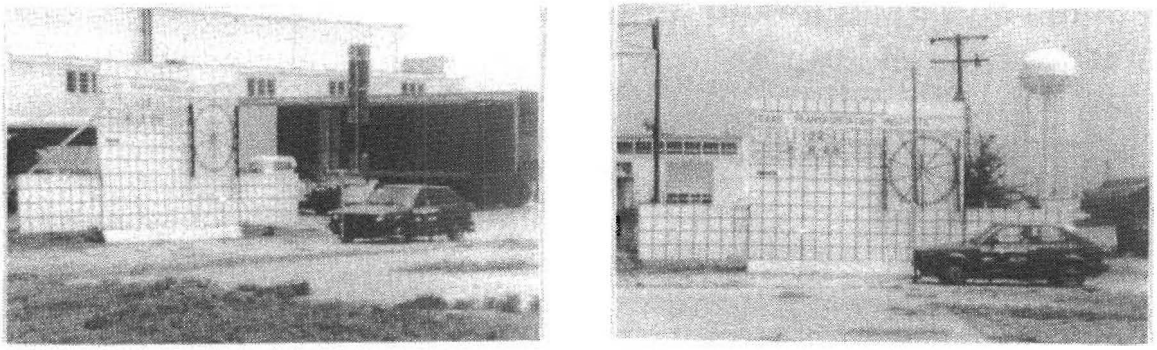
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD

Body Type: 2-DR/Hatch

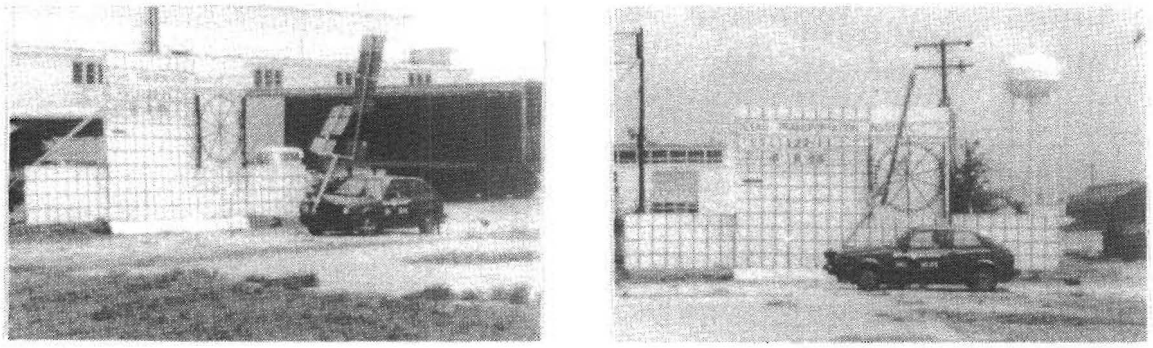
Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

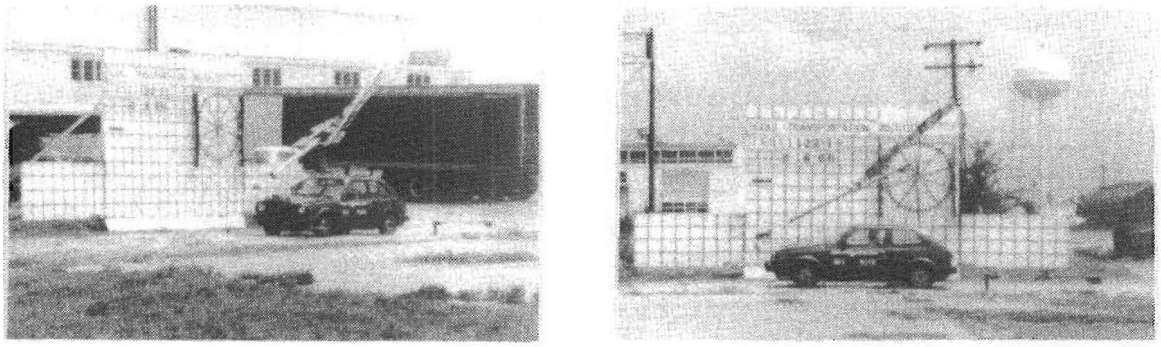
Figure 124. Test vehicle properties (1122-11).



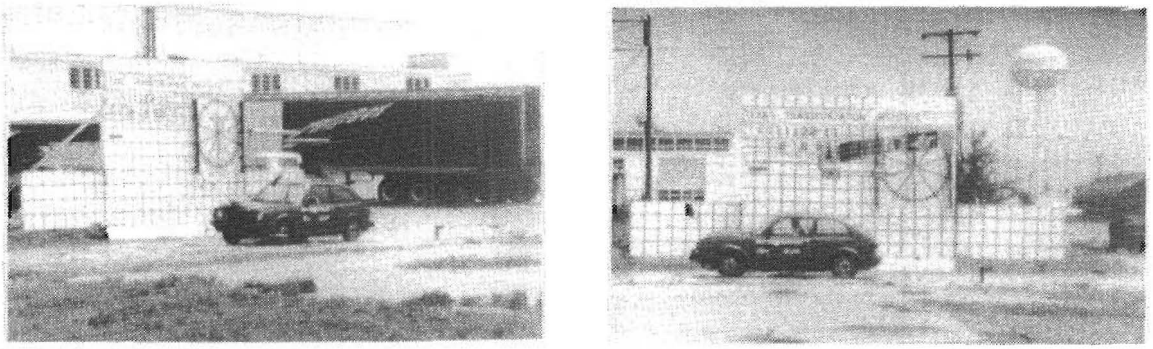
0.000 s



0.055 s

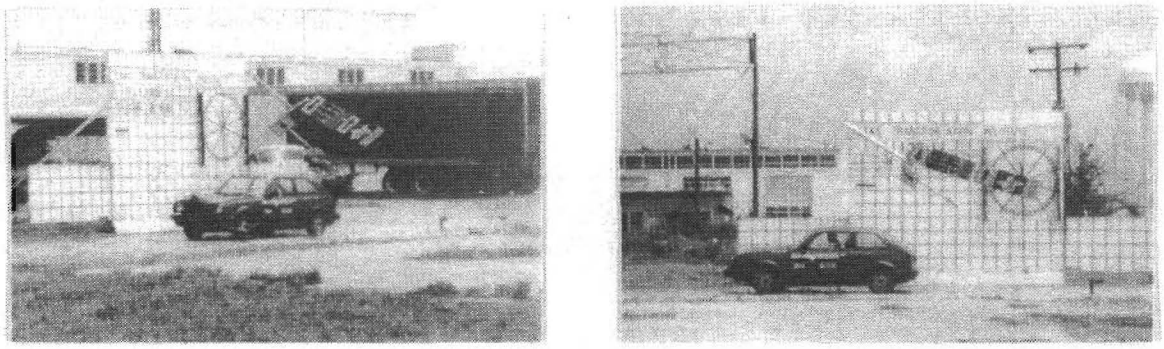


0.111 s

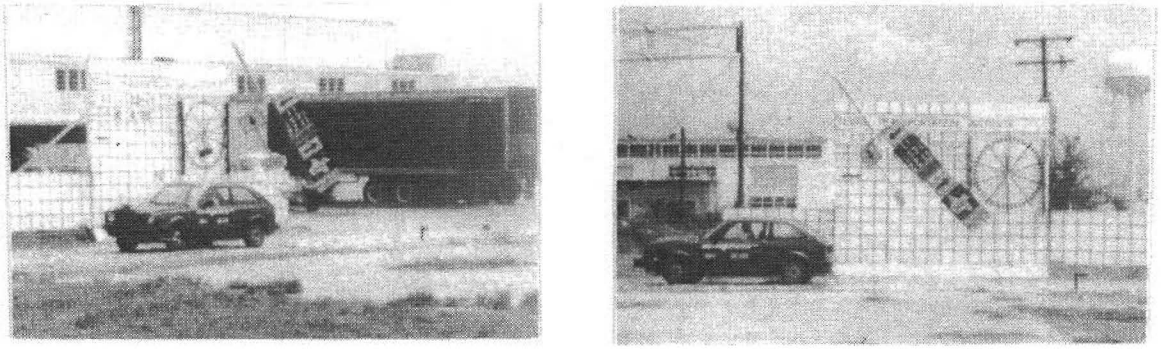


0.166 s

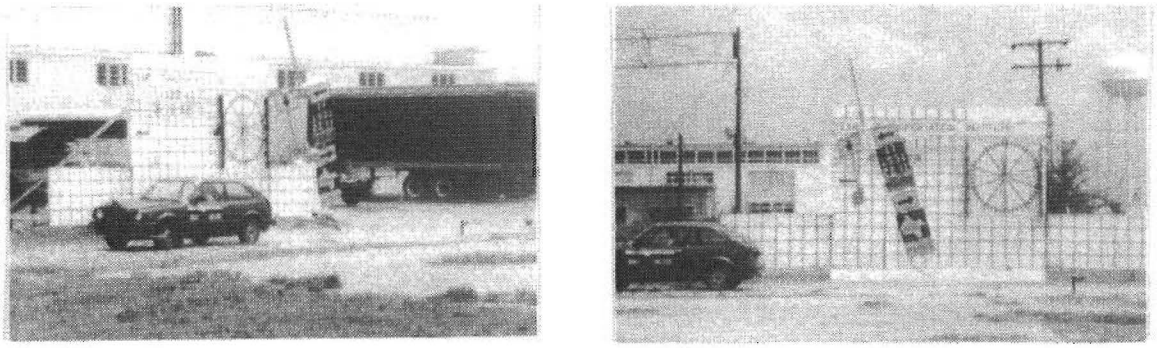
Figure 125. Sequential photographs for test 1122-11.



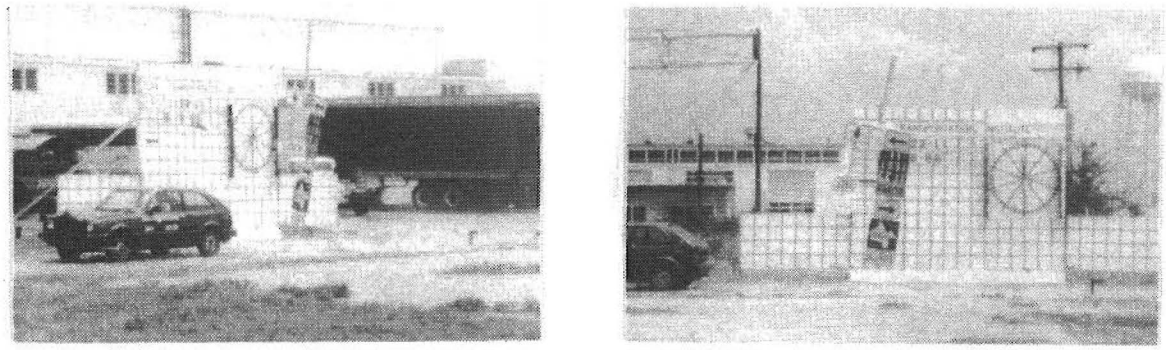
0.222 s



0.277 s



0.332 s



0.388 s

Figure 125. Sequential photographs for test 1122-11. (Continued)

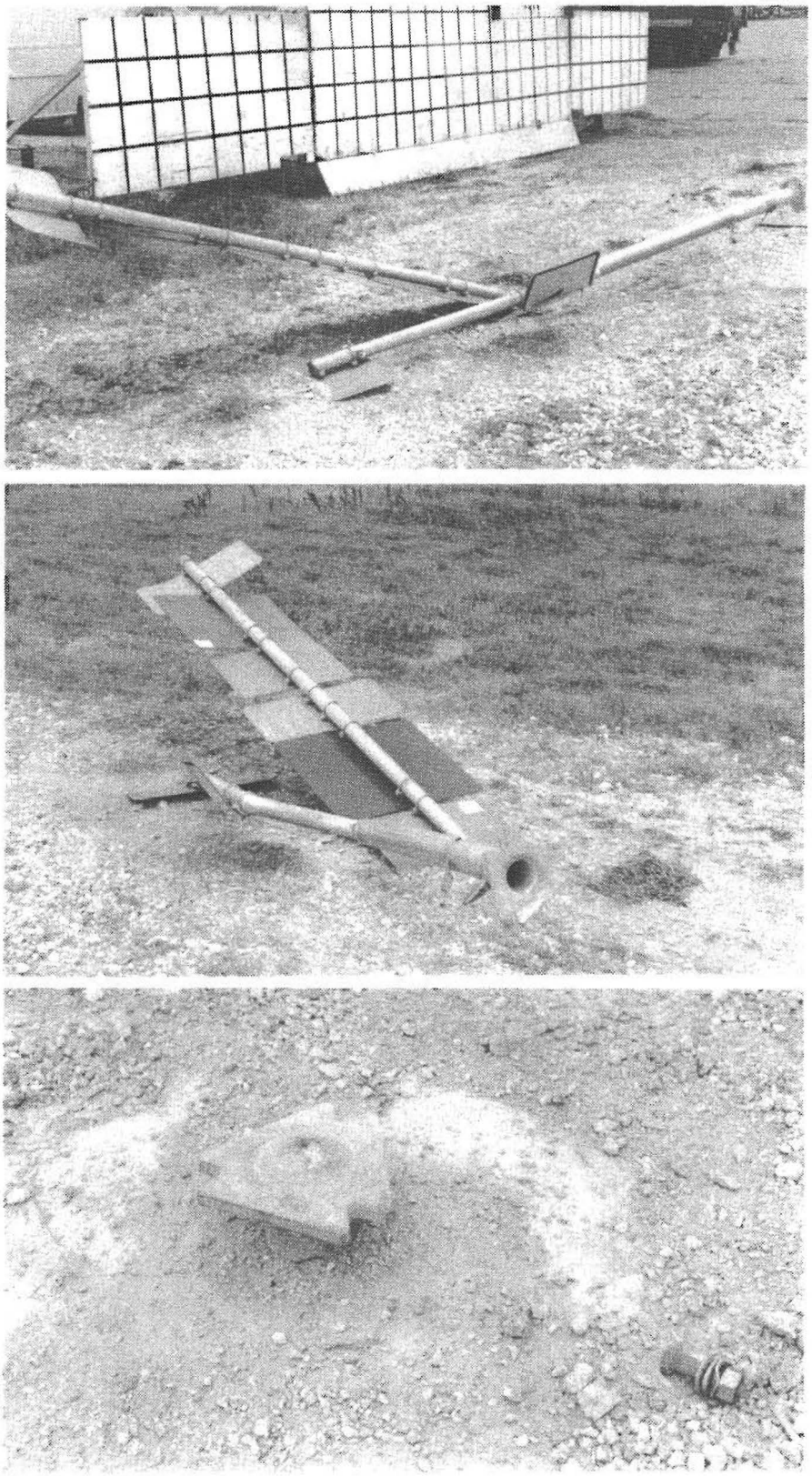
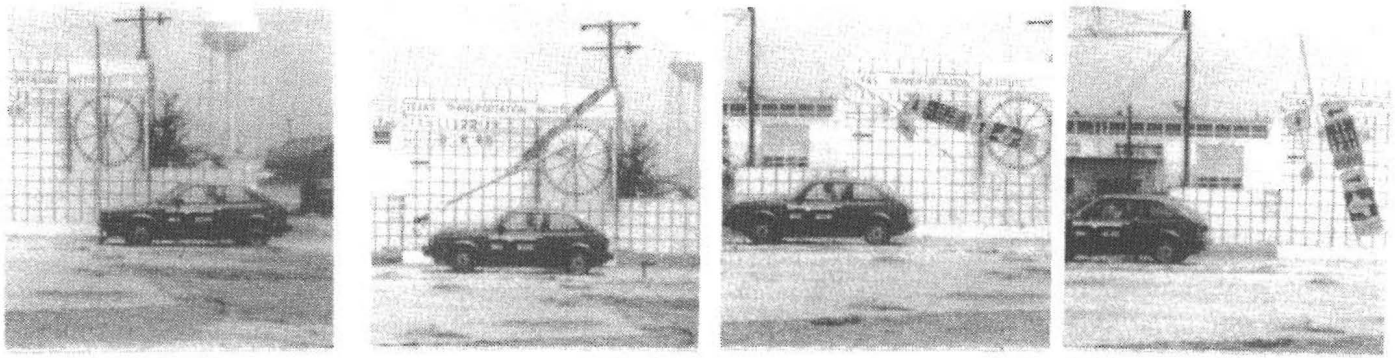
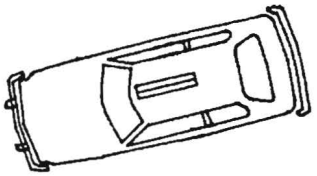


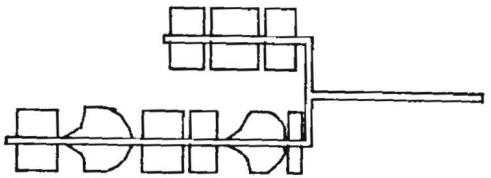
Figure 126. Sign installation after test 1122-11.

Figure 127. Vehicle after test 1122-11.



0.000 s 0.111 s 0.222 s 0.332 s

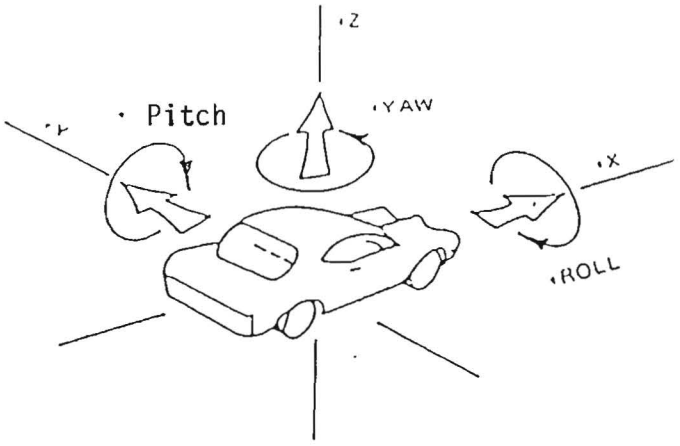




Test No.	1122-11
Date	08/18/88
Test Article	Sign Installation
Support	3" Pipe Support with Triangular Slip Base
Vehicle	1980 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,972 lb (894 kg)
Vehicle Damage Classification	
TAD	12FR2
SAE	12FREN1

Impact Speed.	59.8 mi/h (96.2 km/h)
Change in Velocity . . .	5.5 mi/h (8.9 km/h)
Change in Momentum. . . .	451 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-3.3 g
Lateral	-0.9 g
Occupant Impact Velocity	
Longitudinal.	None
Lateral	None
Occupant Ridedown Accelerations	
Longitudinal	No Contact
Lateral	No Contact

Figure 128. Summary of results for test 1122-11.



Axes are vehicle fixed.
Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

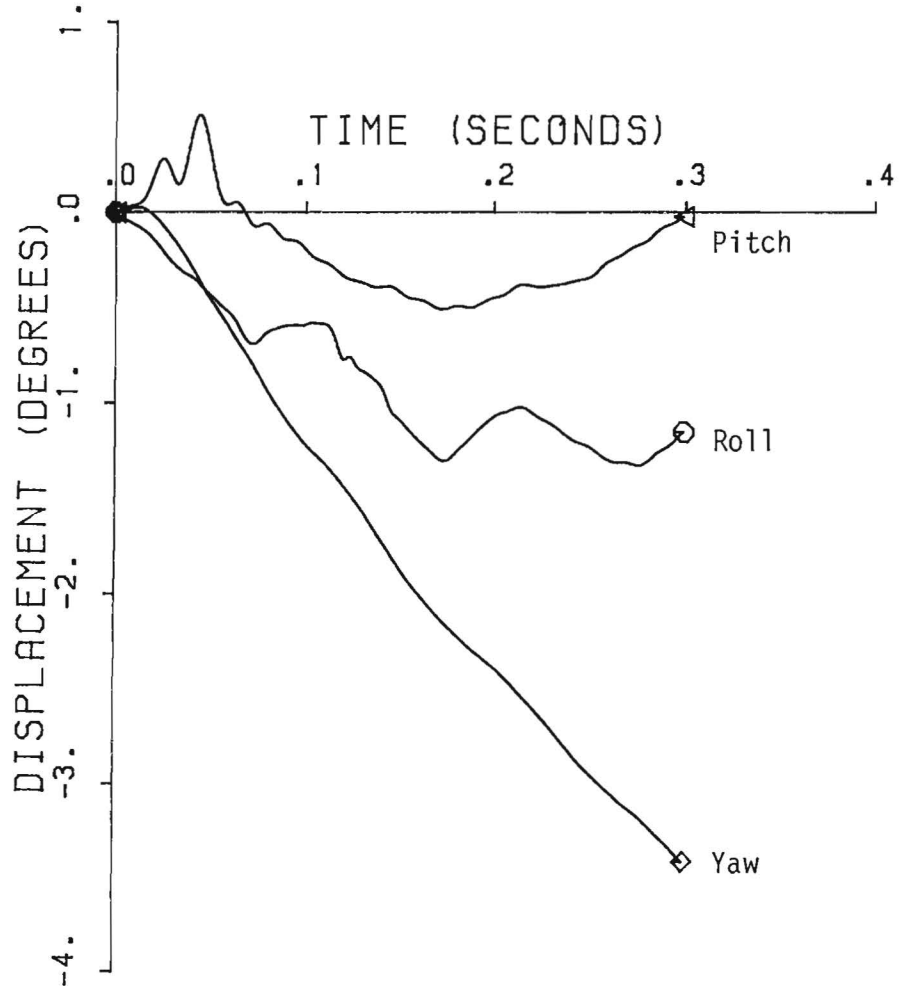


Figure 129. Vehicle angular displacements for test 1122-11.

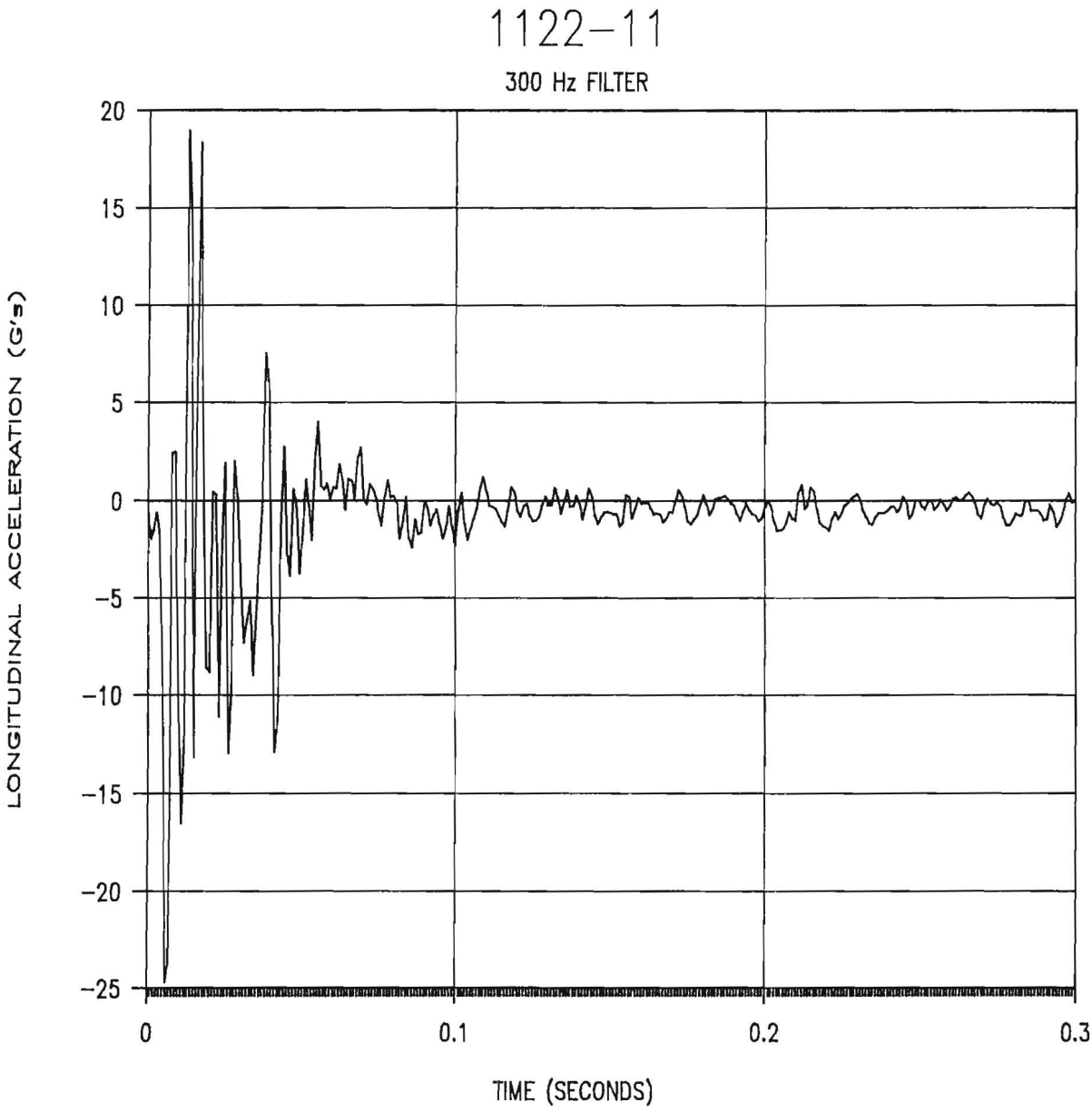


Figure 130. Longitudinal accelerometer trace for test 1122-11.

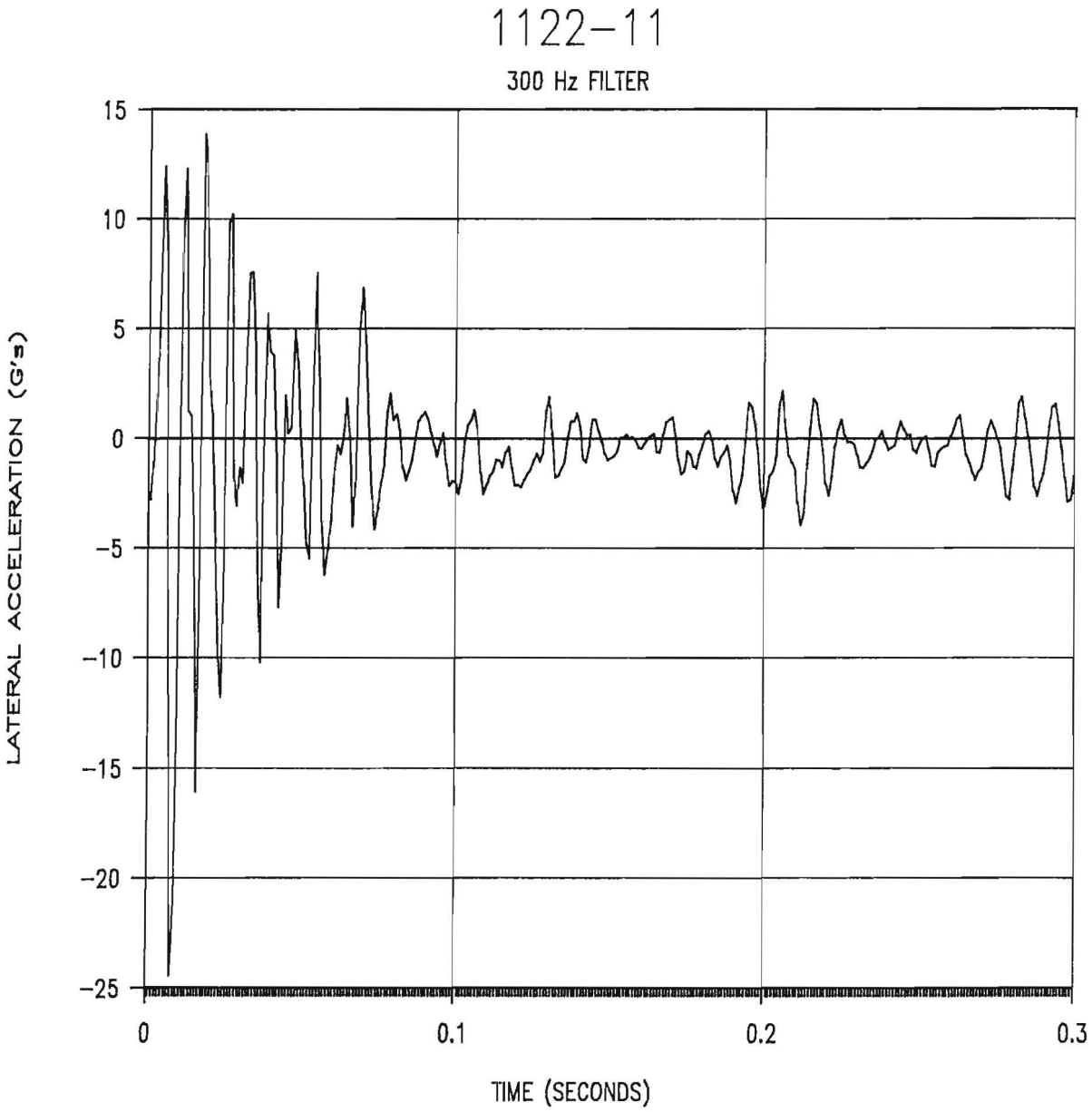


Figure 131. Lateral accelerometer trace for test 1122-11.

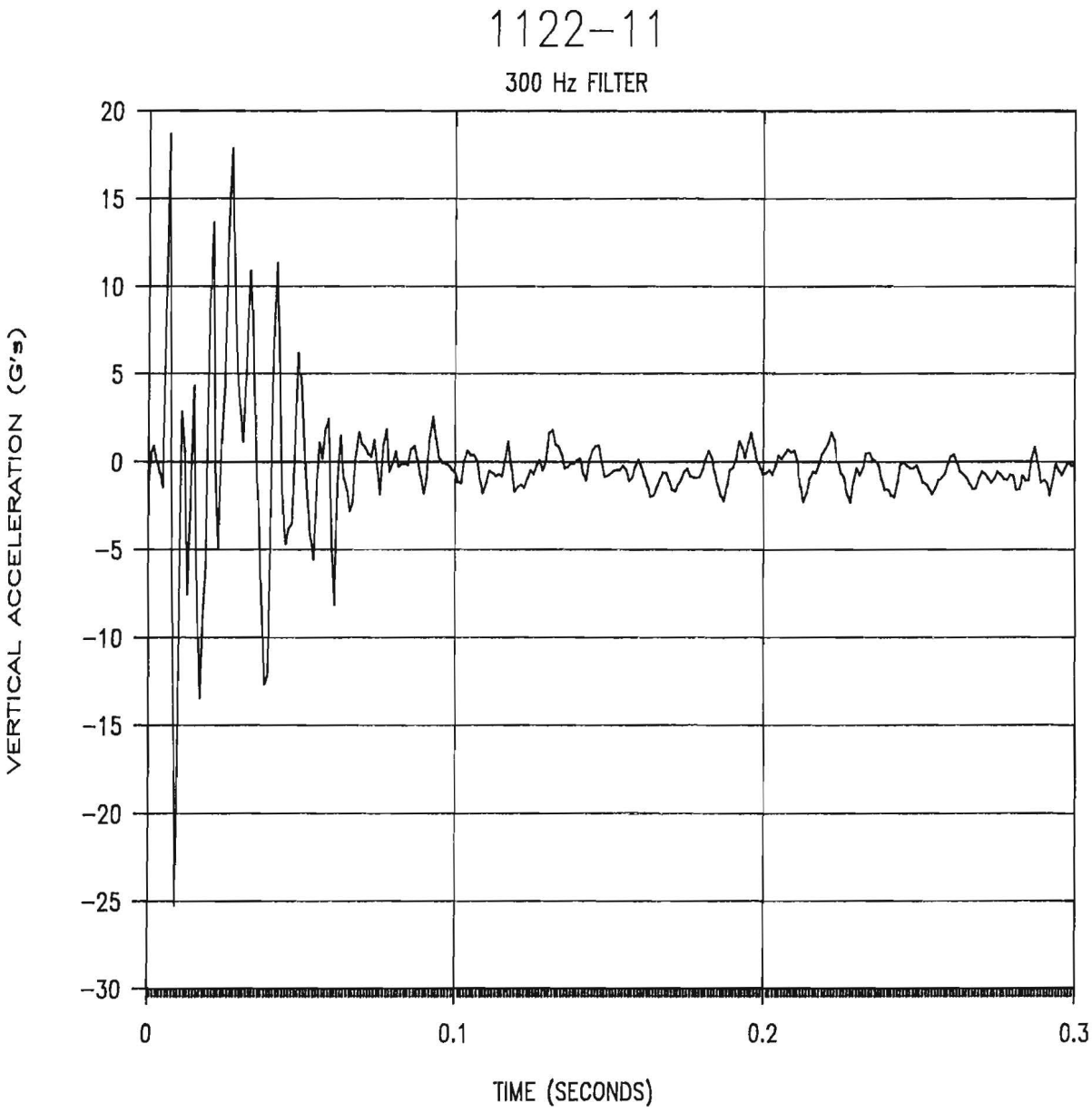


Figure 132. Vertical accelerometer trace for test 1122-11.

VALIDATION OF ANALYTICAL MODEL

The recertification tests provided an excellent opportunity to check the predictions of vehicle performance made using the Kinetic Energy method described earlier. (Note: the new tests were NOT included in the curve fits).

The first sign system tested for which previous data was available was the 40 square foot sign supported by three 4 lb/ft Rail Steel U-Posts (Tests 1122-3 & 4). Table 2 shows a comparison of the actual changes in velocity and the values predicted using the principles presented herein. The values for ΔKE were calculated directly from the least squares equation on Figure 7 for 4 lb nonbreakaway posts. This system was classified as nonbreakaway because large soil deformations prevented activation of the bolted splice. Also, values for the single post in the "actual" column were extrapolated using linear interpolation. The model predicted a change in velocity for three posts at an impact speed of 20 mph, which was greater than the initial velocity. Therefore, our calculations agree very well with the first set of tests (including the ability to predict refusal of the car by the sign).

The next applicable tests involved two 4 lb/ft U-Posts with ground splices (Tests 1122-6 & 7). The changes in Kinetic Energy were calculated from the line fit in Figure 6 and the changes in velocity listed in Table 2. Again there is good correlation, less than 10% difference, between the predictions and the actual values.

Tests 1122-8 & 9 were single 2-1/2 inch standard steel pipe in a threaded coupler. Figure 9 provided the equation to predict the changes in Kinetic Energy. The comparison shows the calculated values do not agree very well with the actual values (see also Table 2). On the other hand, the upper bound parallel offset provided a much better estimation. Such an offset is appropriate for large data scatter, however, the analysis should not be used for systems with such few data points.

The final set of tests, 1122-10 & 11, was a 3 inch pipe tree mounted on a triangular slip base. The changes in velocity were calculated using both the linear and the cubic line fits from Figures 11 and 12 respectively. As originally thought, the linear fit did not model the car's performance very well, even with an offset. However, the data supported the third order fit much more closely. The low speed prediction came within about 3% of the actual change in velocity. Even for the high speed test, with only one previous data point, the predicted change in velocity was within 19%.

TABLE 2 - Comparison of Changes in Velocity

V_i (mph)	Actual ΔV (ft/s)		Estimated ΔV (ft/s)	
	Tests 3 & 4 (Three nonbreakaway 4 lb/ft posts)			
	3 Posts	1 Post	3 Posts	1 Post
20.27	33.25	5.37	>29.73	5.46
61.67	16.56	5.16	16.56	5.16
	Tests 6 & 7 (Two breakaway 4 lb/ft posts)			
	2 Posts	1 Post	2 Posts	1 Post
18.89	10.60	4.68	11.14	4.88
60.46	7.96	3.89	8.74	4.25
Tests 8 & 9 (2-1/2 inch pipe w/threaded coupler - offset = 4660 ft-lb)				
	1 Post		1 Post	w/offset
20.58	16.16		10.65	15.52
61.03	9.75		7.63	8.37
	Tests 10 & 11 (3 inch pipe on triangular slip base)			
	1 Post		Linear	Cubic
19.67	5.87		3.27	6.06
59.77	8.07		4.88	6.55

SUMMARY - PHASE ONE

All of the small sign support systems currently used and maintained along Texas highways, which were tested as a part of this project,have passed recertification requirements for NCHRP 230 strong soil.These systems includeup to two 4 lb/ft U-posts, up to a 3 inch pipe on a triangular slip-base, and a single 2-1/2 inch pipe with threaded coupler. These requirements were satisfied both analytically with the Kinetic Energy calculations and experimentally with actual crash tests. Several systems that were originally included in the problem statement were not tested because of subsequent approval by FHWA.

There were two additional benefits from the crash testing conducted during this phase of the project. First, a generic sign system for the State of Texas passed certification. Tests 1122-6 & 7 were double 4 lb/ft U-Post installations in NCHRP Report 230 classification "strong" soil. This generic ground splice system can support a sign blanks of up to 24 square feet. Second, it appears the Kinetic Energy method may be useful for reducing the number of crash tests or retests necessary in the future.

GENERIC SIGN SYSTEMS - PHASE TWO

INTRODUCTION

The first step in developing a generic sign system for the state of Texas was defining the breadth of the problem. The primary questions were (a) how difficult would it be to meet the weak soil criteria and (b) were other "generic systems" already available. In an attempt to answer these questions, several previously developed sign systems were investigated.

Subsequently, it was decided to crash test a modified generic system developed for the Arizona Department of Transportation. This system used three 3 lb/ft 80 ksi U-posts with ground splices to support a 40 square foot sign. Such a generic system met most of the requirements expressed by the state's advisory committee and had already passed in "strong" soil. The system was modified for "weak" soil by extending the embedment depth of the stubs to 54 inches. It was hoped that this type of modification of a "strong" soil sign support system would allow these systems to be extended to "weak" soil.

DESCRIPTION OF CRASH TEST PROCEDURES

The crash test procedures were in accordance with the guidelines presented in NCHRP Report 230. The details of the instrumentation and data reduction are included in Phase One of this report.

CRASH TESTS

The objective of these tests was to determine the impact characteristics of a multi-leg sign installation when impacted by an 1,800 lb vehicle at 20.0 and 60.0 mi/h. Standards established in AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals" and NCHRP Report 230 were used for analyses and evaluation of this test.

DESCRIPTION OF TEST INSTALLATION FOR 1122-1 & 2

The sign installation used in these tests consisted of a 6 ft-8 in wide x 6 ft high plywood sign panel mounted on three Marion 80 ksi, 3 lb-ft steel supports (Figure 133). These supports were attached to three 60 inch stubs which had been driven into sand (NCHRP Report 230 "weak" soil) at 21 in on center spacing. The supports were attached to the stubs in a nested splice (sign supports in front of the stubs) with 1/2 in spacers and 5/16 inch grade 9 bolts, nuts and washers. The bottom of sign mounting height was 5 ft. The completed installation is shown in Figure 134.

TEST REPORT 1122-1

VEHICLE: 1979 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,968 lbs.

TEST ARTICLE: Multi-Leg Sign Installation
Support: Three Marion 80 ksi,
3 lb-ft supports

IMPACT CONDITIONS: 19.2 mi/h
Center (impact all three
legs of sign)

Crash Test Results

A 1979 Honda Civic (shown in Figure 135) impacted the sign installation at 19.2 miles per hour (30.9 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,968 lb (893 kg). The height to the lower edge of the vehicle bumper was 15.0 inches (38.1 cm) and 19.8 inches (50.2 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 136.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the center of the vehicle. Upon impact, the sign legs began to deform and the vehicle started climbing the sign installation. At approximately 0.145 seconds, the front wheels were clear of the ground and by 0.245 seconds the forward motion of the vehicle had ceased. The sign continued travelling in the direction of impact and the vehicle lost contact with the sign installation. Shortly thereafter, at 0.400 seconds the sign installation slapped the vehicle causing it to travel rearward. The vehicle lost contact with the sign installation at approximately 0.572 seconds and the front wheels returned to the ground at 0.736 seconds. As the vehicle rolled backwards from the installation, the brakes were applied and the vehicle came

to rest approximately 12.0 ft (3.7 m) from the point of impact. Sequential photographs of the test are shown in Figure 137.

The three sign supports were bent and pushed rearward approximately 8.0 in (20.3 cm). The vehicle sustained minor damage to the bumper and windshield, as shown in Figure 139.

A summary of the test results and other information pertinent to this test are given in Figure 140. The maximum 0.050 second average acceleration experienced by the vehicle was -6.0 g in the longitudinal direction and -0.86 g in the lateral direction. Vehicle angular displacements are plotted in Figure 141 and vehicle accelerometer traces are displayed in Figure 142 through 144. Occupant impact velocity in the longitudinal direction was 26.55 feet per second (8.10 m/s) and no occupant impact velocity existed in the lateral direction. The highest 0.10 second occupant ridedown acceleration was -3.29 g (longitudinal). Change in velocity was 19.15 mi/h (30.82 km/h) and change in momentum was 1570 lb-s.

In summary, the sign installation failed to yield to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. The occupant impact velocity was high (NCHRP Report 230 limit is 15 ft/s) and change in momentum was over the recommended limit of 1100 lb-s. This sign installation in "weak" soil is not acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

TEST REPORT 1122-2

VEHICLE: 1979 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,968 lbs.

TEST ARTICLE: Multi-Leg Sign Installation
Support: Three Marion 80 ksi,
3 lb-ft supports

IMPACT CONDITIONS: 60.9 mi/h
Center (impact all three
legs of sign)

Crash Test Results

A 1979 Honda Civic (shown in Figure 145) impacted the sign installation at 60.9 miles per hour (97.9 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,968 lb (893 kg). The height to the lower edge of the vehicle bumper was 15.0 inches (38.1 cm) and 19.8 inches (50.2 cm) to the top of the bumper. The

vehicle from Test 1122-1 was repaired and used for this test. Other dimensions and information on the vehicle are given in Figure 146.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the center of the vehicle. Upon impact, the sign legs began to deform and the vehicle started climbing the sign installation. At approximately 0.025 seconds after impact, the outer legs of the installation were pulled from the ground and the center leg fractured. Shortly thereafter, at 0.099 seconds, the sign face struck the roof of the vehicle. The sign installation remained in front of and attached to the vehicle after impact. As the vehicle exited the impact site, the brakes were applied and the vehicle came to rest approximately 168.0 ft (51.22 m) from the point of impact. Sequential photographs of the test are shown in Figure 147.

The two outside sign support stubs were pulled from the soil. In addition, the center support was fractured 22 in above the soil surface and pushed rearward approximately 7.0 in (17.78 cm). The vehicle sustained minor damage to the bumper, lower valance panel, roof and windshield, as shown in Figure 149.

A summary of the test results and other information pertinent to this test are given in Figure 150. The maximum 0.050 second average acceleration experienced by the vehicle was -8.6 g in the longitudinal direction and -1.3 g in the lateral direction. Vehicle angular displacements are plotted in Figure 151 and vehicle accelerometer traces are displayed in Figure 152 through 154. Occupant impact velocity in the longitudinal direction was 21.57 feet per second (6.58 m/s) and no occupant impact velocity existed in the lateral direction. The highest 0.10 second occupant ridedown acceleration was -2.59 g (longitudinal). Change in velocity was 17.07 mi/h (27.47 km/h) and change in momentum was 1,340 lb-s.

In summary, the sign installation yielded to the vehicle. It should be noted however, the installation did not yield by fracturing at the lap splice bolts. The vehicle sustained very minor damage and did not present undue hazard to other traffic. The occupant impact velocity was high (NCHRP Report 230 limit is 15 ft/s) and change in momentum was over the recommended limit of 1100 lb-s. This sign installation in "weak" soil was not acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

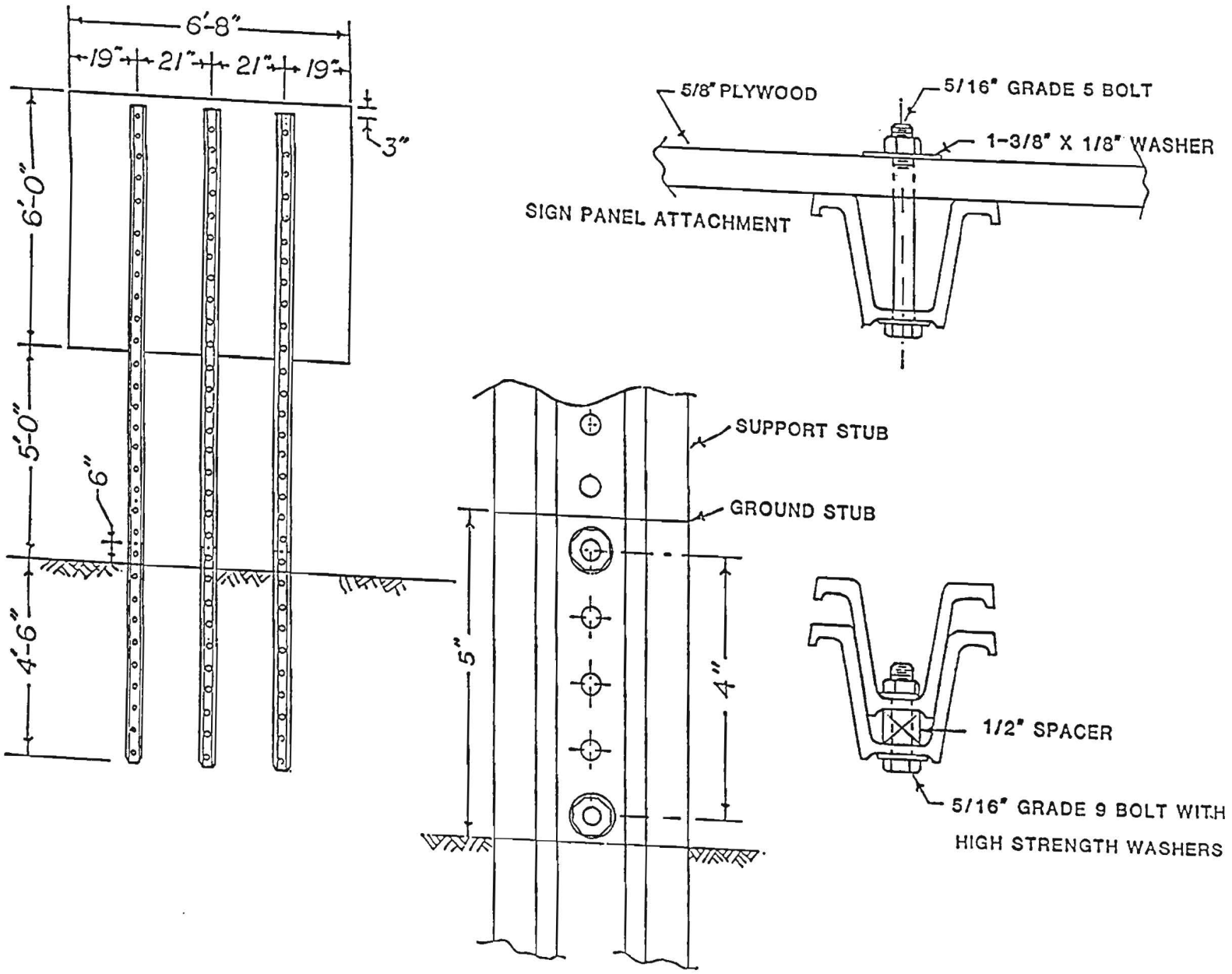


Figure 133. Details of multi-leg sign installation.

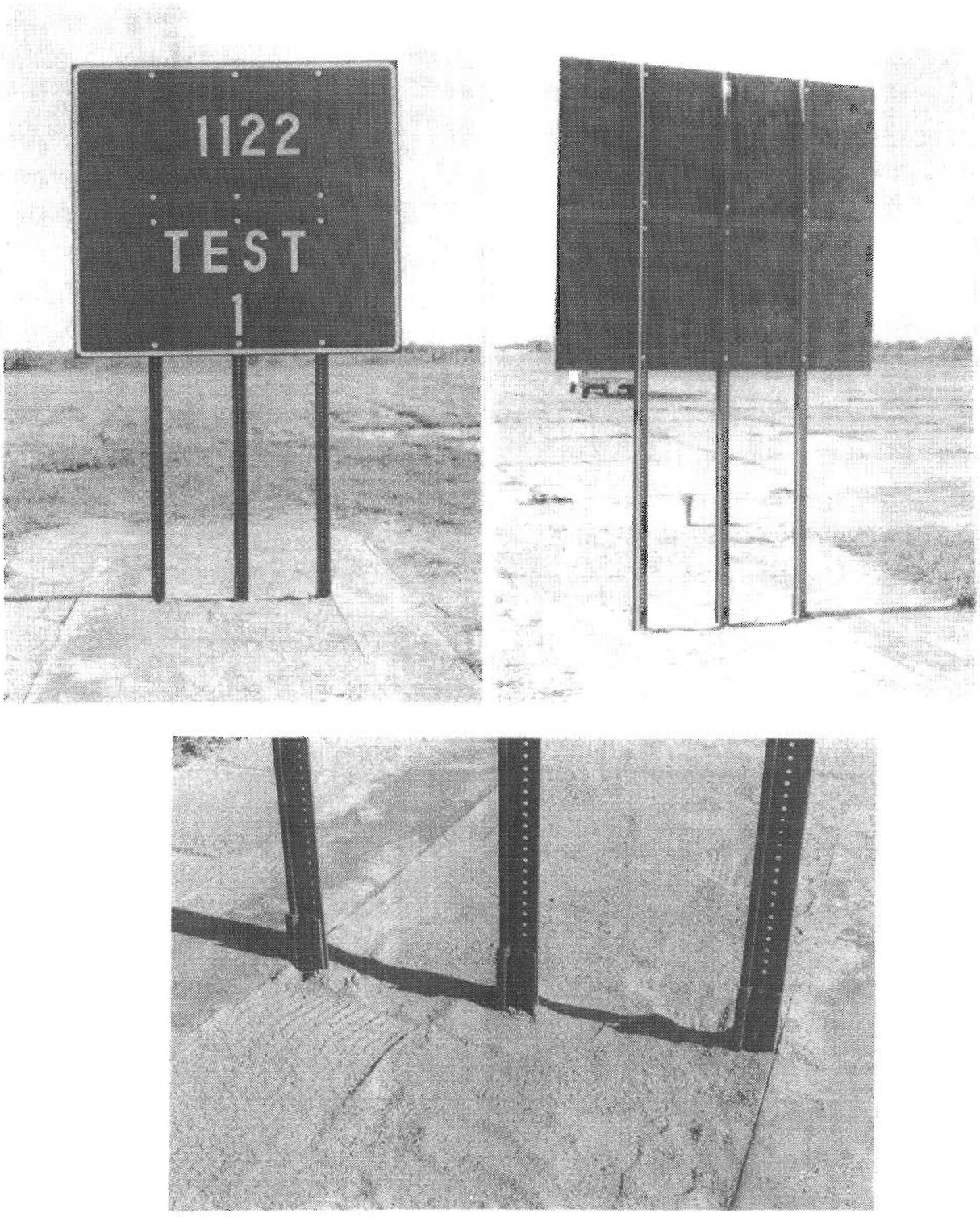


Figure 135. Sign installation before test 1122-1.

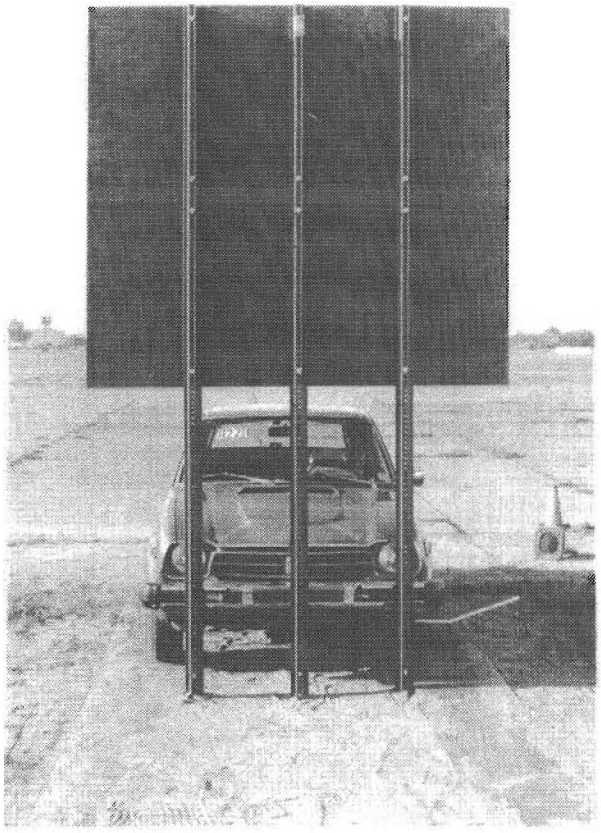
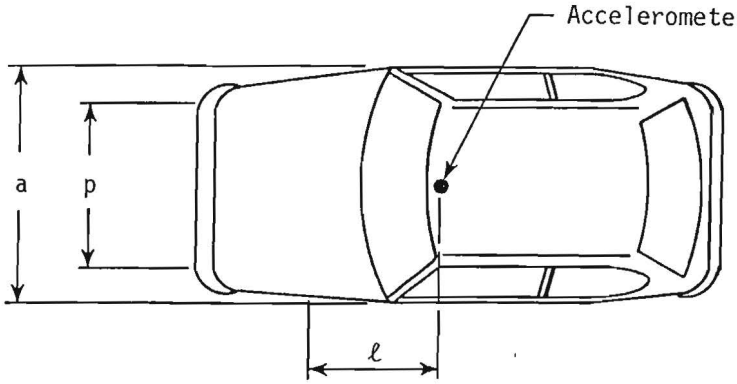


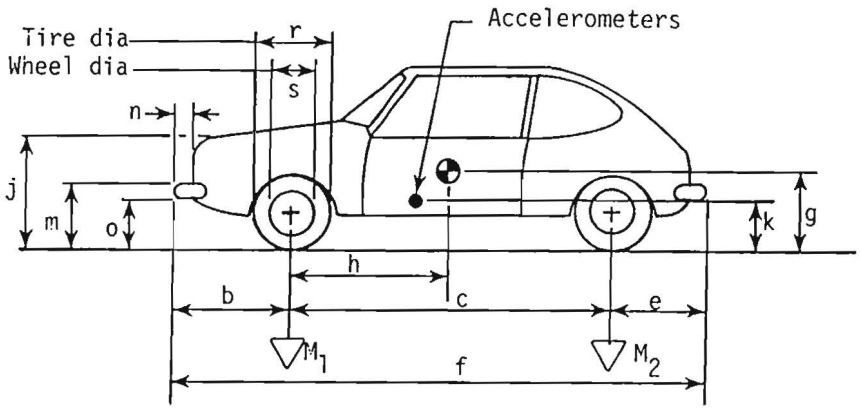
Figure 134. Vehicle before test 1122-1.

Date: 4-19-88 Test No.: 1122-1-2 VIN: SBC-7008873

Make: Honda Model: Civic Year: 1979 Odometer: 88723

Tire Size: 155 SR-12 Ply Rating: 2 Bias Ply: X Belted: ___ Radial: ___





4-wheel weight for c.g. det. ℓf 549 rf 508 ℓr 393 rr 350

Mass - pounds	Curb	Test Inertial	Gross Static
M_1		1057	1138
M_2		743	830
M_T		1800	1968

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Tire Condition: good ___
fair X
badly worn ___

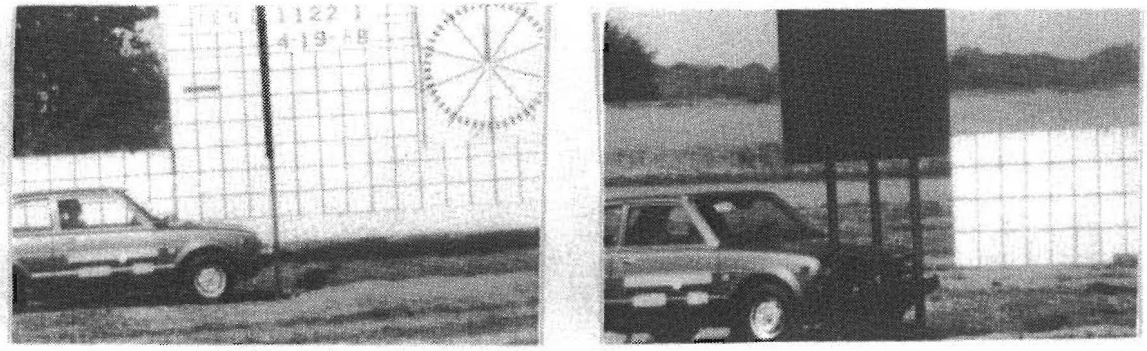
Vehicle Geometry - inches

a	59	b	26½
c	87	d*	51½
e	28½	f	114
g		h	35.9
i	----	j	29¼
k	12½	ℓ	26
m	19 3/4	n	6½
o	15	p	51½
r	21½	s	13¼

Engine Type: 4 cyl
Engine CID: ___
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD
Body Type: Hatch
Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

Figure 136. Test vehicle properties (1122-1).



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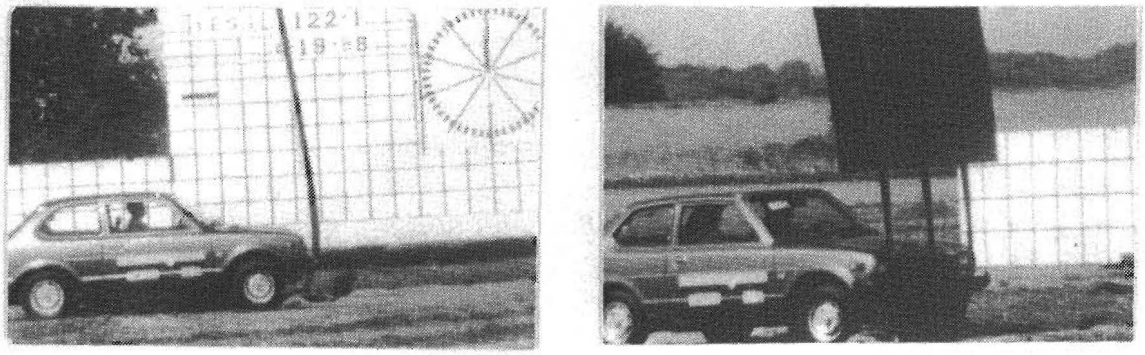

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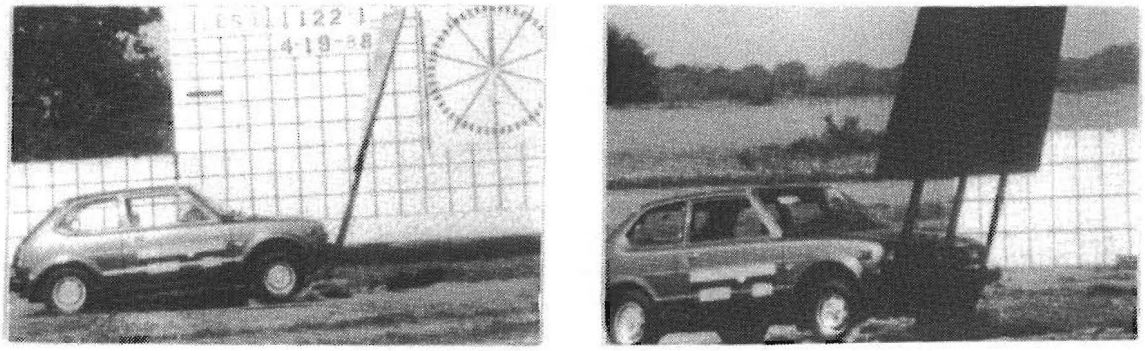
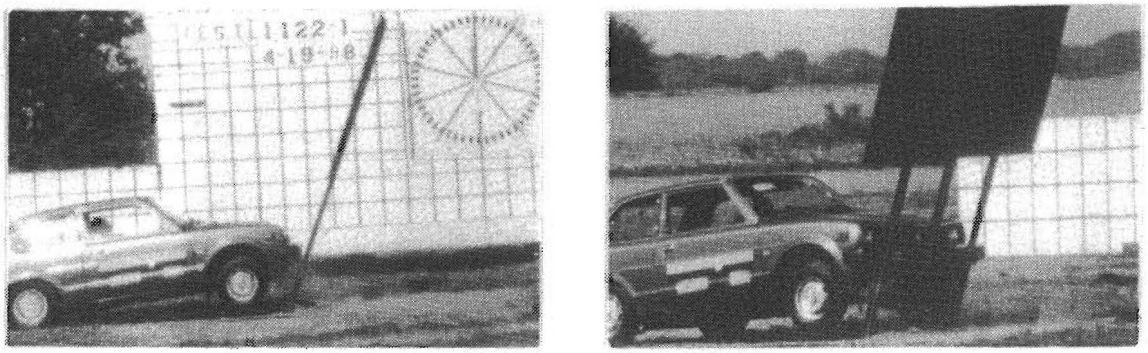
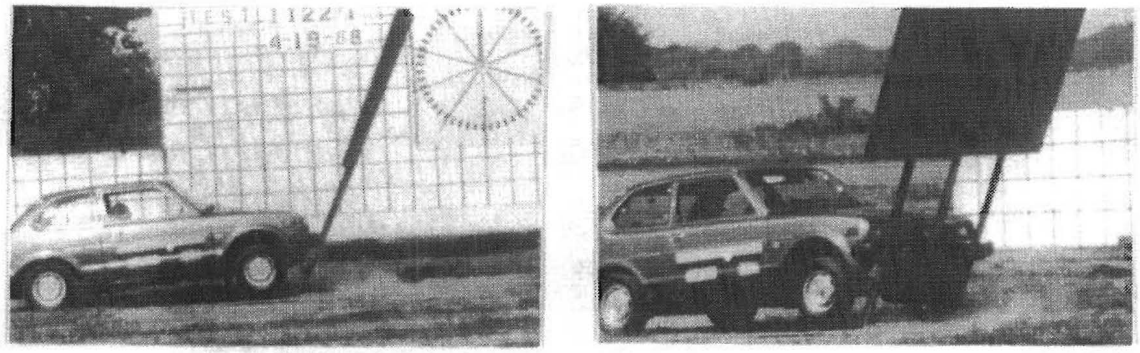


0.168 s

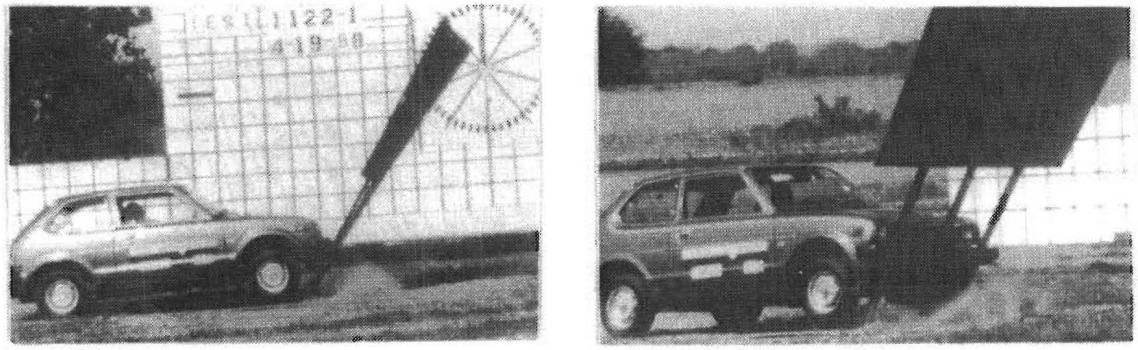


0.252 s

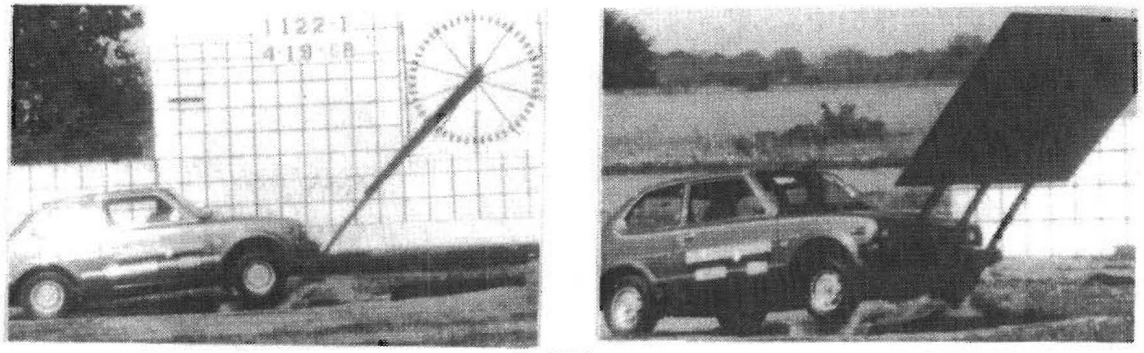
Figure 137. Sequential photographs for test 1122-1.



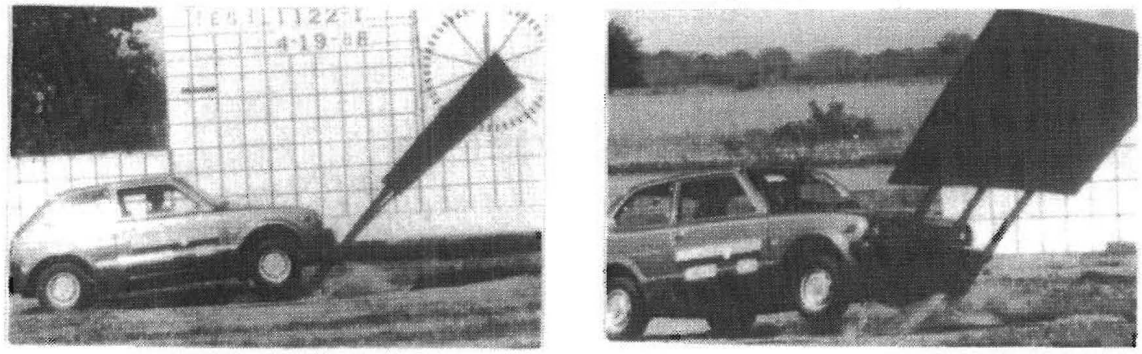
0.336 s



0.420 s



0.506 s



0.593 s

Figure 137. Sequential photographs for test 1122-1. (Continued)

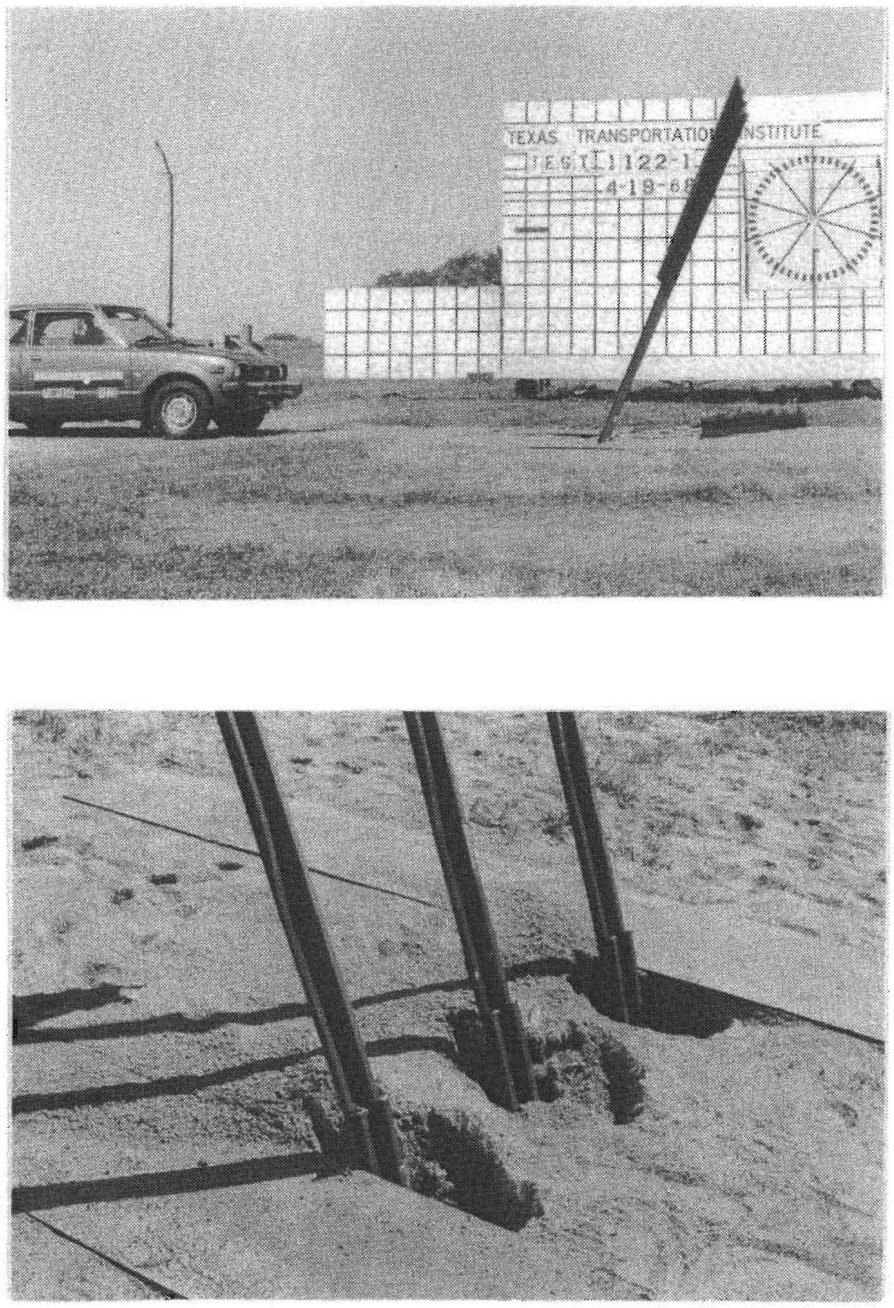
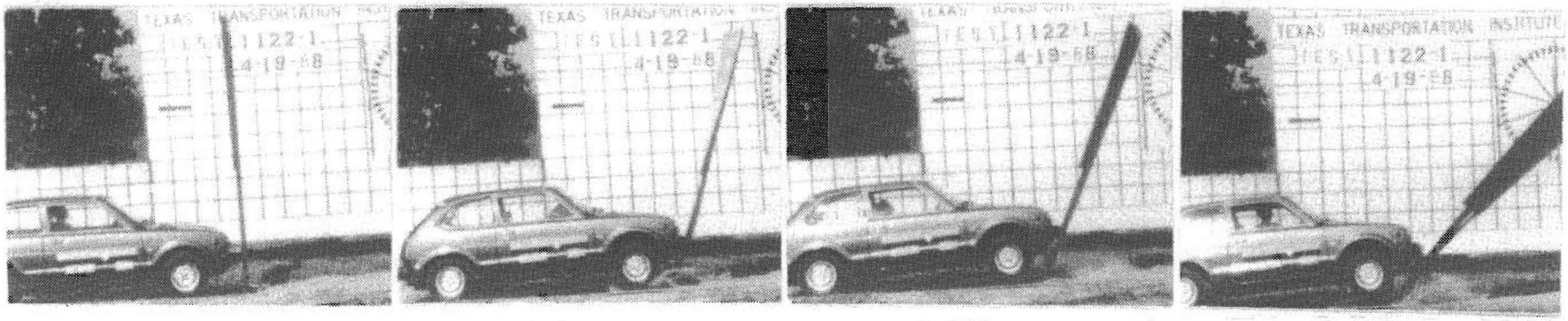
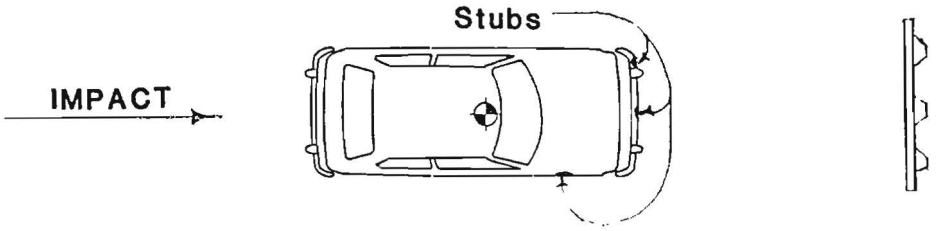


Figure 138. Sign installation after test 1122-1.

Figure 139. Vehicle after test 1122-1.



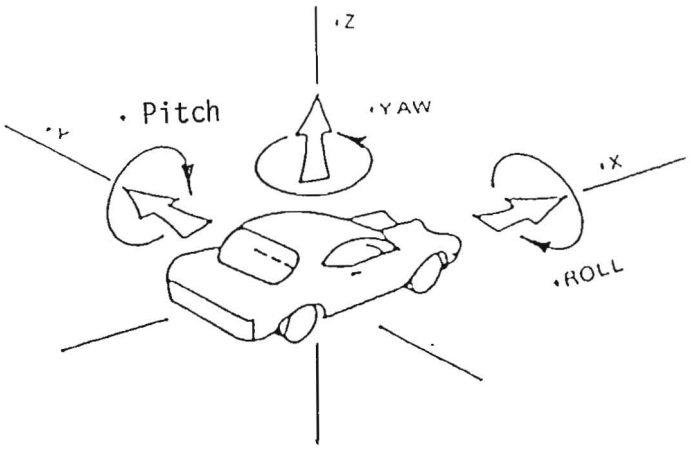
0.000 s 0.168 s 0.336 s 0.593 s



Test No	1122-1
Date	04/19/88
Test	Sign Installation
Support	Three Marion 80 ksi 3 lb-ft support
Vehicle	1979 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,968 lb (893 kg)
Vehicle Damage Classification	
TAD	12FD1
CDC	12FDEW1

Impact Speed	19.2 mi/h (30.9 km/h)
Change in Velocity	19.2 mi/h (30.9 km/h)
Change in Momentum	1,570 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal	-6.0 g
Lateral	-0.86 g
Occupant Impact Velocity	
Longitudinal	26.55 ft/s (8.10 m/s)
Lateral	None
Occupant Ridedown Accelerations	
Longitudinal	-3.29 g
Lateral	N/A

Figure 140. Summary of results for test 1122-1.



Axes are vehicle fixed.
Sequence for determining
orientation is:

1. Yaw
2. Pitch
3. Roll

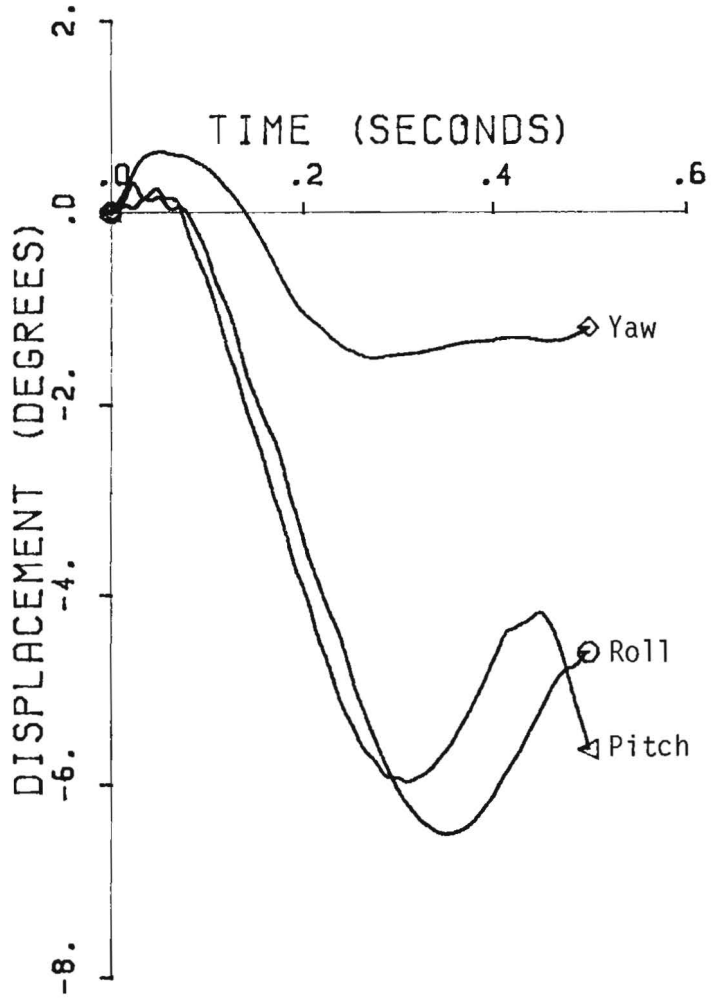


Figure 141. Vehicle angular displacements for test 1122-1.

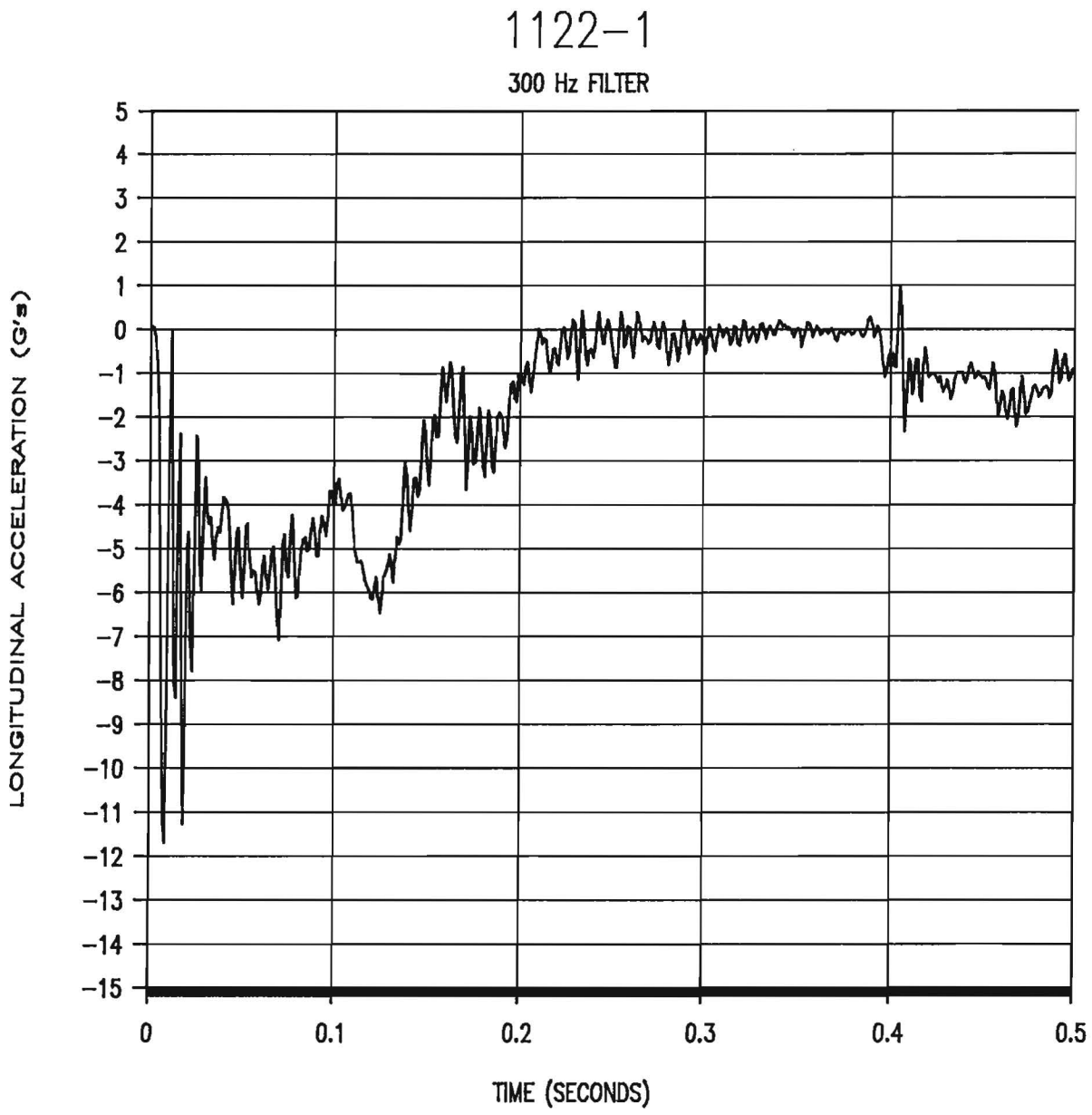


Figure 142. Longitudinal accelerometer trace for test 1122-1.

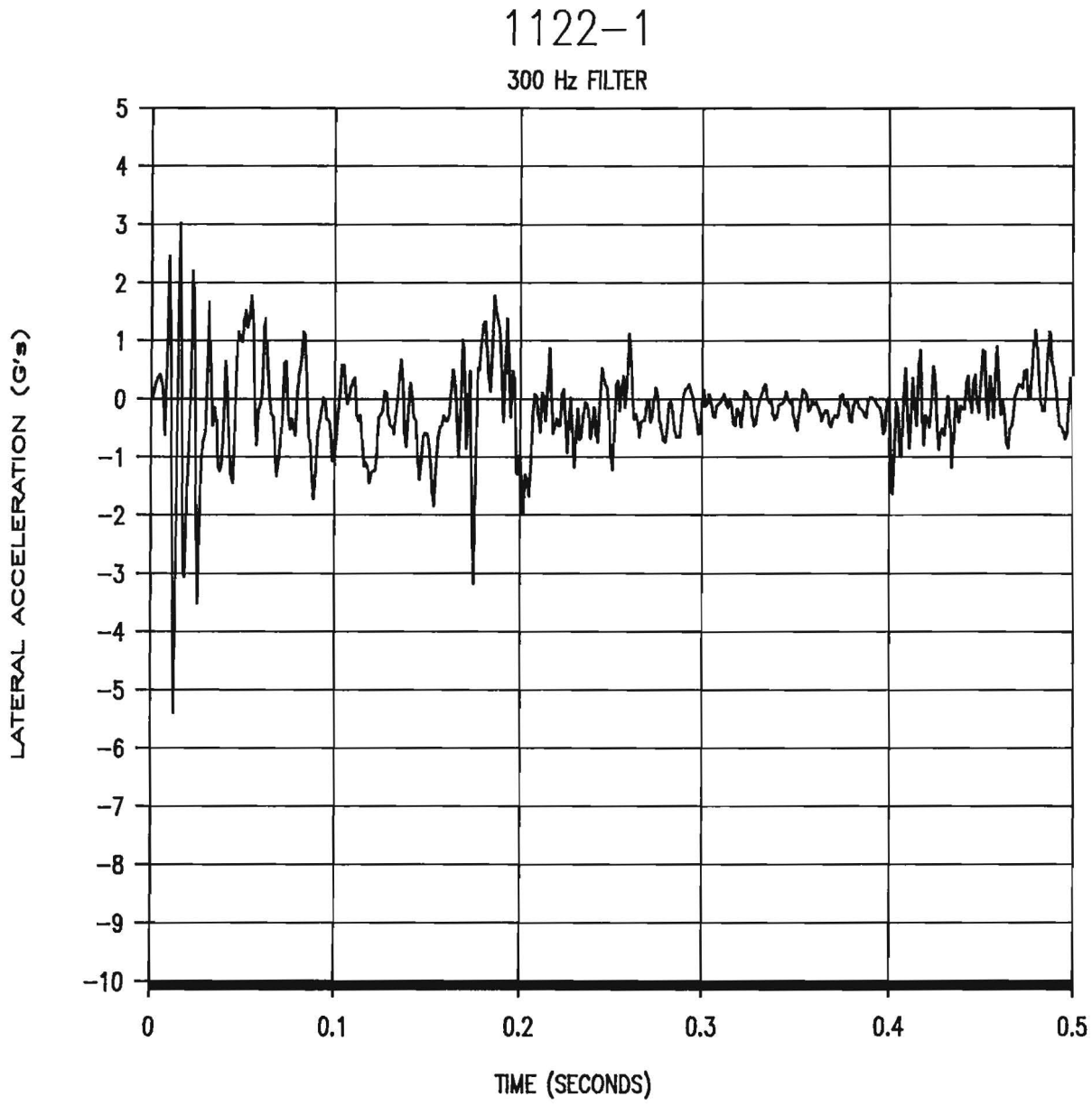


Figure 143. Lateral accelerometer trace for test 1122-1.

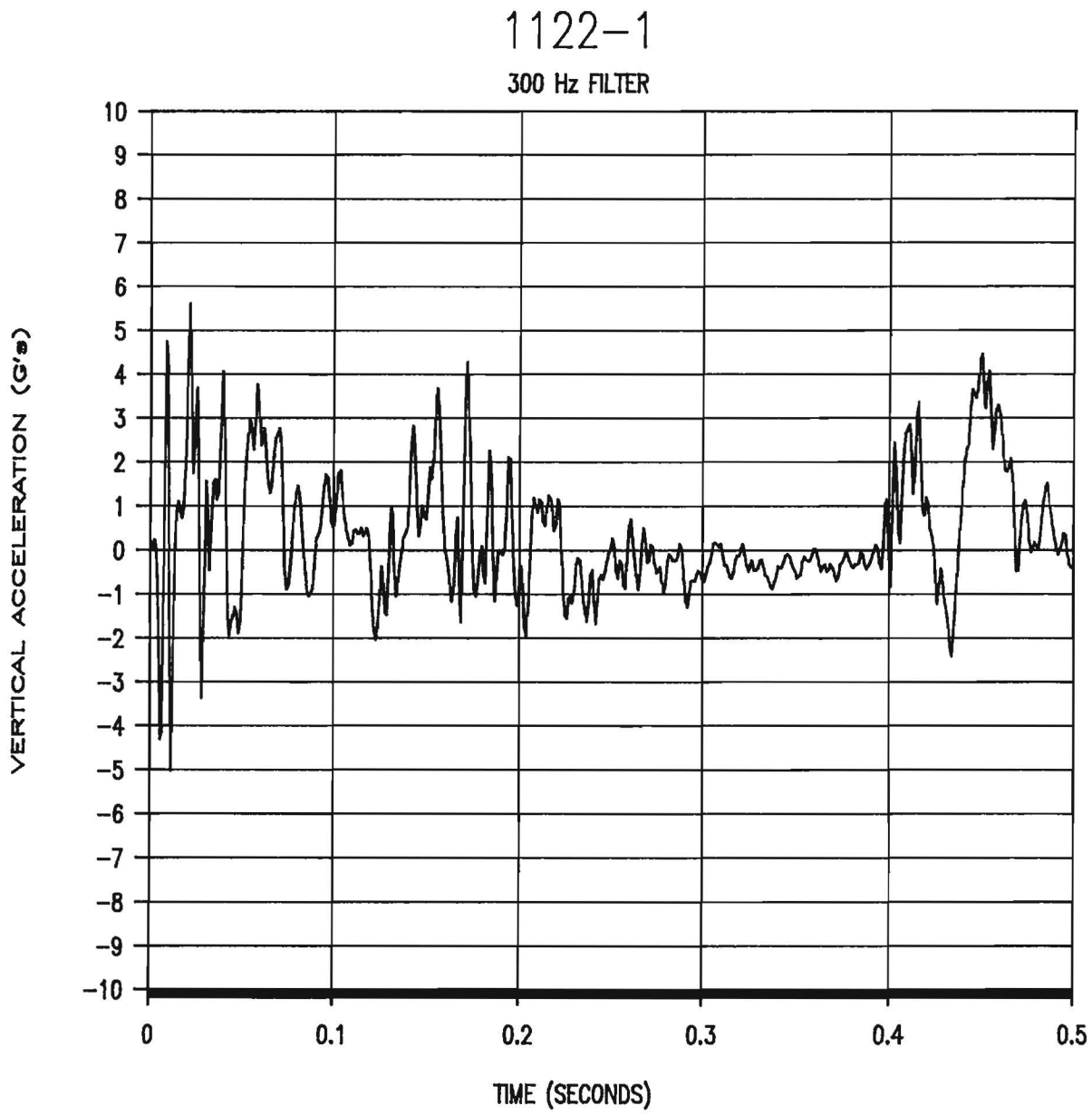


Figure 144. Vertical accelerometer trace for test 1122-1.

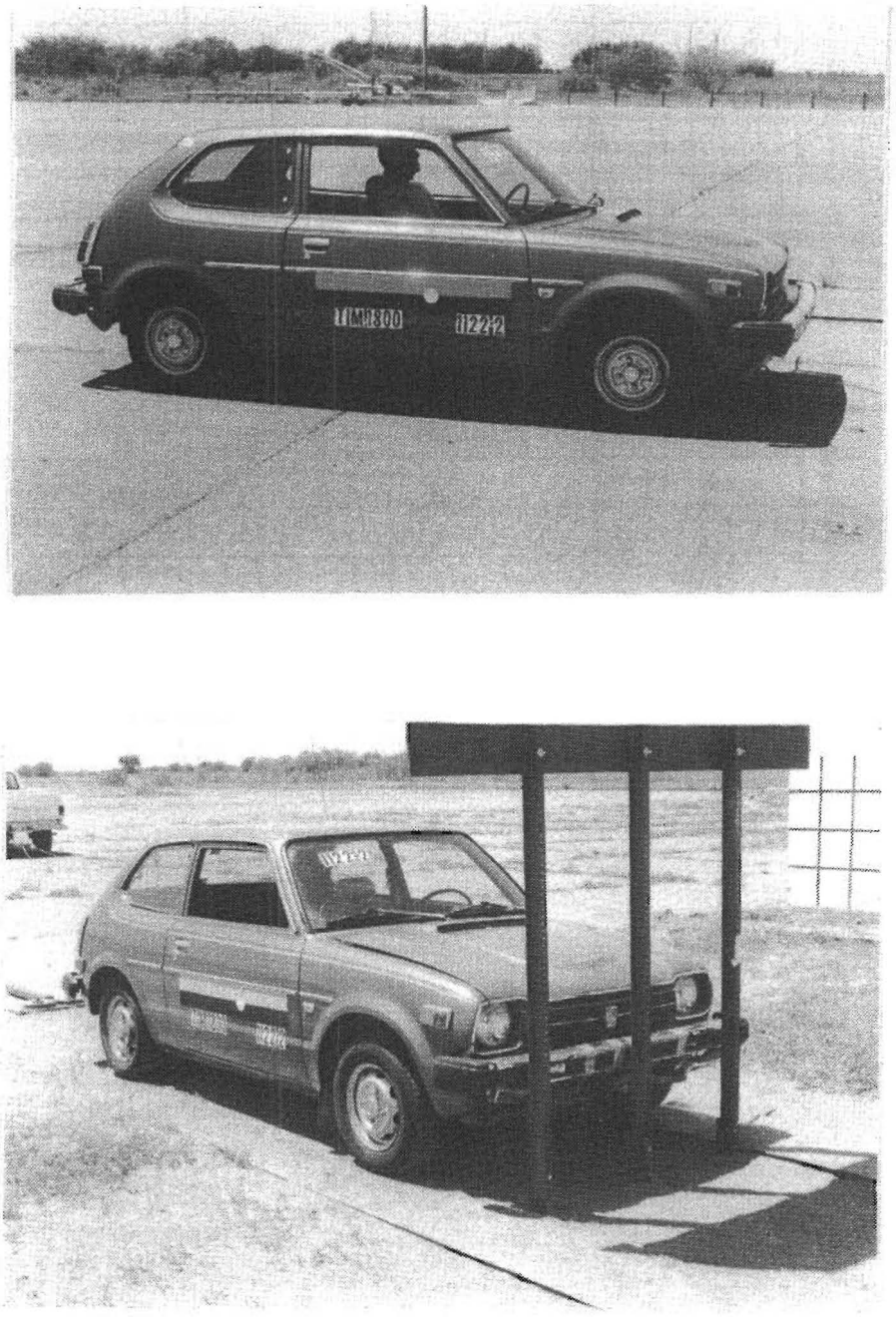


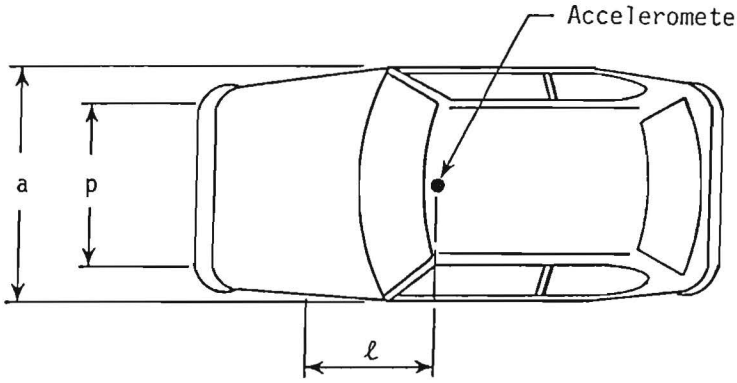
Figure 145. Vehicle before test 1122-2.

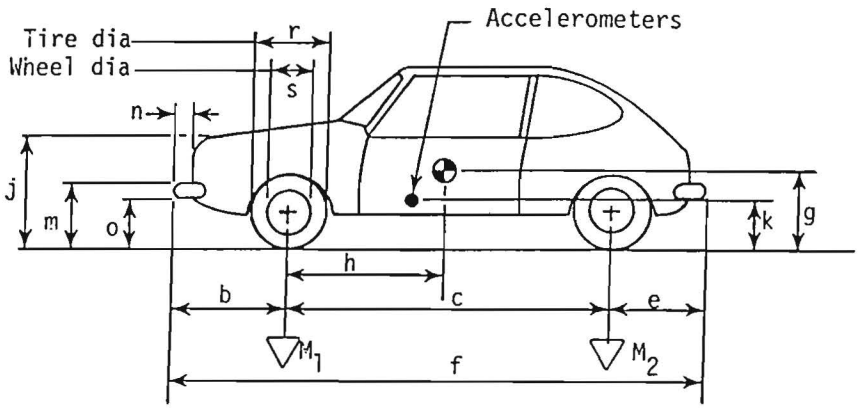
Date: 4-19-88 Test No.: 1122-1-2 VIN: SBC-7003873

Make: Honda Model: Civic Year: 1979 Odometer: 88723

Tire Size: 155 SR-12 Ply Rating: 2 Bias Ply: X Belted: ___ Radial: ___

Tire Condition: good ___
fair X
badly worn ___





4-wheel weight for c.g. det. ℓf 549 rf 508 ℓr 393 rr 350

Mass - pounds	Curb	Test Inertial	Gross Static
M_1		1057	1138
M_2		743	830
M_T		1800	1968

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Vehicle Geometry - inches

a	59	b	26½
c	87	d*	51½
e	28½	f	114
g	----	h	35.9
i	----	j	29¼
k	12½	ℓ	26
m	19 3/4	n	6½
o	15	p	51½
r	21½	s	13¼

Engine Type: 4 cyl

Engine CID: ___

Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD

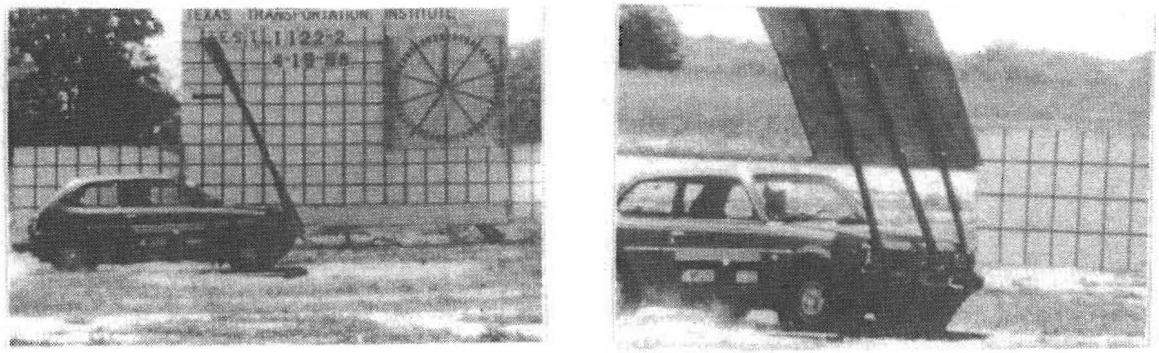
Body Type: Hatch

Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

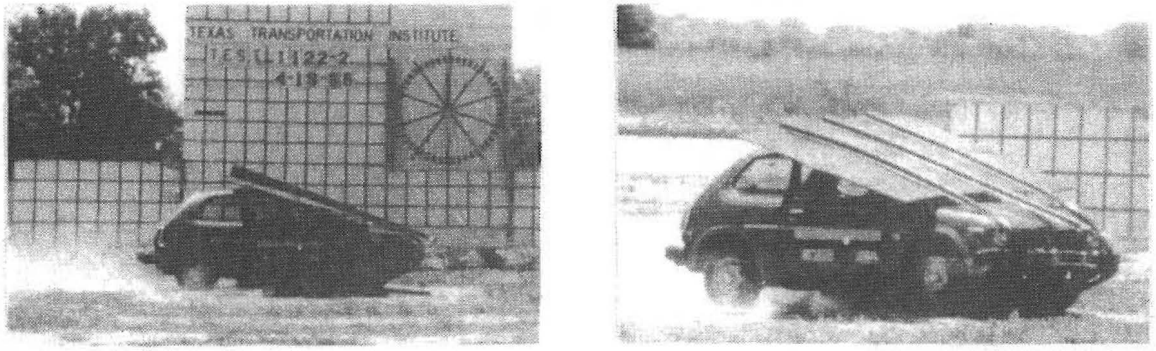
Figure 146. Test vehicle properties (1122-2).

0.000 s



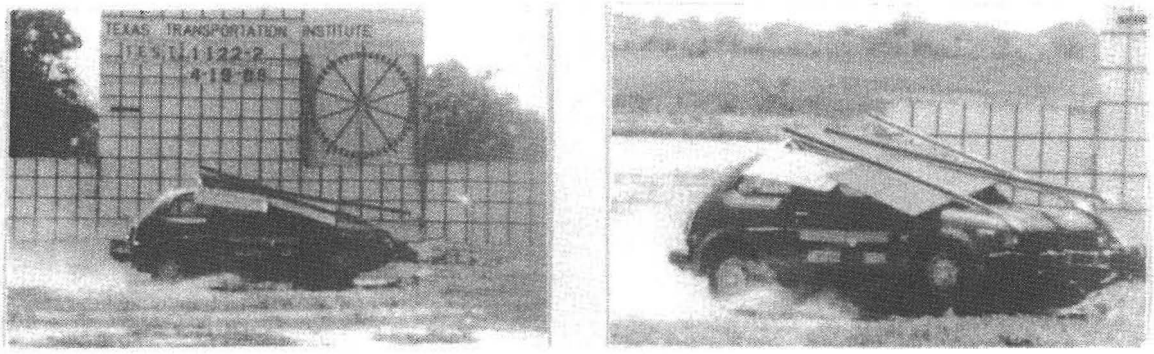
0.035 s

0.069 s

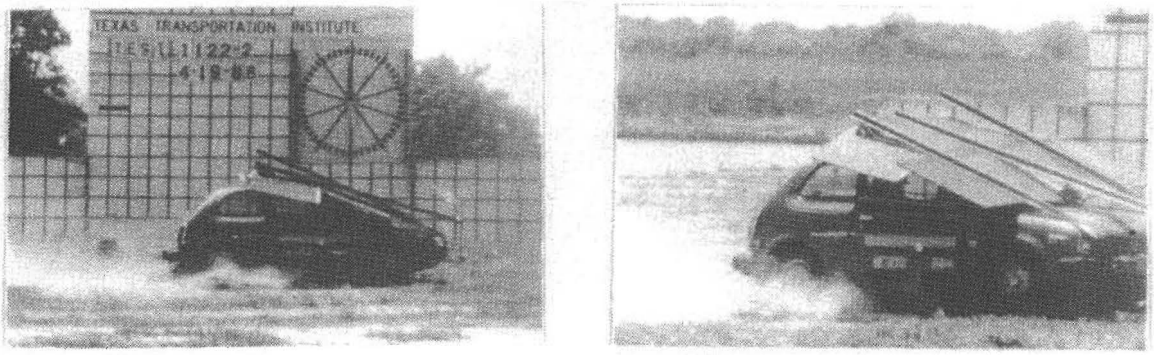


0.104 s

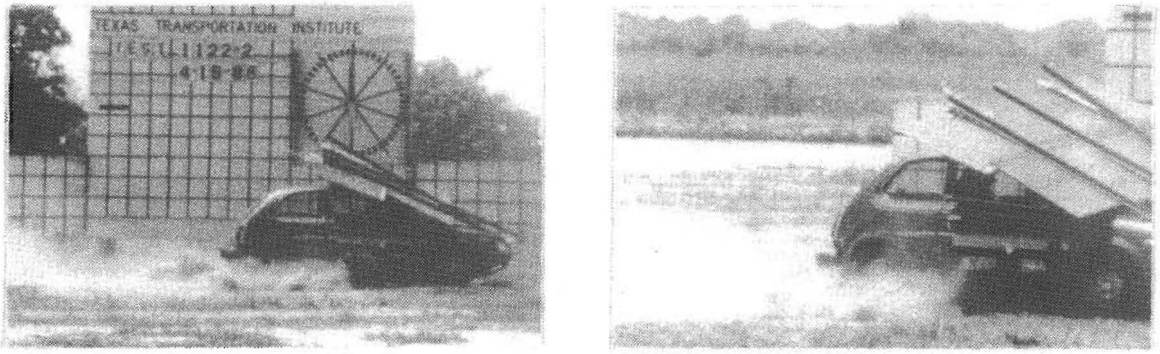
Figure 147. Sequential photographs for test 1122-2.



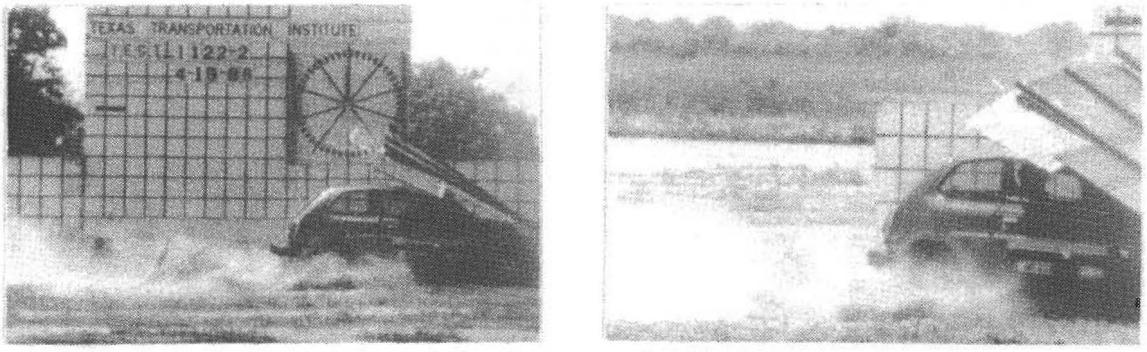
0.139 s



0.176 s



0.213 s



0.248 s

Figure 147. Sequential photographs for test 1122-2. (Continued)

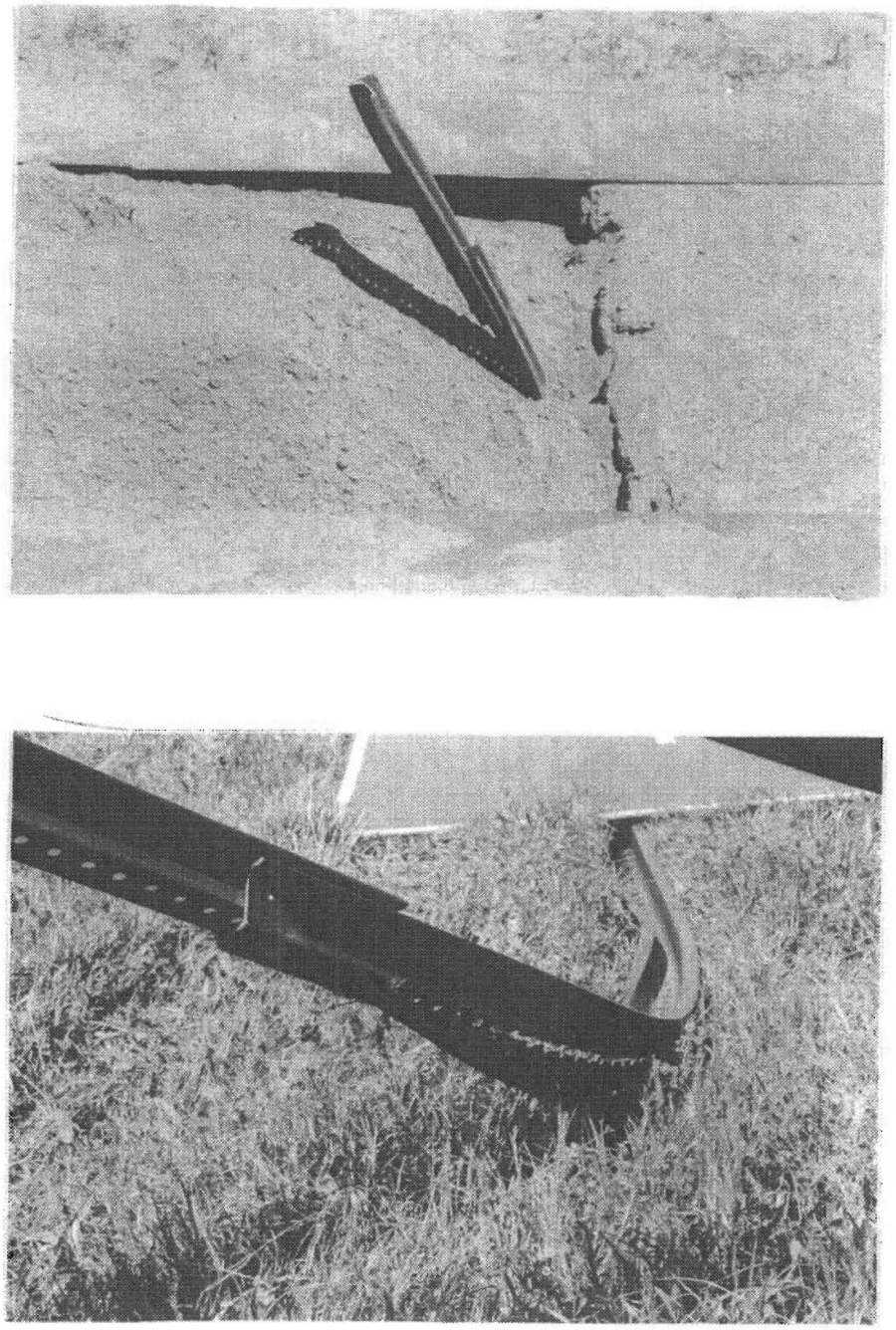
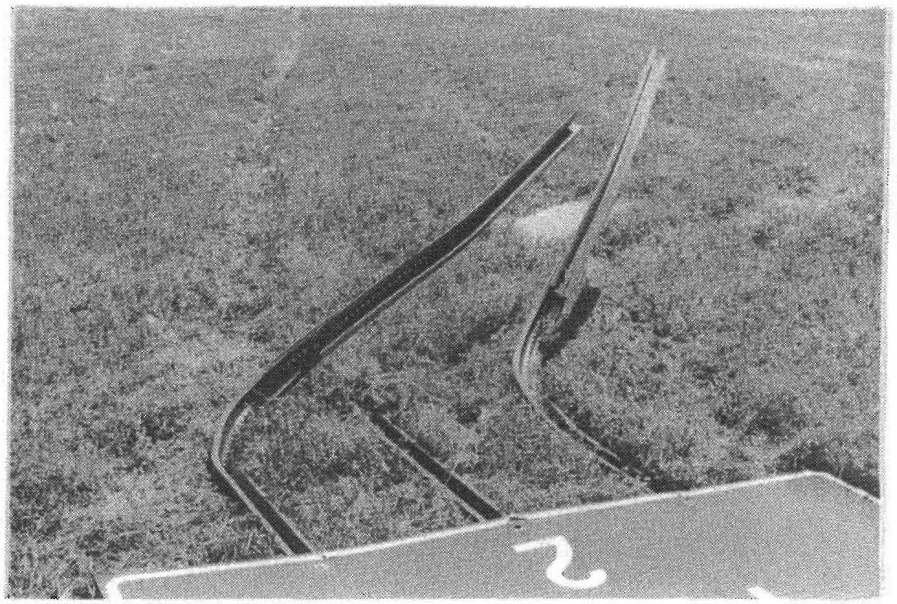


Figure 148. Sign installation after test 1122-2.



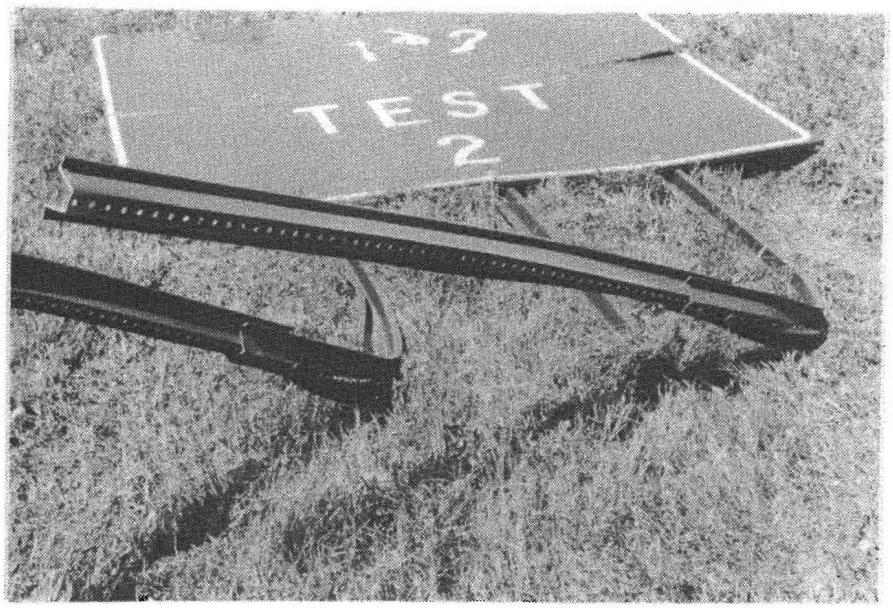
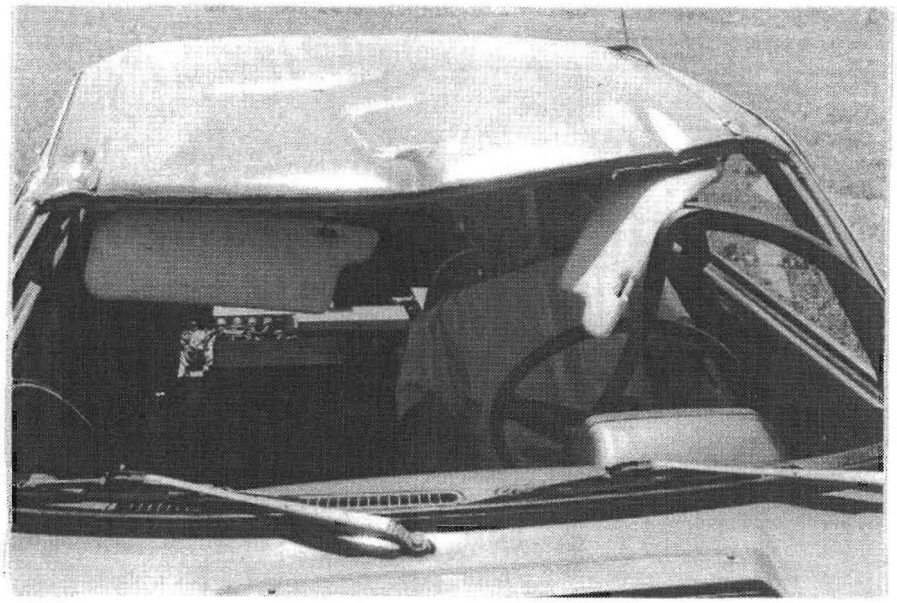


Figure 148. Sign installation after test 1122-2.
(Continued)

Figure 149. Vehicle after test 1122-2.



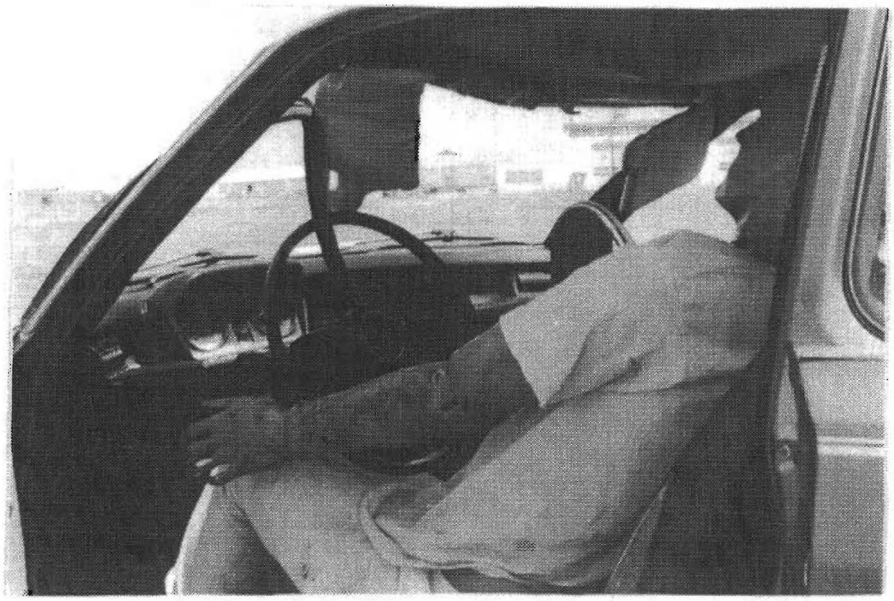
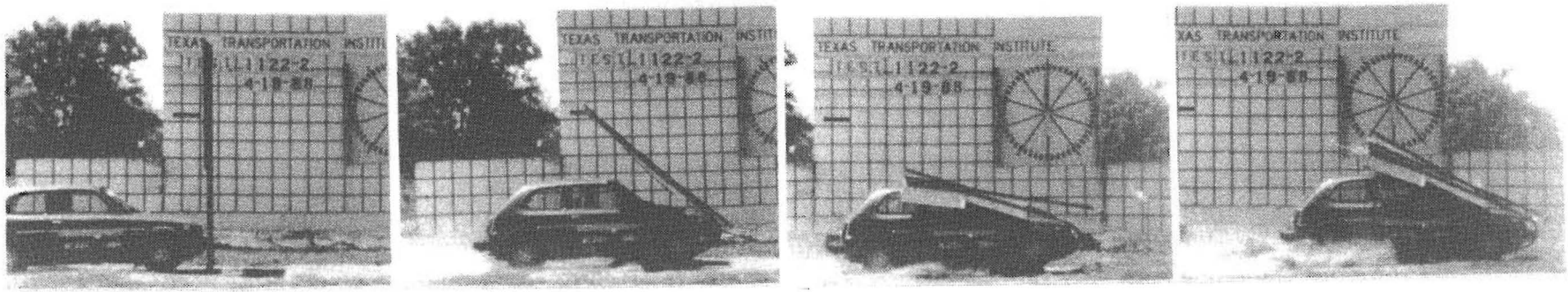
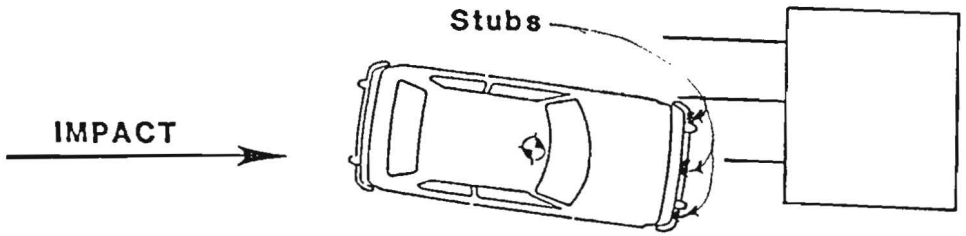


Figure 149. Vehicle after test 1122-2.
(Continued)



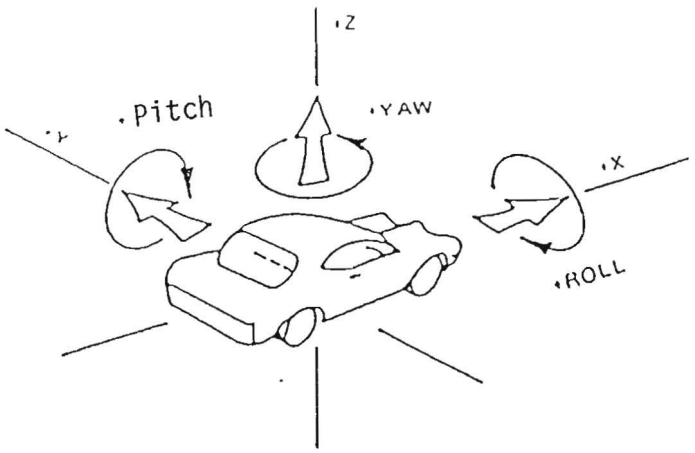
0.000 s 0.069 s 0.139 s 0.213 s



Test No	1122-2
Date	04/19/88
Test	Sign Installation
Support	Three Marion 80 ksi 3 lb-ft support
Vehicle	1979 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,968 lb (893 kg)
Vehicle Damage Classification	
TAD	12FD1
CDC	12FDAW2

Impact Speed	60.9 mi/h (97.9 km/h)
Change in Velocity	17.1 mi/h (27.5 km/h)
Change in Momentum	1,339.5 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal	-8.6 g
Lateral	-1.3 g
Occupant Impact Velocity	
Longitudinal	21.57 ft/s (6.58 m/s)
Lateral	N/A
Occupant Ridedown Accelerations	
Longitudinal	-2.59 g
Lateral	None

Figure 150. Summary of results for test 1122-2.



Axes are vehicle fixed. Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

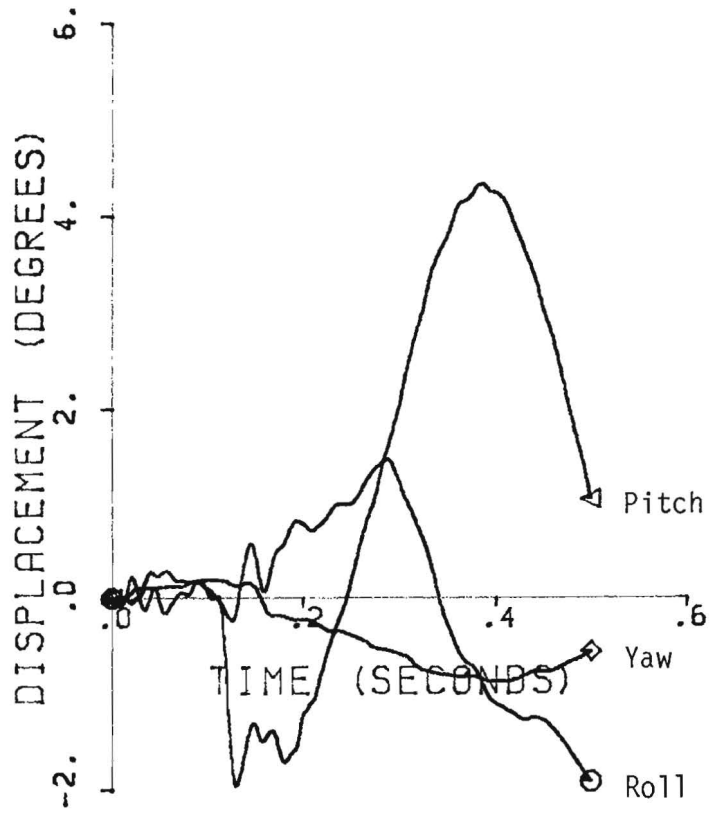


Figure 151. Vehicle angular displacements for test 1122-2.

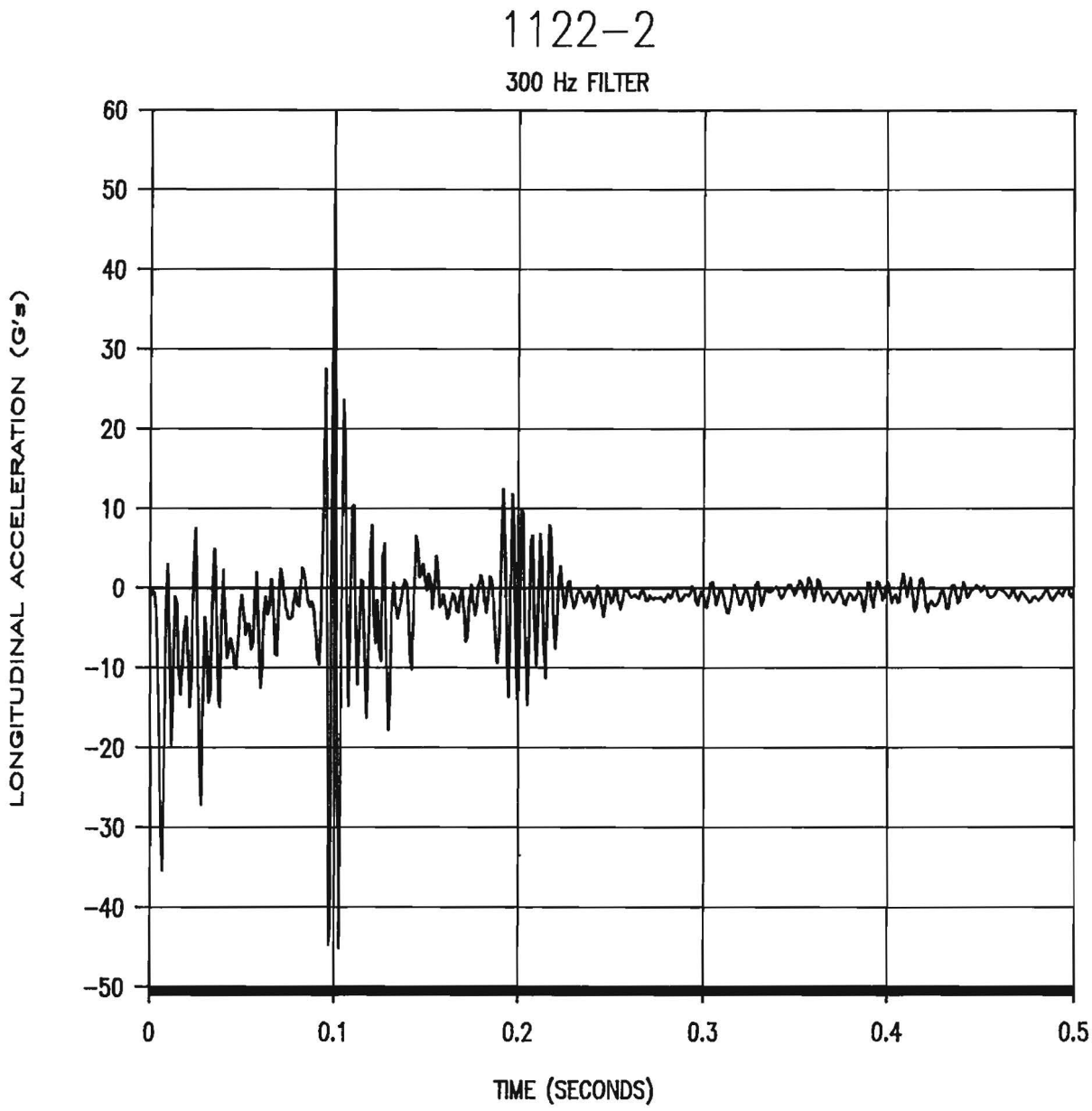


Figure 152. Longitudinal accelerometer trace for test 1122-2.

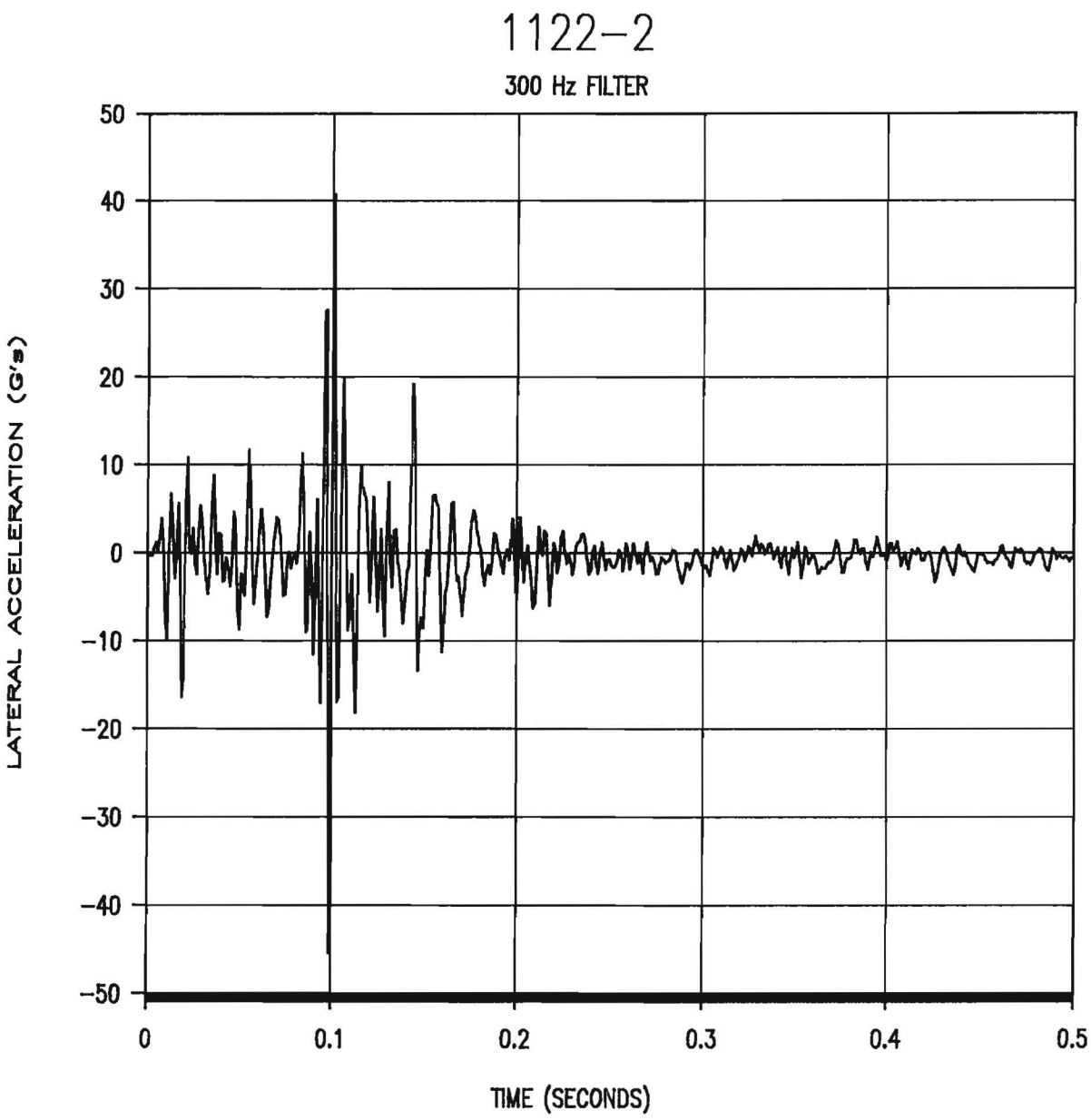


Figure 153. Lateral accelerometer trace for test 1122-2.

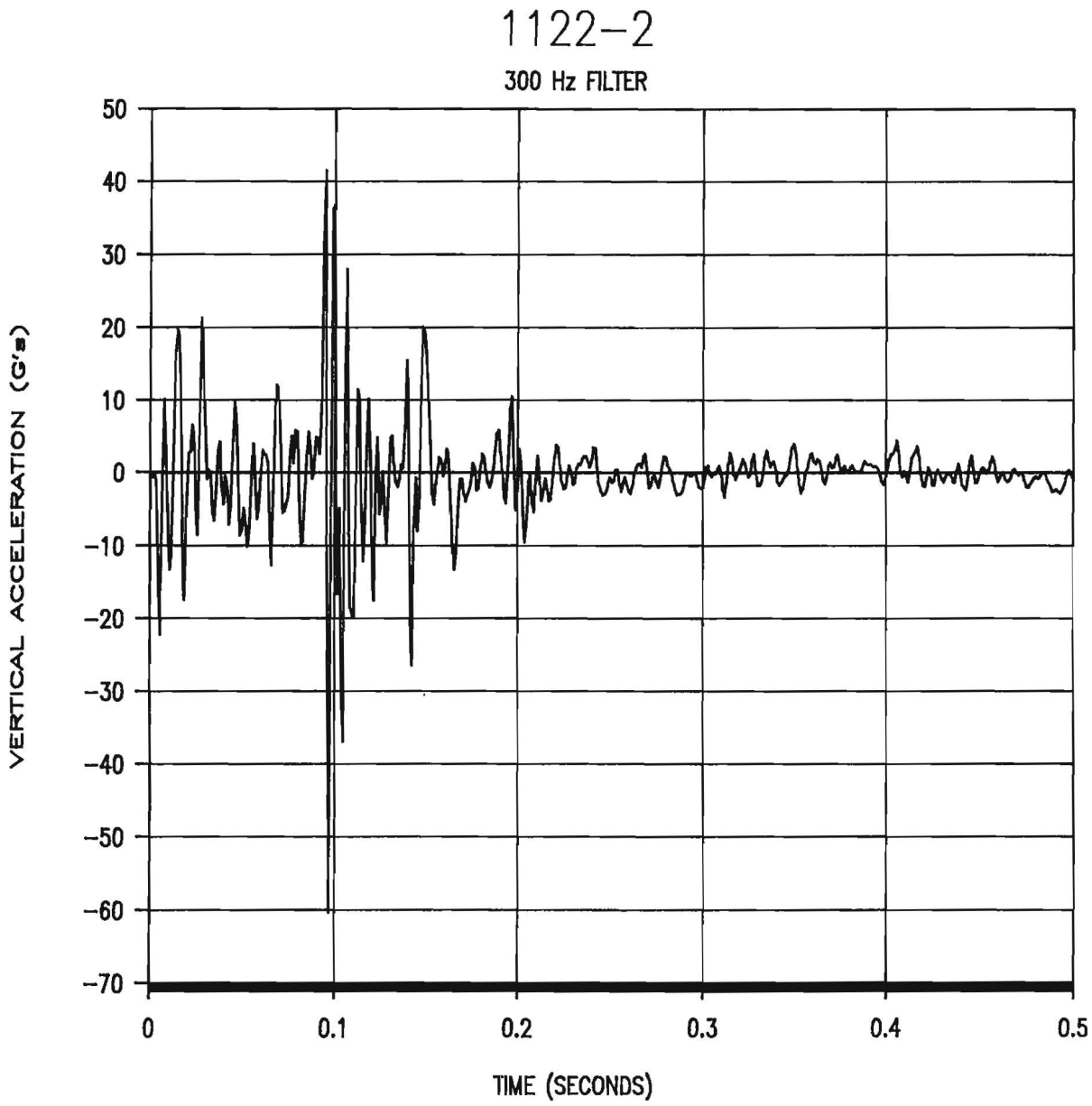


Figure 154. Vertical accelerometer trace for test 1122-2.

WEAK SOIL STUDY

The data from the crash tests gives apparent indication that sign systems behave differently in "weak" soil. Therefore, the new question raised was whether or not NCHRP 230 "weak" soil was a representative soil for the state of Texas. To address this question, a study was undertaken to define the typical "weak" soil encountered along Texas highways.

The study began by polling the individual districts to determine the location of "weak" soils and the problems associated with these soils. The Lufkin and Tyler districts were identified as being good study sites for problem soils. Contacts were made in these districts to identify specific sites. Interestingly, the feedback from the survey also indicated some varibility concerning the definition of "weak" soil.

For most highway districts, "weak" soils were those connected with high maintenance requirements for various sign installations. The maintenance typically stemmed from the soil failing to keep the sign support vertical. Therefore, the State's problems with "weak" soils was associated more with the number of reoccurring trips to straighten sign supports rather than with vehicular impacts.

It was decided that the maintenance problem and the crash test problem were not independent. Therefore, a solution to either problem would greatly benefit both. A consultant was enlisted to compare sites in the Lufkin and Tyler districts with the NCHRP 230 "weak" soil. The primary concern was the lateral strength of both the manufactured and the insitu soils.

A drivable pressuremeter (Reference 13) was used to obtain these lateral soil strengths. Baseline values were measured at TTI's facility first, then compared to values from the designated study sites. Measurements with the pressuremeter and soil samples were taken every foot to a depth of 4-1/2 feet. The test sites were as follows:

(a) TTI Facility (Annex) - baseline tests in dry NCHRP 230 "weak" soil.

(b) TTI Facility (Annex) - baseline tests in wet (saturated) NCHRP 230 "weak" soil.

(c) Site One - US Highway 287, 800 feet south of Loop 304, 27 feet off centerline of roadway.

(d) Site Two - US Highway 287, 750 feet south of Loop 304, 27 feet off centerline of roadway.

(e) Site Three - US Highway 287/19, approximate milepost 7, low side of road (East), center of ditch.

(f) Site Four - US Highway 287/19, approximate milepost 7, high side of road (West), 23 feet from pavement, possible wind blown hill.

(g) Site Five - US Highway 287/19, approximate milepost 7, high side of road (West), 6 feet from pavement.

(h) Site Six - FM 2961, 2-1/2 miles from US Highway 59, South Side, 12 feet from edge of pavement.

(i) Site Seven - FM 2961, 3-1/2 miles from US Highway 59, North Side, 7 feet from edge of pavement.

(j) Site Eight - FM 2961, 3-1/2 miles from US Highway 59, North Side, 12 feet East of Site Seven.

The soil samples were taken back to Texas A&M University and analyzed. A sieve and moisture content analysis was done for each specimen. The sieve sizes were in accordance with NCHRP 230 "weak" soil requirements. The pressuremeter plots for (a), (i) and (j) and specimen analysis for all locations are presented in Figures 155 through 169 and Table 3. Pressuremeter plots for all other locations are presented in the Appendix.

RESULTS OF SOIL ANALYSIS

The data from the soil analysis gave surprising results. First, the sieve analysis indicates that none of the insitu "weak" soils meet the NCHRP requirements. Practically all the field samples, except the top layer in each set, contained an extreme amount of fines (passing 100 sieve). However, a large percentage of fines is usually expected for typical insitu "weak" soils. These soils varied quite noticeably in comparison to the manufactured "weak" soil which have virtually no fines.

The unexpected part is that the lateral strengths are comparable. A review of the data shows the strength of the manufactured soil is very similar to that of the weakest soil tested in the field (Sites 7 & 8). The manufactured soil was slightly weaker in the first foot and a half, but that difference is attributed to normal weathering and compaction of insitu soils.

The manufactured soil could be made to duplicate these effects by better compaction of the top layer. Therefore, it was concluded that for crash test purposes, the NCHRP 230 "weak" soil was representative of "weak" soils along Texas highways.

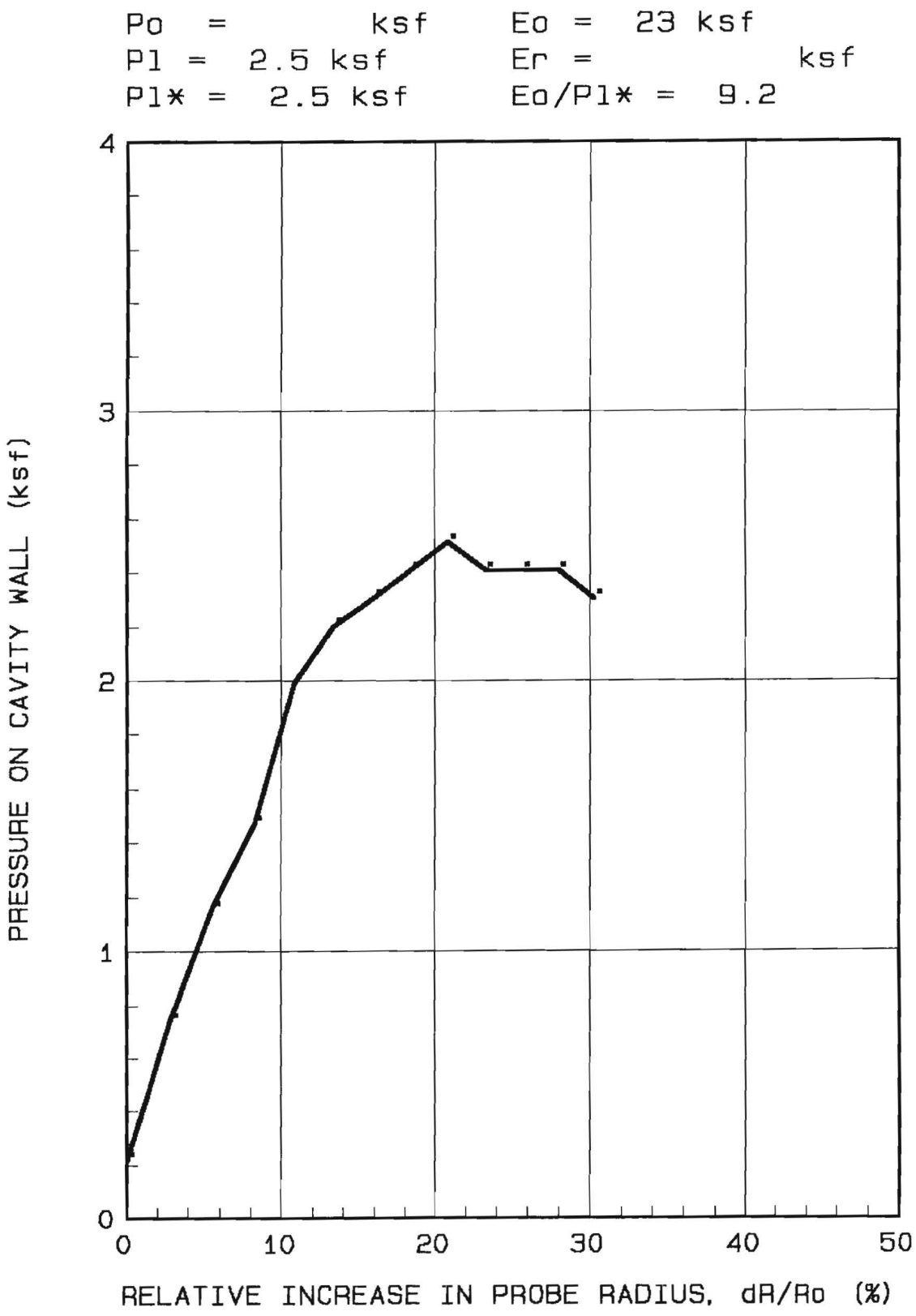


Figure 155. Annex Dry, 0.5 foot depth.

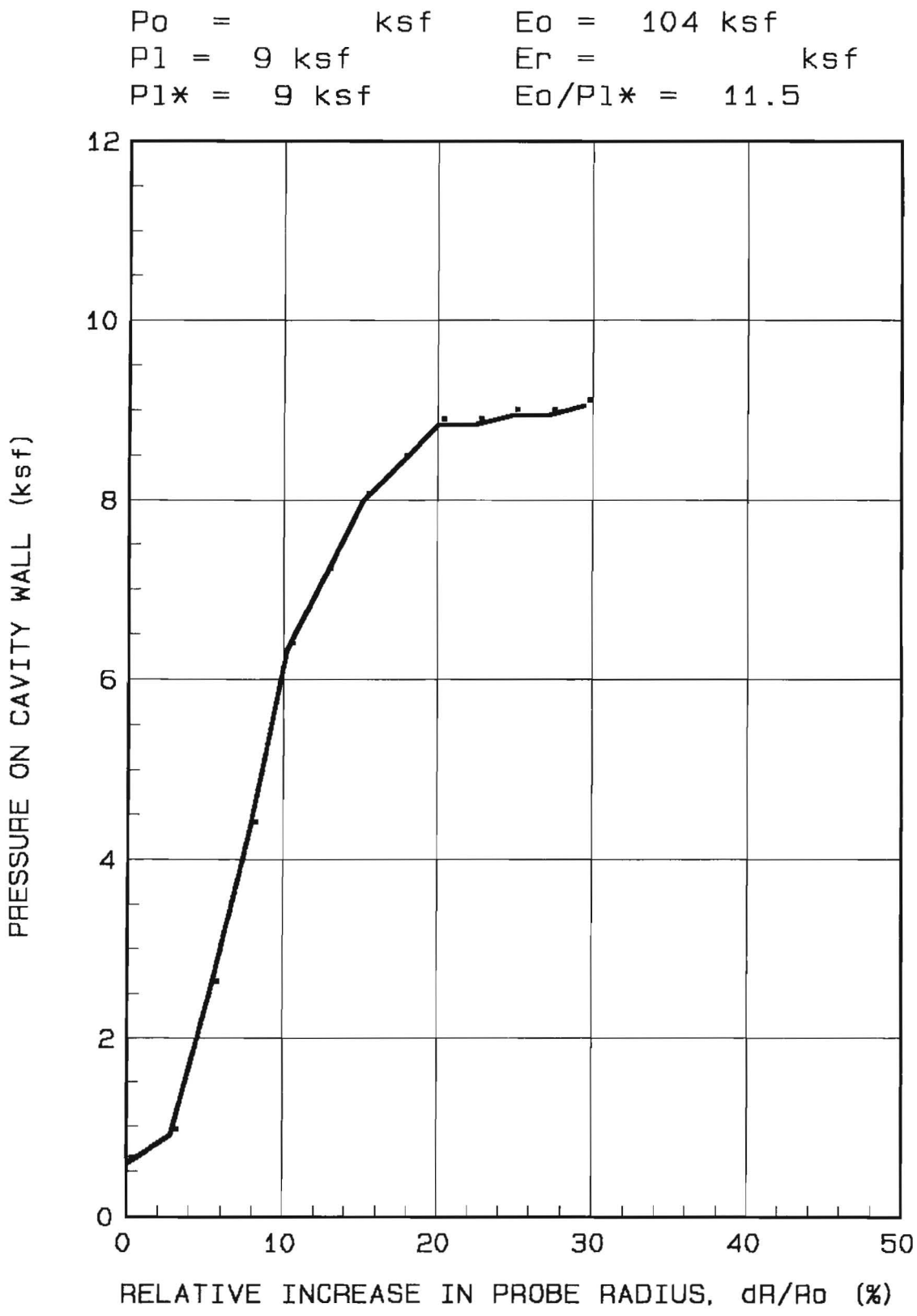


Figure 156. Annex Dry, 1.5 foot depth.

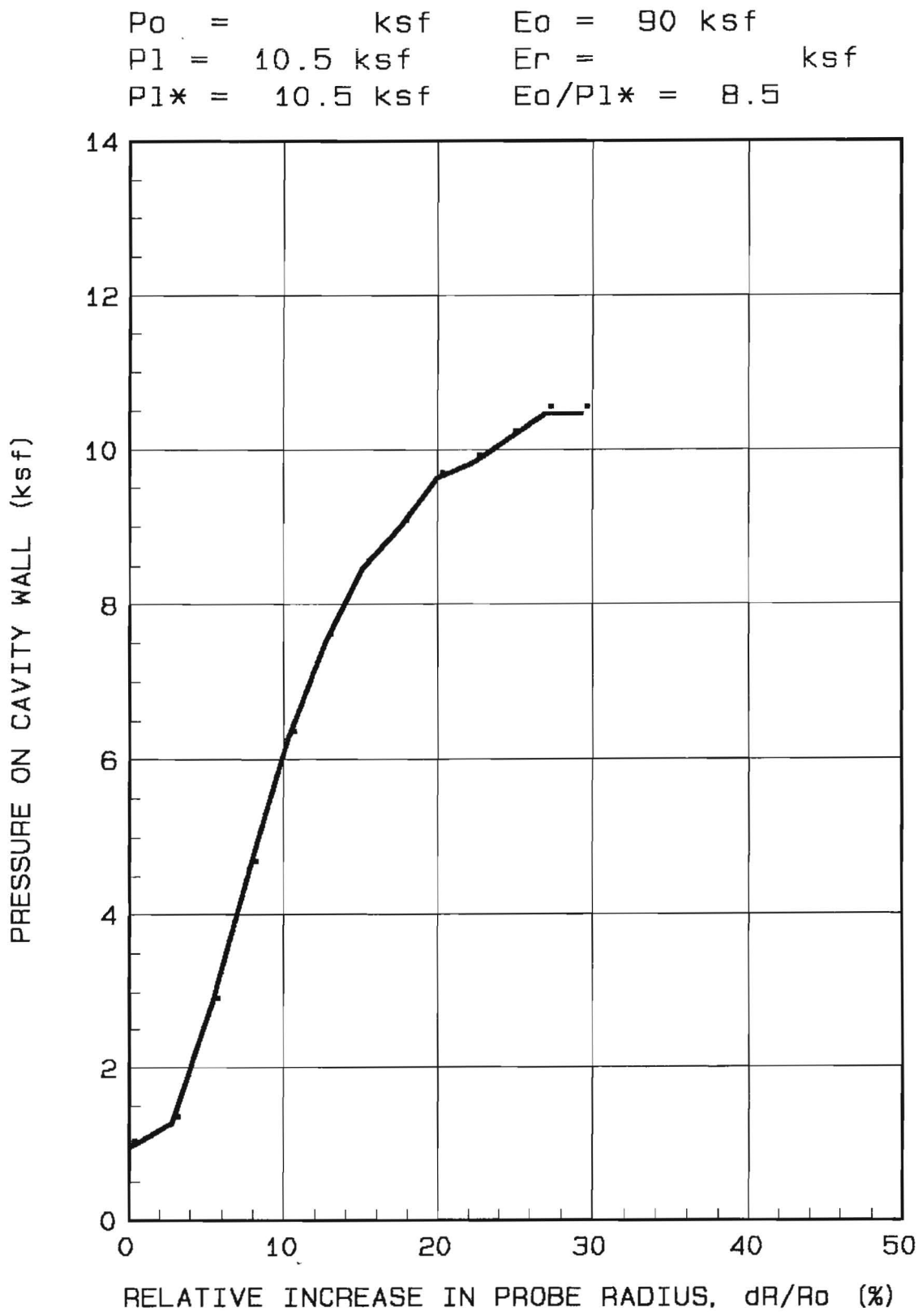


Figure 157. Annex Dry, 2.5 foot depth.

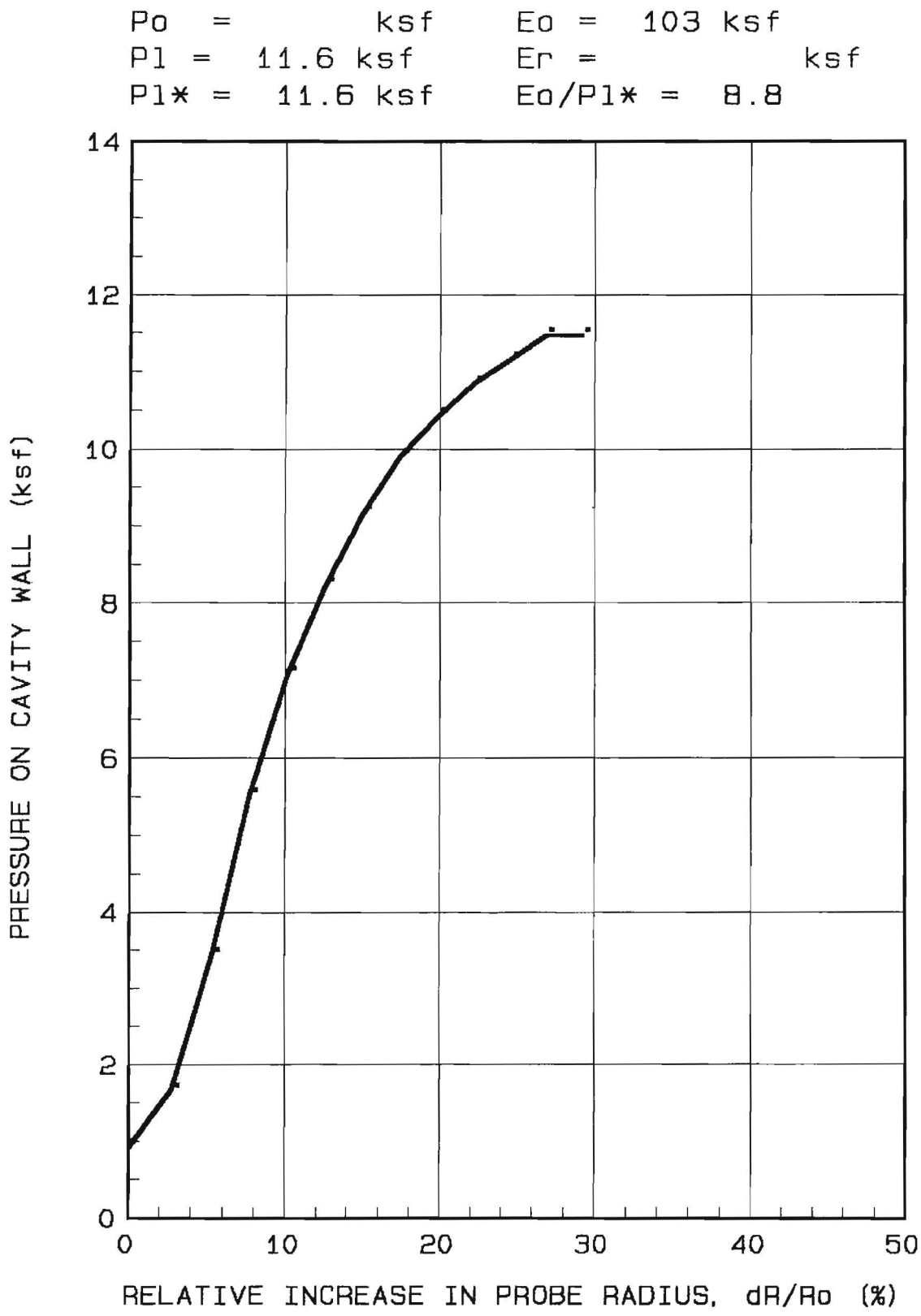


Figure 158. Annex Dry, 3.5 foot depth.

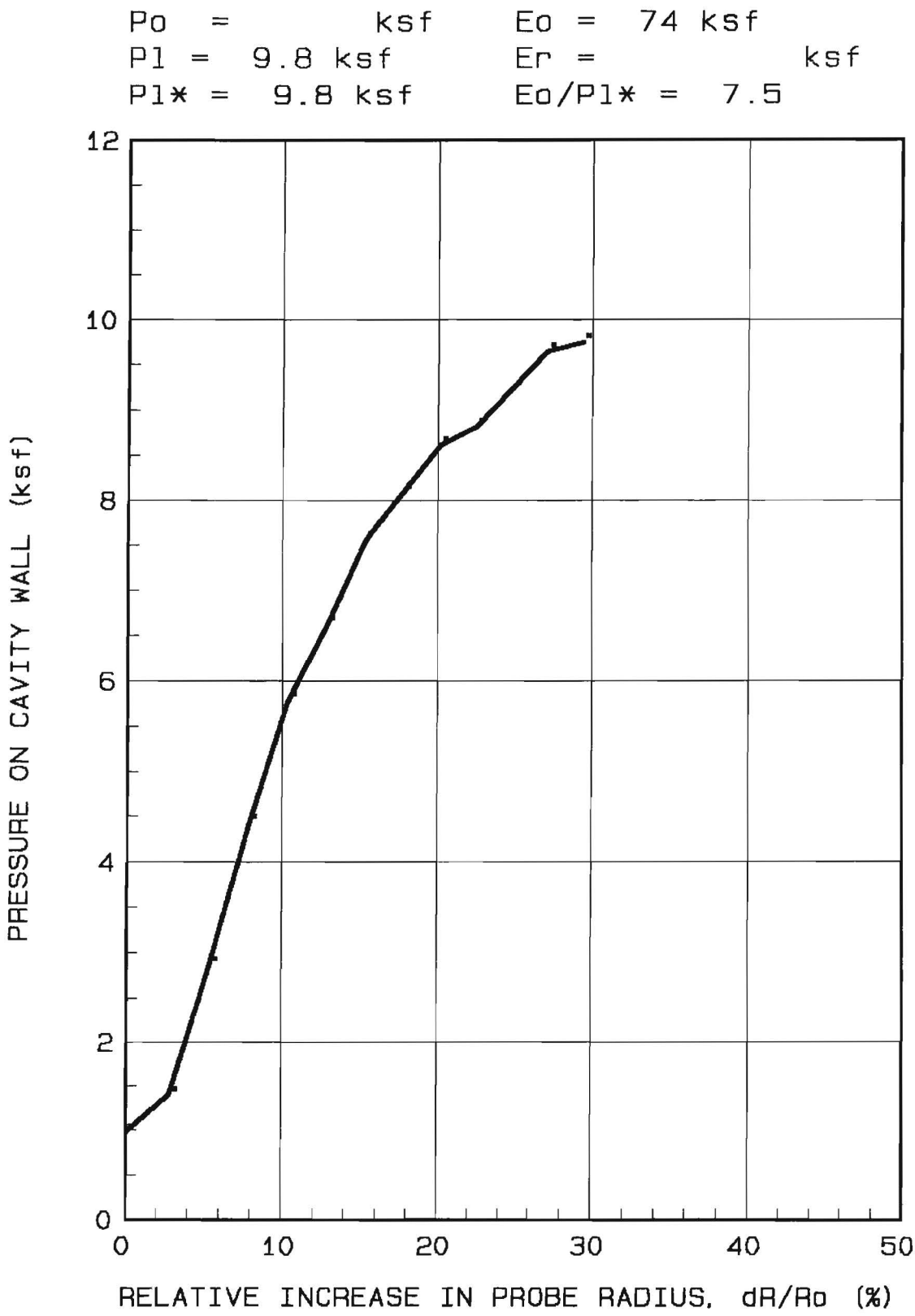


Figure 159. Annex Dry, 4.5 foot depth.

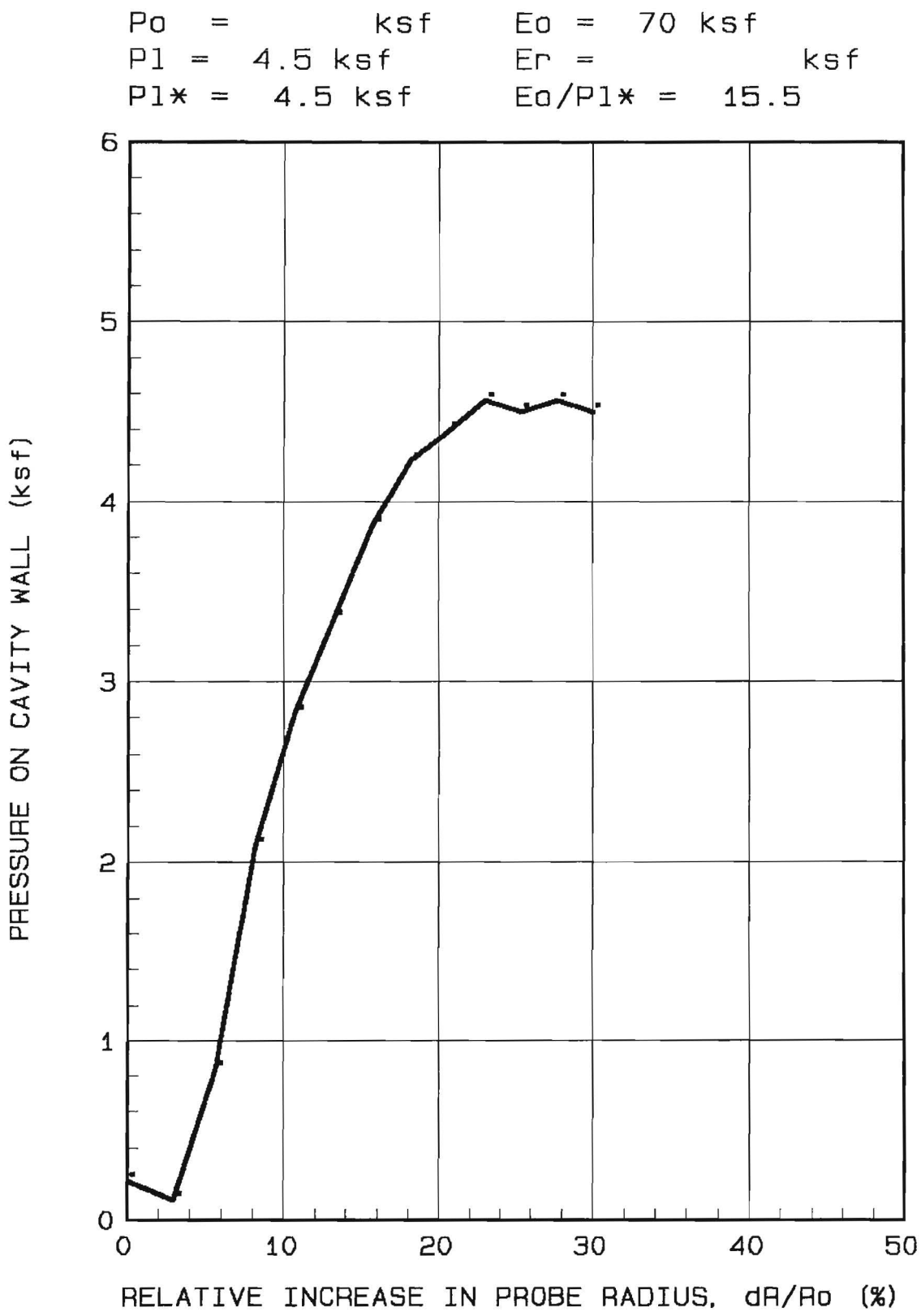


Figure 160. Site 7, 0.5 foot depth.

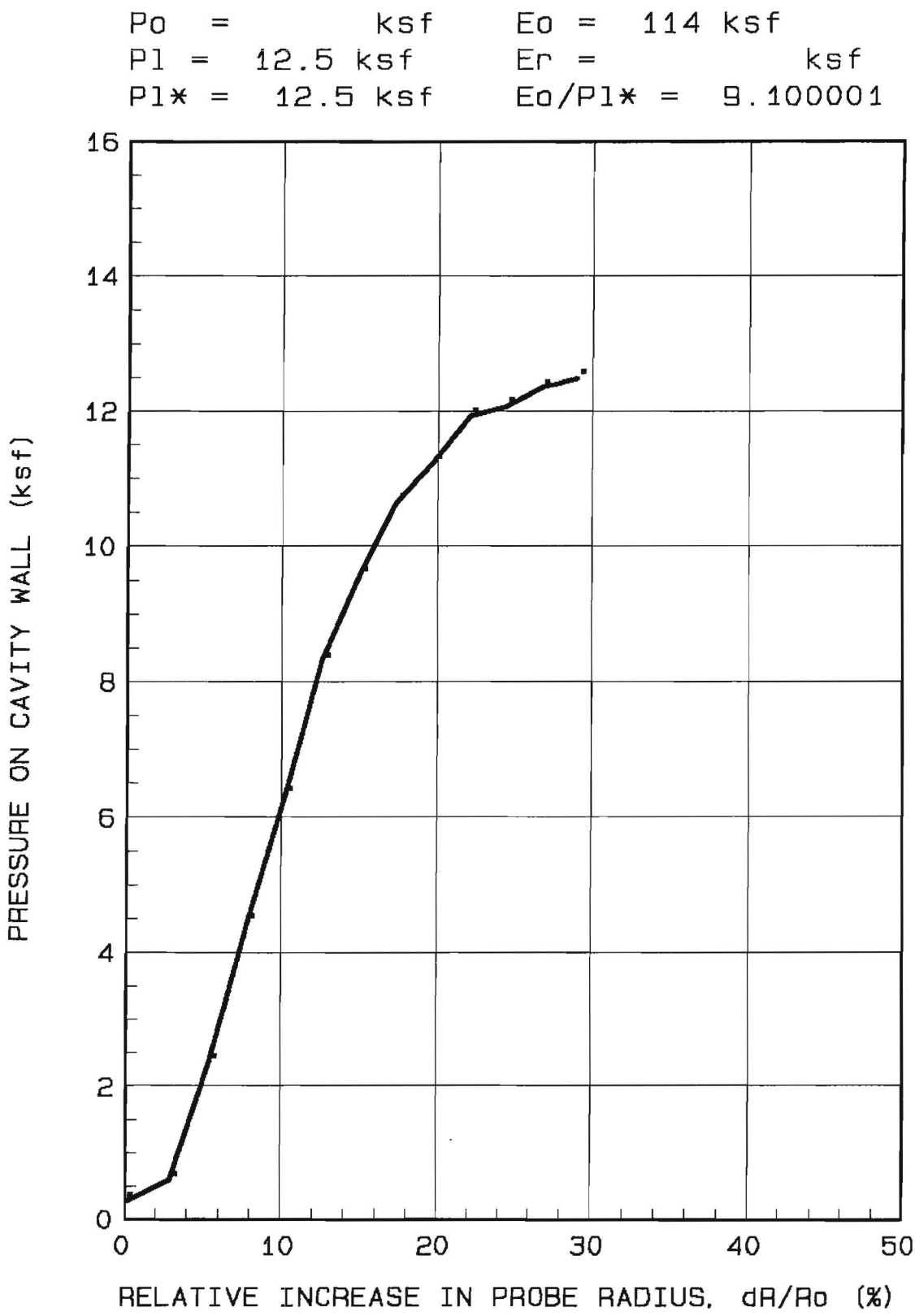


Figure 161. Site 7, 1.5 foot depth.

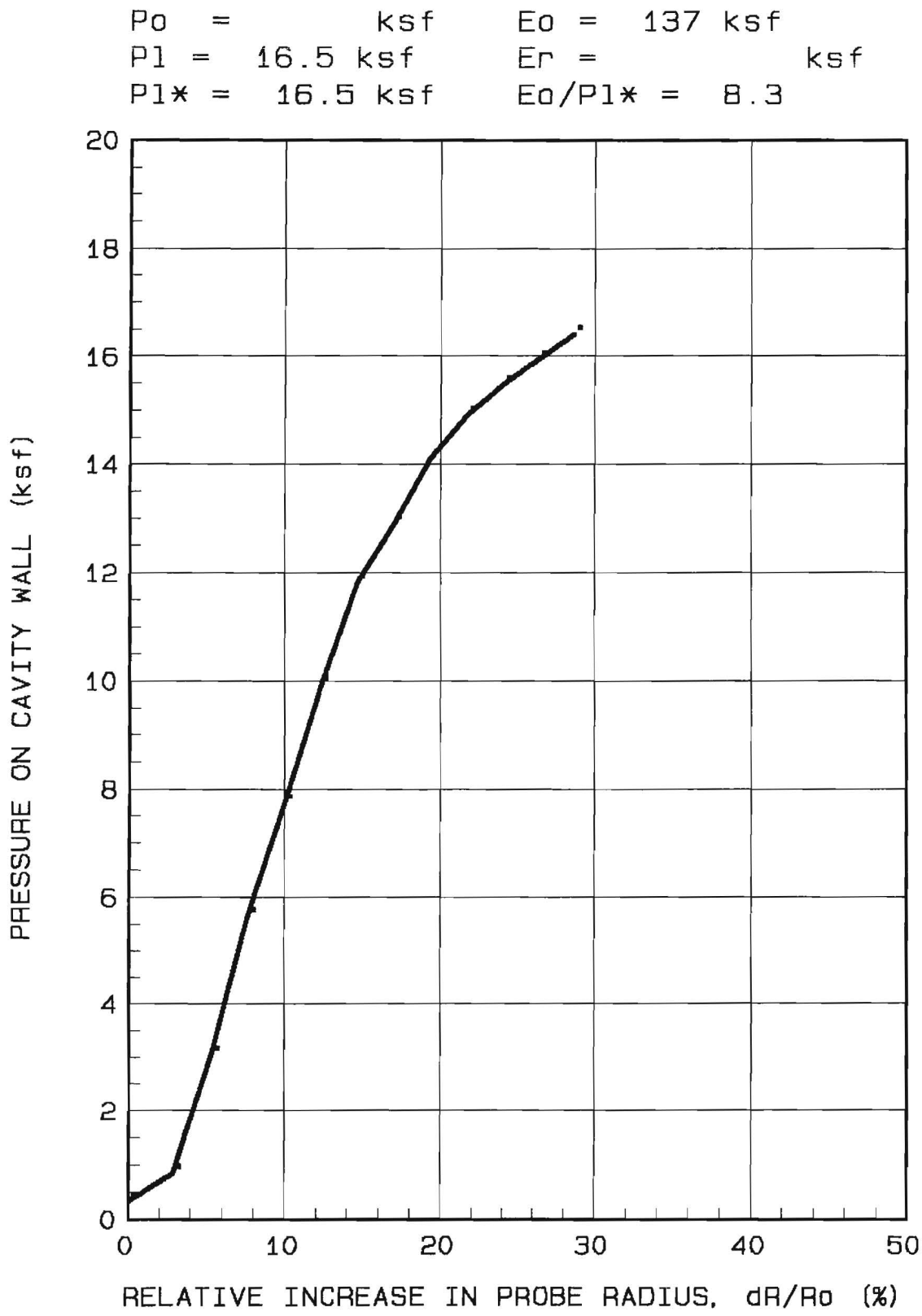


Figure 162. Site 7, 2.5 foot depth.

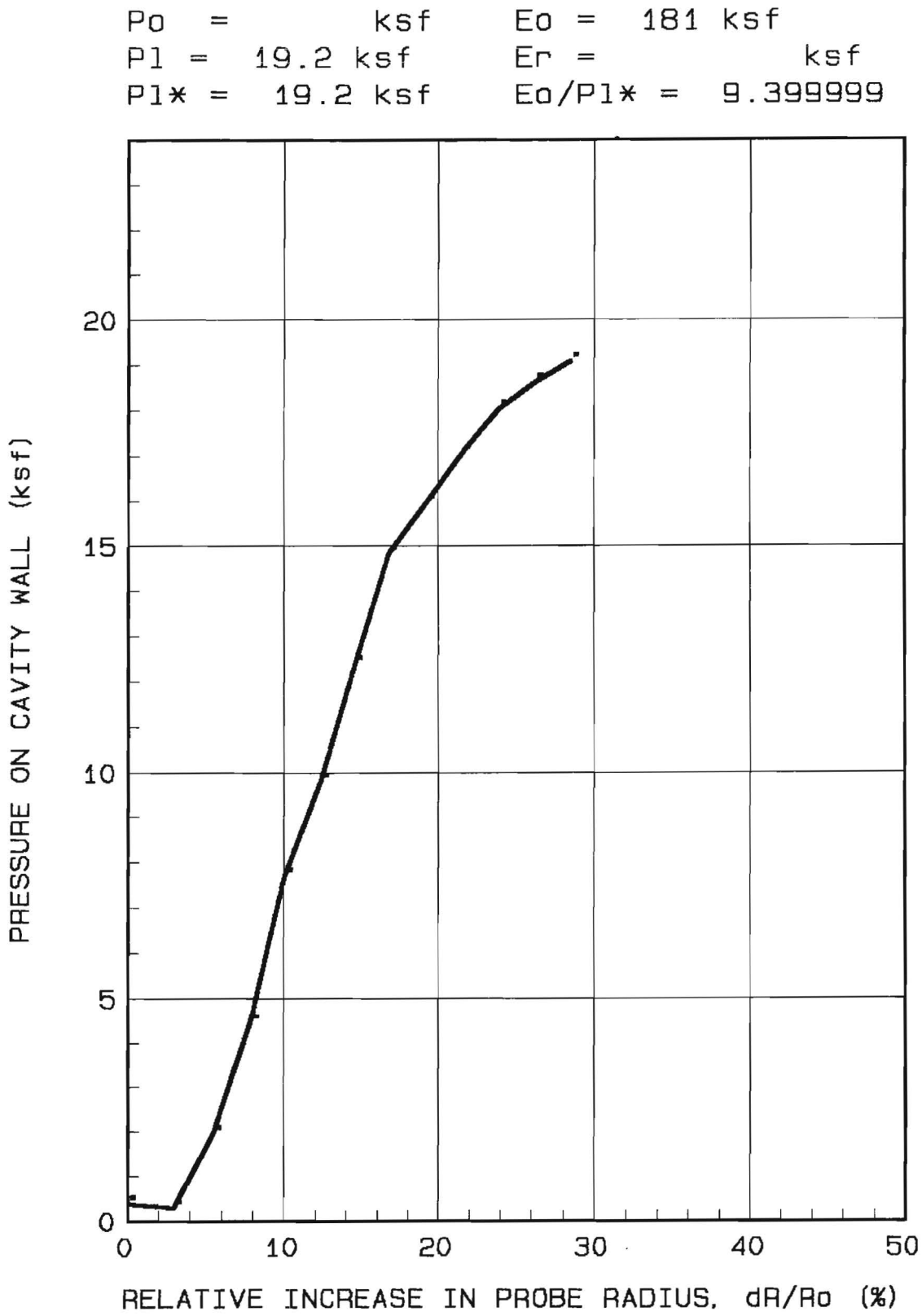


Figure 163. Site 7, 3.5 foot depth.

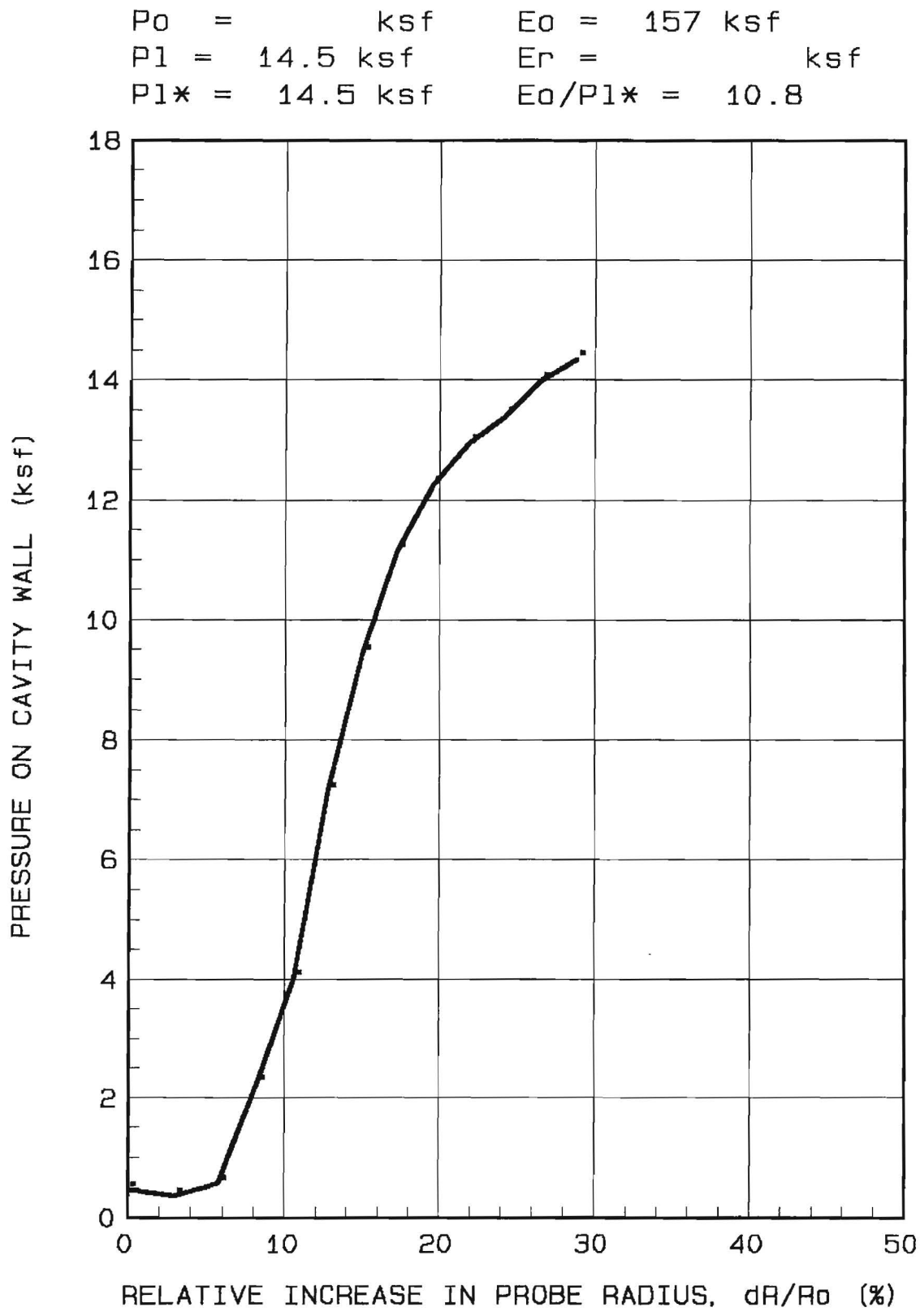


Figure 164. Site 7, 4.5 foot depth.

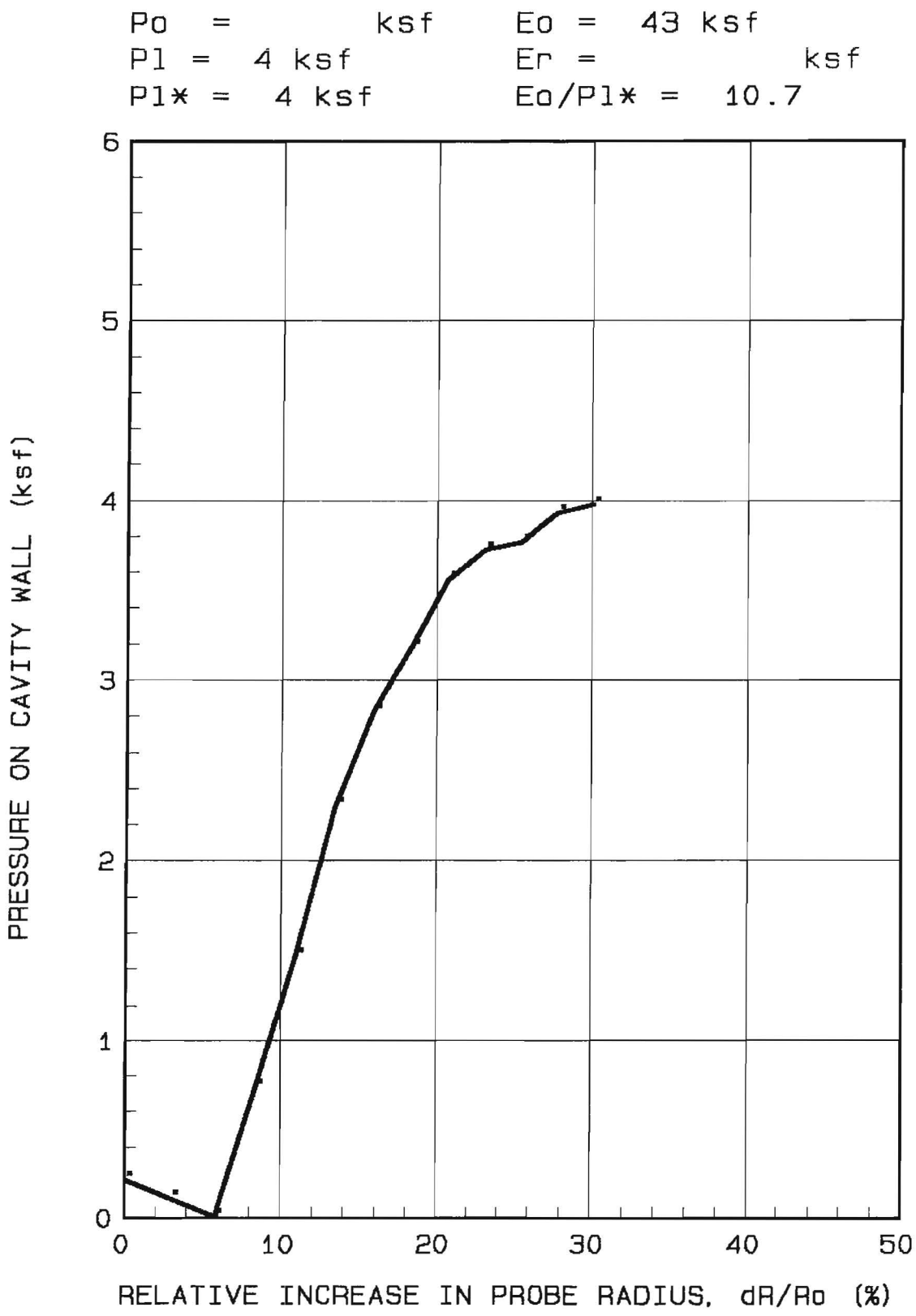


Figure 165. Site 8, 0.5 foot depth.

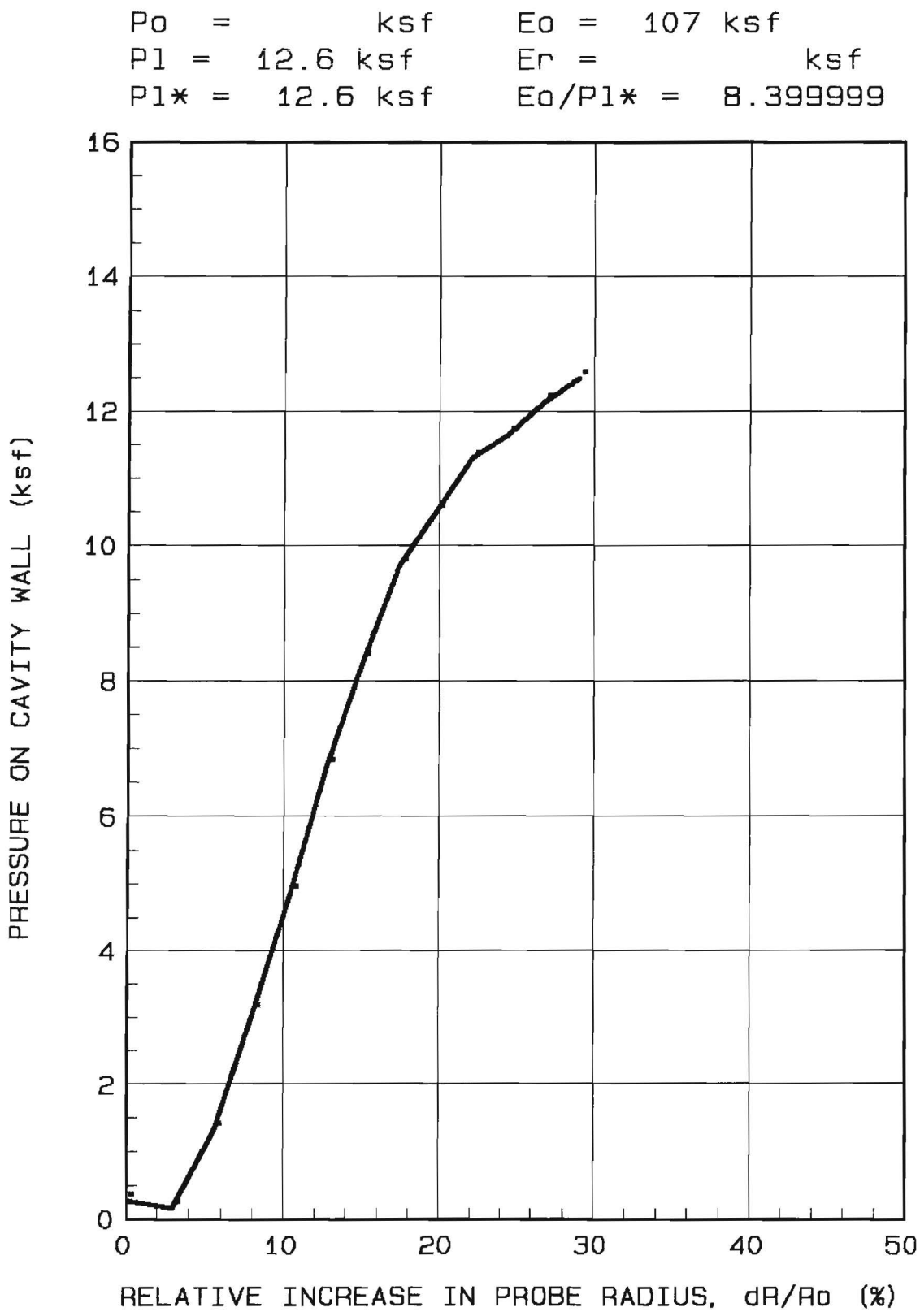


Figure 166. Site 8, 1.5 foot depth.

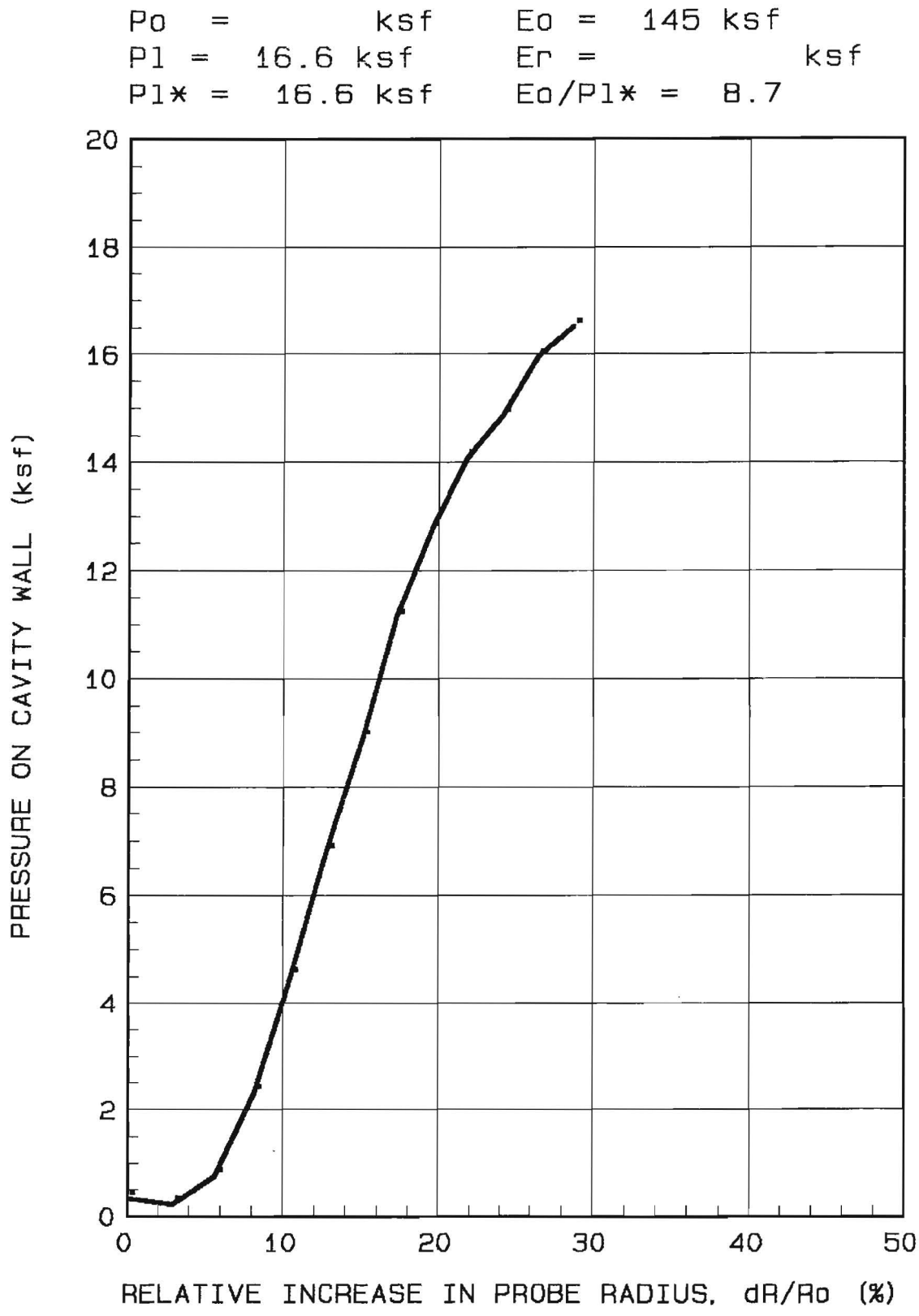


Figure 167. Site 8, 2.5 foot depth.

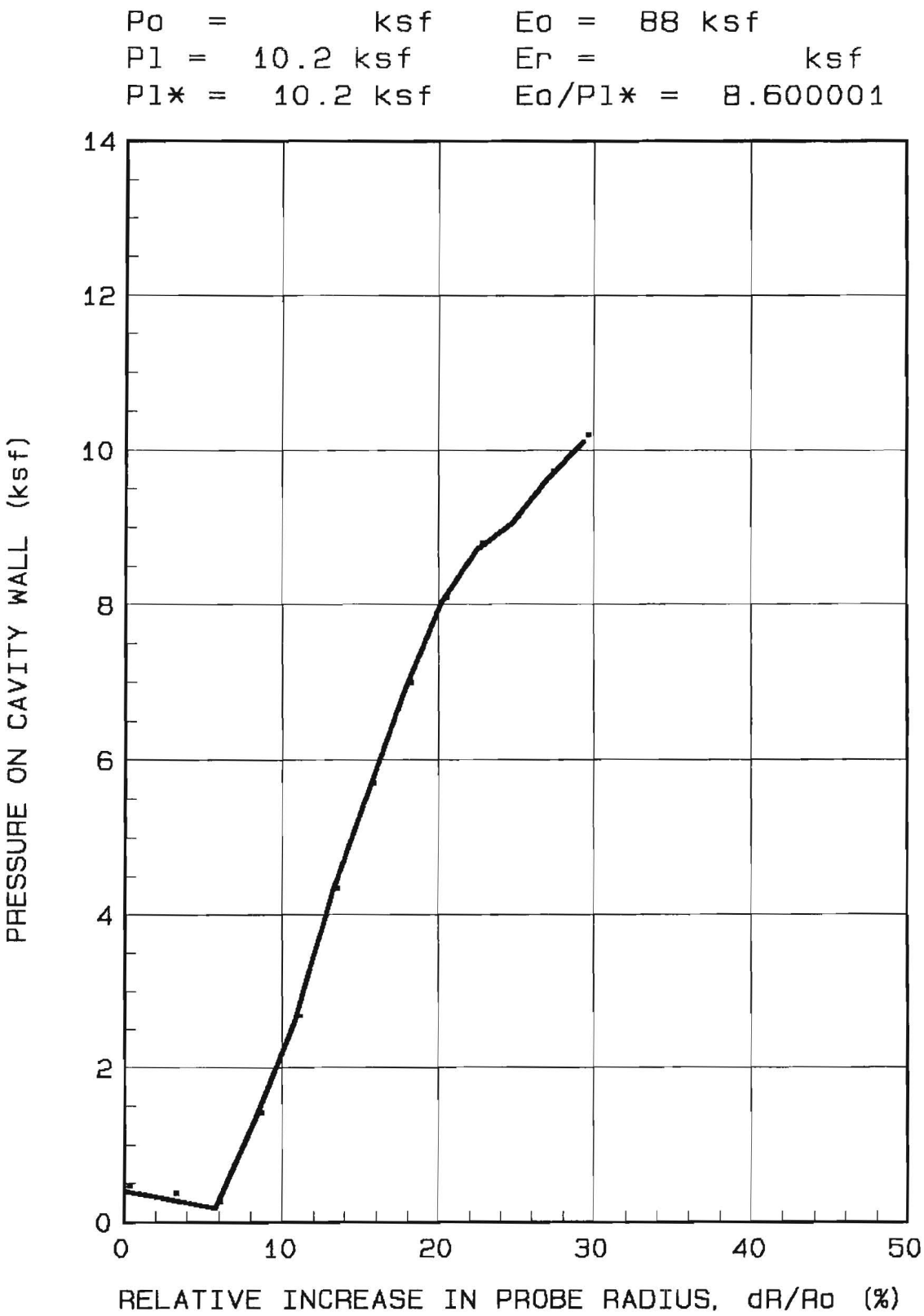


Figure 168. Site 8, 3.5 foot depth.

TABLE 3 - SOIL SPECIMEN ANALYSIS

ANNEX

Sample #	Percent Passing AW-1.5	AW-2.5	AW-3.5	AD-1	AD-2
Sieve Size					
3/8 in.	100	100	100	100	100
No. 4	100	100	99.9	99.6	99.3
No. 16	67.3	66.9	68.9	70.1	69.0
No. 50	15.6	14.5	15.1	21.4	21.5
No. 100	2.9	2.5	3.1	3.6	3.9
Moisture Content (%)	2.2	2.5	2.3	N/A	N/A

SITE ONE

Sample #	Percent Passing 1-0.5	1-1.5	1-2.5	1-3.5	1-4.5
Sieve Size					
3/8 in.	96.6	100	100	100	100
No. 4	89.1	96.6	100	100	100
No. 16	75.0	88.3	99.4	99.6	99.6
No. 50	70.7	84.5	97.7	98.3	98.5
No. 100	64.3	82.2	97.3	97.9	97.7
Moisture Content (%)	16.9	26.1	37.2	26.0	28.9

TABLE 3 - SOIL SPECIMEN ANALYSIS (CONT.)

SITE TWO

Percent Passing

Sample #	2-0.5	2-1.5	2-2.5	2-3.5	2-4.5
Sieve Size					
3/8 in.	100	100	100	100	100
No. 4	98.4	98.7	99.4	100	99.9
No. 16	95.6	96.5	94.7	99.9	99.6
No. 50	94.0	95.1	91.4	99.2	98.9
No. 100	92.4	93.6	88.9	98.7	98.4
Moisture Content (%)	17.0	20.3	23.5	25.0	23.7

SITE THREE

Percent Passing

Sample #	3-0.5	3-1.5	3-2.5	3-3.5	3-4.5
Sieve Size					
3/8 in.	100	100	100	100	100
No. 4	100	99.4	100	99.7	99.9
No. 16	99.9	99.1	97.9	99.3	99.2
No. 50	99.1	98.6	96.4	98.5	98.6
No. 100	69.1	92.2	90.1	92.9	91.9
Moisture Content (%)	16.5	16.6	19.2	16.1	14.8

TABLE 3 - SOIL SPECIMEN ANALYSIS (CONT.)

SITE FOUR

Sample #	4-0.5	4-1.5	4-2.5	4-3.5	4-4.5
	Percent Passing				
Sieve Size					
3/8 in.	99.1	100	100	99.9	100
No. 4	97.9	100	99.9	99.9	100
No. 16	96.8	99.9	99.8	99.8	99.9
No. 50	95.3	99.3	96.9	98.0	99.3
No. 100	42.4	42.9	45.9	56.6	59.6
Moisture Content (%)	5.9	5.5	6.3	6.8	17.4

SITE FIVE

Sample #	5-0.5	5-1.5	5-2.5	5-3.5	5-4.5
	Percent Passing				
Sieve Size					
3/8 in.	89.1	100	100	91.1	99.1
No. 4	83.2	100	100	91.1	99.0
No. 16	71.9	99.2	99.9	90.8	96.5
No. 50	58.0	95.6	97.7	89.7	81.3
No. 100	22.4	46.9	49.0	51.6	59.4
Moisture Content (%)	9.5	8.5	8.9	18.7	16.9

TABLE 3 - SOIL SPECIMEN ANALYSIS (CONT.)

SITE SIX

Percent Passing

Sample #	6-0.5	6-1.5	6-2.5	6-3.5	6-4.5
Sieve Size					
3/8 in.	98.5	Probe Refusal - Hit Rock			
No. 4	92.3				
No. 16	76.3				
No. 50	62.1				
No. 100	26.9				
Moisture Content (%)	19.6				

SITE SEVEN

Percent Passing

Sample #	7-0.5	7-1.5	7-2.5	7-3.5	7-4.5
Sieve Size					
3/8 in.	100	100	100	100	100
No. 4	99.9	99.9	100	99.9	99.9
No. 16	99.7	99.4	99.3	99.9	99.9
No. 50	90.8	90.1	83.3	65.4	74.2
No. 100	27.8	30.3	21.1	10.9	6.6
Moisture Content (%)	5.3	7.0	7.6	9.3	8.1

TABLE 3 - SOIL SPECIMEN ANALYSIS (CONT.)

SITE EIGHT

Sample #	Percent Passing 8-0.5	8-1.5	8-2.5	8-3.5	8-4.5
Sieve Size					
3/8 in.	100	99.9	100	99.9	100
No. 4	99.8	99.9	100	99.7	100
No. 16	99.6	99.9	99.9	99.6	99.9
No. 50	91.9	90.6	88.0	47.7	56.9
No. 100	26.7	23.1	19.5	8.1	9.7
Moisture Content (%)	5.1	6.2	6.9	9.1	9.2

Recommended Soil Foundation For Longitudinal Barrier Posts and Breakaway or Yielding Supports

Strong Soil (S-1)		Weak Soil (S-2)	
Sieve Size	Mass Percent Passing	Sieve Size	Mass Percent Passing
2 in.	100	3/8 in	100
1 in.	75-95	No. 4	95-100
3/8 in.	40-75	No. 16	45-80
No. 4	30-60	No. 50	10-30
No. 10	20-45	No. 100	2-10
No. 40	15- 30		
No. 200	5-20		

GENERIC ANCHOR DESIGN

With the soil question answered, the Texas State Advisory Committee agreed to proceed on with the generic anchor design. Many ideas were discussed as to what were the desirable features for the new anchor. These ideas included the anchors' crash test performance as well as its functionality in the field. Functionality requirements included a driveable base which could be reused and which required no special tools or training.

DESIGN PARAMETERS

The primary goal was to achieve satisfactory crash test performance. Other crash tests done by Southwest Research Institute (SRI), Project No. 06-1244 (Reference 14), supported our findings for the "weak" soil. While the U-Post system tested passed the crash test, the failure mechanism for "weak" soil installations was much different than the mechanism for strong soil installations. This inconsistency of failure mechanisms for both the SRI and the TTI tests caused some concern as to a system's ability to activate reliably in different soil conditions. Therefore, the committee decided the new anchor should have a similar failure mechanism for all types of soil.

In addition to having a sign system that possesed proper breakaway capabilities, a strong opinion was expressed to have one that would erect easily and stay up. Two attributes were chosen to simplify installation procedures. First, the committee agreed the upright should be tubular. Most districts favor tubular shapes for ease of handling and alignment with the roadway. Second, the anchor to upright fastener should be simple yet secure. Several discussions led to the recommendation of some type of set screw as an acceptable fastener.

It was decided that a system strong enough to activate a breakaway mechanism in "weak" soil also would provide sufficient support for normal wind loads. To develop the necessary strength, suggestions were made for using different types of wings and/or spread anchors. However, before prototype anchors could be designed and tested, it was necessary to know how much lateral capacity was needed.

FIELD TESTS

Several existing anchors were tested in the "weak" soil pit at TTI's facility to determine what lateral strength they provided (see Figure 170). The load was applied 17 inches above groundline to simulate the normal impact point of the 1800 lb test vehicle. Also, previous crash tests in strong soil were reviewed to approximate the force necessary to activate a breakaway system.

Several prototype anchors were constructed and tested in the "weak" soil pit. The first generation included both winged extensions and spread anchor rods. These anchors were built to accept both fiber reinforced plastic (FRP, Figures 171 and 172) and steel uprights (Figure 173). Several tests were done varying the length and diameter of the anchor rods. It was concluded from these tests that 30 inch #6 rebar was sufficient to develop the FRP posts in shear and 36 inch #6 rebar for the 2-3/8 steel posts. (The 42 inch rebar yielded with the steel posts and did not supply any significant lateral strength gain.)

The advisory committee reviewed the design and made several suggestions of possible improvements. These ideas were evaluated and incorporated in a final prototype. After further field tests (Figure 174), it was decided that this prototype was acceptable. The anchor supplied lateral strength comparable to the previous prototype but was much smaller and lighter. In addition, the simpler anchor had a much higher reserve strength, as noted in the load necessary to return the anchor to its original position (Figure 174).

With adequate lateral strength provided, the breakaway capability of the system was considered. It was recommended that the embedment depth of the sign support into the anchor be kept to a minimum for ease of pull out. The advisory committee selected steel tubing for the crash tests, so bending tests were conducted with steel to determine minimum embedment depth. The steel tubing chosen was the 2-3/8 inch tubing used by Southwest Pipe Inc. in their POZ-LOC system. This tubing was selected because of its availability and success in other sign systems. The test results using a 9 foot moment arm are as follows:

TABLE 4 - EMBEDMENT TESTS FOR STEEL POSTS

Embedment Depth (in)	Maximum Load (lb)	Deflection @ Yield (in)
12	312	23
9	307	23
6	309	26

A six inch embedment was chosen as a practical limit because it allowed full development of the post with out any end distortion. The failure load of the support provides support for a sign greater than 13 square feet in an 80 mph AASHTO (22 psf) wind at a 9 foot mounting height.

The last requirement necessary to complete the sign system was a locking mechanism. Since some type of set screw was suggested, several screw types and

sizes were tested in a pullout configuration with the steel tubing. From previous experience with pullout mechanisms, a target value of 1200 - 1500 lbs was set for required pullout load. The pullout test results are presented in Table 5.

TABLE 5 - PULLOUT TESTS

	Max. Load (lb)
1) 5/16 pointed bolt (Gr. 5) - 2-1/2 turns	3750
2) Two #8 sheet metal screws	1800
3) 5/16 bolt w/60° point (Gr. 5) 1-1/2 turns	2125
4) 5/16 bolt w/60° point (Gr. 5) - 1 turn	1520

The set screw in test 4 met the desired load and was selected for use in the anchor.

At this point the Texas State Advisory Committee approved the design for crash testing. A diagram of the generic anchor is shown in Figure 176. Several anchors were produced and galvanized as would actual production anchors. Then crash tests in the "weak" soil pit were scheduled.

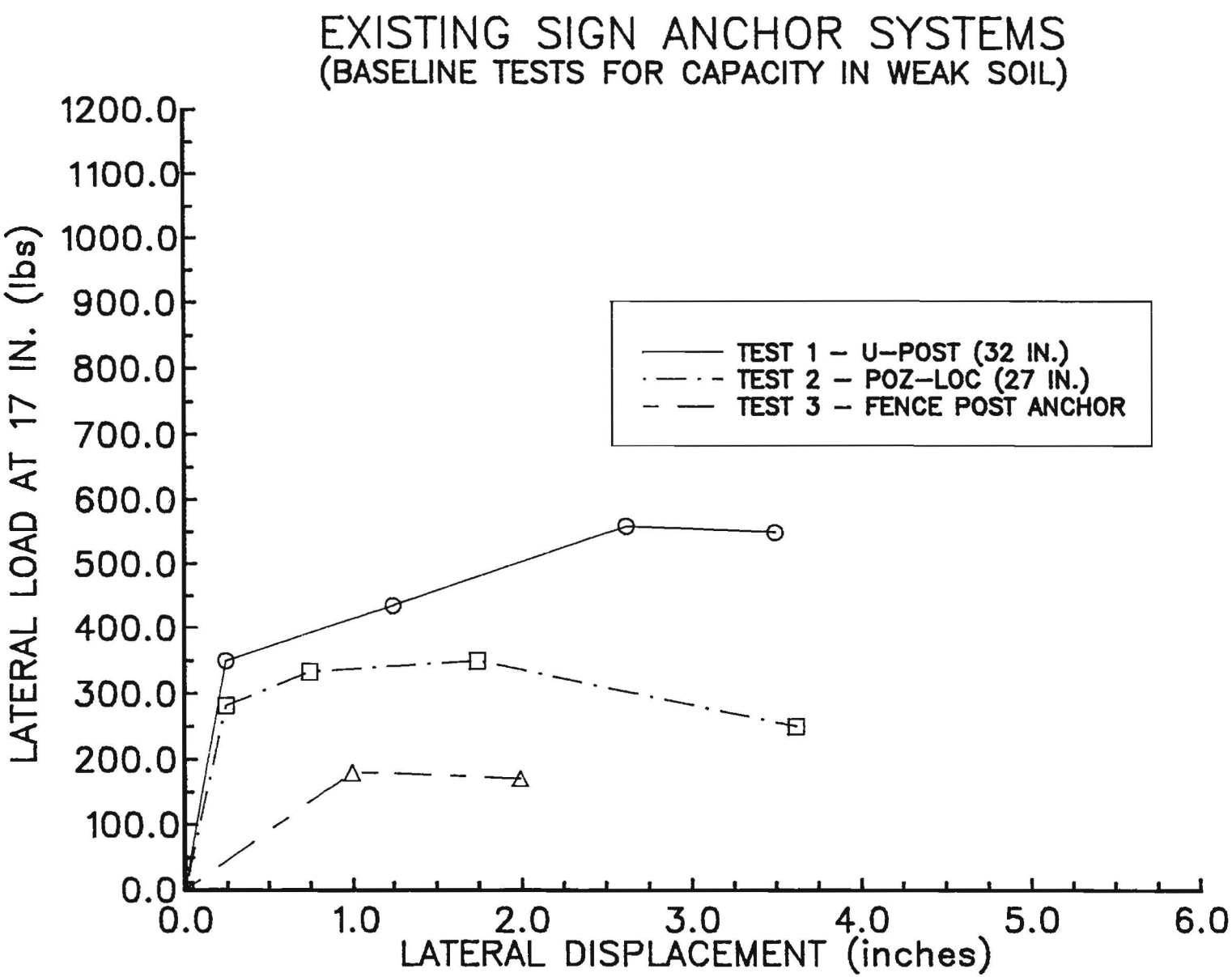


Figure 170. Lateral Load for Existing Anchor Systems.

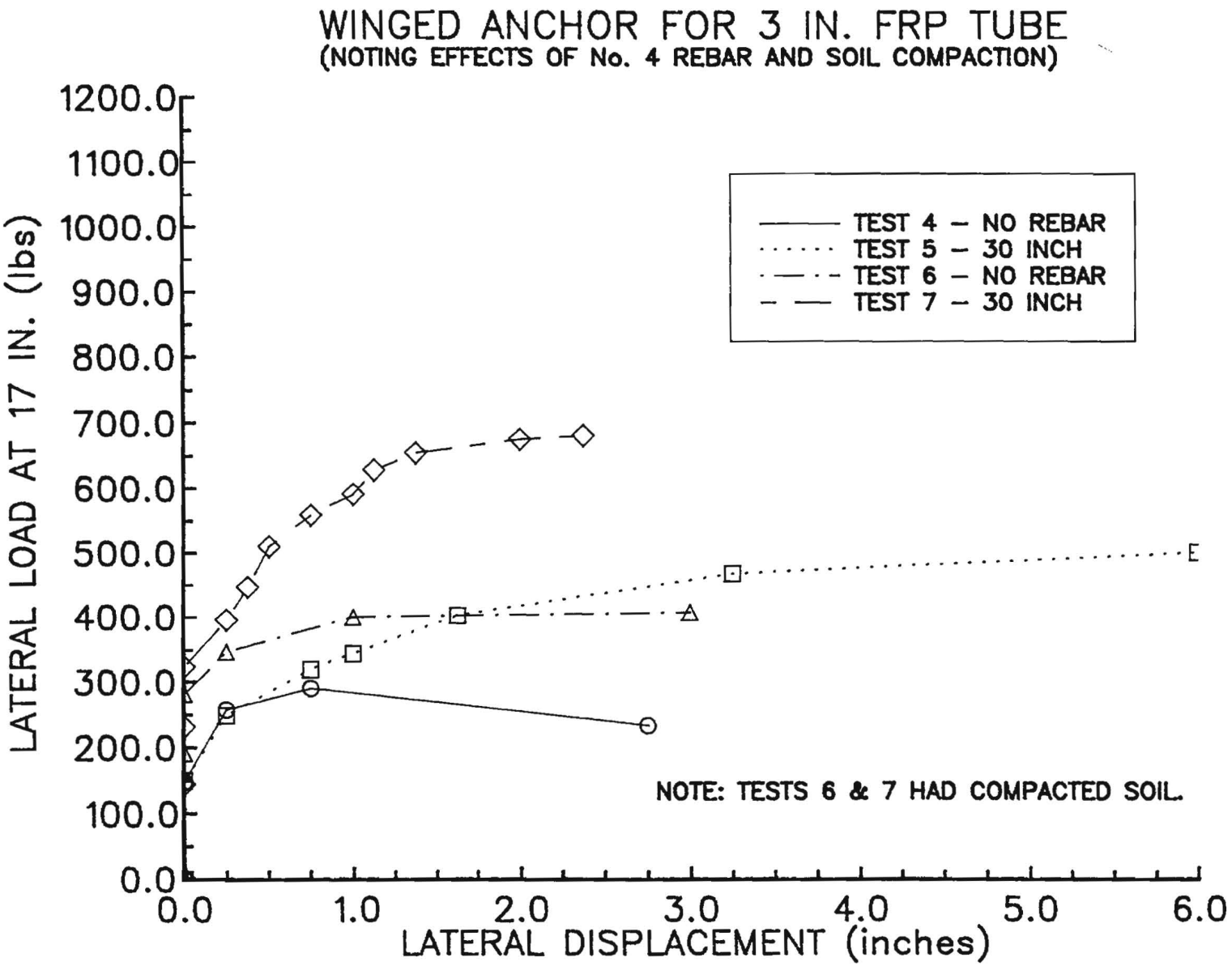


Figure 171. Lateral Load for Winged Anchor W/FRP Post.

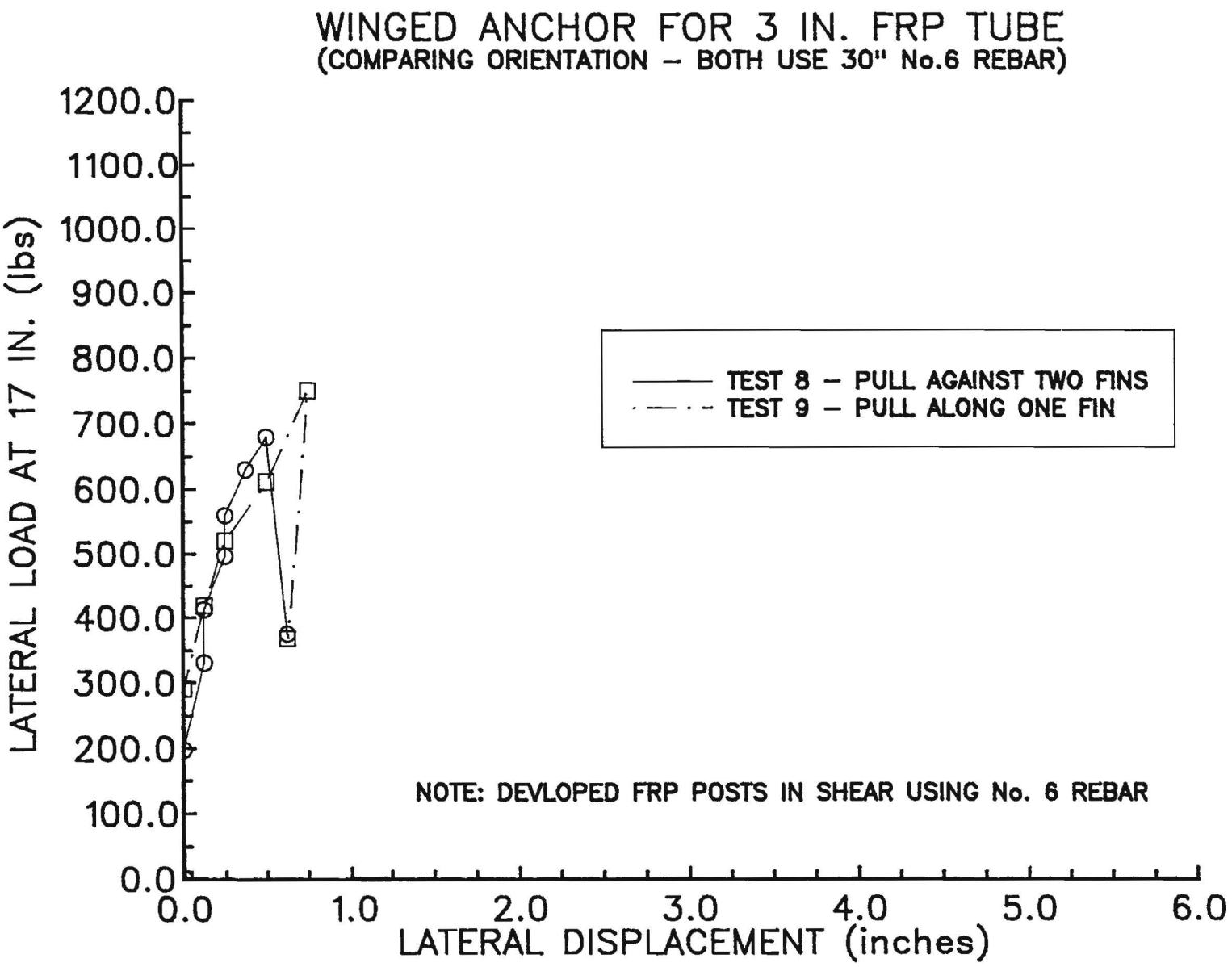


Figure 172. Lateral Load for Anchor varying orientation.

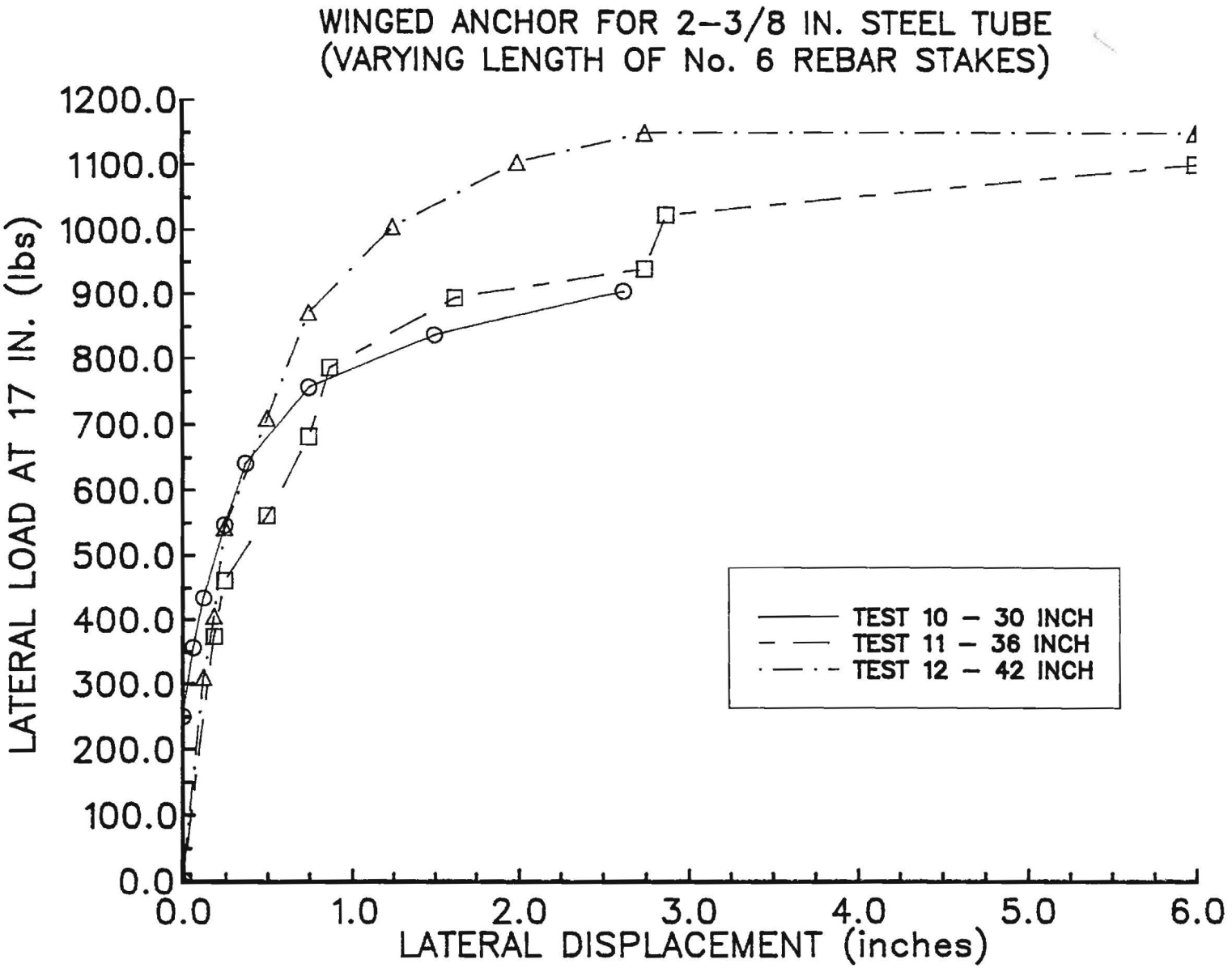


Figure 173. Lateral Load for Winged Anchor W/Steel Post.

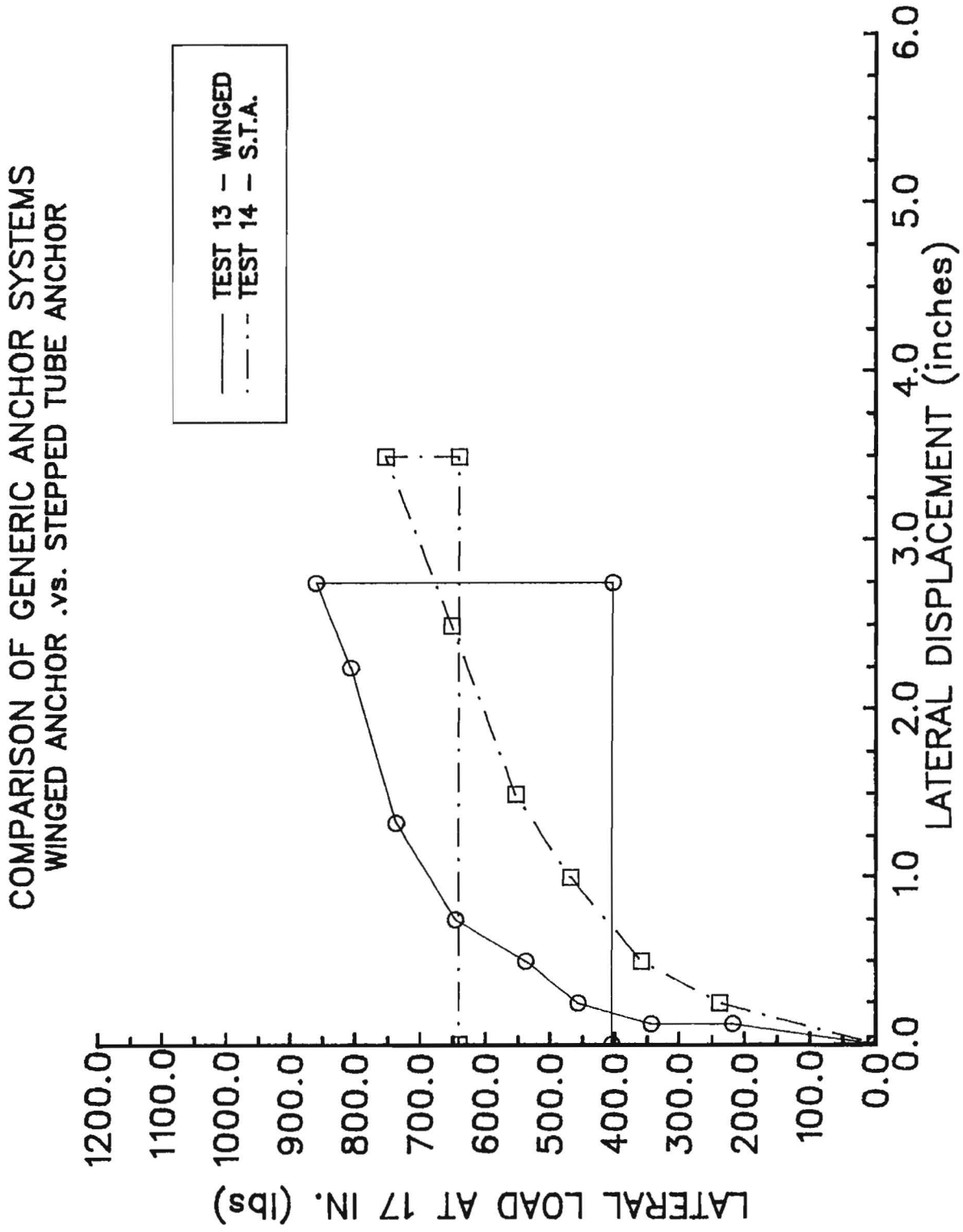


Figure 174. Lateral Load for both generic anchor designs.

CRASH TESTS OF GENERIC SYSTEM

The objective of these tests was to determine the impact characteristics of a sign installations attached to the Texas Generic Sign Anchor and placed in NCHRP Report 230 "weak" or "strong" soil. These tests were conducted on both single and dual post systems using 1,800 lb vehicle travelling at 20.0 and 60.0 mi/h. Standards established in AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals" and NCHRP Report 230 were used for analyses and evaluation of this test.

DESCRIPTION OF TEST INSTALLATIONS FOR 1122-12 THROUGH 16

The sign installation used in these tests consisted of either a 3 ft X 4 ft X 5/8 in plywood sign blank mounted to a single 2-3/8 in O.D. thinwall steel tube support (1122-12,13,14&16) or a 4 ft X 5 ft X 5/8 in plywood sign blank mounted to two 2-3/8 in O.D. thinwall steel tube supports (1122-15). Connections between the sign blanks and sign posts were made using state approved U-bolts with cast connectors. The supports for tests 1122-12&13 were placed into a Texas Generic Sign Anchor driven into NCHRP Report 230 "weak" soil. The supports for tests 1122-14,15&16 were placed into a Texas Generic Sign Anchor driven into NCHRP Report 230 "strong" soil. The bottom of sign mounting height was 7 ft-0 in in all cases.

The Texas Generic Sign Anchor was developed at the Texas Transportation Institute (TTI) in cooperation with the Texas State Department of Highways and Public Transportation (SDHPT). The anchor is fabricated from schedule 40 steel pipe and hot dip galvanized upon completion. The body of the anchor is constructed from 2 in schedule 40 steel pipe, 22 in. in length. Attached to the top of the 2 in pipe, by welding, is a 6 in X 2-1/2 in schedule 40 section of pipe. The 2-1/2 in pipe is used as the sign support anchoring sleeve. The anchor is driven into the ground and cross anchored using #6 grade 40 steel reinforcing rods. The cross anchors are guided and attached through 3/4 in X 4 in steel tubes welded to the outer circumference of the 2-1/2 in pipe at 120 degree intervals using 3/16 in scalloped steel plates. In addition, the steel cross anchor tubes were rotated 30 degrees off of the anchors vertical axis before final attachment. The overall length of the anchor assembly is 28 in.

The completed anchor assembly is driven into the ground and cross anchored using the steel reinforcing rods. The sign support is then placed into the 2-1/2 in sleeve and secured by means of a 5/16 in set screw (ASTM grade 5). The set screw is turned one full turn following contact with the support. Details of the completed anchor and sign installation are shown in Figure 175 through 179.

TEST REPORT 1122-12

VEHICLE: 1981 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,970 lbs.

TEST ARTICLE: Single Support Sign Installation
Support: 2-3/8 in O.D. Steel Tubing
with Texas Generic Sign Anchor

IMPACT CONDITIONS: 19.7 mi/h
Quarter point (on passenger side of vehicle)

Crash Test Results

A 1981 Honda Civic (shown in Figure 180) impacted the sign installation at 19.7 miles per hour (31.7 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,970 lb (894 kg). The height to the lower edge of the vehicle bumper was 14.75 inches (37.5 cm) and 20.25 inches (51.4 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 181.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the quarter point on the passenger side of the vehicle. Upon impact, the sign support began to bend at bumper height. At approximately 0.050 second, the support had completely detached from the anchored base. As the vehicle continued forward, the sign support remained in contact with the vehicle. After exiting the immediate test site, the brakes were applied and the vehicle and sign support came to rest 75 ft (22.9 m) from the point of impact. Sequential photographs of the test are shown in Figure 182.

The sign installation received only minor damages. The sign support was bent at bumper height and came to rest directly in the front of the test

vehicle. The base was pushed back 4.0 in (10.2 cm). The vehicle sustained minimal damage to the bumper, as shown in Figure 183.

A summary of the test results and other information pertinent to this test are given in Figure 185. The maximum 0.050 second average acceleration experienced by the vehicle was -2.2 g in the longitudinal direction and -1.3 g in the lateral direction. Vehicle angular displacements are plotted in Figure 186 and vehicle accelerometer traces are displayed in Figure 187 through 189. Occupant impact velocity in the longitudinal direction was 11.8 ft/s (3.6 m/s) and in the lateral direction it was 7.3 ft/s (2.2 m/s). Occupant ridedown accelerations were -1.4 g in both the longitudinal and lateral direction. Change in velocity was 2.4 mi/h (3.9 km/h) and change in momentum was 197 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. Occupant risk factors were below the recommended limit set forth in NCHRP Report 230. This sign installation in "weak" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

TEST REPORT 1122-13

VEHICLE: 1981 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,970 lbs.

TEST ARTICLE: Single Support Sign Installation
Support: 2-3/8 in O.D. Steel Tubing
with Texas Generic Sign Anchor

IMPACT CONDITIONS: 62.0 mi/h
Quarter point (on passenger
side of vehicle)

Crash Test Results

A 1981 Honda Civic (shown in Figure 190) impacted the sign installation at 62.0 miles per hour (99.8 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (817 kg) and its gross static mass was 1,970 lb (894 kg). The height to the lower edge of the vehicle bumper was 14.75 inches (37.5 cm) and 20.25 inches (51.4 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 191.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the quarter point on the passenger side of the vehicle. Upon impact, the sign support began to yield. At approximately 0.020 second, the support had pulled out of the base and the panel began to slip off the support. The vehicle lost contact with the support at about 0.090 second. As the vehicle continued forward, the support came down on the roof of the vehicle (at 0.134 second). At approximately 0.169 second, the vehicle lost complete contact with the installation. Shortly thereafter, the brakes were applied and the vehicle came to rest 185 ft (56.4 m) from the point of impact. Sequential photographs of the test are shown in Figure 192.

The sign panel came to rest 2 ft (0.6 m) from the point of impact and the support came to rest 75 ft (23 m) from the point of impact. The base was pushed back 1.5 in (3.8 cm). The vehicle sustained minor damage to the bumper, hood and roof, as shown in Figure 194.

A summary of the test results and other information pertinent to this test are given in Figure 195. The maximum 0.050 second average acceleration experienced by the vehicle was -3.3 g in the longitudinal direction and -0.9 g in the lateral direction. Vehicle angular displacements are plotted in Figure 196 and vehicle accelerometer traces are displayed in Figure 197 through 199. Occupant impact velocity was 11.4 ft/s (3.5 m/s) in the longitudinal direction and 7.7 ft/s (2.3 m/s) in the lateral direction. Occupant ridedown accelerations were -1.5 g in the longitudinal direction and -1.6 g in the lateral direction. Change in velocity was 3.5 mi/h (5.6 km/h) and change in momentum was 287 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. There was minimal deformation into the occupant compartment (where the support impacted the roof) but no penetration. Occupant risk factors were within the limits specified in NCHRP Report 230. This sign installation in "weak" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

TEST REPORT 1122-14

VEHICLE: 1982 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,968 lbs.

TEST ARTICLE: Single-Support Sign Installation
Support: 2-3/8 in O.D. Steel Tubing
Support with Texas Generic Sign Anchor

IMPACT CONDITIONS: 20.0 mi/h
Quarter point (on passenger side of vehicle)

Crash Test Results

A 1982 Honda Civic (shown in Figure 200) impacted the sign installation at 20.0 miles per hour (32.2 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (816 kg) and its gross static mass was 1,968 lb (893 kg). The height to the lower edge of the vehicle bumper was 14.0 inches (35.6 cm) and 20.0 inches (50.8 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 202.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the right quarter point of the vehicle. Upon impact, the sign support began to yield. As the support yielded, the vehicle traveled over the installation. At approximately 0.261 second, the vehicle lost contact with the installation, traveling 11.7 mi/h (18.8 km/h). As the vehicle moved away from the impact site, the brakes were applied and the vehicle came to rest 78 ft (23.8 m) from the point of impact. Sequential photographs of the test are shown in Figure 203.

The sign installation came to rest at the point of impact. The support did not disengage from the anchor. The anchor was pushed rearward 0.5 in (1.3 cm). In addition, the support was fractured 16 in (40.6 cm) above roadway level. The vehicle sustained only minor damage to the bumper, as shown in Figure 205.

A summary of the test results and other information pertinent to this test are given in Figure 206. The maximum 0.050 second average acceleration experienced by the vehicle was -2.6 g in the longitudinal direction and -1.4 g in the lateral direction. Vehicle angular displacements are plotted in Figure 207 and vehicle accelerometer traces are displayed in Figure 208

through 210. Occupant impact velocity was 14.9 ft/s (4.5 m/s) in the longitudinal direction and 7.3 ft/s (2.2 m/s) in the lateral direction. Occupant ridedown accelerations were -0.8 g in the longitudinal direction and -1.9 g in the lateral direction. Change in velocity was 8.3 mi/h (13.4 km/h) and change in momentum was 680 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. There was no deformation or penetration into the occupant compartment. Occupant risk factors were within the limits specified in NCHRP 230. This sign installation in "strong" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

TEST REPORT 1122-15

VEHICLE: 1982 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,968 lbs.

TEST ARTICLE: Multi-Support Sign Installation
Support: Two 2-3/8 in O.D. Steel Tubing
Supports with Texas Generic Sign Anchors

IMPACT CONDITIONS: 20.0 mi/h
(Centerline of vehicle with center
of sign installation)

Crash Test Results

A 1982 Honda Civic (shown in Figure 213) impacted the sign installation (Figures 211, 212 and 214) at 20.0 miles per hour (32.2 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (816 kg) and its gross static mass was 1,968 lb (893 kg). The height to the lower edge of the vehicle bumper was 14.0 inches (35.6 cm) and 20.0 inches (50.8 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 215.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the center of the vehicle. Upon impact, the sign support began to yield. At approximately 0.087 second, the vehicle began to travel over the support tubes. Shortly thereafter, the installation came into complete contact with the roadway at approximately 0.390 seconds. The vehicle traveled over the installation and came to rest 8 ft (2.4 m) from the point of impact. The vehicle lost contact

with the installation traveling 4.7 mi/h (7.6 km/h). Sequential photographs of the test are shown in Figure 216.

The sign installation came to rest at the point of impact. The supports did not disengage from the anchors. The anchors were pushed rearward a maximum of 0.8 in (1.9 cm). In addition, the left support was either bent or fractured at 17 in (43.2 cm), 28.5 in (72.4 cm), and 38.5 in (97.8 cm) up from the roadway. The right support also was bent or fractured at 18 in (45.7 cm), 30 in (76.2 cm), and 42 in (106.7 cm). The vehicle sustained only minor damage to the bumper and windshield, as shown in Figure 218.

A summary of the test results and other information pertinent to this test are given in Figure 219. The maximum 0.050 second average acceleration experienced by the vehicle was -4.9 g in the longitudinal direction and -1.5 g in the lateral direction. Vehicle angular displacements are plotted in Figure 220 and vehicle accelerometer traces are displayed in Figure 221 through 223. Occupant impact velocity was 21.3 ft/s (6.5 m/s) in the longitudinal direction and 8.8 ft/s (2.7 m/s) in the lateral direction. Occupant ridedown accelerations were -4.0 g in the longitudinal direction and -1.7 g in the lateral direction. Change in velocity was 14.7 mi/h (23.7 km/h) and change in momentum was 1,205 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. There was no deformation or penetration into the occupant compartment. However, occupant impact velocity in the longitudinal direction was above the recommended limit as specified in NCHRP 230. This sign installation in "strong" soil is not acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

TEST REPORT 1122-16

VEHICLE: 1982 Honda Civic
Test Inertia Mass: 1,800 lbs.
Gross Static Mass: 1,968 lbs.

TEST ARTICLE: Single Support Sign Installation
Support: 2-3/8 in O.D. Steel Tubing
with Texas Generic Sign Anchor

IMPACT CONDITIONS: 60.0 mi/h
Quarter point (on passenger
side of vehicle)

Crash Test Results

A 1982 Honda Civic (shown in Figure 226) impacted the sign installation at 61.5 miles per hour (99.0 km/h) using a cable reverse tow and guidance system. Test inertia mass of the vehicle was 1,800 lb (816 kg) and its gross static mass was 1,968 lb (893 kg). The height to the lower edge of the vehicle bumper was 14.0 inches (35.6 cm) and 20.0 inches (50.8 cm) to the top of the bumper. Other dimensions and information on the vehicle are given in Figure 228.

The vehicle was freewheeling and unrestrained just prior to impact. The point of impact was the center line of the sign with the right quarter point of the vehicle. Upon impact, the sign support began to yield. At approximately 0.028 second, the support disengaged from the anchor. As the vehicle traveled over the anchor and under the support, the vehicle lost initial contact with the installation at approximately 0.100 second. Shortly thereafter, the sign support struck the right side of the vehicle's roof. As the vehicle lost contact with the installation, traveling 58.4 mi/h (94.0 km/h), the brakes were applied and the vehicle came to rest 280 ft (85.4 m) from the point of impact. Sequential photographs of the test are shown in Figure 229.

The sign support stayed with the vehicle and the sign blank remained near the point of impact. The support disengaged from the anchor. The anchor was pushed rearward 2.8 in (7.0 cm). In addition, the support was either fractured or bent between 5.8 in (14.6 cm) and 19.0 in (48.3 cm) above the roadway. The vehicle sustained only minor damages to the bumper, roof and windshield, as shown in Figure 231.

A summary of the test results and other information pertinent to this test are given in Figure 232. The maximum 0.050 second average acceleration experienced by the vehicle was -2.2 g in the longitudinal direction and -1.2 g in the lateral direction. Vehicle angular displacements are plotted in Figure 233 and vehicle accelerometer traces are displayed in Figure 234 through 236. Occupant impact velocity was 7.9 ft/s (2.4 m/s) in the longitudinal direction and 6.2 ft/s (1.9 m/s) in the lateral direction. Occupant ridedown accelerations were -0.7 g in the longitudinal direction and -1.2 g in the lateral direction. Change in velocity was 3.1 mi/h (5.0 km/h) and change in momentum was 254 lb-s.

In summary, the sign installation yielded to the vehicle. The vehicle sustained very minor damage and did not present undue hazard to other traffic. There was minimum deformation and no penetration into the occupant compartment. Occupant risk factors were within the limits specified in NCHRP 230. This sign installation in "strong" soil is acceptable according to the evaluation criteria recommended in NCHRP Report 230 and the AASHTO Standards.

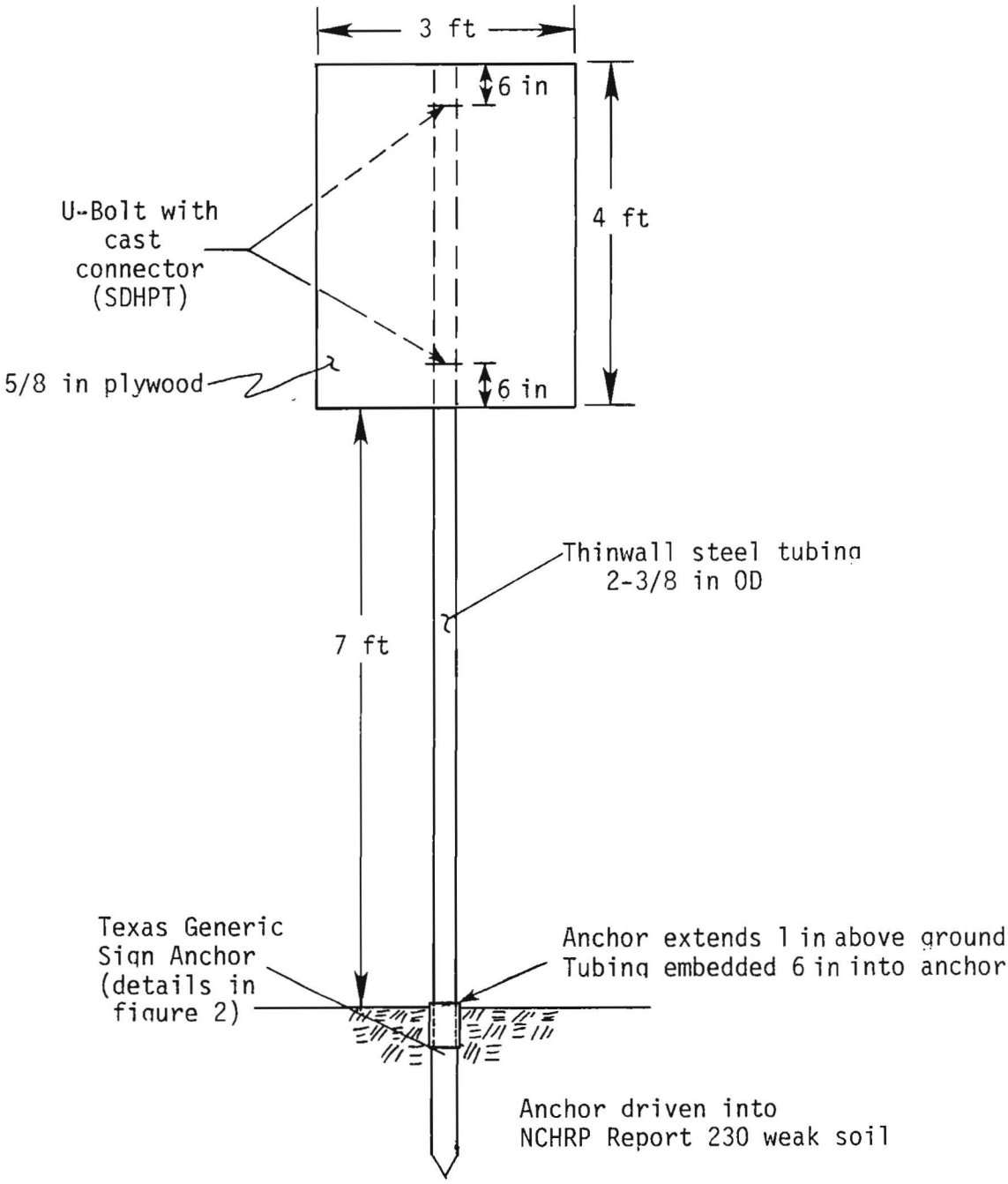


Figure 175. Testing installation details.

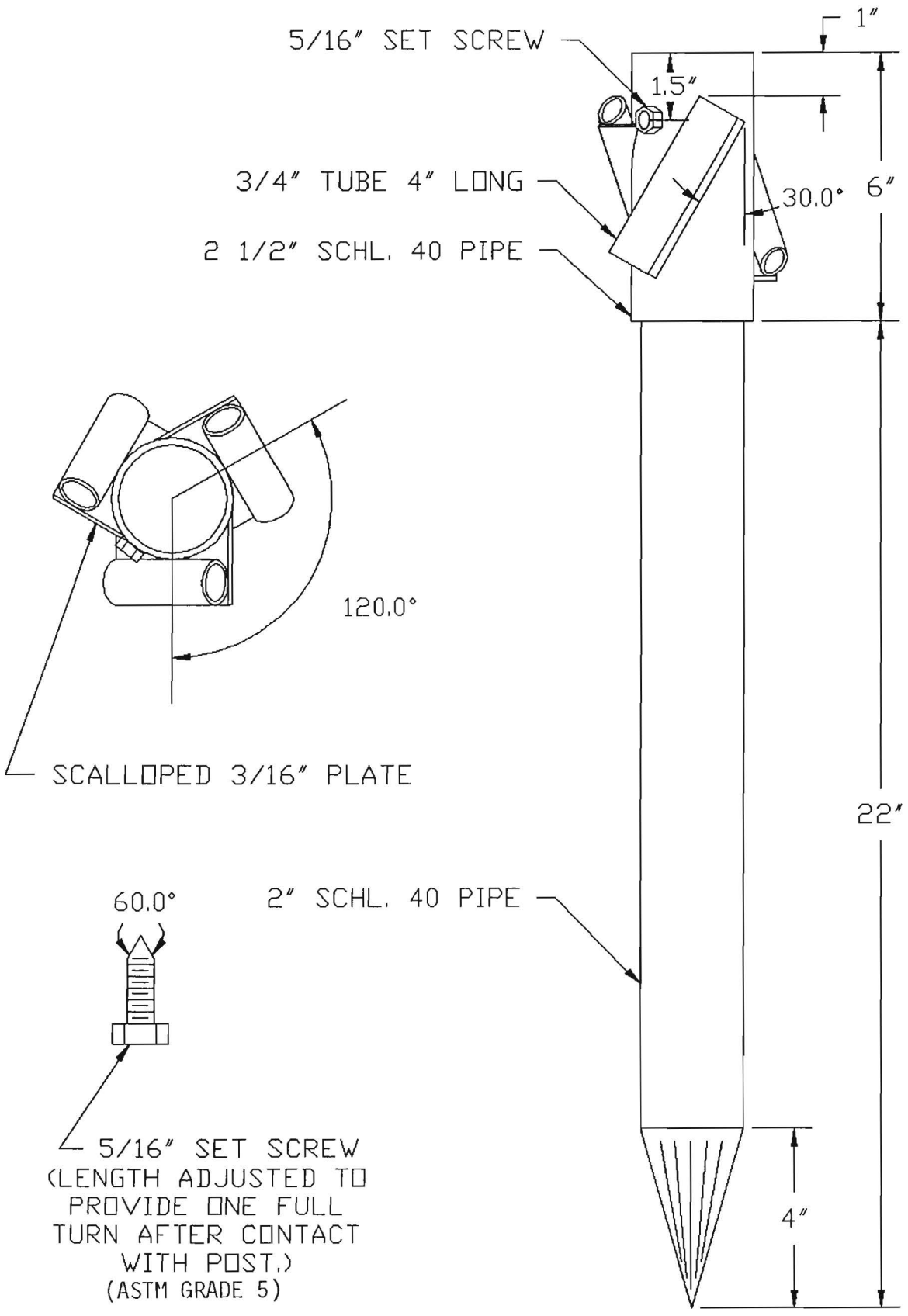


Figure 176. Texas Generic Sign Anchor details.

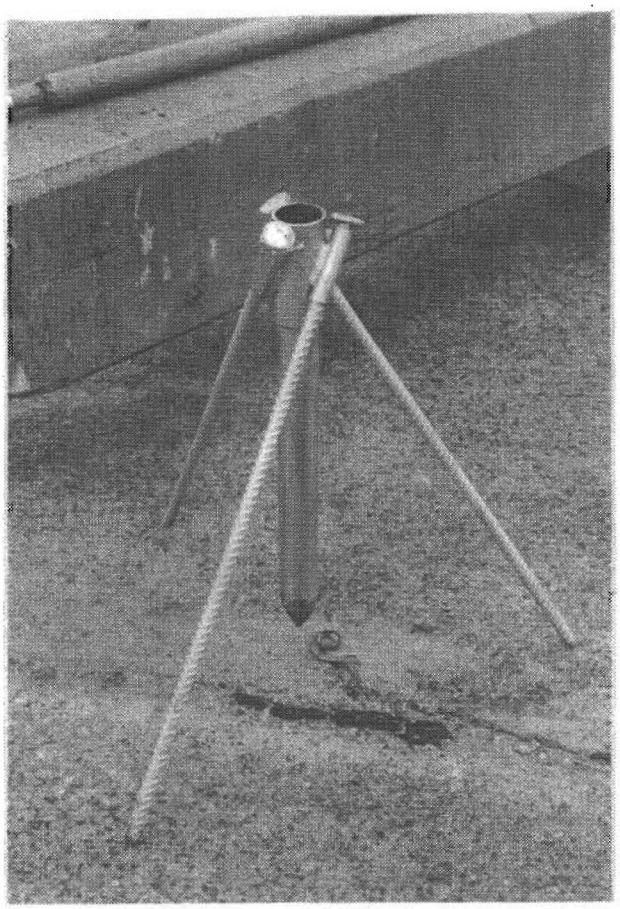


Figure 177. Texas Generic Sign Anchor.

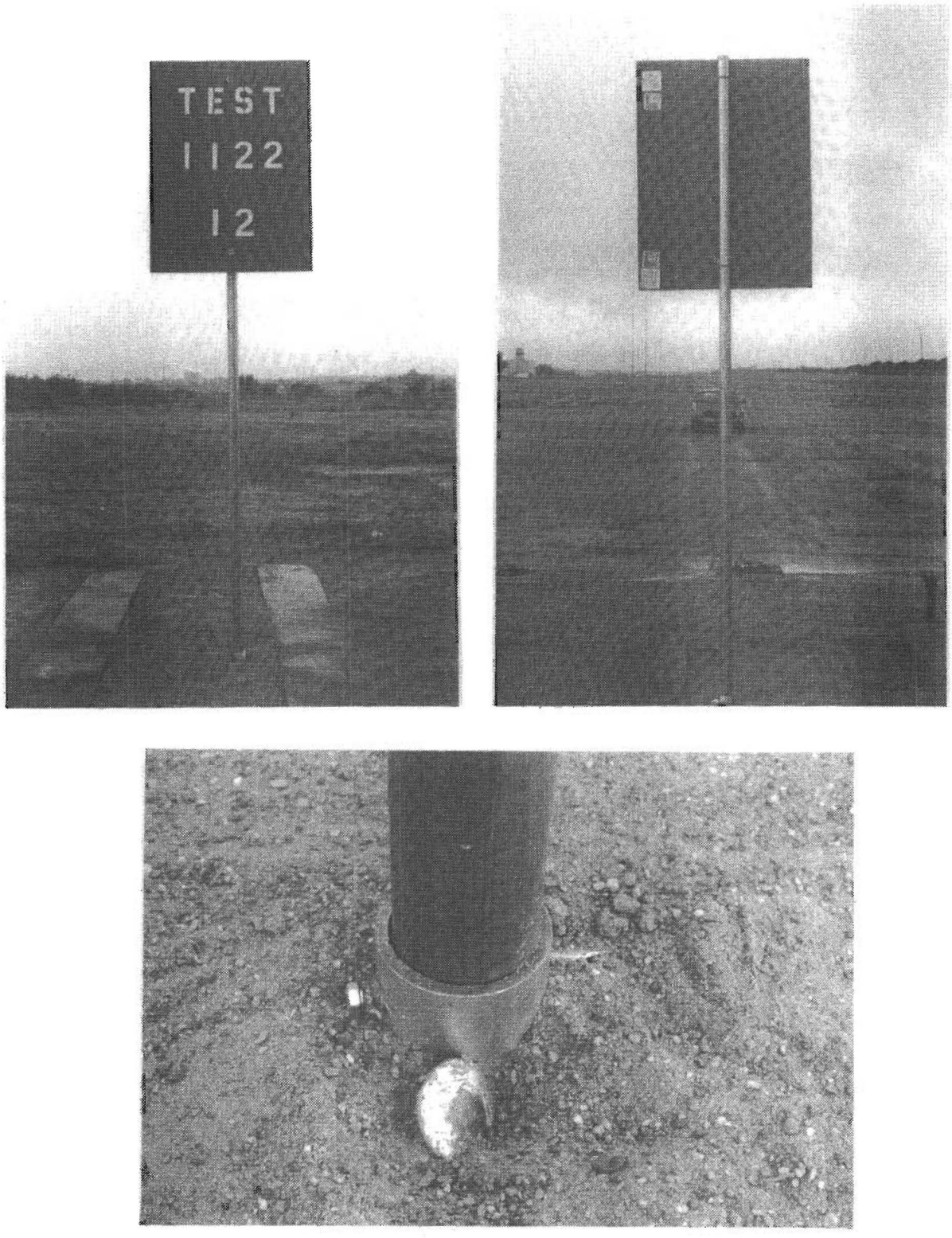


Figure 178. Test installation before test 1122-12.

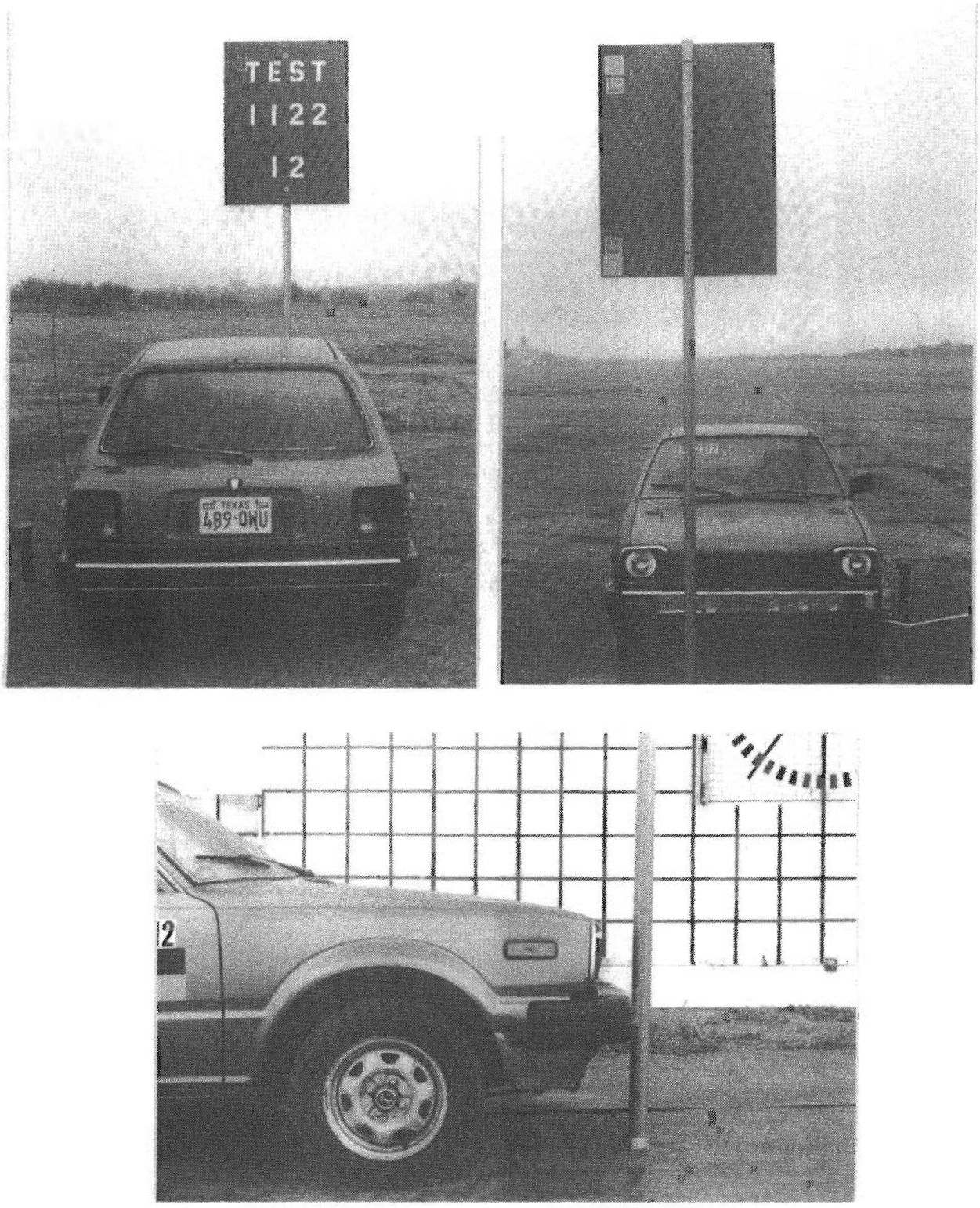


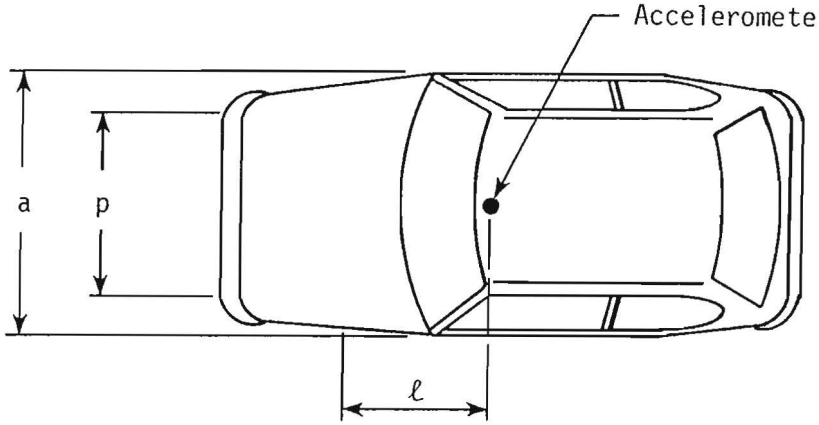
Figure 179. Vehicle/sign installation geometrics for test 1122-12.

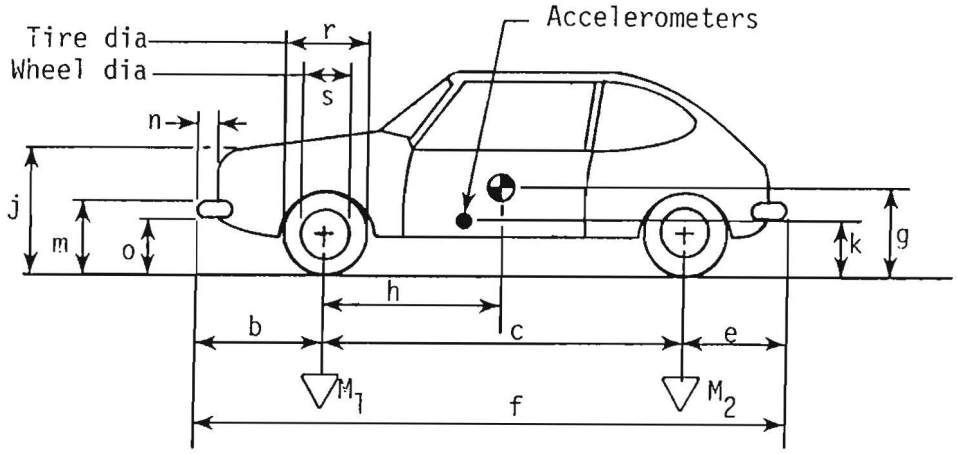
Figure 180. Vehicle before test 1122-12.

Date: 7-27-89 Test No.: 1122-12 & 13 VIN: JHMSR5326BS03050

Make: Honda Model: Civic Year: 1981 Odometer: 121586

Tire Size: P155/80R13 Ply Rating: 2 Bias Ply: ___ Belted: ___ Radial: x





4-wheel weight for c.g. det. ℓf 616 rf 546 ℓr 327 rr 311

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1165	1162	1251
M_2	678	638	719
M_T	1843	1800	1970

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Tire Condition: good ___
fair x
badly worn ___

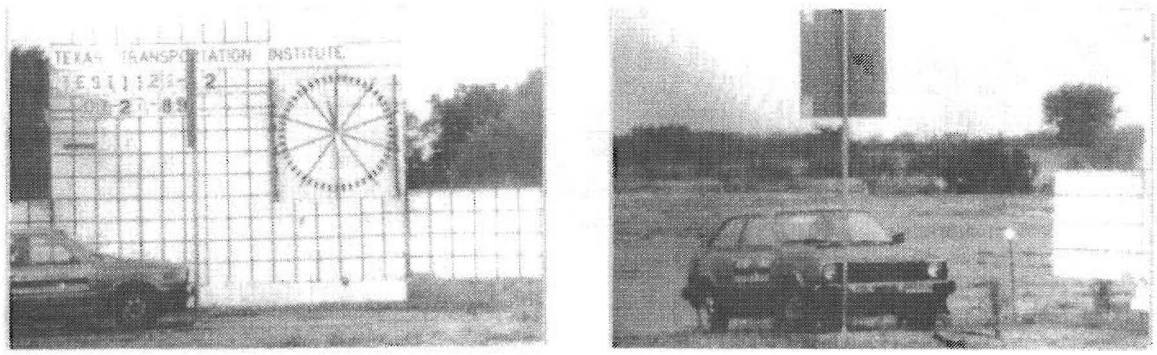
Vehicle Geometry - inches

a	62.5	b	29.5
c	87.5	d*	53.0
e	28.5	f	145.5
g	----	h	31.01
i	----	j	30.0
k	17.0	ℓ	25.25
m	20.5	n	3.0
o	14.75	p	53.0
r	22.5	s	14.25

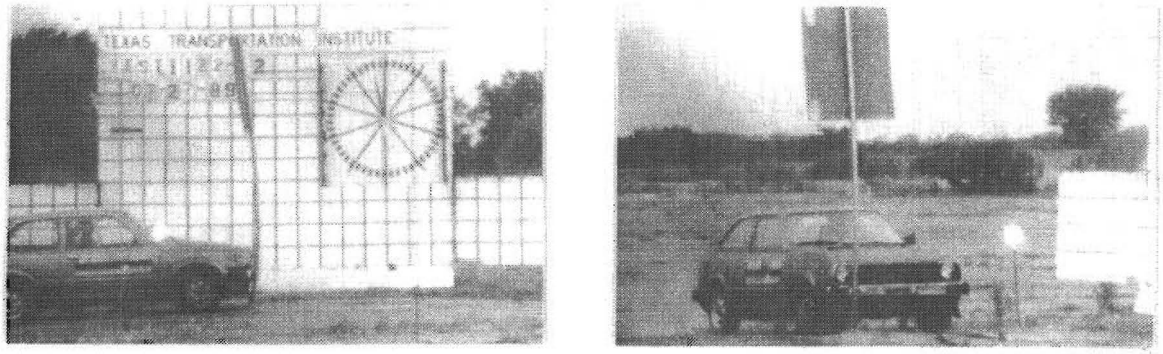
Engine Type: 4 cylinder
Engine CID: ___
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD
Body Type: Hatch
Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:
Front: disc x drum ___
Rear: disc ___ drum x

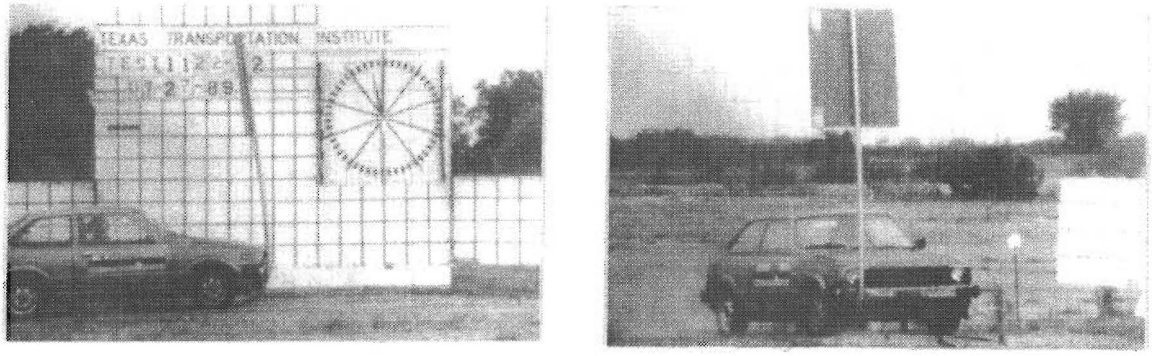
Figure 181. Vehicle properties.



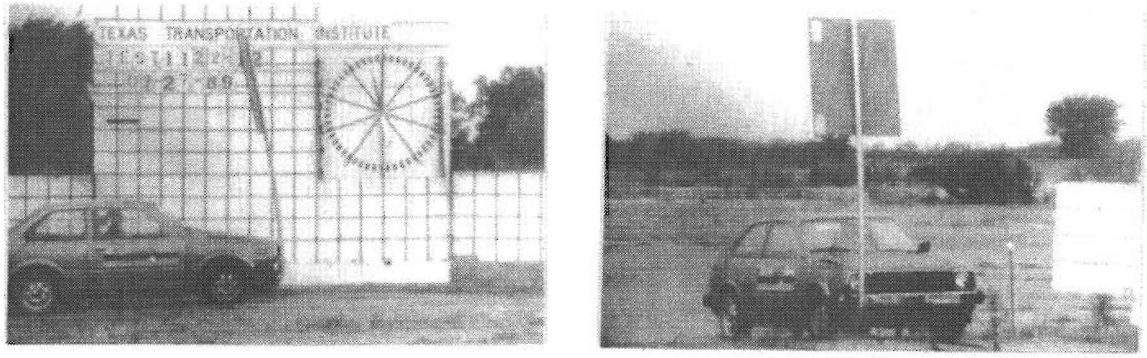
0.000 s



0.025 s

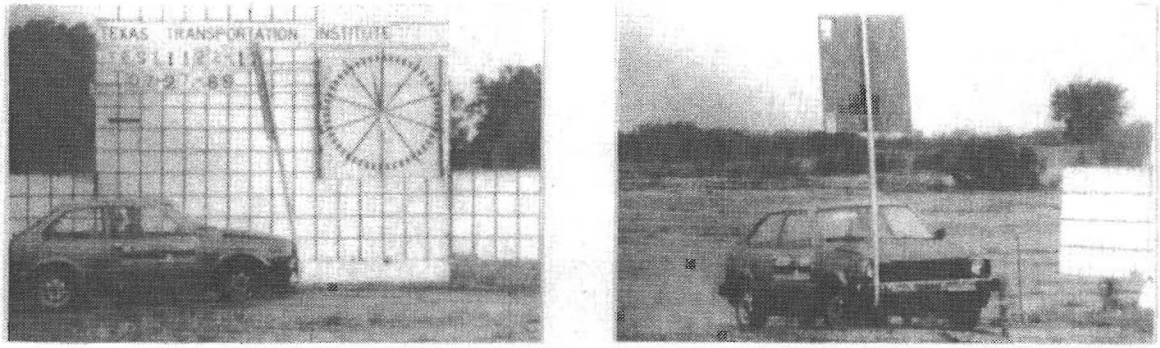


0.050 s

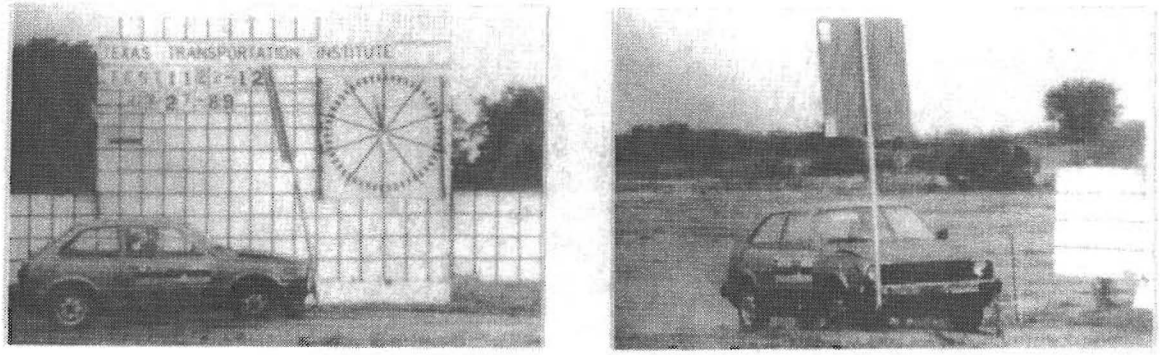


0.075 s

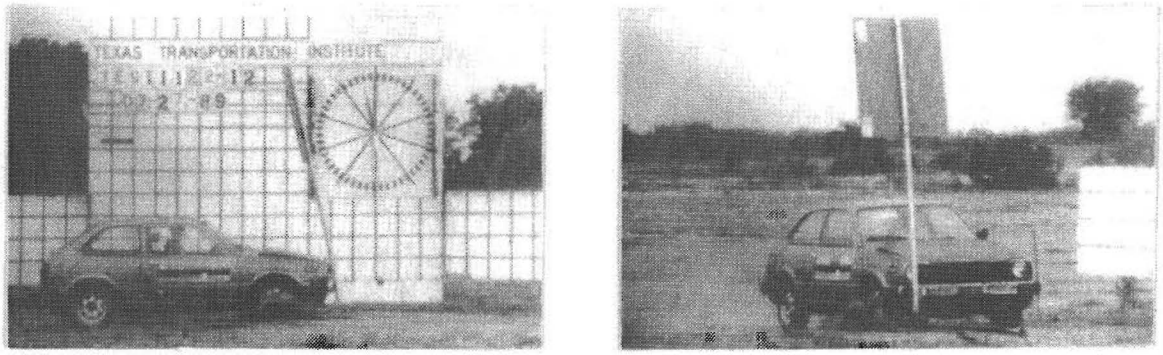
Figure 182. Sequential photographs of test 1122-12.



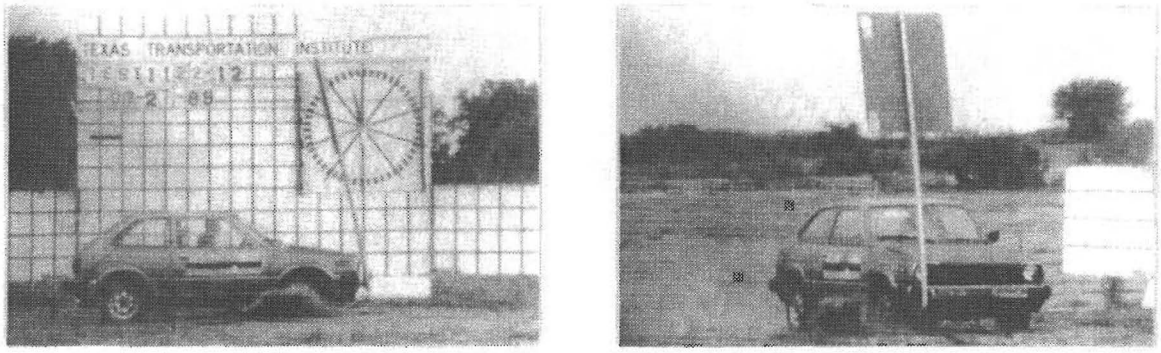
0.100 s



0.124 s



0.174 s



0.249 s

Figure 182. Sequential photographs of test 1122-12. (Continued)

Figure 183. Vehicle after test 1122-12.

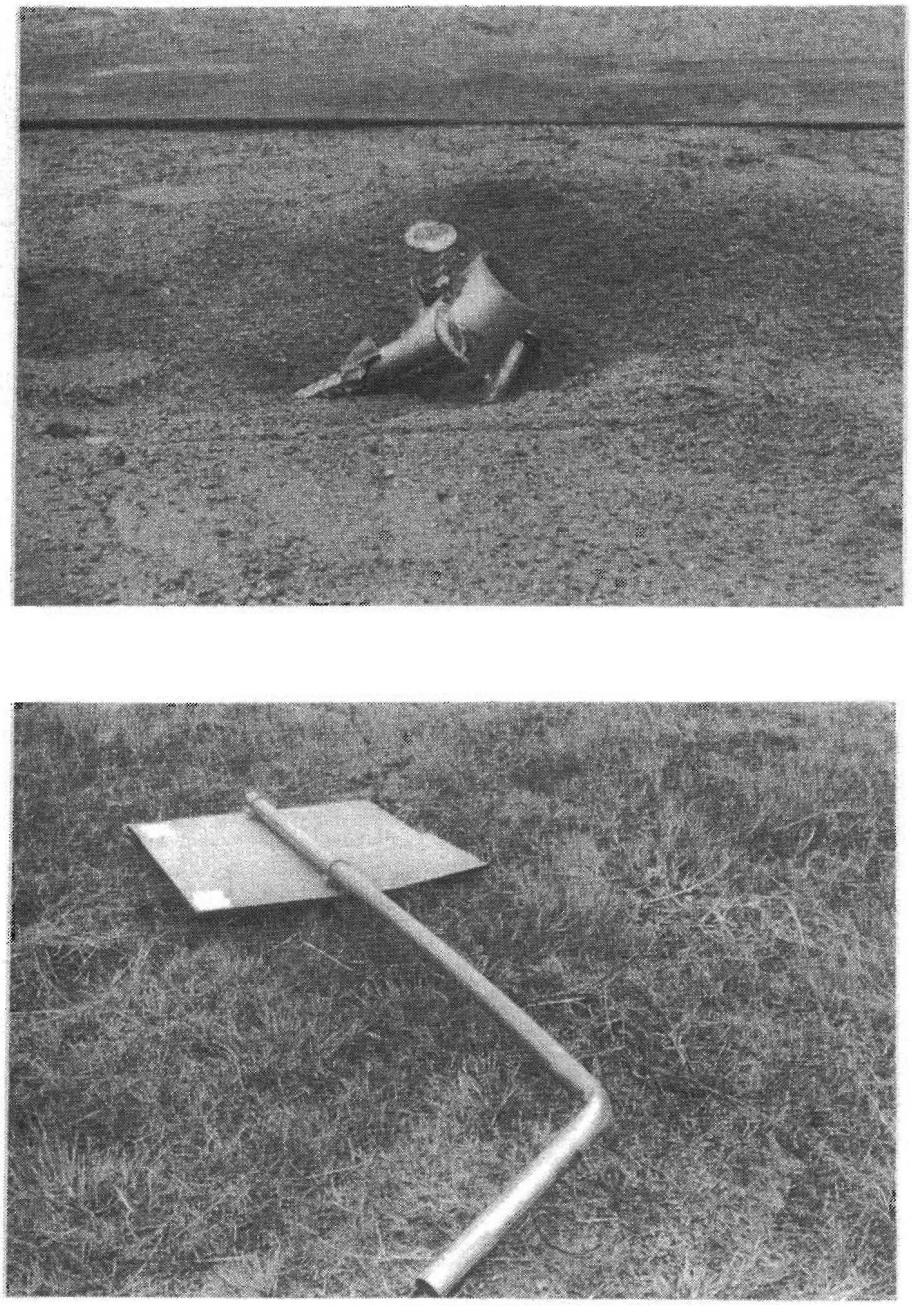
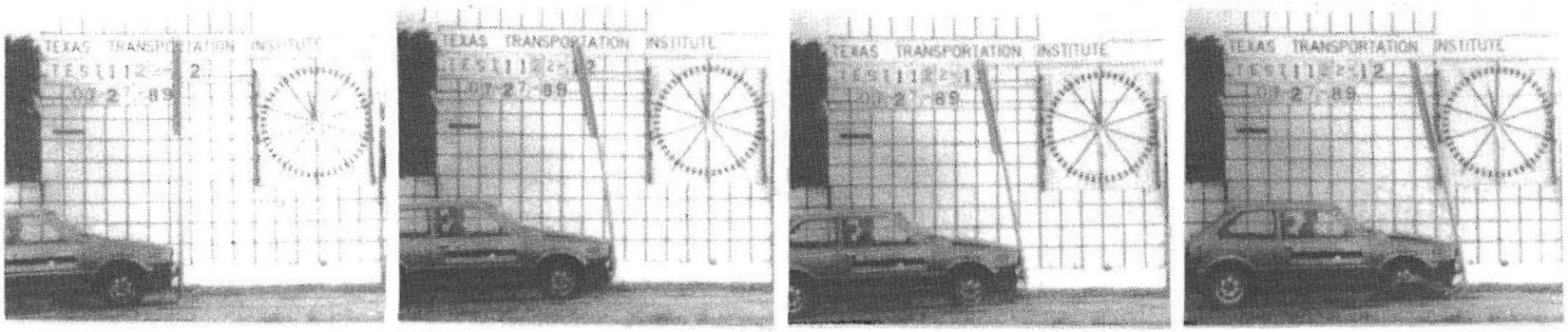
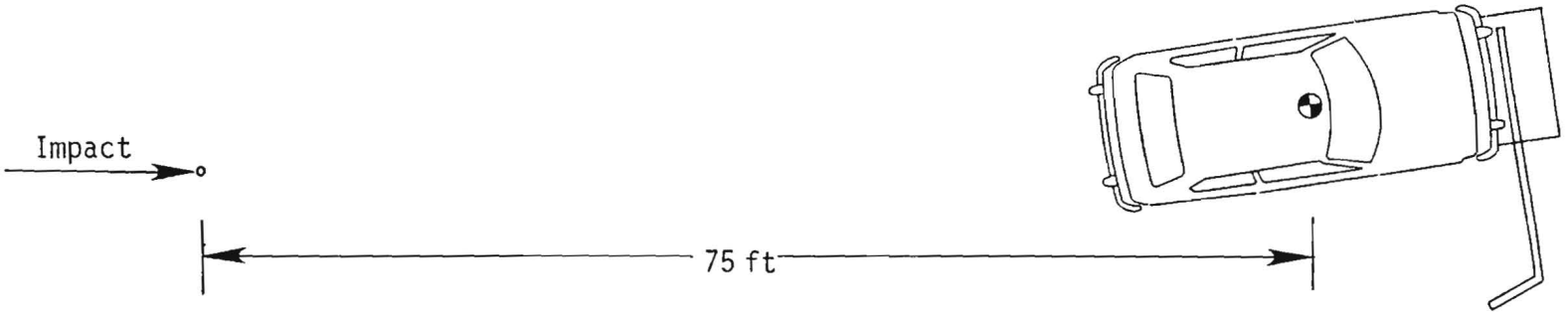


Figure 184. Test installation after test 1122-12.



0.000 s 0.050 s 0.100 s 0.175 s



Test No.	1122-12
Date	7/27/89
Test Article	One-leg Sign Support
Support	2-3/8" OD Steel Tubing with Texas Generic Sign Anchor
Vehicle	1981 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (817 kg)
Gross Static	1,970 lb (894 kg)
Vehicle Damage Classification	
TAD	12FR1
CDC	12FREN1

Impact Speed.	19.7 mi/h (31.7 km/h)
Change in Velocity . . .	2.4 mi/h (3.9 km/h)
Change in Momentum. . . .	197 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-2.2 g
Lateral	-1.3 g
Occupant Impact Velocity	
Longitudinal.	11.8 ft/s (3.6 m/s)
Lateral	7.3 ft/s (2.2 m/s)
Occupant Ridedown Accelerations	
Longitudinal	-1.4 g
Lateral	-1.4 g

Figure 185. Summary of results for test 1122-12.

⊖	1122-12r
◁	1122-12p
◇	1122-12y

Axes are vehicle fixed.
Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

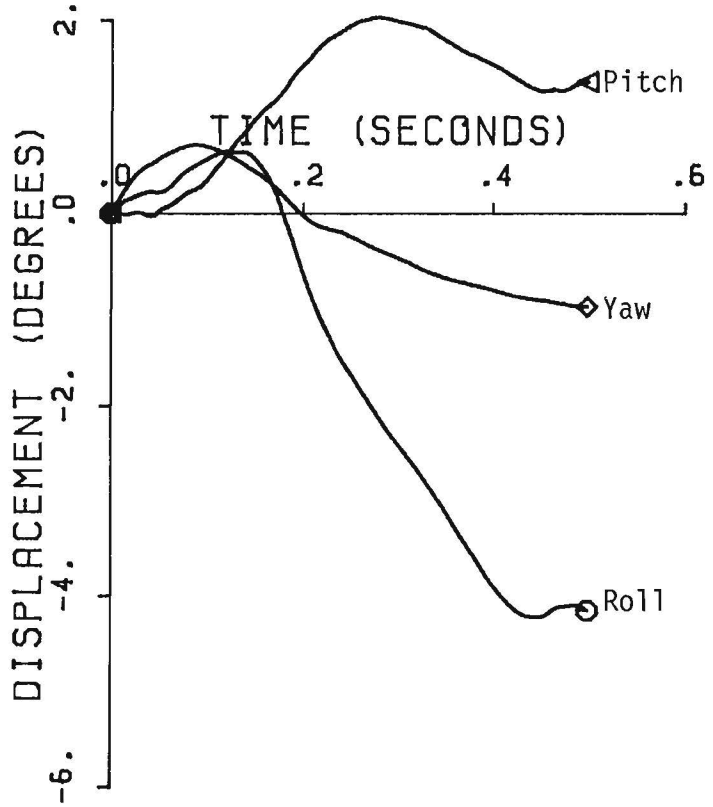


Figure 186. Vehicle angular displacement for test 1122-12.

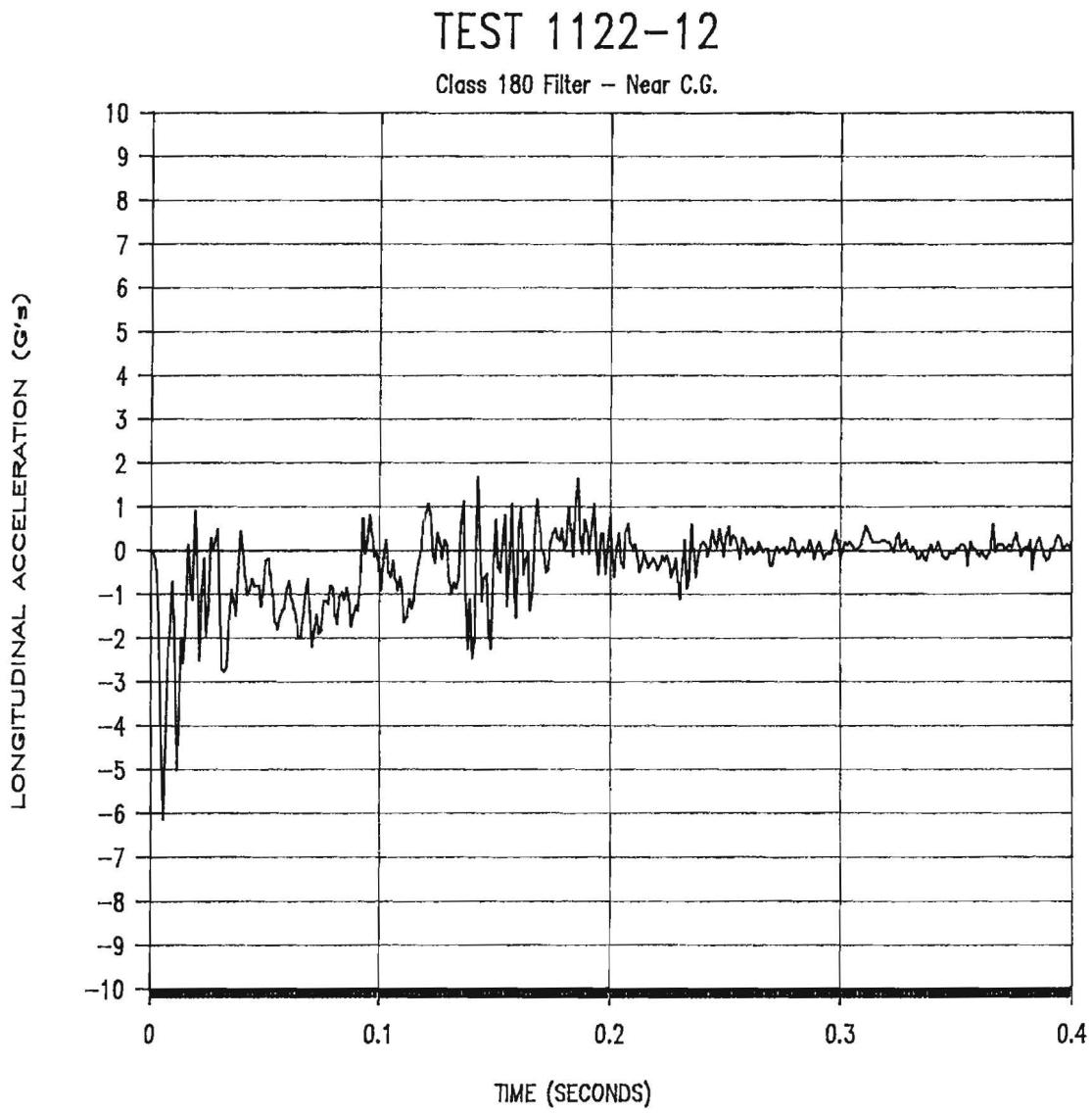


Figure 187. Vehicle longitudinal accelerometer trace for test 1122-12.

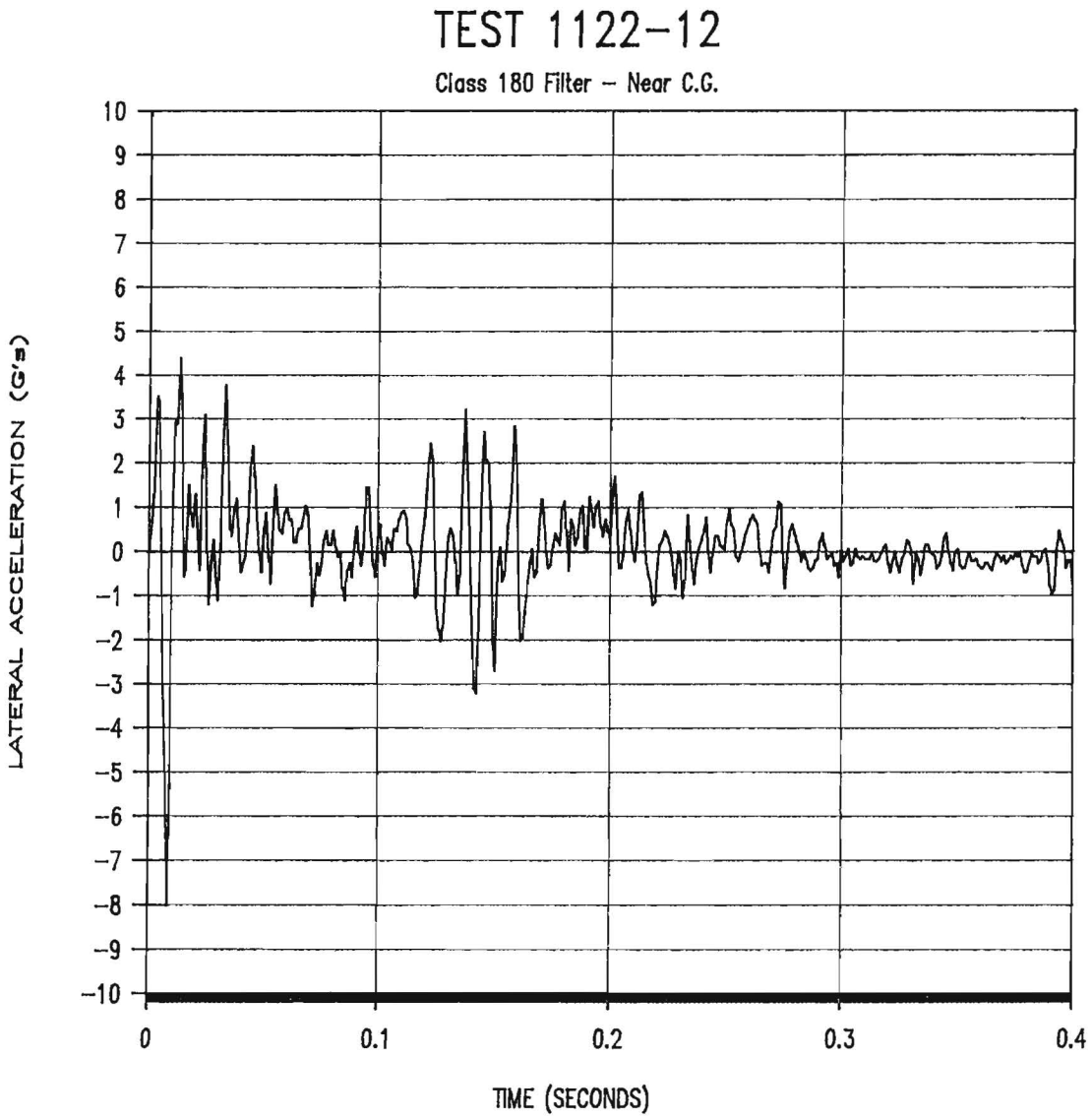


Figure 188. Vehicle lateral accelerometer trace for test 1122-12.

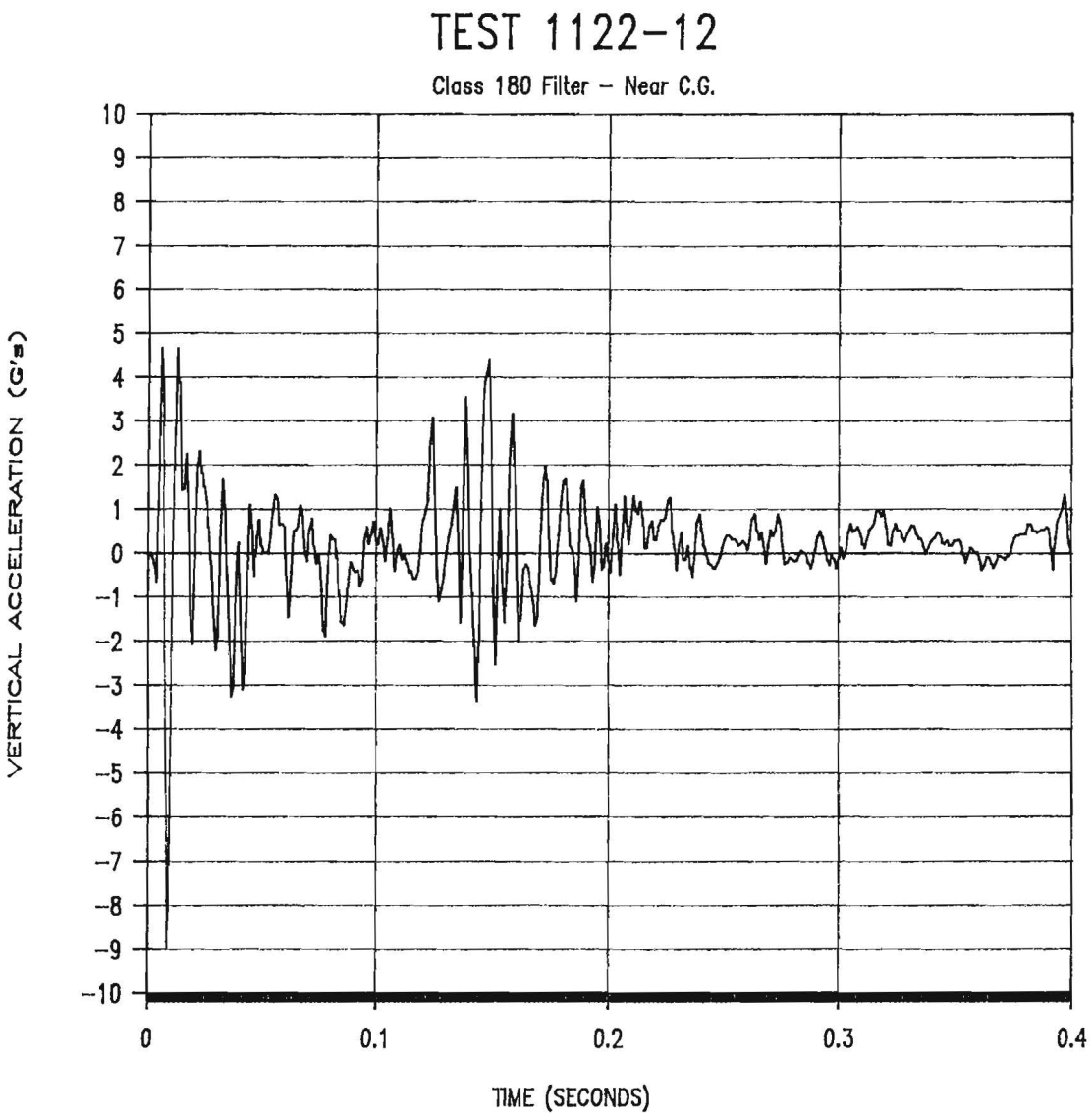


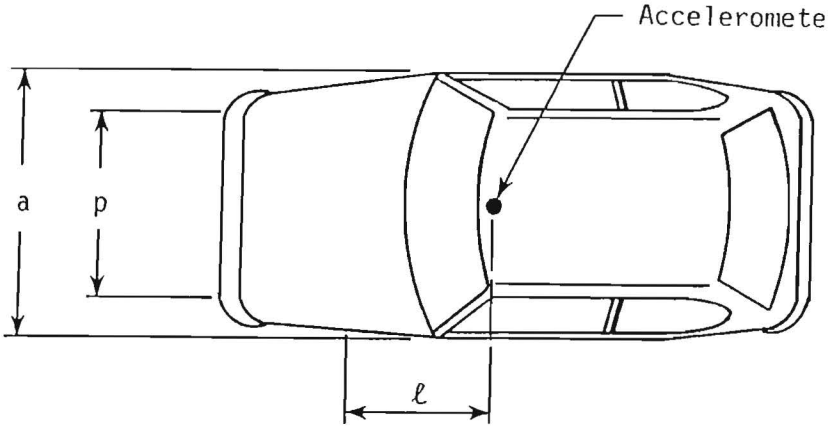
Figure 189. Vehicle vertical accelerometer trace for test 1122-12.

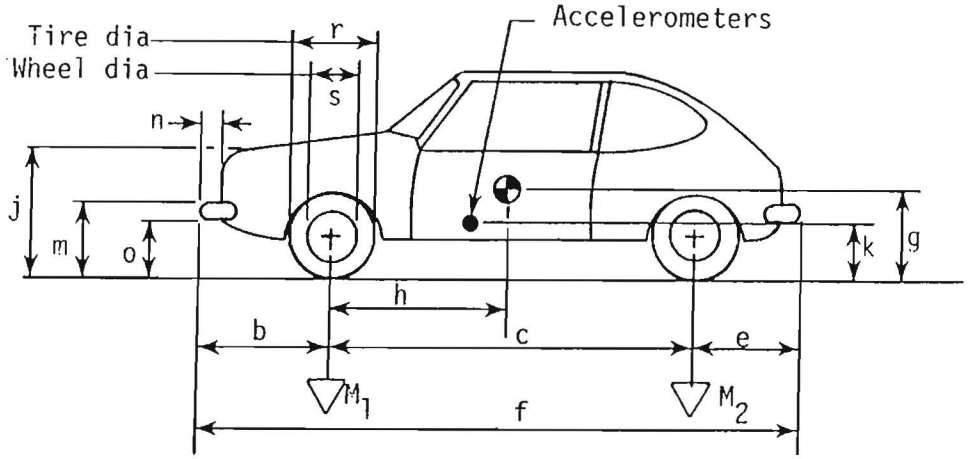
Figure 190. Vehicle before test 1122-13.

Date: 7-27-89 Test No.: 1122-12 & 13 VIN: JHMSR5326BS03050

Make: Honda Model: Civic Year: 1981 Odometer: 121586

Tire Size: P155/80R13 Ply Rating: 2 Bias Ply: ___ Belted: ___ Radial: x





4-wheel weight for c.g. det. ℓf 616 rf 546 ℓr 327 rr 311

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1165	1162	1251
M_2	678	638	719
M_T	1843	1800	1970

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Tire Condition: good ___
fair x
badly worn ___

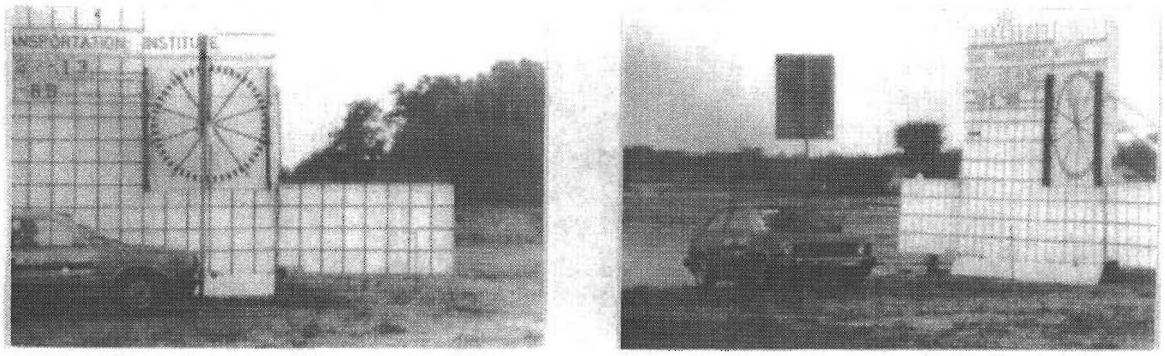
Vehicle Geometry - inches

a	62.5	b	29.5
c	87.5	d*	53.0
e	28.5	f	145.5
g	----	h	31.01
i	----	j	30.0
k	17.0	ℓ	25.25
m	20.5	n	3.0
o	14.75	p	53.0
r	22.5	s	14.25

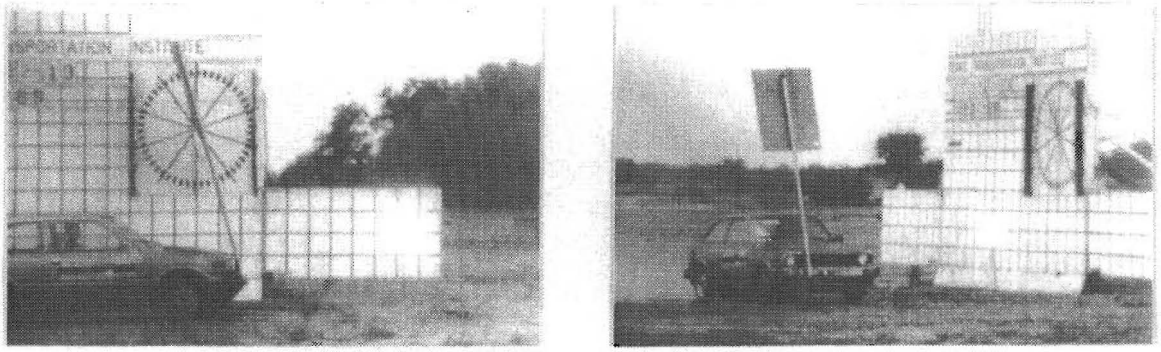
Engine Type: 4 cylinder
Engine CID: ___
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD
Body Type: Hatch
Steering Column Collapse Mechanism:
___ Behind wheel units
___ Convoluted tube
___ Cylindrical mesh units
___ Embedded ball
___ NOT collapsible
___ Other energy absorption
___ Unknown

Brakes:
Front: disc x drum ___
Rear: disc ___ drum x

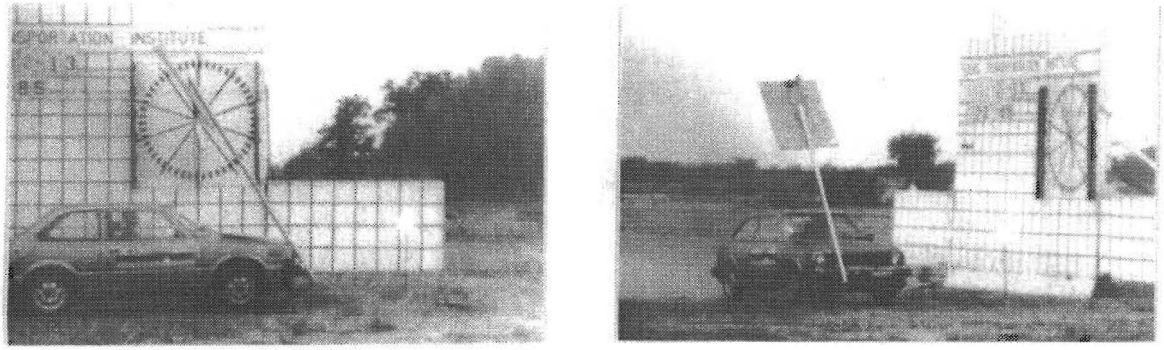
Figure 191. Vehicle properties.



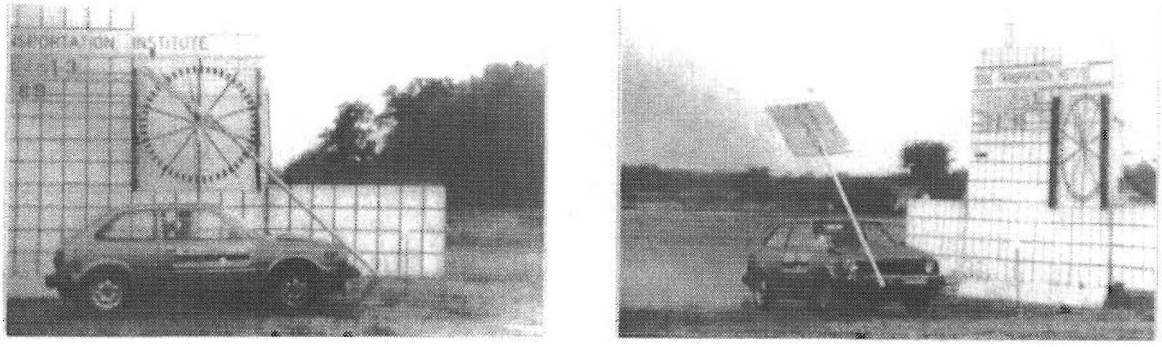
0.000 s



0.025 s



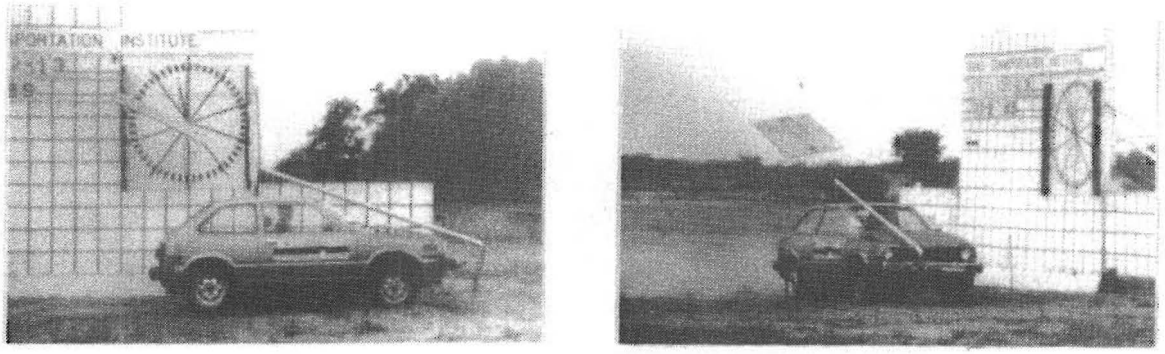
0.050 s



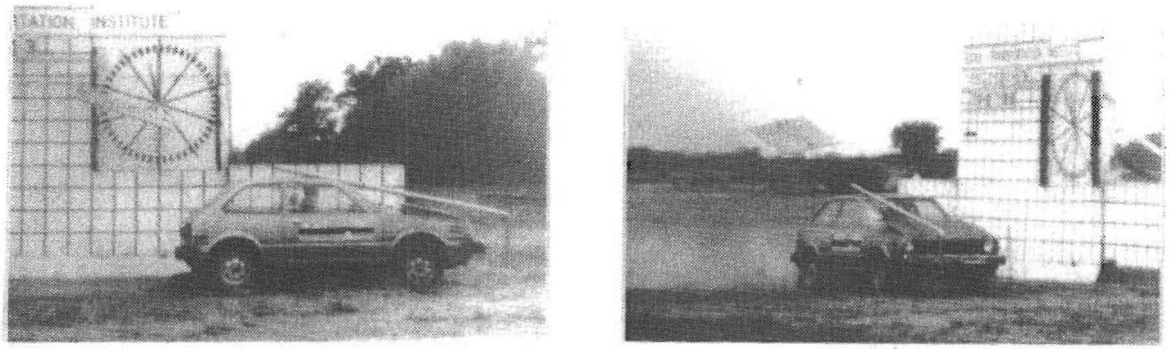
0.075 s

Figure 192. Sequential photographs of test 1122-13.

0.100 s



0.125 s



0.150 s

0.200 s

Figure 192. Sequential photographs of test 1122-13 (Continued)

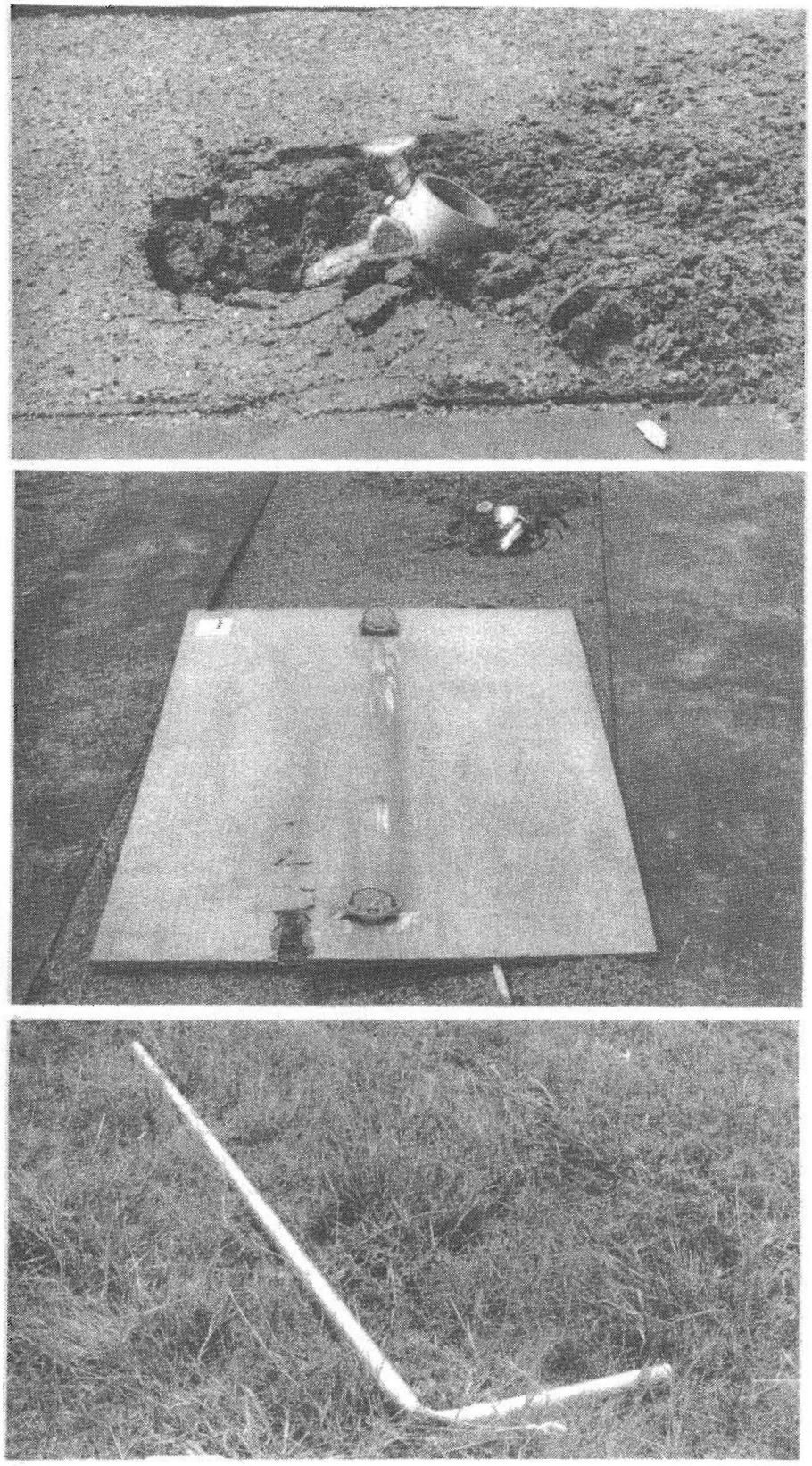
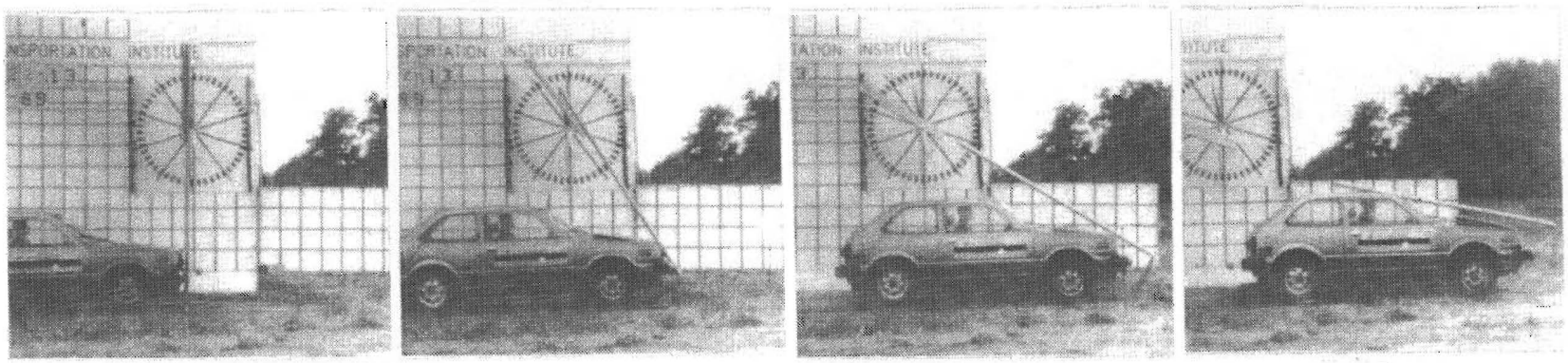
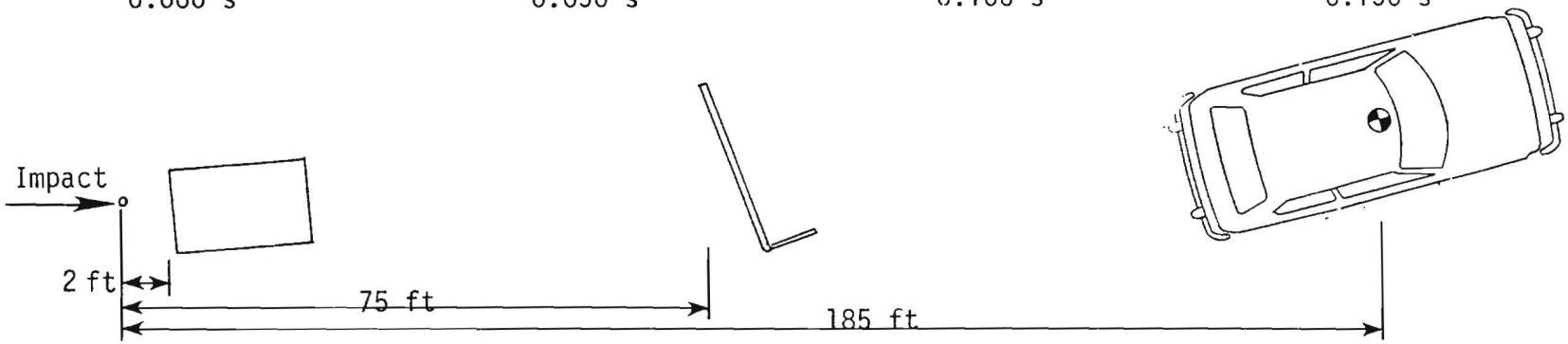


Figure 193. Sign installation after test 1122-13.

Figure 194. Vehicle after test 1122-13.



0.000 s 0.050 s 0.100 s 0.150 s



Test No. 1122-13
Date 7/27/89
Test Article . . . . . One-leg Sign Support
Support . . . . . 2-3/8" OD Steel Tubing with Texas Generic Sign Anchor
Vehicle . . . . . 1981 Honda Civic
Vehicle Weight
  Test Inertia . . . . 1,800 lb (817 kg)
  Gross Static . . . . 1,970 lb (894 kg)
Vehicle Damage Classification
  TAD 12FR1
  CDC 12FRAN1

Impact Speed. . . . . 62.0 mi/h (99.8 km/h)
Change in Velocity . . . 3.5 mi/h (5.6 km/h)
Change in Momentum. . . . 287 lb-s
Vehicle Accelerations
  (Max. 0.050-sec Avg)
  Longitudinal. . . . . -2.3 g
  Lateral . . . . . -1.3 g
Occupant Impact Velocity
  Longitudinal. . . . . 11.4 ft/s (3.5 m/s)
  Lateral . . . . . 7.7 ft/s (2.3 m/s)
Occupant Ridedown Accelerations
  Longitudinal . . . . . -1.5 g
  Lateral . . . . . -1.6 g

Figure 195. Summary of results for test 1122-13.

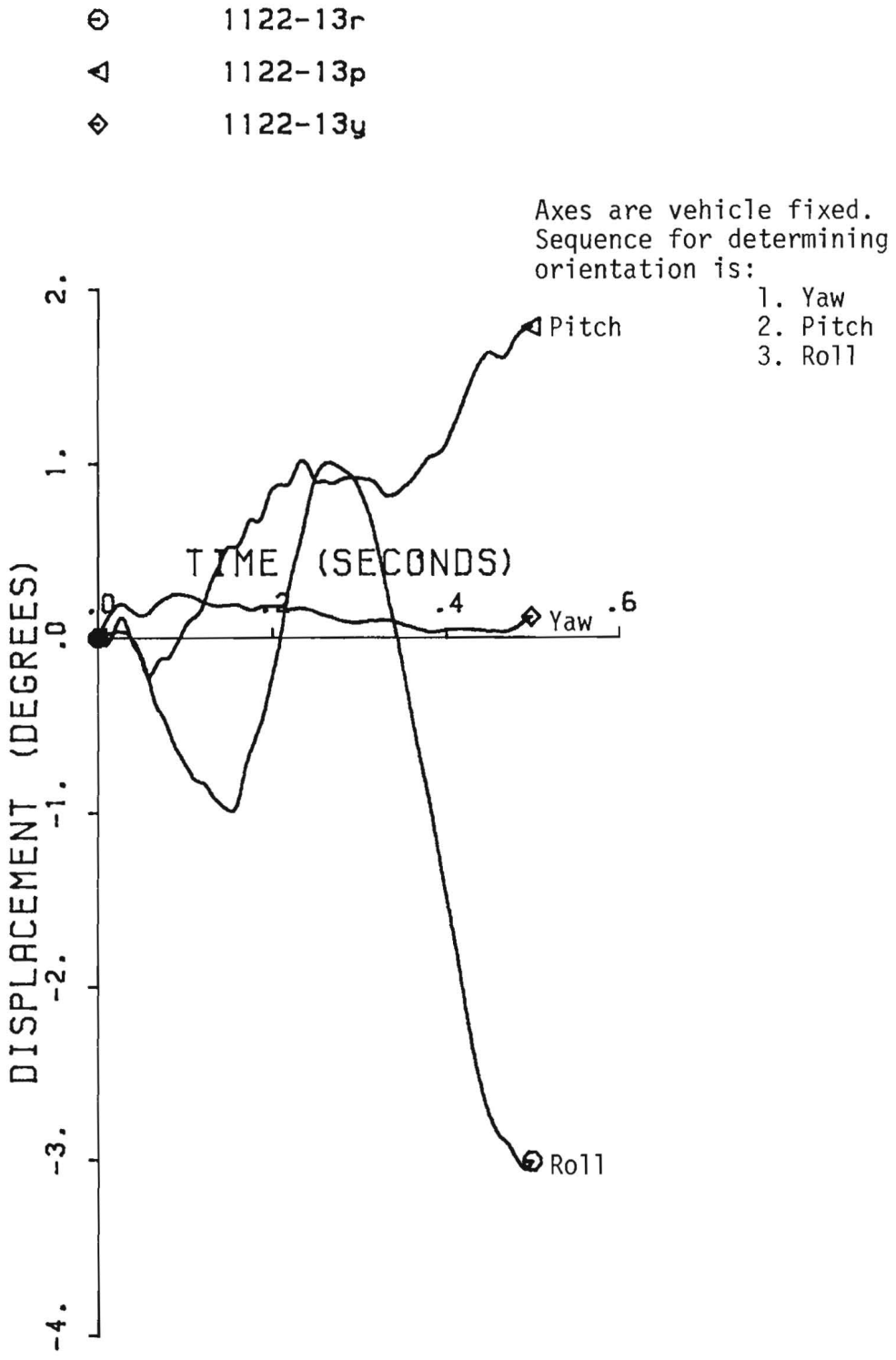


Figure 196. Vehicle angular displacements for test 1122-13.

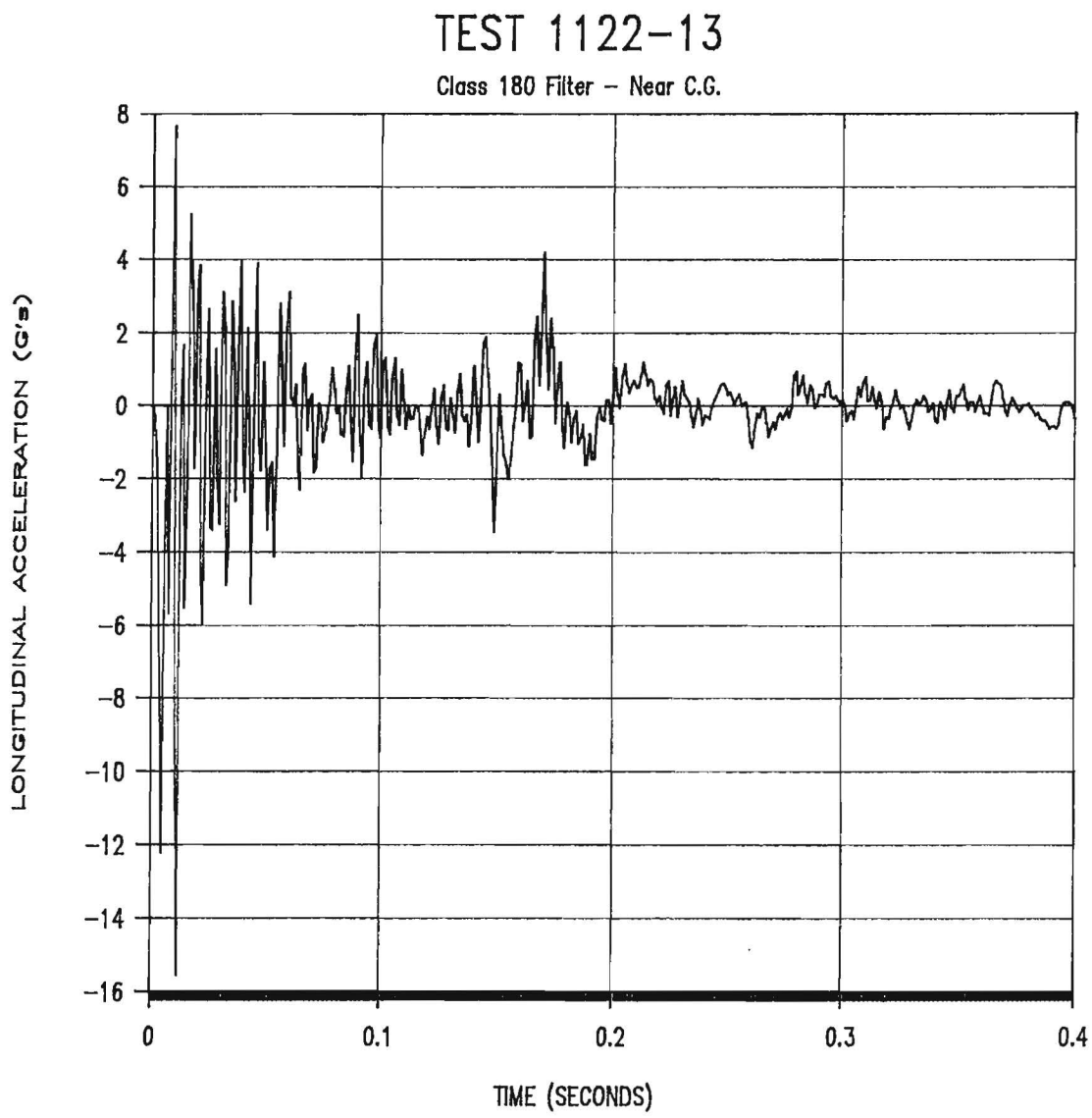


Figure 197. Vehicle longitudinal accelerometer trace for test 1122-13.

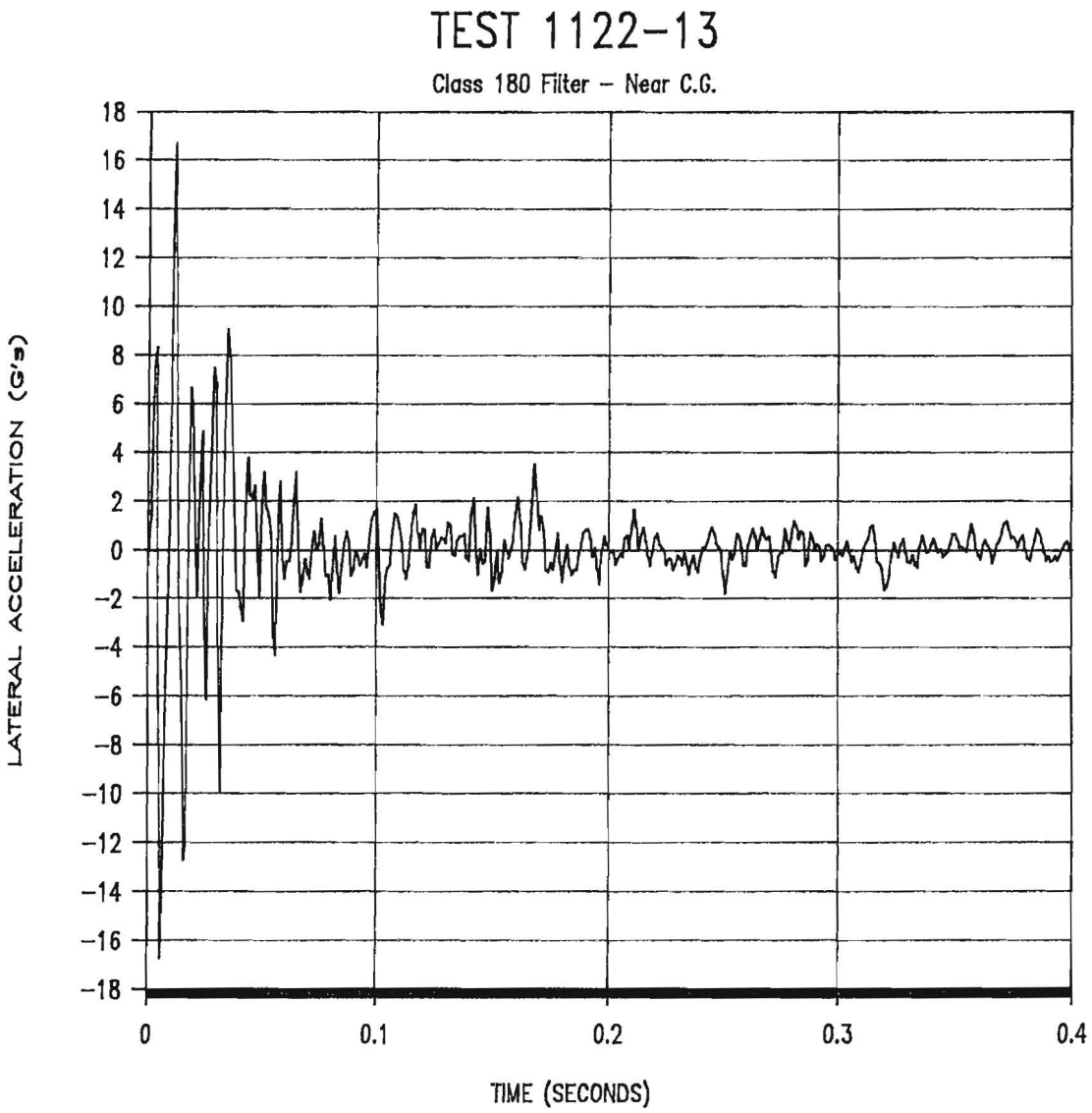


Figure 198. Vehicle lateral accelerometer trace for test 1122-13.

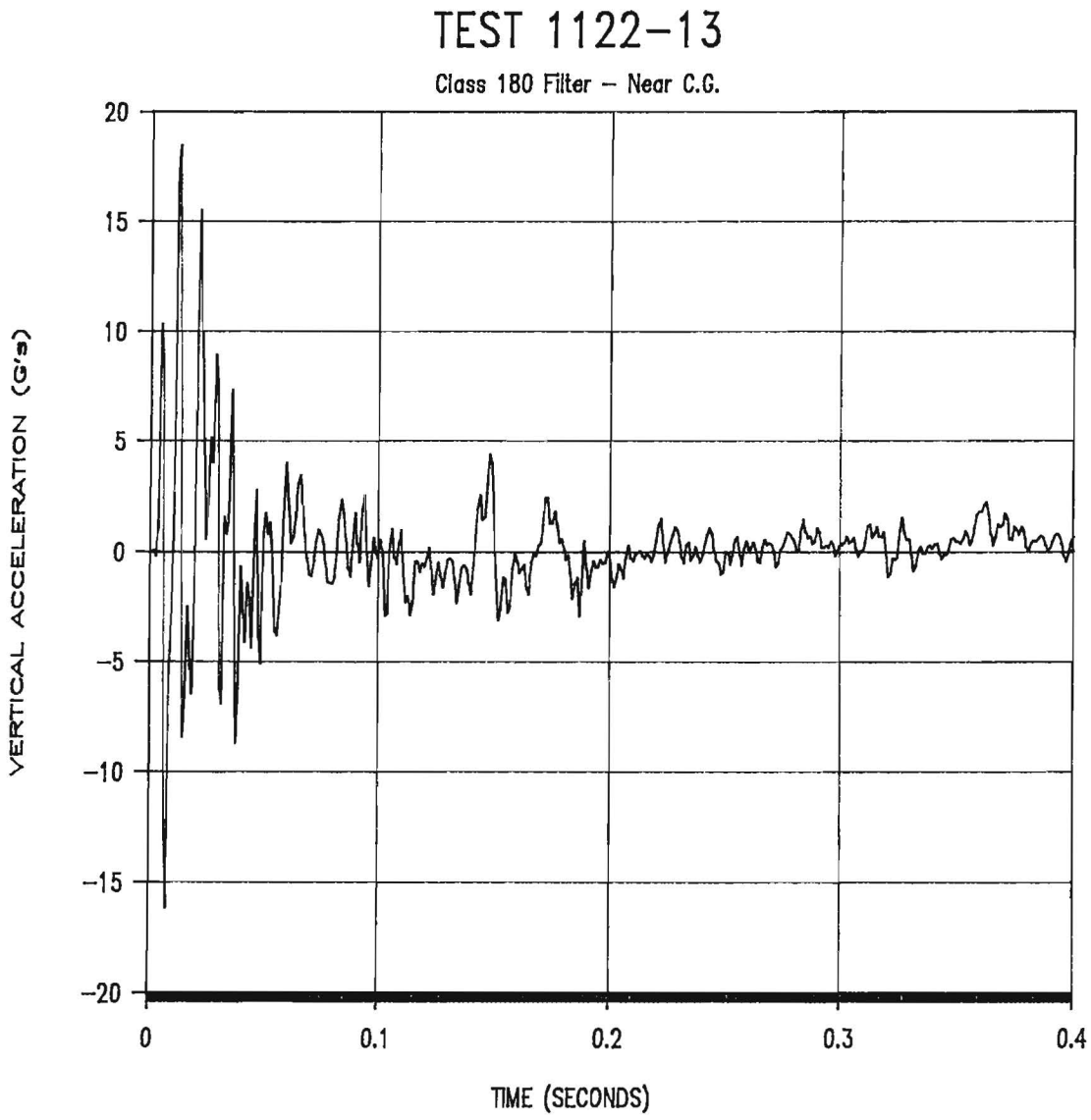


Figure 199. Vehicle vertical accelerometer trace for test 1122-13.

Figure 200. Vehicle before test 1122-14.

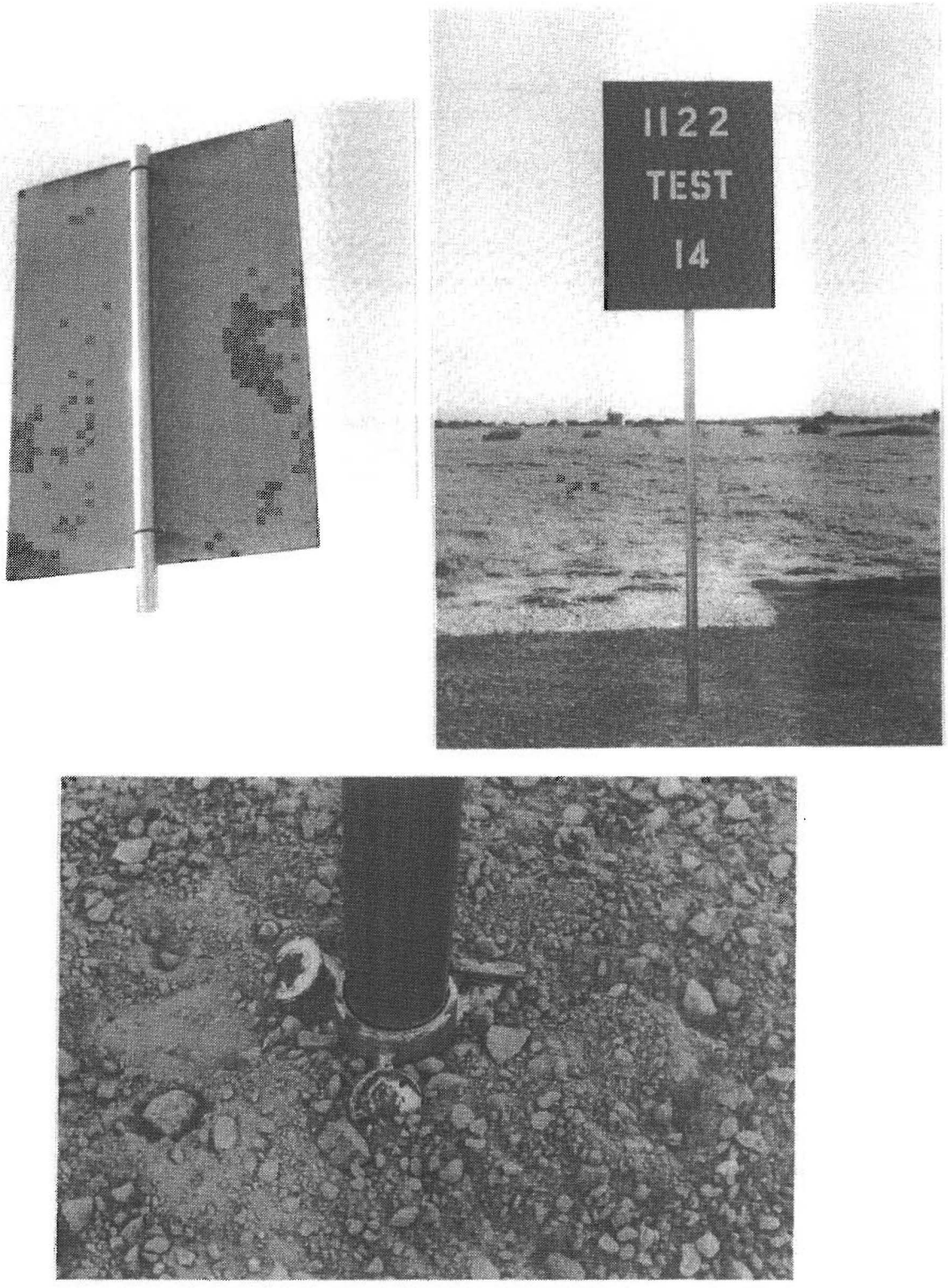


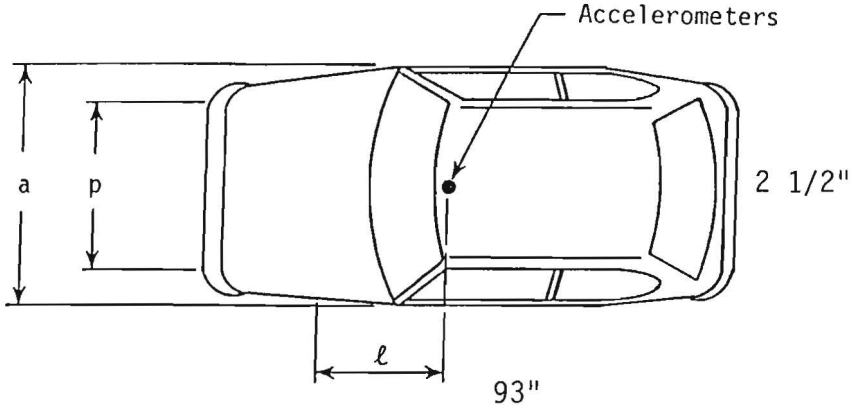
Figure 201. Sign installation before test 1122-14.

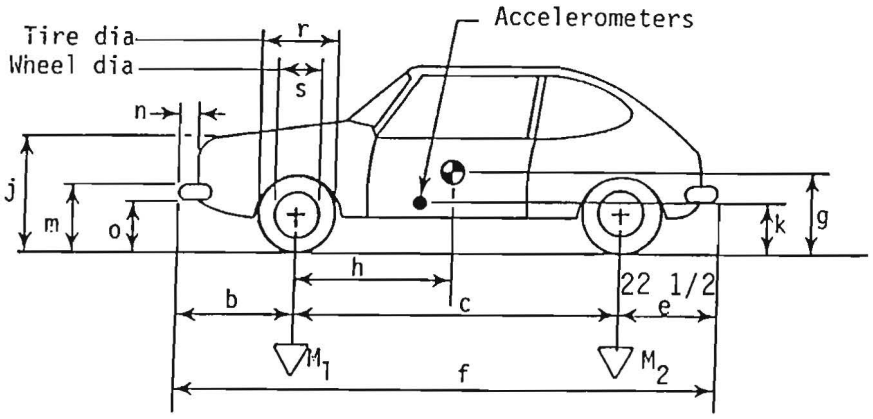
Date: 8/18/89 Test No.: 1122-14 VIN: JHMSL5320C5021206

Make: Honda Model: Civic Year: 1982 Odometer: 167982

Tire Size: 155/SR13 Ply Rating: 2 Bias Ply: ___ Belted: ___ Radial: X

Tire Condition: good ___
fair X
badly worn ___





4-wheel weight for c.g. det. ℓf 593 rf 531 ℓr 339 rr 337

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1106	1124	1201
M_2	683	676	767
M_T	1789	1800	1968

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Vehicle Geometry - inches

a	62 3/4	b	29
c	87 1/2	d*	53
e	29	f	145 1/2
g		h	32.86
i	----	j	29 1/2
k	16 1/2	ℓ	25 1/2
m	20	n	4
o	14	p	54 1/4
r	22	s	14 1/4

Engine Type: 4 cyl

Engine CID: ___

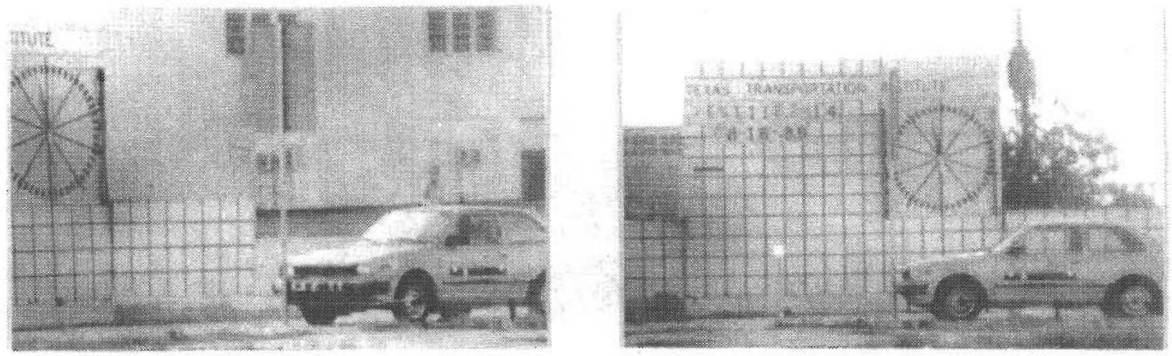
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD

Body Type: Hatch

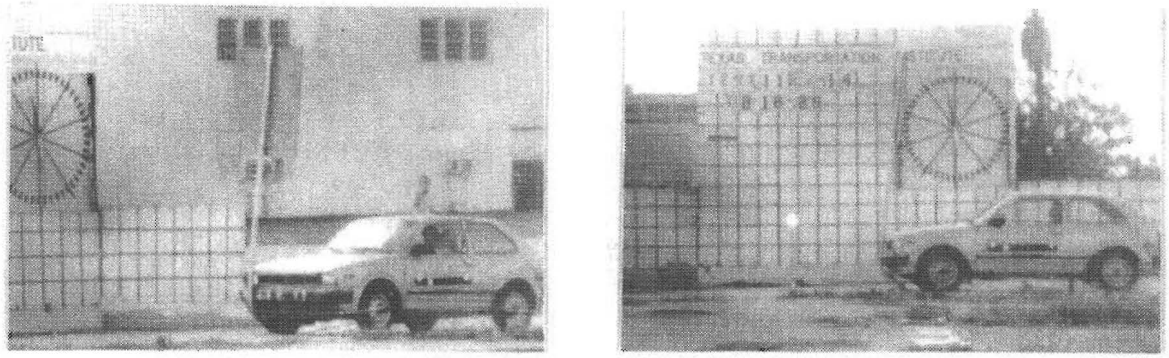
Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

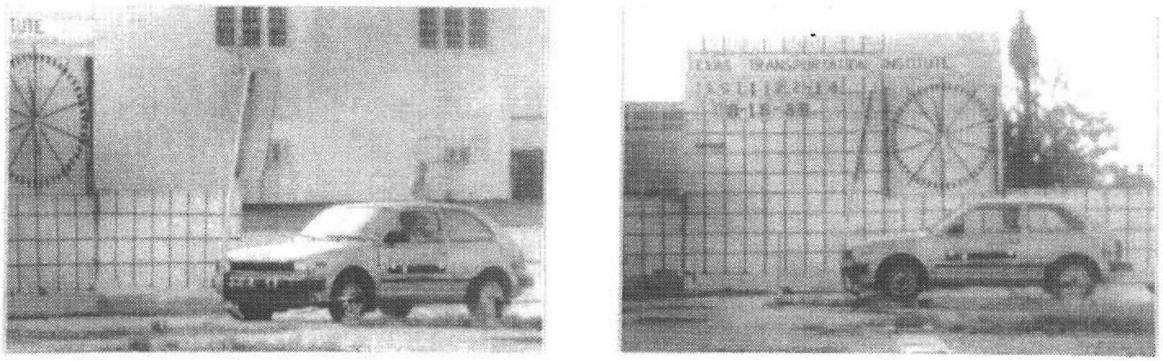
Figure 202. Vehicle properties for test 1122-14.



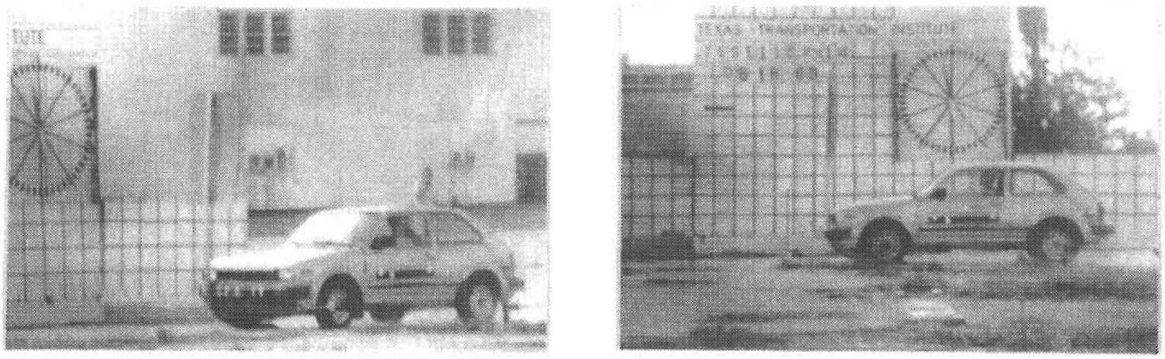
0.000 s



0.050 s

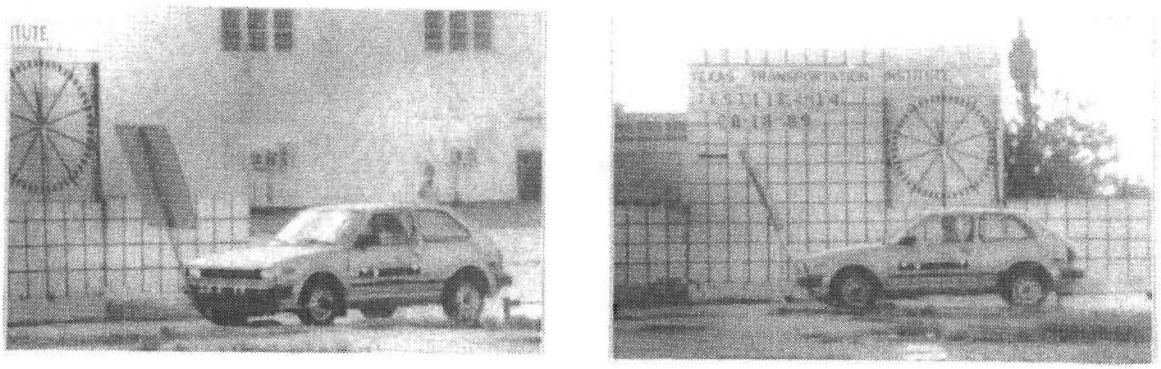


0.100 s

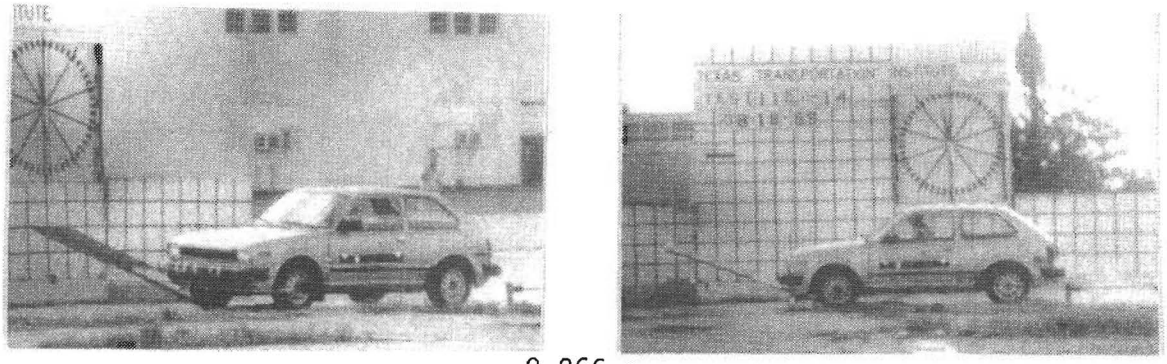


0.149 s

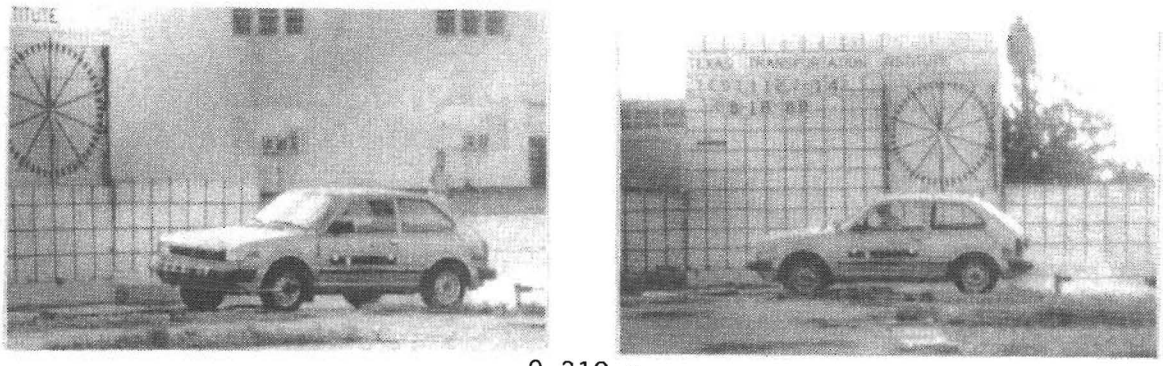
Figure 203. Sequential photographs for test 1122-14.



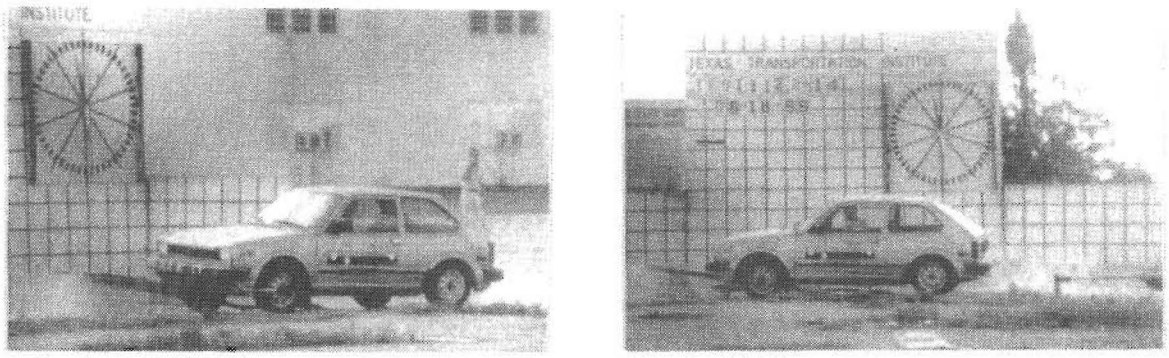
0.199 s



0.266 s



0.318 s



0.425 s

Figure 203. Sequential photographs for test 1122-14.
(Continued)

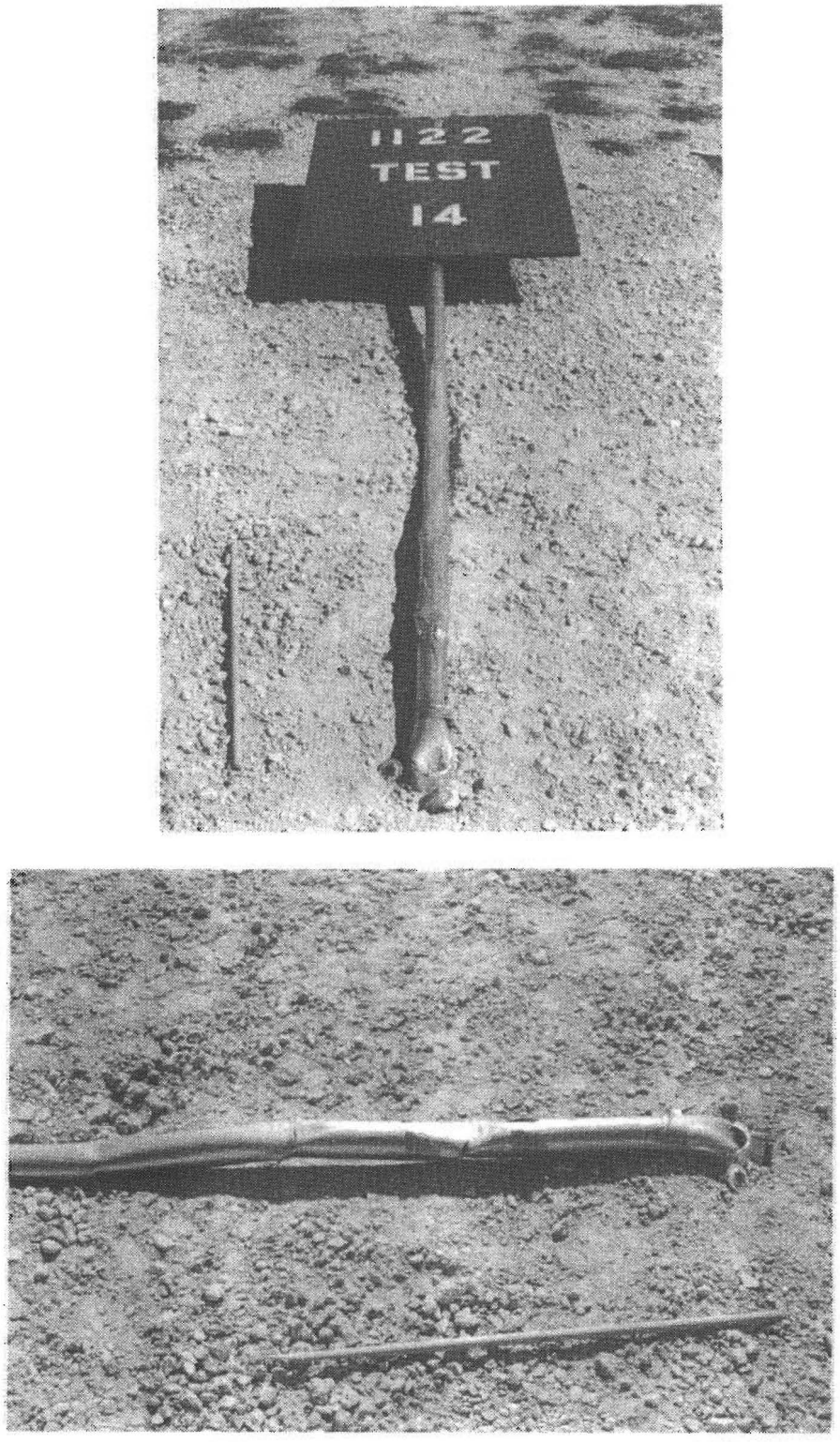
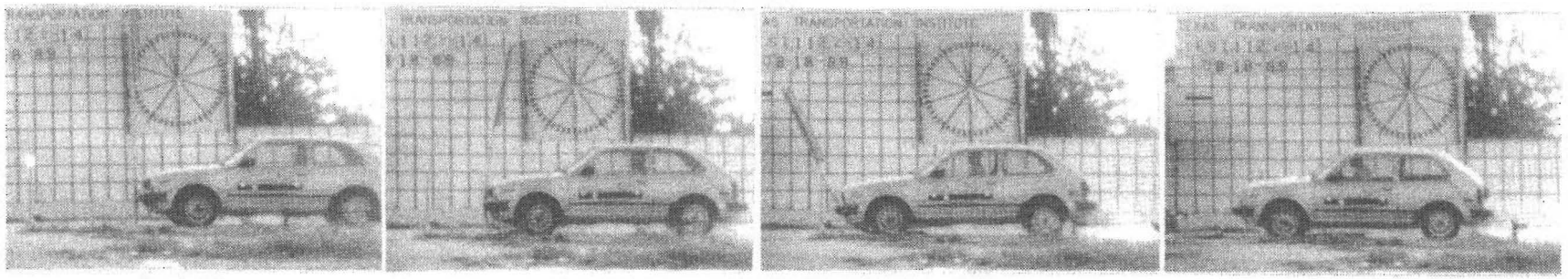
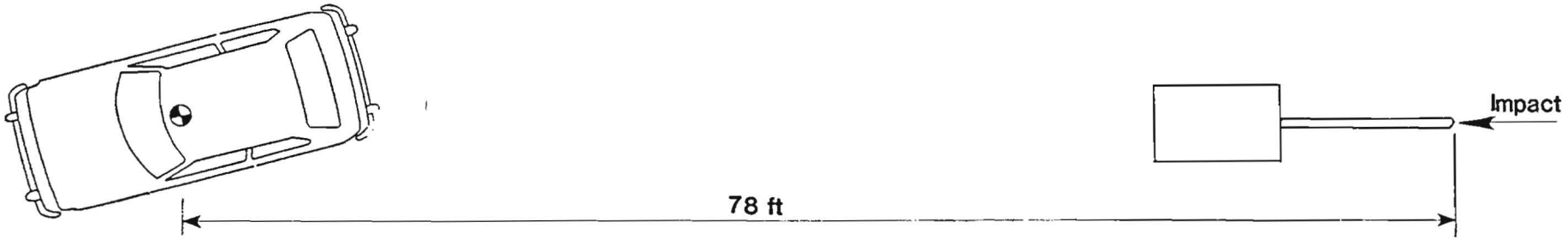


Figure 204. Sign installation after test 1122-14.

Figure 205. Vehicle after test 1122-14.



0.000 s 0.100 s 0.199 s 0.318 s



Test No.	1122-14
Date	08/18/89
Test Article	Sign Installation
Support	Single 2-3/8" O.D. Steel Tubing Support with Texas Generic Sign Anchor
Vehicle	1982 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (816 kg)
Gross Static	1,968 lb (893 kg)
Vehicle Damage Classification	
TAD	12FR1
SAE	12FRLN1

Impact Speed	20.0 mi/h (32.2 km/h)
Change in Velocity	8.3 mi/h (13.4 km/h)
Change in Momentun	680 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal	-2.6 g
Lateral	-1.4 g
Occupant Impact Velocity	
Longitudinal	14.9 ft/s (4.5 m/s)
Lateral	7.3 ft/s (2.2 m/s)
Occupant Ridedown Accelerations	
Longitudinal	-0.8 g
Lateral	-1.9 g

Figure 206. Summary of results for test 1122-14.

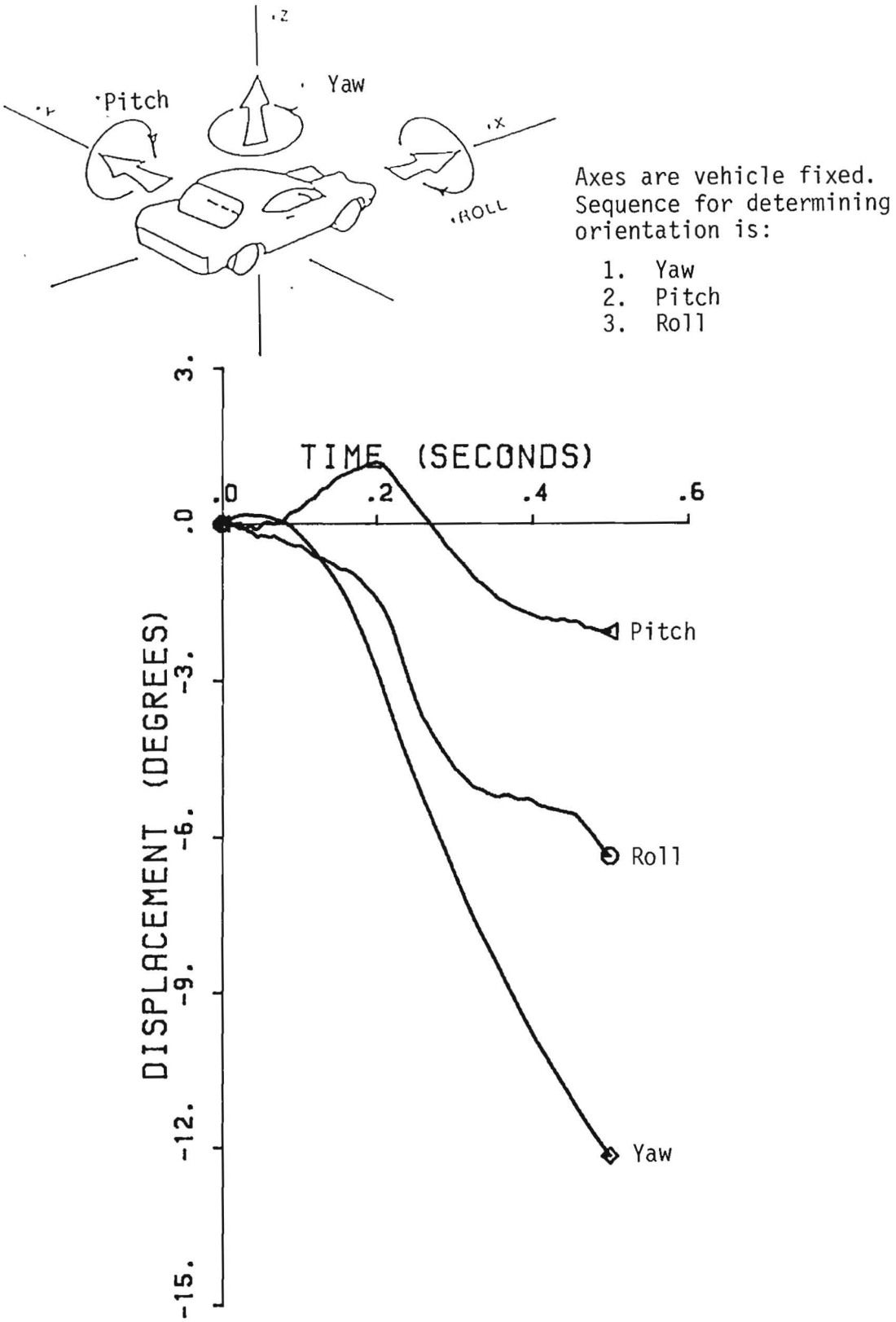


Figure 207. Vehicle angular displacements for test 1122-14.

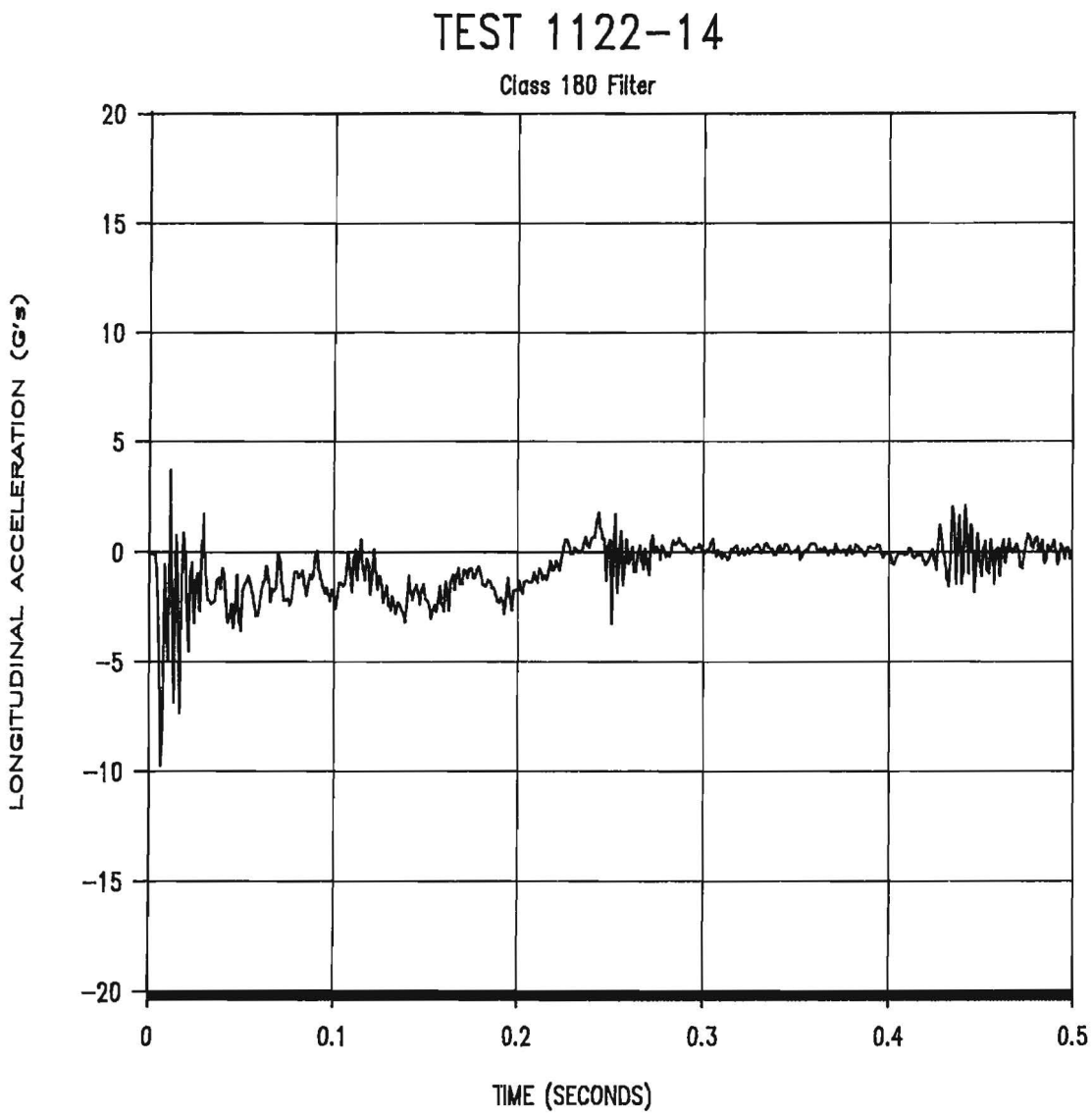


Figure 208. Longitudinal accelerometer trace for test 1122-14.

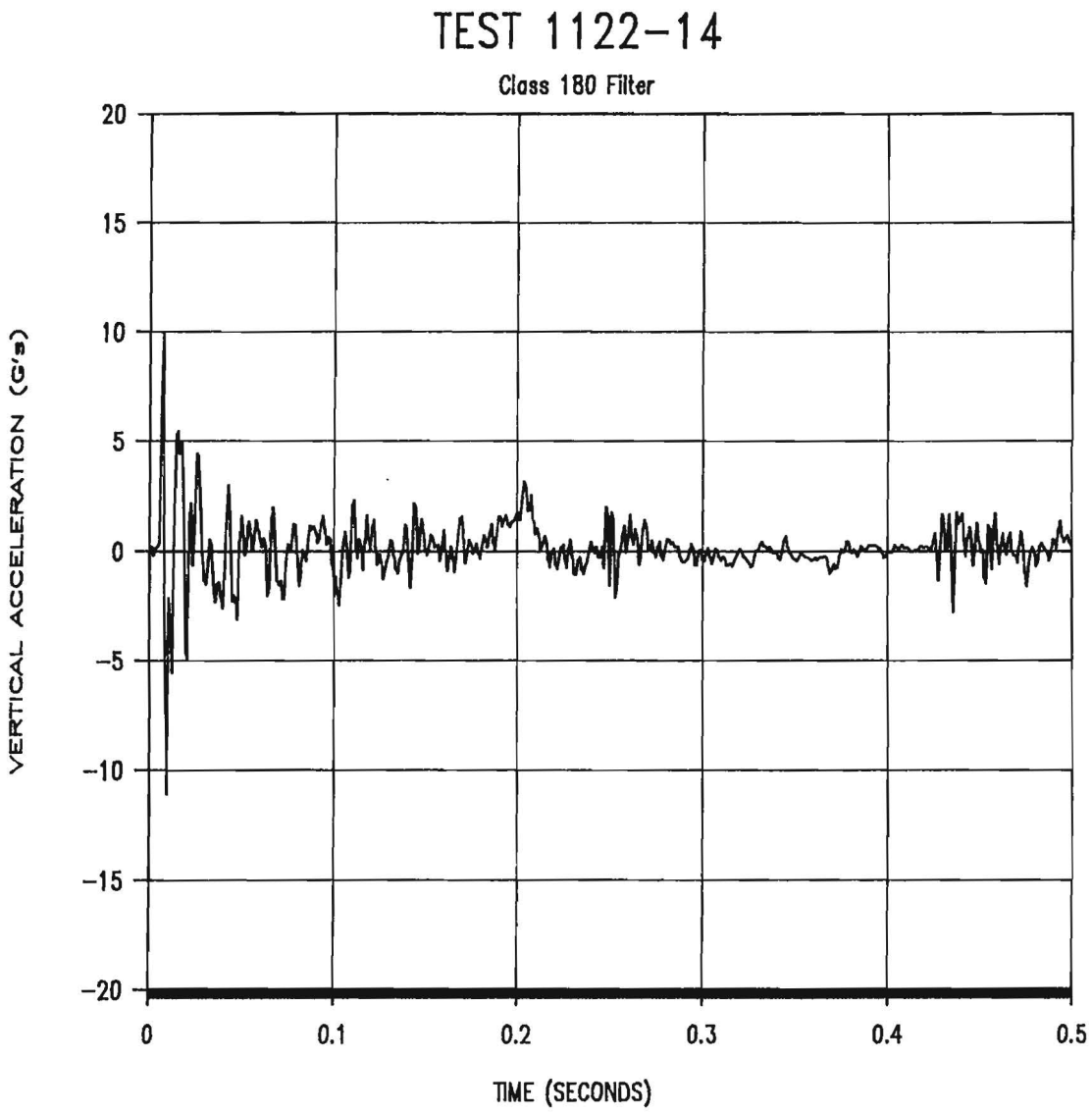


Figure 210. Vertical accelerometer trace for test 1122-14.

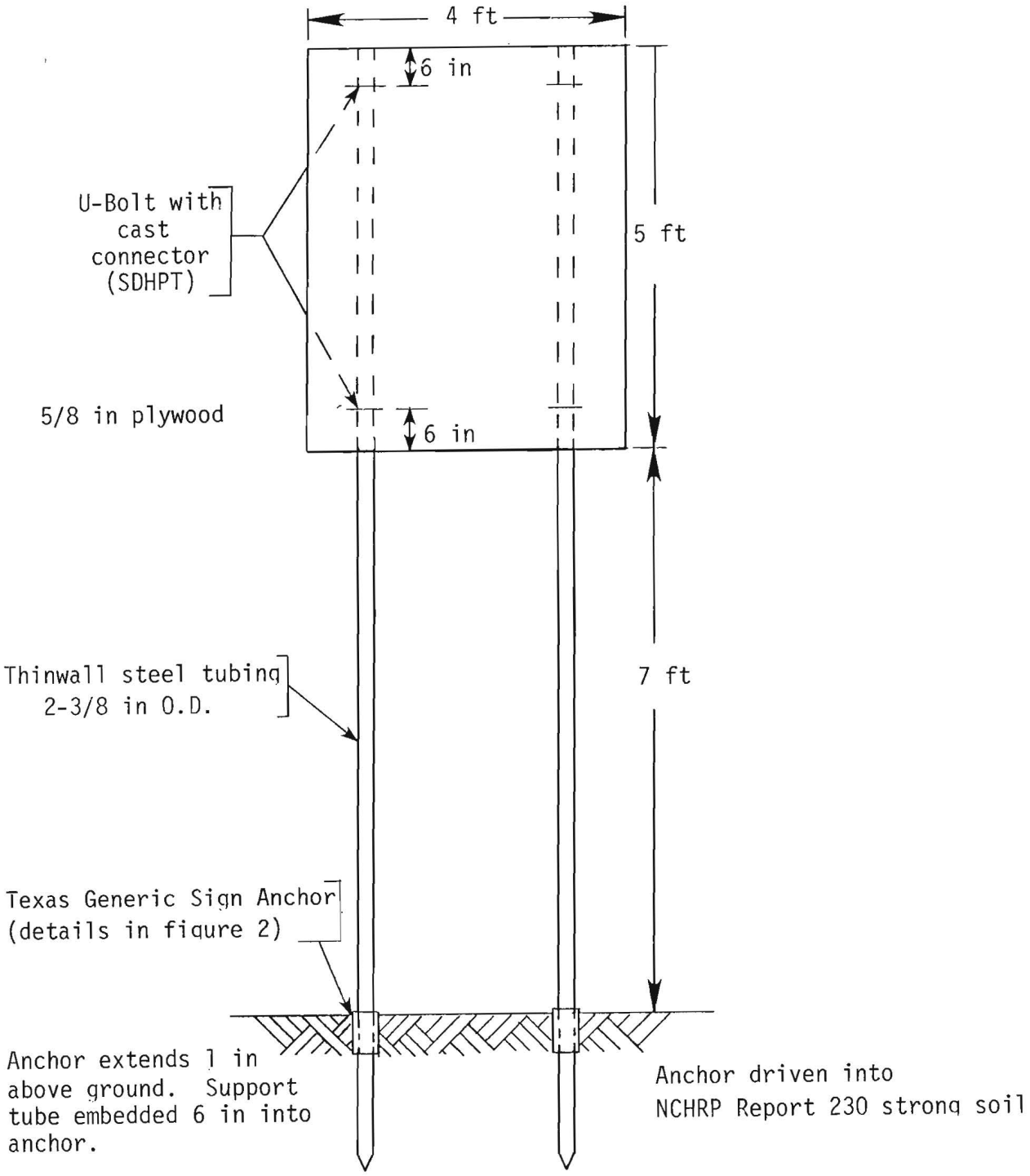
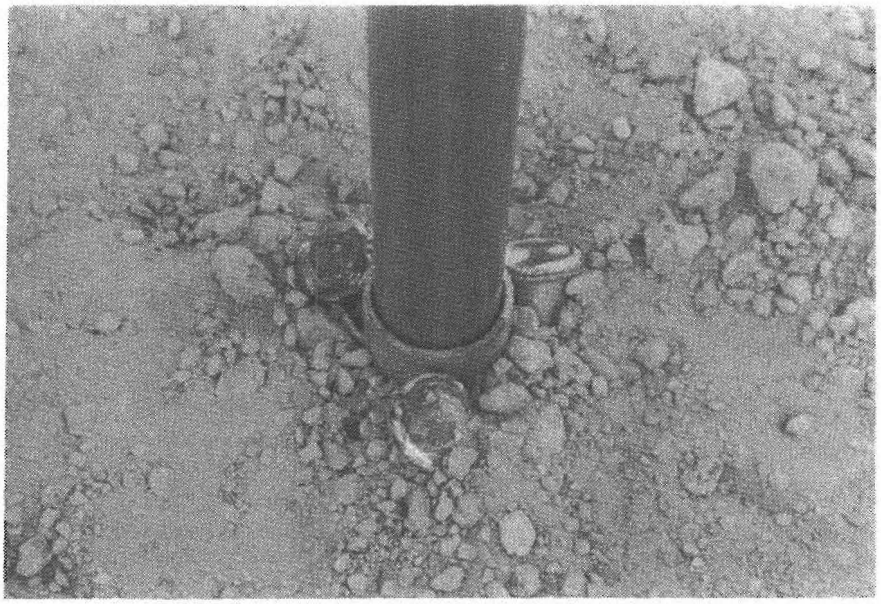


Figure 211. Details of sign installation for test 1122-15.



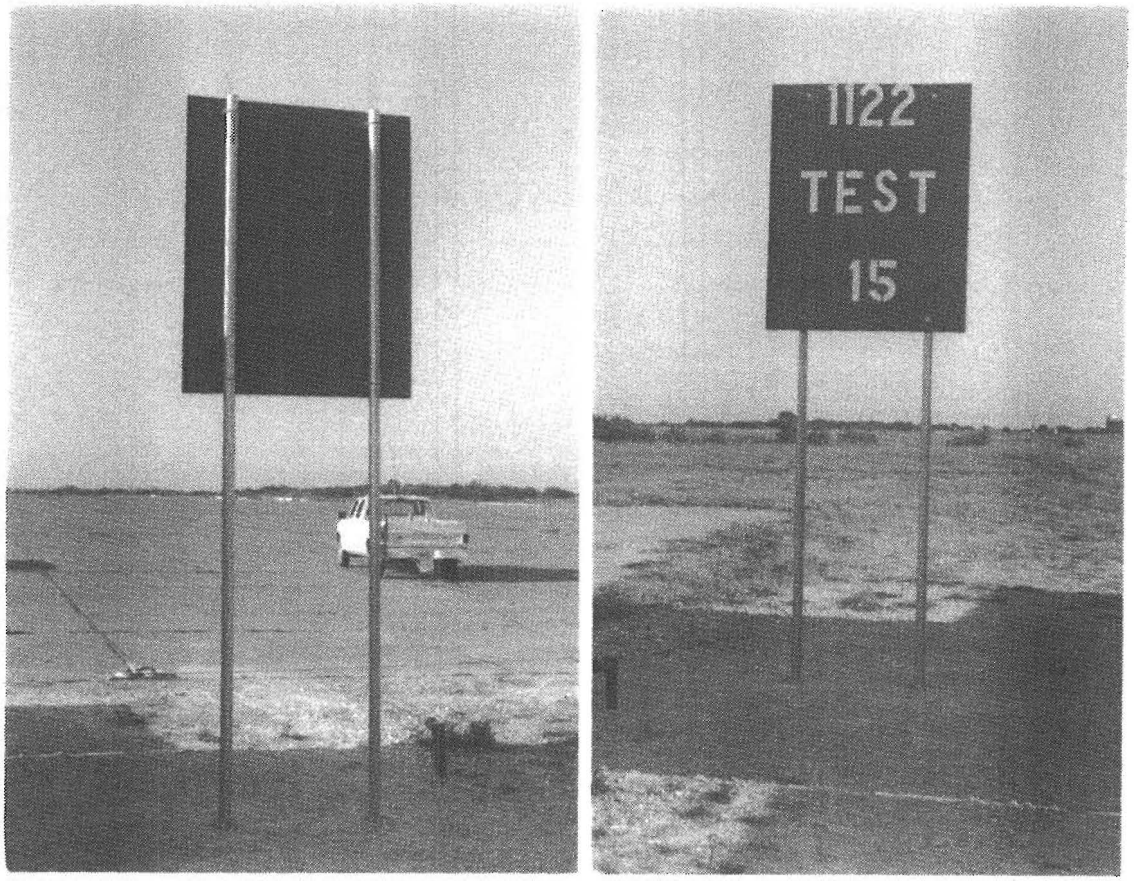


Figure 212. Sign installation before test 1122-15.

Figure 213. Vehicle before test 1122-15.

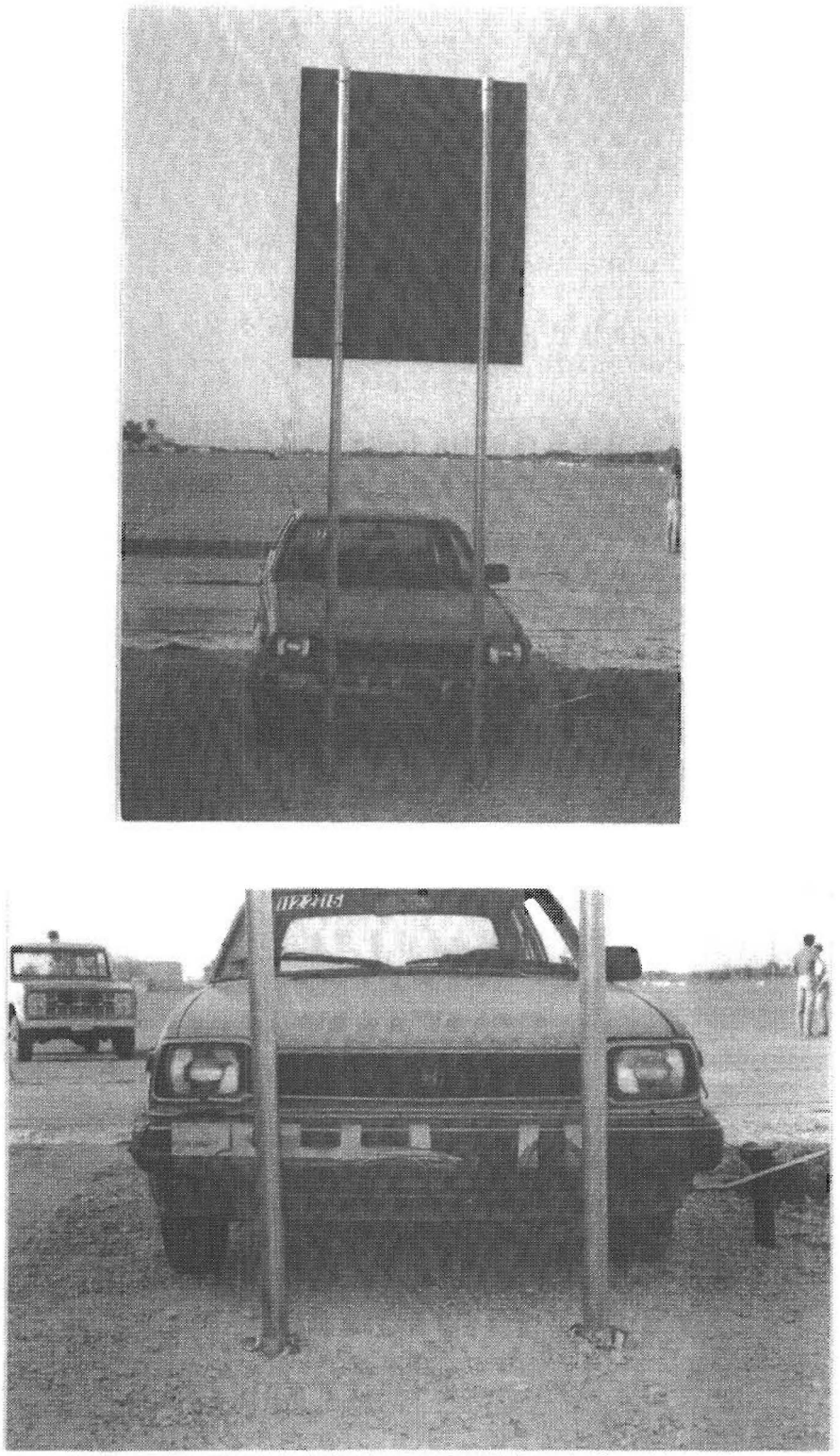


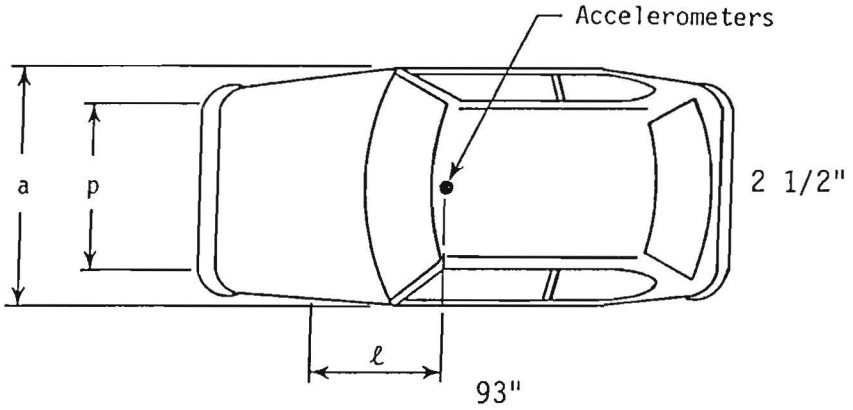
Figure 214. Sign/vehicle geometrics before test 1122-15.

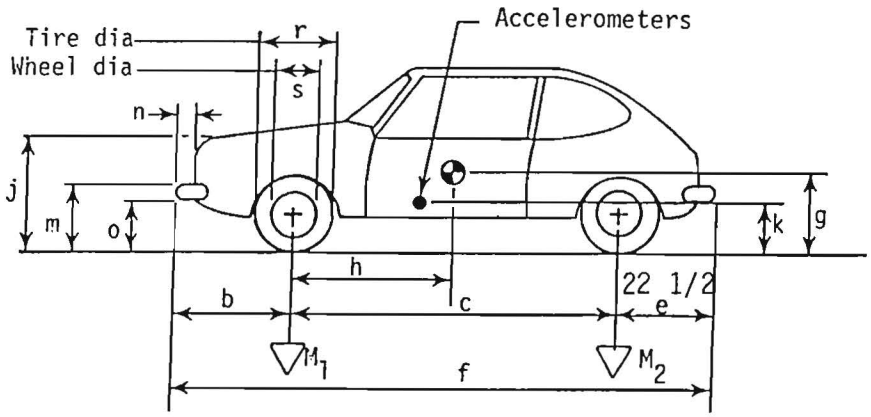
Date: 8/18/89 Test No.: 1122-15 VIN: JHMSL5320C5021206

Make: Honda Model: Civic Year: 1982 Odometer: 167982

Tire Size: 155/SR13 Ply Rating: 2 Bias Ply: ___ Belted: ___ Radial: X

Tire Condition: good ___
fair X
badly worn ___





4-wheel weight for c.g. det. ℓf 593 rf 531 ℓr 339 rr 337

Vehicle Geometry - inches

a	62 3/4	b	29
c	87 1/2	d*	53
e	29	f	145 1/2
g		h	32.86
i	----	j	29 1/2
k	16 1/2	ℓ	25 1/2
m	20	n	4
o	14	p	54 1/4
r	22	s	14 1/4

Engine Type: 4 cyl

Engine CID: ___

Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD

Body Type: Hatch

Steering Column Collapse Mechanism:
___Behind wheel units
___Convoluted tube
___Cylindrical mesh units
___Embedded ball
___NOT collapsible
___Other energy absorption
___Unknown

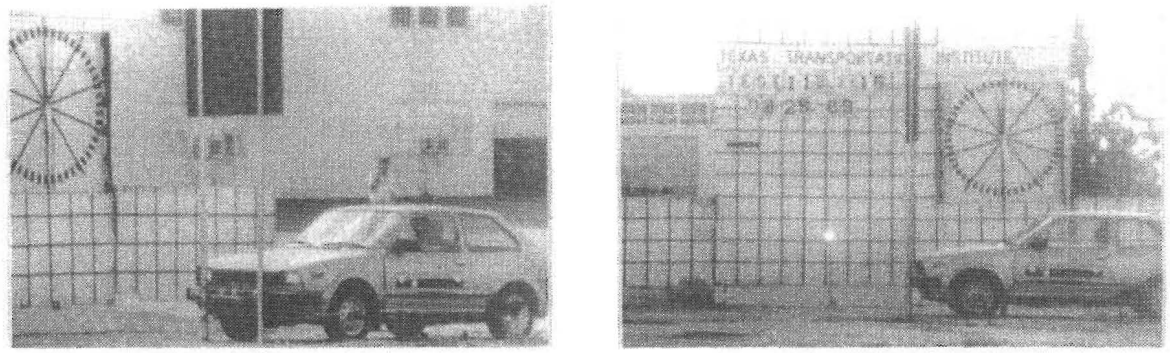
Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1106	1124	1201
M_2	683	676	767
M_T	1789	1800	1968

Note any damage to vehicle prior to test:

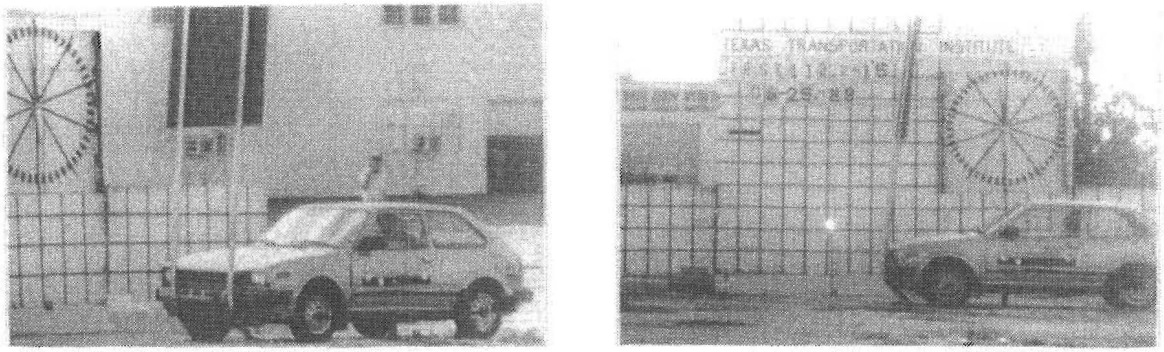
Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

*d = overall height of vehicle

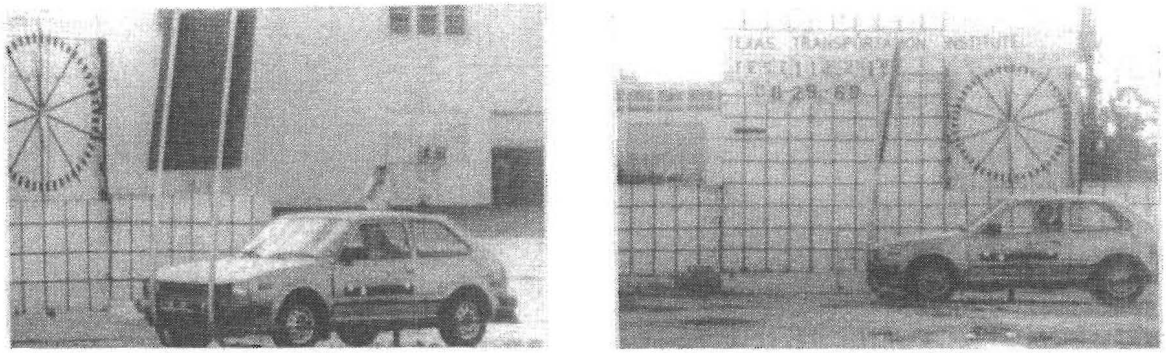
Figure 215. Vehicle properties for test 1122-15.



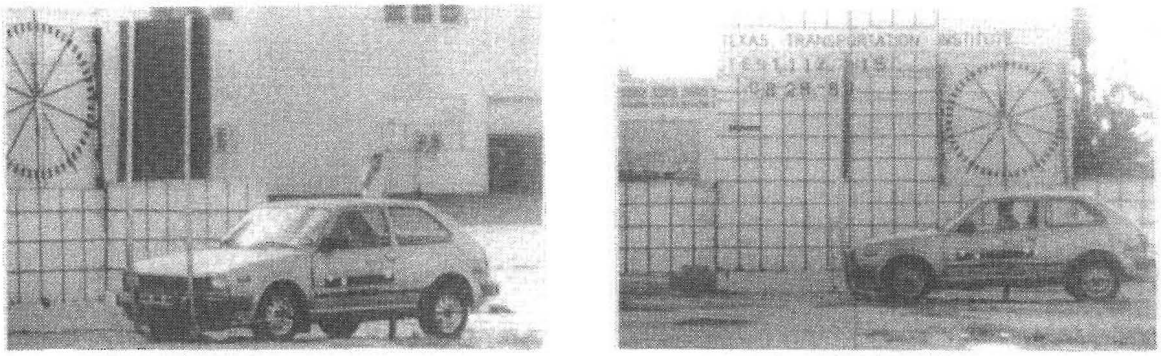
0.000 s



0.047 s

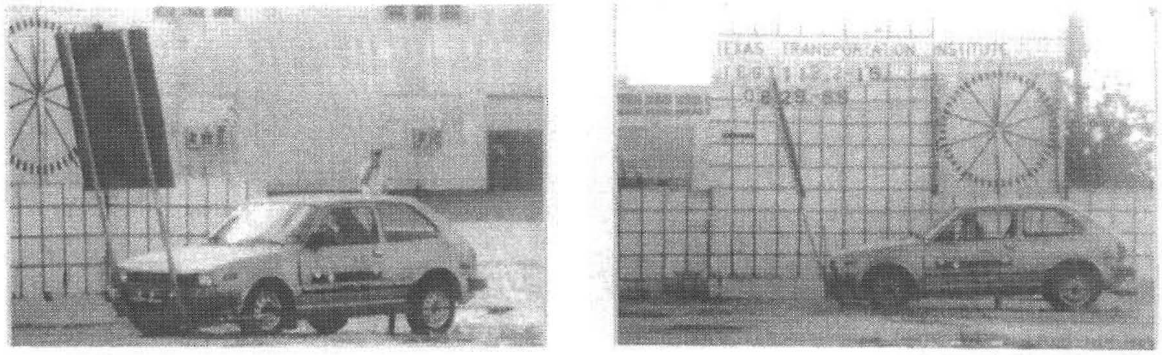


0.095 s

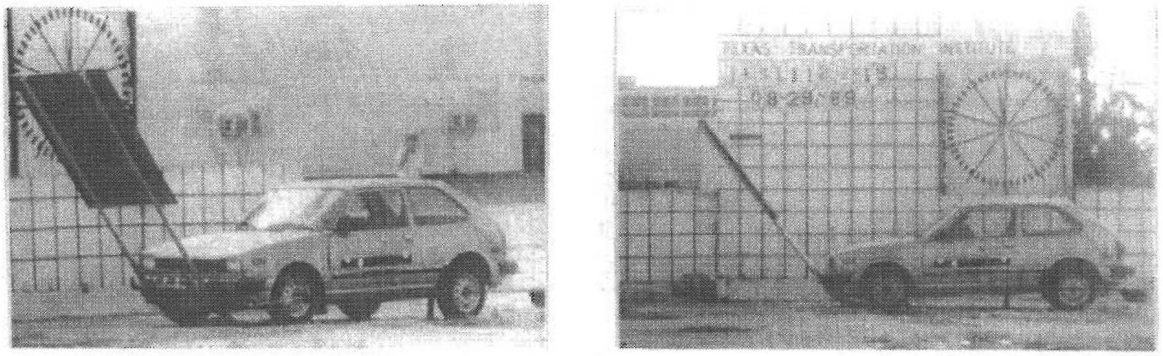


0.142 s

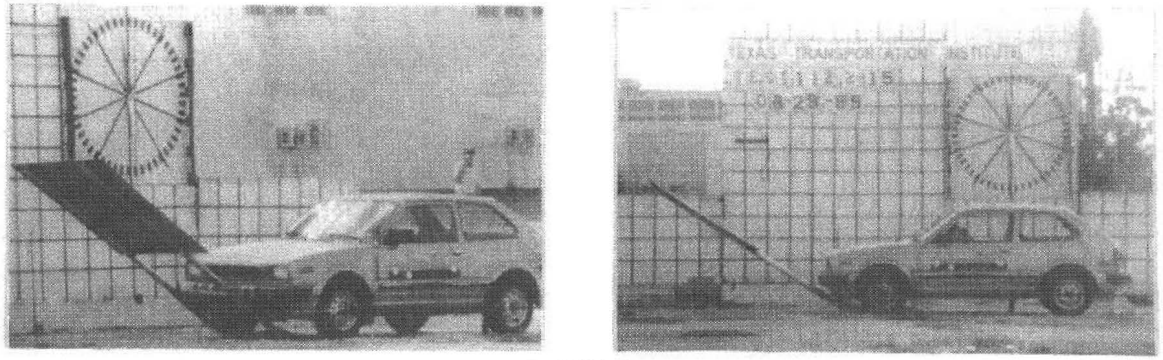
Figure 216. Sequential photographs for test 1122-15.



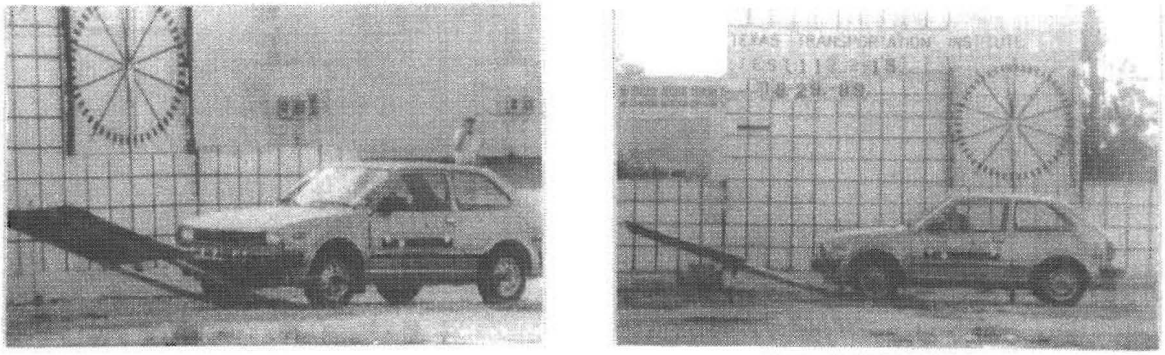
0.190 s



0.237 s

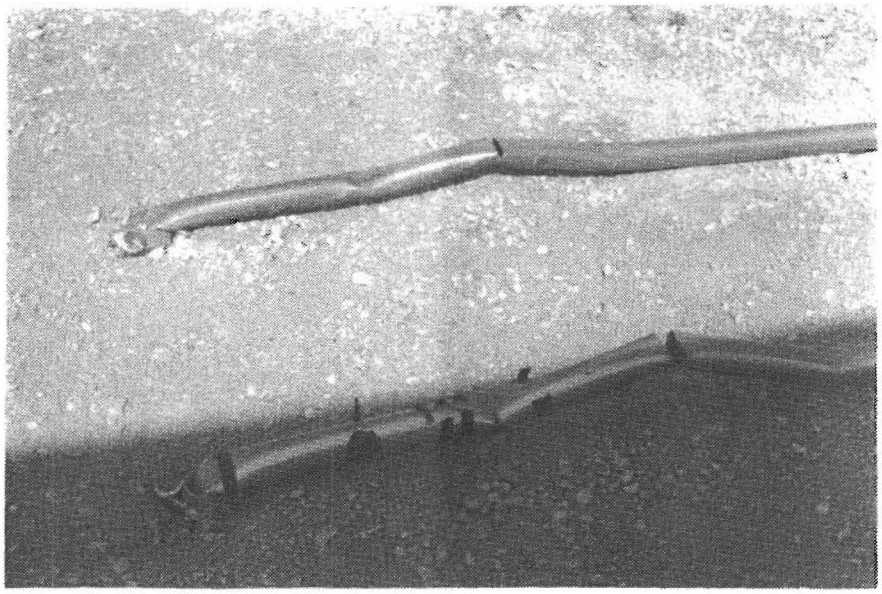


0.285 s



0.332 s

Figure 216. Sequential photographs for test 1122-15. (Continued)



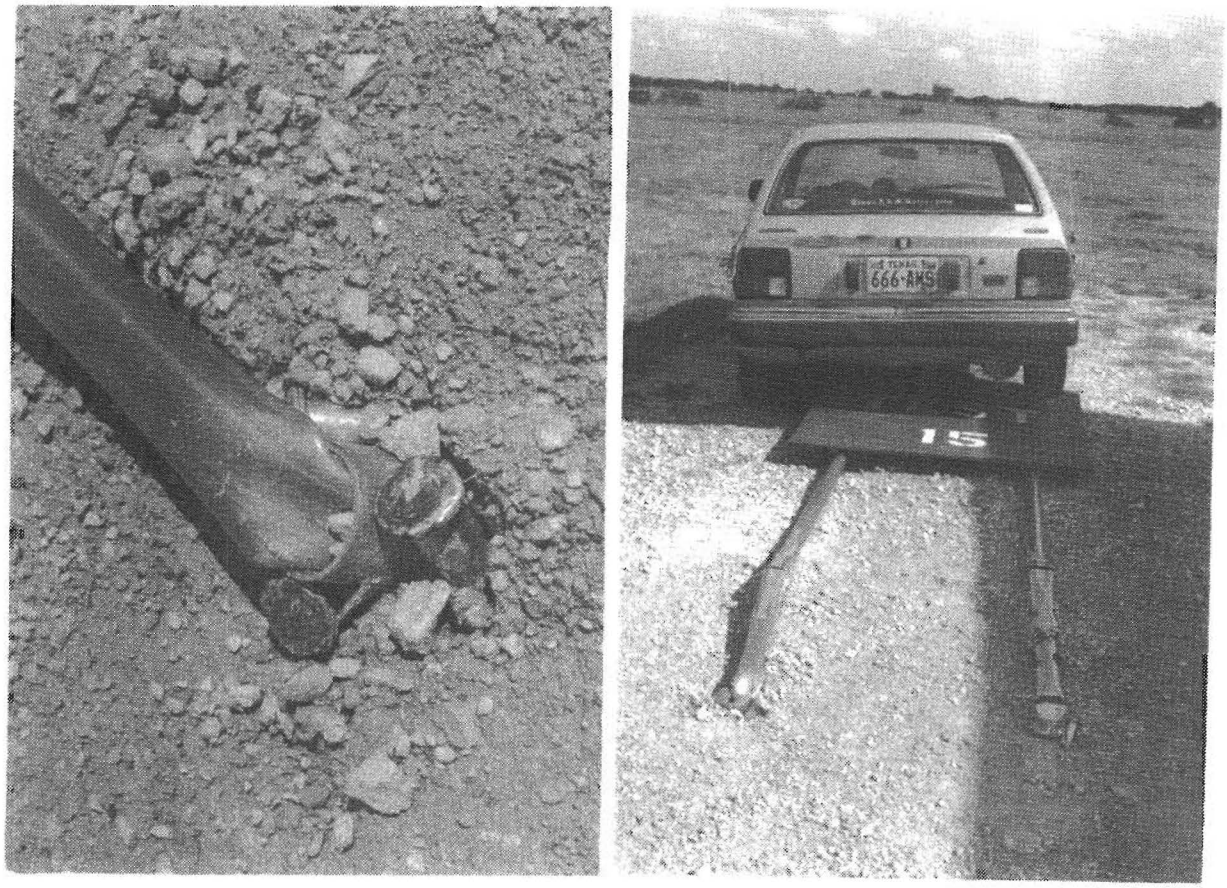


Figure 217. Sign installation after test 1122-15.

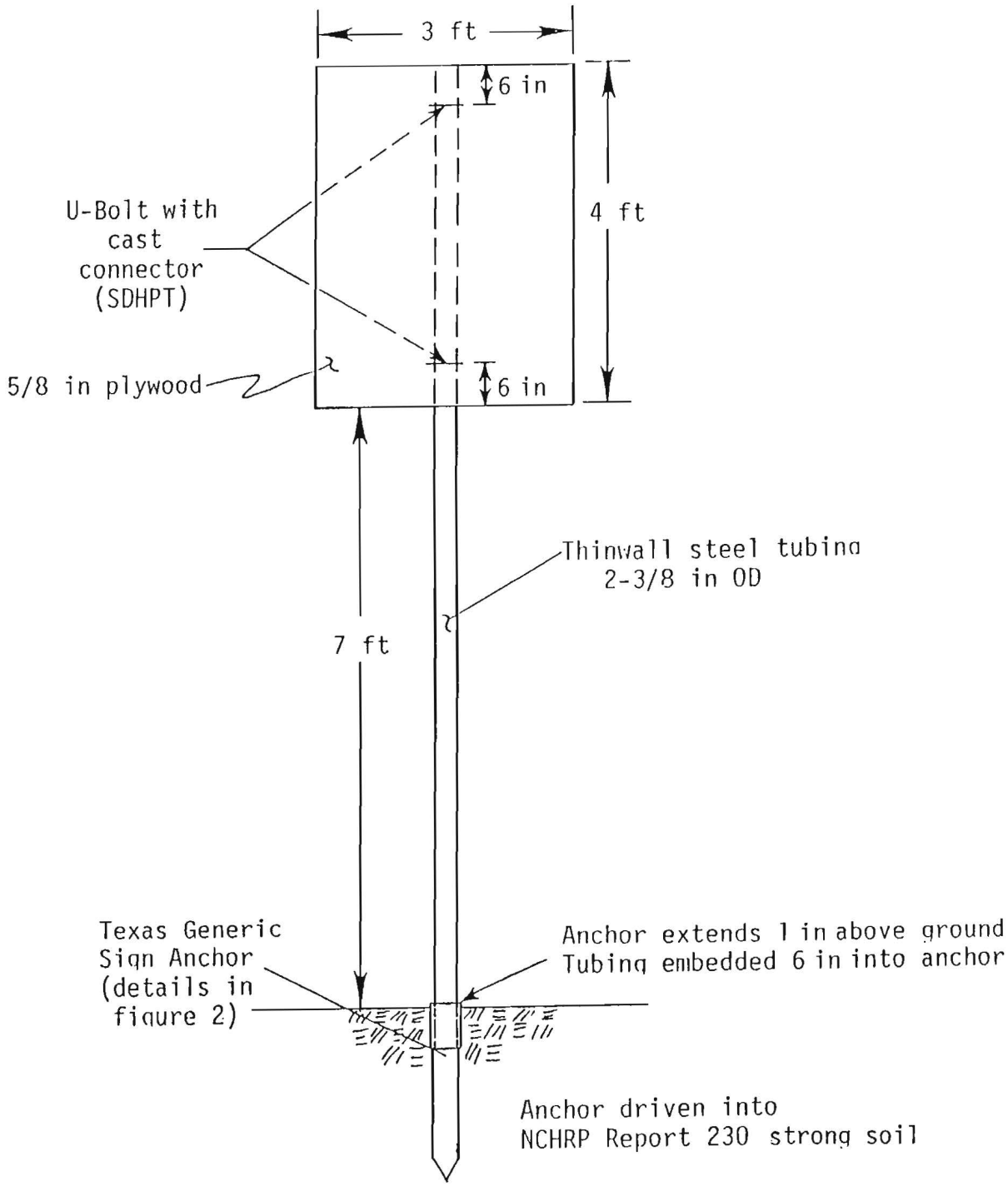
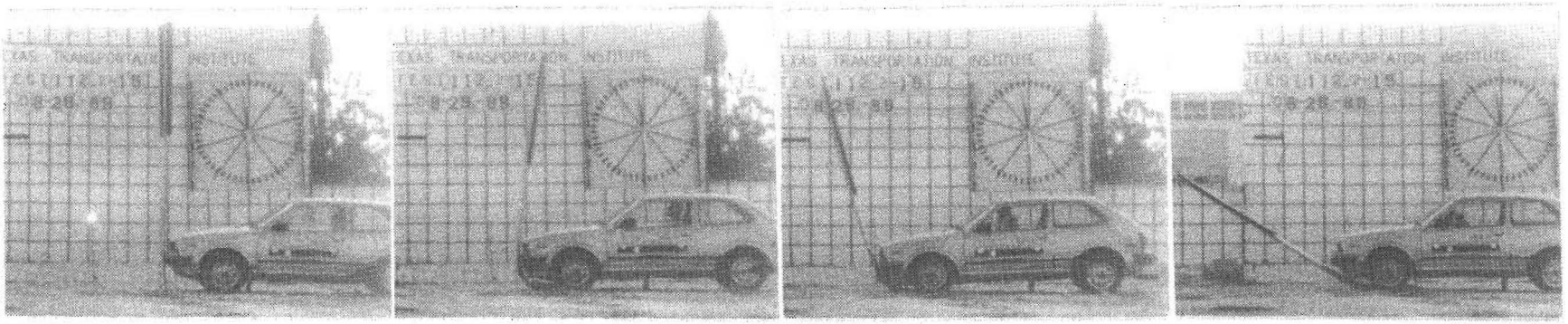
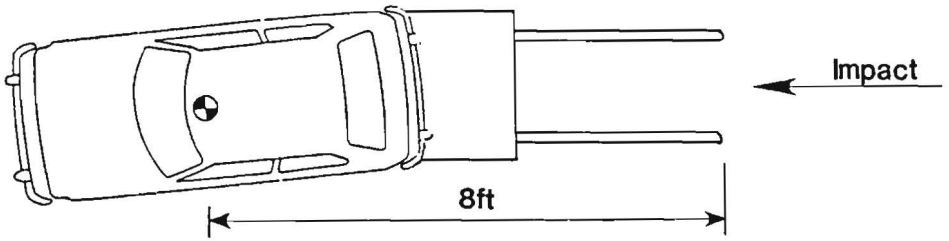


Figure 224. Testing installation details.

Figure 218. Vehicle after test 1122-15.



0.000 s 0.095 s 0.190 s 0.285 s



Test No.	1122-15
Date	08/29/89
Test Article	Sign Installation
Support	Two 2-3/8" O.D. Steel Tubing Support with Texas Generic Sign Anchor
Vehicle	1982 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (816 kg)
Gross Static	1,968 lb (893 kg)
Vehicle Damage Classification	
TAD	12FR1
SAE	12FREN1

Impact Speed	19.4 mi/h (31.2 km/h)
Change in Velocity	14.7 mi/h (23.7 km/h)
Change in Momentun	1,205 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal	-4.9 g
Lateral	-1.5 g
Occupant Impact Velocity	
Longitudinal	21.3 ft/s (6.5 m/s)
Lateral	8.8 ft/s (2.7 m/s)
Occupant Ridedown Accelerations	
Longitudinal	-4.0 g
Lateral	-1.7 g

Figure 219. Summary of results for test 1122-15.

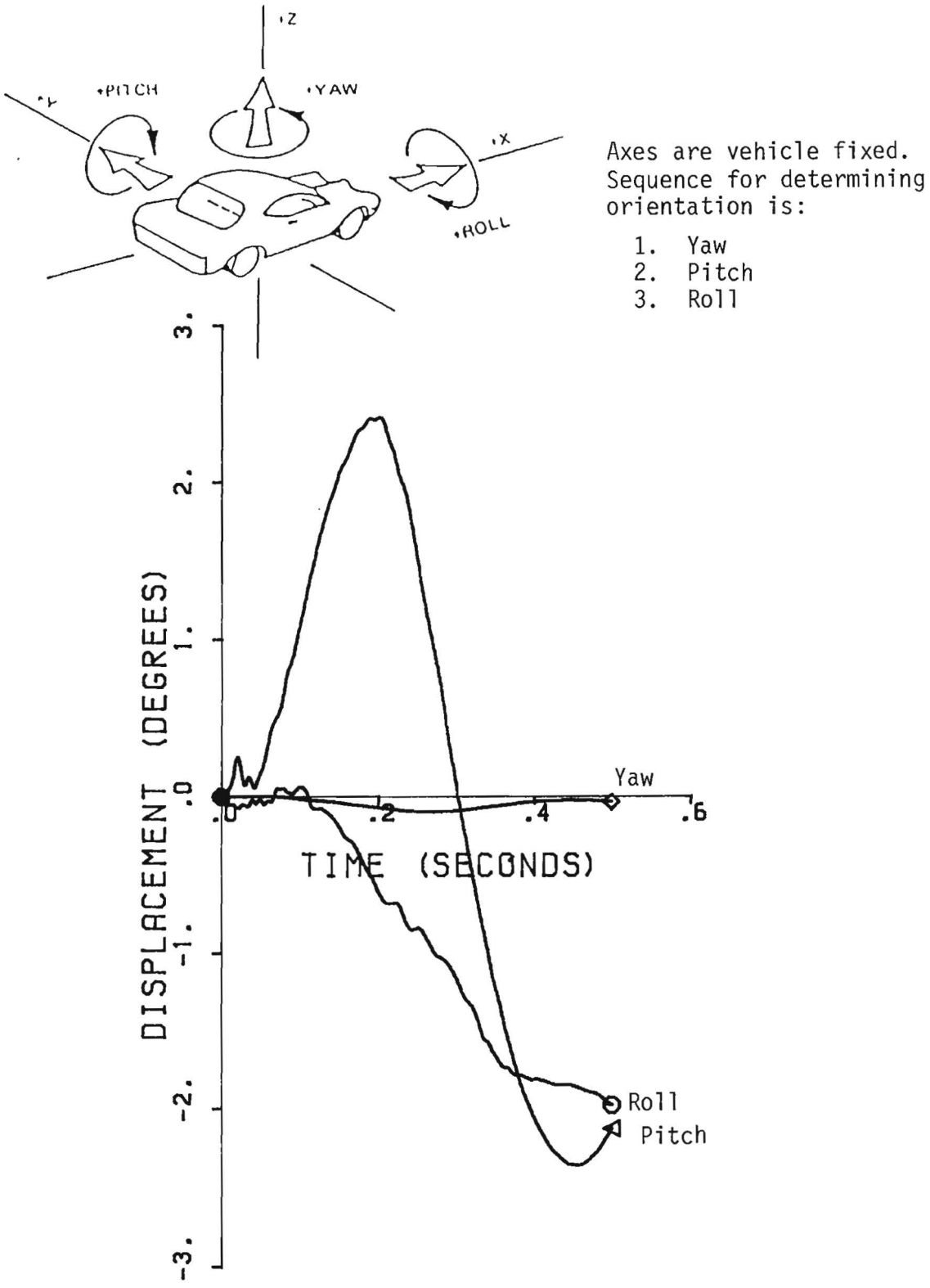


Figure 220. Vehicle angular displacements for test 1122-15.

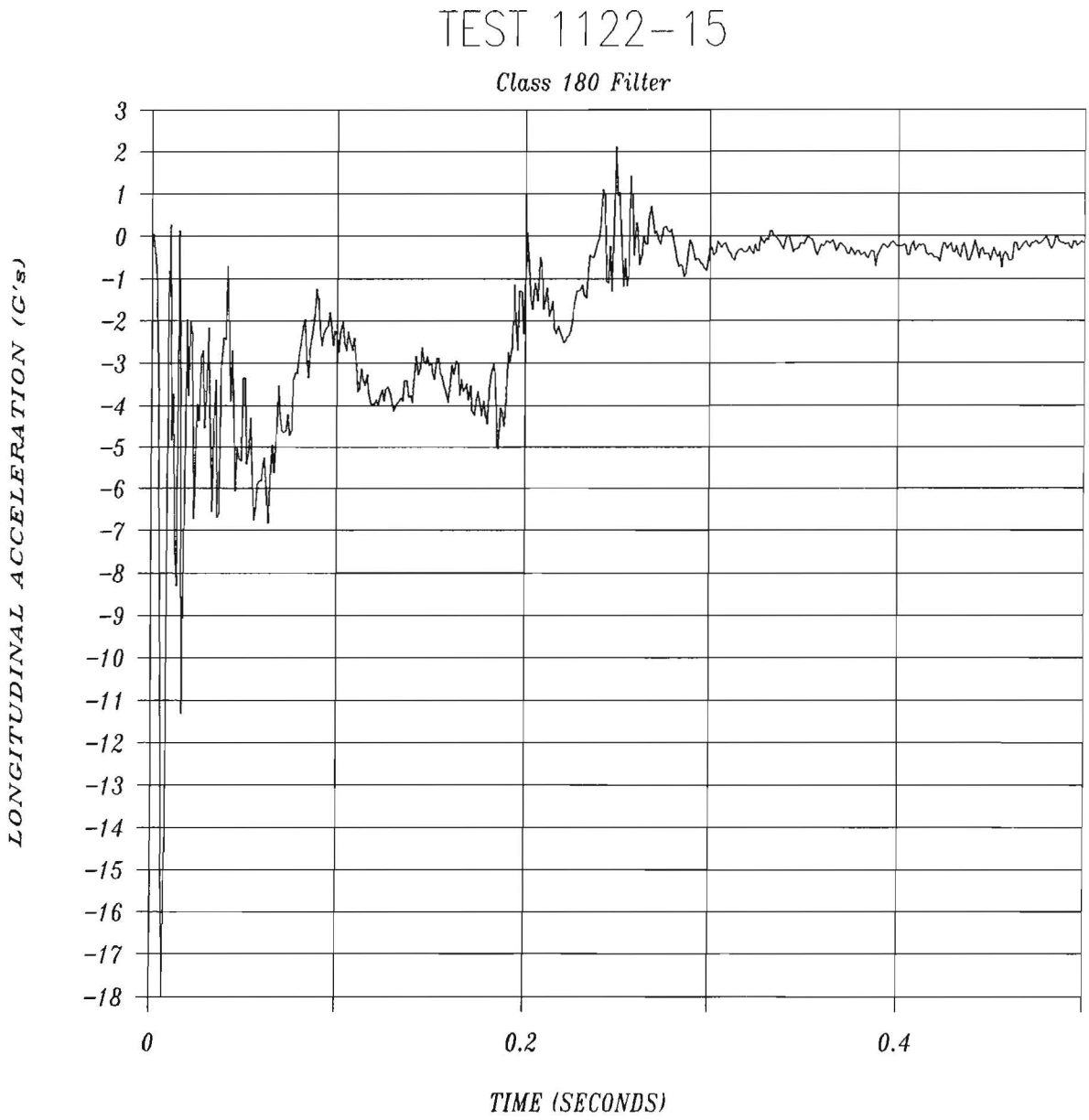


Figure 221. Longitudinal accelerometer trace for test 1122-15.

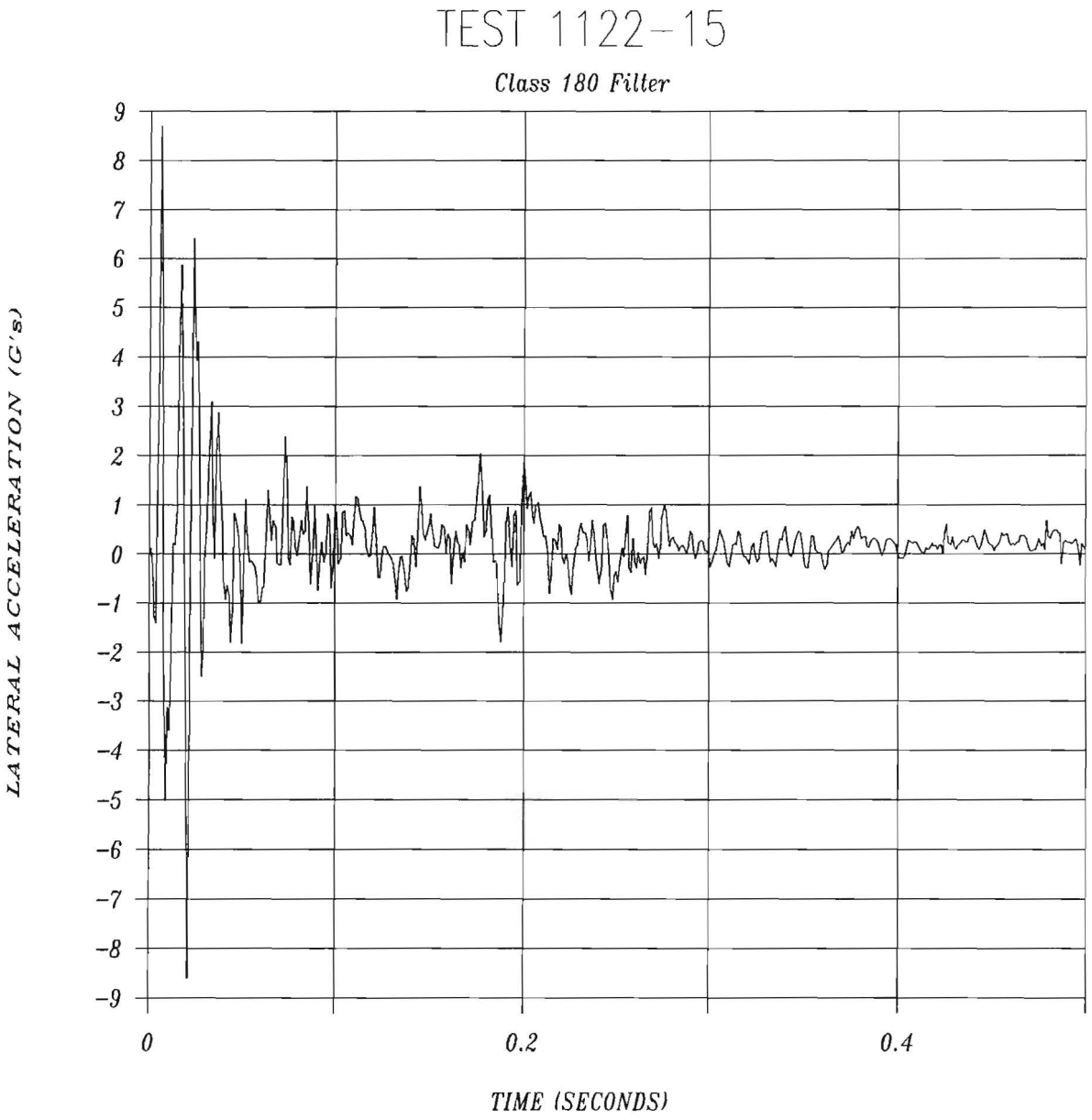


Figure 222. Lateral accelerometer trace for test 1122-15.

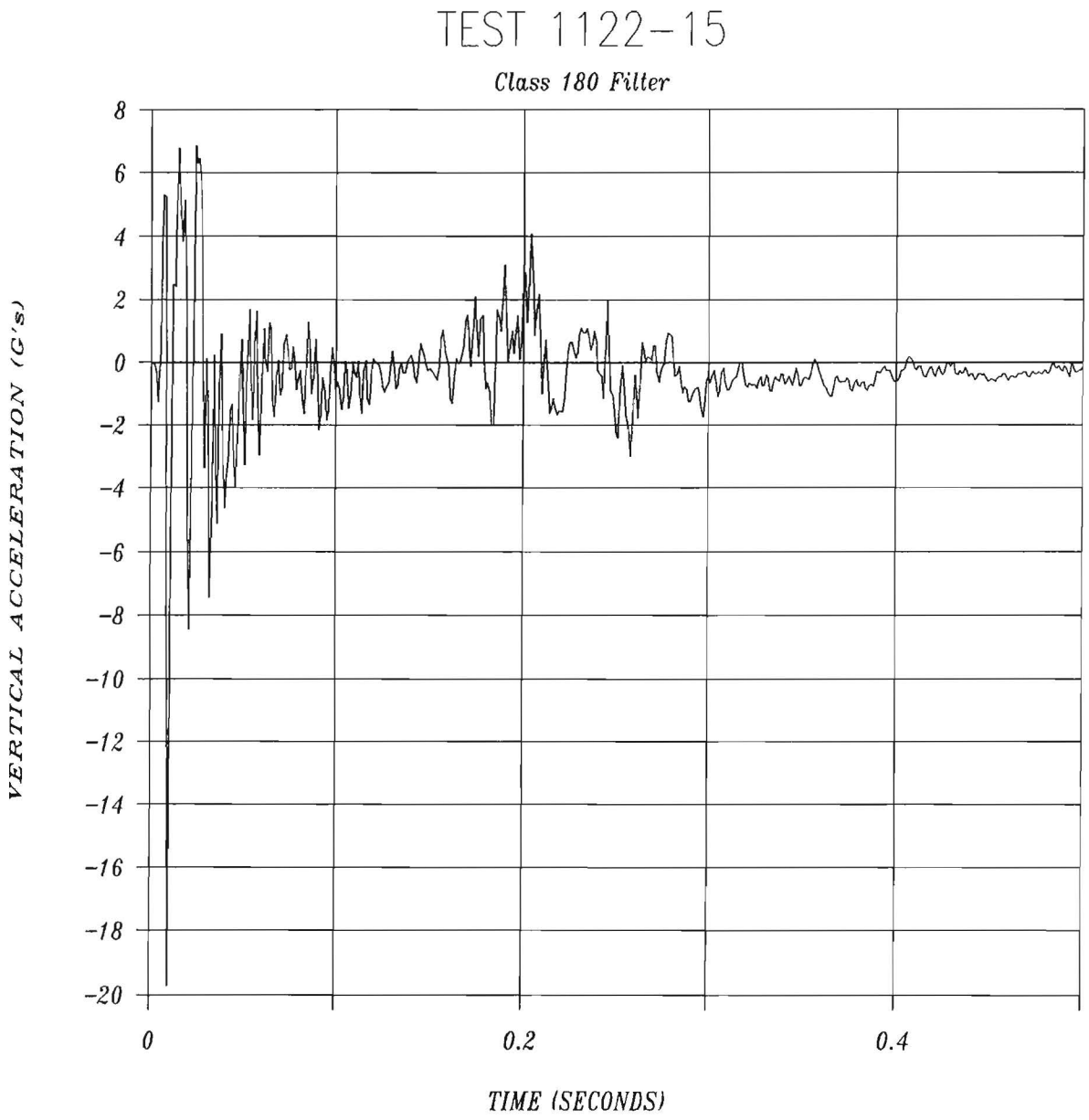
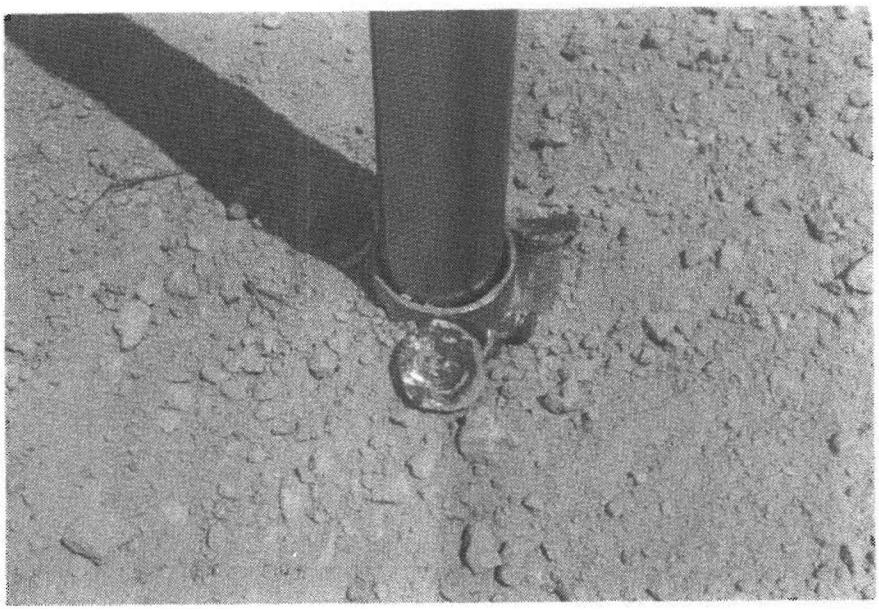


Figure 223. Vertical accelerometer trace for test 1122-15.



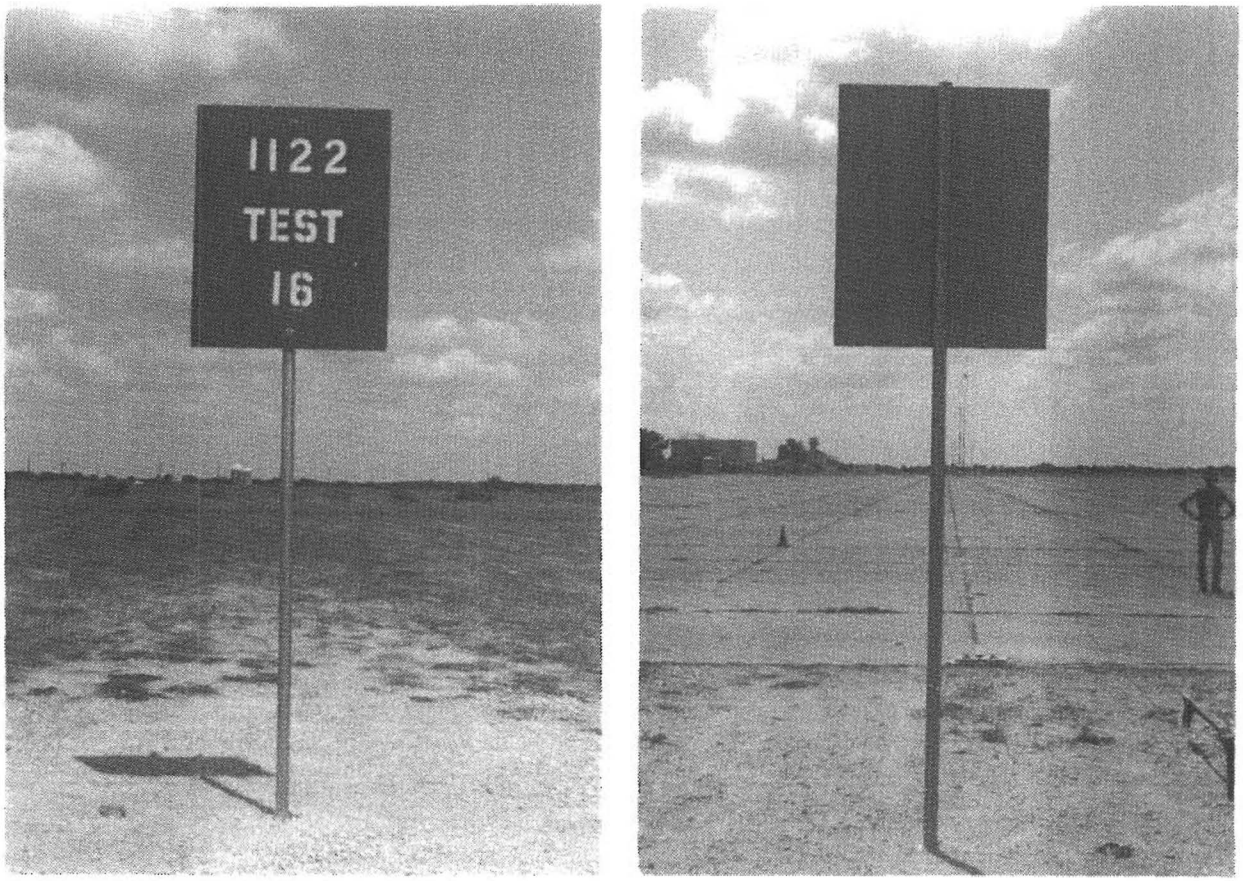


Figure 225. Sign installation before test 1122-16.

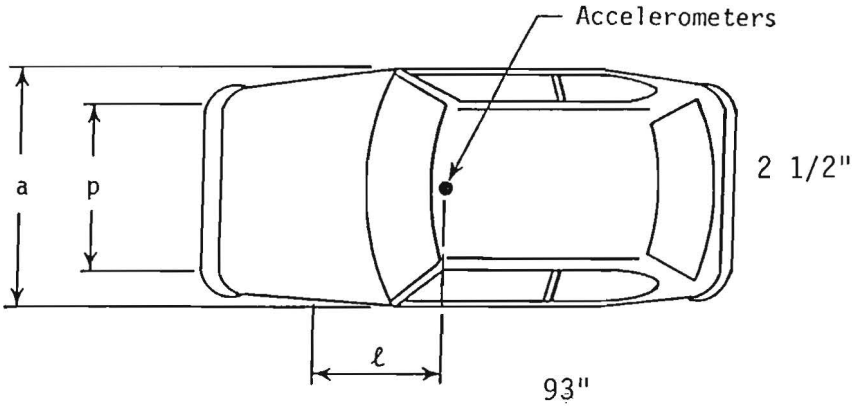
Figure 226. Vehicle before test 1122-16.

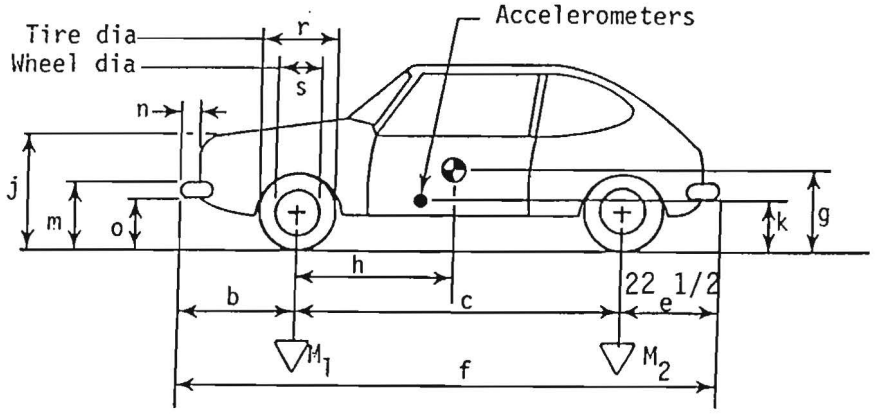
Figure 227. Sign/vehicle geometrics for test 1122-16.

Date: 8/18/89 Test No.: 1122-16 VIN: JHMSL5320C5021206

Make: Honda Model: Civic Year: 1982 Odometer: 167982

Tire Size: 155/SR13 Ply Rating: 2 Bias Ply: ___ Belted: ___ Radial: X





4-wheel weight for c.g. det. ℓf 593 rf 531 ℓr 339 rr 337

Mass - pounds	Curb	Test Inertial	Gross Static
M_1	1106	1124	1201
M_2	683	676	767
M_T	1789	1800	1968

Note any damage to vehicle prior to test:

*d = overall height of vehicle

Tire Condition: good ___
fair X
badly worn ___

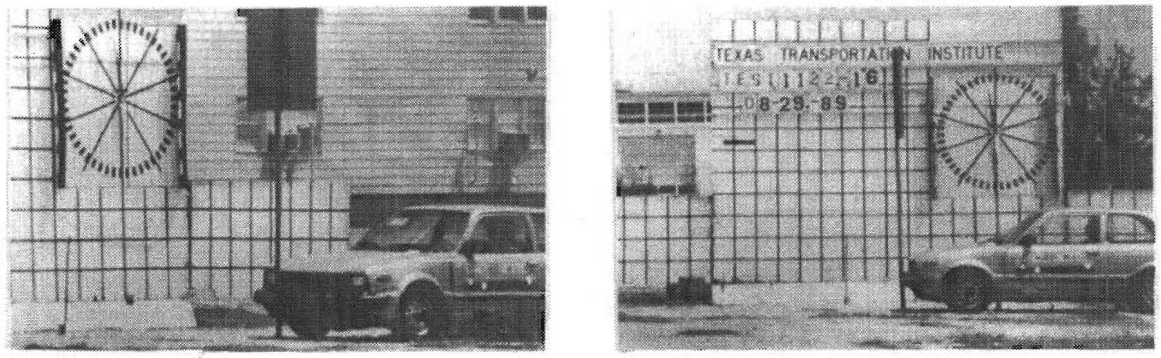
Vehicle Geometry - inches

a	62 3/4	b	29
c	87 1/2	d*	53
e	29	f	145 1/2
g		h	32.86
i	----	j	29 1/2
k	16 1/2	ℓ	25 1/2
m	20	n	4
o	14	p	54 1/4
r	22	s	14 1/4

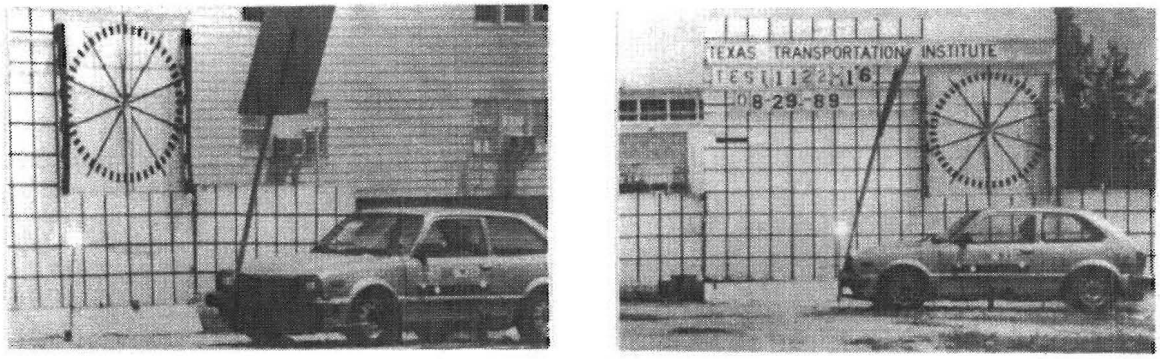
Engine Type: 4 cyl
Engine CID: ___
Transmission Type:
Automatic or (Manual)
(FWD) or RWD or 4WD
Body Type: Hatch
Steering Column Collapse Mechanism:
___ Behind wheel units
___ Convoluted tube
___ Cylindrical mesh units
___ Embedded ball
___ NOT collapsible
___ Other energy absorption
___ Unknown

Brakes:
Front: disc X drum ___
Rear: disc ___ drum X

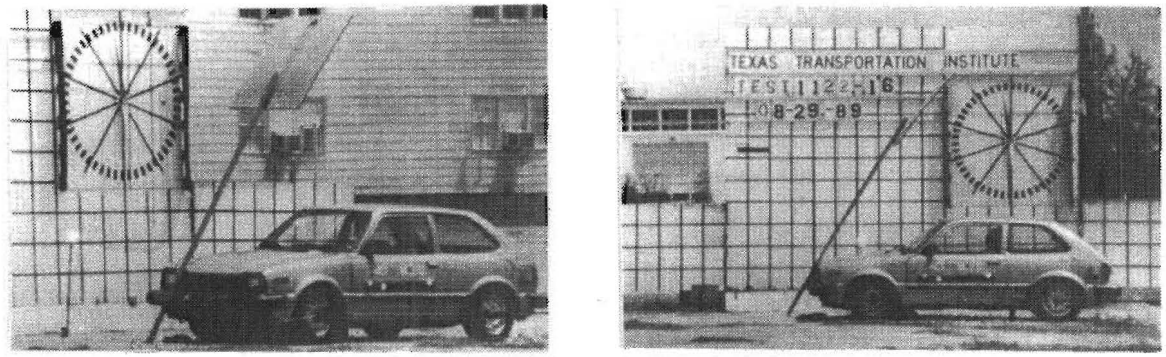
Figure 228. Vehicle properties for test 1122-16.



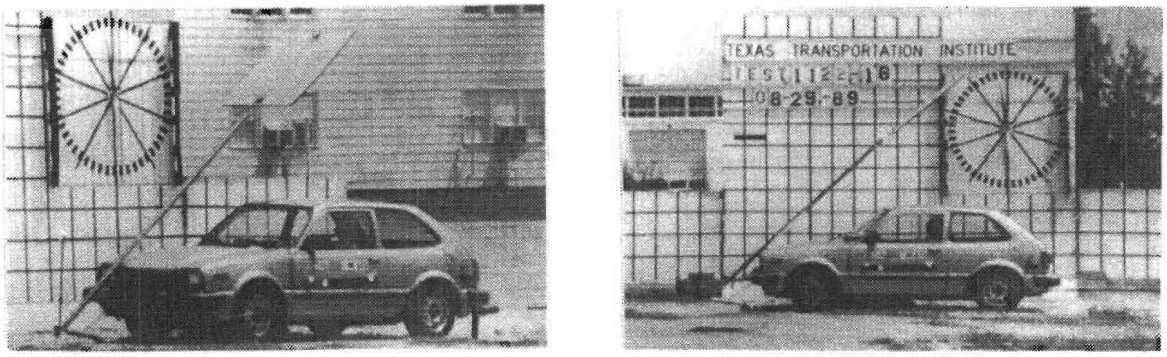
0.000 s



0.025 s

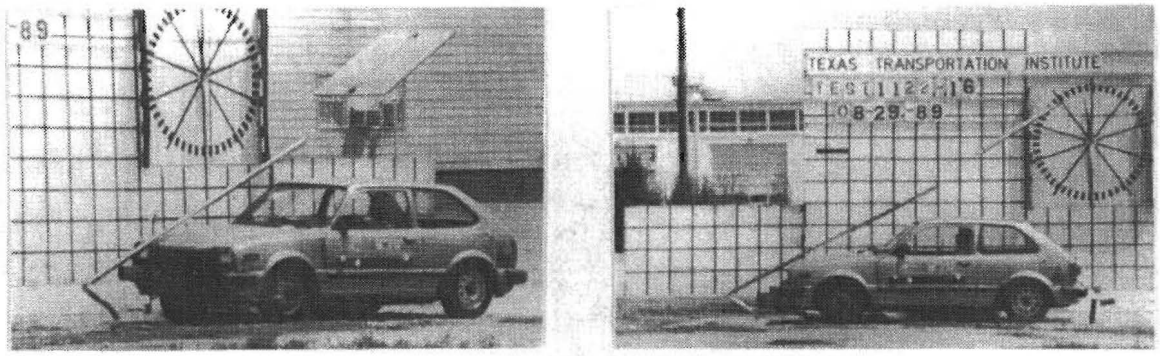


0.050 s

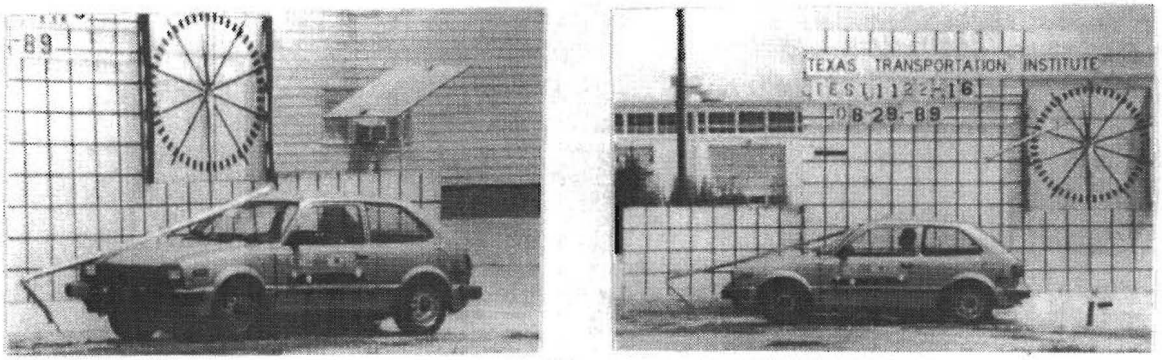


0.075 s

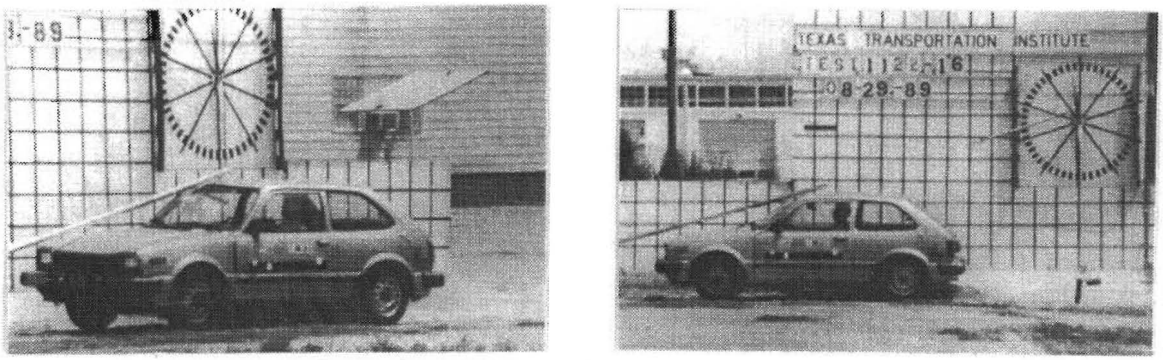
Figure 229. Sequential photographs for test 1122-16.



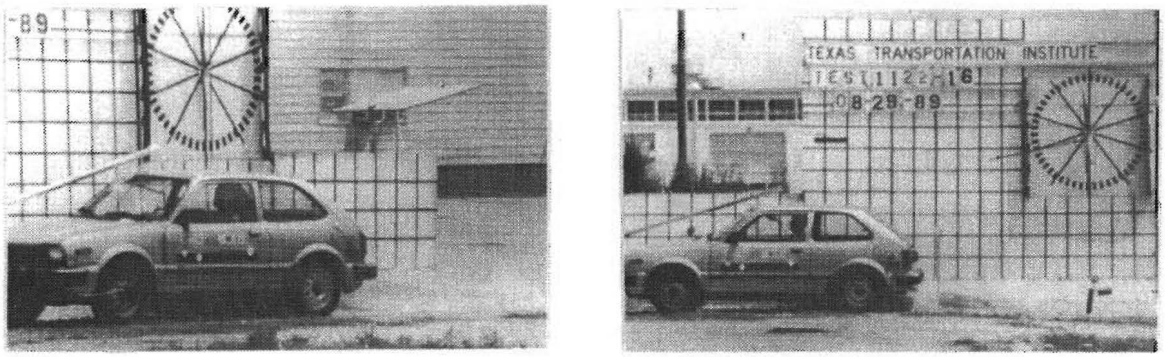
0.100 s



0.125 s



0.150 s



0.175 s

Figure 229. Sequential photographs for test 1122-16. (Continued)

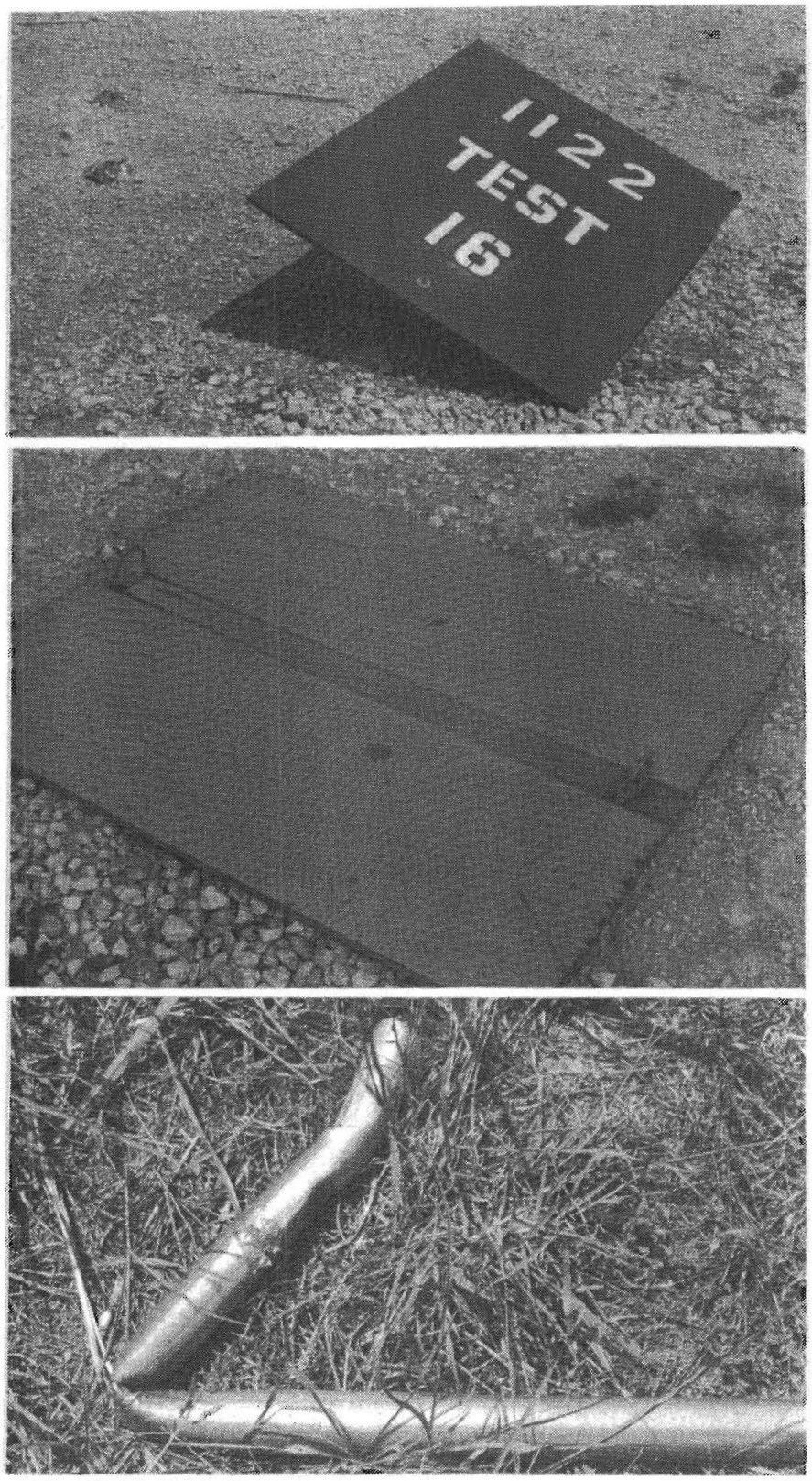


Figure 230. Sign installation after test 1122-16.

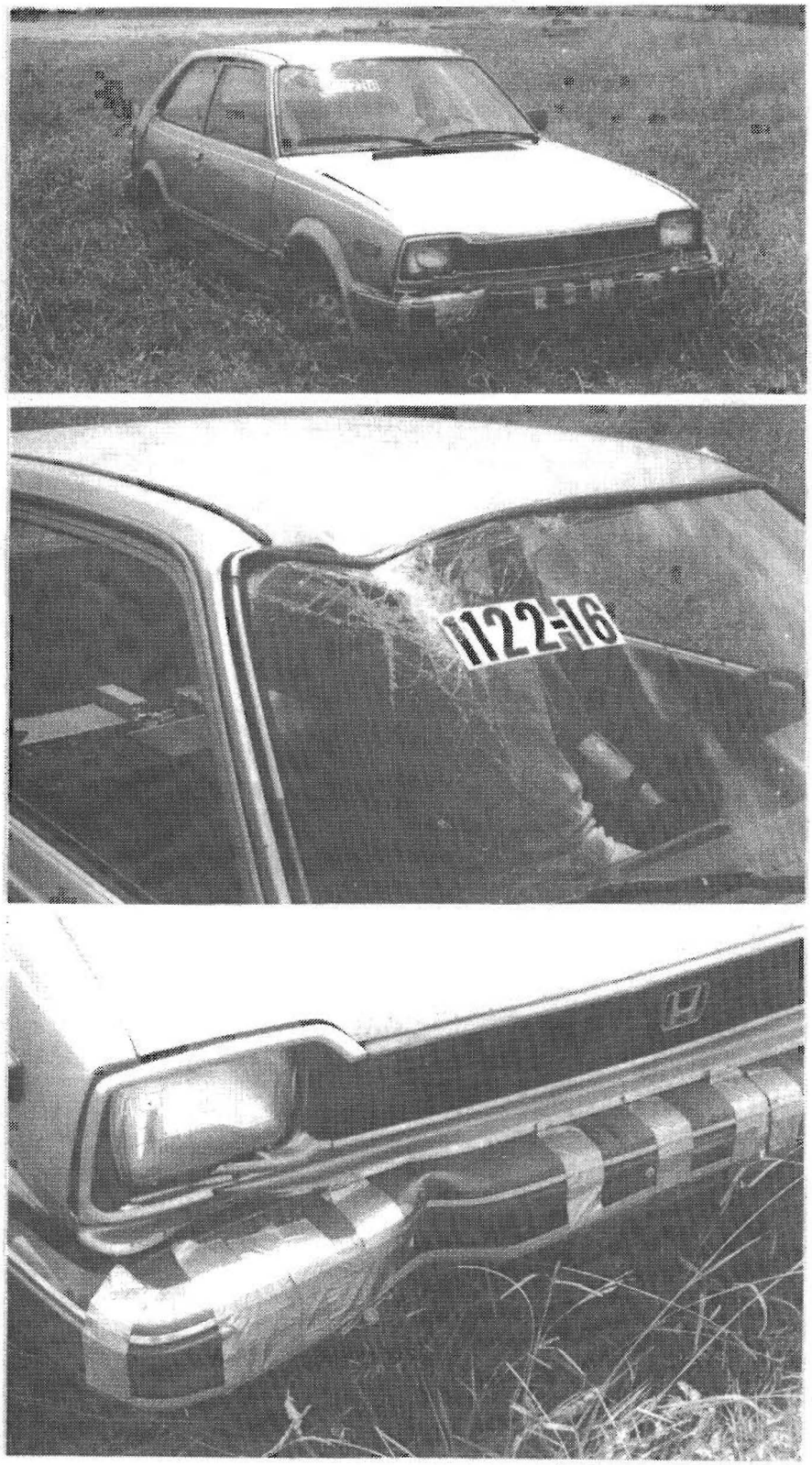
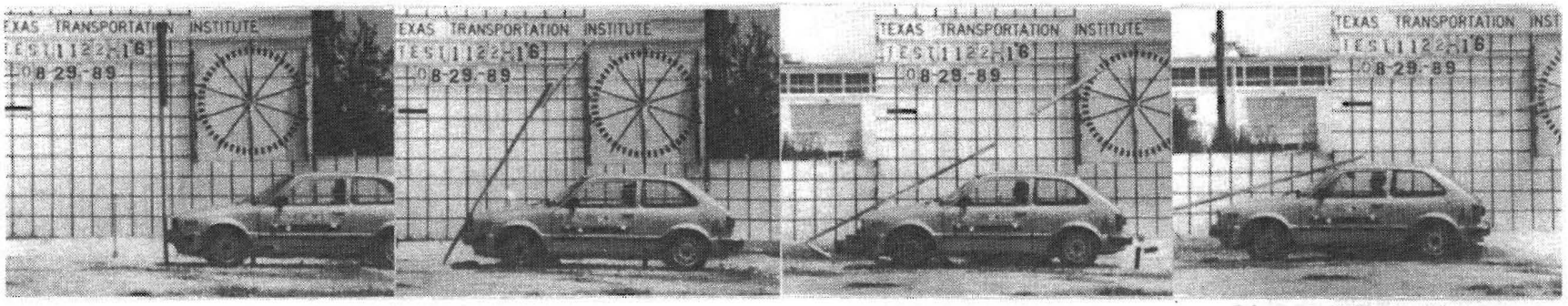
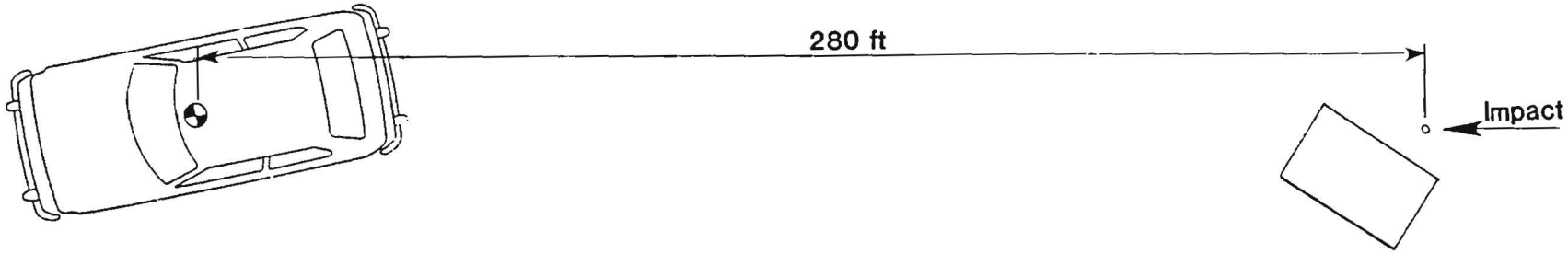


Figure 231. Vehicle after test 1122-16.



0.000 s 0.050 s 0.100 s 0.150 s



Test No.	1122-16
Date	08/29/89
Test Article	Sign Installation
Support.	Single 2-3/8" O.D. Steel Tubing Support with Texas Generic Sign Anchor
Vehicle.	1982 Honda Civic
Vehicle Weight	
Test Inertia	1,800 lb (816 kg)
Gross Static	1,968 lb (893 kg)
Vehicle Damage Classification	
TAD.	12FR1
SAE.	12FRAN1

Impact Speed	61.5 mi/h (99.0 km/h)
Change in Velocity. . . .	3.1 mi/h (5.0 km/h)
Change in Momentun. . . .	254 lb-s
Vehicle Accelerations (Max. 0.050-sec Avg)	
Longitudinal.	-2.2 g
Lateral	-1.2 g
Occupant Impact Velocity	
Longitudinal.	7.9 ft/s (2.4 m/s)
Lateral	6.2 ft/s (1.9 m/s)
Occupant Ridedown Accelerations	
Longitudinal.	-0.7 g
Lateral	-1.2 g

Figure 232.Summary of results for test 1122-16.

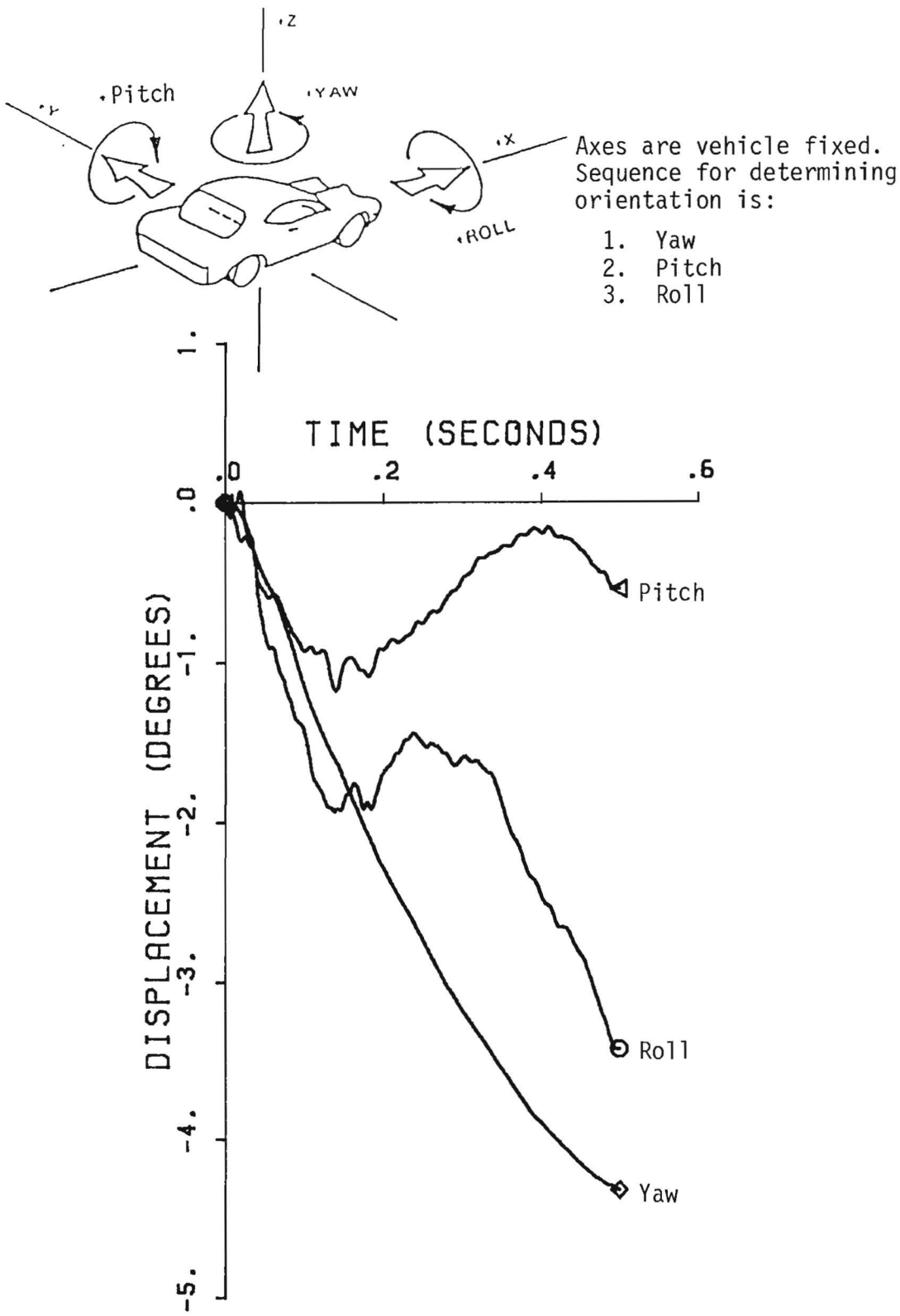


Figure 233. Vehicle angular displacements for test 1122-16.

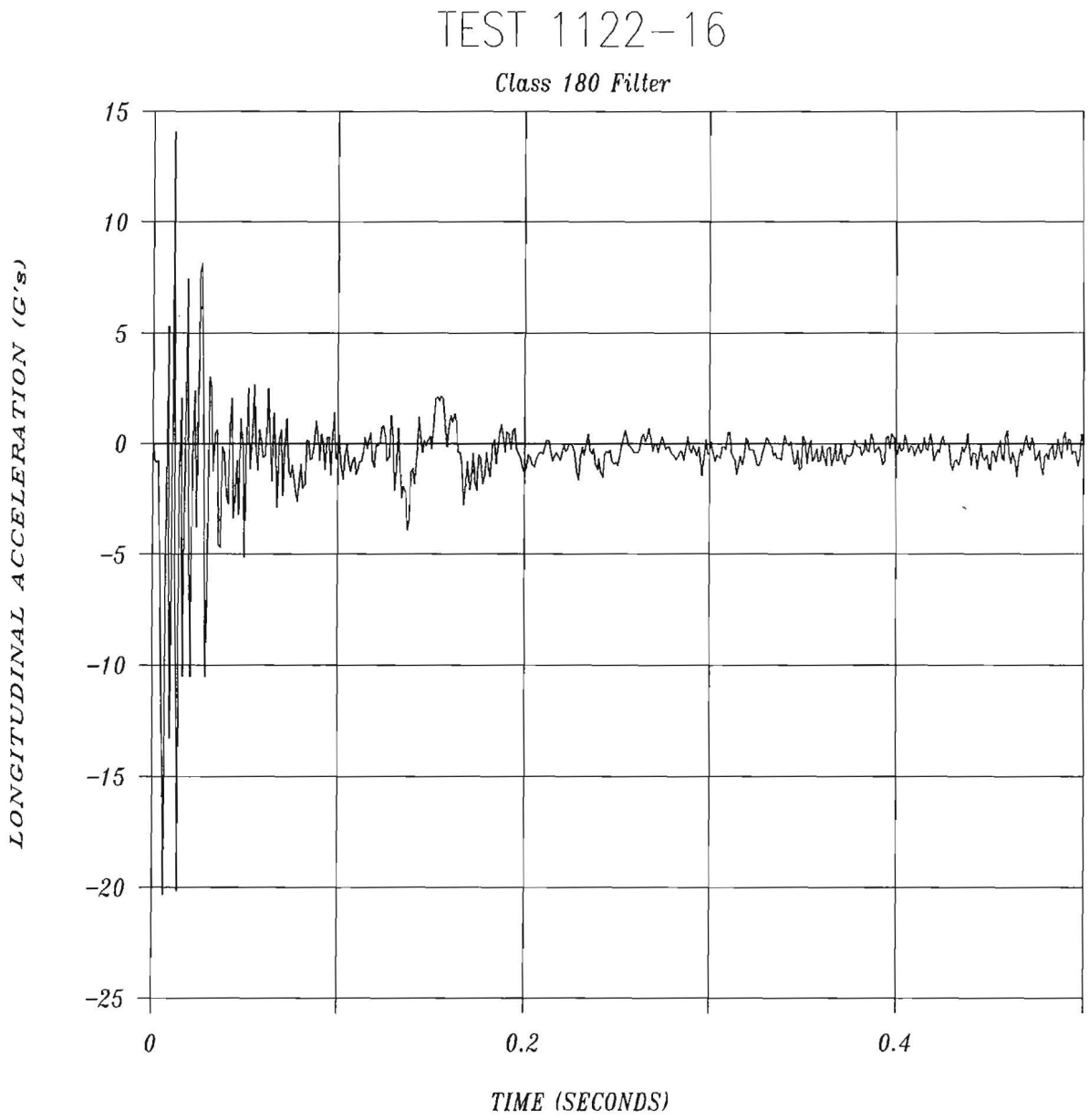


Figure 234. Longitudinal accelerometer trace for test 1122-16.

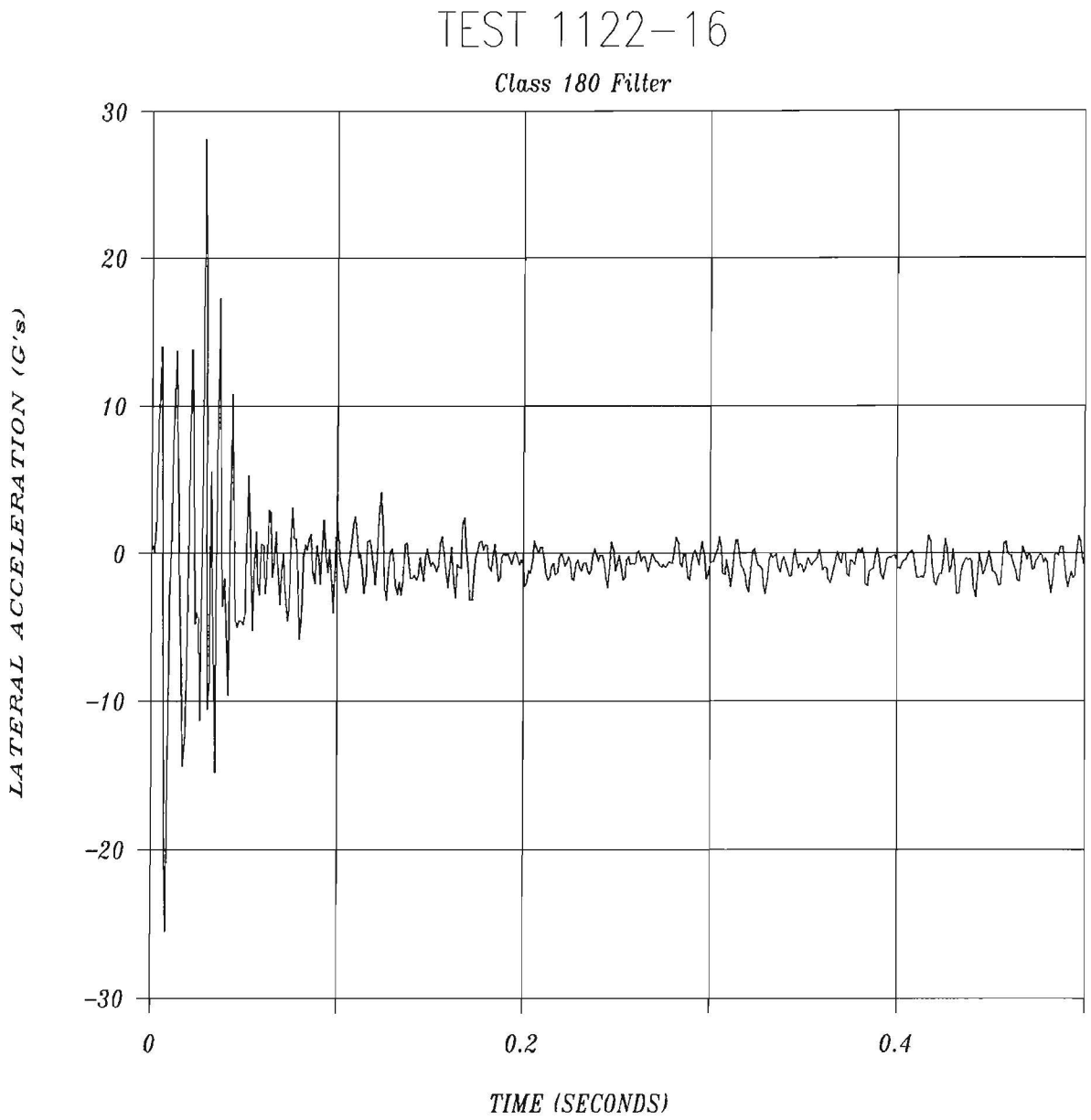


Figure 236. Lateral accelerometer trace for test 1122-16.

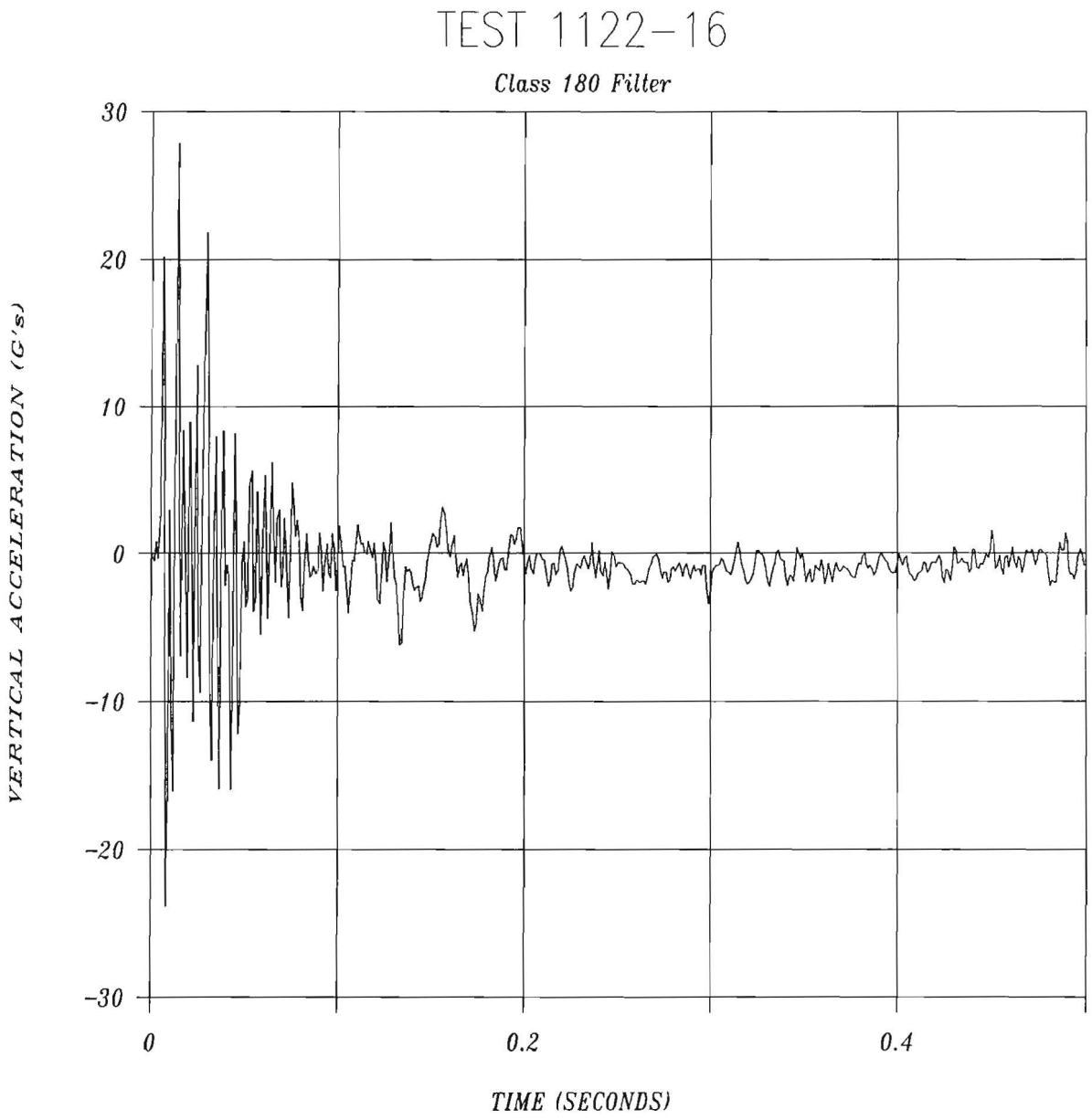


Figure 237. Vertical accelerometer trace for test 1122-16.

SUMMARY - PHASE TWO

The goal of the second phase of this project was to develop a generic small sign support system which would work for any site in the state. Such a system was developed, tested, and passed for single post installations.

The criteria used in the development of the Texas generic sign support system were:

(a) The system provides adequate wind load resistance and satisfactory impact performance in both "weak" and "strong" soils (as defined by NCHRP 230).

(b) The system can be installed easily in both "strong" and "weak" soils.

(c) The system is easily manufactured with commonly found materials.

(d) The system is capable of supporting 12 - 13 square foot sign blanks per support at a 7 foot mounting height.

(e) The anchor can be used for any tubular sign support.

(f) The anchor system is reusable after an impact.

Although promising, further development and testing will be required before dual post generic small sign support systems can be implemented in the field. It is believed that minor modifications to the anchor system will be sufficient to achieve this goal.

REFERENCES

1. Bronstad, M.E. and J.D. Michie, "Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances," National Cooperative Highway Research Report 153, 1974.

2. Michie, Jarvis D., "Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances," Transportation Research Circular 191, February 1978.

3. Michie, Jarvis D.,"Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances," National Cooperative Highway Research Report 230, March 1981.

4. "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals,"American Association of State Highway and Transportation Officials, 1985.

5. Morgan, J.R.,H.E. Ross, and R.E. Schuler,"Small Sign Support Analysis: Static, Pendulum and Full-Scale Crash Test Programs," Draft Report 7024-2, Texas Transportation Institute, Texas A&M University, August 1987.

6. Ross, H.E., K.C. Walker, and M.J. Effenberger,"Crash Tests of Small Highway Sign Supports," Report No. FHWA/RD-80/502, Federal Highway Administration, May 1980 Interim Report.

7. Ross, H.E.,T.J. Dolf, and K.C. Walker, "Crash Test Evaluation of Small Signs Impacted from the Side," Research Report 0941-1, Texas Transportation Institute, Texas A&M University, October 1979.

8. Bloom, J.A. and J.A. Hinch, "Laboratory Evaluation of Existing Breakaway Structures, Volume II Technical Results," Report FHWA/RD-79/140, ENSCO, June 1980.

9. Ross, H.E., J.L. Buffington, G.D. Weaver, and D.L. Schafer, "State of the Practice in Supports for Small Highway Signs," H.E. Research Report 3254-1, Texas Transportation Institute, Texas A&M University, June 1977.

10. Ross, H.E., J.L. Buffington, G.D. Weaver, and D.L. Schafer, "State of the Practice in Supports for Small Highway Signs," Technology Sharing Report No. 80-222, U.S. Department of Transportation, Federal Highway Administration, April 1980.

11. Ross, H.E.Jr., H.S. Perera, D.L. Sicking and R.P. Bligh, "Roadside Safety Design for Small Vehicles," Preliminary Draft Final Report on Project 7043, Texas Transportation Institute, Texas A&M University, April 1988

12. Morgan, James R., Wanda L. Campise and D. Lance Bullard, Jr., Crash Test Reports for Project 1122, "Generic Small Sign Support System and Validation of Existing Support Performance," Texas Transportation Institute, 9/1/87-8/31/89

APPENDIX

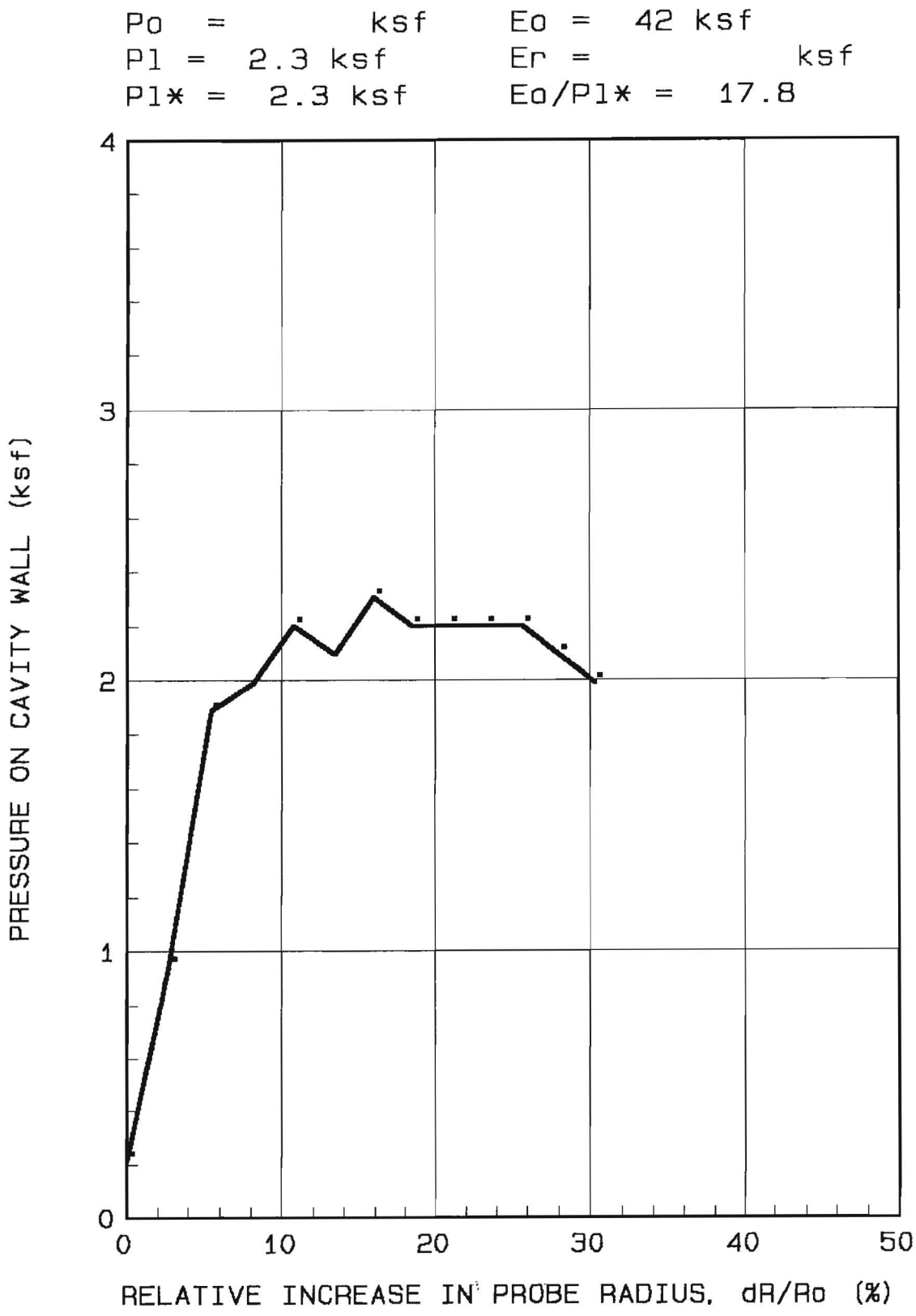


Figure A1. Annex wet, 0.5 foot depth.

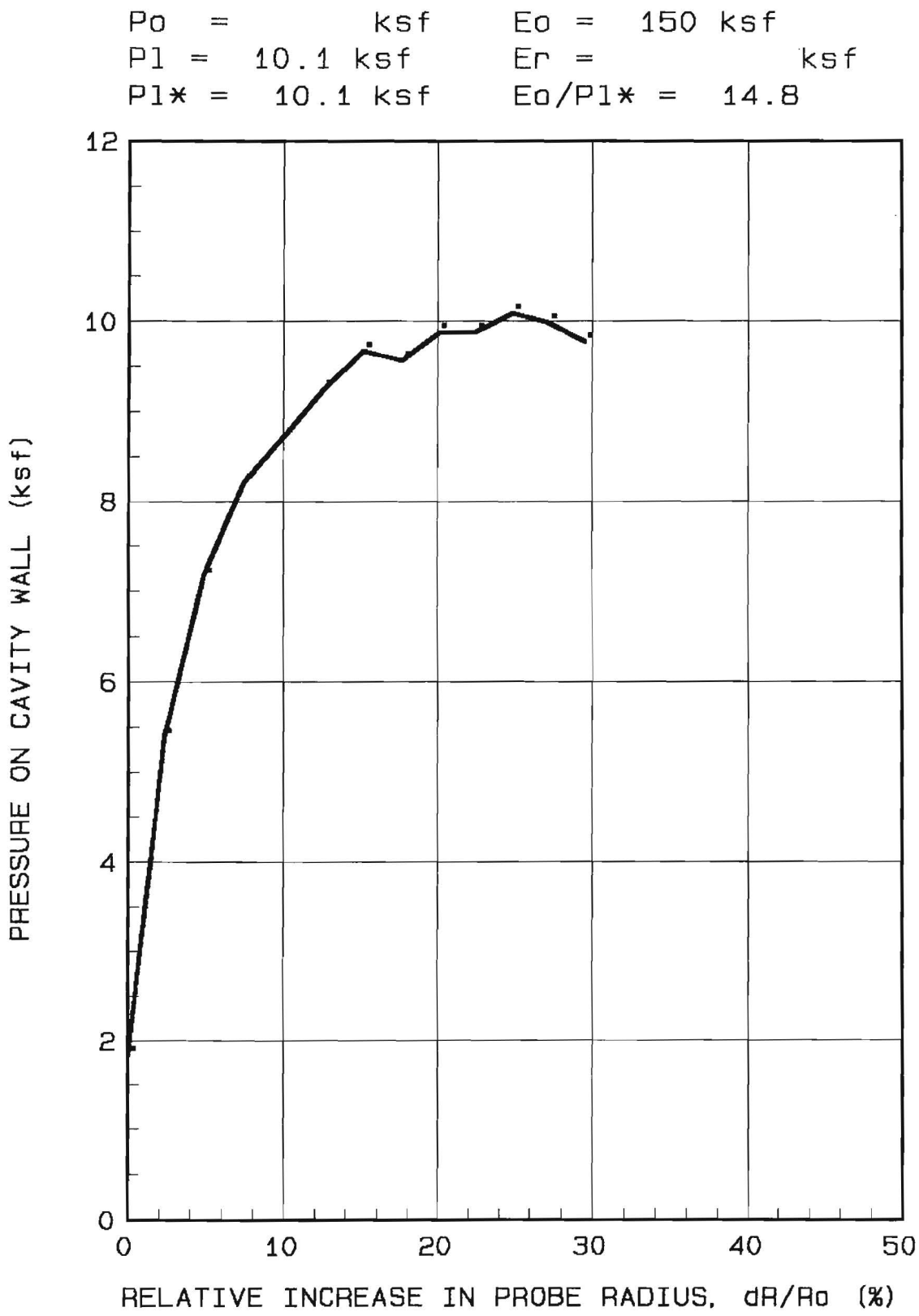


Figure A2. Annex wet, 1.5 foot depth.

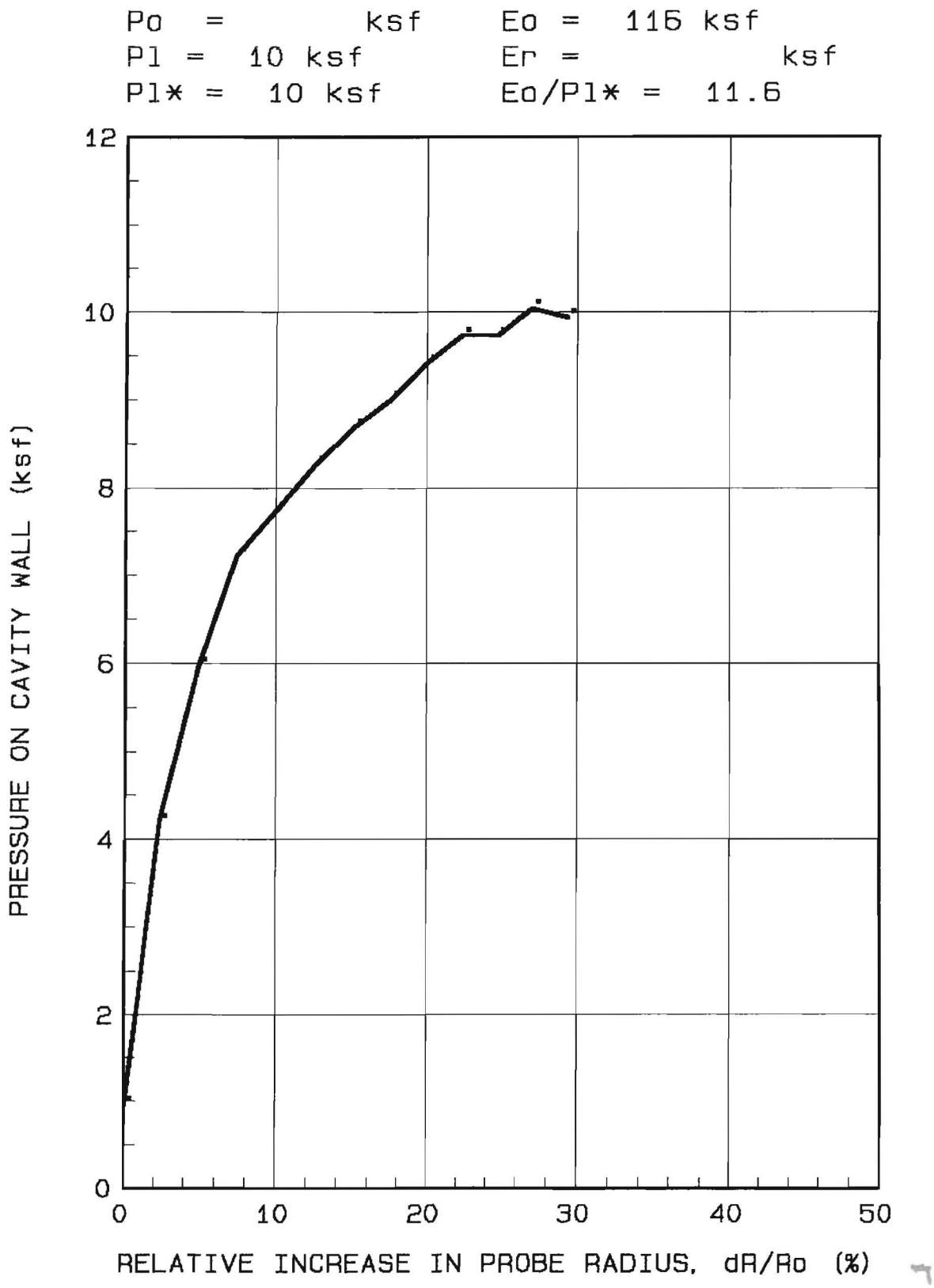


Figure A3. Annex wet, 2.5 foot depth.

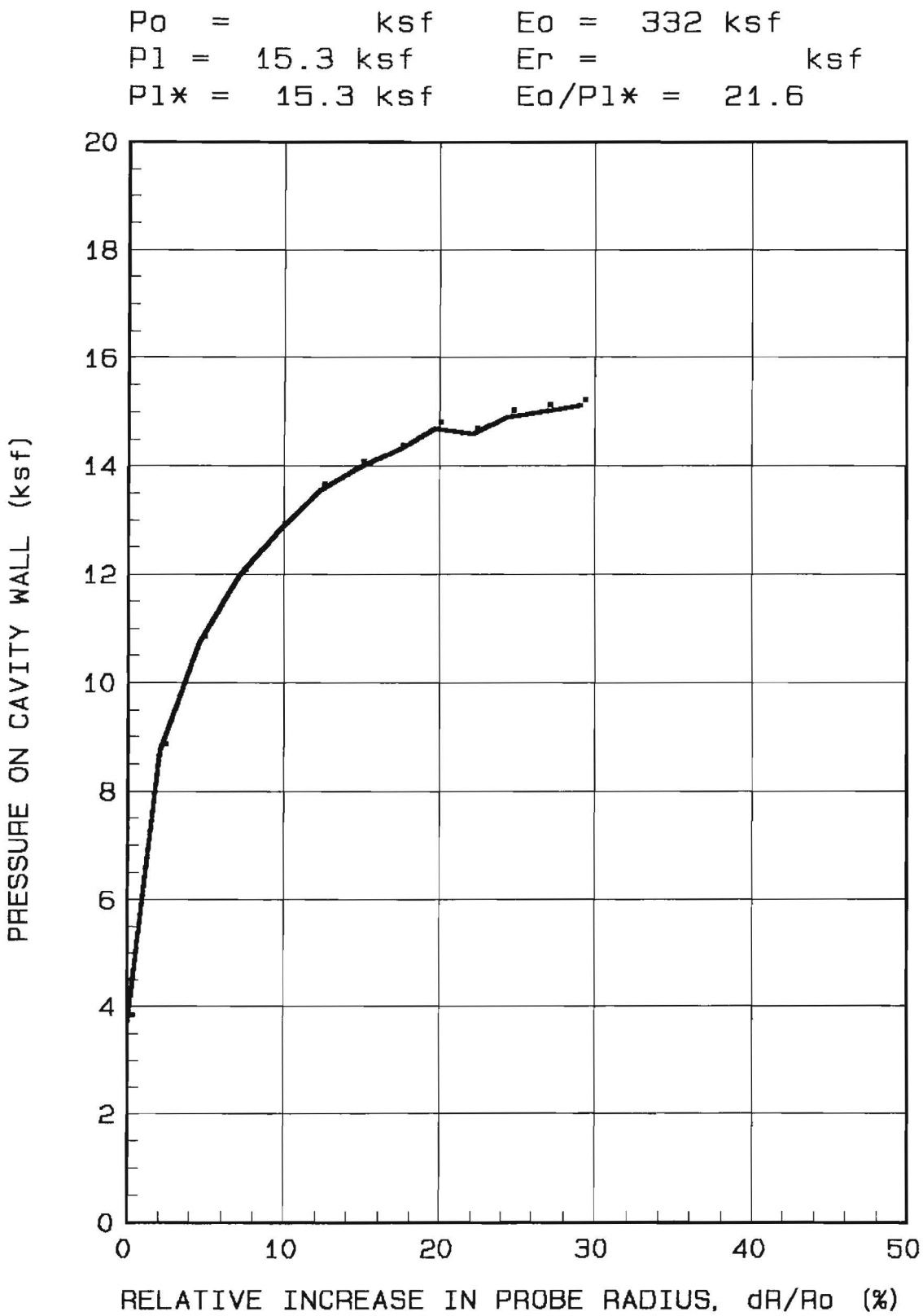


Figure A4. Annex wet, 3.5 foot depth.

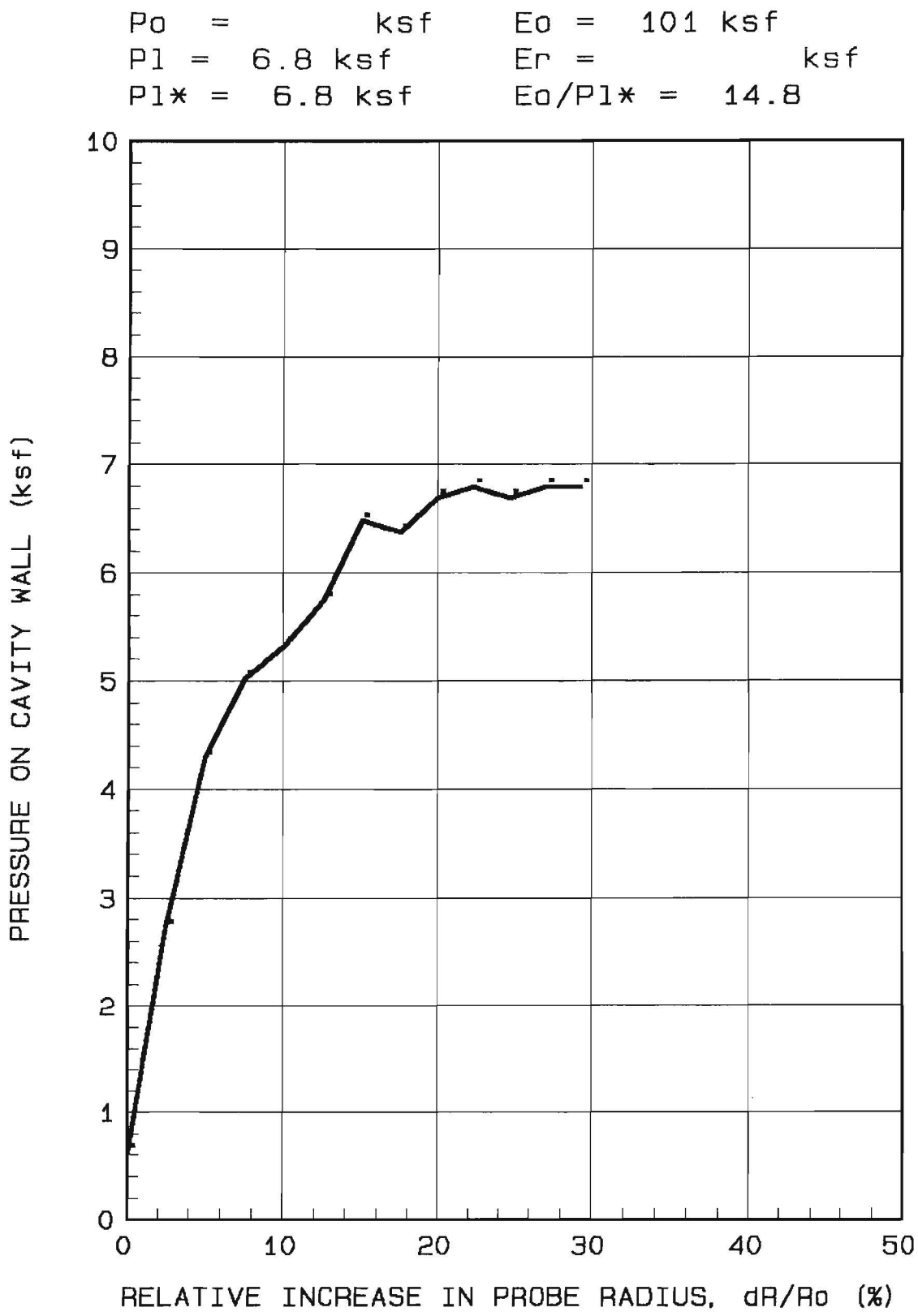


Figure A6. Site 1, 0.5 foot depth.

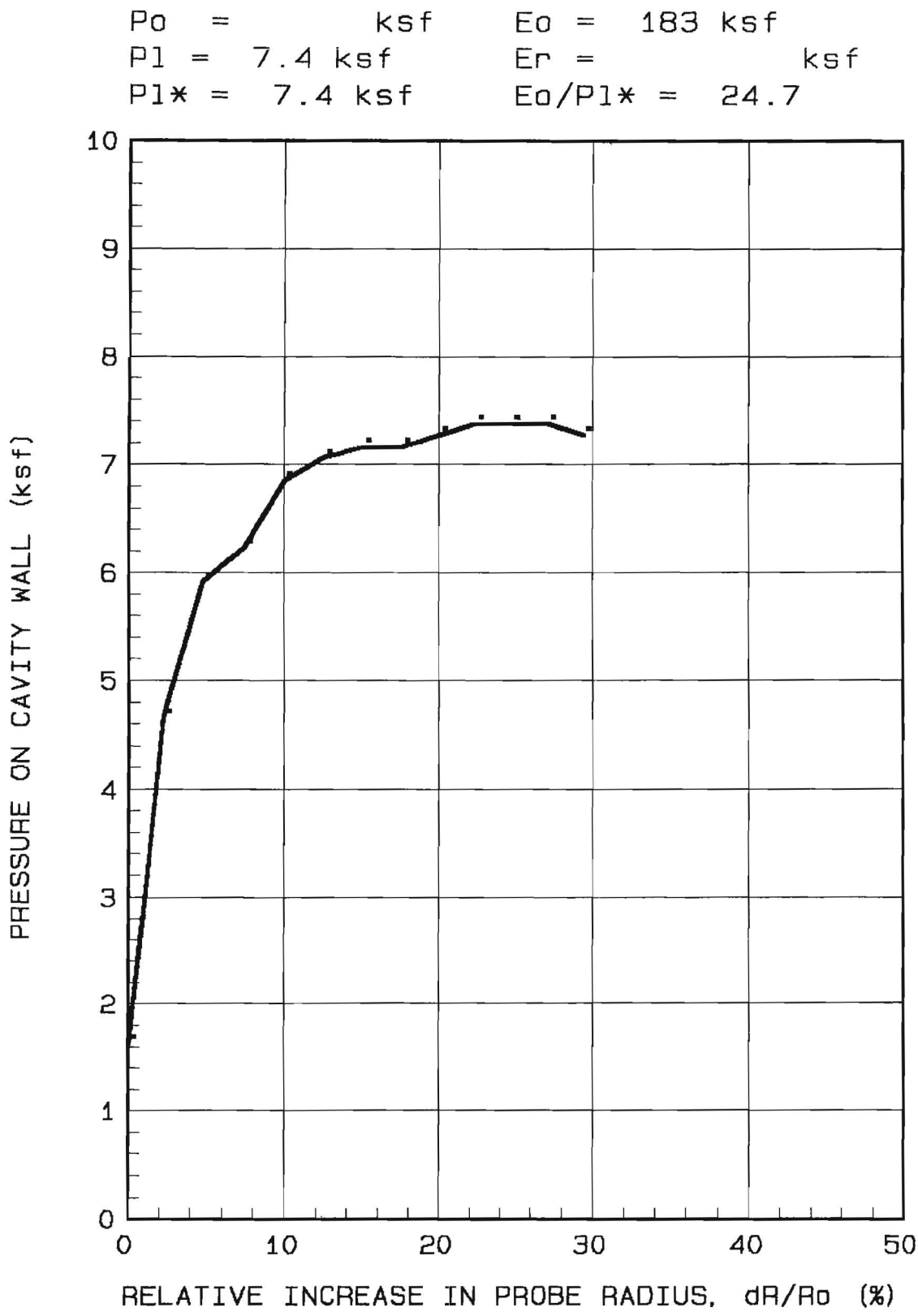


Figure A7. Site 1, 1.5 foot depth.

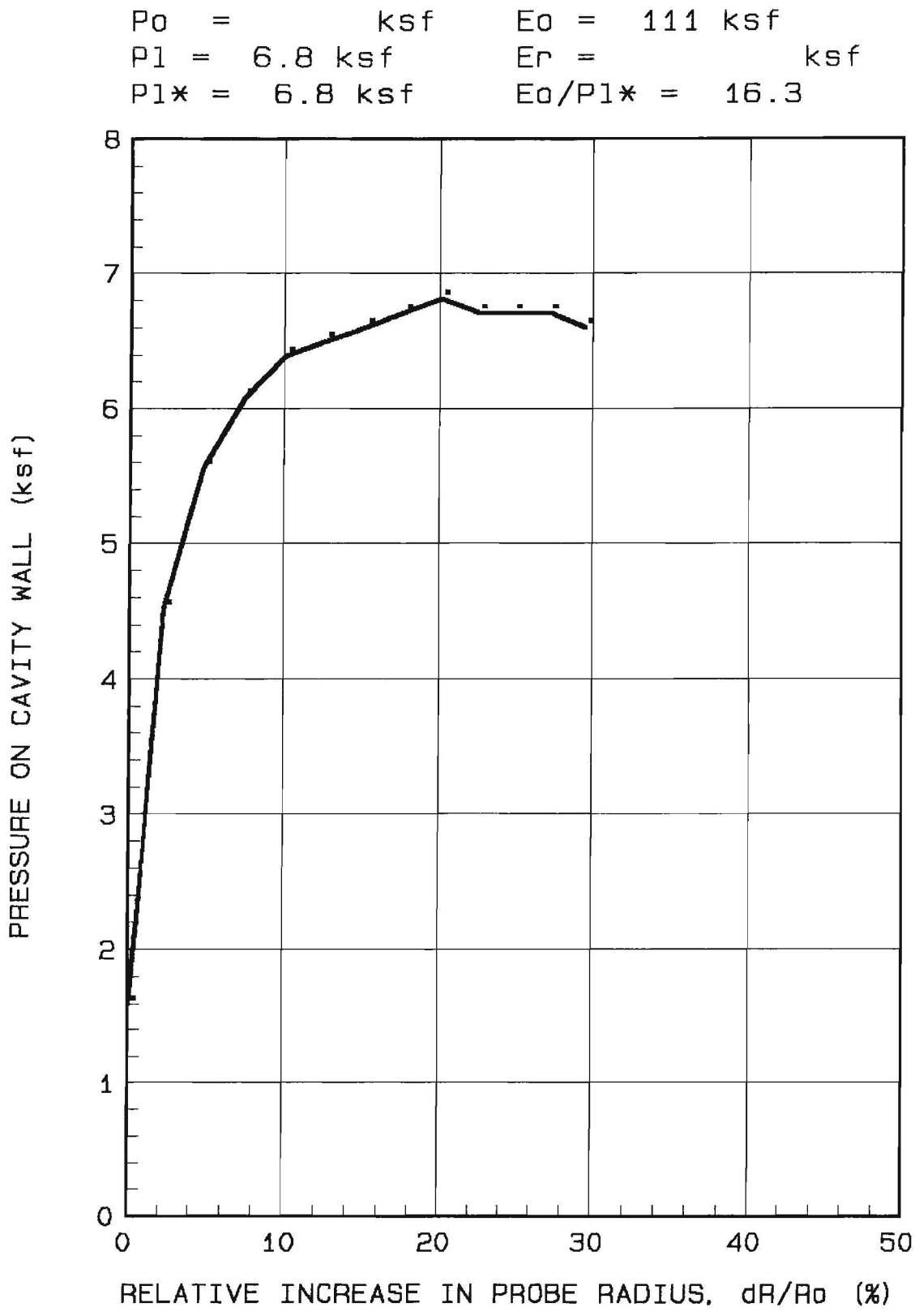


Figure A8. Site 1, 2.5 foot depth.

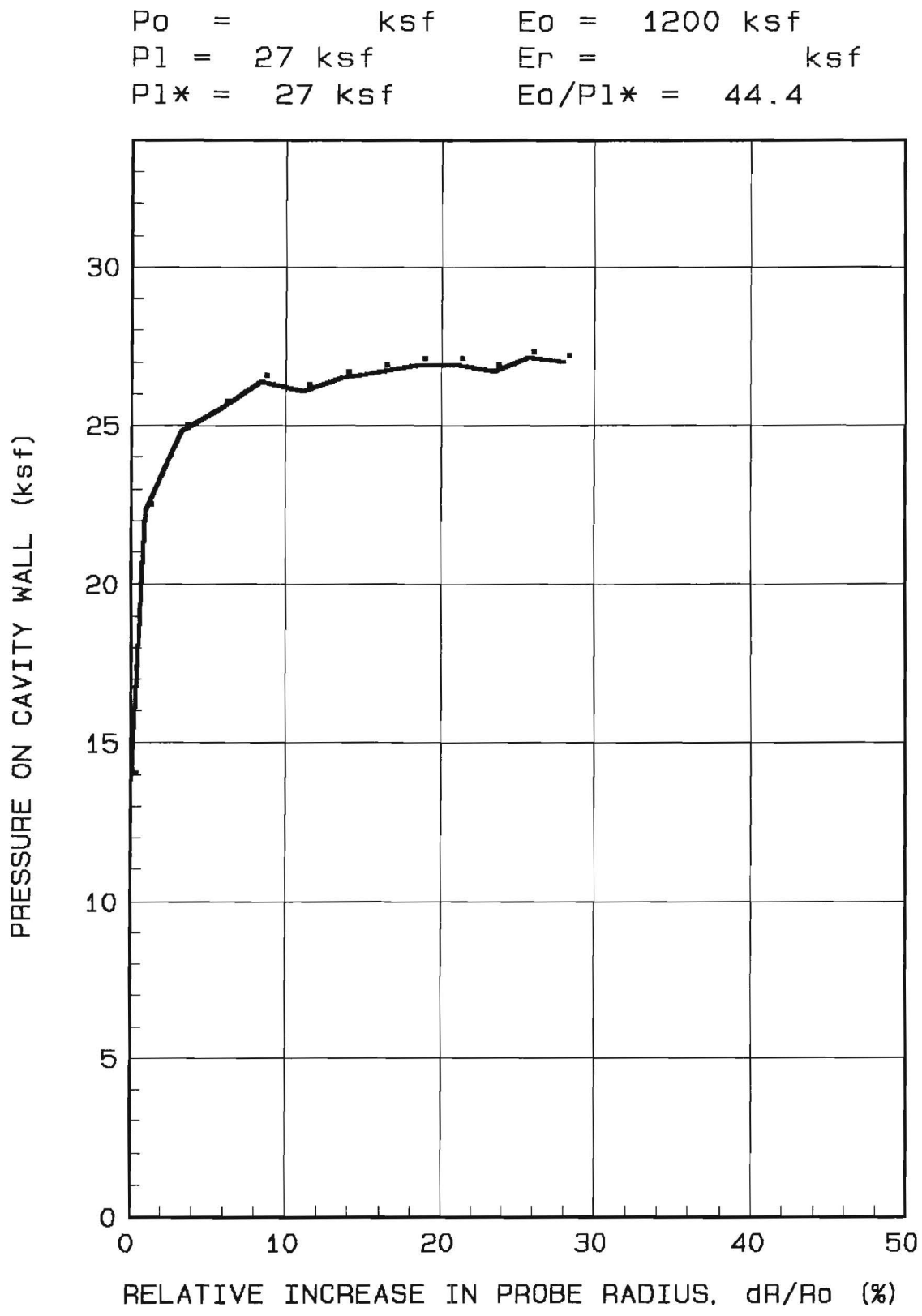


Figure A9. Site 1, 3.5 foot depth.

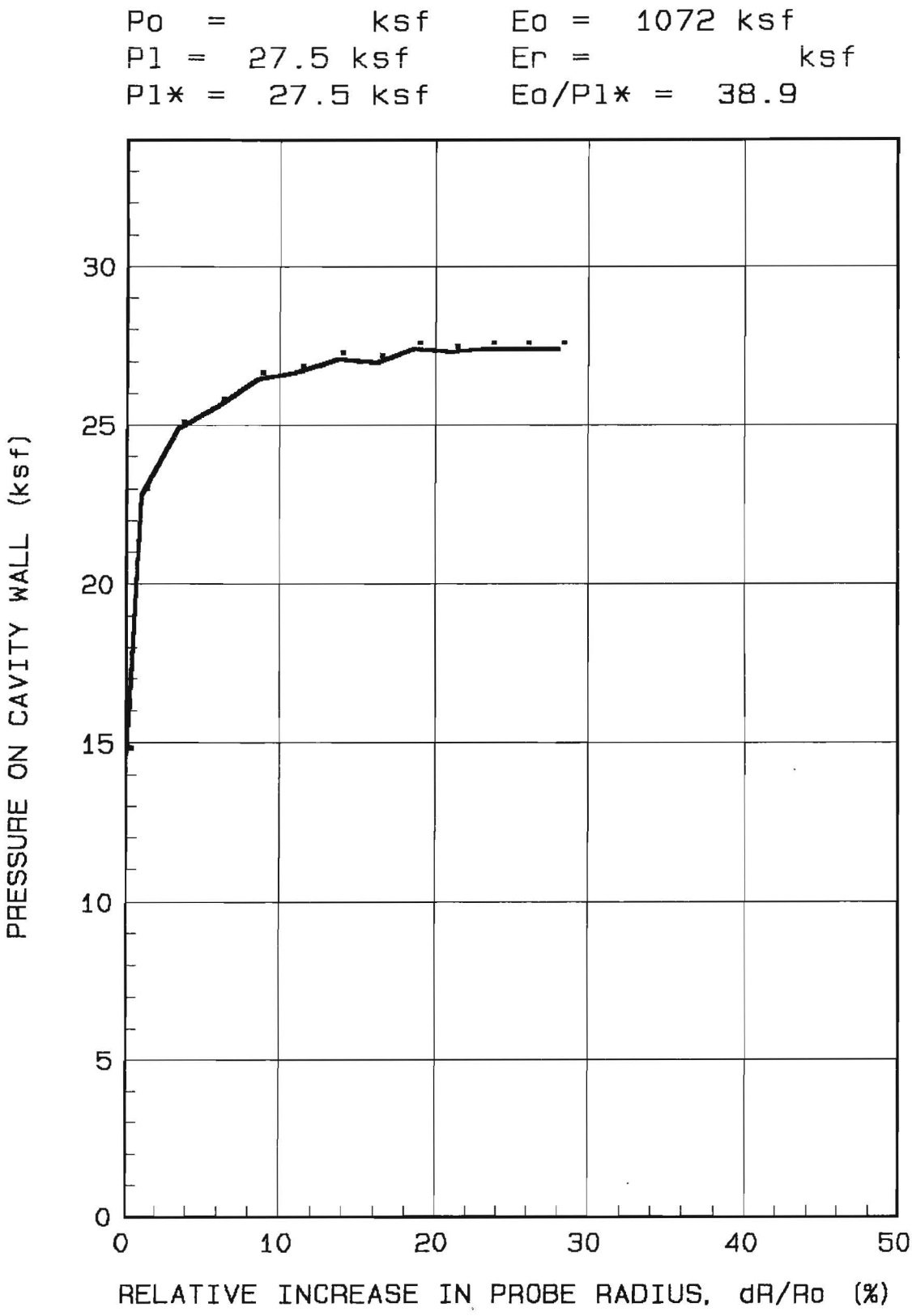


Figure A10. Site 1, 4.5 foot depth.

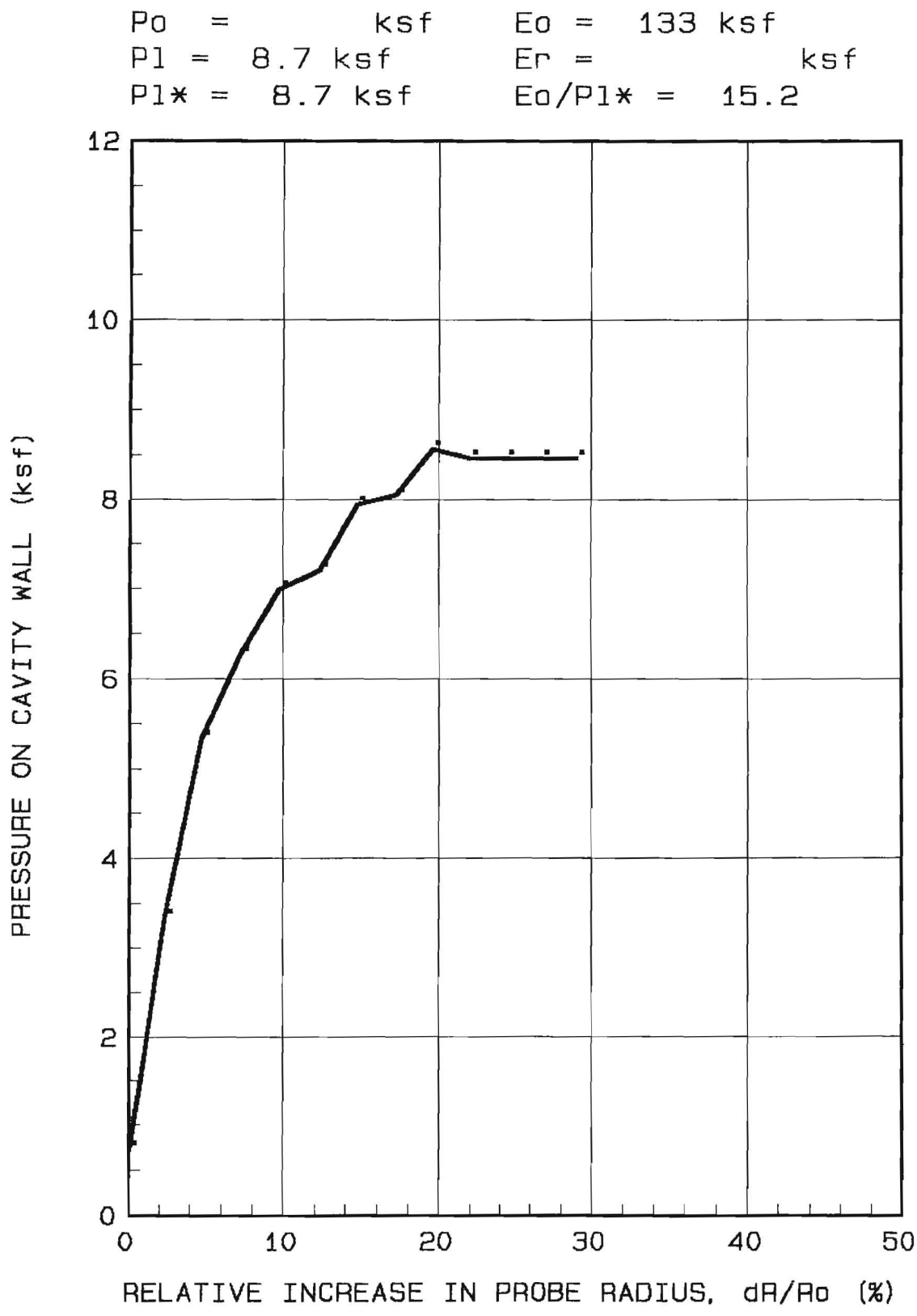


Figure A11. Site 2, 0.5 foot depth.

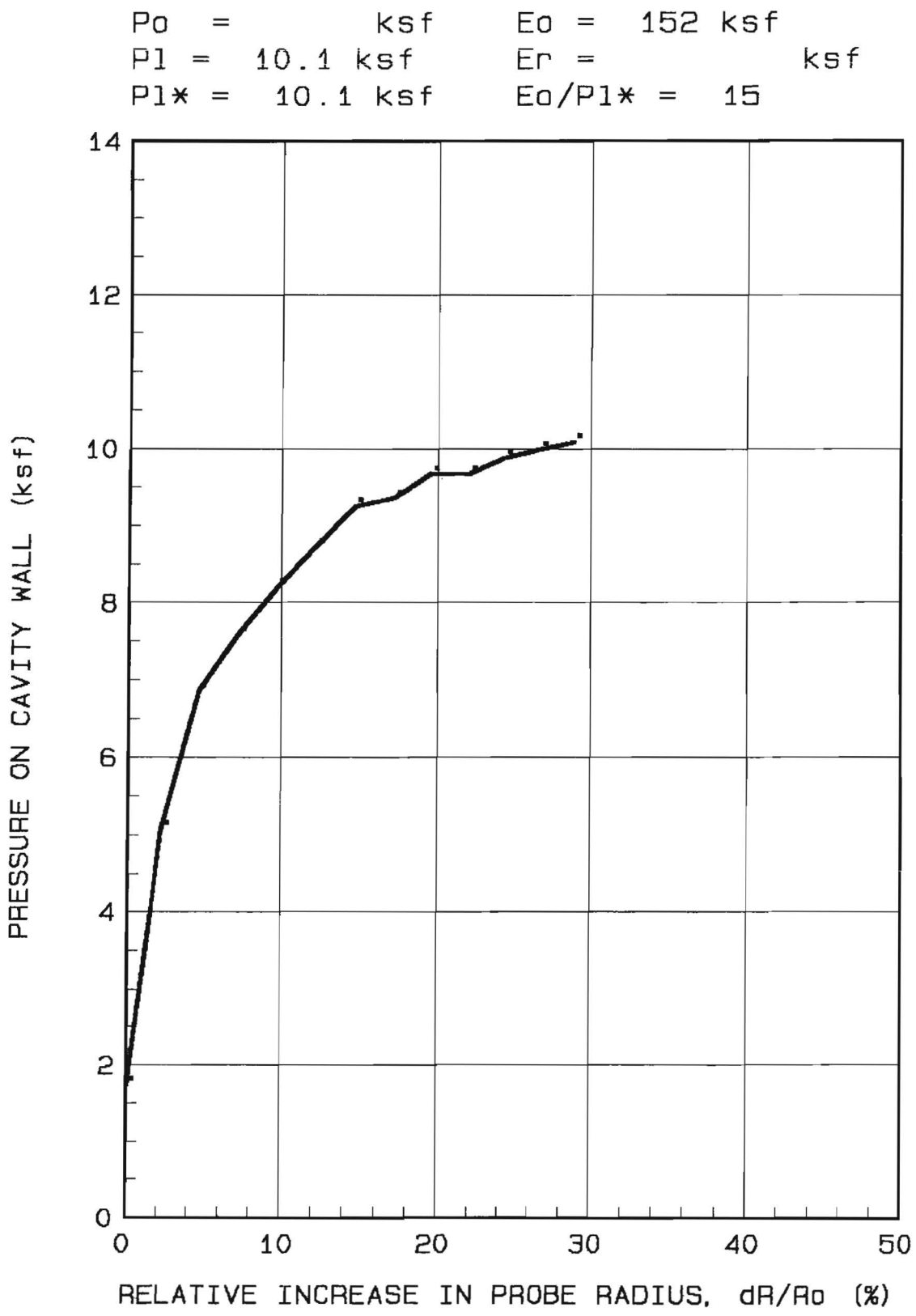


Figure A12. Site 2, 1.5 foot depth.

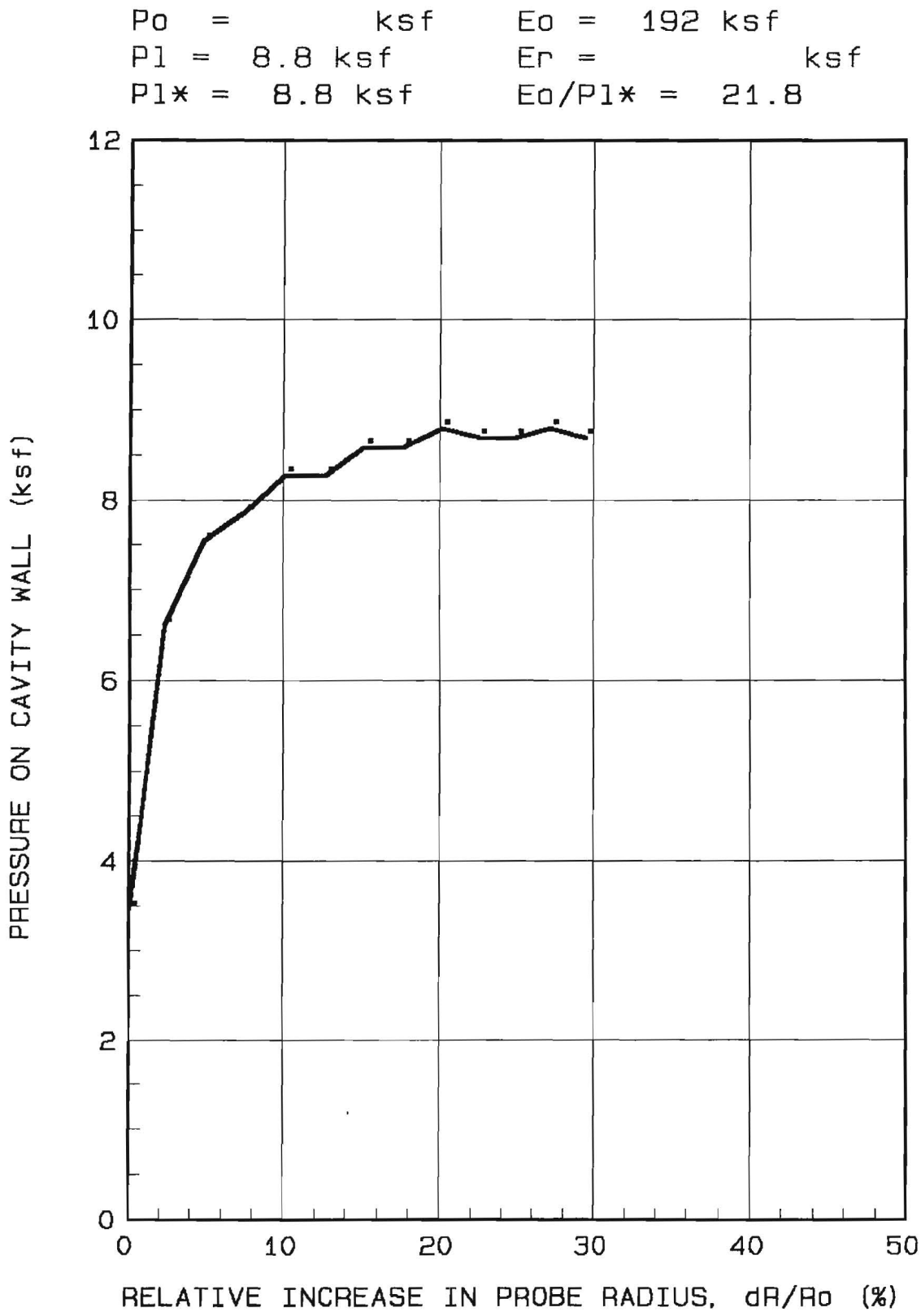


Figure A13. Site 2, 2.5 foot depth.

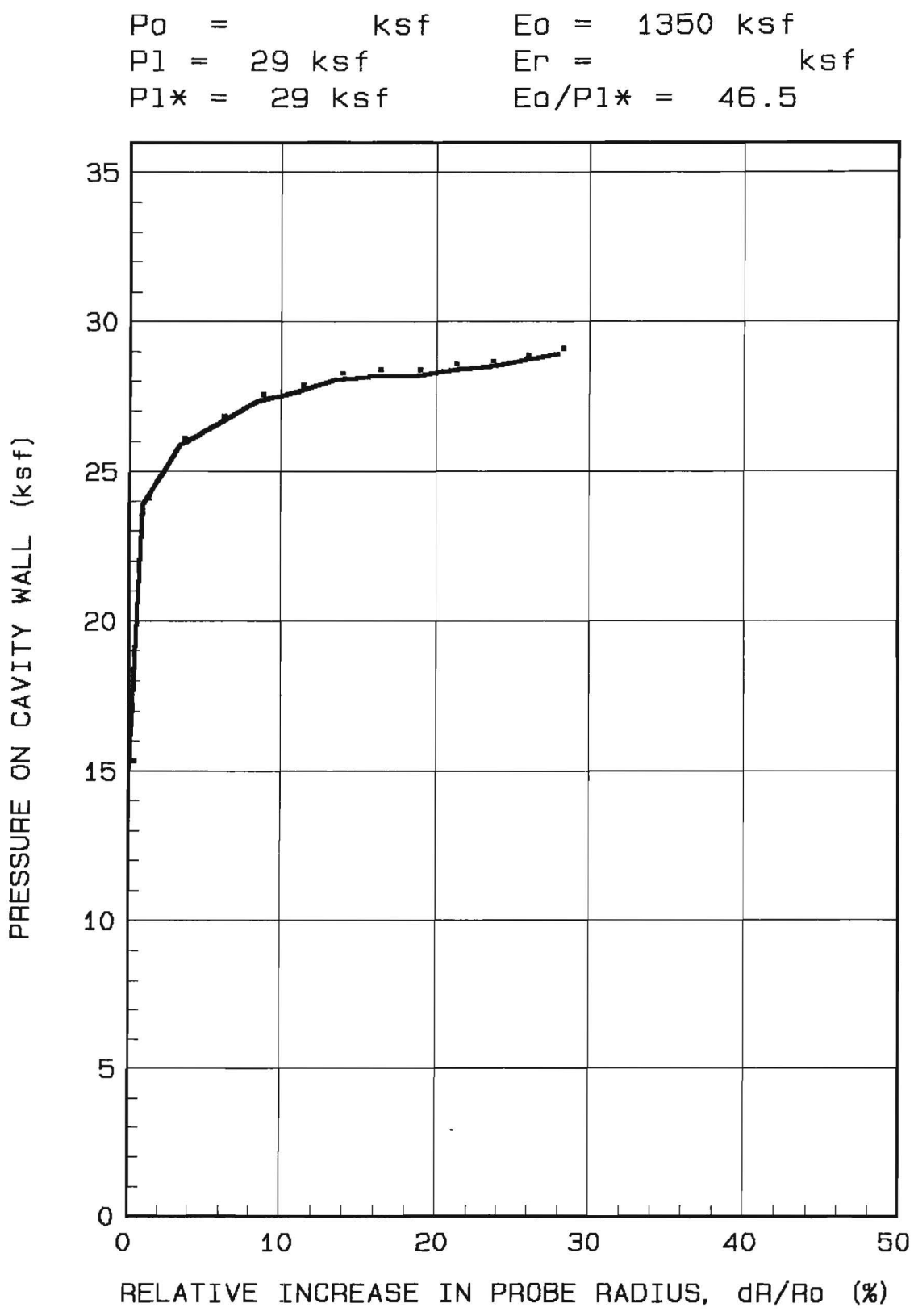


Figure A14. Site 2, 3.5 foot depth.

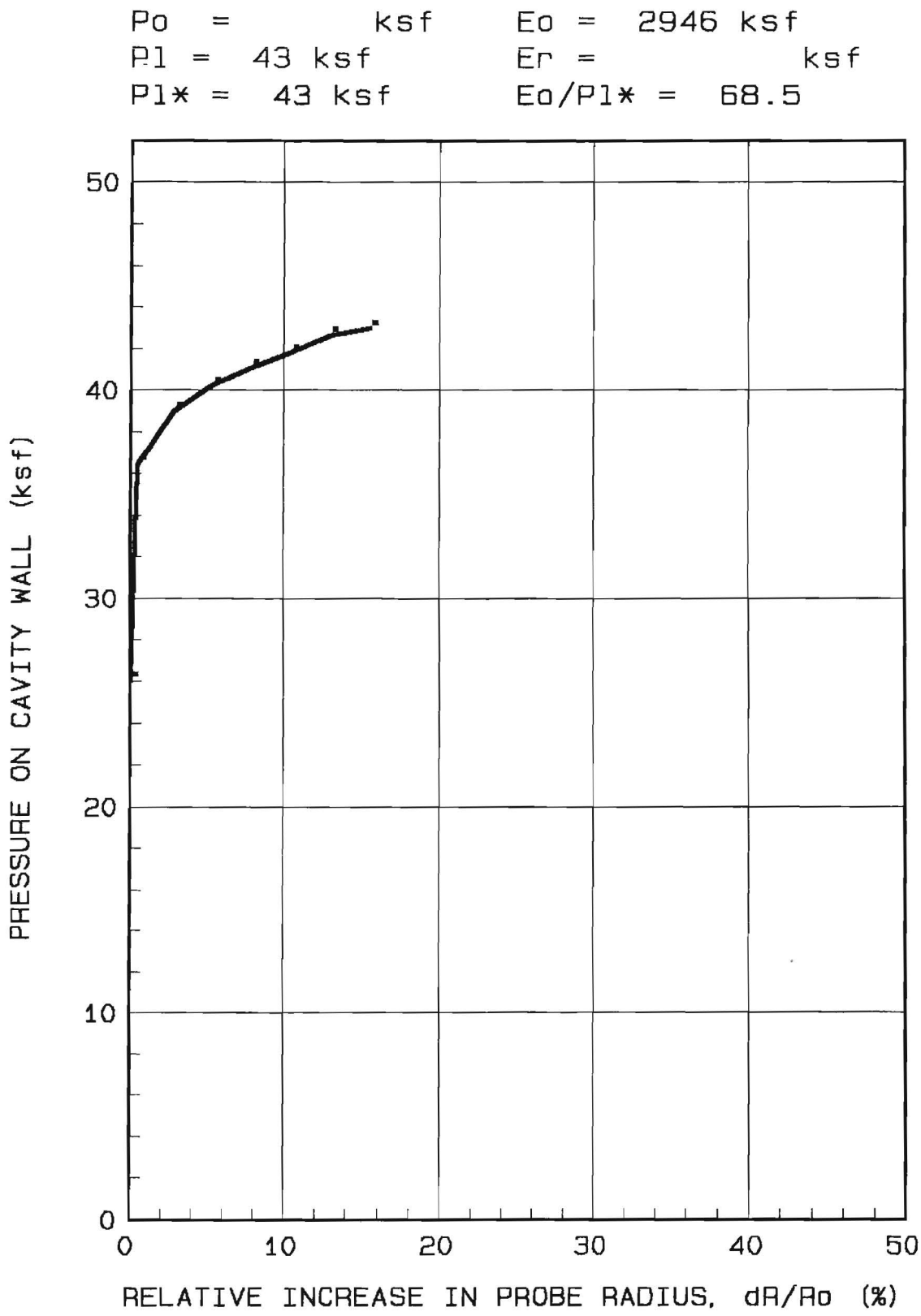


Figure A15. Site 2, 4.5 foot depth.

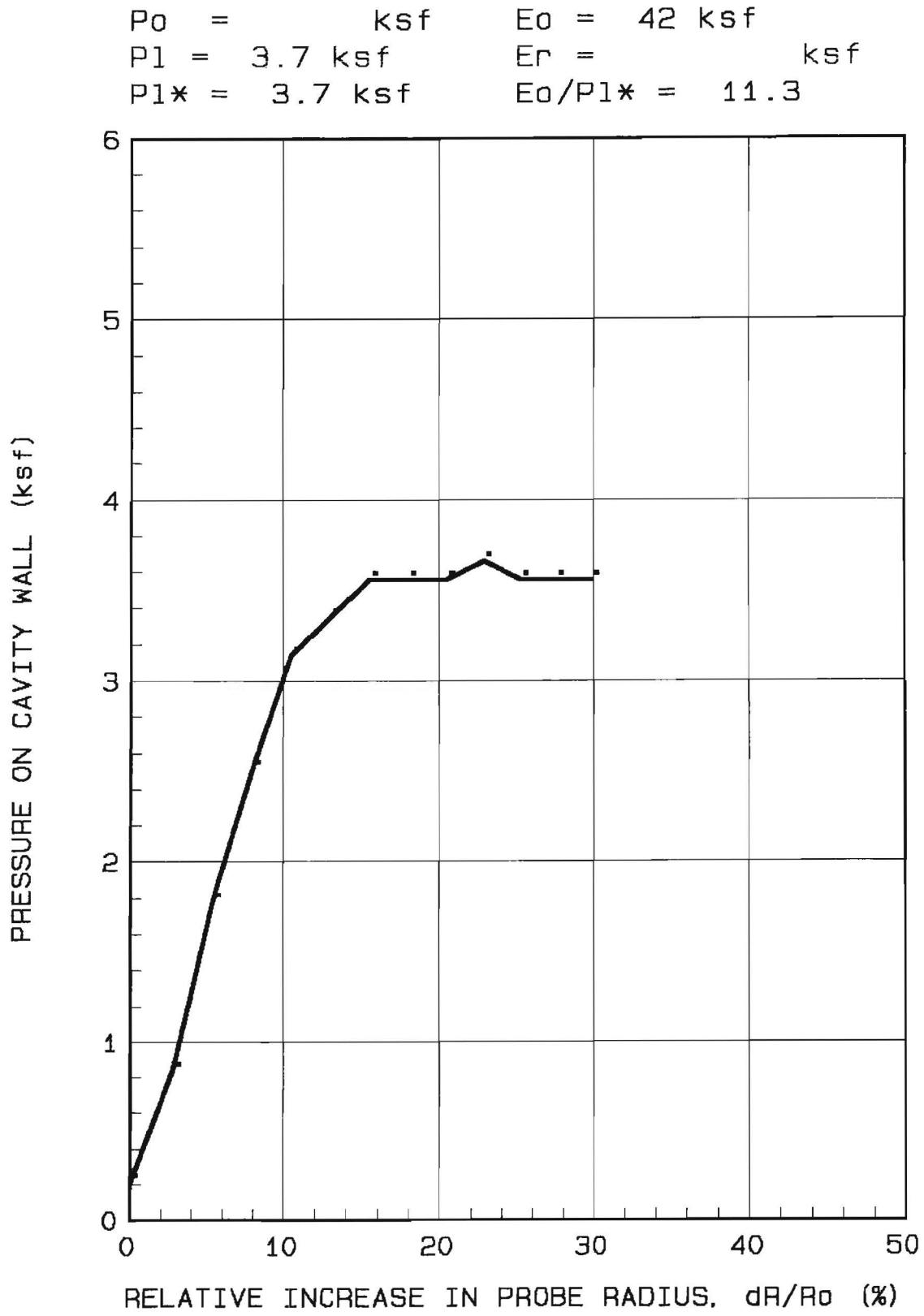


Figure A16. Site 3, 0.5 foot depth.

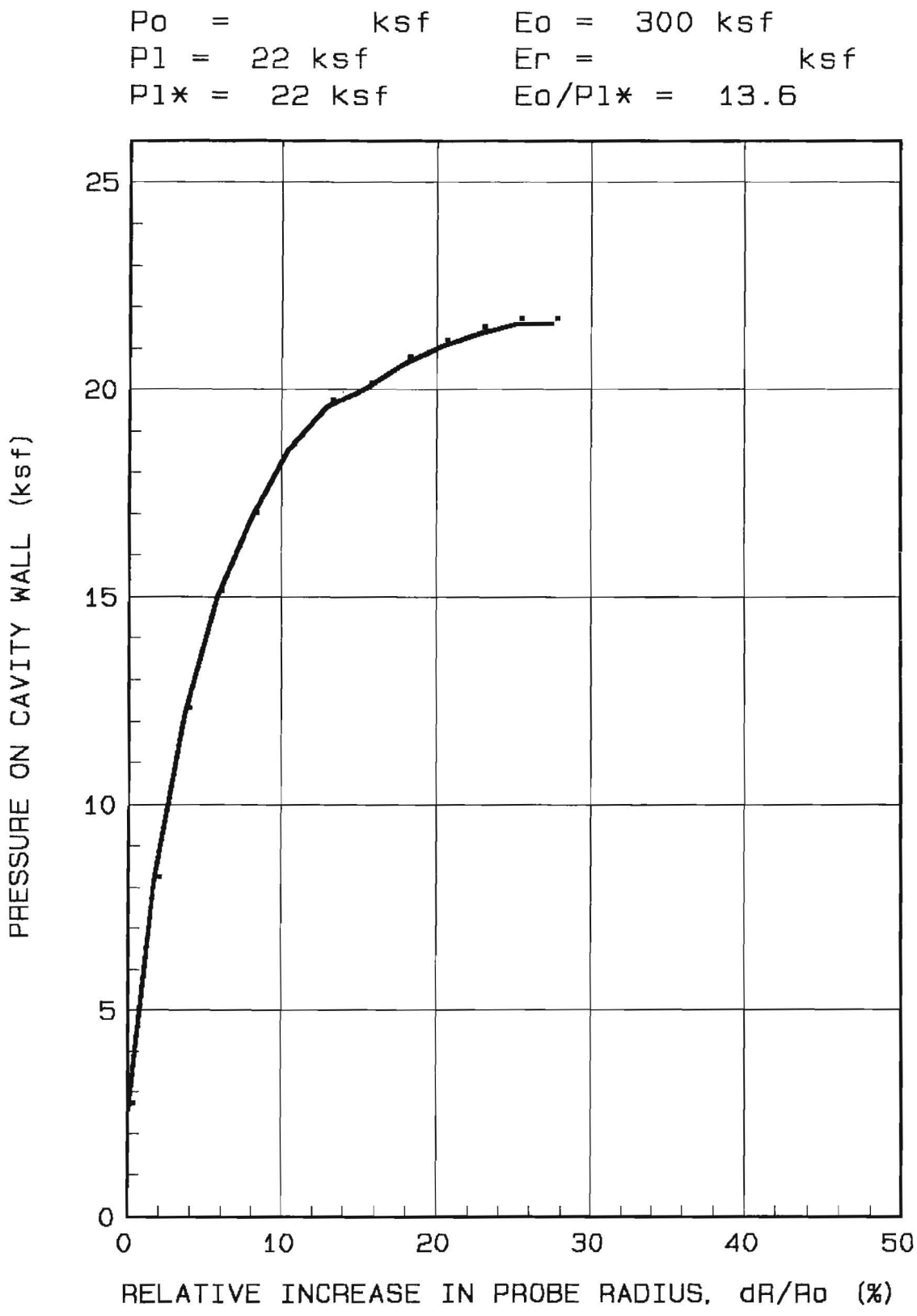


Figure A17. Site 3, 1.5 foot depth.

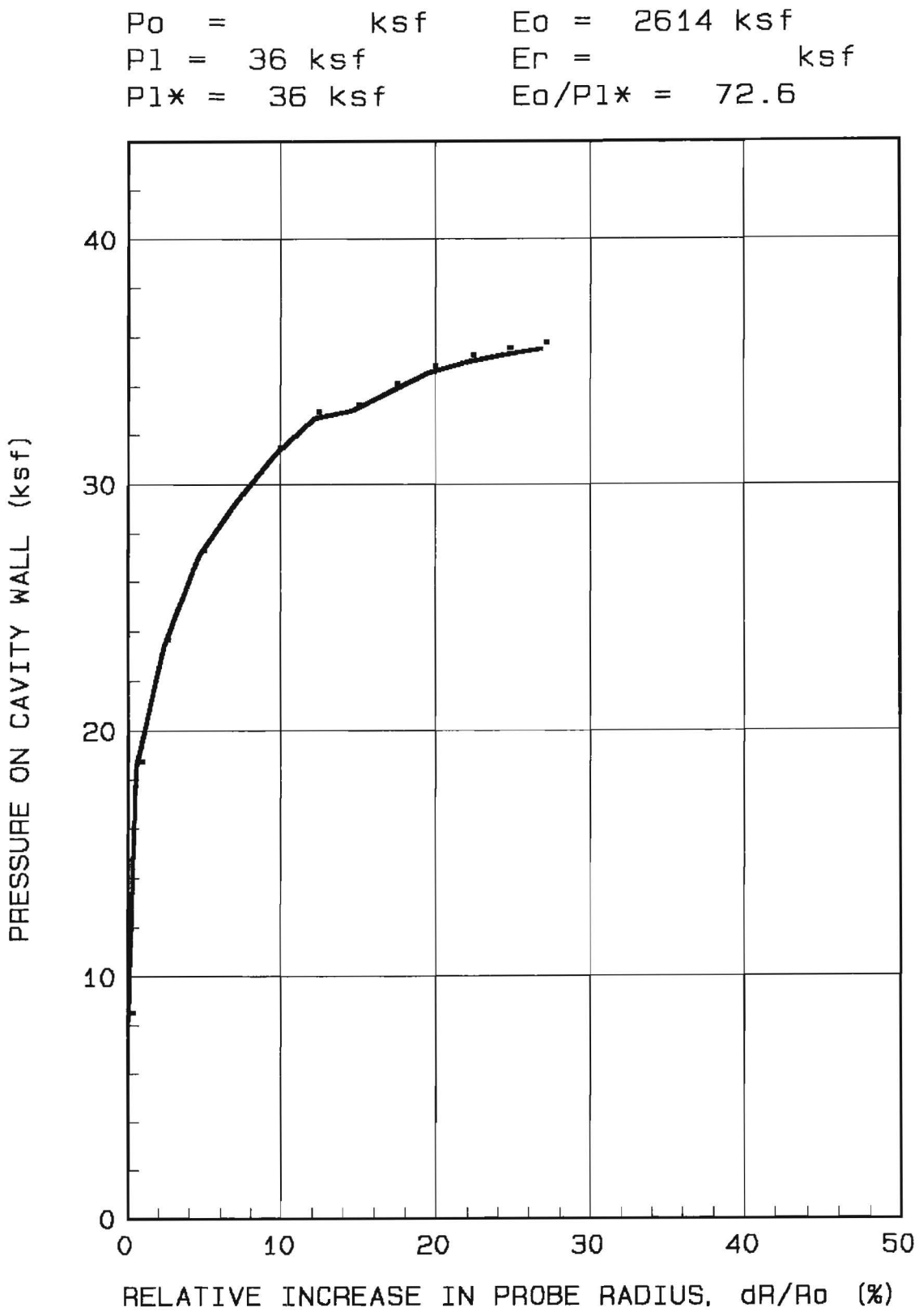


Figure A18. Site 3, 2.5 foot depth.

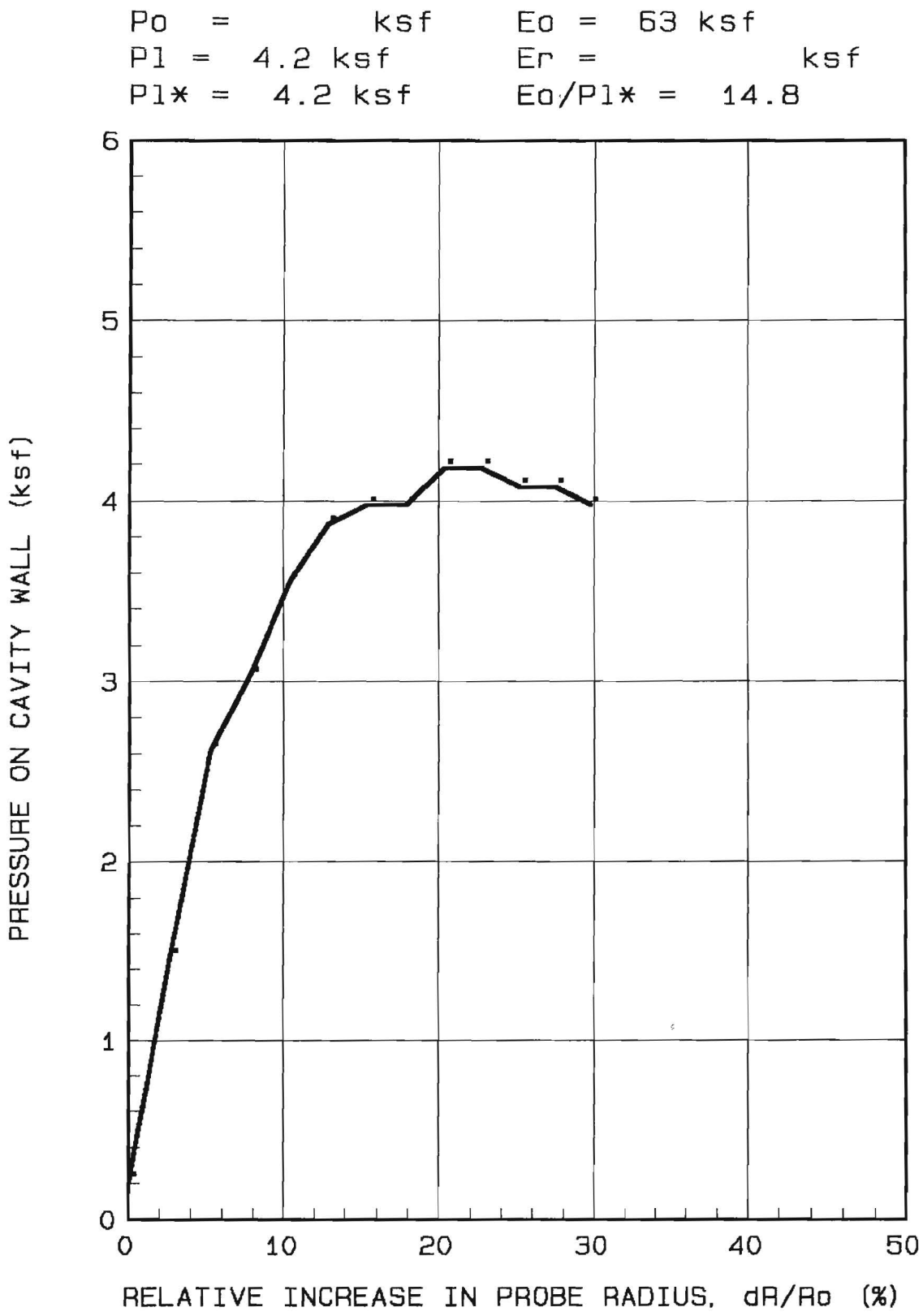


Figure A19. Site 4, 0.5 foot depth.

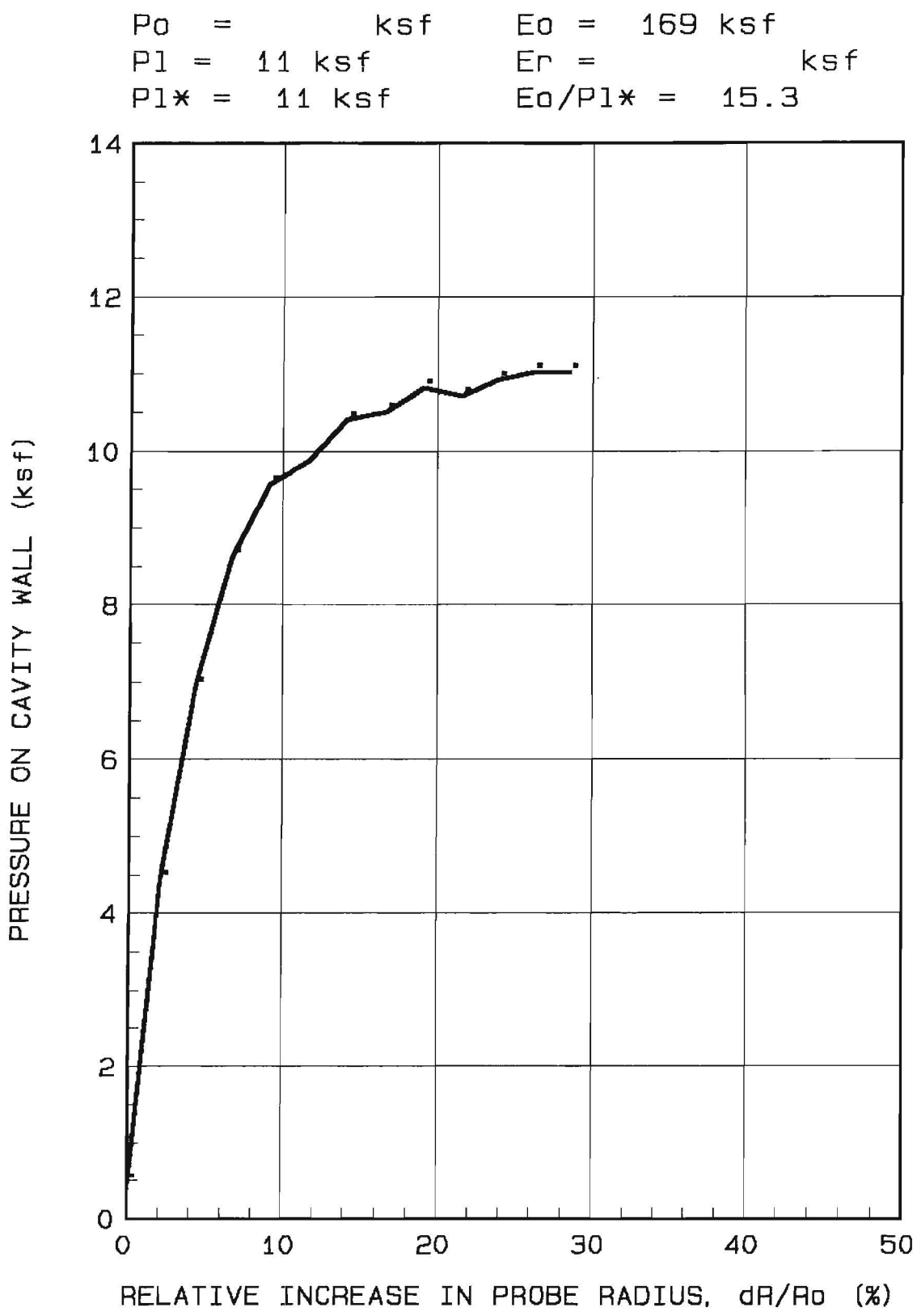


Figure A20. Site 4, 1.5 foot depth.

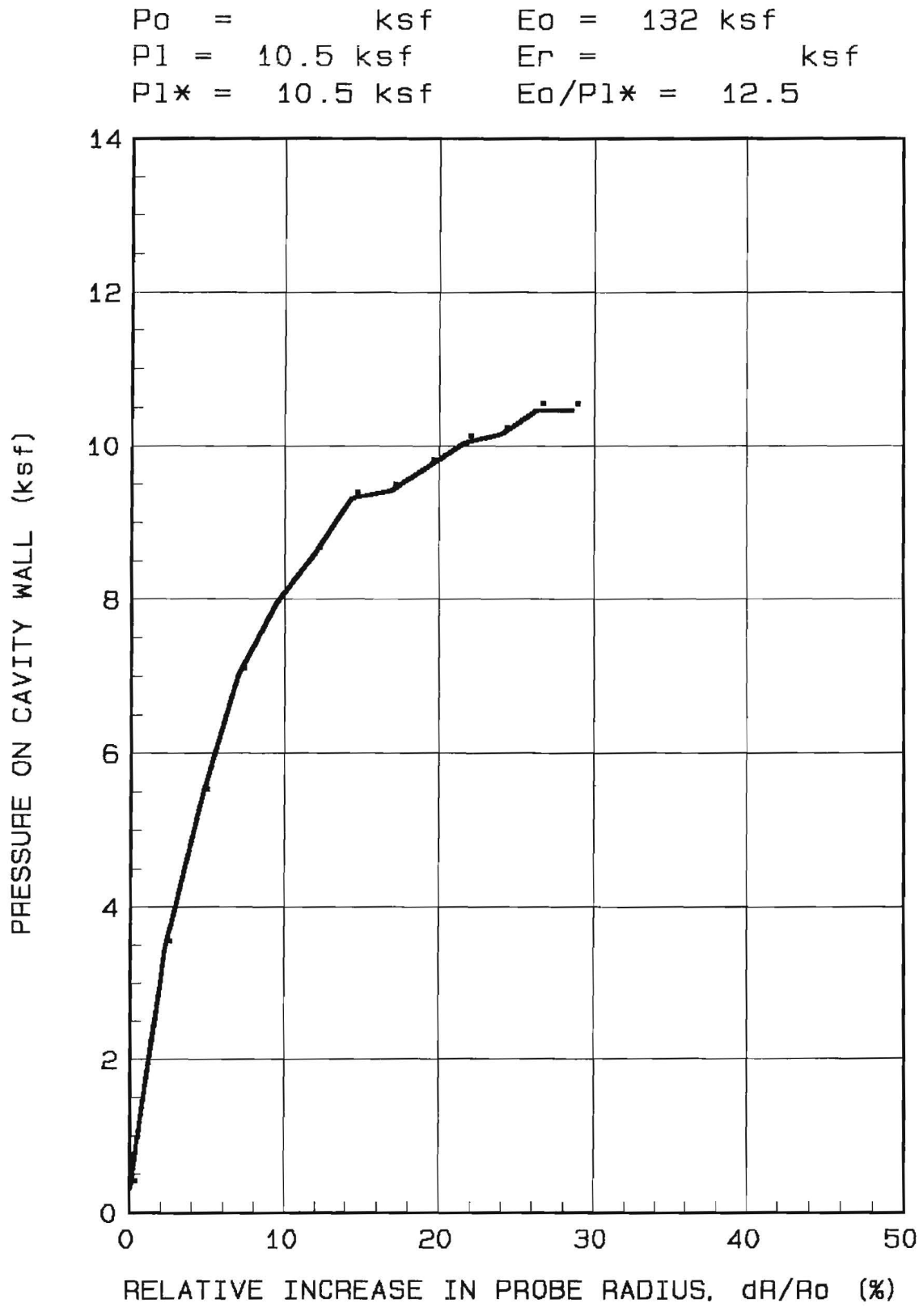


Figure A21. Site 4, 2.5 foot depth.

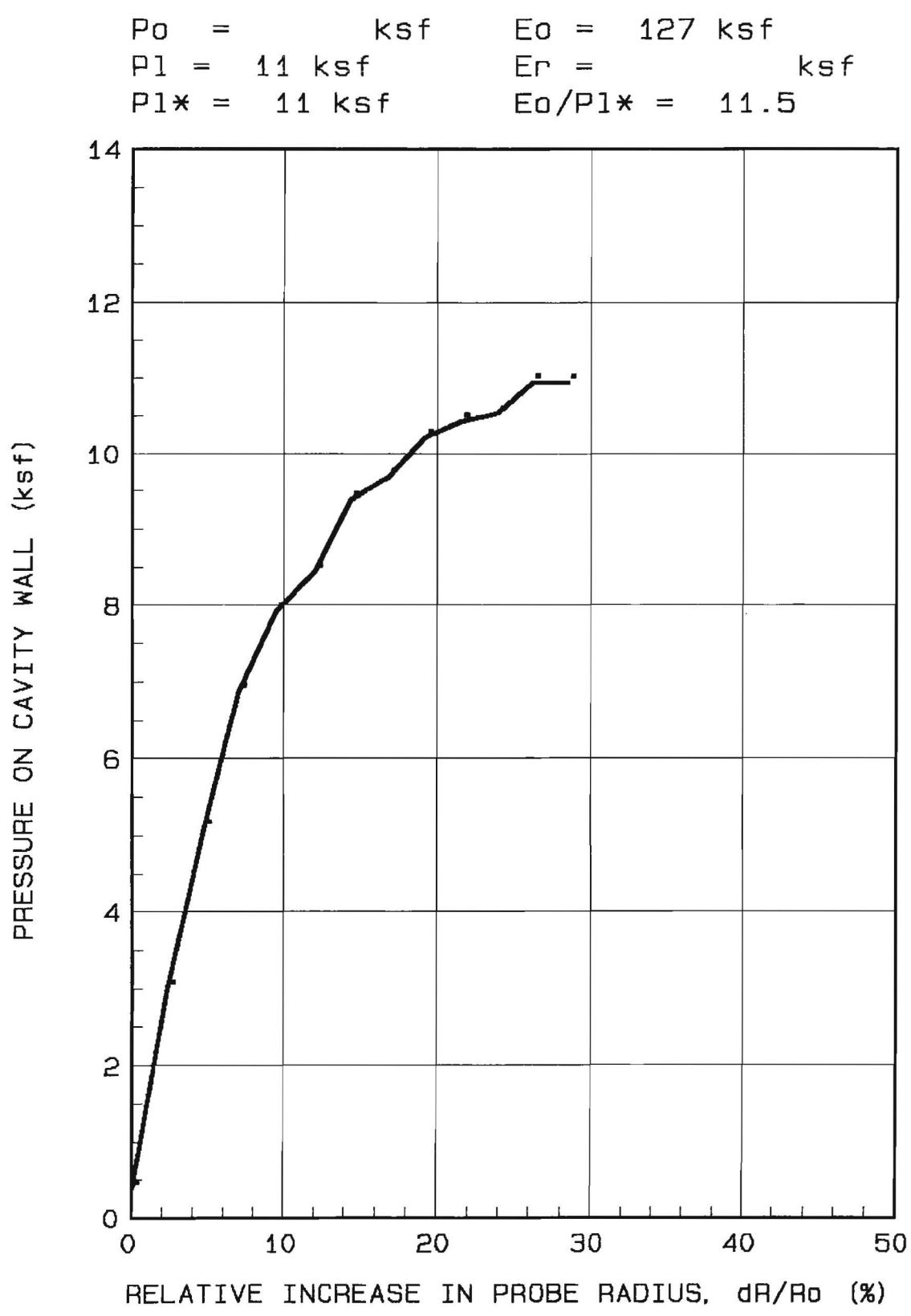


Figure A22. Site 4, 3.5 foot depth.

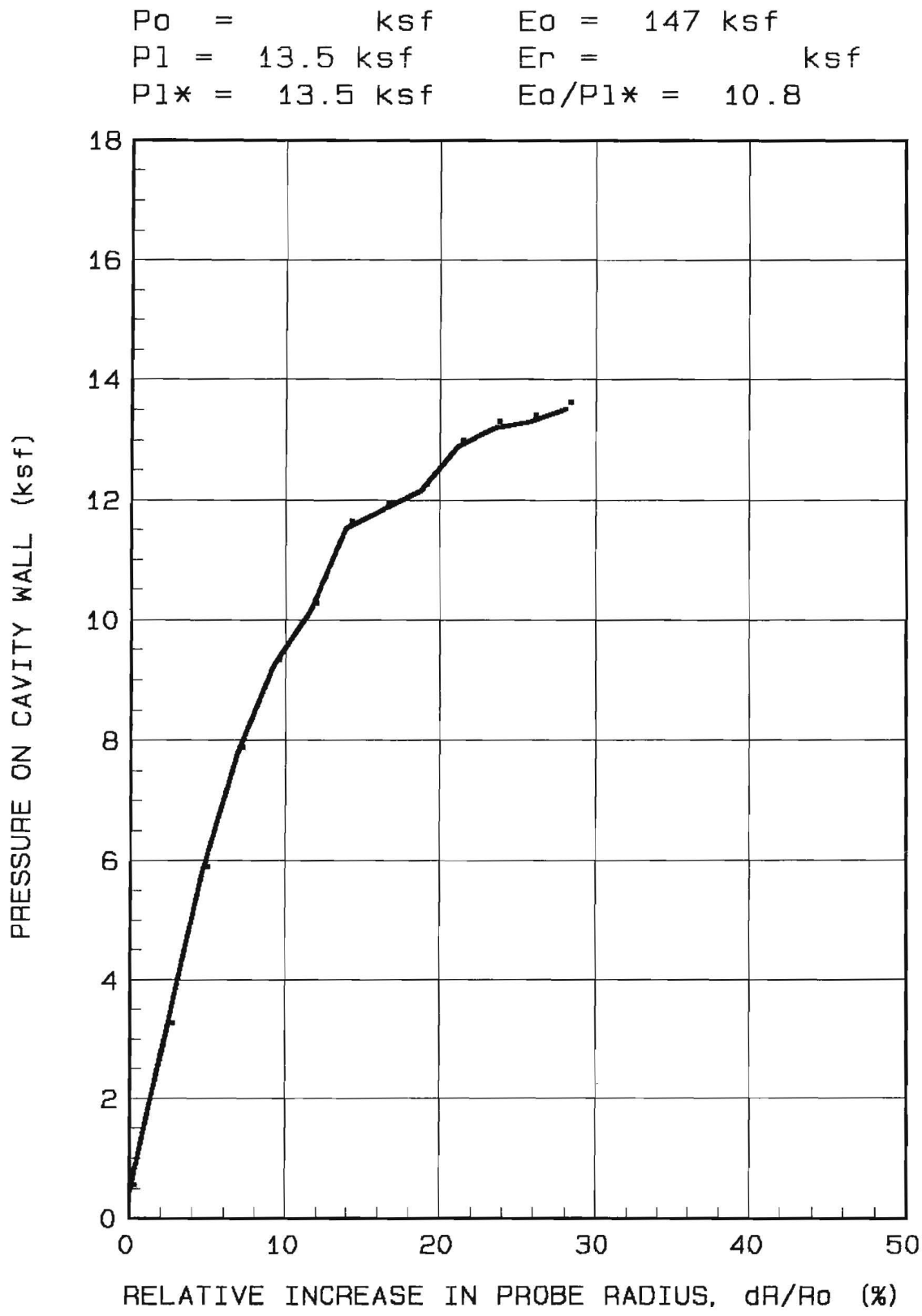


Figure A23. Site 4, 4.5 foot depth.

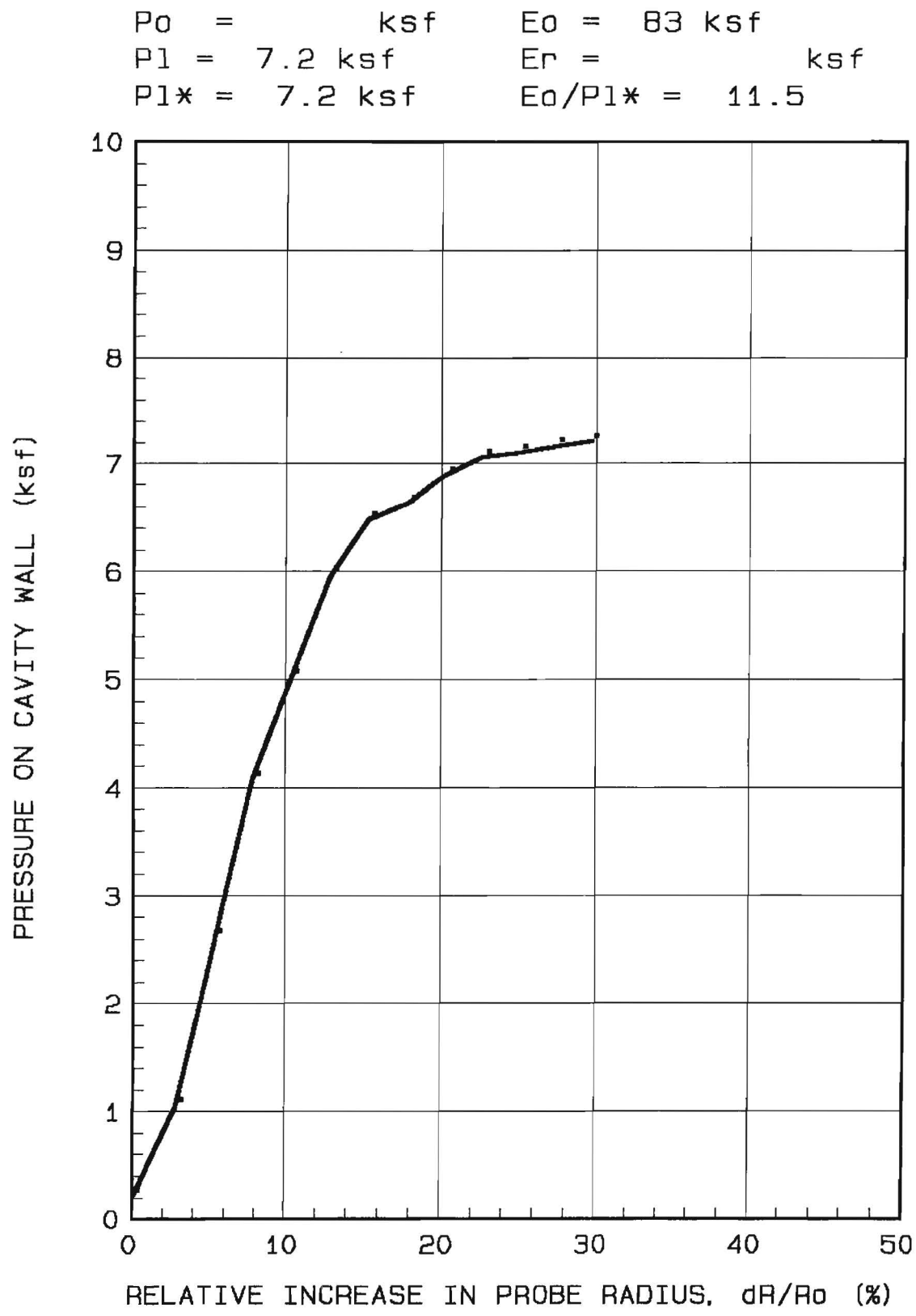


Figure A24. Site 5, 0.5 foot depth.

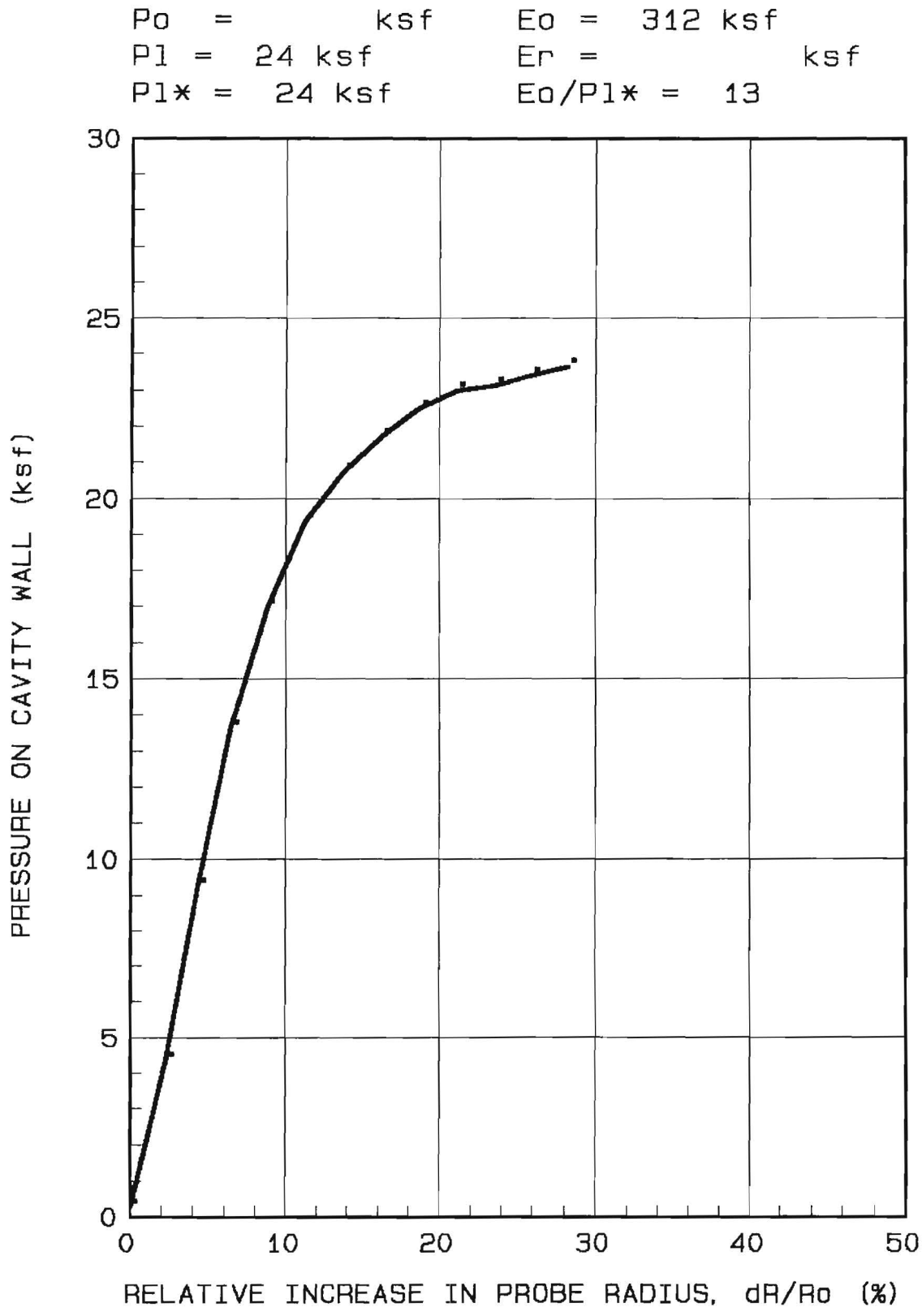


Figure A25. Site 5, 1.5 foot depth.

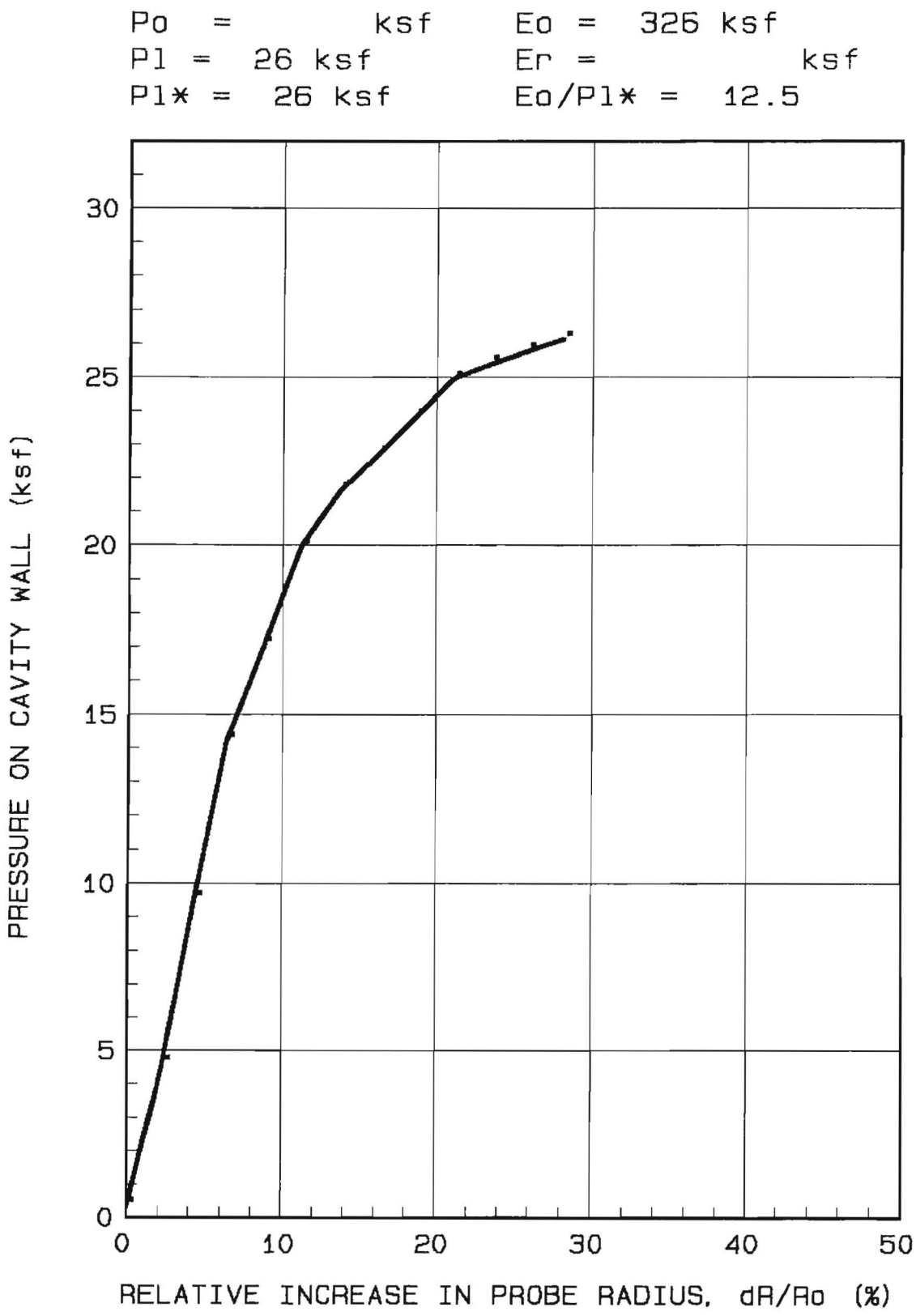


Figure A26. Site 5, 2.5 foot depth.

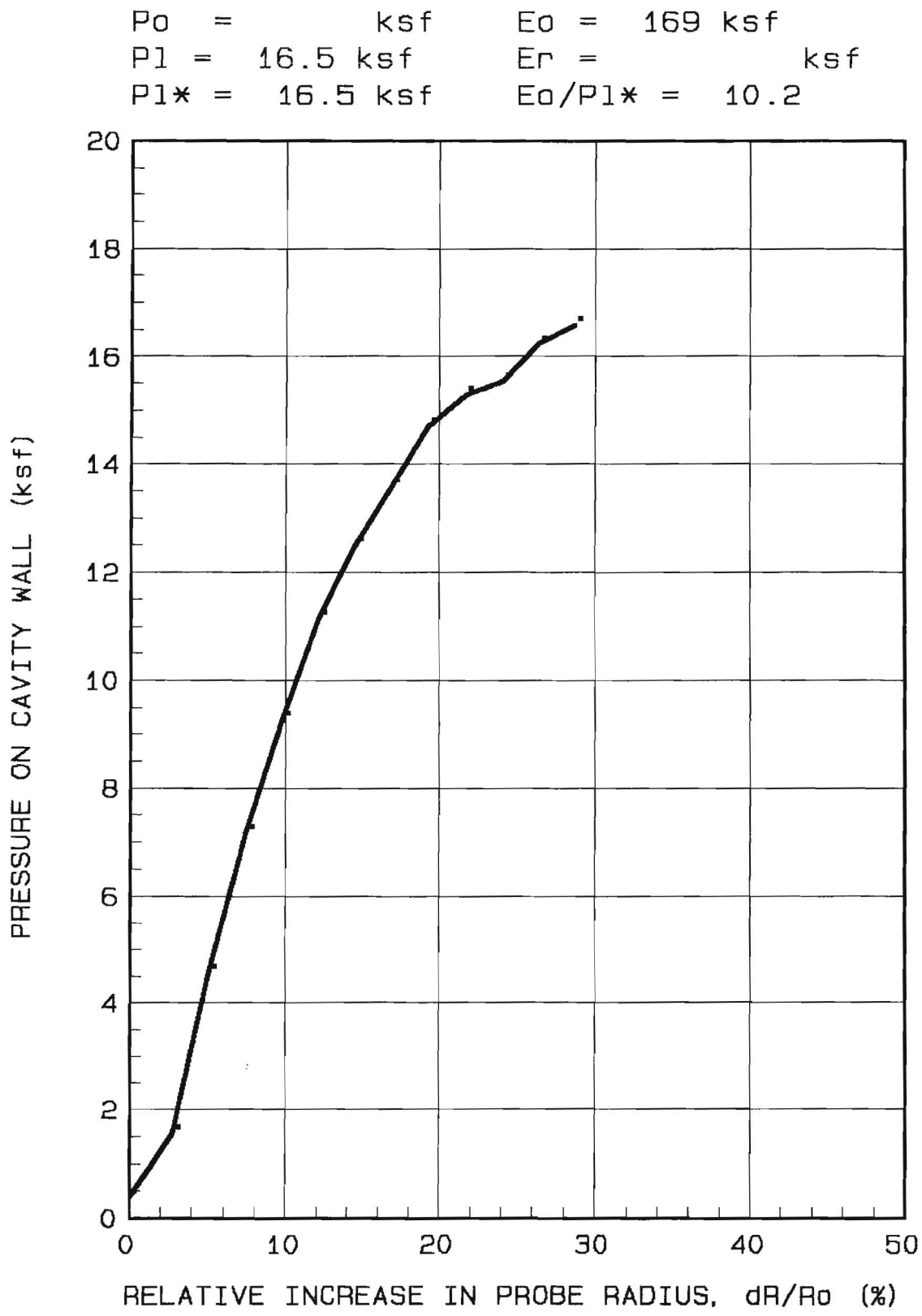


Figure A27. Site 5, 3.5 foot depth.

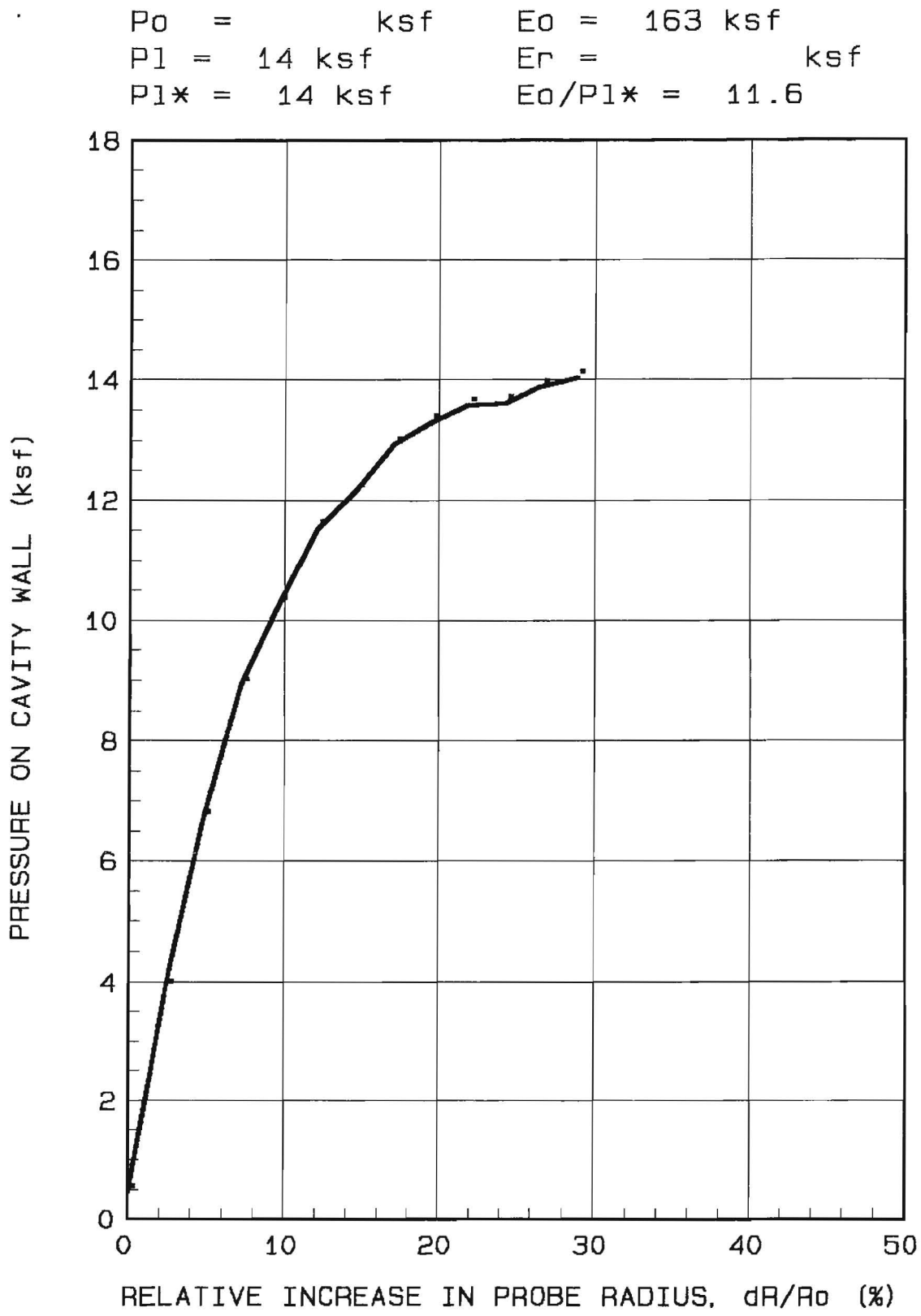


Figure A28. Site 5, 4.5 foot depth.

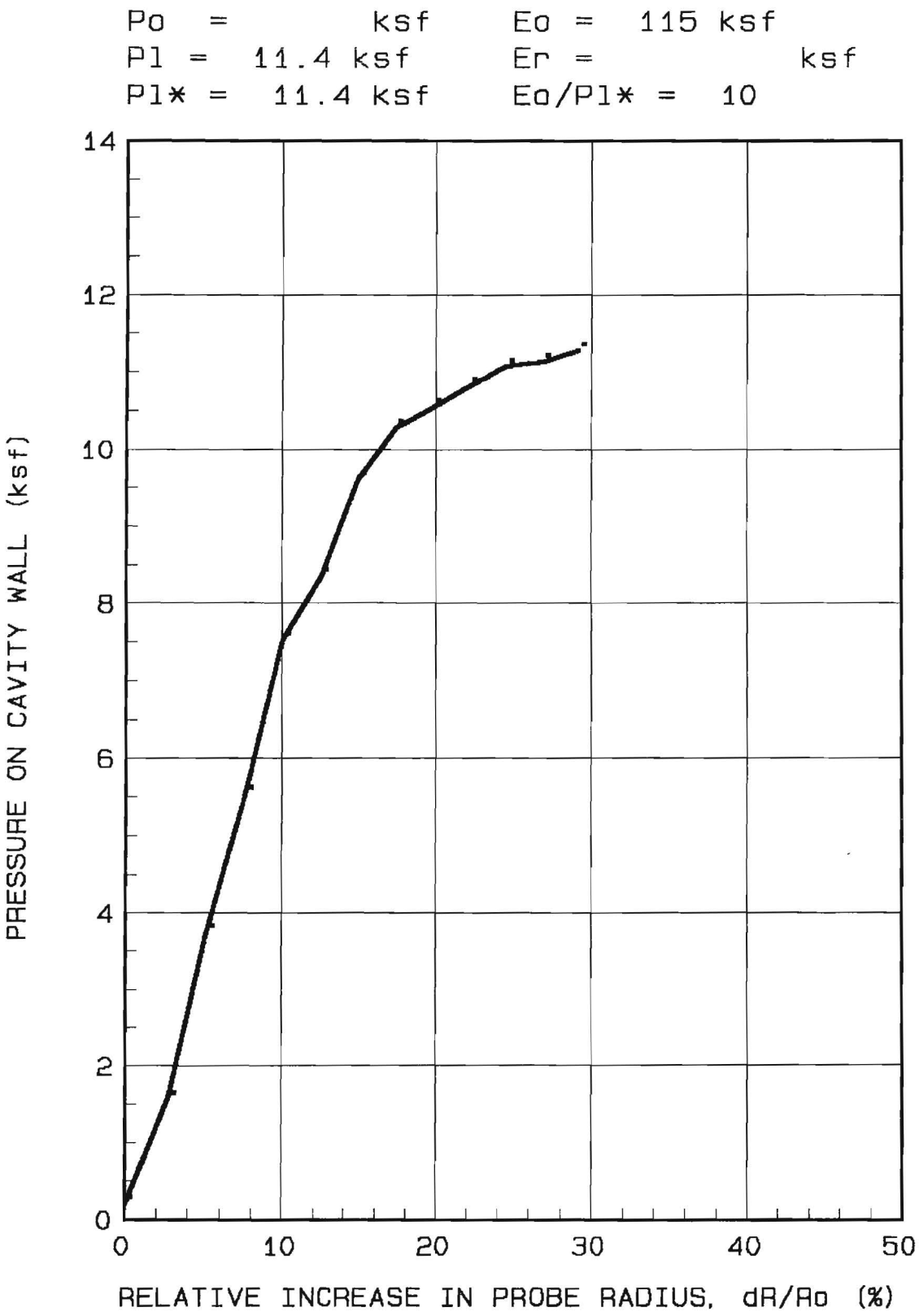


Figure A29. Site 6, 0.5 foot depth.