SD94-14-F

SD Department of Transportation
Office of Research

Crash Testing of Dual 4" x 6" Cedar Posts for Breakaway Applications

Study SD94-14
Final Report

Prepared by
Federal Highway Administration
6300 Georgetown Pike
McLean, VA 22101-2296

July 1995

DISCLAIMER

ACKNOWLEDGEMENTS

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16. Abstract
This test report contains the results of two crash tests performed at the Federal Outdoor Impact Laboratory (FOIL) in McLean, Virginia. The tests were performed on a small sign support system at 35 km/h, test 95F005 and at 100 km/h, test 95F006. The vehicle used for the tests was a 1986 Honda Civic. The purpose of these tests was to evaluate the low- and high-speed safety performance of the South Dakota red cedar post sign support. The sign support was made from a 102-mm by 152-mm western red cedar wood post. No holes were drilled in the posts, and the posts were buried 1.2 m in weak soil. The performance evaluation was based on the latest requirements for breakaway supports as specified in the National Cooperative Highway Research Program, Number 350. These criteria specify, in part, that the occupant change in velocity must be 5 m/s or less, that the significant test article stub height remaining after impact be no more than 102 mm, and no occupant compartment intrusion. The test results indicate that the western red cedar wood post sign support system meets all of the applicable safety criteria for low-speed and high-speed tests in weak soil as specified by the FHWA.

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Acceleration, occupant impact velocity, weak soil, red cedar, stub height, FOIL	No restrictions. This document is available to the public from the sponsoring agency.

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Unclassified	Unclassified	32	

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

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1. BACKGROUND

A majority of breakaway small sign support systems that utilize 102- by 152-mm pressure treated southern yellow pine wood as the breakaway mechanism are constructed with holes drilled in them to enhance the breakaway safety performance of the sign support. However, South Dakota uses western red cedar for small sign support systems. Western red cedar is not as strong as the widely used pressure treated southern yellow pine. As a result of holes drilled in the less sturdy red cedar, South Dakota experienced many sign failures from wind loading. The South Dakota Department of Transportation therefore, was interested in obtaining FHWA approval of a double post sign support made from a 102- by 152-mm western red cedar post without the recommended holes.

2. SCOPE

This test report contains the results of two crash tests performed at the Federal Outdoor Impact Laboratory (FOIL) in McLean, Virginia. The tests, 95F005 and 95F006, were performed on a double-leg small sign support system at nominal speeds of 35 km/h and 100 km/h, respectively. The vehicle used for both tests was a 1986 2-door Honda Civic. The purpose of these tests was to evaluate the low- and high-speed safety performance of a wooden dual-post sign support system mounted in weak soil. The performance evaluation was based on the latest requirements for breakaway supports as specified in the National Cooperative Highway Research Program, Report Number 350 (NCHRP Report 350).[1] These criteria specify, in part, that the occupant change in velocity must be 5.0 m/s or less, that the significant test article stub height remaining after impact be no more than 102 mm, and that there can be no occupant compartment intrusion.

3. TEST MATRIX

The tests were performed on a small sign support system. The nominal speeds for tests 95F005 and 95F006 were 35 km/h and 100 km/h, respectively. On both tests the sign was buried in NCHRP Report 350, S-2 weak soil. A summary of test conditions is presented in table 1.

Table 1. Test matrix.

Test Number	Test Vehicle	Test Weight (kg)	Test Speed (km/h)	Test Article Description	Impact Location
95F005	86′ Honda Civic	839	35	dual leg wood	center
95F006	86′ Honda Civic	839	100	dual leg wood	center

4. VEHICLE

The vehicle used for these tests was a 1986 Honda Civic 2-door hatch-back with a manual transmission. Prior to the tests, the vehicle was stripped, its fluids drained and its inertial properties measured. The test vehicle was ballasted with a data acquisition system, transducers, a brake system, and weight plates (if necessary) to bring its inertial weight to approximately 839 kg. After ballasting the vehicle, the inertial properties were remeasured. The actual test weight of the test vehicle was 839 kg.

5. SIGN SUPPORT

The sign support system consisted of two 102- by 152-mm western red cedar wood posts 3.9 m long. The actual dimensions of the sign legs were 102 mm by 152 mm. The sign legs were 0.9 m apart. One meter and 220 mm of the sign posts were buried in NCHRP Report 350 S-2 weak soil. Attached to the sign posts was a 0.6-m high by 1.5-m wide aluminum sign panel. The panel was made of 3 mm thick aluminum sheet and was installed 2.1 m above ground. The posts were installed without pre-drilled holes. The whole sign support system was assembled and placed in a hole in the weak soil. The hole was backfilled and compacted until the final grade was reached. Figure 2 is a drawing of the sign support system.

6. TEST RESULTS

Prior to impacting the sign support, the test vehicle was accelerated to 35.6 km/h in test 95F005 and to 96.8 km/h in test 95F006. In both tests, the centerline of the vehicle was aligned with the centerline between the two wooden sign posts.

The vehicles' bumper made contact with the sign posts 457 mm above ground in both tests. The two wooden posts began to bow at the point of contact 0.018 s into the event during test 95F005 and 0.006 s into the event in test 95F006. The wood posts failed completely at 0.052 s after impact in test 95F005 and at 0.016 s after impact in test 95F006.

In test 95F005, the sign support structure initially stayed in contact with the vehicle causing the sign panel to hit the windshield on three occasions before falling to the left of the vehicle 13 m from the original sign position. The small pieces of wood created by the sign post fracturing at the point of contact and below ground were propelled forward while the vehicle passed over them. The right rear wheel of the vehicle rolled on one of the small wood fragments which caused the vehicle to yaw 28 degrees to the left of its original trajectory. Except for the windshield crack, there was no structural damage to the test vehicle.

In test 95F006, the sign support was thrown upwards by the test vehicle and then fell upside down causing the sign panel to hit the rear part of the vehicles' roof and bounce off the test vehicle. The small wood fragments caused by the wood posts fracturing at the point of contact and below ground were propelled forward while the vehicle rolled over them. The left rear wheel of the test vehicle rolled over one of the small wood fragments and caused the car to yaw 6 degrees to the right of its original trajectory. The panel's contact with the roof caused a 75 mm dent in the roof and caused the left rear passenger window to shatter.

The sign support fractured in a predictable manner during both crash tests. Damage to the sign support consisted of two fractured wood posts in both tests. Each post fractured at two locations. During test 95F005 the left post fractured once 457 mm above ground and once 127 mm below ground. The right post fractured once 452 mm above and once 118 mm below ground. During test 95F006 the left post fractured once 450 mm above ground and once 129 mm below ground. The right post fractured once 450 mm above ground and once 121 mm below ground. The lower wood fragments of the sign posts remained buried in the weak soil during both tests. The broken wood fragments of the sign support and the sign post would not have presented any danger to other traffic or pedestrians. The panel was in good condition after both tests.

The occupant impact velocity using the 0.6-m fail space model outlined in NCHRP Report 350, was determined to be 2.3 m/s in test 95F005 and 1.9 m/s in test 95F006. The occupant impact velocity was reached 0.31 s after impact in test 95F005 and 0.38 s after impact in test 95F006. The ridedown acceleration was 1.4 g's in test 95F005 and 2.0 g's in test 95F006 . The peak force (300 Hz data) for the impact event was 129 kN in test 95F005 and 299 kN in test 95F006. The vehicle change in velocity was calculated to be 3.1 m/s for test 95F005 and 2.6 m/s for test 95F006.

Figure 3 contains photographs during the impact event in test 95F005 and figure 13 contains photographs during the impact event in test 95F006. Figure 4 depicts a summary of the impact conditions and test results for test 95F005, while figure 14 depicts a summary of the impact conditions and test results for test 95F006. Figures 5 through 8 are plots of data collected during test 95F005 and figures 15 through 18 are plots of data collected during test 95F006. Pre- and post-test photographs of the vehicle and sign support system in test 95F005 are presented in figures 9 through 12. The pre- and post-test photographs of the vehicle and sign support system in test 95F006 are presented in figures 19 through 22.

7. CONCLUSION

The occupant impact velocity was calculated to be 2.3 m/s for test 95F005 and 1.9 m/s for test 95F006 which are both less than the 5 m/s limit specified in NCHRP Report 350. There were no stubs remaining after both tests. In addition, the cracked windshield in test 95F005 and the 75-mm dent in the roof along with the shattered rear passenger window in test 95F006 do not constitute occupant compartment intrusion. Therefore, the small sign support system meets all of the applicable criteria for both low-speed and high-speed tests in weak soil. A summary of test results and assessments is presented in table 2.

Table 2. Test assessment summary			
Test Number	Evaluation Criteria	Test Results	Assessment
95F005	Structural Adequacy The test article should readily activate in a predictable manner by breaking away, fracturing, or yielding.	The two red cedar wood posts fractured in a predictable manner. No stubs left after crash.	Pass
	Occupant Risk Longitudinal occupant impact velocity should satisfy the following: Preferred............ 3 m/s Maximum.............. 5 m/s	Longitudinal Impact Vel. = 2.3 m/s.	Pass
	Vehicle trajectory behind the test article is acceptable.	The vehicle trajectory was 6 degrees to the right of the original trajectory.	Pass
95F006	Structural Adequacy The test article should readily activate in a predictable manner by breaking away, fracturing, or yielding.	The two red cedar wood posts fractured in predictable manner. No stubs left after crash.	Pass
	Occupant Risk Longitudinal occupant impact velocity should satisfy the following: Preferred............ 3 m/s Maximum.............. 5 m/s	Longitudinal Impact Vel. = 1.9 m/s.	Pass
	Vehicle trajectory behind the test article is acceptable.	The vehicle trajectory was 28 degrees to the left of the original trajectory.	Pass

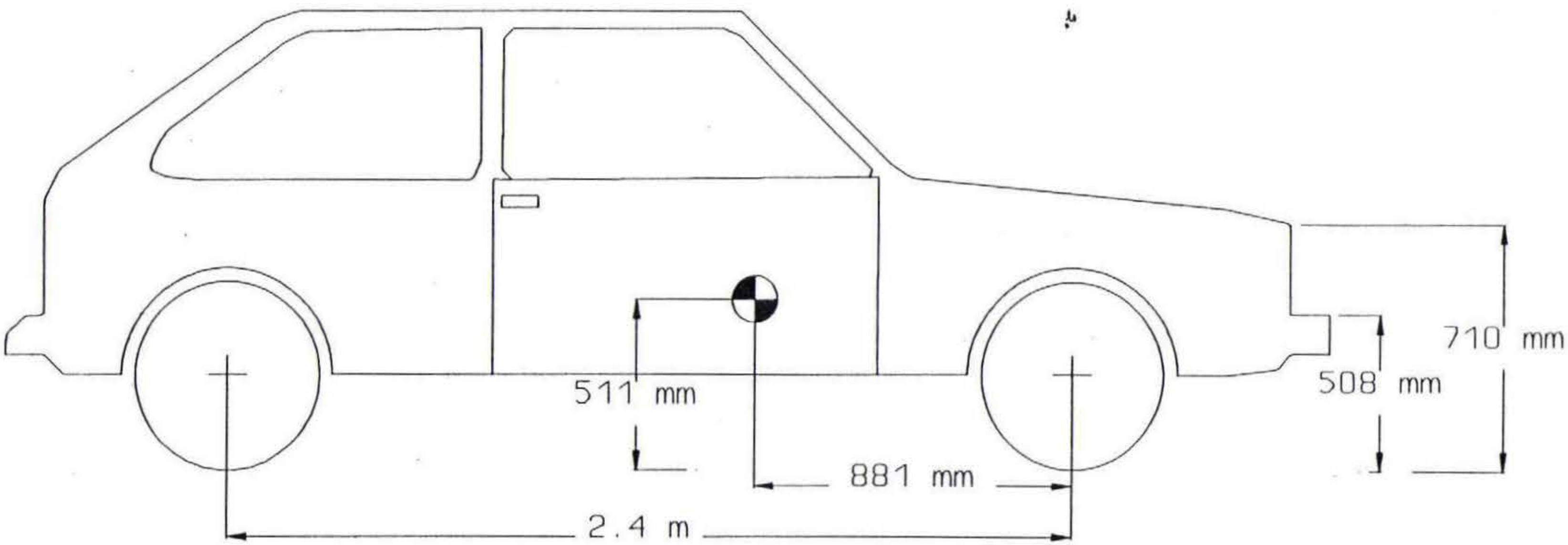


Figure 1. Sketch of test vehicle ('86 Honda Civic).

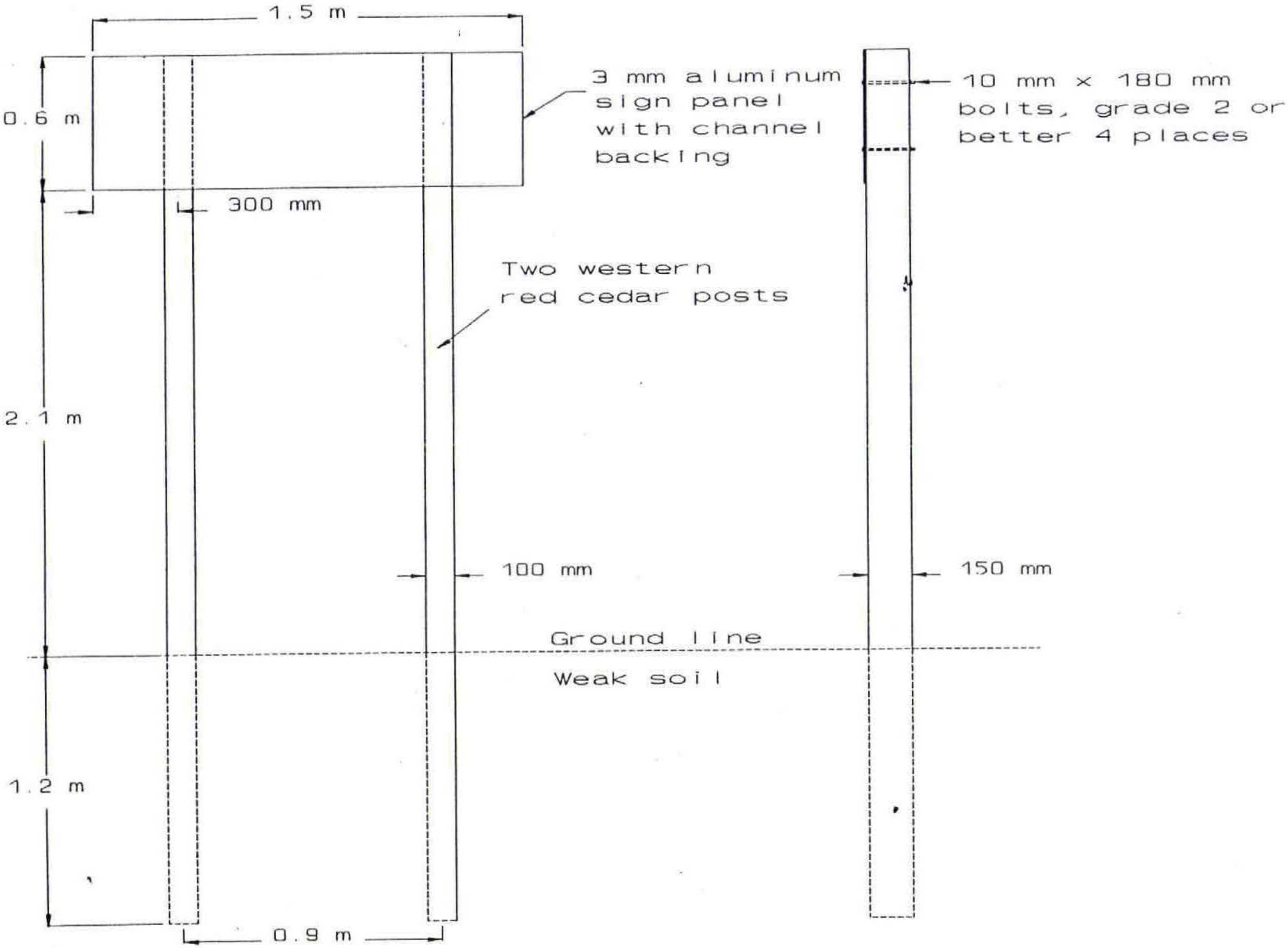
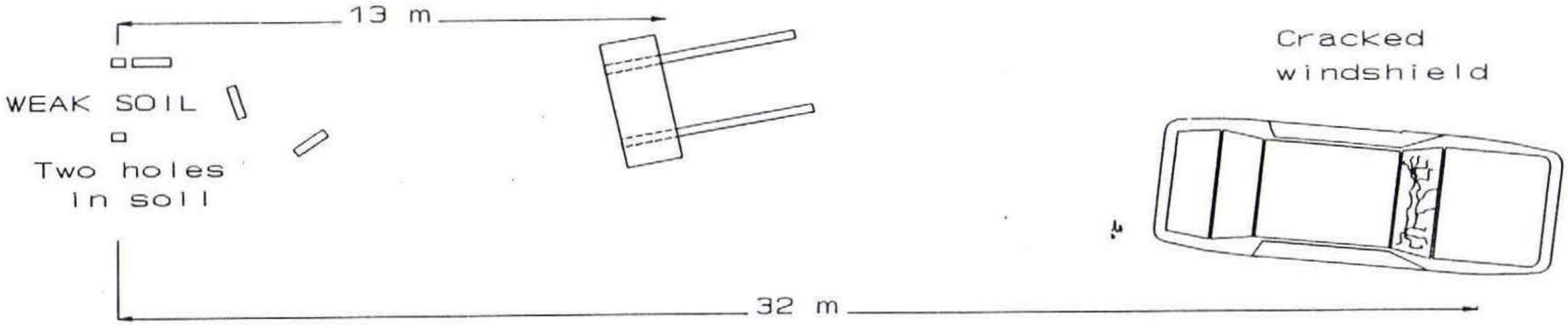


Figure 2. Sketch of small sign support.

Figure 3. Test photographs during impact, test 95F005.



Test number	95F005
Date	February 22, 1995
Test vehicle	86' Honda Civic
Vehicle weight	839 kg
Test article	double-leg small sign support
Material	102 mm by 152 mm red cedar wood
Embedment depth	1.2 m
Panel type	0.6 m by 1.5 m aluminum sheet
Height	2.7 m
Foundation	S-2 weak soil
Impact speed	9.9 m/s
Impact angle	0 degrees
Impact location	Head-on, centerline

Vehicle analysis:	Observed	Design/Limit
Longitudinal:		
Occupant Delta V at 0.61 m	2.3 m/s	≤ 5.0 m/s
Ridedown Acceleration	1.4 g's	15/20 g's
Lateral:		
Occupant Delta V at 0.305 m	no contact	no spec
Ridedown Acceleration	no contact	no spec
Peak 50 msec acceleration		
Longitudinal	3.5 g's	
Lateral	NA	
Vehicle Damage (TAD)	12-FC-1	
(VDI)	12FCAU1	
Crush	No residual deformation	
Vehicle velocity change	3.1 m/s	
Exit angle	0 degrees	

Figure 4. Summary of test 95F005.

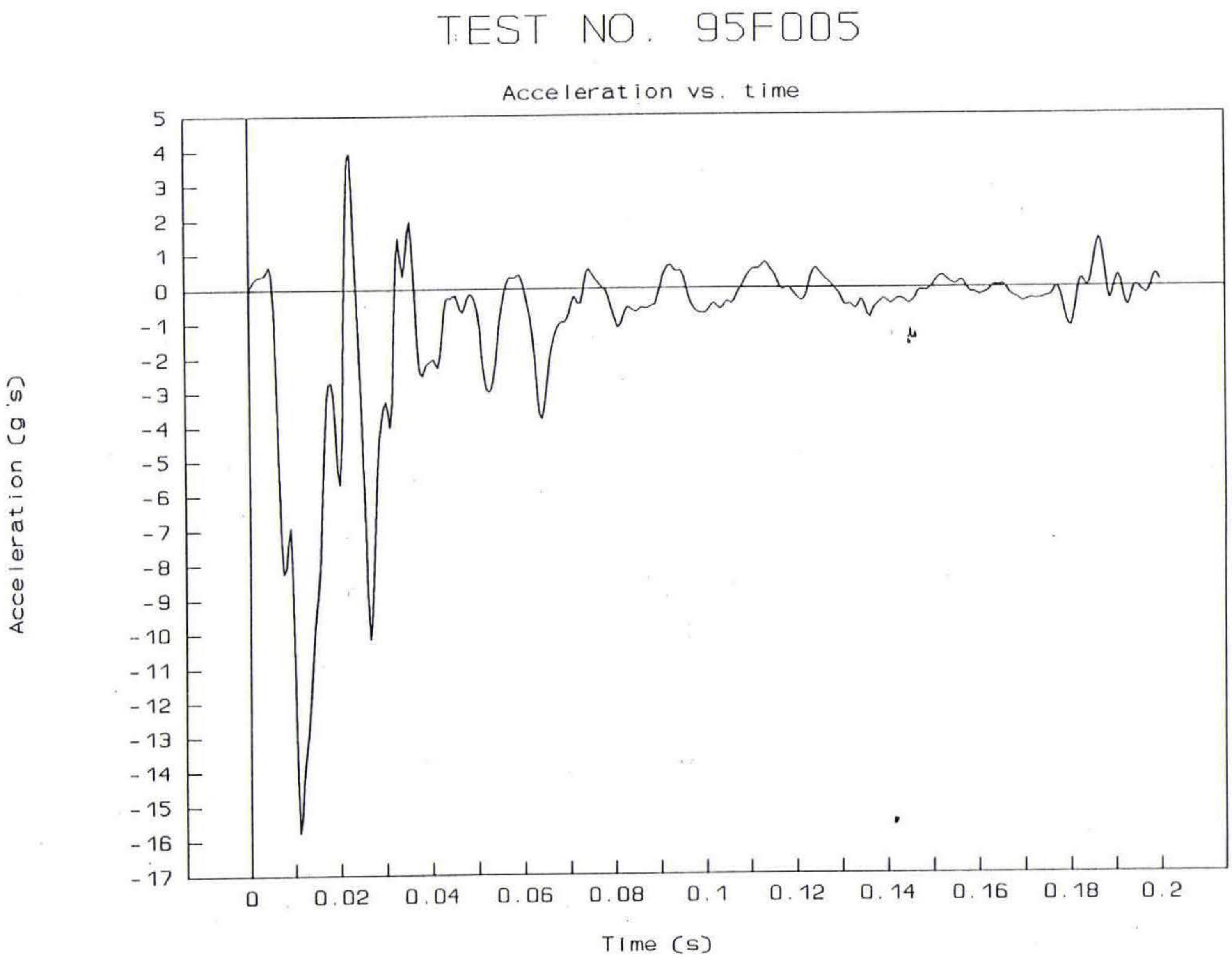


Figure 5. Acceleration vs. time, X-axis, test 95F005.

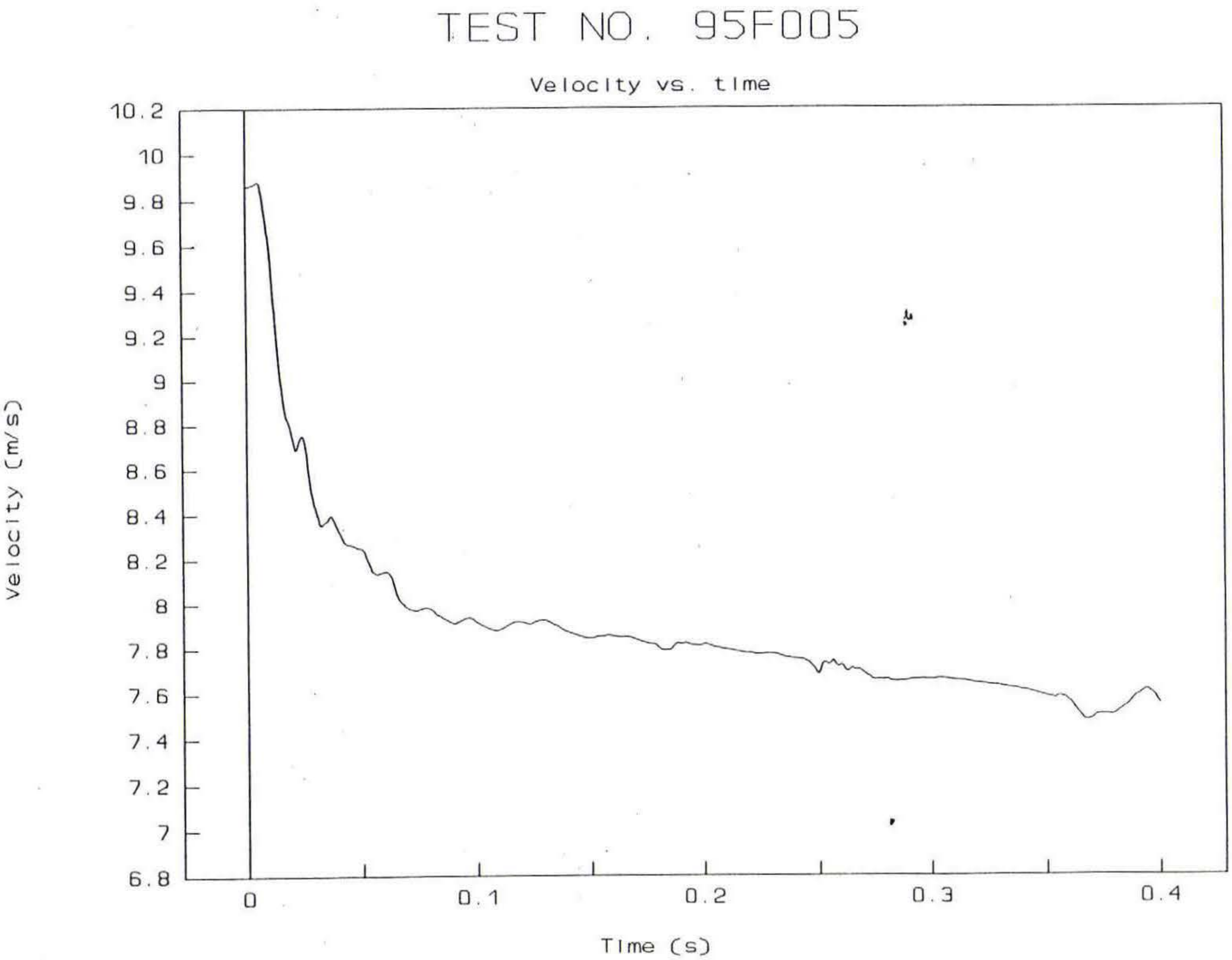


Figure 6. Velocity vs. time, X-axis, test 95F005.

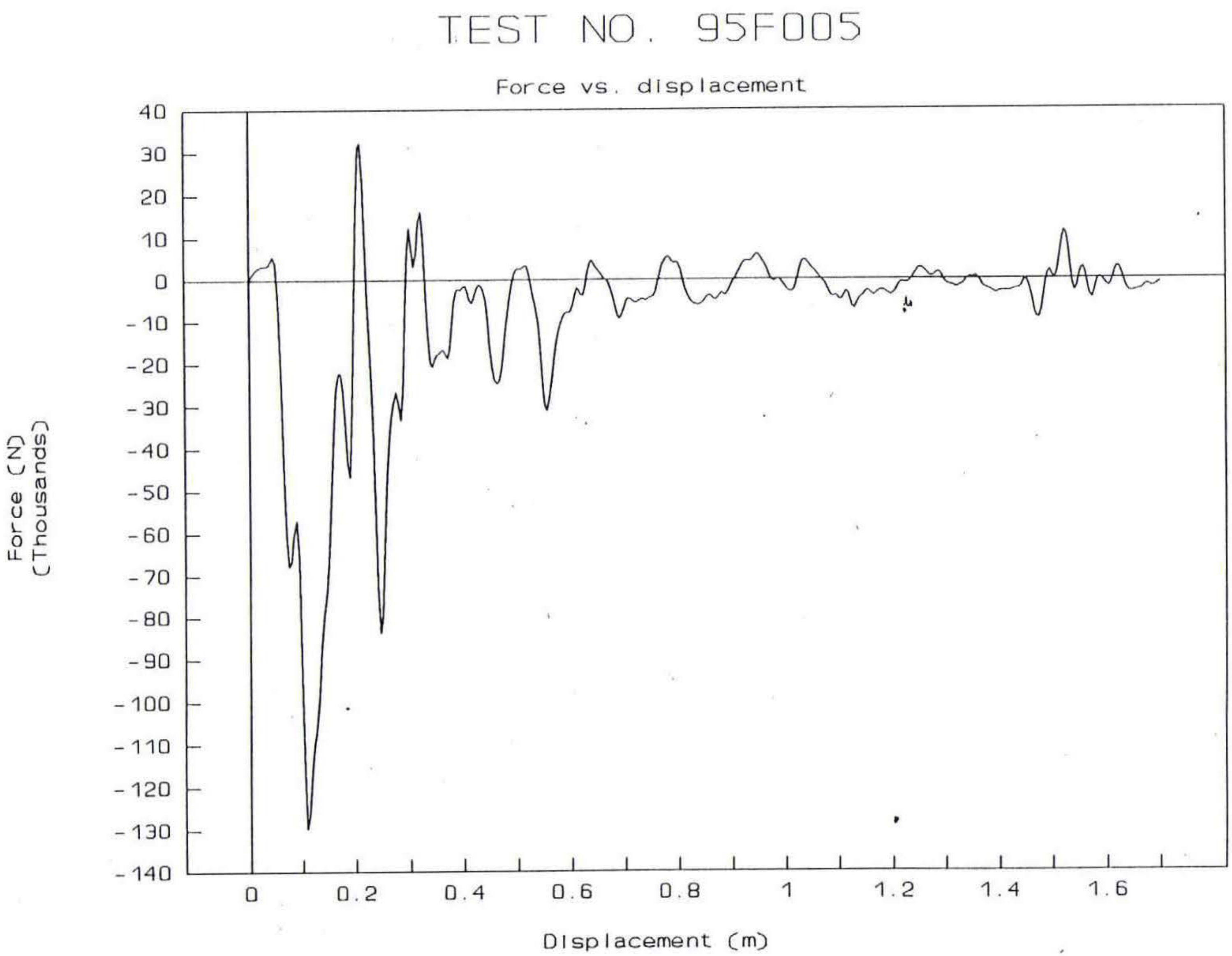


Figure 7. Force vs. displacement, X-axis, test 95F005.

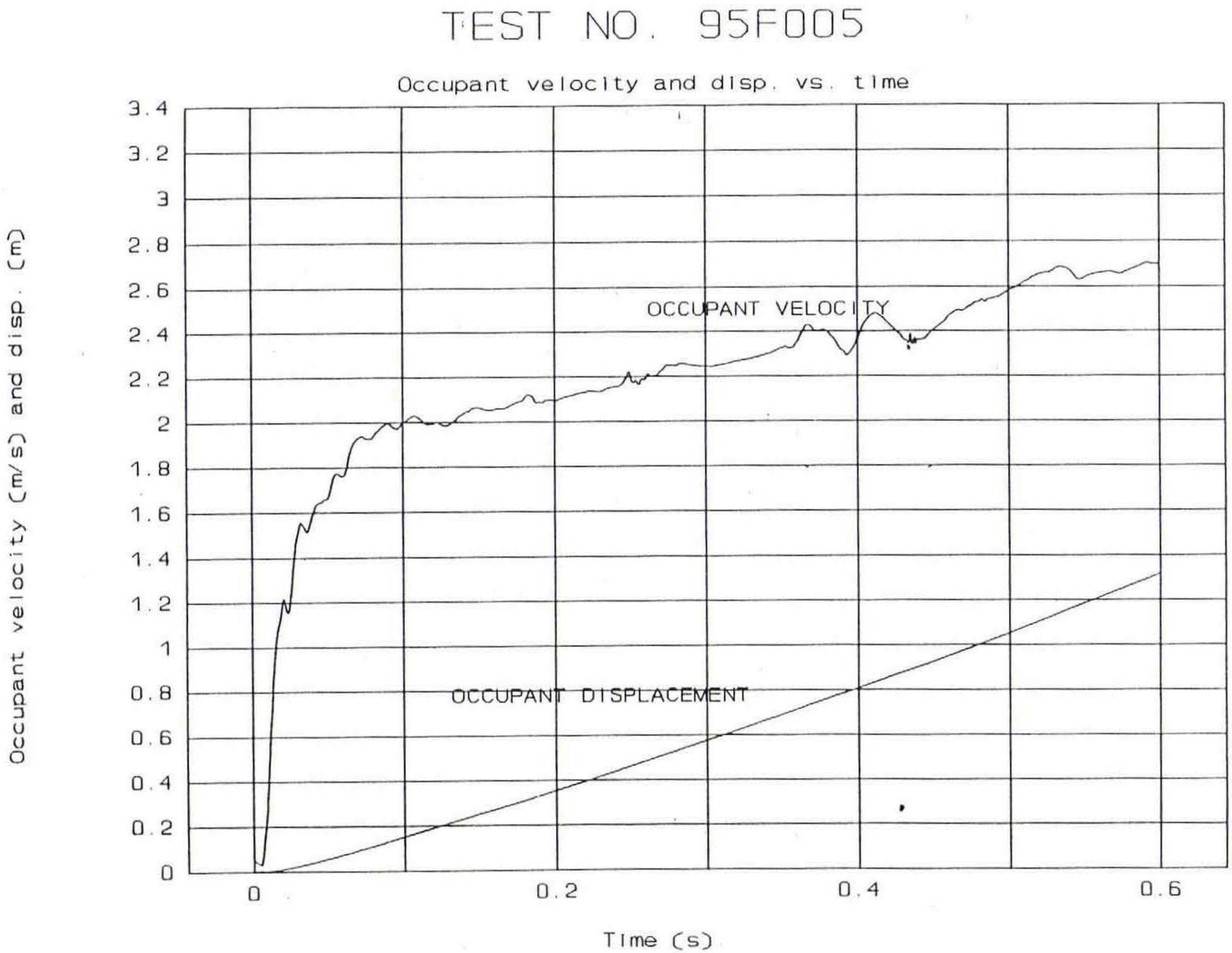


Figure 8. Occupant velocity and relative displacement vs. time, X-axis, test 95F005.

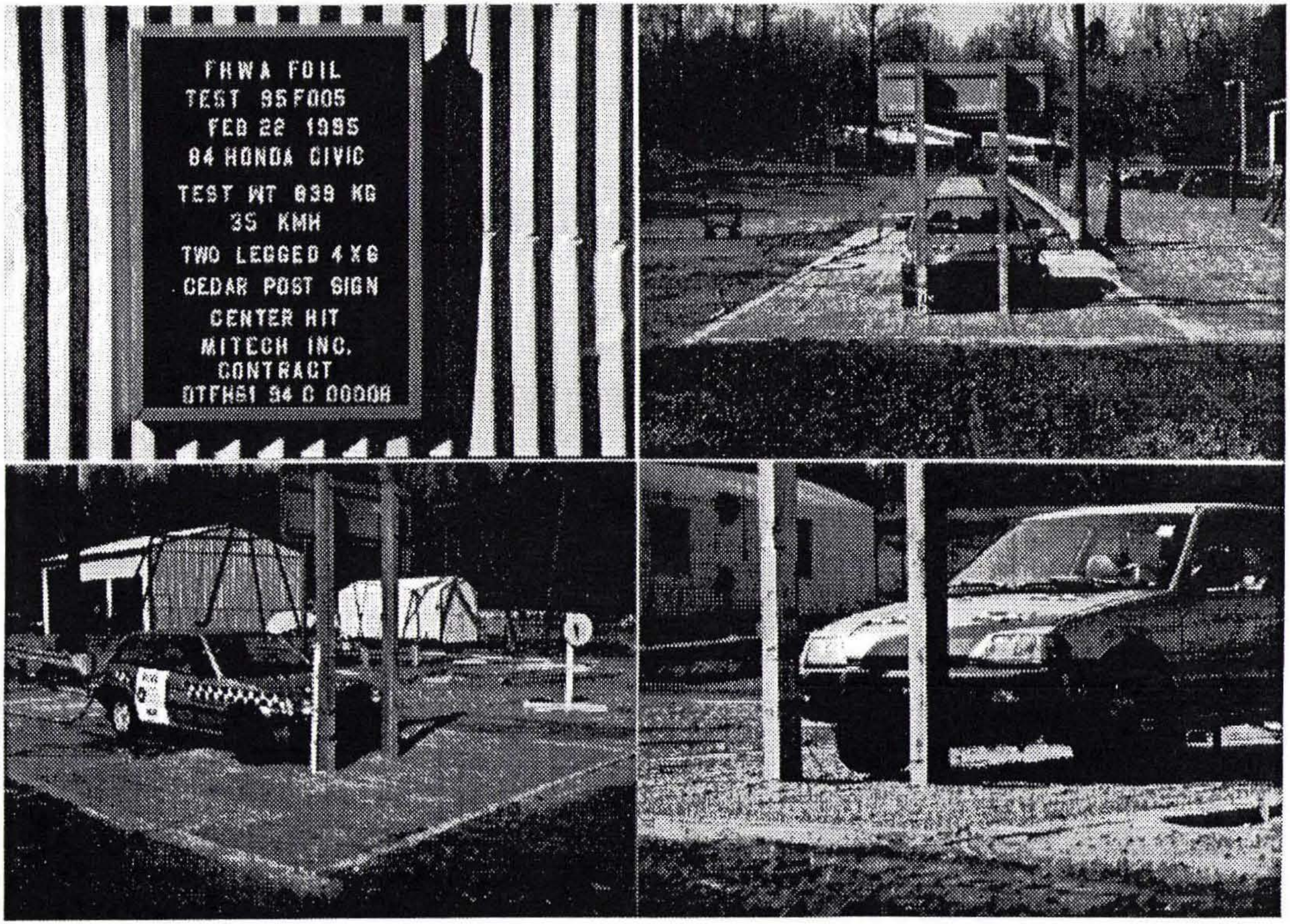


Figure 9. Pre-test photographs of test 95F005.

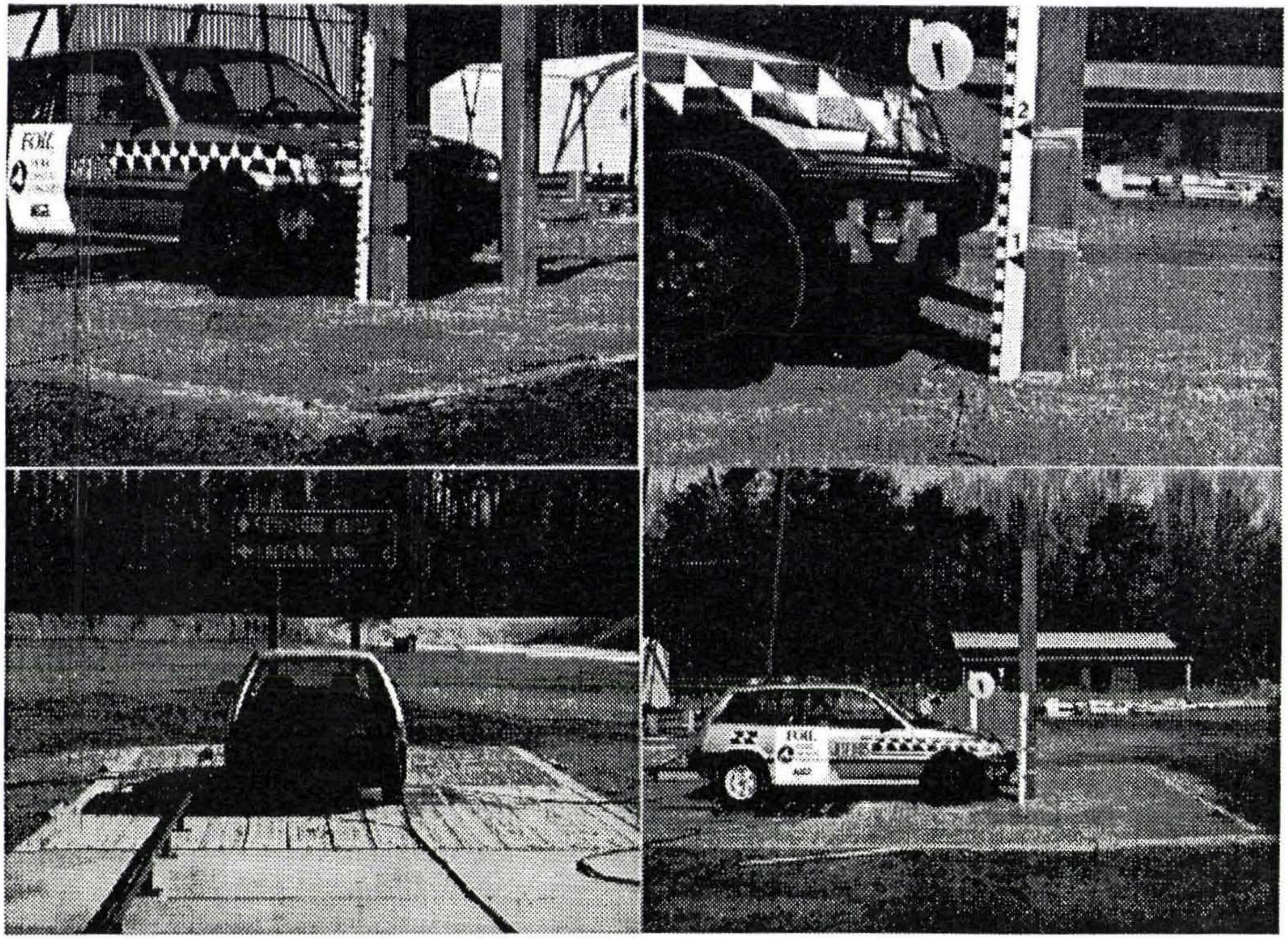


Figure 10. Pre-test photographs of test 95F005 (continued).

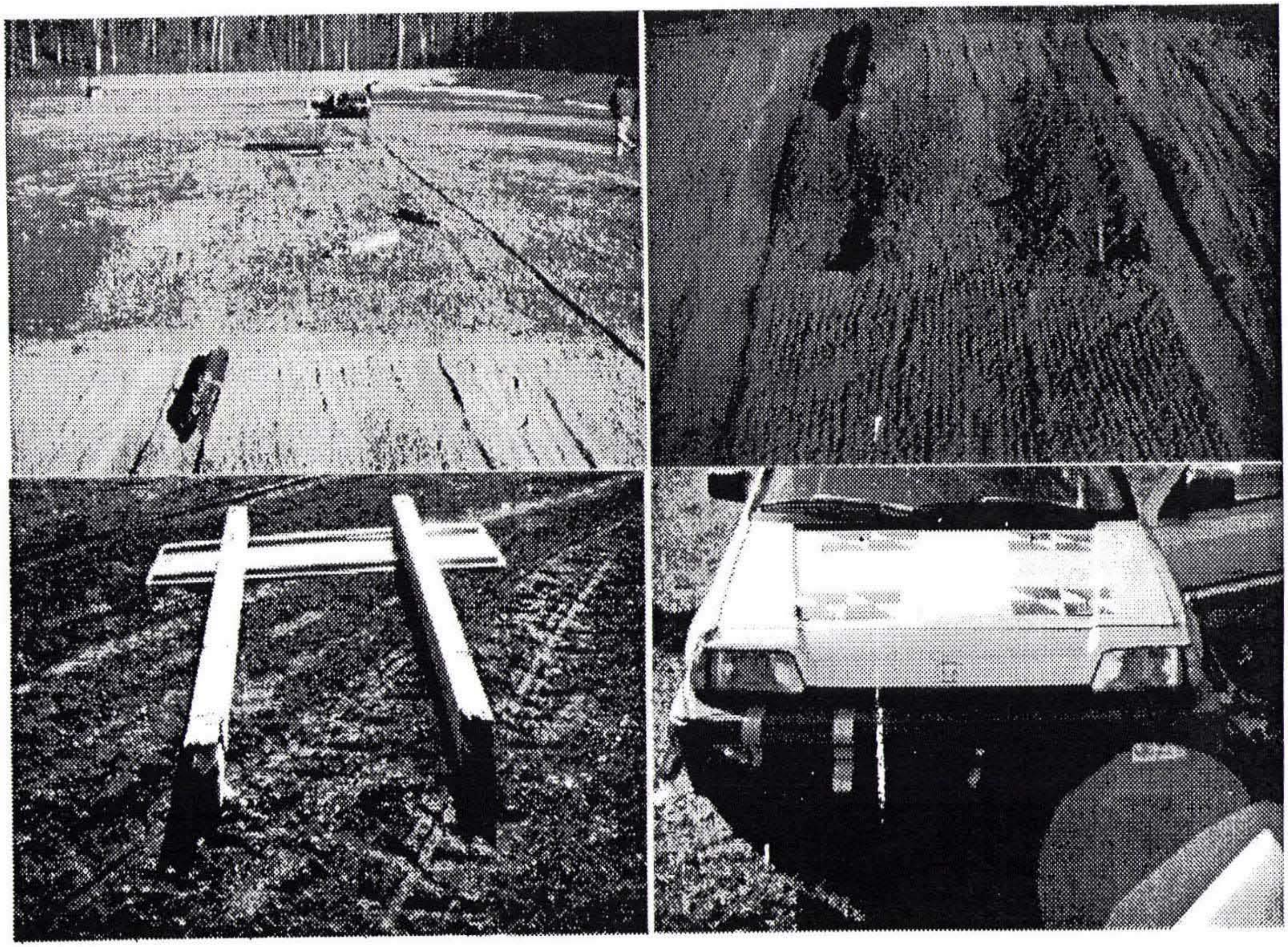


Figure 11. Post-test photographs of test 95F005.

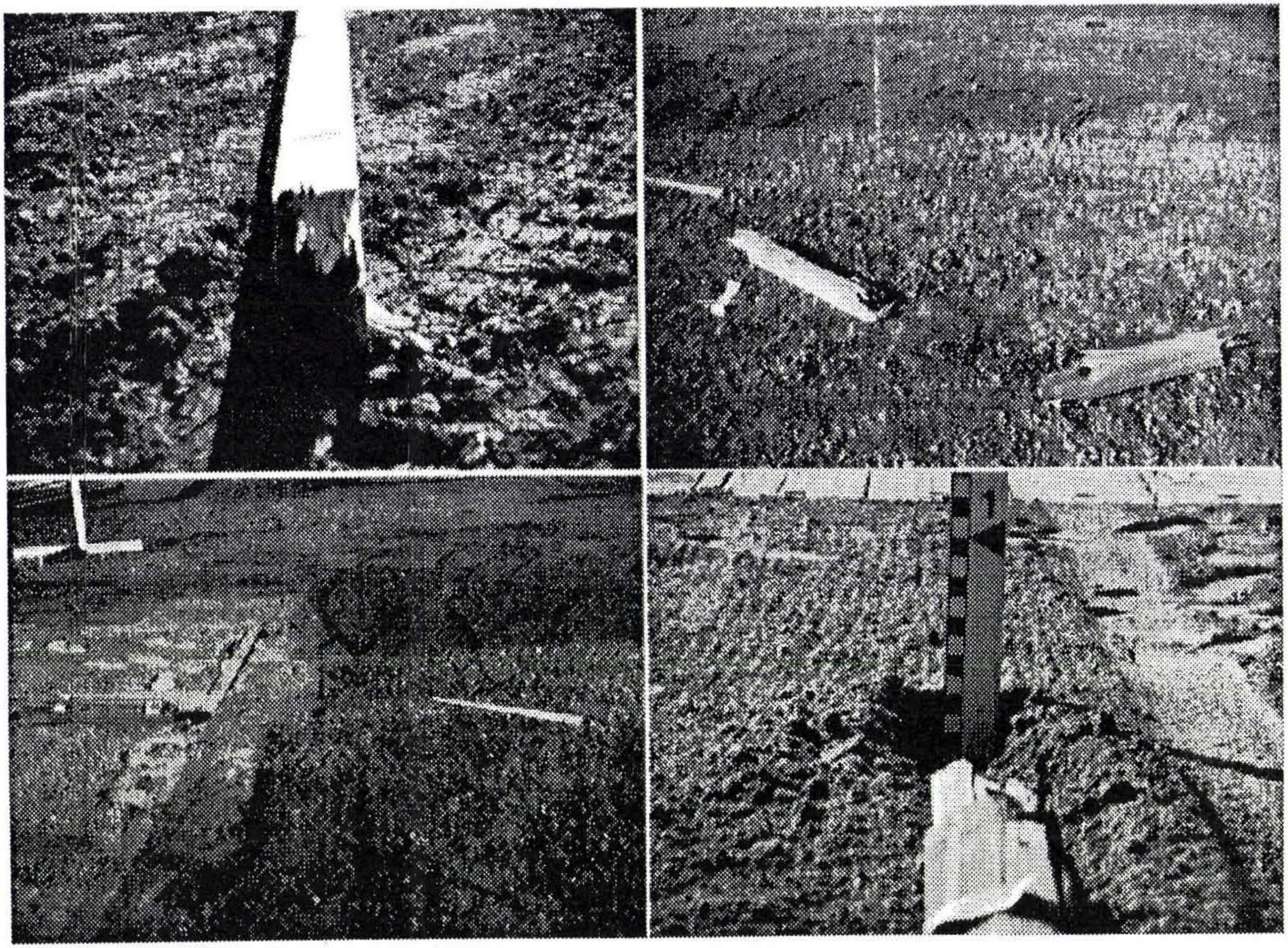


Figure 12. Post-test photographs of test 95F005 (continued).

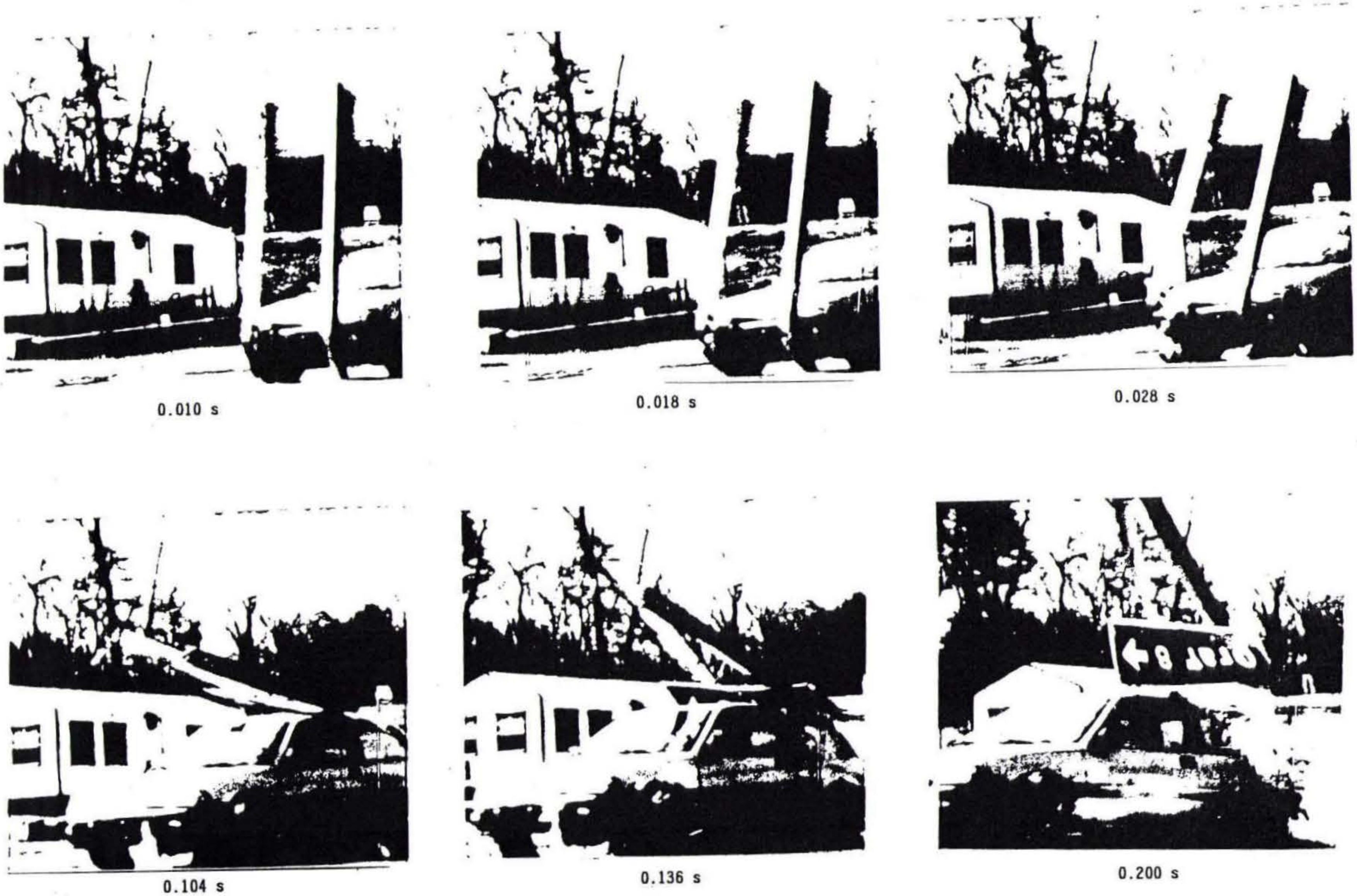
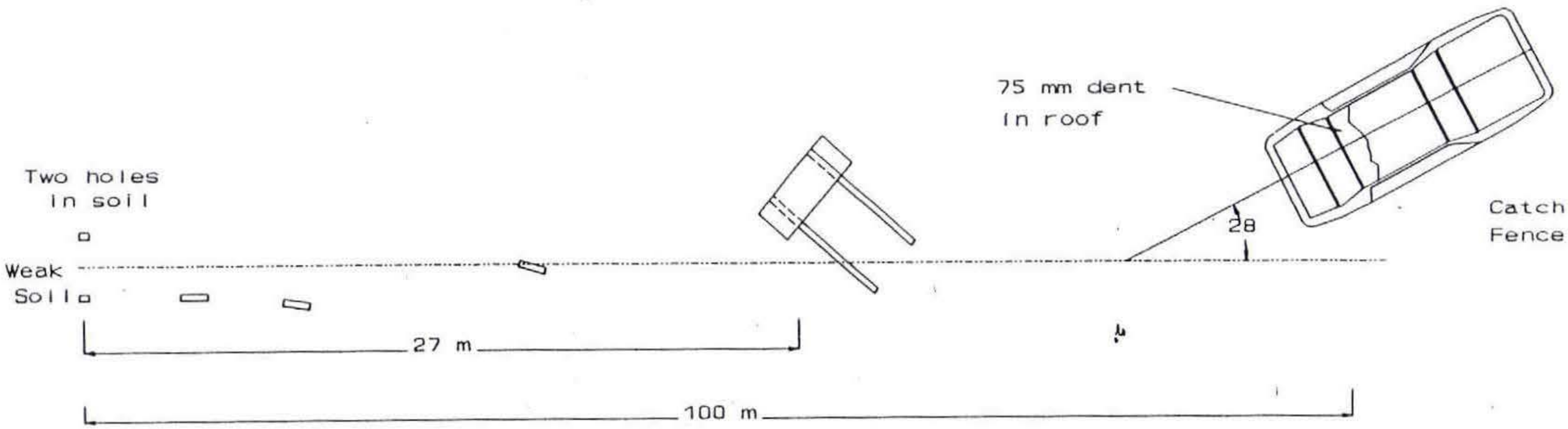


Figure 13. Test photographs during impact, test 95F006.



Test number.. 95F006

Date... March 2, 1995

Test vehicle.................................. '86 Honda Civic

Vehicle weight.................................. 839 kg

Test article.................... double-leg small sign support

Material.......................... 102 mm by 152 mm wood

Embedment depth.................................. 1.2 m

Panel type................ 0.6 m by 1.5 m aluminum sheet

Height.. 2.7 m

Foundation...................................... S-2 weak soil

Impact speed... 26.9 m/s

Impact angle.. 0 degrees

Impact location.......................... Head-on, centerline

Vehicle analysis:	Observed	Design/Limit
Longitudinal:		
Occupant Delta V at 0.61 m..........	1.9 m/s	≤ 5.0 m/s
Ridedown Acceleration...............	2.0 g's	15/20 g's
Lateral:		
Occupant Delta V at 0.305 m........	no contact	no spec
Ridedown Acceleration..............	no contact	no spec

Peak 50 msec acceleration

Longitudinal.................................. 2.6 g's

Lateral.. NA

Vehicle Damage (TAD)................................ 12-FC-1

(VDI)................................32FTAN2

Crush.............................. No residual deformation

Vehicle velocity change............................ 2.6 m/s

Exit angle.. 0 degrees

Roof damage (crush).................................. 75 mm

Figure 14. Summary of test 95F006.

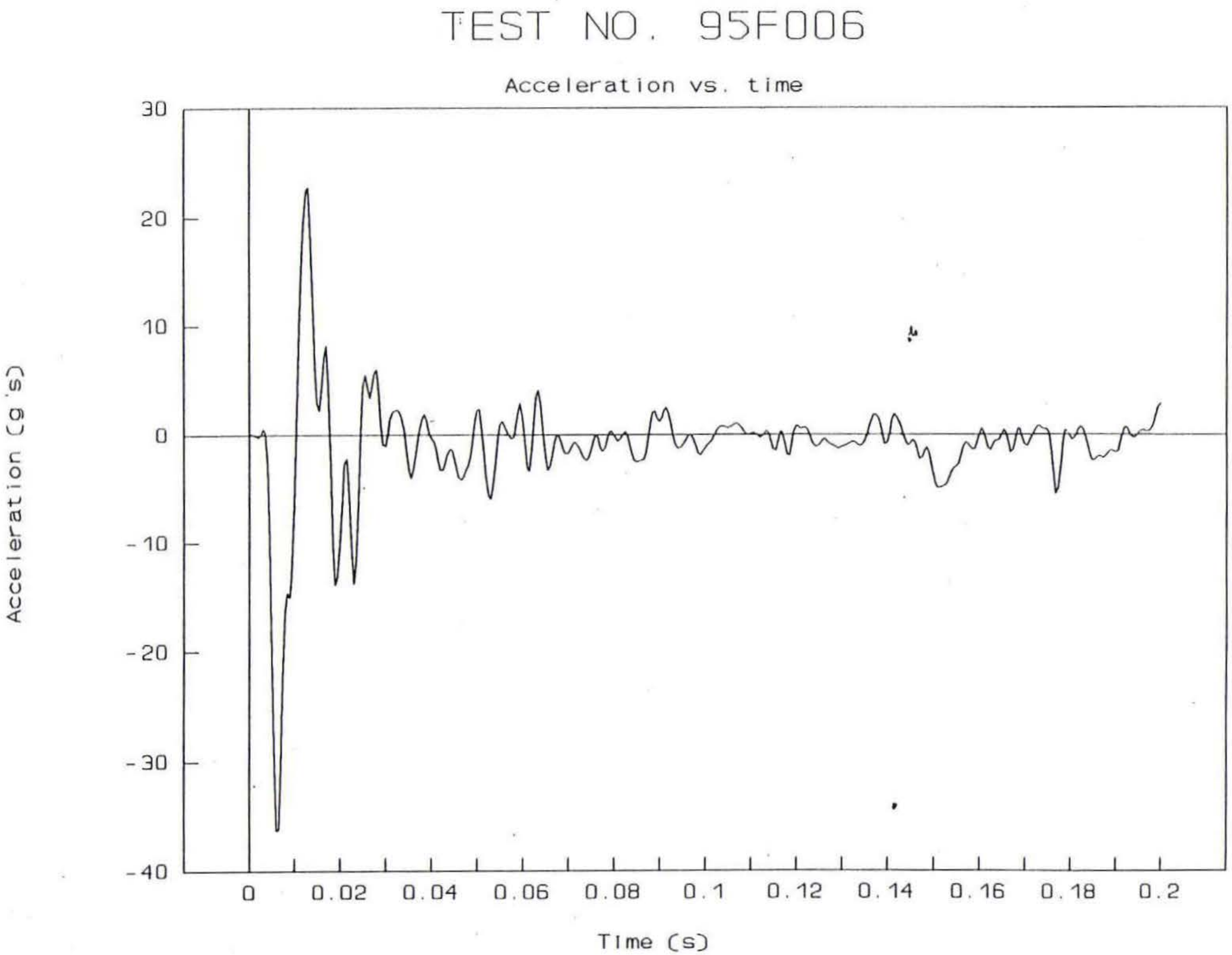


Figure 15. Acceleration vs. time, X-axis, test 95F006.

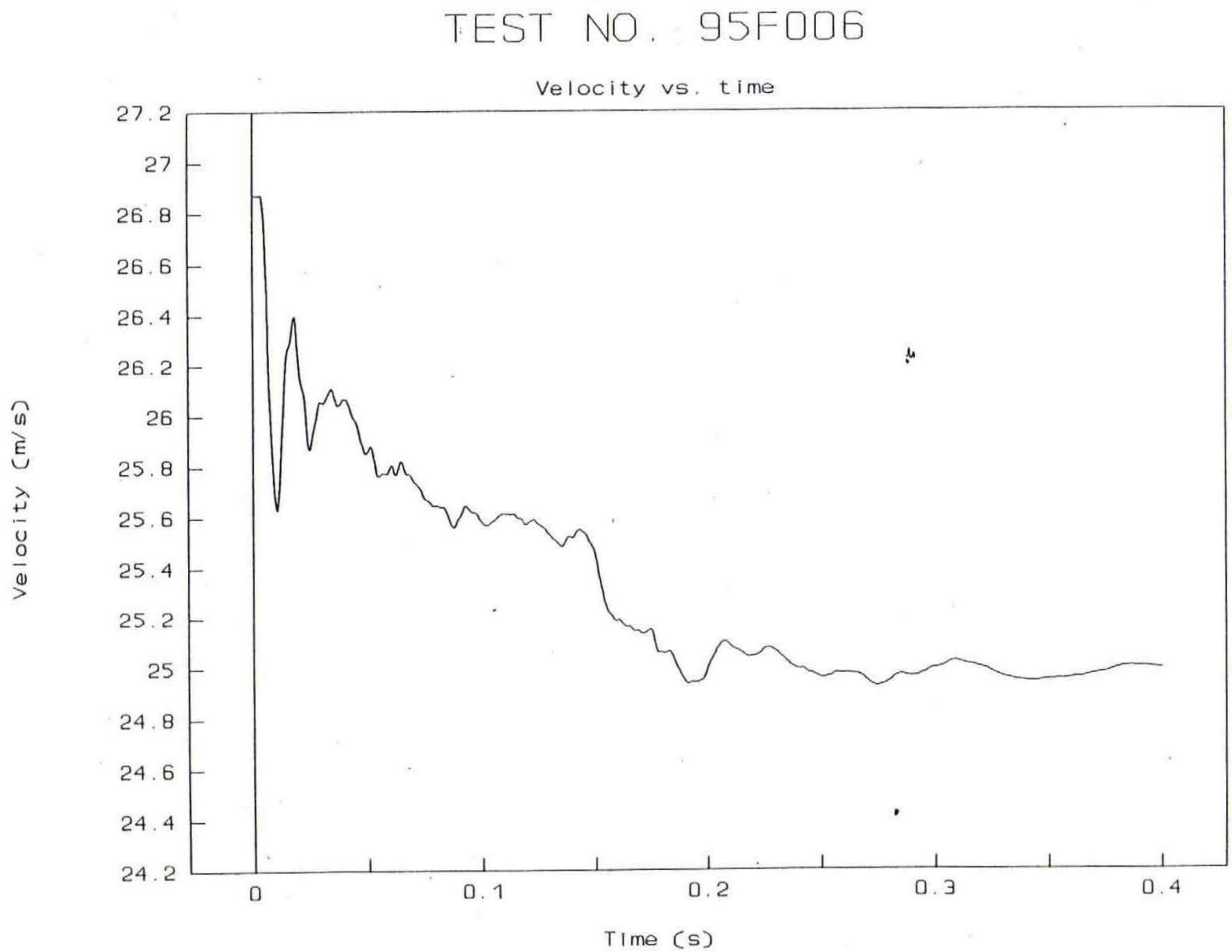


Figure 16. Velocity vs. time, X-axis, test 95F006.

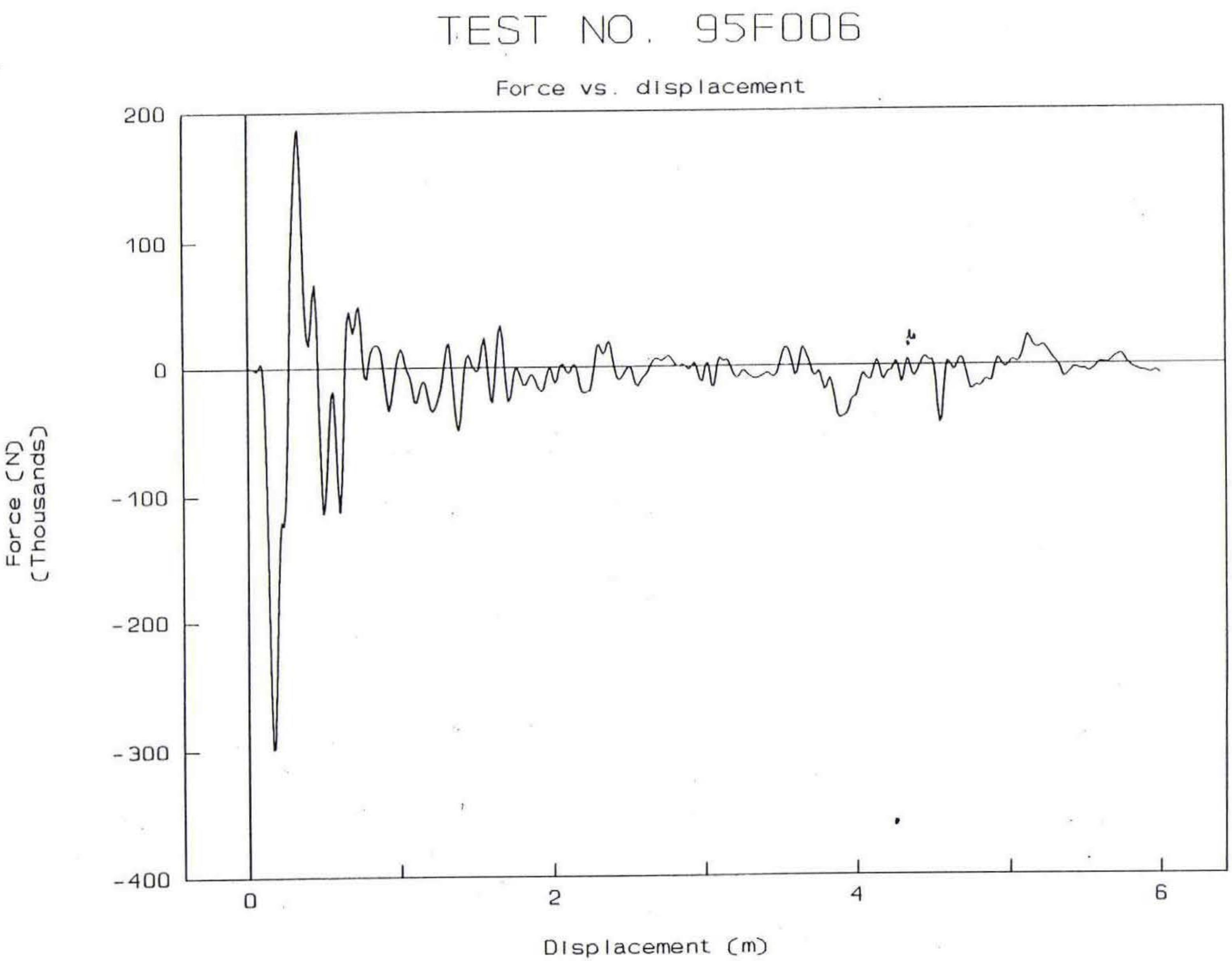


Figure 17. Force vs. displacement, X-axis, test 95F006.

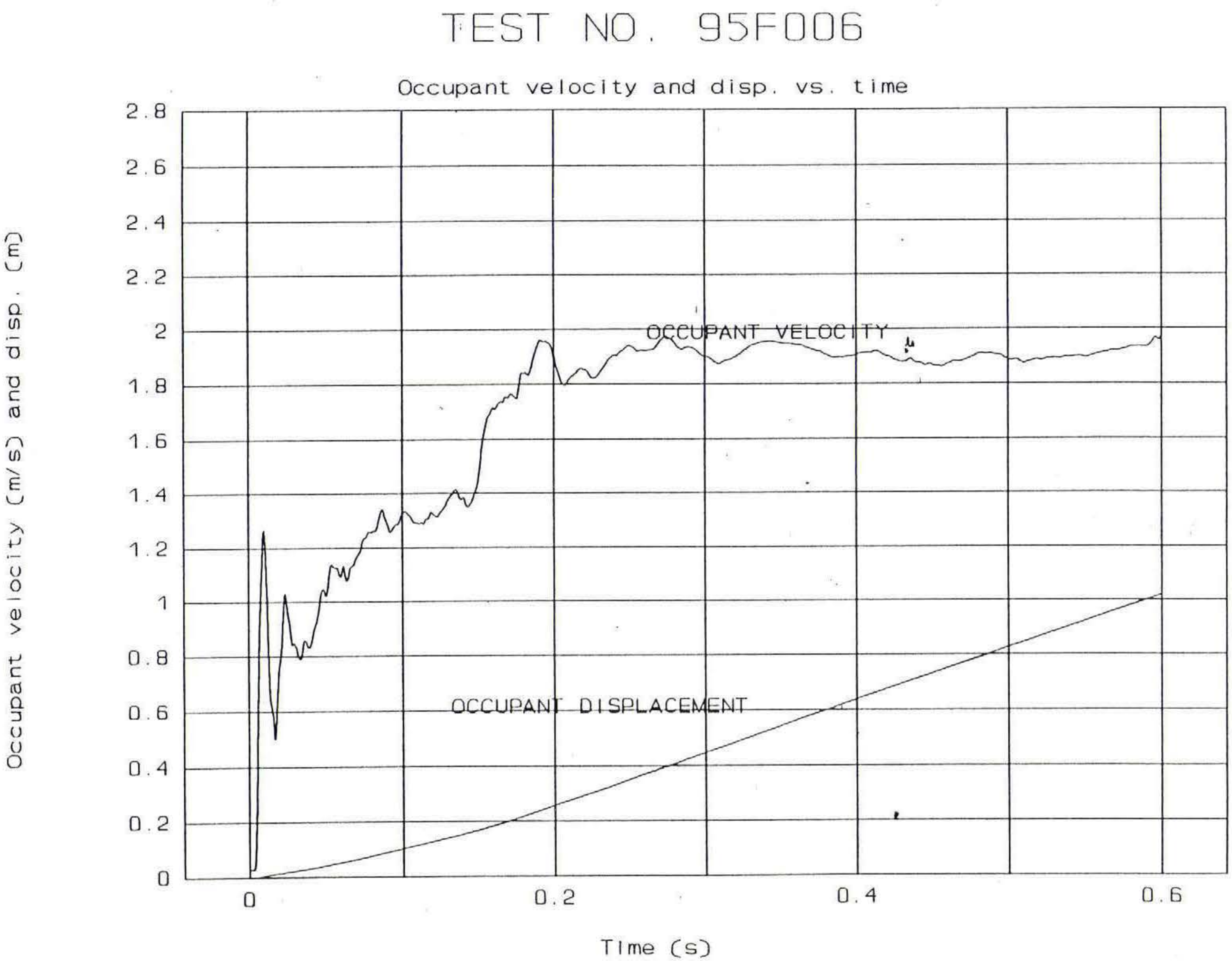


Figure 18. Occupant velocity and relative displacement vs. time, X-axis, test 95F006.

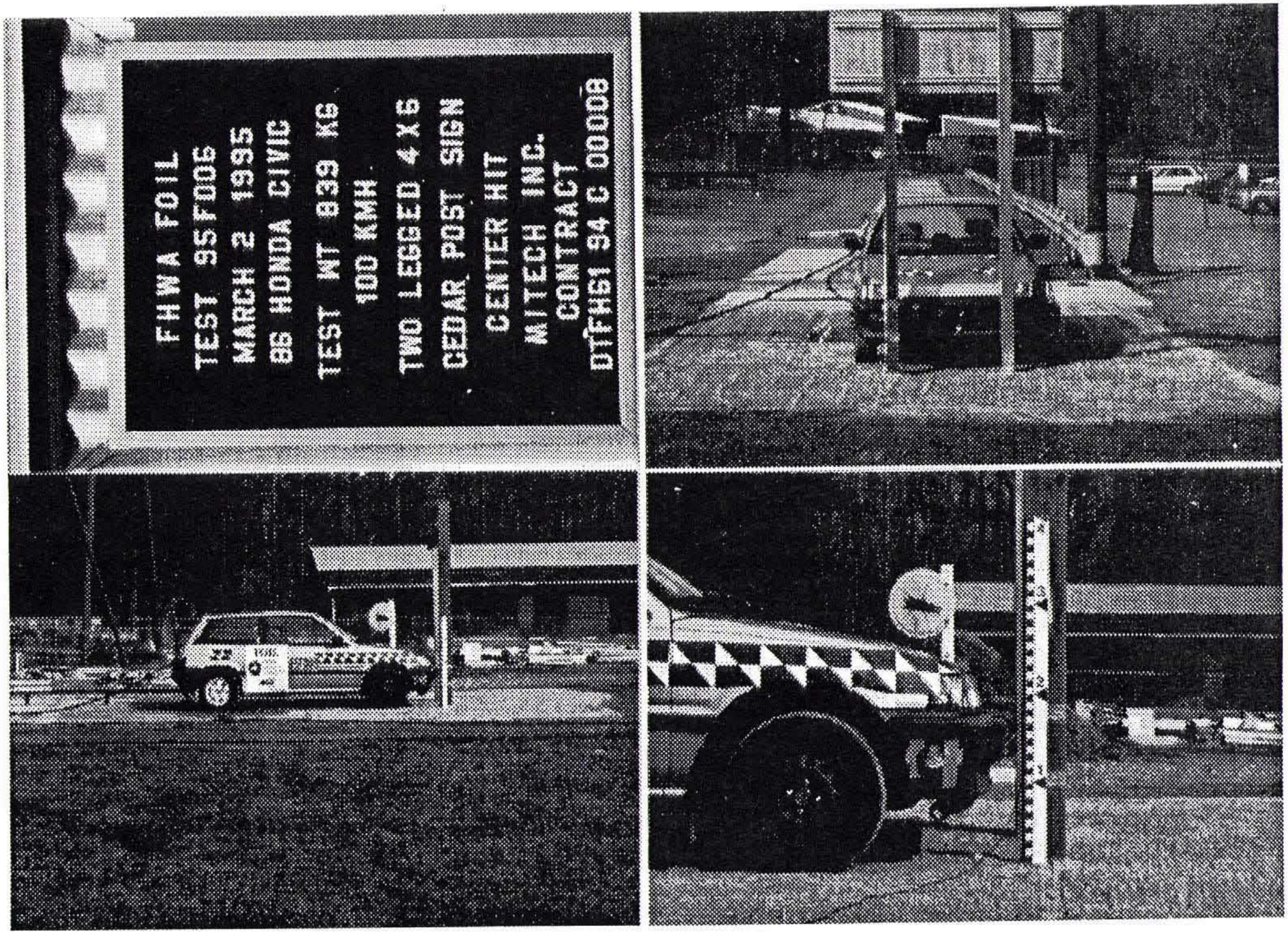


Figure 19. Pre-test photographs of test 95F006.

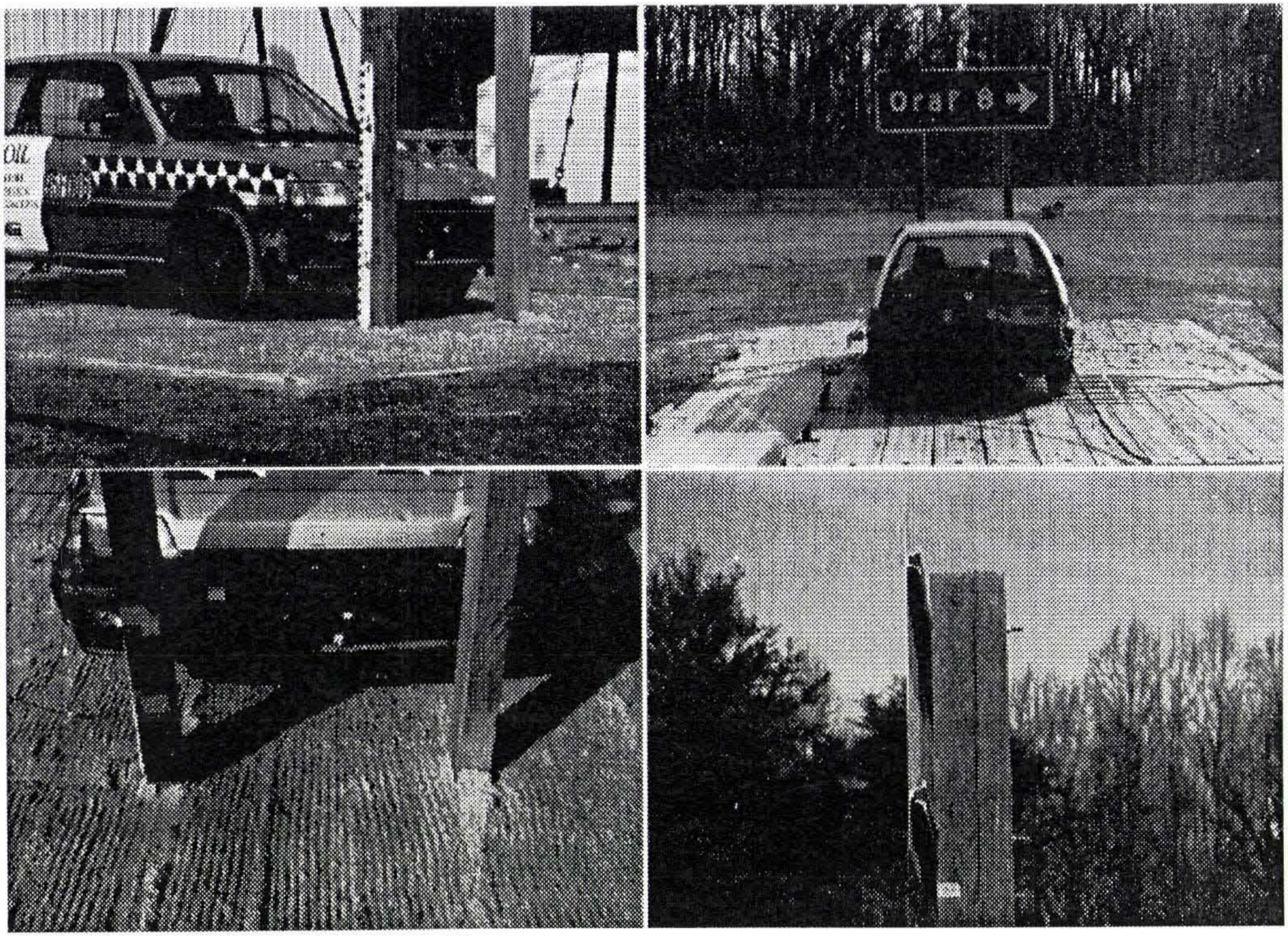


Figure 20. Pre-test photographs of test 95F006 (continued).

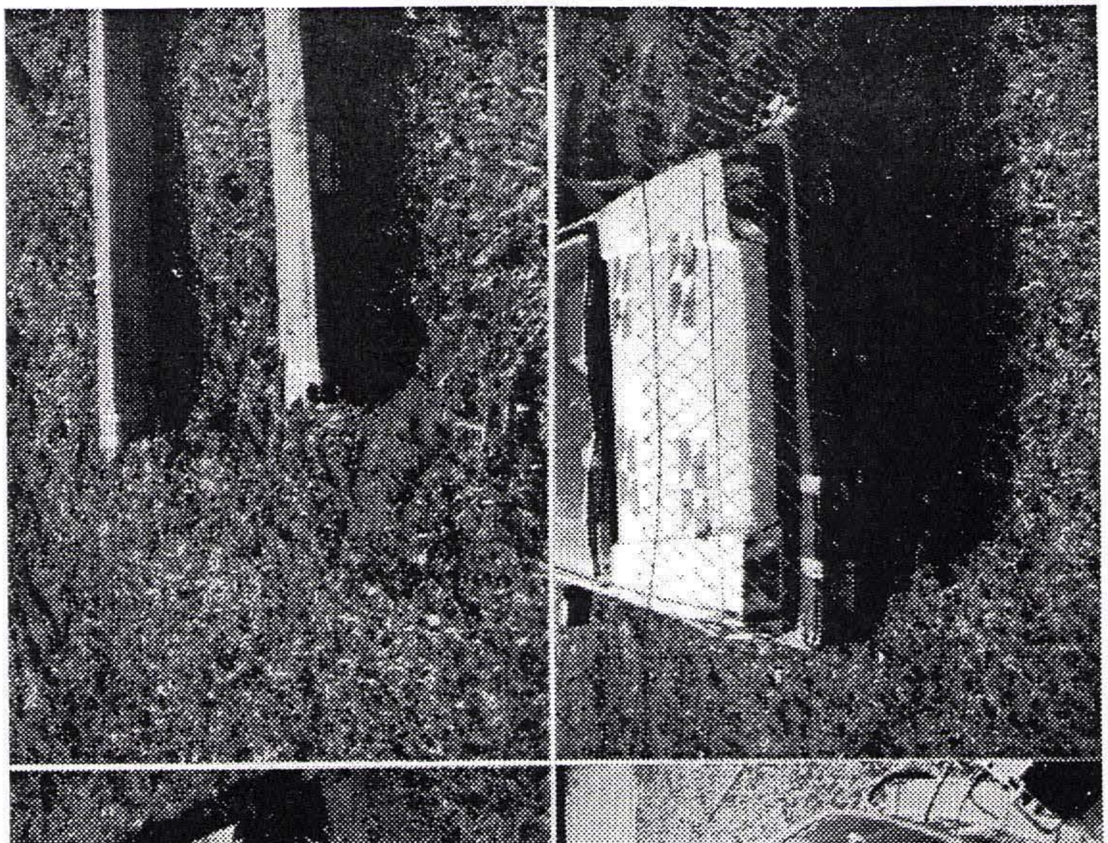


Figure 21. Post-test photographs of test 95F006.

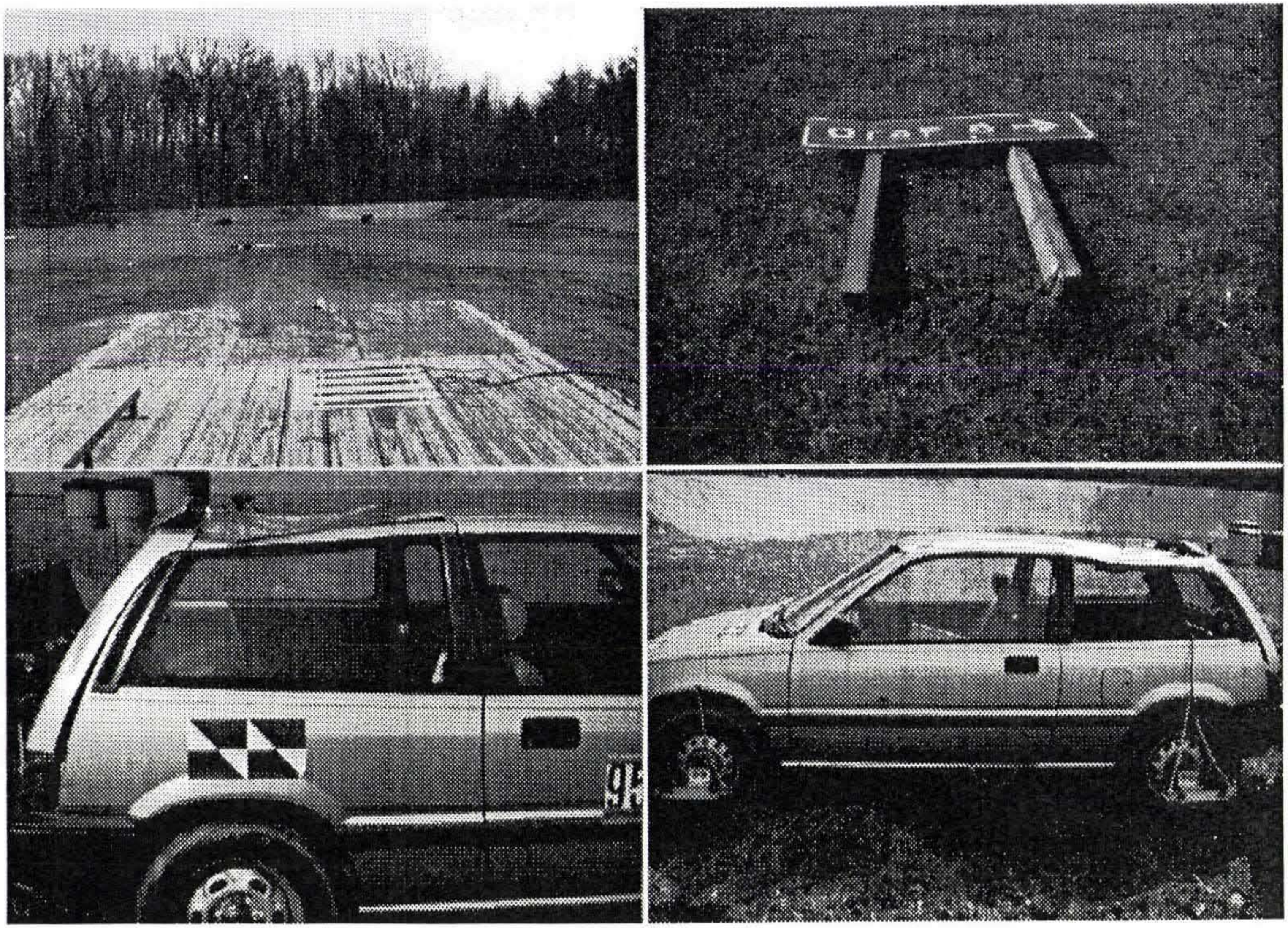


Figure 22. Post-test photographs of test 95F006 (continued).

8. REFERENCES

(1) H. E. Ross, Jr., D. L. Sicking, R. A. Zimmer, and J. D. Michie, *Recommended Procedures for the Safety Performance Evaluation of Highway Features, NCHRP Report 350*, National Cooperative Highway Research Program, Transportation Research Board, Washington, DC, 1993.