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Testing of Small and Large Sign Support Systems FOIL Test Numbers: 92F024 and 92F025

U.S. Department of Transportation
Federal Highway Administration

Research and Development
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, Virginia 22101-2296

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TESTING OF SMALL AND LARGE SIGN SUPPORT SYSTEMS FOIL TEST NUMBERS: 92F024 AND 92F025	6. Performing Organization Code
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15. Supplementary Notes

Contracting Officer's Technical Representative (COTR) - Richard King, HSR-20

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 20 mi/h (8.9 m/s), test 92F024, and 60 mi/h (26.8 m/s), test 92F025. The vehicle used for these tests were a 1984 and a 1985 Honda Civic three-door hatchback with manual transmission. The purpose of the tests was to evaluate the low- and high-speed safety performance of a dual legged steel 2 lb/ft (2.98 kg/m) braced sign support. The performance evaluation was based on the latest requirements for breakaway supports as specified in Volume 54, Number 3 of the Federal Register dated January 5, 1989. These criteria specify, in part, that the occupant change in velocity must be 16 ft/s (4.9 m/s) or less, that the significant test article stub height remaining after impact be no more than 4 in (101.6 mm), and that there can be no occupant compartment intrusion. The test results indicate that the dual legged 2 lb/ft (2.98 kg/m) braced sign support system meets all of the applicable criteria for the low- and high-speed test in weak soil specified by the FHWA.

17. Key Words	18. Distribution Statement
Acceleration, occupant impact velocity, weak soil, u-channel, sign, vehicle, FOIL.	No restrictions. This document is available to the public through the National Technical Information Service Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
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	Mg
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	l
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
psi	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	ac
ha	hectares	2.47	acres	mi^2
km^2	square kilometers	0.386	square miles	
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	megagrams	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	psi

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

(Revised August 1992)

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1. SCOPE

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, one at 20 mi/h (8.9 m/s), test 92F024, and one at 60 mi/h (26.8 m/s), test 92F025. The vehicles used for these tests were Honda Civic two door hatchbacks. The purpose of these tests was to evaluate the low- and high-speed safety performance of a dual legged braced 2 lb/ft (2.98 kg/m) u-channel sign support system in weak soil. The performance evaluation was based on the latest requirements for breakaway supports as specified in Volume 54, Number 3 of the Federal Register dated January 5, 1989. These criteria specify, in part, that the occupant change in velocity must be 16 ft/s (4.9 m/s) or less, that the significant test article stub height remaining after impact be no more than 4 in (101.6 mm), and that there can be no occupant compartment intrusion.

2. TEST MATRIX

Two tests were performed on a small sign support system. The test speeds for the tests were 20 mi/h (8.9 m/s) and 60 mi/h (26.8 m/s). The sign was buried in NCHRP Report Number 230, S-2 weak soil[1]. A summary of the test conditions is presented in table 1.

Table 1. Test matrix.

Test Number	Test Date	Test Vehicle	Test Weight (lb)	Test Speed (mi/h)	Test Article Description	Impact Location
92F024	8-19-92	'85 Honda Civic	1850	20	2 leg 2 lb/ft u-channel braced	center
92F025	8-25-92	'84 Honda Civic	1850	60	2 leg 2 lb/ft u-channel braced	center

3. VEHICLE

The test vehicles were a 1985 and a 1984 Honda Civic two door hatchback with manual transmissions. Prior to the tests, the vehicles' fluids were drained and their inertial measurements measured. The vehicles were stripped of certain components which made space for the installation of test equipment. The vehicles were ballasted with data acquisitions systems, transducers, a brake system and weight plates (if necessary) to bring their inertial weights to approximately 1850 lb (839 kg). The actual weight of the test vehicles was 1850 lb (839 kg). After ballasting, the vehicles' inertial properties were remeasured.

4. SIGN SUPPORT

The sign support system used in these tests consisted of an 8-ft wide by 6-ft (2.4-m by 1.8-m) high aluminum sign panel mounted to two 2 lb/ft (2.98 kg/m) u-channel posts. The two posts were installed 3.5 ft (1.1 m) apart. The posts were spliced to two 6-ft 11-in (2.1-m) stubs which were

installed 3.5 ft (1.1 m) deep in NCHRP, S-2 weak soil (sand). The splice was a 2-ft (0.6-m) overlap splice which started 18 in (457.2 mm) above ground. The splice was configured with the sign posts behind the splice stubs. The overlap splice was fastened using two 3/8-in-(9.5-mm) diameter aluminum bolts. The bolts were 19 in (482.6 mm) and 39 in (990.6 mm) above ground level. The two posts were supported in the rear by an angled wind brace. The wind brace was made from 2 lb/ft (2.98 kg/m) u-channel and was attached to the two sign posts 10 ft (3.1 m) above ground. The other end of the brace was attached to a 3-ft 10-in (1.2-m) stub which was embedded 3.5 ft (1.1 m) in the weak soil. The rear brace stubs were installed 5.5 ft (1.7 m) behind the two vertical sign posts. The two brace stubs were offset 6 in (152.4 mm) on center with the two vertical sign posts. All of the brace attachments, four in total, were made using one aluminum bolt. Figures 1 and 2 are drawings of the sign support system details.

5. TEST RESULTS - 20 MI/H (8.9 M/S), TEST 92F024

The test vehicle was accelerated to 21.5 mi/h (31.6 ft/s (9.6 m/s)) prior to impacting the sign support. The centerline of the test vehicle was aligned with the mid point between the two sign posts.

The bumper made contact with both sign posts on the lower splice bolt, 19 in (482.6 mm) above ground. The sign posts began to push through the weak soil and bow away from the vehicle. The u-channel posts were pushed through the sand 12 in (304.8 mm). The four aluminum splice bolts broke approximately 0.04 s after initial contact. The bumper did not crush significantly during the impact event. The breakaway force was low enough not to cause severe damage to the front end of the vehicle. The upper u-posts began to rotate away from the vehicle while the vehicle continued to flatten the two 3-ft 5-in (1.0-m) splice stubs. The vehicle flattened the two stubs and proceeded forward and made contact with the braces. The vehicle detached the braces from their support stubs while the sign panel fell on the roof of the test vehicle. While the vehicle was rolling over the front stubs, the front stubs began to recoil from the bent position and push upwards on the rear of the vehicle causing the vehicle to pitch. The induced pitch caused concern for higher impact speeds. The pitching motion could cause the vehicle to roll during higher impact speed collisions. After the vehicle exited the sign system the brakes were applied and the vehicle came to rest.

Damage to the vehicle consisted of minor damage to the bumper and a dent approximately 0.5 in (12.7 mm) deep just above the left B-pillar. The two parking lights just below the bumper were shattered. Since no considerable damage was inflicted on the front end of the vehicle no crush measurements were recorded or documented in this report. The damage to the roof was light and just above the B-pillar. No damage was inflicted on the windshield. None of the sign components impaled the occupant compartment.

Damage to the sign support was mainly to the front splice stubs. The stubs were bent and contorted and not reusable. All of the aluminum hardware used to assemble the sign support was destroyed. The splice bolts failed in tension while the brace bolts sheared. The remainder of the u-channel, the braces, the rear brace stubs (in the ground) and the u-channel attached to the sign panel was in usable condition after the test. The braces were launched downrange 30 ft (9.2 m). This is a possible hazard for other traffic and pedestrians.

The occupant impact velocity using the 2-ft (0.6-m) flail space model outlined in NCHRP Report Number 230, was determined to be 11.5 ft/s (3.5 m/s).

The occupant impact velocity was reached 0.255 s into the crash event. The ridedown acceleration was 1.4 g's. The peak force (300 Hz data) for the impact event was 6.3 g's (11.6 kips (51 kN)). Because the sign support-vehicle contact was prolonged the vehicle change in velocity was calculated to be 14.6 ft/s (4.4 m/s).

Photographs during the impact event are presented in figure 3. A summary of the impact conditions and the test results is presented in figure 4. Figures 5 through 8 are plots of data collected during the test. Pre- and post-test photographs of the vehicle and sign support system are presented in figures 9 through 12. Because no residual crush was recorded a sketch depicting the crush was omitted from this report.

6. TEST RESULTS - 60 MI/H (26.8 M/S), TEST 92F025

The test vehicle was accelerated to 60.4 mi/h (88.6 ft/s (27.0 m/s)) prior to impacting the sign support. The centerline of the test vehicle was aligned with the mid point between the two sign posts.

The bumper made contact with both sign posts on the lower splice bolt, 19 in (482.6 mm) above ground. The sign posts began to push through the weak soil and bow away from the vehicle. The u-channel posts were pushed through the sand 12 in (304.8 mm). The four aluminum splice bolts broke approximately 0.014 s after initial contact. The upper u-posts began to rotate away from the vehicle while the vehicle continued to flatten the two 3-ft 5-in (1.0-m) splice stubs. The vehicle flattened the two stubs and proceeded forward and made contact with the braces. The vehicle detached and launched the braces from their support stubs 0.06 s into the crash event. While the vehicle was rolling over the front stubs, they began to recoil from the bent position, however the vehicle was traveling to fast for the rebounding u-channel to impart any pitch motion on the vehicle. After the vehicle exited the sign system the brakes were applied and the vehicle came to rest with help from the FOIL catch fence.

Damage to the vehicle consisted of damage to the bumper and a dents on either side of the hood. The two parking lights just below the bumper were shattered along with both headlights and plastic cosmetic bumper elements. The u-channel penetrated the bumper on the outside edge of each bumper support. The penetration was deep enough to cause damage to minor frame members behind the headlights. No damage was inflicted on the roof or windshield. None of the sign components impaled the occupant compartment.

Damage to the sign support was mainly to the front splice stubs. The stubs were bent and contorted and not reusable. All of the aluminum hardware used to assemble the sign support was destroyed. The splice bolts failed in tension while the brace bolts sheared. The remainder of the u-channel, the braces, the rear brace stubs (in the ground) and the u-channel attached to the sign panel was in usable condition after the test. The braces were launched downrange 110 ft (33.5 m) and 300 ft (91.5 m). This is a possible hazard for other traffic and pedestrians.

The occupant impact velocity using the 2-ft (0.6-m) flail space model outlined in NCHRP Report Number 230, was determined to be 8.4 ft/s (2.6 m/s). The occupant impact velocity was reached 0.313 s into the crash event. The ridedown acceleration was 1.0 g's. The peak force (300 Hz data) for the impact event was 19.6 g's (36.3 kips (161 kN)). Because the sign/vehicle contact was brief the vehicle change in velocity was equal to the occupant impact velocity of 8.4 ft/s (2.6 m/s).

Photographs during the impact event are presented in figure 13. A

summary of the impact conditions and the test results is presented in figure 14. Figures 15 through 18 are data plots of data collected during the test. Pre- and post-test photographs of the vehicle and sign support system are shown in figures 19 through 22. Figure 23 depicts the measured vehicle crush for test 92F025.

7. CONCLUSION

The test results indicate that the 2 lb/ft (2.98 kg/m) braced sign support system meets all of the applicable safety criteria for the low- and high-speed test in weak soil specified by the FHWA. There was no occupant compartment intrusion during either test and the occupant impact velocities of 11.5 ft/s (3.5 m/s) for the low-speed test and 8.4 ft/s (2.6 m/s) for the high-speed test are below the 16 ft/s (4.9 m/s) limit specified by the FHWA. The stub remaining after each test was higher than the 4-in (101.6-mm) limit specified by the FHWA. However the flattening of the u-channel imparted no damage to the vehicle's undercarriage. The primary concern posed by the long stub was the pitch induced into the vehicle as it passed over the stubs during the low- speed test. It was believed that this would cause vaulting or rolling during high-speed impacts. The 60-mi/h (26.8-m/s) test demonstrated that the long stubs were not significant enough to cause vaulting or rolling, therefore the stubs were not a factor in considering compliance with the FHWA specifications.

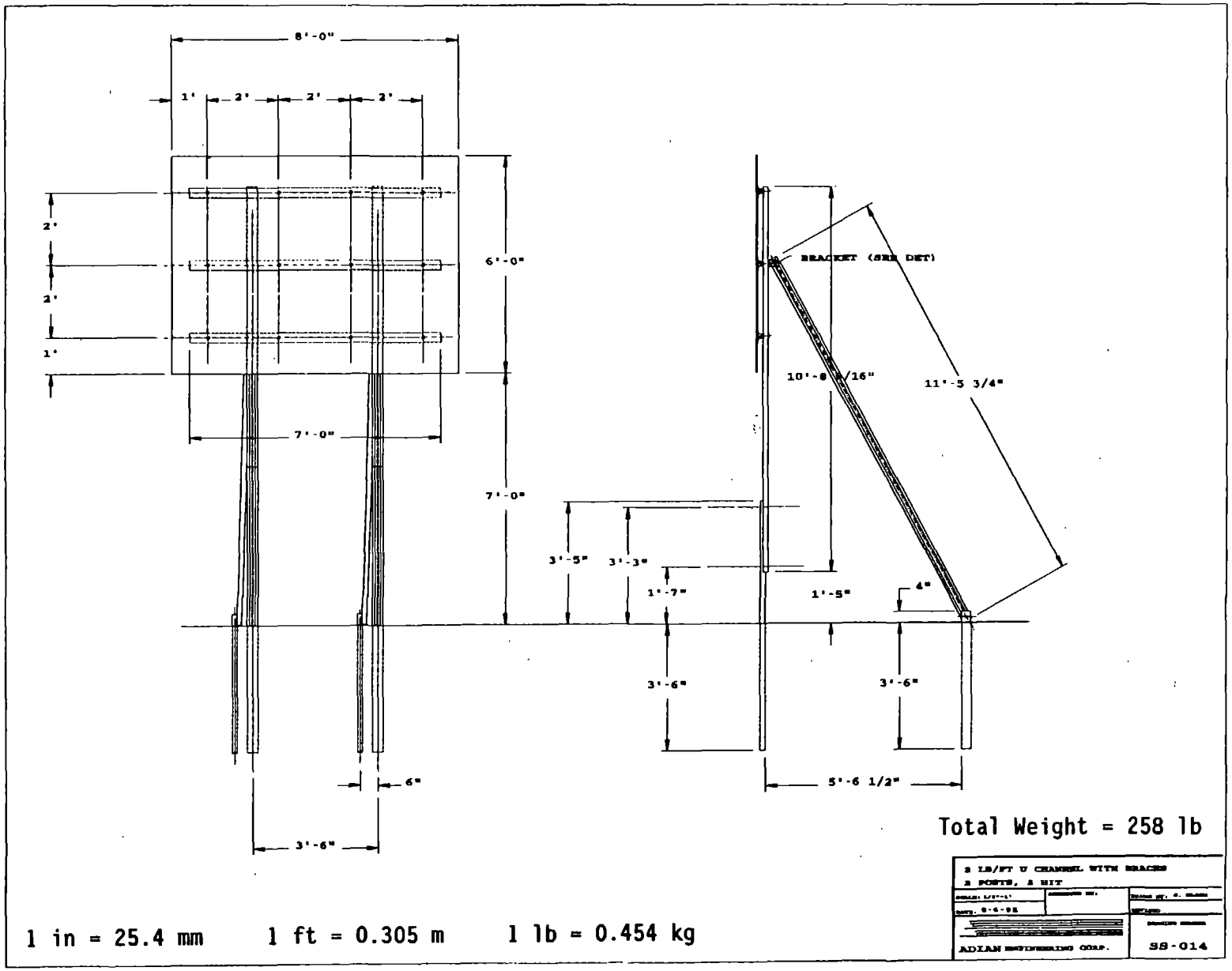
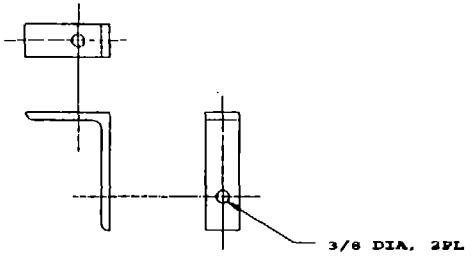
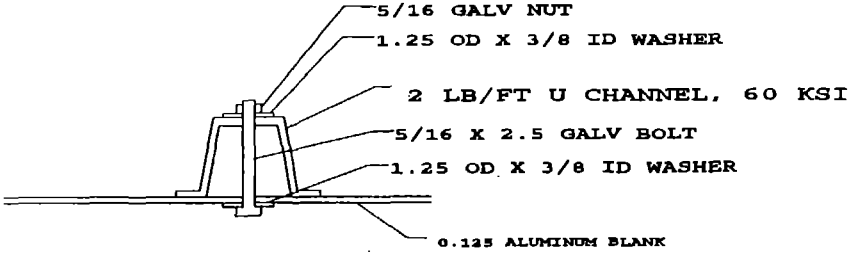


Figure 1. Sketch of small sign support.

NOTES:
1. ALL BOLTS & NUTS TO BE ALUMINUM.
2. ALL U CHANNEL TO BE 2 LB/FT.
3. U CHANNEL WIND BRACES MAY BE OTHER ALLOY.
3. U CHANNEL UPRIGHTS AND STUBS TO BE 60 KSI STEEL.



STEEL BRACKET DETAIL



TEST SERIES 14

2 LB/FT U CHANNEL WITH BRACES
2 POSTS, 2 BIT

ADIAN ENGINEERING CORP.

SS-014

1 in = 25.4 mm

Figure 2. Sketch of small sign support, attachment detail.

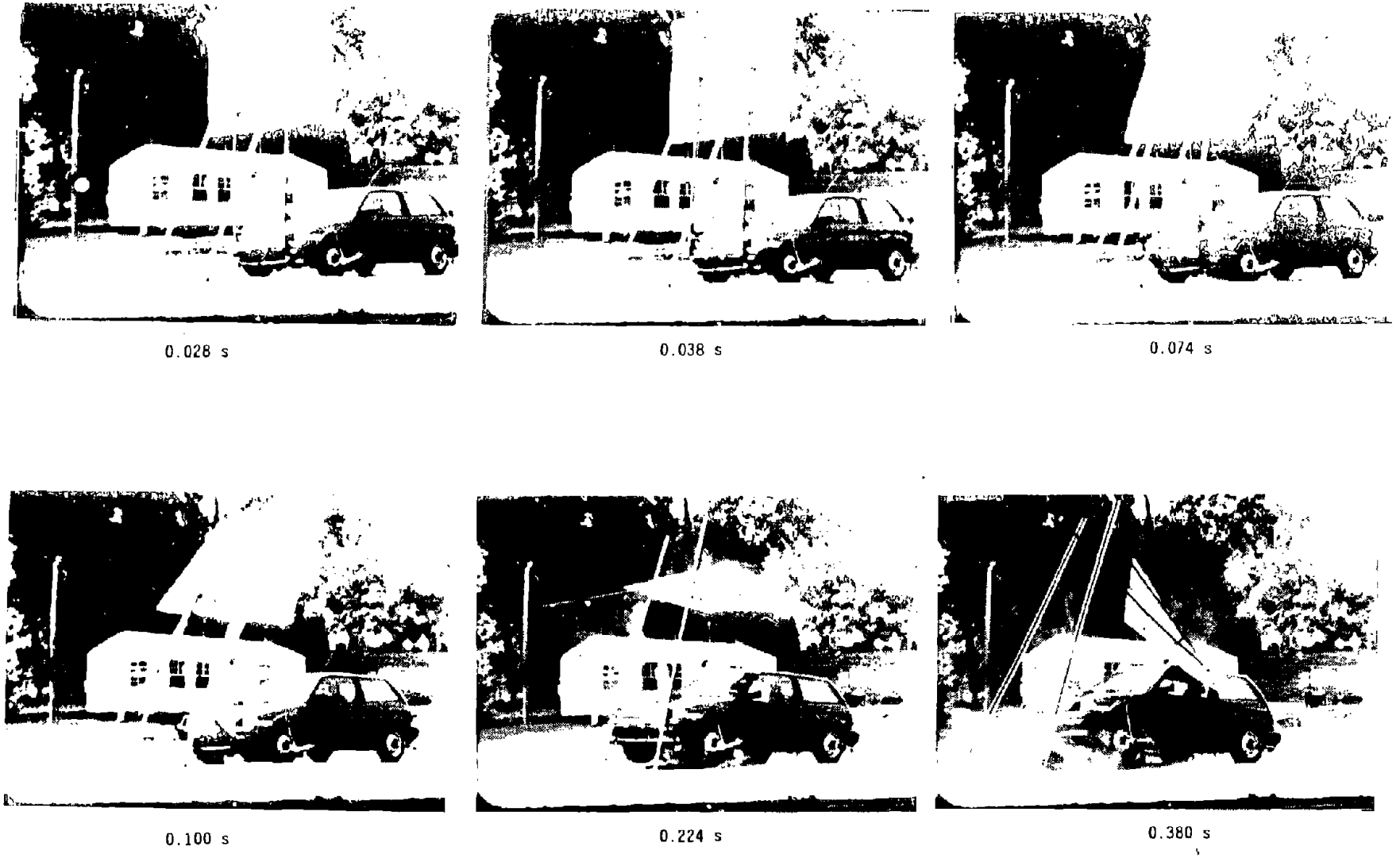
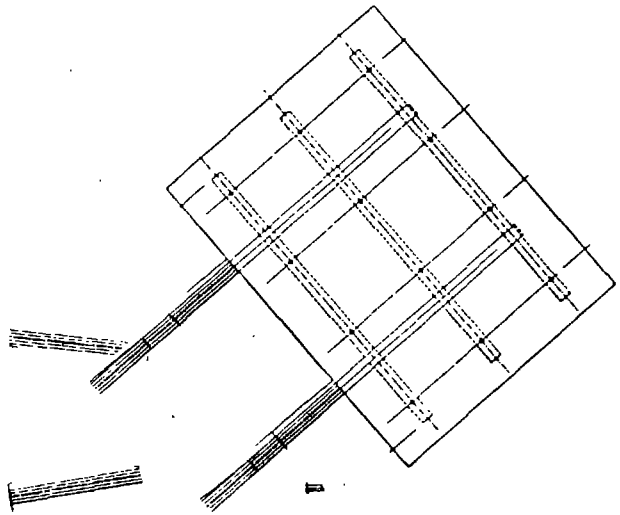
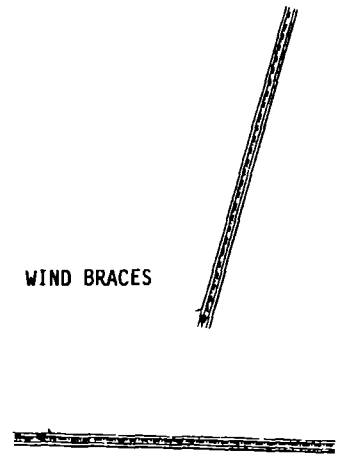


Figure 3. Test photographs during impact, test 92F024.



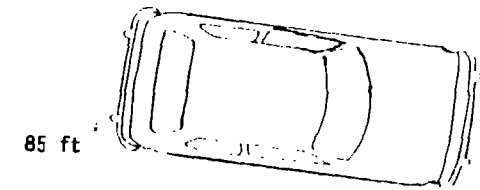
SPLICE STUBS

BRACE STUBS



WIND BRACES

30 ft



85 ft

Test number..... 92F024

Date..... August 19, 1992

Test vehicle.....1985 Honda Civic

Vehicle weight.....1850 lb (839 kg)

Test article.....Small Sign Support

Material..... 2 lb/ft u-channel with 2 lb/ft bracing
2-Leg, 2-Hit

Embedment depth..... 3.5 ft

Panel type..... 6 ft by 8 ft aluminum sheet

Height..... 13 ft

Foundation.....S-2 Weak Soil

Impact speed.....31.6 ft/s (9.6 m/s)

Impact angle.....0 degrees

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

Vehicle analysis:	Observed	Design/Limit
Longitudinal:		
Occupant Delta V at 2 ft	11.5 ft/s	≤16 ft/s
Ridedown Acceleration	1.4 g's	15/20 g's
Lateral:		
Occupant Delta V at 1 ft	no contact	no spec
Ridedown Acceleration	no contact	no spec

Peak 50 msec acceleration
Longitudinal..... 3.2 g's
Lateral..... NA

Vehicle Damage (TAD)..... 12-FC-1
(VDI)..... 12FDAU1

Vehicle crush.....no residual crush

Vehicle velocity change.....14.6 ft/s

Exit angle..... 0 degrees

1 in = 25.4 mm 1 ft = 0.305 m 1 lb = 0.454 kg

Figure 4. Summary of test 92F024.

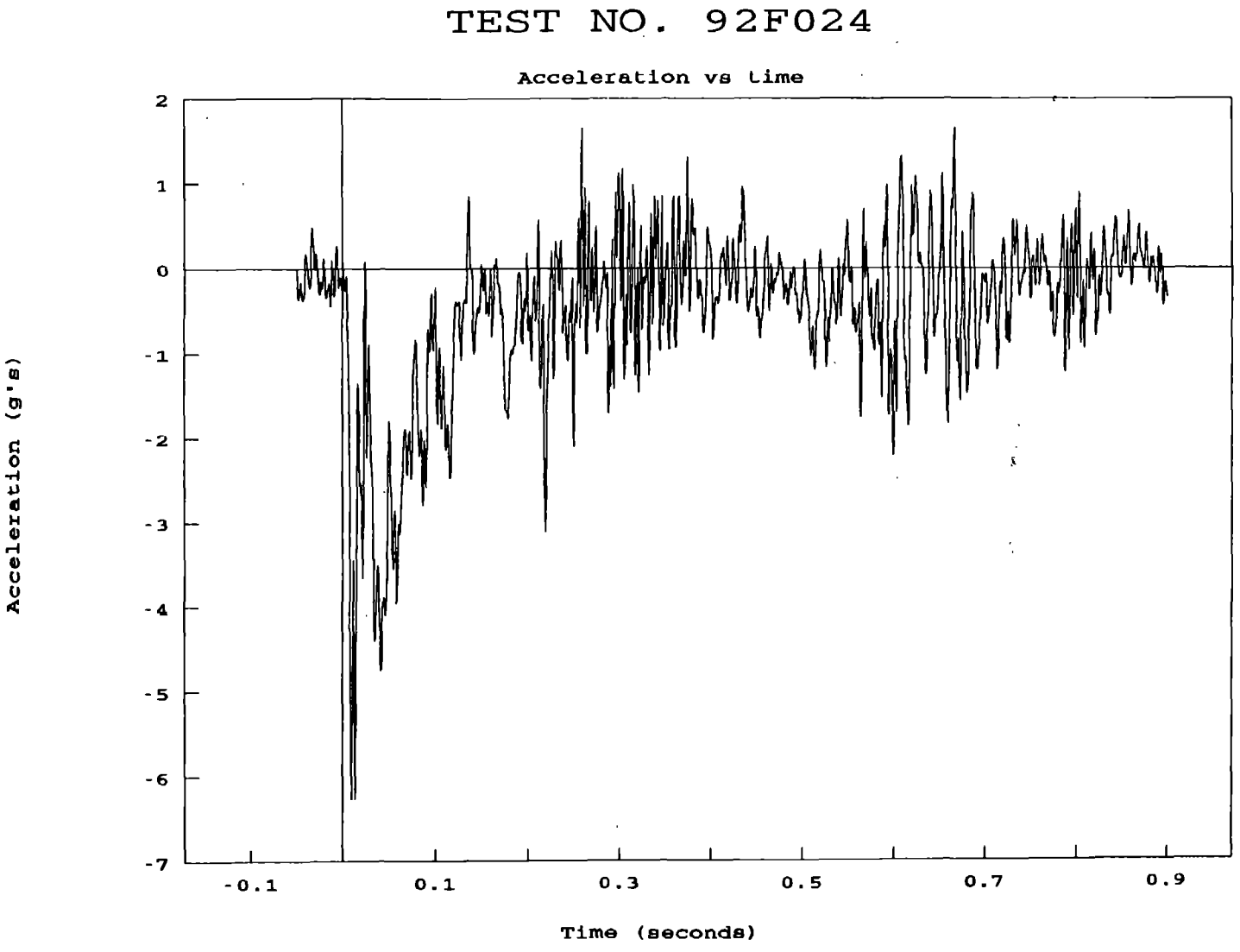
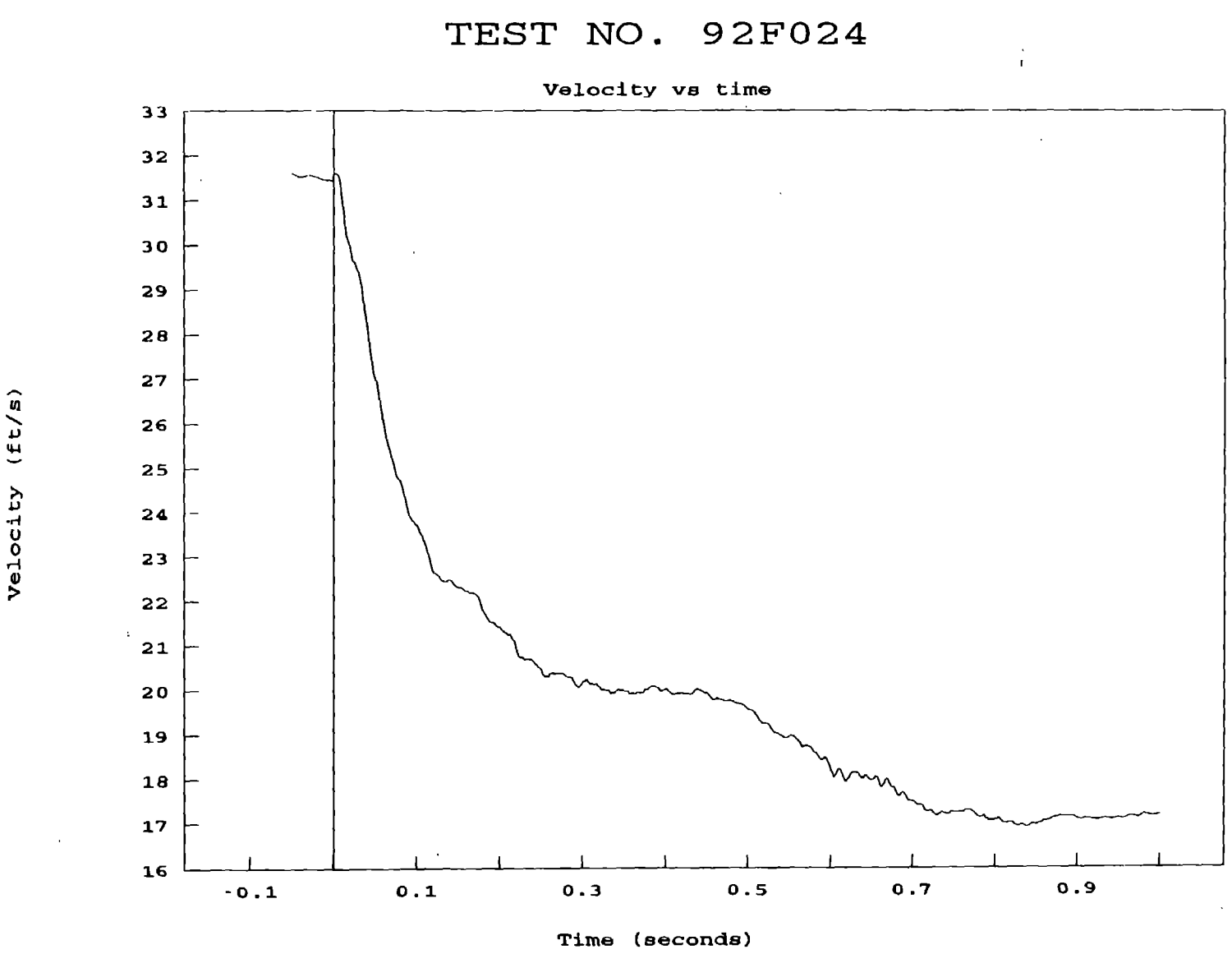
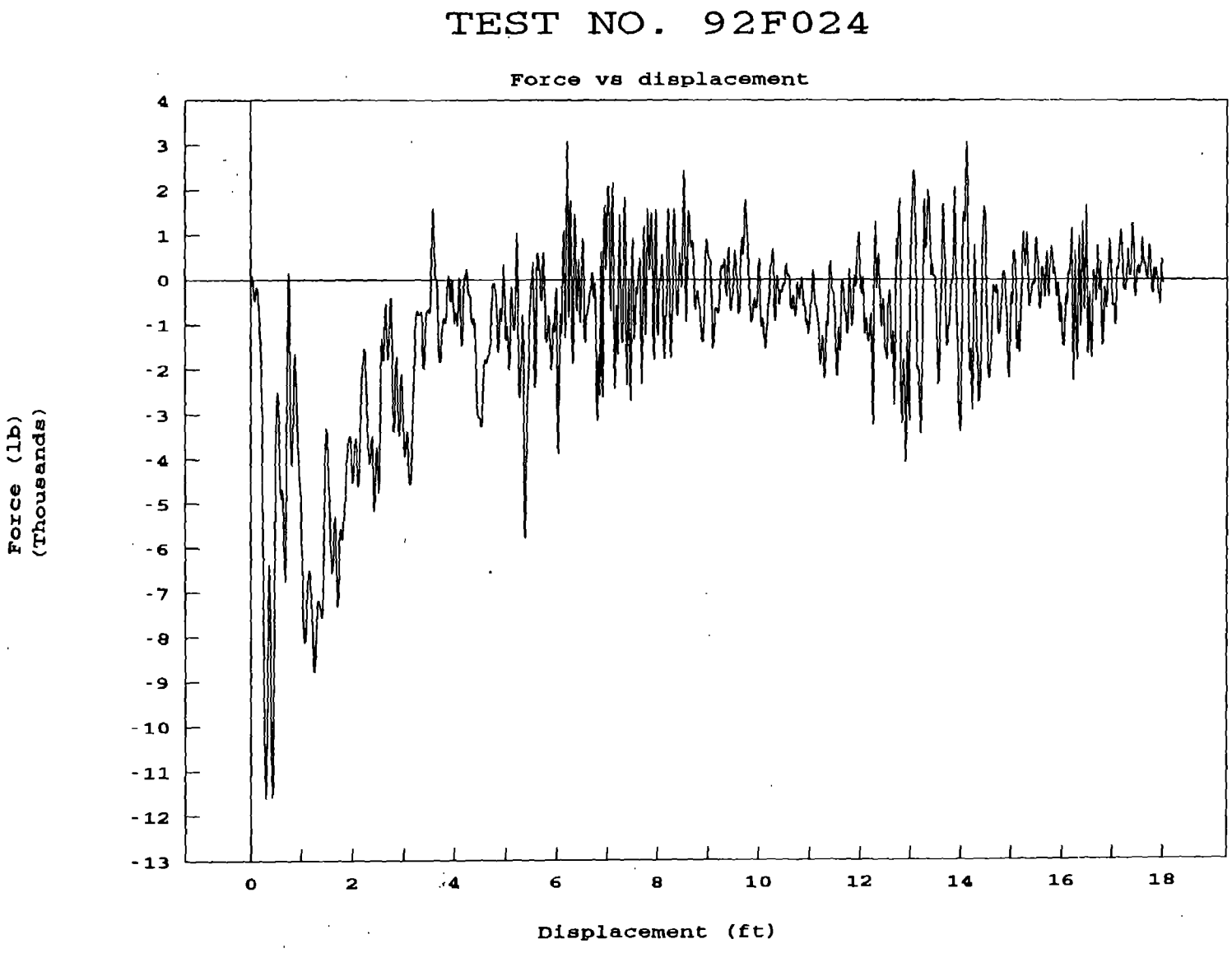


Figure 5. Acceleration versus time, X-axis, test 92F024.



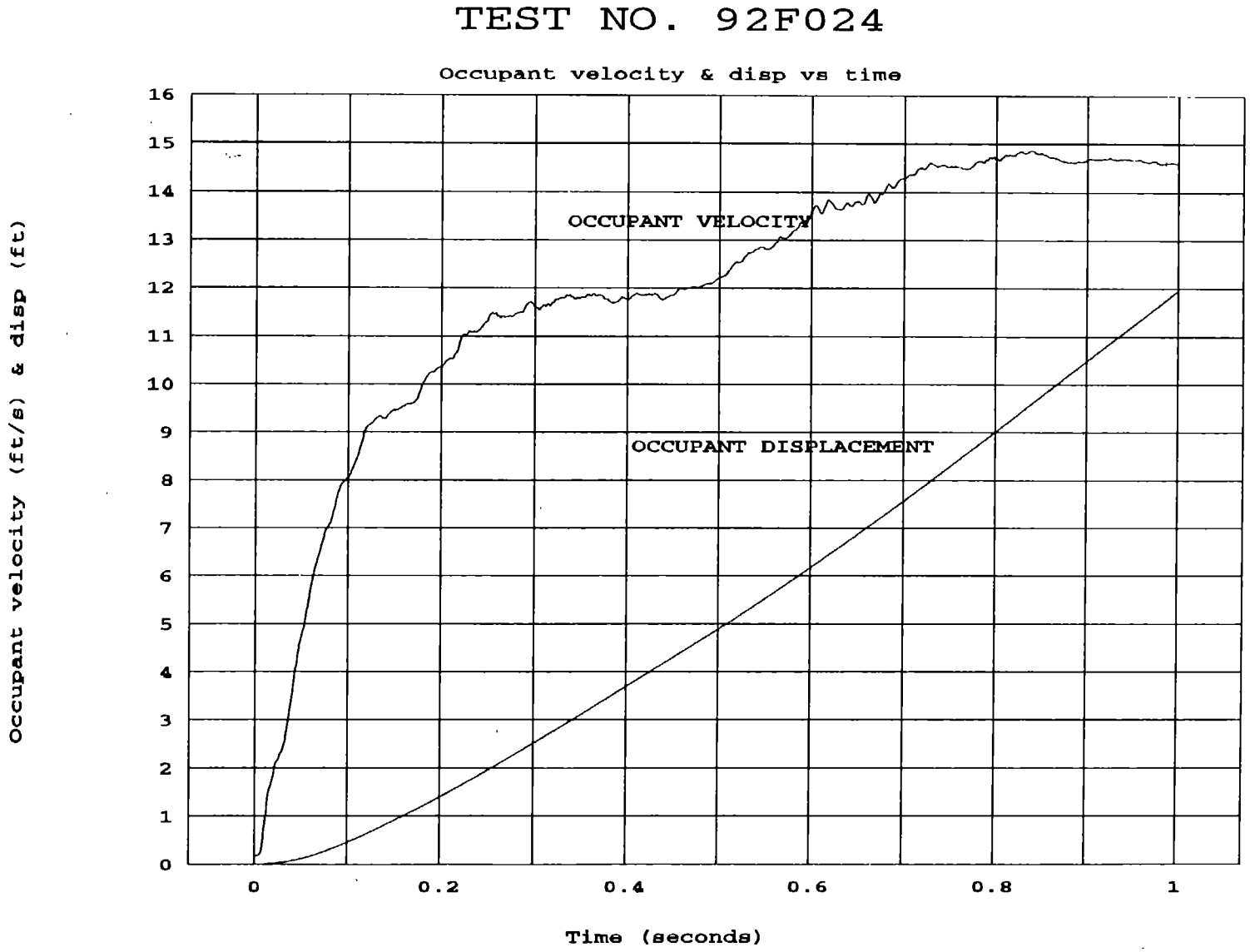
1 ft = 0.305 m

Figure 6. Velocity versus time, X-axis, test 92F024.



1 lbf = 4.45 N 1 ft = 0.305 m

Figure 7. Force versus displacement, X-axis, test 92F024.



1 ft = 0.305 m

Figure 8. Occupant velocity and relative displacement versus time, X-axis, test 92F024.

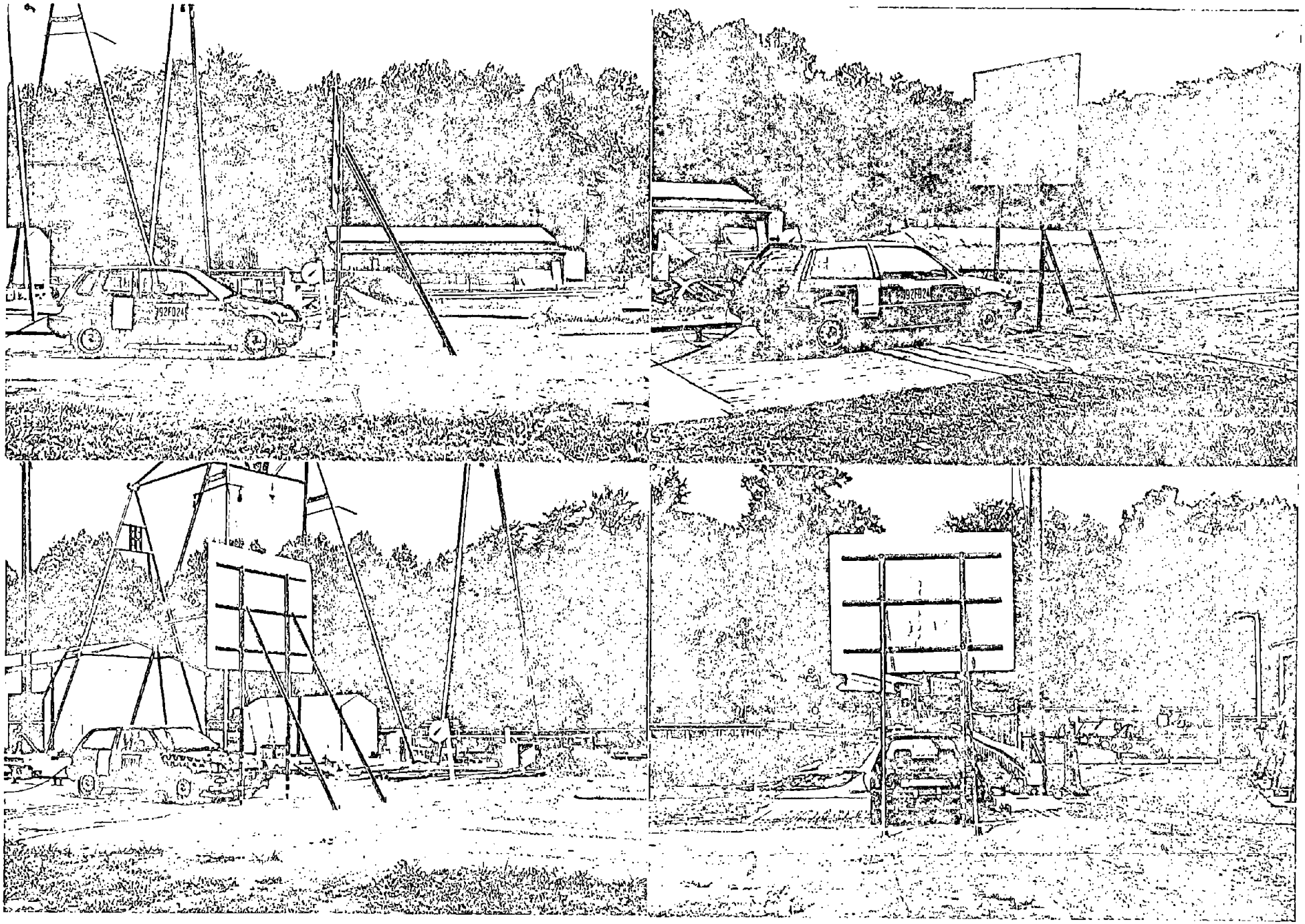


Figure 9. Pretest photographs of test 92F024.

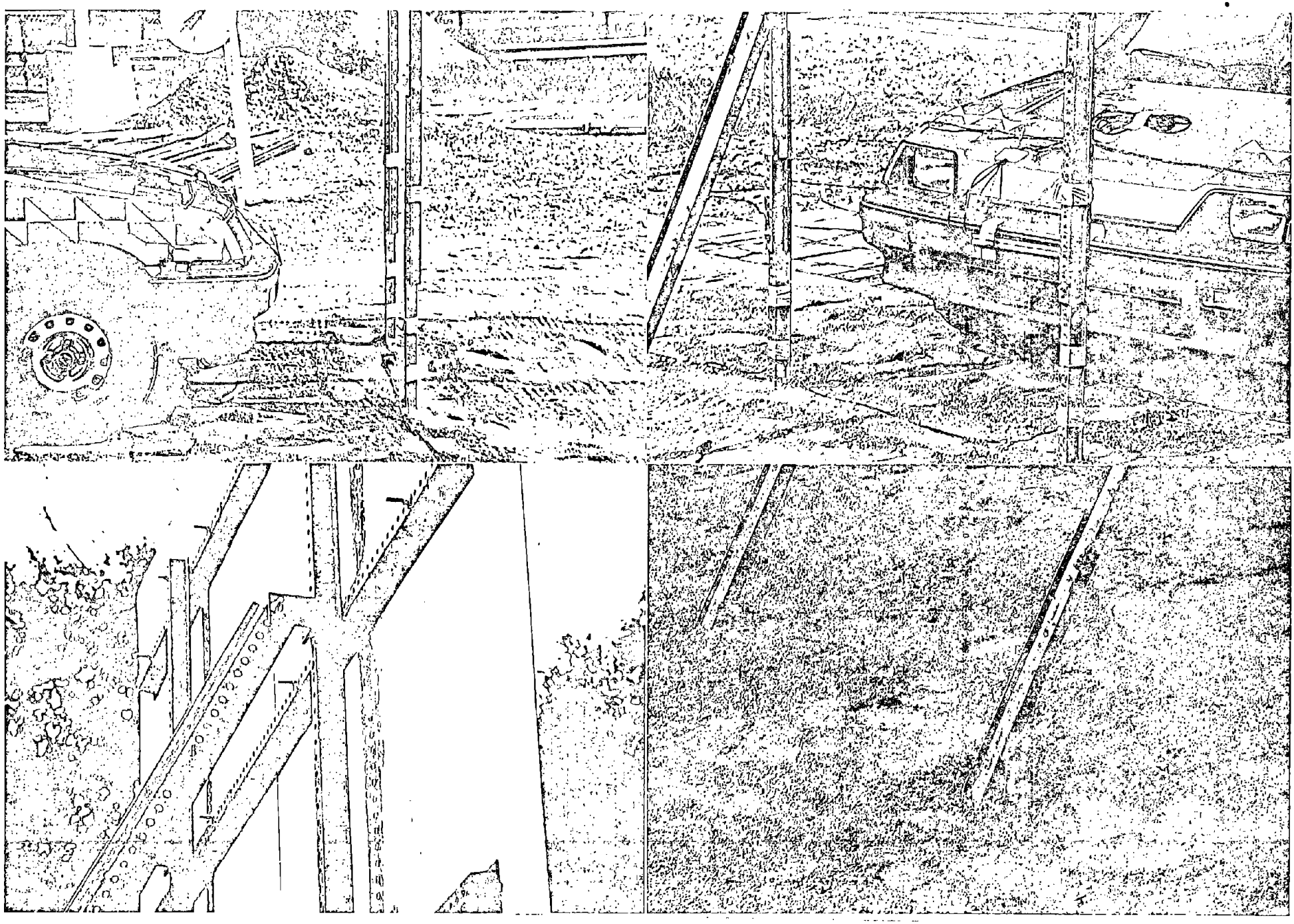


Figure 9. Pretest photographs of test 92F024 (continued).

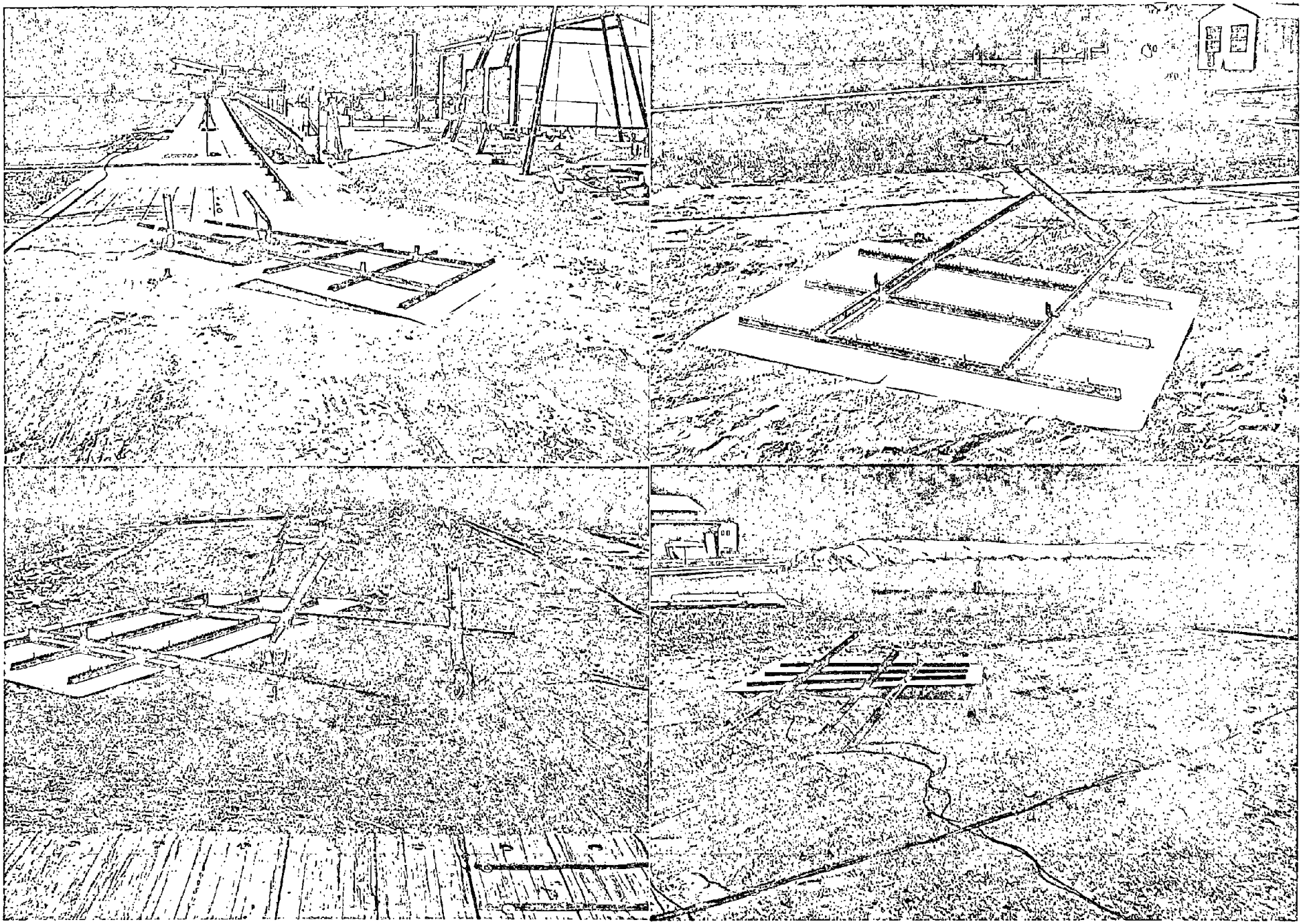


Figure 10. Post-test photographs of test 92F024.

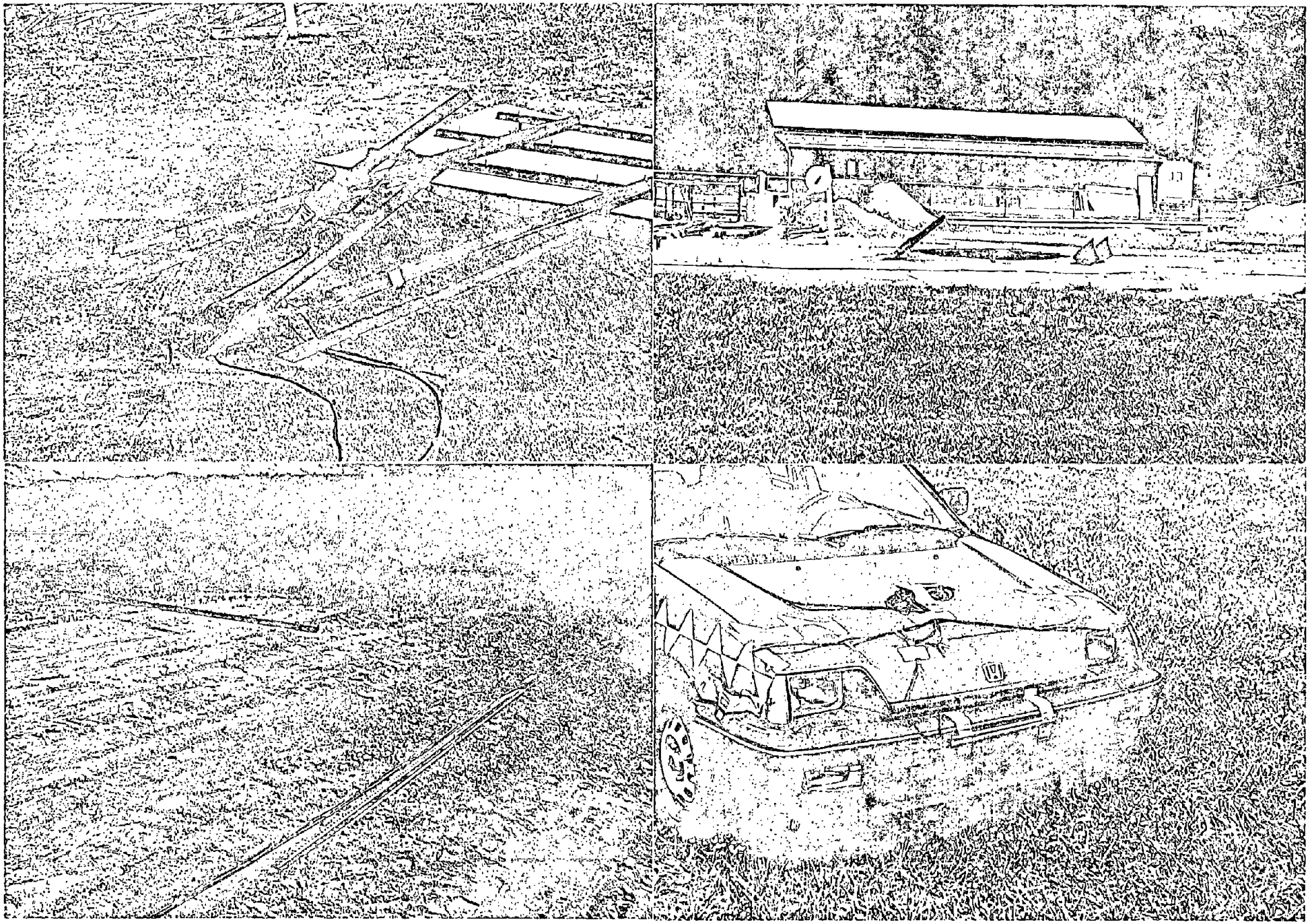
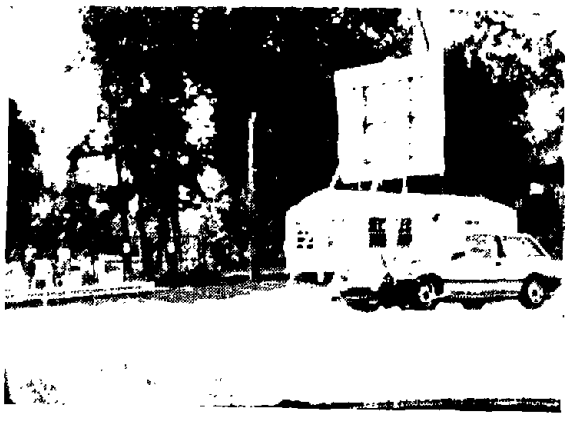
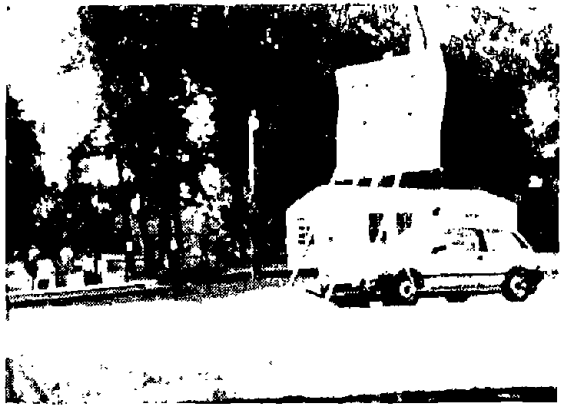


Figure 10. Post-test photographs of test 92F024 (continued).

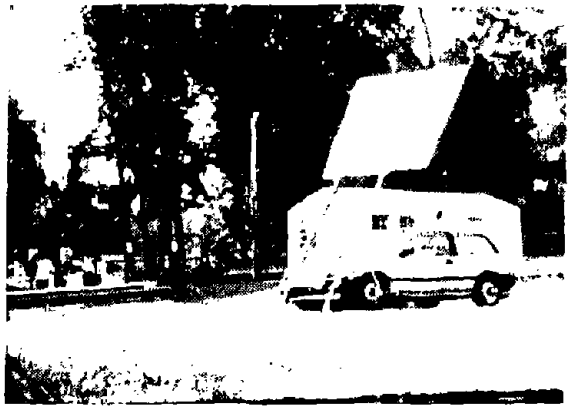
0.010 s



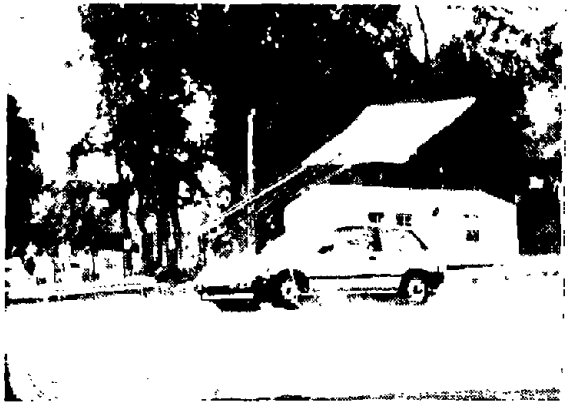
0.022 s



0.038 s



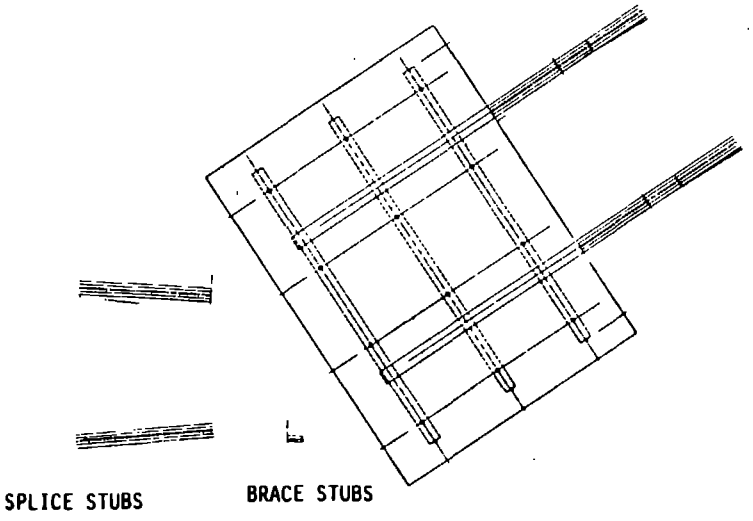
0.070 s

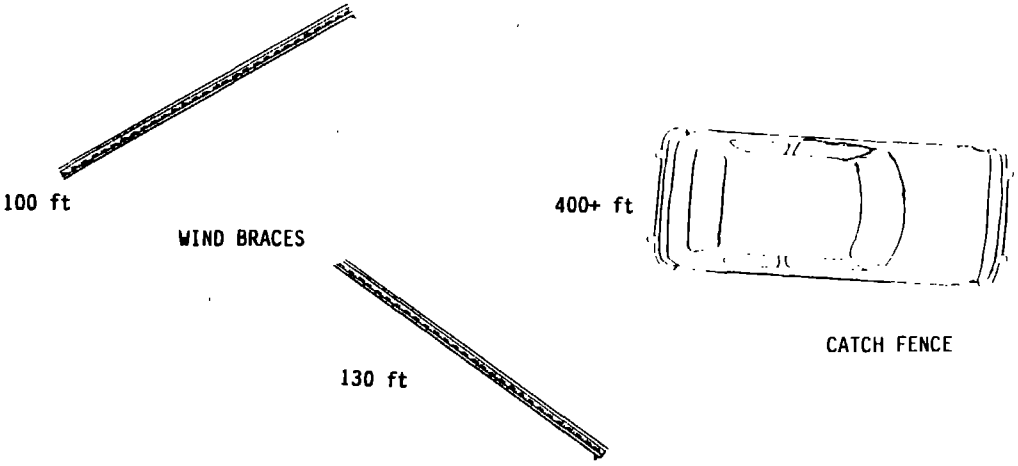


0.124 s

0.294 s

Figure 11. Test photographs during impact, test 92F025.





Test number..... 92F025

Date..... August 25, 1992

Test vehicle..... 1984 Honda Civic

Vehicle weight.....1850 lb (839 kg)

Test article.....Small Sign Support

Material..... 2 lb/ft u-channel with 2 lb/ft bracing
2-Leg, 2-Hit

Embedment depth..... 3.5 ft

Panel type..... 6 ft by 8 ft aluminum sheet

Height..... 13 feet

Foundation.....S-2 Weak Soil

Impact speed.....88.6 ft/s (27.0 m/s)

Impact angle.....0 degrees

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

Vehicle analysis:	Observed	Design/Limit
Longitudinal:		
Occupant Delta V at 2 ft.....	8.4 ft/s	≤16 ft/s
Ridedown Acceleration.....	1.0 g's	15/20 g's
Lateral:		
Occupant Delta V at 1 ft.....	no contact	no spec
Ridedown Acceleration.....	no contact	no spec

Peak 50 msec acceleration
Longitudinal..... 2.9 g's
Lateral..... NA

Vehicle Damage (TAD)..... 12-FC-1
(VDI)..... 12FDEN1

Vehicle crush..... 8.0 in

Vehicle velocity change..... 8.4 ft/s

Exit angle..... 0 degrees

1 in = 25.4 mm 1 ft = 0.305 m 1 lb = 0.454 kg

Figure 12. Summary of test 92F025.

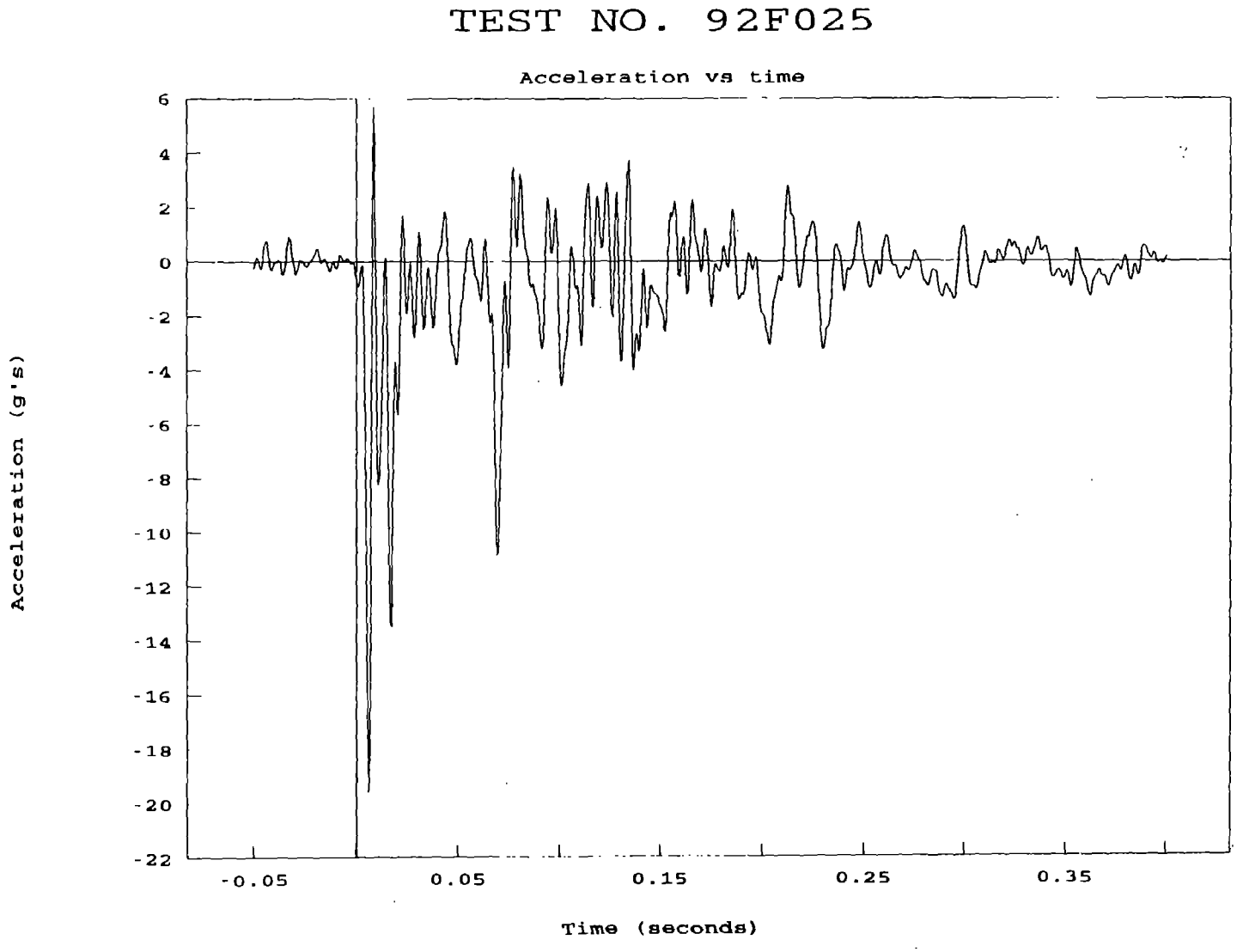
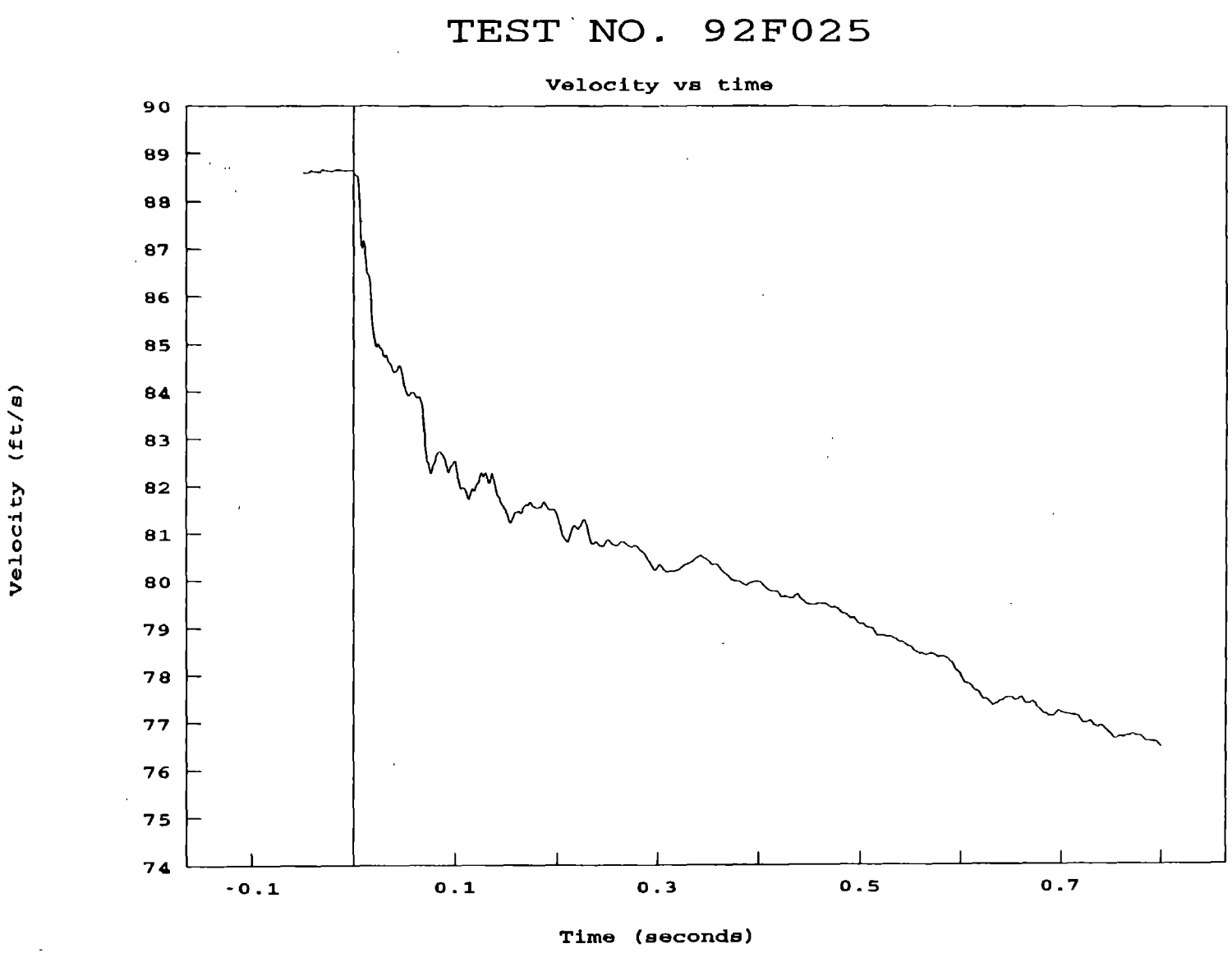
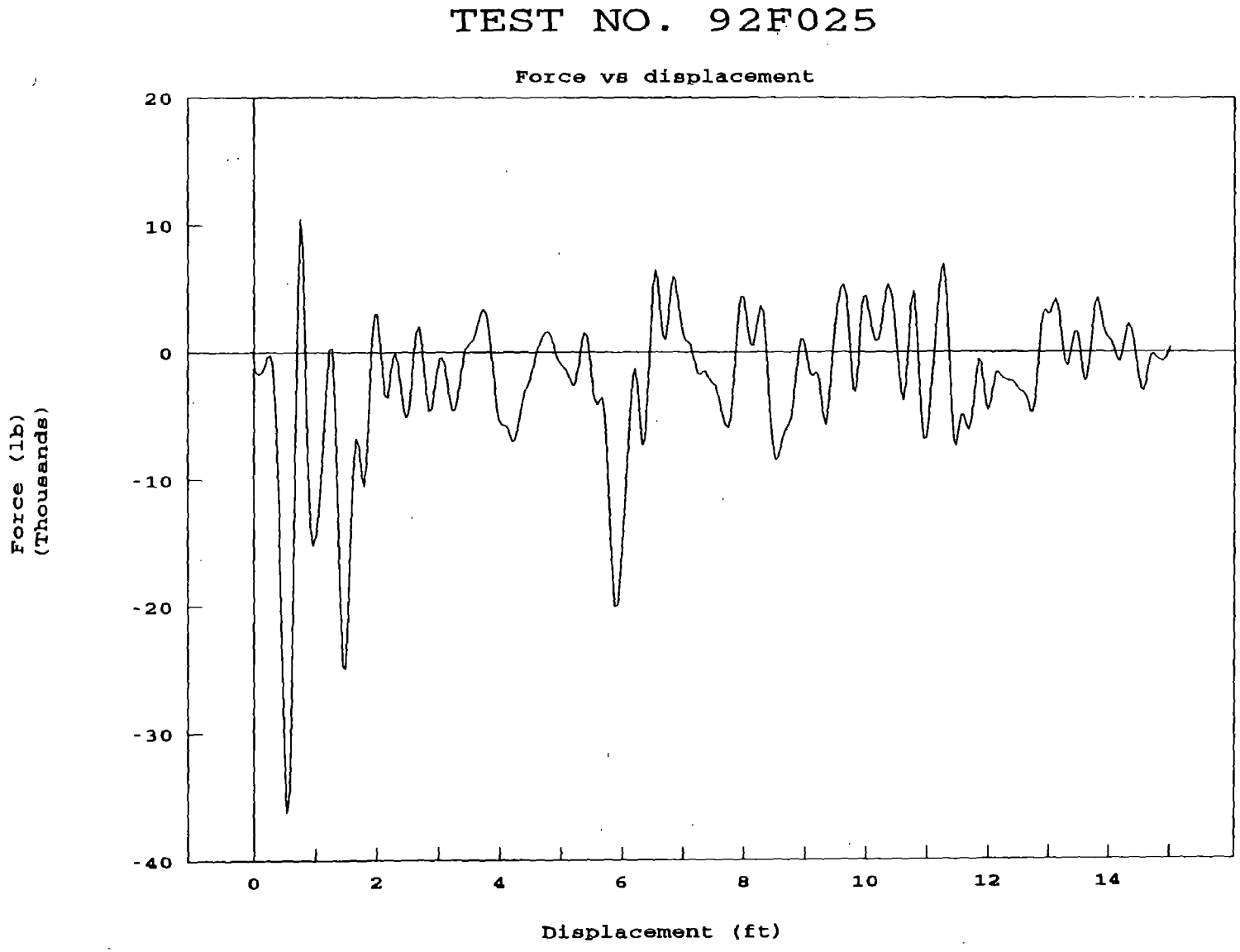


Figure 13. Acceleration versus time, X-axis, test 92F025.



1 ft = 0.305 m

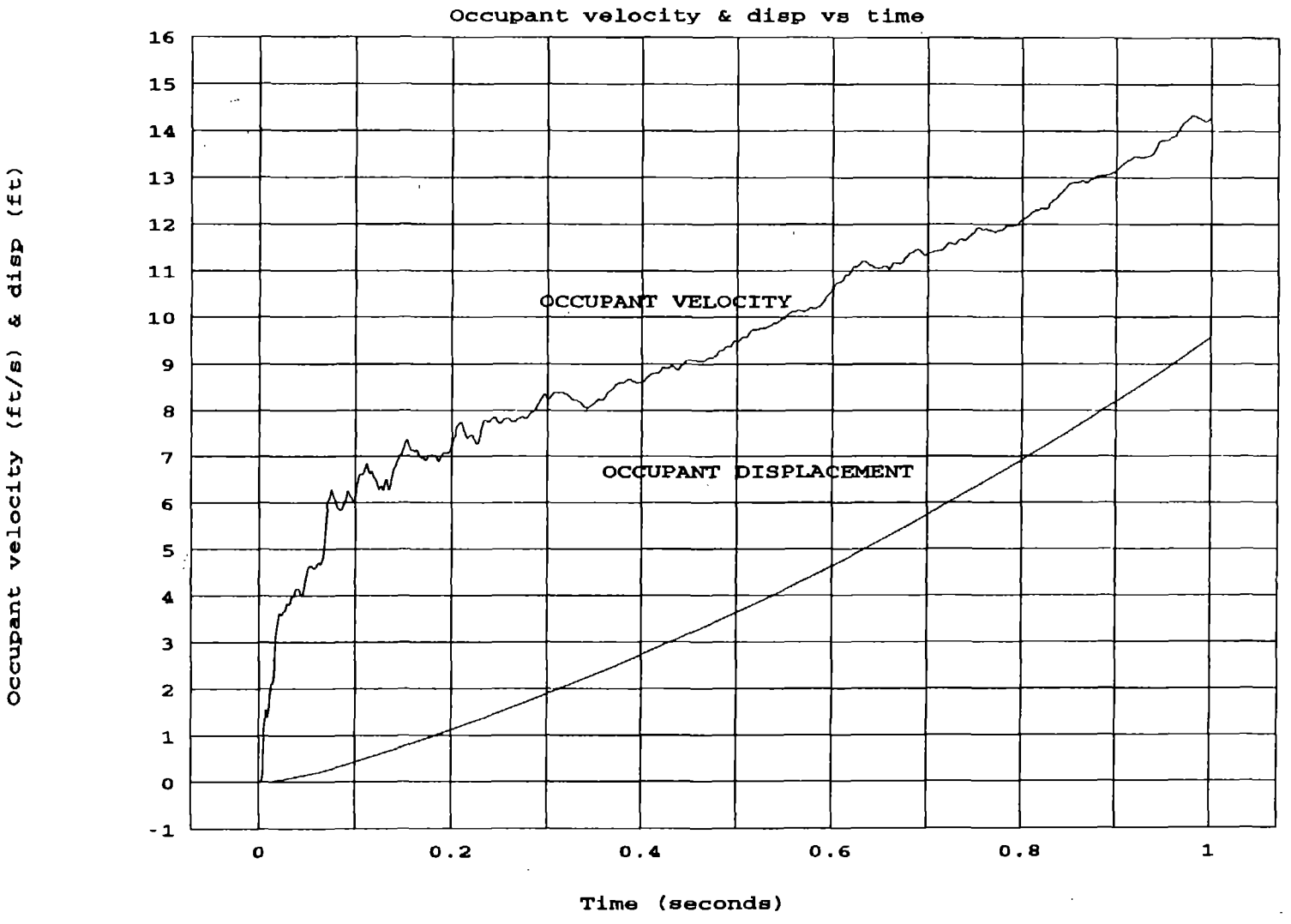
Figure 14. Velocity versus time, X-axis, test 92F025.



1 lbf = 4.45 N 1 ft = 0.305 m

Figure 15. Force versus displacement, X-axis, test 92F025.

TEST NO. 92F025



1 ft = 0.305 m

Figure 16. Occupant velocity and relative displacement versus time, test 92F025.

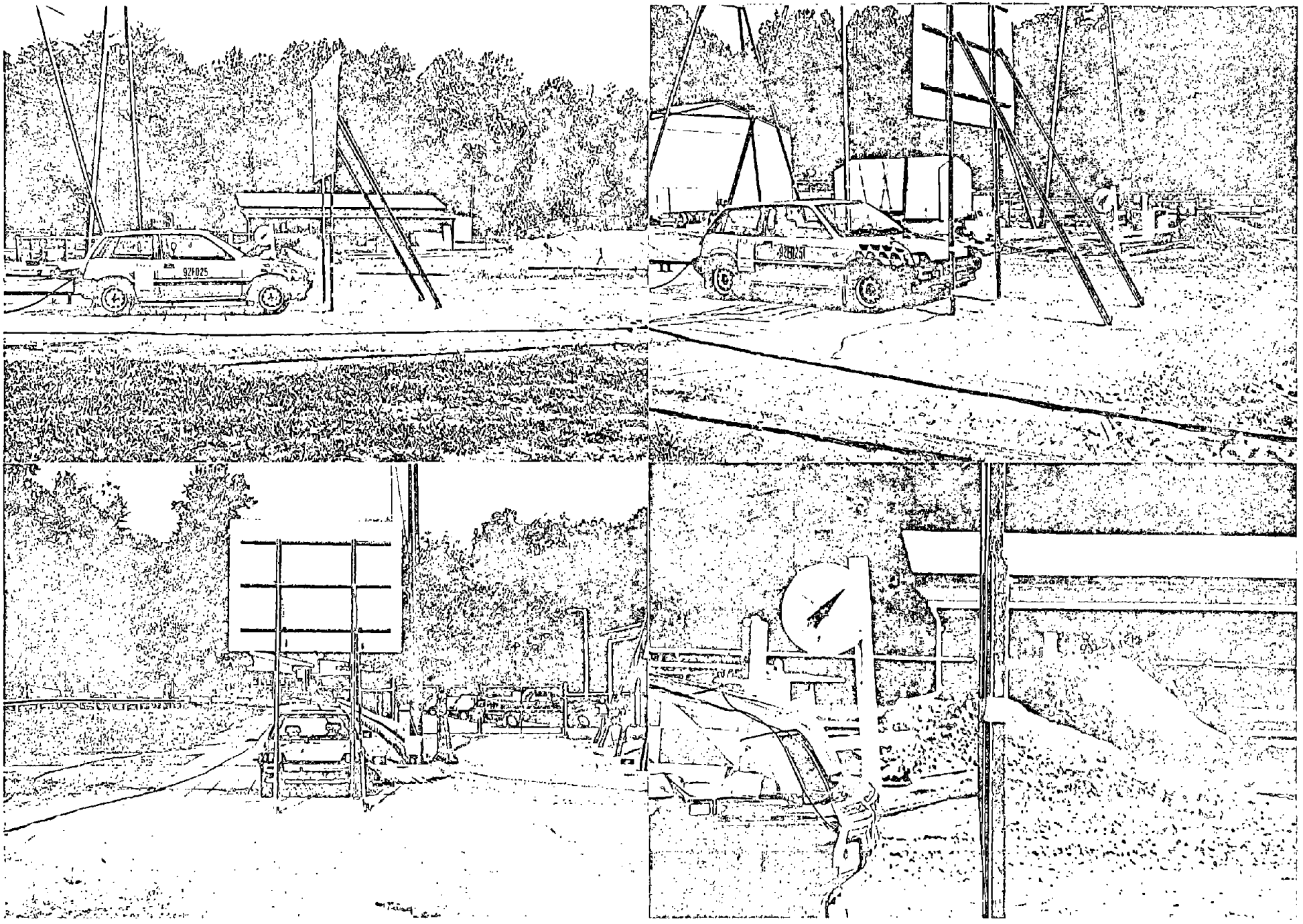


Figure 17. Pretest photographs of test 92F025.

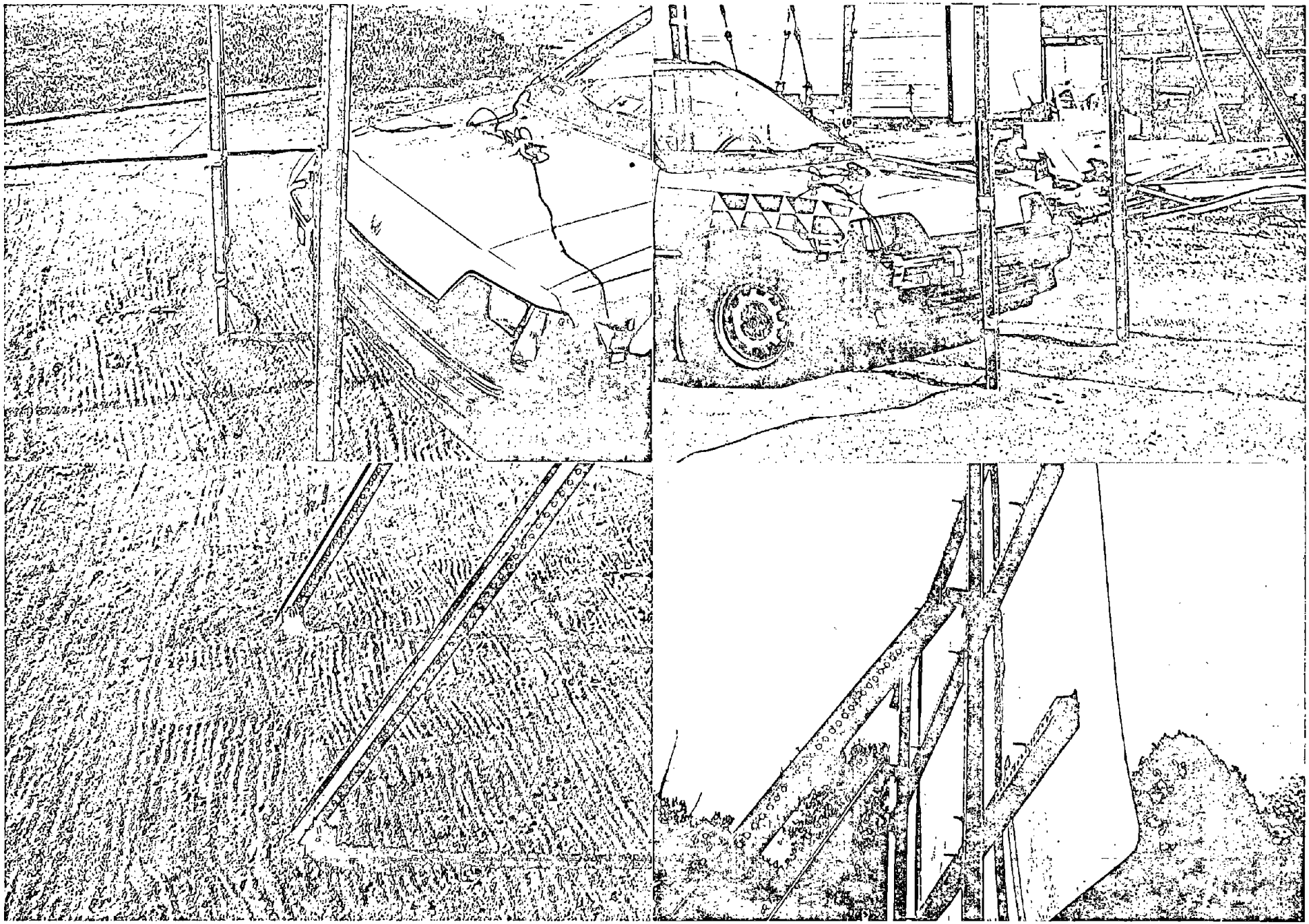


Figure 17. Pretest photographs of test 92F025 (continued).

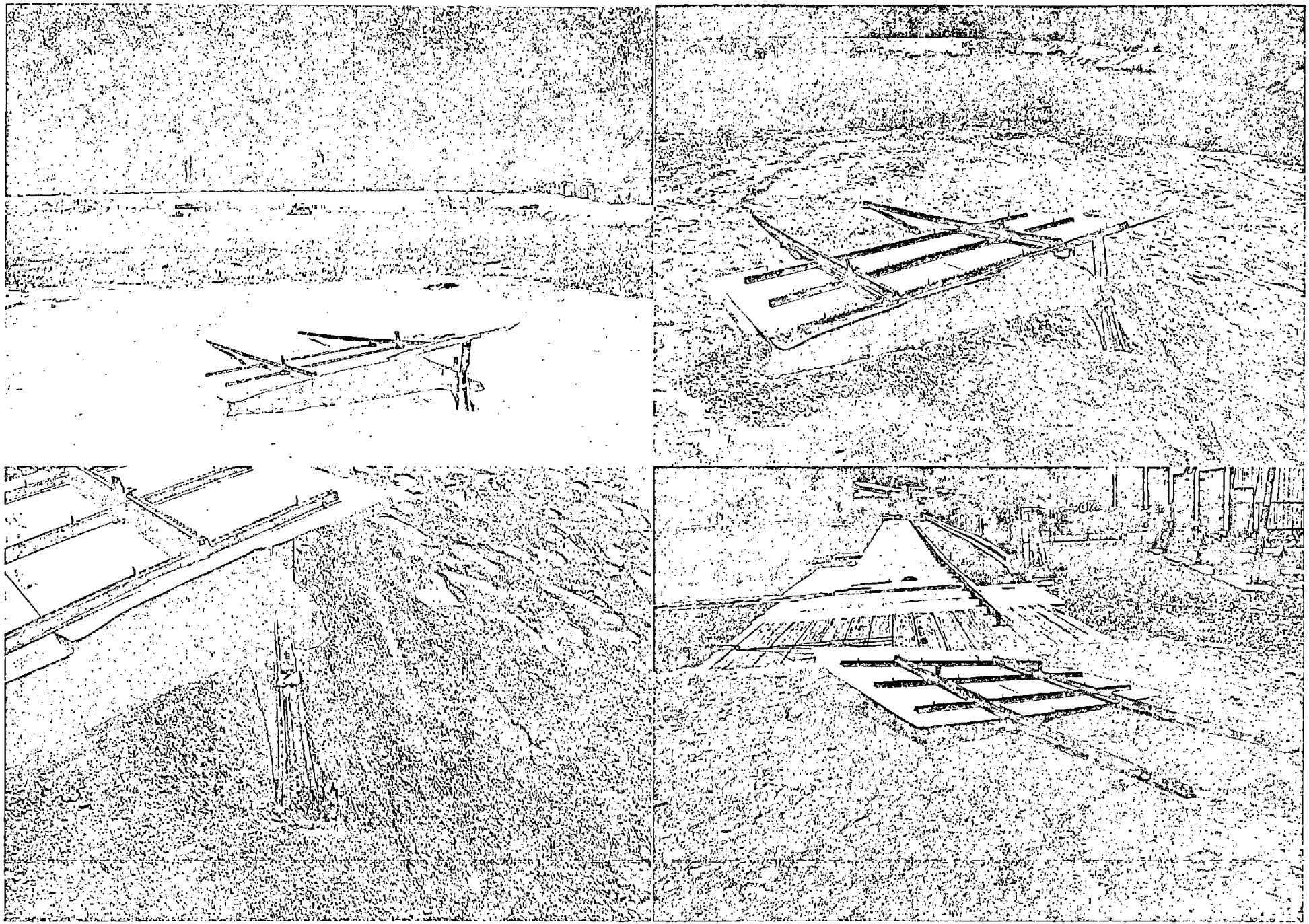


Figure 18. Post-test photographs of test 92F025.

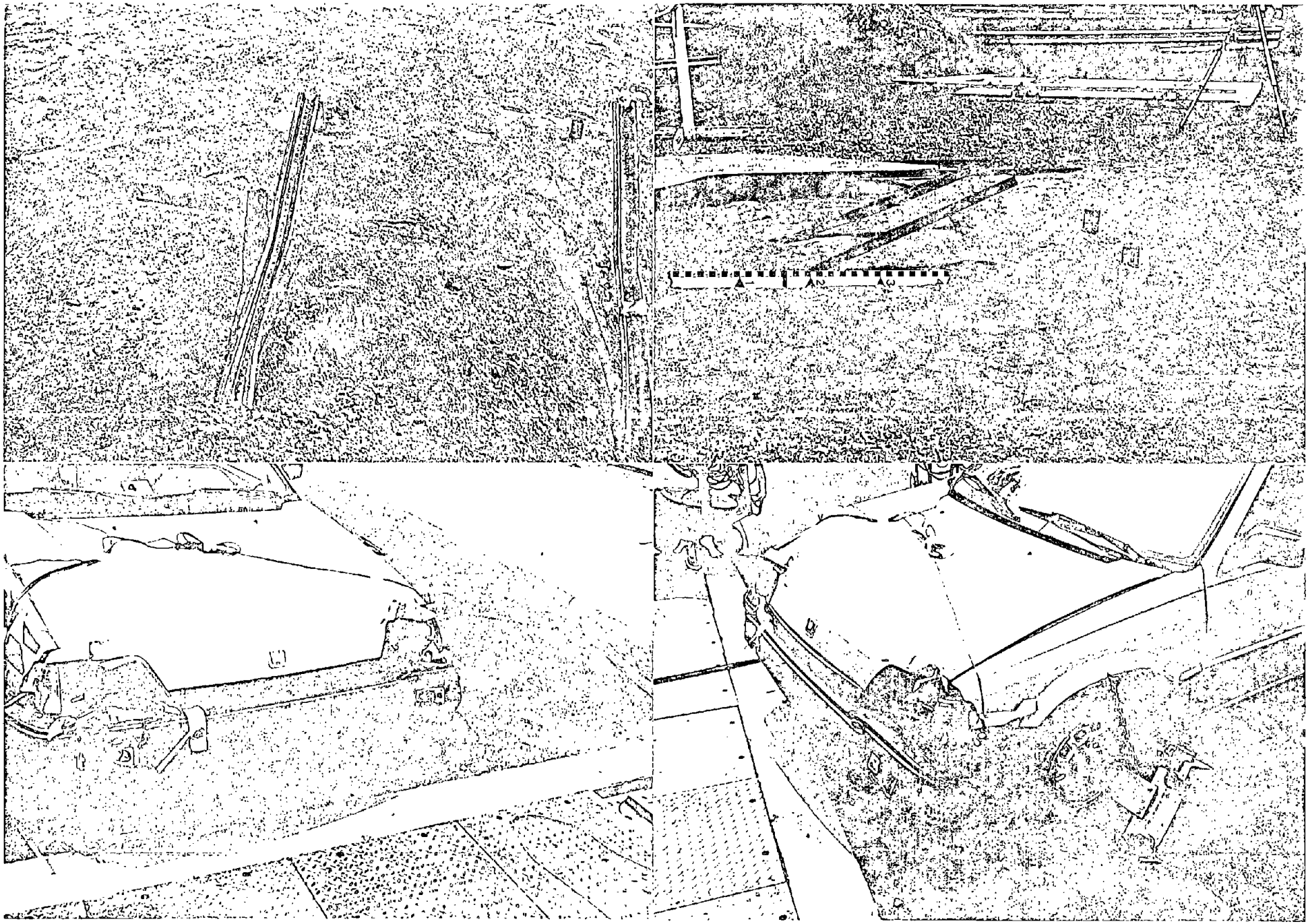
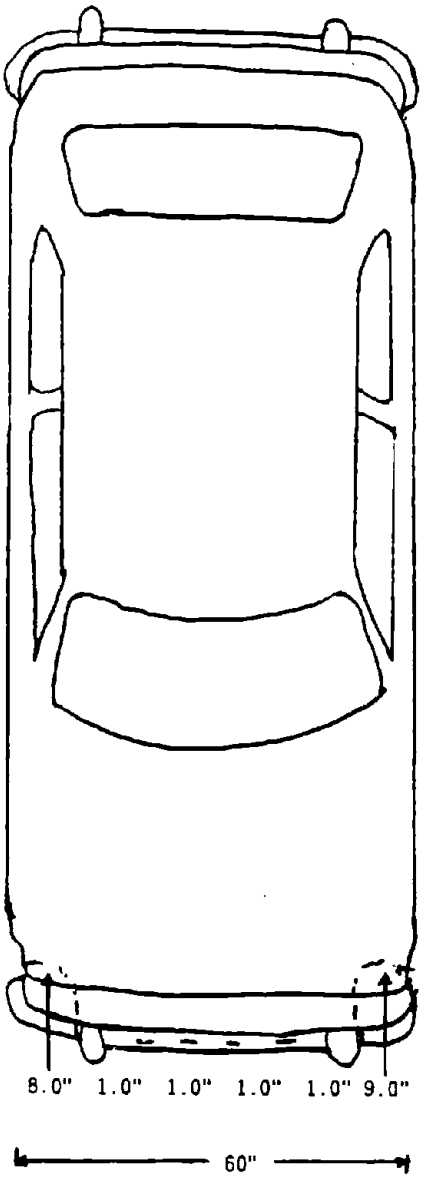


Figure 18. Post-test photographs of test 92F025 (continued).



Max Crush = 9 in

------- Post test

1 in = 25.4 mm

Figure 19. Sketch of vehicle crush, test 92F025.

8. REFERENCES

(1) Jarvis D. Michie, *Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances*, National Cooperative Highway Research Program Report Number 230, March 1981.