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Testing of Small and Large Sign Support Systems FOIL Test Numbers: 92F020 and 92F021

U.S. Department of Transportation
Federal Highway Administration

Research and Development
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6300 Georgetown Pike
McLean, Virginia 22101-2296

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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 20 mi/h (8.9 m/s), test 92F020, and 60 mi/h (26.8 m/s), test 92F021. The vehicle used for these tests was the FOIL reusable bogie vehicle. The purpose of the tests was to evaluate the low- and high-speed safety performance of a dual legged wooden six by eight in concrete foundations, 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 (102 mm), and that there can be no occupant compartment intrusion. The test results indicate that the dual legged wooden 6-ft by 8-ft (1.83-m by 2.44-m) sign support system meets all of the applicable criteria for the low- and high-speed test in weak soil specified by the FHWA.

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Acceleration, occupant impact velocity, weak soil, six by eight, sign, vehicle, FOIL.	No restrictions. This document is available to the public through the National Technical Information Service Springfield, Virginia 22161

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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 92F020, and one at 60 mi/h (26.8 m/s), test 92F021. The vehicle used for these tests was the FOIL's reusable bogie vehicle. The purpose of these tests was to evaluate the low-speed and high-speed safety performance of a dual post, wooden six by eight with concrete foundations, sign support system. 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

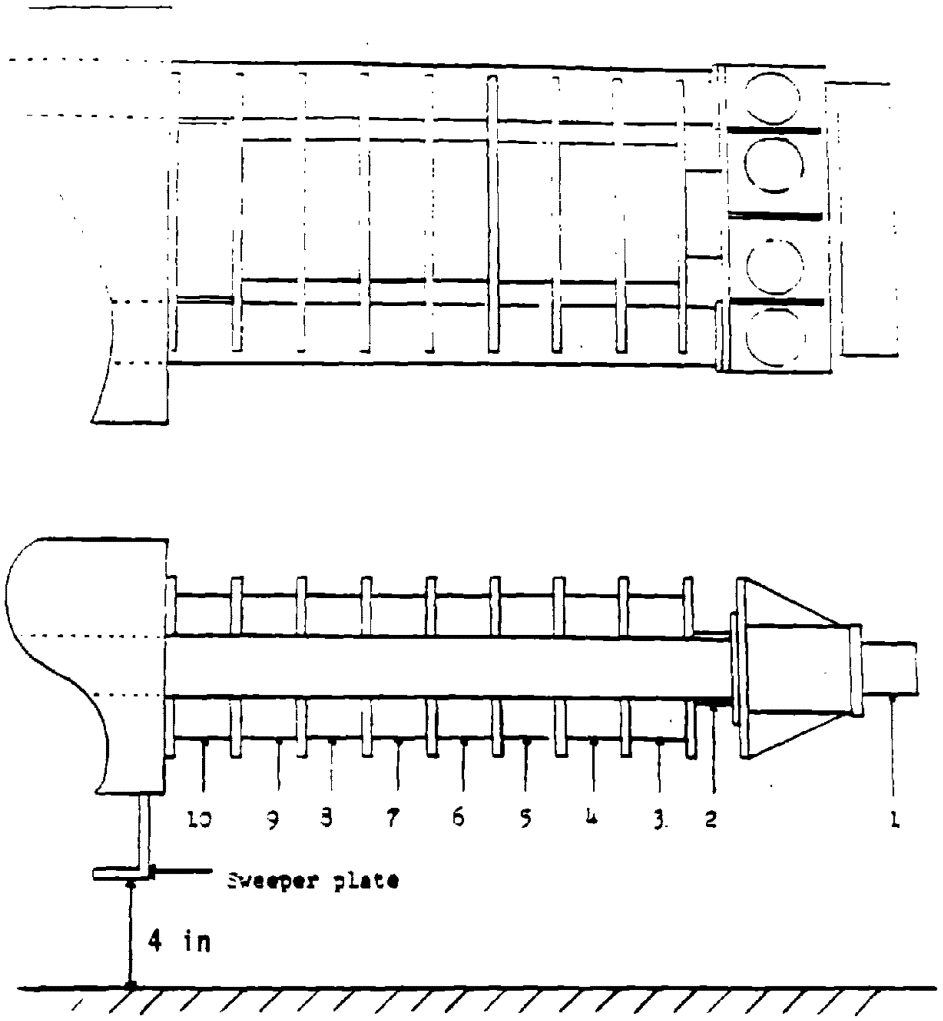
Two tests were performed on a small sign support system. The test speeds for the tests were 20 mi/h (8.9 m/s) and 60 mi/h (26.8 m/s). The sign was buried in NCHRP Report Number 230, S-2 weak soil[1]. A summary of the test conditions are presented in table 1.

Table 1. Test matrix.

Test Number	Test Date	Test Vehicle	Test Weight (lb)	Test Speed (mi/h)	Test Article Description	Impact Location
92F020	7-29-92	FOIL Bogie	1850	20	2 post wood 6x8 impact 1 post	center
92F021	7-31-92	FOIL Bogie	1850	60	2 post wood 6x8 impact 1 post	center

3. VEHICLE

The test vehicle was the FOIL reusable breakaway bogie. Frontal crush of the bogie vehicle which simulates the crush of an actual vehicle was accomplished using multiple cartridges of an expendable aluminum honeycomb material in a sliding nose. After the test, the honeycomb material is replaced and the vehicle reused. The honeycomb was set up to represent the crush characteristics of a 1979 Volkswagen Rabbit's left quarter point.[2] Figure 1 and figure 2 are sketches of the 20-mi/h (8.9-m/s) and 60-mi/h (26.8-m/s) honeycomb configurations used for tests 92F020 and 92F021 respectively. A sweeper plate was attached to bogie vehicle such that it would hang down to a height of 4 in (101.6 mm) above the ground. The sweeper plate was constructed of a section of steel angle welded to a 1/4-in (6.4-mm) steel plate then attached to the bogie using two 3/8-in (9.5-mm) bolts. The sweeper plate was designed as a sacrificial element to simulate the performance of an automobile's undercarriage. The function of the sweeper plate was to determine stub height compliance by the test article. Four wooden 6-ft (1.8-m) four by fours were attached to the top of bogie vehicle to

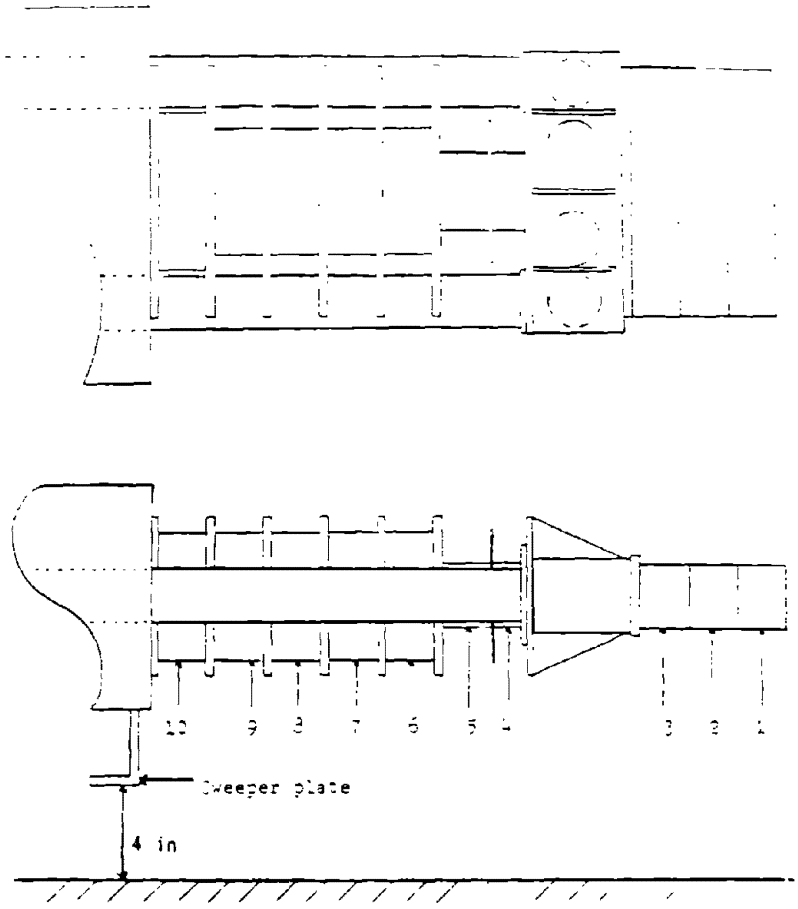


Cartridge Number	Size (in) / punch (in^2)	Static Crush Strength (psi)
1	2-3/4 x 16 x 3	130
2	4 x 5 x 2	25
3	8 x 8 x 3 / 21	130
4	8 x 8 x 3 / 15	230
5	8 x 8 x 3 / 6	230
6	8 x 8 x 3	230
7	8 x 8 x 3 / 21	400
8	8 x 8 x 3 / 12	400
9	8 x 8 x 3	400
10	8 x 10 x 3	400

Spacers are made of fiberglass and are 1/2 in (12.7 mm) thick.

1 in = 25.4 mm
1 in^2 = 645.2 mm^2

Figure 1. Sketch of bogie honeycomb configuration, 20 mi/h (8.9 m/s).



Cartridge Number	Size (in) / punch (in^2)	Static Crush Strength (psi)
1	4 x 16 x 3	130
2	4 x 16 x 3	230
3	4 x 16 x 3	230
4	4 x 5 x 2	25
5	4 x 5 x 3	25
6	8 x 8 x 3	230
7	8 x 8 x 3 / 21	400
8	8 x 8 x 3 / 12	400
9	8 x 8 x 3	400
10	8 x 10 x 3	400

Spacers are made of fiberglass and are 1/2 in (12.7 mm) thick.

1 in_2 = 25.4 mm
1 in^2 = 645.2 mm^2

Figure 2. Sketch of bogie honeycomb configuration, 60 mi/h (26.8 m/s).

protect it from damage. The bogie vehicle was ballasted with a data acquisitions system, transducers, a brake system and weight plates (if necessary) to bring its inertial weight to approximately 1850 lb (839 kg). The actual weight of the bogie was 1850 lb (839 kg).

4. SIGN SUPPORT

The sign support system consisted of two 6-in (152.4-mm) by 8-in (203.2-mm) wooden posts 19 ft (5.8 m) long. The actual dimensions of the sign posts were 5.5 in (139.7 mm) by 7.5 in (190.5 mm). The wooden posts were made from pressure treated southern yellow pine. Two ft (0.9 m) of each leg was inserted inside a steel sleeve which was cast inside a 2-ft (0.6-m)-diameter concrete footer. The footers were 2.5 ft (0.8 m) deep and were buried in NCHRP Report 230 S-2 weak soil (sand). Two 3-in (76.2-mm)-diameter holes were drilled in each sign post, one 4 in (101.6 mm) and the other 18 in (457.2 mm) above ground level. Attached to the 2 posts was a 10-ft high by 12-ft (3.1-m by 3.7-m) wide aluminum sign panel. The final panel was assembled from 10 1-ft by 12-ft (0.3-m by 3.7-m) extruded aluminum panels and was installed 7 ft (2.1 m) above ground. The two posts were installed 6 ft (1.8 m) apart (impact one post). The whole sign support system was assembled and the concrete footers cast. The concrete footers were inserted into a hole in weak soil. The hole was backfilled in 6-in (152.4-mm) lifts and compacted until the final grade was reached. The sign support was then inserted inside the footers. Figure 3 and figure 4 are drawings of the sign support system.

5. TEST RESULTS - 20 MI/H, TEST 92F020

The bogie vehicle was accelerated to 21.4 mi/h (31.4 ft/s (9.6 m/s)) prior to impacting the sign support. The centerline of the bogie vehicle was aligned with the center of the left sign post.

The honeycomb nose made contact with the sign post and began to collapse. The nose made contact 17.5 in (444.5 mm) above ground on the upper hole. The wood post began to fracture at both holes 0.038 s into the impact event. The fourth cartridge of honeycomb had started to crush when the post began to fracture. The fourth cartridge of honeycomb requires approximately 14000 lb (62 kN) to initiate crush. The post had fractured completely 0.090 s after initial contact between the bogie and the sign post. The failure mechanism was fracture at both of the 3-in (76.2-mm) holes. The bogie vehicle's nose remained in contact with the sign post, pushing on the sign post and rotating it upwards. The sign post slid off the nose 0.196 s into the impact event. The post slid to the left and made contact with the bogie vehicle on an upper steel support at 0.224 s. After making contact with the upper support, the bogie continued to rotate the sign post upwards. The lowest hole in the wood post drilled for sign panel attachment 7 ft (2.1 m) above ground performed like a hinge and fractured at 0.280 s. The fracture area was inspected for knots in the wood which may have contributed to the post fracturing at that location. No knots were found in the area. After the post fractured, the 7-ft (2.1-m) section of wood post was free to fall on top of the bogie vehicle. Upon passing through the sign system the bogie vehicle's brakes were applied and bogie came to rest.

Damage to the bogie vehicle consisted of crushed honeycomb material. The damage was to expendable material and not to structural elements of the bogie vehicle. The crush measured after the test and was measured to be 10.1 in (256.5 mm). None of the sign components would have impaled an occupant

compartment had the vehicle been an automobile rather than the bogie vehicle.

Damage to the sign support consisted of one fractured wood post. The right sign post remained upright and was fully supporting the sign panel. The panel was in good condition after the test. The embedded concrete footers remained stationary during the test.

The occupant impact velocity using the 2-ft (0.6-m) flail space model outlined NCHRP Report Number 230, was determined to be 7.4 ft/s (2.2 m/s). The occupant impact velocity was reached 0.344 s into the crash event. The ridedown acceleration was 0.6 g's. The peak force (300 Hz data) for the impact event was 10.3 g's (19.0 kips (84 kN)). Because the sign post-bogie contact was brief the vehicle change in velocity was equal to the occupant impact velocity, 7.4 ft/s (2.2 m/s).

Photographs during the impact event are presented in figure 5. A summary of the impact conditions and the test results is presented in figure 6. Figures 7 through 10 are plots of data collected during the test. Pre- and post-test photographs of the bogie and the sign system are presented in figures 11 through 14.

6. TEST RESULTS - 60 MI/H (26.8 M/S), TEST 92F021

The bogie vehicle was accelerated to 60.5 mi/h (88.7 ft/s (27.1 m/s)) prior to impacting the sign support. The centerline of the bogie vehicle was aligned with the center of the left sign post.

The honeycomb nose made contact with the sign post and began to collapse. The nose made contact 17.5 in (444.5 mm) above ground on the upper hole. The wood post began to fracture at the lower hole 0.010 s into the impact event. The eighth cartridge of honeycomb had started to crush when the post began to fracture. The eighth cartridge of honeycomb requires approximately 21000 lb (93 kN) to initiate crush. The post had fractured completely 0.028 s after initial contact between the bogie and the sign post. The failure mechanism was fracture at the lower 3-in (76.2-mm) hole. The upper hole did not fracture during the impact event. The bogie vehicle's nose remained in contact with the sign post, pushing on the sign post and rotating it upwards. The lowest hole in the wood post drilled for sign panel attachment 7 ft (2.1 m) above ground performed like a hinge and fractured at 0.032 s. The fracture area was inspected for knots in the wood which may have contributed to the post fracturing at that location. No knots were found in the area. After the post fractured, the 7-ft (2.1-m) section of wood post was launched 90 ft (27.5 m) downrange. The flying debris was considered a possible hazard to other traffic and to pedestrians. Upon passing through the sign system the bogie vehicle's brakes were applied and the bogie came to rest with aid from the FOIL catch fence.

Damage to the bogie vehicle consisted of crushed honeycomb material. The damage was to expendable material and not to structural elements of the bogie vehicle. The crush measured after the test and was measured to be 14.8 in (375.9 mm). None of the sign components would have impaled an occupant compartment had the vehicle been an automobile rather than the bogie vehicle.

Damage to the sign support consisted of one fractured wood post. The right sign post remained upright and was fully supporting the sign panel. The panel was in good condition after the test. The embedded concrete footers remained stationary during the test.

The occupant impact velocity using the 2-ft (0.6-m) flail space model outlined NCHRP Report Number 230, was determined to be 3.0 ft/s (0.9 m/s). The occupant impact velocity was reached 0.604 s into the crash event. The

ridedown acceleration was 0.8 g's. The peak force (300 Hz data) for the impact event was 16.3 g's (30.1 kips (133 kN)). Because the sign/vehicle contact was brief the vehicle change in velocity was equal to the occupant impact velocity, 3.0 ft/s (0.9 m/s).

Photographs during the impact event are presented in figure 15. A summary of the impact conditions and the test results is presented in figure 16. Figures 17 through 20 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 21 through 24.

7. CONCLUSION

The test results indicate that the 6-ft by 8-ft (1.83-m by 2.44-m) 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 stub remaining after each test was lower than the 4-in (101.6-mm) limit specified by the FHWA. Furthermore, the occupant impact velocities of 7.4 ft/s (2.2 m/s) for the low-speed test and 3.0 ft/s (0.9 m/s) for the high-speed test are below the 16 ft/s (4.9 m/s) limit specified by the FHWA.

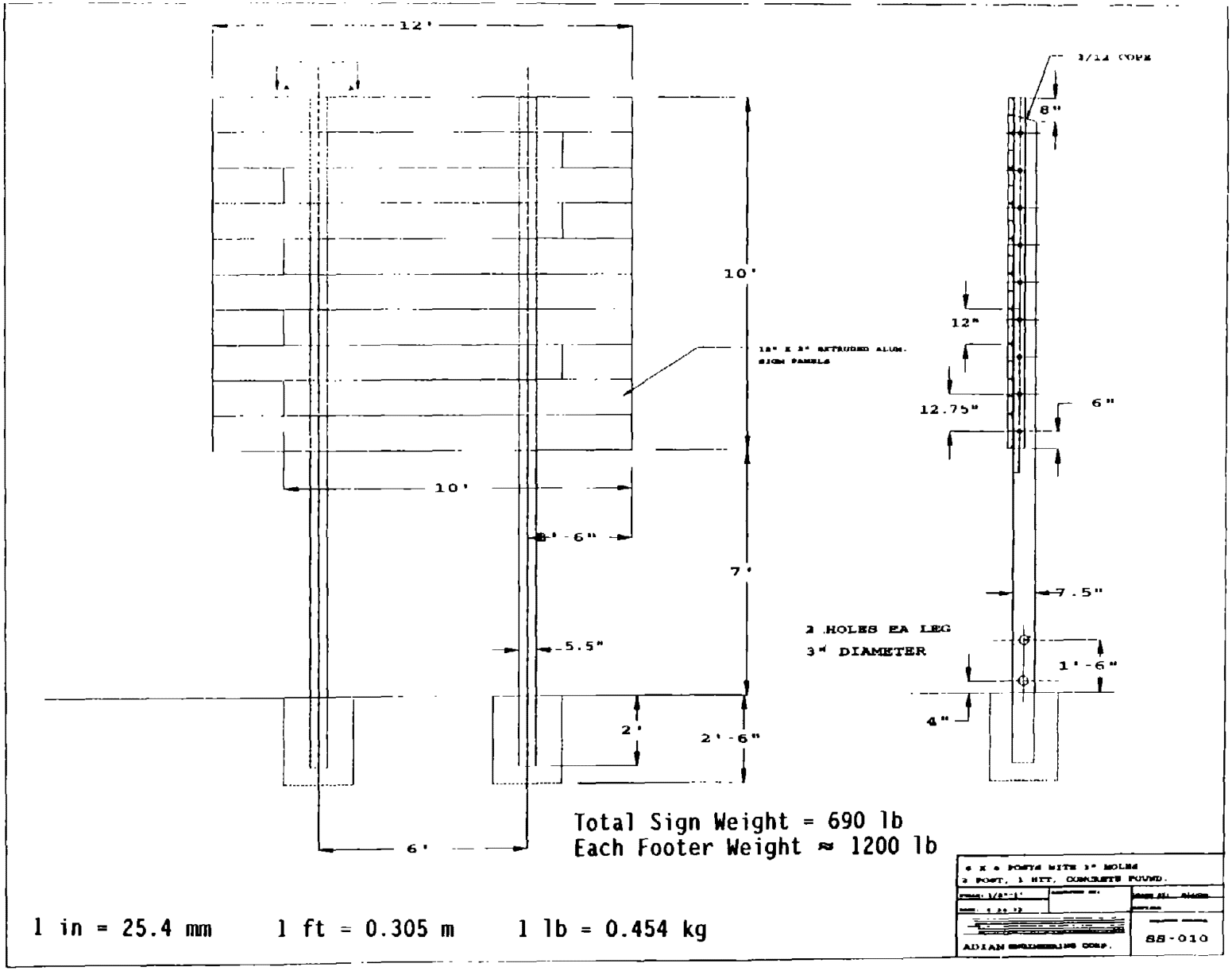


Figure 3. Sketch of small sign support.

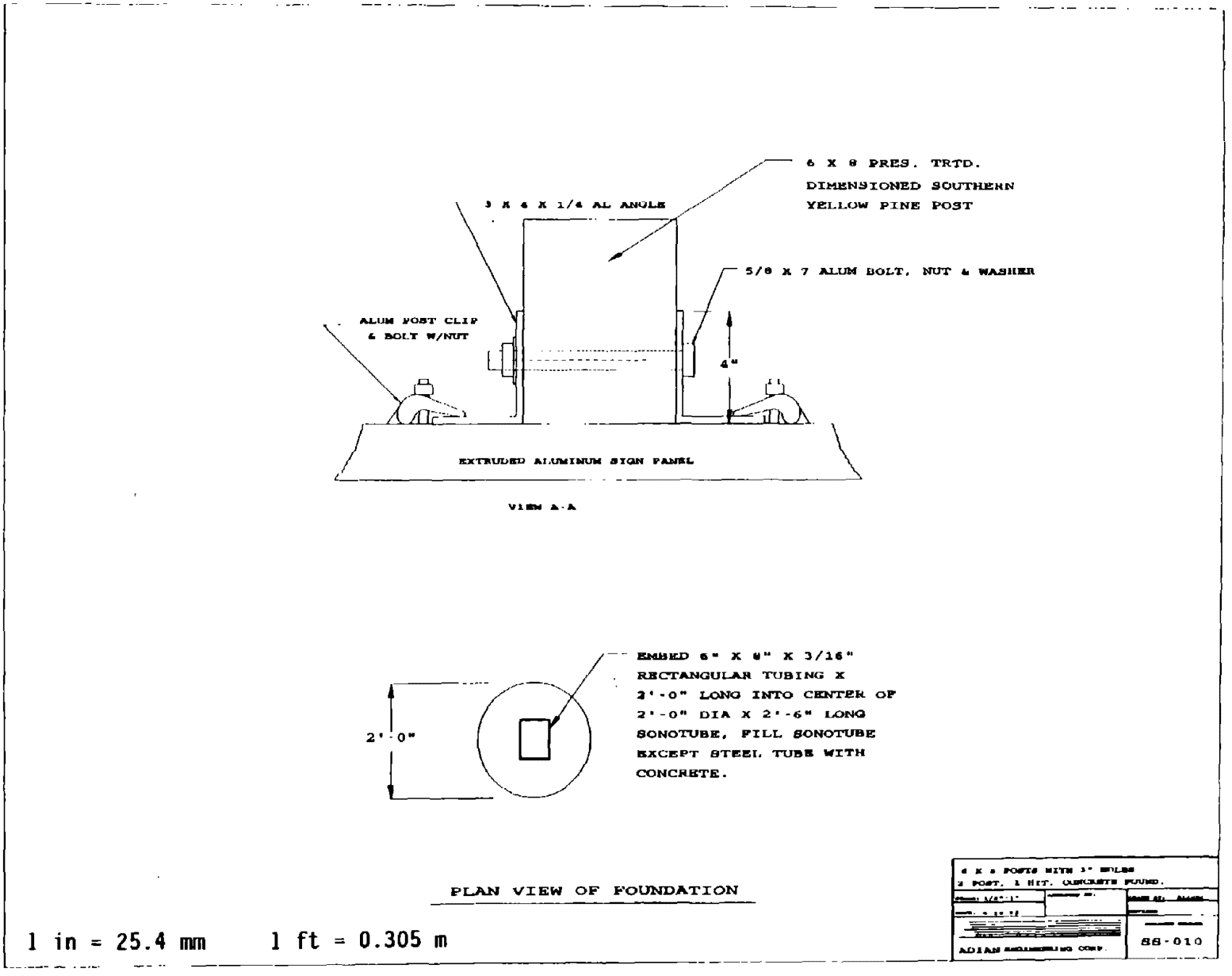
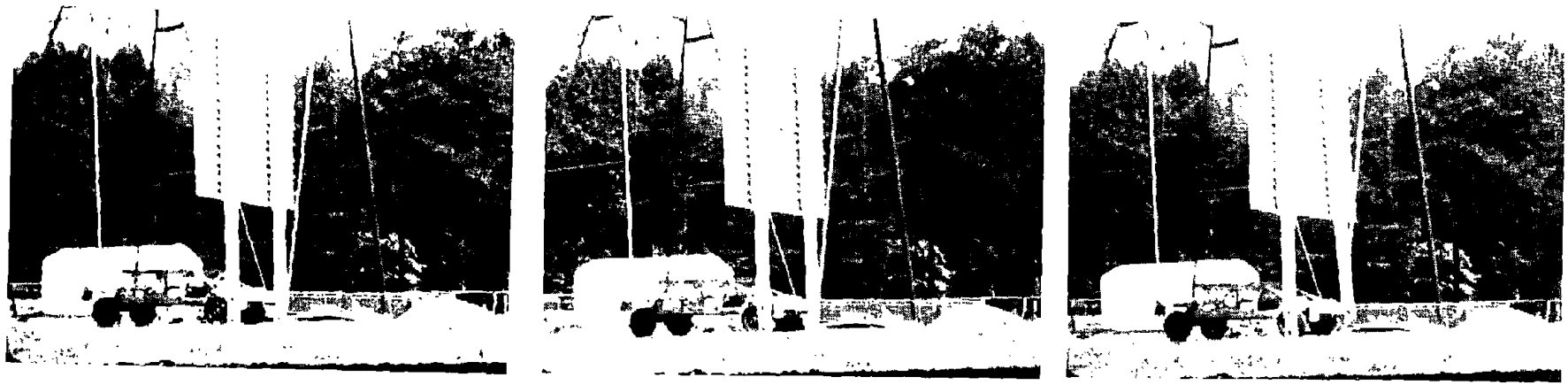
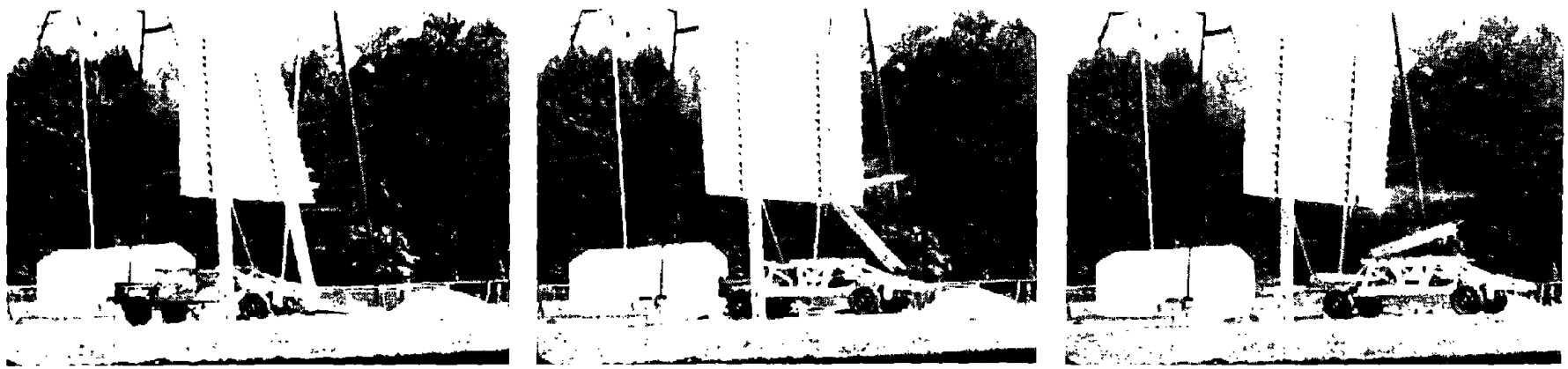


Figure 4. Sketch of small sign support attachment detail.

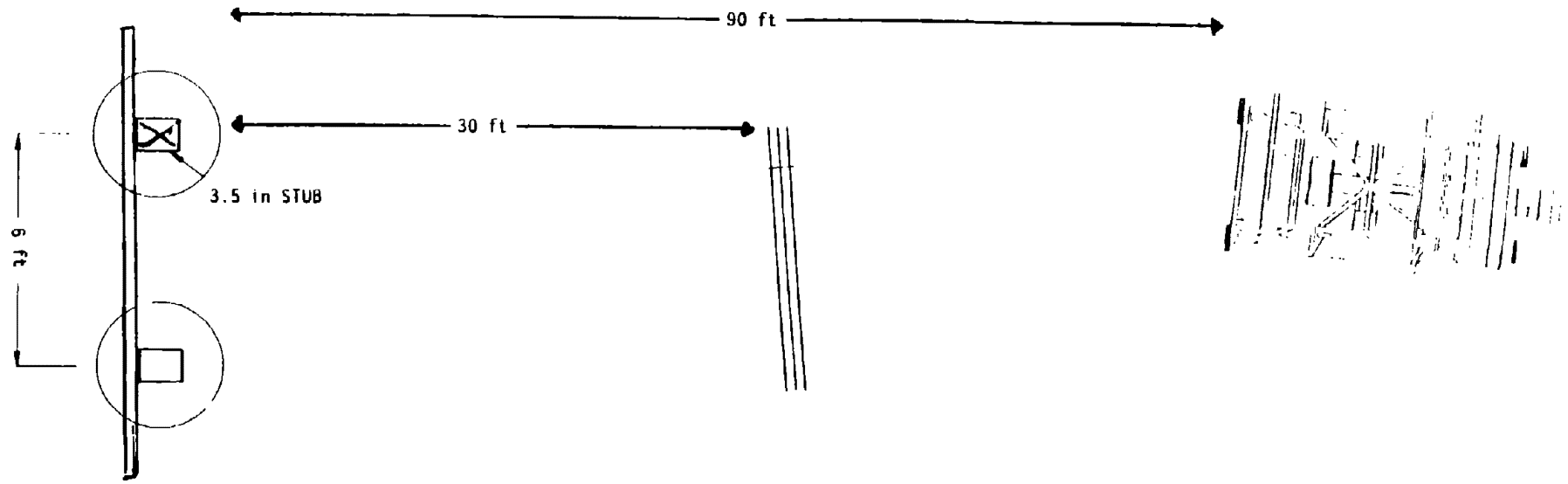


0.020 s 0.032 s 0.050 s



0.110 s 0.294 s 0.472 s

Figure 5. Test photographs during impact, test 92F020.



Test number..... 92F020

Date..... July 29, 1992

Test vehicle..... FOIL Bogie

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

Test article.....Small Sign Support

Material.....6 by 8 wood, two 3-in holes
2-Leg, 1-Hit

Embedment depth..... 2.5 ft

Panel type..... 10 ft by 12 ft extruded aluminum

Height..... 17 ft

Foundation..... 2-ft-diameter concrete foundation
in S-2 Weak Soil

Impact speed.....31.4 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	7.4 ft/s	≤16 ft/s
Ridedown Acceleration	0.6 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..... 3.3 g's
Lateral..... NA

Vehicle Damage (TAD)..... NA
(VDI)..... NA

Honeycomb crush..... 10.1 in

Vehicle velocity change..... 7.5 ft/s

Exit angle..... 0 degrees

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

Figure 6. Summary of test 92F020.

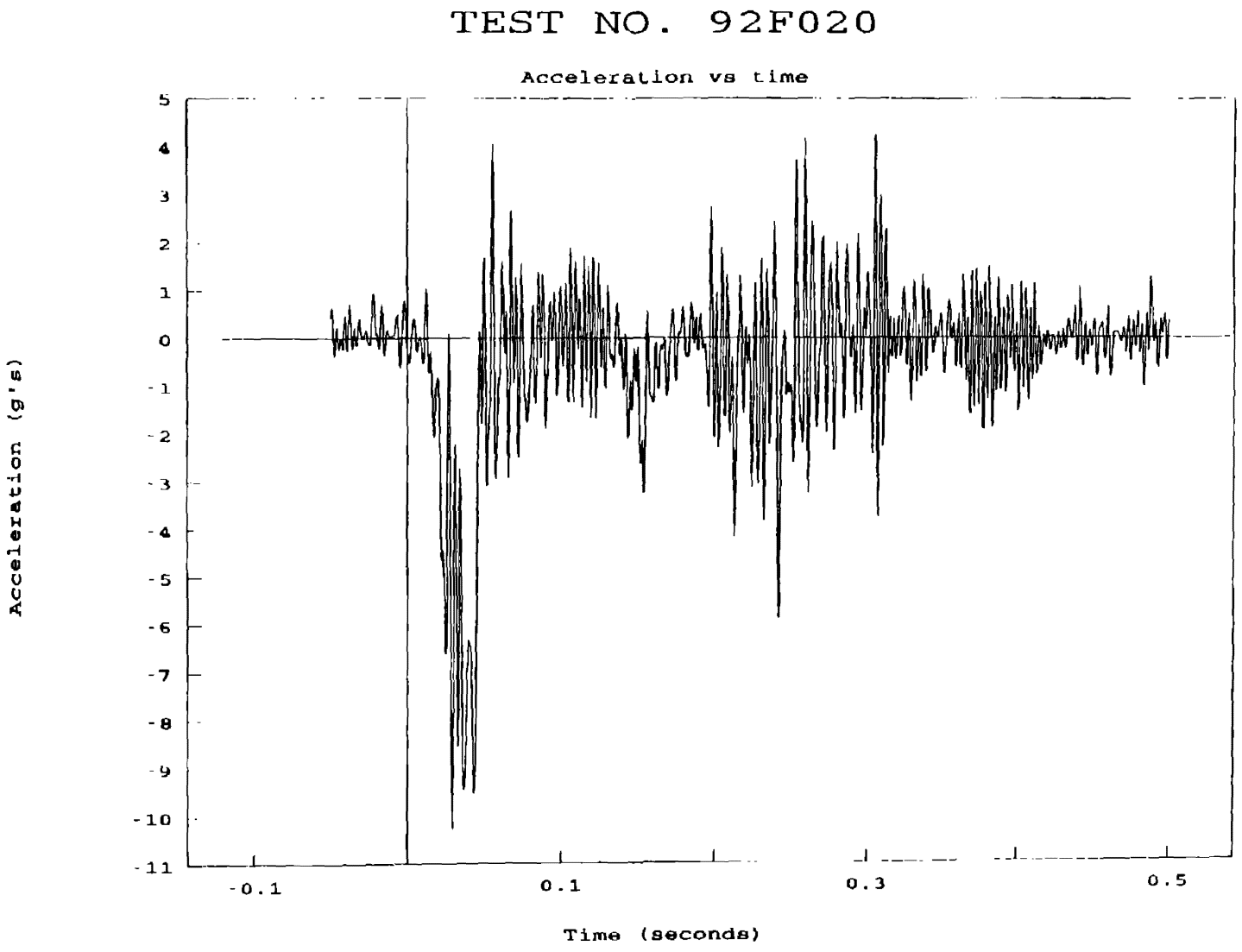
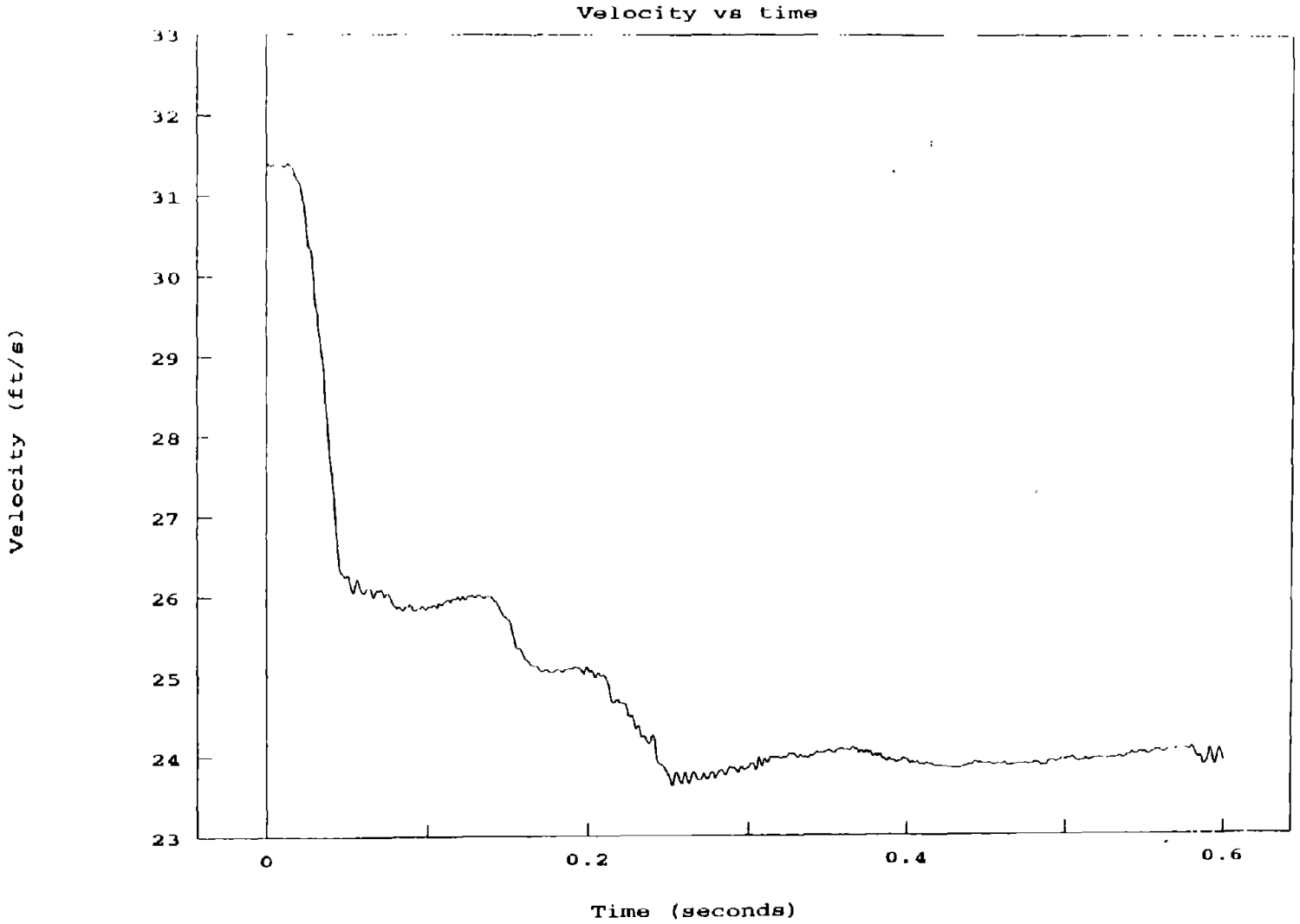


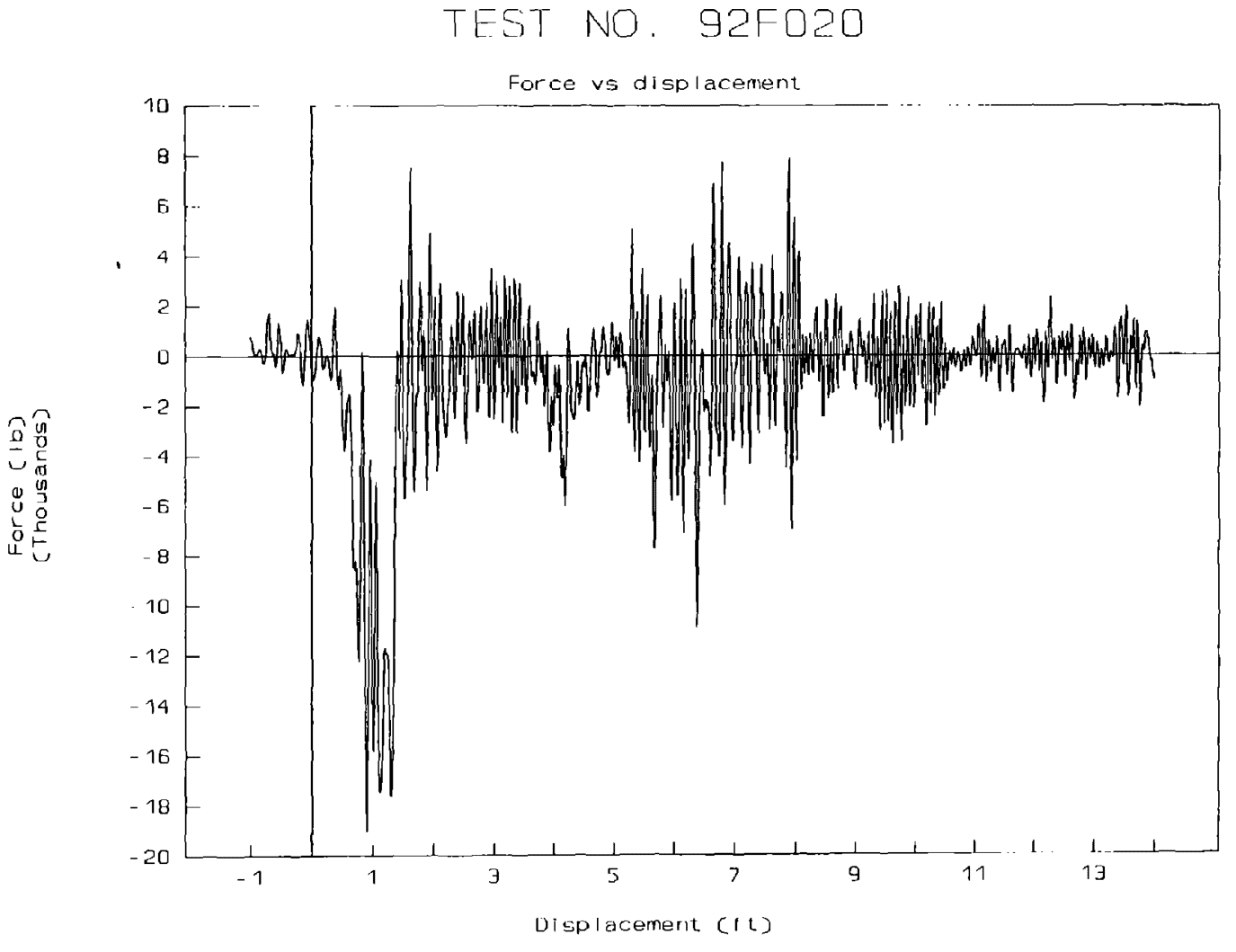
Figure 7. Acceleration versus time, X-axis, test 92F020.

TEST NO. 92F020



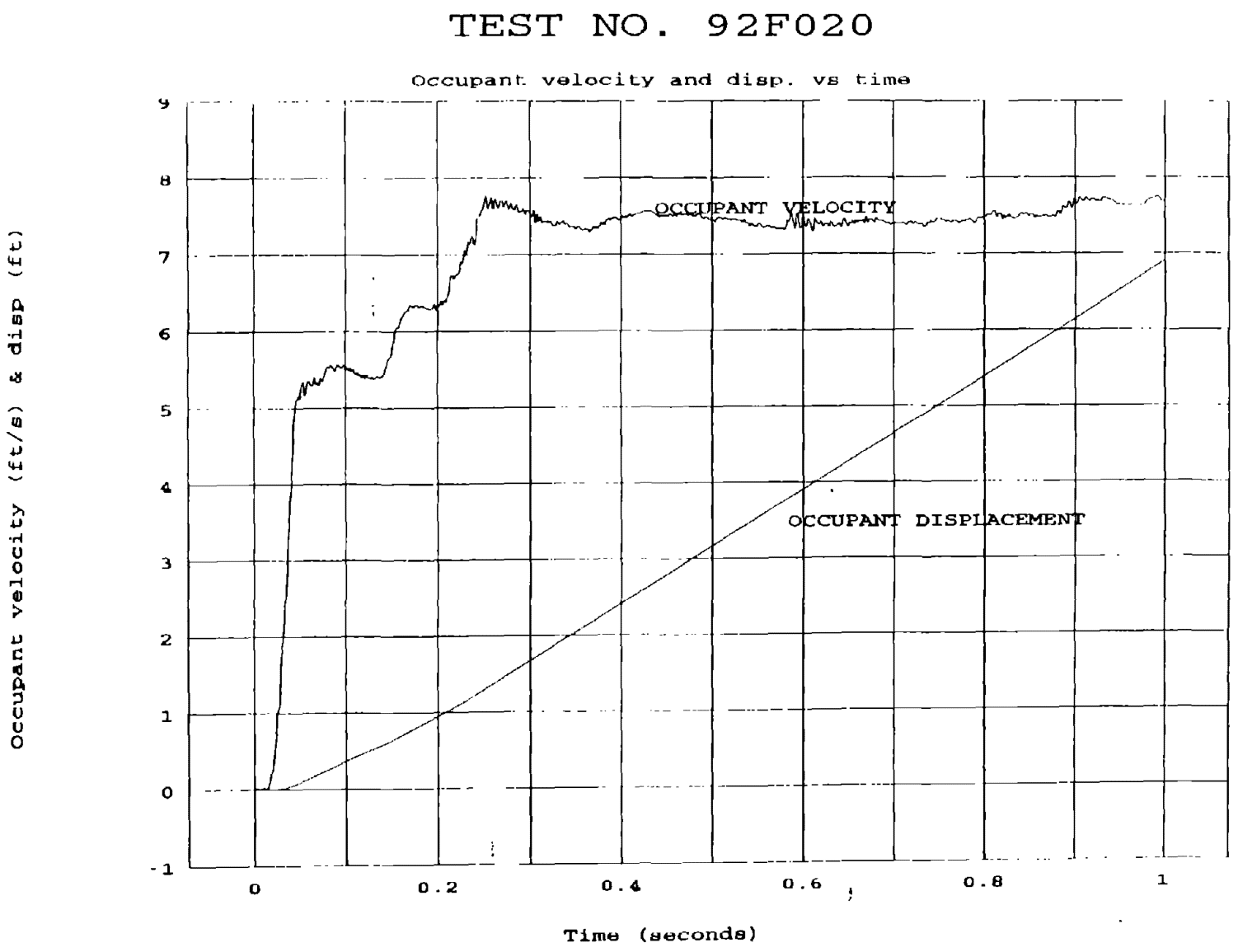
1 ft = 0.305 m

Figure 8. Velocity versus time, X-axis, test 92F020.



1 lbf = 4.45 N 1 ft = 0.305 m

Figure 9. Force versus displacement, X-axis, test 92F020.



1 ft = 0.305 m

Figure 10. Occupant velocity and relative displacement versus time, X-axis, test 92F020.

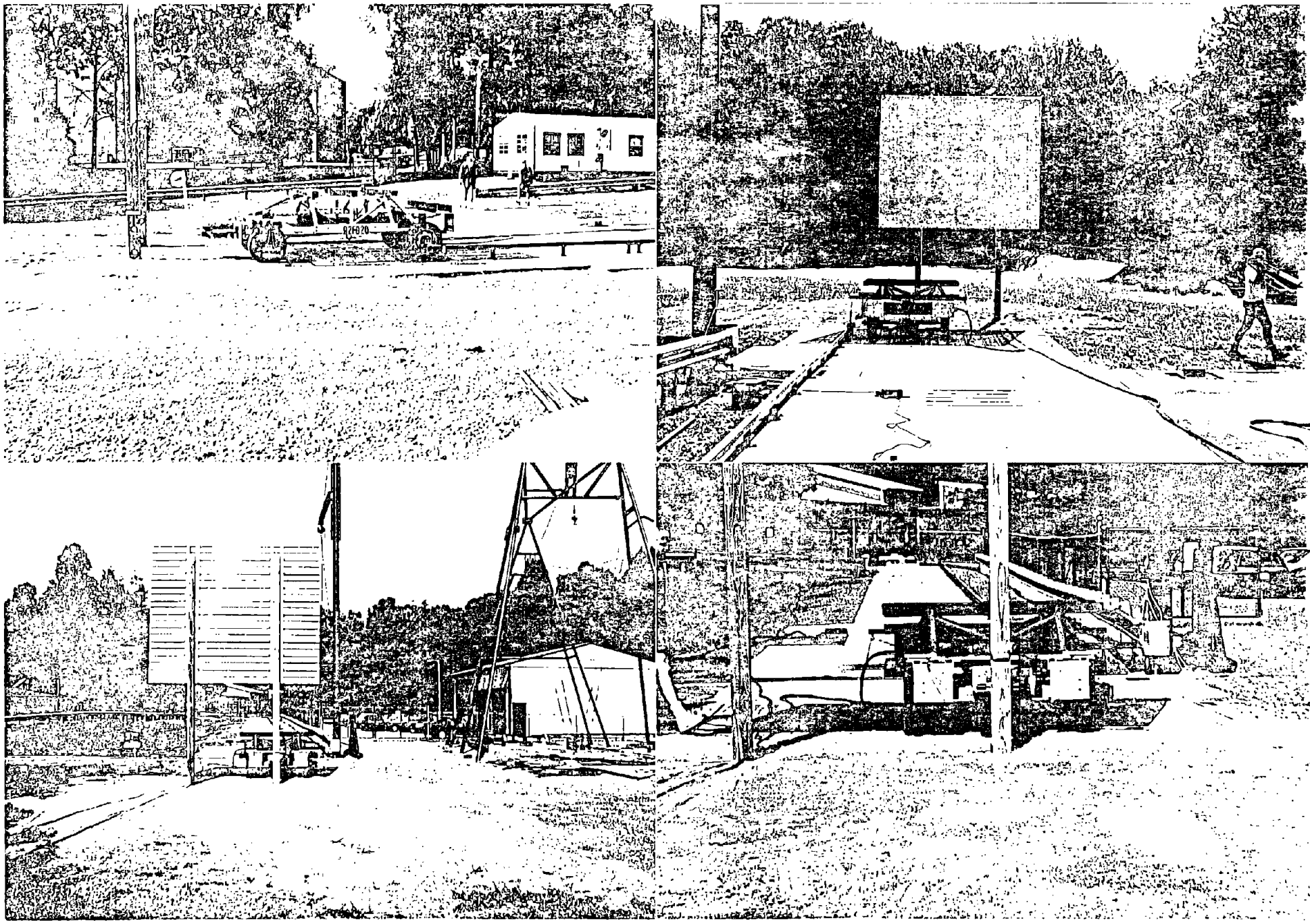


Figure 11. Pretest photographs of test 92F020.

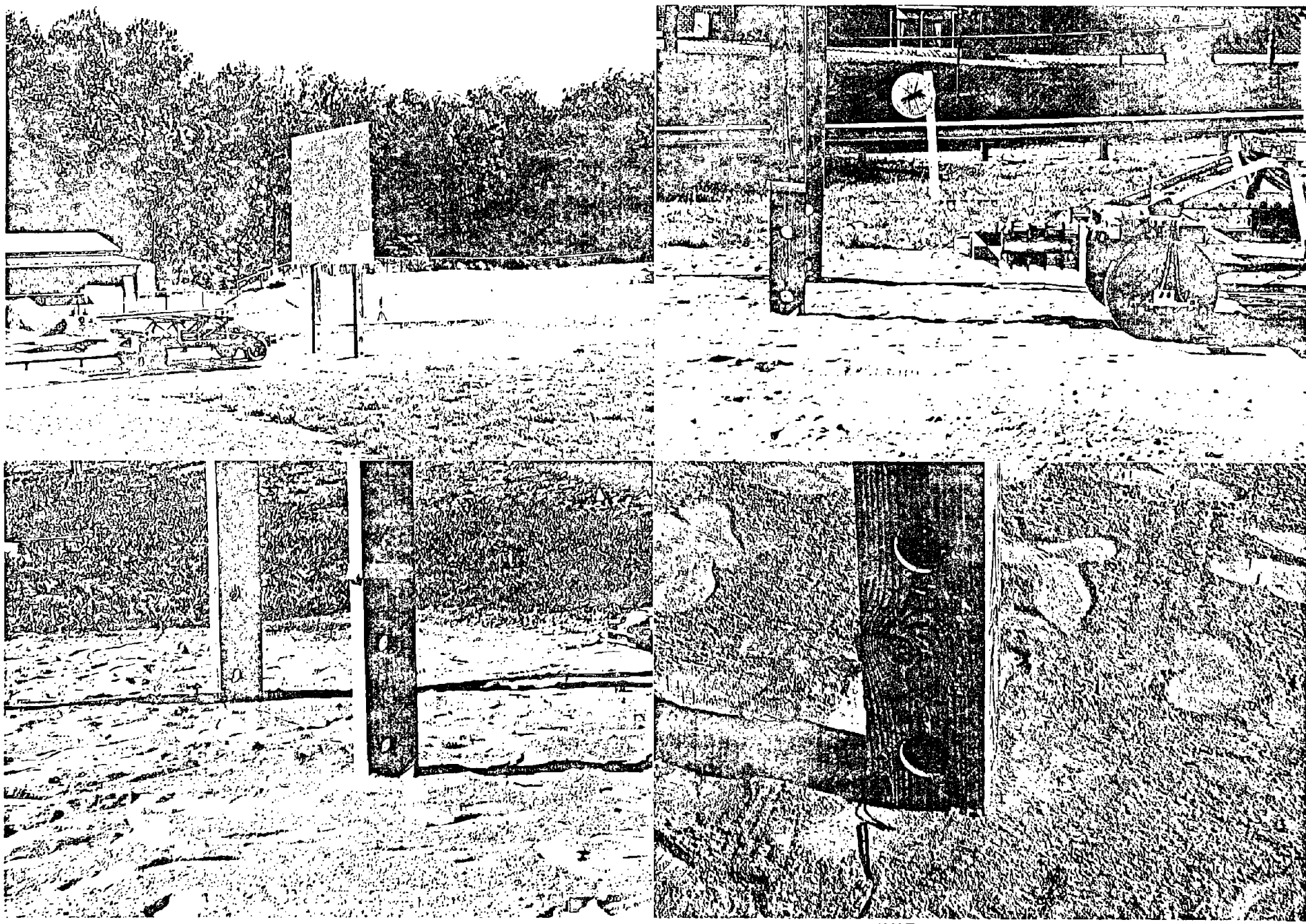


Figure 12. Additional pretest photographs of test 92F020.

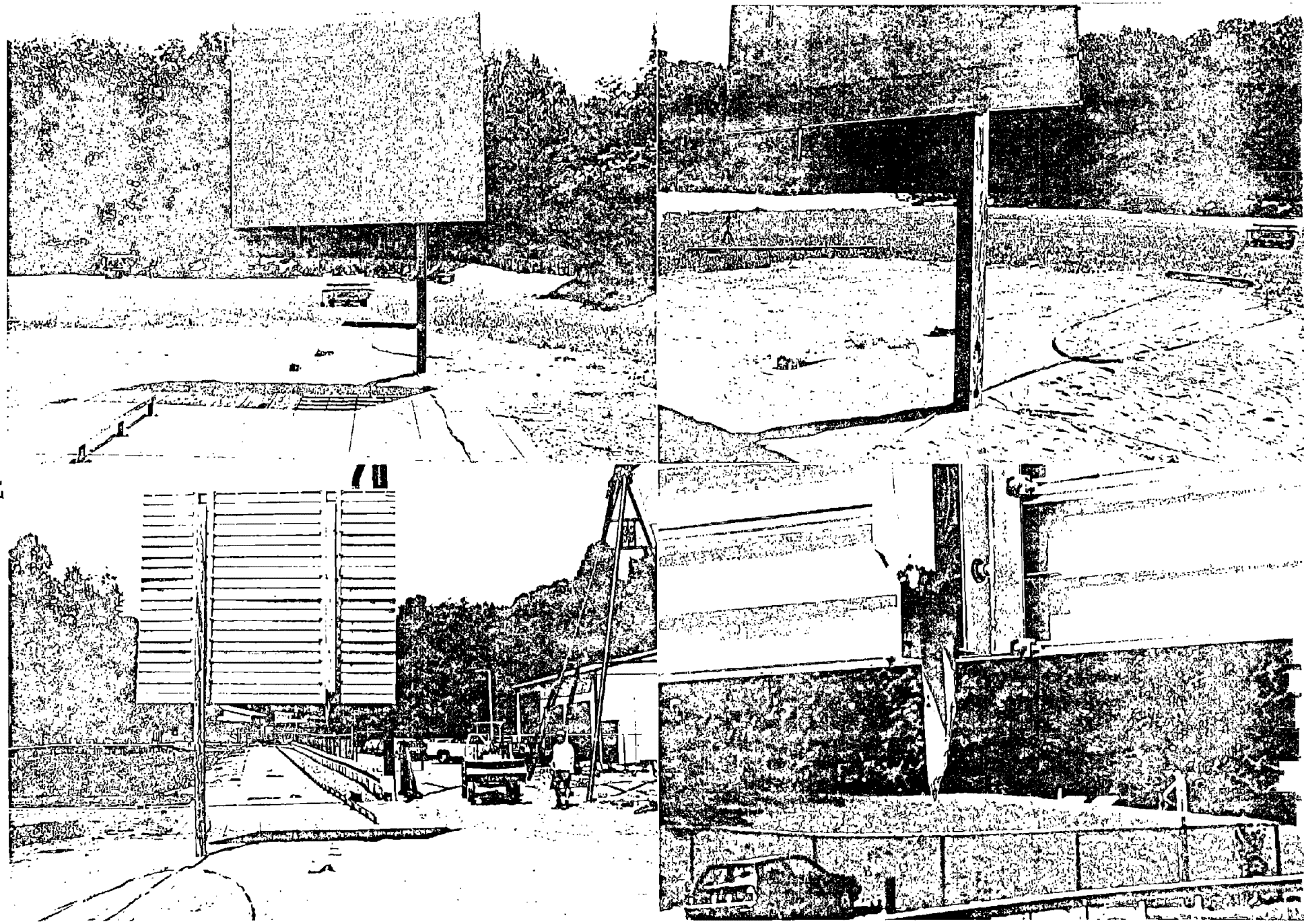


Figure 13. Post-test photographs of test 92F020.

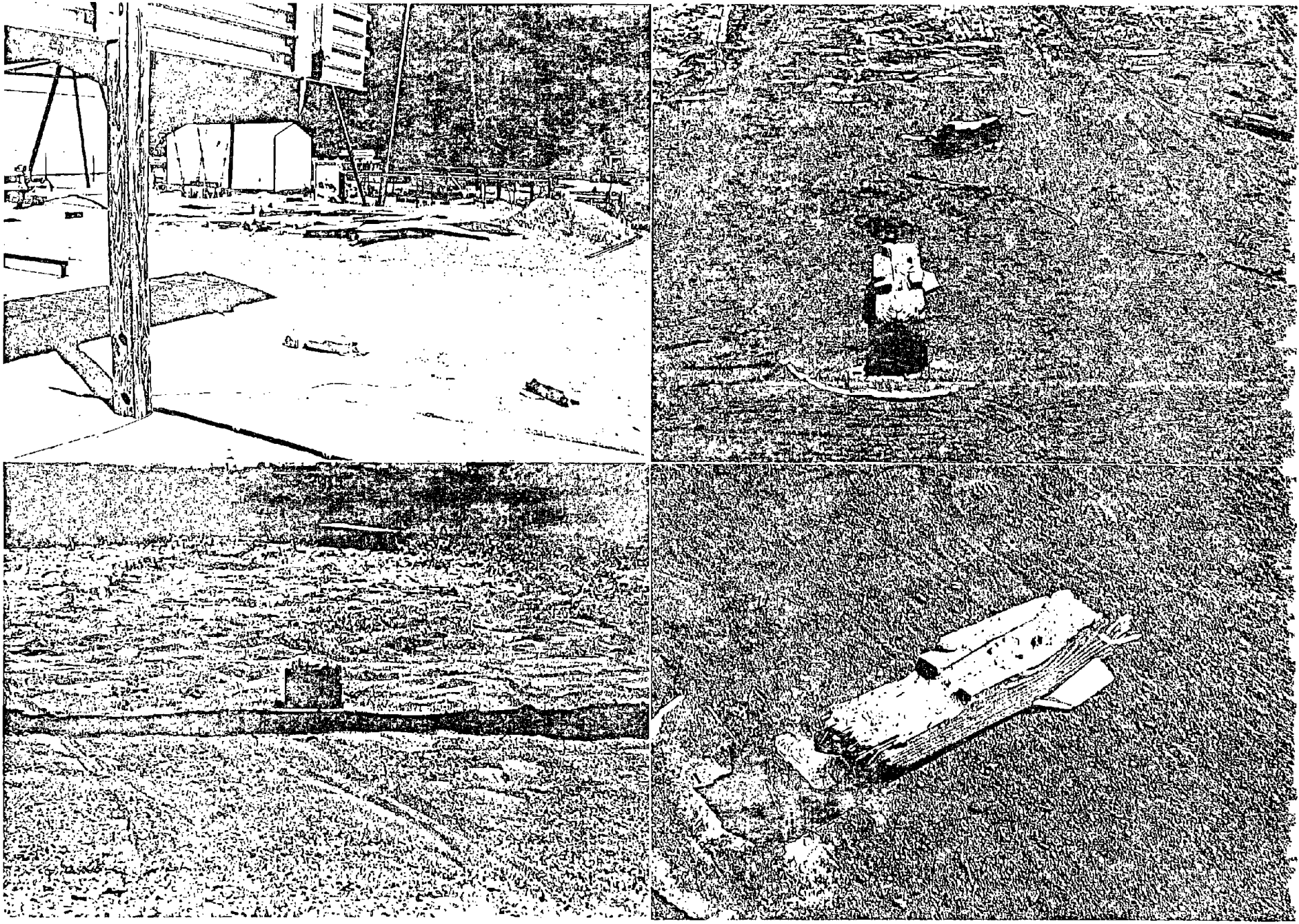


Figure 14. Additional post-test photographs of test 92F020.

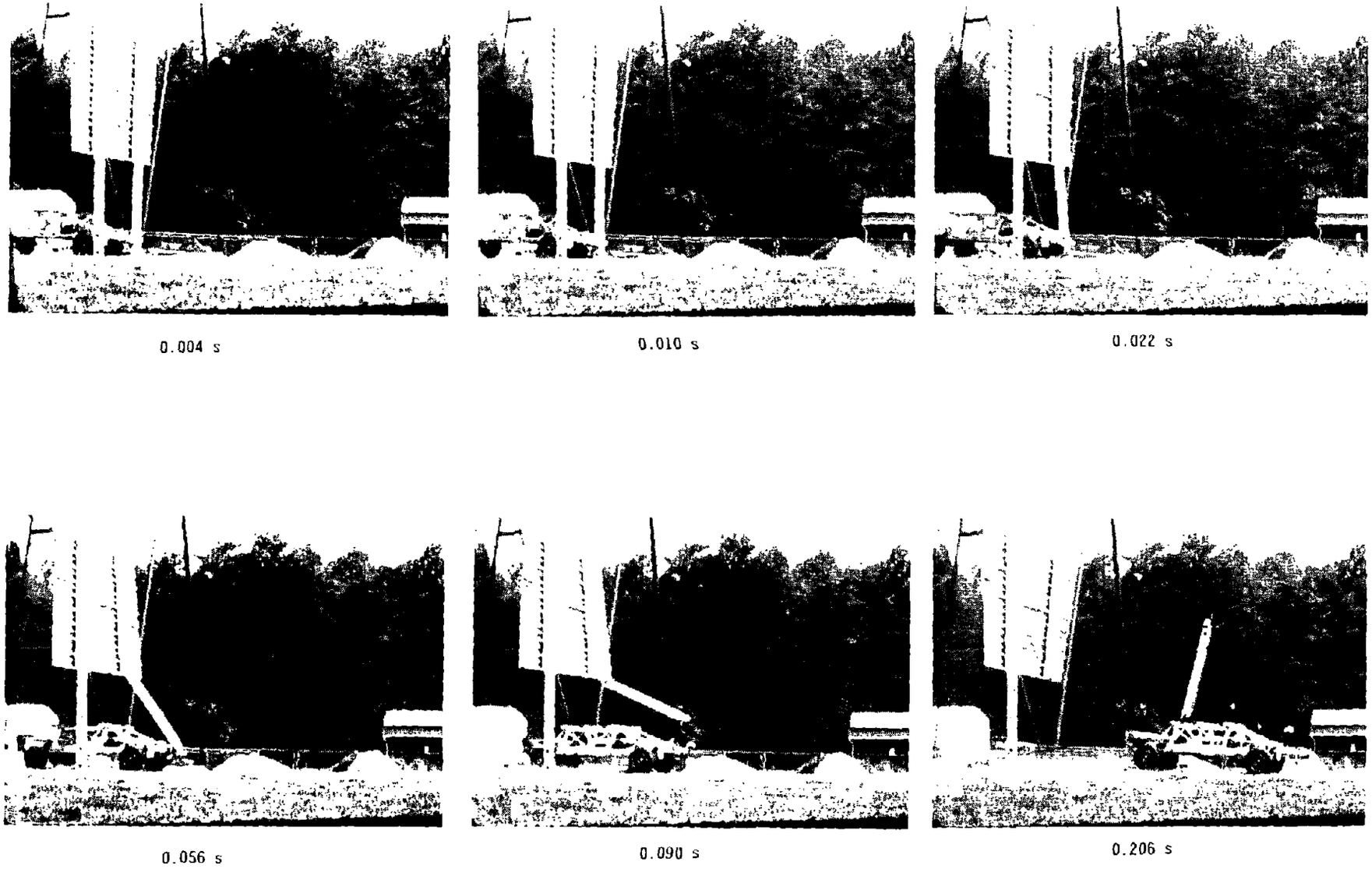
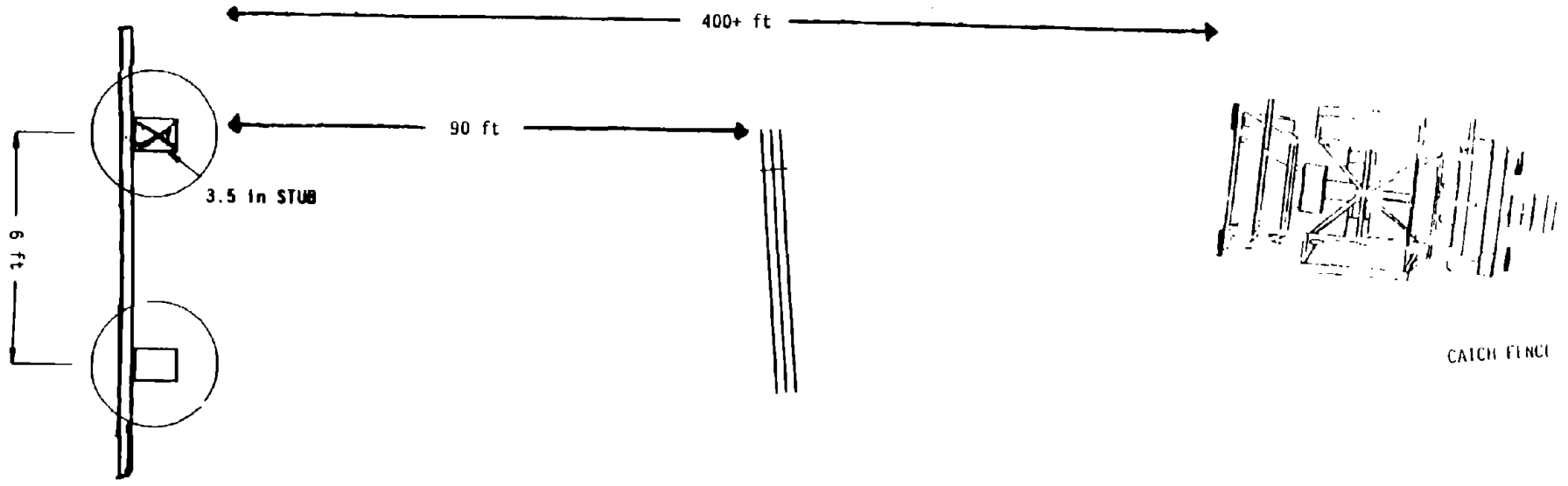


Figure 15. Test photographs during impact, test 92F021.



Test number..... 92F021

Date..... July 31, 1992

Test vehicle..... FOIL Bogie

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

Test article.....Small Sign Support

Material..... 6 by 8 wood, two 3-in holes 2-Leg, 1-Hit

Embedment depth..... 2.5 ft

Panel type..... 10 ft by 12 ft extruded aluminum

Height..... 17 ft

Foundation..... 2-ft-diameter concrete foundations in S-2 Weal Soil

Impact speed..... 88.7 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.....	3.0 ft/s	≤16 ft/s
Ridedown Acceleration.....	0.8 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..... 2.4 g's
Lateral..... NA

Vehicle Damage (TAD)..... NA
(VDI)..... NA

Honeycomb crush..... 14.8 in

Vehicle velocity change..... 3.0 ft/s

Exit angle.....0 degrees

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

Figure 16. Summary of test 92F021.

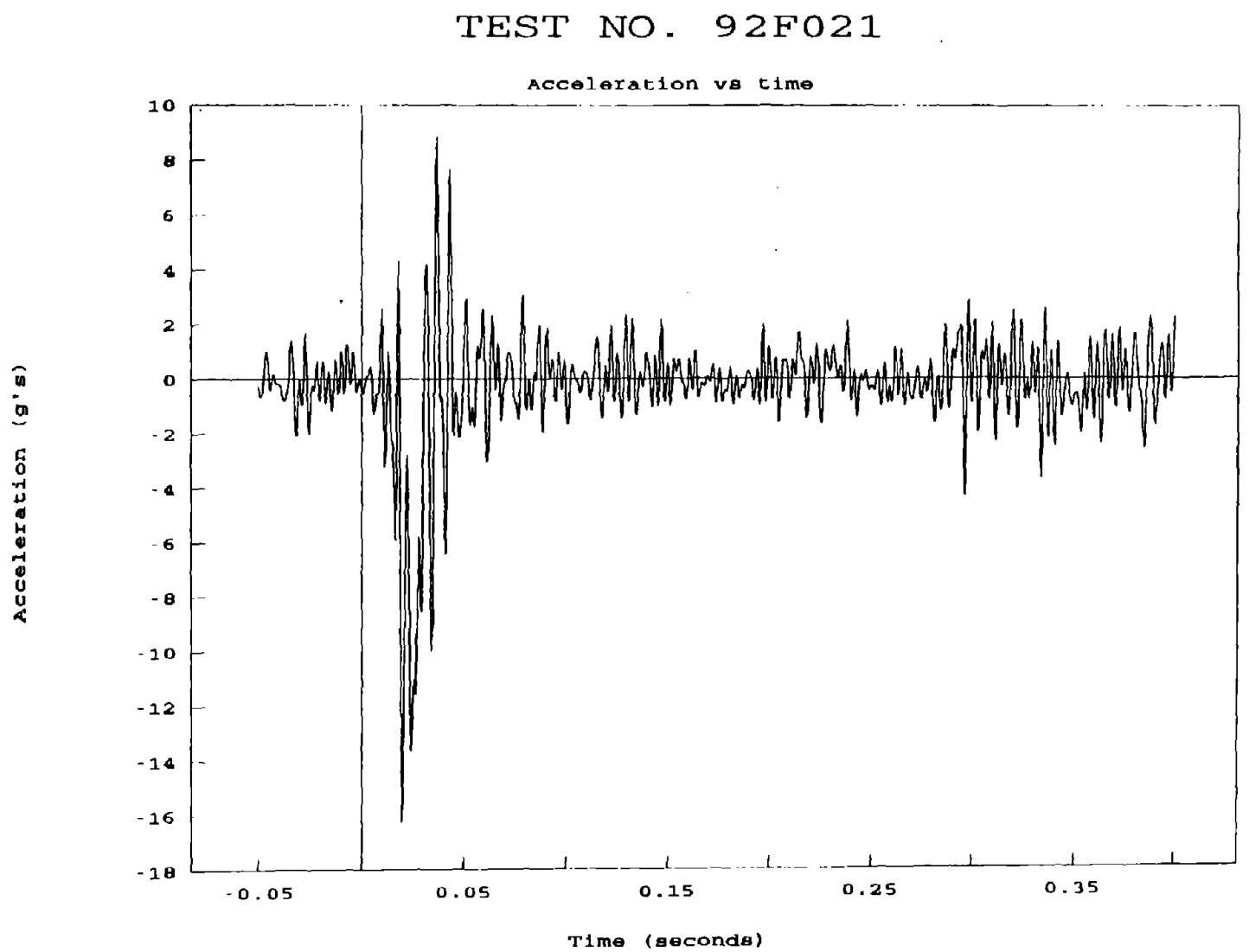
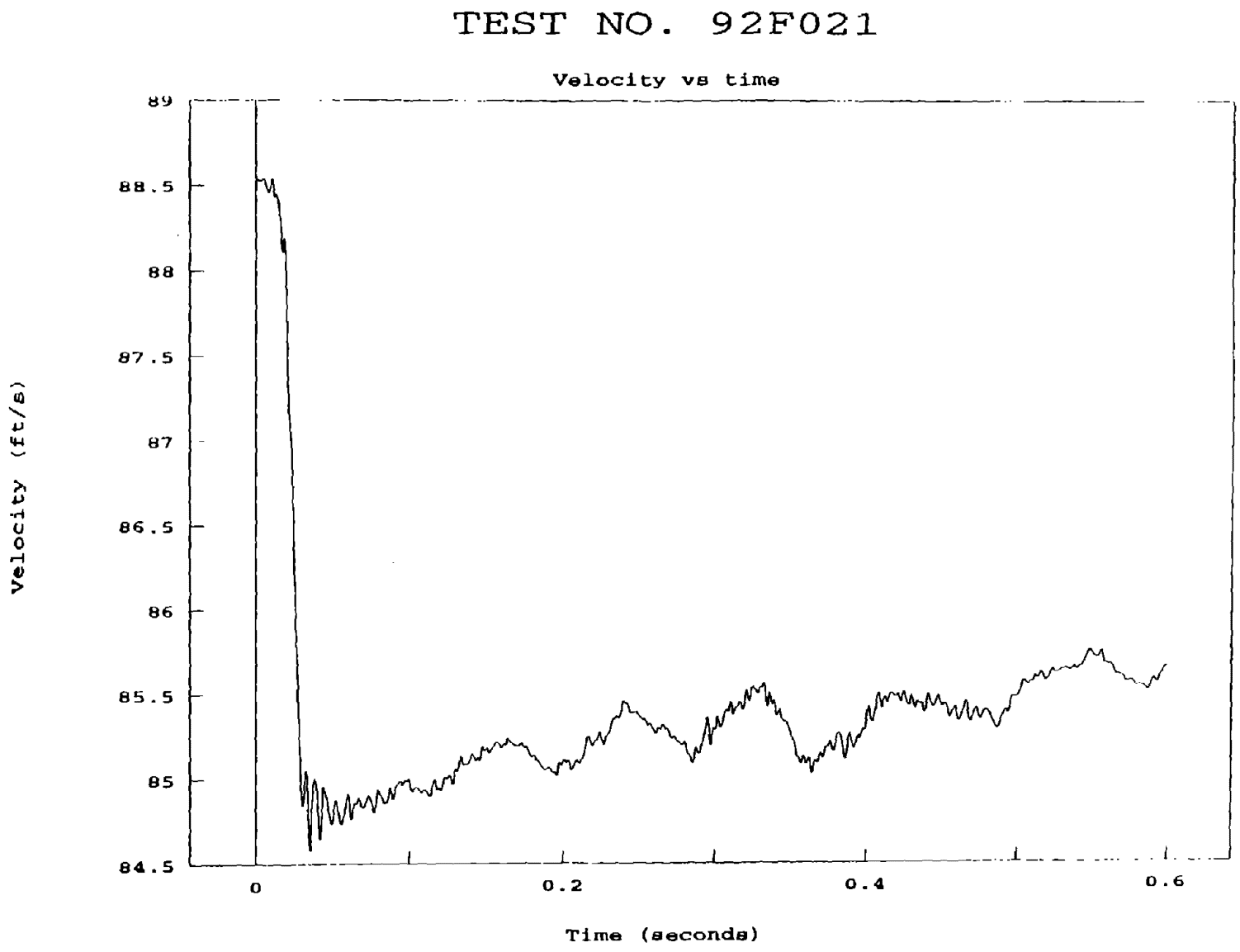
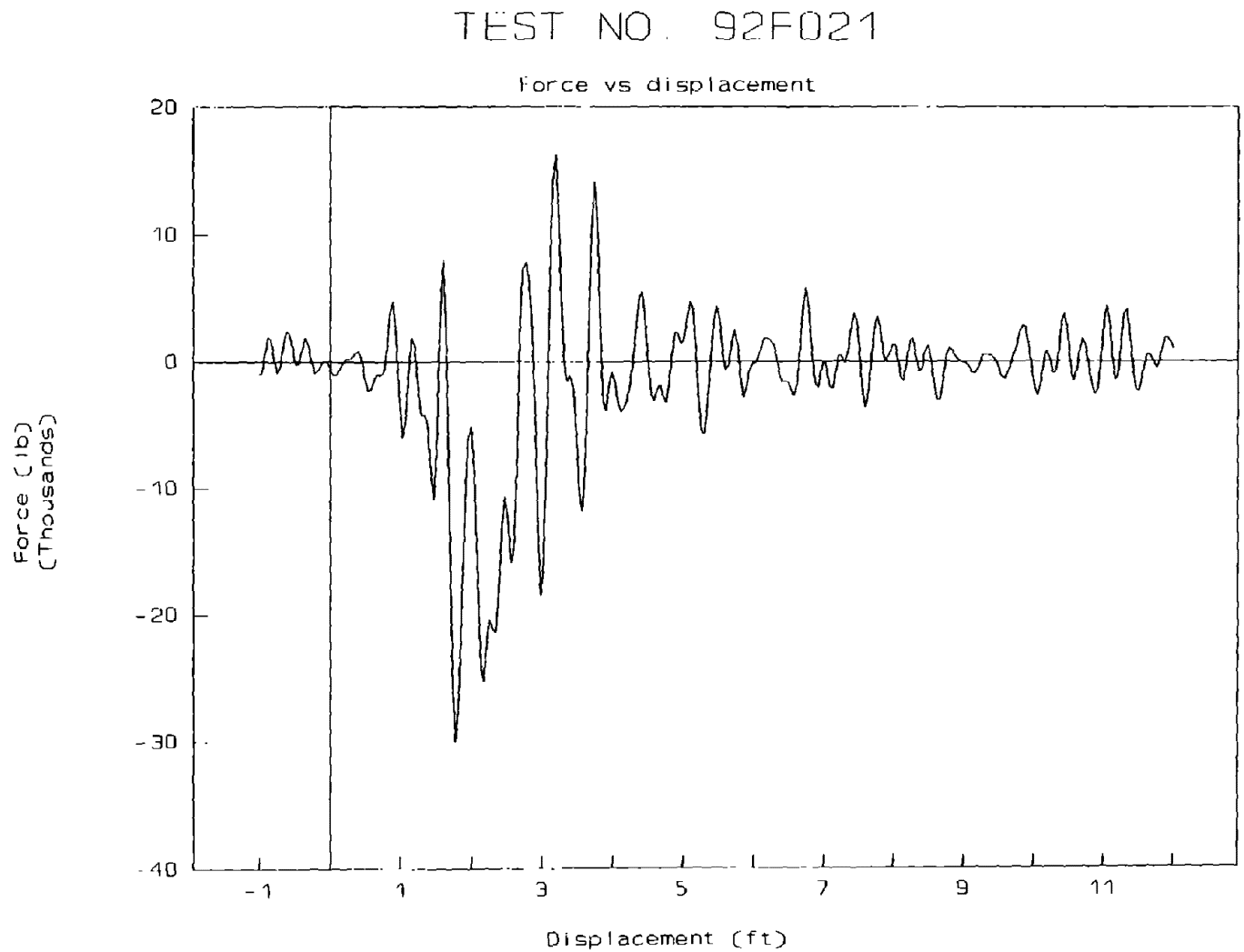


Figure 17. Acceleration versus time, X-axis, test 92F021.



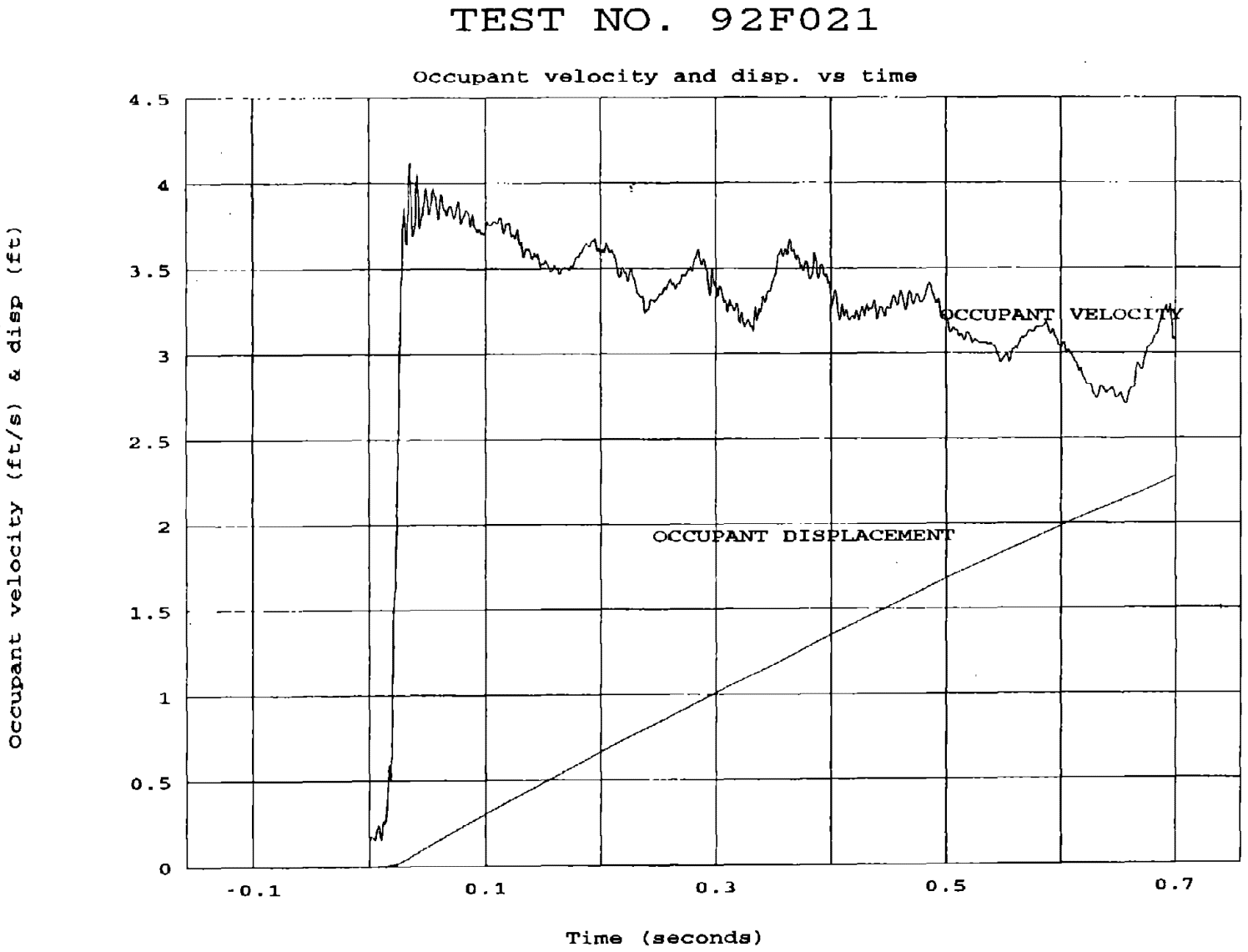
1 ft = 0.305 m

Figure 18. Velocity versus time, X-axis, test 92F021.



1 lbf = 4.45 N 1 ft = 0.305 m

Figure 19. Force versus displacement, X-axis, test 92F021.



1 ft = 0.305 m

Figure 20. Occupant velocity and relative displacement versus time, X-axis, test 92F021.

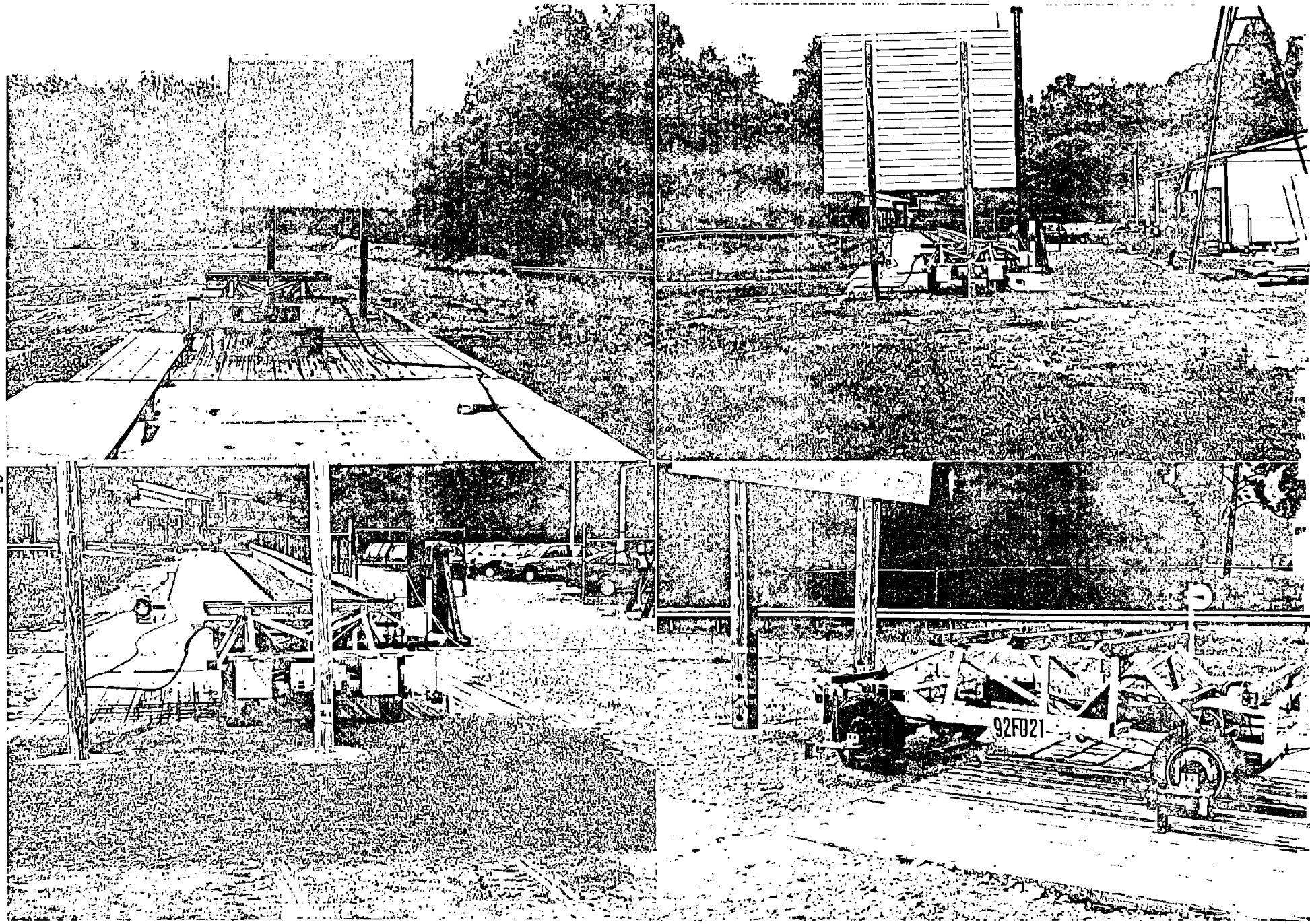


Figure 21. Pretest photographs of test 92F021.

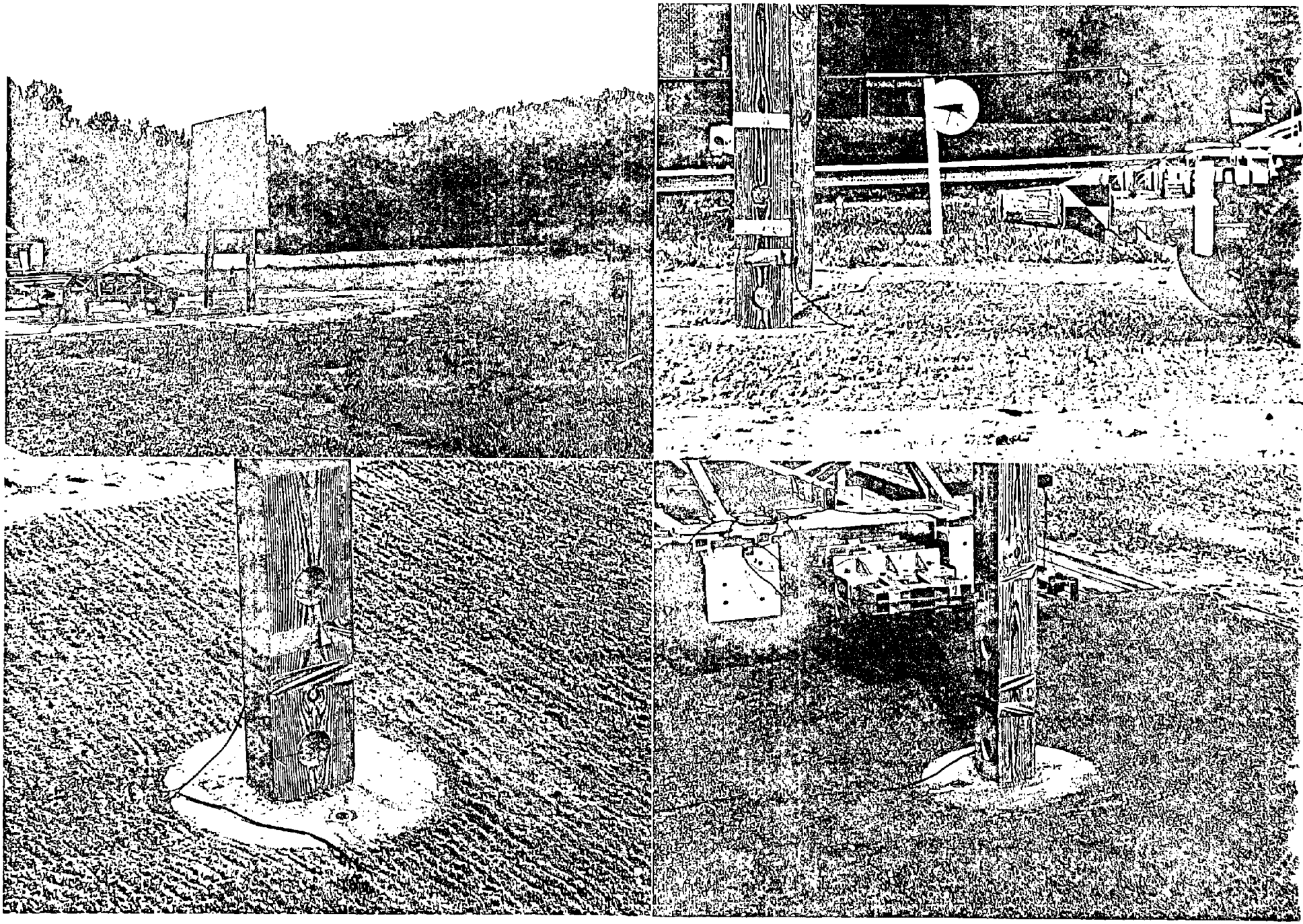


Figure 22. Additional pretest photographs of test 92FO21.

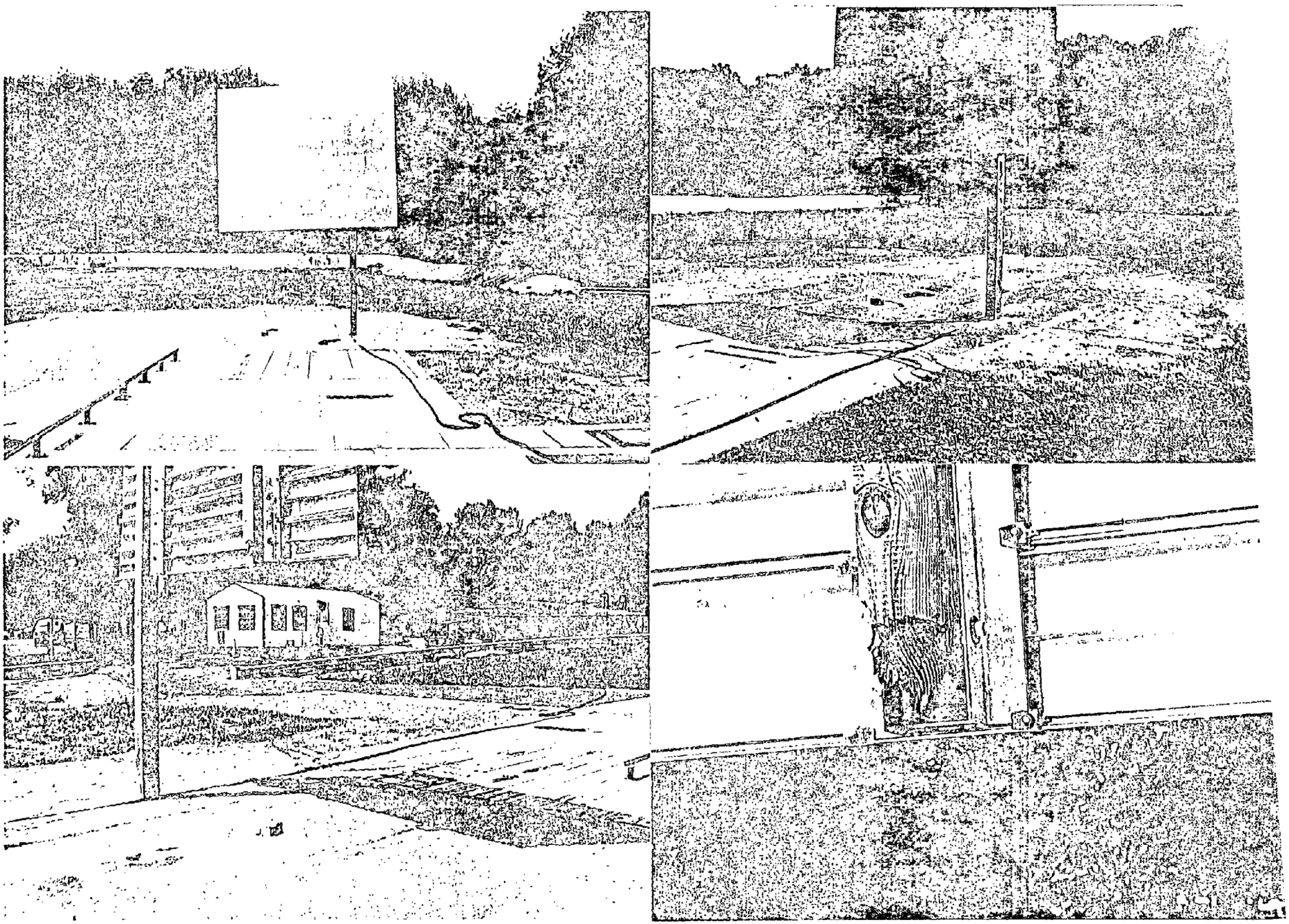


Figure 23. Post-test photographs of test parts

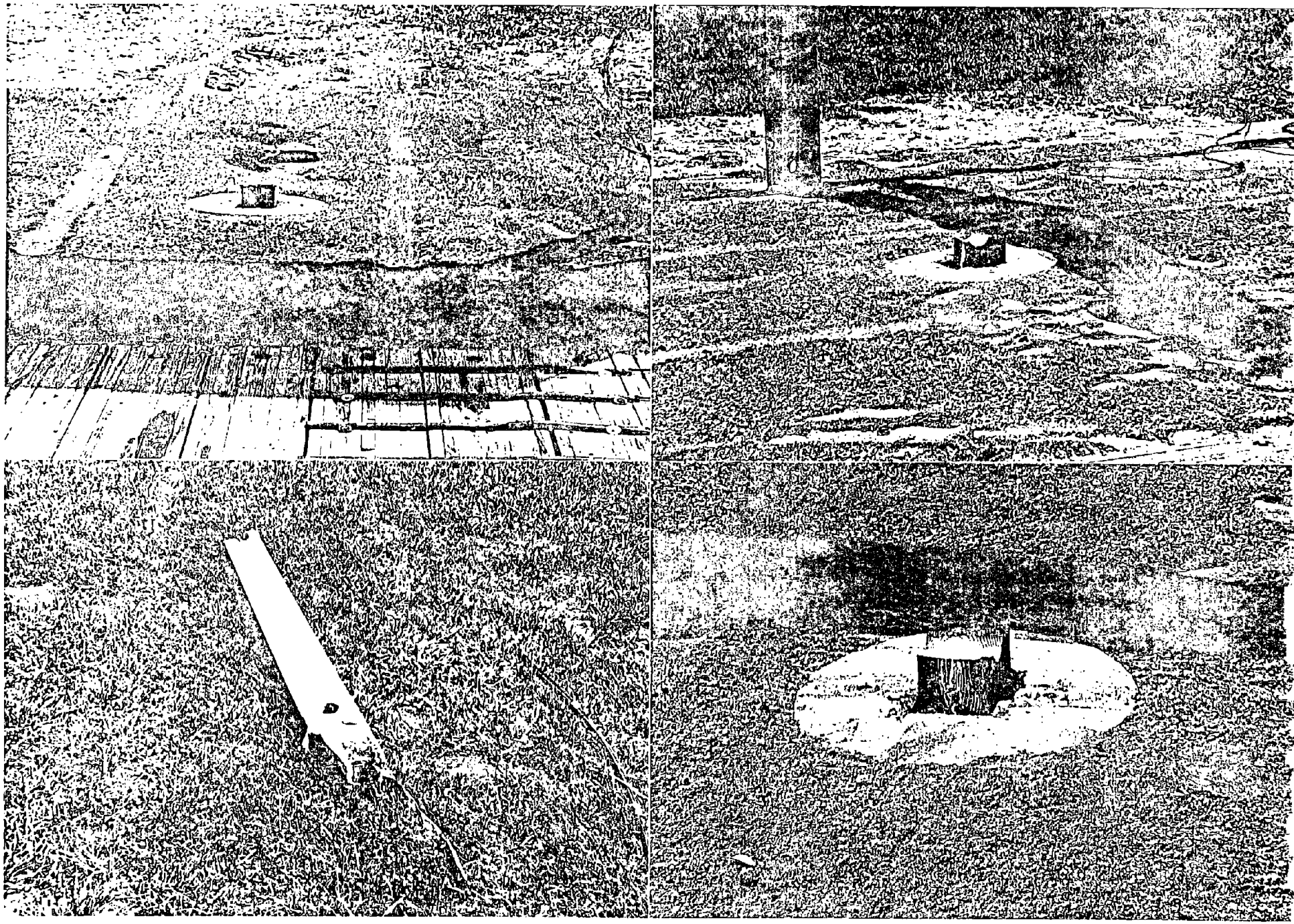


Figure 24. Additional post-test photographs of test 92F021.

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.

(2) Charles R. Hott, Christopher M. Brown, Nick Totani and Allen G. Hansen, *Crush Characteristics of the "Breakaway" Bogie*, Report No. FHWA-RD-89-107, Federal Highway Administration, Washington, DC, July 1990.