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Testing of Small and Large Sign Support Systems FOIL Test Number: 92F016

U.S. Department of Transportation
Federal Highway Administration

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

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		
in²	square inches	645.2	square millimeters	mm²
ft²	square feet	0.093	square meters	m²
yd²	square yards	0.836	square meters	m²
ac	acres	0.405	hectares	ha
mi²	square miles	2.59	square kilometers	km²
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	l
ft³	cubic feet	0.028	cubic meters	m³
yd³	cubic yards	0.765	cubic meters	m³
NOTE: Volumes greater than 1000 l shall be shown in m³.				
		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/m²	cd/m²
		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		
mm²	square millimeters	0.0016	square inches	in²
m²	square meters	10.764	square feet	ft²
m²	square meters	1.195	square yards	ac
ha	hectares	2.47	acres	mi²
km²	square kilometers	0.386	square miles	
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
l	liters	0.264	gallons	gal
m³	cubic meters	35.71	cubic feet	ft³
m³	cubic meters	1.307	cubic yards	yd³
		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/m²	candela/m²	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 a crash test performed at the Federal Outdoor Impact Laboratory (FOIL) in McLean, Virginia. The test was performed on a small sign support system at 20 mi/h (8.9 m/s), test 92F016. The vehicle used for this test was the FOIL's reusable bogie vehicle. The purpose of this test was to evaluate the low speed safety performance of a wooden 5 inch (12.7 cm) diameter post 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 inches (102 mm), and that there can be no occupant compartment intrusion.

2. TEST MATRIX

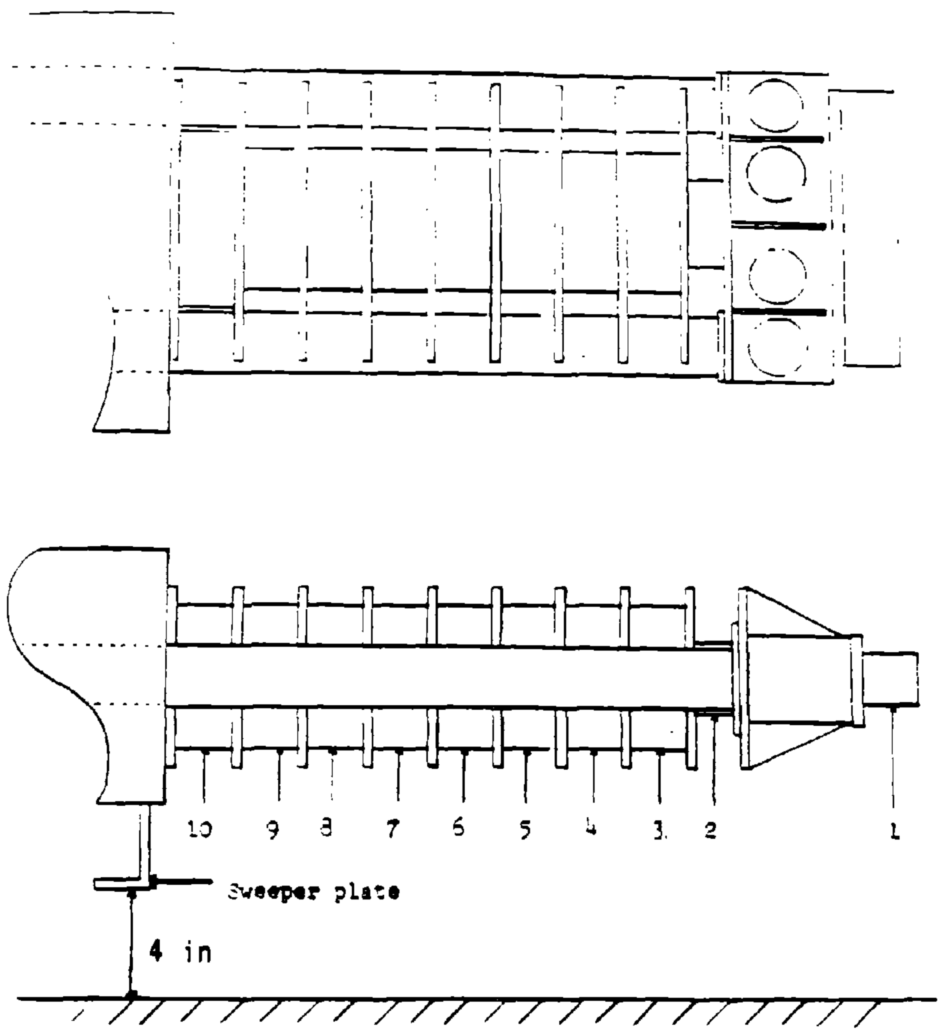
The test was performed on a small sign support system. The test speed was 20 mi/h (8.9 m/s). The sign was buried in NCHRP Report Number 230, S-2 weak soil[1]. A summary of the test conditions is presented in table 1.

Table 1. Test matrix.

Test Number	Test Vehicle	Test Weight (lb)	Test Speed (mi/h)	Test Article Description	Impact Location
92F016	FOIL bogie	1850	20	wood post in soilcrete	center

3. VEHICLE

The test vehicle was FOIL's 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 is a sketch of the 20 mi/h (8.9 m/s) honeycomb configuration used for test 92F016. A sweeper plate was attached to bogie vehicle such that it would hang down to a height of 4 inches above the ground. The sweeper plate was constructed of a section of steel angle welded to a quarter inch steel plate then attached to the bogie using two 3/8 inch (0.9 cm) 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 is to determine stub height compliance by the test article. Four wooden 6 foot (1.8 m) four by fours were attached to the bogie vehicle to 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 pounds (839 kg). The actual weight of the bogie was 1850 pounds (839 kg).



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 0.25 in thick.

1 in = 25.4 mm

Figure 1. Sketch of bogie honeycomb configuration.

4. SIGN SUPPORT

The sign support system consisted of one 5-in (0.127-m) diameter wood post 15 ft 6 in (4.7 m) long. The post dimension was taken from the tapered tip of the sign post. The actual diameter of the sign post at the impact height was 7.0 in (0.178-m). The wood post was made from pressure treated southern yellow pine. Two 2-in (51-mm) holes were drilled in the sign post, one at 6 in (152.4 mm) and one at 18 in (457.2 mm) above ground level. A gain was cut from 4-ft 3-in (1.3 m) above ground to the top of the post. The gain provided a flat area for sign panel attachment. The sign panel used was 1/8-in ((3-mm) thick aluminum sheet measuring 5 ft high by 4 ft (1.5 m by 1.2 m) wide. Three feet six inches (1.1 m) of the sign post was cast in an 18-in (0.457-m) diameter soilcrete foundation. The soilcrete foundation was embedded 3 ft 6 in (1.1 m) deep in NCHRP Report 230 S-2 weak soil (sand). Soilcrete is a mixture of 9 parts native soil and one part portland cement. Because the test was performed in weak soil (sand), sand was used as the native soil. The sign panel was installed 7 ft (2.1 m) above ground. The whole sign support system was assembled and a hole was dug in the weak soil. An 18-in (0.457-m) form was placed in the hole and the sign post was inserted in the form. A 12-in (0.305-m) long 2 by 4 was nailed to the base of the sign post to inhibit the sign post from rotating inside the soilcrete. The soilcrete mixture was placed inside the form in 6-in (0.152-m) lifts and compacted simultaneously with the hole in the weak soil being backfilled in 6-in (0.152-mm) lifts and compacted until the final grade was reached. Figure 2 is a drawing of the sign support system.

5. TEST RESULTS - 20 MI/H (8.9 M/S), TEST 92F016

The test vehicle was accelerated to 21.2 mi/h (31.1 ft/s (9.5 m/s)) prior to impacting the sign support. The centerline of the bogie vehicle was aligned with the centerline of the wood sign post.

The honeycomb nose made contact with the sign leg and began to collapse. The nose made contact 17.5 in (0.444 m) above ground on the upper hole. The wood post began to fracture at the lower hole 0.028 s in the impact event. The post begins to fracture vertically below the lower hole. 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 0.036 s after initial contact between the bogie and the sign post. The wood post did not fracture at the upper hole. The failure mechanism was fracture at the lower hole. The bogie vehicle continued forward and rotated the sign upwards. A second impact occurs between the bogie vehicle's sweeper plate and the remaining 6 in (0.152 m) of sign post protruding from the soilcrete foundation. The contact occurred 0.170 s after the initial contact. The sweeper plate continued to contact the stub for 0.044 s. A third impact occurred when the sign post and panel fell on top of the bogie vehicle. The sign fell on the protective 4 by 4's and did not cause further damage to the bogie. The contact between the sign post (and sign panel) and the bogie vehicle was not significant enough to cause occupant compartment intrusion during a full scale vehicle crash test. The sign post and panel remained on top of the bogie vehicle. The sign panel was in good condition after the test.

Damage to the bogie vehicle consisted of crushed honeycomb. The damage was to expendable material and not to structural members of the bogie. The measured honeycomb crush after the test was recorded to be 8.7 in (0.221 m).

The sweeper plate was bent from contact with the sign stub. None of the sign components would have impaled an actual automobile's occupant compartment.

Damage to the sign consisted of a fractured wooden sign post. The soilcrete foundation did not move during the crash test. The sign panel was in good condition after the test.

The occupant impact velocity using the 2-ft (0.6-m) flail space model outlined in NCHRP Report Number 230, was determined to be 5.3 ft/s (1.6 m/s). The occupant impact velocity was reached 0.442 s into the crash event. The 10-ms ridedown acceleration was determined to be 0.9 g's. The peak force (300 Hz data) for the impact event was 10.3 g's (19.1 kips (85 kN)). The sign post remained in contact with the bogie vehicle for the duration of the test. The vehicle change in velocity was calculated to be 7.2 ft/s (2.2 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.

6. CONCLUSION

The results indicate that the small sign support system meets all of the applicable criteria for the low-speed test in weak soil. There was no occupant compartment intrusion and the occupant impact velocity was 5.3 ft/s (1.6 m/s) which is less than or equal to the 16 ft/s (4.9 m/s) limit specified by the FHWA. The stub remaining after the test was 6 in (0.152 m) which is higher than the 4-in (0.102-m) limit specified by the FHWA. However, the design of the sign support had changed before this test was conducted and was not incorporated in this installation. The change was to lower the 6-in (0.152-m) hole to 4 in (0.102 m) above ground. Because the lower hole is the primary failure mechanism for the sign support and is the location where breakaway occurred during test 92F016, the sign post would have passed the stub height criteria given the correct height of 4 in (0.102 m) for the lower hole.

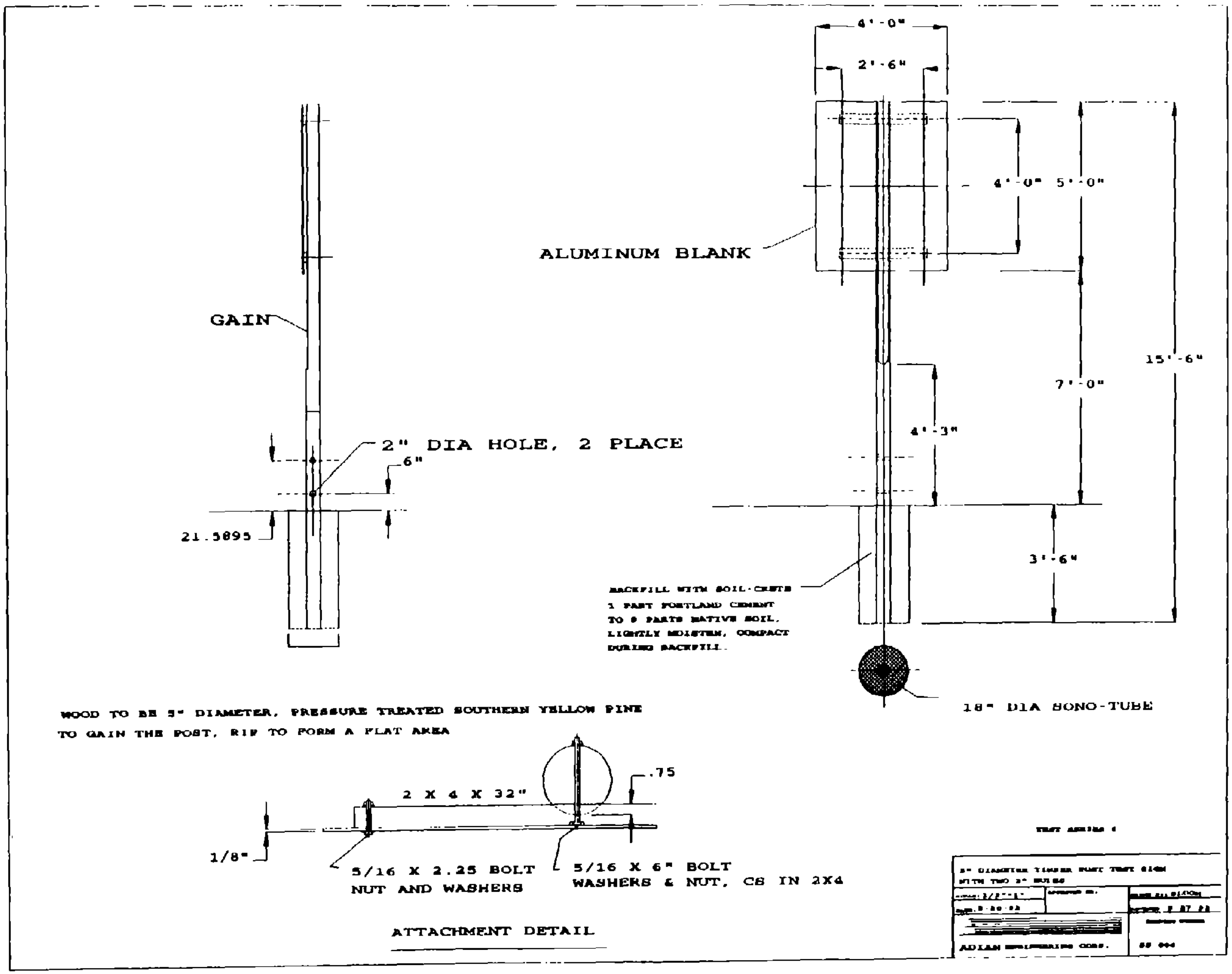


Figure 2. Sketch of small sign support.

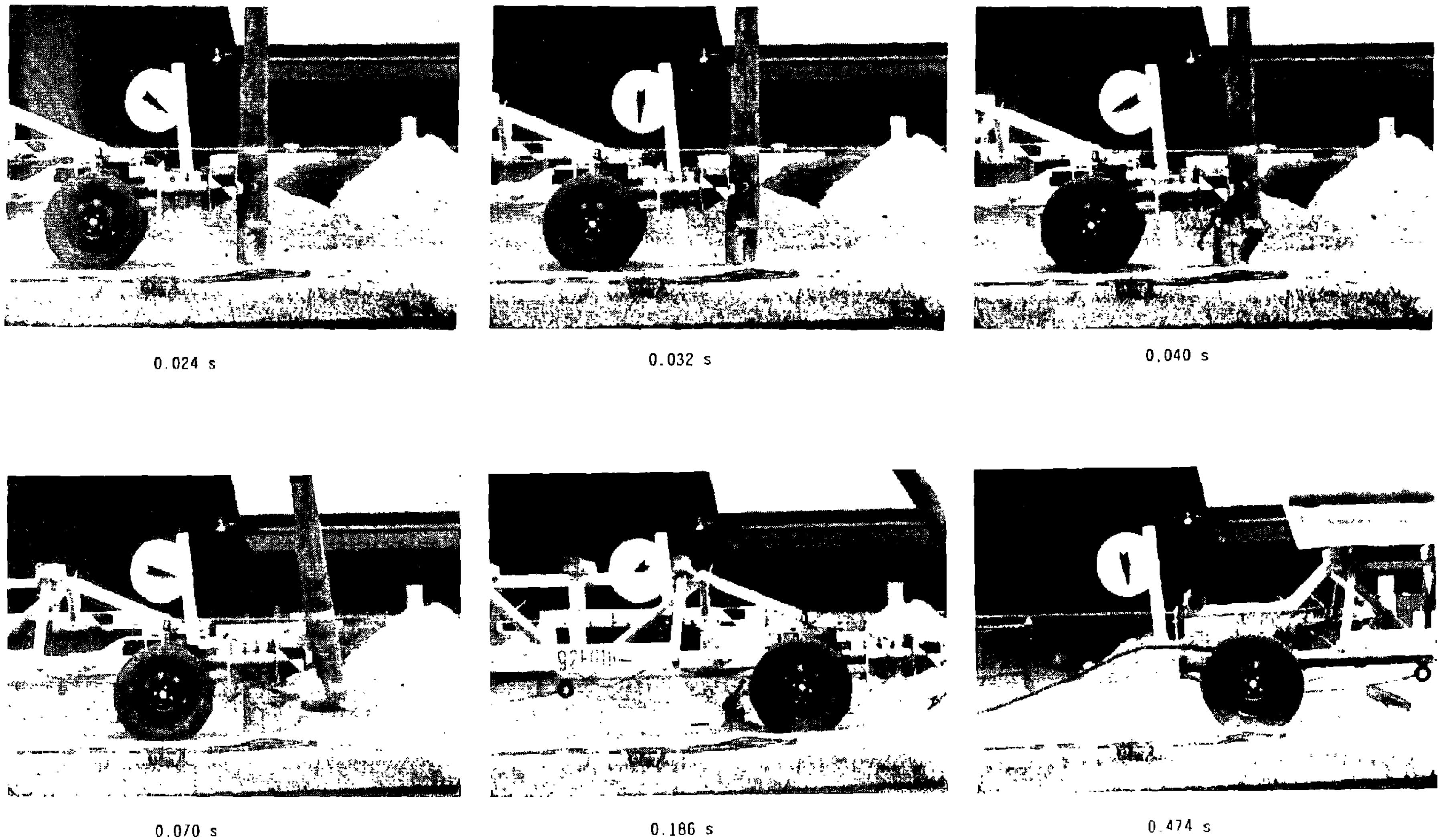
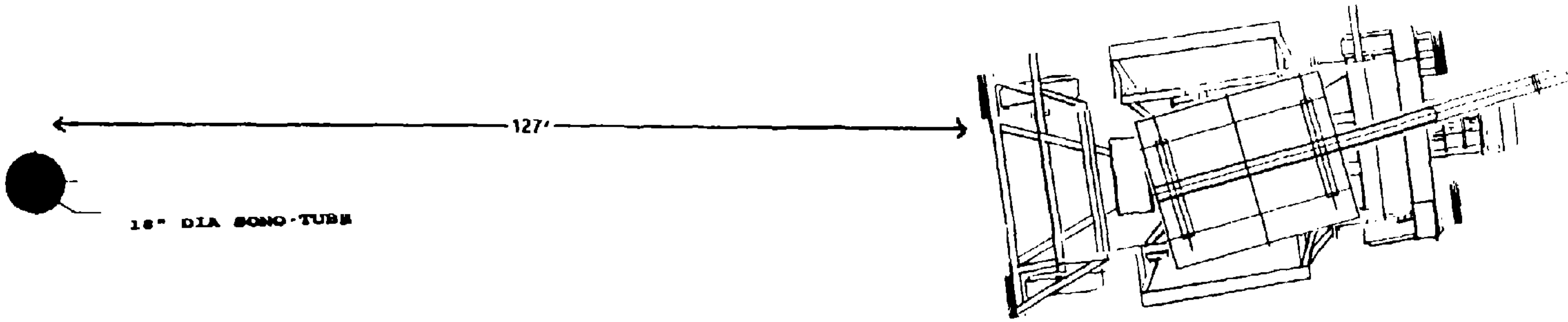


Figure 3. Test photographs during impact, test 92F016.



Test number.. 92F016

Date.. June 23, 1992

Test vehicle....................................FOIL Bogie

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

Test article...............................Small Sign Support

Material................................5 inch diameter wood
1-Leg, 1-Hit

Embedment depth..................................3.5 feet

Panel type......................4 foot by 5 foot alum. sheet

Height..12 feet

Foundation......18 inch dia. soilcrete footer in S-2 Weak Soil

Impact speed..............................31.1 ft/s (9.5 m/s)

Impact angle..0 degrees

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

Vehicle analysis:	Observed	Design/Limit
Longitudinal:		
Occupant Delta V at 2 ft	5.3 ft/s	≤16 ft/s
Ridedown Acceleration	0.9 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..................................2.6 g's
Lateral..NA

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

Honeycomb crush................................8.7 inches

Vehicle velocity change..........................7.2 ft/s

Exit angle......................................0 degrees

Figure 4. Summary of test 92F016.

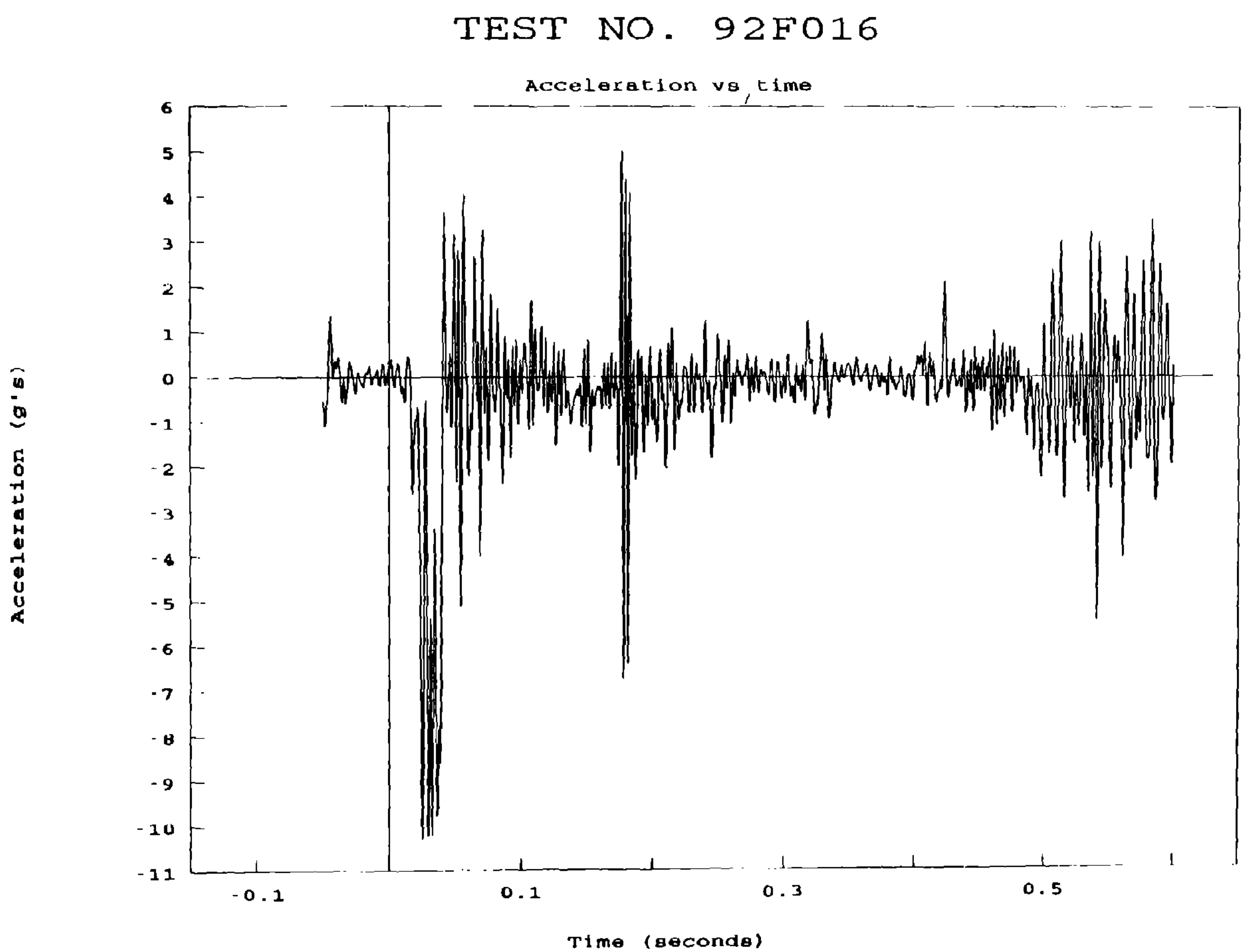


Figure 5. Acceleration versus time, X-axis, test 92F016.

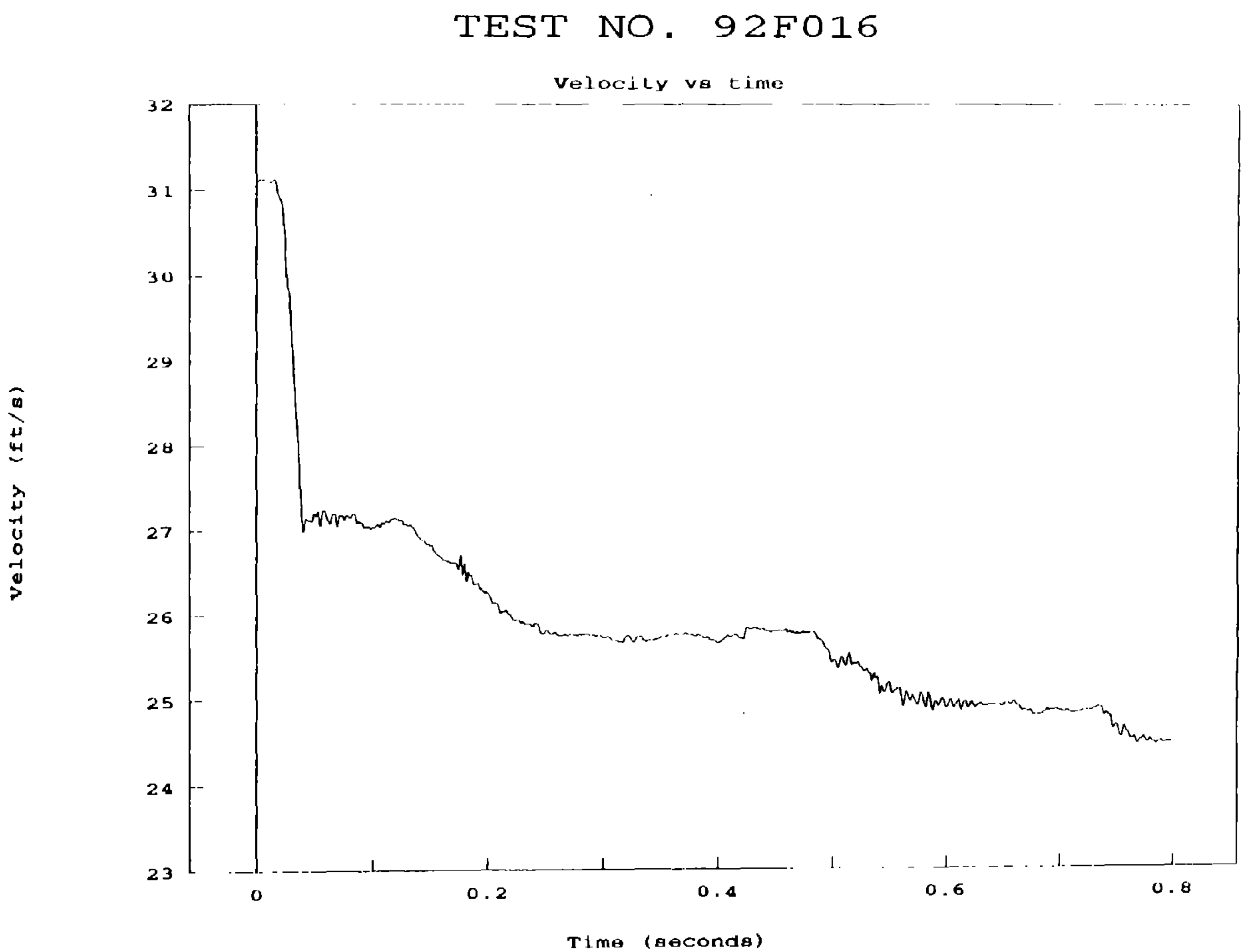


Figure 6. Velocity versus time, X-axis, test 92F016.

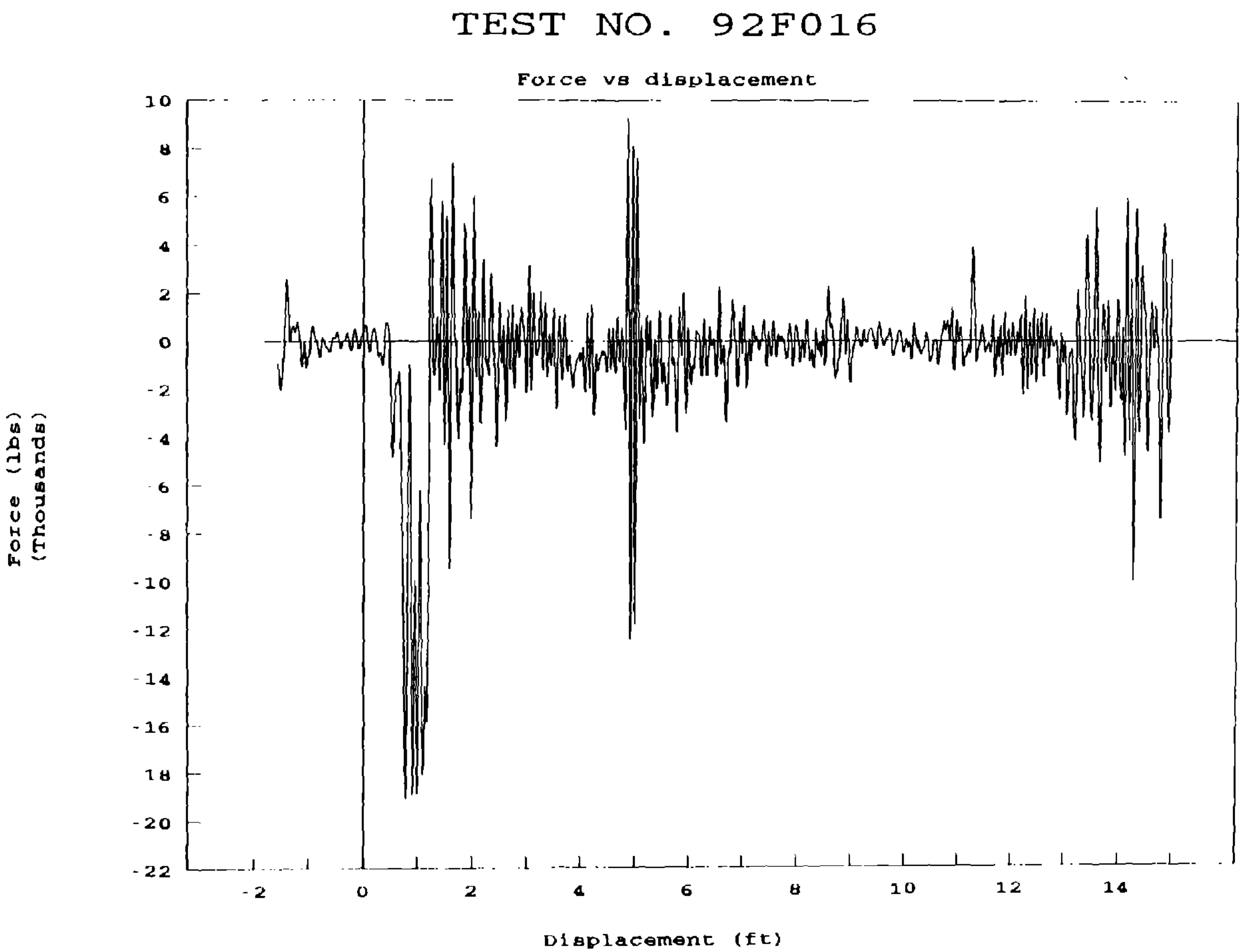


Figure 7. Force versus displacement, X-axis, test 92F016.

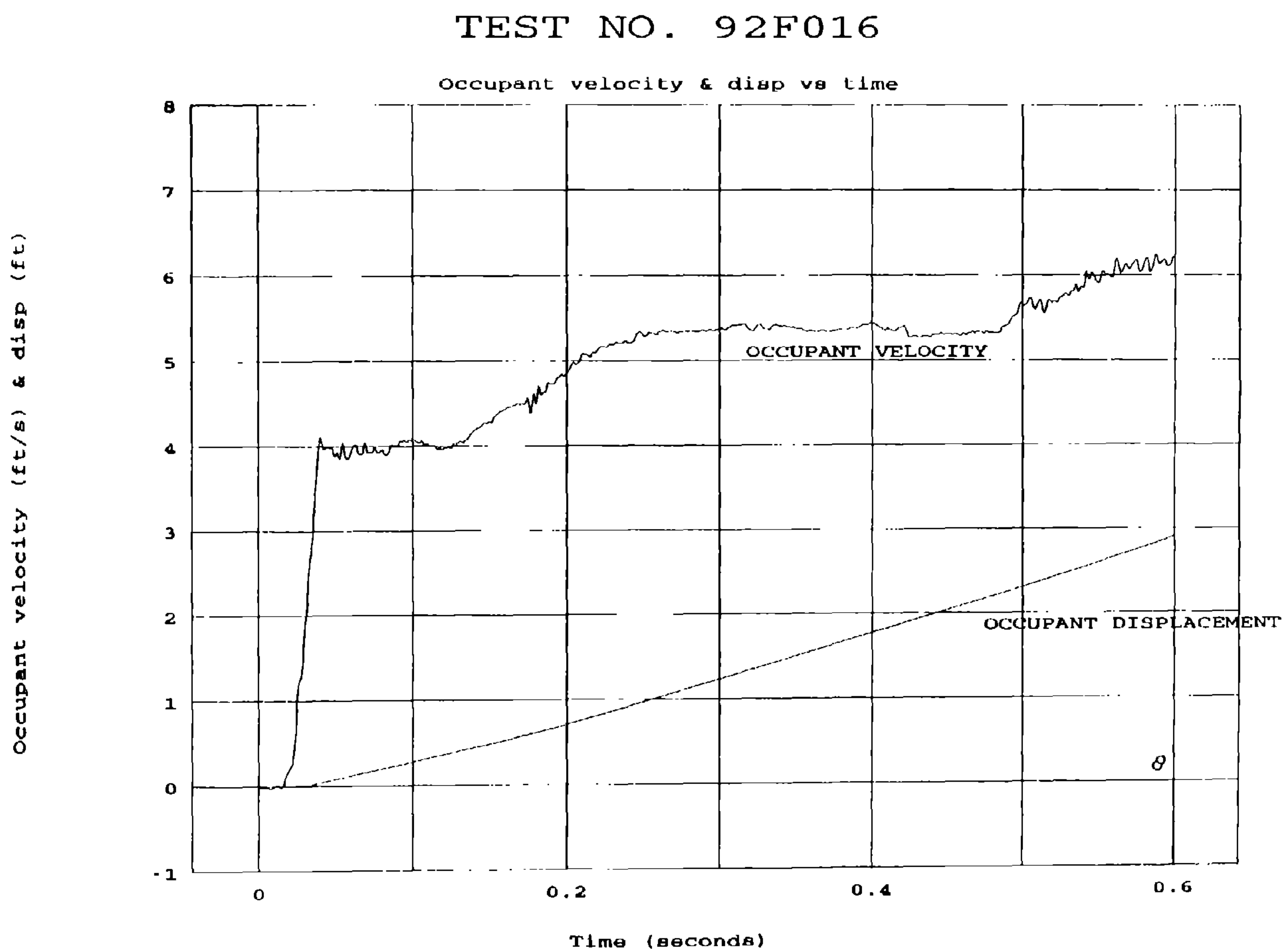


Figure 8. Occupant velocity and relative displacement versus time, X-axis, test 92F016.

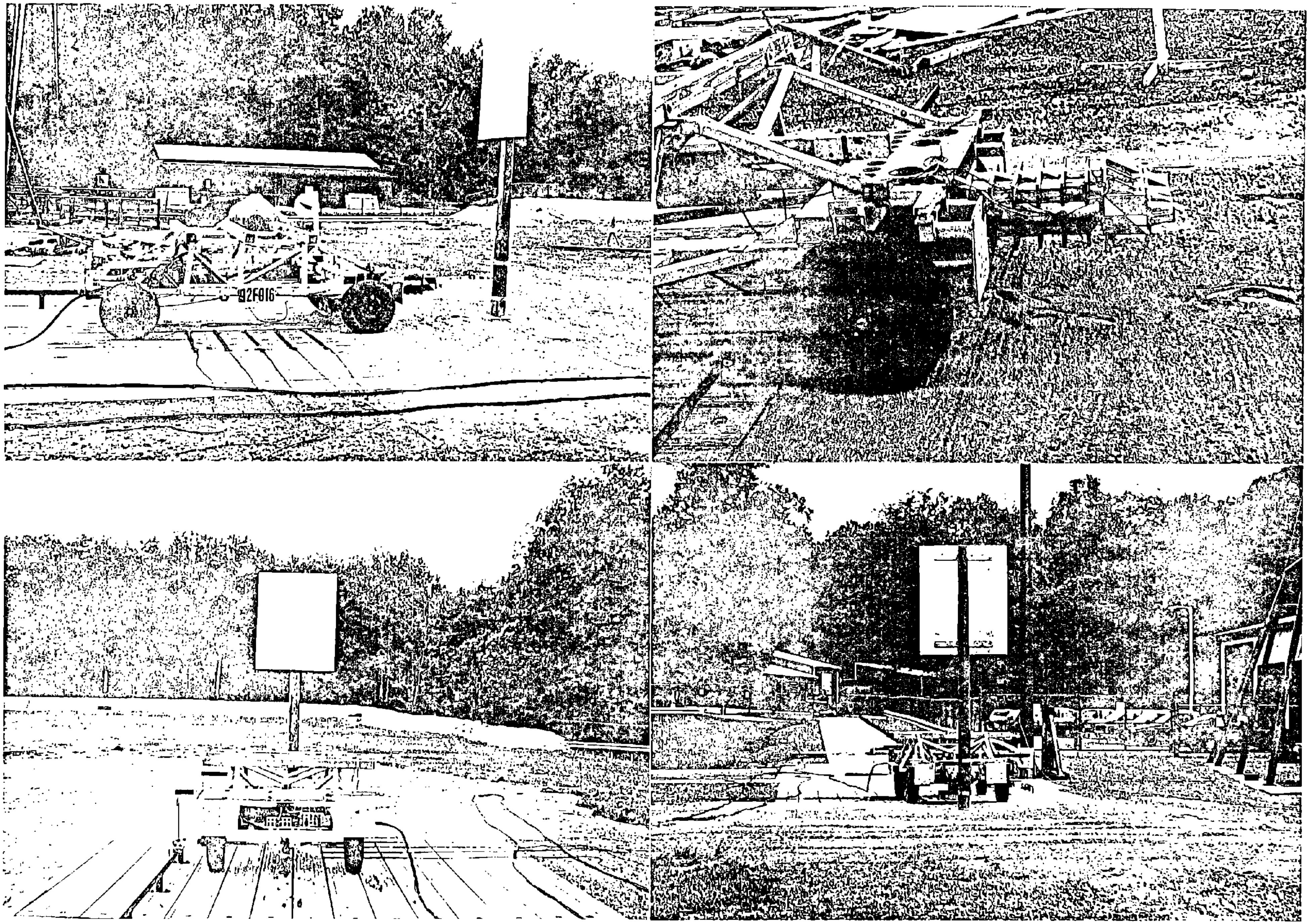


Figure 9. Pretest photographs of test 92F016.

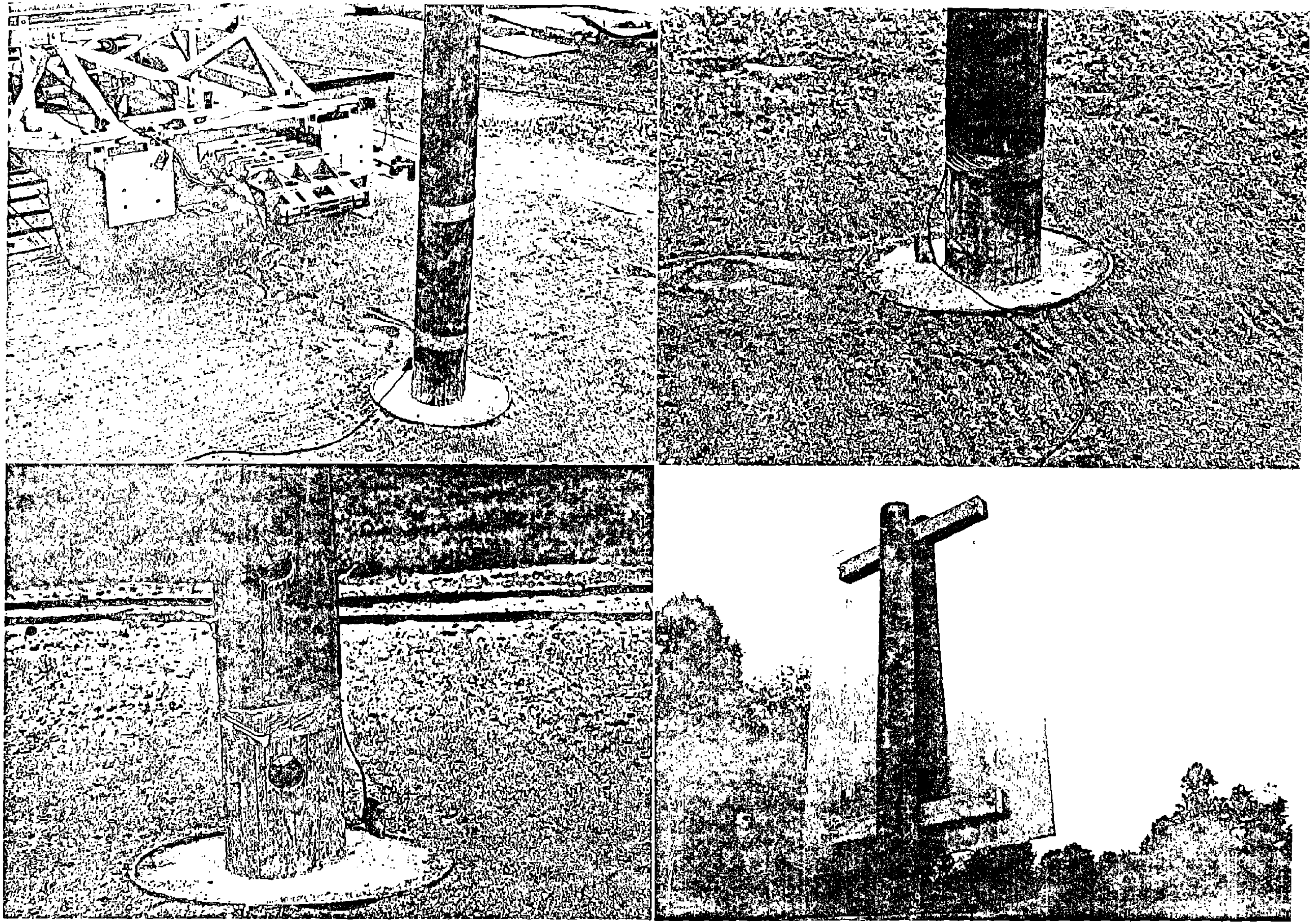


Figure 10. Additional pretest photographs of test 92F016.

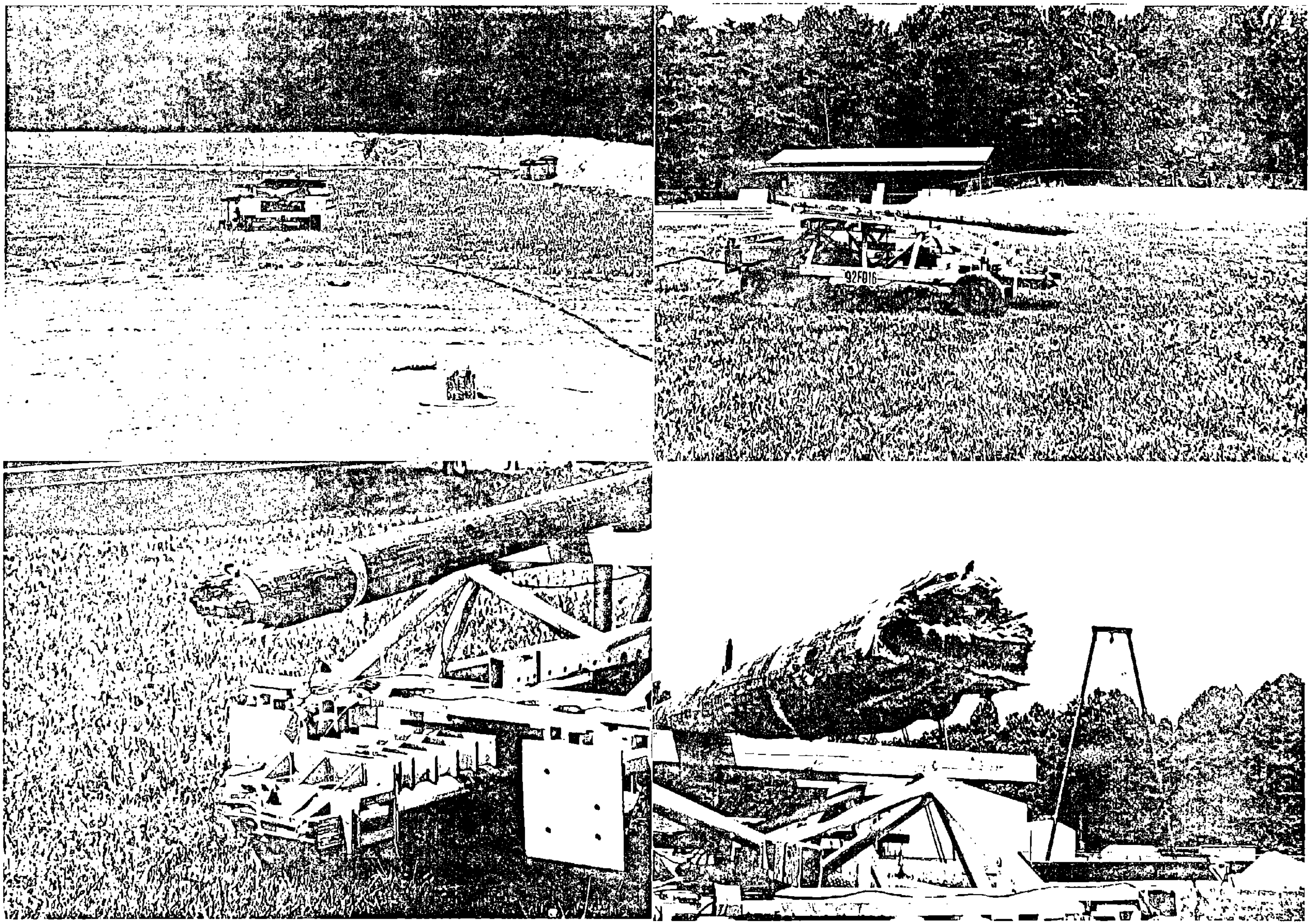


Figure 11. Post-test photographs of test 92F016.

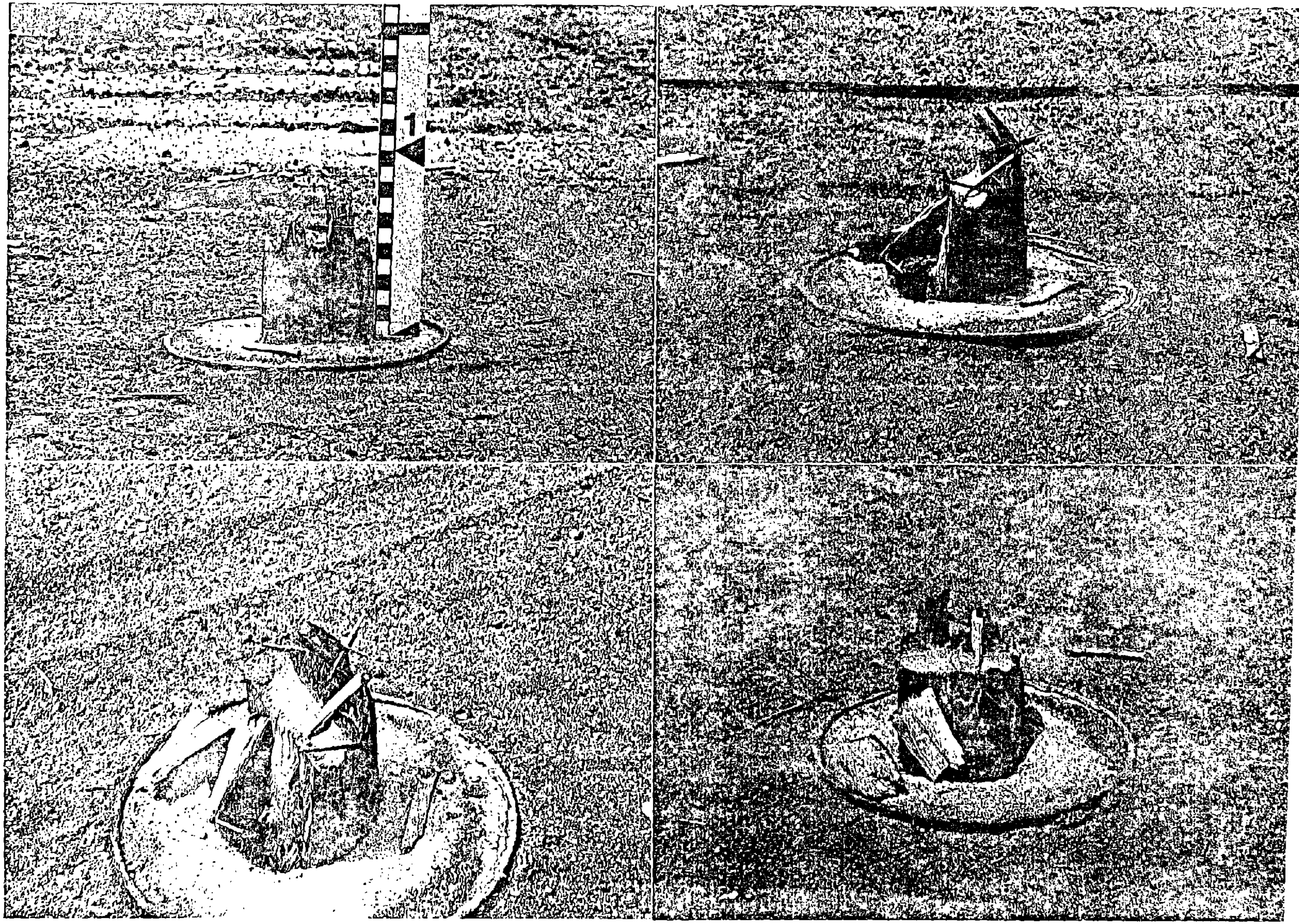


Figure 12. Additional post-test photographs of test 92F016.

8. REFERENCES

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

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

Technical Report Documentation Page

1. Report No.	2.	3. Rec
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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 a crash test performed at the Federal Outdoor Impact Laboratory (FOIL) in McLean, Virginia. The test was performed on a small sign support system at 20 mi/h (8.9 m/s), test 92F016. The vehicle used for these test was the FOIL breakaway bogie. The purpose of this test was to evaluate the low-speed safety performance of a single post sign support with a soilcrete foundation in weak soil. The post was made from a single 5-in (127-mm) diameter timber with two 2-in (51-mm) holes. Soilcrete consists of nine parts native soil mixed with one part cement. Because the sign post was tested in weak soil, sand was used as the native 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 (102 mm), and that there can be no occupant compartment intrusion. The test results indicate that the single wood timber sign support in a soilcrete foundation in weak soil meets all of the applicable performance criteria for roadside safety appurtenances specified by the FHWA.

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

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