FULL-SCALE VEHICLE CRASH TESTS
on
NEBRASKA RURAL MAILBOX DESIGNS

by

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ABSTRACT

The Nebraska Department of Roads, in conjunction with the Federal Highway Administration, have developed a new mailbox support system which could be used to accommodate a wide range of mailbox sizes. To be considered a safe appurtenance, the system had to be subjected to full-scale crash tests, as provided by "Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances," National Cooperative Highway Research Program Report 230, Transportation Research Board, March, 1981. The major concern was to find whether the support system would keep the mailbox attached to the post, not allowing for detached elements to penetrate the passenger compartment.

Four full-scale crash tests were conducted with an 1800-lb vehicle. Two tests, with the post embedded in weak soil, were performed at 20 mph and 60 mph, respectively. Two tests, with the post embedded in strong soil, were conducted at 20 mph and 60 mph, respectively. Three of the tests used a mailbox support system which held two mailboxes (size 1-A). One test used a system which supported one mailbox (size 2).

After analyzing the results of the crash tests, it was evident that all of the performance criteria had been met. The major criteria evaluated were: change in velocity, maximum 0.010 sec average deceleration, whether the mailbox support system kept the mailbox attached to post, and whether the vehicle remained stable and upright during and after the stages of impact.

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INTRODUCTION

Recent federal requirements have made it mandatory, that safe mailbox support systems be designed to yield or breakaway if struck by a vehicle. The Nebraska Department of Roads (NDOR), in cooperation with the Federal Highway Administration (FHWA), have developed a bracket for attaching the mailbox to the support post. The mounting bracket system, which attached the mailbox to the post, was designed so that it was adaptable to fit a wide range of mailbox sizes. In order to certify that the new attaching bracket was effective, it had to meet the criteria, as given by the National Cooperative Highway Research Program (NCHRP), for conducting full-scale crash tests (1). If it met those criteria, it could then be considered a safe mailbox support system and then become installed on the federal, state, and local highway systems.

It was decided that two mailbox support systems were to be tested. The systems were to be mounted to the Franklin Steel eze-erect sign posts, which had already been subjected to crash tests in the past (2)(3). Thus, it was known that the post itself had already met the criteria presented by recommended procedures (1). But now the major concern was whether the mailbox would remain attached to the post. The second concern was whether the mailbox or detached fragments would penetrate or show potential for penetrating the passenger compartment or present undue hazard to other traffic.

FULL-SCALE CRASH TEST DETAILS

TEST DESCRIPTION

Four full-scale crash tests were conducted on mailbox supports shown in Figures 1 and 2. Three of the tests used two mailboxes (size 1-A) mounted side by side. The fourth test used one mailbox (size 2) mounted to the post. Table 1 contains a summary of the test conditions.

Tests 1 and 2 were conducted in weak soil (S-2) and strong soil (S-1), respectively, at approximately 20 mph with the point of impact being at the quarter point of the bumper. Tests 3 and 4 were conducted in weak soil (S-2) and in strong soil (S-1), respectively, at approximately 60 mph with the impact point being at the center of the bumper.

According to the recommended test procedures, a weak soil (S-2) may be appropriate for breakaway/yielding supports. However, due to the variation of soil properties in Nebraska, it was decided that the strong soil (S-1) also be used for the crash tests. The strong soil consisted of a well-graded, crushed limestone, and the weak soil consisted of a fine aggregate meeting the requirements (ASTM C33-78). Two 10-feet long, 8-feet wide, by 5-feet deep pits were excavated and filled with strong soil (S-1) and weak soil (S-2), respectively.

The soil properties and compaction procedures at the test site met the guidelines given in the recommended procedures by NCHRP 230 (1). The strong and weak soils were placed and compacted in 6 to 12 in. layers using a hydraulic, vibrating

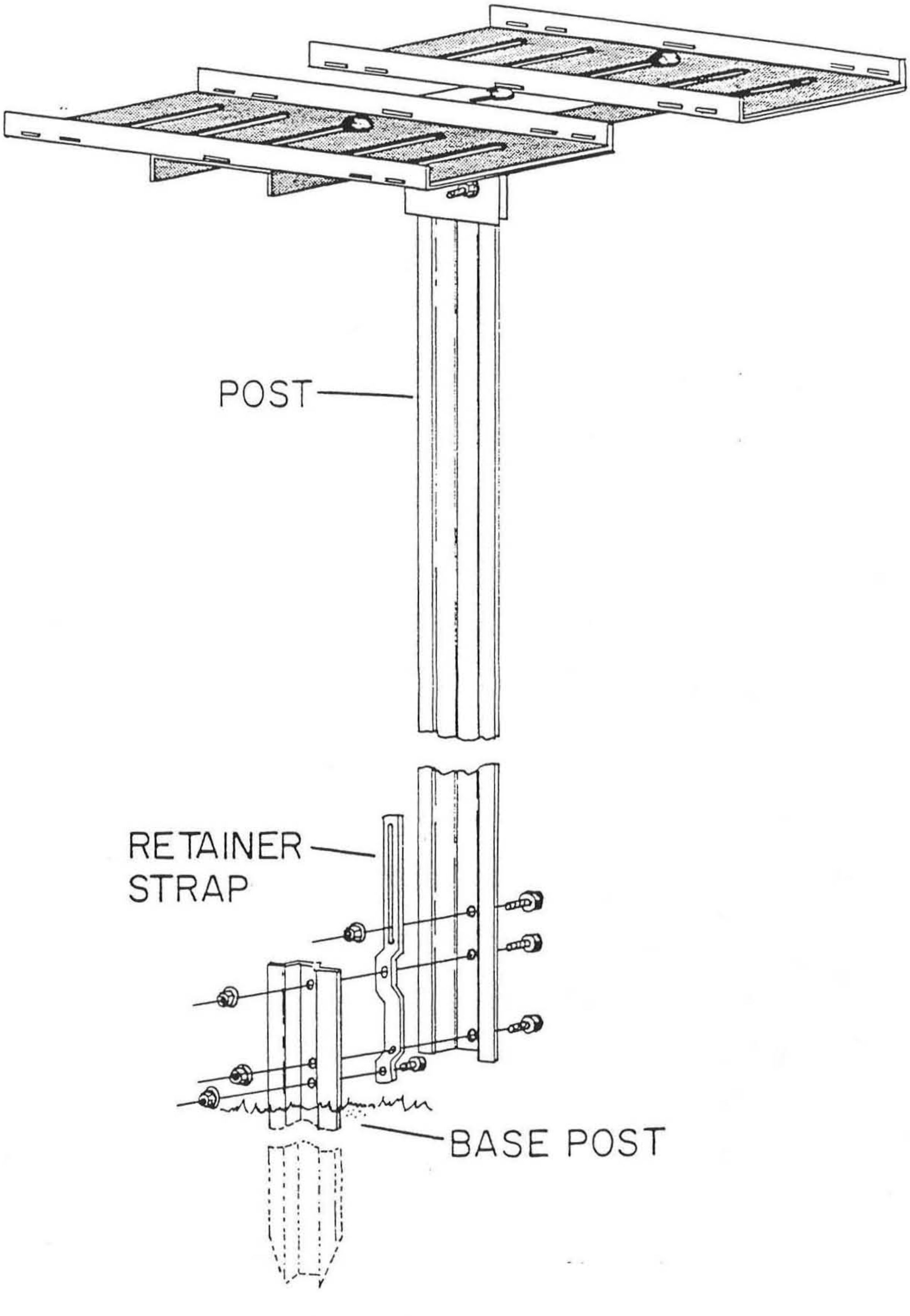


Figure 1. Double Mailbox Support System

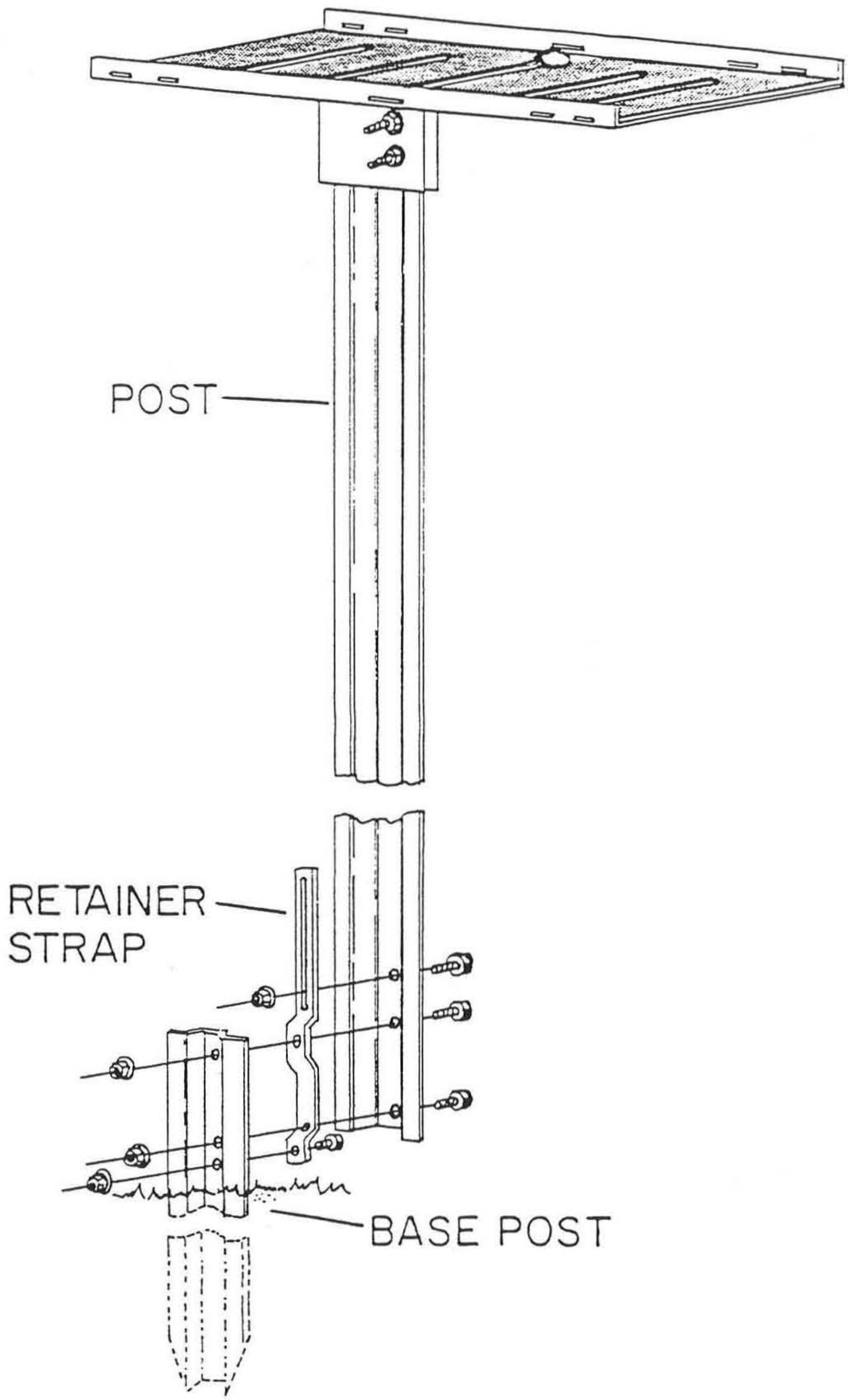


Figure 2. Single Mailbox Support System

TABLE 1. SUMMARY OF TEST CONDITIONS

TEST NO.	VEHICLE TYPE (lbs)	TARGET SPEED (mph)	SOIL TYPE	MAILBOX DESIGN	POST EMBEDMENT		POST SIZE (lbs/ft)	POINT OF IMPACT	TARGET IMPACT SEVERITY (ft-kips)
					DEPTH (in)	METHOD			
1	1800	20	Weak (S-2)	1-Post 2-Mailboxes (size 1-A)	37	Driven	2.0	14" to Right of Center	$24^{-3,+3}$
2	1800	20	Strong (S-1)	1-Post 2-Mailboxes (size 1-A)	37	Driven	2.0	14" to Right of Center	$24^{-3,+3}$
3	1800	60	Weak (S-2)	1-Post 2-Mailboxes (size 1-A)	37	Driven	2.0	Center of Bumper	$216^{-21,+37}$
4	1800	60	Strong (S-1)	1-Post 1-Mailbox (size 2)	37	Driven	2.0	Center of Bumper	$216^{-21,+37}$

tamper with a flat plate mounted onto a backhoe, as shown in Figure 3. The strong soil was compacted to an average density of 95% maximum dry density at an average moisture content of 10%. The results of the strong soil tests, conducted by Geotechnical Services, Inc., are presented in Appendix A. A Troxler Nuclear Density Gage, shown in Figure 4, was used to determine moisture content and compaction.

Figure 3. Photos Showing Placement of Strong Soil

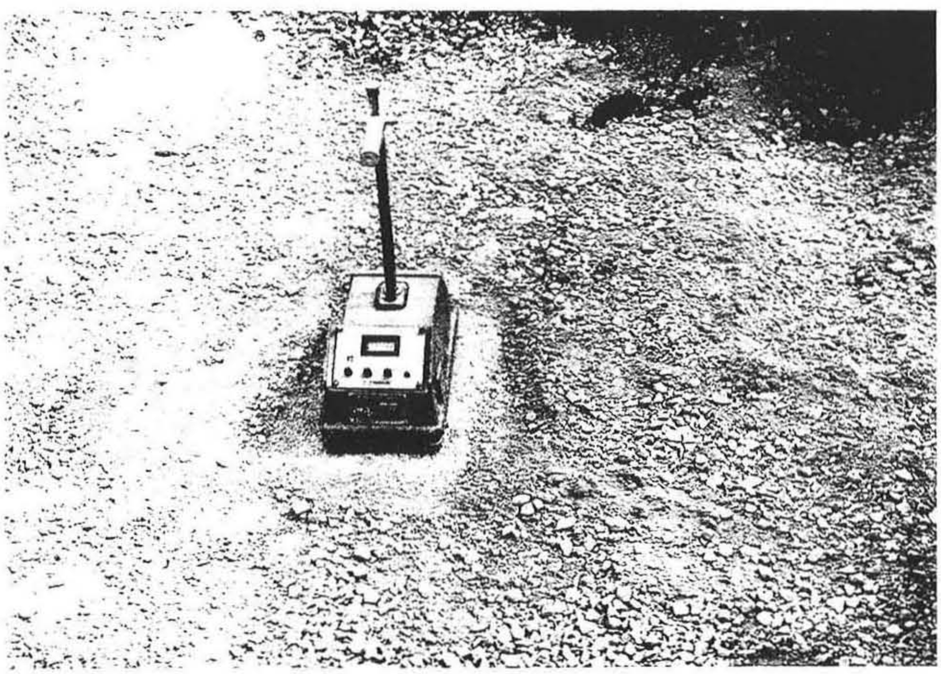


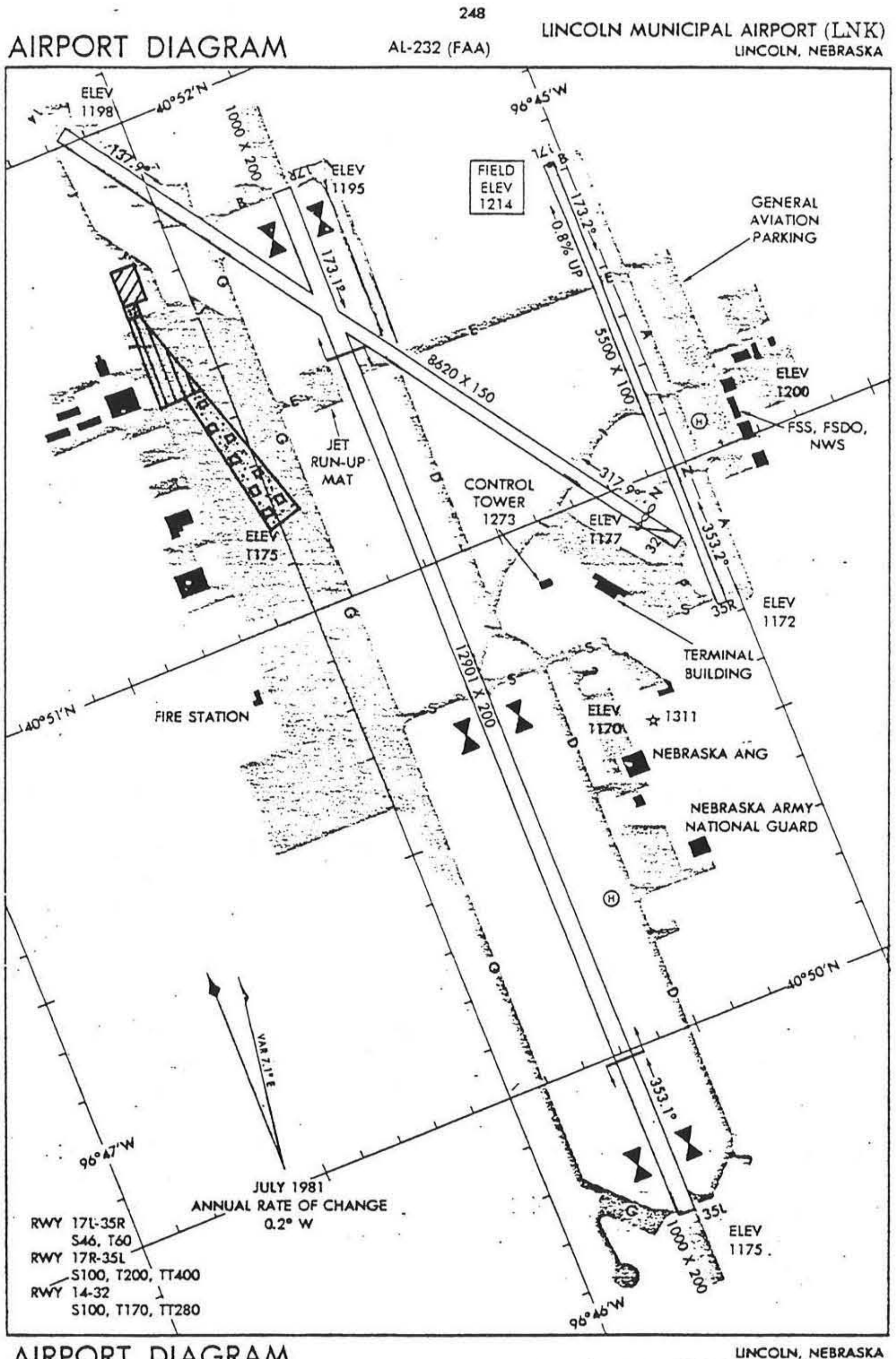
Figure 4. Photos Showing Compaction Testing

TEST FACILITY

The test site facility is located at Lincoln Air-Park on the NW corner of the west apron of the Lincoln Municipal Airport. The test facility, shown in Figure 5, is approximately 7 mi. NW of the University of Nebraska-Lincoln.

A reverse cable tow system, with a 1:2 mechanical advantage, was used to propel the test vehicle. Thus, the distance traveled and speed of the tow vehicle are one-half of that of the test vehicle. A sketch of the cable tow system is shown in Figure 6. The test vehicle was released from the tow cable approximately 6 feet before impact with the mailbox system. Photos of the tow vehicle with attached fifth-wheel are shown in Figure 7.

A vehicle guidance system, developed by Hinch (4), was used to steer the vehicle. Photos of the guidance system are also shown in Figure 7. The guide-flag, attached to the front-left wheel and guide cable, was sheared off approximately 6 feet before impact with the mailbox system. Photos of the sheared off guide-flag are shown in Figure 8. The 3/8 in. dia. guide cable, tensioned to 3,000 lbs., was supported laterally and vertically every 50 feet by stanchions. The hinged stanchions stood upright while holding up the guide cable. When the vehicle passed, the guide-flag struck each stanchion and knocked it to the ground. The vehicle guidance system was approximately 1,000 feet in length.



Zone	Zone Usage	Length (ft)
(vertical hatch)	Automobiles,Pickups,Etc.	1,000
(squares and dots)	Buses,Large Trucks,Etc.	3,000
(dots)	Hardware To Be Tested	200
(diagonal hatch)	Vehicle Runout Area	500

Figure 5 . Test Site Facility

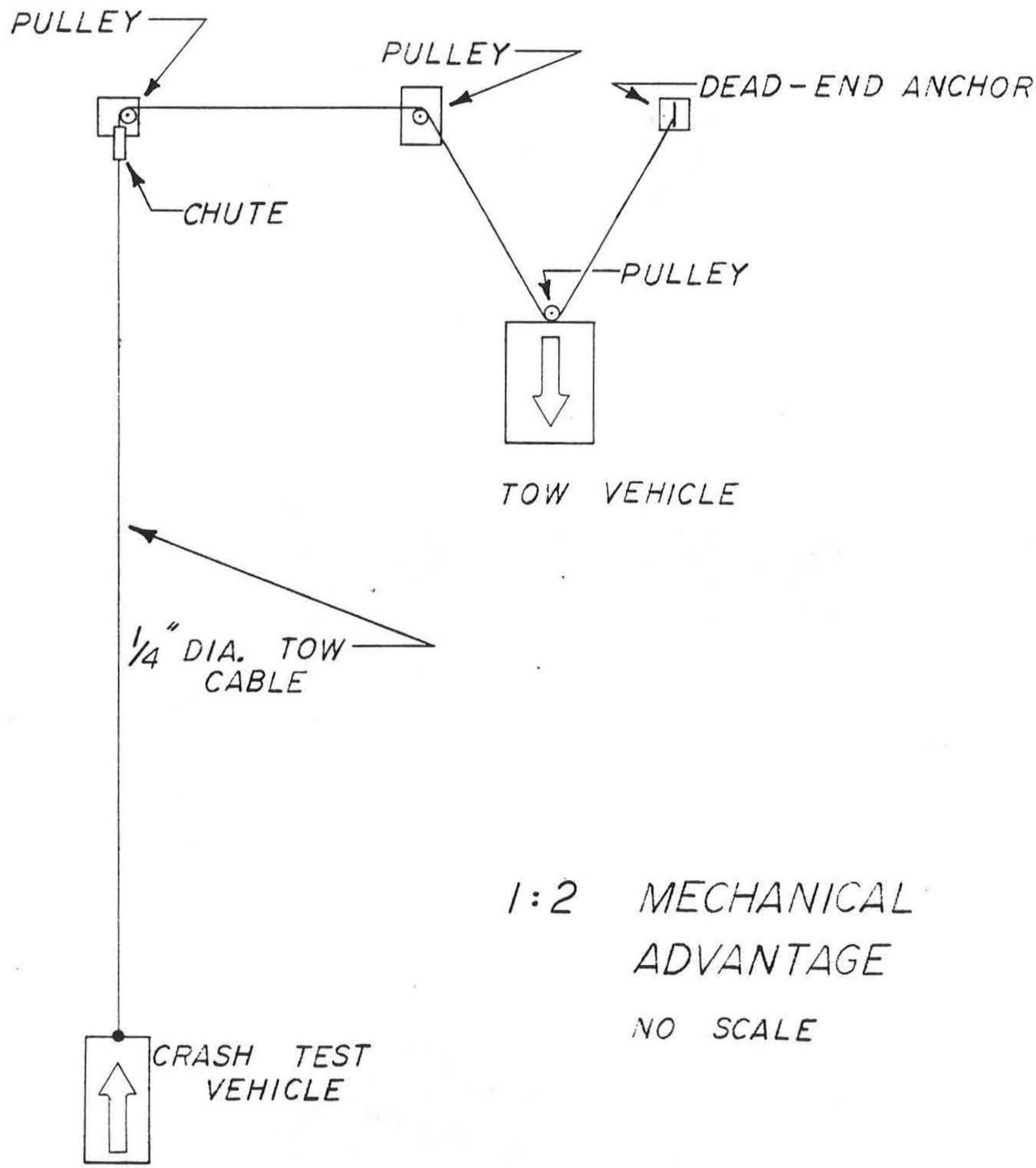


FIGURE 6. SKETCH OF CABLE TOW SYSTEM

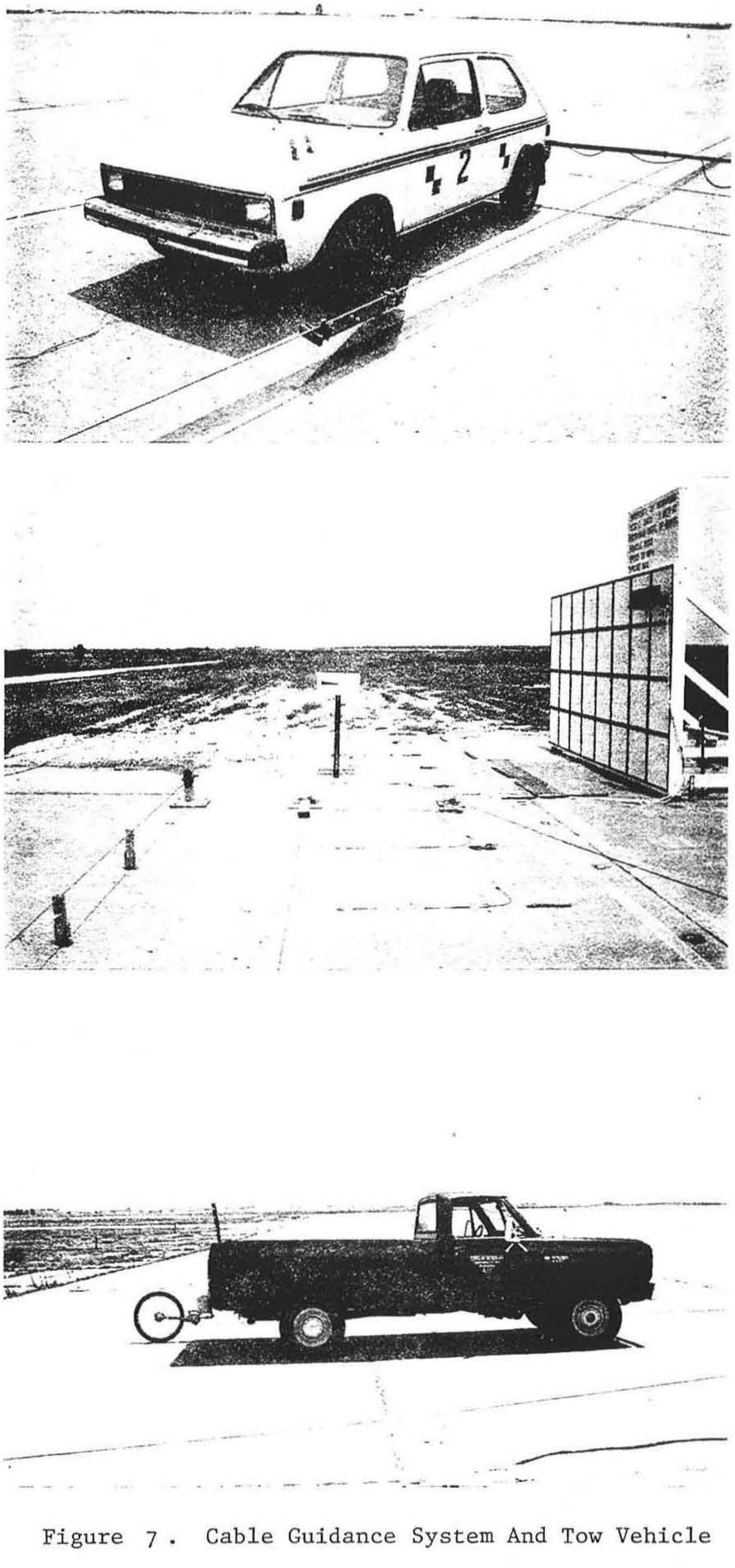


Figure 7. Cable Guidance System And Tow Vehicle

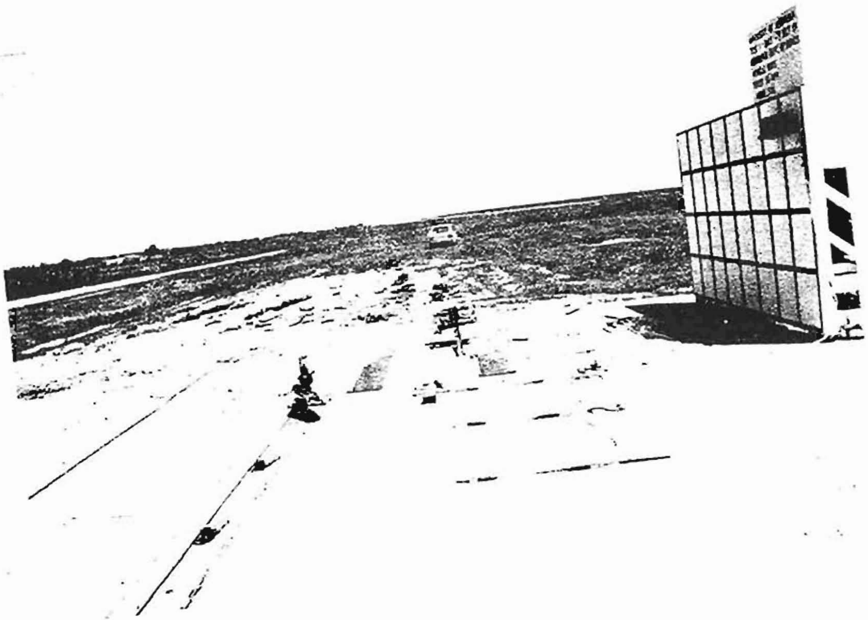


Figure 8 . Photos Of Guide-Flag Sheared Off

TEST ARTICLE DETAILS

Two mailbox support systems were tested. The parts that were used for the support system are shown in Figures 9 and 10.

The first mailbox support system was used to support 2 mailboxes (size 1-A) which were 8 in. wide, 21 in. long, and 10 1/2 in. tall. Under each mailbox there was a pair of platform plates, shown in Figure 9, which bolted to the bottom of each mailbox. The two plates can be adjusted to fit any standard width mailbox. The two mailboxes, with the platform plates, were mounted directly onto the adapter plate or shelf, shown in Figure 9. Then two L-shaped brackets, shown in Figure 9, were used to attach the adapter plate or shelf to the U-shaped post. The double mailbox support system is shown in Figure 1 and the complete system is shown in Figure 11.

The second mailbox support system was used to support one mailbox (size 2) which was 11 1/2 in. wide, 23 1/2 in. long, and 13 1/2 in. tall. Under the mailbox there was a pair of adjustable platform plates, shown in Figure 9, which bolted to the bottom of the mailbox. The larger mailbox, with the platform plates, was mounted directly to the post, with a pair of L-shaped brackets. The brackets are shown in Figure 9. The single mailbox support system is shown in Figure 2 and the complete system is shown in Figure 12.

The post system consisted of four main parts, the top post, the base post, the retainer strap, and the anti-twist plate.

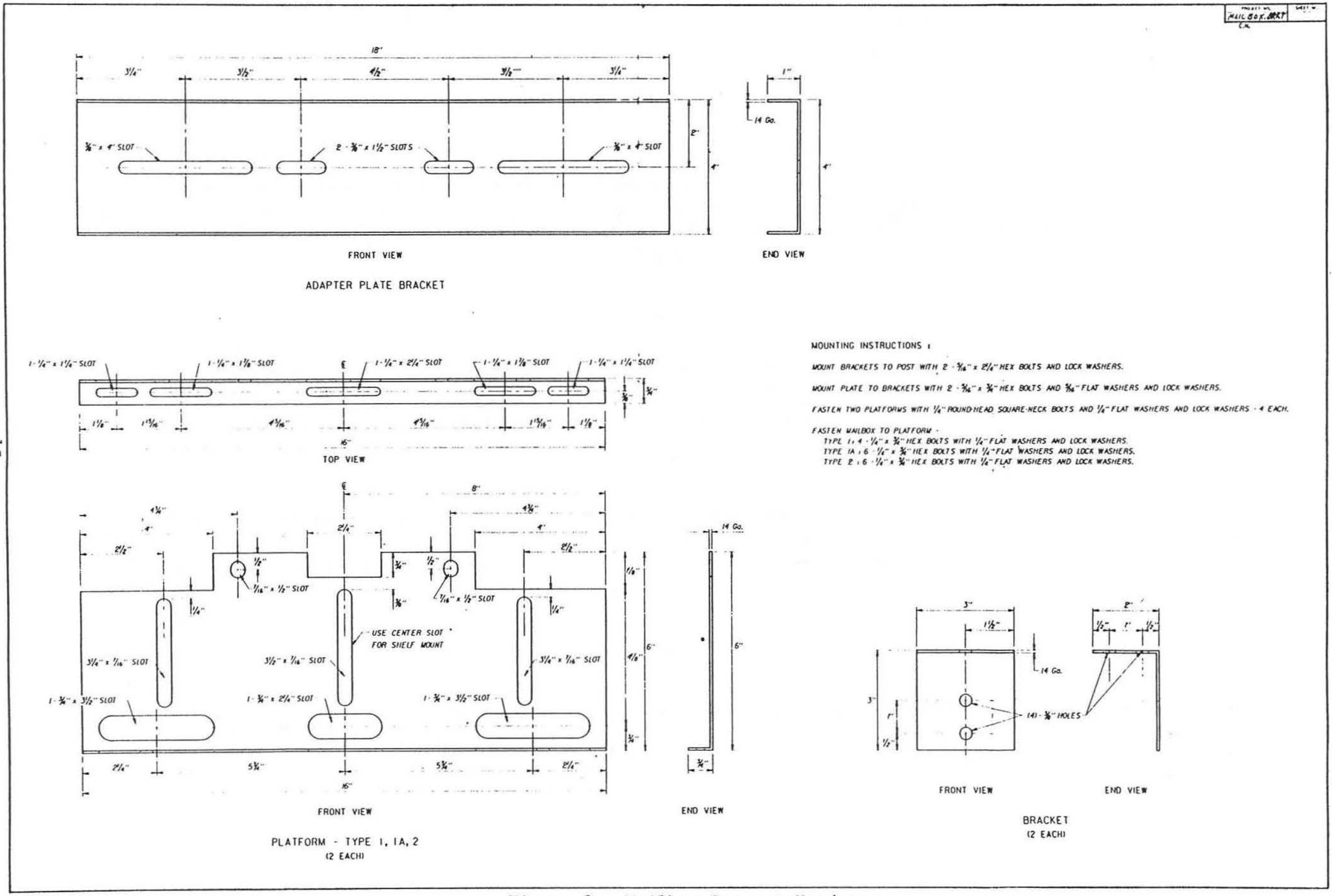


Figure 9. Mailbox Support Hardware

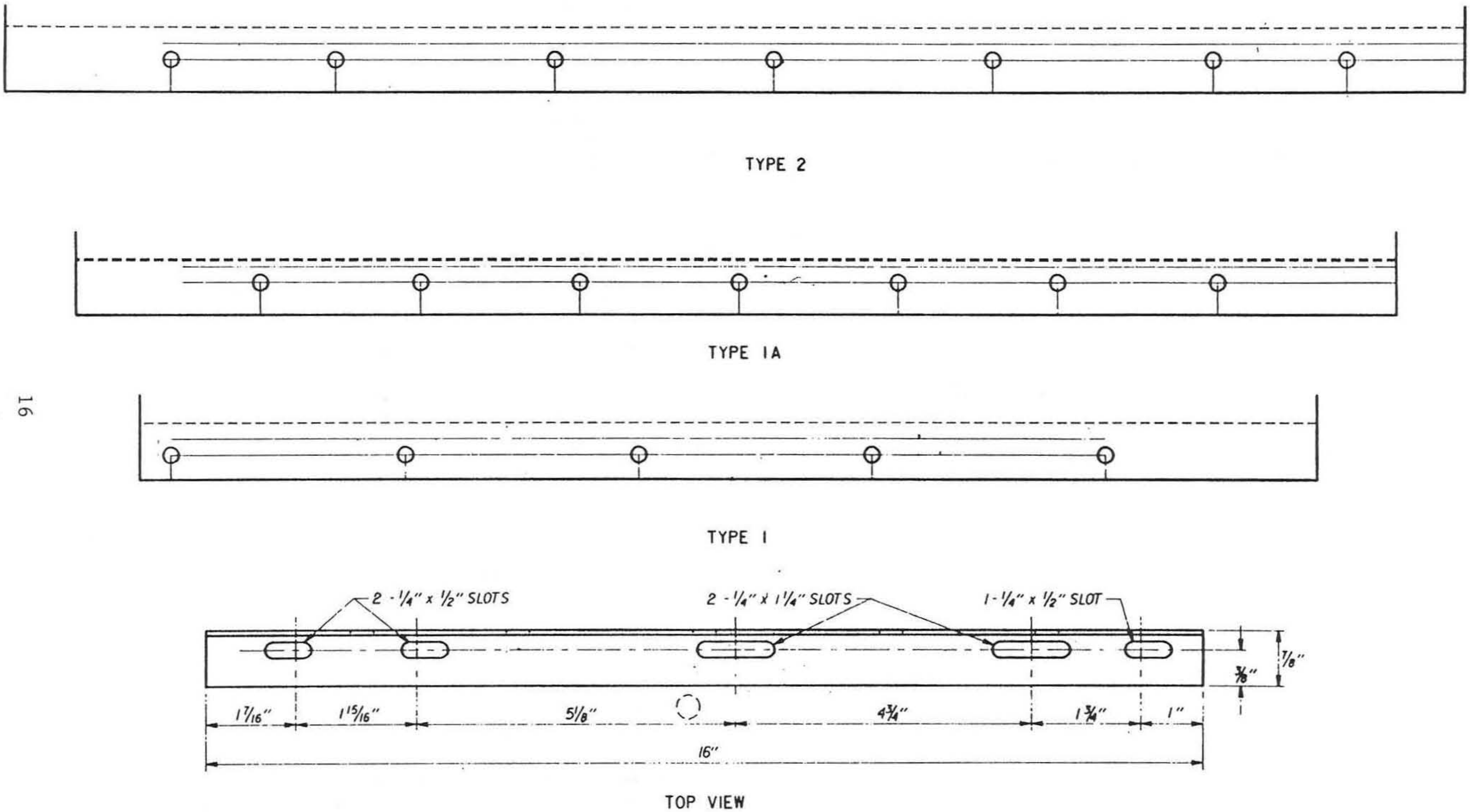


Figure 10. Schematic of Three Adaptable Mailbox Types or Sizes

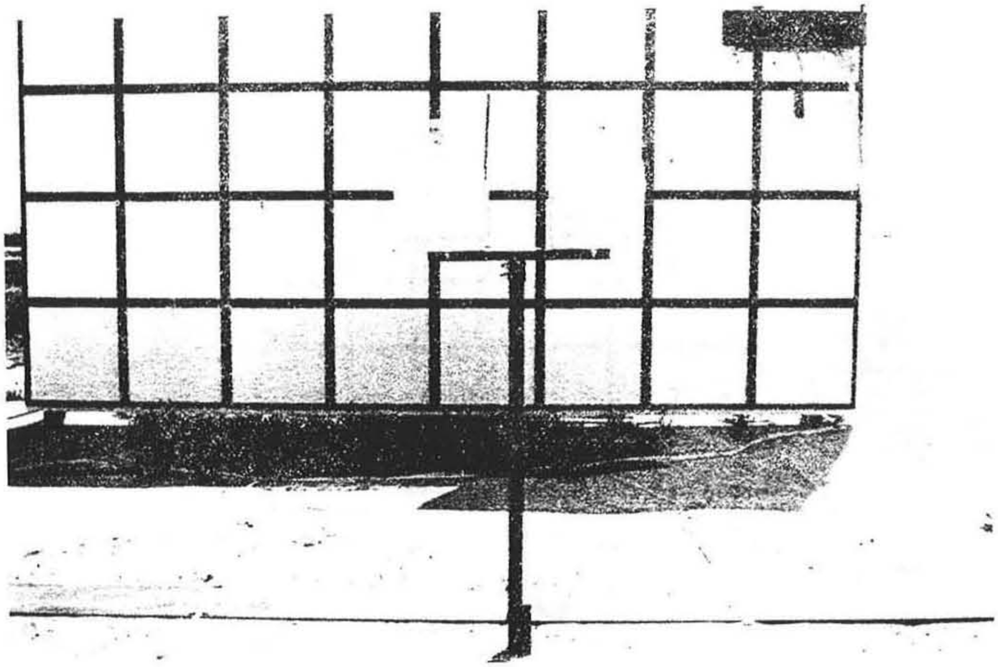
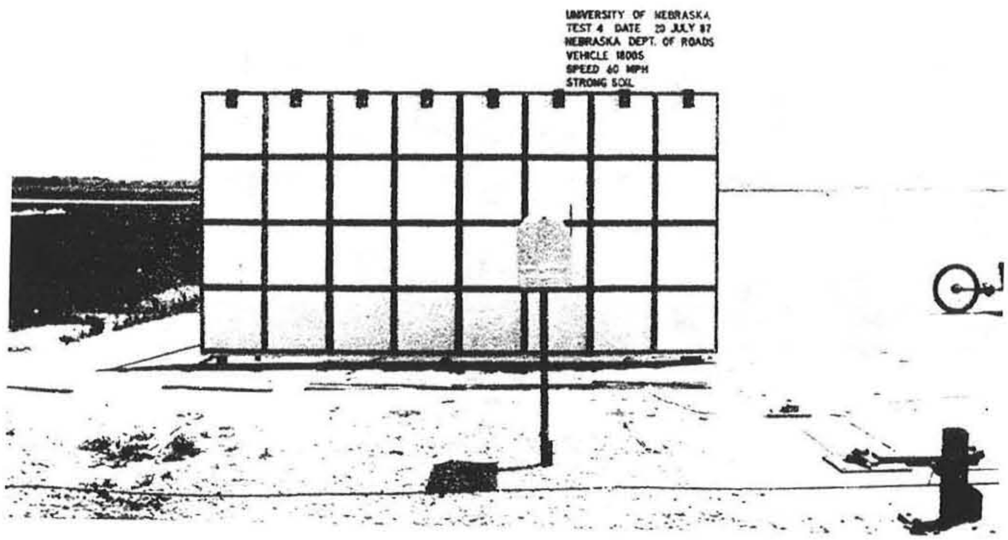


Figure 11. Photos Of The Complete Double Mailbox System



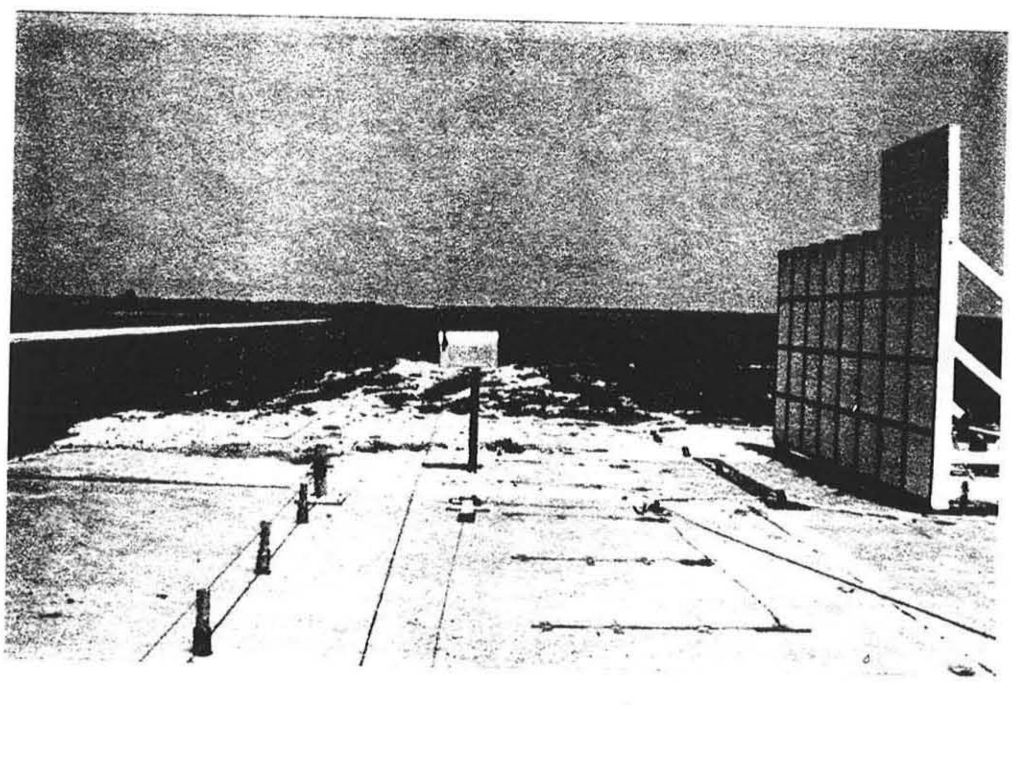


Figure 12. Photos Of The Complete Single Mailbox System

With the exception of the anti-twist plate, the post system is shown in Figure 1.

The top post was 42 in. long and had the cross-sectional dimensions and values as shown in Figure 13.

The base post, which was embedded 37 in. into the soil, was also 42 in. long and had the same dimensions as the top post. The post embedment diagram is shown in Figure 14.

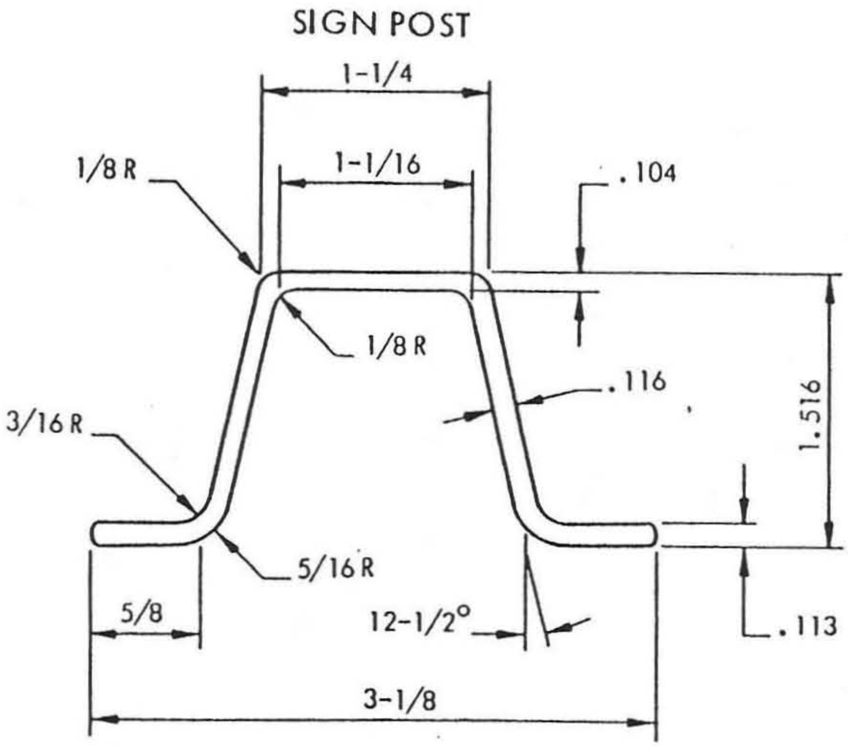
The retainer strap, 17 in. long, was used to connect the two post sections together. The installation instructions for the Franklin Steel eze-erect sign posts are shown in Figure 15. The breakaway or slip feature is demonstrated in Figure 13.

The anti-twist plate was made from a 1/8 in. sheet of galvanized sheet metal. It had the shape of a trapezoid with the following dimensions, top horizontal length, 12 in., bottom horizontal length, 6 in., and height, 6 in. It was bolted to the base post so that it would be positioned below ground level.

TEST VEHICLE

A 1979 Volkswagon Rabbit, weighing approximately 1840 lb, was used as the crash test vehicle. Pictures of the test vehicle are shown in Figure 16. Vehicle dimensions are shown in Figure 17.

The left and right front wheels of the test vehicle were set to a toe-in value of zero-zero to allow the vehicle to track properly along the guide cable.



WEIGHT - 2.00 LBS/FT

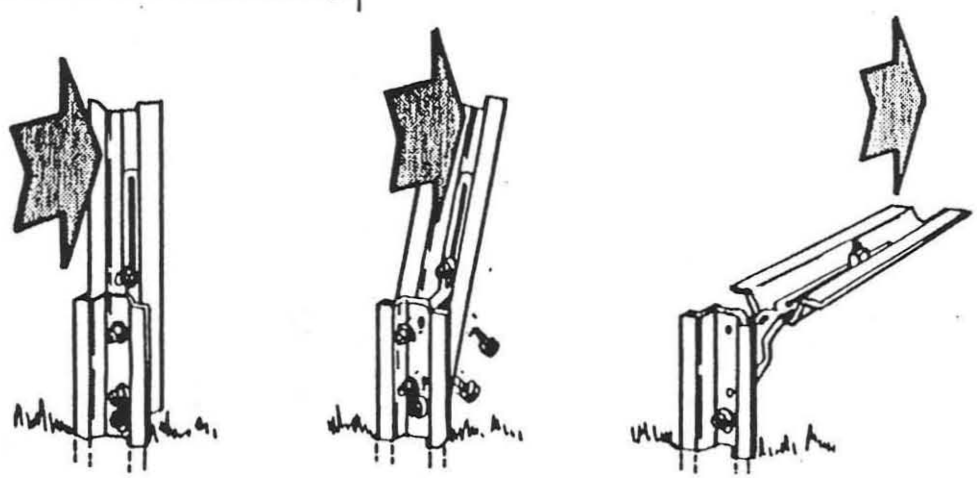
AREA, A (In^2) - .59

MOMENT OF INERTIA, $Ix(In^4)$ - .18

$Iy(In^4)$ - .42

SECTION MODULUS, $Zx(In^3)$ - .23

$Zy(In^3)$ - .27



Mailbox Post Breakaway Feature

Figure 13. Mailbox Post Dimensions and Breakaway Feature

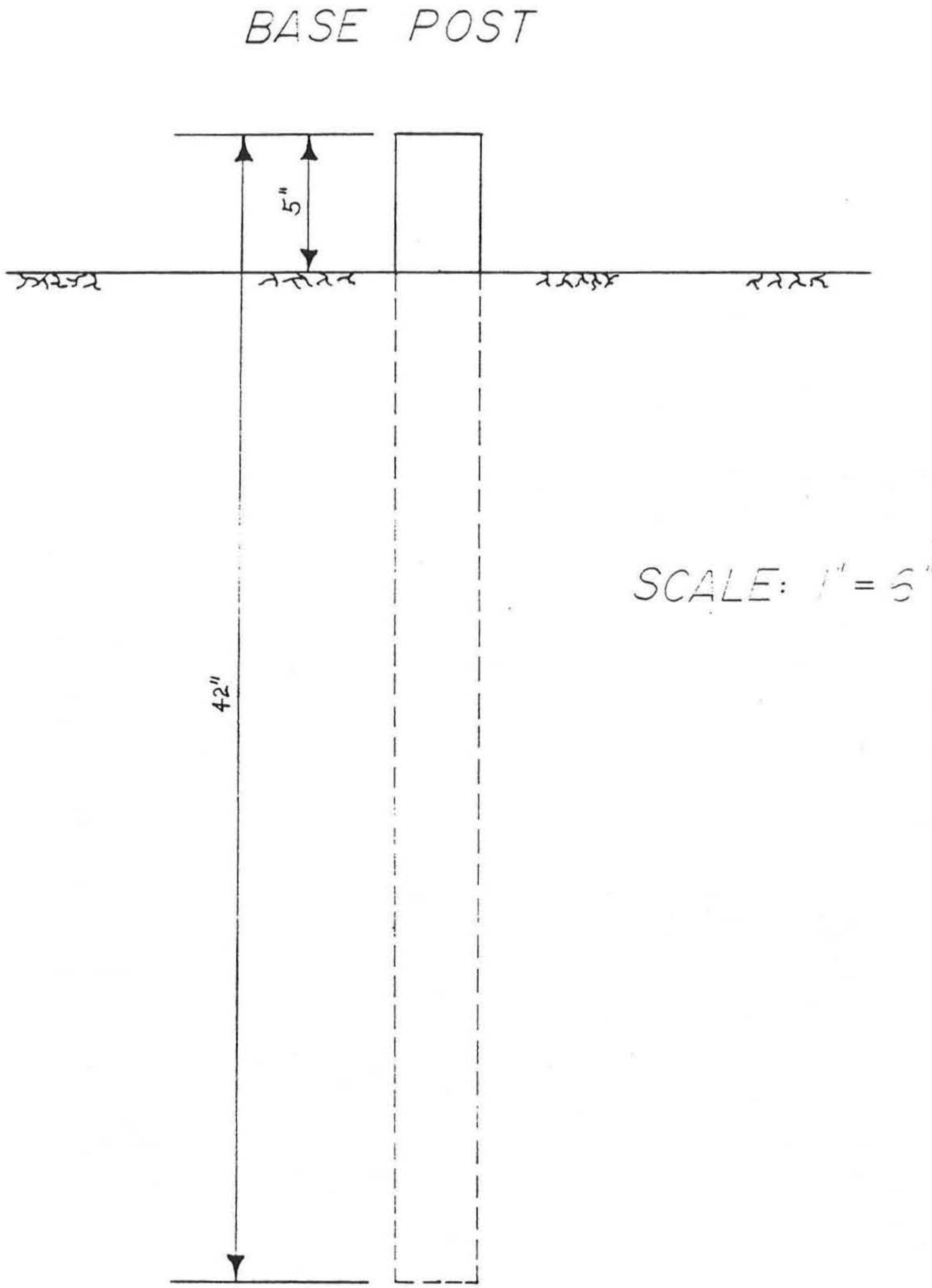


FIGURE 14. POST EMBEDMENT DIAGRAM

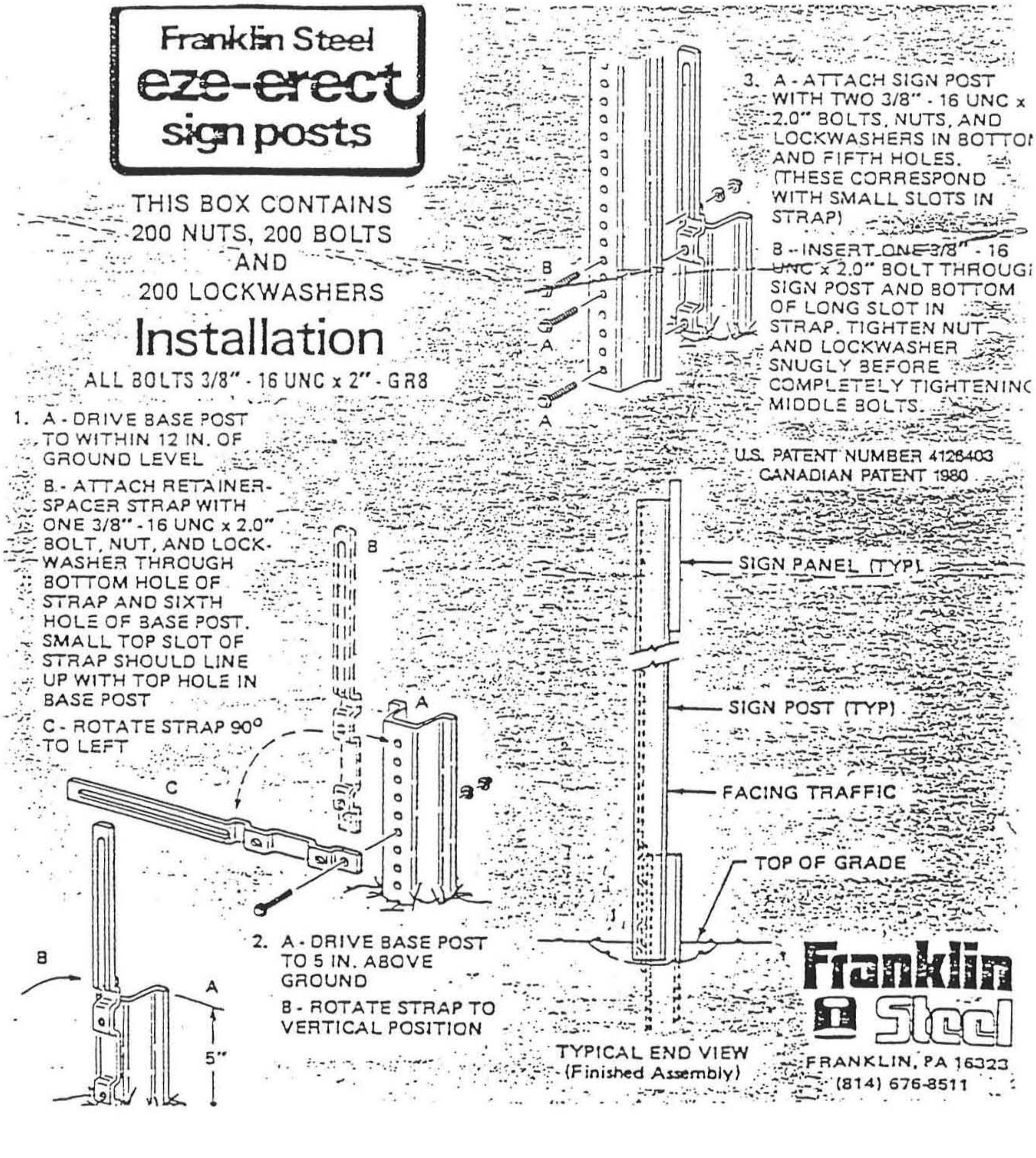


Figure 15. Post Installation Diagram

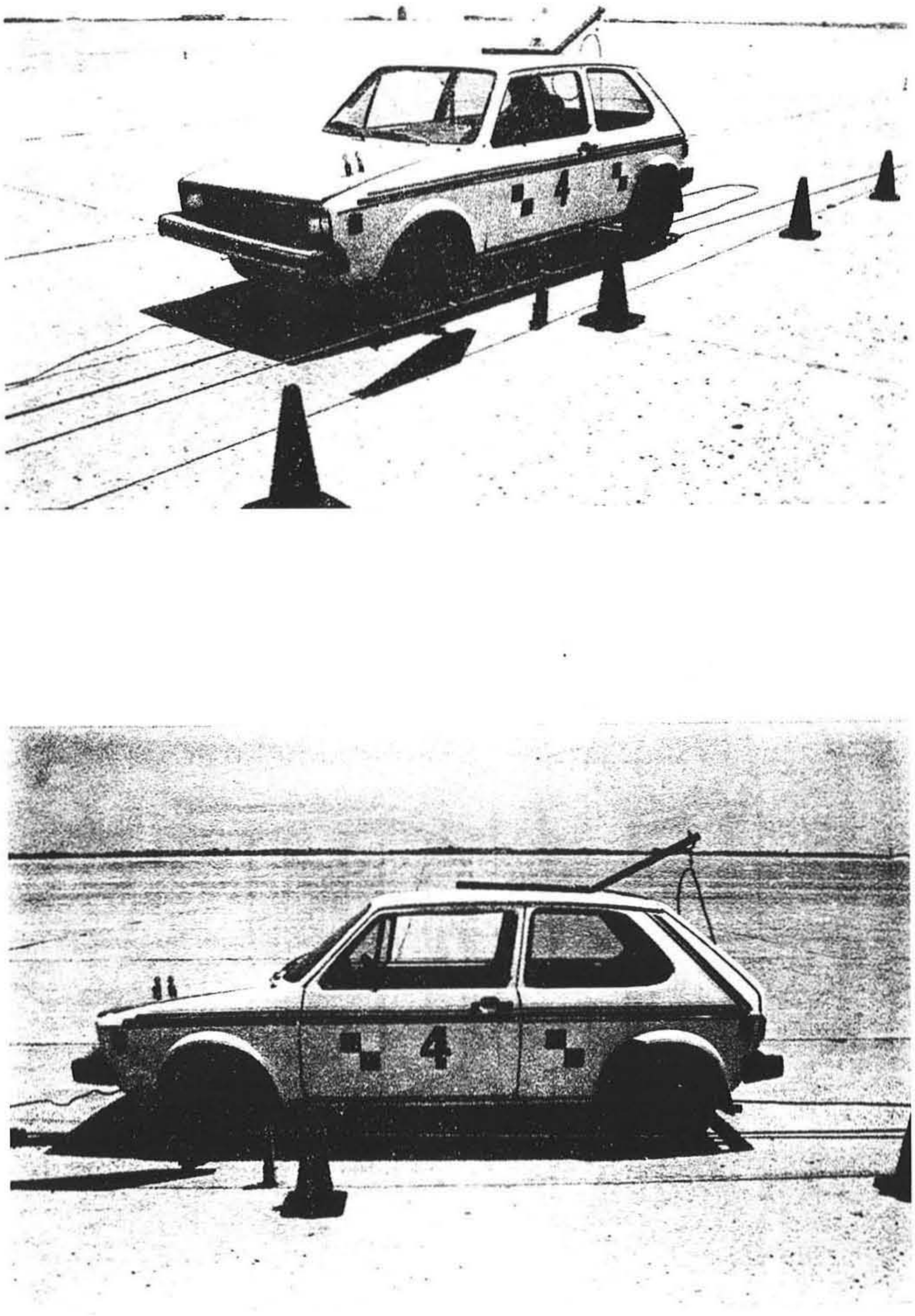
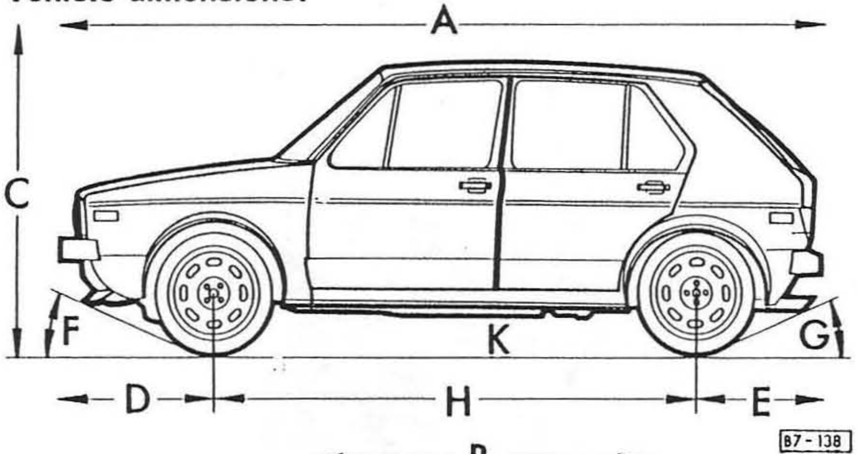
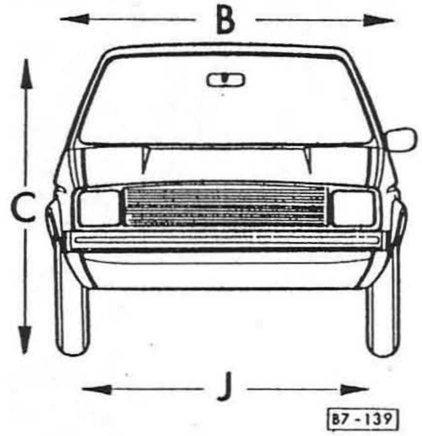


Figure 16. Photos Of The Test Vehicle

Vehicle dimensions:





A	– Length	155.3 in/3945 mm
B	– Width	63.4 in/1610 mm
C	– Height (unladen)	55.5 in/1410 mm
D	– Overhang, front	32.7 in/ 830 mm
E	– Overhang, rear	27.2 in/ 693 mm
F	– Ramp angle, front	24°
G	– Ramp angle, rear	22.5°
H	– Wheelbase	94.5 in/2400 mm
J	– Front track	54.7 in/1390 mm
	Rear track	53.1 in/1350 mm
K	– Ground clearance	4.8 in/ 122 mm

Measured at gross vehicle weight, except item C, which is measured at unladen weight.

Turning circle diameter – approximately 31.5 ft/9.6 m curb to curb.

Gross Vehicle Weight:	2822 lbs.	
Gross Axle Weight:	1609 lbs.	(front)
Gross Axle Weight:	1278 lbs.	(rear)

Figure 17. Crash Test Vehicle Dimensions

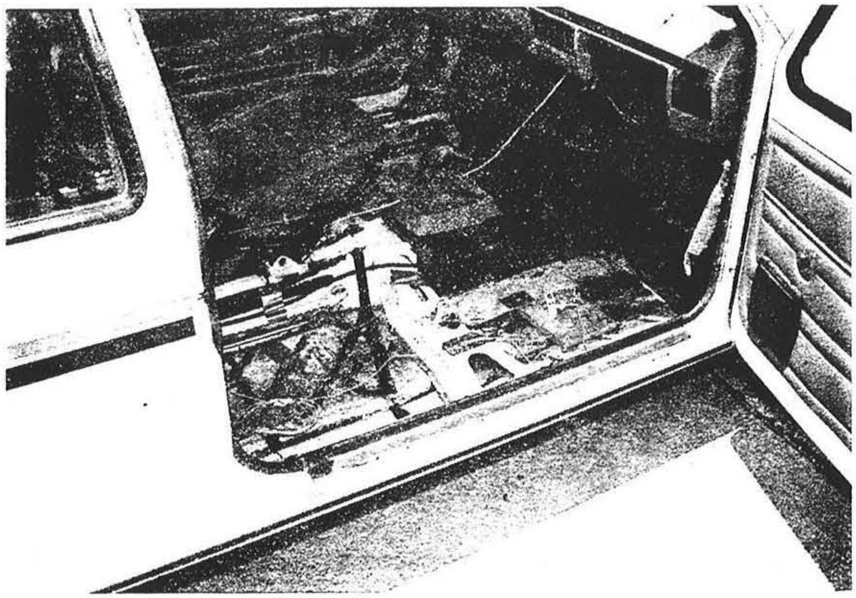
Two 8 in. square, black and white targets were placed on the test vehicle on 42 in. centers to aid with the analysis of the high-speed film.

Two 5B flash-bulbs were mounted on the front hood of the test vehicle to record the time of impact with the mailbox on the high-speed film. The flash-bulbs were fired by a pressure or tape switch which was mounted to the front of the bumper.

DATA ACQUISITION SYSTEMS

Two piezoresistive accelerometers, (model 7264) with a range of 200 g´s, were used to measure the accelerations in the longitudinal direction of the vehicle. The accelerometers were attached to metal blocks which were mounted to the front floor-boards of both the left side (driver) and right side (passenger). Photos of the accelerometers mounted in the test vehicle are shown in Figure 18. The signals from the accelerometers were first sent to the Metraplex FM multiplexed data acquisition system (series 300), and then to the Honeywell 101 analog tape recorder for permanent storage. A flowchart of the accelerometer signals passing through the data acquisition system is shown in Figure 19. Photos of the system located in the test vehicle and the back of a station wagon are shown in Figure 20. The computer program used to analyze and plot the accelerometer data is given in Appendix B.

Two cameras were used to record each test; both of which were high-speed film cameras, running at approximately 500 frames/sec. The first camera, Locam, which used a wide angle



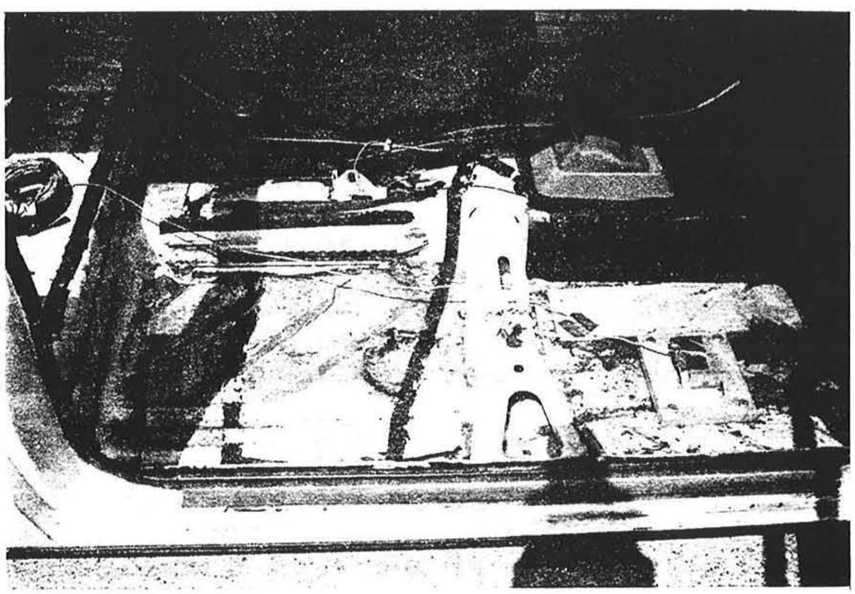


Figure 18. Photos Of Mounted Accelerometers

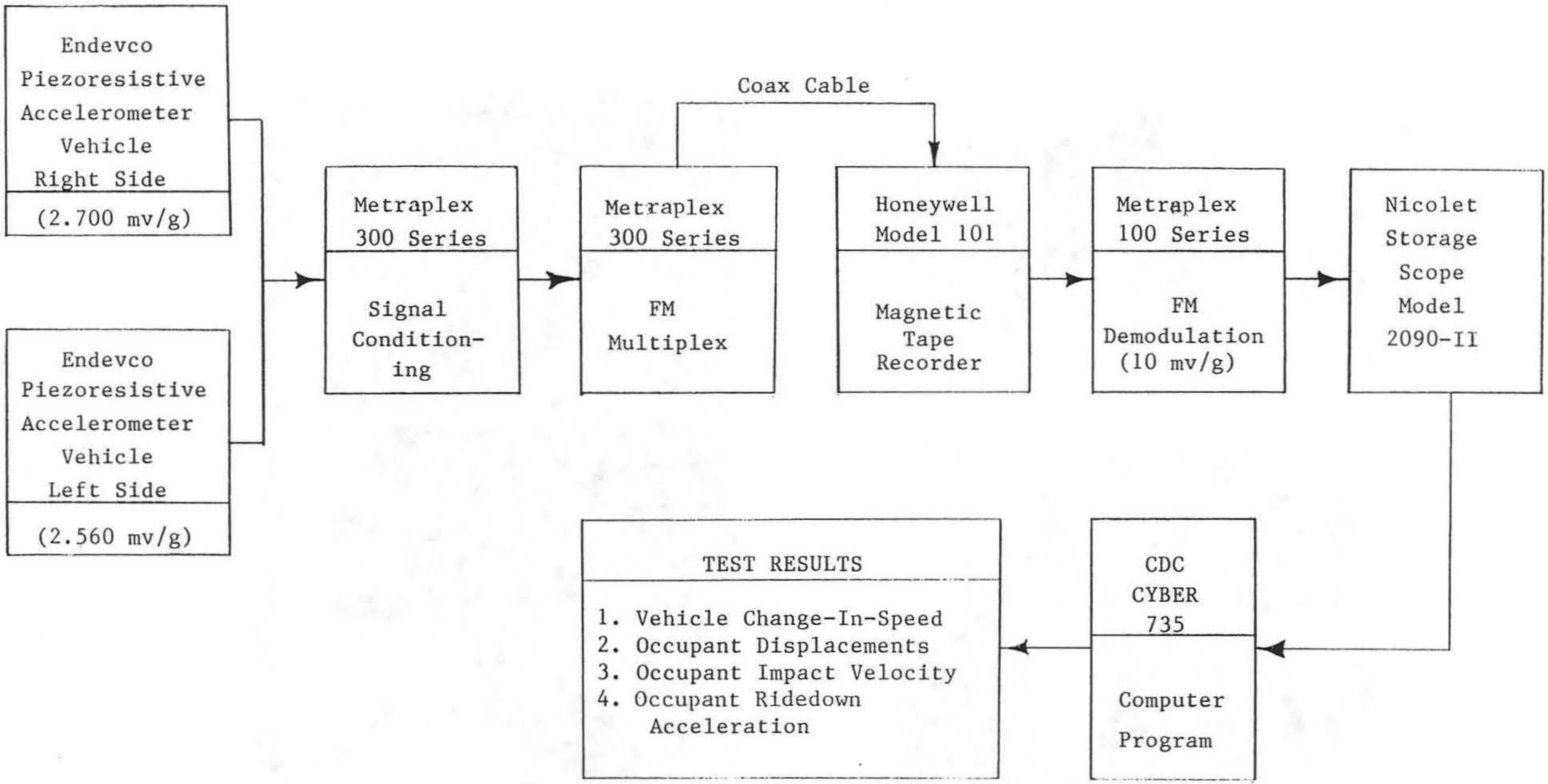
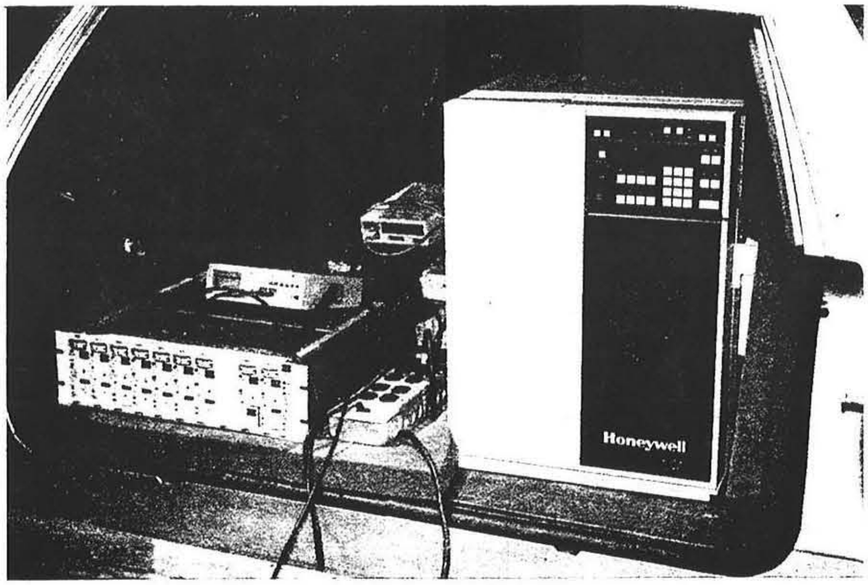


Figure 19. Flowchart of Metraplex Data Acquisition System



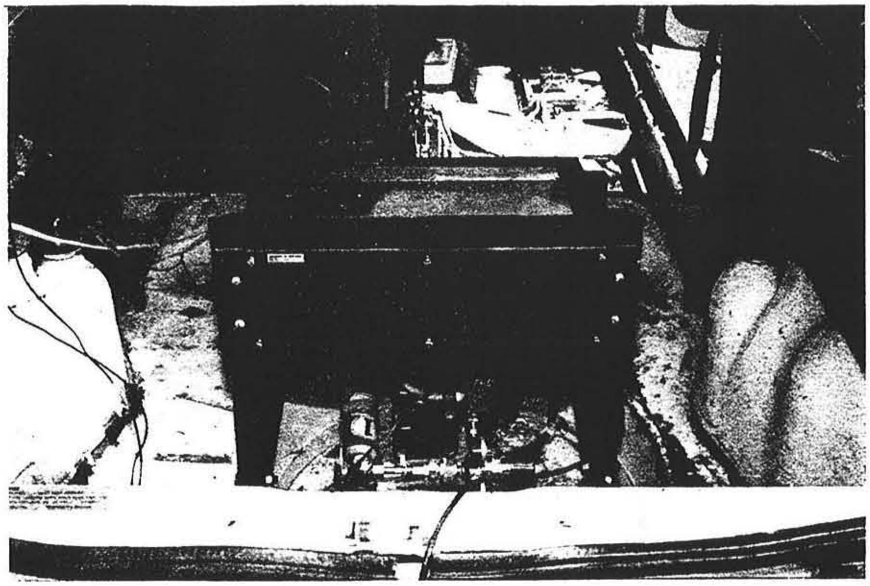


Figure 20. Photos Of Data Acquisition System

lens, was placed approximately 80 feet perpendicular to the direction of the vehicle. The second camera, Photec IV, was also positioned perpendicular to the direction of the vehicle. It was placed at approximately 137 feet. A schematic of the camera layout is shown in Figure 21.

A 8-feet high by 16-feet long backboard, with a 2-feet line grid layout, was used as a reference system for analysis of the high-speed film. The moveable backboard was placed perpendicular at a distance of 13 feet from the centerline of the vehicle path.

Following the tests, the film was analyzed using the Vanguard motion analyzer.

Tape or pressure switches positioned along the length of the impact area, at 5 feet intervals, were activated by the vehicle to indicate the travel time over a known distance. Each switch would fire a blue 5B flash-bulb, which was mounted to the backboard, as the right front tire of the test vehicle passed over it. Thus, the number of film frames was counted between flashes and was used along with the film speed and tape switch spacing to calculate the test vehicle speed. This provided a quick check of the impact speed and also values for change in velocity.

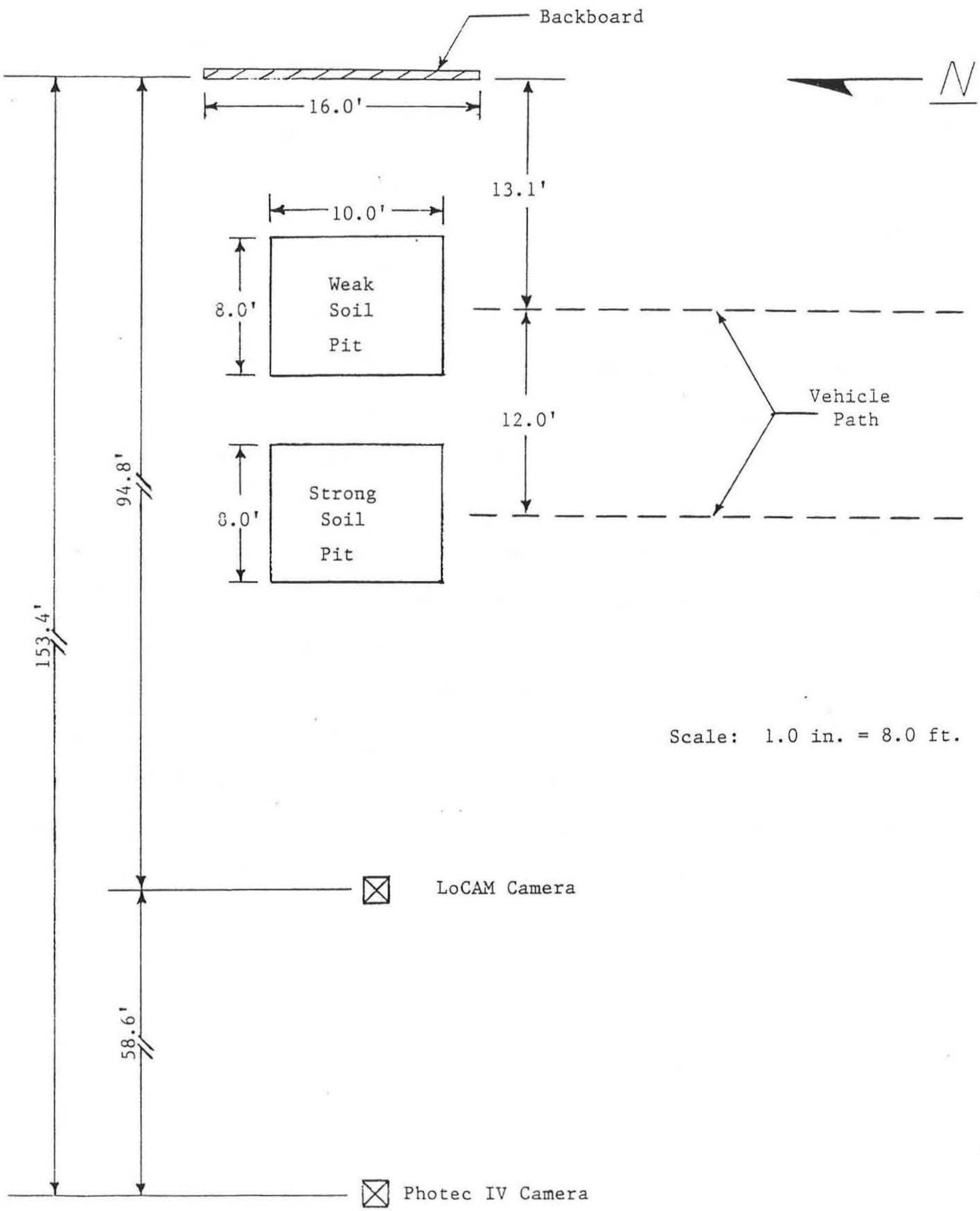


Figure 21. Schematic of Camera Layout

PERFORMANCE STANDARDS

Currently, there are no established guidelines or performance criteria which directly deal with full-scale crash tests on mailbox supports. However, a procedure guide by the American Association of State Highway and Transportation Officials (AASHTO) (5) provides three very useful general criteria:

- The mailbox support details should prevent mailboxes from separating from the post if struck by a vehicle.
- Windshield penetration from the mailbox should be minimized.
- Single or multiple mailbox installations should not cause vehicle ramping or rollover as a result of a mailbox collision.

In addressing safety appurtenances, AASHTO requires all new roadside signs and luminaries on high speed highways, located within the suggested clear zone width, to be placed on breakaway supports unless they are located behind a barrier or crash cushion. Therefore, it was assumed that mailbox support systems should comply with the safety standards required for a breakaway or yielding device. Breakaway supports are all types of devices which are safely displaced under vehicle impact, whether the release mechanism is a slip plane, plastic hinges, fracture elements, or a combination of these.

According to AASHTO, "satisfactory dynamic performance is indicated when the maximum change in velocity for a standard

1800-pound (816.5kg) vehicle, or its equivalent, striking a breakaway support at speeds from 20 mph to 60 mph (29.33 fps to 88 fps) (32 kmph to 97 kmph) does not exceed 15 fps (4.57 mps), but preferably does not exceed 10 fps (3.05 mps) or less." (Standard Specifications for Structural Supports for Highway Signs, Luminaries and Trafic Signals, 1985, AASHTO, Section 1.7.2) (6).

Other specifications require that detached elements, fragments, or other debris from the test article (mailbox assembly) shall not penetrate or show potential for penetrating the occupant compartment or provide undue hazard to other traffic. Also, the vehicle shall remain upright during and after the mailbox crash test (1).

The change in velocity, peak deceleration, maximum 10 ms average deceleration, and occupant displacement (free missile travel) were four types of data that were derived from the accelerometer readings. Change in velocity and occupant displacement are both time dependent. Due to this time dependency, guidelines have been established to determine the "duration of the event" for computation. The duration of the event is defined as the lesser of the following: (1) time between incipient contact and loss of contact between vehicle and the yielding support, or (2) the time for a free missile to travel a distance of 24 inches starting from rest with the same magnitude of vehicle decelerations. (7).

The time between incipient contact and loss of contact between vehicle and yielding support is not easily determined. By using the high-speed film, it was observed that contact between the vehicle and the support may take place over a long period of time if the vehicle moves over the mailbox. Therefore, after reevaluation of the accelerometer graphs, it was decided that the duration of the event was the time between contact and when the acceleration returned to and remained at zero. This decision was made because deceleration cannot remain at zero unless the vehicle reached a constant velocity or has stopped.

After the test, the damage was assessed by the traffic accident data scale (TAD) (8) and the vehicle damage index (VDI) (9).

Because test conditions are sometimes difficult to control, a composite tolerance limit is presented. It is called the impact severity (IS). For structural adequacy, it is preferable for the actual impact severity to be greater than the target value rather than being below it. During low-speed tests, the goal is to determine the lower speed threshold for detaching the appurtenance. Then it is preferable to be on the low side of the target value. The IS target values for the 20 mph and 60 mph tests are $24^{-3,+3}$ ft-kips and $216^{-21,+37}$ ft-kips, respectively. (1).

TESTS RESULTS

In the following section, each test will be explained along with the individual results. Table 2 summarizes the results of the four tests. The accelerometer data was used for the calculation of change in velocity while the high-speed film was used as a backup system and check on the accelerometer results. The computer printout results for each test are shown in Appendix C.

TEST NO. 1

The results of Test 1 are shown in Table 3. Figure 22 shows the sequential photos taken from the high-speed film, and the corresponding time-event summary is given in Table 4. Upon impact, the post first wrapped around the bumper, and then the mailbox hit the front end of the hood. The car then continued to push the mailbox and post to the ground. While the car continued to move over the mailbox and post, the retainer strap held the top section of the post to the base post, which was not pulled out. Photos of the damage to the mailbox system are shown in Figure 23. A diagram of the base post position after impact is shown in Figure 24.

Plots of deceleration, change in velocity, and occupant displacement versus time are shown in Figures 25 through 30.

The vehicle received no damage with the exception of a small dent in the bumper as shown in Figure 31. The damage was

TABLE 3. SUMMARY OF RESULTS, TEST 1

Impact Velocity = 20.5 mph

Actual Impact Severity = 25.8 ft-kips

MAILBOX SUPPORT DATA		
Mailbox	2 boxes (size 1-A)	
Post Type	Steel U-post *	
Size	2.00 lbs/ft	
Embedment Method	Driven into Weak Soil (S-2)	
Embedment Depth	37 in.	
VEHICLE DATA		
Make	Volkswagon	
Model	Rabbit	
Year	1979	
Weight	1840 lbs.	
Impact Point	14 in. to right of center	
ACCELEROMETER DATA	**Left**	**Right**
Change in Velocity (ft/sec)	1.9	3.2
Duration of Event (sec) **	0.082	
Peak Deceleration (g´s)	8.2	22.6
Maximum 0.010 sec Average Deceleration (g´s)	2.74	4.60
Occupant Displacement (in)	1.30	2.10
VEHICLE DAMAGE CLASSIFICATION		
TAD	None	
VDI	12FCLN1	

Did test article penetrate the the passenger compartment? NO

Was windshield broken? NO

*Franklin Steel eze-erect sign post

**Time of Contact

TABLE 2. SUMMARY OF TEST RESULTS.

TEST NO.	ACTUAL VEHICLE WEIGHT (lbs)	IMPACT SPEED (mph)	CHANGE IN VELOCITY (left/right) (fps)	PEAK DECELERATIONS (left/right) (g's)	MAXIMUM 0.010 SEC AVERAGE DECELERATION (left/right) (g's)	OCCUPANT DISPLACEMENT (left/right) (in)	ACTUAL IMPACT SEVERITY (ft-kips)
1	1840	20.5	1.9/3.2	8.2/22.6	2.74/4.60	1.30/2.10	25.8
2	1840	21.3	2.7/3.3	7.5/13.2	3.62/4.03	2.20/1.80	27.9
3	1840	63.6	4.4/4.5*	NA/NA**	NA/NA**	NA/NA**	248.6
4	1840	64.5	2.7/1.1	21.2/26.1	4.86/4.04	2.10/0.50	255.7

*From high-speed film analysis

**Not available due to the breakage of the data cable

TABLE 3. SUMMARY OF RESULTS, TEST 1

Impact Velocity = 20.5 mph

Actual Impact Severity = 25.8 ft-kips

<u>MAILBOX SUPPORT DATA</u>

Mailbox	2 boxes (size 1-A)
Post Type	Steel U-post *
Size	2.00 lbs/ft
Embedment Method	Driven into Weak Soil (S-2)
Embedment Depth	37 in.

<u>VEHICLE DATA</u>

Make	Volkswagon
Model	Rabbit
Year	1979
Weight	1840 lbs.
Impact Point	14 in. to right of center

ACCELEROMETER DATA	Left		Right
Change in Velocity (ft/sec)	1.9		3.2
Duration of Event (sec) **		0.082	
Peak Deceleration (g's)	8.2		22.6
Maximum 0.010 sec Average Deceleration (g's)	2.74		4.60
Occupant Displacement (in)	1.30		2.10

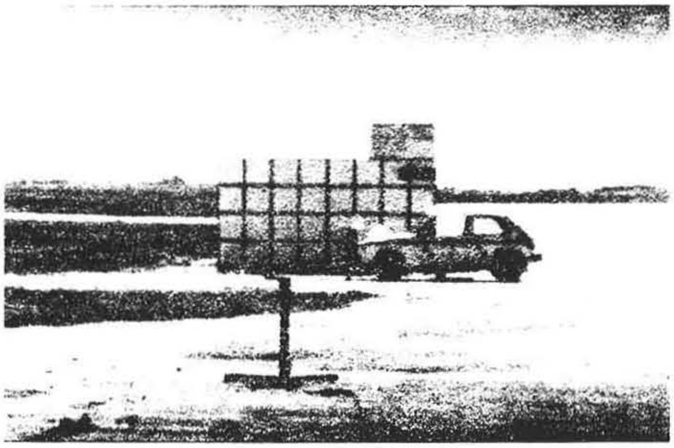
<u>VEHICLE DAMAGE CLASSIFICATION</u>

TAD	None
VDI	12FCLN1

Did test article penetrate the the passenger compartment?	NO
Was windshield broken?	NO

*Franklin Steel eze-erect sign post

**Time of Contact



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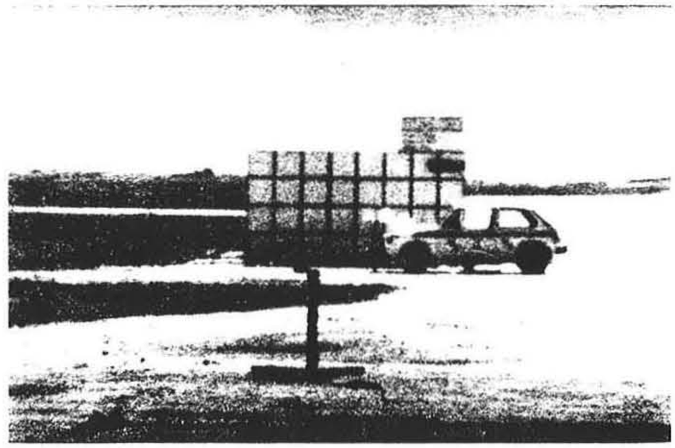

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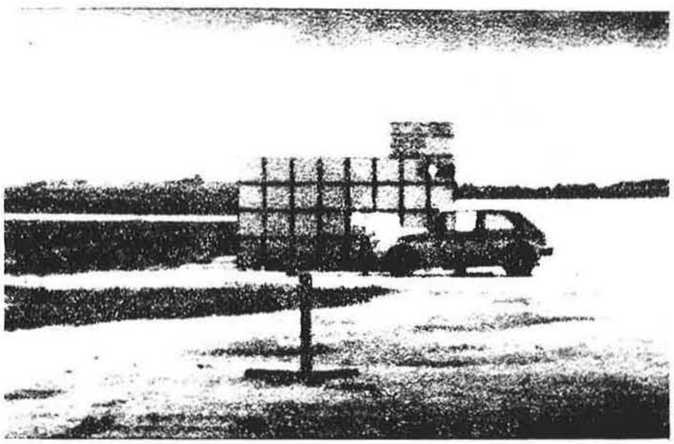

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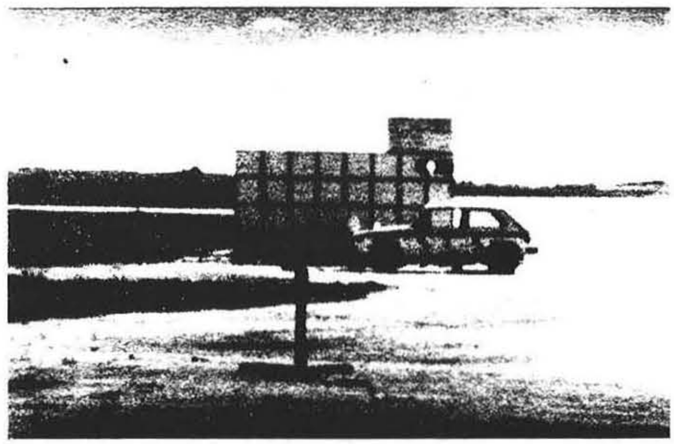

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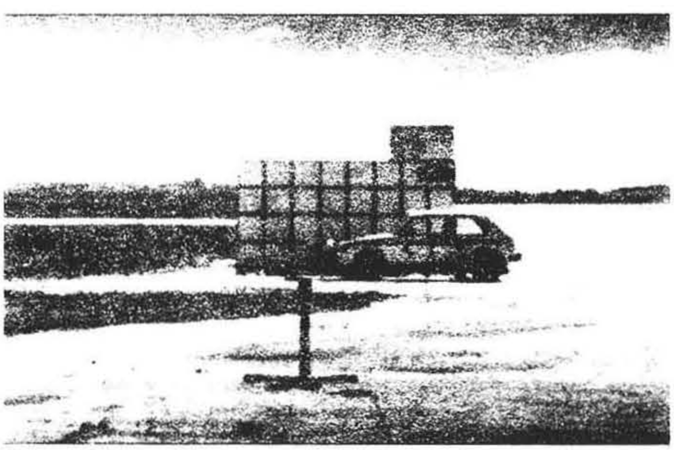


0.095 sec

0.147 sec

Figure 22. Sequential Photos, Test 1

TABLE 4. TIME-EVENT SUMMARY FOR TEST 1.

TIME (sec)	EVENT
0.000	Impact
0.006	Post begins bending
0.018	Post wrapping around bumper
0.050	Mailbox hits front end of hood
0.095	Mailbox and post being pushed over
0.147	First mailbox hits ground

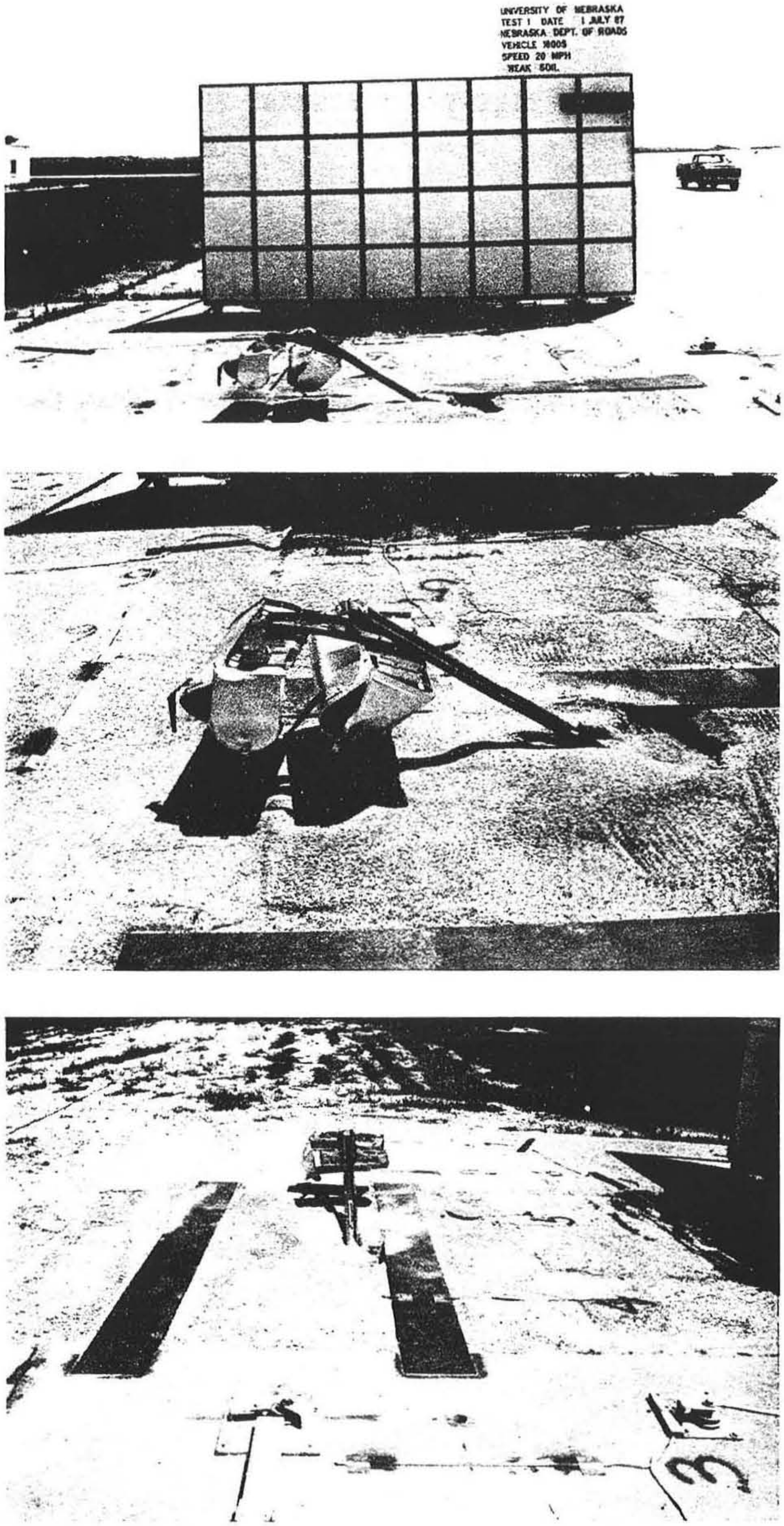


Figure 23. Damages To Mailbox System, Test 1

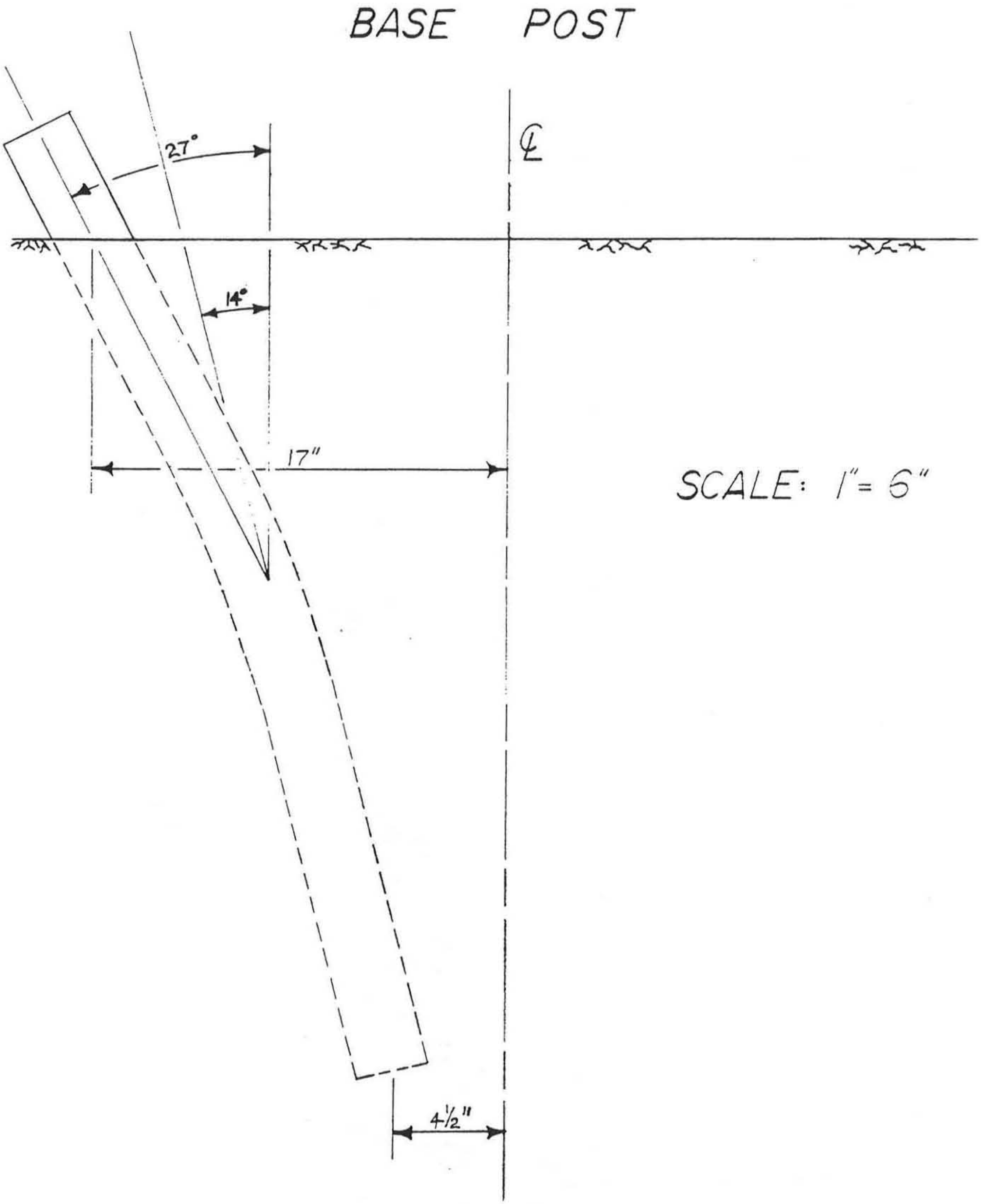


FIGURE 24. POST POSITION AFTER IMPACT, TEST 1

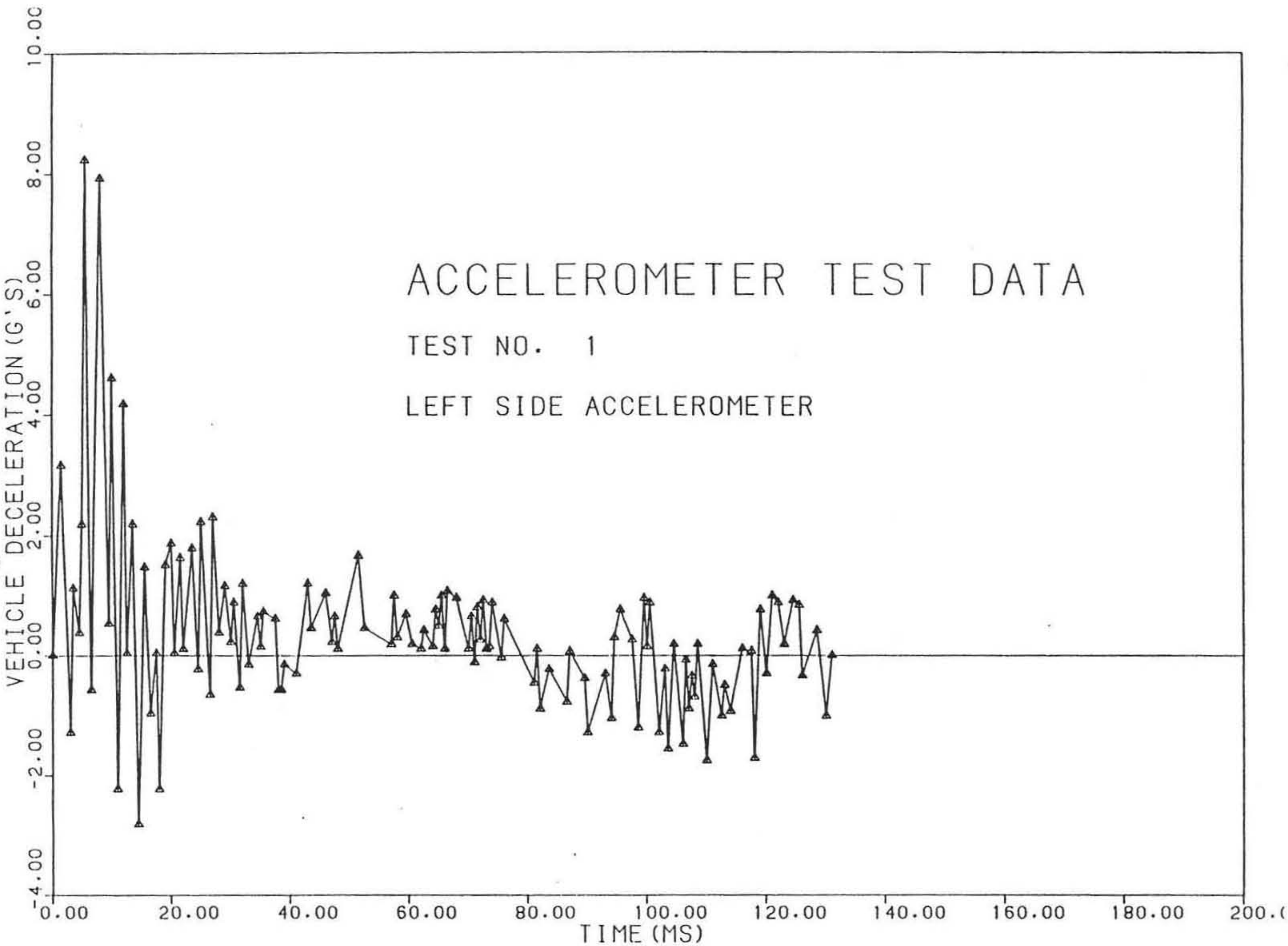


Figure 25. Vehicle Deceleration Versus Time, Test 1

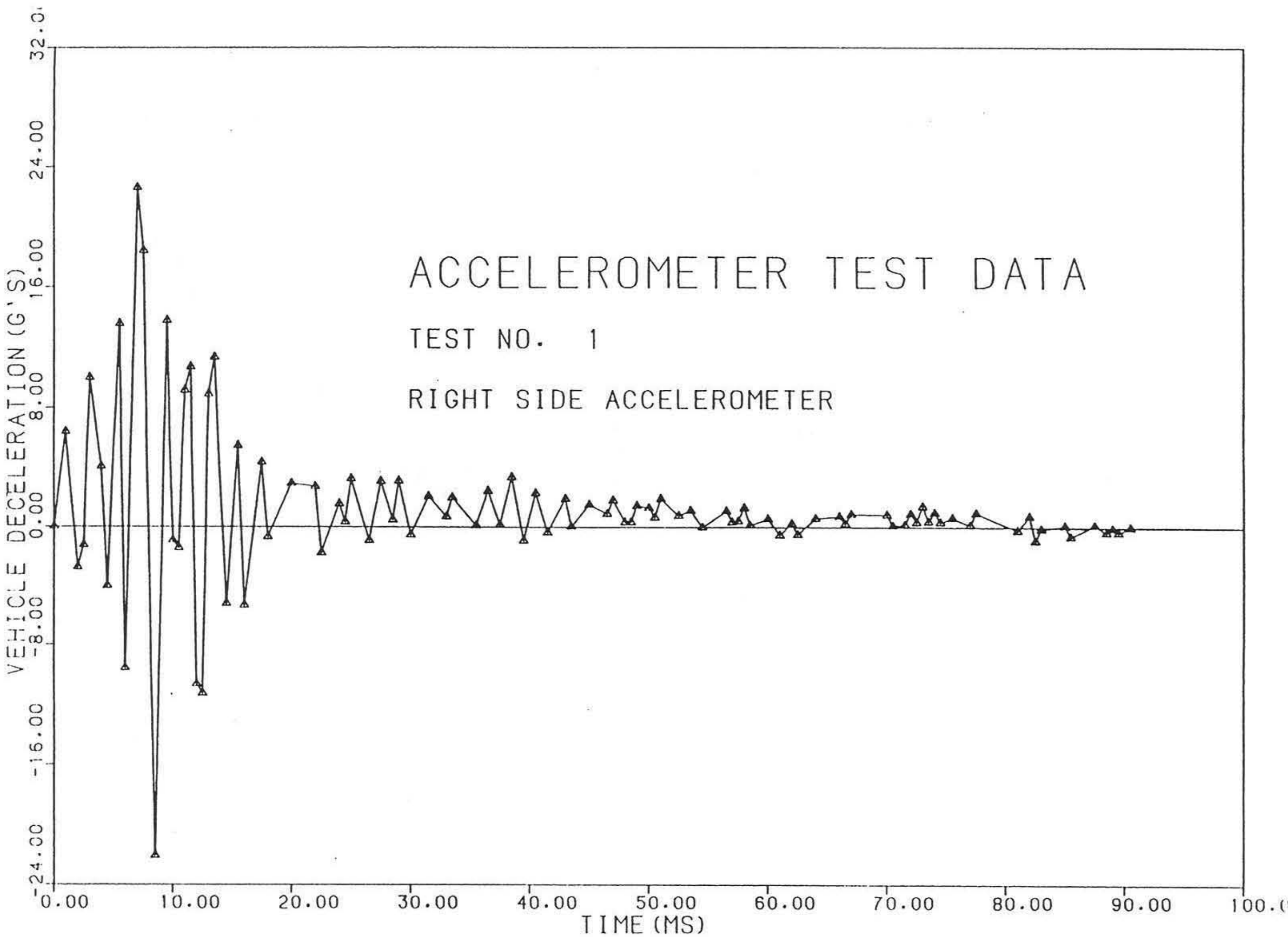


Figure 26. Vehicle Deceleration Versus Time, Test 1

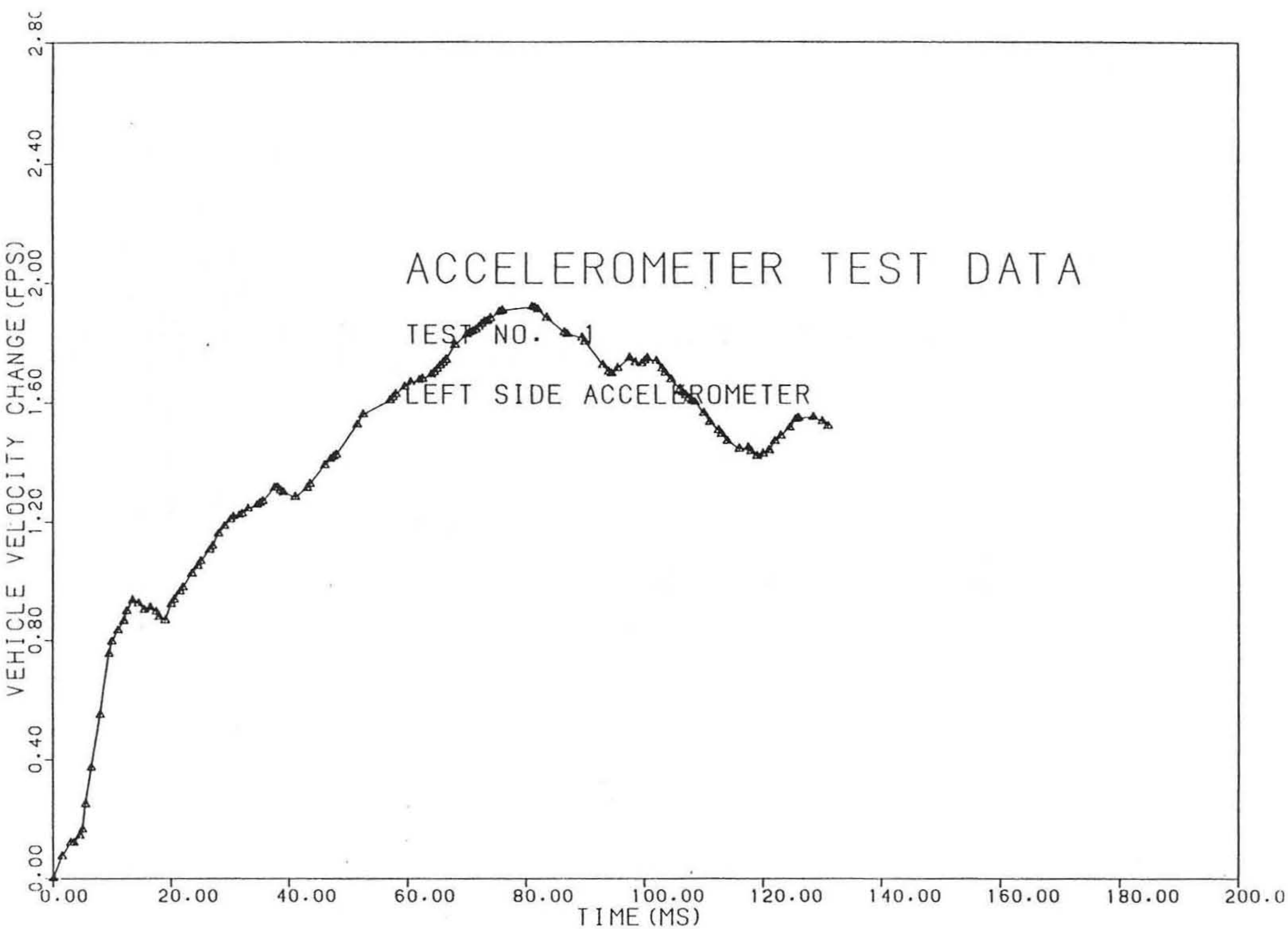


Figure 27. Vehicle Velocity Change Versus Time, Test 1

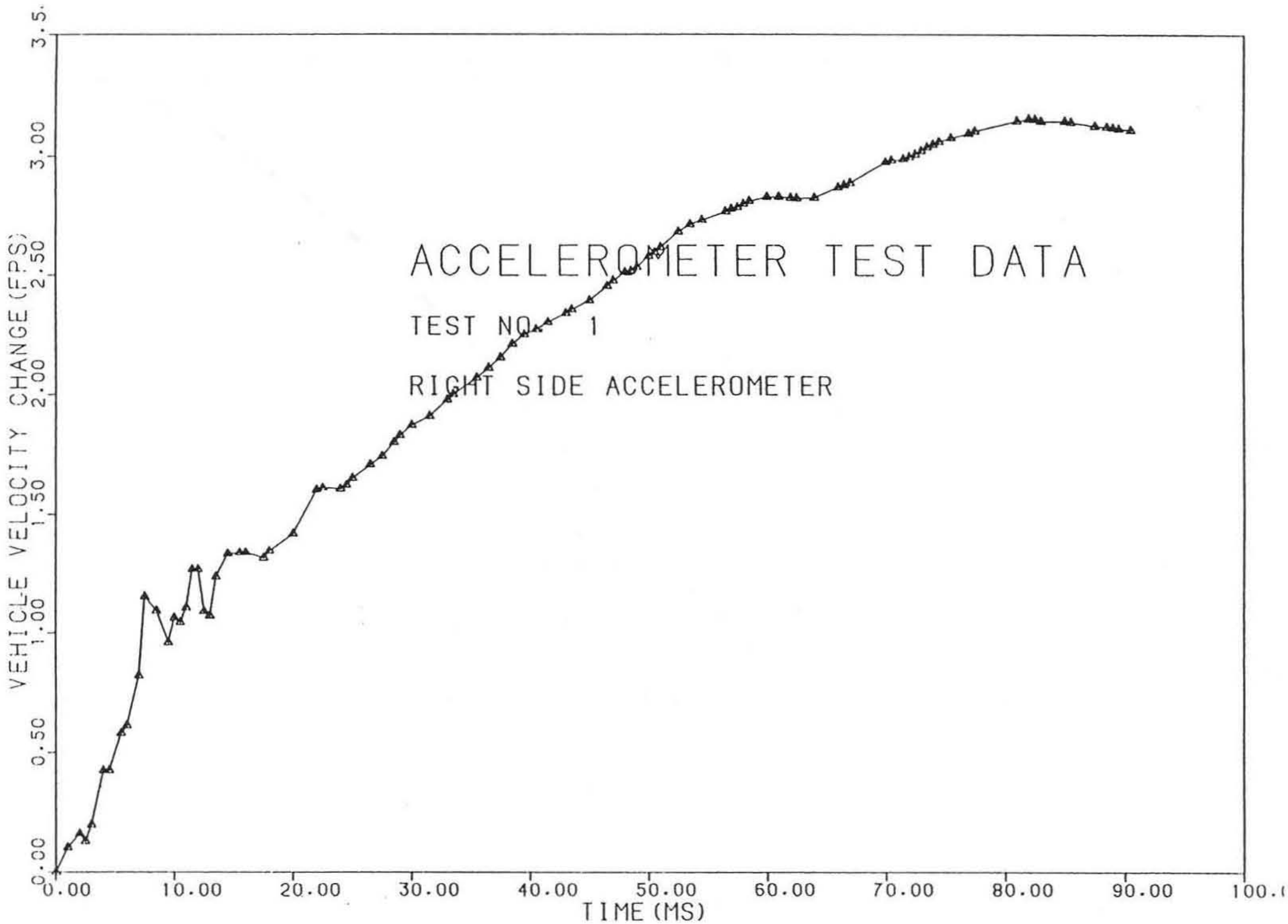


Figure 28. Vehicle Velocity Change Versus Time, Test 1

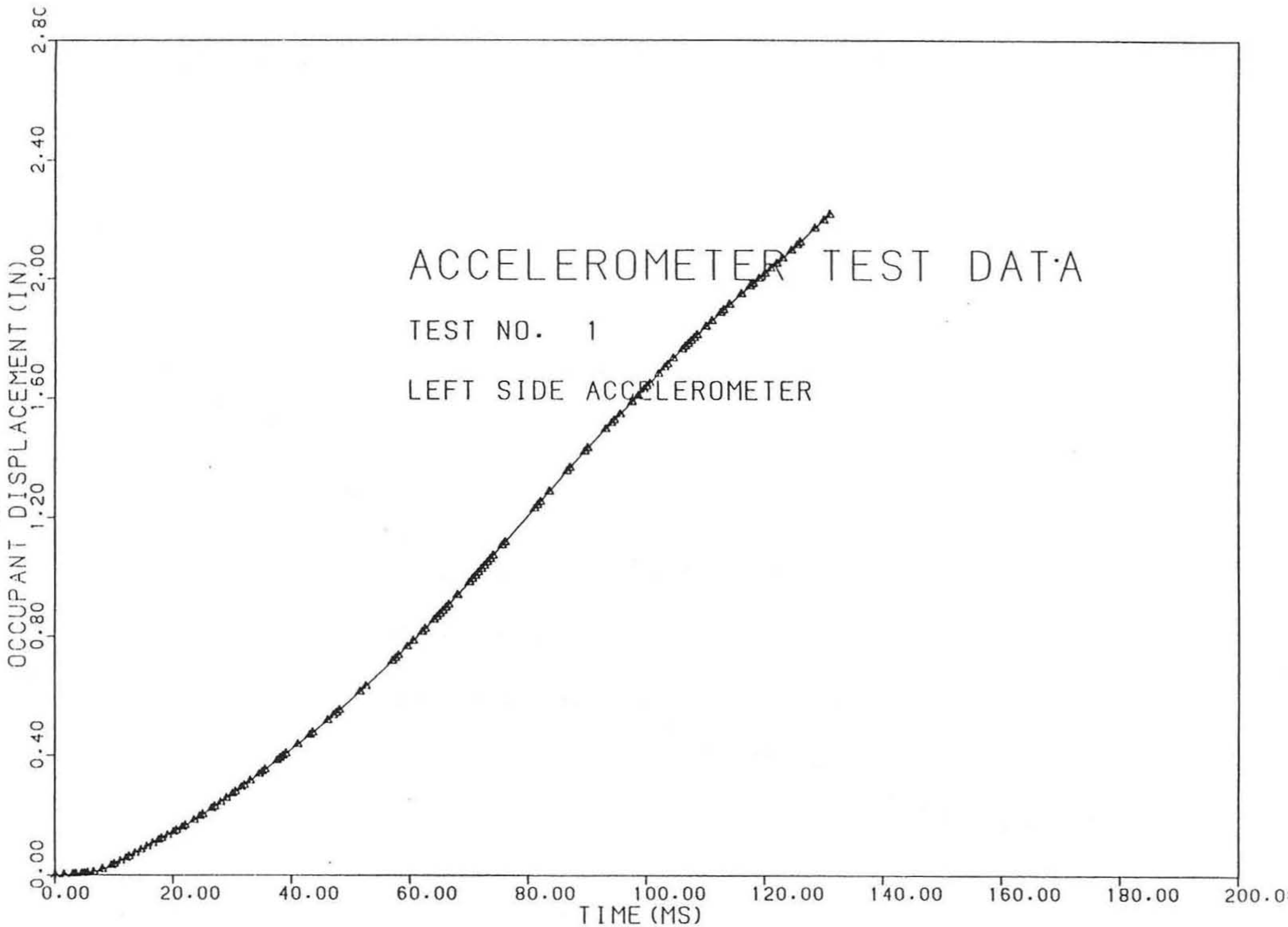


Figure 29. Occupant Displacement Versus Time, Test 1

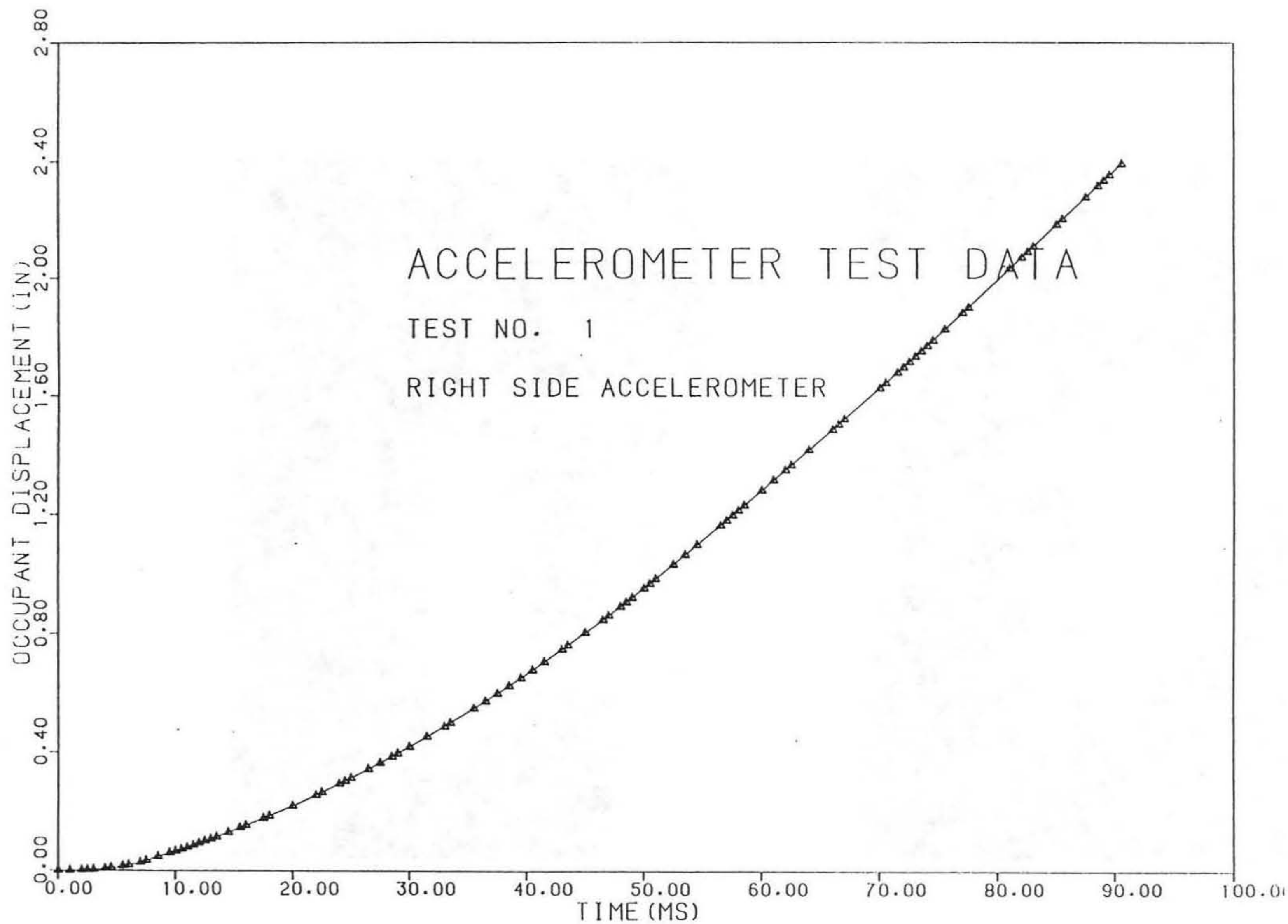


Figure 30. Occupant Displacement Versus Time, Test 1

Figure 31. Damages To Test Vehicle, Test 1

TEST NO. 2

A summary of the results of Test 2 is given in Table 5. The sequential photos taken from the high-speed film are shown in Figure 32. Table 6 gives the time-event summary. Upon impact, the post began to wrap around the bumper, and then the mailbox hit the front end of the hood. As the car continued to travel over the mailbox assembly, the top section of the post broke away from the base post, which remained in the ground. This demonstrated the breakaway or slip feature. Photos of the damage to the mailbox system are presented in Figure 33. Figure 34 shows the position of the base post after impact.

Figures 35 through 40 show deceleration, change in velocity, and occupant displacement versus time.

The only damages to the vehicle were a small dent in the front end of the hood and a minor dent in the bumper and front lower right fender as shown in Figure 41. Table 5 gives the TAD and VDI damage ratings.

TABLE 5. SUMMARY OF RESULTS, TEST 2.

Impact Velocity = 21.3 mph

Actual Impact Severity = 27.9 ft-kips

<u>MAILBOX SUPPORT DATA</u>

Mailbox	2 boxes (size 1-A)
Post Type	Steel U-post *
Size	2.00 lbs/ft
Embedment Method	Driven into Strong Soil (S-1)
Embedment Depth	37 in.

<u>VEHICLE DATA</u>

Make	Volkswagon
Model	Rabbit
Year	1979
Weight	1840 lbs.
Impact Point	14 in. to right of center

ACCELEROMETER DATA	Left		Right
Change in Velocity (ft/sec)	2.7		3.3
Duration of Event (sec)**		0.100	
Peak Deceleration (g's)	7.5		13.2
Maximum 0.010 sec Average Deceleration (g's)	3.62		4.03
Occupant Displacement (in)	2.20		1.80

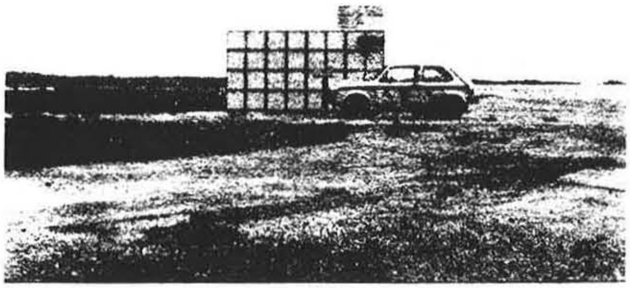
<u>VEHICLE DAMAGE CLASSIFICATION</u>

TAD	None
VDI	12FREE1

Did test article penetrate the passenger compartment?	NO
Was windshield broken?	NO

*Franklin Steel eze-erect sign post

**Time of Contact



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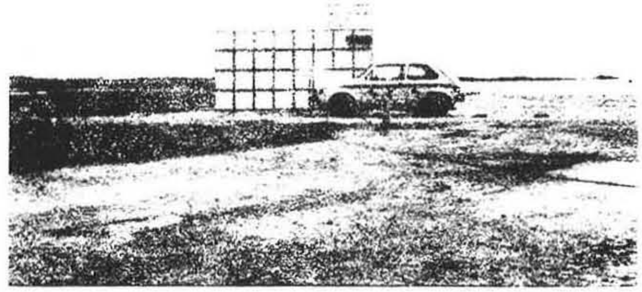

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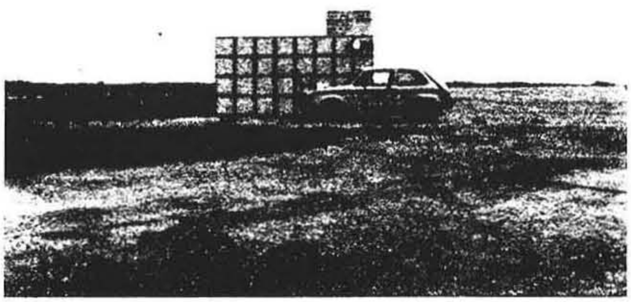

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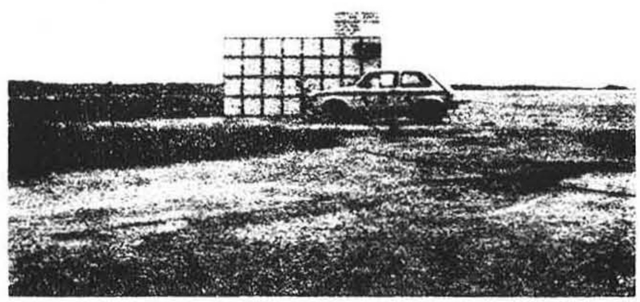

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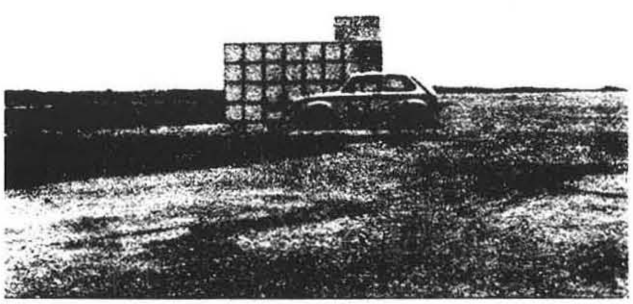

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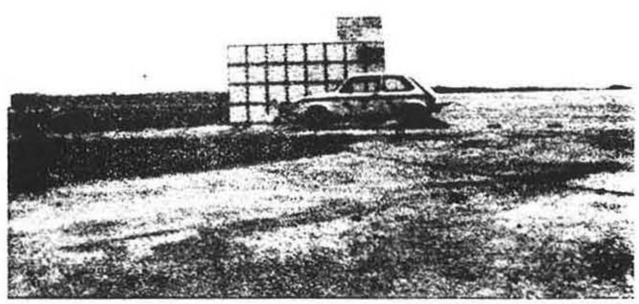


0.118 sec

Figure 32. Sequential Photos, Test 2

TABLE 6. TIME-EVENT SUMMARY FOR TEST 2.

TIME (sec)	EVENT
0.000	Impact
0.008	Post begins bending
0.037	Post wrapping around bumper
0.052	Mailbox hits front end of hood
0.101	Mailbox and post being pushed over
0.118	First mailbox hits ground

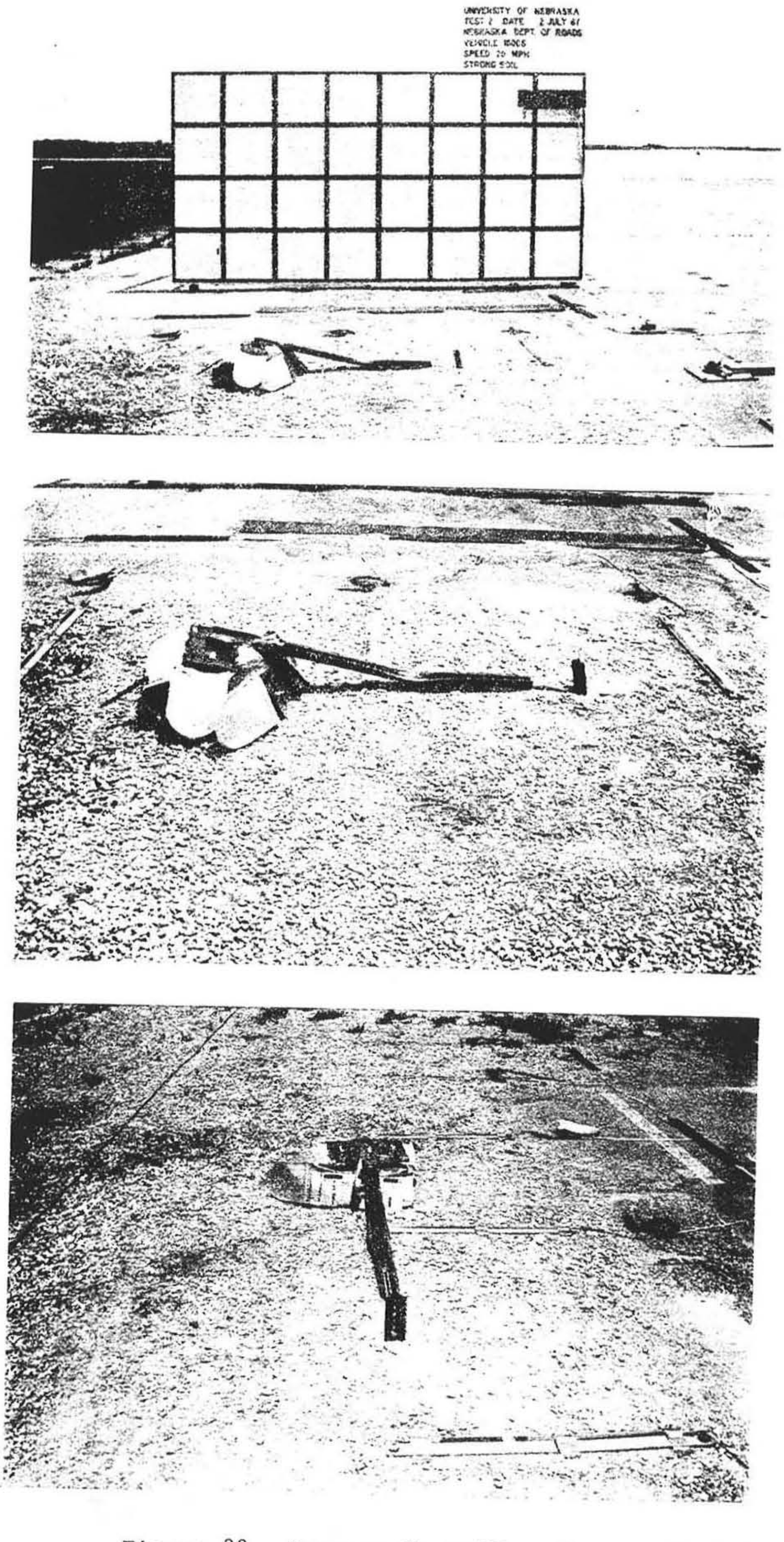


Figure 33. Damages To mailbox System, Test 2

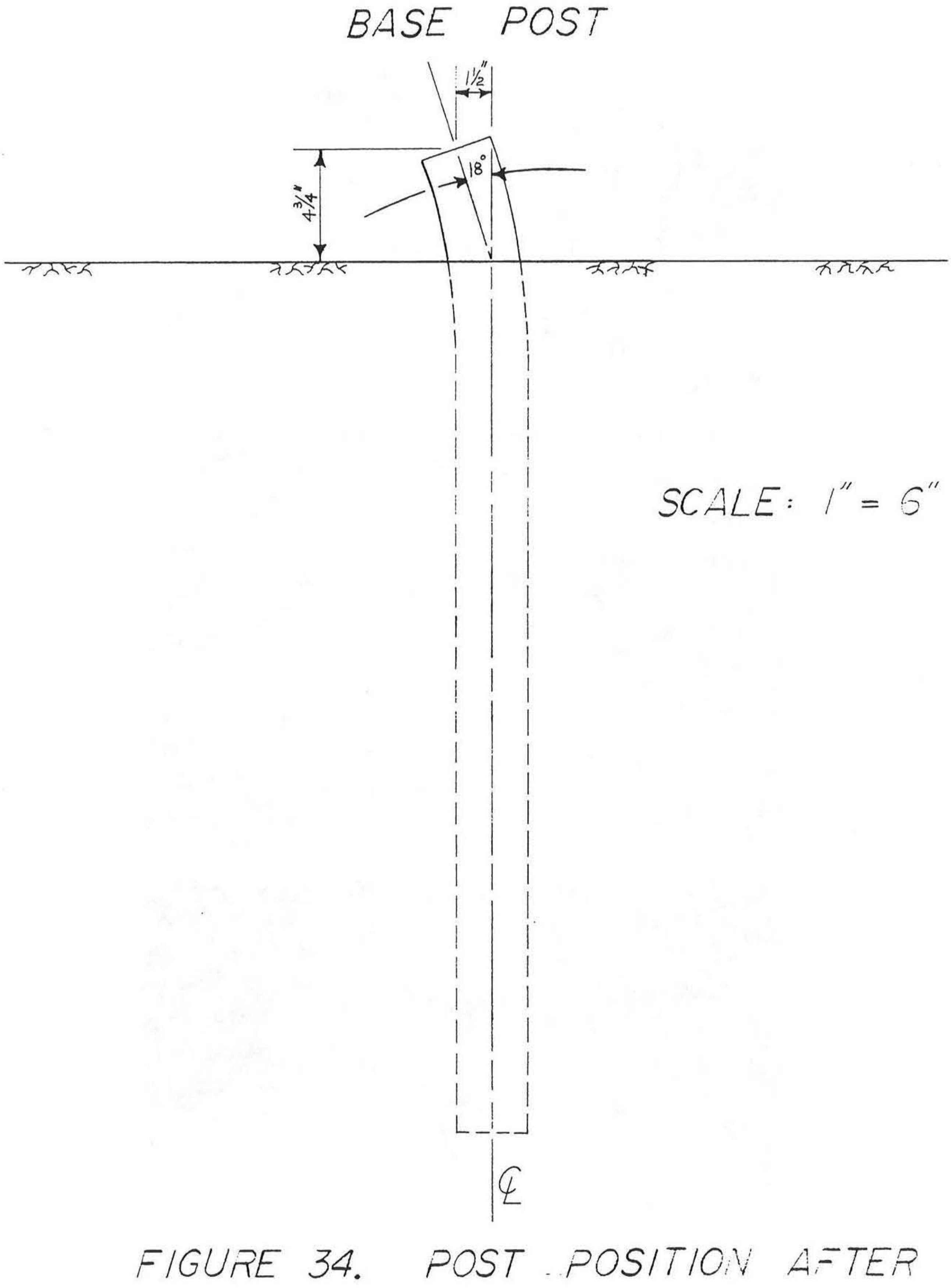


FIGURE 34. POST POSITION AFTER IMPACT, TEST 2

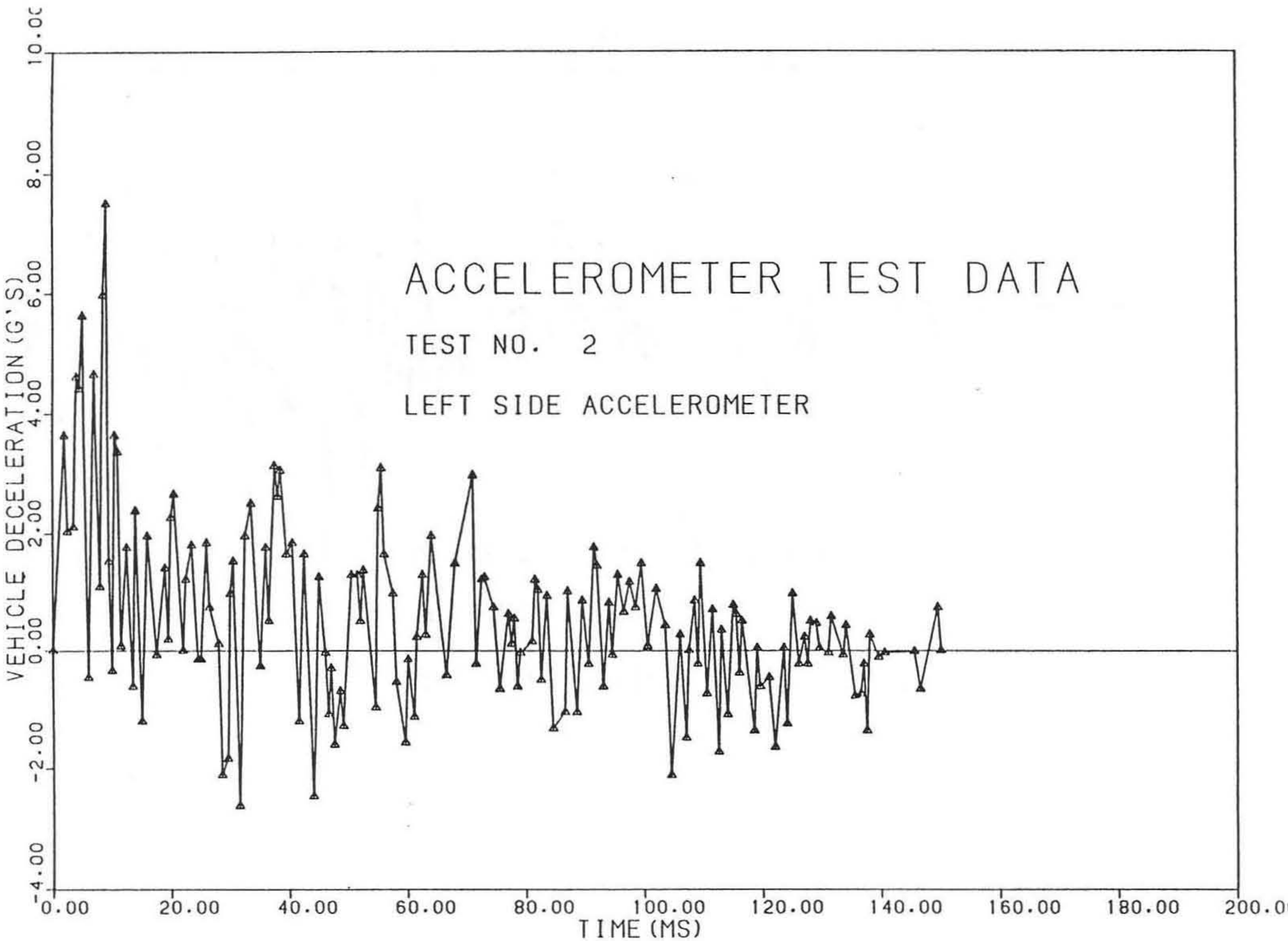


Figure 35. Vehicle Deceleration Versus Time, Test 2

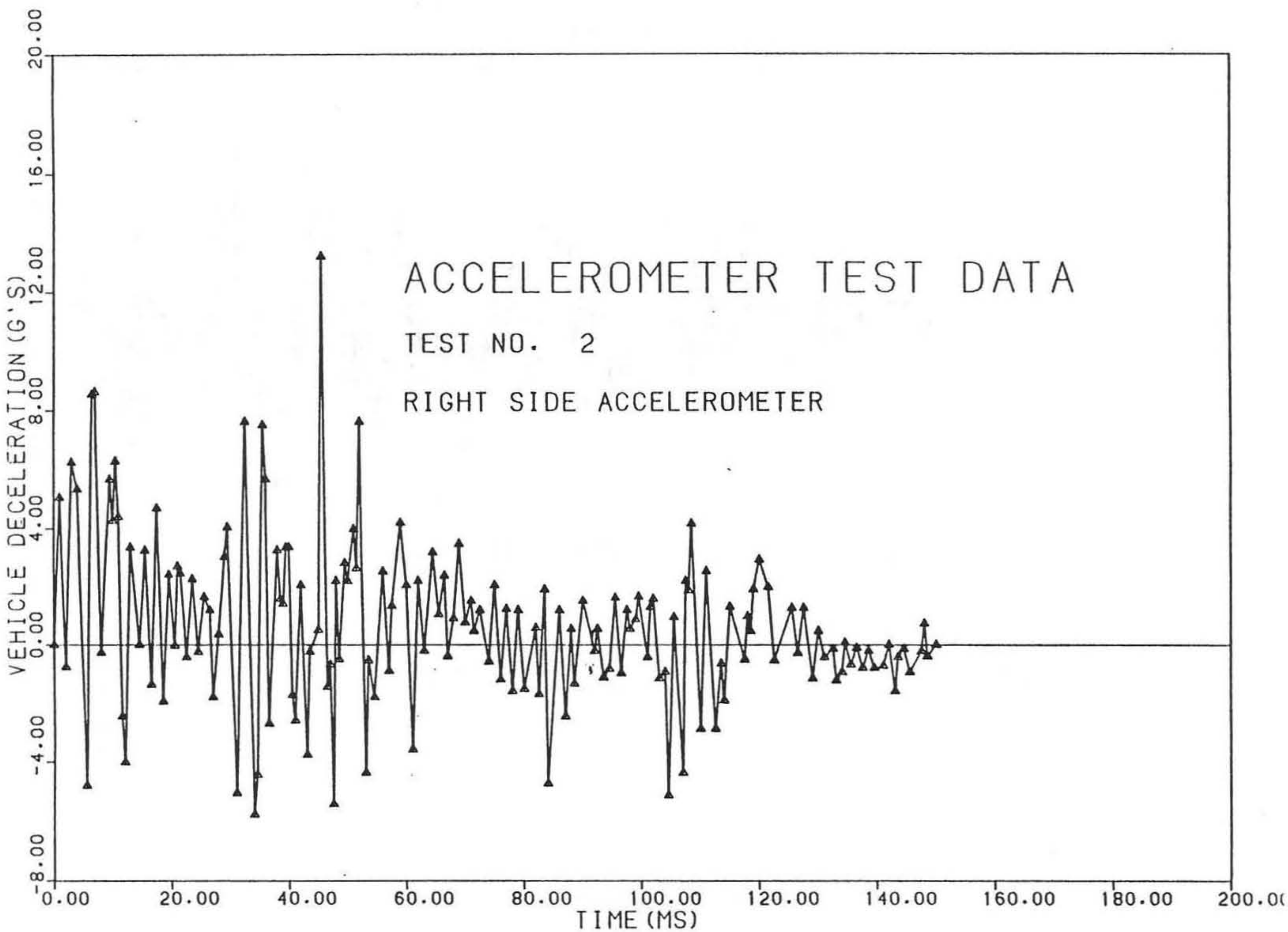


Figure 36. Vehicle Deceleration Versus Time, Test 2

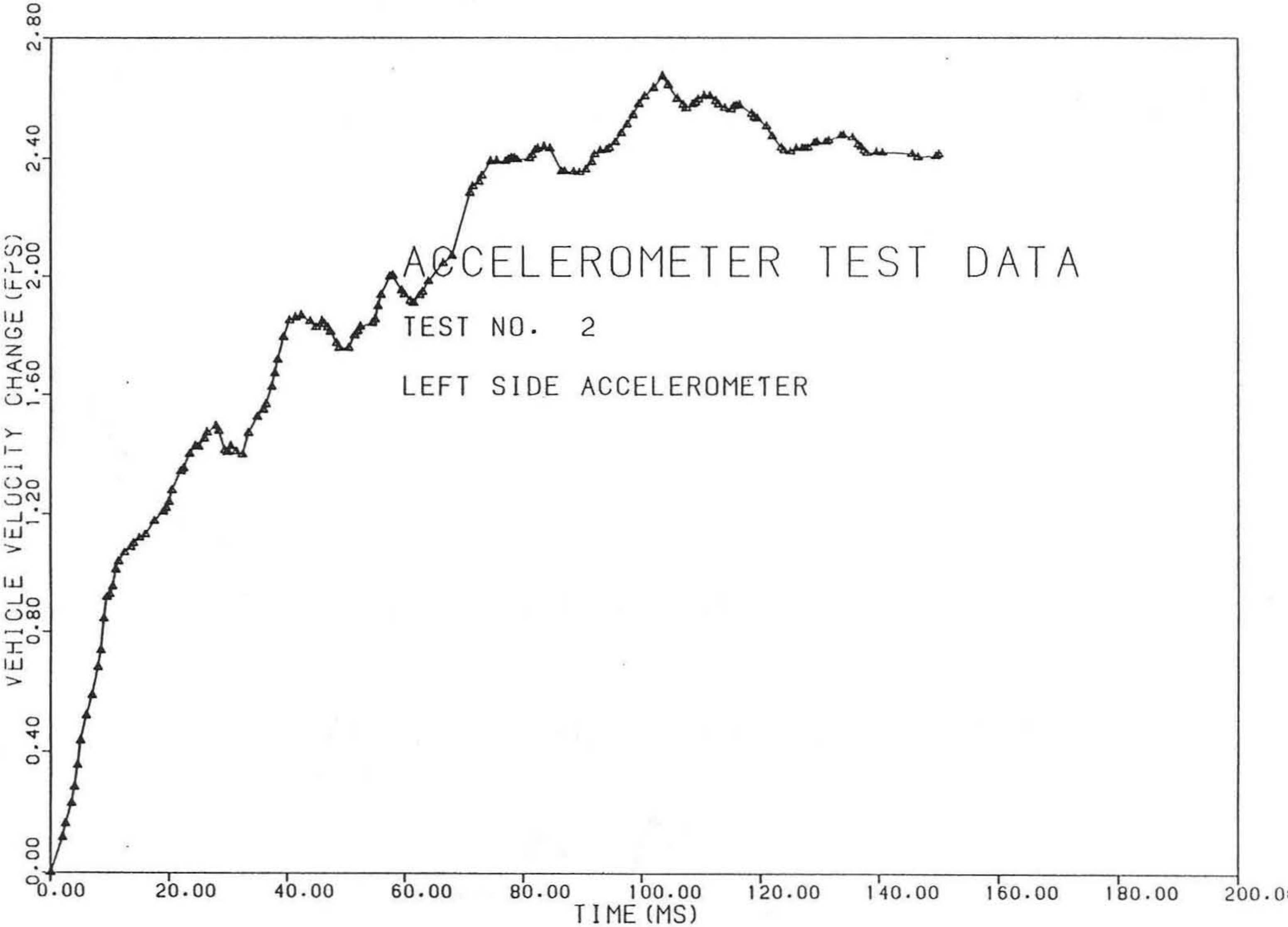


Figure 37. Vehicle Velocity Change Versus Time, Test 2

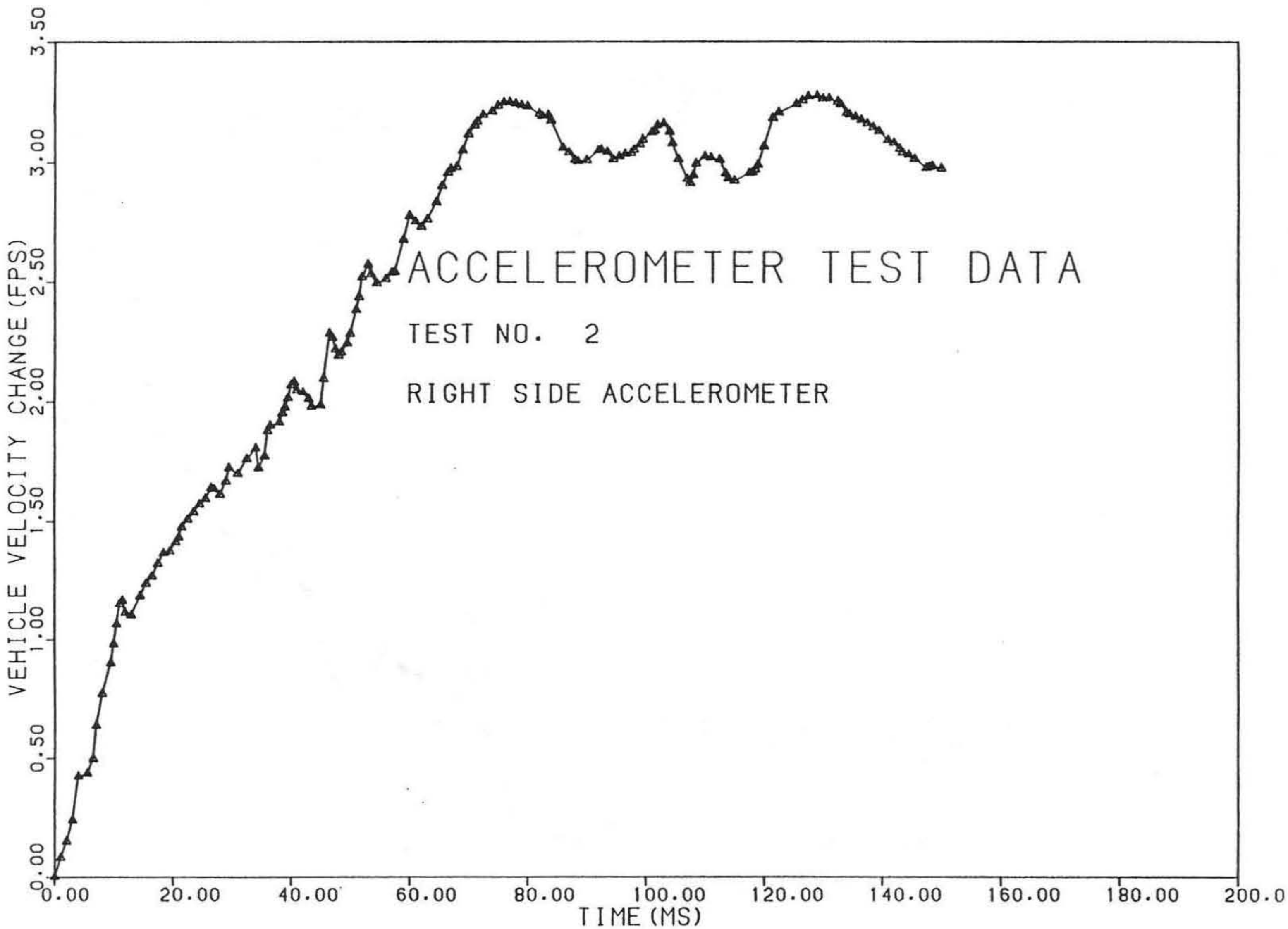


Figure 38. Vehicle Velocity Change Versus Time, Test 2

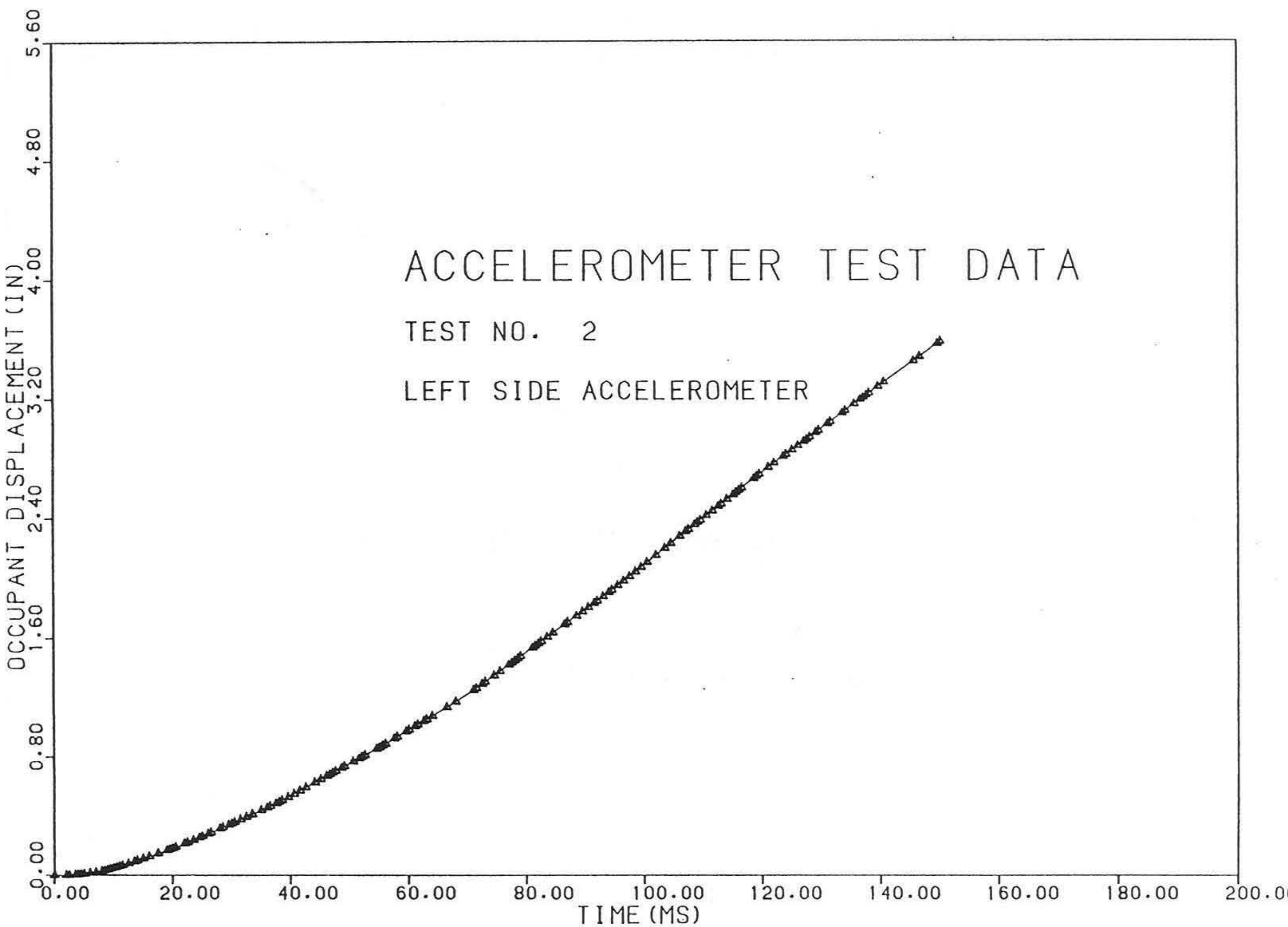


Figure 39. Occupant Displacement Versus Time, Test 2

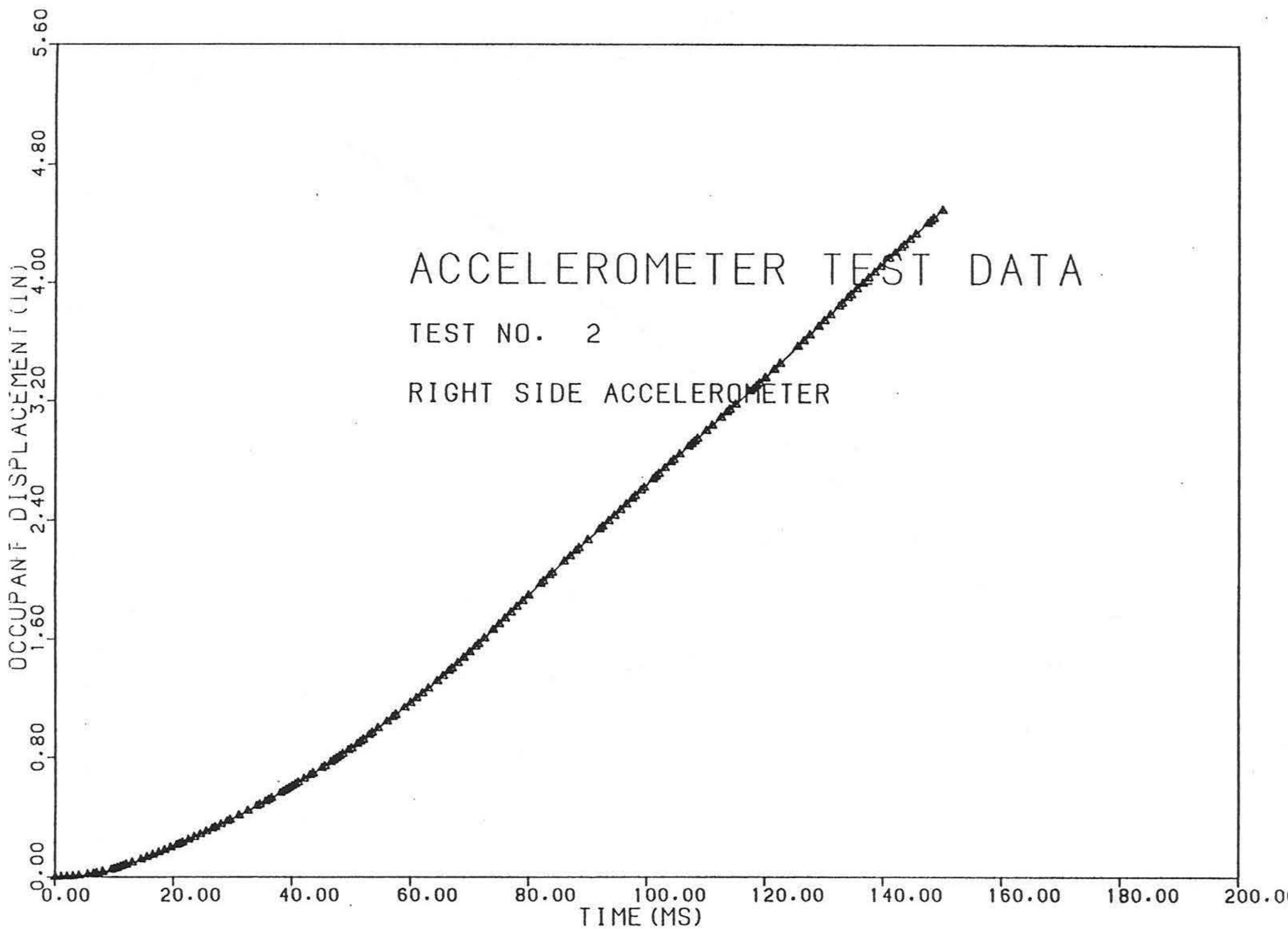


Figure 40. Occupant Displacement Versus Time, Test 2

Figure 41. Damages To Test Vehicle, Test 2

TEST NO. 3

The results of Test 3 are shown in Table 7, and the sequential photos from the high-speed film are presented in Figure 42. The time-event summary is given in Table 8. After impact, the post wrapped around the bumper while the mailbox struck the hood of the car. As the car traveled forward, the mailbox remained on the hood while the post assembly was pulled from the ground. At approximately 0.090 sec after impact, the mailbox assembly started to lose contact with the hood. The base post, top post, and mailbox all remained intact after they came to a rest 366 feet away, when it was run over by the vehicle. Damage to the mailbox system is shown in the photos given in Figure 43.

During Test 3, the data cable, between the onboard metraplex unit and tape recorder, became tangled with the car cable guidance system. Thus, the cable broke before the car had reached the impact point and no accelerometer data was recorded. The NDOR decided not to re-run the test because the needed information could be obtained from the high-speed film and also the vehicle remained stable and upright during and after collision.

The most noticeable damages to the vehicle were a punctured and dented hood and a busted plastic grill plate as shown in Figure 44. The TAD and VDI damage ratings are given in Table 7.

TABLE 7. SUMMARY OF RSULTS, TEST 3.

Impact Velocity = 63.6 mph

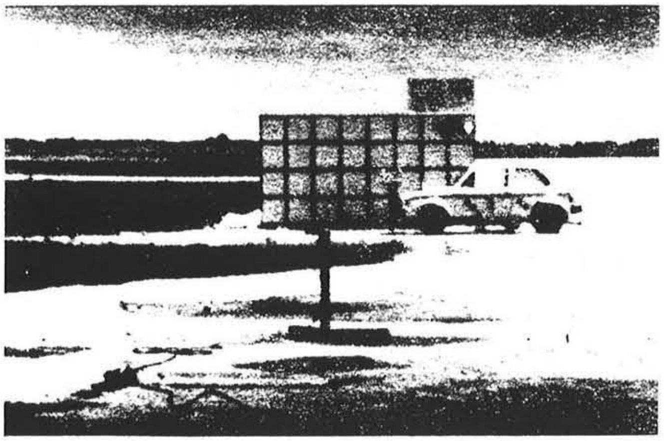
Actual Impact Severity = 248.6 ft-kips

MAILBOX SUPPORT DATA		
Mailbox	2 boxes (size 1-A)	
Post Type	Steel U-post *	
Size	2.00 lbs/ft	
Embedment Method	Driven into Weak Soil (S-2)	
Embedment Depth	37 in.	
VEHICLE DATA		
Make	Volkswagon	
Model	Rabbit	
Year	1979	
Weight	1840 lbs.	
Impact Point	Center of bumper	
ACCELEROMETER DATA	Left	Right
Change in Velocity (ft/sec)***	4.4 (Photec)	4.5 (Locam)
Duration of Event (sec)**	0.090	
Peak Deceleration (g´s)	Not Available	
Maximum 0.010 sec Average Deceleration (g´s)	Not Available	
Occupant Displacement (in)	Not Available	
VEHICLE DAMAGE CLASSIFICATION		
TAD	FC-1	
VDI	12TFCN5	
Did test article penetrate the passenger compartment?	NO	
Was windshield broken?	NO	

*Franklin Steel eze-erect sign post

**Time of Contact

***From high-speed film analysis



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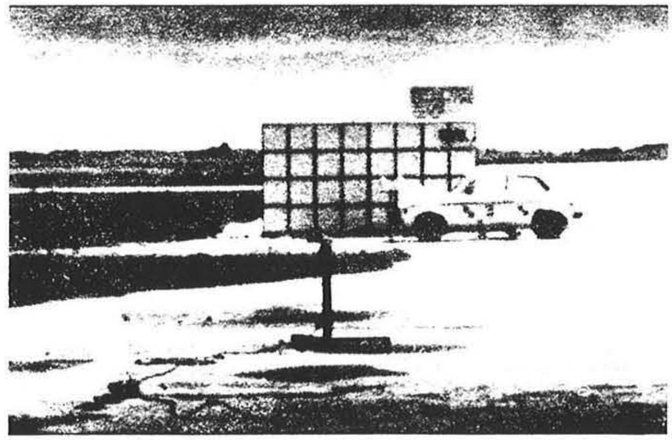

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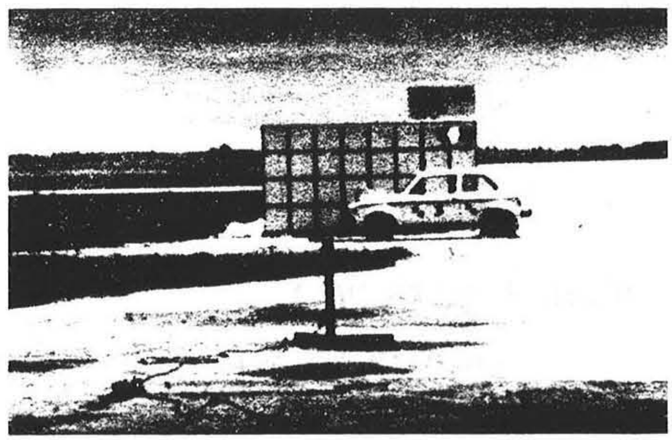
0.006 sec



0.040 sec

0.080 sec

0.090 sec

Figure 42 . Sequential Photos, Test 3

TABLE 8. TIME-EVENT SUMMARY FOR TEST 3.

TIME (sec)	EVENT
0.000	Impact
0.002	Post begins bending
0.006	Post wrapping around bumper
0.016	Mailbox hits hood
0.040	Mailbox on hood and post being pulled out
0.080	Post dragging through sand
0.090	Mailbox loses contact with hood

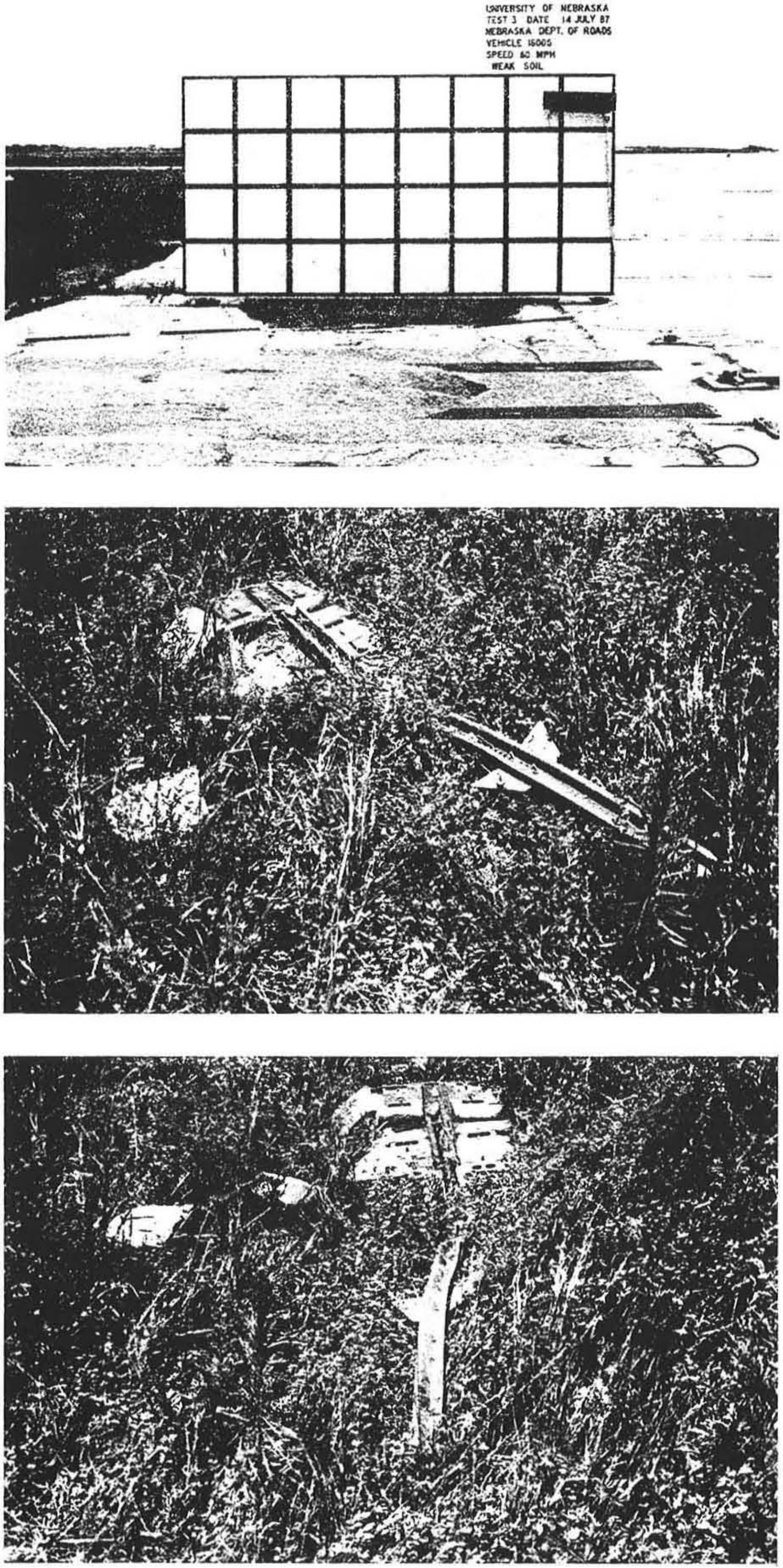


Figure 43 . Damages To Mailbox System, Test 3

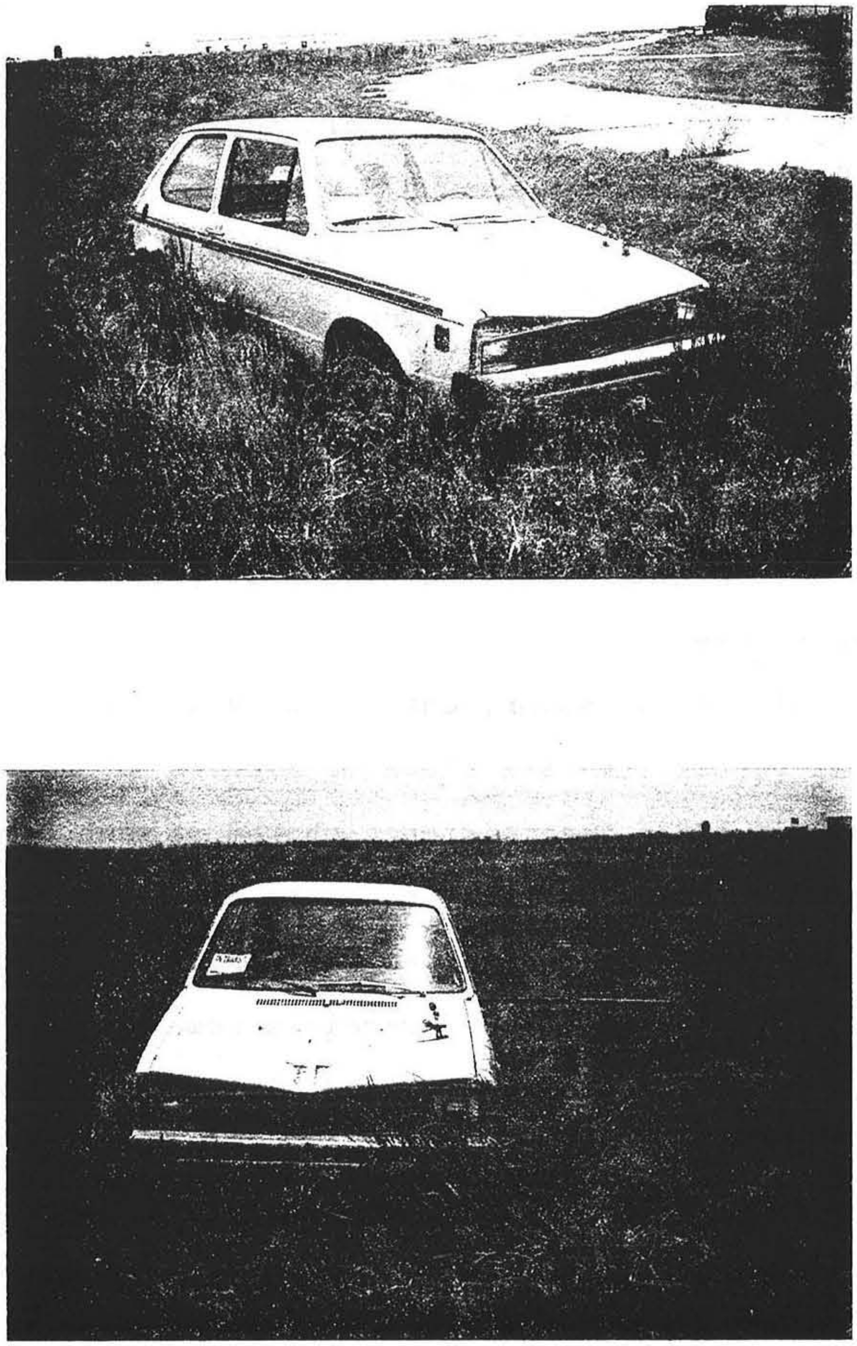


Figure 44. Damages To Test Vehicle, Test 3

TEST NO. 4

A summary of the Test 4 results is given in Table 9. The sequential photos are shown in Figure 45 and time-event summary is given in Table 10. As the vehicle moved through the impact, the mailbox post wrapped around the bumper, and then the top section of the post separated from the base post. The base post remained embedded in the soil. The mailbox then struck the hood and was carried for a distance before being thrown from the car. The final resting place of the mailbox assemble was 130 feet from the point of impact. Photos of the damaged mailbox can be viewed in Figure 46. A diagram of the base post position after impact is shown in Figure 47.

Plots of deceleration, change in velocity, and occupant displacement versus time are shown in Figures 48 through 53. It is noted that a minor inconsistency showed up when comparing the results obtained from the left and right accelerometers.

The vehicle's hood received the most significant damage although the center grill area received some dents as shown in Figure 54. Table 9 gives the TAD and VDI damage ratings for Test 4.

TABLE 9. SUMMARY OF RESULTS, TEST 4.

Impact Velocity = 64.5 mph

Actual Impact Severity = 255.7 ft-kips

MAILBOX SUPPORT DATA

Mailbox	1 box (size 2)
Post Type	Steel U-post*
Size	2.00 lbs/ft
Embedment Method	Driven into Strong Soil (S-1)
Embedment Depth	37 in.

VEHICLE DATA

Make	Volkswagon
Model	Rabbit
Year	1979
Weight	1840 lbs.
Impact Point	Center of bumper

ACCELEROMETER DATE	Left		Right
Change in Velocity (ft/sec)	2.7		1.1
Duration of Event (sec)**		0.048	
Peak Deceleration (g's)**	21.2		26.1
Maximum 0.010 sec Average Deceleration (g's)	4.86		4.04
Occupant Displacement (in)	2.1		0.50

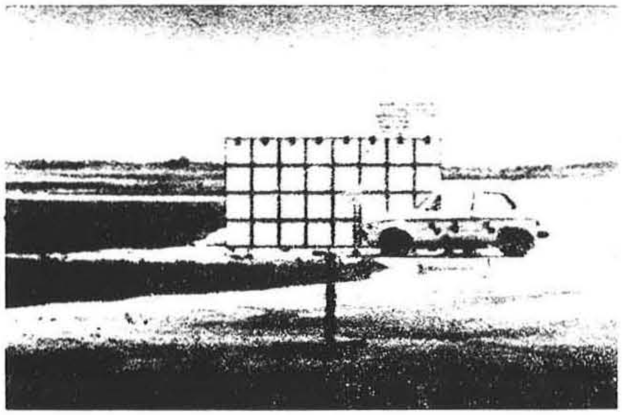
VEHICLE DAMAGE CLASSIFICATION

TAD	FC-1
VDI	12TFDW5

Did test article penetrate the passenger compartment?	NO
Was windshield broken?	NO

*Franklin Steel eze-erect sign post

**Time of Contact



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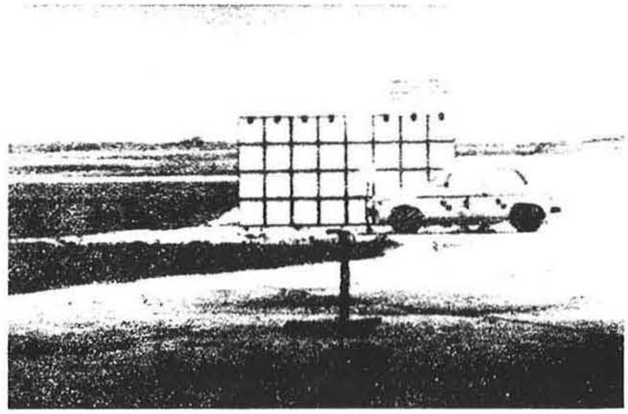

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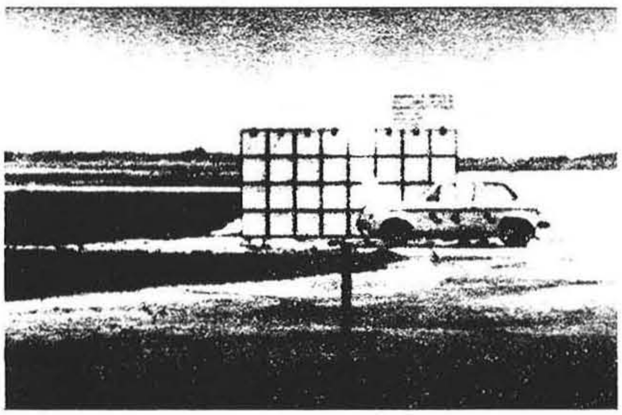

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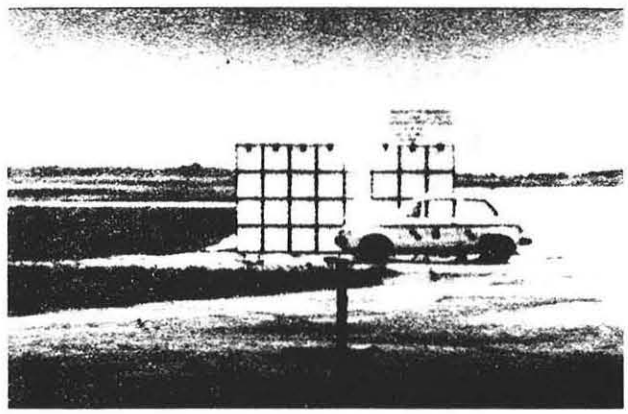

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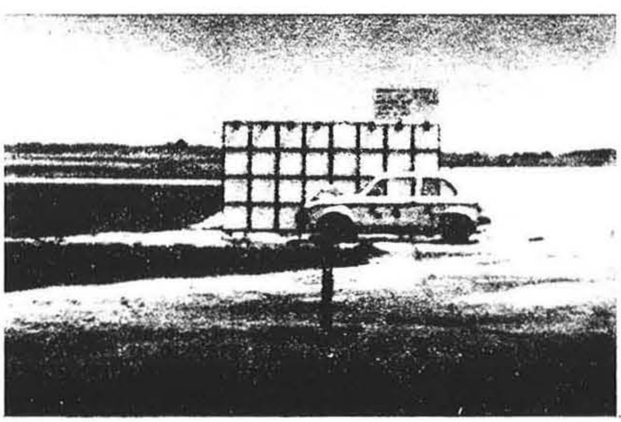

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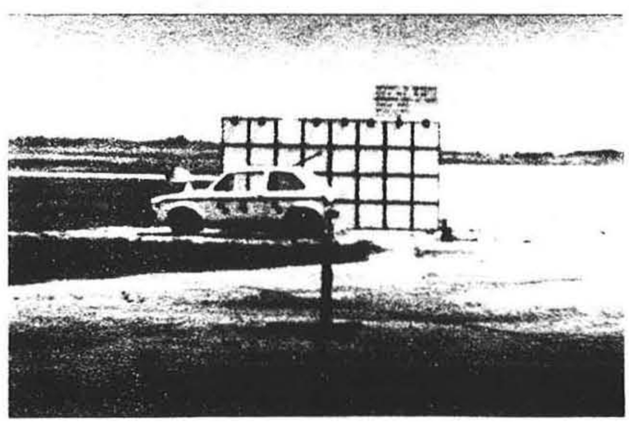

0.148 sec

Figure 45. Sequential Photos, Test 4

TABLE 10. TIME-EVENT SUMMARY FOR TEST 4.

TIME (sec)	EVENT
0.000	Impact
0.002	Post begins bending
0.010	Post wrapping around bumper
0.022	Post separates from base
0.026	Mailbox hits hood
0.040	Mailbox on hood
0.148	Mailbox leaving hood

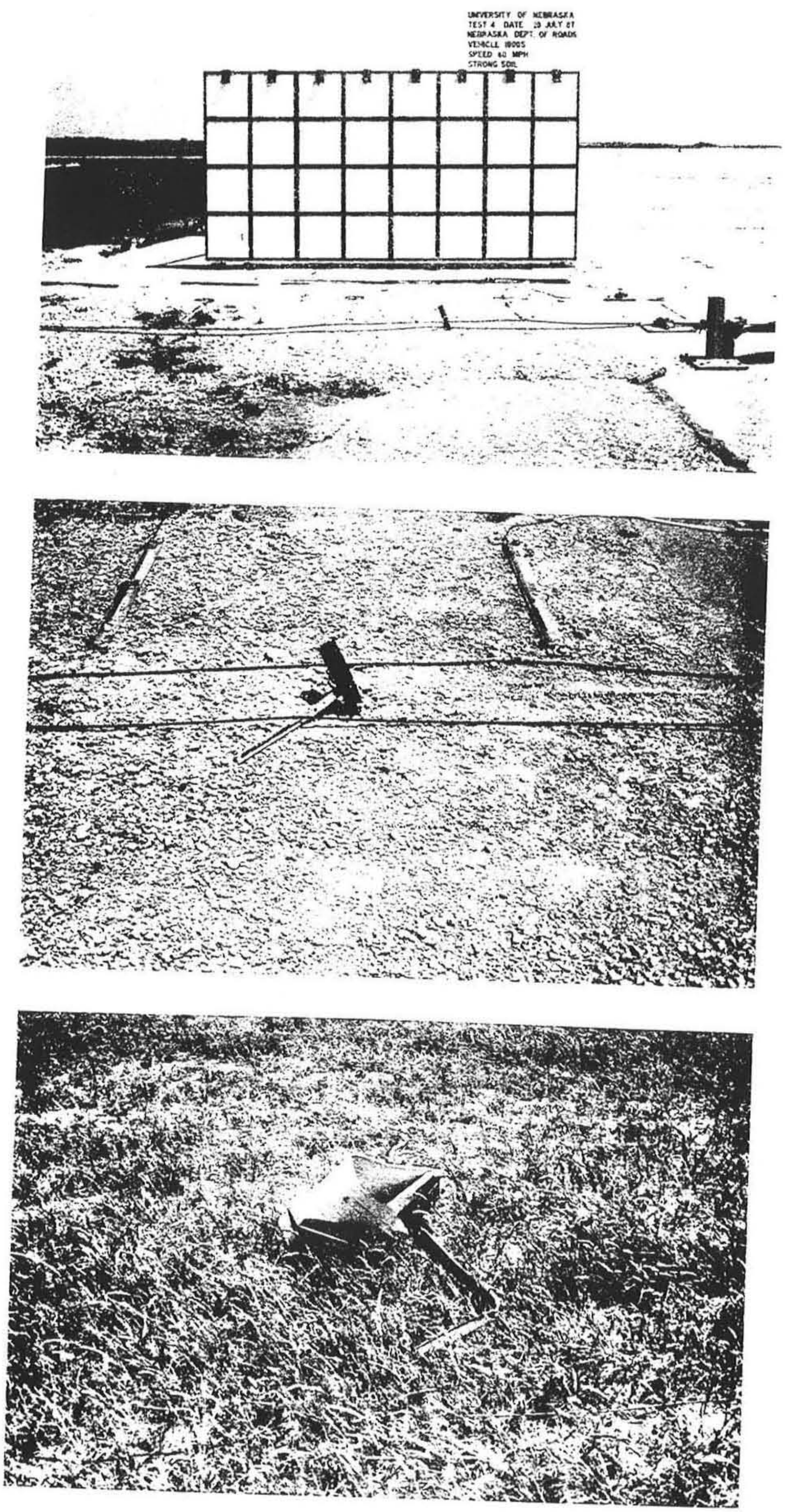

Figure 46. Damages To Mailbox System, Test 4

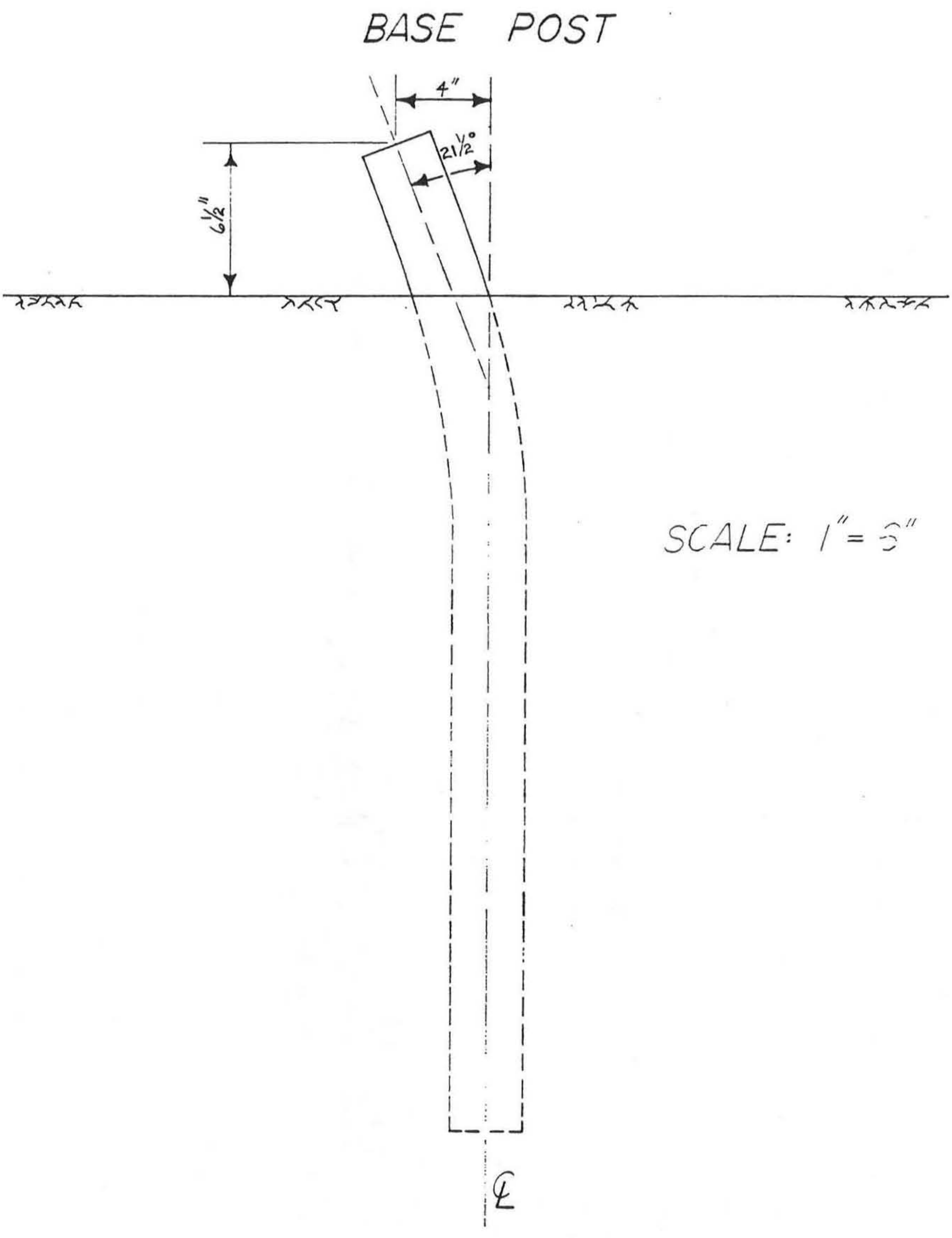

FIGURE 47. POST POSITION AFTER IMPACT, TEST 4

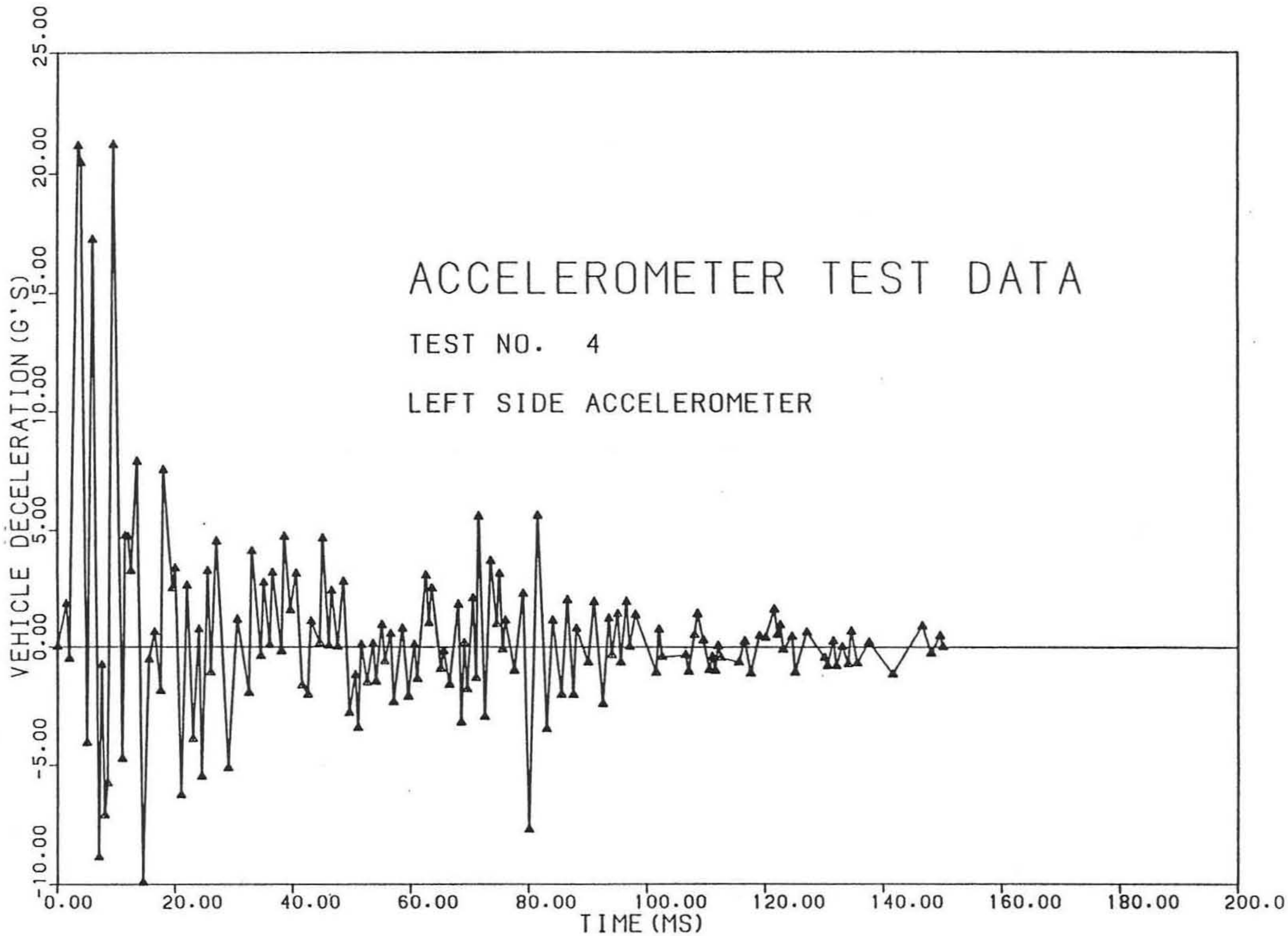

Figure 48. Vehicle Deceleration Versus Time, Test 4

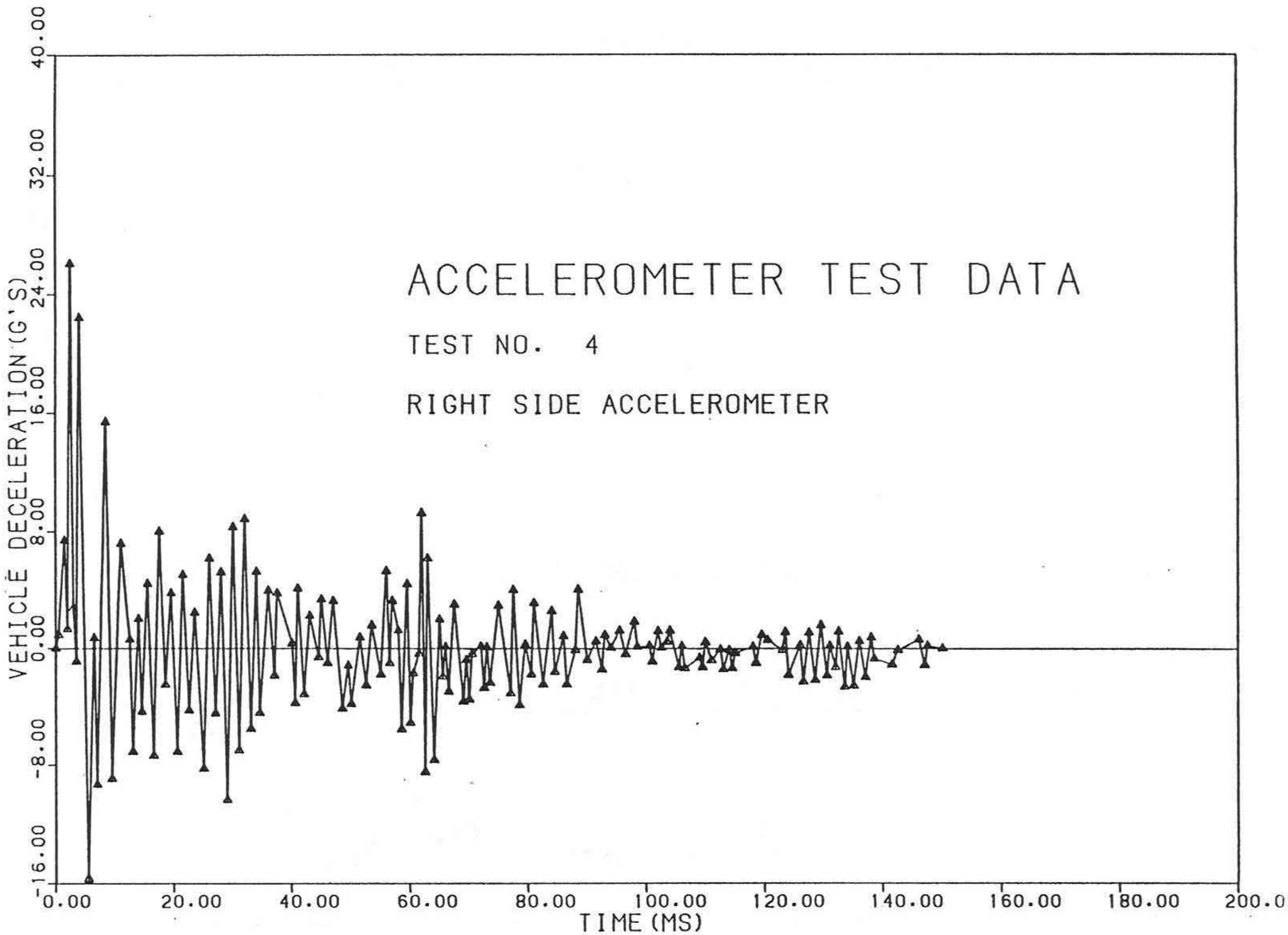

Figure 49. Vehicle Deceleration Versus Time, Test 4

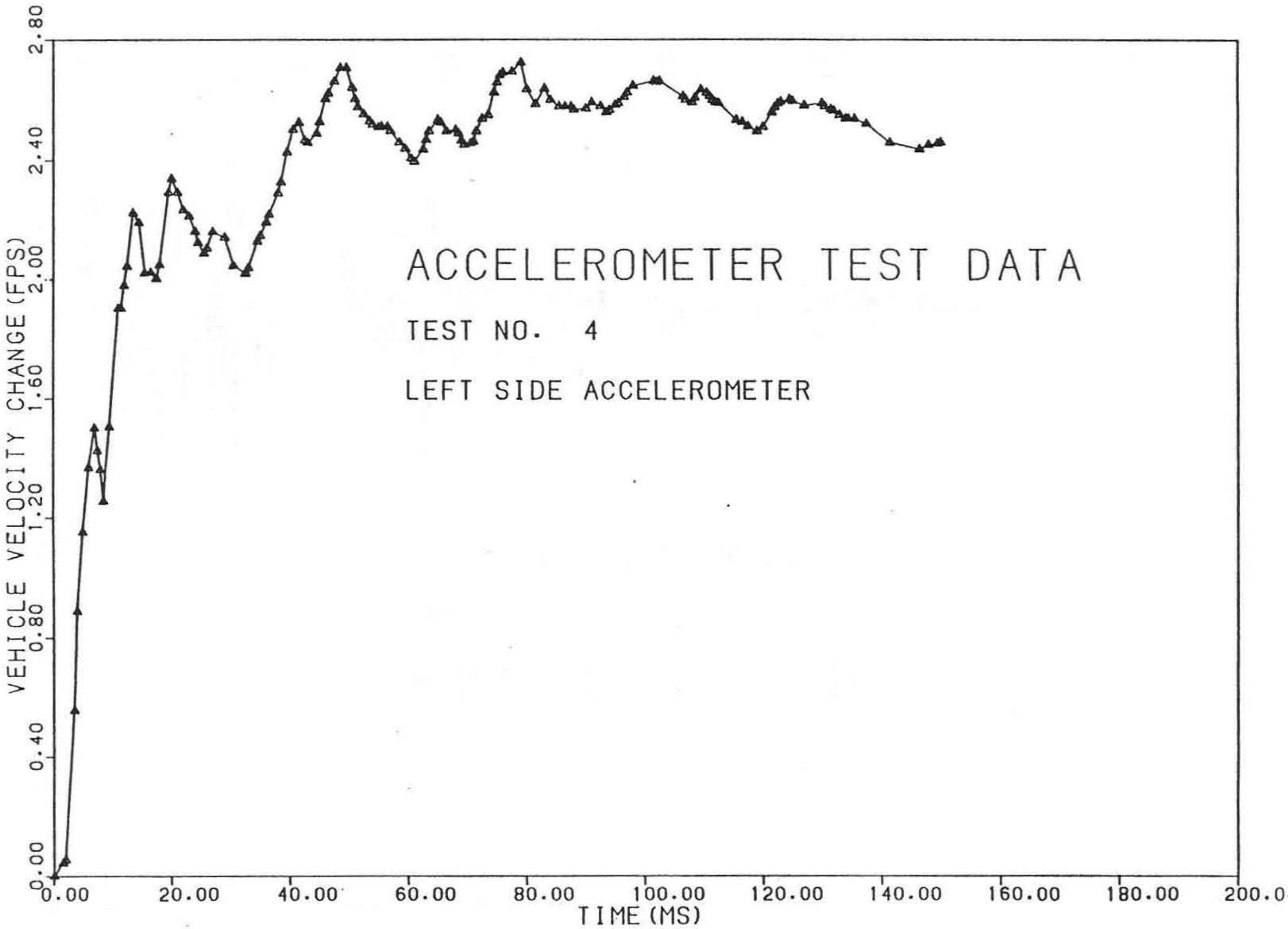

Figure 50. Vehicle Velocity Change Versus Time, Test 4

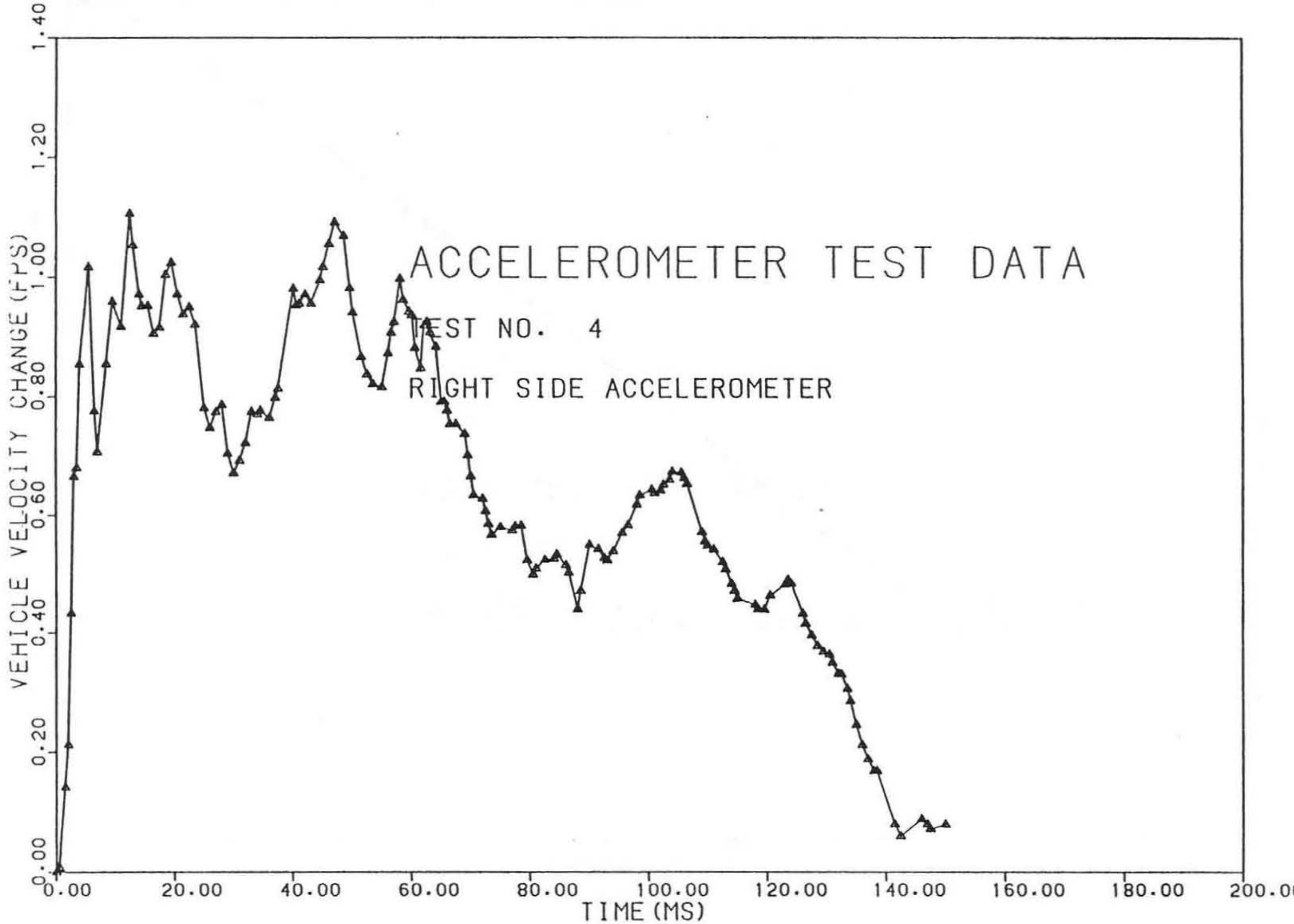

Figure 51. Vehicle Velocity Change Versus Time, Test 4

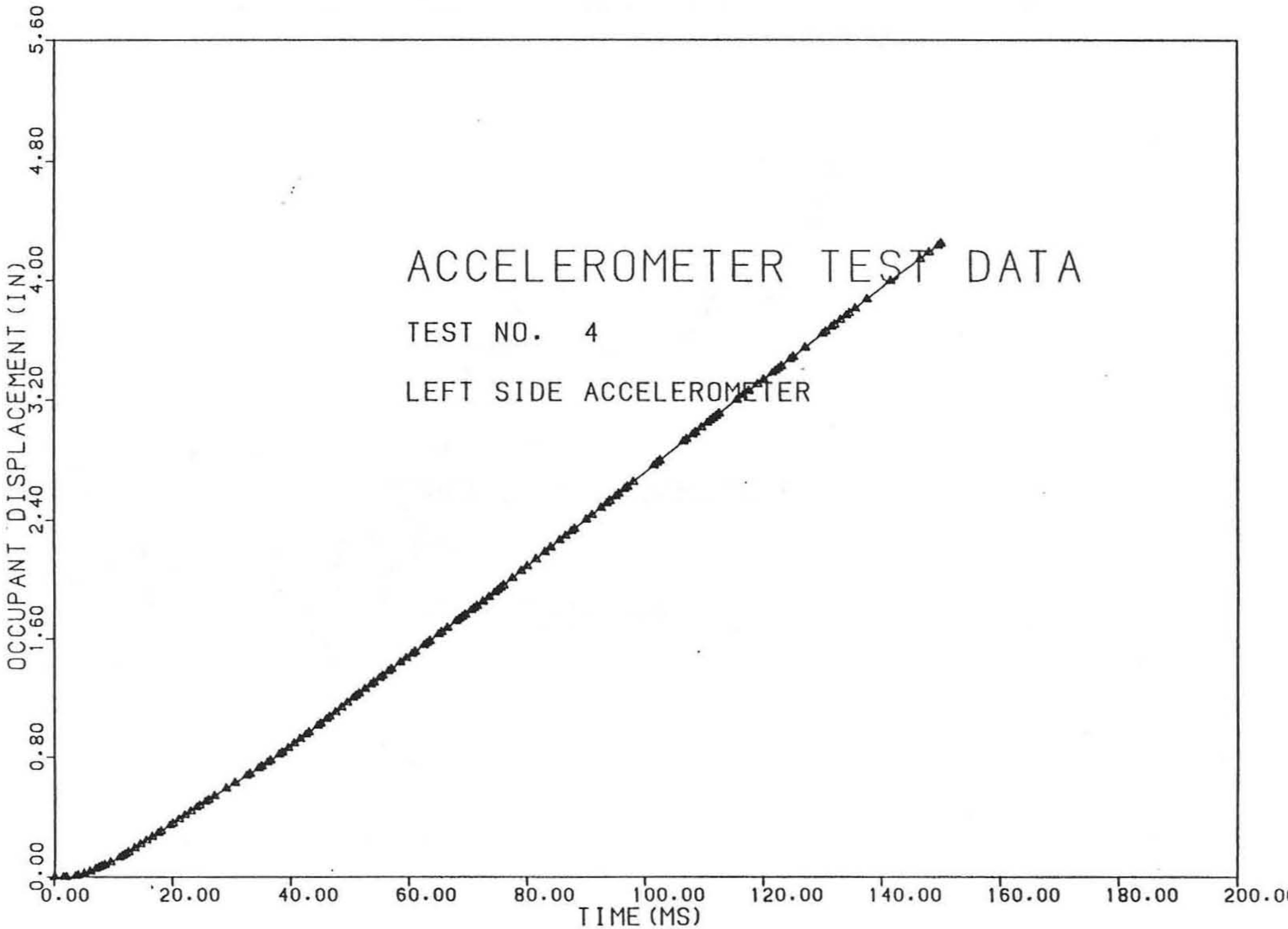

Figure 52. Occupant Displacement Versus Time, Test 4

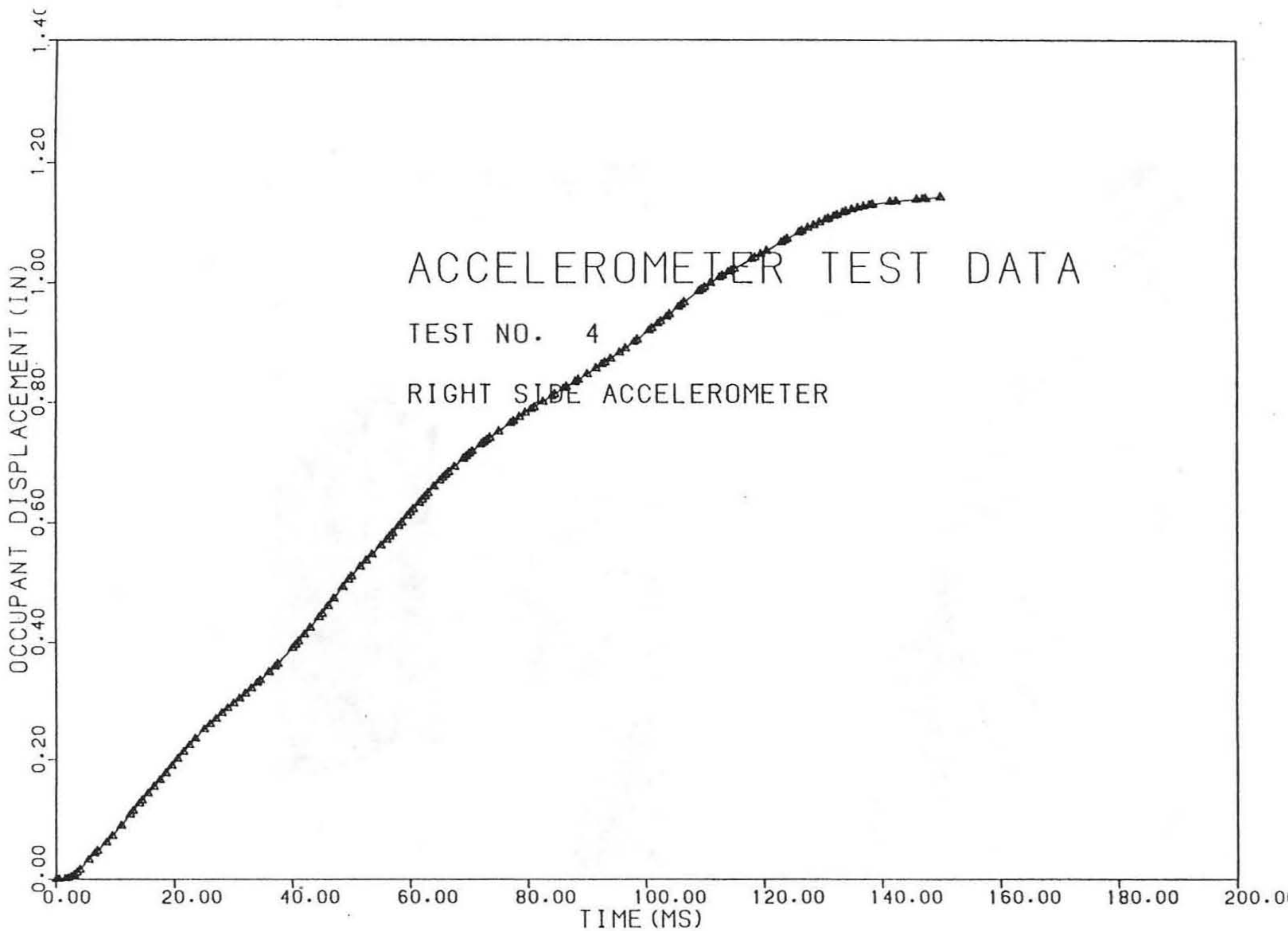

Figure 53. Occupant Displacement Versus Time, Test 4

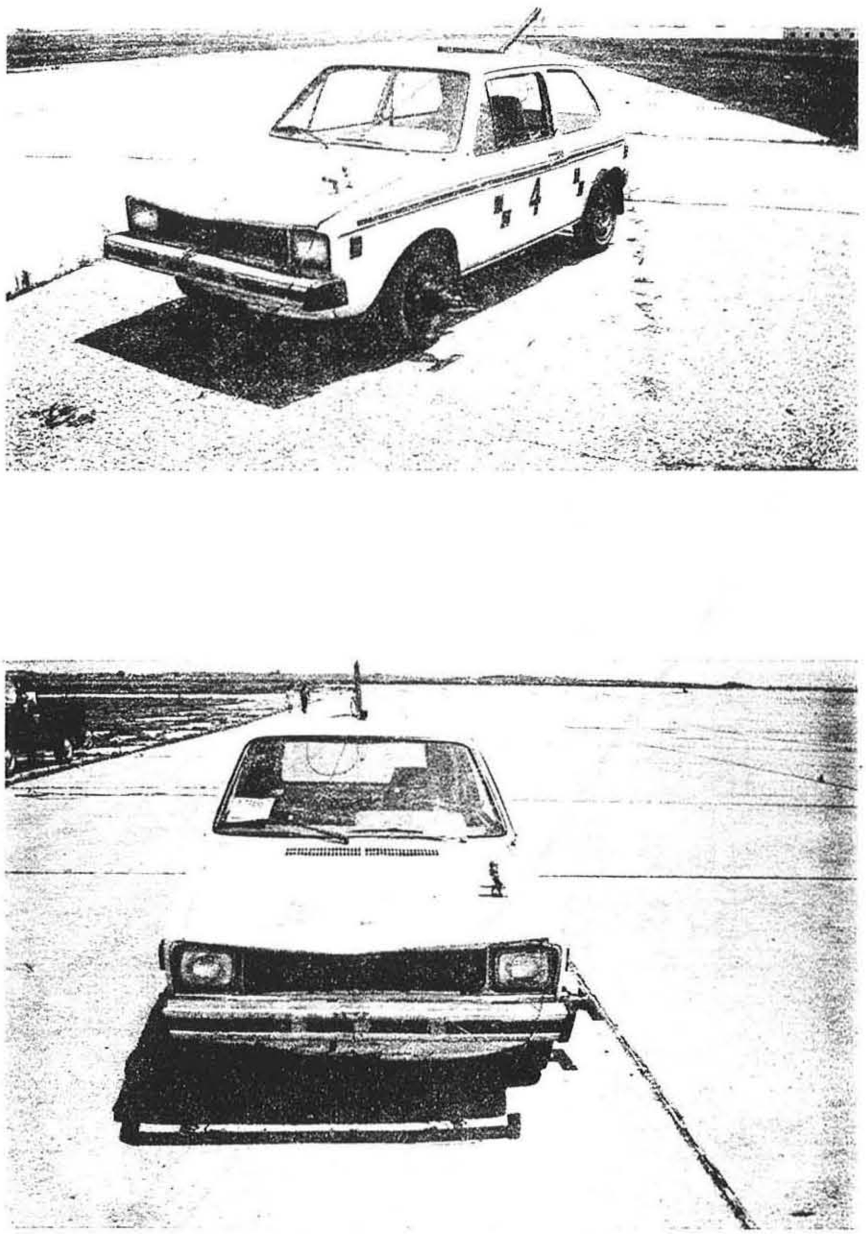

Figure 54. Damages To Test Vehicle, Test 4

CONCLUSIONS

Four full-scale crash tests were conducted to evaluate the impact behavior on two NDOR mailbox support systems. One design used two mailboxes (size 1-A) mounted side-by-side, and the other design consisted of one mailbox (size 2) mounted to the top of the post.

The analysis of the four crash tests revealed the following:

1. In Tests 1 and 3, the actual impact severity was within the recommended limits. During Tests 2 and 4, the actual impact severity exceeded the recommended limits by 3.3% and 1.5%, respectively. Since the error was small, the tests were taken to be valid.
2. In each test the change in velocity of the vehicle was well below the recommended limit of 15 fps and also the preferable limit of 10 fps.
3. In each test where accelerometer data was available, the maximum 0.010 sec average deceleration was well below the recommended limit of 15 g's.
4. In all of the tests, the mailbox support system functioned as intended. It kept the mailbox attached to the top of the post, not allowing any detached fragments or elements to penetrate or show potential for penetration into the passenger compartment.
5. In each test the vehicle remained stable and upright during and after impact and also showed no potential for ramping or rolling over. Also, there were no severe

damages assessed to the vehicle during each of the four tests.

6. The breakaway device functioned as intended for Tests 2 and 4. During Tests 1 and 3, which were conducted in the weak soil, the breakaway device did not function. In Test 1, the post system pushed over allowing the vehicle to safely pass over it. In Test 3, the entire post system pulled out of the ground.

Based upon the above listed items, the results of each test are acceptable according to the NCHRP 230 guidelines.

RECOMMENDATIONS

In order to more securely tighten together the mailbox support system, it was suggested that the circular holes in the platform and L-shaped bracket be either punched to a larger size diameter or punched square so the carriage bolt can fit in the hole.

Also, it was suggested that the support system consisting of the platform plates, the adapter plate, and L-shaped brackets be treated with some type of protective surface coating such as paint or zinc plating. This would reduce the effects of rust on the system and possible mailbox detachment due to weakened steel parts.

REFERENCES

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2. Effenberger, M.J. and Ross, H.E. Jr., "Report on the Static and Dynamic Testing of Franklin's U-Post and Eze-Erect Connection," Final Report to Franklin Steel Company, Project RF 3491, Texas Transportation Institute, Texas A&M University, June, 1977.

3. Ross, H.E. Jr. and Walker, K., "Static and Dynamic Testing of Franklin Steel Signposts," Final Report to Franklin Steel Company, Project RF 3636, Texas Transportation Institute, Texas A&M University, February, 1978.

4. Hinch, J., Yang, T-L, and Owings, R., "Guidance Systems for Vehicle Testing," ENSCO, Inc., Springfield, VA, 1986.

5. "A Guide for Erecting Mailboxes on Highways," American Association of State Highway and Transportation Officials, 1984.

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

7. "Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances," Transportation Research Circular No. 191, Transportation Research Board, Washington, D.C., February, 1978.

8. "Vehicle Damage Scale for Traffic Accident Investigators," Traffic Accident Data Project Technical Bulletin No. 1, National Safety Council, Chicago, Ill., 1971.

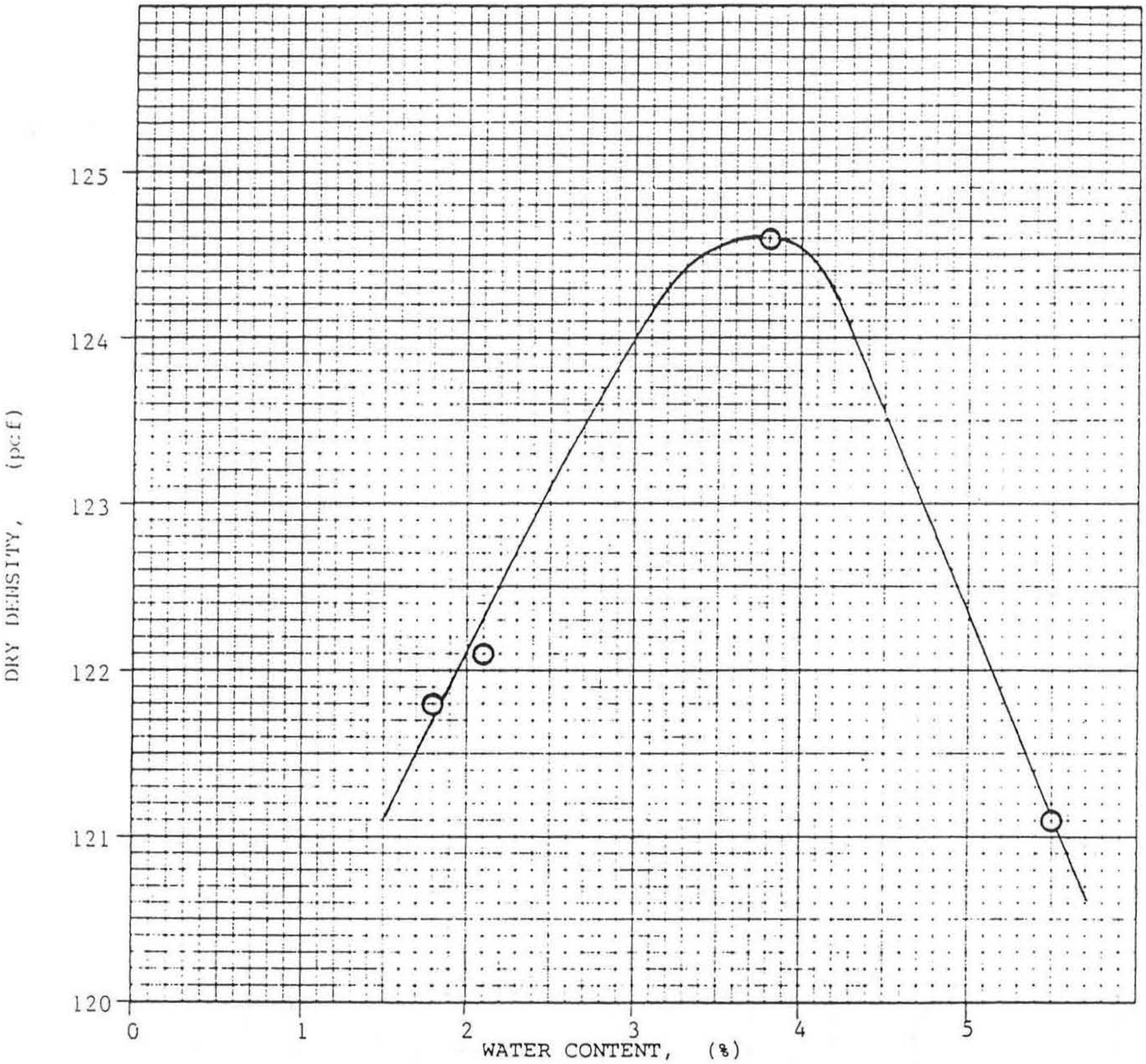
9. "Collision Deformation Classification, Recommended Practice J224 Mar 80," SAE Handbook Vol. 4, Society of Automotive Engineers, Warrendale, Penn., 1985.

APPENDICES

APPENDIX A.

Strong Soil Tests

MOISTURE-DENSITY RELATIONSHIP REPORT



TYPE OF TEST	OPTIMUM DRY DENSITY (pcf)	OPTIMUM WATER CONTENT (%)
ASTM D-698 (ASSHTO T-99)	124.6	3.8

JOB NO.	LAB NO.	DATE TESTED	SUBMITTED BY:
335BL14	A-419	3-26-87	Wm. C. Arneson,

LOCATION SAMPLED	SAMPLE NO.	SAMPLE DEPTH
On Site Stock Pile		
SOIL DESCRIPTION	**ATTERBERG LIMITS**	**SOIL CLASSIFICATION**
Well graded crushed rock	LL____ PL____ PI____	Kirford MA-6 (modified gradation)
PROJECT	**~~ARCHITECT~~/ENGINEER/~~CONTRACTOR~~**	
PROPSOED CRASH SITE	Prof. Post	
LOCATION OF PROJECT	**OWNER**	
North end of Air Guard Landing Apron W Cumming Street and NW 36th Street, Lincoln	University of Nebraska	

GEOTECHNICAL SERVICES, INC.

5730 South 86th Circle	3814 Arch Avenue	4921 North 57th Street
Omaha, Nebraska 68127	Grand Island, Nebraska 68801	Lincoln, Nebraska 68507
402-399-6104	308-381-1987	402-466-8154

COMPACTION TEST REPORT

PROJECT	LOCATION
CRASH SITE	W Cumming Street & NW 36th, Lincoln, NE
TYPE OF TEST	CONTRACTOR
Backfill	Strohmyer
JOB NUMBER: 335BL14	

GEOTECHNICAL SERVICES, INC.
CONSULTING GEOTECHNICAL ENGINEERS AND GEOLOGISTS
Lincoln, Grand Island & Omaha, Nebraska
Salina, Kansas
Ames, Iowa

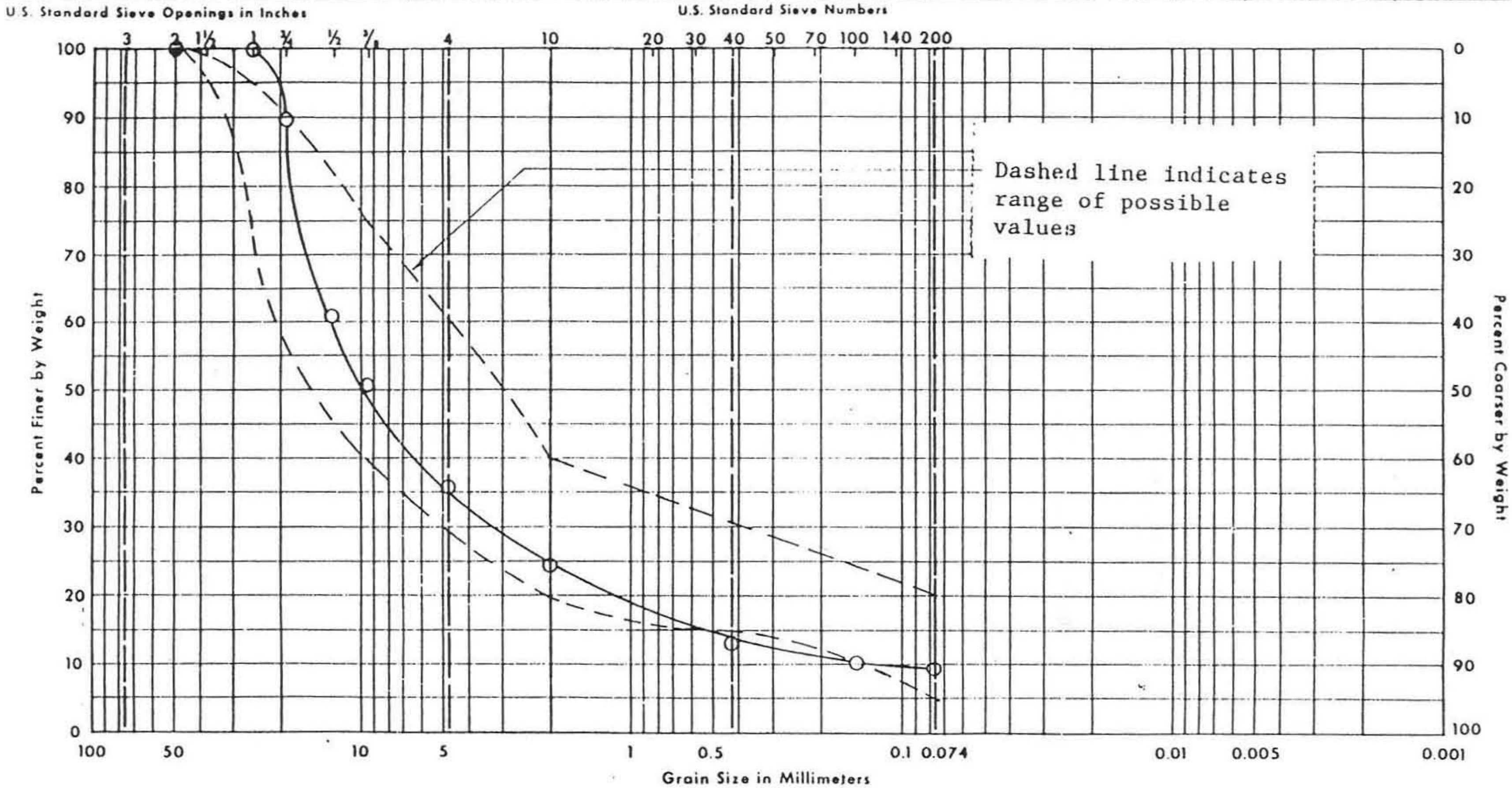
TEST NO	DATE TESTED	LOCATION	DEPTH OF FILL (ft)	SOIL DESCRIPTION	M D RESULTS		REQUIREMENTS		TEST RESULTS		RESULTS			REMARKS
					MAX DENS (pcf)	OPT MOIST (%)	COMP (%)	MOIST ± OPT	DENSITY (pcf)	MOIST (%)	COMP (%)	MOIST ± OPT	PASS FAIL	
D1272 1	RE:3-31-87 3-26-87	North end of runway Air Park in the center of the test site	2-3	Crushed Rock	124.6	3.8	STD 95		110.1	14.8	88	+11.0	FAIL	
D1273 1A	3-27-87	"	"	"	"	"	"		117.8	6.6	95	+ 2.8	PASS	
D1274 2	"	Center of test pit N.end of apron at Crash Site	3-4	Gray Rock	"	"	"		145.5	6.8	100	+ 3.0	PASS	
D1275 3	"	"	Grade	"	"	"	"		118.0	11.8	95	+ 8.0	PASS	

COPIES.
ORIGINAL: File 1-Post
NOTE: Test numbers followed by an alphabetical letter indicates a RETEST.

466 8154

SUBMITTED BY: Wm. C. Arneson
Wm. C. Arneson, P.E.

GRAIN SIZE ANALYSIS CURVES



UNIFIED	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	FINES	
AASHO	GRAVEL		COARSE SAND	FINE SAND	SILT	CLAY

Drill Hole	Sample No.	Sample Depth	LL	PL	PI	Water Cont.%	Classification
							Manufactured gravel base

Project: CRASH SITE

Date: 4-14-87 Job No: 335BL14

GEOTECHNICAL SERVICES, INC.
OMAHA, LINCOLN, GRAND ISLAND AND SALINA

APPENDIX B.

Computer Program

```
C        *    COMPUTER PROGRAM TO COMPUTE  VEHICLE CHANGE IN          *
C        *    VELOCITY AND OCCUPANT IMPACT VELOCITY DURING            *
C        *    HEAD-ON IMPACT WITH SMALL SIGNS                         *
C        *                                                            *
C        **************************************************************
C
C    INPUT DATA NAMES
C
C    NPTS   = NUMBER OF INPUT DATA POINTS
C    ITEST  = TEST NUMBER
C    SPEED  = ACTUAL VEHICLE IMPACT SPEED (MPH)
C    IVEL   = TARGET VEHICLE IMPACT SPEED (MPH)
C    IACCEL = ACCELERATION NUMBER
C                NO. 1....LEFT SIDE
C                NO. 2....RIGHT SIDE
C    ACAL   = ACCELEROMETER CALIBRATION FACTOR (MV/G)
C    A(I)   = ACCELEROMETER DATA (MV)
C    T(I)   = TIME DATA (MSEC)
C
C
      PROGRAM SIGN(MABX4R,OUTPUT,TAPE5=MABX4R,TAPE6=OUTPUT)
      DIMENSION A(1000),T(1000),G(1000),V(1000),SPD(1000),D(1000)
C
      READ(5,400) NPTS,ITEST,IVEL,IACCEL,ACAL,SPEED
      WRITE(6,500) ITEST,SPEED,IACCEL
      WRITE(6,505)
C
      TSUM=0.0
      VEL=0.0
      DISP=0.0
      V(1)=0.0
      D(1)=0.0
      SPD(1)=SPEED*(88.0/60.0)
      J=0
 1000 CONTINUE
      J=J+1
C
      DO 100 I=1,NPTS
      IF(J.EQ.2) GO TO 95
      READ(5,405) A(I),T(I)
      A(I)=(A(I)/(50.0*ACAL))*32.2
      G(I)=A(I)/32.2
   95 CONTINUE
  100 CONTINUE
C
      L=NPTS-1
      DO 200 I=1,L
      TT=(T(I+1)-T(I))/1000.0
      IF(J.EQ.2)GO TO 105
      A1=A(I)
      A2=A(I+1)
      GO TO 110
  105 CONTINUE
      TSUM=TSUM + TT
      A1=SPD(I)
      A2=SPD(I+1)
  110 CONTINUE
      IF( A1 .GE. 0.0 .AND. A2 .GE. 0.0 )GO TO 130
      IF( A1 .LT. 0.0 .AND. A2 .LT. 0.0 )GO TO 150
      IF( A1 .GE. 0.0 .AND. A2 .LT. 0.0 )GO TO 134
      IF( A1 .LT. 0.0 .AND. A2 .GE. 0.0 )GO TO 156
C
C
```

```
      [illegible]
      GO TO 160
C
  154 CONTINUE
      T1=((TT)/(A1-A2))*A1
      T2=TT-T1
      AREA=(0.5*A1*T1) + (0.5*A2*T2)
      GO TO 160

  156 CONTINUE
      T1=((TT)/(-A1+A2))*(-A1)
      T2=TT-T1
      AREA=(0.5*A1*T1) + (0.5*A2*T2)
C
  160 CONTINUE
C
      IF(J.EQ.2)GO TO 170
      VEL=VEL + AREA
      V(I+1)=VEL
      SPD(I+1)=SPEED*(88.0/60.0) - VEL
      GO TO 180
  170 CONTINUE
      DISP=DISP + AREA
      D(I+1)=(SPEED*(88.0/60.0)*TSUM) - DISP
  180 CONTINUE
  200 CONTINUE
C
      IF(J.EQ.1)GO TO 1000
      DO 210 I=1,NPTS
      D(I)=D(I)*12.0
      WRITE(6,510)T(I),G(I),V(I),D(I)
  210 CONTINUE
C
C    WRITE STATEMENTS
C
  500 FORMAT(1H1,///,T43,'A N A L Y S I S',//,T49,'O F',//,T33,
     *         'A C C E L E R O M E T E R   D A T A',////,T45,'TEST NO.',
     *          I2,/,T43,'SPEED',F5.1,T54,'MPH',/,T40,'ACCELEROMETER NO.',
     *          I2)
C
  505 FORMAT(/////,T22,'TIME',T34,'ACCELERATION',T53,'VELOCITY',
     *         T70,'OCCUPANT',/,T54,'CHANGE',T68,'DISPLACEMENT',/,
     *         T21,'(MSEC)',T38,'(G)',T55,'(FPS)',T72,'(IN)',//)
C
  510 FORMAT(T21,F5.1,T37,F5.1,T55,F5.1,T72,F4.1)
C
C
C    READ STATEMENTS
C
  400 FORMAT(4I5,2F10.0)
C
C
  405 FORMAT(2F10.0)
C
C
C
      CALL PLOTS(0,0,1)
      CALL PLOT(0.5,0.5,-3)
      DO 10 I=1,3
      IF(ITEST.EQ.1) GO TO 701
      IF(ITEST.EQ.2) GO TO 702
      IF(ITEST.EQ.3) GO TO 703
      IF(ITEST.EQ.4) GO TO 704
      IF(ITEST.EQ.5) GO TO 705
      IF(ITEST.EQ.6) GO TO 706
      GO TO [illegible]
      [illegible]
```

```
      [illegible]
      GO TO 720
 703  CALL SYMBOL(4.5,4.5,0.15,1H3,0.0,1)
      GO TO 720
 704  CALL SYMBOL(4.5,4.5,0.15,1H4,0.0,1)
      GO TO 720
 705  CALL SYMBOL(4.5,4.5,0.15,1H5,0.0,1)
      GO TO 720
 706  CALL SYMBOL(4.5,4.5,0.15,1H6,0.0,1)
 720  CALL SYMBOL(3.0,4.5,0.15,8HTEST NO.,0.0,8)
      IF(IACCEL.EQ.2) GO TO 721
      CALL SYMBOL(3.0,4.0,0.15,23HLEFT SIDE ACCELEROMETER,0.0,23)
      GO TO 730
 721  CALL SYMBOL(3.0,4.0,0.15,24HRIGHT SIDE ACCELEROMETER,0.0,24)
 730  CONTINUE
      IF(I.EQ.1) GO TO 601
      IF(I.EQ.2) GO TO 602
      IF(I.EQ.3) GO TO 603
 601  CALL PLOT(0.0,7.0,3)
      CALL PLOT(10.0,7.0,2)
      CALL PLOT(10.0,0.0,2)
      CALL PLOT(0.0,2.0,3)
      CALL PLOT(10.0,2.0,2)
      CALL SCALE(T,10.0,NPTS,1)
      CALL SCALE(G,7.0,NPTS,1)
      CALL AXIS(0.0,0.0,8HTIME(MS),-8,10.0, 0.0,T(NPTS+1),
     *T(NPTS+2))
      CALL AXIS(0.0,0.0,25HVEHICLE DECELERATION(G'S),25,7.0,
     *90.0,G(NPTS+1),G(NPTS+2))
      CALL LINE(T,G,NPTS,1,1,2)
      CALL SYMBOL( 3.0,5.0,0.25,23HACCELEROMETER TEST DATA,
     * 0.0,23)
      CALL PLOT(12.0,0.0,-3)
      GO TO 10
C
C
 602  CALL SCALE(T,10.0,NPTS,1)
      CALL SCALE(V,7.0,NPTS,1)
      CALL PLOT(0.0,0.0,-3)
      CALL PLOT(0.0,7.0,3)
      CALL PLOT(10.0,7.0,2)
      CALL PLOT(10.0,0.0,2)
      CALL AXIS(0.0,0.0,8HTIME(MS),-8,10.0,0.0,T(NPTS+1),
     *T(NPTS+2))
      CALL AXIS(0.0,0.0,28HVEHICLE VELOCITY CHANGE(FPS),28,
     *7.0,90.0,V(NPTS+1),V(NPTS+2))
      CALL LINE(T,V,NPTS,1,1,2)
      CALL SYMBOL(3.0,5.0,0.25,23HACCELEROMETER TEST DATA,
     *0.0,23)
      CALL PLOT(12.0,0.0,-3)
      GO TO 10
C
C
 603  CALL SCALE(T,10.0,NPTS,1)
      CALL SCALE(D,7.0,NPTS,1)
      CALL PLOT(0.0,0.0,-3)
      CALL PLOT(0.0,7.0,3)
      CALL PLOT(10.0,7.0,2)
      CALL PLOT(10.0,0.0,2)
      CALL AXIS(0.0,0.0,8HTIME(MS),-8,10.0,0.0,T(NPTS+1),
     *T(NPTS+2))
      CALL AXIS(0.0,0.0,25HOCCUPANT DISPLACEMENT(IN),25,7.0,
     *90.0,D(NPTS+1),D(NPTS+2))
      CALL LINE(T,D,NPTS,1,1,2)
      CALL SYMBOL(3.0,5.0,0.25,23HACCELEROMETER TEST DATA,
     *0.0,23)
```

APPENDIX C.

Computer Printout Test Results

ANALYSIS OF ACCELEROMETER DATA

TEST NO. 1
SPEED 20.5 MPH
ACCELEROMETER NO. 1 LEFT SIDE

TIME (MSEC)	ACCELERATION (G)	VELOCITY CHANGE (FPS)	OCCUPANT DISPLACEMENT (IN)
.0	.0	.0	.0
1.5	3.2	.1	.0
3.0	-1.8	.1	.0
3.5	1.1	.1	.0
4.5	.4	.1	.0
5.0	2.2	.2	.0
5.5	8.2	.2	.0
6.5	-.6	.4	.0
8.0	7.9	.6	.0
9.5	.5	.8	.0
10.0	4.6	.8	.0
11.0	-2.2	.8	.0
12.0	4.2	.9	.1
12.5	.0	.9	.1
13.5	2.2	.9	.1
14.5	-2.8	.9	.1
15.5	1.5	.9	.1
16.5	-1.0	.9	.1
17.5	.0	.9	.1
18.0	-2.2	.9	.1
19.0	1.5	.9	.1
20.0	1.9	.9	.1
20.5	.0	.9	.1
21.5	1.6	1.0	.2
22.0	.1	1.0	.2
23.5	1.8	1.0	.2
24.5	-.2	1.1	.2
25.0	2.2	1.1	.2
26.5	-.7	1.1	.2
27.0	2.3	1.1	.2
28.0	.4	1.2	.2
29.0	1.2	1.2	.3
30.0	.2	1.2	.3
30.5	.9	1.2	.3
31.5	-.5	1.2	.3
32.0	1.2	1.2	.3
33.0	-.2	1.2	.3
34.5	.7	1.3	.3
35.0	.2	1.3	.3
35.5	.7	1.3	.4
	5	2	

[illegible]	.2	[illegible]	[illegible]
43.5	.5	1.3	.5
46.0	1.1	1.4	.5
47.0	.2	1.4	.5
47.5	.7	1.4	.5
48.0	.1	1.4	.6
51.5	1.7	1.5	.6
52.5	.5	1.6	.6
57.0	.2	1.6	.7
57.5	1.0	1.6	.7
58.0	.3	1.6	.7
59.5	.7	1.7	.8
60.5	.2	1.7	.8
62.0	.1	1.7	.8
62.5	.4	1.7	.8
64.0	.2	1.7	.9
64.5	.8	1.7	.9
65.0	.5	1.7	.9
65.5	1.0	1.7	.9
66.0	.1	1.7	.9
66.5	1.1	1.7	.9
68.0	1.0	1.8	.9
70.0	.1	1.8	1.0
70.5	.7	1.8	1.0
71.0	-.1	1.8	1.0
71.5	.8	1.8	1.0
72.0	.3	1.9	1.0
72.5	.9	1.9	1.0
73.0	.1	1.9	1.1
73.5	.2	1.9	1.1
74.0	.9	1.9	1.1
75.5	.0	1.9	1.1
76.0	.6	1.9	1.1
81.0	-.5	1.9	1.2
81.5	.1	1.9	1.2
82.0	-.9	1.9	1.3
83.5	-.2	1.9	1.3
86.5	-.8	1.8	1.4
87.0	.1	1.8	1.4
89.5	-.4	1.8	1.4
90.0	-1.3	1.8	1.4
93.0	-.3	1.7	1.5
94.0	-1.1	1.7	1.5
94.5	.3	1.7	1.5
95.5	.8	1.7	1.5
97.5	.3	1.7	1.6
98.5	-1.2	1.7	1.6
99.5	1.0	1.7	1.6
100.0	.2	1.7	1.6
100.5	.9	1.7	1.7
102.0	-1.3	1.7	1.7
103.0	-.2	1.7	1.7
103.5	-1.6	1.7	1.7
104.5	.2	1.7	1.7
106.0	-1.5	1.6	1.8
106.5	-.1	1.6	1.8
107.0	-.9	1.6	1.8
107.5	-.4	1.6	1.8
108.0	-.7	1.6	1.8
108.5	.2	1.6	1.8
110.0	-1.8	1.6	1.8
111.0	-.2	1.5	1.9
112.5	-1.0	1.5	1.9
113.0	-.5	1.5	1.9
[illegible]	[illegible]	[illegible]	[illegible]

3/5

[illegible]	.1	1.4	2.0
117.5	.1	1.4	2.0
118.0	-1.7	1.4	2.0
119.0	.8	1.4	2.0
120.0	-.3	1.4	2.0
121.0	1.0	1.4	2.0
122.0	.9	1.5	2.1
123.0	.2	1.5	2.1
124.5	.9	1.5	2.1
125.5	.9	1.5	2.1
126.0	-.4	1.5	2.1
128.5	.4	1.6	2.2
130.0	-1.0	1.5	2.2
131.0	.0	1.5	2.2

405.0	1.5
-165.0	3.0
145.0	3.5
50.0	4.5
280.0	5.0
1055.0	5.5
-75.0	6.5
1015.0	8.0
70.0	9.5
590.0	10.0
-285.0	11.0
585.0	12.0
5.0	12.5
280.0	13.5
-360.0	14.5
190.0	15.5
-125.0	16.5
5.0	17.5
-285.0	18.0
195.0	19.0
240.0	20.0
5.0	20.5
210.0	21.5
15.0	22.0
230.0	23.5
-30.0	24.5
285.0	25.0
-85.0	26.5
295.0	27.0
50.0	28.0
150.0	29.0
30.0	30.0
115.0	30.5
-70.0	31.5
155.0	32.0
-20.0	33.0
85.0	34.5
20.0	35.0
95.0	35.5
80.0	37.5
-75.0	38.0
-75.0	38.5
-20.0	39.0
-40.0	41.0
155.0	43.0
60.0	43.5
135.0	46.0
30.0	47.0
85.0	47.5
15.0	48.0
215.0	51.5
60.0	52.5
25.0	57.0
130.0	57.5
40.0	58.0
90.0	59.5
25.0	60.5
15.0	62.0
55.0	62.5
20.0	64.0
100.0	64.5
65.0	65.0
130.0	65.5

140.0	66.5
125.0	68.0
15.0	70.0
85.0	70.5
-15.0	71.0
105.0	71.5
35.0	72.0
120.0	72.5
15.0	73.0
20.0	73.5
115.0	74.0
-5.0	75.5
80.0	76.0
-60.0	81.0
15.0	81.5
-115.0	82.0
-30.0	83.5
-100.0	86.5
10.0	87.0
-50.0	89.5
-165.0	90.0
-40.0	93.0
-135.0	94.0
40.0	94.5
100.0	95.5
35.0	97.5
-155.0	98.5
125.0	99.5
20.0	100.0
115.0	100.5
-165.0	102.0
-30.0	103.0
-200.0	103.5
25.0	104.5
-190.0	106.0
-10.0	106.5
-115.0	107.0
-45.0	107.5
-90.0	108.0
25.0	108.5
-225.0	110.0
-20.0	111.0
-130.0	112.5
-65.0	113.0
-120.0	114.0
15.0	116.0
10.0	117.5
-220.0	118.0
100.0	119.0
-40.0	120.0
130.0	121.0
115.0	122.0
25.0	123.0
120.0	124.5
110.0	125.5
-45.0	126.0
55.0	128.5
-130.0	130.0
0.0	131.0

A N A L Y S I S

O F

A C C E L E R O M E T E R   D A T A

TEST NO. 1
SPEED 20.5 MPH
ACCELEROMETER NO. 2   RIGHT SIDE

TIME (MSEC)	ACCELERATION (G)	VELOCITY CHANGE (FPS)	OCCUPANT DISPLACEMENT (IN)
.0	.0	.0	.0
1.0	6.4	.1	.0
2.0	-2.8	.2	.0
2.5	-1.3	.1	.0
3.0	10.0	.2	.0
4.0	4.1	.4	.0
4.5	-4.0	.4	.0
5.5	13.6	.6	.0
6.0	-9.6	.6	.0
7.0	22.6	.8	.0
7.5	18.4	1.2	.0
8.5	-22.1	1.1	.0
9.5	13.8	1.0	.1
10.0	-.9	1.1	.1
10.5	-1.4	1.0	.1
11.0	9.2	1.1	.1
11.5	10.7	1.3	.1
12.0	-10.6	1.3	.1
12.5	-11.3	1.1	.1
13.0	8.9	1.1	.1
13.5	11.4	1.2	.1
14.5	-5.2	1.3	.1
15.5	5.5	1.3	.1
16.0	-5.3	1.3	.2
17.5	4.4	1.3	.2
18.0	-.7	1.3	.2
20.0	3.0	1.4	.2
22.0	2.7	1.6	.3
22.5	-1.8	1.6	.3
24.0	1.6	1.6	.3
24.5	.4	1.6	.3
25.0	3.3	1.7	.3
26.5	-.9	1.7	.3
27.5	3.1	1.7	.4
28.5	.5	1.8	.4
29.0	3.1	1.8	.4
30.0	-.5	1.9	.4
31.5	2.1	1.9	.5
33.0	.7	2.0	.5
33.5	2.0	2.0	.5
35.5	.1	2.1	.5
[illegible]	[illegible]	[illegible]	[illegible]

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[illegible]	[illegible]	[illegible]	[illegible]
38.5	3.4	2.2	.6
39.5	-.9	2.2	.7
40.5	2.3	2.3	.7
41.5	-.4	2.3	.7
43.0	1.9	2.3	.7
43.5	.0	2.4	.8
45.0	1.6	2.4	.8
46.5	.9	2.5	.8
47.0	1.8	2.5	.9
48.0	.4	2.5	.9
48.5	.4	2.5	.9
49.0	1.5	2.5	.9
50.0	1.3	2.6	1.0
50.5	.7	2.6	1.0
51.0	1.9	2.6	1.0
52.5	.8	2.7	1.0
53.5	1.2	2.7	1.1
54.5	.0	2.7	1.1
56.5	1.1	2.8	1.2
57.0	.4	2.8	1.2
57.5	.4	2.8	1.2
58.0	1.3	2.8	1.2
58.5	.1	2.8	1.2
60.0	.6	2.8	1.3
61.0	-.5	2.8	1.3
62.0	.3	2.8	1.4
62.5	-.5	2.8	1.4
64.0	.6	2.8	1.4
66.0	.8	2.9	1.5
66.5	.3	2.9	1.5
67.0	.9	2.9	1.5
70.0	.9	3.0	1.6
70.5	.1	3.0	1.6
71.5	.2	3.0	1.7
72.0	.9	3.0	1.7
72.5	.4	3.0	1.7
73.0	1.4	3.0	1.7
73.5	.4	3.0	1.8
74.0	1.0	3.0	1.8
74.5	.4	3.1	1.8
75.5	.6	3.1	1.8
77.0	.1	3.1	1.9
77.5	1.0	3.1	1.9
81.0	-.2	3.1	2.0
82.0	.8	3.2	2.1
82.5	-.9	3.2	2.1
83.0	-.1	3.1	2.1
85.0	.1	3.1	2.2
85.5	-.6	3.1	2.2
87.5	.1	3.1	2.3
88.5	-.4	3.1	2.3
89.0	-.1	3.1	2.3
89.5	-.4	3.1	2.4
90.5	.0	3.1	2.4

0.J	0.J
890.0	1.0
-335.0	2.0
-175.0	2.5
1335.0	3.0
565.0	4.0
-560.0	4.5
1880.0	5.5
-1325.0	6.0
3135.0	7.0
2550.0	7.5
-3055.0	8.5
1910.0	9.5
-130.0	10.0
-200.0	10.5
1270.0	11.0
1485.0	11.5
-1475.0	12.0
-1560.0	12.5
1235.0	13.0
1575.0	13.5
-725.0	14.5
760.0	15.5
-740.0	16.0
605.0	17.5
-95.0	18.0
410.0	20.0
380.0	22.0
-245.0	22.5
220.0	24.0
50.0	24.5
455.0	25.0
-130.0	26.5
430.0	27.5
70.0	28.5
435.0	29.0
-75.0	30.0
290.0	31.5
100.0	33.0
280.0	33.5
15.0	35.5
340.0	36.5
20.0	37.5
470.0	38.5
-130.0	39.5
320.0	40.5
-50.0	41.5
270.0	43.0
5.0	43.5
215.0	45.0
130.0	46.5
255.0	47.0
50.0	48.0
50.0	48.5
205.0	49.0
185.0	50.0
95.0	50.5
270.0	51.0
110.0	52.5
160.0	53.5
0.0	54.5
155.0	56.5
50.0	57.0
60.0	57.5

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[illegible]	[illegible]
80.0	60.0
-75.0	61.0
35.0	62.0
-70.0	62.5
85.0	64.0
105.0	66.0
35.0	66.5
125.0	67.0
120.0	70.0
15.0	70.5
25.0	71.5
130.0	72.0
50.0	72.5
200.0	73.0
55.0	73.5
140.0	74.0
50.0	74.5
90.0	75.5
20.0	77.0
135.0	77.5
-30.0	81.0
105.0	82.0
-130.0	82.5
-15.0	83.0
15.0	85.0
-90.0	85.5
20.0	87.5
-50.0	88.5
-10.0	89.0
-50.0	89.5
0.0	90.5

A N A L Y S I S
O F
A C C E L E R O M E T E R   D A T A

TEST NO. 2
SPEED 21.3 MPH
ACCELEROMETER NO. 1 LEFT SIDE

TIME (MSEC)	ACCELERATION (G)	VELOCITY CHANGE (FPS)	OCCURANT DISPLACEMENT (IN)
.0	.0	.0	.0
2.0	3.6	.1	.0
2.5	2.0	.2	.0
3.5	2.1	.2	.0
4.0	4.6	.3	.0
4.5	4.4	.4	.0
5.0	5.6	.4	.0
6.0	-.5	.5	.0
7.0	4.6	.6	.0
8.0	1.1	.7	.0
8.5	6.0	.7	.0
9.0	7.5	.8	.0
9.5	1.5	.9	.0
10.0	-.4	.9	.1
10.5	3.6	1.0	.1
11.0	3.4	1.0	.1
11.5	.1	1.0	.1
12.5	1.8	1.1	.1
13.5	-.6	1.1	.1
14.0	2.4	1.1	.1
15.0	-1.2	1.1	.1
16.0	2.0	1.1	.1
17.5	-.1	1.2	.1
19.0	1.4	1.2	.2
19.5	.2	1.2	.2
20.0	2.3	1.2	.2
20.5	2.7	1.3	.2
22.0	.0	1.3	.2
22.5	1.2	1.4	.2
23.5	1.8	1.4	.2
24.5	-.2	1.4	.3
25.0	-.2	1.4	.3
26.0	1.8	1.5	.3
26.5	.7	1.5	.3
28.0	.1	1.5	.3
28.5	-2.1	1.5	.3
29.5	-1.8	1.4	.3
30.0	1.0	1.4	.4

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[illegible]	[illegible]	1.4	.4
32.5	2.0	1.4	.4
33.5	2.5	1.5	.4
35.0	-.8	1.5	.4
36.0	1.8	1.5	.5
36.5	.5	1.6	.5
37.5	3.1	1.6	.5
38.0	2.6	1.7	.5
38.5	3.0	1.7	.5
39.5	1.6	1.8	.5
40.5	1.8	1.8	.5
41.5	-1.2	1.9	.6
42.5	1.6	1.9	.6
44.0	-2.5	1.8	.6
45.0	1.3	1.8	.6
46.0	.0	1.8	.7
46.5	-1.1	1.8	.7
47.0	-.8	1.8	.7
47.5	-1.6	1.8	.7
48.5	-.7	1.8	.7
49.0	-1.3	1.8	.7
50.5	1.8	1.8	.8
51.5	1.3	1.8	.8
52.0	.5	1.8	.8
52.5	1.4	1.8	.8
54.5	-1.0	1.8	.9
55.0	2.4	1.9	.9
55.5	3.1	1.9	.9
56.0	1.6	1.9	.9
57.5	1.0	2.0	.9
58.0	-.5	2.0	.9
59.5	-1.6	2.0	1.0
60.0	-.2	1.9	1.0
61.0	-1.1	1.9	1.0
61.5	.2	1.9	1.0
62.5	1.3	1.9	1.0
63.0	.3	1.9	1.1
64.0	2.0	2.0	1.1
66.5	-.4	2.0	1.1
68.0	1.5	2.1	1.2
71.0	3.0	2.3	1.3
71.5	-.2	2.3	1.3
72.5	1.2	2.3	1.3
73.0	1.3	2.3	1.3
74.5	.7	2.4	1.4
75.5	-.7	2.4	1.4
77.0	.6	2.4	1.4
77.5	.1	2.4	1.4
78.0	.5	2.4	1.5
78.5	-.6	2.4	1.5
79.0	.0	2.4	1.5
81.0	.2	2.4	1.5
81.5	1.2	2.4	1.6
82.0	1.0	2.4	1.6
82.5	-.5	2.4	1.6
83.5	.9	2.4	1.6
84.5	-1.3	2.4	1.6
86.5	-1.1	2.4	1.7
87.0	1.0	2.4	1.7
88.5	-1.1	2.4	1.8
89.5	.9	2.4	1.8
90.5	-.2	2.4	1.8
91.5	1.8	2.4	1.8
92.0	1.4	2.4	1.9
93.0	-.6	2.4	1.9
94.0	.8	2.4	1.9
	1	4	

[illegible]	1.5	2.6	[illegible]
100.5	.1	2.6	2.1
102.0	1.1	2.6	2.2
103.5	.4	2.7	2.2
104.5	-2.1	2.6	2.2
106.0	.3	2.6	2.3
107.0	-1.5	2.6	2.3
107.5	.0	2.6	2.3
108.5	.9	2.6	2.4
109.0	-.2	2.6	2.4
109.5	1.5	2.6	2.4
110.5	-.7	2.6	2.4
111.5	.7	2.6	2.5
112.5	-1.7	2.6	2.5
113.0	.4	2.6	2.5
114.0	-1.1	2.6	2.5
115.0	.8	2.6	2.6
115.5	.6	2.6	2.6
116.0	-.4	2.6	2.6
116.5	.5	2.6	2.6
118.5	-1.4	2.5	2.7
119.0	.0	2.5	2.7
119.5	-.6	2.5	2.7
121.0	-.5	2.5	2.7
122.0	-1.6	2.5	2.8
123.5	.0	2.4	2.8
124.0	-1.3	2.4	2.8
125.0	1.0	2.4	2.9
126.0	-.2	2.4	2.9
127.0	.2	2.4	2.9
127.5	-.2	2.4	2.9
128.0	.5	2.4	2.9
129.0	.5	2.5	3.0
129.5	.0	2.5	3.0
131.0	.0	2.5	3.0
131.5	.6	2.5	3.1
133.5	-.1	2.5	3.1
134.0	.4	2.5	3.1
135.5	-.8	2.5	3.2
136.5	-.7	2.4	3.2
137.0	-.2	2.4	3.2
137.5	-1.4	2.4	3.2
138.0	.3	2.4	3.2
139.5	-.1	2.4	3.3
140.5	.0	2.4	3.3
145.5	.0	2.4	3.5
146.5	-.7	2.4	3.5
149.5	.7	2.4	3.6
150.0	.0	2.4	3.6

INPUT DATA

159	2	20	1	2.560	21.3
	0.0		0.0		
	465.0		2.0		
	260.0		2.5		
	270.0		3.5		
	590.0		4.0		
	565.0		4.5		
	720.0		5.0		
	-60.0		6.0		
	595.0		7.0		
	140.0		8.0		
	765.0		8.5		
	960.0		9.0		
	195.0		9.5		
	-45.0		10.0		
	465.0		10.5		
	430.0		11.0		
	10.0		11.5		
	225.0		12.5		
	-80.0		13.5		
	305.0		14.0		
	-155.0		15.0		
	250.0		16.0		
	-10.0		17.5		
	180.0		19.0		
	25.0		19.5		
	290.0		20.0		
	340.0		20.5		
	0.0		22.0		
	155.0		22.5		
	230.0		23.5		
	-20.0		24.5		
	-20.0		25.0		
	235.0		26.0		
	95.0		26.5		
	15.0		28.0		
	-270.0		28.5		
	-235.0		29.5		
	125.0		30.0		
	195.0		30.5		
	-335.0		31.5		
	250.0		32.5		
	320.0		33.5		
	-35.0		35.0		
	225.0		36.0		
	65.0		36.5		
	400.0		37.5		
	335.0		38.0		
	390.0		38.5		
	210.0		39.5		
	235.0		40.5		
	-155.0		41.5		
	210.0		42.5		
	-315.0		44.0		
	160.0		45.0		
	-5.0		46.0		
	-140.0		46.5		
	-40.0		47.0		
	-205.0		47.5		
	-90.0		48.5		
	[illegible]		[illegible]		

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[illegible]	[illegible]
.75..	[illegible]
-125.0	54.5
310.0	55.0
395.0	55.5
210.0	56.0
125.0	57.5
-70.0	58.0
-200.0	59.5
-20.0	60.0
-145.0	61.0
30.0	61.5
165.0	62.5
35.0	63.0
250.0	64.0
-55.0	66.5
190.0	68.0
380.0	71.0
-30.0	71.5
155.0	72.5
160.0	73.0
95.0	74.5
-85.0	75.5
80.0	77.0
15.0	77.5
70.0	78.0
-80.0	78.5
-5.0	79.0
20.0	81.0
155.0	81.5
133.0	82.0
-65.0	82.5
120.0	83.5
-170.0	84.5
-135.0	86.5
130.0	87.0
-135.0	88.5
110.0	89.5
-30.0	90.5
225.0	91.5
185.0	92.0
-80.0	93.0
105.0	94.0
-10.0	94.5
165.0	95.5
85.0	96.5
150.0	97.5
95.0	98.5
190.0	99.5
10.0	100.5
135.0	102.0
55.0	103.5
-270.0	104.5
35.0	106.0
-190.0	107.0
0.0	107.5
110.0	108.5
-30.0	109.0
190.0	109.5
-95.0	110.5
90.0	111.5
-220.0	112.5
45.0	113.0
-140.0	114.0
100.0	115.0
80.0	115.5
-50.0	116.0

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[illegible]	[illegible]
5.0	119.0
-80.0	119.5
-60.0	121.0
-210.0	122.0
5.0	123.5
-160.0	124.0
125.0	125.0
-30.0	126.0
30.0	127.0
-30.0	127.5
65.0	128.0
60.0	129.0
5.0	129.5
-5.0	131.0
75.0	131.5
-10.0	133.5
55.0	134.0
-100.0	135.5
-95.0	136.5
-30.0	137.0
-175.0	137.5
35.0	138.0
-15.0	139.5
-5.0	140.5
-2.0	145.5
-85.0	146.5
95.0	149.5
0.0	150.0

A N A L Y S I S

O F

A C C E L E R O M E T E R   D A T A

TEST NO. 2
SPEED 21.3 MPH
ACCELEROMETER NO. 2   RIGHT SIDE

TIME (MSEC)	ACCELERATION (G)	VELOCITY CHANGE (FPS)	OCCUPANT DISPLACEMENT (IN)
.0	.0	.0	.0
1.0	5.1	.1	.0
2.0	-.8	.2	.0
3.0	6.2	.2	.0
4.0	5.3	.4	.0
5.5	-4.8	.4	.0
6.5	8.6	.5	.0
7.0	8.6	.6	.0
8.0	-.3	.8	.0
9.5	5.7	.9	.0
10.0	4.3	1.0	.1
10.5	6.3	1.1	.1
11.0	4.4	1.2	.1
11.5	-2.5	1.2	.1
12.0	-4.0	1.1	.1
13.0	3.4	1.1	.1
14.5	.0	1.2	.1
15.5	3.2	1.2	.1
16.5	-1.4	1.3	.1
17.5	4.7	1.3	.2
18.5	-1.9	1.4	.2
19.5	2.4	1.4	.2
20.5	.0	1.4	.2
21.0	2.7	1.4	.2
21.5	2.5	1.5	.2
22.5	-.4	1.5	.2
23.5	2.3	1.5	.3
24.5	-.3	1.6	.3
25.5	1.7	1.6	.3
26.5	1.2	1.6	.3
27.0	-1.8	1.6	.3
28.0	.4	1.6	.3
29.0	3.0	1.7	.4
29.5	4.0	1.7	.4
31.0	-5.1	1.7	.4
32.5	7.6	1.8	.4
34.0	-5.8	1.8	.5
34.5	-4.4	1.7	.5

[illegible]	[illegible]	[illegible]	[illegible]
36.5	-2.7	1.9	.5
38.0	3.2	1.9	.6
38.5	1.6	2.0	.6
39.0	1.4	2.0	.6
39.5	3.4	2.0	.6
40.0	3.4	2.1	.6
40.5	-1.7	2.1	.6
41.0	-2.6	2.0	.6
42.0	2.1	2.0	.7
43.0	-3.8	2.0	.7
43.5	-.3	2.0	.7
45.0	.5	2.0	.7
45.5	13.2	2.1	.7
46.5	-1.4	2.3	.8
47.0	-.7	2.3	.8
47.5	-5.4	2.2	.8
48.0	2.2	2.2	.8
48.5	-.5	2.2	.8
49.5	2.8	2.2	.8
50.0	2.2	2.3	.9
51.0	4.0	2.4	.9
51.5	2.6	2.4	.9
52.0	7.6	2.5	.9
53.0	-4.4	2.6	1.0
53.5	-.5	2.5	1.0
54.5	-1.8	2.5	1.0
56.0	2.5	2.5	1.0
57.0	-.9	2.5	1.1
57.5	1.3	2.5	1.1
59.0	4.2	2.7	1.1
60.0	2.1	2.8	1.2
61.0	-3.6	2.8	1.2
62.0	2.2	2.7	1.2
63.0	-.2	2.8	1.3
64.5	3.2	2.8	1.3
65.5	1.0	2.9	1.4
66.5	2.4	3.0	1.4
67.0	-.4	3.0	1.4
68.0	.9	3.0	1.4
69.0	3.5	3.1	1.5
70.0	.8	3.1	1.5
71.0	1.5	3.2	1.5
71.5	.5	3.2	1.6
72.5	1.2	3.2	1.6
74.0	-.6	3.2	1.7
75.0	2.1	3.2	1.7
76.0	-1.2	3.3	1.7
77.0	1.2	3.3	1.8
78.0	-1.6	3.2	1.8
79.0	1.2	3.2	1.9
80.0	-1.5	3.2	1.9
82.0	.6	3.2	2.0
82.5	-1.7	3.2	2.0
83.5	1.9	3.2	2.0
84.0	-4.7	3.2	2.1
86.0	1.2	3.1	2.1
87.0	-2.5	3.0	2.2
88.0	.5	3.0	2.2
88.5	-1.3	3.0	2.2
90.0	1.5	3.0	2.3
92.0	-.2	3.1	2.3
92.5	.5	3.1	2.4
93.5	-1.1	3.0	2.4
94.5	-.8	3.0	2.4
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

101.0	-.4	[illegible]	[illegible]
101.5	1.3	3.1	2.7
102.0	1.6	3.2	2.7
103.0	-1.2	3.2	2.8
104.0	-.9	3.1	2.8
104.5	-5.1	3.1	2.8
105.5	.9	3.0	2.8
107.0	-4.4	2.9	2.9
107.5	2.2	2.9	2.9
108.0	1.9	2.9	2.9
108.5	4.2	3.0	2.9
110.0	-2.9	3.0	3.0
111.0	2.5	3.0	3.0
112.5	-2.9	3.0	3.1
113.5	-.6	3.0	3.1
114.0	-1.9	2.9	3.1
115.0	1.3	2.9	3.2
117.5	-.5	3.0	3.3
118.0	1.0	3.0	3.3
118.5	.5	3.0	3.3
119.0	1.9	3.0	3.3
120.0	2.9	3.1	3.4
121.5	2.0	3.2	3.4
122.5	-.5	3.2	3.5
125.5	1.3	3.2	3.6
126.5	-.3	3.3	3.6
127.5	1.3	3.3	3.6
129.0	-1.2	3.3	3.7
130.0	.5	3.3	3.7
131.0	-.4	3.3	3.8
132.5	-.1	3.3	3.8
133.0	-1.2	3.2	3.9
134.0	-.9	3.2	3.9
134.5	.1	3.2	3.9
135.5	-.7	3.2	4.0
136.5	-.1	3.2	4.0
137.5	-.8	3.2	4.0
138.5	-.2	3.1	4.1
139.5	-.8	3.1	4.1
141.0	-.7	3.1	4.2
142.0	.0	3.1	4.2
143.0	-1.6	3.1	4.2
143.5	-.4	3.0	4.3
144.5	-.1	3.0	4.3
145.5	-.9	3.0	4.3
147.5	-.2	3.0	4.4
148.0	.7	3.0	4.4
148.5	-.4	3.0	4.4
150.0	.0	3.0	4.5

INPUT DATA

159	2	20	2	2.770	21.3
0.0		0.0			
700.0		1.0			
-105.0		2.0			
865.0		3.0			
740.0		4.0			
-665.0		5.5			
1185.0		6.5			
1195.0		7.0			
-38.0		8.0			
785.0		9.5			
590.0		10.0			
870.0		10.5			
610.0		11.0			
-340.0		11.5			
-555.0		12.0			
465.0		13.0			
0.0		14.5			
450.0		15.5			
-190.0		16.5			
650.0		17.5			
-270.0		18.5			
335.0		19.5			
-5.0		20.5			
375.0		21.0			
340.0		21.5			
-60.0		22.5			
315.0		23.5			
-35.0		24.5			
230.0		25.5			
165.0		26.5			
-250.0		27.0			
50.0		28.0			
420.0		29.0			
560.0		29.5			
-700.0		31.0			
1055.0		32.5			
-300.0		34.0			
-615.0		34.5			
1040.0		35.5			
785.0		36.0			
-375.0		36.5			
450.0		38.0			
220.0		38.5			
195.0		39.0			
465.0		39.5			
465.0		40.0			
-240.0		40.5			
-360.0		41.0			
285.0		42.0			
-520.0		43.0			
-35.0		43.5			
70.0		45.0			
1330.0		45.5			
-200.0		46.5			
-95.0		47.0			
-750.0		47.5			
305.0		48.0			
-70.0		48.5			
390.0		49.5			
05		0 (			
. 0 .		1 .			

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[illegible]	[illegible]
[illegible]	[illegible]
-75.0	53.5
-250.0	54.5
350.0	56.0
-125.0	57.0
185.0	57.5
580.0	59.0
285.0	60.0
-495.0	61.0
305.0	62.0
-30.0	63.0
440.0	64.5
145.0	65.5
330.0	66.5
-55.0	67.0
125.0	68.0
480.0	69.0
105.0	70.0
210.0	71.0
65.0	71.5
165.0	72.5
-80.0	74.0
285.0	75.0
-165.0	76.0
170.0	77.0
-220.0	78.0
165.0	79.0
-210.0	80.0
80.0	82.0
-235.0	82.5
265.0	83.5
-655.0	84.0
165.0	86.0
-840.0	87.0
75.0	88.0
-185.0	88.5
210.0	90.0
-30.0	92.0
75.0	92.5
-155.0	93.5
-115.0	94.5
225.0	95.5
-135.0	96.5
165.0	97.5
75.0	98.0
120.0	99.0
230.0	99.5
-60.0	101.0
180.0	101.5
220.0	102.0
-160.0	103.0
-130.0	104.0
-710.0	104.5
130.0	105.5
-605.0	107.0
305.0	107.5
260.0	108.0
575.0	108.5
-400.0	110.0
350.0	111.0
-400.0	112.5
-90.0	113.5
-265.0	114.0
180.0	115.0
-70.0	117.5
[illegible]	[illegible]

[illegible]	119.0
405.0	120.0
275.0	121.5
-75.0	122.5
175.0	125.5
-40.0	126.5
175.0	127.5
-160.0	129.0
65.0	130.0
-60.0	131.0
-20.0	132.5
-170.0	133.0
-130.0	134.0
10.0	134.5
-95.0	135.5
-15.0	136.5
-110.0	137.5
-30.0	138.5
-110.0	139.5
-100.0	141.0
0.0	142.0
-220.0	143.0
-60.0	143.5
-20.0	144.5
-130.0	145.5
-30.0	147.5
100.0	148.0
-55.0	148.5
0.0	150.0

A N A L Y S I S
O F
A C C E L E R O M E T E R   D A T A

TEST NO. 4
SPEED 64.5 MPH
ACCELEROMETER NO. 1 LEFT SIDE

TIME (MSEC)	ACCELERATION (G)	VELOCITY CHANGE (FPS)	OCCUPANT DISPLACEMENT (IN)
.0	.0	.0	.0
1.5	1.8	.0	.0
2.0	-.5	.1	.0
3.5	21.2	.6	.0
4.0	20.5	.9	.0
5.0	-4.1	1.2	.0
6.0	17.2	1.4	.0
7.0	-8.9	1.5	.1
7.5	-.8	1.4	.1
8.0	-7.1	1.4	.1
8.5	-5.7	1.3	.1
9.5	21.2	1.5	.1
11.0	-4.7	1.9	.1
11.5	4.8	1.9	.1
12.0	4.7	2.0	.2
12.5	3.2	2.0	.2
13.5	7.9	2.2	.2
14.5	-9.9	2.2	.2
15.5	-.5	2.0	.2
16.5	.6	2.0	.3
17.5	-1.9	2.0	.3
18.0	7.5	2.0	.3
19.5	2.5	2.3	.3
20.0	3.4	2.3	.4
21.0	-6.3	2.3	.4
22.0	2.6	2.2	.4
23.0	-3.9	2.2	.4
24.0	.7	2.2	.5
24.5	-5.5	2.1	.5
25.5	3.2	2.1	.5
26.0	-1.1	2.1	.5
27.0	4.5	2.2	.5
29.0	-5.1	2.1	.6
30.5	1.2	2.0	.6
32.5	-2.0	2.0	.7
33.0	4.1	2.0	.7
34.5	-.4	2.1	.7
35.0	2.7	2.1	.7

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38.0	-.2	2.3	.8
38.5	4.7	2.3	.8
39.5	1.6	2.4	.9
40.5	3.1	2.5	.9
41.5	-1.6	2.5	.9
42.5	-2.0	2.5	.9
43.0	1.1	2.5	1.0
44.5	.2	2.5	1.0
45.0	4.6	2.5	1.0
46.0	.0	2.6	1.1
46.5	2.4	2.6	1.1
47.5	.0	2.7	1.1
48.5	2.8	2.7	1.1
49.5	-2.8	2.7	1.2
50.5	-1.2	2.6	1.2
51.0	-3.4	2.6	1.2
51.5	.1	2.6	1.2
52.5	-1.5	2.6	1.3
53.5	.1	2.5	1.3
54.0	-1.5	2.5	1.3
55.0	.9	2.5	1.3
55.5	-.6	2.5	1.4
56.5	.5	2.5	1.4
57.0	-2.3	2.5	1.4
58.5	.8	2.5	1.4
59.5	-2.1	2.4	1.5
60.5	.1	2.4	1.5
61.0	-1.4	2.4	1.5
62.5	3.0	2.4	1.6
63.0	1.0	2.5	1.6
63.5	2.5	2.5	1.6
65.0	-.9	2.5	1.6
65.5	-.2	2.5	1.6
66.5	-1.6	2.5	1.7
68.0	1.8	2.5	1.7
68.5	-3.2	2.5	1.7
69.0	.2	2.5	1.8
69.5	-1.8	2.5	1.8
70.5	2.1	2.5	1.8
71.0	-1.3	2.5	1.8
71.5	5.6	2.5	1.8
72.5	-3.0	2.5	1.9
73.5	3.7	2.6	1.9
74.5	1.0	2.6	1.9
75.0	3.1	2.7	1.9
75.5	-.1	2.7	2.0
76.0	1.1	2.7	2.0
77.5	-1.0	2.7	2.0
79.0	2.3	2.7	2.1
80.0	-7.7	2.6	2.1
81.5	5.6	2.6	2.1
83.0	-3.5	2.6	2.2
84.0	1.1	2.6	2.2
85.5	-2.0	2.6	2.3
86.5	2.0	2.6	2.3
87.5	-2.0	2.6	2.3
88.0	.8	2.6	2.3
90.0	-.7	2.6	2.4
91.0	1.9	2.6	2.4
92.5	-2.4	2.6	2.5
93.5	1.2	2.6	2.5
94.0	-.4	2.6	2.5
95.0	1.4	2.6	2.6
95.5	-.7	2.6	2.6
96.5	1.9	2.6	2.6
	0	6	

[illegible]	-.4	[illegible]	[illegible]
106.5	-.4	2.6	2.9
107.0	-1.1	2.6	2.9
108.0	.5	2.6	3.0
108.5	1.4	2.6	3.0
109.5	.3	2.6	3.0
110.5	-1.0	2.6	3.1
111.0	-.4	2.6	3.1
111.5	-1.0	2.6	3.1
112.0	.0	2.6	3.1
112.5	-.5	2.6	3.1
115.5	-.7	2.5	3.2
116.5	.2	2.5	3.2
117.5	-1.1	2.5	3.3
119.0	.5	2.5	3.3
120.0	.4	2.5	3.3
121.5	1.6	2.6	3.4
122.0	.5	2.6	3.4
122.5	.9	2.6	3.4
123.0	-.1	2.6	3.4
124.5	.4	2.6	3.5
125.0	-1.1	2.6	3.5
127.0	.6	2.6	3.6
130.0	-.5	2.6	3.7
130.5	-.8	2.6	3.7
131.5	.2	2.6	3.7
132.0	-.3	2.6	3.7
133.0	.0	2.6	3.7
134.0	-.7	2.5	3.8
134.5	.7	2.5	3.8
135.5	-.7	2.5	3.8
137.5	.2	2.5	3.9
141.5	-1.2	2.5	4.0
146.5	.9	2.4	4.1
148.0	-.3	2.5	4.2
149.5	.5	2.5	4.2
150.0	.0	2.5	4.2

INPUT DATA

146 4 60 1 2.560 64.5

0.0	0.0
235.0	1.5
-65.0	2.0
2710.0	3.5
2620.0	4.0
-520.0	5.0
2205.0	6.0
-1135.0	7.0
-100.0	7.5
-910.0	8.0
-735.0	8.5
2715.0	9.5
-605.0	11.0
610.0	11.5
605.0	12.0
415.0	12.5
1010.0	13.5
-1270.0	14.5
-70.0	15.5
80.0	16.5
-240.0	17.5
965.0	18.0
820.0	19.5
430.0	20.0
-800.0	21.0
335.0	22.0
-500.0	23.0
95.0	24.0
-700.0	24.5
415.0	25.5
-140.0	26.0
580.0	27.0
-655.0	29.0
150.0	30.5
-250.0	32.5
525.0	33.0
-50.0	34.5
350.0	35.0
10.0	36.0
405.0	36.5
-25.0	38.0
605.0	38.5
200.0	39.5
400.0	40.5
-210.0	41.5
-260.0	42.5
140.0	43.0
20.0	44.5
595.0	45.0
5.0	46.0
305.0	46.5
0.0	47.5
355.0	48.5
-360.0	49.5
-155.0	50.5
-440.0	51.0
10.0	51.5
-195.0	52.5
15.0	53.5
190.[illegible]	[illegible]4.[illegible]
0	5

-270.0	[illegible]
10.0	60.5
-175.0	61.0
390.0	62.5
130.0	63.0
320.0	63.5
-120.0	65.0
-25.0	65.5
-205.0	66.5
230.0	68.0
-410.0	68.5
20.0	69.0
-230.0	69.5
265.0	70.5
-170.0	71.0
715.0	71.5
-380.0	72.5
470.0	73.5
125.0	74.5
400.0	75.0
-15.0	75.5
145.0	76.0
-130.0	77.5
290.0	79.0
-985.0	80.0
720.0	81.5
-445.0	83.0
145.0	84.0
-260.0	85.5
255.0	86.5
-260.0	87.5
100.0	88.0
-85.0	90.0
245.0	91.0
-310.0	92.5
155.0	93.5
-45.0	94.0
180.0	95.0
-85.0	95.5
245.0	96.5
0.0	97.0
175.0	98.0
-140.0	101.5
95.0	102.0
-55.0	102.5
-45.0	106.5
-135.0	107.0
65.0	108.0
180.0	108.5
35.5	109.5
-125.0	110.5
-55.0	111.0
-130.0	111.5
5.0	112.0
-60.0	112.5
-65.0	115.5
30.0	116.5
-145.0	117.5
60.0	119.0
50.0	120.0
205.0	121.5
65.0	122.0
120.0	122.5
-15.0	123.0

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-140.0	125.0
80.0	127.0
-60.0	130.0
-105.0	130.5
30.0	131.5
-105.0	132.0
0.0	133.0
-95.0	134.0
85.0	134.5
-90.0	135.5
25.0	137.5
-150.0	141.5
115.0	146.5
-35.0	148.0
60.0	149.5
0.0	150.0

A N A L Y S I S

O F

A C C E L E R O M E T E R   D A T A

TEST NO. 4
SPEED 64.5 MPH
ACCELEROMETER NO. 2 **RIGHT SIDE**

TIME (MSEC)	ACCELERATION (G)	VELOCITY CHANGE (FPS)	OCCUPANT DISPLACEMENT (IN)
.0	.0	.0	.0
.5	.9	.0	.0
1.5	7.4	.1	.0
2.0	1.3	.2	.0
2.5	26.1	.4	.0
3.0	2.8	.7	.0
3.5	-.9	.7	.0
4.0	22.4	.9	.0
5.5	-15.7	1.0	.0
6.5	.7	.8	.0
7.0	-9.3	.7	.0
8.5	15.4	.9	.1
9.5	-8.9	1.0	.1
11.0	7.2	.9	.1
12.5	.6	1.1	.1
13.0	-7.1	1.1	.1
14.0	2.0	1.0	.1
14.5	-4.4	1.0	.1
15.5	4.4	1.0	.1
16.5	-7.4	.9	.2
17.5	8.0	.9	.2
18.5	-2.5	1.0	.2
19.5	3.8	1.0	.2
20.5	-7.1	1.0	.2
21.5	5.1	.9	.2
22.5	-4.3	.9	.2
23.5	2.5	.9	.2
25.0	-8.2	.8	.3
26.0	6.2	.7	.3
27.0	-4.5	.8	.3
28.0	5.2	.8	.3
29.0	-10.3	.7	.3
30.0	8.3	.7	.3
31.0	-7.0	.7	.3
32.0	8.8	.7	.3
33.0	-5.6	.8	.3
34.0	5.3	.8	.3
34.5	-4.5	.8	.3

37.0	-1.9	.8	.4
37.5	3.8	.8	.4
40.0	.4	1.0	.4
40.5	-3.8	1.0	.4
41.0	4.1	1.0	.4
42.0	-3.2	1.0	.4
43.0	2.2	1.0	.4
44.5	-.6	1.0	.4
45.0	3.4	1.0	.4
46.0	-1.0	1.1	.5
47.0	3.2	1.1	.5
48.5	-4.2	1.1	.5
49.5	-1.2	1.0	.5
50.0	-3.9	.9	.5
51.5	.8	.9	.5
52.5	-2.6	.8	.5
53.5	1.6	.8	.5
55.0	-1.8	.8	.6
56.0	5.3	.9	.6
56.5	-1.0	.9	.6
57.0	3.2	.9	.6
58.0	1.2	1.0	.6
58.5	-5.6	1.0	.6
59.5	4.4	.9	.6
60.0	-5.2	.9	.6
60.5	-1.7	.9	.6
61.5	-.4	.8	.6
62.0	9.2	.9	.6
62.5	-8.4	.9	.6
63.0	6.2	.9	.6
64.0	-7.7	.9	.7
65.0	2.0	.8	.7
65.5	-1.9	.8	.7
66.0	.1	.8	.7
66.5	-3.0	.8	.7
67.5	3.0	.8	.7
69.0	-3.7	.7	.7
69.5	-.8	.7	.7
70.0	-3.5	.7	.7
70.5	-.4	.6	.7
72.0	.1	.6	.7
72.5	-2.7	.6	.7
73.0	.1	.6	.7
73.5	-2.4	.6	.7
75.0	2.9	.6	.8
77.0	-3.1	.6	.8
77.5	4.0	.6	.8
78.5	-3.9	.6	.8
79.5	.3	.5	.8
80.5	-1.8	.5	.8
81.0	3.1	.5	.8
82.5	-2.5	.5	.8
84.0	2.6	.5	.8
84.5	-1.6	.5	.8
86.0	.9	.5	.8
86.5	-2.5	.5	.8
88.0	-.1	.4	.8
88.5	4.0	.5	.8
90.0	-.8	.6	.8
91.5	.5	.5	.9
92.5	-1.4	.5	.9
93.0	.9	.5	.9
94.0	.0	.5	.9
95.5	1.2	.6	.9
96.5	-.4	.6	.9
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	

103.5	.5	.7	[illegible]
104.0	1.2	.7	.9
105.5	-1.3	.7	1.0
106.0	.1	.7	1.0
106.5	-1.4	.7	1.0
109.0	-.6	.6	1.0
109.5	-1.3	.6	1.0
110.0	.4	.5	1.0
111.0	-.8	.5	1.0
112.5	-.1	.5	1.0
113.0	-1.4	.5	1.0
114.0	-.1	.5	1.0
114.5	-1.4	.5	1.0
115.0	-.3	.5	1.0
118.0	.1	.4	1.0
118.5	-1.0	.4	1.0
119.5	.9	.4	1.0
120.5	.6	.5	1.1
123.0	-.1	.5	1.1
123.5	1.1	.5	1.1
124.0	-1.8	.5	1.1
126.0	.2	.4	1.1
126.5	-2.3	.4	1.1
127.5	1.1	.4	1.1
128.5	-2.2	.4	1.1
129.5	1.6	.4	1.1
130.5	-1.9	.4	1.1
131.0	.2	.4	1.1
132.0	-1.3	.3	1.1
132.5	1.2	.3	1.1
133.5	-2.7	.3	1.1
134.0	.1	.3	1.1
135.0	-2.6	.2	1.1
136.0	.5	.2	1.1
137.0	-2.0	.2	1.1
138.0	.8	.2	1.1
138.5	-.7	.2	1.1
141.5	-1.1	.1	1.1
142.5	-.1	.1	1.1
146.0	.6	.1	1.1
147.0	-1.2	.1	1.1
147.5	.2	.1	1.1
150.0	.0	.1	1.1

INPUT DATA

153 4 60 2 2.770 64.5

0.0	0.0
130.0	0.5
1025.0	1.5
185.0	2.0
3610.0	2.5
385.0	3.0
-125.0	3.5
3105.0	4.0
-2170.0	5.5
100.0	6.5
-1290.0	7.0
2135.0	8.5
-1235.0	9.5
995.0	11.0
85.0	12.5
-985.0	13.0
280.0	14.0
-610.0	14.5
615.0	15.5
-1020.0	16.5
1110.0	17.5
-350.0	18.5
525.0	19.5
-985.0	20.5
700.0	21.5
-595.0	22.5
340.0	23.5
-1140.0	25.0
855.0	26.0
-625.0	27.0
725.0	28.0
-1430.0	29,0
1150.0	30.0
-970.0	31.0
1225.0	32.0
-770.0	33.0
730.0	34.0
-620.0	34.5
550.0	36.0
-260.0	37.0
525.0	37.5
50.0	40.0
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570.0	41.0
-440.0	42.0
310.0	43.0
-85.0	44.5
465.0	45.0
-140.0	46.0
450.0	47.0
-580.0	48.5
-165.0	49.5
-535.0	50.0
105.0	51.5
-855.0	52.5
220.0	53.5
-250.0	55.0
735.0	56.0
-140.0	56.5
450.0	57.0
0	3

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[illegible]10	[illegible]
715.0	60.0
-240.0	60.5
-50.0	61.5
1280.0	62.0
-1170.0	62.5
855.0	63.0
-1060.0	64.0
275.0	65.0
-270.0	65.5
15.0	66.0
-415.0	66.5
415.0	67.5
-510.0	69.0
-110.0	69.5
-490.0	70.0
-55.0	70.5
20.0	72.0
-880.0	72.5
10.0	73.0
-830.0	73.5
405.0	75.0
-430.0	77.0
555.0	77.5
-545.0	78.5
40.0	79.5
-250.0	80.5
430.0	81.0
-845.0	82.5
355.0	84.0
-225.0	84.5
120.0	86.0
-845.0	86.5
-15.0	88.0
560.0	88.5
-110.0	90.0
70.0	91.5
-200.0	92.5
130.0	93.0
5.0	94.0
170.0	95.5
-55.0	96.5
255.0	98.0
15.0	98.5
25.0	100.5
-125.0	101.0
165.0	102.0
5.0	102.5
65.0	103.5
170.0	104.0
-180.0	105.5
20.0	106.0
-190.0	106.5
-90.0	109.0
-180.0	109.5
60.0	110.0
-115.0	111.0
-10.0	112.5
-200.0	113.0
-15.0	114.0
-190.0	114.5
-45.0	115.0
15.0	118.0

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30.0	126.0
-320.0	126.5
150.0	127.5
-305.0	128.5
220.0	129.5
-260.0	130.5
25.0	131.0
-180.0	132.0
160.0	132.5
-370.0	133.5
15.0	134.0
-360.0	135.0
70.0	136.0
-275.0	137.0
105.0	138.0
-100.0	138.5
-155.0	141.5
-15.0	142.5
85.0	146.0
-160.0	147.0
25.0	147.5
0.0	150.0