CRASH TEST EVALUATION OF GUARDRAIL SYSTEMS UTILIZING THE NEW CHARLEY POST

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FINAL REPORT

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Prepared for

Anderson Safeway Guard Rail Corp.
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Syro Steel Co.
Trinity Industries, Inc.

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The tests were conducted at Southwest Research Institute by the Department of Structural Research. The contributions of G. W. Deel, R. P. Guillot, R. Guerra, B. Johnson and C. A. Walker are recognized.

Cooperation of several offices within the Federal Highway Administration is gratefully acknowledged. The test series was formulated to comply with FHWA recommendations.

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INTRODUCTION

Due to decisions by several steel companies, the standard W6x8.5 steel guardrail post has become increasingly difficult to obtain. Recognizing the immediate need for an alternate to this widely used element, the program sponsors conceived other post configurations which might replace the standard. One of these post concepts, referred to as the CHARLEY post, was evaluated in a crash test series described in this report.

BACKGROUND

Over thirty states utilize the W6x8.5 steel element as guardrail and median barrier posts. The systems which employ this post and spacer element are described in NCHRP Report 118[(1)*] and are known as G4S and MB4S guardrail and median barrier systems. Basically, the systems utilize the standard 12-ga. W-beam mounted on a 6-in. spacer (also W6x8.5) which in turn is mounted to posts spaced at 6'-3" centers.

Although the systems are widely used, crash test experience on the systems as previously described is somewhat limited. A summary of tests conducted thus far is contained in Table 1 along with the results of the three

*Numbers in parentheses refer to references at end of paper

TABLE 1

SUMMARY OF GUARDRAIL CRASH TESTS

Test No.	Ref.	Beam	Post	Spacer	Post Spacing (ft-in.)	Post Embedment (in.)	Beam Height (in.)	Vehicle Test Conditions: Weight (lbs)	Vehicle Test Conditions: Speed (mph)	Vehicle Test Conditions: Impact Angle (deg)	Vehicle Accelerations (g's): Long.	Vehicle Accelerations (g's): Lat.	Maximum Deflection (in.): Dynamic	Maximum Deflection (in.): Permanent	Remarks
119	3	12 ga. W-beam	W6x8.5	none	6-3	41.5	27	4169	53.4	30.2	-4.6	4.4	2.7	2.7	Large exit angle, beam partially severed
120	3	12 ga. W-beam	W6x8.5	W6x8.5	6-3	41.5	27	3813	56.8	28.4	-4.0	7.0	4.1	2.9	Vehicle redirected
121	3	12 ga. W-beam	W6x8.5	Two W6x8.5 (12")	6-3	41.5	27	4478	56.2	27.4	-3.7	6.8	3.1	2.1	Vehicle redirected
122	3	12 ga. W-beam	W6x8.5	Two W6x8.5 (12")	6-3	41.5	27	4570	62.9	25.3	-3.9	7.7	5.0	2.9	Vehicle redirected
19	4	12 ga. W-beam	W6x8.5	W8x10	6-3	38	27	3900	59.0	25.0	11.2[a]				Rail tore - separated; vehicle pocketed, rolled over
274	5	12 ga. W-beam	W6x8.5	W6x8.5	6-3	44	27	4960	63.0	24.0	-5.80[b]	4.75[b]			Vehicle penetrated rail, cable anchor slipped in clips
276	5	12 ga. W-beam[c]	W6x8.5	W6x8.5	6-3	44	27	4960	66.0	25.0	-3.78[b]	6.85[b]	n/a	1.8	Vehicle redirected
AS-6		12 ga. Thrie beam[c]	CHARLEY	CHARLEY	6-3	48	32	4323	61.3	25.0	-3.6[a]	6.1[a]	2.6	1.8	Vehicle redirected
AS-7		12 ga. W-beam[c]	CHARLEY	CHARLEY	6-3	44	27	4323	62.0	25.0	-3.4[a]	5.9[a]	3.5	2.7	Vehicle redirected although slippage occurred in anchor cable
AS-8		12 ga. W-beam[c]	CHARLEY	CHARLEY	6-3	44	27	4323	59.0	25.0	3.7[a]	6.8[a]	2.9	1.8	Vehicle redirected

(a) Maximum 50 msec avg. obtained from high-speed film analysis
(b) Maximum 50 msec avg. obtained from accelerometers mounted in car near c.g.
(c) 12-in. wide doublers used at intermediate posts

tests in this program. Other general performance test results on the G4S and MB4S systems are not known to the authors.

Recent decisions by the producers of this W6x8.5 shape have forced the fabricators/suppliers to look for alternates due to the availability of the standard post. Posts which can be cold formed from steel sheet are attractive for two primary reasons:

- Sheet steel availability is favorable compared to hot rolled structural shapes
- A large number of manufacturers can produce cold formed elements

Accordingly, the sponsors conceived and fabricated prototype post sections referred to as the CHARLEY post. Southwest Research Institute was selected to evaluate under standard crash test conditions guardrail systems utilizing this new post element. Appendix A contains comparison of structural properties of the CHARLEY post and the W6x8.5 post.

CRASH TEST PROGRAM

The objective of this test series was to evaluate the CHARLEY post under the recommended crash test conditions of draft document on testing criteria which is part of the current NCHRP-22-2/1 project at SwRI. Specifically, this document recommends the following test conditions for a guardrail installation:

Vehicle weight - 4500 lbs ± 200
Impact speed - 60 mph ± 2 mph
Impact angle - 25 deg ± 2 deg

Test installations utilizing the new post and spacer were constructed as described in Figure 1. As shown in this figure, the first test utilized the CHARLEY (C) post with the new Thrie beam(2) mounted at 32 in. above grade. The remaining tests evaluated the C post with the standard 12-ga W-beam. In the first two tests (AS-6 and AS-7) the web of the post was facing the approaching vehicle; in the last test (AS-8) the open section faced the approaching vehicle.

The posts were driven to grade utilizing a new post driver as shown in Figure 2. The Sterling Self-Contained Impulse Post Driver* is a hydraulic-powered, nitrogen gas impulse unit which delivers 600 ft-lbs/blow at 890 blows/minute.

Identical vehicles were used in the three tests. The 1969 Plymouth sedans shown in Figure 3 were ballasted as shown to a test weight of 4323 lbs.

TEST PROCEDURES

The crash tests in this program were conducted with vehicles running under power guided by the left wheels riding in a guide channel terminated prior to impact. Vehicle ignition and brakes were controlled remotely through a tether line, which also carried the signals from two strain gage accelerometers located in the longitudinal and lateral (or transverse) directions of the

*Manufactured by Sterling Engineering Company, Wilkes-Barre, Pa.

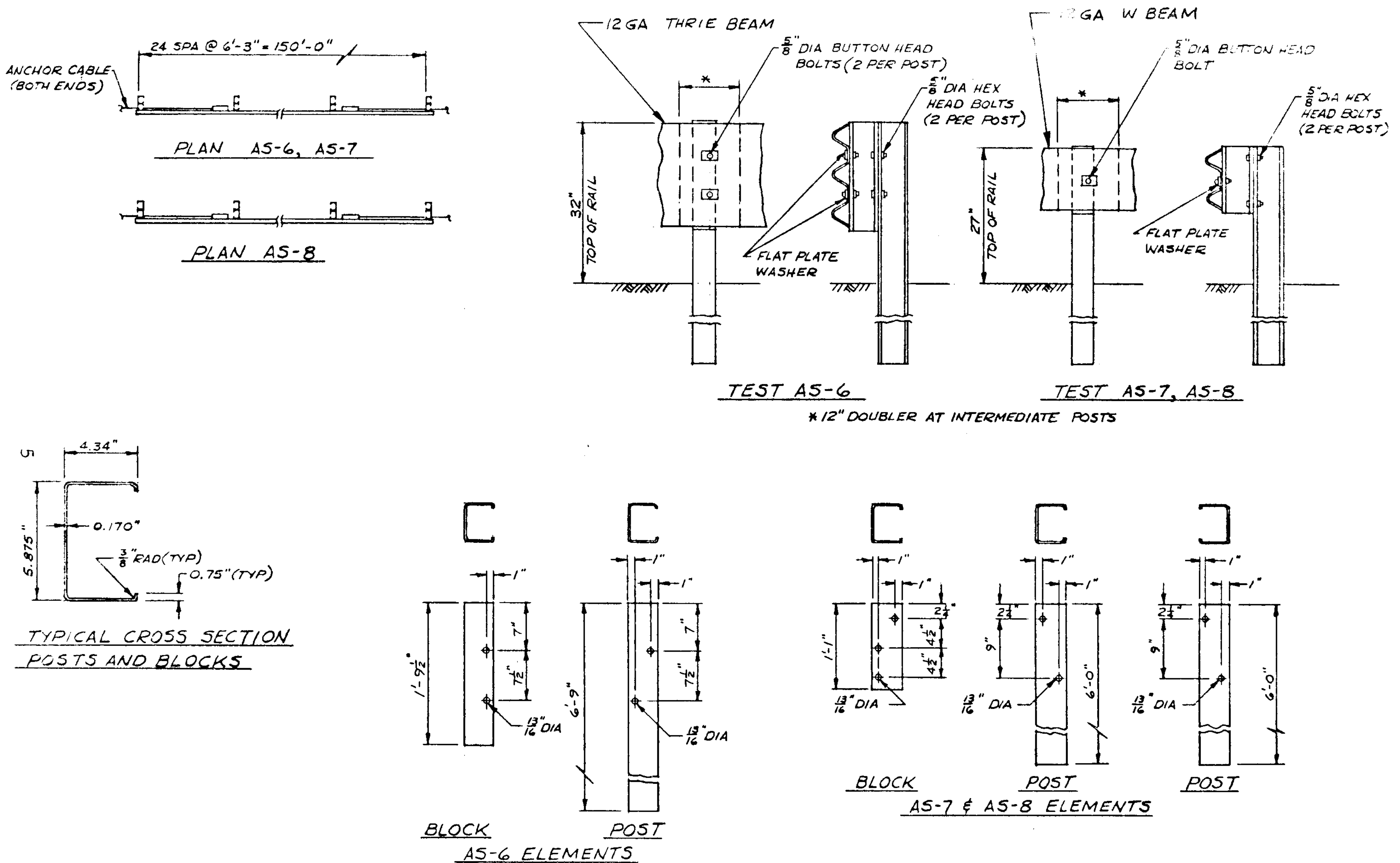


FIGURE 1. TEST AS-6, -7, AND -8 INSTALLATION DRAWING

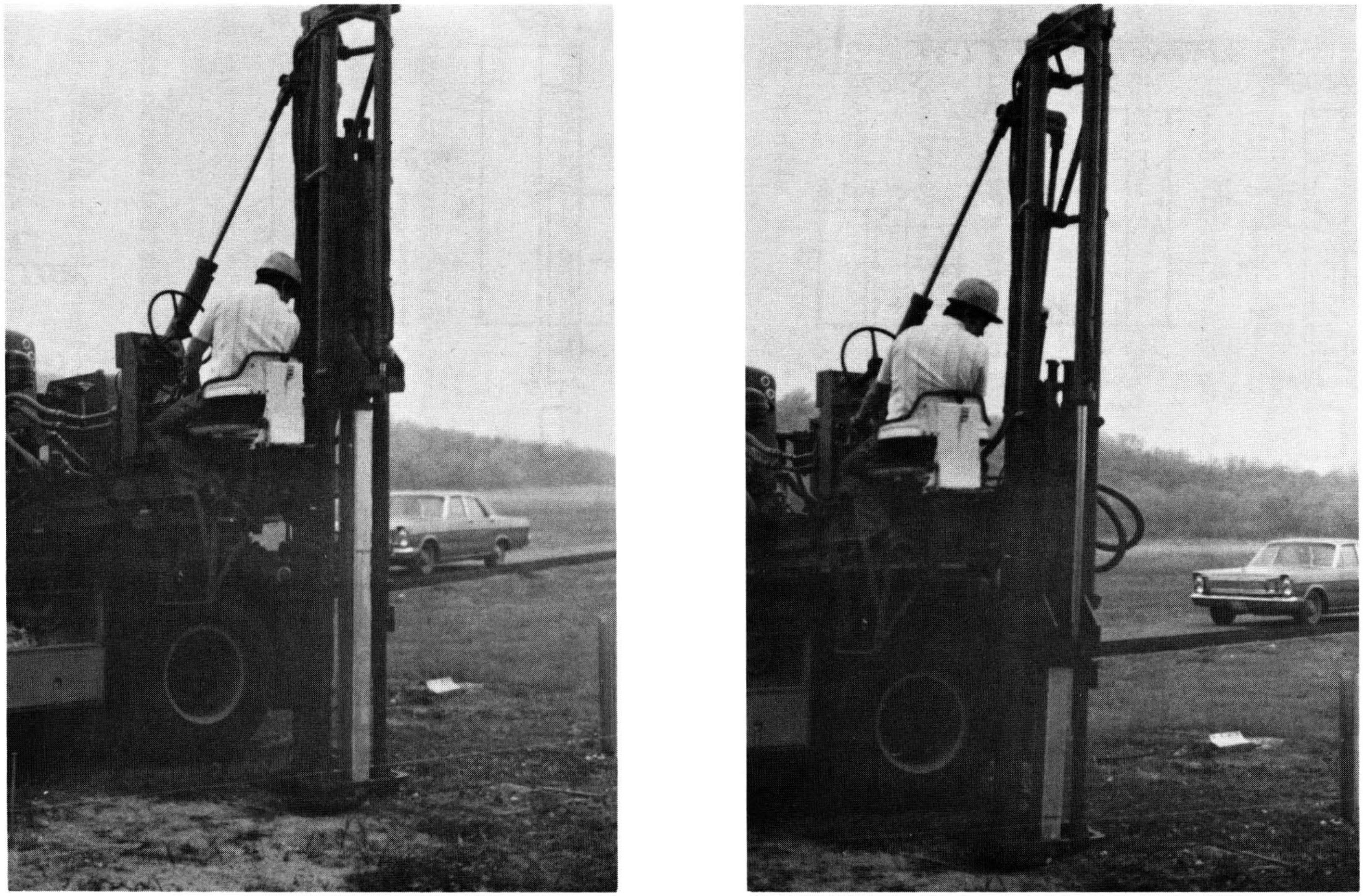


FIGURE 2.   STERLING ENGINEERING COMPANY - POST DRIVER

Test Vehicle

Ballast

FIGURE 3. TEST VEHICLE

vehicle. These transducers were mounted along or near the vehicle longitudinal centerline (a figure showing exact locations is included with accelerometer trace), and the signals were continuously recorded on high-speed magnetic tape.

A summary of the data acquisition systems is presented in Table 2. Test events were also documented by motion and still photography. Five high-speed and two documentary 16mm movie cameras provided extensive coverage of the test details before, during and after the tests.

DATA PROCESSING

Data were derived from two primary sources:

1. Micromotion analysis of high-speed film
2. Accelerometers

Data were taken from film using a Vanguard motion analyzer and then processed by the SwRI Data III motion analysis computer program. Timing marks on the film edge and event markers (i.e., flash bulbs) assured frame rate accuracy and synchronization of the film data.

Accelerometer signals were recorded at 60 ips on magnetic tape; the signals were recorded on oscillograph charts and transferred to standard forms.

Film analysis and electronic transducer data are presented in Appendix B.

TABLE 2

CRASH TEST ELECTRONIC DATA ACQUISITION SYSTEM

Component	Function	Equipment	General Description
Transducer	Converts a physical phenomenon to an electric signal	Accelerometer	Bell & Howell 4-202-001 strain gage accelerometer
Line Driver	Scales and amplifies transducer signal	SwRI Design	Completes transducer circuit and amplifies signal to 1.0v for full-scale response; contains calibration circuit to introduce 0-1000 mv signal. Frequency response DC to 100 kc minimum
Tape Recorder	Provides permanent, high quality magnetic tape record of test data	CEC VR-330 Magnetic Tape Recorder/ Reproducer	14 channels FM recorder; tape speeds: 30 to 60 ips; extended bandwidth: DC to 20 kc; 108 kc center frequency; signal/noise: 55 db minimum; input sensitivity: 0.5 to 10.0 v rms; linearity: 0.5% of full scale
Oscillograph	Provides analog traces of raw and filtered data	CEC Oscillograph 5-124 A	8 channel oscillograph with independent galvonometer and galvonometer circuits. Galvonometers used are CEC 7-338 (within ±5% flat frequency response from 0 to 125 hz)

TEST RESULTS

Results of the test series are presented in chronological order.

AS-6

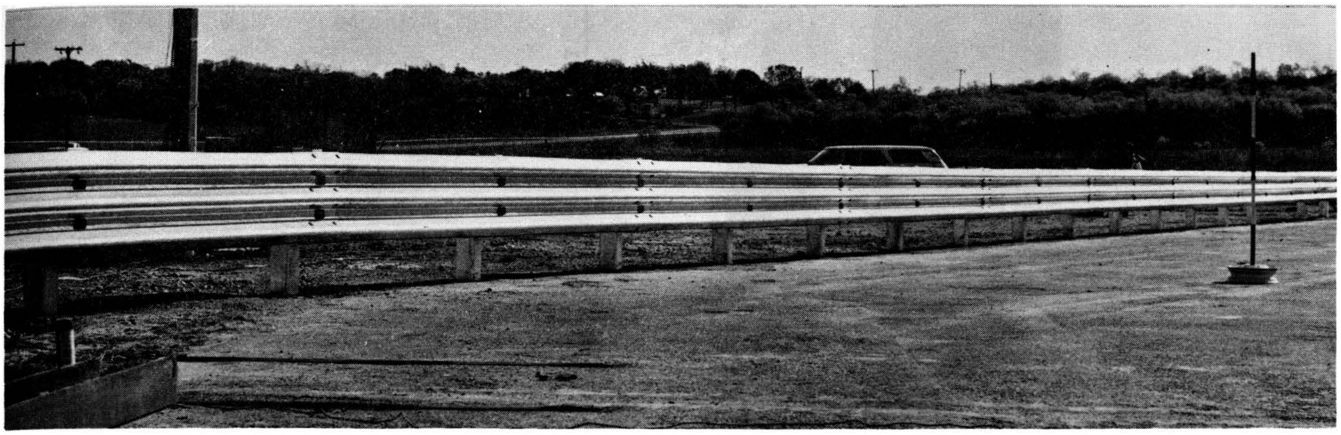
Purpose: Objective was to evaluate a C post installed with 12-ga Thrie beam element under proposed standard test conditions.

Test Installation: The installation is described in Figure 1 and shown in Figure 4.

Performance: The 4323-lb vehicle impacted the barrier with a speed of 61.3 mph and an impact angle of 25 deg. The vehicle was redirected as shown in Plate 1 and Figure 5; evidence of wheel contact with Posts 11 and 12 was noted (tire marks on post face) although no snagging resulted. Maximum dynamic deflection of 2.6 ft occurred between Posts 11 and 12; maximum average (50 msec) decelerations were 3.6 g's (longitudinal) and 6.1 g's (lateral).

Installation Damage: Damage to the installation included two rail sections between Posts 9 and 13, and posts and spacer blocks at Posts 10, 11, and 12 as shown in Figure 6. Table 3 contains permanent deflection and damage information.

Vehicle Damage: As shown in Figure 6, damage to the vehicle was confined to the left front quadrant. Rim damage at the left front wheel could be attributed to post contact.



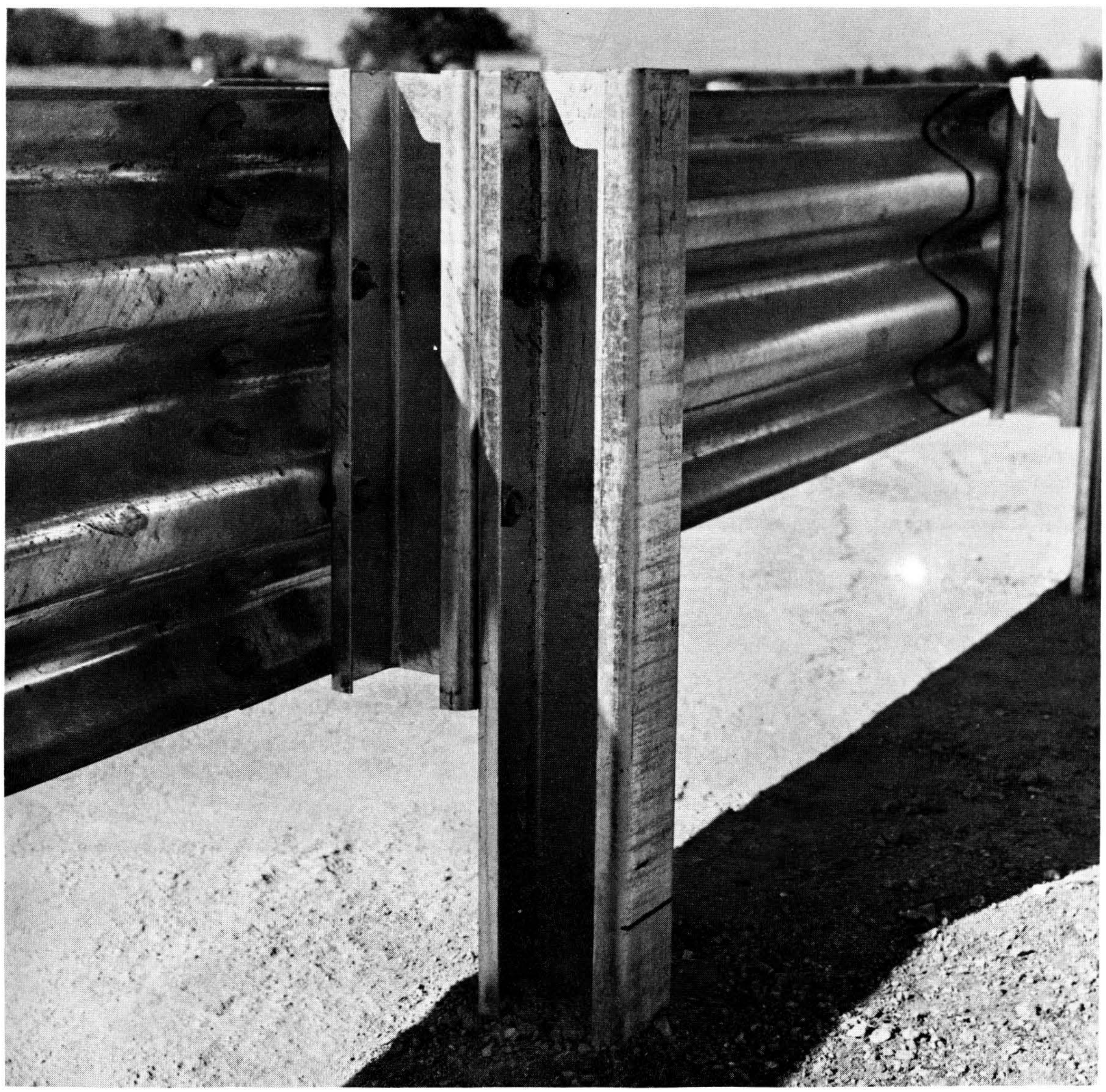
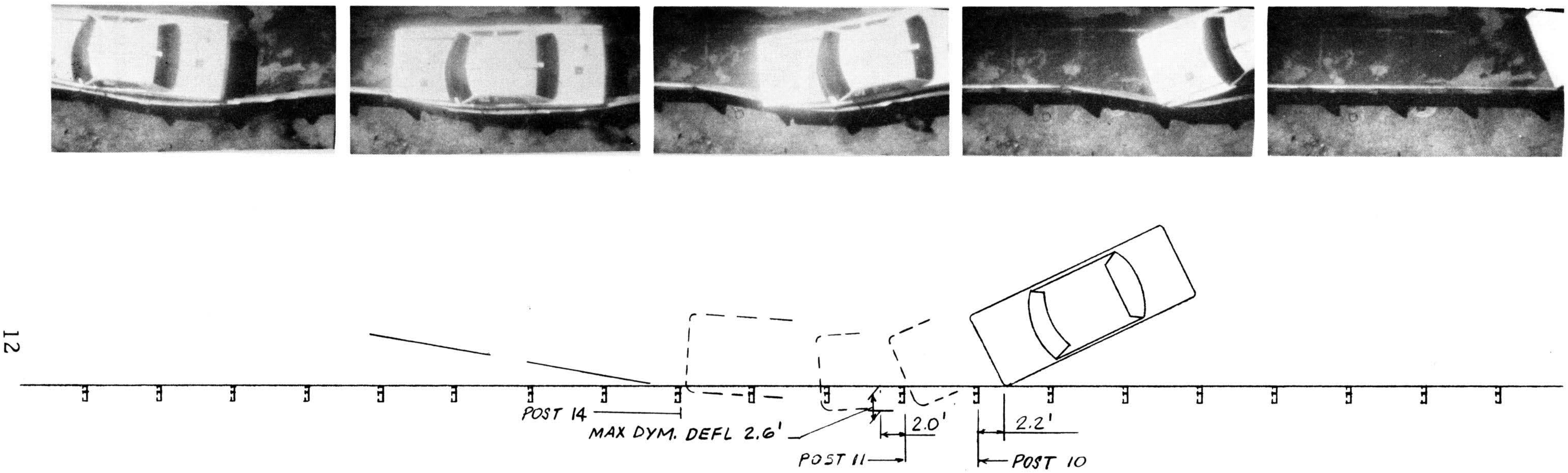


FIGURE 4. TEST AS-6 INSTALLATION PHOTOGRAPHS



Barrier .... Guardrail
Beam .... 12-ga. Thrie Beam
Post ...... CHARLEY post (0.170 thickness) x 6'-9" long
Post Embedment .... 48"
Post Spacing .... 6'-3"
Length of Installation .... 150'
Ground Condition .... Dry

Test No. AS-6
Date 3/19/74
Vehicle .... 1969 Plymouth
Vehicle Weight
(w/ballast and instrumentation) .. 4323 lbs
Impact Speed .... 61.3 mph
Impact Angle .... 25 deg
Maximum Deflection, ft
(dynamic/permanent)............ 2.6/1.7

PLATE 1. SUMMARY OF RESULTS, CRASH TEST AS-6

FIGURE 5. TEST AS-6 SEQUENTIAL PHOTOGRAPHS

FIGURE 6. PHOTOGRAPHS AFTER TEST AS-6

TABLE 3

TEST AS-6 INSTALLATION DAMAGE SUMMARY

Post No.	Beam Defl. (in.)	Remarks
7	0	
8	3/4	
9	4-3/4	
10	12-1/2	
11	18-1/2 20 (max)	Block pinched shut at bottom wheel contact on post under beam
12	16	Block opened, wheel contact just below beam
13	5-1/4	
14	1-1/4	
15	0	

No evidence of tearing of rail or failure of any fasteners.

AS-7

Purpose: Objective was to evaluate under standard test conditions the G4S guardrail system utilizing the C post and spacer instead of the W6x8.5.

Test Installation: The installation is described in Figure 1 and shown in Figure 7. The web of the post was facing the approaching vehicle.

Performance: The 4323-lb vehicle impacted the barrier upstream of Post 10 with a speed of 62 mph and an angle of impact of 25 deg. The vehicle was redirected as shown in Plate 2 and Figure 8. Evidence of wheel contact with Posts 11 and 12 was noted. Slippage of the upstream anchor cable at the clips permitted the upstream end post to translate 3-1/2 in. downstream. This longitudinal movement not only resulted in a larger dynamic deflection, but also extended the length of vehicle contact with the barrier. Appendix C contains a discussion of the cable anchorage problem. Maximum dynamic deflection of 3.5 ft occurred at Post 12; maximum average (50 msec) vehicle decelerations were 3.4 g's (longitudinal and 5.9 g's (lateral).

Installation Damage: Damage to the installation included three rail sections between Posts 9 and 15 as shown in Figures 7 and 9. A summary of the permanent deflections and damage is given in Table 4. Figure 10 contains photographs of upstream anchor after test.

Vehicle Damage: Damage was confined to left front quadrant and the left rear wheel where a bent rim caused tire deflation (Fig. 9).

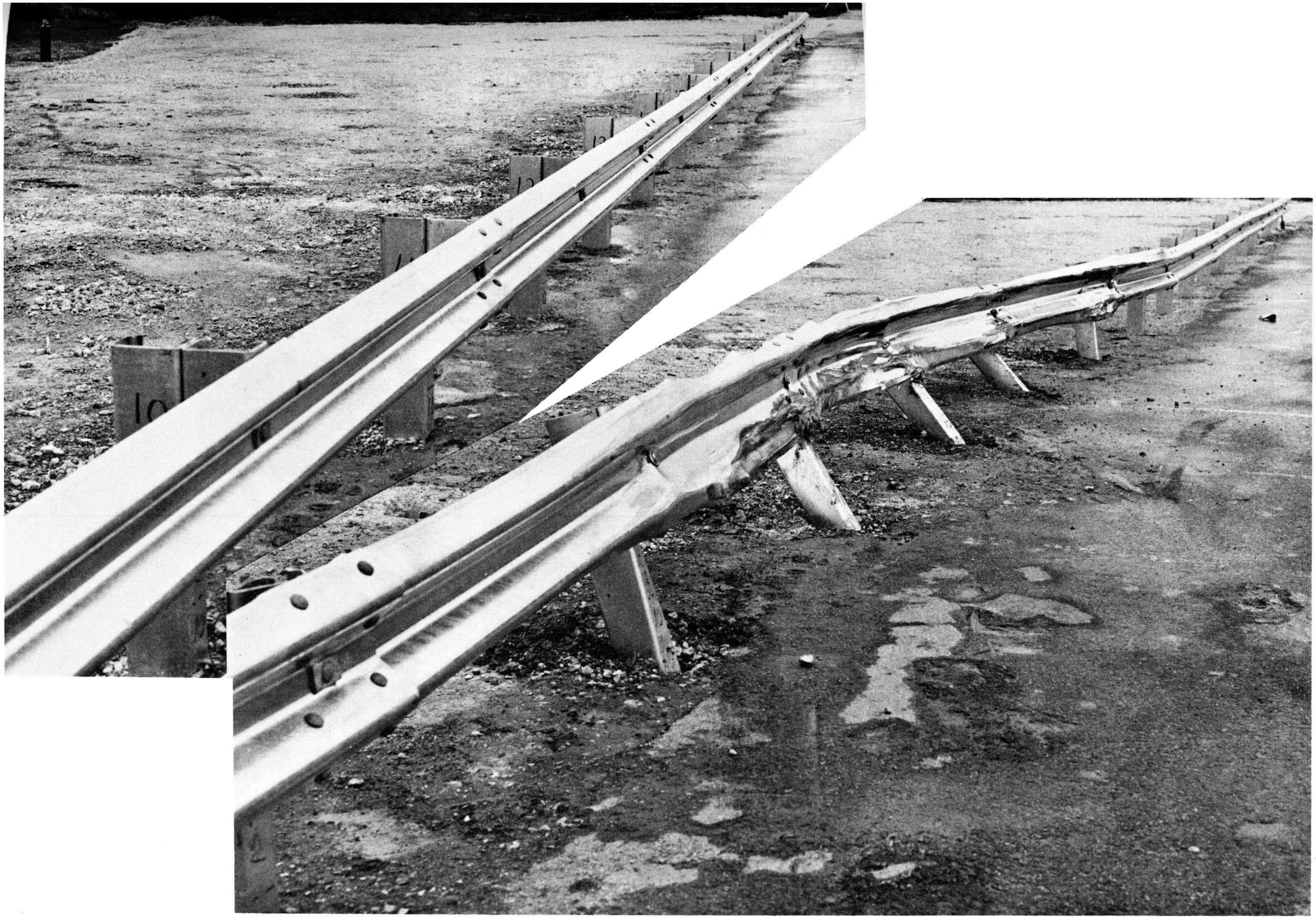
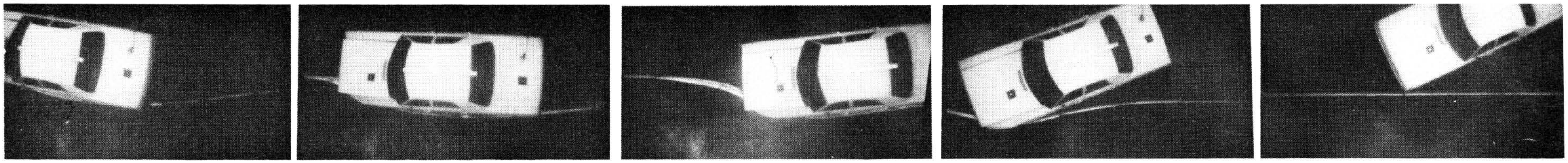
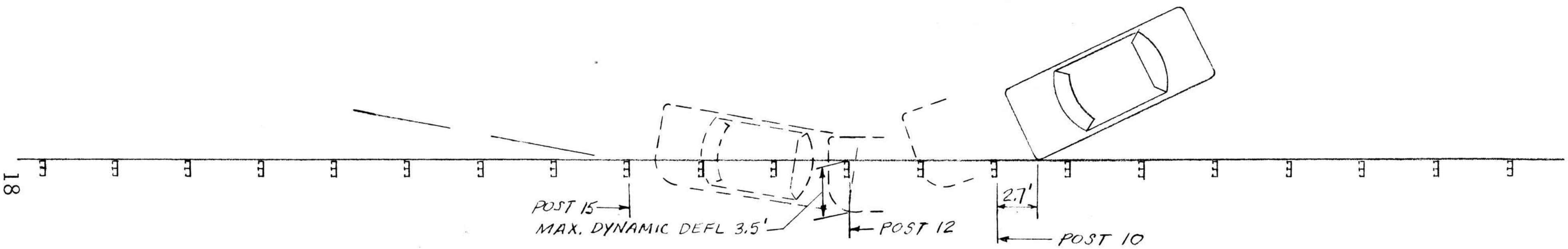


FIGURE 7. TEST AS-7 INSTALLATION PHOTOGRAPHS

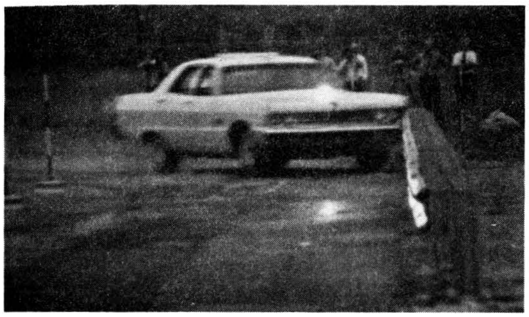




Barrier	Guardrail
Beam	12-ga. W-beam
Post	CHARLEY post (0.170 thickness) x 6'-0" long
Post Embedment	44"
Post Spacing	6'-3"
Length of Installation	150'
Ground Condition	Dry

Test No.	AS-7
Date	3/20/74
Vehicle	1969 Plymouth
Vehicle Weight (w/ballast and instrumentation)	4323 lbs
Impact Speed	62.0 mph
Impact Angle	25 deg
Maximum Deflection, ft (dynamic/permanent)	3.5/2.7

PLATE 2. SUMMARY OF RESULTS, CRASH TEST AS-7



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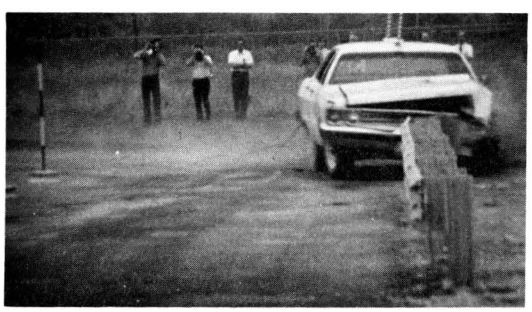

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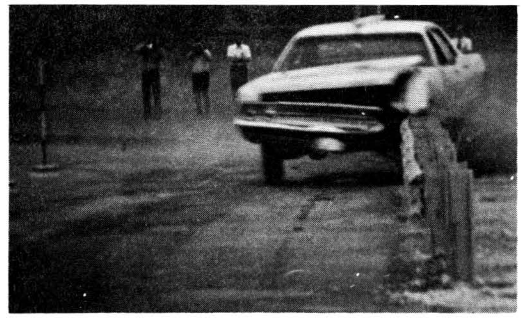

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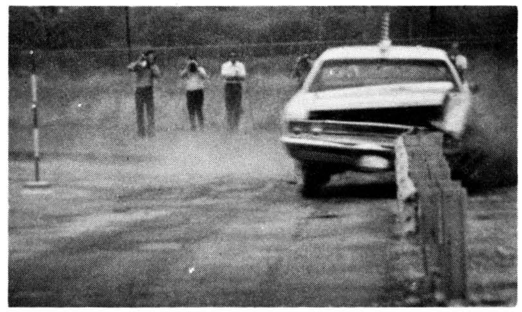

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FIGURE 8. TEST AS-7 SEQUENTIAL PHOTOGRAPHS

FIGURE 9. PHOTOGRAPHS AFTER TEST AS-7

TABLE 4

TEST AS-7 INSTALLATION DAMAGE SUMMARY

Post No.	Max. Defl. (in.)	Remarks
1	0	3-1/2" downstream displacement
2	0	Spacer blocks twisted elastically downstream (posts 2–9)
3	0	
4	0	
5	0	
6	0	
7	0	
8	3/4	
9	4-1/4	
10	15	Spacer block and post twisted (yield) counter-clockwise (looking down)
11	27-1/2	Post pushed back in soil, spacer flattened due to post translation downstream
12	33	Post pushed back in soil, spacer flattened due to post translation downstream
13	27-1/2	Post and spacer twisted (yield) CCW looking down
14	9	Post and block twisted (yield) CCW looking down
15	1/2	
16	0	

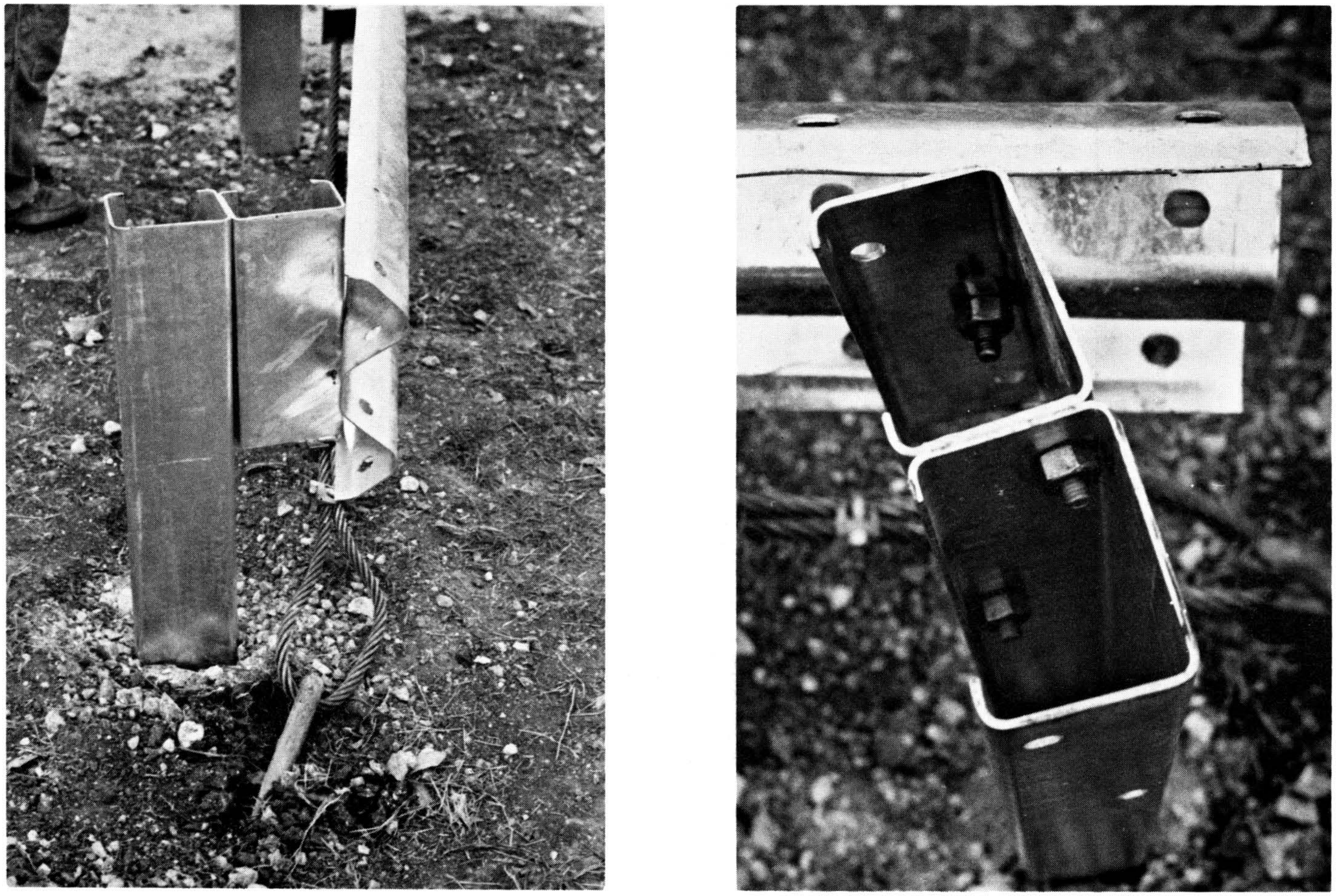


FIGURE 10. ANCHORAGE PHOTOGRAPHS AFTER TEST AS-7

AS-8

Purpose: Objective was to evaluate under standard test conditions the G4S system with the C post facing the opposite direction from Test AS-7.

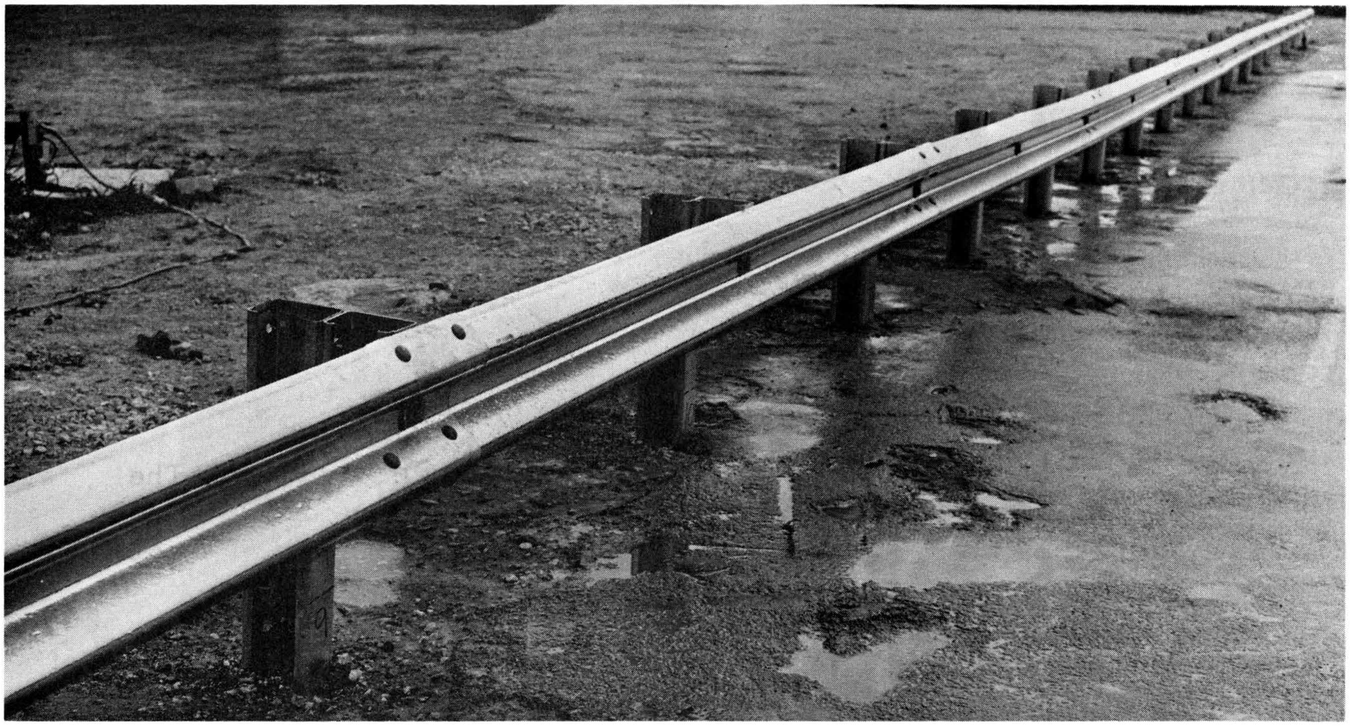
Test Installation: The installation as described in Figure 1 and shown in Figure 11 was identical to that of AS-7 with two exceptions:

- The C post and spacers were rotated 180°
- The five anchor cable clips were torqued to 90 ft-lbs. The anchor cable preload corresponded to a torque of 90 ft-lbs on the 1 in. dia stud. This load was on the threshold of causing W-beam deformation

Performance: The 4323-lb vehicle impacted the barrier upstream of Post 10 with a speed of 59 mph and at an angle of 25 deg. The vehicle was smoothly redirected as shown in Plate 3 and Figure 12. Maximum dynamic deflection of 2.9 ft occurred between Posts 11 and 12; maximum average (50 msec) vehicle decelerations were 3.7 g's (longitudinal) and 6.8 g's (lateral).

Installation Damage: Installation damage was confined to two beam sections between Posts 9 and 13. The damage is shown in Figures 11 and 13 and summarized in Table 5. No evidence of anchorage cable slip was noted. The two upstream beam splices at Posts 3 and 5 showed no evidence of slip.

Vehicle Damage: Damage was confined to left front quadrant of vehicle as shown in Figure 13.



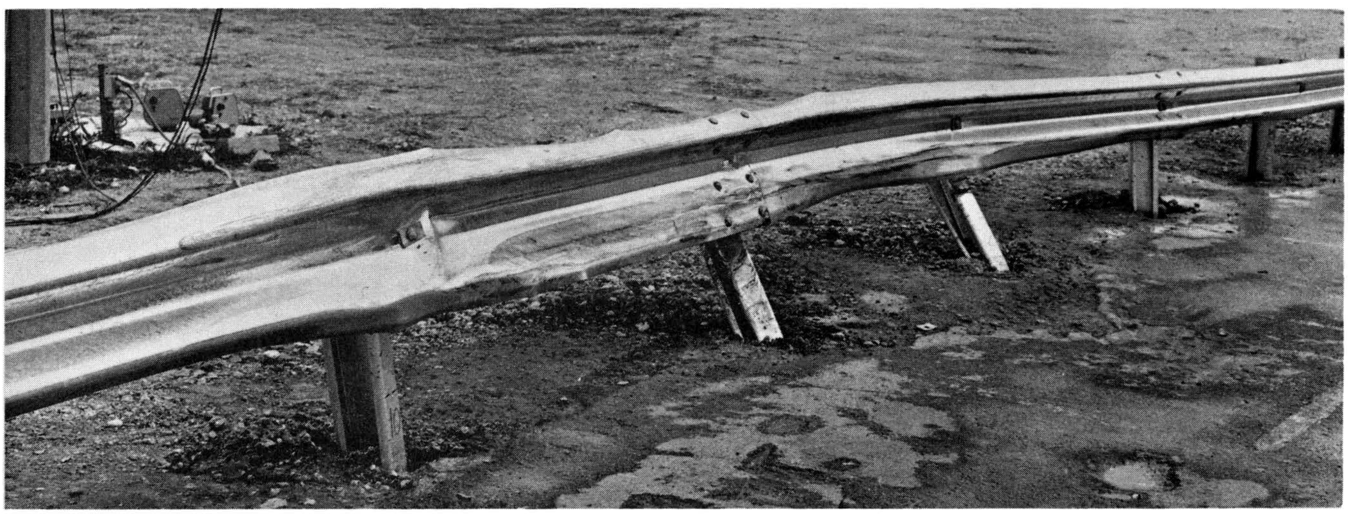
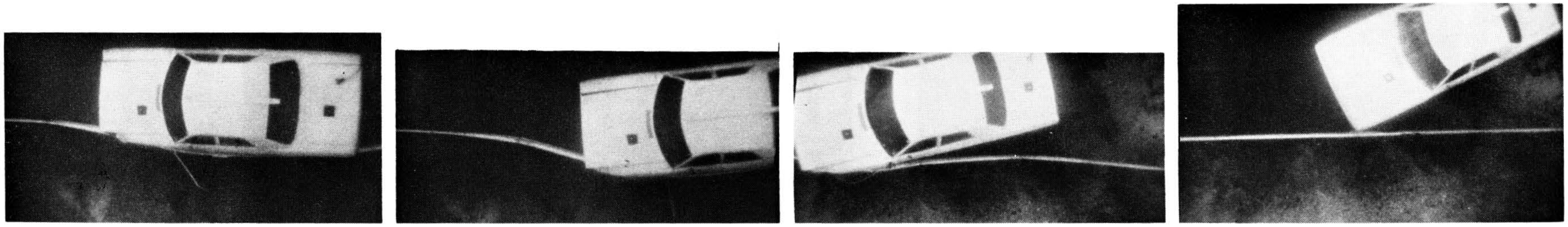
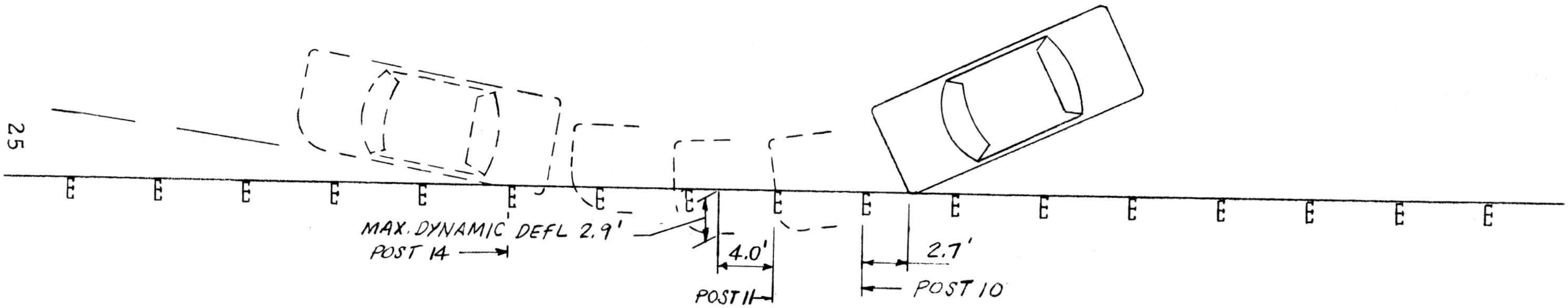


FIGURE 11. TEST AS-8 INSTALLATION PHOTOGRAPHS

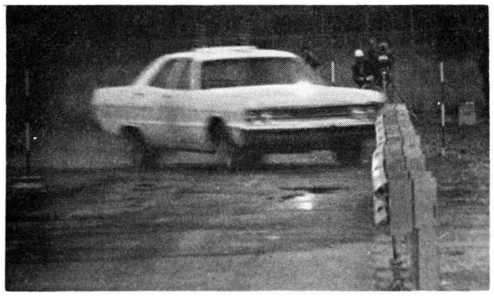




Barrier	Guardrail
Beam	12-ga. W-beam
Post	CHARLEY post (0.170 thickness) x 6'-0" long
Post Embedment	44"
Post Spacing	6'-3"
Length of Installation	150'
Ground Condition	Dry

Test No.	AS-8
Date	3/21/74
Vehicle	1969 Plymouth
Vehicle Weight (w/ballast and instrumentation)	4323 lbs
Impact Speed	59.0 mph
Impact Angle	25 deg
Maximum Deflection, ft (dynamic/permanent)	2.9/1.8

PLATE 3. SUMMARY OF RESULTS, CRASH TEST AS-8



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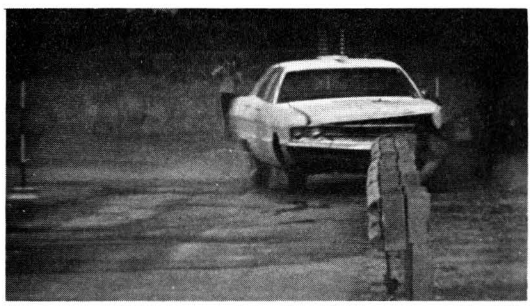

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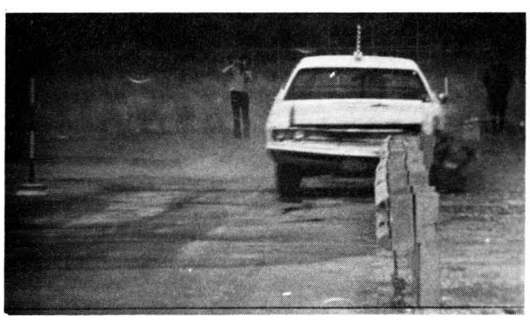

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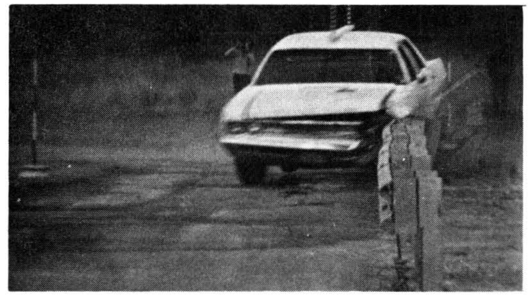

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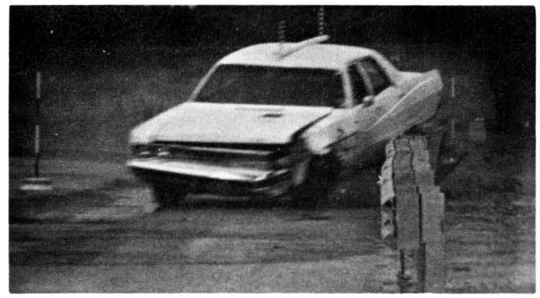

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FIGURE 12. TEST AS-8 SEQUENTIAL PHOTOGRAPHS

TABLE 5

TEST AS-8 INSTALLATION DAMAGE SUMMARY

Post No.	Permanent Defl. (in.)	Splice Joint Slip (in.)	Remarks
7	0	1/16	
8	0		
9	2	5/32	Spacer partially closed
10	9-3/4		Spacer pinched closed, block and spacer twisted CCW looking down
11	19-3/4 22 max	21/32	Rail separated from spacer by bolt head shear. Spacer flattened by downstream translation of post. Post pinched closed at grade
12	21		Spacer flattened by downstream translation of post; post partially closed at grade
13	9-1/2	5/32	Post twisted CCW (looking down). Spacer flattened by downstream translation and twisting of post
14	1-3/4		
15	0	5/16	

FIGURE 13. PHOTOGRAPHS AFTER TEST AS-8

DISCUSSION OF RESULTS

Vehicle redirection/containment was achieved in all tests in this series. No evidence was noted of near failure of the system in any of the tests. Comparison of these test results with others can be made from Table 1 and also by detailed information in the references. Although the number of variables are considerable when comparing the test results (e.g., vehicle size and speed, impact angle, soil condition, etc.), the acceleration and deflection values are all within a reasonable range for both CHARLEY and W6x8.5 post tests.

Vehicle stability during the impact events was noticeably better in the Thrie beam test (AS-6) than in the two W-beam tests (AS-7 and AS-8). The greater width and height of the Thrie beam would seem to control redirection of the vehicle in a superior manner.

The anchorage cable slip which occurred in Test AS-7, while no doubt affecting the results of the test, did not result in failure of the system; in a test conducted by California[5], the anchorage slip did contribute to a failure of the W-beam. It should be noted that back-up doublers at intermediate posts were not utilized in the California test whereas they were used in the AS series. The failure in the CDH test occurred at an intermediate post.

RECOMMENDATIONS

Based on the results of this test series, the CHARLEY post is recommended as an alternate post for use with the G4S and MB4S systems.

Approval of the CHARLEY post as an alternate to the W6x8.5 steel post was granted in FHWA Notice N 5040.2 dated April 30, 1974 (Appendix D).

LIST OF REFERENCES

1. Michie, J. D. and Bronstad, M. E., "Location, Selection, and Maintenance of Highway Traffic Barriers," NCHRP Report 118, 1971.

2. Bronstad, M. E., Michie, J. D., Viner, J. G., and Behm, W. E, "Crash Test Evaluation of Thrie Beam Traffic Barriers," paper presented at Highway Research Board Annual Meeting, 1974.

3. Michie, J. D., Calcote, L. R., and Bronstad, M. E., "Guardrail Performance and Design," NCHRP Report 115, 1971.

4. Graham, M. D., et al, "New Highway Barriers: The Practical Application of Theoretical Design," Highway Research Record No. 174, 1967, pp. 88-183.

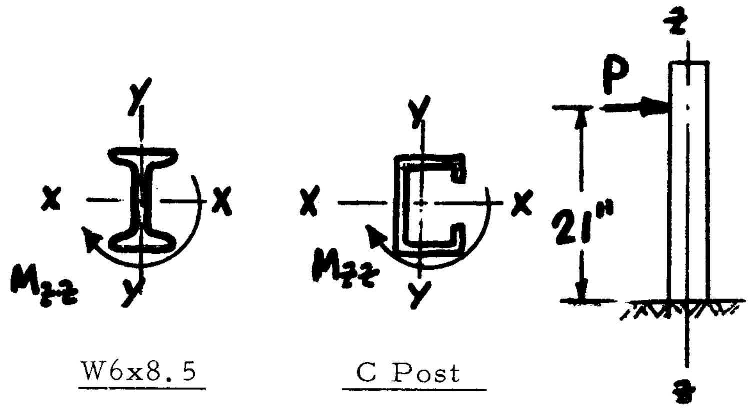
5. Draft Report, "Dynamic Tests of Metal Beam Guardrail, Series XXVII," California Division of Highways, 1974.

APPENDIX A

STRUCTURAL PROPERTIES OF POSTS

STRUCTURAL PROPERTY COMPARISON

σ_e = stress of material



	W6x8.5	C Post	Ratio C Post / W6x8.5
1. Plastic moment $M_{P\ x-x}$	5.566 σ_e	5.511 σ_e	0.99
2. Plastic moment $M_{P\ y-y}$	0.773 σ_e	1.826 σ_e	2.36
3. Plastic moment $M_{P\ z-z}$	0.265 σ_e	0.203 σ_e	0.90
4. Buckling P_x	0.265 σ_e	0.263 σ_e	0.99
5. Buckling P_y	0.037 σ_e	0.087 σ_e	2.36

SKYLINE STRUCTURES

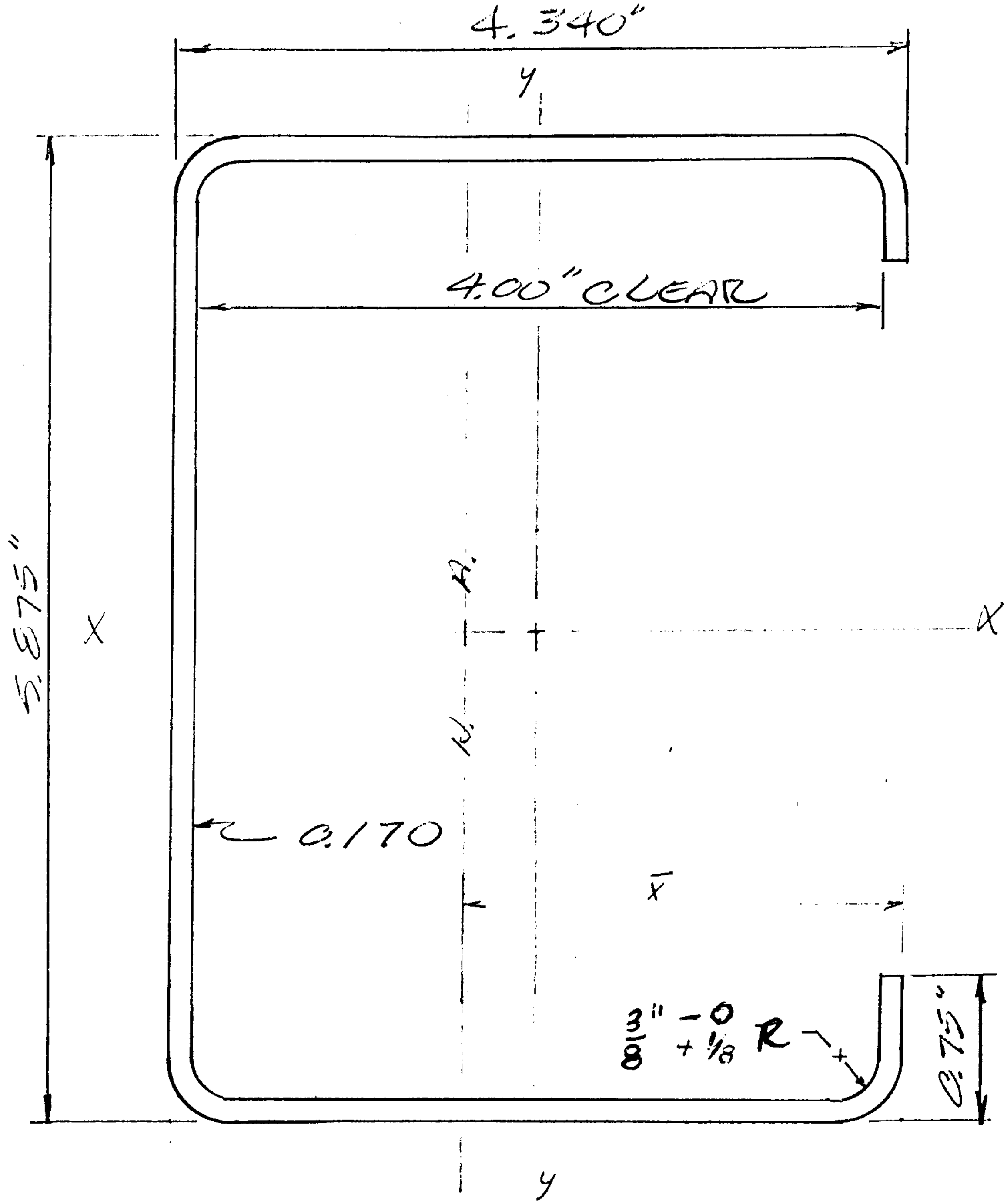
MFR'S OF OVERHEAD SIGN SPANS AND TRANSMISSION POLES

Division of Anderson *"Safeway"* Guard Rail Corp.

FLINT, MICHIGAN • LIMA, OHIO

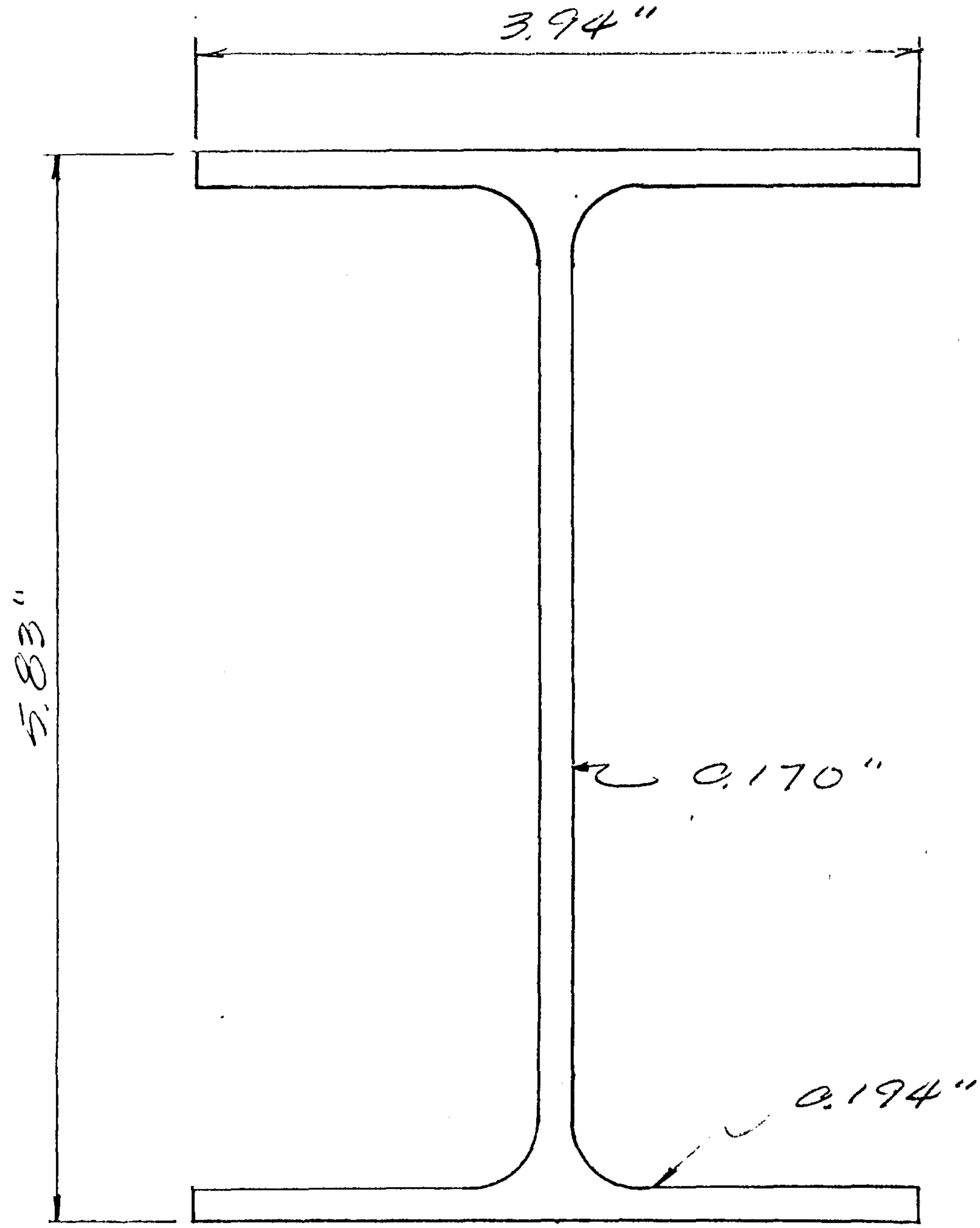
FOR: "C" POST DATE: 1-22-74 SH. NO. 1

SUBJECT: BY: KELLY APPV'D:



SKYLINE STRUCTURES
MFR'S OF OVERHEAD SIGN SPANS AND TRANSMISSION POLES
Division of Anderson *"Safeway"* Guard Rail Corp.
FLINT, MICHIGAN • LIMA, OHIO

FOR: W6 x 8.5 DATE: 1-22-74 SH. NO. 2
SUBJECT: BY: KELLY APPV'D:



W6 x 8.5

AISC
DESIGN
DIMENSIONS.

SKYLINE STRUCTURES
MFR'S OF OVERHEAD SIGN SPANS AND TRANSMISSION POLES
Division of Anderson *"Safeway"* Guard Rail Corp.
FLINT, MICHIGAN • LIMA, OHIO

FOR: 6" POST DATE: 1-22-74 SH. NO. 3
SUBJECT: BY: KELLY APPV'D:

"X - X"

$$I_{xx} = \frac{4.34(5.875)^3}{12} - \frac{4.0(5.535)^3}{12} - \frac{0.17(4.375)^3}{12}$$

$$I_{xx} = 15.63\ in^4$$

$$S_{xx} = \frac{I_{xx}}{c} = \frac{15.63}{2.9375} = 5.32\ in^3$$

SHT WIDTH $= \frac{\pi}{2}(\tfrac{1}{2} + 0.84) + 2(4.34 - 0.84) + 2(\tfrac{3}{4} - 0.42) + (5\tfrac{7}{8} - 0.84)$

$= 14.80$ INS USE $14\tfrac{13}{16}$"

WGT/L.FT $= \frac{14\tfrac{13}{16}}{12} \times 40.8 \times 0.170 = 8.56$#

CROSS-SECTIONAL AREA $= 14\tfrac{13}{16} \times 0.170$

$= 2.52\ in^2$

SKYLINE STRUCTURES
MFR'S OF OVERHEAD SIGN SPANS AND TRANSMISSION POLES
Division of Anderson *"Safeway"* Guard Rail Corp.
FLINT, MICHIGAN • LIMA, OHIO

FOR: "C" POST DATE: 1-22-74 SH. NO. 4
SUBJECT: BY: KELLY APPV'D:

"Y - Y"

$$\bar{X} = [(5.875)(0.17)(4.255) + (4)(0.34)(2.17) + (1.5)(0.17)(0.085)] \div [(5.875 + 8.0 + 1.5)(0.17)]$$

$$= \frac{4.250 + 2.951 + 0.022}{2.614} = \underline{\underline{2.763''}}$$

$$\therefore I_{yy} = (5.875 \times 0.17)(1.577)^2 + 2\left(\frac{0.17 \times 4^3}{12} + 4(0.17)(0.593)^2\right) + (1.5 \times 0.17)(2.763)^2$$

$$= 2.484 + 2.292 + 1.947 = \underline{\underline{6.72 \text{ in}^4}}$$

$$S_{yy_{min}} = \frac{I_{yy}}{c} = \frac{6.72}{2.763} = \underline{\underline{2.43 \text{ in}^3}}$$

SKYLINE STRUCTURES

MFR'S OF OVERHEAD SIGN SPANS AND TRANSMISSION POLES

Division of Anderson *"Safeway"* Guard Rail Corp.

FLINT, MICHIGAN • LIMA, OHIO

FOR: DATE: 1-22-74 SH. NO. 5

SUBJECT: BY: KELLY APPV'D:

PROPERTY	W6x8.5	"C" POST
AREA (A_{cs})	2.51	2.52
DEPTH (INS)	5.83	5.875
FLG. WD. (INS)	3.94	4.34
WGT/L. FT.	8.5#	8.6#
I_{xx} IN^4	14.8	15.6
S_{xx} IN^3	5.08	5.32
I_{yy} IN^4	1.98	6.72
S_{yy} IN^3	1.01	2.43

APPENDIX B

ACCELEROMETER AND FILM ANALYSIS DATA

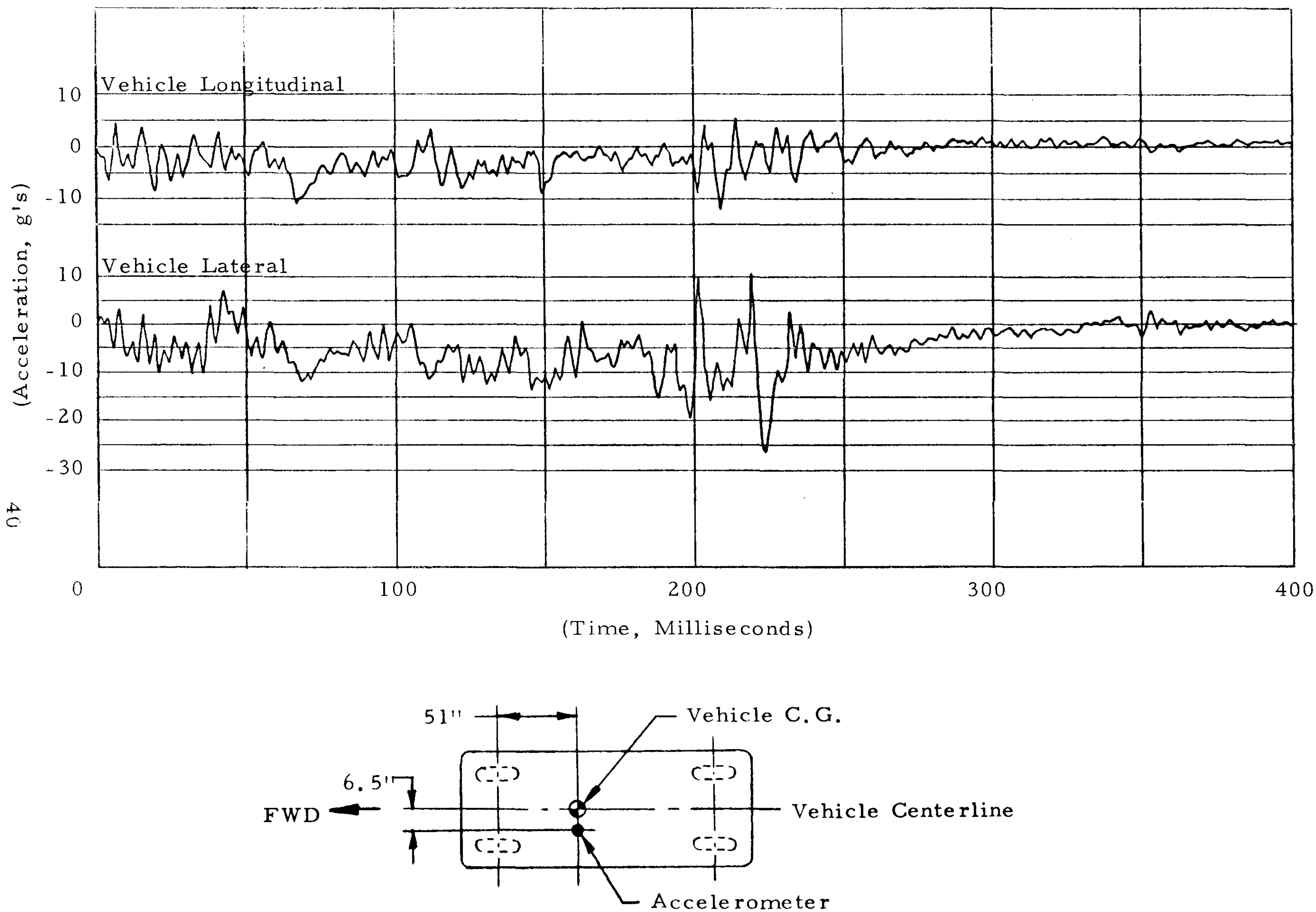


FIGURE B.1 AS-6 ACCELEROMETER DATA

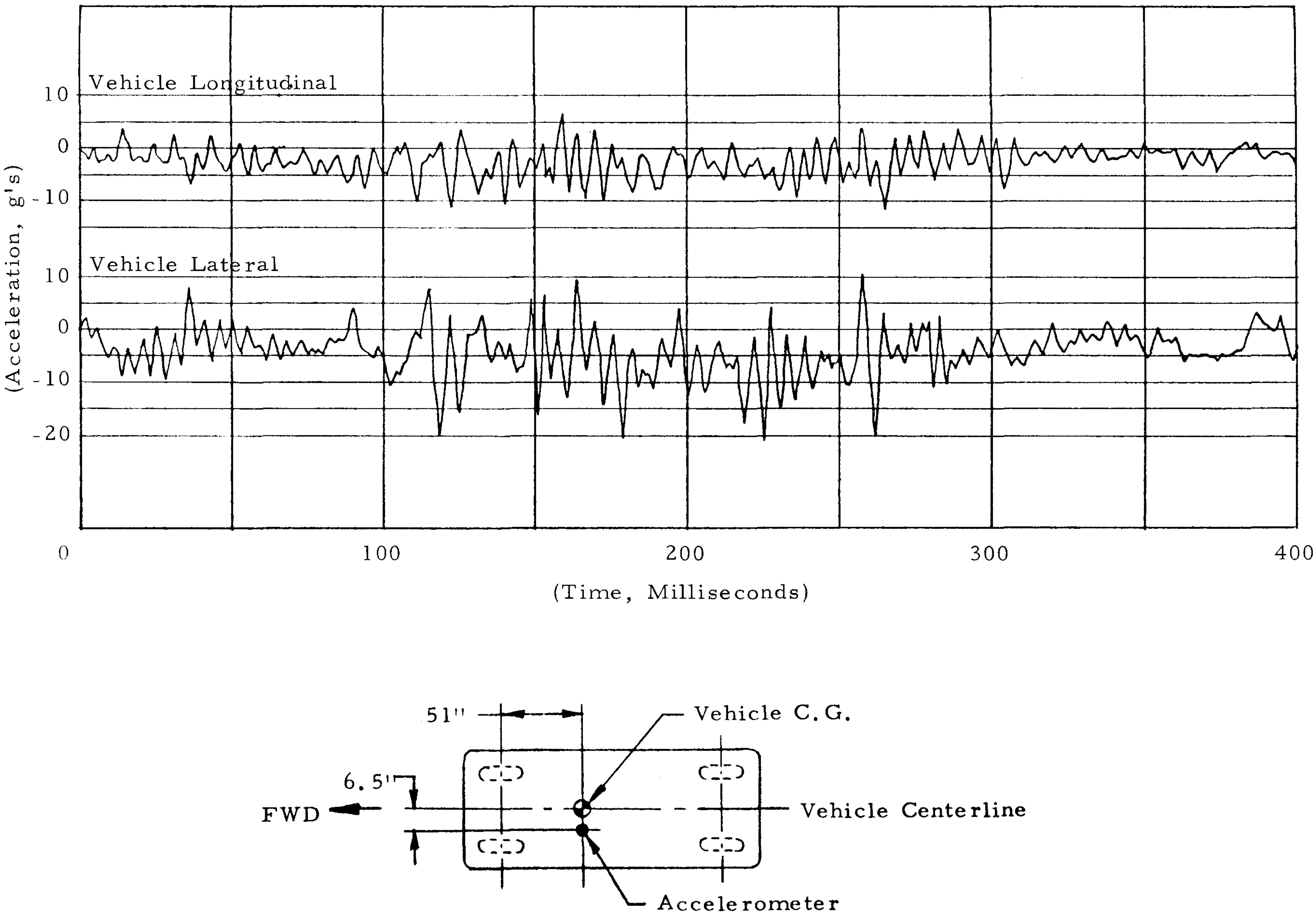


FIGURE B.2 AS-7 ACCELEROMETER DATA

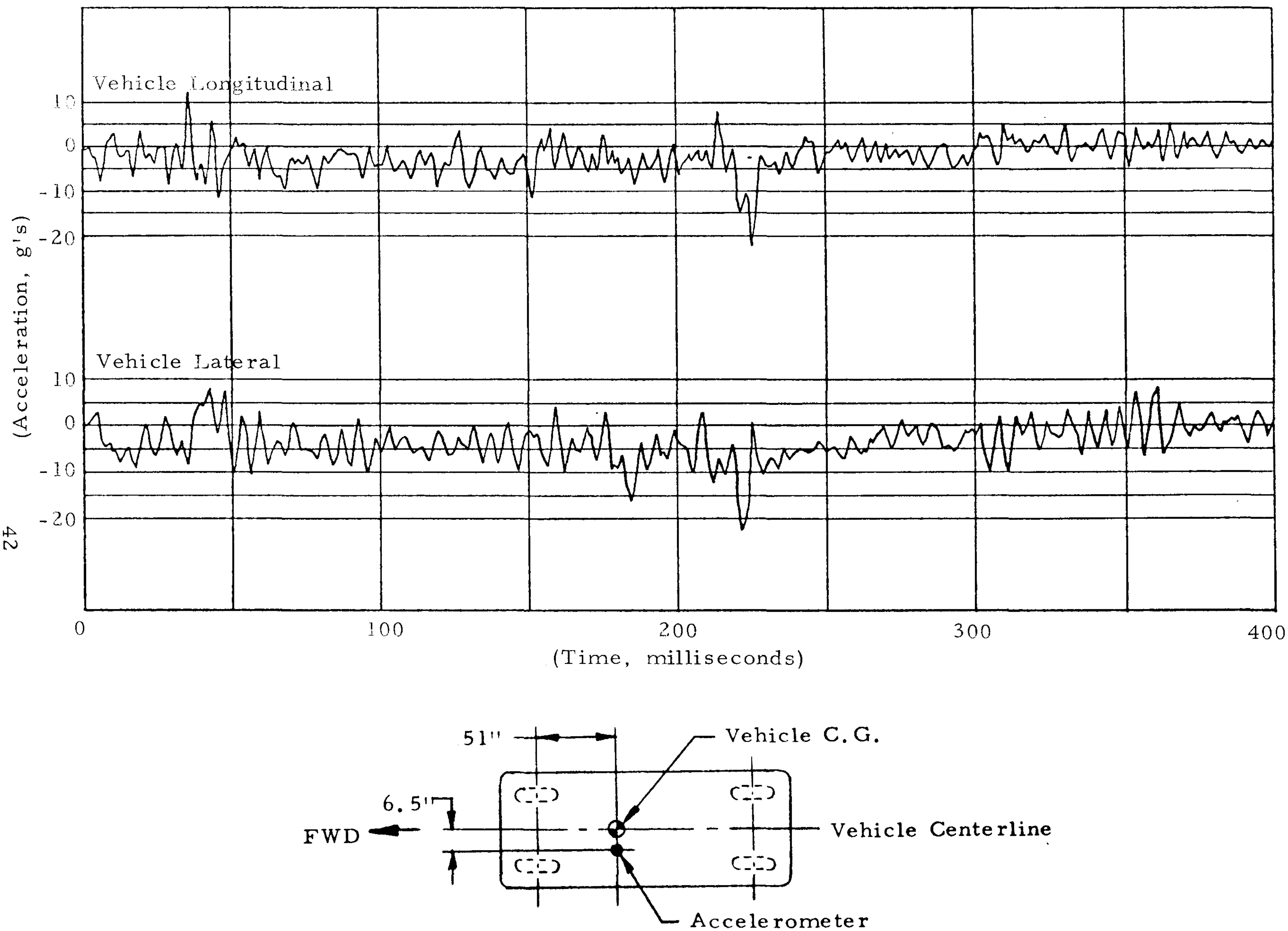


FIGURE B.3 AS-8 ACCELEROMETER DATA

TABLE B. 1

SUMMARY OF VEHICLE KINEMATIC AND DYNAMIC DATA   GUARDRAIL TEST AS-6   3/19/74

TIME AFTER IMPACT(SEC)	VEHICLE C. G. COORDINATES(FT) X	Y	HEADING ANGLE (DEG)	VEHICLE VELOCITY (FT/SEC) LONG	LAT	VEHICLE ACCELERATION(G'S) AT TIME T LONG	LAT	AVERAGE OVER .05 SEC. LONG	LAT	APPROX. BARRIER FORCES(LB) X	Y
0.000	-30.77	-12.95	24.67	88.95	2.23	-.56	.49	0.00	0.00	3074	-885
.010	-29.97	-12.56	24.72	88.69	2.18	-1.03	-.32	0.00	0.00	3468	3099
.020	-29.17	-12.17	24.84	88.29	1.78	-1.47	-1.05	0.00	0.00	3848	6751
.030	-28.38	-11.79	24.98	87.76	1.11	-1.88	-1.71	-1.64	-1.32	4214	10081
.040	-27.59	-11.41	25.10	87.09	.27	-2.25	-2.31	-2.04	-1.95	4562	13100
.050	-26.81	-11.04	25.16	86.31	-.64	-2.59	-2.85	-2.39	-2.52	4892	15817
.060	-26.03	-10.69	25.11	85.43	-1.56	-2.90	-3.33	-2.71	-3.04	5201	18244
.070	-25.25	-10.35	24.92	84.46	-2.42	-3.16	-3.76	-2.99	-3.50	5489	20389
.080	-24.47	-10.02	24.56	83.42	-3.17	-3.37	-4.15	-3.22	-3.92	5753	22265
.090	-23.70	-9.71	24.02	82.34	-3.78	-3.53	-4.51	-3.40	-4.30	5994	23880
.100	-22.94	-9.42	23.29	81.24	-4.24	-3.65	-4.82	-3.54	-4.64	6209	25246
.110	-22.18	-9.15	22.37	80.12	-4.55	-3.71	-5.11	-3.62	-4.95	6397	26373
.120	-21.42	-8.89	21.28	79.01	-4.73	-3.72	-5.36	-3.64	-5.22	6559	27270
.130	-20.67	-8.66	20.03	77.92	-4.78	-3.69	-5.57	-3.63	-5.46	6692	27949
.140	-19.92	-8.45	18.66	76.86	-4.74	-3.61	-5.76	-3.56	-5.67	6796	28420
.150	-19.18	-8.26	17.17	75.84	-4.64	-3.50	-5.90	-3.46	-5.84	6871	28693
.160	-18.45	-8.09	15.60	74.86	-4.50	-3.35	-6.01	-3.33	-5.97	6917	28778
.170	-17.72	-7.94	13.99	73.93	-4.36	-3.18	-6.08	-3.16	-6.06	6932	28685
.180	-16.99	-7.82	12.36	73.06	-4.23	-2.99	-6.11	-2.98	-6.11	6917	28426
.190	-16.27	-7.71	10.73	72.25	-4.14	-2.78	-6.10	-2.79	-6.12	6873	28010
.200	-15.56	-7.63	9.14	71.50	-4.10	-2.58	-6.05	-2.58	-6.09	6798	27447
.210	-14.85	-7.57	7.61	70.82	-4.13	-2.37	-5.96	-2.38	-6.01	6693	26749
.220	-14.14	-7.52	6.15	70.19	-4.24	-2.16	-5.83	-2.18	-5.90	6560	25924
.230	-13.44	-7.50	4.79	69.63	-4.42	-1.97	-5.67	-1.99	-5.75	6397	24985
.240	-12.75	-7.50	3.52	69.13	-4.67	-1.78	-5.47	-1.80	-5.57	6207	23940
.250	-12.06	-7.51	2.35	68.68	-5.00	-1.61	-5.24	-1.63	-5.35	5989	22800
.260	-11.37	-7.54	1.30	68.28	-5.39	-1.45	-4.99	-1.48	-5.11	5746	21576
.270	-10.69	-7.58	.35	67.93	-5.82	-1.30	-4.71	-1.33	-4.84	5478	20278
.280	-10.01	-7.65	-.51	67.63	-6.28	-1.17	-4.41	-1.19	-4.56	5186	18916
.290	-9.34	-7.72	-1.27	67.36	-6.75	-1.04	-4.09	-1.07	-4.25	4872	17500
.300	-8.67	-7.81	-1.95	67.12	-7.22	-.93	-3.76	-.96	-3.93	4537	16041
.310	-8.00	-7.91	-2.56	66.92	-7.66	-.82	-3.42	-.85	-3.59	4184	14549
.320	-7.34	-8.02	-3.12	66.75	-8.06	-.72	-3.08	-.75	-3.25	3815	13035
.330	-6.68	-8.14	-3.63	66.61	-8.39	-.63	-2.72	-.66	-2.90	3431	11508
.340	-6.02	-8.27	-4.12	66.49	-8.64	-.54	-2.37	-.57	-2.55	3035	9979
.350	-5.36	-8.41	-4.59	66.41	-8.80	-.45	-2.01	-.48	-2.19	2630	8459
.360	-4.71	-8.56	-5.05	66.34	-8.85	-.37	-1.66	-.40	-1.84	2218	6957
.370	-4.06	-8.71	-5.52	66.31	-8.79	-.29	-1.31	-.32	-1.49	1802	5484
.380	-3.40	-8.86	-6.00	66.30	-8.60	-.22	-.97	-.25	-1.15	1385	4051
.390	-2.75	-9.01	-6.50	66.31	-8.28	-.15	-.64	-.18	-.82	971	2666
.400	-2.11	-9.17	-7.02	66.35	-7.84	-.09	-.33	-.12	-.50	562	1342
.410	-1.46	-9.33	-7.55	66.40	-7.27	-.03	-.03	-.06	-.19	163	88
.420	-.81	-9.49	-8.11	66.46	-6.60	.02	.26	-.01	.10	-222	-1085
.430	-.16	-9.65	-8.67	66.53	-5.82	.06	.52	.04	.37	-590	-2168
.440	.49	-9.81	-9.24	66.61	-4.95	.10	.76	.07	.62	-936	-3150
.450	1.14	-9.96	-9.81	66.69	-4.01	.13	.97	.11	.84	-1256	-4020
.460	1.79	-10.11	-10.37	66.77	-3.01	.15	1.16	.13	1.04	-1545	-4769
.470	2.44	-10.26	-10.91	66.85	-1.98	.17	1.31	.16	1.20	-1799	-5386
.480	3.10	-10.40	-11.42	66.92	-.95	.19	1.43	.17	1.34	-2012	-5860
.490	3.75	-10.54	-11.90	66.99	.08	.20	1.51	.18	1.44	-2178	-6182
.500	4.41	-10.68	-12.33	67.05	1.08	.21	1.55	.19	1.50	-2294	-6341
.510	5.07	-10.81	-12.71	67.11	2.04	.21	1.56	.20	1.52	-2352	-6327
.520	5.73	-10.93	-13.04	67.16	2.92	.21	1.51	.20	1.49	-2346	-6129
.530	6.39	-11.06	-13.32	67.21	3.72	.21	1.42	.20	1.42	-2272	-5738
.540	7.05	-11.17	-13.55	67.26	4.42	.20	1.28	.19	1.30	-2121	-5143
.550	7.72	-11.28	-13.73	67.31	5.02	.19	1.08	.18	1.13	-1888	-4333
.560	8.38	-11.39	-13.88	67.35	5.50	.17	.83	.17	.91	-1566	-3299
.570	9.05	-11.50	-13.99	67.39	5.85	.14	.52	.15	.62	-1148	-2030
.580	9.72	-11.61	-14.08	67.42	6.07	.11	.15	.12	.28	-626	-515
.590	10.39	-11.71	-14.17	67.44	6.15	.07	-.28	.08	-.13	8	1255

TABLE B.2

SUMMARY OF VEHICLE KINEMATIC AND DYNAMIC DATA GUARDRAIL TEST AS-7 3/20/74

TIME AFTER IMPACT(SEC)	VEHICLE C. G. COORDINATES(FT) X	Y	HEADING ANGLE (DEG)	VEHICLE VELOCITY (FT/SEC) LONG	LAT	VEHICLE ACCELERATION(G'S) AT TIME T LONG	LAT	AVERAGE OVER .05 SEC. LONG	LAT	APPROX. BARRIER FORCES(LB) X	Y
0.000	-30.12	-12.19	24.58	90.64	-.30	-.98	-1.72	0.00	0.00	763	8476
.010	-29.29	-11.82	24.50	90.27	-.79	-1.30	-2.14	0.00	0.00	1260	10678
.020	-28.47	-11.46	24.42	89.81	-1.40	-1.57	-2.33	0.00	0.00	2008	11894
.030	-27.65	-11.10	24.34	89.27	-2.03	-1.81	-2.36	-1.66	-2.22	2918	12442
.040	-26.83	-10.76	24.23	88.65	-2.62	-2.03	-2.29	-1.90	-2.26	3915	12578
.050	-26.01	-10.42	24.07	87.98	-3.09	-2.23	-2.19	-2.12	-2.22	4937	12506
.060	-25.19	-10.10	23.83	87.24	-3.41	-2.43	-2.08	-2.32	-2.14	5934	12382
.070	-24.39	-9.78	23.50	86.45	-3.56	-2.61	-1.99	-2.50	-2.07	6867	12323
.080	-23.58	-9.47	23.06	85.61	-3.54	-2.78	-1.95	-2.68	-2.02	7706	12408
.090	-22.78	-9.17	22.51	84.72	-3.35	-2.94	-1.98	-2.84	-2.03	8429	12687
.100	-21.99	-8.88	21.84	83.79	-3.01	-3.09	-2.06	-2.99	-2.09	9023	13181
.110	-21.20	-8.61	21.05	82.81	-2.55	-3.22	-2.22	-3.13	-2.22	9482	13894
.120	-20.43	-8.34	20.15	81.79	-2.01	-3.33	-2.45	-3.24	-2.41	9804	14810
.130	-19.66	-8.08	19.15	80.73	-1.42	-3.41	-2.73	-3.33	-2.66	9992	15899
.140	-18.89	-7.83	18.07	79.65	-.83	-3.46	-3.06	-3.39	-2.96	10055	17123
.150	-18.14	-7.60	16.91	78.54	-.29	-3.47	-3.43	-3.42	-3.30	10004	18436
.160	-17.39	-7.38	15.71	77.43	.19	-3.45	-3.81	-3.41	-3.66	9853	19787
.170	-16.65	-7.18	14.47	76.32	.56	-3.39	-4.20	-3.36	-4.04	9617	21126
.180	-15.91	-6.99	13.22	75.22	.81	-3.30	-4.58	-3.28	-4.41	9313	22402
.190	-15.19	-6.82	11.97	74.16	.90	-3.17	-4.93	-3.17	-4.76	8959	23568
.200	-14.46	-6.67	10.73	73.14	.85	-3.02	-5.24	-3.03	-5.09	8573	24579
.210	-13.75	-6.53	9.53	72.18	.64	-2.85	-5.51	-2.87	-5.37	8171	25398
.220	-13.04	-6.42	8.38	71.28	.28	-2.67	-5.72	-2.70	-5.59	7772	25994
.230	-12.34	-6.32	7.27	70.45	-.22	-2.48	-5.86	-2.52	-5.76	7390	26342
.240	-11.64	-6.24	6.22	69.69	-.84	-2.29	-5.93	-2.33	-5.86	7038	26426
.250	-10.95	-6.18	5.24	69.01	-1.56	-2.12	-5.93	-2.16	-5.89	6729	26239
.260	-10.27	-6.15	4.31	68.38	-2.35	-1.95	-5.87	-1.99	-5.86	6473	25781
.270	-9.59	-6.13	3.44	67.82	-3.18	-1.81	-5.73	-1.84	-5.76	6277	25054
.280	-8.91	-6.13	2.63	67.31	-4.04	-1.68	-5.53	-1.72	-5.59	6145	24090
.290	-8.24	-6.15	1.86	66.84	-4.88	-1.59	-5.28	-1.61	-5.37	6080	22897
.300	-7.57	-6.18	1.13	66.41	-5.68	-1.51	-4.97	-1.53	-5.10	6082	21508
.310	-6.91	-6.23	.43	66.01	-6.42	-1.46	-4.63	-1.47	-4.78	6147	19958
.320	-6.25	-6.30	-.25	65.62	-7.07	-1.44	-4.26	-1.44	-4.43	6270	18284
.330	-5.60	-6.38	-.93	65.24	-7.61	-1.44	-3.87	-1.42	-4.06	6441	16530
.340	-4.95	-6.47	-1.60	64.87	-8.03	-1.45	-3.47	-1.43	-3.67	6651	14737
.350	-4.30	-6.58	-2.28	64.50	-8.31	-1.48	-3.07	-1.45	-3.29	6886	12950
.360	-3.66	-6.69	-2.99	64.12	-8.45	-1.52	-2.69	-1.48	-2.91	7131	11213
.370	-3.03	-6.81	-3.71	63.73	-8.44	-1.57	-2.33	-1.52	-2.54	7370	9567
.380	-2.40	-6.94	-4.47	63.33	-8.30	-1.61	-2.00	-1.56	-2.21	7585	8050
.390	-1.78	-7.08	-5.26	62.92	-8.03	-1.65	-1.72	-1.60	-1.91	7757	6696
.400	-1.17	-7.22	-6.08	62.49	-7.64	-1.68	-1.47	-1.64	-1.65	7868	5531
.410	-.56	-7.36	-6.93	62.06	-7.16	-1.69	-1.28	-1.65	-1.43	7897	4577
.420	.05	-7.51	-7.81	61.62	-6.59	-1.68	-1.13	-1.65	-1.26	7829	3847
.430	.65	-7.66	-8.71	61.18	-5.98	-1.64	-1.04	-1.62	-1.14	7645	3345
.440	1.24	-7.81	-9.63	60.75	-5.33	-1.56	-.99	-1.56	-1.07	7331	3067
.450	1.83	-7.97	-10.54	60.35	-4.68	-1.44	-.98	-1.46	-1.03	6876	2998
.460	2.41	-8.12	-11.45	59.98	-4.05	-1.29	-1.00	-1.32	-1.03	6273	3115
.470	2.99	-8.28	-12.34	59.65	-3.45	-1.09	-1.04	-1.14	-1.05	5517	3385
.480	3.56	-8.45	-13.19	59.39	-2.90	-.84	-1.10	-.92	-1.09	4612	3766
.490	4.13	-8.61	-14.01	59.20	-2.42	-.57	-1.15	-.67	-1.13	3567	4210
.500	4.70	-8.78	-14.77	59.09	-2.01	-.26	-1.19	-.39	-1.16	2397	4662
.510	5.26	-8.95	-15.47	59.08	-1.68	.06	-1.20	-.08	-1.18	1130	5063
.520	5.83	-9.13	-16.10	59.17	-1.41	.39	-1.18	.23	-1.16	-199	5351
.530	6.39	-9.31	-16.66	59.36	-1.20	.71	-1.12	.54	-1.11	-1544	5467
.540	6.96	-9.49	-17.15	59.65	-1.04	1.00	-1.00	.83	-1.01	-2844	5357
.550	7.53	-9.68	-17.57	60.02	-.89	1.24	-.82	1.07	-.86	-4027	4975
.560	8.10	-9.87	-17.92	60.45	-.76	1.41	-.59	1.26	-.66	-5002	4290
.570	8.6[illegible]	-10.05	-18.21	60.93	-.59	1.49	-.32	1.36	-.41	-5665	3241
.580	9.25	-10.26	-18.46	61.40	-.38	1.45	-.01	1.35	-.14	-5890	1992
.590	9.84	-10.46	-18.67	61.84	-.10	1.25	.31	1.20	.15	-5532	443

TABLE B.3

SUMMARY OF VEHICLE KINEMATIC AND DYNAMIC DATA GUARDRAIL TEST AS-8 3/21/74

TIME AFTER IMPACT(SEC)	VEHICLE C. G. COORDINATES(FT) X	Y	HEADING ANGLE (DEG)	VEHICLE VELOCITY (FT/SEC) LONG	LAT	VEHICLE ACCELERATION(G'S) AT TIME T LONG	LAT	AVERAGE OVER .05 SEC. LONG	LAT	APPROX. BARRIER FORCES(LB) X	Y
0.000	-30.90	-12.65	24.78	87.34	.53	-3.07	.00	0.00	0.00	11149	5127
.010	-30.11	-12.28	24.88	86.26	.22	-3.50	-1.05	0.00	0.00	10933	9681
.020	-29.33	-11.92	24.89	85.16	-.30	-3.23	-2.06	0.00	0.00	8241	12891
.030	-28.56	-11.57	24.81	84.21	-.99	-2.65	-2.90	-2.81	-2.29	4771	14980
.040	-27.80	-11.23	24.65	83.45	-1.79	-2.11	-3.50	-2.49	-2.97	1844	16233
.050	-27.03	-10.91	24.41	82.84	-2.63	-1.80	-3.82	-2.18	-3.43	231	16900
.060	-26.27	-10.60	24.11	82.29	-3.44	-1.79	-3.90	-2.05	-3.66	172	17164
.070	-25.50	-10.30	23.73	81.70	-4.15	-2.07	-3.77	-2.13	-3.68	1487	17141
.080	-24.74	-10.01	23.29	81.00	-4.70	-2.53	-3.51	-2.40	-3.55	3727	16904
.090	-23.98	-9.74	22.77	80.14	-5.04	-3.06	-3.19	-2.78	-3.33	6326	16506
.100	-23.22	-9.49	22.16	79.14	-5.17	-3.53	-2.88	-3.18	-3.07	8727	15999
.110	-22.47	-9.24	21.43	78.01	-5.06	-3.85	-2.64	-3.51	-2.85	10477	15445
.120	-21.73	-9.01	20.59	76.82	-4.74	-3.95	-2.50	-3.68	-2.69	11281	14922
.130	-21.00	-8.79	19.62	75.64	-4.25	-3.81	-2.49	-3.66	-2.64	11023	14516
.140	-20.28	-8.58	18.52	74.54	-3.63	-3.45	-2.62	-3.43	-2.71	9758	14320
.150	-19.56	-8.39	17.30	73.58	-2.93	-2.90	-2.87	-3.03	-2.90	7681	14415
.160	-18.86	-8.20	15.97	72.81	-2.22	-2.25	-3.22	-2.49	-3.18	5088	14863
.170	-18.15	-8.03	14.56	72.24	-1.54	-1.55	-3.65	-1.88	-3.55	2322	15694
.180	-17.45	-7.87	13.10	71.88	-.95	-.89	-4.13	-1.26	-3.97	-269	16902
.190	-16.75	-7.72	11.61	71.71	-.50	-.34	-4.64	-.71	-4.43	-2380	18439
.200	-16.04	-7.59	10.12	71.67	-.21	.04	-5.14	-.27	-4.90	-3777	20218
.210	-15.33	-7.47	8.67	71.73	-.13	.23	-5.63	.01	-5.36	-4320	22118
.220	-14.62	-7.38	7.27	71.81	-.27	.23	-6.08	.11	-5.80	-3971	23992
.230	-13.91	-7.30	5.96	71.86	-.63	.03	-6.46	.03	-6.19	-2793	25680
.240	-13.19	-7.24	4.73	71.84	-1.23	-.32	-6.75	-.20	-6.50	-934	27022
.250	-12.48	-7.20	3.60	71.70	-2.02	-.78	-6.93	-.56	-6.71	1390	27871
.260	-11.76	-7.19	2.57	71.41	-2.98	-1.30	-6.98	-.99	-6.81	3924	28108
.270	-11.05	-7.20	1.64	70.96	-4.04	-1.80	-6.86	-1.44	-6.77	6401	27650
.280	-10.34	-7.23	.78	70.38	-5.16	-2.23	-6.59	-1.87	-6.57	8566	26460
.290	-9.64	-7.28	-.01	69.69	-6.25	-2.55	-6.14	-2.21	-6.22	10209	24551
.300	-8.95	-7.36	-.74	68.92	-7.24	-2.72	-5.53	-2.44	-5.71	11176	21987
.310	-8.26	-7.45	-1.45	68.13	-8.06	-2.73	-4.79	-2.52	-5.07	11385	18879
.320	-7.59	-7.55	-2.13	67.38	-8.66	-2.56	-3.94	-2.46	-4.31	10835	15376
.330	-6.92	-7.67	-2.82	66.70	-8.98	-2.25	-3.03	-2.25	-3.47	9597	11660
.340	-6.26	-7.79	-3.51	66.15	-9.01	-1.83	-2.10	-1.92	-2.59	7813	7927
.350	-5.61	-7.93	-4.22	65.75	-8.72	-1.33	-1.20	-1.51	-1.72	5675	4376
.360	-4.96	-8.06	-4.94	65.51	-8.14	-.82	-.37	-1.06	-.89	3405	1194
.370	-4.32	-8.20	-5.68	65.43	-7.30	-.34	.33	-.62	-.16	1239	-1460
.380	-3.68	-8.34	-6.44	65.47	-6.23	.05	.88	-.22	.44	-606	-3465
.390	-3.03	-8.47	-7.20	65.61	-5.02	.33	1.24	.08	.88	-1947	-4747
.400	-2.39	-8.60	-7.96	65.80	-3.72	.47	1.40	.27	1.14	-2656	-5288
.410	-1.74	-8.73	-8.70	66.00	-2.41	.47	1.37	.33	1.22	-2672	-5125
.420	-1.09	-8.85	-9.43	66.15	-1.17	.32	1.15	.26	1.12	-2013	-4348
.430	-.44	-8.97	-10.13	66.22	-.04	.05	.79	.08	.87	-768	-3092
.440	.21	-9.08	-10.79	66.18	.91	-.29	.33	-.19	.50	904	-1528
.450	.87	-9.20	-11.43	66.01	1.67	-.68	-.18	-.51	.07	2792	156
.460	1.51	-9.31	-12.03	65.71	2.23	-1.05	-.67	-.83	-.39	4655	1767
.470	2.16	-9.43	-12.61	65.30	2.60	-1.35	-1.10	-1.13	-.80	6246	3128
.480	2.80	-9.55	-13.17	64.80	2.82	-1.55	-1.41	-1.34	-1.14	7340	4094
.490	3.43	-9.67	-13.71	64.26	2.95	-1.61	-1.57	-1.45	-1.35	7762	4568
.500	4.06	-9.80	-14.26	63.72	3.06	-1.52	-1.55	-1.42	-1.41	7411	4510
.510	4.68	-9.92	-14.81	63.24	3.19	-1.27	-1.35	-1.25	-1.32	6277	3944
.520	5.30	-10.06	-15.37	62.86	3.43	-.88	-1.01	-.96	-1.08	4452	2961
.530	5.92	-10.19	-15.96	62.61	3.81	-.39	-.56	-.56	-.73	2125	1706
.540	6.53	-10.33	-16.55	62.53	4.37	.13	-.06	-.12	-.31	-428	368
.550	7.14	-10.46	-17.16	62.60	5.09	.62	.41	.33	.11	-2873	-841
.560	7.75	-10.60	-17.78	62.81	5.96	1.03	.78	.72	.47	-4857	-1715
.570	8.37	-10.73	-18.39	63.12	6.92	1.27	.97	.99	.69	-6052	-2079
.580	9.00	-10.87	-18.99	63.46	7.90	1.32	.94	1.10	.74	-6206	-1820
.590	9.62	-11.00	-19.56	63.78	8.79	1.15	.65	1.04	.58	-5199	-910

APPENDIX C

ANCHORAGE CONSIDERATIONS

ANCHORAGE CONSIDERATIONS

The guardrail systems tested in this series were anchored at upstream and downstream ends as shown in Figure C.1. In Tests AS-6 and AS-7, no specified torque was applied to either the cable clips or the anchor cable stud. Since the drawings for the G4 and MB4 anchorage do not contain a torque specification, SwRI personnel have always assumed that more care was taken in test installations of the anchor than could reasonably be assumed in a field installation.

As a result of the cable slip which occurred in Test AS-7, the clips and stud were tightened to a specified torque in Test AS-8. No slippage in the anchor cable resulted in this test. The torques for test AS-8 were as follow:

Cable Clips	Anchor Cable Stud
90 ft-lbs	90 ft-lbs

A U.S. Steel Wire Rope* manual recommends for a 3/4-in. dia cable the following values:

No. of Clips	Clip Torque
4	130 ft-lbs

It is noteworthy that California had torqued the five cable clips in their Test 274 installation to 50 ft-lbs each. Slippage occurred at this value in Test 274.

*Tiger Brand Wire Rope Manual AD VSS 55-2460, September 1967, United States Steel Corp.

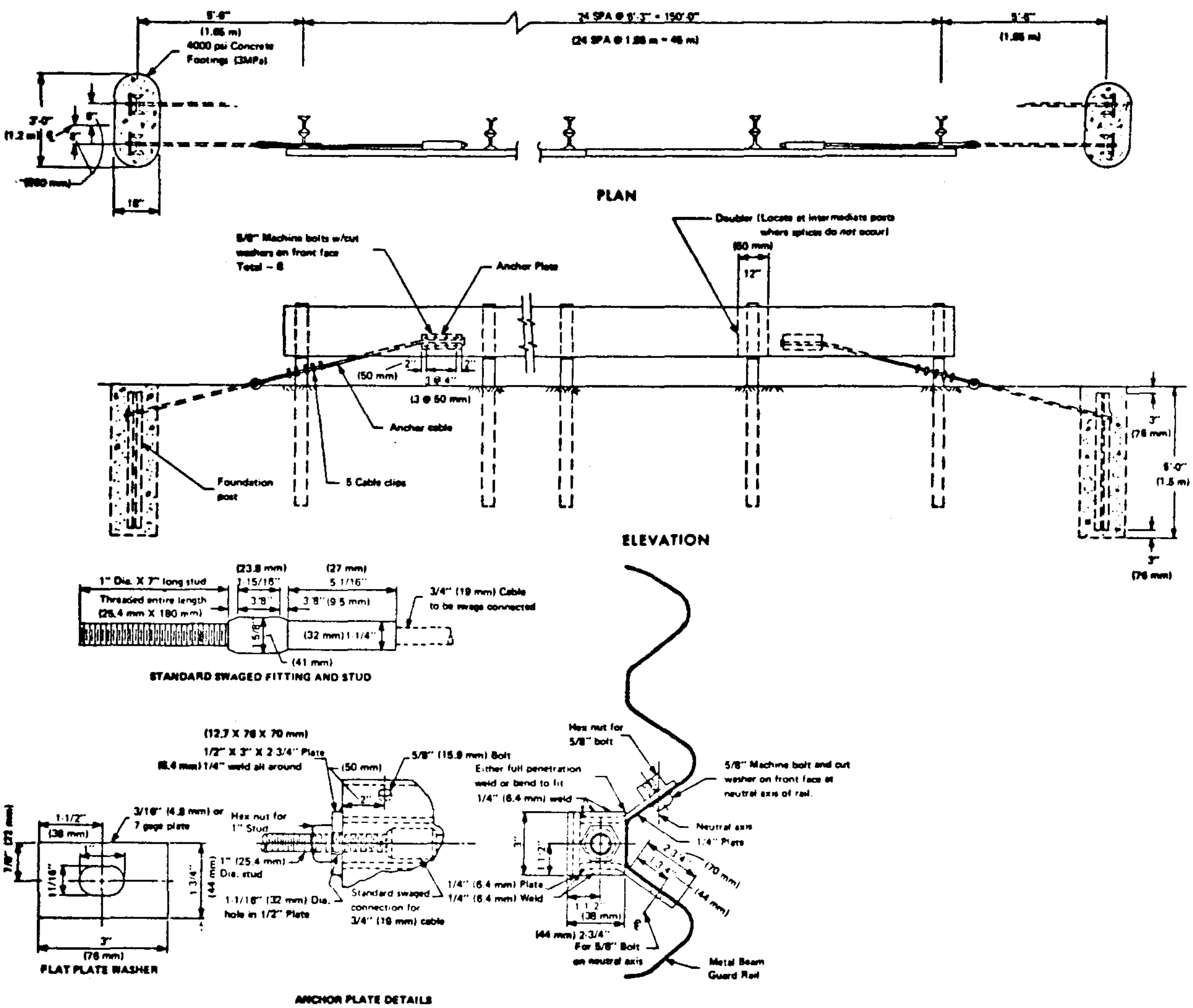


FIGURE C. 1 GUARDRAIL ANCHORAGE

APPENDIX D

FHWA NOTICE

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

SUBJECT
Alternate Steel Post for Guardrail and Median Barrier Installation

FHWA NOTICE
N 5040.2
April 30, 1974

1. PURPOSE: This Notice advises all FHWA field offices regarding the possible non-availability of certain barrier system posts and identifies acceptable alternate posts.

2. BACKGROUND:

a. In late 1973, our attention was called to the fact that several steel mills, which roll light structural shapes, were shortly going to discontinue the rolling of two shapes which are used extensively in the erection of highway guardrail and median barrier. The steel shapes in question are S3 x 5.7 (used in "weak" post designs) and W6 x 8.5 (used in "strong" post designs).

b. Development of two alternative shapes, cold formed from steel strip, sheet or plate, was undertaken by several interested members of the guardrail industry. They contracted with the Southwest Research Institute to make a comparative study of the two standard hot rolled shapes versus the two new cold formed shapes. This comparison included:

(1) static structural properties

(2) dynamic tests using a swinging pendulum ("weak" post alternate)

(3) dynamic full scale crash tests ("strong" post alternate)

c. Reports on this testing have been reviewed by appropriate FHWA personnel. In addition, several conferences have been held at which personnel from FHWA, the guardrail industry, and Southwest Research Institute have participated.

d. The guardrail industry has proposed that these two new cold formed shapes be approved as alternates to the two hot rolled structural shapes as follows:

(1) S3 x 5.7 - proposed equal-alternate, "C" shape 3.375" x 2.250" x 0.250"

(more)

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(2) W6 x 8.5 - proposed equal-alternate, "C" shape 5.875" x 4.340" x 0.170"

e. Appendix 1 shows shape dimensions and section properties.

3. <u>ACTION:</u> The use of these two new cold formed steel "C" shapes may be approved as equal-alternates for post and blockout members in the installation of both guardrail and median barriers on new and ongoing Federal-aid projects. Since the expected shortage is the reason for the general acceptance of the "C" shapes without field experience, the States should be encouraged to undertake a special program to monitor and report on the performance of these new posts.

4. <u>INSTALLATION RECOMMENDATIONS</u>:

a. The new "C" shapes are non-symmetrical. It was not possible from the tests to determine any significantly different vehicle reaction whether posts and blockouts were installed with the closed face toward or away from the impacting vehicle, nevertheless it is recommended that all posts in a given run of barrier rail be installed uniformly.

b. From the information currently available, it appears that the use of the new posts for maintenance will not have a significant adverse effect on the efficiency of the barrier system. Yet, because of lack of data on this point it is suggested that on maintenance and new construction that mixing of post types, and particularly blockout types, be avoided.

c. During the test program significant cable slippage in the end anchorage was noted in one test. Details of the anchorage used are shown in NCHRP Report 118. It is recommended that the five cable clips, which are standard, be torqued to 130 ft. lb. minimum each. This recommendation applies to all cable end anchorages for W-beam barrier systems regardless of the type of posts used.

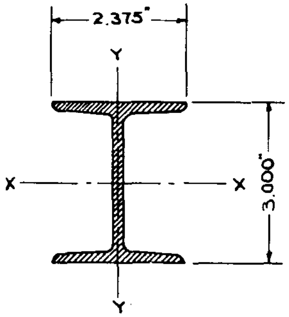
d. On barrier systems which use either the W6 x 8.5 post or the new 6" - "C" post, the use of a 12" back-up plate, at all posts where rail splices do not occur, is recommended. This is the arrangement used in testing the new "strong" post and the need for the back-up plate has been observed in tests of W-beam rails mounted on the W6 x 8.5 posts.

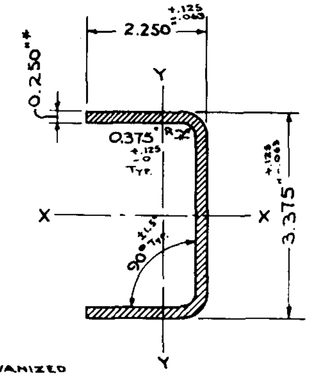
H. A. Lindberg
Associate Administrator for
Engineering and Traffic Operations

Attachment

Appendix I

"Weak" Posts





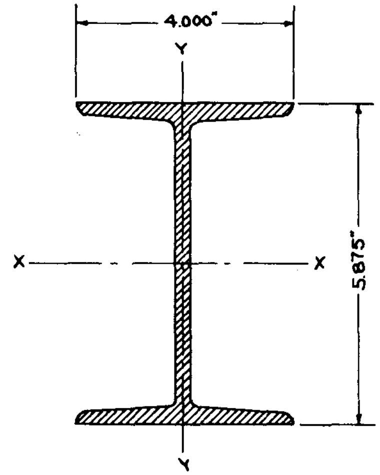
*Ungalvanized Thickness

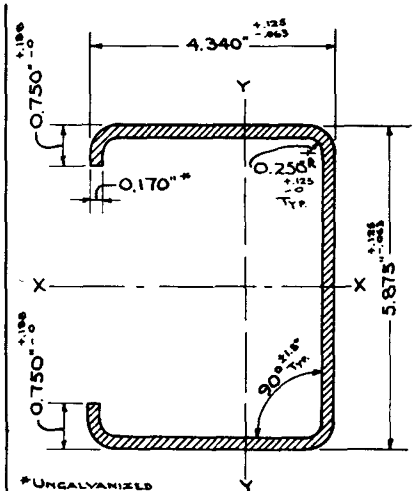
S3 × 5.7		3"-"C"
1.67	Area (in²)	1.73
2.52	$I_{x\text{-}x}$ (in⁴)	3.25
1.68	$S_{x\text{-}x}$ (in³)	1.93
0.455	$I_{y\text{-}y}$ (in⁴)	0.875
0.390	$S_{y\text{-}y}$ (in³)	0.565

Applicable Specifications

AASHTO M183 (ASTM A36)	Material	AASHTO M183 (ASTM A36)
AASHTO M111 (ASTM A123)	Galvanizing	AASHTO M111 (ASTM A123)

"Strong" Posts





*Ungalvanized Thickness

W6 × 8.5		6"-"C"
2.51	Area (in²)	2.52
14.8	$I_{x\text{-}x}$ (in⁴)	15.6
5.08	$S_{x\text{-}x}$ (in³)	5.32
1.98	$I_{y\text{-}y}$ (in⁴)	6.72
1.01	$S_{y\text{-}y}$ (in³)	2.43

Applicable Specifications

AASHTO M183 (ASTM A36)	Material	ASTM A570 - With Mechanical Properties Equal To A36
AASHTO M111 (ASTM A123)	Galvanizing	AASHTO M111 (ASTM A123)