MS-552

TECHNICAL MEMORANDUM 505-14

Texas Transportation Institute
Texas A&M Research Foundation

FIBERGLASS MEDIAN BARRIER

A Test And Evaluation Report On Contract No. CPR-11-5851

U.S. Department of Transportation
Federal Highway Administration

by

G. G. Hayes
Research Associate

M. A. Pittman
Research Associate

and

T. J. Hirsch
Research Engineer

The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the Federal Highway Administration.

These crash tests and evaluations were conducted under the Office of Research and Development, Structural and Applied Mechanics Division's Research Program on Structural Systems in Support of Highway Safety (4S Program).

May 1971

Introduction

A full-scale vehicle crash test was conducted on a prototype soil-filled fiberglass median barrier designed and fabricated by the Molded Fiberglass Resin Company of Ashtabula, Ohio. The median barrier was previously analyzed and subjected to scale-model tests by IIT Research Institute of Chicago, Illinois.[1,2*] This report presents the results of the single crash test.

*Superscript numerals refer to corresponding numerals in selected references.

Barrier Description

The barrier consists of a fiberglass trough containing fill material. Ten foot sections are bolted together to form the trough. Figure 1 is a drawing of a section of the barrier, while Figures 2, 3, and 4 are photographs of the test installation. A fiberglass guardrail or rubrail is attached to the outside of the barrier to form a vehicle redirectional surface. This rail is shown in Figures 1 and 2. The lower portion of the barrier rests in a 10 in. wide by 11 in. deep trench parallel to the roadway. Pea gravel was used as fill material for the test conducted by TTI. A 150 ft. length of median barrier was installed adjacent to a concrete vehicle-approach area as shown in Figure 4.

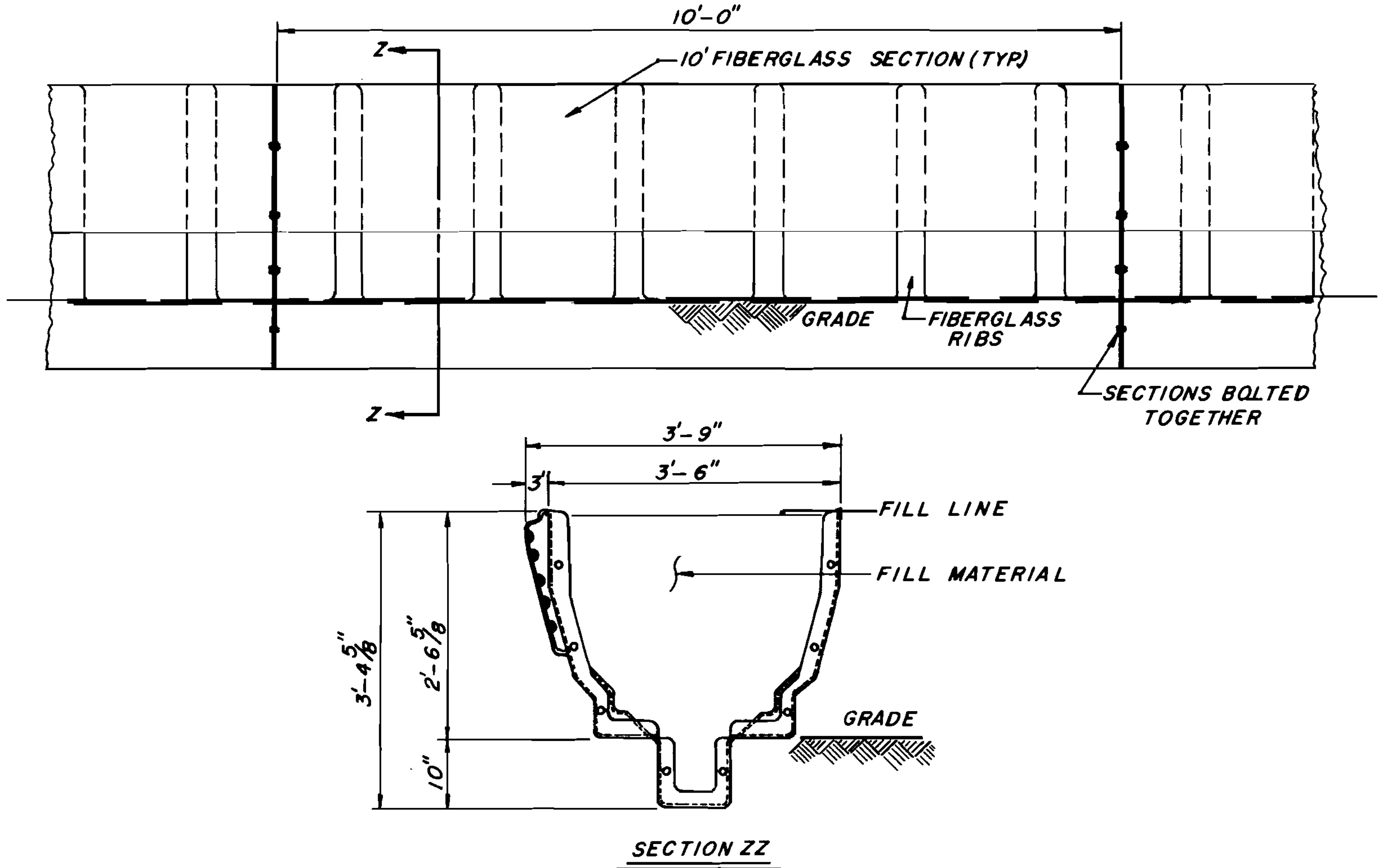


Figure 1   Detail of fiberglass section.

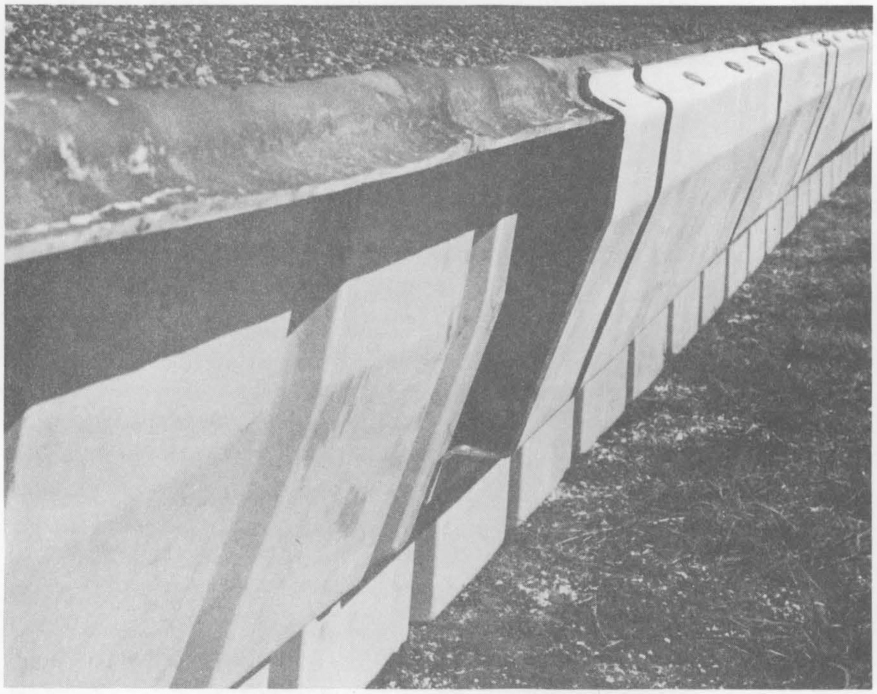


Figure 2 , Ground Level View of Rubrail Bolted
To Fiberglass Trough

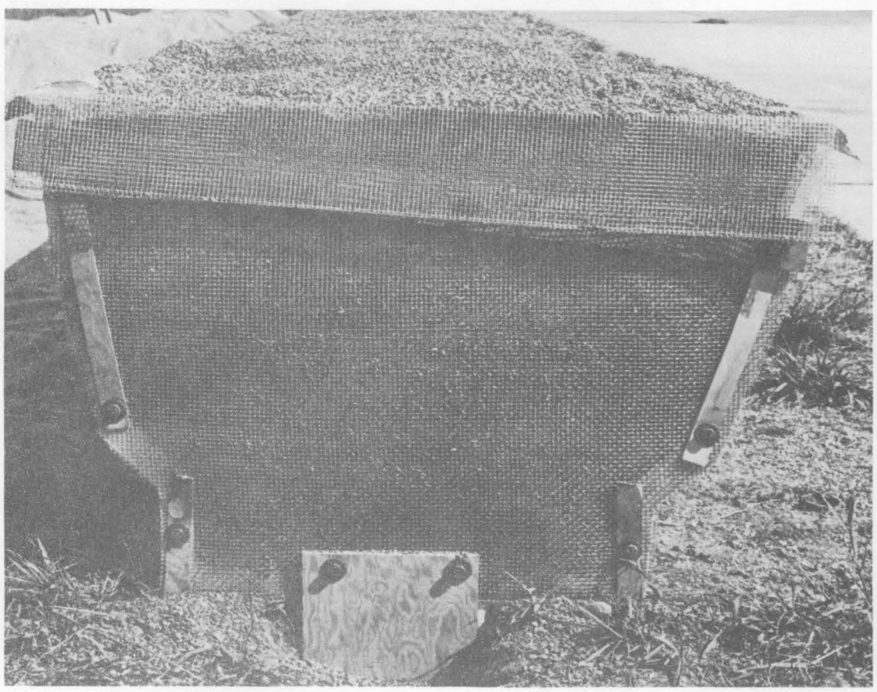


Figure 3 , End View of Fiberglass Median Barrier

Figure 4 , Overhead View of Median Barrier
Before Test

INSTRUMENTATION

For this test, four strain gage type accelerometers were mounted on the frame of the vehicle. Two were placed on the left frame member and two on the right frame member. One accelerometer on each frame measured transverse decelerations and the other measured longitudinal decelerations. Longitudinal decelerations represent decelerations toward the rear of the vehicle and transverse decelerations are toward the left of the vehicle. A tri-axial electromechanical deceleration device (an Impact-O-Graph) was located on the right rear floorboard of the vehicle.

An Alderson anthropometric dummy, weighing 160 lbs., was placed on the driver's side of the vehicle with a lap belt fastened across the pelvic region. A strain gage load cell was connected to the lap belt to measure the force on the lap belt during impact. The lap belt force trace is shown as a negative force because it represents a rearward force on the dummy.

The signals from the four accelerometers and the load cell were transmitted by telemetry to a ground station where they were recorded on magnetic tape. These data were then passed through an 80 HZ low-pass filter to reduce the effects of "ringing", and then displayed on Visicorder paper.

Four high-speed cameras were used in this test to cover the event. One was placed perpendicular to the barrier; another parallel to the barrier; another perpendicular to the initial path of the vehicle; and the other provided a view from overhead. Each of the high-speed films had timing lights so that elapsed time at any point could be calculated. A stadia board marked in increments of 3 in. on the left side of the vehicle was used in determining distance traveled. These distances were measured on a Vanguard Motion Analyzer.

Initial speed was then computed from the time-displacement data obtained. Two other low-speed cameras, one a panned shot and one a stationary view parallel to the barrier, provided a qualitative coverage of the crash test.

DESCRIPTION OF TEST

A 1966 Chevrolet sedan traveling 54 mph impacted the Fiberglass Barrier at an angle of 25°. The point of impact was 84.5 ft. from the north end of the barrier. The fiberglass trough and rubrail began shattering at 0.046 sec. after impact and allowed the vehicle to penetrate the barrier. The vehicle then ramped and came to a stop astride the barrier (see Figures 5 through 8).

The barrier was damaged severely. Twelve feet of the front wall was completely destroyed, and the back wall collapsed. The vehicle was also damaged extensively, as evidenced by a right front fender residual deformation of 3.1 ft.

A summary of the pertinent data obtained is presented in Table 1. Accelerometers indicated an average longitudinal deceleration of 5.2 g's (average of left and right frame members) over 0.248 sec. and an average transverse deceleration of 2.0 g's (average of left and right frame members) over 0.213 sec.

Time-displacement data from the high-speed films are given in Table 2, and reproductions of the accelerometer and lap belt force traces are shown in Figures 9, 10 and 11. There is some accelerometer activity past the times shown in Figures 9 and 10, but the major decelerations have been included.

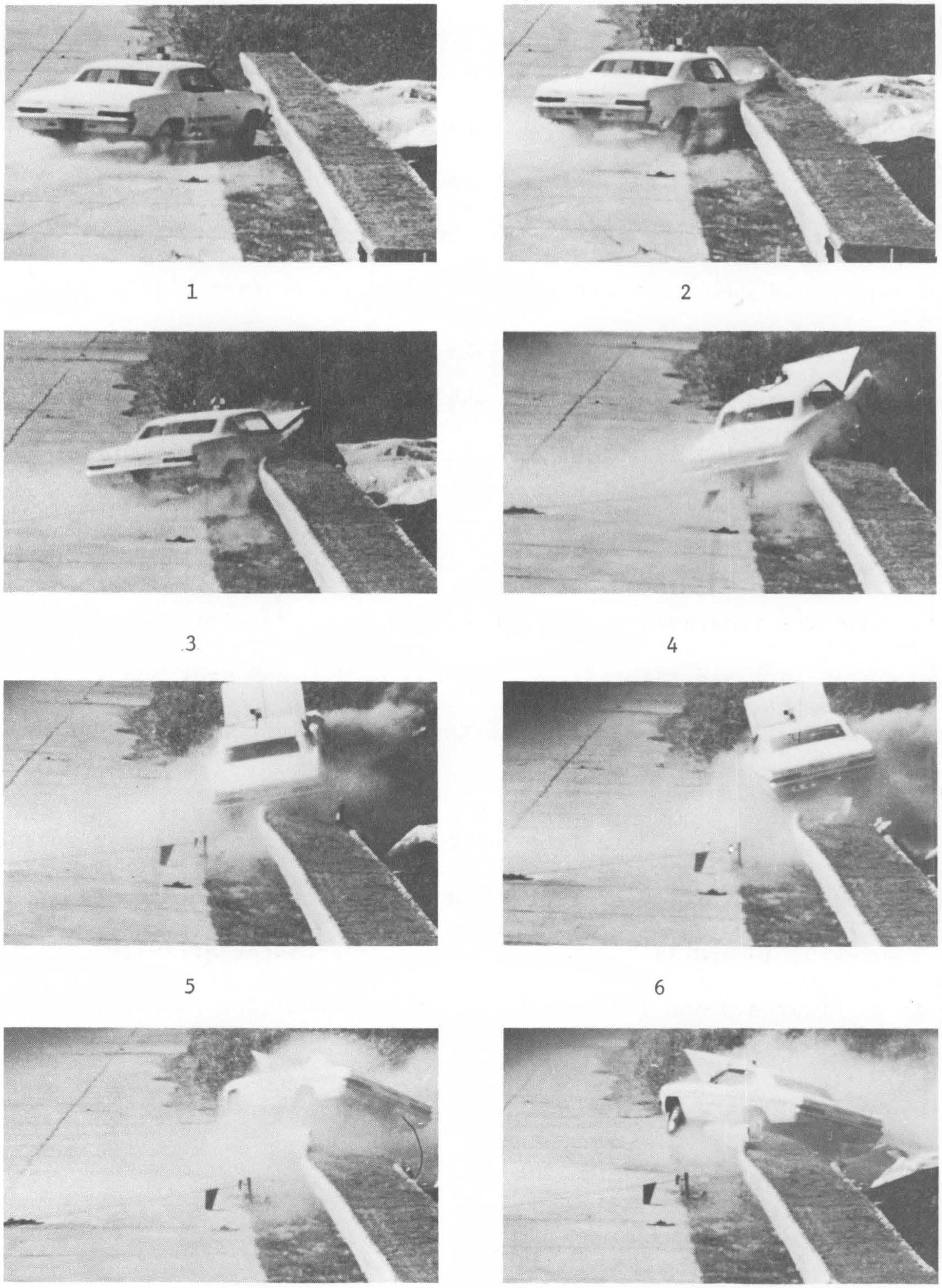
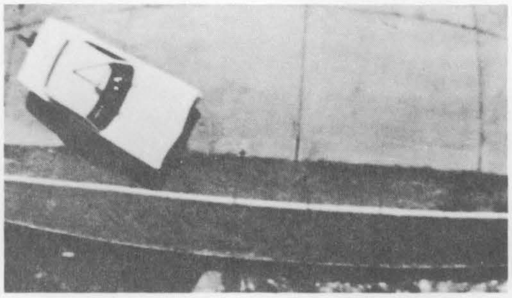
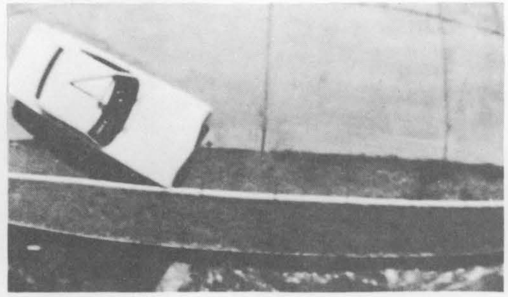


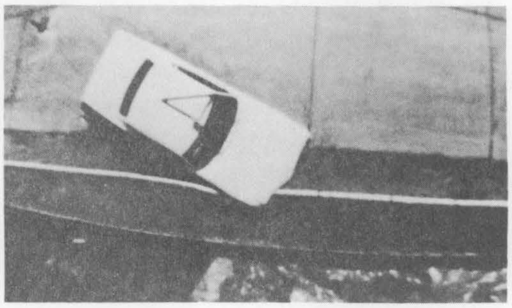
Figure 5, Sequential Photographs of Test FG-A (Parallel to Barrier)



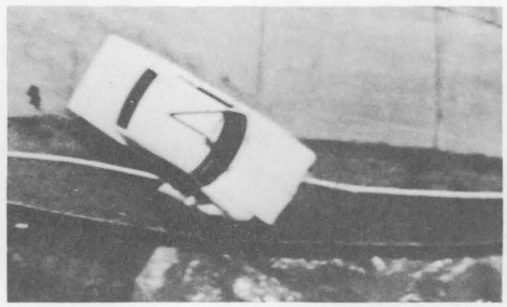
I - 0.046 sec.



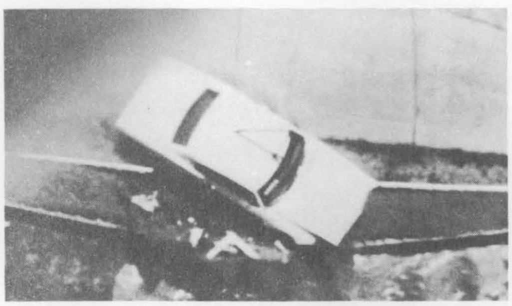
Impact



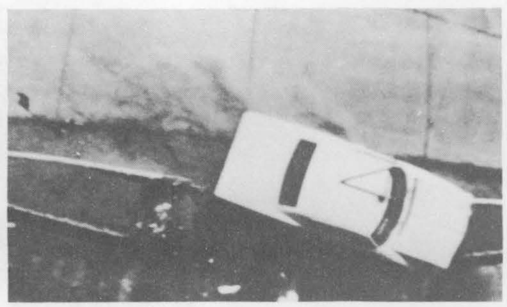
I + 0.054 sec.



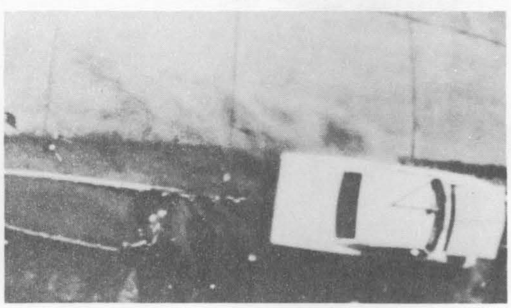
I + 0.120 sec.



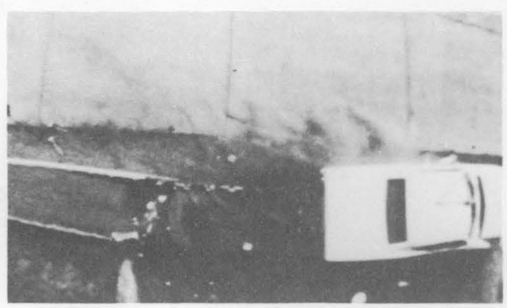
I + 0.262 sec.



I + 0.491 sec.



I + 0.665 sec.



I + 0.834 sec.

Figure 6 , Sequential Photographs of Test FG-A (Overhead View)

Figure 7 , Vehicle Before and After Test FG-A

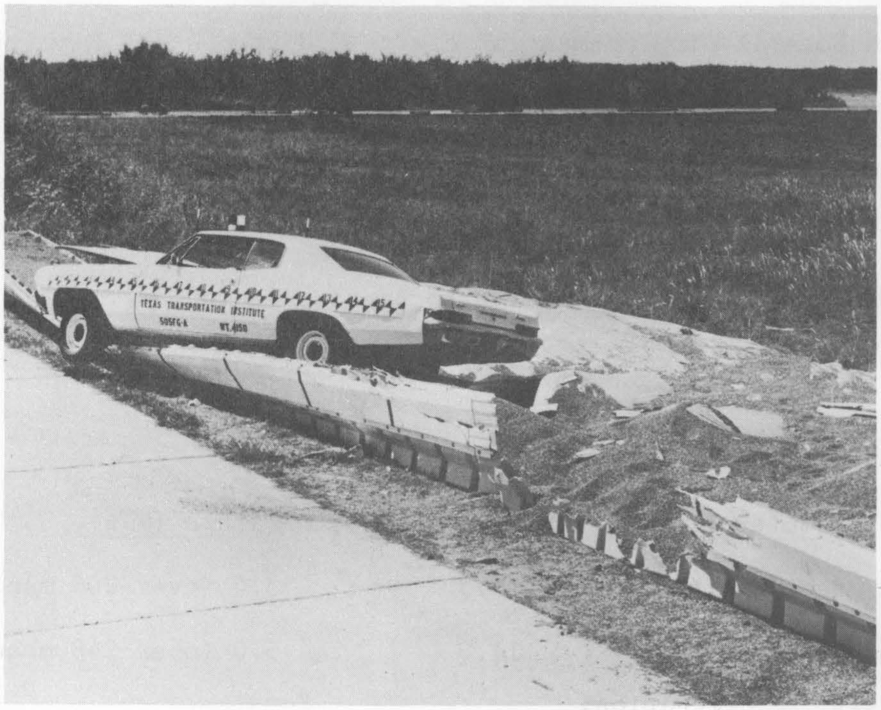


Figure 8 , Vehicle and Barrier After Test FG-A

Table 1

TEST 505 FG-A

SUMMARY OF DATA

Vehicle Make: 1966 Chevrolet Caprice

Impact Angle: 25°

Initial Speed: 79.2 ft./sec. or 54.0 mph

Maximum Lateral Penetration of Barrier: 5.3 ft.

Maximum Lateral Displacement of c.g.: 7.8 ft.

Longitudinal Stopping Distance: 38.0 ft.

Avg. Longitudinal Deceleration (computed): 2.6 g's
$(v^2/ 2gs)$

Avg. Deceleration Perpendicular to Barrier (computed): 2.2 g's
$((v \sin \theta)^2/2gs)$

Longitudinal Deceleration:

Accelerometer	Maximum (g's)	Average (g's)
Left Frame Member	12.5	5.4 (over 248 msec)
Right Frame Member	14.8	5.0 (over 248 msec)

Transverse Deceleration:

Accelerometer	Maximum (g's)	Average (g's)
Left Frame Member	8.6	2.4 (over 213 msec)
Right Frame Member	6.7	1.6 (over 213 msec)

Seat Belt:

Maximum force - 591 lb.

Average force - 156 lb. (over 257 msec)

Table 2

TEST 505 FG-A

High-Speed Film Data

Time (milliseconds)	Displacement (feet)	Time (milliseconds)	Displacement (feet)
-50.9	-4.0	137.3	9.6
-38.1	-3.0	145.0	10.0
-25.4	-2.0	152.6	10.4
-12.7	-1.0	165.3	10.9
0 Impact	0	178.0	11.5
7.6	0.6	190.7	12.0
15.3	1.2	203.4	12.5
22.9	1.8	216.2	12.9
30.5	2.4	228.9	13.3
38.1	3.0	241.6	13.8
45.8	3.6	254.3	14.1
53.4	4.1	267.0	14.5
61.0	4.7	279.7	14.9
68.7	5.2	292.4	15.3
76.3	5.8	305.2	15.7
83.9	6.3	330.6	16.4
91.5	6.8	356.0	17.0
99.2	7.4	381.4	17.7
106.8	7.9	406.9	18.3
114.4	8.3	432.3	19.0
122.1	8.8	457.7	19.6
129.7	9.2	483.2	20.2

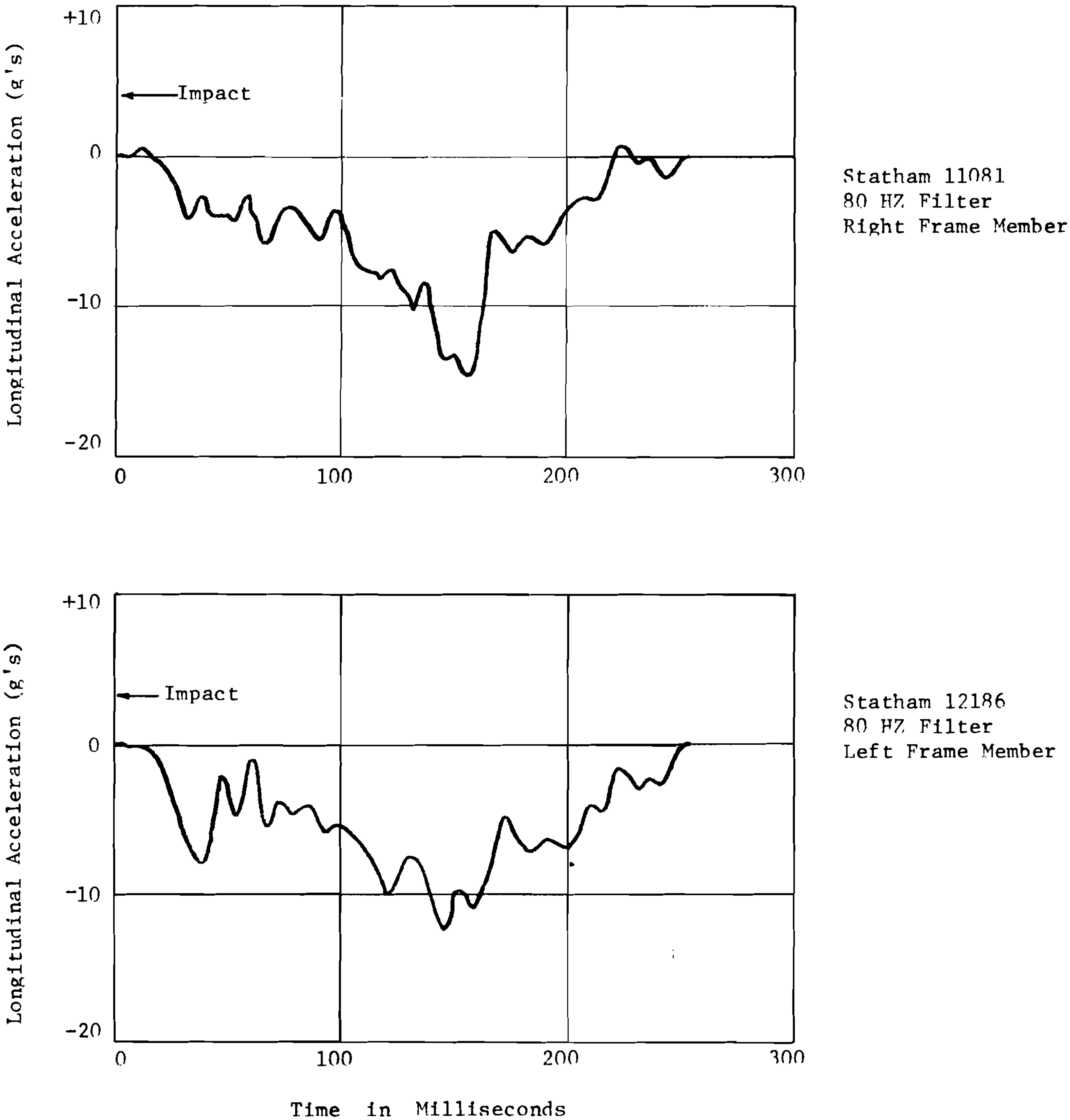


Figure 9 , Longitudinal Accelerometer Data, Test 505 FG-A

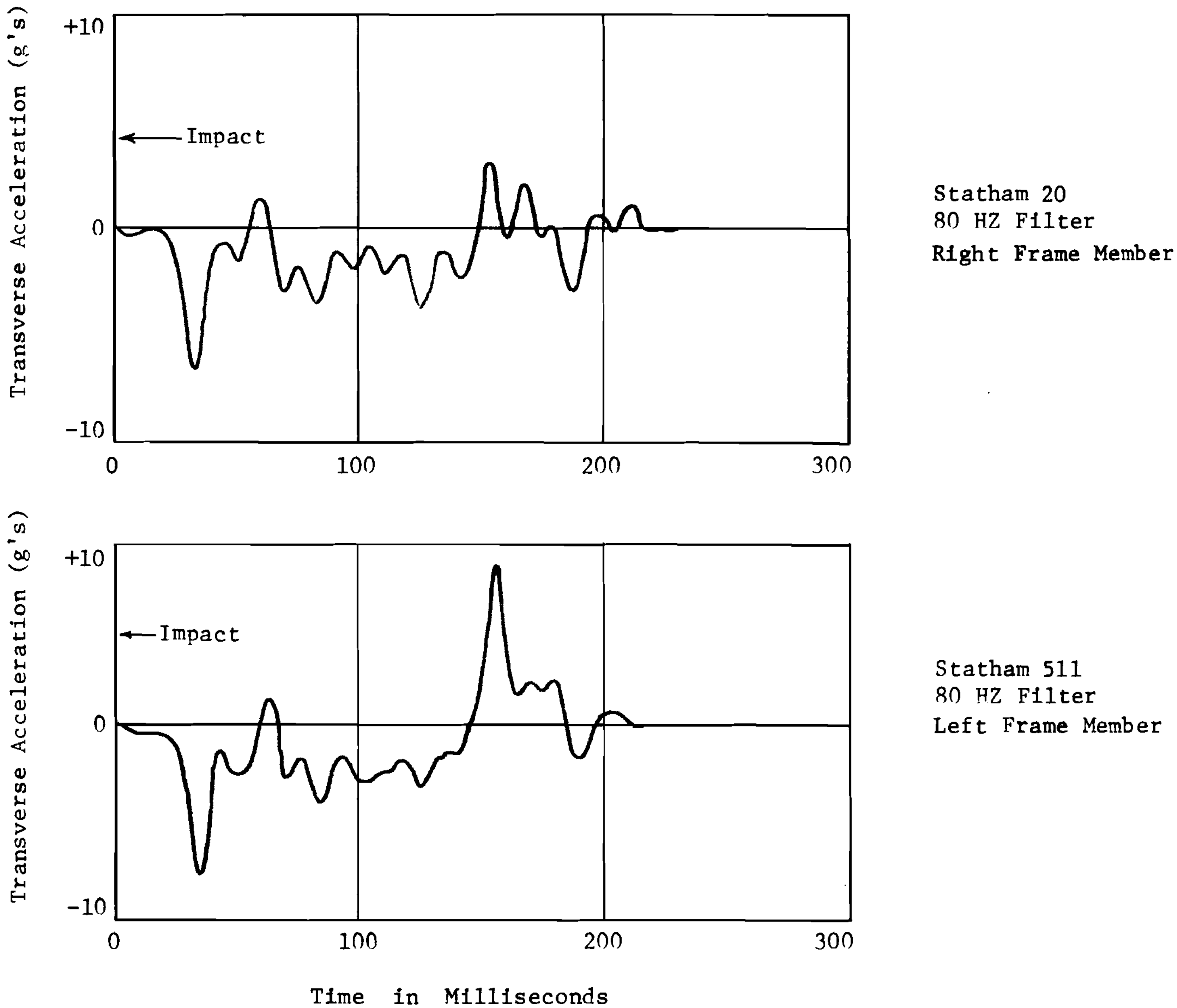


Figure 10, Transverse Accelerometer Data, Test 505 FG-A

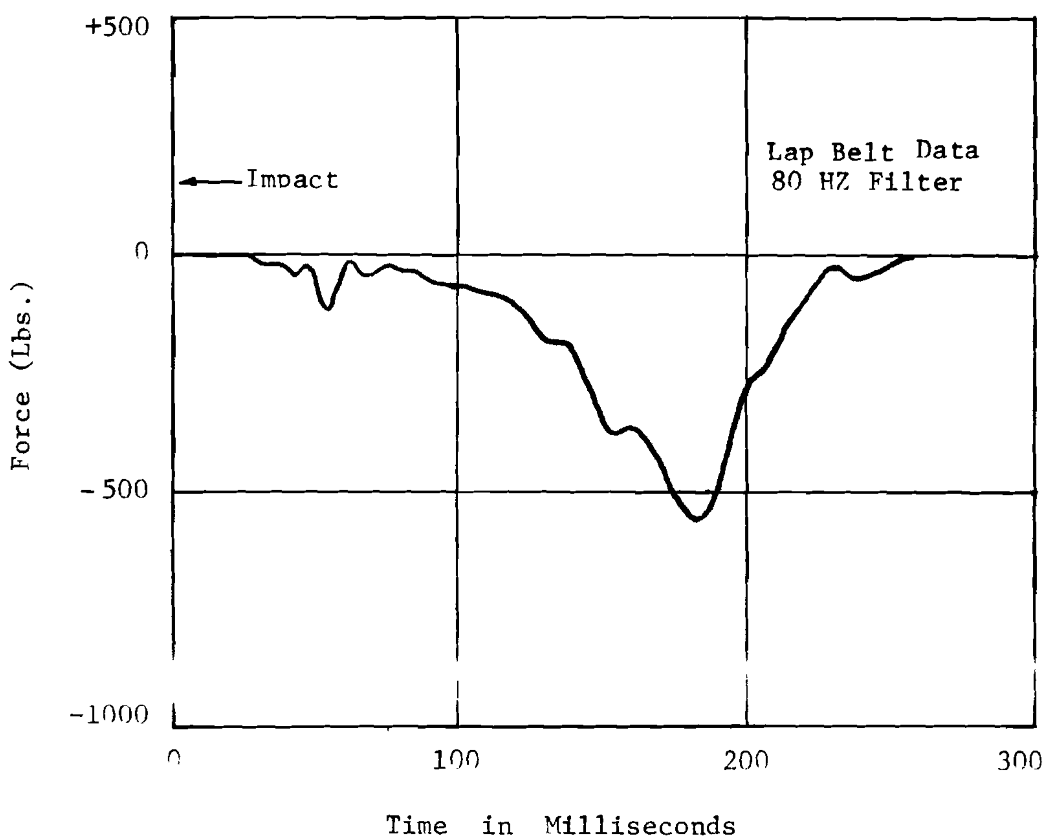


Figure 11, Lap Belt Data, Test 505 FG-A

CONCLUSION

Although the vehicle decelerations observed in this test were tolerable to properly restrained passengers,[3] the median barrier did not redirect the vehicle as intended or desired. The fiberglass barrier lacked strength and roughness to prevent the vehicle from penetrating it. In particular, the barrier contact surfaces and connections could possibly be altered to prevent disintegration of the side of the barrier under vehicular impact. This might be accomplished by replacing the fiberglass guardrail or rubrail with the common metal W-section flexbeam railing. However, this is only speculation and further design modifications would probably be necessary. The bolted connections employed throughout the system appeared to be totally unsatisfactory. Steel bolts in holes in the fiberglass created many areas of high stress concentration which the non-ductile (or brittle) fiberglass could not tolerate.

The fact that most fiberglass lacks ductility (the ability to undergo large plastic deformation) creates many difficult design and fabrication problems for impact resistant structures. Ductile materials generally perform better than brittle materials under impact loads, particularly at connections and in areas of high stress concentration since by yielding, the ductile material can redistribute high stress concentrations.

REFERENCES

1. Nelson, D.N. and Singh, M.M., "Investigation of Soil Filled Median Barriers," Report prepared by ITT Research Institute for the Molded Fiberglass Body Company, March 1969.

2. Rao, P.N., "Investigation of Energy Absorption of Soil Filled Guard Rails," Final report of IIT Research Institute Project D6055 for Molded Fiberglass Resin Company, subcontract P.O. No. L5832 (under Department of Transportation Prime Contract), July 1970.

3. Damon, A., Stoudt, H.W. and McFarland, R.A., "The Human Body in Equipment Design," Harvard University Press, 1966.