TECHNICAL MEMORANDUM 505-20

Texas Transportation Institute
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FEASIBILITY OF SNAGGING A VEHICLE WITH HOOK AND CABLE SYSTEM

A Test and Evaluation Report on Contract No. CPR-11-5851

U.S. Department of Transportation
Federal Highway Administration

by

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

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DESCRIPTION OF TESTS

In December of 1967 two tests were conducted to determine if it was feasible to stop a vehicle using a hook and cable system.[1] A steel hook (fabricated from 1.5 in. thick steel plate--see Figures 1 and 2) was welded to the frame of a 1958 Plymouth sedan (see Figure 4). Each end of a 7/8 in. diameter 6 x 19 wire rope 50 ft. long was attached to a Van Zelm Metal Bender (25,000 lb. capacity).[2] The metal benders were attached to steel anchor posts 12 ft. apart as shown in Figures 3 and 4.

The first test was conducted with the vehicle traveling 60 mph and at an angle of 5° from a normal to a line between the anchorage points. The vehicle passed over the cable without snagging it (a clean miss). This happened despite the fact that the steel hook had a ground clearance of only 2.5 in.

For the second test the hook was modified as shown in Figure 1 reducing the hook ground clearance to 1.5 in. The cable was placed in a lazy W position as shown in Figure 3 and blocked up at the center approximately 5 in. off the ground so the vehicle hook could engage it. This configuration was found necessary to prevent the front wheels of the vehicle from depressing the cable to the ground where the vehicle hook could not engage it.

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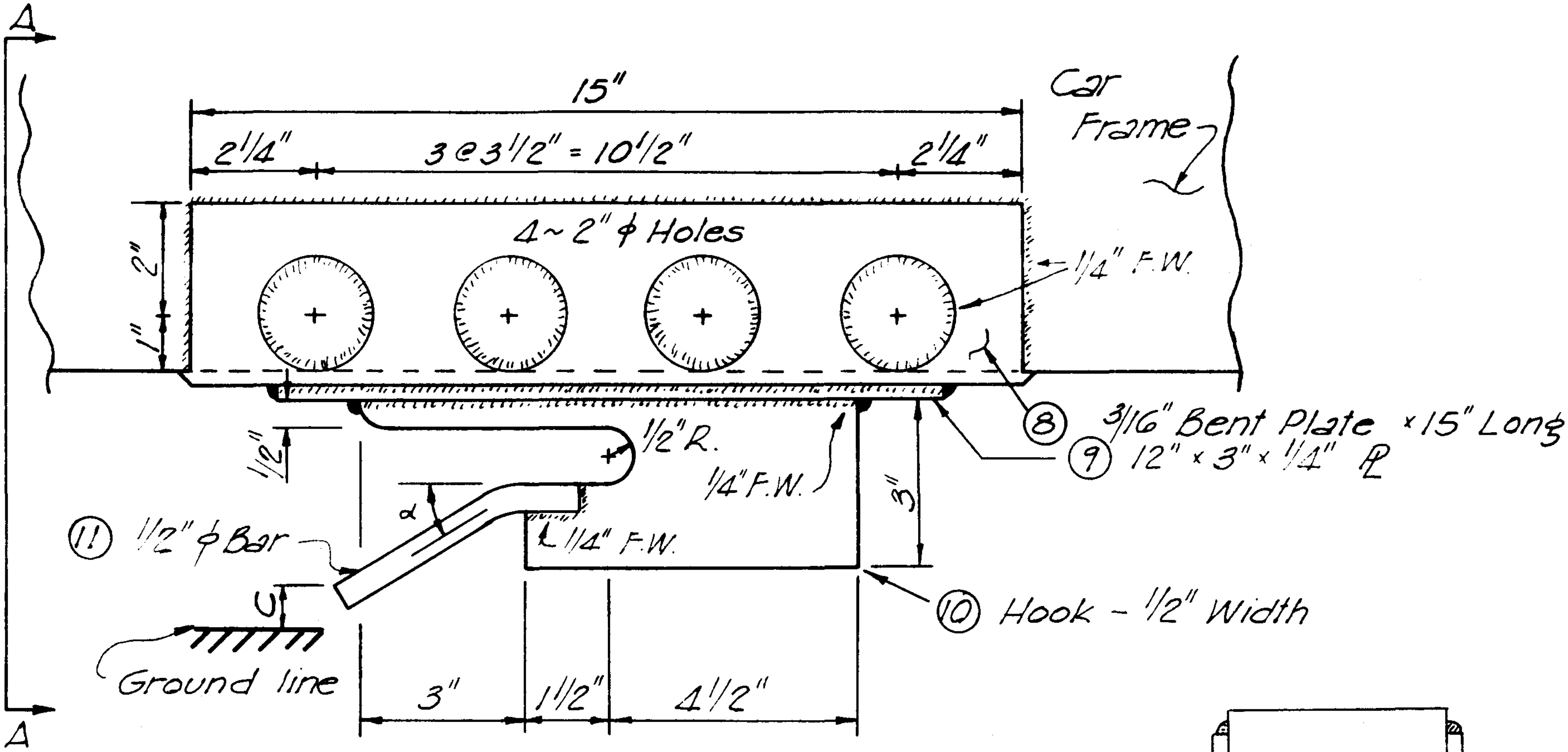
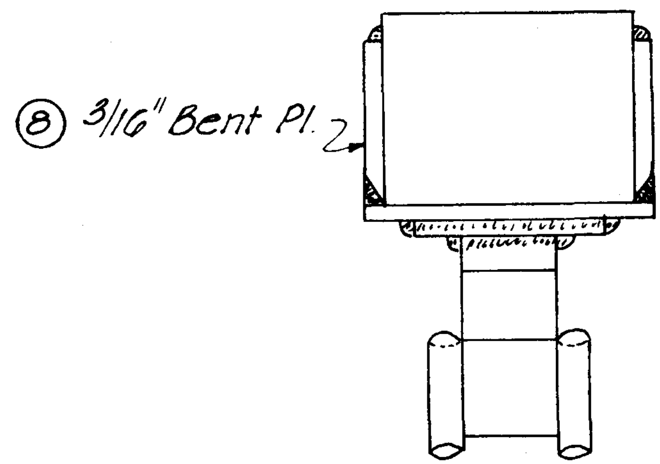
1. Magyar, N., "Vehicle Arresting System," Conceptual Studies, Program-Phase "A", Martin Marietta Corp., Baltimore, Maryland, FHWA Contract FH-11-6621, Volume II, September, 1968.

2. Hirsch, T. J., Hayes, G. G., and Ivey, D. L., "Dragnet Vehicle Arresting System," Texas Transportation Institute, February 28, 1969, Technical Memorandum 505-4.

Since the cable was attached to two 25,000 lb. metal benders, the maximum possible stopping force could reach 50,000 lb. Consequently, the frame of the vehicle was reinforced with 3/16 in. thick steel plates in an attempt to strengthen the point where the steel hook was attached (Figures 1 and 6). Previous analysis indicated there was no single point on the vehicle frame capable of resisting forces of 50,000 lb.[1]





NOTE:

α - Approx. 30°

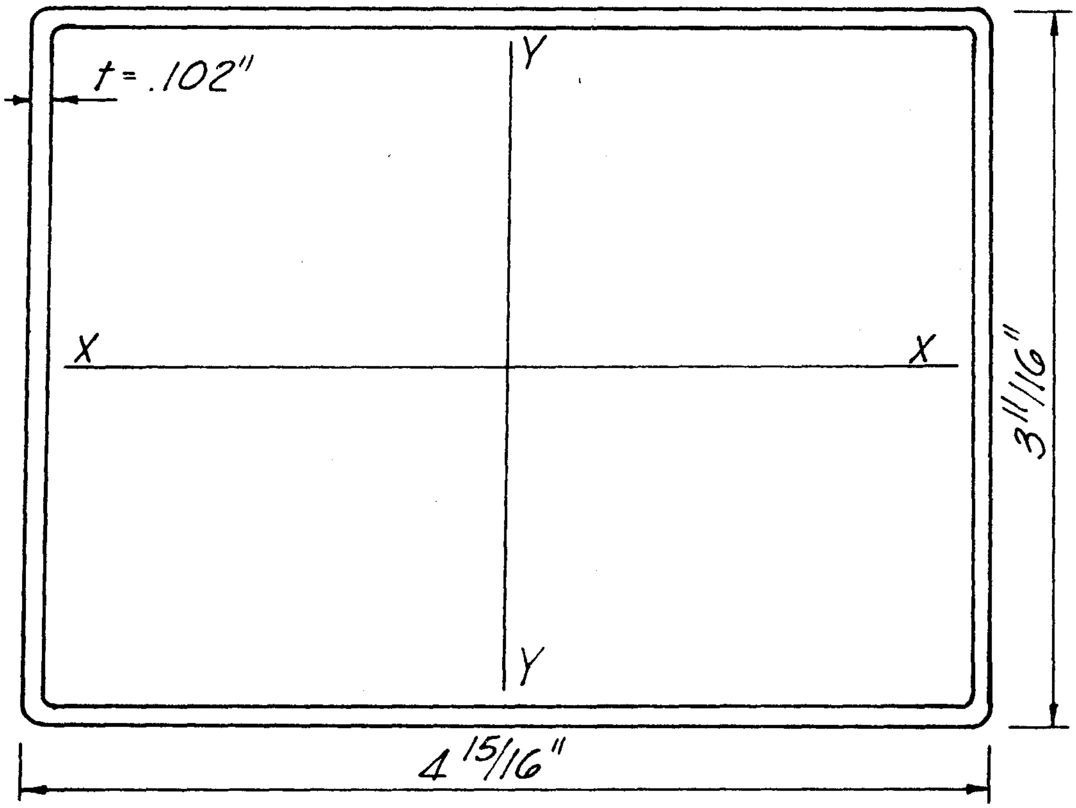
- Fillet Weld all around

Make Plate for right hand side of car

C = 2.5" for Test 1

C = 1.5" for Test 2

FIGURE 1. HOOK DETAILS



'58 PLYMOUTH FRAME PROPERTIES
(TEST VEHICLE 505-3A 12-6-67)

$$I_{X-X} = 2[(4.84)(.102)(1.78)^2 + 1/12(.102)(3.59)^3]$$
$$= 2[1.56 + 0.39] = 3.90 \text{ in.}^4$$
$$I_{Y-Y} = 2[(3.59)(.102)(2.42)^2 + 1/12(.102)(4.84)^3]$$
$$= 2[2.12 + 0.97] = 6.18 \text{ in.}^4$$
$$A = (2)(1.02)(4.84 + 3.59) = 1.72 \text{ in.}^2$$

Weight 3600 lbs.

'67 FORD PROPERTIES

$I_{X-X} = 2.3$ in.^{4} $I_{Y-Y} = 0.94$ in.^{4} $A = 0.87$ in.^{2} Wt. 3800 lbs.

$I_{X-X} = 0.59$
$I_{Y-Y} = 0.15$
$A = 0.50$
Wt. = 1.05

RATIO OF '67 FORD TO '58 PLYMOUTH PROPERTIES

FIGURE 2 - FRAME PROPERTIES OF '58 PLYMOUTH

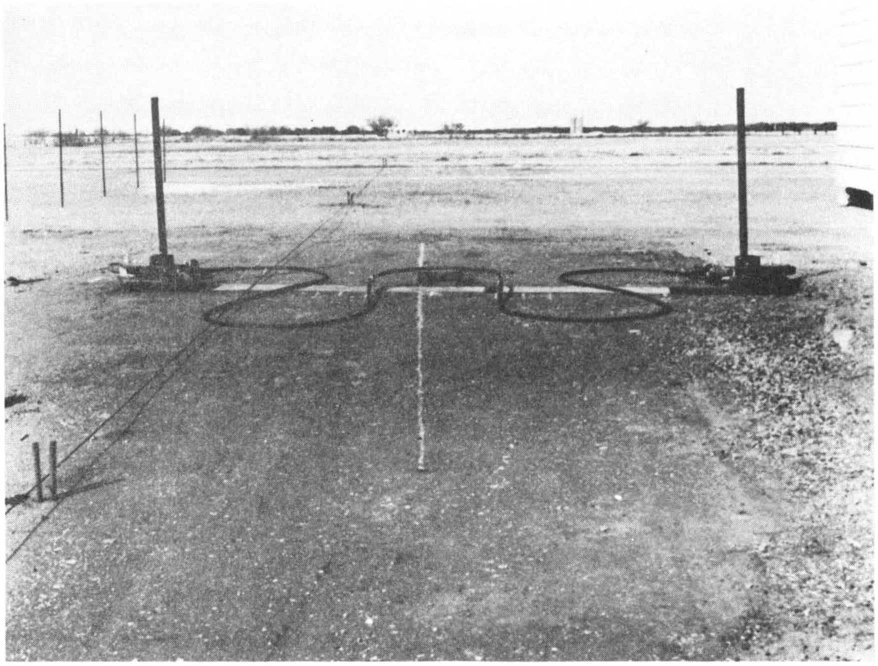


Figure 3: Snag Cable and Metal Benders before Test.
7/8 in. diameter cable 50 ft. long blocked up approximately 5 in. off ground. Metal benders 12 ft. apart.

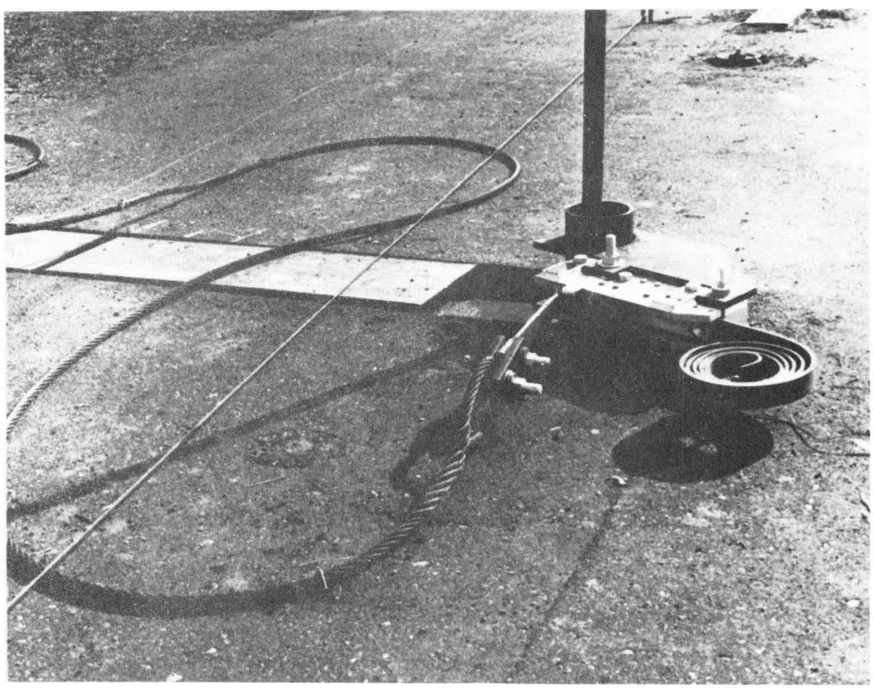


Figure 4: Metal bender with 25,000 lb. metal tape to supply stopping force.

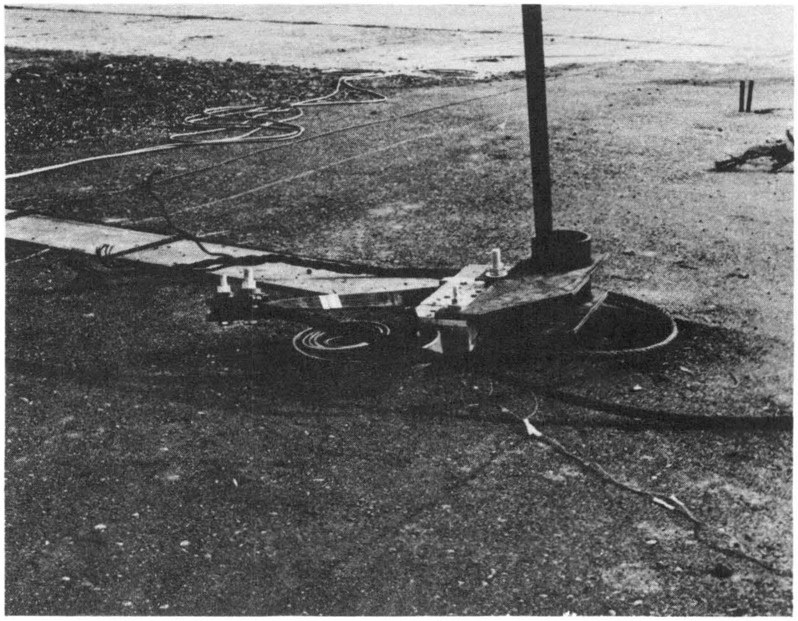


Figure 5: Metal bender and broken cable after test.

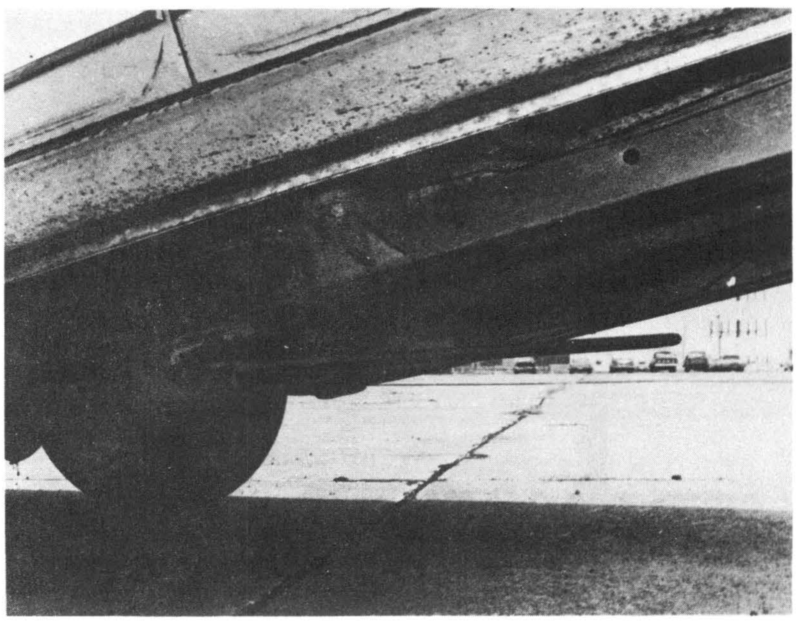
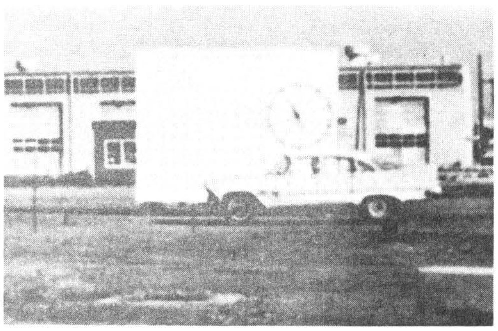
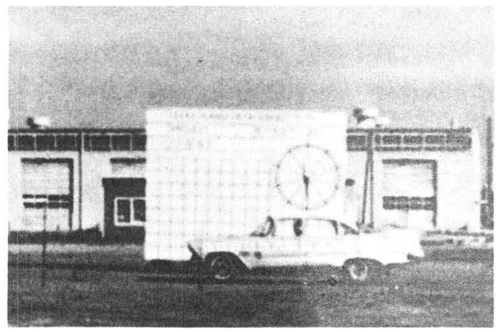


Figure 6 : Snag hook welded to frame of vehicle. Photo taken after test.
Vehicle frame bent and several weld fractured.

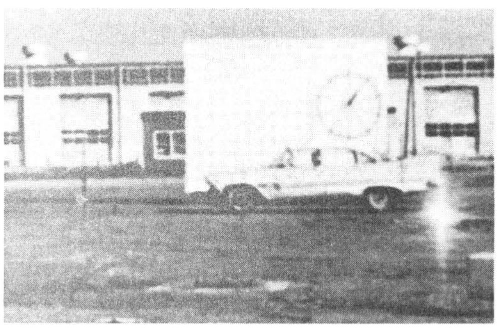
-.306 sec.



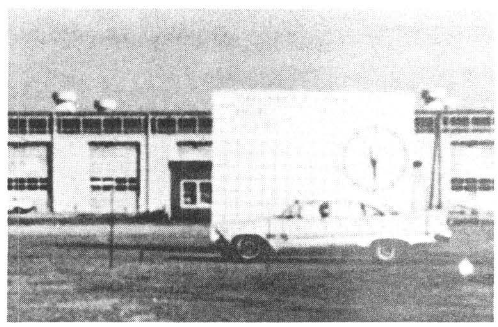
-.020 sec.



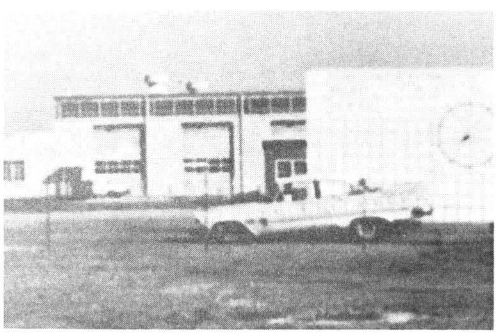
snag .000 sec.



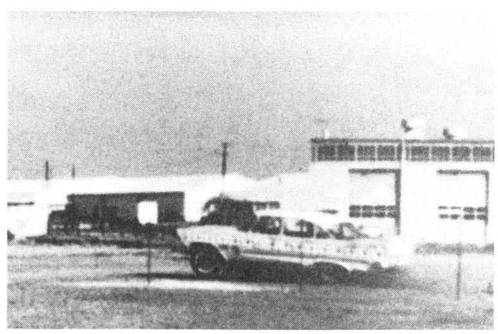
.020 sec.



.035 sec.



.144 sec.



.418 sec.

Figure 7: Sequential Photographs of Test 505-3B.

TEST RESULTS (Second Test)

Figure 7 presents sequential photographs of the vehicle during the test. The 3600 lb. vehicle engaged the cable while traveling at a speed of 57.3 mph at an angle of about 5° from the normal of a line between the two anchorages. The initial engagement occurred at -.286 sec. At 0 sec. (Figure 7 snag) the cable became taut and began exerting the stopping force. At 0.061 sec. the cable broke after slowing the vehicle to 48.8 mph over 4.86 ft. of travel. The average longitudinal deceleration imposed on the vehicle was approximately 6.3 g's as indicated by the data presented in Table 1.

Table 1. Data From Film Analysis
Test 505-3B (Second Test)

Vehicle Weight	3600 lb.
Initial Speed, V_i	57.3 mph (84.1 fps)
Final Speed, F_f (immediately after cable broke)	48.8 mph (71.6 fps)
Time in Contact (T)	0.061 sec.
Distance Vehicle Traveled (S) in contact with cable	4.86 ft.

Average Longitudinal Deceleration

$$\frac{V_i^2 - V_f^2}{2gS} = 6.2 \text{ g's}$$

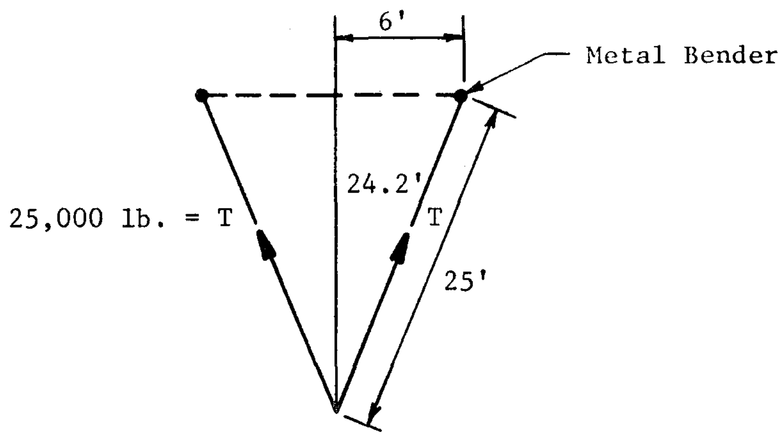
$$\frac{V_i - V_f}{gT} = 6.4 \text{ g's}$$

Approximately 13.5 in. of tape was pulled out of each metal bender accounting for approximately 56,000 ft.-lb. of energy consumed by the metal benders. The total vehicle kinetic energy was 395,000 ft.-lb. thus only about 15% of the vehicle kinetic energy was consumed by the metal benders.

The cable apparently broke because of the sharp bend it made around the vehicle snagging hook.

The frame of the vehicle was displaced about 2.5 in. relative to the car body during the test. In the three attachment points of the car body to frame forward of the snag hook, the frame was found to be torn on the tension side of the bracket. In the attachment to the rear of the snag hook the attachment bolt was on the verge of pulling loose from the car body. It appeared that the car frame was on the verge of being torn from the car body when the cable failed.

Knowing the tape capacity of the metal benders to be 25,000 lb., a simple analysis indicates the maximum deceleration imposed on the vehicle to be approximately 13.5 g's.



Maximum Stopping Force $= 2 \times 25{,}000\ (\frac{24.2}{25})$

$= 48{,}400$ lb.

Maximum Deceleration $= \frac{F}{W} = \frac{48{,}400}{3{,}600}$

$= 13.5$ g's (computed)

The difference between the computed maximum deceleration of 13.5 g's and the average deceleration of approximately 6.3 g's (determined from film analysis) can be attributed to several things as follows:

1. The vehicle engaged the cable at an angle of about 5°, thus one end of the cable became taut before the other,
2. The 50 ft. length of cable stretched as the force was applied,
3. In analysis of the high speed movie film, it was difficult to determine precisely the time and distance of engagement when the cable broke completely and released the vehicle.

CONCLUSIONS

Analytical studies made forthe Federal Highway Administration by Martin Marietta Corporation [1] indicated that no single point on a standard weight passenger car (1967) is capable of resisting forces of approximately twelve times the weight of the vehicle (12 g's). The experience gained from the full scale test report here support this conclusion.

It is clear that even if substantial lower deceleration forces are used that many practical engineering problems must be resolved before this concept could be employed to stop or arrest errant vehicles leaving the highway.[1] Some of these problems are as follows:

1. Attachment of snagging hook to vehicle needs careful study for strength and desirable location.
2. Cable location and configuration needs careful study.
3. A positive engaging system needs to be developed.
4. Capacity and location of metal bender (or other energy absorber) needs careful study.