Minicar Crash Test Evaluation of Longitudinal Traffic Barriers

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ABSTRACT

The number of small cars in use in the United States is growing rapidly, and the changing characteristics of the vehicle fleet should be considered in highway safety design. Before the series of crash tests described in this paper was performed, few of the current operational barrier systems had been evaluated for the 1,800-lb car test in NCHRP Report 230. Eleven barrier systems were selected for evaluation and findings indicate that all systems met impact test requirements for the 1,800-lb car at 60 mph and a 15-degree angle. The 11 barrier systems included 5 guardrail, 2 median-barrier, and 4 bridge-railing systems.

The number of small cars in use in the United States is growing rapidly, and the changing characteristics of the vehicle fleet should be considered in highway safety design. NCHRP Report 230 (1), published in 1981, tentatively specifies a crash test using an 1,800-lb vehicle as a replacement for the test using a 2,250-lb small car at 60 mph and a 15-degree angle. Before the series of crash tests described in this paper was performed, few of the current operational barrier systems had been evaluated for the 1,800-lb-car test requirements. As the first phase of NCHRP Project 22-4 (2), 11 typical operational barrier designs were selected and then evaluated with regard to dynamic performance with the 1,800-lb car. The results of these evaluations are described.

The 11 barrier systems were selected on the basis primarily of use and on the AASHTO barrier guide (3); they are described in Figures 1 through 3. The test vehicle used in the evaluations was a Honda Civic with a nominal weight of 1,800 lb excluding the side impact dummy (SID) used in all tests. The unrestrained dummy was placed in the front seat on the impact side. Results of the tests were compared with the recommended assessment criteria presented in NCHRP Report 230.

FINDINGS

The 11 tests are briefly described in the following sections; the tests are summarized in Tables 1 through 3, which include an assessment regarding compliance with the recommended evaluation criteria of NCHRP Report 230 (1, Table 6). In judging these tests, the researchers did not consider the values as absolute, and some small exceedance of one value was allowed if all other values were within the recommended limits. Thus, two of the barrier systems that had one test value slightly in excess of the recommended value were given marginal pass ratings. A third resulted in a test failure due to a secondary end treatment impact that resulted in rollover (not considered a system failure).

Test GR-1

Test GR-1 evaluated System G4(2W), a blocked-out W-beam on 6 x 8-in. timber posts. The vehicle was smoothly redirected with a maximum dynamic barrier deflection of 7.7 in. as shown in Figure 4. Damage to the barrier and vehicle was moderate, as shown in Figure 5. The vehicle was operable after coming off the rail, and the barrier was fully serviceable with small permanent deformations. Measured data indicated compliance with the recommended values of NCHRP Report 230.

Test GR-2

Test GR-2 evaluated System G9, a blocked-out thrie beam on steel posts. The test vehicle was smoothly redirected with a maximum dynamic barrier deflection of 6.0 in. as shown in Figure 6. Damage to the barrier and the vehicle was moderate, as shown in Figure 5. The vehicle was operable after the test with mostly sheet metal damage, and the barrier was fully serviceable with negligible permanent deformation. Test values indicated marginal compliance with the recommended occupant risk lateral impact velocity change (ΔV) values of NCHRP Report 230. The test was judged to be successful.

Test GR-3

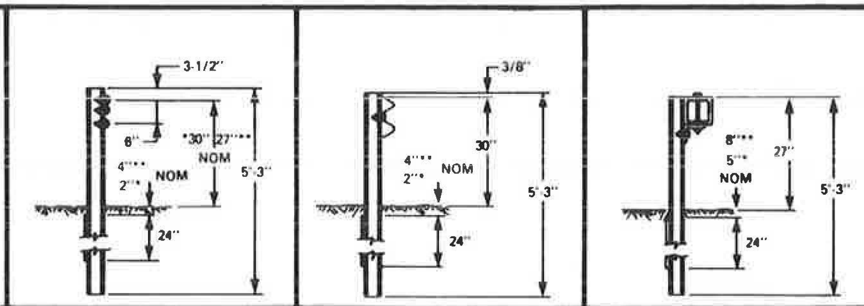
Test GR-3 evaluated System G2, a W-beam on weak steel posts. The vehicle was smoothly redirected with a maximum dynamic barrier deflection of 16.0 in. as shown in Figure 7. Contact with the posts caused the rear of the vehicle to yaw away from the barrier as it left the rail. There was sheet metal and left front wheel and tire damage to the vehicle resulting from contact with the posts. Damage to the barrier was sufficient to reduce the serviceability. One post was completely out of service. Measured test values indicated compliance with NCHRP Report 230.

Test GR-4

Test GR-4 evaluated System G3, a box beam on weak steel posts. The vehicle was smoothly redirected with a maximum dynamic barrier deflection of 6.4 in. as shown in Figure 8. Contact with the posts caused the rear of the vehicle to yaw away from the barrier as it left the rail; the vehicle recontacted the

*BARRIER GUIDE
**AS TESTED

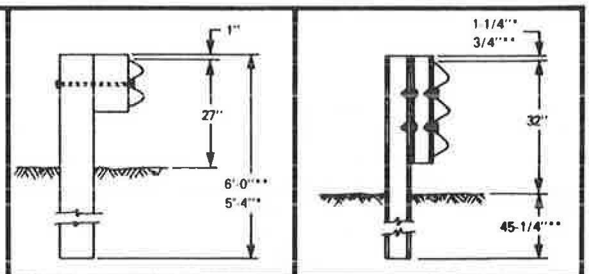
METRIC CONVERSIONS
1 ft. = 0.305 m
1 in. = 25.4 mm
1 mph = 1.61 km/hr
1 lb = 0.454 kg



SYSTEM	G1 CABLE GUARDRAIL	G2 "W" BEAM (STEEL WEAK POST)	G3 BOX BEAM
BARRIER DESCRIPTION			
POST SPACING	16'0"	12'6" NOMINAL	6'4"
POST TYPE	S3 x 5.7 STEEL	S3 x 5.7 STEEL	S3 x 5.7 STEEL
BEAM TYPE	THREE 3/4" DIAMETER STEEL CABLES	STEEL "W" SECTION, 12 GA.	6" x 6" x 0.180" STEEL TUBE
OFFSET BRACKETS	....	.....	L5" x 3-1/2" x 1/4" STEEL ANGLE, 4-1/2" L
MOUNTINGS	5/16" DIAMETER STEEL HOOK BOLTS	5/16" DIAMETER STEEL BOLT	3/8" DIA. STEEL BOLT (BEAM TO ANGLE)
FOOTINGS	1/4" x 8" x 24" STEEL PLATE WELDED TO POST	1/4" x 8" x 24" STEEL PLATE WELDED TO POST	1/4" x 8" x 24" STEEL PLATE WELDED TO POST

*BARRIER GUIDE
**AS TESTED

METRIC CONVERSIONS
1ft. = 0.305 m
1 in. = 24.4 mm
1 mph = 161 km/hr
1 lb = 0.454 kg

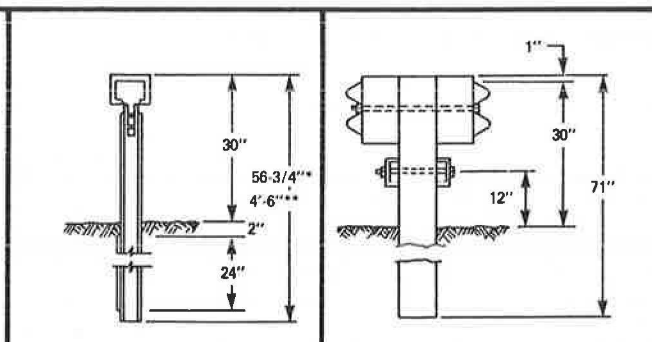


SYSTEM	G4(2W) BLOCKED-OUT "W" BEAM (WOOD POST)	G9 BLOCKED-OUT "THRIE BEAM" (STEEL POST)
BARRIER DESCRIPTION		
POST SPACING	6'3"	6'3"
POST TYPE	6" x 8" DOUGLAS FIR³	W6 x 8.5 STEEL
BEAM TYPE	STEEL "W" SECTION, 12 GA	THRIE BEAM, STEEL, 12 GA
OFFSET BRACKETS	6" x 8" x 14" DOUGLAS FIR BLOCK ³	W6 x 8.5 AND M14 x 17.2, STEEL
MOUNTINGS	5/8" DIAMETER CARRIAGE BOLTS	2 5/8" DIAMETER STEEL BOLTS
FOOTINGS	NONE ³SOUTHERN PINE (TESTED)	NONE

FIGURE 1 NCHRP Project 22-4 guardrail systems, Phase 1.

*BARRIER GUIDE
**AS TESTED

METRIC CONVERSIONS
1 ft. = 0.305 m
1 in. = 25.4 mm
1 mph = 1.61 km/hr
1 lb. = 0.454 kg



SYSTEM	MB3 BOX BEAM	MB4W BLOCKED-OUT "W" BEAM (WOOD POSTS)
BARRIER DESCRIPTION		
POST SPACING	6'0"	6'3"
POST TYPE	S3 x 5.7	8" x 8" DOUGLAS FIR³
BEAM TYPE	8" x 6" x 1/4" STEEL TUBE	TWO "W" SECTION, TWO C6 x 8.2 RUBRAILS
OFFSET BRACKETS	NONE	TWO 8" x 8" x 14" DOUGLAS FIR BLOCKS
MOUNTINGS	STEEL PADDLES	5/8" DIAMETER BOLTS
FOOTINGS	8" x 1/4" x 24" STEEL PLATE WELDED TO POST	NONE ³SOUTHERN PINE (TESTED)

FIGURE 2 NCHRP Project 22-4 median barrier systems, Phase 1.

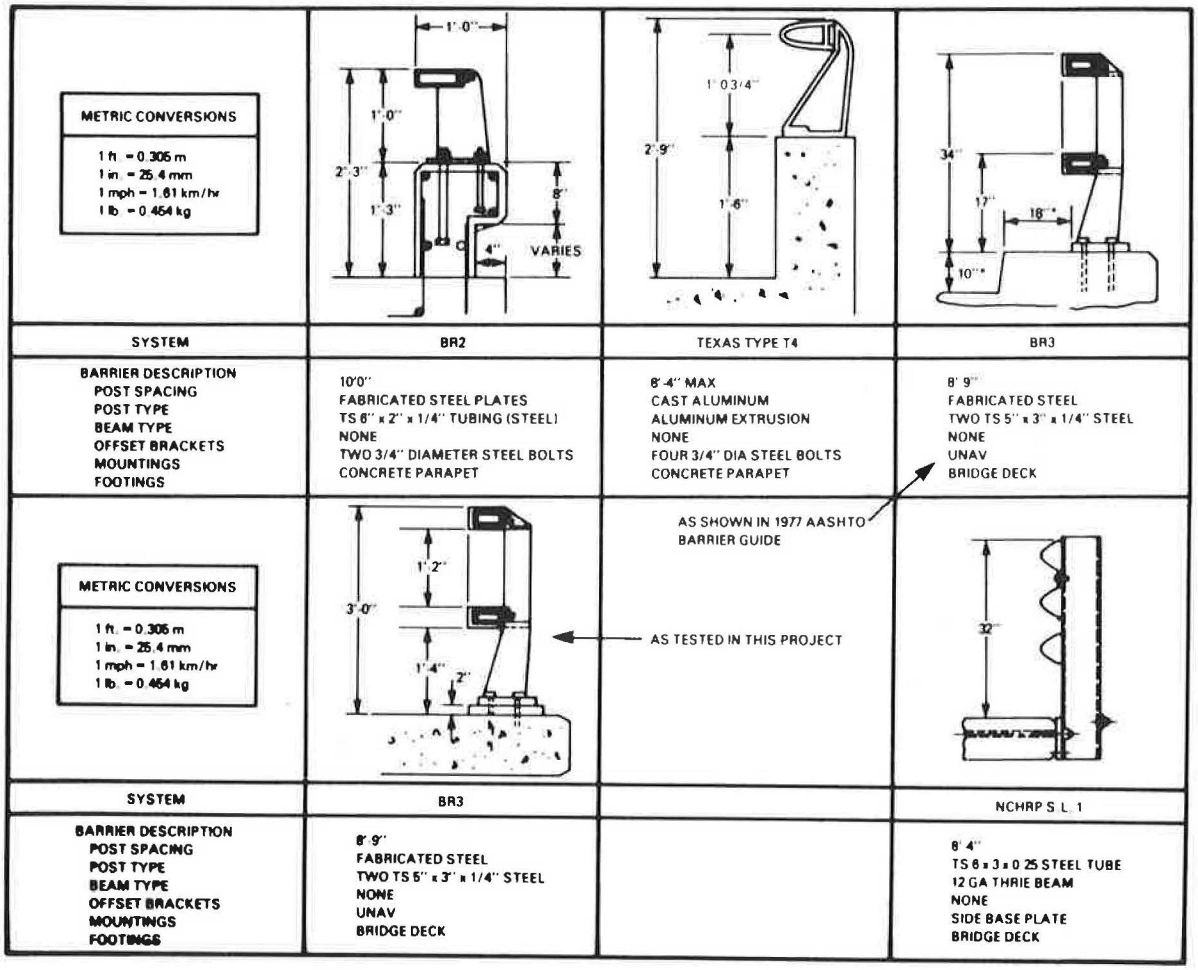


FIGURE 3 NCHRP Project 22-4 bridge-rail systems, Phase 1.

TABLE 1 Summary of Guardrail Crash Tests

	Test No.				
	GR-1	GR-2	GR-3	GR-4	GR-5
Barrier[a]	G4(2W)	G9	G2	G3	G1
Test-vehicle year[b]	1977	1978	1976	1978	1976
Gross vehicle weight (lb)	1,989	1,948	1,857	1,916	1,973
Impact speed (film) (mph)	60.1	59.3	59.7	60.4	60.5
Impact angle (degrees)	15.5	14.4	15.4	15.3	15.8
Impact duration (sec)	0.25	0.22	0.38	0.27	0.84
Maximum deflection (in.)					
Dynamie	7.7	6.0	16.0	6.4	43.4
Permanent	3.2	1.5	11.9	0	Slack cables
Exit angle (degrees)					
Film	-2.1	-3.5	-1.7	4.1	NA
Yaw rate transducer	-1.6	-4.0	-6.0	2.4	1.7
Exit speed (mph)					
Film	54.7	52.3	50.4	49.3	NA
Accelerometer	55.9	52.1	59.0	46.8	43.8
Maximum 50-msec avg acceleration (film/accelerometer)					
Longitudinal	1.8/2.1	3.5/3.1	2.1/2.3	3.2/4.1	2.9/2.1
Lateral	5.9/7.3	6.7/8.1	4.3/6.9	6.7/5.9	2.7/2.2
Occupant risk[c] (film/accelerometer)					
Longitudinal ΔV (fps) (30)	-[d]/-[d]	-[d]/-[d]	15.7/-[d]	-[d]/18.3	12.7/9.8
Lateral ΔV (fps) (20)	19.8/18.6	21.5/20.4	17.0/17.3	18.9/17.8	11.9/10.6
Ridedown acceleration (g) (accelerometer)					
Longitudinal (15)	-[d]	-[d]	-[d]	6.2	1.7
Lateral (15)	13.8	10.6	14.7	10.0	8.7
NCHRP Report 230 evaluation					
Structural adequacy (A,D)	Pass	Pass	Pass	Pass	Pass
Occupant risk (E,F,G)	Pass	Pass (marginal F)	Pass	Pass	Fail (E)
Vehicle trajectory (H,I)	Pass	Pass	Pass	Pass	Pass (marginal I)
Barrier damage rating[e]	2	2	3	3	4
Posts not serviceable	None	None	1	2	3

Note: NA = data not available.

[a]AASHTO barrier guide designation (1977).
[b]All tests used a Honda Civic.
[c]Numbers in parentheses are recommended values for NCHRP Report 230.
[d]Occupant did not travel the flail distance.
[e]Barrier damage code: 1, undamaged; 2, fully serviceable, but moderately damaged; 3, reduced service due to damage in impact area; 4, not serviceable in impact area. Damage repair indicated for 3, immediate damage repair for 4.

TABLE 2 Summary of Median Barrier Tests

	Test No.	
	MB-1	MB-2
Barrier[a]	MB4W	MB3
Test-vehicle year[b]	1977	1978
Gross vehicle weight (lb)	1,947	1,979
Impact speed (film) (mph)	58.5	61.6
Impact angle (degrees)	17.2	14.5
Impact duration (sec)	0.24	0.38
Maximum deflection (in.)		
Dynamic	2.5	7.0
Permanent	0	0
Exit angle (degrees)		
Film	-5.3	2.5
Yaw rate transducer	NA	2.6
Exit speed (mph)		
Film	54.7	46.7
Accelerometer	NA	49.2
Maximum 50-msec avg acceleration (film/accelerometer)		
Longitudinal	2.2/NA	3.8/3.8
Lateral	7.4/NA	5.1/5.1
Occupant risk[c] (film/accelerometer)		
Longitudinal ΔV (fps) (30)	-[d]/NA	16.6/13.8
Lateral ΔV (fps) (20)	21.4/NA	16.1/16.9
Ridedown acceleration (*g*) (accelerometer)		
Longitudinal (15)	NA	3.6
Lateral (15)	NA	5.9
NCHRP Report 230 evaluation		
Structural adequacy (A,D)	Pass	Pass
Occupant risk (E,F,G)	Pass (marginal F)	Pass
Vehicle trajectory (H,I)	Pass	Pass
Barrier damage rating[e]	2	3
Post not serviceable	0	3

Note: NA = data not available.

[a]AASHTO barrier guide designation (1977).

[b]All tests used a Honda Civic.

[c]Numbers in parentheses are recommended values for NCHRP Report 230.

[d]Occupant did not travel the flail distance.

[e]Barrier damage code: 1, undamaged; 2, fully serviceable, but moderately damaged; 3, reduced service due to damage in impact area; 4, not serviceable in impact area. Damage repair indicated for 3, immediate damage repair for 4.

TABLE 3 Summary of Bridge-Rail Tests

	Test No.			
	BR-1	BR-2	BR-3	BR-4
Barrier[a]	BR2	Texas Type T4	BR3	NCHRP SL 1
Test-vehicle year[b]	1978	1978	1979	1978
Gross vehicle weight (lb)	1,929	1,980	1,990	1,987
Impact speed (film) (mph)	60.9	61.0	61.0	61.4
Impact angle (degrees)	13.1	15.0	14.2	14.1
Impact duration (sec)	0.24	0.25	0.28	0.32
Maximum deflection (in.)				
Dyamic	0	0	0	17.2
Permanent	0	0	0	6.8
Exit angle (degrees)				
Film	-4.1	-5.6	0.5	-5.5
Yaw rate transducer	0.2	0.3	0.3	-1.6
Exit speed (mph)				
Film	57.9	54.5	51.0	55.9
Accelerometer	55.0	50.0	48.2	58.1
Maximum 50-msec avg acceleration (film/accelerometer)				
Longitudinal	2.7/3.8	1.9/6.1	3.1/6.9	1.8/2.0
Lateral	4.6/10.2	4.8/10.3	6.1/8.0	3.5/6.4
Occupant risk[c] (film/accelerometer)				
Longitudinal ΔV (fps) (30)	-[d]/5.9	-[d]/13.1	12.0/15.8	11.7/8.4
Lateral ΔV (fps) (20)	17.2/16.2	17.5/18.5	19.5/18.0	15.1/17.0
Ridedown acceleration (*g*) (accelerometer)				
Longitudinal (15)	-[d]	2.90	3.5	0.8
Lateral (15)	9.6	14.1	13.2	8.5
NCHRP Report 230 evaluation				
Structural adequacy (A,D)	Pass	Pass	Pass	Pass
Occupant risk (E,F,G)	Pass	Pass	Pass	Pass
Vehicle trajectory (H,I)	Pass	Pass	Pass	Pass
Barrier damage rating[e]	1	1	1	3
Posts not serviceable	0	0	0	2

[a]AASHTO barrier guide designation (1977).

[b]All tests used a Honda Civic.

[c]Numbers in parentheses are recommended values for NCHRP Report 230.

[d]Occupant did not travel the flail distance.

[e]Barrier damage code: 1, undamaged; 2, fully serviceable, but moderately damaged; 3, reduced service due to damage in impact area; 4, not serviceable in impact area. Damage repair indicated for 3, immediate damage repair for 4.

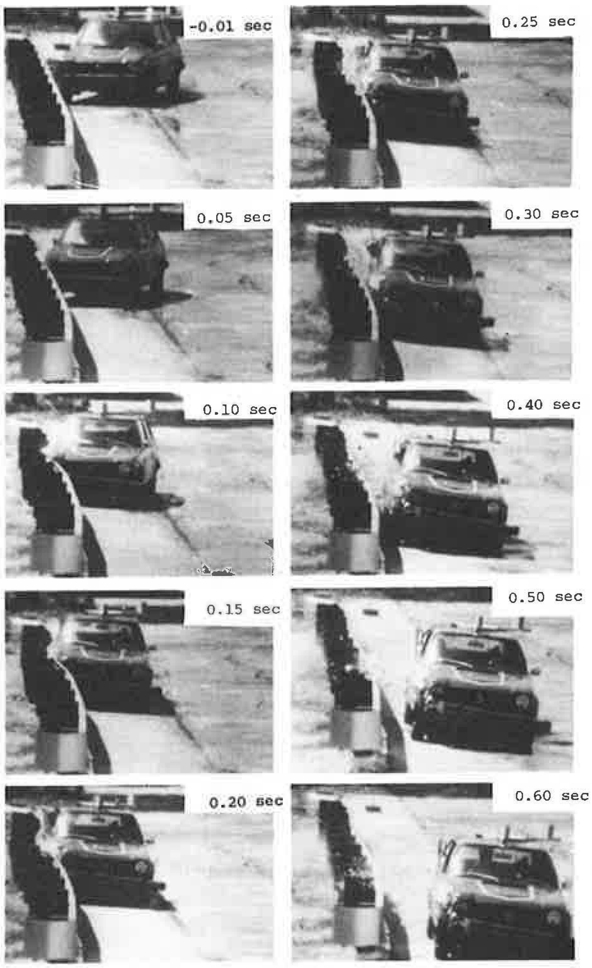


FIGURE 4 Sequential photographs, Test GR-1.

barrier downstream. There was considerable front wheel damage because of contact with the posts; sheet metal damage was extensive in the front quadrant. There was no permanent set in the rail although two posts were completely out of service and another was detached from the rail. Test values measured indicated compliance with NCHRP Report 230. Vehicle and barrier damage are shown in Figure 5.

Test GR-5

Test GR-5 evaluated System G1, a cable on weak steel posts. The vehicle was smoothly redirected with a maximum dynamic barrier deflection of 43.4 in. as shown in Figure 9. The rear of the vehicle yawed away from the barrier as the vehicle left the barrier; the vehicle then recontacted the barrier terminal, snagged, and rolled over. The breakaway feature of the terminal failed to release the cables from the anchorage. Vehicle damage before rollover was confined to sheet metal and the front wheel (because of post contact). Barrier damage was extensive with three posts out of service and cables lying on the ground as shown in Figure 5. Before the rollover the test would have been judged successful except for the 15-mph velocity change criterion of NCHRP Report 230 (1, Table 6, I). This value was slightly exceeded and a marginal pass was indicated.

Test MB-1

Test MB-1 evaluated System MB4W, a blocked-out W-beam on 8 x 8-in. timber posts with channel rub rail. The test vehicle was redirected with a maximum dynamic barrier deflection of 2.5 in. as shown in Figure 10. There was no evidence of vehicle contact with the rub rail. The vehicle sustained side sheet metal and

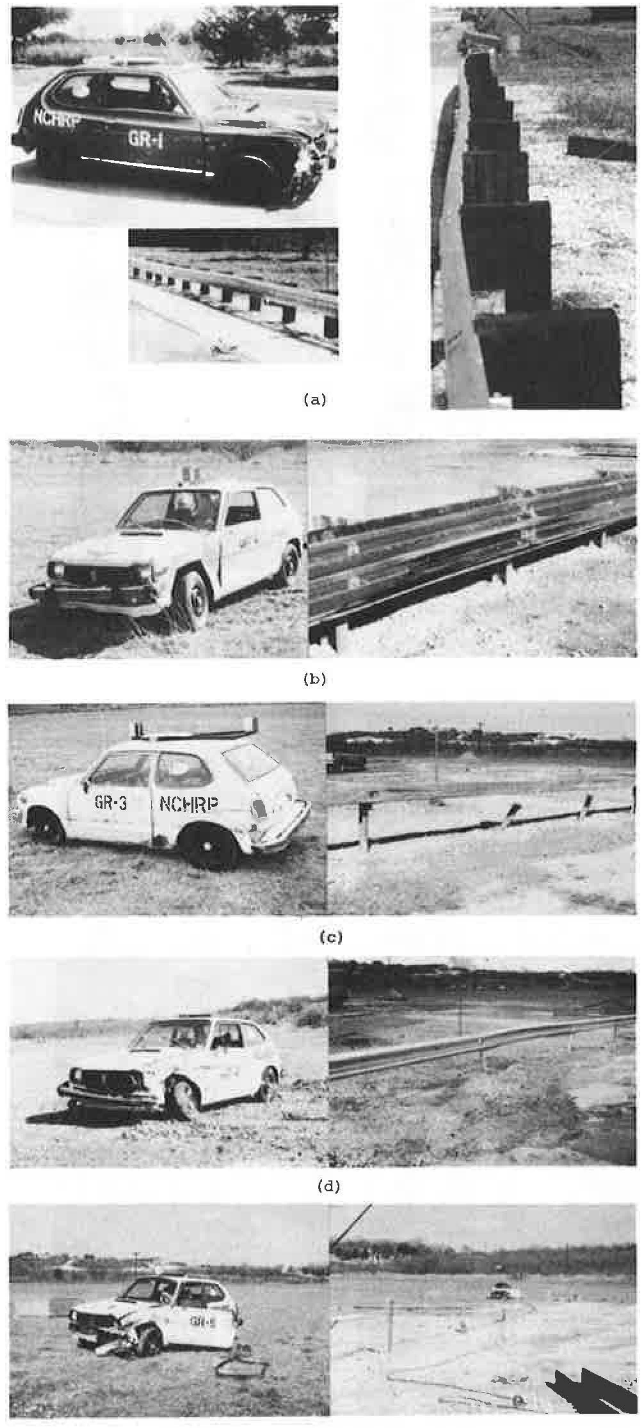


FIGURE 5 Barrier and vehicle damage after guardrail tests: (a) Test GR-1, System G4 (2W); (b) Test GR-2, System G9; (c) Test GR-3, System G2; (d) Test GR-4, System G3; (e) Test GR-5, System G1.

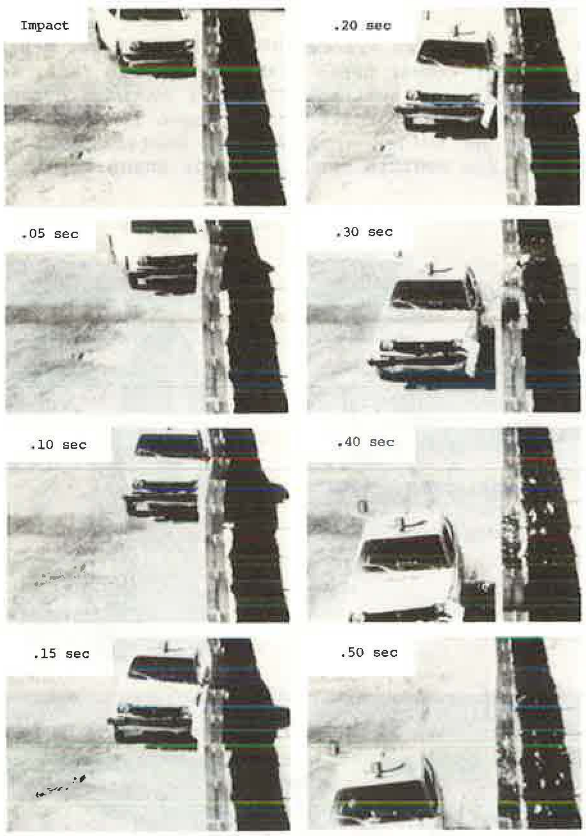


FIGURE 6 Sequential photographs, Test GR-2.

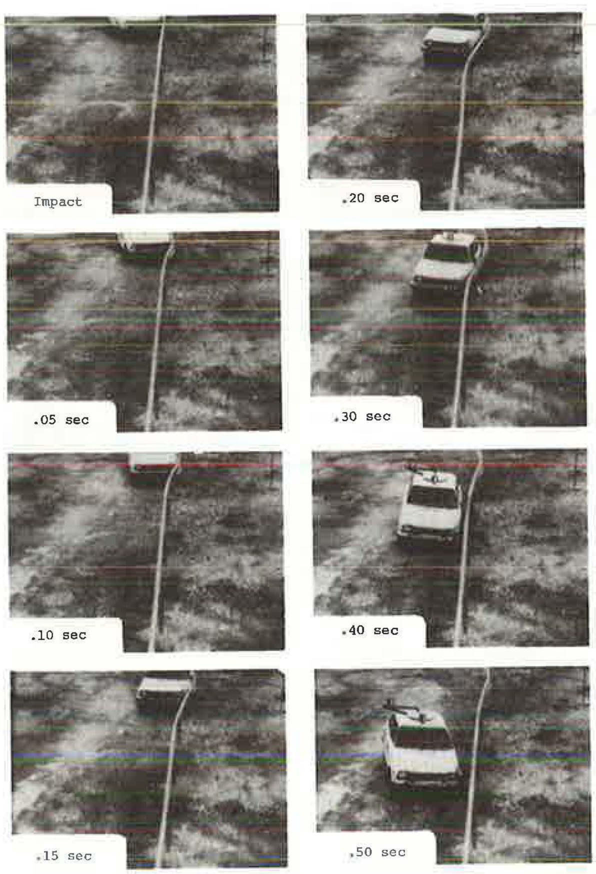


FIGURE 7 Sequential photographs, Test GR-3.

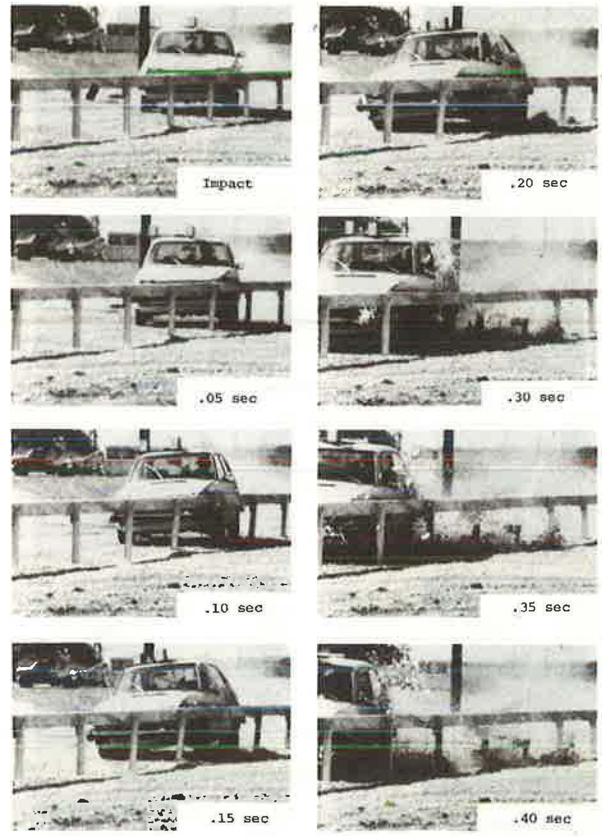


FIGURE 8 Sequential photographs, Test GR-4.

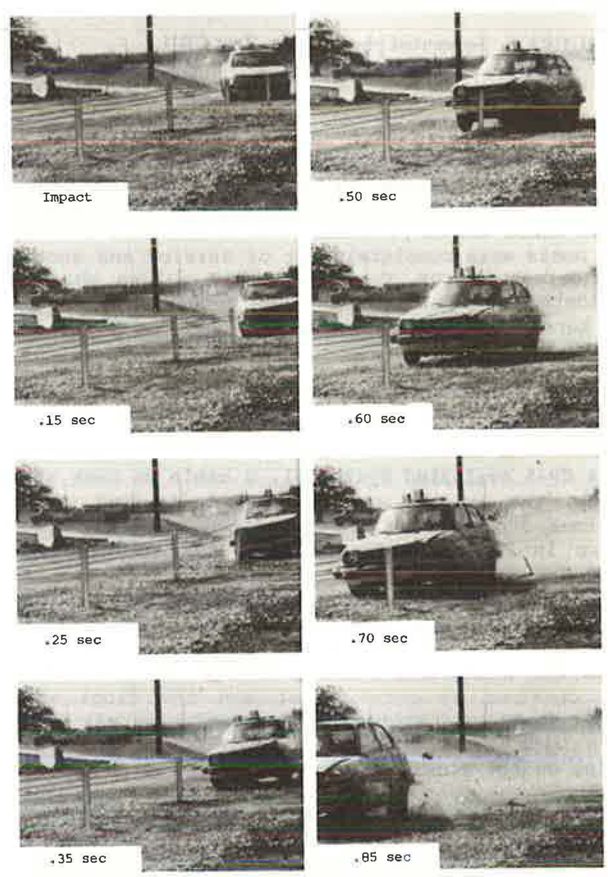


FIGURE 9 Sequential photographs, Test GR-5.

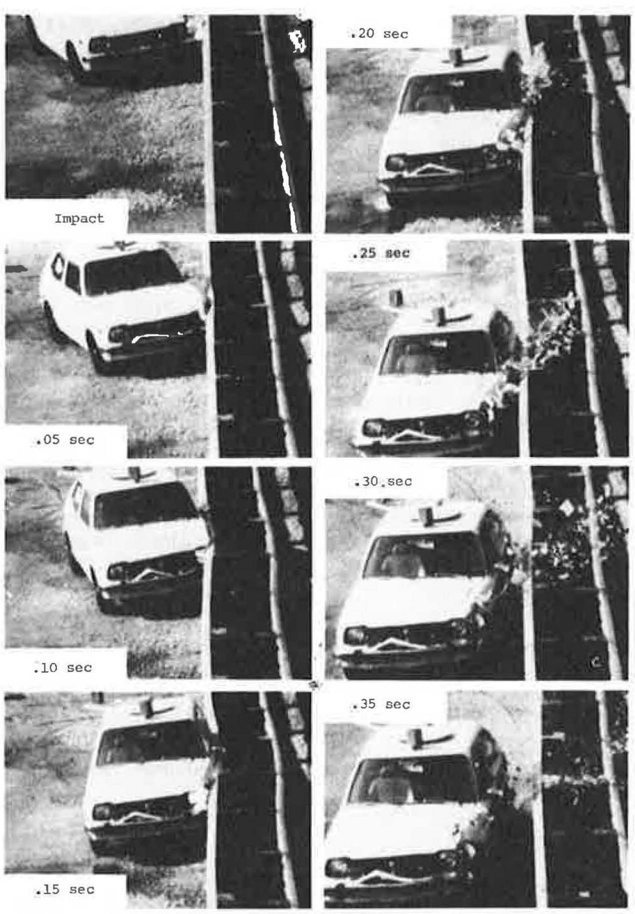


FIGURE 10. Sequential photographs, Test MB-1.

bumper damage; it was operable after the test. Damage to the barrier consisted of local beam deformation at two block-outs as shown in Figure 11. The barrier was fully serviceable with no measurable permanent deformation. On the basis of measured values, the test was judged to be successful although the occupant risk lateral ΔV slightly exceeded the NCHRP Report 230 value.

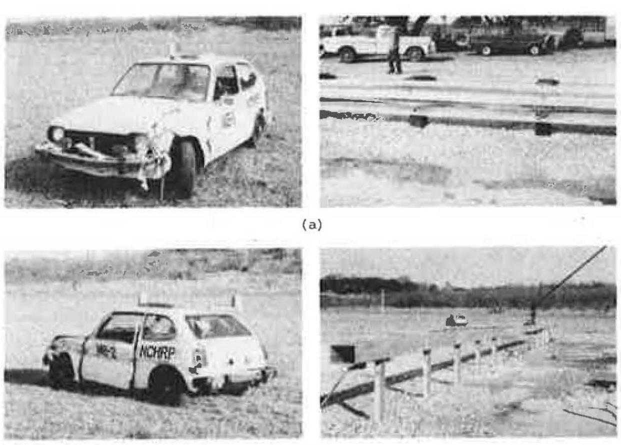


FIGURE 11 Barrier and vehicle damage after median-barrier tests: (a) Test MB-1, System MB4W; (b) Test MB-2, System MB3.

Test MB-2

Test MB-2 evaluated the performance of System MB3, a box beam on weak steel posts. The test vehicle was redirected with a maximum dynamic barrier deflection of 7.0 in. as shown in Figure 12. Because of contact with the posts, the rear of the vehicle yawed away from the barrier as contact with the barrier was lost. Vehicle damage was limited to sheet metal and bumper; all tires remained inflated and the vehicle was operable after the test. Damage to the barrier consisted of three failed posts as shown in Figure 11; there was no permanent set in the rail. Measured values indicated full compliance with the recommendations oF NCHRP Report 230.

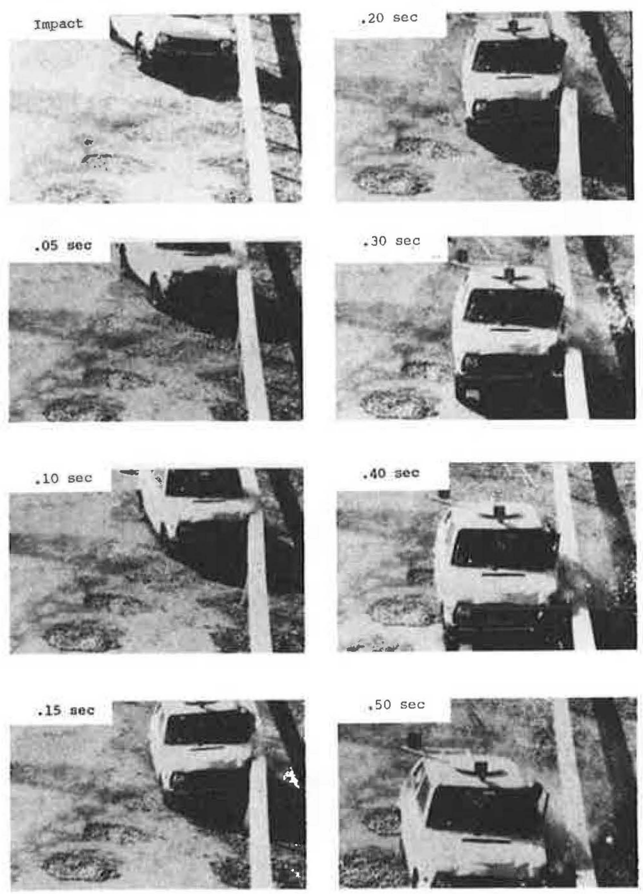


FIGURE 12 Sequential photographs, Test MB-2.

Test BR-1

Test BR-1 evaluated System BR2, a California Type 9, featuring a steel rail mounted on a 15-in.-high parapet [this is 3 in. below the requirement of the AASHTO specifications (4)]. The vehicle was smoothly redirected with no barrier deflection, as shown in Figure 13. No snagging or wedging of the vehicle under the rail was noted. There was sheet metal deformation of the right front and side of the vehicle; the vehicle was operable after the test. No damage to the barrier was noted, as shown in Figure 14. Measured values indicated compliance with NCHRP Report 230.

Test BR-2

Test BR-2 evaluated the Texas Type T4 (aluminum) bridge rail mounted on a parapet 18 in. high. The

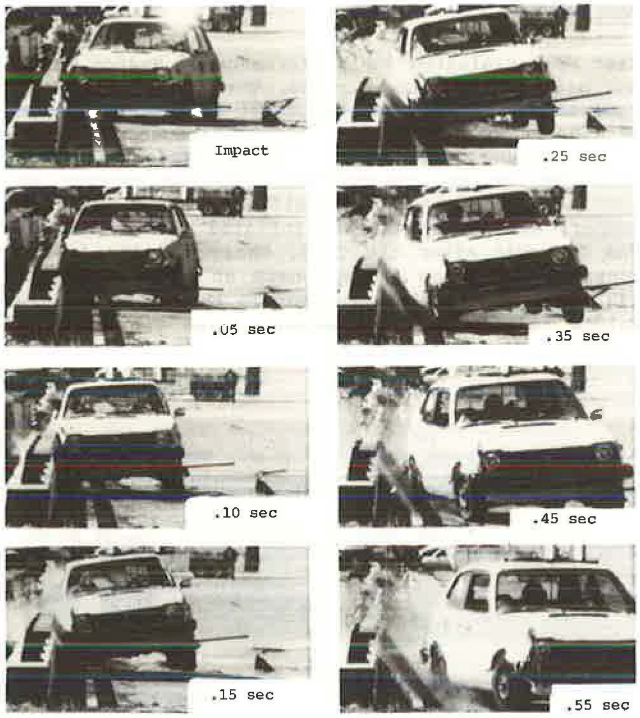


FIGURE 13 Sequential photographs, Test BR-1.

vehicle was smoothly redirected with no barrier deflection and no evidence of snagging, as shown in Figure 15. The vehicle sustained front and side sheet metal damage. All tires remained inflated and the vehicle was considered operable after the test. No damage to the barrier was evident, as shown in Figure 14. Measured values indicated compliance with NCHRP Report 230.

Test BR-3

Test BR-3 evaluated System BR3, a New York box beam bridge rail mounted on a flush deck. The test vehicle was redirected after significant wheel snagging had occurred on the first downstream post as shown in Figure 16. The redirected vehicle remained essentially parallel to the rail for a considerable distance. No barrier deflection was evident, as shown in Figure 14. There was extensive sheet metal damage to the vehicle. A-pillar, windshield, and the right A-frame were significantly damaged. No significant damage to the barrier system was evident. Measured values indicated compliance with NCHRP Report 230.

Test BR-4

Test BR-4 evaluated the NCHRP Service Level 1 bridge-rail system, which uses a thrie beam mounted on breakaway steel posts. The test vehicle was smoothly redirected after a 17.2-in. maximum dynamic barrier deflection as shown in Figure 17. Although the right

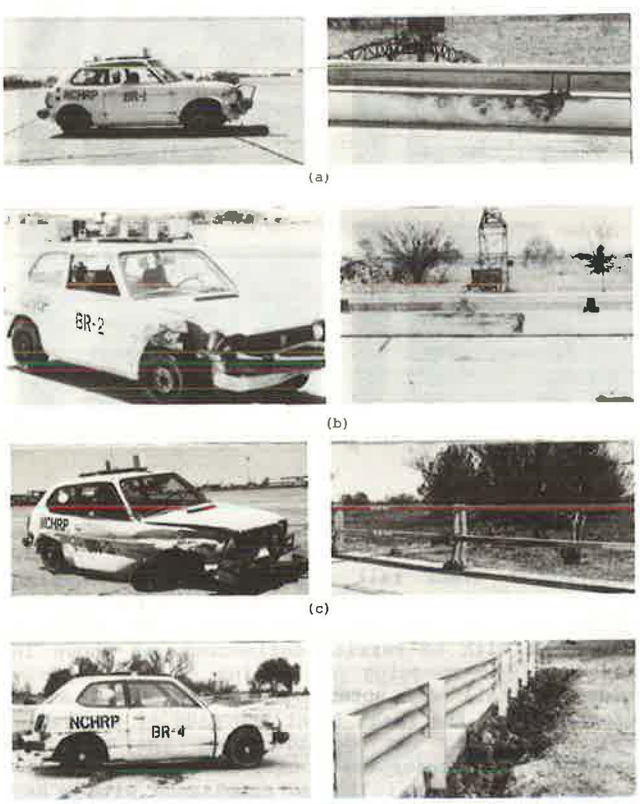


FIGURE 14 Barrier and vehicle damage after bridge-rail tests: (a) Test BR-1, System BR2; (b) Test BR-2, Texas Type T4; (c) Test BR-3, System BR3; (d) Test BR-4, Service Level 1 bridge rail.

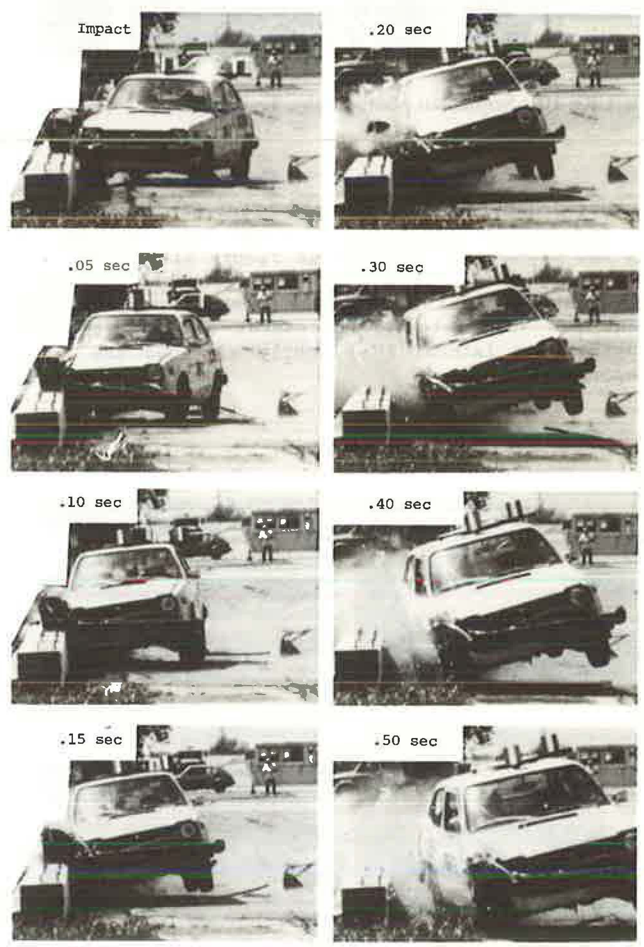


FIGURE 15 Sequential photographs, Test BR-2.

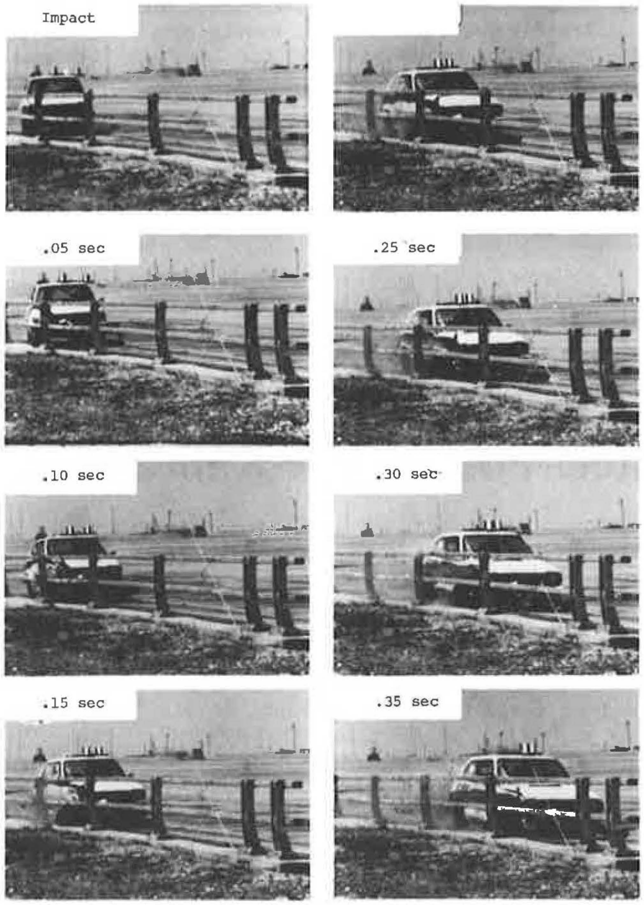


FIGURE 16 Sequential photographs, Test BR-3.

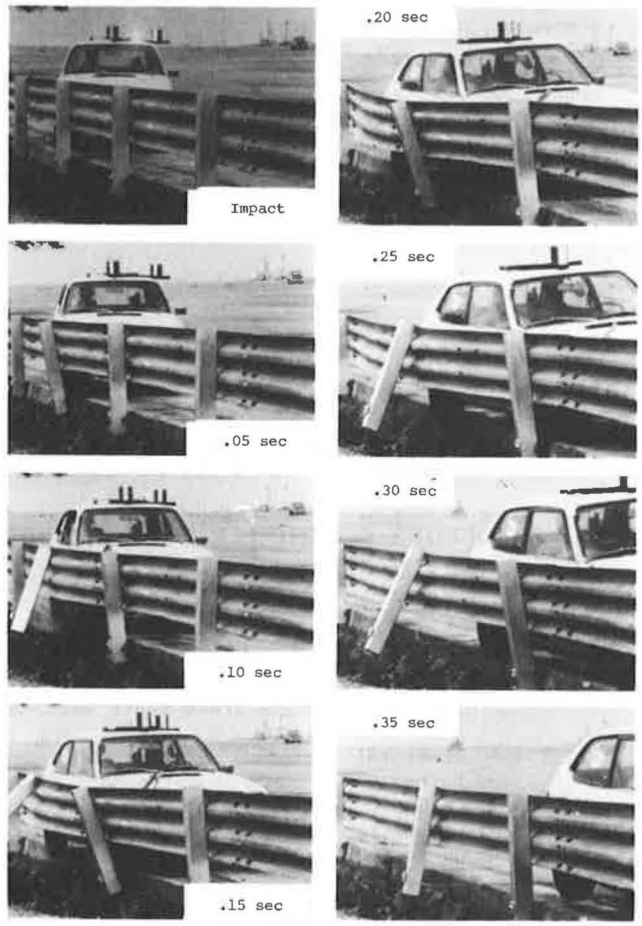


FIGURE 17 Sequential photographs, Test BR-4.

wheels of the vehicle dropped off and below the deck upper surface, they returned to the deck as the redirection continued. The vehicle damage was slight and confined to sheet metal. The vehicle was operable after the test. The barrier damage included one slightly deformed thrie-beam section and two posts that were detached from the base plate, as shown in Figure 14. Measured values indicated compliance with NCHRP Report 230.

CONCLUSIONS

On the basis of findings of the tests described in this paper, the following conclusions have been developed:

1. With minor exceptions, all 11 longitudinal barrier systems evaluated according to NCHRP Report 230, Test 12 (1,800-lb vehicle, 60 mph, and 15-degree angle) performed well and are deemed to have satisfied the assessment criteria. The vehicles remained upright [rollover in System G1 cable guardrail test (Test GR-5) was considered an end-treatment problem], were smoothly redirected, and sustained only moderate damage. Potential modifications to enhance the performance of the barrier systems with the Test 12 conditions are considered unwarranted.

2. With regard to limits of barrier performance with the minicar, Test 12 was not a discerning experiment because all 11 longitudinal barrier systems passed the evaluation criteria. A more discerning test, Test S13 (1,800-lb car, 60 mph, 20-degree angle), is considered desirable to thoroughly evaluate the snagging and possible occupant risk limits of the 11 barrier systems. There is recent evidence that a significant percentage of reported accidents occur where the impact angle exceeds 15 degrees (5).

3. Although the 11 barrier systems have been demonstrated to perform satisfactorily with NCHRP Report 230 minimum matrix Tests 10 and 12, two supplementary but important performance properties have not been evaluated, namely, capability of performing with vehicles that have a high center of gravity such as vans and school buses and the structural limit to contain higher service level loadings.

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Performance of a Thrie-Beam Steel-Post Bridge-Rail System

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ABSTRACT

Twelve full-scale crash tests were performed to evaluate the performance of a thrie-beam bridge-rail system. The railing consisted of 10-gauge thrie-beam steel rail attached to W6x9 steel posts spaced at 8 ft 4 in. Posts were attached to the deck by using base plates and anchor bolts. The system was tested both with and without a 6-in. curb with the rail at a height of 33 in. (measured from the deck) for both designs. Also tested were transitions from W-beam guiderail on S3x5.7 posts to thrie-beam guiderail on W6x9 posts and from the thrie-beam guiderail to the bridge rail. Tests with both 4,500- and 1,800-lb vehicles showed that the railing system generally meets the recommended performance standards in NCHRP Report 230.

The reconstruction of older structures to replace existing railings with new ones that meet current standards is prohibitively expensive, so the New York State Department of Transportation (NYSDOT) has initiated efforts to improve performance by installing additional railing components. Called "upgradings" or "retrofits," these designs use existing railing and superstructure components to the greatest extent possible and add only the necessary railings, posts, and connectors to achieve the desired performance. Several bridge-railing retrofits have already been tested and are now in use on bridges with discontinuous-panel railings (1,2).

However, some structures do not permit simple attachment of the retrofit to the existing railing system. One solution developed by the Structures Design and Construction Division is shown on Standard Sheet BDD 81-57F (Details for Attaching Thrie-Beam Railing to Bridge Railing). This design mounts 10-gauge thrie-beam railing on new heavy steel posts that are attached to the deck by using an anchor plate and grouted anchor bolts. Analytical procedures used to develop that design indicated the need for W6x25 posts spaced at 4 ft 6 in. Southwest Research Institute has previously tested a similar design that used 12-gauge tubular thrie-beam rail with good results (3). A 12-gauge thrie-beam on W6x9 post spaced at 5 ft that could redirect a 4,500-lb vehicle at 60 mph and 15 degrees was also developed for use as a low-service-level bridge rail (4). The NYSDOT design, which used a single 10-gauge thrie beam, appeared to offer several advantages:

1. Less complex splices are required,
2. Handling is easier because of its lighter weight,
3. Fewer inventory items are required for repair, and
4. Construction and maintenance costs should be lower.

The principal disadvantage of the proposed New York design was heavy steel posts at close spacing; the necessity of grouting so many bolts into the deck would add substantially to the railing's cost. However, other Texas Transportation Institute tests (5) evaluated a railing system composed of two W-beam rails overlapped to form three corrugations similar to a thrie beam. That railing performed adequately when attached to steel posts spaced at 8 ft 4 in., which indicated that it may be possible to increase the post spacing of the New York design.

METHODOLOGY

A total of 12 full-scale tests were conducted in 1982 and 1983 following the recommendations of NCHRP Report 230 (6). These tests were planned to determine maximum permissible post spacing as well as the level of performance provided by this railing system. In addition, tests of proposed transitions to W-beam approach guiderail were needed to ensure their adequate performance. Concrete footings 3 ft wide by 3 ft deep by 40 ft long simulated bridge