EVALUATION OF TIMBER WEAK-POST GUARDRAIL SYSTEMS

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Six full-scale vehicle crash tests were conducted on guardrail systems to evaluate the effectiveness of substituting timber posts for the standard 3I5.7 steel posts specified in a current guardrail standard. Results of the tests indicate that timber is a suitable post material for the "weak-post" concept. Although there was some difficulty in determining the proper rail attachment to the post, solutions to the problem are suggested in this report. Basically, the timber post design calls for a 12-gage flexural beam mounted on 6- by 7-in. or 5½-in. diameter pine posts spaced at 12.5-ft centers. A ¼-in. diameter steel bolt and a pipe insert provide proper attachment of rail to post. The sixth test of the series provided an evaluation of the effectiveness of a continuous installation composed of the new timber weak-post system and the department's strong-post system. The test results indicated that the transition design between the two systems was satisfactory, but design changes could improve performance.

•PRIOR TO 1967 and publication of the Yellow Book on Highway Safety (1), Ohio's guardrail design for most projects featured a steel W-shaped rail mounted on heavy round or square sawed wood posts or on 6B8.5 steel posts spaced 12.5 ft center to center.

In 1967 the Federal Highway Administration announced that guardrails used in new construction projects had to conform to requirements for systems that had been subjected to dynamic testing. This requirement limited guardrail design at that time to those developed by California and New York. Ohio was not prepared to accept the new concepts developed by New York and elected to continue use of the universal beam rail element mounted on heavy posts and offset blocks at 6.25-ft spacings.

The Federal Highway Administration subsequently announced that existing guardrail installations must also be made to conform with current safety standards. Meanwhile, guardrail costs for new construction in Ohio increased from $2.20 per foot in 1966 for the old design to $3.62 per foot in 1968 for the new design.

It was estimated that 90 percent of the guardrails erected on the Ohio Interstate system to date could conform to the New York W-beam concept of weak posts by notching existing timber strong posts (design deflections of New York design could be tolerated). It was, therefore, considered desirable to design a guardrail system for highway shoulder applications that would take advantage of much lower costs on new construction and also lend itself to inexpensive conversion of existing systems. It was also considered desirable to permit use of a wood-post alternate on new construction because many of the posts are produced in the depressed areas of southern Ohio by low-income landowners.

Because of maintenance considerations and in order to attain a certain continuity in design, it was considered desirable to use a single rail element for all applications by varying the post stiffness and spacing to achieve a range of lateral deflections. To do

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this it was proposed that the New York W-beam concept be used where considerable lateral deflection could be tolerated and that the California blocked-out W-beam concept be used where obstacles dictate restricted lateral deflection.

To connect the two systems where both occurred in a single run of guardrail, it was necessary to design and test a flexibility transition. A similar design could also be used as a flexibility transition between bridge parapets.

The W-beam and weak-post system concept developed by New York consists of a 12-gage steel W-beam mounted on 3I5.7 steel posts spaced at 12.5 ft; a $\frac{5}{16}$-in. diameter bolt provides the beam-to-post attachment. This system is standard G2 as reported by Michie and Calcote (2). To determine if a timber post could be substituted for the steel posts and otherwise meet the requirements of guardrail systems in Ohio, the Ohio Department of Highways contracted with the Department of Structural Research of Southwest Research Institute to conduct a full-scale crash-test program for concept evaluation. Objectives of the program were to determine (a) post size required to furnish a timber post alternate to the 3I5.7 steel post, (b) "notching" required to modify existing strong timber posts, and (c) proper rail-to-post attachment.

Although the G2 top-of-rail height had been recently raised from 30 in. to 33 in. by New York State, the rail height for this program was set at 27 in., thus conforming with the height of rail common to many existing installations in Ohio. Using the information from this test program, the Ohio Department of Highways intends to modify its installations by notching these existing strong posts. Five tests were conducted in this program to determine the optimum post size and rail-to-post attachment required to achieve desirable performance. In order to evaluate the performance of an installation incorporating a transition from a weak-post to strong-post system, a sixth test was conducted with the point of impact several feet upstream from the transition.

DISCUSSION OF TEST PROGRAM

The Ohio Department of Highways prepared a series of preliminary standard construction drawings that included a guardrail system designated as type 7. This design was similar to the G2 system mentioned previously (2) with three exceptions:

1. Wood posts were included along with the G2 standard 3I5.7 steel post;
2. The top of rail was specified as 27 in. instead of the G2 standard of 30 in.; and
3. The bolt hole in the standard washer was offset to improve support of the standard flexural beam (W-beam).

A test program was formulated to evaluate the feasibility of these changes in a proved system and to determine the size of wood post that could be substituted for the 3I5.7 steel post.

Six full-scale crash tests were conducted. All guardrail systems tested were composed of standard 12-gage steel flexural beam mounted on treated timber posts. A summary of the test series is given in Table 1. The posts were driven to grade with a

TABLE 1

SUMMARY OF TEST SERIES

Test No.	Post	Post Area (in.^{2})	Post Bolt	Vehicle Weight (lb)	Vehicle Speed (mph)	Impact Angle (deg)	Maximum Dynamic Deflection (ft)	Maximum Permanent Deflection (ft)	Guardrail Performance or Vehicle Reaction
ODH-1	4 by 4 in.	16	$\frac{5}{16}$-in. diameter steel	4,589	67.0	25.0	13+	10.0	Vehicle straddled rail, rolled 3½ times
ODH-2	4 by 6 in.	24	$\frac{5}{16}$-in. diameter steel	4,404	62.0	25.3	6.9	5.7	Vehicle straddled rail, good redirection
ODH-3	7-in. diameter	38.4	$\frac{5}{16}$-in. diameter steel with pipe insert	4,445	62.5	28.7	4.3	2.2	Vehicle pocketed, rolled over
ODH-4	6-in. diameter	28.2	$\frac{5}{16}$-in. diameter steel with pipe insert	4,242	63.1	28.3	6.5	5.2	Good redirection, vehicle rolled 15 deg but remained upright
ODH-5	6 by 6 in. (notched)	36 (30)	¼-in. diameter steel with pipe insert	4,407	70.8	26.7	7.2	2.9	Good redirection
ODH-7	_[a]	_[a]	_[a]	4,292	58.2	26.3	6.8	2.7	Some tendency to pocket, but overall good performance

[a]Transition test; see Appendix for details.

mechanical driver. Self-powered, full-size, four-door sedans were used as test vehicles. Electronic instrumentation permitted continuous recording of an anthropometric dummy's reaction to the crash-test events. Complete camera coverage included high-speed and documentary photography. The use of a motion analyzer and computer data-reduction program provided a record of time versus displacement information for the crash tests. Specific details of the test installations are shown by installation drawings in the Appendix. Several changes were incorporated as experience was gained with each test. Beginning with a post size from the preliminary Ohio Department of Highways type 7 plans, the program is described in chronological order with a discussion of the rationale for changes in the initial design. Test photographs and information summary are shown in the Appendix.

Test ODH-1

The first test in the series was conducted on a system featuring 4- by 4-in. posts. The vehicle impacted the 200-ft test installation at near midlength with a speed of 67 mph and an impact angle of 25 deg. Although the vehicle was redirected, loss of rail height and lack of sufficient post strength allowed it to straddle the rail. This contributed to multiple rollover that began as the vehicle neared the downstream terminal section. The 5/16-in. diameter post bolts did not shear. Rail separation from the posts, which occurred only at the posts in the immediate impact area, was due to forcing of the bolt and rear washer through the post material. Because of camera malfunctions, high-speed movie data were unobtainable; however, accelerations measured in the dummy chest cavity registered peaks of -2 g longitudinally, -7 g laterally, and +4.5 g vertically before the multiple rollover occurred. Seat belt and shoulder harness loads were a maximum of 500 lb, also before rollover.

All posts in the installation were broken near ground level (Appendix, Figs. 8 and 9). Failure of the upstream posts clearly indicated the lack of sufficient post strength. Because of the extended contact with the system, the vehicle engaged the downstream terminal treatment, which indicated there was insufficient installation length for a general performance test.

Test ODH-2

Based on the results of the first test, 4- by 6-in. posts were installed for the test and an additional 50 ft was added to the length of the test installation. The test vehicle impacted the installation with a speed of 62 mph and an angle of 25.3 deg (Appendix, Figs. 10 and 11). Although loss of rail height after impact permitted the vehicle to straddle the rail (Fig. 1), the vehicle was contained by the system and redirected. The vehicle was launched, but remained upright and was braked to a stop with moderate vehicle damage. Peak vertical and lateral dummy accelerations were +3 and -3 g respectively. Peak vehicle accelerations were -2.8 g and -2.4 g in the lateral and longitudinal directions respectively. As in test ODH-1, the 5/16-in. diameter post bolts did not shear. Rail separation from the post was accomplished by forcing the rear washer through the post material.

Although the vehicle accelerations and maximum dynamic deflection of the system were considered satisfactory for test ODH-2, two undesirable phenomena were observed that indicated a change in design to be justified:

1. The rail dropped excessively permitting the vehicle to straddle the rail; and
2. The vehicle remained in contact with the system for an extensive distance, resulting in excessive system damage.

Lack of sufficient post strength and failure of the post bolts to shear on impact were considered primary causes of these undesirable results.

Test ODH-3

It was apparent from the previous two tests that the resiliency of wood would prevent the instantaneous shearing of the 5/16-in. diameter bolts. For test ODH-3, a pipe

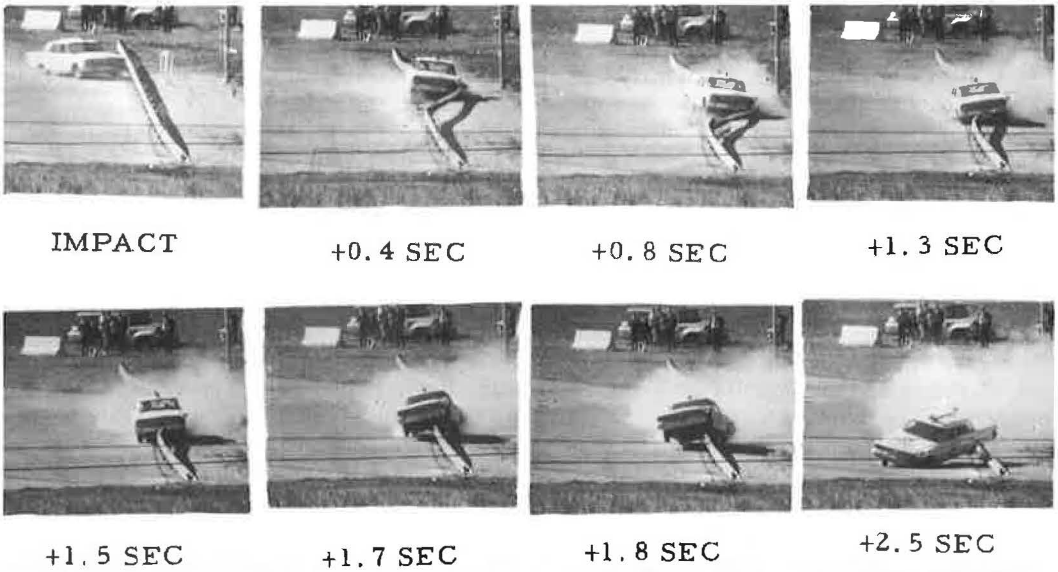


Figure 1. Sequence of events, test ODH-2.

section was inserted in the post bolt hole to provide a shearing surface similar to that provided by the steel flange of the G2 standard post. A 7-in. nominal diameter post was selected as the next size to be evaluated.

Test ODH-3 impact conditions were 62.5 mph at a 28.7-deg angle (Appendix, Figs. 12 and 13). The vehicle was initially redirected, but pocketing occurred about 30 ft from impact, and the vehicle rolled over and remained inverted (Fig. 2). Vehicle ac-

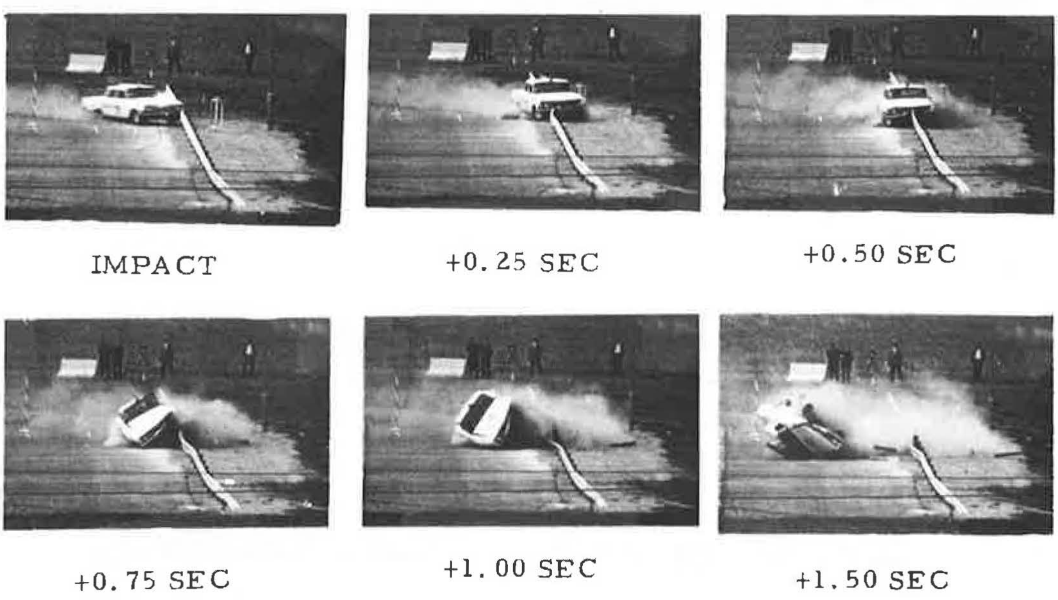


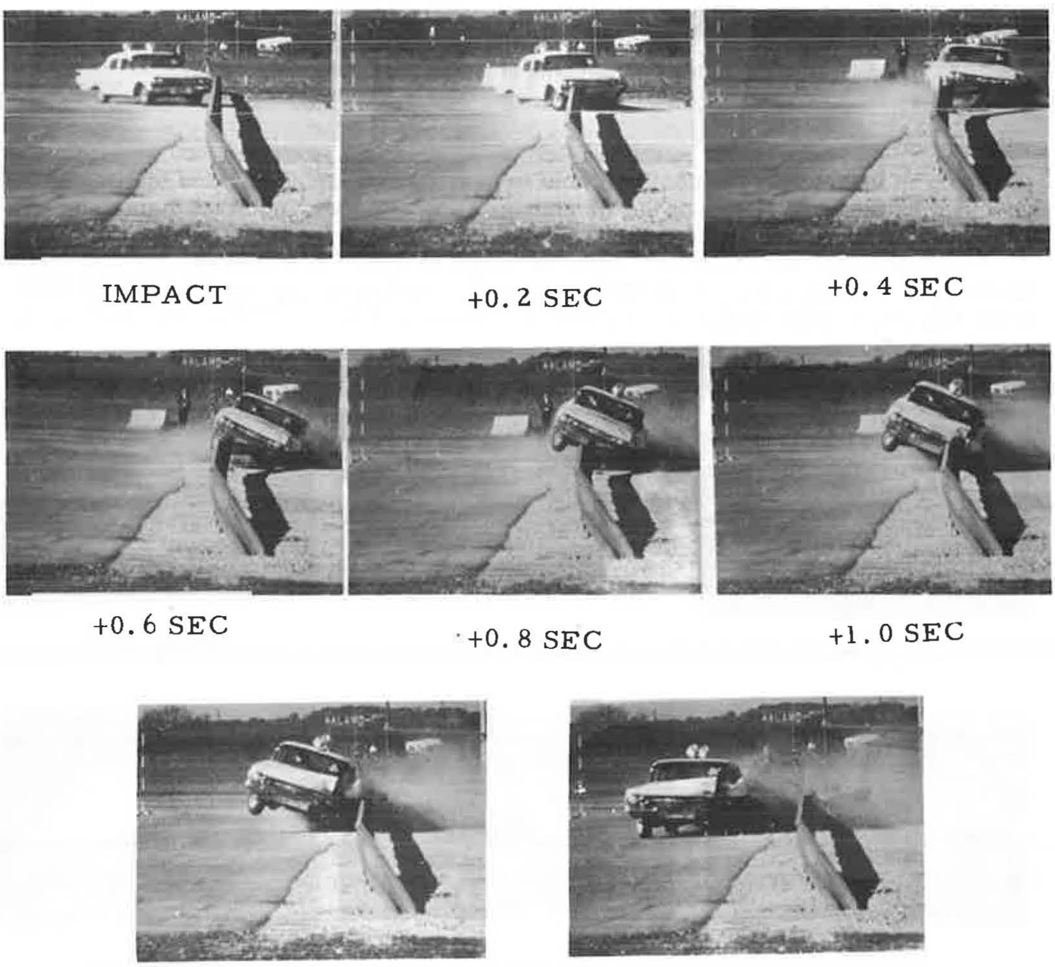
Figure 2. Sequence of events, test ODH-3.

celeration levels before rollover reached maximum values of -4 g laterally and -7.5 g longitudinally. Dummy accelerations reached maximum values of -11 g longitudinally, -8 g laterally, and -11 g vertically before rollover. Seat-belt and shoulder-harness loads reached maximum values of approximately 2,000 lb before rollover.

As indicated by the magnitude of the forces and accelerations measured prior to rollover, the 7-in. diameter posts were too formidable for the weak-post concept. Although the rollover was a clear indicator of system failure, other measured events before the rollover provided equally clear indications of the need for a weaker post. A positive result of this test was the success in achieving bolt shear in the impact area.

Test ODH-4

A 6-in. diameter post was selected for test ODH-4; all other details (including pipe inserts) were the same as for test ODH-3. The vehicle impacted the rail with a speed of 63.1 mph and an angle of 28.3 deg (Appendix, Figs. 14 and 15). The vehicle was contained and redirected by the system, but loss of rail height again occurred due to lack of bolt shear. As the rail dropped, the vehicle rolled about 15 deg but remained upright throughout; the vehicle did not straddle the rail (Fig. 3). Vehicle accelerations



IMPACT | +0.2 SEC | +0.4 SEC

+0.6 SEC | +0.8 SEC | +1.0 SEC

+1.2 SEC | +1.4 SEC

Figure 3. Sequence of events, test ODH-4.

reached maximum values of -3.8 g laterally and -3.1 g longitudinally. Maximum values of -5.0 g longitudinally, -10 g laterally, and -7 g vertically were recorded from the dummy response. Maximum seat-belt and shoulder-harness loads were 1,000 and 650 lb respectively. Failure to achieve rail separation from the posts in impact area through bolt shear was considered to be the principal cause of the rail drop.

Test ODH-5

A 1/4-in. diameter bolt was substituted for the previously used 5/16-in. diameter bolt. A close-fit pipe insert was selected for compatibility with the new bolt size. Because the 6-in. diameter posts from test ODH-4 were considered to be somewhat overstrength, a 6- by 6-in. post with 1/2-in. notches on upstream and downstream edges 2 in. above grade was selected. The vehicle impacted with a speed of 70.8 mph and an angle of 26.7 deg (Appendix, Figs. 16 and 17). Redirection of the vehicle was good, and the rail remained at an effective height throughout the test (Fig. 4). The elusive bolt shear phenomenon was attained; however, it was not confined to impact area, as all but one of the bolts sheared. Maximum vehicle accelerations were -4.6 g laterally and -3 g longitudinally. A maximum of 8.8 g laterally was recorded from the dummy; seat-belt and shoulder-harness loads reached maximum values of 1,000 and 800 lb respect respectively.

Although the test vehicle attained a speed well in excess of the desired test value, the system performed well under severe conditions. The notching of the posts had no effect on the performance, as all posts broke approximately 12 in. below ground level.

Test ODH-7

Based on the success of test ODH-5, 6- by 6-in. posts were installed as the weak-post system in line with the ODH strong-post system with a transition section between these two systems. Details of the installation are shown in the Appendix (Figs. 18 through 21). A change from test ODH-5 moved the 1/2-in. notches to grade level. The strong-post system as installed was composed of the 12-gage flexural beam mounted on 60 by 8-in. wood posts (6 ft 3 in. spacing) with a 5/8-in. diameter post bolt and a 6- by 8-in. wood offset block. The vehicle impacted the system with a speed of 58.2 mph and an angle of 26.3 deg approximately 48 ft upstream from the first 6- by 8-in. post. The vehicle was contained and exited at this first strong post. A tendency to

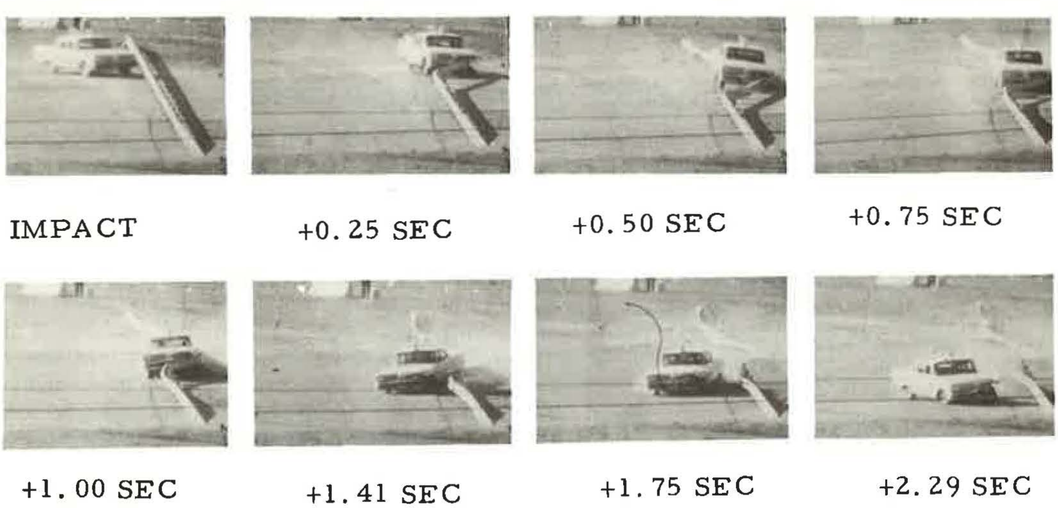


Figure 4. Sequence of events, test ODH-5.

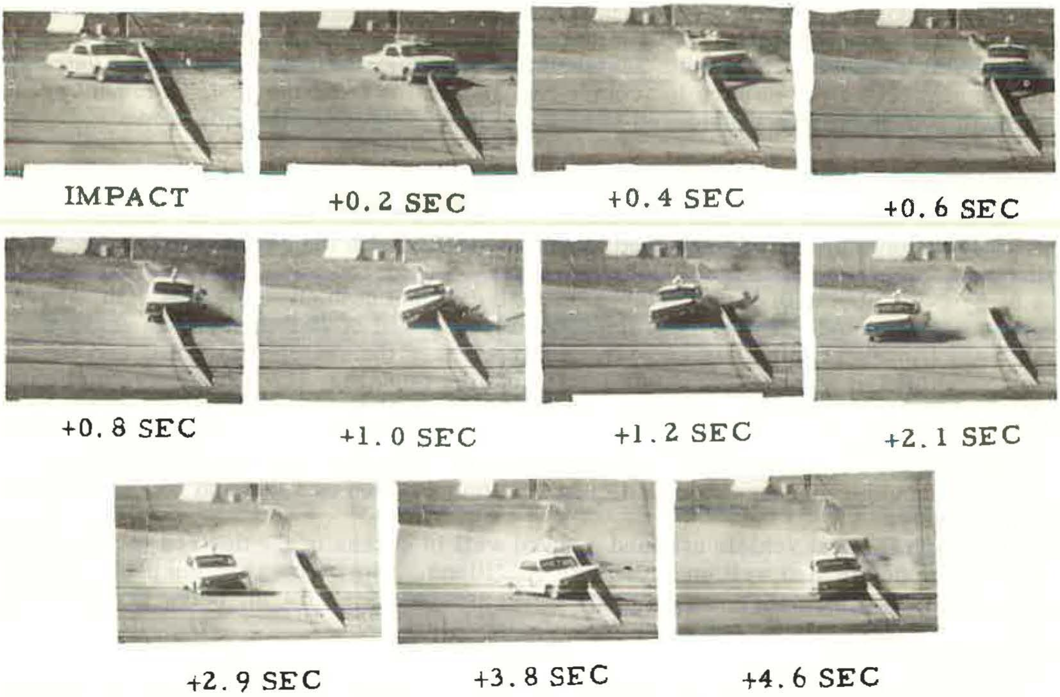


Figure 5. Sequence of events, test ODH-7.

pocket near this exit point was evident, but the vehicle ranged only about 14 ft off the rail line before the brakes were applied and a subsequent second impact with the rail system occurred (Fig. 5). Maximum vehicle accelerations from film data were -3.2 g laterally and -4.3 g longitudinally. Dummy accelerations reached maximum value of -3.0 g longitudinally, -7.5 g laterally, and -6.5 g vertically. A maximum of 1,200 lb was recorded from the right seat-belt load cell. The ¼-in. diameter bolt shear was again extensive and the effect of the notch was negated by post failure occurring below the notch line.

CONCLUSIONS AND RECOMMENDATIONS

Of the five general performance tests conducted during this test series, three installations performed successfully. After analyzing the events of test ODH-2, it could be surmised that, if the pipe insert or the ¼-in. diameter bolt or both had been used, the rail would have remained at effective height and thus prevented the vehicle from straddling the rail. The loss of rail height that occurred during test ODH-4 could possibly have been prevented through the use of ¼-in. diameter bolts or perhaps a closer fitting insert for the 5/16-in. diameter bolt. The performance of the test ODH-5 installation was good, although the extensive bolt shear and subsequent loss of rail support after impact could prove to be a maintenance problem. The other two test installations (tests ODH-1 and ODH-3) must be considered as unsatisfactory because of overall performance. The transition test (test ODH-7) is considered to be a technical success, although the tendency to pocket at the exit point should indicate that improvements are necessary.

Vehicle accelerations presented in this report can be compared to permissible vehicle accelerations that have been suggested to be within the limits of human tolerance (3). As given in Table 2, such vehicle accelerations are classified according to direction and degree of occupant restraint and are based on a duration not to exceed 0.2 sec,

TABLE 2

MAXIMUM AVERAGE VEHICLE ACCELERATIONS FOR HUMAN TOLERANCE

Restraint	Maximum Average Acceleration (g)		
	Lateral	Longitudinal	Total
Unrestrained occupant	3	5	6
Occupant restrained by seat belt	5	10	12
Occupant restrained by seat belt and shoulder harness	15	25	25

Note: Maximum average accelerations are for 200 millisecond duration.

TABLE 3

SUMMARY OF MAXIMUM AVERAGE VEHICLE ACCELERATION

Test No.	Maximum Average Acceleration (g)[a]	
	Lateral	Longitudinal
ODH-2	-2.6	-1.2
ODH-3	-3.5[b]	-5.1[b]
ODH-4	-3.4	-2.6
ODH-5	-3.9	-2.2
ODH-7	-2.9	-3.6

Note: Maximum average accelerations are for 200 millisecond duration.
[a]As measured by high-speed film analysis.
[b]Maximum average values prior to rollover.

with rate of onset not to exceed 500 g/sec. Note that the vehicle occupants are more vulnerable to lateral accelerations regardless of restraint. A summary of the maximum average acceleration values for each test is given in Table 3; it is clear that passenger restraint would be required for all tests of this series except tests ODH-2 and ODH-7, according to the criteria in Table 2.

Because all of the installations in this test series were constructed with pine posts, different post sizes would be required using other timber materials such as oak or hickory. The optimum post size for the weak-post concept indicated by the test results appears to be a 6- by 5-in. sawed rectangular post and a 5½-in. diameter round post of southern yellow pine. In all tests in this series, post strength was developed

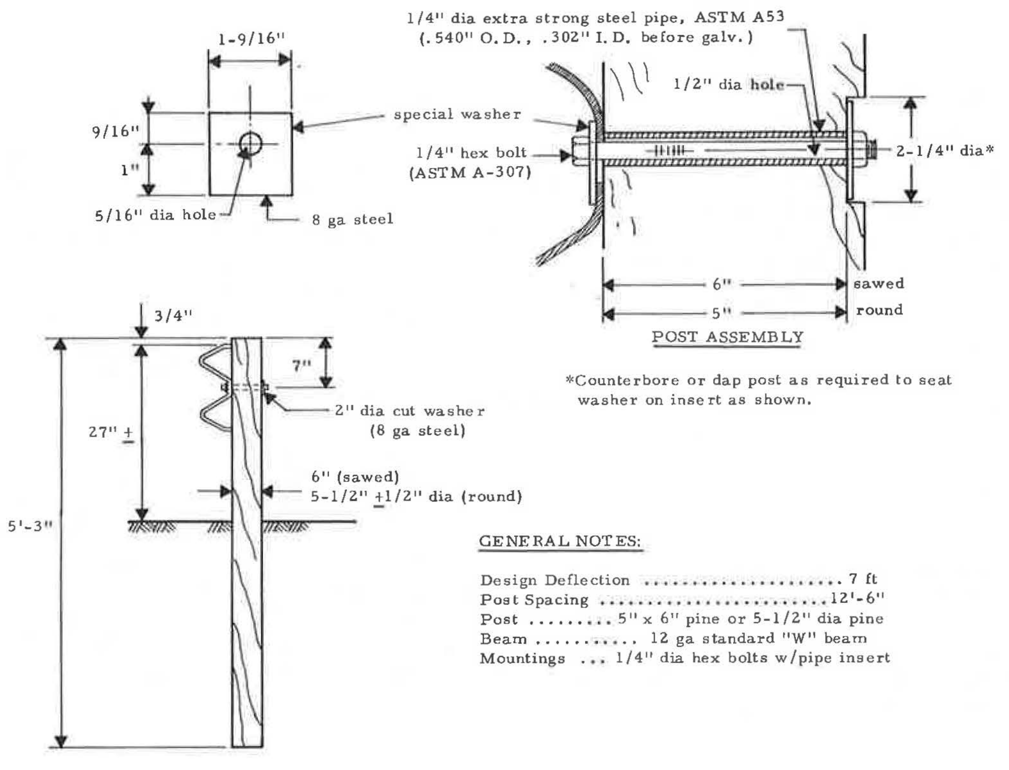


Figure 6. Timber post design for Ohio type 7 guardrail.

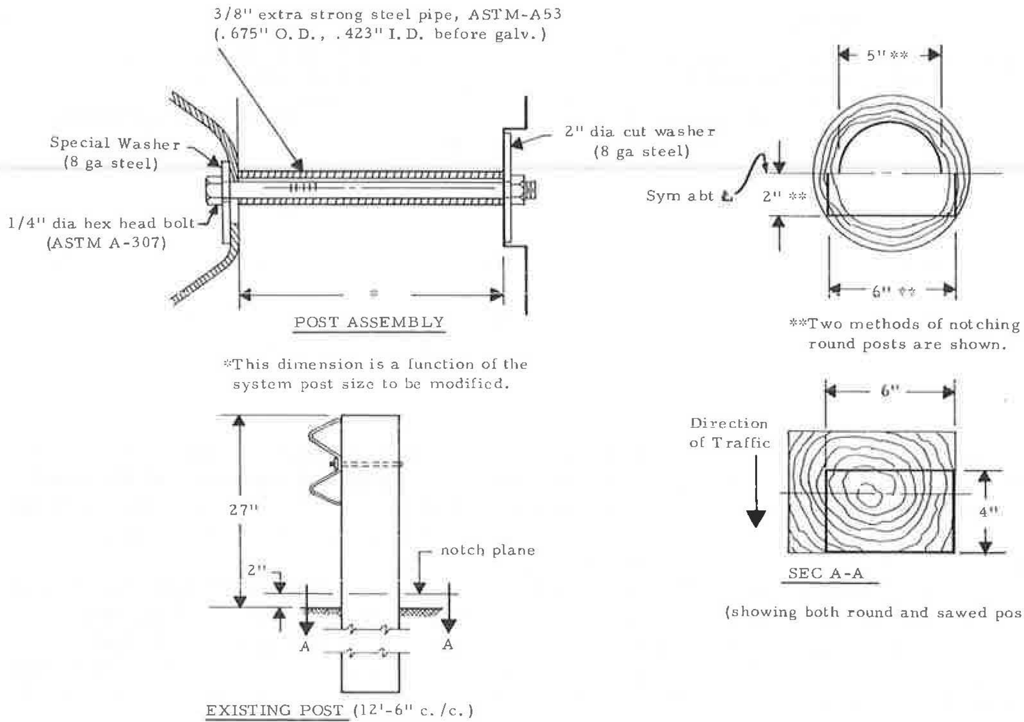


Figure 7. Recommended modification of existing strong-post systems.

by the soil; substitution of a smaller post of a stronger material than pine should be verified by test. The ODH standard washer with the offset hole proved to be of sound design. By offsetting the hole, bending of the bolt at the head during bolt tightening is eliminated. This bending normally occurs with the G2 standard washer, which has the hole in the center of the washer.

Because of problems of achieving bolt shear during this test series, a $\frac{1}{4}$-in. diameter bolt was substituted for the $\frac{5}{16}$-in. diameter bolt initially tested. As stated previously, this $\frac{1}{4}$-in. diameter bolt could prove to be a maintenance problem of some proportion. The insert selected for the $\frac{1}{4}$-in. diameter bolt provided an extremely close fit, while the insert used with the $\frac{5}{16}$-in. diameter bolt provided a comparatively loose fit. Should maintenance prove to be a problem with the $\frac{1}{4}$-in. diameter bolt, inserts with different inside diameters might be a solution with either the $\frac{1}{4}$-in. or the $\frac{5}{16}$-in. diameter bolts.

Recent experience in New York has prompted this developer of the G2 system to raise the top of rail height to 33 in. Because the Ohio Department of Highways desires not only to modify its existing strong-post systems (timber posts spaced at 12.5-ft centers with top of rail 27 in. above grade) but also to formulate new standards, consideration of raising the rail height for new installations would be in order.

Design information for the suggested timber-post-system designs for ODH type 7 guardrail is shown in Figure 6. For the existing timber strong-post installations, notches cut near grade should be of sufficient depth to provide a net section of 6 by 4 in. with the 6-in. dimension normal to the roadway. As shown in Figure 7, these notches should be located 2 in. above grade.

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2. Michie, J. D., and Calcote, L. R. Location, Selection, and Maintenance of Highway Guardrails and Median Barriers. NCHRP Rept. 54, 1968.
3. Shoemaker, N. W., and Radt, H. S. Summary Report of Highway Barrier Analysis and Test Program. Cornell Aeronautical Laboratory, Inc., Rept. VJ-1472-V-3, July 1961.

Appendix

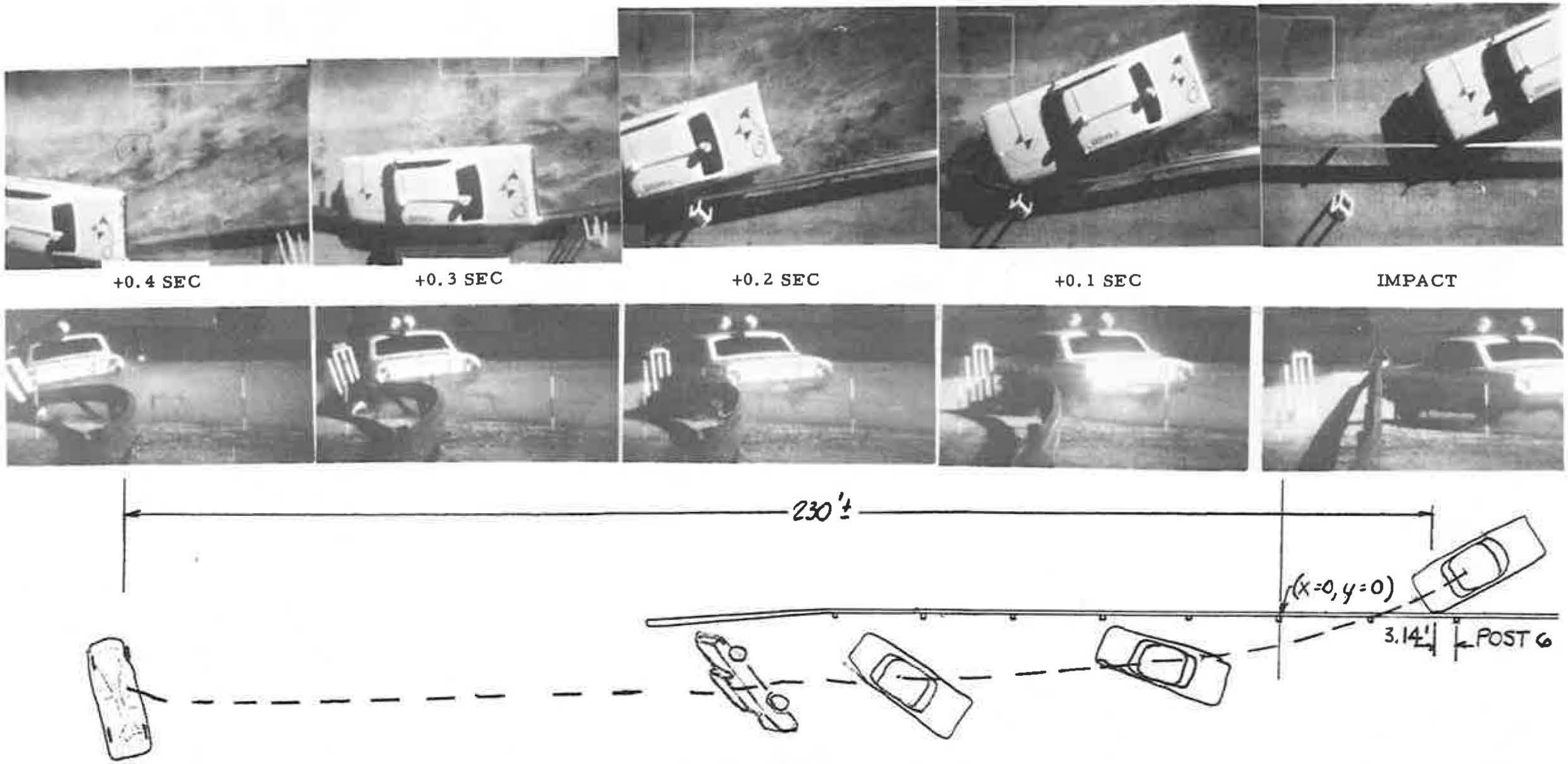
DETAILS OF INDIVIDUAL TESTS

The following figures contain pertinent data and photographs of the impact tests discussed in this report.

(a) Looking downstream (see insert for before test photograph)

(b) Impact area

Figure 8. Photographs of test ODH-1.



Beam Rail .... 12 ga Galv Steel x 12'-6"	Test No. ODH-1
Post .... 4"x4"x5'-3"SY Pine	Date 11/12/69
Post Bolt .... 5/16 w/std ODH washer	Vehicle .... 1964 Ford Sedan
Post Embedment .... 35"	Vehicle Weight .... 4589 lb (w/dummy & instrumentation)
Post Spacing .... 12'-6"	Impact Speed .... 67 mph
Height of Rail Above Grade .... 27"	Impact Angle .... 25°
Length of Installation .... 202'	Exit Angle ... Vehicle rolled 3-1/2 times
Ground Condition .... Damp	Dummy Restraint ...... Lap Belt and Shoulder Strap
Beam Rail Deflection - Max Permanent . .10'	
Beam Rail Deflection - Max Dynamic ... 13'+	

Figure 9. Summary of results, test ODH-1.

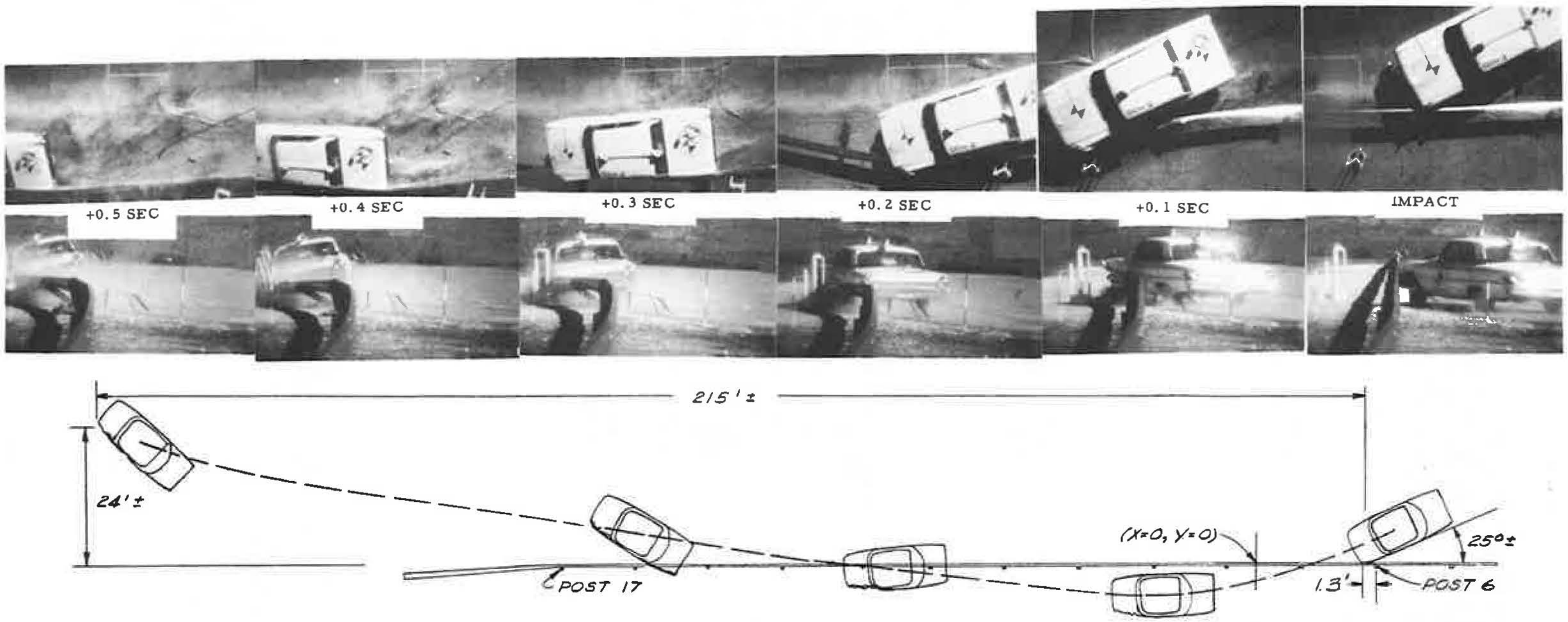
(a) View from vehicle approach before test

(b) Typical post

(c) Looking downstream after test

(d) View from vehicle approach after test

Figure 10. Scenes from test ODH-2.



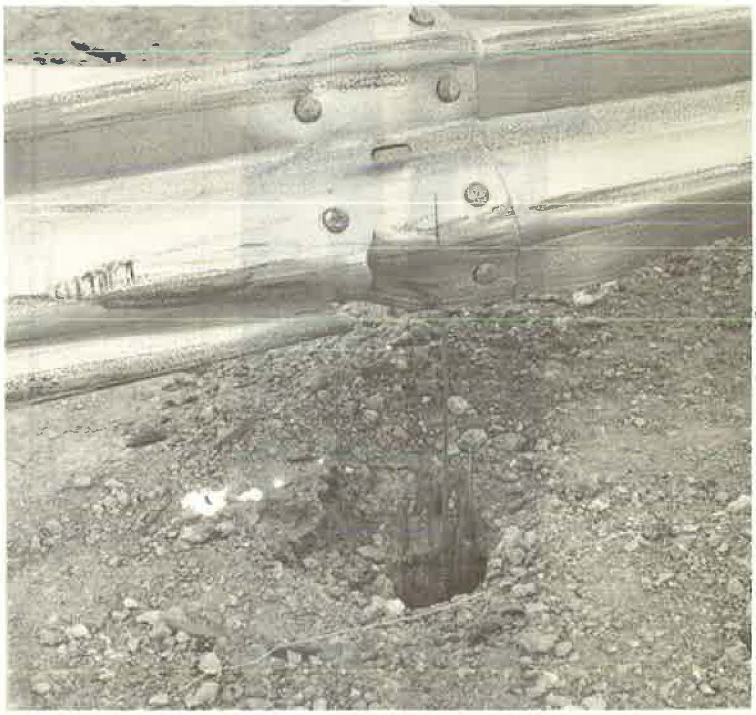
Beam Rail	12 ga Galv Steel x 12'-6"
Post	4"x6"x5'-3" SY Pine
Post Bolt	5/16 w/std ODH washer
Post Embedment	35"
Post Spacing	12'-6"
Height of Rail Above Grade	27"
Length of Installation	250'
Ground Condition	Dry
Beam Rail Deflection - Max Permanent	5.7'
Beam Rail Deflection - Max Dynamic	6.9'

Test No.	ODH-2
Date	11/20/69
Vehicle	1963 Ford Sedan
Vehicle Weight (w/dummy & instrumentation)	4404 lb
Impact Speed	62 mph
Impact Angle	25.3°
Exit Angle	-8°
Dummy Restraint	Lap Belt and Shoulder Strap

Figure 11. Summary of results, test ODH-2.

(a) View from vehicle approach

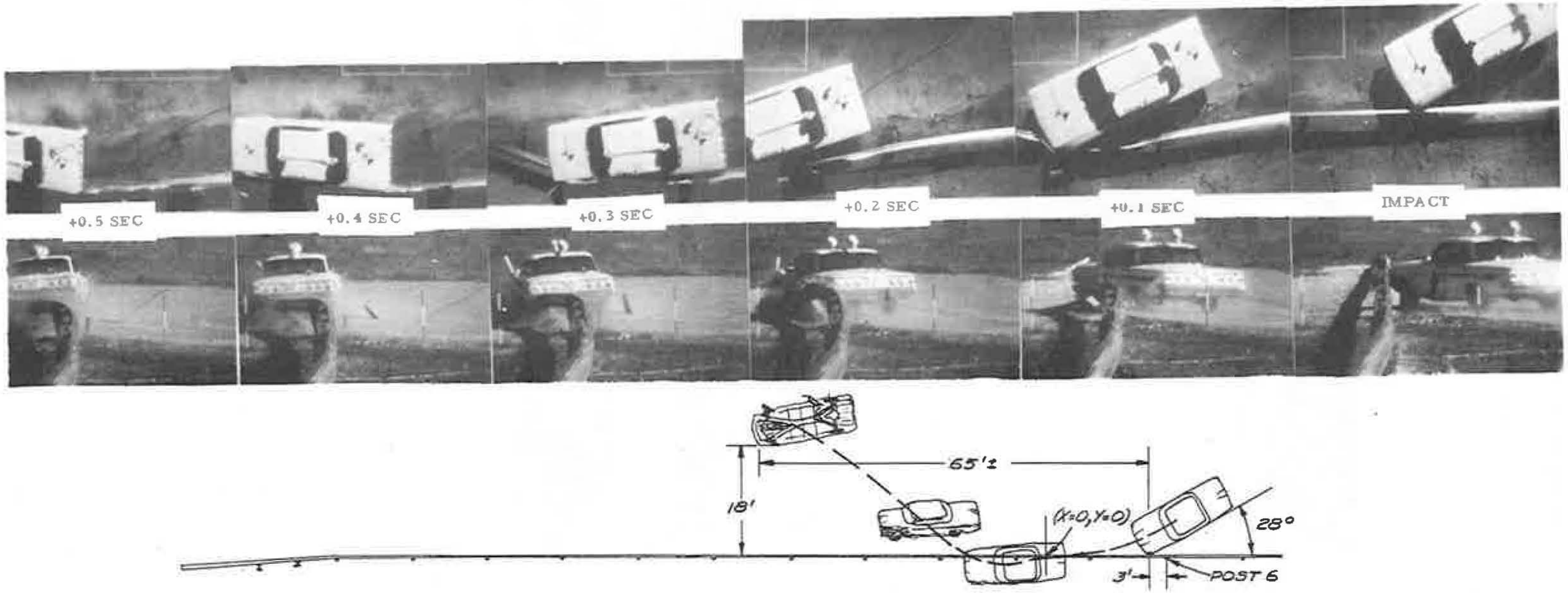
(b) Post detail



(c) Typical post failure (note tear in rail section)

(d) View from vehicle approach

Figure 12. Scenes from test ODH-3.



Beam Rail .... 12 ga Galv Steel x 12'-6"	Test No. ODH-3
Post .... 7" dia x 5'-3" SY Pine	Date 11/24/69
Post Bolt .. 5/16" dia w/ODH std washer and pipe insert	Vehicle .... 1961 Chevrolet Sedan
Post Embedment .... 35"	Vehicle Weight .... 4445 lb (w/dummy & instrumentation)
Post Spacing .... 12'-6"	Impact Speed .... 62.5 mph
Height of Rail Above Grade .... 27"	Impact Angle .... 28.7°
Length of Installation .... 250'	Exit Angle .... Vehicle rolled over
Ground Condition .... Dry	Dummy Restraint .... Lap Belt and Shoulder Strap
Beam Rail Deflection - Max Permanent .. 2.2'	
Beam Rail Deflection - Max Dynamic .. 4.3'	

Figure 13. Summary of results, test ODH-3.

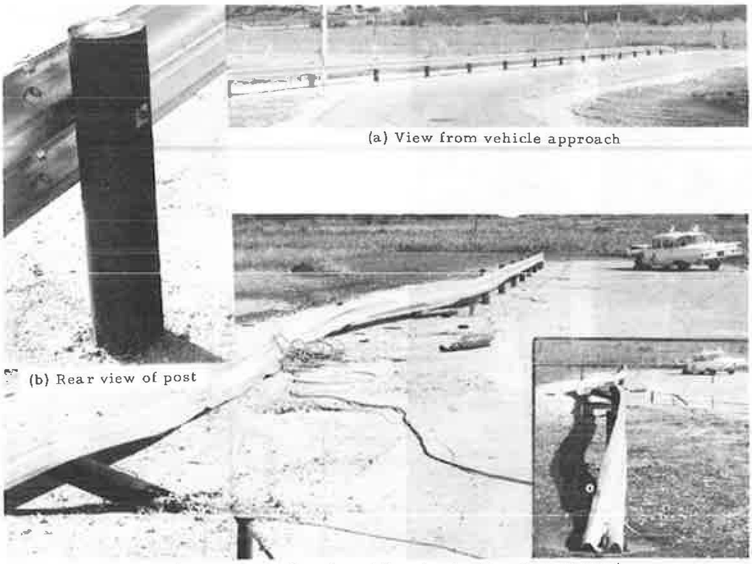
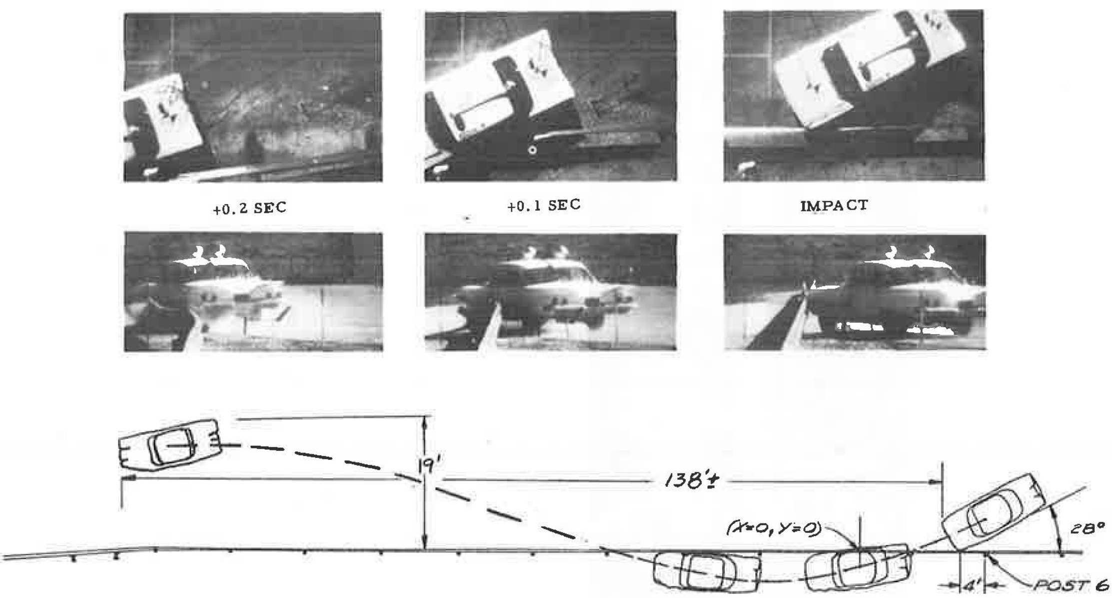


Figure 14. Scenes from test ODH-4.



Beam Rail	12 ga Galv Steel x 12'-6"
Post	6" dia x 5'-3" SY Pine
Post Bolt	5/16" dia w/ODH std washer & pipe insert
Post Embedment	35"
Post Spacing	12'-6"
Height of Rail Above Grade	27"
Length of Installation	250'
Ground Condition	Damp
Beam Rail Deflection - Max Permanent	5.2'
Beam Rail Deflection - Max Dynamic	6.5'

Test No.	ODH-4
Date	12/10/69
Vehicle	1960 Chevrolet
Vehicle Weight (w/dummy & instrumentation)	4242 lb
Impact Speed	63.1 mph
Impact Angle	28.3°
Exit Angle	-18°
Dummy Restraint	Lap Belt and Shoulder Strap

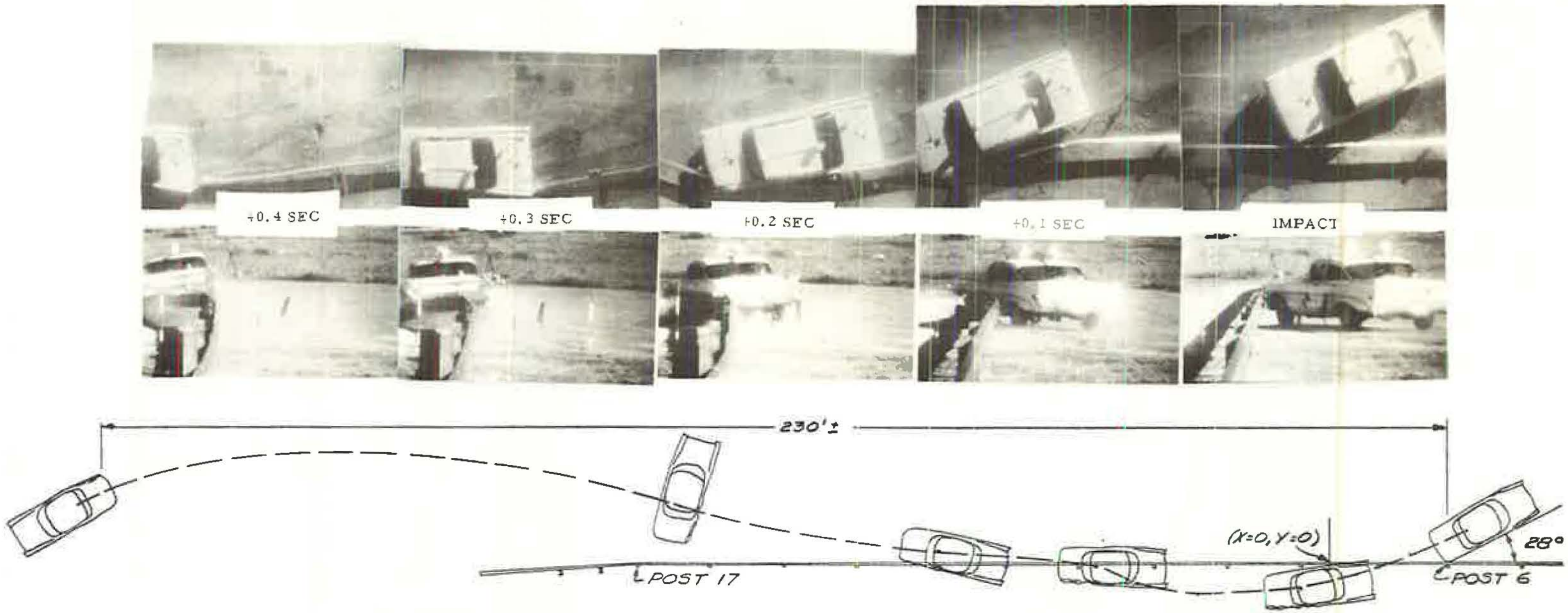
Figure 15. Summary of results, test ODH-4.

(a) View from vehicle approach

(b) Front view of post

(c) View from vehicle approach (see insert for overall view from upstream)

Figure 16. Scenes from test ODH-5.

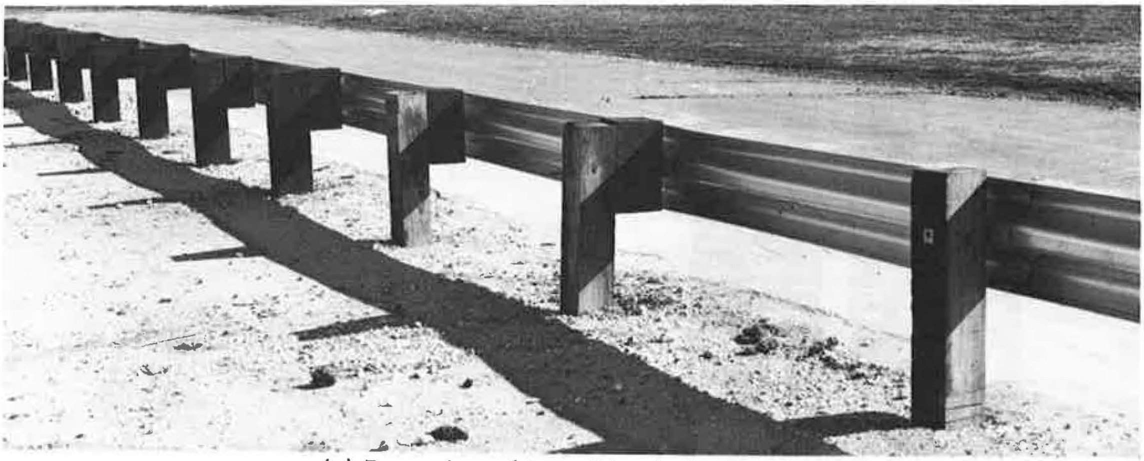


Beam Rail	12 ga Galv Steel x 12'-6"
Post	6"x6"x5'-3" SY Pine *
Post Bolt	1/4" dia w/ODH std washer & pipe insert
Post Embedment	35"
Post Spacing	12'-6"
Height of Rail Above Grade	27"
Length of Installation	250'
Ground Condition	Dry
Beam Rail Deflection - Max Permanent	2.9'
Beam Rail Deflection - Max Dynamic	7.2'

Test No.	ODH-5
Date	12/16/69
Vehicle	1959 Pontiac Sedan
Vehicle Weight (w/dummy & instrumentation)	4407 lb
Impact Speed	70.8 mph
Impact Angle	26.7°
Exit Angle	-7°
Dummy Restraint	Lap Belt and Shoulder Strap

*See installation drawing for notch details.

Figure 17. Summary of results, test ODH-5.



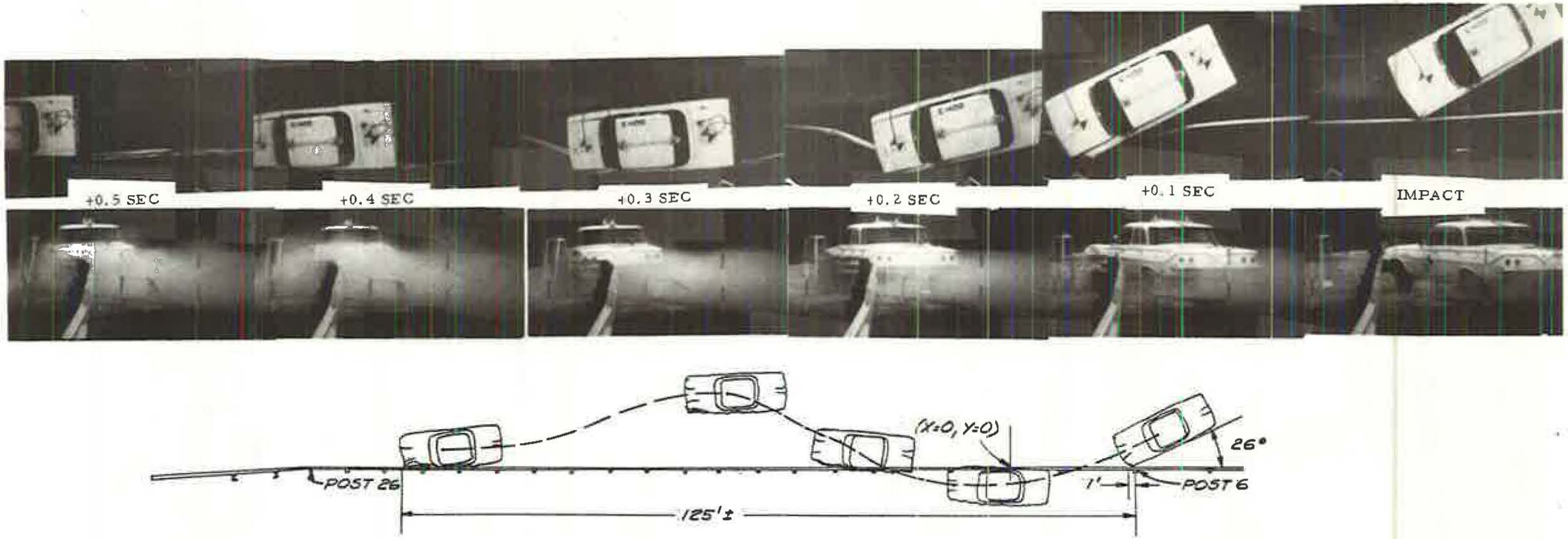
(a) Rear view of transition before test

(b) View from vehicle approach before test

(c) View from vehicle approach after test

(d) View from behind rail after test

Figure 18. Scenes from test ODH-7.



Beam Rail .... 12 ga Galv Steel x 12'-6"
Post .... See installation drawing
Post Bolt .... See installation drawing
Post Embedment .... 35"
Post Spacing .... 12'-6"
Height of Rail Above Grade .... 27"
Length of Installation .... 250'
Ground Condition .... Damp
Beam Rail Deflection - Max Permanent .. 2.7'
Beam Rail Deflection - Max Dynamic ... 6.8'

Test No. ODH-7
Date 1/12/70
Vehicle .... 1961 Chevrolet
Vehicle Weight .... 4292 lb
(w/dummy & instrumentation)
Impact Speed .... 58.2 mph
Impact Angle .... 26.3°
Exit Angle .... -25°
Dummy Restraint .... Lap Belt and Shoulder Strap

Figure 19. Summary of results, test ODH-7.

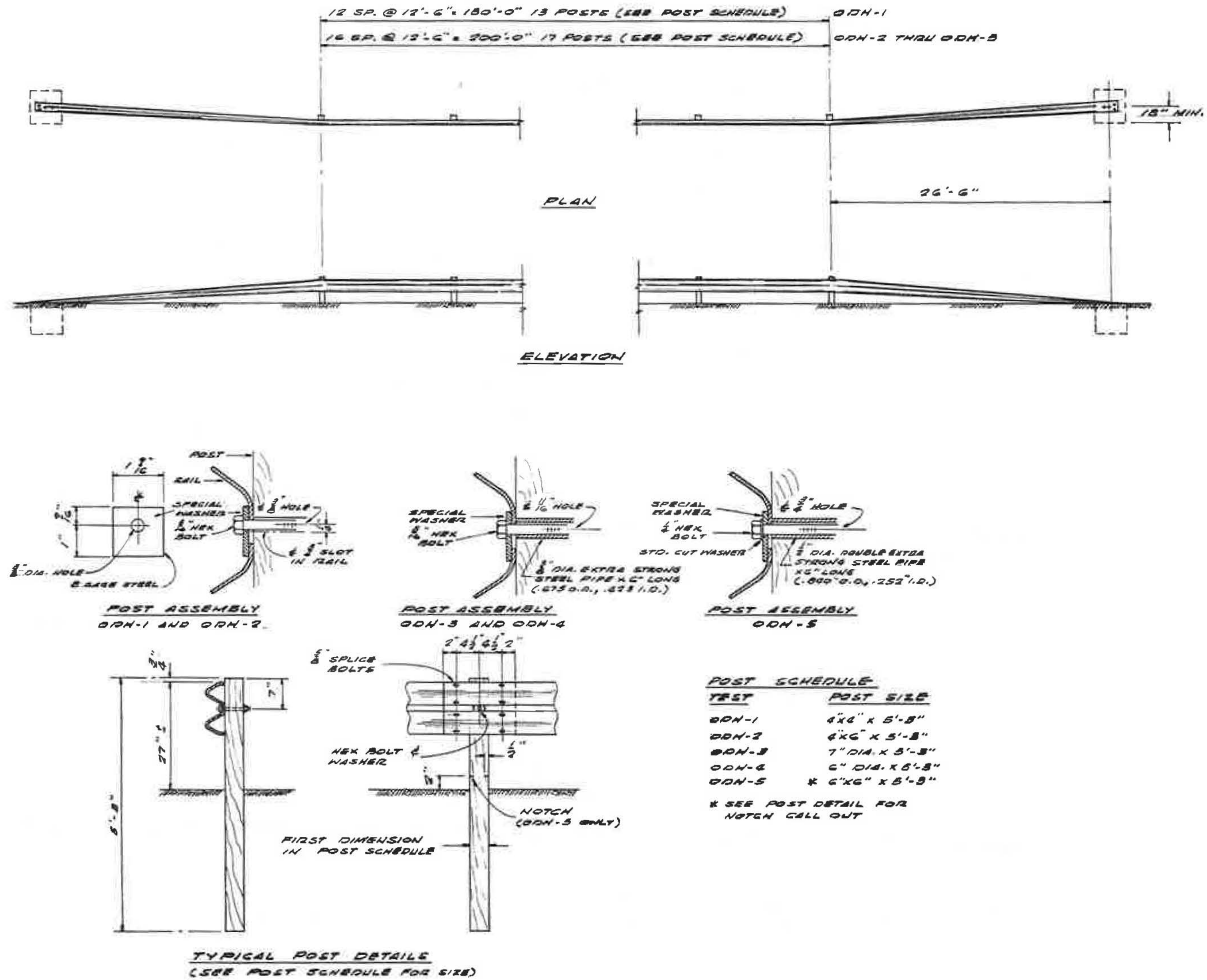


Figure 20. Installation drawing 1.

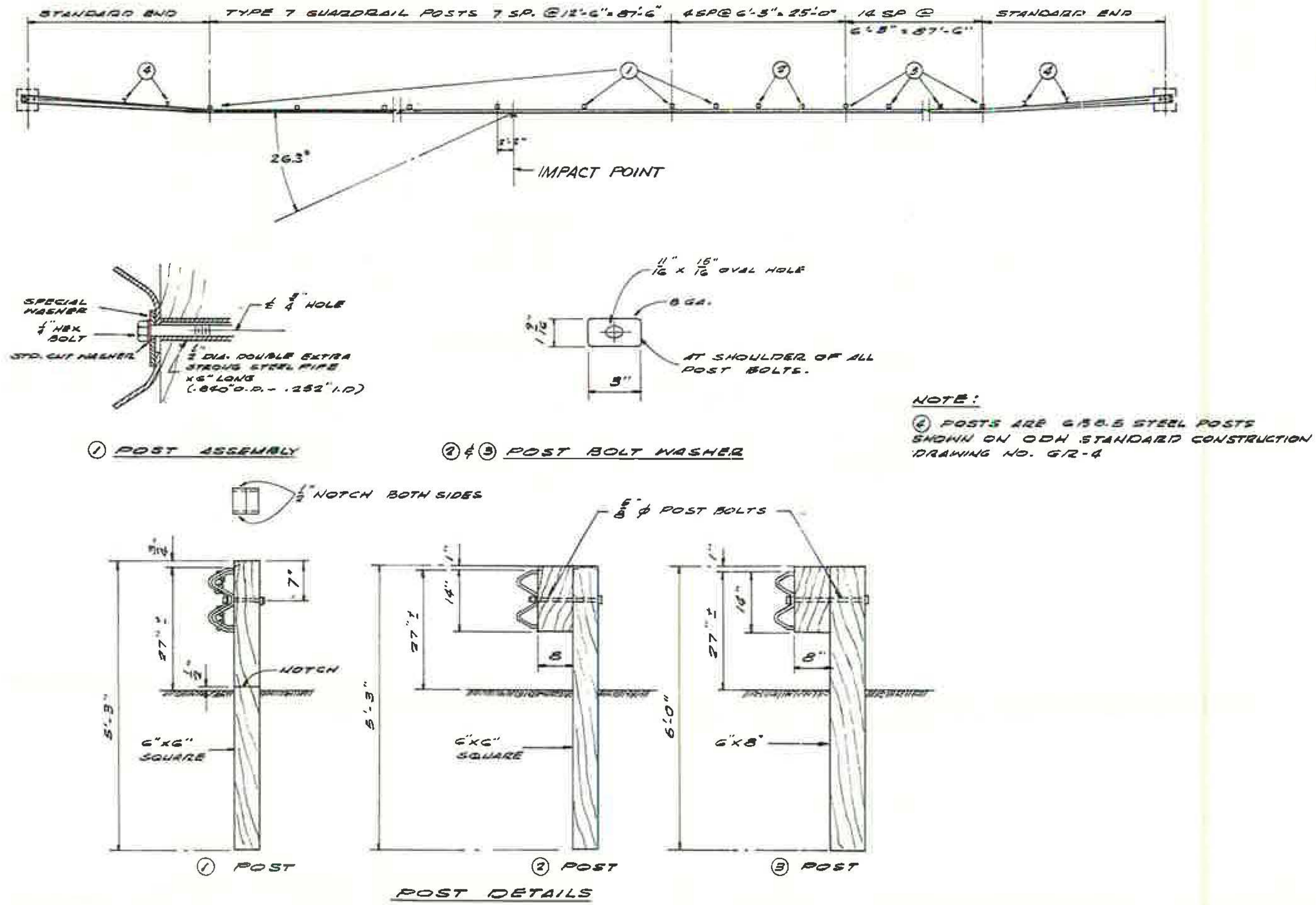


Figure 21. Installation drawing 2.