Abridgment

Impact Performance of the Minnesota 1.5-m-Radius Plate Beam Guardrail

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The Minnesota Department of Transportation employs a 1.5-m-radius (5-ft-radius) plate beam end treatment for median rails at twin bridges and piers or divided roadways. The crashworthiness of this end treatment was evaluated in a program that included two full-scale vehicle crash tests. A small-size and a full-size test vehicle were towed head-on into the median rail system at 96.6 km/h (60 mph). Performance of the system was excellent in both tests.

DESCRIPTION OF GUARDRAIL

The hardware components and geometrics of the end treatment are described in Minnesota Department of Transportation standard drawings. The department uses 15.2 × 20.3 × 183-cm (6 × 8 × 72-in) wooden posts spaced 1.9 m (6 ft, 3 in) apart. In the test installation, which is shown in Figure 1, the posts were set approximately 114 cm (45 in) in oversized holes backfilled with lean concrete to simulate frozen ground conditions. Standard 12-gauge plate beam was used for the rail. Two 56-cm-diameter (22-in-diameter) concrete posts (simulated piers) were placed 10.7 m (35 ft) behind the nose of the guardrail.

DESCRIPTION AND RESULTS OF TESTS

Test B1

A 1971 Chevrolet Vega weighing 1039 kg (2290 lb) impacted the guardrail head-on at 99 km/h (61.5 mph) (Figure 2). On impact, the foremost post failed at ground level. As the vehicle advanced into the attenuator, the guardrail buckled and wrapped around the front of the vehicle, and posts on each side of the installation were successively broken at ground level. Significant yaw displacement of the vehicle occurred, but pitching and rolling motions were negligible. After failure of five wooden posts and partial failure of four others, the vehicle came to rest with a yaw angle of 33 deg. The vehicle center of mass penetrated 7.1 m (23.2 ft) into the barrier.

The average deceleration of the test vehicle computed from the impact velocity and the stopping distance of the vehicle center of gravity was 5.3 *g* (1). The highest average deceleration determined over a 200-ms interval was 6.1 *g*, and over 50 ms was 9.1 *g*.

The vehicle received moderate damage in the form of distortion of front frame members and considerable sheet metal deformation. Based on the TAD scale (2), the vehicle damage rating was FD-5. The Society of Automotive Engineers (SAE) collision deformation classification was 12FDEW3 (3).

Test B2

A 1969 Chrysler weighing 2041 kg (4500 lb) impacted the guardrail head-on at 100.26 km/h (62.3 mph) (Figure 3). On impact, the foremost post was broken, and the vehicle began to yaw counterclockwise as it advanced. The rail wrapped around the vehicle, and posts on each side of the installation were successively broken as the vehicle advanced. In the final stages of the collision, the rearward force on the steel guardrail caused the remaining three posts supporting the left side to split, and the guardrail fell to the ground. The test vehicle continued to advance

Figure 1. Installation at test site.

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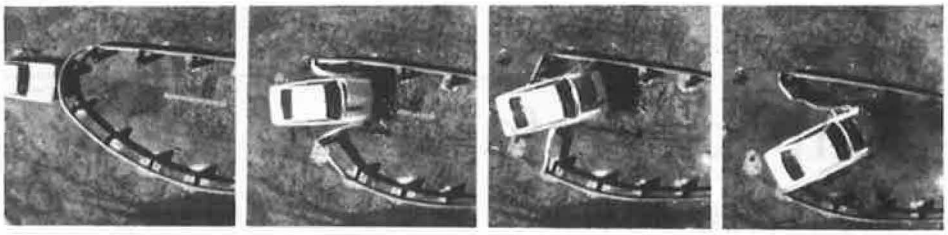
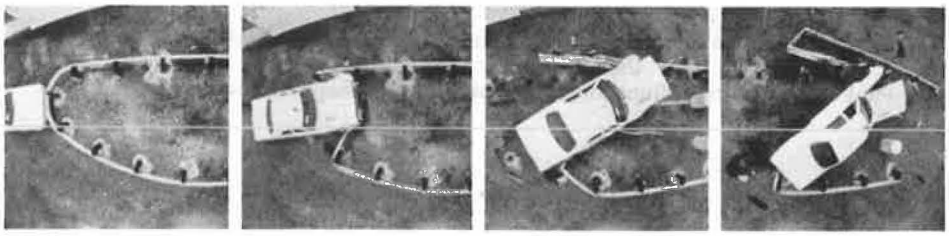
Figure 2. Test B1.



t = 0 ms t = 274 ms t = 370 ms t = 959 ms

Figure 3. Test B2.



t = 0 ms t = 147 ms t = 441 ms t = 1029 ms

and yaw counterclockwise until the right front corner impacted one of the simulated concrete piers. During contact with the pier, the vehicle roll displacement reached about 45 deg. The vehicle rebounded approximately 0.61 m (2 ft) and came to rest with a yaw angle of 43 deg. The vehicle center of mass penetrated 11.83 m (38.8 ft) during impact.

Average deceleration of the vehicle computed from the impact speed and stopping distance was 3.8 *g*, which is well below the acceptable limit. The highest average longitudinal deceleration over a 200-ms interval, obtained from the accelerometer traces, was 3.4 *g*; the highest over 50 ms was 4.7 *g*.

At the time of impact with the simulated pier, the forward velocity of the vehicle had been reduced to such a level that the impact was entirely acceptable. Damage to the front of the vehicle consisted of severely deformed sheet metal and somewhat distorted front frame members. Damage to the right rear consisted of minor dents in the sheet metal. The vehicle damage rating was FD-5 and RBQ-3 (2), and the SAE collision deformation classification was 12FDEW1 (3).

CONCLUSIONS

The Minnesota 1.5-m-radius (5-ft-radius) plate beam guardrail performed satisfactorily under full-scale 96.6-km/h (60-mph), head-on impacts with 1039-kg (2290-lb) and 2041-kg (4500-lb) vehicles. The values of average deceleration are well below the Federal Highway Administration design criteria of 12 *g* (4) for vehicles within the weight category tested. Accelerometer data for test B1 indicate that vehicle occupants may have received some minor injuries, but accelerometer data from test B2 place the occupants in the zone of safety (5).

The passenger compartments of the test vehicles remained intact and were not penetrated by any foreign objects.

Significant but acceptable transverse accelerations were imposed on the test vehicles as a result of the yaw displacement during impact.

The system, as constructed and tested, performs adequately when struck head-on by both large and small automobiles. The W-section experienced severe local damage in each case. Although tensile load in this element was not measured, vehicle condition after impact indicated that it was loaded near ultimate capacity and that not much reserve strength existed, especially in test B2.

REFERENCES

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