TRUCK TESTS ON TEXAS CONCRETE MEDIAN BARRIER

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The Texas concrete median barrier, with inclined surfaces, satisfactorily restrained and redirected a large 48,800-lb tractor-trailer truck with load under the full-scale impact test conditions of 35 mph at a 19-deg angle, 34 mph at a 16-deg angle, and 45 mph at a 15-deg angle. The truck was remotely controlled from a chase pickup vehicle. There was damage to the sheet metal of the front fender and running board of the tractor. Estimated repair cost was less than $200. Maintenance of the barrier would require, at most, a light sandblasting job to remove the unsightly tire scrub markings. The small amount of concrete spalling that occurred in the immediate area of impact would require no maintenance. The fence and light pole on top of the barrier were not damaged.

• RECENT accident information compiled by the Texas Highway Department and reported by Olson (1) shows that the number of trucks involved in traffic barrier fatal accidents has increased from 16 to 21 percent over a period of approximately 2 years. These accident figures include single-unit trucks, combination tractor-trailer trucks, and pickup trucks. Highway engineers are, therefore, very much concerned over the inadequate height and strength of many current types of traffic barriers.

The massive concrete traffic barrier, with a lower inclined surface of about 55 deg, has proved to be under test and field conditions an effective design in restraining and redirecting automobiles. Tests conducted by Lundstrom (2) have further demonstrated that the concrete barrier performed satisfactorily in restraining and redirecting a single-unit 16,000-lb truck, with load, under the impact conditions of 37 mph and 13 deg.

The promising medium-sized truck test results of Lundstrom (2) on the concrete barrier were instrumental in the development of additional research. The objective of this research project was to tentatively determine, based on a limited number of full-scale tests, the capability of the Texas concrete median barrier to restrain and redirect a large-sized tractor-trailer truck under typical highway encroachment conditions.

DESCRIPTIONS AND PROCEDURES FOR TESTS

Median Barrier

The median barrier used in the full-scale truck tests was the rigid Texas concrete median barrier, designated as CMB-70. Earlier tests conducted by Hirsch (3) demonstrated that the Texas CMB remained intact in restraining and redirecting a standard-sized 4,000-lb passenger vehicle under the severe impact conditions of 60 mph and 25 deg.

The CMB, shown in Figure 1, has a weight of 507 lb/lin ft, a height of 32 in. above the roadway, a lower 10-in. high inclined surface of 55 deg, a base width of 27 in., and a top width of 8 in.

The CMB was constructed in two continuous length sections of 50 and 150 ft as shown in Figure 1. The construction joint between the two sections offers no lateral restraint. The light pole was mounted on top of the shorter 50-ft section. Three 18-in. diameter drilled concrete shafts were used to support the shorter 50-ft section against possible overturning due to wind and vibratory forces on the light pole. The longer 150-ft section, on which the truck tests were conducted, contains no mechanical anchors

to the roadway. The 1-in. layer of hot-mix asphalt at the base of the CMB was used to provide some restraint to sliding during a vehicle collision. Details of the chain-link fence and light pole were discussed by Hirsch (3).

Test Vehicle

The test vehicle used in the full-scale tests was a large-sized tractor-trailer truck weighing 48,800 lb with load. The truck in a loaded condition prior to the tests is shown in Figure 2. Pertinent data of the truck are shown in Figure 3.

The truck trailer was loaded with concrete blocks weighing 22,800 lb. The arrangement of the concrete blocks is shown in Figure 2c and Figure 3. The blocks were stacked to an average height of about 24 in. over a distance of about two-thirds the length of the trailer.

The wheel loads and height measurements of the truck before and after loading are shown in Figure 3. The lumped center-of-mass of the loaded trailer body (excluding the rear tandem wheel assemblies) is located at a height slightly above the top of the concrete blocks and at a height of 6.0 ft above the level roadway, and the location of the lumped center-of-mass of the tractor is approximately 2.6 ft above the roadway.

Truck Control Apparatus

A 5-channel radio remote system was used to control the truck from a chase pickup vehicle. The truck control apparatus consisted of on-off steer control (hydraulic), on-off clutch control (pneumatic), on-off trailer brake control (pneumatic), and on-off accelerator pedal control (pneumatic).

The on-off steer control apparatus consisted of a 4-way hydraulic solenoid valve and a double-acting hydraulic cylinder coupled between the front axle and the tie rod of the truck. A pump, driven by the truck engine, was used as the hydraulic power source. The 4-way hydraulic solenoid valve unit, mounted in the toolbox of the truck, is shown in Figure 4a.

The on-off clutch and accelerator pedal truck controls both had a 3-way pneumatic valve and a single-acting pneumatic cylinder. The truck air compressor was used as the pneumatic power source. The single-acting pneumatic cylinders, mounted on the clutch and accelerator pedal, are shown in Figure 4.

The on-off brake control consisted of a 3-way pneumatic valve spliced into the brake air lines of the truck trailer. The brakes on the truck tractor were not used to minimize the possibilities of jackknifing.

The test truck was started from a rest position by a pushing second vehicle. In the rest position, the truck was in gear with its engine running and its clutch disengaged by the pneumatic control cylinder. After reaching a sufficient speed, the pushing vehicle reduced its speed and turned away. The clutch of the test truck was then engaged, and the truck proceeded on toward the barrier under power and under the control of the chase pickup vehicle.

The angle of steer and the accelerator pedal truck controls were held fixed in position subsequent to the instant of barrier contact. The brakes of the truck trailer were applied after the truck was clear of the 200-ft long barrier test section.

Truck Instrumentation

An Impact-O-Graph was used to record the longitudinal, lateral, and vertical acceleration components of the truck tractor compartment at a location on the floor and directly under the passenger seat. The Impact-O-Graph was remotely turned on from the chase pickup vehicle just prior to impact with the CMB.

DISCUSSION AND EVALUATION OF TESTS

Barrier Performance

Three full-scale angle collision truck tests, designated as CMB-5, CMB-6, and CMB-7, were conducted on the Texas CMB. The CMB, subjected to the impact conditions measured below, performed satisfactorily in restraining and redirecting the loaded 48,800-lb

Figure 1. Texas concrete median barrier (CMB-70).

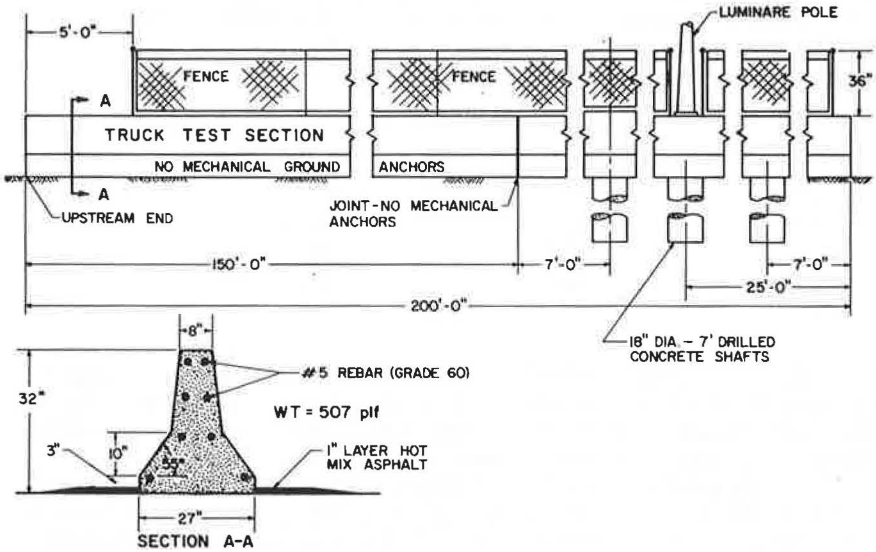
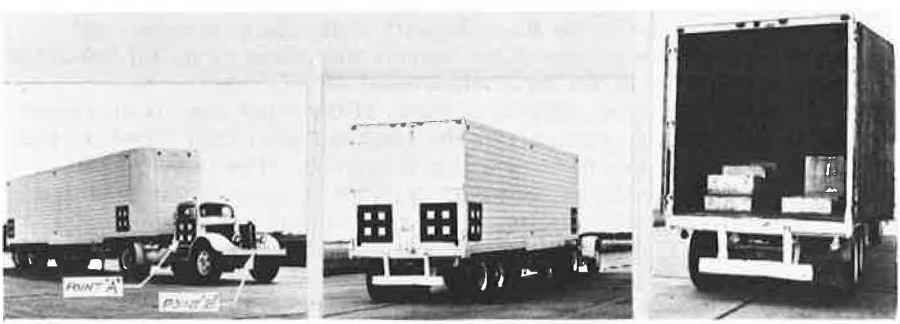
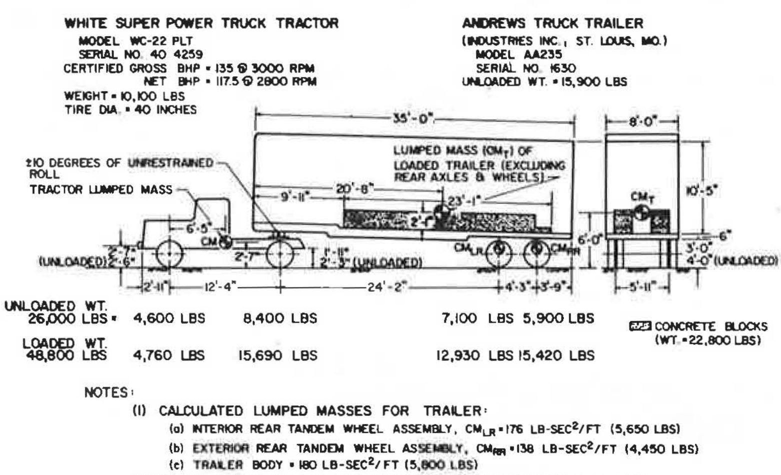


Figure 2. Test truck in loaded condition prior to tests.



(a) (b) (c)

Figure 3. Pertinent truck data.



tractor-trailer truck. No permanent rotational and lateral displacements of the unanchored and continuously reinforced 150-ft barrier test section were visible. Test conditions were as follows:

Test	Measured Impact Speed (mph)	Measured Impact Angle (deg)
CMB-5	34.9	19.1
CMB-6	33.8	15.5
CMB-7	44.7	15.0

Truck Motion

Sequence panning photographs of the truck motion during redirection are shown in Figures 5 and 6 for the CMB-5 test, Figure 7 for the CMB-6 test, and Figure 8 for the CMB-7 test. End-view sequence photographs of the truck motion were not available for the CMB-6 and CMB-7 tests because of a camera malfunction.

The vertical motion of a point on the tractor bumper relative to the top of the CMB is shown in Figure 9 for the 3 tests. The bumper point selected was located, as shown in Figure 2a, at the midheight of the bumper and at the longitudinal centerline of the tractor. The highest bumper rise above the top of the barrier was about 7 in. for the CMB-5 and CMB-6 tests; the highest rise was about 11 in. for the CMB-7 test.

The vertical motion of a point on the tractor door relative to the top of the barrier is also shown in Figure 9. This point, designated as point "A" in Figure 2a, was normal to the Impact-O-Graph mounted on the floor directly under the passenger seat. The highest rise of point "A" above the top of the barrier was about 14 in. for the CMB-5 test; the highest rise was about 18 in. for the CMB-6 and CMB-7 tests.

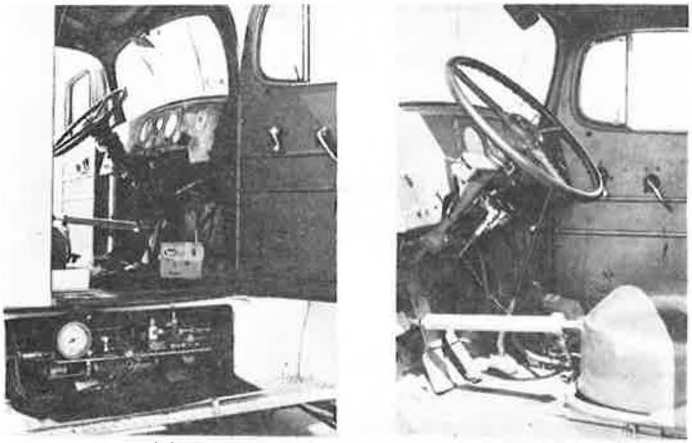
Figure 9 shows that the vertical and pitching motions of the truck tractor continued throughout the entire length of barrier contact as the front and rear dual wheels of the tractor rode up and down on the lower barrier inclined surface. The truck remained in contact with the barrier because the remote-control steering system was held in a straight ahead position before and after impact. The vertical and pitching motions were much more pronounced in the 45-mph CMB-7 test than in the two 10-mph CMB-5 and CMB-6 tests.

Comparisons of the rolling motion of the truck trailer during the 3 tests are shown in Figure 10. The rolling motion plots were obtained from an analysis of the high-speed film using the Vanguard Motion Analyzer and the IBM 360/65 computer. Measurements of the tractor-trailer truck swivel connection showed that the rolling motion of the trailer was independent of the tractor for angles of about 10 deg and less. As shown in Figure 10, the trailer rolling motion in the CMB-5 and CMB-6 tests was less than 8 deg and, hence, independent of the tractor rolling motion. In the CMB-7 test, however, the trailer rolling motion was not independent of the tractor rolling motion. The trailer in the CMB-7 test reached a maximum roll angle of 17 deg at a time of 1.2 sec after impact. It can be seen in the sequence photographs of Figure 9 that, at a time of 1.2 sec, the tractor rear dual wheels on the passenger side were lifted off the ground for a height of about 7 in. as a result of the trailer roll angle exceeding the unrestrained swivel roll angle of 10 deg. This observation may be significant for the selected truck under a higher impact speed of, for example, 50 to 55 mph, in that the inertia of the tractor would greatly assist in minimizing the possibility of roll-over (provided that the swivel roll pin does not fracture) and, if the swivel roll pin does fracture, there may be a possibility that the trailer would roll over the CMB.

Truck Damage

The damage to the truck was relatively minor. The sheet metal damage of the tractor after the CMB-5 test is shown in Figure 11a. The sheet metal and bumper damage of the tractor after the CMB-5, CMB-6, and CMB-7 tests is shown in Figure 11b. Dam-

Figure 4. Remotely operated on-off truck controls.



(a) (b)

Figure 5. Sequence photographs of CMB-5 test (side view).

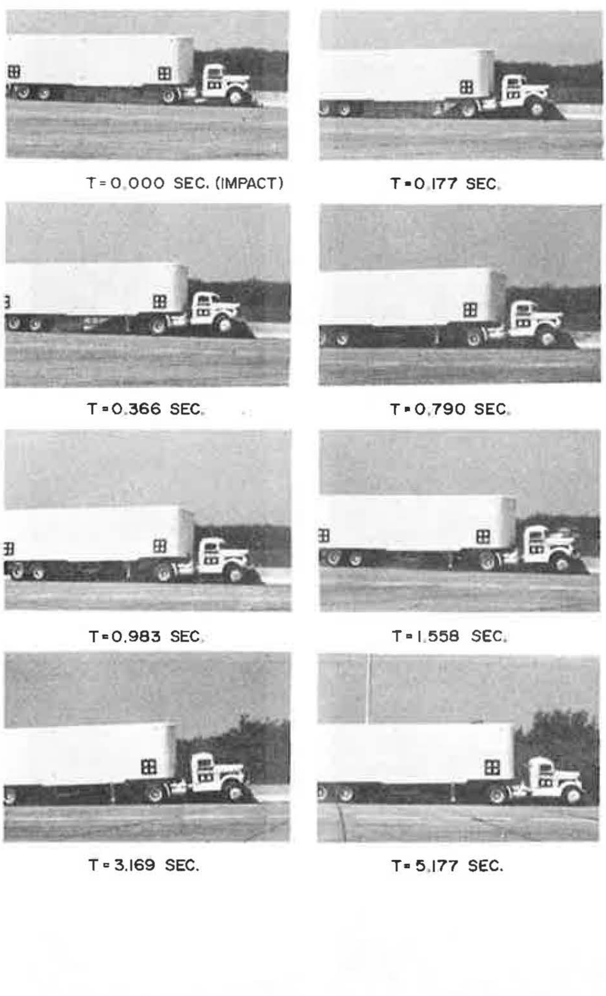


Figure 6. Sequence photographs of CMB-5 test (rear view).

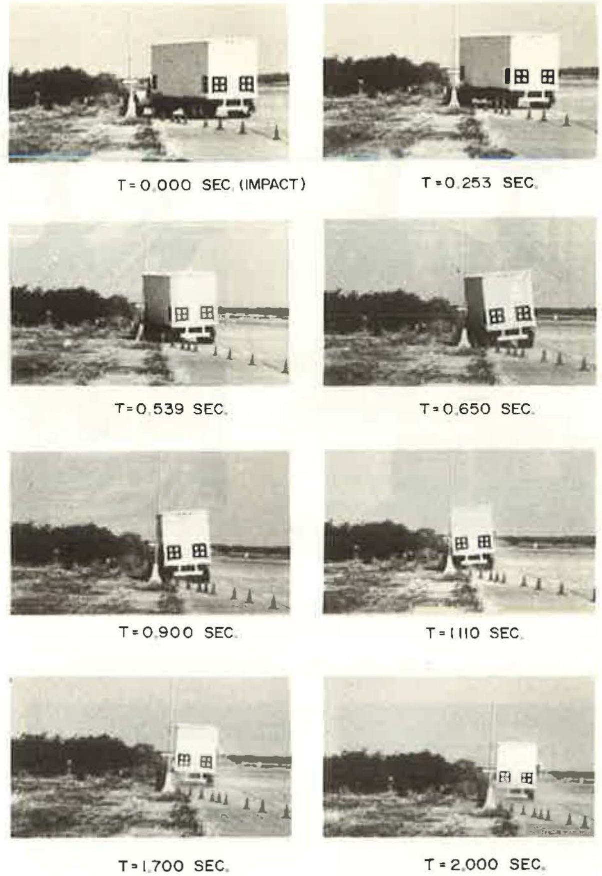


Figure 7. Sequence photographs of CMB-6 test.

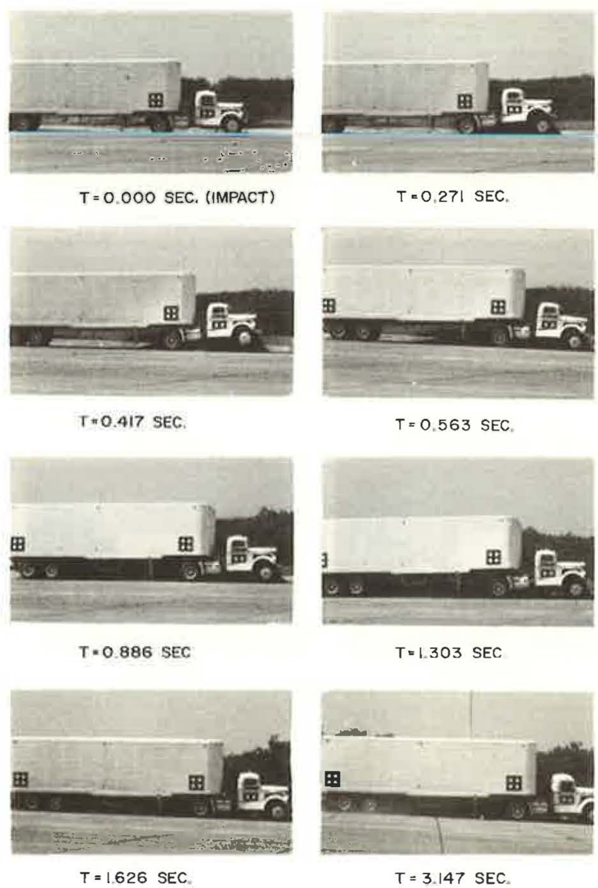


Figure 8. Sequence photographs of CMB-7 test.

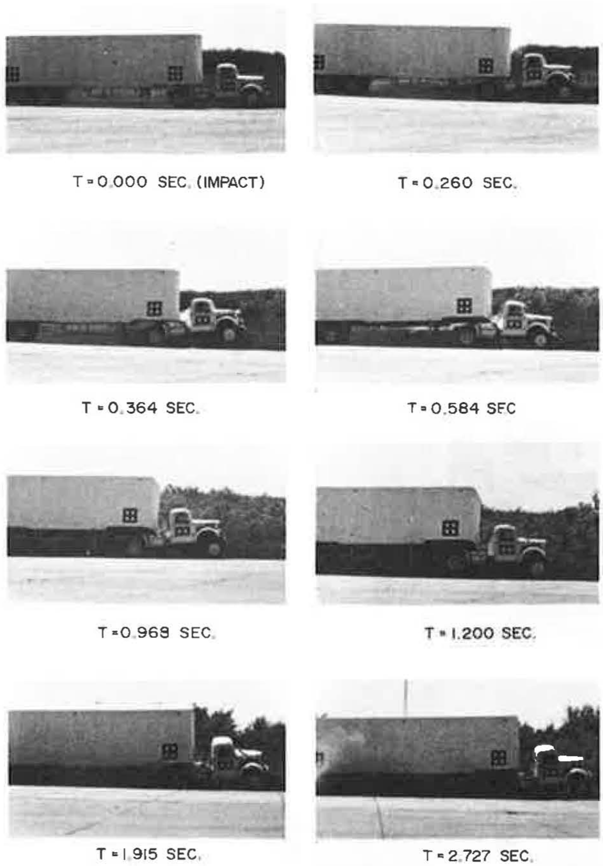


Figure 9. Motion of tractor relating to top of barrier.

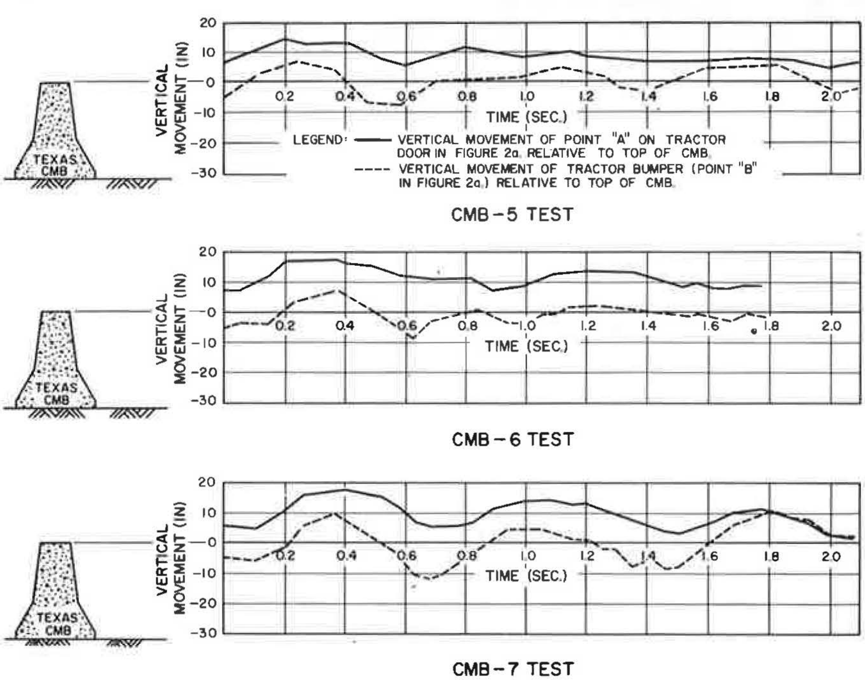


Figure 10. Rolling motion of truck trailer.

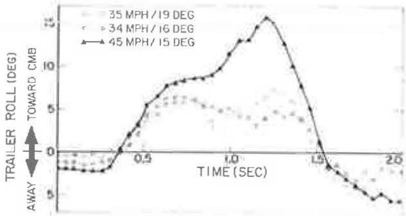
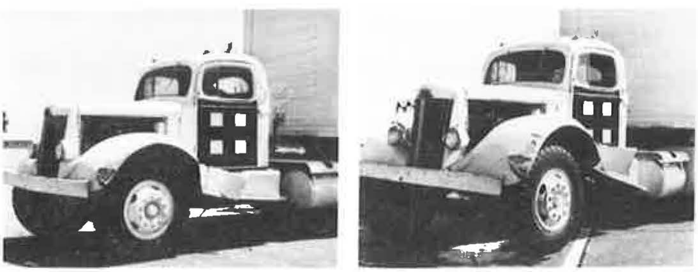


Figure 11. Tractor damage during CMB tests.



(a) (b)

Figure 12. CMB barrier damage.

OVERALL VIEW OF BARRIER AFTER CMB-5, CMB-6, & CMB-7 TESTS.

BARRIER AFTER CMB-5 TEST.

BARRIER AFTER CMB-6, AND CMB-7 TESTS.

age to the trailer consisted of several small indentations near the rear tandem wheels. The window on the side of the passenger was cracked prior to testing.

The estimated cost required to repair the fender, bumper, and running board of the truck tractor was less than $200.

Barrier Damage

Photographs of the CMB after testing are shown in Figure 12. Maintenance of the barrier would require, at most, a light sandblasting job to remove the unsightly tire scrub markings. The small amount of concrete spalling that occurred would require no maintenance. It can also be seen in the photographs that the fencing and light pole on top of the barrier were not damaged.

The tire scrub markings extend over the entire length of the barrier beyond the points of impact because, as mentioned earlier, the front wheels were locked in a straight ahead steering position subsequent to impact.

CONCLUSIONS

Although preliminary in scope, this series of truck tests demonstrated that the performance of the Texas concrete median barrier is promising from a consideration of (a) low maintenance and (b) having the capability to restrain a large-sized truck. In turn, these considerations will result in increased safety and economy.

No attempt was made in this study to determine the conditions under which the performance of the Texas concrete median barrier would have been unsatisfactory.

ACKNOWLEDGMENT

The contents of this paper reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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