TESTING AND EVALUATION OF IBC MK-7 BARRIER 
(WITH STABILIZED FILL MATERIAL) 
WITH AN 80,000-POUND TRACTOR VAN-TRAILER

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Project No. RF 71320

Sponsored by

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August 1989

Texas Transportation Institute
Texas A&M Research Foundation
College Station, Texas 77843
We are sorry but some of the older reports or AS IS.

The pictures are of poor quality.
DISCLAIMER

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### METRIC CONVERSION FACTORS

#### APPROXIMATE CONVERSIONS FROM METRIC MEASURES

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>WHEN YOU KNOW</th>
<th>MULTIPLY BY</th>
<th>TO FIND</th>
<th>SYMBOL</th>
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<tr>
<td><strong>LENGTH</strong></td>
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<td>in</td>
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<td>2.5</td>
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<td>ft</td>
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<tr>
<td>mi</td>
<td>miles</td>
<td>1.6</td>
<td>kilometers</td>
<td>km</td>
</tr>
</tbody>
</table>

| **AREA** | | | | |
| in² | square inches | 6.5 | square centimeters | cm² |
| ft² | square feet | 0.09 | square meters | m² |
| yd² | square yards | 0.8 | square meters | m² |
| mi² | square miles | 2.6 | square kilometers | km² |
| acres | hectares | 0.4 | hectares | ha |

| **MASS (weight)** | | | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |

| **VOLUME** | | | | |
| tsp | tablespoons | 5 | milliliters | ml |
| tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| ft³ | cubic feet | 0.03 | cubic meters | m³ |
| yd³ | cubic yards | 0.76 | cubic meters | m³ |

| **TEMPERATURE (exact)** | | | | |
| °F | Fahrenheit | 5/9 (after subtracting 32) | Celsius temperature | °C |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |

| °F | -40 | 0 | 32 | 99.6 | 120 | 160 | 200 | 212 | °F |
| °C | -40 | -20 | 0 | 20 | 80 | 120 | 160 | 212 | °C |
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I. INTRODUCTION

The ATA Foundation, Inc. contracted with the Texas A&M Research Foundation/Texas Transportation Institute (TTI) to crash test and evaluate the performance of the International Barrier Corporation (IBC) MK-7 barrier with stabilized fill material when impacted by an 80,000-pound tractor van-trailer. This effort was supported by the USX Corporation, and the International Barrier Corporation provided the materials and funding to construct the IBC MK-7 barrier used in the crash test.

The scope of the project included the conduct and evaluation of one crash test in accordance with guidelines established in NCHRP (National Cooperative Highway Research Program) Report 230 and the 1989 AASHTO (American Association of State Highway and Transportation Officials) "Guide Specifications for Bridge Railings", as appropriate.

General descriptions of the study approach, including the test barrier installation and the crash test and data analysis procedures, are presented in Section II of this report. Data and evaluation results of the crash test are described in Section III and a summary of findings and conclusions is presented in Section IV.
II. STUDY APPROACH

Description of Test Installation
The IBC MK-7 barrier consists of modules with corrugated side panels attached to vertical bulkheads. Each module is 10.5 feet (3.2 m) in length and a barrier installation may consist of any number of modules as required. The side panels and bulkheads are made of 14-gage galvanized steel sheet metal. The overall cross-sectional dimensions of the barrier are 46 inches (1.2 m) high and 44 inches (1.1 m) wide. The barrier modules are filled with Portland cement stabilized sand to the top of the barrier and covered with non-structural 20-gage galvanized sheet metal lids. The dimensions and details of the IBC MK-7 barrier module are shown in Figure 1.

The test installation consisted of 33 modules (10.5 feet for each module) of the standard MK-7 barrier for a total length of 346.5 feet (105.6 m). The barrier modules were filled with Portland cement stabilized sand and mechanically compacted. The stabilized fill material consisted of pit-run sand mixed with 10 percent Portland cement with a 10 percent moisture content (i.e., 100 pounds of sand mixed with 10 pounds of Portland cement and 10 pounds of water). Test cylinders of the stabilized sand were made during placement of the fill material into the test barrier and subsequently tested for its unit weight, compressive and tensile strength, and the Modulus of Elasticity. The results of the cylinder tests are summarized in Table 1. Note that the crash test was conducted 61 days after placement of the stabilized sand. The test installation was placed directly on a concrete pavement surface with no anchorage to the pavement. Photographs of the test installation are shown in Figure 2.

Description of Crash Test Procedures
The crash test procedures were in accordance with guidelines presented in NCHRP Report 230 and the 1989 AASHTO "Guide Specifications for Bridge Railings".

The test tractor was a 1979 White Road Boss with an empty weight of 16,240 pounds (7,464 kg). Figure 3 shows the key dimensions of the tractor. It should be noted that the wheelbase of the tractor (from the center of the front axle to the center of the rear tandem axle assembly) was modified and shortened to conform with the required wheelbase length of 169 inches (429 cm). The trailer was a Theurer enclosed van-trailer with an empty weight of 13,060 pounds (5,936 kg). The tandem axle assembly of the trailer was also moved so that the distance
Figure 1. Details of MK7 standard barrier assembly.
Table 1. Properties of Portland Cement Stabilized Sand Used in the Test Barrier

<table>
<thead>
<tr>
<th>Properties</th>
<th>Time After Placement of Stabilized Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 Days</td>
</tr>
<tr>
<td>Unit Weight (lbs/cu.ft.)</td>
<td>114.0</td>
</tr>
<tr>
<td>Compressive Strength (psi)</td>
<td>300</td>
</tr>
<tr>
<td>Tensile Strength (psi)</td>
<td>60</td>
</tr>
<tr>
<td>Modulus of Elasticity (psi)</td>
<td>976,767</td>
</tr>
</tbody>
</table>

Note: The barrier was tested at 61 days.
Figure 2. IBC MK-7 barrier before test 7132-1.
1979 White Road Boss
TRACTOR

Figure 3. Test vehicle properties (tractor only for test 7132-1).
from the center of the tandem axle assembly to the rear of the trailer would conform with the required dimension of 4.5 feet (1.37 m). The combined tractor-trailer empty weight was 29,480 pounds (13,400 kg). Photographs of the tractor-trailer are shown as Figure 4.

The tractor-trailer was loaded with sandbags and wooden pallets to a test inertia mass of 80,000 pounds, as shown in Figure 5. The loads were so located that the test vehicle center of gravity would conform with guidelines presented in the 1989 AASHTO "Guide Specifications for Bridge Railings", as shown in Table 2. The key dimensions, of the tractor-trailer, the actual locations of center of gravity for the load, trailer and load, and the combined tractor, trailer and load, and the empty and loaded axle weights are shown in Figure 6.

The test tractor-trailer was instrumented with three rate transducers to measure roll, pitch, and yaw rates. In addition, the tractor-trailer was instrumented with one set of triaxial accelerometers and three sets of biaxial accelerometers to measure acceleration levels during the impact. The triaxial accelerometers were mounted near the rear of the fifth wheel. The three sets of biaxial accelerometers were located at the front of the tractor, near the front of the trailer, and at the rear tandem axles of the trailer. The locations of the accelerometers are shown in Figure 7.

The electronic signals from the accelerometers and transducers were telemetered to a base station for recording on magnetic tape and for display on a real-time strip chart. Provision was made for transmission of calibration signals before and after the test, and accurate time reference signal was simultaneously recorded with the data. Contact switches on the bumper were actuated just prior to impact by wooden dowels to indicate the elapsed time over a known distance to provide a measurement of impact velocity. The initial contact also produced an "event" mark on the data record to establish the exact instant of impact.

The test tractor-trailer was guided into the barrier using a radio control guidance system from a chase vehicle. The test tractor-trailer was initially pushed with another vehicle to a speed of approximately 35 to 40 mi/h (56.3 to 64.4 km/h) before proceeding under its own power. The tractor-trailer then continued to accelerate to the desired impact speed under its own power.

Photographic coverage of the tests included four high-speed cameras, two overhead at the point of impact, one perpendicular to the barrier, and the fourth in line with the barrier downstream from the point of impact. One of the two
Figure 4. Tractor-trailer before test 7132-1.
Figure 5. Trailer load before test 7132-1.
# Table 2. Bridge Railing Performance Levels and Crash Test Criteria.
(Excerpt from 1989 AASHTO/Guide Specifications for Bridge Rails)

## Specifications

**Table G2.7.1.3A** Bridge Railing Performance Levels and Crash Test Criteria

<table>
<thead>
<tr>
<th>PERFORMANCE LEVELS</th>
<th>PERFORMANCE LEVELS</th>
<th>CRASH TEST EVALUATION CRITERIA¹</th>
<th>CRASH TEST EVALUATION CRITERIA¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Automobile</td>
<td>Pickup Truck</td>
<td>Required a, b, c, d, g</td>
<td>Desired e, f, h</td>
</tr>
<tr>
<td>W = 1.8 Kips</td>
<td>W = 5.4 Kips</td>
<td>a, b, c, d</td>
<td>e, l, g, h</td>
</tr>
<tr>
<td>A = 5.4 ± 0.1'</td>
<td>A = 8.5 ± 0.1'</td>
<td>a, b, c</td>
<td>d, e, f, h</td>
</tr>
<tr>
<td>B = 5.5'</td>
<td>B = 6.5'</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>Hₕ = 20° ± 1°</td>
<td>Hₕ = 20° ± 1°</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>t = 20 deg.</td>
<td>t = 20 deg.</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>W = 50 Kips</td>
<td>W = 50 Kips</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>A = 12.5 ± 0.5'</td>
<td>A = 12.5 ± 0.5'</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>B = 8.0'</td>
<td>B = 8.0'</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>Hₕ = 49° ± 1°</td>
<td>Hₕ = See Note 4</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>t = 15 deg.</td>
<td>t = See Note 4</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>W = 50 Kips</td>
<td>W = 50 Kips</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>A = 12.5 ± 0.5'</td>
<td>A = 12.5 ± 0.5'</td>
<td>a, b</td>
<td>e, l, h</td>
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<tr>
<td>B = 8.0'</td>
<td>B = 8.0'</td>
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<td>e, l, h</td>
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<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>t = 15 deg.</td>
<td>t = See Note 4</td>
<td>a, b</td>
<td>e, l, h</td>
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<tr>
<td>W = 50 Kips</td>
<td>W = 50 Kips</td>
<td>a, b</td>
<td>e, l, h</td>
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<tr>
<td>A = 12.5 ± 0.5'</td>
<td>A = 12.5 ± 0.5'</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>B = 8.0'</td>
<td>B = 8.0'</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>Hₕ = 49° ± 1°</td>
<td>Hₕ = See Note 4</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
<tr>
<td>t = 15 deg.</td>
<td>t = See Note 4</td>
<td>a, b</td>
<td>e, l, h</td>
</tr>
</tbody>
</table>

### Notes:
1. Except as noted, all full-scale tests shall be conducted and reported in accordance with the requirements in NCHRP Report No. 230. In addition, the maximum loads that can be transmitted from the bridge railing to the bridge deck are to be determined from static force measurements or ultimate strength analysis and reported.
2. Permissible tolerances on the test speeds and angles are as follows:
   - Speed: ± 1.0 mph ± 2.5 mph
   - Angle: ± 1.0 deg. ± 2.5 deg.

   Tests that indicate acceptable railing performance but that exceed the allowable upper tolerances will be accepted.
3. Criteria for evaluating bridge railing crash test results are as follows:
   - a. The test article shall contain the vehicle; neither the vehicle nor its cargo shall penetrate or go over the installation. Controlled lateral deflection of the test article is acceptable.
   - b. Detached elements, fragments, or other debris from the test article shall not penetrate or show potential for penetrating the passenger compartment or present undue hazard to other traffic.
   - c. Integrity of the passenger compartment must be maintained with no intrusion and essentially no deformation.
   - d. The vehicle shall remain upright during and after collision.
   - e. The test article shall smoothly redirect the vehicle. A redirection is deemed smooth if the rear of the vehicle or, in the case of a combination vehicle, the rear of the tractor or trailer does not yaw more than 5 degrees away from the railing from time of impact until the vehicle separates from the railing.
   - f. The smoothness of the vehicle-railing interaction is further assessed by the effective coefficient of friction, μ:

\[
\mu = \frac{(1 - \sqrt{\frac{V}{2g}})}{\tan(\theta)}
\]

<table>
<thead>
<tr>
<th>Assessment</th>
<th>μ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>0-0.25</td>
</tr>
<tr>
<td>Fair</td>
<td>0.26-0.35</td>
</tr>
<tr>
<td>Marginal</td>
<td>&gt;0.35</td>
</tr>
</tbody>
</table>
TABLE 2. (continued)

GUIDE SPECIFICATIONS FOR BRIDGE RAILINGS

TABLE G2.7.1.3A (Continued)  Bridge Railing Performance Levels and Crash Test Criteria

g. The impact velocity of a hypothetical front seat passenger against the vehicle interior, calculated from vehicle accelerations and 2.0-ft. longitudinal and 1.0-ft. lateral displacements, shall be less than:

<table>
<thead>
<tr>
<th>Occupant Impact Velocity—ips</th>
<th>Longitudinal</th>
<th>Lateral</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

and the vehicle highest 10-ms average accelerations subsequent to the instant of hypothetical passenger impact should be less than:

<table>
<thead>
<tr>
<th>Occupant Ridedown Acceleration—g's</th>
<th>Longitudinal</th>
<th>Lateral</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

h. Vehicle exit angle from the barrier shall not be more than 12 degrees. Within 100 ft plus the length of the test vehicle from the point of initial impact with the railing, the trailing side of the vehicle shall move no more than 20 ft from the line of the traffic face of the railing. The brakes shall not be applied until the vehicle has traveled at least 100 ft. plus the length of the test vehicle from the point of initial impact.

4. Values A and R are estimated values describing the test vehicle and its loading. Values of A and R are described in the figure below and calculated as follows:

- Min. Load = 20.5 Kips
- \( L_1 = 30° ± 1° \)
- \( \frac{L_1}{2} = 169° ± 4° \)

\[ A = L_1 + \frac{W_1 L_2}{W_4} + \frac{W_2 L_3}{W_4} \]

\[ R = \frac{W_4 + W_5 + W_6}{W} \]

\( W = W_1 + W_2 + W_3 + W_4 + W_5 \) = total vehicle weight.

5. Test articles that do not meet the desirable evaluation criteria shall have their performance evaluated by a designated authority that will decide whether the test article is likely to meet its intended use requirements.
1979 Road Boss
Theurer Enclosed Van-Trailer

TRACTOR-TRAILER

EMPTY WEIGHTS:
Weight on front axle 8,720
Weight on center axles 11,920
Weight on rear axles 8,840
Total Empty Weight 29,480

LOADED WEIGHTS
Weight on front axle 11,230
Weight on center axles 34,510
Weight on rear axles 34,260
Total Loaded Weight 80,000

Figure 6. Test vehicle properties (tractor/van-trailer for test 7132-1).
1979 White Road Boss
Theurer Enclosed Van-Trailer

TRACTOR-TRAILER

Ax,y,z, C.G. - Accelerometer mounted near fifth wheel
Ax,y TF - Accelerometer mounted outside trailer on floor, 6.1 in left of centerline
Ax, y F - Accelerometer mounted inside tractor, 3.5 in left of centerline
Ax, y TR - Accelerometer mounted outside trailer on floor between axles, 6.3 in left of centerline

Figure 7. Location of accelerometers on tractor-trailer used in test 7132-1.
overhead cameras was pointed approximately 35 degrees downstream from impact to observe tractor-trailer trajectory behavior after the initial impact with the barrier. The films from these high-speed cameras were used to observe phenomena occurring during collision and to obtain time-event, displacement and angular data. A 3/4-inch videotape and still cameras were also used for documentary purposes.

Data Analysis Procedures

The data analysis procedures were in accordance with guidelines presented in NCHRP Report 230. Performance evaluation was in accordance with the crash test evaluation criteria outlined in the 1989 AASHTO "Guide Specifications for Bridge Railings". The analog data from the accelerometers and transducers were digitized, using a microcomputer, for analysis and evaluation of performance. The digitized data were then analyzed using a number of computer programs: DIGITIZE, PLOTANGLE and commercially available LOTUS software. Brief descriptions on each of these computer programs are provided as follows.

The DIGITIZE program uses digitized data from vehicle-mounted linear accelerometers to compute occupant/compartment impact velocities, time of occupant/compartment impact after vehicle impact, final occupant displacement, highest 0.010-second average ridedown accelerations. In addition, the DIGITIZE program also calculates a vehicle impact velocity, the change in vehicle velocity at the end of a given impulse period, and maximum average accelerations over 0.050-second intervals for the longitudinal, lateral, and vertical directions.

The PLOTANGLE program uses the digitized data from the yaw, pitch, and roll rate charts to compute angular displacement in degrees at 0.001-second intervals and then instructs a plotter to draw a reproducible plot: yaw, pitch, and roll versus time. It should be noted that these angular displacements are sequence dependent with the sequence being yaw-pitch-roll for the data presented in this report. These displacements are in reference to the vehicle-fixed coordinate system with the initial position and orientation of the vehicle-fixed coordinate system being that which existed at initial impact.

The LOTUS program plots acceleration versus time curves for the longitudinal, lateral, and vertical directions using digitized data from the vehicle mounted linear accelerometers.
III. CRASH TEST RESULTS

A 1979 White Road Boss tractor and Theuer enclosed van-trailer (shown in Figure 8) impacted near the center of the eleventh module, approximately 110 ft (33.5 m) from the beginning of the barrier installation, at a speed of 50.9 miles per hour (81.9 km/h) and at an angle of 15.0 degrees. Test inertia mass of the vehicle was 80,000 pounds (36,287 kg). The height to the lower edge of the vehicle bumper was 20.8 inches (52.7 cm) and 36.8 inches (93.3 cm) to the top of the bumper. Other dimensions and information on the tractor-trailer are previously given in Figure 6.

The vehicle was free wheeling and unrestrained just prior to impact. Upon impact, the left front of the tractor began to deform and shortly thereafter, the left front tire made contact with the barrier and began to turn away from the barrier. At approximately 0.062 second, the rearward movement of the left front wheel caused the steer axle to push the right front wheel forward. As the tractor began to redirect, the front of the trailer impacted the barrier at 0.161 second. The right front wheel of the tractor lost contact with the roadway surface at 0.185 second as the tractor leaned into the barrier. Shortly thereafter, the rear tractor wheels also lost contact with the roadway surface, as the tractor continued down the barrier with the rear of the tractor climbing the barrier. At approximately 0.309 second, the tractor began to travel parallel to the barrier. The right front and rear wheels of the tractor came back down in contact with the roadway surface at approximately 0.468 second.

As mentioned previously, the front of the trailer impacted the barrier at 0.161 second. As the trailer began to redirect, the bottom of the left side of the trailer slid on top of the barrier while the rear of the trailer moved toward the barrier. At 0.554 second, the right rear trailer wheels lost contact with the roadway surface. At 0.758 second, the rear of the trailer came into contact with the barrier and the trailer began to travel parallel to the barrier. As the trailer travelled down the barrier, the rear of the trailer climbed up the side of the barrier face. The rear trailer wheels came back into contact with the roadway at 1.934 seconds, as the tractor-trailer continued travelling parallel to the barrier. The tractor-trailer remained in contact with the barrier until the end of the barrier. Upon losing contact with the end of the barrier, the brakes were applied and the tractor-trailer turned to the left, and came to rest almost perpendicular to the barrier. The tractor-trailer traveled
Figure 8. Tractor-trailer/barrier geometrics before test 7132-1.
a total distance of 275 feet (83.8 m) from the initial point of impact to the
point of final rest. Sequential photographs of the test are shown in Figure 9.

The barrier received minor damages as shown in Figure 10. The maximum
permanent residual deformation to the barrier was 4.0 inches (10.2 cm). The
maximum permanent lateral movement was 7.0 inches (17.8 cm) and the maximum
dynamic deflection was 12.0 inches (30.5 cm). The stabilized sand fill material
remained basically intact after the impact with only localized areas of crushing,
as shown in Figure 11. While the vehicle was in contact with the barrier for
a total length of 239.0 feet (72.9 m), the major damages to the barrier were
confined to the first three modules, or roughly 30 feet (9.1 m), downstream from
the point of initial impact. Damages to the other modules were limited to
scrapes and tears of the side panels as the tractor-trailer slid along the
barrier to its final rest position. The effective friction coefficient of the
vehicle/railing interaction was found to be 0.135.

The vehicle received severe damages, as shown in Figures 12. The front­
left corner of the bumper was deformed and the left side of the tractor was
damaged. The left front wheel was deformed from impact with the barrier and the
wheel was displaced 18 inches rearward from its normal position into the battery
box. The rearward displacement was a result of the fracturing of both left­
side, and one right-side U-bolts mounting the front axle to the front leaf
springs. The lower left-front and upper right-front shock absorber mounts were
separated from the axle assembly and the pitman arm from the steering assembly
as the axle was displaced rearward. The battery box was deformed and displaced
rearward into the front surface of the left fuel tank, but the fuel tank remained
intact with only minor deformations.

The left frame rail was displaced rearward 6 inches relative to the right
rail. The left outer tires of the tractor's rear tandem axles were deflated and
the rims were severely deformed as a result of contact with the barrier. The
tractor's rear tandem axles were shifted back on the left side approximately 2.0
inches.

The trailer received direct contact damage along the entire lower left
side. The left frame was fractured allowing the floor to drop down approximately
22.8 inches, forming a "V" shaped left side surface. The left wall of the
trailer shifted to the left approximately 40 inches (when viewed from the rear)
and separated from the roof structure at the top joint. The right wall was
deformed slightly due to induced damage. Both left-outer tires on the trailer
Figure 9. Sequential photographs for test 7132-1.
Figure 9. Sequential photographs for test 7132-1. (Continued)
Figure 10. IBC MK-7 barrier after test 7132-1.
Figure 11. IBC MK-7 barrier internal structure at impact after test 7132-1.
Figure 12. Tractor-trailer after test 7132-1.
Figure 12. Tractor-trailer after test 7132-1. (Continued)
axles were deflated and the rims were damaged extensively. The trailer landing gear also received minor damages.

A detailed documentation of the vehicle damages with accompanying narratives and field forms was conducted and the results are presented as Appendix A to the report.

A summary of the test results and other information pertinent to this test are given in Figure 13. The maximum 0.050-second average acceleration experienced by the tractor-trailer at the various accelerometer locations along the tractor-trailer are summarized in Table 3. For instance, the maximum 0.050-second average acceleration experienced by the tractor near the fifth wheel was -5.4 g in the longitudinal direction, -10.2 g in the lateral direction, and 3.2 g in the vertical direction. Acceleration traces of the various accelerometers are displayed in Figures 14 through 22, and the vehicle angular displacements are plotted in Figure 23.

Occupant impact velocity in the longitudinal direction was 8.8 feet per second (2.7 m/s) and 13.9 feet per second (4.2 m/s) in the lateral direction. The highest 0.10-second occupant ridedown accelerations were -2.6 g (longitudinal) and -4.6 g (lateral). These occupant impact velocities and ridedown accelerations are from the accelerometers mounted in the passenger compartment at the front of the tractor. It should be noted, however, that the criteria on occupant impact velocity and ridedown accelerations are not applicable to this crash test, but are reported for information purposes.
<table>
<thead>
<tr>
<th>Test No.</th>
<th>7132-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>05/31/89</td>
</tr>
<tr>
<td>Test Installation</td>
<td>IBC MK-7 Median Barrier w/stabilized fill material</td>
</tr>
<tr>
<td>Installation Length</td>
<td>346.5 ft (105.6 m)</td>
</tr>
<tr>
<td>Vehicle</td>
<td>1979 White Road Boss Tractor w/van-trailer</td>
</tr>
<tr>
<td>Vehicle Weight</td>
<td>80,000 lb (36,287 kg)</td>
</tr>
<tr>
<td>Test Inertia</td>
<td>80,000 lb (36,287 kg)</td>
</tr>
<tr>
<td>Impact Speed</td>
<td>50.9 mi/h (81.9 km/h)</td>
</tr>
<tr>
<td>Impact Angle</td>
<td>15.0 deg</td>
</tr>
<tr>
<td>Exit Speed</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Exit Trajectory</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Vehicle Accelerations</td>
<td>(Max. 0.050-sec Avg)</td>
</tr>
<tr>
<td>Longitudinal</td>
<td>-5.4 g</td>
</tr>
<tr>
<td>Lateral</td>
<td>-10.2 g</td>
</tr>
<tr>
<td>Occupant Impact Velocity</td>
<td>(Max. 0.050-sec Avg)</td>
</tr>
<tr>
<td>Longitudinal</td>
<td>15.0 ft/s (4.6 m/s)</td>
</tr>
<tr>
<td>Lateral</td>
<td>14.9 ft/s (4.5 m/s)</td>
</tr>
<tr>
<td>Occupant Ridedown Accelerations</td>
<td></td>
</tr>
<tr>
<td>Longitudinal</td>
<td>-5.4 g</td>
</tr>
<tr>
<td>Lateral</td>
<td>-20.9 g</td>
</tr>
</tbody>
</table>

Figure 13 Summary of results for test 7132-1.
Table 3. Summary of Maximum 0.050-Second Average Acceleration At Various Locations Along Tractor-Trailer

<table>
<thead>
<tr>
<th>Location of Accelerometer</th>
<th>Maximum 0.050-Second Average Acceleration (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Longitudinal</td>
</tr>
<tr>
<td>Front of Tractor</td>
<td>- 3.2</td>
</tr>
<tr>
<td>Near Fifth Wheel of Tractor</td>
<td>- 5.4</td>
</tr>
<tr>
<td>Front of Trailer*</td>
<td>- 1.7</td>
</tr>
<tr>
<td>Rear of Trailer</td>
<td>- 2.5</td>
</tr>
</tbody>
</table>

N/A - Not applicable.

* Note. Signal loss for this accelerometer group at 0.460 second after impact.
Figure 14. Longitudinal accelerometer trace for test 7132-1. (Front of tractor)
Figure 15. Lateral accelerometer trace for test 7132-1. (Front of tractor)
Figure 16. Longitudinal accelerometer trace for test 7132-1. (Rear of fifth wheel)
Figure 17. Lateral accelerometer trace for test 7132-1. (Rear of fifth wheel)
Figure 18. Vertical accelerometer trace for test 7132-1.
(Rear of fifth wheel)
Figure 19. Longitudinal accelerometer trace for test 7132-1. (Front of trailer)

NOTE: Signal loss at 0.460 second
Figure 20. Lateral accelerometer trace for test 7132-1.
(Front of trailer)
NOTE: Signal loss at 0.460 second.
Figure 21. Longitudinal accelerometer trace for test 7132-1.
(Rear of trailer)
Figure 22. Lateral accelerometer trace for test 7132-1. (Rear of trailer)
Axes are vehicle fixed. Sequence for determining orientation is:

1. Yaw
2. Pitch
3. Roll

Figure 23. Tractor-trailer angular displacements for test 7132-1.
IV. FINDINGS AND CONCLUSIONS

Results of the crash test indicate that the IBC MK-7 barrier with stabilized fill meets with the guidelines set forth in NCHRP Report 230 and the 1989 AASHTO "Guide Specifications for Bridge Railings" for a performance level 3 (PL-3) barrier. The barrier successfully contained and redirected the 80,000-lb tractor van-trailer. The barrier received only minor damages with maximum permanent lateral movement of approximately 7 inches. The tractor-trailer received severe damages, but there was no debris or detached elements and no deformation or intrusion into the occupant compartment. The vehicle traveled along the barrier after impact until the end of the barrier, indicating minimal potential for intrusion into adjacent traffic lanes. The vehicle remained upright throughout the test although the vehicle did exhibit a considerable amount of rolling against the barrier.
APPENDIX A

TRUCK AND TRAILER INSPECTION REPORT

By

James R. Lock
Assistant Research Scientist

Tractor: 1979 White Model RB2L-64T
Road Boss 2 6X4 Tractor
Tire Size - 11R24.5
Wheel Type - Disc (10-hole Budd)
116" BBC Conventional Cab
30" Front Axle Setback
Frame: 110,000 psi heat-treated alloy steel channel
VIN: CPPCPSG026750

Trailer: Theurer, Inc.
45 Foot Enclosed Van
2 axles
Tire Size - 11R24.5
Wheel Type - Disc (10-hole Budd)

Tractor

The tractor received direct contact damage with the barrier of 25.8 inches along the frontal plane at bumper level. The front-left corner had associated direct contact damage with fiberglass breakage and cracking extending across the headlamp and along the left side over the front left wheel. The left front wheel was deformed from impact with the barrier and the wheel was displaced rearward into the battery box. The rearward displacement was a result of the fracturing of both left-side, and one right-side U-bolts mounting the front axle to the front leaf springs. The wheel was 18 inches rearward of its normal position at the time of inspection. Sheet metal contact behind and around the wheel indicates it had been moved forward from its most rearward position prior to the inspection. The lower left-front and upper right-front shock absorber mounts were separated from the axle assembly and the pitman arm from the steering assembly as the axle was displaced rearward.

The frame is a parallel two channel alloy steel configuration. The left frame rail was displaced rearward 6 inches relative to the right rail. The tire from the number two axle’s (front axle of the tractor’s rear tandem) left outer position was separated from the rim. The rim was severely deformed approximately

38
300 degrees around its circumference as a result of contact with the barrier. The left outer tire on the number three axle (rear axle of the tractor's rear tandem) was deflated and the rim had evidence of deformation approximately 270 degrees around its circumference. Both rear tandem axles were shifted back on the left side approximately 2.0 inches giving the rear a left (-) steer angle of approximately 1.3 degrees.

The battery box was deformed and had residual rearward displacement of 8.4 inches. The displacement was inhibited by the front surface of the left fuel tank. The right and left cylindrical aluminum fuel tanks were identified as follows:

Alcan Canada Products Ltd.
Alcan Pipe Vernon B.C.
Meets All FHWA Side Mounted Tank Requirements
Part Number 43001-0059
Manufactured 10/78
Useable Capacity 100 U.S. Gal.

Each fuel tank was mounted with two metal straps which also served as the mounting position for the aluminum cab steps. The dimensions of the fuel tanks and the strap locations are shown on the fuel tank sketch form. No damage was noted on the right side tank or to the Velvac 68D-14 filler cap.

The left side tank was deformed on the circular front face from contact with the battery box. The deformation was located at the 2 o'clock position (when viewing the front of the tank) and was measured to be approximately 0.7 inch deep. The aluminum step was separated from the front mounting strap at the three rivet attachment points. The tank had a small area of surface deformation along the rear strap at the step attachment location. There were no puncture holes or seam separations noted in the tank. The tank showed evidence of approximately 1.8 inches of rearward movement within the mounting system relative to the right tank. The Velvac 68D-14 filler cap was not damaged and remained in position. All fuel lines and pickup points were attached and in good condition. There was no fuel system integrity loss noted.

Trailer

The 45-foot semi-trailer received direct contact damage along the entire lower left side. The contact damage is located 12.0 inches from the front of the trailer and extends upward approximately 14.4 inches. The left frame was fractured allowing the floor to drop down approximately 22.8 inches, forming a
"V" shaped left side surface. The left wall of the trailer shifted to the left approximately 40 inches (when viewed from the rear), forming a parallelogram with the rear of the trailer. The left wall separated from the roof structure at the top joint. The right wall was deformed slightly concave near the rear of the trailer due to induced damage. The front of the trailer was inclined to the left at a 9.0 degree angle.

Both left-outer tires on the number four and number five axles (front and rear of trailer tandem axles) were deflated as the rims received extensive damage 360 degrees around the circumference from contact with the barrier. The trailer landing gear, located 10.3 feet from the front of the trailer, received minor direct contact damages. No rear axle steer angle was noted. The fifth wheel was attached and appeared to be undamaged. However, problems were encountered in detaching the trailer from the tractor.
DAMAGE DESCRIPTION

Tire—Wheel Damage
Rotation physically restricted
RF_2_ For rear wheels
LF_1_ circle axle(s)
RR_2_ 2 3 4
LR_2_ 5 6 7
(1) Yes, (2) No, (8) NA, (9) Unk.

0.5'
Frame
Ribs
Shift
L R

TRACTORS
Straight Cab
Sleeper Version

TYPE OF TRANSMISSION

\[ \checkmark \] Manual \[ \_ \] Automatic

Front Track:
Cab Width:
Curb Weight:
Overall Length:
Wheel Base:
Engine Size: cyl.
disp_

WHEEL STEER ANGLES
(For locked front wheels or displaced rear axles only)
RF ± 1 0° For rear wheels
LF ± 1 0° circle axle(s)
RR ± 0 1° 2 3 4
LR ± 0 1° 5 6 7
Within ± 5 degrees

Number of Axles:
Total 5
Tractor 3
Semi 2
Full

Rim Damage
(All left side)
Tire off Rim

Hole in Fiberglass
25.8"

11-24.5 Tires

Fiberglass Crushed

Note: Sketch new perimeter and cross hatch direct damage and single hatch induced damage on all views. Annotate observations which might be useful in reconstructing the accident e.g., grass in tire bead, direction of striations, scuff on sidewall, etc. If pulling trailer sketch type of trailer and damage received on the back of this page. Annotate any damage caused by extrication such as component removal by torching, prying or hydraulic shears. Annotate any tires which are deflated due to damage on the vehicle sketch.
Both Left Tires Deflated
Left Side Floor/Frame Failure

14" Rail Contact

Extensive Rim Damage

Left Side Separation

Concave

CASE NUMBER 7132-1

Sketch trailer and damage. Provide dimensions on sketch.
FUEL TANK SKETCH FORM

TANK IDENTIFICATION LF LR RF RR OTHER (Circle)

COPY AND PHOTOGRAPH MANUFACTURER ID PLATE.

Alcan Canada Products LTD
Alcan Pipe Vernon S.C.
Part # 43001-0059 10/78
100 U.S. Gal.

---

SKETCH ALL VALVES, LINES, FITTINGS AND CAPS. SHOW ALL DIMENSIONS.
ANNOTATE AND SKETCH ALL DAMAGE TO TANK OR HARDWARE.

4/87
FUEL TANK SKETCH FORM

TANK IDENTIFICATION (LF) LR RF RR OTHER (Circle)
COPY AND PHOTOGRAPH MANUFACTURER ID PLATE.
(Alcan Canada Products LTD)

10/78
100 U.S. Gal

TOP
- Plug o Gauge
- Filler Cap

BOTTOM
- No Damage Noted

OUTSIDE
- Slight Deformation
- ~4" Straps

INSIDE
- No Damage Noted

SKETCH ALL VALVES, LINES, FITTINGS AND CAPS. SHOW ALL DIMENSIONS.
ANNOTATE AND SKETCH ALL DAMAGE TO TANK OR HARDWARE.
4/87