Crash tests of the Tric-Bloc precast concrete median barrier

by Thomas Turbell
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PREFACE

The work presented in this report was sponsored by A-BETONG AB and TRIC-BLOC Marketing Co. AB.

The contents of this report refer strictly to the products as investigated from the crash performance aspects. This report is not a certification and the Institute provides no assurance, either expressed or implied, concerning the products.
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Crash tests of the Trio-Bloc precast concrete median barrier
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ABSTRACT

Ten vehicular crash tests of the Trio-Bloc precast concrete median barrier have been made at the National Swedish Road and Traffic Research Institute (VTI). The first series of tests made in 1977 have been presented in VTI Report No. 158. In 1980 a major change in the profile of the barrier and its connection system was made. This report describes tests with this new design at speeds up to 109 kmph, impact angles up to 25° and vehicle masses up to 2040 kg. The conclusion from these tests is that the new design offers a considerably better safety performance than the old one. The structural adequacy and the vehicle trajectory hazard requirements as specified in the USA seem to be met.
INTRODUCTION

Median barriers are used to prevent errant vehicles from crossing a median and conflicting with the opposing traffic stream. Two major principles dominate today the designs of such barriers.

- The double steel beam barrier which is yielding and will absorb some of the impact energy. Due to the space needed for the deformation this type of barrier can conflict with the opposing lane when used on a narrow median. It also has to be repaired after a moderate impact. This type of barrier is today the dominating type in Europe.

- The concrete median barrier (CMB) which is rigid and will not absorb any significant amount of energy at an impact. This barrier is not deforming and can therefore be used even on very narrow medians. Repair is usually not necessary unless the impact is very severe. The CMB which is usually cast-in-place is common in the USA and has the last years also been installed in Europe, especially in France and Belgium. Precast concrete median barriers (PCMB) have also been used in the USA. The main reason for using the PCMB is that it can easily be removed and is therefore also suitable as a temporary barrier. PCMB's used in the USA have usually been made in 4 to 9 m sections and the main problem at the tests made has been damage at the joints /1, 2/. The profile of the CMB is usually of the "New Jersey-type" or small variations of it.
THE TRIC-BLOC SYSTEM

The design objectives of the TRIC-BLOC system, developed by a Swedish company, have been to combine some of the advantages of the existing concepts.

The TRIC-BLOC is a PCMB which is designed to give some flexibility and energy absorption at severe impacts. Dimensions and details of the connection system can be found in figures 1-4.

Tests of the first version of Tric-Bloc were carried out by VTI in 1977. These tests are reported in VTI Report 158 /3/. In the conclusions from these tests it was stressed that the profile of the first version of Tric-Bloc introduced a high risk of rollover and also a tendency for the impacting cars to climb the barrier and end up at the other side.

Further tests conducted by Dynamic Science in 1979 /4/ confirmed the results mentioned above.

During 1980 the Tric-Bloc was redesigned with regard to the shape and connecting system. The main features of this design change are a steeper profile and a stronger connecting system.
Fig. 1 Dimensions of the modified TRIC-BLOC

Fig. 2 Details of final version of coupling
Fig. 3 Coupling detail
Fig. 4 End view of TRIC-BLOC
3 TEST OBJECTIVES

The purpose of the full-scale vehicle crash tests was to determine if the new design met the requirements specified in USA /5, 6/. The main points of these recommended requirements are.

3.1 Structural Adequacy

A. The test article shall redirect the vehicle; hence, the vehicle shall not penetrate or vault over the installation.

B. The test article shall not pocket or snag the vehicle causing abrupt deceleration or spinout or shall not cause the vehicle to rollover. The vehicle shall remain upright during and after impact although moderate roll and pitching are acceptable. The integrity of the passenger compartment must be maintained. There shall be no loose elements, fragments or other debris that could penetrate the passenger compartment or present undue hazard to other traffic.
3.2 Impact Severity

These requirements specify limits for the accelerations of the vehicle and anthropomorphic dummies in the vehicle. These measurements were not made in the tests presented in this report since it was considered that the extra cost for these measurements was too high considering the following:

- Vehicle acceleration is very sensitive to minor differences in the shape and state of the vehicle tested.

- Earlier experience has shown that there seems to be no significant correlation between accelerations measured according to the proposed requirements and the severity of the impact.

- The anthropomorphic dummies available at present are designed for frontal impacts and are not suitable for measuring lateral impacts.

3.3 Vehicle Trajectory Hazard

After impact, the vehicle trajectory and final stopping position shall intrude a minimum distance into adjacent traffic lanes.
TEST MATRIX

The table below shows all tests done at VTI with the TRIC-BLOC system. Tests TB-1, 2 and 3 with the older design have been reported before /3/ and some of the recent tests where different designs of the connecting systems were tested are not reported in detail since they are not relevant for the final design.

<table>
<thead>
<tr>
<th>Date</th>
<th>Test No.</th>
<th>Angle</th>
<th>Speed kmph</th>
<th>Vehicle Type</th>
<th>Mass kg</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>771130</td>
<td>TB 1</td>
<td>25°</td>
<td>70 (44)</td>
<td>Ford Taunus</td>
<td>1000 (2203)</td>
<td>Reported in VTI Report 158</td>
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<tr>
<td>771207</td>
<td>Tu 2</td>
<td>15°</td>
<td>73 (45)</td>
<td>Volvo</td>
<td>900 (343)</td>
<td>- &quot; -</td>
</tr>
<tr>
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<td>TB 3</td>
<td>25°</td>
<td>75 (47)</td>
<td>Volvo</td>
<td>900 (343)</td>
<td>- &quot; -</td>
</tr>
<tr>
<td>1980</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>Volvo</td>
<td>2000 (142)</td>
<td>Pretest</td>
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<td>Ford Taunus</td>
<td>2000 (142)</td>
<td>Aborted test due to propulsion system</td>
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<tr>
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<td>TB 6</td>
<td>25°</td>
<td>85 (53)</td>
<td>Ford Taunus</td>
<td>2000 (142)</td>
<td>Pretest</td>
</tr>
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<td>801203</td>
<td>TB 7</td>
<td>25°</td>
<td>109 (68)</td>
<td>Dodge Charger</td>
<td>2040 (4493)</td>
<td>Connection broke Not reported</td>
</tr>
<tr>
<td>801208</td>
<td>TB 8</td>
<td>15°</td>
<td>96 (60)</td>
<td>VW Golf (Rabbit)</td>
<td>1020 (2247)</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>810127</td>
<td>TB 9</td>
<td>25°</td>
<td>96 (60)</td>
<td>Tornado</td>
<td>2040 (4493)</td>
<td>Connection broke Not reported</td>
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<tr>
<td>810128</td>
<td>TB 10</td>
<td>25°</td>
<td>75 (47)</td>
<td>Volvo</td>
<td>900 (343)</td>
<td>- &quot; -</td>
</tr>
<tr>
<td>1981-02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>810225</td>
<td>TB 11</td>
<td>25°</td>
<td>96 (60)</td>
<td>Buic Skylark</td>
<td>2040 (4493)</td>
<td></td>
</tr>
</tbody>
</table>

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TEST PROCEDURE

All tests were made at VTI's outdoor track. The vehicles were towed by the electric propulsion system and released from the tow cable 10 m before impact. Impact speed was measured by trap switches and photocells immediately before impact. High speed 16 mm films were taken from 3 directions at a speed of 250 fps. Higher speeds were not possible due to bad weather conditions. Hand-held real-time movie cameras and still cameras were also used.

The barrier was mounted on a flat asphalt surface. The barrier consisted of 25 blocks (= 50 m) and the impact point was situated 5 blocks (= 10 m) from the end. Ice and snow were removed from vital parts of the test area.

Apart from the anchoring chain for the tow cable no special arrangements were made to the vehicles.
RESULTS

6.1 Test TB 8  (Fig. 5-8)

A 1020 kg (2247 lb) Volkswagen Golf (Rabbit) impacted the barrier at 15° and 96 kmph (60 mph). Two dummies were belted as ballast in the front seat.

After impact the vehicle was airborne for about 14 m with no roll motion. The front wheels left the ground approx 0.3 m and the rear of the vehicle was approx 1.0 m from the ground when the vehicle landed. The vehicle followed parallel to, and in touch with, the barrier for 40 m where the barrier ended. Then the vehicle turned to the left, skidded into a pile of frozen gravel and stopped.

Damage to the vehicle was concentrated to the left front wheel which was destroyed. There was also minor damage to the left side and the left rear wheel. The rear door opened during impact. At the secondary impact with the frozen gravel the right front wheel was destroyed.

The impact block was displaced 5 cm and was slightly damaged at the base.
Fig. 5 Sequence photographs of test TB 8
Fig. 6  Sequence photographs of test TB 8

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Fig. 7  Test TB 8. Vehicle pre-test configuration

Fig. 8  Test TB 8. Vehicle post-test configuration

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6.2 Test TB 10 Fig. 9-12

A 900 kg (1,982 lb) Volvo 343 impacted the barrier at 25° and 75 kmph (47 mph).

After impact the left front wheel followed the barrier almost to the top. The left rear wheel followed to half the height of the barrier. Then the vehicle was airborne for approx 10 m with an approx roll angle of 10°. When it landed the outermost part of the vehicle was less than 3 m from the barrier. 14 m after impact the vehicle impacted the barrier again and followed close and parallel to the barrier until it ended 40 m from impact. Speed was then very low and the vehicle turned around the end of the barrier and stopped.

Damage to the vehicle was concentrated to the left front part. The left front wheel was destroyed, the radiator leaked water and the bonnet was out of position.

The impacted block was displaced 10 cm and the adjacent ones were displaced 5 cm. There was no damage to the barrier.
Fig. 9 Sequence photographs of test TB 10
Fig. 10 Sequence photographs of test TB 10
Fig. 11 Test TB 10. Vehicle pre-test configuration

Fig. 12 Test TB 10. Vehicle post-test configuration

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A 2040 kg (4493 lb) Buic Skylark (1971) impacted the barrier at 25° and 96 kmph (60 mph). Four dummies were belted in the vehicle as ballast.

After impact the left wheels climbed over the barrier to a roll angle of approx 45°. The vehicle was then airborne and turned approx 90° before it landed sideways close to the barrier approx 20 m after impact. During this motion only the left rear wheel passed the centerline of the barrier and the right front wheel was very close to or in contact with the ground all the time. When the vehicle landed it skidded without any tendency to roll over on the wet surface and finally stopped in the snow.

Damage to the vehicle was concentrated to the left front part with the left front wheel totally destroyed. The body of the vehicle was also deformed so that the front doors were jammed.

Barrier configuration after impact was as follows:

<table>
<thead>
<tr>
<th>Bloc No.</th>
<th>Displacement</th>
<th>Damage</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>-2</td>
<td>0 cm</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>-1</td>
<td>25 cm</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>60 cm</td>
<td>Replace</td>
<td>First impact</td>
</tr>
<tr>
<td>+1</td>
<td>90 cm</td>
<td>Replace</td>
<td></td>
</tr>
<tr>
<td>+2</td>
<td>90 cm</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>+3</td>
<td>55 cm</td>
<td>None</td>
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<tr>
<td>+4</td>
<td>20 cm</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>+5</td>
<td>0 cm</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 13 Sequence photographs of test TB 11
Fig. 14 Sequence photographs of test TB 11 (continued)
Fig. 15 Sequence photographs of test TB 11
Fig. 16 Sequence photographs of test TB 11 (continued)
Fig. 17 Test TB 11. Vehicle pre-test configuration

Fig. 18 Test TB 11. Vehicle post-test configuration
Fig. 19 Test TB 11. Barrier damage

Fig. 20 Test TB 11. Barrier after impact

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6.4 Tests TB 4 and TB 6

The intention of these tests was to check the propulsion system. The cars were so heavily ballasted that it is doubtful if the impact performance can be regarded as typical. However, at these tests there were no conflicts with the requirements discussed above (fig. 21, 22).

6.5 Tests TB 7 and TB 9

In these tests with the heavy vehicles and the extreme impact conditions the connection between the blocks broke. The behaviour of the cars was, however, within the general requirements.

Before the last test, TB 11, with this extreme impact condition the connection system was completely redesigned.
Fig. 21  Sequence photographs of test TB 4

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Fig. 22 Sequence photographs of test TB 6

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CONCLUSIONS

The new design of the Tric-Bloc system constitutes a major improvement compared to the old design. The structural adequacy and the vehicle trajectory hazard requirements as specified in the USA seem to be met. Impact severity requirements were not measured in these tests but it is our opinion that the impact severity probably is lower than with non-deforming concrete barriers.

Installation and maintenance cost and practical aspects from the use of the Tric-Bloc have not been considered. With the present knowledge of the crash-performance it is our opinion that it would be valuable to have the complete system tested in practice as an alternative to rigid concrete median barriers and also as temporary barriers.
REFERENCES


/6/ Recommended procedures for vehicle crash testing of highway appurtenances. Transportation Research Circular No. 191 (1978).