Concrete Step Barrier Design Guidance
CSB: Early Traffic Loading

APPLICATIONS

- **Traffic Management**

Design Guidance Notes

Traffic Management and Construction

Construction of the concrete step barrier is a high output automated process using slip forming techniques. Typically 250 to 400 m of standard profile CSB can be laid in an eight hour shift. This would reduce to 150-300 m for the WCSB.

Within 24 hours of construction the newly formed concrete is provided with a saw cuts at a spacing of 3 m to significantly reduce the tendency for random cracking of the barrier. Once installed the barrier should requires no future maintenance.

The barrier will usually be laid on an existing motorway with a high vehicle usage (>25,000 vehicles per day) requiring 2 lanes of motorway on one side of the barrier and a 1 m strip on the other side to safely accommodate delivery vehicles and carry out the construction.

Whilst safety of the workforce is paramount, the early removal of traffic management to allow the motorway to be used at full lane capacity will provide significant benefit.

Figure 1

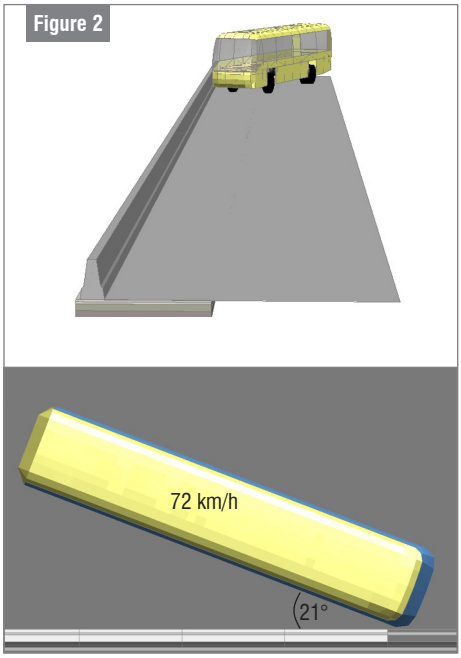
Traffic management during construction

Method

The relationship between barrier strength and containment performance was investigated at concrete strengths between 20-100% of the specified value using a finite element model of the TB 51 bus impact test.

The software used to calculate the results was LS-DYNA ®, a commercial nonlinear finite element code widely used for impact, crashworthiness and other types of simulations. The model (Figure 2) consists of the bus, CSB, road and foundation. The bus model was correlated to test, such that the predicted kinematic motion and force applied to the CSB were similar to those occurring in the physical crash test.

Figure 2



Model simulation layout

Analysis

To allow for variations in concrete behaviour, the simulation was carried out using pessimistic and realistic concrete properties for each considered concrete strength which were then compared to behaviour during test.

The pessimistic concrete properties included cracks at the saw-cut positions extending through the full thickness of the barrier, based on the assumption that full-depth shrinkage cracks would occur at every saw-cut. The model with realistic properties had no cracks.

The pessimistic concrete property predicted widespread cracking and deflections of the CSB that were not apparent during the physical crash test. Conversely the realistic properties, which had been derived from earlier models gave good agreement when directly compared to the physical test.

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Results

Results are summarized in Table 1

	Pessimistic model	Realistic model
Concrete strength (mm)	Final deflection (mm)	Final deflection (mm)
20%	failed	22
40%	306	5
60%	199	1
80%	145	0
100%	27	0

Table 1: Model predictions

The bus is predicted to be contained in every case, except for the most immature of the pessimistic model (20% strength). Given that the pessimistic model at 100% strength under-estimates the performance of the CSB, and that the bus is predicted to be contained in all cases at 40% of its design strength , it is concluded that this level represents a suitable minimum acceptance level for the removal of traffic management and exposing the barrier to traffic. The results from the realistic model suggest a strength as low as 20% would suffice. However, in the absence of full validation and to allow for variations in concrete quality the 40% intervention level appears reasonable. The extent of cracking at different stages of concrete maturity are illustrated in Figure 3.

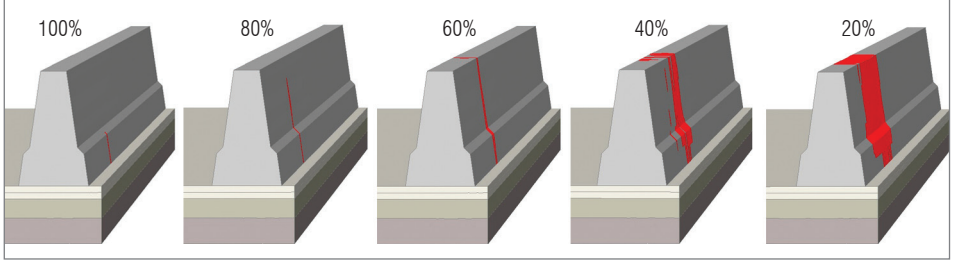
Conclusions

Immature CSB provides H2 containment (TB 51 coach test) when the concrete strength reaches 14 N/mm^2. (i.e. 40% of design strength). The deflection of the CSB in this case would be in the order of 5 mm. This therefore represents a suitable minimum level for which the barrier can be exposed to traffic.

It is likely that the bus would still be contained when the concrete strength is only 7 N/mm^2 although variability of concrete would not guarantee this.

Bus impact on immature CSB would probably cause visible cracking or other damage that may necessitate repair.

Figure 3



Realistic model results – cracked areas show in red

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