# **Concrete Step Barrier** Design Guidance
# CSB and the Road User

DRAWINGS CSB/002 CSB/1000

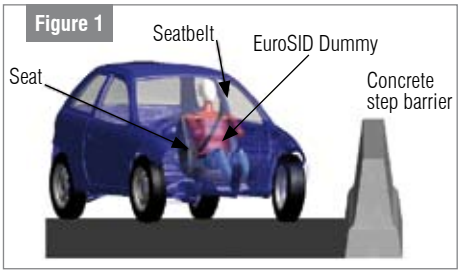
## APPLICATIONS

The CSB products illustrated on the Britpave drawings and described in these data sheets conform to BS EN 1317.

BS EN 1317[1] specifies physical crash tests for vehicles impacting at an angle of 20° to the barrier. These have been recreated in computer simulations to assess the likelihood and degree of injury sustained by occupants.

A computer model representing a car with BS EN 1317 TB11[2] initial conditions was generated. The computer simulation consisted of a vehicle model, a seat and seat belt, and a 50th percentile male EuroSID Dummy (Figure 1). CSB and the central reserve were modelled.

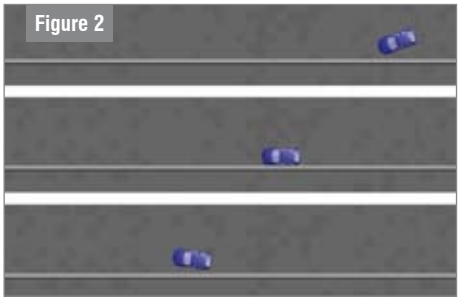
Figure 1




Model components

The computer model was correlated against the LIER CSB crash test see (Data Sheet DS/CSB/516) to increase confidence in subsequent predictions. The model was then used to predict results for impact with CSB. Simulations show that the car will be contained and redirected back to the highway from the face of the barrier (Figure 2) which correlates with observed results.

Figure 2



Vehicle contained and redirected

### Injury Predictions

In crash simulation tests a series of measurements are taken from the EuroSID dummy and compared to limits set out in ECE Regulation 95 for Lateral Collision Protection. In Table 1 below, the measurements recorded for the dummy in the simulation are compared against the injury criteria limits.

| Injury criterion | CSB | ECE R95 Limit |
|---|---|---|
| Head Injury Criterion (HIC) | 87 | 1000 |
| Viscous Criterion (m/s) (Chest Injury Predictor) | 0.1 | 1.0 |
| Rib Deflection (mm) (Chest Injury Predictor) | 19 | 42 |
| Pubic Symphysis Force (kN) (Pelvis I.P.) | 1.5 | 6 |

Table 1: Injury criteria limits

The injuries predicted by the computer simulation are very much lower than the ECE Regulation 95 limits. It is clear that injuries resulting from a BS EN 1317 type impact with the CSB are very unlikely to be serious. Table 2 below shows a summary of the probability of injury from impact with CSB using the abbreviated injury scale (AIS).

| Area of the Body | Probability of AIS 2+ (Moderate) | Probability of AIS 3+ (Serious) |
|---|---|---|
| Head | 0.2% | 0.003% |
| Chest | - | 0.07% |
| Pelvis | 1.8% | 0.3% |

Table 2: Probability of injury from impact with CSB

[1] BS EN 1317-2: Road Restraint Systems. Performance classes, impact test acceptance criteria and test methods for safety barriers

[2] Concrete Barrier Studies: Injury Prediction for CSB, Arup, 2006.

[3] Concrete Step Barrier Studies. Initial Estimates of Implications for Injury and Comparison with Steel Barriers. Arup, 2005.

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Figures 3a to 3d show motion of the dummy during the simulation. As the vehicle impacts the barrier it decelerates and its speed reduces. The dummy continues to move inside the vehicle at its initial speed. The speed difference results in the dummy's head impacting the cantrail and then its chest impacting the door. This causes the dummy to decelerate to the new speed of the vehicle. The dummy then begins to rebound back into its seat. The likelihood of injury resulting from the crash is very low and is of similar nature to that with deformable steel barriers.

The Study drew the following conclusions

- All the injury criteria resulting from the BS EN 1317 impact with the CSB are predicted to be very low compared to the limits set in ECE Regulation 95 for vehicle crash worthiness performance in a side impact.
- Based on published statistical injury models, the probability of AIS 2+ (Abbreviated Injury Scale - moderate) injury to the head and pelvis is negligible, and the probability of AIS 3+ (serious) injury to the chest is also negligible. A statistical model for AIS 2+ injury to the chest was not available.
- Risk of injury due to failure of containment, excessive barrier deflection allowing interaction with vehicles on the other carriageway and loss of control of the vehicle on soft verges, etc is eliminated by CSB.

## Comparison Between CSB and Steel Barriers

Collision between vehicles and CSB shows greater Accident Severity Index (ASI 1.4) than collision with deformable steel barriers, but studies have shown ASI is not directly relevant to injury[3]. The most relevant data is the THIV (theoretical impact velocity of the occupant on the inside of the vehicle), for which comparisons are available with steel barriers used in the UK. On this basis, the potential for injury in impacts with CSB is not significantly different from that with steel barriers. A similar conclusion is reached from comparison with Occupant Impact Velocity (OIV) data from American W-section barriers. In addition, in assessing overall risk of injury, other factors should be taken into account such as the higher containment level of CSB and hence reduced risk of injury due to crossover accidents.

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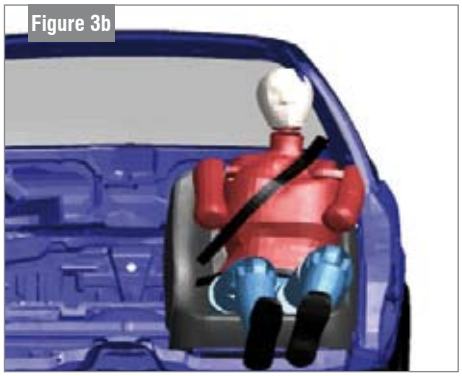

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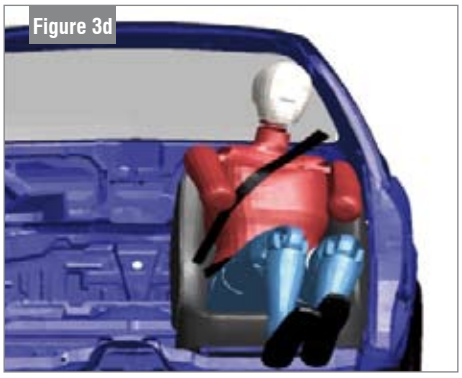

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