Concrete Step Barrier Design Guidance

CSB: Controlling, Monitoring and Repair of Cracks

DRAWINGS CSB/002

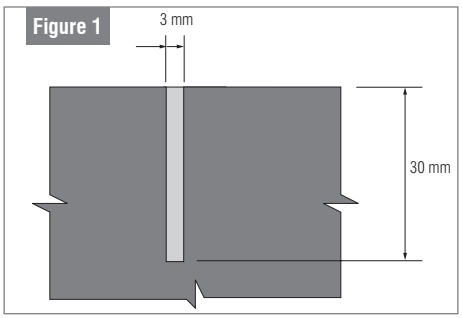
APPLICATIONS

- **Measures to control cracking**
- **Limit of acceptable crack width and frequency**
- **Measurement of crack widths**

Measures to Control Cracking

Early thermal shrinkage during curing and thermal expansion / contraction and shrinkage after curing is likely to lead to random and irregular crack patterns unless adequate measures are taken. These cracks may affect the structural integrity and durability of the barrier and would be considered unsightly.

The probability of random and irregular cracking occurring can be significantly reduced by inserting saw-cut joints at 3 m intervals to induce cracking (as applied to highway pavements). A typical saw-cut detail is indicated in Figure 1 (saw-cut 3 mm wide and 30 mm deep).



Saw-cut crack detail

The saw-cuts should be installed as soon as possible, after the concrete has hardened sufficiently to enable a sharp edged groove to be produced without disrupting the concrete, and before random cracks develop in the CSB. Where the CSB is cast on a rigid base, this must feature transverse joints at 3 m centres to coincide with the CSB saw-cuts. The application of curing compounds, to reduce the evaporation from the concrete surface, will also be of benefit.

Limits of Acceptable Crack Width and Frequency

To maintain the integrity of CSB as a barrier, the number and width of cracks should be limited.

To date, physical crash tests and computer simulations of CSB performance have assumed the inclusion of longitudinal reinforcement (either reinforcing bar or pre-stressing strand) which acts as part of the structure. As such, the reinforcement should be protected from corrosion. Structural design standards such as BS 5400-4[1] give a limit on crack widths of 0.15 mm for surfaces directly affected by de-icing salts. However, as the reinforcement in the CSB has a greater depth of cover than the nominal value assumed in the standard, the limiting crack width can be increased to 0.5 mm. Therefore a crack width of 0.5 mm should be considered to be the maximum for which no treatment is not required.

Crack width is the range of 0.5-3 mm require monitoring. However when these occure regularly (1 every 5 m or less) remedial action will be required.

For crack widths greater than 3 mm, the shear connection cannot be relied upon to provide sufficient load transfer along the barrier and performance may be impaired. Any sections of barrier cracked in this way should be repaired so that the structural integrity of the CSB is restored.

However, where cracks greater than 3 mm wide occur at intervals $>$ 60 m, the structural performance of the barrier will not be affected and no action is required.

Measured Crack Width x	Action
$x \leq 0.5$ mm	No Action
0.5 mm $< x \leq$ 3 mm	Non conformance report (NCR) required to identify the crack widths and to agree additional monitoring. Remedial action will be required within or adjacent bay where lighting column is fixed or when more frequent than 5 m
$x >$ 3 mm	Non-Conformance Report (NCR) required. Cracks should be filled with a non-shrink cementitious grout or suitable epoxy resin crack filler.

Table1: Limits of acceptable crack width and associated treatments.

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Measurement of Crack Widths

As the CSB experiences thermal variations, the cracks will distribute themselves more evenly along the length of the barrier. Therefore cracks might not form at the crack inducers immediately after casting but may form at a later stage. This may also mean that cracks that are initially wider than 3 mm, may reduce over time.

Due to the thermal contraction of the barrier, the cracks will be widest at low temperatures. This means that even if the cracks are measured as less than 3 mm during the summer, they may become wider than 3 mm during the winter.

Therefore the optimum time to measure the cracks is after a full thermal cycle has been completed (i.e. a winter and summer have passed since construction) and at the lowest expected temperature for the region. However, it is accepted that this may not be achievable under contract conditions and as such it is the designer's responsibility to ensure that temperature and time since casting are taken into consideration when assessing crack widths.

Method of Crack Repair

The insertion of saw-cuts to induce cracking at known and regular intervals should ensure that cracking in other locations is reduced in frequency and width. Nevertheless, all cracks should be assessed for severity in accordance with Table 1, and the appropriate remedial action taken.

Where cracking requires remedial action to be taken, a non-conformance report (NCR) should be prepared and the appropriate action agreed as outlined in Table 1.

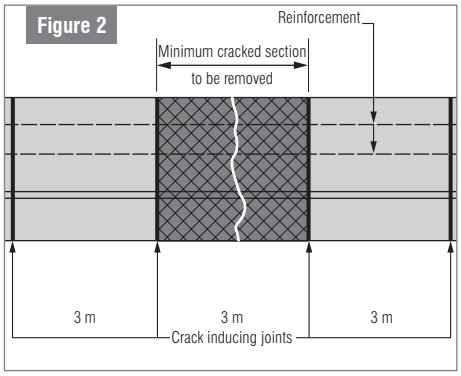
Where the cracks are to be sealed, or filled, this should be carried out using non-shrink cementitious grout or a suitable epoxy resin crack filler.

Where more than 20% of a section between two crack inducers is affected by cracking, it is considered to be 'extensive' (see BD 63[2]). In this instance the entire section between two crack inducers should be removed and recast. There may also be situations where less than 20% of a section is affected by cracking but it is more economical to replace the section than to fill the cracks individually.

Where the removal and recasting of a section is necessary, the process is described below and shown in Figures 2 and 3:

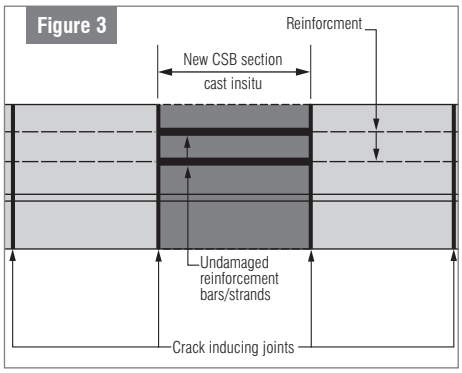
- Re-saw existing saw-cut to a depth of 100 mm, to ensure a clean edge.
- Break out concrete, ensuring that the reinforcement remains undamaged. An uneven finish should be left to the majority of the cross-section, to enable a good shear connection with the new concrete.
- If the reinforcement has been damaged, replace reinforcement over the full of length of removed barrier.
- Reinforcement should be drilled and fixed into the adjacent CSB, with the lap then welded in accordance with the standard detail on CSB/010. Alternatively a mechanical coupler can be used, as specified in Clause 3.6 of CSB/002.
- Cast in new section of barrier to the CSB profile.
- Saw-cut crack inducing joints to match the existing appearance of the barrier.

Figure 2



Minimum length of CSB to be replaced

Figure 3



Minimum length of CSB to be replaced

[1] BS 5400-4 Code of practice for concrete bridges
[2] BD 63 Inspection of Highway Structures

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