Reference: CPD Supporting Document | Steel Framed Buildings and Precast Floors

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Introduction:

This document has been produced to support Beresford's Flooring Limited certified CPD Seminar "Good Practice When Specifying Hollowcore Flooring onto Steel Framed Buildings" which was created to promote hollowcore flooring from design through to installation. BFL have worked closely with all the major manufacturers of hollowcore flooring for more than 35 years and this CPD offers a non-biased view on the variances to consider.

BFL have over 100 standard details with regards steel beams and hollowcore flooring which have been developed over the last 20 years.

Background:

The following information covers some of the key design topics covered within CPD and is intended as a guide only, which represents our interpretation of relevant codes and standards.

Topics Covered

- Composite Steel Beam Design with Hollowcore Floors
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- Progressive Collapse Classification 2B (Steel Frame and Hollowcore Floors)
- Progressive Collapse Classification 2B (Steel Frame and Hollowcore Floors)
- Diaphragm Action Without Structural Topping (Hollowcore Floors)

Composite Steel Beam Design:

Composite Internal Beams – Hollowcore Floors

In accordance with SCI Publication 287 and 401 shear studs are required to ensure composite action is achieved and centres are generally 150mm which interact with transverse reinforcement. The transverse reinforcement is generally 16mm Ø at 200mm to 350mm centres but this will depend on the hollowcore manufacturers core centres.

The overall slab depth to be considered in design is limited to 260mm and composite steel beam design can be achieved without a mesh reinforced structural topping being present (ie: hollowcore depth only).

With this design detail Progressive Collapse Class 2B would inherently be satisfied as the transverse reinforcement are providing a continuous tie over the support.

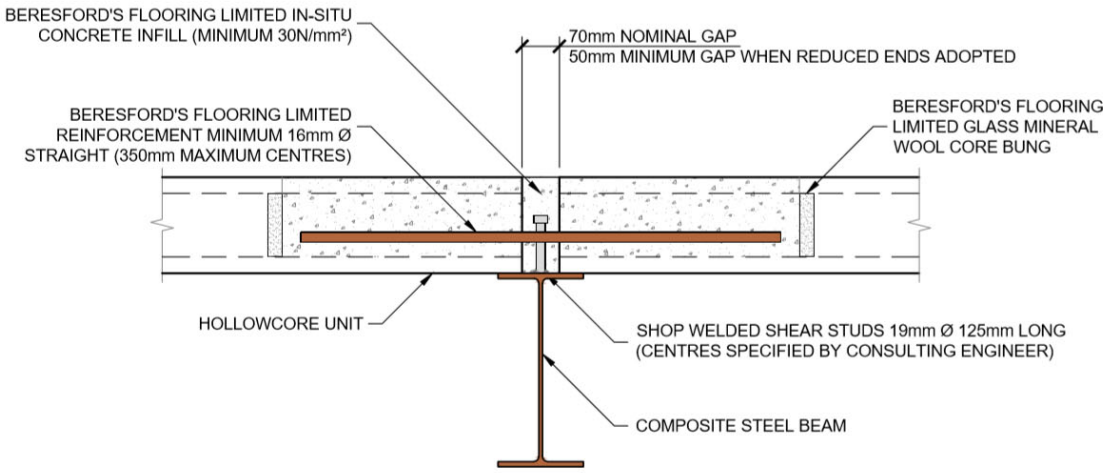

Fig 1. Typical Internal Beam Section – Composite

Composite Internal Beams – Solid Precast Floors

In accordance with SCI Publication 287 and 401 shear studs are required to ensure composite action is achieved and centres are generally 150mm which interact with transverse reinforcement. The transverse reinforcement is generally 10mm Ø at 300mm centres.

The overall slab depth to be considered in design is a minimum 150mm (75mm solid precast unit plus 75mm mesh reinforced structural topping).

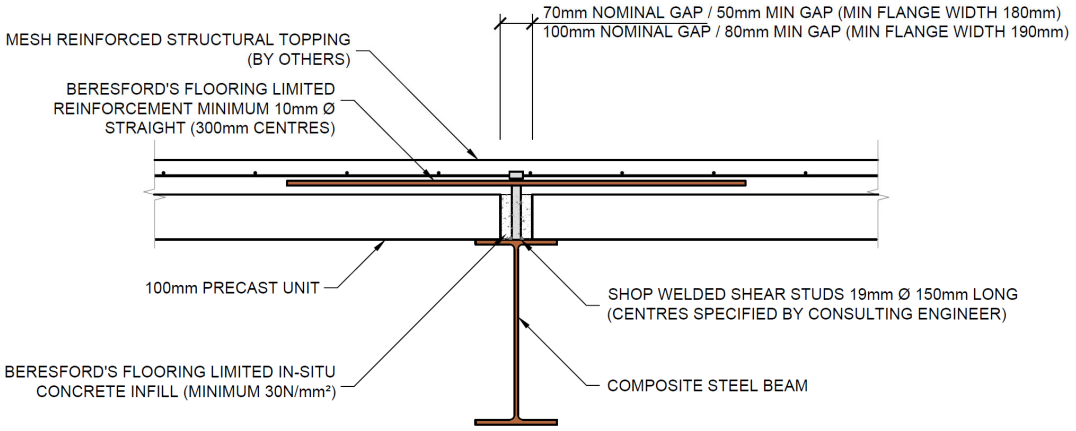

Fig 2. Typical Internal Beam Section – Composite

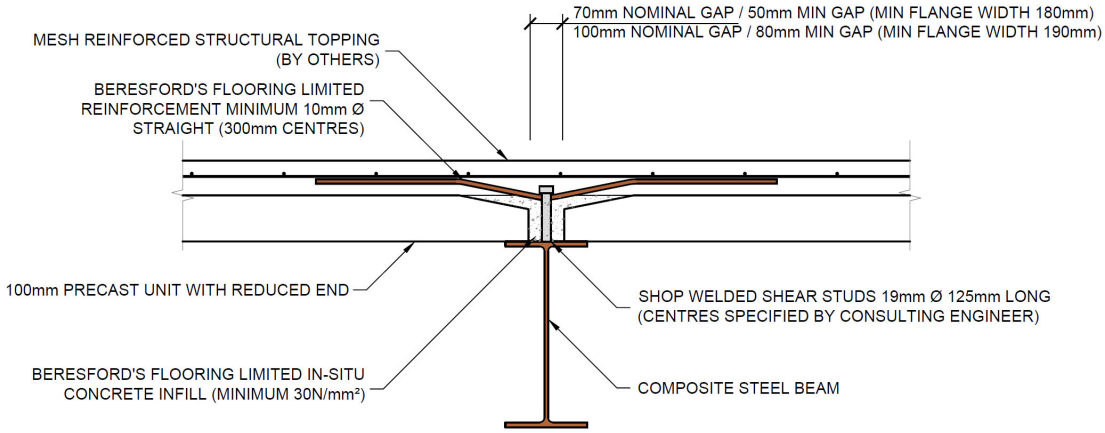

Fig 3. Typical Internal Beam Section – Composite

Because solid plank units are normally used with an in situ topping, both the secondary and primary beams may be assumed to act compositely with the slab (SCI Publication 287 Clause 3).

Composite Edge Beams

In accordance with SCI Publication 287 and 401 the minimum steel beam flange width is 210mm / 230mm and for this reason the composite approach is not normally adopted, as in most cases the non-composite steel size would be a smaller section size.

Progressive Collapse Classification 2B:

In accordance with Approved Document A horizontal ties are to be provided in accordance with relevant standards (EN 1990 / EN1992 / EN1993).

Further reading on this matter can be found within SCI Publication 341 (Guidance On Meeting The Robustness Requirements in Approved Document A) and SCI Publication 351 (Precast Concrete Floors in Steel Framed Buildings).

Albeit not directly related to steel framed buildings reference could also be made to PhD Paper titled "Effect of Floor-To-Floor Joint Design on the Robustness Of Precast Concrete Cross Wall Buildings" and the reason for referencing this is because within this paper there is extensive pull out testing relating to the behaviour of the bonded reinforcement within hollowcore open cores.

Our interpretation of these codes and standards is that with a steel framed building the peripheral ties are inherently provided by the three dimensional tied steel frame and subsequently the hollowcore floor units only has to be tied in the direction of its span (SCI Publication 341 5.2.5), either continuously over a support (internal beams) or anchored at support (edge beams).

According to SCI Publication 351 a T12 high yield reinforcement bar (with a yield strength of 500N/mm²) that is properly anchored will provide a tie capacity of approximately 49kN and a T16 bar will provide a tie capacity of approximately 87kN.

In most if not all cases where the internal beams are non-composite shear studs are not required as the horizontal tie is continuous over the support. The absence of shear studs also reduces the issue with eccentric loading from the hollowcore flooring when loaded on one side during construction, as it is not practical to stagger load the steel beams, this issue is also unavoidable at phased locations.

Internal Beams – Hollowcore Floors

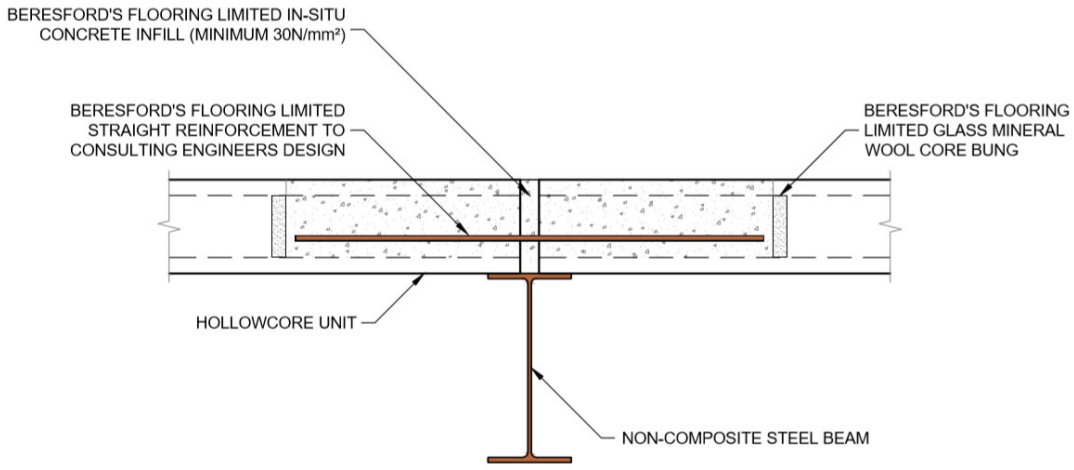

Fig 4. Typical Internal Beam Section – Non-Composite

Internal Beams – Solid Precast Floors

If the precast units have a structural topping, it may be possible to us the reinforcement in the topping to provide the required tying capacity, as shown in Figure 4.11 (SCI Publication 287) for downstand beams.

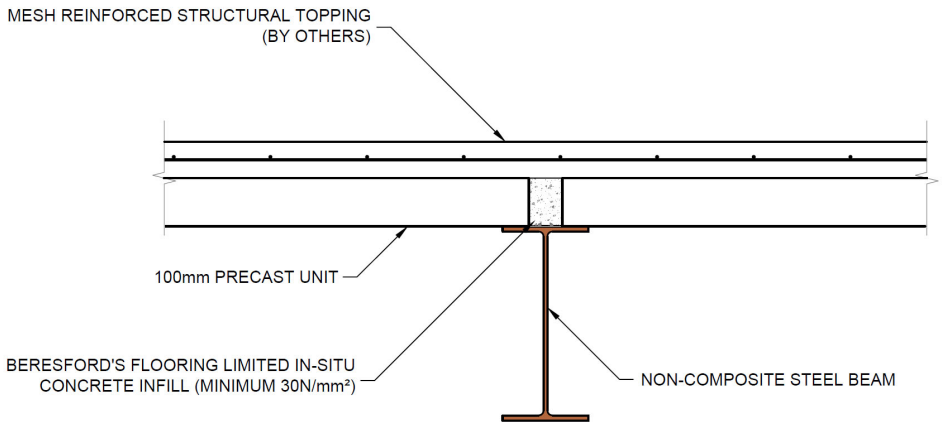

Fig 5. Typical Internal Beam Section – Non-Composite

Edge Beams – Hollowcore Floors

In all cases edge beams (end bearing condition only) require shear studs or welded cleats / lugs to ensure the horizontal tie is anchored at the support. There are two options with achieving this:

1) U-Bars around shear studs which are located during detail design stage with hollowcore manufacturer. Most hollowcore manufacturers have different core profiles and the location of shear studs needs to be coordinated with the final slab layout.

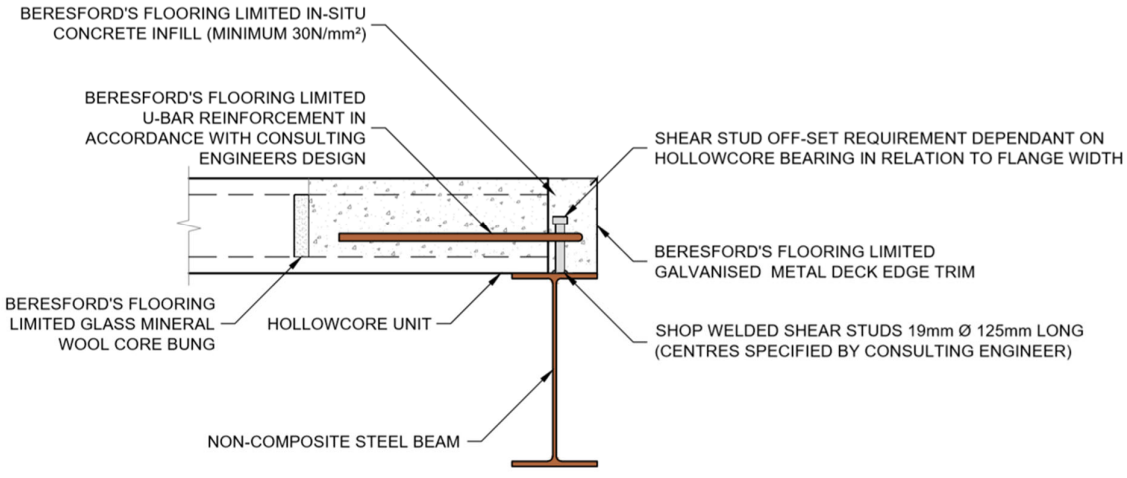

Fig 6. Typical Edge Beam Section – Non-Composite

2) L-Bars which lap around the shear stud and bond / locate along the length of the steel beam. The benefit of this approach is standard shear stud centres can be established at an earlier stage of the design process.

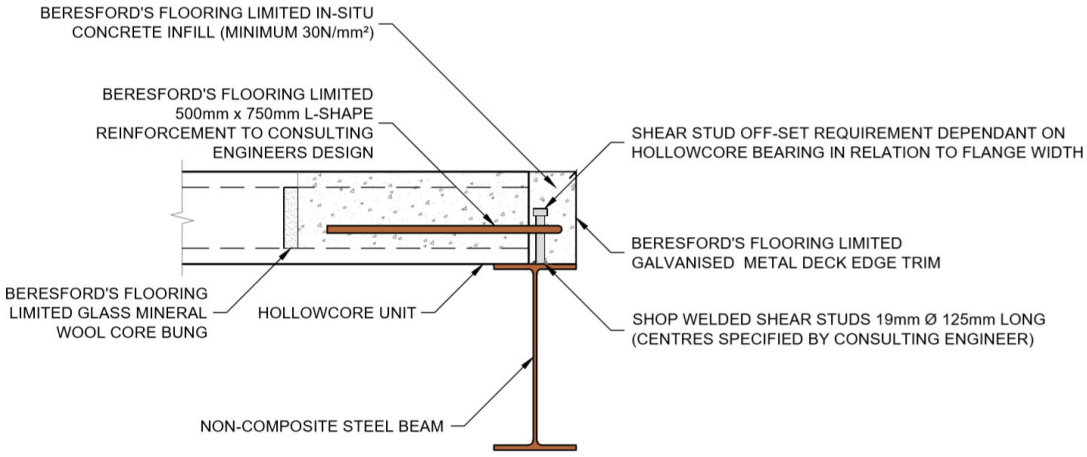

Fig 7. Typical Edge Beam Section – Non-Composite

Edge Beams – Solid Precast Floors

In all cases edge beams (end bearing condition only) require shear studs or welded cleats / lugs to ensure the horizontal tie is anchored at the support. There are two options with achieving this:

1) Where the shear stud does not protrude above the precast solid flooring unit U-Bars around shear studs.

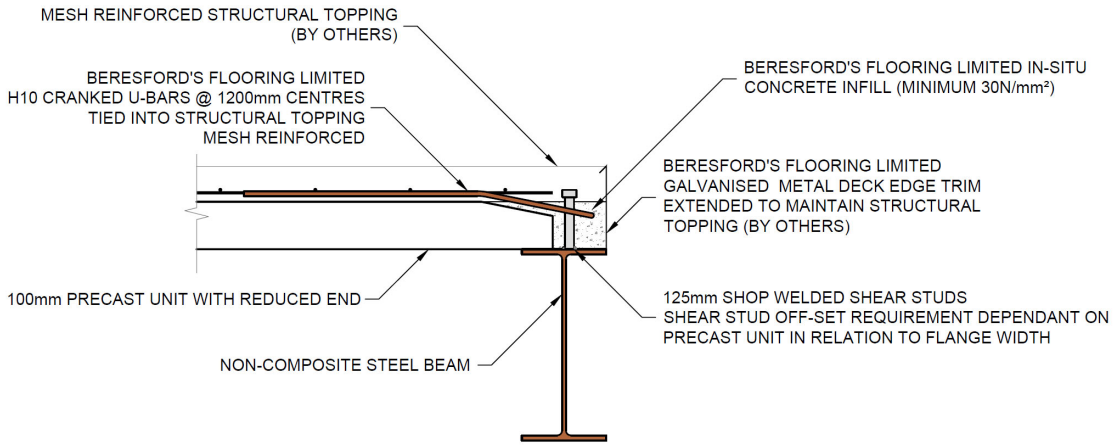

Fig 8. Typical Edge Beam Section – Non-Composite

2) Where the shear stud does protrude above the precast solid flooring unit the mesh reinforcement can be detailed as such that it wraps around the shear stud.

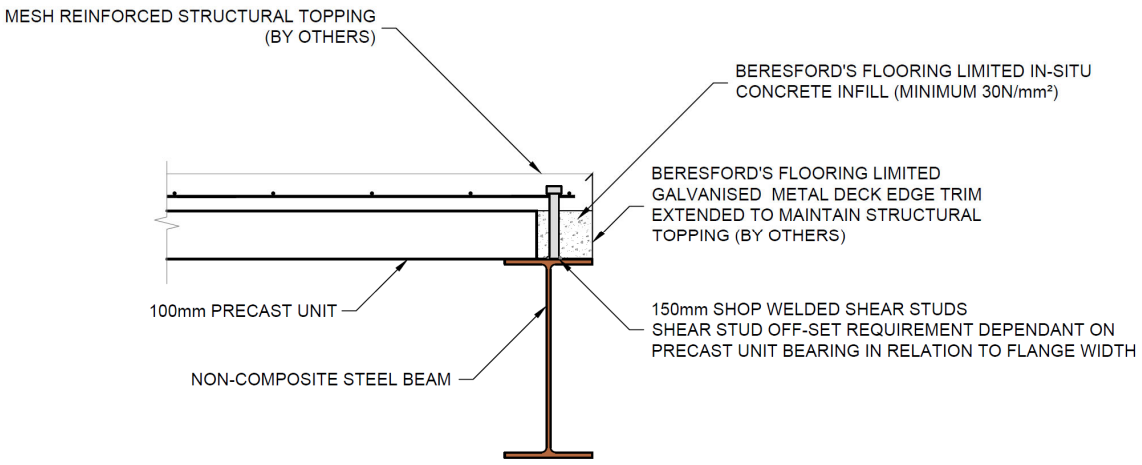

Fig 9. Typical Edge Beam Section – Non-Composite

Diaphragm Action Without Structural Topping (Hollowcore Flooring):

Structural stability is provided by the floor acting as a diaphragm transferring the forces to vertical walls and cores which resist the forces by racking. The use of hollowcore floors, without a mesh reinforced structural topping, requires a different approach than the normal floor system due to the lack of transverse reinforcement and the inclusion of joints between hollowcore floors at 1200mm centres. Within published paper titled "Horizontal Diaphragm Action in Precast Concrete Floors" (authors: G Davies, KS Elliott and Wahid Omar) it has been demonstrated that provided that a crack of not greater than 0.5mm does not develop, the longitudinal joint has a shear capacity of approximately 0.10N/mm² or greater.

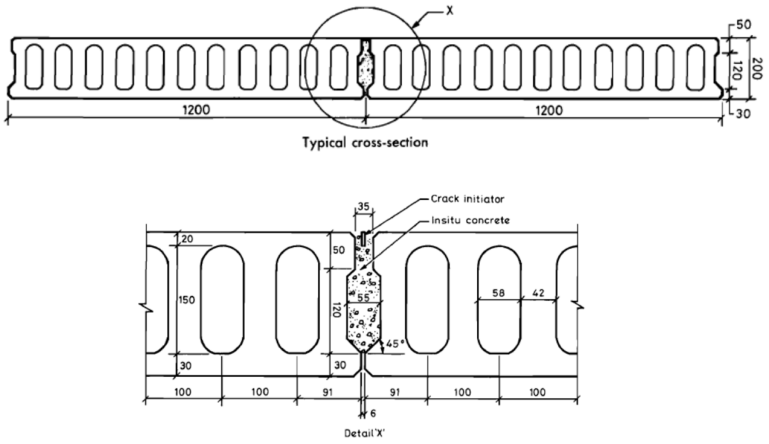

Fig 5. Cross-section of floor slabs

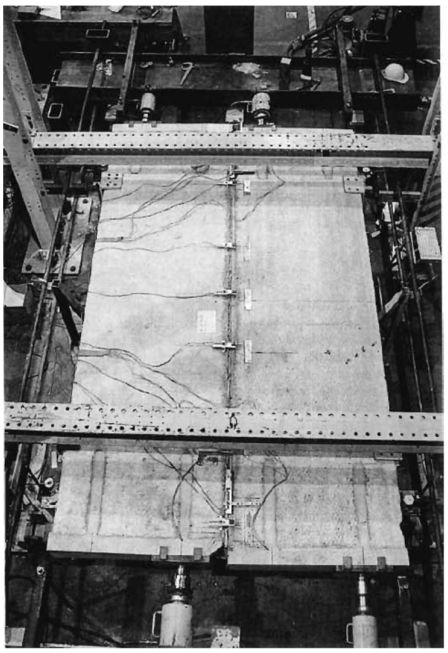

Fig 10. Test Slab Assembly

This approached has become widely used, particularly when a raised access floor is required as no wet finishing screeds are required.

Based on the tables and results contained within this paper it does indirectly highlight the importance of using high quality well compacted jointing concrete between hollowcore floor joints and around column locations. This ensures lateral forces are transferred between structural components to the vertical braced zones. As a minimum BFL use a minimum 30N/mm² concrete with a maximum 10mm aggregate.

Industry wide poor practice is to utilise site mixed concrete which is a practice BFL would not recommend.

Using substandard infill materials between hollowcore joints also breaches Robust Detail E-FC-4 and Building Regulations (Part B / Part E / Part F).

If a mesh reinforced structural topping was present then the diaphragm would clearly be enhanced.

End.

References:

- SCI Publication 341
- SCI Publication 351
- SCI Publication 287
- SCI Publication 401
- Approved Document A – The Building Regulations 2010
- Horizontal Diaphragm Action in Precast Concrete Floors" (authors: G Davies, KS Elliott and Wahid Omar)
- PhD Paper titled "Effect of Floor-To-Floor Joint Design on the Robustness Of Precast Concrete Cross Wall Buildings