STEEL INDUSTRY GUIDANCE NOTES

Shallow Floor Solutions in Steel

In some circumstances designers may be faced with the need to restrict the depth of beams. In multi-storey construction this may be due to planning height restrictions or in an attempt to include an extra floor within the same height of building. On other occasions, it could be a cost saving measure to save on expensive cladding material for the same number of storeys or when service penetration of the beam web is not appropriate. This briefing note aims to remind the designer that, whatever the reason, shallow floor solutions in steel are efficient, economic and programme efficient.

Columns for beams

Whilst UKC sections are not as efficient in bending as UKB sections, their design is straightforward. Web bearing and buckling at the supports is less likely due to the reduced web d/t ratios and lateral torsional buckling is less likely to govern design due to wider flanges providing greater lateral stiffness. Wider flanges may also benefit in supporting flooring units.

Connections

Shallow beams will reduce the space available to accommodate the bolts to carry end shear. Welded cleats offer one solution. Extending the connection below the beam depth with seating cleats is an option although a need to limit the connection to be within the beam depth may restrict this method. Designing frames with moment connections will reduce beam mid-span moments and deflection thereby enabling shallower beams to be used. Whilst full fixity at the connections may be unrealistic, some degree of continuity between beam and column can be achieved with thicker end plates. Careful analysis of the frame will be required since the principles of simple construction will not apply.

Slimflor

Slimflor beams were developed at the start of the 1990s as a means of containing the structure within the depth of the floor slab. By integrating the structure, floor-to-floor depths can be typically reduced by 300mm and, when multiplied by the number of storeys of a modest building, this leads to significant savings on cladding costs.

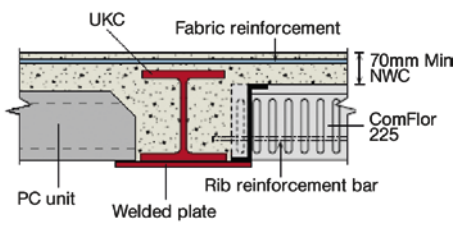

Figure 1 Slimflor with ComFlor 225 or PC Unit

A Slimflor beam is a fabrication typically consisting of a column section up to 305UKC with a 15mm plate, (Fig.1). The plate forms a 100mm outstand which accommodates bearing for the decking units, either PC units or ComFlor 225 “deep” metal decking. Deck spanning capability is enhanced with a structural topping (Fig. 1). The weld connecting the UKC and the plate is continuous, 8mm for PC unit and 6mm with ComFlor 225. These weld sizes are required for fire design purposes. 60 mins fire resistance period is easily achievable without additional fire protection. Slimflor beams can be non-composite or composite with the inclusion of a shear stud as shown in Fig. 2. Typical grid sizes for 5+1kN/m^2 loading, normal weight concrete with non-composite unpropped construction are 9.0m Slimflor beams (305UKC158) at 6.0m centres. Beam centres of up to 9.0m can be achieved with propping.

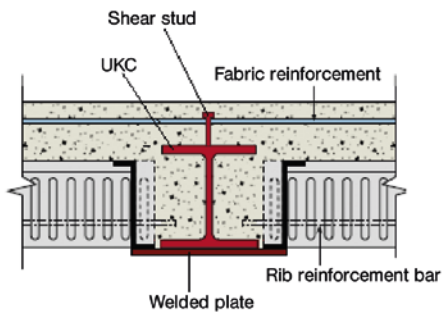

Figure 2 Composite Slimflor

A list of Slimflor beam section properties is printed in the Corus *Advance* sections brochure.

Slimdek

Slimdek (Fig.3) is a shallow floor system that incorporates a rolled Asymmetric Slimflor Beam (ASB) with ComFlor 225 metal decking. The ASB has thickened flanges to aid torsional stiffness and a patterned top flange to enhance composite action with the overlying concrete without the need for shear studs. Dynamic and static load tests have shown that a design shear bond of 0.6N/mm^2 may be developed around the top flange and pattern. ASBs are available in two depths, nominally 280 and 300mm deep, and a range of weights that enables an inherent 60 minutes fire resistance for some sizes

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(designated by FE). A T25 rebar is placed in the trough of the ComFlor 225 deck for the fire condition. Individually ASBs are able to span up to 10m and ComFlor 225 up to 6m with a live load of 4+1kN/m^2. Grids of 9m by 9m are achieved with propping. For both Slimflor and Slimdek there is no need for secondary members within the column grid.

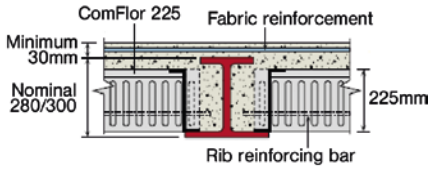

Figure 3 Slimdek

Ties are used where grid members span parallel to the decking units and should be designed assuming a 300/500mm wide UDL from floor loadings. The Slimdek Manual and associated design software, SIDS, is available from Corus.

Fabricated shallow beams

As with plate girders and cellular beams in downstand construction, shallow versions of fabricated beams can be sourced from various specialist suppliers. Whilst this may offer the designers an amount of flexibility due to bespoke manufacture, care is needed to ensure that claimed attributes of other shallow solutions, such as performance in fire or composite action, are supported by adequate test data. Designers also need to be aware of any limitations on minimum depth of plated beams imposed by the need for welding access.

Other considerations

Deflection: Shallow solutions may have reduced stiffness making deflection a consideration. Dead load deflections can be taken out by precambering the beam.

Weight: The raw steel in a typical multi-storey building represents approximately 2-3% of the total building cost. Any steel weight increase therefore represents a very small rise in total construction costs. This rise will be negated by the benefits of cladding cost savings.

Acoustics: Shallow floors and the associated grid dimensions make these solutions attractive in market sectors such as residential where acoustics is a key concern. Robust Details (RD) exist for many steel solutions therefore avoiding the need for precompletion testing. For non-RD, confidence can be gained from published acoustic test data that shows precompletion testing should be satisfied. Compliance with Building Regulations Part E is easily achievable.

Vibration: The NHS specification HTML 08-01 (previously HTML 2045) requires floors in theatres and sensitive areas to satisfy a response factor of less than 1.0. Steel frames, including shallow solutions, are able to satisfy this exacting requirement using design rules developed by the SCI. Post-fit out testing of several hospitals has proved that response factors of less than 1.0 have been achieved in the completed building.

Thermal mass: For a diurnal cycle, 100mm of slab depth is required to utilise thermal mass. This is within the capability of shallow steel solutions.

Product developments

Fig 4 shows a shallow floor made up of Slimflor beams manufactured from 152 or 203UKC and utilising the development of closed ends on the ComFlor 60 profile. Whilst the closed end acts to contain the concrete without the need for a diaphragm it also acts as an effective fire and acoustic stop. This detail is capable of deck spans up to 4.5m with a slab depth circa 150 to 240mm dependant on the section weight.

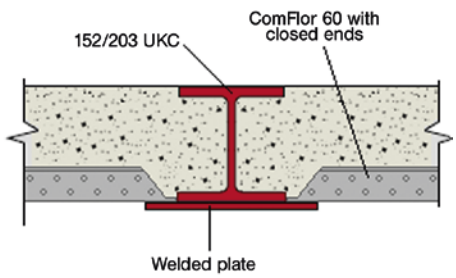

Figure 4 Slimflor using ComFlor 60 with closed end

Note that Figs 1 to 4 are indicative of construction details. Refer to the further sources of information for full details.

The Corus Advance range of sections (UKB, UKC, etc) encompasses all the UB,UC, etc sections in BS4-1:2005. The dimensions and properties of the Advance sections are the same as those of the corresponding British Standard sections and the same standards for dimensional tolerance apply. The Advance range also includes additional beam and column sections not in BS4-1:2005.

Key Points

- Several shallow steel solutions are available allowing engineers to choose the most appropriate.
- Shallow steel solutions offer cost savings on cladding.
- Shallow Steel solutions offer effective floors for residential buildings.
- Acoustic, vibration and thermal mass considerations are easily catered for with shallow steel solutions.

Further Sources of Information

1. Joints in Steel Construction: Moment Connections, BCSA/SCI 207/95.

2. Slimdek Manual, available from the Corus Technical Hotline 01724 405060.

3. Design of Slimflor Fabricated Beams Using Deep Composite Decking, SCI-P248.

4. Design of Floors for Vibration: A new Approach, SCI-P342.

5. Acoustic Detailing for Steel Construction, SCI-P372.

6. Slimdek CAD detail and SIDS software are available from www.corusconstruction.com

7. Sustainability and Thermal Mass information is available at www.corusconstruction.com