Long span composite beams

The introduction of steel composite design into the UK provided the specifier with an array of new possibilities. Not only was it possible to design shallower floors, but specifiers could now offer long span solutions with real tangible benefits for both the client and the end-user. Today, it is estimated that around 35% of steel-framed buildings incorporate long spans in excess of 12m. This guidance note reminds designers of the benefits of long span composite construction.

Why long span?
The principal benefit of a long span floor is column free space and the ease with which the interiors can be changed giving the building a longer life. Perhaps more important now in this age of sustainable development. There are also other secondary benefits. Compared to typical short span schemes long span solutions have fewer pieces. That means fewer connections, and so fabrication and erection times are reduced. Long span beams have more favourable H/A ratios (section factor) and are often more cost effective to fire protect. Furthermore, all long span solutions have the ability to accommodate services within the structural zone. Studies show that in a long span building where structure and service zones are combined, that the increased cost is less than 1% compared to the short span equivalent.

What are the options?
The composite revolution of the 1980s created an environment of experimentation within the consulting engineering sector. Engineers explored various long span structural schemes with integrated services. These included simple downstand composite beams with web penetrations, composite trusses, stub girders, tapered plate girders, the parallel beam approach, etc. Each of these solutions had its merits, all were used successfully, and all have relevance today. However in the 1990s the cellular beam, which replaced the castellated beam, gained prominence. Cellular beams are now estimated to have an 80% share of the long span market and are used in more than half the car parks built each year in the UK. This dominance is due to several factors including:

1. Compared to the other long span alternatives, the fabrication content is significantly less.
2. Asymmetric cellular beams allow greater design economy.
3. Regular service holes allow greater flexibility for service integration.

What constitutes a long span floor?
For the purpose of this guidance note long spans are considered to be in the range of 12m to 18m. Composite action between the concrete floor slab and the steel beam is achieved using shear studs welded to the top flange of the beam.

For short to medium spans a downstand composite UKB often provides the most cost effective solution. This approach uses standard components and products with which the industry is familiar. In the 10m to 12m span range this traditional solution starts to lose ground to cellular beam solutions but the precise point is dependent on weight savings compared with the manufacturing cost of a cellular beam. This can be further complicated by the need for service integration.

At spans up to 18m, economic, strength-governed solutions, are possible. Beyond 18m serviceability criteria will have an increasingly significant influence on design.

Long span primary or long span secondary, what's the answer?
In the case of cellular beam solutions, if minimum depth is key, the long span secondary approach will always yield the shallowest option. An efficient strength-driven design typically has a span/depth of 20 to 25. If depth is critical the ratio can rise to 35 plus, but at the expense of weight, as the design becomes serviceability driven. Therefore for a 15m long span the designer can consider a depth range of 400 - 750mm. Other benefits, compared to a long span primary option, include a lower piece count leading to quicker fabrication and erection.

The long span primary option offers a different kind of flexibility. Primary beams are more heavily loaded and rather than a UDL the load is applied as a series of point loads. Therefore there is limited scope for variation on depth. Shear and vierendeel effects become more significant and so typical span/depth ratios tend to be between 20 and 25. However, the greater spacing between the primaries and the differential beam depth between the deeper primary beams and the shallower
Further sources of Information

1. Supporting the commercial decision (Corus publication)
2. Design of Steel-Framed Buildings for service integration (SCI P166)
4. Composite Slabs and Beams Using Steel Decking: Best Practice for Design and Construction (SCI P300)
5. Precast Concrete Floors in Steel-Framed Building (SCI P351)
6. Fire Safe Design: A New Approach
7. Cellular beam manufacturers’ websites
   a. Fabsec: http://www.fabsec.co.uk/
   b. Westok: http://www.westok.co.uk/website