STEEL INSIGHT #08

MULTI-STOREY COMMERCIAL BUILDINGS

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When planning and costing a multi-storey commercial building, considering site-specific factors can be key to choosing the right structural frame

01 | Introduction

Previous Steel Insights have provided general guidance for quantity surveyors when cost planning structural steel-framed buildings, along with a detailed study of two typical commercial buildings, to explore not only the cost but also the programme and sustainability benefits of structural steel solutions. Recent articles have focused on education, industrial and healthcare buildings.

This article continues the sector focus with multi-storey commercial buildings, a key sector for structural steelwork, together with a commentary on the related subject of fire protection. The latest Construction Markets annual survey commissioned by the BCSA and Tata Steel shows that in 2012 steel frames accounted for 67.1% of all non-domestic framed multi-storey construction in the UK (see Figure 1) and for 70.4% of the multi-storey offices market compared with a market share of 21% for insitu concrete.

It is important to make a distinction between "multi-storey" and "tall" buildings. "Multi-storey" typically describes buildings of between five and 15 storeys, whereas in the UK, "tall" generally exceeds 20 storeys. Tall buildings were examined in some detail in Article 4 of this series.

This article will conclude with the cost models for all building types, including updated location indices and a forward view of the market through the remainder of 2013.

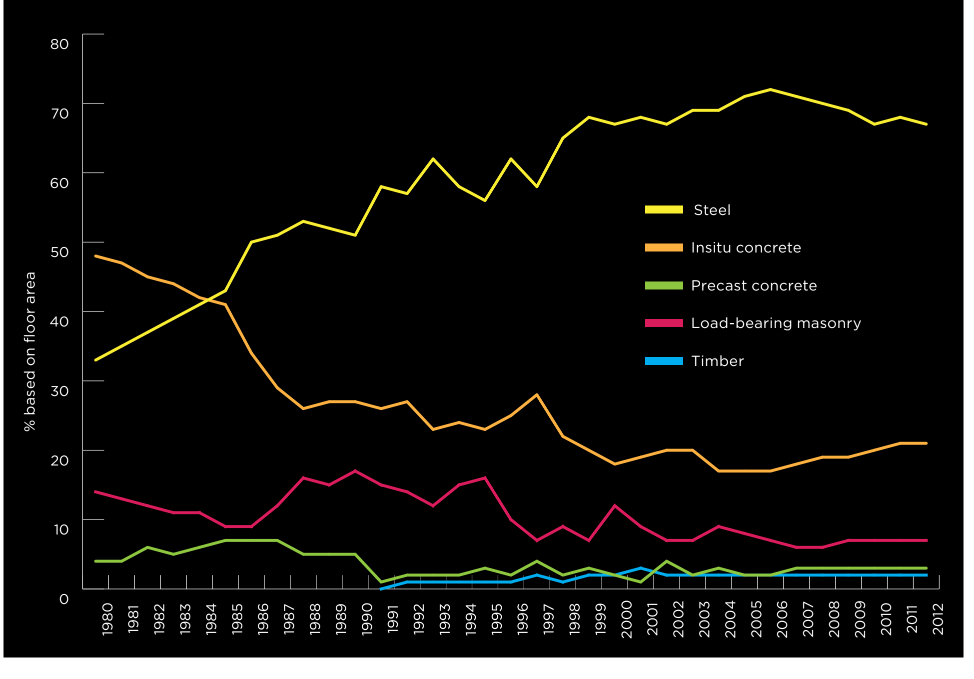
02 | Typical multi-storey buildings (5-15 storeys)

Multi-storey commercial buildings are a typical feature of city centre construction. They are often speculative, where no specific tenant or purchaser is involved in or influences the design process, and they may also contain elements of retail space at lower levels.

The speculative nature of these buildings means that flexibility to meet the needs of a range of different tenants and also provide attractive space is very important. This will typically require the provision of open-plan, lettable floor areas, maximised floor-to-ceiling heights and efficient services zones, requirements that directly impact on the configuration of the structural frame.

The majority of multi-storey commercial buildings are constructed in city centre or constrained site locations, so party wall, Rights of Light and oversailing issues are particular considerations. The project-specific site constraints will impact on the development of the achievable building form and structural frame at the design stages and will also have a direct impact on logistics and buildability during construction.

FIGURE 1: CONSTRUCTION MARKETS SURVEY DATA (2012)



03 | Multi-storey commercial - Structural steel frames

For typical city centre, multi-storey commercial buildings, with the requirement to provide open-plan, flexible space and a generous floor-to-ceiling height, it is common for a long span structural steel frame to be adopted. This provides a largely column free internal space and maximum floor plate flexibility.

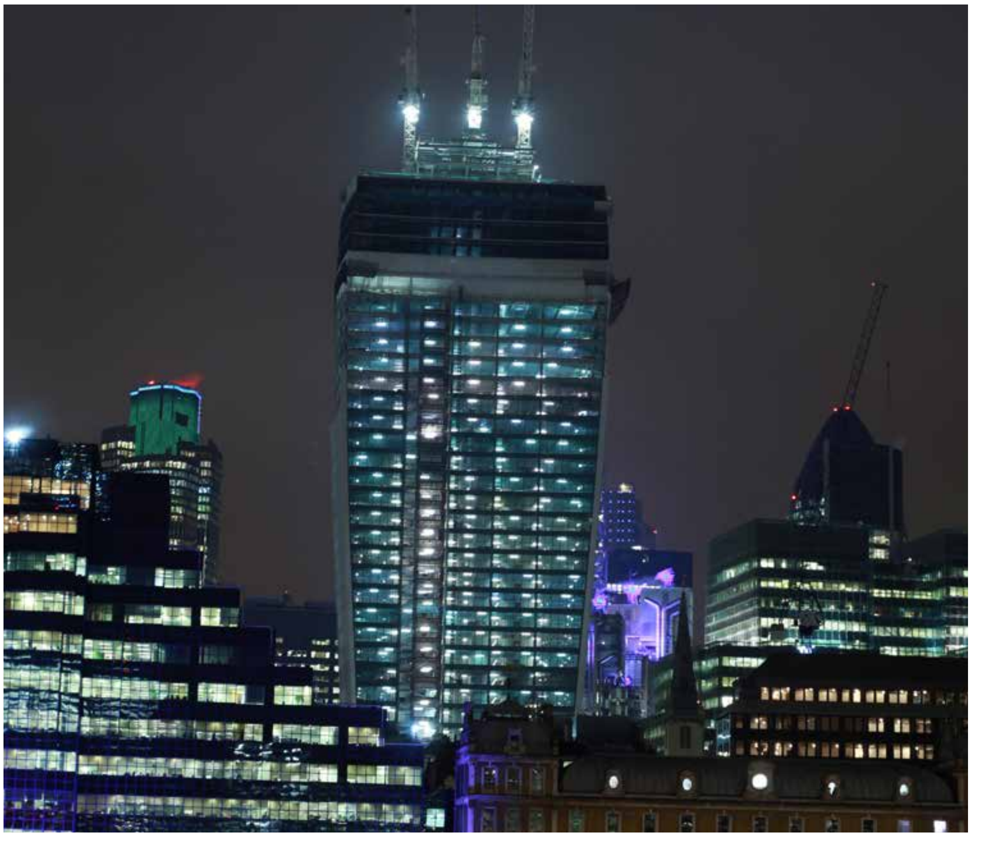
To maximise floor-to-ceiling heights while minimising impact on building height, long span cellular beams with service integration are typically used. Regular web openings in the beams provide flexibility in the initial Cat A services fit-out and tenant fit-out.

While column free space and a long span grid is a typical requirement for city centre

commercial buildings, a 7-9m standard grid may be adequate to provide the floor plate flexibility and lettable space required for out of town, multi-storey office buildings.

Standard steel construction brings programme benefits over other frame types through a quicker erection time on-site. It can also bring benefits in the substructure construction due to typically lighter frame weights than concrete frames. Common floor systems in the commercial office sector (composite metal deck with a concrete topping or precast concrete planks) are compatible with standard steel construction and are supported on downstand beams, allowing services to be suspended from the soffit of the floor slab and distributed with flexibility within each structural bay.

For multi-storey commercial office buildings with a standard 7-9m repetitive grid and, for example, five or six storeys, the steel frame cost range is typically £75-£100 per m² GIFA (BCIS location index 100) assuming a frame weight of around 55kg/m² GIFA. If the building is higher rise or uses a long span cellular beam solution, the cost range for Frame Type 2 of £125-£150 per m² GIFA at BCIS location index 100 for a frame weight of around 70-75kg/m² will be appropriate due to the higher frame weight.



04 | Key cost drivers for multi-storey buildings

As the design develops and the costing methodology progresses to quantifying and costing the specific building design rather than utilising typical cost ranges, key cost drivers remain important for making sure a realistic cost is included within cost plans and also to enable the design team and client to understand how building-specific factors have influenced the structural frame cost in relation to benchmarked schemes.

In particular, **location and site constraints** are key cost drivers as the site will influence the achievable design and the costs of construction. This is particularly relevant to the multi-storey commercial sector as construction typically occurs on previously developed sites in city centre locations which, as well as impacting on design, can impact on construction methodology and programme with limitations on noise, deliveries and working hours and limits on storage and craneage. Even where two proposed buildings have a similar frame design, the logistics and access arrangements may vary significantly.

The erection of the steel frame typically accounts for around 10-15% of the total frame cost so at the cost planning stages the site requires consideration to make sure that logistics and costs for preliminaries associated with restricted access or constrained conditions are costed.

Site configuration also impacts on the building design, including floor plate configuration, grid, storey height and overall building height. Where the structural grid has to change across the building to account for site factors such as Rights of Light or other restrictions from adjacent buildings, the efficiencies of repetition across the frame may not be realised and additional allowances should be made to the standard cost ranges. A less constrained site can enable a more regular grid to be set and repetitive structures provide material cost and on-site erection efficiencies.

Site constraints and configuration can also impact on the **overall building height** of the proposed development, which will impact on the total frame cost. The frame cost for space provided on small floor

plates across multiple storeys will differ from the same area provided on larger floor plates in a lower-rise building as the steel frame weight per kg/m² GIFA will differ.

While site-specific factors will have an impact on structural design and cost, the requirement for the provision of attractive lettable space must also be reviewed.

As noted earlier, different **structural steel frame types, grids and configurations** can be adopted depending on the requirements for column free space, maximised floor-to-ceiling heights and efficient services zones and distribution. Considering only the frame is unlikely to reflect the true cost impact of these factors. When undertaking cost analyses of different structural options, it is therefore important to include the impact of each option on other building elements too, such as heavier foundations or reduced facade area.

Where the structural grid is configured to maximise provision of open-plan lettable floor space within the constraints dictated by the site and location, it is common that a span of over 12m can be adopted. However, where spans in excess of 16m are proposed, additional allowances may need to be made during early cost plans.

If the cost model considers only the physical steel cost (kg/m² of steel) then longer spans could be viewed as attracting a cost premium as the weight of the steel frame per unit of floor area will be higher. However, consideration should also be given to the value benefits of increased open-plan lettable space, the construction programme improvements that can be achieved with long span steel construction and potential reductions to substructure costs as fewer columns are required. This can be significant in city centre construction or where there is a requirement to limit the impact on adjacent structures or features such as underground tunnels. As previous articles have illustrated, material cost is only one element of overall cost, so while a long span layout may have a higher overall frame weight, there may be efficiencies in other areas of the construction that can compensate for this.

Where longer spans are required, steel also provides cost benefits over other frame solutions, as is illustrated by its greater market share on commercial schemes compared with concrete structures and also through cost comparison between frame solutions to achieve a long span layout. This is demonstrated in Figure 5, which compares the cost of a long span steel cellular composite frame solution with a post-tensioned concrete band beam solution for Building 2, an eight-storey speculative city centre office building with a 7.5m x 15m grid.

While the overall rate per tonne of a cellular beam will be higher than for a standard rolled section, their use can result in savings in the total frame weight of up to 30% over longer spans, with a resulting impact on substructure, and through a reduced depth of floor and services zone this can be used to either reduce the height of the building to bring savings in cladding costs or maximise the floor-to-ceiling height without affecting the overall building height.

As the specialist systems themselves are often more complex and procured from more limited sources, the cost for the structural frame itself may be higher than if a more standard system is used. However, potential benefits such as a quicker programme reducing costs for preliminaries, or shallower floors reducing cladding costs, can result in a lower overall building cost.

05 | Fire protection

Fire protection typically accounts for around 10-15% of the steel frame cost in commercial multi-storey buildings, so the requirements and approach adopted can impact on where the cost of a particular building sits in comparison to others and therefore should not be overlooked during cost planning.

As with all construction materials, when temperatures increase in a fire, steel begins to lose its strength. Fire protection is used to increase the time taken for the steel to reach its failure temperature and allow occupants sufficient time to escape the building.

Fire ratings for buildings are expressed in terms of the length of time the structure must remain structurally sound in a fire and they depend on the type of building, its occupancy and the size of the steel members themselves.

The typical fire rating for a multi-storey office building varies from 60 minutes to 120 minutes plus sprinklers. The costs for fire protection included in Figure 6 are based on a 60 minute fire rating.

Design studies on fire protection options should also review whether it would be more economical to use slightly heavier structural members which inherently resist fire for longer and may allow the fire rating to be achieved with a reduced volume of fire protection materials and therefore at a reduced overall cost.

For some projects, it may also be beneficial to carry out a specialist fire engineering study. Specialist fire safety engineering involves a risk-based approach to design, which considers where the actual risks in fire are, rather than relying on the more simple prescriptive guidance contained in the Building Regulations. This approach can lead to reduced fire ratings for some elements of the structure and therefore lower costs of fire protection, without compromising safety.

When the fire rating for the project has been established, the selection of the appropriate fire protection materials is important, as there can be significant cost differences between the methods and it may be useful to seek advice from the supply chain before finalisation of the design. There are a number of fire protection materials available. Nowadays these primarily include:

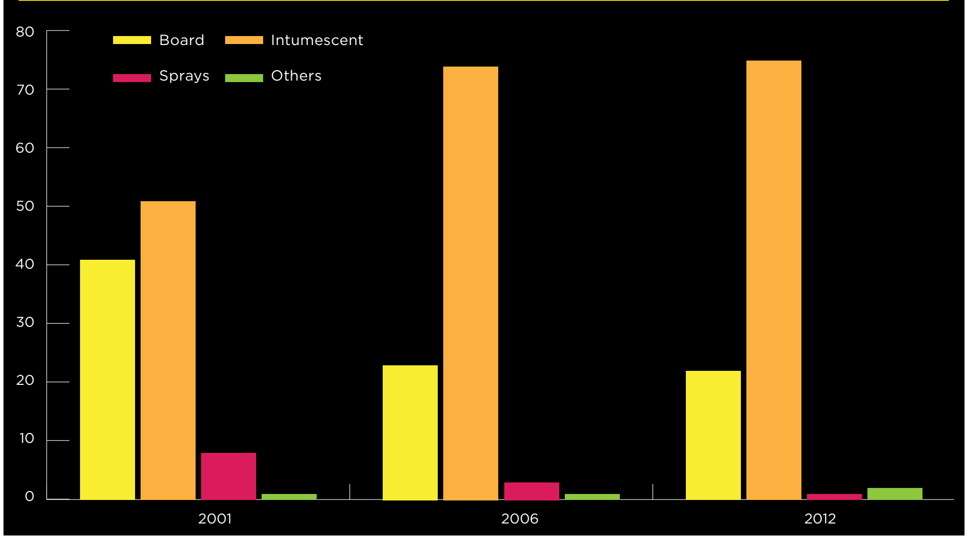
- **Boards, which are a common method**

of fire protecting structural steelwork and are often used where the structure will be visible, such as with exposed columns. They provide a clean, boxed appearance and can be pre-finished or are suitable for decoration and are a dry application that should not affect other trades or the critical path.

■ Intumescent Coatings are thin-film coatings of less than 1mm thick for 60 minutes fire resistance, which swell when heated to provide insulation to the steel. Up to 90 minutes resistance can be achieved at a competitive cost and up to 120 minutes resistance is available, albeit at a premium. Intumescent coatings have aesthetic benefits where exposed steelwork is part of the design, as the shape of the underlying steel is still apparent following application. Application costs have reduced through improved technology and increased competition and they are now the predominant method for fire protection in the UK, as shown in Figure 2. Off-site applied intumescent coatings have also become increasingly popular in recent years, with the advantage that they can reduce programme times, bringing both cost savings on-site and an earlier building completion. As the application is carried out under factory conditions, high standards of finish and quality are also achievable.

In reality it is likely that a mixture of fire protection methods will be used on a proposed development, for example, intumescent coatings to beams with boarding to visible columns. It is important to ensure that allowances for fire protection are discussed with both the structural engineer and architect as the method adopted will depend on both performance and aesthetic requirements.

FIGURE 2: FIRE PROTECTION MATERIALS SHARE 2001-2012



06 | Summary and conclusion

Structural steelwork provides a number of frame solutions that respond to the key requirements of the multi-storey commercial office sector, including standard steel construction for lower-rise, out of town business park offices and long span cellular beam construction for multi-storey city centre offices.

The use of steel frame construction is dominant in multi-storey commercial sector and can provide a number of advantages including flexible layouts and efficient services integration in an efficient and economic manner and programme benefits where rapid delivery is often necessary to maximise returns. It is therefore important that the key cost drivers are fully understood to enable realistic cost plans to be produced during the design stages and especially during the early stages when a number of frame options may be under consideration.

A number of key cost drivers for typical multi-storey office buildings have been considered to provide guidance on how to assess where an emerging design sits in relation to the standard cost ranges and comparisons should include not only the relative frame cost of each option, but also a consideration of related impacts on the cost of building elements, such as substructure, cladding and services installations to ensure that costs are assessed holistically.

07 | **Cost model update**

Steel Insight Article 3 analysed two typical commercial buildings to provide cost and programme guidance when considering the options available during the design and selection of a structural frame.

Building 1 considered a typical out of town speculative three-storey business park office with a gross internal area of 3,200m² and a rectangular, open-plan floor space. Cost models were developed for four frame types: steel composite, steel and precast concrete slab, reinforced concrete flat slab and post-tensioned concrete flat slab.

Building 2 considered an L-shaped eight-storey speculative city centre office building with a gross internal area of 16,500m² and a 7.5m x 15m grid. Cost models were developed for two frame types: steel cellular composite and post-tensioned concrete band beam and slab.

Steel Insight Article 7 reviewed the February 2013 Business, Innovation and Skills (BIS) material price indices, which showed that while there was some movement across the quarter, the price indices for cement, concrete, precast concrete and reinforcing bar were at largely the same level in January 2013 as in October 2012, while cement prices had increased by 1% and fabricated structural steel material prices had marginally decreased.

As Figure 3 shows, over the last quarter, the indices for cement, concrete and fabricated structural steel have remained stable, while precast concrete prices have marginally increased (1.4%) and concrete reinforcing bars have marginally decreased (by 1.3%).

The continued general stability in the prices of these frame materials has also been reflected in tender prices; consequently, the cost model tables for both Building 1 and Building 2 below (Figures 4 and 5) have remained constant.

As Figure 4 shows, the steel composite beam and slab option remains the most competitive for Building 1, with both the lowest frame and upper floors cost and lowest total building cost. For Building 2, as shown in Figure 5, the cellular steel composite option has both a lower frame and floor cost and lower total building cost than the post-tensioned concrete band beam option, with lower substructure costs, a lower roof cost and a lower floor-to-floor height, resulting in a lower external envelope cost.

The stability in the tender pricing levels of structural steelwork across the last quarter is also reflected in the structural steel frame cost table, where the cost ranges for each of the building types have also remained constant (Figure 6).

UK construction as a whole remains weak despite some signs of recovery. Figures from the Office of National Statistics show a mixed picture; while output rose 5.5% in February, Q4 2012 was down 9% on the previous year. Nonetheless, the February 2013 growth brings an end to the decline that has been persistent since Q3 2011, with growth in the private housing and infrastructure sectors offsetting a reduction in non-residential new works.

There have also been some early signs of recovery in the London commercial sector, which along with the growth in the private housing sector is expected to result in a modest recovery in London in 2014, followed by the South-east and South-west.

This is reflected in Gardiner & Theobald's

FIGURE 3: DEPARTMENT FOR BUSINESS, INNOVATION AND SKILLS CONSTRUCTION COST INDICES (MAY 2013)

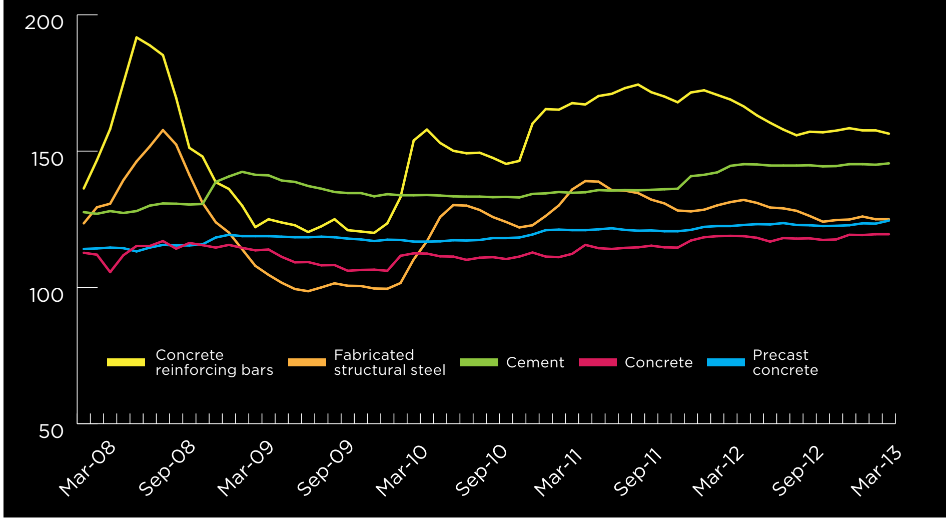


FIGURE 4: BUILDING 1 COST MODEL (KEY COSTS PER M² GIFA, CITY OF LONDON LOCATION)

	Steel composite	Steel and precast concrete slabs	Reinforced concrete flat slab	Post-tensioned concrete flat slab
Substructure	£52	£55	£67	£62
Frame and upper floors	£140	£151	£153	£150
Total building	£1,535	£1,561	£1,628	£1,610

FIGURE 5: BUILDING 2 COST MODEL (KEY COSTS PER M² GIFA, CITY OF LONDON LOCATION)

	Steel cellular composite	Post-tensioned concrete band beam and slab
Substructure	£56	£60
Frame and upper floors	£194	£210
Total building	£1,861	£1,922

(G&T) 2nd Quarter 2013 Tender Price Annual Percentage Change forecast, which shows tenders across 2013 remaining largely flat for London, the South-east and South-west, followed by a 2% increase across 2014, 2.5% across 2015 and 3% across 2016.

The regional picture is less positive, while a 6% growth is forecast in private housebuilding in 2013, partly boosted by the government's Funding for Lending Scheme, continuing decline in the public non-housing sector, a key catalyst for construction demand across the UK, means that regional recovery is expected to be delayed until 2015/2016.

G&T's latest Tender Price Annual Percentage Change forecast suggests tender prices in regions outside of London, the South-east and South-west will remain flat across 2013, with growth of 1-1.5% across 2014, 2% across 2015 and 2.5% across 2016.

Activity over the remainder of 2013 looks set to be relatively constant and it is unlikely that upwards pressure on steel prices will be reflected in tender returns as tender pricing strategy will remain key to securing work.

The forecasts for 2014 and 2015 do show signs of recovery; consideration should therefore be given to the inclusion of inflation allowances for estimates for projects that are expected to be tendered after 2013.

To use the table, a) identify which frame type most closely relates to the proposed project b) select and add the preferred floor type c) add fire protection if required.

As highlighted in previous Steel Insights, before using such "standard ranges" it is important to confirm the anticipated frame weight and variables such as the floor-to-floor heights with the design team and to adjust the rate used accordingly.

FIGURE 6: INDICATIVE COST RANGES BASED ON GROSS INTERNAL FLOOR AREA

TYPE	GIFA rate (£) BCIS index 100	GIFA rate (£) City of London
Frame – low rise, short spans, repetitive grid / sections, easy access (Building 1)	75-100/m²	90-120/m²
Frame – high rise, long spans, easy access, repetitive grid (Building 2)	125-150/m²	140-170/m²
Frame – high rise, long spans, complex access, irregular grid, complex elements	145-170/m²	165-190/m²
Floor – metal decking and lightweight concrete topping	40-58/m²	45-65/m²
Floor – precast concrete composite floor and topping	45-60/m²	50-70/m²
Fire protection (60-min resistance)	7-14/m²	8-16/m²
Portal frames – low eaves (6-8m)	45-65/m²	55-75/m²
Portal frames – high eaves (10-13m)	55-75/m²	65-90/m²

FIGURE 7: BCIS LOCATION FACTORS, AS AT 13 JUNE 2013

Location	BCIS Index	Location	BCIS Index
City of London	120	Leeds	93
Nottingham	93	Newcastle	89
Birmingham	100	Glasgow	108
Manchester	96	Belfast	66
Liverpool	92	Cardiff	98

Steel construction webinars

The following webinars are proposed:

- **26 September: Pricing** will consider the key aspects of pricing structural steelwork and their implications on the cost model.
- **17 October: Fire protection** will lead the designer through the process to determine fire rating and introduce the simplified design approach that may enable fire protection on secondary steelwork to be omitted.
- **14 November: Cost comparison** will consider the cost and programme implications for low-rise and high-rise office buildings.

For details on these and other topics, check out **www.steelconstruction.info.**

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THE STEEL INSIGHT SERIES

This article was produced by Rachel Oldham (associate) and Alastair Wolstenholme (partner) of Gardiner & Theobald. It is the eighth in a series that will provide guidance on the realistic costing of structural steelwork. If you are considering using structural steelwork for your building, bridge or structure, we recommend an early dialogue with a specialist steelwork contractor. They can offer a range of support and advice, including budget estimates and value engineering. Steelwork contractors can be sourced according to project size and technical competency. This searchable function along with comprehensive design information on structural steelwork and the previous Steel Insight articles are available at

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