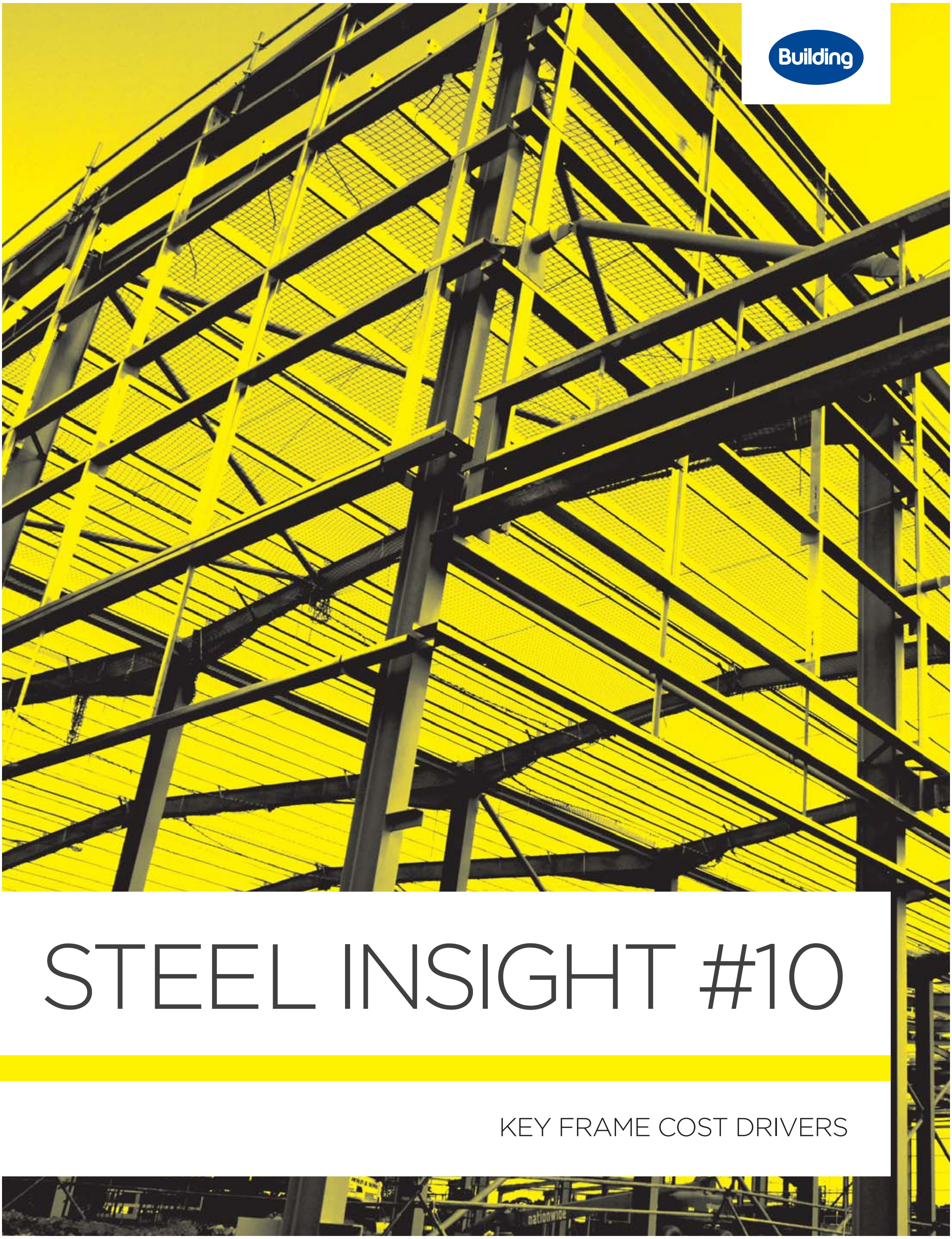


STEEL INSIGHT #10

KEY FRAME COST DRIVERS

STEEL INSIGHT

KEY FRAME COST DRIVERS

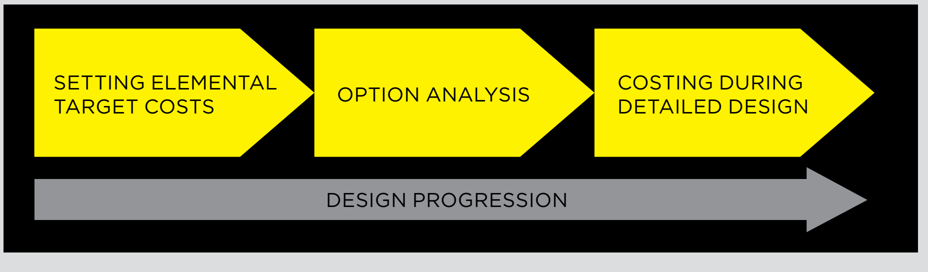
The latest article in the series focuses on the key cost drivers that have to be identified at the elemental target cost stage, and how these vary from sector to sector

01 | Introduction

The previous article reviewed the primary considerations when cost planning structural steelwork through the three stages of setting elemental target costs, option analysis and costing through detailed design.

This article summarises the key cost drivers identified within the Steel Insight series for buildings in different sectors at the elemental target cost stage of cost planning.

The article will conclude with updated cost models for all building types, including location indices, and a forward view of the market for the remainder of 2014 and into early 2015.



02 | Key frame cost drivers for steel buildings

■ **Location and site constraints –** These are key cost drivers for all building types, as the specific site will directly impact on the proposed building, influencing both the achievable design and the costs of construction. The characteristics of a proposed site will vary significantly for a building in a tight city centre location as opposed to one on a previously undeveloped or unconstrained out-of-town, suburban, campus or business park location.

■ **Site configuration –** This will impact on the building design in a number of areas, 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 or adjacent buildings, the efficiencies of repetition across the frame may not be realised. A less constrained site can enable a more regular grid to be set and more repetitive structures provide efficiencies in both material cost and on-site erection. The extent to which a proposed building is influenced by factors that reduce the level of repetition should be assessed during cost planning to determine if these restrictions can be overcome. If not, they may result in additional costs above those captured in standard frame cost ranges or previous project benchmarks.

■ **Overall building height –** Site constraints and configuration can also impact on the overall building height of the proposed development, which can 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 low rise building, as a higher steel frame weight per kg/m^2 of gross internal floor area (GIFA) is required on multi-storey construction. Therefore an understanding of the likely building form and height is important even at the earliest cost planning stages.

■ **Site specifics –** It is also important to identify if the proposed construction works are on an occupied site or campus, which is common in some sectors, such as business or retail parks, healthcare and education, or on previously developed sites in city centre locations, which is common for commercial buildings. In these cases,

the specifics of the site will directly impact on the proposed building, influencing both the achievable design and the costs of construction. Cost models should consider the impact on construction methodology and programme of limitations on noise, deliveries, working hours, storage and craneage. Otherwise, the additional logistics and costs for preliminaries associated with restricted access, constrained conditions or an extended construction programme could be overlooked.

■ **Associated building elements –** As with all projects, pressures on the design team during the development phase of the project may tend towards only reviewing the comparative costs of different frame materials alone to inform decision making, but this is an overly simplistic approach as the frame design itself will also impact on the cost of associated building elements. For example, varying structural zones of different solutions and configurations will result in different floor-to-floor heights, which will impact on cladding costs. Different frame weights will also impact on the design and cost of the substructure, as well as the overall programme and associated costs for preliminaries. All of these factors should be considered in any comparative cost studies to ensure that the most cost-effective material is chosen on a whole building basis.

03 | Other key frame cost drivers for education buildings

■ Facilities – The facilities to be provided are a key factor to consider during early cost planning; although most schools will need to provide similar facilities, consideration as to the proportion of each type of space provided should be made, as this will often have a direct impact on the developing structural frame design. For example, projects with a range of spaces (teaching, atrium, hall, workshops and so on) will have different grid and loading requirements to an all-teaching facility. The facilities mix is a key cost driver for further education and higher education buildings due to the high variance in types of facility that might be proposed. This may make the building significantly different from those considered in standard ranges and benchmarks.

■ Standardisation – Alternatively, if the proposed design lends itself to standardisation and it is proposed at an early stage to use a standardised or specialist system, then the typical cost ranges based on a traditional build are unlikely to apply. In this case, advice should be sought from the supply chain during cost planning to ensure that estimates are not only based on the system proposed, but that they take account of market conditions and order books.

■ Partnering and framework arrangements – These are common in the education sector and costs may therefore already be set out with one or a number of contractors for different types of projects and this will need to be factored into initial cost estimates.

■ Programme – This can be a key driver for education projects, due to the constraints of the academic calendar and the common requirement for new or refurbished space to be provided to coincide with the beginning of an academic year. This can result in contractors and subcontractors having a large number of projects to tender and construct with similar timeframes. Inevitably this means that some projects are favoured by the market while others are not, which can result in some variations in pricing. Throughout the design process it is important to liaise with the market and to ensure that sufficient time is given to tender periods and that the market is aware of the project and has factored it into estimating workloads.

■ Specification and standards – At the early design stages it is also important to gain an understanding of the client's required specification and any applicable standards to be met. For example, if aesthetics are important, consideration should be given to the extent of boxing in required for a steel frame or whether a high quality finish will need to be specified for any exposed concrete. For all frame types the method of acoustic attenuation will also need to be assessed and included in early cost estimates.

04 | Other key frame cost drivers for industrial buildings

■ **Portal frames –** Given the existence of a number of common characteristics and requirements across the sector, including clear internal space, high bays and highly flexible internal layouts, it is not surprising that many industrial buildings and supermarkets have similar structural frame design solutions. The most commonly adopted structural solution to address these requirements is a steel portal frame. Portal frames are relatively lightweight structures that provide clear internal spans and flexible space by efficiently delivering large spans from 25m to 40m with standard spacings between frames of 6m to 10m.

■ **Ancillary accommodation –** A key variable to be considered during early cost planning is the required building height, which is generally driven by the building function and is also a key driver of the requirements for ancillary accommodation (back-of-house offices, welfare, storage and so on). This will also impact on the overall building frame weight. For high eaves buildings, such as distribution centres with overhead craneage requirements or high bay racking, the extent of the proposed upper floor areas should be considered as this can vary significantly, with ancillary space potentially being provided across as many as three mezzanine levels. The frame costs for these buildings will therefore need to be considered on a building-by-building basis with adjustments likely to be required to standard cost ranges, which are more typically based on one level of mezzanine accommodation.

■ **Fire protection –** A further cost consideration for industrial buildings is the required level of fire protection for the structure. Typically, fire protection is only required in single storey buildings where it is needed to satisfy boundary conditions or where there is a need to access the roof (for example for plant maintenance). However, for buildings with upper floor levels, mezzanines or internal offices the fire strategy will need to be clarified with the design team during cost planning to ensure that the extent and method of protection required is captured.

■ **Design features –** At the early design stages, it is also important to gain an understanding of any design features that may require variations to the standard steel portal frame design. For example, the incorporation of northlights for maximising natural light can result in an increase to the frame cost by as much as 35% due to the additional steelwork required to form the more complex roof profile.

05 | Other key frame cost drivers for healthcare buildings

■ Facilities – The healthcare sector includes numerous building types and uses, with wide-ranging design requirements and priorities. Therefore the facilities to be provided should be reviewed during early cost planning. Although certain functions are typical across the sector, the proportion of each type of space in the proposed building should be considered, as this will often directly impact on the developing structural frame design. Facilities such as wards, operating theatres, atriums and other communal spaces may have different structural grid and loading requirements and the incorporation of a number of functions can therefore reduce the repetition of the structure throughout the building. Hospital buildings tend to contain a greater variety of functions than smaller health centres or other building types.

■ Specialist spaces – The proportion of space with specialist requirements will also need to be reviewed. In the healthcare sector, functions such as operating theatres have strict vibration control requirements, and this will have an impact on the frame design and cost that may not be considered in standard cost ranges. Similarly, the requirements for and method of acoustic attenuation also needs assessing in early cost estimates as this can vary depending on the frame adopted. An exposed soffit solution is unusual in this sector, with suspended ceilings typically being specified for infection control purposes as well as contributing economically to acoustic requirements. Therefore allowances for suspended ceilings should typically be included for all frame types in early frame material cost comparisons.

■ Partnering and frameworks – As with the education sector, these arrangements are common in healthcare, with projects procured under ProCure 21+, PFIs and LIFT. This can mean that costs or solutions may already be set out with one or a number of contractors for different types of projects.

■ Standardisation – If it is proposed to use a modular, prefabricated or specialist system, which is a common solution for

rooftop extensions to existing facilities, then the standard cost ranges based on a traditional build are unlikely to apply. In this case, advice should be sought from the supply chain.

06 | Other key frame cost drivers for multi-storey buildings (5-15 storeys)

■ **Desirability –** 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 may also contain elements of retail space at lower levels. Across the sector, the key design driver and requirement is therefore the provision of attractive lettable space, which is typically open-plan, flexible to meet the needs of a range of tenants and with a maximised floor-to-ceiling height, all within the typical city centre site constraints of party wall, rights of light and oversailing restrictions.

■ **Maximised space –** There are a number of different structural steel frame types, grids and configurations that can be adopted to address the requirements for column free space, maximised floor-to-ceiling heights and efficient services zones and distribution, including long span frames and cellular beams. When undertaking cost analyses of different structural options it is important that the cost analysis is not limited to the comparison of the structural frame costs in isolation.

■ **Long spans –** Where the structural grid is configured to maximise the provision of open-plan lettable floor space within the constraints dictated by the site and location, it is common for a span of over 12m to be adopted. However, where spans in excess of 16m are proposed, additional allowances may need to be made during early cost plans as this may not be fully captured within cost models based on more typical commercial buildings.

If the cost model considers only the physical steel cost (kg/m^2 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 than for shorter spans. 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 the potential reductions to substructure costs as fewer columns are required.

■ **Cellular beams –** When considering longer spans it is common to use cellular beams. Although 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. The reduced depth of floor and services zone can be used to either reduce the overall height of the building, bringing savings in cladding costs, or to maximise the floor-to-ceiling height without affecting the overall building height.

07 | **Cost model update**

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

Building 1 is a typical out-of-town, speculative, three-storey business park office with a GIFA of 3,200m² and 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 is an L-shaped, eight-storey speculative city centre office building with a GIFA of 16,500m² and a 7.5m x 15m grid. Cost models were developed for a steel cellular composite frame and post-tensioned concrete band beam and slab.

Steel Insight 9 reviewed the September 2013 Business Innovation and Skills (BIS) material price indices, which showed that cement and precast concrete had remained stable over the preceding quarter, while both concrete reinforcing bar and structural steel had marginally decreased and concrete prices had risen by 1.93%.

As Figure 1 shows, over the last quarter, while the indices for cement and precast concrete have remained stable, concrete prices have continued to increase and are 3.5% higher than six months ago. Concrete reinforcing bar prices have fluctuated significantly over the period, but are currently 1.5% higher than in September 2013. Fabricated structural steel has again marginally decreased, by less than 1% over the same period, despite a 20% rise in iron ore prices over the last six months.

Looking across UK construction as a whole, economic recovery accelerated over the last quarter of 2013 with a resurgence in commercial workload in London and the South-east and improved confidence in many other regions. This has resulted in a 1% tender price increase on average.

With demand widening from the whole of the construction sector, price increases were recorded in the last quarter of 2013 for structural steel and reinforcement, both up 1.5%, and concrete, up 3%. Tata Steel increased steel section prices by £25/tonne in late 2013 and similar increases are expected quarterly moving forwards.

Along with material prices, wages and salaries have also started to come under pressure, with many contractors seeking to increase head office headcount, particularly in estimating and design functions. Wage rates for workers covered by the Construction Industry Joint Council will increase by 3% from June 2014 and again in 2015.

Continued increased demand for construction through 2014 and 2015, combined with supply constraints and increased wage expectation pressure, is expected to result in increased tender price inflation. This has been reflected in Gardiner & Theobald's 2nd Quarter 2014 Tender Price Annual Percentage Change forecast, which predicts that tenders will rise by over 13% in the next three years in London and the South-east.

Average tender rates across the UK are forecast to increase by 3% for 2014 (up from the previous forecast of 2.5%), 3.5% in 2015 and 4% in 2016. The corresponding figures for London are 4%, 4.5% and 4.5%.

The increase to tender prices seen in 2013 has been reflected in the cost model tables for both Buildings 1 and 2 (Figures 2 and 3), with all rates inflated by 1%. In addition, the increases to

FIGURE 1: DEPARTMENT FOR BUSINESS, INNOVATION AND SKILLS CONSTRUCTION COST INDICES (FEBRUARY 2014)

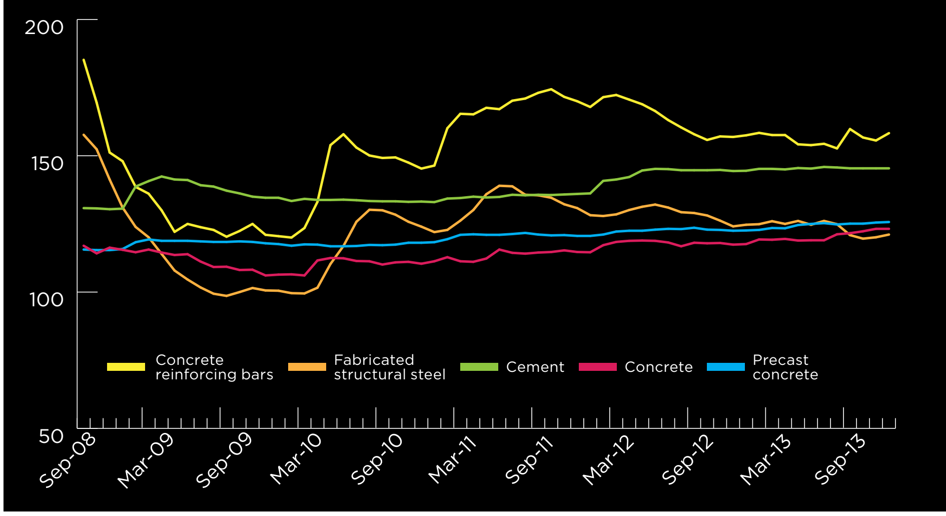


FIGURE 2: BUILDING 1 COST MODEL (KEY COSTS PER M² GIFA, CITY OF LONDON LOCATION)

	Steel composite	**Steel and precast concrete slabs**	**Reinforced concrete flat slab**	**Post-tensioned concrete flat slab**
Substructure	£54	£57	£68	£64
Frame and upper floors	£144	£155	£154	£154
Total building	£1,563	£1,590	£1,659	£1,640

FIGURE 3: BUILDING 2 COST MODEL (KEY COSTS PER M² GIFA, CITY OF LONDON LOCATION)

	Steel cellular composite	**Post-tensioned concrete band beam and slab**
Substructure	£58	£61
Frame and upper floors	£198	£216
Total building	£1,895	£1,959

structural steel and concrete reinforcing bars returns of 1.5% and concrete returns of 3% have been applied to the relevant frame rates. All other rates have increased by a further 1% to account for the first quarter of the 4% tender price increase forecast for London in 2014.

As Figure 2 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 3, 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 strong signs of recovery forecast for 2014 and 2015, particularly in London and the South-east, mean that consideration should be given to the inclusion of inflation allowances for estimates for projects tendered in the remainder of 2014 and beyond.

The increases to tender prices seen at the end of 2013 and across the first quarter of 2014 have also been reflected in the structural steel frame cost table (Figure 4).

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 and adjust the rate used accordingly.

Similarly, all of the other key cost drivers of complexity, site conditions, location, function, logistics, programme and procurement strategy should be considered in turn.

FIGURE 4: INDICATIVE COST RANGES BASED ON GROSS INTERNAL FLOOR AREA (Q1 2014)

TYPE	**GIFA rate (£) BCIS index 100**	**GIFA rate (£) City of London**
Frame – low rise, short spans, repetitive grid / sections, easy access (Building 1)	77 – 103/m²	92 – 123/m²
Frame – high rise, long spans, easy access, repetitive grid (Building 2)	128 – 154/m²	143 – 174/m²
Frame – high rise, long spans, complex access, irregular grid, complex elements	148 – 174/m²	169 – 195/m²
Floor – metal decking and lightweight concrete topping	41 – 59/m²	46 – 66/m²
Floor – precast concrete composite floor and topping	46 – 62/m²	52 – 72/m²
Fire protection (60 min resistance)	7 – 15/m²	8 – 17/m²
Portal frames – low eaves (6-8m)	46 – 67/m²	56 – 77/m²
Portal frames – high eaves (10-13m)	56 – 77/m²	66 – 92/m²

FIGURE 5: BCIS LOCATION FACTORS, AS AT 21 OCTOBER 2013

Location	**BCIS Index**	**Location**	**BCIS Index**
City of London	121	Leeds	98
Nottingham	93	Newcastle	90
Birmingham	97	Glasgow	103
Manchester	96	Belfast	63
Liverpool	92	Cardiff	100

Steelwork cost guide online

Tata Steel and the BCSA have produced a guide for cost planning structural steelwork compiled from the Steel Insight series – *Steel Construction: Cost*.

The 40-page guide is designed to walk through each stage of the cost planning process and sets out the primary considerations when cost planning during the initial design stages, through option analysis and into detailed design to support informed decision-making throughout the design process.

The online version of the guide is updated with latest costs and can be downloaded for free at www.steelconstruction.info/Steel_construction_news.

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THE STEEL INSIGHT SERIES

This article was produced by Rachel Oldham (senior associate) and Alastair Wolstenholme (partner) of Gardiner & Theobald. It is the tenth 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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