Building

STEEL INSIGHT #14

COST UPDATE AND CASE STUDIES

STEEL INSIGHT

The latest article in the series provides an update from Gardiner & Theobald on construction costs, while overleaf we have two case studies of structural steel used in leisure buildings

01 MATERIAL PRICES UPDATE

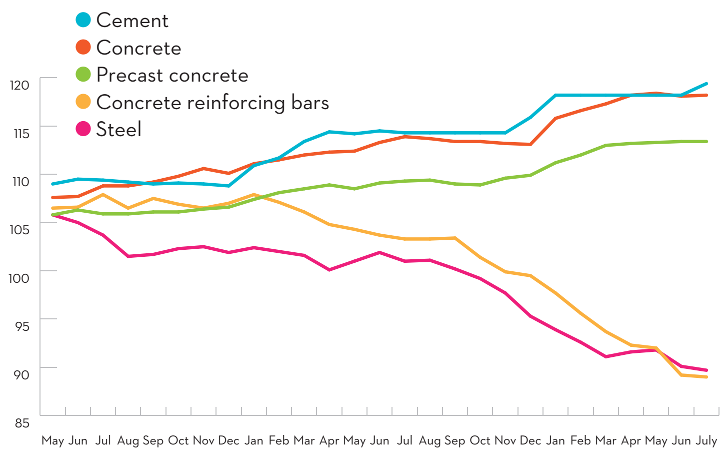
The August 2015 Business Innovation and Skills Construction Cost indices (Figure 1) show a continuation of the diverging trends in key component material price movements, although a slowdown in the rate of change is evident for all materials across Q2 2015.

While cement prices increased slightly between April and July 2015, concrete and precast concrete prices were the same in July 2015 as they had been in April 2015. The second quarter of 2015 therefore showed a period of stabilisation in concrete framing material prices compared to the two previous quarters. Whether this is a short term effect due to uncertainty during the general election or is the start of a longer term trend will need to be monitored over the remainder of 2015.

A continuation of historically low global iron ore and oil prices and subdued demand for construction in China again saw falls in both concrete reinforcing bar and structural steel material prices between April and July 2015, with concrete reinforcing bar prices more than 3% lower and structural steel 2% lower.

While variances have been recorded in material prices for the considered framing materials over the last quarter, labour costs, capacity and overall demand are also key factors in determining tender pricing and can outweigh changes in material input costs.

Figure 1: Department for Business, Innovation and Skills Construction Material Cost indices (August 2015)



02 TENDER PRICES UPDATE

Increased demand coupled with reduced regional and trade specific capacity as well as further increases in labour and overhead rates generally continued to push up tender prices across Q3 2015.

While the Construction Products Association (CPA) recorded a small fall in construction output in August 2015, the CPA is forecasting 4.9% growth in 2015 and 4.2% growth in 2016, with notable increases recorded for the infrastructure and industrial sectors in particular compared to the same point last year.

In specialist areas such as private residential, where signs of overheating are being seen, the viability of some projects is likely to be affected moving forwards and could lead to some reduction in demand. It is expected that the volume of demand will start to ease in 2016 and that balanced growth market conditions will be reached in 2017.

The upwards pressures on wage and overhead rates and continued demand for concrete framed construction in particular sectors, coupled with availability of specialist contractors, resulted in further increases to concrete tender prices in Q3 2015. Increases of 2.5% for concrete were recorded, while falling material prices largely offset these cost pressures for reinforcement.

Increased demand, wage, and overhead increases have surpassed the fall in material prices for fabricated structural steel, with tender prices rising 1.5% in Q3 2015.

For the remainder of 2015 increased demand for construction combined with supply constraints for certain trades and increased wage expectations are all likely to drive further tender price rises.

This has been reflected in Gardiner & Theobald's Q3 2015 Tender Price Annual Percentage Change forecast, where average tender rates across the UK are anticipated to increase by 4.5% across 2015 and by 7.0% in London.

The forecast cooling of demand in 2016 and 2017 is reflected in forecast average UK tender rate increases of 4.0% and 3.5% respectively; 4.5% and 3.5% in London.

03 COST MODEL UPDATE

Steel Insight 3 "Cost Comparison study" (April 2012) 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 gross internal floor area of 3,200m^2 and rectangular open-plan floor space. Cost models were produced for four frame types developed by Peter Brett Associates to reflect the typical available framing options: 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 gross internal floor area of 16,500m^2 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, being two frame and upper floor types that could economically achieve the required span and building form.

In updating this cost model, all general cost items have increased by 2% to re-base costs from Q2 to Q3 2015 prices and to reflect the revised G&T assessment of 2015 London tender price inflation (7.0% up from 6.5%). Specific increases have also been applied to the relevant frame rates for concrete and structural steel to reflect recorded and expected tender price changes for these materials to Q3 2015.

As Figure 2 shows, the steel composite beam and slab option remains the most competitive for Building 1, with the lowest frame and upper floors cost and total building cost.

For Building 2 (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, lower roof costs and a lower floor-to-floor height resulting in lower external envelope costs.

The tender price increases seen for Q3 2015 have also been reflected in the structural steel frame cost table (Figure 4).

It should be noted that typical costs are based upon the particular project being attractive to the market and the selection of an appropriate procurement route.

In overheated areas of the market it is important that a well-considered procurement strategy is developed and early engagement with the supply chain undertaken. Where the procurement strategy is not well thought through and doesn't take into account market conditions, the cost impact on individual package tender returns can be dramatic.

High demand is continuing to put pressure on estimating resource and lead times for key packages and has hardened attitudes to risk transfer, complexity and the number of bidders, reducing the number of returns being procured for many projects.

The BCIS location factors show a number of regional cities moving closer to the UK mean of 100 as the economic recovery is felt more strongly across the UK (see Figure 5).

Looking forward, the continuing pressures on tender pricing from the forecast increases in demand for construction coupled with higher wage expectations mean that consideration should continue to be given to the inclusion of substantial inflation allowances for estimates for projects that are expected to be tendered in the remainder of 2015 and beyond.

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.

Before using such standard ranges it is important to confirm the anticipated frame weight and variables such as the floor-to-floor heights to determine whether they are above or below the average and to 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 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	£62	£65	£80	£74
Frame and upper floors	£161	£177	£163	£176
Total building	**£1,757**	**£1,800**	**£1,875**	**£1,852**

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	£65	£70
Frame and upper floors	£221	£247
Total building	**£2,208**	**£2,301**

Figure 4: Indicative cost ranges based on Gross Internal Floor Area (Q3 2015)

TYPE	GIFA Rate (£) BCIS Index 100	GIFA Rate (£) City of London
Frame - low rise, short spans, repetitive grid / sections, easy access (Building 1)	105 - 130/m²	115 - 140/m²
Frame - high rise, long spans, easy access, repetitive grid (Building 2)	145 - 175/m²	165 - 195/m²
Frame - high rise, long spans, complex access, irregular grid, complex elements	180 - 205/m²	205 - 230/m²
Floor - metal decking and lightweight concrete topping	50 - 69/m²	57 - 77/m²
Floor – precast concrete composite floor and topping	55 - 74/m²	62 - 82/m²
Fire protection (60 min resistance)	17 – 26/m²	18 - 28/m²
Portal frames – low eaves (6-8m)	59 - 80/m²	65 - 87/m²
Portal frames – high eaves (10-13m)	73 - 97/m²	82 - 107/m²

Figure 5: BCIS location factors, as 17 September 2015

Location	BCIS Index	Location	BCIS Index
City of London	113	Leeds	91
Nottingham	105	Newcastle	100
Birmingham	94	Glasgow	103
Manchester	96	Belfast	59
Liverpool	92	Cardiff	90

This and the previous Steel Insight articles produced by Rachel Oldham (partner) and Alastair Wolstenholme (partner) of Gardiner & Theobald are available at www.steelconstruction.info

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CHELTENHAM RACECOURSE GRANDSTAND

Construction of Cheltenham Racecourse's £45m new grandstand was shaped by the racing calendar, so steel's flexibility made it the obvious choice for the structure

Cheltenham is one of the most prestigious names in racing, and for next year's Gold Cup, racegoers will be able to sit in a brand new, 6,500-capacity grandstand.

But construction of the £45m stand has been complicated. Racecourse owner The Jockey Club did not want to cancel any race meetings, so main contractor Kier has had to schedule the build programme around the racing calendar; in all, the contractor had to meet 14 sectional completion dates to accommodate race meetings since taking possession of the site in March 2014.

With so many interruptions, the design and construction strategy was understandably shaped by the need for flexibility and speed on site. The huge hospitality areas under the stand were another consideration, with the client keen on column-free circulation areas. That all pointed to a steel frame.

"The grid is quite large – 11m x 8m for the bar areas, with 8m x 5m for the back-of-house areas – so the only sensible option was steel," says Paul Haines, director with structural engineer Furness Partnership. "But we also factored in programme too, which was pretty tight, and steel frames fly up pretty quickly."

The five-storey grandstand, which will stand around 30m-high, will include: basement toilets, ground floor circulation areas with public bars and access to the precast terraces at the front. There will be private bars on the first and second floors, hospitality boxes on the third and fourth floors, and balconies on each level from the first floor upwards. The project includes a refurbishment of the weighing room and jockey changing rooms, plus new public realm space and elevated walkways above the parade ring.

The steel structure sits on 700 CFA piles and gets its stability from vertical bracing, located in the stair and lift cores at the back of the stand, a rigid frame at the front, where unobstructed views for spectators was the prime consideration, and diaphragm action from composite floors.

Originally, the flooring was entirely precast slabs, but Kier redesigned these as composite with concrete poured onto metal decking.

"The original design required a considerable amount of horizontal bracing; the composite slabs meant we could remove the bracing and use smaller steel beams instead," explains Kier design manager Andy Bolas. "This made it easier for us to accommodate the service zones."

The balconies which front onto the course are made from precast concrete, and each one weighs 20 tonnes. They are 8m long, to follow the structural grid, and cantilever out from the steel frame by 3.5m. "There is a significant amount of weight to be supported," acknowledges Bolas, "so we have had to install huge brackets which can handle forces up to 900kN.m."

Because of the shape of the terracing at the front of the balconies, these could not be conventional rolled plate sections, explains Haines: "So instead, they are bespoke brackets, which were designed by the fabricators Hambleton Steel, and connect on to the internal floor beam."

The only exception is the Royal Box, where the balcony is composite, rather than the precast, for security reasons. "The security advice was that a composite slab would withstand a blast better," explains Bolas.

The other cantilever feature of the building is the eye-catching roof, which extends out 21m over the terracing below.

Wind has been a factor in its design. "Cheltenham Racecourse sits on a hill, and the wind loadings are significant, so the roof structure has been designed for speeds up to 31m/s – which you would more commonly find on the west coast of Scotland," says Bolas. "This has added more weight to the roof, though the foundations were designed to accommodate this."

The roof's eight warren trusses, which sit at 8m intervals, are each split into two sections: an 11m length which runs from the centre of the grandstand structure and is then bolted onto another 21m length which cantilevers off the building. Their depth ranges from 3m at the back end, where they connect onto the structural frame, and tapers down to around 1m at the front.

The erection was carried out by a mix of tower and crawler cranes, but Bolas said the wind "was a factor, with gusts up to 60mph", meaning a few days of complete shutdown.

For Kier, scheduling work around race meetings has been a major challenge, with a complete site shut-down required to ensure the grandstand site was secure and safe for spectators. The most significant sectional handover to date was the terracing at the front of the grandstand, in time for the March 2015 Cheltenham Festival.

Opposite: The last steel sections for the roof are lifted into place
This page: Large bespoke brackets support the balconies

CHELTENHAM RACECOURSE SITS ON A HILL, AND THE WIND LOADINGS ARE SIGNIFICANT, SO THE ROOF STRUCTURE HAS BEEN DESIGNED FOR SPEEDS UP TO 31M/S – WHICH YOU WOULD MORE COMMONLY FIND ON THE WEST COAST OF SCOTLAND

ANDY BOLAS, KIER

"There are only 16 days of racing during our work programme but each of those has meant a lot of disruption," says Bolas.

The racing calendar has also meant some trades working in close proximity to meet the handover dates. "The steel started going up while we were still pouring foundations at the other end of the site, so careful coordination was required between piling contractors and steel erectors, and later on between the steel and precast trades," says Bolas.

Kier will complete its contract next month, in time for the Showcase race meeting on 23 October, with further work to be carried out by the client's fit-out contractors before the full opening in time for the 2016 Gold Cup next March.

PROJECT TEAM

CLIENT: The Jockey Club
ARCHITECT: Roberts Limbrick Architects
STRUCTURAL ENGINEER: Furness Partnership
MAIN CONTRACTOR: Kier Construction
STEELWORK CONTRACTOR: Hambleton Steel

BELFAST WATERFRONT CENTRE

● The Belfast Waterfront Centre will soon have an eye-catching extension. The unusual 'floating' design of its upper floors meant steel was the obvious choice for the structural frame

The Belfast Waterfront has played a key role in the city's economic and social development since it opened in 1997 as a conference and arts centre. So much so, that it is being extended.

Work began on the £29.5m project in July 2014, and its striking design, including cantilevered V-shaped projection balconies overlooking the River Lagan, is now taking shape alongside the existing Waterfront.

The extension will double the centre's capacity, and provide an additional 4,000m² of conference, exhibition and banqueting space, including a major hall of 1,850m² and a minor hall of 700m². The halls can be subdivided using partitions. The extension also includes a commercial kitchen to cater for a 750-person banquet, plus plant and back-of-house areas.

Although the original centre was built from concrete and will link to the extension, the new building will have a steel frame. It is however structurally independent.

"Steel was the only consideration for the structure," says Kieran Mooney, project manager for client Belfast City Council. "To work as a conference and exhibition hall, we required large column-free spaces, which obviously steel is better suited for.

"We also had a very tight programme to meet, and the structural design is quite complicated. It would not have been possible to deliver using concrete in the timeframe available."

The design, by local practice Todd Architects, has been shaped by a number of constraints. The extension is being built over a service bay for the existing centre and the nearby Hilton Hotel. This area had to be incorporated into the design. When finished, the ground floor of the new extension will house the service areas, with the exhibition spaces at first floor level and above.

Peter Minnis, project architect with Todd,

Opposite: The extension will be structurally independent from the original concrete building
This page: A CGI rendering of the finished project
Below: A temporary column supports a feature 9m cantilever and will be removed later in the programme

explains: "The service area had a significant influence on the design, because the structure for the halls is not taken off the ground, but off the beams at first floor level. So the steelwork here is pretty heavy-duty."

This level has the longest spans on the project. The grid is 23.5m × 6m to accommodate turning trucks in the service bay. A series of plate girders from 1,500mm up to 1,800mm in depth spans the ground floor area and supports the exhibition hall structure above. This section also includes the heaviest girder, weighing in at 21.7 tonnes.

Being an exhibition centre, the floor has to cope with high loads and vibration levels, so the stiffness of the steel frame is crucial. The floors been designed to absorb loading of 10kN/m^2.

Another constraint of the site was the presence of a pedestrian walkway and cycle route along the river, which the extension could not block. The design has cleverly turned this potential problem into an opportunity, by cantilevering an extension at first floor level out over the walkway.

"This is a 3.5m cantilever, which projects the upper floors of the exhibition centre across towards the river," explains Minnis. "These are supported by cantilever trusses some 1,250mm deep.

"At the 'sharp end' where the balconies are located, it will provide a break-out space for conference delegates who can look out over the Lagan."

The cantilevered section runs the full length of the new building – over 100m – so the design increases the exhibition floor space on the upper floors by some 350m^2.

"It is a hugely attractive feature, which gives the impression of the extension being a 'floating box' when viewed from the other side of the river," says Mooney.

Inside the centre, the largest exhibition hall is 80m in length and 23m wide, with a ceiling height of 9m. The roof of the centre is built from 23.5m-long Westok rafters plus secondary beams on a 3m × 3m grid. Frame stiffness is again a consideration here as the roof will have to support rigging and exhibits.

WE HAD A VERY TIGHT PROGRAMME TO MEET, AND THE STRUCTURAL DESIGN IS COMPLICATED. IT WOULD NOT HAVE BEEN POSSIBLE TO DELIVER USING CONCRETE IN THE TIMEFRAME AVAILABLE

KIERAN MOONEY,
BELFAST CITY COUNCIL

For Mooney, the biggest challenge on the project has been the timeframe. "We have tried to 'parallel track' certain packages to speed up the programme, but that has meant managing multiple contractors on site at the same time," he says.

Construction was also complicated by the presence of utilities in the service bay area. Mooney explains: "There was everything imaginable in the ground – fibre optics, high voltage cables, natural gas, water mains. Given the tight programme, we decided the sensible option was to move all this into a channel under the cantilever, which would allow the CFA piling and the steelwork to proceed without finding any nasty surprises. This will also make future maintenance access easier."

For greater speed, the erection of the steelwork was broken into sections, one beginning at the projection balcony end of the site, the other in the opposite corner. However, this did pose a problem with the cantilevered balcony.

"Because of the sheer weight of the cantilever, the stability would have been compromised and the balcony section would potentially have toppled," says Mooney. "So an extra temporary column was installed at the point of the projection balcony to provide extra support."

Steelwork specialist Walter Watson completed the steelwork phase in June, a programme of less than six months. Main contractor McLaughlin & Harvey will move off site in January, and following a programme of fit-out works, the extension will open in May 2016.

PROJECT TEAM

CLIENT: Belfast City Council
ARCHITECT: Todd Architects
STRUCTURAL ENGINEER: Doran Consulting
MAIN CONTRACTOR: McLaughlin & Harvey
STEELWORK CONTRACTOR: Walter Watson