STEEL INSIGHT #15

COST UPDATE AND CASE STUDIES

STEEL INSIGHT

The latest article in the series provides an update from Gardiner & Theobald on construction costs, while overleaf are two case studies of steel structures used in school campuses

COST MODEL UPDATE

Steel Insight 3 "Cost Comparison study" (April 2012) analysed two typical commercial buildings to provide cost and programme guidance when considering 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 3,200m² 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 16,500m² 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, being two frame and upper floor types that could economically achieve the required span and building form.

The cost models are regularly updated by G&T, and the latest data for Q4 2015 is presented here.

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

For Building 2 (Figure 2), the cellular steel composite option has both a lower frame and upper floors cost and a 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 in Q4 2015 have also been reflected in the structural steel frame cost table (Figure 3). These typical costs are based upon the particular project being attractive to the market and the selection of an appropriate procurement route.

Tender price increases from Q3 to Q4 2015 mean that consideration should be given to the inclusion of inflation allowances for estimates that are expected to be tendered in the remainder of 2016.

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, d) adjust the total according to the BCIS location factor (Figure 4).

Before using such standard ranges it is important to confirm the anticipated frame weight and variables such as 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 1: Building 1 Cost Model (key costs per m² Gross Internal Floor Area (GIFA), City of London location)

	Steel composite	Steel and precast concrete slabs	Reinforced concrete flat slab	Post-tensioned concrete flat slab
Substructure	£67	£71	£86	£80
Frame and upper floors	£171	£187	£170	£198
Total building	**£1,878**	**£1,988**	**£2,070**	**£2,056**

Figure 2: Building 2 Cost Model (key costs per m² GIFA, City of London location)

	Steel cellular composite	Post-tensioned concrete band beam and slab
Substructure	£77	£82
Frame and upper floors	£237	£270
Total building	**£2,337**	**£2,434**

Figure 3: Indicative cost ranges based on GIFA (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)	110 - 130/m²	145 - 170/m²
Frame - high rise, long spans, easy access, repetitive grid (Building 2)	155 - 175/m²	215 - 230/m²
Frame - high rise, long spans, complex access, irregular grid, complex elements	190 - 215/m²	260 - 285/m²
Floor - metal decking and lightweight concrete topping	55 - 70/m²	65 - 85/m²
Floor – precast concrete composite floor and topping	65 - 80/m²	80 - 100/m²
Fire protection (60 min resistance)	17 – 26/m²	20 - 30/m²
Portal frames – low eaves (6-8m)	60 - 80/m²	70 - 90/m²
Portal frames – high eaves (10-13m)	75 - 100/m²	90 - 120/m²

Figure 4: BCIS location factors, as 22 January 2016 (UK mean = 100)

Location	BCIS Index	Location	BCIS Index
City of London	131	Leeds	94
Nottingham	103	Newcastle	99
Birmingham	99	Glasgow	82
Manchester	96	Belfast	60
Liverpool	91	Cardiff	92

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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STRENGTHENING STEEL

Steel for Life is a new initiative from the constructional steelwork sector, aimed at promoting the material's benefits. Will Mann explains

British constructional steel can make an impressive boast. "We have the highest market share in structural frames of any country in the world – we are regarded as an exemplar internationally," says Sarah McCann-Bartlett, director general of the British Constructional Steelwork Association (BCSA).

But the association is not resting on its laurels. With one market development programme funded jointly by Tata Steel and the BCSA coming to a natural conclusion, the association has launched Steel for Life – an invigorated version of previous market development strategies which over the past 30 years have helped steel's market share – according to BCSA's figures – rise from 30% to over 70% in sectors like multi-storey buildings.

"The Steel for Life advisory board will be made up of representatives from across the constructional steelwork supply chain allowing a broader industry input than previous market development programmes," says McCann-Bartlett.

The aim is to support and educate specifiers and consulting engineers, particularly about the benefits of using steel in markets where steel may have lower penetration, says Wendy Coney, BCSA president and managing director of Shipley Structures.

Steel for Life will be supported by in-depth technical studies to demonstrate steel's suitability across a range of construction sectors, quantifying its benefits compared to other materials.

"Based on studies of typical office projects – steel construction is 7% cheaper and 5% quicker for a low-rise business park office, and for a city centre high-rise, the cost is 4% lower and the programme 11% shorter," says Coney.

"It is more sustainable – 99% of constructional steel is re-used or recycled. And it can be recycled over and again without loss of quality unlike other materials. Embodied carbon is lower than with concrete – by 23% according to our study, and by 11% even if cement replacement is used in the concrete."

Left to right: Sarah McCann-Bartlett, BCSA Director General; Wendy Coney, BCSA President and Managing Director of Shipley Structures Ltd

> STEEL IS SAFER, BECAUSE IT IS MANUFACTURED OFFSITE, CAN BE ERECTED QUICKLY, AND FEWER WORKERS ARE REQUIRED ON SITE
>
> SARAH MCCANN-BARTLETT, BCSA

"Steel is safer, because it is manufactured offsite, can be erected quickly, and fewer workers are required on site," adds McCann-Bartlett. "And of course, because it is made in a controlled factory environment, the quality is guaranteed."

The quality of the product is only enhanced by the BIM aptitude of steelwork suppliers.

"We are streets ahead of the rest of the supply chain," says Coney. "Steelwork contractors have been working with 3D models for decades. Members who have worked on BIM projects report positive feedback from main contractors who say how easy it is to work with steel fabricators. We are ready for BIM Level 2 on 1 April.

"We are also saying to clients that BIM is a reason to involve steelwork contractors earlier. It's not rocket science that if we are involved earlier, we can speed up delivery, which makes sense commercially and is in line with government construction targets."

If there's little doubt about the capability of the BCSA membership, there are external concerns which may be harder for the association to control. Regarding the cutbacks at British steel manufacturing plants, McCann-Bartlett says: "There is no issue with capacity or supply of UK constructional steelwork. There's always been a balance of domestic and imported steel used by UK fabricators. Of course there are benefits from having a UK steelmaker – it sets standards that others must then follow."

At present, the BCSA estimates that 98% of constructional steelwork in this country is built by UK steelwork contractors. But across the Thames from the BCSA's Westminster office is One Nine Elms, one of the first major UK construction projects awarded to a contractor from China. Is the association concerned that Chinese steel fabricators could soon be working on this and other UK projects?

McCann-Bartlett says she is watching the situation closely: "UK manufacturing needs to be supported by the government. With imported construction products, you lose the social and economic multiplier effect. Coming from Melbourne, I've seen manufacturing in Australia completely hollowed out by imports, so I feel very strongly about this".

UK steelwork contractors are among the most efficient in the world in terms of design capability and productivity according to McCann-Bartlett. She says there is plenty of UK capacity and this local resource provides the UK with key social and economic benefits. "Using UK steelwork contractors delivers a range of advantages to clients including: shorter lead times, contractual security, exceptional quality of design work, better on site logistics, a reduced carbon footprint and certainty on delivery dates."

Steel for Life would like to thank its sponsors:

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HOLYWELL LEARNING CAMPUS

The Holywell Learning Campus in North Wales is laid out in a figure-of-eight design – providing a testing challenge for the steelwork team. By Will Mann

Few schools currently in planning have designs as ambitious as Holywell Learning Campus, or such challenging site conditions.

Construction work on the £27.6m development in Flintshire, North Wales, began in January 2015. The project, the first awarded through the North Wales Schools and Public Buildings Contractor Framework, co-locates a primary and secondary school on one site, and is being constructed on an existing playing field, while the school remains operational alongside. The primary school will offer 315 pupil places and the secondary school another 600.

Architect Lovelock Mitchell's design for the campus building resembles a figure-of-eight, when viewed from above. Associate Ed Mortell explains the thinking: "The genesis of the design was the mathematical sign for infinity, and the synergy of the concept of infinity with the client's lifelong learning strategy for education development for the 21st Century."

The design has factored in the steeply sloping site; from the top, southern end, it drops by 30m over a distance of 500m.

"Floor plates were developed which allowed the single-storey primary school to be situated at the upper end of the site, with the three-storey secondary school being set slightly downhill, linked by a two-storey main entrance plus administration area and a shared community hub, with the sports hall element at the lower end of the site," explains Mortell.

The primary school forms the top loop of the figure-of-eight, with classrooms curving around an elliptical-shaped courtyard, while in the bottom loop, the secondary school classrooms are built around a three-storey atrium, also elliptical.

It is a complex design, with curves in the roof as well as the elevation. Little wonder then, that steel was picked for the structural frame. "The geometry of the design would have made reinforced concrete very difficult," says Graham Ford, senior project manager with main contractor Galliford Try. "Steel is more flexible and quicker to design, fabricate and erect."

Because of the slope, a major earthmoving operation was required to create a partially levelled plateau for the campus building, which is around 90m long. Some 90,000m^3 was shifted in a cut-and-fill exercise, and a temporary retaining wall was constructed to separate the site from the operational school. There is a 2m drop from one end of the campus building to the other, which is compensated for by a step in the ground floor slab in the middle section. Some 600 CFA piles, ranging in diameter from 300mm to 450mm, and driven to depths of up to 15m, have been used in the foundations.

Planning the steel frame has been challenging. "The elliptical form of the courtyard and atrium do not follow standard curves, and there are four different grids to follow, for each of the different zones in the building," says Ford.

"The grid for classrooms is typically 7.5m x 9.5m for schools projects, but because of the geometry of the building, the layout here is very different."

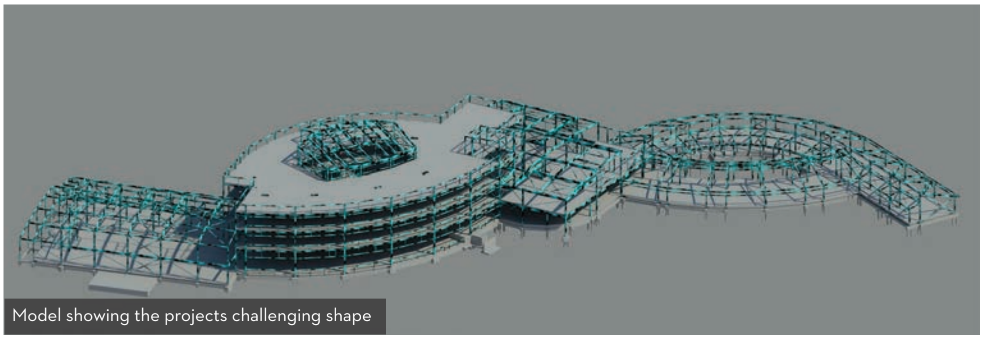
The classrooms are generally 7m wide, and split into pairs with a shared cloakroom sandwiched in the middle. Vertical steel members are kept in the exterior walls and corridors, leaving classrooms column free, and bracing is positioned in partition walls and stairwells. The interior spaces are generous and airy, with the single-storey primary school classrooms having a higher ceiling – 5m – than those in the secondary school block.

The use of BIM has played a vital role in planning the steelwork. Lovelock Mitchell was appointed by the client two years prior to contract award, which led to early adoption of 3D modelling, and this was extended to other design and construction team members, including steelwork contractor EvadX, during the two-stage tender process.

"This collaboration ensured that subcontractor modelling for elements such as the steel frame benefitted from extensive clash detection, reducing the lead time to manufacture and errors in installation," says Mortell. "For example, the design development of curved steel members carrying staircases in the secondary school atrium, which were redesigned to provide a faceted steel structure with a curved plasterboard lining. This simplified the installation and reduced the material cost for the steel framing elements in this area."

The 25m-long by 12m-wide atrium is the most complicated section of the whole structure, according to James Mackey, project engineer with Waterman Structures.

The school's curvature responds to the sites slopes



Model showing the projects challenging shape

THE GEOMETRY OF THE DESIGN WOULD HAVE MADE REINFORCED CONCRETE VERY DIFFICULT. STEEL IS MORE FLEXIBLE AND QUICKER TO DESIGN, FABRICATE AND ERECT

GRAHAM FORD, GALLIFORD TRY

"The classrooms on the first and second floors open out on to balconies which ring the atrium, but it was a requirement of the design that the space below had to be column-free," he explains. "So these balconies are cantilevered off supporting columns which are hidden at the back of the corridors."

There are, however, two mono columns that support two 18m-long link bridges which span the atrium at first and second-floor level.

The longest spans in the atrium are 15m, though these are not the biggest on the campus – they are found in the sports hall, and run to 18m.

The steelwork erection started in the secondary school zone and fanned out, with two crews using two mobile cranes. "It was logical to tackle the three-storey section first, and bring the two-storey and single-storey sections off there," says Ford.

The campus building is scheduled for completion on 5 August, but it is only the first phase of the whole project. The second phase involves demolition of the existing school, followed by another major earthworks phase, and construction of sports pitches and other external works. Galliford Try is due to finish this phase on 17 February 2017.

PROJECT TEAM

CLIENT: Flintshire County Council
ARCHITECT: Lovelock Mitchell
MAIN CONTRACTOR: Galliford Try
STRUCTURAL ENGINEER: Waterman Structures
STEELWORK CONTRACTOR: EvadX

WICK COMMUNITY CAMPUS

A lack of accessibility was one key reason why steel was specified for the frame of a new education campus in a remote part of Scotland's far north. By Will Mann

Wick Community Campus is one of the UK's most remote construction sites – and its location has played a significant role in the choice of suppliers and materials on the project, including the specification of a steel frame.

This £48.5m scheme on the north-eastern tip of the Scottish Highlands replaces one secondary and two primary schools with a single education campus that will also provide facilities for the wider local population.

The client is hub North Scotland, which was created in 2011 to drive public building projects across the north of Scotland and has a £400m pipeline over the next three years. Wick Community Campus is being delivered under a DBFM (design, build, finance and maintain) model by Galliford Try, which has invested £1.6m in finance for the scheme, and will provide facilities management for 25 years. The group's Scottish subsidiary Morrison Construction is building the project, and started on site in July 2014.

The campus effectively comprises six blocks. A 120m-long, roughly east-west aligned 'circulation street' forms the spine of the development, with five arms extending outwards at perpendicular angles. To the south are three two-storey teaching blocks: two of them for the secondary school, each 72m in length, with the primary and nursery school block slightly longer at 113m. To the north is the high school's sports hall, and another block shared between the schools and the local community, which houses a library, fitness suite and swimming pool. This is a separate structure, as it will be open to the general public and not just students, and is separated by a 5m gap from the rest of the development.

The location of the project has influenced procurement planning from the scheme's earliest stages, says project director Linda Shearer from Sweett Group.

"Construction projects in the far north of Scotland tend to have a budget 18% higher compared to similar schemes in the central belt, because of the transportation costs for most of the supply chain," she explains.

"hub Scotland were keen to involve as many local suppliers as possible, but for some specialist trades, that simply wasn't possible. So we have tried to use off-site manufacturing wherever we can, and that was one of the reasons for picking a steel frame. It can be transported to site easily, – even though the steel fabricator is based more

The steelwork took 16 weeks to erect

than 250 miles to the south in Lanarkshire – provides more certainty, and reduces the impact of any inclement weather, which can obviously affect concrete pours.

"Wick is also prone to high winds, which was factored into the construction programme, so it was important to pick a framing material that could be erected quickly, as is the case with steel."

Both swimming pool and sports hall require long spans, another reason why steel was favoured.

The new facility is being constructed on the playing field site adjacent to the existing Wick High School, which will be demolished upon completion of the new facility.

As the steel frame is relatively lightweight, Morrison Construction was able to use shallow pad foundations, which helped reduce the scheme's cost.

Lanarkshire-based steelwork contractor BHC began the frame erection in March 2015. It tackled the more straightforward teaching blocks first, because additional design work was required on the pool and community structure. The pool also had to be excavated before its steel frame was erected. The steelwork took 16 weeks to erect using two mobile cranes, and has included installation of precast slabs and lift shafts, and stairs.

"Because of the speed of the steel erection, and the layout of the the street and teaching wings, these areas could be handed over earlier than expected to allow the follow-on trades to start work," says Morrison Construction project manager Craig Struthers.

The frames for the teaching blocks and the 'street' are set out along 6m or 8m grids, with bracing in stairwells and lift shafts. The blocks are mostly two-storey, though the 'street' accommodates staff rooms and offices on the upper level and includes some double-height spaces for circulation and dining areas. The final 30m of the primary school block is single-storey due to the presence of a large outcrop of rock, so a retaining wall replaces the lower level of the structure.

The sports hall has spans of up to 19m, but the most complicated aspect of the steel erection has been the shared school/community block, which is divided into three sections: a two-storey library; a fitness suite above a ground floor plant area; and a double-height space for the swimming pool.

"There were several differing ground levels in the area around the structure, which required greater planning and co-ordination regarding positioning the cranes," explains Struthers. "It also has the longest steel members on the project at 26m – the rafters spanning the swimming pool hall."

Wick Community Campus is due to open its doors in September 2016. Morrison will remain on site for the demolition of the old school, construction of sports pitches and external landscaping works.

The facility has already drawn plaudits, winning the 'Best Education Project' category at the 2015 Partnerships Awards.

WICK IS PRONE TO HIGH WINDS, SO IT WAS IMPORTANT TO PICK A FRAMING MATERIAL THAT COULD BE ERECTED QUICKLY, AS IS THE CASE WITH STEEL

LINDA SHEARER, SWEETT GROUP

Above: Visualisation of the project

Opposite: Aerial view showing the three teaching wings, the connecting street and the adjacent library and pool structures

PROJECT TEAM

CLIENT: hub North Scotland

ARCHITECT: Ryder Architecture

MAIN CONTRACTOR: Morrison Construction (part of Galliford Try)

STRUCTURAL ENGINEER: BuroHappold Engineering

STEELWORK CONTRACTOR: BHC

PROJECT DIRECTOR: Sweett Group