

COSTING STEELWORK #2

EDUCATION FOCUS

COSTING STEELWORK

MARKET UPDATE

● Costing Steelwork is a series from Aecom, BCSA and Steel for Life that provides guidance on costing structural steelwork. This quarter focuses on the education sector

Materials cost inflation picked up in Q4 2016 and again in Q1 2017, largely as a result of sterling's weakness. This increase in materials cost inflation added to the overall pressure in the construction value chain, which has experienced sustained and high rates of labour cost inflation in recent years. A composite measure of building costs increased over the last 12 months to Q1 2017 by more than 4%.

According to data published in the Department for Business, Energy and Industrial Strategy's latest building materials bulletin (see Figure 1), a larger spread of cost changes are evident across individual materials items; the changes over the year (Q1 2016 to Q1 2017) were between 1% for ready-mixed concrete to 25% for steel reinforcement. Fabricated steel costs were up nearly 18% on a yearly basis, however this was off a much lower base. A range of factors are driving these increases including raw material costs, exchange rate movements and labour cost inflation.

After a year of rising commodity prices throughout 2016, some of the gains were reversed in the first quarter of 2017. The commodity price rises of last year started to unwind after a reappraisal of global economic growth rate expectations and their link to commodities demand loosened the strength of the price growth trends.

Building prices rose in Q2 2017 by 4% from Q2 2016 according to Aecom's tender price index (see Figure 2), which uses Greater London as a base location. This yearly rate of change moves the prevailing rate of change closer to long-run averages for tender price inflation.

For the construction sector overall, capacity constraints and the difficulty in securing adequately skilled site and managerial resources are leading to tangible project delivery issues.

Over the near and medium term, continuing sterling weakness – exacerbated by a minority government alliance – might well provide an offsetting effect to any falls in pricing brought about by flatter output growth or reduced work pipelines among contractors.

Aecom's baseline forecasts for tender price inflation are 3.1% from Q3 2017 to Q3 2018, and

3.2% from Q3 2018 to Q3 2019. Upside risks to pricing have increased over the first forecast period, reflecting the rising strains from domestic inflation and imported inflationary pressures. But the latter forecast period is expected to see more downside price risks as political and economic uncertainty weigh more on the UK's fortunes.

Business confidence was not unduly affected by the Brexit vote last year for a significant period of time. This has changed recently, as latest business confidence surveys show a marked reduction as a result of the outcome of the UK general election,

higher political uncertainty and the effect that this might have on Brexit negotiations.

Brexit is a process not an event – the negotiations will therefore take time and the totality of their impacts are not expected to become clear in the near-term, given the complexity of discussions and the scale of related policies. However, should economic turbulence increase, as a result of the Brexit process, fiscal stimulus could follow to offset any economic slowdown. Construction would be a beneficiary of higher public capital expenditure.

Figure 1: Material price trends

Price indices of construction materials 2010=100. Source Department of Business, Energy and Industrial Strategy

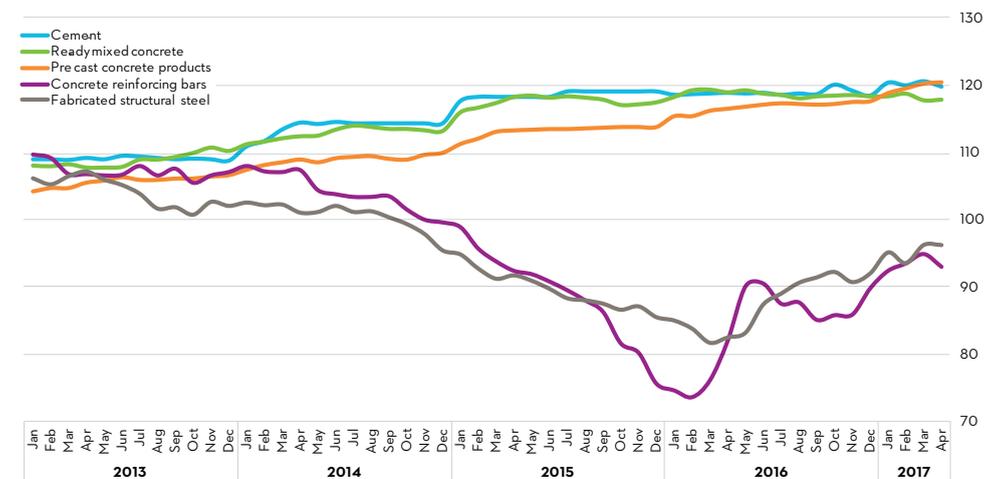


Figure 2: Tender price inflation, Aecom Tender Price Index, 1976 = 100

Quarter	2014	2015	2016	2017	Forecast		
					2018	2019	2020
1	467	492	542	569	587	604	623
2	464	505	552	574	591	609	627
3	474	520	557	578	596	615	633
4	482	532	563	583	600	620	639

AECOM

STEEL
for life

About the Costing Steelwork series

Published each quarter, Costing Steelwork examines the key cost drivers for different sectors, provides a building type-specific cost comparison and includes a cost table, which indicates cost ranges for various frame types.

These cost ranges can be used at all design stages to act as a comparative cost benchmark. Subsequent articles will provide updates to ensure the data remains current.

The series will comprise studies into office, education, mixed-use, retail and industrial buildings. This second article in the series focuses on the education sector, examining the process of cost planning throughout the design stages, the key steel framing cost drivers for education buildings, and providing a detailed cost model based on an actual education building.



Figure 3: Indicative cost ranges based on gross internal floor area

TYPE	Central London (£/m ²)	Notes
Frames		
Steel frame to low-rise building	116-140	Steelwork design based on 55kg/m ²
Steel frame to high-rise building	197-223	Steelwork design based on 90kg/m ²
Complex steel frame	223-263	Steelwork design based on 110kg/m ²
Floors		
Composite floors, metal decking and lightweight concrete topping	75-111	Two-way spanning deck, typical 3m span with concrete topping up to 150mm
Precast concrete composite floor with concrete topping	116-167	Hollowcore precast concrete planks with structural concrete topping, spanning between primary steel beams
Fire protection		
Fire protection to steel columns and beams (60 minutes resistance)	18-25	Factory applied intumescent
Fire protection to steel columns and beams (90 minutes resistance)	20-36	Factory applied intumescent

Figure 4: BCIS Location Factors, as at Q2 2017

Location	BCIS Index	Location	BCIS Index
Central London	122	Nottingham	93
Manchester	98	Glasgow	92
Birmingham	102	Newcastle	93
Liverpool	96	Cardiff	84
Leeds	97	Dublin	90*

*Aecom index

SOURCING COST INFORMATION

When estimating and cost planning buildings, it is important to assess the relevance of the source cost information. If this is sourced from previous projects then the base data and building form must be considered and compared between the current and past projects.

Figure 3 represents the costs associated with the structural framing of a building in Central London expressed as a cost/m² on GIFA. The range of costs represents the variances in the key cost drivers, as noted later in the article. If a building's frame cost sits outside these ranges, this should act as a prompt to interrogate the design and determine the contributing factors. The location of a project is a key factor in price determination and indices are available to enable the adjustment of cost data across different regions. The variances in these indices, such as the BCIS location factors (Figure 4), highlight the existence of different market conditions in different regions, which must not be overlooked.

To use the tables:

1. Identify which frame type most closely relates to the project under consideration
2. Select and add the floor type under consideration
3. Add fire protection as required.

For example, for a typical low-rise school with a composite metal deck floor and 60 minutes' fire resistance, the overall frame rate (based on the average of each range) would be:

$$£128 + £93 + £21.50 = £242.50 \text{ per m}^2 \text{ GIFA}$$

The rates should then be adjusted (if necessary) using the BCIS location factors appropriate to the location of the project.

KEY COST DRIVERS: EDUCATION

● There are a number of factors which can have a significant influence on the cost of education buildings. While the standard considerations still apply such as logistics, building form, fire protection levels and erection, specific key cost drivers for education buildings include:

BUILDING REQUIREMENTS

There are several functions that make up an education building beyond the classroom. These include functions such as sports halls, workshops, laboratories and other uses, all of which have their own specific requirements.

For example, column-free spaces will be required for a sports hall and larger-plan space will be required for workshops/technical rooms. These areas and requirements do not always sit with the standard structural grid and therefore the extent of these will influence the final solution and cost.

The differing requirements of schools versus further education (FE) and higher education (HE) institutions should also be considered.

Unlike schools, a number of these establishments will need to adjust courses to meet demand, so their offering, their requirements and therefore how they configure their buildings will vary from year to year. As the range of subjects taught is also greater than in schools, more specialist space is typically required, such as workshops, studios, laboratories and lecture theatres.

END USER REQUIREMENTS

Working with the project's stakeholders to ensure the integration of actual requirements with the building and availability of solutions can also affect the programme for education buildings in particular.

This is because the stakeholders can be both internal and external to the project and extremely diverse. Direct end users include staff and students; and external stakeholders include those such as education departments, local authorities, boards of governors, parents and disability support groups.

INFORMATION AND COMPUTER TECHNOLOGY (ICT)

The emphasis on ICT requirements including the future proofing of systems can put additional constraints on the building. This can result in



West Calder High School, West Lothian

additional services distribution through vertical risers and routes through the structure. The consequence of this requires more co-ordination and additional penetrations through structural elements.

LOGISTICS AND PROGRAMMING

Site conditions have a direct impact on costs which manifests itself in the erection and package-specific preliminaries. Site specific preliminaries are influenced by tower crane availability, building height, uniformity of grid, on-site welding requirements, delivery timings and quiet periods.

While the programme is a consideration for all construction projects, it tends to be a key driver for education projects because of 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 construct all within similar timeframes. This will inevitably lead to some projects being favoured by the market over others, which can result in 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; it is also important that the market is aware of the project and has factored it into future workloads.

MARKET INFLUENCES

External factors such as currency exchange rates, buoyancy of the market, labour availability and commodity prices all influence market dynamics and as such should be considered at the time of developing the estimate/cost plan. It is advisable to always include exchange rates in the basis and assumptions of the cost document.

AECOM

STEEL
for life

MODERN METHODS OF CONSTRUCTION

Education requirements based on function and size are relatively prescriptive, which allows for a greater degree of off-site manufacture and modularisation. Developing a kit of parts for educational projects may be beneficial and can be compatible for steelwork solutions. Such an adaptable system has the ability to be used on any size of school bringing a greater degree of certainty on cost, programme and quality.

PROCUREMENT

The type of procurement needs to be taken into consideration as this is likely to have an influence on the costs. Education projects can be single projects or part of a framework, either regional or national.

RISK ALLOCATION

Public projects as a rule are more risk averse and, as such, the risks are passed on to the contractor where possible. This will manifest as a cost premium within tender returns.

The Employer's Requirements set out comparatively high liquidated damages to act as a deterrent to non-completion within the set timescales - this may restrict the tender list and put added pressure on cost.

SITE CONFIGURATION

Site configuration will impact on the building design in a number of areas, including floorplate configuration, grid and building height. It can therefore also be a key consideration when estimating the structural frame cost of schools, as a school building on an unrestricted site would typically be single storey, whereas a tight site may result in two or more storeys being required to maintain the minimum requirements of external space provision.

This may have an associated cost impact both in terms of site logistics and a longer programme attracting higher costs for preliminaries. A more repetitive structure will be more cost-efficient both in terms of material cost and on-site erection, so the extent to which a proposed building utilises repetition in its design influences the cost planning.

It is also important to identify if the proposed construction works are to take place on an

existing campus, which is common for education projects.

A site within an existing campus will typically require restrictions to working times to limit noise, which may attract additional cost for preliminaries and may impact on programme.

THERMAL MASS

Thermal mass has traditionally been identified as a cost-effective method of reducing operational carbon by lowering the requirements for mechanical heating and cooling through the use of the building fabric, in particular the cooling of the building by the introduction

of night-time purging (drawing cooler night-time air into the building to precool the slabs, which is slowly released during the following day).

Introducing thermal mass into the building can primarily be done in the floor slab build-up. The increased mass also helps with noise transfer and is likely to be introduced using precast concrete floors.

Independent research has shown that the optimum thickness of concrete floor slab for providing thermal mass on a diurnal cycle of heating and cooling in the UK is 75-100mm. This thickness of concrete floor slab is available in almost all steel-framed buildings.

KEY COST ADVANTAGES OF STEEL FRAMING FOR EDUCATION BUILDINGS

■ **Erection time** Due to the extent of prefabrication in structural steel assembly the on site erection time is significantly reduced. This speed of construction is particularly important due to much of the work being undertaken (particularly extensions) during non school periods.

The main continuous non school period is during the summer shut down which restricts the available time to carry out the works.

The adoption of a steel frame works well with the restrictive periods available and allows for the outer shell to be in place leaving only internal works which can be better accommodated during the school periods as required.

■ **Flexibility** A well designed building should allow for future uses, steel framed buildings are easily adapted in comparison to buildings constructed with loadbearing masonry.

The flexibility of the framing allows horizontal adaptation where rooms can be altered in size to accommodate changing requirements. Adopting a steel frame allows the design to accommodate the various functions, all of which may not suit a rigid layout where workshops have differing sizes to classrooms, for example. In the instance of column-free space for sports halls, these need to be achieved by a steel framed solution.

■ **Off site manufacture** Steel components are manufactured off site with the main site activity being assembly. This results in a reduction in on site labour which as a consequence reduces health and safety risks.

Particularly in large buildings or programmes of works there is likely to be a drive towards standardisation which allows for the adoption of modern methods of construction. These are made more viable with the volume of repetition and are well suited to a steel framed building.

■ **Restrictive/existing sites** Steel is particularly relevant to projects requiring an extension to existing buildings and/or the development of additional buildings within a campus due to its prefabricated nature.

A key advantage of steel is that it arrives on site prefabricated which in conjunction with the speed of erection limits the amount of disruptive time to the adjacent buildings.

COST COMPARISON: EDUCATION

● This quarter’s education cost comparison costs a secondary school building in Merseyside

The building used for the cost model is the Christ the King Centre for Learning a secondary school in Knowsley, Merseyside.

The building’s key features are:

- Three storeys, with no basement levels
- Typical clear spans of 9m x 9m
- 591m² sports hall (with glulam frame), 770 m² activity area and atrium
- Plant at roof level.

This building was originally part of the Target Zero study conducted by a consortium of organisations including Tata Steel, Aecom, SCI, Cyril Sweett and BCSA in 2010 to provide guidance on the design and construction of sustainable, low and zero-carbon buildings in the UK.

This cost comparison updates the cost models developed for the Target Zero project and provides up-to-date costs for the three alternative framing solutions considered.

ABOUT THE BUILDING

Christ the King Centre for Learning secondary school in Knowsley, Merseyside, was part of the Building Schools of the future programme (BSF), it was completed in December 2008 and constructed to be occupied by 900 pupils and 50 staff. The gross internal floor area of the school is 9,637m². The building is based on a 9m x 9m structural grid with many classrooms 9m deep.

The main architectural features of the building are: a standardised 9m x 9m structural grid, a 591m² sports hall, a winter garden covered by an ETFE roof, a three-storey high atrium and some external terraces at upper floors. The school has a structural steel frame supporting precast concrete floor slabs and is clad in a combination of timber cladding, aluminium curtain walling and terracotta rainscreen.

This Costing Steelwork article produced by Patrick McNamara (director) and Michael Hubbard (associate) of Aecom is available at www.steelconstruction.info. The data and rates contained in this article have been produced for comparative purposes only and should not be used or relied upon for any other purpose without further discussion with Aecom. Aecom does not owe a duty of care to the reader or accept responsibility for any reliance on the foregoing.

COST COMPARISON

Three structural options for the building were assessed as shown in Figure 5 which include;

- Base case: Steel frame; 250mm hollowcore precast concrete planks; 75mm structural screed
- Option 1: In situ 350mm reinforced concrete flat slab with 400 x 400mm columns
- Option 2: Steel frame; 130mm concrete topping on structural metal deck.

The comparative costs highlight the importance of considering total building cost when selecting the structural frame material during design. The concrete flat slab option has a marginally lower frame and floor cost compared with the steel composite option, but on a total building basis, the steel composite option has a lower overall cost (£2,982/m² compared with £3,008/m²). This is because of lower substructure and roof costs and

lower preliminaries resulting from the shorter programme.

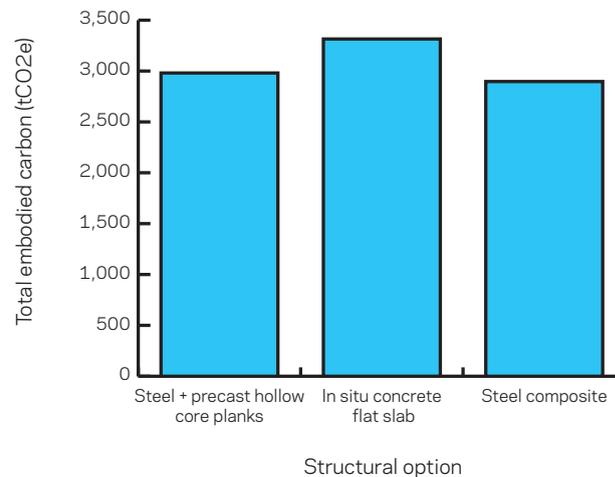
EMBODIED CARBON COMPARISON

The original Target Zero project also included a comparison of the embodied carbon of the three framing solutions. This was on a “cradle-to-cradle” basis that included the manufacture and transport of construction materials, the construction process and the demolition and disposal of the building materials at the end-of-life. The results, which are presented in Figure 6 showed that the embodied carbon of the steel frame solution with precast hollow core floor slab was 11% lower than the in situ concrete flat slab alternative while the steel frame solution with decking and in situ concrete topping was a further 3% lower.

Figure 5: Key costs £/m² (GIFA) for Merseyside secondary school

Elements	Steel and precast hollowcore planks	In situ concrete flat slab	Steel composite
Frame and upper floors	273	236	247
Total building	3,035	3,008	2,982

Figure 6: Embodied carbon comparison





COSTING STEELWORK: OFFICES UPDATE

Below is an update to the offices cost comparison originally published in the Costing Steelwork feature in Building magazine in April 2017.

One Kingdom Street key features

- 10 storeys, with two levels of basement
- Typical clear spans of 12m x 10.5m
- Three cores - one main core with open atrium, scenic atrium bridges and lifts
- Plant at roof level

Cost comparison

Two structural options for the office building were assessed: the base case, a steel frame, comprising fabricated cellular steel beams supporting a lightweight concrete slab on a profiled steel deck, and a 350mm thick post-tensioned concrete flat slab with a 650 x 1050mm perimeter beam. The full building cost plans for each structural option have been reviewed and updated to provide current costs at Q2 2017. The costs, which include preliminaries, overheads, profit and a contingency, are summarised in Figure 7.

The analysis shows that the cost of the steel composite solution was 8% lower than the post-tensioned concrete flat slab alternative in terms of the frame and upper floors, and 5% lower on a total building basis. The key cost movement from the previous quarter has been driven primarily by labour rates on concrete and increases in steel supply costs. The effect of the labour costs has increased the concrete costs by 2% in the quarter compared with 1.25% for steelwork.

Figure 7: Key Costs £/m² (GIFA), for City of London Office Building

Elements	Steel composite	Post-tensioned concrete flat slab
Substructure	84	89
Frame and upper floors	407	442
Total building	2,506	2,642



Christ the King Centre for Learning, Knowsley, Merseyside

Steel for Life sponsors:

Headline



Gold

AJN Steelstock Ltd | Ficep UK Ltd | Kingspan Limited | National Tube Stockholders and Cleveland Steel & Tubes | ParkerSteel | Peddinghaus Corporation | voestalpine Metsec plc | Wedge Group Galvanizing Ltd

Silver

Hadley Group | Jack Tighe Ltd