COSTING STEELWORK #3

INDUSTRIAL 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 industrial sector

Construction prices rose by 3.4% over the 12 months to Q2 2017 provisionally, according to Aecom's tender price index (figure 2). The yearly rate of change recorded at Q1 2017 has been revised downwards to 4.6% from the provisional figure of 5.0% reported in the last market forecast. While the demand-side and supply-side factors driving recent price increases are unchanged, they are now having a lesser effect. It is uncertain when an inflection point might arise where supply-side factors weigh more heavily than those on the demand side.

Input costs continue to support prices. Building materials costs increased by 3.9% between Q2 2016 and Q2 2017, according to Aecom's building cost index. Price movements between Q1 2017 and Q2 2017 were relatively small, though, indicating a slight easing in the rate of increase. Some respite is seen in commodity prices, which continue to unwind after the price rebounds seen in the second half of 2016. Producer price rises have also eased in 2017, as prices for materials and fuels consumed by UK manufacturers rose more slowly: by 9.9% over the year to June. Crucially, almost all main and trade contractor firms expect to see materials and input costs rise for their work.

Long-term skills shortages, compounded by rising cost pressures, increase the likelihood of contractors passing on higher prices to clients – at least if overall workloads hold up. However, there is a risk that these upward cost and price pressures might conspire to reduce client demand. Although recent movements in official data point to a falling output trend, a reduction in activity might still feel like firms are busy because of how stretched they have been for some time. As input costs and output prices evolve, so do the commercial signals in the market place. Evidently, there is growing tolerance for parts of the supply chain to fix prices for defined periods of time, which was one of the sources of commercial negotiation in recent years.

Construction labour rates rose by more than 3% in the 12 months to Q2 2017. The pace of wage inflation in the trades picked up marginally from Q1 2017, underlining the robustness of demand. Within the trades there is some monthly and quarterly variation in the average rates of change, but the market is positive for construction workers overall, particularly with real wages in the broader economy now falling due to higher consumer price inflation.

Domestic inflation is expected to continue as a feature of the economic picture over the short term and into 2018, although sterling may strengthen moderately against major currencies. The effects on construction will be ongoing pressure for suppliers to maintain or increase the prices of construction inputs: namely components and materials.

Aecom's baseline forecasts for tender price inflation are 3.3% from Q2 2017 to Q2 2018, and 1.7% from Q2 2018 to Q2 2019. Upside risks to future pricing are higher this time, reflecting demand/supply interactions still in evidence across the industry. Pricing over the past 12-month period has been to the upside of many baseline forecasts published this time last year. Price expectations for the second forecast period are lower, as political events are expected to act as a drag on the UK economy and construction. Reflective of this, a greater balance of risks to the downside is expected. The full extent of Brexit will be clearer by that point, and is likely to create increased turbulence before some calm returns.

Figure 1: Material price trends

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

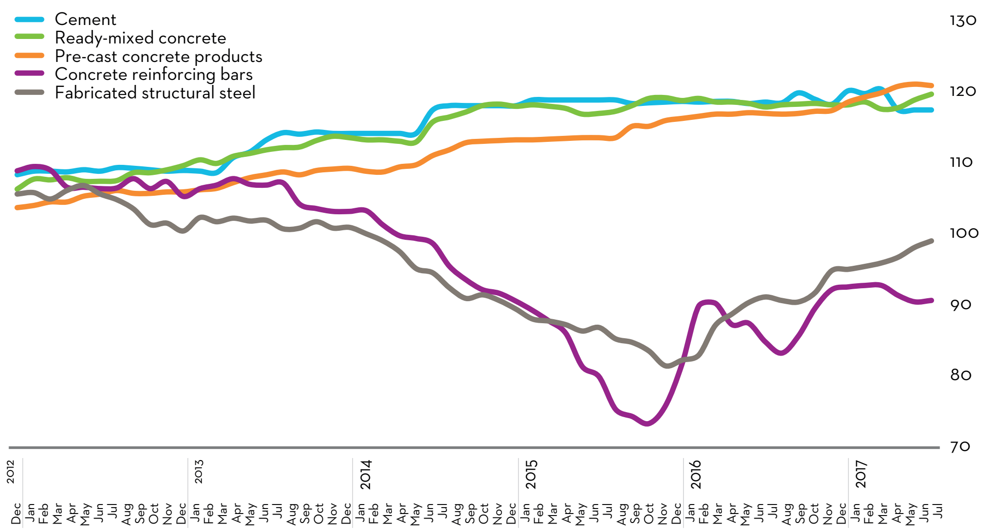


Figure 2: Tender price inflation, Aecom Tender Price Index, 1976 = 100

					Forecast		
Quarter	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
1	467	492	542	567	585	597	609
2	464	505	552	571	589	599	615
3	474	520	557	576	592	602	621
4	482	532	563	580	594	605	627

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

SOURCING COST INFORMATION

Cost information is derived from various sources, including similar projects, market testing and benchmarking, and it is important that the source information is relevant to the comparison building in size, form and complexity.

Figure 3 represents the costs associated with the structural framing of a building with a BCIS location factor of 100 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.

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 warehouse portal frame with a mezzanine composite metal deck floor to 4% of the area and 60 minutes' fire resistance, the overall frame rate (based on the average of each range) would be:

£84 x 96% + (£106 + £75) x 4% + £17 x 4% = £88.56

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

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

TYPE	Base index 100 (£/m²)	Notes
Frames		
Steel frame to low-rise building	96-116	Steelwork design based on 55kg/m²
Steel frame to high-rise building	162-184	Steelwork design based on 90kg/m²
Complex steel frame	184-216	Steelwork design based on 110kg/m²
Floors		
Composite floors, metal decking and lightweight concrete topping	60-90	Two-way spanning deck, typical 3m span, with concrete topping up to 150mm
Precast concrete composite floor with concrete topping	96-136	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)	14-20	Factory-applied intumescent coating
Fire protection to steel columns and beams (90 minutes' resistance)	16-29	Factory-applied intumescent coating
Portal frames		
Large-span single-storey building with low eaves (6-8m)	72-94	Steelwork design based on 35kg/m²
Large-span single-storey building with high eaves (10-13m)	82-112	Steelwork design based on 45kg/m²

Figure 4: BCIS location factors, as at Q3 2017

Location	BCIS Index	Location	BCIS Index
Central London	125	Nottingham	101
Manchester	99	Glasgow	90
Birmingham	101	Newcastle	92
Liverpool	97	Cardiff	84
Leeds	98	Dublin	91*

*Aecom index

KEY COST DRIVERS: INDUSTRIAL

The industrial sector covers a range of building functions and types, including distribution centres, warehouses and small industrial units. The sector is characterised by a common requirement for long span structural solutions. The standard cost considerations apply, but as the building form shows less variation, location is more important. Key cost drivers for industrial buildings include:

LOGISTICS AND PROGRAMMING

Speed of erection is a key consideration and characteristic of construction in this sector. Generally a quick turnaround on site is expected, and therefore framing methods that allow for this are the primary choice. The component sections used in industrial projects are relatively large due to prefabrication, which requires sufficient space on the site to allow for unloading. However, this is largely offset by the common requirement for service yards and car parks in industrial projects, as this provides sufficient areas of the site that are not being built upon and can therefore be used for construction set-up, loading and lay down areas.

SITE CONSTRAINTS

The location of the site is an important factor and has a direct impact on logistics and the project programme. New-build warehouse units are ideally located with access to the road network to allow for distribution and delivery of goods. This can result in sites being adjacent and close to areas of heavy traffic, which in turn can lead to restrictions on deliveries during the construction stage. In many cases new junctions may need to be created on existing highways to allow access to these new units. The added time and cost of this will need to be taken into consideration. As noted, industrial buildings are generally assembled from prefabricated components, which requires the building to be assembled using cranes. If the project site is close to railways or similar infrastructure, this will necessitate the derating of cranes for safety reasons (for example, ensuring reduced lift capacity). The requirement to have a safety factor on crane lifts will result in uprated (larger) cranes; this will increase the erection costs.

ADAPTABILITY

When designing and/or reviewing a site for a potential industrial building it is important to determine whether the building's requirements

are likely to change over time to try to minimise additional development costs at a later date. The most common change is an increase in area requirement. It is important that the building design is developed to allow for easy extension without having a detrimental impact on the operation of building.

ANCILLARY ACCOMMODATION

Additional functionality in the form of ancillary spaces is generally required in industrial buildings; this could include space for office working and visitors. The building height is generally driven by the building function, and this is also a key driver of the requirements for ancillary accommodation and the structure needed to provide it, which will affect the overall building frame weight.

The benefit here of the large-volume space common to industrial buildings is that office accommodation can be located on a mezzanine to minimise loss of storage space. For high eaves buildings, the extent of the proposed upper floor areas should be considered as this can vary significantly between buildings, with ancillary space potentially being provided across as many as three mezzanine levels. The frame costs for these buildings will need to be looked at carefully on a building-by-building basis, with adjustments likely to be required to standard cost ranges.

Depending on the extent and type of external visitors, it is not unusual for the facade treatment to the office area to be different from the main warehouse facades. These are often fully glazed with canopies and subject to aesthetic treatments. The building frame needs to be able to take this alternative elevational treatment into account.

BUILDING HEIGHT

This is a particularly important cost driver for industrial buildings and should be a key consideration during early cost planning when estimates are likely to be based on a frame weight per m^2 of floor area. While the gross internal floor area may be the same, the weight of the steel frame will vary between a low and high eaves building on a kg/m^2 basis, resulting in different overall frame costs per m^2 GIFA. Furthermore, should the proposed building have a very high bay configuration, with clear heights of up to 20m, adjustments will need to be made to the high eaves typical cost range to account for the further increased frame weight.

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. For example, the incorporation of northlights for architectural, planning or site orientation reasons can result in an increase to the frame cost due to the additional steelwork required to form the more complex roof profile. With these being function-driven spaces, the end use of the building has a larger bearing on the design.

FIRE PROTECTION

Another cost driver for industrial buildings is fire protection. Typically, fire protection is required only in single-storey buildings, where it is needed to satisfy boundary conditions or where there is a need to access the roof (such as for plant access). 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.

KEY COST ADVANTAGES OF STEEL FRAMING FOR INDUSTRIAL BUILDINGS

■ **Adaptions** It is relatively simple to extend a steel framed building, as making steel-to-steel connections is very straightforward. A major advantage of using steel framing is the level of prefabrication, which minimises time on site. The connections to the existing frame can be made with discrete pockets in the facade so that the waterproofing of the building is not compromised. The extension can be built independently of the existing building, with the final structural bays and cladding connected at the latter stages of the construction. The limited time required to make this final connection allows the final works to be undertaken outside operational hours, which keeps disruption to an absolute minimum.

■ **Building height** Steel portal frames can also be constructed to a range of building heights to provide the high eaves required for certain building functions. For example, distribution centres typically include overhead craneage and therefore require a clear internal height of 10–13m or more, while warehouses are more likely to require between 4m and 6m of clear height, depending on the storage racking system used.

■ **Internal space requirements** Large column-free space with high eaves is the optimum design for distribution centres and allows flexibility in offloading and storage. These large column-free volumes can be achieved at relatively low cost with a steel portal frame. Often on multi-span frames the intermediate valley columns are omitted ("hit-and-miss") so that on, say, a 45m-span frame, with bay centres of 8m, each column-free "box" covers an area of more than 700m^2.

■ **Flexibility** The need for large column-free spaces is easily accommodated with steel frame construction. It allows for the maximum usable space to be achieved. This ability to deliver long-span solutions provides the flexibility to set out columns in the optimum position to allow easier vehicle movement and reduce obstructions within the main building volume.

■ **Lightweight structure** The lightweight nature of a steel portal frame can reduce the size of the required foundations and therefore the extent of the associated excavation, substructure and ground risk. This can be particularly beneficial on previously developed or urban sites, where substructure costs are a significant proportion of overall building costs.

■ **Prefabrication** Aside from the obvious speed of works on site, a major advantage of prefabrication is the reduced/lack of wet trades on site. This dry construction method eliminates dust or other pollution which could contaminate produce or stock stored in an existing facility. This ability to construct without risk of contamination is essential when extending existing facilities.

SPONSORED FEATURE

COST COMPARISON: INDUSTRIAL

This quarter's industrial cost comparison costs a distribution warehouse in Stoke-on-Trent

The building used for the cost model is a distribution warehouse on ProLogis Park in Stoke-on-Trent. The building's key features are:

- Warehouse: four-span, steel portal frame, with a net internal floor area of 34,000m^2
- Office: 1,400m^2, two-storey office wing with a braced steel frame with columns.

This building was 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

The building on which the warehouse research was based was the DC3 distribution warehouse on ProLogis Park, Stoke-on-Trent. The distribution warehouse was completed in December 2007 and was at the time leased to a large UK retailer.

The net internal floor area of the warehouse is 34,000m^2. Attached to the warehouse is a two-storey office wing providing 1,400m^2 of space.

The warehouse structure is a four-span, steel portal frame. Each span is 35m with a duo-pitch, lightweight roof supported on cold rolled steel purlins. The facade columns are at 8m centres and internal columns at 16m. The primary steel beams support the intermediate rafters. The office structure is a braced steel frame with columns on a 7.3m x 6.4m grid. The first floor comprises precast concrete units. The warehouse and office buildings are clad in steel built-up systems and the warehouse roof has 15% rooflights. The building is supported on concrete pad foundations.

COST COMPARISON

Three frame options were considered to establish the optimum solution for the building, as follows:

- The base option – a steel portal frame with a simple roof solution
- Option 1 – a hybrid option, consisting of precast concrete column and glulam beams with timber rafters
- Option 2 – a steel portal frame with a northlight roof solution.

The steel portal frame option provides the optimum build value at £659/m^2, with the glulam option being the least cost-efficient. This is primarily due to the cost premium for the structural members required to provide the required spans, which are otherwise efficiently catered for in the steelwork solution. The consequence of having a hybrid option is that the component elements are from different suppliers, which contributes to the increases in cost.

The northlights option is directly comparable with the portal frame in relation to the warehouse and office frame; the variance is in the roof framing. There is significantly more roof framing to form the northlights. The additional costs beyond the frame are related to the glazing of the northlights and the overall increase in relative roof area. Overall, the steel portal frame option efficiently satisfied the brief from both cost and time perspectives.

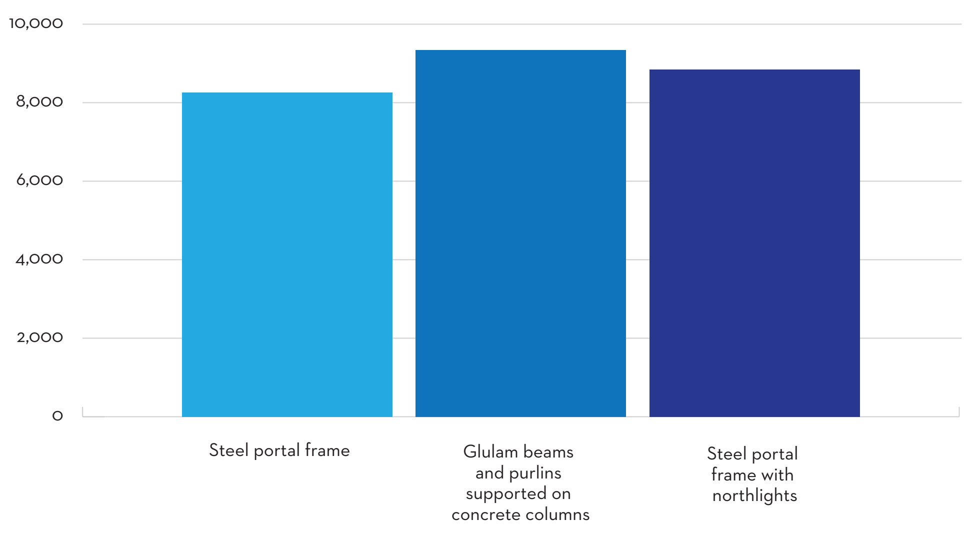
EMBODIED CARBON COMPARISON

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

Figure 5: Key costs £/m^2 (GIFA) for Stoke-on-Trent distribution warehouse

Elements	Steel portal frame	Glulam beams and purlins supported on concrete columns	Steel portal frame with northlights
Warehouse	69	136	80
Office	123	163	123
Total frame	71	137	82
Total building	**659**	**738**	**707**

Figure 6: Embodied carbon comparison



and the demolition and disposal of the building materials at end-of-life.

The results, which are presented in figure 6, show the total embodied carbon impact of the base-case warehouse building and the two alternative structural options studied. Relative to the base case, the concrete/glulam structure (option 1) has a higher (14%) embodied carbon impact and the steel portal frame with northlights (option 2) has a 7% greater impact.

Normalising the data to the total floor area of the building gives the following embodied carbon emissions of 234, 266 and 251kgCO2e/m² for the base case and structural options 1 and 2 respectively.

This Costing Steelwork article produced by Patrick McNamara (director) and Michael Hubbard (associate) of Aecom is available at www.steelconstruction.info.
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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, London, 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 650mm x 1050mm perimeter beam. The full building cost plans for each structural option have been reviewed and updated to provide current costs at Q3 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 is 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 Q2 has been driven primarily by reinforcement supply costs on concrete and material increases in steel supply costs. The notifications are primarily going to come into effect for FY18; however, the costs are starting to be reflected in current prices to reflect the premiums required for fixed-priced contracts.

Figure 7: Key costs £/m² (GIFA), for City of London office building

Elements	Steel composite	Post-tensioned concrete flat slab
Substructure	86	91
Frame and upper floors	419	455
Total building	**2,531**	**2,668**

COSTING STEELWORK: EDUCATION UPDATE

Below is an update to the education cost comparison originally published in the Costing Steelwork Education focus feature in Building magazine in July 2017.

Christ the King Centre for Learning, Merseyside, key features

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

Cost comparison

Three structural options for the building were assessed (as shown in figure 8), which include:

- Base case – steel frame, 250mm hollowcore precast concrete planks with 75mm structural screed
- Option 1 – in situ 350mm reinforced concrete flat slab with 400mm x 400mm columns
- Option 2 – steel frame, 130mm concrete topping on structural metal deck.

The full building cost plans for each option have been updated to provide current costs at Q3 2017. The comparative costs highlight the importance of considering total building cost when selecting the structural frame material. 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 (£3,012/m² compared with £3,038/m²). This is because of lower substructure and roof costs, and lower preliminaries resulting from the shorter programme. Materials cost increases (current and pending) are the primary reason for the uplift in cost.

Figure 8: Key costs £/m² (GIFA), for Merseyside secondary school

Elements	Steel + precast hollow-core planks	In situ concrete flat slab	Steel comp-osite
Frame and upper floors	281	243	254
Total building	**3,065**	**3,038**	**3,012**