



COSTING STEELWORK #5

MIXED-USE FOCUS



COSTING STEELWORK

MARKET UPDATE

● Costing Steelwork is a series from Aecom, BCSA and Steel for Life that provides guidance on costing structural steelwork. The second update this year focuses on the mixed-use sector

Aecom's tender price index pushed higher by 3% in Q4 2017 versus the same period in 2016. This is tangible evidence of the inflationary pressures still in the construction supply chain and is supported by the findings of many industry surveys throughout last year, in which supply chain firms indicated they were experiencing rising costs and prices. Furthermore, many of the surveys see a continuation of the trends in the short term and beyond. The same underlying inflationary input cost drivers are still prevalent; however, not all the cost increases are being incorporated into the sale price, as has been the case in recent years.

There is some respite from the earlier foreign exchange-driven input cost inflation. However, inflation is still being imported into the UK economy because of sterling's weakness. Although sterling is now strengthening against the US dollar, it has not made the same amount of headway against the euro.

A considerable proportion of the materials used in UK construction are imported from the Eurozone. The impact of euro-denominated cost fluctuations has stabilised somewhat and upward pressure on these input costs will remain: firstly, from sterling's lower rate against the euro; secondly, because it is believed episodes of foreign exchange-related inflation linger in economic systems. It follows that consumer price inflation is very likely to experience above-average levels of change for an extended period. Likewise, in the construction sector, weaker sterling exchange rates combined with material price inflation will be a source of challenge for some time.

There is ongoing uncertainty about the outlook for sterling as economic growth in the euro area drives inflationary expectations, and concerns about the political and economic ramifications of Brexit start to ease sterling's recent high against the US dollar.

Manufacturing input costs rose 4.7% in the 12 months to January 2018. While still an elevated rate of annual change, this does mark the lowest recorded value for 18 months – down from 5.4% in December 2017. Again, the largest upward pressure came from crude oil, driven primarily by sharp price rises in imported crude petroleum and natural gas.

Commodity prices continued to rise on the back of higher demand from increased global economic activity. An average 24% rise in 2017 marks a

significant rebound in commodity markets, with non-energy commodity prices showing seven consecutive months of rises. If this global pick-up maintains its pace, metals commodity prices should see further rises through 2018. Tight supply for base metals such as zinc, nickel and lead is also expected to offer price support. But the imposition of import tariffs by the US on steel and aluminium may cast a shadow over the mechanics of global trade, particularly if other countries take retaliatory measures.

Concerns around construction labour availability remain. ICAEW's business confidence survey records construction as the UK industry sector with the

greatest concerns about the availability of non-management skills. Sectors with this anxiety tend to rely on non-UK workers, according to ICAEW. The Federation of Master Builders' State of Trade survey corroborates this broader problem, suggesting the current labour shortages are the worst for a decade, with two-thirds of firms struggling to hire key site trades. More generally, Experian's industry survey recorded only a third of firms reporting no constraints to their work, which is down from half of firms in the middle of 2017. Wages for site staff have matched output changes – higher over the year but at a slower rate and a yearly change of 1.5 to 2%.

Figure 1: Material price trends

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

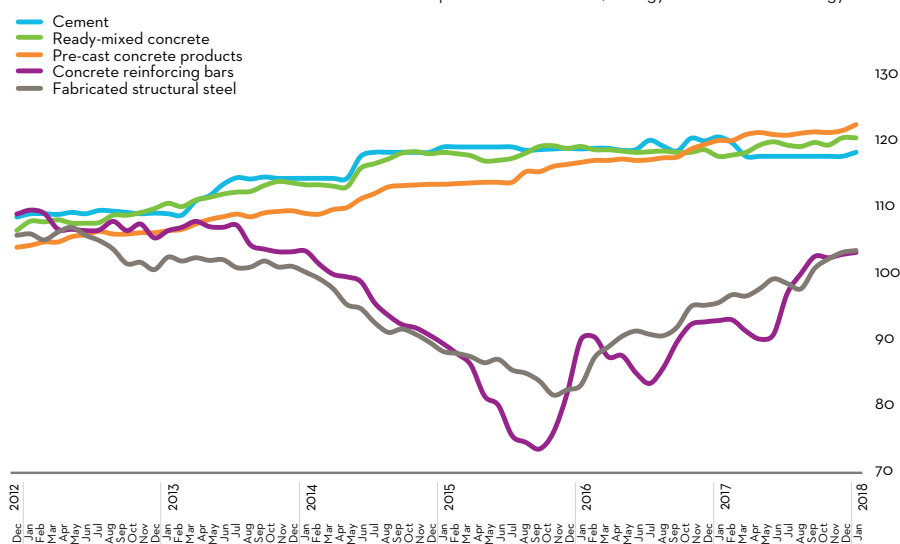


Figure 2: Tender price inflation, Aecom Tender Price Index, 1976 = 100

Quarter	2014	2015	2016	2017	Forecast		
					2018	2019	2020
1	467	492	542	567	581	594	607
2	464	505	552	569	584	597	611
3	474	520	557	574	588	599	616
4	482	532	563	578	591	602	620

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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 hotel/office frame with a composite metal deck floor and 60 minutes' fire resistance, the overall frame rate (based on the average of each range) would be:

$$£108 + £76.50 + £17 = £201.50$$

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

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

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

TYPE	Base index 100 (£/m ²)	Notes
Frames		
Steel frame to low-rise building	98-118	Steelwork design based on 55kg/m ²
Steel frame to high-rise building	165-187	Steelwork design based on 90kg/m ²
Complex steel frame	187-220	Steelwork design based on 110kg/m ²
Floors		
Composite floors, metal decking and lightweight concrete topping	61-92	Two-way spanning deck, typical 3m span, with concrete topping up to 150mm
Precast concrete composite floor with concrete topping	98-138	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)	74-96	Steelwork design based on 35kg/m ²
Large-span single-storey building with high eaves (10-13m)	84-114	Steelwork design based on 45kg/m ²

Figure 4: BCIS location factors, as at Q1 2018

Location	BCIS Index	Location	BCIS Index
Central London	126	Nottingham	104
Manchester	106	Glasgow	90
Birmingham	102	Newcastle	96
Liverpool	101	Cardiff	84
Leeds	89	Dublin	92*

*Aecom index

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KEY COST DRIVERS: MIXED-USE

● Mixed-use buildings are unique in composition. The mix of uses in a single building creates a series of integration issues from structural, services and aesthetic perspectives. The term ‘mixed-use’ does not narrow down the building type but refers to hybrid buildings with any number of combinations. Each have their challenges, but all mixed-use buildings have common key cost drivers and issues:

STACKING BUILDING USES

A key consideration is how the different uses are stacked within a building. In some instances there are multiple uses within a single building, such as the Shard, which has the building types stacked on top of each other (offices, hotel, residential and public gallery). By comparison, buildings such as MediaCityUK are more akin to a campus, with the different uses coming off an integrated podium.

STRUCTURAL ALIGNMENT

The layout and structural grid will vary between building types; this is driven by necessity in many instances. The preference for large retail units or supermarkets is to have a large, open-plan space with limited or no visual interruptions. This can be compared against residential developments which have an efficient frame set out against apartment sizes and layouts. When the structural grids are not compatible it is necessary to consider transfer structures to allow the transition from one building type to another. It is possible in some cases to deal with the transfers within the depth of the transitional slab. However, this is not always the case and a deeper transfer structure might need to be considered depending on the extent of the loads: this may have to occur over several storeys.

When a transfer structure is required it is important to understand the optimum solution. The initial approach should be to determine whether, through compromise or slight adjustments to the grid, if the transfer can be eliminated. Where it is not possible to avoid transfers, careful consideration needs to be taken to determine which solution works practically, while still maintaining servicing zones and aesthetic considerations.

CORE OPTIONS

Where building types do not naturally stack on top of each other, the type of core and the servicing strategy of the building are key areas of consideration. In the case of large, open-plan

spaces at the base or podium level of a building with alternative uses above, it is often advantageous to transfer out the core at the lower levels. Structurally it is possible to achieve this using a braced steel core, which is easier to drop out than a concrete core. The issue arises when the fire, vertical transportation and services strategies of the building are considered. There are key elements within the building which must run from ground

level up through the building above; these include fire escapes, lifts and primary services and risers. It is possible to introduce offsets but not possible to eliminate them in their entirety.

How the functional aspects of the upper-building types are dealt with are key cost drivers, as there are various ways of addressing the issue particularly where offset options can be considered.



Lime Street regeneration in Liverpool: a mixed-use scheme consisting of student accommodation, a hotel and retail/leisure

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KEY COST ADVANTAGES OF STEEL FRAMING FOR MIXED-USE BUILDINGS

■ **Column-free floorplates** Steel framing is an economic means of providing long spans without the requirement for intermediate columns, thus creating increased open-plan spaces which are advantageous to adapting to various structural grids. This in turn reduces potential elements that would otherwise need to be transferred.

■ **Offsite manufacture** There are invariably an increased number of uniquely framed floors, which are commonly a trait in mixed-use buildings. These floors will have a framing solution that differs from the regular floorplates. The approach to these floors needs to be planned to ensure that the detailing and site construction can be undertaken without any delays or issues arising. Complex interfaces can also be designed and fabricated with any issues having been dealt with prior to the components arriving on site. Additionally, it allows unique floors and transfers to be set out and in extreme cases test fitted before arrival to site.

■ **Site constraints** Steel-framed solutions allow sites that might be deemed too difficult for development to be considered. An example of this is rail infrastructure over site developments

(OSDs). This is of particular interest when evaluating mixed-use developments, due to the variety of building uses that could be considered. The direct links these sites have with public transport and increased footfall will have particular benefits to retail uses. However, retail use in isolation might not be sufficient to warrant the expense incurred in building over a station, therefore the ability to be able to consider multiple uses makes this option more viable. It would be difficult to realise these development opportunities without the use of structural steelwork.

■ **Services integration** Steelwork through its adaptability and framing form allows for ease of services integration and co-ordination throughout the building. The integration of services within the structural elements of buildings leads to economies by reducing the floor-to-floor height, which has the double benefit of reducing the external cladding required and also reducing heat loss through the envelope. In multi-storey buildings, service integration can allow extra floors to be provided within the same overall building height. Additionally, the transfer structure can be framed and accommodated with trusses which

are not continuous solid barriers, thus allowing services to pass through the structural zones.

■ **Lightweight** The reduced weight of a steel-framed building has a beneficial effect on the structure and foundation by which the building is supported. Structural steel permits the upper building types to be constructed over restricted load areas, such as railway station boxes and transfer structures, where this otherwise might not be possible. Another benefit is that it allows the upper levels to be hung from the roof, thereby divorcing the structural dependency and reliance of the differing building uses throughout the building.

■ **Programme** The use of a steel frame can also assist in meeting and even reducing construction programmes. With so much work carried out offsite, the on-site construction programme is reduced and the build programme is relatively unaffected by adverse weather conditions. Additionally, the impact of steel-based construction on local communities is minimised by the relatively short building programme, minimal site deliveries and the dry, dust-free and comparatively quiet construction process.

LEVEL OF FLEXIBILITY

When designing mixed-use buildings, developing a solution that can be adapted to the ultimate building uses is key. It is therefore important to establish the uses that are required and, following this, decide how best to place or stack these uses. Another question is whether the site is sufficient to place areas of large-span or open spaces adjacent to the main building stack: typically this applies to leisure, retail and entertainment venues as opposed to smaller grid uses such as residential. Having this level of flexibility is essential if major issues with transfer structure and MEP servicing are to be avoided.

SECURITY, FIRE AND ACOUSTIC REQUIREMENTS

Different building uses will be required to meet different security, fire and acoustic criteria. In addition to the specific criteria for the individual uses, there are further requirements where the building transitions from one use to another. At the transition points and levels there is a requirement for full separation from a security, fire and acoustic perspective.

How this separation is achieved can be a significant cost driver; the level of separation is

driven by which building uses sit adjacent to each other. The context of what is above the lower levels needs to be taken into consideration. Key structural requirements such as preventing progressive collapse may require the additional structure to be accommodated at the lower levels. The risk of transferring out a large proportion of the structural grid puts pressure on the remaining columns at ground-floor level – this is not a risk for single-storey or low-rise versions of the ground-floor use such as retail or leisure. However, they have a major impact on the potential high-rise or multiple-storey building that sits above.

SERVICE INTEGRATION

There is added services co-ordination required when considering mixed-use buildings. The requirements of the other uses contained within the building need to be factored into the space planning of each building use. Where possible, it is advantageous to align uses so that commonality of requirements can be incorporated without adverse impacts. Connectivity of services is an important consideration, which invariably leads to larger ducts needing to be factored into the design in addition to what servicing is required for each of the uses.

For example, kitchen extraction ducts need to be taken to the highest point of a building: therefore when placing a tower over a restaurant it will result in fire-rated ductwork taken from the base of the building to the roof. Where the plant is positioned is important; should all the plant be housed in the basement or on the roof the servicing for all the use types needs to be accommodated into the risers, which has a knock-on effect to services distribution and riser sizes. Both options will have their own associated cost implications.

A benefit of mixed-use is that the different uses have different peak load times. Residential peak loads are early morning and evening, whereas offices peak during daytime working hours. This allows efficiencies in plant sizing and heat recovery.

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 AND UPDATES

● This quarter's cost comparison costs a mixed-use hotel and office building in Manchester

The building on which the mixed-use research is based is the Holiday Inn tower located in MediaCityUK, Manchester. Phase one of MediaCityUK started in 2007 and completed in 2011.

The 17-storey Holiday Inn tower attached to the main studio 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 17-storey Holiday Inn tower is attached to the main studio building at ground-floor, mezzanine and first-floor levels. An atrium connects the office floors of the tower block to the studio block (floors two to six).

The building accommodates 7,153m² of open-plan office space on five floors (floors two to six) and 9,265m² of hotel space on eight floors (floors eight to 15). The ground and mezzanine floors accommodate the hotel reception and a restaurant. Floor seven houses plant for the office floors and Floor 16 houses plant serving the hotel.

The gross internal floor area of the building is 18,625m². The 67m-high building is rectilinear with approximate dimensions of 74m x 15.3m.

The building has a steel frame structure with Slimdek floors. The steel columns are located on a 6.35m x 2.6m x 6.35m grid spaced at 7.5m. Two concrete cores, one at each extremity of the building, provide the stability of the tower as well as housing the risers and lifts. The foundations are 750mm-diameter CFA concrete piles.

Figure 5: Key costs £/m² (GIFA) for hotel/office building in Manchester

Elements	Slimdek	Concrete flat slab	Composite deck on cellular beams (offices) and UCs used as beams (hotel)
Structural unit cost	500	418	343
Total building unit cost	2,711	2,611	2,509

COST COMPARISON

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

- Base option – steel frame with Slimdek floors
- Option 1 – concrete flat slab
- Option 2 – composite deck on cellular beams (offices) and UCs used as beams (hotel).

The steel frame with composite deck provides the optimum build value at £2,509/m².

However, it is important to note some project-specific factors influencing the decision to use a Slimdek solution for the actual building, and hence the base case, building structure. The Holiday Inn tower building is connected to an adjacent studio block between floors one and seven. The long-span requirements for the studio could only be achieved using steel and therefore it was preferable to use a steel structure for the tower block to facilitate the integration of the two structures. Speed of construction was also important for the tower block, and this integration gave programme benefits relative to concrete solutions.

The mixed-use tower block was originally designed with the lower floors as residential accommodation. Key design considerations for the hotel/residential tower block were floor depth and acoustic performance, and hence a Slimdek design was chosen. It was not possible to achieve the required floor depths using a cellular steel beam solution with downstands. The decision to change the residential accommodation to office floors was taken only at a very late stage of the project; this, coupled with the time constraints for the project, precluded redesign of the tower block and hence the original Slimdek design was constructed.

The base case building structure is therefore a relatively unusual solution reflecting the constraints imposed by the wider MediaCityUK development and Options 1 and 2 are arguably more typical solutions for a building of this type.

COSTING STEELWORK: OFFICES UPDATE

Below is an update to the offices cost comparison originally published in the Costing Steelwork Offices 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 1,050mm perimeter beam.

The full building cost plans for each structural option have been reviewed and updated to provide current costs at Q1 2018. The costs, which include preliminaries, overheads, profit and a contingency, are summarised in figure 6.

The cost of the steel composite solution is 8% lower than the post-tensioned concrete flat slab alternative for the frame and upper floors, and 5% lower on a total-building basis. The key cost movement from Q4 has been minor rises in steel supply costs and in reinforcement supply costs on concrete. January has seen the erection labour cost increases take effect.

Figure 6: Key costs £/m² (GIFA), for City of London office building

Elements	Steel composite	Post-tensioned concrete flat slab
Substructure	87	92
Frame and upper floors	426	460
Total building	2,562	2,700



COSTING STEELWORK: EDUCATION UPDATE

Below is an update to the education cost comparison originally published in the Costing Steelwork Education 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 7), 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 Q1 2018. 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 (£3,048/m² against £3,074/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 7: Key costs £/m² (GIFA), for Merseyside secondary school

Elements	Steel + precast hollow-core planks	In situ concrete flat slab	Steel composite
Frame and upper floors	285	246	258
Total building	3,101	3,074	3,048

COSTING STEELWORK: INDUSTRIAL UPDATE

Below is an update to the industrial cost comparison originally published in the Costing Steelwork Industrial feature in Building magazine in October 2017.

Distribution warehouse in ProLogis Park, Stoke-on-Trent, key features

- Warehouse: four-span, steel portal frame, with a net internal floor area of 34,000m²
- Office: 1,400m², two-storey office wing with a braced steel frame with columns

Cost comparison

Three frame options were considered:

- Base option – a steel portal frame with a simple roof solution
- Option 1 – a hybrid option: precast concrete column and glulam beams with timber rafters
- Option 2 – a steel portal frame with a northlight roof solution.

The full building cost plans for each option have been updated to provide costs at Q1 2018. The steel portal frame provides optimum build value at £667/m²; glulam is least cost-efficient. This is primarily due to the cost premium for the structural members necessary to provide the required spans, which are otherwise efficiently catered for in the steelwork solution. With a hybrid, the elements are from different suppliers, which raises the 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 as the northlights need more. Other additional costs relate to the glazing of the northlights.

Figure 8: Key costs £/m² (GIFA), for Stoke-on-Trent distribution warehouse

Elements	Steel portal frame	Glulam beams + purlins + concrete columns	Steel portal frame + northlights
Warehouse	70	138	81
Office	125	166	125
Total frame	72	139	84
Total building	667	747	716

COSTING STEELWORK: RETAIL UPDATE

Below is an update to the retail cost comparison originally published in the Costing Steelwork retail feature in Building magazine in January 2018.

Asda food store, Stockton-on-Tees, key features

- Total floor area of 9,393m²
- Retail area based on 12m x 12m structural grid

Cost comparison

Three frame options were considered (as shown in figure 9) to establish the optimum solution for the building, as follows:

- Base option – a steel portal frame on CFA piles
- Option 1 – glulam timber rafters and columns on CFA piles
- Option 2 – a steel portal frame with a northlight roof solution on driven steel piles.

The full building cost plans for each option have been updated to provide costs at Q1 2018. The steel portal frame provides the optimum build value at £2,536/m², with the glulam option the least cost-efficient. The greater cost is due to the direct comparison of the steel frame solution against the glulam columns and beams/rafters. A significant proportion of the building cost is in the M&E services and fit-out elements, which reduce the impact of the structural changes. The northlights option is directly comparable to the portal frame in relation to the main supermarket; the variance is in the roof framing as the northlights require more. Additional costs beyond the frame are related to the glazing of the northlights and the overall increase in relative roof area.

Figure 9: Key costs £/m² (GIFA), for Stockton-on-Tees food store

Elements	Steel portal frame	Glulam timber rafters + columns	Steel portal frame + northlights
Structural unit cost	139	170	156
Total building unit cost	2,536	2,576	2,546