Corus Construction & Industrial

Supporting the commercial decision

Comparing the cost of steel and concrete framing options for commercial buildings

Material choice

Whether to use steel or concrete for the structural frame is one of the most significant early decisions of any project.

This choice has a wide-ranging affect on many subsequent aspects of the building design, programme and performance. These, in turn, all have an impact on the cost and value of the project and are fundamental to its overall success.

Steel has, for many years, been the dominant form of construction for commercial buildings in the UK. The reasons for this are numerous and well known, but made abundantly clear by the results of this latest Corus funded independent cost comparison study. The study looks in detail at the costs of commercial buildings, built using a range of steel and concrete framing options. Corus employed the services of leading practitioners in the industry – including Arup, MACE, Davis Langdon and the Steel Construction Institute – to ensure the study drew on the most up to date knowledge and expertise.

This publication sets out the results of that study, which examined steel and concrete systems in two typical commercial buildings. The buildings were fully designed, taking into account all the major variables of structure, foundations, cladding and services. The results enable us to compare in great depth the costs and other related benefits of the different construction materials.

The study is also relevant to hospitals, educational and retail buildings.

Savings with steel

The results conclusively demonstrate that steel-based options are, in all cases, the most cost effective. The cheapest option in terms of structure costs alone was the composite beam and slab, showing why this form of construction is the most popular multi-storey flooring solution in the UK. When variable costs, such as cladding and foundations are considered, Slimdek® becomes an equally cost effective alternative. In general, reinforced concrete systems are three to eight per cent more expensive than the steel options.

The study also highlighted the many other advantages of steel frames. These include speed of construction, adaptability and ease of service integration. If we adopt a more global approach to costing – moving beyond structure costs alone – then cellular beams become the most economic long span option, thanks to the improved integration of services and greater flexibility of design that this system affords.

The cost and design benefits offered by steel, allied with its speed of construction, flexibility and consistent quality make it the construction material of choice for commercial buildings. Add to this the minimal disruption caused during construction – and its limited impact on the environment – and steel truly deserves its position as the dominant form of construction for commercial buildings throughout the UK.

Buildings in detail

The two buildings in the study represent typical modern commercial structures, for which a number of steel and concrete systems were examined.

Building 'A' is typical of a speculative office building of modest specification in a regional UK city. This study assumes it is located in Manchester, which is a major area of growth in steel construction. It is a four storey building, of a width that permits good natural ventilation and lets in plenty of natural light. The building is not air conditioned, but does have perimeter heating. It is serviced from zones at each end of the building, where the stairs and lifts are also located. There are three ten-person lifts.

Inside the building is generally open plan, but may be divided into individual offices. It has a fire resistance of 60 minutes, and is not sprinkler protected. It is clad in traditional brick, with regularly spaced individual windows making up a quarter of the building façade.

Building A – standard regional office block

Structural systems for Building A

Five structural systems for Building A are detailed in this publication. They are:

- Composite beam and slab
- Slimdek®
- Long span cellular beams
- Reinforced concrete flat slab
- Insitu concrete with precast floors

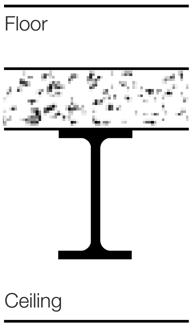
The foundations are pad footings on sand, and the ground floor is not suspended. The top floor is designed to take the same loads as all other floors. There is an additional roof structure comprising steel portals, purlins and tiles, which is not suitable for occupancy.

Minor pipework in this building is passed underneath or through the beams or floor. Provision for lighting units, fire protection, ceiling depths and an allowance for deflections are included in the depth of the floor zone.

Floor zones

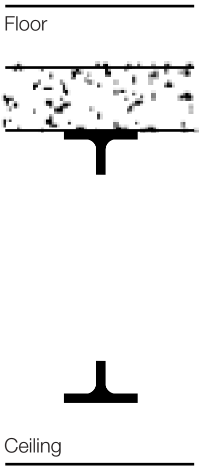
Composite beam and slab

= 150mm raised floor
\+ 130mm slab
\+ 352mm beam
\+ 150mm ceiling & lighting
= 782mm ≈ 800mm



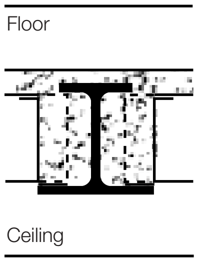
Cellular beams

= 150mm raised floor
\+ 130mm slab
\+ 660mm beam
\+ 150mm ceiling & lighting
= 1090mm ≈ 1100mm



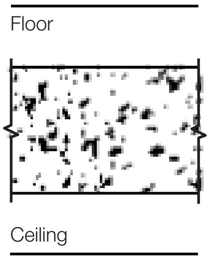
Slimdek®

= 150mm raised floor
\+ 300mm slab
\+ 150mm ceiling & lighting
= 600mm



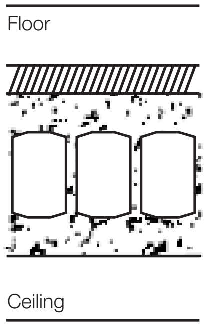
Reinforced concrete flat slab

= 150mm raised floor
\+ 300mm concrete slab
\+ 150mm ceiling & lighting
= 600mm

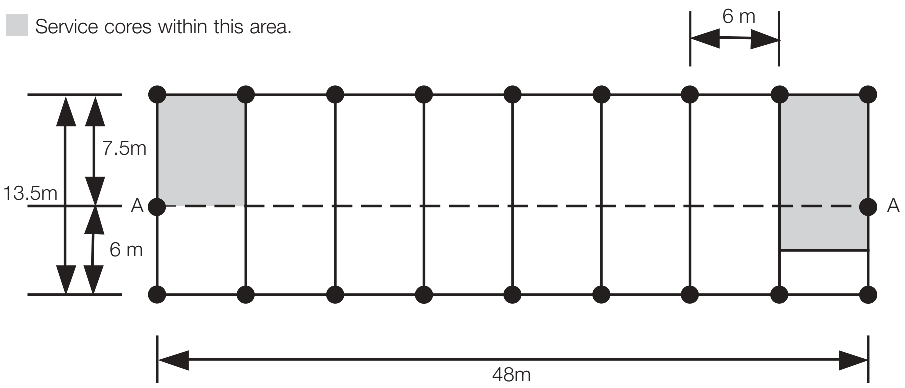


Insitu frame with precast hollow core units

= 150mm raised floor
\+ 75mm screed
\+ 400mm hollow core
\+ 150mm ceiling & lighting
= 775mm ≈ 800mm

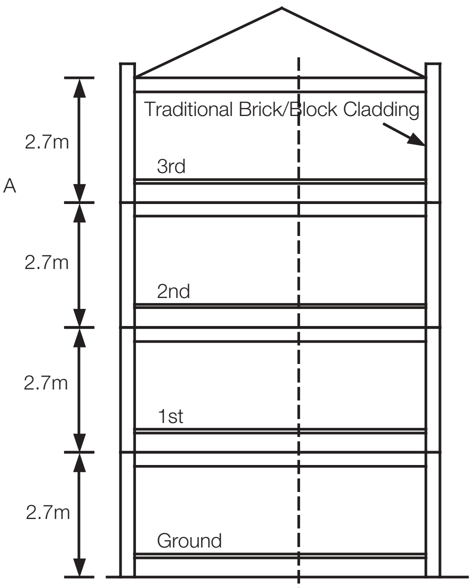


Idealised plan



Additional line of columns on A-A for short span systems

Section



Building B – prestige company headquarters

Structural systems for Building B

Five structural systems for Building B are detailed in this publication. They are:

- Composite beam and slab
- Slimdek®
- Long span cellular beams
- Reinforced concrete flat slab
- Post tensioned ribbed slab

Building B is typical of a prestige office building in central London, suitable for a company headquarters or similar high status function. It is a more complex structure than Building A, designed around a central covered atrium. It is eight storeys high and is comfort cooled by a fan coil system.

The structure is serviced from two main zones at opposite ends of the building. The service cores also include fire-fighting lifts and fire-protected lobbies. There are three stairways in the building, and three 16-person lifts adjacent to the entrance lobby, as well as two ten-person lifts in the outer cores.

It has a fire resistance of 90 minutes and is not sprinkler protected.

Inside, the building is open plan, but may be sub-divided to create individual offices or meeting rooms around the perimeter. Outside, the façade is glazed, using a proprietary glass curtain walling system. The atrium roof is constructed from tubular steel and glass, and has a mechanical smoke extraction system.

The foundations for this building are single large-diameter under-reamed piles, bearing in clay. The pile capacity is achieved by end bearing and side friction. The upper floor has two areas that house the air conditioning equipment, close to the cores that they service. This top floor is designed to take the same loads as other floors, with local strengthening under the heavy equipment. Further plant and major services are located in a basement, which covers a quarter of the building plan area.

Floor zones

Composite beam and slab

= 150mm raised floor
+ 130mm slab
+ 358mm beam
+ 400mm services
+ 150mm ceiling & lighting
= 1188mm ≈ 1200mm

Slimdek®

= 150mm raised floor
+ 300mm floor slab
+ 400mm fan coil unit/duct
+ 150mm ceiling & lighting
= 1000mm

Cellular beams

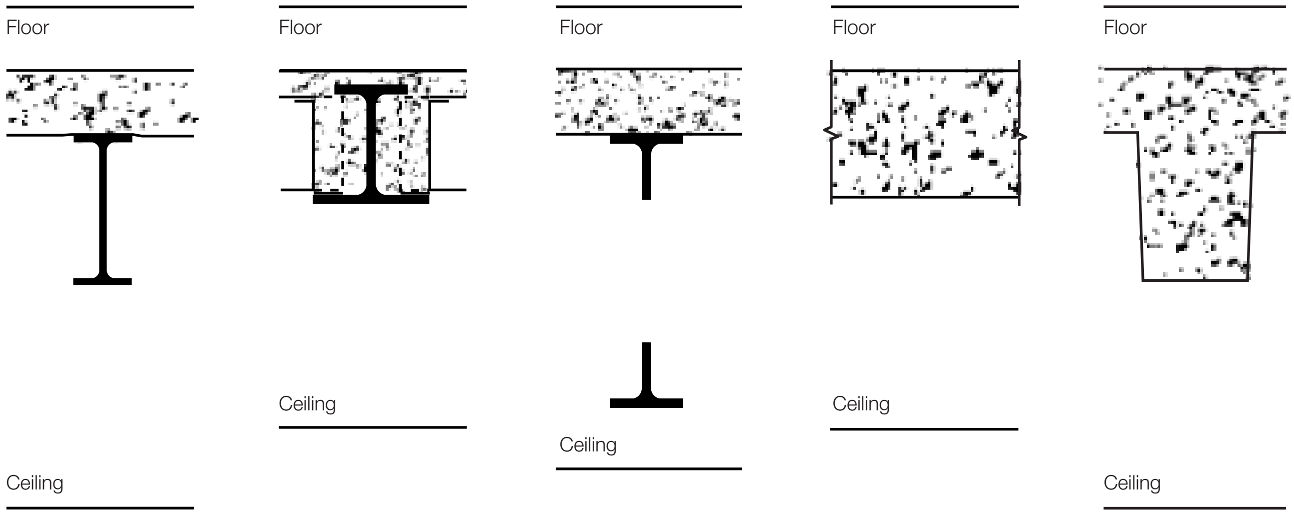
= 150mm raised floor
+ 130mm floor slab
+ 668mm beam
+ 150mm ceiling & lighting
= 1098mm ≈ 1100mm

Reinforced concrete flat slab

= 150mm raised floor
+ 300mm concrete slab
+ 400mm fan coil unit/duct
+ 150mm ceiling & lighting
= 1000mm

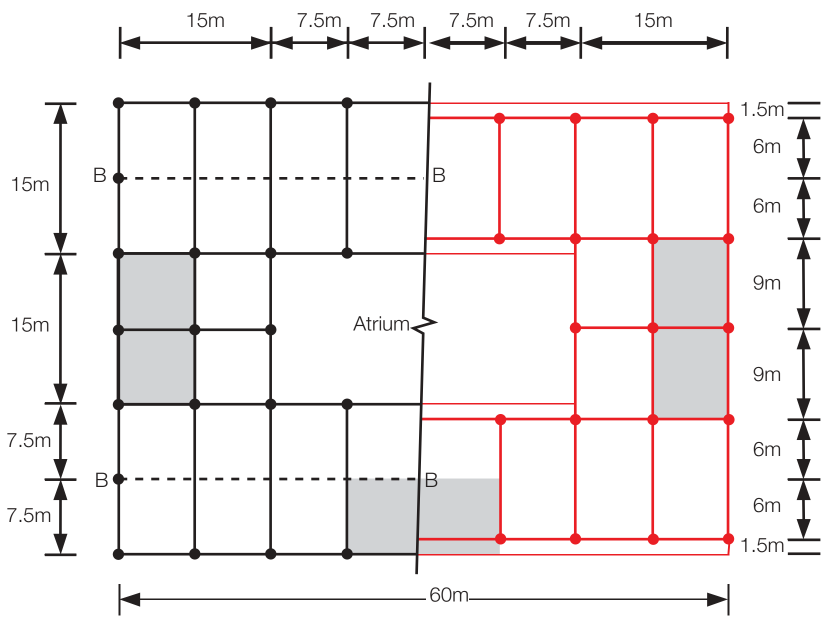
Post tensioned ribbed slab

= 150mm raised floor
+ 500mm beam and slab
+ 400mm services
+ 150mm ceiling & lighting
= 1200mm



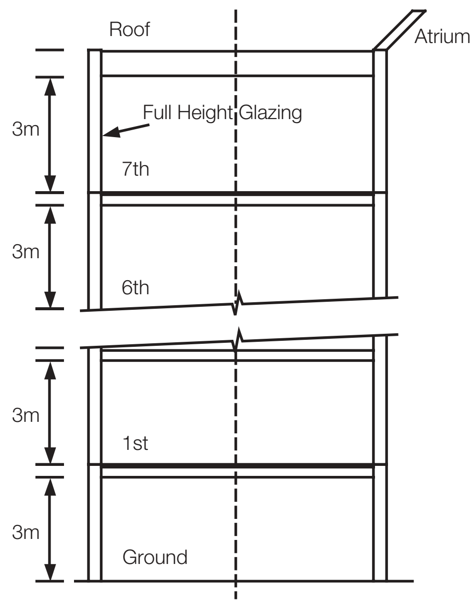
Idealised plan

Service cores within this area.



Additional line of columns on B-B for short span systems
Red grid shows adjustment for post tension design

Section



Study methods

The overall study considered 20 layouts covering 12 different structural forms.

This included virtually every regular form of steel and concrete design used in modern multi-storey construction. The complete set of results appear in the updated Steel Construction Institute publication SCI-P-137 'Comparative Structure Cost of Modern Commercial Buildings', but for the purpose of brevity only the most cost-effective options for each material type have been detailed in this summary version.

The study was conducted using some of the industry's top construction specialists. Their expertise and independence ensures the credibility and accuracy of the study results.

The design of the steel and composite options was carried out by the Steel Construction Institute, while concrete options and the foundations were designed by Arup. MACE detailed each construction programme and Davis Langdon then priced up all the options.

Design assumptions
The Steel Construction Institute provided the steel designs and Arup provided those for concrete. Where necessary, column grids were adapted to suit a particular construction form, such as post tensioned concrete. A list of the main design parameters and assumptions are shown in Appendix one.

Fire protection
For effective fire protection, it is assumed that an intumescent coating is used for the beams and bracing, and that a board system is used for the columns. Asymmetric Slimflor® Beams (ASBs) are partially encased in concrete and do not require any additional protection for 60 minutes fire resistance.

Construction programme assumptions
The programming for all options was undertaken by MACE. It is assumed that the programming and plant resources for each option are consistent – so that they do not favour any form of construction. The key interfaces between preceding and following trades are assumed to be well maintained.

Building A is erected using one mobile crane, while Building B requires two tower cranes. Both buildings employ a concrete pump to install insitu concrete, and all concrete options use table forms. The steel columns in both buildings are a maximum of two storeys high during construction and all options use precast stairs.

Costing assumptions

The pricing of all options was carried out by Davis Langdon. In some cases, where a construction form had many possible arrangements, cost was used to determine the preferred layout. Price levels in the study are those prevailing in the final quarter of 2003.

The rates for steel fabrication include design, connections, transport and erection, but assume that the steel is not to be painted. Other steel-related components, such as fire protection, shear studs and steel decking, have also been accurately costed.

The itemised rates for the various concrete components, including foundations, ground floor, basement, upper floors and roof – as well as the associated work such as excavation, reinforcement and formwork – have similarly been compiled from recently tendered projects.

The composite unit rates used for other elements in the buildings have been compiled from Davis Langdon's costs database, and reflect a typical developer's standard specification.

A contingency and design reserve of 7.5 per cent has been added to reflect the typical cost for the generic offices represented by the two buildings. No allowance has been made for external works and services, drainage and non-construction costs, such as furniture, professional fees and VAT.

Regional cost adjustment

Although Building A is located in Manchester and Building B in central London, the study results can be adjusted to take account of regional price differences, using the table below.

Adjustment to cost tables (%)

	Building A	Building B
Outer London	+16	-7
Central London	+23	0
East Anglia	-4	-16
East Midlands	-1	-19
North East	-2	-20
North West	0	-19
Northern Ireland	-15	-30
Scotland	-1	-20
South East	+11	-11
South West	0	-19
Wales	-1	-20
West Midlands	0	-19
Yorkshire and Humberside	-4	-22

Cost-effective construction

The study showed that steel-based systems offer the cheapest and quickest forms of construction for commercial buildings.

Cheaper in steel

For Building A, the study showed that the composite beam and slab system was the lowest cost option, closely followed by Slimdek®. In Building B, Slimdek® was the cheapest structural system, with composite beam and slab not far behind. In both buildings, the two concrete options proved to be the most expensive solutions.

In general, the variation in total cost of all the steel-based options is relatively small - and all are considerably cheaper than the concrete-based systems.

The study results also show that the premium paid for long spans is relatively small. In Building B, the additional cost for such column-free space is about one per cent of the total building cost. This option provides open-plan interiors that offer total flexibility in the internal layout.

The cellular beam option is particularly economic in the highly serviced Building B, as the beams are perfectly designed for the integration of air distribution pipework.

The cost of foundations is also relatively small for both buildings. Here again, the long span steel option offers further cost savings, since it incorporates fewer columns.

BUILDING A – a four storey office building in Manchester with a gross floor area of 2,600m²

Elemental building cost per SQ M gross floor area for structural options

Code	Description	Composite beam and slab	Slimdek®	Long span cellular beams	Reinforced concrete flat slab	Insitu concrete frame with precast concrete floors
		£/m²	**£/m²**	**£/m²**	**£/m²**	**£/m²**
1	Substructure	25	26	26	37	34
2	Frame and upper floors	71	90	91	118	101
3	Pitched roof	20	20	20	20	20
4	Stairs	19	18	20	18	19
5	External walls	70	67	77	67	71
6	Windows and external doors	99	99	99	99	99
7	Internal walls, partitions and doors	33	32	35	32	33
8	Wall finishes	16	16	16	16	16
9	Floor finishes	63	63	63	63	63
10	Ceiling finishes	25	25	25	25	25
11	Fittings	10	10	10	10	10
12	Sanitary fittings and disposal	44	44	44	44	44
13	Mechanical services	97	97	97	97	97
14	Electrical services	85	85	85	85	85
15	Lift installation	42	42	42	42	42
16	Builders work in connection	33	33	33	33	33
	Subtotal	751	765	782	804	791
Preliminaries (approximately 13.00%)		103	99	101	107	105
	Subtotal	854	864	883	911	896
Contingency (7.50%)		64	64	66	68	67
Total building cost/m² GFA		**918**	**928**	**949**	**979**	**962**
Construction period (weeks)		42	40	41	43	43
Extra/(saving) in finance costs @ 6 % p.a.		-2	-3	-2	0	0
Net building cost/m² GFA		**916**	**925**	**947**	**979**	**962**

BUILDING B – an eight storey prestige company headquarters in London with a gross floor area of 18,000m²

Elemental building cost per SQ M gross floor area for structural options

Code	Description	Composite beam and slab	Slimdek®	Long span cellular beams	Reinforced concrete flat slab	Post tension ribbed slab
		£/m²	**£/m²**	**£/m²**	**£/m²**	**£/m²**
1	Substructure	41	40	37	48	48
2	Frame and upper floors	83	100	105	144	170
3	Pitched roof	34	34	34	34	34
4	Stairs	25	24	25	25	24
5	External walls	310	295	303	310	288
6	Windows and external doors	4	4	4	4	4
7	Internal walls, partitions and doors	95	92	95	92	88
8	Wall finishes	16	16	16	16	16
9	Floor finishes	85	85	85	85	85
10	Ceiling finishes	46	46	46	46	46
11	Fittings	4	4	4	4	4
12	Sanitary fittings and disposal	46	46	46	46	46
13	Mechanical services	231	229	233	235	235
14	Electrical services	97	97	99	97	100
15	Lift installation	58	58	58	58	58
16	Builders work in connection	78	78	78	78	78
	Subtotal	1,253	1,248	1,268	1,323	1,324
Preliminaries (approximately 15.00%)		178	178	176	198	200
	Subtotal	1,431	1,426	1,444	1,521	1,524
Contingency (7.50%)		107	107	108	114	114
Total building cost/m² GFA		**1,538**	**1,533**	**1,552**	**1,635**	**1,638**
Construction period (weeks)		67	67	66	76	77
Extra/(saving) in finance costs @ 6 % p.a.		-8	-8	-9	0	0
Net building cost/GFA		**1,530**	**1,525**	**1,543**	**1,635**	**1,638**

Rapid construction

The speed of construction of steel structures was highlighted by the study. For both steel and concrete, the erection of the structure is a relatively small proportion of the overall programme time – but steel was shown to be the faster option.

For Building A, steel structural systems could be erected in six or seven weeks, compared with eight weeks for reinforced concrete systems. In addition, all concrete frame structures need to begin later than the steel alternatives, since a ground-bearing slab must be constructed first.

In Building B the differences were even more marked. Steel options took 13 weeks to erect, whereas reinforced concrete systems required 18 weeks. The long span steel option is the fastest construction system, since there are fewer pieces to assemble, requiring less use of the crane.

Time-related savings

Faster construction has additional benefits. It results in savings in the cost of site management and on-site activities. It reduces the cost of finance, since a shorter construction period reduces the time during which interest has to be paid. The rapid completion of a building also brings an earlier return on investment. New tenants can move in sooner, offsetting the cost of borrowing.

Building A - Time related savings

Structural form	Frame (weeks)	Overall (weeks)
Composite beam and slab	7	42
Slimdek®	6	40
Cellular beams	6	41
Reinforced concrete flat slab	8	43
Insitu concrete frame with precast concrete floors	8	43

Building B - Time related savings

Structural form	Frame (weeks)	Overall (weeks)
Composite beam and slab	13	67
Slimdek®	13	67
Cellular beams	13	66
Reinforced concrete flat slab	18	76
Post tension ribbed slab	19	77

Additional measurements

The tables below compare the finished structural dimensions and weights of each of the five construction systems for each building. These findings illustrate some of the merits of the different systems, but should not be considered in isolation. For example, the weight of steel is only a crude measurement of efficiency - and does not take into account the reduced costs of fire protection and cladding and the ease of service installation.

Building A - Additional measurements

Structural form	Beam and slab depth (mm)	Overall floor zone (mm)	Building height (m)	Area fire protection (m^2/m^2 floor area)	Basic steel frame weight per floor area (kg/m^2)	Total steel weight per floor area (kg/m^2)
Composite beam and slab	482	800	14	0.66	35.5	43.7
Slimdek®	311	600	13.2	0.44	34.1	42.3
Cellular beams	790	1100	15.2	0.90	44.4	52.6
Reinforced concrete flat slab	300	600	13.2			
Insitu concrete frame with precast concrete floors	475	800	14			

Building B - Additional measurements

Structural form	Beam and slab depth (mm)	Overall floor zone (mm)	Building height (m)	Area fire protection (m^2/m^2 floor area)	Basic steel frame weight per floor area (kg/m^2)	Total steel weight per floor area (kg/m^2)
Composite beam and slab	490	1200	31.2	0.69	35.4	37.4
Slimdek®	320	1000	29.6	0.42	38.4	40.4
Cellular beams	800	1100	30.4	0.74	44.4	46.4
Reinforced concrete flat slab	300	1000	29.6			
Post tension ribbed slab	500	1200	31.2			

Note: Total steel weight includes that required for wind posts, cladding rails, pitched roof, plant room, atrium roof etc.

The value of steel

Steel offers considerable advantages over concrete, making it the first choice material for large building construction in any location.

Minimal disruption
Steel construction can dramatically reduce the impact of building activities on the surrounding area. This is particularly important in inner city locations or sites close to residential areas. Steel construction minimises noise and dust, shortens the construction period and reduces the amount of waste generated. Deliveries can even be timed to suit local traffic conditions and keep disruption in the area to a minimum.

Flexible solution
Long span steel construction reduces the number of vertical columns in a building and offers complete flexibility of internal layout. It means a building can be configured to incorporate any combination of large open-plan areas, individual offices, meeting rooms and corridors. All internal walls can be repositioned, allowing buildings to be adapted endlessly to suit the changing needs of their occupants. Also, if when contructed the building use changes, steel frames are easier to alter than the concrete alternative.

Built-in quality
Off-site fabrication improves the quality of the building frame, since the majority of work is carried out under closely controlled factory conditions – where it is not affected by on-site trades or the weather. All steel frames are prefabricated leading to a right-first-time build and minimising time and disruption on site.

Steel does not suffer from creep or shrinkage and, when properly protected, does not rot or decay.

Environmental benefits
Steel offers a clean, efficient and rapid construction method, which reduces the impact of building activities on the environment. The small amount of waste produced is generally recycled, and all steel is potentially reusable. Today, around 40 per cent of steel is produced from scrap.

Steel **flooring solutions**

Composite beam and slab

Composite beam and slab is the most popular form of multi-storey frame construction in the UK. This fast, efficient, lightweight solution comprises of a shallow metal deck spanning, typically, 2.5m to 4.5m between supporting steel beams. The effective span range of the beams is 5m to 12m. A shallow concrete slab is cast on the decking and composite action between the beam and slab is generated by shear studs that have been welded through the decking on to the supporting beams.

The speed and structural performance, coupled with many other benefits, makes composite construction the preferred option for offices and other multi-storey building frames.

Slimdek®

Slimdek® is an engineered shallow depth flooring system for multi-storey buildings. The system comprises of rolled asymmetric steel beams (ASB) supporting deep metal decking on an open grid up to 9m x 9m with no secondary steelwork. During construction, the ASB beam is encased within the concrete floor slab and composite action is generated without shear studs. This results in a floor of between 300mm and 400mm depth with a flat soffit and no downstands.

Due to the encasement of the steel beam, the system has inherent fire resistance up to 60 minutes without the need for fire protection. Another key benefit of the system is the ease of service integration within the floor depth.

Cellular beams

Courtesy of Fabsec Limited.

Cellular beams provide long clear spans offering tremendous flexibility of space. The effective span range is 10m to 18m. Web openings allow simple service integration within the structural zone. The beams work compositely with the floor slab and can be fabricated asymmetrically for improved efficiency. The beams are commonly treated with an intumescent fire protective coating, which is applied off-site as part of the manufacturing process. Modern fire protective coatings are thin build, but highly durable to withstand the rigours of transport and erection.

The cost study investigated cellular beams as both primary and secondary members. For both buildings, the long span secondary beam option proved to be the most economic, so it is that arrangement which is included in this summary report.

Appendix one
Design parameters and assumptions

Common features

The common features of the structural design of both buildings are as follows:

- They are designed for a specified imposed load of $3.5kN/m^2$, plus $1kN/m^2$ for partitions and $0.7kN/m^2$ for the ceiling, services and raised floor. Although these loads are slightly higher than required by the Building Regulations, they are typical of those specified in modern commercial buildings.
- Deflection limits are taken as defined in BS 5950 Part 1. Total deflections of the beams or slabs of all options are limited to a maximum of span/200 or, alternatively, a maximum of 60mm in the long span options. Deflection of beams supporting the glazed façade is limited to a maximum of span/500 or 25mm. In practice, deflections will be much less than these limits, owing to the stiffness of the connections.
- The natural frequency limit is taken as 4Hz with a response factor of 8 for a busy office.
- The planning grid adopted is 1.5m, and therefore column spacing and beam spans are generally based on multiples of this dimension i.e. 6, 7.5, 13.5 and 15m.
- The span of the composite slab is taken as either 3 or 3.75m, depending on the column grid. This necessitates a change in the deck profile where unpropped construction is used.
- Normal weight concrete is used for Building A, and lightweight concrete for the composite slab options in Building B.
- S355 steel (to BS EN 10 025) is used in the heavily loaded members such as the long span beams and columns. S275 steel is used for secondary beams, which are controlled by serviceability criteria.
- The 2002 Building Regulations also require that all buildings possess ‘robustness’ through provision of tying action. This necessitates the placement of an additional insitu slab with reinforcement across the beams in the Slimdek® and precast concrete options.
- The steel options for both buildings are designed as braced against wind load with bracing accommodated within the core area. In the concrete options, reinforced concrete shear walls or ‘cores’ are used to provide stability.
- Fire protection is taken as board for columns. Internal beams and bracing members are assumed to be protected by intumescent coatings. For the cellular beam option in Building B, the intumescent coatings are applied off-site. In Slimdek® the ASB beams are partially encased in concrete, and only require protection for more than 60 minutes fire resistance.
- The core positions are selected to offer the required escape routes and zones for vertical services. Their size is sufficient to accommodate lifts, stairways and vertical ducts and pipes. In Building B, the location of the vertical risers controls the horizontal distribution of ducts and can have an influence on the required depth of the construction. However, although the cores are located and designed on a simplistic basis, it is not expected that they will have a major influence on the final design quantities and costs.
- The ground floor is a reinforced concrete slab with under-slab thermal insulation in all cases. Additional concrete works are required for the lift shafts and basement area, which are common to all schemes.

Internal walls: Core walls are medium dense concrete masonry. Other walls are demountable lightweight steel/plasterboard partitions.

Raised access flooring: Medium duty 600 x 600mm with loose lay carpet tile finish. Vinyl flooring to ancillary areas. Ceramic tiles to toilet floors and epoxy paint to plant room floors. The raised flooring is 150mm deep in Building A and 200mm deep in Building B to accommodate telecommunications equipment.

Suspended ceiling: 500 x 500mm suspended ceiling with concealed grid. The ceiling grid is 1500mm square to match the structural grid.

Toilets: Proprietary cubicles, modular duct panels and vanity units.

Internal doors: Veneered solid core within a hardwood frame with stainless steel ironmongery.

Internal finishes: Wall finishes are plaster/plasterboard with emulsion paint finish.

Feature finishes: High quality reception area with perhaps some granite flooring local to the main entrance.

Roof: In Building A, a portal frame supporting roof tiles is provided. In Building B, a steel roof enclosure is provided over the major air conditioning plant and lift motor rooms with louvered sides, where necessary. Elsewhere the roof is a ballasted flat roof.

Staircases: The staircases are generally precast concrete with powder coated balustrades and hardwood handrails.

Windows: Windows to Building A are openable aluminium polyester powder-coated double-glazed. The windows are to be 2100mm high with a sill level of 600mm above raised floor level. Windows to Building B are of the same specification, but are sealed.

Building A

The specific features of the structural design for Building A are:

- Occupancy level of one person per 10m^2 of net floor area, which allows for a maximum occupancy of 200. Net floor area may be taken as 80% of the gross floor area (GFA).
- Male/female toilets located together in opposite cores with additional toilets at ground floor level.
- Three 10-person lifts with a maximum speed of 0.6m/s are provided, each requiring a shaft size of 1.9m x 2.3m. Two lifts are located adjacent to the entrance lobby.
- The building is generally open-plan but may be divided into individual offices with adequate day lighting and means of escape.
- Means of escape is via 1100mm wide protected staircases at both ends of the building.

Building B

The specific features of the structural design for Building B are:

- Occupancy level of one person per 10m^2 of net floor area, which allows for a maximum occupancy of 1400. Net floor area may be taken as 80% of the gross floor area.
- The vertical risers in the main service cores occupy an area of 5m x 2.5m.
- Male/female toilets located in two cores, with additional toilets at ground floor level. The toilet units are 7.5m x 3.5m.
- Three 16-person lifts are provided and these are located adjacent to the entrance lobby. The lifts have a minimum speed of 1.6m/s and require a shaft size of 2.6 x 3.3m each. A motor room of 80m^2 plan area will also be required. Two 10-person lifts are also provided in the other cores.
- The building is generally open-plan but may be sub-divided to include perimeter offices of 3m width and 4.5m depth.
- Internal heat gains are assumed to be 80W/m^2 in the design of the comfort cooling system.
- Means of escape is via three 1100mm wide protected staircases, which are separated from the atrium. The maximum travel distance is 45m.
- Three 8-person fire-fighting lifts are provided, one adjacent to the entrance lobby and one in each of the main service cores. Each lift requires a shaft size of 2.5 x 2.2m.
- The atrium is provided with a mechanical smoke extract system.
- The costs do not include those for non-combustible glazing to the atrium walls. A detailed approach to fire engineering may provide alternative options, depending on means of escape and use of sprinklers, etc.

Appendix two
Major element rates

The unit cost rates used in this study are those found to be typical during the fourth quarter of 2003 for Building A in Manchester and Building B in Central London.

The cost rates for some of the major elements used for the frame and floor costings in the study are included here for information but do not necessarily reflect current competitive pricing.

		Building A	Building B
Structural steelwork	**Unit**		
Universal beams	Tonne	£1,000.00	£1,100.00
Universal columns	Tonne	£975.00	£1,050.00
Cellular beams	Tonne	£1,300.00	£1,400.00
Asymmetric Slimflor® beams - S355	Tonne	£1,075.00	£1,120.00
Tubular wall bracing	Tonne	£1,550.00	£1,650.00
Tubular wind posts	Tonne	£1,250.00	
Fire protection			
Conlit Board	m^2	£9.50	
Firecase S board	m^2	£16.00	£20.00
Mandolite spray	m^2	£8.65	
Intumescent coating for 60mins (on-site)	m^2	£10.50	
Intumescent coating for 90mins (on-site)	m^2		£23.00
Intumescent coating for 90mins (off-site)	m^2		£32.00
Other structural items			
19mm diameter x 100mm long shear studs	Each	£1.30	£1.40
A142 mesh reinforcement	m^2	£2.00	
A193 mesh reinforcement	m^2	£2.50	£3.00
Normal weight concrete slab - pumped	m^2	£97.00	£115.00
Light weight concrete slab - pumped	m^2		£130.00
PMF CF70 steel floor deck	m^2	£12.00	
Ribdeck E60 steel floor deck	m^2		£13.50
SD225 steel floor deck	m^2	£26.00	£25.00
Reinforcement bar	Tonne	£575.00	£730.00
Concrete columns and walls			
- 400 x 400mm, reinforcement - 295kg/m^3	m	£93.60	
- 600 x 200mm, reinforcement - 185kg/m^3	m	£71.40	
- 450 x 450mm, reinforcement - 280kg/m^3	m		£154.00
- 600 x 600mm, reinforcement - 200kg/m^3	m		£192.00
Reinforced concrete shear wall - 250mm thick	m^2	£99.10	
Reinforced concrete shear wall - 300mm thick	m^2		£137.00
Concrete floor slab			
Reinforced concrete flat slab - 300mm thick	m^2	£81.20	£100.00
Attached reinforced concrete beams - 200 x 400mm	m	£48.80	
Isolated reinforced concrete edge beams - 500 x 825mm	m	£165.60	
Bison precast concrete floor slabs - 400mm thick	m^2	£51.00	
Reinforced post tensioned concrete slab - 150mm thick	m^2		£125.30
Attached reinforced concrete beams - 500 x 500mm	m		£160.00
Reinforcement interface between slabs and columns	Each	£240.00	£310.00

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