Better Value in Steel

Hospitals and Health Buildings using Steel

Meeting the needs of the health sector for modern, rapid-build, adaptable hospitals

A range of steel-intensive technologies provides construction solutions for the health sector that can be used in major hospital projects to meet strict NHS standards and the needs of PFI funding.

The Steel Construction Institute

Buildings

Hospital and Health Buildings using Steel

The health sector demands buildings that are flexible and adaptable in use, and which can be constructed rapidly to meet tight programmes. Many of these buildings are procured through the Private Finance Initiative (PFI), where the provider may also be responsible for the long-term performance of the building.

Recent major hospital projects demonstrate that steel construction is well placed to meet the demands in the health sector. A number of construction systems have been developed to ensure that the designer has a range of options with which to address the particular issues and choices.

Steel construction is mainly an off-site manufacturing process, which improves quality, reduces waste and increases speed of site construction. This aligns closely with the recommendations of the Egan Report *Rethinking Construction*. It is a clean, reliable, quality assured product and recent research has shown that the various design options can successfully meet strict NHS standards for acoustic insulation and floor vibration levels.

Steel Construction Systems

Steel construction building systems offer complete solutions to hospital design. Steel composite floor systems create conduits for services and ventilation as well as achieving high acoustic performance.

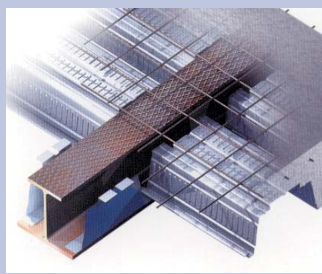
Light steel walls and modular construction allow for speed of installation and flexibility of design. The following systems offer adaptable and flexible solutions to designers.

Composite beams and slabs

Downstand beams acting compositely with the slab, through welded shear connectors, provide excellent stiffness and economy. For normal design, beam spans up to 18 m are achievable using standard rolled steel sections.

Composite slabs normally use decking of 45 to 80 mm depth to create a 120 to 160 mm deep slab. Deck spans of 2.5 to 4 m can be achieved, and composite action is sufficiently good that heavy machinery may be supported. Services can be suspended from the soffit of the slab.

Slimdek®



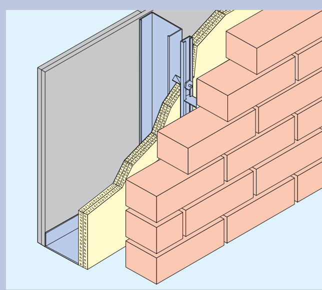
Slimdek® comprises Asymmetric *Slimflor®* Beams (ASB) supporting SD225 deep decking and in-situ concrete. A wide range of ASB sizes is available. The beams act compositely with the slab and spans up to 10 m may be achieved. *Slimdek®* has no downstand beams and the webs can be perforated for ducts and pipes (openings up to 160 mm diameter can be created).

SD225 decking is a special deep decking profile that is part of the *Slimdek®* system. It achieves spans of up to 6 m when unpropped and 9 m when propped temporarily during construction. The final slab depth is typically 300 mm, excluding any in-situ screed that may be added. Composite action leads to excellent stiffness of the slab and reduced sensitivity to vibrations.

Long-span beams

A wide range of beams can be 'tailor-made' by fabrication to suit the particular depth and loading requirements. Beams can have parallel flanges or may be tapered along their length, and they can be perforated by circular or rectangular openings. Perforations may accommodate large service ducts, or may be used to minimise the weight of the beams. Spans up to 25 m can be achieved.

Light steel infill walls



Light steel infill walls use galvanized steel, typically 1.2 to 2.4 mm thick, roll-formed into C-sections of 75 to 200 mm depth. Separating walls use double C-sections and, with suitable insulation materials, achieve excellent acoustic insulation and fire resistance. These steel walls are lightweight and can be dismantled and moved easily. They create a 'rapid dry envelope' early in the construction process, which facilitates installation of services and fit-out.

Modular units

Light steel frames (frames of cold-formed galvanized steel sections, of various shapes and sizes) are used in modular units such as plant rooms, toilets and specialist facilities. The units are manufactured off-site and are typically restricted to 4 m width for ease of transportation. They can be installed using 'air movers' to cross completed floors.

Modular construction

Modular construction uses pre-engineered volumetric units that are installed on site as fitted out and serviced 'building blocks'. As well as offering speed of construction and quality, they have added benefits of economy of scale and single point procurement. Light steel framing is an integral part of modular construction.

For major hospital projects, modular construction is ideal for the rapid and economic provision of key-worker accommodation up to 9 storeys, whilst providing architecturally attractive solutions.

Case Examples

The following Case Examples illustrate the use of a wide range of steel options in hospitals.

Cumberland Infirmary

This PFI-funded project in Carlisle consists of four separate but linked buildings with a total floor area of 33,000 m^2.

The steel framed structure uses composite beams with light steel infill walls. The form of construction was selected after a value engineering exercise by the contractor, Amec. The client wished to have flexibility of internal planning, which the chosen scheme provided. The structure was completed in only six months.

Darrant Valley Hospital, Kent

This 50,000 m^2 hospital by Dartford and Gravesham NHS Trust was one of the first to be built under PFI. It consists of two distinct wings whose curved sweeping roof and supporting columns are in tubular steel.

The steel structure and highly glazed facade were chosen to maximize natural lighting internally and to provide a clean, modern environment. The contractor was Carillion Building Special Projects.

Sunderland Royal Hospital

This major hospital renovation project required considerable provision for future flexibility in services and use of internal space. Large openings were required in the slabs for services.

The use of *Slimflor*® (an earlier version *Slimdek*®) allowed new floor levels to be aligned with the existing building while providing a deep space for services.

An additional benefit was that the lightweight structure minimised the loads on the foundations, which were on poor ground. The contractor for the 16,000 m^2 extension to the Sunderland Royal Hospital was HBG Construction.

Leeds Nuffield Hospital

Long span beams with regular openings were chosen by Shepherd Construction for this new 20,000 m² hospital in the centre of Leeds. The steel structure was built in advance of the concrete core in order to be able to install modular plant rooms on the roof. Also, modular toilets were slid into place on the completed floor to further speed up the construction process.

An interesting feature of the design was that the fire resistance (normally required to be 90 minutes for buildings of this type) was reduced to 60 minutes following a fire engineering assessment.

Furthermore, the use of design guidance derived from large-scale fire tests carried out at BRE Cardington meant that the secondary beams did not require fire protection.

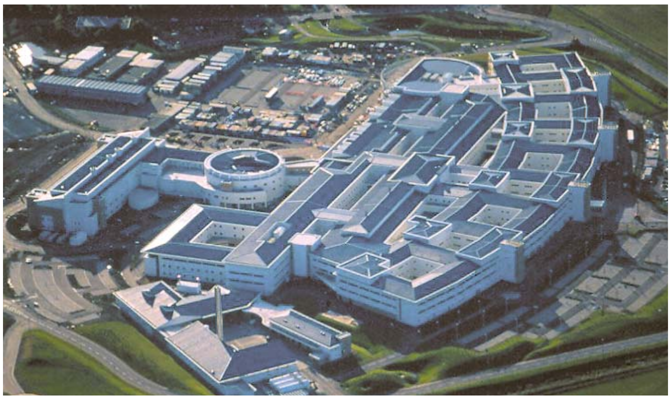
Royal Infirmary of Edinburgh and University of Edinburgh Medical School

Consort Healthcare, the Lothian University Hospitals NHS Trust and the University of Edinburgh commissioned this major new hospital and teaching facility attached to the University.

The project, the largest PFI hospital project in the UK to date, comprises a 120,000 m² new hospital block and 11,000 m² of combined laboratory and academic accommodation for the medical school.

Originally designed as a concrete structure, a steel framed building was chosen by the contractor because of the faster speed of construction.

The design and construction of the new hospital was carried out in a joint venture by Balfour Beatty Construction, Morrison Construction and Haden Young. The steel frame and decking were completed in 20 weeks.



Trauma Unit, John Radcliffe Hospital, Oxford

The Oxford Radcliffe Hospitals NHS Trust commissioned this new 4-storey Trauma Unit, which is attached to the existing John Radcliffe Hospital. *Slimdek®* was chosen for this 4,000 m² building due to the speed of construction and flexibility of internal layout that it offers.

The use of *Slimdek®* allowed the new floor levels to be aligned with the adjacent existing hospital, while providing a deep zone for services, which were distributed below the flat soffit of the floor. The contractor for the project was Bovis Lend Lease Limited.

Benefits of Steel Construction in Hospitals

SPEED OF CONSTRUCTION

Steel construction uses prefabricated components and construction periods can be reduced compared with concrete construction. Benefits can be achieved by:

- Reduced site preliminaries.
- Creation of a 'rapid dry envelope' for early fit-out.
- Installation of modular services.
- Earlier return on the investment.

The time-related savings can represent 3 to 5% of the overall hospital project value and are crucial in the decision-making process for major projects.

FLEXIBILITY AND FUTURE ADAPTABILITY

Long span steel construction creates column-free space and allows partitions to be installed on the floor plan to meet the current and future needs.

Slimdek® provides a 'flat' soffit without downstands and permits complete flexibility of layout of internal walls.

Light steel internal walls can be relocated, leading to fully adaptable buildings to meet future needs.

QUALITY

Off-site prefabrication improves quality by using factory-controlled production. Off -site construction reduces dependency on site trades and weather.

Steel does not suffer from creep or shrinkage and does not rot or decay.

Modular components such as bathrooms and 'clean rooms' achieve much greater levels of quality and can be commissioned or tested off-site.

MINIMISED DISRUPTION

Minimum disruption is important in inner city locations and in extensions to existing hospitals. Disruption caused by the construction process can be reduced using steel construction by:

- Off-site prefabrication.
- Reducing materials use and waste.
- Minimising noise, dust and vibrations.
- Reducing the construction period.

CLEANLINESS

Painted steel surfaces can be kept clean, and steel decking is free from dust and contamination.

Intumescent coatings for fire protection can be sprayed and dried off-site and do not produce dust or dirt.

VIBRATION AND ACOUSTIC PERFORMANCE

Steel construction can be designed to achieve high levels of acoustic insulation and low vibration response to meet stringent NHS requirements, without compromising structural efficiency.

SERVICE INTEGRATION

Services represent up to 30% of the completed building cost and effective integration of services is important in order to achieve economies. Perforated long-span beams provide for freedom of service distribution and major ducts can be located through elongated openings. *Slimdek*® provides for flexibility of service distribution, and air can be circulated between the ribs and through regular openings in the beams.

Where the service provider can influence the initial design (as is usually the case in PFI projects), services can be distributed efficiently below downstand beams.

THERMAL INSULATION OF CLADDING

Light steel infill walls can provide a high degree of thermal insulation.

Insulation material is placed outside the frames, creating a 'warm frame', which reduces thermal bridging. A variety of cladding materials may be used to provide additional insulation.

ENVIRONMENTAL BENEFITS

Steel construction is produced efficiently and waste is minimised and recycled; all steel is potentially reusable. Worldwide, up to 40% of steel is made from recycled material and in the UK all steel contains at least 20% recycled material.

Technical Aspects

The design of multi-storey steel framed buildings is well covered by SCI publications. The particular issues that the designer should address in relation to the health sector are:

Floor vibrations

NHS standards require a Response Factor of not more than 1 for continuous vibrations in theatre areas and not more than 1.4 for intermittent vibrations in ward areas. This can only be achieved by mobilising a high effective mass of the floor through a continuous floor slab. Vibration tests on a hospital comprising a long span composite structure before and after fit-out showed the following Response Factors (*R*) and natural frequencies (*f*) (see Table 1).

Table 1*: Vibration performance of 11.3 m span composite beams with a 300 mm in-situ composite slab.*

Parameter	Condition	Measured
Response factor	*Bare structure*	R = 2.7
	After fit-out	R = 0.25
Natural frequency	*Bare structure*	f = 9.0 Hz
	After fit-out	f = 6.4 Hz

These results demonstrate excellent performance of composite construction, which achieves the strict NHS standards for limits on vibrations. Similar performance characteristics may be expected from *Slimdek*®.

Acoustic insulation

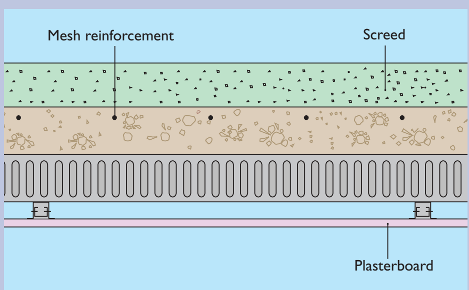
To meet NHS acoustic and vibration standards, a screeded floor is generally required, with or without a suspended ceiling. Acoustic tests on a wide range of composite construction and *Slimdek*® floors have demonstrated that an airborne sound reduction of over 60 dB can be achieved (see Table 2).

Table 2*: Data for acoustic performance of Slimdek® and composite slabs.*

FORM OF CONSTRUCTION	ACOUSTIC PERFORMANCE	
	Airborne sound reduction	Impact sound transmission
NHS Standard (R_w)	> 52 dB	< 61 dB
Slimdek® with plasterboard ceiling	57 dB	69 dB*
Slimdek® with 60 mm concrete screed and plasterboard ceiling	60 dB	53 dB
Composite slab with plasterboard ceiling	54 dB	66 dB*
Composite slab with 60 mm concrete screed and plasterboard ceiling	65 dB	57 dB

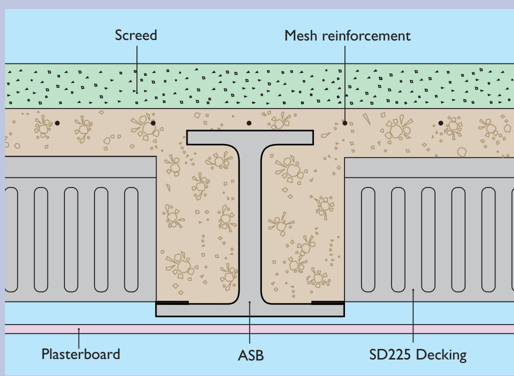
*Acceptable with a resilient floor covering.

Composite slab



Cross-section through composite slab.

Slimdek® construction



Cross-section through Slimdek® floor beam.

Fire resistance

Large hospitals generally require 90 minutes fire resistance. All forms of composite construction can achieve up to 120 minutes fire resistance by traditional fire protection measures such as boards, sprays or intumescent coatings. Partially encased *Slimdek*® beams normally achieve 60 minutes fire resistance without applied protection; higher periods are possible where fire protection is provided to the exposed bottom flange.

Intumescent coatings are cost effective on downstand beams for fire resistance periods up to 90 minutes. However, off-site intumescent coatings have been developed which provide up to 120 minutes fire resistance economically for fabricated sections.

Intumescent coating being checked off-site.

Sources of Information

A wide range of advice is given in SCI publications:

Steel and composite construction

Design of Fabricated Composite Beams in Buildings (P059)

Commentary on BS 5950: Part 3 Section 3.1 Composite Beams (P078)

Design Guide on Vibration of Floors (P076)

Interfaces: Design of Steel Framed Buildings for Service Integration (P166)

Fire Safe Design: A New Approach to Multi-storey Steel Framed Buildings (P288)

Composite Floors and Slabs using Steel Decking: Best Practice for Design and Construction (P300) (published jointly with MCMRA)

***Slimdek*®**

Design of Asymmetric *Slimflor*® Beams using Deep Composite Decking (P175)

Service Integration in *Slimdek*® (P273)

Value and Benefits of *Slimdek*® Construction (P279)

Slimdek® Case Studies (P309)

Light Steel

Building Design using Cold Formed Steel Sections: Acoustic Insulation (P128)

Case Studies on Light Steel Framing (P176)

Modular Construction using Light Steel Framing: An Architect's Guide (P272)

Building Design using Cold Formed Steel Sections: Light Steel Framing in Residential Buildings (P301)

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