Technical Information Sheet ED011

Light Steel Residential Buildings

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Multi-storey residential building is an important market for light steel framing and modular construction. These forms of construction are widely adopted because of the speed of construction, high quality and the high level of sustainability that are achieved through off-site manufacture.

Key benefits

The benefits of light steel and modular construction in relation to residential buildings are:

- Speed of construction (up to 50% faster than traditional methods).
- Excellent performance characteristics e.g. fire resistance, acoustic insulation, and thermal insulation.
- High level of quality control, accuracy and freedom from shrinkage, reducing call-backs for defects.
- Light weight for medium-rise and mixed use buildings, in which the residential floors can be supported on a podium level, thereby reducing foundation requirements.
- Minimum disturbance to the locality during construction, with fewer deliveries; this is particularly advantageous where site constraints may limit the storage space available.
- Waste recycling in manufacture and reduction of on-site waste.
- Structural robustness and ability to create long spans and large openings.

Forms of construction

Light steel framing and modular construction are load-bearing systems that are suitable for residential and mixed use buildings. The use of these forms of construction in residential buildings is strongly dependent on the wider benefits that are offered to the developer and the purchaser. The benefits are greatest for multi-storey residential buildings up to 10 storeys high, and buildings comprising commercial space or car parking at the lower levels with residential units above.

The various design topics related to compliance with the Building Regulations, including structural safety, acoustic and thermal insulation, are presented in the SCI publications: *Building Design using Cold Formed steel: Residential Buildings* (P301) and *Residential Buildings using Modular Construction* (P302).

This technical information sheet reviews the basic principles of design that are applicable to the following residential building types:

- Private and social housing in multi-storey buildings
- Mixed use commercial and residential buildings
- Key worker accommodation
- Care homes and sheltered accommodation
- Renovation, e.g. roof-top residential extensions to existing buildings.

Apartments with brick cladding and below ground car parking
(Image courtesy of Metek UK)

High rise modular residential building
(Image courtesy of Ayrshire Framing and Futureform)

Light steel 4-storey residential building in Glasgow
(Image courtesy of Kingspan Profiles & Sections)

Light Steel Framing

Load-bearing light steel framing may be used in multi-storey residential buildings up to 10 storeys high.

Form of construction

In multi-storey residential buildings, the walls are constructed from load-bearing light steel panels comprising C sections that are generally spaced at 600 mm centres. The floors are supported by the walls.

Lateral stability is provided by load-bearing and braced cross-walls, which are often also designed as separating walls for acoustic insulation and fire resistance purposes. Bracing can be flat strap X-bracing or integral K-bracing.

Applications

Multi-storey apartments, key worker accommodation etc.

Technical details

C sections in the wall panels are typically 100 mm deep and 1.5 to 2.0 mm thick, depending on their loading (i.e. varying with storey). At the lower levels, C sections are often placed in pairs; single C sections in decreasing thickness are used at the upper levels.

Two types of floor construction are commonly used:

- Light steel floor joists
- Composite floor slabs.

In the first case, the floor joists are 200 to 250 mm deep and span 4 to 6 m between cross-walls (longer spans are achievable with heavier gauge sections). The self-weight of a joisted floor is typically 0.8 kN/m^2, including the built up layers used for acoustic separation.

Figure 1 X-braced walls in light steel framing
(Image courtesy of Metek UK)

In the second case, the composite slab is 150 to 200 mm deep and can span a similar distance, but its self-weight is higher at 3.0 to 4.5 kN/m^2. Propping may be required for longer spans.

Figure 2 Construction of a light steel residential development
(Image courtesy of Kingspan Profiles & Sections)

The main technical issues affecting the design of medium-rise residential buildings with light steel framing are:

- Stability under wind loading
- Acoustic insulation
- Fire resistance.

Generally, two layers of 15 mm thick fire resisting plasterboard with mineral wool between the C sections is sufficient to provide 90 minutes fire resistance and a high level of acoustic insulation for light steel separating walls.

Figure 3 Pre-fabricated light steel wall panels with bonded insulation
(Image courtesy of Fusion Building Systems)

Light Steel Framing on a Podium

Light steel framing used for the upper storeys, and hot rolled steel or concrete frames used for the lower storeys is a common solution for mixed use buildings.

Form of construction

The supporting beams of the podium level are aligned with the load bearing walls of the light steel structure above. Modular bathrooms and kitchens may be combined with the light steel framing.

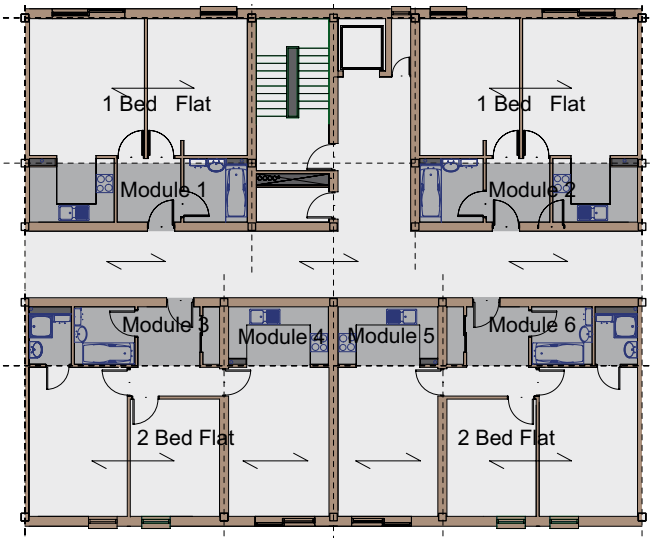
Applications

Mixed use commercial and residential buildings, often with below-ground car parking.

Figure 4 Light steel frame supported on a composite steel structure above a supermarket in Farnborough
(Image courtesy of Metek UK)

Technical details

The supporting steel framed structure is designed conventionally and is often designed to span 9 to 15 m using cellular beams. The light steel framing above leads to a loading of less than 3 kN/m^2 per storey.



Note: Modules are shown shaded; other walls are light steel framing.

Figure 5 Mixed use of light steel framing and modules

Steel Frames with Infill Walls

Structural steel frames are often combined with light steel infill walls that are designed to span between the floors and support the cladding.

Form of construction

Structural steel frames supporting light steel infill walls that span 2.4 m to 5 m between floors.

Application:

Schools, mixed commercial and residential buildings.

Technical details

The C section studs are typically 100 mm deep for spans up to 3 m and 150 mm deep for spans up to 5 m. Infill walls are designed to resist wind pressures and large openings can be created. The C sections may be installed on-site or alternatively, large wall panels may be pre-fabricated and installed by crane.

Figure 6 Light steel infill wall used in a multi-storey steel-framed residential building
(Image courtesy of Metek UK)

Figure 7 Prefabricated light steel infill wall panels used in a multi-storey steel-framed residential building
(Image courtesy of Kingspan Profiles & Sections)

Roofing Systems

Many types of roofing systems may be designed using light steel components, particularly where habitable roof space is created.

Form of construction

The various forms of steel roofing system include:

- C section joisted flat roofs
- Purlins spanning between cross-walls
- Open roof trusses
- Lattice members
- Modular roofing systems.

These roofing systems may be combined with tiles supported on battens and counter-battens, composite roof panels, and 'green' roofs. Increasingly, the roof can also act as support for photo-voltaic panels.

Figure 8 Photo-voltaic roof tiles on a light steel building
(Image courtesy of Fusion Building Systems)

Applications

Provide habitable space for a range of buildings. Pre-fabricated modular roofs.

Technical details

Light steel roofing systems are formed from C and Z sections. Purlins are typically 200 to 300 mm deep for spans of 5 to 9 m. Structural liner trays or composite panels may span perpendicular to the purlins. Liner trays are filled with mineral wool and sarking felt is placed on top. Tiles may be supported on timber battens and counter-battens that are fixed to the upstands of the liner tray.

Prefabricated roof trusses of various forms may also be supplied with their roofing pre-attached. Upstands may be created to attach the rails of PV panels.

Figure 9 Composite panel with tiled finish supported on Z section purlins
(Image courtesy of Kingspan Panels)

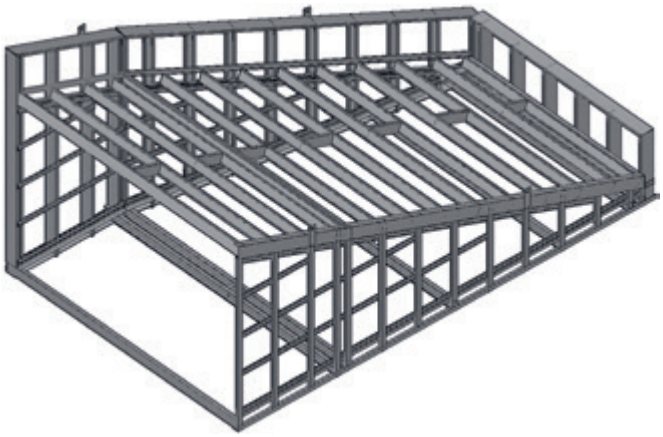


Figure 10 Light steel roof module with integrated parapet
(Image courtesy of Ayrshire Framing)

Figure 11 Light steel sections supported on cross-walls to form a curved roof
(Image courtesy of Metek UK)

Modular Buildings

Modular construction is often used in residential buildings where repetitive use of similar sized modules leads to benefits in terms of speed of construction and economy of scale in manufacture.

Form of construction

Modular construction typically consists of room-sized units that are suitable for transportation. The structure of the modules consists of light steel framing. Modules used in residential buildings are typically up to 4 m wide and 10 m long and they are often fully fitted out in the factory.

Modules can also be supported on a steel structure at podium level, where the lower floors are used for commercial space.

Applications

Student residences, social housing, hotels and military accommodation.

Technical details

Modules are generally formed with C sections in the walls and floors. The form of construction is similar to light steel framing. Double walls, floors and ceilings are created, which provides a high level of acoustic insulation.

The use of off-site manufacture of the modules ensures that a high level of thermal insulation and air-tightness is achieved. The modular housing project shown in Figure 12 achieved a U-value of less than 0.2 W/m^2 K.

Figure 12 Code level 5 modular apartments in west London
(Image courtesy of Futureform and Ayrshire Framing)

Building Extension and Renovation

Light steel framing and modular construction are often used in the extension and renovation of existing buildings, as they are light-weight and can span between the existing beams or columns at roof level.

Form of construction

Light steel framing can be used to extend buildings vertically and horizontally, and also to convert larger buildings into smaller units.

Applications

Private and social housing where the existing roof can support new light weight floors. The most common application is in one and two-storey building extensions. Light steel is also used in over-cladding applications.

Figure 13 Building extension using modular units in London

Technical details

In the case of roof-top extensions, the new light steel structure is supported either by the existing roof slab or beams, or it spans between the cross-walls of the supporting structure. In some cases, the facade walls of the existing building may be used to support the new structure.

In most respects, roof-top extensions are similar in form to single or two-storey light steel framing, although wind loading may be higher, depending on the building height.

In the case of over-cladding of an existing poor quality façade, a light steel sub-structure may be designed to span between the floors and therefore by-pass the existing façade. A new cladding system and thermal insulation may be attached to the new sub-structure.

Technical Solutions in Residential Buildings

Stability and structural integrity

Overall stability is provided by bracing that is integral to the light steel framing, or by an additional structure, such as a concrete core. Structural integrity or robustness is achieved by multiple inter-connections between the light steel members. Connections are designed to provide the required tying capacities between different elements of the structure.

Cladding

Various forms of cladding may be used, such as:

- Brickwork
- Rainscreen
- Metallic
- Insulated render
- Board materials.

Lightweight cladding often requires the use of a sheathing board, which adds to the shear resistance of the walls.

Acoustic performance

Floors and ceilings, and separating walls, achieve excellent airborne and impact sound reductions. Airborne sound reductions of over 52 dB (with low frequency correction factor), are achieved, which are up 5 to 10 dB better than required by Part E of the Building Regulations. Impact sound transmissions are also low (< 30 dB).
A concrete screed can be introduced to increase sound insulation, although this adds to the floor weight.

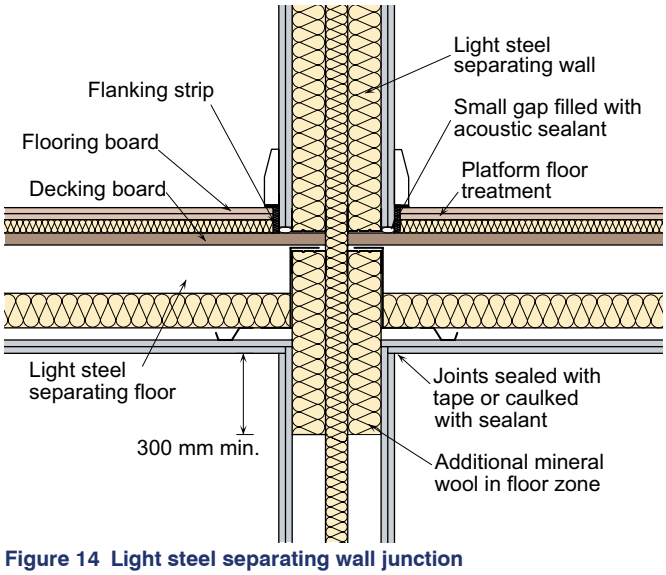


Figure 14 Light steel separating wall junction

Thermal insulation

Thermal insulation is characterised by the heat loss per square metre of the façade (U value). Low U values of below 0.2 W/m²°C can be achieved by placing insulation boards of 70 to 100 mm thickness outside the light steel structure supplemented by mineral wool between the C sections. Excellent air-tightness can be achieved by external sheathing boards or internal continuous membranes, where practical.

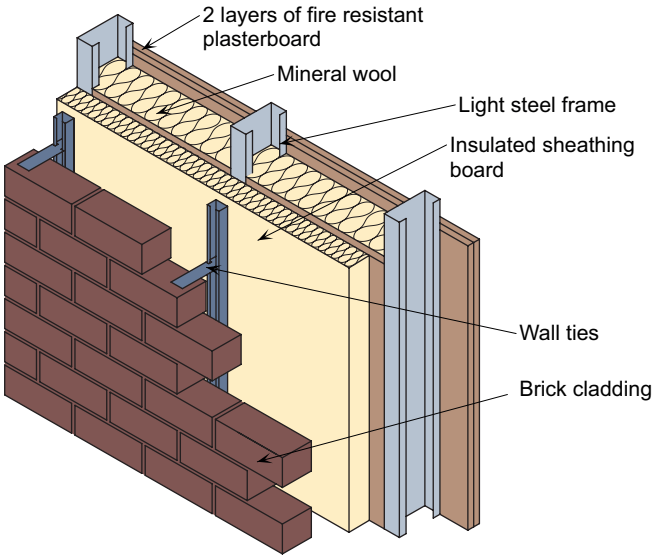


Figure 15 Brick cladding attached to light steel walls

Fire resistance

Fire resistance is provided by multiple layers of fire resisting boards (Type F to BS EN 520). For load-bearing walls, two 15 mm thick fire resisting plaster-board layers internally plus 100 mm thick mineral wool between the C sections achieve a fire resistance of 90 minutes to BS EN 1365. For joisted floors, three layers of 12.5 mm fire resisting plasterboard achieve 90 minutes fire resistance.

In modular construction, the internal boards prevent passage of fire between the modules. External sheathing boards and fire stops between the modules prevent smoke from passing through the cavity space.

Where masonry cladding is used, fire stops must be placed in the cavity between light steel frame inner leaf and the masonry outer leaf.

Services

Openings can be formed for services at regular positions within floor joists, as shown in Figure 16. Where the services pass through a plasterboard ceiling, fire dampers or seals are required.

Figure 16 Services installed through openings in light steel floor joists

Balconies

Balconies may be constructed in various ways:

- Ground-supported balconies with a self standing steel structure.
- Cantilever balconies attached to (typically) square hollow sections within the light steel frame.

An example of a mixed use residential building where balconies are supported by the structure is shown in Figure 18. Careful detailing is required at balcony support locations to avoid cold-bridging.

Figure 17 Ground supported balcony in a light steel care home building
(Image courtesy of Kingspan Profiles and Sections)

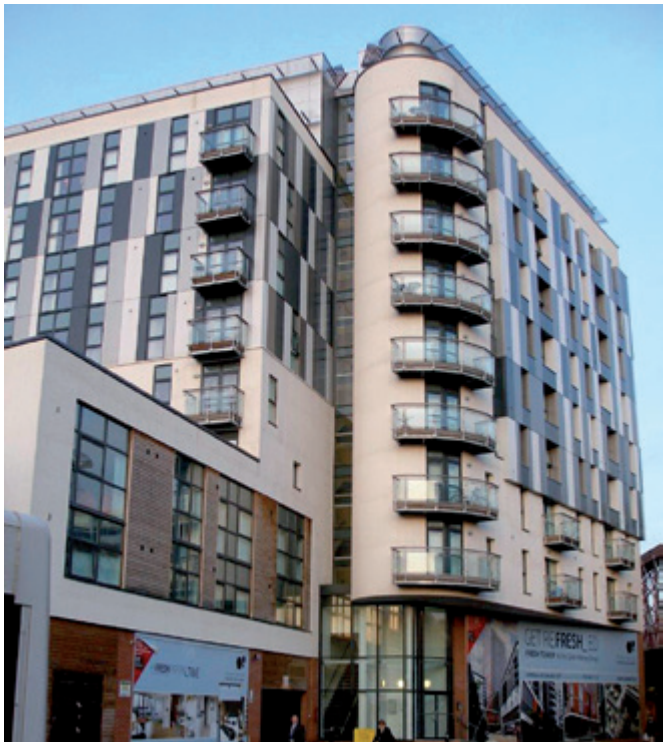


Figure 18 Balconies in a light steel residential building
(Image courtesy of Ayrshire Framing)

Building information management

Details of light steel framing are readily incorporated into a client's Building Information Management (BIM) system.

The structure is designed and detailed; the information is then sent electronically to manufacture with all components accurately located and detailed. Most light steel frame designers use software that allows intelligent data to be attached to the component details.

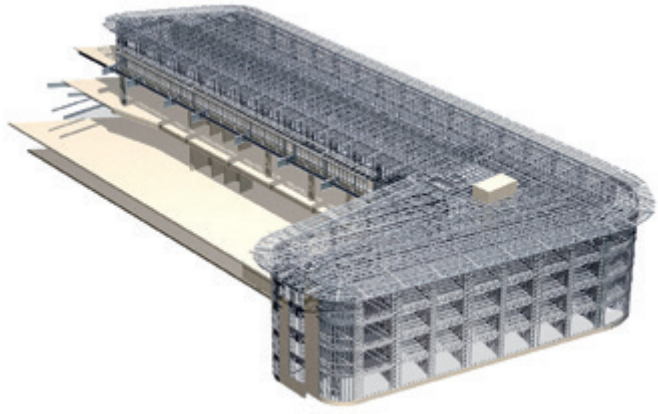


Figure 19 Structural model of light steel framing used in design and manufacture
(Image courtesy of Metek UK)

Sources of Information

Other technical information sheets

The following technical information sheets provide further guidance about light steel construction.

- ED010: Light Steel Solutions for All Applications
- ED012: Light Steel Framed Housing
- ED013: Light Steel Infill Walls
- ED014: Light Steel Modular construction
- ED015: Acoustic Performance of Light Steel Construction
- ED016: Fire Safety of Light Steel Construction

Manufacturers

The following manufacturers are active in the light steel and modular construction sector and may be contacted for further information.

Ayrshire Metal Products Ltd - www.ayrshire.co.uk

BW Industries Ltd - www.bw-industries.co.uk

Fusion Building Systems - www.fusionbuild.com

Kingspan Profiles & Sections - www.kingspanprofiles.com

Metek UK Ltd - www.metek.co.uk

Figure 20 Residential development in London using light steel external walling
(Image courtesy of Kingspan Profiles & Sections)

Bibliography

The following publications may be referred to for more information on light steel framing and modular construction.

Building design using cold formed steel sections: Residential buildings (P301)
Gorgolewski M T, Grubb P J and Lawson R M
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Way A G J and Couchman G H
The Steel Construction Institute, 2008

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