

Sustainability of steel in housing and residential buildings

Sustainability



Courtesy, Framing Solutions.

The 1987 report ‘Our Common Future’ also known as the Brundtland Report, described Sustainable Development as:

“Meeting the needs of the present generation without compromising the ability of future generations to meet their needs.”

Although the general principles of sustainable development are understood, the quantification of sustainability as an indicator of environmental, economic and social impacts of a particular building or housing development is more complex as it is based on a range of issues related to choice of materials, energy use in building operation and impacts on the local environment.

These issues may be expressed in terms of specific criteria, such as efficient materials use, waste minimisation, reduction in primary energy use (and CO₂ production), pollution and other impacts, coupled with social issues related to reduction in transport and improvements in quality of life, well-being and biodiversity.



Courtesy, Fusion Building Systems.

Various environmental assessment methods have been developed, such as BRE's EcoHomes, which provide a means of assessing the impact of a project in terms of various sustainability metrics. The Government's Code for Sustainable Homes provides a framework to achieve various measures of sustainability in the design, construction and operation of new homes.



Courtesy, Metsec.

The Code for Sustainable Homes is voluntary at present and it is expected that the three star rating will become the preferred target for all new houses and apartments. In the future, the Code may become mandatory and also extend to other building types.

Although sustainability is partly related to choice of the materials and construction process, the majority of the sustainability benefits arise from improvements in the built environment and the performance of buildings in service, including future adaptability and end of life issues.



Courtesy, Caledonian Building Systems.

Sustainable buildings, therefore, are high quality, energy efficient, long life and adaptable to future demands, and add to the economic and social life of the community and the built environment.

Front cover: Oakfern redevelopment, Basingstoke. Courtesy, HTA Architects.

Sustainability of steel in housing and residential buildings

SCI Publication P370

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This publication summarises the requirements for sustainability in construction and presents the broad sustainability benefits of steel technologies used in housing and residential buildings. It shows examples of current housing and residential projects using steel.

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Modular construction, Murray Grove, London. Courtesy, Cartwright Pickard Architects, and Yorkon.



The Steel Construction Institute (SCI) develops and promotes the effective use of steel in construction. It is an independent, membership based organisation.

SCI's research and development activities cover multi-storey structures, industrial buildings, bridges, civil engineering and offshore engineering.

Activities encompass design guidance on structural steel, light steel and stainless steels, dynamic performance, fire engineering, sustainable construction, architectural design, building physics (acoustic and thermal performance), value engineering, and information technology.

www.steel-sci.org



Steel Homes Group develops and promotes the effective use of steel in residential construction. Its core values are:

- To advance the use of steel products and systems in residential construction.
- To be a professional and authoritative voice for industry and to present a rigorous, positive and united image of the value of steel in residential construction to occupiers, owners, other stakeholders and their representative bodies.
- To act as the guardian of quality standards on behalf of clients and users by putting in place appropriate industry standards that are focused on the needs of owners and occupiers, while meeting the needs of wider stakeholders.

www.steelhomesgroup.com

Introduction

Steel construction is a highly versatile and sustainable technology that is widely used in all sectors of the building industry, and is used increasingly in housing and residential buildings.

All steel systems used in buildings are produced as industrialised components by modern manufacturing processes. These systems are often highly pre-fabricated, minimise on-site processes and impact beneficially on sustainability of construction.

Design is carried out by Computer Aided Design (CAD) systems that are linked to manufacturing processes, which increase efficiency, reduce waste, and improve quality and accuracy.

The high strength : weight ratio of steel components minimises material use.

Factory conditions provide safe, warm and high quality environments for workers.

Steel components are delivered 'just in time' to the construction site and are installed rapidly, generally by crane or other equipment. This leads to lower costs in site management, storage and other facilities, resulting in a more productive construction process and shorter construction programmes in comparison to site-intensive building.

Risk to the client is reduced by programme predictability and the client can expect an earlier return on the investment costs.

The operational benefits of steel construction include: energy-efficient building envelopes, flexibility in long-term use, non-combustability and freedom from rot and shrinkage, ease of extension and adaptation, and ultimately, refurbishment, recycling and re-use.



Light steel framing with brickwork as used in housing. Courtesy, Terrapin.



Apartments and shop using light steel framing. Courtesy, HTA Architects.



Light steel infill walls in a multi-storey apartment building. Courtesy, RDJW Architects.



Steel framework for multi-storey apartments. Courtesy, Unite Modular Solutions.



Modules supported on a steel podium at first floor. Courtesy, The Design Büro/Ayrshire Framing.



Mixed modular and light steel framing in a social housing project. Courtesy, Feilden Clegg Bradley.

Steel components

Steel components in housing and residential buildings are used in:

- Load-bearing structures, including walls and flooring
- Roofs, particularly long span and 'open' roof systems
- The building envelope, including façades and roofing
- External walls in steel or concrete framed multi-storey buildings
- Sub-structures, including foundations and basements
- Modular and other pre-fabricated components
- Internal partitions and separating walls
- Services and other installations
- Balconies, stairs and lifts.

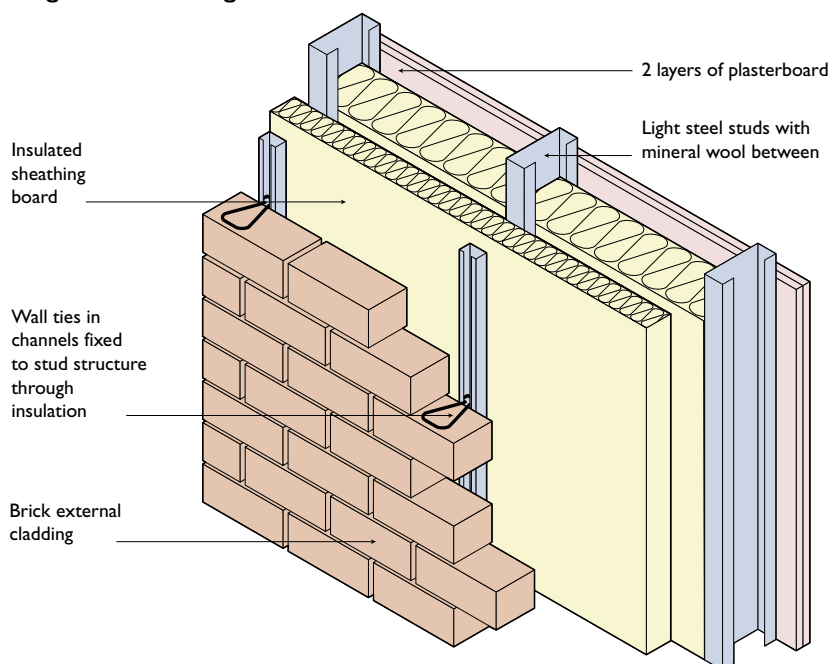
These components are often highly pre-fabricated by advanced factory production, which increases the speed of construction on site.

The lightweight steel components in the building envelope are highly insulated and have proven performance characteristics. 'Warm frame' construction provides a thermally efficient building solution (see below).



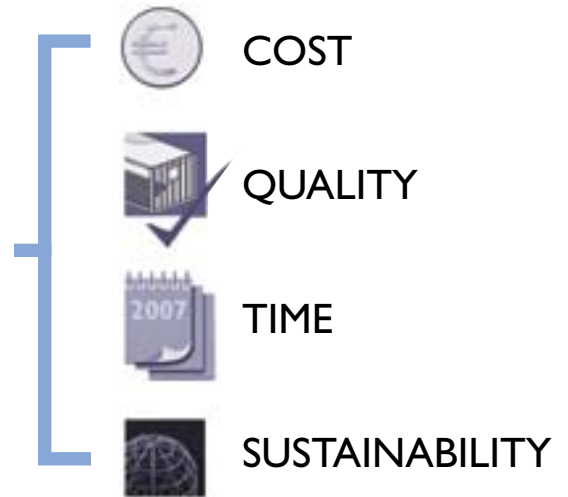
Advanced factory production of light steel framing panels.

Typical 'warm frame' construction showing insulation and brick cladding attached to light steel framing.



Key drivers for steel construction in the residential sector

Sustainability is one of the drivers or key factors which influences the use of steel in housing and residential construction. These drivers may be classified under the headings of Cost, Quality, Time and Sustainability.



Cost



Courtesy, Banro.

Cost of construction is related to use of materials, labour, specialist components, equipment and machinery. Cost is also influenced by time-related factors.

Steel construction achieves high levels of productivity and therefore labour costs are reduced both in the factory and on the construction site in comparison to site-based construction.

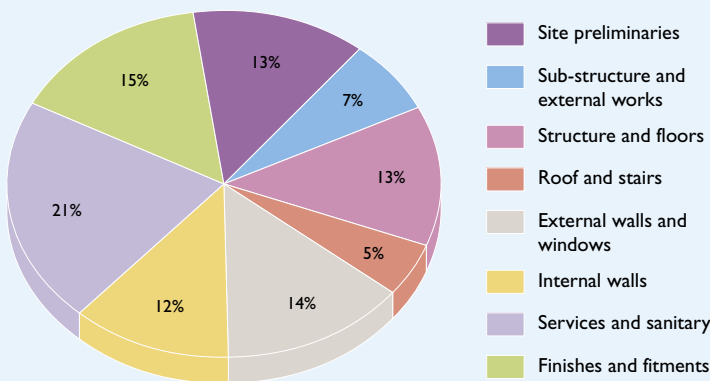
Speed of construction and safety are increased by the higher levels of pre-fabrication implicit in steel-intensive construction systems.

Cost studies have shown that steel construction leads to cost savings of up to 6% relative to concrete, for a 6-storey apartment building in an urban location.

The cost of the steel framework is typically only 12-15% of the as-built cost of the building, and therefore it is the influence of the choice of structure on the other building components and on speed of installation, which are the dominant contributory factors in achieving savings in the construction process.

Life cycle costing shows that in housing, the operational costs can be more than the construction costs over a 50 year life, and therefore, the operational benefits due to energy savings, low maintenance and flexibility in use are of prime importance in choosing the method of construction.

Breakdown of construction costs in a 6-storey residential building



SAVINGS RELATIVE TO REINFORCED CONCRETE FRAME CONSTRUCTION

Sub-structure	1%
Structure	1-2%
Site preliminaries	2-3%
TOTAL	4-6%

Data provided from Corus publication 'Facts of Living' based on study by SCI and consultants, DLC.

Quality

Quality is related to performance, reliability and design elegance, which are more difficult to quantify than economic factors.

Steel is a high quality material produced to exacting standards, and components are dimensionally accurate when manufactured and installed. This leads to improved accuracy and long term reliability.

Cracking due to shrinkage caused by drying out of materials, is essentially eliminated by 'dry' construction technologies using steel.

Flexibility in the use of a building over its life affects its asset value, which is an important aspect of a client's investment plan.

Architectural quality can be achieved by a variety of façade treatments and building forms, including creation of open plan space. This can be provided easily by longer spanning steel construction technologies.

Modular and pre-fabricated construction improve quality. Expensive components and services can be installed and pre-tested remote from the construction site. Losses due to damage on site are largely eliminated.



Courtesy, Framing Solutions.

Time

'Time' is measured in terms of speed of construction, as the faster the construction process, the greater the potential savings in cost to the client and main contractor, due to:

- Fixed site facilities
- Less disruption (particularly important in building extensions)
- Opportunity costs of resources and staff involved in the project
- Interest due to borrowing
- Early income from rental or business use.

All types of steel construction are highly prefabricated and are installed rapidly on site, leading to time-related benefits.

A key indicator is the time to create a weather-tight envelope, which can reduce to 20% of the time required for traditional brick and block construction. The overall on-site

construction period can be reduced by as much as 60%. These time-related benefits lead to an earlier return on the client's investment.

The National Audit Office (NAO) has published a report 'Using Modern Methods of Construction to Build Homes More Quickly and Efficiently', which is based on various workshops and site observations from the BRE's CALIBRE database. It presents various findings on the time and productivity benefits of different forms of construction with various levels of pre-fabrication.

These types of construction were investigated: 2D panels, hybrid 2D and 3D, and fully 3D or modular construction. These were compared to traditional construction.

The key results of the report in terms of the important time- and cost-related factors in pre-fabricated systems are presented below.



Courtesy, Fusion Building Systems.

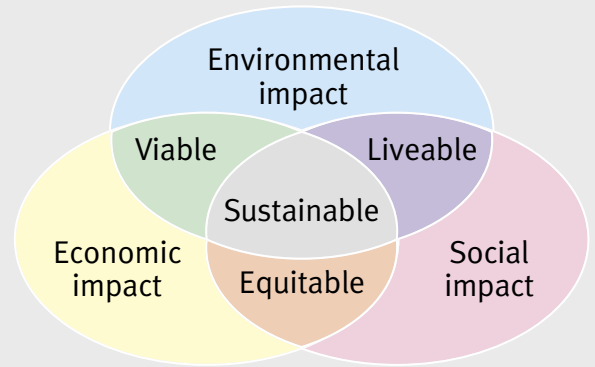
Comparison of key time and cost factors in systems with various levels of pre-fabrication

CRITERIA	TRADITIONAL BRICK/BLOCK CONSTRUCTION	PANEL (2D) CONSTRUCTION	HYBRID PANEL AND MODULAR CONSTRUCTION	FULLY MODULAR CONSTRUCTION
Total construction period	100%	75%	70%	40%
Time to create weather-tight envelope	100%	55%	50%	20%
On-site labour requirement (as a proportion)	100%	80%	70%	25%
Proportion of total cost in on-site materials	65%	55%	45%	15%
Proportion of total cost in on-site labour	35%	25%	20%	10%
Proportion of total cost of off-site manufacture	0%	20%	35%	75%

Source: National Audit Office, 2004

Sustainability in construction

The following sections present the background to sustainability in relation to steel construction.



Materials and Resources

The BRE Green Guide rates all light steel and modular construction technologies as A+ or A in terms of environmental performance.

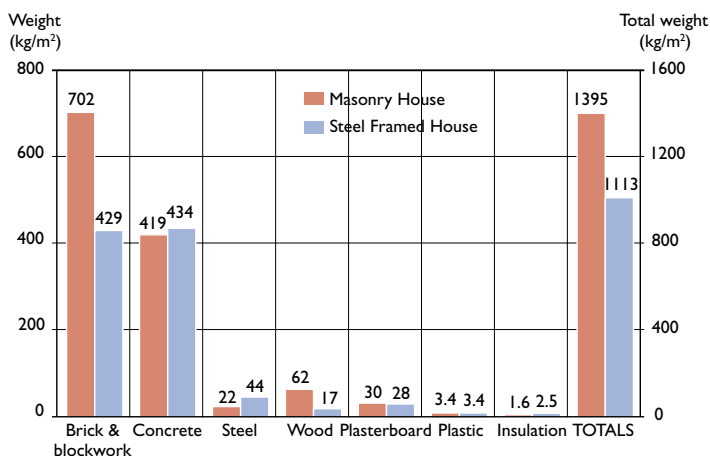


Construction is one of the major users of materials and resources, and it is important to minimise their use and to maximise their recyclability. This can be achieved effectively using steel construction.

- A typical lightweight steel framed house typically uses only 40-45 kg of steel per m² floor area (see figure below)
- Lightweight steel construction reduces material use by up to 30% in brick-clad houses and up to 70% when using lightweight cladding relative to traditional housing
- Lightweight steel technologies achieve an A+ or A rating in BRE's Green Guide to Housing Specification, 2007
- Steel components are manufactured efficiently and can be recycled or re-used.

A light steel framework is protected by lightweight materials, such as plasterboard and mineral wool insulation, and so the physical weight and use of materials is much less than in more traditional construction.

Weight of construction materials used in a typical brick-clad, 2-storey house (by gross floor area)



Source: SCI Report 763 Environmental Life Cycle Assessment of Housing, 1999.

The revised BRE Green Guide environmental ratings will be used as a key part of the 'Materials' scoring in the Code for Sustainable Homes. In the Green Guide, all lightweight construction technologies, including light steel framing, score extremely well in comparison to heavier weight brick/block or precast/in-situ concrete.

In low-rise residential buildings, the weight of the framework of a light steel structure is less than 20% of that of a concrete frame and is even lighter than a timber frame. In medium-rise residential buildings, the weight of a primary steel structure with a composite floor is only 50% of that of a reinforced concrete structure and floor slab.

All steel is recyclable and steel components can be unbolted and dismantled and reused in the future.

BRE Green Guide environmental rating of materials (2007)

Floors	RATING
Light steel joists or floor cassette and plasterboard ceiling	A+
Modular light steel floor and ceiling	A+
Composite slab with acoustic resilient layers	B
Walls	
Light steel separating wall with insulation and 2 layers of plasterboard per side	A
Brickwork outer leaf, light steel framing, plasterboard	A+

Waste

Steel construction minimises waste in manufacture and on site; all steel can be re-used or recycled.



Waste is the unusable part of the manufacture and construction process and occurs with both recyclable and non-recyclable materials and products. The UK construction industry produces 0.5 tonnes of waste per person per year (excluding quarry waste) and a high proportion goes to landfill. Steel construction leads to minimal waste:

- All scrap steel in factory production is recycled
- The quality of the steel is not reduced by the recycling process
- 90%+ of steel in demolition projects is recycled or reused
- 50% of current European steel production is from recycled sources (scrap)
- Pre-fabrication of building components means that waste on site is greatly reduced
- No waste charges are made, as materials are not sent to landfill
- Water use is minimised by 'dry' processes and water is recycled where used in manufacture.

Steel wastage is minimised by the efficient use of materials. In factory production, all steel off-cuts and drill swarf are sent for re-cycling back into new steel components.

The breakdown in terms of recycling or re-use of steel components from demolition projects is shown below:

Recycling/reuse of steel products

TYPE OF STEEL	SECTIONS	PURLINS	CLADDING	DECKING	REINFORCEMENT
Recycling	86	89	79	79	91
Re-use	13	10	15	6	1
Total %	99	99	94	85	92

On some large building projects, off-cuts of plasterboard are collected and returned to the producer for recycling. This is important because steel and plasterboard are used as synergistic materials in many forms of lightweight construction.

Steel cladding and steel components can also be dis-assembled and re-used in the future. An example is in modular construction, where the asset value of the modules is maintained.

Energy

Operational energy is reduced by thermally efficient and air-tight 'warm frame' steel technologies. Energy use in manufacture is less than 5% of the operational energy over the building's life.



The most effective way of reducing energy consumption in buildings is by reducing operational energy, which is achieved by good energy efficient design and facilities management.

- A typical, recently constructed, 2-storey house using steel construction consumes less than 100 kWh/m² per annum in service (for 100 m² floor area), which is up to 30% less than in traditional buildings
- Steel frames can be designed to be highly insulating with U values as low as 0.15 W/m²°C
- Air-tightness is much better in highly insulated steel framed buildings than in traditional buildings
- 'Zero-energy' building is possible by introducing renewable energy systems, such as photo-voltaics
- 11% of the total energy used in manufacture and construction activities is related to on-site processes. Steel components require less on-site energy and transport to site.

The Building Regulations Part L require improved thermal insulation and air-tightness levels (see table) in order to reduce energy use in the housing sector. External walls and roofs are being designed to be highly insulating and air-tight, and reduce primary energy demand by up to 70% relative to traditional buildings.

Studies* show that over a 50 year design life of a typical residential building, the energy required by all activities of a material's production process is equivalent to only 3 to 5% of the operational energy of the building.

* SBI Report 229-2. Sustainability of Modular Construction.

Maximum U-values (W/m²K) to achieve compliance with the Building Regulations

Requirement to:	External walls	Ground floors	Pitched roof insulation
Calculated Values to Regulations (2006)			
Gas heating	0.30	0.22	0.16
Other heating	0.25	0.22	0.16
Code for Sustainable Homes (2006) – Level 3 rating			
Gas heating	0.20	0.20	0.15

U-values (W/m²K) achieved using light steel framing

Light Steel Framing:	Walls	Ground floors	Pitched roof insulation
Typical construction	0.25	0.22	0.15
Best practice	0.15	0.20	0.10

Transport



Transport of materials and personnel to construction sites is greatly reduced by use of pre-fabricated steel construction technologies.

Transport of materials and personnel in construction is responsible for 10% of all vehicle movements in the UK and 40% of the energy used in construction is related to transport of materials and products. Steel construction can reduce these impacts.

- Transport of pre-fabricated steel components is reduced by 70% relative to the materials used in brick-block or concrete construction
- Steel is pre-fabricated into frames and modules that are transported 'just in time' to the building site
- Deliveries to site can be timed to suit local traffic conditions and reduce local congestion
- Fewer workers on site mean fewer journeys to site and less demand for car parking locally
- Minimal transport of waste to landfill sites is achieved by off-site construction.

The pre-fabricated nature of steel construction means that deliveries of relatively large components can be made to suit local traffic conditions, rather than requiring many smaller deliveries of materials.

For example, it is estimated that a total of 6 deliveries of materials are required to build 10 houses using light steel framing in comparison to 40 deliveries to build 10 traditional masonry houses. Therefore, in this example, vehicular transport is reduced by 85%.

Sustainability is also linked to the proximity of the transport infrastructure and use of public transport systems. Steel buildings are sufficiently lightweight that they can be constructed over railway lines or on poor ground and former 'brownfield' sites.

Flexible use buildings can be designed using steel construction to provide a 'live-work-play' environment, which minimises car use.



Modules delivered 'just in time' to site in Manchester. Courtesy, Yorkon and ShedKM Architects.

Minimising pollution



Minimising pollution in construction and in service is dependent on careful selection of materials and processes, such as the use of pre-fabricated 'dry' steel construction technologies.

Steel construction has negligible impact in terms of pollution at the construction site and in-service. Steel manufacturing facilities are very efficient and modern.

In manufacture:

- Steel is an inert material, which is recycled at the end of its life
- Pre-fabricated steel components are produced in factory-controlled conditions using energy saving and pollution-reducing technologies
- Slag from steel production is used as cement replacement and road sub-base and is non-polluting. Slag is also used in fertiliser.

In construction:

- 'Dry' construction processes minimises water use
- On-site pollution during construction is eliminated by pre-fabricated off-site technologies
- Transport pollution is minimised by fewer deliveries and daily worker travel to the building site.

In-service:

- Steel does not rot or deteriorate in an internal environment
- Steel is non-combustible and does not produce noxious fumes.



Semi-automated production line at Corus Living Solutions' factory.

Performance and quality



Steel construction has good performance characteristics in comparison to traditional building materials.

Performance may be defined by a range of characteristics related to design, aesthetics, use of robust and durable materials, reliability, long life and flexibility in use.

In-service performance:

- Steel is manufactured accurately and has guaranteed material properties that are unaffected over time
- The strength : weight ratio of steel means that longer spans can be achieved and provides more adaptable space for current and future use
- Excellent acoustic insulation is achieved using lightweight construction
- High levels of thermal insulation are provided, leading to reduced heating costs
- No cracking or long term movement occurs due to shrinkage, reducing maintenance costs
- Steel does not rot or decay, if properly protected
- A high level of fire resistance is provided. Steel and plasterboards do not add to the potential fire load.

Performance during construction:

- Lightweight materials are better suited for use on poor ground
- Construction programmes are reduced by 30 to 70% compared with traditional building
- Connections and attachments can be made relatively easily in the future.

Aesthetic building forms can be designed using highly pre-fabricated components. Balconies, penthouses, walkways and other attachments are made easily.



Private balconies can be attached easily to steel frames.

Health and well-being



Steel framed buildings provide flexible, efficient and functional spaces.

Health and well-being are important because, in the EU, people spend an average of 90% of their lives in buildings.

In service:

- Steel framed buildings with high levels of thermal insulation are pleasant environments in which to work
- Noise transmission is minimised, which is important in multi-occupancy use
- Balconies and other private spaces can be easily provided
- Aesthetic, functional and adaptable space is provided, and a 'live-work-play' environment can be created.

In construction:

- Steel manufacturing, fabricating and installation processes are very safe in comparison to site-based operations
- Noise, dust and pollution (on the building site) are reduced.

Social issues



Steel construction contributes to an improved built environment and a high standard of living by the design of more functional and adaptable buildings.

Social aspects of sustainability in construction include issues such as care for workers and users, and reduction in the impact and disturbance of the construction process, both on the local environment and on society as a whole.

In service:

- High quality and long life buildings are achieved, which improves comfort and user satisfaction
- Pressure on landfill sites due to wastage of materials is dramatically reduced.

In construction:

- Productivity, working conditions and safety are greatly improved in the factory and on the construction site relative to traditional building
- Excellent training and job opportunities are maintained by factory-intensive construction and by specialist installation teams.

Steel technologies in housing and residential buildings



Open habitable roofs using light steel C sections.



Load bearing wall panels.
Courtesy, Framing Solutions.



Floor joists, usually of C or Z sections that are placed individually or installed as pre-fabricated floor cassettes.



Composite slabs used in water-tight ground floors and basements.



Light steel framing during construction. Oakfern redevelopment, Basingstoke. Courtesy, HTA Architects.

A wide range of steel technologies may be used in the housing and residential building sectors, including:

- Light steel framing in housing
- Light steel framing in apartments
- Modular construction
- Steel frames with light steel infill walls.



Lattice joists used for longer spans.



Prefabricated load-bearing wall panels using C sections.



A range of cladding systems can be used.



Roofing technologies using steel.
Courtesy, Kingspan.

Light steel framing in housing

Light steel framing is used for single family detached housing, terraced housing and for smaller apartments and multi-occupancy buildings.

The various steel components that may be used in these applications are:

- Prefabricated load-bearing wall panels using C sections
- Floor joists, usually of C sections that are placed individually or installed as pre-fabricated floor cassettes
- Lattice joists or I beams used for longer spans
- Non-load bearing wall panels used as partitions between rooms
- Composite slabs used in water-tight ground floors and basements (see opposite)
- Open habitable roofs using light steel C sections
- Cladding and roofing systems, such as composite panels.

Thermal insulation is provided by rigid insulation boards placed externally to the light steel framework in 'warm frame' construction, and additionally by mineral wool placed between the C sections, in the form of inter-stud insulation. This achieves U values below $0.25 \text{ W/m}^2\text{K}$.

The structure may be clad in brickwork to give a traditional appearance. In external walls and roofing, slotted or perforated C sections may be used to reduce heat loss due to 'cold bridging', and are preferred in highly insulating applications (they are used widely in Sweden and Finland to achieve U values of $0.15 \text{ W/m}^2\text{K}$).

A variety of other cladding materials may also be used.

House construction by Terrapin, Milton Keynes.



Application Benefits

- In 2- or 3-storey housing, walls are load-bearing and support floors directly
- Wall panels and floor cassettes may be pre-fabricated for rapid installation
- Lattice joists achieve longer spans and provide for services in the floor zone
- Open habitable roofs can be created
- Plasterboard provides fire resistance and acoustic insulation
- Lightweight construction is suitable for extensions and renovation of existing buildings
- Impermeable composite ground floors reduce gas infiltration.

Sustainability Benefits

- Rapid 'dry' construction with high accuracy in installation
- Lightweight, for poor ground conditions
- High levels of thermal insulation (U values < 0.25 W/m²K)
- Reduced site storage of materials in comparison to brickwork, for example
- Minimal waste on site and in the factory. Steel and plasterboard waste can be recycled
- Galvanized steel is free from deterioration, rot and shrinkage
- Worker safety is improved on site and in the factory
- Easy to dismantle, re-use or re-cycle.



Production of light steel frames. Courtesy, Framing Solutions.



House using light steel framing. Courtesy, Adrian James Architects and Metsec.



Load bearing light steel frames. Courtesy, Fusion Building Systems.



Light steel framing in apartments

Light steel framing may be used to provide the load-bearing structure of multi-storey apartments of 3 to 6 storeys height.

Various forms of construction include:

- Prefabricated wall panels, often with pre-attached cladding
- Mixed use of hot rolled steel and light steel components
- Lattice joists for service integration
- Thin gypsum screed placed on steel decking and supported by light steel floor joists
- Composite slabs used as intermediate separating floors or podium level.

A wide variety of building forms can be created, often requiring different uses at ground floor and the upper floors. For example, in urban locations, shops or community space is often provided at ground level.

The same forms of construction may be used as for housing, except that the loading is higher and consequently the light steel sections are deeper or thicker.

In multi-storey apartment buildings, higher fire resistance periods and acoustic insulation are required, which may lead to the use of composite floors. A variety of cladding materials may be used, including lightweight cladding, such as insulated render and clay tiles. The structure may be clad in brickwork to give a traditional appearance. Balconies can be attached to Square Hollow Section steel posts built into the walls.

Thermal insulation is provided by a variety of methods, including pre-insulated panels and insulation placed externally on to the light steel



Apartments using light steel framing. Courtesy, Fusion Building Systems.

framework, creating 'warm frame' construction. Additional mineral wool or other insulation materials placed between the C sections, in the form of inter-stud insulation, achieve U values below $0.25 \text{ W/m}^2\text{°C}$.

The good fire resistance and non-combustibility of light steel framing and lightweight boards make it an ideal solution for medium-rise residential buildings.

Light steel framing for social housing, Fulham. Courtesy, Feilden Clegg Bradley.



Application Benefits

- Medium-rise apartments of 3-6 storeys can be designed for commercial use at ground level
- Longer spans of 4-6 m using lattice joists achieve flexibility of service distribution and internal space planning
- Composite slabs may be used to span between cross walls to provide floors of high stiffness and fire resistance
- Excellent acoustic insulation is provided using double layers of boards and mineral wool between the C sections
- 90 minutes fire resistance is provided using 2 layers of fire resisting plasterboard. Steel is non-combustible and does not add to the fire load
- Heavier loads can be resisted locally by use of hot rolled steel beams and SHS posts
- Balconies can easily be attached to the steel framework.



3-storey apartments and shop using light steel framing. Oakfern redevelopment, Basingstoke. Courtesy, HTA Architects.

Sustainability Benefits

- More useable and efficient space is created, which can be re-configured to suit user requirements
- Light steel framing reduces foundation loads (important in 'brownfield' sites)
- Future adaptability by use of relocatable internal light steel walls and roof-top extensions
- High levels of thermal efficiency in walls and roofs
- Rapid construction technology, which is important in urban locations
- Minimum on-site disruption, which is often important for urban projects
- Freedom from long term movements and cracking
- Steel can be re-used and recycled.



Multi-storey light steel framing with some hot rolled steel members. Courtesy, Fusion Building Systems.



Apartments using load-bearing light steel frames. Courtesy, Framing Solutions.

Modular construction

For cellular buildings, such as hotels, student residences and key worker accommodation, production of repeatable modular units is very efficient. The structure of the modules consists of light steel framing with strategically placed posts using steel Square Hollow Sections or angles.

Modules can be delivered 'just in time' and are installed rapidly. Lightweight cladding can be pre-attached or alternatively, any type of cladding can be site-constructed and attached to the modules.

The various types of modular construction are:

- Load-bearing modules for 4–10 storey buildings
- Mixed modular and panel construction for creation of open plan space
- Modules supported by a primary steel frame at a first or second floor podium
- Non-load bearing modules supported by a primary steel frame
- Modules supported by an existing structure, e.g. in roof-top extensions.

The Forge, Sheffield: Modular construction for student accommodation.
Courtesy, Unite Modular Solutions Limited.



Application benefits

- Economy of scale in production for hotels, key worker accommodation, student residences etc.
- Rapid installation on site (an average of 6–10 units per day)
- Two modular units can be placed together to create larger spaces
- Robustness can be achieved by attaching the units together at their corners
- Stability of tall buildings can be provided by a braced steel core
- Good fire resistance. Fire stopping between the units prevents fire spread
- Excellent acoustic insulation due to the double layer floors and walls
- Suitable for roof-top extensions or in difficult working areas.

Sustainability Benefits

- High quality factory production of modules
- Materials can be ordered for maximum efficiency in production
- Minimal waste on-site and in the factory
- Rapid installation process leads to less disruption to the locality during construction
- Excellent acoustic insulation and in-service performance characteristics
- Very safe construction technology, which is less dependant on weather and site conditions
- Modules can be dismantled easily and re-used elsewhere
- 'Asset' value of the modules is maintained after re-use.



Ashorne Hill Management College, Leamington Spa.
Courtesy, Terrapin and Corus Living Solutions.



Modular student accommodation, Manchester.
Courtesy, The Design Büro, Caledonian Building Systems.



Light steel module with an internal corridor.
Courtesy, Kingspan Off-Site.



Modular residential project, London.
Courtesy, Spacecover.

Steel frames with light steel infill walls

A primary steel frame may be used as the structure of multi-storey buildings to provide long spans, flexibility in space use and future adaptability.

Light steel infill walls are relocatable to suit internal planning.

Light steel walls may be used in the following applications in combination with a primary steel frame:

- Infill walls at the periphery of the building, which create a 'rapid dry envelope' in the temporary condition and which provide for wind resistance and lateral support to the cladding in the permanent condition
- Separating walls between units of accommodation internally, which provide both acoustic insulation and fire compartmentation functions
- Partition walls to separate rooms, which can be located to suit the user's requirements.

Primary steel frames can be constructed using composite slabs and I or H sections, or Rectangular Hollow Sections for the beams and Square Hollow Sections for the columns. The steel elements can be visually exposed.

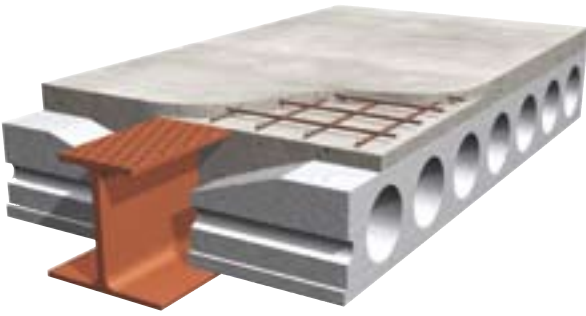
The design of light steel infill walls depends on the wind loading and the spacing of the wall studs, which can be varied to resist the higher wind loading at the upper levels in a multi-storey building or at the corners of the building. Generally, 100 mm deep C sections are satisfactory for low or medium-rise buildings, increasing to 150 mm C sections in high-rise buildings.

A variety of cladding materials may be used, including glazing systems that may be adapted from the commercial sector. Separating wall and partitions may also use light steel walling and multi-layers of plasterboard for fire resistance and acoustic insulation.

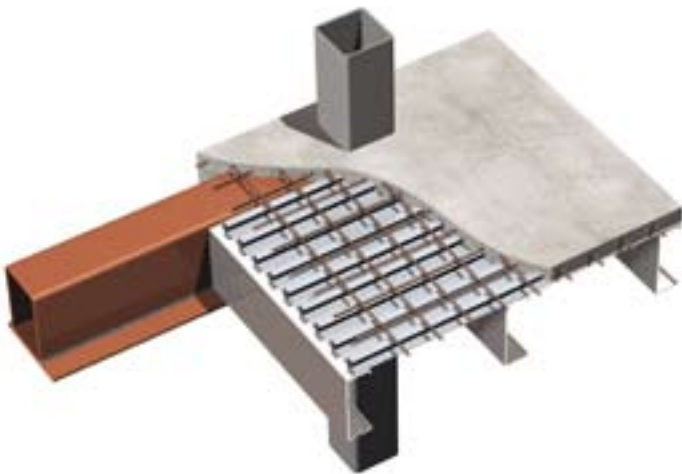


Ocean Village, Southampton: Multi-storey composite building with balconies. Courtesy, Broadway Malyan Architects.

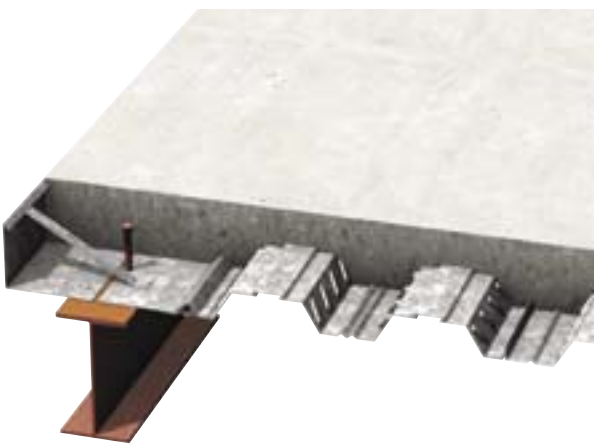
The steel frame and floor may take various forms:



Asymmetric steel beams and pre-cast concrete slabs.
Courtesy, Corus.



Rectangular Hollow Sections support light steel floor joists and a thin composite slab.



Composite edge beam and slab used as the primary structure.
Courtesy, Kingspan.

All these forms of construction can use light steel infill walls, which are non-load bearing but which provide fire resistance and acoustic separation functions.

Application benefits

- Narrow beams and columns can be located within separating walls – no projection outside the wall
- Integrated slim floor beams lead to minimum floor zone
- Long span construction is useful for 'mixed' residential and retail projects
- Lower self weight than in reinforced concrete (50% reduction in weight, typically)
- Stability can be provided through the frame (up to 4 storeys) or by bracing or cores (taller buildings)
- Intumescent fire resistant coatings can be applied off-site to achieve up to 120 minutes fire resistance
- Excellent acoustic insulation of the floors and separating walls is achieved
- A variety of cladding materials may be used
- Below-ground car parking can be provided.

Sustainability Benefits

- A primary steel frame provides for flexibility in layout of the space
- Light steel infill walls are fast to install and provide a rapid dry envelope
- Internal walls can be moved as space requirements change
- Beams and columns are rapidly erected and can be un-bolted and re-used, if required
- Connections and extensions can be made easily, leading to flexibility in future use
- Balconies and private or public open space can be provided easily to improve the internal environment
- Composite floors provide excellent stiffness, acoustic insulation and fire resistance and allow for freedom in internal planning
- Services can be integrated within the structure
- Rapid construction system for multi-storey buildings, particularly in urban locations.



Slimdek structure with light steel infill walls.

Sustainability Check List for the Use of Steel in Residential Buildings

The following sustainability check-list for the use of steel in housing and residential buildings relates to the building fabric and other design issues in choice of the construction system. It uses the broad headings of The Code for Sustainable Homes.

Energy Use and CO₂ Reduction	CO ₂ production in service is reduced by energy efficient design, which can be improved by off-site manufacture.
	Renewable energy systems can be introduced into the roofing and cladding, and the as part of the whole building design.
	Embodied energy is minimised by use of lightweight construction. The steel use is typically only 40 kg/m ² floor area.
	High levels of thermal insulation (< 0.25 W/m ² °C) can be achieved cost effectively.
	Air-tight buildings can be achieved which reduces heat loss (< 2 m ³ /m ² h air leakage).
	Steel buildings can be extended and modified easily in the future, which reduces future energy demand.
Water	Water is recycled during steel production.
	Steel technologies are essentially 'dry' processes on site.
Materials	Steel construction scores an A or A+ rating under BRE's 'Green Guide to Housing Specification'.
	Steel is reliable in terms of its properties and is robust to damage, durable and long life. Steel components are free from movements and cracking due to creep and shrinkage.
	Materials are used efficiently in off-site manufacture by exact ordering of materials, reduction in waste etc.
	Transport of materials and products is minimised by pre-fabrication. Components can be delivered 'just in time' to site.
	Steel can be fully recycled or re-used. The asset value of the components is maintained, when the building is dismantled.
Pollution	Steel components are inert and do not deteriorate or lead to waste.
	Steel is non-combustible and does not add to the fire load.
Health and Well-being	Excellent acoustic insulation is achieved (> 60 dB airborne sound reduction).
	Flexible space provision allows for multi-use, and can create a 'live-work-play' environment.
	Minimum disruption occurs during construction process, which is especially important for urban and renovation projects.
	'Gas-tight' and water-tight ground floors can be achieved.
	Private balcony space can be provided by attachment to the steel structure.
	Off-site processes improve on-site safety. Conditions for workers are much improved by the high levels of investment in off-site manufacture.
Management	Neighbourhood disruption by site activities during the construction process is minimised.
	Steel suppliers are part of the <i>Considerate Constructors</i> scheme.
	Compliance with <i>Secured by Design</i> .
	Urban residential projects provide better links to provide transport, and steel buildings can be constructed next to transport links.
Ecology	Steel buildings may be designed to minimise the impact on the local environment. 'Green' roofs can be provided.
	Building footprints are reduced by building to medium- or high-rise in steel.

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