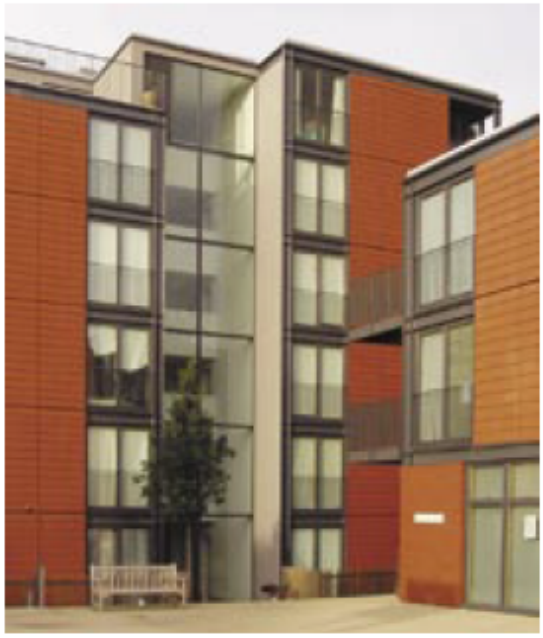





Energy Efficient Housing using Light Steel Framing

Light Steel

Energy efficient housing using light steel framing

The housing and residential sector increasingly demands more energy-efficient and higher quality buildings. In 2006, an important revision to Part L* of the Building Regulations was implemented. The objective of this and future improvements is to reduce CO_2 emissions in new buildings by 60%, in stages between 2006 and 2050.

The Goverment's Code for Sustainable Homes*, launched in December 2006, forsees a 'step change' in building practice, that includes energy efficiency as a key element in its 'star' rating of sustainability.

How to meet the requirements of Part L of the Building Regulations

- Various Building Regulations presents various measures to improve the energy efficiency of houses and residential buildings in new construction.
- The current requirements relevant to housing are published in two Parts: L1A for new dwellings and L1B for existing dwellings.
- A minimum overall energy performance in terms of a limit on CO_2 emissions must be met for each new dwelling and is calculated by using SAP 2005 (or SBEM if the dwelling is over 450m^2 area).
- Design| using elemental U-values, target U-value and carbon index will no longer, on their own, be acceptable methods of demonstrating compliance in new dwellings.
- A package of measures, including reduced U-values, control of air permeability and energy efficient condensing boilers will be required to reduce CO_2 emissions by 22% in houses and 18% in flats (an average reduction of 20% for dwellings).
- High levels of insulation and lower air leakage rates in light steel framing satisfy modern comfort standards and energy efficiency targets economically.
- Light steel framing is able to satisfy the Part L requirements without increasing overall wall thickness.
- The 'warm' frame concept maintains the light steel components within the heated envelope, avoiding condensation and durability problems.

Architects and developers can exploit the benefits of light steel framing and modular construction as an economic and versatile alternative to traditional construction systems.

Hybrid modular light steel housing,

Compliance with Part L1A and the Code for Sustainable Homes

Thermal insulation

The thermal insulation of the building envelope is characterised by its U-value (in W/m^2K). Lower U-values lead to higher levels of insulation.

Table I shows the former U-values when using the elemental method and the calculated values to the new Regulations, using SAP 2005. (U-value requirements may vary depending on the efficiency of the services, air permeability,glazing and use of renewable energy generation technologies).

Table 2 shows U-values that can be typically achieved using light steel framing.

Energy performance

- The minimum overall energy performance is expressed in terms of a limit on $C0_2$ emissions. This is calculated using the Standard Assessment Procedure for energy rating of dwellings, SAP 2005, or SBEM if the dwelling is over $450m^2$ floor area. SBEM is the calculation tool for non-domestic buildings.
- To comply, the Dwelling C02 Emission Rate (DER) should not exceed the Target $C0_2$ Emissions Rate (TER) which is the minimum energy requirement for new dwellings. The DER is based on calculated annual energy for space heating, water heating and lighting, less any emissions saved by renewable energy generation technologies.
- TheTER is expressed in kg of $C0_2$ per m^2 floor area per year, emitted by provision of heating, hot water, ventilation and lighting for a standardised household.
- Minimum performance requirements must be met for the building fabric, including U-values, air permeability and building services efficiency.
- Heat loss attributed to thermal bridging is included in the SAP 2005 calculation with an improved allowance if the Accredited Design Details are used.
- There is a requirement to check the effects of solar gain in summer to limit high internal temperatures.
- The quality of construction must be demonstrated by: a final check that the DER still meets the TER, air pressure testing of the building, completion of site checklists and inspections, and the certification of heating and hot water systems.
- Operating and maintenance instructions must be provided to ensure that owners/occupants operate and maintain the building in an energy efficient manner.

Code for Sustainable Homes

The energy ratings in the Code for Sustainable Homes relate to the minimum standard of the 2006 Building Regulations. A'Level 3' rating achieves a 25% reduction in the C02 emissions with respect to the 2006 Regulations.This level reflects the anticipated change to Approved Document L1A in 2010.

For further information visit www.comrnuritties.gov.uk

Table 1 Maximum U-values (W/m^2K) to achieve compliance with the Building Regulations

Requirement to:	Walls	Ground floors	Pitched roof insulation		Flat roof
			Between joists	Between rafters	
Former Regulations (2002)	0.35	0.25	0.20	0.20	0.25
Calculated Values to New Regulations (2006)					
Gas heating	0.30	0.22	0.16	0.16	0.20
Other heating	0.25	0.22	0.16	0.16	0.20
Code for Sustainable Homes (2006) – Level 3 rating					
Gas heating	0.20	0.20	0.15	0.15	0.20

Table 2 U-values (W/m^2K) achieved using light steel framing

Light steel framing:	Walls	Ground floors	Pitched roof insulation		Flat roof
			Between joists	Between rafters	
Typical construction	0.30	0.25	0.16	0.16	0.20
Best practice	0.20	0.20	0.15	0.15	0.15

HOUSING USING LIGHT STEEL FRAMING

House using light steel framing for walls, floor and roof

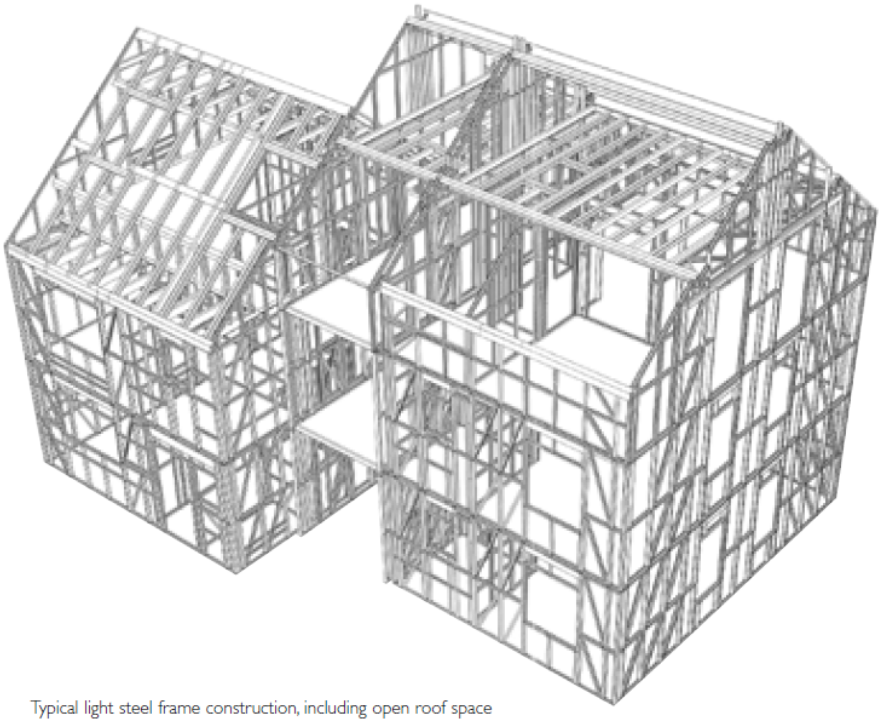
Architect's house, Oxford, with a curved roof

Apartments and shops

Modular housing

Technology of light steel framing

Steel is a quality assured, accurate, high strength, long life, adaptable, recycled and recyclable material manufactured to strict specifications. It does not suffer from twisting, warping or movement due to changes in moisture content. This results in easier fixing of linings and higher quality finishes, avoiding problems such as cracking around doors and architraves.



Typical light steel frame construction, including open roof space

Structure

Light steel frames typically comprise C and Z shaped galvanised cold-formed steel sections, usually 1.2 to 3.2 mm thick, that are produced by roll forming. For walls, C sections are generally 75 to 150 mm deep and are placed at 600 mm centres.

Where necessary, back to back sections can be used for higher load resistance. For floors, 150 to 300 mm deep C sections can span from 3.5 to 6 m. These sections can also be fabricated into long lattice joists, which provide for service integration.

On site, connections between the light steel elements may be made by self-drilling self-tapping screws, or by bolts. In the factory, rivets and welding are also used to connect the pre-fabricated components.

There are three basic forms of light steel construction:

Individual light steel components, assembled on site (stick build).

- Panels or sub-frames prefabricated in a factory and assembled on site to create whole building structures (panel construction).

Volumetric production of whole rooms with internal finishes and services fitted in the factory (modular construction).

For 2- or 3-storey houses, light steel framing is widely used. In 4- to 6-storey buildings, light steel framing may be combined with hot rolled steel members if additional load resistance is required.

For cellular-type buildings, such as hotels and student residences, modular construction has established a strong market due to the speed of installation and its factory-based fit-out. The light steel structure of the modules generally uses 70 mm or 100 mm C sections for the walls and 150 mm C sections for the floors.

Cladding

Light steel framing is suitable for use with a variety of claddings. For a traditional finish, an external leaf of brickwork (or other masonry finish) with a 50 mm cavity is used. The brickwork is connected to the light steel framing using stainless steel wall ties located into vertical runners fixed to the light steel framework through the insulation board placed in the cavity.

Inter-stud insulation adds to the thermal performance of the wall and reduces the total wall thickness.

Lightweight claddings, such as insulated renders, metal claddings, timber T&G boarding or tiling can be fixed through the insulation boards to the light steel frame with a ventilated air space behind the cladding.

Fire resistance

A single layer of fire resistant plasterboard can achieve 30 minutes fire resistance, and two layers can achieve 60 minutes fire resistance for walls and floors. Often, additional mineral wool is required between the wall studs or joists for insulation purposes. Longer periods of fire resistance can be achieved by using thicker or multiple layers of fire resistant plasterboard.

Acoustics

Standards well above the current and future requirements of the Building Regulations Part E for acoustic performance can readily be achieved in light steel framing.

A double layer separating wall can achieve sound reductions over 60 dB (or 52 dB with the low frequency correction) and can be enhanced by additional layers of plasterboard and inter-stud insulation.
A high performance system uses 'resilient bars' attached to the light steel frame to which the plasterboard is fixed. A built-up floor including resilient bars can achieve similar airborne sound reduction to a separating wall and an impact sound transmission of below 50 dB. More guidance is given in SCI P336.

Foundations

Light steel frames can be located on a variety of foundations and lead to smaller foundations due to their lighter weight. Strip or trench footings are most commonly used; and mini-pile foundations are particularly suited to poor ground conditions and can achieve high levels of accuracy for line and level. Light steel framing is fixed through the bottom track to the concrete, or is restrained by straps fixed to the studs and concrete footings.

Light steel framing construction details - Brickwork

'Warm' Frame

In light steel framing, all or most of the insulation is placed on the outside of the steel frame, leading to a 'warm' frame construction. This eliminates the thermal bridging of the steel elements, thereby minimising the risk of cold areas occurring on the internal surface of the wall. It also maintains the steel above the dew point temperature, avoiding interstitial condensation.

For external brickwork, insulation boards are placed in the cavity between the light steel frame and the brickwork, and also provide a weather-resisting function.

Table 3 shows the required thickness of closed-cell insulation board and typical overall wall thickness in walls using brick cladding that satisfy the current and future Part L requirements. Mineral wool placed between the wall studs provides improved thermal performance and is recommended practice for highly insulated walls and roofs.

Detailing

Thermal bridges may occur around windows and door openings and at the junction of walls with floors and roofs. This is avoided by maintaining the thermal resistance of the external envelope at junctions. Light steel frames using the 'warm' frame principle permit continuity of insulation around the building. Insulation can be brought right up to the window and door frames (see details opposite).

Air-tightness

Air-tightness is achieved in light steel framing by the creation of an air barrier. This can be provided either by the plasterboard lining, sealed appropriately at junctions and penetrations, or by a membrane integrated within the wall construction. Excellent air-tightness and, hence, reduced air leakage are provided by the details shown, which further reduces heat loss through the building fabric.

Vapour control layer

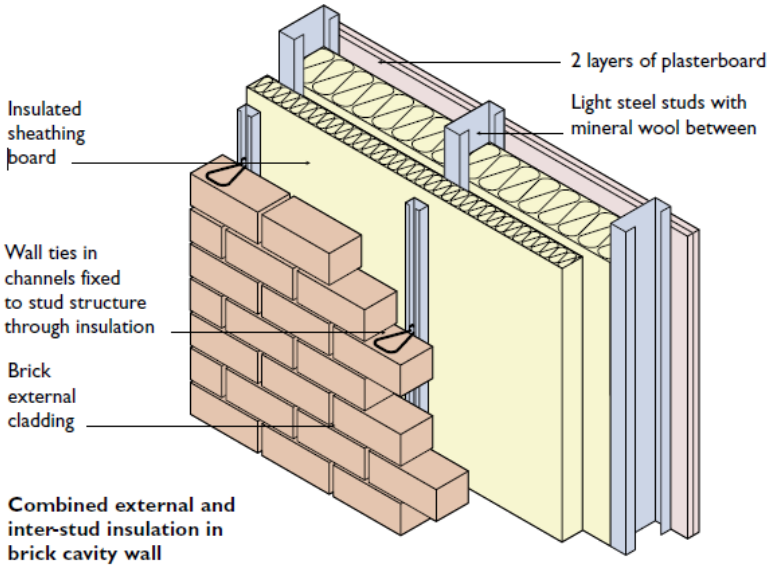
In 'warm' frame construction, a vapour barrier is generally not necessary as interstitial condensation should not occur on the frame.Where a significant amount of inter-stud insulation is included within the light steel structure, a vapour control layer or vapour resistant plasterboard may be necessary on the warmer side of the steel. As a simple rule, to avoid these problems, no more than half of the total insulation level should be provided by inter-stud insulation.

Table 3 Insulation thickness and overall wall thickness for 'warm' frame construction with a brick façade

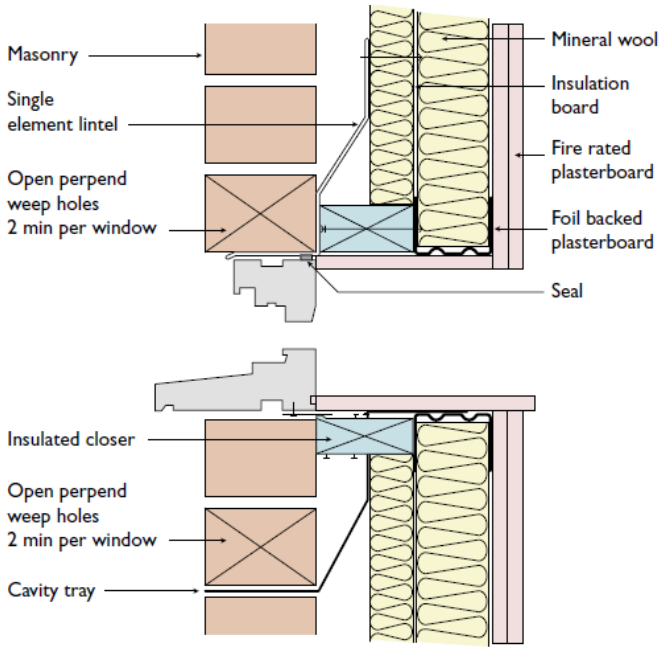
U-value (W/m²K) of wall	Typical insulation thickness*	Overall wall thickness
0.35	40 mm	290 mm
0.30	50 mm	300 mm
0.27	60 mm	310 mm
0.25	50 mm plus inter-stud insulation	300 mm
0.22	70 mm plus inter-stud insulation	320 mm
0.20	80 mm plus inter-stud insulation	330 mm

* Assuming board insulation with a thermal conductivity of 0.023m²K/W and inter-stud insulation with a thermal conductivity of 0.040 m²K/W

Table 3 is indicative and manfacturers have their own thermal data and insulation details to meet these standards.



Combined external and inter-stud insulation in brick cavity wall



Details at windows to avoid cold bridging

Light steel framing - Other cladding systems

Cladding Materials

A range of other cladding materials may be used in combination with light steel framing, such as:

- insulated render
- clay tiles and brick slips
- composite panels
- 'rain-screens'
- metallic and board fascias

Insulated Render

Insulated render is generally fixed to an external sheathing board, and in some systems, a nominal drainage cavity is created. The external insulation is often in the form of polyisocyanurate or polystyrene board or mineral wool to which the render is bonded. An external insulation thickness of 60 to 80 mm is generally provided to create a'warm' frame. Additional inter-stud mineral wool insulation may also be used, as defined in Table 4 (below).

Detailing of insulated render attached to light steel framing is presented in SCI Publication P343.

Clay tiles and brick slips

Clay tiles and brick slips may be attached to rails or steel backing sheets that are screw fixed through the insulation boards. The insulation board thicknesses should be increased by 10 mm relative to Table 3 for brickwork, to allow for loss of a solid external brick layer and its cavity.

Composite panels

Composite panels consist of two metallic layers with bonded insulation in between. They are manufactured in a range of thicknesses and textures, provide a high level of thermal insulation and are weather-tight.

Large composite panels are typically up to 1.2 m wide and 16 m long and may be orientated horizontally or vertically They are screw-fixed to the supporting members every 1.2 to 2 m. Composite panels are generally designed as sealed through their joints, thus external insulation boards are not required in this case.

Rain-screens

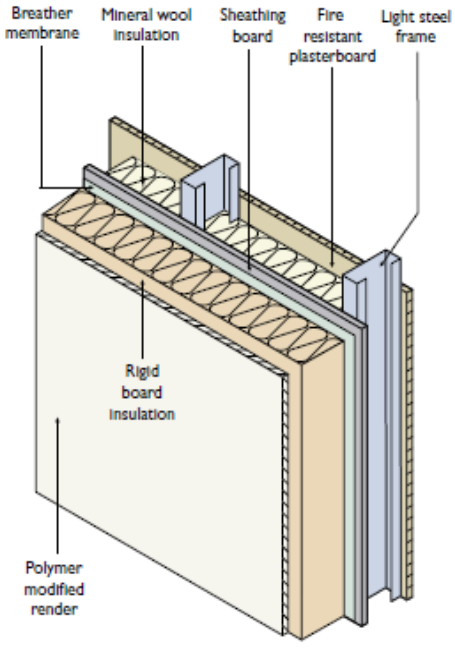
'Rain-screens' provide for pressure equalisation behind the external board in such a way that water ingress due to wind-driven rain does not occur through the joints. Insulation boards are attached to the light steel frame, and a weather-proofing barrier is required in the region of the joints in the rain screen cladding. Rain-screens may use a range of materials, including metallic cladding, tiles and weather resisting boards.

Metallic fascias

Metallic fascias are often used in multi-storey residential applications and can be in large cassette form. The thickness of insulation board may be taken as Table 4. A breather membrane is placed over the insulation board to prevent any water ingress that may enter behind the fascia.

Insulated render attached to light steel frame

Steel cassette attached to light steel frame



Detail of insulated render (without cavity)

Table 4 Insulation thickness and typical overall wall thickness for 'warm' frame construction with an insulated render façade

U-value (W/m²K) of wall	Typical insulation thickness*	Overall wall thickness
0.30	60 mm	210 mm
0.27	80 mm	230 mm
0.25	60 mm plus inter-stud insulation	210 mm
0.22	80 mm plus inter-stud insulation	230 mm
0.20	100 mm plus inter-stud insulation	250 mm

* Using external insulation board with a thermal conductivity of 0.023 m²K/W and inter-stud insulation with a thermal conductivity of 0.040 m²K/W

Table 4 is indicative and manfacturers have their own thermal data for the particular insulation materials and board types used.

Measured performance

A demonstration building using light steel framing was constructed at Oxford Brookes University. It was built to high thermal insulation standards with U-values of 0.2 W/m^2K in the walls and 0.I5Wm^2K in the roof.

Finished building used for long term monitoring

In total. 10 bed spaces were created in the form of a brick-clad house linked to a 3-storey student residence.

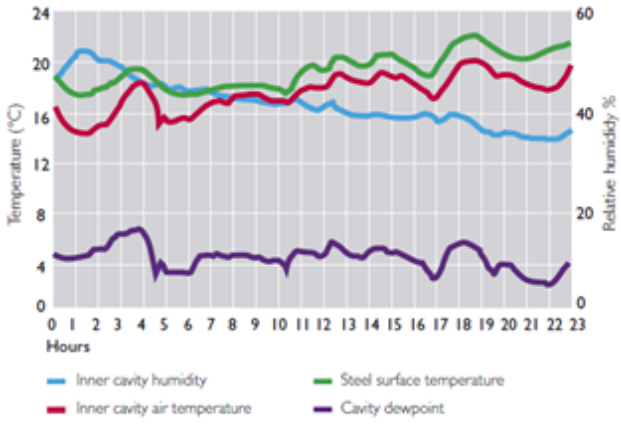
The ground floor was constructed as an insulated composite slab, and the roof space was occupied by creating an 'open roof in light steel framing. Sensors were built into the fabric of the building in order to monitor and collect a wide range of environmental data.

The key findings showed that:

- In 'warm' frame construction, cold bridging of the external fabric is avoided.
- The temperature of the light steel framing is close to the internal temperature.
- Measured U-values compare well with the theoretical values.
- No condensation occurred on the light steel frame structure.

Temperature and relative humidity measured at cross-sections through the north wall showed that the steel temperature was always well above the dew point temperature. Typical results for a winter's day are shown below.

The long term durability of the light steel components is also part of this monitoring study, and a design life of 100 years is predicted.



External north wall in living room/kitchen measured

Measured temperatures and relative humidity compared with dewpoint temperature.

Benefits of light steel framing

The benefits of light steel framing in housing and residential buildings in terms of sustainability, economic and social criteria may be summarised as follows:

Energy Saving

- High levels of insulation easily achieved.
- Variety of cladding systems may be used.
- Light weight provides thermally responsive construction.
- Thermal bridging is minimised.
- Achieves air-tight construction.
- Proven performance in service.

Rethinking Construction

- Faster speed of construction.
- Increased value to client.
- Increased site productivity.
- Predictability of process.
- Safer construction process.
- Improved quality.
- Ease of integration of components.

Sustainability

- Reduced CO_2 emissions.
- Low waste in construction.
- Fewer materials used (by weight).
- High recycled content.
- Less disruption during construction process.
- Adaptability to changing or future requirements.
- Can be recycled at end of life.

Value Benefits

- Less call backs for making good.
- Construction periods reduced by up to 50%.
- Increased rate of return for the builder.
- Improved turnover generated from capital.
- Reduced heating bills.