

Chapter 9 STRUCTURAL CONCEPT FOR LIGHT GAUGE STEEL FRAME SYSTEM

9.1 BACKGROUND

Steel is widely used in the construction of multi-storey buildings. However, steel construction is seldom used and is traditionally considered uneconomical for landed properties. In many parts of the world, timber or structural brickwork is preferred whereas in Singapore, reinforced concrete construction is usually preferred for landed properties.

Over the years, various improved systems have been developed for use in landed properties. An economical light gauge steel frame system is increasingly being used in America, Europe, Australia and New Zealand. This light gauge steel frame is developed through a cold-formed process without the use of heat. This process enables steel manufacturers to produce light-weight but high tensile steel sheets. The sheet surface is coated with a zinc alloy that completely covers the steel surface and seals it from the corrosive action of its environment. This results in buildings that are more solid, rigid, stronger, durable and easier to build.

As such, the light gauge steel frame system is an attractive alternative for use in landed properties. This is particularly in view of concerns on the depletion of timber resources and low productivities associated with reinforced concrete construction.



Completed house at Upper Changi Road East

9.2 WHY USE LIGHT GAUGE STEEL FRAMING SYSTEM



Benefits

Buildability: The use of pre-fabricated and pre-assembled steel components reduces site works, reduces material waste and improves quality.

Speed: This system requires a shorter construction period compared to that for a conventional system.



Strong but Lightweight: Steel has one of the highest strength-to-weight ratios of any construction material. This results in savings in the foundation required and the lightness also makes for easier on-site handling.

Safety: Steel's inherent strength and non-combustible qualities enable light steel frame houses to resist such devastating events as fires, earthquakes, and hurricanes. Homes can be designed to meet the highest seismic and wind load specifications in any part of the country.

Quality: A better quality finished house that is durable and low in maintenance.

Easy to Remodel: Remodeling can be easily accomplished. Non-load bearing walls can be readily relocated, removed or altered.

Design Flexibility: Because of its strength, steel can span longer lengths, offering larger open spaces and increased design flexibility without requiring intermediate columns or load bearing walls.

Recyclable: All steel products are recyclable.

9.3 STEEL FRAMING LANGUAGE

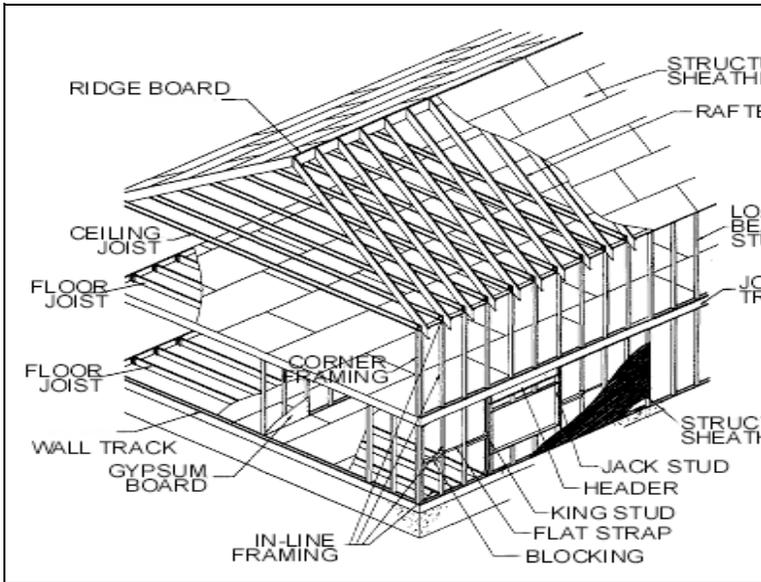


Figure 9.1 Steel Framed Building

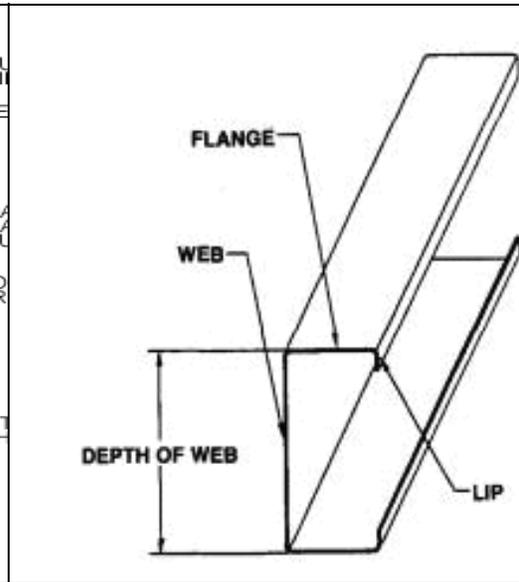


Figure 9.2 Components of a C shaped cold-formed steel member

Bottom Plate: A plate that contains the bottom end of a wall stud. The top plate has a web and flanges, but no lips.

Ceiling Joist: A horizontal structural framing member that supports a ceiling and/or attic loads (See Figure 9.1).

C-section: Used for structural framing members such as studs, joists, beams, girders, and rafters. The name comes from the member's "C" shaped cross-sectional configuration consisting of a web, flange and lip. C-section web depth and flange width measurements use outside dimensions (See Figure 9.2).

Clip Angle: An L-shaped short piece of metal (normally with a 90 degree bend) typically used for connections.

Cold-forming: A process where light-gauge steel members are manufactured without the use of heat.

Flange: The part of a C-section or track that is perpendicular to the web (See Figure 9.2).

Flat Strap: Sheet steel cut to a specified width without any bends, typically used for bracing and other flat applications (See Figure 9.1).

Floor Joist: A horizontal structural framing member that supports floor loads (See Figure 9.1).

Galvanized Steel: Steel that has a zinc protective coating for resistance against corrosion. The level of coated protection is measured by the weight of the galvanized coating applied to the surface area of the steel (e.g. G-40 or G-60).

Gauge: A unit of measurement traditionally used to describe the nominal thickness of steel. The lower the gauge, the greater the thickness.

Header: A horizontal built-up structural framing member used over wall or roof openings to carry loads across the opening (See Figure 9.1).

In-Line Framing: Frame systems where all vertical and horizontal load carrying members are aligned (See Figure 9.1).

Jack Stud: A vertical structural member that does not span the full height of the wall and supports vertical loads and/or transfers lateral loads. Jack studs are used to support headers (See Figure 9.1).

King Stud: A vertical structural member that spans the full height of the wall and supports vertical loads and lateral loads. Usually located at both ends of a header adjacent to the jack studs to resist lateral loads (See Figure 9.1).

Lip: The part of a C-section that extends from the flange at the open end. The lip increases the strength characteristics of the member and acts as a stiffener to the flange (See Figure 9.2).

Load Bearing Wall: A wall that carries vertical loads from above or lateral loads resulting from wind. These loads may act separately or in combination. Both internal and external walls may be load bearing.

Material Thickness: The base metal thickness excluding any protective

coatings. Thickness is expressed in mils (traditionally expressed in gauge).

Mil: A unit of measurement typically used in measuring the thickness of thin elements. One mil equals 1/1000 of an inch.

Multiple Span: The span made by a continuous member having intermediate supports.

Non-Load Bearing Wall: Walls which do not support any loads.

Punch-out: A hole in the web of a steel framing member allowing for the installation of plumbing, electrical, and other trade installation.

Rafter: A structural framing member (sloped) that supports roof loads (See Figure 9.1).

Shearwall: A wall assembly capable of resisting lateral forces to prevent racking from wind or seismic loads acting parallel to the plane of the wall.

Single Span: The span made by one continuous structural member without any intermediate supports.

Span: The clear horizontal distance between bearing supports.

Structural Sheathing: The covering (e.g. steel sheets) used directly over structural members (e.g. studs or joists) to distribute loads, brace walls, and strengthen the assembly (See Figure 9.1).

Stud: Vertical structural element of a wall assembly that supports vertical loads and/or transfers lateral loads (See Figure 9.1).

Top Plate: A plate used to carry truss loads from the roof to the studs, where the studs are not located directly under the truss load points. The top plate has a web and flanges but no lips.

Track: Used for applications such as top and bottom plate for walls and band joists for flooring systems. The track has a web and flanges, but no lips. Track web depth measurements are taken to the inside of the flanges (See Figure 9.2).

Web: The part of a C-section or track that connects the two flanges (See Figure 9.2)

Web Stiffener: Additional material that is attached to the web to strengthen the member against web crippling. Also called bearing stiffener.

Yield Strength: A characteristic of the basic strength of the steel material. It is the highest unit stress that the material can endure before permanent deformation occurs.

9.4 STEEL FRAMING DESIGN

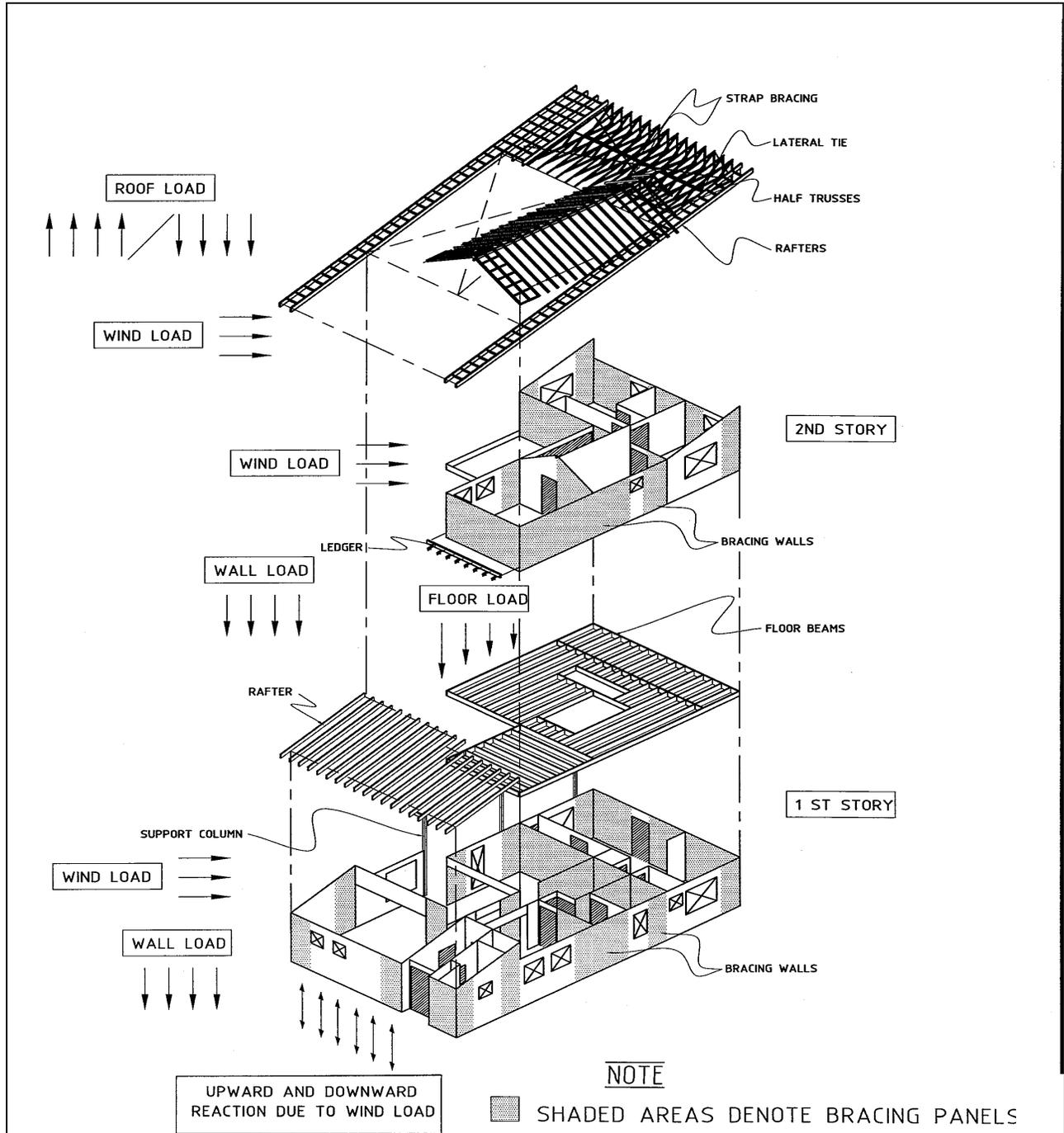


Figure 9.3 Loading Path Diagram
Details recommended by BHP Steel Lysaght

In a steel framed house, the loading path of the house structure is used to determine the design requirement (See Figure 9.3). The roof loads, wind loads, wall loads and floor loads will be transferred all the way down to the ground floor.

A steel framed house would normally be built on a reinforced concrete ground floor slab. The ground floor wall panels would then be fastened and held down to the ground floor slab. The second storey floor bearers would then sit on the top of load bearing walls. These bearers would connect and carry the floor joists. The floor joists would in turn carry the floor boards and the wall panels above. The roof trusses would then sit on the wall panels to carry the roof system and roof loads.

The sizes and spacing of the structural members would depend on the design loads. Generally, BHP Steel Lysaght recommends the following:

- Lysaght C75 and Lysaght C100 sections would be used as the wall studs.
- As for the floor joists, they can be chosen from a range of sections ranging from Lysaght C100 to Lysaght C250 sections depending on design loads and floor configuration.

Connections for steel framing can consist of self-drilling screws, bolts and anchors. Welding is usually not required and mechanical fasteners would suffice in most cases.

9.5 WALL SYSTEM

9.5a Load Bearing Walls

A load bearing wall is one which carries vertical loads from the construction above or lateral loads resulting from the wind. These loads may act separately or in combination. Both internal and external walls may be load bearing.

BHP Steel Lysaght recommends the following for the load bearing walls:

- All load bearing studs shall be minimum Lysaght C75 G550 cold formed section.
- A structural top plate is used to carry truss loads from the roof to the studs, where the studs are not located directly under the truss load points. Top plates shall be Lysaght G550 cold formed section (Structural plate). The top plate shall be secured transversely at a maximum of 1800mm centres by incoming trusses or rafters with approved wall support brackets.
- The bottom plate shall be minimum G550 cold-formed section. The bottom plate must be fully supported under every load-bearing stud. This is critical with studs beside openings, or studs carrying major loads for the roof, ceiling or upper floor construction. The support can be provided by a floor joist, blocking piece or concrete slab located directly under the stud.
- Lintels are needed for openings greater than 1200mm of load bearing walls. Lintels under sheet metal roofs are principally designed for uplift from wind loading on the roof structure while lintels under tile roofs are designed principally to support downward loads from the roof trusses.
- Noggings in the form of a notched plate may be used in load bearing walls to provide lateral restraint to the wall studs.
- Bracing is needed in certain walls to provide racking resistance against wind load. It could be in the form of bracing straps or bracing sheets depending on the requirement.
- The studs, joists and trusses must be properly aligned in order to transfer the loads to the member below.

9.5b Non-Load Bearing Walls

Internal walls which do not support truss loads are considered non-load bearing.

BHP Steel Lysaght recommends the following for non-load bearing walls:

- Studs for internal non-load bearing walls shall be minimum Lysaght G550 C75 cold formed section.
- Top plate should be minimum G550 cold formed section and shall be fixed to trusses at 1800 mm maximum centres to provide lateral stability for the wall. The connection shall not transmit vertical loads to the wall.
- The bottom plate shall be minimum G550 cold formed section
- Angle lintels are not required for openings in non-load bearing wall frames.
- Noggings is generally not needed for internal non-load bearing walls.

9.5c Wall details and connections

Steel framing is fastened to the floor structure through the bottom plate after all panels have been correctly aligned and plumbed. For concrete floor slabs the frame is fixed in place by using masonry anchors, which are generally hammer-driven nails, expanding shell anchors or chemical anchors. Exact recommendations for the type and frequency of anchors would be available from steel suppliers or the engineer. The wall panels are usually connected together by mechanical fasteners such as self-drilling screws.





Figure 9.4 Load Bearing Wall Details & Installation

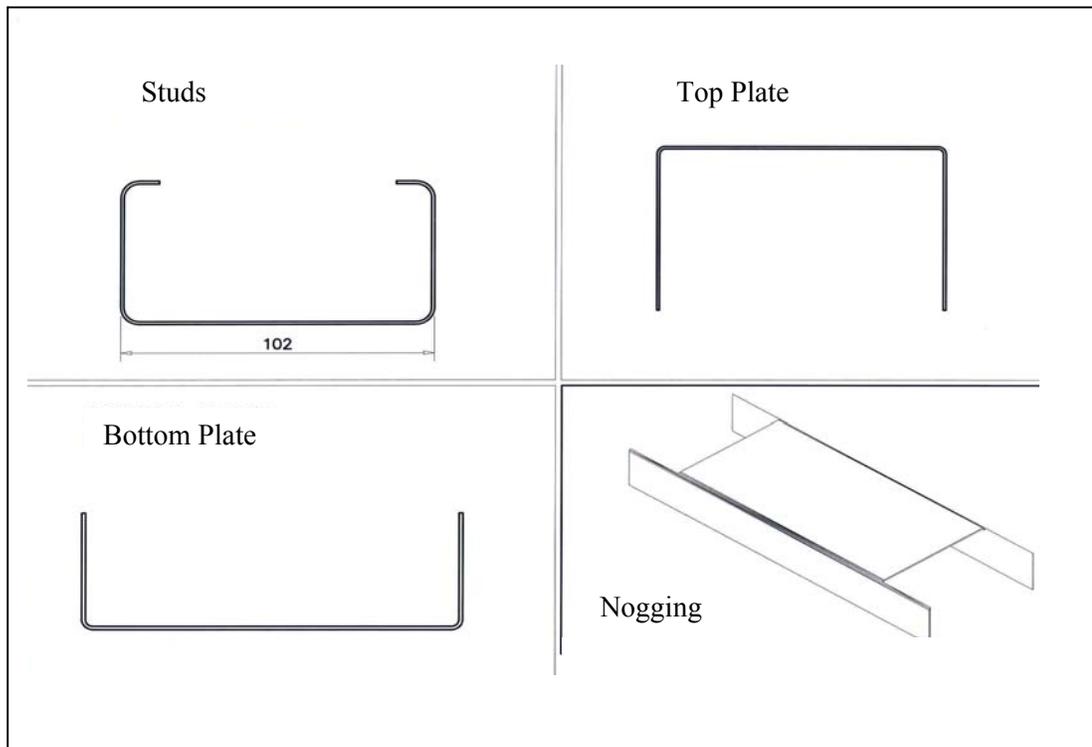


Figure 9.5 Studs, Plates & Nogging Sections
Details recommended by BHP Steel Lysaght

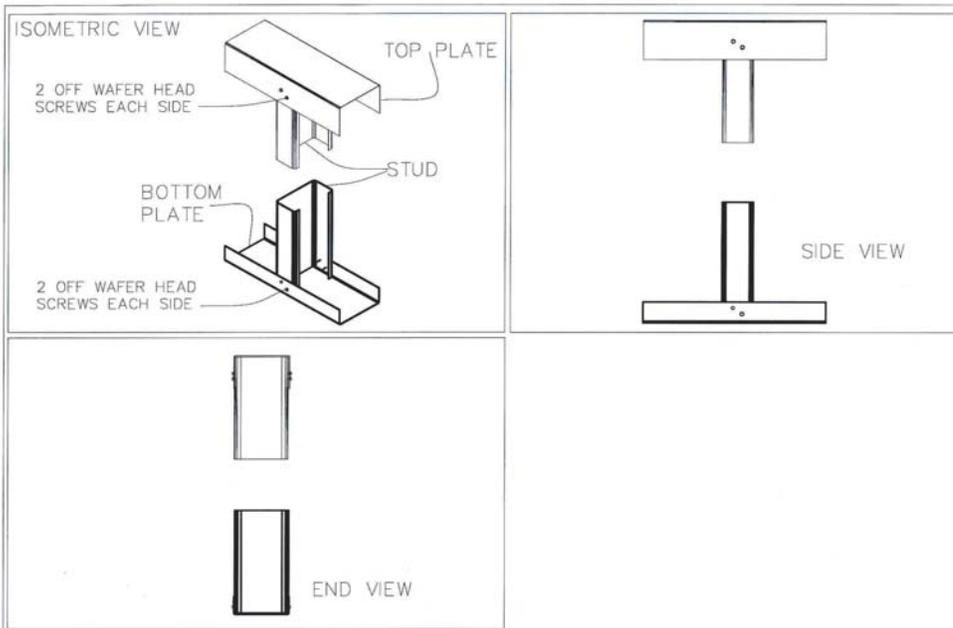


Figure 9.6 Stud to Plate Connection
Details recommended by BHP Steel Lysaght

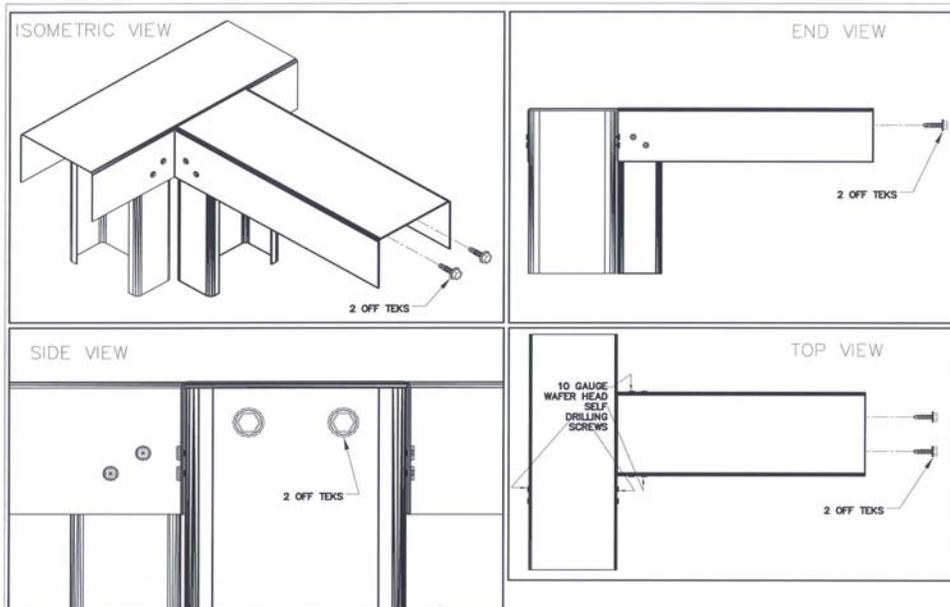


Figure 9.7 Internal to External Wall Connection
Details recommended by BHP Steel Lysaght

9.5d Wall Openings

External Door and Window Frames

The same door and window frames used in timber-framed construction are also used in steel-framed construction. If aluminium window frames are fitted into timber, they can be installed by fastening through the jamb studs into the back of the reveal after positioning. If it is not possible to secret-fix the frame, as may be the case with a window or door head, self-drilling screws of appropriate length can be driven through the frame and packing into the steel framing. The same type of screws may also be used to fasten aluminium window frames direct to steel frame openings.

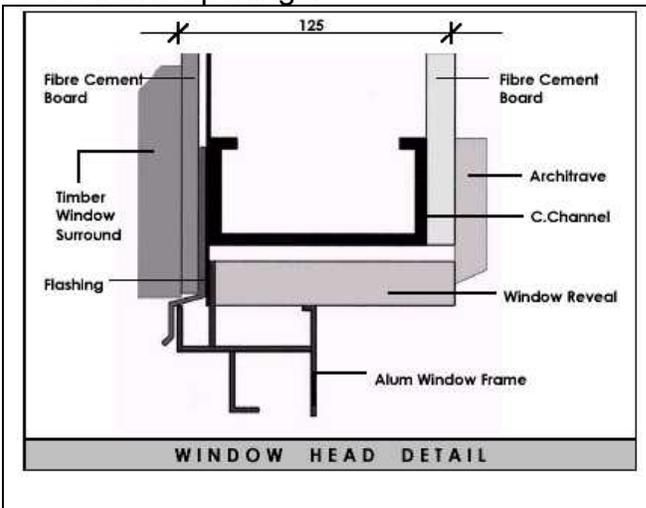


Figure 9.8 Window head details

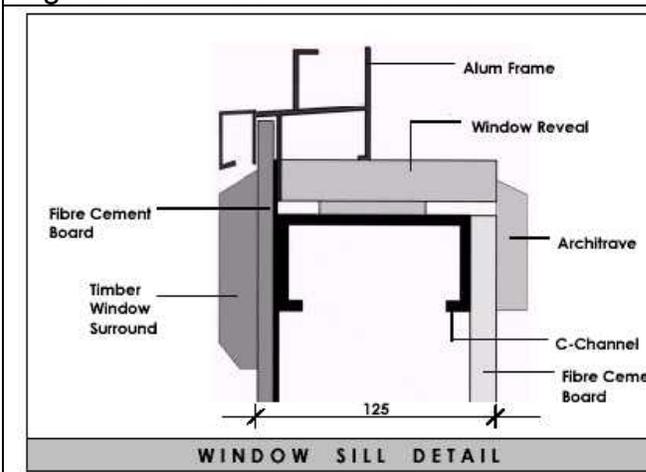


Figure 9.9 Window sill details

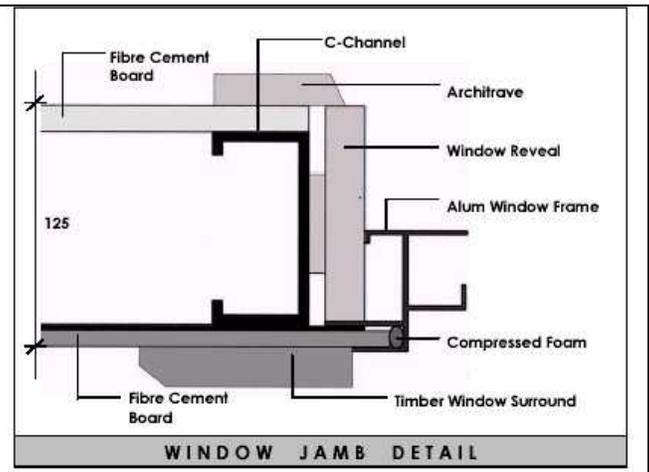


Figure 9.10 Window jamb details

Internal Door Frames

Timber door frames in internal walls can be secret-fixed through the back of jamb studs with screws or nails. Alternatively the frame may be fastened through the jamb into the studs with self-drilling screws.

9.5e Wall Cladding & Partitions

If required in the external walls, reflective foil sarking may be attached to the external flange of the steel studs with self-drilling screws fitted with 25mm flat fibre washers. Alternatively wafer head screws may be used. Wire brick ties which simply clip on to steel studs are available for brick veneer construction. For single wall construction, fibre cement sheeting can be fixed to steel frames with self-drilling, self-embedding head screws. Timber weatherboards can be fastened to steel studs with extended point countersunk head self-drilling screws. Steel sheet cladding is also fixed with self-drilling screws.

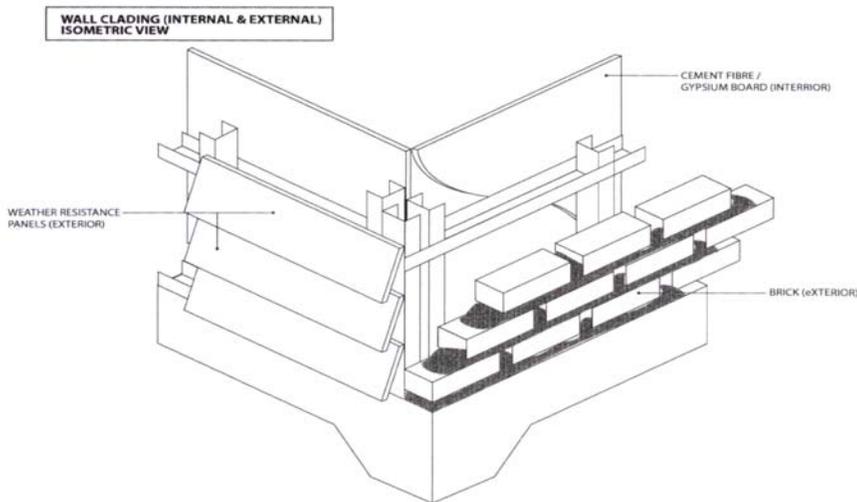


Figure 9.11 Internal & External Wall cladding

9.6 FLOORING SYSTEM

The flooring system can be made up of C-sections as joists connected to C-section bearers. The floor joists can be designed from a range of C-section sizes depending on loading parameters.

Lattice Beam Flooring (see Figure 9.14) gives a stronger and stiffer base for the floor-board to be fitted onto. This will eliminate squeaky sounds made when floor-boards are not properly fastened onto the beams. It also gives better sound insulation between the ground and upper floor. This flooring can be used on platform support or where the ground is split-leveled.

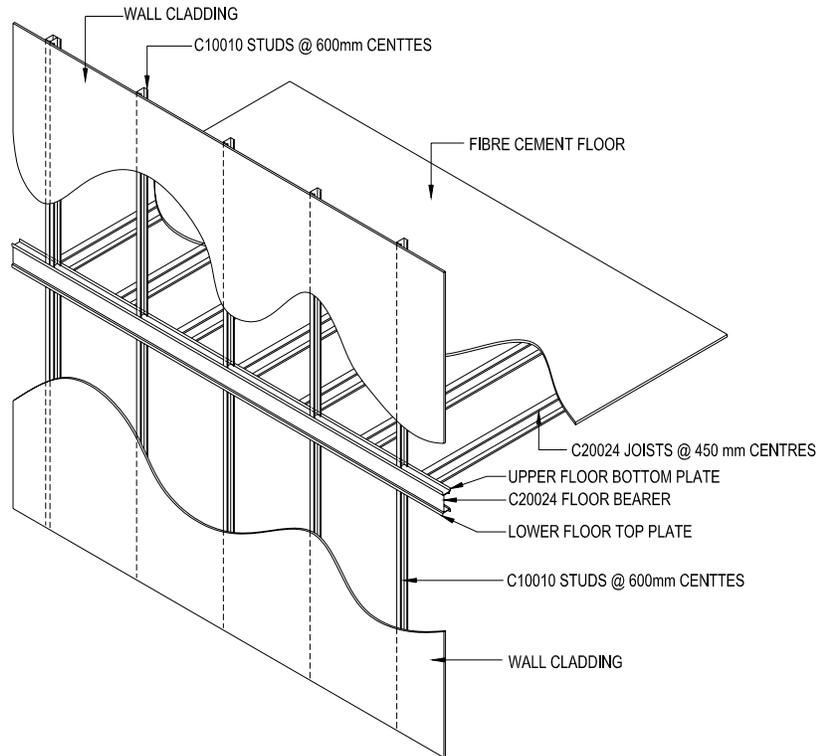


Figure 9.12 Steel frame wall & flooring using C-sections

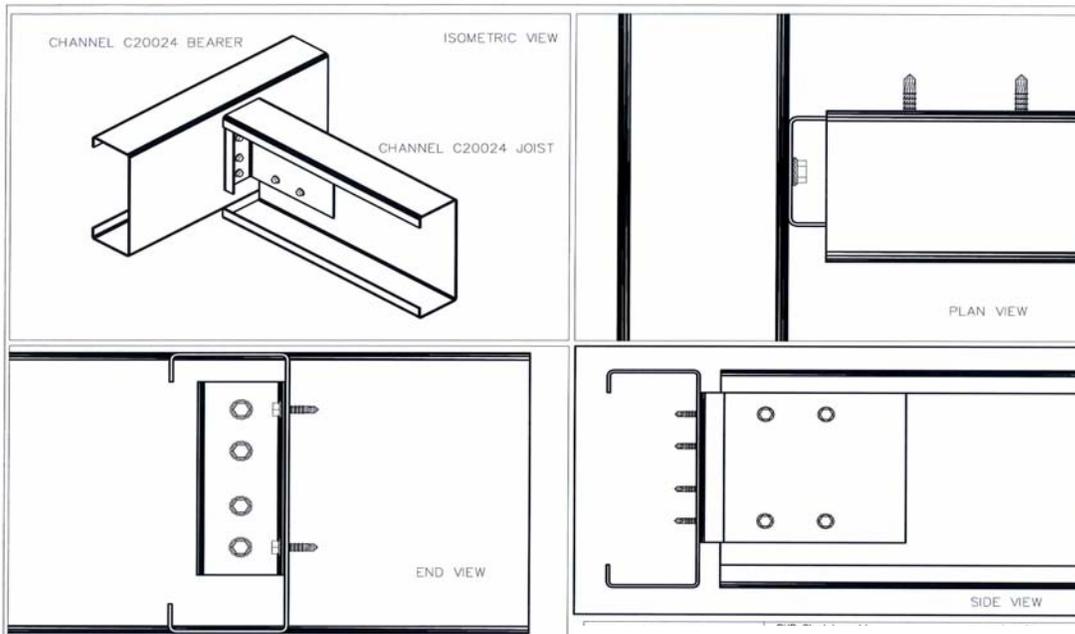


Figure 9.13 Joist to C-Section Bearer Connection for Flooring
Details recommended by BHP Steel Lysaght

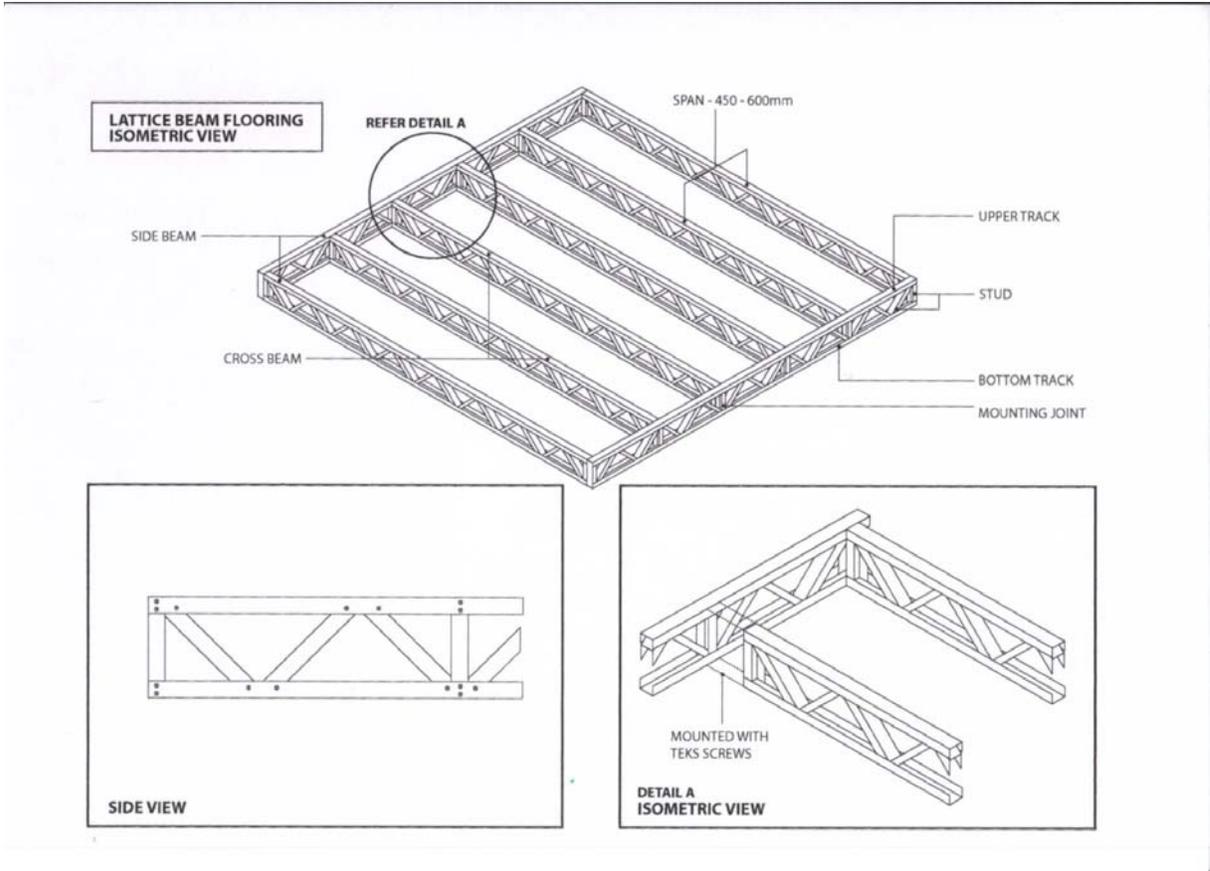


Figure 9.14 Lattice Beam Flooring
 Details recommended by QWik Built-Tech International Pte Ltd

The following shows some suggested details of floor finishes on the floor board:

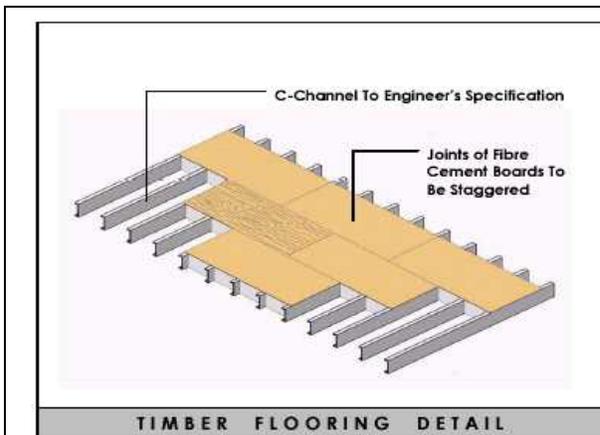


Figure 9.15 Floor finishes with timber flooring

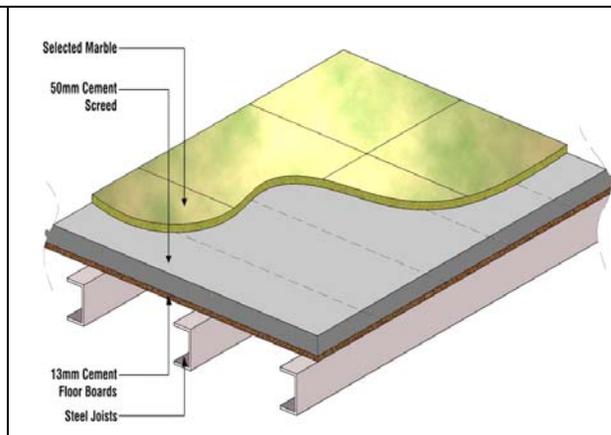


Figure 9.16 Alternative floor finishes with granite flooring

9.7 ROOF SYSTEM

The roof structure is generally a steel truss system which can be designed for metal sheets or tiles. This is a roof truss system which typically consists of C75 and C100 sections as the chord and web members of the truss. The steel roof framing system can suit all types of roof design – hip, gable, dutch dable, steel roof sheeting or tile and would be screwed directly onto the wall frame.

When using tiles, wooden-styled roof trusses are used with purlins running across them for the tiles to be fitted.



Figure 9.17 Roof Truss

9.8 M & E Services

Pre-punched service holes in the web of the steel frame allows electrical, gas and plumbing services to be installed within the wall framing system. Plastic grommets and silicone seals are used to fasten and protect wiring and pipes from corrosion and damage arising from vibrations.



Figure 9.18 Pre-punched service holes for M & E Services