Chapter 05: **Metal and mixed constructions**

I- Connections of metal structures in buildings and industrial halls

The steel-framed building derives most of its competitive advantage from the virtues of prefabricated components, which can be assembled speedily at site. Unlike concreting, which is usually a wet process conducted at site, steel is produced and subsequently fabricated within a controlled environment. This ensures high quality, manufacture offsite with improved precision and enhanced speed of construction at site.

Connections form an important part of any structure and are designed more conservatively than members. This is because, connections are more complex than members to analyse, and the discrepancy between analysis and actual behaviour is large.

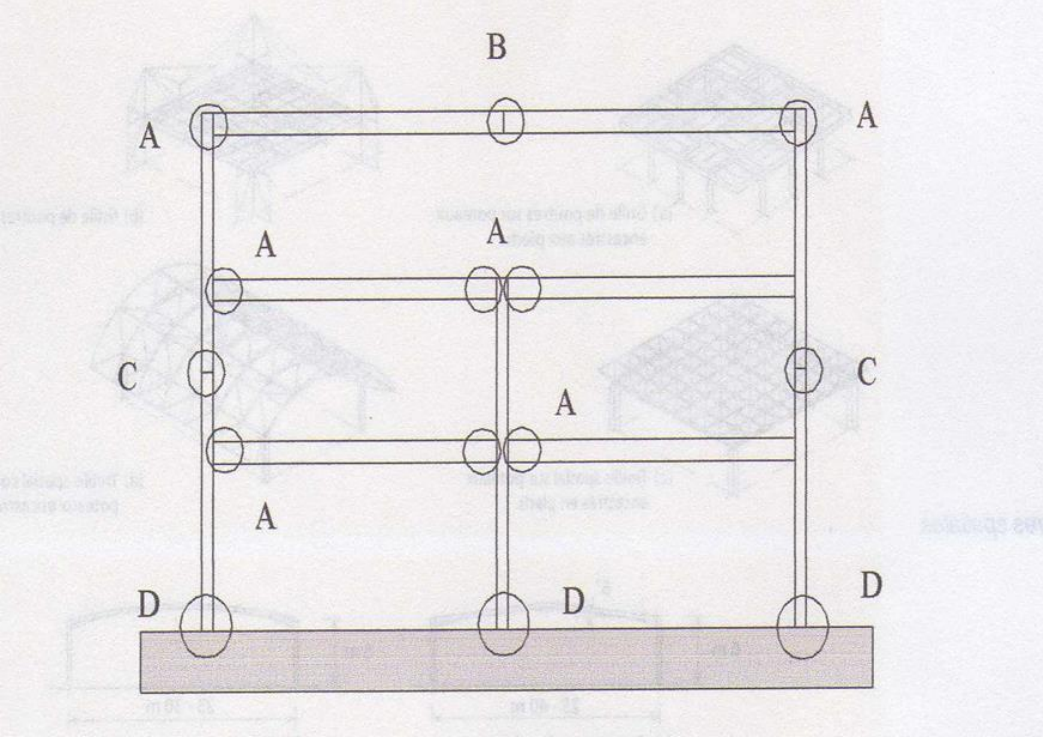
Further, in case of overloading, we prefer the failure confined to an individual member rather than in connections, which could affect many members.

Connections account for more than half the cost of structural steelwork and so their design and detailing are of primary importance for the economy of the structure.

The type of connection designed has an influence on member design and so must be decided even prior to the design of the structural system and design of members.

1- Connections classification:

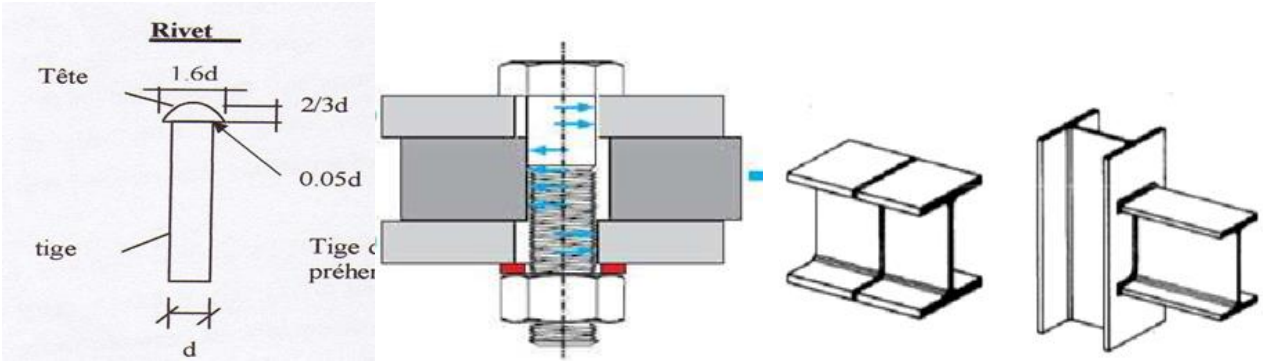
Connections are classified into idealised types while designing. But the actual behaviour of the connection may be different and this point should always be kept in mind so that the connection designed does not differ significantly from the intended type.



The connections provided in steel structures can be classified as:

1) riveted
2) bolted an
3) welded connections.

Riveted connections were once very popular and are still used in some cases but will gradually be replaced by bolted connections. This is due to the low strength of rivets, higher installation costs and the inherent inefficiency of the connection.
Welded connections have the advantage that no holes need to be drilled in the member and consequently have higher efficiencies. However, welding in the field may be difficult, costly, and time consuming. Welded connections are also susceptible to failure by cracking under repeated cyclic loads due to fatigue which may be due to working loads such as trains passing over a bridge (high-cycle fatigue) or earthquakes (low-cycle fatigue). A special type of bolted connection using High Strength Friction Grip (HSFG)



I-1 BOLTED CONNECTIONS

Connections can also be classified in the following ways:

(a) Classification based on the type of resultant force transferred:

The bolted connections are referred to as concentric connections (force transfer in tension and compression member), eccentric connections (in reaction transferring brackets) or moment resisting connections (in beam to column connections in frames).

Ideal concentric connections should have only one bolt passing through all the members meeting at a joint [Fig. 1(*a*)]. However, in practice, this is not usually possible and so it is only ensured that the centroidal axes of the members meet at one point [See Fig. 1(*b*)].

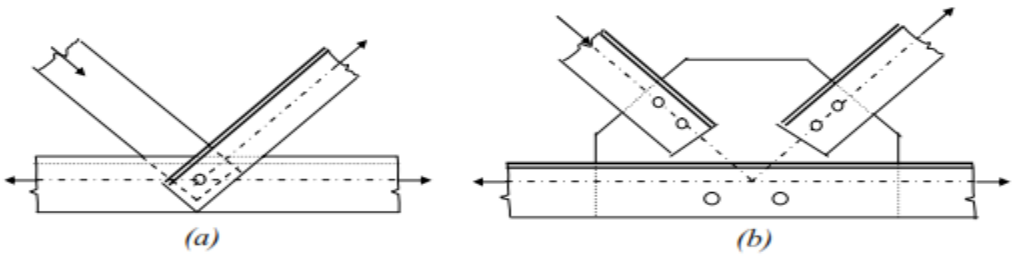


Fig. 1 Concentric Connections

The Moment connections are more complex to analyse compared to the above two types and are shown in Fig. 2(*a*) and Fig. 2(*b*). The connection in Fig. 2(*a*) is also known as bracket connection and the resistance is only through shear in the bolts.

The connection shown in Fig. 2(*b*) is often found in moment resisting frames where the beam moment is transferred to the column. The connection is also used at the base of the column where a base plate is connected to the foundation by means of anchor bolts.
In this connection, the bolts are subjected to a combination of shear and axial tension.
Moment resisting connections will be dealt with in the next chapter.

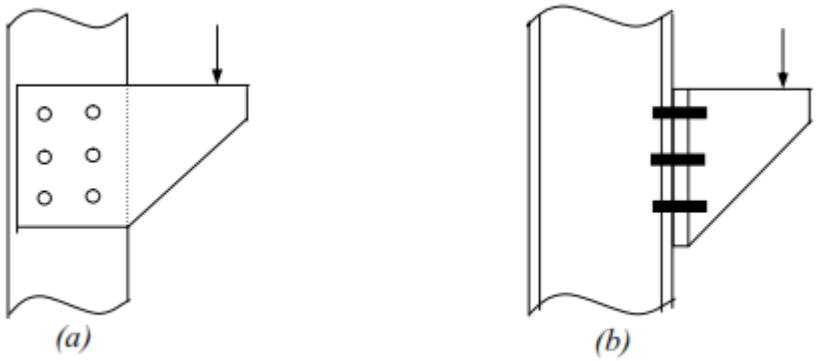


Fig. 2 Moment Connections

***(b) Classification based on the type of force experienced by the bolts*:**
The bolted connections can also be classified based on geometry and loading conditions into three types namely, shear connections, tension connections and combined shear and tension connections.

Typical shear connections occur as a *lap* or a *butt* joint used in the tension members [See Fig. 3]. While the lap joint has a tendency to bend so that the forces tend to become collinear, the butt joint requires *cover plates*. Since the load acts in the plane of the plates, the load transmission at the joint will ultimately be through shearing forces in the bolts.
In the case of lap joint or a single cover plate butt joint, there is only one shearing plane, and so the bolts are said to be in *single shear*. In the case of double cover butt joint, there are two shearing planes and so the bolts will be in *double shear*. It should be noted that the single cover type butt joint is nothing but lap joints in series and also bends so that the centre of the cover plate becomes collinear with the forces.

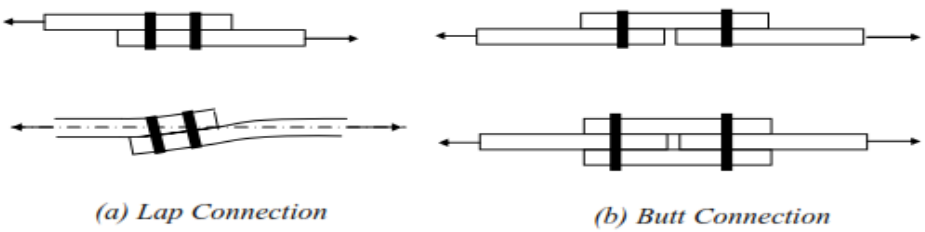


Fig. 3 Shear Connections

A hanger connection is shown in Fig. 4(*a*). In this connection, load transmission is by pure tension in the bolts. In the connection shown in Fig. 4(*b*), the bolts are subjected to
both tension and shear.

(b) Classification based on force transfer mechanism by bolts:

The bolted connections are classified as bearing type (bolts bear against the holes to transfer the force) or friction type (force transfer between the plates due to the clamping force generated by the pre– tensioning of the bolts).

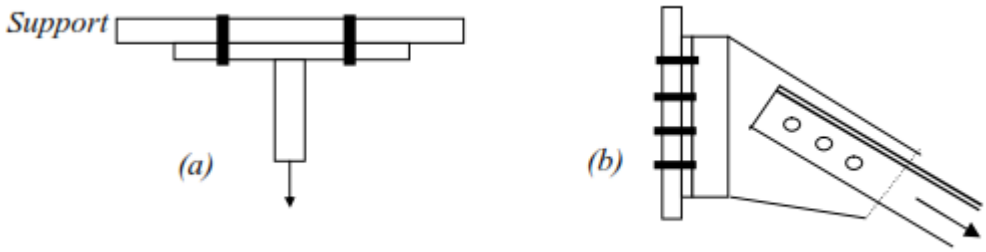
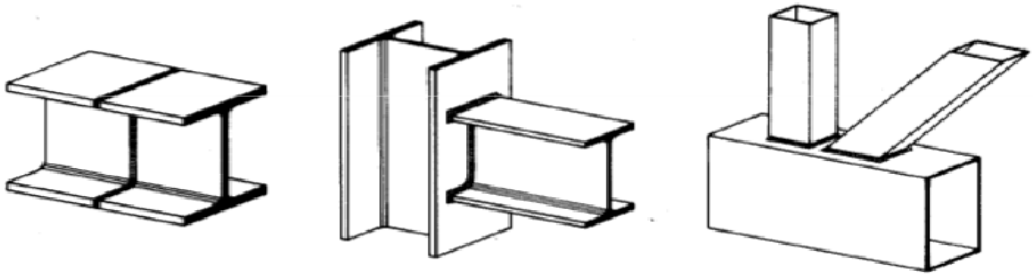


Fig. 4 (a) Tension Connection (b) Tension plus Shear Connection

II-2 Welded connections

Welded connections are connections whose components are joined together primarily by welds.
Welds can be classified according to: Types of welds: groove, fillet, plug, and slot welds. Positions of the welds: horizontal, vertical, overhead, and flat welds.



Advantages Of Welding Joints

- A welded connection is the favoured option for a useful purpose. With this type of connection, there is a 100% guarantee that the connection is strong enough to withhold pressure. Riveted joints usually come with at least 75% of the sturdiness connection.

- Steel structures can be complicated at times and in those steel structures, the most convenient way to make a connection is through welding. In cases of steel pipes, it is important to note that complicated structures are more accessible to put together for a stronger connection by welding.

- Welding is a method that provides a more rigid connected for steel structures. This is a significant requirement in structural frames made of steel.

While riveting may be a good strategy to put metal pieces together, it is not the best option for structures that will be sued on populated areas.

- Welded structures are more pleasing to the eye as their a connection between metals become aesthetically one. Compared to riveting where the connections can be distinctly identified, welding makes the whole structure made into one.

Disadvantages of Welding Joints

- Welded connections do not allow any form of expansion. Contractions in the connection could make it weak. It is prone to developing cracks after some time.

- Internal and external distortions can happen while the areas of connection are exposed to uneven heating during the process of welding.

- Due to possible extreme heating, fatigue may take place where a connection of steel is made. That's why it is essential that only an expert works with the steel connection through welding to ensure that the connection is not exposed to too much heat.

- Inspection work for welded steel requires more time and accuracy. Checking the stability of the connection requires more attention.

II- Composite constructions

II- 1 Presentation:

Composite slabs consist of profiled steel decking with an in-situ reinforced concrete topping. The decking not only acts as permanent formwork to the concrete, but also provides sufficient shear bond with the concrete so that, when the concrete has gained strength, the two materials act together compositely. Composite beams are normally hot rolled or fabricated steel sections that act compositely with the slab. The composite interaction is achieved by the attachment of shear connectors to the top flange of the beam. These connectors generally take the form of headed studs. It is standard practice in the UK for the studs to be welded to the beam through the decking (known as 'thru-deck' welding) prior to placing the concrete. The shear connectors provide sufficient longitudinal shear connection between the beam and the concrete so that they act together structurally. Composite slabs and beams are commonly used (with steel columns) in the commercial, industrial, leisure, health and residential building sectors due to the speed of construction and general structural economy that can be achieved. Although most commonly used on steel framed buildings, composite slabs may also be supported off masonry or concrete components.

Figure 4 A typical example of composite floor construction, showing decking placed on a steel frame

II-2 Benefits of composite construction

Composite construction has contributed significantly to the dominance of steel frames in the commercial building sector in the UK. The main benefits of composite construction are:

Speed of construction

Bundles of decking can be positioned on the structure by crane and the individual sheets then installed by hand. Using this process, crane time is minimal, and in excess of 400 m2 of decking can be installed by one team in a day, depending on the shape and size of the building footprint. The use of the decking as a working platform speeds up the construction process for following trades. Minimal reinforcement is required, and large areas of floor can be poured quickly. Floors can be concreted in rapid succession. The use of fibre reinforced concrete can further reduce the programme, as the reinforcement installation period is significantly reduced.

Safe method of construction

The decking can provide a safe working platform and act as a safety 'canopy' to protect workers below from falling objects.

Saving in weight

Composite construction is considerably stiffer and stronger than many other floor systems, so the weight and size of the primary structure can be reduced. Consequently, foundation sizes can also be reduced.

Saving in transport

Decking is light and is delivered in pre-cut lengths that are tightly packed into bundles. Typically, one lorry can transport in excess of 1000 m2 of decking. Therefore, a smaller number of deliveries are required when compared to other forms of construction.

Structural stability

The decking can act as an effective lateral restraint for the beams, provided that the decking fixings have been designed to carry the necessary loads and specified accordingly. The decking may also be designed to act as a large floor diaphragm to redistribute wind loads in the construction stage, and the composite slab can act as a diaphragm in the completed

structure. The floor construction is robust due to the continuity achieved between the decking, reinforcement, concrete and primary structure.

Shallower construction

The stiffness and bending resistance of composite beams means that shallower floors can be achieved than in non-composite construction. This may lead to smaller storey heights, more room to accommodate services in a limited ceiling to floor zone, or more storeys for the same overall height. This is especially true for slim floor construction, whereby the beam depth is contained within the slab depth

Sustainability

Steel has the ability to be recycled repeatedly without reducing its inherent properties. This makes steel framed composite construction a sustainable solution. 'Sustainability' is a key factor for clients, and at least 94% of all steel construction products can be either re-used or recycled upon demolition of a building.

. Easy installation of services

Cable trays and pipes can be hung from hangers that are attached using special 'dovetail' recesses rolled into the decking profile, thereby facilitating the installation of services such as electricity, telephone and information technology network cabling. These hangers also allow for convenient installation of false ceilings and ventilation equipment

II- 3 Applications

Composite constructions have traditionally found their greatest application in steel framed office buildings, but they are also appropriate for the following types of building:

• Other commercial buildings • Industrial buildings and warehouses • Leisure buildings • Stadia • Hospitals • Schools • Cinemas • Housing; both individual houses and residential buildings • Refurbishment projects.