Chapter 02. **Steel connections**

I. 1- DEFINITION AND ROLE OF AN ASSEMBLY.

The essential characteristic of metal constructions is that they are composed of a set of bar elements **(columns-beams)** made up of rolled or welded profiles, often in the shape of an **(I** or **H**) that must be joined together to form the framework.
The connections between these different elements represent what are commonly called **assemblages**. These are specific components for steel construction,
They play a very important role, they can be defined as connecting elements that make it possible to join and solidify several elements together, ensuring the transmission and distribution of the various stresses between the assembled elements, without generating parasitic forces.
A poorly designed, miscalculated, or poorly executed assembly can lead to the collapse of the structure. As a result, the design and calculation of the connections is of paramount importance.

2- DIFFERENT FORMS OF ASSEMBLY ENCOUNTERED IN C.M.

In the frames of metal buildings, the structural elements are connected by **connections**. Depending on the nature of the assembled elements, a distinction can be made (Figure **I.1**) among others:
-Beam-beam connections (B)
-Beam-column assemblies (A)
-Continuity assemblies (C)
-Connections in a "one-node" lattice system (E)
-Column-foundation assemblies "pied de post" (D)

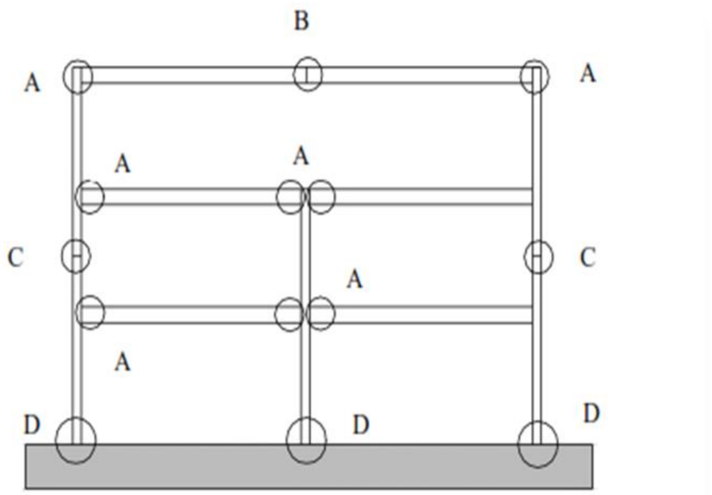


Figure I.1 Différents des types d'assemblages dans une ossature de bâtiment

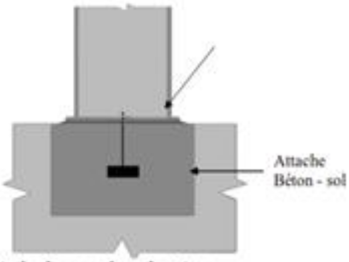


Figure I.2 Attache dans une base de poteau

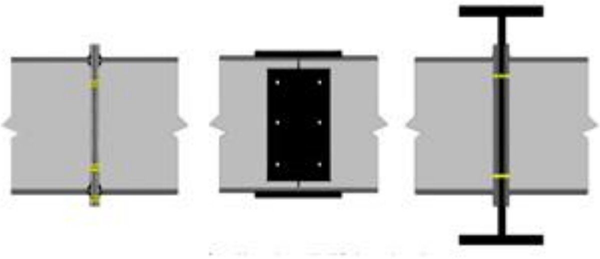
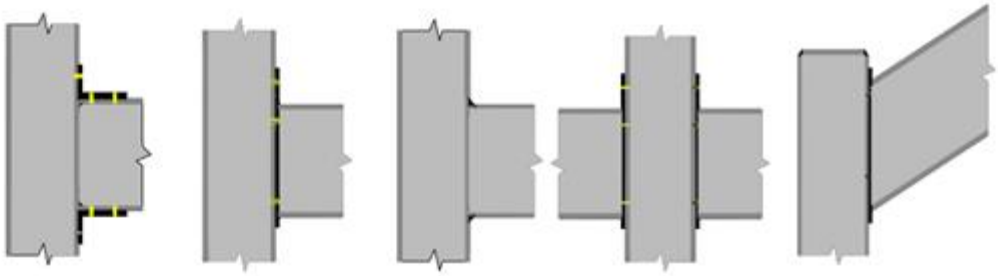


Figure I.3 Assemblage Poutre- Poutre
(B)



(A)Figure I.4 Assemblage Poteau- Poutre

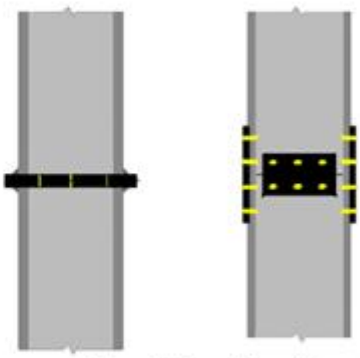


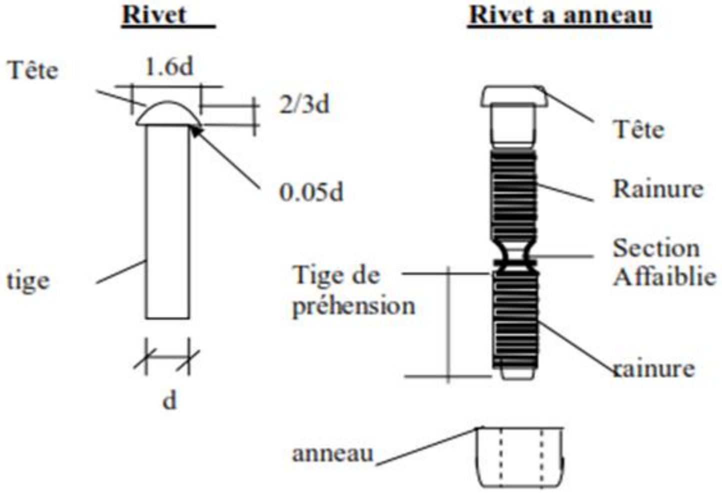
Figure I.5 Assemblage Poteau- Poteau

I-4 MODES OF ASSEMBLY:

The various forms of assemblies mentioned above are generally made by the The following main assembly methods:

A)-riveting

Rivets were the first means of assembly used in metal construction. Currently The use of rivets is limited and in most industrialized countries they are preferred to bolts and welding. They are therefore mainly found in ancient structures, dating from the beginning of this century .their diameter generally varies from 10 to 28mm.



Ring rivet:

Ring rivets are mechanical connecting elements that are both rivet (insofar as it has the same head shape and introduces a prestressing force) and bolt (because part of its shank is grooved).

The main features: the shank consists of two grooved (not threaded) parts, separated by a portion of stem whose section is weakened. The steel of ring rivets is a steel a high-strength steel type

B)-Bolting

The characteristics of the different types of steels used for bolts **Table 1.1** show the following characteristics:

Yield strength values and tensile strength of the four quality classes used for bolts (the meaning of the numbers to define the quality class is given in this paragraph).

boulons	Classe De qualité	$f_{yB}(N/mm^2)$	$f_{uB}(N/mm^2)$
De charpente	4.6 5.6	240 300	400 500
A haute résistance	8.8 10.9	640 900	800 1000

Table I.1 Mechanical Properties of Bolt Steels

This table also shows that there are two types of bolts, which are differentiated by their more or less high mechanical characteristics:

Structural steel bolts (steels 4.6 and 5.6).
High-strength bolts (steels 8.8 and 10.9).

Structural steel bolts are commonly used to make low-stress connections in halls and buildings. High-strength bolts are typically used for bridge connections, as well as for connections that are heavily stressed or subject to dynamic effects. Only high-strength bolts can be prestressed,

Euro code 3 adds quality classes 4.8, 5.8 and 6.8 to those given in the table and uses the notion of ordinary bolt instead of structural bolt

Remark:

Regardless of the type of bolts, the normal clearance between the bolt shank and the hole of the parts to be assembled is set at 2mm for bolt diameters less than or equal to 24mm, and at 3mm for bolt diameters equal to or greater than 27mm. The diameter d 0 of the hole is therefore :

- $d0 = d+2mm$ for $d \leq 24mm$.
- $d0=d+3mm$ for $d \leq 27mm$.

The **euro code 3** offers the same hole diameters, except for bolt diameters $d \leq 14mm$, for which $d0=d+1mm$.

In some cases, a smaller clearance may be required. The use of adjusted bolts offers the advantage of creating joints with a very small relative movement, and therefore structures that are not very deformable. However, the making of the holes must be precise, which significantly increases the cost of this type of assembly. Adjusted bolts should therefore only be used when absolutely necessary.

The following figure shows the different parts of a structural bolt and a high-strength bolt. The latter can be distinguished from structural steel bolts by the inscription of the quality class of the steel of the bolt on their head and washers,
It is always necessary to provide a washer under the part that will be turned when the bolt is put in place (usually the nut, sometimes the head, often both).to place bolts in the wings of the profiles.

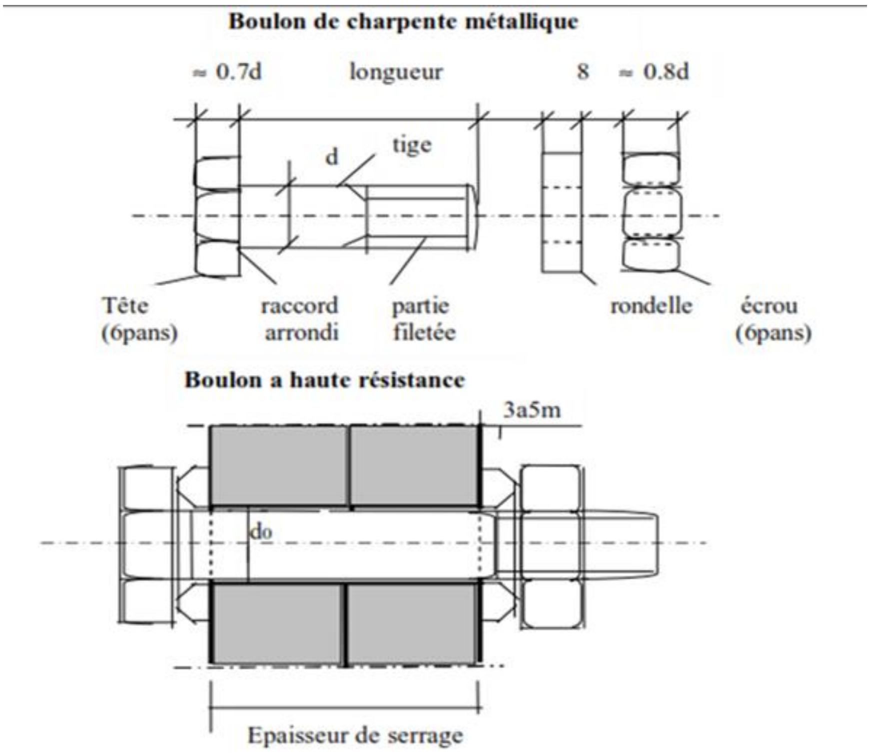


Figure I-7 Structural Bolt and High-Strength Bolt

c)-welding :

Welding is a process that allows parts to be joined together by intimate bonding of the material, obtained by melting or plasticizing.
Welding therefore involves:

- the existence of a sufficient source of heat to obtain the fusion of the material, it can be of electrical origin (resistance, arc, plasma), chemical (gas combustion) Mechanical (friction).
- a suitability of the material to be welded, called weld ability, high-temperature weld ability depends on the qualities of the material, but also on various limiting parameters, such as:

- changes in the physico-chemical structure of the material
- the appearance of cracks and cracks on cooling
- The appearance of geometric deformations due to the effects of expansion and shrinkage.
- the birth of internal constraints.

These therefore require a series of precautions to be taken.

Welding has several advantages over bolting:

- It ensures the continuity of the material, and thus guarantees a good transmission of the stresses
- It dispenses with secondary parts (gussets, fasteners,.......)
- It is less cumbersome and more aesthetically pleasing than bolting.

On the other hand, it has various disadvantages:

- The base metal must be weldable.
- Weld inspection is necessary and expensive.
- The inspection of the welds is random.
- Welding requires a skilled workforce and specific equipment

I-5 OPERATION OF THE ASSEMBLIES:

a)- Operation by obstacle:

This is the case for ordinary, non-prestressed bolts whose rods take up the forces and operate in shear.

b)- Adhesion operation:

In this case, the transmission of forces takes place by adhesion of the surfaces of the parts in contact. This concerns welding, and bolting by High Strength bolts.

c)- Mixed operation:

This is the case of riveting (and in extreme cases, HR bolting), i.e. the rivets ensure the transmission of forces by adhesion of the parts up to a certain limit, which, when exceeded, causes the rivets to intervene by obstacle, to the shear

II- CALCULATION OF THE JOINTS (Welded and bolted):

1. Introduction

The sizing of a tensioned element is very simple:

The cross-section of the element must be sufficient To withstand the stress applied.

$$\boxed{\text{section nécessaire} = \frac{\text{effort appliqué}}{\text{résistance de l'acier}}}$$

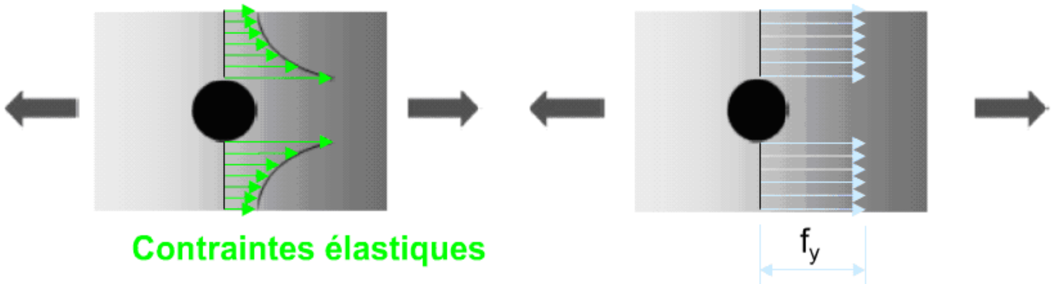
- Connections of tensioned elements are important

- In many cases, assemblies govern the calculation.

2. Assemblies:

- Usually, a uniform distribution of stresses is considered

- Assembly details disrupt this distribution for two reasons



The cross-section of the element is reduced by the holes that create stress concentrations: net cross-section

3. Strength of the sections

- For welded **elements, the** design strength is:

$$\boxed{N_{pl.Rd} = \frac{Af_y}{\gamma_{M0}}}$$

A: is the raw cross-section of the element.

- for **bolted** elements, the design resistance section is reduced because of the holes. It is equal to the lesser of:

$$\boxed{N_{pl.Rd} = \frac{Af_y}{\gamma_{M0}}} \text{ ou } \boxed{N_{u.Rd} = 0{,}9\frac{A_{net}f_u}{\gamma_{M2}}}$$

Discount 0.9 for:

-Eccentricities

- Stress concentration...etc.

4. Determination of the net cross-section:

- The net cross-section is equal to:

The rough section – the fixing holes and other openings.

- For each hole:

The deduction is the ***gross cross-section of the hole***

- If the holes are not staggered:

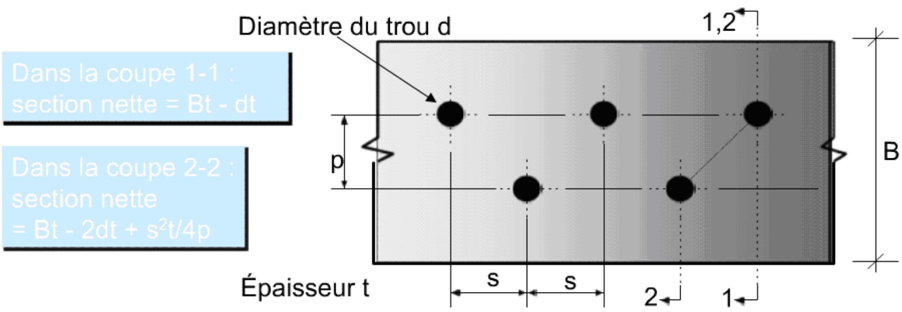
The cross-section to be reduced is the ***maximum sum*** of the cross-sections of the holes located on any perpendicular to the axis of the member.

- Special rules apply to wing-attached angles for T's and U's attached by their console parts.

5. Staggered fastening:

The total cross-section to be reduced is the greater between:

- The section of the holes located in a section perpendicular to the axis of the bar.
- The sum of the sections of the holes located on any broken line minus as many times $\frac{s^2t}{4p}$ that there are intervals between two successive holes encountered.



Generally: $$\boxed{A_{nette} = A - n.d_{tr}.t + \sum\left(\frac{s_i^2 t}{4p_i}\right)}$$

T: The thickness of the sheet metal
A: Gross Section Area (A=B×t)
D_{tr}: hole diameter
n: number of holes in the section under consideration
S_I: Longitudinal distance between holes
p_i: transverse distance between holes

6. *Ability for Service:*

- The tensioned elements transmit the forces very effectively:
  - They therefore lead to relatively small steel cross-sections
  - They are thus susceptible to high elongation under axial load.
- As a result, they can lead to:
  - A very large displacement of a structure if the tie rod is part of a bracing system.
  - A significant deflection under self-weight.
- Thin profiles can be easily damaged during transport.
- In practice, the slenderness of the tensioned elements is limited to:
  - 300 for the main elements.
  - 400 for secondary elements.