



Design of Structural Bolts

An Online Continuing Education Course for Engineers

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Introduction

It is well known to structural engineers that a major advantage of steel structures is that they are fabricated in the workshop then erected on site. Giving the schedule of the project an accelerated rate than concrete structures.

To understand the process, this course teaches what the components of the steel buildings are, and how they are assembled.

The steel portal frame shown in the figure (01), is the main system of a building, the erected steel frame is composed of four steel assemblies, two-column assembly and two rafter assembly, as shown in figure (02) demonstrates a column assembly.

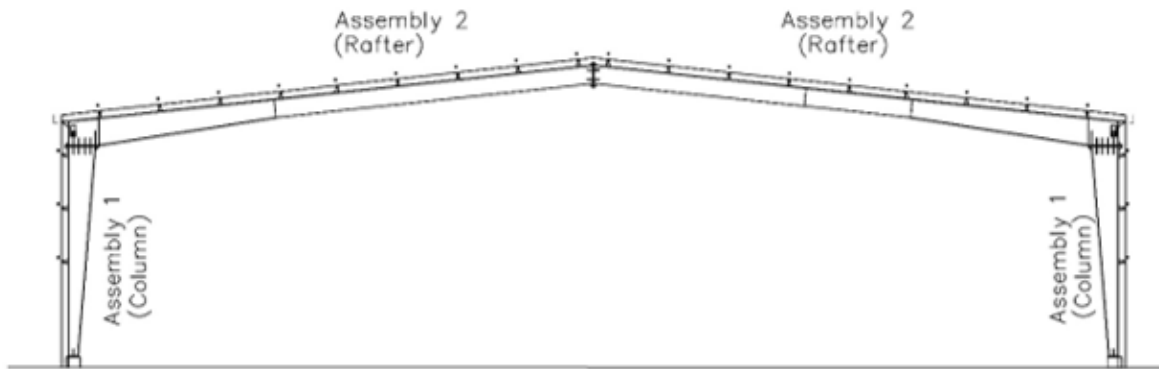


Figure (01).Typical Portal Frame

Each assembly is composed of hot rolled section/plate girder welded to some stiffeners at knee connections, gusset plates at bracing connections, and clips at purlins/girts connections, as shown in figure (02) demonstrating a bracing gusset plate welded to the column.



Figure (02).Frame Column Assembly

Stiffeners, gusset plates, end plates, and clips are called parts in the steel structures industry, but according to AISC360, they are called connecting elements, as they connect the structural members (assemblies) together through bolts or welds.

From the previous paragraphs, we can notice that connections are commonly composed of four elements:

- Welds.
- Bolts/Threaded Parts (anchors).
- Connecting Elements (stiffeners, gusset plates, end plates, and clips).
- Connected Elements (elements of supporting and supported members)

Commonly, connecting elements (parts) are welded to connected elements (assemblies) at the workshop, and members (assemblies) are bolted together at the site.

Sometimes, the connection is totally bolted, and other times, it is totally welded.

Figure (03) show a typical moment connection showing welds, bolts & connecting element.

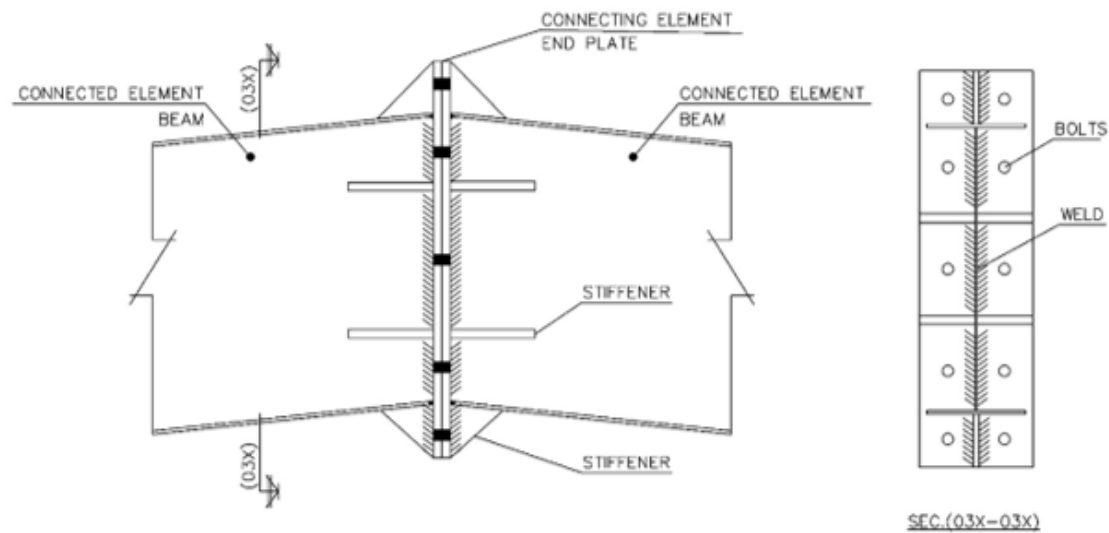


Figure (03). Typical Moment Connection

Proper understating of design of each component, is a great entry to the design of any connection in steel structures, such as shear connections, moment connections, bracing connections, base plate connections, HSS connections, which will be studied, separately, through many next courses.

In the following sections, we will study the bolts types, designation, strengths, tightening types, minimum and maximum bolt spacing, minimum and maximum edge distance, and analysis of bolted connections.

Types of Bolts

According to specifications of Research Council on Structural Connections (RCSC), bolts are classified to the following types:

a. High Strength Bolts:

High Strength Bolts are classified into 2 groups:

- Group A: ASTM A325, A325M, F1852, A354 Grade BC, & A449.
- Group B: ASTM A490, A490M, F2280, A354 Grade BD.

In practice, the most commonly used grades are ASTM A325 & ASTM A490.

b. Unfinished Bolts:

The most commonly used grades are ASTM A307.

Bolts Designation

When identifying bolts on design drawings, it shall be identified with the following designation:

a. Designation of threads in case of bearing type (snug tightened or pretensioned) :

- A490-X: as (X) means that the threads are excluded from calculations of bolt strength.
- A490-N: as (N) means that the threads are included in calculations of bolt strength.

b. Designation of connection type:

- A490-SC: as (SC) means that the connection is slip critical type.
- A490-ST: as (ST) means that the connection is snug tightened type.
- A490-PT: as (PT) means that the connection is pretensioned type.

Types of Bolted Joints

Bolted joints are classified into three types, based on the method of installation. Each type of these methods has its own design concept and gives different values of strength.

a. Bearing Type-Snug Tightened Joints:

Snug tightened condition is the tightness required to bring the connected piles into firm contact, with a few impacts of an impact wrench or the full effort of an ironworker using an ordinary spud wrench.

All types of bolts are permitted to be snugly tightened, including unfinished bolts and high strength bolts.

No faying surface preparation is required, and also no minimum or maximum pretension force is required.

The load transfer depends on the shear acting on bolts and bearing acting on plates, as shown in figure (04)

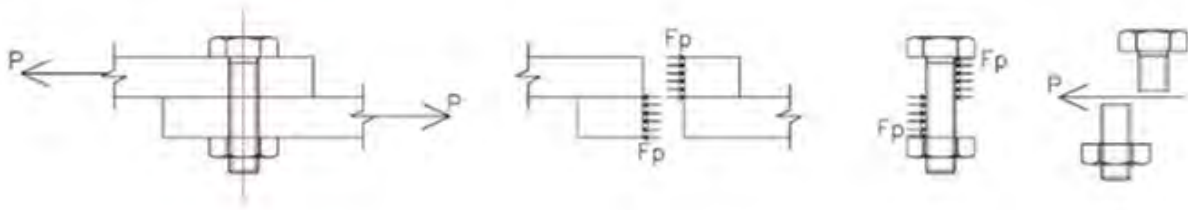


Figure (04). Load Transfer in Bearing Type Joints

It should be used in:

- Tension or combined shear and tension for Group A only, where loosening or fatigue due to vibration or load fluctuations are not a design concern.
- When pretensioned joints or slip, critical joints are not required.
- In shear connections, when no moment are required to transfer between members.
- When no dynamic load is acting on the connection.
- It is acceptable to use in intermediate connectors of built-up members according to AISC360-10-Section-E6.1.

b. Bearing Type-Pretensioned Joints:

Pretensioned Joint is the joint in which the bolts are pretensioned through applying a specific torque to the bolts, when necessary to prevent slip.

Only high strength bolts are permitted to be pretensioned.

No faying surface preparation is required, but pretension force is required for reasons other than slip resistance.

The load transfer depends on the shear acting on bolts and bearing acting on plates, as shown in figure (04)

It should be used, according to Specifications for Structural Joints Using High Strength Bolts (RCSC), in:

- Joints in which fastener pretension is required in the specification or code that invokes this specification.
- Joints that are subjected to significant load reversal.

- Joints that are subject to fatigue load with no reversal of the loading direction.
- Joints with ASTM A325 or F1852 bolts that are subject to tensile fatigue.
- Joints with ASTM A490 or F2280 bolts that are subject to tension or combined shear and tension, with or without fatigue.

It should be used, according to AISC360-10, in:

- Columns splice in all multi-story structures over 125 ft (38m) in height.
- Connections of members that provide bracing to columns in structures over 125 ft (38m) in height.
- Various connections in buildings with cranes over 5-ton capacity.
- Connections of supports of running machinery and other sources of impact or load reversal.

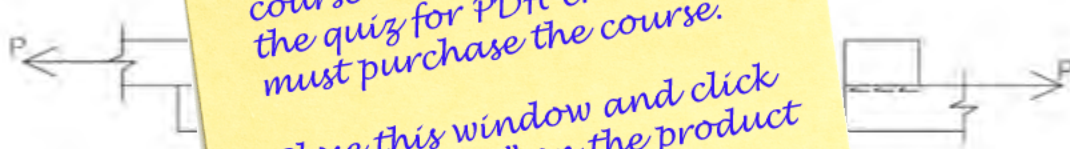
c. Slip Critical Joints:

Slip Critical Joint is the joint in which the bolts are pretensioned through applying a specific torque to the bolts, and also the surface preparation is to make the faying surface rough enough.

Only high strength bolts are permitted to be pretensioned.

Preparation of the faying surfaces

The load is applied to the surfaces between the connected members.



It should be used according to the specifications for Structural Joints Using High Strength Bolts (RCSC), in:

