

CE 415

DESIGN OF STEEL STRUCTURES

LECTURE 7

BOLTS

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COURSE TEACHER: SAURAV BARUA

CONTACT NO: +8801715334075

EMAIL: saurav.ce@diu.edu.bd

OUTLINE

- Bolts, failure types of bolt connection
- Math problem on tension member capacity

Structural Fasteners

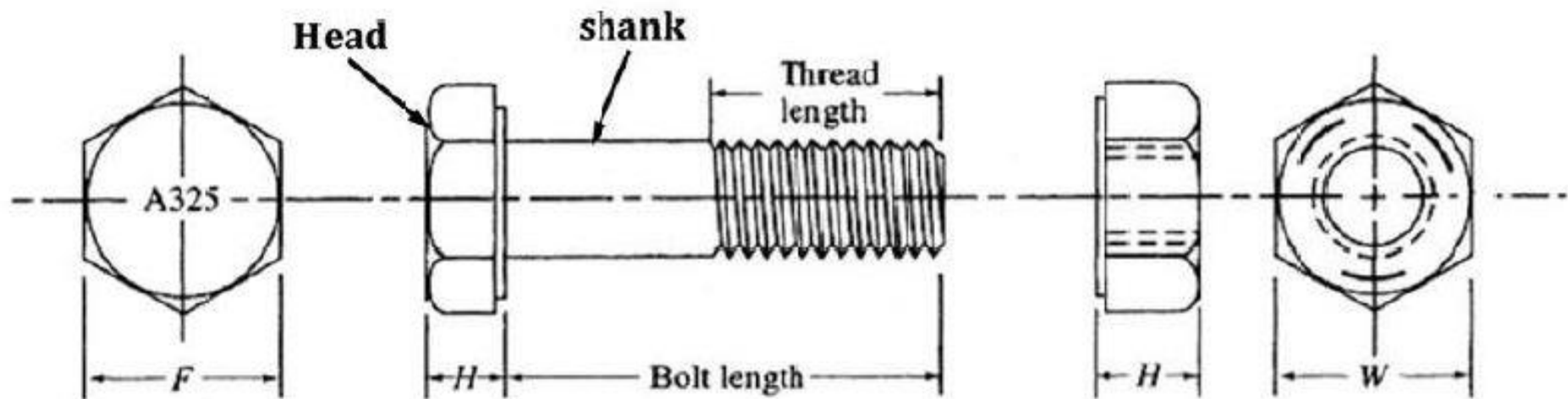
In the construction of a steel structure, member are fabricated at factory and assembled at site.

□ Bolts

Bolts are commonly used to assemble different components of a steel structure.



- ❑ A325 bolt is most commonly used
- ❑ A490 bolt is occasionally used
- ❑ Both of these are heavy hexagon head bolts with heavy hexagon head nuts
- ❑ The ASTM designation is on the top of the head as shown



Nut may be chamfered
on both faces

Load Transfer through a bolted joint

The transfer of service loads through a joint is due to

- i) friction developed in the pieces being joined
- ii) the bearing stress developed between the bolt shank and the bolt holes.

Types of bolted joints

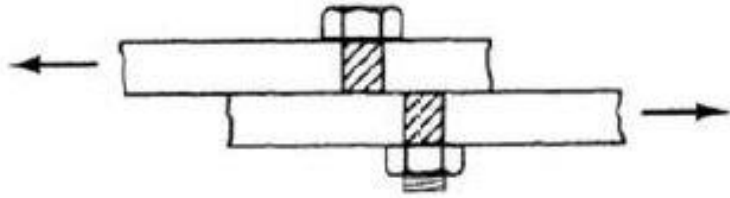
Friction type bolted joint:

Joint containing high-strength bolts are designed either as slip-critical where high slip resistance is desired

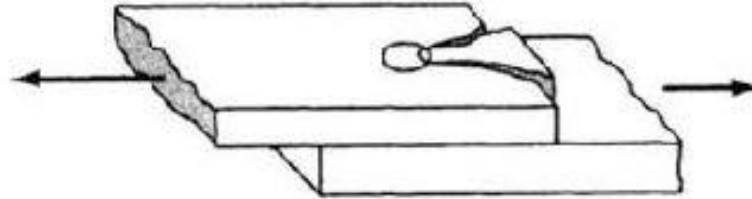
Bearing Type bolted joint:

As bearing type where high slip resistance at service load is unnecessary

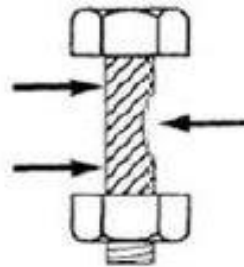
Possible Limit States or Failure Modes for bolted connections



(a) Shear failure of bolt



(b) Shear failure of plate

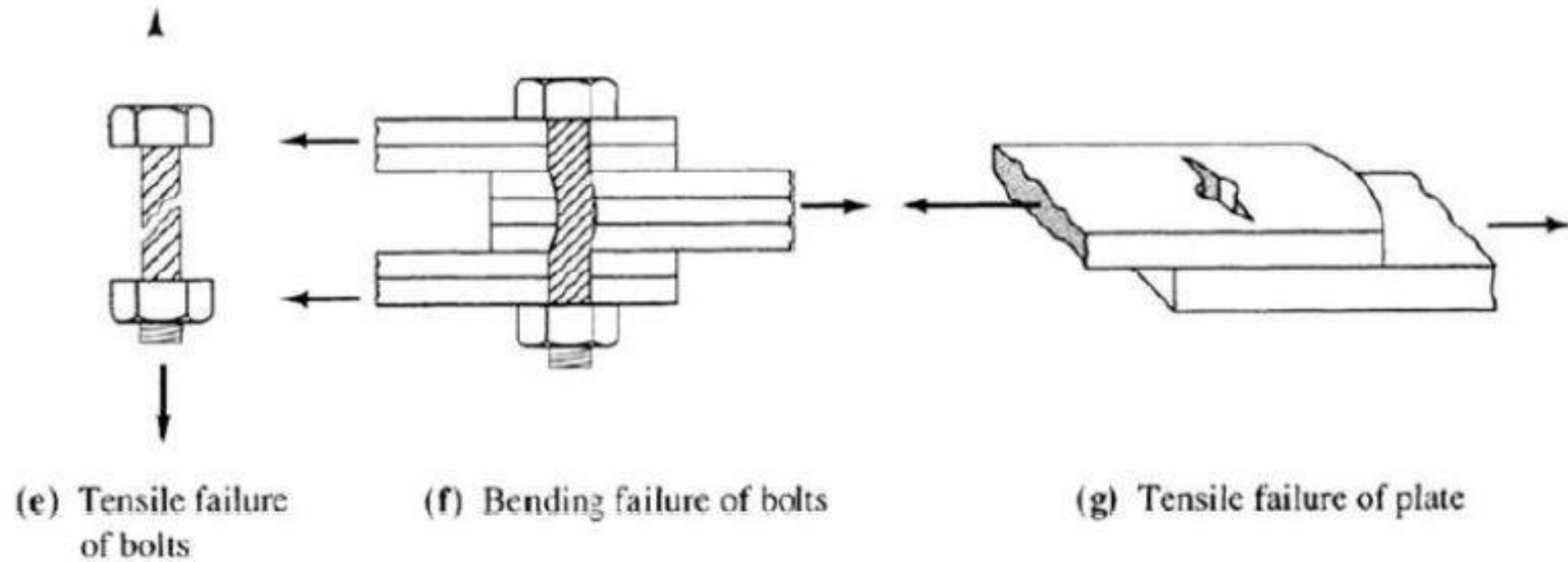


(c) Bearing failure of bolt



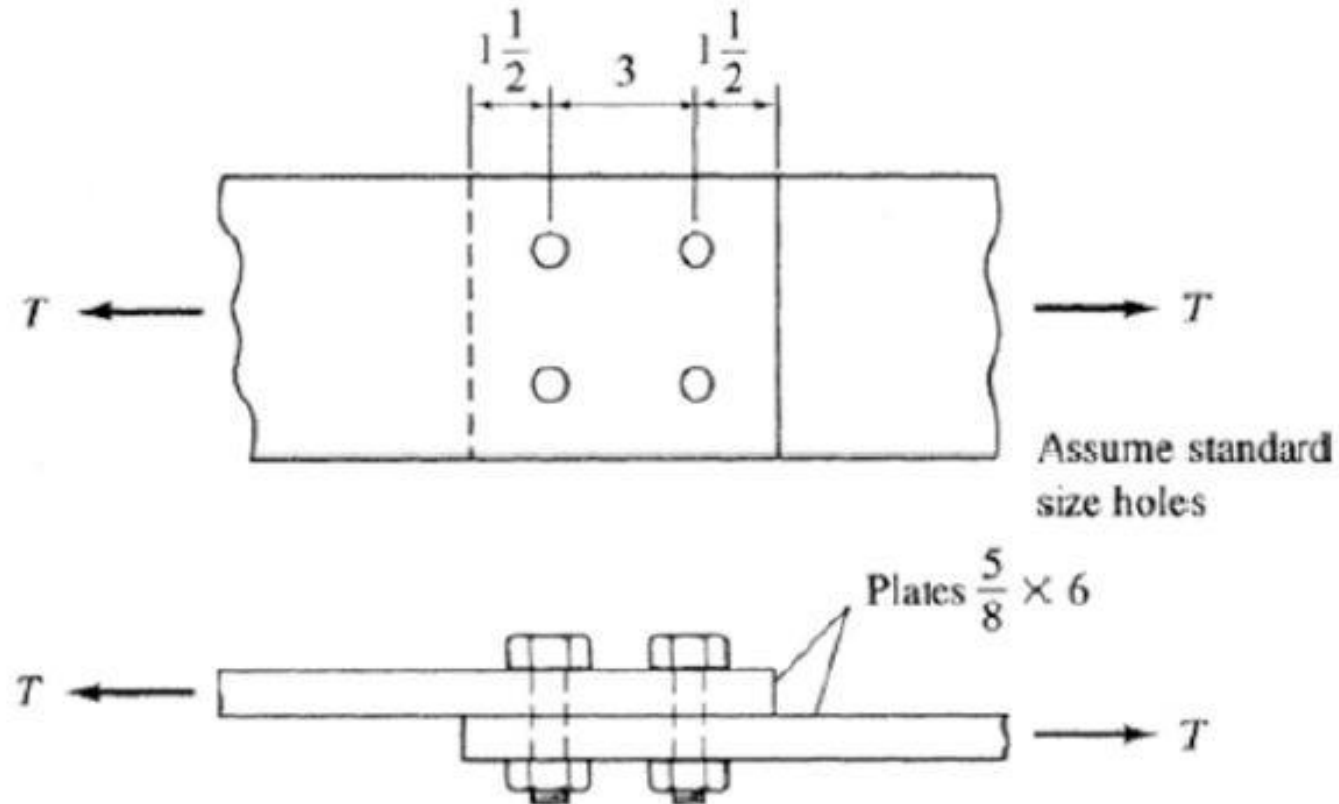
(d) Bearing failure of plate

Possible Limit States or Failure Modes for bolted connections



Example:

Investigate the capacity of the tension member connection of Fig. based on bolt limit states only. The connection is a bearing-type connection, with threads excluded from the shear planes, using $\frac{7}{8}$ -in. diam. A325 bolts in standard holes. The plates are A572 Grade 50 steel. Use the AISC Specification ASD Method.



Bolt shear limit state:

For A325 bolts,

$F_y = 90 \text{ ksi}$, $F_u = 120 \text{ ksi}$.

Threads are excluded from shear plane.

Therefore,

$$F_{nv} = 0.5F_u = 0.5 (120) = 60 \text{ ksi.}$$

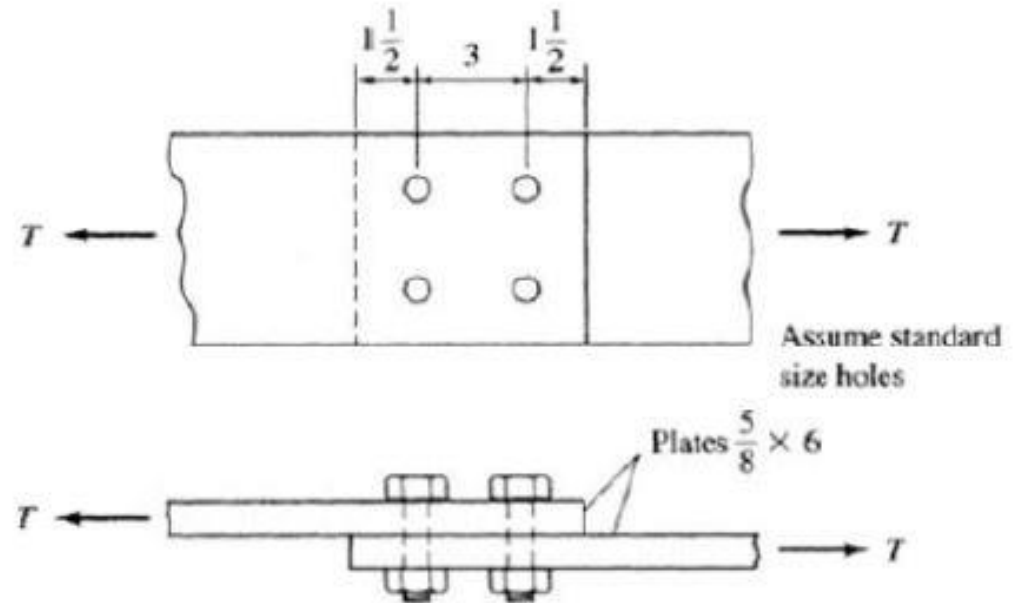
$\frac{7}{8}$ -in. diam. Bolts. $A_b = 0.601 \text{ in}^2$.

The allowable strength R_n/Ω in single

shear from Eq. 4.6.2 is
$$\frac{R_n}{\Omega} = \frac{F_{nv}m A_b}{\Omega} = \frac{60(1)0.6013}{2.0} = 18.0 \text{ kips/bolt}$$

\therefore Total allowable load,

$$T = 4(18) = 72 \text{ kip (based on bolt shear capacity)}$$



Bolt bearing limit state:

$$\begin{aligned} & 2.4dtF_u/\Omega \\ & = 2.4(7/8)(5/8)65/2.0 \\ & = 42.7 \text{ kip per bolt} \end{aligned}$$

For holes near edge

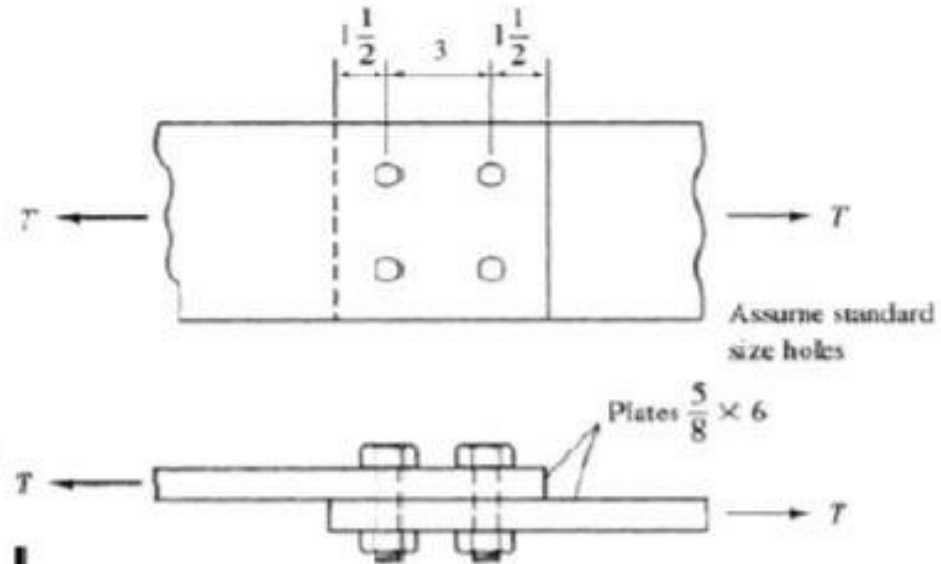
$$L_c = 1.5 - 0.5(7/8 + 1/16) = 1.03 \text{ in.}$$

$$\begin{aligned} \therefore R_n/\Omega & = 1.2L_c tF_u/\Omega \\ & = 1.2(1.03)(5/8)65/2.0 \\ & = 25.1 \text{ kip/bolts} < 2.4dtF_u/\Omega \end{aligned}$$

For interior holes

$$L_c = 3 - (7/8 + 1/16) = 2.063 \text{ in.}$$

$$\begin{aligned} \therefore R_n/\Omega & = 1.2L_c tF_u/\Omega \\ & = 1.2(2.063)(5/8)65/2.0 \\ & = 50.28 \text{ kip per bolt} > 2.4dtF_u/\Omega \\ \therefore R_n/\Omega & = 2.4dtF_u/\Omega \\ & = 42.7 \text{ kip per bolt} \end{aligned}$$



$$\begin{aligned} \therefore \text{Total capacity based on bearing} \\ & = 2(25.1) + 2(42.7) \\ & = 135.6 \text{ kip} \end{aligned}$$

Thus, the allowable capacity is 72 kips based on bolt shear.