# CE 415
# DESIGN OF STEEL STRUCTURES

## LECTURE 7
## BOLTS

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# OUTLINE

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

## Structural Fasteners

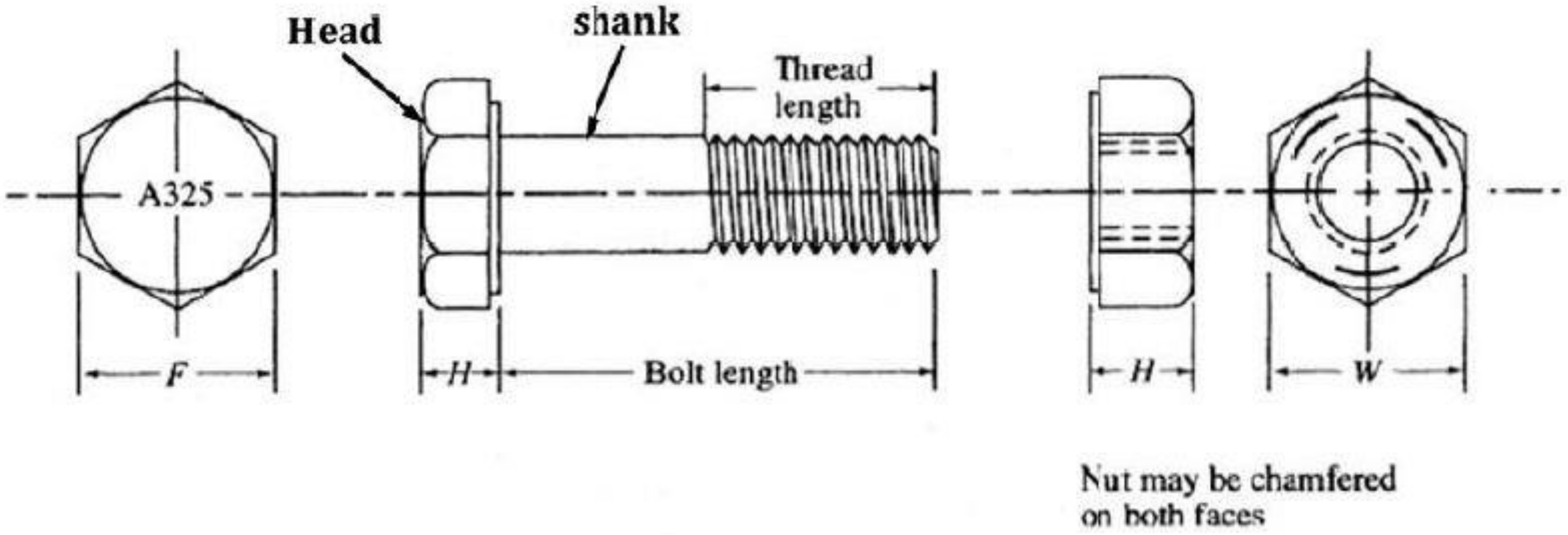
In the construction of a steel structure, member are fabricated at factory and assembled at site.

- **Bolts**

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


Bolt, nut & washer

- 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



## 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

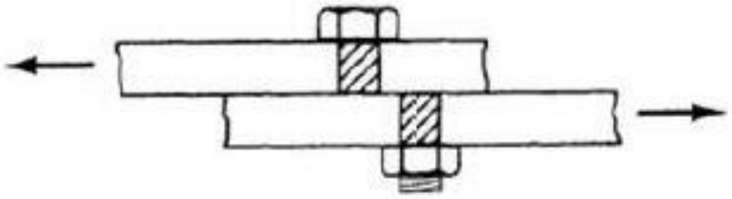
- **Friction type bolted joint**:

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

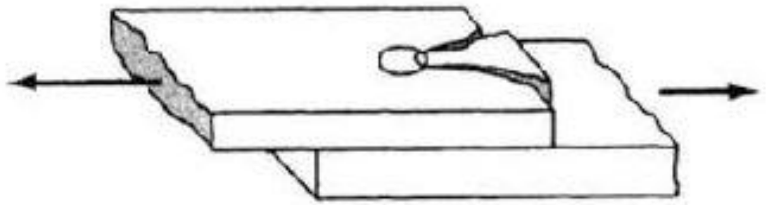
- **Bearing Type bolted joint**:

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

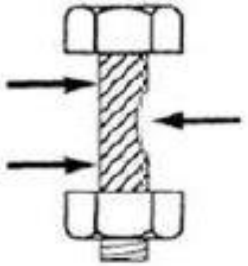
# Possible Limit States or Failure Modes for bolted connections



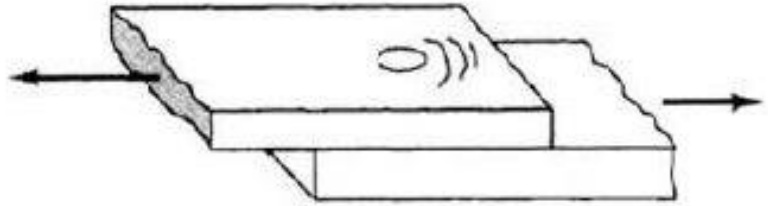
**(a)** Shear failure of bolt



**(b)** Shear failure of plate

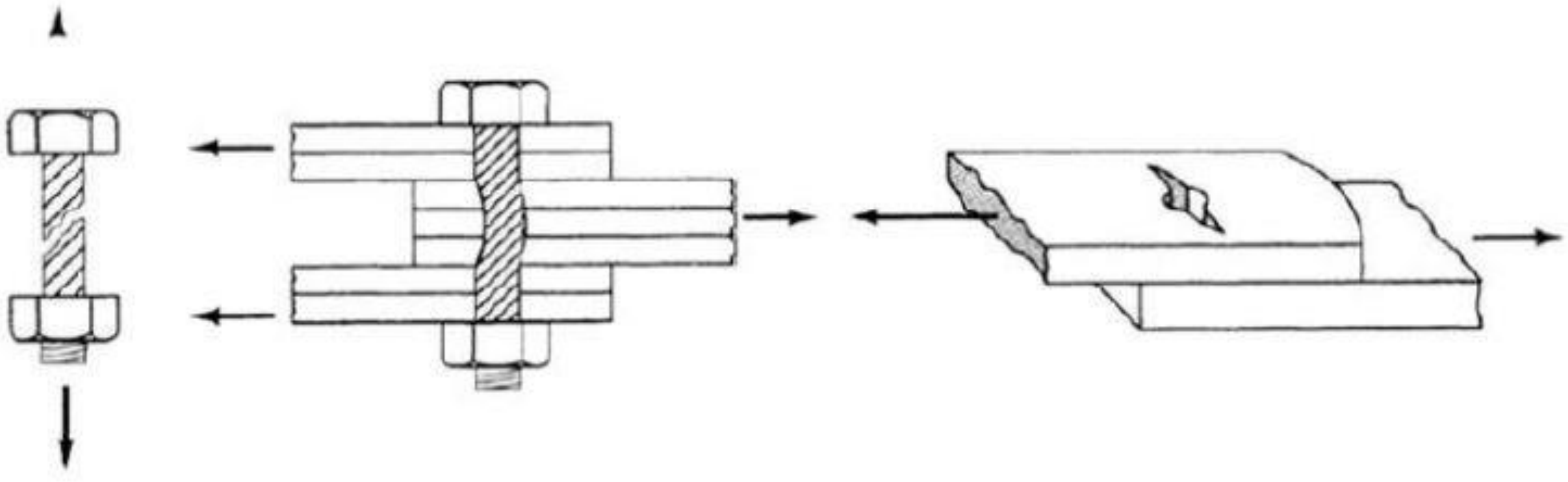


**(c)** Bearing failure of bolt



**(d)** Bearing failure of plate

# Possible Limit States or Failure Modes for bolted connections



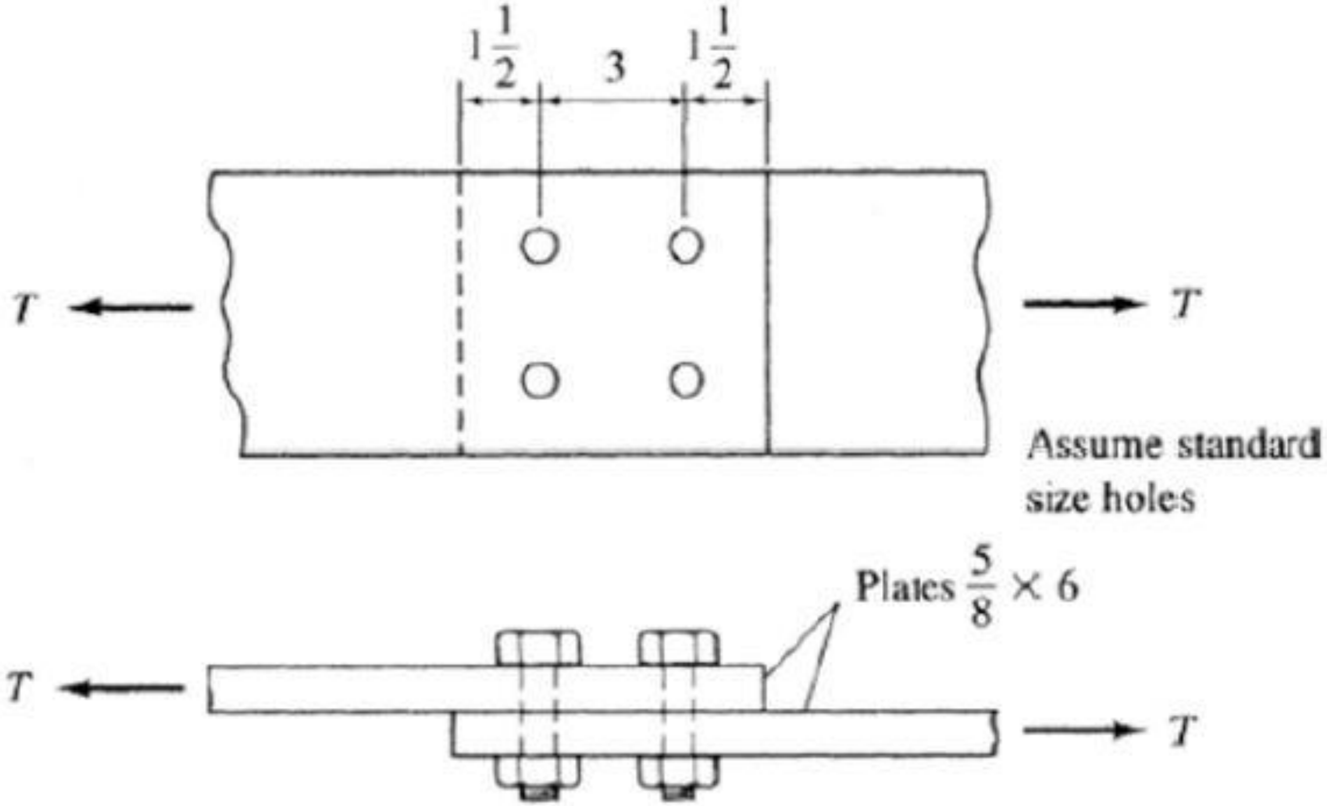
(e) Tensile failure of bolts

(f) Bending failure of bolts

(g) Tensile failure of plate

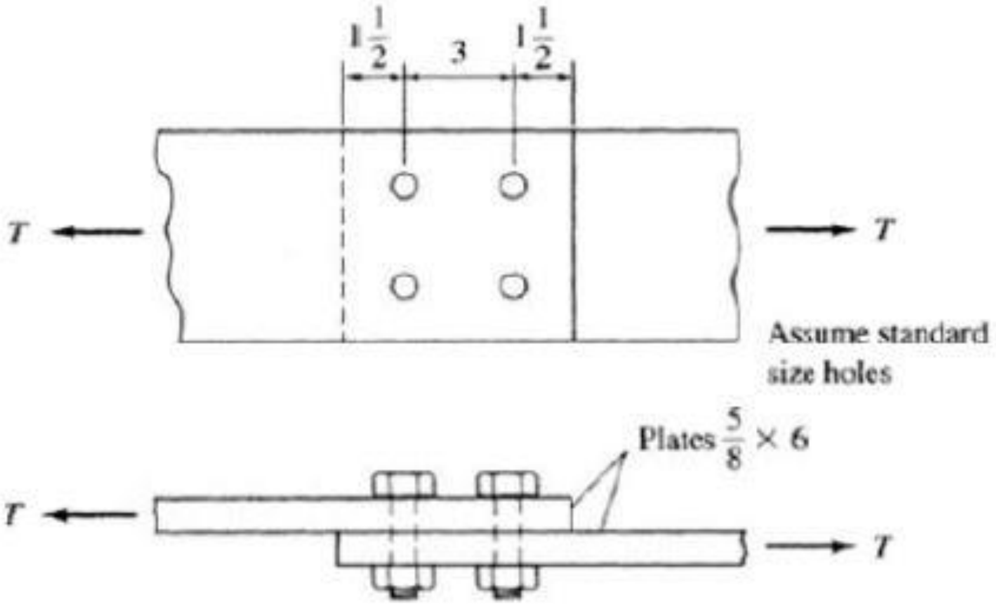
# Example:

**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 $^7/_8$-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,
$F_y$=90ksi, $F_u$=120ksi.
Threads are excluded from shear plane.
Therefore,
$F_{nv} = 0.5F_u = 0.5\ (120) = 60$ ksi.




$^7/_8$-in. diam. Bolts. $A_b = 0.601$ in$^2$.
The allowable strength $R_n/\Omega$ in single shear from Eq. 4.6.2 is $\dfrac{R_n}{\Omega} = \dfrac{F_{nv} m A_b}{\Omega} = \dfrac{60(1)0.6013}{2.0} = 18.0$ kips/bolt

$\therefore$ Total allowable load,
$T = 4(18) = 72$ kip (based on bolt shear capacity)

**Bolt bearing limit state:**

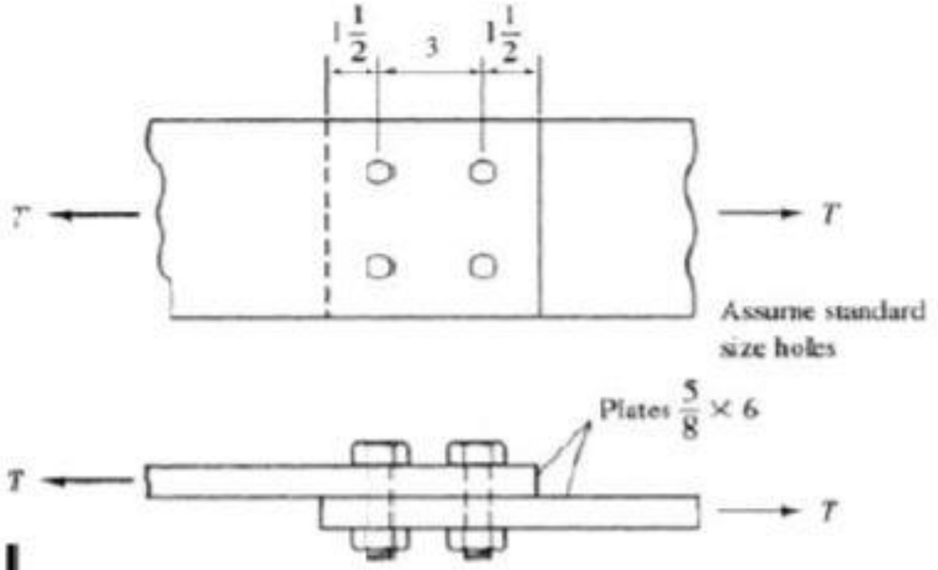
$2.4dtF_u/\Omega$
$= 2.4\,(7/8)(5/8)65/2.0$
$= 42.7$ kip per bolt

For holes near edge

$L_c = 1.5 - 0.5(7/8+1/16) = 1.03$ in.
$\therefore R_n/\Omega = 1.2L_c\,tF_u/\Omega$
$=1.2(1.03)(5/8)65/2.0$
$=25.1$ kip/bolts $< 2.4dtF_u/\Omega$

For interior holes

$L_c = 3 - (7/8 + 1/16) = 2.063$ in.
$\therefore R_n/\Omega = 1.2L_c\,tF_u/\Omega$
$= 1.2(2.063)(5/8)65/2.0$
$= 50.28$ kip per bolt $> 2.4dtF_u/\Omega$
$\therefore R_n/\Omega = 2.4dtF_u/\Omega$
$= 42.7$ kip per bolt




$\therefore$ Total capacity based on bearing
$= 2(25.1) + 2(42.7)$
$= 135.6$ kip

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