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

Head   shank

Thread length

A325

F   H   Bolt length   H   W
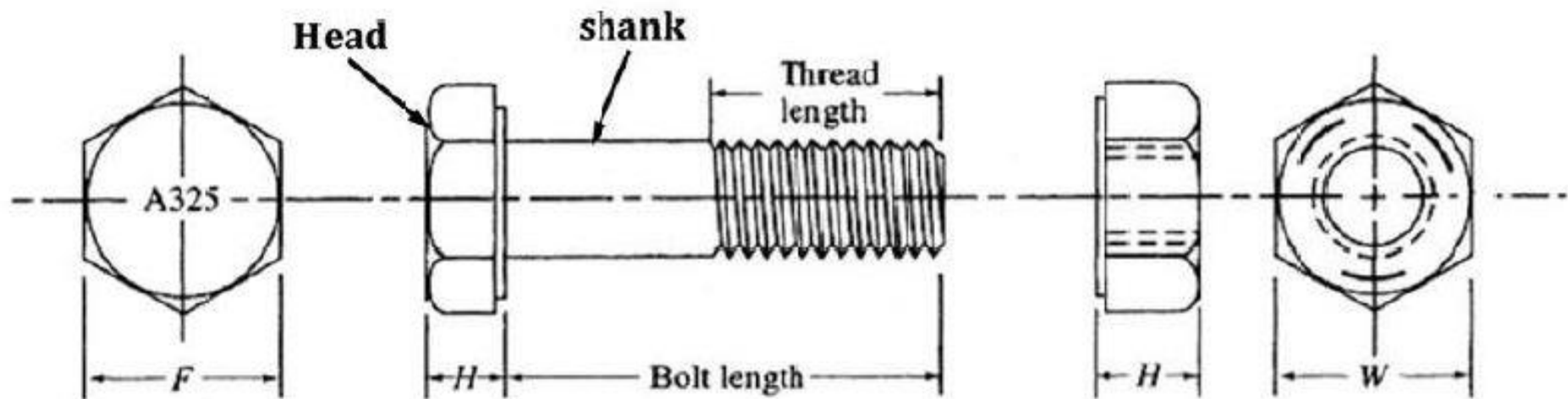
Nut may be chamfered on both faces

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.

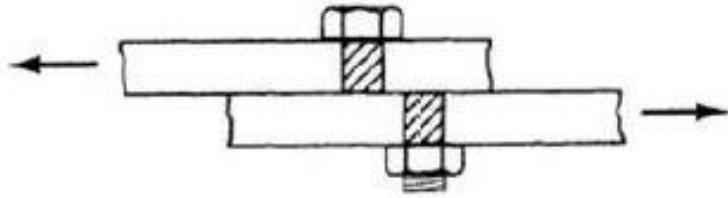## Types of bolted joints

❑ Friction type bolted joint:
Joint containing high-strength bolts are designed either as slip-critical where high slip resistance is desired
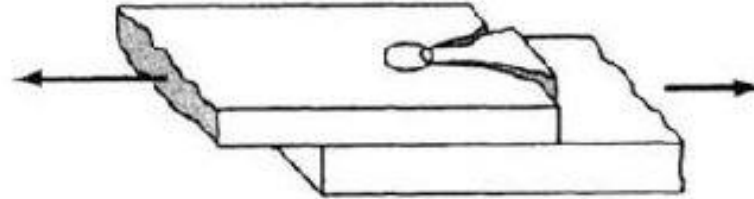
❑ Bearing Type bolted joint:
As bearing type where high slip resistance at service load is unnecessary
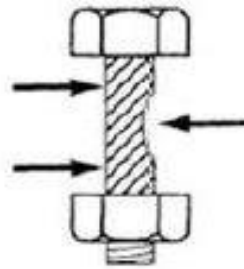
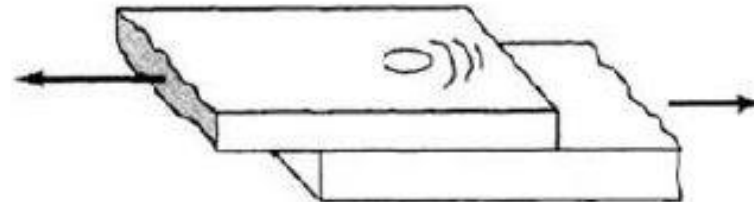# Possible Limit States or Failure Modes for bolted connections

(a) Shear failure of bolt
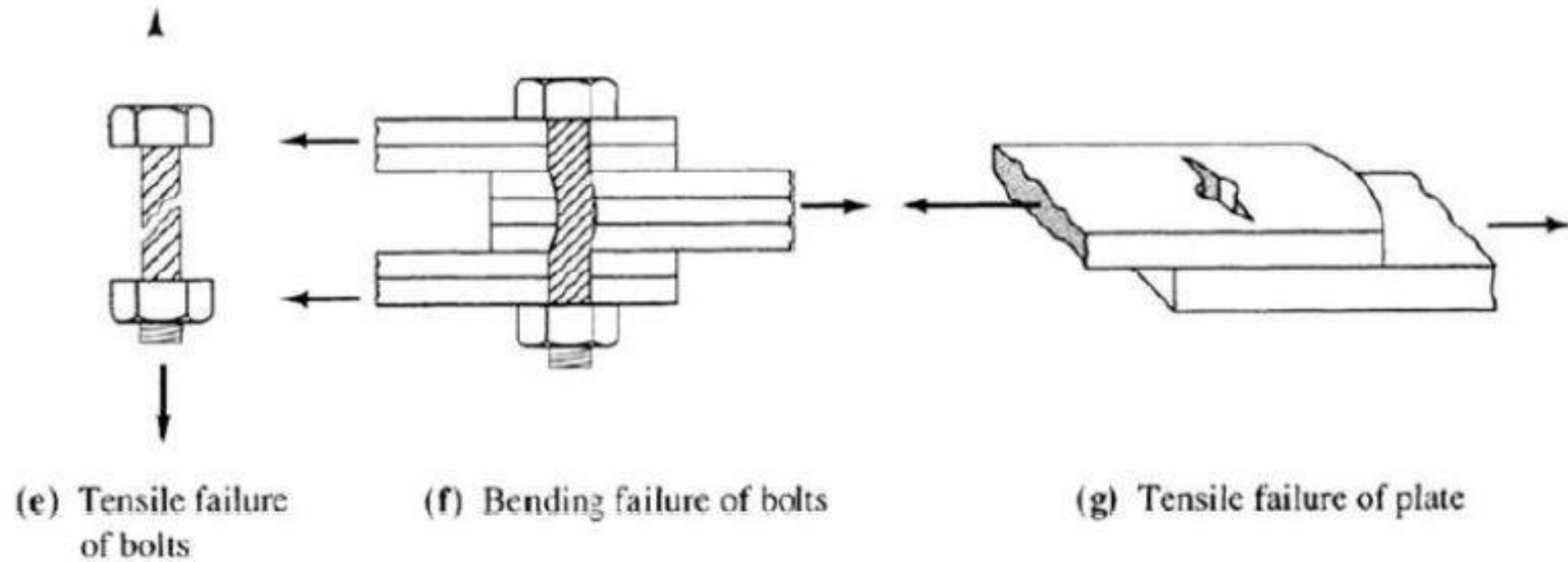
(b) Shear failure of plate

(c) Bearing failure of bolt

(d) Bearing failure of plate

Possible Limit States or Failure Modes for bolted connections

(e) Tensile failure of bolts

(f) Bending failure of bolts

(g) Tensile failure of plate

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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.

Assume standard size holes

Plates $\frac{5}{8} \times 6$
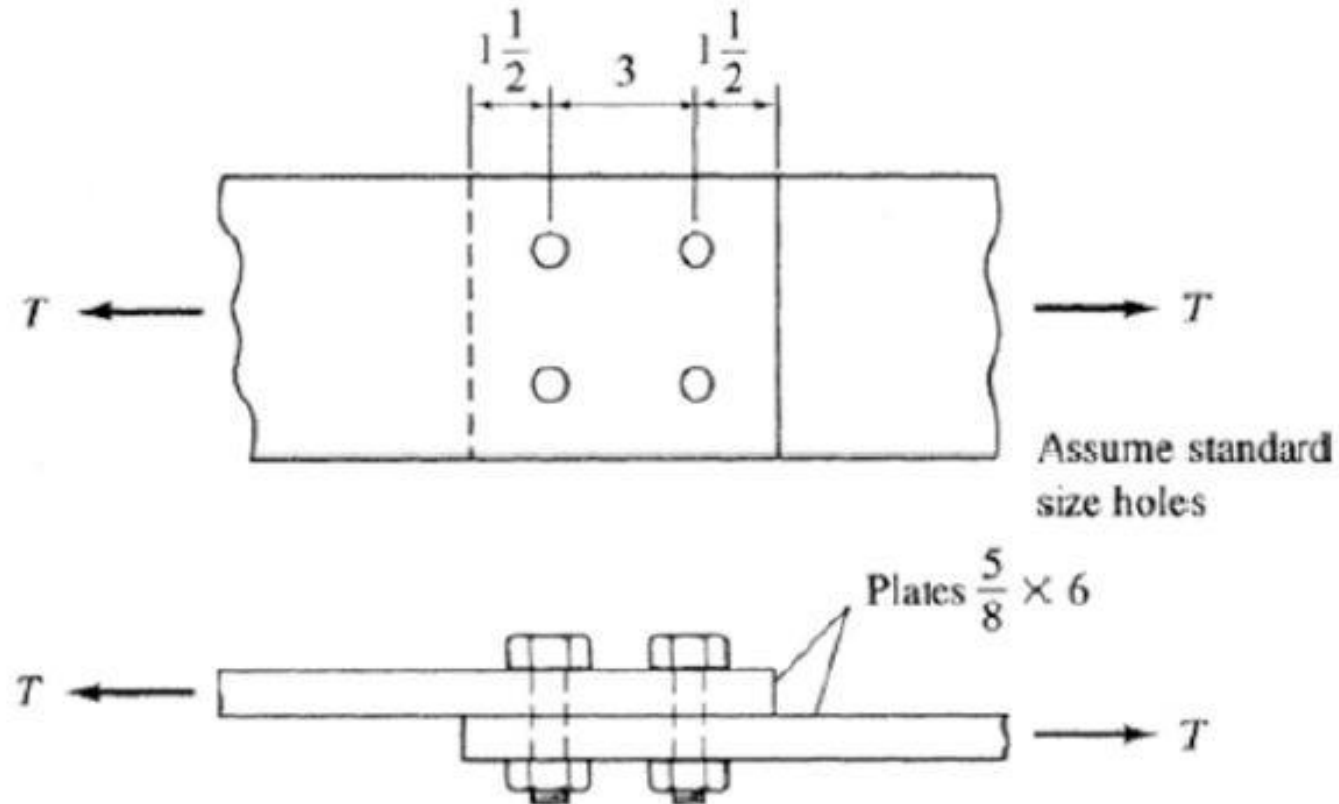
Bolt shear limit state:

For A325 bolts,
$F_y = 90$ksi, $F_u = 120$ksi.
Threads are excluded from
shear plane.
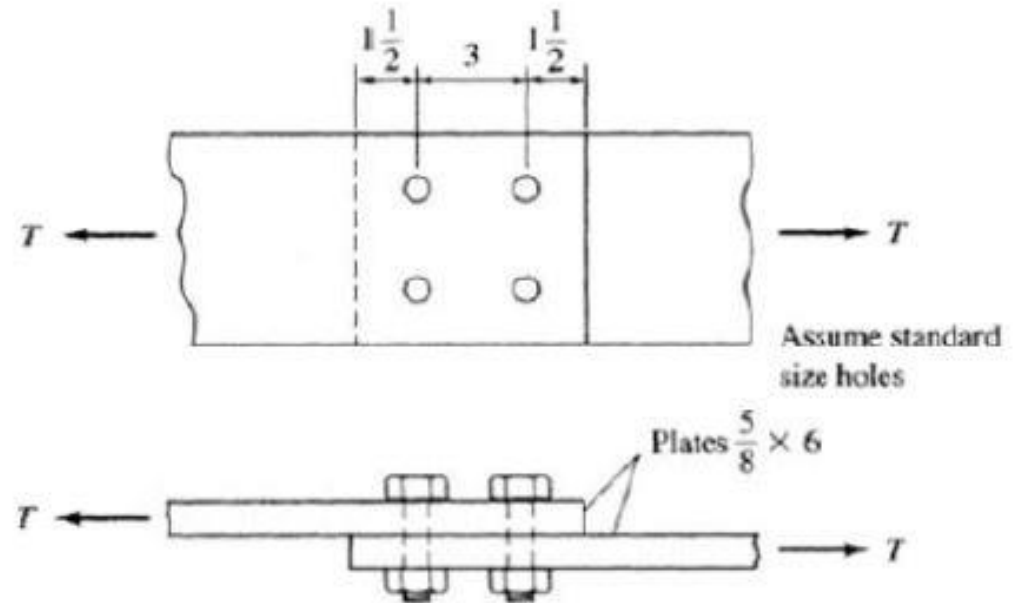Therefore,

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

Assume standard size holes

Plates $\frac{5}{8} \times 6$

$^7/_8$-in. diam. Bolts. $A_b = 0.601$ in^2.
The allowable strength R_n/Ω 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

∴ 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

Assume standard size holes

Plates $\frac{5}{8} \times 6$
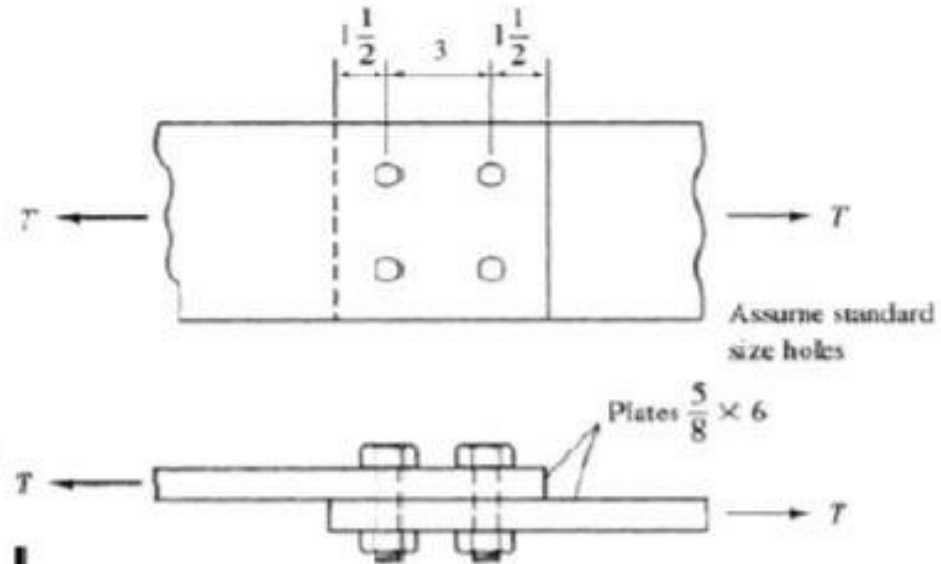
$\therefore$ Total capacity based on bearing
$= 2(25.1) + 2(42.7)$
$= 135.6$ kip

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