CE 415
DESIGN OF STEEL STRUCTURES

LECTURE 8
BOLTS (continue)

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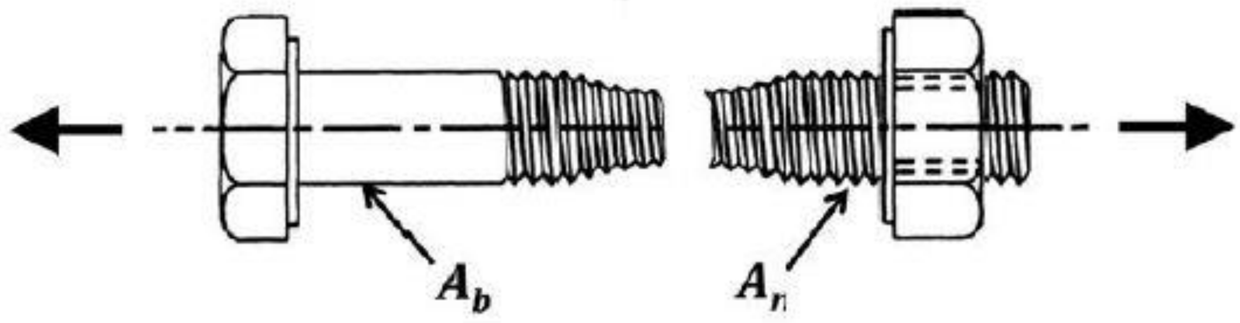
OUTLINE

- Tensile strength of bolt
- Bearing type
- Problem on bearing and shearing strength of bolts

Tensile Strength of a bolt shank



The nominal tensile strength Rn of a bolt

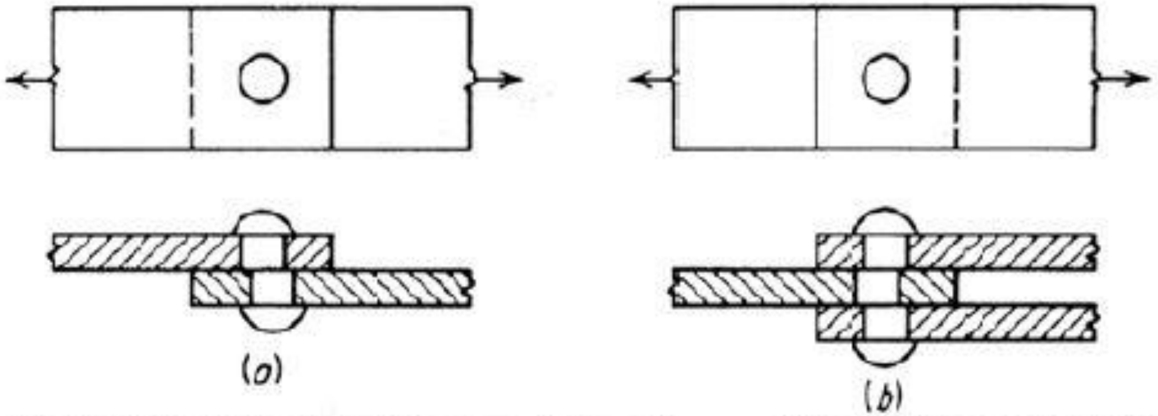
$$Rn = Fu^b An$$

Where, Rn = nominal strength of a bolt
Fu^b = tensile strength of bolt material
An = net area of bolt at the threaded portion
Ab **=** gross area of bolt shank
Generally $An = 0.75Ab$ to $0.79Ab$

Bearing type bolts

Bearing type bolts have two limit states
i) Shear Strength
ii) Bearing Strength

- Shear Strength



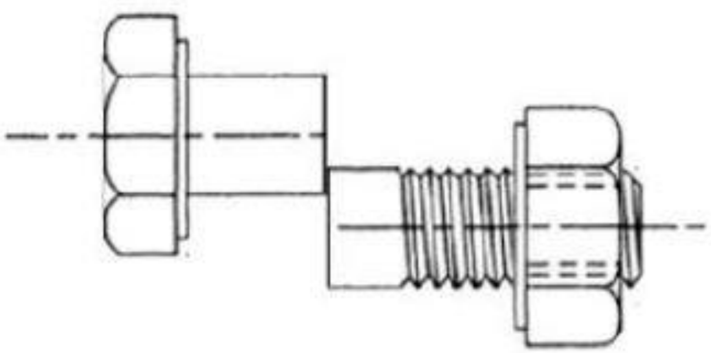
Single shear plane, m = 1 **Double shear plane, m = 2**

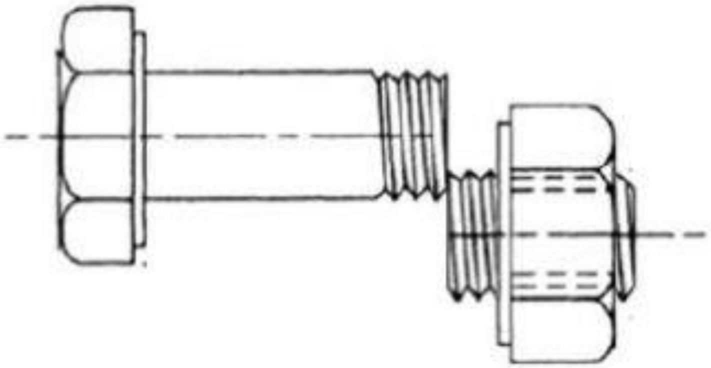
Nominal shear strength per bolt, $R_n = mA_bF_{nv}$

Where, A_b = gross area of bolt at shank
F_{nv} = nominal shear stress of bolt

Bearing type bolts

- Shear Strength continued..





Case I : No threads in shear plane

F_{nv} = nominal shear stress of bolt = $0.5F_u{}^b$

$F_u{}^b$ = tensile strength of **bolt material**

Case II : When threads are included in shear plane

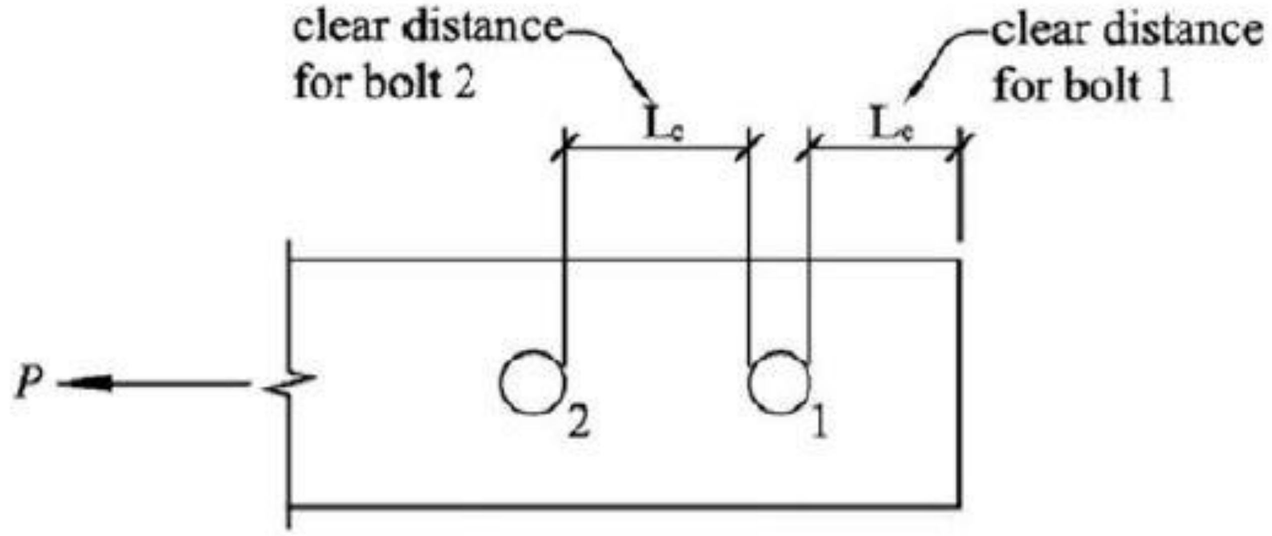
F_{nv} = nominal shear stress of bolt = $0.4F_u{}^b$

$F_u{}^b$ = tensile strength of **bolt material**

If nothing mentioned about shear plane, assume threads are included in shear plane (Case II)

Bearing type bolts

- Bearing strength



Nominal Bearing Strength per bolt, $R_n = 1.2 L_c t F_u \leq 2.4 d t F_u$

Where,
Lc = clear distance
t = thickness of plate
d = dia of bolt
Fu = Ultimate tensile strength of **plate material**

Bearing type bolts

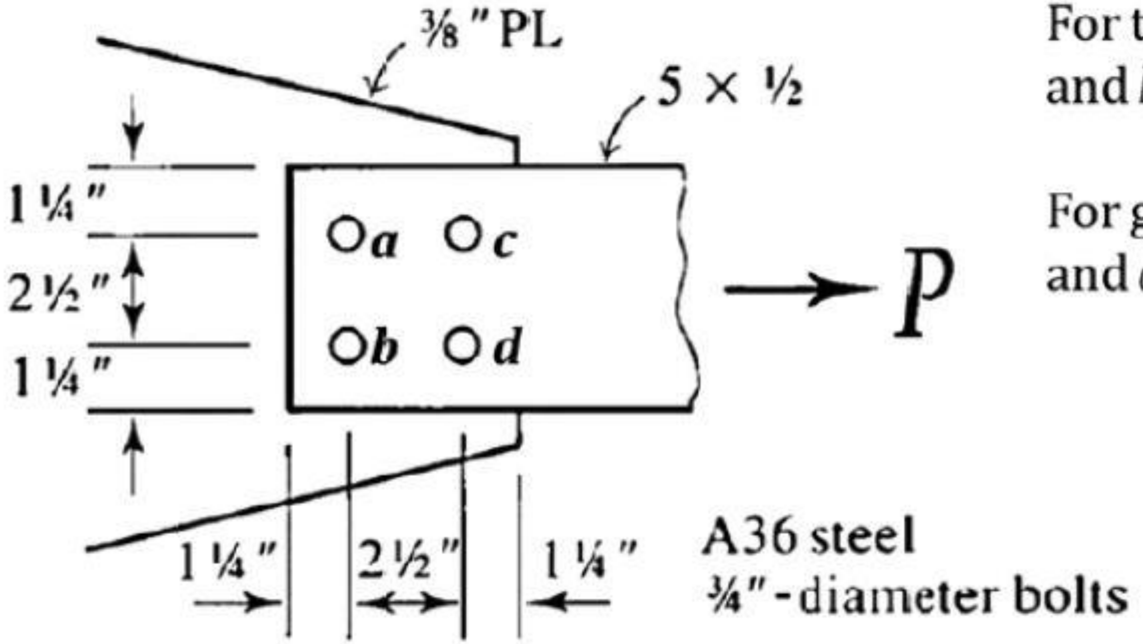
After investigating the strength in both shear and bearing, the smaller value controls. The next step is to find the design strength as per LRFD or ASD

Design strength (LRFD) = ΦR_n
Where, Φ = 0.75

Allowable strength (ASD) = $\frac{R_n}{\Omega}$
Where, Ω = 2.00

Example:

Determine the design load *P* for the bolted connection shown in Fig. below. Consider bearing and shear strength of bolts only. All bolts are A490 (F_{by} = 130 ksi, F_{bu} = 150 ksi) and plates are A36 steel (F_y = 36 ksi, F_u=58 ksi).



For tension plate, bolts *a* and *b* are exterior bolts.

For gusset plate, bolts *c* and *d* are exterior bolts.

SOLUTION:

Assume threads are included in shear plane. Nominal shear capacity of each bolt,

$R_{ns} = mF_{nv}A_b = 1.0(0.4\times150)(\pi/4)(3/4)^2 = 26.5$ **kip**

Bearing Strength

GUSSET PLATE: $2.4dtF_u = 2.4(3/4)(3/8)58 = 39.15$ kip

Exterior bolt: $L_c = 1.25 - (3/4 + 1/16)/2 = 0.844$ in.

$\therefore R_{ne} = 1.2L_ctF_u = 1.2(0.844)(3/8)58 = 22$ kip/bolt

Interior bolt: $L_c = 2.5 - (3/4 + 1/16) = 1.69$ in

$\therefore R_{ni} = 1.2L_ctF_u = 1.2(1.69)(3/8)58 = 44 \text{ k} > 2.4dtF_u \quad \therefore R_{ni} = 39.15$ kip/bolt

TENSION PLATE: $2.4dtF_u = 2.4(3/4)(1/2)58 = 52.2$ kip

Exterior bolt: $L_c = 1.25 - (3/4 + 1/16)/2 = 0.844$ in.

$\therefore R_{ne} = 1.2L_ctF_u = 1.2(0.844)(1/2)58 = 29.4$ kip/bolt

Interior bolt: $L_c = 2.5 - (3/4 + 1/16) = 1.69$ in

$\therefore R_{ni} = 1.2L_ctF_u = 1.2(1.69)(1/2)58 = 58.8 \text{ k} > 2.4dtF_u \quad \therefore R_{ni} = 52.2$ kip/bolt

Gusset plate strengths are lower than tension plate strengths. Comparing bearing and shear strengths, it is observed that for gusset plate:

exterior bolts → *bearing governs* **and for**

interior bolts → *shear governs*

Thus $P_n = 2(22) + 2(26.5) = 97$ kip

ASD: $P_n/\Omega = 97/2.0 = 48.5$ kip

LRFD: $\varphi P_n = 0.75(97) = 72.75$ kip