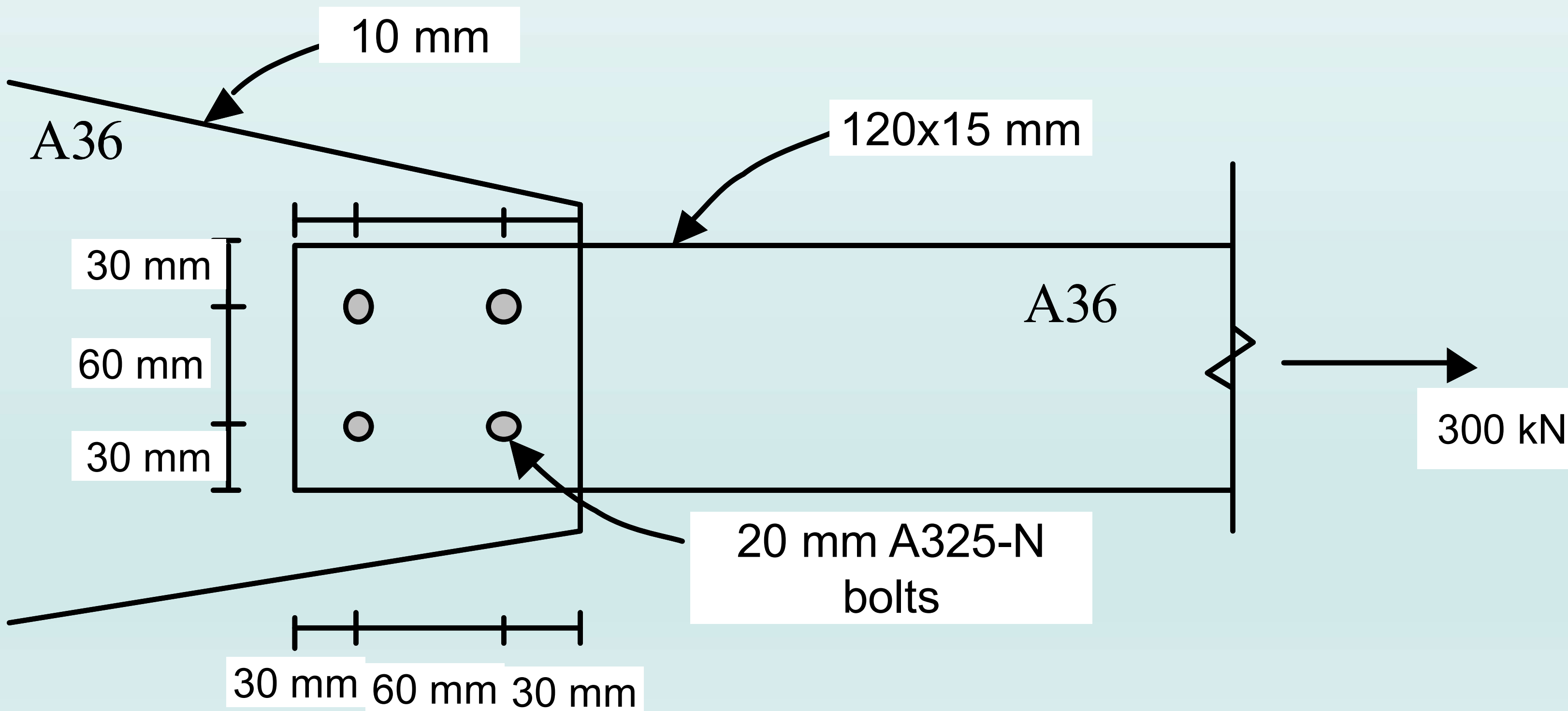
Ex. 6.1 - Design Strength

- Calculate and check the design strength of the simple connection shown below. Is the connection adequate for carrying the factored load of 300 kN.



Ex. 6.1 - Design Strength

- **Step I.** Shear strength of bolts
  - The design shear strength of one bolt in shear = $\phi F_n A_b$ = 0.75 x 330 x π x 20^2/4000 = 77.8 kN
    - $\phi F_n A_b$ = 77.8 kN per bolt (See Table J3.2)
    - Shear strength of connection = 4 x 77.8 = 311.2 kN

Ex. 6.1 - Design Strength

- **Step II.** Minimum edge distance and spacing requirements
  - See Table J3.4M, minimum edge distance = 26 mm for rolled edges of plates
    - The given edge distances (30 mm) > 26 mm. Therefore, minimum edge distance requirements are satisfied.
  - Minimum spacing = 2.67 d_b = 2.67 x 20 = 53.4 mm.

    (AISC Specifications J3.3)
    - Preferred spacing = 3.0 d_b = 3.0 x 20 = 60 mm.
    - The given spacing (60 mm) = 60 mm. Therefore, spacing requirements are satisfied.

Ex. 6.1 - Design Strength

TABLE J 3.4M
Minimum Edge Distance[a] from Center of Standard Hole[b] to Edge of Connected Part, mm

Bolt Diameter, mm	Minimum Edge Distance
16	22
20	26
22	28
24	30
27	34
30	38
36	46
Over 36	1.25*d*

[a] If necessary, lesser edge distances are permitted provided the appropriate provisions from Sections J 3.10 and J 4 are satisfied, but edge distances less than one bolt diameter are not permitted without approval from the engineer of record.
[b] For oversized or slotted holes, see Table J 3.5M.

Ex. 6.1 - Design Strength

- **Step III.** Bearing strength at bolt holes.
  - Bearing strength at bolt holes in connected part (120x15 mm plate)
    - At edges, L_c = 30 – hole diameter/2 = 30 – (20 + 1.6)/2 = 19.2
    - ϕR_n = 0.75 x (1.2 L_c t F_u) = 0.75 x (1.2 x19.2 x15x400)/1000 = 103.7 kN
    - But, $\phi R_n \le$ 0.75 (2.4 d_b t F_u) = 0.75 x (2.4 x 20x15x400)/1000 = 216 kN
    - Therefore, ϕR_n = 103.7 kN at edge holes.
    - *At other holes, s = 60* mm, *L_c = 60 – (20 + 1.6) = 38.4 mm.*
    - ϕR_n = *0.75 x (1.2 L_c t F_u) = 0.75x(1.2 x 38.4 x15 x400)/1000 = 207.4 kN*
    - *But,* $\phi R_n \le$ *0.75 (2.4 d_b t F_u) = 216 kN. Therefore* ϕR_n *= 207.4 kN*

Ex. 6.1 - Design Strength

- Therefore, ϕR_n = 216 kN at other holes
- Therefore, bearing strength at holes = 2 x 103.7 + 2 x 207.4 = 622.2 kN

- Bearing strength at bolt holes in gusset plate (10 mm plate)
  - At edges, L_c = 30 – hole diameter/2 = 30 – (20 + 1.6)/2 = 19.2 mm.
  - $\phi R_n = 0.75 \times (1.2\ L_c\ t\ F_u) = 0.75 \times (1.2 \times 19.2 \times 10 \times 400)/1000 = 69.1$ kN
  - But, $\phi R_n \leq 0.75\ (2.4\ d_b\ t\ F_u) = 0.75 \times (2.4 \times 20 \times 10 \times 400)/1000 = 144$ kN.
  - Therefore, ϕR_n = 69.1 kN at edge holes.

Ex. 6.1 - Design Strength

- At other holes, s = 60 mm, L_c = 60 – (20 +1.6) = 38.4 mm.
- ϕR_n = 0.75 x (1.2 L_c t F_u) = 0.75 x (1.2 x 38.4 x 10x 400)/1000 = 138.2 kN
- But, $\phi R_n \leq$ 0.75 (2.4 d_b t F_u) = 144 kN
- Therefore, ϕR_n = 138.2 kN at other holes
- Therefore, bearing strength at holes = 2 x 69.1 + 2 x 138.2 = 414.6 kN

- Bearing strength of the connection is the smaller of the bearing strengths = 414.6 kN

Ex. 6.1 - Design Strength

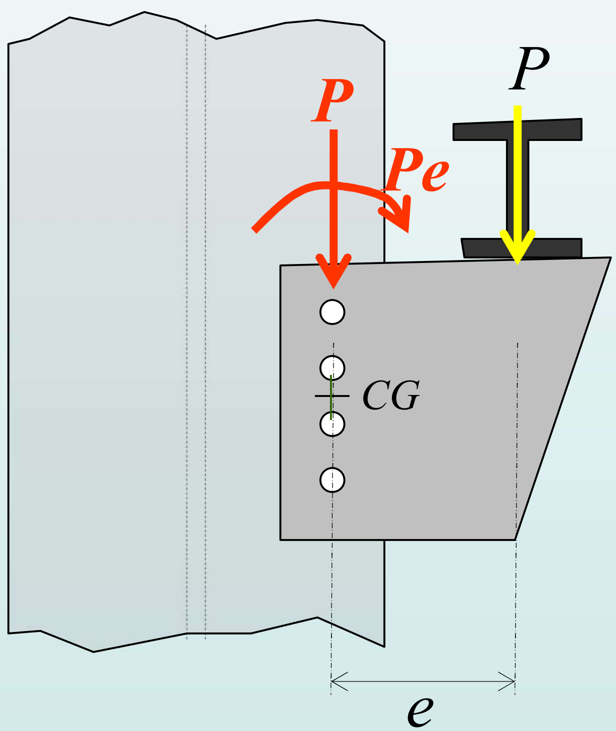
Connection Strength
Shear strength = 311.2
Bearing strength (plate) = 622.2 kN
Bearing strength (gusset) = 414.6 kN

Connection strength (ϕR_n) > applied factored loads (γQ).
311.2 > 300 *Therefore ok.*

- Only connections is designed here

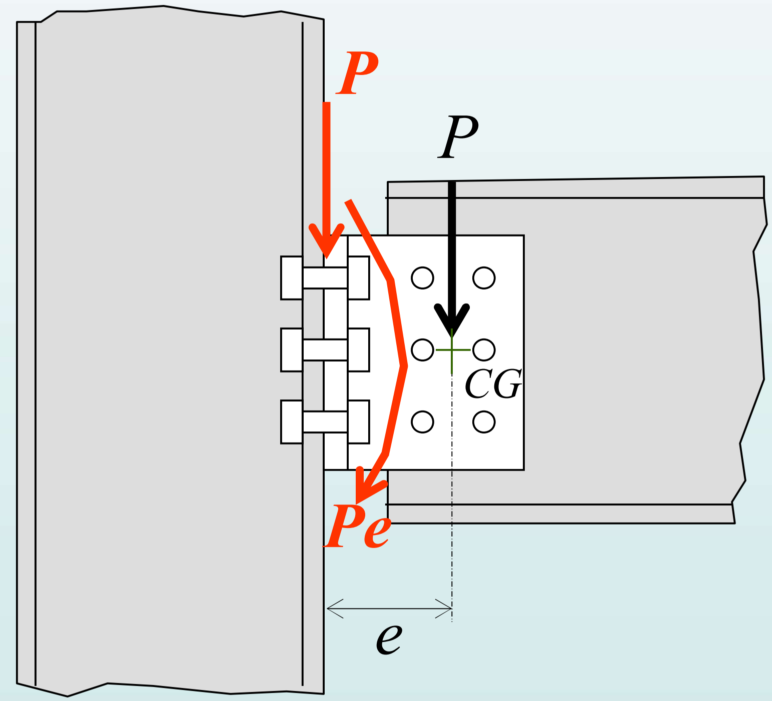
  Need to design tension member and gusset plate

Eccentrically-Loaded Bolted Connections



Eccentricity in the plane of the faying surface

Direct Shear + Additional Shear due to moment *Pe*



Eccentricity normal to the plane of the faying surface

Direct Shear + Tension and Compression (above and below neutral axis)

Forces on Eccentrically-Loaded Bolts

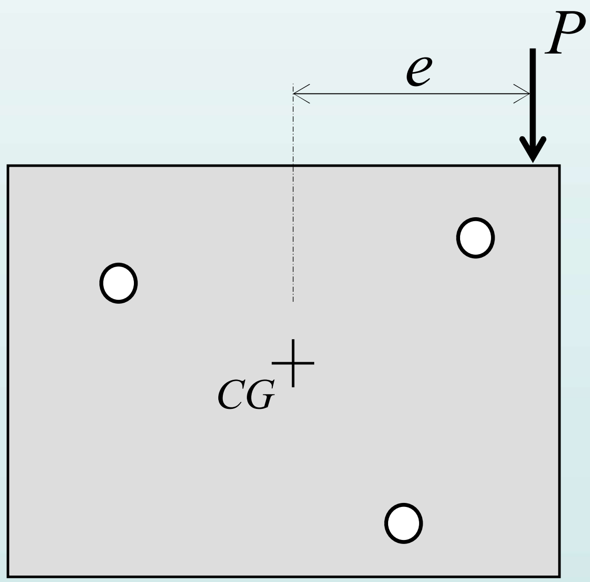
Eccentricity in the plane of the faying surface

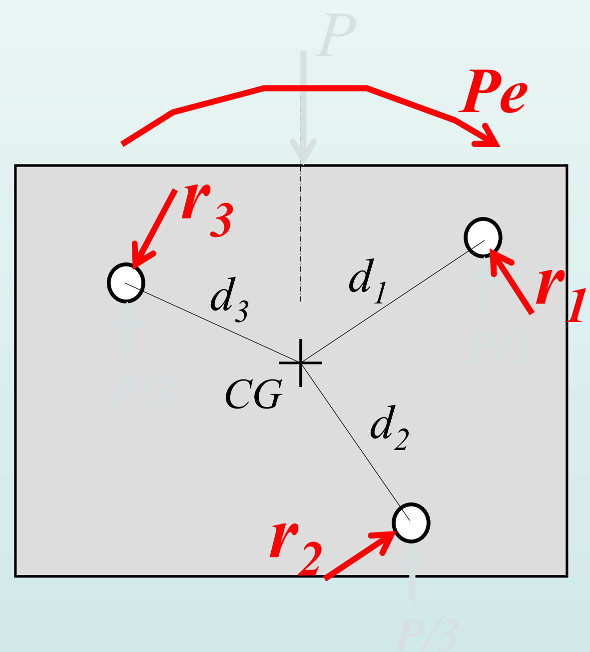
LRFD Spec. presents values for computing design strengths of individual bolt only. To compute forces on group of bolts that are eccentrically loaded, there are two common methods:

- *Elastic Method:* Conservative. Connected parts assumed rigid. Slip resistance between connected parts neglected.
- *Ultimate Strength Method (or Instantaneous Center of Gravity Method):* Most realistic but tedious to apply

Forces on Eccentrically-Loaded Bolts with Eccentricity on the Faying Surface

- Elastic Method





Assume plates are perfectly rigid and bolts perfectly elastic → rotational displacement at each bolt is proportional to its distance from the *CG* → stress is greatest at bolt farthest from *CG*