Example Bolt-1

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CIVE 3205

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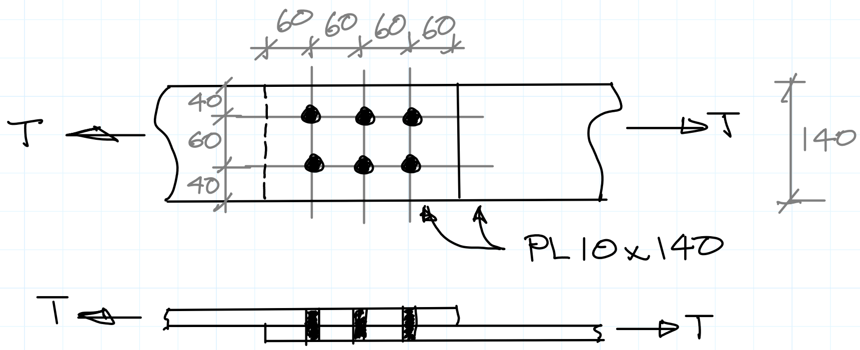
- revisions:
  - Apr 26, 2019: corrected length check (new S16) (page 3)
  - Feb 6, 2012: clarifying note added to page 1 (max edge distance).

Example Bolt-1

Calculate the resistance of the following assembly
1) as a bearing-type connection, and
2) as a slip-critical connection



Plates: 350W steel, sheared edges
Bolts: A325M M20 punched holes

Plates:

$F_y = 350$ MPa
$F_u = 450$ MPa

Bolts:

$F_u = 830$ MPa (Table 3-3 or §13.12.1.2)
$d_h = 24$ mm (§22.3.5.1 + §12.3.2)
(hole allowance)

Check Bolting Details

Min spacing: (§ 22.3.1)

$= 2.7d = 2.7 \times 20\text{mm} = 54\text{mm}$
$60 > 54\text{mm}$ O.K.

Min edge distance: (§22.3.2)
from Table 6 for d=20mm, sheared edge
$e_{min} = 34\text{mm}$
$40 > 34\text{mm}$ O.K.

Min end distance: (§ 22.3.4)
from Table 6
$e_{min} = 34\text{mm}$ (as above)
$60 > 34\text{mm}$ O.K

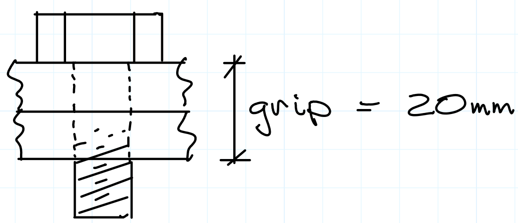
Max edge distance: (§22.3.3)
$e_{max} = 12 \times 10\text{mm} = 120\text{mm}$

$60 < 120\text{mm}$ O.K.

read carefully, §22.3.3 applies to end distance as well

Fastener Strength

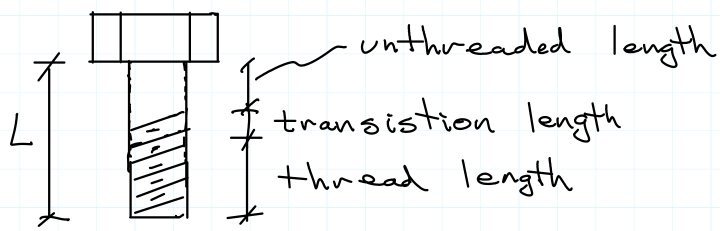
Check grip & thread length M20 bolts
grip req'd = 10mm + 10mm = 20mm



from p. 6-161, M20

L	min grip	max grip
45	–	23
50	14	28
55	19	32

only these 3 bolts lengths are possible.



From p 6-159, M20 bolts

L	thread length	transition length	unthreaded length
45	36	7.5	0
50	36	7.5	6.5
55	36	7.5	11.5

Compare unthreaded length to thickness of one plate. If less, then shear plane intercepts threads.

In this case, for 45 & 50mm bolts, threads would be intercepted, for L=55mm they would not.

As a practical matter, it is difficult to ensure that the correct bolts are used, so we should take the conservative assumption that threads are intercepted.

Strength – Bearing-Type Connection

Bolt shear: §13.12.1.2 (c)

$$V_r = 0.70 \times 0.60 \phi_b n m A_b F_u$$
$$= 0.70 \times 0.60 \times 0.8 \times 6 \times 1 \times \frac{\pi \times (20\,mm)^2}{4} \times 830 \frac{N}{mm^2} \times 10^{-3} \frac{kN}{N}$$
$$\underline{= 526\ kN}$$

check length: (§ 13.12.1.2 c))

$L = 120\ mm$

$L < 760\ mm$

$\therefore$ no reduction necessary

Plate bearing: §13.12.1.2 (a)

$$B_r = 3\phi_{br} n t d F_u$$
$$= 3 \times 0.8 \times 6 \times 10\,mm \times 20\,mm \times 450 \frac{N}{mm^2} \times 10^{-3} \frac{kN}{N}$$
$$\underline{= 1296\ kN}$$

Plate – gross area yielding:

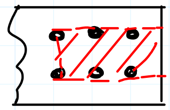
$$T_r = \phi A_g F_y$$
$$= 0.9 \times 10\,mm \times 140\,mm \times 350 \frac{N}{mm^2} \times 10^{-3} \frac{kN}{N}$$
$$\underline{= 441\ kN}$$

Plate – net section fracture:

$$A_n = (140\,mm - 2 \times 24\,mm) \times 10\,mm$$
$$= 920\ mm^2$$

$$T_r = \phi_u A_n F_u$$
$$= 0.75 \times 920\,mm^2 \times 450 \frac{N}{mm^2} \times 10^{-3} \frac{kN}{N}$$
$$\underline{= 310\ kN} \leftarrow \text{governs}$$

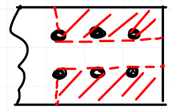
Plate – Block Shear: §13.11

1) 

$A_n = (60-24)\times 10 = 360\,mm^2$

$A_{gv} = 3\times 60\times 10\times 2 = 3600\,mm^2$

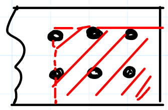
$U_t = 1.0$

2) 

$A_n = 2\times\left(40-\frac{24}{2}\right)\times 10 = 560\,mm^2$

$A_{gv} = 3600\,mm^2$

$U_t = 0.9$

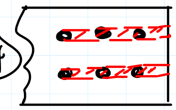
3) 

$A_n = (60+40-1.5\times 24)\times 10$

$= 640\,mm^2$

$A_{gv} = 1800\,mm^2$

$U_t = 0.6$

4) 

$A_n = 0$

$A_{gv} = 7200\,mm^2$

$$T_r = \phi_u\left[U_t A_n F_u + 0.6 A_{gv}\left(\frac{F_y+F_u}{2}\right)\right]$$

$$= 0.75\left[450\,U_t A_n + 240\,A_{gv}\right]$$

case	A_n	U_t	A_{gv}	T_r
1)	360	1.0	3600	770 kN
2)	560	0.9	3600	818 kN
3)	640	0.6	1800	454 kN
4)	0	—	7200	1296 kN

∴ As a bearing-type connection

$T_r = 310$ kN (plates) ← governs

$T_r = 526$ kN (fasteners)

As a slip-critical connection:

You must check <u>all</u> of the above (§13.12.2.1)
plus the following:

$$V_s = 0.53\, c_1 k_s\, m\, n\, A_b F_u \qquad (§13.12.2.2)$$

From Table 3, class A, A325M bolts
$c_1 = 0.82$
$k_s = 0.33$

$$V_s = 0.53 \times 0.82 \times 0.33 \times 1 \times 6 \times \pi \times \frac{20^2}{4} mm^2 \times \frac{830 N}{mm^2} \times 10^{-3} \frac{kN}{N}$$

$$\underline{V_s = 224 \text{ kN}}$$

As a slip-critical connection:
∴ Limit for service loads

$$T_s = 224 \text{ kN}$$

Limit for factored loads

$$T_r = 310 \text{ kN}$$