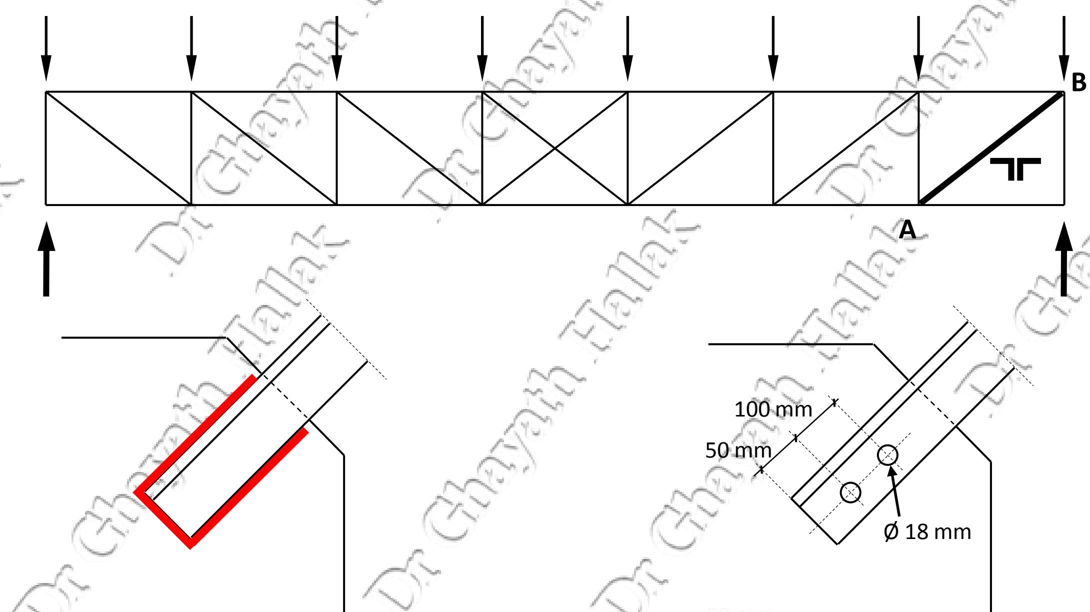
SIMPLE CONNECTIONS Examples

Example: 1

Consider the member AB of the steel truss, indicated in Figure, assuming it is subjected to a design tensile axial force of N_{Ed} = 220 kN. The cross section consists of two angles of equal legs, in steel grade S235. Design member AB assuming two distinct possibilities for the connections:

a) Welded connections, b) bolted connections



a) Welded connections *b) Bolted connections*

Steel truss

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SIMPLE CONNECTIONS Examples

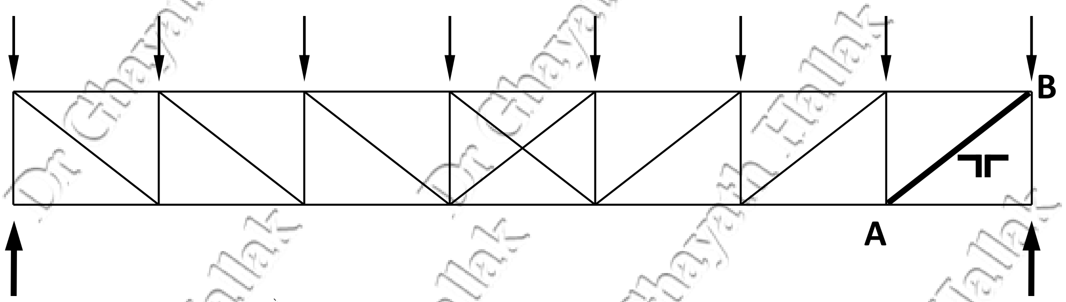
Example: 1

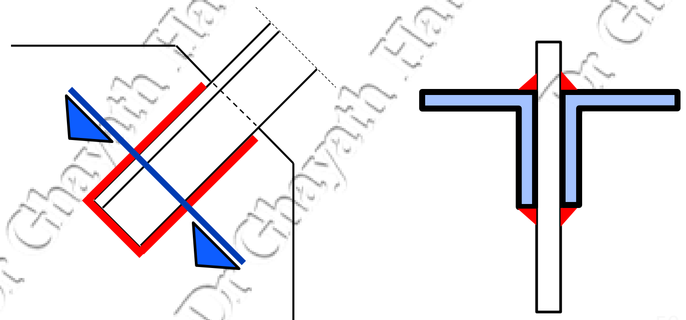
a) Welded connections

The member is made up by two angles of equal legs, but the connection is made only in one leg of the angle. Thus, according to clause 4.13 of the EC3-1-8, the effective area can be considered equal to the gross area. Therefore, the following conditions must be satisfied:

$$N_{Ed} \leq N_{t,Rd} = \frac{Af_y}{\gamma_{M0}}$$

Considering the design axial force= 220 *kN*, then:





a) Welded connections

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SIMPLE CONNECTIONS Examples

Example: 1

a) Welded connections

$$220 \leq \frac{A \times 235 \times 10^3}{1.0} \Rightarrow A \geq 9.36 \times 10^{-4}\, m^2 = 9.36\, cm^2$$

From a table of commercial profiles, a solution with two angles 50×50×5 mm, with a total area of $2 \times 4.8 = 9.6$ cm^2, satisfies the above safety requirement.

b) Bolted connections

In this case, the member is made up by two angles of equal legs is connected by two bolts only in one leg. According to clause 3.10.3 of the EC3-1-8, the following design conditions must be ensured:

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SIMPLE CONNECTIONS Examples

Example: 1

b) Bolted connections

$$N_{Ed} \leq N_{t,Rd} = min\left[N_{pl,Rd} = \frac{A f_y}{\gamma_{M0}}; N_{u,Rd} = \frac{\beta_2 A_{net} f_u}{\gamma_{M2}}\right]$$

β_2 is a factor obtained from Table 3.8 of EC-1-8.

A first check based on the plastic design of the gross section leads to:

$$220 \leq \frac{A \times 235 \times 10^3}{1.0} \Rightarrow A \geq 9.36 \times 10^{-4}\ m^2 = 9.36\ cm^2$$

Hence, the section obtained in the previous design, two angles 50×50×5 mm, with a total area of 2 × 4.8 = 9.6 cm^2, also satisfies this safety requirement.

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SIMPLE CONNECTIONS Examples

Example: 1

b) Bolted connections

The second condition (3.12, EC3-1-8), requires the evaluation of the net area A_{net}, and the factor β_2, both evaluated according to clause 3.10.3 of EC3-1-8.

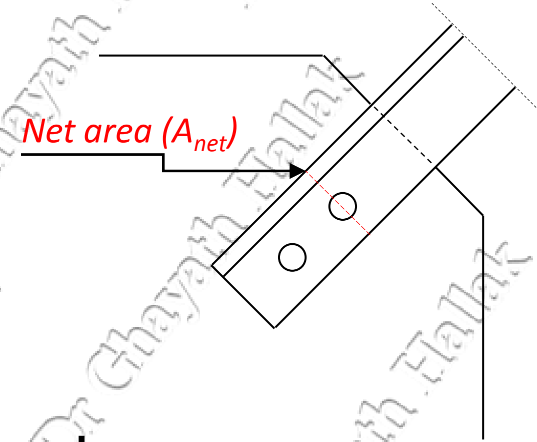
For d_0 = 18 mm, 2.5d_0 = 45 mm and 5d_0 = 90 mm.

As p_1 = 100 mm > 90 mm, then β_2 = 0.7.

The net area of the bolted section made up of two angles is given by:

$A_{net} = A - 2td_0 = 9.6 - 2 \times 0.5 \times 1.8$

$= 7.8\ cm^2$.



Thus, the design ultimate resistance is given by:

$$N_{u,Rd} = \frac{0.7 \times 7.8 \times 10^{-4} \times 360 \times 10^{3}}{1.25} = 157.2\ kN$$

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SIMPLE CONNECTIONS Examples

Example: 1

b) Bolted connections

However, N_{Ed} = 220 *kN* > $N_{u, Rd}$ = 157.2 *kN*; therefore, the chosen cross section is not appropriate. By adopting a cross section with enhanced resistance, for example, two angles 60×60×6 mm (A = 13.82 cm^2 and A_{net} = 11.6 cm^2), then:

$N_{pl, Rd} = 13.82\times10^{-4}\times235\times10^{3}/1.0 = 324.8\ kN > N_{Ed} = 220\ kN$

$$N_{u,Rd} = \frac{0.7 \times 11.6 \times 10^{-4} \times 360 \times 10^{3}}{1.25} = 235.1\ kN > N_{Ed} = 220kN$$

As $N_{pl, Rd}$ = 324.8 *kN* > $N_{u, Rd}$ = 235.1 *kN*, failure is non-ductile; however, since this is not a design condition, the section defined by two angles 60×60×6mm can be adopted.

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SIMPLE CONNECTIONS Examples

Example: 1 ACCORDING TO BS5950:2000

(Clause 4.6.3.2)

$A_e = K_e\, A_{net} \leq A$, $a_2 = A - a_1$

Reduce Effective Area $= A_{e,Reduced} = (A_e - 0.25 a_2)$ for *bolted* connections

and

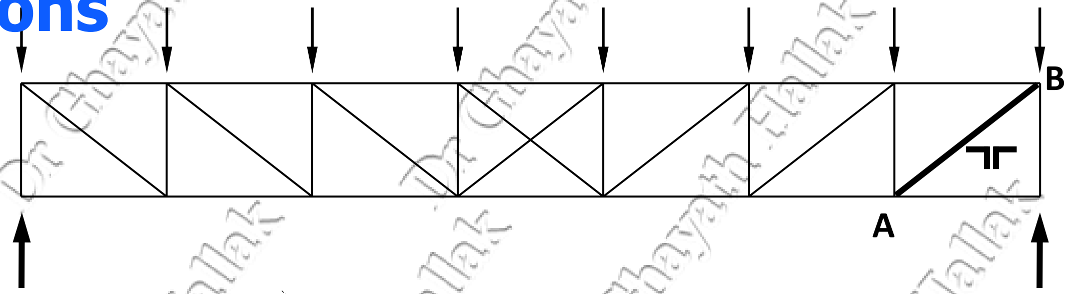
$= (A_g - 0.15 a_2)$ for *welded* connections

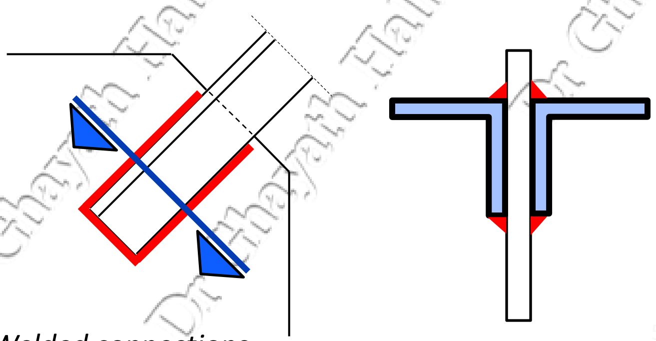
a) Welded connections

$$220 \leq \frac{A \times 235 \times 10^3}{1.0}$$

$$\Rightarrow A \geq 9.36 \times 10^{-4}\, m^2$$

$$= 9.36\, cm^2$$





a) Welded connections

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SIMPLE CONNECTIONS Examples

Example: 1 ACCORDING TO BS5950:2000

(Clause 4.6.3.2)

a) Welded connections

From a table of commercial profiles, a solution with two angles 50×50×5 mm, with a total area of 2 × 4.8 = 9.6 cm², satisfies the above safety requirement.

$N_t = f_y (A_g - 0.15 a_2)$

$a_1 = 50x5x2 = 500mm^2$, $a_2 = A_g - a_1 = 960 - 500 = 460mm^2$

$N_t = 235x(960 - 0.15x460)/1000 = 209.4kN$

$N_{Ed} = 220\ kN > N_{t,Rd} = 209.4\ kN$; therefore, the chosen cross section is not appropriate. By adopting a cross section with enhanced resistance, for example, two angles 60×60×6 mm (A = 13.82 cm²)

$a_1 = 60x6x2 = 720mm^2$, $a_2 = A_g - a_1 = 1382 - 720 = 662mm2$

$N_t = 235x(1382 - 0.15x662)/1000 = 301.4kN > N_{Ed} = 220\ kN$

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SIMPLE CONNECTIONS Examples

Example: 1

b) Bolted connections $K_e=1.2$

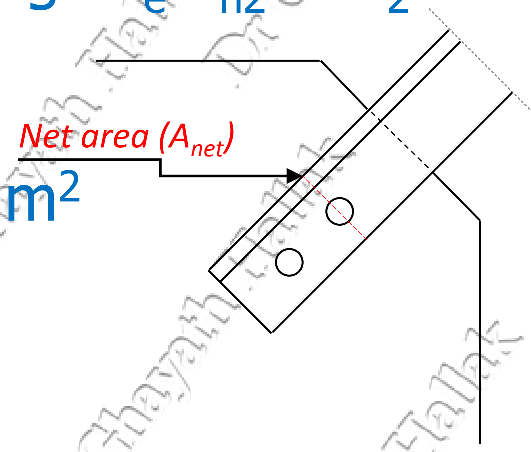
$N_{t,Rd}= f_y (A_e - 0.25a_2)$, $A_e=(a_{e1}+a_{e2})\leq 1.2(a_{n1}+a_{n2})$

a_{e1}= effective area of the connected leg$=K_e\ a_{n1} \leq a_1$

a_{e2}= effective area of the Unconnected leg$=K_e\ a_{n2} \leq a_2$

$a_{n1}= (a_1$ –area of bolt holes)

$a_{n2}= (a_2$ –area of bolt holes if any)



$a_1= 50x5x2=500mm^2$, $a2=960-500=460mm^2$

$a_{n1}= (500 –2x5x18)=320mm^2$

$a_{n2}= (460 –0)=460mm^2$

$a_{e1}= 1.2x(320)=384mm^2$

$a_{e2}= 1.0x(460)=460mm^2$, $K_e=1$ No holes, not connected leg

$A_e=(a_{e1}+a_{e2})=(384+460)=844mm^2 \leq 1.2(320+460)=936$ OK

$N_{t,Rd}= 235x(844-0.25x460)=171.3kN <220kN$ NOT OK

Use two angles 60×60×6 mm (A = 13.82 cm^2)

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SIMPLE CONNECTIONS Examples

Example: 1

b) Bolted connections $K_e=1.2$

$a_1= 60x6x2=720mm^2$, $a2=1382-720=662mm^2$

$a_{n1}= (720 - 2x5x18)=540mm^2$

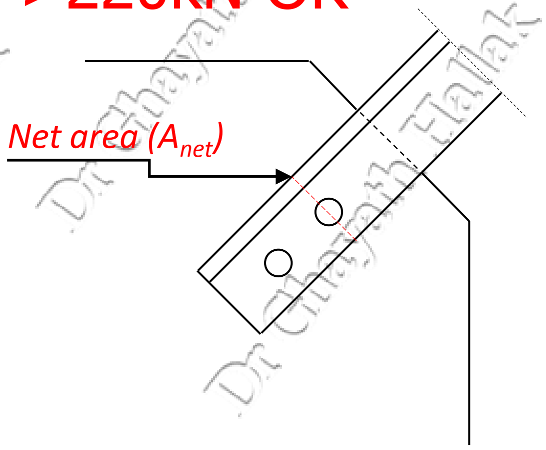
$a_{n2}= (662-0)=662mm^2$

$a_{e1}= 1.2x(540)=648mm^2$

$a_{e2}= 1.0x(662)=662mm^2$, $K_e=1$ No holes, not connected leg

$A_e=(a_{e1}+a_{e2})=(648+662)=1310mm^2 \leq 1.2(540+662)=1442$ OK

$N_{t,Rd}= 235x(1310-0.25x662)=268.96kN > 220kN$ OK



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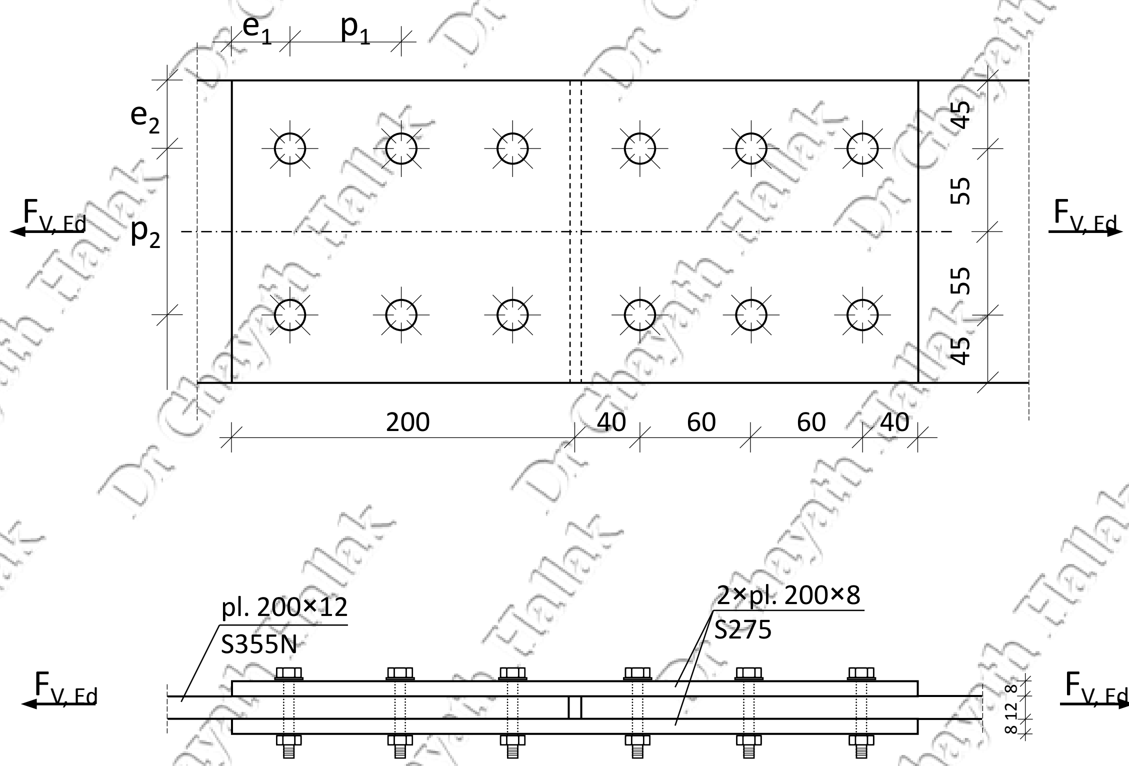
SIMPLE CONNECTIONS Examples

Example: 2

Check the design of shear connection shown in Figure.

- The connection is Category A: Bearing type
- Bolts 6M20(4.8); d = 20 mm; d_0 = 20+2 = 22 mm,
- Used two cover plates 200×8 (S275).
- $F_{V,Ed}$ = 650 kN



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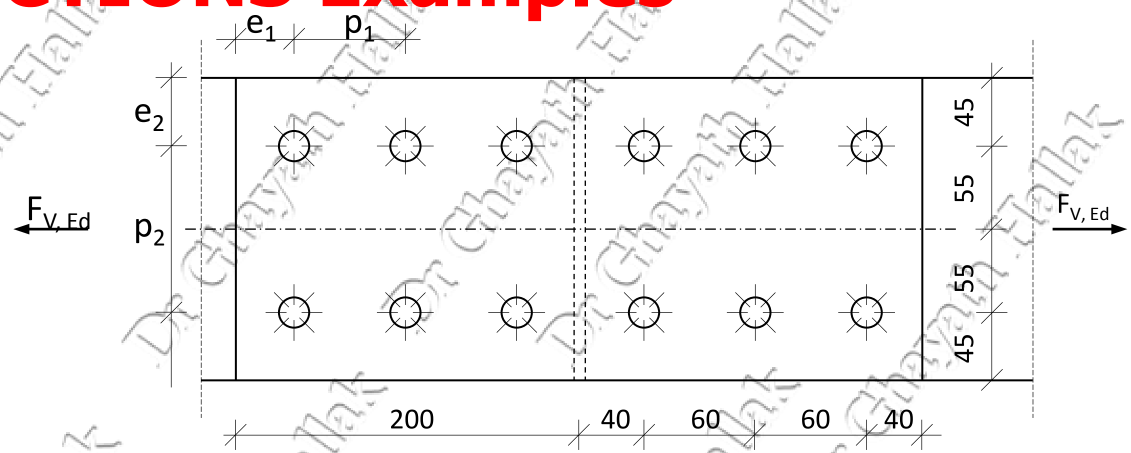
SIMPLE CONNECTIONS Examples

Example: 2



Minimum and maximum spacing, end and edge distances checking (Table 3-3 EN 1993-1-8 : 2005 (E)):

$e_{1min} = 1.2d_0 = 1.2\times22 = 26.4$ mm < 40 mm /OK/

$e_{1max} = 4t + 40$ mm $= 4\times8 + 40 = 72$ mm > 40 mm /OK/

$e_{2min} = 1.2d_0 = 1.2\times22 = 26.4$ mm < 45 mm /OK/

$e_{2max} = 4t + 40$ mm $= 4\times8 + 40 = 72$ mm > 45 mm /OK/

$p_{1min} = 2.2d_0 = 2.2\times22 = 48.4$ mm < 60 mm /OK/

$p_{1max} = \min.(14t = 14\times8 = 112; 200) = 112 > 60$ mm /OK/

$p_{2min} = 2.4d_0 = 2.4\times22 = 52.8$ mm < 110 mm /OK/

$p_{2max} = \min.(14t = 14\times8 = 112; 200) = 112 > 110$ mm /OK/

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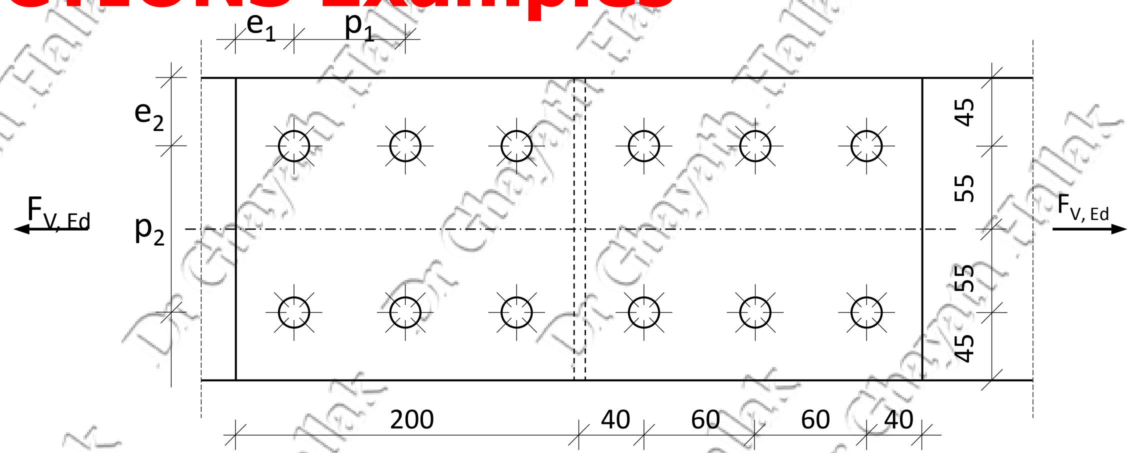
SIMPLE CONNECTIONS Examples

Example: 2



Steel S355N (for t ≤ 40mm) → f_y = 355 MPa, f_u = 510 MPa (Table 3-1 EN 1993-1-1 : 2005 (E))

Steel S275 (for t ≤ 40mm) → f_y = 275 MPa, f_u = 430 MPa (Table 3-1 EN 1993-1-1 : 2005 (E))

Nominal values of the yield strength f_{yb} and the ultimate tensile strength f_{ub} for bolts (Table 3-1 EN 1993-1-8 : 2005 (E)):

Bolts grade 4.8 → f_{yb} = 320 MPa, f_{ub} =400 MPa.

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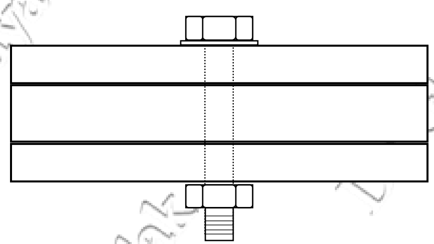
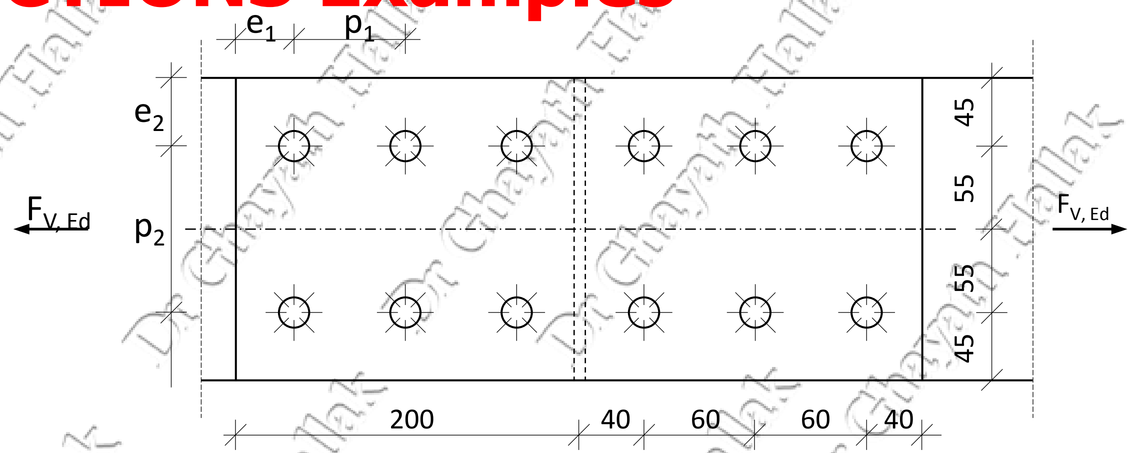
SIMPLE CONNECTIONS Examples

Example: 2





The thread of a fit bolt should not be included in the shear plane

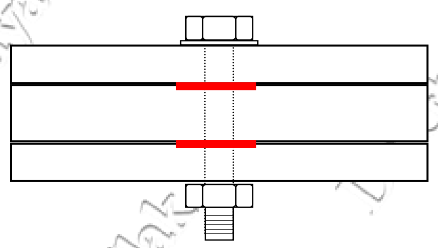
$$A = \pi d^2 / 4 = \pi \times 20^2 / 4 = 314 \text{ mm}^2$$

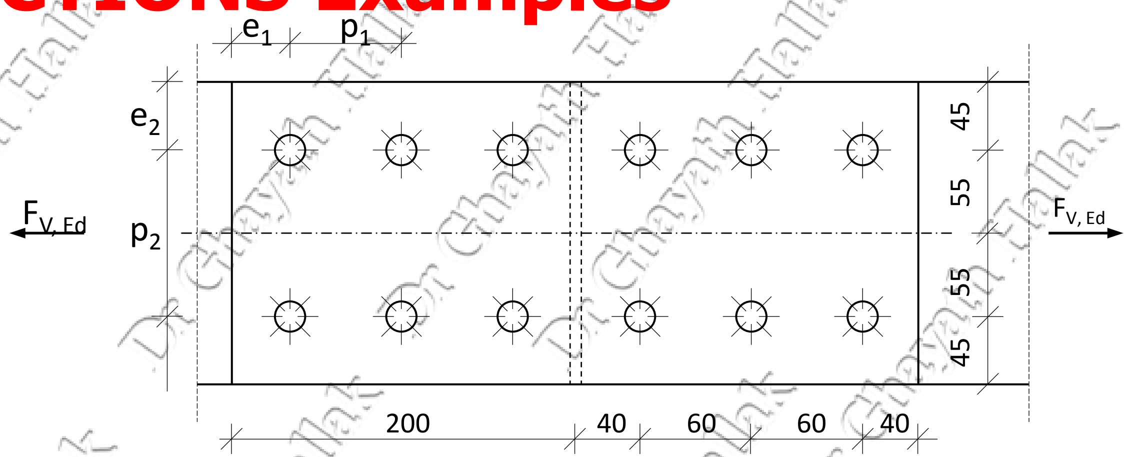
Design resistance for individual fastener subjected to shear per shear plane (Table 3-4 EN 1993-1-8 : 2005 (E))

$$F_{V,Rd} = \frac{\alpha_V \, f_{ub} \, A}{\gamma_{M2}} = \frac{0.6 \times 400 \times 314}{1.25} = 60288 \, N = 60.288 \, kN$$

SIMPLE CONNECTIONS Examples

Example: 2





Because bolt is in double shear → $F_{V,Rd} = 2 \times 60.288 = 120.576$ kN

Bearing resistance (Table 3-4 EN 1993-1-8 : 2005 (E))

$$F_{b,Rd} = \frac{k_1\, a_b\, f_u\, d\, t}{\gamma_{M2}}$$

Attention: Steel grade and thickness of tension member and cover plates not the same

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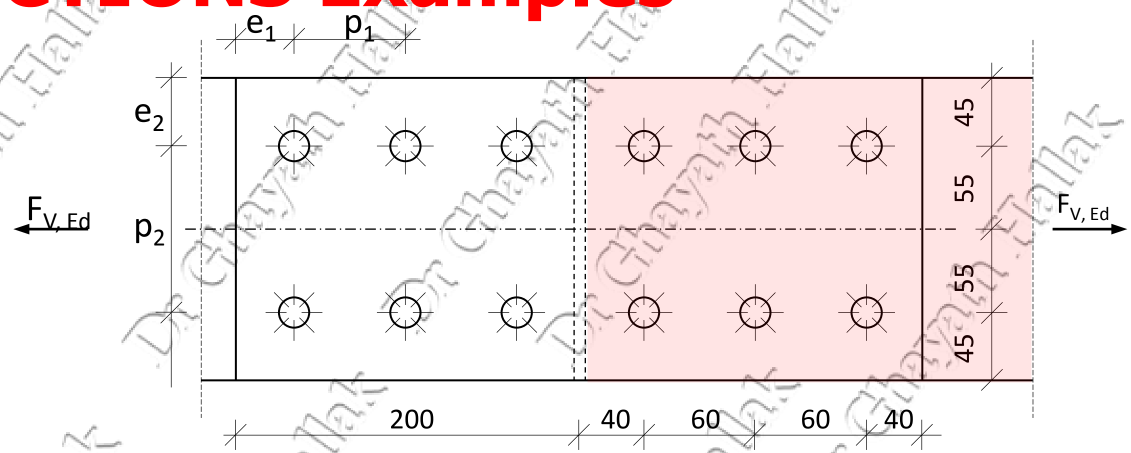
SIMPLE CONNECTIONS Examples

Example: 2

$$F_{b,Rd} = \frac{k_1\, a_b\, f_u\, d\, t}{\gamma_{M2}}$$



1- End bolts bearing on plate of connected part

t = 12 mm, f_u = 510 MPa, d = 20 mm, $\gamma_{M2} = 1.25$

$$\alpha_d = \frac{e_1}{3d_0} = \frac{40}{3 \times 22} = 0.61$$

$$\alpha_b = min.\left(\alpha_d; \frac{f_{ub}}{f_u}; 1.0\right) = min.\left(0.61; \frac{400}{510} = 0.78; 1.0\right) = 0.61$$

$$k_1 = min.\left(2.8\frac{e_2}{d_0} - 1.7;\ 1.4\frac{p_2}{d_0} - 1.7; 2.5\right)$$

$$= min.\left(2.8 \times \frac{45}{22} - 1.7 = 4.0;\ 1.4 \times \frac{110}{22} - 1.7 = 5.3; 2.5\right) = 2.5$$

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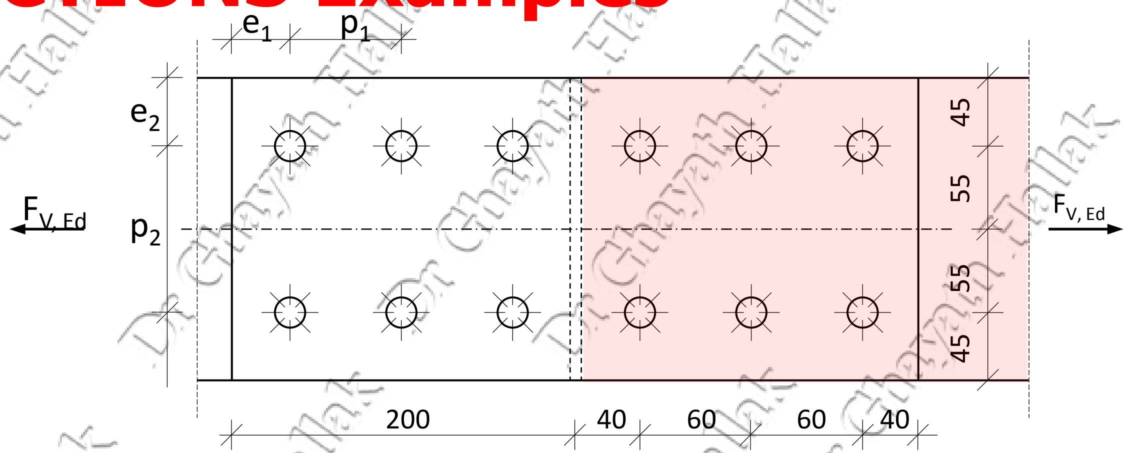
SIMPLE CONNECTIONS Examples

Example: 2

$$F_{b,Rd} = \frac{k_1\, a_b\, f_u\, d\, t}{\gamma_{M2}}$$



1- End bolts bearing on plate of connected part

$$F_{b,Rd} = \frac{k_1\, \alpha_b\, f_u\, d\, t}{\gamma_{M2}} = \frac{2.5 \times 0.61 \times 510 \times 20 \times 12}{1.25} = 149328\, N = 149.3\, kN$$

2- Inner bolts bearing on plate of connected part

$t = 12$ mm, $f_u = 510$ MPa, $d = 20$ mm, $\gamma_{M2} = 1.25$

$$\alpha_d = \frac{p_1}{3d_0} - \frac{1}{4} = \frac{60}{3 \times 22} - \frac{1}{4} = 0.66 \quad , k_1 = 2.5$$

$$\alpha_b = min.\left(\alpha_d; \frac{f_{ub}}{f_u}; 1.0\right) = min.\left(0.66; \frac{400}{510} = 0.78\, ; 1.0\right) = 0.66$$

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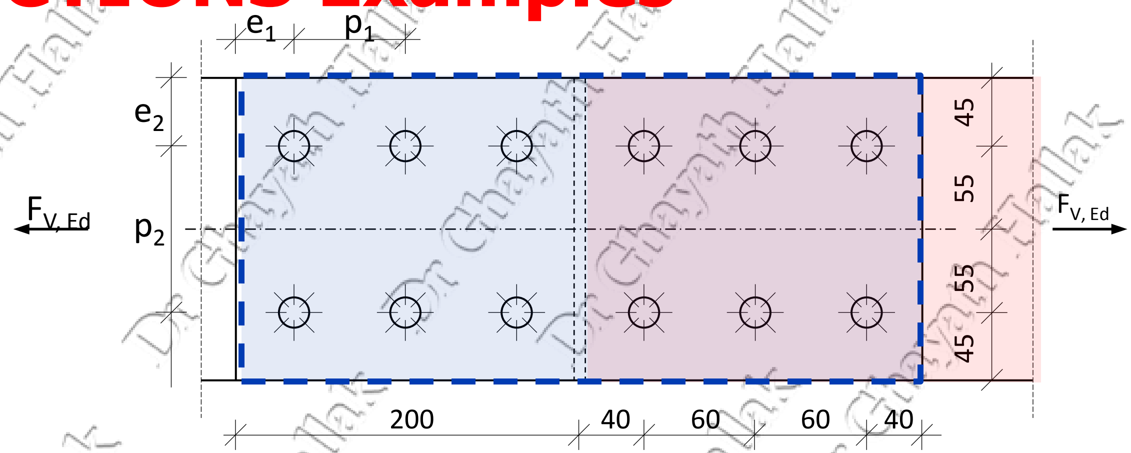
SIMPLE CONNECTIONS Examples

Example: 2

$$F_{b,Rd} = \frac{k_1 \, a_b \, f_u \, d \, t}{\gamma_{M2}}$$



2- Inner bolts bearing on plate of connected part

$$F_{b,Rd} = \frac{k_1 \, \alpha_b \, f_u \, d \, t}{\gamma_{M2}} = \frac{2.5 \times 0.66 \times 510 \times 20 \times 12}{1.25} = 161568 \, N = 161.6 \, kN$$

3- End bolts bearing on cover plate

$t = 2{\times}8 = 16$ mm, $f_u = 430$ MPa, $d = 20$ mm, $\gamma_{M2} = 1.25$

$$\alpha_d = \frac{e_1}{3d_0} = \frac{40}{3 \times 22} = 0.61$$

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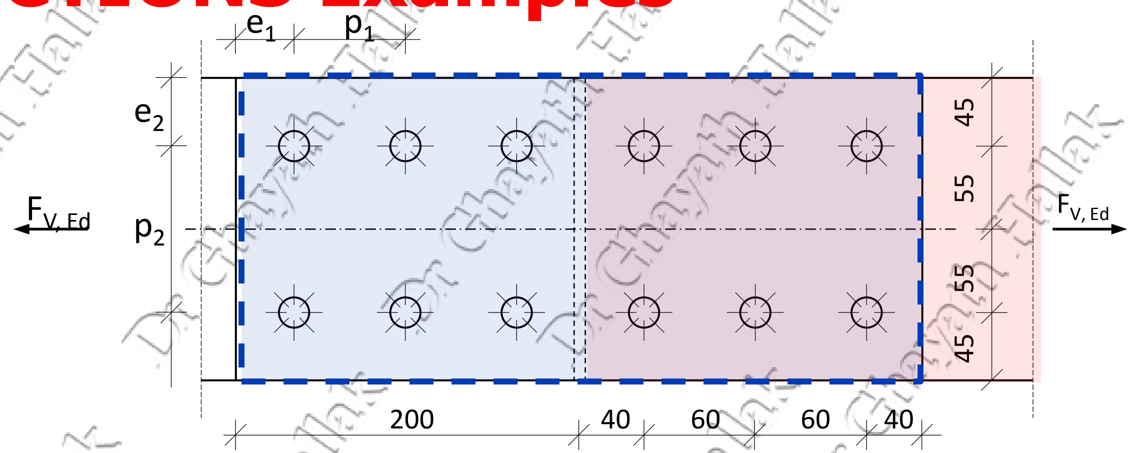
SIMPLE CONNECTIONS Examples

Example: 2

$$F_{b,Rd} = \frac{k_1\, \alpha_b\, f_u\, d\, t}{\gamma_{M2}}$$



3- End bolts bearing on cover plate

$$\alpha_b = min.\left(\alpha_d;\ \frac{f_{ub}}{f_u};\ 1.0\right) = min.\left(0.61;\ \frac{400}{430} = 0.93;\ 1.0\right) = 0.61$$

$$k_1 = min.\left(2.8\frac{e_2}{d_0} - 1.7;\ 1.4\frac{p_2}{d_0} - 1.7;\ 2.5\right)$$

$$= min.\left(2.8 \times \frac{45}{22} - 1.7 = 4.0; 1.4 \times \frac{110}{22} - 1.7 = 5.3;\ 2.5\right) = 2.5$$

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u\, d\, t}{\gamma_{M2}} = \frac{2.5 \times 0.61 \times 430 \times 20 \times 16}{1.25} = 167870\ N$$

$$= 167.87\ kN$$

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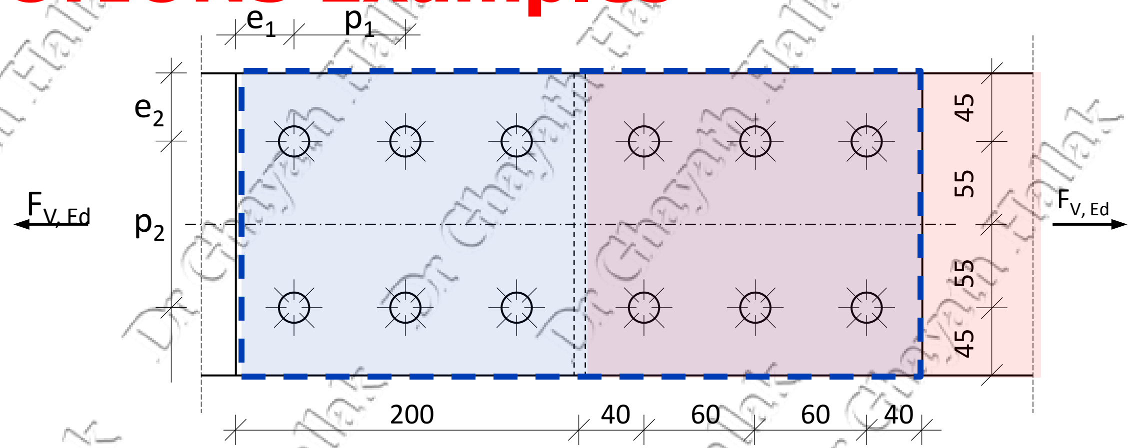
SIMPLE CONNECTIONS Examples

Example: 2

$$F_{b,Rd} = \frac{k_1 \, a_b \, f_u \, d \, t}{\gamma_{M2}}$$



4- Inner bolts bearing on cover plate

$t = 2 \times 8 = 16$ mm, $f_u = 430$ MPa, $d = 20$ mm, $\gamma_{M2} = 1.25$

$$\alpha_d = \frac{p_1}{3d_0} - \frac{1}{4} = \frac{60}{3 \times 22} - \frac{1}{4} = 0.66 \quad , \quad k_1 = 2.5$$

$$\alpha_b = min.\left(\alpha_d; \frac{f_{ub}}{f_u}; 1.0\right) = min.\left(0.66; \frac{400}{430} = 0.93; 1.0\right) = 0.66$$

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u \, d \, t}{\gamma_{M2}} = \frac{2.5 \times 0.66 \times 430 \times 20 \times 16}{1.25} = 181630 \; N$$

$$= 181.63 \; kN$$

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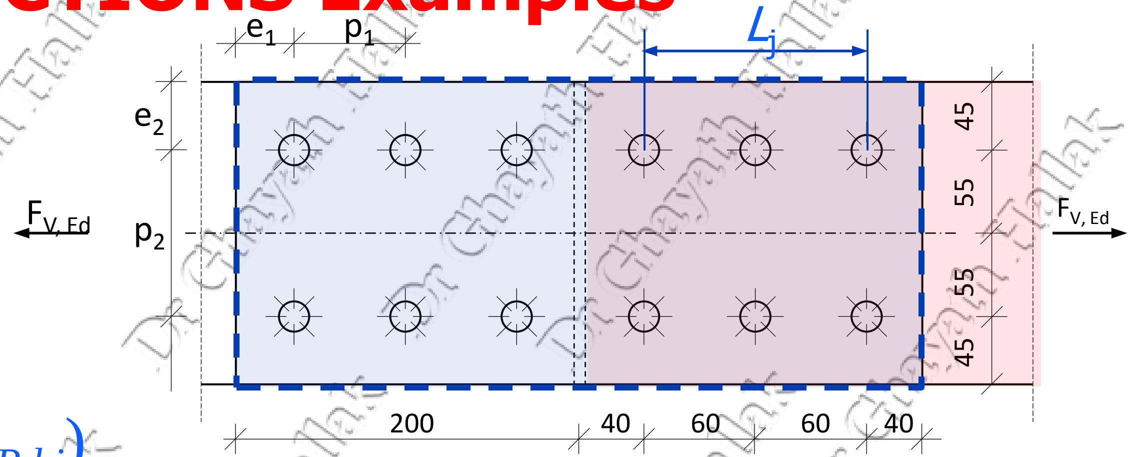
SIMPLE CONNECTIONS Examples

Example: 2



$$F_{V,Rd} = n_b \, F_{Rd,min,i}$$

$$F_{Rd,min,i} = min.(F_{V,Rd;} \; F_{b,Rd,i})$$

$$= min.(120.576;\ 149.3;\ 161.6;\ 167.87;\ 181.63) = 120.576 \text{kN}$$

Checking the connection if it is long Joint:

IF L_j >15d, Then

The design shear resistance $F_{v,Rd}$ of all the fasteners calculated according to Table 3.4 should be reduced by multiplying it by a reduction factor β_{Lf},

$$1.0 \leq \beta_{Lf} = 1 - \frac{L_j - 15d}{200d} \geq 0{,}75$$

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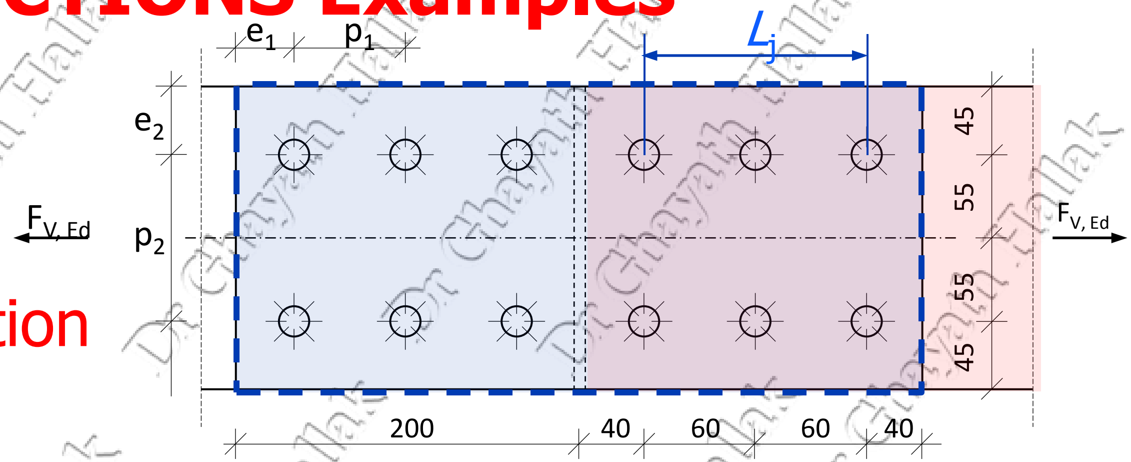
SIMPLE CONNECTIONS Examples

Example: 2



Checking the connection if it is long Joint:

$L_j = 2 \times 60 = 120 < 15d = 15 \times 20 = 300$ mm $\therefore$ short Joint, No Reduction to the bolts shear resistance

$F_{V,Ed} = 650$ kN $<$ $F_{V,Rd} = 6 \times 120.576 = 723.456$ kN **/OK/**

Check design tension resistance for cross section of connected part reduced by holes

$$N_{pl,Rd} = \frac{A f_y}{\gamma_{M0}} = \frac{200 \times 12 \times 355}{1.0} = 852000\ N = 852\ kN$$

$$A_{net} = A - n_V\, d_0\, t = 200 \times 12 - 2 \times 22 \times 12 = 1872\ mm^2$$

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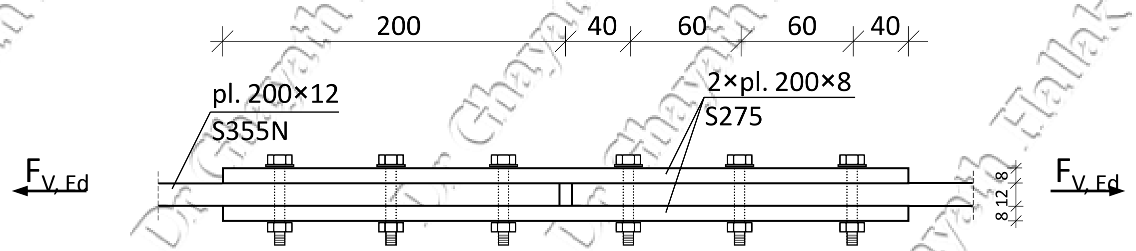
SIMPLE CONNECTIONS Examples

Example: 2



Check design tension resistance for cross section of connected part reduced by holes

$$N_{u,Rd} = \frac{0.9 A_{net} f_u}{\gamma_{M2}} = \frac{0.9 \times 1872 \times 510}{1.25} = 687298 \ N = 687.3 \ kN < N_{pl,Rd}$$

$$F_{V,Ed} = 650 \text{ kN} < N_{u,Rd} = 687.30 \text{ kN} \qquad \textbf{/OK/}$$

Check design tension resistance for cross section of cover plates reduced by holes

$$N_{pl,Rd} = \frac{A f_y}{\gamma_{M0}} = \frac{200 \times 2 \times 8 \times 275}{1.0} = 880000 \ N = 880 \ kN$$

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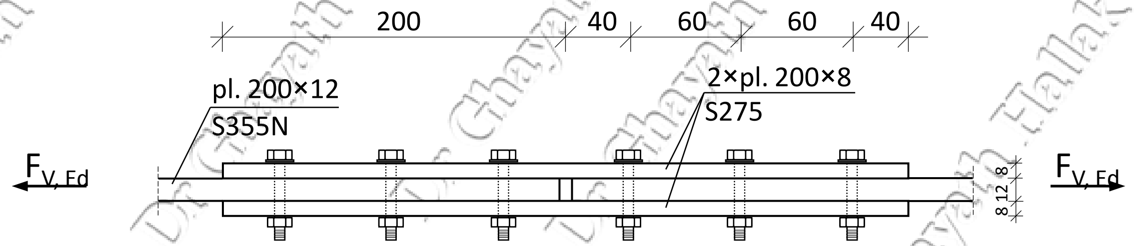
SIMPLE CONNECTIONS Examples

Example: 2



Check design tension resistance for cross section of cover plates reduced by holes

$$A_{net} = A - n_V\, d_0\, t = 200 \times 2 \times 8 - 2 \times 22 \times 2 \times 8 = 2496\, mm^2$$

$$N_{u,Rd} = \frac{0.9 A_{net} f_u}{\gamma_{M2}} = \frac{0.9 \times 2496 \times 430}{1.25} = 772700\, N = 772.7\, kN < N_{pl,Rd}$$

$F_{V,Ed} = 650$ kN < $N_{u,Rd} = 772.7$ kN **/OK/**

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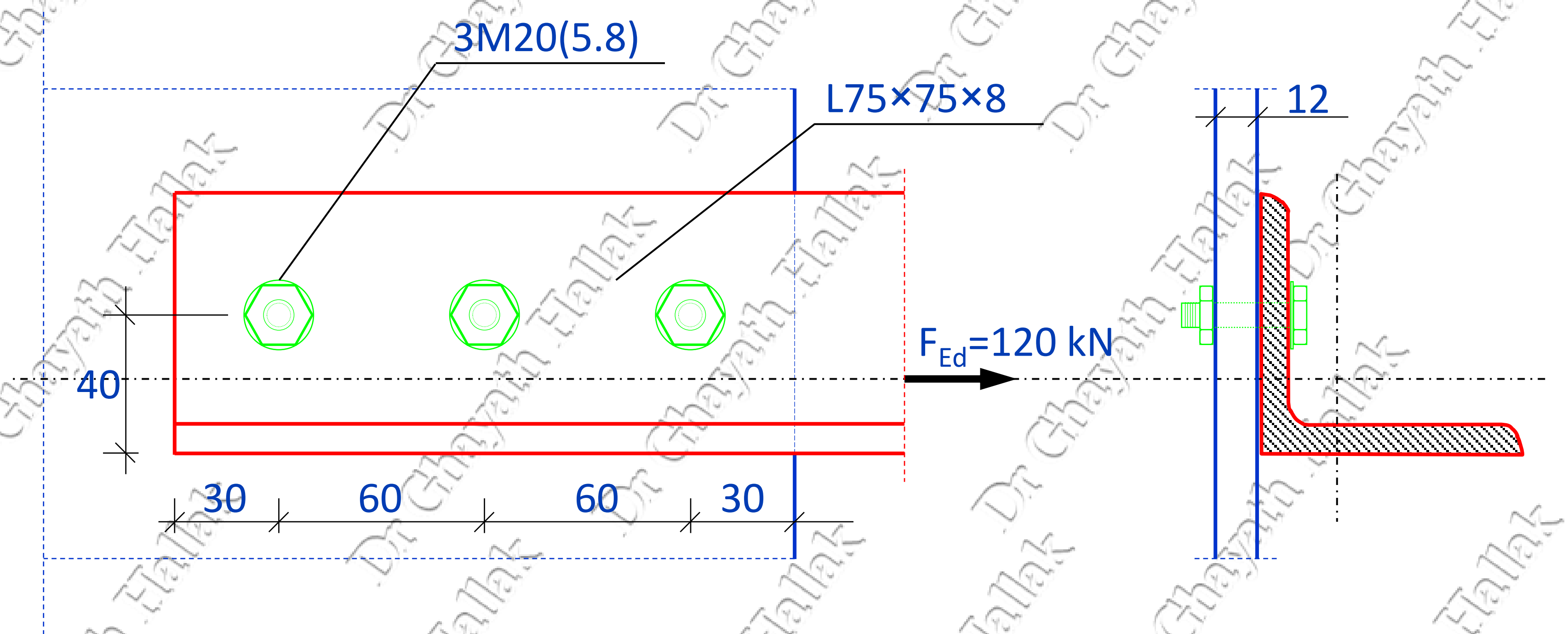
SIMPLE CONNECTIONS Examples

Example: 3

Check the design of shear connection shown in Figure.



- The connection is Category A: Bearing type
- Steel S355 (for t ≤ 40mm) → f_y = 355 MPa, f_u = 510 MPa.
- F_{Ed} = 120 kN

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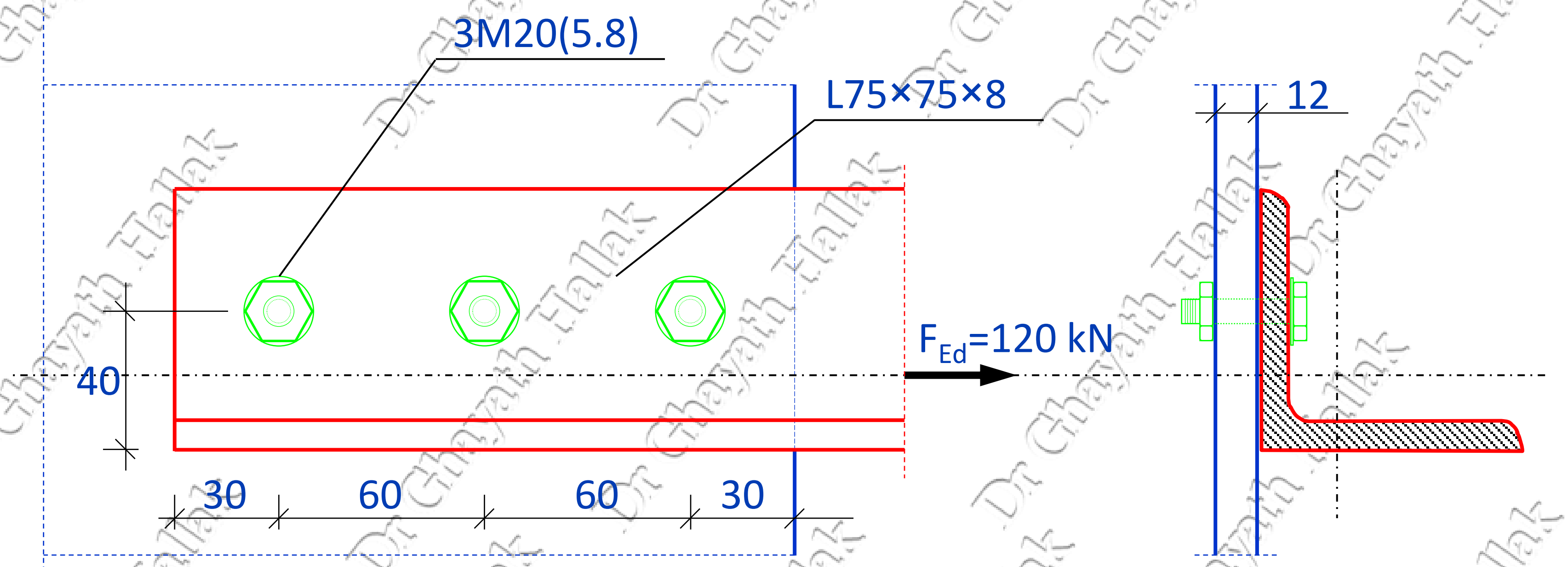
SIMPLE CONNECTIONS Examples

Example: 3

Check the design of shear connection shown in Figure.



• Bolts 3M20(5.8); d = 20 mm; d_0 = 20+2 = 22 mm,

A_s = 245 mm^2, f_{yb} = 400 MPa, f_{ub} = 500 Mpa

t = 12 mm (gusset plate); t_1 = 8 mm (angle)

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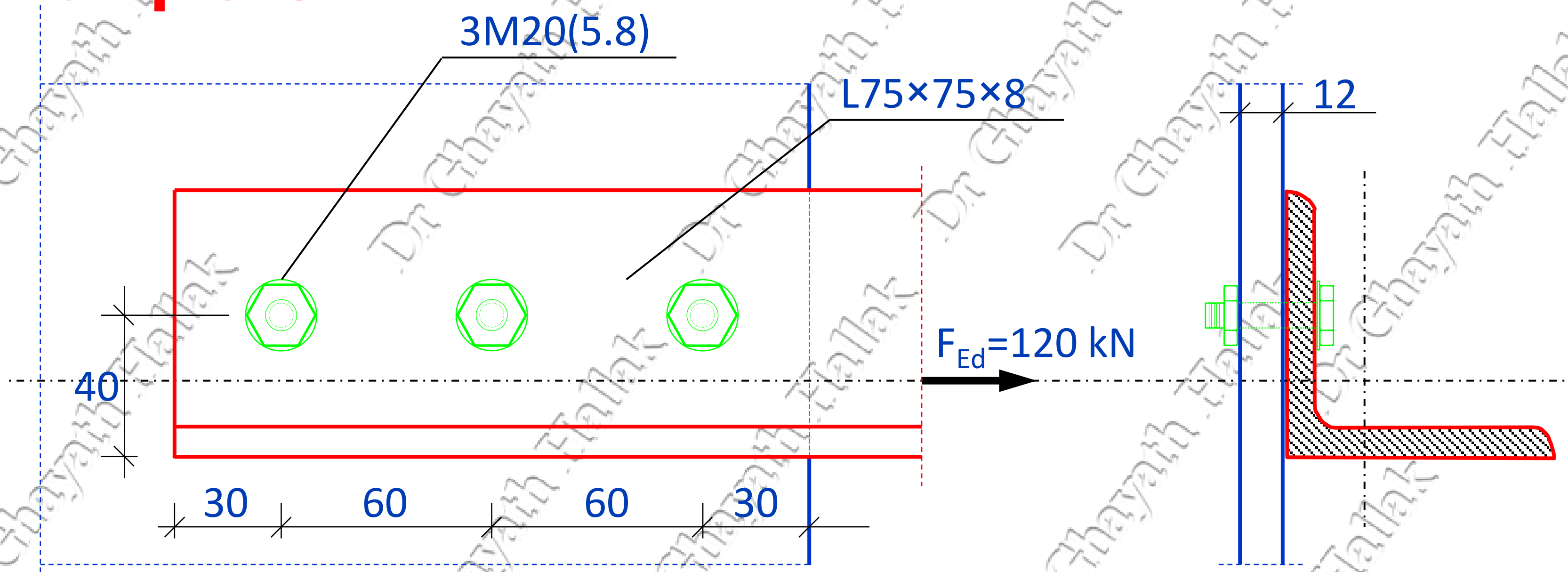
SIMPLE CONNECTIONS Examples

Example: 3



Minimum and maximum spacing, end and edge distances checking (Table 3-3 EN 1993-1-8 : 2005 (E)):

$e_{1min} = 1.2d_0 = 1.2\times22 = 26.4$ mm < 30 mm /OK/

$e_{1max} = 4t + 40$ mm $= 4\times8 + 40 = 72$ mm > 30 mm /OK/

$e_{2min} = 1.2d_0 = 1.2\times22 = 26.4$ mm < 35 mm /OK/

$e_{2max} = 4t + 40$ mm $= 4\times8 + 40 = 72$ mm > 35 mm /OK/

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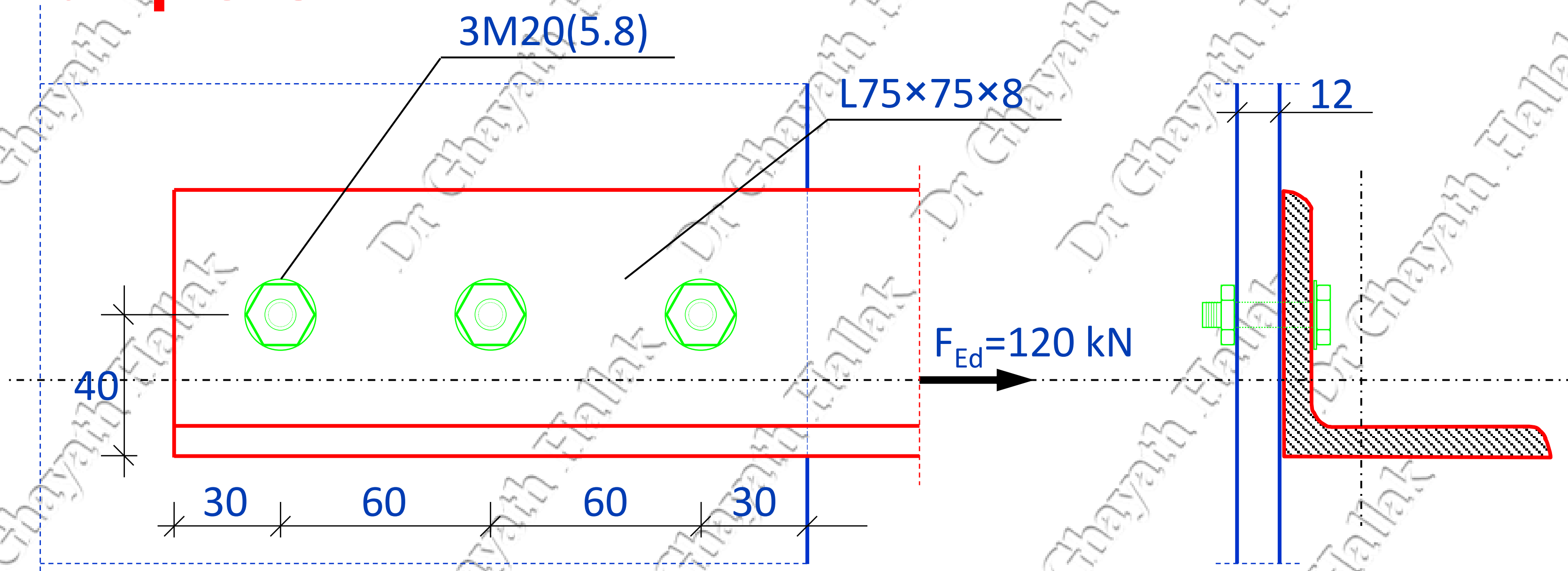
SIMPLE CONNECTIONS Examples

Example: 3



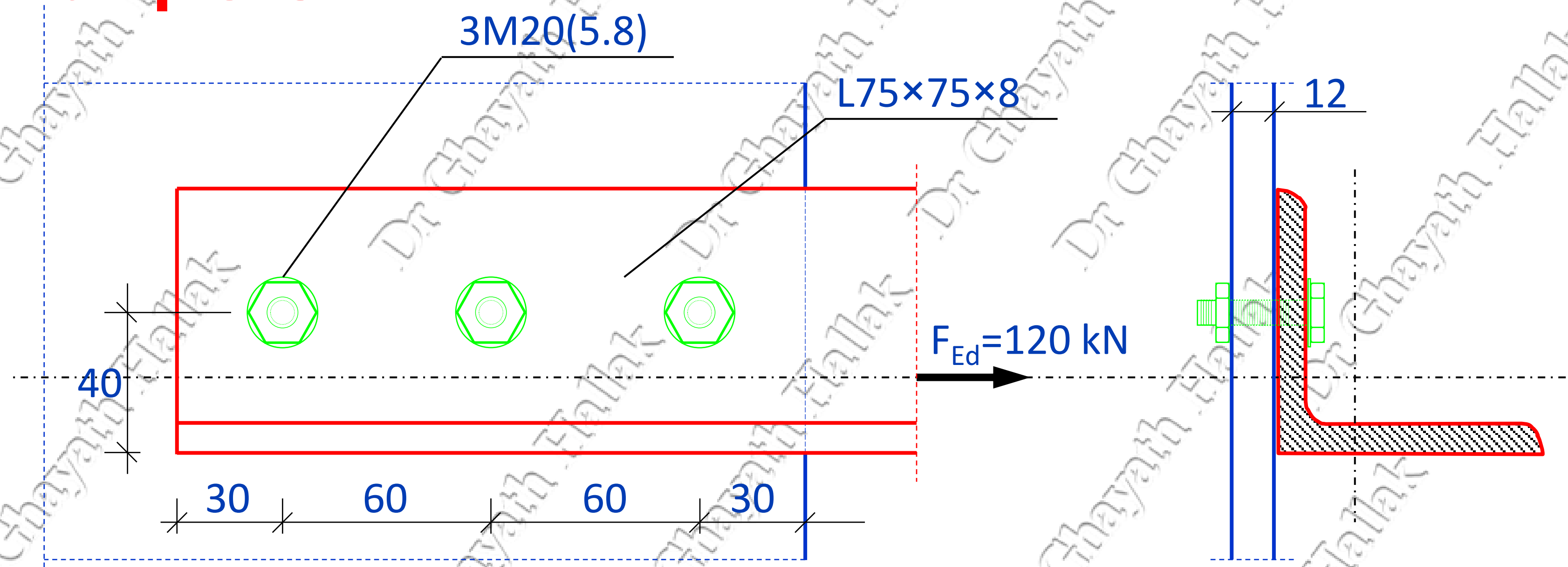
Minimum and maximum spacing, end and edge distances checking (Table 3-3 EN 1993-1-8 : 2005 (E)):

$p_{1min} = 2.2d_0 = 2.2\times22 = 48.4$ mm < 60 mm /OK/

$p_{1max} = \min.(14t = 14\times8 = 112;\ 200) = 112 > 60$ mm /OK/

SIMPLE CONNECTIONS Examples

Example: 3



The thread of a fit bolt should be included in the shear plane

Design resistance for individual fastener subjected to shear per shear plane (Table 3-4 EN 1993-1-8 : 2005 (E)):

$$F_{v,Rd} = \frac{\alpha_v\, f_{ub}\, A_s}{\gamma_{M2}} = \frac{0.5 \times 500 \times 245}{1.25} = 49000\ N = 49\ kN$$

α_v=0.5 for strength grades 4.8, 5.8, 6.8 and 10.9

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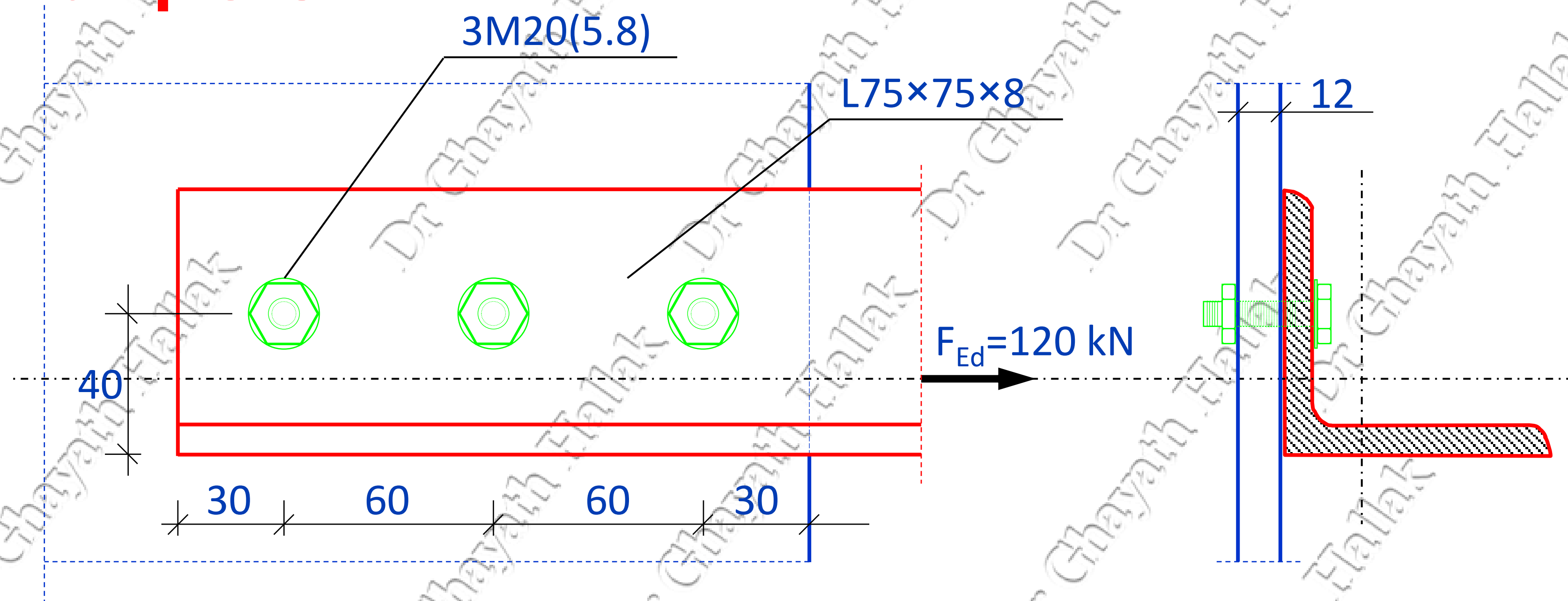
SIMPLE CONNECTIONS Examples

Example: 3



Bearing resistance (Table 3-4 EN 1993-1-8 : 2005 (E))

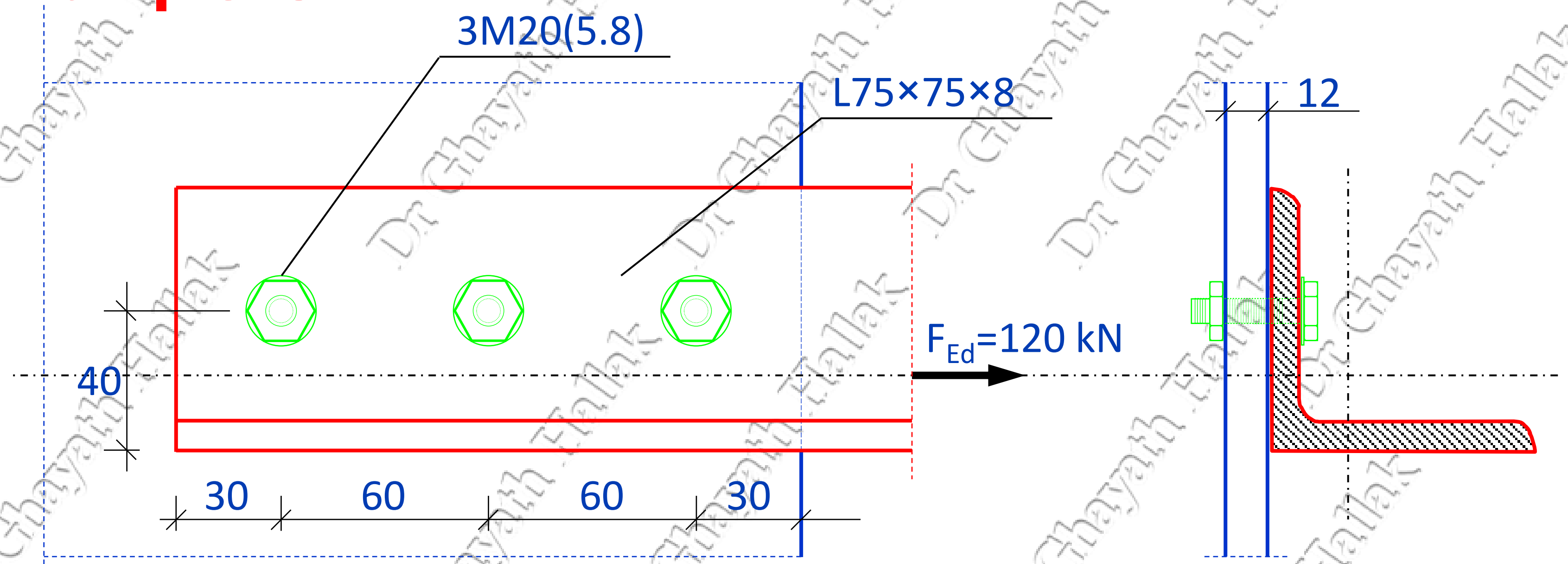
$$F_{b,Rd} = \frac{k_1 \alpha_b f_u \, d \, t}{\gamma_{M2}}$$

1- End bolts bearing on angle

t_1 = 8 mm, f_u = 510 MPa, d = 20 mm, $\gamma_{M2} = 1.25$

SIMPLE CONNECTIONS Examples

Example: 3



Bearing resistance (Table 3-4 EN 1993-1-8 : 2005 (E))

1- End bolts bearing on angle

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u \, d \, t}{\gamma_{M2}}$$

$$\alpha_d = \frac{e_1}{3d_0} = \frac{30}{3 \times 22} = 0.455$$

$$\alpha_b = min.\left(\alpha_d;\ \frac{f_{ub}}{f_u};\ 1.0\right) = min.\left(0.455;\ \frac{500}{510} = 0.98;\ 1.0\right) = 0.455$$

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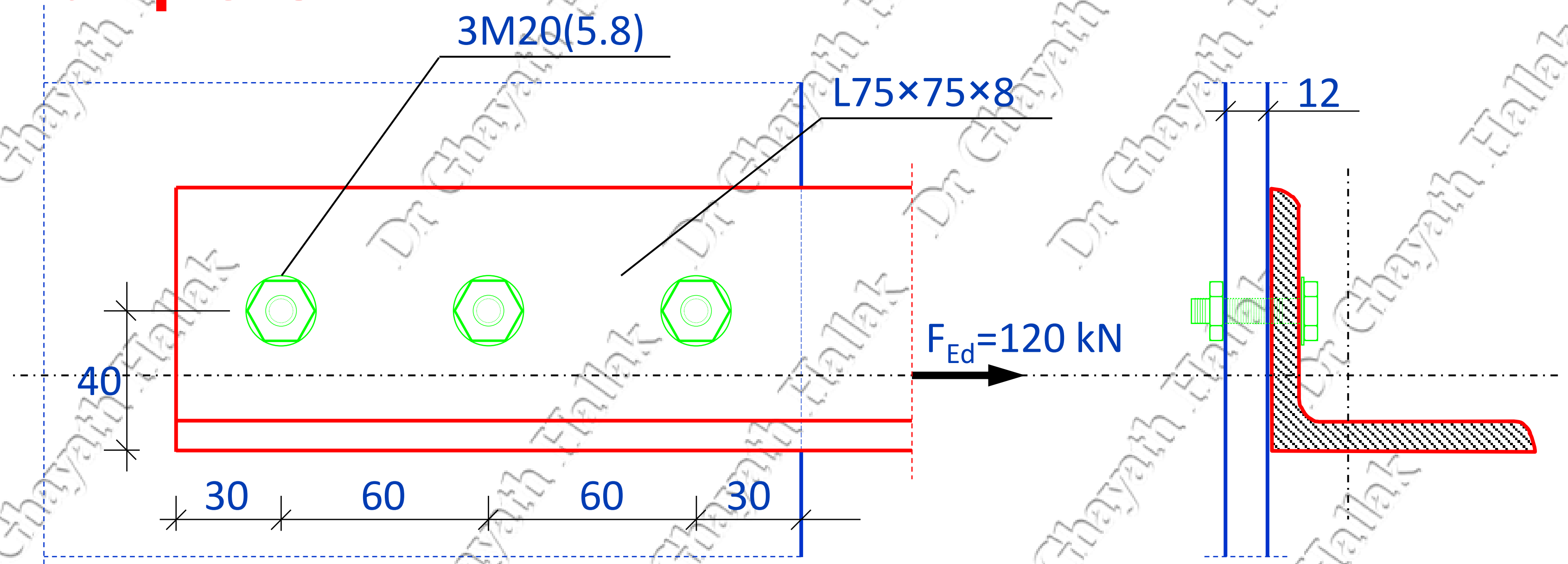
SIMPLE CONNECTIONS Examples

Example: 3



Bearing resistance (Table 3-4 EN 1993-1-8 : 2005 (E))

1- End bolts bearing on angle

$$k_1 = min.\left(2.8\frac{e_2}{d_0} - 1.7;\ 2.5\right) = min.\left(2.8 \times \frac{35}{22} - 1.7 = 2.75;\ 2.5\right) = 2.5$$

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u\, d\, t}{\gamma_{M2}} = \frac{2.5 \times 0.455 \times 510 \times 20 \times 8}{1.25} = 74256\, N = 74.256\, kN$$

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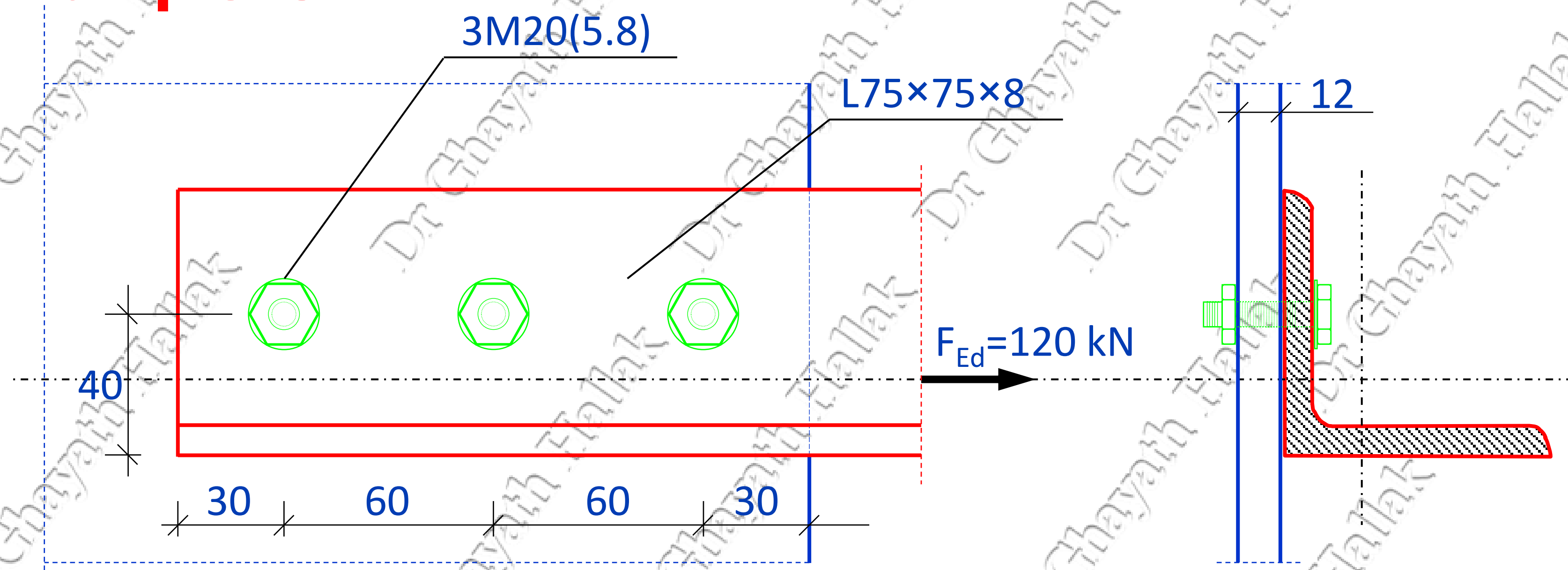
SIMPLE CONNECTIONS Examples

Example: 3



Bearing resistance (Table 3-4 EN 1993-1-8 : 2005 (E))

1- Inner bolts bearing on angle

$t_1 = 8$ mm, $f_u = 510$ MPa, $d = 20$ mm, $\gamma_{M2} = 1.25$

$$\alpha_d = \frac{p_1}{3d_0} - \frac{1}{4} = \frac{60}{3 \times 22} - \frac{1}{4} = 0.66$$

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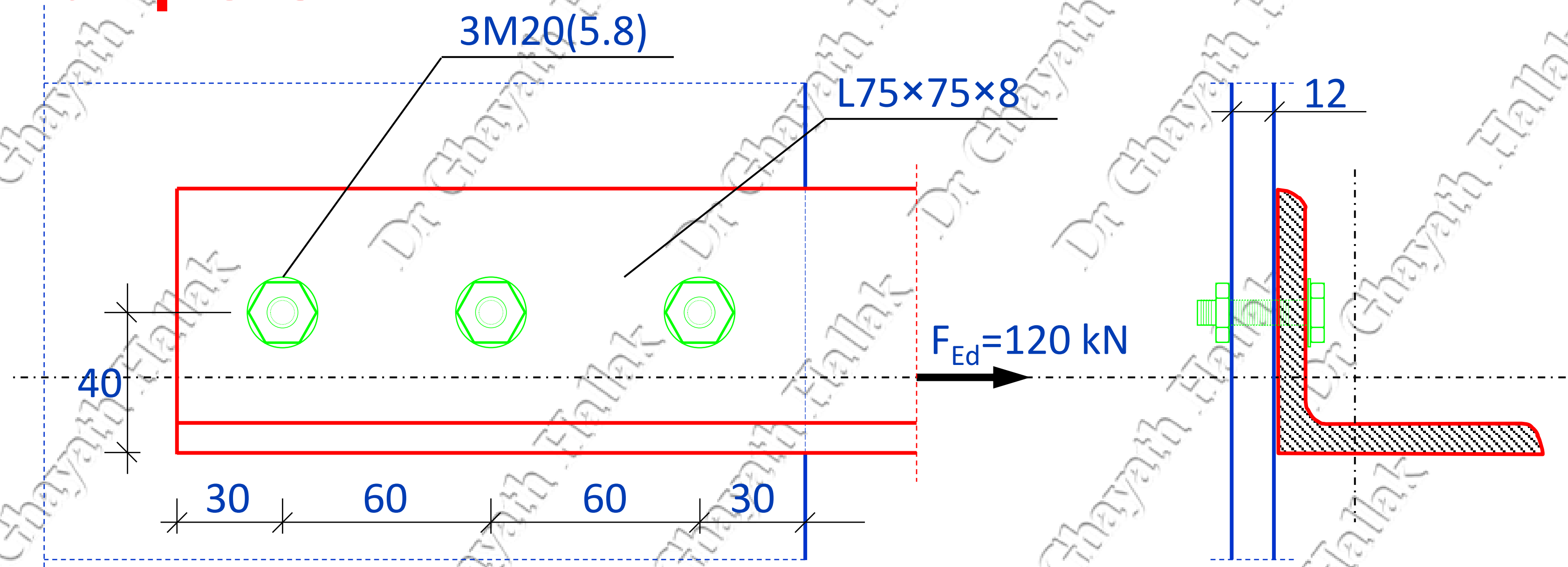
SIMPLE CONNECTIONS Examples

Example: 3



Bearing resistance (Table 3-4 EN 1993-1-8 : 2005 (E))

1- Inner bolts bearing on angle

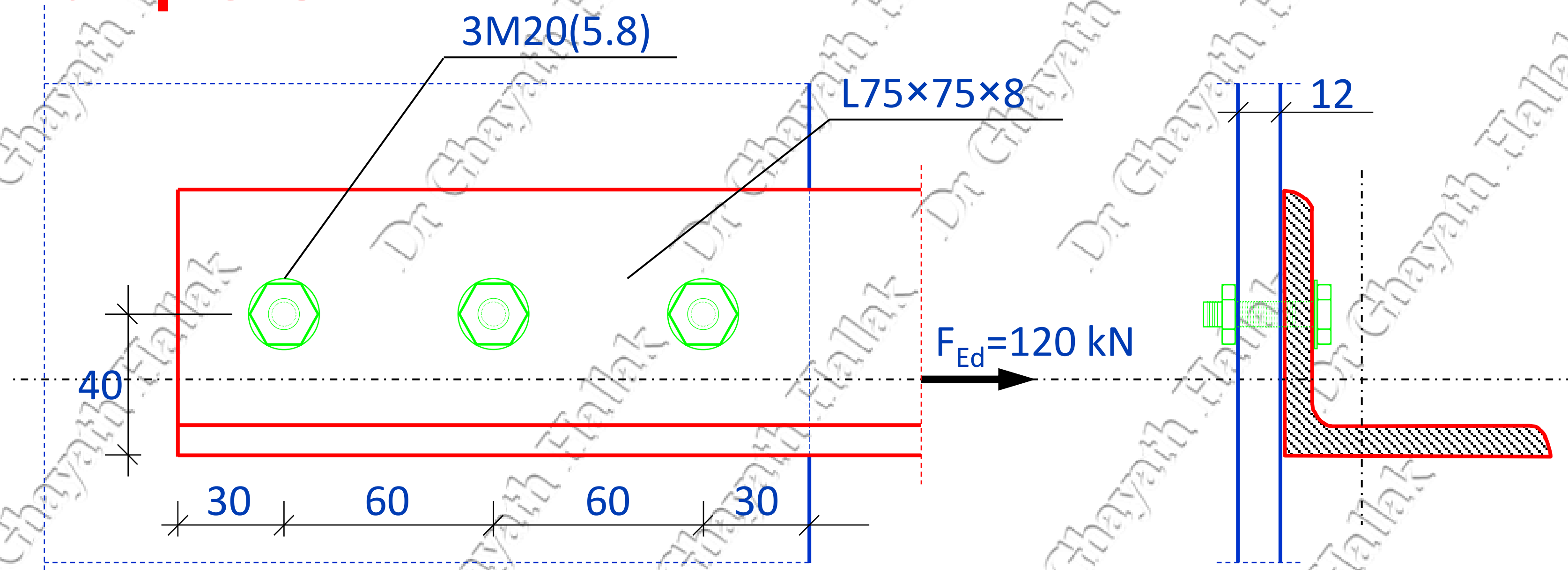
$$\alpha_b = min.\left(\alpha_d;\ \frac{f_{ub}}{f_u};\ 1.0\right) = min.\left(0.66;\ \frac{500}{510} = 0.980;\ 1.0\right) = 0.66$$

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u\, d\, t}{\gamma_{M2}} = \frac{2.5 \times 0.66 \times 510 \times 20 \times 8}{1.25} = 107712\ N$$

$$= 107.712\ kN$$

SIMPLE CONNECTIONS Examples

Example: 3



$$F_{V,Rd} = n_b \; F_{Rd,mini}$$

$$F_{Rd,min} = \min.(F_{V,Rd;}\; F_{b,Rdi}) = \min.(49;\, 74.256;\, 107.712) = 49 \text{ kN}$$

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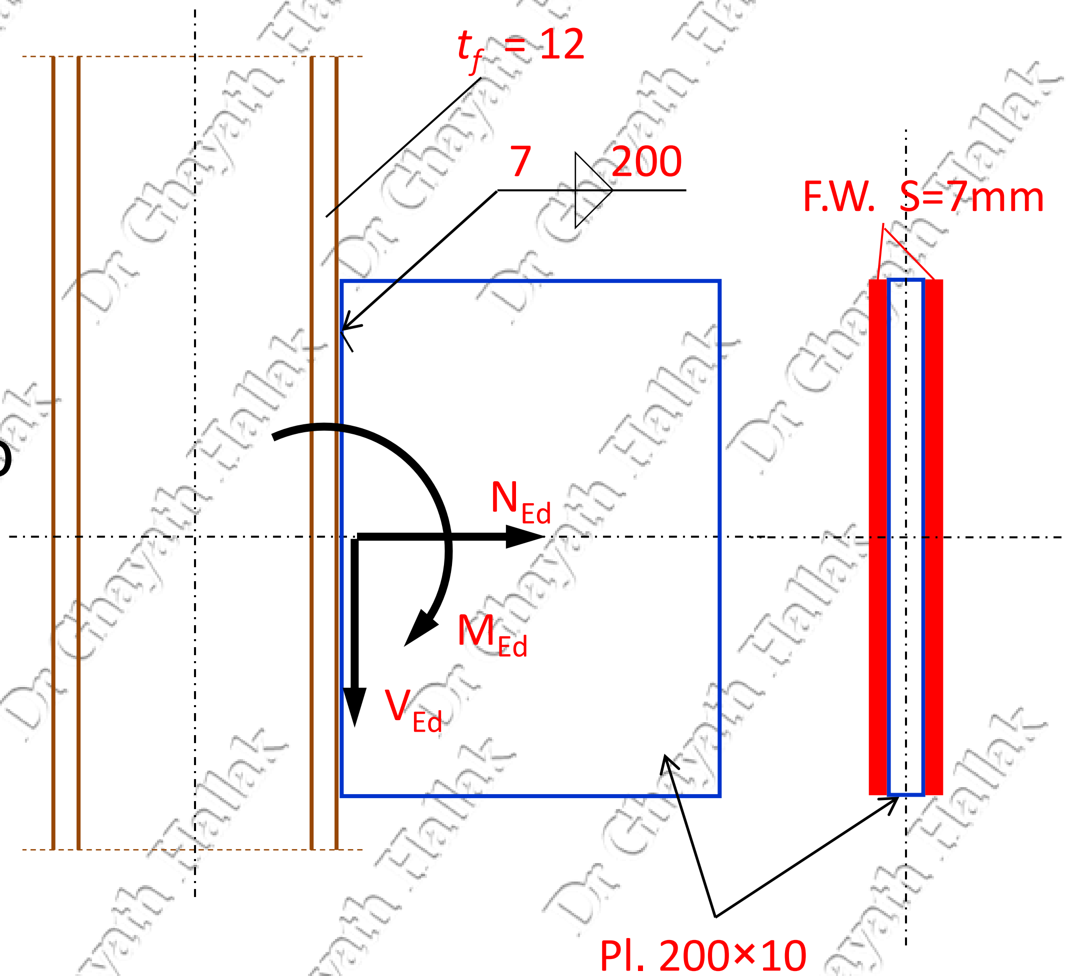
SIMPLE CONNECTIONS Examples

Example: 4

The Fig. shows a fillet weld connection of a Gusset Plate (200x10) into steel column. The connection subjected to N_{Ed}=100kN , V_{Ed}=100kN, M_{Ed}=10kN.m. Check the fillet welds needed to connect the gusset plate to the column using Grade S275 steel. (poor weld)



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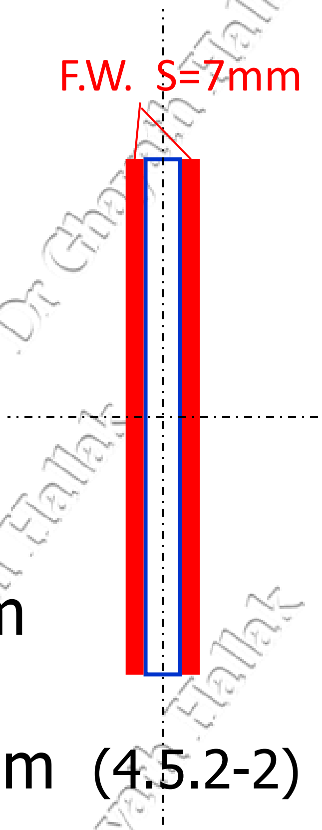
SIMPLE CONNECTIONS Examples

Steel S275 (t<40) →

f_y = 275 MPa; f_u=430MPa

Directional method:

$$\sqrt{\sigma_{\perp}^2 + 3\left(\tau_{\perp}^2 + \tau_{\parallel}^2\right)} \leq \frac{f_u}{\beta_w \gamma_{M2}} \text{ and } \sigma_{\perp} \leq \frac{0.9 f_u}{\gamma_{M2}}$$



Check a_w=0.7 S =0.7(7)=4.9mm

$0.2t_{max} \leq a_w \leq 0.7t_{min}$ but $a_w \geq 3$mm

$0.2 \times 12 = \mathbf{2.4} \leq a_w \leq 0.7 \times 10 = \mathbf{7.0} > a_{w,min} = \mathbf{3}$mm (4.5.2-2)

a_w = 4.9 mm **/OK/**

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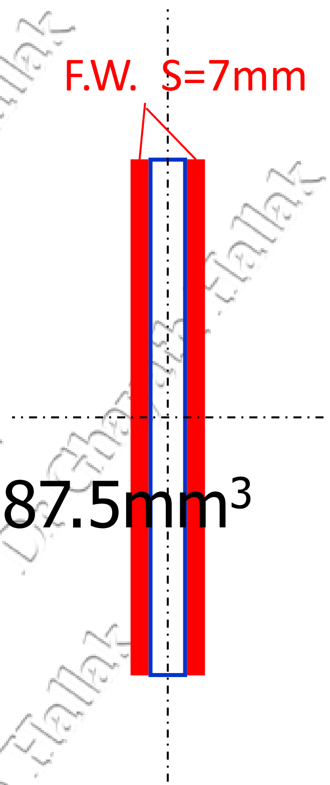
SIMPLE CONNECTIONS Examples

Directional method:



$$\sqrt{\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)} \le \frac{f_u}{\beta_w \gamma_{M2}} \text{ and } \sigma_{\perp} \le \frac{0.9 f_u}{\gamma_{M2}}$$

$$A_w = 2a \mathscr{L}_{eff} = 2\times4.9\times(200-2\times4.9) = 1864 \text{ mm}^2$$

$$W_w = 2a \mathscr{L}_{eff}^2/6 = 2\times4.9\times(200-2\times4.9)^2/6 = 59087.5 \text{mm}^3$$

$$\sigma_w = \frac{N_{Ed}}{A_w} + \frac{M_{Ed}}{W_w} = \frac{100\times10^3}{1864} + \frac{10\times10^6}{59087.5} = 223 MPa$$

$$\sigma_{\perp} = \tau_{\perp} = \frac{\sigma_w}{\sqrt{2}} = \frac{223}{\sqrt{2}} = 157.7 MPa < \frac{0.9\times430}{1.25} = 309.6 MPa$$

$$\tau_X = \frac{V_{Ed}}{A_w} = \frac{100\times10^3}{1864} = 53.6 MPa$$

$$\sqrt{157.7^2 + 3(157.7^2 + 53.6^2)} = 328.8 MPa < \left\{ \frac{fu}{\beta_w \gamma_{M2}} = \frac{430}{0.85\times1.25} = 404.7 MPa \quad OK \right.$$

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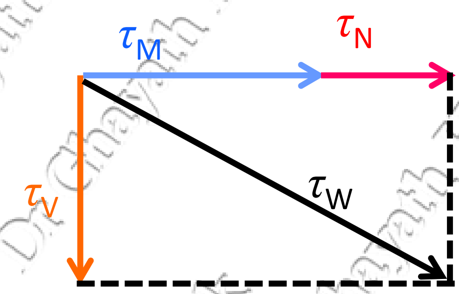
SIMPLE CONNECTIONS Examples

Simplified method



$$\tau_M = \frac{M_{Ed}}{W_w} = \frac{10 \times 10^6}{59087.5} = 169.2 MPa$$

$$\tau_N = \frac{N_{Ed}}{A_w} = \frac{100 \times 10^3}{1864} = 53.6 MPa$$

$$\tau_V = \frac{V_{Ed}}{A_w} = \frac{100 \times 10^3}{1864} = 53.6 MPa$$

$$\tau_w = \sqrt{(\tau_M + \tau_N)^2 + \tau_V^2} = \sqrt{(169.2 + 53.6)^2 + 53.6^2} = 229.2 MPa <$$

$$\left\{ \frac{fu}{\sqrt{3}\beta_w \gamma_{M2}} = \frac{430}{\sqrt{3} \times 0.85 \times 1.25} = 233.65 MPa \quad OK \right.$$

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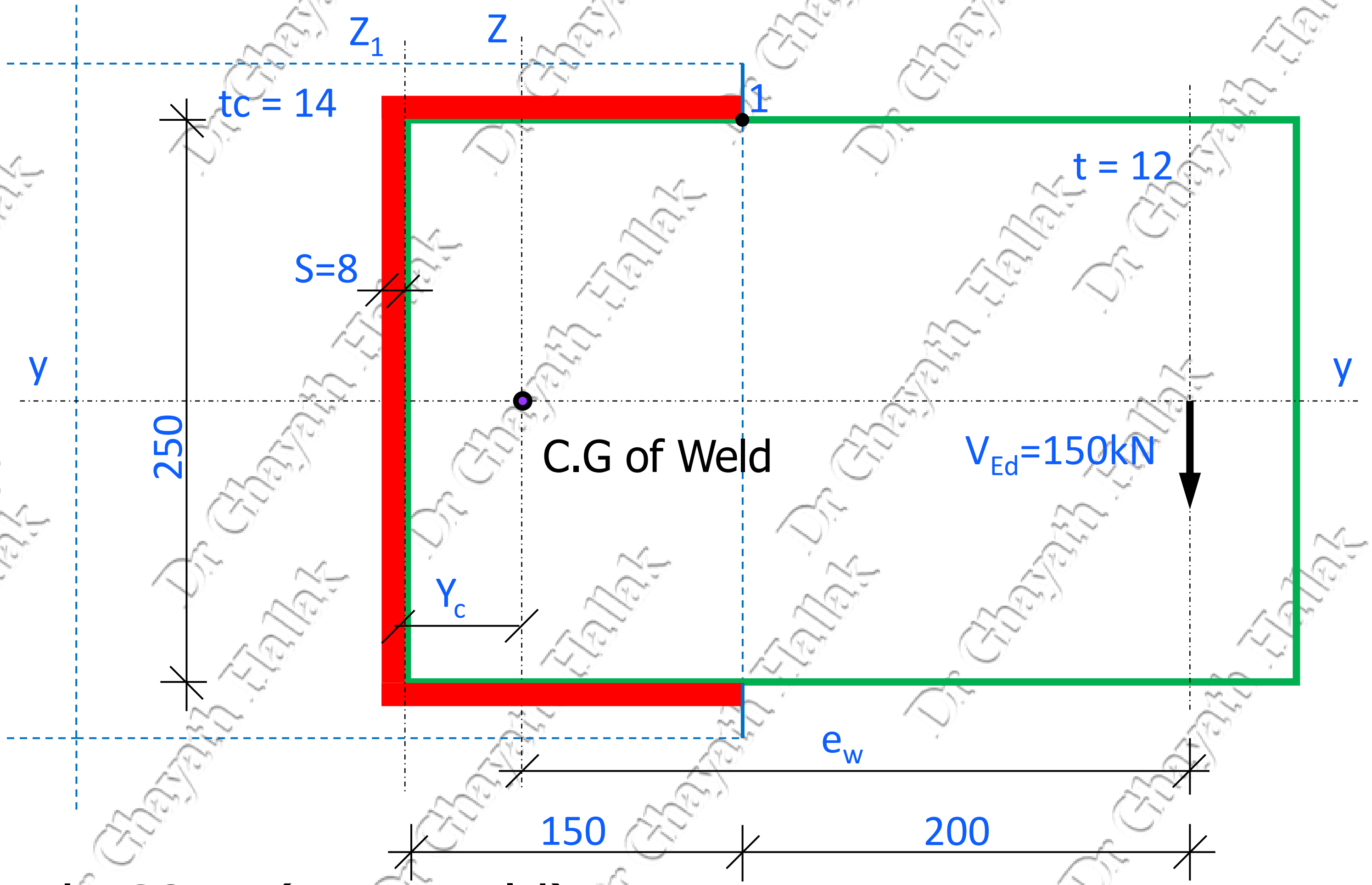
SIMPLE CONNECTIONS Example: 5

The Fig. shows a fillet weld connection of a Gusset Plate into steel column. The connection subjected to V_{Ed}=100kN.

Check the fillet welds needed to connect the gusset plate to the column



using Grade S275 (poor weld)

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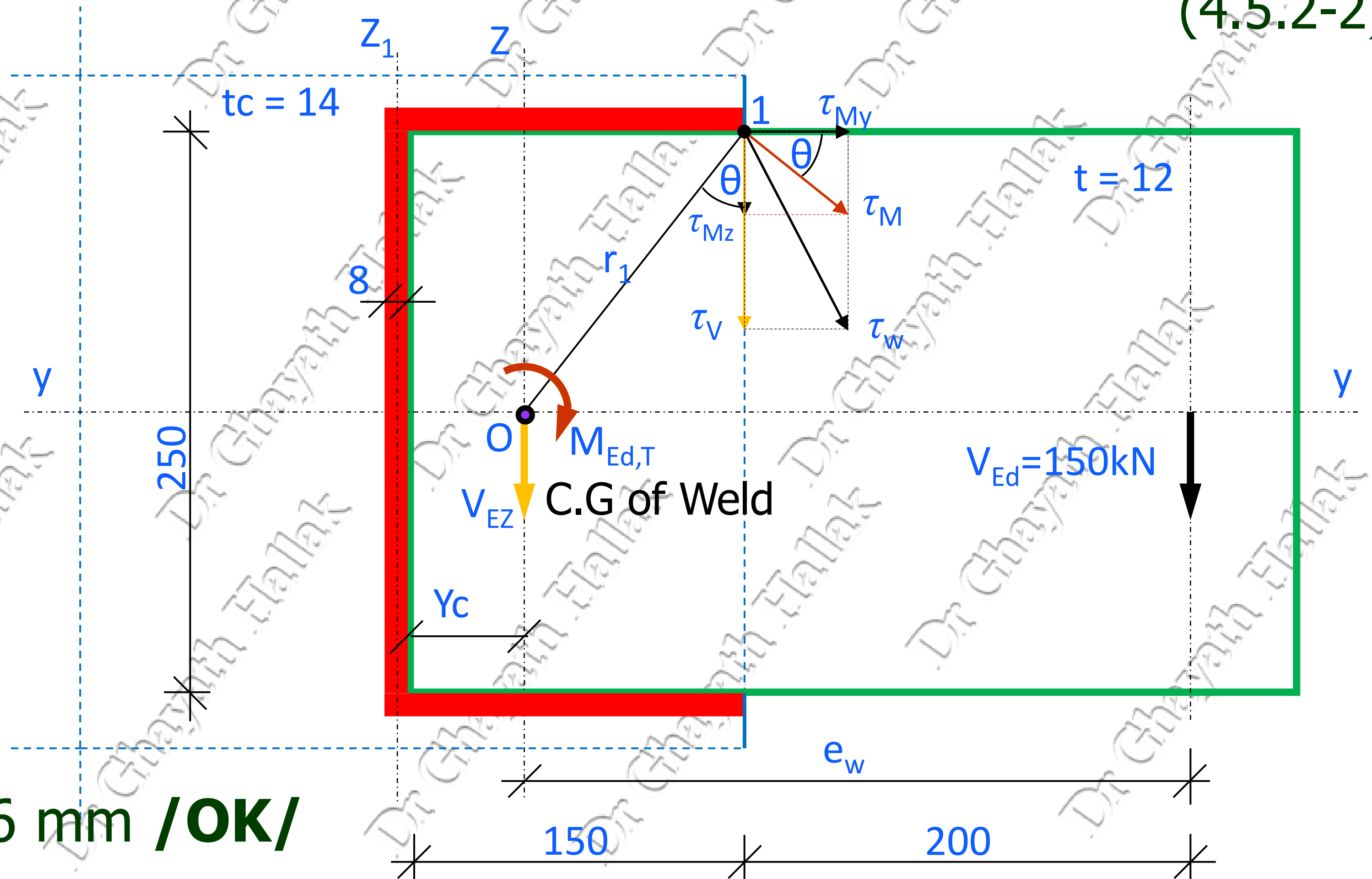
SIMPLE CONNECTIONS Example: 5

Steel S275 (t<40) → f_y = 275 MPa; f_u = 430MPa, a_w = 0.7S=5.6mm

Check a_w: $0.2t_{max} \leq a_w \leq 0.7t_{min}$ but $a_w \geq 3$mm

$0.2\times 14 = \mathbf{2.8} \leq a_w \leq 0.7\times 12 = \mathbf{8.4} > a_{w,min} = \mathbf{3}$mm

(4.5.2-2)



a_w = 5.6 mm **/OK/**

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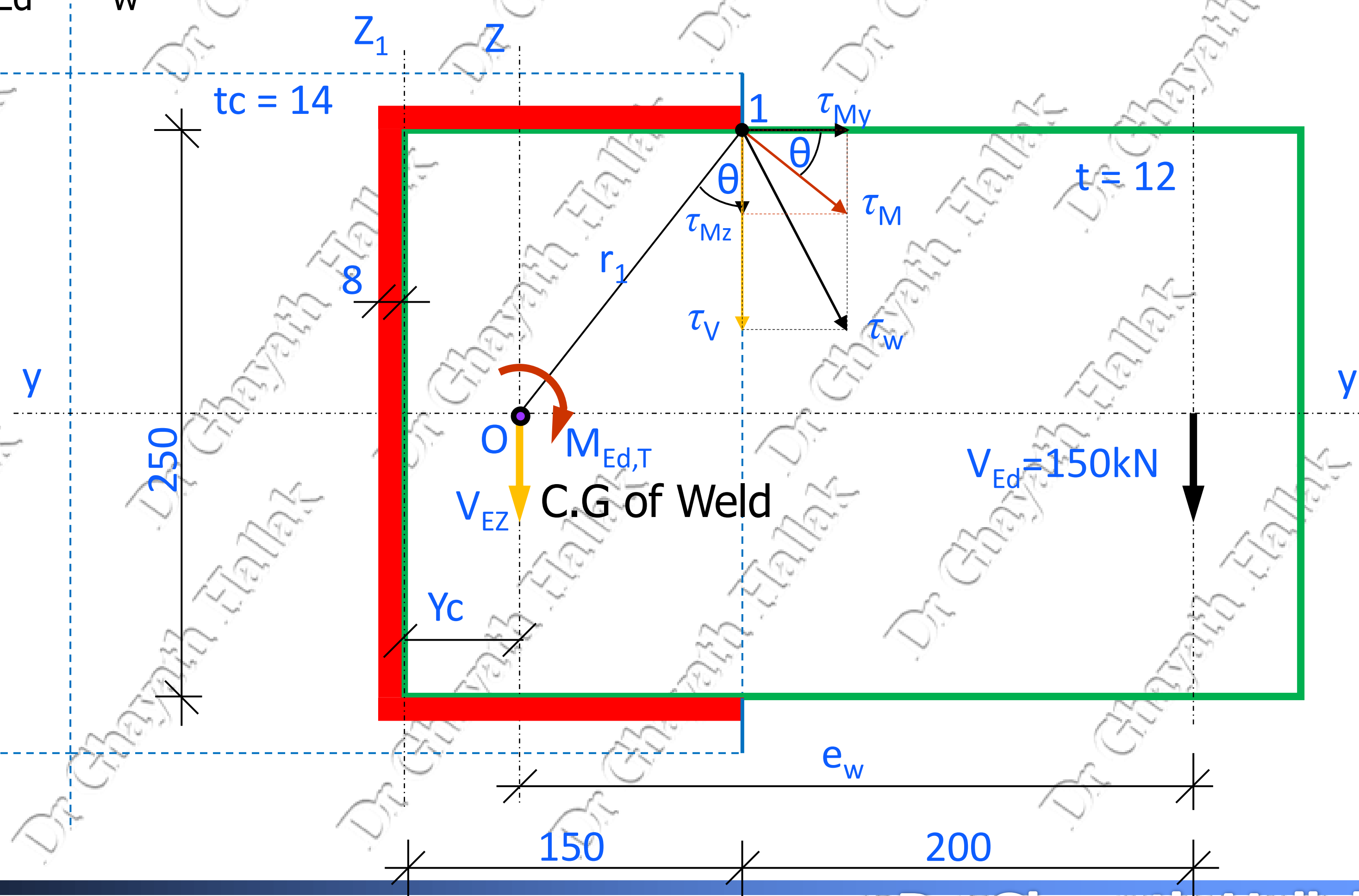
SIMPLE CONNECTIONS Example: 5

$Yc = \sum Li\, Yi / \sum Li = (250\times0+150\times75\times2)/(250+150*2) = 40.91mm$

$e_w = 200+150-40.91 = 309.1mm$, $V_{Ez} = V_{Ed} = 150\ kN$

$M_{Ed,T} = V_{Ed}\ .\ e_w = 150\times309.1 = 46365\ KN.mm = 46.365kN.m$



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SIMPLE CONNECTIONS Example: 5

$r_1=\sqrt{y_1^2+z_1^2}=\sqrt{(109.09)^2+(125)^2}=165.91\text{mm}$

$I_{wy}=250^3\times5.6/12+2\times150\times5.6\times125^2=33.54\times10^6\ \text{mm}^4$

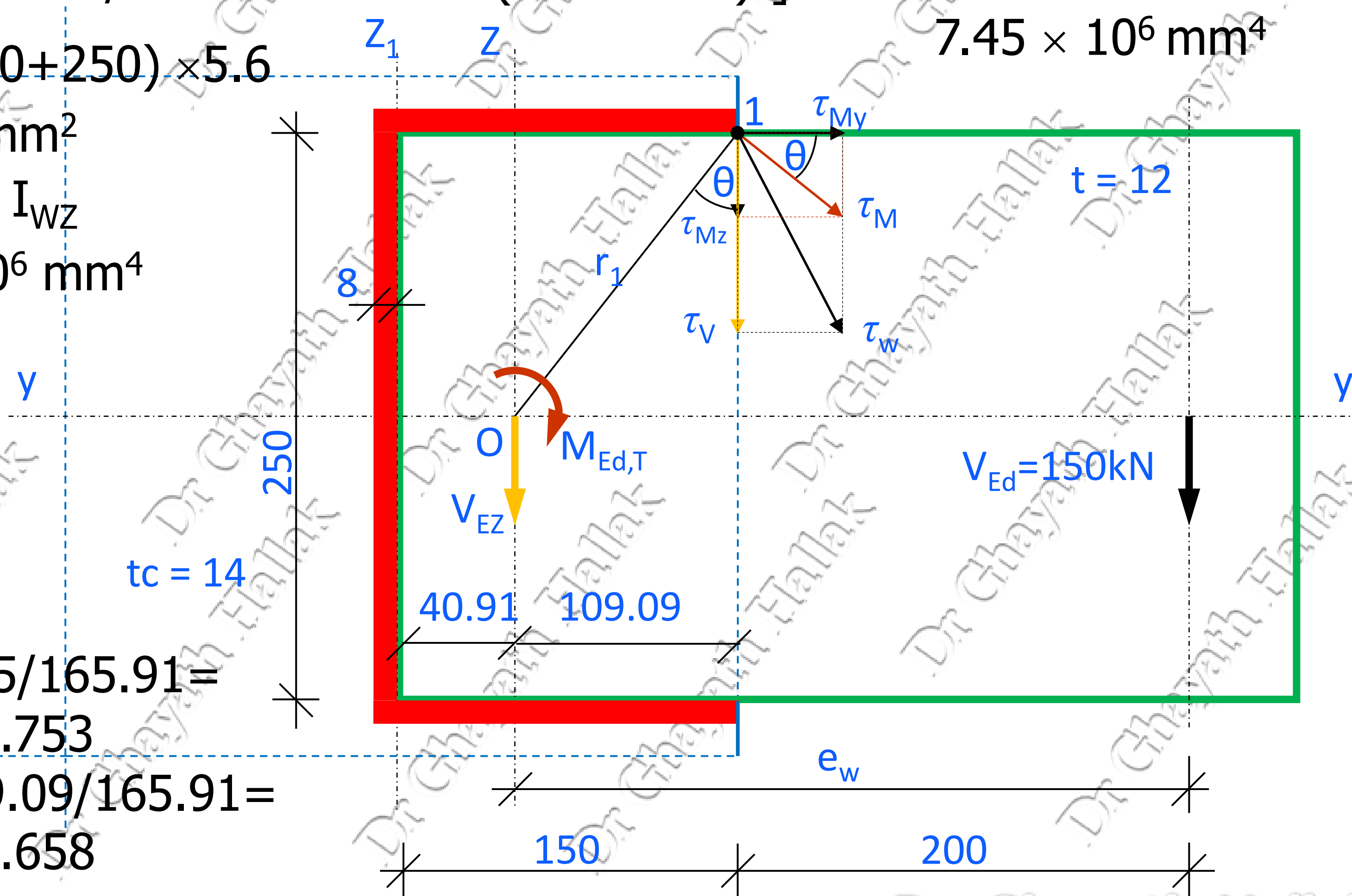
$I_{wz}=2[150^3\times5.6/12+150\times5.6\times(109.09-75)^2]+250\times5.6\times40.91^2=7.45\times10^6\ \text{mm}^4$

$A_w=(2\times150+250)\times5.6$

$A_w=3080\text{mm}^2$

$I_{wO}=I_{WY}+I_{WZ}$

$I_{wO}=41\times10^6\ \text{mm}^4$



$\text{Cos}\theta=125/165.91=0.753$

$\text{Sin}\theta=109.09/165.91=0.658$

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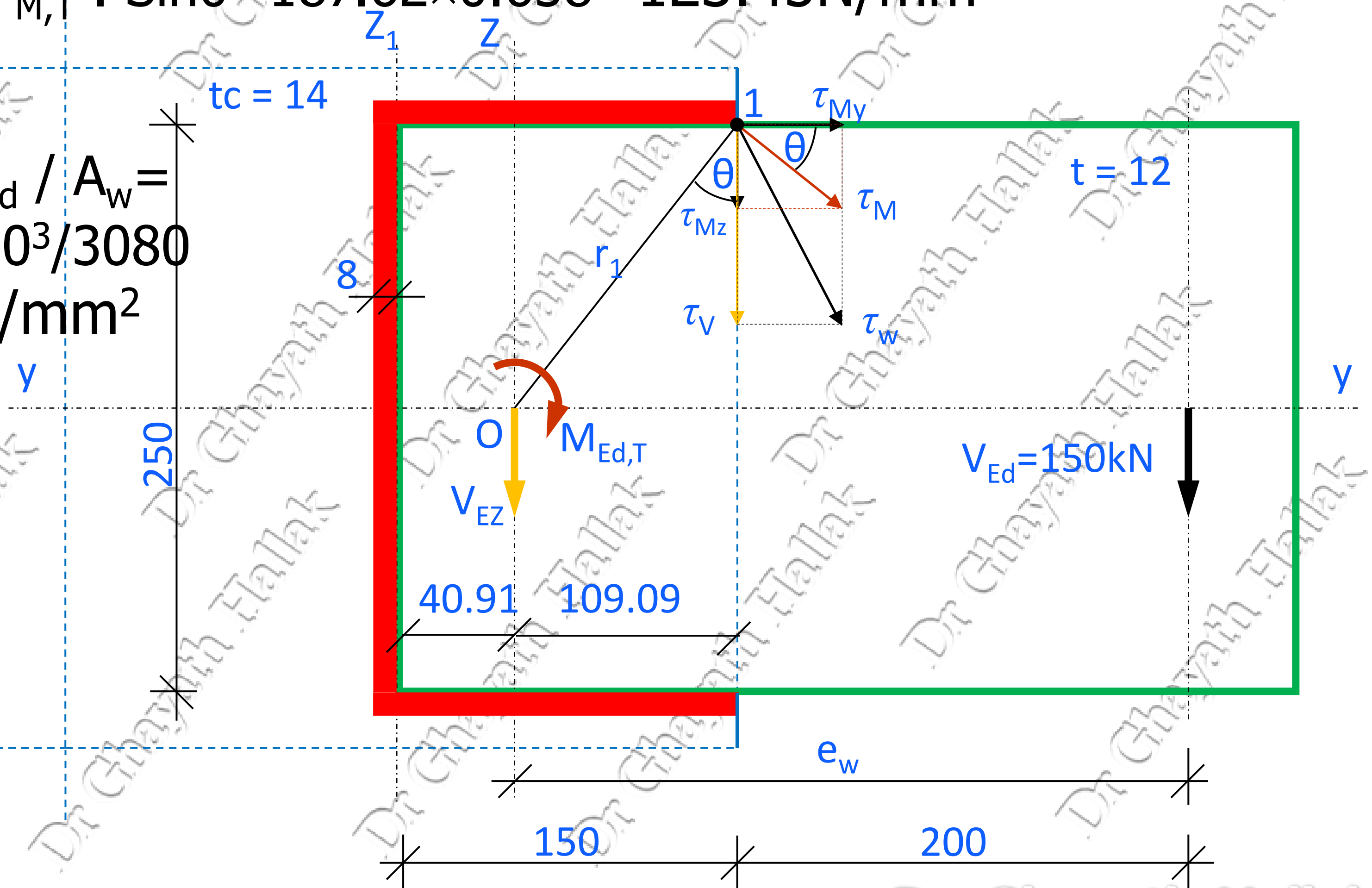
SIMPLE CONNECTIONS Example: 5

$$\tau_{M,T} = M_{Ed,T} \cdot r_1 / I_{wo} = 46.365 \times 10^6 \times 165.91 / 41 \times 10^6 = 187.62 N/mm^2$$

$$\tau_{M,T,y} = \tau_{M,T} \,.\, Cos\theta = 187.62 \times 0.753 = 141.28 N/mm^2$$

$$\tau_{M,T,z} = \tau_{M,T} \,.\, Sin\theta = 187.62 \times 0.658 = 123.45 N/mm^2$$

$$\tau_{v,z} = V_{Ed} / A_w = $$
$$= 150 \times 10^3 / 3080$$
$$= 48.7 N/mm^2$$



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SIMPLE CONNECTIONS Example: 5

$$\tau_w = \sqrt{(\tau_{M,T,y})^2 + (\tau_{M,T,z} + \tau_{v,z})^2} = \sqrt{(141.28)^2 + (123.45 + 48.7)^2}$$

$= 222.7 N/mm^2 < f_{vw,d}$ OK

$$f_{vw,d} = \frac{F_u}{\sqrt{3}\beta_w \gamma_{M2}} = \frac{430}{\sqrt{3} \times 0.85 \times 1.25} = 233.66\ MPa$$

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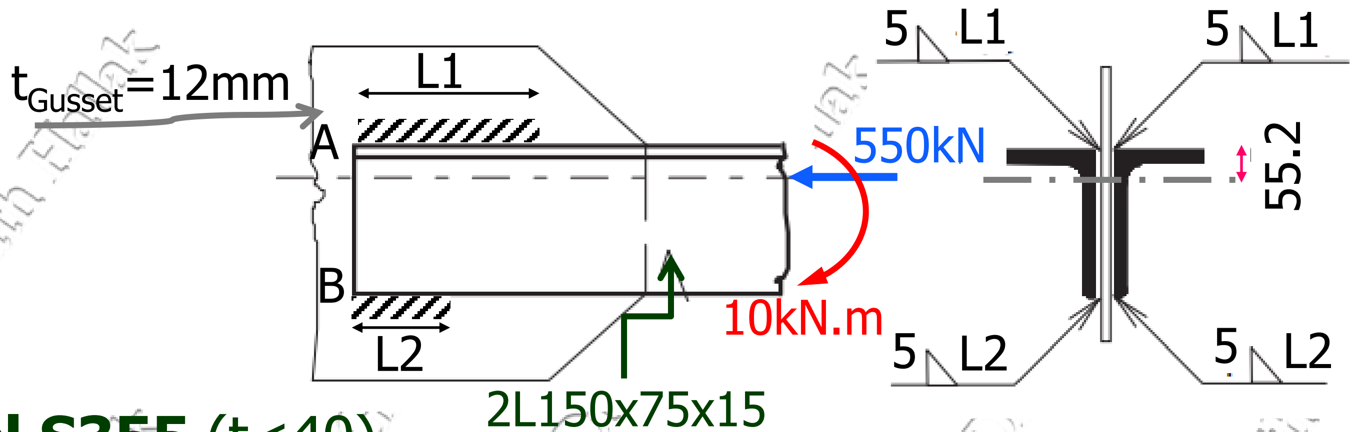
SIMPLE CONNECTIONS Example: 6

The connection shown in the Fig is subjected to factored compressive force of 550kN and a factored moment of 10kN.m. Find the length L1 and L2 of the weld. S355 and the size of the weld is 5mm.(*poor weld at the start and the stop*)



Steel S355 (t<40)

→ f_y = 355 MPa; f_u = 510MPa, a_w = 0.7S = 3.5mm

Check a_w: $0.2t_{max} \le a_w \le 0.7t_{min}$ but $a_w \ge 3$mm

$0.2{\times}15 = \mathbf{3} \le a_w \le 0.7{\times}12 = \mathbf{8.4} > a_{w,min} = \mathbf{3}$ (4.5.2-2) /OK/

Steel Section Properties L150X75X15→ C_y = 55.2mm, C_z = 18.1mm, A = 3170mm^2

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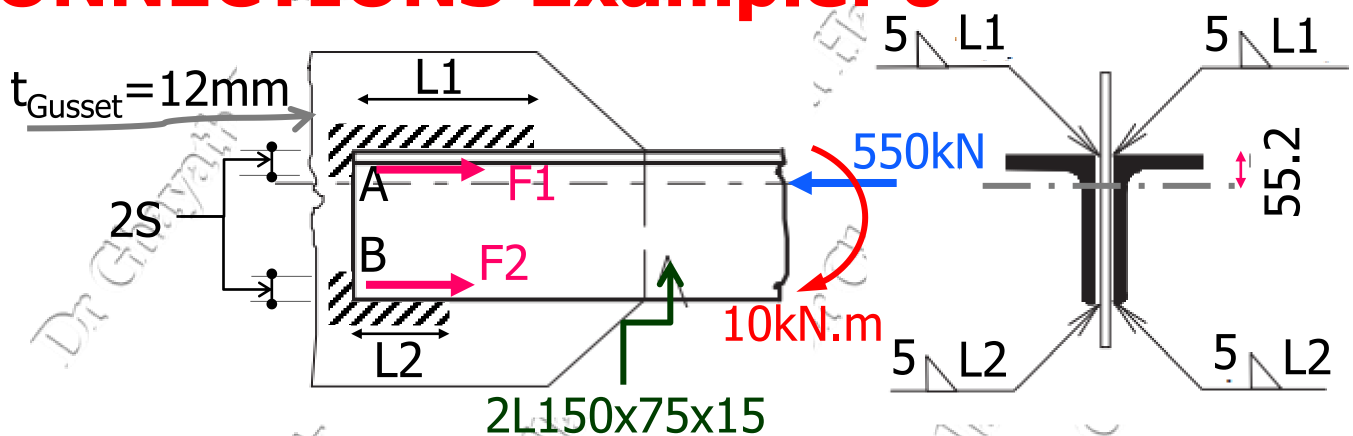
SIMPLE CONNECTIONS Example: 6



$\sum MB=0 \rightarrow 550x(150-55.2)=F1x150+10x10^3 \rightarrow F1=280.94kN$

$F1/2=$**140.47**kN at each face.

$F1+F2=F \rightarrow F2=550-280.94=269.06kN \rightarrow F2/2=$**134.53**kN at each face.

$$f_{vw,d}=\frac{F_u}{\sqrt{3}\beta_w\gamma_{M2}}=\frac{510}{\sqrt{3}\times\ 0.9\times 1.25}=\ 261.73\ N/mm^2$$

$A_{1,w}=(L_{1eff})x\ a \rightarrow \tau_1=(0.5F1)/A_{1,w}=f_{vw,d} \rightarrow 261.73=140.47x10^3/(a\ x\ L_{1eff})$ $\rightarrow L_{1eff}=153.34mm \rightarrow L_{1eff}=L_1-2a \rightarrow L_1=153.34+7=160.34mm$

→ as recommended by the code, a continues return weld of length 2S at edge A has to be provided then $L_1=160.34+2x5=170.34mm$ ∴ use 175mm

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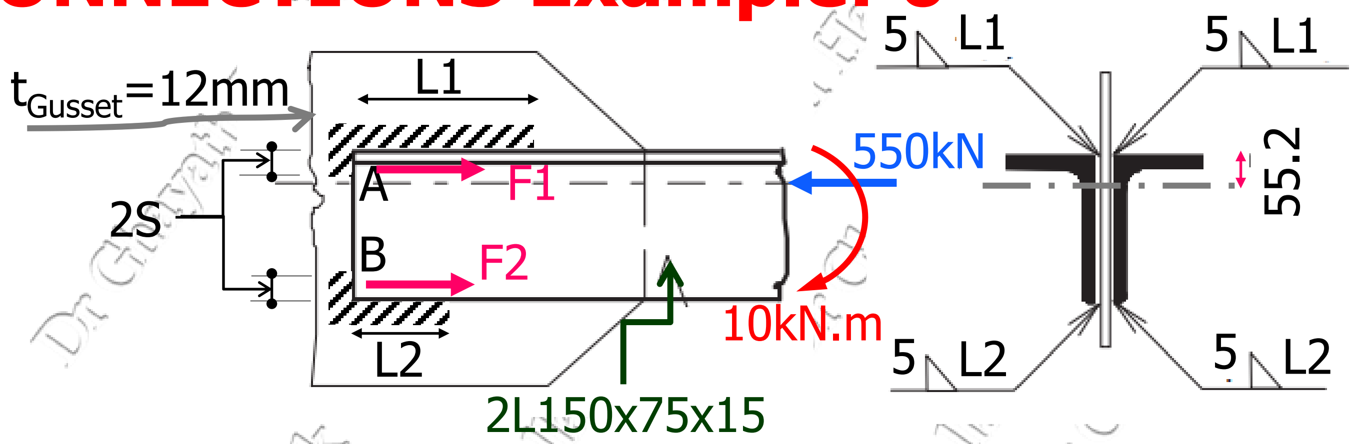
SIMPLE CONNECTIONS Example: 6



$A_{2,w}=(L_{2eff})x\ a \rightarrow \tau_2=(0.5F2)/A_{2,w}=f_{vw,d} \rightarrow 261.73=134.53x10^3/(a\ x\ L_{2eff})$
$\rightarrow L_{2eff}$ =146.86mm $\rightarrow L_{2eff} = L_2 - 2a \rightarrow L_2$ =146.56+7=153.56mm
→ as recommended by the code, a continues return weld of length 2S at edge B has to be provided then L_2 =153.56+2x5= 163.56mm ∴ use 165mm

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