

## WORKED EXAMPLE 7.2

### Fixed Column Base

Calculate the design moment resistance  $M_{Rd}$  of the fixed column base. The column base is subject to the factored force  $F_{Sd} = 500 \text{ kN}$ . The column cross-section is HE 200 B. The base plate thickness is  $30 \text{ mm}$ . The concrete foundation block dimensions are  $1600 \times 1600 \times 1000 \text{ mm}$ . The steel is Grade S235. The concrete is Grade C12/15. The material partial safety factors are  $\gamma_{M0} = 1,15$  and  $\gamma_c = 1,50$ .

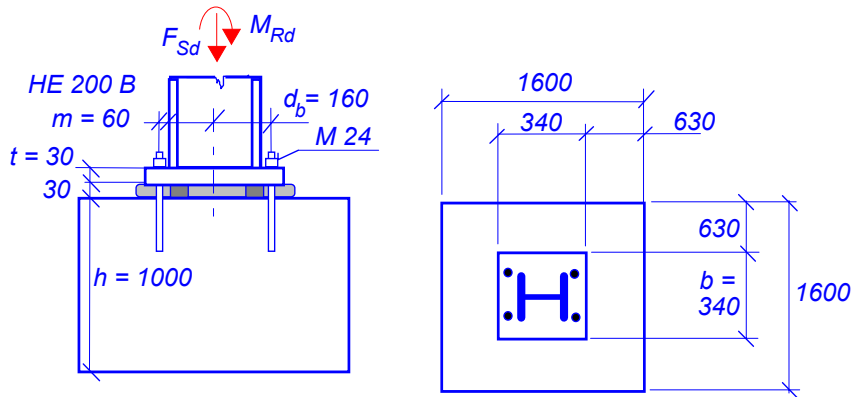


Figure 1WE7-2

#### Tension part

The tension resistance of two anchor bolts M 24 (net section  $A_s = 353 \text{ mm}^2$ ) is

$$F_{2s.Rd} = 2F_{s.Rd} = 2 f_{yb} A_s / \gamma_{Mb} = 2 * 235 * 353 / 1,45 = 114 * 10^3 \text{ N}$$

The resistance of the base plate in bending loaded by the force is

$$F_{p.Rd} = \frac{W_{el} f_y}{m \gamma_{M0}} = \frac{b t^2 f_y}{6 m \gamma_{M0}} = \frac{340 * 30^2 * 235}{6 * 60 * 1,15} = 137,7 * 10^3 \text{ N} > F_{2s.Rd}$$

#### Compressed part

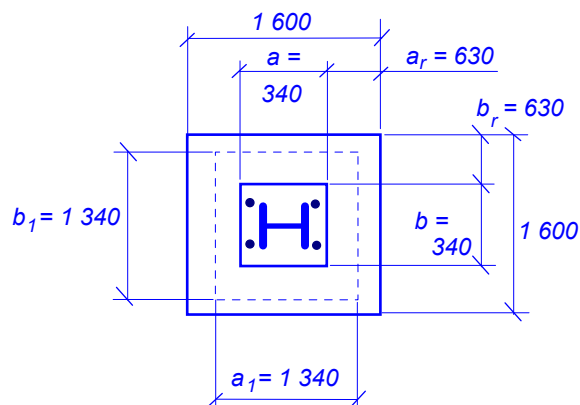


Figure 2WE7-2

For the effective cross section of the foundation block is

$$a_1 = \min \left\{ \begin{array}{l} a + 2a_r = 340 + 2 * 630 = 1\ 600 \\ 5 a = 5 * 340 = 1\ 700 \\ a + h = 340 + 1\ 000 = 1\ 340 \\ 5 b_1 = 5 * 1600 = 8\ 000 \end{array} \right\} = 1\ 340\text{mm} ,$$

and from symmetry  $a_1 = b_1$ .

The the stress concentration factor is

$$k_j = \sqrt{\frac{a_1 b_1}{a b}} = \sqrt{\frac{13\ 40 * 1\ 340}{340 * 340}} = 3,94 .$$

The bearing strength of the concrete under the base plate is

$$f_j = \frac{0,67 k_j f_{ck}}{\gamma_c} = \frac{0,67 * 3,94 * 12,0}{1,50} = 21,1\ \text{MPa} .$$

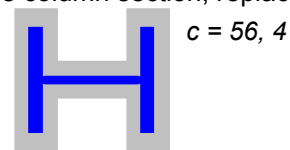
The effective area of the concrete in compression is calculated based on the force equilibrium:

$$F_{Sd} = A_{eff} f_j - F_{2s,Rd} ,$$

$$A_{eff} = \frac{F_{Sd} + F_{2s,Rd}}{f_j} = \frac{500 * 10^3 + 114 * 10^3}{21,1} = 29\ 100\ \text{mm}^2 .$$

The rigid plate of effective width  $c$ , see Fig. 5.19.3 surrounding the column section, replaces the flexible plate

$$c = t \sqrt{\frac{f_y}{3 f_j \gamma_{M0}}} = 30 * \sqrt{\frac{235}{3 * 21,1 * 1,05}} = 56,4\ \text{mm} .$$



The width of effective area is

$$b_{eff} = \frac{29\ 100}{200 + 2 * 56,4} = 93,0\ \text{mm}$$

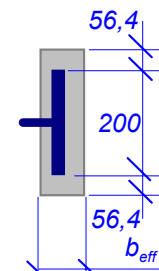


Figure 3WE7-2

The concrete lever arm is

$$d_c = h_c / 2 + c - \frac{b_{eff}}{2} = 100 + 56,4 - \frac{93,0}{2} = 109,9\ \text{mm} .$$

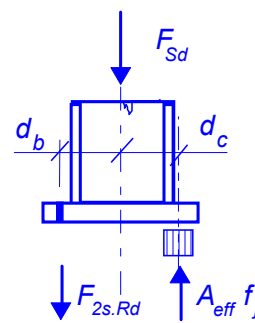


Figure 4WE7-2

The base plate bending resistance is

$$M_{Rd} = F_{2s,Rd} d_b + A_{eff} f_j d_c =$$

$$= 114 * 10^3 * 140 + 29\,100 * 21,1 * 109,9 = 83,4 * 10^6 \text{ Nmm} = 83,4 \text{ kNm} .$$

The column base transfer under axial force 500 kN the bending moment 83,4 kNm.

Notes:

1) The column normal force resistance is

$$N_{pl,Rd} = A f_y / \gamma_{M0} = 14\,910 * 235 / 1,15 = 3\,047 * 10^3 \text{ N} .$$

The column bending resistance is

$$M_{pl,Rd} = W_{pl} f_y / \gamma_{M0} = 1\,869 * 10^3 * 235 / 1,15 = 382 * 10^6 \text{ Nmm} .$$

The interaction of the normal force and bending moment:

$$M_{Sd} / M_{pl,Rd} + N_{Sd} / N_{pl,Rd} = 85,7 / 131,3 + 500 / 1\,596 = 0,97 < 1,00$$

The column cross-section resistance is higher compare to the column base resistance.

2) The column base resistance is compared to the column resistance for the different base plate thickness in Fig. 5WE7-2 For plate P 30 are shown the major points of the diagram, e.g. the pure compression, the highest bending resistance (the point of the coincidence of the neutral axis and the axis of symmetry of the cross section), the pure bending, and the pure tension.

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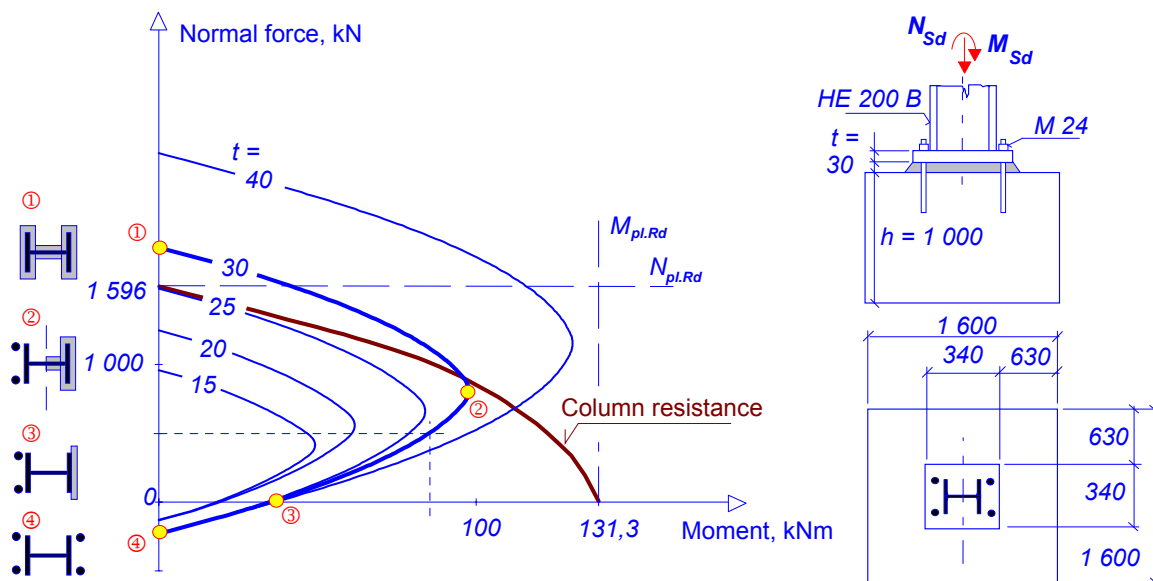


Figure 5WE7-2 The column base resistance for the different base plate thickness

Prepared based on [Wald et al, 2001].