Example 325 Stepoc Stem Calculation for a Retaining wall

The calculations assume a stem height of 3.4 m using 325 Stepoc block

These calculations are based on BS EN 1996-1-1

The following parameters are assumed for the purpose of design:

Soil unit weight γ = 19 kN/m^3
Coefficient of lateral earth pressure ka = 0.30
Surcharge = 10 kPa
γfe = 1.35 (partial load factor earth pressure)
γfq = 1.5 (partial load factor surcharge)

(Partial load factors adopted are for quick design - refer to BS EN 1997 for more detailed design approach)

Using classical Raknine soil theory:

$$\text{Pressure} = ka\,(z\,\gamma\,\gamma fe + q\,\gamma fq)$$

$$\text{Shear} = ka\left(\frac{1}{2}z^2\,\gamma\,\gamma fe + q\,z\,\gamma fq\right)$$

$$\text{Bending moment} = \frac{1}{2}ka\left(\frac{1}{3}z^3\,\gamma\,\gamma fe + q\,z^2\,\gamma fq\right)$$

Where q = surcharge & z = depth below surface in metres

Apply a stem height of 3.4 m to the above equations:

Shear force = 59.7771 kN
Bending moment = 76.4174 kNm

Establish bending steel

The bending steel area is calculated using BS EN 1996-1-1 clause 6.6.2 based on equilibrium of the stress block presented in Figure 6.4 of the standard as noted below:

$$M_{Rd} = A_s\,f_{yd}\,z \;\;\&\;\; z = d\left(1 - 0.50\,\frac{A_s\,f_{yd}}{b\,d\,f_d}\right)$$

with a moment limit from (6.24a) to limit the compressive stress block in the section:

$$M_{Rd} < 0.40\,f_d\,b\,d^2$$

Where:

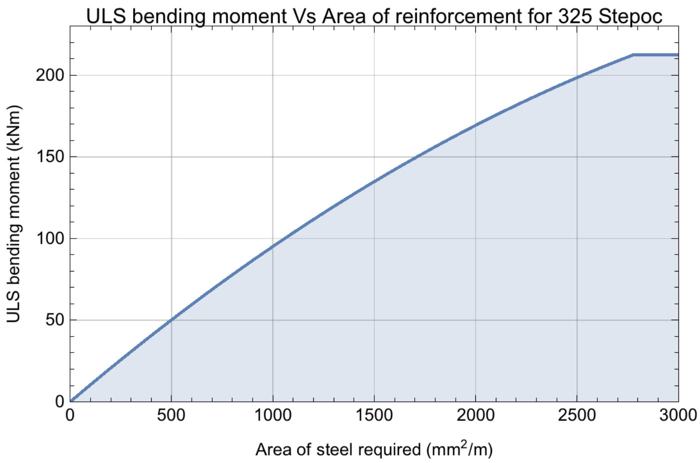
d = effect depth, γMm = partial factor of safety on material

f_d = design strength of masonry, b = breadth of section

f_{yd} = design strength of reinforcement, As = area of bending steel

These equilibrium calculations are solved and presented graphically in the Stepoc bending strength curves

Using the bending strength curves from the Stepoc literature and reading across from the moment axis to the curve and down to the area of steel:



From this graph it can be seen that the area of steel required = 784.07 mm^2

Use H16 bars at 162.5 mm centres to provide 1237.3 mm^2

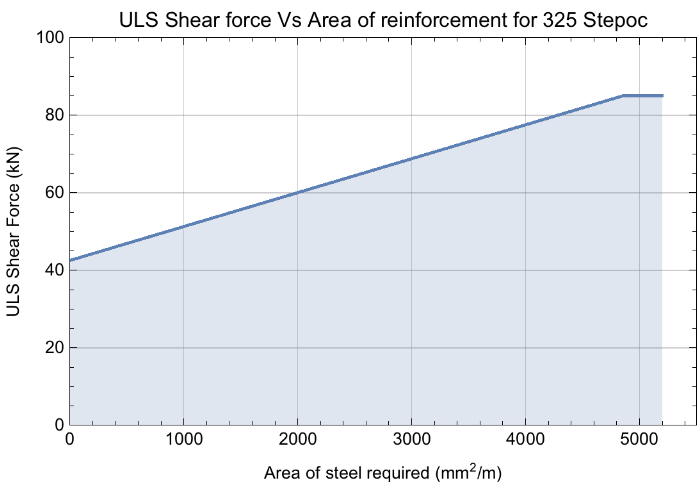
Establish the shear capacity of the section

The shear capacity of the section is assessed based on the calculation procedure within Annex J of BS EN 1996-1-1

The base design shear strength $f_{vd} = \frac{0.35 + 17.5\,\rho}{\gamma Mm}$

Where $\rho = \frac{As}{b\,d}$ (d = effective depth and b = breadth of section)

These equations are solved for shear force by multiply shear strength by the breadth and effective depth of the section the solution presented in graphical form. Below is the relevant graph



On this graph we read up from the area of bending steel that we have chosen above to calculate the basic ULS shear capacity of the section.

Shear capacity $F_{vd\,basic}$ = 53.3514 kN

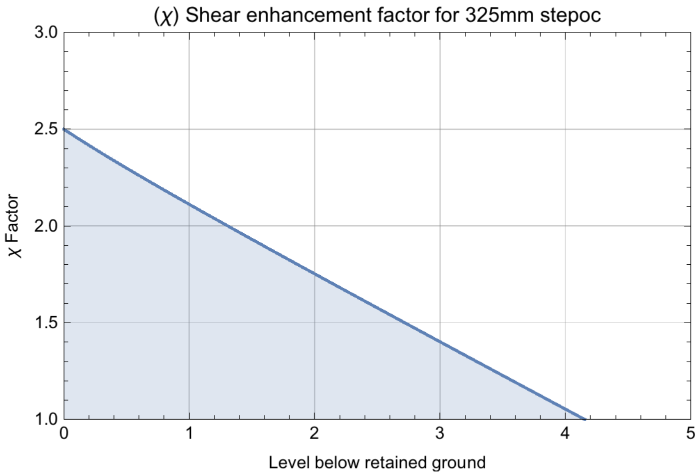
It is possible where $\frac{a_v}{d}$ in cantilevers and simply supported beams is 6 or less to enhance the shear capacity of the section. In which:

shear span $a_v = \frac{(\text{maximum moment})}{(\text{maximum shear})}$

The enhancement factor is given by: $\chi = (2.5 - 0.25\,\frac{a_v}{d})$

So the Enhanced shear capacity = $f_{vd}\ \chi$

Specifically for the common application of retaining strucutres (as the relationship between shear and moment can be defined under earth pressure) the above equations have been solved to provide the shear enhancement factor chart:



From this graph χ = 1.1848

The maximum shear occurs at the base of the retaining wall stem. Therefore, the level below retained ground that we use is the height of the stem (3.4m)

The enhancement factor is found by reading up from 3.4m to the diagonal line and across to the vertical axis

The final ULS shear capacity of the section is:

$F_{vd} = \chi\ F_{vd\,basic}$ = 1.1848 x 53.3514 = 63.2109 kN

Since this shear capacity is greater than the applied shear the section is adequate at ULS with the reinforcement stated