Plain & Reinforced Concrete-II

CE-413

Masonry Wall Footing Design

Ref. Concrete Structures Part – II, 2nd Edition
Zahid Ahmad Siddiqi
(§ 20.4.9 – 20.4.11)

By Dr. Usman Akmal

Assumptions

1. The structural load is assumed to be uniformly distributed at foundation level, neglecting the effect of openings.
2. The overlapping effect of foundations near the junction of two walls may be ignored.
3. The soil pressure distribution is assumed to be uniform in the transverse direction. A 35% increase in applied pressure may be taken when the footing is on one side of the wall and a 70% increase may be considered when the load is applied at the corner of the footing.
4. Effect of presence of beams in changing the load path is also ignored.
5. The backfill may be given half of the factor of safety against bearing (FOS = 1.5)

Design of Masonry Wall Footing

$$\text{Total Load}, W = 385 \times \left(\sum \ell_i\right) + 1920 \times \sum \left(h_i \times t_i\right) + 0.5 \times \sum \left(\ell_i \times q_i\right) kg/m$$

ℓ_i = Total clear span of the slabs supported by a wall, m

h_i = Center – to – center wall height for each story, m

t_i = Thickness of wall for any story, m

q_i = Partition load on a slab, kg/m^2

$$\text{Approximate base width}, W_{appr} = \frac{10W\gamma_2}{\left(q_a - 10D\right)}$$

γ_2 = Factor to account for eccentricity of loading

$\gamma_2 = 1.0$ For interior footing, $\gamma_2 = 1.35$ for exterior footing

$\gamma_2 = 1.70$ for corner footing

q_a = Allowable bearing capacity, kPa

D = Depth of footing from plinth level, m

Base Width of Masonry Footing

Required number of brick steps, n

$$n = \frac{W_{appr} - t - mh}{114}$$

(Round to higher whole number)

Base Width, $L = t + n \times 114 + m \times h$

L = Width of the footing, mm

t = Ground floor wall thickness, mm

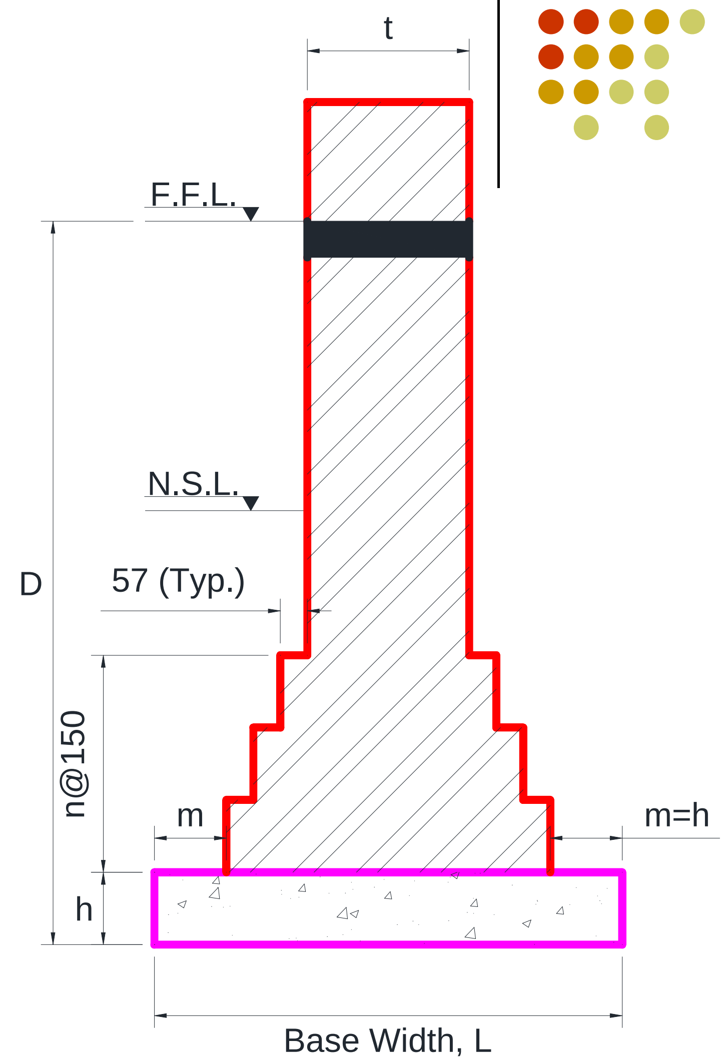
n = Number of brick steps

m = Number of overhangs of P.C.C.

m = 2 for Interior Footing

m = 1 for Exterior Footing

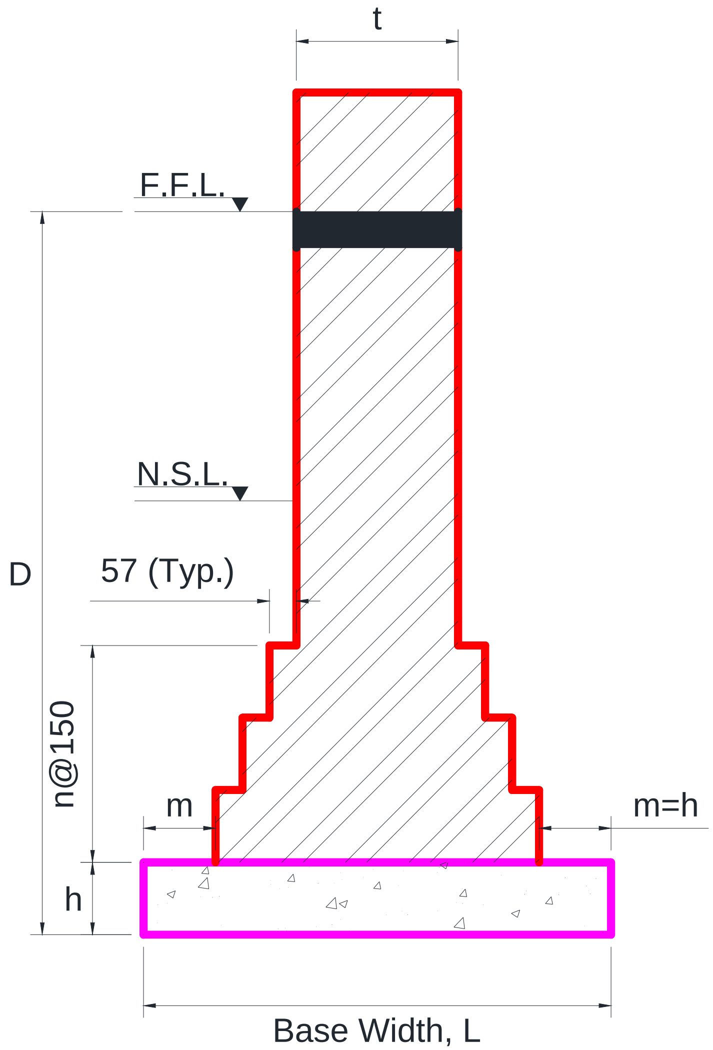
h = Thickness of P.C.C. pad under footing, mm



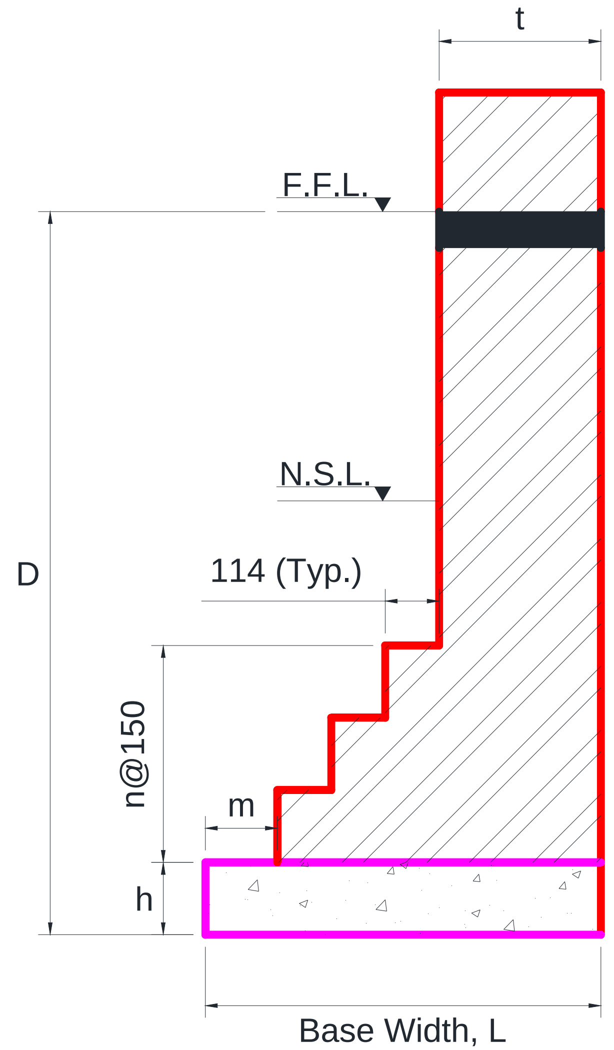
INTERNAL WALL FOOTING

Base Width of Masonry Footing (contd.)

$$\text{Base Width}, L = t + n \times 114 + m \times h$$



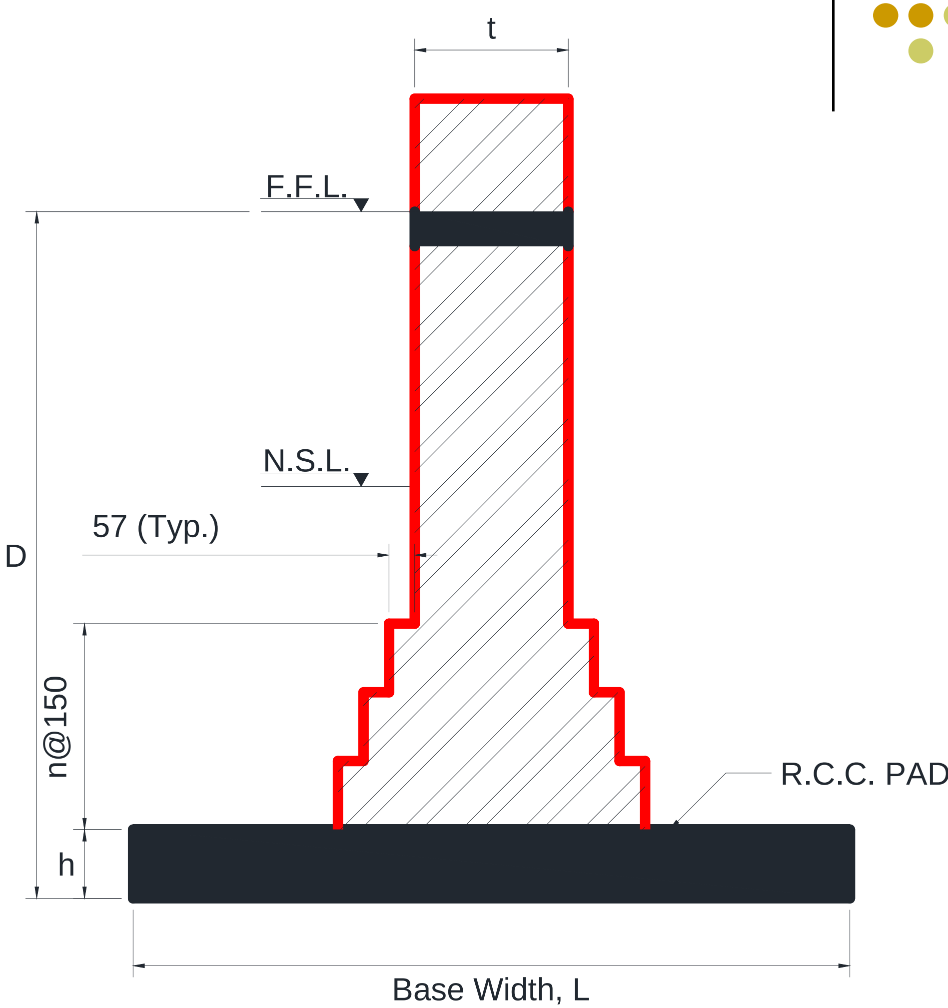
INTERNAL WALL FOOTING



EXTERNAL WALL FOOTING

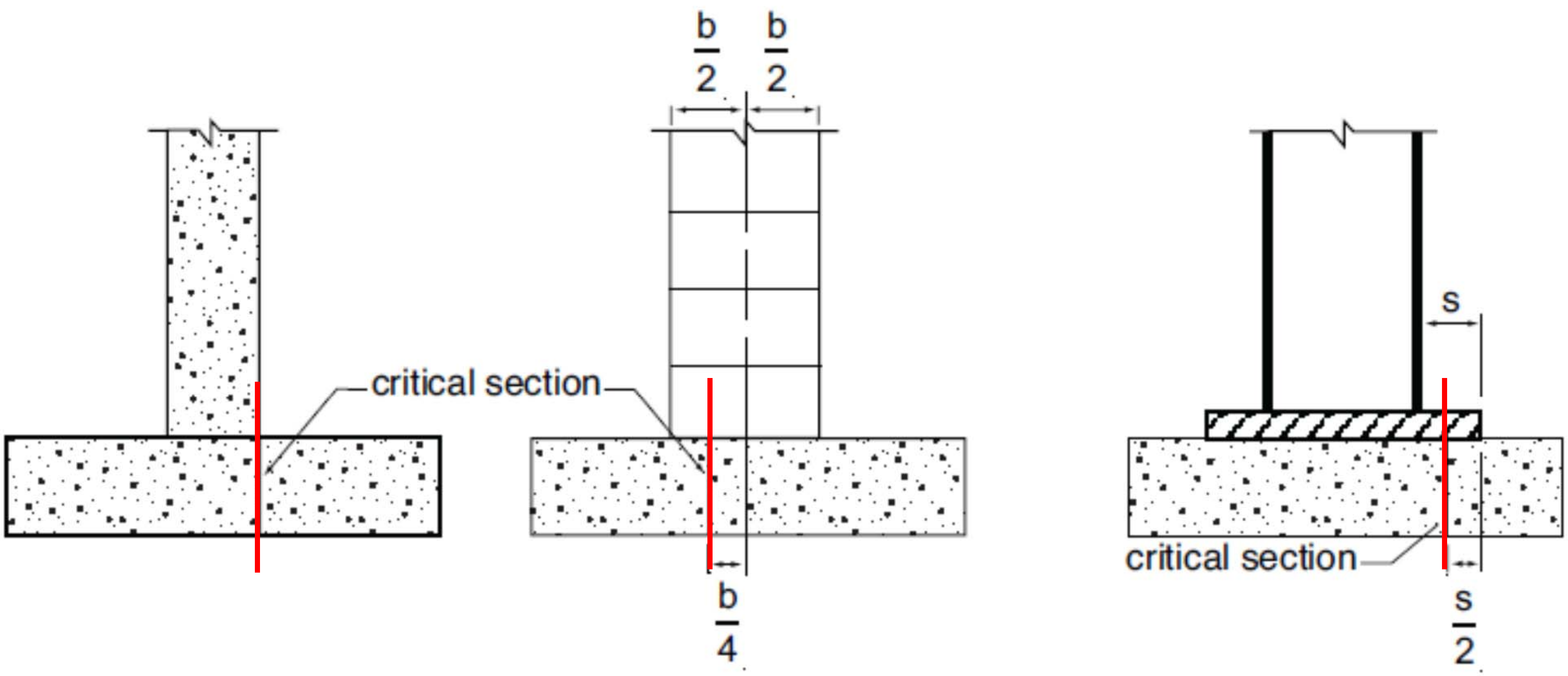
Masonry Wall Footing With RC Pad

When the wall load is very high and number of steps required to spread the load are very large, a R.C.C. pad may be designed under the brick wall footing.



BENDING MOMENT AND STEEL REINFORCEMENT

Critical Section for Moment (cont.)



(a) Concrete Column, Pedestal or Wall

(b) Masonry Wall

(c) Column with Steel Base Plate

[Ref.: PCA NOTES on ACI 318-08]

Example 20.3

Design a central wall footing for the following data;

GF slab spans = 6 m and 5 m

FF slab span = 5 m

Height of GF center from P.L. = 3.5 m

Height of FF (c/c) = 4 m

Height of parapet = 1 m

Thickness of GF wall = 0.342 m

Thickness of FF wall = 0.228 m

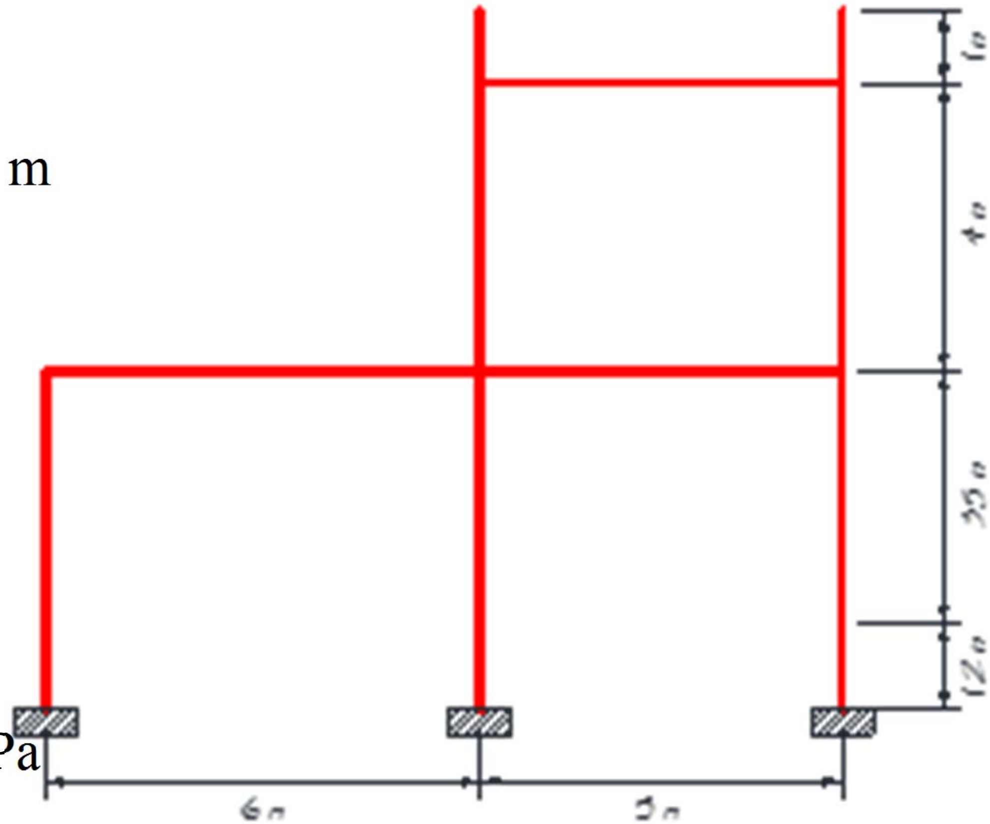
Thickness of parapet = 0.125 m

Depth of footing from P.L. = 1.2 m

Allowable bearing capacity = 120 kPa

Thickness of P.C.C. pad = 100 mm

GF partition load = 100 kg/m^2



Example 20.3

$$W = 385 \times \sum \ell_i + 1920 \times \sum (h_i \times t_i) + 0.5 \times \sum (q_i \times \ell_i)\ kg/m$$

$$W = 385 \times (6 + 5 + 5) + 1920 \times [(1.2 \times 0.342) + (3.5 \times 0.342) + (4 \times 0.228) + (1 \times 0.125)] + 0.5 \times [(6 \times 100) + (5 \times 100)]\ kg/m$$

$$W = 6160 + 5077.25 + 550 = 11787.25\ kg/m$$

$$Approximate\ width, W)_{app} = \frac{10W\gamma_2}{(q_a - 10D)}\ mm$$

$$= \frac{10 \times 11787.25 \times 1.0}{(120 - 10 \times 1.2)} = 1092\ mm$$

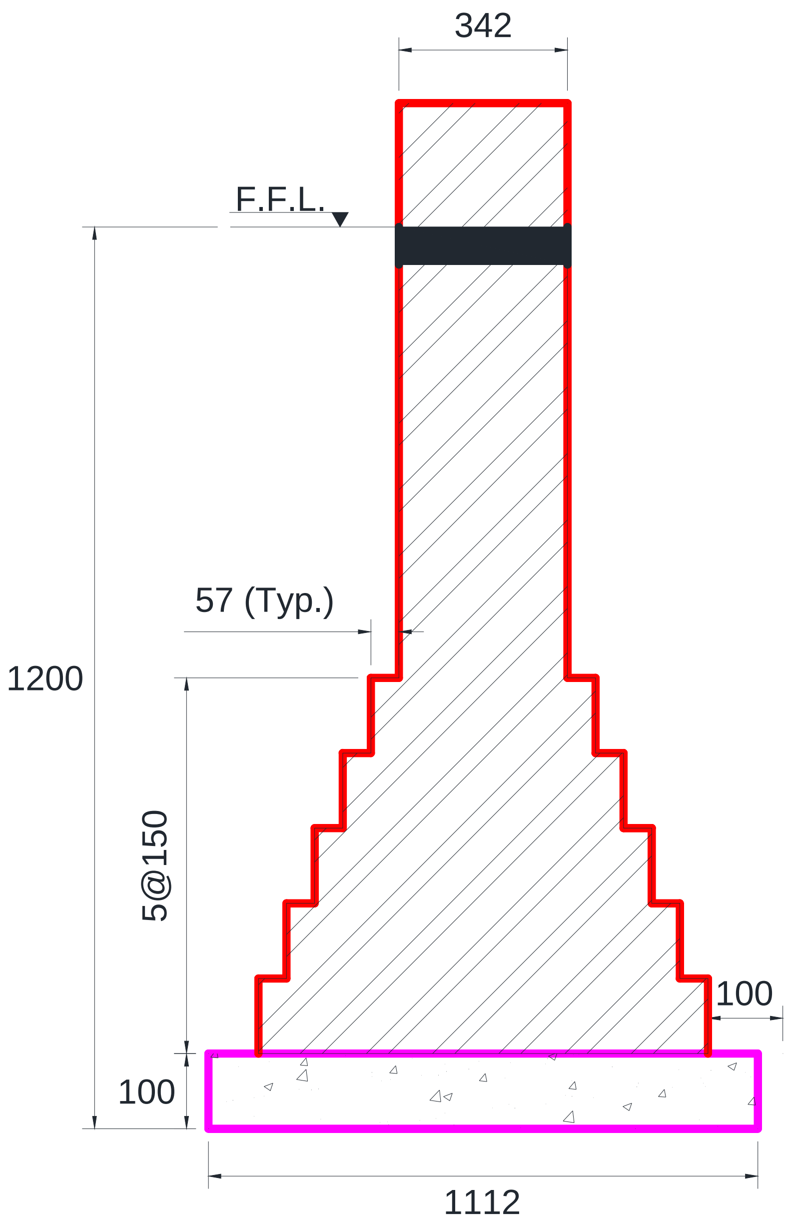
$$No. of\ brick\ steps, n = \frac{W)_{app} - t - m \times h}{114}$$

$$= \frac{1092 - 342 - 2 \times 100}{114} = 4.82 \approx 5$$

$$Final\ width, L = t + m \times h + n \times 114$$

$$= 342 + 2 \times 100 + 5 \times 114 = \mathbf{1112\ mm}$$

Example 20.3



Example 20.3 [with RC footing]

Design the same central wall footing for data given in Problem 1 with RC pad using fc'=17.25 Mpa and fy = 300 MPa

Solution:

$$W = 385 \times \sum \ell_i + 1920 \times \sum (h_i \times t_i) + 0.5 \times \sum (q_i \times \ell_i)\ kg/m$$

$$W = 385 \times (6 + 5 + 5) + 1920 \times [(1.2 \times 0.342) + (3.5 \times 0.342) + (4 \times 0.228) + (1 \times 0.125)] + 0.5 \times [(6 \times 100) + (5 \times 100)]\ kg/m$$

$$W = 6160 + 5077.25 + 550 = 11787.25\ kg/m$$

$$Approximate\ width, W)_{app} = \frac{10W\gamma_2}{(q_a - 10D)}\ mm$$

$$= \frac{10 \times 11787.25 \times 1.0}{(120 - 10 \times 1.2)} = 1092\ mm$$

$Final\ width, B =$ $\mathbf{1125\ mm}$

For thickness

$$q_u = \frac{Factored\ load}{A_f} = \frac{\left(\frac{1.2+1.6}{2}\right) \times 11787.25 \times 9.81/1000}{1 \times 1.125}$$

$$= 143.9\ kPa$$

$$V_u = q_u \times \left[\left(\frac{B-t}{2} - \frac{d}{1000}\right) \times 1\right]\ kN$$

$$From\ \emptyset_v V_c = V_u \implies \frac{\left(\frac{\emptyset_v}{6} \times \sqrt{f_c'}bd\right)}{1000} = q_u \times \left[\left(\frac{B-t}{2} - \frac{d}{1000}\right) \times 1\right]$$

$$\frac{\left(\frac{0.75}{6} \times \sqrt{17.25} \times 1000 \times d\right)}{1000} = 143.9 \times \left[\left(\frac{1.125-0.342}{2} - \frac{d}{1000}\right) \times 1\right]$$

$$\implies d = 85\ mm$$

$$h = d + 60 = 145\ mm \not< 225\ mm$$

$$\boldsymbol{So,\ h = 225\ mm \implies d = 225 - 60 = 165\ mm}$$

Design of steel reinforcement

$$M_u = \frac{w_u \ell^2}{2}\ kN.m$$

$$Length\ of\ cantilever, \ell = \frac{B-t}{2} + \frac{t}{4} = \frac{1.125 - 0.342}{2} + \frac{0.342}{4} = 0.477\ m$$

$$w_u = 143.9\ kN/m$$

$$M_u = \frac{143.9 \times (0.477)^2}{2} = 16.37\ kN.m$$

$$R = \frac{M_u}{bd^2} = \frac{16.37 \times 10^6}{1000 \times (165)^2} = 0.6013$$

$$\rho = \frac{0.85 f_c'}{f_y}\left[1 - \sqrt{1 - \frac{2.614R}{f_c'}}\right] = \frac{0.85 \times 17.25}{300}\left[1 - \sqrt{1 - \frac{2.614 \times 0.6013}{17.25}}\right]$$

$$= 0.00228$$

$$A_s = \rho bd = 0.00228 \times 1000 \times 165 = 377\ mm^2/m$$

$$A_s)_{min} = 0.002bh = 0.002 \times 1000 \times 225 = \mathbf{450\ mm^2/m}$$

Design of steel reinforcement (contd.)

$A_s)_{req} = 450 \; mm^2/m$

$$\#13@280 \; mmc/c < S)_{max} = 450 \; mm$$

Distribution Steel

$A_s)_{min} = 0.002bh = 0.002 \times 1000 \times 225 = 450 \; mm^2/m$

$$\#13@280 \; mmc/c$$

Check for development length

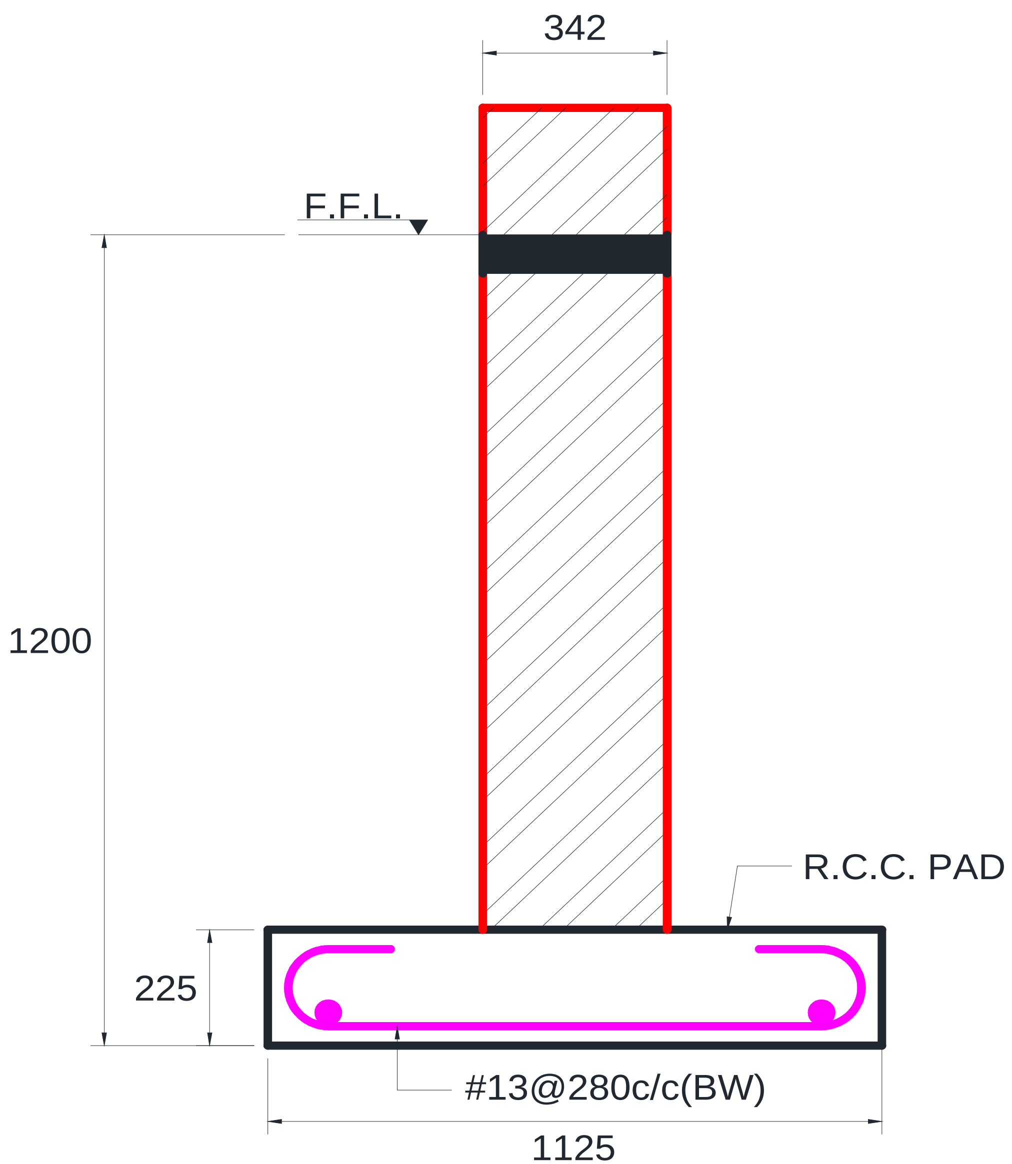
$$\ell_d = 0.485 \frac{f_y}{\sqrt{f_c'}} d_b \geq 300 \; mm$$

$$\ell_d = 0.485 \times \frac{300}{\sqrt{17.25}} \times 13 = 456 \; mm \geq 300 \; mm \; [\boldsymbol{OK}]$$

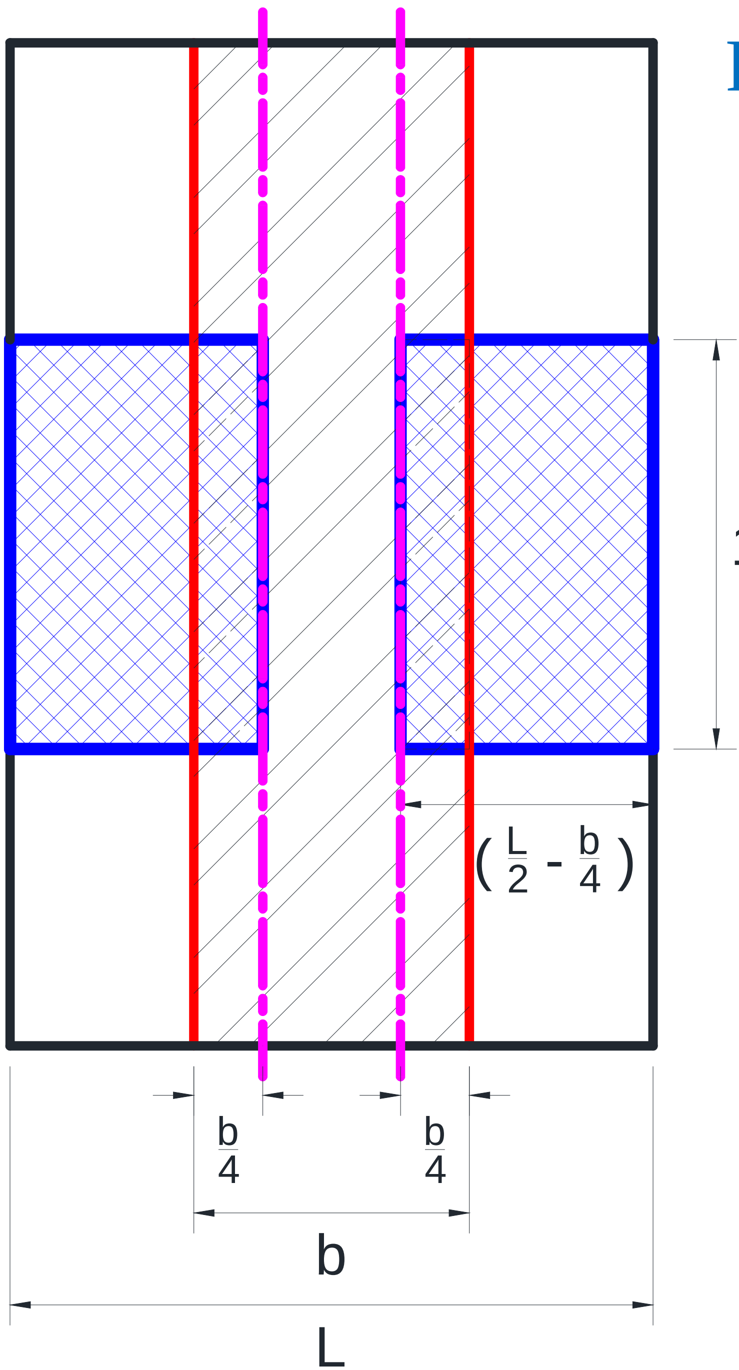
$$Available \; space = \ell - 75 = 477 - 75 = 402 \text{ mm} < \ell_d \; [\boldsymbol{NOT \; OK}]$$

so, provide 180° hook.

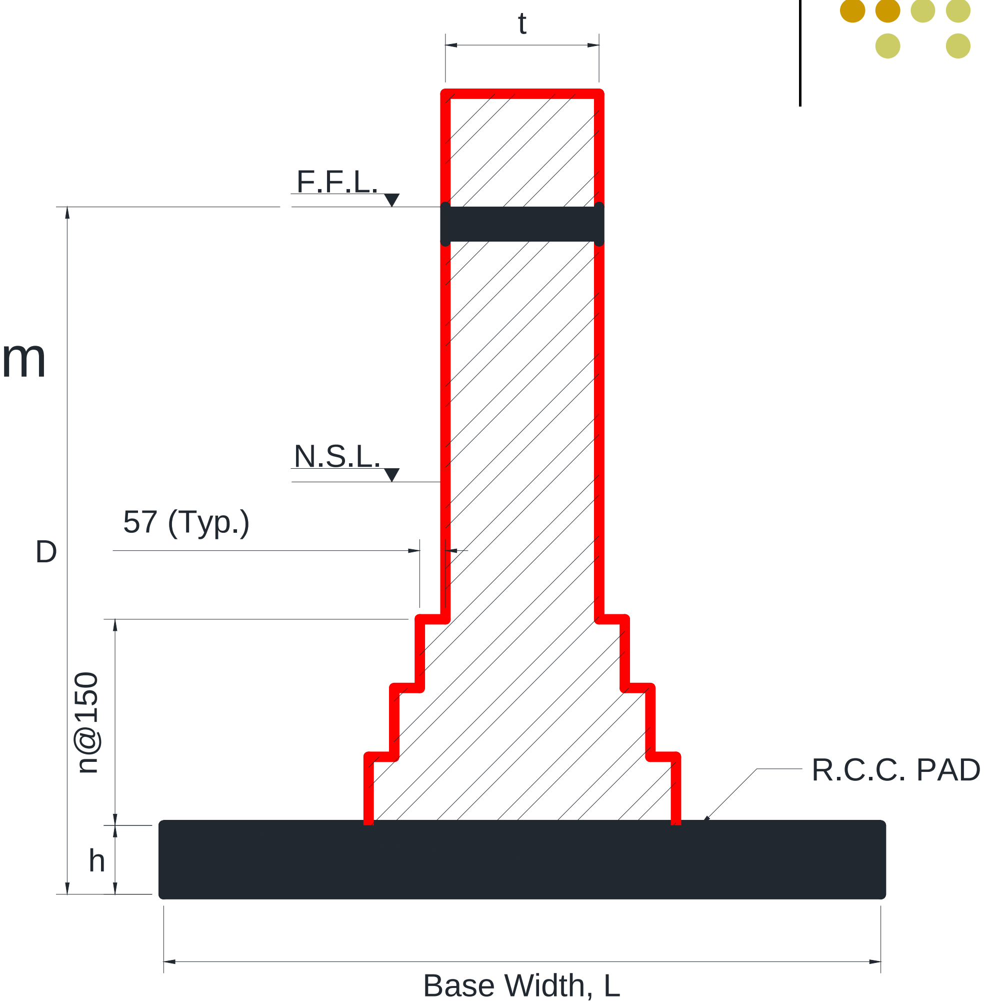
Example 20.3 [with RC footing]

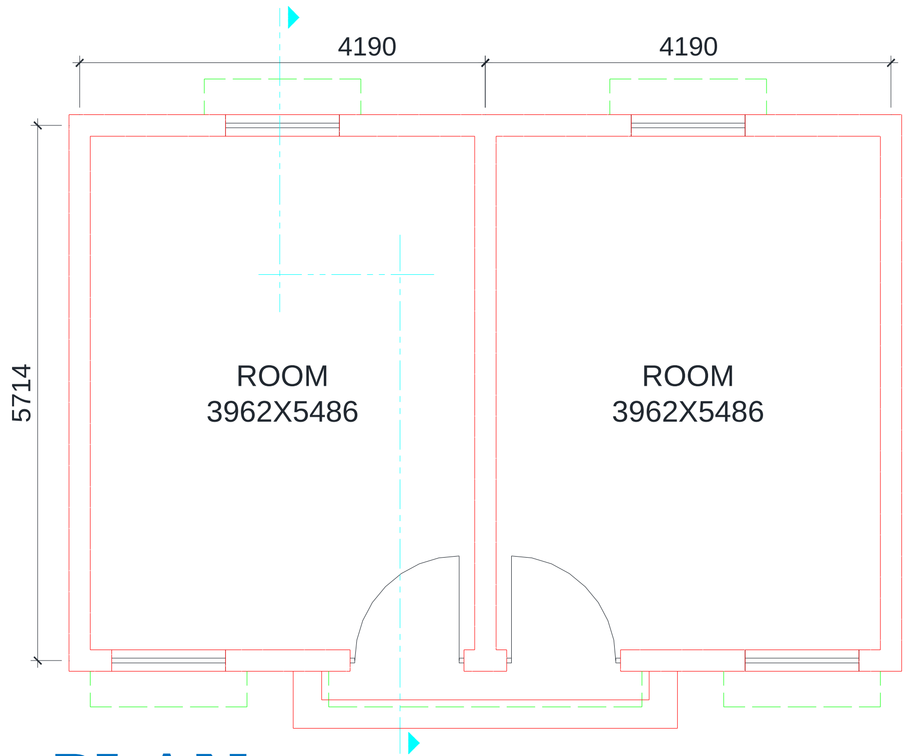


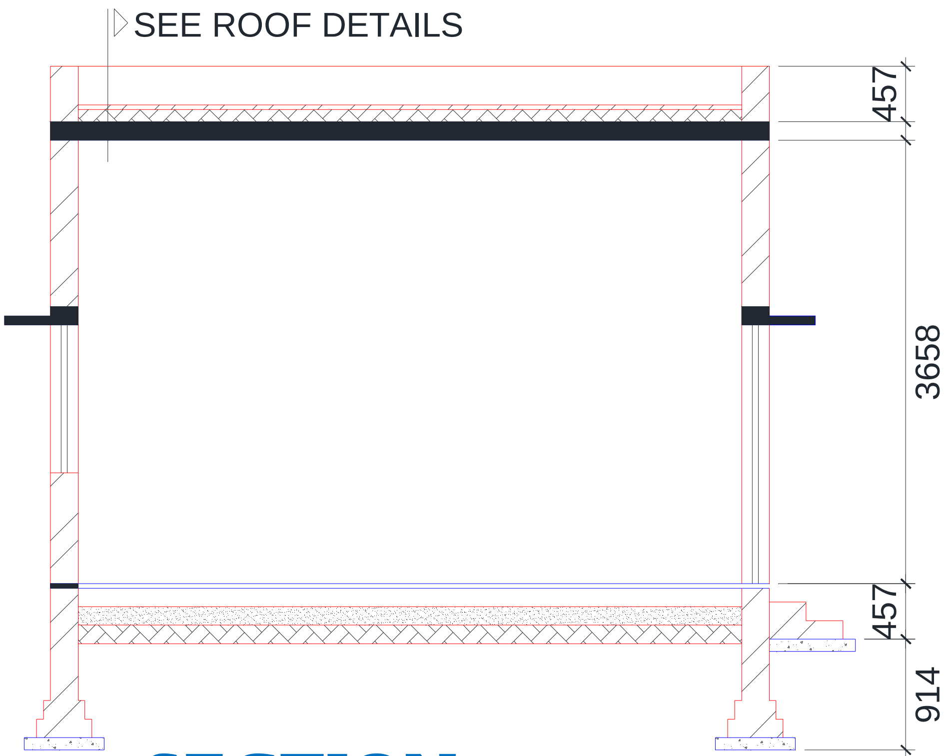
PLAN



SECTION







PLAN

SECTION

Design masonry footings for the plan shown. Allowable bearing capacity at foundation level is 110 kPa. Consider a roof live load of 200 kg/m^2 and density of backfill material as 2100 kg/m^3.

ROOF FINISH DETAILS;

38 mm thick brick tiles laid in (1:3) c/s mortar over
25 mm thick properly sloped mud plaster over
75 mm thick earth insulation over, Polyethylene sheet over
2 coats of hot bitumen over, 150 mm thick R.C.C. slab