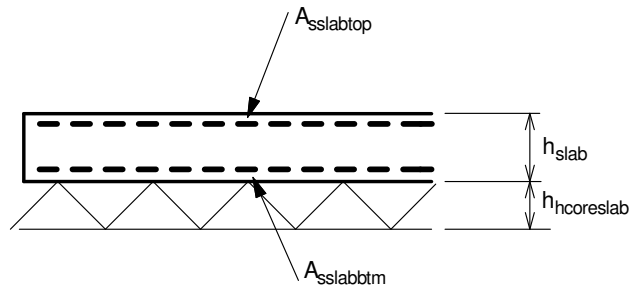


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RAFT FOUNDATION DESIGN (BS8110 : PART 1 : 1997)

Tedds calculation version 1.0.13



Soil and raft definition

Soil definition

Allowable bearing pressure

$q_{allow} = 50.0 \text{ kN/m}^2$

Number of types of soil forming sub-soil

One type only

Soil density

Firm to loose

Depth of hardcore beneath slab

$h_{coreslab} = 150 \text{ mm}$ (Dispersal allowed for bearing pressure check)

Density of hardcore

$\gamma_{hcore} = 19.0 \text{ kN/m}^3$

Basic assumed diameter of local depression

$\phi_{depbasic} = 2000 \text{ mm}$

Diameter under slab modified for hardcore

$\phi_{depslab} = \phi_{depbasic} - h_{coreslab} = 1850 \text{ mm}$

Raft slab definition

Max dimension/max dimension between joints

$l_{max} = 7.500 \text{ m}$

Slab thickness

$h_{slab} = 175 \text{ mm}$

Concrete strength

$f_{cu} = 35 \text{ N/mm}^2$

Poissons ratio of concrete

$\nu = 0.2$

Slab mesh reinforcement strength

$f_{yslab} = 500 \text{ N/mm}^2$

Partial safety factor for steel reinforcement

$\gamma_s = 1.15$

From C&CA document 'Concrete ground floors' Table 5

Minimum mesh required in top for shrinkage

A142

Actual mesh provided in top

A393 ($A_{sslabbtop} = 393 \text{ mm}^2/\text{m}$)

Mesh provided in bottom

A393 ($A_{sslabbtm} = 393 \text{ mm}^2/\text{m}$)

Top mesh bar diameter

$\phi_{slabbtop} = 10 \text{ mm}$

Bottom mesh bar diameter

$\phi_{slabbtm} = 10 \text{ mm}$

Cover to top reinforcement

$C_{top} = 20 \text{ mm}$

Cover to bottom reinforcement

$C_{btm} = 35 \text{ mm}$

Average effective depth of top reinforcement

$d_{tslabav} = h_{slab} - C_{top} - \phi_{slabbtop} = 145 \text{ mm}$

Average effective depth of bottom reinforcement

$d_{bslabav} = h_{slab} - C_{btm} - \phi_{slabbtm} = 130 \text{ mm}$

Overall average effective depth

$d_{slabav} = (d_{tslabav} + d_{bslabav})/2 = 138 \text{ mm}$

Minimum effective depth of top reinforcement

$d_{tslabmin} = d_{tslabav} - \phi_{slabbtop}/2 = 140 \text{ mm}$

Minimum effective depth of bottom reinforcement

$d_{bslabmin} = d_{bslabav} - \phi_{slabbtm}/2 = 125 \text{ mm}$

Slab edge reinforcement

Mesh provided in top

A393 ($A_{sedgetop} = 393 \text{ mm}^2/\text{m}$)

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Mesh provided in bottom

A393 ($A_{\text{sedgcbtm}} = 393 \text{ mm}^2/\text{m}$)

Internal slab design checks

Basic loading

Slab self weight

$$w_{\text{slab}} = 24 \text{ kN/m}^3 \times h_{\text{slab}} = \mathbf{4.2 \text{ kN/m}^2}$$

Hardcore

$$w_{\text{hcoreslab}} = \gamma_{\text{hcore}} \times h_{\text{hcoreslab}} = \mathbf{2.9 \text{ kN/m}^2}$$

Applied loading

Uniformly distributed dead load

$$w_{\text{Dudl}} = \mathbf{1.8 \text{ kN/m}^2}$$

Uniformly distributed live load

$$w_{\text{Ludl}} = \mathbf{1.5 \text{ kN/m}^2}$$

Internal slab bearing pressure check

Total uniform load at formation level

$$w_{\text{udl}} = w_{\text{slab}} + w_{\text{hcoreslab}} + w_{\text{Dudl}} + w_{\text{Ludl}} = \mathbf{10.4 \text{ kN/m}^2}$$

PASS - $w_{\text{udl}} \leq q_{\text{allow}}$ - Applied bearing pressure is less than allowable

Internal slab bending and shear check

Applied bending moments

Span of slab

$$l_{\text{slab}} = \phi_{\text{depslab}} + d_{\text{tslabav}} = \mathbf{1995 \text{ mm}}$$

Ultimate self weight udl

$$w_{\text{swult}} = 1.4 \times w_{\text{slab}} = \mathbf{5.9 \text{ kN/m}^2}$$

Self weight moment at centre

$$M_{\text{csw}} = w_{\text{swult}} \times l_{\text{slab}}^2 \times (1 + \nu) / 64 = \mathbf{0.4 \text{ kNm/m}}$$

Self weight moment at edge

$$M_{\text{esw}} = w_{\text{swult}} \times l_{\text{slab}}^2 / 32 = \mathbf{0.7 \text{ kNm/m}}$$

Self weight shear force at edge

$$V_{\text{sw}} = w_{\text{swult}} \times l_{\text{slab}} / 4 = \mathbf{2.9 \text{ kN/m}}$$

Moments due to applied uniformly distributed loads

Ultimate applied udl

$$w_{\text{udlult}} = 1.4 \times w_{\text{Dudl}} + 1.6 \times w_{\text{Ludl}} = \mathbf{4.9 \text{ kN/m}^2}$$

Moment at centre

$$M_{\text{cudl}} = w_{\text{udlult}} \times l_{\text{slab}}^2 \times (1 + \nu) / 64 = \mathbf{0.4 \text{ kNm/m}}$$

Moment at edge

$$M_{\text{eudl}} = w_{\text{udlult}} \times l_{\text{slab}}^2 / 32 = \mathbf{0.6 \text{ kNm/m}}$$

Shear force at edge

$$V_{\text{udl}} = w_{\text{udlult}} \times l_{\text{slab}} / 4 = \mathbf{2.5 \text{ kN/m}}$$

Resultant moments and shears

Total moment at edge

$$M_{\Sigma_e} = \mathbf{1.3 \text{ kNm/m}}$$

Total moment at centre

$$M_{\Sigma_c} = \mathbf{0.8 \text{ kNm/m}}$$

Total shear force

$$V_{\Sigma} = \mathbf{5.4 \text{ kN/m}}$$

Reinforcement required in top

K factor

$$K_{\text{slabtop}} = M_{\Sigma_e} / (f_{\text{cu}} \times d_{\text{tslabav}}^2) = \mathbf{0.002}$$

Lever arm

$$z_{\text{slabtop}} = d_{\text{tslabav}} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{\text{slabtop}}/0.9)}) = \mathbf{137.8 \text{ mm}}$$

Area of steel required for bending

$$A_{\text{sslabtopbend}} = M_{\Sigma_e} / ((1.0/\gamma_s) \times f_{\text{yslab}} \times z_{\text{slabtop}}) = \mathbf{22 \text{ mm}^2/\text{m}}$$

Minimum area of steel required

$$A_{\text{sslabmin}} = 0.0013 \times h_{\text{slab}} = \mathbf{228 \text{ mm}^2/\text{m}}$$

Area of steel required

$$A_{\text{sslabtopreq}} = \max(A_{\text{sslabtopbend}}, A_{\text{sslabmin}}) = \mathbf{228 \text{ mm}^2/\text{m}}$$

PASS - $A_{\text{sslabtopreq}} \leq A_{\text{sslabtop}}$ - Area of reinforcement provided in top to span local depressions is adequate

Reinforcement required in bottom

K factor

$$K_{\text{slabbtm}} = M_{\Sigma_c} / (f_{\text{cu}} \times d_{\text{bslabav}}^2) = \mathbf{0.001}$$

Lever arm

$$z_{\text{slabbtm}} = d_{\text{bslabav}} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{\text{slabbtm}}/0.9)}) = \mathbf{123.5 \text{ mm}}$$

Area of steel required for bending

$$A_{\text{sslabbtmbend}} = M_{\Sigma_c} / ((1.0/\gamma_s) \times f_{\text{yslab}} \times z_{\text{slabbtm}}) = \mathbf{15 \text{ mm}^2/\text{m}}$$

Area of steel required

$$A_{\text{sslabbtmreq}} = \max(A_{\text{sslabbtmbend}}, A_{\text{sslabmin}}) = \mathbf{228 \text{ mm}^2/\text{m}}$$

PASS - $A_{\text{sslabbtmreq}} \leq A_{\text{sslabbtm}}$ - Area of reinforcement provided in bottom to span local depressions is adequate

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Shear check

Applied shear stress

$$v = V_{\Sigma}/d_{\text{slabmin}} = \mathbf{0.038 \text{ N/mm}^2}$$

Tension steel ratio

$$\rho = 100 \times A_{\text{sslaptop}}/d_{\text{slabmin}} = \mathbf{0.281}$$

From BS8110-1:1997 - Table 3.8

Design concrete shear strength

$$v_c = \mathbf{0.602 \text{ N/mm}^2}$$

PASS - $v \leq v_c$ - Shear capacity of the slab is adequate

Internal slab deflection check

Basic allowable span to depth ratio

$$\text{Ratio}_{\text{basic}} = \mathbf{26.0}$$

Moment factor

$$M_{\text{factor}} = M_{\Sigma c}/d_{\text{bslabav}}^2 = \mathbf{0.048 \text{ N/mm}^2}$$

Steel service stress

$$f_s = 2/3 \times f_{\text{yslab}} \times A_{\text{sslabbtmbend}}/A_{\text{sslabbtm}} = \mathbf{12.731 \text{ N/mm}^2}$$

Modification factor

$$MF_{\text{slab}} = \min(2.0, 0.55 + [(477\text{N/mm}^2 - f_s)/(120 \times (0.9\text{N/mm}^2 +$$

$$M_{\text{factor}})))$$

$$MF_{\text{slab}} = \mathbf{2.000}$$

Modified allowable span to depth ratio

$$\text{Ratio}_{\text{allow}} = \text{Ratio}_{\text{basic}} \times MF_{\text{slab}} = \mathbf{52.000}$$

Actual span to depth ratio

$$\text{Ratio}_{\text{actual}} = l_{\text{slab}}/d_{\text{bslabav}} = \mathbf{15.346}$$

PASS - $\text{Ratio}_{\text{actual}} \leq \text{Ratio}_{\text{allow}}$ - Slab span to depth ratio is adequate

Slab edge design checks

Basic loading

Hardcore

$$w_{\text{hcoreslab}} = \gamma_{\text{hcore}} \times h_{\text{hcoreslab}} = \mathbf{2.9 \text{ kN/m}^2}$$

Slab self weight

$$w_{\text{slab}} = 24 \text{ kN/m}^3 \times h_{\text{slab}} = \mathbf{4.2 \text{ kN/m}^2}$$

Edge load number 1

Load type

Longitudinal line load

Dead load

$$w_{\text{Dedge1}} = \mathbf{1.4 \text{ kN/m}}$$

Live load

$$w_{\text{Ledget1}} = \mathbf{0.0 \text{ kN/m}}$$

Ultimate load

$$w_{\text{ultedge1}} = 1.4 \times w_{\text{Dedge1}} + 1.6 \times w_{\text{Ledget1}} = \mathbf{2.0 \text{ kN/m}}$$

Longitudinal line load width

$$b_{\text{edge1}} = \mathbf{100 \text{ mm}}$$

Centroid of load from outside face of raft

$$x_{\text{edge1}} = \mathbf{50 \text{ mm}}$$

Slab edge bearing pressure check

Total uniform load at formation level

$$w_{\text{udledge}} = w_{\text{Dudl}} + w_{\text{Ludl}} + w_{\text{slab}} + w_{\text{hcoreslab}} = \mathbf{10.4 \text{ kN/m}^2}$$

Centroid of longitudinal and equivalent line loads from outside face of raft

Load x distance for edge load 1

$$\text{Moment}_1 = w_{\text{ultedge1}} \times x_{\text{edge1}} = \mathbf{0.1 \text{ kN}}$$

Sum of ultimate longitud'l and equivalent line loads $\Sigma\text{UDL} = \mathbf{2.0 \text{ kN/m}}$

Sum of load x distances

$$\Sigma\text{Moment} = \mathbf{0.1 \text{ kN}}$$

Centroid of loads

$$x_{\text{bar}} = \Sigma\text{Moment}/\Sigma\text{UDL} = \mathbf{50 \text{ mm}}$$

Initially assume no moment transferred into slab due to load/reaction eccentricity

Sum of unfactored longitud'l and eff'tive line loads $\Sigma\text{UDLsls} = \mathbf{1.4 \text{ kN/m}}$

Allowable bearing width

$$b_{\text{allow}} = 2 \times x_{\text{bar}} + 2 \times h_{\text{hcoreslab}} \times \tan(30) = \mathbf{273 \text{ mm}}$$

Bearing pressure due to line/point loads

$$q_{\text{linepoint}} = \Sigma\text{UDLsls}/b_{\text{allow}} = \mathbf{5.1 \text{ kN/m}^2}$$

Total applied bearing pressure

$$q_{\text{edge}} = q_{\text{linepoint}} + w_{\text{udledge}} = \mathbf{15.5 \text{ kN/m}^2}$$

PASS - $q_{\text{edge}} \leq q_{\text{allow}}$ - Allowable bearing pressure is not exceeded

Slab edge bending check

Considering a 1.0m width of slab

Divider for moments due to udl's

$$\beta_{\text{udl}} = \mathbf{8.0}$$

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Applied bending moments

Span of slab	$l_{edge} = \phi_{depslab} + d_{tslabmin} = 1990 \text{ mm}$
Ultimate self weight udl	$w_{edgeult} = 1.4 \times w_{slab} = 5.9 \text{ kN/m}^2$
Self weight bending moment	$M_{edgesw} = w_{edgeult} \times l_{edge}^2 / 10 = 2.3 \text{ kNm/m}$
Self weight shear force	$V_{edgesw} = w_{edgeult} \times l_{edge} / 2 = 5.9 \text{ kN/m}$

Moments due to applied uniformly distributed loads

Ultimate udl	$w_{edgeudl} = w_{udult} = 4.9 \text{ kN/m}^2$
Bending moment	$M_{edgeudl} = w_{edgeudl} \times l_{edge}^2 / \beta_{udl} = 2.4 \text{ kNm/m}$
Shear force	$V_{edgeudl} = w_{edgeudl} \times l_{edge} / 2 = 4.9 \text{ kN/m}$

Moment and shear due to load number 1

Effective slab width	$b_{eff1} = \min(x_{edge1}, b_{edge1}/2 + 0.3 \times l_{edge}) + b_{edge1}/2 + 0.3 \times l_{edge} = 697 \text{ mm}$
Bending moment	$M_{edge1} = w_{ultedge1} \times l_{edge}^2 / (\beta_{udl} \times b_{eff1}) = 1.4 \text{ kNm/m}$
Shear force	$V_{edge1} = w_{ultedge1} \times l_{edge} / (2 \times b_{eff1}) = 2.8 \text{ kN/m}$

Resultant moments and shears

Total moment (hogging and sagging)	$M_{\Sigma edge} = 6.2 \text{ kNm/m}$
Maximum shear force	$V_{\Sigma edge} = 13.5 \text{ kN/m}$

Reinforcement required in top

K factor	$K_{edgetop} = M_{\Sigma edge} / (f_{cu} \times d_{tslabmin}^2) = 0.009$
Lever arm	$z_{edgetop} = d_{tslabmin} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{edgetop}/0.9)}) = 133 \text{ mm}$
Area of steel required for bending	$A_{sedge\text{topbend}} = M_{\Sigma edge} / ((1.0/\gamma_s) \times f_{yslab} \times z_{edgetop}) = 106 \text{ mm}^2/\text{m}$
Area of steel required	$A_{sedge\text{topreq}} = \max(A_{sedge\text{topbend}}, A_{sslabmin}) = 228 \text{ mm}^2/\text{m}$

PASS - $A_{sedge\text{topreq}} \leq A_{sedge\text{top}}$ - Area of reinforcement provided in top of slab is adequate

Reinforcement required in bottom

K factor	$K_{edge\text{btm}} = M_{\Sigma edge} / (f_{cu} \times d_{bslabmin}^2) = 0.011$
Lever arm	$z_{edge\text{btm}} = d_{bslabmin} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{edge\text{btm}}/0.9)}) = 119 \text{ mm}$
Area of steel required for bending	$A_{sedge\text{btmbend}} = M_{\Sigma edge} / ((1.0/\gamma_s) \times f_{yslab} \times z_{edge\text{btm}}) = 119 \text{ mm}^2/\text{m}$
Area of steel required	$A_{sedge\text{btmreq}} = \max(A_{sedge\text{btmbend}}, A_{sslabmin}) = 228 \text{ mm}^2/\text{m}$

PASS - $A_{sedge\text{btmreq}} \leq A_{sedge\text{btm}}$ - Area of reinforcement provided in bottom of slab is adequate

Applied shear stress	$v_{edge} = V_{\Sigma edge} \times 1.0\text{m} / (1000\text{mm} \times d_{tslabmin}) = 0.097 \text{ N/mm}^2$
Tension steel ratio	$\rho_{edge} = 100 \times A_{sedge\text{top}} \times 1.0\text{m} / (1000\text{mm} \times d_{tslabmin}) = 0.281$
From BS8110-1:1997 - Table 3.8	
Design concrete shear strength	$v_{cedge} = 0.602 \text{ N/mm}^2$

PASS - $v_{edge} \leq v_{cedge}$ - Shear capacity of the slab is not exceeded

Slab edge deflection check

Basic allowable span to depth ratio	$\text{Ratio}_{\text{basicedge}} = 26.0$
Moment factor	$M_{\text{factoredge}} = M_{\Sigma edge} / d_{bslabmin}^2 = 0.394 \text{ N/mm}^2$
Steel service stress	$f_{\text{sedge}} = 2/3 \times f_{yslab} \times A_{sedge\text{btmbend}} / A_{sedge\text{btm}} = 101.130 \text{ N/mm}^2$
Modification factor	$MF_{\text{edge}} = \min(2.0, 0.55 + [(477\text{N/mm}^2 - f_{\text{sedge}}) / (120 \times (0.9\text{N/mm}^2 + M_{\text{factoredge}}))])$
$MF_{\text{edge}} = 2.000$	
Modified allowable span to depth ratio	$\text{Ratio}_{\text{allowedge}} = \text{Ratio}_{\text{basicedge}} \times MF_{\text{edge}} = 52.000$
Actual span to depth ratio	$\text{Ratio}_{\text{actualedge}} = l_{edge} / d_{tslabmin} = 14.214$

PASS - $\text{Ratio}_{\text{actualedge}} \leq \text{Ratio}_{\text{allowedge}}$ - Slab span to depth ratio is adequate

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Corner design checks

Basic loading

Corner load number 1

Load type

Dead load

Live load

Ultimate load

Centroid of load from outside face of raft

Centroid of load from outside face of raft

Point load

$$W_{Dcorner1} = 7.5 \text{ kN}$$

$$W_{Lcorner1} = 7.0 \text{ kN}$$

$$W_{ultcorner1} = 1.4 \times W_{Dcorner1} + 1.6 \times W_{Lcorner1} = 21.7 \text{ kN}$$

$$x_{corner1} = 100 \text{ mm}$$

$$y_{corner1} = 100 \text{ mm}$$

Corner bearing pressure check

Total uniform load at formation level

$$W_{udlcorner} = W_{Dudl} + W_{Ludl} + W_{slab} + W_{hcoreslab} = 10.4 \text{ kN/m}^2$$

Net bearing press avail to resist line/point loads

$$q_{netcorner} = q_{allow} - W_{udlcorner} = 39.7 \text{ kN/m}^2$$

Total line/point loads

Total unfactored line load in x direction

$$W_{\Sigma line x} = 0.0 \text{ kN/m}$$

Total ultimate line load in x direction

$$W_{\Sigma ultline x} = 0.0 \text{ kN/m}$$

Total unfactored line load in y direction

$$W_{\Sigma line y} = 0.0 \text{ kN/m}$$

Total ultimate line load in y direction

$$W_{\Sigma ultline y} = 0.0 \text{ kN/m}$$

Total unfactored point load

$$W_{\Sigma point} = 14.5 \text{ kN}$$

Total ultimate point load

$$W_{\Sigma ultpoint} = 21.7 \text{ kN}$$

Length of side of sq reqd to resist line/point loads

$$p_{corner} = [W_{\Sigma line x} + W_{\Sigma line y} + \sqrt{((W_{\Sigma line x} + W_{\Sigma line y})^2 + 4 \times q_{netcorner} \times W_{\Sigma point})}] / (2 \times q_{netcorner})$$

$$p_{corner} = 605 \text{ mm}$$

Bending moment about x-axis due to load/reaction eccentricity

Total moment due to load 1 (point load)

$$M_{xtotal1} = \max(0 \text{ kNm}, W_{ultcorner1} \times (p_{corner}/2 - y_{corner1})) = 4.4 \text{ kNm}$$

Slab width resisting moment

$$l_1 = \min(p_{corner}/2 - y_{corner1}, x_{corner1}) + (p_{corner}/2 - y_{corner1}) = 302 \text{ mm}$$

Effective moment

$$M_{x1} = M_{xtotal1} / l_1 = 14.5 \text{ kNm/m}$$

Total moment about x axis

$$M_{\Sigma x} = 14.5 \text{ kNm/m}$$

Bending moment about y-axis due to load/reaction eccentricity

Total moment due to load 1 (point load)

$$M_{ytotal1} = \max(0 \text{ kNm}, W_{ultcorner1} \times (p_{corner}/2 - x_{corner1})) = 4.4 \text{ kNm}$$

Slab width resisting moment

$$l_1 = \min(p_{corner}/2 - x_{corner1}, y_{corner1}) + (p_{corner}/2 - x_{corner1}) = 302 \text{ mm}$$

Effective moment

$$M_{y1} = M_{ytotal1} / l_1 = 14.5 \text{ kNm/m}$$

Total moment about y axis

$$M_{\Sigma y} = 14.5 \text{ kNm/m}$$

Check top reinforcement in slab for load/reaction eccentric moment

Max moment due to load/reaction eccentricity

$$M_{\Sigma} = \max(M_{\Sigma x}, M_{\Sigma y}) = 14.5 \text{ kNm/m}$$

From slab edge design checks away from corner

Moment due to slab edge spanning depression

$$M_{\Sigma edge} = 6.2 \text{ kNm/m}$$

Total moment to be resisted

$$M_{\Sigma cornerbp} = M_{\Sigma} + M_{\Sigma edge} = 20.7 \text{ kNm/m}$$

K factor

$$K_{cornerbp} = M_{\Sigma cornerbp} / (f_{cu} \times d_{slabmin}^2) = 0.030$$

Lever arm

$$z_{cornerbp} = d_{slabmin} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{cornerbp}/0.9)}) = 133 \text{ mm}$$

Area of steel required

$$A_{scornerbp} = M_{\Sigma cornerbp} / ((1.0/\gamma_s) \times f_{yslab} \times z_{cornerbp}) = 358 \text{ mm}^2/\text{m}$$

PASS - $A_{scornerbp} \leq A_{sedgebp}$ - Area of reinforcement provided to resist eccentric moment is adequate

The allowable bearing pressure at the corner will not be exceeded

Slab corner bending check

Cantilever span of slab at corner

$$l_{corner} = \phi_{depslab} / \sqrt{(2)} + d_{slabav} / 2 = 1381 \text{ mm}$$

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Moment and shear due to self weight

Considering triangular loading

Maximum ultimate self weight udl

$$w_{\text{swult}} = 1.4 \times w_{\text{slab}} \times \phi_{\text{depslab}}/\sqrt{2} = 7.7 \text{ kN/m}$$

Self weight bending moment

$$M_{\text{cornersw}} = w_{\text{swult}} \times l_{\text{corner}}^2/(6 \times \phi_{\text{depslab}}/\sqrt{2}) = 1.9 \text{ kNm/m}$$

Self weight shear force

$$V_{\text{cornersw}} = w_{\text{swult}} \times l_{\text{corner}}/(2 \times \phi_{\text{depslab}}/\sqrt{2}) = 4.1 \text{ kN/m}$$

Moment and shear due to udl's

Maximum ultimate udl

$$w_{\text{cornerudl}} = ((1.4 \times w_{\text{Dudl}}) + (1.6 \times w_{\text{Ludl}})) \times \phi_{\text{depslab}}/\sqrt{2} = 6.4 \text{ kN/m}$$

Bending moment

$$M_{\text{cornerudl}} = w_{\text{cornerudl}} \times l_{\text{corner}}^2/(6 \times \phi_{\text{depslab}}/\sqrt{2}) = 1.6 \text{ kNm/m}$$

Shear force

$$V_{\text{cornerudl}} = w_{\text{cornerudl}} \times l_{\text{corner}}/(2 \times \phi_{\text{depslab}}/\sqrt{2}) = 3.4 \text{ kN/m}$$

Moment and shear due to line loads in x direction

Initially assume this only produces a moment about y axis

Bending moment

$$M_{\text{cornerlinex}} = w_{\Sigma \text{ultlinex}} \times l_{\text{corner}}^2/(2 \times \phi_{\text{depslab}}/(2 \times \sqrt{2})) = 0.0 \text{ kNm/m}$$

Shear force

$$V_{\text{cornerlinex}} = w_{\Sigma \text{ultlinex}} \times l_{\text{corner}}/(\phi_{\text{depslab}}/(2 \times \sqrt{2})) = 0.0 \text{ kN/m}$$

Moment and shear due to line loads in y direction

Initially assume this only produces a moment about x axis

Bending moment

$$M_{\text{cornerliney}} = w_{\Sigma \text{ultliney}} \times l_{\text{corner}}^2/(2 \times \phi_{\text{depslab}}/(2 \times \sqrt{2})) = 0.0 \text{ kNm/m}$$

Shear force

$$V_{\text{cornerliney}} = w_{\Sigma \text{ultliney}} \times l_{\text{corner}}/(\phi_{\text{depslab}}/(2 \times \sqrt{2})) = 0.0 \text{ kN/m}$$

Moments and shears due to point loads

Approximate x axis moment due to load 1 (point)

$$M_{x\text{corner1}} = \max(0 \text{ kNm/m}, w_{\text{ultcorner1}}/2 \times (l_{\text{corner}} - y_{\text{corner1}})/(\min(x_{\text{corner1}}, l_{\text{corner}} - y_{\text{corner1}}) + l_{\text{corner}} - y_{\text{corner1}}))$$

$$M_{x\text{corner1}} = 10.1 \text{ kNm/m}$$

Approximate y axis moment due to load 1 (point)

$$M_{y\text{corner1}} = \max(0 \text{ kNm/m}, w_{\text{ultcorner1}}/2 \times (l_{\text{corner}} - x_{\text{corner1}})/(\min(y_{\text{corner1}}, l_{\text{corner}} - x_{\text{corner1}}) + l_{\text{corner}} - x_{\text{corner1}}))$$

$$M_{y\text{corner1}} = 10.1 \text{ kNm/m}$$

Approximate shear force due to load 1 (point)

$$V_{\text{corner1}} = w_{\text{ultcorner1}}/(2 \times (\phi_{\text{depslab}}/\sqrt{2})) = 8.3 \text{ kN/m}$$

Total moments and shears due to point loads

Bending moment about x axis

$$M_{\text{cornerpointx}} = 10.1 \text{ kNm/m}$$

Bending moment about y axis

$$M_{\text{cornerpointy}} = 10.1 \text{ kNm/m}$$

Shear force

$$V_{\text{cornerpoint}} = 8.3 \text{ kN/m}$$

Resultant moments and shears

Total moment about x axis

$$M_{\Sigma \text{cornerx}} = M_{\text{cornersw}} + M_{\text{cornerudl}} + M_{\text{cornerlinex}} + M_{\text{cornerpointx}} = 13.5 \text{ kNm/m}$$

Total shear force about x axis

$$V_{\Sigma \text{cornerx}} = V_{\text{cornersw}} + V_{\text{cornerudl}} + V_{\text{cornerlinex}} + V_{\text{cornerpoint}} = 15.7 \text{ kN/m}$$

Total moment about y axis

$$M_{\Sigma \text{cornery}} = M_{\text{cornersw}} + M_{\text{cornerudl}} + M_{\text{cornerliney}} + M_{\text{cornerpointy}} = 13.5 \text{ kNm/m}$$

Total shear force about y axis

$$V_{\Sigma \text{cornery}} = V_{\text{cornersw}} + V_{\text{cornerudl}} + V_{\text{cornerliney}} + V_{\text{cornerpoint}} = 15.7 \text{ kN/m}$$

Deflection of both edge beams at corner will be the same therefore design for average of these moments and shears

Design bending moment

$$M_{\Sigma \text{corner}} = (M_{\Sigma \text{cornerx}} + M_{\Sigma \text{cornery}})/2 = 13.5 \text{ kNm/m}$$

Design shear force

$$V_{\Sigma \text{corner}} = (V_{\Sigma \text{cornerx}} + V_{\Sigma \text{cornery}})/2 = 15.7 \text{ kN/m}$$

Reinforcement required in top of slab at corners

K factor

$$K_{\text{corner}} = M_{\Sigma \text{corner}}/(f_{\text{cu}} \times d_{\text{tslabmin}}^2) = 0.020$$

Lever arm

$$Z_{\text{corner}} = d_{\text{tslabmin}} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{\text{corner}}/0.9)}) = 133 \text{ mm}$$

Area of steel required for bending

$$A_{\text{scornerbend}} = M_{\Sigma \text{corner}}/((1.0/\gamma_s) \times f_{\text{yslab}} \times Z_{\text{corner}}) = 233 \text{ mm}^2/\text{m}$$

Area of steel required

$$A_{\text{scorner}} = \max(A_{\text{scornerbend}}, A_{\text{sslabmin}}) = 233 \text{ mm}^2/\text{m}$$

PASS - $A_{\text{scorner}} \leq A_{\text{sedgetop}}$ - Area of reinforcement provided in top of slab at corners is adequate

nicoll+mcbrayne Nicoll McBrayne Ltd The Hub, Union Street, Long Eaton, NG10 1HH	Project Old Hayes Farm, Ratby				Job no. 24094	
	Calcs for Raft Foundation				Start page no./Revision C 7	
	Calcs by RM	Calcs date 09/09/2024	Checked by SC	Checked date	Approved by	Approved date

Applied shear stress	$V_{corner} = V_{\Sigma corner}/d_{tslabmin} = 0.112 \text{ N/mm}^2$
Tension steel ratio	$\rho_{corner} = 100 \times A_{sedgetop}/d_{tslabmin} = 0.281$
From BS8110-1:1997 - Table 3.8	
Design concrete shear strength	$V_{ccorner} = 0.602 \text{ N/mm}^2$
	Pass - $V_{corner} \leq V_{ccorner}$ - Shear capacity of the slab is not exceeded
Slab corner deflection check	
Basic allowable span to depth ratio	$Ratio_{basiccorner} = 7.0$
Moment factor	$M_{factorcorner} = M_{\Sigma corner}/d_{tslabmin}^2 = 0.689 \text{ N/mm}^2$
Steel service stress	$f_{scorner} = 2/3 \times f_{yslab} \times A_{scornerbend}/A_{sedgetop} = 197.945 \text{ N/mm}^2$
Modification factor	$MF_{corner} = \min(2.0, 0.55 + [(477 \text{ N/mm}^2 -$
$f_{scorner})/(120 \times (0.9 \text{ N/mm}^2 + M_{factorcorner}))])$	
$MF_{corner} = 2.000$	
Modified allowable span to depth ratio	$Ratio_{allowcorner} = Ratio_{basiccorner} \times MF_{corner} = 14.000$
Actual span to depth ratio	$Ratio_{actualcorner} = l_{corner}/d_{tslabmin} = 9.862$
	PASS - $Ratio_{actualcorner} \leq Ratio_{allowcorner}$ - Slab span to depth ratio is adequate