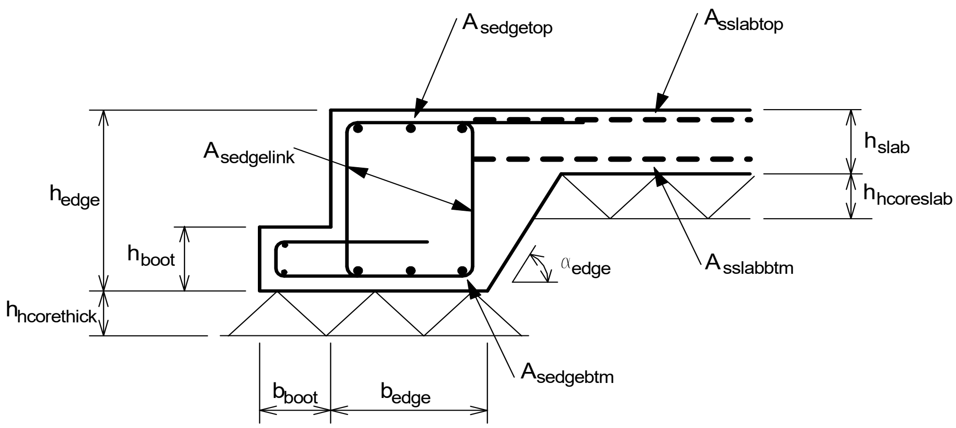
PlanningApplications.com Summer House, Upper Court Road Woldingham Surrey CR3 7BF support@planningapplications.com 07922 148 701	Project Rear 1 storey extension - RAFT FOUNDATION - 150mm slab				Job no. 2023-7459	
	Calcs for Mr Colin Williams, 59 Oakhill Road, Horsham RH13 5LE				Start page no./Revision 1	
	Calcs by SB	Calcs date 16/10/2023	Checked by DB	Checked date 16/10/2023	Approved by SB	Approved date 16/10/2023

RAFT FOUNDATION DESIGN (BS8110 : PART 1 : 1997)

Tedds calculation version 1.0.12



Soil and raft definition

Soil definition

Allowable bearing pressure q_{allow} = **50.0** kN/m^2

Number of types of soil forming sub-soil **One type only**

Soil density **Firm**

Depth of hardcore beneath slab $h_{hcoreslab}$ = **150** mm (Dispersal allowed for bearing pressure check)

Depth of hardcore beneath thickenings $h_{hcorethick}$ = **150** mm (Dispersal allowed for bearing pressure check)

Density of hardcore γ_{hcore} = **20.0** kN/m^3

Basic assumed diameter of local depression $\phi_{depbasic}$ = **1500**mm

Diameter under slab modified for hardcore $\phi_{depslab} = \phi_{depbasic} - h_{hcoreslab}$ = **1350** mm

Diameter under thickenings modified for hardcore $\phi_{depthick} = \phi_{depbasic} - h_{hcorethick}$ = **1350** mm

Raft slab definition

Max dimension/max dimension between joints l_{max} = **3.000** m

Slab thickness h_{slab} = **150** mm

Concrete strength f_{cu} = **35** N/mm^2

Poissons ratio of concrete ν = **0.2**

Slab mesh reinforcement strength f_{yslab} = **500** N/mm^2

Partial safety factor for steel reinforcement γ_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 ($A_{sslabtop}$ = 393 mm^2/m)**

Mesh provided in bottom **A393 ($A_{sslabbtm}$ = 393 mm^2/m)**

Top mesh bar diameter $\phi_{slabtop}$ = **10** mm

Bottom mesh bar diameter $\phi_{slabbtm}$ = **10** mm

Cover to top reinforcement c_{top} = **20** mm

Cover to bottom reinforcement c_{btm} = **35** mm

Average effective depth of top reinforcement $d_{tslabav} = h_{slab} - c_{top} - \phi_{slabtop}$ = **120** mm

Average effective depth of bottom reinforcement $d_{bslabav} = h_{slab} - c_{btm} - \phi_{slabbtm}$ = **105** mm

Overall average effective depth $d_{slabav} = (d_{tslabav} + d_{bslabav})/2 = \mathbf{113}$ mm

Minimum effective depth of top reinforcement $d_{tslabmin} = d_{tslabav} - \phi_{slabtop}/2 = \mathbf{115}$ mm

Minimum effective depth of bottom reinforcement $d_{bslabmin} = d_{bslabav} - \phi_{slabbtm}/2 = \mathbf{100}$ mm

Edge beam definition

Overall depth $h_{edge} = \mathbf{300}$ mm

Width $b_{edge} = \mathbf{300}$ mm

Depth of boot $h_{boot} = \mathbf{200}$ mm

Width of boot $b_{boot} = \mathbf{175}$ mm

Angle of chamfer to horizontal $\alpha_{edge} = \mathbf{60}$ deg

Strength of main bar reinforcement $f_y = \mathbf{500}$ N/mm^2

Strength of link reinforcement $f_{ys} = \mathbf{500}$ N/mm^2

Reinforcement provided in top **3 H12 bars ($A_{sedgetop}$ = 339 mm^2)**

Reinforcement provided in bottom **3 H12 bars ($A_{sedgebtm}$ = 339 mm^2)**

Link reinforcement provided **2 H12 legs at 300 ctrs (A_{sv}/s_v = 0.754 mm)**

Bottom cover to links $c_{beam} = \mathbf{35}$ mm

Effective depth of top reinforcement $d_{edgetop} = h_{edge} - c_{top} - \phi_{slabtop} - \phi_{edgelink} - \phi_{edgetop}/2 = \mathbf{252}$ mm

Effective depth of bottom reinforcement $d_{edgebtm} = h_{edge} - c_{beam} - \phi_{edgelink} - \phi_{edgebtm}/2 = \mathbf{247}$ mm

Boot main reinforcement **H12 bars at 300 ctrs (A_{sboot} = 377 mm^2/m)**

Effective depth of boot reinforcement $d_{boot} = h_{boot} - c_{beam} - \phi_{boot}/2 = \mathbf{159}$ mm

Internal slab design checks

Basic loading

Slab self weight $w_{slab} = 24\ \text{kN/m}^3 \times h_{slab} = \mathbf{3.6}$ kN/m^2

Hardcore $w_{hcoreslab} = \gamma_{hcore} \times h_{hcoreslab} = \mathbf{3.0}$ kN/m^2

Applied loading

Uniformly distributed dead load $w_{Dudl} = \mathbf{5.0}$ kN/m^2

Uniformly distributed live load $w_{Ludl} = \mathbf{5.0}$ kN/m^2

Slab load number 1

Load type **Two way line load**

Dead load 1 $w_{D11} = \mathbf{2.0}$ kN/m

Live load 1 $w_{L11} = \mathbf{2.0}$ kN/m

Ultimate load 1 $w_{ult11} = 1.4 \times w_{D11} + 1.6 \times w_{L11} = \mathbf{6.0}$ kN/m

Line load 1 width $b_{11} = \mathbf{600}$ mm

Dead load 2 $w_{D21} = \mathbf{2.0}$ kN/m

Live load 2 $w_{L21} = \mathbf{2.0}$ kN/m

Ultimate load 2 $w_{ult21} = 1.4 \times w_{D21} + 1.6 \times w_{L21} = \mathbf{6.0}$ kN/m

Line load 2 width $b_{21} = \mathbf{500}$ mm

Internal slab bearing pressure check

Total uniform load at formation level $w_{udl} = w_{slab} + w_{hcoreslab} + w_{Dudl} + w_{Ludl} = \mathbf{16.6}$ kN/m^2

Bearing pressure beneath load number 1

Net bearing pressure available to resist line load $q_{net} = q_{allow} - w_{udl} = \mathbf{33.4}$ kN/m^2

Line load 1

Net 'ultimate' bearing pressure available $q_{netult1} = q_{net} \times w_{ult11}/(w_{D11} + w_{L11}) = \mathbf{50.1}$ kN/m^2

Loaded width required at formation $l_{req11} = w_{ult11}/q_{netult1} = \mathbf{0.120}$ m

Effective loaded width at u/side slab $l_{eff11} = \max(b_{11}, l_{req11} - 2 \times h_{hcoreslab} \times \tan(30)) = \mathbf{0.600}$ m

Effective net ult bearing pressure at u/side slab $q_{netulteff1} = q_{netult1} \times l_{req11}/l_{eff11} = \mathbf{10.0}$ kN/m^2

Cantilever bending moment $M_{cant11} = q_{netulteff1} \times [(l_{eff11} - b_{11})/2]^2/2 =$ **0.0** kNm/m

Line load 2

Net ‘ultimate’ bearing pressure available $q_{netult2} = q_{net} \times w_{ult21}/(w_{D21} + w_{L21}) =$ **50.1** kN/m^2

Loaded width required at formation $l_{req21} = w_{ult21}/q_{netult2} =$ **0.120** m

Effective loaded width at u/side slab $l_{eff21} = \max(b_{21}, l_{req21} - 2 \times h_{hcoreslab} \times \tan(30)) =$ **0.500** m

Effective net ult bearing pressure at u/side slab $q_{netulteff2} = q_{netult2} \times l_{req21}/l_{eff21} =$ **12.0** kN/m^2

Cantilever bending moment $M_{cant21} = q_{netulteff2} \times [(l_{eff21} - b_{21})/2]^2/2 =$ **0.0** kNm/m

Maximum cantilever moment $M_{cant1} = \max(M_{cant11}, M_{cant21}) =$ **0.0** kNm/m

Reinforcement required in bottom

Maximum cantilever moment $M_{cantmax} =$ **0.0** kNm/m

K factor $K_{slabbp} = M_{cantmax}/(f_{cu} \times d_{bslabmin}^2) =$ **0.000**

Lever arm $z_{slabbp} = d_{bslabmin} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slabbp}/0.9)}) =$ **95.0** mm

Area of steel required $A_{sslabbpreq} = M_{cantmax}/((1.0/\gamma_s) \times f_{yslab} \times z_{slabbp}) =$ **0** mm^2/m

PASS - $A_{sslabbpreq}$ <= $A_{sslabbtm}$ - Area of reinforcement provided to distribute the load is adequate

The allowable bearing pressure will not be exceeded

Internal slab bending and shear check

Applied bending moments

Span of slab $l_{slab} = \phi_{depslab} + d_{tslabav} =$ **1470** mm

Ultimate self weight udl $w_{swult} = 1.4 \times w_{slab} =$ **5.0** kN/m^2

Self weight moment at centre $M_{csw} = w_{swult} \times l_{slab}^2 \times (1 + \nu) / 64 =$ **0.2** kNm/m

Self weight moment at edge $M_{esw} = w_{swult} \times l_{slab}^2 / 32 =$ **0.3** kNm/m

Self weight shear force at edge $V_{sw} = w_{swult} \times l_{slab} / 4 =$ **1.9** kN/m

Moments due to applied uniformly distributed loads

Ultimate applied udl $w_{udlult} = 1.4 \times w_{Dudl} + 1.6 \times w_{Ludl} =$ **15.0** kN/m^2

Moment at centre $M_{cudl} = w_{udlult} \times l_{slab}^2 \times (1 + \nu) / 64 =$ **0.6** kNm/m

Moment at edge $M_{eudl} = w_{udlult} \times l_{slab}^2 / 32 =$ **1.0** kNm/m

Shear force at edge $V_{udl} = w_{udlult} \times l_{slab} / 4 =$ **5.5** kN/m

Moment due to load number 1

Approximate equivalent udl line load 1 $w_{udl11} = w_{ult11}/(2 \times 0.3 \times l_{slab}) =$ **6.8** kN/m^2

Approximate equivalent udl line load 2 $w_{udl21} = w_{ult21}/(2 \times 0.3 \times l_{slab}) =$ **6.8** kN/m^2

Moment at centre $M_{c1} = (w_{udl11}+w_{udl21}) \times l_{slab}^2 \times (1 + \nu) / 64 =$ **0.6** kNm/m

Moment at edge $M_{e1} = (w_{udl11}+w_{udl21}) \times l_{slab}^2 / 32 =$ **0.9** kNm/m

Shear force at edge $V_1 = (w_{udl11}+w_{udl21}) \times l_{slab} / 4 =$ **5.0** kN/m

Resultant moments and shears

Total moment at edge $M_{\Sigma e} =$ **2.3** kNm/m

Total moment at centre $M_{\Sigma c} =$ **1.4** kNm/m

Total shear force $V_{\Sigma} =$ **12.4** kN/m

Reinforcement required in top

K factor $K_{slabtop} = M_{\Sigma e}/(f_{cu} \times d_{tslabav}^2) =$ **0.005**

Lever arm $z_{slabtop} = d_{tslabav} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slabtop}/0.9)}) =$ **114.0** mm

Area of steel required for bending $A_{sslabtopbend} = M_{\Sigma e}/((1.0/\gamma_s) \times f_{yslab} \times z_{slabtop}) =$ **46** mm^2/m

Minimum area of steel required $A_{sslabmin} = 0.0013 \times h_{slab} =$ **195** mm^2/m

Area of steel required $A_{sslabtopreq} = \max(A_{sslabtopbend}, A_{sslabmin}) =$ **195** mm^2/m

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

Reinforcement required in bottom

K factor $K_{slabbtm} = M_{\Sigma c}/(f_{cu} \times d_{bslabav}^2) = \mathbf{0.004}$

Lever arm $z_{slabbtm} = d_{bslabav} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slabbtm}/0.9)}) = \mathbf{99.7}$ mm

Area of steel required for bending $A_{sslabbtmbend} = M_{\Sigma c}/((1.0/\gamma_s) \times f_{yslab} \times z_{slabbtm}) = \mathbf{31}$ mm²/m

Area of steel required $A_{sslabbtmreq} = \max(A_{sslabbtmbend}, A_{sslabmin}) = \mathbf{195}$ mm²/m

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

Shear check

Applied shear stress $v = V_{\Sigma}/d_{tslabmin} = \mathbf{0.108}$ N/mm²

Tension steel ratio $\rho = 100 \times A_{sslabtop}/d_{tslabmin} = \mathbf{0.342}$

From BS8110-1:1997 - Table 3.8

Design concrete shear strength $v_c = \mathbf{0.675}$ N/mm²

PASS - v <= v_c - Shear capacity of the slab is adequate

Internal slab deflection check

Basic allowable span to depth ratio $Ratio_{basic} = \mathbf{26.0}$

Moment factor $M_{factor} = M_{\Sigma c}/d_{bslabav}^2 = \mathbf{0.124}$ N/mm²

Steel service stress $f_s = 2/3 \times f_{yslab} \times A_{sslabbtmbend}/A_{sslabbtm} = \mathbf{26.660}$ N/mm²

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

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

Modified allowable span to depth ratio $Ratio_{allow} = Ratio_{basic} \times MF_{slab} = \mathbf{52.000}$

Actual span to depth ratio $Ratio_{actual} = l_{slab}/ d_{bslabav} = \mathbf{14.000}$

PASS - $Ratio_{actual}$ <= $Ratio_{allow}$ - Slab span to depth ratio is adequate

Edge beam design checks

Basic loading

Hardcore $w_{hcorethick} = \gamma_{hcore} \times h_{hcorethick} = \mathbf{3.0}$ kN/m²

Edge beam

Rectangular beam element $w_{beam} = 24$ kN/m³ $\times h_{edge} \times b_{edge} = \mathbf{2.2}$ kN/m

Boot element $w_{boot} = 24$ kN/m³ $\times h_{boot} \times b_{boot} = \mathbf{0.8}$ kN/m

Chamfer element $w_{chamfer} = 24$ kN/m³ $\times (h_{edge} - h_{slab})^2/(2 \times \tan(\alpha_{edge})) = \mathbf{0.2}$ kN/m

Slab element $w_{slabelmt} = 24$ kN/m³ $\times h_{slab} \times (h_{edge} - h_{slab})/\tan(\alpha_{edge}) = \mathbf{0.3}$ kN/m

Edge beam self weight $w_{edge} = w_{beam} + w_{boot} + w_{chamfer} + w_{slabelmt} = \mathbf{3.5}$ kN/m

Edge load number 1

Load type **Longitudinal line load**

Dead load $w_{Dedge1} = \mathbf{5.0}$ kN/m

Live load $w_{Ledge1} = \mathbf{2.0}$ kN/m

Ultimate load $w_{ultedge1} = 1.4 \times w_{Dedge1} + 1.6 \times w_{Ledge1} = \mathbf{10.2}$ kN/m

Longitudinal line load width $b_{edge1} = \mathbf{175}$ mm

Centroid of load from outside face of raft $x_{edge1} = \mathbf{88}$ mm

Edge beam bearing pressure check

Effective bearing width of edge beam $b_{bearing} = b_{edge} + b_{boot} + (h_{edge} - h_{slab})/\tan(\alpha_{edge}) = \mathbf{562}$ mm

Total uniform load at formation level $w_{udledge} = w_{Dudl}+w_{Ludl}+w_{edge}/b_{bearing}+w_{hcorethick} = \mathbf{19.2}$ kN/m²

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

Load x distance for edge load 1 $Moment_1 = w_{ultedge1} \times x_{edge1} = \mathbf{0.9}$ kN

Sum of ultimate longitud'l and equivalent line loads $\Sigma UDL = \mathbf{10.2}$ kN/m

Sum of load x distances $\Sigma Moment = \mathbf{0.9}$ kN

Centroid of loads x_{bar} = ΣMoment/ΣUDL = **87** mm

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

Sum of unfactored longitud'l and eff'tive line loads ΣUDLsls = **7.0** kN/m

Allowable bearing width $b_{allow} = 2 \times x_{bar} + 2 \times h_{hcoreslab} \times \tan(30)$ = **348** mm

Bearing pressure due to line/point loads $q_{linepoint} = \Sigma UDLsls / b_{allow}$ = **20.1** kN/m^2

Total applied bearing pressure $q_{edge} = q_{linepoint} + w_{udledge}$ = **39.3** kN/m^2

PASS - q_{edge} <= q_{allow} - Allowable bearing pressure is not exceeded

Edge beam bending check

Divider for moments due to udl's β_{udl} = **10.0**

Applied bending moments

Span of edge beam $l_{edge} = \phi_{depthick} + d_{edgetop}$ = **1602** mm

Ultimate self weight udl $w_{edgeult} = 1.4 \times w_{edge}$ = **4.9** kN/m

Ultimate slab udl (approx) $w_{edgeslab}$ = max(0 kN/m,1.4×w_{slab}×(($\phi_{depthick}$/2×3/4)-(b_{edge}+(h_{edge}-h_{slab})/tan(α_{edge}))))

$w_{edgeslab}$ = **0.6** kN/m

Self weight and slab bending moment $M_{edgesw} = (w_{edgeult} + w_{edgeslab}) \times l_{edge}^2/\beta_{udl}$ = **1.4** kNm

Self weight shear force $V_{edgesw} = (w_{edgeult} + w_{edgeslab}) \times l_{edge}/2$ = **4.4** kN

Moments due to applied uniformly distributed loads

Ultimate udl (approx) $w_{edgeudl} = w_{udlult} \times \phi_{depthick}/2 \times 3/4$ = **7.6** kN/m

Bending moment $M_{edgeudl} = w_{edgeudl} \times l_{edge}^2/\beta_{udl}$ = **1.9** kNm

Shear force $V_{edgeudl} = w_{edgeudl} \times l_{edge}/2$ = **6.1** kN

Moment and shear due to load number 1

Bending moment $M_{edge1} = w_{ultedge1} \times l_{edge}^2/\beta_{udl}$ = **2.6** kNm

Shear force $V_{edge1} = w_{ultedge1} \times l_{edge}/2$ = **8.2** kN

Resultant moments and shears

Total moment (hogging and sagging) $M_{\Sigma edge}$ = **6.0** kNm

Maximum shear force $V_{\Sigma edge}$ = **18.6** kN

Reinforcement required in top

Width of section in compression zone $b_{edgetop} = b_{edge} + b_{boot}$ = **475** mm

Average web width $b_w = b_{edge} + (h_{edge}/\tan(\alpha_{edge}))/2$ = **387** mm

K factor $K_{edgetop} = M_{\Sigma edge}/(f_{cu} \times b_{edgetop} \times d_{edgetop}^2)$ = **0.006**

Lever arm $z_{edgetop} = d_{edgetop} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{edgetop}/0.9)})$ = **239** mm

Area of steel required for bending $A_{sedgetopbend} = M_{\Sigma edge}/((1.0/\gamma_s) \times f_y \times z_{edgetop})$ = **57** mm^2

Minimum area of steel required $A_{sedgetopmin} = 0.0013 \times 1.0 \times b_w \times h_{edge}$ = **151** mm^2

Area of steel required $A_{sedgetopreq} = \max(A_{sedgetopbend}, A_{sedgetopmin})$ = **151** mm^2

PASS - $A_{sedgetopreq}$ <= $A_{sedgetop}$ - Area of reinforcement provided in top of edge beams is adequate

Reinforcement required in bottom

Width of section in compression zone $b_{edgebtm} = b_{edge} + (h_{edge} - h_{slab})/\tan(\alpha_{edge}) + 0.1 \times l_{edge}$ = **547** mm

K factor $K_{edgebtm} = M_{\Sigma edge}/(f_{cu} \times b_{edgebtm} \times d_{edgebtm}^2)$ = **0.005**

Lever arm $z_{edgebtm} = d_{edgebtm} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{edgebtm}/0.9)})$ = **235** mm

Area of steel required for bending $A_{sedgebtmbend} = M_{\Sigma edge}/((1.0/\gamma_s) \times f_y \times z_{edgebtm})$ = **58** mm^2

Minimum area of steel required $A_{sedgebtmmin} = 0.0013 \times 1.0 \times b_w \times h_{edge}$ = **151** mm^2

Area of steel required $A_{sedgebtmreq} = \max(A_{sedgebtmbend}, A_{sedgebtmmin})$ = **151** mm^2

PASS - $A_{sedgebtmreq}$ <= $A_{sedgebtm}$ - Area of reinforcement provided in bottom of edge beams is adequate

Edge beam shear check

Applied shear stress — $v_{edge} = V_{\Sigma edge}/(b_w \times d_{edgetop}) = \mathbf{0.191}\ N/mm^2$

Tension steel ratio — $\rho_{edge} = 100 \times A_{sedgetop}/(b_w \times d_{edgetop}) = \mathbf{0.348}$

From BS8110-1:1997 - Table 3.8

Design concrete shear strength — $v_{cedge} = \mathbf{0.558}\ N/mm^2$

v_{edge} <= v_{cedge} + 0.4N/mm² - Therefore minimum links required

Link area to spacing ratio required — $A_{sv}\_upon\_s_{vreqedge} = 0.4N/mm^2 \times b_w/((1.0/\gamma_s) \times f_{ys}) = \mathbf{0.356}\ mm$

Link area to spacing ratio provided — $A_{sv}\_upon\_s_{vprovedge} = N_{edgelink} \times \pi \times \phi_{edgelink}^2/(4 \times s_{vedge}) = \mathbf{0.754}\ mm$

PASS - $A_{sv}\_upon\_s_{vreqedge}$ <= $A_{sv}\_upon\_s_{vprovedge}$ - Shear reinforcement provided in edge beams is adequate

Boot design check

Effective cantilever span — $l_{boot} = b_{boot} + d_{boot}/2 = \mathbf{255}\ mm$

Approximate ultimate bearing pressure — $q_{ult} = 1.55 \times q_{allow} = \mathbf{77.5}\ kN/m^2$

Cantilever moment — $M_{boot} = q_{ult} \times l_{boot}^2/2 = \mathbf{2.5}\ kNm/m$

Shear force — $V_{boot} = q_{ult} \times l_{boot} = \mathbf{19.7}\ kN/m$

K factor — $K_{boot} = M_{boot}/(f_{cu} \times d_{boot}^2) = \mathbf{0.003}$

Lever arm — $z_{boot} = d_{boot} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{boot}/0.9)}) = \mathbf{151}\ mm$

Area of reinforcement required — $A_{sbootreq} = M_{boot}/((1.0/\gamma_s) \times f_{yboot} \times z_{boot}) = \mathbf{38}\ mm^2/m$

PASS - $A_{sbootreq}$ <= A_{sboot} - Area of reinforcement provided in boot is adequate for bending

Applied shear stress — $v_{boot} = V_{boot}/d_{boot} = \mathbf{0.124}\ N/mm^2$

Tension steel ratio — $\rho_{boot} = 100 \times A_{sboot}/d_{boot} = \mathbf{0.237}$

From BS8110-1:1997 - Table 3.8

Design concrete shear strength — $v_{cboot} = \mathbf{0.551}\ N/mm^2$

PASS - v_{boot} <= v_{cboot} - Shear capacity of the boot is adequate

Corner design checks

Basic loading

Corner bearing pressure check

Total uniform load at formation level — $w_{udlcorner} = w_{Dudl}+w_{Ludl}+w_{edge}/b_{bearing}+w_{hcorethick} = \mathbf{19.2}\ kN/m^2$

PASS - $w_{udlcorner}$ <= q_{allow} - Applied bearing pressure is less than allowable

Corner beam bending check

Cantilever span of edge beam — $l_{corner} = \phi_{depthick}/\sqrt{(2)} + d_{edgetop}/2 = \mathbf{1081}\ mm$

Moment and shear due to self weight

Ultimate self weight udl — $w_{edgeult} = 1.4 \times w_{edge} = \mathbf{4.9}\ kN/m$

Average ultimate slab udl (approx) — $w_{cornerslab} = \max(0\ kN/m, 1.4 \times w_{slab} \times (\phi_{depthick}/(\sqrt{(2)} \times 2)-(b_{edge}+(h_{edge}-h_{slab})/\tan(\alpha_{edge}))))$

$w_{cornerslab} = \mathbf{0.5}\ kN/m$

Self weight and slab bending moment — $M_{cornersw} = (w_{edgeult} + w_{cornerslab}) \times l_{corner}^2/2 = \mathbf{3.1}\ kNm$

Self weight and slab shear force — $V_{cornersw} = (w_{edgeult} + w_{cornerslab}) \times l_{corner} = \mathbf{5.7}\ kN$

Moment and shear due to udls

Maximum ultimate udl — $w_{cornerudl} = ((1.4 \times w_{Dudl})+(1.6 \times w_{Ludl})) \times \phi_{depthick}/\sqrt{(2)} = \mathbf{14.3}\ kN/m$

Bending moment — $M_{cornerudl} = w_{cornerudl} \times l_{corner}^2/6 = \mathbf{2.8}\ kNm$

Shear force — $V_{cornerudl} = w_{cornerudl} \times l_{corner}/2 = \mathbf{7.7}\ kN$

Resultant moments and shears

Total design moment — $M_{\Sigma corner} = M_{cornersw} + M_{cornerudl} = \mathbf{5.9}\ kNm$

Total design shear force — $V_{\Sigma corner} = V_{cornersw} + V_{cornerudl} = \mathbf{13.5}\ kN$

Reinforcement required in top of edge beam

K factor $K_{corner} = M_{\Sigma corner}/(f_{cu} \times b_{edgetop} \times d_{edgetop}^2) = \mathbf{0.006}$

Lever arm $z_{corner} = d_{edgetop} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{corner}/0.9)}) = \mathbf{239}$ mm

Area of steel required for bending $A_{scornerbend} = M_{\Sigma corner}/((1.0/\gamma_s) \times f_y \times z_{corner}) = \mathbf{57}$ mm^2

Minimum area of steel required $A_{scornermin} = A_{sedgetopmin} = \mathbf{151}$ mm^2

Area of steel required $A_{scorner} = \max(A_{scornerbend}, A_{scornermin}) = \mathbf{151}$ mm^2

PASS - $A_{scorner}$ <= $A_{sedgetop}$ - Area of reinforcement provided in top of edge beams at corners is adequate

Corner beam shear check

Average web width $b_w = b_{edge} + (h_{edge}/\tan(\alpha_{edge}))/2 = \mathbf{387}$ mm

Applied shear stress $v_{corner} = V_{\Sigma corner}/(b_w \times d_{edgetop}) = \mathbf{0.138}$ N/mm^2

Tension steel ratio $\rho_{corner} = 100 \times A_{sedgetop}/(b_w \times d_{edgetop}) = \mathbf{0.348}$

From BS8110-1:1997 - Table 3.8

Design concrete shear strength $v_{ccorner} = \mathbf{0.497}$ N/mm^2

v_{corner} <= $v_{ccorner}$ + 0.4N/mm^2 - Therefore minimum links required

Link area to spacing ratio required $A_{sv}\_upon\_s_{vreqcorner} = 0.4N/mm^2 \times b_w/((1.0/\gamma_s) \times f_{ys}) = \mathbf{0.356}$ mm

Link area to spacing ratio provided $A_{sv}\_upon\_s_{vprovedge} = N_{edgelink} \times \pi \times \phi_{edgelink}^2/(4 \times s_{vedge}) = \mathbf{0.754}$ mm

PASS - $A_{sv}\_upon\_s_{vreqcorner}$ <= $A_{sv}\_upon\_s_{vprovedge}$ - Shear reinforcement provided in edge beams at corners is adequate

Corner beam deflection check

Basic allowable span to depth ratio $Ratio_{basiccorner} = \mathbf{7.0}$

Moment factor $M_{factorcorner} = M_{\Sigma corner}/(b_{edgetop} \times d_{edgetop}^2) = \mathbf{0.195}$ N/mm^2

Steel service stress $f_{scorner} = 2/3 \times f_y \times A_{scornerbend}/A_{sedgetop} = \mathbf{55.574}$ N/mm^2

Modification factor $MF_{corner} = \min(2.0, 0.55 + [(477N/mm^2 - f_{scorner})/(120 \times (0.9N/mm^2 + M_{factorcorner}))])$

$MF_{corner} = \mathbf{2.000}$

Modified allowable span to depth ratio $Ratio_{allowcorner} = Ratio_{basiccorner} \times MF_{corner} = \mathbf{14.000}$

Actual span to depth ratio $Ratio_{actualcorner} = l_{corner}/ d_{edgetop} = \mathbf{4.288}$

PASS - $Ratio_{actualcorner}$ <= $Ratio_{allowcorner}$ - Edge beam span to depth ratio is adequate