

FAR Structures Ltd
Consulting Structural Engineers

20 Caswell Avenue
Caswell
Swansea
SA3 4RU

m: +44(0)7703 043 608
e: andrew@farstructures.uk

STRUCTURAL CALCULATIONS

For

REINFORCED CONCRETE RAFT FOUNDATION

at

**NEW DWELLING
ALLTYGRUG ROAD
YSTALYFERA
NEATH PORT TALBOT**

Date: July 2020

FAR Structures Ltd
Consulting Structural Engineers

20 Caswell Avenue
Caswell
Swansea
SA3 4RU

m: +44(0)7703 043 608
e: andrew@farstructures.uk

REINFORCED CONCRETE RAFT FOUNDATION

NEW DWELLING OFF ALLTYGRUG ROAD, YSTALYFERA, NEATH PORT TALBOT

LOADINGS

DEAD:

kN/m²

ROOF:

Tiles	0.60
Felt & battens	0.04
Rafters	0.12
Insulation	0.04
Plasterboard & skim	<u>0.15</u>
	0.95 kN/m ²

UPPER FLOORS:

Finishes	0.10
Decking & joists	0.35
Plasterboard & skim	<u>0.15</u>
	0.60 kN/m ²

MASONRY:

100mm thick & finishes	2.50 kN/m ²
------------------------	------------------------

TIMBER FRAME:

Self weight & finishes	0.60 kN/m ²
------------------------	------------------------

IMPOSED:

ROOF:

Snow	0.60 kN/m ²
------	------------------------

UPPER FLOORS:

Residential	1.50 kN/m ²
-------------	------------------------

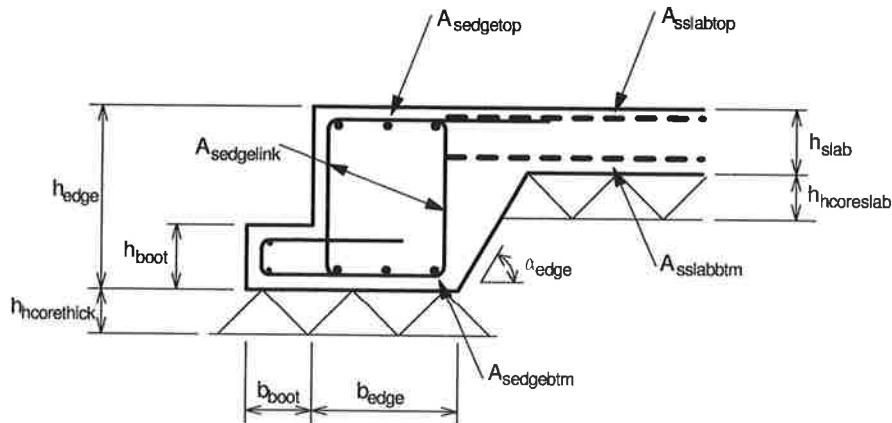
GROUND FLOOR:

Residential	1.50 kN/m ²
Garage	2.50 kN/m ²

Tekla Tedds FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project New Dwelling, Alltygrug Road, Ystalyfera, NPT			Job no.	
	Calcs for RC Raft Foundation			Start page no./Revision 2	
	Calcs by AR	Calcs date 04/07/2020	Checked by	Checked date	Approved by Approved date

RAFT FOUNDATION DESIGN (BS8110 : PART 1 : 1997)

Tedds calculation version 1.0.12



Soil and raft definition

Soil definition

Allowable bearing pressure
 Number of types of soil forming sub-soil
 Soil density
 Depth of hardcore beneath slab
 Depth of hardcore beneath thickenings
 Density of hardcore
 Basic assumed diameter of local depression
 Diameter under slab modified for hardcore
 Diameter under thickenings modified for hardcore

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

One type only

Firm to loose

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

$$h_{hcorethick} = 0 \text{ mm (Dispersion allowed for bearing pressure check)}$$

$$\gamma_{hcore} = 18.0 \text{ kN/m}^3$$

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

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

$$\phi_{depthick} = \phi_{depbasic} - h_{hcorethick} = 2000 \text{ mm}$$

Raft slab definition

Max dimension/max dimension between joints
 Slab thickness
 Concrete strength
 Poissons ratio of concrete
 Slab mesh reinforcement strength
 Partial safety factor for steel reinforcement
 From C&CA document 'Concrete ground floors' Table 5
 Minimum mesh required in top for shrinkage
 Actual mesh provided in top
 Mesh provided in bottom
 Top mesh bar diameter
 Bottom mesh bar diameter
 Cover to top reinforcement
 Cover to bottom reinforcement
 Average effective depth of top reinforcement
 Average effective depth of bottom reinforcement
 Overall average effective depth

$$l_{max} = 14.500 \text{ m}$$

$$h_{slab} = 150 \text{ mm}$$

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

$$\nu = 0.2$$

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

$$\gamma_s = 1.15$$

A142

$$\mathbf{A252 (A_{sslabbtop} = 252 \text{ mm}^2/\text{m})}$$

$$\mathbf{A252 (A_{sslabbtm} = 252 \text{ mm}^2/\text{m})}$$

$$\phi_{slabbtop} = 8 \text{ mm}$$

$$\phi_{slabbtm} = 8 \text{ mm}$$

$$C_{top} = 25 \text{ mm}$$

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

$$d_{slabbav} = h_{slab} - C_{top} - \phi_{slabbtop} = 117 \text{ mm}$$

$$d_{bslabav} = h_{slab} - C_{btm} - \phi_{slabbtm} = 107 \text{ mm}$$

$$d_{slabbav} = (d_{slabbav} + d_{bslabav})/2 = 112 \text{ mm}$$

Tekla Tedds FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project New Dwelling, Alltygrug Road, Ystalyfera, NPT				Job no.	
	Calcs for RC Raft Foundation				Start page no./Revision 3	
	Calcs by AR	Calcs date 04/07/2020	Checked by	Checked date	Approved by	Approved date

Minimum effective depth of top reinforcement

$$d_{slabmin} = d_{slabav} - \phi_{slabtop}/2 = 113 \text{ mm}$$

Minimum effective depth of bottom reinforcement

$$d_{slabmin} = d_{slabav} - \phi_{slabbtm}/2 = 103 \text{ mm}$$

Edge beam definition

Overall depth

$$h_{edge} = 675 \text{ mm}$$

Width

$$b_{edge} = 400 \text{ mm}$$

Depth of boot

$$h_{boot} = 225 \text{ mm}$$

Width of boot

$$b_{boot} = 250 \text{ mm}$$

Angle of chamfer to horizontal

$$\alpha_{edge} = 60 \text{ deg}$$

Strength of main bar reinforcement

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

Strength of link reinforcement

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

Reinforcement provided in top

$$3 \text{ H20 bars } (A_{sedgetop} = 942 \text{ mm}^2)$$

Reinforcement provided in bottom

$$3 \text{ H20 bars } (A_{sedgebtm} = 942 \text{ mm}^2)$$

Link reinforcement provided

$$2 \text{ H10 legs at 200 ctrs } (A_{sv}/s_v = 0.785 \text{ mm})$$

Bottom cover to links

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

Effective depth of top reinforcement

$$d_{edgetop} = h_{edge} - C_{top} - \phi_{slabtop} - \phi_{edgelink} - \phi_{edgetop}/2 = 622 \text{ mm}$$

Effective depth of bottom reinforcement

$$d_{edgebtm} = h_{edge} - C_{beam} - \phi_{edgelink} - \phi_{edgebtm}/2 = 620 \text{ mm}$$

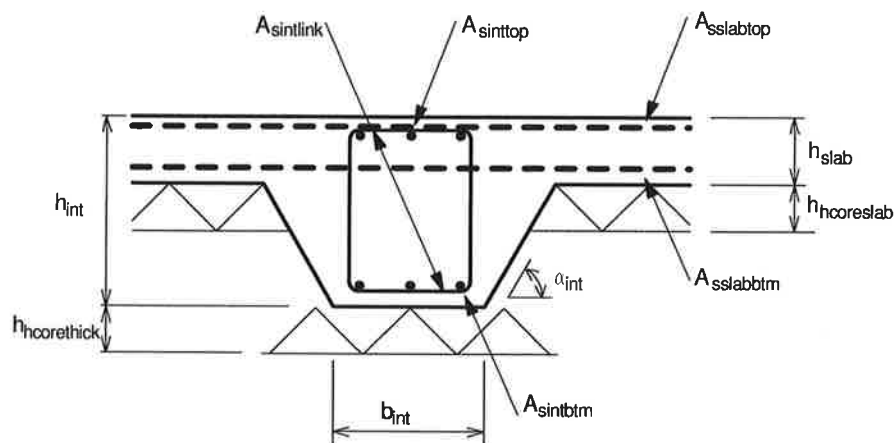
Boot main reinforcement

$$\text{H10 bars at 225 ctrs } (A_{sboot} = 349 \text{ mm}^2/\text{m})$$

Effective depth of boot reinforcement

$$d_{boot} = h_{boot} - C_{beam} - \phi_{boot}/2 = 185 \text{ mm}$$

Internal beam definition



Overall depth

$$h_{int} = 675 \text{ mm}$$

Width

$$b_{int} = 450 \text{ mm}$$

Angle of chamfer to horizontal

$$\alpha_{int} = 60 \text{ deg}$$

Strength of main bar reinforcement

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

Strength of link reinforcement

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

Reinforcement provided in top

$$3 \text{ H20 bars } (A_{sinttop} = 942 \text{ mm}^2)$$

Reinforcement provided in bottom

$$3 \text{ H20 bars } (A_{sintbtm} = 942 \text{ mm}^2)$$

Link reinforcement provided

$$2 \text{ H10 legs at 200 ctrs } (A_{sv}/s_v = 0.785 \text{ mm})$$

Effective depth of top reinforcement

$$d_{inttop} = h_{int} - C_{top} - 2 \times \phi_{slabtop} - \phi_{inttop}/2 = 624 \text{ mm}$$

Effective depth of bottom reinforcement

$$d_{intbtm} = h_{int} - C_{beam} - \phi_{intlink} - \phi_{intbtm}/2 = 620 \text{ mm}$$

Tekla Tedds FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project New Dwelling, Alltygrug Road, Ystalyfera, NPT				Job no.	
	Calcs for RC Raft Foundation				Start page no./Revision 4	
	Calcs by AR	Calcs date 04/07/2020	Checked by	Checked date	Approved by	Approved date

Internal slab design checks

Basic loading

Slab self weight

$$W_{slab} = 24 \text{ kN/m}^3 \times h_{slab} = 3.6 \text{ kN/m}^2$$

Hardcore

$$W_{hcoreslab} = \gamma_{hcore} \times h_{hcoreslab} = 2.7 \text{ kN/m}^2$$

Applied loading

Uniformly distributed dead load

$$W_{Dudl} = 2.0 \text{ kN/m}^2$$

Uniformly distributed live load

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

Internal slab bearing pressure check

Total uniform load at formation level

$$W_{udl} = W_{slab} + W_{hcoreslab} + W_{Dudl} + W_{Ludl} = 9.8 \text{ kN/m}^2$$

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

Internal slab bending and shear check

Applied bending moments

Span of slab

$$l_{slab} = \phi_{dep} + d_{slab} = 1967 \text{ mm}$$

Ultimate self weight udl

$$W_{swult} = 1.4 \times W_{slab} = 5.0 \text{ kN/m}^2$$

Self weight moment at centre

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

Self weight moment at edge

$$M_{esw} = W_{swult} \times l_{slab}^2 / 32 = 0.6 \text{ kNm/m}$$

Self weight shear force at edge

$$V_{sw} = W_{swult} \times l_{slab} / 4 = 2.5 \text{ kN/m}$$

Moments due to applied uniformly distributed loads

Ultimate applied udl

$$W_{udult} = 1.4 \times W_{Dudl} + 1.6 \times W_{Ludl} = 5.2 \text{ kN/m}^2$$

Moment at centre

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

Moment at edge

$$M_{eudl} = W_{udult} \times l_{slab}^2 / 32 = 0.6 \text{ kNm/m}$$

Shear force at edge

$$V_{udl} = W_{udult} \times l_{slab} / 4 = 2.6 \text{ kN/m}$$

Resultant moments and shears

Total moment at edge

$$M_{\Sigma e} = 1.2 \text{ kNm/m}$$

Total moment at centre

$$M_{\Sigma c} = 0.7 \text{ kNm/m}$$

Total shear force

$$V_{\Sigma} = 5.0 \text{ kN/m}$$

Reinforcement required in top

K factor

$$K_{slabtop} = M_{\Sigma e} / (f_{cu} \times d_{slab}^2) = 0.003$$

Lever arm

$$Z_{slabtop} = d_{slab} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slabtop}/0.9)}) = 111.1 \text{ mm}$$

Area of steel required for bending

$$A_{slabtopbend} = M_{\Sigma e} / ((1.0/\gamma_s) \times f_{yslab} \times Z_{slabtop}) = 26 \text{ mm}^2/\text{m}$$

Minimum area of steel required

$$A_{slabmin} = 0.0013 \times h_{slab} = 195 \text{ mm}^2/\text{m}$$

Area of steel required

$$A_{slabtopreq} = \max(A_{slabtopbend}, A_{slabmin}) = 195 \text{ mm}^2/\text{m}$$

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

Reinforcement required in bottom

K factor

$$K_{slabbtm} = M_{\Sigma c} / (f_{cu} \times d_{slab}^2) = 0.002$$

Lever arm

$$Z_{slabbtm} = d_{slab} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slabbtm}/0.9)}) = 101.6 \text{ mm}$$

Area of steel required for bending

$$A_{slabbtmbend} = M_{\Sigma c} / ((1.0/\gamma_s) \times f_{yslab} \times Z_{slabbtm}) = 17 \text{ mm}^2/\text{m}$$

Area of steel required

$$A_{slabbtmreq} = \max(A_{slabbtmbend}, A_{slabmin}) = 195 \text{ mm}^2/\text{m}$$

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

Shear check

Applied shear stress

$$v = V_{\Sigma} / d_{slabmin} = 0.045 \text{ N/mm}^2$$

Tension steel ratio

$$\rho = 100 \times A_{slabtop} / d_{slabmin} = 0.223$$

From BS8110-1:1997 - Table 3.8

Tekla Tedds FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project				Job no.	
	New Dwelling, Alltygrug Road, Ystalyfera, NPT				Start page no./Revision	
	Calcs for				5	
	RC Raft Foundation					
Calcs by		Calcs date	Checked by	Checked date	Approved by	Approved date
AR		04/07/2020				

Design concrete shear strength

$$v_c = 0.588 \text{ N/mm}^2$$

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

Internal slab deflection check

Basic allowable span to depth ratio

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

Moment factor

$$M_{\text{factor}} = M_{\text{Ed}} / d_{\text{bslabav}}^2 = 0.065 \text{ N/mm}^2$$

Steel service stress

$$f_s = 2/3 \times f_{\text{yslab}} \times A_{\text{sslabbtmbend}} / A_{\text{sslabbtm}} = 22.234 \text{ N/mm}^2$$

Modification factor

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

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

Modified allowable span to depth ratio

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

Actual span to depth ratio

$$\text{Ratio}_{\text{actual}} = l_{\text{slab}} / d_{\text{bslabav}} = 18.383$$

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

Edge beam design checks

Basic loading

Hardcore

$$W_{\text{hcorethick}} = \gamma_{\text{hcore}} \times h_{\text{hcorethick}} = 0.0 \text{ kN/m}^2$$

Edge beam

Rectangular beam element

$$W_{\text{beam}} = 24 \text{ kN/m}^3 \times h_{\text{edge}} \times b_{\text{edge}} = 6.5 \text{ kN/m}$$

Boot element

$$W_{\text{boot}} = 24 \text{ kN/m}^3 \times h_{\text{boot}} \times b_{\text{boot}} = 1.4 \text{ kN/m}$$

Chamfer element

$$W_{\text{chamfer}} = 24 \text{ kN/m}^3 \times (h_{\text{edge}} - h_{\text{slab}})^2 / (2 \times \tan(\alpha_{\text{edge}})) = 1.9 \text{ kN/m}$$

Slab element

$$W_{\text{slabemt}} = 24 \text{ kN/m}^3 \times h_{\text{slab}} \times (h_{\text{edge}} - h_{\text{slab}}) / \tan(\alpha_{\text{edge}}) = 1.1 \text{ kN/m}$$

Edge beam self weight

$$W_{\text{edge}} = W_{\text{beam}} + W_{\text{boot}} + W_{\text{chamfer}} + W_{\text{slabemt}} = 10.8 \text{ kN/m}$$

Edge load number 1

Load type

Longitudinal line load

Dead load

$$W_{\text{Dedge1}} = 14.0 \text{ kN/m}$$

Live load

$$W_{\text{Ledge1}} = 0.0 \text{ kN/m}$$

Ultimate load

$$W_{\text{ultedge1}} = 1.4 \times W_{\text{Dedge1}} + 1.6 \times W_{\text{Ledge1}} = 19.6 \text{ kN/m}$$

Longitudinal line load width

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

Centroid of load from outside face of raft

$$X_{\text{edge1}} = 100 \text{ mm}$$

Edge load number 2

Load type

Longitudinal line load

Dead load

$$W_{\text{Dedge2}} = 10.0 \text{ kN/m}$$

Live load

$$W_{\text{Ledge2}} = 11.0 \text{ kN/m}$$

Ultimate load

$$W_{\text{ultedge2}} = 1.4 \times W_{\text{Dedge2}} + 1.6 \times W_{\text{Ledge2}} = 31.6 \text{ kN/m}$$

Longitudinal line load width

$$b_{\text{edge2}} = 140 \text{ mm}$$

Centroid of load from outside face of raft

$$X_{\text{edge2}} = 320 \text{ mm}$$

Edge beam bearing pressure check

Effective bearing width of edge beam

$$b_{\text{bearing}} = b_{\text{edge}} + b_{\text{boot}} + (h_{\text{edge}} - h_{\text{slab}}) / \tan(\alpha_{\text{edge}}) = 953 \text{ mm}$$

Total uniform load at formation level

$$W_{\text{udledge}} = W_{\text{Dudl}} + W_{\text{Ludl}} + W_{\text{edge}} / b_{\text{bearing}} + W_{\text{hcorethick}} = 14.9 \text{ kN/m}^2$$

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

Load x distance for edge load 1

$$\text{Moment}_1 = W_{\text{ultedge1}} \times X_{\text{edge1}} = 2.0 \text{ kN}$$

Load x distance for edge load 2

$$\text{Moment}_2 = W_{\text{ultedge2}} \times X_{\text{edge2}} = 10.1 \text{ kN}$$

Sum of ultimate longitud'l and equivalent line loads $\Sigma \text{UDL} = 51.2 \text{ kN/m}$

Sum of load x distances

$$\Sigma \text{Moment} = 12.1 \text{ kN}$$

Centroid of loads

$$X_{\text{bar}} = \Sigma \text{Moment} / \Sigma \text{UDL} = 236 \text{ mm}$$

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

Sum of unfactored longitud'l and eff'tive line loads $\Sigma \text{UDLsls} = 35.0 \text{ kN/m}$

Tekla Tedds FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project New Dwelling, Alltygrug Road, Ystalyfera, NPT				Job no.	
	Calcs for RC Raft Foundation				Start page no./Revision 6	
	Calcs by AR	Calcs date 04/07/2020	Checked by	Checked date	Approved by	Approved date

Allowable bearing width

$$b_{allow} = 2 \times x_{bar} + 2 \times h_{coreslab} \times \tan(30) = \mathbf{645 \text{ mm}}$$

Bearing pressure due to line/point loads

$$q_{linepoint} = \Sigma UDLs / b_{allow} = \mathbf{54.3 \text{ kN/m}^2}$$

Total applied bearing pressure

$$q_{edge} = q_{linepoint} + w_{udledge} = \mathbf{69.1 \text{ kN/m}^2}$$

$q_{edge} > q_{allow}$ - The slab is required to resist a moment due to eccentricity

Now assume moment due to load/reaction eccentricity is resisted by slab

Bearing width required

$$b_{req} = \Sigma UDLs / (q_{allow} - w_{udledge}) = \mathbf{996 \text{ mm}}$$

Effective bearing width at u/s of slab

$$b_{reqeff} = b_{req} - 2 \times h_{coreslab} \times \tan(30) = \mathbf{823 \text{ mm}}$$

Load/reaction eccentricity

$$e = b_{reqeff} / 2 - x_{bar} = \mathbf{176 \text{ mm}}$$

Ultimate moment to be resisted by slab

$$M_{ecc} = \Sigma UDL \times e = \mathbf{9.0 \text{ kNm/m}}$$

From slab bending check

Moment due to depression under slab (hogging)

$$M_{\Sigma e} = \mathbf{1.2 \text{ kNm/m}}$$

Total moment to be resisted by slab top steel

$$M_{slabtop} = M_{ecc} + M_{\Sigma e} = \mathbf{10.2 \text{ kNm/m}}$$

K factor

$$K_{slab} = M_{slabtop} / (f_{cu} \times d_{slabmin}^2) = \mathbf{0.023}$$

Lever arm

$$Z_{slab} = d_{slabmin} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slab}/0.9)}) = \mathbf{107 \text{ mm}}$$

Area of steel required

$$A_{sslabreq} = M_{slabtop} / ((1.0/\gamma_s) \times f_y \times Z_{slab}) = \mathbf{219 \text{ mm}^2/\text{m}}$$

PASS - $A_{sslabreq} \leq A_{sslabtop}$ - Area of reinforcement provided to transfer moment into slab is adequate

The allowable bearing pressure under the edge beam will not be exceeded

Library item - B pressure with moment transfer

Edge beam bending check

Divider for moments due to udl's

$$\beta_{udl} = \mathbf{10.0}$$

Applied bending moments

Span of edge beam

$$l_{edge} = \phi_{depth} + d_{edgetop} = \mathbf{2622 \text{ mm}}$$

Ultimate self weight udl

$$w_{edgeult} = 1.4 \times w_{edge} = \mathbf{15.2 \text{ kN/m}}$$

Ultimate slab udl (approx)

$$w_{edgeslab} = \max(0 \text{ kN/m}, 1.4 \times w_{slab} \times ((\phi_{depth}/2 \times 3/4) - (b_{edge} + (h_{edge} - h_{slab})/\tan(\alpha_{edge}))))$$

$$w_{edgeslab} = \mathbf{0.2 \text{ kN/m}}$$

Self weight and slab bending moment

$$M_{edgesw} = (w_{edgeult} + w_{edgeslab}) \times l_{edge}^2 / \beta_{udl} = \mathbf{10.6 \text{ kNm}}$$

Self weight shear force

$$V_{edgesw} = (w_{edgeult} + w_{edgeslab}) \times l_{edge} / 2 = \mathbf{20.2 \text{ kN}}$$

Moments due to applied uniformly distributed loads

Ultimate udl (approx)

$$w_{edgeudl} = w_{udult} \times \phi_{depth} / 2 \times 3/4 = \mathbf{3.9 \text{ kN/m}}$$

Bending moment

$$M_{edgeudl} = w_{edgeudl} \times l_{edge}^2 / \beta_{udl} = \mathbf{2.7 \text{ kNm}}$$

Shear force

$$V_{edgeudl} = w_{edgeudl} \times l_{edge} / 2 = \mathbf{5.1 \text{ kN}}$$

Moment and shear due to load number 1

Bending moment

$$M_{edge1} = w_{ultedge1} \times l_{edge}^2 / \beta_{udl} = \mathbf{13.5 \text{ kNm}}$$

Shear force

$$V_{edge1} = w_{ultedge1} \times l_{edge} / 2 = \mathbf{25.7 \text{ kN}}$$

Moment and shear due to load number 2

Bending moment

$$M_{edge2} = w_{ultedge2} \times l_{edge}^2 / \beta_{udl} = \mathbf{21.7 \text{ kNm}}$$

Shear force

$$V_{edge2} = w_{ultedge2} \times l_{edge} / 2 = \mathbf{41.4 \text{ kN}}$$

Resultant moments and shears

Total moment (hogging and sagging)

$$M_{\Sigma edge} = \mathbf{48.5 \text{ kNm}}$$

Maximum shear force

$$V_{\Sigma edge} = \mathbf{92.4 \text{ kN}}$$

Reinforcement required in top

Width of section in compression zone

$$b_{edgetop} = b_{edge} + b_{boot} = \mathbf{650 \text{ mm}}$$

Average web width

$$b_w = b_{edge} + (h_{edge} / \tan(\alpha_{edge})) / 2 = \mathbf{595 \text{ mm}}$$

K factor

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

Lever arm

$$Z_{edgetop} = d_{edgetop} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{edgetop}/0.9)}) = \mathbf{591 \text{ mm}}$$

 FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project New Dwelling, Alltygrug Road, Ystalyfera, NPT			Job no.	
	Calcs for RC Raft Foundation			Start page no./Revision 7	
	Calcs by AR	Calcs date 04/07/2020	Checked by	Checked date	Approved by Approved date

Area of steel required for bending

$$A_{s\text{edgetopbend}} = M_{\Sigma\text{edge}} / ((1.0/\gamma_s) \times f_y \times Z_{\text{edgetop}}) = \mathbf{189 \text{ mm}^2}$$

Minimum area of steel required

$$A_{s\text{edgetopmin}} = 0.0013 \times 1.0 \times b_w \times h_{\text{edge}} = \mathbf{522 \text{ mm}^2}$$

Area of steel required

$$A_{s\text{edgetopreq}} = \max(A_{s\text{edgetopbend}}, A_{s\text{edgetopmin}}) = \mathbf{522 \text{ mm}^2}$$

PASS - $A_{s\text{edgetopreq}} \leq A_{s\text{edgetop}}$ - Area of reinforcement provided in top of edge beams is adequate

Reinforcement required in bottom

Width of section in compression zone

$$b_{\text{edgebtm}} = b_{\text{edge}} + (h_{\text{edge}} - h_{\text{slab}}) / \tan(\alpha_{\text{edge}}) + 0.1 \times l_{\text{edge}} = \mathbf{965 \text{ mm}}$$

K factor

$$K_{\text{edgebtm}} = M_{\Sigma\text{edge}} / (f_{cu} \times b_{\text{edgebtm}} \times d_{\text{edgebtm}}^2) = \mathbf{0.004}$$

Lever arm

$$Z_{\text{edgebtm}} = d_{\text{edgebtm}} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{\text{edgebtm}}/0.9)}) = \mathbf{589 \text{ mm}}$$

Area of steel required for bending

$$A_{s\text{edgebtmbend}} = M_{\Sigma\text{edge}} / ((1.0/\gamma_s) \times f_y \times Z_{\text{edgebtm}}) = \mathbf{189 \text{ mm}^2}$$

Minimum area of steel required

$$A_{s\text{edgebtmmin}} = 0.0013 \times 1.0 \times b_w \times h_{\text{edge}} = \mathbf{522 \text{ mm}^2}$$

Area of steel required

$$A_{s\text{edgebtmreq}} = \max(A_{s\text{edgebtmbend}}, A_{s\text{edgebtmmin}}) = \mathbf{522 \text{ mm}^2}$$

PASS - $A_{s\text{edgebtmreq}} \leq A_{s\text{edgebtm}}$ - Area of reinforcement provided in bottom of edge beams is adequate

Edge beam shear check

Applied shear stress

$$V_{\text{edge}} = V_{\Sigma\text{edge}} / (b_w \times d_{\text{edgetop}}) = \mathbf{0.250 \text{ N/mm}^2}$$

Tension steel ratio

$$\rho_{\text{edge}} = 100 \times A_{s\text{edgetop}} / (b_w \times d_{\text{edgetop}}) = \mathbf{0.255}$$

From BS8110-1:1997 - Table 3.8

Design concrete shear strength

$$V_{\text{cedge}} = \mathbf{0.448 \text{ N/mm}^2}$$

$V_{\text{edge}} \leq V_{\text{cedge}} + 0.4 \text{ N/mm}^2$ - Therefore minimum links required

Link area to spacing ratio required

$$A_{sv_upon_sv\text{reqedge}} = 0.4 \text{ N/mm}^2 \times b_w / ((1.0/\gamma_s) \times f_{ys}) = \mathbf{0.547 \text{ mm}}$$

Link area to spacing ratio provided

$$A_{sv_upon_sv\text{provedge}} = N_{\text{edge}} \times \pi \times \phi_{\text{edgelink}}^2 / (4 \times S_{\text{vedge}}) = \mathbf{0.785 \text{ mm}}$$

PASS - $A_{sv_upon_sv\text{reqedge}} \leq A_{sv_upon_sv\text{provedge}}$ - Shear reinforcement provided in edge beams is adequate

Boot design check

Effective cantilever span

$$l_{\text{boot}} = b_{\text{boot}} + d_{\text{boot}}/2 = \mathbf{343 \text{ mm}}$$

Approximate ultimate bearing pressure

$$q_{\text{ult}} = 1.55 \times q_{\text{allow}} = \mathbf{77.5 \text{ kN/m}^2}$$

Cantilever moment

$$M_{\text{boot}} = q_{\text{ult}} \times l_{\text{boot}}^2 / 2 = \mathbf{4.5 \text{ kNm/m}}$$

Shear force

$$V_{\text{boot}} = q_{\text{ult}} \times l_{\text{boot}} = \mathbf{26.5 \text{ kN/m}}$$

K factor

$$K_{\text{boot}} = M_{\text{boot}} / (f_{cu} \times d_{\text{boot}}^2) = \mathbf{0.004}$$

Lever arm

$$Z_{\text{boot}} = d_{\text{boot}} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{\text{boot}}/0.9)}) = \mathbf{176 \text{ mm}}$$

Area of reinforcement required

$$A_{s\text{bootreq}} = M_{\text{boot}} / ((1.0/\gamma_s) \times f_{y\text{boot}} \times Z_{\text{boot}}) = \mathbf{59 \text{ mm}^2/\text{m}}$$

PASS - $A_{s\text{bootreq}} \leq A_{s\text{boot}}$ - Area of reinforcement provided in boot is adequate for bending

Applied shear stress

$$V_{\text{boot}} = V_{\text{boot}} / d_{\text{boot}} = \mathbf{0.143 \text{ N/mm}^2}$$

Tension steel ratio

$$\rho_{\text{boot}} = 100 \times A_{s\text{boot}} / d_{\text{boot}} = \mathbf{0.189}$$

From BS8110-1:1997 - Table 3.8

Design concrete shear strength

$$V_{\text{cboot}} = \mathbf{0.492 \text{ N/mm}^2}$$

PASS - $V_{\text{boot}} \leq V_{\text{cboot}}$ - Shear capacity of the boot is adequate

Corner design checks

Basic loading

Corner load number 1

Load type

Line load in x direction

Dead load

$$W_{\text{Dcorner1}} = \mathbf{14.0 \text{ kN/m}}$$

Live load

$$W_{\text{Lcorner1}} = \mathbf{0.0 \text{ kN/m}}$$

Ultimate load

$$W_{\text{ultcorner1}} = 1.4 \times W_{\text{Dcorner1}} + 1.6 \times W_{\text{Lcorner1}} = \mathbf{19.6 \text{ kN/m}}$$

Centroid of load from outside face of raft

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

Corner load number 2

Load type

Line load in y direction

Tekla Tedds FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project New Dwelling, Alltygrug Road, Ystalyfera, NPT				Job no.	
	Calcs for RC Raft Foundation				Start page no./Revision 8	
	Calcs by AR	Calcs date 04/07/2020	Checked by	Checked date	Approved by	Approved date

Dead load	$W_{Dcorner2} = 14.0 \text{ kN/m}$
Live load	$W_{Lcorner2} = 0.0 \text{ kN/m}$
Ultimate load	$W_{ultcorner2} = 1.4 \times W_{Dcorner2} + 1.6 \times W_{Lcorner2} = 19.6 \text{ kN/m}$
Centroid of load from outside face of raft	$X_{corner2} = 100 \text{ mm}$
Corner load number 3	
Load type	Line load in x direction
Dead load	$W_{Dcorner3} = 10.0 \text{ kN/m}$
Live load	$W_{Lcorner3} = 10.0 \text{ kN/m}$
Ultimate load	$W_{ultcorner3} = 1.4 \times W_{Dcorner3} + 1.6 \times W_{Lcorner3} = 30.0 \text{ kN/m}$
Centroid of load from outside face of raft	$y_{corner3} = 320 \text{ mm}$
Corner load number 4	
Load type	Line load in y direction
Dead load	$W_{Dcorner4} = 10.0 \text{ kN/m}$
Live load	$W_{Lcorner4} = 10.0 \text{ kN/m}$
Ultimate load	$W_{ultcorner4} = 1.4 \times W_{Dcorner4} + 1.6 \times W_{Lcorner4} = 30.0 \text{ kN/m}$
Centroid of load from outside face of raft	$X_{corner4} = 320 \text{ mm}$
Corner bearing pressure check	
Total uniform load at formation level	$W_{udlcorner} = W_{Dudl} + W_{Ludl} + W_{edge}/b_{bearing} + W_{hcorethick} = 14.9 \text{ kN/m}^2$
Net bearing press avail to resist line/point loads	$Q_{netcorner} = Q_{allow} - W_{udlcorner} = 35.1 \text{ kN/m}^2$
Total line/point loads	
Total unfactored line load in x direction	$W_{\Sigma line x} = 34.0 \text{ kN/m}$
Total ultimate line load in x direction	$W_{\Sigma ultline x} = 49.6 \text{ kN/m}$
Total unfactored line load in y direction	$W_{\Sigma line y} = 34.0 \text{ kN/m}$
Total ultimate line load in y direction	$W_{\Sigma ultline y} = 49.6 \text{ kN/m}$
Total unfactored point load	$W_{\Sigma point} = 0.0 \text{ kN}$
Total ultimate point load	$W_{\Sigma ultpoint} = 0.0 \text{ kN}$
Length of side of sq reqd to resist line/point loads	$p_{corner} = [W_{\Sigma line x} + W_{\Sigma line y} + \sqrt{(W_{\Sigma line x} + W_{\Sigma line y})^2 + 4 \times Q_{netcorner} \times W_{\Sigma point}}] / (2 \times Q_{netcorner})$ $p_{corner} = 1935 \text{ mm}$
Bending moment about x-axis due to load/reaction eccentricity	
Moment due to load 1 (x line)	$M_{x1} = \max(0 \text{ kNm}, W_{ultcorner1} \times p_{corner} \times (p_{corner}/2 - y_{corner1})) = 32.9 \text{ kNm}$
Moment due to load 3 (x line)	$M_{x3} = \max(0 \text{ kNm}, W_{ultcorner3} \times p_{corner} \times (p_{corner}/2 - y_{corner3})) = 37.6 \text{ kNm}$
Total moment about x axis	$M_{\Sigma x} = 70.5 \text{ kNm}$
Bending moment about y-axis due to load/reaction eccentricity	
Moment due to load 2 (y line)	$M_{y2} = \max(0 \text{ kNm}, W_{ultcorner2} \times p_{corner} \times (p_{corner}/2 - x_{corner2})) = 32.9 \text{ kNm}$
Moment due to load 4 (y line)	$M_{y4} = \max(0 \text{ kNm}, W_{ultcorner4} \times p_{corner} \times (p_{corner}/2 - x_{corner4})) = 37.6 \text{ kNm}$
Total moment about y axis	$M_{\Sigma y} = 70.5 \text{ kNm}$
Check top reinforcement in edge beams for load/reaction eccentric moment	
Max moment due to load/reaction eccentricity	$M_{\Sigma} = \max(M_{\Sigma x}, M_{\Sigma y}) = 70.5 \text{ kNm}$
Assume all of this moment is resisted by edge beam	
From edge beam design checks away from corners	
Moment due to edge beam spanning depression	$M_{\Sigma edge} = 48.5 \text{ kNm}$
Total moment to be resisted	$M_{\Sigma cornerbp} = M_{\Sigma} + M_{\Sigma edge} = 119.0 \text{ kNm}$
Width of section in compression zone	$b_{edgetop} = b_{edge} + b_{boot} = 650 \text{ mm}$
K factor	$K_{cornerbp} = M_{\Sigma cornerbp} / (f_{cu} \times b_{edgetop} \times d_{edgetop}^2) = 0.014$
Lever arm	$Z_{cornerbp} = d_{edgetop} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{cornerbp}/0.9)}) = 591 \text{ mm}$
Total area of top steel required	$A_{scornerbp} = M_{\Sigma cornerbp} / ((1.0/\gamma_s) \times f_y \times Z_{cornerbp}) = 463 \text{ mm}^2$

Tekla Tedds FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project New Dwelling, Alltygrug Road, Ystalyfera, NPT				Job no.	
	Calcs for RC Raft Foundation				Start page no./Revision 9	
	Calcs by AR	Calcs date 04/07/2020	Checked by	Checked date	Approved by	Approved date

PASS - $A_{scornerbp} \leq A_{sedgetop}$ - Area of reinforcement provided to resist eccentric moment is adequate
The allowable bearing pressure at the corner will not be exceeded

Corner beam bending check

Cantilever span of edge beam

$$l_{corner} = \phi_{depth} / \sqrt{2} + d_{edgetop} / 2 = 1725 \text{ mm}$$

Moment and shear due to self weight

Ultimate self weight udl

$$W_{edgeult} = 1.4 \times W_{edge} = 15.2 \text{ kN/m}$$

Average ultimate slab udl (approx)

$$W_{cornerslab} = \max(0 \text{ kN/m}, 1.4 \times W_{slab} \times (\phi_{depth} / (\sqrt{2} \times 2) - (b_{edge} + (h_{edge} - h_{slab}) / \tan(\alpha_{edge}))))$$

$$W_{cornerslab} = 0.0 \text{ kN/m}$$

Self weight and slab bending moment

$$M_{cornersw} = (W_{edgeult} + W_{cornerslab}) \times l_{corner}^2 / 2 = 22.6 \text{ kNm}$$

Self weight and slab shear force

$$V_{cornersw} = (W_{edgeult} + W_{cornerslab}) \times l_{corner} = 26.2 \text{ kN}$$

Moment and shear due to udl

Maximum ultimate udl

$$W_{cornerudl} = ((1.4 \times W_{Dudl}) + (1.6 \times W_{Ludl})) \times \phi_{depth} / \sqrt{2} = 7.4 \text{ kN/m}$$

Bending moment

$$M_{cornerudl} = W_{cornerudl} \times l_{corner}^2 / 6 = 3.6 \text{ kNm}$$

Shear force

$$V_{cornerudl} = W_{cornerudl} \times l_{corner} / 2 = 6.3 \text{ kN}$$

Moment and shear due to line loads in x direction

Bending moment

$$M_{cornerlinex} = W_{\Sigma ultlinex} \times l_{corner}^2 / 2 = 73.8 \text{ kNm}$$

Shear force

$$V_{cornerlinex} = W_{\Sigma ultlinex} \times l_{corner} = 85.6 \text{ kN}$$

Moment and shear due to line loads in y direction

Bending moment

$$M_{cornerliney} = W_{\Sigma ultliney} \times l_{corner}^2 / 2 = 73.8 \text{ kNm}$$

Shear force

$$V_{cornerliney} = W_{\Sigma ultliney} \times l_{corner} = 85.6 \text{ kN}$$

Total moments and shears due to point loads

Bending moment about x axis

$$M_{cornerpointx} = 0.0 \text{ kNm}$$

Bending moment about y axis

$$M_{cornerpointy} = 0.0 \text{ kNm}$$

Shear force

$$V_{cornerpoint} = 0.0 \text{ kN}$$

Resultant moments and shears

Total moment about x axis

$$M_{\Sigma cornerx} = M_{cornersw} + M_{cornerudl} + M_{cornerliney} + M_{cornerpointx} = 100.1 \text{ kNm}$$

Total shear force about x axis

$$V_{\Sigma cornerx} = V_{cornersw} + V_{cornerudl} + V_{cornerliney} + V_{cornerpoint} = 118.1 \text{ kN}$$

Total moment about y axis

$$M_{\Sigma cornery} = M_{cornersw} + M_{cornerudl} + M_{cornerlinex} + M_{cornerpointy} = 100.1 \text{ kNm}$$

Total shear force about y axis

$$V_{\Sigma cornery} = V_{cornersw} + V_{cornerudl} + V_{cornerlinex} + V_{cornerpoint} = 118.1 \text{ kN}$$

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

Design bending moment

$$M_{\Sigma corner} = (M_{\Sigma cornerx} + M_{\Sigma cornery}) / 2 = 100.1 \text{ kNm}$$

Design shear force

$$V_{\Sigma corner} = (V_{\Sigma cornerx} + V_{\Sigma cornery}) / 2 = 118.1 \text{ kN}$$

Reinforcement required in top of edge beam

K factor

$$K_{corner} = M_{\Sigma corner} / (f_{cu} \times b_{edgetop} \times d_{edgetop}^2) = 0.011$$

Lever arm

$$Z_{corner} = d_{edgetop} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{corner} / 0.9)}) = 591 \text{ mm}$$

Area of steel required for bending

$$A_{scornerbend} = M_{\Sigma corner} / ((1.0 / \gamma_s) \times f_y \times Z_{corner}) = 389 \text{ mm}^2$$

Minimum area of steel required

$$A_{scornermin} = A_{sedgetopmin} = 522 \text{ mm}^2$$

Area of steel required

$$A_{scorner} = \max(A_{scornerbend}, A_{scornermin}) = 522 \text{ mm}^2$$

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

Corner beam shear check

Average web width

$$b_w = b_{edge} + (h_{edge} / \tan(\alpha_{edge})) / 2 = 595 \text{ mm}$$

Applied shear stress

$$v_{corner} = V_{\Sigma corner} / (b_w \times d_{edgetop}) = 0.319 \text{ N/mm}^2$$

Tension steel ratio

$$\rho_{corner} = 100 \times A_{sedgetop} / (b_w \times d_{edgetop}) = 0.255$$

From BS8110-1:1997 - Table 3.8

Tekla Tedds FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project New Dwelling, Alltygrug Road, Ystalyfera, NPT				Job no.	
	Calcs for RC Raft Foundation				Start page no./Revision 10	
	Calcs by AR	Calcs date 04/07/2020	Checked by	Checked date	Approved by	Approved date

Design concrete shear strength

$$V_{ccorner} = 0.401 \text{ N/mm}^2$$

$$V_{corner} \leq V_{ccorner} + 0.4 \text{ N/mm}^2 - \text{Therefore minimum links required}$$

Link area to spacing ratio required

$$A_{sv_upon_svreqcorner} = 0.4 \text{ N/mm}^2 \times b_w / ((1.0/\gamma_s) \times f_{ys}) = 0.547 \text{ mm}$$

Link area to spacing ratio provided

$$A_{sv_upon_svprovedge} = N_{edge} \times \pi \times \phi_{edge}^2 / (4 \times s_{vedge}) = 0.785 \text{ mm}$$

PASS - $A_{sv_upon_svreqcorner} \leq A_{sv_upon_svprovedge}$ - Shear reinforcement provided in edge beams at corners is adequate

Corner beam deflection check

Basic allowable span to depth ratio

$$\text{Ratio}_{basiccorner} = 7.0$$

Moment factor

$$M_{factorcorner} = M_{\Sigma corner} / (b_{edgetop} \times d_{edgetop}^2) = 0.398 \text{ N/mm}^2$$

Steel service stress

$$f_{scorner} = 2/3 \times f_y \times A_{scorner} / A_{sedgetop} = 137.743 \text{ N/mm}^2$$

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

$$\text{Ratio}_{allowcorner} = \text{Ratio}_{basiccorner} \times MF_{corner} = 14.000$$

Actual span to depth ratio

$$\text{Ratio}_{actualcorner} = l_{corner} / d_{edgetop} = 2.774$$

PASS - $\text{Ratio}_{actualcorner} \leq \text{Ratio}_{allowcorner}$ - Edge beam span to depth ratio is adequate

Internal beam design checks

Basic loading

Hardcore

$$W_{hcorethick} = \gamma_{hcore} \times h_{hcorethick} = 0.0 \text{ kN/m}^2$$

Internal beam self weight

$$W_{int} = 24 \text{ kN/m}^3 \times [(h_{int} \times b_{int}) + (h_{int} - h_{slab})^2 / \tan(\alpha_{int}) + 2 \times h_{slab} \times (h_{int} - h_{slab}) / \tan(\alpha_{int})]$$

$$W_{int} = 13.3 \text{ kN/m}$$

Internal beam load number 1

Load type

Longitudinal line load

Dead load

$$W_{Dint1} = 8.0 \text{ kN/m}$$

Live load

$$W_{Lint1} = 8.0 \text{ kN/m}$$

Ultimate load

$$W_{Ulint1} = 1.4 \times W_{Dint1} + 1.6 \times W_{Lint1} = 24.0 \text{ kN/m}$$

Longitudinal line load width

$$b_{int1} = 100 \text{ mm}$$

Centroid of load from centreline of beam

$$x_{int1} = 0 \text{ mm}$$

Internal beam bearing pressure check

Total uniform load at formation level

$$W_{udint} = W_{Dudl} + W_{Ludl} + W_{hcorethick} + 24 \text{ kN/m}^3 \times h_{int} = 19.7 \text{ kN/m}^2$$

Sum of factored longitudinal and effective line loads

$$\Sigma UDL_{int} = 24.0 \text{ kN/m}$$

Sum of unfactored longitudinal and effective line loads

$$\Sigma UDL_{slsint} = 16.0 \text{ kN/m}$$

Centroid of loads from centreline of internal beam

Load x distance for internal load 1

$$\text{Moment}_{int1} = W_{Ulint1} \times x_{int1} = 0.0 \text{ kN}$$

Sum of load x distances

$$\Sigma \text{Moment}_{int} = 0.0 \text{ kN}$$

Centroid of loads

$$x_{barint} = \Sigma \text{Moment}_{int} / \Sigma UDL_{int} = 0.0 \text{ mm}$$

Moment due to eccentricity to be resisted by slab

$$M_{eccint} = \Sigma UDL_{int} \times \text{abs}(x_{barint}) = 0.0 \text{ kNm/m}$$

Assume moment due to eccentricity is resisted equally by top steel of slab on one side and bottom steel of slab on other

From slab bending check

Moment due to depression under slab (hogging)

$$M_{\Sigma e} = 1.2 \text{ kNm/m}$$

Total moment to be resisted by slab top steel

$$M_{slabtopint} = M_{eccint} / 2 + M_{\Sigma e} = 1.2 \text{ kNm/m}$$

K factor

$$K_{slabtopint} = M_{slabtopint} / (f_{cu} \times d_{slabmin}^2) = 0.003$$

Lever arm

$$z_{slabtopint} = d_{slabmin} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slabtopint} / 0.9)}) = 107 \text{ mm}$$

Area of steel required

$$A_{sslabtopintreq} = M_{slabtopint} / ((1.0/\gamma_s) \times f_{yslab} \times z_{slabtopint}) = 27 \text{ mm}^2/\text{m}$$

PASS - $A_{sslabtopintreq} \leq A_{sslabtop}$ - Area of reinforcement in top of slab is adequate to transfer moment into slab

Mt to be resisted by slab btm stl due to load eccentricity

$$M_{slabbtmint} = M_{eccint} / 2 = 0.0 \text{ kNm/m}$$

 Tekla Tedds FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project New Dwelling, Alltygrug Road, Ystalyfera, NPT				Job no.	
	Calcs for RC Raft Foundation				Start page no./Revision 11	
	Calcs by AR	Calcs date 04/07/2020	Checked by	Checked date	Approved by	Approved date

K factor

$$K_{slab\text{btm}} = M_{slab\text{btm}} / (f_{cu} \times d_{slab\text{btm}}^2) = 0.000$$

Lever arm

$$Z_{slab\text{btm}} = d_{slab\text{btm}} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slab\text{btm}}/0.9)}) = 98 \text{ mm}$$

Area of steel required in bottom

$$A_{slab\text{btm}} = M_{slab\text{btm}} / ((1.0/\gamma_s) \times f_{yslab} \times Z_{slab\text{btm}}) = 0 \text{ mm}^2/\text{m}$$

PASS - $A_{slab\text{btm}} \leq A_{slab\text{btm}} - \text{Area of reinforcement in bottom of slab is adequate to transfer moment into slab}$

Bearing pressure

Initially check bearing pressure based on beam soffit/chamfer width only

Allowable bearing width

$$b_{bear\text{int}} = \min(2 \times (b_{\text{int}}/2 \times \tan(\alpha_{\text{int}}) + h_{\text{int}}) / (1 + \tan(\alpha_{\text{int}})), b_{\text{int}} + 2 \times (h_{\text{int}} - h_{\text{slab}}) / \tan(\alpha_{\text{int}}))$$

$$b_{bear\text{int}} = 779 \text{ mm}$$

Bearing pressure due to line/point loads

$$q_{line\text{point}\text{int}} = \Sigma UDLs_{\text{int}} / b_{bear\text{int}} = 20.5 \text{ kN/m}^2$$

Total applied bearing pressure

$$q_{\text{int}} = q_{line\text{point}\text{int}} + w_{ud\text{int}} = 40.2 \text{ kN/m}^2$$

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

Internal beam bending check

Divider for moments due to udl's

$$\beta_{udl} = 10.0$$

Applied bending moments

Span of internal beam

$$l_{\text{int}} = \phi_{\text{depth}} + d_{\text{inttop}} = 2624 \text{ mm}$$

Ultimate self weight udl

$$w_{\text{intult}} = 1.4 \times w_{\text{int}} = 18.6 \text{ kN/m}$$

Ultimate slab udl (approx)

$$w_{\text{intslab}} = \max(0 \text{ kN/m}, 1.4 \times w_{\text{slab}} \times ((\phi_{\text{depth}} \times 3/4) - (b_{\text{int}} + 2 \times (h_{\text{int}} - h_{\text{slab}}) / \tan(\alpha_{\text{int}}))))$$

$$w_{\text{intslab}} = 2.2 \text{ kN/m}$$

Self weight and slab bending moment

$$M_{\text{intsw}} = (w_{\text{intult}} + w_{\text{intslab}}) \times l_{\text{int}}^2 / \beta_{udl} = 14.4 \text{ kNm}$$

Self weight shear force

$$V_{\text{intsw}} = (w_{\text{intult}} + w_{\text{intslab}}) \times l_{\text{int}} / 2 = 27.3 \text{ kN}$$

Moments due to applied uniformly distributed loads

Ultimate udl (approx)

$$w_{\text{intudl}} = w_{\text{udult}} \times \phi_{\text{depth}} \times 3/4 = 7.8 \text{ kN/m}$$

Bending moment

$$M_{\text{intudl}} = w_{\text{intudl}} \times l_{\text{int}}^2 / \beta_{udl} = 5.4 \text{ kNm}$$

Shear force

$$V_{\text{intudl}} = w_{\text{intudl}} \times l_{\text{int}} / 2 = 10.2 \text{ kN}$$

Moment and shear due to load number 1

Bending moment

$$M_{\text{int1}} = w_{\text{ultint1}} \times l_{\text{int}}^2 / \beta_{udl} = 16.5 \text{ kNm}$$

Shear force

$$V_{\text{int1}} = w_{\text{ultint1}} \times l_{\text{int}} / 2 = 31.5 \text{ kN}$$

Resultant moments and shears

Total moment (hogging and sagging)

$$M_{\Sigma\text{int}} = 36.2 \text{ kNm}$$

Maximum shear force

$$V_{\Sigma\text{int}} = 69.1 \text{ kN}$$

Reinforcement required in top

Width of section in compression zone

$$b_{\text{inttop}} = b_{\text{int}} = 450 \text{ mm}$$

Average web width

$$b_{\text{wint}} = b_{\text{int}} + h_{\text{int}} / \tan(\alpha_{\text{int}}) = 840 \text{ mm}$$

K factor

$$K_{\text{inttop}} = M_{\Sigma\text{int}} / (f_{cu} \times b_{\text{inttop}} \times d_{\text{inttop}}^2) = 0.006$$

Lever arm

$$Z_{\text{inttop}} = d_{\text{inttop}} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{\text{inttop}}/0.9)}) = 593 \text{ mm}$$

Area of steel required for bending

$$A_{\text{inttopbend}} = M_{\Sigma\text{int}} / ((1.0/\gamma_s) \times f_y \times Z_{\text{inttop}}) = 141 \text{ mm}^2$$

Minimum area of steel

$$A_{\text{inttopmin}} = 0.0013 \times b_{\text{wint}} \times h_{\text{int}} = 737 \text{ mm}^2$$

Area of steel required

$$A_{\text{inttopreq}} = \max(A_{\text{inttopbend}}, A_{\text{inttopmin}}) = 737 \text{ mm}^2$$

PASS - $A_{\text{inttopreq}} \leq A_{\text{inttop}} - \text{Area of reinforcement provided in top of internal beams is adequate}$

Reinforcement required in bottom

Width of section in compression zone

$$b_{\text{intbtm}} = b_{\text{int}} + 2 \times (h_{\text{int}} - h_{\text{slab}}) / \tan(\alpha_{\text{int}}) + 0.2 \times l_{\text{int}} = 1581 \text{ mm}$$

K factor

$$K_{\text{intbtm}} = M_{\Sigma\text{int}} / (f_{cu} \times b_{\text{intbtm}} \times d_{\text{intbtm}}^2) = 0.002$$

Lever arm

$$Z_{\text{intbtm}} = d_{\text{intbtm}} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{\text{intbtm}}/0.9)}) = 589 \text{ mm}$$

Area of steel required for bending

$$A_{\text{intbtmbend}} = M_{\Sigma\text{int}} / ((1.0/\gamma_s) \times f_y \times Z_{\text{intbtm}}) = 142 \text{ mm}^2$$

 Tekla Tedds FAR Structures Ltd 20 Caswell Avenue, Caswell, Swansea, SA3 4RU t: +44 (0)7703 043 608 e:andrew@farstructures.uk	Project				Job no.	
	New Dwelling, Alltygrug Road, Ystalyfera, NPT				Start page no./Revision	
	RC Raft Foundation				12	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date	
AR	04/07/2020					

Minimum area of steel required

$$A_{sintbmin} = 0.0013 \times 1.0 \times b_{wint} \times h_{int} = 737 \text{ mm}^2$$

Area of steel required

$$A_{sintbreq} = \max(A_{sintbmbend}, A_{sintbmin}) = 737 \text{ mm}^2$$

PASS - $A_{sintbreq} \leq A_{sintblm}$ - Area of reinforcement provided in bottom of internal beams is adequate

Internal beam shear check

Applied shear stress

$$v_{int} = V_{int}/(b_{wint} \times d_{inttop}) = 0.132 \text{ N/mm}^2$$

Tension steel ratio

$$\rho_{int} = 100 \times A_{sinttop}/(b_{wint} \times d_{inttop}) = 0.180$$

From BS8110-1:1997 - Table 3.8

Design concrete shear strength

$$v_{cint} = 0.357 \text{ N/mm}^2$$

$v_{int} \leq v_{cint} + 0.4 \text{ N/mm}^2$ - Therefore minimum links required

Link area to spacing ratio required

$$A_{sv_upon_svreqint} = 0.4 \text{ N/mm}^2 \times b_{wint}/((1.0/\gamma_s) \times f_{ys}) = 0.773 \text{ mm}$$

Link area to spacing ratio provided

$$A_{sv_upon_svprovint} = N_{intlink} \times \pi \times \phi_{intlink}^2 / (4 \times s_{vint}) = 0.785 \text{ mm}$$

PASS - $A_{sv_upon_svreqint} \leq A_{sv_upon_svprovint}$ - Shear reinforcement provided in internal beams is adequate