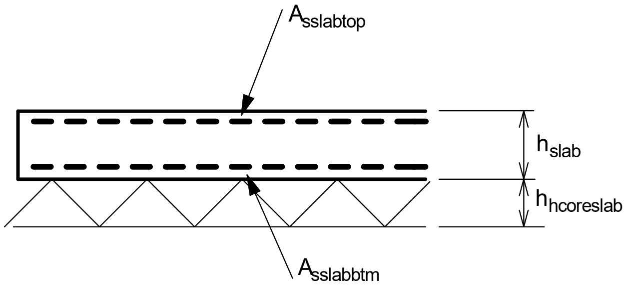
MLM Consulting Engineers Ltd 190 Eureka Park, Upper Pemberton Ashford, Kent TN25 4AZ	Project Gin Distillery				Job no. 669931	
	Calcs for Kithen Pod Slab				Start page no./Revision 1	
	Calcs by JOT	Calcs date 06/11/18	Checked by	Checked date	Approved by	Approved date

RAFT FOUNDATION DESIGN (BS8110 : PART 1 : 1997)

Tedds calculation version 1.0.12



Soil and raft definition

Soil definition

Allowable bearing pressure q_{allow} = **25.0** kN/m^2

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

Soil density **Firm to loose**

Depth of hardcore beneath slab $h_{hcoreslab}$ = **200** mm (Dispersal allowed for bearing pressure check)

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

Basic assumed diameter of local depression $\phi_{depbasic}$ = **2000**mm

Diameter under slab modified for hardcore $\phi_{depslab} = \phi_{depbasic} - h_{hcoreslab}$ = **1800** mm

Raft slab definition

Max dimension/max dimension between joints l_{max} = **10.500** m

Slab thickness h_{slab} = **250** mm

Concrete strength f_{cu} = **40** 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} = **30** mm

Cover to bottom reinforcement c_{btm} = **40** mm

Average effective depth of top reinforcement $d_{tslabav} = h_{slab} - c_{top} - \phi_{slabtop}$ = **210** mm

Average effective depth of bottom reinforcement $d_{bslabav} = h_{slab} - c_{btm} - \phi_{slabbtm}$ = **200** mm

Overall average effective depth $d_{slabav} = (d_{tslabav} + d_{bslabav})/2$ = **205** mm

Minimum effective depth of top reinforcement $d_{tslabmin} = d_{tslabav} - \phi_{slabtop}/2$ = **205** mm

Minimum effective depth of bottom reinforcement $d_{bslabmin} = d_{bslabav} - \phi_{slabbtm}/2$ = **195** mm

Slab edge reinforcement

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

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

Internal slab design checks

Basic loading

Slab self weight w_{slab} = 24 kN/m^3 × h_{slab} = **6.0** kN/m^2

Hardcore $w_{hcoreslab}$ = γ_{hcore} × $h_{hcoreslab}$ = **4.0** kN/m^2

Applied loading

Uniformly distributed dead load w_{Dudl} = **0.0** kN/m^2

Uniformly distributed live load w_{Ludl} = **1.5** kN/m^2

Internal slab bearing pressure check

Total uniform load at formation level w_{udl} = w_{slab} + $w_{hcoreslab}$ + w_{Dudl} + w_{Ludl} = **11.5** kN/m^2

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

Internal slab bending and shear check

Applied bending moments

Span of slab l_{slab} = $\phi_{depslab}$ + $d_{tslabav}$ = **2010** mm

Ultimate self weight udl w_{swult} = 1.4 × w_{slab} = **8.4** kN/m^2

Self weight moment at centre M_{csw} = w_{swult} × l_{slab}^2 × (1 + ν) / 64 = **0.6** kNm/m

Self weight moment at edge M_{esw} = w_{swult} × l_{slab}^2 / 32 = **1.1** kNm/m

Self weight shear force at edge V_{sw} = w_{swult} × l_{slab} / 4 = **4.2** kN/m

Moments due to applied uniformly distributed loads

Ultimate applied udl w_{udlult} = 1.4 × w_{Dudl} + 1.6 × w_{Ludl} = **2.4** kN/m^2

Moment at centre M_{cudl} = w_{udlult} × l_{slab}^2 × (1 + ν) / 64 = **0.2** kNm/m

Moment at edge M_{eudl} = w_{udlult} × l_{slab}^2 / 32 = **0.3** kNm/m

Shear force at edge V_{udl} = w_{udlult} × l_{slab} / 4 = **1.2** kN/m

Resultant moments and shears

Total moment at edge $M_{\Sigma e}$ = **1.4** kNm/m

Total moment at centre $M_{\Sigma c}$ = **0.8** kNm/m

Total shear force V_{Σ} = **5.4** kN/m

Reinforcement required in top

K factor $K_{slabtop}$ = $M_{\Sigma e}$/(f_{cu} × $d_{tslabav}^2$) = **0.001**

Lever arm $z_{slabtop}$ = $d_{tslabav}$ × min(0.95, 0.5 + √(0.25 - $K_{slabtop}$/0.9)) = **199.5** mm

Area of steel required for bending $A_{sslabtopbend}$ = $M_{\Sigma e}$/((1.0/γ_s) × f_{yslab} × $z_{slabtop}$) = **16** mm^2/m

Minimum area of steel required $A_{sslabmin}$ = 0.0013 × h_{slab} = **325** mm^2/m

Area of steel required $A_{sslabtopreq}$ = max($A_{sslabtopbend}$, $A_{sslabmin}$) = **325** 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} × $d_{bslabav}^2$) = **0.001**

Lever arm $z_{slabbtm}$ = $d_{bslabav}$ × min(0.95, 0.5 + √(0.25 - $K_{slabbtm}$/0.9)) = **190.0** mm

Area of steel required for bending $A_{sslabbtmbend}$ = $M_{\Sigma c}$/((1.0/γ_s) × f_{yslab} × $z_{slabbtm}$) = **10** mm^2/m

Area of steel required $A_{sslabbtmreq}$ = max($A_{sslabbtmbend}$, $A_{sslabmin}$) = **325** mm^2/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_{Σ}/$d_{tslabmin}$ = **0.026** N/mm^2

Tension steel ratio ρ = 100 × $A_{sslabtop}$/$d_{tslabmin}$ = **0.192**

From BS8110-1:1997 - Table 3.8

Design concrete shear strength v_c = **0.504** N/mm^2

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

Internal slab deflection check

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

Moment factor $M_{factor} = M_{\Sigma c}/d_{bslabav}{}^2$ = **0.020** N/mm^2

Steel service stress $f_s = 2/3 \times f_{yslab} \times A_{sslabbtmbend}/A_{sslabbtm}$ = **8.400** N/mm^2

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

MF_{slab} = **2.000**

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

Actual span to depth ratio $Ratio_{actual} = l_{slab}/ d_{bslabav}$ = **10.050**

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

Slab edge design checks

Basic loading

Hardcore $w_{hcoreslab} = \gamma_{hcore} \times h_{hcoreslab}$ = **4.0** kN/m^2

Slab self weight $w_{slab} = 24\text{ kN/m}^3 \times h_{slab}$ = **6.0** kN/m^2

Edge load number 1

Load type **Longitudinal line load**

Dead load w_{Dedge1} = **0.0** kN/m

Live load w_{Ledge1} = **16.3** kN/m

Ultimate load $w_{ultedge1} = 1.4 \times w_{Dedge1} + 1.6 \times w_{Ledge1}$ = **26.1** kN/m

Longitudinal line load width b_{edge1} = **140** mm

Centroid of load from outside face of raft x_{edge1} = **0** mm

Slab edge bearing pressure check

Total uniform load at formation level $w_{udledge} = w_{Dudl} + w_{Ludl} + w_{slab} + w_{hcoreslab}$ = **11.5** kN/m^2

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

Load x distance for edge load 1 $Moment_1 = w_{ultedge1} \times x_{edge1}$ = **0.0** kN

Sum of ultimate longitud'l and equivalent line loads ΣUDL = **26.1** kN/m

Sum of load x distances $\Sigma Moment$ = **0.0** kN

Centroid of loads $x_{bar} = \Sigma Moment/\Sigma UDL$ = **0** mm

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

Sum of unfactored longitud'l and eff'tive line loads $\Sigma UDLsls$ = **16.3** kN/m

Allowable bearing width $b_{allow} = 2 \times x_{bar} + 2 \times h_{hcoreslab} \times \tan(30)$ = **231** mm

Bearing pressure due to line/point loads $q_{linepoint} = \Sigma UDLsls/ b_{allow}$ = **70.6** kN/m^2

Total applied bearing pressure $q_{edge} = q_{linepoint} + w_{udledge}$ = **82.1** 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 $b_{req} = \Sigma UDLsls/(q_{allow} - w_{udledge})$ = **1207** mm

Effective bearing width at u/s of slab $b_{reqeff} = b_{req} - 2 \times h_{hcoreslab} \times \tan(30)$ = **976** mm

Load/reaction eccentricity $e = b_{reqeff}/2 - x_{bar}$ = **488** mm

Ultimate moment to be resisted by slab $M_{ecc} = \Sigma UDL \times e$ = **12.7** kNm/m

From slab bending check

Moment due to depression under slab (hogging) $M_{\Sigma e}$ = **1.4** kNm/m

Total moment to be resisted by slab top steel $M_{slabtop} = M_{ecc} + M_{\Sigma e}$ = **14.1** kNm/m

K factor $K_{slab} = M_{slabtop}/(f_{cu} \times d_{tslabmin}{}^2)$ = **0.008**

Lever arm $z_{slab} = d_{tslabmin} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slab}/0.9)}) = \mathbf{195}$ mm

Area of steel required $A_{sslabreq} = M_{slabtop}/((1.0/\gamma_s) \times f_y \times z_{slab}) = \mathbf{166}$ mm²/m

PASS - $A_{sslabreq}$ <= $A_{sslabtop}$ - 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

Slab edge bending check

Considering a 1.0m width of slab

Divider for moments due to udl's $\beta_{udl} = \mathbf{10.0}$

Applied bending moments

Span of slab $l_{edge} = \phi_{depslab} + d_{tslabmin} = \mathbf{2005}$ mm

Ultimate self weight udl $w_{edgeult} = 1.4 \times w_{slab} = \mathbf{8.4}$ kN/m²

Self weight bending moment $M_{edgesw} = w_{edgeult} \times l_{edge}^2/10 = \mathbf{3.4}$ kNm/m

Self weight shear force $V_{edgesw} = w_{edgeult} \times l_{edge}/2 = \mathbf{8.4}$ kN/m

Moments due to applied uniformly distributed loads

Ultimate udl $w_{edgeudl} = w_{udlult} = \mathbf{2.4}$ kN/m²

Bending moment $M_{edgeudl} = w_{edgeudl} \times l_{edge}^2/\beta_{udl} = \mathbf{1.0}$ kNm/m

Shear force $V_{edgeudl} = w_{edgeudl} \times l_{edge}/2 = \mathbf{2.4}$ kN/m

Moment and shear due to load number 1

Effective slab width $b_{eff1} = \min(x_{edge1}, b_{edge1}/2 + 0.3 \times l_{edge}) + b_{edge1}/2 + 0.3 \times l_{edge} = \mathbf{672}$ mm

Bending moment $M_{edge1} = w_{ultedge1} \times l_{edge}^2/(\beta_{udl} \times b_{eff1}) = \mathbf{15.6}$ kNm/m

Shear force $V_{edge1} = w_{ultedge1} \times l_{edge}/(2 \times b_{eff1}) = \mathbf{38.9}$ kN/m

Resultant moments and shears

Total moment (hogging and sagging) $M_{\Sigma edge} = \mathbf{20.0}$ kNm/m

Maximum shear force $V_{\Sigma edge} = \mathbf{49.8}$ kN/m

Reinforcement required in top

K factor $K_{edgetop} = M_{\Sigma edge}/(f_{cu} \times d_{tslabmin}^2) = \mathbf{0.012}$

Lever arm $z_{edgetop} = d_{tslabmin} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{edgetop}/0.9)}) = \mathbf{195}$ mm

Area of steel required for bending $A_{sedgetopbend} = M_{\Sigma edge}/((1.0/\gamma_s) \times f_{yslab} \times z_{edgetop}) = \mathbf{236}$ mm²/m

Area of steel required $A_{sedgetopreq} = \max(A_{sedgetopbend}, A_{sslabmin}) = \mathbf{325}$ mm²/m

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

Reinforcement required in bottom

K factor $K_{edgebtm} = M_{\Sigma edge}/(f_{cu} \times d_{bslabmin}^2) = \mathbf{0.013}$

Lever arm $z_{edgebtm} = d_{bslabmin} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{edgebtm}/0.9)}) = \mathbf{185}$ mm

Area of steel required for bending $A_{sedgebtmbend} = M_{\Sigma edge}/((1.0/\gamma_s) \times f_{yslab} \times z_{edgebtm}) = \mathbf{248}$ mm²/m

Area of steel required $A_{sedgebtmreq} = \max(A_{sedgebtmbend}, A_{sslabmin}) = \mathbf{325}$ mm²/m

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

Applied shear stress $v_{edge} = V_{\Sigma edge} \times 1.0\text{m}/(1000\text{mm} \times d_{tslabmin}) = \mathbf{0.243}$ N/mm²

Tension steel ratio $\rho_{edge} = 100 \times A_{sedgetop} \times 1.0\text{m}/(1000\text{mm} \times d_{tslabmin}) = \mathbf{0.192}$

From BS8110-1:1997 - Table 3.8

Design concrete shear strength $v_{cedge} = \mathbf{0.504}$ N/mm²

PASS - v_{edge} <= v_{cedge} - Shear capacity of the slab is not exceeded

Slab edge deflection check

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

Moment factor $M_{factoredge} = M_{\Sigma edge}/d_{bslabmin}^2 = \mathbf{0.525}$ N/mm²

Steel service stress $f_{sedge} = 2/3 \times f_{yslab} \times A_{sedgebtmbend}/A_{sedgebtm} = \mathbf{210.137}$ N/mm²

Modification factor MF_{edge}=min(2.0,0.55+[(477N/mm^2-f_{sedge})/(120×(0.9N/mm^2+$M_{factoredge}$))])

MF_{edge} = **2.000**

Modified allowable span to depth ratio $Ratio_{allowedge}$ = $Ratio_{basicedge}$ × MF_{edge} = **52.000**

Actual span to depth ratio $Ratio_{actualedge}$ = l_{edge}/ $d_{tslabmin}$ = **9.780**

PASS - $Ratio_{actualedge}$ <= $Ratio_{allowedge}$ - Slab span to depth ratio is adequate

Corner design checks

Basic loading

Corner bearing pressure check

Total uniform load at formation level $w_{udlcorner}$ = w_{Dudl} + w_{Ludl} + w_{slab} + $w_{hcoreslab}$ = **11.5** kN/m^2

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

Slab corner bending check

Cantilever span of slab at corner l_{corner} = $\phi_{depslab}$/√(2) + $d_{tslabav}$/2 = **1378** mm

Moment and shear due to self weight

Considering triangular loading

Maximum ultimate self weight udl w_{swult} = 1.4 × w_{slab} × $\phi_{depslab}$/√(2) = **10.7** kN/m

Self weight bending moment $M_{cornersw}$ = w_{swult} × l_{corner}^2/(6 × $\phi_{depslab}$/√(2)) = **2.7** kNm/m

Self weight shear force $V_{cornersw}$ = w_{swult} × l_{corner}/(2 × $\phi_{depslab}$/√(2)) = **5.8** kN/m

Moment and shear due to udls

Maximum ultimate udl $w_{cornerudl}$ = ((1.4×w_{Dudl})+(1.6×w_{Ludl})) × $\phi_{depslab}$/√(2) = **3.1** kN/m

Bending moment $M_{cornerudl}$ = $w_{cornerudl}$ × l_{corner}^2/(6 × $\phi_{depslab}$/√(2)) = **0.8** kNm/m

Shear force $V_{cornerudl}$ = $w_{cornerudl}$ × l_{corner}/(2 × $\phi_{depslab}$/√(2)) = **1.7** kN/m

Resultant moments and shears

Total design moment $M_{\Sigma corner}$ = $M_{cornersw}$+ $M_{cornerudl}$ = **3.4** kNm/m

Total design shear force $V_{\Sigma corner}$ = $V_{cornersw}$+ $V_{cornerudl}$ = **7.4** kN/m

Reinforcement required in top of slab at corners

K factor K_{corner} = $M_{\Sigma corner}$/(f_{cu} × $d_{tslabmin}^2$) = **0.002**

Lever arm z_{corner} = $d_{tslabmin}$ × min(0.95, 0.5 + √(0.25 - K_{corner}/0.9)) = **195** mm

Area of steel required for bending $A_{scornerbend}$ = $M_{\Sigma corner}$/((1.0/γ_s) × f_{yslab} × z_{corner}) = **40** mm^2/m

Area of steel required $A_{scorner}$ = max($A_{scornerbend}$, $A_{sslabmin}$) = **325** mm^2/m

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

Applied shear stress v_{corner} = $V_{\Sigma corner}$/$d_{tslabmin}$ = **0.036** N/mm^2

Tension steel ratio ρ_{corner} = 100 × $A_{sedgetop}$/$d_{tslabmin}$ = **0.192**

From BS8110-1:1997 - Table 3.8

Design concrete shear strength $v_{ccorner}$ = **0.504** N/mm^2

Pass - v_{corner} <= $v_{ccorner}$ - Shear capacity of the slab is not exceeded

Slab corner deflection check

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

Moment factor $M_{factorcorner}$ = $M_{\Sigma corner}$/$d_{tslabmin}^2$ = **0.081** N/mm^2

Steel service stress $f_{scorner}$ = 2/3 × f_{yslab} × $A_{scornerbend}$/$A_{sedgetop}$ = **34.228** N/mm^2

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

MF_{corner} = **2.000**

Modified allowable span to depth ratio $Ratio_{allowcorner}$ = $Ratio_{basiccorner}$ × MF_{corner} = **14.000**

Actual span to depth ratio $Ratio_{actualcorner}$ = l_{corner}/ $d_{tslabmin}$ = **6.721**

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