FOUNDATION ANALYSIS

In accordance with EN1997-1:2004 + A1:2013 incorporating corrigendum February 2009 and the UK National Annex incorporating corrigendum No.1

Tedds calculation version 3.3.04

Summary table

Description	Unit	Allowable	Actual	Utilisation	Result
Base pressure	kN/m^2	515.7	300.6	0.583	Pass
Description	**Unit**	**Provided**	**Required**	**Utilisation**	**Result**
Reinforcement x-direction	mm^2	2212	1603	0.725	Pass
Reinforcement y-direction	mm^2	2212	1518	0.686	Pass
Description	**Unit**	**Allowable**	**Actual**	**Utilisation**	**Result**
Shear x-axis	kN	325	276	0.852	Pass
Shear y-axis	kN	325	250	0.770	Pass
Punching shear	N/mm^2	0.654	0.451	0.689	Pass

Pad foundation details

Length of foundation; L_x = **2000** mm

Width of foundation; L_y = **2000** mm

Foundation area; $A = L_x \times L_y$ = **4.000** m^2

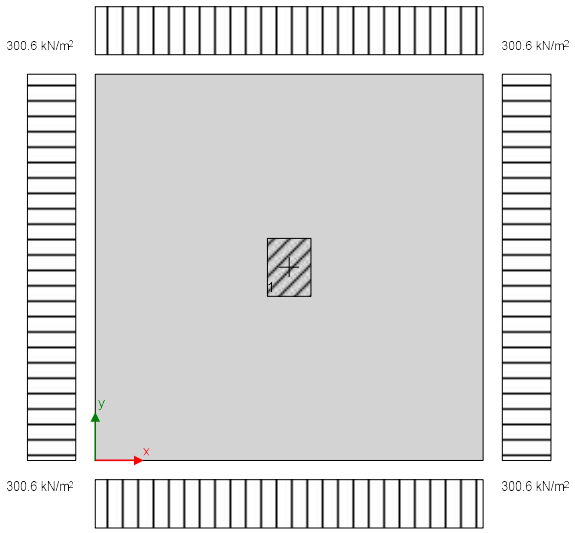
Depth of foundation; h = **550** mm

Depth of soil over foundation; h_{soil} = **950** mm

Level of water; h_{water} = **0** mm

Density of water; γ_{water} = **9.8** kN/m^3

Density of concrete; γ_{conc} = **25.0** kN/m^3



Column no.1 details

Length of column; l_{x1} = **225** mm

Width of column;	l_{y1} = **300** mm
position in x-direction;	x_1 = **1000** mm
position in y-direction;	y_1 = **1000** mm
Soil properties	
Density of soil;	γ_{soil} = **15.1** kN/m^3
Characteristic cohesion;	c'$_k$ = **2.8** kN/m^2
Characteristic effective shear resistance angle;	ϕ'_k = **30.4** deg
Characteristic friction angle;	δ_k = **5** deg
Foundation loads	
Self weight;	$F_{swt} = h \times \gamma_{conc}$ = **13.8** kN/m^2
Soil weight;	$F_{soil} = h_{soil} \times \gamma_{soil}$ = **14.3** kN/m^2
Column no.1 loads	
Permanent axial load;	F_{Gz1} = **786.0** kN
Variable axial load;	F_{Qz1} = **234.0** kN
Design approach 1	
Partial factors on actions - Combination1	
Partial factor set;	A1
Permanent unfavourable action - Table A.3;	γ_G = **1.35**
Permanent favourable action - Table A.3;	γ_{Gf} = **1.00**
Variable unfavourable action - Table A.3;	γ_Q = **1.50**
Variable favourable action - Table A.3;	γ_{Qf} = **0.00**
Partial factors for soil parameters - Combination1	
Soil factor set;	M1
Angle of shearing resistance - Table A.4;	$\gamma_{\phi'}$ = **1.00**
Effective cohesion - Table A.4;	$\gamma_{c'}$ = **1.00**
Weight density - Table A.4;	γ_γ = **1.00**
Partial factors for spread foundations - Combination1	
Resistance factor set;	R1
Bearing - Table A.5;	$\gamma_{R.v}$ = **1.00**
Sliding - Table A.5;	$\gamma_{R.h}$ = **1.00**
Bearing resistance (Section 6.5.2)	
Forces on foundation	
Force in z-direction;	$F_{dz} = \gamma_G \times (A \times (F_{swt} + F_{soil}) + F_{Gz1}) + \gamma_Q \times F_{Qz1}$ = **1563.8** kN
Moments on foundation	
Moment in x-direction;	$M_{dx} = \gamma_G \times (A \times (F_{swt} + F_{soil}) \times L_x / 2 + F_{Gz1} \times x_1) + \gamma_Q \times F_{Qz1} \times x_1$ = **1563.8** kNm
Moment in y-direction;	$M_{dy} = \gamma_G \times (A \times (F_{swt} + F_{soil}) \times L_y / 2 + F_{Gz1} \times y_1) + \gamma_Q \times F_{Qz1} \times y_1$ = **1563.8** kNm
Eccentricity of base reaction	
Eccentricity of base reaction in x-direction;	$e_x = M_{dx} / F_{dz} - L_x / 2$ = **0** mm
Eccentricity of base reaction in y-direction;	$e_y = M_{dy} / F_{dz} - L_y / 2$ = **0** mm

Effective area of base

Effective length; $L'_x = L_x - 2 \times e_x =$ **2000** mm

Effective width; $L'_y = L_y - 2 \times e_y =$ **2000** mm

Effective area; $A' = L'_x \times L'_y =$ **4.000** m^2

Pad base pressure

Design base pressure; $f_{dz} = F_{dz} / A' =$ **391** kN/m^2

Ultimate bearing capacity under drained conditions (Annex D.4)

Design angle of shearing resistance; $\phi'_d = \text{atan}(\tan(\phi'_k) / \gamma_{\phi'}) =$ **30.400** deg

Design effective cohesion; $c'_d = c'_k / \gamma_{c'} =$ **2.800** kN/m^2

Effective overburden pressure; $q = (h + h_{soil}) \times \gamma_{soil} - h_{water} \times \gamma_{water} =$ **22.650** kN/m^2

Design effective overburden pressure; $q' = q / \gamma_\gamma =$ **22.650** kN/m^2

Bearing resistance factors; $N_q = \text{Exp}(\pi \times \tan(\phi'_d)) \times (\tan(45 \text{ deg} + \phi'_d / 2))^2 =$ **19.258**

$N_c = (N_q - 1) \times \cot(\phi'_d) =$ **31.120**

$N_\gamma = 2 \times (N_q - 1) \times \tan(\phi'_d) =$ **21.424**

Foundation shape factors; $s_q = 1 + (L'_y / L'_x) \times \sin(\phi'_d) =$ **1.506**

$s_\gamma = 1 - 0.3 \times (L'_y / L'_x) =$ **0.700**

$s_c = (s_q \times N_q - 1) / (N_q - 1) =$ **1.534**

Load inclination factors; $H =$ **0.0** kN

$m_y = [2 + (L'_y / L'_x)] / [1 + (L'_y / L'_x)] =$ **1.500**

$m_x = [2 + (L'_x / L'_y)] / [1 + (L'_x / L'_y)] =$ **1.500**

$m = m_x =$ **1.500**

$i_q = [1 - H / (F_{dz} + A' \times c'_d \times \cot(\phi'_d))]^m =$ **1.000**

$i_\gamma = [1 - H / (F_{dz} + A' \times c'_d \times \cot(\phi'_d))]^{m+1} =$ **1.000**

$i_c = i_q - (1 - i_q) / (N_c \times \tan(\phi'_d)) =$ **1.000**

Ultimate bearing capacity; $n_f = c'_d \times N_c \times s_c \times i_c + q' \times N_q \times s_q \times i_q + 0.5 \times \gamma_{soil} \times L'_y \times N_\gamma \times s_\gamma \times i_\gamma =$ **1017.0** kN/m^2

PASS - Ultimate bearing capacity exceeds design base pressure

Design approach 1

Partial factors on actions - Combination2

Partial factor set; A2

Permanent unfavourable action - Table A.3; $\gamma_G =$ **1.00**

Permanent favourable action - Table A.3; $\gamma_{Gf} =$ **1.00**

Variable unfavourable action - Table A.3; $\gamma_Q =$ **1.30**

Variable favourable action - Table A.3; $\gamma_{Qf} =$ **0.00**

Partial factors for soil parameters - Combination2

Soil factor set; M2

Angle of shearing resistance - Table A.4; $\gamma_{\phi'} =$ **1.25**

Effective cohesion - Table A.4; $\gamma_{c'} =$ **1.25**

Weight density - Table A.4; $\gamma_\gamma =$ **1.00**

Partial factors for spread foundations - Combination2

Resistance factor set; R1

Bearing - Table A.5; $\gamma_{R.v}$ = **1.00**

Sliding - Table A.5; $\gamma_{R.h}$ = **1.00**

Bearing resistance (Section 6.5.2)

Forces on foundation

Force in z-direction; $F_{dz} = \gamma_G \times (A \times (F_{swt} + F_{soil}) + F_{Gz1}) + \gamma_Q \times F_{Qz1}$ = **1202.6** kN

Moments on foundation

Moment in x-direction; $M_{dx} = \gamma_G \times (A \times (F_{swt} + F_{soil}) \times L_x / 2 + F_{Gz1} \times x_1) + \gamma_Q \times F_{Qz1} \times x_1$ = **1202.6** kNm

Moment in y-direction; $M_{dy} = \gamma_G \times (A \times (F_{swt} + F_{soil}) \times L_y / 2 + F_{Gz1} \times y_1) + \gamma_Q \times F_{Qz1} \times y_1$ = **1202.6** kNm

Eccentricity of base reaction

Eccentricity of base reaction in x-direction; $e_x = M_{dx} / F_{dz} - L_x / 2$ = **0** mm

Eccentricity of base reaction in y-direction; $e_y = M_{dy} / F_{dz} - L_y / 2$ = **0** mm

Effective area of base

Effective length; $L'_x = L_x - 2 \times e_x$ = **2000** mm

Effective width; $L'_y = L_y - 2 \times e_y$ = **2000** mm

Effective area; $A' = L'_x \times L'_y$ = **4.000** m^2

Pad base pressure

Design base pressure; $f_{dz} = F_{dz} / A'$ = **300.6** kN/m^2

Ultimate bearing capacity under drained conditions (Annex D.4)

Design angle of shearing resistance; $\phi'_d = \text{atan}(\tan(\phi'_k) / \gamma_{\phi'})$ = **25.143** deg

Design effective cohesion; $c'_d = c'_k / \gamma_{c'}$ = **2.240** kN/m^2

Effective overburden pressure; $q = (h + h_{soil}) \times \gamma_{soil} - h_{water} \times \gamma_{water}$ = **22.650** kN/m^2

Design effective overburden pressure; $q' = q / \gamma_\gamma$ = **22.650** kN/m^2

Bearing resistance factors; $N_q = \text{Exp}(\pi \times \tan(\phi'_d)) \times (\tan(45 \text{ deg} + \phi'_d / 2))^2$ = **10.824**

$N_c = (N_q - 1) \times \cot(\phi'_d)$ = **20.932**

$N_\gamma = 2 \times (N_q - 1) \times \tan(\phi'_d)$ = **9.222**

Foundation shape factors; $s_q = 1 + (L'_y / L'_x) \times \sin(\phi'_d)$ = **1.425**

$s_\gamma = 1 - 0.3 \times (L'_y / L'_x)$ = **0.700**

$s_c = (s_q \times N_q - 1) / (N_q - 1)$ = **1.468**

Load inclination factors; H = **0.0** kN

$m_y = [2 + (L'_y / L'_x)] / [1 + (L'_y / L'_x)]$ = **1.500**

$m_x = [2 + (L'_x / L'_y)] / [1 + (L'_x / L'_y)]$ = **1.500**

$m = m_x$ = **1.500**

$i_q = [1 - H / (F_{dz} + A' \times c'_d \times \cot(\phi'_d))]^m$ = **1.000**

$i_\gamma = [1 - H / (F_{dz} + A' \times c'_d \times \cot(\phi'_d))]^{m+1}$ = **1.000**

$i_c = i_q - (1 - i_q) / (N_c \times \tan(\phi'_d))$ = **1.000**

Ultimate bearing capacity; $n_f = c'_d \times N_c \times s_c \times i_c + q' \times N_q \times s_q \times i_q + 0.5 \times \gamma_{soil} \times L'_y \times N_\gamma \times s_\gamma \times i_\gamma$ = **515.7** kN/m^2

PASS - Ultimate bearing capacity exceeds design base pressure