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## 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 <sup>2</sup>	515.7	300.6	0.583	Pass			
Description	Unit	Provided	Required	Utilisation	Result			
Reinforcement x-direction	mm <sup>2</sup>	2212	1603	0.725	Pass			
Reinforcement y-direction	mm <sup>2</sup>	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 <sup>2</sup>	0.654	0.451	0.689	Pass			

## **Pad foundation details** Length of foundation;

Width of foundation;

Foundation area; Depth of foundation;

L <sub>x</sub> = <b>2000</b> mm
L <sub>y</sub> = <b>2000</b> mm
$A = L_x \times L_y = \textbf{4.000} \ m^2$
h = <b>550</b> mm
h <sub>soil</sub> = <b>950</b> mm
h <sub>water</sub> = <b>0</b> mm
$\gamma_{water}$ = <b>9.8</b> kN/m <sup>3</sup>
γ <sub>conc</sub> = <b>25.0</b> kN/m <sup>3</sup>



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	Width of column;		l <sub>y1</sub> = <b>300</b> mm					
	position in x-direction;		x <sub>1</sub> = <b>1000</b> mm					
	position in y-direction;		y1 = <b>1000</b> mm					
	Soil properties							
	Density of soil;		γ <sub>soil</sub> = <b>15.1</b> kN/	m <sup>3</sup>				
	Characteristic cohesior	ז;	c' <sub>k</sub> = <b>2.8</b> kN/m <sup>2</sup>	2				
	Characteristic effective	shear resistance angle;	φ' <sub>k</sub> = <b>30.4</b> deg					
	Characteristic friction a	ingle;	$\delta_k = 5 \deg$					
	Foundation loads							
	Self weight;		$F_{swt} = h \times \gamma_{conc}$	= <b>13.8</b> kN/m <sup>2</sup>				
	Soil weight;		$F_{soil} = h_{soil} \times \gamma_{so}$	<sub>pil</sub> = <b>14.3</b> kN/m <sup>2</sup>	2			
	Column no.1 loads							
	Permanent axial load;		F <sub>Gz1</sub> = <b>786.0</b> k	N				
	Variable axial load;		F <sub>Qz1</sub> = <b>234.0</b> k	N				
	Design approach 1							
	Partial factors on acti	ions - Combination1						
	Partial factor set;		A1					
	Permanent unfavourab	le action - Table A.3;	γ <sub>G</sub> = <b>1.35</b>					
	Permanent favourable	action - Table A.3;	γ <sub>Gf</sub> = <b>1.00</b>					
	Variable unfavourable	action - Table A.3;	γ <b>Q</b> = <b>1.50</b>					
	Variable favourable act	tion - Table A.3;	$\gamma_{Qf} = 0.00$					
	Partial factors for soil	l parameters - Combinati	on1					
	Soil factor set;		M1					
	Angle of shearing resis	stance - Table A.4;	$\gamma_{\Phi'} = 1.00$					
	Effective cohesion - Ta	ble A.4;	$\gamma_{c'} = 1.00$					
	Weight density - Table	A.4;	$\gamma_{\gamma} = 1.00$					
	Partial factors for spr	ead foundations - Comb	ination1					
	Resistance factor set;		R1					
	Bearing - Table A.5;		γ <sub>R.v</sub> = <b>1.00</b>					
	Sliding - Table A.5;		γ <sub>R.h</sub> = <b>1.00</b>					
	Bearing resistance (S	ection 6.5.2)						
	Forces on foundation	1						
	Force in z-direction;		$F_{dz} = \gamma_G \times (A \times$	$(F_{swt} + F_{soil}) +$	F <sub>Gz1</sub> ) + γ <sub>Q</sub> × Fα	<sub>2z1</sub> = <b>1563.8</b> kN		
	Moments on foundati	on						
	Moment in x-direction;		M <sub>dx</sub> = γ <sub>G</sub> × (A > kNm	< (F <sub>swt</sub> + F <sub>soil</sub> ) ×	L <sub>x</sub> / 2 + F <sub>Gz1</sub> ×	$x_1$ ) + $\gamma_Q \times F_{Qz1} \times$	x <sub>1</sub> = <b>1563.8</b>	
	Moment in y-direction;		$M_{dy} = \gamma_G \times (A > kNm)$	$\times$ (F <sub>swt</sub> + F <sub>soil</sub> ) $\times$	Ly / 2 + F <sub>Gz1 ×</sub>	$y_1$ ) + $\gamma_Q \times F_{Qz1} \times$	y <sub>1</sub> = <b>1563.8</b>	
	Eccentricity of base r	reaction						
	Eccentricity of base rea	action in x-direction;	$e_x = M_{dx} / F_{dz}$ -	L <sub>x</sub> / 2 = <b>0</b> mm				

 $e_y = M_{dy} / F_{dz} - L_y / 2 = 0 mm$ 

Eccentricity of base reaction in y-direction;

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Effective area of	base								
Effective length;		$L'_x = L_x - 2 \times e$	<sub>x</sub> = <b>2000</b> mm						
Effective width;		$L'_y = L_y - 2 \times e$	y = <b>2000</b> mm						
Effective area;		$A' = L'_x \times L'_y =$	<b>4.000</b> m <sup>2</sup>						
Pad base pressu	ire								
Design base pres	sure;	$f_{dz} = F_{dz} / A' =$	<b>391</b> kN/m²						
Ultimate bearing	capacity under drained cor	nditions (Annex D.	4)						
Design angle of s	hearing resistance;	∳' <sub>d</sub> = atan(tan(	$\phi'_{d} = atan(tan(\phi'_{k}) / \gamma_{\phi'}) = 30.400 \text{ deg}$						
Design effective of	cohesion;	c' <sub>d</sub> = c' <sub>k</sub> / γ <sub>c'</sub> = <b>2.800</b> kN/m <sup>2</sup>							
Effective overbure	den pressure;	q = (h + $h_{soil}$ ) × $\gamma_{soil}$ - $h_{water}$ × $\gamma_{water}$ = <b>22.650</b> kN/m <sup>2</sup>							
Design effective of	overburden pressure;	q' = q / γ <sub>γ</sub> = <b>22.650</b> kN/m <sup>2</sup>							
Bearing resistanc	e factors;	$N_q = Exp(\pi \times tan(\phi'_d)) \times (tan(45 \text{ deg } + \phi'_d / 2))^2 = 19.258$							
		$N_c = (N_q - 1) \times \cot(\phi'_d) = 31.120$							
			$N_{\gamma} = 2 \times (N_q - 1) \times tan(\phi'_d) = 21.424$						
Foundation shape	e 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 fa	actors;	H = 0.0  kN							
		$m_y = [2 + (L'_y / L'_x)] / [1 + (L'_y / L'_x)] = 1.500$							
		$m_x = [2 + (L'_x / m_z - m_z - 1.50)]$	L'y)] / [1 + (L'x	/ L'y)] = <b>1.500</b>					
		$m = m_x = 1.300$ $i_x = [1 - H/(E_x + A' \times c'_x \times cot(A'_x))]m = 1.000$							
		$i_{u} = [1 - H / (H_{dz} + A' \times C_{d} \times Cot(\psi^{a}))] = 1.000$ $i_{u} = [1 - H / (F_{dz} + A' \times C_{d} \times Cot(\psi^{a}))]^{m+1} = 1.000$							
		$i_{\gamma} = [1 - 117, (1 - 127) + A + C_{0} + C_{0}(\psi_{0}))] = 1.000$							
Ultimate bearing (	capacity:	$n_{f} = n_{f} - (1 - n_{f}) / (1 + n_{f}) + (1 + n_{f}) = 1.000$ $n_{f} = C'_{d} \times N_{c} \times S_{c} \times i_{c} + d' \times N_{c} \times S_{c} \times i_{c} + 0.5 \times v_{coll} \times L'_{v} \times N_{v} \times S_{v} \times i_{v} =$							
chimate bearing (	sapaony,	1017.0 kN/m <sup>2</sup>							
		PASS -	Ultimate bea	ring capacity o	exceeds design l	base press			
Design approacl	h 1				-	-			
Partial factors of	n actions - Combination2								
Partial factor set;		A2							
Permanent unfavourable action - Table A.3;		γ <sub>G</sub> = <b>1.00</b>							
Permanent favou	rable action - Table A.3;	$\gamma_{\rm Gf}$ = 1.00							
Variable unfavourable action - Table A.3;		$\gamma_{\rm Q}$ = 1.30							
Variable favourab	le action - Table A.3;	γ <sub>Qf</sub> = <b>0.00</b>							

## Partial factors for soil parameters - Combination2

2
= 1.25
= 1.25
= 1.00

Partial factors for spread foundations - Combination2Resistance factor set;R1

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Bearing - Table	A.5;	γ <sub>R.v</sub> = <b>1.00</b>							
Sliding - Table A	5;	γ <sub>R.h</sub> = <b>1.00</b>							
Bearing resista	nce (Section 6.5.2)								
Forces on foun	dation								
Force in z-direct	ion;	$F_{dz} = \gamma_G \times (A$	× (F <sub>swt</sub> + F <sub>soil</sub> ) +	F <sub>Gz1</sub> ) + γ <sub>Q</sub> × F <sub>Q</sub>	<sub>z1</sub> = <b>1202.6</b> kN				
Moments on fo	undation								
Moment in x-dire	ection;	$M_{dx} = \gamma_G \times (A)$	$\times$ (F <sub>swt</sub> + F <sub>soil</sub> ) $\times$	$L_x$ / 2 + $F_{Gz1}$ ×	<b>x</b> <sub>1</sub> ) + $\gamma_Q \times F_{Qz1} \times$	x <sub>1</sub> = <b>1202.</b>			
		kNm							
Moment in y-dire	ection;	M <sub>dy</sub> = γ <sub>G</sub> × (A kNm	$\begin{split} M_{dy} = \gamma_G \times (A \times (F_{swt} + F_{soil}) \times L_y \ / \ 2 + F_{Gz1} \times y_1) + \gamma_Q \times F_{Qz1} \times y_1 = \textbf{1202.6} \\ kNm \end{split}$						
Eccentricity of	base reaction								
Eccentricity of b	ase reaction in x-direction;	$e_x = M_{dx} / F_{dz}$	$e_x = M_{dx} / F_{dz} - L_x / 2 = 0 mm$						
Eccentricity of b	ase reaction in y-direction;	$e_y = M_{dy} / F_{dz}$	- L <sub>y</sub> / 2 = <b>0</b> mm						
Effective area of	of base								
Effective length;		$L'_x = L_x - 2 \times 10^{-1}$	e <sub>x</sub> = <b>2000</b> mm						
Effective width;		$L'_y = L_y - 2 \times 10^{-1}$	e <sub>y</sub> = <b>2000</b> mm						
Effective area;		$A' = L'_{x} \times L'_{y} =$	A' = L' <sub>x</sub> × L' <sub>y</sub> = <b>4.000</b> m <sup>2</sup>						
Pad base press	sure								
Design base pre	ssure;	$f_{dz} = F_{dz} / A' =$	<b>300.6</b> kN/m <sup>2</sup>						
Ultimate bearin	g capacity under drained	l conditions (Annex D	.4)						
Design angle of	shearing resistance;	∳'₅ = atan(tar	(φ' <sub>k</sub> ) / γ <sub>φ'</sub> ) = <b>25.1</b>	<b>43</b> deg					
Design effective	cohesion;	$c'_{d} = c'_{k} / \gamma_{c'} =$	<b>2.240</b> kN/m <sup>2</sup>						
Effective overbu	rden pressure;	$q = (h + h_{soil})$	$ imes \gamma_{soil}$ - $h_{water}  imes \gamma$	water = <b>22.650</b> k	κN/m²				
Design effective	overburden pressure;	$\mathbf{q'} = \mathbf{q} / \gamma_{\gamma} = 2$	<b>2.650</b> kN/m <sup>2</sup>						
Bearing resistan	ce factors;	$N_q = Exp(\pi \times$	$N_q = Exp(\pi \times tan(\phi'_d)) \times (tan(45 \text{ deg } + \phi'_d / 2))^2 = 10.824$						
		$N_{c} = (N_{q} - 1)$	$\times \cot(\phi'_d) = 20.9$	32					
		$N_{\gamma} = 2 \times (N_q - 1) \times tan(\phi'_d) = 9.222$							
Foundation shap	be factors;	$s_q = 1 + (L'_y /$	$s_q = 1 + (L'_y / L'_x) \times sin(\phi'_d) = 1.425$						
		$s_{\gamma} = 1 - 0.3 \times$	$s_{\gamma} = 1 - 0.3 \times (L'_y / L'_x) = 0.700$						
	f 1	$s_c = (s_q \times N_q - 1) / (N_q - 1) = 1.468$							
Load inclination	Tactors;	H = U.U KIN $m = [2 + (1 + (1 + 1)) / [1 + (1 + (1 + 1))] = 1 500$							
		my = [2 + (Ly m₂ = [2 + (L')	/ L x)] / [1 + (L y	$(  \cdot x_{1})  = 1.500$					
		$m = m_x = 1.5$	, _ y)], [' ' (' X 00	, _ y/] = 1.000					
		i <sub>g</sub> = [1 - H / (F	$F_{dz} + A' \times C'_d \times C'_d$	ot( <b>o'</b> d))] <sup>m</sup> = <b>1.00</b>	0				
		i <sub>γ</sub> = [1 - Η / (F	$d_{dz} + A' \times C'_{d} \times CC$	$pt(\phi'_d))]^{m+1} = 1.$	000				
		$i_c = i_a - (1 - i_a)$	) / (N <sub>c</sub> × tan(Ⴛ'a))	= 1.000					

kN/m<sup>2</sup>

Ultimate bearing capacity;

PASS - Ultimate bearing capacity exceeds design base pressure

 $n_{f} = c'_{d} \times N_{c} \times s_{c} \times i_{c} + q' \times N_{q} \times s_{q} \times i_{q} + 0.5 \times \gamma_{\text{soil}} \times L'_{y} \times N_{\gamma} \times s_{\gamma} \times i_{\gamma} = \textbf{515.7}$