Design Criteria

CROUCH WATERFALL

Project Title:	Job N°	By	Date
St. Ishmaels Sea Defence	*22166*	*RB*	*APR'22*
	Checked *SAG*	Date *APR'22*	Page *00* of *04*

References

Element of Works

Unreinforced Pad foundation

Results

Intended Use

Permanent Works

Loading

Concrete self weight

Standards Adopted

EUROCODES

Materials

Concrete C35/45

Design Assumptions / Limitations

Computer Analysis Reference

Tedds

Design Check Level

Internal	Internal	External
CAT I	CAT II	CAT III

Checked Internally By:

Sergio Alarcon Gener

Associate

Date: *APR'22*

Approved By:

Julian Howe

Director

Date: *APR'22*

Checked Externally By:

Company:

Date:

Comments

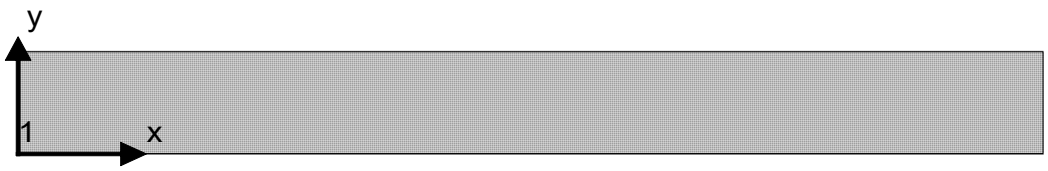
UNREINFORCED PAD FOUNDATION EXAMPLE

Foundation analysis in accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the recommended values

Tedds calculation version 3.3.00

Pad foundation details

Length of foundation	L_x = **10500** mm
Width of foundation	L_y = **1150** mm
Foundation area	$A = L_x \times L_y$ = **12.075** m^2
Depth of foundation	h = **800** mm
Depth of soil over foundation	h_{soil} = **0** 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} = **10490** mm
Width of column	l_{y1} = **1140** mm
position in x-direction	x_1 = **5250** mm
position in y-direction	y_1 = **575** mm

Soil properties

Density of soil	γ_{soil} = **18.0** kN/m^3
Characteristic cohesion	c'_k = **0** kN/m^2
Characteristic effective shear resistance angle	ϕ'_k = **30** deg
Characteristic friction angle	δ_k = **20** deg

Foundation loads

Variable surcharge load	F_{Qsur} = **100.0** kN/m^2
Self weight	$F_{swt} = h \times \gamma_{conc}$ = **20.0** kN/m^2

Column no.1 loads

Permanent axial load	F_{Gz1} = **1.0** 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 $\gamma_{\phi'} = \mathbf{1.00}$

Effective cohesion - Table A.4 $\gamma_{c'} = \mathbf{1.00}$

Weight density - Table A.4 $\gamma_{\gamma} = \mathbf{1.00}$

Partial factors for spread foundations - Combination1

Resistance factor set R1

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

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

Bearing resistance (Section 6.5.2)

Forces on foundation

Force in z-direction $F_{dz} = \gamma_G \times (A \times F_{swt} + F_{Gz1}) + \gamma_Q \times A \times F_{Qsur} = \mathbf{2138.6}$ kN

Moments on foundation

Moment in x-direction $M_{dx} = \gamma_G \times (A \times F_{swt} \times L_x / 2 + F_{Gz1} \times x_1) + \gamma_Q \times A \times F_{Qsur} \times L_x / 2 = \mathbf{11227.8}$ kNm

Moment in y-direction $M_{dy} = \gamma_G \times (A \times F_{swt} \times L_y / 2 + F_{Gz1} \times y_1) + \gamma_Q \times A \times F_{Qsur} \times L_y / 2 = \mathbf{1229.7}$ kNm

Eccentricity of base reaction

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

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

Effective area of base

Effective length $L'_x = L_x - 2 \times e_x = \mathbf{10500}$ mm

Effective width $L'_y = L_y - 2 \times e_y = \mathbf{1150}$ mm

Effective area $A' = L'_x \times L'_y = \mathbf{12.075}$ m^2

Pad base pressure

Design base pressure $f_{dz} = F_{dz} / A' = \mathbf{177.1}$ kN/m^2

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

Design angle of shearing resistance $\phi'_d = \text{atan}(\tan(\phi'_k) / \gamma_{\phi'}) = \mathbf{30.000}$ deg

Design effective cohesion $c'_d = c'_k / \gamma_{c'} = \mathbf{0.000}$ kN/m^2

Effective overburden pressure $q = (h + h_{soil}) \times \gamma_{soil} - h_{water} \times \gamma_{water} = \mathbf{14.400}$ kN/m^2

Design effective overburden pressure $q' = q / \gamma_{\gamma} = \mathbf{14.400}$ kN/m^2

Bearing resistance factors $N_q = \text{Exp}(\pi \times \tan(\phi'_d)) \times (\tan(45 \text{ deg} + \phi'_d / 2))^2 = \mathbf{18.401}$

$N_c = (N_q - 1) \times \cot(\phi'_d) = \mathbf{30.140}$

$N_{\gamma} = 2 \times (N_q - 1) \times \tan(\phi'_d) = \mathbf{20.093}$

Foundation shape factors $s_q = 1 + (L'_y / L'_x) \times \sin(\phi'_d) = \mathbf{1.055}$

$s_{\gamma} = 1 - 0.3 \times (L'_y / L'_x) = \mathbf{0.967}$

$s_c = (s_q \times N_q - 1) / (N_q - 1) = \mathbf{1.058}$

Load inclination factors $H = \mathbf{0.0}$ kN

$m_y = [2 + (L'_y / L'_x)] / [1 + (L'_y / L'_x)] = \mathbf{1.901}$

$m_x = [2 + (L'_x / L'_y)] / [1 + (L'_x / L'_y)] = \mathbf{1.099}$

$m = m_x = \mathbf{1.099}$

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

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

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

Ultimate bearing capacity $n_f = c'_d \times N_c \times s_c \times i_c + q' \times N_q \times s_q \times i_q + 0.5 \times \gamma_{soil} \times L'_y \times N_{\gamma} \times s_{\gamma} \times i_{\gamma} = \mathbf{480.6}$ 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	γ_G = **1.00**
Permanent favourable action - Table A.3	γ_{Gf} = **1.00**
Variable unfavourable action - Table A.3	γ_Q = **1.30**
Variable favourable action - Table A.3	γ_{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	γ_γ = **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	$F_{dz} = \gamma_G \times (A \times F_{swt} + F_{Gz1}) + \gamma_Q \times A \times F_{Qsur}$ = **1812.3** kN

Moments on foundation

Moment in x-direction	$M_{dx} = \gamma_G \times (A \times F_{swt} \times L_x / 2 + F_{Gz1} \times x_1) + \gamma_Q \times A \times F_{Qsur} \times L_x / 2$ = **9514.3** kNm
Moment in y-direction	$M_{dy} = \gamma_G \times (A \times F_{swt} \times L_y / 2 + F_{Gz1} \times y_1) + \gamma_Q \times A \times F_{Qsur} \times L_y / 2$ = **1042.0** 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	$L'_x = L_x - 2 \times e_x$ = **10500** mm
Effective width	$L'_y = L_y - 2 \times e_y$ = **1150** mm
Effective area	$A' = L'_x \times L'_y$ = **12.075** m^2

Pad base pressure

Design base pressure	$f_{dz} = F_{dz} / A'$ = **150.1** kN/m^2

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

Design angle of shearing resistance	$\phi'_d = \text{atan}(\tan(\phi'_k) / \gamma_{\phi'})$ = **24.791** deg
Design effective cohesion	$c'_d = c'_k / \gamma_{c'}$ = **0.000** kN/m^2
Effective overburden pressure	$q = (h + h_{soil}) \times \gamma_{soil} - h_{water} \times \gamma_{water}$ = **14.400** kN/m^2
Design effective overburden pressure	$q' = q / \gamma_\gamma$ = **14.400** kN/m^2
Bearing resistance factors	$N_q = \text{Exp}(\pi \times \tan(\phi'_d)) \times (\tan(45 \text{ deg} + \phi'_d / 2))^2$ = **10.431**
	$N_c = (N_q - 1) \times \cot(\phi'_d)$ = **20.418**
	$N_\gamma = 2 \times (N_q - 1) \times \tan(\phi'_d)$ = **8.712**
Foundation shape factors	$s_q = 1 + (L'_y / L'_x) \times \sin(\phi'_d)$ = **1.046**

	$s_\gamma = 1 - 0.3 \times (L'_y / L'_x) =$ **0.967**
	$s_c = (s_q \times N_q - 1) / (N_q - 1) =$ **1.051**
Load inclination factors	H = **0.0** kN
	$m_y = [2 + (L'_y / L'_x)] / [1 + (L'_y / L'_x)] =$ **1.901**
	$m_x = [2 + (L'_x / L'_y)] / [1 + (L'_x / L'_y)] =$ **1.099**
	$m = m_x =$ **1.099**
	$i_q = [1 - H / (F_{dz} + A' \times c'_d \times \cot(\phi'_d))]^m =$ **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	$n_f = c'_d \times N_c \times s_c \times i_c + q' \times N_q \times s_q \times i_q + 0.5 \times \gamma_{soil} \times L'_y \times N_\gamma \times s_\gamma \times i_\gamma =$ **244.3** kN/m^2
	PASS - Ultimate bearing capacity exceeds design base pressure

UNREINFORCED PAD FOUNDATION EXAMPLE

Foundation design in accordance with EN1992-1-1:2004 incorporating Corrigendum dated January 2008 and the recommended values

Tedds calculation version 3.3.00

Concrete details (Table 3.1 - Strength and deformation characteristics for concrete)

Concrete strength class	C30/37
Characteristic compressive cylinder strength	f_{ck} = **30** N/mm^2
Mean value of axial tensile strength	$f_{ctm} = 0.3$ N/mm^2 $\times (f_{ck}/ 1$ N/mm$^2)^{2/3} =$ **2.9** N/mm^2
5% fractile of axial tensile strength	$f_{ctk,0.05} = 0.7 \times f_{ctm} =$ **2.0** N/mm^2
Partial factor for concrete (Table 2.1N)	$\gamma_C =$ **1.50**
Tens.strength coeff.for plain concrete (cl.12.3.1(1))	$\alpha_{ct,pl} =$ **0.80**
Des.tens.strength for plain concrete (exp.12.1)	$f_{ctd,pl} = \alpha_{ct,pl} \times f_{ctk,0.05} / \gamma_C =$ **1.1** N/mm^2

Strip and pad footings (Section 12.9.3)

Design base pressure	f_{dz} = **177.1** kN/m^2
Projection from column face	a = **5** mm
Max.projection from column face - (exp.12.13)	$a_{max} = 0.85 \times h / \sqrt{[3 \times f_{dz} / f_{ctd,pl}]} =$ **970** mm

PASS - Projection from the column face doesn't exceed permissible limit for plain concrete