



Structural Survey at Site off Heath House Lane

Prepared by
Ideal Design Solutions



Our Ref:19296-IDS-BR-ZZ-RPS-0001
Structural Condition Survey
Date: March 2020

Document History

Prepared by : Craig Wynne

Position : Associate

Date : 16/03/2020

Authorised by : Simon Ward

Position : Director

Date : 16/03/2020

Document Status : Draft/Preliminary/Final

Revision : C01

Revision	Date	Comment	Editor
C01	16/03/2020	Original Issue	CW

Contents

1.0	Scope	4
2.0	Building Description	5
2.1	External Envelope	5
2.2	Roof	5
2.3	Structural Framing	5
2.3	Foundations	5
3.0	Structural Works	6
3.1	Existing Frame Capacity	6
3.2	Foundation Capacity	6

Appendices

1.0 Scope

The following document appraises the existing barn located in a field adjacent to Heath House Lane, Lower Tean. The report is prepared in support of a Class Q application to Staffordshire Moorlands District Council.

The report appraises the existing structural condition of the building and its structural integrity with a view to converting the building from an agricultural building to a dwelling. The following elements are considered in detail.

- Load carrying capacity of the existing structure under both vertical and lateral loading.
- Structural capacity of the primary steel frame.
- Structural capacity of the foundations.

2.0 Building Description

2.1 External Envelope

The external envelope of the building is constructed from single skin metal cladding to both gable elevations and one side elevation. Cladding sheets are supported by timber cladding rails at circa 1.5m centres. The front elevation is currently completely open.

2.2 Roof

The existing roof consists of a single skin metal sheeting supported by timber purlins at circa 1.5m centres.

2.3 Structural Framing

The building is a portal frame structure, with 3No frames spaced at approximately 4.5m c/c. Frame span is 6.0m. To the open elevation, there is a small cantilever off the portal column and a change in roof pitch direction. The frame is stabilised parallel to the frame direction via rotational stiffness of the portal frame. And in the direction perpendicular to the frame direction, is stabilised by the horizontal and vertical bracing.

2.3 Foundations

The building foundations comprise of mass fill concrete pocket bases. Following excavation of concrete footing, each base consists of 1.0m³. The steel columns are embedded into the concrete.

3.0 Structural Works

3.1 Existing Frame Capacity

The existing frame has been analysed in consideration of the proposed loads to be imparted as a result of the change of use for the building. The following loads have been applied. (All in kN/m² UNO).

Sheeting	0.12
Purlins	0.05
Services	0.15
Imposed	0.60

The results of the frame analysis can be found in appendix I. This analysis provides structural justification for the additional load to be imparted onto the frame under both vertical and lateral loading. It is worth noting that the additional loading onto the frame is a relatively small increase in loading.

3.2 Foundation Capacity

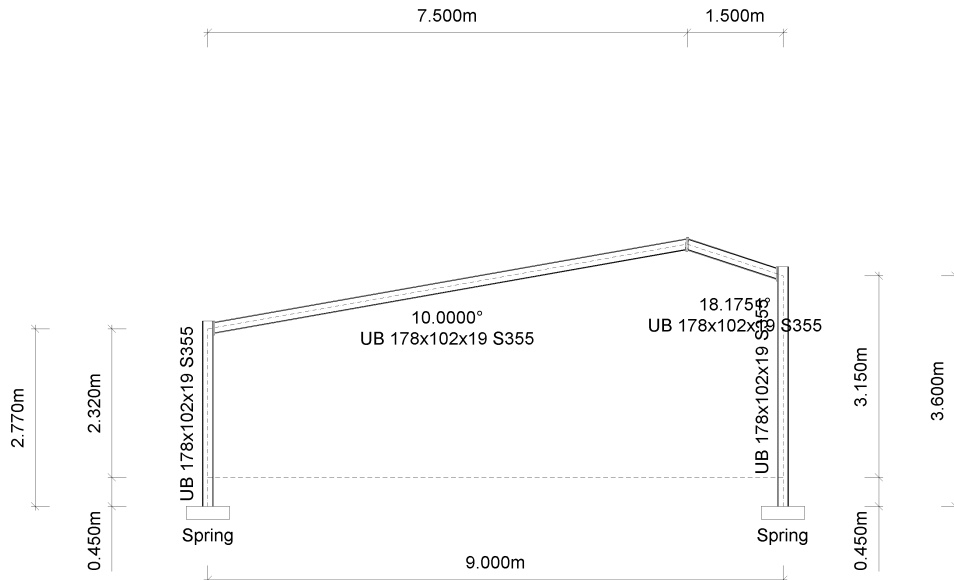
IDS have been informed that the existing foundations are 1.0m³ pocket bases. It is assumed that these bases are of C25 concrete or equivalent. Typically, this type of building was constructed utilising pocket bases whereby the steel columns would be cast a min 900mm into the 1m³ concrete. This type of construction will inherently offer an amount of rotational capacity to the frame and will want to stop the frame from racking over under lateral load. This has been ignored when the building has been analysed and would only offer additional support to the building if considered.

The bases have been analysed as pinned bases. The analysis can be found in appendix II. Typically, with small portal frames, the load combinations that have the higher lateral loads and lower vertical loads are the governing combinations for design of the foundations. A base shear of 10kN has been applied to the foundations (onerously) and zero axial load. Base sizes of 1m³ are deemed adequate.

Appendix I

Frame Analysis

REFERENCE: Portal Frame 1
Frame Diagram



Frame Details

No. Spans 1
Effective Frame Centres 4.500 m

Span Geometry

Span	Type	Axis	Lh Eaves [m]	Lh Apex [m]	Apex [m]	Rh Apex [m]	Rh Eaves [m]
Span 1	Asymmetric	X	0.0	-	7.500	-	9.000
		Z	2.320	-	3.642	-	3.150

Wind Options

Wind Method Standard
Basic Wind Speed (Vb) 21.3 m/s
Ground Roughness Country
Upwind distance from sea to site 90.0 km
Altitude factor (Sa) 1.1650
Seasonal factor (Ss) 1.0000
Probability factor (Sp) 1.0000

Loadcases

Frame Dead Load (Dead)

Area Loads

Load Type	Span Member	Direction	Load ₁ [kN/m ²]	a [m]	Load ₂ [kN/m ²]	b [m]	Centres [m]
Sheeting	Span 1	Vert.	0.170	-	-	-	4.500

Frame Service Load (Dead)

Area Loads

Load Type	Span Member	Direction	Load ₁ [kN/m ²]	a [m]	Load ₂ [kN/m ²]	b [m]	Centres [m]
Span Area	Span 1	Vert.	0.150	-	-	-	4.500

Frame Imposed Load (Imposed)

Area Loads

Load Type	Span Member	Direction	Load ₁ [kN/m ²]	a [m]	Load ₂ [kN/m ²]	b [m]	Centres [m]
Span Area	Span 1	Vert.	0.600	-	-	-	4.500

ULS, Wind: Side Left, Cpi -0.3000, Roof Cpe -ve

Frame is considered to be in Intermediate zone

Building Length	9.000	m
Building Width	9.000	m
Building reference height, H_r	3.642	m
Building effective height, H_e	3.642	m
Altitude factor, S_a	1.1650	
Seasonal factor, S_s	1.0000	
Probability factor, S_p	1.0000	
Directional factor, S_d	1.0000	
Eaves Line orientation EON	0.0	°
Critical Wind Angle	270.0000	°

Wind Speeds

Member	Sh	Sc	Tc	St	Tt	gt	Sb	Vs [m/s]	Ve [m/s]
Span 1 Lh Column	0.0	0.0	0.0	0.0	0.0	0.0	1.3758	24.8	34.1
Span 1 Lh Rafter	0.0	0.0	0.0	0.0	0.0	0.0	1.3758	24.8	34.1
Span 1 Rh Rafter	0.0	0.0	0.0	0.0	0.0	0.0	1.3758	24.8	34.1
Span 1 Rh Column	0.0	0.0	0.0	0.0	0.0	0.0	1.3758	24.8	34.1
Span 1 Lh Column	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Span 1 Lh Rafter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Span 1 Lh Rafter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Span 1 Rh Rafter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Span 1 Rh Rafter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Span 1 Rh Column	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Wind Loads

Member	qs [kN/m ²]	Cpi	Cpe	L [m]	a [m]	Cae	Cai	%
Span 1 Lh Column	0.714	-0.3000	0.6626	2.770	5.284	0.9973	1.0000	100.00
Span 1 Lh Rafter	0.714	-0.3000	-1.0000	0.740	8.846	0.9584	1.0000	100.00
Span 1 Lh Rafter			-0.5000	6.876				
Span 1 Rh Rafter	0.714	-0.3000	-0.5000	0.812	4.769	1.0000	1.0000	100.00
Span 1 Rh Rafter			-0.8153	0.767				
Span 1 Rh Column	0.714	-0.3000	-0.5000	3.600	5.763	0.9908	1.0000	100.00

ULS, Wind: Gable End Top, Cpi -0.3000, Roof Cpe -ve

Frame is considered to be in Intermediate zone

Building Length	9.000	m
Building Width	9.000	m
Building reference height, H_r	3.642	m
Building effective height, H_e	3.642	m
Lh Gap	5.540	m
Rh Gap	7.200	m
Altitude factor, S_a	1.1650	
Seasonal factor, S_s	1.0000	
Probability factor, S_p	1.0000	
Directional factor, S_d	1.0000	
Eaves Line orientation EON	0.0	°
Critical Wind Angle	0.0	°

Wind Speeds

Member	Sh	Sc	Tc	St	Tt	gt	Sb	Vs [m/s]	Ve [m/s]
Span 1 Lh Column	0.0	0.0	0.0	0.0	0.0	0.0	1.3758	24.8	34.1
Span 1 Lh Rafter	0.0	0.0	0.0	0.0	0.0	0.0	1.3758	24.8	34.1
Span 1 Rh Rafter	0.0	0.0	0.0	0.0	0.0	0.0	1.3758	24.8	34.1
Span 1 Rh Column	0.0	0.0	0.0	0.0	0.0	0.0	1.3758	24.8	34.1
Span 1 Lh Column	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Span 1 Lh Rafter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Span 1 Rh Rafter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Span 1 Rh Column	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Wind Loads

Member	qs [kN/m ²]	Cpi	Cpe	L [m]	a [m]	Cae	Cai	%
Span 1 Lh Column	0.714	-0.3000	-0.8000	2.770	5.284	0.9973	1.0000	100.00
Span 1 Lh Rafter	0.714	-0.3000	-0.6000	7.616	8.846	0.9584	1.0000	100.00

Member	qs [kN/m ²]	Cpi	Cpe	L [m]	a [m]	Cae	Cai	%
Span 1 Rh Rafter	0.714	-0.3000	-0.6000	1.579	4.769	1.0000	1.0000	100.00
Span 1 Rh Column	0.714	-0.3000	-0.8000	3.600	5.763	0.9908	1.0000	100.00

Combinations**Sw + Dead + Serv. + Imp.**

Frame Imperfection off

Loadcase	Type	Ultimate P.S.F.	Service P.S.F.
Self weight	Dead	1.4000	1.0000
Frame Dead Load	Dead	1.4000	1.0000
Frame Service Load	Dead	1.4000	1.0000
Frame Imposed Load	Imposed	1.6000	1.0000

Wind 1

Frame Imperfection off

Loadcase	Type	Ultimate P.S.F.	Service P.S.F.
Self weight	Dead	1.0000	1.0000
Frame Dead Load	Dead	1.0000	1.0000
Frame Service Load	Dead	1.0000	1.0000
ULS, Wind: Side Left, Cpi -0.3000, Roof Cpe -ve	Wind	1.4000	1.0000

Wind 2

Frame Imperfection off

Loadcase	Type	Ultimate P.S.F.	Service P.S.F.
Self weight	Dead	1.0000	1.0000
Frame Dead Load	Dead	1.0000	1.0000
Frame Service Load	Dead	1.0000	1.0000
ULS, Wind: Gable End Top, Cpi -0.3000, Roof Cpe -ve	Wind	1.4000	1.0000

Design Wizard Options**Design Criteria**

BS5950 Part1 : 2000	
Maximum Hinge Rotation	6.0000 °
Percent Mp for Plasticity	99.00 %
Axial Load Factor	1.2500

Design Limits

Eaves Deflection	No Limit
Apex Deflection	No Limit
Cladding Stiffness	0.0 %
Tie Elongation	No Limit

Design Code: BS5950**Design Summary**

Design Combination	Lambda p	Lambda r	Status
Sw + Dead + Serv. + Imp.	1.772	1.000	Pass
Wind 1	5.426	1.000	Pass
Wind 2	22.645	1.000	Pass

Member Stability Status: Fail

Design Cases**Sw + Dead + Serv. + Imp.****Sections**

Member	Section	Grade	Length	Mass	Weight	Mp	Mpr	UR
Span 1 Lh Column	UB 178x102x19	S355	2.770	19.05	52.76	60.8	60.7	0.485
Span 1 Lh Rafter	UB 178x102x19	S355	7.616	19.05	145.04	60.8	60.8	0.485
Span 1 Rh Rafter	UB 178x102x19	S355	1.579	19.05	30.07	60.8	60.7	0.629
Span 1 Rh Column	UB 178x102x19	S355	3.600	19.05	68.56	60.8	60.7	0.630
Total Rafter					175.11			
Total Column					121.32			
Total Haunch					0.0			
Total					296.43			

Hinge History

Hinge History

Event	Lambda 1st Order	Lambda 2nd Order	Status	Member	Distance(B)	Distance(A)	Status
Event 1	1.5859	1.5656	Formed	Span 1 Rh Column	3.600	3.600	
Event 2	1.7951	1.7721	Formed	Span 1 Lh Rafter	7.616	5.966	

ULS Plastic Deflections

Coord. X	Coord. Z	Delta X	Delta Y
0.0	-450.0	0.0	0.0
0.0	2320.0	17.568	0.170
7500.0	3642.5	21.651	24.335
9000.0	3150.0	29.507	0.222
9000.0	-450.0	0.0	0.0

Strength

Rafters

Member	U.R.	Status
Span 1 Lh Rafter	0.491	Pass
Span 1 Rh Rafter	0.636	Pass

Columns

Member	U.R.	Status
Span 1 Lh Column	0.490	Pass
Span 1 Rh Column	0.636	Pass

Haunches

Frame Stability

SCI Publication P 292

Item	Value	Units	Clause Ref.
Elastic critical load factor λ_{crit}	15.1864		
Second order failure load factor λ_f	1.7721		
Pass			

Wind 1

Sections

Member	Section	Grade	Length	Mass	Weight	Mp	Mpr	UR
Span 1 Lh Column	UB 178x102x19	S355	2.770	19.05	52.76	60.8	60.8	0.146
Span 1 Lh Rafter	UB 178x102x19	S355	7.616	19.05	145.04	60.8	60.8	0.146
Span 1 Rh Rafter	UB 178x102x19	S355	1.579	19.05	30.07	60.8	60.8	0.225
Span 1 Rh Column	UB 178x102x19	S355	3.600	19.05	68.56	60.8	60.8	0.225
Total Rafter					175.11			
Total Column					121.32			
Total Haunch					0.0			
Total					296.43			

Hinge History

Hinge History

Event	Lambda 1st Order	Lambda 2nd Order	Status	Member	Distance(B)	Distance(A)	Status
Event 1	4.4314	4.4078	Formed	Span 1 Rh Column	3.600	3.600	
Event 2	5.4554	5.4264	Formed	Span 1 Lh Rafter	3.808	2.358	

ULS Plastic Deflections

Coord. X	Coord. Z	Delta X	Delta Y
0.0	-450.0	0.0	0.0
0.0	2320.0	37.934	0.0
7500.0	3642.5	37.772	-0.773
9000.0	3150.0	37.494	0.039
9000.0	-450.0	0.0	0.0

Strength

Rafters

Member	U.R.	Status
Span 1 Lh Rafter	0.147	Pass
Span 1 Rh Rafter	0.226	Pass

Columns

Member	U.R.	Status
Span 1 Lh Column	0.162	Pass
Span 1 Rh Column	0.226	Pass

Haunches Frame Stability SCI Publication P 292

Item	Value	Units	Clause Ref.
Elastic critical load factor λ_{crit}	176.6594		
Second order failure load factor λ_f	5.4264		

Pass

WInd 2 Sections

Member	Section	Grade	Length	Mass	Weight	Mp	Mpr	UR
Span 1 Lh Column	UB 178x102x19	S355	2.770	19.05	52.76	60.8	60.8	0.038
Span 1 Lh Rafter	UB 178x102x19	S355	7.616	19.05	145.04	60.8	60.8	0.044
Span 1 Rh Rafter	UB 178x102x19	S355	1.579	19.05	30.07	60.8	60.8	0.044
Span 1 Rh Column	UB 178x102x19	S355	3.600	19.05	68.56	60.8	60.8	0.081
Total Rafter					175.11			
Total Column					121.32			
Total Haunch					0.0			
Total					296.43			

Hinge History Hinge History

Event	Lambda 1st Order	Lambda 2nd Order	Status	Member	Distance(B)	Distance(A)	Status
Event 1	22.6123	22.6123	Formed	Span 1 Rh Column	3.600	3.600	
Event 2	22.6451	22.6451	Formed	Span 1 Lh Rafter	7.616	6.460	

ULS Plastic Deflections

Coord. X	Coord. Z	Delta X	Delta Y
0.0	-450.0	0.0	0.0
0.0	2320.0	0.150	0.010
7500.0	3642.5	0.851	3.712
9000.0	3150.0	2.073	0.017
9000.0	-450.0	0.0	0.0

Strength Rafters

Member	U.R.	Status
Span 1 Lh Rafter	0.044	Pass
Span 1 Rh Rafter	0.044	Pass

Columns

Member	U.R.	Status
Span 1 Lh Column	0.057	Pass
Span 1 Rh Column	0.081	Pass

Haunches Frame Stability SCI Publication P 292

Item	Value	Units	Clause Ref.
Elastic critical load factor λ_{crit}	273.3404		
Second order failure load factor λ_f	22.6460		

Pass

Foundation Loads Self weight

Span	M [kNm]	F [kN]	N [kN]
Span 1 Lh Column	0.0	0.3	1.4
Span 1 Rh Column	0.0	-0.3	1.5

Frame Dead Load

Span	M [kNm]	F [kN]	N [kN]
Span 1 Lh Column	0.0	1.2	3.5
Span 1 Rh Column	0.0	-1.2	3.5

Frame Service Load

Span	M [kNm]	F [kN]	N [kN]
Span 1 Lh Column	0.0	1.1	3.0
Span 1 Rh Column	0.0	-1.1	3.0

Frame Imposed Load

Span	M [kNm]	F [kN]	N [kN]
Span 1 Lh Column	0.0	4.3	12.1
Span 1 Rh Column	0.0	-4.3	12.2

ULS, Wind: Side Left, Cpi -0.3000, Roof Cpe -ve

Span	M [kNm]	F [kN]	N [kN]
Span 1 Lh Column	0.0	-8.5	-5.4
Span 1 Rh Column	0.0	-2.0	-1.7

ULS, Wind: Gable End Top, Cpi -0.3000, Roof Cpe -ve

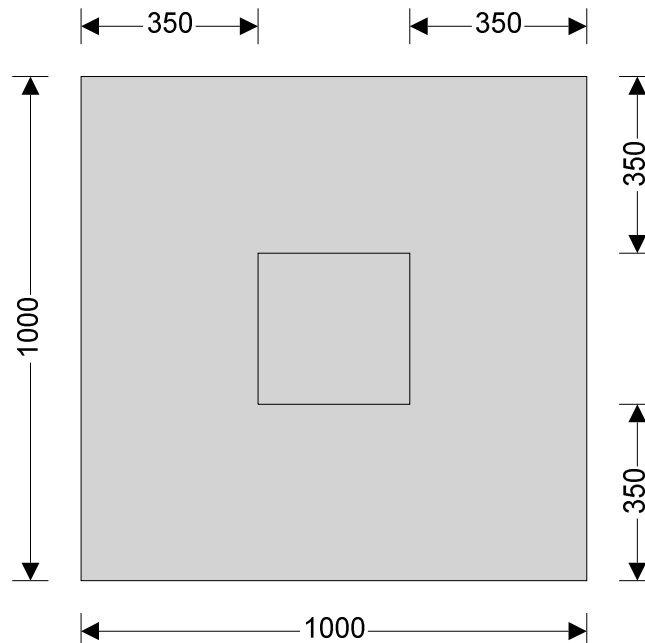
Span	M [kNm]	F [kN]	N [kN]
Span 1 Lh Column	0.0	0.9	-4.2
Span 1 Rh Column	0.0	-1.5	-3.9

Appendix II

Foundation Analysis

PAD FOOTING ANALYSIS AND DESIGN (BS8110-1:1997)

TEDDS calculation version 2.0.07



Pad footing details

Length of pad footing;
Width of pad footing;
Area of pad footing;
Depth of pad footing;
Depth of soil over pad footing;
Density of concrete;

$L = 1000$ mm
 $B = 1000$ mm
 $A = L \times B = 1.000$ m²
 $h = 1000$ mm
 $h_{\text{soil}} = 200$ mm
 $\rho_{\text{conc}} = 23.6$ kN/m³

Column details

Column base length;
Column base width;
Column eccentricity in x;
Column eccentricity in y;

$l_A = 300$ mm
 $b_A = 300$ mm
 $e_{PxA} = 0$ mm
 $e_{PyA} = 0$ mm

Soil details

Density of soil;
Design shear strength;
Design base friction;
Allowable bearing pressure;

$\rho_{\text{soil}} = 20.0$ kN/m³
 $\phi' = 25.0$ deg
 $\delta = 19.3$ deg
 $P_{\text{bearing}} = 150$ kN/m²

Foundation loads

Dead surcharge load;
Imposed surcharge load;
Pad footing self weight;
Soil self weight;
Total foundation load;

$F_{\text{Gsur}} = 0.000$ kN/m²
 $F_{\text{Qsur}} = 0.000$ kN/m²
 $F_{\text{swt}} = h \times \rho_{\text{conc}} = 23.600$ kN/m²
 $F_{\text{soil}} = h_{\text{soil}} \times \rho_{\text{soil}} = 4.000$ kN/m²
 $F = A \times (F_{\text{Gsur}} + F_{\text{Qsur}} + F_{\text{swt}} + F_{\text{soil}}) = 27.6$ kN

Horizontal loading on column base

Dead horizontal load in x direction;

$H_{\text{GxA}} = 10.0$ kN

Imposed horizontal load in x direction;	$H_{QxA} = 0.0 \text{ kN}$
Wind horizontal load in x direction;	$H_{WxA} = 0.0 \text{ kN}$
Total horizontal load in x direction;	$H_{xA} = 10.0 \text{ kN}$
Dead horizontal load in y direction;	$H_{GyA} = 0.0 \text{ kN}$
Imposed horizontal load in y direction;	$H_{QyA} = 0.0 \text{ kN}$
Wind horizontal load in y direction;	$H_{WyA} = 0.0 \text{ kN}$
Total horizontal load in y direction;	$H_{yA} = 0.0 \text{ kN}$

Check stability against sliding

Resistance to sliding due to base friction

$$H_{\text{friction}} = \max([P_{GA} + (F_{G\text{sur}} + F_{\text{swt}} + F_{\text{soil}}) \times A], 0 \text{ kN}) \times \tan(\delta) = 9.7 \text{ kN}$$

Passive pressure coefficient;

$$K_p = (1 + \sin(\phi')) / (1 - \sin(\phi')) = 2.464$$

Stability against sliding in x direction

Passive resistance of soil in x direction;

$$H_{\text{xpas}} = 0.5 \times K_p \times (h^2 + 2 \times h \times h_{\text{soil}}) \times B \times \rho_{\text{soil}} = 34.5 \text{ kN}$$

Total resistance to sliding in x direction;

$$H_{\text{xres}} = H_{\text{friction}} + H_{\text{xpas}} = 44.2 \text{ kN}$$

PASS - Resistance to sliding is greater than horizontal load in x direction**Check stability against overturning in x direction**

Total overturning moment;

$$M_{\text{xOT}} = M_{xA} + H_{xA} \times h = 10.000 \text{ kNm}$$

Restoring moment in x direction

Foundation loading;

$$M_{\text{xsur}} = A \times (F_{G\text{sur}} + F_{\text{swt}} + F_{\text{soil}}) \times L / 2 = 13.800 \text{ kNm}$$

Axial loading on column;

$$M_{\text{xaxial}} = (P_{GA}) \times (L / 2 - e_{PxA}) = 0.000 \text{ kNm}$$

Total restoring moment;

$$M_{\text{xres}} = M_{\text{xsur}} + M_{\text{xaxial}} = 13.800 \text{ kNm}$$

PASS - Overturning safety factor exceeds the minimum of 1 in the x direction**Calculate pad base reaction**

Total base reaction;

$$T = F + P_A = 27.6 \text{ kN}$$

Eccentricity of base reaction in x;

$$e_{Tx} = (P_A \times e_{PxA} + M_{xA} + H_{xA} \times h) / T = 362 \text{ mm}$$

Eccentricity of base reaction in y;

$$e_{Ty} = (P_A \times e_{PyA} + M_{yA} + H_{yA} \times h) / T = 0 \text{ mm}$$

Check pad base reaction eccentricity

$$\text{abs}(e_{Tx}) / L + \text{abs}(e_{Ty}) / B = 0.362$$

Base reaction acts outside of middle third of base**Calculate pad base pressures**

$$q_1 = 0.000 \text{ kN/m}^2$$

$$q_2 = 0.000 \text{ kN/m}^2$$

$$q_3 = 2 \times T / [3 \times B \times (L / 2 - \text{abs}(e_{Tx}))] = 133.642 \text{ kN/m}^2$$

$$q_4 = 2 \times T / [3 \times B \times (L / 2 + \text{abs}(e_{Tx}))] = 133.642 \text{ kN/m}^2$$

Minimum base pressure;

$$q_{\text{min}} = \min(q_1, q_2, q_3, q_4) = 0.000 \text{ kN/m}^2$$

Maximum base pressure;

$$q_{\text{max}} = \max(q_1, q_2, q_3, q_4) = 133.642 \text{ kN/m}^2$$

PASS - Maximum base pressure is less than allowable bearing pressure

