alternativeHEAT
Commercial Energy Solutions

Structural Report

Structural Report at Streatham Ice and Leisure Centre for Cenergist

AlternativeHEAT; Commercial Energy Solutions
Unit 19a
Scarva Road Industrial Estate
Banbridge
BT32 3QD
Tel: 028 4377 0700
Email; rorymcmahon@alternativeheat.co.uk

Seinor Structural Engineer;
Rory McMahon MEng CEng MIEI MIStructE

Revision	Description	Date	Created By	Authorised By
P01	Primary Issue	21.08.23	RMcM	RMcM

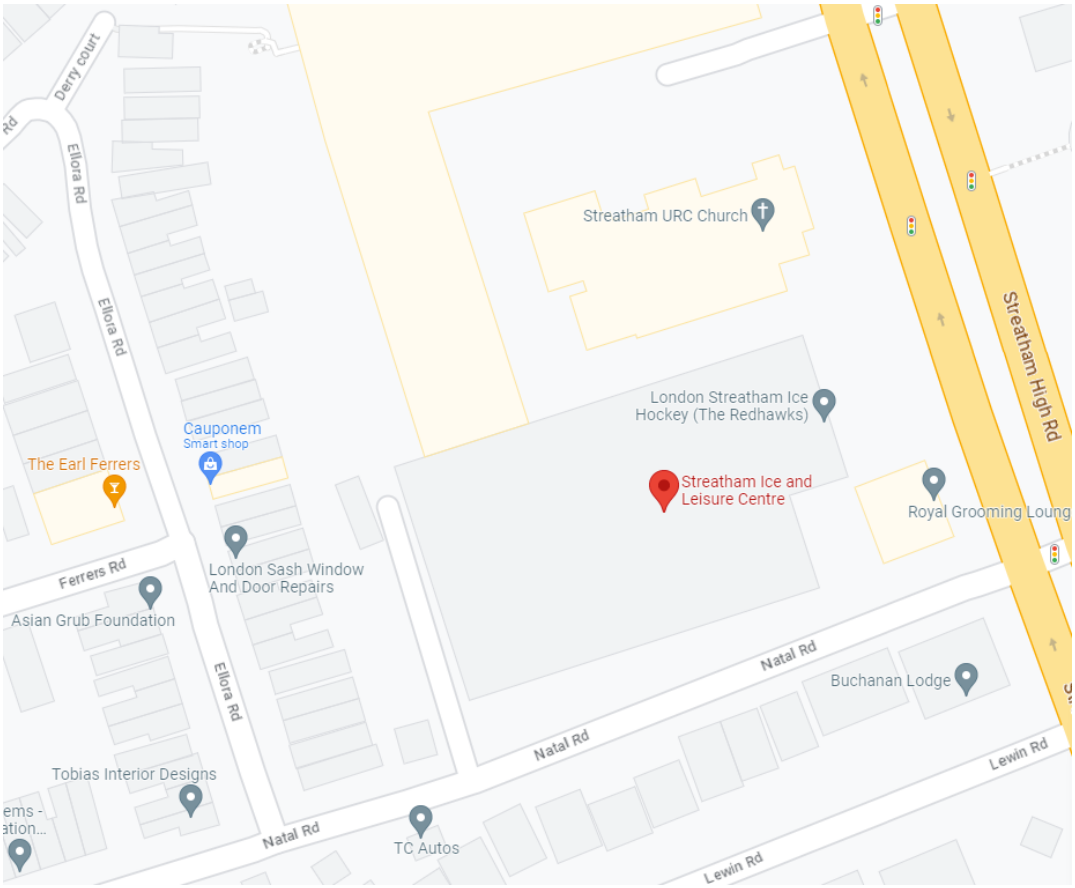
Contents:

INTRODUCTION

A structural report had been requested to find a suitable location to position 2no. ASHP's as part of the decarbonization works being carried out at Streatham Ice and Leisure Centre. The low roof facing Streatham High Road was identified as the preferred location.

The AlternativeHEAT design team had attended the site on the 16th August 2023 and carried out non-intrusive visual surveys. These surveys were aided with "as-built" record drawings located on site.

Site Location map



Proposed Roof Location

DESIGN STANDARDS

Any design calculations carried out to aid in the assessment have been carried out in accordance with the following British Standards;

1. BS6399; Part 1 - Loadings for buildings, code of practice for dead and imposed loads.
2. BS6399; Part 2 - Loadings for buildings, code of practice wind loads.
3. BS6399; Part 3 - Loadings for buildings, code of practice for imposed roof loads.
4. BS5950; Part 1 - Structural use of steelwork in building, Code of practice for design in simple and continuous construction: hot rolled sections
5. BS5950; Part 4 – Structural use of steelwork in building, Code of practice for design of composite slabs with profiled steel sheeting.
6. SCI Green Book – Simple Connections
7. SCI Green Book – Moment Connections
8. BS8110; Part 1 - Structural use of concrete, Code of practice for design and construction

DESIGN SOFTWARE

As well as using hand calculations, additional structural assessments have been undertaken using the following industry standard software;

- Masterseries.

DESIGN NOTES

Record Drawings used for the structural review can be reviewed in Appendix A.
Detailed calcs will be required when final proposed layouts are confirmed.

INSPECTIONS

The main building consists of a tapered plate girder portal frame structure with a beam and post construction to one gable. The main building roof is constructed from lightweight insulated metal panels, with the beam and post construction consisting of concrete metal deck diaphragm forming the roof and floors. The super structure is constructed from a reinforced concrete basement formed from secant pile walls and piled raft basement foundation. (The overall structural drawings can be reviewed in appendix A)

For the purposes of this report, we will carry out structural assessments via calculation to determine the impact of adding additional loads to the beam and post roof structure. As the final proposal has not been confirmed we will apply a uniform load of 4kN/m² to the entire roof structure. The 4kN/m² load is to allow for the installation of the ASHP, Bigfoot supporting frame and bases (examples in Appendix B) and any acoustic louvres that may be required (examples in Appendix C).

This assessment will identify any risks or concerns that may arise due to loading the roof structure.

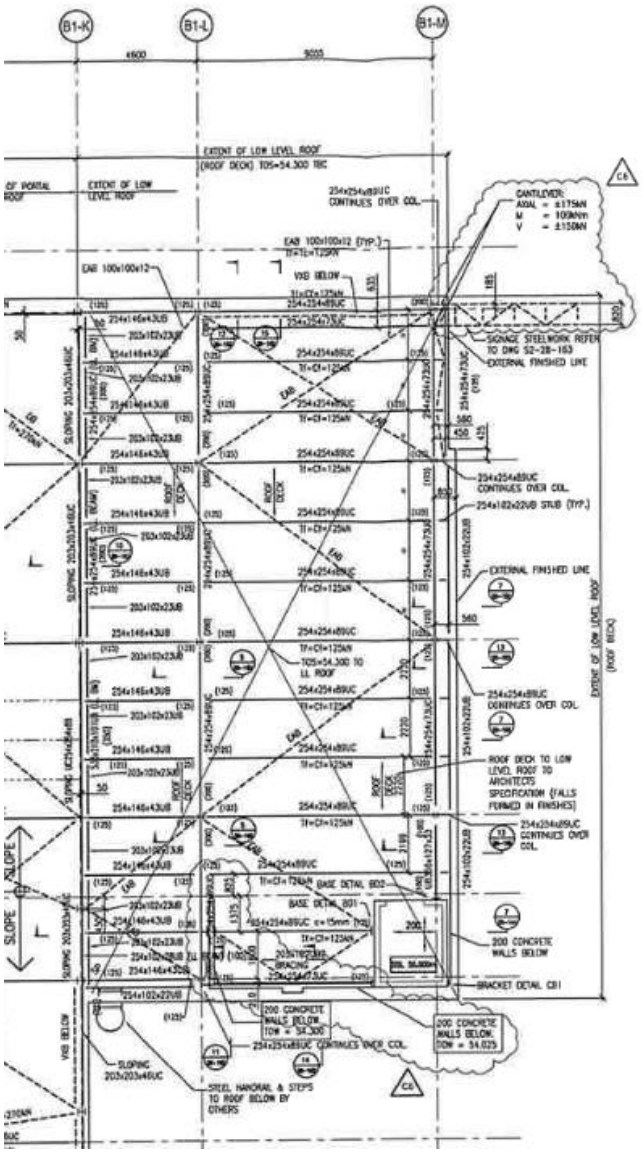
STRUCTURAL MARK UP

This scheme proposes to utilise the beam and post areas as highlighted in the extract below from the "as built" drawings.

11. LOW ROOF

LIVE LOAD (SNOW)	0.75 kN/m²
MAINTENANCE LOAD	1.5 kN/m²
ROOFING AND DECK	1.6 kN/m²
CEILING, MECHANICAL & ELECT. SERVICES	0.5 kN/m²

Design loads used for original structural design.



ASHP units proposed to be located between Gridlines (B1-K to B1-M) and Gridlines (B1-7 to B1-11)

ASHP Specification;

Dry Weight; 39.90kN

Wet Weight; 41.01kN

UP TO DATE
CHILLER SELECTION

RHOSS

User	Steve Webster (Alternative Heat)	**Date**	02/08/2023
Reference:	HP2334 Henry Fawcett PS		

SELECTION

Family	WinPOWER ECO
	THAETU 4370-6660
Model	THAETU 4410 DP1
Webcode	WPE05

The images are for reference purposes only and may not represent exactly the models or the equipment subject of this document.
The certified standard performances and the certified software tool version can be verified in www.eurovent-certification.com

Size and weight

Length	[mm]	4840
Height	[mm]	2480
Depth	[mm]	2260
Empty weight (7)	[kg]	3990
User side inlet/outlet connections	Ø	DN80 VIC

Technical features

Refrigerant: (5)		R454B
Amount of refrigerant (7)	[kg]	83
Global Warming Potential (GWP)		466
Equivalent CO_2	[ton]	38.68
Compressors		Scroll
Oil charge	[kg]	28.8

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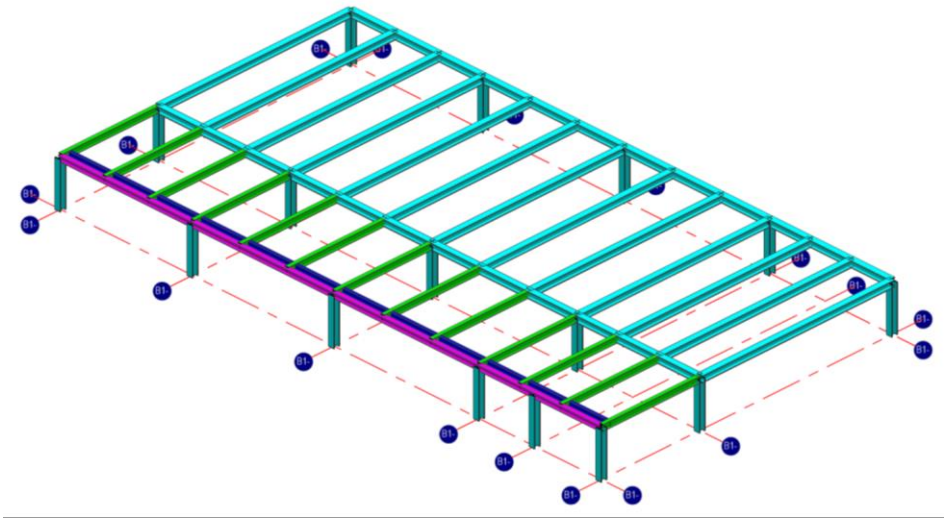
MasterFrame : Graphics



Section Size
254x146 UB 43 [S 355]
203x102 UB 23 [S 355]
254x254 UC 89 [S 355]
203x203 UC 46 [S 355]

Frame Geometry - Full Frame - X+030 Y+045 Z+000

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MASTERFRAME DATA FILE

LOADING CASES AND LOAD COMBINATION

Load Group Labels

Load Group UT	Unity Load Factor (All Cases)
Load Group D1	Dead Load
Load Group L1	Live Load

Load Case 001 : Dead plus Live (Ultimate)

Load Combination + 1.00 UT + 1.40 D1 + 1.60 L1

Load Case 002 : Live Only (Serviceability)

Load Combination + 1.00 UT + 1.00 L1

THE NODAL CO-ORDINATES

Node	X (m)	Y (m)	Z (m)	Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000	2	0.000	2.000	0.000
3	6.185	0.000	0.000	4	12.805	0.000	0.000
5	19.590	0.000	0.000	6	22.190	0.000	0.000
7	25.315	0.000	0.000	8	0.000	0.000	4.600
9	6.185	0.000	4.600	10	12.805	0.000	4.600
11	19.590	0.000	4.600	12	25.315	0.000	4.600
13	0.000	0.000	13.600	14	2.062	2.000	0.000
15	4.123	2.000	0.000	16	0.000	2.000	0.400
17	6.185	2.000	0.000	18	0.000	2.000	4.600
19	0.000	2.000	13.600	20	6.185	0.000	13.600
21	2.062	2.000	0.400	22	8.392	2.000	0.000
23	10.598	2.000	0.000	24	12.805	2.000	0.000
25	12.805	0.000	13.600	26	3.962	2.000	0.400
27	4.123	2.000	0.400	28	6.185	2.000	0.400
29	15.067	2.000	0.000	30	8.392	2.000	0.400
31	10.598	2.000	0.400	32	17.328	2.000	0.000
33	19.590	2.000	0.000	34	12.805	2.000	0.400
35	19.590	0.000	13.600	36	15.067	2.000	0.400
37	21.498	2.000	0.000	38	22.190	2.000	0.000
39	17.328	2.000	0.400	40	23.407	2.000	0.000
41	25.315	2.000	0.000	42	19.590	2.000	0.400
43	25.315	0.000	13.600	44	21.498	2.000	0.400
45	23.407	2.000	0.400	46	25.315	2.000	0.400
47	2.062	2.000	4.600	48	4.123	2.000	4.600
49	6.185	2.000	4.600	50	8.392	2.000	4.600
51	10.598	2.000	4.600	52	12.805	2.000	4.600
53	15.067	2.000	4.600	54	17.328	2.000	4.600
55	19.590	2.000	4.600	56	21.498	2.000	4.600
57	23.407	2.000	4.600	58	25.315	2.000	4.600
59	2.062	2.000	13.600	60	4.123	2.000	13.600
61	6.185	2.000	13.600	62	8.392	2.000	13.600
63	10.598	2.000	13.600	64	12.805	2.000	13.600
65	15.067	2.000	13.600	66	17.328	2.000	13.600
67	19.590	2.000	13.600	68	21.498	2.000	13.600
69	23.407	2.000	13.600	70	25.315	2.000	13.600

MEMBER PROPERTIES

Members 1-3, 5, 9-11, 15, 18-19, 22-23 & 25

M ... ... 203x203 UC 46 [S 355]

A 58.73E-4 Ix 4571E-8 Iy 1551E-8 J 22.15E-8

E 205.0E6 G 78.85E6

```
   Members 4, 8, 12-14, 16-17, 20-21, 24 & 26-28
M  ...  ...         203x102 UB 23 [S 355]
 A 29.39E-4          Ix 2106E-8          Iy 164.8E-8         J 7.02E-8
 E 205.0E6           G 78.85E6

   Members 6-7, 29-50, 56 & 78-105
M  ...  ...         254x254 UC 89 [S 355]
 A 113.3E-4          Ix 14275E-8         Iy 4864E-8          J 102.3E-8
 E 205.0E6           G 78.85E6

   Members 51-55 & 57-77
M  ...  ...         254x146 UB 43 [S 355]
 A 54.77E-4          Ix 6545E-8          Iy 678.3E-8         J 23.88E-8
 E 205.0E6           G 78.85E6
```

MEMBER LOADING

Member Self Weight Density Load Included in Load Group D1, defined by Modulus of Elasticity

E kN/mm²	Density kN/m³
>= 200.00	77.01
>= 20.00	24.00
>= 2.00	10.00

Members 1-105 - MasterFrame Pro Loads

```
   D1 D     077.010             ( kN/m³)

    Members 51-55, 57-58, 60-64, 66-72, 74-76 & 87-88
   UT Spacing 02.250 [Multiply AllLoads]
   D1 UDLY -001.600             [ kN/m ]
   D1 UDLY -000.500             [ kN/m ]
   L1 UDLY -000.750             [ kN/m ]
   L1 UDLY -001.500             [ kN/m ]

    Member 56
   UT Spacing 01.000 [Multiply AllLoads]
   D1 UDLY -001.600             [ kN/m ]
   D1 UDLY -000.500             [ kN/m ]
   L1 UDLY -000.750             [ kN/m ]
   L1 UDLY -004.000             [ kN/m ]

    Members 59 & 65
   UT Spacing 02.250 [Multiply AllLoads]
   D1 UDLY -001.600             [ kN/m ]
   D1 UDLY -000.500             [ kN/m ]
   L1 UDLY -000.750             [ kN/m ]
   L1 UDLY -004.000             [ kN/m ]

    Members 73, 77 & 89
   UT Spacing 00.950 [Multiply AllLoads]
   D1 UDLY -001.600             [ kN/m ]
   D1 UDLY -000.500             [ kN/m ]
   L1 UDLY -000.750             [ kN/m ]
   L1 UDLY -001.500             [ kN/m ]

    Members 78-79
   UT Spacing 02.000 [Multiply AllLoads]
   D1 UDLY -001.600             [ kN/m ]
   D1 UDLY -000.500             [ kN/m ]
   L1 UDLY -000.750             [ kN/m ]
   L1 UDLY -004.000             [ kN/m ]

    Members 80 & 86
   UT Spacing 02.100 [Multiply AllLoads]
   D1 UDLY -001.600             [ kN/m ]
   D1 UDLY -000.500             [ kN/m ]
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    L1 UDLY -000.750              [ kN/m ]
    L1 UDLY -004.000              [ kN/m ]

     Members 81-85
    UT Spacing 02.200 [Multiply AllLoads]
    D1 UDLY -001.600              [ kN/m ]
    D1 UDLY -000.500              [ kN/m ]
    L1 UDLY -000.750              [ kN/m ]
    L1 UDLY -004.000              [ kN/m ]
```

MEMBER ORIENTATION

Members 90-105 ß +090.00

MEMBER END RELEASES

Symbols End 1 torsion-minor-major End 2 torsion-minor-major O Released ® Fixed

6	®OO	®®®	7	®OO	®®®	30	®®®	®OO	31	®OO	®®®
33	®®®	®OO	34	®OO	®®®	36	®®®	®OO	37	®OO	®®®
39	®®®	®OO	41	®®®	®OO	42	®OO	®®®	44	®®®	®OO
45	®OO	®®®	47	®®®	®OO	48	®OO	®®®	50	®®®	®OO
51	®OO	®®®	52	®OO	®®®	53	®OO	®®®	54	®®®	®OO
55	®OO	®®®	56	®OO	®OO	57	®®®	®OO	58	®OO	®®®
59	®OO	®®®	60	®OO	®®®	61	®®®	®OO	62	®®®	®OO
63	®OO	®®®	64	®®®	®OO	65	®®®	®OO	66	®OO	®®®
67	®OO	®®®	68	®®®	®OO	69	®®®	®OO	70	®OO	®®®
71	®®®	®OO	72	®OO	®®®	73	®OO	®®®	74	®®®	®OO
75	®®®	®OO	76	®®®	®OO	77	®®®	®OO	78	®OO	®OO
79	®OO	®OO	80	®OO	®OO	81	®OO	®OO	82	®OO	®OO
83	®OO	®OO	84	®OO	®OO	85	®OO	®OO	86	®OO	®OO
87	®OO	®OO	88	®OO	®OO	89	®OO	®OO			

NODAL LOADING AND SUPPORT CONDITIONS

NODES 1, 3-13, 20, 25, 35 & 43

```
    UT Rs 1 1 1 0 1 0
```

NODES 2, 19, 41 & 70

```
    UT Rs 1 0 1 0 0 0 (Horizontally Restraint)
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	Project				Job Ref.	
alternativeHEAT Commercial Energy Solutions	Streatham Ice and Leisure Centre				Lambeth - Streatham	
	Section				Sheet no./rev.	
	Structural Report				P01	
	Calc. by	Date	Chk'd by	Date	App'd by	Date
	RMCM	Aug '23	RMCM	Aug '23	RMCM	Aug '23

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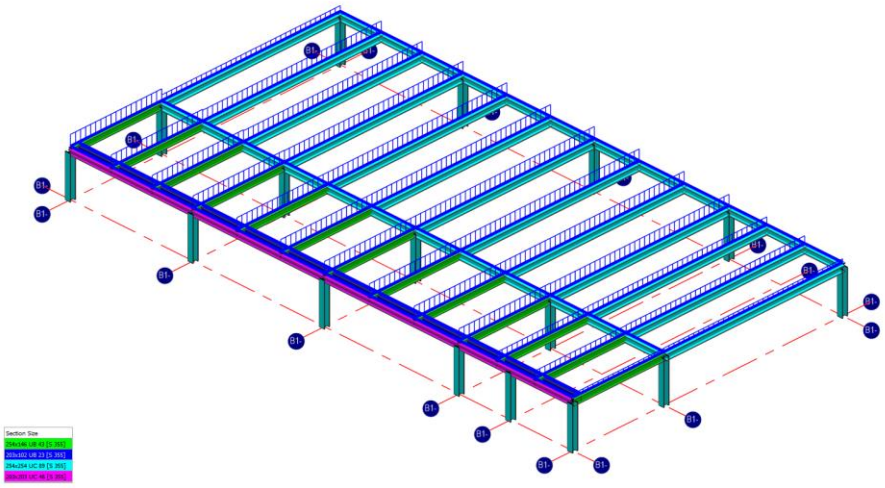

Load Diagram - 001 : Dead plus Live (Ultimate) - All Groups
Frame Geometry - Full Frame - X+030 Y+045 Z+000

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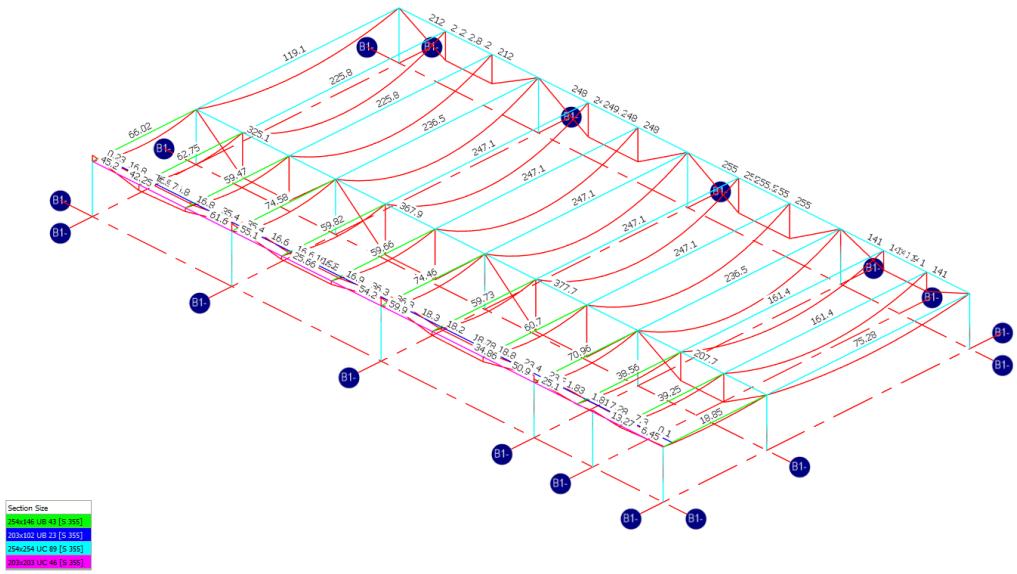
MasterFrame : Graphics



Load Case 001 : Dead plus Live (Ultimate)
Bending Moment Diagram (Major Axis) - Full Frame - X+030 Y+045 Z+000
Bending Moment Values (kN.m)
200 kN.m = 1m

	Project				Job Ref.	
alternativeHEAT Commercial Energy Solutions	Streatham Ice and Leisure Centre				Lambeth - Streatham	
	Section				Sheet no./rev.	
	Structural Report				P01	
	Calc. by	Date	Chk'd by	Date	App'd by	Date
	RMCM	Aug '23	RMCM	Aug '23	RMCM	Aug '23

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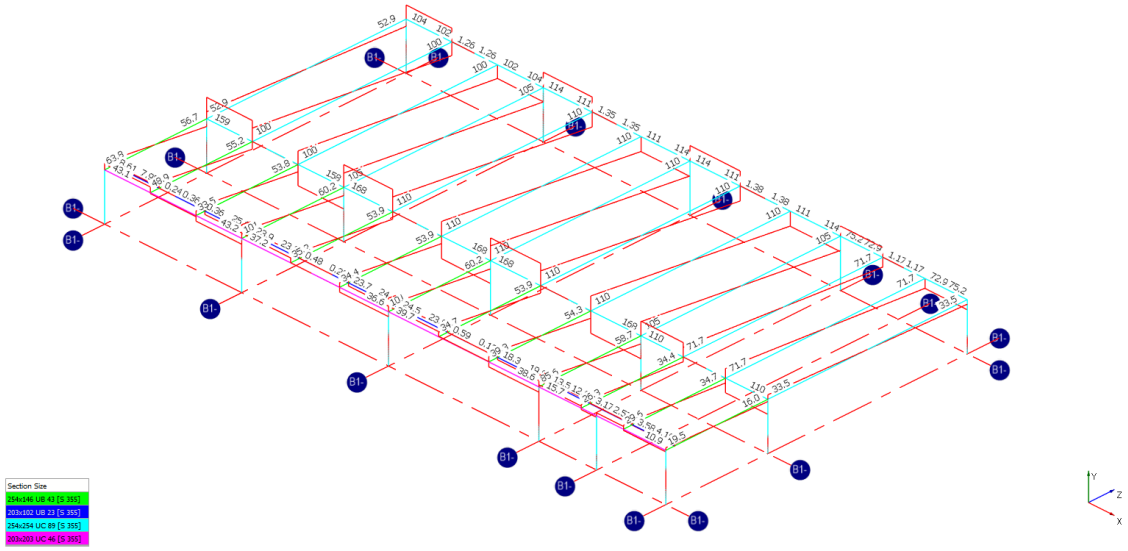

Load Case 001 : Dead plus Live (Ultimate)
Shear Force Diagram (Major Axis) - Full Frame - X+030 Y+045 Z+000
Shear Force Values (kN)
200 kN = 1m

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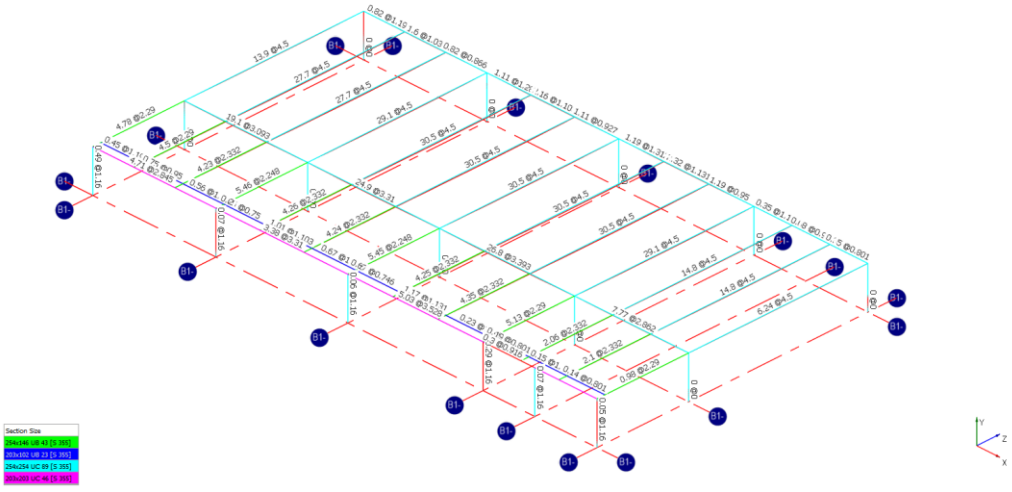
MasterFrame : Graphics



Load Case 002 : Live Only (Serviceability)
Deflected Shape - Full Frame - X+030 Y+045 Z+000
Member Deflection (mm)
1 Magnification

	Project				Job Ref.	
alternativeHEAT Commercial Energy Solutions	Streatham Ice and Leisure Centre				Lambeth - Streatham	
	Section				Sheet no./rev.	
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	Calc. by	Date	Chk'd by	Date	App'd by	Date
	RMCM	Aug '23	RMCM	Aug '23	RMCM	Aug '23

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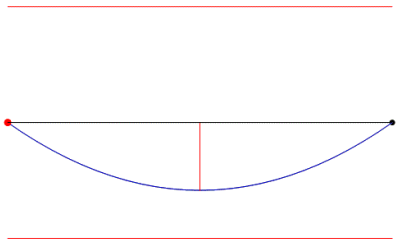
AXIAL WITH MOMENTS (BEAM 1)

Member SB B1-8-B1-9\B1-L-B1-ML1Id 51 @ Level 1 in Load Case 1

Member Loading and Member Forces

```
Loading Combination : 1 UT + 1.4 D1 + 1.6 L1

D1 D     077.010              ( kN/m³)
UT Spacing 02.200 [Multiply AllLoads]
D1 UDLY -001.600              [ kN/m ]
D1 UDLY -000.500              [ kN/m ]
L1 UDLY -000.750              [ kN/m ]
L1 UDLY -004.000              [ kN/m ]
```



Member Forces in Load Case 1 and Maximum Deflection from Load Case 2

Member No.	Node End1 End2	Axial Force (kN)	Torque Moment (kN.m)	Shear Force (kN)		Bending Moment (kN.m)		Maximum Moment (kN.m @ m)		Maximum Deflection (mm @ m)
				x-x	y-y	x-x	y-y	x-x	y-y	
82	51	0.00C	0.04	109.84	0.00	0.00	0.00	247.15	0.00	30.50
	63	0.00C	-0.04	-109.84	0.00	0.00	0.00	@ 4.500	@ 0.000	@ 4.500

Classification and Properties (BS 5950: 2000)

Section (88.95 kg/m)	254x254 UC 89 [S 355]		
Class = Fn(b/T,d/t,py,F,Mx,My)	7.41, 19.45, 345, 0, 247.14, 0	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1		

Shear Capacity Check

Fvx/Pvx	109.848 / 554.986 =	0.198	OK

Local Capacity Check

Fvx/Pvx	0.003 / 554.986 =	0	Low Shear
Mcx = py.Sxx≤1.2 py.Zxx	345 x 1223.9≤1.2 x 345 x 1096.79 =	422.246 kN.m	
Pz = Ag.py	113.31 x 345 =	3909.195 kN	
n = F/Pz	0.003 / 3909.195 =	0.000	OK
Srx = Fn(Sxx, n)	1223.9, 0	1223.9 cm³	
Mrx = Srx.py	1223.9 x 345	422.246 kN.m	
$(Mx/Mrx)^{Z1}+(My/Mry)^{Z2}$	$(247.14/422.246)^2+(0)^1$=	0.343	OK

Compression Resistance Pc

λx = Lex/rxx	100x1x9/11.22 =	80.2	OK
Pcx = Area.pcx	113.31x207.137/10 =	2347.066 kN	Table 24 b
λy = Ley/ryy	100x1x9/6.55 =	137.4	OK
Pcy = Area.pcy	113.31x84/10 =	951.847 kN	Table 24 c

Equivalent Uniform Moment Factors mLT, mx, my and myx

$m_{LT}=0.2+(.15M_2+.5M_3+.15M_4)/M_{max}$	0.2+(.15x185+.5x247+.15x185)/247 = 0.44	0.925	Table 18
$m_y=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 = .8x0/0	1	Table 26
$m_x=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x185+.6x247+.1x185)/247 = .8x247/247	0.95	Table 26
$m_{yx}=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 = .8x0/0	1	Table 26

Lateral Buckling Check Mb

Le = 1.00 L	1 x 9 =	9 m	
λ = Le/ryy	9 / 6.55	137.4	OK
v = Fn (x,Le,ryy,λ)	14.512, 9, 6.55, 137.4	0.654	Table 19
λ_{LT}= u.v.λ.√βw	0.85 x 0.654 x 137.4 √ 1	76.33	
pb = Fn (py,λ_{LT})	345, 76.33	197.87 N/mm²	Table 16
Mb = Sxx.pb ≤ Mc	1223.9 x 197.87 ≤ 422.246 =	242.178 kN.m	

Combined Axial Compression and Bending to Annex I

$r_b=m_{LT}.M_{LT}/M_b$	0.925x247.1/242.2	0.944	
$r_c=F_c/P_{cy}$	0/951.8	0.000	
$\lambda_r=(r_b\lambda_{LT}+r_c\lambda_y)/(r_b+r_c)$	(0.944•76.3+0•137.4)/(0.944+0)	76.329	
$\lambda_{ro}=17.15\ \varepsilon\ (2r_b+r_c)/(r_b+r_c)$	17.15•0.893(2•0.944+0)/(0.944+0)	30.623	

$M_{ob}= M_b(1-F_c/P_{cy})$	242.178(1-0/951.8)		242.177	
$M_{xy}= M_{cx}(1-F_c/ P_{cy})^{½}$	422.246(1-0/951.8)^{½}		422.245	
$M_{ox}= M_{cx}(1-F_c/P_{cx})/(1+0.5F_c/P_{cx})$	422.246(1-0/2347.1)/(1+0.5•0/2347.1)		422.245	
$M_{oy}= M_{cy}(1-F_c/P_{cy})/(1+k_y(F_c/P_{cy}))$	157.150(1-0/951.8)/(1+1.0(0/951.8))		157.149	
M_{ab}=fn(λ_r, λ_{ro}, ε, M_{xy}, M_{ob})	76.329, 30.623, 0.893, 422.245, 242.177		243.249	
M_{ax}=fn(λ_x, ε, M_{rx}, M_{ox})	80.214, 0.893, 422.246, 422.245		422.245	
M_{ay}=fn(λ_y, ε, M_{ry}, M_{oy})	137.405, 0.893, 157.150, 157.149		157.149	
$m_x.M_x/M_{ax}$	0.95x247.1/422.2		0.556	OK
$m_{LT}.M_{LT}/M_{ab}$	0.925x247.1/243.2		0.940	OK
$m_x.M_x/M_{ax}$	0.95x247.1/422.2		0.556	OK
Compare with Simplied to 4.8.3.3	0.62, 0.944, 0.944		0.944	
Compare with MoreExact to 4.8.3.3	0.557, 0.944, 0.541		0.944	

Deflection Check - Load Case 2

In-span δ ≤ Span/290	30.5 ≤ 9000 / 290	30.5 mm	OK

alternativeHEAT Commercial Energy Solutions	Project: Streatham Ice and Leisure Centre				Job Ref.: Lambeth - Streatham	
	Section: Structural Report				Sheet no./rev.: P01	
	Calc. by: RMCM	Date: Aug '23	Chk'd by: RMCM	Date: Aug '23	App'd by: RMCM	Date: Aug '23

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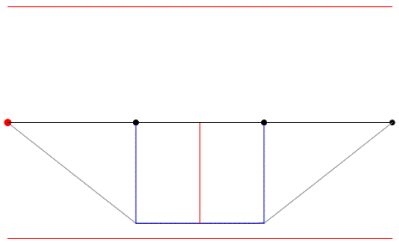
AXIAL WITH MOMENTS (BEAM 2)
Member SB B1-L\B1-9-B1-8L1Id 19 @ Level 1
Between 2.207 and 4.413 m, in Load Case 1

Member Loading and Member Forces

```
Loading Combination : 1 UT + 1.4 D1 + 1.6 L1

D1 D      077.010              ( kN/m³)
```



Member Forces in Load Case 1 and Maximum Deflection from Load Case 2										
Member No.	Node End1 End2	Axial Force (kN)	Torque Moment (kN.m)	Shear Force (kN)		Bending Moment (kN.m)		Maximum Moment (kN.m @ m)		Maximum Deflection (mm @ m)
				x-x	y-y	x-x	y-y	x-x	y-y	
-	49	0.00C	0.00	167.79	0.00	0.00	0.00	367.92	-0.01	24.88
	52	0.00C	0.00	-167.76	0.00	0.00	0.00	@ 3.266	@ 2.163	@ 3.310

Classification and Properties (BS 5950: 2000)

Section (88.95 kg/m)	254x254 UC 89 [S 355]		
Class = Fn(b/T,d/t,py,F,Mx,My)	7.41, 19.45, 345, 0, 367.92, 0.01	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1		

Shear Capacity Check

Fvx/Pvx	1.371 / 554.986 =	0.002	OK

Local Capacity Check

Fvx/Pvx	0.023 / 554.986 =	0	Low Shear
Mcx = py.Sxx≤1.2 py.Zxx	345 x 1223.9≤1.2 x 345 x 1096.79 =	422.246 kN.m	
Fvy/Pvy	0 / 1652.104 =	0	Low Shear
Mcy = py.Syy≤1.2 py.Zyy	345 x 575.3≤1.2 x 345 x 379.59 =	157.15 kN.m	
Pz = Ag.py	113.31 x 345 =	3909.195 kN	
n = F/Pz	0.004 / 3909.195 =	0.000	OK
Srx = Fn(Sxx, n)	1223.9, 0	1223.9 cm³	
Mrx = Srx.py	1223.9 x 345	422.246 kN.m	
Sry = Fn(Syy, n)	575.3, 0	575.3 cm³	
Mry = Sry.py	575.3 x 345	157.15 kN.m	
$(Mx/Mrx)^{Z1}+(My/Mry)^{Z2}$	$(367.916/422.246)^2+(0.007/157.15)^1$=	0.759	OK

Compression Resistance Pc

λx = Lex/rxx	100x1x6.62/11.22 =	59	OK
Pcx = Area.pcx	113.31x268.628/10 =	3043.821 kN	Table 24 b
λy = Ley/ryy	100x1x2.206/6.55 =	33.7	OK
Pcy = Area.pcy	113.31x307.48/10 =	3484.024 kN	Table 24 c

Equivalent Uniform Moment Factors mLT, mx, my and myx

$m_{LT}=0.2+(.15M_2+.5M_3+.15M_4)/M_{max}$	0.2+(.15x368+.5x368+.15x368)/368 = 0.44	1	Table 18
$m_y=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 = .8x0/0	0.925	Table 26
$m_x=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x276+.6x368+.1x276)/368 = .8x368/368	0.95	Table 26
$m_{yx}=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 = .8x0/0	0.8	Table 26

Lateral Buckling Check Mb

Le = 1.00 L	1 x 2.206 =	2.206 m	
λ = Le/ryy	2.206 / 6.55	33.68	OK
v = Fn (x,Le,ryy,λ)	14.512, 2.206, 6.55, 33.68	0.942	Table 19
λ_{LT}= u.v.λ.√β_W	0.85 x 0.942 x 33.68 √ 1	26.97	
pb = Fn (py,λ_{LT})	345, 26.97	345 N/mm²	Table 16
Mb = Sxx.pb ≤ Mc	1223.9 x 345 ≤ 422.246 =	422.246 kN.m	

Simplified Approach

py.Zx	345x1096.79	378.393 kN.m	
py.Zy	345x379.59	130.959 kN.m	
F/Pc+mx.Mx/py.Zx+my.My/py.Zy	0.004/3043.821+0.95x367.9/378.4+0.925x0/131	0.924	OK
F/Pcy+m_{LT}.M_{LT}/Mb+my.My/py.Zy	0.004/3484.024+1x367.9/422.2+0.925x0/131	0.871	OK

More Exact Approach

Max=Mcx/(1+.5F/Pcx)	422.2/(1+.5x0/3043.8)	422.245 kN.m	
May=Mcy/(1+F/Pcy)	157.2/(1+0/3484)	157.15 kN.m	
F/Pcx+mx.Mx/Max+.5myx.My/Mcy	0/3043.8+0.95x367.9/422.2+.5x0.8x0/157.2	0.828	OK
F/Pcy+m_{LT}.M_{LT}/Mb+my.My/May	0/3484+1x367.9/422.2+0.925x0/157.2	0.871	OK
Max=Mcx(1-F/Pcx)/(1+.5F/Pcx)	422.2(1-0/3043.8)/(1+.5x0/3043.8)	422.245 kN.m	
May=Mcy(1-F/Pcy)/(1+F/Pcy)	157.2(1-0/3484)/(1+0/3484)	157.15 kN.m	
m.Mx/Max+m.My/May	0.95x367.916/422.245+0.925x0.007/157.15	0.871	OK

Deflection Check - Load Case 2

In-span δ ≤ Span/250	24.88 ≤ 6620 / 250	24.88 mm	OK

	Project				Job Ref.	
alternativeHEAT Commercial Energy Solutions	Streatham Ice and Leisure Centre				Lambeth - Streatham	
	Section				Sheet no./rev.	
	Structural Report				P01	
	Calc. by	Date	Chk'd by	Date	App'd by	Date
	RMCM	Aug '23	RMCM	Aug '23	RMCM	Aug '23

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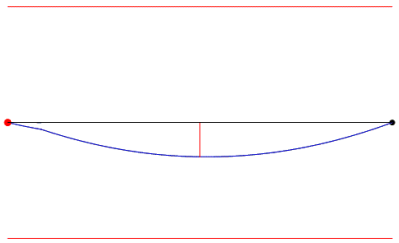
AXIAL WITH MOMENTS (BEAM 3)

Member SB B1-8-B1-9\B1-K-B1-LL1Id 39 @ Level 1 in Load Case 1

Member Loading and Member Forces

```
Loading Combination : 1 UT + 1.4 D1 + 1.6 L1

D1 D     077.010              ( kN/m³)
UT Spacing 02.250 [Multiply AllLoads]
D1 UDLY -001.600              [ kN/m ]
D1 UDLY -000.500              [ kN/m ]
L1 UDLY -000.750              [ kN/m ]
L1 UDLY -004.000              [ kN/m ]
```



Member Forces in Load Case 1 and Maximum Deflection from Load Case 2										
Member No.	Node End1 End2	Axial Force (kN)	Torque Moment (kN.m)	Shear Force (kN)		Bending Moment (kN.m)		Maximum Moment (kN.m @ m)		Maximum Deflection (mm @ m)
				x-x	y-y	x-x	y-y	x-x	y-y	
-	23	0.01C	-0.06	34.44	0.01	0.00	0.00	59.66	0.00	4.24
	51	0.01C	0.04	-53.85	0.00	0.00	0.00	@ 2.374	@ 0.000	@ 2.332

Classification and Properties (BS 5950: 2000)

Section (42.99 kg/m)	254x146 UB 43 [S 355]		
Class = Fn(b/T,d/t,py,F,Mx,My)	5.8, 30.42, 355, 0.01, 59.65, 0	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1		

Shear Capacity Check

Fvx/Pvx	53.855 / 398.123 =	0.135	OK

Local Capacity Check

Fvx/Pvx	2.052 / 398.123 =	0.005	Low Shear
Mcx = py.Sxx≤1.2 py.Zxx	355 x 566.3≤1.2 x 355 x 504.21 =	201.037 kN.m	
Fvy/Pvy	0.001 / 717.23 =	0	Low Shear
Mcy = py.Syy≤1.2 py.Zyy	355 x 141.1≤1.2 x 355 x 92.1 =	39.235 kN.m	
Pz = Ag.py	54.77 x 355 =	1944.335 kN	
n = F/Pz	0.007 / 1944.335 =	0.000	OK
Srx = Fn(Sxx, n)	566.3, 0	566.3 cm³	
Mrx = Srx.py	566.3 x 355	201.037 kN.m	
Sry = Fn(Syy, n)	141.1, 0	141.1 cm³	
Mry = Sry.py	141.1 x 355	39.235 kN.m	
$(Mx/Mrx)^{Z1}+(My/Mry)^{Z2}$	$(59.573/201.037)^{2}+(0.002/39.235)^{1}$=	0.088	OK

Compression Resistance Pc

λx = Lex/rxx	100x1x4.6/10.93 =	42.1	OK
Pcx = Area.pcx	54.77x329.957/10 =	1807.174 kN	Table 24 a
λy = Ley/ryy	100x1x4.6/3.52 =	130.7	OK
Pcy = Area.pcy	54.77x99.75/10 =	546.306 kN	Table 24 b

Equivalent Uniform Moment Factors mLT, mx, my and myx

$m_{LT}=0.2+(.15M_2+.5M_3+.15M_4)/M_{max}$	0.2+(.15x41+.5x60+.15x46)/60 = 0.44	0.918	Table 18
$m_y=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 = .8x0/0	0.95	Table 26
$m_x=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x41+.6x60+.1x46)/60 = .8x60/60	0.945	Table 26
$m_{yx}=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 = .8x0/0	0.533	Table 26

Lateral Buckling Check Mb

Le = 1.00 L	1 x 4.6 =	4.6 m	
λ = Le/ryy	4.6 / 3.52	130.68	OK
v = Fn (x,Le,ryy,λ)	21.216, 4.6, 3.52, 130.68	0.766	Table 19
λ_{LT}= u.v.λ.√βw	0.891 x 0.766 x 130.68 √ 1	89.26	
pb = Fn (py,λ_{LT})	355, 89.26	163.91 N/mm²	Table 16
Mb = Sxx.pb ≤ Mc	566.3 x 163.91 ≤ 201.037 =	92.821 kN.m	

Simplified Approach

py.Zx	355x504.21	178.995 kN.m	
py.Zy	355x92.1	32.696 kN.m	

F/Pc+mx.Mx/py.Zx+my.My/py.Zy	0.007/546.306+0.945x59.7/179+0.95x0/32.7	0.315	OK
F/Pcy+m_{LT}.M_{LT}/Mb+my.My/py.Zy	0.007/546.306+0.918x59.6/92.8+0.95x0/32.7	0.589	OK

More Exact Approach

Max=Mcx/(1+.5F/Pcx)	201/(1+.5x0/1807.2)	201.036 kN.m	
May=Mcy/(1+F/Pcy)	39.2/(1+0/546.3)	39.234 kN.m	
F/Pcx+mx.Mx/Max+.5myx.My/Mcy	0/1807.2+0.945x59.7/201+.5x0.533x0/39.2	0.280	OK
F/Pcy+m_{LT}.M_{LT}/Mb+my.My/May	0/546.3+0.918x59.6/92.8+0.95x0/39.2	0.589	OK
Max=Mcx(1-F/Pcx)/(1+.5F/Pcx)	201(1-0/1807.2)/(1+.5x0/1807.2)	201.035 kN.m	
May=Mcy(1-F/Pcy)/(1+F/Pcy)	39.2(1-0/546.3)/(1+0/546.3)	39.234 kN.m	
m.Mx/Max+m.My/May	0.945x59.573/201.035+0.95x0.002/39.234	0.272	OK

Deflection Check - Load Case 2

In-span δ ≤ Span/360	4.24 ≤ 4600 / 360	4.24 mm	OK

RESULTS / CONCLUSION

The structural calculations confirm that the roof structure is a suitable area to position the 2no. ASHP.
The main steel members are within their structural capacities; however, the limiting deflections are close to those allowed by building regulations so a final detailed calculation and load take down should be carried out to confirm exact lay out prior to construction works being undertaken.

APPENDIX A

APPENDIX B

APPENDIX C