| ♦ David Smith Associates LLP ♦<br>8 Duncan Close ♦ Moulton Park ♦ Northampton NN3 6WL<br>Tel: (01604) 782620 ♦ Fax: (01604) 782629<br>E-mail: post@dsagroup.co.uk | Project No: | 24/54720 | Sheet No: | 53 |
|---|---|---|---|---|
| | Made By: | OAM | Revision: | |
| | Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

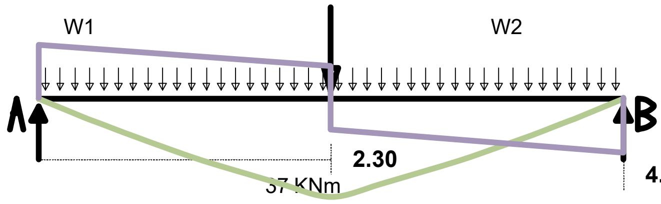
**H rolled section** S355

**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **FB2.04**

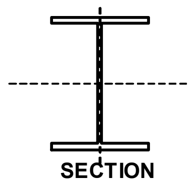
Loads are unfactored

| | | |
|---|---|---|
| Wd1= | **0.60** | KN/m2 |
| Wl1= | **1.50** | KN/m2 |
| Wd2= | **0.60** | KN/m2 |
| wl2= | **1.50** | KN/m2 |
| P1= | **16.00** | KN |
| a= | **2.30** | m |
| Span= | **4.60** | m |
| Cover= | **1.00** | m |




| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | **16.00** KN | **24** KN |
| **AV-Dead+s/w=** | 0.90 KN/m' | 1.26 KN/m' |
| **Live=** | 1.50 KN/m' | 2.4 KN/m' |
| | 2.4 KN/m' | 3.66 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6




**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 13.5 KN | **20.4** KN |
| RB= | 13.5 KN | **20.4** KN |
| Shear zero at | X= | 2.30 m |

Maximum Bending Moment **Mx =** **37** KNm

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 32.4 KNm | Local capacity | PASS | 0.396 |
| Maximum BM about axis Y | MY= | 3.24 KNm | Overall buckling 1 | PASS | 0.471 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | PASS | 0.627 |
| Shear force in x axis | Fv= | 20.4 KN | Deflection (dead)= | PASS | 1/ 1739 |
| Beam span | L= | 4.60 m | Deflection(live)= | PASS | 1/ 695 |
| Effective length about axis X | LX eff= | 4.60 m | Deflection (d+l)= | PASS | 1/ 496 |
| Effective length about axis Y | LYeff= | 2.74 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 105 cm3 | | | |

**Section properties**

Section size (Ref. No= **66** ) **203x133 30 kg UB S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 206.8 mm | | |
| Width of section | B= | 133.8 mm | | |
| Thickness of web | t= | 6.3 mm | Mcx= | 111.22 KNm |
| Thickness of flange | T= | 9.6 mm | Mcy= | 31.258 KNm |
| Root radius | r= | 9.6 mm | Mb L= | 69.553 KNm |
| Second moment of area x-x | Ix= | 2887 cm4 | Mlt= | **0.869** TABLE 18 |
| Second moment of area y-y | Iy= | 384 cm4 | | |
| Plastic modulus x-x | Sx= | 313.3 cm3 | Sx eff= | 273.81 cm3 |
| Plastic modulus y-y | Sy= | 88.05 cm3 | Sy eff= | 52.45 cm3 |
| Area of section | Ag= | 38 cm2 | An= | 34.55 cm2 ke= 1.1 |

**DEFLECTION**

| | | | unfactored |
|---|---|---|---|
| Unfactored dead load deflection= | 2.64 mm | E UDL= | 2.68 KN/m' |
| Unfactored live load deflection= | **6.61** mm | E UDL= | 6.71 KN/m' |
| Unfactored dead+ live load def = | 9.26 mm | E UDL= | 9.40 KN/m' |
| Span/def. ratio for dead load= | 1739 | | |
| Span/def. ratio for live load= | **696** | **>360** | |
| Span/def. ratio fordead+ live load= | 497 | | |

CONTINUE OF FB2.04

**Strength of steel** Clause 3.1.1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Design strength | **(Grade S 355 )** | | | | | | |
| for thickness of | 9.6 mm | **py=** | **355** N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 66.9 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 6.97 | b/Tlim= | 7.92 | 8.80 | 13.20 |

**The section is class1 plastic**

| | | | | | | |
|---|---|---|---|---|---|---|
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.26 | r2=Fc/(Agxpyw)= | 0.0007 | | |
| Depth between fillets | d= | 172.3 mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 27.35 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.206 | d/tlim= | 55.90 | 63.35 | 105.46 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 1302.8 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 278 KN | | |
| Shear force | | Fvy= | 20.4 KN | Fvy/Pvy= 0.07 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 279.3 cm3 | Mcx1= | 99.152 |
| Plastic modulus | Sx= | 313 cm3 | Mcx2= | 111.22 |
| Moment capacity for section | Mcx= | **111.2** KNm | | |
| Elastic modulus | Zy= | 57.4 cm3 | Mcy1= | 20.377 |
| Plastic modulus | Sy= | 88.1 cm3 | mcy2= | 31.258 |
| Moment capacity for section | Mcy= | **31.3** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\ py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.001 + 0.291 + 0.104 = **0.396** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 4600 mm | normal condition |
| Effective length | Lelt2= | 2736.8 mm | |
| | L e lt= | 3668.4 mm | |
| Radius of gyration y-y | ry= | 3.18 cm | |
| | rx= | 8.72 cm | |
| | Lam'y= | 86.1 | |
| | La'mx= | 52.8 | |

CONTINUE OF FB2.04

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for H section | | | | |
| | a= | 5.5 | | |
| Perry factor | eta= | 0.39 | | |
| Euler strength | pe= | 273 N/mm2 | | |
| Factor | phi= | 367 N/mm2 | | |
| Compressive strength | pcy= | **172.4** N/mm2 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lam'y= | 86.1 | La'mx= | 52.75 | | | Lamy/x= | 4.00293 |
| Slenderness of section | Lamda= | 86.1 | | | | | Lamx/x= | 2.4536 |
| Torsional index | x= | 21.5 | | | | | | |
| | N= | 0.5 | | | | | | |
| Slenderness factor | v= | 0.86 from Table 19 | | | | | | |
| | β w = | 1.0 | | | | | | |
| Buckling parameter | u= | 0.882 | | | | | | |
| Equivalent slenderness | lamlt= | 65.3 | | | | | | |
| Buckling strength (Table 16) | pb= | 222 N/mm2 | | for lamlt= | 70 | | py= | 355 |
| Buckling resisrance moment | Mb= | 69.6 KNm | | | | | | |
| | Mb L= | 69.6 KNm | | | | | | |
| | Mry= | 31.3 KNm | | | | | | |
| | Pc= | 655.3 KN | | | | | | |
| | Pcy= | 655.3 KN | | | | | | |

$$\frac{Fc}{PC} + W_x \frac{Mx}{Py\,Zx} + W_y \frac{My}{py\,Zy} = \le 1$$

W x= 0.95
W y= 1

0.002 + 0.311 + 0.159 = **0.471** **The interaction formula is satisfied**

$$\frac{Fc}{Pcy} + W_{LT} \frac{M\,lt}{Mb} + W_y \frac{My}{py\,Zy} = \le 1$$

0.002 + 0.466 + 0.159 = **0.627** **The interaction formula is satisfied**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

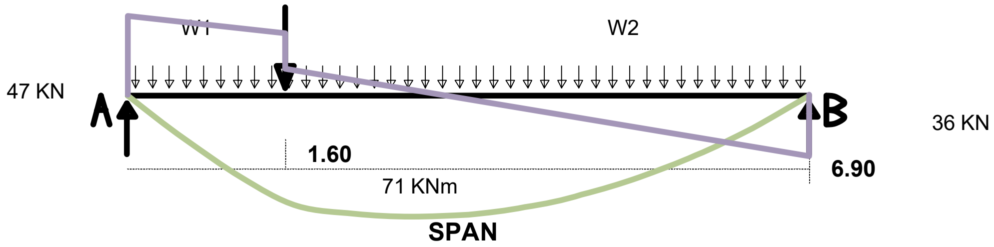
**H rolled section** S355

LOCATION= **FB2.05**

**Calculation in accordance with BS 5950: 1: 2000**

Loads are unfactored

| | | |
|---|---|---|
| Wd1= | **0.60** | KN/m2 |
| Wl1= | **1.50** | KN/m2 |
| Wd2= | **0.60** | KN/m2 |
| wl2= | **1.50** | KN/m2 |
| P1= | **14.00** | KN |
| a= | **1.60** | m |
| Span= | **6.90** | m |
| Cover= | **2.50** | m |

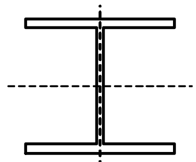



| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | **14.00** KN | **21** KN |
| **AV-Dead+s/w=** | 2.10 KN/m' | 2.94 KN/m' |
| **Live=** | 3.75 KN/m' | 6 KN/m' |
| | 5.85 KN/m' | 8.94 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | | |
|---|---|---|
| RA= | 30.9 KN | **47.0** KN |
| RB= | 23.4 KN | **35.7** KN |
| Shear zero at | X= | 2.91 m |
| Maximum Bending Moment | **Mx =** | **71** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 66.3 KNm | Local capacity | **PASS** | 0.348 |
| Maximum BM about axis Y | MY= | 6.63 KNm | Overall buckling 1 | **PASS** | 0.400 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | **PASS** | 0.553 |
| Shear force in x axis | Fv= | 47.0 KN | Deflection (dead)= | **PASS** | 1/ 1278 |
| Beam span | L= | 6.90 m | Deflection(live)= | **PASS** | 1/ 511 |
| Effective length about axis X | LX eff= | 6.90 m | Deflection (d+l)= | **PASS** | 1/ 365 |
| Effective length about axis Y | LYeff= | 6.04 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 201 cm3 | | | |

**Section properties**

Section size (Ref. No= **97** ) **203x203 60 kg UC S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 209.6 mm | | |
| Width of section | B= | 205.2 mm | | |
| Thickness of web | t= | 9.3 mm | Mcx= | 231.46 KNm |
| Thickness of flange | T= | 14.2 mm | Mcy= | 107.53 KNm |
| Root radius | r= | 14.2 mm | Mb L= | 144.74 KNm |
| Second moment of area x-x | Ix= | 6088 cm4 | Mlt= | **0.929** TABLE 18 |
| Second moment of area y-y | Iy= | 2041 cm4 | | |
| Plastic modulus x-x | Sx= | 652 cm3 | Sx eff= | 570.67 cm3 |
| Plastic modulus y-y | Sy= | 302.9 cm3 | Sy eff= | 183.71 cm3 |
| Area of section | Ag= | 75.8 cm2 | An= | 68.91 cm2 ke= 1.1 |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 5.40 mm | | E UDL= | 2.28 KN/m' |
| Unfactored live load deflection= | 13.50 mm | | E UDL= | 5.71 KN/m' |
| Unfactored dead+ live load def = | 18.90 mm | | E UDL= | 7.99 KN/m' |
| Span/def. ratio for dead load= | 1278 | | | |
| Span/def. ratio for live load= | **511** | **>360** | | |
| Span/def. ratio fordead+ live load= | 365 | | | |

CONTINUE OF FB2.05

**Strength of steel** Clause 3.1.1
Design strength **(Grade S 355 )**
for thickness of 14.2 mm **py=** **355** N/mm2 py= **355.0** N/mm2 pyw= py
Young's Modulus **E=** 205 KN/mm2

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section
Constant ε = 0.880 class 1 class 2 class 3
Outstand of flange b= 102.6 mm plastic compac semi compact
Ratio b/T= 7.23 b/Tlim= 7.92 8.80 13.20
**The section is class1 plastic**
r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.19 r2=Fc/(Agxpyw)= 0.0004
Depth between fillets d= 160.8 mm TABLE 11 rolled section
ratio d/t= 17.29 class 1 class 2 class 3
40 ε = 35.206 d/tlim= 59.25 68.62 105.54
The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3
Shear area Av y= 1949.3 mm2 (t x D)
Shear capacity (0.6pyA) Pvy= 415 KN
Shear force Fvy= 47.0 KN Fvy/Pvy= 0.11 **SHEAR PASS OK**

**Moment Capacity**
Elastic modulus Zx= 581.1 cm3 Mcx1= 206.29
Plastic modulus Sx= 652 cm3 Mcx2= 231.46
Moment capacity for section Mcx= **231.5** KNm

Elastic modulus Zy= 199 cm3 Mcy1= 70.645
Plastic modulus Sy= 302.9 cm3 mcy2= 107.53
Moment capacity for section Mcy= **107.5** KNm

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.000 + 0.286 + 0.062 = **0.348** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13
Effective length Le lt1= 6900 mm normal condition
Effective length Lelt2= 6039.6 mm
L e lt= 6469.8 mm

Radius of gyration y-y ry= 5.19 cm
rx= 8.96 cm
Lam'y= 116.4
La'mx= 77.0

CONTINUE OF FB2.05

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | | 30.20 TABLE 16 |
| Robertson constant for H section | | | | | |
| | a= | 5.5 | | | |
| Perry factor | eta= | 0.56 | | | |
| Euler strength | pe= | 149 N/mm2 | | | |
| Factor | phi= | 294 N/mm2 | | | |
| Compressive strength | pcy= | **111.4** N/mm2 | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 116.4 | La'mx= | 77.01 | | Lamy/x= | 8.25319 |
| Slenderness of section | Lamda= | 116.4 | | | | Lamx/x= | 5.46163 |
| Torsional index | x= | 14.1 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.7 from Table 19 | | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.847 | | | | | |
| Equivalent slenderness | lamlt= | 69.0 | | | | | |
| Buckling strength (Table 16) | pb= | 222 N/mm2 | | for lamlt= | 70 | py= | 355 |
| Buckling resisrance moment | Mb= | 144.7 KNm | | | | | |
| | Mb L= | 144.7 KNm | | | | | |
| | Mry= | 107.5 KNm | | | | | |
| | Pc= | 844.17 KN | | | | | |
| | Pcy= | 844.17 KN | | | | | |

$$\frac{Fc}{PC} + \frac{W_x Mx}{Py\,Zx} + \frac{W_y My}{py\,Zy} = \le 1$$

W x= 0.95

W y= 1

0.001 + 0.305 + 0.094 = **0.400** **The interaction formula is satisfied**

$$\frac{Fc}{Pcy} + \frac{W_{LT} M_{lt}}{Mb} + \frac{W_y My}{py\,Zy} = \le 1$$

0.001 + 0.458 + 0.094 = **0.553** **The interaction formula is satisfied**

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 59 |
| Made By: | *OAM* | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

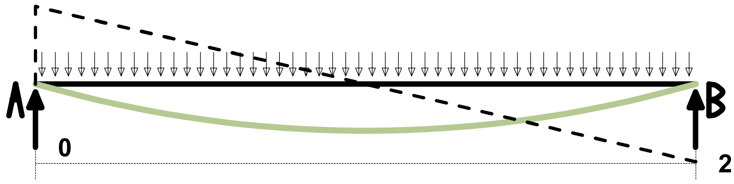
**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **FB2.06**

Loads are unfactored

Wd= **12.08** KN/m2
Wl= **1.50** KN/m2

24 KN




Span= **2.40** m
Cover= **1.00** m

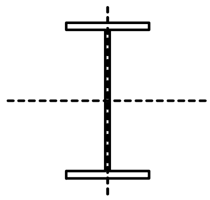
24 KN

**SPAN**

14 KNm

| Load on beam | unfactored | factored |
|---|---|---|
| **Dead+s/w=** | 12.31 KN/m' | 17.23 KN/m' |
| **Live=** | 1.50 KN/m' | 2.40 KN/m' |
| | 13.81 KN/m' | 19.63 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6



**SECTION**

**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 16.6 KN | **23.6** KN |
| RB= | 16.6 KN | **23.6** KN |
| Shear zero at X= | | 1.20 m |
| Maximum Bending Moment **Mx =** | | **14.1** KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 13.1 KNm | Local capacity | PASS | 0.291 |
| Maximum BM about axis Y | MY= | 1.31 KNm | Overall buckling 1 | PASS | 0.415 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.541 |
| Shear force in x axis | Fv= | 23.6 KN | Deflection (dead)= | PASS | 1/ 1933 |
| Beam span | L= | 2.40 m | Deflection(live)= | PASS | 1/ 15868 |
| Effective length about axis X | LX eff= | 2.40 m | Deflection (d+l)= | PASS | 1/ 1723 |
| Effective length about axis Y | LYeff= | 2.40 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 40 cm3 | | | |

**Section properties**

Section size (Ref. No= **68** ) **203x102 23 kg UB S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 203.2 mm | | | | |
| Width of section | B= | 101.6 mm | Pcy= | 442 KN | | |
| Thickness of web | t= | 5.2 mm | Mcx= | 82.36 KNm | | |
| Thickness of flange | T= | 9.3 mm | Mcy= | 17.57 KNm | | 244.89 |
| Root radius | r= | 7.6 mm | Mb L= | 44.08 KNm | | |
| Second moment of area x-x | Ix= | 2090 cm4 | Mlt= | **0.925** | Pcy= | 442.23 KN |
| Second moment of area y-y | Iy= | 163 cm4 | | | | |
| Plastic modulus x-x | Sx= | 232 cm3 | Sx eff= | 202.16 cm3 | | |
| Plastic modulus y-y | Sy= | 49.5 cm3 | Sy eff= | 29.53 cm3 | | |
| Area of section | Ag= | 29 cm2 | An= | 26.36 cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 1.24 mm | | E UDL= | 12.31 KN/m' |
| Unfactored live load deflection= | 0.15 mm | | E UDL= | 1.50 KN/m' |
| Unfactored dead+ live load def = | 1.39 mm | | E UDL= | 13.81 KN/m' |
| Span/def. ratio for dead load= | 1934 | | | |
| Span/def. ratio for live load= | **15869** | **>360** | | |
| Span/def. ratio fordead+ live load= | 1724 | | | |

CONTINUE OF FB2.06

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** | **)** | | | | | |
| for thickness of | 9.3 | mm | **py=** | **355** N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | | | **E=** | 205 KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 50.8 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 5.46 | b/Tlim= | 7.92 | 8.80 | 13.20 |

The classification is based on the outsatnd element — **The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.19 — r2=Fc/(Agxpyw)= 0.058

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth between fillets | d= | 169.4 mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 32.58 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.21 | d/tlim= | 59.08 | 68.34 | 94.59 |

The classification is based on the general web condition — **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | |
|---|---|---|---|---|
| Shear area | | Av y= | 1057 mm2 | (t x D) |
| Shear capacity | (0.6pyA) | Pvy= | 225 KN | |
| Shear force | | Fvy= | 23.6 KN | Fvy/Pvy= 0.10 **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 206 cm3 | Mcx1= | 73.13 |
| Plastic modulus | Sx= | 232 cm3 | Mcx2= | 82.36 |
| Moment capacity for section | Mcx= | **82** KNm | | |
| Elastic modulus | Zy= | 32.1 cm3 | Mcy1= | 11.4 |
| Plastic modulus | Sy= | 50 cm3 | mcy2= | 17.57 |
| Moment capacity for section | Mcy= | **18** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.058 + 0.159 + 0.074 = **0.291** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 2400 mm | normal condition |
| Effective length | Lelt2= | 2400 mm | |
| | L e lt= | 2400 mm | |
| Radius of gyration y-y | ry= | 2.37 cm | |
| | rx= | 8.49 cm | |
| | Lam'y= | 101.3 | |
| | La'mx= | 28.3 | |

CONTINUE OF FB2.06

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for section | | | | | |
| | a= | 3.5 | for table 23 | b | |
| Perry factor | eta= | 0.30 | | | |
| Euler strength | pe= | 197 | N/mm2 | | |
| Factor | phi= | 306 | N/mm2 | | |
| Compressive strength | pcy= | **152.5** | N/mm2 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 101.3 | | La'mx= | 28.27 | Lamy/x= | 4.4808 |
| Slenderness of section | Lamda= | 101.3 | | | | Lamx/x= | 1.2508 |
| Torsional index | x= | 22.6 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.84 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.89 | | | | | |
| Equivalent slenderness | lamlt= | 75.8 | | | | | |
| Buckling strength (Table 16) | pb= | 190 | N/mm2 | for lamlt= | 80 | py= | 355 |
| Buckling resisrance moment | Mb= | 44 | KNm | | | | |
| | Mb L= | 44 | KNm | | | | |
| | Mry= | 18 | KNm | | | | |
| | Pc= | 442.2 | KN | | | | |
| | Pcy= | 442.2 | KN | | | | |

Fc/PC + W x Mx/(Py Zx) + W y My/(py Zy) = <=1          W x= 0.95          W y= 0.95

0.136 + 0.170 + 0.109 = **0.415**          **The interaction formula is satisfied**

Fc/Pcy + W LT M lt/Mb + W y My/(py Zy) = <=1

0.136 + 0.297 + 0.109 = **0.541**          **The interaction formula is satisfied**

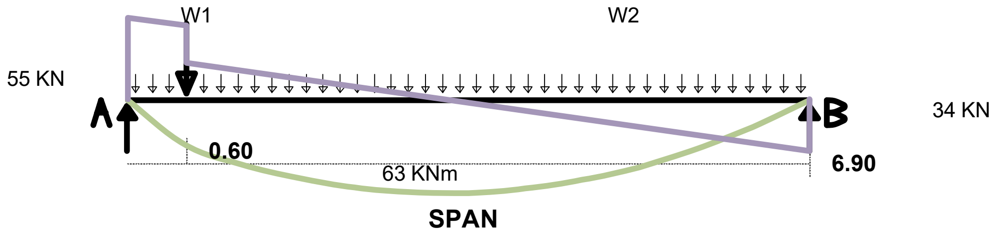
**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= **FB2.07**

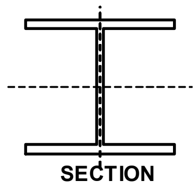
Loads are unfactored

| | | |
|---|---|---|
| Wd1= | **0.60** | KN/m2 |
| Wl1= | **1.50** | KN/m2 |
| Wd2= | **0.60** | KN/m2 |
| wl2= | **1.50** | KN/m2 |
| P1= | **17.00** | KN |
| a= | **0.60** | m |
| Span= | **6.90** | m |
| Cover= | **2.60** | m |




| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | **17.00** KN | **25.5** KN |
| **AV-Dead+s/w=** | 2.16 KN/m' | 3.024 KN/m' |
| **Live=** | 3.90 KN/m' | 6.24 KN/m' |
| | 6.06 KN/m' | 9.264 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6




**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 36.4 KN | **55.2** KN |
| RB= | 22.4 KN | **34.2** KN |
| Shear zero at | X= | 3.21 m |
| Maximum Bending Moment | **Mx =** | **63** KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 58.7 KNm | Local capacity | PASS | 0.309 |
| Maximum BM about axis Y | MY= | 5.87 KNm | Overall buckling 1 | PASS | 0.355 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | PASS | 0.524 |
| Shear force in x axis | Fv= | 55.2 KN | Deflection (dead)= | PASS | 1/ 1445 |
| Beam span | L= | 6.90 m | Deflection(live)= | PASS | 1/ 578 |
| Effective length about axis X | LX eff= | 6.90 m | Deflection (d+l)= | PASS | 1/ 413 |
| Effective length about axis Y | LYeff= | 7.14 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 178 cm3 | | | |

**Section properties**

Section size (Ref. No= **97** ) **203x203 60 kg UC S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 209.6 mm | | |
| Width of section | B= | 205.2 mm | | |
| Thickness of web | t= | 9.3 mm | Mcx= | 231.46 KNm |
| Thickness of flange | T= | 14.2 mm | Mcy= | 107.53 KNm |
| Root radius | r= | 14.2 mm | Mb L= | 133.66 KNm |
| Second moment of area x-x | Ix= | 6088 cm4 | Mlt= | **0.931** TABLE 18 |
| Second moment of area y-y | Iy= | 2041 cm4 | | |
| Plastic modulus x-x | Sx= | 652 cm3 | Sx eff= | 570.67 cm3 |
| Plastic modulus y-y | Sy= | 302.9 cm3 | Sy eff= | 183.71 cm3 |
| Area of section | Ag= | 75.8 cm2 | An= | 68.91 cm2 ke= 1.1 |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 4.77 mm | | E UDL= | 2.02 KN/m' |
| Unfactored live load deflection= | 11.93 mm | | E UDL= | 5.04 KN/m' |
| Unfactored dead+ live load def = | 16.70 mm | | E UDL= | 7.06 KN/m' |
| Span/def. ratio for dead load= | 1446 | | | |
| Span/def. ratio for live load= | **578** | **>360** | | |
| Span/def. ratio fordead+ live load= | 413 | | | |

CONTINUE OF FB2.07

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** | **)** | | | | | |
| for thickness of | 14.2 | mm | **py=** | **355** | N/mm2 | py= | **355.0** N/mm2 | pyw= py |
| Young's Modulus | | | **E=** | 205 | KN/mm2 | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 102.6 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 7.23 | | b/Tlim= | 7.92 | 8.80 | 13.20 |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.19    r2=Fc/(Agxpyw)= 0.0004

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Depth between fillets | d= | 160.8 | mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 17.29 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.206 | | d/tlim= | 59.25 | 68.62 | 105.54 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 1949.3 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 415 KN | | |
| Shear force | | Fvy= | 55.2 KN | Fvy/Pvy= | 0.13 **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 581.1 cm3 | Mcx1= | 206.29 |
| Plastic modulus | Sx= | 652 cm3 | Mcx2= | 231.46 |
| Moment capacity for section | Mcx= | **231.5** KNm | | |
| Elastic modulus | Zy= | 199 cm3 | Mcy1= | 70.645 |
| Plastic modulus | Sy= | 302.9 cm3 | mcy2= | 107.53 |
| Moment capacity for section | Mcy= | **107.5** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.000 + 0.254 + 0.055 = **0.309** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 6900 mm | normal condition |
| Effective length | Lelt2= | 7139.6 mm | |
| | L e lt= | 7019.8 mm | |
| Radius of gyration y-y | ry= | 5.19 cm | |
| | rx= | 8.96 cm | |
| | Lam'y= | 137.6 | |
| | La'mx= | 77.0 | |

CONTINUE OF FB2.07

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | | 30.20 TABLE 16 |
| Robertson constant for H section | | | | | |
| | a= | 5.5 | | | |
| Perry factor | eta= | 0.67 | | | |
| Euler strength | pe= | 107 N/mm2 | | | |
| Factor | phi= | 267 N/mm2 | | | |
| Compressive strength | pcy= | **84.4** N/mm2 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 137.6 | La'mx= | 77.01 | Lamy/x= | 9.75635 |
| Slenderness of section | Lamda= | 137.6 | | | Lamx/x= | 5.46163 |
| Torsional index | x= | 14.1 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.64 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.847 | | | | |
| Equivalent slenderness | lamlt= | 74.6 | | | | |
| Buckling strength (Table 16) | pb= | 205 N/mm2 | for lamlt= | 75 | py= | 355 |
| Buckling resisrance moment | Mb= | 133.7 KNm | | | | |
| | Mb L= | 133.7 KNm | | | | |
| | Mry= | 107.5 KNm | | | | |
| | Pc= | 640.06 KN | | | | |
| | Pcy= | 640.06 KN | | | | |

$\frac{Fc}{PC} + W_x \frac{Mx}{Py\,Zx} + W_y \frac{My}{py\,Zy} = \le 1$ W x= 0.95, W y= 1

0.002 + 0.270 + 0.083 = **0.355** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + W_{LT} \frac{M\,lt}{Mb} + W_y \frac{My}{py\,Zy} = \le 1$

0.002 + 0.439 + 0.083 = **0.524** **The interaction formula is satisfied**

| ♦ David Smith Associates LLP ♦ | Project No: | 24/54720 | Sheet No: | 65 |
|---|---|---|---|---|
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**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

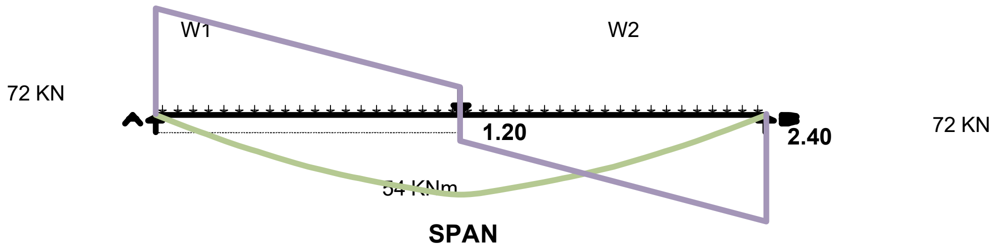
**H rolled section** S355

**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **FB2.08**

Loads are unfactored

| | | |
|---|---|---|
| Wd1= | **26.56** | KN/m2 |
| Wl1= | **4.40** | KN/m2 |
| Wd2= | **26.56** | KN/m2 |
| wl2= | **4.40** | KN/m2 |
| P1= | **24.00** | KN |
| a= | **1.20** | m |
| Span= | **2.40** | m |
| Cover= | **1.00** | m |

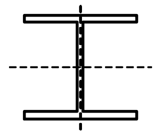



| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | **24.00** KN | **36** KN |
| **AV-Dead+s/w=** | 26.93 KN/m' | 37.702 KN/m' |
| **Live=** | 4.40 KN/m' | 7.04 KN/m' |
| | 31.33 KN/m' | 44.742 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 49.6 KN | **71.7** KN |
| RB= | 49.6 KN | **71.7** KN |
| Shear zero at | X= | 1.20 m |
| Maximum Bending Moment | **Mx =** | **54** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 48.2 KNm | Local capacity | PASS | 0.535 |
| Maximum BM about axis Y | MY= | 4.82 KNm | Overall buckling 1 | PASS | 0.618 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | PASS | 0.586 |
| Shear force in x axis | Fv= | 71.7 KN | Deflection (dead)= | PASS | 1/ 590 |
| Beam span | L= | 2.40 m | Deflection(live)= | PASS | 1/ 3567 |
| Effective length about axis X | LX eff= | 2.40 m | Deflection (d+l)= | PASS | 1/ 506 |
| Effective length about axis Y | LYeff= | 1.48 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 152 cm3 | | | |

**Section properties**

Section size (Ref. No= **100** ) **152x152 37 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 161.8 mm | | | | |
| Width of section | B= | 154.4 mm | | | | |
| Thickness of web | t= | 8.1 mm | | Mcx= | 110.09 KNm | |
| Thickness of flange | T= | 11.5 mm | | Mcy= | 49.736 KNm | |
| Root radius | r= | 11.5 mm | | Mb L= | 110.09 KNm | |
| Second moment of area x-x | Ix= | 2218 cm4 | | Mlt= | **0.895** | TABLE 18 |
| Second moment of area y-y | Iy= | 709 cm4 | | | | |
| Plastic modulus x-x | Sx= | 310.1 cm3 | Sx eff= | 268.25 cm3 | | |
| Plastic modulus y-y | Sy= | 140.1 cm3 | Sy eff= | 83.77 cm3 | | |
| Area of section | Ag= | 47.4 cm2 | An= | 43.09 cm2 | | ke= 1.1 |

**DEFLECTION**

| | | | unfactored |
|---|---|---|---|
| Unfactored dead load deflection= | 4.06 mm | E UDL= | 42.75 KN/m' |
| Unfactored live load deflection= | 0.67 mm | E UDL= | 7.08 KN/m' |
| Unfactored dead+ live load def = | 4.73 mm | E UDL= | 49.83 KN/m' |
| Span/def. ratio for dead load= | 591 | | |
| Span/def. ratio for live load= | **3567** | **>360** | |
| Span/def. ratio fordead+ live load= | 507 | | |

CONTINUE OF FB2.08

**Strength of steel** Clause 3.1.1

Design strength (Grade S 355 )
for thickness of 11.5 mm **py= 355** N/mm2 py= **355.0** N/mm2 pyw= py
Young's Modulus **E=** 205 KN/mm2

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 77.2 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 6.71 | b/Tlim= | 7.92 | 8.80 | 13.20 |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.28 r2=Fc/(Agxpyw)= 0.0006

TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth between fillets | d= | 123.4 mm | | | | |
| ratio | d/t= | 15.23 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.206 | d/tlim= | 54.93 | 61.86 | 105.49 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | |
|---|---|---|---|---|
| Shear area | | Av y= | 1310.6 mm2 | (t x D) |
| Shear capacity | (0.6pyA) | Pvy= | 279 KN | |
| Shear force | | Fvy= | 71.7 KN | Fvy/Pvy= 0.26 **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 274.2 cm3 | Mcx1= | 97.341 |
| Plastic modulus | Sx= | 310 cm3 | Mcx2= | 110.09 |
| Moment capacity for section | Mcx= | **110.1** KNm | | |
| Elastic modulus | Zy= | 91.78 cm3 | Mcy1= | 32.582 |
| Plastic modulus | Sy= | 140.1 cm3 | mcy2= | 49.736 |
| Moment capacity for section | Mcy= | **49.7** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.001 + 0.437 + 0.097 = **0.535** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 2400 mm | normal condition |
| Effective length | Lelt2= | 1481.8 mm | |
| | L e lt= | 1940.9 mm | |
| Radius of gyration y-y | ry= | 3.87 cm | |
| | rx= | 6.84 cm | |
| | Lam'y= | 38.3 | |
| | La'mx= | 35.1 | |

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**Project:** **34 NASSAU ROAD, LONDON**

CONTINUE OF FB2.08

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | | 30.20 TABLE 16 |
| Robertson constant for H section | | | | | |
| | a= | 5.5 | | | |
| Perry factor | eta= | 0.13 | | | |
| Euler strength | pe= | 1380 N/mm2 | | | |
| Factor | phi= | 956 N/mm2 | | | |
| Compressive strength | pcy= | **305.1** N/mm2 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 38.3 | La'mx= | 35.09 | Lamy/x= | 2.8789 |
| Slenderness of section | Lamda= | 38.3 | | | Lamx/x= | 2.63817 |
| Torsional index | x= | 13.3 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.91 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.848 | | | | |
| Equivalent slenderness | lamlt= | 29.5 | | | | |
| Buckling strength (Table 16) | pb= | 355 N/mm2 | for lamlt= | 30 | py= | 355 |
| Buckling resisrance moment | Mb= | 110.1 KNm | | | | |
| | Mb L= | 110.1 KNm | | | | |
| | Mry= | 49.7 KNm | | | | |
| | Pc= | 1445.9 KN | | | | |
| | Pcy= | 1445.9 KN | | | | |

$\frac{Fc}{PC} + \frac{W_x Mx}{Py\,Zx} + \frac{W_y My}{py\,Zy} = \;<=1$     W x= 0.95, W y= 1

0.001 + 0.470 + 0.148 = **0.618**     **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + \frac{W_{LT} M_{lt}}{Mb} + \frac{W_y My}{py\,Zy} = \;<=1$

0.001 + 0.437 + 0.148 = **0.586**     **The interaction formula is satisfied**

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| Project No: | 24/54720 | Sheet No: | 68 |
|---|---|---|---|
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.NO WORK SHOULD START BEFORE THE CALCULATIONS HAVE BEEN RECEIVED AND APPROVED BY THE LA BUILDING CONTROL.**

**FIRST FLOOR LEVEL**

**TIMBER SLOPE RAFTERS** TJ1

Max span = 3.7 m

**USE 195X47 C24 AT 400 C/C** SEE PAGE 69 - 71

**STEEL BEAM** FB1.01

Max span = 5.7 m
Cover= 2.6 m

**USE 203x203x46 UC S355** SEE PAGE 72 - 74

**STEEL BEAM** FB1.02

Max span = 6.9 m
Cover= 2.4 m

**USE 203x203x60 UC S355** SEE PAGE 75 - 77

**STEEL BEAM** FB1.03

Max span = 5.4 m
Cover= 1 m

**USE 203x133x30 UB S355** SEE PAGE 78 - 80

**STEEL BEAM** FB1.04

Max span = 4.9 m

| BEAM LOADING | | D LOAD | I LOAD | cover y | | dead load | live load |
|---|---|---|---|---|---|---|---|
| | | KN/m2 | KN/m2 | m | | KN/m' | KN/m' |
| ROOF | dead | **1.2** | | **3.5** | => 3.5* 1.2= | 4.2 | |
| | live | | **1.00** | **3.5** | => 3.5*1.00= | | 3.5 |
| second floor | dead | **0.6** | | **3.5** | => 3.5* .6= | 2.1 | |
| | live | | **1.50** | **3.5** | => 3.5*1.50= | | 5.25 |
| first floor | dead | **0.5** | | **0.6** | => .6* .5= | 0.3 | |
| | live | | **1.50** | **0.6** | => .6*1.50= | | 0.9 |
| FLAT ROOF | dead | **2** | | **1.2** | => 1.2* 2= | 2.4 | |
| | live | | **0.75** | **1.2** | => 1.2*0.75= | | 0.9 |
| wall | dead | **7.5** | | **5.4** | => 5.4* 7.5= | 40.5 | |
| | | | | | **UDL** | **49.5 KN/m'** | **10.55 KN/m'** |

**USE 305x305x97 UC S355** SEE PAGE 81 - 83

go to page 84

**TIMBER JOIST DESIGN (BS5268-2:2002)**

Tedds calculation version 1.1.04

**Joist details**

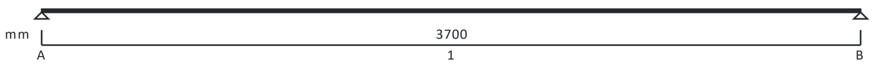
Joist breadth b = **47** mm

Joist depth h = **195** mm

Joist spacing s = **400** mm

Timber strength class **C24**

Service class of timber **1**

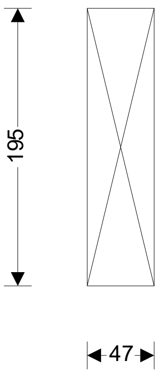


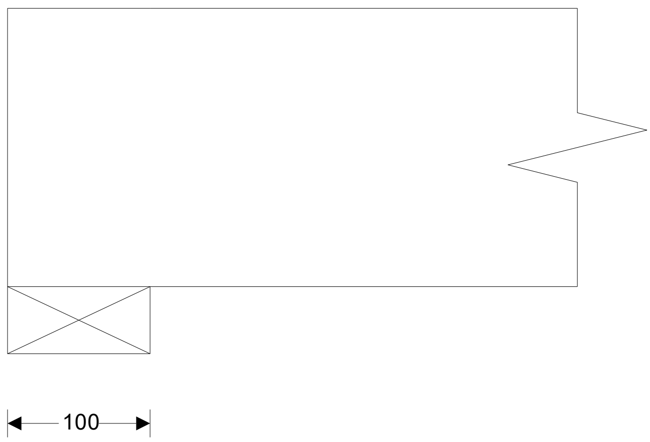

**Span details**

Number of spans $N_{span}$ = **1**

Length of bearing $L_b$ = **100** mm

Effective length of span $L_{s1}$ = **3700** mm




**Section properties**

Second moment of area $I = b \times h^3 / 12$ = **29041594** $mm^4$

Section modulus $Z = b \times h^2 / 6$ = **297863** $mm^3$

**Loading details**

Joist self weight $F_{swt} = b \times h \times \rho_{char} \times g_{acc}$ = **0.03** kN/m

Dead load $F_{d\_udl}$ = **0.75** $kN/m^2$

Imposed UDL(Long term) $F_{i\_udl}$ = **1.50** $kN/m^2$

Imposed point load (Medium term) $F_{i\_pt}$ = **1.40** kN

**Modification factors**

Service class for bending parallel to grain $K_{2m}$ = **1.00**

Service class for compression $K_{2c}$ = **1.00**

| | |
|---|---|
| Service class for shear parallel to grain | $K_{2s}$ = **1.00** |
| Service class for modulus of elasticity | $K_{2e}$ = **1.00** |
| Section depth factor | $K_7$ = **1.05** |
| Load sharing factor | $K_8$ = **1.10** |

**Consider long term loads**

| | |
|---|---|
| Load duration factor | $K_3$ = **1.00** |
| Maximum bending moment | M = **1.594** kNm |
| Maximum shear force | V = **1.723** kN |
| Maximum support reaction | R = **1.723** kN |
| Maximum deflection | $\delta$ = **7.556** mm |

**Check bending stress**

| | |
|---|---|
| Bending stress | $\sigma_m$ = **7.500** N/mm$^2$ |
| Permissible bending stress | $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **8.650** N/mm$^2$ |
| Applied bending stress | $\sigma_{m\_max}$ = M / Z = **5.351** N/mm$^2$ |

***PASS - Applied bending stress within permissible limits***

**Check shear stress**

| | |
|---|---|
| Shear stress | $\tau$ = **0.710** N/mm$^2$ |
| Permissible shear stress | $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.781** N/mm$^2$ |
| Applied shear stress | $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.282** N/mm$^2$ |

***PASS - Applied shear stress within permissible limits***

**Check bearing stress**

| | |
|---|---|
| Compression perpendicular to grain (no wane) | $\sigma_{cp1}$ = **2.400** N/mm$^2$ |
| Permissible bearing stress | $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **2.640** N/mm$^2$ |
| Applied bearing stress | $\sigma_{c\_max} = R / (b \times L_b)$ = **0.367** N/mm$^2$ |

***PASS - Applied bearing stress within permissible limits***

**Check deflection**

| | |
|---|---|
| Permissible deflection | $\delta_{adm}$ = min($L_{s1}$ × 0.003, 14 mm) = **11.100** mm |
| Bending deflection (based on $E_{mean}$) | $\delta_{bending}$ = **7.247** mm |
| Shear deflection | $\delta_{shear}$ = **0.309** mm |
| Total deflection | $\delta = \delta_{bending} + \delta_{shear}$ = **7.556** mm |

***PASS - Actual deflection within permissible limits***

**Consider medium term loads**

| | |
|---|---|
| Load duration factor | $K_3$ = **1.25** |
| Maximum bending moment | M = **1.862** kNm |
| Maximum shear force | V = **2.013** kN |
| Maximum support reaction | R = **2.013** kN |
| Maximum deflection | $\delta$ = **7.650** mm |

**Check bending stress**

| | |
|---|---|
| Bending stress | $\sigma_m$ = **7.500** N/mm$^2$ |
| Permissible bending stress | $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **10.813** N/mm$^2$ |
| Applied bending stress | $\sigma_{m\_max}$ = M / Z = **6.252** N/mm$^2$ |

***PASS - Applied bending stress within permissible limits***

**Check shear stress**

Shear stress $\tau$ = **0.710** N/mm$^2$

Permissible shear stress $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.976** N/mm$^2$

Applied shear stress $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.329** N/mm$^2$

***PASS - Applied shear stress within permissible limits***

**Check bearing stress**

Compression perpendicular to grain (no wane) $\sigma_{cp1}$ = **2.400** N/mm$^2$

Permissible bearing stress $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **3.300** N/mm$^2$

Applied bearing stress $\sigma_{c\_max} = R / (b \times L_b)$ = **0.428** N/mm$^2$

***PASS - Applied bearing stress within permissible limits***

**Check deflection**

Permissible deflection $\delta_{adm} = \min(L_{s1} \times 0.003, 14 \text{ mm})$ = **11.100** mm

Bending deflection (based on $E_{mean}$) $\delta_{bending}$ = **7.289** mm

Shear deflection $\delta_{shear}$ = **0.361** mm

Total deflection $\delta = \delta_{bending} + \delta_{shear}$ = **7.650** mm

***PASS - Actual deflection within permissible limits***

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

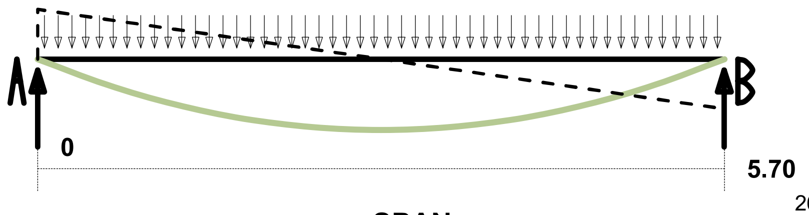
H rolled section S355
Calculation in accordance
with BS 5950: 1: 2000

LOCATION= **FB1.01**

Loads are unfactored

Wd= **0.60** KN/m2
Wl= **1.50** KN/m2

Span= **5.70** m
Cover= **2.60** m

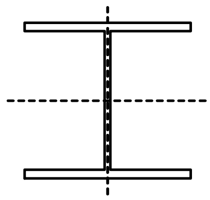



**SPAN**

| Load on beam | unfactored | factored | |
|---|---|---|---|
| | | | 37 KNm |
| | | | Partial safety factor for load |
| **Dead+s/w=** | 2.02 KN/m' | 2.83 KN/m' | dead= 1.4 |
| **Live=** | 3.90 KN/m' | 6.24 KN/m' | live= 1.6 |
| | 5.92 KN/m' | 9.07 KN/m' | |

**Reaction**

| | | unfactored | | factored |
|---|---|---|---|---|
| RA= | | 16.9 KN | | **25.8** KN |
| RB= | | 16.9 KN | | **25.8** KN |
| Shear zero at | | | X= | 2.85 m |
| Maximum Bending Moment | | | **Mx =** | **36.8** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 34.1 KNm | Local capacity | PASS | 0.263 |
| Maximum BM about axis Y | MY= | 3.41 KNm | Overall buckling 1 | PASS | 0.349 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.480 |
| Shear force in x axis | Fv= | 25.8 KN | Deflection (dead)= | PASS | 1/ 1920 |
| Beam span | L= | 5.70 m | Deflection(live)= | PASS | 1/ 994 |
| Effective length about axis X | LX eff= | 5.70 m | Deflection (d+l)= | PASS | 1/ 655 |
| Effective length about axis Y | LYeff= | 5.70 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 104 cm3 | | | |

**Section properties**

Section size (Ref. No= **99** ) **203x203 46 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 203.2 mm | | | | |
| Width of section | B= | 203.2 mm | Pcy= | 700 KN | | |
| Thickness of web | t= | 7.3 mm | Mcx= | 176.6 KNm | | |
| Thickness of flange | T= | 11 mm | Mcy= | 81.65 KNm | | 566.48 |
| Root radius | r= | 10.2 mm | Mb L= | 102 KNm | | |
| Second moment of area x-x | Ix= | 4564 cm4 | Mlt= | **0.925** | Pcy= | 700.16 KN |
| Second moment of area y-y | Iy= | 1539 cm4 | | | | |
| Plastic modulus x-x | Sx= | 497.4 cm3 | Sx eff= | 442.53 cm3 | | |
| Plastic modulus y-y | Sy= | 230 cm3 | Sy eff= | 140.06 cm3 | | |
| Area of section | Ag= | 58.8 cm2 | An= | 53.45 cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 2.97 mm | | E UDL= | 2.02 KN/m' |
| Unfactored live load deflection= | 5.73 mm | | E UDL= | 3.90 KN/m' |
| Unfactored dead+ live load def = | 8.70 mm | | E UDL= | 5.92 KN/m' |
| Span/def. ratio for dead load= | 1921 | | | |
| Span/def. ratio for live load= | **995** | **>360** | | |
| Span/def. ratio fordead+ live load= | 655 | | | |

CONTINUE OF FB1.01

**Strength of steel** Clause 3.1.1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Design strength | **(Grade S 355 )** | | | | | | |
| for thickness of | 11 mm | **py=** | **355** | N/mm2 | py= | **355.0** N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 | KN/mm2 | | | |

**Classification of cross section** (clause 3.5.2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | TABLE 11 rolled section | | |
| Constant (table 11 note b) | ε = | 0.880 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 101.6 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 9.24 | | b/Tlim= | 7.92 | 8.80 | 13.20 |

The classification is based on the outsatnd element — **The section is class 3 semi compact**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.14 r2=Fc/(Agxpyw)= 0.029

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | TABLE 11 rolled section | | |
| Depth between fillets | d= | 160.8 | mm | | | | |
| ratio | d/t= | 22.03 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.21 | | d/tlim= | 61.55 | 72.38 | 99.88 |

The classification is based on the general web condition — **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 1483 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 316 KN | | |
| Shear force | | Fvy= | 25.8 KN | Fvy/Pvy= 0.08 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 449.2 cm3 | Mcx1= | 159.5 |
| Plastic modulus | Sx= | 497 cm3 | Mcx2= | 176.6 |
| Moment capacity for section | Mcx= | **177** KNm | | |
| Elastic modulus | Zy= | 151 cm3 | Mcy1= | 53.61 |
| Plastic modulus | Sy= | 230 cm3 | mcy2= | 81.65 |
| Moment capacity for section | Mcy= | **82** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.029 + 0.193 + 0.042 = **0.263** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 5700 mm | normal condition |
| Effective length | Lelt2= | 5700 mm | |
| | L e lt= | 5700 mm | |
| Radius of gyration y-y | ry= | 5.11 cm | |
| | rx= | 8.81 cm | |
| | Lam'y= | 111.5 | |
| | La'mx= | 64.7 | |

CONTINUE OF FB1.01

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 | N/mm2 |
| For buckling about y-y | | | λ L0= | | 30.20 | TABLE 16 |
| Robertson constant for section | | | | | | |
| | a= | 5.5 | for table 23 | c | | |
| Perry factor | eta= | 0.53 | | | | |
| Euler strength | pe= | 163 | N/mm2 | | | |
| Factor | phi= | 302 | N/mm2 | | | |
| Compressive strength | pcy= | **119.1** | N/mm2 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lam'y= | 111.5 | | La'mx= | 64.70 | | Lamy/x= | 6.302 |
| Slenderness of section | Lamda= | 111.5 | | | | | Lamx/x= | 3.6553 |
| Torsional index | x= | 17.7 | | | | | | |
| | N= | 0.5 | | | | | | |
| Slenderness factor | v= | 0.76 | from Table 19 | | | | | |
| | β w = | 1.0 | | | | | | |
| Buckling parameter | u= | 0.846 | | | | | | |
| Equivalent slenderness | lamlt= | 71.8 | | | | | | |
| Buckling strength (Table 16) | pb= | 205 | N/mm2 | for lamlt= | 75 | | py= | 355 |
| Buckling resisrance moment | Mb= | 102 | KNm | | | | | |
| | Mb L= | 102 | KNm | | | | | |
| | Mry= | 82 | KNm | | | | | |
| | Pc= | 700.2 | KN | | | | | |
| | Pcy= | 700.2 | KN | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fc / PC | | +W x Mx / Py Zx | | +W y My / py Zy | = | <=1 | W x= | 0.95 |
| | | | | | | | W y= | 0.95 |
| 0.086 | + | 0.203 | + | 0.060 | = | **0.349** | **The interaction formula is satisfied** | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Fc / Pcy | | +W LT M lt / Mb | | +W y My / py Zy | = | <=1 | |
| 0.086 | + | 0.334 | + | 0.060 | = | **0.480** | **The interaction formula is satisfied** |

| David Smith Associates LLP | Project No: | 24/54720 | Sheet No: | 75 |
|---|---|---|---|---|
| 8 Duncan Close ♦ Moulton Park ♦ Northampton NN3 6WL<br>Tel: (01604) 782620 ♦ Fax: (01604) 782629<br>E-mail: post@dsagroup.co.uk | Made By: | OAM | Revision: | |
| | Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

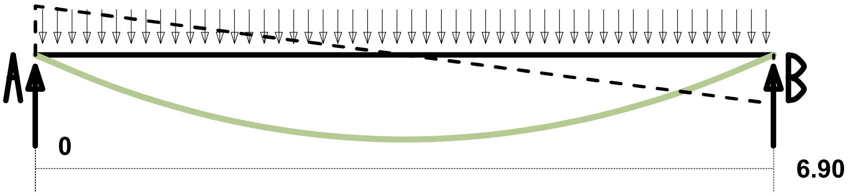
**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **FB1.02**

Loads are unfactored

Wd= **0.60** KN/m2
Wl= **1.50** KN/m2

Span= **6.90** m
Cover= **2.40** m




**SPAN**

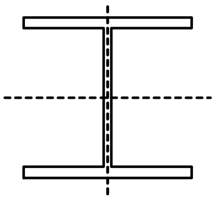
51 KNm

| Load on beam | unfactored | factored |
|---|---|---|
| **Dead+s/w=** | 2.04 KN/m' | 2.86 KN/m' |
| **Live=** | 3.60 KN/m' | 5.76 KN/m' |
| | 5.64 KN/m' | 8.62 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | | unfactored | factored |
|---|---|---|---|
| RA= | | 19.5 KN | **29.7** KN |
| RB= | | 19.5 KN | **29.7** KN |
| Shear zero at | X= | | 3.45 m |
| Maximum Bending Moment | **Mx =** | | **51.3** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 47.4 KNm | Local capacity | **PASS** | 0.271 |
| Maximum BM about axis Y | MY= | 4.74 KNm | Overall buckling 1 | **PASS** | 0.403 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | **PASS** | 0.601 |
| Shear force in x axis | Fv= | 29.7 KN | Deflection (dead)= | **PASS** | 1/ 1430 |
| Beam span | L= | 6.90 m | Deflection(live)= | **PASS** | 1/ 810 |
| Effective length about axis X | LX eff= | 6.90 m | Deflection (d+l)= | **PASS** | 1/ 517 |
| Effective length about axis Y | LYeff= | 8.28 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 144 cm3 | | | |

**Section properties**

Section size (Ref. No= **97** ) **203x203 60 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 209.6 mm | | | | |
| Width of section | B= | 205.2 mm | Pcy= | 495 KN | | |
| Thickness of web | t= | 9.3 mm | Mcx= | 231.5 KNm | | |
| Thickness of flange | T= | 14.2 mm | Mcy= | 107.5 KNm | | 633.89 |
| Root radius | r= | 10.2 mm | Mb L= | 114.1 KNm | | |
| Second moment of area x-x | Ix= | 6088 cm4 | Mlt= | **0.925** | Pcy= | 494.73 KN |
| Second moment of area y-y | Iy= | 2041 cm4 | | | | |
| Plastic modulus x-x | Sx= | 652 cm3 | Sx eff= | 571.71 cm3 | | |
| Plastic modulus y-y | Sy= | 302.9 cm3 | Sy eff= | 185.24 cm3 | | |
| Area of section | Ag= | 75.8 cm2 | An= | 68.91 cm2 | ke= 1.1 | |

**DEFLECTION**

| | | | unfactored |
|---|---|---|---|
| Unfactored dead load deflection= | 4.82 mm | E UDL= | 2.04 KN/m' |
| Unfactored live load deflection= | 8.51 mm | E UDL= | 3.60 KN/m' |
| Unfactored dead+ live load def = | 13.34 mm | E UDL= | 5.64 KN/m' |
| Span/def. ratio for dead load= | 1430 | | |
| Span/def. ratio for live load= | **810** | **>360** | |
| Span/def. ratio fordead+ live load= | 517 | | |

CONTINUE OF FB1.02

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** | **)** | | | | | |
| for thickness of | 14.2 | mm | **py=** | **355** | N/mm2 | py= | **355.0** | N/mm2 pyw= py |
| Young's Modulus | | | **E=** | 205 | KN/mm2 | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 102.6 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 7.23 | | b/Tlim= | 7.92 | 8.80 | 13.20 |
| The classification is based on the outsatnd element | | | | | **The section is class1 plastic** | | |
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.11 | | r2=Fc/(Agxpyw)= | 0.022 | | |
| Depth between fillets | d= | 160.8 | mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 17.29 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.21 | | d/tlim= | 63.26 | 75.26 | 101.11 |
| The classification is based on the general web condition | | | | | **The section is class1 plastic** | | |

**Shear capacity** CL 4.2.3

| | | | | | | |
|---|---|---|---|---|---|---|
| Shear area | | Av y= | 1949 | mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 415 | KN | | |
| Shear force | | Fvy= | 29.7 | KN | Fvy/Pvy= 0.07 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 581.1 | cm3 | Mcx1= | 206.3 |
| Plastic modulus | Sx= | 652 | cm3 | Mcx2= | 231.5 |
| Moment capacity for section | Mcx= | **231** | KNm | | |
| Elastic modulus | Zy= | 199 | cm3 | Mcy1= | 70.65 |
| Plastic modulus | Sy= | 303 | cm3 | mcy2= | 107.5 |
| Moment capacity for section | Mcy= | **108** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$\frac{F}{Ag.\ py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \;<=1$

0.022 + 0.205 + 0.044 = **0.271** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 6900 | mm | normal condition |
| Effective length | Lelt2= | 8280 | mm | |
| | L e lt= | 7590 | mm | |
| Radius of gyration y-y | ry= | 5.19 | cm | |
| | rx= | 8.96 | cm | |
| | Lam'y= | 159.5 | | |
| | La'mx= | 77.0 | | |

CONTINUE OF FB1.02

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for section | | | | | |
| | a= | 5.5 | for table 23 | c | |
| Perry factor | eta= | 0.79 | | | |
| Euler strength | pe= | 79 | N/mm2 | | |
| Factor | phi= | 249 | N/mm2 | | |
| Compressive strength | pcy= | **65.3** | N/mm2 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 159.5 | La'mx= | 77.01 | | Lamy/x= | 11.315 |
| Slenderness of section | Lamda= | 159.5 | | | | Lamx/x= | 5.4616 |
| Torsional index | x= | 14.1 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.61 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.847 | | | | | |
| Equivalent slenderness | lamlt= | 81.9 | | | | | |
| Buckling strength (Table 16) | pb= | 175 | N/mm2 | for lamlt= | 85 | py= | 355 |
| Buckling resisrance moment | Mb= | 114 | KNm | | | | |
| | Mb L= | 114 | KNm | | | | |
| | Mry= | 108 | KNm | | | | |
| | Pc= | 494.7 | KN | | | | |
| | Pcy= | 494.7 | KN | | | | |

$\frac{Fc}{PC}$ +W $\frac{x\ Mx}{Py\ Zx}$ +W $\frac{y\ My}{py\ Zy}$ = <=1 W x= 0.95 W y= 0.95

0.121 + 0.218 + 0.064 = **0.403** **The interaction formula is satisfied**

$\frac{Fc}{Pcy}$ +W $\frac{LT\ M\ lt}{Mb}$ +W $\frac{y\ My}{py\ Zy}$ = <=1

0.121 + 0.416 + 0.064 = **0.601** **The interaction formula is satisfied**

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 78 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

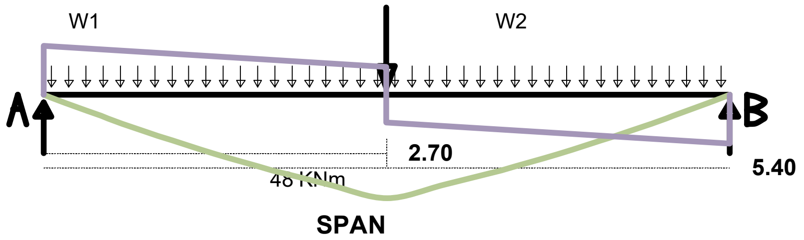
**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= **FB1.03**

Loads are unfactored

| | | |
|---|---|---|
| Wd1= | **0.60** | KN/m2 |
| Wl1= | **1.50** | KN/m2 |
| Wd2= | **0.60** | KN/m2 |
| wl2= | **1.50** | KN/m2 |
| P1= | **17.00** | KN |
| a= | **2.70** | m |
| Span= | **5.40** | m |
| Cover= | **1.00** | m |

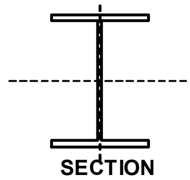



| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | **17.00** KN | **25.5** KN |
| **AV-Dead+s/w=** | 0.90 KN/m' | 1.26 KN/m' |
| **Live=** | 1.50 KN/m' | 2.4 KN/m' |
| | 2.4 KN/m' | 3.66 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | | |
|---|---|---|
| RA= | 15.0 KN | **22.6** KN |
| RB= | 15.0 KN | **22.6** KN |
| Shear zero at | X= | 2.70 m |
| Maximum Bending Moment | **Mx =** | **48** KNm |




| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 41.6 KNm | Local capacity | **PASS** | 0.508 |
| Maximum BM about axis Y | MY= | 4.16 KNm | Overall buckling 1 | **PASS** | 0.605 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | **PASS** | 0.854 |
| Shear force in x axis | Fv= | 22.6 KN | Deflection (dead)= | **PASS** | 1/ 1156 |
| Beam span | L= | 5.40 m | Deflection(live)= | **PASS** | 1/ 462 |
| Effective length about axis X | LX eff= | 5.40 m | Deflection (d+l)= | **PASS** | 1/ 330 |
| Effective length about axis Y | LYeff= | 3.18 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 135 cm3 | | | |

**Section properties**

Section size (Ref. No= **66** ) **203x133 30 kg UB S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 206.8 mm | | |
| Width of section | B= | 133.8 mm | | |
| Thickness of web | t= | 6.3 mm | Mcx= | 111.22 KNm |
| Thickness of flange | T= | 9.6 mm | Mcy= | 31.258 KNm |
| Root radius | r= | 9.6 mm | Mb L= | 64.227 KNm |
| Second moment of area x-x | Ix= | 2887 cm4 | Mlt= | **0.871** TABLE 18 |
| Second moment of area y-y | Iy= | 384 cm4 | | |
| Plastic modulus x-x | Sx= | 313.3 cm3 | Sx eff= | 273.81 cm3 |
| Plastic modulus y-y | Sy= | 88.05 cm3 | Sy eff= | 52.45 cm3 |
| Area of section | Ag= | 38 cm2 | An= | 34.55 cm2 ke= 1.1 |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 4.67 mm | | E UDL= | 2.50 KN/m' |
| Unfactored live load deflection= | 11.67 mm | | E UDL= | 6.24 KN/m' |
| Unfactored dead+ live load def = | 16.34 mm | | E UDL= | 8.74 KN/m' |
| Span/def. ratio for dead load= | 1156 | | | |
| Span/def. ratio for live load= | **463** | **>360** | | |
| Span/def. ratio fordead+ live load= | 330 | | | |

CONTINUE OF FB1.03

**Strength of steel** Clause 3.1.1

| | | | | | | |
|---|---|---|---|---|---|---|
| Design strength | (Grade S 355 ) | | | | | |
| for thickness of 9.6 mm | **py=** | **355** N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | **E=** | 205 KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 66.9 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 6.97 | b/Tlim= | 7.92 | 8.80 | 13.20 |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.26 r2=Fc/(Agxpyw)= 0.0007

Depth between fillets d= 172.3 mm TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| ratio | d/t= | 27.35 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.206 | d/tlim= | 55.90 | 63.35 | 105.46 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 1302.8 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 278 KN | | |
| Shear force | | Fvy= | 22.6 KN | Fvy/Pvy= 0.08 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 279.3 cm3 | Mcx1= | 99.152 |
| Plastic modulus | Sx= | 313 cm3 | Mcx2= | 111.22 |
| Moment capacity for section | Mcx= | **111.2** KNm | | |
| Elastic modulus | Zy= | 57.4 cm3 | Mcy1= | 20.377 |
| Plastic modulus | Sy= | 88.1 cm3 | mcy2= | 31.258 |
| Moment capacity for section | Mcy= | **31.3** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\ py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \ <=1$$

0.001 + 0.374 + 0.133 = **0.508** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 5400 mm | normal condition |
| Effective length | Lelt2= | 3176.8 mm | |
| | L e lt= | 4288.4 mm | |
| Radius of gyration y-y | ry= | 3.18 cm | |
| | rx= | 8.72 cm | |
| | Lam'y= | 99.9 | |
| | La'mx= | 61.9 | |

CONTINUE OF FB1.03

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for H section | | | | |
| | a= | 5.5 | | |
| Perry factor | eta= | 0.47 | | |
| Euler strength | pe= | 203 N/mm2 | | |
| Factor | phi= | 326 N/mm2 | | |
| Compressive strength | pcy= | **140.7** N/mm2 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lam'y= | 99.9 | La'mx= | 61.93 | | | Lamy/x= | 4.64648 |
| Slenderness of section | Lamda= | 99.9 | | | | | Lamx/x= | 2.88031 |
| Torsional index | x= | 21.5 | | | | | | |
| | N= | 0.5 | | | | | | |
| Slenderness factor | v= | 0.82 from Table 19 | | | | | | |
| | β w = | 1.0 | | | | | | |
| Buckling parameter | u= | 0.882 | | | | | | |
| Equivalent slenderness | lamlt= | 72.3 | | | | | | |
| Buckling strength (Table 16) | pb= | 205 N/mm2 | | for lamlt= | 75 | py= | 355 | |
| Buckling resisrance moment | Mb= | 64.2 KNm | | | | | | |
| | Mb L= | 64.2 KNm | | | | | | |
| | Mry= | 31.3 KNm | | | | | | |
| | Pc= | 534.56 KN | | | | | | |
| | Pcy= | 534.56 KN | | | | | | |

$\frac{Fc}{PC}$ +W $\frac{x\ Mx}{Py\ Zx}$ +W $\frac{y\ My}{py\ Zy}$ = <=1    W x= 0.95, W y= 1

0.002 + 0.399 + 0.204 = **0.605**    **The interaction formula is satisfied**

$\frac{Fc}{Pcy}$ +W $\frac{LT\ M\ lt}{Mb}$ +W $\frac{y\ My}{py\ Zy}$ = <=1

0.002 + 0.648 + 0.204 = **0.854**    **The interaction formula is satisfied**

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 81 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

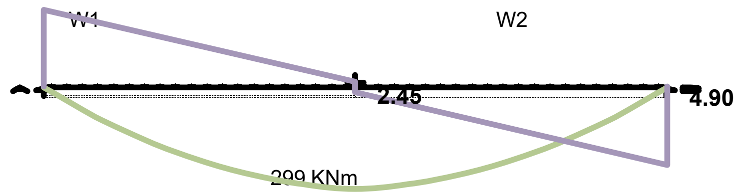
**H rolled section** **S355**
**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **FB1.04**

Loads are unfactored

| | | |
|---|---|---|
| Wd1= | **49.50** | KN/m2 |
| Wl1= | **10.55** | KN/m2 |
| Wd2= | **49.50** | KN/m2 |
| wl2= | **10.55** | KN/m2 |
| P1= | **20.00** | KN |
| a= | **2.45** | m |
| Span= | **4.90** | m |
| Cover= | **1.00** | m |

229 KN

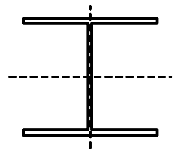



229 KN

**SPAN**

| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | **20.00** KN | **30** KN |
| **AV-Dead+s/w=** | 50.47 KN/m' | 70.658 KN/m' |
| **Live=** | 10.55 KN/m' | 16.88 KN/m' |
| | 61.02 KN/m' | 87.538 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6



**SECTION**

**Reaction**

| | | |
|---|---|---|
| RA= | 159.5 KN | **229.5** KN |
| RB= | 159.5 KN | **229.5** KN |
| Shear zero at | X= | 2.45 m |
| Maximum Bending Moment | **Mx =** | **299** KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 274.3 KNm | Local capacity | **PASS** | 0.593 |
| Maximum BM about axis Y | MY= | 27.43 KNm | Overall buckling 1 | **PASS** | 0.671 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | **PASS** | 0.668 |
| Shear force in x axis | Fv= | 229.5 KN | Deflection (dead)= | **PASS** | 1/ 541 |
| Beam span | L= | 4.90 m | Deflection(live)= | **PASS** | 1/ 2542 |
| Effective length about axis X | LX eff= | 4.90 m | Deflection (d+l)= | **PASS** | 1/ 446 |
| Effective length about axis Y | LYeff= | 3.00 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 844 cm3 | | | |

**Section properties**

Section size (Ref. No= **89** ) **305x305 97 kg UC S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 307.8 mm | | |
| Width of section | B= | 304.8 mm | | |
| Thickness of web | t= | 9.9 mm | Mcx= | 564.1 KNm |
| Thickness of flange | T= | 15.4 mm | Mcy= | 256.84 KNm |
| Root radius | r= | 15.4 mm | Mb L= | 541.85 KNm |
| Second moment of area x-x | Ix= | 22202 cm4 | Mlt= | **0.916** TABLE 18 |
| Second moment of area y-y | Iy= | 7268 cm4 | | |
| Plastic modulus x-x | Sx= | 1589 cm3 | Sx eff= | 1422.46 cm3 |
| Plastic modulus y-y | Sy= | 723.5 cm3 | Sy eff= | 444.13 cm3 |
| Area of section | Ag= | 123.3 cm2 | An= | 112.09 cm2 ke= 1.1 |

**DEFLECTION**

| | | | unfactored |
|---|---|---|---|
| Unfactored dead load deflection= | 9.04 mm | E UDL= | 54.83 KN/m' |
| Unfactored live load deflection= | 1.93 mm | E UDL= | 11.69 KN/m' |
| Unfactored dead+ live load def = | 10.97 mm | E UDL= | 66.52 KN/m' |
| Span/def. ratio for dead load= | 542 | | |
| Span/def. ratio for live load= | **2542** | **>360** | |
| Span/def. ratio fordead+ live load= | 447 | | |

CONTINUE OF FB1.04

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Strength of steel** | Clause 3.1.1 | | | | | | |
| Design strength | **(Grade** | **S 355** | **)** | | | | |
| for thickness of | 15.4 mm | **py=** | **355** N/mm2 | py= | **355.0** N/mm2 | | pyw= py |
| Young's Modulus | | **E=** | 205 KN/mm2 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Classification of cross section** | | | (clause 3.5.2) | | TABLE 11 rolled section | | |
| Constant | ε = | | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | | b= | 152.4 mm | | plastic | compac | semi compact |
| Ratio | | b/T= | 9.90 | b/Tlim= | 7.92 | 8.80 | 13.20 |
| | | | | | **The section is class 3 semi compact** | | |
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | | 0.12 | r2=Fc/(Agxpyw)= | 0.0002 | | |
| Depth between fillets | | d= | 246.6 mm | | TABLE 11 rolled section | | |
| ratio | | d/t= | 24.91 | | class 1 | class 2 | class 3 |
| | 40 ε | = | 35.206 | d/tlim= | 63.13 | 75.03 | 105.57 |
| The classification is based on the general web condition | | | | | **The section is class1 plastic** | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Shear capacity** | CL 4.2.3 | | | | | |
| Shear area | | Av y= | 3047.2 mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 649 KN | | | |
| Shear force | | Fvy= | 229.5 KN | Fvy/Pvy= | 0.35 | **SHEAR PASS OK** |

| | | | | |
|---|---|---|---|---|
| **Moment Capacity** | | | | |
| Elastic modulus | Zx= | 1442 cm3 | Mcx1= | 511.91 |
| Plastic modulus | Sx= | 1589 cm3 | Mcx2= | 564.1 |
| Moment capacity for section | Mcx= | **564.1** KNm | | |
| Elastic modulus | Zy= | 476.9 cm3 | Mcy1= | 169.3 |
| Plastic modulus | Sy= | 723.5 cm3 | mcy2= | 256.84 |
| Moment capacity for section | Mcy= | **256.8** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.000 + 0.486 + 0.107 = **0.593** **LOCAL CAPACITY IS SATISFIED**

| | | | |
|---|---|---|---|
| **restraint/effective length Clause 4.31 to 4.3.5** | | | TABLE 13 |
| Effective length | Le lt1= | 4900 mm | normal condition |
| Effective length | Lelt2= | 3002.8 mm | |
| | L e lt= | 3951.4 mm | |
| Radius of gyration y-y | ry= | 7.68 cm | |
| | rx= | 13.4 cm | |
| | Lam'y= | 39.1 | |
| | La'mx= | 36.6 | |

CONTINUE OF FB1.04

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for H section | | | | |
| | a= | 5.5 | | |
| Perry factor | eta= | 0.13 | | |
| Euler strength | pe= | 1324 N/mm2 | | |
| Factor | phi= | 927 N/mm2 | | |
| Compressive strength | pcy= | **303.1** N/mm2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 39.1 | La'mx= | 36.57 | Lamy/x= | 2.02585 |
| Slenderness of section | Lamda= | 39.1 | | | Lamx/x= | 1.89467 |
| Torsional index | x= | 19.3 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.96 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.85 | | | | |
| Equivalent slenderness | lamlt= | 31.9 | | | | |
| Buckling strength (Table 16) | pb= | 341 N/mm2 | for lamlt= | 35 | py= | 355 |
| Buckling resisrance moment | Mb= | 541.8 KNm | | | | |
| | Mb L= | 541.8 KNm | | | | |
| | Mry= | 256.8 KNm | | | | |
| | Pc= | 3737.3 KN | | | | |
| | Pcy= | 3737.3 KN | | | | |

$\frac{Fc}{PC}$ +W $\frac{x\ Mx}{Py\ Zx}$ +W $\frac{y\ My}{py\ Zy}$ = <=1          W x= 0.95, W y= 1

0.000 + 0.509 + 0.162 = **0.671**          **The interaction formula is satisfied**

$\frac{Fc}{Pcy}$ +W $\frac{LT\ M\ lt}{Mb}$ +W $\frac{y\ My}{py\ Zy}$ = <=1

0.000 + 0.506 + 0.162 = **0.668**          **The interaction formula is satisfied**

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| Project No: | 24/54720 | Sheet No: | 84 |
|---|---|---|---|
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.NO WORK SHOULD START BEFORE THE CALCULATIONS HAVE BEEN RECEIVED AND APPROVED BY THE LA BUILDING CONTROL.**

**FIRST FLOOR LEVEL**

**STEEL BEAM** FB1.05

Max span = 5.4 m

| BEAM LOADING | | D LOAD | I LOAD | cover y | | dead load | live load |
|---|---|---|---|---|---|---|---|
| | | KN/m2 | KN/m2 | m | | KN/m' | KN/m' |
| ROOF | dead | **1.2** | | **3.5** | => 3.5* 1.2= | 4.2 | |
| | live | | **1.00** | **3.5** | => 3.5*1.00= | | 3.5 |
| second floor | dead | **0.6** | | **3.5** | => 3.5* .6= | 2.1 | |
| | live | | **1.50** | **3.5** | => 3.5*1.50= | | 5.25 |
| first floor | dead | **0.5** | | **0.6** | => .6* .5= | 0.3 | |
| | live | | **1.50** | **0.6** | => .6*1.50= | | 0.9 |
| FLAT ROOF | dead | **0.8** | | **0.3** | => .3* .8= | 0.24 | |
| | live | | **0.75** | **0.3** | => .3*0.75= | | 0.225 |
| wall | dead | **7.5** | | **5.4** | => 5.4* 7.5= | 40.5 | |
| | | | | | **UDL** | **47.34 KN/m'** | **9.875 KN/m'** |

**USE 305x305x97 UC** **S355** SEE PAGE 85 - 87

**STEEL BEAM**

Max span = 3.9 m **FB1.06**

Cover= 1 m AS FB1.05

**USE 254x254x73 UC** +PLATE **S355** SEE PAGE 88 - 90

**STEEL BEAM** FB1.07

Max span = 8.6 m

| BEAM LOADING | | D LOAD | I LOAD | cover y | | dead load | live load |
|---|---|---|---|---|---|---|---|
| | | KN/m2 | KN/m2 | m | | KN/m' | KN/m' |
| ROOF | dead | **0.8** | | **2.6** | => 2.6* .8= | 2.08 | |
| | live | | **0.75** | **2.6** | => 2.6*0.75= | | 1.95 |
| second floor | dead | **0.6** | | **0.6** | => .6* .6= | 0.36 | |
| | live | | **1.50** | **0.6** | => .6*1.50= | | 0.9 |
| first floor | dead | **0.5** | | **1.2** | => 1.2* .5= | 0.6 | |
| | live | | **1.50** | **1.2** | => 1.2*1.50= | | 1.8 |
| FLAT ROOF | dead | **2** | | **2.1** | => 2.1* 2= | 4.2 | |
| | live | | **0.75** | **2.1** | => 2.1*0.75= | | 1.575 |
| wall | dead | **7.5** | | **3.6** | => 3.6* 7.5= | 27 | |
| | | | | | **UDL** | **34.24 KN/m'** | **6.225 KN/m'** |

**USE 356x406x287 UC** **S355** SEE PAGE 91 - 93

go to page 94

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 85 |
| Made By: | *OAM* | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

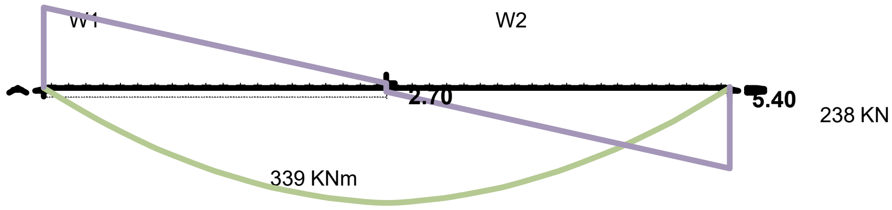
**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **FB1.05**

Loads are unfactored

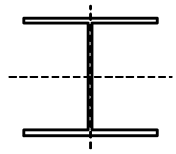
| | | |
|---|---|---|
| Wd1= | **47.34** | KN/m2 |
| Wl1= | **9.88** | KN/m2 |
| Wd2= | **47.34** | KN/m2 |
| wl2= | **9.88** | KN/m2 |
| P1= | **17.00** | KN |
| a= | **2.70** | m |
| Span= | **5.40** | m |
| Cover= | **1.00** | m |




**SPAN**

| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | **17.00** KN | **25.5** KN |
| **AV-Dead+s/w=** | 48.31 KN/m' | 67.634 KN/m' |
| **Live=** | 9.88 KN/m' | 15.8 KN/m' |
| | 58.185 KN/m' | 83.434 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6



**SECTION**

**Reaction**

| | | |
|---|---|---|
| RA= | 165.6 KN | **238.0** KN |
| RB= | 165.6 KN | **238.0** KN |
| Shear zero at | X= | 2.70 m |
| Maximum Bending Moment | **Mx =** | **339** KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 310.6 KNm | Local capacity | **PASS** | 0.672 |
| Maximum BM about axis Y | MY= | 31.06 KNm | Overall buckling 1 | **PASS** | 0.760 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | **PASS** | 0.757 |
| Shear force in x axis | Fv= | 238.0 KN | Deflection (dead)= | **PASS** | 1/ 433 |
| Beam span | L= | 5.40 m | Deflection(live)= | **PASS** | 1/ 2077 |
| Effective length about axis X | LX eff= | 5.40 m | Deflection (d+l)= | **PASS** | 1/ 358 |
| Effective length about axis Y | LYeff= | 3.28 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 954 cm3 | | | |

**Section properties**

Section size (Ref. No= **89** ) **305x305 97 kg UC S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 307.8 mm | | |
| Width of section | B= | 304.8 mm | | |
| Thickness of web | t= | 9.9 mm | Mcx= | 564.1 KNm |
| Thickness of flange | T= | 15.4 mm | Mcy= | 256.84 KNm |
| Root radius | r= | 15.4 mm | Mb L= | 541.85 KNm |
| Second moment of area x-x | Ix= | 22202 cm4 | Mlt= | **0.917** TABLE 18 |
| Second moment of area y-y | Iy= | 7268 cm4 | | |
| Plastic modulus x-x | Sx= | 1589 cm3 | Sx eff= | 1422.46 cm3 |
| Plastic modulus y-y | Sy= | 723.5 cm3 | Sy eff= | 444.13 cm3 |
| Area of section | Ag= | 123.3 cm2 | An= | 112.09 cm2 ke= 1.1 |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 12.46 mm | | E UDL= | 51.23 KN/m' |
| Unfactored live load deflection= | 2.60 mm | | E UDL= | 10.69 KN/m' |
| Unfactored dead+ live load def = | 15.06 mm | | E UDL= | 61.92 KN/m' |
| Span/def. ratio for dead load= | 433 | | | |
| Span/def. ratio for live load= | **2077** | **>360** | | |
| Span/def. ratio fordead+ live load= | 359 | | | |

CONTINUE OF FB1.05

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** | **)** | | | | | |
| for thickness of | 15.4 | mm | **py=** | **355** | N/mm2 | py= | **355.0** N/mm2 | pyw= py |
| Young's Modulus | | | **E=** | 205 | KN/mm2 | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 152.4 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 9.90 | | b/Tlim= | 7.92 | 8.80 | 13.20 |

**The section is class 3 semi compact**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.12 | | r2=Fc/(Agxpyw)= | 0.0002 | | |
| Depth between fillets | d= | 246.6 | mm | TABLE 11 rolled section | | | |
| ratio | d/t= | 24.91 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.206 | | d/tlim= | 63.13 | 75.03 | 105.57 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | | |
|---|---|---|---|---|---|---|
| Shear area | | Av y= | 3047.2 mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 649 KN | | | |
| Shear force | | Fvy= | 238.0 KN | Fvy/Pvy= | 0.37 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 1442 cm3 | Mcx1= | 511.91 |
| Plastic modulus | Sx= | 1589 cm3 | Mcx2= | 564.1 |
| Moment capacity for section | Mcx= | **564.1** KNm | | |
| Elastic modulus | Zy= | 476.9 cm3 | Mcy1= | 169.3 |
| Plastic modulus | Sy= | 723.5 cm3 | mcy2= | 256.84 |
| Moment capacity for section | Mcy= | **256.8** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \le 1$$

0.000 + 0.551 + 0.121 = **0.672** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 5400 mm | normal condition |
| Effective length | Lelt2= | 3277.8 mm | |
| | L e lt= | 4338.9 mm | |
| Radius of gyration y-y | ry= | 7.68 cm | |
| | rx= | 13.4 cm | |
| | Lam'y= | 42.7 | |
| | La'mx= | 40.3 | |

CONTINUE OF FB1.05

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for H section | | | | |
| | a= | 5.5 | | |
| Perry factor | eta= | 0.15 | | |
| Euler strength | pe= | 1111 N/mm2 | | |
| Factor | phi= | 817 N/mm2 | | |
| Compressive strength | pcy= | **294.3** N/mm2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 42.7 | La'mx= | 40.30 | Lamy/x= | 2.21138 |
| Slenderness of section | Lamda= | 42.7 | | | Lamx/x= | 2.08801 |
| Torsional index | x= | 19.3 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.96 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.85 | | | | |
| Equivalent slenderness | lamlt= | 34.8 | | | | |
| Buckling strength (Table 16) | pb= | 341 N/mm2 | for lamlt= | 35 | py= | 355 |
| Buckling resisrance moment | Mb= | 541.8 KNm | | | | |
| | Mb L= | 541.8 KNm | | | | |
| | Mry= | 256.8 KNm | | | | |
| | Pc= | 3628.4 KN | | | | |
| | Pcy= | 3628.4 KN | | | | |

Fc / PC +W x Mx / Py Zx +W y My / py Zy = <=1    W x= 0.95, W y= 1

0.000 + 0.576 + 0.183 = **0.760**    **The interaction formula is satisfied**

Fc / Pcy +W LT M lt / Mb +W y My / py Zy = <=1

0.000 + 0.573 + 0.183 = **0.757**    **The interaction formula is satisfied**

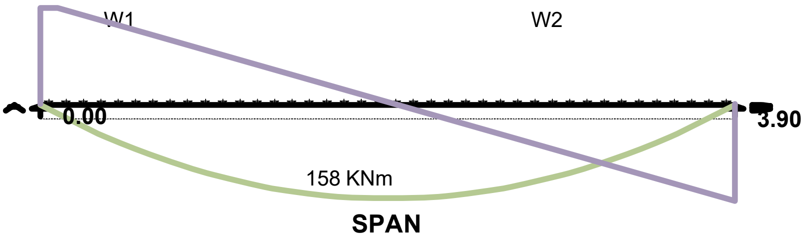
**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= **FB1.06**

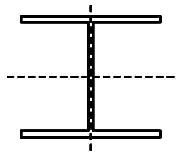
Loads are unfactored

| | | |
|---|---|---|
| Wd1= | **47.34** | KN/m2 |
| Wl1= | **9.88** | KN/m2 |
| Wd2= | **47.34** | KN/m2 |
| wl2= | **9.88** | KN/m2 |
| P1= | **0.00** | KN |
| a= | **0.10** | m |
| Span= | **3.90** | m |
| Cover= | **1.00** | m |




| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | **0.00** KN | **0** KN |
| **AV-Dead+s/w=** | 48.07 KN/m' | 67.298 KN/m' |
| **Live=** | 9.88 KN/m' | 15.8 KN/m' |
| | 57.945 KN/m' | 83.098 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6




**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 113.0 KN | **162.0** KN |
| RB= | 113.0 KN | **162.0** KN |
| Shear zero at | X= | 1.95 m |
| Maximum Bending Moment | **Mx =** | **158** KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 146.1 KNm | Local capacity | **PASS** | 0.506 |
| Maximum BM about axis Y | MY= | 14.61 KNm | Overall buckling 1 | **PASS** | 0.573 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | **PASS** | 0.675 |
| Shear force in x axis | Fv= | 162.0 KN | Deflection (dead)= | **PASS** | 1/ 657 |
| Beam span | L= | 3.90 m | Deflection(live)= | **PASS** | 1/ 3153 |
| Effective length about axis X | LX eff= | 3.90 m | Deflection (d+l)= | **PASS** | 1/ 544 |
| Effective length about axis Y | LYeff= | 4.43 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 445 cm3 | | | |

**Section properties**

Section size (Ref. No= **94** ) **254x254 73 kg UC S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 254 mm | | |
| Width of section | B= | 254 mm | | |
| Thickness of web | t= | 8.6 mm | Mcx= | 350.95 KNm |
| Thickness of flange | T= | 14.2 mm | Mcy= | 164.15 KNm |
| Root radius | r= | 14.2 mm | Mb L= | 270.88 KNm |
| Second moment of area x-x | Ix= | 11360 cm4 | Mlt= | **0.925** TABLE 18 |
| Second moment of area y-y | Iy= | 3873 cm4 | | |
| Plastic modulus x-x | Sx= | 988.6 cm3 | Sx eff= | 881.11 cm3 |
| Plastic modulus y-y | Sy= | 462.4 cm3 | Sy eff= | 282.61 cm3 |
| Area of section | Ag= | 92.9 cm2 | An= | 84.45 cm2 ke= 1.1 |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 5.93 mm | | E UDL= | 45.84 KN/m' |
| Unfactored live load deflection= | 1.24 mm | | E UDL= | 9.56 KN/m' |
| Unfactored dead+ live load def = | 7.17 mm | | E UDL= | 55.40 KN/m' |
| Span/def. ratio for dead load= | 658 | | | |
| Span/def. ratio for live load= | **3153** | **>360** | | |
| Span/def. ratio fordead+ live load= | 544 | | | |

CONTINUE OF FB1.06

**Strength of steel** Clause 3.1.1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Design strength | (Grade S 355 ) | | | | | | |
| for thickness of | 14.2 mm | py= | 355 N/mm2 | py= | 355.0 | N/mm2 | pyw= py |
| Young's Modulus | | E= | 205 KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 127 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 8.94 | b/Tlim= | 7.92 | 8.80 | 13.20 |

**The section is class 3 semi compact**

| | | | | | | |
|---|---|---|---|---|---|---|
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.16 | r2=Fc/(Agxpyw)= | 0.0003 | | |
| Depth between fillets | d= | 200.2 mm | TABLE 11 rolled section | | | |
| ratio | d/t= | 23.28 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.206 | d/tlim= | 60.51 | 70.67 | 105.55 |

The classification is based on the general web condition — **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 2184.4 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 465 KN | | |
| Shear force | | Fvy= | 162.0 KN | Fvy/Pvy= 0.35 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 894.5 cm3 | Mcx1= | 317.55 |
| Plastic modulus | Sx= | 989 cm3 | Mcx2= | 350.95 |
| Moment capacity for section | Mcx= | **351.0** KNm | | |
| Elastic modulus | Zy= | 305 cm3 | Mcy1= | 108.28 |
| Plastic modulus | Sy= | 462.4 cm3 | mcy2= | 164.15 |
| Moment capacity for section | Mcy= | **164.2** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.000 + 0.416 + 0.089 = **0.506** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 3900 mm | normal condition |
| Effective length | Lelt2= | 4434 mm | |
| | L e lt= | 4167 mm | |
| Radius of gyration y-y | ry= | 6.46 cm | |
| | rx= | 11.1 cm | |
| | Lam'y= | 68.6 | |
| | La'mx= | 35.1 | |

CONTINUE OF FB1.06

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for H section | | | | |
| | a= | 5.5 | | |
| Perry factor | eta= | 0.29 | | |
| Euler strength | pe= | 429 N/mm2 | | |
| Factor | phi= | 455 N/mm2 | | |
| Compressive strength | pcy= | **221.0** N/mm2 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lam'y= | 68.6 | La'mx= | 35.14 | | | Lamy/x= | 3.9675 |
| Slenderness of section | Lamda= | 68.6 | | | | | Lamx/x= | 2.03093 |
| Torsional index | x= | 17.3 | | | | | | |
| | N= | 0.5 | | | | | | |
| Slenderness factor | v= | 0.86 from Table 19 | | | | | | |
| | β w = | 1.0 | | | | | | |
| Buckling parameter | u= | 0.849 | | | | | | |
| Equivalent slenderness | lamlt= | 50.1 | | | | | | |
| Buckling strength (Table 16) | pb= | 274 N/mm2 | | for lamlt= | 55 | | py= | 355 |
| Buckling resisrance moment | Mb= | 270.9 KNm | | | | | | |
| | Mb L= | 270.9 KNm | | | | | | |
| | Mry= | 164.2 KNm | | | | | | |
| | Pc= | 2052.8 KN | | | | | | |
| | Pcy= | 2052.8 KN | | | | | | |

$\frac{Fc}{PC} + W \frac{x\,Mx}{Py\,Zx} + W \frac{y\,My}{py\,Zy} = \;<=1$   W x= 0.95   W y= 1

0.000 + 0.437 + 0.135 = **0.573**   **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + W \frac{LT\,M\,lt}{Mb} + W \frac{y\,My}{py\,Zy} = \;<=1$

0.000 + 0.540 + 0.135 = **0.675**   **The interaction formula is satisfied**

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 91 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

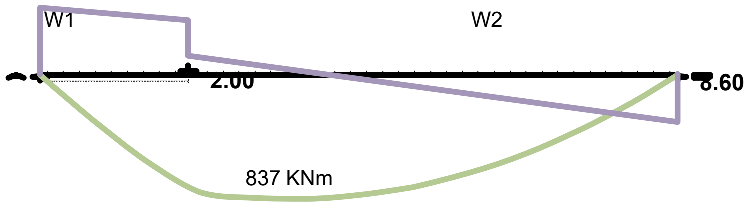
**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **FB1.07**

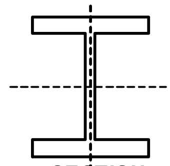
Loads are unfactored

| | | |
|---|---|---|
| Wd1= | **34.24** | KN/m2 |
| Wl1= | **6.23** | KN/m2 |
| Wd2= | **34.24** | KN/m2 |
| wl2= | **6.23** | KN/m2 |
| P1= | **160.00** | KN |
| a= | **2.00** | m |
| Span= | **8.60** | m |
| Cover= | **1.00** | m |




| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | **160.00** KN | **240** KN |
| **AV-Dead+s/w=** | 37.07 KN/m' | 51.898 KN/m' |
| **Live=** | 6.23 KN/m' | 9.96 KN/m' |
| | 43.295 KN/m' | 61.858 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6




**Reaction**

| | | |
|---|---|---|
| RA= | 309.0 KN | **450.2** KN |
| RB= | 223.4 KN | **321.8** KN |
| Shear zero at | X= | 3.40 m |
| Maximum Bending Moment | **Mx =** | **837** KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 774.0 KNm | Local capacity | PASS | 0.552 |
| Maximum BM about axis Y | MY= | 77.40 KNm | Overall buckling 1 | PASS | 0.660 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | PASS | 0.696 |
| Shear force in x axis | Fv= | 450.2 KN | Deflection (dead)= | PASS | 1/ 381 |
| Beam span | L= | 8.60 m | Deflection(live)= | PASS | 1/ 2099 |
| Effective length about axis X | LX eff= | 8.60 m | Deflection (d+l)= | PASS | 1/ 323 |
| Effective length about axis Y | LYeff= | 7.63 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 2499 cm3 | | | |

**Section properties**

| | | | | |
|---|---|---|---|---|
| Section size | (Ref. No= **83** ) | **305x305 283 kg UC S355** | | |
| Depth of steel section | D= | 365.3 mm | | |
| Width of section | B= | 321.8 mm | | |
| Thickness of web | t= | 26.9 mm | Mcx= | 1708.8 KNm |
| Thickness of flange | T= | 44.1 mm | Mcy= | 782.9 KNm |
| Root radius | r= | 44.1 mm | Mb L= | 1423.2 KNm |
| Second moment of area x-x | Ix= | 78777 cm4 | Mlt= | **0.925** TABLE 18 |
| Second moment of area y-y | Iy= | 24545 cm4 | | |
| Plastic modulus x-x | Sx= | 5101 cm3 | Sx eff= | 4219.95 cm3 |
| Plastic modulus y-y | Sy= | 2337 cm3 | Sy eff= | 1427.96 cm3 |
| Area of section | Ag= | 360.4 cm2 | An= | 327.64 cm2 ke= 1.1 |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 22.53 mm | | E UDL= | 51.08 KN/m' |
| Unfactored live load deflection= | 4.10 mm | | E UDL= | 9.29 KN/m' |
| Unfactored dead+ live load def = | 26.62 mm | | E UDL= | 60.36 KN/m' |
| Span/def. ratio for dead load= | 382 | | | |
| Span/def. ratio for live load= | **2100** | **>360** | | |
| Span/def. ratio fordead+ live load= | 323 | | | |

CONTINUE OF FB1.07

**Strength of steel** Clause 3.1.1

Design strength (Grade S 355 )
for thickness of 44.1 mm **py=** **335** N/mm2 py= **335.0** N/mm2 pyw= py
Young's Modulus **E=** 205 KN/mm2

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | ε = | 0.906 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 160.9 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 3.65 | b/Tlim= | 8.15 | 9.06 | 13.59 |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.04 r2=Fc/(Agxpyw)= 8E-05

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth between fillets | d= | 246.6 mm | TABLE 11 rolled section | | | |
| ratio | d/t= | 9.17 | | class 1 | class 2 | class 3 |
| 40 ε | = | 36.241 | d/tlim= | 69.36 | 84.87 | 108.71 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | |
|---|---|---|---|---|
| Shear area | | Av y= | 9826.6 mm2 | (t x D) |
| Shear capacity | (0.6pyA) | Pvy= | 1975 KN | |
| Shear force | | Fvy= | 450.2 KN | Fvy/Pvy= 0.23 **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 4314 cm3 | Mcx1= | 1445.2 |
| Plastic modulus | Sx= | 5101 cm3 | Mcx2= | 1708.8 |
| Moment capacity for section | Mcx= | **1708.8** KNm | | |
| Elastic modulus | Zy= | 1525 cm3 | Mcy1= | 510.88 |
| Plastic modulus | Sy= | 2337.0 cm3 | mcy2= | 782.9 |
| Moment capacity for section | Mcy= | **782.9** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.000 + 0.453 + 0.099 = **0.552** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 8600 mm | normal condition |
| Effective length | Lelt2= | 7625.3 mm | |
| | L e lt= | 8112.7 mm | |
| Radius of gyration y-y | ry= | 8.25 cm | |
| | rx= | 14.8 cm | |
| | Lam'y= | 92.4 | |
| | La'mx= | 58.1 | |

CONTINUE OF FB1.07

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.54 | py= | 335 N/mm2 |
| For buckling about y-y | | | λ L0= | 31.10 TABLE 16 |
| Robertson constant for H section | | | | |
| | a= | 5.5 | | |
| Perry factor | eta= | 0.42 | | |
| Euler strength | pe= | 237 N/mm2 | | |
| Factor | phi= | 336 N/mm2 | | |
| Compressive strength | pcy= | **152.8** N/mm2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 92.4 | La'mx= | 58.11 | Lamy/x= | 12.0821 |
| Slenderness of section | Lamda= | 92.4 | | | Lamx/x= | 7.59583 |
| Torsional index | x= | 7.65 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.58 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.855 | | | | |
| Equivalent slenderness | lamlt= | 45.8 | | | | |
| Buckling strength (Table 16) | pb= | 279 N/mm2 | for lamlt= | 50 | py= | 335 |
| Buckling resisrance moment | Mb= | 1423.2 KNm | | | | |
| | Mb L= | 1423.2 KNm | | | | |
| | Mry= | 782.9 KNm | | | | |
| | Pc= | 5507.8 KN | | | | |
| | Pcy= | 5507.8 KN | | | | |

Fc/PC +W x Mx/Py Zx +W y My/py Zy = <=1 W x= 0.95, W y= 1

0.000 + 0.509 + 0.152 = **0.660** **The interaction formula is satisfied**

Fc/Pcy +W LT M lt/Mb +W y My/py Zy = <=1

0.000 + 0.544 + 0.152 = **0.696** **The interaction formula is satisfied**

**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.NO WORK SHOULD START BEFORE THE CALCULATIONS HAVE BEEN RECEIVED AND APPROVED BY THE LA BUILDING CONTROL.**

**FIRST FLOOR LEVEL**

**TIMBER SLOPE RAFTERS** **R2** GREEN

Max span = 4 m

**USE** **195X63 C24 AT 400 C/C** SEE PAGE 95 - 97

**TIMBER SLOPE RAFTERS** **R3**

Max span = 2.4 m

**USE** **195X47 C24 AT 400 C/C** BY INSPECTION

**STEEL BEAM** **T1**

Max span = 3.2 m GREEN

Cover= 1.8 m

**USE** **203x133x25 UB** **S355** SEE PAGE 98 - 100

**STEEL BEAM** **T2**

Max span = 4.2 m GREEN

Cover= 0.6 m

**USE** **203x133x25 UB** **S355** SEE PAGE 101 - 103

**STEEL BEAM** **T3** **T4** **T5** **T6**

Max span = 5.4 m

Cover= 0.6 m

**USE** **203x133x25 UB** **S355** SEE PAGE 104 - 106

**STEEL BEAM** **E1**

Max span = 4 m GREEN

| BEAM LOADING | | D LOAD | l LOAD | cover y | | dead load | live load |
|---|---|---|---|---|---|---|---|
| | | KN/m2 | KN/m2 | m | | KN/m' | KN/m' |
| ROOF | 1 dead | **2** | | **0.4** | => .4* 2* 1= | 0.8 | |
| | live | | **0.75** | **0.4** | => .4*0.75* 1= | | 0.3 |
| wall | dead | **3.85** | | **0.6** | => .6* 3.85= | 2.31 | |
| | | | | | **UDL** | **3.11 KN/m'** | **0.3 KN/m'** |

**USE** **203x133x30 UB** +PLATE **S355** SEE PAGE 107 - 109

**STEEL BEAM** **FB1.08**

Max span = 8.6 m

Cover= 2.5 m

**USE** **305x305x240 UC** **S355** SEE PAGE 110 - 112

go to page 113

All design calculations have been author reviewed and subject to additional review by the project team, as required by David Smith Associates Quality Assurance procedures.

**TIMBER JOIST DESIGN (BS5268-2:2002)**

Tedds calculation version 1.1.04

**Joist details**

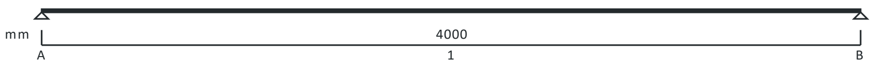
Joist breadth b = **63** mm

Joist depth h = **195** mm

Joist spacing s = **400** mm

Timber strength class **C24**

Service class of timber **1**

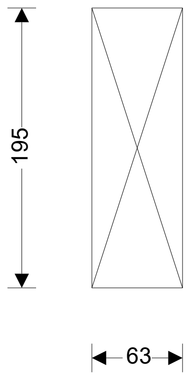


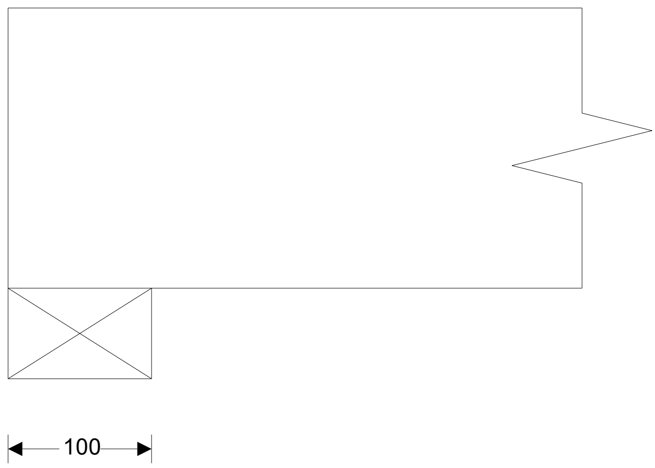

**Span details**

Number of spans $N_{span}$ = **1**

Length of bearing $L_b$ = **100** mm

Effective length of span $L_{s1}$ = **4000** mm




**Section properties**

Second moment of area $I = b \times h^3 / 12$ = **38928094** $mm^4$

Section modulus $Z = b \times h^2 / 6$ = **399263** $mm^3$

**Loading details**

Joist self weight $F_{swt} = b \times h \times \rho_{char} \times g_{acc}$ = **0.04** kN/m

Dead load $F_{d\_udl}$ = **2.00** $kN/m^2$

Imposed UDL(Medium term) $F_{i\_udl}$ = **0.60** $kN/m^2$

Imposed point load (Short term) $F_{i\_pt}$ = **0.90** kN

**Modification factors**

Service class for bending parallel to grain $K_{2m}$ = **1.00**

Service class for compression $K_{2c}$ = **1.00**

Service class for shear parallel to grain $K_{2s}$ = **1.00**
Service class for modulus of elasticity $K_{2e}$ = **1.00**
Section depth factor $K_7$ = **1.05**
Load sharing factor $K_8$ = **1.10**

**Consider medium term loads**

Load duration factor $K_3$ = **1.25**
Maximum bending moment M = **2.164** kNm
Maximum shear force V = **2.164** kN
Maximum support reaction R = **2.164** kN
Maximum deflection $\delta$ = **8.893** mm

**Check bending stress**

Bending stress $\sigma_m$ = **7.500** N/mm$^2$
Permissible bending stress $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **10.813** N/mm$^2$
Applied bending stress $\sigma_{m\_max}$ = M / Z = **5.421** N/mm$^2$

***PASS - Applied bending stress within permissible limits***

**Check shear stress**

Shear stress $\tau$ = **0.710** N/mm$^2$
Permissible shear stress $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.976** N/mm$^2$
Applied shear stress $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.264** N/mm$^2$

***PASS - Applied shear stress within permissible limits***

**Check bearing stress**

Compression perpendicular to grain (no wane) $\sigma_{cp1}$ = **2.400** N/mm$^2$
Permissible bearing stress $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **3.300** N/mm$^2$
Applied bearing stress $\sigma_{c\_max} = R / (b \times L_b)$ = **0.344** N/mm$^2$

***PASS - Applied bearing stress within permissible limits***

**Check deflection**

Permissible deflection $\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm})$ = **12.000** mm
Bending deflection (based on $E_{mean}$) $\delta_{bending}$ = **8.580** mm
Shear deflection $\delta_{shear}$ = **0.313** mm
Total deflection $\delta = \delta_{bending} + \delta_{shear}$ = **8.893** mm

***PASS - Actual deflection within permissible limits***

**Consider short term loads**

Load duration factor $K_3$ = **1.50**
Maximum bending moment M = **2.584** kNm
Maximum shear force V = **2.584** kN
Maximum support reaction R = **2.584** kN
Maximum deflection $\delta$ = **9.905** mm

**Check bending stress**

Bending stress $\sigma_m$ = **7.500** N/mm$^2$
Permissible bending stress $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **12.976** N/mm$^2$
Applied bending stress $\sigma_{m\_max}$ = M / Z = **6.473** N/mm$^2$

***PASS - Applied bending stress within permissible limits***

**Check shear stress**

Shear stress — $\tau$ = **0.710** N/mm$^2$

Permissible shear stress — $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **1.172** N/mm$^2$

Applied shear stress — $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.316** N/mm$^2$

***PASS - Applied shear stress within permissible limits***

**Check bearing stress**

Compression perpendicular to grain (no wane) — $\sigma_{cp1}$ = **2.400** N/mm$^2$

Permissible bearing stress — $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **3.960** N/mm$^2$

Applied bearing stress — $\sigma_{c\_max} = R / (b \times L_b)$ = **0.410** N/mm$^2$

***PASS - Applied bearing stress within permissible limits***

**Check deflection**

Permissible deflection — $\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm})$ = **12.000** mm

Bending deflection (based on $E_{mean}$) — $\delta_{bending}$ = **9.531** mm

Shear deflection — $\delta_{shear}$ = **0.374** mm

Total deflection — $\delta = \delta_{bending} + \delta_{shear}$ = **9.905** mm

***PASS - Actual deflection within permissible limits***

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

H rolled section **S355**

Calculation in accordance with BS 5950: 1: 2000

LOCATION= **T1**

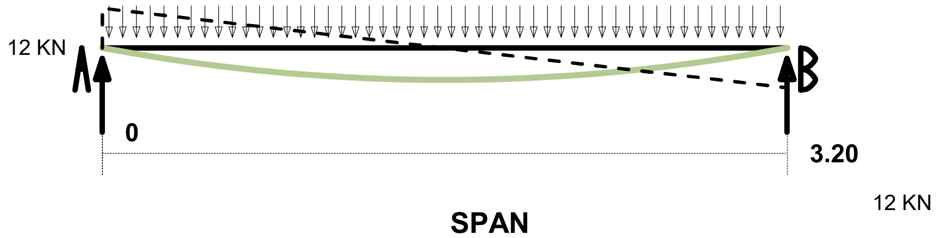
Loads are unfactored

Wd= **2.00** KN/m2

Wl= **0.75** KN/m2

Span= **3.20** m

Cover= **1.80** m




**SPAN**

10 KNm

| Load on beam | unfactored | factored |
|---|---|---|
| **Dead+s/w=** | 3.85 KN/m' | 5.39 KN/m' |
| **Live=** | 1.35 KN/m' | 2.16 KN/m' |
| | 5.20 KN/m' | 7.55 KN/m' |

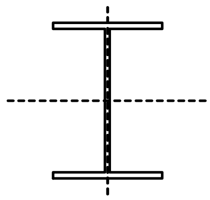
Partial safety factor for load

dead= 1.4

live= 1.6

**Reaction**

| | | | |
|---|---|---|---|
| RA= | 8.3 KN | | **12.1** KN |
| RB= | 8.3 KN | | **12.1** KN |
| Shear zero at | | X= | 1.60 m |
| Maximum Bending Moment | | **Mx =** | **9.7** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 8.9 KNm | Local capacity | **PASS** | 0.185 |
| Maximum BM about axis Y | MY= | 0.89 KNm | Overall buckling 1 | **PASS** | 0.281 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | **PASS** | 0.359 |
| Shear force in x axis | Fv= | 12.1 KN | Deflection (dead)= | **PASS** | 1/ 2940 |
| Beam span | L= | 3.20 m | Deflection(live)= | **PASS** | 1/ 8385 |
| Effective length about axis X | LX eff= | 3.20 m | Deflection (d+l)= | **PASS** | 1/ 2176 |
| Effective length about axis Y | LYeff= | 3.20 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 27 cm3 | | | |

**Section properties**

Section size (Ref. No= **67** ) **203x133 25 kg UB S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 203.2 mm | | | | |
| Width of section | B= | 133.4 mm | Pcy= | 477 KN | | |
| Thickness of web | t= | 5.8 mm | Mcx= | 92.23 KNm | | |
| Thickness of flange | T= | 7.8 mm | Mcy= | 25.34 KNm | | 274.23 |
| Root radius | r= | 7.6 mm | Mb L= | 49.36 KNm | | |
| Second moment of area x-x | Ix= | 2356 cm4 | Mlt= | **0.925** | Pcy= | 476.57 KN |
| Second moment of area y-y | Iy= | 310 cm4 | | | | |
| Plastic modulus x-x | Sx= | 259.8 cm3 | Sx eff= | 227.90 cm3 | | |
| Plastic modulus y-y | Sy= | 71.39 cm3 | Sy eff= | 42.82 cm3 | | |
| Area of section | Ag= | 32.2 cm2 | An= | 29.27 cm2 | ke= 1.1 | |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 1.09 mm | | E UDL= | 3.85 KN/m' |
| Unfactored live load deflection= | **0.38** mm | | E UDL= | 1.35 KN/m' |
| Unfactored dead+ live load def = | 1.47 mm | | E UDL= | 5.20 KN/m' |
| Span/def. ratio for dead load= | 2940 | | | |
| Span/def. ratio for live load= | **8385** | **>360** | | |
| Span/def. ratio fordead+ live load= | 2177 | | | |

CONTINUE OF T1

**Strength of steel** Clause 3.1.1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Design strength | **(Grade S 355 )** | | | | | | |
| for thickness of 7.8 mm | **py=** | **355** | N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | **E=** | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 66.7 mm | | | plastic | compac | semi compact |
| Ratio | b/T= | 8.55 | b/Tlim= | | 7.92 | 8.80 | 13.20 |

The classification is based on the outsatnd element — **The section is class2 compact**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.17 r2=Fc/(Agxpyw)= 0.052

Depth between fillets d= 172.3 mm TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| ratio | d/t= | 29.71 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.21 | d/tlim= | 60.23 | 70.20 | 95.58 |

The classification is based on the general web condition — **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | Av y= | 1179 mm2 | (t x D) | | |
| Shear capacity (0.6pyA) | Pvy= | 251 KN | | | |
| Shear force | Fvy= | 12.1 KN | Fvy/Pvy= | 0.05 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 231.9 cm3 | Mcx1= | 82.32 |
| Plastic modulus | Sx= | 260 cm3 | Mcx2= | 92.23 |
| Moment capacity for section | Mcx= | **92** KNm | | |
| Elastic modulus | Zy= | 46.4 cm3 | Mcy1= | 16.47 |
| Plastic modulus | Sy= | 71 cm3 | mcy2= | 25.34 |
| Moment capacity for section | Mcy= | **25** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.052 + 0.097 + 0.035 = **0.185** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 3200 mm | normal condition |
| Effective length | Lelt2= | 3200 mm | |
| | L e lt= | 3200 mm | |
| Radius of gyration y-y | ry= | 3.1 cm | |
| | rx= | 8.54 cm | |
| | Lam'y= | 103.2 | |
| | La'mx= | 37.5 | |

CONTINUE OF T1

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | | 30.20 TABLE 16 |
| Robertson constant for section | | | | | |
| | a= | 3.5 | for table 23 | b | |
| Perry factor | eta= | 0.31 | | | |
| Euler strength | pe= | 190 | N/mm2 | | |
| Factor | phi= | 302 | N/mm2 | | |
| Compressive strength | pcy= | **148.0** | N/mm2 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 103.2 | | La'mx= | 37.47 | Lamy/x= | 4.064 |
| Slenderness of section | Lamda= | 103.2 | | | | Lamx/x= | 1.4752 |
| Torsional index | x= | 25.4 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.86 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.876 | | | | | |
| Equivalent slenderness | lamlt= | 77.8 | | | | | |
| Buckling strength (Table 16) | pb= | 190 | N/mm2 | for lamlt= | 80 | py= | 355 |
| Buckling resisrance moment | Mb= | 49 | KNm | | | | |
| | Mb L= | 49 | KNm | | | | |
| | Mry= | 25 | KNm | | | | |
| | Pc= | 476.6 | KN | | | | |
| | Pcy= | 476.6 | KN | | | | |

$\frac{Fc}{PC}$ +W $\frac{x\ Mx}{Py\ Zx}$ +W $\frac{y\ My}{py\ Zy}$ = <=1 W x= 0.95, W y= 0.95

0.126 + 0.103 + 0.052 = **0.281** **The interaction formula is satisfied**

$\frac{Fc}{Pcy}$ +W $\frac{LT\ M\ lt}{Mb}$ +W $\frac{y\ My}{py\ Zy}$ = <=1

0.126 + 0.181 + 0.052 = **0.359** **The interaction formula is satisfied**

| ♦ David Smith Associates LLP♦ 8 Duncan Close ♦ Moulton Park ♦ Northampton NN3 6WL Tel: (01604) 782620 ♦ Fax: (01604) 782629 E-mail: post@dsagroup.co.uk | Project No: | 24/54904 | Sheet No: | 101 |
|---|---|---|---|---|
| | Made By: | OAM | Revision: | |
| | Date: | Mar-24 | Checked By: | TG |

**Project:** 38 SKEENA HILL, LONDON

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

LOCATION= **T2** SPAN= **4.20** m **S275**
Uniform distributed load COVER= **0.60** m

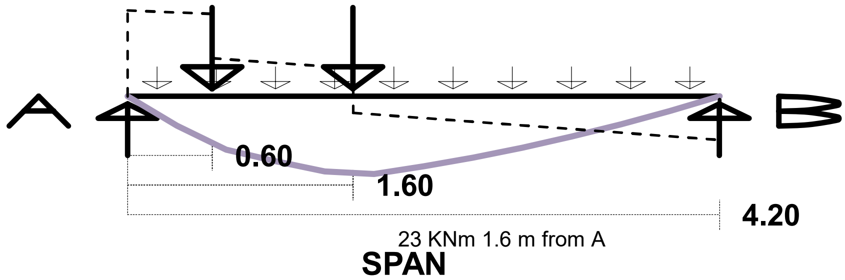
| | Unfactored | | Factored | |
|---|---|---|---|---|
| wdl= | **2.00** KN/m2 | | ( **2.80** ) | |
| wll = | **0.75** KN/m2 | | ( **1.20** ) | |
| | **2.75** | | **4.00** | KN/m2 |
| | | factor= | **1.45** | |

**H rolled section**
**Calculation in accordance with BS 5950: 1: 2000**

Point load

| | | | | |
|---|---|---|---|---|
| **P1=** | **8.40** | KN | ( **12.6** | )KN |
| **a1=** | **0.60** | m | | |
| **P2=** | **8.4** | KN | ( **12.60** | )KN |
| **a2=** | **1.60** | **m** | | |

Partial safety factor for load
dead= 1.4
live= 1.6




| | Unfactored | (Factored ) |
|---|---|---|
| Wd= | 1.45 KN/m' | ( 2.03 ) |
| Wl = | 0.45 kKN/m' | ( 0.72 ) |
| | 1.9 KN/m' | **2.75** KN/m' |

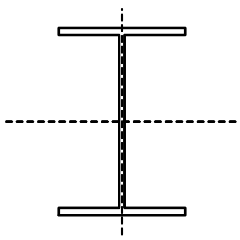
**Reactions**

| | | |
|---|---|---|
| **RA=** | 16.39 KN | ( **24.4** KN |
| **RB=** | 8.39 KN | ( **12.4** KN |

Desidn bending moment(factored)=

| | | |
|---|---|---|
| M@P1 = | **14.1** | KNm |
| M@P2 = | **22.9** | KNm |
| X= | **1.60** | m from A |
| M@ X= | **22.9** | KNm |
| **DBM=** | **22.9** | **KNm** |

Eq. udl = 10.376 KN/m' (factored)
Eq. ud l= 1.8866 IKN/m' (live unfactored)



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 19.0 KNm | Local capacity | **PASS** | 0.391 |
| Maximum BM about axis Y | MY= | 1.90 KNm | Overall buckling 1 | **PASS** | 0.519 |
| Axial compressive load | Fc= | 24.38 KN | Overall buckling 2 | **PASS** | 0.821 |
| Shear force in x axis | Fv= | 24.4 KN | Deflection (dead)= | **PASS** | 1/ 1684 |
| Beam span | L= | 4.20 m | Deflection(live)= | **PASS** | 1/ 4903 |
| Effective length about axis X | LX eff= | 4.20 m | Deflection (d+l)= | **PASS** | 1/ 1253 |
| Effective length about axis Y | LYeff= | 4.20 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 69 cm3 | | | |

**Section properties**

Section size (Ref. No= **67** ) **203x133 25 kg 25 S275**

| | | | | | |
|---|---|---|---|---|---|
| Depth of steel section | D= | 203.2 mm | | | |
| Width of section | B= | 133.4 mm | | | |
| Thickness of web | t= | 5.8 mm | Mcx= | 71.45 KNm | |
| Thickness of flange | T= | 7.8 mm | Mcy= | 19.63 KNm | |
| Root radius | r= | 7.8 mm | Mb L= | 32.48 KNm | |
| Second moment of area x-x | Ix= | 2356 cm4 | mlt= | **0.831** AUTO | |
| Second moment of area y-y | Iy= | 310 cm4 | | | |
| Plastic modulus x-x | Sx= | 259.8 cm3 | Sx eff= | 222.60 cm3 | |
| Plastic modulus y-y | Sy= | 71.39 cm3 | Sy eff= | 38.07 cm3 | |
| Area of section | Ag= | 32.2 cm2 | An= | 26.83 cm2 | ke= 1.2 |

CONTINUE OF T2

**DEFLECTION**

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | unfactored | | |
| Unfactored dead load deflection= | 2.49 | mm | | E UDL= | 5.28 | KN/m' |
| Unfactored live load deflection= | 0.86 | mm | | E UDL= | 1.89 | KN/m' |
| Unfactored dead+ live load def = | 3.35 | mm | | E UDL= | 7.17 | KN/m' |
| Span/def. ratio for dead load= | 1684 | | | | | |
| Span/def. ratio for live load= | **4904** | | **>360** | | | |
| Span/def. ratio fordead+ live load= | 1254 | | | | | |

**Strength of steel** Clause 3.1.1

Design strength **(Grade S 275 )**

for thickness of 7.8 mm **py=** **275** N/mm2 py= **275.0** N/mm2 pyw= py

Young's Modulus **E=** 205 KN/mm2

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Constant | ε = | 1.000 | | | class 1 | class 2 | class 3 | |
| Outstand of flange | b= | 56 | mm | | plastic | compac | semi compact | |
| Ratio | b/T= | 7.18 | | b/Tlim= | 9.00 | 10.00 | 15.00 | |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 1.00 r2=Fc/(Agxpyw)= 0.028

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | TABLE 11 rolled section | | |
| Depth between fillets | d= | 172.3 | mm | | | | |
| ratio | d/t= | 29.71 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 40 | | d/tlim= | 40.00 | 40.00 | 113.74 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shear area | | Av y= | 1178.6 | mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 194 | KN | | | |
| Shear force | | Fvy= | 24.4 | KN | Fvy/Pvy= | 0.13 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 231.9 | cm3 | Mcx1= | 63.77 |
| Plastic modulus | Sx= | 260 | cm3 | Mcx2= | 71.45 |
| Moment capacity for section | Mcx= | **71.4** | KNm | | |
| Elastic modulus | Zy= | 46.4 | cm3 | Mcy1= | 12.76 |
| Plastic modulus | Sy= | 71.4 | cm3 | mcy2= | 19.63 |
| Moment capacity for section | Mcy= | **19.6** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \le 1$$

0.028 + 0.266 + 0.097 = **0.391** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 4200 | mm | normal condition |
| Effective length | Lelt2= | 4200 | mm | |
| | L e lt= | 4200 | mm | |
| Radius of gyration y-y | ry= | 3.1 | cm | |
| | rx= | 8.54 | cm | |
| | Lam'y= | 135.5 | | |
| | La'mx= | 49.2 | | |

CONTINUE OF T2

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 17.16 | | py= | 275 N/mm2 |
| For buckling about y-y | | | | λ L0= | 34.80 TABLE 16 |
| Robertson constant for H section | | | | | |
| | a= | 5.5 | | | |
| Perry factor | eta= | 0.65 | | | |
| Euler strength | pe= | 110 | N/mm2 | | |
| Factor | phi= | 228 | N/mm2 | | |
| Compressive strength | pcy= | **80.5** | N/mm2 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 135.5 | La'mx= | 49.18 | | Lamy/x= | 5.334 |
| Slenderness of section | Lamda= | 135.5 | | | | Lamx/x= | 1.9362 |
| Torsional index | x= | 25.4 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.82 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.876 | | | | | |
| Equivalent slenderness | lamlt= | 97.3 | | | | | |
| Buckling strength (Table 16) | pb= | 125 | N/mm2 | for lamlt= | 100 | py= | 275 |
| Buckling resisrance moment | Mb= | 32.5 | KNm | | | | |
| | Mb L= | 32.5 | KNm | | | | |
| | Mry= | 19.6 | KNm | | | | |
| | Pc= | 259.28 | KN | | | | |
| | Pcy= | 259.28 | KN | | | | |

Fc / PC +W x Mx / Py Zx +W y My / py Zy = <=1 W x= 0.95, W y= 0.95

0.094 + 0.283 + 0.142 = **0.519** **The interaction formula is satisfied**

Fc / Pcy +W LT M lt / Mb +W y My / py Zy = <=1

0.094 + 0.586 + 0.142 = **0.821** **The interaction formula is satisfied**

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|---|---|---|---|---|
| | Made By: | OAM | Revision: | |
| | Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

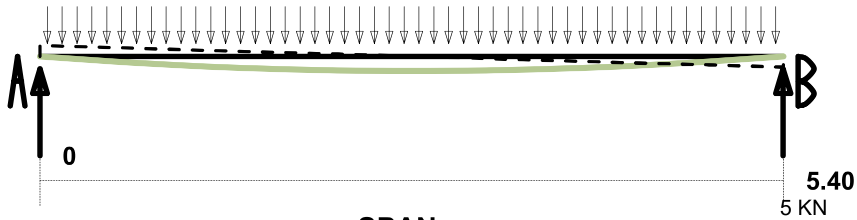
H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= T3

Loads are unfactored

Wd= **0.80** KN/m2
Wl= **0.75** KN/m2

Span= **5.40** m
Cover= **0.60** m

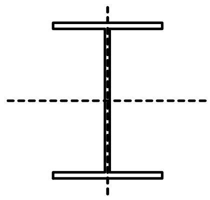



| Load on beam | unfactored | factored |
|---|---|---|
| **Dead+s/w=** | 0.73 KN/m' | 1.02 KN/m' |
| **Live=** | 0.45 KN/m' | 0.72 KN/m' |
| | 1.18 KN/m' | 1.74 KN/m' |

6 KNm
Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | | | |
|---|---|---|---|
| RA= | 3.2 KN | | **4.7** KN |
| RB= | 3.2 KN | | **4.7** KN |
| Shear zero at | | X= | 2.70 m |
| Maximum Bending Moment | | **Mx =** | **6.3** KNm |



SECTION

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 5.9 KNm | Local capacity | PASS | 0.139 |
| Maximum BM about axis Y | MY= | 0.59 KNm | Overall buckling 1 | PASS | 0.416 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.552 |
| Shear force in x axis | Fv= | 4.7 KN | Deflection (dead)= | PASS | 1/ 3226 |
| Beam span | L= | 5.40 m | Deflection(live)= | PASS | 1/ 5234 |
| Effective length about axis X | LX eff= | 5.40 m | Deflection (d+l)= | PASS | 1/ 1996 |
| Effective length about axis Y | LYeff= | 5.40 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 18 cm3 | | | |

**Section properties**

Section size (Ref. No= **67** ) **203x133 25 kg UB S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 203.2 mm | | | | |
| Width of section | B= | 133.4 mm | Pcy= | 191 KN | | |
| Thickness of web | t= | 5.8 mm | Mcx= | 92.23 KNm | | |
| Thickness of flange | T= | 7.8 mm | Mcy= | 25.34 KNm | | 160.21 |
| Root radius | r= | 7.6 mm | Mb L= | 28.84 KNm | | |
| Second moment of area x-x | Ix= | 2356 cm4 | Mlt= | **0.925** | Pcy= | 190.76 KN |
| Second moment of area y-y | Iy= | 310 cm4 | | | | |
| Plastic modulus x-x | Sx= | 259.8 cm3 | Sx eff= | 227.90 cm3 | | |
| Plastic modulus y-y | Sy= | 71.39 cm3 | Sy eff= | 42.82 cm3 | | |
| Area of section | Ag= | 32.2 cm2 | An= | 29.27 cm2 | ke= 1.1 | |

**DEFLECTION**

| | | | unfactored |
|---|---|---|---|
| Unfactored dead load deflection= | 1.67 mm | | E UDL= 0.73 KN/m' |
| Unfactored live load deflection= | 1.03 mm | | E UDL= 0.45 KN/m' |
| Unfactored dead+ live load def = | 2.70 mm | | E UDL= 1.18 KN/m' |
| Span/def. ratio for dead load= | 3227 | | |
| Span/def. ratio for live load= | **5235** | **>360** | |
| Span/def. ratio fordead+ live load= | 1996 | | |

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| Project No: | 24/54720 | Sheet No: | 105 |
|---|---|---|---|
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

CONTINUE OF T3

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** | **)** | | | | | |
| for thickness of | 7.8 mm | **py=** | **355** | N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 66.7 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 8.55 | | b/Tlim= | 7.92 | 8.80 | 13.20 |

The classification is based on the outsatnd element — **The section is class2 compact**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.17 — r2=Fc/(Agxpyw)= 0.052

Depth between fillets TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Depth between fillets | d= | 172.3 | mm | | | | |
| ratio | d/t= | 29.71 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.21 | | d/tlim= | 60.23 | 70.20 | 95.58 |

The classification is based on the general web condition — **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shear area | | Av y= | 1179 | mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 251 | KN | | | |
| Shear force | | Fvy= | 4.7 | KN | Fvy/Pvy= | 0.02 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 231.9 | cm3 | Mcx1= | 82.32 |
| Plastic modulus | Sx= | 260 | cm3 | Mcx2= | 92.23 |
| Moment capacity for section | Mcx= | **92** | KNm | | |
| Elastic modulus | Zy= | 46.4 | cm3 | Mcy1= | 16.47 |
| Plastic modulus | Sy= | 71 | cm3 | mcy2= | 25.34 |
| Moment capacity for section | Mcy= | **25** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.052 + 0.064 + 0.023 = **0.139** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 5400 | mm | normal condition |
| Effective length | Lelt2= | 5400 | mm | |
| | L e lt= | 5400 | mm | |
| Radius of gyration y-y | ry= | 3.1 | cm | |
| | rx= | 8.54 | cm | |
| | Lam'y= | 174.2 | | |
| | La'mx= | 63.2 | | |

CONTINUE OF T3

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 | N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 | TABLE 16 |
| Robertson constant for section | | | | | | |
| | a= | 3.5 | for table 23 | b | | |
| Perry factor | eta= | 0.56 | | | | |
| Euler strength | pe= | 67 | N/mm2 | | | |
| Factor | phi= | 229 | N/mm2 | | | |
| Compressive strength | pcy= | **59.2** | N/mm2 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lam'y= | 174.2 | | La'mx= | 63.23 | | Lamy/x= | 6.858 |
| Slenderness of section | Lamda= | 174.2 | | | | | Lamx/x= | 2.4894 |
| Torsional index | x= | 25.4 | | | | | | |
| | N= | 0.5 | | | | | | |
| Slenderness factor | v= | 0.74 | from Table 19 | | | | | |
| | β w = | 1.0 | | | | | | |
| Buckling parameter | u= | 0.876 | | | | | | |
| Equivalent slenderness | lamlt= | 112.8 | | | | | | |
| Buckling strength (Table 16) | pb= | 111 | N/mm2 | for lamlt= | 115 | | py= | 355 |
| Buckling resisrance moment | Mb= | 29 | KNm | | | | | |
| | Mb L= | 29 | KNm | | | | | |
| | Mry= | 25 | KNm | | | | | |
| | Pc= | 190.8 | KN | | | | | |
| | Pcy= | 190.8 | KN | | | | | |

$\frac{Fc}{PC} + W \frac{x\ Mx}{Py\ Zx} + W \frac{y\ My}{py\ Zy} = \leq 1$ W x= 0.95, W y= 0.95

0.315 + 0.068 + 0.034 = **0.416** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + W \frac{LT\ M\ lt}{Mb} + W \frac{y\ My}{py\ Zy} = \leq 1$

0.315 + 0.204 + 0.034 = **0.552** **The interaction formula is satisfied**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

LOCATION= **E1** SPAN= **4.00** m **S355**
Uniform distributed load COVER= **0.60** m

| | Unfactored | | Factored | |
|---|---|---|---|---|
| wdl= | **3.11** | KN/m2 | ( **4.35** ) | |
| wll = | **0.30** | KN/m2 | ( **0.48** ) | |
| | **3.41** | | **4.83** | KN/m2 |
| | | factor= | **1.42** | |

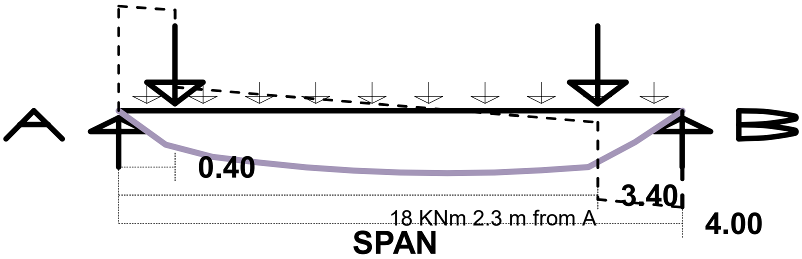
**H rolled section**
**Calculation in accordance with BS 5950: 1: 2000**

Point load

| | | | | |
|---|---|---|---|---|
| **P1=** | **14.60** | KN | ( **21.9** | )KN |
| **a1=** | **0.40** | m | | |
| **P2=** | **14.6** | KN | ( **21.90** | )KN |
| **a2=** | **3.40** | **m** | | |

Partial safety factor for load
dead= 1.4
live= 1.6

30 KN




27 KN

| | Unfactored | | (Factored ) | |
|---|---|---|---|---|
| Wd= | 2.17 | KN/m' | ( 3.03 ) | |
| Wl = | 0.18 | kKN/m' | ( 0.29 ) | |
| | 2.346 | KN/m' | **3.32** | KN/m' |

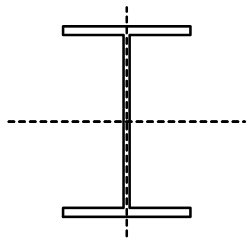
**Reactions**

| | | | | |
|---|---|---|---|---|
| **RA=** | 20.022 | KN | ( **29.6** | KN |
| **RB=** | 18.562 | KN | ( **27.4** | KN |

Desidn bending moment(factored)=

| | | |
|---|---|---|
| M@P1 = | **11.6** | KNm |
| M@P2 = | **15.9** | KNm |
| X= | **2.33** | m from A |
| M@ X= | **17.8** | KNm |
| **DBM=** | **17.8** | **KNm** |

Eq. udl = 8.8857 KN/m' (factored)
Eq. ud l= 0.5212 lKN/m' (live unfactored)



**SECTION**

| | | | | | | factor |
|---|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 17.1 | KNm | Local capacity | **PASS** | 0.231 |
| Maximum BM about axis Y | MY= | 1.71 | KNm | Overall buckling 1 | **PASS** | 0.323 |
| Axial compressive load | Fc= | 29.64 | KN | Overall buckling 2 | **PASS** | 0.497 |
| Shear force in x axis | Fv= | 29.6 | KN | Deflection (dead)= | **PASS** | 1/ 1993 |
| Beam span | L= | 4.00 | m | Deflection(live)= | **PASS** | 1/ 22570 |
| Effective length about axis X | LX eff= | 4.00 | m | Deflection (d+l)= | **PASS** | 1/ 1831 |
| Effective length about axis Y | LYeff= | 4.00 | m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** | or 14 mm | | | |
| | z rep= | 48 | cm3 | | | |

**Section properties**

Section size (Ref. No= **66** ) **203x133 30 kg UB S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 206.8 | mm | | | |
| Width of section | B= | 133.8 | mm | | | |
| Thickness of web | t= | 6.3 | mm | Mcx= | 111.2 | KNm |
| Thickness of flange | T= | 9.6 | mm | Mcy= | 31.26 | KNm |
| Root radius | r= | 9.6 | mm | Mb L= | 50.75 | KNm |
| Second moment of area x-x | Ix= | 2887 | cm4 | mlt= | **0.964** | AUTO |
| Second moment of area y-y | Iy= | 384 | cm4 | | | |
| Plastic modulus x-x | Sx= | 313.3 | cm3 | Sx eff= | 267.97 | cm3 |
| Plastic modulus y-y | Sy= | 88.05 | cm3 | Sy eff= | 47.18 | cm3 |
| Area of section | Ag= | 38 | cm2 | An= | 34.55 | cm2 ke= 1.1 |

CONTINUE OF E1

**DEFLECTION** unfactored

| | | | | | | |
|---|---|---|---|---|---|---|
| Unfactored dead load deflection= | 2.01 | mm | | E UDL= | 5.76 | KN/m' |
| Unfactored live load deflection= | 0.18 | mm | | E UDL= | 0.52 | KN/m' |
| Unfactored dead+ live load def = | 2.18 | mm | | E UDL= | 6.28 | KN/m' |
| Span/def. ratio for dead load= | 1994 | | | | | |
| Span/def. ratio for live load= | **22570** | | **>360** | | | |
| Span/def. ratio fordead+ live load= | 1832 | | | | | |

**Strength of steel** Clause 3.1.1

Design strength **(Grade S 355 )**

for thickness of 9.6 mm **py=** **355** N/mm2 py= **355.0** N/mm2 pyw= py

Young's Modulus **E=** 205 KN/mm2

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 54.15 mm | | | plastic | compac | semi compact |
| Ratio | b/T= | 5.64 | b/Tlim= | | 7.92 | 8.80 | 13.20 |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 1.00 r2=Fc/(Agxpyw)= 0.022

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth between fillets | d= | 172.3 mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 27.35 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.206 | d/tlim= | 35.21 | 35.21 | 101.17 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | |
|---|---|---|---|---|
| Shear area | Av y= | 1302.8 mm2 | (t x D) | |
| Shear capacity (0.6pyA) | Pvy= | 278 KN | | |
| Shear force | Fvy= | 29.6 KN | Fvy/Pvy= 0.11 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 279.3 cm3 | Mcx1= | 99.15 |
| Plastic modulus | Sx= | 313 cm3 | Mcx2= | 111.2 |
| Moment capacity for section | Mcx= | **111.2** KNm | | |
| Elastic modulus | Zy= | 57.4 cm3 | Mcy1= | 20.38 |
| Plastic modulus | Sy= | 88.1 cm3 | mcy2= | 31.26 |
| Moment capacity for section | Mcy= | **31.3** KNm | | |

**Local capacity check Clause 4.8.3.2**

$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \leq 1$

0.022 + 0.154 + 0.055 = **0.231** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 4000 mm | normal condition |
| Effective length | Lelt2= | 4000 mm | |
| | L e lt= | 4000 mm | |
| Radius of gyration y-y | ry= | 3.18 cm | |
| | rx= | 8.72 cm | |
| | Lam'y= | 125.8 | |
| | La'mx= | 45.9 | |

CONTINUE OF E1

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 | | |
| For buckling about y-y | | | | λ L0= | 30.20 TABLE 16 | | |
| Robertson constant for H section | | | | | | | |
| | a= | 5.5 | | | | | |
| Perry factor | eta= | 0.61 | | | | | |
| Euler strength | pe= | 128 | N/mm2 | | | | |
| Factor | phi= | 280 | N/mm2 | | | | |
| Compressive strength | pcy= | **98.1** | N/mm2 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 125.8 | | La'mx= | 45.87 | Lamy/x= | 5.8505 |
| Slenderness of section | Lamda= | 125.8 | | | | Lamx/x= | 2.1336 |
| Torsional index | x= | 21.5 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.77 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.882 | | | | | |
| Equivalent slenderness | lamlt= | 85.4 | | | | | |
| Buckling strength (Table 16) | pb= | 162 | N/mm2 | for lamlt= | 90 | py= | 355 |
| Buckling resisrance moment | Mb= | 50.8 | KNm | | | | |
| | Mb L= | 50.8 | KNm | | | | |
| | Mry= | 31.3 | KNm | | | | |
| | Pc= | 372.91 | KN | | | | |
| | Pcy= | 372.91 | KN | | | | |

$\frac{Fc}{PC} + W\frac{x\,Mx}{Py\,Zx} + W\frac{y\,My}{py\,Zy} = \;<=1$  W x= 0.95, W y= 0.95

0.079 + 0.164 + 0.080 = **0.323** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + W\frac{LT\,M\,lt}{Mb} + W\frac{y\,My}{py\,Zy} = \;<=1$

0.079 + 0.337 + 0.080 = **0.497** **The interaction formula is satisfied**

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| Project No: | 24/54720 | Sheet No: | 110 |
|---|---|---|---|
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

LOCATION= **FB1.08** SPAN= **8.60** m **S355**
Uniform distributed load COVER= **2.50** m

| | Unfactored | | Factored | |
|---|---|---|---|---|
| wdl= | **0.60** KN/m2 | ( | **0.84** | ) |
| wll = | **1.50** KN/m2 | ( | **2.40** | ) |
| | **2.10** | | **3.24** | KN/m2 |
| | factor= | | **1.54** | |

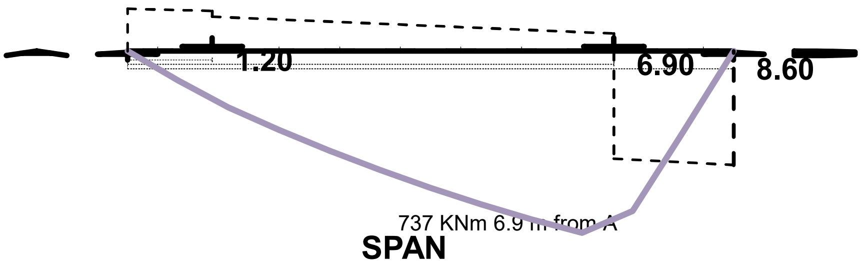
**H rolled section**
**Calculation in accordance**
**with BS 5950: 1: 2000**

Point load

| | | | | |
|---|---|---|---|---|
| **P1=** | **15.00** | KN | ( **22.5** | )KN |
| **a1=** | **1.20** | m | | |
| **P2=** | **325.0** | KN | ( **487.50** | )KN |
| **a2=** | **6.90** | **m** | | |

Partial safety factor for load
dead= 1.4
live= 1.6

165 KN




444 KN

| | Unfactored | | (Factored ) | |
|---|---|---|---|---|
| Wd= | 3.90 KN/m' | ( | 5.46 | ) |
| Wl = | 3.75 kKN/m' | ( | 6.00 | ) |
| | 7.65 KN/m' | | **11.46** | KN/m' |

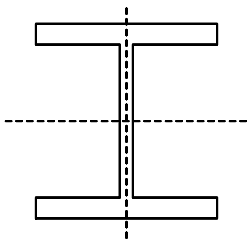
**Reactions**

| | | | | |
|---|---|---|---|---|
| **RA=** | 110.05 KN | ( | **165.0** | KN |
| **RB=** | 295.74 KN | ( | **443.6** | KN |

Desidn bending moment(factored)=

| | | |
|---|---|---|
| M@P1 = | **189.8** | KNm |
| M@P2 = | **737.5** | KNm |
| X= | **6.90** | m from A |
| M@ X= | **737.5** | KNm |
| **DBM=** | **737.5** | **KNm** |

Eq. udl = 79.77 KN/m' (factored)
Eq. ud l= 37.986 lKN/m' (live unfactored)



**SECTION**

| | | | | | | factor |
|---|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 566.6 KNm | Local capacity | **PASS** | | 0.487 |
| Maximum BM about axis Y | MY= | 56.66 KNm | Overall buckling 1 | **PASS** | | 0.593 |
| Axial compressive load | Fc= | 165.00 KN | Overall buckling 2 | **PASS** | | 0.663 |
| Shear force in x axis | Fv= | 443.6 KN | Deflection (dead)= | **PASS** | | 1/ 1440 |
| Beam span | L= | 8.60 m | Deflection(live)= | **PASS** | | 1/ 736 |
| Effective length about axis X | LX eff= | 8.60 m | Deflection (d+l)= | **PASS** | | 1/ 487 |
| Effective length about axis Y | LYeff= | 8.60 m | Fully restraint for Ly& LX <1. | | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | | |
| | z rep= | 1642 cm3 | | | | |

**Section properties**

Section size (Ref. No= **84** ) **305x305 240 kg UC S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 352.6 mm | | |
| Width of section | B= | 317.9 mm | | |
| Thickness of web | t= | 23 mm | Mcx= | 1465 KNm |
| Thickness of flange | T= | 37.7 mm | Mcy= | 671.7 KNm |
| Root radius | r= | 37.7 mm | Mb L= | 1138 KNm |
| Second moment of area x-x | Ix= | 64177 cm4 | mlt= | **0.768** AUTO |
| Second moment of area y-y | Iy= | 20239 cm4 | | |
| Plastic modulus x-x | Sx= | 4245 cm3 | Sx eff= | 3439.67 cm3 |
| Plastic modulus y-y | Sy= | 1947 cm3 | Sy eff= | 1048.33 cm3 |
| Area of section | Ag= | 305.6 cm2 | An= | 277.82 cm2 ke= 1.1 |

CONTINUE OF FB1.08

**DEFLECTION**

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | unfactored | |
| Unfactored dead load deflection= | 5.97 | mm | | E UDL= | 15.26 | KN/m' |
| Unfactored live load deflection= | 11.67 | mm | | E UDL= | 37.99 | KN/m' |
| Unfactored dead+ live load def = | 17.64 | mm | | E UDL= | 53.25 | KN/m' |
| Span/def. ratio for dead load= | 1441 | | | | | |
| Span/def. ratio for live load= | **737** | | **>360** | | | |
| Span/def. ratio fordead+ live load= | 488 | | | | | |

**Strength of steel** Clause 3.1.1

Design strength **(Grade S 355 )**

for thickness of 37.7 mm **py=** **345** N/mm2 py= **345.0** N/mm2 pyw= py

Young's Modulus **E=** 205 KN/mm2

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | ε = | 0.893 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 109.75 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 2.91 | | b/Tlim= | 8.04 | 8.93 | 13.39 |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 1.00 r2=Fc/(Agxpyw)= 0.016

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | TABLE 11 rolled section | | |
| Depth between fillets | d= | 246.6 | mm | | | | |
| ratio | d/t= | 10.72 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.712 | | d/tlim= | 35.71 | 35.71 | 103.88 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | | |
|---|---|---|---|---|---|---|
| Shear area | | Av y= | 8109.8 | mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 1679 | KN | | |
| Shear force | | Fvy= | 443.6 | KN | Fvy/Pvy= 0.26 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 3641 | cm3 | Mcx1= | 1256 |
| Plastic modulus | Sx= | 4245 | cm3 | Mcx2= | 1465 |
| Moment capacity for section | Mcx= | **1464.5** | KNm | | |
| Elastic modulus | Zy= | 1273 | cm3 | Mcy1= | 439.2 |
| Plastic modulus | Sy= | 1947.0 | cm3 | mcy2= | 671.7 |
| Moment capacity for section | Mcy= | **671.7** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = <=1$

0.016 + 0.387 + 0.084 = **0.487** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 8600 | mm | normal condition |
| Effective length | Lelt2= | 8600 | mm | |
| | L e lt= | 8600 | mm | |
| Radius of gyration y-y | ry= | 8.14 | cm | |
| | rx= | 14.5 | cm | |
| | Lam'y= | 105.7 | | |
| | La'mx= | 59.3 | | |

CONTINUE OF FB1.08

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.32 | | py= | 345 N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.60 TABLE 16 |
| Robertson constant for H section | | | | | |
| | a= | 5.5 | | | |
| Perry factor | eta= | 0.50 | | | |
| Euler strength | pe= | 181 | N/mm2 | | |
| Factor | phi= | 308 | N/mm2 | | |
| Compressive strength | pcy= | **128.1** | N/mm2 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 105.7 | | La'mx= | 59.31 | Lamy/x= | 12.102 |
| Slenderness of section | Lamda= | 105.7 | | | | Lamx/x= | 6.7939 |
| Torsional index | x= | 8.73 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.58 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.854 | | | | | |
| Equivalent slenderness | lamlt= | 52.3 | | | | | |
| Buckling strength (Table 16) | pb= | 268 | N/mm2 | for lamlt= | 55 | py= | 345 |
| Buckling resisrance moment | Mb= | 1137.7 | KNm | | | | |
| | Mb L= | 1137.7 | KNm | | | | |
| | Mry= | 671.7 | KNm | | | | |
| | Pc= | 3914.3 | KN | | | | |
| | Pcy= | 3914.3 | KN | | | | |

$\frac{Fc}{PC} + W\frac{x\,Mx}{Py\,Zx} + W\frac{y\,My}{py\,Zy} = \le 1$ W x= 0.95, W y= 0.95

0.042 + 0.429 + 0.123 = **0.593** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + W\frac{LT\,M\,lt}{Mb} + W\frac{y\,My}{py\,Zy} = \le 1$

0.042 + 0.498 + 0.123 = **0.663** **The interaction formula is satisfied**

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**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.NO WORK SHOULD START BEFORE THE CALCULATIONS HAVE BEEN RECEIVED AND APPROVED BY THE LA BUILDING CONTROL.**

**FIRST FLOOR LEVEL**

**STEEL BEAM** **FB1.09**

Max span = 8.6 m
Cover= 3.5 m

**USE 305x305x240 UC** **S355** SEE PAGE 114 - 116

**STEEL BEAM** **FB1.10**

Max span = 3.2 m
Cover= 2.5 m

**USE 203x133x30 UB** **S355** SEE PAGE 117 - 119

go to page 120

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 114 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

LOCATION= **FB1.09** SPAN= **8.60** m **S355**
Uniform distributed load COVER= **3.50** m

| | Unfactored | | Factored | |
|---|---|---|---|---|
| wdl= | **0.60** | KN/m2 | ( **0.84** ) | |
| wll = | **1.50** | KN/m2 | ( **2.40** ) | |
| | **2.10** | | **3.24** | KN/m2 |
| | | factor= | **1.54** | |

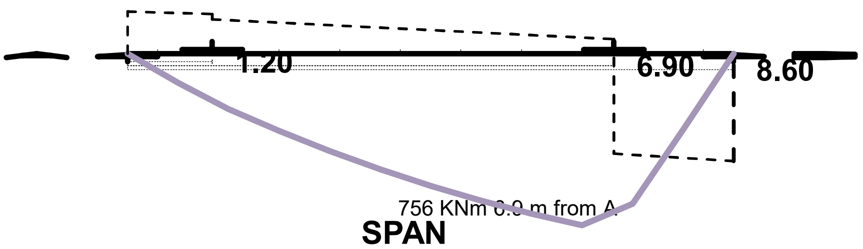
**H rolled section**
**Calculation in accordance**
**with BS 5950: 1: 2000**

Point load

| | | | | |
|---|---|---|---|---|
| **P1=** | **15.00** | KN | ( **22.5** | )KN |
| **a1=** | **1.20** | m | | |
| **P2=** | **325.0** | KN | ( **487.50** | )KN |
| **a2=** | **6.90** | **m** | | |

Partial safety factor for load
dead= 1.4
live= 1.6

179 KN




457 KN

**SPAN**

| | Unfactored | | (Factored ) | |
|---|---|---|---|---|
| Wd= | 4.50 | KN/m' | ( 6.30 ) | |
| Wl = | 5.25 | kKN/m' | ( 8.40 ) | |
| | 9.75 | KN/m' | **14.70** | KN/m' |

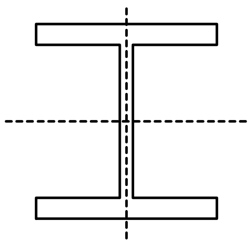
**Reactions**

| | | | | |
|---|---|---|---|---|
| **RA=** | 119.08 | KN | ( **178.9** | KN |
| **RB=** | 304.77 | KN | ( **457.5** | KN |

Desidn bending moment(factored)=

| | | |
|---|---|---|
| M@P1 = | **204.1** | KNm |
| M@P2 = | **756.5** | KNm |
| X= | **6.90** | m from A |
| M@ X= | **756.5** | KNm |
| **DBM=** | **756.5** | **KNm** |

Eq. udl = 81.826 KN/m' (factored)
Eq. ud l= 38.965 lKN/m' (live unfactored)



**SECTION**

| | | | | | | factor |
|---|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 592.1 | KNm | Local capacity | **PASS** | 0.509 |
| Maximum BM about axis Y | MY= | 59.21 | KNm | Overall buckling 1 | **PASS** | 0.622 |
| Axial compressive load | Fc= | 178.94 | KN | Overall buckling 2 | **PASS** | 0.694 |
| Shear force in x axis | Fv= | 457.5 | KN | Deflection (dead)= | **PASS** | 1/ 1366 |
| Beam span | L= | 8.60 | m | Deflection(live)= | **PASS** | 1/ 688 |
| Effective length about axis X | LX eff= | 8.60 | m | Deflection (d+l)= | **PASS** | 1/ 457 |
| Effective length about axis Y | LYeff= | 8.60 | m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** | or 14 mm | | | |
| | z rep= | 1716 | cm3 | | | |

**Section properties**

Section size (Ref. No= **84** ) **305x305 240 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 352.6 | mm | | | |
| Width of section | B= | 317.9 | mm | | | |
| Thickness of web | t= | 23 | mm | Mcx= | 1465 | KNm |
| Thickness of flange | T= | 37.7 | mm | Mcy= | 671.7 | KNm |
| Root radius | r= | 37.7 | mm | Mb L= | 1138 | KNm |
| Second moment of area x-x | Ix= | 64177 | cm4 | mlt= | **0.783** | AUTO |
| Second moment of area y-y | Iy= | 20239 | cm4 | | | |
| Plastic modulus x-x | Sx= | 4245 | cm3 | Sx eff= | 3439.67 | cm3 |
| Plastic modulus y-y | Sy= | 1947 | cm3 | Sy eff= | 1048.33 | cm3 |
| Area of section | Ag= | 305.6 | cm2 | An= | 277.82 | cm2 |

ke= 1.1

CONTINUE OF FB1.09

**DEFLECTION** unfactored

| | | | | | | |
|---|---|---|---|---|---|---|
| Unfactored dead load deflection= | 6.29 | mm | | E UDL= | 15.31 | KN/m' |
| Unfactored live load deflection= | 12.48 | mm | | E UDL= | 38.96 | KN/m' |
| Unfactored dead+ live load def = | 18.78 | mm | | E UDL= | 54.27 | KN/m' |
| Span/def. ratio for dead load= | 1367 | | | | | |
| Span/def. ratio for live load= | **689** | | **>360** | | | |
| Span/def. ratio fordead+ live load= | 458 | | | | | |

**Strength of steel** Clause 3.1.1

Design strength **(Grade S 355 )**

for thickness of 37.7 mm **py=** **345** N/mm2 py= **345.0** N/mm2 pyw= py

Young's Modulus **E=** 205 KN/mm2

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Constant | ε = | 0.893 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 109.75 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 2.91 | | b/Tlim= | 8.04 | 8.93 | 13.39 |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 1.00 r2=Fc/(Agxpyw)= 0.017

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Depth between fillets | d= | 246.6 | mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 10.72 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.712 | | d/tlim= | 35.71 | 35.71 | 103.62 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | | |
|---|---|---|---|---|---|---|
| Shear area | Av y= | 8109.8 | mm2 | (t x D) | | |
| Shear capacity (0.6pyA) | Pvy= | 1679 | KN | | | |
| Shear force | Fvy= | 457.5 | KN | Fvy/Pvy= | 0.27 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 3641 | cm3 | Mcx1= | 1256 |
| Plastic modulus | Sx= | 4245 | cm3 | Mcx2= | 1465 |
| Moment capacity for section | Mcx= | **1464.5** | KNm | | |
| Elastic modulus | Zy= | 1273 | cm3 | Mcy1= | 439.2 |
| Plastic modulus | Sy= | 1947.0 | cm3 | mcy2= | 671.7 |
| Moment capacity for section | Mcy= | **671.7** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$\frac{F}{Ag.\ py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = <=1$

0.017 + 0.404 + 0.088 = **0.509** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 8600 | mm | normal condition |
| Effective length | Lelt2= | 8600 | mm | |
| | L e lt= | 8600 | mm | |
| Radius of gyration y-y | ry= | 8.14 | cm | |
| | rx= | 14.5 | cm | |
| | Lam'y= | 105.7 | | |
| | La'mx= | 59.3 | | |

CONTINUE OF FB1.09

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.32 | | py= | 345 | N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.60 | TABLE 16 |
| Robertson constant for H section | | | | | | |
| | a= | 5.5 | | | | |
| Perry factor | eta= | 0.50 | | | | |
| Euler strength | pe= | 181 | N/mm2 | | | |
| Factor | phi= | 308 | N/mm2 | | | |
| Compressive strength | pcy= | **128.1** | N/mm2 | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 105.7 | | La'mx= | 59.31 | Lamy/x= | 12.102 |
| Slenderness of section | Lamda= | 105.7 | | | | Lamx/x= | 6.7939 |
| Torsional index | x= | 8.73 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.58 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.854 | | | | | |
| Equivalent slenderness | lamlt= | 52.3 | | | | | |
| Buckling strength (Table 16) | pb= | 268 | N/mm2 | for lamlt= | 55 | py= | 345 |
| Buckling resisrance moment | Mb= | 1137.7 | KNm | | | | |
| | Mb L= | 1137.7 | KNm | | | | |
| | Mry= | 671.7 | KNm | | | | |
| | Pc= | 3914.3 | KN | | | | |
| | Pcy= | 3914.3 | KN | | | | |

$$\frac{Fc}{PC} + W\frac{x\,Mx}{Py\,Zx} + W\frac{y\,My}{py\,Zy} = \;<=1$$

W x= 0.95

W y= 0.95

0.046 + 0.448 + 0.128 = **0.622** **The interaction formula is satisfied**

$$\frac{Fc}{Pcy} + W\frac{LT\,M\,lt}{Mb} + W\frac{y\,My}{py\,Zy} = \;<=1$$

0.046 + 0.520 + 0.128 = **0.694** **The interaction formula is satisfied**

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 117 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

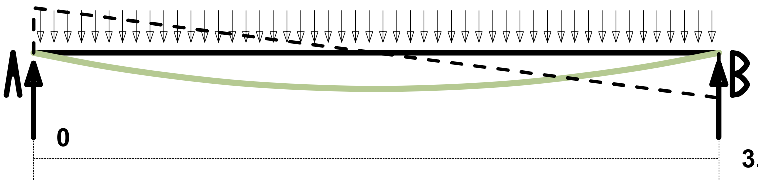
**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **FB1.10**

Loads are unfactored

Wd= **0.60** KN/m2
Wl= **1.50** KN/m2

Span= **3.20** m
Cover= **2.50** m

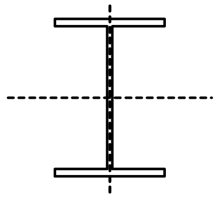



**SPAN**

| Load on beam | unfactored | factored | 11 KNm |
|---|---|---|---|
| | | | Partial safety factor for load |
| **Dead+s/w=** | 1.8 KN/m' | 2.52 KN/m' | dead= 1.4 |
| **Live=** | 3.75 KN/m' | 6.00 KN/m' | live= 1.6 |
| | 5.55 KN/m' | 8.52 KN/m' | |

**Reaction**

| | | | |
|---|---|---|---|
| RA= | 8.9 KN | | **13.6** KN |
| RB= | 8.9 KN | | **13.6** KN |
| Shear zero at | | X= | 1.60 m |
| Maximum Bending Moment | | **Mx =** | **10.9** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 10.1 KNm | Local capacity | PASS | 0.167 |
| Maximum BM about axis Y | MY= | 1.01 KNm | Overall buckling 1 | PASS | 0.282 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.369 |
| Shear force in x axis | Fv= | 13.6 KN | Deflection (dead)= | PASS | 1/ 7706 |
| Beam span | L= | 3.20 m | Deflection(live)= | PASS | 1/ 3698 |
| Effective length about axis X | LX eff= | 3.20 m | Deflection (d+l)= | PASS | 1/ 2499 |
| Effective length about axis Y | LYeff= | 3.84 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 31 cm3 | | | |

**Section properties**

Section size (Ref. No= **66** ) **203x133 30 kg UB S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 206.8 mm | | | | |
| Width of section | B= | 133.8 mm | Pcy= | 435 KN | | |
| Thickness of web | t= | 6.3 mm | Mcx= | 111.2 KNm | | |
| Thickness of flange | T= | 9.6 mm | Mcy= | 31.26 KNm | | 304.6 |
| Root radius | r= | 7.6 mm | Mb L= | 54.83 KNm | | |
| Second moment of area x-x | Ix= | 2887 cm4 | Mlt= | **0.925** | Pcy= | 434.6 KN |
| Second moment of area y-y | Iy= | 384 cm4 | | | | |
| Plastic modulus x-x | Sx= | 313.3 cm3 | Sx eff= | 274.52 cm3 | | |
| Plastic modulus y-y | Sy= | 88.05 cm3 | Sy eff= | 53.09 cm3 | | |
| Area of section | Ag= | 38 cm2 | An= | 34.55 cm2 | ke= 1.1 | |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 0.42 mm | | E UDL= | 1.80 KN/m' |
| Unfactored live load deflection= | 0.87 mm | | E UDL= | 3.75 KN/m' |
| Unfactored dead+ live load def = | 1.28 mm | | E UDL= | 5.55 KN/m' |
| Span/def. ratio for dead load= | 7706 | | | |
| Span/def. ratio for live load= | **3699** | **>360** | | |
| Span/def. ratio fordead+ live load= | 2499 | | | |

CONTINUE OF FB1.10

**Strength of steel** Clause 3.1.1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Design strength | **(Grade S 355 )** | | | | | | |
| for thickness of | 9.6 mm | **py=** | **355** N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | TABLE 11 rolled section | | | |
| Constant (table 11 note b) | ε = | 0.880 | | class 1 | class 2 | class 3 | |
| Outstand of flange | b= | 66.9 mm | | plastic | compac | semi compact | |
| Ratio | b/T= | 6.97 | b/Tlim= | 7.92 | 8.80 | 13.20 | |
| The classification is based on the outsatnd element | | | | **The section is class1 plastic** | | | |
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.16 | r2=Fc/(Agxpyw)= | 0.044 | | | |
| Depth between fillets | d= | 172.3 mm | | TABLE 11 rolled section | | | |
| ratio | d/t= | 27.35 | | class 1 | class 2 | class 3 | |
| 40 ε | = | 35.21 | d/tlim= | 60.93 | 71.35 | 96.99 | |
| The classification is based on the general web condition | | | | **The section is class1 plastic** | | | |

**Shear capacity** CL 4.2.3

| | | | | | | |
|---|---|---|---|---|---|---|
| Shear area | | Av y= | 1303 mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 278 KN | | | |
| Shear force | | Fvy= | 13.6 KN | Fvy/Pvy= | 0.05 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 279.3 cm3 | Mcx1= | 99.15 |
| Plastic modulus | Sx= | 313 cm3 | Mcx2= | 111.2 |
| Moment capacity for section | Mcx= | **111** KNm | | |
| Elastic modulus | Zy= | 57.4 cm3 | Mcy1= | 20.38 |
| Plastic modulus | Sy= | 88 cm3 | mcy2= | 31.26 |
| Moment capacity for section | Mcy= | **31** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\ py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \;<=1$$

0.044 + 0.091 + 0.032 = **0.167** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 3200 mm | normal condition |
| Effective length | Lelt2= | 3840 mm | |
| | L e lt= | 3520 mm | |
| Radius of gyration y-y | ry= | 3.18 cm | |
| | rx= | 8.72 cm | |
| | Lam'y= | 120.8 | |
| | La'mx= | 36.7 | |

CONTINUE OF FB1.10

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for section | | | | | |
| | a= | 3.5 | for table 23 | b | |
| Perry factor | eta= | 0.37 | | | |
| Euler strength | pe= | 139 | N/mm2 | | |
| Factor | phi= | 273 | N/mm2 | | |
| Compressive strength | pcy= | **114.4** | N/mm2 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 120.8 | | La'mx= | 36.70 | Lamy/x= | 5.6165 |
| Slenderness of section | Lamda= | 120.8 | | | | Lamx/x= | 1.7068 |
| Torsional index | x= | 21.5 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.79 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.882 | | | | | |
| Equivalent slenderness | lamlt= | 84.1 | | | | | |
| Buckling strength (Table 16) | pb= | 175 | N/mm2 | for lamlt= | 85 | py= | 355 |
| Buckling resisrance moment | Mb= | 55 | KNm | | | | |
| | Mb L= | 55 | KNm | | | | |
| | Mry= | 31 | KNm | | | | |
| | Pc= | 434.6 | KN | | | | |
| | Pcy= | 434.6 | KN | | | | |

$\frac{Fc}{PC}$ +W $\frac{x\ Mx}{Py\ Zx}$ +W $\frac{y\ My}{py\ Zy}$ = <=1  W x= 0.95  W y= 0.95

0.138 + 0.097 + 0.047 = **0.282**  **The interaction formula is satisfied**

$\frac{Fc}{Pcy}$ +W $\frac{LT\ M\ lt}{Mb}$ +W $\frac{y\ My}{py\ Zy}$ = <=1

0.138 + 0.184 + 0.047 = **0.369**  **The interaction formula is satisfied**

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**Project:** 34 NASSAU ROAD, LONDON

**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.NO WORK SHOULD START BEFORE THE CALCULATIONS HAVE BEEN RECEIVED AND APPROVED BY THE LA BUILDING CONTROL.**

**GROUND FLOOR LEVEL**

Max span = 3.5 m


200mm COMPOSITE FLOOR

KINGSPAN MULTIDECK MD80 V2 (1.2mm THK) WITH 200mm THK RC28/35 CONCRETE TOPPING AND 1 LAYER **A193** MESH LAID CENTRALLY

**STEEL BEAM** **FB0.01**

Max span = 7.5 m
Cover= 2.7 m

**USE 254x254x107 UC** **S355** SEE PAGE 121 - 123

**STEEL BEAM** **FB0.02**

Max span = 5.5 m
Cover= 0.6 m

**USE 254x254x73 UC** **S355** SEE PAGE 124 - 126

**STEEL BEAM** **FB0.03 FB0.04**

Max span = 2.7 m
Cover= 1 m

**USE 203x133x30 UB** **S355** SEE PAGE 127 - 129

**STEEL BEAM** **FB0.05 FB0.06**

Max span = 9.2 m
Cover= 2.4 m

**USE 305x305x198 UC** **S355** SEE PAGE 130 - 132

**STEEL BEAM** **FB0.07**

Max span = 8.8 m
Cover= 3.4 m

**USE 305x305x240 UC** **S355** SEE PAGE 133 - 135

go to page 136

All design calculations have been author reviewed and subject to additional review by the project team, as required by David Smith Associates Quality Assurance procedures.

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 121 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

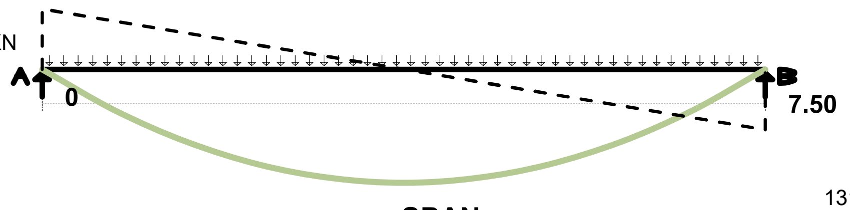
LOCATION= **FB0.01**

Loads are unfactored

Wd= **6.00** KN/m2
Wl= **2.50** KN/m2

Span= **7.50** m
Cover= **2.70** m

131 KN




131 KN

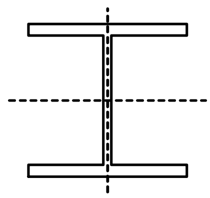
**SPAN**

| Load on beam | unfactored | | factored | |
|---|---|---|---|---|
| **Dead+s/w=** | 17.27 | KN/m' | 24.18 | KN/m' |
| **Live=** | 6.75 | KN/m' | 10.80 | KN/m' |
| | 24.02 | KN/m' | 34.98 | KN/m' |

246 KNm
Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | | | | | |
|---|---|---|---|---|---|
| RA= | 90.1 | KN | | **131.2** | KN |
| RB= | 90.1 | KN | | **131.2** | KN |
| Shear zero at | | | X= | 3.75 | m |
| Maximum Bending Moment | | | **Mx =** | **245.9** | KNm |



**SECTION**

| | | | | | | factor |
|---|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 227.5 | KNm | Local capacity | PASS | 0.552 |
| Maximum BM about axis Y | MY= | 22.75 | KNm | Overall buckling 1 | PASS | 0.634 |
| Axial compressive load | Fc= | 60.0 | KN | Overall buckling 2 | PASS | 0.767 |
| Shear force in x axis | Fv= | 131.2 | KN | Deflection (dead)= | PASS | 1/ 378 |
| Beam span | L= | 7.50 | m | Deflection(live)= | PASS | 1/ 968 |
| Effective length about axis X | LX eff= | 7.50 | m | Deflection (d+l)= | PASS | 1/ 272 |
| Effective length about axis Y | LYeff= | 1.00 | m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** | or 14 mm | | | |
| | z rep= | 713 | cm3 | | | |

**Section properties**

Section size (Ref. No= **92** ) **254x254 107 kg UC S355**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Depth of steel section | D= | 266.7 | mm | | | | | |
| Width of section | B= | 258.3 | mm | Pcy= | 3048 | KN | | |
| Thickness of web | t= | 13 | mm | Mcx= | 512.3 | KNm | | |
| Thickness of flange | T= | 20.5 | mm | Mcy= | 239.9 | KNm | | 2070.8 |
| Root radius | r= | 12.7 | mm | Mb L= | 372.7 | KNm | | |
| Second moment of area x-x | Ix= | 17510 | cm4 | Mlt= | **0.925** | | Pcy= | 3048.1 KN |
| Second moment of area y-y | Iy= | 5901 | cm4 | | | | | |
| Plastic modulus x-x | Sx= | 1485 | cm3 | Sx eff= | 1291.74 | cm3 | | |
| Plastic modulus y-y | Sy= | 695.5 | cm3 | Sy eff= | 427.40 | cm3 | | |
| Area of section | Ag= | 136.6 | cm2 | An= | 124.18 | cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | unfactored | | |
| Unfactored dead load deflection= | 19.82 | mm | | E UDL= | 17.27 | KN/m' |
| Unfactored live load deflection= | 7.75 | mm | | E UDL= | 6.75 | KN/m' |
| Unfactored dead+ live load def = | 27.57 | mm | | E UDL= | 24.02 | KN/m' |
| Span/def. ratio for dead load= | 378 | | | | | |
| Span/def. ratio for live load= | **968** | | **>360** | | | |
| Span/def. ratio fordead+ live load= | 272 | | | | | |

CONTINUE OF FB0.01

**Strength of steel** Clause 3.1.1

| | | | | | | |
|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355 )** | | | | |
| for thickness of | 20.5 mm | **py=** | **345** N/mm2 | py= | **345.0** N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 KN/mm2 | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.893 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 129.2 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 6.30 | b/Tlim= | 8.04 | 8.93 | 13.39 |

The classification is based on the outsatnd element — **The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.07 r2=Fc/(Agxpyw)= 0.013

TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth between fillets | d= | 200.2 mm | | | | |
| ratio | d/t= | 15.40 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.71 | d/tlim= | 66.95 | 81.15 | 104.48 |

The classification is based on the general web condition — **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | |
|---|---|---|---|
| Shear area | Av y= | 3467 mm2 | (t x D) |
| Shear capacity (0.6pyA) | Pvy= | 718 KN | |
| Shear force | Fvy= | 131.2 KN | Fvy/Pvy= 0.18 **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 1313 cm3 | Mcx1= | 453 |
| Plastic modulus | Sx= | 1485 cm3 | Mcx2= | 512.3 |
| Moment capacity for section | Mcx= | **512** KNm | | |
| Elastic modulus | Zy= | 456.9 cm3 | Mcy1= | 157.6 |
| Plastic modulus | Sy= | 696 cm3 | mcy2= | 239.9 |
| Moment capacity for section | Mcy= | **240** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\ py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \ <=1$$

0.013 + 0.444 + 0.095 = **0.552** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 7500 mm | normal condition |
| Effective length | Lelt2= | 1000 mm | |
| | L e lt= | 4250 mm | |
| Radius of gyration y-y | ry= | 6.57 cm | |
| | rx= | 11.3 cm | |
| | Lam'y= | 15.2 | |
| | La'mx= | 66.4 | |

CONTINUE OF FB0.01

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.32 | | py= | 345 | N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.60 | TABLE 16 |
| Robertson constant for section | | | | | | |
| | a= | 5.5 | for table 23 | c | | |
| Perry factor | eta= | 0.28 | | | | |
| Euler strength | pe= | 459 | N/mm2 | | | |
| Factor | phi= | 467 | N/mm2 | | | |
| Compressive strength | pcy= | **223.1** | N/mm2 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lam'y= | 15.2 | | La'mx= | 66.37 | | Lamy/x= | 1.2275 |
| Slenderness of section | Lamda= | 66.4 | | | | | Lamx/x= | 5.3526 |
| Torsional index | x= | 12.4 | | | | | | |
| | N= | 0.5 | | | | | | |
| Slenderness factor | v= | 0.98 | from Table 19 | | | | | |
| | β w = | 1.0 | | | | | | |
| Buckling parameter | u= | 0.848 | | | | | | |
| Equivalent slenderness | lamlt= | 55.3 | | | | | | |
| Buckling strength (Table 16) | pb= | 251 | N/mm2 | for lamlt= | 60 | | py= | 345 |
| Buckling resisrance moment | Mb= | 373 | KNm | | | | | |
| | Mb L= | 373 | KNm | | | | | |
| | Mry= | 240 | KNm | | | | | |
| | Pc= | 3048 | KN | | | | | |
| | Pcy= | 3048 | KN | | | | | |

$\frac{Fc}{PC} + m\frac{x\,Mx}{Py\,Zx} + m\frac{y\,My}{py\,Zy} = <=1$  m x= 0.95, m y= 0.95

0.020 + 0.477 + 0.137 = **0.634** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m\frac{LT\,M\,lt}{Mb} + m\frac{y\,My}{py\,Zy} = <=1$

0.020 + 0.610 + 0.137 = **0.767** **The interaction formula is satisfied**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

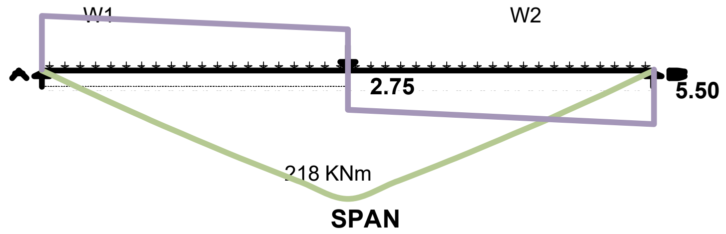
H rolled section S355

Calculation in accordance with BS 5950: 1: 2000

LOCATION= FB0.02

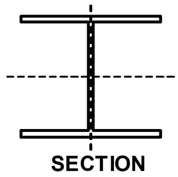
Loads are unfactored

| | | |
|---|---|---|
| Wd1= | 6.00 | KN/m2 |
| Wl1= | 2.50 | KN/m2 |
| Wd2= | 6.00 | KN/m2 |
| wl2= | 2.50 | KN/m2 |
| P1= | 90.00 | KN |
| a= | 2.75 | m |
| Span= | 5.50 | m |
| Cover= | 0.60 | m |




| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | 90.00 KN | 135 KN |
| AV-Dead+s/w= | 4.33 KN/m' | 6.062 KN/m' |
| Live= | 1.50 KN/m' | 2.4 KN/m' |
| | 5.83 KN/m' | 8.462 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6




**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 61.0 KN | 90.8 KN |
| RB= | 61.0 KN | 90.8 KN |
| Shear zero at | X= | 2.75 m |
| Maximum Bending Moment | Mx = | 218 KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 187.4 KNm | Local capacity | PASS | 0.648 |
| Maximum BM about axis Y | MY= | 18.74 KNm | Overall buckling 1 | PASS | 0.734 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | PASS | 0.757 |
| Shear force in x axis | Fv= | 90.8 KN | Deflection (dead)= | PASS | 1/ 396 |
| Beam span | L= | 5.50 m | Deflection(live)= | PASS | 1/ 952 |
| Effective length about axis X | LX eff= | 5.50 m | Deflection (d+l)= | PASS | 1/ 280 |
| Effective length about axis Y | LYeff= | 3.28 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | 360.0 or 14 mm | | | |
| | z rep= | 613 cm3 | | | |

**Section properties**

Section size (Ref. No= 94 ) | 254x254 73 kg UC S355 |

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 254 mm | | |
| Width of section | B= | 254 mm | | |
| Thickness of web | t= | 8.6 mm | Mcx= | 350.95 KNm |
| Thickness of flange | T= | 14.2 mm | Mcy= | 164.15 KNm |
| Root radius | r= | 14.2 mm | Mb L= | 321.3 KNm |
| Second moment of area x-x | Ix= | 11360 cm4 | Mlt= | 0.861 TABLE 18 |
| Second moment of area y-y | Iy= | 3873 cm4 | | |
| Plastic modulus x-x | Sx= | 988.6 cm3 | Sx eff= | 881.11 cm3 |
| Plastic modulus y-y | Sy= | 462.4 cm3 | Sy eff= | 282.61 cm3 |
| Area of section | Ag= | 92.9 cm2 | An= | 84.45 cm2 ke= 1.1 |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 13.86 mm | | E UDL= | 27.08 KN/m' |
| Unfactored live load deflection= | 5.77 mm | | E UDL= | 11.28 KN/m' |
| Unfactored dead+ live load def = | 19.63 mm | | E UDL= | 38.37 KN/m' |
| Span/def. ratio for dead load= | 397 | | | |
| Span/def. ratio for live load= | 953 | >360 | | |
| Span/def. ratio fordead+ live load= | 280 | | | |

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| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

CONTINUE OF FB0.02

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** | **)** | | | | | |
| for thickness of | 14.2 mm | **py=** | **355** | N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 127 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 8.94 | b/Tlim= | 7.92 | 8.80 | 13.20 |

**The section is class 3 semi compact**

| | | | | | | |
|---|---|---|---|---|---|---|
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.16 | r2=Fc/(Agxpyw)= | 0.0003 | | |
| Depth between fillets | d= | 200.2 mm | TABLE 11 rolled section | | | |
| ratio | d/t= | 23.28 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.206 | d/tlim= | 60.51 | 70.67 | 105.55 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 2184.4 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 465 KN | | |
| Shear force | | Fvy= | 90.8 KN | Fvy/Pvy= 0.20 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 894.5 cm3 | Mcx1= | 317.55 |
| Plastic modulus | Sx= | 989 cm3 | Mcx2= | 350.95 |
| Moment capacity for section | Mcx= | **351.0** KNm | | |
| Elastic modulus | Zy= | 305 cm3 | Mcy1= | 108.28 |
| Plastic modulus | Sy= | 462.4 cm3 | mcy2= | 164.15 |
| Moment capacity for section | Mcy= | **164.2** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \;<=1$$

0.000 + 0.534 + 0.114 = **0.648** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 5500 mm | normal condition |
| Effective length | Lelt2= | 3279 mm | |
| | L e lt= | 4389.5 mm | |
| Radius of gyration y-y | ry= | 6.46 cm | |
| | rx= | 11.1 cm | |
| | Lam'y= | 50.8 | |
| | La'mx= | 49.5 | |

CONTINUE OF FB0.02

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | | 30.20 TABLE 16 |
| Robertson constant for H section | | | | | |
| | a= | 5.5 | | | |
| Perry factor | eta= | 0.20 | | | |
| Euler strength | pe= | 785 N/mm2 | | | |
| Factor | phi= | 647 N/mm2 | | | |
| Compressive strength | pcy= | **272.9** N/mm2 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 50.8 | La'mx= | 49.55 | Lamy/x= | 2.93402 |
| Slenderness of section | Lamda= | 50.8 | | | Lamx/x= | 2.86414 |
| Torsional index | x= | 17.3 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.91 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.849 | | | | |
| Equivalent slenderness | lamlt= | 39.2 | | | | |
| Buckling strength (Table 16) | pb= | 325 N/mm2 | for lamlt= | 40 | py= | 355 |
| Buckling resisrance moment | Mb= | 321.3 KNm | | | | |
| | Mb L= | 321.3 KNm | | | | |
| | Mry= | 164.2 KNm | | | | |
| | Pc= | 2535.7 KN | | | | |
| | Pcy= | 2535.7 KN | | | | |

$$\frac{Fc}{PC} + \frac{m_x Mx}{Py\,Zx} + \frac{m_y My}{py\,Zy} = \le 1 \qquad m_x = 0.95 \qquad m_y = 1$$

0.000 + 0.561 + 0.173 = **0.734** **The interaction formula is satisfied**

$$\frac{Fc}{Pcy} + \frac{m_{LT} M_{lt}}{Mb} + \frac{m_y My}{py\,Zy} = \le 1$$

0.000 + 0.583 + 0.173 = **0.757** **The interaction formula is satisfied**

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| Project No: | 24/54720 | Sheet No: | 127 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

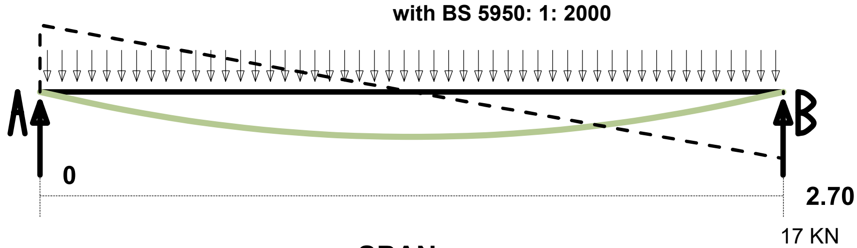
**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **FB0.03**

Loads are unfactored

Wd= **6.00** KN/m2
Wl= **2.50** KN/m2

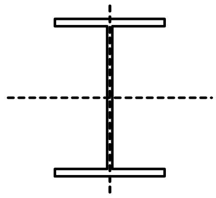
Span= **2.70** m
Cover= **1.00** m




12 KNm

| Load on beam | unfactored | factored |
|---|---|---|
| **Dead+s/w=** | 6.3 KN/m' | 8.82 KN/m' |
| **Live=** | 2.50 KN/m' | 4.00 KN/m' |
| | 8.80 KN/m' | 12.82 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6



SECTION

**Reaction**

| | | | |
|---|---|---|---|
| RA= | 11.9 KN | | **17.3** KN |
| RB= | 11.9 KN | | **17.3** KN |
| Shear zero at | | X= | 1.35 m |
| Maximum Bending Moment | | **Mx =** | **11.7** KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 10.8 KNm | Local capacity | PASS | 0.176 |
| Maximum BM about axis Y | MY= | 1.08 KNm | Overall buckling 1 | PASS | 0.201 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.195 |
| Shear force in x axis | Fv= | 17.3 KN | Deflection (dead)= | PASS | 1/ 3665 |
| Beam span | L= | 2.70 m | Deflection(live)= | PASS | 1/ 9236 |
| Effective length about axis X | LX eff= | 2.70 m | Deflection (d+l)= | PASS | 1/ 2624 |
| Effective length about axis Y | LYeff= | 1.00 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 33 cm3 | | | |

**Section properties**

Section size (Ref. No= **66** ) **203x133 30 kg UB S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 206.8 mm | | | | |
| Width of section | B= | 133.8 mm | Pcy= | 1263 KN | | |
| Thickness of web | t= | 6.3 mm | Mcx= | 111.2 KNm | | |
| Thickness of flange | T= | 9.6 mm | Mcy= | 31.26 KNm | | 617.9 |
| Root radius | r= | 7.6 mm | Mb L= | 111.2 KNm | | |
| Second moment of area x-x | Ix= | 2887 cm4 | Mlt= | **0.925** | Pcy= | 1262.7 KN |
| Second moment of area y-y | Iy= | 384 cm4 | | | | |
| Plastic modulus x-x | Sx= | 313.3 cm3 | Sx eff= | 274.52 cm3 | | |
| Plastic modulus y-y | Sy= | 88.05 cm3 | Sy eff= | 53.09 cm3 | | |
| Area of section | Ag= | 38 cm2 | An= | 34.55 cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 0.74 mm | | E UDL= | 6.30 KN/m' |
| Unfactored live load deflection= | 0.29 mm | | E UDL= | 2.50 KN/m' |
| Unfactored dead+ live load def = | 1.03 mm | | E UDL= | 8.80 KN/m' |
| Span/def. ratio for dead load= | 3665 | | | |
| Span/def. ratio for live load= | **9237** | **>360** | | |
| Span/def. ratio fordead+ live load= | 2624 | | | |

CONTINUE OF FB0.03

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | (Grade | S 355 ) | | | | | | |
| for thickness of | 9.6 mm | py= | 355 | N/mm2 | py= | 355.0 | N/mm2 | pyw= py |
| Young's Modulus | | E= | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | class 1 | class 2 | class 3 | |
| Outstand of flange | b= | 66.9 | mm | plastic | compac | semi compact | |
| Ratio | b/T= | 6.97 | b/Tlim= | 7.92 | 8.80 | 13.20 | |
| The classification is based on the outsatnd element | | | | The section is class1 plastic | | | |
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.16 | r2=Fc/(Agxpyw)= | 0.044 | | | |
| Depth between fillets | d= | 172.3 | mm | TABLE 11 rolled section | | | |
| ratio | d/t= | 27.35 | | class 1 | class 2 | class 3 | |
| 40 ε | = | 35.21 | d/tlim= | 60.93 | 71.35 | 96.99 | |
| The classification is based on the general web condition | | | | The section is class1 plastic | | | |

**Shear capacity** CL 4.2.3

| | | | | | | |
|---|---|---|---|---|---|---|
| Shear area | | Av y= | 1303 mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 278 KN | | | |
| Shear force | | Fvy= | 17.3 KN | Fvy/Pvy= | 0.06 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 279.3 cm3 | Mcx1= | 99.15 |
| Plastic modulus | Sx= | 313 cm3 | Mcx2= | 111.2 |
| Moment capacity for section | Mcx= | **111** KNm | | |
| Elastic modulus | Zy= | 57.4 cm3 | Mcy1= | 20.38 |
| Plastic modulus | Sy= | 88 cm3 | mcy2= | 31.26 |
| Moment capacity for section | Mcy= | **31** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\ py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.044 + 0.097 + 0.035 = **0.176** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 2700 mm | normal condition |
| Effective length | Lelt2= | 1000 mm | |
| | L e lt= | 1850 mm | |
| Radius of gyration y-y | ry= | 3.18 cm | |
| | rx= | 8.72 cm | |
| | Lam'y= | 31.4 | |
| | La'mx= | 31.0 | |

CONTINUE OF FB0.03

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 | N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 | TABLE 16 |
| Robertson constant for section | | | | | | |
| | a= | 3.5 | for table 23 | b | | |
| Perry factor | eta= | 0.06 | | | | |
| Euler strength | pe= | 2046 | N/mm2 | | | |
| Factor | phi= | 1259 | N/mm2 | | | |
| Compressive strength | pcy= | **332.3** | N/mm2 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 31.4 | La'mx= | 30.96 | Lamy/x= | 1.4626 |
| Slenderness of section | Lamda= | 31.4 | | | Lamx/x= | 1.4402 |
| Torsional index | x= | 21.5 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.97 | from Table 19 | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.882 | | | | |
| Equivalent slenderness | lamlt= | 27.0 | | | | |
| Buckling strength (Table 16) | pb= | 355 N/mm2 | for lamlt= | 30 | py= | 355 |
| Buckling resisrance moment | Mb= | 111 KNm | | | | |
| | Mb L= | 111 KNm | | | | |
| | Mry= | 31 KNm | | | | |
| | Pc= | 1263 KN | | | | |
| | Pcy= | 1263 KN | | | | |

$\frac{Fc}{PC} + m\frac{x\,Mx}{Py\,Zx} + m\frac{y\,My}{py\,Zy}$ = <=1  m x= 0.95  m y= 0.95

0.048 + 0.104 + 0.050 = **0.201** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m\frac{LT\,M\,lt}{Mb} + m\frac{y\,My}{py\,Zy}$ = <=1

0.048 + 0.097 + 0.050 = **0.195** **The interaction formula is satisfied**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

LOCATION= **FB0.05** SPAN= **9.20** m **S355**

Uniform distributed load COVER= **2.40** m

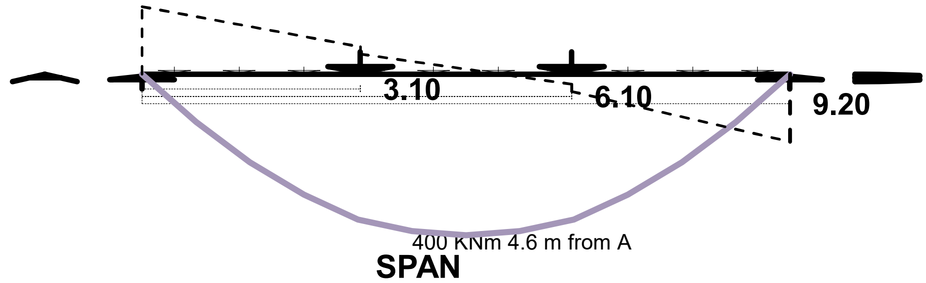
| | Unfactored | | Factored | |
|---|---|---|---|---|
| wdl= | **6.00** | KN/m2 | ( **8.40** ) | |
| wll = | **2.50** | KN/m2 | ( **4.00** ) | |
| | **8.50** | | **12.40** | KN/m2 |
| | factor= | | **1.46** | |

**H rolled section**
**Calculation in accordance with BS 5950: 1: 2000**

Point load

| | | | |
|---|---|---|---|
| **P1=** | **12.00** | KN | ( **18.0** )KN |
| **a1=** | **3.10** | m | |
| **P2=** | **12.0** | KN | ( **18.00** )KN |
| **a2=** | **6.10** | **m** | |

Partial safety factor for load
dead= 1.4
live= 1.6



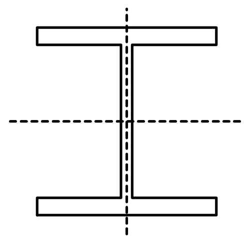

| | Unfactored | | (Factored ) | |
|---|---|---|---|---|
| Wd= | 16.38 | KN/m' | ( 22.93 ) | |
| Wl = | 6 | kKN/m' | ( 9.60 ) | |
| | 22.38 | KN/m' | **32.53** | KN/m' |

**Reactions**

| | | | | |
|---|---|---|---|---|
| **RA=** | 114.95 | KN | ( **167.6** | KN |
| **RB=** | 114.95 | KN | ( **167.6** | KN |

Desidn bending moment(factored)=

| | | |
|---|---|---|
| M@P1 = | **363.4** | KNm |
| M@P2 = | **363.4** | KNm |
| X= | **4.60** | m from A |
| M@ X= | **400.0** | KNm |
| **DBM=** | **400.0** | **KNm** |



**SECTION**

Eq. udl = 37.806 KN/m' (factored)
Eq. ud l= 7.413 lKN/m' (live unfactored)

| | | | | | | factor |
|---|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 369.9 KNm | Local capacity | **PASS** | | 0.399 |
| Maximum BM about axis Y | MY= | 36.99 KNm | Overall buckling 1 | **PASS** | | 0.498 |
| Axial compressive load | Fc= | 167.65 KN | Overall buckling 2 | **PASS** | | 0.586 |
| Shear force in x axis | Fv= | 167.6 KN | Deflection (dead)= | **PASS** | | 1/ 566 |
| Beam span | L= | 9.20 m | Deflection(live)= | **PASS** | | 1/ 1525 |
| Effective length about axis X | LX eff= | 9.20 m | Deflection (d+l)= | **PASS** | | 1/ 412 |
| Effective length about axis Y | LYeff= | 9.20 m | Fully restraint for Ly& LX <1. | | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | | |
| | z rep= | 1072 cm3 | | | | |

**Section properties**

Section size (Ref. No= **85** ) **305x305 198 kg UC S355**

| | | | | | |
|---|---|---|---|---|---|
| Depth of steel section | D= | 339.9 mm | | | |
| Width of section | B= | 314.1 mm | | | |
| Thickness of web | t= | 19.2 mm | Mcx= | 1185 KNm | |
| Thickness of flange | T= | 31.4 mm | Mcy= | 543.7 KNm | |
| Root radius | r= | 31.4 mm | Mb L= | 862.4 KNm | |
| Second moment of area x-x | Ix= | 50832 cm4 | mlt= | **0.925** AUTO | |
| Second moment of area y-y | Iy= | 16230 cm4 | | | |
| Plastic modulus x-x | Sx= | 3436 cm3 | Sx eff= | 2842.67 cm3 | |
| Plastic modulus y-y | Sy= | 1576 cm3 | Sy eff= | 853.33 cm3 | |
| Area of section | Ag= | 252.3 cm2 | An= | 229.36 cm2 | ke= 1.1 |

CONTINUE OF FB0.05

**DEFLECTION** unfactored

| | | | | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 16.25 mm | | E UDL= | 18.60 KN/m' |
| Unfactored live load deflection= | **6.03** mm | | E UDL= | 7.41 KN/m' |
| Unfactored dead+ live load def = | 22.28 mm | | E UDL= | 26.01 KN/m' |
| Span/def. ratio for dead load= | 566 | | | |
| Span/def. ratio for live load= | **1525** | **>360** | | |
| Span/def. ratio fordead+ live load= | 413 | | | |

**Strength of steel** Clause 3.1.1

Design strength **(Grade S 355 )**

for thickness of 31.4 mm **py=** **345** N/mm2 py= **345.0** N/mm2 pyw= py

Young's Modulus **E=** 205 KN/mm2

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | class 1 | class 2 | class 3 |
|---|---|---|---|---|---|---|
| Constant | ε = | 0.893 | | | | |
| Outstand of flange | b= | 116.05 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 3.70 | b/Tlim= | 8.04 | 8.93 | 13.39 |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 1.00 r2=Fc/(Agxpyw)= 0.019

| | | | | class 1 | class 2 | class 3 |
|---|---|---|---|---|---|---|
| Depth between fillets | d= | 246.6 mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 12.84 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.712 | d/tlim= | 35.71 | 35.71 | 103.16 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | |
|---|---|---|---|---|
| Shear area | Av y= | 6526.1 mm2 | (t x D) | |
| Shear capacity (0.6pyA) | Pvy= | 1351 KN | | |
| Shear force | Fvy= | 167.6 KN | Fvy/Pvy= 0.12 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 2991 cm3 | Mcx1= | 1032 |
| Plastic modulus | Sx= | 3436 cm3 | Mcx2= | 1185 |
| Moment capacity for section | Mcx= | **1185.4** KNm | | |
| Elastic modulus | Zy= | 1034 cm3 | Mcy1= | 356.7 |
| Plastic modulus | Sy= | 1576.0 cm3 | mcy2= | 543.7 |
| Moment capacity for section | Mcy= | **543.7** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \;<=1$$

0.019 + 0.312 + 0.068 = **0.399** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 9200 mm | normal condition |
| Effective length | Lelt2= | 9200 mm | |
| | L e lt= | 9200 mm | |
| Radius of gyration y-y | ry= | 8.02 cm | |
| | rx= | 14.2 cm | |
| | Lam'y= | 114.7 | |
| | La'mx= | 64.8 | |

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| Project No: | 24/54904 | Sheet No: | 132 |
|---|---|---|---|
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **38 SKEENA HILL, LONDON**

CONTINUE OF FB0.05

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.32 | | py= | 345 N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.60 TABLE 16 |
| Robertson constant for H section | | | | | |
| | a= | 5.5 | | | |
| Perry factor | eta= | 0.55 | | | |
| Euler strength | pe= | 154 | N/mm2 | | |
| Factor | phi= | 291 | N/mm2 | | |
| Compressive strength | pcy= | **112.9** | N/mm2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 114.7 | La'mx= | 64.79 | Lamy/x= | 11.246 |
| Slenderness of section | Lamda= | 114.7 | | | Lamx/x= | 6.3518 |
| Torsional index | x= | 10.2 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.6 | from Table 19 | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.854 | | | | |
| Equivalent slenderness | lamlt= | 58.8 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Buckling strength (Table 16) | pb= | 251 N/mm2 | for lamlt= | 60 | py= | 345 |
| Buckling resisrance moment | Mb= | 862.4 KNm | | | | |
| | Mb L= | 862.4 KNm | | | | |
| | Mry= | 543.7 KNm | | | | |
| | Pc= | 2847.9 KN | | | | |
| | Pcy= | 2847.9 KN | | | | |

$\frac{Fc}{PC} + m\frac{x\,Mx}{Py\,Zx} + m\frac{y\,My}{py\,Zy} = \;<=1$ m x= 0.95, m y= 0.95

0.059 + 0.341 + 0.098 = **0.498** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m\frac{LT\,M\,lt}{Mb} + m\frac{y\,My}{py\,Zy} = \;<=1$

0.059 + 0.429 + 0.098 = **0.586** **The interaction formula is satisfied**

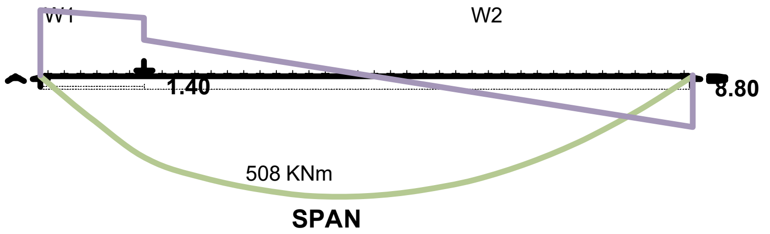
**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= FB0.07

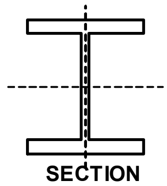
Loads are unfactored

| | | |
|---|---|---|
| Wd1= | 6.00 | KN/m2 |
| Wl1= | 2.50 | KN/m2 |
| Wd2= | 6.00 | KN/m2 |
| wl2= | 2.50 | KN/m2 |
| P1= | 62.00 | KN |
| a= | 1.40 | m |
| Span= | 8.80 | m |
| Cover= | 3.40 | m |




| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | 62.00 KN | 93 KN |
| AV-Dead+s/w= | 22.80 KN/m' | 31.92 KN/m' |
| Live= | 8.50 KN/m' | 13.6 KN/m' |
| | 31.3 KN/m' | 45.52 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6




**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 189.9 KN | 278.5 KN |
| RB= | 147.6 KN | 215.1 KN |
| Shear zero at | X= | 4.07 m |
| Maximum Bending Moment | Mx = | 508 KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 473.2 KNm | Local capacity | PASS | 0.394 |
| Maximum BM about axis Y | MY= | 47.32 KNm | Overall buckling 1 | PASS | 0.466 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | PASS | 0.524 |
| Shear force in x axis | Fv= | 278.5 KN | Deflection (dead)= | PASS | 1/ 600 |
| Beam span | L= | 8.80 m | Deflection(live)= | PASS | 1/ 1440 |
| Effective length about axis X | LX eff= | 8.80 m | Deflection (d+l)= | PASS | 1/ 423 |
| Effective length about axis Y | LYeff= | 8.49 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | 360.0 or 14 mm | | | |
| | z rep= | 1473 cm3 | | | |

**Section properties**

Section size (Ref. No= 84 ) **305x305 240 kg UC S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 352.6 mm | | |
| Width of section | B= | 317.9 mm | | |
| Thickness of web | t= | 23 mm | Mcx= | 1464.5 KNm |
| Thickness of flange | T= | 37.7 mm | Mcy= | 671.72 KNm |
| Root radius | r= | 37.7 mm | Mb L= | 1137.7 KNm |
| Second moment of area x-x | Ix= | 64177 cm4 | Mlt= | 0.931 TABLE 18 |
| Second moment of area y-y | Iy= | 20239 cm4 | | |
| Plastic modulus x-x | Sx= | 4245 cm3 | Sx eff= | 3568.12 cm3 |
| Plastic modulus y-y | Sy= | 1947 cm3 | Sy eff= | 1191.68 cm3 |
| Area of section | Ag= | 305.6 cm2 | An= | 277.82 cm2 ke= 1.1 |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 14.66 mm | | E UDL= | 24.70 KN/m' |
| Unfactored live load deflection= | 6.11 mm | | E UDL= | 10.29 KN/m' |
| Unfactored dead+ live load def = | 20.77 mm | | E UDL= | 35.00 KN/m' |
| Span/def. ratio for dead load= | 600 | | | |
| Span/def. ratio for live load= | 1440 | >360 | | |
| Span/def. ratio fordead+ live load= | 424 | | | |

CONTINUE OF FB0.07

**Strength of steel** Clause 3.1.1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** | **)** | | | | |
| for thickness of | 37.7 mm | **py=** | **345** N/mm2 | py= | **345.0** | N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant | ε = | 0.893 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 158.95 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 4.22 | b/Tlim= | 8.04 | 8.93 | 13.39 |

**The section is class1 plastic**

| | | | | | | |
|---|---|---|---|---|---|---|
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.05 | r2=Fc/(Agxpyw)= | 9E-05 | | |
| Depth between fillets | d= | 246.6 mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 10.72 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.712 | d/tlim= | 67.95 | 82.92 | 107.12 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | |
|---|---|---|---|---|
| Shear area | | Av y= 8109.8 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= 1679 KN | | |
| Shear force | | Fvy= 278.5 KN | Fvy/Pvy= 0.17 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | |
|---|---|---|---|
| Elastic modulus | Zx= 3641 cm3 | Mcx1= | 1256.1 |
| Plastic modulus | Sx= 4245 cm3 | Mcx2= | 1464.5 |
| Moment capacity for section | Mcx= **1464.5** KNm | | |
| Elastic modulus | Zy= 1273 cm3 | Mcy1= | 439.19 |
| Plastic modulus | Sy= 1947.0 cm3 | mcy2= | 671.72 |
| Moment capacity for section | Mcy= **671.7** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \le 1$$

0.000 + 0.323 + 0.070 = **0.394** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 8800 mm | normal condition |
| Effective length | Lelt2= | 8492.6 mm | |
| | L e lt= | 8646.3 mm | |
| Radius of gyration y-y | ry= | 8.14 cm | |
| | rx= | 14.5 cm | |
| | Lam'y= | 104.3 | |
| | La'mx= | 60.7 | |

CONTINUE OF FB0.07

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.32 | py= | 345 N/mm2 |
| For buckling about y-y | | | λ L0= | 30.60 TABLE 16 |
| Robertson constant for H section | | | | |
| | a= | 5.5 | | |
| Perry factor | eta= | 0.49 | | |
| Euler strength | pe= | 186 N/mm2 | | |
| Factor | phi= | 311 N/mm2 | | |
| Compressive strength | pcy= | **130.5** N/mm2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 104.3 | La'mx= | 60.69 | Lamy/x= | 11.9509 |
| Slenderness of section | Lamda= | 104.3 | | | Lamx/x= | 6.95185 |
| Torsional index | x= | 8.73 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.58 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.854 | | | | |
| Equivalent slenderness | lamlt= | 51.7 | | | | |
| Buckling strength (Table 16) | pb= | 268 N/mm2 | for lamlt= | 55 | py= | 345 |
| Buckling resisrance moment | Mb= | 1137.7 KNm | | | | |
| | Mb L= | 1137.7 KNm | | | | |
| | Mry= | 671.7 KNm | | | | |
| | Pc= | 3988.3 KN | | | | |
| | Pcy= | 3988.3 KN | | | | |

$$\frac{Fc}{PC} + \frac{m_x Mx}{Py\ Zx} + \frac{m_y My}{py\ Zy} = \; <=1 \qquad m_x = 0.95 \quad m_y = 1$$

0.000 + 0.358 + 0.108 = **0.466** **The interaction formula is satisfied**

$$\frac{Fc}{Pcy} + \frac{m_{LT} M_{lt}}{Mb} + \frac{m_y My}{py\ Zy} = \; <=1$$

0.000 + 0.416 + 0.108 = **0.524** **The interaction formula is satisfied**

**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.NO WORK SHOULD START BEFORE THE CALCULATIONS HAVE BEEN RECEIVED AND APPROVED BY THE LA BUILDING CONTROL.**

**GROUND FLOOR LEVEL**

**STEEL BEAM** **FB0.08 FB0.09**

Max span = 3.5 m
Cover= 2.2 m

**USE 203x203x46 UC** **S355** SEE PAGE 137 - 139

**STEEL BEAM** **FB0.10** GLASSING

Max span = 5.8 m
Cover= 3.5 m WIND

**USE 150x150x10 SHS** **S355** SEE PAGE 140 - 142

**STEEL BEAM** **FB0.11**

Max span = 2.4 m
Cover= 1 m

**USE 203x133x30 UB** **S355** SEE PAGE 143 - 145

**STEEL BEAM** **FB0.12 FB0.13**

Max span = 8.8 m
Cover= 2.4 m

**USE 305x305x137 UC** **S355** SEE PAGE 146 - 148

**STEEL BEAM** **FB0.14**

Max span = 2.8 m
Cover= 2 m

**USE 203x203x46 UC** **S355** SEE PAGE 149 - 151

**STEEL BEAM** **FB0.15**

Max span = 3.5 m
Cover= 1 m

**USE 203x203x46 UC** **S355** SEE PAGE 152 - 154

**STEEL BEAM** **FB0.16**

Max span = 1.8 m
Cover= 1 m

**USE 203x133x30 UB** **S355** SEE PAGE 155 - 157

go to page 152

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| | | | |
|---|---|---|---|
| **Project No:** | **24/54720** | **Sheet No:** | **137** |
| **Made By:** | ***OAM*** | **Revision:** | |
| **Date:** | **Mar-24** | **Checked By:** | **TG** |

**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

**H rolled section** **S355**
**Calculation in accordance with BS 5950: 1: 2000**

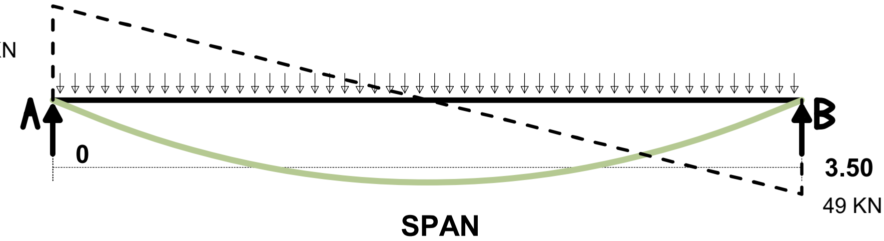
LOCATION= **FB0.08**

Loads are unfactored

Wd= **6.00** KN/m2
Wl= **2.50** KN/m2

Span= **3.50** m
Cover= **2.20** m

49 KN

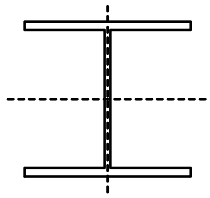



**SPAN**

| Load on beam | unfactored | factored | 43 KNm |
|---|---|---|---|
| | | | Partial safety factor for load |
| **Dead+s/w=** | 13.66 KN/m' | 19.12 KN/m' | dead= 1.4 |
| **Live=** | 5.50 KN/m' | 8.80 KN/m' | live= 1.6 |
| | 19.16 KN/m' | 27.92 KN/m' | |

**Reaction**

| | | |
|---|---|---|
| RA= | 33.5 KN | **48.9** KN |
| RB= | 33.5 KN | **48.9** KN |
| Shear zero at | X= | 1.75 m |
| Maximum Bending Moment | **Mx =** | **42.8** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 39.6 KNm | Local capacity | **PASS** | 0.301 |
| Maximum BM about axis Y | MY= | 3.96 KNm | Overall buckling 1 | **PASS** | 0.362 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | **PASS** | 0.435 |
| Shear force in x axis | Fv= | 48.9 KN | Deflection (dead)= | **PASS** | 1/ 1226 |
| Beam span | L= | 3.50 m | Deflection(live)= | **PASS** | 1/ 3047 |
| Effective length about axis X | LX eff= | 3.50 m | Deflection (d+l)= | **PASS** | 1/ 874 |
| Effective length about axis Y | LYeff= | 4.20 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 120 cm3 | | | |

**Section properties**

Section size (Ref. No= **99** ) **203x203 46 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 203.2 mm | | | | |
| Width of section | B= | 203.2 mm | Pcy= | 1073 KN | | |
| Thickness of web | t= | 7.3 mm | Mcx= | 176.6 KNm | | |
| Thickness of flange | T= | 11 mm | Mcy= | 81.65 KNm | | 710.18 |
| Root radius | r= | 10.2 mm | Mb L= | 127.8 KNm | | |
| Second moment of area x-x | Ix= | 4564 cm4 | Mlt= | **0.925** | Pcy= | 1073.3 KN |
| Second moment of area y-y | Iy= | 1539 cm4 | | | | |
| Plastic modulus x-x | Sx= | 497.4 cm3 | Sx eff= | 442.53 cm3 | | |
| Plastic modulus y-y | Sy= | 230 cm3 | Sy eff= | 140.06 cm3 | | |
| Area of section | Ag= | 58.8 cm2 | An= | 53.45 cm2 | ke= 1.1 | |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 2.85 mm | | E UDL= | 13.66 KN/m' |
| Unfactored live load deflection= | 1.15 mm | | E UDL= | 5.50 KN/m' |
| Unfactored dead+ live load def = | 4.00 mm | | E UDL= | 19.16 KN/m' |
| Span/def. ratio for dead load= | 1227 | | | |
| Span/def. ratio for live load= | **3047** | **>360** | | |
| Span/def. ratio fordead+ live load= | 875 | | | |

CONTINUE OF FB0.08

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Strength of steel** | | Clause 3.1.1 | | | | | | |
| Design strength | **(Grade** | **S 355** **)** | | | | | | |
| for thickness of | 11 mm | **py=** | **355** | N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 | KN/mm2 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Classification of cross section** | | (clause 3.5.2) | | TABLE 11 rolled section | | | |
| Constant (table 11 note b) | ε = | 0.880 | | class 1 | class 2 | class 3 | |
| Outstand of flange | b= | 101.6 mm | | plastic | compac | semi compact | |
| Ratio | b/T= | 9.24 | b/Tlim= | 7.92 | 8.80 | 13.20 | |
| The classification is based on the outsatnd element | | | | **The section is class 3 semi compact** | | | |
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.14 | r2=Fc/(Agxpyw)= | 0.029 | | | |
| Depth between fillets | d= | 160.8 mm | | TABLE 11 rolled section | | | |
| ratio | d/t= | 22.03 | | class 1 | class 2 | class 3 | |
| 40 ε | = | 35.21 | d/tlim= | 61.55 | 72.38 | 99.88 | |
| The classification is based on the general web condition | | | | **The section is class1 plastic** | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Shear capacity** | CL 4.2.3 | | | | | |
| Shear area | | Av y= | 1483 mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 316 KN | | | |
| Shear force | | Fvy= | 48.9 KN | Fvy/Pvy= | 0.15 | **SHEAR PASS OK** |

| | | | | |
|---|---|---|---|---|
| **Moment Capacity** | | | | |
| Elastic modulus | Zx= | 449.2 cm3 | Mcx1= | 159.5 |
| Plastic modulus | Sx= | 497 cm3 | Mcx2= | 176.6 |
| Moment capacity for section | Mcx= | **177** KNm | | |
| Elastic modulus | Zy= | 151 cm3 | Mcy1= | 53.61 |
| Plastic modulus | Sy= | 230 cm3 | mcy2= | 81.65 |
| Moment capacity for section | Mcy= | **82** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \; <=1$$

0.029 + 0.224 + 0.048 = **0.301** **LOCAL CAPACITY IS SATISFIED**

| | | | |
|---|---|---|---|
| **restraint/effective length Clause 4.31 to 4.3.5** | | | TABLE 13 |
| Effective length | Le lt1= | 3500 mm | normal condition |
| Effective length | Lelt2= | 4200 mm | |
| | L e lt= | 3850 mm | |
| Radius of gyration y-y | ry= | 5.11 cm | |
| | rx= | 8.81 cm | |
| | Lam'y= | 82.2 | |
| | La'mx= | 39.7 | |

CONTINUE OF FB0.08

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 | N/mm2 |
| For buckling about y-y | | | λ L0= | | 30.20 | TABLE 16 |
| Robertson constant for section | | | | | | |
| | a= | 5.5 | for table 23 | c | | |
| Perry factor | eta= | 0.37 | | | | |
| Euler strength | pe= | 300 | N/mm2 | | | |
| Factor | phi= | 383 | N/mm2 | | | |
| Compressive strength | pcy= | **182.5** | N/mm2 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lam'y= | 82.2 | La'mx= | 39.73 | | | Lamy/x= | 4.6436 |
| Slenderness of section | Lamda= | 82.2 | | | | | Lamx/x= | 2.2445 |
| Torsional index | x= | 17.7 | | | | | | |
| | N= | 0.5 | | | | | | |
| Slenderness factor | v= | 0.83 | from Table 19 | | | | | |
| | β w = | 1.0 | | | | | | |
| Buckling parameter | u= | 0.846 | | | | | | |
| Equivalent slenderness | lamlt= | 57.9 | | | | | | |
| Buckling strength (Table 16) | pb= | 257 | N/mm2 | for lamlt= | 60 | py= | 355 | |
| Buckling resisrance moment | Mb= | 128 | KNm | | | | | |
| | Mb L= | 128 | KNm | | | | | |
| | Mry= | 82 | KNm | | | | | |
| | Pc= | 1073 | KN | | | | | |
| | Pcy= | 1073 | KN | | | | | |

$\frac{Fc}{PC} + m\frac{x\,Mx}{Py\,Zx} + m\frac{y\,My}{py\,Zy} = \leq 1$     m x= 0.95, m y= 0.95

0.056 + 0.236 + 0.070 = **0.362**    **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m\frac{LT\,M\,lt}{Mb} + m\frac{y\,My}{py\,Zy} = \leq 1$

0.056 + 0.309 + 0.070 = **0.435**    **The interaction formula is satisfied**

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| Project No: | 24/54720 | Sheet No: | 140 |
|---|---|---|---|
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

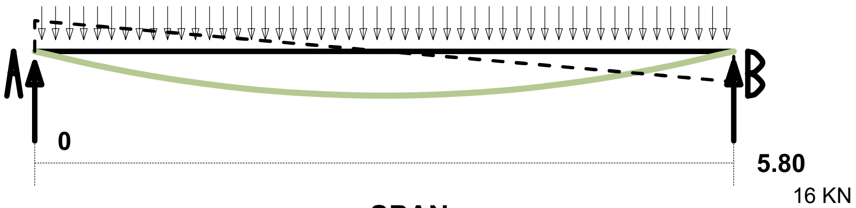
H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= FB1.10

Loads are unfactored

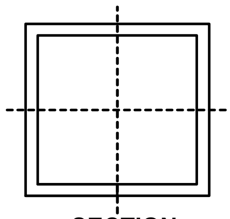
Wd= 0.80 KN/m2
Wl= 0.25 KN/m2

Span= 5.80 m
Cover= 3.50 m




SPAN

| Load on beam | unfactored | factored | |
|---|---|---|---|
| | | | 23 KNm |
| | | | Partial safety factor for load |
| Dead+s/w= | 2.9 KN/m' | 4.06 KN/m' | dead= 1.4 |
| Live= | 0.88 KN/m' | 1.40 KN/m' | live= 1.6 |
| | 3.78 KN/m' | 5.46 KN/m' | |



SECTION

**Reaction**

| | unfactored | | factored |
|---|---|---|---|
| RA= | 10.9 KN | | **15.8** KN |
| RB= | 10.9 KN | | **15.8** KN |
| Shear zero at | | X= | 2.90 m |
| Maximum Bending Moment | | **Mx =** | **23.0** KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 21.2 KNm | Local capacity | PASS | 0.257 |
| Maximum BM about axis Y | MY= | 2.12 KNm | Overall buckling 1 | PASS | 0.326 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.657 |
| Shear force in x axis | Fv= | 15.8 KN | Deflection (dead)= | PASS | 1/ 500 |
| Beam span | L= | 5.80 m | Deflection(live)= | PASS | 1/ 1659 |
| Effective length about axis X | LX eff= | 5.80 m | Deflection (d+l)= | PASS | 1/ 384 |
| Effective length about axis Y | LYeff= | 5.80 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 65 cm3 | | | |

**Section properties**

Section size (Ref. No= **156** ) **150x150 10 mm SHS S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 150 mm | | | | |
| Width of section | B= | 150 mm | Pcy= | 920 KN | | |
| | | | Mcx= | 103 KNm | | |
| | T= | 10 mm | Mcy= | 103 KNm | | 207.83 |
| | | | Mb L= | 37.41 KNm | | |
| Second moment of area x-x | Ix= | 1800 cm4 | Mlt= | **0.925** | Pcy= | 919.91 KN |
| Second moment of area y-y | Iy= | 1800 cm4 | | | | |
| Plastic modulus x-x | Sx= | 290 cm3 | Sx eff= | 233.11 cm3 | | |
| Plastic modulus y-y | Sy= | 290 cm3 | Sy eff= | 233.11 cm3 | | |
| Area of section | Ag= | 55.5 cm2 | An= | 50.45 cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 11.58 mm | | E UDL= | 2.90 KN/m' |
| Unfactored live load deflection= | 3.49 mm | | E UDL= | 0.88 KN/m' |
| Unfactored dead+ live load def = | 15.07 mm | | E UDL= | 3.78 KN/m' |
| Span/def. ratio for dead load= | 501 | | | |
| Span/def. ratio for live load= | **1660** | **>360** | | |
| Span/def. ratio fordead+ live load= | 385 | | | |

CONTINUE OF FB1.10

**Strength of steel** Clause 3.1.1

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Design strength | (Grade | | S 355 | ) | | | | | |
| for thickness of | 10 | mm | py= | 355 | N/mm2 | py= | 355.0 | N/mm2 | pyw= py |
| Young's Modulus | | | E= | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 150 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 15.00 | | b/Tlim= | 7.92 | 8.80 | 13.20 |
| The classification is based on the outsatnd element | | | | | **The section is class 3 semi compact** | | |
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.14 | | r2=Fc/(Agxpyw)= | 0.03 | | |
| Depth between fillets | d= | 120 | mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 12.00 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.21 | | d/tlim= | 61.72 | 72.66 | 99.55 |
| The classification is based on the general web condition | | | | | **The section is class1 plastic** | | |

**Shear capacity** CL 4.2.3

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shear area | | Av y= | 3000 | mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 639 | KN | | | |
| Shear force | | Fvy= | 15.8 | KN | Fvy/Pvy= | 0.02 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 240 | cm3 | Mcx1= | 85.2 |
| Plastic modulus | Sx= | 290 | cm3 | Mcx2= | 103 |
| Moment capacity for section | Mcx= | **103** | KNm | | |
| Elastic modulus | Zy= | 240 | cm3 | Mcy1= | 85.2 |
| Plastic modulus | Sy= | 290 | cm3 | mcy2= | 103 |
| Moment capacity for section | Mcy= | **103** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\ py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \ <=1$$

0.030 + 0.206 + 0.021 = **0.257** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 5800 | mm | normal condition |
| Effective length | Lelt2= | 5800 | mm | |
| | L e lt= | 5800 | mm | |
| Radius of gyration y-y | ry= | 5.7 | cm | |
| | rx= | 5.7 | cm | |
| | Lam'y= | 101.8 | | |
| | La'mx= | 101.8 | | |

CONTINUE OF FB1.10

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 | N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 | TABLE 16 |
| Robertson constant for section | | | | | | |
| | a= | 2 | for table 23 | a | | |
| Perry factor | eta= | 0.17 | | | | |
| Euler strength | pe= | 195 | N/mm2 | | | |
| Factor | phi= | 292 | N/mm2 | | | |
| Compressive strength | pcy= | **165.7** | N/mm2 | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 101.8 | La'mx= | 101.75 | | Lamy/x= | 0.036 |
| Slenderness of section | Lamda= | 101.8 | | | | Lamx/x= | 0.036 |
| Torsional index | x= | 2830 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 1.00 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 1 | | | | | |
| Equivalent slenderness | lamlt= | 101.8 | | | | | |
| Buckling strength (Table 16) | pb= | 129 | N/mm2 | for lamlt= | 105 | py= | 355 |
| Buckling resisrance moment | Mb= | 37 | KNm | | | | |
| | Mb L= | 37 | KNm | | | | |
| | Mry= | 103 | KNm | | | | |
| | Pc= | 716 | KN | | | | |
| | Pcy= | 919.9 | KN | | | | |

$\frac{Fc}{PC} + \frac{m\ x\ Mx}{Py\ Zx} + \frac{m\ y\ My}{py\ Zy} = \ <=1$ m x= 0.95, m y= 0.95

0.065 + 0.237 + 0.024 = **0.326** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + \frac{m\ LT\ M\ lt}{Mb} + \frac{m\ y\ My}{py\ Zy} = \ <=1$

0.065 + 0.568 + 0.024 = **0.657** **The interaction formula is satisfied**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

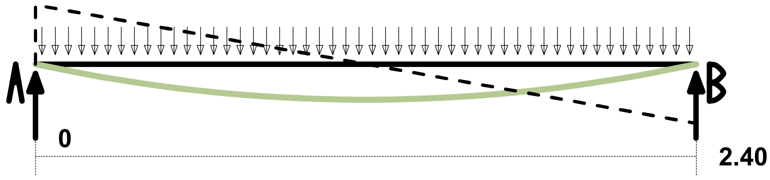
LOCATION= **FB0.01**

Loads are unfactored

Wd= **6.00** KN/m2
Wl= **2.50** KN/m2

Span= **2.40** m
Cover= **1.00** m

15 KN




15 KN

**SPAN**

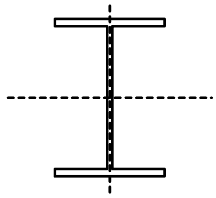
9 KNm

| Load on beam | unfactored | factored |
|---|---|---|
| **Dead+s/w=** | 6.3 KN/m' | 8.82 KN/m' |
| **Live=** | 2.50 KN/m' | 4.00 KN/m' |
| | 8.80 KN/m' | 12.82 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 10.6 KN | **15.4** KN |
| RB= | 10.6 KN | **15.4** KN |
| Shear zero at X= | | 1.20 m |
| Maximum Bending Moment Mx = | | **9.2** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 8.5 KNm | Local capacity | PASS | 0.149 |
| Maximum BM about axis Y | MY= | 0.85 KNm | Overall buckling 1 | PASS | 0.169 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.164 |
| Shear force in x axis | Fv= | 15.4 KN | Deflection (dead)= | PASS | 1/ 5219 |
| Beam span | L= | 2.40 m | Deflection(live)= | PASS | 1/ 13151 |
| Effective length about axis X | LX eff= | 2.40 m | Deflection (d+l)= | PASS | 1/ 3736 |
| Effective length about axis Y | LYeff= | 1.00 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | 360.0 or 14 mm | | | |
| | z rep= | 26 cm3 | | | |

**Section properties**

Section size (Ref. No= **66** ) **203x133 30 kg UB S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 206.8 mm | | | | |
| Width of section | B= | 133.8 mm | Pcy= | 1263 KN | | |
| Thickness of web | t= | 6.3 mm | Mcx= | 111.2 KNm | | |
| Thickness of flange | T= | 9.6 mm | Mcy= | 31.26 KNm | | 617.9 |
| Root radius | r= | 7.6 mm | Mb L= | 111.2 KNm | | |
| Second moment of area x-x | Ix= | 2887 cm4 | Mlt= | **0.925** | Pcy= | 1262.7 KN |
| Second moment of area y-y | Iy= | 384 cm4 | | | | |
| Plastic modulus x-x | Sx= | 313.3 cm3 | Sx eff= | 274.52 cm3 | | |
| Plastic modulus y-y | Sy= | 88.05 cm3 | Sy eff= | 53.09 cm3 | | |
| Area of section | Ag= | 38 cm2 | An= | 34.55 cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 0.46 mm | | E UDL= | 6.30 KN/m' |
| Unfactored live load deflection= | 0.18 mm | | E UDL= | 2.50 KN/m' |
| Unfactored dead+ live load def = | 0.64 mm | | E UDL= | 8.80 KN/m' |
| Span/def. ratio for dead load= | 5219 | | | |
| Span/def. ratio for live load= | **13152** | **>360** | | |
| Span/def. ratio fordead+ live load= | 3736 | | | |

CONTINUE OF FB0.01

**Strength of steel** Clause 3.1.1

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | | **S 355** | **)** | | | | | |
| for thickness of | 9.6 | mm | **py=** | **355** | N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | | | **E=** | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | class 1 | class 2 | class 3 | |
| Outstand of flange | b= | 66.9 | mm | plastic | compac | semi compact | |
| Ratio | b/T= | 6.97 | b/Tlim= | 7.92 | 8.80 | 13.20 | |

The classification is based on the outsatnd element — **The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.16 — r2=Fc/(Agxpyw)= 0.044

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Depth between fillets | d= | 172.3 | mm | TABLE 11 rolled section | | | |
| ratio | d/t= | 27.35 | | class 1 | class 2 | class 3 | |
| 40 ε | = | 35.21 | d/tlim= | 60.93 | 71.35 | 96.99 | |

The classification is based on the general web condition — **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | Av y= | 1303 | mm2 | (t x D) | |
| Shear capacity (0.6pyA) | Pvy= | 278 | KN | | |
| Shear force | Fvy= | 15.4 | KN | Fvy/Pvy= 0.06 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 279.3 | cm3 | Mcx1= | 99.15 |
| Plastic modulus | Sx= | 313 | cm3 | Mcx2= | 111.2 |
| Moment capacity for section | Mcx= | **111** | KNm | | |
| Elastic modulus | Zy= | 57.4 | cm3 | Mcy1= | 20.38 |
| Plastic modulus | Sy= | 88 | cm3 | mcy2= | 31.26 |
| Moment capacity for section | Mcy= | **31** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \;<=1$$

0.044 + 0.077 + 0.027 = **0.149** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 2400 | mm | normal condition |
| Effective length | Lelt2= | 1000 | mm | |
| | L e lt= | 1700 | mm | |
| Radius of gyration y-y | ry= | 3.18 | cm | |
| | rx= | 8.72 | cm | |
| | Lam'y= | 31.4 | | |
| | La'mx= | 27.5 | | |

CONTINUE OF FB0.01

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for section | | | | | |
| | a= | 3.5 | for table 23 | b | |
| Perry factor | eta= | 0.06 | | | |
| Euler strength | pe= | 2046 | N/mm2 | | |
| Factor | phi= | 1259 | N/mm2 | | |
| Compressive strength | pcy= | **332.3** | N/mm2 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 31.4 | La'mx= | 27.52 | | Lamy/x= | 1.4626 |
| Slenderness of section | Lamda= | 31.4 | | | | Lamx/x= | 1.2801 |
| Torsional index | x= | 21.5 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.97 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.882 | | | | | |
| Equivalent slenderness | lamlt= | 27.0 | | | | | |
| Buckling strength (Table 16) | pb= | 355 N/mm2 | | for lamlt= | 30 | py= | 355 |
| Buckling resisrance moment | Mb= | 111 KNm | | | | | |
| | Mb L= | 111 KNm | | | | | |
| | Mry= | 31 KNm | | | | | |
| | Pc= | 1263 KN | | | | | |
| | Pcy= | 1263 KN | | | | | |

$\frac{Fc}{PC} + m\frac{x\ Mx}{Py\ Zx} + m\frac{y\ My}{py\ Zy} = \ <=1$ m x= 0.95, m y= 0.95

0.048 + 0.082 + 0.040 = **0.169** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m\frac{LT\ M\ lt}{Mb} + m\frac{y\ My}{py\ Zy} = \ <=1$

0.048 + 0.077 + 0.040 = **0.164** **The interaction formula is satisfied**

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 146 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

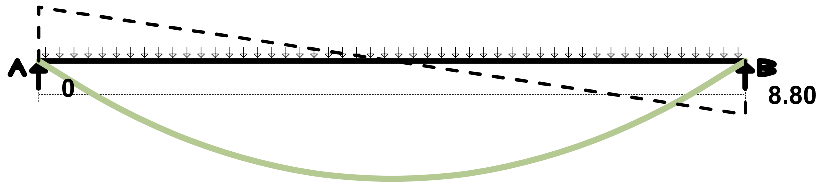
**Project:** 34 NASSAU ROAD, LONDON

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= FB0.12
Loads are unfactored
Wd= 6.00 KN/m2
Wl= 2.50 KN/m2

Span= 8.80 m
Cover= 2.40 m

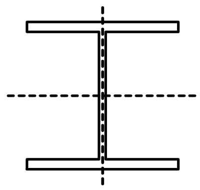



| Load on beam | unfactored | factored |
|---|---|---|
| Dead+s/w= | 15.77 KN/m' | 22.08 KN/m' |
| Live= | 6.00 KN/m' | 9.60 KN/m' |
| | 21.77 KN/m' | 31.68 KN/m' |

307 KNm
Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 95.8 KN | **139.4** KN |
| RB= | 95.8 KN | **139.4** KN |
| Shear zero at | X= | 4.40 m |
| Maximum Bending Moment | **Mx =** | **306.6** KNm |



SECTION

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 283.6 KNm | Local capacity | PASS | 0.446 |
| Maximum BM about axis Y | MY= | 28.36 KNm | Overall buckling 1 | PASS | 0.509 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.589 |
| Shear force in x axis | Fv= | 139.4 KN | Deflection (dead)= | PASS | 1/ 481 |
| Beam span | L= | 8.80 m | Deflection(live)= | PASS | 1/ 1264 |
| Effective length about axis X | LX eff= | 8.80 m | Deflection (d+l)= | PASS | 1/ 348 |
| Effective length about axis Y | LYeff= | 1.00 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 889 cm3 | | | |

**Section properties**

Section size (Ref. No= 87 ) **305x305 137 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 320.5 mm | | | | |
| Width of section | B= | 308.7 mm | Pcy= | 4002 KN | | |
| Thickness of web | t= | 13.8 mm | Mcx= | 792.8 KNm | | |
| Thickness of flange | T= | 21.7 mm | Mcy= | 362.9 KNm | | 3421.5 |
| Root radius | r= | 15.2 mm | Mb L= | 615.9 KNm | | |
| Second moment of area x-x | Ix= | 32838 cm4 | Mlt= | **0.925** | Pcy= | 4002 KN |
| Second moment of area y-y | Iy= | 10672 cm4 | | | | |
| Plastic modulus x-x | Sx= | 2298 cm3 | Sx eff= | 2018.96 cm3 | | |
| Plastic modulus y-y | Sy= | 1052 cm3 | Sy eff= | 647.89 cm3 | | |
| Area of section | Ag= | 174.6 cm2 | An= | 158.73 cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 18.29 mm | | E UDL= | 15.77 KN/m' |
| Unfactored live load deflection= | 6.96 mm | | E UDL= | 6.00 KN/m' |
| Unfactored dead+ live load def = | 25.25 mm | | E UDL= | 21.77 KN/m' |
| Span/def. ratio for dead load= | 481 | | | |
| Span/def. ratio for live load= | **1264** | **>360** | | |
| Span/def. ratio fordead+ live load= | 348 | | | |

CONTINUE OF FB0.12

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** | **)** | | | | | |
| for thickness of | 21.7 mm | **py=** | **345** | N/mm2 | py= | **345.0** | N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.893 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 154.4 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 7.11 | b/Tlim= | 8.04 | 8.93 | 13.39 |

The classification is based on the outsatnd element — **The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.05 r2=Fc/(Agxpyw)= 0.01

TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth between fillets | d= | 246.6 mm | | | | |
| ratio | d/t= | 17.87 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.71 | d/tlim= | 67.95 | 82.92 | 105.04 |

The classification is based on the general web condition — **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | | |
|---|---|---|---|---|---|---|
| Shear area | | Av y= | 4423 mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 916 KN | | | |
| Shear force | | Fvy= | 139.4 KN | Fvy/Pvy= | 0.15 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 2049 cm3 | Mcx1= | 706.9 |
| Plastic modulus | Sx= | 2298 cm3 | Mcx2= | 792.8 |
| Moment capacity for section | Mcx= | **793** KNm | | |
| Elastic modulus | Zy= | 691.4 cm3 | Mcy1= | 238.5 |
| Plastic modulus | Sy= | 1052 cm3 | mcy2= | 362.9 |
| Moment capacity for section | Mcy= | **363** KNm | | |

**Local capacity check Clause 4.8.3.2**

$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$

0.010 + 0.358 + 0.078 = **0.446** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 8800 mm | normal condition |
| Effective length | Lelt2= | 1000 mm | |
| | L e lt= | 4900 mm | |
| Radius of gyration y-y | ry= | 7.82 cm | |
| | rx= | 13.7 cm | |
| | Lam'y= | 12.8 | |
| | La'mx= | 64.2 | |

CONTINUE OF FB0.12

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.32 | | py= | 345 N/mm2 |
| For buckling about y-y | | | λ L0= | | 30.60 TABLE 16 |
| Robertson constant for section | | | | | |
| | a= | 5.5 for table 23 | c | | |
| Perry factor | eta= | 0.27 | | | |
| Euler strength | pe= | 490 N/mm2 | | | |
| Factor | phi= | 484 N/mm2 | | | |
| Compressive strength | pcy= | **229.2** N/mm2 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 12.8 | La'mx= | 64.23 | Lamy/x= | 0.9069 |
| Slenderness of section | Lamda= | 64.2 | | | Lamx/x= | 4.5556 |
| Torsional index | x= | 14.1 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.99 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.851 | | | | |
| Equivalent slenderness | lamlt= | 54.1 | | | | |
| Buckling strength (Table 16) | pb= | 268 N/mm2 | for lamlt= | 55 | py= | 345 |
| Buckling resisrance moment | Mb= | 616 KNm | | | | |
| | Mb L= | 616 KNm | | | | |
| | Mry= | 363 KNm | | | | |
| | Pc= | 4002 KN | | | | |
| | Pcy= | 4002 KN | | | | |

$\frac{Fc}{PC} + \frac{m_x Mx}{Py\ Zx} + \frac{m_y My}{py\ Zy} = \leq 1$ m x= 0.95, m y= 0.95

0.015 + 0.381 + 0.113 = **0.509** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + \frac{m_{LT} M_{lt}}{Mb} + \frac{m_y My}{py\ Zy} = \leq 1$

0.015 + 0.461 + 0.113 = **0.589** **The interaction formula is satisfied**

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|---|---|---|---|
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

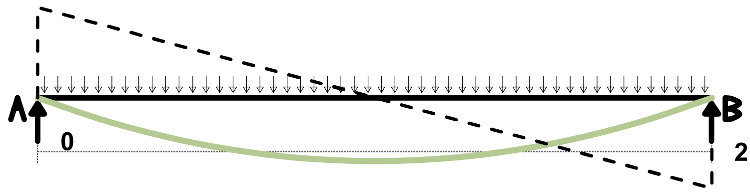
H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= **FB0.14**

Loads are unfactored

Wd= **6.00** KN/m2
Wl= **5.00** KN/m2

Span= **2.80** m
Cover= **2.00** m

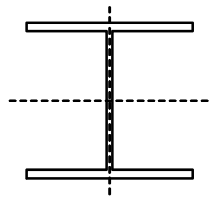



**SPAN**

| Load on beam | unfactored | factored | |
|---|---|---|---|
| | | | 33 KNm |
| | | | Partial safety factor for load |
| **Dead+s/w=** | 12.46 KN/m' | 17.44 KN/m' | dead= 1.4 |
| **Live=** | 10.00 KN/m' | 16.00 KN/m' | live= 1.6 |
| | 22.46 KN/m' | 33.44 KN/m' | |

**Reaction**

| | | | |
|---|---|---|---|
| RA= | 31.4 KN | | **46.8** KN |
| RB= | 31.4 KN | | **46.8** KN |
| Shear zero at | | X= | 1.40 m |
| Maximum Bending Moment | | **Mx =** | **32.8** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 30.3 KNm | Local capacity | PASS | 0.238 |
| Maximum BM about axis Y | MY= | 3.03 KNm | Overall buckling 1 | PASS | 0.266 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.257 |
| Shear force in x axis | Fv= | 46.8 KN | Deflection (dead)= | PASS | 1/ 2627 |
| Beam span | L= | 2.80 m | Deflection(live)= | PASS | 1/ 3273 |
| Effective length about axis X | LX eff= | 2.80 m | Deflection (d+l)= | PASS | 1/ 1457 |
| Effective length about axis Y | LYeff= | 1.00 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 92 cm3 | | | |

**Section properties**

Section size (Ref. No= **99** ) **203x203 46 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 203.2 mm | | | | |
| Width of section | B= | 203.2 mm | Pcy= | 1882 KN | | |
| Thickness of web | t= | 7.3 mm | Mcx= | 176.6 KNm | | |
| Thickness of flange | T= | 11 mm | Mcy= | 81.65 KNm | | 980.98 |
| Root radius | r= | 10.2 mm | Mb L= | 176.6 KNm | | |
| Second moment of area x-x | Ix= | 4564 cm4 | Mlt= | **0.925** | Pcy= | 1881.9 KN |
| Second moment of area y-y | Iy= | 1539 cm4 | | | | |
| Plastic modulus x-x | Sx= | 497.4 cm3 | Sx eff= | 442.53 cm3 | | |
| Plastic modulus y-y | Sy= | 230 cm3 | Sy eff= | 140.06 cm3 | | |
| Area of section | Ag= | 58.8 cm2 | An= | 53.45 cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 1.07 mm | | E UDL= | 12.46 KN/m' |
| Unfactored live load deflection= | 0.86 mm | | E UDL= | 10.00 KN/m' |
| Unfactored dead+ live load def = | 1.92 mm | | E UDL= | 22.46 KN/m' |
| Span/def. ratio for dead load= | 2627 | | | |
| Span/def. ratio for live load= | **3273** | **>360** | | |
| Span/def. ratio fordead+ live load= | 1457 | | | |

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| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

CONTINUE OF FB0.14

**Strength of steel** Clause 3.1.1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355 )** | | | | | |
| for thickness of | 11 mm | **py=** | **355** N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 101.6 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 9.24 | b/Tlim= | 7.92 | 8.80 | 13.20 |
| The classification is based on the outsatnd element | | | **The section is class 3 semi compact** | | | |
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.14 | r2=Fc/(Agxpyw)= | 0.029 | | |
| Depth between fillets | d= | 160.8 mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 22.03 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.21 | d/tlim= | 61.55 | 72.38 | 99.88 |
| The classification is based on the general web condition | | | **The section is class1 plastic** | | | |

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 1483 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 316 KN | | |
| Shear force | | Fvy= | 46.8 KN | Fvy/Pvy= 0.15 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 449.2 cm3 | Mcx1= | 159.5 |
| Plastic modulus | Sx= | 497 cm3 | Mcx2= | 176.6 |
| Moment capacity for section | Mcx= | **177** KNm | | |
| Elastic modulus | Zy= | 151 cm3 | Mcy1= | 53.61 |
| Plastic modulus | Sy= | 230 cm3 | mcy2= | 81.65 |
| Moment capacity for section | Mcy= | **82** KNm | | |

**Local capacity check Clause 4.8.3.2**

$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \;<=1$

0.029 + 0.172 + 0.037 = **0.238** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 2800 mm | normal condition |
| Effective length | Lelt2= | 1000 mm | |
| | L e lt= | 1900 mm | |
| Radius of gyration y-y | ry= | 5.11 cm | |
| | rx= | 8.81 cm | |
| | Lam'y= | 19.6 | |
| | La'mx= | 31.8 | |

CONTINUE OF FB0.14

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | | 30.20 TABLE 16 |
| Robertson constant for section | | | | | |
| | a= | 5.5 for table 23 | c | | |
| Perry factor | eta= | 0.09 | | | |
| Euler strength | pe= | 2003 N/mm2 | | | |
| Factor | phi= | 1271 N/mm2 | | | |
| Compressive strength | pcy= | **320.0** N/mm2 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 19.6 | La'mx= | 31.78 | Lamy/x= | 1.1056 |
| Slenderness of section | Lamda= | 31.8 | | | Lamx/x= | 1.7956 |
| Torsional index | x= | 17.7 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.99 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.846 | | | | |
| Equivalent slenderness | lamlt= | 26.5 | | | | |
| Buckling strength (Table 16) | pb= | 355 N/mm2 | for lamlt= | 30 | py= | 355 |
| Buckling resisrance moment | Mb= | 177 KNm | | | | |
| | Mb L= | 177 KNm | | | | |
| | Mry= | 82 KNm | | | | |
| | Pc= | 1882 KN | | | | |
| | Pcy= | 1882 KN | | | | |

Fc/PC + m x Mx/(Py Zx) + m y My/(py Zy) = <=1          m x= 0.95, m y= 0.95

0.032 + 0.181 + 0.054 = **0.266**     **The interaction formula is satisfied**

Fc/Pcy + m LT M lt/Mb + m y My/(py Zy) = <=1

0.032 + 0.172 + 0.054 = **0.257**     **The interaction formula is satisfied**

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| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

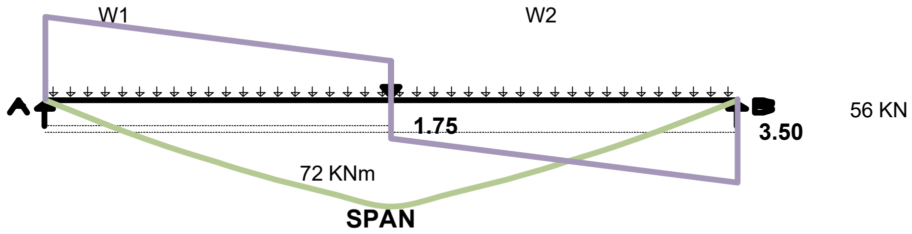
**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= FB0.15

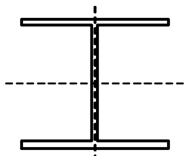
Loads are unfactored

| | | |
|---|---|---|
| Wd1= | 6.00 | KN/m2 |
| Wl1= | 5.00 | KN/m2 |
| Wd2= | 6.00 | KN/m2 |
| wl2= | 5.00 | KN/m2 |
| P1= | 35.00 | KN |
| a= | 1.75 | m |
| Span= | 3.50 | m |
| Cover= | 1.00 | m |




| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | 35.00 KN | 52.5 KN |
| AV-Dead+s/w= | 6.46 KN/m' | 9.044 KN/m' |
| Live= | 5.00 KN/m' | 8 KN/m' |
| | 11.46 KN/m' | 17.044 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6




**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 37.6 KN | 56.1 KN |
| RB= | 37.6 KN | 56.1 KN |
| Shear zero at | X= | 1.75 m |
| Maximum Bending Moment | Mx = | 72 KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 63.2 KNm | Local capacity | PASS | 0.436 |
| Maximum BM about axis Y | MY= | 6.32 KNm | Overall buckling 1 | PASS | 0.495 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | PASS | 0.491 |
| Shear force in x axis | Fv= | 56.1 KN | Deflection (dead)= | PASS | 1/ 979 |
| Beam span | L= | 3.50 m | Deflection(live)= | PASS | 1/ 1175 |
| Effective length about axis X | LX eff= | 3.50 m | Deflection (d+l)= | PASS | 1/ 534 |
| Effective length about axis Y | LYeff= | 2.13 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | 360.0 or 14 mm | | | |
| | z rep= | 203 cm3 | | | |

**Section properties**

Section size (Ref. No= 99 ) **203x203 46 kg UC S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 203.2 mm | | |
| Width of section | B= | 203.2 mm | | |
| Thickness of web | t= | 7.3 mm | Mcx= | 176.58 KNm |
| Thickness of flange | T= | 11 mm | Mcy= | 81.65 KNm |
| Root radius | r= | 11 mm | Mb L= | 169.61 KNm |
| Second moment of area x-x | Ix= | 4564 cm4 | Mlt= | 0.877 TABLE 18 |
| Second moment of area y-y | Iy= | 1539 cm4 | | |
| Plastic modulus x-x | Sx= | 497.4 cm3 | Sx eff= | 441.61 cm3 |
| Plastic modulus y-y | Sy= | 230 cm3 | Sy eff= | 138.57 cm3 |
| Area of section | Ag= | 58.8 cm2 | An= | 53.45 cm2 ke= 1.1 |

**DEFLECTION**

| | | | unfactored |
|---|---|---|---|
| Unfactored dead load deflection= | 3.57 mm | | E UDL= 17.11 KN/m' |
| Unfactored live load deflection= | 2.98 mm | | E UDL= 14.26 KN/m' |
| Unfactored dead+ live load def = | 6.55 mm | | E UDL= 31.36 KN/m' |
| Span/def. ratio for dead load= | 980 | | |
| Span/def. ratio for live load= | 1176 | >360 | |
| Span/def. ratio fordead+ live load= | 534 | | |

CONTINUE OF FB0.15

**Strength of steel** Clause 3.1.1

Design strength **(Grade** **S 355** **)**
for thickness of 11 mm **py=** **355** N/mm2 py= **355.0** N/mm2 pyw= py
Young's Modulus **E=** 205 KN/mm2

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | class 1 | class 2 | class 3 |
|---|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | | plastic | compac | semi compact |
| Outstand of flange | b= | 101.6 | mm | | | | |
| Ratio | b/T= | 9.24 | | b/Tlim= | 7.92 | 8.80 | 13.20 |

**The section is class 3 semi compact**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.24 r2=Fc/(Agxpyw)= 0.0005

Depth between fillets d= 160.8 mm TABLE 11 rolled section

| | | | | class 1 | class 2 | class 3 |
|---|---|---|---|---|---|---|
| ratio | d/t= | 22.03 | | | | |
| 40 ε | = | 35.206 | d/tlim= | 56.78 | 64.72 | 105.52 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 1483.4 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 316 KN | | |
| Shear force | | Fvy= | 56.1 KN | Fvy/Pvy= 0.18 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 449.2 cm3 | Mcx1= | 159.47 |
| Plastic modulus | Sx= | 497 cm3 | Mcx2= | 176.58 |
| Moment capacity for section | Mcx= | **176.6** KNm | | |
| Elastic modulus | Zy= | 151 cm3 | Mcy1= | 53.605 |
| Plastic modulus | Sy= | 230.0 cm3 | mcy2= | 81.65 |
| Moment capacity for section | Mcy= | **81.7** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.000 + 0.358 + 0.077 = **0.436** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 3500 mm | normal condition |
| Effective length | Lelt2= | 2128.2 mm | |
| | L e lt= | 2814.1 mm | |
| Radius of gyration y-y | ry= | 5.11 cm | |
| | rx= | 8.81 cm | |
| | Lam'y= | 41.6 | |
| | La'mx= | 39.7 | |

CONTINUE OF FB0.15

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for H section | | | | |
| | a= | 5.5 | | |
| Perry factor | eta= | 0.15 | | |
| Euler strength | pe= | 1166 N/mm2 | | |
| Factor | phi= | 846 N/mm2 | | |
| Compressive strength | pcy= | **296.9** N/mm2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 41.6 | La'mx= | 39.73 | Lamy/x= | 2.35298 |
| Slenderness of section | Lamda= | 41.6 | | | Lamx/x= | 2.2445 |
| Torsional index | x= | 17.7 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.96 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.846 | | | | |
| Equivalent slenderness | lamlt= | 33.8 | | | | |
| Buckling strength (Table 16) | pb= | 341 N/mm2 | for lamlt= | 35 | py= | 355 |
| Buckling resisrance moment | Mb= | 169.6 KNm | | | | |
| | Mb L= | 169.6 KNm | | | | |
| | Mry= | 81.7 KNm | | | | |
| | Pc= | 1745.5 KN | | | | |
| | Pcy= | 1745.5 KN | | | | |

$\frac{Fc}{PC} + m\frac{x\,Mx}{Py\,Zx} + m\frac{y\,My}{py\,Zy} = \leq 1$ m x= 0.95, m y= 1

0.001 + 0.376 + 0.118 = **0.495** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m\frac{LT\,M\,lt}{Mb} + m\frac{y\,My}{py\,Zy} = \leq 1$

0.001 + 0.373 + 0.118 = **0.491** **The interaction formula is satisfied**

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| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

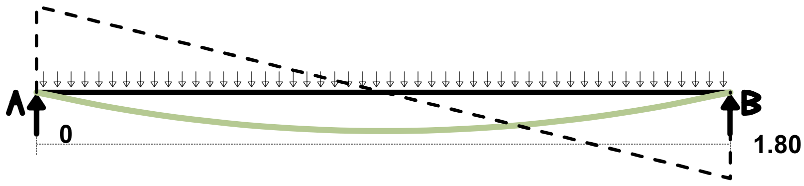
LOCATION= **FB0.16**

Loads are unfactored

Wd= **6.00** KN/m2
Wl= **5.00** KN/m2

30 KN

Span= **1.80** m
Cover= **2.00** m



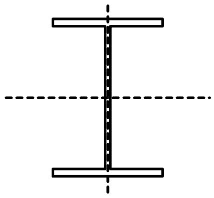

**SPAN**

| Load on beam | unfactored | | factored | |
|---|---|---|---|---|
| **Dead+s/w=** | 12.3 | KN/m' | 17.22 | KN/m' |
| **Live=** | 10.00 | KN/m' | 16.00 | KN/m' |
| | 22.30 | KN/m' | 33.22 | KN/m' |

13 KNm
Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | | | | |
|---|---|---|---|---|
| RA= | 20.1 KN | | **29.9** | KN |
| RB= | 20.1 KN | | **29.9** | KN |
| Shear zero at | | X= | 0.90 | m |
| Maximum Bending Moment | | **Mx =** | **13.5** | KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 12.4 KNm | Local capacity | PASS | 0.196 |
| Maximum BM about axis Y | MY= | 1.24 KNm | Overall buckling 1 | PASS | 0.225 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.217 |
| Shear force in x axis | Fv= | 29.9 KN | Deflection (dead)= | PASS | 1/ 6336 |
| Beam span | L= | 1.80 m | Deflection(live)= | PASS | 1/ 7793 |
| Effective length about axis X | LX eff= | 1.80 m | Deflection (d+l)= | PASS | 1/ 3494 |
| Effective length about axis Y | LYeff= | 1.00 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 38 cm3 | | | |

**Section properties**

Section size (Ref. No= **66** ) **203x133 30 kg UB S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 206.8 mm | | | | |
| Width of section | B= | 133.8 mm | Pcy= | 1263 KN | | |
| Thickness of web | t= | 6.3 mm | Mcx= | 111.2 KNm | | |
| Thickness of flange | T= | 9.6 mm | Mcy= | 31.26 KNm | | 617.9 |
| Root radius | r= | 7.6 mm | Mb L= | 111.2 KNm | | |
| Second moment of area x-x | Ix= | 2887 cm4 | Mlt= | **0.925** | Pcy= | 1262.7 KN |
| Second moment of area y-y | Iy= | 384 cm4 | | | | |
| Plastic modulus x-x | Sx= | 313.3 cm3 | Sx eff= | 274.52 cm3 | | |
| Plastic modulus y-y | Sy= | 88.05 cm3 | Sy eff= | 53.09 cm3 | | |
| Area of section | Ag= | 38 cm2 | An= | 34.55 cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 0.28 mm | | E UDL= | 12.30 KN/m' |
| Unfactored live load deflection= | 0.23 mm | | E UDL= | 10.00 KN/m' |
| Unfactored dead+ live load def = | 0.52 mm | | E UDL= | 22.30 KN/m' |
| Span/def. ratio for dead load= | 6336 | | | |
| Span/def. ratio for live load= | **7794** | **>360** | | |
| Span/def. ratio fordead+ live load= | 3495 | | | |

CONTINUE OF FB0.16

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | | **S 355** | **)** | | | | |
| for thickness of | 9.6 | mm | **py=** | **355** | N/mm2 | py= | **355.0** N/mm2 | pyw= py |
| Young's Modulus | | | **E=** | 205 | KN/mm2 | | | |

**Classification of cross section** (clause 3.5.2)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | TABLE 11 rolled section | | | |
| Constant (table 11 note b) | ε = | 0.880 | | class 1 | class 2 | class 3 | |
| Outstand of flange | b= | 66.9 mm | | plastic | compac | semi compact | |
| Ratio | b/T= | 6.97 | b/Tlim= | 7.92 | 8.80 | 13.20 | |
| The classification is based on the outsatnd element | | | | **The section is class1 plastic** | | | |
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.16 | r2=Fc/(Agxpyw)= | 0.044 | | | |
| Depth between fillets | d= | 172.3 mm | | TABLE 11 rolled section | | | |
| ratio | d/t= | 27.35 | | class 1 | class 2 | class 3 | |
| 40 ε | = | 35.21 | d/tlim= | 60.93 | 71.35 | 96.99 | |
| The classification is based on the general web condition | | | | **The section is class1 plastic** | | | |

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 1303 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 278 KN | | |
| Shear force | | Fvy= | 29.9 KN | Fvy/Pvy= 0.11 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 279.3 cm3 | Mcx1= | 99.15 |
| Plastic modulus | Sx= | 313 cm3 | Mcx2= | 111.2 |
| Moment capacity for section | Mcx= | **111** KNm | | |
| Elastic modulus | Zy= | 57.4 cm3 | Mcy1= | 20.38 |
| Plastic modulus | Sy= | 88 cm3 | mcy2= | 31.26 |
| Moment capacity for section | Mcy= | **31** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \;<=1$$

0.044 + 0.112 + 0.040 = **0.196** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 1800 mm | normal condition |
| Effective length | Lelt2= | 1000 mm | |
| | L e lt= | 1400 mm | |
| Radius of gyration y-y | ry= | 3.18 cm | |
| | rx= | 8.72 cm | |
| | Lam'y= | 31.4 | |
| | La'mx= | 20.6 | |

CONTINUE OF FB0.16

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 | N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 | TABLE 16 |
| Robertson constant for section | | | | | | |
| | a= | 3.5 | for table 23 | b | | |
| Perry factor | eta= | 0.06 | | | | |
| Euler strength | pe= | 2046 | N/mm2 | | | |
| Factor | phi= | 1259 | N/mm2 | | | |
| Compressive strength | pcy= | **332.3** | N/mm2 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lam'y= | 31.4 | | La'mx= | 20.64 | | Lamy/x= | 1.4626 |
| Slenderness of section | Lamda= | 31.4 | | | | | Lamx/x= | 0.9601 |
| Torsional index | x= | 21.5 | | | | | | |
| | N= | 0.5 | | | | | | |
| Slenderness factor | v= | 0.97 | from Table 19 | | | | | |
| | β w = | 1.0 | | | | | | |
| Buckling parameter | u= | 0.882 | | | | | | |
| Equivalent slenderness | lamlt= | 27.0 | | | | | | |
| Buckling strength (Table 16) | pb= | 355 | N/mm2 | for lamlt= | 30 | | py= | 355 |
| Buckling resisrance moment | Mb= | 111 | KNm | | | | | |
| | Mb L= | 111 | KNm | | | | | |
| | Mry= | 31 | KNm | | | | | |
| | Pc= | 1263 | KN | | | | | |
| | Pcy= | 1263 | KN | | | | | |

$\frac{Fc}{PC} + m\frac{x\,Mx}{Py\,Zx} + m\frac{y\,My}{py\,Zy} = \;<=1$    m x= 0.95, m y= 0.95

0.048 + 0.119 + 0.058 = **0.225**    **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m\frac{LT\,M\,lt}{Mb} + m\frac{y\,My}{py\,Zy} = \;<=1$

0.048 + 0.112 + 0.058 = **0.217**    **The interaction formula is satisfied**

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 158 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.NO WORK SHOULD START BEFORE THE CALCULATIONS HAVE BEEN RECEIVED AND APPROVED BY THE LA BUILDING CONTROL.**

**GROUND FLOOR LEVEL**

**STEEL BEAM** **FB0.17**

Max span = 6.6 m
Cover= 0.8 m

**USE 254x254x107 UC** **S355** SEE PAGE 159 - 161

**STEEL BEAM** **FB0.18**

Max span = 8.8 m SIMPLIFIED'

| BEAM LOADING | | D LOAD | I LOAD | cover y | | dead load | live load |
|---|---|---|---|---|---|---|---|
| | | KN/m2 | KN/m2 | m | | KN/m' | KN/m' |
| ROOF | dead | **2** | | **2** | => 2* 2= | 4 | |
| | live | | **0.75** | **2** | => 2*0.75= | | 1.5 |
| G floor | dead | **6** | | **1.2** | => 1.2* 6= | 7.2 | |
| | live | | **2.50** | **1.2** | => 1.2*2.50= | | 3 |
| wall | dead | **3.85** | | **2.7** | => 2.7* 3.85= | 10.395 | |
| | | | | | **UDL** | **21.595 KN/m'** | **4.5 KN/m'** |

**USE 305x305x158 UC** **S355** SEE PAGE 162 - 164

**STEEL BEAM** **FB0.19 IF REQUIRED**

Max span = 3.5 m
Cover= 2 m

**USE 203x133x30 UB** **S355** SEE PAGE 165 - 167

go to page 168

All design calculations have been author reviewed and subject to additional review by the project team, as required by David Smith Associates Quality Assurance procedures.

date printed 28/03/24

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| | | | |
|---|---|---|---|
| Project No: | 24/54904 | Sheet No: | 159 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **38 SKEENA HILL, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

LOCATION= **FB0.05** SPAN= **8.60** m **S355**
Uniform distributed load COVER= **0.80** m

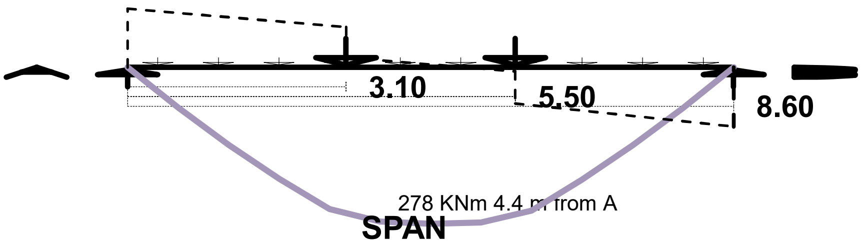
| | Unfactored | | Factored | |
|---|---|---|---|---|
| wdl= | **6.00** | KN/m2 | ( **8.40** ) | |
| wll = | **2.50** | KN/m2 | ( **4.00** ) | |
| | **8.50** | | **12.40** | KN/m2 |
| | factor= | | **1.46** | |

**H rolled section**
**Calculation in accordance**
**with BS 5950: 1: 2000**

Point load

| | | | | |
|---|---|---|---|---|
| **P1=** | **36.00** | KN | ( **54.0** )KN | |
| **a1=** | **3.10** | m | | |
| **P2=** | **38.0** | KN | ( **57.00** )KN | |
| **a2=** | **5.50** | **m** | | |

Partial safety factor for load
dead= 1.4
live= 1.6




| | Unfactored | | (Factored ) | |
|---|---|---|---|---|
| Wd= | 5.87 | KN/m' | ( 8.22 ) | |
| Wl = | 2 | kKN/m' | ( 3.20 ) | |
| | 7.87 | KN/m' | **11.42** | KN/m' |

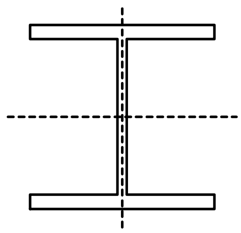
**Reactions**

| | | | | |
|---|---|---|---|---|
| **RA=** | 70.562 | KN | ( **104.2** | KN |
| **RB=** | 71.12 | KN | ( **105.0** | KN |

Desidn bending moment(factored)=

| | | | |
|---|---|---|---|
| M@P1 | = | **268.1** | KNm |
| M@P2 | = | **270.7** | KNm |
| X= | | **4.39** | m from A |
| M@ X= | | **277.7** | KNm |
| **DBM=** | | **277.7** | **KNm** |

Eq. udl = 30.034 KN/m' (factored)
Eq. ud l= 5.8889 lKN/m' (live unfactored)



**SECTION**

| | | | | | | factor |
|---|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 253.9 KNm | Local capacity | **PASS** | | 0.623 |
| Maximum BM about axis Y | MY= | 25.39 KNm | Overall buckling 1 | **PASS** | | 0.724 |
| Axial compressive load | Fc= | 104.18 KN | Overall buckling 2 | **PASS** | | 0.830 |
| Shear force in x axis | Fv= | 105.0 KN | Deflection (dead)= | **FAIL** | | 1/ 347 |
| Beam span | L= | 8.60 m | Deflection(live)= | **PASS** | | 1/ 912 |
| Effective length about axis X | LX eff= | 8.60 m | Deflection (d+l)= | **PASS** | | 1/ 251 |
| Effective length about axis Y | LYeff= | 4.30 m | Fully restraint for Ly& LX <1. | | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | | |
| | z rep= | 736 cm3 | | | | |

**Section properties**

Section size (Ref. No= **92** ) **254x254 107 kg UC S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 266.7 mm | | |
| Width of section | B= | 258.3 mm | | |
| Thickness of web | t= | 13 mm | Mcx= | 512.3 KNm |
| Thickness of flange | T= | 20.5 mm | Mcy= | 239.9 KNm |
| Root radius | r= | 20.5 mm | Mb L= | 398 KNm |
| Second moment of area x-x | Ix= | 17510 cm4 | mlt= | **0.914** AUTO |
| Second moment of area y-y | Iy= | 5901 cm4 | | |
| Plastic modulus x-x | Sx= | 1485 cm3 | Sx eff= | 1255.67 cm3 |
| Plastic modulus y-y | Sy= | 695.5 cm3 | Sy eff= | 377.37 cm3 |
| Area of section | Ag= | 136.6 cm2 | An= | 124.18 cm2 ke= 1.1 |

CONTINUE OF FB0.05

| | | | | | | |
|---|---|---|---|---|---|---|
| **DEFLECTION** | | | | | unfactored | |
| Unfactored dead load deflection= | 24.75 | mm | | E UDL= | 14.81 | KN/m' |
| Unfactored live load deflection= | 9.43 | mm | | E UDL= | 5.89 | KN/m' |
| Unfactored dead+ live load def = | 34.18 | mm | | E UDL= | 20.70 | KN/m' |
| Span/def. ratio for dead load= | 347 | | | | | |
| Span/def. ratio for live load= | **912** | | **>360** | | | |
| Span/def. ratio fordead+ live load= | 252 | | | | | |

**Strength of steel** Clause 3.1.1

Design strength **(Grade S 355 )**

for thickness of 20.5 mm **py=** **345** N/mm2 py= **345.0** N/mm2 pyw= py

Young's Modulus **E=** 205 KN/mm2

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | ε = | 0.893 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 102.15 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 4.98 | | b/Tlim= | 8.04 | 8.93 | 13.39 |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 1.00 r2=Fc/(Agxpyw)= 0.022

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | TABLE 11 rolled section | | |
| Depth between fillets | d= | 200.2 | mm | | | | |
| ratio | d/t= | 15.40 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.712 | | d/tlim= | 35.71 | 35.71 | 102.60 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shear area | | Av y= | 3467.1 | mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 718 | KN | | | |
| Shear force | | Fvy= | 105.0 | KN | Fvy/Pvy= | 0.15 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 1313 | cm3 | Mcx1= | 453 |
| Plastic modulus | Sx= | 1485 | cm3 | Mcx2= | 512.3 |
| Moment capacity for section | Mcx= | **512.3** | KNm | | |
| Elastic modulus | Zy= | 456.9 | cm3 | Mcy1= | 157.6 |
| Plastic modulus | Sy= | 695.5 | cm3 | mcy2= | 239.9 |
| Moment capacity for section | Mcy= | **239.9** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$\frac{F}{Ag.\ py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \; <=1$

0.022 + 0.496 + 0.106 = **0.623** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 8600 | mm | normal condition |
| Effective length | Lelt2= | 4300 | mm | |
| | L e lt= | 6450 | mm | |
| Radius of gyration y-y | ry= | 6.57 | cm | |
| | rx= | 11.3 | cm | |
| | Lam'y= | 65.4 | | |
| | La'mx= | 76.1 | | |

CONTINUE OF FB0.05

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.32 | | py= | 345 N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.60 TABLE 16 |
| Robertson constant for H section | | | | | |
| | a= | 5.5 | | | |
| Perry factor | eta= | 0.33 | | | |
| Euler strength | pe= | 349 | N/mm2 | | |
| Factor | phi= | 406 | N/mm2 | | |
| Compressive strength | pcy= | **195.9** | N/mm2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 65.4 | La'mx= | 76.11 | Lamy/x= | 5.2781 |
| Slenderness of section | Lamda= | 76.1 | | | Lamx/x= | 6.1376 |
| Torsional index | x= | 12.4 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.82 | from Table 19 | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.848 | | | | |
| Equivalent slenderness | lamlt= | 52.9 | | | | |
| Buckling strength (Table 16) | pb= | 268 | N/mm2 | for lamlt= 55 | py= | 345 |
| Buckling resisrance moment | Mb= | 398.0 | KNm | | | |
| | Mb L= | 398.0 | KNm | | | |
| | Mry= | 239.9 | KNm | | | |
| | Pc= | 2675.8 | KN | | | |
| | Pcy= | 2675.8 | KN | | | |

Fc/PC + m x Mx/Py Zx + m y My/py Zy = <=1      m x= 0.95   m y= 0.95

0.039 + 0.532 + 0.153 = **0.724**      **The interaction formula is satisfied**

Fc/Pcy + m LT M lt/Mb + m y My/py Zy = <=1

0.039 + 0.638 + 0.153 = **0.830**      **The interaction formula is satisfied**

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| Project No: | 24/54720 | Sheet No: | 162 |
|---|---|---|---|
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

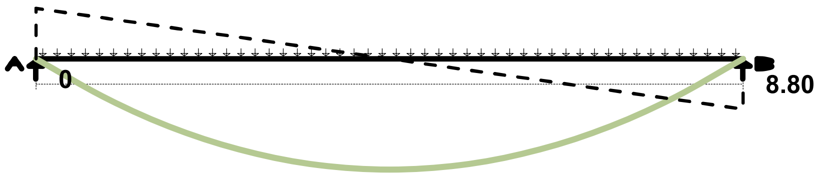
**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **FB0.18**

Loads are unfactored

Wd= **21.60** KN/m2
Wl= **4.50** KN/m2

174 KN




174 KN

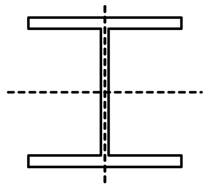
**SPAN**

Span= **8.80** m
Cover= **1.00** m

| Load on beam | unfactored | factored | |
|---|---|---|---|
| | | | 384 KNm |
| | | | Partial safety factor for load |
| **Dead+s/w=** | 23.175 KN/m' | 32.45 KN/m' | dead= 1.4 |
| **Live=** | 4.50 KN/m' | 7.20 KN/m' | live= 1.6 |
| | 27.68 KN/m' | 39.65 KN/m' | |

**Reaction**

| | unfactored | | factored |
|---|---|---|---|
| RA= | 121.8 KN | | **174.4** KN |
| RB= | 121.8 KN | | **174.4** KN |
| Shear zero at | | X= | 4.40 m |
| Maximum Bending Moment | | **Mx =** | **383.8** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 355.0 KNm | Local capacity | PASS | 0.476 |
| Maximum BM about axis Y | MY= | 35.50 KNm | Overall buckling 1 | PASS | 0.547 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.628 |
| Shear force in x axis | Fv= | 174.4 KN | Deflection (dead)= | PASS | 1/ 386 |
| Beam span | L= | 8.80 m | Deflection(live)= | PASS | 1/ 1988 |
| Effective length about axis X | LX eff= | 8.80 m | Deflection (d+l)= | PASS | 1/ 323 |
| Effective length about axis Y | LYeff= | 1.00 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 1112 cm3 | | | |

**Section properties**

Section size (Ref. No= **86** ) **305x305 158 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 327.2 mm | | | | |
| Width of section | B= | 310.6 mm | Pcy= | 4664 KN | | |
| Thickness of web | t= | 15.7 mm | Mcx= | 924.6 KNm | | |
| Thickness of flange | T= | 25 mm | Mcy= | 423.7 KNm | | 3990.2 |
| Root radius | r= | 15.2 mm | Mb L= | 718.2 KNm | | |
| Second moment of area x-x | Ix= | 38740 cm4 | Mlt= | **0.925** | Pcy= | 4664.5 KN |
| Second moment of area y-y | Iy= | 12524 cm4 | | | | |
| Plastic modulus x-x | Sx= | 2680 cm3 | Sx eff= | 2330.72 cm3 | | |
| Plastic modulus y-y | Sy= | 1228 cm3 | Sy eff= | 755.91 cm3 | | |
| Area of section | Ag= | 201.2 cm2 | An= | 182.91 cm2 | ke= 1.1 | |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 22.79 mm | | E UDL= | 23.18 KN/m' |
| Unfactored live load deflection= | 4.42 mm | | E UDL= | 4.50 KN/m' |
| Unfactored dead+ live load def = | 27.21 mm | | E UDL= | 27.68 KN/m' |
| Span/def. ratio for dead load= | 386 | | | |
| Span/def. ratio for live load= | **1989** | **>360** | | |
| Span/def. ratio fordead+ live load= | 323 | | | |

CONTINUE OF FB0.18

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** | **)** | | | | | |
| for thickness of | 25 mm | **py=** | **345** | N/mm2 | py= | **345.0** | N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.893 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 155.3 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 6.21 | | b/Tlim= | 8.04 | 8.93 | 13.39 |
| The classification is based on the outsatnd element | | | | | **The section is class1 plastic** | | |
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.04 | | r2=Fc/(Agxpyw)= | 0.009 | | |
| Depth between fillets | d= | 246.6 | mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 15.71 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.71 | | d/tlim= | 68.35 | 83.64 | 105.32 |
| The classification is based on the general web condition | | | | | **The section is class1 plastic** | | |

**Shear capacity** CL 4.2.3

| | | | | | | |
|---|---|---|---|---|---|---|
| Shear area | | Av y= | 5137 | mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 1063 | KN | | |
| Shear force | | Fvy= | 174.4 | KN | Fvy/Pvy= 0.16 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 2368 | cm3 | Mcx1= | 817 |
| Plastic modulus | Sx= | 2680 | cm3 | Mcx2= | 924.6 |
| Moment capacity for section | Mcx= | **925** | KNm | | |
| Elastic modulus | Zy= | 806.3 | cm3 | Mcy1= | 278.2 |
| Plastic modulus | Sy= | 1228 | cm3 | mcy2= | 423.7 |
| Moment capacity for section | Mcy= | **424** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.009 + 0.384 + 0.084 = **0.476** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 8800 | mm | normal condition |
| Effective length | Lelt2= | 1000 | mm | |
| | L e lt= | 4900 | mm | |
| Radius of gyration y-y | ry= | 7.89 | cm | |
| | rx= | 13.9 | cm | |
| | Lam'y= | 12.7 | | |
| | La'mx= | 63.3 | | |

CONTINUE OF FB0.18

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.32 | | py= | 345 N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.60 TABLE 16 |
| Robertson constant for section | | | | | |
| | a= | 5.5 | for table 23 | c | |
| Perry factor | eta= | 0.26 | | | |
| Euler strength | pe= | 505 | N/mm2 | | |
| Factor | phi= | 492 | N/mm2 | | |
| Compressive strength | pcy= | **231.8** | N/mm2 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 12.7 | | La'mx= | 63.31 | Lamy/x= | 1.0139 |
| Slenderness of section | Lamda= | 63.3 | | | | Lamx/x= | 5.0647 |
| Torsional index | x= | 12.5 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.99 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.852 | | | | | |
| Equivalent slenderness | lamlt= | 53.3 | | | | | |
| Buckling strength (Table 16) | pb= | 268 | N/mm2 | for lamlt= | 55 | py= | 345 |
| Buckling resisrance moment | Mb= | 718 | KNm | | | | |
| | Mb L= | 718 | KNm | | | | |
| | Mry= | 424 | KNm | | | | |
| | Pc= | 4664 | KN | | | | |
| | Pcy= | 4664 | KN | | | | |

$\frac{Fc}{PC} + m\frac{x\,Mx}{Py\,Zx} + m\frac{y\,My}{py\,Zy} = \ <=1$ m x= 0.95, m y= 0.95

0.013 + 0.413 + 0.121 = **0.547** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m\frac{LT\,M\,lt}{Mb} + m\frac{y\,My}{py\,Zy} = \ <=1$

0.013 + 0.494 + 0.121 = **0.628** **The interaction formula is satisfied**

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|---|---|---|---|---|
| | Made By: | OAM | Revision: | |
| | Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

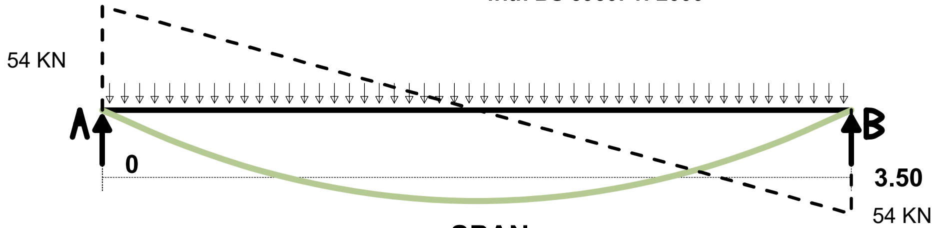
H rolled section S355
Calculation in accordance
with BS 5950: 1: 2000

LOCATION= FB0.18

Loads are unfactored

Wd= 8.00 KN/m2
Wl= 2.50 KN/m2

Span= 3.50 m
Cover= 2.00 m

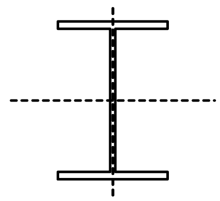



**SPAN**

| Load on beam | unfactored | factored | |
|---|---|---|---|
| | | | 47 KNm |
| | | | Partial safety factor for load |
| **Dead+s/w=** | 16.3 KN/m' | 22.82 KN/m' | dead= 1.4 |
| **Live=** | 5.00 KN/m' | 8.00 KN/m' | live= 1.6 |
| | 21.30 KN/m' | 30.82 KN/m' | |

**Reaction**

| | | | |
|---|---|---|---|
| RA= | 37.3 KN | | **53.9** KN |
| RB= | 37.3 KN | | **53.9** KN |
| Shear zero at | | X= | 1.75 m |
| Maximum Bending Moment | | **Mx =** | **47.2** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 43.7 KNm | Local capacity | PASS | 0.577 |
| Maximum BM about axis Y | MY= | 4.37 KNm | Overall buckling 1 | PASS | 0.671 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.662 |
| Shear force in x axis | Fv= | 53.9 KN | Deflection (dead)= | PASS | 1/ 650 |
| Beam span | L= | 3.50 m | Deflection(live)= | PASS | 1/ 2120 |
| Effective length about axis X | LX eff= | 3.50 m | Deflection (d+l)= | PASS | 1/ 497 |
| Effective length about axis Y | LYeff= | 1.00 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | 360.0 or 14 mm | | | |
| | z rep= | 133 cm3 | | | |

**Section properties**

Section size (Ref. No= 66 ) **203x133 30 kg UB S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 206.8 mm | | | | |
| Width of section | B= | 133.8 mm | Pcy= | 1207 KN | | |
| Thickness of web | t= | 6.3 mm | Mcx= | 111.2 KNm | | |
| Thickness of flange | T= | 9.6 mm | Mcy= | 31.26 KNm | | 593.53 |
| Root radius | r= | 7.6 mm | Mb L= | 106.8 KNm | | |
| Second moment of area x-x | Ix= | 2887 cm4 | Mlt= | **0.925** | Pcy= | 1207.4 KN |
| Second moment of area y-y | Iy= | 384 cm4 | | | | |
| Plastic modulus x-x | Sx= | 313.3 cm3 | Sx eff= | 274.52 cm3 | | |
| Plastic modulus y-y | Sy= | 88.05 cm3 | Sy eff= | 53.09 cm3 | | |
| Area of section | Ag= | 38 cm2 | An= | 34.55 cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 5.38 mm | | E UDL= | 16.30 KN/m' |
| Unfactored live load deflection= | 1.65 mm | | E UDL= | 5.00 KN/m' |
| Unfactored dead+ live load def = | 7.03 mm | | E UDL= | 21.30 KN/m' |
| Span/def. ratio for dead load= | 650 | | | |
| Span/def. ratio for live load= | **2120** | **>360** | | |
| Span/def. ratio fordead+ live load= | 498 | | | |

CONTINUE OF FB0.18

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | (Grade | S 355 ) | | | | | | |
| for thickness of | 9.6 mm | py= | 355 | N/mm2 | py= | 355.0 | N/mm2 | pyw= py |
| Young's Modulus | | E= | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | class 1 | class 2 | class 3 | |
| Outstand of flange | b= | 66.9 | mm | plastic | compac | semi compact | |
| Ratio | b/T= | 6.97 | b/Tlim= | 7.92 | 8.80 | 13.20 | |
| The classification is based on the outsatnd element | | | | **The section is class1 plastic** | | | |
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.16 | r2=Fc/(Agxpyw)= | 0.044 | | | |
| Depth between fillets | d= | 172.3 | mm | TABLE 11 rolled section | | | |
| ratio | d/t= | 27.35 | | class 1 | class 2 | class 3 | |
| 40 ε | = | 35.21 | d/tlim= | 60.93 | 71.35 | 96.99 | |
| The classification is based on the general web condition | | | | **The section is class1 plastic** | | | |

**Shear capacity** CL 4.2.3

| | | | | | | |
|---|---|---|---|---|---|---|
| Shear area | | Av y= | 1303 mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 278 KN | | | |
| Shear force | | Fvy= | 53.9 KN | Fvy/Pvy= | 0.19 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 279.3 cm3 | Mcx1= | 99.15 |
| Plastic modulus | Sx= | 313 cm3 | Mcx2= | 111.2 |
| Moment capacity for section | Mcx= | **111** KNm | | |
| Elastic modulus | Zy= | 57.4 cm3 | Mcy1= | 20.38 |
| Plastic modulus | Sy= | 88 cm3 | mcy2= | 31.26 |
| Moment capacity for section | Mcy= | **31** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \; <=1$$

0.044 + 0.392 + 0.140 = **0.577** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 3500 mm | normal condition |
| Effective length | Lelt2= | 1000 mm | |
| | L e lt= | 2250 mm | |
| Radius of gyration y-y | ry= | 3.18 cm | |
| | rx= | 8.72 cm | |
| | Lam'y= | 31.4 | |
| | La'mx= | 40.1 | |

CONTINUE OF FB0.18

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 | N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 | TABLE 16 |
| Robertson constant for section | | | | | | |
| | a= | 3.5 | for table 23 | b | | |
| Perry factor | eta= | 0.09 | | | | |
| Euler strength | pe= | 1256 | N/mm2 | | | |
| Factor | phi= | 860 | N/mm2 | | | |
| Compressive strength | pcy= | **317.7** | N/mm2 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lam'y= | 31.4 | | La'mx= | 40.14 | | Lamy/x= | 1.4626 |
| Slenderness of section | Lamda= | 40.1 | | | | | Lamx/x= | 1.8669 |
| Torsional index | x= | 21.5 | | | | | | |
| | N= | 0.5 | | | | | | |
| Slenderness factor | v= | 0.97 | from Table 19 | | | | | |
| | β w = | 1.0 | | | | | | |
| Buckling parameter | u= | 0.882 | | | | | | |
| Equivalent slenderness | lamlt= | 34.5 | | | | | | |
| Buckling strength (Table 16) | pb= | 341 | N/mm2 | for lamlt= | 35 | | py= | 355 |
| Buckling resisrance moment | Mb= | 107 | KNm | | | | | |
| | Mb L= | 107 | KNm | | | | | |
| | Mry= | 31 | KNm | | | | | |
| | Pc= | 1207 | KN | | | | | |
| | Pcy= | 1207 | KN | | | | | |

$\frac{Fc}{PC} + m\frac{x\,Mx}{Py\,Zx} + m\frac{y\,My}{py\,Zy} = \;<=1$ m x= 0.95, m y= 0.95

0.050 + 0.418 + 0.204 = **0.671** **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m\frac{LT\,M\,lt}{Mb} + m\frac{y\,My}{py\,Zy} = \;<=1$

0.050 + 0.409 + 0.204 = **0.662** **The interaction formula is satisfied**

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 168 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

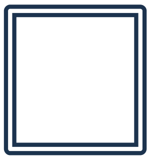
**Project:** 34 NASSAU ROAD, LONDON

**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.NO WORK SHOULD START BEFORE THE CALCULATIONS HAVE BEEN RECEIVED AND APPROVED BY THE LA BUILDING CONTROL.**

**STEEL COLUMNS** **C1**

| LOAD | SLS | ULS |
|---|---|---|
| | KN | KN |
| FB0.10 | 10 | 15 |
| | 0 | 0 |
| | **10** | **15** |

Max HIGH = 6.4 m

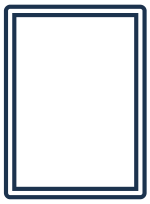


**USE 150x150x10 SHS S355** SEE PAGE 169 - 171

**STEEL COLUMNS** **C2** **C3**

| LOAD | SLS | ULS |
|---|---|---|
| | KN | KN |
| FB1.07 | 310 | 465 |
| T2 | 9 | 13.5 |
| | **319** | **478.5** |

Max HIGH = 3 m

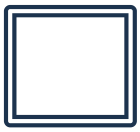


**USE 250x150x10 RHS S355** SEE PAGE 172 - 173

**STEEL COLUMNS** **C4**

| LOAD | SLS | ULS |
|---|---|---|
| | KN | KN |
| E1 | 20 | 30 |
| E1 | 12 | 18 |
| | **32** | **48** |

Max HIGH = 3 m

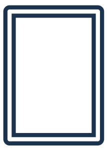


**USE 100x100x6.3 SHS S355** SEE PAGE 174 - 175

**STEEL COLUMNS** **C5**

| LOAD | SLS | ULS |
|---|---|---|
| | KN | KN |
| FB1.06 | 115 | 172.5 |
| | 5 | 7.5 |
| | **120** | **180** |

Max HIGH = 3 m



**USE 150x100x10 RHS S355** SEE PAGE 176 - 177

go to page 178

All design calculations have been author reviewed and subject to additional review by the project team, as required by David Smith Associates Quality Assurance procedures.

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 169 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

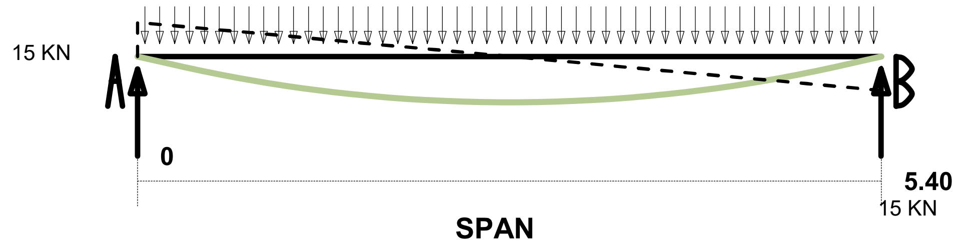
**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= C1
Loads are unfactored

Wd= 0.80 KN/m2
Wl= 0.25 KN/m2

Span= 5.40 m
Cover= 3.50 m

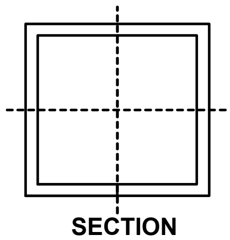



| Load on beam | unfactored | factored |
|---|---|---|
| Dead+s/w= | 2.9 KN/m' | 4.06 KN/m' |
| Live= | 0.88 KN/m' | 1.40 KN/m' |
| | 3.78 KN/m' | 5.46 KN/m' |

20 KNm
Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | | |
|---|---|---|
| RA= | 10.2 KN | **14.7** KN |
| RB= | 10.2 KN | **14.7** KN |
| Shear zero at | X= | 2.70 m |
| Maximum Bending Moment | **Mx =** | **19.9** KNm |




| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 18.4 KNm | Local capacity | PASS | 0.227 |
| Maximum BM about axis Y | MY= | 1.84 KNm | Overall buckling 1 | PASS | 0.284 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.502 |
| Shear force in x axis | Fv= | 14.7 KN | Deflection (dead)= | PASS | 1/ 620 |
| Beam span | L= | 5.40 m | Deflection(live)= | PASS | 1/ 2056 |
| Effective length about axis X | LX eff= | 5.40 m | Deflection (d+l)= | PASS | 1/ 476 |
| Effective length about axis Y | LYeff= | 5.40 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 56 cm3 | | | |

**Section properties**

Section size (Ref. No= **156** ) **150x150 10 mm SHS S355**

| | | | | | |
|---|---|---|---|---|---|
| Depth of steel section | D= | 150 mm | | | |
| Width of section | B= | 150 mm | Pcy= | 1032 KN | |
| | | | Mcx= | 103 KNm | |
| | T= | 10 mm | Mcy= | 103 KNm | 241.67 |
| | | | Mb L= | 43.5 KNm | |
| Second moment of area x-x | Ix= | 1800 cm4 | Mlt= | **0.925** | Pcy= 1032 KN |
| Second moment of area y-y | Iy= | 1800 cm4 | | | |
| Plastic modulus x-x | Sx= | 290 cm3 | Sx eff= | 233.11 cm3 | |
| Plastic modulus y-y | Sy= | 290 cm3 | Sy eff= | 233.11 cm3 | |
| Area of section | Ag= | 55.5 cm2 | An= | 50.45 cm2 | ke= 1.1 |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 8.70 mm | | E UDL= | 2.90 KN/m' |
| Unfactored live load deflection= | 2.63 mm | | E UDL= | 0.88 KN/m' |
| Unfactored dead+ live load def = | 11.33 mm | | E UDL= | 3.78 KN/m' |
| Span/def. ratio for dead load= | 621 | | | |
| Span/def. ratio for live load= | **2057** | **>360** | | |
| Span/def. ratio fordead+ live load= | 477 | | | |

CONTINUE OF C1

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** **)** | | | | | | |
| for thickness of | 10 | mm | **py=** | **355** N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | | | **E=** | 205 KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 150 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 15.00 | b/Tlim= | 7.92 | 8.80 | 13.20 |

The classification is based on the outsatnd element **The section is class 3 semi compact**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.14 r2=Fc/(Agxpyw)= 0.03

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth between fillets | d= | 120 mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 12.00 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.21 | d/tlim= | 61.72 | 72.66 | 99.55 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 3000 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 639 KN | | |
| Shear force | | Fvy= | 14.7 KN | Fvy/Pvy= 0.02 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 240 cm3 | Mcx1= | 85.2 |
| Plastic modulus | Sx= | 290 cm3 | Mcx2= | 103 |
| Moment capacity for section | Mcx= | **103** KNm | | |
| Elastic modulus | Zy= | 240 cm3 | Mcy1= | 85.2 |
| Plastic modulus | Sy= | 290 cm3 | mcy2= | 103 |
| Moment capacity for section | Mcy= | **103** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \; <=1$$

0.030 + 0.179 + 0.018 = **0.227** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 5400 mm | normal condition |
| Effective length | Lelt2= | 5400 mm | |
| | L e lt= | 5400 mm | |
| Radius of gyration y-y | ry= | 5.7 cm | |
| | rx= | 5.7 cm | |
| | Lam'y= | 94.7 | |
| | La'mx= | 94.7 | |

CONTINUE OF C1

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 | N/mm2 |
| For buckling about y-y | | | λ L0= | | 30.20 | TABLE 16 |
| Robertson constant for section | | | | | | |
| | a= | 2 | for table 23 | a | | |
| Perry factor | eta= | 0.16 | | | | |
| Euler strength | pe= | 225 | N/mm2 | | | |
| Factor | phi= | 308 | N/mm2 | | | |
| Compressive strength | pcy= | **185.9** | N/mm2 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lam'y= | 94.7 | | La'mx= | 94.74 | | Lamy/x= | 0.0335 |
| Slenderness of section | Lamda= | 94.7 | | | | | Lamx/x= | 0.0335 |
| Torsional index | x= | 2830 | | | | | | |
| | N= | 0.5 | | | | | | |
| Slenderness factor | v= | 1.00 | from Table 19 | | | | | |
| | β w = | 1.0 | | | | | | |
| Buckling parameter | u= | 1 | | | | | | |
| Equivalent slenderness | lamlt= | 94.7 | | | | | | |
| Buckling strength (Table 16) | pb= | 150 | N/mm2 | for lamlt= | 95 | | py= | 355 |
| Buckling resisrance moment | Mb= | 44 | KNm | | | | | |
| | Mb L= | 44 | KNm | | | | | |
| | Mry= | 103 | KNm | | | | | |
| | Pc= | 832.5 | KN | | | | | |
| | Pcy= | 1032 | KN | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fc / PC | + m | x Mx / Py Zx | + m | y My / py Zy | = | <=1 | | m x= | 0.95 |
| | | | | | | | | m y= | 0.95 |
| 0.058 | + | 0.205 | + | 0.021 | = | **0.284** | **The interaction formula is satisfied** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Fc / Pcy | + m | LT M lt / Mb | + m | y My / py Zy | = | <=1 | |
| 0.058 | + | 0.423 | + | 0.021 | = | **0.502** | **The interaction formula is satisfied** |

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 172 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | HJ |

**Project: 34 NASSAU ROAD, LONDON**

## 1.0 DESIGN OF STEEL COLUMN

LOCATION= **C2** — S275

Clause 2.4.2.3

For sway stability a notional horizontal force of 0.5 % of the dead and imposed vertical loads are considered in the design of the columns.

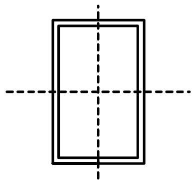
**H rolled section**
**Calculation in accordance with BS 5950: 1: 2000**

FACTORED LOAD = **480** KN
notional force = 2.4 KN

Partial safety factor for load
dead= 1.4
live= 1.6

## 1.1 All applied loads and moment are factored

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM about axis X | MX= | 64.41 KNm | Local capacity | PASS | 0.682 |
| Maximum BM about axis Y | MY= | 7.20 KNm | Overall buckling | PASS | 0.726 |
| Axial compressive load | F= | 480.0 KN | | | |
| Shear force in x axis | Fv= | 10.00 KN | | | |
| Length of column | L= | 3.00 m | | | |
| Effective length about axis X | LX= | 3.00 m | | | |
| Effective length about axis Y | LY= | 3.00 m | Fully restraint for Ly& LX <1. | | |



**SECTION**

## 1.2 Section properties

Section size (Ref. No= **245** ) — **250x150 10 RHS S275**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 250 mm | | |
| Width of section | B= | 150 mm | | |
| | | | Mcx= | 165.3 KNm |
| | T= | 10 mm | Mcy= | 118.3 KNm |
| | | | Mbs= | 148 KNm |
| Second moment of area x-x | Ix= | 6260 cm4 | Pc = | **1900** KN |
| Second moment of area y-y | Iy= | 2780 cm4 | | |
| Plastic modulus x-x | Sx= | 618 cm3 | Mlt= | **0.925** |
| Plastic modulus y-y | Sy= | 430 cm3 | | |
| Area of section | A= | 75.5 cm2 | | |

## 1.3 Strength of steel

Clause 3.1.1

Design strength **(Grade S 275 )**
for thickness of 10 mm **py=** **275** N/mm2
Young's Modulus **E=** 205 KN/mm2

## 1.4 Classification of cross section

(clause 3.5.2) — TABLE 11 rolled section

| | | | | class 1 | class 2 | class 3 |
|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 1.00 | | plastic | compac | semi compact |
| Outstand of flange | b= | 75 mm | | | | |
| Ratio | b/T= | 7.500 mm | b/Tlim= | 9.00 | 10.00 | 15.00 |

The classification is based on the outsatnd element — **The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.79 — r2=Fc/(Agxpyw)= 0.231

TABLE 11 rolled section

| | | | | class 1 | class 2 | class 3 |
|---|---|---|---|---|---|---|
| Depth between fillets | d= | 220 mm | | | | |
| ratio | d/t= | 22.00 | | | | |
| 40 ε | = | 40 | d/tlim= | 44.61 | 45.66 | 82.06 |

The classification is based on the general web condition — **The section is class1 plastic**

## 1.5 Shear capacity

CL 4.2.3

| | | | |
|---|---|---|---|
| Shear area | Av= | 5000 mm2 | |
| Shear capacity (0.6pyA) | Pv= | 825.0 KN | |
| Shear force | Fv= | 10.00 KN | LOW SHEAR LOAD |

CONTINUE OF C2

**1.6 Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 501 cm3 | Mcx1= | 165.3 | (1.2 py Zx) |
| Plastic modulus | Sx= | 618 cm3 | Mcx2= | 170 | |
| Moment capacity for section | Mcx= | **165.3** KNm | | | |
| Elastic modulus | Zy= | 371 cm3 | Mcy1= | 153 | (1.5 py Zy) |
| Plastic modulus | Sy= | 430 cm3 | mcy2= | 118.3 | |
| Moment capacity for section | Mcy= | **118.25** KNm | | | |

**Local capacity check** CL 4.8.3.2

$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \; <=1$

0.231 + 0.390 + 0.061 = **0.682** **LOCAL CAPACITY IS SATISFIED**

**1.7 Compressive Resistnace section 4.7**

**1.7 Slenderness Clause 4.7.3**

| | | |
|---|---|---|
| Effective length x-x | Lex= | 3000 mm |
| Effective length y-y | Ley= | 3000 mm |
| Radius of gyration y-y | ry= | 6.07 cm |
| | rx= | 9.1 cm |
| | Lam'y= | 49.4 |
| | La'mx= | 33.0 |

**1.8 Compressive strength:perry strust formula from Appendex C.1**

| | | | |
|---|---|---|---|
| Limiting slenderness | lam 0= | 17.16 | |
| For buckling about y-y | | | |
| Robertson constant for section | a= | 2 for table 23 | a |
| Perry factor | eta= | 0.06 | |
| Euler strength | pe= | 828 N/mm2 | |
| Factor | phi= | 578 N/mm2 | |
| Compressive strength | pcy= | **251.7** N/mm2 | |
| | Pc = | 1900.1 KN | |

**1.9 Resistance to Lteral-Buckling resistance SECTION 4.3**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 34.31 | Lamy/x= | 0.01 | |
| Slenderness of section | Lamda= | 49.4 | Torsional index x= | 6080.00 | |
| Slenderness factor | v= | 1 from Table 19 | N= | 0.5 | |
| Buckling parameter | u= | 1 | β w = | 1.0 | 0.0 |
| Equivalent slenderness | lamlt= | 49.4 | | | 1 |
| Perry coefficient | eta lt= | 0.1058 | | | |
| Elastic strength | pe= | 828 N/mm2 | | | |
| Factor | phi lt= | 595 N/mm2 | Mb L= | 147.9 KNm | |
| Factor | pey= | 227784 | Mry= | 118.3 KNm | |
| Buckling strength (Table 16) | pb= | 239.38 N/mm2 | Pc= | 1900.1 KN | |
| Buckling resisrance moment | Mb= | **147.9** KNm | Pcy= | 1900.1 KN | |

Overall buckling check

For member with moment about both axes 275

for lateral torsional buckling

$\frac{Fc}{Pcy} + \frac{m\,LT\,M\,lt}{Mb} + \frac{m\,y\,My}{py\,Zy}(1+FC/FCY) = \; <=1$

m x= 0.93

m y= 0.93

0.253 + 0.403 + 0.071 = **0.726** **The interaction formula is satisfied**

## 1.0 DESIGN OF STEEL COLUMN

LOCATION= **C4**

**S275**

Clause 2.4.2.3
For sway stability a notional horizontal force of 0.5 %
of the dead and imposed vertical loads are considered
in the design of the columns.

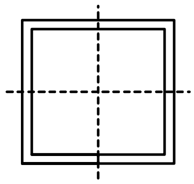
**H rolled section**
**Calculation in accordance**
**with BS 5950: 1: 2000**

FACTORED LOAD = **50** KN
notional force = 0.25 KN

Partial safety factor for load
dead= 1.4
live= 1.6

## 1.1 All applied loads and moment are factored

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM about axis X | MX= | 6.91 KNm | Local capacity | **PASS** | 0.418 |
| Maximum BM about axis Y | MY= | 0.75 KNm | Overall buckling | **PASS** | 0.602 |
| Axial compressive load | F= | 50.0 KN | | | |
| Shear force in x axis | Fv= | 10.00 KN | | | |
| Length of column | L= | 3.00 m | | | |
| Effective length about axis X | LX= | 3.00 m | | | |
| Effective length about axis Y | LY= | 3.00 m | Fully restraint for Ly& LX <1. | | |



## 1.2 Section properties

Section size (Ref. No= **145** ) **100x100 6.3 SHS S275**

**SECTION**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 100 mm | | |
| Width of section | B= | 100 mm | | |
| | | | Mcx= | 22.51 KNm |
| | T= | 6.3 mm | Mcy= | 22.55 KNm |
| | | | Mbs= | 14 KNm |
| Second moment of area x-x | Ix= | 341 cm4 | Pc = | **482** KN |
| Second moment of area y-y | Iy= | 341 cm4 | | |
| Plastic modulus x-x | Sx= | 82 cm3 | Mlt= | **0.925** |
| Plastic modulus y-y | Sy= | 82 cm3 | | |
| Area of section | A= | 23.4 cm2 | | |

## 1.3 Strength of steel

Clause 3.1.1

Design strength **(Grade S 275 )**
for thickness of 6.3 mm **py=** **275** N/mm2
Young's Modulus **E=** 205 KN/mm2

## 1.4 Classification of cross section

(clause 3.5.2)

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | TABLE 11 rolled section | | |
| Constant (table 11 note b) | ε = | 1.00 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 50 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 7.937 mm | b/Tlim= | 9.00 | 10.00 | 15.00 |

The classification is based on the outsatnd element — **The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.36 r2=Fc/(Agxpyw)= 0.078

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | TABLE 11 rolled section | | |
| Depth between fillets | d= | 81.1 mm | | | | |
| ratio | d/t= | 12.87 | | class 1 | class 2 | class 3 |
| 40 ε | = | 40 | d/tlim= | 59.00 | 65.20 | 103.86 |

The classification is based on the general web condition — **The section is class1 plastic**

## 1.5 Shear capacity

CL 4.2.3

| | | | |
|---|---|---|---|
| Shear area | Av= | 1260 mm2 | |
| Shear capacity (0.6pyA) | Pv= | 207.9 KN | |
| Shear force | Fv= | 10.00 KN | **LOW SHEAR LOAD** |

CONTINUE OF C4

**1.6 Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 68.2 | cm3 | Mcx1= | 22.51 (1.2 py Zx) |
| Plastic modulus | Sx= | 82 | cm3 | Mcx2= | 22.55 |
| Moment capacity for section | Mcx= | **22.5** | KNm | | |
| Elastic modulus | Zy= | 68.2 | cm3 | Mcy1= | 28.13 (1.5 py Zy) |
| Plastic modulus | Sy= | 82 | cm3 | mcy2= | 22.55 |
| Moment capacity for section | Mcy= | **22.55** | KNm | | |

**Local capacity check** CL 4.8.3.2

$\frac{F}{Ag.\ py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \ <=1$

0.078 + 0.307 + 0.033 = **0.418** **LOCAL CAPACITY IS SATISFIED**

**1.7 Compressive Resistnace section 4.7**

**1.7 Slenderness Clause 4.7.3**

| | | | |
|---|---|---|---|
| Effective length x-x | Lex= | 3000 | mm |
| Effective length y-y | Ley= | 3000 | mm |
| Radius of gyration y-y | ry= | 3.81 | cm |
| | rx= | 3.81 | cm |
| | Lam'y= | 78.7 | |
| | La'mx= | 78.7 | |

**1.8 Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 17.16 | | |
| For buckling about y-y | | | | |
| Robertson constant for section | a= | 2 | for table 23 | a |
| Perry factor | eta= | 0.12 | | |
| Euler strength | pe= | 326 | N/mm2 | |
| Factor | phi= | 321 | N/mm2 | |
| Compressive strength | pcy= | **206.1** | N/mm2 | |
| | Pc = | 482.3 | KN | |

**1.9 Resistance to Lteral-Buckling resistance SECTION 4.3**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 34.31 | | Lamy/x= | 0.15 | | |
| Slenderness of section | Lamda= | 78.7 | | Torsional index x= | 533.00 | | |
| Slenderness factor | v= | 0.9997 | from Table 19 | N= | 0.5 | | |
| Buckling parameter | u= | 1 | | β w = | 1.0 | | 0.0 |
| Equivalent slenderness | lamlt= | 78.7 | | | | | 0.9997 |
| Perry coefficient | eta lt= | 0.3109 | | | | | |
| Elastic strength | pe= | 327 | N/mm2 | | | | |
| Factor | phi lt= | 352 | N/mm2 | Mb L= | 13.8 | KNm | |
| Factor | pey= | 89791 | | Mry= | 22.6 | KNm | |
| Buckling strength (Table 16) | pb= | 167.75 | N/mm2 | Pc= | 482.3 | KN | |
| Buckling resisrance moment | Mb= | **13.8** | KNm | Pcy= | 482.3 | KN | |

Overall buckling check

For member with moment about both axes 275

for lateral torsional buckling

$\frac{Fc}{Pcy} + m\frac{LT\ M\ lt}{Mb} + m\frac{y\ My}{py\ Zy}$ (1+FC/FCY) = <=1    m x= 0.93, m y= 0.93

0.104 + 0.465 + 0.034 = **0.602** **The interaction formula is satisfied**

**1.0 DESIGN OF STEEL COLUMN**

LOCATION= **C5** S275

Clause 2.4.2.3

For sway stability a notional horizontal force of 0.5 %
of the dead and imposed vertical loads are considered
in the design of the columns.

**H rolled section**
**Calculation in accordance**
**with BS 5950: 1: 2000**

FACTORED LOAD = **150** KN
notional force = 0.75 KN

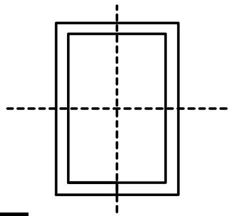
Partial safety factor for load
dead= 1.4
live= 1.6

**1.1 All applied loads and moment are factored**

| | | | factor |
|---|---|---|---|
| Local capacity | **PASS** | | 0.441 |
| Overall buckling | **PASS** | | 0.599 |

| | | | |
|---|---|---|---|
| Maximum BM about axis X | MX= | 15.66 | KNm |
| Maximum BM about axis Y | MY= | 2.25 | KNm |
| Axial compressive load | F= | 150.0 | KN |
| Shear force in x axis | Fv= | 10.00 | KN |
| Length of column | L= | 3.00 | m |
| Effective length about axis X | LX= | 3.00 | m |
| Effective length about axis Y | LY= | 3.00 | m |

Fully restraint for Ly& LX <1.



**SECTION**

**1.2 Section properties**

Section size (Ref. No= **230** ) | **150x100 10 RHS S275** |

| | | | |
|---|---|---|---|
| Depth of steel section | D= | 150 | mm |
| Width of section | B= | 100 | mm |
| | T= | 10 | mm |
| Second moment of area x-x | Ix= | 1310 | cm4 |
| Second moment of area y-y | Iy= | 678 | cm4 |
| Plastic modulus x-x | Sx= | 220 | cm3 |
| Plastic modulus y-y | Sy= | 164 | cm3 |
| Area of section | A= | 45.5 | cm2 |

| | | |
|---|---|---|
| Mcx= | 57.75 | KNm |
| Mcy= | 45.1 | KNm |
| Mbs= | 37 | KNm |
| Pc = | **948** | KN |
| Mlt= | **0.925** | |

**1.3 Strength of steel** Clause 3.1.1

Design strength **(Grade** **S 275** **)**
for thickness of 10 mm **py=** **275** N/mm2
Young's Modulus **E=** 205 KN/mm2

**1.4 Classification of cross section** (clause 3.5.2)

Constant (table 11 note b) ε = 1.00
Outstand of flange b= 50 mm
Ratio b/T= 5.000 mm

| TABLE 11 rolled section | class 1 | class 2 | class 3 |
|---|---|---|---|
| | plastic | compac | semi compact |
| b/Tlim= | 9.00 | 10.00 | 15.00 |

The classification is based on the outsatnd element **The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.45 r2=Fc/(Agxpyw)= 0.12

Depth between fillets d= 120 mm
ratio d/t= 12.00
40 ε = 40

| TABLE 11 rolled section | class 1 | class 2 | class 3 |
|---|---|---|---|
| d/tlim= | 55.00 | 59.46 | 96.79 |

The classification is based on the general web condition **The section is class1 plastic**

**1.5 Shear capacity** CL 4.2.3

| | | | |
|---|---|---|---|
| Shear area | | Av= | 3000 mm2 |
| Shear capacity | (0.6pyA) | Pv= | 495.0 KN |
| Shear force | | Fv= | 10.00 KN |

**LOW SHEAR LOAD**

CONTINUE OF C5

**1.6 Moment Capacity**

| | | | | | | |
|---|---|---|---|---|---|---|
| Elastic modulus | Zx= | 175 | cm3 | Mcx1= | 57.75 | (1.2 py Zx) |
| Plastic modulus | Sx= | 220 | cm3 | Mcx2= | 60.5 | |
| Moment capacity for section | Mcx= | **57.8** | KNm | | | |
| Elastic modulus | Zy= | 136 | cm3 | Mcy1= | 56.1 | (1.5 py Zy) |
| Plastic modulus | Sy= | 164 | cm3 | mcy2= | 45.1 | |
| Moment capacity for section | Mcy= | **45.10** | KNm | | | |

**Local capacity check** CL 4.8.3.2

$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \; <=1$

0.120 + 0.271 + 0.050 = **0.441** **LOCAL CAPACITY IS SATISFIED**

**1.7 Compressive Resistnace section 4.7**

**1.7 Slenderness Clause 4.7.3**

| | | | |
|---|---|---|---|
| Effective length x-x | Lex= | 3000 | mm |
| Effective length y-y | Ley= | 3000 | mm |
| Radius of gyration y-y | ry= | 3.86 | cm |
| | rx= | 5.37 | cm |
| | Lam'y= | 77.7 | |
| | La'mx= | 55.9 | |

**1.8 Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 17.16 | | |
| For buckling about y-y | | | | |
| Robertson constant for section | a= | 2 | for table 23 | a |
| Perry factor | eta= | 0.12 | | |
| Euler strength | pe= | 335 | N/mm2 | |
| Factor | phi= | 325 | N/mm2 | |
| Compressive strength | pcy= | **208.3** | N/mm2 | |
| | Pc = | 947.7 | KN | |

**1.9 Resistance to Lteral-Buckling resistance SECTION 4.3**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 34.31 | | Lamy/x= | 0.05 | | |
| Slenderness of section | Lamda= | 77.7 | | Torsional index x= | 1430.00 | | |
| Slenderness factor | v= | 1 | from Table 19 | N= | 0.5 | | |
| Buckling parameter | u= | 1 | | β w = | 1.0 | | 0.0 |
| Equivalent slenderness | lamlt= | 77.7 | | | | | 1 |
| Perry coefficient | eta lt= | 0.3039 | | | | | |
| Elastic strength | pe= | 335 | N/mm2 | | | | |
| Factor | phi lt= | 356 | N/mm2 | Mb L= | 37.4 | KNm | |
| Factor | pey= | 92120 | | Mry= | 45.1 | KNm | |
| Buckling strength (Table 16) | pb= | 170.05 | N/mm2 | Pc= | 947.7 | KN | |
| Buckling resisrance moment | Mb= | **37.4** | KNm | Pcy= | 947.7 | KN | |

Overall buckling check

For member with moment about both axes 275

for lateral torsional buckling

$\frac{Fc}{Pcy} + m\frac{LT\ M\ lt}{Mb} + m\frac{y\ My}{py\ Zy}$ (1+FC/FCY) = <=1 m x= 0.93

m y= 0.93

0.158 + 0.387 + 0.053 = **0.599** **The interaction formula is satisfied**

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| | | | |
|---|---|---|---|
| **Project No:** | **24/54720** | **Sheet No:** | **178** |
| **Made By:** | ***OAM*** | **Revision:** | |
| **Date:** | **Mar-24** | **Checked By:** | **TG** |

**Project:** **34 NASSAU ROAD, LONDON**

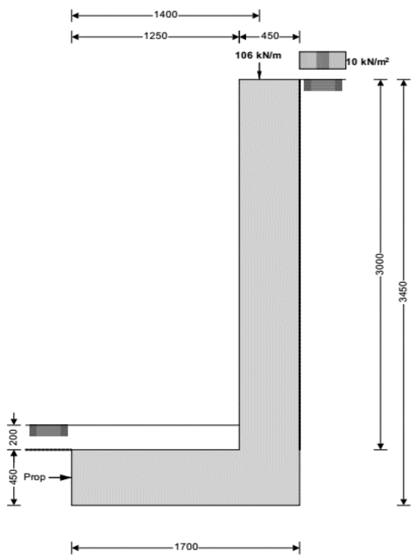
**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.**

UNDERPINING AND

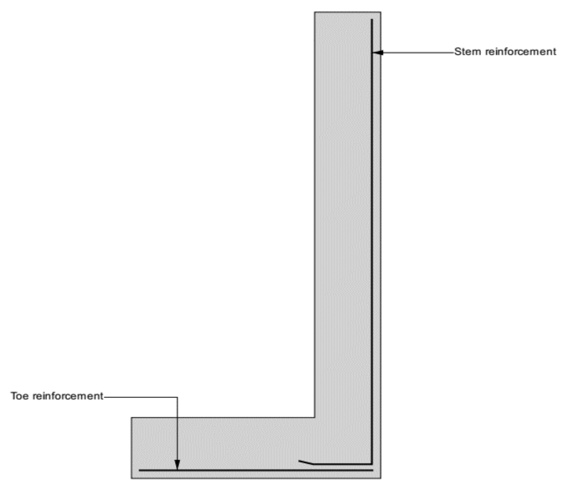
**RETAINNIG WALLS** **RW1**

Max HIGH = 2.8 m

| **WALL LOADING** | | D LOAD | I LOAD | cover y | | dead load | live load |
|---|---|---|---|---|---|---|---|
| | | KN/m2 | KN/m2 | m | | KN/m' | KN/m' |
| ROOF | dead | **1.2** | | **4** | => 4* 1.2= | 4.8 | |
| | live | | **1.00** | **4** | => 4*1.00= | | 4 |
| second floor | dead | **0.6** | | **4** | => 4* .6= | 2.4 | |
| | live | | **1.50** | **4** | => 4*1.50= | | 6 |
| first floor | dead | **0.5** | | **4** | => 4* .5= | 2 | |
| | live | | **1.50** | **4** | => 4*1.50= | | 6 |
| G FLOOR | dead | **6** | | **1.2** | => 1.2* 6= | 7.2 | |
| | live | | **2.50** | **4** | => 4*2.50= | | <u>10</u> |
| wall | dead | **7.5** | | **8.4** | => 8.4* 7.5= | <u>63</u> | |
| | | | | | **UDL** | **79.4 KN/m'** | **26 KN/m'** |




**Indicative retaining wall reinforcement diagram**



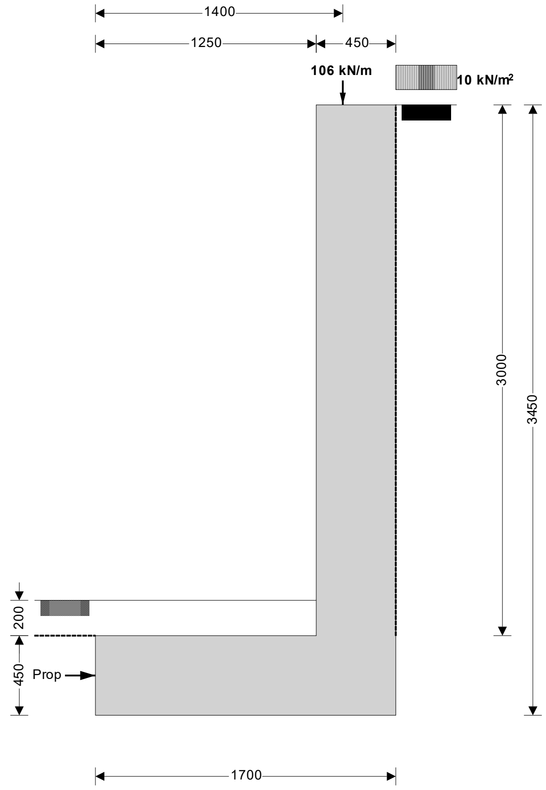

Toe bars - 20 mm dia.@ 200 mm centres - (1571 mm²/m)
Stem bars - 20 mm dia.@ 200 mm centres - (1571 mm²/m)

SEE PAGE 179 - 187

All design calculations have been author reviewed and subject to additional review by the project team, as required by David Smith Associates Quality Assurance procedures.

**RETAINING WALL ANALYSIS (BS 8002:1994)**

TEDDS calculation version 1.2.01.08




**Wall details**

| | |
|---|---|
| Retaining wall type | **Cantilever propped at base** |
| Height of retaining wall stem | $h_{stem}$ = **3000** mm |
| Thickness of wall stem | $t_{wall}$ = **450** mm |
| Length of toe | $l_{toe}$ = **1250** mm |
| Length of heel | $l_{heel}$ = **0** mm |
| Overall length of base | $l_{base} = l_{toe} + l_{heel} + t_{wall}$ = **1700** mm |
| Thickness of base | $t_{base}$ = **450** mm |
| Depth of downstand | $d_{ds}$ = **0** mm |
| Position of downstand | $l_{ds}$ = **0** mm |
| Thickness of downstand | $t_{ds}$ = **450** mm |
| Height of retaining wall | $h_{wall} = h_{stem} + t_{base} + d_{ds}$ = **3450** mm |
| Depth of cover in front of wall | $d_{cover}$ = **200** mm |
| Depth of unplanned excavation | $d_{exc}$ = **200** mm |
| Height of ground water behind wall | $h_{water}$ = **0** mm |
| Height of saturated fill above base | $h_{sat} = \max(h_{water} - t_{base} - d_{ds}, 0 \text{ mm})$ = **0** mm |
| Density of wall construction | $\gamma_{wall}$ = **23.6** kN/m$^3$ |
| Density of base construction | $\gamma_{base}$ = **23.6** kN/m$^3$ |
| Angle of rear face of wall | $\alpha$ = **90.0** deg |
| Angle of soil surface behind wall | $\beta$ = **0.0** deg |
| Effective height at virtual back of wall | $h_{eff} = h_{wall} + l_{heel} \times \tan(\beta)$ = **3450** mm |

**Retained material details**

Mobilisation factor — M = **1.5**

Moist density of retained material — $\gamma_m$ = **18.0** kN/m$^3$

Saturated density of retained material — $\gamma_s$ = **21.0** kN/m$^3$

Design shear strength — $\phi'$ = **24.2** deg

Angle of wall friction — $\delta$ = **0.0** deg

**Base material details**

Moist density — $\gamma_{mb}$ = **18.0** kN/m$^3$

Design shear strength — $\phi'_b$ = **24.2** deg

Design base friction — $\delta_b$ = **18.6** deg

Allowable bearing pressure — $P_{bearing}$ = **100** kN/m$^2$

**Using Coulomb theory**

Active pressure coefficient for retained material

$$K_a = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}]^2) = \mathbf{0.419}$$

Passive pressure coefficient for base material

$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2) = \mathbf{4.187}$$

**At-rest pressure**

At-rest pressure for retained material — $K_0 = 1 - \sin(\phi') = \mathbf{0.590}$

**Loading details**

Surcharge load on plan — Surcharge = **10.0** kN/m$^2$

Applied vertical dead load on wall — $W_{dead}$ = **80.0** kN/m

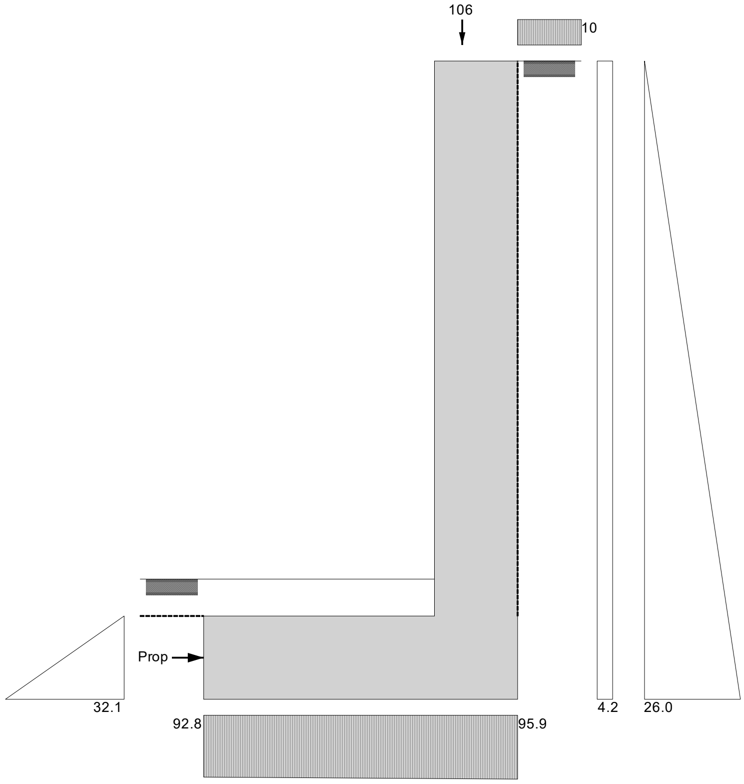
Applied vertical live load on wall — $W_{live}$ = **26.0** kN/m

Position of applied vertical load on wall — $l_{load}$ = **1400** mm

Applied horizontal dead load on wall — $F_{dead}$ = **0.0** kN/m

Applied horizontal live load on wall — $F_{live}$ = **0.0** kN/m

Height of applied horizontal load on wall — $h_{load}$ = **0** mm




Loads shown in kN/m, pressures shown in kN/m$^2$

**Vertical forces on wall**

Wall stem $w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall}$ = **31.9** kN/m

Wall base $w_{base} = l_{base} \times t_{base} \times \gamma_{base}$ = **18.1** kN/m

Soil in front of wall $w_p = l_{toe} \times d_{cover} \times \gamma_{mb}$ = **4.5** kN/m

Applied vertical load $W_v = W_{dead} + W_{live}$ = **106** kN/m

Total vertical load $W_{total} = w_{wall} + w_{base} + w_p + W_v$ = **160.4** kN/m

**Horizontal forces on wall**

Surcharge $F_{sur} = K_a \times Surcharge \times h_{eff}$ = **14.4** kN/m

Moist backfill above water table $F_{m\_a} = 0.5 \times K_a \times \gamma_m \times (h_{eff} - h_{water})^2$ = **44.8** kN/m

Total horizontal load $F_{total} = F_{sur} + F_{m\_a}$ = **59.3** kN/m

**Calculate propping force**

Passive resistance of soil in front of wall $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **7.2** kN/m

Propping force $F_{prop} = \max(F_{total} - F_p - (W_{total} - w_p - W_{live}) \times \tan(\delta_b), 0 \text{ kN/m})$

$F_{prop}$ = **8.3** kN/m

**Overturning moments**

Surcharge $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **24.9** kNm/m

Moist backfill above water table $M_{m\_a} = F_{m\_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **51.6** kNm/m

Total overturning moment $M_{ot} = M_{sur} + M_{m\_a}$ = **76.5** kNm/m

**Restoring moments**

Wall stem $M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2)$ = **47** kNm/m

Wall base $M_{base} = w_{base} \times l_{base} / 2$ = **15.3** kNm/m

Design vertical dead load $M_{dead} = W_{dead} \times l_{load} =$ **112** kNm/m

Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} =$ **174.3** kNm/m

**Check bearing pressure**

Soil in front of wall $M_{p\_r} = w_p \times l_{toe} / 2 =$ **2.8** kNm/m

Design vertical live load $M_{live} = W_{live} \times l_{load} =$ **36.4** kNm/m

Total moment for bearing $M_{total} = M_{rest} - M_{ot} + M_{p\_r} + M_{live} =$ **137.1** kNm/m

Total vertical reaction $R = W_{total} =$ **160.4** kN/m

Distance to reaction $x_{bar} = M_{total} / R =$ **855** mm

Eccentricity of reaction $e = abs((l_{base} / 2) - x_{bar}) =$ **5** mm

***Reaction acts within middle third of base***

Bearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) =$ **92.8** kN/m$^2$

Bearing pressure at heel $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2) =$ **95.9** kN/m$^2$

***PASS - Maximum bearing pressure is less than allowable bearing pressure***

**RETAINING WALL DESIGN (BS 8002:1994)**

TEDDS calculation version 1.2.01.08

**Ultimate limit state load factors**

Dead load factor $\gamma_{f\_d}$ = **1.4**

Live load factor $\gamma_{f\_l}$ = **1.6**

Earth and water pressure factor $\gamma_{f\_e}$ = **1.4**

**Factored vertical forces on wall**

Wall stem $w_{wall\_f} = \gamma_{f\_d} \times h_{stem} \times t_{wall} \times \gamma_{wall}$ = **44.6** kN/m

Wall base $w_{base\_f} = \gamma_{f\_d} \times l_{base} \times t_{base} \times \gamma_{base}$ = **25.3** kN/m

Soil in front of wall $w_{p\_f} = \gamma_{f\_d} \times l_{toe} \times d_{cover} \times \gamma_{mb}$ = **6.3** kN/m

Applied vertical load $W_{v\_f} = \gamma_{f\_d} \times W_{dead} + \gamma_{f\_l} \times W_{live}$ = **153.6** kN/m

Total vertical load $W_{total\_f} = w_{wall\_f} + w_{base\_f} + w_{p\_f} + W_{v\_f}$ = **229.8** kN/m

**Factored horizontal at-rest forces on wall**

Surcharge $F_{sur\_f} = \gamma_{f\_l} \times K_0 \times Surcharge \times h_{eff}$ = **32.6** kN/m

Moist backfill above water table $F_{m\_a\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2$ = **88.5** kN/m

Total horizontal load $F_{total\_f} = F_{sur\_f} + F_{m\_a\_f}$ = **121.1** kN/m

**Calculate propping force**

Passive resistance of soil in front of wall $F_{p\_f} = \gamma_{f\_e} \times 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **10.1** kN/m

Propping force $F_{prop\_f} = \max(F_{total\_f} - F_{p\_f} - (W_{total\_f} - w_{p\_f} - \gamma_{f\_l} \times W_{live}) \times \tan(\delta_b), 0 \text{ kN/m})$

$F_{prop\_f}$ = **49.7** kN/m

**Factored overturning moments**

Surcharge $M_{sur\_f} = F_{sur\_f} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **56.2** kNm/m

Moist backfill above water table $M_{m\_a\_f} = F_{m\_a\_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **101.8** kNm/m

Total overturning moment $M_{ot\_f} = M_{sur\_f} + M_{m\_a\_f}$ = **158** kNm/m

**Restoring moments**

Wall stem $M_{wall\_f} = w_{wall\_f} \times (l_{toe} + t_{wall} / 2)$ = **65.8** kNm/m

Wall base $M_{base\_f} = w_{base\_f} \times l_{base} / 2$ = **21.5** kNm/m

Soil in front of wall $M_{p\_r\_f} = w_{p\_f} \times l_{toe} / 2$ = **3.9** kNm/m

Design vertical load $M_{v\_f} = W_{v\_f} \times l_{load}$ = **215** kNm/m

Total restoring moment $M_{rest\_f} = M_{wall\_f} + M_{base\_f} + M_{p\_r\_f} + M_{v\_f}$ = **306.3** kNm/m

**Factored bearing pressure**

Total moment for bearing $M_{total\_f} = M_{rest\_f} - M_{ot\_f}$ = **148.3** kNm/m

Total vertical reaction $R_f = W_{total\_f}$ = **229.8** kN/m

Distance to reaction $x_{bar\_f} = M_{total\_f} / R_f$ = **645** mm

Eccentricity of reaction $e_f = \text{abs}((l_{base} / 2) - x_{bar\_f})$ = **205** mm

***Reaction acts within middle third of base***

Bearing pressure at toe $p_{toe\_f} = (R_f / l_{base}) + (6 \times R_f \times e_f / l_{base}^2)$ = **232.8** kN/m²

Bearing pressure at heel $p_{heel\_f} = (R_f / l_{base}) - (6 \times R_f \times e_f / l_{base}^2)$ = **37.6** kN/m²

Rate of change of base reaction $rate = (p_{toe\_f} - p_{heel\_f}) / l_{base}$ = **114.84** kN/m²/m

Bearing pressure at stem / toe $p_{stem\_toe\_f} = \max(p_{toe\_f} - (rate \times l_{toe}), 0 \text{ kN/m}^2)$ = **89.2** kN/m²

Bearing pressure at mid stem $p_{stem\_mid\_f} = \max(p_{toe\_f} - (rate \times (l_{toe} + t_{wall} / 2)), 0 \text{ kN/m}^2)$ = **63.4** kN/m²

Bearing pressure at stem / heel $p_{stem\_heel\_f} = \max(p_{toe\_f} - (rate \times (l_{toe} + t_{wall})), 0 \text{ kN/m}^2)$ = **37.6** kN/m²

## Design of reinforced concrete retaining wall toe (BS 8002:1994)

**Material properties**

Characteristic strength of concrete — $f_{cu}$ = **35** N/mm²

Characteristic strength of reinforcement — $f_y$ = **500** N/mm²

**Base details**

Minimum area of reinforcement — k = **0.13** %

Cover to reinforcement in toe — $c_{toe}$ = **50** mm

**Calculate shear for toe design**

Shear from bearing pressure — $V_{toe\_bear} = (p_{toe\_f} + p_{stem\_toe\_f}) \times l_{toe} / 2$ = **201.3** kN/m

Shear from weight of base — $V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times l_{toe} \times t_{base}$ = **18.6** kN/m

Shear from weight of soil — $V_{toe\_wt\_soil} = w_{p\_f} - (\gamma_{f\_d} \times \gamma_m \times l_{toe} \times d_{exc})$ = **0** kN/m

Total shear for toe design — $V_{toe} = V_{toe\_bear} - V_{toe\_wt\_base} - V_{toe\_wt\_soil}$ = **182.7** kN/m

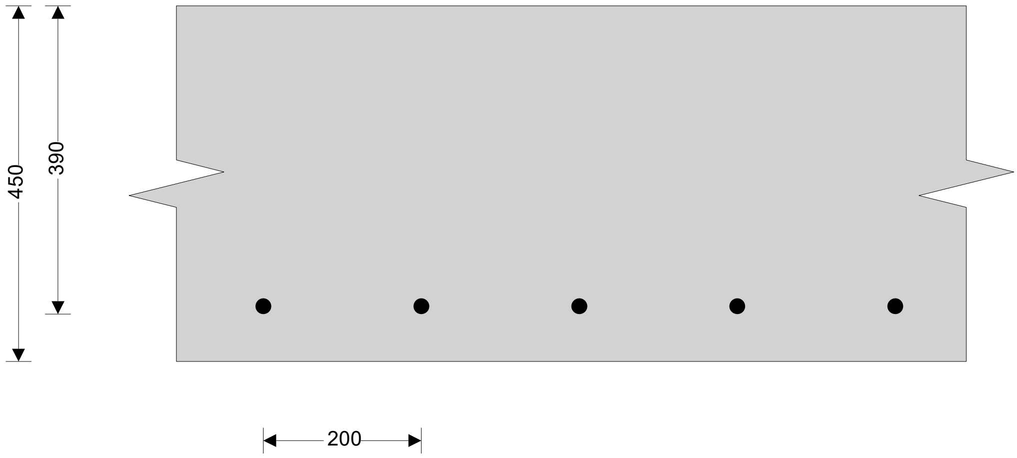
**Calculate moment for toe design**

Moment from bearing pressure — $M_{toe\_bear} = (2 \times p_{toe\_f} + p_{stem\_mid\_f}) \times (l_{toe} + t_{wall} / 2)^2 / 6$ = **191.8** kNm/m

Moment from weight of base — $M_{toe\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2)$ = **16.2** kNm/m

Moment from weight of soil — $M_{toe\_wt\_soil} = (w_{p\_f} - (\gamma_{f\_d} \times \gamma_m \times l_{toe} \times d_{exc})) \times (l_{toe} + t_{wall}) / 2$ = **0** kNm/m

Total moment for toe design — $M_{toe} = M_{toe\_bear} - M_{toe\_wt\_base} - M_{toe\_wt\_soil}$ = **175.6** kNm/m




**Check toe in bending**

Width of toe — b = **1000** mm/m

Depth of reinforcement — $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2)$ = **390.0** mm

Constant — $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu})$ = **0.033**

***Compression reinforcement is not required***

Lever arm — $z_{toe} = \min(0.5 + \sqrt{(0.25 - (\min(K_{toe}, 0.225) / 0.9))}, 0.95) \times d_{toe}$

$z_{toe}$ = **371** mm

Area of tension reinforcement required — $A_{s\_toe\_des} = M_{toe} / (0.87 \times f_y \times z_{toe})$ = **1090** mm²/m

Minimum area of tension reinforcement — $A_{s\_toe\_min} = k \times b \times t_{base}$ = **585** mm²/m

Area of tension reinforcement required — $A_{s\_toe\_req} = \max(A_{s\_toe\_des}, A_{s\_toe\_min})$ = **1090** mm²/m

Reinforcement provided — **20 mm dia.bars @ 200 mm centres**

Area of reinforcement provided — $A_{s\_toe\_prov}$ = **1571** mm²/m

***PASS - Reinforcement provided at the retaining wall toe is adequate***

**Check shear resistance at toe**

Design shear stress $v_{toe} = V_{toe} / (b \times d_{toe})$ = **0.468** N/mm$^2$

Allowable shear stress $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1 \text{ N/mm}^2)}, 5) \times 1 \text{ N/mm}^2$ = **4.733** N/mm$^2$

***PASS - Design shear stress is less than maximum shear stress***

**From BS8110:Part 1:1997 – Table 3.8**

Design concrete shear stress $v_{c\_toe}$ = **0.525** N/mm$^2$

***$v_{toe} < v_{c\_toe}$ - No shear reinforcement required***

**Design of reinforced concrete retaining wall stem (BS 8002:1994)**

**Material properties**

Characteristic strength of concrete $f_{cu}$ = **35** N/mm$^2$

Characteristic strength of reinforcement $f_y$ = **500** N/mm$^2$

**Wall details**

Minimum area of reinforcement k = **0.13** %

Cover to reinforcement in stem $c_{stem}$ = **50** mm

Cover to reinforcement in wall $c_{wall}$ = **50** mm

**Factored horizontal at-rest forces on stem**

Surcharge $F_{s\_sur\_f} = \gamma_{f\_l} \times K_0 \times \text{Surcharge} \times (h_{eff} - t_{base} - d_{ds})$ = **28.3** kN/m

Moist backfill above water table $F_{s\_m\_a\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2$ = **66.9** kN/m

**Calculate shear for stem design**

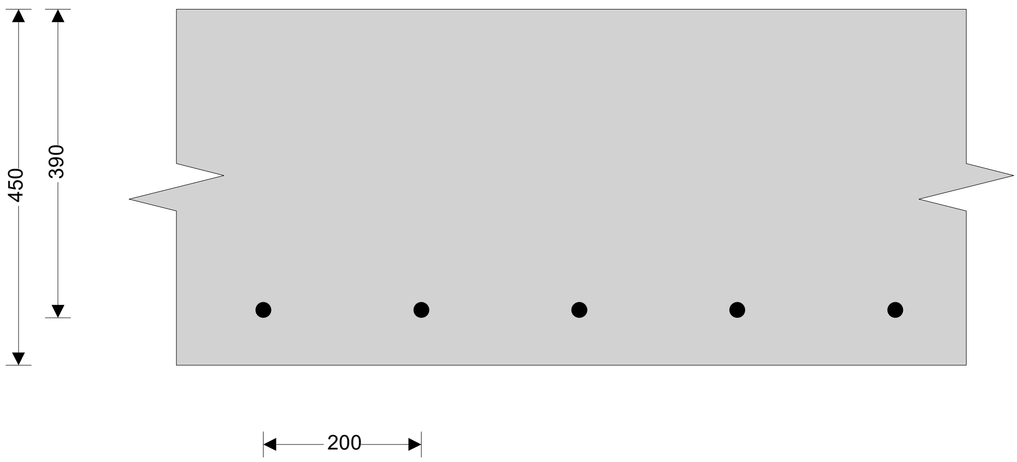
Shear at base of stem $V_{stem} = F_{s\_sur\_f} + F_{s\_m\_a\_f} - F_{prop\_f}$ = **45.5** kN/m

**Calculate moment for stem design**

Surcharge $M_{s\_sur} = F_{s\_sur\_f} \times (h_{stem} + t_{base}) / 2$ = **48.9** kNm/m

Moist backfill above water table $M_{s\_m\_a} = F_{s\_m\_a\_f} \times (2 \times h_{sat} + h_{eff} - d_{ds} + t_{base} / 2) / 3$ = **82** kNm/m

Total moment for stem design $M_{stem} = M_{s\_sur} + M_{s\_m\_a}$ = **130.8** kNm/m




**Check wall stem in bending**

Width of wall stem b = **1000** mm/m

Depth of reinforcement $d_{stem} = t_{wall} - c_{stem} - (\phi_{stem} / 2)$ = **390.0** mm

Constant $K_{stem} = M_{stem} / (b \times d_{stem}^2 \times f_{cu})$ = **0.025**

***Compression reinforcement is not required***

Lever arm $z_{stem} = \min(0.5 + \sqrt{(0.25 - (\min(K_{stem}, 0.225) / 0.9))}, 0.95) \times d_{stem}$

$z_{stem}$ = **371** mm

Area of tension reinforcement required $A_{s\_stem\_des} = M_{stem} / (0.87 \times f_y \times z_{stem})$ = **812** mm²/m

Minimum area of tension reinforcement $A_{s\_stem\_min} = k \times b \times t_{wall}$ = **585** mm²/m

Area of tension reinforcement required $A_{s\_stem\_req} = Max(A_{s\_stem\_des}, A_{s\_stem\_min})$ = **812** mm²/m

Reinforcement provided **20 mm dia.bars @ 200 mm centres**

Area of reinforcement provided $A_{s\_stem\_prov}$ = **1571** mm²/m

***PASS - Reinforcement provided at the retaining wall stem is adequate***

**Check shear resistance at wall stem**

Design shear stress $v_{stem} = V_{stem} / (b \times d_{stem})$ = **0.117** N/mm²

Allowable shear stress $v_{adm} = min(0.8 \times \sqrt{(f_{cu} / 1 N/mm^2)}, 5) \times 1 N/mm^2$ = **4.733** N/mm²

***PASS - Design shear stress is less than maximum shear stress***

**From BS8110:Part 1:1997 – Table 3.8**

Design concrete shear stress $v_{c\_stem}$ = **0.525** N/mm²

***$v_{stem} < v_{c\_stem}$ - No shear reinforcement required***

**Check retaining wall deflection**

Basic span/effective depth ratio $ratio_{bas}$ = **7**

Design service stress $f_s = 2 \times f_y \times A_{s\_stem\_req} / (3 \times A_{s\_stem\_prov})$ = **172.3** N/mm²

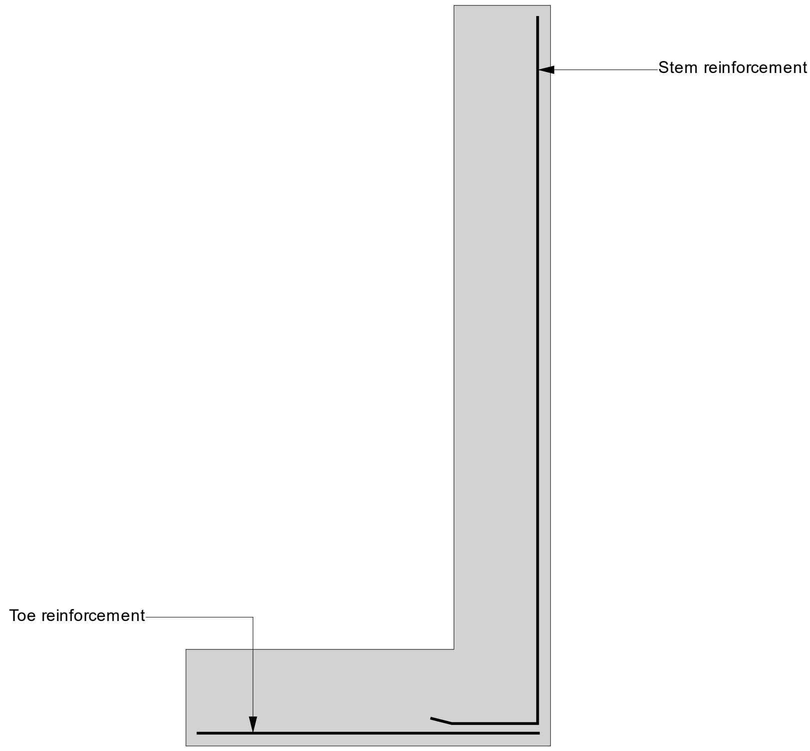
Modification factor $factor_{tens} = min(0.55 + (477 N/mm^2 - f_s)/(120 \times (0.9 N/mm^2 + (M_{stem}/(b \times d_{stem}^2)))),2)$ = **1.99**

Maximum span/effective depth ratio $ratio_{max} = ratio_{bas} \times factor_{tens}$ = **13.95**

Actual span/effective depth ratio $ratio_{act} = h_{stem} / d_{stem}$ = **7.69**

***PASS - Span to depth ratio is acceptable***

**Indicative retaining wall reinforcement diagram**




Toe bars - 20 mm dia.@ 200 mm centres - (1571 mm$^2$/m)
Stem bars - 20 mm dia.@ 200 mm centres - (1571 mm$^2$/m)

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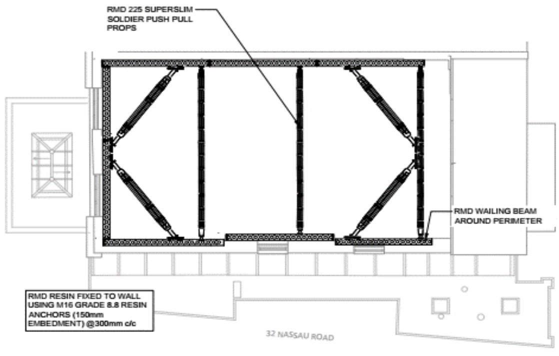
| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 201 |
| Made By: | *OAM* | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project: 34 NASSAU ROAD, LONDON**

**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.**

**PROPOSE HORIZONTAL BRACING**

BELOW FLAT ROOF LEVEL L3


SECOND FLOOR PLAN

**BELOW CEILING**

wind load say 0.75 KN/m2

h= 2.4 m

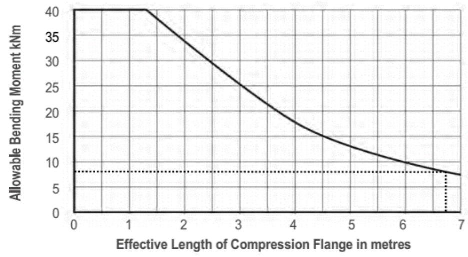
/ROOF /l floor 0.75* 2.4/2= 0.90 KN/m

**PROPOSED WALER BEAMS TO RESTRAIN THEWALL**

MAX SPAN= 3.2 m

bending moment= 0.90* 3.2* 3.2/8= 1.15 KNm

**USE RMD 225 SUPER SLIM SOLDIER PROPS**



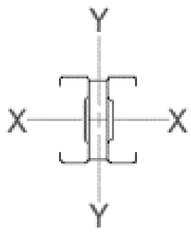

PROP DESIGN length= 5.60 m MAX

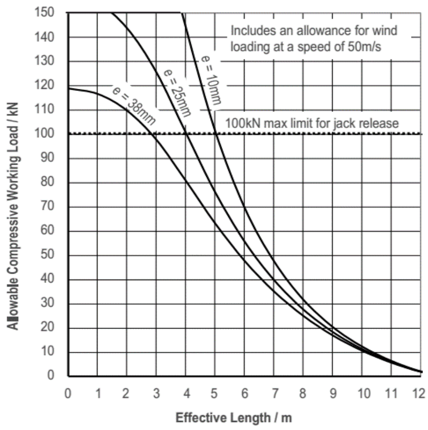
total load= 3.2*0.90= **2.88** KN

**PROPS DESIGN**

MAX REACTION= 2.88 KN

MAX EFFECTIVE LENGTH 3 m




FOR 3 m LE, CAPACITY= 100 KN

m= 2.88*1/4= 0.72 KNm

**USE RMD 225 SUPER SLIM SOLDIER PROPS**

**FINXING TO BRICK WALL**

MAX SHEAR FORCE= 5.76 KN

CAPACITY OF 15 MM TIE BAR= 5.00 KN

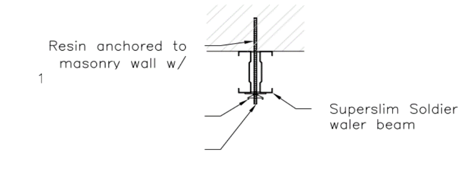
REQUIRED PER LEG= 2.88/5.00= **0.58** BAR

MINIMUM LEG LENGTH= 1000 mm

MINIMUM SPACES OF BARS= 1000/0.58= **1736.1** mm

**USE M16 FIS V PLUS BOLTS AT 300 C/C**

**85 mm EMBEDMENT**




TYPICAL FIXING DETAIL

All design calculations have been author reviewed and subject to additional review by the project team, as required by David Smith Associates Quality Assurance procedures.

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| | | | |
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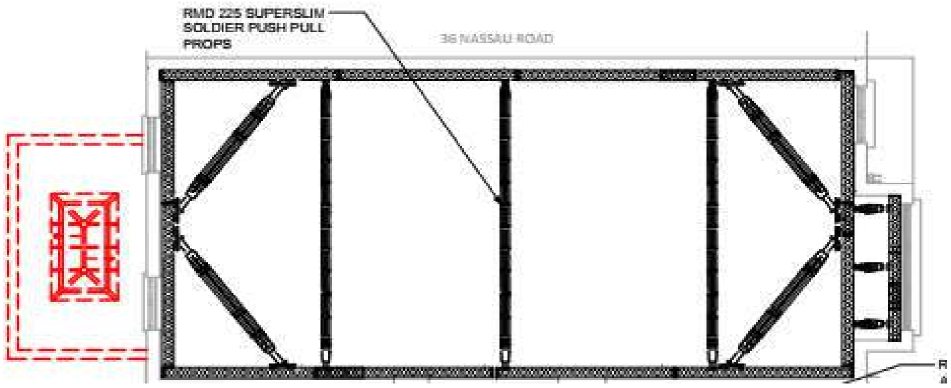
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.**

**PROPOSE HORIZONTAL BRACING**

ABOVE SECOND FLOOR LEVEL L2




**ABOVE FLOOR**

wind load say 0.75 KN/m2

h= 2.4 m

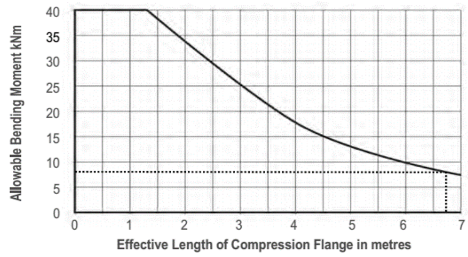
/ROOF /I floor 0.75* 2.4= 1.80 KN/m

**PROPOSED WALER BEAMS TO RESTRAIN THEWALL**

MAX SPAN= 4 m

bending moment= 0.90* 4* 4/8= 1.80 KNm

**USE RMD 225 SUPER SLIM SOLDIER PROPS**



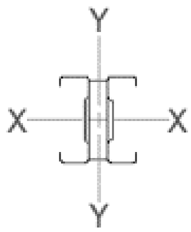

PROP DESIGN length= 5.60 m MAX

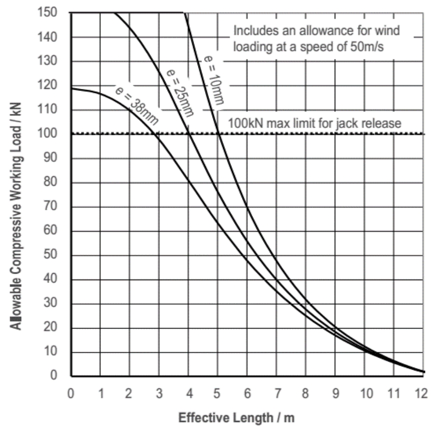
total load= 4*0.90= **3.60** KN

**PROPS DESIGN**

MAX REACTION= 3.60 KN

MAX EFFECTIVE LENGTH 3 m




FOR 3 m LE, CAPACITY= 100 KN

m= 3.60*1/4= 0.9 KNm

**USE RMD 225 SUPER SLIM SOLDIER PROPS**

**FINXING TO BRICK WALL**

MAX SHEAR FORCE= 7.20 KN

CAPACITY OF 15 MM TIE BAR= 5.00 KN

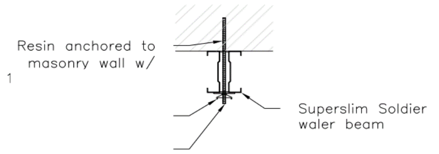
REQUIRED PER LEG= 3.60/5.00= **0.72** BAR

MINIMUM LEG LENGTH= 1000 mm

MINIMUM SPACES OF BARS= 1000/0.72= **1388.9** mm

**USE M16 FIS V PLUS BOLTS AT 300 C/C**

**85 mm EMBEDMENT**




TYPICAL FIXING DETAIL

All design calculations have been author reviewed and subject to additional review by the project team, as required by David Smith Associates Quality Assurance procedures.

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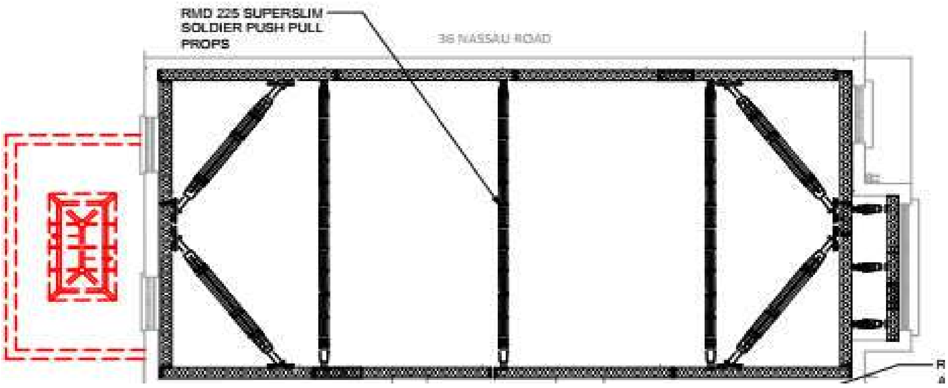
**PROPOSE HORIZONTAL BRACING**

ABOVE FIRST FLOOR LEVEL L1




**ABOVE FLOOR**

wind load say 0.75 KN/m2

h= 2.4 m

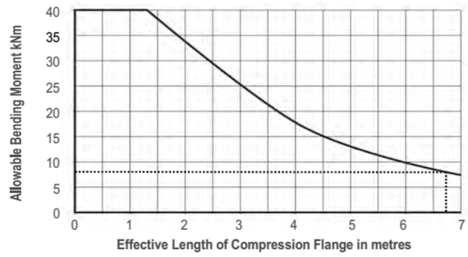
/ROOF /I floor 0.75* 2.4= 1.80 KN/m

**PROPOSED WALER BEAMS TO RESTRAIN THEWALL**

MAX SPAN= 4 m

bending moment= 0.90* 4* 4/8= 1.80 KNm

**USE RMD 225 SUPER SLIM SOLDIER PROPS**



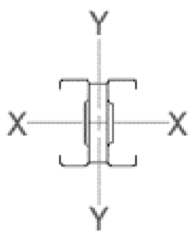

PROP DESIGN length= 5.60 m MAX

total load= 4*0.90= **3.60** KN

**PROPS DESIGN**

MAX REACTION= 3.60 KN

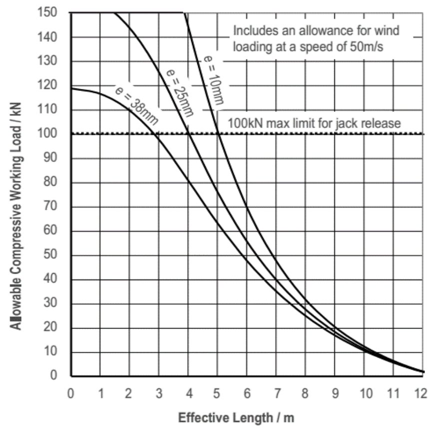
MAX EFFECTIVE LENGTH 3 m




FOR 3 m LE, CAPACITY= 100 KN

m= 3.60*1/4= 0.9 KNm

**USE RMD 225 SUPER SLIM SOLDIER PROPS**




**FINXING TO BRICK WALL**

MAX SHEAR FORCE= 7.20 KN

CAPACITY OF 15 MM TIE BAR= 5.00 KN

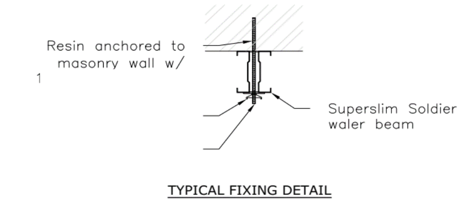
REQUIRED PER LEG= 3.60/5.00= **0.72** BAR

MINIMUM LEG LENGTH= 1000 mm

MINIMUM SPACES OF BARS= 1000/0.72= **1388.9** mm

**USE M16 FIS V PLUS BOLTS AT 300 C/C**

**85 mm EMBEDMENT**




All design calculations have been author reviewed and subject to additional review by the project team, as required by David Smith Associates Quality Assurance procedures.

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| Project No: | 24/54720 | Sheet No: | 210 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.NO WORK SHOULD START BEFORE THE CALCULATIONS HAVE BEEN RECEIVED AND APPROVED BY THE LA BUILDING CONTROL.**

**TEMPORARY SUPPORT AT FIRST FLOOR LEVEL**

**NEEDLE STEEL BEAM** NB1

Max span = 2 m

**LOAD ONSTEEL BEAM** FB1.07

| BEAM LOADING | | D LOAD | I LOAD | cover y | | dead load | live load |
|---|---|---|---|---|---|---|---|
| | | KN/m2 | KN/m2 | m | | KN/m' | KN/m' |
| ROOF | dead | 0.8 | | 2.6 | => 2.6* .8= | 2.08 | |
| | live | | 0.75 | 2.6 | => 2.6*0.75= | | 1.95 |
| second floor | dead | 0.6 | | 2 | => 2* .6= | 1.2 | |
| | live | | 1.50 | 2 | => 2*1.50= | | 3 |
| first floor | dead | 0.5 | | 2 | => 2* .5= | 1 | |
| | live | | 1.50 | 2 | => 2*1.50= | | 3 |
| FLAT ROOF | dead | 0 | | 2.1 | => 2.1* 0= | 0 | |
| | live | | 0.00 | 2.1 | => 2.1*0.00= | | 0 |
| wall | dead | 7.5 | | 5.4 | => 5.4* 7.5= | 40.5 | |
| | | | | | UDL | **44.78 KN/m'** | **7.95 KN/m'** |

TRY NEEDLEAT MAX 900 MM C/C — TOTA= 0.9*( 44.78+ 7.95)= **47.46** KN

**USE 152x152x37 UC** **S355** SEE PAGE 211 - 213

**STEEL BEAM** SB1

Max span = 5 m

**USE 254x254x73 UC** SEE PAGE 214 - 216

go to page 217

All design calculations have been author reviewed and subject to additional review by the project team, as required by David Smith Associates Quality Assurance procedures.

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| | Date: | Mar-24 | Checked By: | TG |

**Project:** 34 NASSAU ROAD, LONDON

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

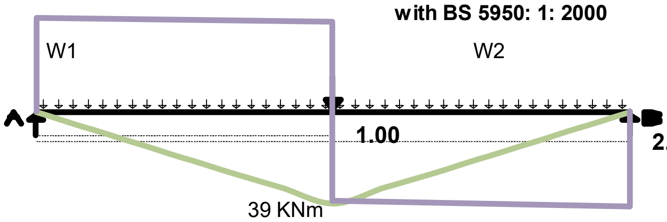
H rolled section S355

Calculation in accordance with BS 5950: 1: 2000

LOCATION= **NEEDLE BEAMS NB1**

Loads are unfactored

| | | |
|---|---|---|
| Wd1= | 0.50 | KN/m2 |
| Wl1= | 0.50 | KN/m2 |
| Wd2= | 0.50 | KN/m2 |
| wl2= | 0.50 | KN/m2 |
| P1= | 50.00 | KN |
| a= | 1.00 | m |
| Span= | 2.00 | m |
| Cover= | 1.00 | m |



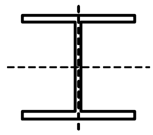

| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | **50.00** KN | **75** KN |
| **AV-Dead+s/w=** | 0.87 KN/m' | 1.218 KN/m' |
| **Live=** | 0.50 KN/m' | 0.8 KN/m' |
| | 1.37 KN/m' | 2.018 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 26.4 KN | **39.5** KN |
| RB= | 26.4 KN | **39.5** KN |
| Shear zero at | X= | 1.00 m |

Maximum Bending Moment **Mx =** **39** KNm




| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 32.8 KNm | Local capacity | **PASS** | 0.299 |
| Maximum BM about axis Y | MY= | 0.00 KNm | Overall buckling 1 | **PASS** | 0.321 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | **PASS** | 0.299 |
| Shear force in x axis | Fv= | 39.5 KN | Deflection (dead)= | **PASS** | 1/ 1700 |
| Beam span | L= | 2.00 m | Deflection(live)= | **PASS** | 1/ 1700 |
| Effective length about axis X | LX eff= | 2.00 m | Deflection (d+l)= | **PASS** | 1/ 850 |
| Effective length about axis Y | LYeff= | 1.26 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 108 cm3 | | | |

**Section properties**

Section size (Ref. No= **100** ) **152x152 37 kg UC S355**

| | | | | |
|---|---|---|---|---|
| Depth of steel section | D= | 161.8 mm | | |
| Width of section | B= | 154.4 mm | | |
| Thickness of web | t= | 8.1 mm | Mcx= | 110.09 KNm |
| Thickness of flange | T= | 11.5 mm | Mcy= | 49.736 KNm |
| Root radius | r= | 11.5 mm | Mb L= | 110.09 KNm |
| Second moment of area x-x | Ix= | 2218 cm4 | Mlt= | **0.852** TABLE 18 |
| Second moment of area y-y | Iy= | 709 cm4 | | |
| Plastic modulus x-x | Sx= | 310.1 cm3 | Sx eff= | 268.25 cm3 |
| Plastic modulus y-y | Sy= | 140.1 cm3 | Sy eff= | 83.77 cm3 |
| Area of section | Ag= | 47.4 cm2 | An= | 43.09 cm2 ke= 1.1 |

**DEFLECTION**

| | | | unfactored |
|---|---|---|---|
| Unfactored dead load deflection= | 1.18 mm | E UDL= | 25.67 KN/m' |
| Unfactored live load deflection= | 1.18 mm | E UDL= | 25.67 KN/m' |
| Unfactored dead+ live load def = | 2.35 mm | E UDL= | 51.35 KN/m' |
| Span/def. ratio for dead load= | 1700 | | |
| Span/def. ratio for live load= | **1700** | **>360** | |
| Span/def. ratio fordead+ live load= | 850 | | |

CONTINUE OF NEEDLE BEAMS NB1

**Strength of steel** Clause 3.1.1

| | | | | | | |
|---|---|---|---|---|---|---|
| Design strength | (Grade | S 355 ) | | | | |
| for thickness of | 11.5 mm | py= | 355 N/mm2 | py= | 355.0 N/mm2 | pyw= py |
| Young's Modulus | | E= | 205 KN/mm2 | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 77.2 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 6.71 | b/Tlim= | 7.92 | 8.80 | 13.20 |

**The section is class1 plastic**

| | | | | | | |
|---|---|---|---|---|---|---|
| r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= | | 0.28 | r2=Fc/(Agxpyw)= | 0.0006 | | |
| Depth between fillets | d= | 123.4 mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 15.23 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.206 | d/tlim= | 54.93 | 61.86 | 105.49 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | | |
|---|---|---|---|---|---|---|
| Shear area | | Av y= | 1310.6 mm2 | (t x D) | | |
| Shear capacity | (0.6pyA) | Pvy= | 279 KN | | | |
| Shear force | | Fvy= | 39.5 KN | Fvy/Pvy= | 0.14 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 274.2 cm3 | Mcx1= | 97.341 |
| Plastic modulus | Sx= | 310 cm3 | Mcx2= | 110.09 |
| Moment capacity for section | Mcx= | **110.1** KNm | | |
| Elastic modulus | Zy= | 91.78 cm3 | Mcy1= | 32.582 |
| Plastic modulus | Sy= | 140.1 cm3 | mcy2= | 49.736 |
| Moment capacity for section | Mcy= | **49.7** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.001 + 0.298 + 0.000 = **0.299** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 2000 mm | normal condition |
| Effective length | Lelt2= | 1261.8 mm | |
| | L e lt= | 1630.9 mm | |
| Radius of gyration y-y | ry= | 3.87 cm | |
| | rx= | 6.84 cm | |
| | Lam'y= | 32.6 | |
| | La'mx= | 29.2 | |

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| Project No: | 24/54720 | Sheet No: | 213 |
|---|---|---|---|
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

CONTINUE OF NEEDLE BEAMS NB1

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for H section | | | | |
| | a= | 5.5 | | |
| Perry factor | eta= | 0.10 | | |
| Euler strength | pe= | 1903 N/mm2 | | |
| Factor | phi= | 1221 N/mm2 | | |
| Compressive strength | pcy= | **318.2** N/mm2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 32.6 | La'mx= | 29.24 | Lamy/x= | 2.45148 |
| Slenderness of section | Lamda= | 32.6 | | | Lamx/x= | 2.19848 |
| Torsional index | x= | 13.3 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.96 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.848 | | | | |
| Equivalent slenderness | lamlt= | 26.5 | | | | |
| Buckling strength (Table 16) | pb= | 355 N/mm2 | for lamlt= | 30 | py= | 355 |
| Buckling resisrance moment | Mb= | 110.1 KNm | | | | |
| | Mb L= | 110.1 KNm | | | | |
| | Mry= | 49.7 KNm | | | | |
| | Pc= | 1508.3 KN | | | | |
| | Pcy= | 1508.3 KN | | | | |

$$\frac{Fc}{PC} + \frac{m_x Mx}{Py\ Zx} + \frac{m_y My}{py\ Zy} = \ <=1$$

m x= 0.95

m y= 1

0.001 + 0.320 + 0.000 = **0.321** **The interaction formula is satisfied**

$$\frac{Fc}{Pcy} + \frac{m_{LT} M_{lt}}{Mb} + \frac{m_y My}{py\ Zy} = \ <=1$$

0.001 + 0.298 + 0.000 = **0.299** **The interaction formula is satisfied**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

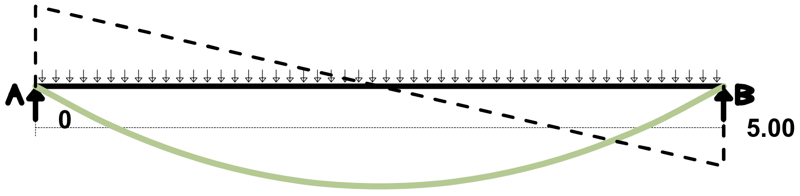
H rolled section S355
Calculation in accordance with BS 5950: 1: 2000

LOCATION= **SB1**

Loads are unfactored

Wd= **44.78** KN/m2
Wl= **7.95** KN/m2

Span= **5.00** m
Cover= **0.50** m




**SPAN**

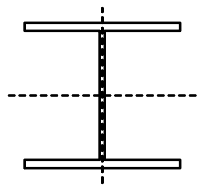
121 KNm

| Load on beam | unfactored | factored |
|---|---|---|
| **Dead+s/w=** | 23.12 KN/m' | 32.37 KN/m' |
| **Live=** | 3.98 KN/m' | 6.36 KN/m' |
| | 27.10 KN/m' | 38.73 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6

**Reaction**

| | unfactored | | factored |
|---|---|---|---|
| RA= | 67.7 KN | | **96.8** KN |
| RB= | 67.7 KN | | **96.8** KN |
| Shear zero at | | X= | 2.50 m |
| Maximum Bending Moment | | **Mx =** | **121.0** KNm |



**SECTION**

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 111.9 KNm | Local capacity | PASS | 0.405 |
| Maximum BM about axis Y | MY= | 11.19 KNm | Overall buckling 1 | PASS | 0.475 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | PASS | 0.613 |
| Shear force in x axis | Fv= | 96.8 KN | Deflection (dead)= | PASS | 1/ 618 |
| Beam span | L= | 5.00 m | Deflection(live)= | PASS | 1/ 3599 |
| Effective length about axis X | LX eff= | 5.00 m | Deflection (d+l)= | PASS | 1/ 528 |
| Effective length about axis Y | LYeff= | 6.00 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 341 cm3 | | | |

**Section properties**

Section size (Ref. No= **94** ) **254x254 73 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 254 mm | | | | |
| Width of section | B= | 254 mm | Pcy= | 1449 KN | | |
| Thickness of web | t= | 8.6 mm | Mcx= | 351 KNm | | |
| Thickness of flange | T= | 14.2 mm | Mcy= | 164.2 KNm | | 1312.6 |
| Root radius | r= | 12.7 mm | Mb L= | 236.3 KNm | | |
| Second moment of area x-x | Ix= | 11360 cm4 | Mlt= | **0.925** | Pcy= | 1448.7 KN |
| Second moment of area y-y | Iy= | 3873 cm4 | | | | |
| Plastic modulus x-x | Sx= | 988.6 cm3 | Sx eff= | 882.31 cm3 | | |
| Plastic modulus y-y | Sy= | 462.4 cm3 | Sy eff= | 284.60 cm3 | | |
| Area of section | Ag= | 92.9 cm2 | An= | 84.45 cm2 | ke= | 1.1 |

**DEFLECTION**

| | | | | unfactored |
|---|---|---|---|---|
| Unfactored dead load deflection= | 8.08 mm | | E UDL= | 23.12 KN/m' |
| Unfactored live load deflection= | 1.39 mm | | E UDL= | 3.98 KN/m' |
| Unfactored dead+ live load def = | 9.47 mm | | E UDL= | 27.10 KN/m' |
| Span/def. ratio for dead load= | 619 | | | |
| Span/def. ratio for live load= | **3600** | **>360** | | |
| Span/def. ratio fordead+ live load= | 528 | | | |

CONTINUE OF SB1

**Strength of steel** Clause 3.1.1

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Design strength | (Grade | | S 355 | ) | | | | | |
| for thickness of | 14.2 | mm | py= | 355 | N/mm2 | py= | 355.0 | N/mm2 | pyw= py |
| Young's Modulus | | | E= | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 127 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 8.94 | | b/Tlim= | 7.92 | 8.80 | 13.20 |

The classification is based on the outsatnd element — **The section is class 3 semi compact**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.10 r2=Fc/(Agxpyw)= 0.018

TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Depth between fillets | d= | 200.2 | mm | | | | |
| ratio | d/t= | 23.28 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.21 | | d/tlim= | 64.12 | 76.72 | 101.91 |

The classification is based on the general web condition — **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 2184 | mm2 | (t x D) |
| Shear capacity | (0.6pyA) | Pvy= | 465 | KN | |
| Shear force | | Fvy= | 96.8 | KN | Fvy/Pvy= 0.21 **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 894.5 | cm3 | Mcx1= | 317.5 |
| Plastic modulus | Sx= | 989 | cm3 | Mcx2= | 351 |
| Moment capacity for section | Mcx= | **351** | KNm | | |
| Elastic modulus | Zy= | 305 | cm3 | Mcy1= | 108.3 |
| Plastic modulus | Sy= | 462 | cm3 | mcy2= | 164.2 |
| Moment capacity for section | Mcy= | **164** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} = \ <=1$$

0.018 + 0.319 + 0.068 = **0.405** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 5000 | mm | normal condition |
| Effective length | Lelt2= | 6000 | mm | |
| | L e lt= | 5500 | mm | |
| Radius of gyration y-y | ry= | 6.46 | cm | |
| | rx= | 11.1 | cm | |
| | Lam'y= | 92.9 | | |
| | La'mx= | 45.0 | | |

CONTINUE OF SB1

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for section | | | | | |
| | a= | 5.5 | for table 23 | c | |
| Perry factor | eta= | 0.43 | | | |
| Euler strength | pe= | 235 | N/mm2 | | |
| Factor | phi= | 345 | N/mm2 | | |
| Compressive strength | pcy= | **155.9** | N/mm2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 92.9 | La'mx= | 45.05 | Lamy/x= | 5.3687 |
| Slenderness of section | Lamda= | 92.9 | | | Lamx/x= | 2.6038 |
| Torsional index | x= | 17.3 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.80 | from Table 19 | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.849 | | | | |
| Equivalent slenderness | lamlt= | 63.1 | | | | |
| Buckling strength (Table 16) | pb= | 239 | N/mm2 | for lamlt= 65 | py= | 355 |
| Buckling resisrance moment | Mb= | 236 | KNm | | | |
| | Mb L= | 236 | KNm | | | |
| | Mry= | 164 | KNm | | | |
| | Pc= | 1449 | KN | | | |
| | Pcy= | 1449 | KN | | | |

$\frac{Fc}{PC} + m\frac{x\,Mx}{Py\,Zx} + m\frac{y\,My}{py\,Zy} = \le 1$     m x= 0.95, m y= 0.95

0.041 + 0.335 + 0.098 = **0.475**    **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m\frac{LT\,M\,lt}{Mb} + m\frac{y\,My}{py\,Zy} = \le 1$

0.041 + 0.474 + 0.098 = **0.613**    **The interaction formula is satisfied**

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**DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.NO WORK SHOULD START BEFORE THE CALCULATIONS HAVE BEEN RECEIVED AND APPROVED BY THE LA BUILDING CONTROL.**

**TEMPORARY SUPPORT AT FIRST FLOOR LEVEL**

**NEEDLE STEEL BEAM** **NB2**

Max span = 2 m

**LOAD ONSTEEL BEAM** **FB1.04 FB1.05 FB1.06**

| **BEAM LOADING** | | D LOAD | I LOAD | cover y | | dead load | live load |
|---|---|---|---|---|---|---|---|
| | | KN/m2 | KN/m2 | m | | KN/m' | KN/m' |
| ROOF | dead | **1.2** | | **3.5** | => 3.5* 1.2= | 4.2 | |
| | live | | **1.00** | **3.5** | => 3.5*1.00= | | 3.5 |
| second floor | dead | **0.6** | | **3.5** | => 3.5* .6= | 2.1 | |
| | live | | **0.25** | **3.5** | => 3.5*0.25= | | 0.875 |
| first floor | dead | **0.5** | | **3.5** | => 3.5* .5= | 1.75 | |
| | live | | **0.25** | **3.5** | => 3.5*0.25= | | 0.875 |
| FLAT ROOF | dead | **0.8** | | **1.2** | => 1.2* .8= | 0.96 | |
| | live | | **0.25** | **1.2** | => 1.2*0.25= | | 0.3 |
| wall | dead | **7.5** | | **5.4** | => 5.4* 7.5= | 40.5 | |
| | | | | | **UDL** | **49.51 KN/m'** | **5.55 KN/m'** |

TRY NEEDLEAT MAX 900 MM C/C    TOTA= 0.9*( 49.51+ 5.55)= **49.55** KN

**USE 152x152x37 UC** **S355** SEE PAGE 218 - 220

**STEEL BEAM** **SB2**

Max span = 5 m

**USE 254x254x73 UC** SEE PAGE 221 - 223

go to page 224

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 218 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

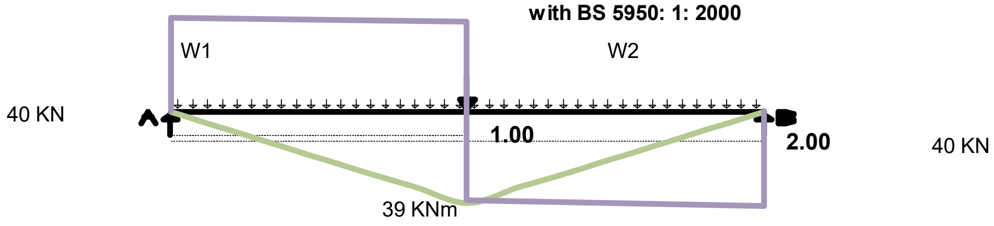
**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

LOCATION= **NEEDLE BEAMS NB2**

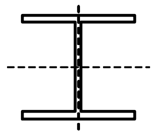
Loads are unfactored

| | | |
|---|---|---|
| Wd1= | 0.50 | KN/m2 |
| Wl1= | 0.50 | KN/m2 |
| Wd2= | 0.50 | KN/m2 |
| wl2= | 0.50 | KN/m2 |
| P1= | 50.00 | KN |
| a= | 1.00 | m |
| Span= | 2.00 | m |
| Cover= | 1.00 | m |




| Load on beam | unfactored | factored |
|---|---|---|
| Point load= | 50.00 KN | 75 KN |
| AV-Dead+s/w= | 0.87 KN/m' | 1.218 KN/m' |
| Live= | 0.50 KN/m' | 0.8 KN/m' |
| | 1.37 KN/m' | 2.018 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6




**Reaction**

| | unfactored | factored |
|---|---|---|
| RA= | 26.4 KN | 39.5 KN |
| RB= | 26.4 KN | 39.5 KN |
| Shear zero at X= | | 1.00 m |

Maximum Bending Moment **Mx =** 39 KNm

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 32.8 KNm | Local capacity | PASS | 0.299 |
| Maximum BM about axis Y | MY= | 0.00 KNm | Overall buckling 1 | PASS | 0.321 |
| Axial compressive load | Fc= | 1.00 KN | Overall buckling 2 | PASS | 0.299 |
| Shear force in x axis | Fv= | 39.5 KN | Deflection (dead)= | PASS | 1/ 1700 |
| Beam span | L= | 2.00 m | Deflection(live)= | PASS | 1/ 1700 |
| Effective length about axis X | LX eff= | 2.00 m | Deflection (d+l)= | PASS | 1/ 850 |
| Effective length about axis Y | LYeff= | 1.26 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | 360.0 or 14 mm | | | |
| | z rep= | 108 cm3 | | | |

**Section properties**

Section size (Ref. No= 100) **152x152 37 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 161.8 mm | | | | |
| Width of section | B= | 154.4 mm | | | | |
| Thickness of web | t= | 8.1 mm | | Mcx= | 110.09 KNm | |
| Thickness of flange | T= | 11.5 mm | | Mcy= | 49.736 KNm | |
| Root radius | r= | 11.5 mm | | Mb L= | 110.09 KNm | |
| Second moment of area x-x | Ix= | 2218 cm4 | | Mlt= | 0.852 | TABLE 18 |
| Second moment of area y-y | Iy= | 709 cm4 | | | | |
| Plastic modulus x-x | Sx= | 310.1 cm3 | Sx eff= | 268.25 cm3 | | |
| Plastic modulus y-y | Sy= | 140.1 cm3 | Sy eff= | 83.77 cm3 | | |
| Area of section | Ag= | 47.4 cm2 | An= | 43.09 cm2 | | ke= 1.1 |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 1.18 mm | | E UDL= | 25.67 KN/m' |
| Unfactored live load deflection= | 1.18 mm | | E UDL= | 25.67 KN/m' |
| Unfactored dead+ live load def = | 2.35 mm | | E UDL= | 51.35 KN/m' |
| Span/def. ratio for dead load= | 1700 | | | |
| Span/def. ratio for live load= | 1700 | >360 | | |
| Span/def. ratio fordead+ live load= | 850 | | | |

CONTINUE OF NEEDLE BEAMS NB2

**Strength of steel** Clause 3.1.1

| | | | | | | |
|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** ) | | | | |
| for thickness of | 11.5 mm | **py=** | **355** N/mm2 | py= | **355.0** N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 KN/mm2 | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant | ε = | 0.880 | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 77.2 mm | | plastic | compac | semi compact |
| Ratio | b/T= | 6.71 | b/Tlim= | 7.92 | 8.80 | 13.20 |

**The section is class1 plastic**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.28 r2=Fc/(Agxpyw)= 0.0006

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth between fillets | d= | 123.4 mm | | TABLE 11 rolled section | | |
| ratio | d/t= | 15.23 | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.206 | d/tlim= | 54.93 | 61.86 | 105.49 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | |
|---|---|---|---|---|
| Shear area | | Av y= | 1310.6 mm2 | (t x D) |
| Shear capacity | (0.6pyA) | Pvy= | 279 KN | |
| Shear force | | Fvy= | 39.5 KN | Fvy/Pvy= 0.14 **SHEAR PASS OK** |

**Moment Capacity**

| | | | | |
|---|---|---|---|---|
| Elastic modulus | Zx= | 274.2 cm3 | Mcx1= | 97.341 |
| Plastic modulus | Sx= | 310 cm3 | Mcx2= | 110.09 |
| Moment capacity for section | Mcx= | **110.1** KNm | | |
| Elastic modulus | Zy= | 91.78 cm3 | Mcy1= | 32.582 |
| Plastic modulus | Sy= | 140.1 cm3 | mcy2= | 49.736 |
| Moment capacity for section | Mcy= | **49.7** KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.001 + 0.298 + 0.000 = **0.299** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | |
|---|---|---|---|
| Effective length | Le lt1= | 2000 mm | normal condition |
| Effective length | Lelt2= | 1261.8 mm | |
| | L e lt= | 1630.9 mm | |
| Radius of gyration y-y | ry= | 3.87 cm | |
| | rx= | 6.84 cm | |
| | Lam'y= | 32.6 | |
| | La'mx= | 29.2 | |

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| Project No: | 24/54720 | Sheet No: | 220 |
|---|---|---|---|
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

**Project:** **34 NASSAU ROAD, LONDON**

CONTINUE OF NEEDLE BEAMS NB2

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | |
|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | py= | 355 N/mm2 |
| For buckling about y-y | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for H section | | | | |
| | a= | 5.5 | | |
| Perry factor | eta= | 0.10 | | |
| Euler strength | pe= | 1903 N/mm2 | | |
| Factor | phi= | 1221 N/mm2 | | |
| Compressive strength | pcy= | **318.2** N/mm2 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Lam'y= | 32.6 | La'mx= | 29.24 | Lamy/x= | 2.45148 |
| Slenderness of section | Lamda= | 32.6 | | | Lamx/x= | 2.19848 |
| Torsional index | x= | 13.3 | | | | |
| | N= | 0.5 | | | | |
| Slenderness factor | v= | 0.96 from Table 19 | | | | |
| | β w = | 1.0 | | | | |
| Buckling parameter | u= | 0.848 | | | | |
| Equivalent slenderness | lamlt= | 26.5 | | | | |
| Buckling strength (Table 16) | pb= | 355 N/mm2 | for lamlt= | 30 | py= | 355 |
| Buckling resisrance moment | Mb= | 110.1 KNm | | | | |
| | Mb L= | 110.1 KNm | | | | |
| | Mry= | 49.7 KNm | | | | |
| | Pc= | 1508.3 KN | | | | |
| | Pcy= | 1508.3 KN | | | | |

$$\frac{Fc}{PC} + m\frac{x\,Mx}{Py\,Zx} + m\frac{y\,My}{py\,Zy} = \le 1$$

m x= 0.95
m y= 1

0.001 + 0.320 + 0.000 = **0.321** **The interaction formula is satisfied**

$$\frac{Fc}{Pcy} + m\frac{LT\,M\,lt}{Mb} + m\frac{y\,My}{py\,Zy} = \le 1$$

0.001 + 0.298 + 0.000 = **0.299** **The interaction formula is satisfied**

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| | | | |
|---|---|---|---|
| Project No: | 24/54720 | Sheet No: | 221 |
| Made By: | OAM | Revision: | |
| Date: | Mar-24 | Checked By: | TG |

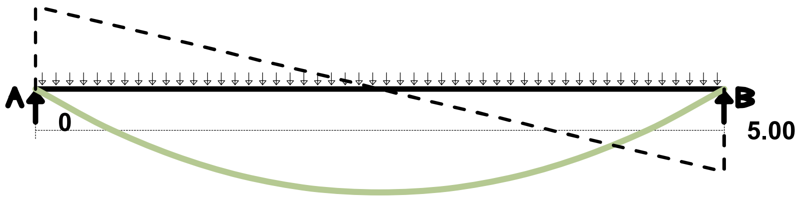
**Project: 34 NASSAU ROAD, LONDON**

**DESIGN OF STEEL BEAM, SIMPLY SUPPORTED**

**H rolled section** S355
**Calculation in accordance with BS 5950: 1: 2000**

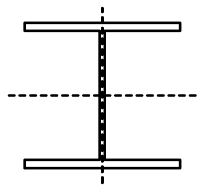
LOCATION= **SB2**
Loads are unfactored
Wd= **49.51** KN/m2
Wl= **5.55** KN/m2

Span= **5.00** m
Cover= **0.50** m




| Load on beam | unfactored | factored |
|---|---|---|
| **Dead+s/w=** | 25.485 KN/m' | 35.68 KN/m' |
| **Live=** | 2.78 KN/m' | 4.44 KN/m' |
| | 28.26 KN/m' | 40.12 KN/m' |

Partial safety factor for load
dead= 1.4
live= 1.6




**Reaction**

| | | | |
|---|---|---|---|
| RA= | 70.7 KN | | **100.3** KN |
| RB= | 70.7 KN | | **100.3** KN |
| Shear zero at | | X= | 2.50 m |
| Maximum Bending Moment | | **Mx =** | **125.4** KNm |

| | | | | | factor |
|---|---|---|---|---|---|
| Maximum BM for check | M LT= | 116.0 KNm | Local capacity | **PASS** | 0.419 |
| Maximum BM about axis Y | MY= | 11.60 KNm | Overall buckling 1 | **PASS** | 0.490 |
| Axial compressive load | Fc= | 60.0 KN | Overall buckling 2 | **PASS** | 0.634 |
| Shear force in x axis | Fv= | 100.3 KN | Deflection (dead)= | **PASS** | 1/ 561 |
| Beam span | L= | 5.00 m | Deflection(live)= | **PASS** | 1/ 5156 |
| Effective length about axis X | LX eff= | 5.00 m | Deflection (d+l)= | **PASS** | 1/ 506 |
| Effective length about axis Y | LYeff= | 6.00 m | Fully restraint for Ly& LX <1. | | |
| Limiting span/deflection (live) | = | **360.0** or 14 mm | | | |
| | z rep= | 353 cm3 | | | |

**Section properties**

Section size (Ref. No= **94** ) **254x254 73 kg UC S355**

| | | | | | | |
|---|---|---|---|---|---|---|
| Depth of steel section | D= | 254 mm | | | | |
| Width of section | B= | 254 mm | Pcy= | 1449 KN | | |
| Thickness of web | t= | 8.6 mm | Mcx= | 351 KNm | | |
| Thickness of flange | T= | 14.2 mm | Mcy= | 164.2 KNm | | 1312.6 |
| Root radius | r= | 12.7 mm | Mb L= | 236.3 KNm | | |
| Second moment of area x-x | Ix= | 11360 cm4 | Mlt= | **0.925** | Pcy= | 1448.7 KN |
| Second moment of area y-y | Iy= | 3873 cm4 | | | | |
| Plastic modulus x-x | Sx= | 988.6 cm3 | Sx eff= | 882.31 cm3 | | |
| Plastic modulus y-y | Sy= | 462.4 cm3 | Sy eff= | 284.60 cm3 | | |
| Area of section | Ag= | 92.9 cm2 | An= | 84.45 cm2 | ke= 1.1 | |

**DEFLECTION**

| | | | unfactored | |
|---|---|---|---|---|
| Unfactored dead load deflection= | 8.91 mm | | E UDL= | 25.49 KN/m' |
| Unfactored live load deflection= | 0.97 mm | | E UDL= | 2.78 KN/m' |
| Unfactored dead+ live load def = | 9.88 mm | | E UDL= | 28.26 KN/m' |
| Span/def. ratio for dead load= | 561 | | | |
| Span/def. ratio for live load= | **5156** | **>360** | | |
| Span/def. ratio fordead+ live load= | 506 | | | |

CONTINUE OF SB2

**Strength of steel** Clause 3.1.1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Design strength | **(Grade** | **S 355** | **)** | | | | | |
| for thickness of | 14.2 mm | **py=** | **355** | N/mm2 | py= | **355.0** | N/mm2 | pyw= py |
| Young's Modulus | | **E=** | 205 | KN/mm2 | | | | |

**Classification of cross section** (clause 3.5.2) TABLE 11 rolled section

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant (table 11 note b) | ε = | 0.880 | | | class 1 | class 2 | class 3 |
| Outstand of flange | b= | 127 | mm | | plastic | compac | semi compact |
| Ratio | b/T= | 8.94 | | b/Tlim= | 7.92 | 8.80 | 13.20 |

The classification is based on the outsatnd element **The section is class 3 semi compact**

r1 =min(1.0,max(-0.1,Fc/(dxtxpyw)))= 0.10 r2=Fc/(Agxpyw)= 0.018

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Depth between fillets | d= | 200.2 | mm | TABLE 11 rolled section | | | |
| ratio | d/t= | 23.28 | | | class 1 | class 2 | class 3 |
| 40 ε | = | 35.21 | | d/tlim= | 64.12 | 76.72 | 101.91 |

The classification is based on the general web condition **The section is class1 plastic**

**Shear capacity** CL 4.2.3

| | | | | | |
|---|---|---|---|---|---|
| Shear area | | Av y= | 2184 mm2 | (t x D) | |
| Shear capacity | (0.6pyA) | Pvy= | 465 KN | | |
| Shear force | | Fvy= | 100.3 KN | Fvy/Pvy= 0.22 | **SHEAR PASS OK** |

**Moment Capacity**

| | | | | | |
|---|---|---|---|---|---|
| Elastic modulus | Zx= | 894.5 | cm3 | Mcx1= | 317.5 |
| Plastic modulus | Sx= | 989 | cm3 | Mcx2= | 351 |
| Moment capacity for section | Mcx= | **351** | KNm | | |
| Elastic modulus | Zy= | 305 | cm3 | Mcy1= | 108.3 |
| Plastic modulus | Sy= | 462 | cm3 | mcy2= | 164.2 |
| Moment capacity for section | Mcy= | **164** | KNm | | |

**Local capacity check Clause 4.8.3.2**

$$\frac{F}{Ag.\,py} + \frac{Mx}{Mcx} + \frac{My}{Mcy} <= 1$$

0.018 + 0.330 + 0.071 = **0.419** **LOCAL CAPACITY IS SATISFIED**

**restraint/effective length Clause 4.31 to 4.3.5** TABLE 13

| | | | | |
|---|---|---|---|---|
| Effective length | Le lt1= | 5000 | mm | normal condition |
| Effective length | Lelt2= | 6000 | mm | |
| | L e lt= | 5500 | mm | |
| Radius of gyration y-y | ry= | 6.46 | cm | |
| | rx= | 11.1 | cm | |
| | Lam'y= | 92.9 | | |
| | La'mx= | 45.0 | | |

CONTINUE OF SB2

**Buckling resistance Clause 4.8.3.3.1**

**Compressive strength:perry strust formula from Appendex C.1**

| | | | | | |
|---|---|---|---|---|---|
| Limiting slenderness | lam 0= | 15.10 | | py= | 355 N/mm2 |
| For buckling about y-y | | | | λ L0= | 30.20 TABLE 16 |
| Robertson constant for section | | | | | |
| | a= | 5.5 | for table 23 | c | |
| Perry factor | eta= | 0.43 | | | |
| Euler strength | pe= | 235 | N/mm2 | | |
| Factor | phi= | 345 | N/mm2 | | |
| Compressive strength | pcy= | **155.9** | N/mm2 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lam'y= | 92.9 | | La'mx= | 45.05 | Lamy/x= | 5.3687 |
| Slenderness of section | Lamda= | 92.9 | | | | Lamx/x= | 2.6038 |
| Torsional index | x= | 17.3 | | | | | |
| | N= | 0.5 | | | | | |
| Slenderness factor | v= | 0.80 | from Table 19 | | | | |
| | β w = | 1.0 | | | | | |
| Buckling parameter | u= | 0.849 | | | | | |
| Equivalent slenderness | lamlt= | 63.1 | | | | | |
| Buckling strength (Table 16) | pb= | 239 | N/mm2 | for lamlt= | 65 | py= | 355 |
| Buckling resisrance moment | Mb= | 236 | KNm | | | | |
| | Mb L= | 236 | KNm | | | | |
| | Mry= | 164 | KNm | | | | |
| | Pc= | 1449 | KN | | | | |
| | Pcy= | 1449 | KN | | | | |

$\frac{Fc}{PC} + m \frac{x\,Mx}{Py\,Zx} + m \frac{y\,My}{py\,Zy} = \;<=1$   m x= 0.95, m y= 0.95

0.041 + 0.347 + 0.102 = **0.490**   **The interaction formula is satisfied**

$\frac{Fc}{Pcy} + m \frac{LT\,M\,lt}{Mb} + m \frac{y\,My}{py\,Zy} = \;<=1$

0.041 + 0.491 + 0.102 = **0.634**   **The interaction formula is satisfied**

## APPENDIX C
## GROUND INVESTIGATION

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| PRELIMINARY SUMMARY | |
|---|---|
| **CLIENT** | Tom Richards |
| **SITE ADDRESS** | 34 Nassau Road SW13 9QE |
| **REPORT REFERENCE** | GWPR5909.<br>The conditions and limitations of this preliminary summary can be viewed within Appendix A. |
| **ENGINEER** | Adam Young, Ground and Water Limited |
| **PROPOSED DEVELOPMENT** | At the time of reporting, March 2024, the proposed development was understood to comprise the construction of a basement under the existing house to a maximum depth of 4.00m bgl, along with a pool in the rear garden. |
| **INVESTIGATION LOCATIONS AND SCOPE OF WORKS** | Site works were undertaken on 08/03/2024 and comprised the drilling of the 2no. Modular Window Sample Boreholes to 3.00m and 6.00m bgl with Standard Penetration Tests at 1.00m intervals. Boreholes were terminated early due to density of strata. Boreholes were terminated early due to density of strata. Super Heavy Dynamic Probes (DP1) were undertaken through the base of WS1 to final depths of 7.00m bgl.<br><br>A trial hole location plan has been provided within Figure 1. |
| **GROUND CONDITIONS ENCOUNTERED** | A summary of the ground conditions encountered can be viewed below. The trial hole logs can be seen within Appendix B. |

| Summary of Strata Encountered (BH1) | | | |
|---|---|---|---|
| Strata | Top Depth (m bgl) | Base Depth (m bgl) | Thickness (m) |
| **MADE GROUND:** Dark brown sandy gravelly CLAY. Sand is fine. gravel is fine to coarse, angular to sub-rounded of flint (80%), brick (15%) and chalk (5%). | GL | 1.20 | 1.20 |
| **Kempton Park Gravel Member:** Orange, brown very sandy CLAY. Sand is fine. | 1.20 | 1.80 – 2.20 | 0.60 – 1.00 |
| **KEMPTON PARK GRAVEL MEMBER:** Light brown very sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, angular to subrounded of flint. | 1.80 – 2.20 | >3.00 - >4.00 | >1.20 - >1.80 |

**IN-SITU STRENGTH TESTING (SPTs and SHDPs)**

A summary of the in-situ strength testing conducted has been summarised in the following table.

| Interpretation of In-situ Geotechnical Testing Results | | | | | |
|---|---|---|---|---|---|
| Strata | SPT "N" Blow Counts/Equivalent SPT "N Value from DP | Equivalent Undrained Shear Strength (Cu) (kPa) | Soil Type | | Trial Hole/s |
| | | | Granular (Density) | Cohesive (Cu) | |
| **Kempton Park Gravel Member (Granular)** | 21 – 52 | - | Dense – Very Dense | - | WS1/1.20 – 3.00m bgl<br>WS2/1.20 – 3.00m bgl |
| ***Inferred Kempton Park Gravel Member (Granular)*** | *17 – 39* | - | *Medium – Dense* | - | DP02/4.20 – 6.00m bgl |

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## PRELIMINARY SUMMARY

| | | | | | |
|---|---|---|---|---|---|
| ***Inferred London Clay Formation (Cohesive)*** | *12 – 14* | *60 – 70* | *-* | *Medium* | DP02/6.00 – 7.00m bgl |

**GROUNDWATER**

Groundwater strikes were noted at 2.80m bgl within WS1 (rose to 2.70m bgl after 20 minutes) and also 2.90m bgl within WS2 (rose to 2.80m bgl after 20 minutes).

Changes in groundwater level occur for a number of reasons including seasonal effects and variations in drainage. The investigation was undertaken in March 2024 when groundwater levels are likely to be at their annual maximum (highest elevation). Exact groundwater levels may only be determined through long term measurements from monitoring wells installed on-site.

**ROOTS**

The depths of root penetration can be seen tabulated below.

| Summary of Root Penetration | |
|---|---|
| **Trial Hole** | **Fresh Root Depth (m bgl)** |
| WS1 | 1.20 |
| WS2 | 1.50 |

It should be noted that the accuracy of determining the depth of root penetration within narrow diameter boreholes is considered low. Roots may be found to greater depths at other locations on the site, particularly close to trees and/or trees that have been removed both within the site and its close environs.

**ANTICIPATED VOLUME CHANGE POTENTIAL**

The following volume change potential was anticipated based on a physical and visual appraisal of the soils encountered and was subject to confirmation of results of geotechnical classification testing:

- **KEMPTON PARK GRAVEL MEMBER (cohesive):** Likely to have medium to high volume change potential in accordance with NHBC Standards Chapter 4.2 and BRE240.
- **KEMPTON PARK GRAVEL MEMBER (granular):** Likely to have no to low volume change potential in accordance with NHBC Standards Chapter 4.2 and BRE240.

**FOUNDATION RECOMMENDATIONS**

The following conclusions have been noted following the site works:

- Made Ground was proven to a maximum depth of 1.20m bgl.
- The shallow, cohesive Kempton Park Gravel Member was anticipated to have medium to high volume change potential, whereas the underlying Kempton Park Gravel Member was anticipated to have no to low volume change potential.
- In-situ strength testing classified the Head Deposits as having high undrained shear strength. The Kempton Park Gravel Member was classified as dense to very dense. The formations below 4.00m bgl were inferred from surrounding boreholes and SPT data. The inferred, deeper Kempton Park Gravel Member was classified as medium to dense, whereas the inferred underlying London Clay Formation had a medium undrained shear strength.
- Live roots were noted to a maximum depth of 1.50m bgl. Roots may be encountered at greater depths within the vicinity of trees.
- Groundwater was noted at 2.90m bgl within WS1 and 2.80m bgl within WS2, these rose to 2.80m bgl and 2.70m bgl respectively.

| PRELIMINARY SUMMARY | |
|---|---|
| | Foundations should be taken through any Made Ground and extend 300mm below root penetrated soils, before founding onto competent, moisture stable soils of the Kempton Park Gravel Member at the basement depth, 4.00m bgl. Foundations constructed at 4.00m bgl can be designed based on a presumed allowable bearing capacity of 180 – 200kN/m$^2$. This is based on trial hole records, the results of in-situ testing, inspection of samples recovered, and referral to BS 8004:2015, Code of Practice for Foundations, and based on a 5m long by 1m wide foundation and a maximum settlement of 25mm. Settlement loading are likely to be moderate to high.<br><br>It also should be noted that instability issues may arise within excavations in granular soils and Made Ground, especially when combined with perched water/groundwater. |
| **CONTAMINATION** | 2No. samples were sent to the laboratory for a suite of contaminants of concern. The results were not available at the time of reporting and a summary of the results will be forwarded as soon as these become available. During the site works no visual or olfactory evidence of contamination were noted. |

**Figure 1** **Trial Hole Location Plan**
**Appendix A** **Conditions and Limitations**
**Appendix B** **Trial Hole Logs**

**This preliminary information may be subject to amendment in the final report and no liability can be accepted for any actions based on this preliminary information.**

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# FIGURES


| | |
|---|---|
| **34 Nassau Road SW13 9QE** | |
| | **March 2024** |
| **Figure 1 – Trial Hole Location Plan** | **GWPR5909** |

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# APPENDIX A: Conditions and Limitations

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The ground is a product of continuing natural and artificial processes. As a result, the ground will exhibit a variety of characteristics that vary from place to place across a site, and also with time. Whilst a ground investigation will mitigate to a greater or lesser degree against the resulting risk from variation, the risks cannot be eliminated.

The report has been prepared on the basis of information, data and materials which were available at the time of writing. Accordingly any conclusions, opinions or judgements made in the report should not be regarded as definitive or relied upon to the exclusion of other information, opinions and judgements.

The investigation, interpretations, and recommendations given in this report were prepared for the sole benefit of the client in accordance with their brief; as such these do not necessarily address all aspects of ground behaviour at the site. No liability is accepted for any reliance placed on it by others unless specifically agreed in writing.

Any decisions made by you, or by any organisation, agency or person who has read, received or been provided with information contained in the report ("you" or "the Recipient") are decisions of the Recipient and we will not make, or be deemed to make, any decisions on behalf of any Recipient. We will not be liable for the consequences of any such decisions.

Current regulations and good practice were used in the preparation of this report. An appropriately qualified person must review the recommendations given in this report at the time of preparation of the scheme design to ensure that any recommendations given remain valid in light of changes in regulation and practice, or additional information obtained regarding the site.

Any Recipient must take into account any other factors apart from the Report of which they and their experts and advisers are or should be aware. The information, data, conclusions, opinions and judgements set out in the report may relate to certain contexts and may not be suitable in other contexts. It is your responsibility to ensure that you do not use the information we provide in the wrong context.

This report is based on readily available geological records, the recorded physical investigation, the strata observed in the works, together with the results of completed site and laboratory tests. Whilst skill and care has been taken to interpret these conditions likely between or below investigation points, the possibility of other characteristics not revealed cannot be discounted, for which no liability can be accepted. The impact of our assessment on other aspects of the development required evaluation by other involved parties.

The opinions expressed cannot be absolute due to the limitations of time and resources within the context of the agreed brief and the possibility of unrecorded previous in ground activities. The ground conditions have been sampled or monitored in recorded locations and tests for some of the more

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common chemicals generally expected. Other concentrations of types of chemicals may exist. It was not part of the scope of this report to comment on environment/contaminated land considerations.

The conclusions and recommendations relate to 34 Nassau Road SW13 9QE.

Trial hole is a generic term used to describe a method of direct investigation. The term trial pit, borehole or window sampler borehole implies the specific technique used to produce a trial hole.

The depth to roots and/or of desiccation may vary from that found during the investigation. The client is responsible for establishing the depth to roots and/or of desiccation on a plot-by-plot basis prior to the construction of foundations. Where trees are mentioned in the text this means existing trees, recently removed trees (approximately 15 years to full recovery on cohesive soils) and those planned as part of the site landscaping.

Ownership of copyright of all printed material including reports, laboratory test results, trial pit and borehole log sheets, including drillers log sheets, remain with Ground and Water Limited. Licence is for the sole use of the client and may not be assigned, transferred or given to a third party.

Only our client may rely on this report and should this report or any information contained in it be provided to any third party we accept no responsibility to the third party for the contents of this report save to the extent expressly outlined by us in writing in a reliance letter addressed from us to the third party.

Recipients are not permitted to publish this report outside of their organisation without our express written consent.

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# APPENDIX B: Trial Hole Logs

geotechnical and environmental consultants

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# Ground Investigation Report/Basement Impact Assessment

| |
|---|
| 34 Nassau Road SW13 9QE |

| |
|---|
| On behalf of Tom Richards |

| Report Reference: GWPR5909/GIR/April 2024 V1.02 | | | Status: Final |
|---|---|---|---|
| Issue | Prepared By | Checked By | Verified By |
| V1.02 | Adam Young<br>BSc (Hons) FGS<br>Engineer | Miltiadis Mellios<br>MSc(Eng) GMICE FGS<br>MIEnvSc<br>Principal Engineer | Francis Williams MGeol (Hons) FGS CEnv CGeol<br>Director |

Site Investigations | Environmental Consultants | Geotechnical Engineers

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| EXECUTIVE SUMMARY | |
|---|---|
| **PROPOSED DEVELOPMENT** | At the time of reporting, March 2024, the proposed development was understood to comprise the construction of a basement under the existing house and a small extension to the rear, to a maximum depth of 3.80m bgl, along with a small lightwell to the front.<br><br>A pool, pool house and patio are also proposed in the rear garden.<br><br>The levels on-site were considered to remain the same. |
| **GEOLOGY** | The BGS Solid and Drift Geological Map for the area revealed that the site was underlain by the superficial Kempton Park Gravel Member, underlain by the bedrock of the London Clay Formation. Alluvium was noted to be ~148m north-west of the site. An area of artificial ground was noted ~190m south-east of the site. |
| **HYDROGEOLOGY** | The DEFRA online maps indicated that the site was located on Secondary A Aquifer associated with the superficial Kempton Park Gravel Member, underlain by Unproductive Strata associated with the London Clay Formation.<br><br>From analysis of hydrogeological and topographical maps the groundwater table was anticipated to be encountered at shallow to moderate depth within the Kempton Park Gravel Member, capping the impermeable London Clay Formation. Perched water was also likely to be found within the Made Ground, especially after periods of intense or prolonged rainfall. It was considered that the groundwater was flowing westwards, towards the River Thames and in alignment with local topography. |
| **VOLUME CHANGE POTENTIAL** | Shallow Kempton Park Gravel member (cohesive): Medium – High<br>Depper Kempton Park Gravel Member (granular): No |
| **FOUNDATION DESIGN** | The design and construction of the basement and associated structural elements would need to take into account the volume change potential of the respective soils. The basement is expected to be constructed within the deeper, granular KPGM deposits, while the cohesive shallow zone of high VCP, should be considered as a main factor for the pool house.<br>Any shallow foundations (eg pool house) should take into account seasonal heave and special precautions may be required (void, compressible material for foundations, etc).<br>For the pool house, a suspended slab is recommended, as a result of the Made Ground thickness recorded and the shallow cohesive zone of high VCP. |
| **SUB-SURFACE CONCRETE** | According to BRE Special Digest 1, 2005, 'Concrete in Aggressive Ground' a Sulphate Design Class of DS-1 could be used for sub-surface concrete in contact with the Kempton Park Gravel Member. Table C1 of the Digest indicated an ACEC (Aggressive Chemical Environment for Concrete) classification of AC-1. |
| **CONTAMINATION** | Elevated levels of Lead, Benzo(a)pyrene, Benzo(b)fluoranthene and Dibenz(a,h)anthracene were found within the Made Ground sample WS01/1.20m bgl, therefore, a Full Contamination Assessment is recommended, which was not within the scope of this report. |

# 1.0 INTRODUCTION

## 1.1 General

Ground and Water Limited were instructed by Tom Richards on 04/03/2024 to conduct a Ground Investigation Report on the site referred to as 34 Nassau Road SW13 9QE. The scope of the investigation was detailed within the Ground and Water Limited fee proposal (reference: QU-0154REV2).

## 1.2 Aims of the Investigation

The aim of the investigation was understood to be to supply the client and their designers with information regarding the ground conditions underlying the site to assist them in preparing an appropriate scheme for development.

The investigation was to be undertaken to provide parameters for the design of foundations by means of in-situ and laboratory geotechnical testing undertaken on soil samples recovered from trial holes.

The proposed development includes a basement. A Basement Impact Assessment, including screening and detailed comment on surface water flooding/management or combined flooding (sourced from SFRA or similar sources) was part of the remit of the report.

The requirements of the following reports were reviewed with respect to this project:

- The London Borough of Richmond Upon Thames, Planning Advice Note: Good Practice Guide on Basement Developments (May 2015);
- The London Borough of Richmond Upon Thames: Further Groundwater Investigations (March 2021);
- The London Borough of Richmond Upon Thames: Strategic Flood Risk Assessment Level 1 (March 2021); and
- The London Borough of Richmond Upon Thames: Basement Assessment User Guide (March 2021).

In addition, a Ground Movement Assessment for the impact of the proposed development on surrounding properties and assets was not in the remit of the report.

A full scale Environmental Desk Study and Contamination Assessment including a gas risk assessment were not part of the remit of this report; however Included within the fee proposal was an allowance to undertake chemical laboratory testing on soil samples recovered from the site to enable recommendations for the safe redevelopment of the site and the protection of site workers, end-users and the public from any potential contamination identified.

The techniques adopted for the investigation were chosen considering the requirements of the client, anticipated ground conditions, and bearing in mind the nature of the site, limitations to site access and other logistical limitations.

## 1.3 Conditions and Limitations

This report has been prepared based on the terms, conditions and limitations outlined within

Appendix A.

### 1.4 Technical Glossary

Generic technical terms can be viewed within the glossary provided within Appendix B.

## 2.0 SITE SETTING

### 2.1 Site Location

The site comprised a 800m$^2$ rectangular shaped plot of land, with a north-east to south-west orientation, located along the south side of Nassau Road. The site was located within Barns, a mainly residential area within The London Borough of Richmond Upon Thames. A Site Location Plan is provided within Figure 1 and a plan showing the site development area is given within Figure 2.

### 2.2 Site Description

A Site Walkover was undertaken on 19/03/2024. A description of the site, as noted during the Site Walkover, is tabulated below. An aerial view of the site, showing an approximate site boundary, is given within Figure 3.

| Site Description Sheet | |
|---|---|
| **Variable** | **Description** |
| Use of site | The site was made up of a semi-detached residential building, with a back garden with a small building within. |
| Area topography | The area was relatively flat. |
| Structures on-site | The main house was in the north-eastern portion of the site, with a small outbuilding in the centre of the site. |
| Structures off-site | Semi-detached and detached houses along Nassau Road. |
| Use of surrounding ground | A residential area. |
| Boundary features | North-East: Nassau Road.<br>South-East: Wooden Fence.<br>South-West: Wooden Fence.<br>North-West: Wooden Fence. |
| Site covering | The site is mainly soft landscape, with hardstanding under the buildings on-site, along with a small area of decking to the south of the main house. |
| Contamination sources on-site | None noted. |
| Contamination sources off-site | None noted. |
| Vegetation on-site | Semi-mature to mature trees, as well as bushes and shrubs. |
| Vegetation off-site | Large, mature trees in close proximity to the site. |
| Services | General housing services noted such as drains and electrics/arial. |

### 2.3 Site Topography

The site was noted to be relatively flat and level with no major slopes. The site did not contain a basement/lower ground floor. The area in which the site was located was noted to be generally sloping downwards in a north-western direction from Sidmouth Wood towards the River Thames. A contour map has been provided within Figure 3.

### 2.4 Historical Map Review

The site formed part of a larger undeveloped area, with a development of residential housing located ~200m south-west, this was shown in the earliest historical maps available (1868). The River Thames was noted ~200m west of the site. The 1896 maps showed that a very small portion of the south of the site was taken up by a Pavilion. The sites environs also included a cricket ground~15m north, as well as a gravel pit ~115m north-west.

The next available map is the 1913 map, which showed residential development within the sites environs and the site itself. The site contained a semi-detached house in the northern portion, with a small building in the centre of the site. Almost the entire of the site's close environs (within 100m) have been developed with semi-detached or detached residential houses, with a small open space ~80m north-west of the site. The gravel pit had been filled in by that time.

The 1933 maps showed that major residential development has extended to the site's northern environs up to 250m from the site. A new factory was located ~90m south of the site, however this had been demolished and a new building has been built in its place by the 1950 maps. No other significant changes were noted up to the most recent historical mapping in 2024.

Historical maps, obtained from GroundSure, can be viewed within Appendix C.

### 2.5 Nearby Assets and Subterranean Developments

No railway cuttings were noted within a 250m radius of the site. No London Underground tunnels were noted within a 250m radius of the site. The site is not in close proximity to any National Rail lines. The site was considered to be not sufficiently close to underground transport services, in order for these to affect the property and there are no approved proposals for any TfL services in the vicinity that would affect the development.

The properties along Nassau Road, were mainly 2-to-3 storey, semi-detached and detached residential properties. No lower ground floors were noted in close proximity to the site.

5No. Listed buildings were noted ~144m south-east; ~165m south-east; ~173m south; ~210m south-east and ~235m south.

### 2.6 Proposed Development

At the time of reporting, March 2024, the proposed development was understood to comprise the construction of a basement under the existing house and a small extension to the rear, to a maximum depth of 3.80m bgl, along with a small lightwell to the front.

A pool, pool house and patio are also proposed in the rear garden.

The levels on-site were considered to remain the same.

The proposed development fell within Geotechnical Design Category 2 in accordance with Eurocode 7. A cross-section of the proposed development is provided within Figure 5.

### 2.7 Geology

The BGS Solid and Drift Geological Map for the area revealed that the site was underlain by the superficial Kempton Park Gravel Member, underlain by the bedrock of the London Clay Formation. Alluvium was noted to be ~148m north-west of the site. An area of artificial ground was noted ~190m south-east of the site. No other superficial deposits, outcrops of other bedrock deposits or areas of Made/Worked Ground were noted within a 250m radius of the site.

### 2.8 Hydrogeology and Hydrology

The DEFRA online maps indicated that the site was located on Secondary A Aquifer associated with the superficial Kempton Park Gravel Member, underlain by Unproductive Strata associated with the London Clay Formation.

From analysis of hydrogeological and topographical maps the groundwater table was anticipated to be encountered at shallow to moderate depth within the Kempton Park Gravel Member, capping the impermeable London Clay Formation. Perched water was also likely to be found within the Made Ground, especially after periods of intense or prolonged rainfall. It was considered that the groundwater was flowing westwards, towards the River Thames and in alignment with local topography.

The nearest surface water feature was observed to be the river Thames, approximately 200m west of the site.

### 2.9 BGS Borehole Records

A BGS borehole record in similar geology ~250m west of the site (ref.: TQ27NW879) noted Topsoil to 0.40m bgl, overlying gravelly clay to 4.30m bgl, this is underlain by a sandy gravel to 6.00m ngl, with a silty clay for the remaining depth of the borehole (9.50m bgl). A groundwater strike was noted at 4.30m bgl.

Another BGS borehole record in similar geology ~417m south-east of the site (ref.: TQ27NW426), noted the London Clay Formation to 44.00m bgl.

### 2.10 Flooding

A summary of the risk of various flooding types has been summarised in the following table.

| Summary of Flood Risk | | | |
|---|---|---|---|
| **Type of Flooding** | **Figure Reference** | **On-site Flood Risk** | **Maximum Nearby Flood Risk** |
| Rivers and Seas | Figure 6 | Flood Zone 3 | On-site |
| Flood Defences | Figure 7 | Yes | On-site |
| Reservoir | Figure 8 | Yes, when rivers flood | Within 50m |
| Surface Water Flooding | Figure 9 | Low | Within 50m |
| Groundwater and Throughflow Flooding | Figure 13, 14 and 15 | Groundwater – yes between 50 – 74.9%<br><br>Site **not** in a throughflow catchment area | Similar to on-site |
| Sewer Flooding | Figure 16 | SW13 | Records of sewer flooding: 10No. indoor incidents and 7No. outdoor incidents within the Post Code District. |
| Critical Drainage Areas | Figure 17 | No | N/A |

### 2.11 Radon

A review of the freely available UK Health Security Agency radon database, UK Radon, indicated that the site was located within a 1km grid square, where the maximum radon potential of <1% was recorded. Basic radon protection measures are required in areas where more than 3% of houses are at or above the Action Level.

The proposed construction included a basement, this is a vulnerable structure when it comes to radon, therefore waterproofing should be upgraded to include radon protection.

### 2.12 Unexploded Ordnance Review

A review of the data available on www.zeticauxo.com/ revealed the site was located within the London high-risk area associated with unexploded ordnance (UXO). The London area is further separated into 25No. categories based on bombing densities, where green is indicated for areas having <10 bombs dropped per $km^2$ and red is indicated for areas having >150 bombs dropped per $km^2$. The site is situated within the orange area, ~halfway through the spectrum. 1No. known Luftwaffe Bombing Target site was located ~1.00km north-east of the site.

# 3.0 BASEMENT IMPACT ASSESSMENT

A scoping and screening assessment was undertaken for the proposed development based on the supplementary planning document (SPD) for the London Borough of Richmond Upon Thames. This stage should identify any areas of concern and therefore focus efforts on further investigation.

## 3.1 Stage 1: Screening

The screening questions/fields for three distinct topics (surface water/flooding, groundwater, and stability) have been summarised within this section of the report.

### 3.1.1 Subterranean Screening Flowchart

Questions relating to groundwater, as well as discussion and conclusions, can be viewed tabulated below.

| **Subterranean Characteristics Screening Flowchart** | | |
|---|---|---|
| **Question** | **Discussion** | **Conclusion** |
| Does the recorded water table extend above the base of the proposed subsurface structure? | **Potentially:** The DEFRA online maps, online SFRA mapping tool and nearby BGS geological boreholes indicated that the site was underlain by a Secondary (A) Aquifer of the Kempton Park Gravel Member and then Unproductive strata of the London Clay Formation. A BGS borehole record in similar geology ~250m south-west of the site (ref: TQ27NW879) noted a groundwater strike at 4.30m bgl.<br><br>Some amounts of perched water was likely to be found within localised Made Ground and within the sandy gravelly, especially after periods of intense or prolonged rainfall. | **Take forward to scoping** |
| Is the proposed subsurface development structure within 100m of a watercourse or spring line? | **No:** Reference to OS mapping, the River Thames was noted ~200m west of the site. | No further action required |
| Are infiltration methods proposed as part of the site's drainage strategy? | It is understood that infiltration methods will be applied to drain the site and prevent surface water flooding; therefore, no unsuitable risk of surface water flooding was to be anticipated once the proposed development is operational. | No further action required |
| Does the proposed excavation during the construction phase extend below the local water table level or spring line (if applicable)? | **Maybe:** Based on nearby BGS record, groundwater levels were expected to be near the depth of the basement level with a groundwater strike recorded at 4.30m bgl. The SFRA highlighted the site was located within an area of permeable superficial deposits with the potential for elevated groundwater levels. | **Take forward to scoping** |
| Is the shallowest geological strata at the site London Clay? | **No:** The BGS Solid and Drift Geological Map for the Richmond Area highlighted the site was underlain by the superficial deposits of the Kempton Park Gravel Member. | **Take forward to scoping** |
| Is the site underlain by an aquifer and/or permeable geology? | **Yes:** The BGS Solid and Drift Geological Map for the Richmond Area highlighted the site was underlain by the superficial deposits of the Kempton Park Gravel Member and then the bedrock deposits of the London Clay Formation.<br><br>The DEFRA online maps and online SFRA map tool indicated the site was underlain by a Secondary (A) Aquifer of the Kempton Park Gravel Member and then an Unproductive Aquifer of the London Clay Formation. | **Take forward to scoping** |

### 3.1.2 Land Stability

Questions relating to land stability, as well as discussion and conclusions, can be viewed tabulated below.

| Land Stability Screening Flowchart | | |
|---|---|---|
| **Question** | **Discussion** | **Conclusion** |
| Does the site, or neighbouring area, topography include slopes that are greater than 7˚? | **No:** The site was noted to have no major slopes and/or undulations. No significant slopes, natural or man-made, were noted within close proximity to the site. No deep failures were expected due to the geology and the depth of the basement. | No further action required |
| Will changes to the site's topography result in slopes that are greater than 7˚? | **No:** The gradients on-site were considered to remain similar to the existing. | No further action required |
| Will the proposed subsurface structure extend significantly deeper underground compared to the foundations of the neighbouring properties? | **Maybe/Yes:** The proposed development was understood to comprise the excavation of a new basement beneath the existing property to a maximum depth of ~3.80m bgl, with a small extension to the rear and lightwell to the front. The site walkover did not highlight basements / lower ground floors within the neighbouring structures. | **Take forward to scoping** |
| Will the implementation of the proposed subsurface structure require any trees to be felled or uprooted? | **Yes:** The Arboricultural Report undertaken highlighted that trees were to be removed. | **Take forward to scoping** |
| Has the ground at the site been previously worked? | **No:** With reference to the BGS Solid and Drift Geological Map for the area, an area of artificial ground was noted ~190m south-east of the site. | No further action required |
| Is the site within the vicinity of any tunnels or railway lines? | **No:** No railway (above ground and/or underground) infrastructure was noted within a 250m radius of the site. | No further action required |

### 3.1.3 Flood Risk and Drainage

Questions relating to Flood Risk and Drainage as well as discussion and conclusions, can be viewed tabulated below and below.

| Flood Risk and Drainage Screening Flowchart | | |
|---|---|---|
| **Question** | **Discussion** | **Conclusion** |
| Will the proposed subsurface development result in a change in impermeable area coverage on the site? | The amount of hardstanding anticipated to increase, which in turn could create a larger risk of surface water flooding; however, the change is expected to be small and site drainage is to be implemented which will reduce this risk to an acceptable level. | **Take forward to scoping** |
| Will the proposed subsurface development impact the flow profile of throughflow, surface water or groundwater to downstream areas? | The proposed development would comprise excavation of a small basement to the relatively shallow depth of ~3.80m bgl, therefore surface flow patterns are not expected to be altered.<br><br>The site was not located within an Throughflow Catchment and/or potential throughflow catchment area.<br><br>The above should be supported by the results of a ground investigation and the depth to impermeable strata. | **Take forward to scoping** |
| Will the proposed subsurface development increase throughflow or groundwater flood risk to neighbouring properties? | Given the relatively small size of the structure, it was unlikely to form a significant barrier to cause an increased risk to flooding of neighbouring properties. The basement is expected to be formed within the superficial more permeable soils of the KPGM and therefore groundwater can flow below and at the sides of | No further action required |

| Flood Risk and Drainage Screening Flowchart | | |
|---|---|---|
| Question | Discussion | Conclusion |
| | the structure. The surrounding structures were not expected to have basements; therefore, flow is expected to be less restricted.<br><br>The above should be supported by the results of a ground investigation.<br><br>The site was **not** within a throughflow catchment area. | |

### 3.2 Stage 2: Scoping

There are areas of concerns that the Screening process have highlighted.

- **Perched Water and Groundwater:** It was anticipated that groundwater was to be found within the Secondary (A) Aquifer of the Kempton Park Gravel Member. Given the proposed basement depth, it was likely that the basement may encounter the groundwater level during construction. **This is to be taken forward for further assessment through a ground investigation and the installation of a monitoring well.**

- **Seasonal Soil Moisture and Volume Change Potential:** Anticipated geology considered the presence of granular superficial soils of the Kempton Park Gravel Member underlain by cohesive soils of the London Clay Formation. Localised cohesive bands may also be found within the superficial soils and the bedrock soils are likely to be subject to subsidence due to shrinkage-swelling. **The depth and volume change potential of the underlying soils should be investigated.**

- **Pressure Induced Settlement and Heave:** Given the overburden pressure release following excavation of soil, as well as the loading of retaining wall foundations, the pressure across the basement is likely to cause differential settlement and heave. **Regarding the bulk basement construction, care will need to be taken to ensure that the slab is protected through accommodating heave (primarily) and any seasonal if applicable.**

- **Retaining Wall Design:** Given the design of basements, retaining walls should be appropriately designed to withstand the horizontal pressure of adjacent strata. **Retaining walls should be appropriately designed**.

- **Instability During Excavation:** Stability issues may arise during the excavation through natural soils and Made Ground. **Indicative measures that can be undertaken throughout excavation and construction will be discussed within this report, and more specific measures within the construction method statement.**

- **Ground Movement and Nearby Assets:** Various buildings and structures were noted in close proximity to the site, with the site itself having a proposed lower ground floor, and neighbouring properties not; therefore, differential foundation depths would cause potential damage to the walls of nearby buildings, due to soil displacement following the excavation/installation of the basement. This may also cause damage to nearby roads, pavements and utilities. **A Ground Movement Assessment (GMA) is recommended to assess the soil displacement and damage to nearby buildings, roads, pavements and utilities.**

- **Sub-Surface Concrete in Aggressive Ground Conditions:** Concrete may corrode if unsuitable concrete is used. A suitable concrete class should be used for all sub-surface concrete used for all foundations, based on the levels of sulphates and the pH within the ground it is being constructed on/through. **Testing in accordance with BRE Special Digest is required to be undertaken and a concrete specification is to be provided.**

- **Surface Water Flooding and Site Drainage:** Data from the Environment Agency website indicated that the site, and the majority of the surrounding area, was at a low risk of surface water flooding. The amount of hardstanding was expected to increase following the construction of the proposed development. It is understood that infiltration methods will be applied to drain the site and prevent surface water flooding.

  **The effect the proposed development will have on surface water flooding and the requirements to prevent surface water flooding and site drainage are to be discussed further within this report.**

- **Groundwater Flooding and Flow:** As the site was underlain by a Secondary (A) Aquifer, underlain by Unproductive Strata, there was considered to be a risk of groundwater flooding. **A groundwater monitoring well should be installed as part of the site investigation, as well as groundwater dip measurements following the site works, to investigate groundwater levels. Throughflow issues were discussed within the screening section, however they will also be discussed within the end of the report, after the ground investigation results and having all data together.**

- **Sewer Flooding:** Given their subterranean position, basements can be susceptible to flooding from sewers. 10No. indoor incidents and 7No. outdoor incidents within the postcode area. **The effect the basement will have on the risk of sewer flooding and the requirements to prevent sewer flooding is to be discussed further within this report.**

- It is understood that some trees will be removed and/or planted. Any potential geotechnical/structural impact of that activity should be discussed and addressed.

A site-specific ground investigation has been undertaken to inform design, including provision of information on the existing foundations. The results of this investigation and subsequent engineering considerations are provided within this report.

**The submission of a drainage scheme will likely be required. It is understood this will form part of the overall Structural Scheme and will be included in the Structural Engineers report.**

# 4.0 SITE WORKS

## 4.1 Scope of Works

Site works were undertaken on 08/03/2024 and comprised the drilling of the 2no. Modular Window Sample Boreholes to 3.00m and 6.00m bgl with Standard Penetration Tests at 1.00m intervals. Boreholes were terminated early due to density of strata. Boreholes were terminated early due to density of strata. Super Heavy Dynamic Probes (DP1) were undertaken through the base of WS1 to final depths of 7.00m bgl.

| Combined Ground-gas and Groundwater Monitoring Well Construction | | | | | | |
|---|---|---|---|---|---|---|
| **Trial Hole** | **Type of Installation** | **Depth of Installation (m bgl)** | **Thickness of slotted piping with gravel filter pack (m)** | **Depth of plain piping with bentonite seal (m bgl)** | **Response Zone (m bgl)** | **Piping internal diameter (mm)** |
| WS01 | Standpipe | 3.00 | 2.00 | 1.00 | 1.00 – 3.00 | 50 |
| WS02 | Standpipe | 3.00 | 2.00 | 1.00 | 1.00 – 3.00 | 50 |

The approximate location of the trial hole locations can be seen within Figure 18.

Prior to commencing the ground investigation, a walkover survey was carried out to identify the presence of underground services and drainage. Where underground services/drainage were suspected and/or positively identified, the exploratory position was relocated away from these areas.

As a further precautionary measure, the borehole was hand excavated to 1.00m below the local ground level (bgl) and scanned with a Cable Avoidance Tool (CAT scanner) to minimise the risk to services.

Upon completion of the drilling works, the trial holes were backfilled and made good, in relation to the surrounding area.

## 4.2 Sampling Procedures

Small disturbed samples were recovered from the trial holes at the depths shown on the trial hole records. Soil samples were generally retrieved from each change of strata and/or at specific areas of concern. Samples were also taken at approximately 0.5m intervals during broad homogenous soil horizons.

A selection of samples were despatched for geotechnical testing purposes. A programme of chemical laboratory testing, scheduled by Ground and Water Limited and carried out by an accredited chemical testing laboratory, was undertaken on soils samples recovered from the boreholes.

# 5.0 ENCOUNTERED GROUND CONDITIONS

## 5.1 Soil Conditions

The trial holes were logged by a Ground and Water Limited representative, generally in accordance with BS EN 14688 'Geotechnical Investigation and Testing – Identification and Classification of Soil'.

The ground conditions encountered within the trial holes constructed on the site did generally conform to that anticipated from examination of the geology map. A capping of Made Ground was noted to overlie the superficial Kempton Park Gravel Member.

The succession of conditions and description of soils encountered in the trial holes in descending order is tabulated below.

| Summary of Strata Encountered (WS01 – WS02) | | | |
|---|---|---|---|
| **Strata** | **Top Depth (m bgl)** | **Base Depth (m bgl)** | **Thickness (m)** |
| **MADE GROUND:** Dark brown sandy gravelly CLAY. Sand is fine. gravel is fine to coarse, angular to sub-rounded of flint (80%), brick (15%) and chalk (5%). | GL | 1.20 | 1.20 |
| **KEMPTON PARK GRAVEL MEMBER:** Orange, brown very sandy CLAY. Sand is fine. | 1.20 | 1.80 – 2.20 | 0.60 – 1.00 |
| **KEMPTON PARK GRAVEL MEMBER:** Light brown very sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, angular to subrounded of flint. | 1.80 – 2.20 | >3.00 - >4.00 | >1.20 - >1.80 |

For details of the composition of the soils encountered at particular points, reference must be made to the individual trial hole logs within Appendix D of this report.

## 5.2 Roots Encountered

Roots were noted to a maximum depth of 1.50m bgl. A summary of the depth of root penetration can be viewed below.

| Root Depth | |
|---|---|
| **Trial Hole** | **Fresh Root Penetration (m bgl)** |
| WS01 | 1.20 |
| WS02 | 1.50 |

It must be noted that the chance of determining actual depth of root penetration through a narrow diameter borehole is low. Roots may be found to greater depths at other locations on the site, particularly close to trees and/or trees that have been removed both within the site and its close environs.

## 5.3 Groundwater Conditions

A summary of the groundwater observations during site works has been provided below.

| Groundwater Strikes during Drilling | | |
|---|---|---|
| Trial Hole | Groundwater reading (m bgl) | Depth after 20 minutes (m bgl) |
| WS01 | 2.80 | 2.70 |
| WS02 | 2.90 | 2.80 |

Changes in groundwater level occur for a number of reasons including seasonal effects and variations in drainage. The investigation was undertaken in March 2024 when groundwater levels are likely to be at their annual maximum (highest elevation). Exact groundwater levels may only be determined through long term measurements from monitoring wells installed on-site.

Groundwater monitoring was undertaken on two occasions to date. The results can be seen tabulated below.

| Groundwater Observations | | | |
|---|---|---|---|
| Date | Trial Hole | Water Level (m bgl) | Final Well Depth (m bgl) |
| 19/03/2024 | WS01 | Dry | 2.45 |
| | WS02 | 3.10 | 3.19 |
| 02/04/2024 | WS01 | Dry | 2.30 |
| | WS02 | 2.90 | 3.00 |

### 5.4 Obstructions

No SPT could be undertaken at 4.00m bgl due to the sands filling up the casing.

No other artificial or natural sub-surface obstructions were noted during construction of the trial holes.

# 6.0 IN-SITU AND LABORATORY TESTING

## 6.1 In-Situ Strength Testing

Standard Penetration Tests (SPTs) and Super Heavy Dynamic Probes (SHDPs) were undertaken as part of the site investigation. The results of the SPT's have not been amended to consider hammer efficiency, rod lengths and overburden pressure in accordance with Eurocode 7. The test results are presented on the borehole logs within Appendix D. An interpretation of the in-situ geotechnical testing results is given in the table below.

| Interpretation of In-situ Geotechnical Testing Results | | | | | |
|---|---|---|---|---|---|
| **Strata** | **SPT "N" Blow Counts/Equivalent SPT "N Value from DP** | **Equivalent Undrained Shear Strength (Cu) (kPa)** | **Soil Type** | | **Trial Hole/s** |
| | | | **Granular (Density)** | **Cohesive (Cu)** | |
| Shallow Kempton Park Gravel Member (Cohesive) | 21 – 28 | 105 – 140 | - | High | WS01/1.20m bgl<br>WS02/1.20m bgl |
| Deeper Kempton Park Gravel Member (Granular) | >27 – 52 | - | Dense – Very Dense | - | BH1/2.75 – 3.80m bgl<br>WS1/1.00 – 2.50m bgl |
| *Assumed Kempton Park Gravel Member (Granular)* | *14 – 39* | - | *Medium – Dense* | - | *DP2/4.00 – 6.00m bgl* |
| *Assumed London Clay Formation (Cohesive)* | *12 – 13* | *60 – 65* | - | *Medium* | *DP2/6.00 – 7.00m bgl* |

It must be noted that field measurements of undrained shear strength (Cu) are dependent on a number of variables including disturbance of sample, method of investigation and also the size of specimen or test zone.

## 6.2 Geotechnical Laboratory Testing

A programme of geotechnical laboratory testing, scheduled by Ground and Water Limited and carried out by an accredited geotechnical testing laboratory was undertaken on samples recovered. Details of the specific tests used in each case are given below.

| Standard Methodology for Laboratory Geotechnical Testing | | |
|---|---|---|
| **Test** | **Standard** | **Number of Tests** |
| **Atterberg Limit Tests** | BS1377:2016:Part 2:Clauses 3.2, 4.3 & 5 | 2 |
| **Moisture Content Determinations** | BS1377:2016:Part 2:Clause 3.2 | 2 |
| **Particle Size Distribution Tests** | BS1377:2016:Part 2:Clause 9 | 3 |
| **Water Soluble Sulphate and pH Test** | BS1377:2018:Part 3:Clause 5 | 1 |
| **BRE Special Digest 1 Tests** | BRE Special Digest 1 "Concrete in Aggressive Ground (BRE, 2005). | 2 |

### 6.2.1 Atterberg Limit Testing

A précis of Atterberg limit testing undertaken can be seen tabulated below. The test results are presented within Appendix E.

| Atterberg Limit Tests Results Summary | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stratum | Moisture Content (%) | Passing 425 µm sieve (%) | Modified PI (%) | Soil Class | Consistency Index (Ic) | Volume Change Potential | |
| | | | | | | BRE | NHBC |
| Kempton Park Gravel Member (cohesive) | 21 – 29 | 36 – 54 | 26.64 – 41.04 | CL | Very Soft | Medium – High | Medium – High |

- **NP – Non-plastic**
- **BRE Volume Change Potential refers to BRE Digest 240 (based on Atterberg results)**
- **Soil Classification based on British Soil Classification System.**
- **Consistency Index (Ic) based on BS EN IS0 14688-2:2018.**

### 6.2.2 Moisture Deficit Assessment

The results of the Atterberg Limit tests were analysed to determine the Liquidity Index of the samples, to give an indication as to whether the samples recovered showed a moisture deficit as well assessing their degree of consolidation. Liquid Limit analyses was undertaken to assess whether there were any potentially significant moisture deficits within the samples tested.

A potential moisture deficit, caused by lithology, was noted within WS2 at 2.00m bgl.

### 6.2.3 Particle Size Distribution Testing

The results of particle size distribution (PSD) testing undertaken show that the deeper granular Kempton Park Gravel Member does not have volume change potential in accordance with BRE240 and NHBC Standards Chapter 4.2. The results of the PSD testing can be viewed within Appendix E.

| Particle Size Distribution Tests Results Summary | | | |
|---|---|---|---|
| Stratum | Range Passing 63µm Sieve (%) | Volume Change Potential | |
| | | BRE | NHBC |
| Kempton Park Gravel Member (granular) | 2 – 4 | No | No |

- **Volume Change Potential refers to BRE Digest 240 (based on Grading test results).**
- **Shrinkability refers to NHBC Standards Chapter 4.2 (based on Grading test results).**
- **BRE 240 states that a soil has a volume change potential when the clay fraction exceeds 15%. Only the silt and clay combined fraction are determined by sieving therefore the volume change potential is estimated from the percentage passing the 63µm sieve.**
- **NHBC Standards Chapter 4.2 states that a soil is shrinkable if the percentage of silt and clay passing the 63µm sieve is greater than 35% and the Plasticity Index is greater than 10%.**

## 6.3 Chemical Laboratory Testing

An un-targeted set of samples (2No. Made Ground and 3No. Kempton Park Gravel Member) were submitted to the accredited chemical laboratory for analysis. The results can be viewed in Appendix F.

Based on the proposed development, the results of the chemical laboratory testing were compared to the Generic Assessment Criteria (GAC) for a 'Residential with homegrown produce' land-use scenario, as this was considered the most appropriate land-use scenario.

Elevated levels of Lead, Benzo(a)pyrene, Benzo(b)fluoranthene and Dibenz(a,h)anthracene were found within the Made Ground sample WS01/1.20m bgl, therefore, a Full Contamination Assessment is recommended, which was not within the scope of this report.

# 7.0 ENGINEERING CONSIDERATIONS

## 7.1 Soil Characteristics and Foundation Considerations

A summary of the soil characteristics following the intrusive site investigation and laboratory testing and the relevant foundation considerations has been provided below. The following information from the ground investigation was considered pertinent to the design of foundations.

- Foundations should be taken through any Made Ground and either into, or onto a suitable underlying natural stratum of adequate bearing characteristics.
- The design and construction of the basement and associated structural elements would need to take into account the volume change potential of the respective soils. The basement is expected to be constructed within the deeper, granular KPGM deposits, while the cohesive shallow zone of high VCP, should be considered as a main factor for the pool house.
- The loads of proposed foundations should not exceed the allowable bearing capacity of the soils they are founding upon.
- Foundations must not be placed within fresh root penetrated and/or desiccated soils with volume change potential. It is recommended that foundations are taken at least 300mm into non-fresh root penetrated strata if the soils have volume change potential, or into soils of no volume change potential.
- The influence of trees on or surrounding the site will need to be taken into account in final design (NHBC Standards Chapter 4. 2) (tree rings).
- Any shallow foundations (eg pool house) should take into account seasonal heave and special precautions may be required (void, compressible material for foundations, etc).
- For the pool house, a suspended slab is recommended, as a result of the Made Ground thickness recorded and the shallow cohesive zone of high VCP.
- Any water ingress must be prevented from entering foundation trenches and excavations must be kept dry and either concreted or blinded as soon after excavation as possible. If water were allowed to accumulate within the excavation for even a short period of time, an increase in heave may occur. The shear strength will also be reduced, resulting in lower bearing capacities, resulting in increased settlements. Instability issues may arise within the foundation trenches, in case of perched water being present.
- Final designs for the foundations should be carried out by a suitably qualified Engineer based on the findings of this investigation and with reference to the anticipated loadings, serviceability requirements for the structure and the developments proximity to former, present, and proposed trees.

## 7.2 Geotechnical Analysis

This section of the report states suitable geotechnical parameters for the soils encountered as well as comments on the bearing capacity of the soils. A settlement/heave analysis was undertaken following the construction of the proposed development using Pdisp from Oasys.

### 7.2.1 Geotechnical Parameters for Modelling

Following a literature review from well documents publications, the short-term and long-term Young's Modulus (E short term and E') has been produced. The parameters, shown below, were used when undertaking the settlement/heave analysis within Pdisp.

| Summary of Geotechnical Parameters | | | | | | | |
|---|---|---|---|---|---|---|---|
| Geological Strata | Depth (m bgl) | | Short-term Young's Modulus (Eu short term) (kPa) | | Long-term, Young's Modulus (E' long term) (kPa) | | Poisson's Ratio |
| | Top | Base | Top | Base | Top | Base | |
| **Made Ground** | 0.00 | 1.20 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 0.45 |
| **Kempton Park Gravel Member (Cohesive)** | 1.20 | 2.20 | 24,150.00 | 24,150.00 | 18,112.50 | 18,112.50 | 0.45 |
| **Kempton Park Gravel Member (Granular)** | 2.20 | 4.00 | 100,000.00 | 100,000.00 | 100,000.00 | 100,000.00 | 0.30 |
| **Assumed Kempton Park Gravel Member (granular)** | 4.00 | 6.00 | 78,000.00 | 32,000.00 | 78,000.00 | 32,000.00 | 0.30 |
| **Assumed London Clay Formation (cohesive)** | 6.00 | 7.00 | 22,500.00 | 45,000.00 | 16,875.00 | 33,750.00 | 0.45 |
| | 7.00 | 44.00 | 45,000.00 | 265,500.00 | 33,750.00 | 199,125.00 | 0.45 |

### Made Ground

Made Ground was modelled between ground level and 0.70m bgl. A short-term and long-term Young Modulus (Eu and E') of 10MPa was suitable and on the conservative side, regarding Made Ground encountered on site. A Poisson's Ratio of 0.45 was considered suitable for these soils, given their variable nature.

### Kempton Park Gravel Member (Cohesive)

Cohesive Kempton Park Gravel Member (Cohesive) were modelled between 1.20m – 2.20m bgl. A relationship of 1.15*N for the Eu value (in MPa) was considered suitable for the shallow Kempton Park Gravel Member (Cohesive), based on published literature (CIRIA 1995 / Butler 1975). (Eu/N = 1.0 – 1.2 for cohesive soils). A Poisson's Ratio of 0.45 was considered suitable for these soils, given their cohesive nature.

### Kempton Park Gravel Member (Granular)

Granular Kempton Park Gravel Member were modelled between 2.20m – 6.00m bgl. Given the granular soils are permeable, no significant long-term draining of the soil was anticipated to occur and therefore the short and long-term modulus was considered sensible to remain the same. The widely accepted relationship between recorded SPTs within granular soils and E values of 2000* SPT "N" values was used for this consideration. The value was cross-referenced with representative published data (Obrzud & Truty 2012), showing a range of between 50 – 320MPa for the Young Modulus for dense sands and gravels. This also aligns with the drained modulus (30 – 160MPa) for River Terrace Gravels included in *"Burland JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension CIRIA Special Publication 200".* A Poisson's Ratio of 0.30 was considered suitable for the granular soils.

### London Clay Formation

Cohesive soils of the assumed London Clay Formation were encountered from 6.00m to the base of the dynamic probe, a depth of 7.00m bgl. Based on the nearby BGS boreholes the London Clay formation was understood to extend to a depth >44.00m bgl.

Where SPT "N" Values were undertaken, the Cu could be calculated by multiplying by 5, as stated by Stroud (1974). Where the London Clay Formation was inferred, a design line was taken from "*Burland*

*JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension CIRIA Special Publication 200*". The equation was undrained shear strength = (depth into the LCF x 8) + 50.

The relationship between Eu and Cu is generally dependent on strain levels. For small strains, a ratio of 750 can be adopted based on well documented publications. This is also reflected for the London Clay Formation, after extensive research, within graphs depicting strains and Eu/Cu ratios included in *"Burland JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension CIRIA Special Publication 200".* A Poisson's Ratio of 0.45 was considered suitable for these soils, given their cohesive nature.

**Long-Term Conditions**
A ratio of E' to Eu of ~0.75 was considered a sensible approach for this stage in the design, for cohesive soils. For Made Ground, it was considered suitable for E' and Eu to be equal, given that these soils are more permeable and to limit the level of anticipated Young Modulus at a representative value.

### 7.2.2 Bearing Capacity

The following allowable bearing capacities were anticipated for the basement depth at 3.80m bgl. Based on the soil profiles within WS01 and WS02.

| Allowable Bearing Capacities | |
|---|---|
| **Foundation Depth (m bgl)** | **Allowable Bearing Capacity (kN/m$^2$)** |
| **3.80 (basement)** | 250 - 270 |
| **1.00/1.20 – 2.00 (Shallow cohesive zone)** | 200 |

### 7.2.3 Settlement/Heave Analysis

Analysis of vertical ground movements, using the Mindlin analysis method within Pdisp software, was undertaken to assess the potential movements resulting from changes of vertical pressure. Geotechnical parameters noted in the previous section of this report were used for the model. A rigid boundary at depth was considered at 44.00m bgl, for calculation purposes. The inputs and outputs of this analysis can be viewed within Appendix H.

Five representative stages of construction, in terms of the net change in vertical pressure, have been modelled. These were considered to adequately approximate the movements rising from the basement construction.

- **Stage 1:** Excavation of the retaining wall voids, with short-term conditions;
- **Stage 2:** Representative net loads associated with the construction of the retaining walls, with short-term conditions;
- **Stage 3:** Stage 2 loads as well as loads associated with the mass excavation of the basement footprint, with short-term conditions;
- **Stage 4:** Mass excavation load, as well as loads associated with the construction of the basement slab, with short term conditions and full net pressure at retaining wall locations. The basement is fully constructed from this stage onwards;
- **Stage 5:** Stage 4 arrangement but for long-term conditions.

A load of 30kN/m² was anticipated during construction and the mass excavation. The final loads were based on calculations by the structural engineers and they were selected to be representative of the site, this was 93kN/m².

Given the overall rectangular shape of the basement, the excavation was based on a rectangle using the maximum length and width of the basement. This was considered conservative and will ensure accurate results.

The overburden pressure release following the excavation and removal of soils was based on a specific weight of soil of 19kN/m. Based on a proposed basement depth of 3.80m bgl, an overburden pressure release of 72.2kN/m². The overburden pressure release was modelled at 3.80m bgl.

Retaining wall loads were modelled as extending 1.00m towards the centre of the basement and as having a representative uniform load of 30kN/m² in the short term, and 93kN/m² in the long term once fully loaded. This was selected in order not to underestimate the heave and overestimate any settlement. The load of the basement slab was unknown at the time of reporting and was assumed to be 10kN/m². All loads were modelled at 3.80m bgl.

A tabulated summary of all applied loads, at each stage/model, can be viewed below.

| Summary of Net Bearing Pressure Changes for PDisp Analysis | | | | |
|---|---|---|---|---|
| Description | Applied Load (+ive)/ Load Removal (-ive) (kN/m²) | | | |
| | Stage 1 | Stage 2 | Stage 3 | Stage 4 and 5 |
| **Excavation of Retaining Wall Voids** | -72.2 | | | |
| **Construction of Retaining Walls** | | 30 | 30 | 93 |
| **Mass Excavation Void** | | | -72.2 | -72.2 |
| **Construction of Basement Slabs** | | | | 10.00 |

The method stated above was considered to comprise a comprehensive and reasonably conservative approach, in order to estimate the maximum potential heave and settlements.

A tabulated summary concluding the amount of soil displacement shown at the basement depth within the contour plots can be viewed below. It should be noted that the soil displacement between models are not cumulative values; therefore, the amount of soil displacement between models should not be added together as each model shows each construction stage individually.

| Settlement/Heave Analysis | |
|---|---|
| Model | Soil Displacement |
| **Model 1** | 0.74 – 2.98mm heave. No settlement |
| **Model 2** | 0.31 – 1.24mm settlement. No heave |
| **Model 3** | 0.72 – 9.23mm heave. No settlement |
| **Model 4** | 1.70mm (settlement) – 7.16mm heave. |
| **Model 5** | 1.85mm (settlement) – 8.98mm heave. |
| **Diagrammatic representation can be viewed within Appendix H.<br>Please note that the above figures should not be added together (or be superimposed) and that they represent anticipated movements at different accumulated stages of construction, in order to approach and test all expected combinations of loading regimes (models).** | |

A maximum amount of heave of 9.23mm was noted following the mass excavation of the basement void (Model 3), and was noted to be the maximum amount of heave during the construction phases. Once constructed, the maximum amount of heave increased from 7.16mm for short term conditions (Model 4), to 8.98mm for long term conditions (Model 5); therefore, the highest risk of movement will likely occur during the construction of the basement and later through long-term heave of the constructed basement.

#### 7.2.4 Additional Comments

Regarding the bulk basement construction, care will need to be taken to ensure that the slab is protected through accommodating heave. Heave protection measures will need to be incorporated.

Final designs for the foundations should be carried out by a suitably qualified Engineer based on the findings of this investigation and with reference to the anticipated loadings, serviceability requirements for the foundations. A Structural Engineer will also need to review the anticipated ground movements and assess their potential impact on the existing structure and neighbouring properties. It must be noted that finalised construction will aid the structural stability of the neighbouring party walls, reducing the risk of the seasonal movements noted during the structural works.

The location of the proposed tree removals will not have an affect on the proposed basement, due to the distance. However, the pool house may be affected, geotechnical conditions regarding this are outlined within the report.

### 7.3 Retaining Walls, Excavations and Stability

Shallow excavations in the Made Ground are likely to be marginally stable at best. Long, deep excavations, through these strata and into the underlying KPGM are likely to become unstable.

Appropriate propping and support should be incorporated during construction of the basement.

The excavation of the basement must not affect the integrity of the adjacent structures beyond the boundaries. The excavation must be supported by suitably designed retaining walls. It is considered unlikely that battering the sides of the excavation, casting the retaining walls and then backfilling to the rear of the walls would be suitable given the close proximity of the party walls.

The retaining walls for the basement will need to be constructed based on the soils encountered with an appropriate angle of shear resistance (Φ') and effective cohesion (C') for the ground conditions encountered, regarding long-term considerations, as well using an appropriate undrained shear strength Cu for short-term considerations.

The overlying Made Ground needs to be considered in the design of the basement. A conservative value of Cu will need to be considered.

Based on the ground conditions encountered within the boreholes the following parameters tabulated below could be used in the design of retaining walls, for a long-term consideration. These have been designed based on the in-situ strength testing profile recorded, results of geotechnical classification tests and reference to literature.

| Retaining Wall/Basement Design Parameters | | | | | |
|---|---|---|---|---|---|
| **Strata** | **Unit Volume Weight (kN/m³)** | **Cohesion Intercept (c') (kPa)** | **Angle of Shearing Resistance (°)** | **Ka (Rankine)** | **Kp (Rankine)** |
| Made Ground | ~19 | 0 | 12 | 0.66 | 1.52 |
| Kempton Park Gravel Member (Cohesive) | ~20 – 22 | 0 | 24 – 28 | 0.36 – 0.42 | 2.37 – 2.77 |
| Kempton Park Gravel Member (Granular) | ~20 – 22 | 0 | 32 – 40 | 0.22 – 0.31 | 3.25 – 4.60 |

It should be noted that the Ka and Kp values presented in the table, are shown for guidance and they are derived from the Rankine theory for soil pressures. The values for angles of internal friction provided are considered to be characteristic values of the soils encountered.

According to C760, a design method (e.g. EC7) should be adopted and followed through the whole design process. In addition, the following considerations should be considered during the design process:

- Appropriate consideration of groundwater levels.
- Surcharge pressure equivalent to the pressures of any adjacent buildings.
- Surcharge pressures from potential piling work platforms and heavy plant traffic.

Unsupported earth faces formed during excavation may be liable to collapse without warning and suitable safety precautions should therefore be taken to ensure that such earth faces are adequately supported before excavations are entered by personnel.

**Ground Instability Recommendations**
Specific measures should be included in a competent Construction Method Statement for the works on this site by the structural engineer and the contractor. If instability is noted, the following could be applied for good workmanship and mitigation of any risk. It should be noted that these are indicative.

- Where soft/loose spots are encountered, trench sheets should be left in. Alternatively, a back prop with precast lintels or sacrificial boards should be installed. If the soil support to the ends of the lintels is insufficient, brace the ends of the PC lintels with 150x150 C24 timbers and prop with Acrows diagonally back to the ground.
- Where voids are present, trench sheeting with 75mm diameter holes should be installed, to allow the concrete to flow behind the trench sheeting thereby filling any voids encountered in soils behind.
- Prior to casting, a layer of DPM should be installed between trench sheeting (or PC lintels) and new concrete. The lintels should be cut into the soil by 150mm either side of the pin. A site stock of a minimum of 10 lintels should be present to prevent delays due to ordering.

## 7.4 Sub-Surface Concrete Design

Concrete to be placed in contact with soil or groundwater must be designed in accordance with the recommendations of Building Research Establishment Special Digest 1, 2005, *'Concrete in Aggressive Ground'* considering the pH of the soils. For the classification given below, the "mobile" and "natural" case was adopted given the geology encountered and the residential use of the site.

**Made Ground**

Made Ground was noted to have water soluble sulphates between 10 – 13.6 mg/l and pH of 7.7 – 8.0.

**Kempton Park Gravel Member**

According to Box C6 of BRE Special Digest 1, 2005, 'Concrete in Aggressive Ground' the Kempton Park Gravel Member did not fall within a list of UK geological formations known to contain pyrite. Consequently, it was not required to consider the levels of total potential sulphate in the classification process.

The water soluble sulphate concentration ranged between 8.44 – 23mg/l, with a pH range of 8.0 – 8.4.

**London Clay Formation**

The soils of the London Clay Formation are expected at ~6.00m bgl. Therefore, no construction is expected to be taking place at that depth.

### 7.5 Hydrogeological Effects, Flooding and Surface Water Disposal

Basements have potential to greatly impact hydrological and hydrogeological regimes. Numerous comments and considerations reflecting on the relationship between the basement and groundwater/surface water have been discussed below.

#### 7.5.1 Basement Construction

If the construction works take place during the winter months, when the groundwater level is expected to be at its higher elevation, water could accumulate thus dewatering could be required to facilitate the construction and prevent the base of the excavation blowing before the slab was cast. **The lower ground floors must be suitably tanked to prevent ingress of groundwater and also surface water run-off. A dewatering or permitting grout contingency plan should be included within the Construction Method Statement and considered in the final design. As there will be potential for groundwater to collect behind the retaining walls, the basement should be waterproofed and designed to withstand hydrostatic pressures in accordance with BS8102:2009: Code of Practice for the Protection of Below Ground Structures against Water from the Ground.**

Should groundwater/perched water be encountered across the site, dewatering from sumps introduced into the floor of the excavation may be required. Consideration could be given to creating a coffer dam using contiguous piled or sheet piled walls to aid construction below the perched water table if groundwater becomes a significant issue. **The advice of a reputable dewatering company should be sought.**

#### 7.5.2 Site Drainage

The majority of new developments are encouraged to use Sustainable Urban Drainage Systems (SUDS) to manage surface water drainage. This ensures that any volumes and peak flow rates of surface water leaving a developed site are no greater than the rates prior to the proposed development unless specific off-site arrangements are made and result in the same effect.

The principles of SUDS and the requirements of the London Plan Policy 5.13 Sustainable Drainage should be applied to reduce the risk of flooding from surface water ponding and collection associated with the construction of the basement.

In accordance with the London Plan Policy 5.13 Sustainable Drainage the surface water run-off should be managed as close to its source as possible in line with the following drainage hierarchy.

- Rainwater use as a resource (for example rainwater harvesting, blue roofs for irrigation)
- Rainwater infiltration to ground at or close to source
- Rainwater attenuation in green infrastructure features for gradual release (for example green roofs, rain gardens)
- Rainwater discharge direct to a watercourse (unless not appropriate)
- Controlled rainwater discharge to a surface water sewer or drain
- Controlled rainwater discharge to a combined sewer.

Drainage should be designed and implemented in ways that deliver other policy objectives of this Plan, including water use efficiency and quality, biodiversity, amenity and recreation.

Soakage testing in accordance with BRE365 was beyond the scope of this investigation.

**Any soakaways should be located sufficiently away from buildings and infrastructure, in order to prevent undermining of foundations. Additional drainage may be considered should significant amounts of water be encountered.**

The submission of a Sustainable Urban Drainage Scheme (SUDS) is likely to be required for this site due to the proposed development increasing the amounts of hardstanding.

**It is understood that measures will be implemented, like green roofs, garden, to account for surface water management and infiltration.**

Consultation with the Environment Agency must be sought regarding any use that may have an impact on groundwater resources, abstractions and surface water features/watercourses.

#### 7.5.3 Additional Comments, Groundwater, Throughflow

The site itself has the potential to flood from groundwater, due to a Secondary Aquifer underlain by Unproductive Strata. Perched water may be encountered within the Made Ground and the underlying geological formations, especially after periods of prolonged or intense rainfall. **This should be considered in final design.**

Groundwater was recorded at 2.80 – 3.10m bgl.

Groundwater is expected to flow through the more permeable Kempton Park Gravel Member. The proposed basement does not extend into the cohesive London Clay Formation (expected at ~6.00m bgl), so when groundwater is elevated to above basement level, it can flow beneath the basement as well as around; therefore, groundwater flow direction will not be affected. In addition, the site is not within a throughflow catchment area.

Given their subterranean position, lower ground floors can be susceptible to flooding from sewers. In order to minimise the risk of sewer flooding to the development, all subterranean development must be connected to the sewerage network, installed with a positively pumped non-return valve device.

**Consultation with the Environment Agency must be sought regarding any use that may have an impact on groundwater resources, abstractions and surface water features/watercourses.**

### 7.6 Discovery Strategy

A full contamination assessment was beyond the scope of this investigation, where targeted sampling was not undertaken. There may be areas of contamination that have not been identified during the course of the intrusive investigation (e.g. underground storage tanks). Such occurrences may be discovered during the construction phases for the redevelopment of the site.

Groundworkers should be instructed to report to the Site Manager any evidence for such contamination; this may comprise visual indicators, such as fibrous materials within the soil, discolouration, or odours and emission. Upon discovery advice must be taken from a suitably qualified person and then the Local Authority will need to be informed.

### 7.7 Waste Disposal

The excavation of foundations and soils is likely to produce waste which will require classification and then recycling or removal from site.

Under the Landfill (England and Wales) Regulations 2002 (as amended), prior to disposal all waste must be classified as;

- Inert;
- Non-hazardous, or;
- Hazardous.

The Environment Agency's Hazardous Waste Technical Guidance (WM3) document outlines the methodology for classifying wastes. Once classified the waste can be removed to the appropriately licensed facilities, with some waste requiring pre-treatments prior to disposal.

Following the investigation, 2No. samples of Made Ground were submitted to the analytical laboratory to undergo a suite of testing for contamination testing, as discussed in the previous sections. Sampling depths were chosen to reflect the receptor of concern, human health, and typically comprised a surface or near surface sample and periodically to 1.00m bgl. Any horizon where olfactory or visual evidence of contamination was present was also sampled.

Based on a risk phase analysis of the chemical laboratory test results, in accordance with EC Hazardous Waste Directive and undertaken by Ground and Water Limited, all soil samples of Made Ground encountered on-site were NON-HAZARDOUS. The results of the assessment are given within Appendix I.

It is important to note that whilst we consider our in-house assessment tool to be an accurate interpretation of the requirements of WM3, therefore producing an initial classification in accordance with the guidance, this method classifies soils as either non-hazardous or hazardous and landfill operators have their own assessment tools and can often come to different conclusions. As a result, some landfill operators could refuse to take apparently suitable waste. It is recommended that the receiving landfill views the results of this assessment and the chemical laboratory results to determine their own classification.

In addition to the samples described above, 1No. sample was scheduled to undergo Waste Acceptance Criteria (WAC) testing with single batch leachate from a singular sample. This sample was labelled as inert waste.

Where contaminated soils are to be removed, they should be placed on an impermeable membrane (visqueen or similar) to ensure that no cross-contamination of soils occurs.

### 7.8 Duty of Care

Groundworkers must maintain a good standard of personal hygiene including the wearing of overalls, boots, gloves and eye protectors and the use of dust masks during periods of dry weather.

To prevent exposure to airborne dust by both the general public and construction personnel the site should be kept damp during dry weather and at other times when dust would be generated as a result of construction activities.

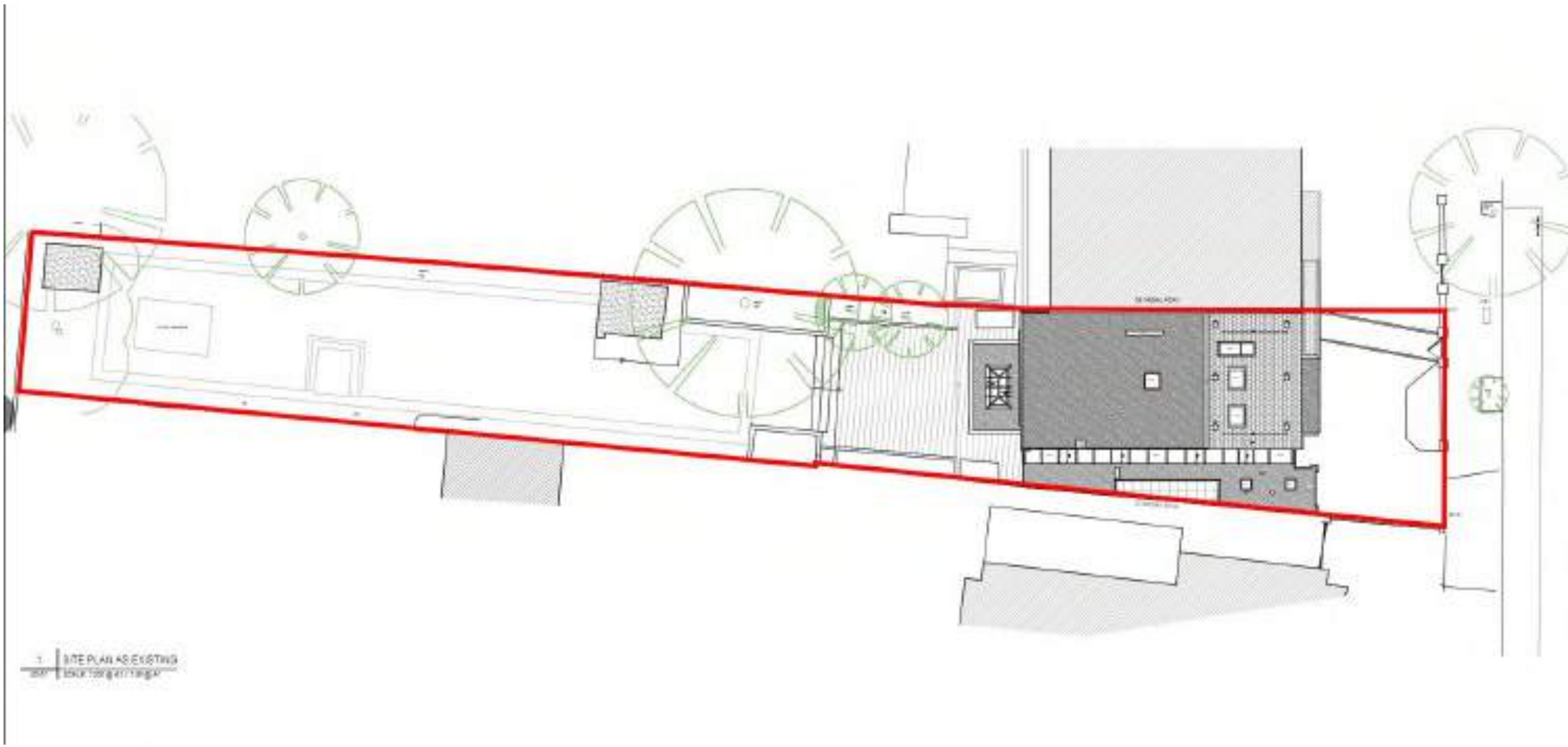
The site should be securely fenced at all times to prevent unauthorised access. Washing facilities should be provided and eating restricted to mess huts.

# FIGURES

2 The Long Barn, Norton Farm, Selborne Road, Alton, Hampshire GU34 3NB
0333 600 1221 enquiries@groundandwater.co.uk **groundandwater.co.uk**


| | |
|---|---|
| 34 Nassau Road SW13 9QE | |
| Tom Richards | April 2024 |
| **Figure 1 – Site Location Plan** | GWPR5909 |

ground&water

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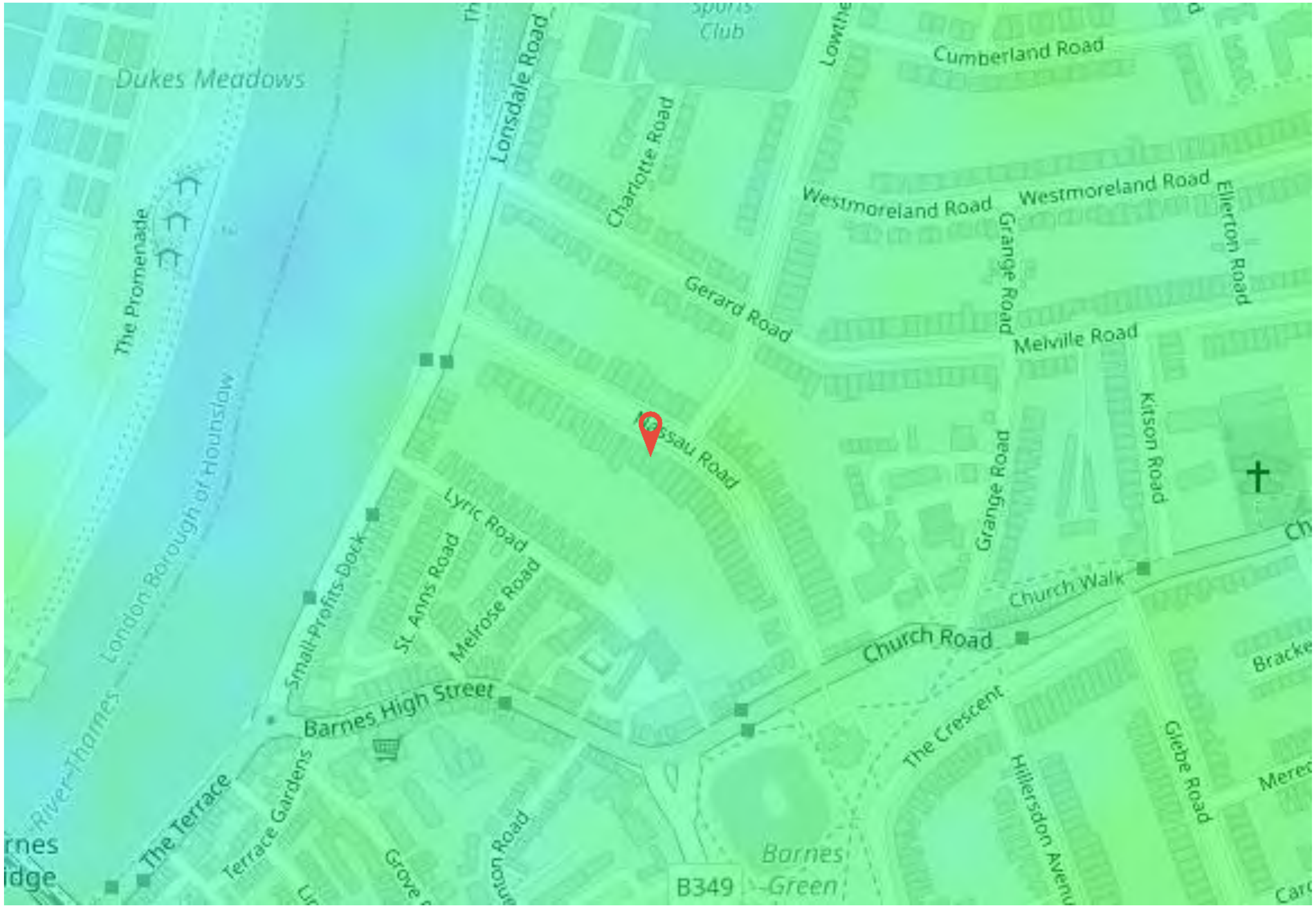
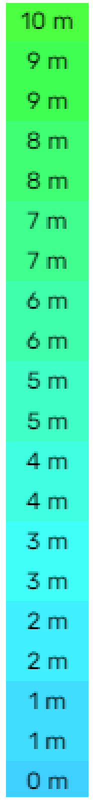
| **34 Nassau Road SW13 9QE** | |
| **Tom Richards** | **April 2024** |
| **Figure 2 – Existing Plan** | **GWPR5909** |

ground&water




Site Location

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| **34 Nassau Road SW13 9QE** | |
| **Tom Richards** | **April 2024** |
| **Figure 3 – Topographical Contour Map** | **GWPR5909** |

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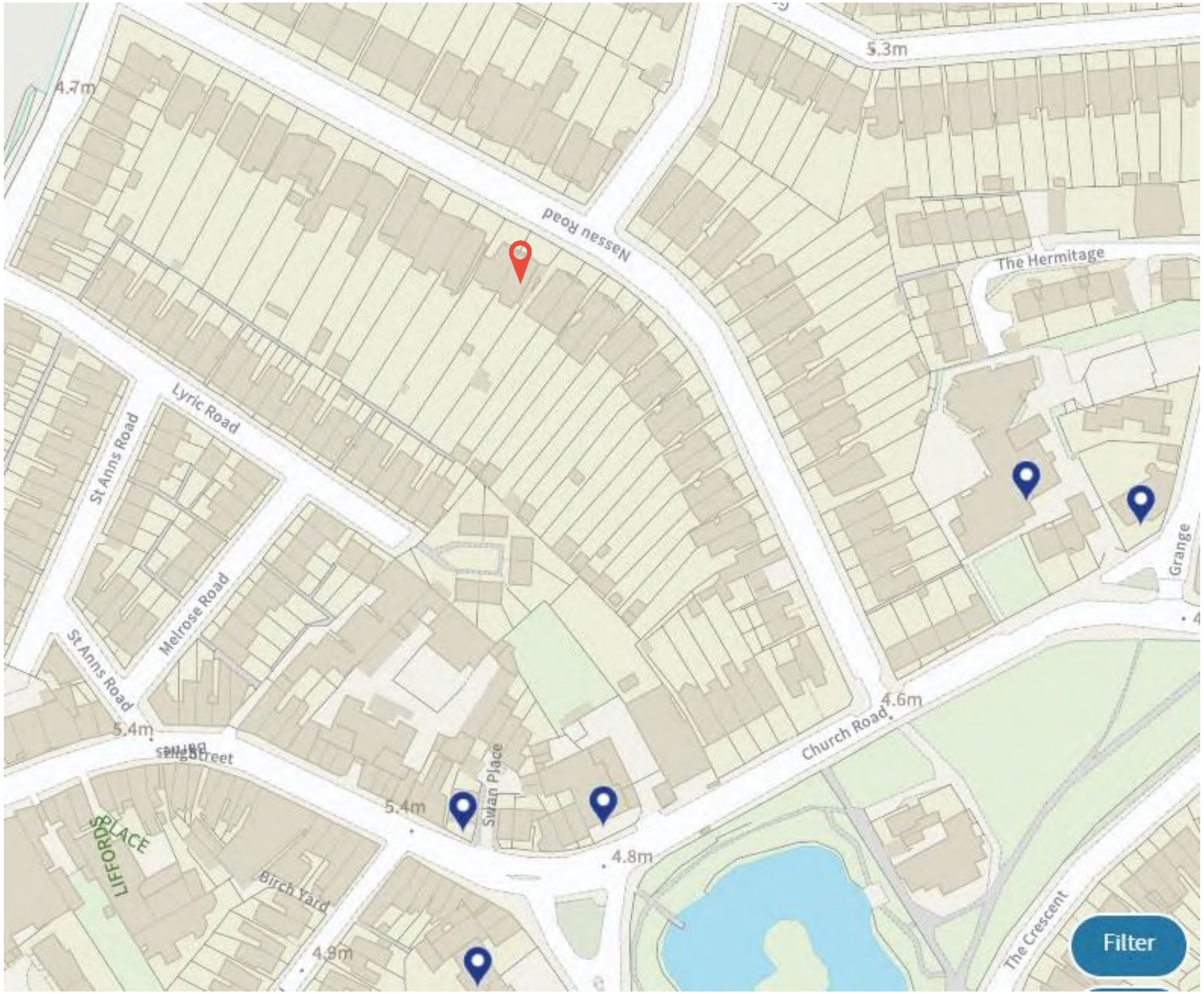


Site Location

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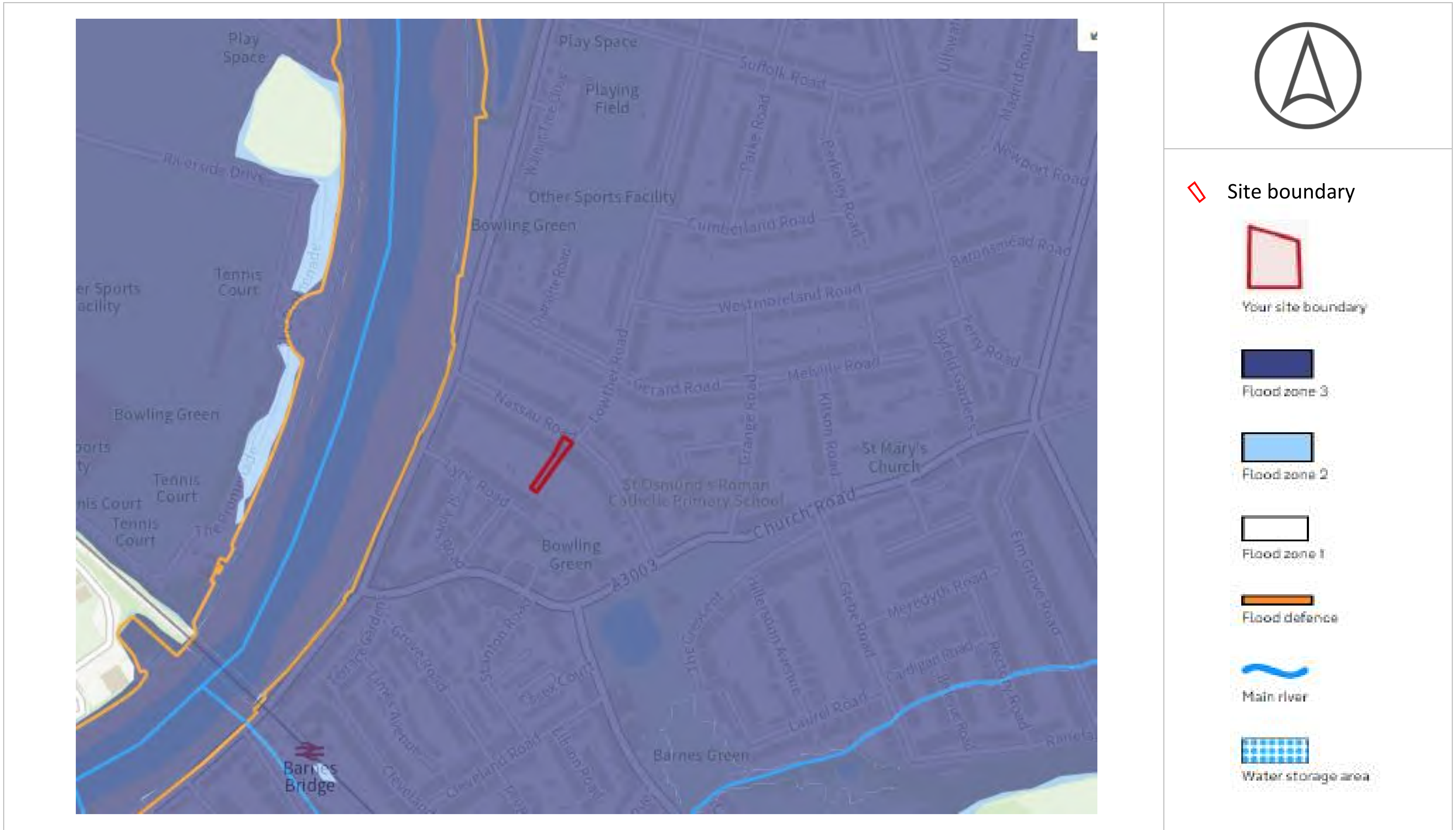
| **34 Nassau Road SW13 9QE** | |
| **Tom Richards** | **April 2024** |
| **Figure 4 – Nearby Listed Buildings** | **GWPR5909** |

| | |
|---|---|
| **34 Nassau Road SW13 9QE** | |
| **Tom Richards** | **April 2024** |
| **Figure 5 – Proposed Development Section** | **GWPR5909** |

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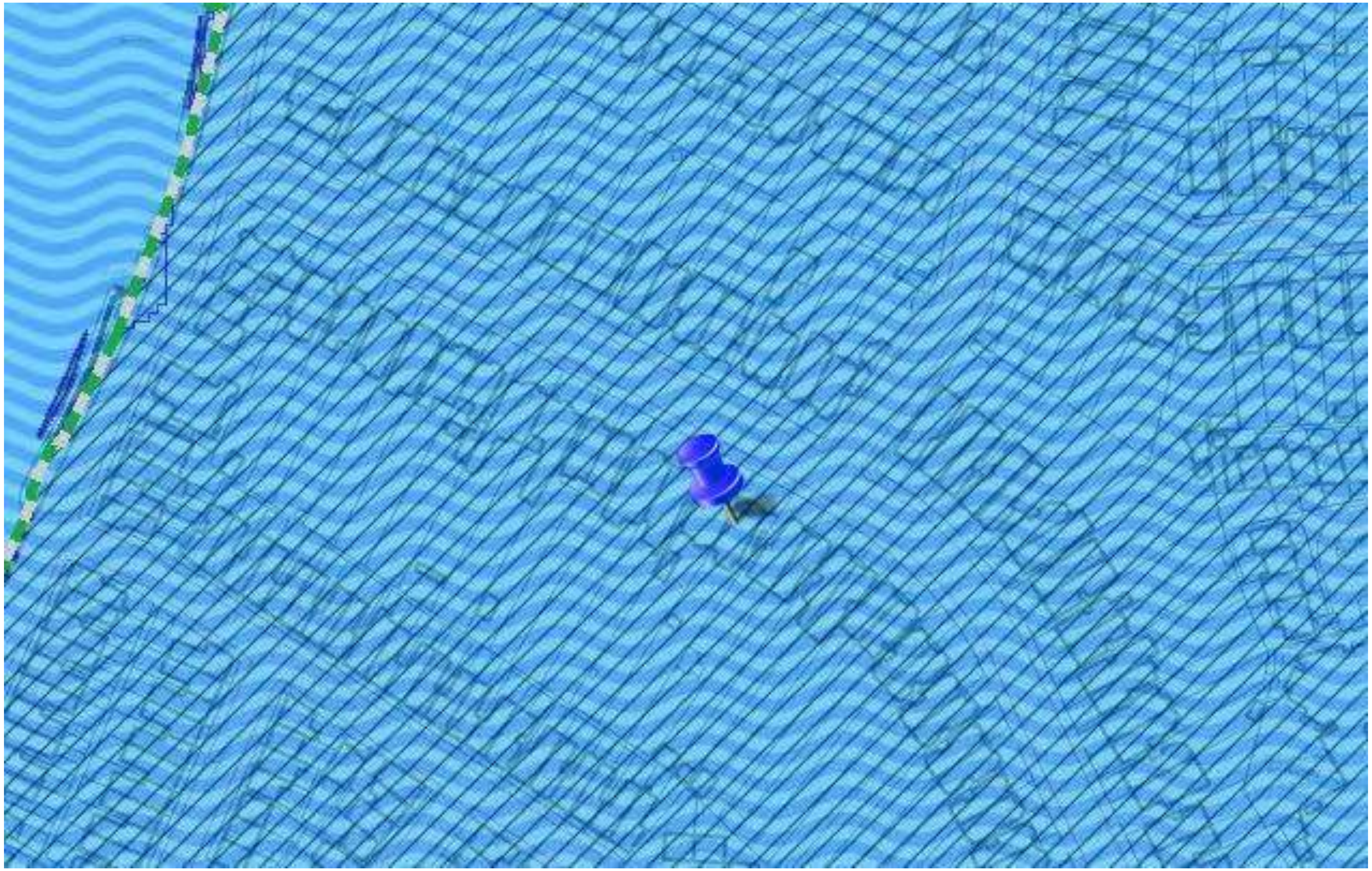
|---|---|---|
| **34 Nassau Road SW13 9QE** | | |
| **Tom Richards** | **April 2024** | |
| **Figure 6 – EA Flooding From Rivers and Seas** | **GWPR5909** | |

ground&water

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| **34 Nassau Road SW13 9QE** | |
| **Tom Richards** | **April 2024** |
| **Figure 7 – SFRA Flood Zones/Defences** | **GWPR5909** |

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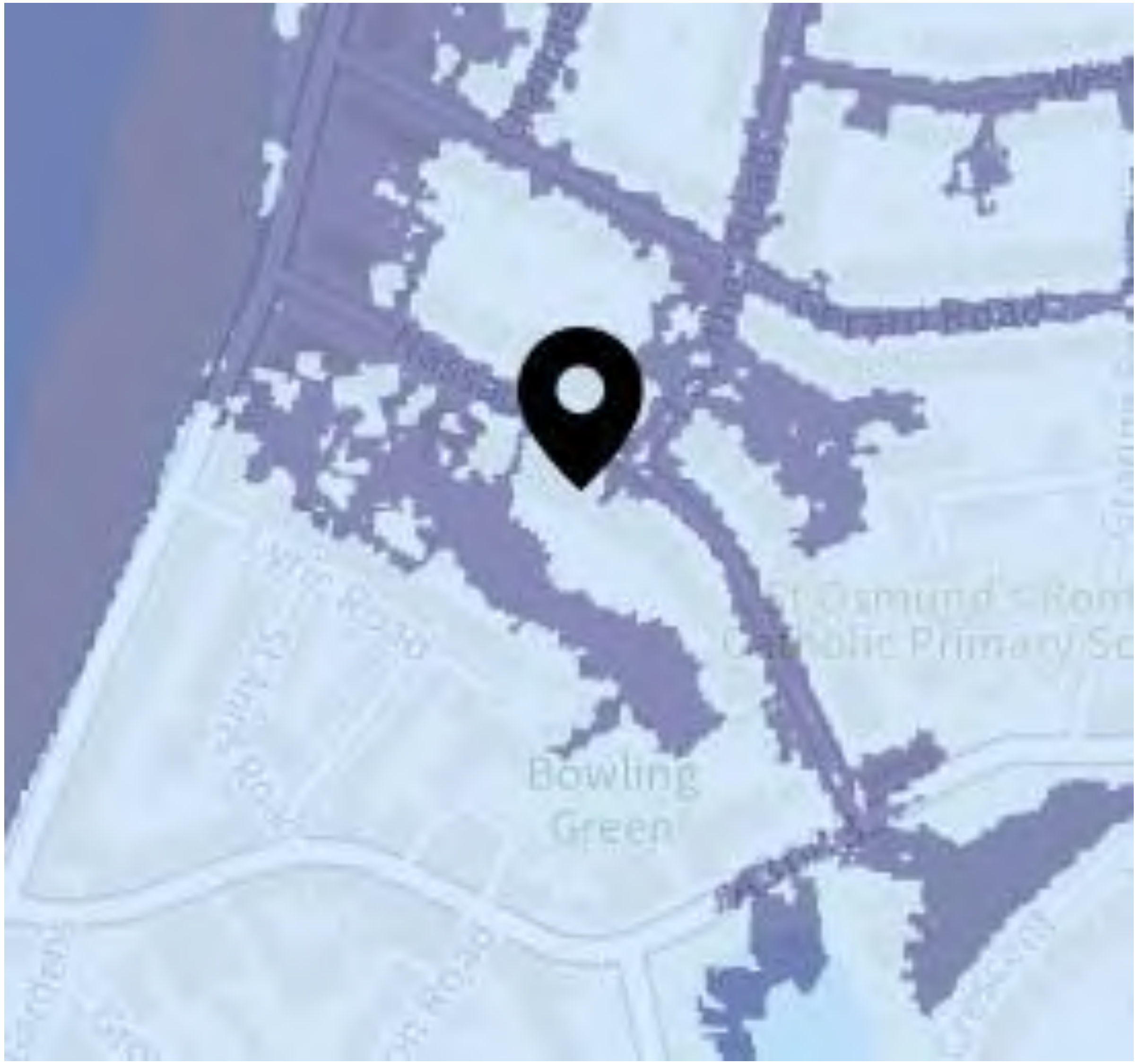


Site Location

When river levels are normal

When there is also flooding from rivers

| | |
|---|---|
| **34 Nassau Road SW13 9QE** | |
| **Tom Richards** | **April 2024** |
| **Figure 8 – EA Reservoir Flooding** | **GWPR5909** |

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Site Location

Risk of Flooding from Surface Water Extent 1 in 30 Chance © Environment Agency

Risk of Flooding from Surface Water Extent 1 in 100 Chance (ie 1 in 100 year Surface Water Extent) © Environment Agency

Risk of Flooding from Surface Water Extent 1 in 1000 Chance © Environment Agency

| 34 Nassau Road SW13 9QE | |
|---|---|
| Tom Richards | April 2024 |
| **Figure 9 – SFRA Surface Water Flooding** | GWPR5909 |

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Site Location

Risk of Flooding from Surface Water Depth 1 in 1000 chance © Environment Agency

- 0.00 - 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- 0.90 - 1.20m
- > 1.20m

| 34 Nassau Road SW13 9QE | |
|---|---|
| **Tom Richards** | **April 2024** |
| **Figure 10 – Depth of Surface Water Flooding (1 in 1000 Chance Event)** | **GWPR5909** |

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Site Location

Risk of Flooding from Surface Water Depth 1 in 100 chance © Environment Agency

- 0.00 - 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- 0.90 - 1.20m
- > 1.20m

| | |
|---|---|
| **34 Nassau Road SW13 9QE** | |
| **Tom Richards** | **April 2024** |
| **Figure 11 – Depth of Surface Water Flooding (1 in 100 Chance Event)** | **GWPR5909** |

ground&water

Site Location

Risk of Flooding from Surface Water depth 1 in 30 chance © Environment Agency

- 0.00 - 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- 0.90 - 1.20m
- > 1.20m

| 34 Nassau Road SW13 9QE | |
|---|---|
| Tom Richards | April 2024 |
| Figure 12 – Depth of Surface Water Flooding (1 in 30 Chance Event) | GWPR5909 |


Site Location

Area Susceptible To Groundwater Flood © Environment Agency

- less than 25%
- between 25% and 49.9%
- between 50% and 74.9%
- 75% or more

| 34 Nassau Road SW13 9QE | |
|---|---|
| **Tom Richards** | **April 2024** |
| **Figure 13 – EA Area Susceptible to Groundwater Flooding** | **GWPR5909** |

ground&water


Site Location

Increased Potential for Elevated Groundwater - GLA Drain London

Consolidated

Consolidated & Permeable Superficial

Permeable Superficial

| | |
|---|---|
| 34 Nassau Road SW13 9QE | |
| Tom Richards | April 2024 |
| Figure 14 – SFRA Increased Potential For Elevated Groundwater | GWPR5909 |

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Site Location

Throughflow Catchment Area (Throughflow and Groundwater Policy Zone)

Potential Throughflow Catchment Area

| | |
|---|---|
| **34 Nassau Road SW13 9QE** | |
| **Tom Richards** | **April 2024** |
| **Figure 15 – Throughflow Catchment Area** | **GWPR5909** |

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Site Location

Incident - Thames Water

- 0 to 10 incidents reported
- 10 to 20 incidents reported
- 20 to 30 incidents reported
- 30 to 40 incidents reported

| | |
|---|---|
| **34 Nassau Road SW13 9QE** | |
| **Tom Richards** | **April 2024** |
| **Figure 16 – Sewer Flooding Incidents** | **GWPR5909** |

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Site Location

Critical Drainage Area

| | |
|---|---|
| 34 Nassau Road SW13 9QE | |
| Tom Richards | April 2024 |
| Figure 17 – Critical Drainage Area | GWPR5909 |

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Site boundary

Windowless Sampler Borehole

NTS

| | |
|---|---|
| **34 Nassau Road SW13 9QE** | |
| **Tom Richards** | **April 2024** |
| **Figure 18 – Trial Hole Location Plan** | **GWPR5909** |

# APPENDIX A: Conditions and Limitations

2 The Long Barn, Norton Farm, Selborne Road, Alton, Hampshire GU34 3NB
0333 600 1221 enquiries@groundandwater.co.uk **groundandwater.co.uk**

The ground is a product of continuing natural and artificial processes. As a result, the ground will exhibit a variety of characteristics that vary from place to place across a site, and also with time. Whilst a ground investigation will mitigate to a greater or lesser degree against the resulting risk from variation, the risks cannot be eliminated.

The report has been prepared on the basis of information, data and materials which were available at the time of writing. Accordingly, any conclusions, opinions or judgements made in the report should not be regarded as definitive or relied upon to the exclusion of other information, opinions and judgements.

The investigation, interpretations, and recommendations given in this report were prepared for the sole benefit of the client in accordance with their brief; as such these do not necessarily address all aspects of ground behaviour at the site. No liability is accepted for any reliance placed on it by others unless specifically agreed in writing.

Any decisions made by you, or by any organisation, agency or person who has read, received or been provided with information contained in the report ("you" or "the Recipient") are decisions of the Recipient and we will not make, or be deemed to make, any decisions on behalf of any Recipient. We will not be liable for the consequences of any such decisions.

Current regulations and good practice were used in the preparation of this report. An appropriately qualified person must review the recommendations given in this report at the time of preparation of the scheme design to ensure that any recommendations given remain valid in light of changes in regulation and practice, or additional information obtained regarding the site.

Any Recipient must take into account any other factors apart from the Report of which they and their experts and advisers are or should be aware. The information, data, conclusions, opinions and judgements set out in the report may relate to certain contexts and may not be suitable in other contexts. It is your responsibility to ensure that you do not use the information we provide in the wrong context.

This report is based on readily available geological records, the recorded physical investigation, the strata observed in the works, together with the results of completed site and laboratory tests. Whilst skill and care has been taken to interpret these conditions likely between or below investigation points, the possibility of other characteristics not revealed cannot be discounted, for which no liability can be accepted. The impact of our assessment on other aspects of the development required evaluation by other involved parties.

The opinions expressed cannot be absolute due to the limitations of time and resources within the context of the agreed brief and the possibility of unrecorded previous in ground activities. The ground conditions have been sampled or monitored in recorded locations and tests for some of the more common chemicals generally expected. Other concentrations of types of chemicals may exist. It was not part of the scope of this report to comment on environment/contaminated land considerations.

The conclusions and recommendations relate to 34 Nassau Road SW13 9QE.

Trial hole is a generic term used to describe a method of direct investigation. The term trial pit, borehole or window sampler borehole implies the specific technique used to produce a trial hole.

The depth to roots and/or of desiccation may vary from that found during the investigation. The client is responsible for establishing the depth to roots and/or of desiccation on a plot-by-plot basis prior to the construction of foundations. Where trees are mentioned in the text this means existing trees, recently removed trees (approximately 15 years to full recovery on cohesive soils) and those planned as part of the site landscaping.

Ownership of copyright of all printed material including reports, laboratory test results, trial pit and borehole log sheets, including drillers log sheets, remain with Ground and Water Limited. Licence is for the sole use of the client and may not be assigned, transferred or given to a third party.

Only our client may rely on this report and should this report or any information contained in it be provided to any third party we accept no responsibility to the third party for the contents of this report save to the extent expressly outlined by us in writing in a reliance letter addressed from us to the third party.

Recipients are not permitted to publish this report outside of their organisation without our express written consent.

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# APPENDIX B: Technical Glossary

2 The Long Barn, Norton Farm, Selborne Road, Alton, Hampshire GU34 3NB
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# TECHNICAL GLOSSARY

The list of possible definitions within the report may be seen below. Please note that some definitions may not be relevant to this report.

**HYDROGEOLOGY:**

A **Principal Aquifer** is a layer of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

**Secondary (A) Aquifers** consist of deposits with permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as Minor Aquifers.

**Secondary (B) Aquifers** consist of deposits with predominantly lower permeability layers with may stoke and yield limited amounts of groundwater due to localised features such as fissures, think permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

**Secondary Aquifers (Undifferentiated)** are assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both a minor aquifer and non-aquifer in different locations due to the variable characteristics of the rock type.

**Unproductive Strata** are rock layers with low permeability that have negligible significance for water supply or river base flow. These were formerly classified as non-aquifers.

**FLOOD ZONES:**

**Environment Agency Flood Zone 2**, defined as; land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding.

**Environment Agency Flood Zone 3** shows the extent of a river flood with a 1 in 100 (1%0 or greater chance of occurring in any year or a sea flood with a 1 in 200 (0.5%) or greater chance of occurring in any year.

**Environment Agency Flood Zone 3 area that benefits from flood defences**, defined as; land and property in this flood zone would have a high probability of flooding without the local flood defences. These protect the area against a river flood with a 1% chance of happening each year, or a flood from the sea with a 0.5% chance of happening each year.

**GROUNDWATER SOURCE PROTECTION ZONES (SPZS):**

**Inner Zone (SPZ1):** This zone is 50 day travel time of pollutant to source with a 50 metres default minimum radius.

**Outer Zone (SPZ2):** This zone is 400 day travel time of pollutant to source. This has a 250 or 500 metres minimum radius around the source depending on the amount of water taken.

**Total Catchment (SPZ3):** This is the area around a supply source within which all the groundwater ends up at the abstraction point. This is the point from where the water is taken. This could extend some distance from the source point.

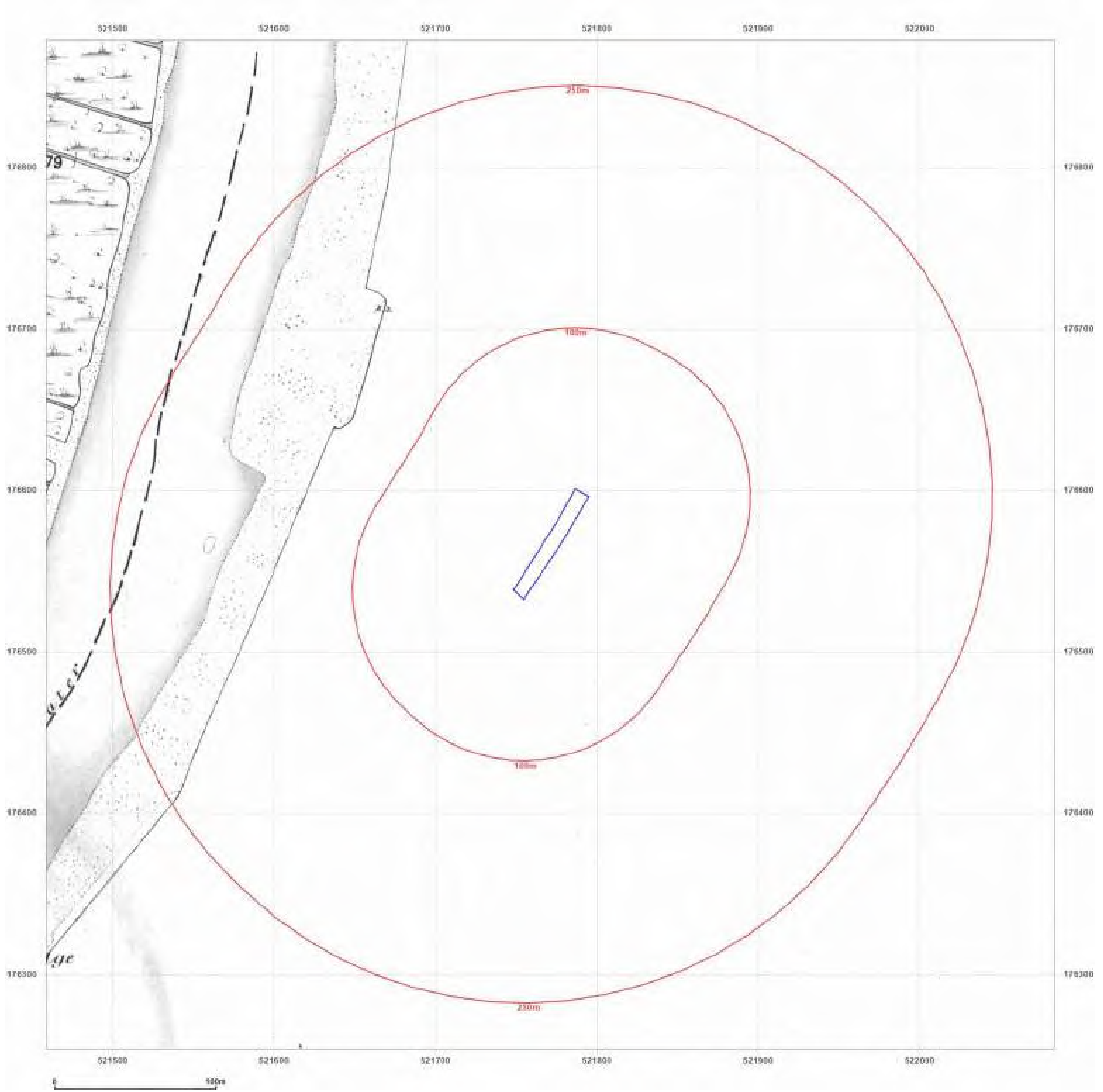
**Zone of Special Interest (SPZ4):** This zone is where local conditions require additional protection.

**IN-SITU STRENGTH GEOTECHNICAL TESTING:**

**Windowless Sample and/or Cable Percussion and/or Rotary Boreholes** provide samples of the ground for assessment but they do not give any engineering data. The standard penetration test (SPT) is an in-situ dynamic penetration test designed to provide information on the geotechnical engineering properties of soil. The test uses a thick-walled sample tube, with an outside diameter of 50mm and an inside diameter of 35mm, and a length of around 650mm. This is driven into the ground at the bottom of a borehole by blows from a slide hammer with a weight of 63.5kg falling through a distance of 760mm. The sample tube is driven 150mm into the ground and then the number of blows needed for the tube to penetrate each 75mm up to a depth of 450mm is recorded. The sum of the number of blows is termed the "standard penetration resistance" or the "N-value".

**Dynamic Probing** involves the driving of a metal cone into the ground via a series of steel rods. These rods are driven from the surface by a hammer system that lifts and drops a 63.5kg (SHDP) hammer onto the top of the rods through a set height, thus ensuring a consistent energy input. The number of hammer blows that are required to drive the cone down by each 100mm increment are recorded. These blow counts then provide a comparative assessment from which correlations have been published, based on dynamic energy, which permits engineering parameters to be generated. (The Dynamic Probe 'Super Heavy' (SHDP) Tests were conducted in accordance with BS 1377; 1990; Part 9, Clause 3.2).

# APPENDIX C: GroundSure Historical Mapping




Groundsure
INSIGHTS

**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1867**

**Scale:** 1:2,500

**Printed at:** 1:2,500

N
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Surveyed 1867
Revised 1867
Edition N/A
Copyright N/A
Levelled N/A

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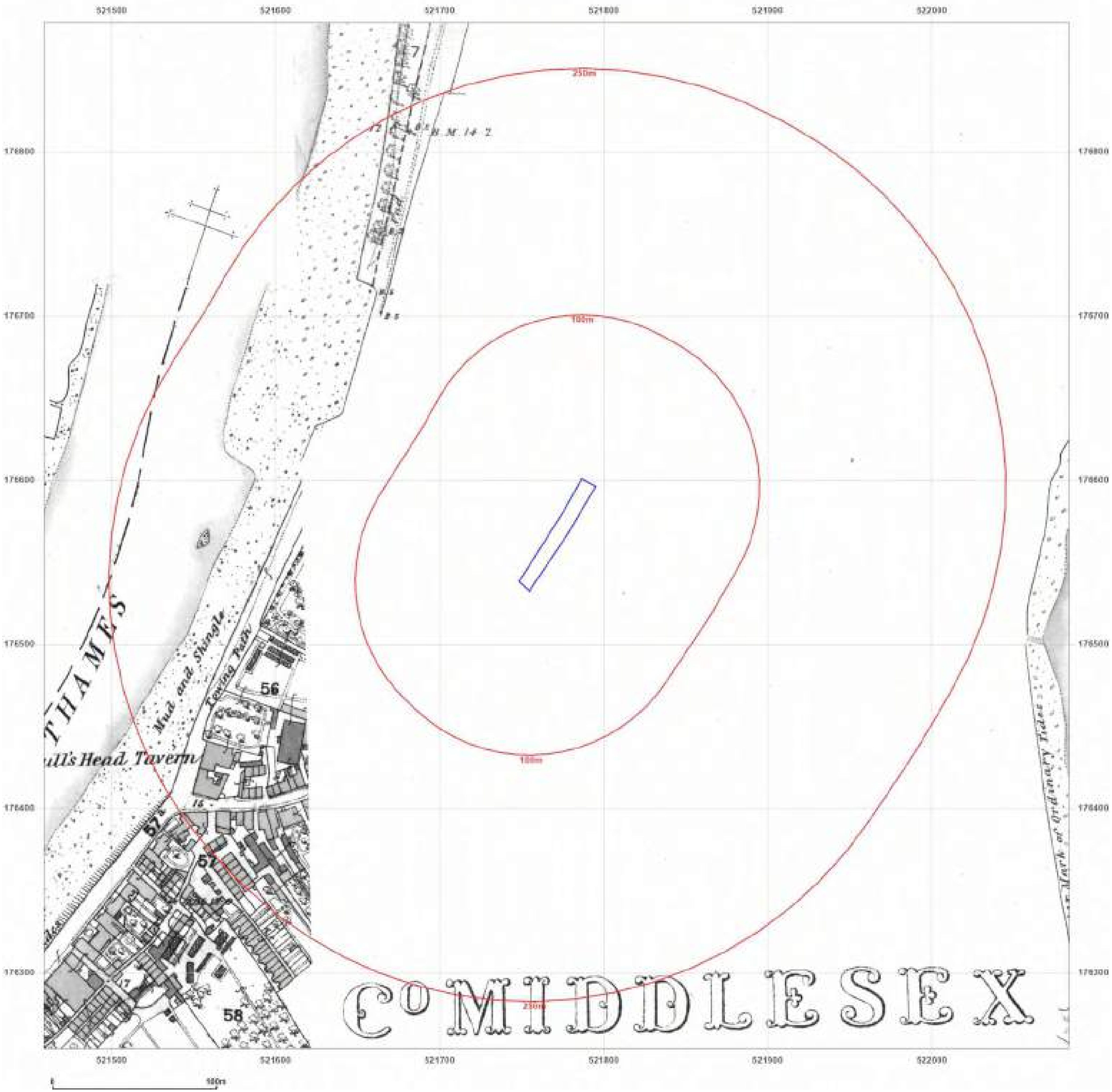


**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1868-1869**

**Scale:** 1:2,500

**Printed at:** 1:2,500

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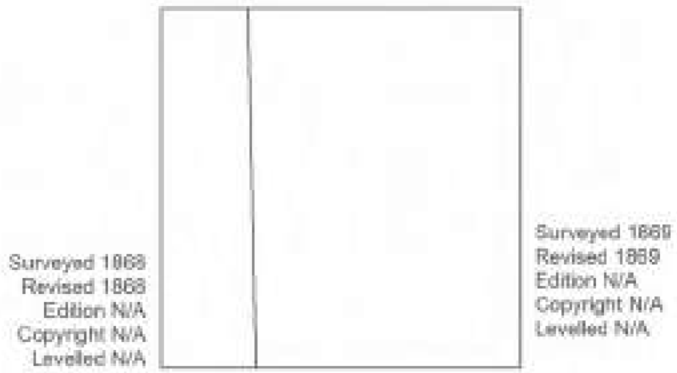


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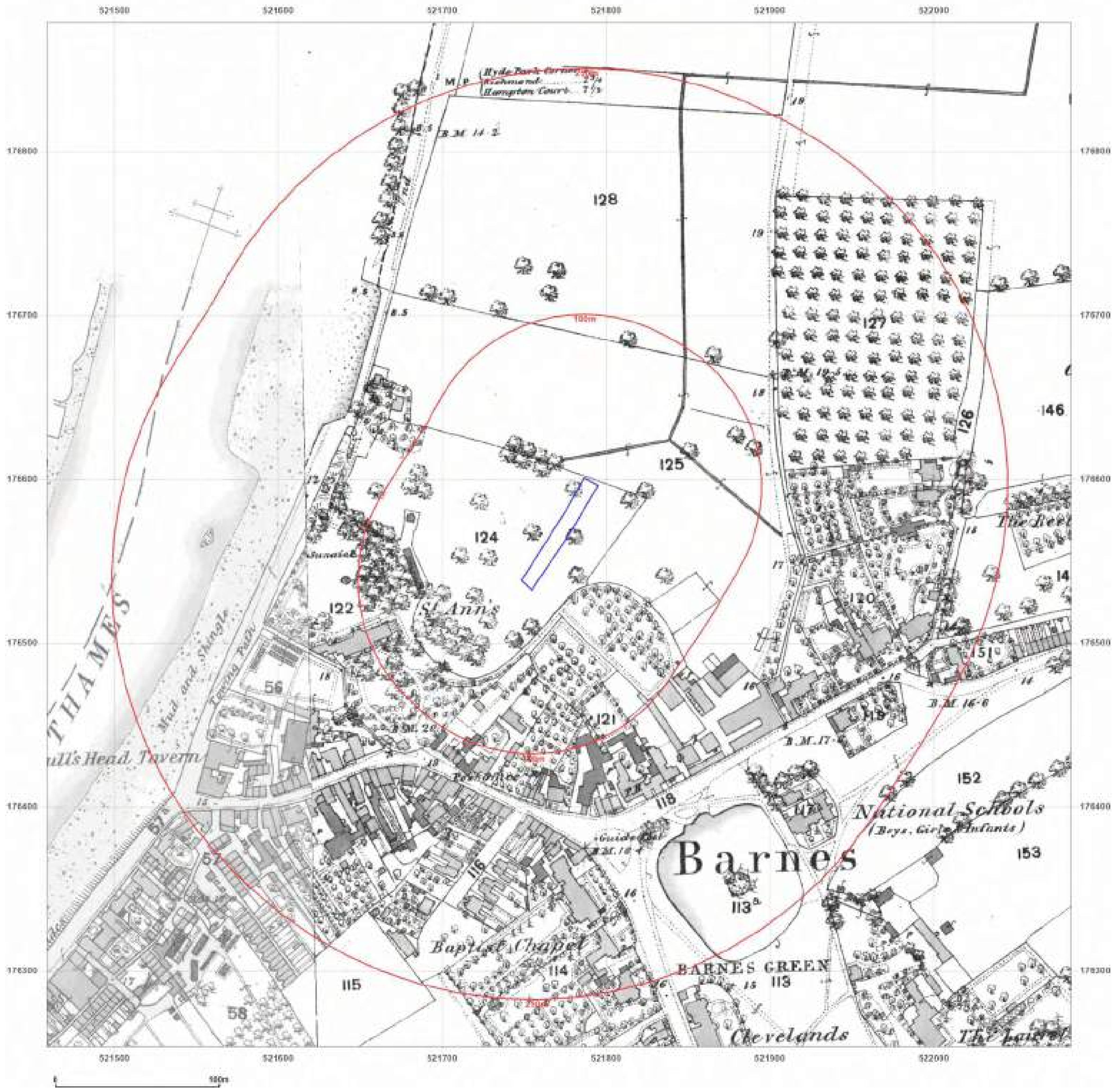


**Site Details:**

34, NASSAU ROAD, BARNES,
LONDON, RICHMOND UPON
THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1868-1869**

**Scale:** 1:2,500

**Printed at:** 1:2,500

N
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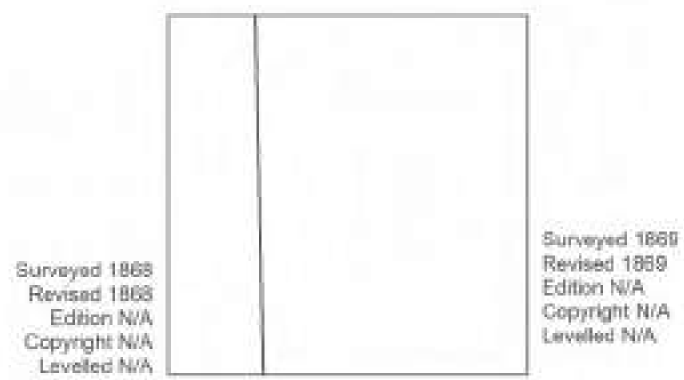


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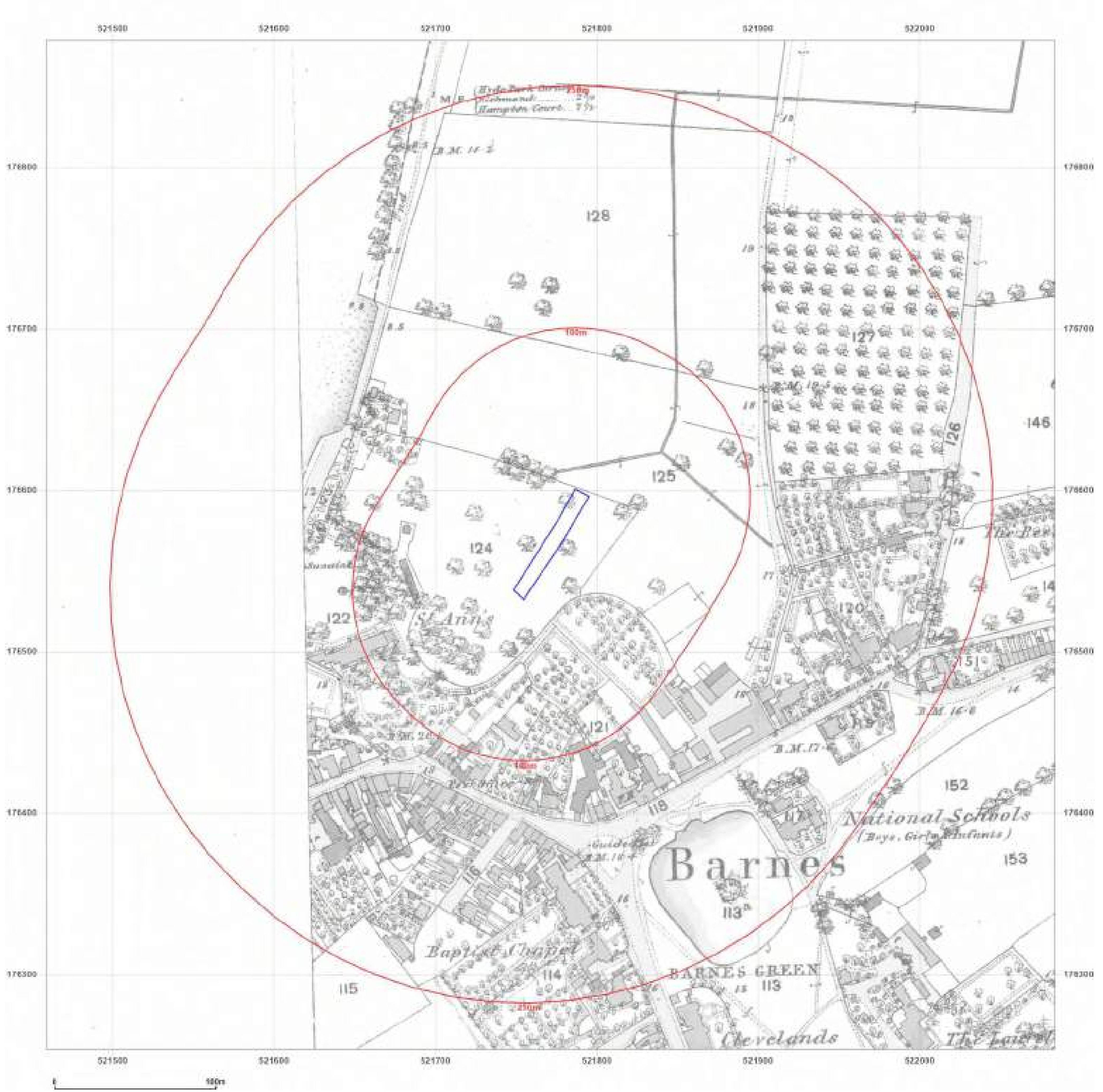


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**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

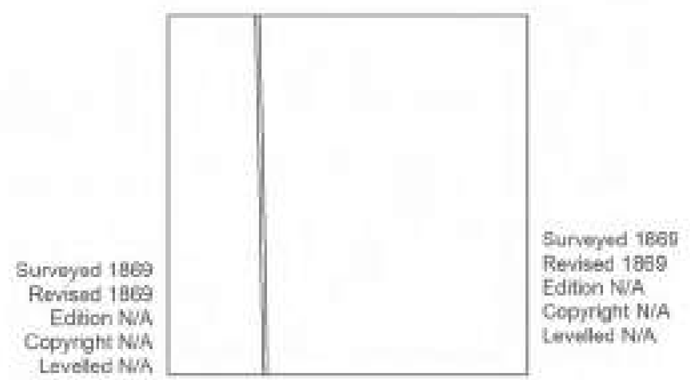
**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1869**

**Scale:** 1:2,500

**Printed at:** 1:2,500

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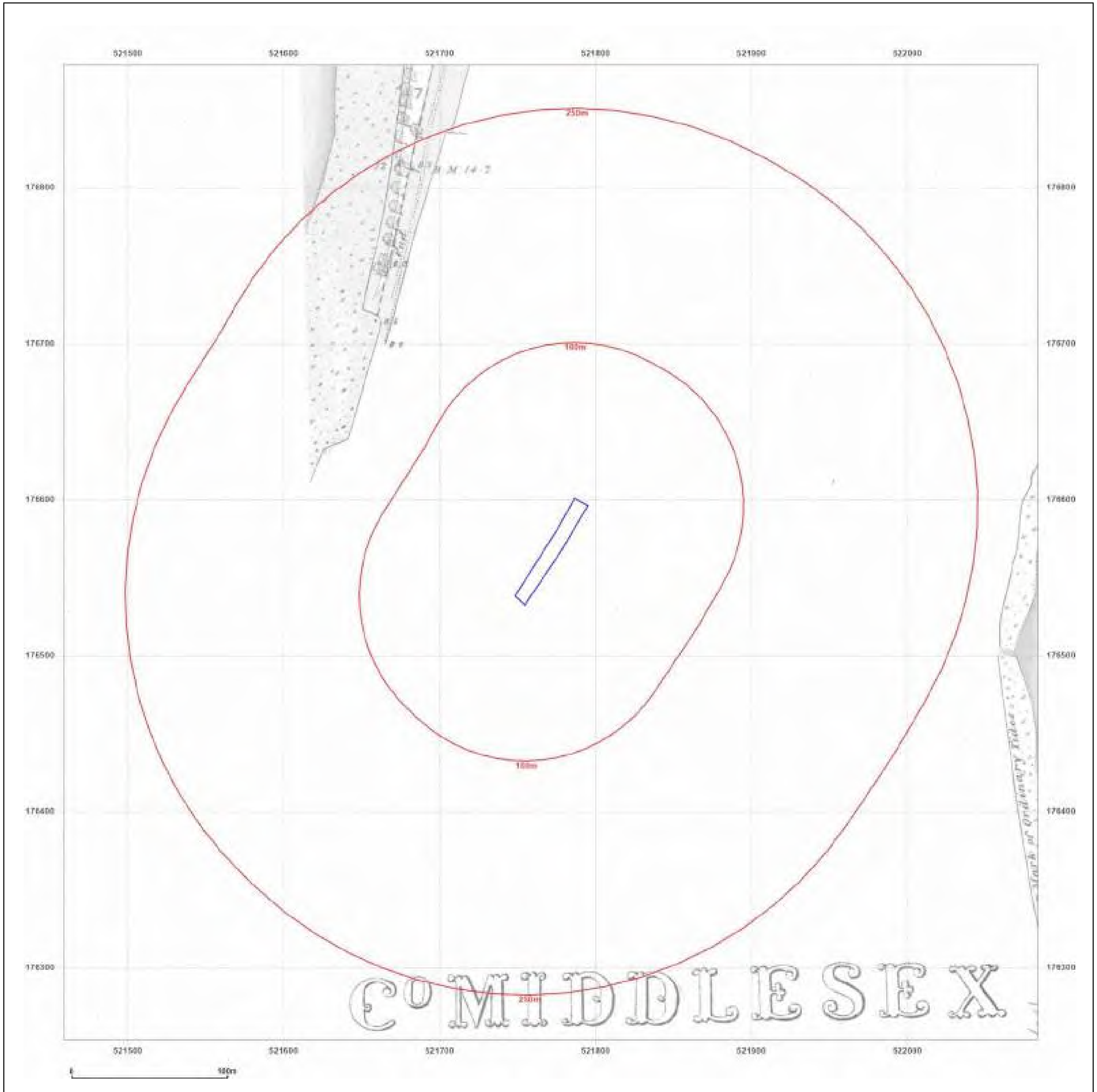


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**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

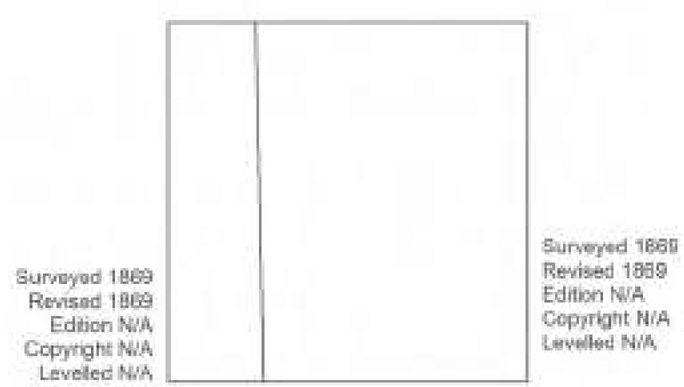
**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1869**

**Scale:** 1:2,500

**Printed at:** 1:2,500

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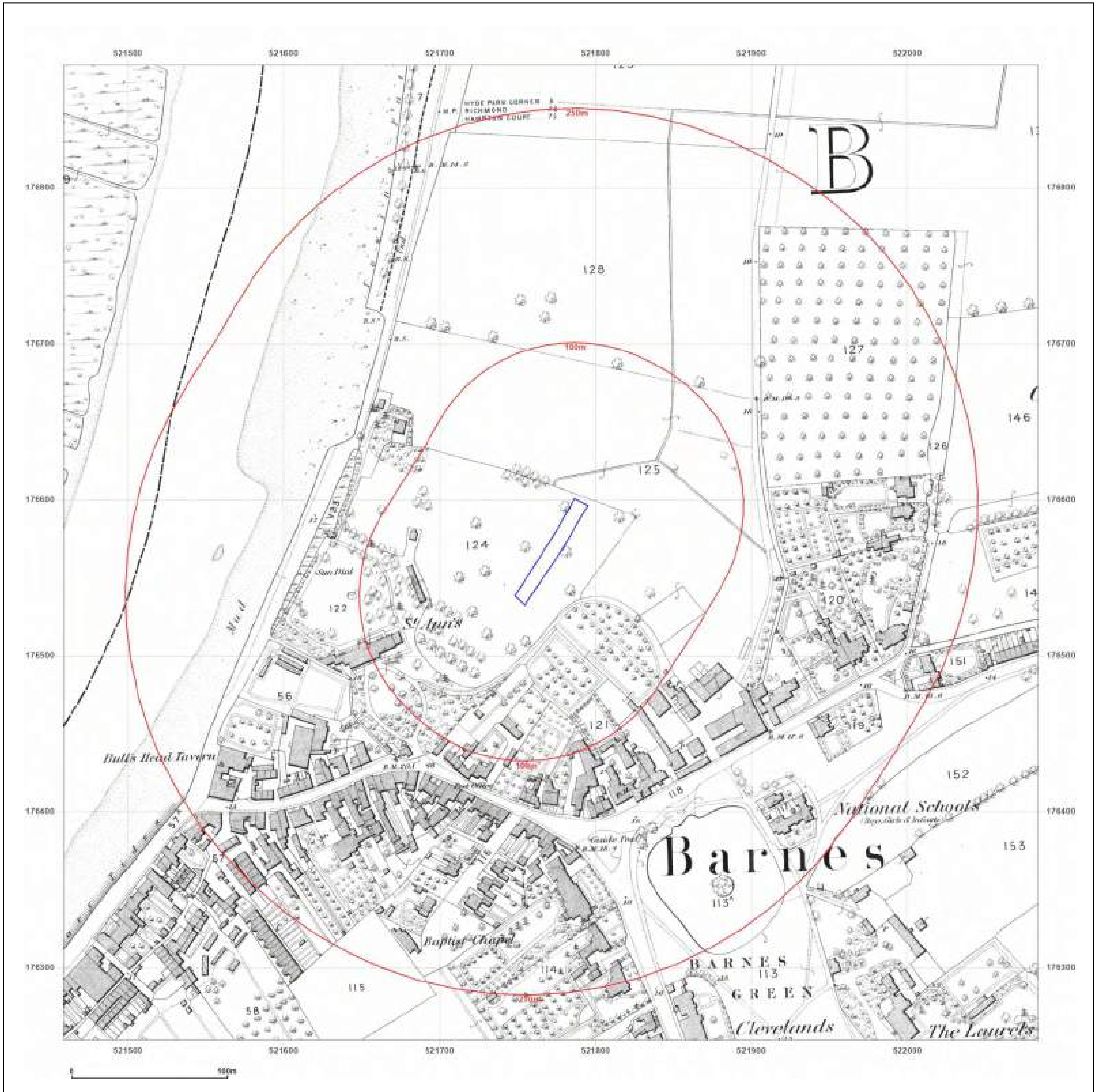


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**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1870**

**Scale:** 1:2,500

**Printed at:** 1:2,500

N
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Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled N/A

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**Site Details:**

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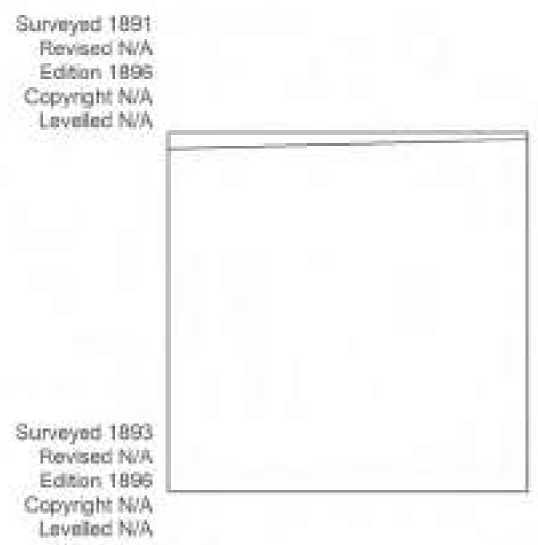
**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** 1056 Scale Town Plan

**Map date:** **1896**

**Scale:** 1:1,056

**Printed at:** 1:1,056

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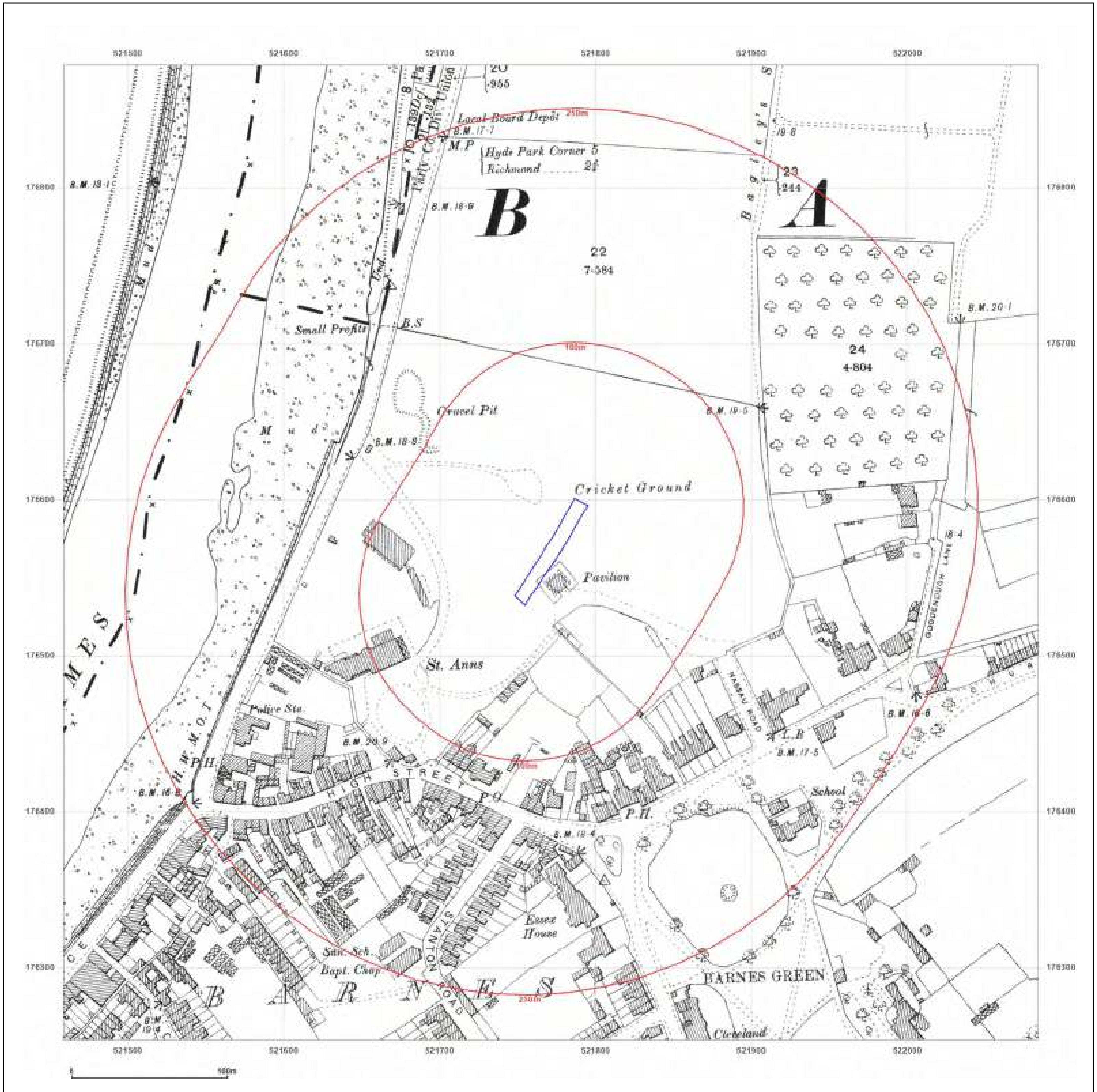


**Site Details:**

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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1896**

**Scale:** 1:2,500

**Printed at:** 1:2,500

Surveyed 1896
Revised 1896
Edition N/A
Copyright N/A
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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1913**

**Scale:** 1:2,500

**Printed at:** 1:2,500

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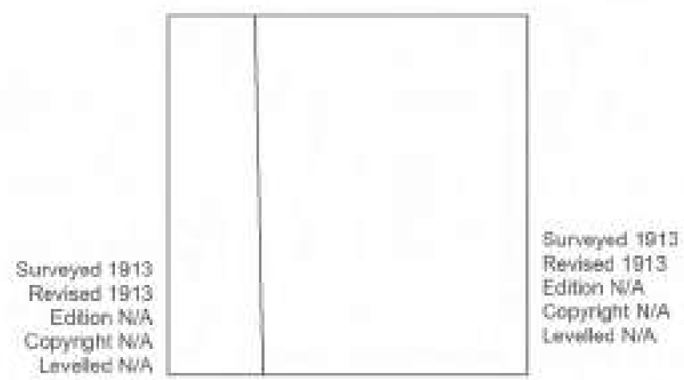


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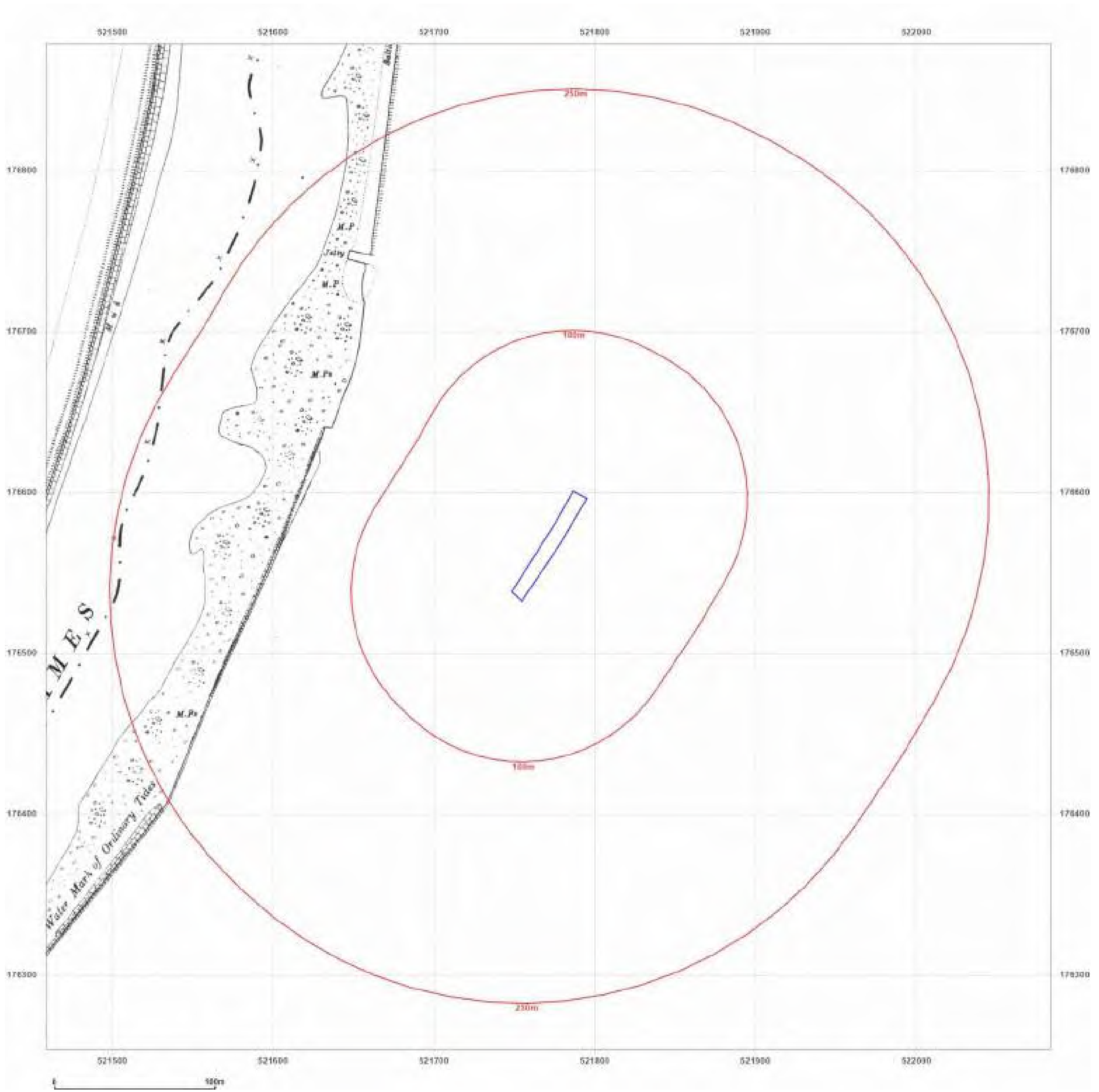


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**Site Details:**

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|---|---|
| **Client Ref:** | GWPR5909 |
| **Report Ref:** | GS-R7I-VE4-EA3-BPT |
| **Grid Ref:** | 521771, 176566 |

| | |
|---|---|
| **Map Name:** | County Series |
| **Map date:** | **1914** |
| **Scale:** | 1:2,500 |
| **Printed at:** | 1:2,500 |

N
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Surveyed 1914
Revised 1914
Edition N/A
Copyright N/A
Levelled N/A

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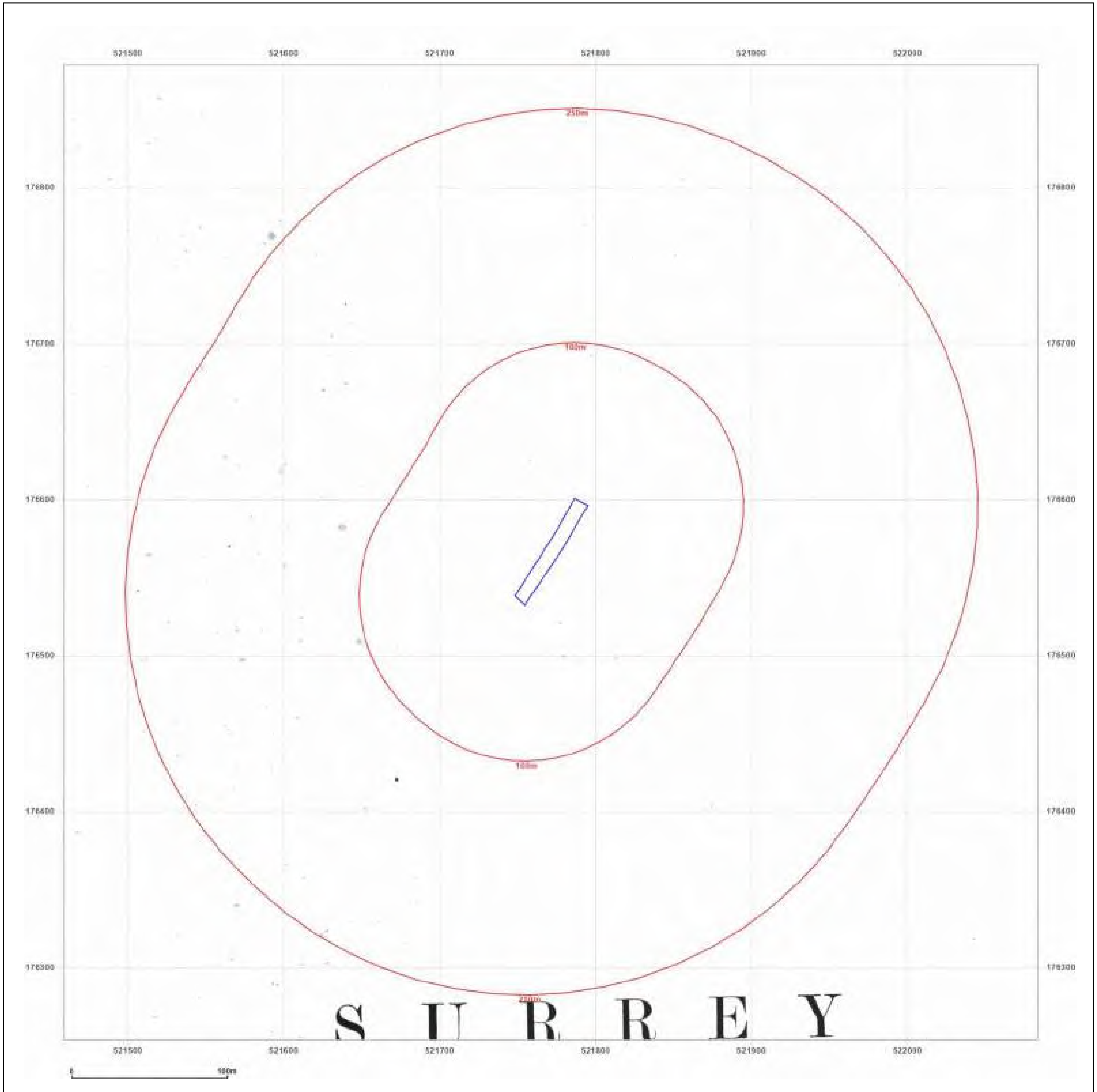


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**Site Details:**

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LONDON, RICHMOND UPON
THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1915**

**Scale:** 1:2,500

**Printed at:** 1:2,500

N
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Surveyed 1915
Revised 1915
Edition N/A
Copyright N/A
Levelled N/A

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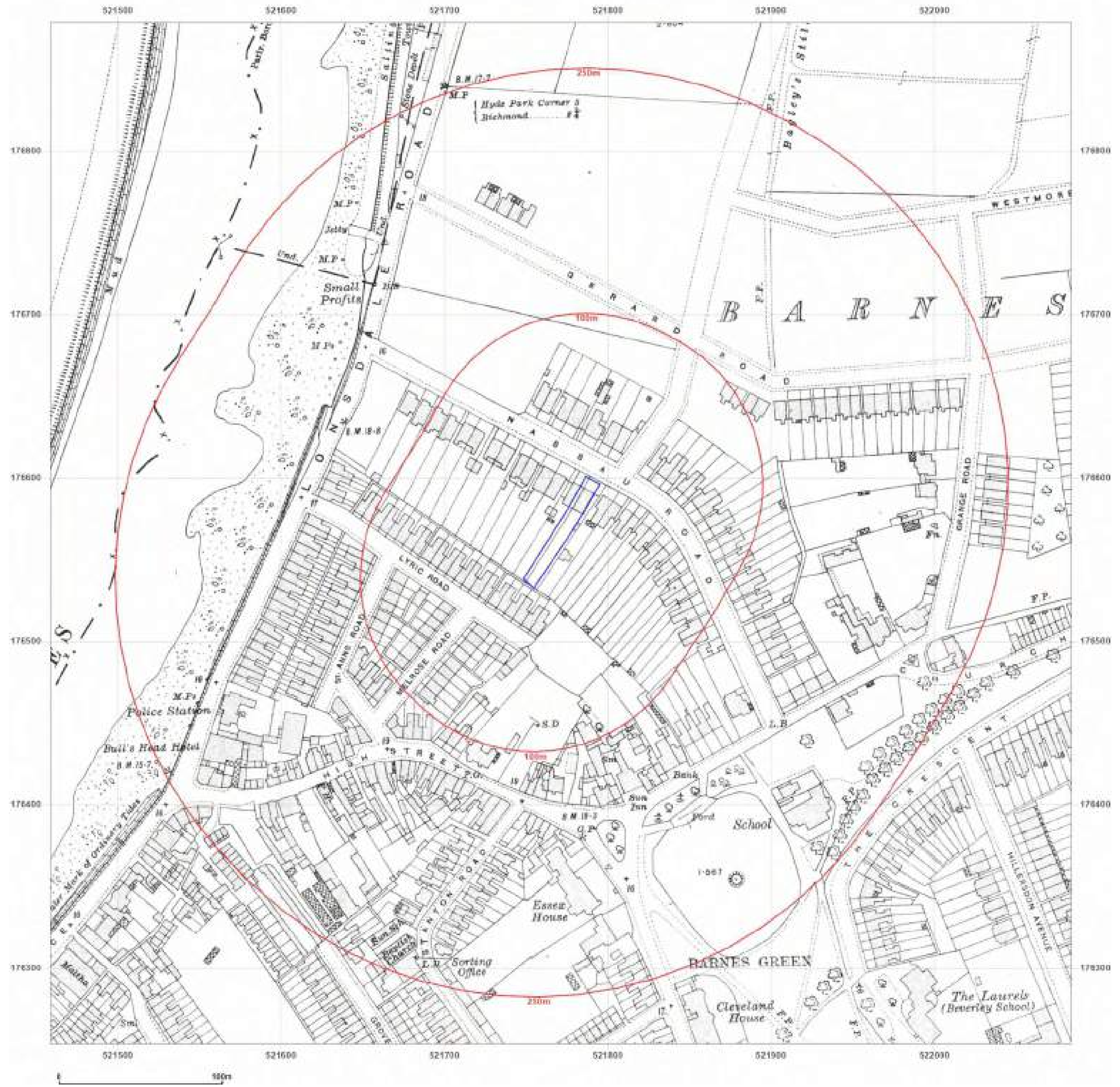


Site Details:

34, NASSAU ROAD, BARNES,
LONDON, RICHMOND UPON
THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** 1919

**Scale:** 1:2,500

**Printed at:** 1:2,500

N
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Surveyed 1919
Revised 1919
Edition N/A
Copyright N/A
Levelled N/A

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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1933**

**Scale:** 1:2,500

**Printed at:** 1:2,500

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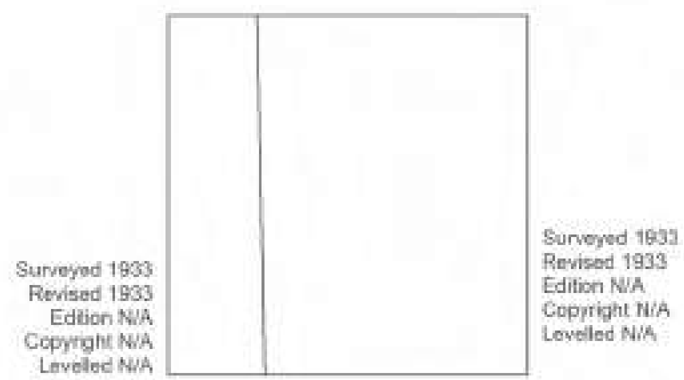


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**Site Details:**

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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1934**

**Scale:** 1:2,500

**Printed at:** 1:2,500

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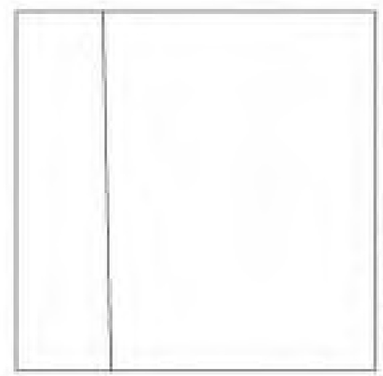

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Revised 1934
Edition N/A
Copyright N/A
Levelled N/A

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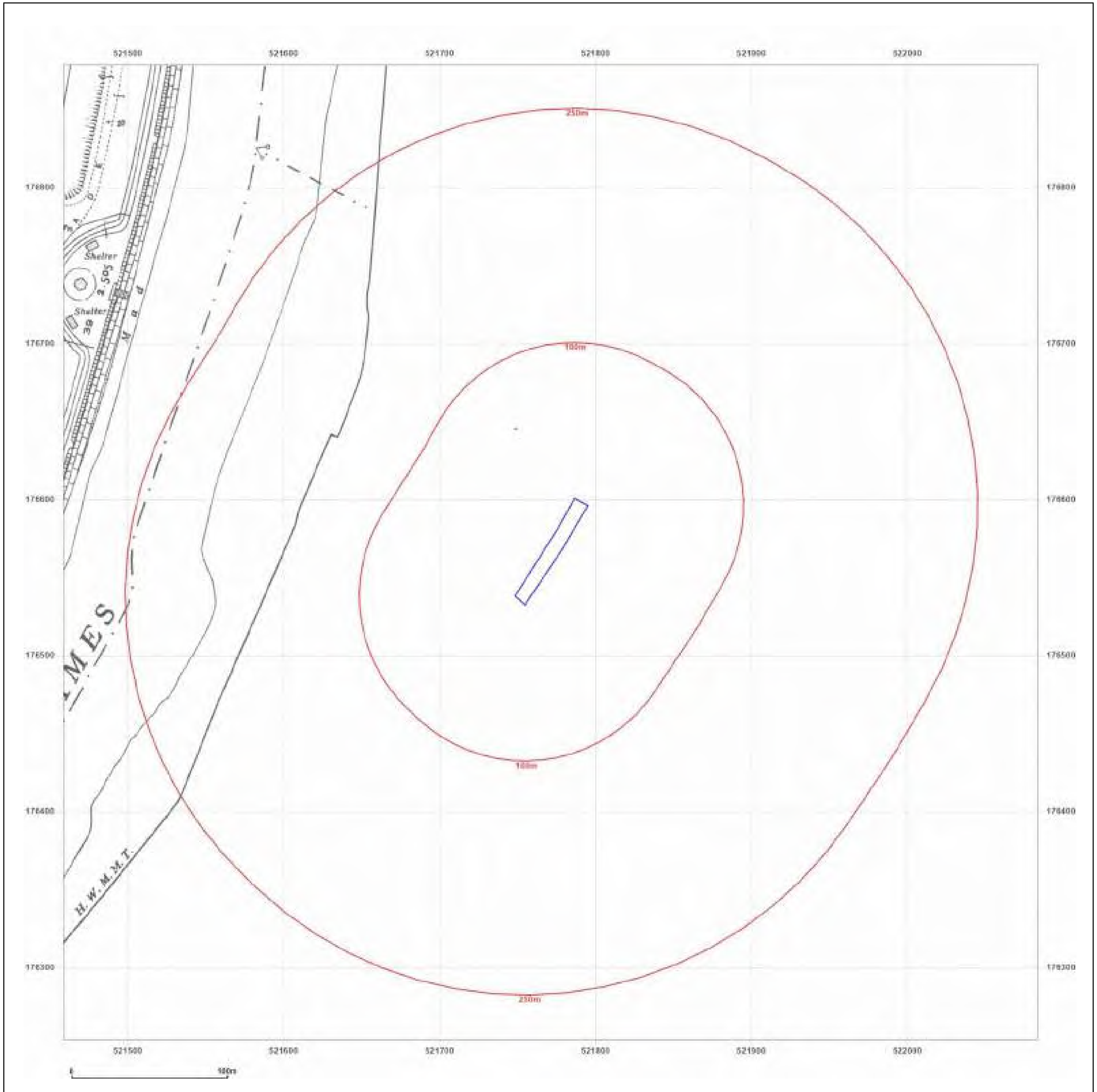


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**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

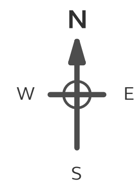
**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

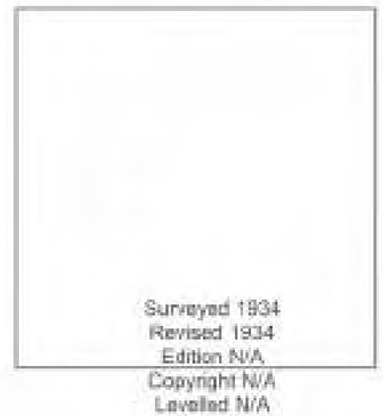
**Map Name:** County Series

**Map date:** 1934

**Scale:** 1:2,500

**Printed at:** 1:2,500

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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1940**

**Scale:** 1:2,500

**Printed at:** 1:2,500


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**Site Details:**

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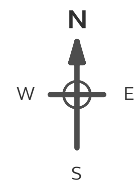
**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

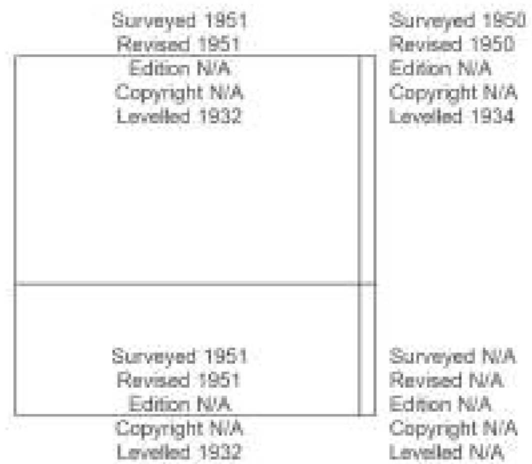
**Map Name:** National Grid

**Map date:** **1950-1951**

**Scale:** 1:1,250

**Printed at:** 1:2,000

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Site Details:

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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** 1951

**Scale:** 1:2,500

**Printed at:** 1:2,500

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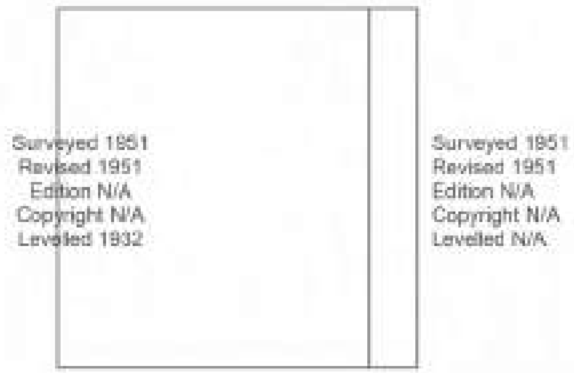


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**Site Details:**

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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** 1951

**Scale:** 1:2,500

**Printed at:** 1:2,500

N
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Surveyed 1951
Revised 1951
Edition N/A
Copyright N/A
Levelled 1932

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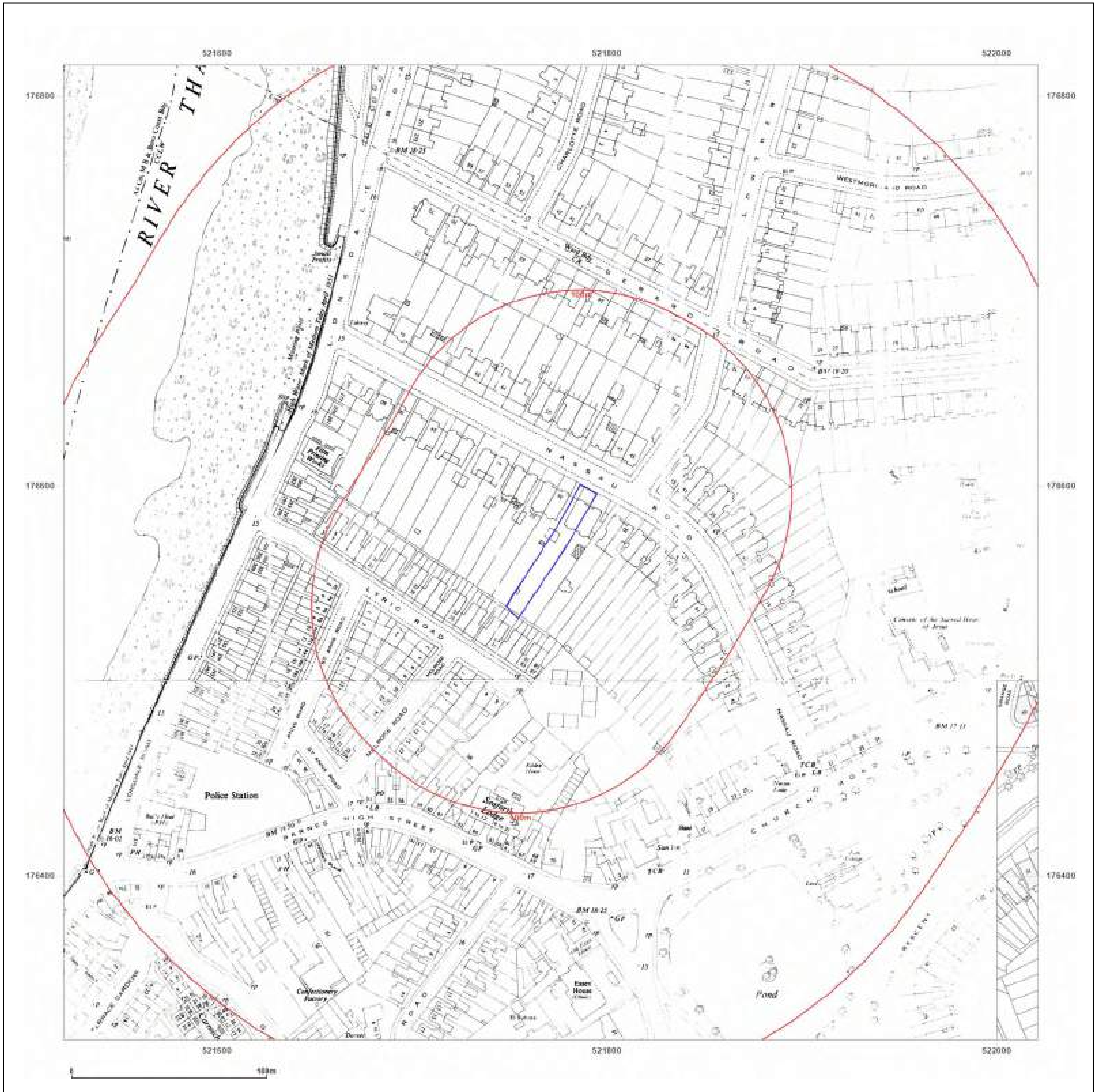


**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** **1951-1952**

**Scale:** 1:1,250

**Printed at:** 1:2,000

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Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled N/A

Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled N/A

Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled N/A

Surveyed 1951
Revised 1951
Edition N/A
Copyright N/A
Levelled 1934

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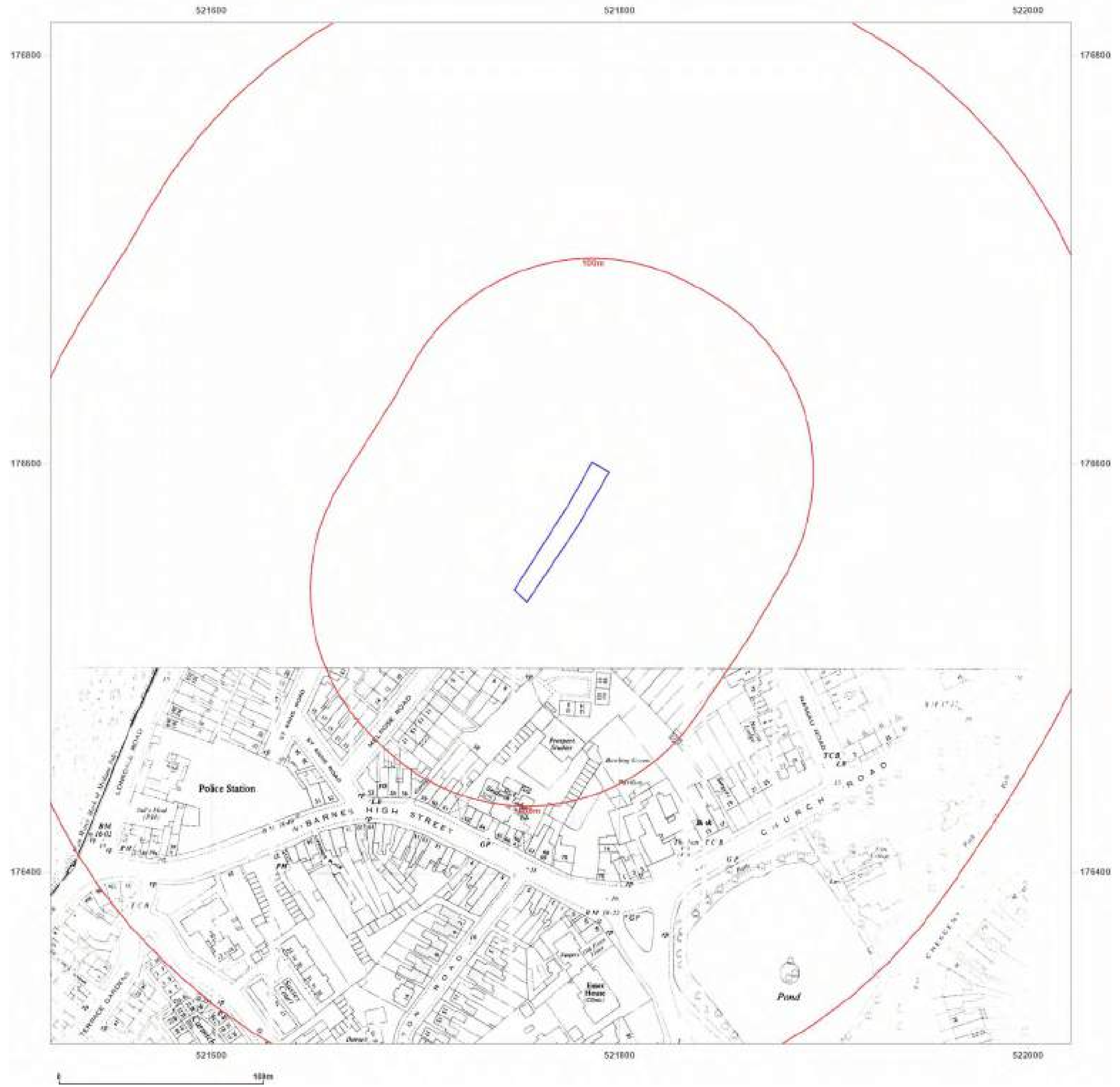


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**Site Details:**

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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** **1964**

**Scale:** 1:1,250

**Printed at:** 1:2,000

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Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled N/A

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| **Client Ref:** | GWPR5909 |
| **Report Ref:** | GS-R7I-VE4-EA3-BPT |
| **Grid Ref:** | 521771, 176566 |

| | |
|---|---|
| **Map Name:** | National Grid |
| **Map date:** | **1966** |
| **Scale:** | 1:2,500 |
| **Printed at:** | 1:2,500 |

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Surveyed 1967
Revised 1967
Edition N/A
Copyright 1968
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**Site Details:**

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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** **1963-1967**

**Scale:** 1:1,250

**Printed at:** 1:2,000

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Surveyed 1951
Revised 1966
Edition N/A
Copyright 1967
Levelled 1954

Surveyed 1963
Revised 1963
Edition N/A
Copyright N/A
Levelled N/A

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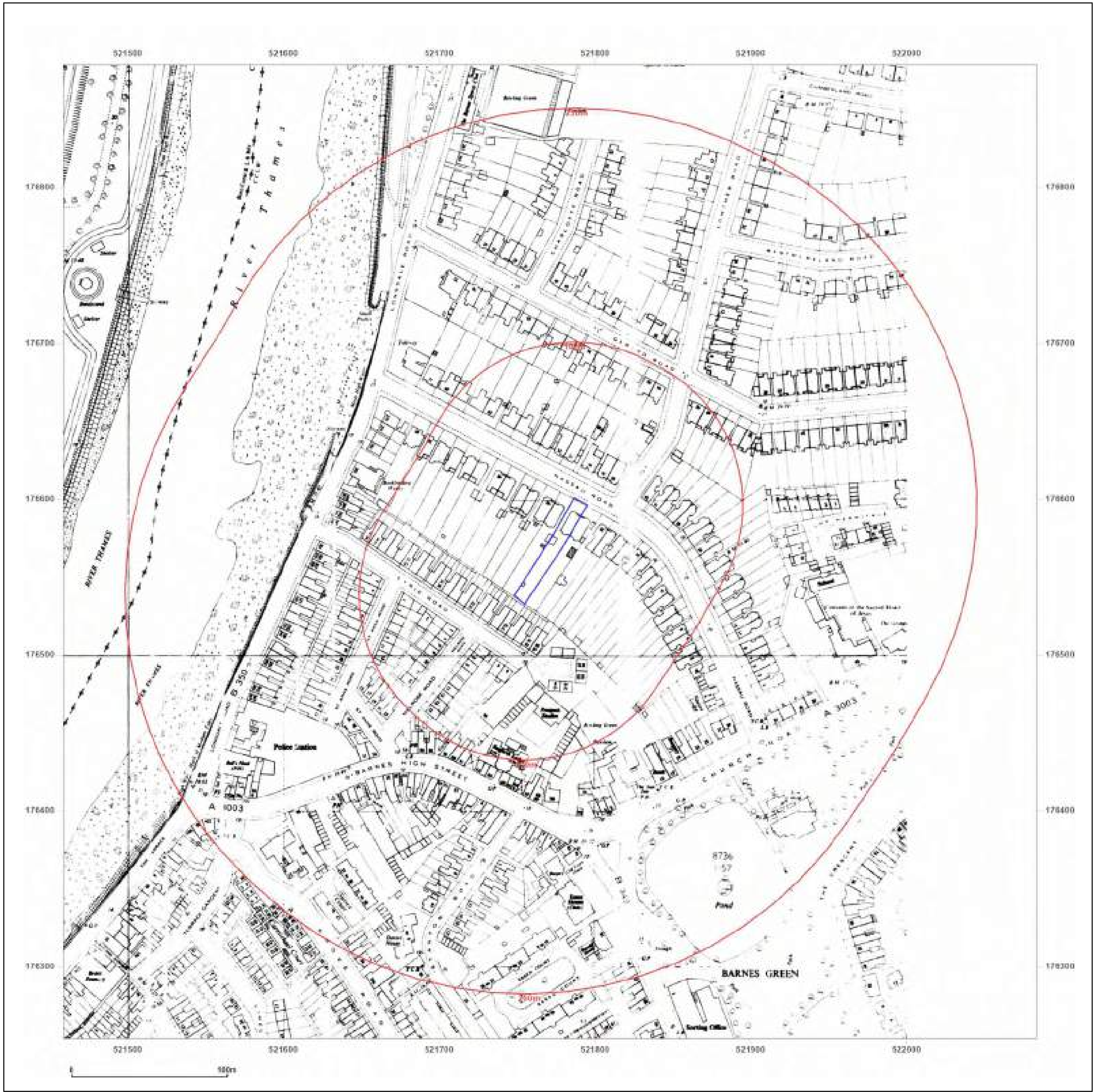


Groundsure INSIGHTS

**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** **1968**

**Scale:** 1:2,500

**Printed at:** 1:2,500

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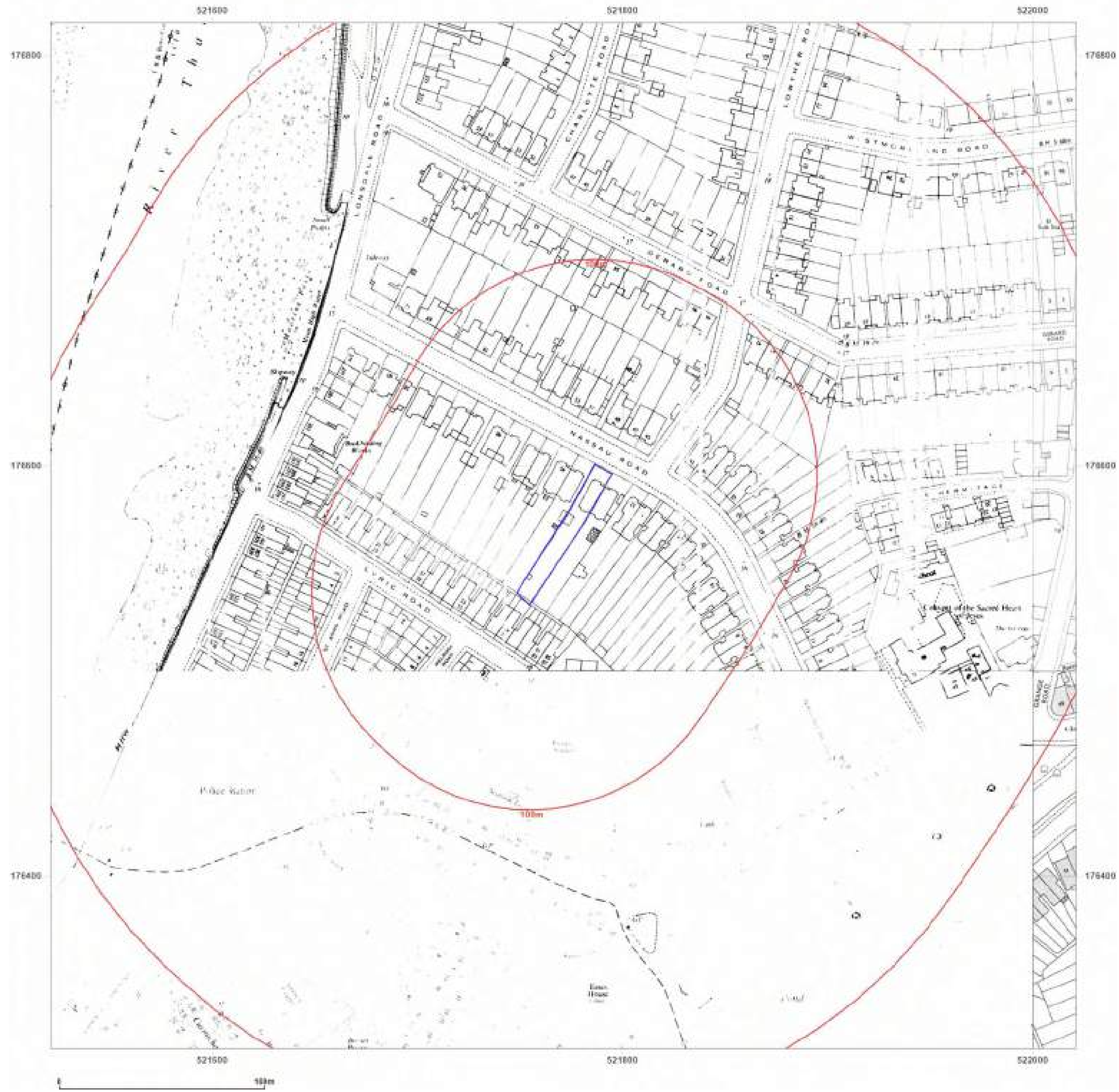


Groundsure INSIGHTS

**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** **1972-1974**

**Scale:** 1:1,250

**Printed at:** 1:2,000

N W E S

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|---|---|
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| Surveyed N/A<br>Revised N/A<br>Edition N/A<br>Copyright N/A<br>Levelled N/A | Surveyed 1951<br>Revised 1973<br>Edition N/A<br>Copyright 1974<br>Levelled 1954 |

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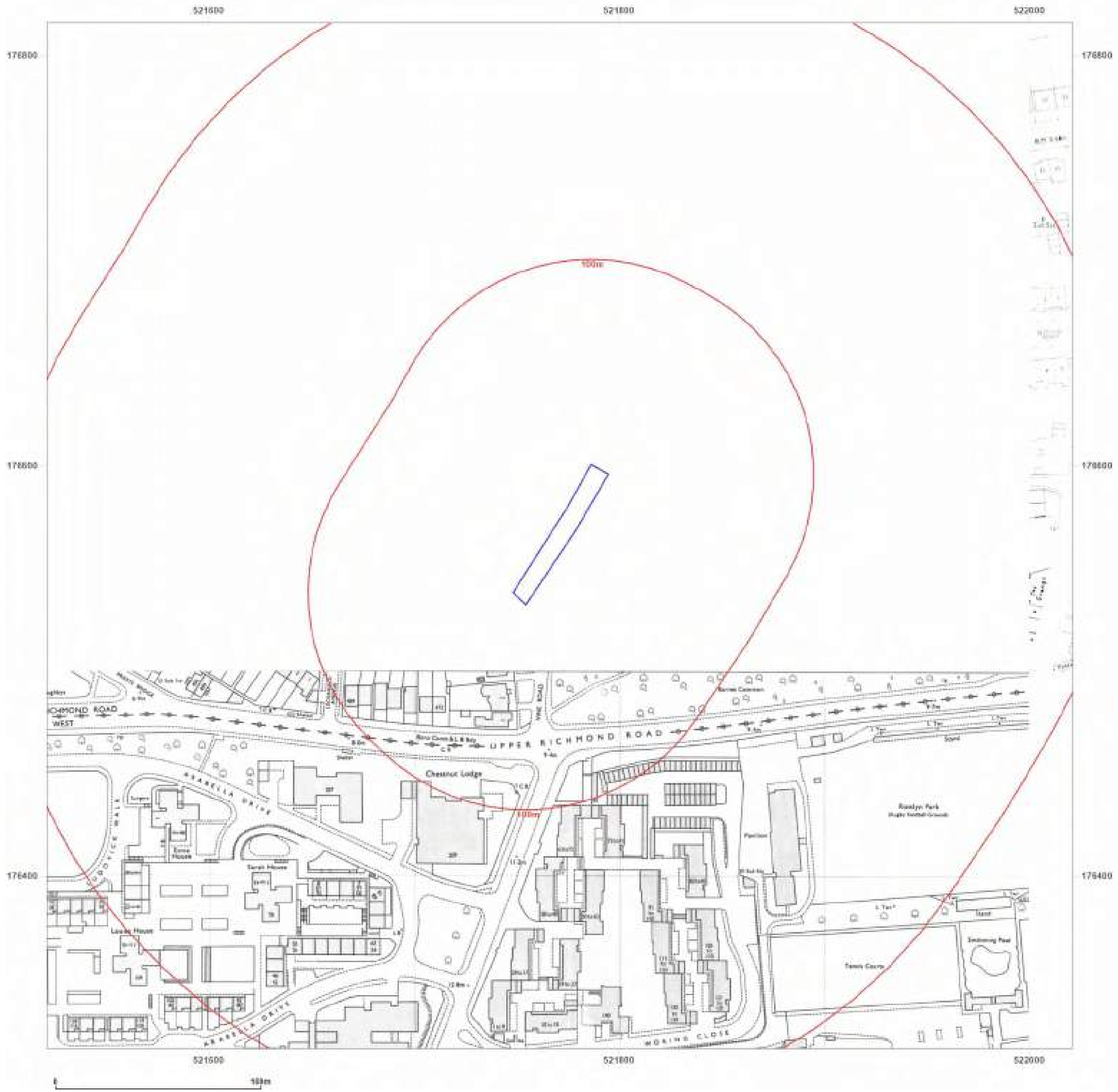


Groundsure INSIGHTS

**Site Details:**

34, NASSAU ROAD, BARNES,
LONDON, RICHMOND UPON
THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** **1979-1983**

**Scale:** 1:1,250

**Printed at:** 1:2,000

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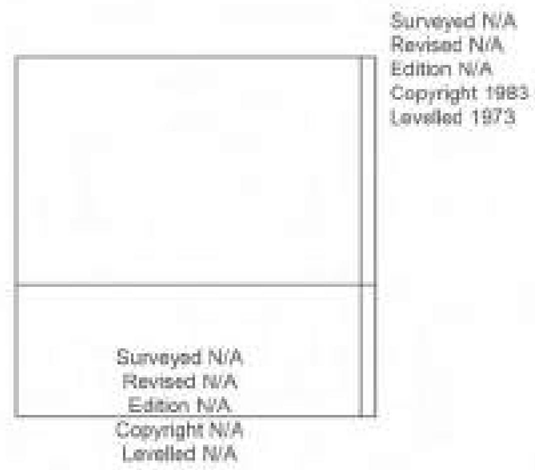


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**Groundsure** INSIGHTS

**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** **1986-1991**

**Scale:** 1:1,250

**Printed at:** 1:2,000

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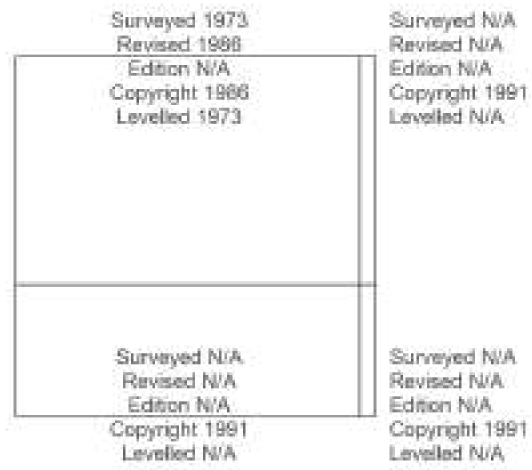


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Groundsure INSIGHTS

**Site Details:**

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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** 1991

**Scale:** 1:1,250

**Printed at:** 1:2,000

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**Site Details:**

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**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** **1991-1993**

**Scale:** 1:1,250

**Printed at:** 1:2,000

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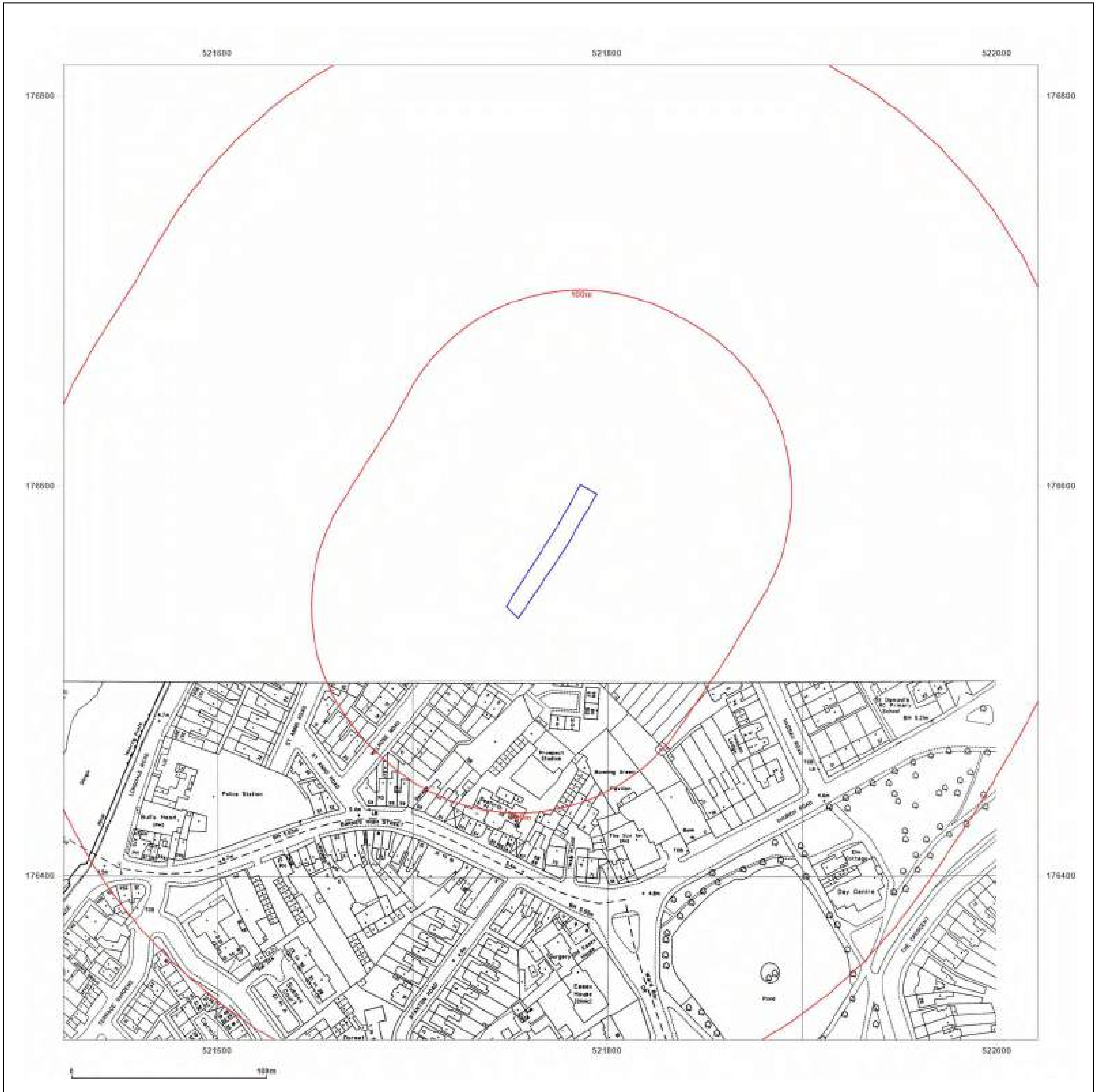


Groundsure INSIGHTS

**Site Details:**

34, NASSAU ROAD, BARNES,
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THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** National Grid

**Map date:** **1993**

**Scale:** 1:1,250

**Printed at:** 1:2,000

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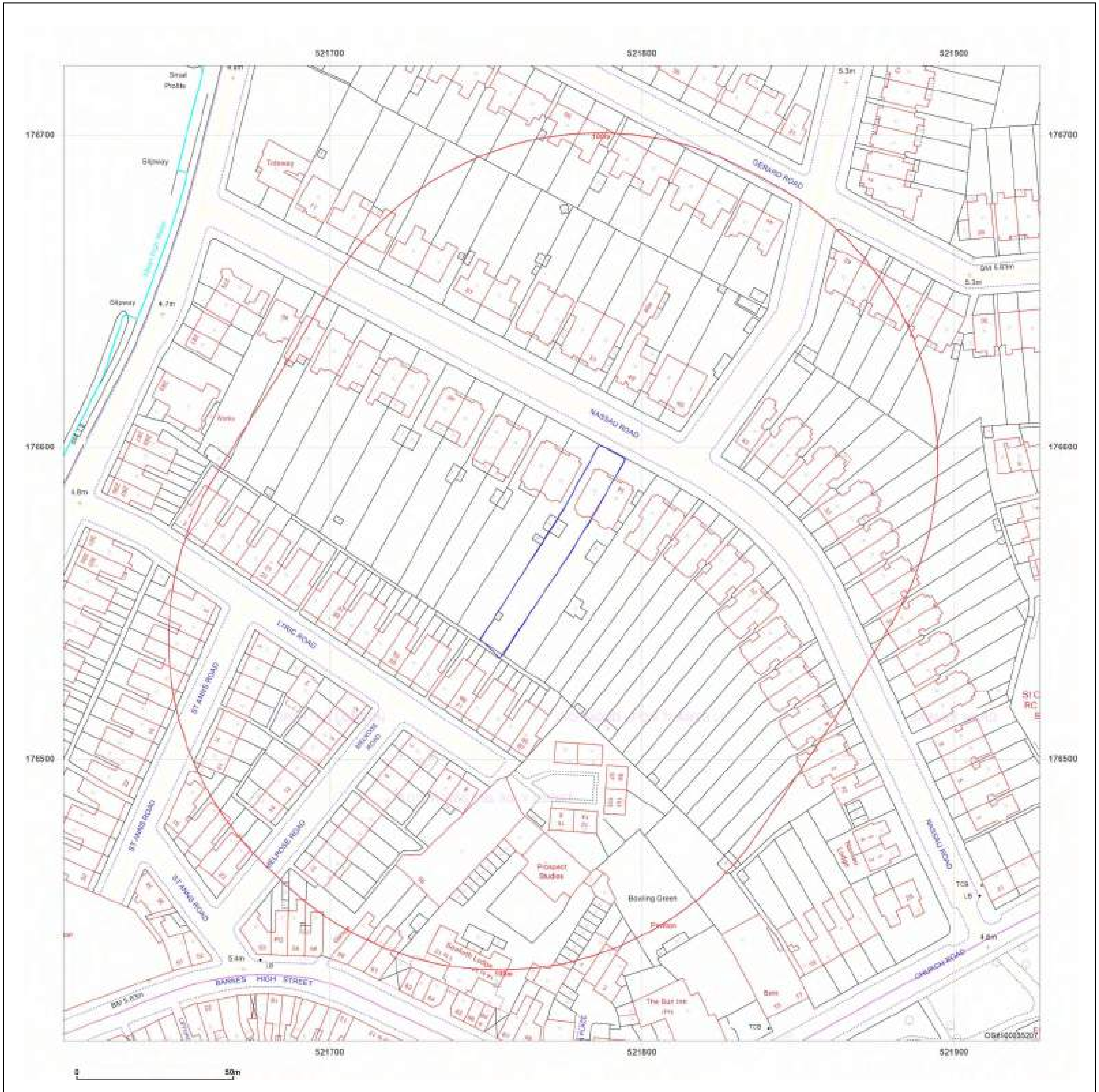


**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** LandLine

**Map date:** 2003

**Scale:** 1:1,250

**Printed at:** 1:1,250

N W E S

2003

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Production date: 03 April 2024

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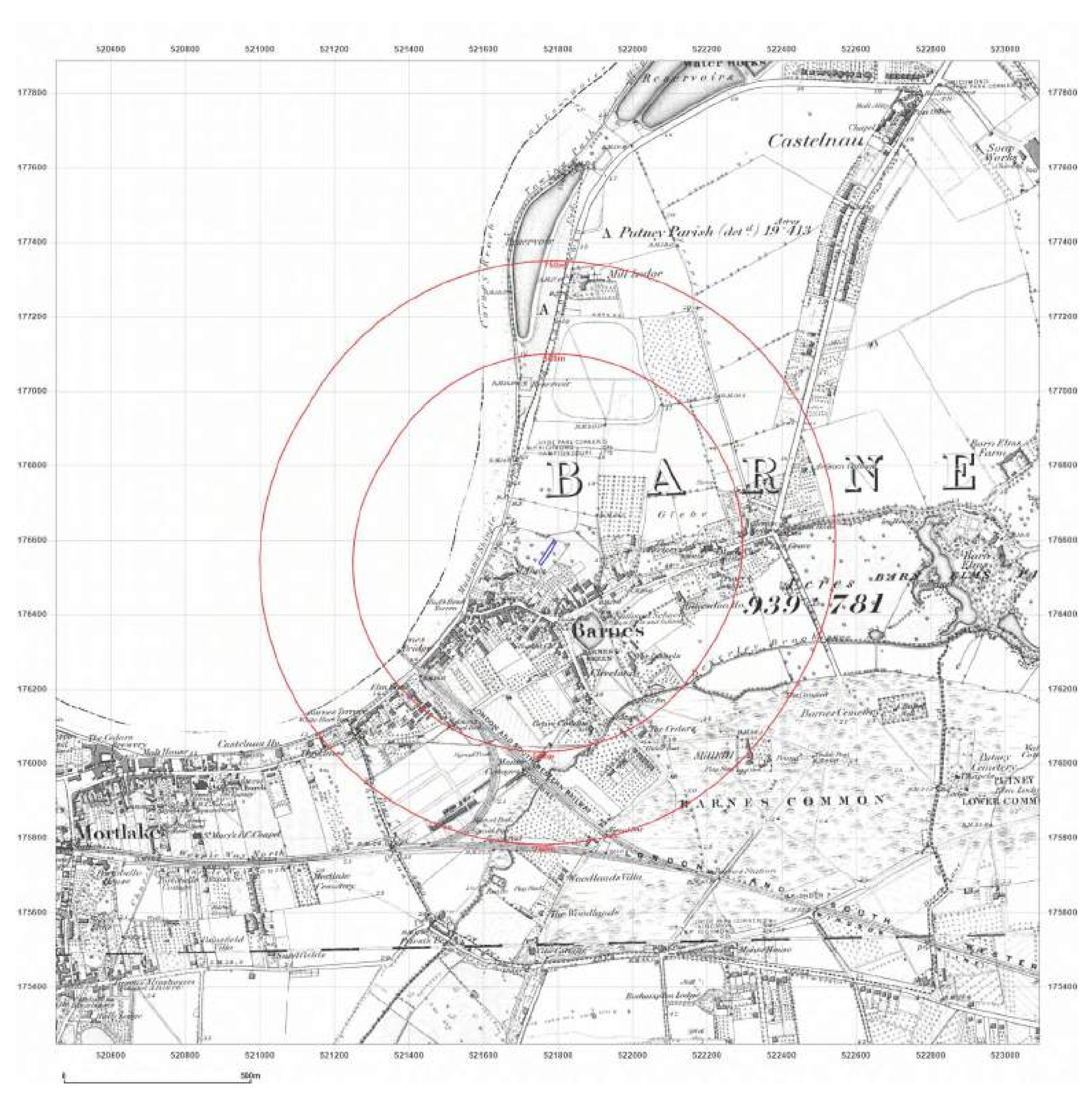




**Site Details:**

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

**Client Ref:** GWPR5909
**Report Ref:** GS-R7I-VE4-EA3-BPT
**Grid Ref:** 521771, 176566

**Map Name:** County Series

**Map date:** **1865-1866**

**Scale:** 1:10,560

**Printed at:** 1:10,560

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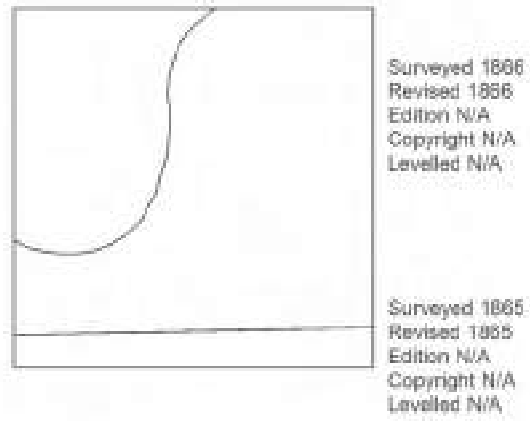


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