construction method statement
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typical underpinning construction sequence

(extract from RBKC town planning policy on subterranean development doc REP/123002/001 draft rev b, by Arup Geotechnics)
1.0 INTRODUCTION

The following report has been prepared to accompany an application for a new basement to the residential property at 7 Selwood Terrace, London, SW7 3QN. This report should be read in conjunction with all relevant information provided by Alan Higgs Architects.

2.0 PROPOSED BASEMENT CONSTRUCTION

In considering the viability of constructing a new basement to the rear of the existing 4 storey property and below the rear 2 storey closet wing, we acknowledge that it is a significantly challenging engineering endeavour and that if poorly planned or executed could cause damage to the existing property.

We have reviewed and consider the contents of the RBKC Town Planning policy on Subterranean Development, Phase 1 – Scoping Study, doc ref REP/123002/001/DRAFT prepared by Arup Geotechnics and have responded to the relevant matters in developing our structural design.

We have also commissioned a detailed site investigation in order to fully study the existing foundations, the existing geology and the existing hydrology. In addition, opening up works will be carried out to investigate the existing structure to the floors over.

2.1 site investigation

The site investigation comprised the following:

- 1 No continuous flight auger Boreholes to a depth of 8.0m below existing lower ground floor level.
- gas and groundwater monitoring standpipe to a depth of 5.0m in the borehole
- 2 No trial pits to expose the existing foundations to the party wall, rear wall and internal wall.
- sampling & insitu testing as appropriate to the ground conditions encountered in the borehole & trial pits.
- laboratory testing of soil properties and contamination testing.

The preliminary risk assessment, geo-environmental and geotechnical site assessment report prepared by RSK Environment Limited, reference, 26185 R01 (00) dated March 2013 is attached, refer to appendix c.
In summary the ground conditions encountered were consistent with geological records and comprised approximately 0.6-1.85 of made ground over 5.05m of Kempton Park Gravel with London Clay Formation encountered at 6.8m top the base of the borehole depth. The Kempton Park gravel was encountered at a depth between 1.75 and 1.85 below ground level and comprised initially very dense, becoming medium dense with depth, orange brown, locally clayey, medium to coarse sand, and fine to coarse gravel of flint. The London Clay Formation was encountered beneath the Kempton Park Gravel at a depth of 6.8m bgl and proven to the full depth of investigation. Based on the site descriptions and in-situ and laboratory testing carried out, this stratum can be described as dark brown and grey slightly sandy Clay.

Groundwater was encountered during the investigation within BH1 at a depth of 6m bgl. Whilst a groundwater monitoring standpipe was installed within the borehole, it was limited to a depth of 4.7m begl due to instability at the base of the Kempton Park Gravel. No groundwater was recorded during the subsequent monitoring of the standpipe installation, confirming the standing groundwater within the shallow aquifer to be below a depth of 4.7m begl.

The existing foundations for the property were encountered between 600mm & 1350mm below existing lower ground floor level, in the natural material. The main rear wall foundation comprised brick only with no corbelling. The tarden walls and side walls generally have brick corbelling on a mass concrete strip.

Other than those typically found in urban fill material there are no contamination issues or gas issues on site.

3.0 DESIGN CONSIDERATIONS

The site investigation has confirmed that the existing ground conditions are suited to the construction of the proposed basement with no adverse instability, gas or water ingress issues.

The proposed basement is located to the rear of the main building liner and below the existing rear closet wing. The existing rear lower ground floor extension will be reconfigured with the basement extending below the rear extension from party wall to party wall.

The proposed basement construction would see foundations and retaining structures being constructed approximately 4.0m below existing lower ground floor and garden level. Refer to drawings contained within appendix A. Taking a factor of safety of about 3 against shear failure an allowable net bearing pressure of approximately 200 kN/m2 is recommended. Total and differential settlement is expected to be within acceptable limits and should not exceed 25mm under the anticipated design loadings and should generally be substantially complete (80% or 10mm) by the end of the construction period. The new foundations and retaining walls will be designed and constructed in accordance with the recommendations contained within the site investigation report contained in appendix C. Refer to calculations contained in appendix b.
The current foundations of the building and the proposed foundations and retaining walls will be below the zone of influence of the root system of the existing tree located with the rear garden.

The existing foundation to the rear elevation of the main building, which has been confirmed as plain, un-corbelled brick located at 600mm below existing ground level, will be retained and the proposed works will not impact on them.

A mini piled retaining wall will be constructed complete with reinforced concrete capping beam and internal reinforced concrete liner wall. The piling will be offset from the rear elevation to provide construction tolerance and the ground beam will be isolated from the existing foundation using a slip membrane or compressible filler.

The existing foundation to garden wall and adjacent closet wing will be underpinned to form the new perimeter retaining wall and these works will be carried out in accordance with normal industry practice, with the pin width limited to 1000mm and limited number of pins excavated at any given time. This will ensure that ground stability is maintained and limit the requirement for temporary shoring. For typical details and sequence of work refer to appendix d.

There are no signs of historic movement within the rear façade or internal walls. Generally the property and terrace as a whole does not show any signs of long term movement or structural distress. The walls are suitable robust to allow the works to progress adjacent to the existing foundations and for underpinning to be carried out safely and without affecting the integrity of the wall locally or globally. The sections of existing foundation to garden wall and adjacent closet wing below ground level will be retained as part of the works, with any projecting brick nibs or corbels removed to create a flush internal face. The base of the underpin will be integral with the enhanced base of the retaining wall in order to achieve a bearing stress similar to that created under the existing foundations.

Although we are changing the depth of the foundations we have designed the foundation to bear within the same strata, the Kempton Gravels and to have a similar bearing pressure to the existing foundations. This is proposed to prevent a hard point or sudden change with the foundation that could lead to hinging and reflected cracking.

The site investigation confirms that the Aggressive Chemical Environment for Concrete Classification is AC-1 therefore the buried concrete elements will be designed in accordance with BRE Special Digest 1 : 2005 for full DS-1 conditions.

Given the nature of the works Party Wall Awards will be required with each adjoining owner. As part of the party wall process we would seek to carry out structural pre-condition surveys of the adjoining properties in order to identify any inherent structural defects prior to commencing site works.
4.0 CONSTRUCTION METHODOLOGY

Given the nature of the project the construction works would be carried out by a specialist ground works contractor. A detailed construction methodology will be developed prior to commencing the works on site. The works are not unusual within London and there are now a small number of specialist contractors who are practiced in such works and could undertake this project without affecting the integrity of the property over, adjacent properties and structures.

The steel box frame to the existing closet wing will be installed prior to commencing basement excavation in order to reduce the required temporary works and limit working at height.

The existing brick foundation to rear elevation of main building to be retained with new concrete works isolated from it and the edge of the foundation should be exposed by hand digging in order allow the piling to be set out accurately. Piling setting out / pilling offset from rear wall determined by the minimum nosing distance of the piling rig, currently assumed to be 250mm to c/l of pile, subject to verification by specialist piling contractor.

Mini piles to the specialist piling contractors design will be rotary bored and lined as required. As the general excavations progress the piles are to be fully propped until capping beam and liner wall are cast. The piles will be constructed integral with a new reinforced concrete pile cap / ground beam which is to be isolated from existing foundations using a slip membrane or 50mm compressible fill. The works to the rear elevation of the main property will be completed with a new reinforced concrete liner wall, 150mm thick, to be cast to internal face of piled retaining wall and capping beam, following which any temporary props can be removed. A detailed method statement will be developed by the specialist contractor prior to commencing.

The exact sequence of construction of the underpinning will be determined by the specialist contractor in conjunction with the District Surveyor, depending on the structural environment and access constraints. Typical details and sequence of works is contained in appendix d. We would anticipate the works progressing as outlined below.

- The access trench is first excavated, directly underneath the wall to be underpinned. The length of any base is individually assessed on site with due regard to the type and condition of the foundation, and structural geometry above. The maximum length of any underpinning base will be 1000mm.
- Carefully remove and trim back any projecting brick footing to the brick wall.
- Excavate using hand and compressed air tools removing spoil until the design depth is reached, and removed to muck away conveyor.
• Soils, where unstable in the temporary condition, will be shored. For clays or dense sands exhibiting effective cohesion, shoring may not be implemented. Shoring system design will be undertaken by the specialist contractor if required.

• Once the excavation is completed to the design depth and width. The stratum at the proposed founding depth is confirmed as being appropriate by the engineers.

• The design steel reinforcement will be fixed in the toe section of the underpinning base. This will be checked by the engineer and building control inspector prior to concreting.

• Following construction of the toe section, the design steel reinforcement will then be fixed in the stem (or wall) section. This will be checked by the engineer and building control inspector prior to concreting.

• A single sided shutter is then erected, and concrete poured to form the underpinning base up to a maximum of 75mm below the underside of the existing foundation.

• After 24 hours the temporary wall shutters are removed. The void between the top of the underpin base and underside of the existing foundation will then be dry-packed with a mixture of sharp sand and cement (Ratio 3:1).

• A further 24 hours is allowed before adjacent sections can be excavated. Construction joints, if required, are formed using a suitable shear key or joggle joint. In exceptional circumstances, dowel bars are incorporated. Typically these are post drilled and resin fixed with specification as per structural design.

• A record will be kept of the sequence of construction, which will be in strict accordance with recognised industry procedures. The as-built records will be updated as necessary and issued to involved parties during the works.

• A detailed construction methodology will be developed prior to commencing the works on site.

5.0 CONCLUSIONS

The site investigation has confirmed that the existing ground conditions are suited to the construction of the proposed basement with no adverse instability, gas or water ingress issues.

The proposed works will not adversely affect the structural integrity or the stability of the individual property or terrace as a whole.
proposed basement plan
proposed lower ground floor plan
proposed first floor plan
proposed section a-a

proposed drawings
Notes:
This drawing is to be read in conjunction with the architect’s drawings and all other relevant drawings and specifications.

For General Engineering Notes refer to drawing 935/P/500.

Temporary works proposals to be submitted for review by the Engineer for all works prior to proceeding.

1. Existing foundation to garden wall and adjacent closet wing to be underpinned to allow new basement to be excavated. Underpinning to be constructed in hit and miss pin, maximum 1.0m wide and with a maximum of 25% of the total length of the wall excavated at any time. Underpinning to be reinforced with adjacent pins dowelled together for continuity. Detailed sequence of works to be developed by the specialist contractor for approval of the engineer prior to progressing. Underpinning to maintain thickness of existing foundation to wall over.

2. New retaining wall to garden to be constructed with base reinforcement integral slab and wall reinforcement integral with underpins at each end. Contractor to provide temp works to rear face to prevent loss of material including made ground during construction, such as trench sheeting and propping, to be installed as the excavations progress.

3. Typically 400x1000mm RCC6 ground bearing slab. Allow for Cordek void former to the underside of slab to cater for heave. Slab complete with insulation and waterproofing in accordance with architect’s details.

4. External courtyards to be provided with a gully and existing drainage to be modified locally with design and installation by the contractor.

5. Existing brick foundation to rear elevation of main building to be retained with new concrete works isolated from it.

6. CFA mini piles, assumed 200mm dia. To be fully propped until capping beam and liner wall are cast. Actual size of piles and detail design by specialist piling contractor.

7. Piling set out / piling offset from rear wall determined by min nosing distance of rig, currently assumed to be 250mm to c/l of pile, subject to verification by specialist piling contractor.

8. New reinforced concrete pile cap / ground beam to be isolated from existing foundations using 50mm compressible fill.

9. New reinforced concrete liner wall, 150mm thick, to be cast to internal face of piled retaining wall.

Underpinning Notes:

A. The contractor shall be responsible for ensuring that his operations do not in anyway impair the safety or condition of the existing structure. He shall provide any temporary supports required for this purpose and shall carefully inspect the condition of both before and during the excavation of the works and immediately inform the engineer if he considers that any stringent procedure than that specified is necessary.

B. Continuous underpinning where relevant is to be carried out to the satisfaction of the engineer and building inspector in short sections not exceeding 1000mm. The works are to be carried out in a sequence such that the unsupported lengths of the existing foundations are equally distributed along the wall length being underpinned. The sum of the unsupported lengths are not to exceed one fifth of the total length. In no cases is a section to be excavated immediately adjacent to one which has just been completed.

C. The underside of existing footings are to be cleaned and free from any soil or loose material before underpinning.

D. The body of the underpinning is to be cast to suit the width of the existing foundation and depth as shown on relevant sections. As far as practicable excavations and consisting of any section of underpinning shall be carried out on the same day.

E. The concrete for the underpinning is to be poured to 75mm below the soffit of existing foundations. The concrete is to be fully compacted using a mechanical vibrator. The remaining top 75mm is to be Dry-Packed tight to the underside of existing footings with a well rammed 1:3 cement & sharp sand mix 24 hours after pouring.

F. Excavation of any section of underpinning shall not commence until at least 48 hours after the completion of any adjacent section of works and when the adjacent section concrete strength has reached a strength of 10N/mm² minimum.

G. A detailed method statement indicating sequence of works to be submitted by contractor prior to commencing work.

H. The contractor is to ensure that no excavations undermine adjacent structures. If adjacent structures may be undermined by any proposed excavations the engineer is to be notified immediately.
Notes:

This drawing is to be read in conjunction with the architect's drawings and all other relevant drawings and specifications.

For General Engineering Notes refer to drawing 935/P/500.

Temporary works proposals to be submitted for review by the Engineer for all works prior to proceeding.

1. Outline of underpinning below existing foundations to garden wall and adjacent closel vang.

2. Outline of new retaining wall to garden to be constructed with base reinforcement integral slabs and wall reinforcement integral with underpins at each end. Contractor to provide temp works to rear face to prevent loss of material including made ground during construction, such as trench sheeting and propping, to be installed as the excavations progress.

3. New timber floor costs with full depth noggings at 1/3 spans and supported each end on joist hangers. Floor complete with 18mm WBP ply decking, fully screwed to costs.

4. Fabricated metal grating to external courtyard.

5. Existing brick foundation to rear elevation of main building to be retained with new concrete works isolated from it.

6. New reinforced concrete pile cap / ground beam to be isolated from existing foundations using 50mm compressible fill.

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Notes:
This drawing is to be read in conjunction with the architect’s drawings and all other relevant drawings and specifications.

For General Engineering Notes refer to drawing 935/P/500.

Temporary works proposals to be submitted for review by the Engineer for all works prior to proceeding.

1. New box frame to support retained side wall of closet wing comprising Beam A over columns C1 and Beam B below.
2. Existing roof to be retained.
3. Assumed span of existing floor joists.
Notes:
This drawing is to be read in conjunction with the architect’s drawings and all other relevant drawings and specifications.

For General Engineering Notes refer to drawing 935/P/500.

Temporary works proposals to be submitted for review by the Engineer for all works prior to proceeding.

1. Existing foundation to garden wall and adjacent closet wing to be underpinned to allow new basement to be excavated. Underpinning to be constructed in hit and miss pin, maximum 1m wide and with a maximum of 25% of the total length of the wall excavated at any time. Underpinning to be reinforced with adjacent pins dowelled together for continuity. Detailed sequence of works to be developed by the specialist contractor for approval of the engineer prior to progressing. Underpinning to match thickness of existing foundation to wall over.

2. New retaining wall to garden to be constructed with base reinforcement integral slab and wall reinforcement integral with underpins at each end. Contractor to provide temporary works to rear face to prevent loss of material including made ground during construction, such as trench sheeting and propping, to be installed as the excavations progress.

3. Typically 400mm RC25 ground bearing slab. Allow for Cordek void former to the underside of slab to cater for heave. Slab complete with insulation and waterproofing in accordance with architect’s details.

4. New box frame to support retained side wall of closet wing comprising Beam A over, columns C1 and Beam B below.

5. Fabricated metal grating to external courtyard.

6. Existing garden wall.

7. Existing closet wing wall.

8. Existing rear elevation of property.

9. Existing brick foundation to rear elevation of main building to be retained with new concrete works isolated from it.

10. CFA mini piles, assumed 200mm dia. To be fully propped until capping beam and liner wall are cast. Actual size of piles and detail design by specialist piling contractor.

11. Piling set out / pilling offset from rear wall determined by min nosing distance of rig, currently assumed to be 250mm to c/l of pile, subject to verification by specialist piling contractor.

12. New reinforced concrete pile cap / ground beam to be isolated from existing foundations using 50mm compressible fill.

13. New reinforced concrete liner wall, 150mm thick, to be cast to internal face of piles retaining wall.
design calculations
Date: March 2012
Job No: 935
Project: Services Design

New Master En Suite Wardrobe

- Bathroom located at 1st floor level & surface
  - Site lines & closet lines
  - Floor layout
  - Door lines - ensuite
  - Door lines - how to unfurl room

- Bathroom plan

Floor - 2000
Row - 2000

1. Bathroom to ensuiteWC & ensuite C1 - located back to ensuite WC & back
2. Please confirm connection to future base.
3. Column C1's support to bathroom & ensuite C1

4. Bathroom & ensuite WC floor finishes, within & Lines of column/senior to load & metal beam

Engineer: [Signature]
Checked: [Signature]

Sheet No: 10.
Date: Monday 13
Job No: 935
Project: Selwood Residence

a. Beam & column sizes are based on foundations.

b. Site to be excavated.

c. ADAR

Beam A: 230 x 116 UB 31
B: 200 200 x 133 UB 20
C: 200 x 122 UB 30

D: 150 x 90 x 20 lite - steel reinforce

C1: 152 x 23
### Beam: A - Closet Wing 1st Floor

<table>
<thead>
<tr>
<th>Load name</th>
<th>Loading w1</th>
<th>Start x1</th>
<th>Loading w2</th>
<th>End x2</th>
<th>R1comp</th>
<th>R2comp</th>
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<td>U D o.w.</td>
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<td>0</td>
<td>L</td>
<td>0.73</td>
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<tr>
<td>U D Roof SW</td>
<td>0.7x(2.4/2)</td>
<td>0</td>
<td>L</td>
<td>1.53</td>
<td>1.53</td>
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<tr>
<td>U L Roof Imposed</td>
<td>0.75x(2.4/2)</td>
<td>0</td>
<td>L</td>
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<tr>
<td>U D 1st Floor SW</td>
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<td>L</td>
<td>0.99</td>
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<tr>
<td>U L 1st Floor Imposed</td>
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<td>0</td>
<td>L</td>
<td>3.29</td>
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<tr>
<td>U D New Roof SW</td>
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<td>0</td>
<td>L</td>
<td>2.04</td>
<td>2.04</td>
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<tr>
<td>U L New Roof Imposed</td>
<td>0.75x(2.8/2)</td>
<td>0</td>
<td>L</td>
<td>1.92</td>
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<tr>
<td>U D Masonry Flank Wall SW</td>
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<td>0</td>
<td>L</td>
<td>32.46</td>
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**Unfactored reactions (kN) Total:**

- Dead: 37.75
- Live: 6.84

**Factored reactions:**

- Dead: 63.80
- Live: 6.84

**Total load: 89.18/127.60 kN Unfactored/Factored**

- Load types: U:UDL  D: Dead;  L: Live  (positions in m. from R1)

Maximum B.M. (factored) = 58.2 kNm at 1.83 m. from R1

Maximum S.F. (factored) = 63.8 kN at R1

Live load deflection = $8.67 \times 10^8/EI$ at 1.83 m. from R1 ($E$ in N/mm$^2$, $I$ in cm$^4$)

Total deflection = $56.5 \times 10^8/EI$ at 1.83 m. from R1

Beam calculation to BS5950-1:2000 using S275 steel

**SECTION SIZE : 254 x 146 x 31 UB  S275 (compact)**

$D=251.4 \text{ mm } B=146.1 \text{ mm } t=6.0 \text{ mm } T=8.6 \text{ mm } I_x=4,410 \text{ cm}^4$  $r_y=3.36 \text{ cm}$  $S_x=393 \text{ cm}^3$  $x=29.6$

**Shear**

Shear capacity = $0.6 \times p_y \times t \times D = 0.6 \times 275 \times 6.0 \times 251.4/1000 = 249 \text{ kN (>=63.8) OK}$

**Bending**

Maximum moment = 58.21 kNm at 1.83 m. from R1

Moment capacity, $M_c = p_y \times S_x = 275 \times 393/1000 = 108.1 \text{ kNm OK}$

**Lateral-torsional buckling**

Beam is laterally restrained at supports only; effective length = 1.0L

Bending strength, $p_b = 156.1 \text{ N/mm}^2$

Maximum moment within segment, $M_x = 58.21 \text{ kNm}$

Equivalent uniform moment factor, $m_{LT} = 0.925$  ($M_2=43.7$, $M_3=58.2$, $M_4=43.7$)

Equivalent uniform moment = $0.925 \times 58.21 = 53.85 \text{ kNm}$

Buckling resistance moment, $M_b = p_y \times S_x = 156.1 \times 393/1000 = 61.35 \text{ kNm OK}$

**Web capacity**

Check unstiffened web capacity with load of 63.80 kN

- $C_1 = 53.5 \text{ kN}$;  $C_2 = 1.65 \text{ kN/mm}$;  $C_4 = 170$;  $K = \min(0.5+(a_e/1.4d),1.0)$;  $p_{yw} = 275\text{N/mm}^2$

(for derivation of $C$ factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)

Bearing capacity, $P_w = C_1+b_1C_2$  ($a_e$ taken as zero)  Buckling capacity, $P_x = K \times (C_4 \times P_w)$

Minimum required stiff bearing length, $b_1 = 20\text{ mm}$  ($a_e = 10\text{ mm}$;  $K = 0.533$)

Buckling capacity, $P_x = 64.5 \text{kN}$
milk structures

With $b_t = 20\text{mm}$, bearing capacity, $P_w = 86.5 \text{kN}$

**Deflection**

LL deflection $= 8.665 \times 10^8 / 205,000 \times 4,410 = 1.0 \text{mm} \ (L/3808) \ OK$

TL deflection $= 56.46 \times 10^8 / 205,000 \times 4,410 = 6.2 \text{mm} \ (L/584)$

*Encase beam to provide one hour fire resistance as per specification*
milk structures

<table>
<thead>
<tr>
<th>Pos Load</th>
<th>Dead kN</th>
<th>Live kN</th>
<th>Fact. kN</th>
<th>Offset</th>
<th>M_xx</th>
<th>M_yy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bm: A - Closet Wing : R1</td>
<td>37.75</td>
<td>6.84</td>
<td>63.80</td>
<td>100</td>
<td>-11.24</td>
<td>0.00</td>
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<tr>
<td>Total load</td>
<td>37.75</td>
<td>6.84</td>
<td>63.80</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional user-entered moments:

|                          | 5.00 | 5.00 | 16.24 | 5.00 |

Load offsets are measured in mm. from faces of member; moments in kNm

SECTION SIZE : 152 x 152 x 23 UC  S275

Design strength, \( p_y = 275 \text{N/mm}^2 \) \( \varepsilon = 1.00 \)

Classification: Flange: \( b/T = 76.1/6.8 = 11.2 \leq 15 \varepsilon (15.0) \): semi-compact (Table 11)  
Web: \( r_1 = 0.324; \ r_2 = 0.079 \)
\( d/t = 123.6/5.8 = 21.3 \leq 80 \varepsilon + r_1 (60.4) \): plastic

For design purposes section classification is semi-compact

Major axis: \( L_E = 1.0L = 3.00 \text{ m}. \)  Slenderness, \( \lambda_x = 3.00 \times 100/6.54 = 45.9 \)

Minor axis: \( L_E = 1.0L = 3.00 \text{ m}. \)  Slenderness, \( \lambda_y = 3.00 \times 100/3.70 = 81.1 \)

Compression:

Compressive strength, \( p_{cx} = 242.4 \text{N/mm}^2 \) (Annex C, strut curve b: \( a = 3.5 \))  
\( p_{cy} = 159.1 \text{N/mm}^2 \) (Annex C, strut curve c: \( a = 5.5 \))

Compression resistance, \( P_c = A_g \cdot p_y = 29.2 \times 100 \times 159.1/1000 = 464.7 \text{kN} \)

Bending about major axis:

Moment capacity, \( M_{cx} = p_y \cdot S_{eff} = 275 \times 176/1000 = 48.47 \text{kNm} \)

Equivalent slenderness, \( \lambda_{LT} = 0.5 \times 3.00 \times 100/3.70 = 40.5 \text{ (4.7.7)} \)

Bending strength, \( p_b = 260.6 \text{N/mm}^2 \) (Table 16)

\[
P_z = A_g \cdot p_y = 29.2 \times 100/275 = 803 \text{kN}
\]

\[
F_c/P_z = 63.80/803 = 0.079; \ S_{eff} = 176 \text{ cm}^3
\]

Buckling resistance moment, \( M_{bs} = p_b \cdot S_{eff} = 260.6 \times 176/1000 = 45.93 \text{kNm} \)

Bending about minor axis:

Moment capacity, \( M_{cy} = p_y \cdot Z_y = 275 \times 52.56/1000 = 14.45 \text{kNm} \)

Summary:

\[
F_c/P_c = 63.80/464.7 = 0.137 [1]
M_{x}/M_{bs} = 16.24/45.93 = 0.354 [2]
M_{y}/P_y \cdot Z_y = 5.000/14.45 = 0.346 [3]
\]

Sum of stress ratios [1] + [2] + [3] = \textcolor{red}{0.837} OK

Baseplate calculation (considering axial load only)

Factored load on base = 1.4 x 37.748 + 1.6 x 6.844 = 63.798 kN

Concrete strength, \( f_{cu} = 20 \text{N/mm}^2 \)
milk structures

Minimum area required = \( F_c/0.6f_{cu} = 63.8 \times 1000/(0.6 \times 20) = 5,316\, \text{mm}^2 \)

K (min reqd proj) = 2.68mm  Minimum base plate size = 158 x 158mm

Minimum thickness = \( K \sqrt{3 \times 0.6f_{cu}/p_{yp}} = 0.968\, \text{mm} \)  \( (p_{yp} = 275\, \text{N/mm}^2) \)

Use 175 x 175 x 5mm base plate

*Encase beam to provide one hour fire resistance as per specification*
**Beam: B - Closet Wing Ground Floor Beam**

<table>
<thead>
<tr>
<th>Load name</th>
<th>Loading w1</th>
<th>Start x1</th>
<th>Loading w2</th>
<th>End x2</th>
<th>R1comp</th>
<th>R2comp</th>
</tr>
</thead>
<tbody>
<tr>
<td>U D o.w.</td>
<td>0.65</td>
<td>0</td>
<td>L</td>
<td>1.33</td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>U D Ground Floor SW</td>
<td>0.5x(5.2/2)</td>
<td>0</td>
<td>L</td>
<td>2.66</td>
<td>2.66</td>
<td></td>
</tr>
<tr>
<td>U L Ground Floor imposed</td>
<td>1.5x(5.2/2)</td>
<td>0</td>
<td>L</td>
<td>7.99</td>
<td>7.99</td>
<td></td>
</tr>
<tr>
<td>P D Col: C1 - Supports Beam</td>
<td>37.75 [B/F]</td>
<td>0.3</td>
<td></td>
<td>34.99</td>
<td>2.76</td>
<td></td>
</tr>
<tr>
<td>P L Col: C1 - Supports Beam</td>
<td>6.84 [B/F]</td>
<td>0.3</td>
<td></td>
<td>6.34</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>P D Bm: A - Closet Wing : R2</td>
<td>37.75 [B/F]</td>
<td>3.8</td>
<td></td>
<td>2.76</td>
<td>34.99</td>
<td></td>
</tr>
<tr>
<td>P L Bm: A - Closet Wing : R2</td>
<td>6.84 [B/F]</td>
<td>3.8</td>
<td></td>
<td>0.50</td>
<td>6.34</td>
<td></td>
</tr>
</tbody>
</table>

**Unfactored reactions (kN) Total:**

- **Dead:** 41.75
- **Live:** 14.84

**Total load:** 113.17/164.37 kN  
Unfactored/Factored

<table>
<thead>
<tr>
<th>Load types: U:UDL  P:PL  D: Dead;  L: Live (positions in m. from R1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total deflection = 49.4 x 10^8/EI at 2.05 m. from R1</td>
</tr>
</tbody>
</table>

**Beam calculation to BS5950-1:2000 using S275 steel**

**SECTION SIZE:** 2No 203 x 133 x 30 UB S275 (compact)

<table>
<thead>
<tr>
<th>D=206.8 mm</th>
<th>B=133.9 mm</th>
<th>t=6.4 mm</th>
<th>T=9.6 mm</th>
<th>I_x=2,900 cm^4</th>
<th>r_y=3.17 cm</th>
<th>S_x=314 cm^3</th>
<th>x=21.5</th>
</tr>
</thead>
</table>

**Shear**

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 2 x 6.4 x 206.8/1000 = 437 kN (>=82.2) OK

**Bending**

Maximum moment = 37.99 kNm at 2.05 m. from R1

Moment capacity, M_c = p_y.S_x = 275 x 314 x 2/1000 = 172.7 kNm OK

**Lateral-torsional buckling**

Beam is laterally restrained at supports only; effective length = 1.0L

Bending strength, p_b = 147.5 N/mm^2

Maximum moment within segment, M_x = 37.99 kNm

Equivalent uniform moment factor, m_{LT} = 0.963  \quad (M_2=33.3, M_3=38.0, M_4=33.3)

Equivalent uniform moment = 0.963 x 37.99 = 36.57 kNm

Buckling resistance moment, M_b = p_b.S_x = 147.5 x 314 x 2/1000 = 92.65 kNm OK

**Web capacity**

Check unstiffened web capacity with load of 82.19/2 = 41.09 kN

C1 = 60.5 kN;  C2 = 1.76 kN/mm;  C4 = 261;  K = min(0.5+(a_e/1.4d),1.0);  p_{yw} = 275N/mm^2

(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)

Bearing capacity, P_w = C1+b_C2  \quad (b_e taken as zero)  \quad Buckling capacity, P_x = K./(C4.P_w)

Unstiffened web bearing capacity, P_w = 60.5 kN: no minimum stiff bearing length required
Deflection

LL deflection = 18.63 x 1e8/2 x 205,000 x 2,900 = 1.6 mm  (L/2617) OK
TL deflection = 49.43 x 1e8/2 x 205,000 x 2,900 = 4.2 mm  (L/986)

Sections to be bolted together with tube spacers or suitable alternative connection at max 0.6m c/s Encase beam to provide one hour fire resistance as per specification
Beam: C - Rear Elevation Beam Ground Floor

<table>
<thead>
<tr>
<th>Load name</th>
<th>Loading w1</th>
<th>Start x1</th>
<th>Loading w2</th>
<th>End x2</th>
<th>R1comp</th>
<th>R2comp</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>0.3</td>
<td>0</td>
<td>L</td>
<td>0.47</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>L Sliding Doors Over</td>
<td>1</td>
<td>0</td>
<td>L</td>
<td>1.55</td>
<td>1.55</td>
<td></td>
</tr>
<tr>
<td>L Sliding Doors Below</td>
<td>1</td>
<td>0</td>
<td>L</td>
<td>1.55</td>
<td>1.55</td>
<td></td>
</tr>
</tbody>
</table>

Unfactored reactions (kN)  Total: 3.56 3.56

Dead: 0.47 0.47
Live: 3.10 3.10

Total load: 7.13/11.22 kN

Factored reactions: 5.61 5.61

Load types: U:UDL  D: Dead;  L: Live  (positions in m. from R1)

Maximum B.M. (factored) = 4.35 kNm at 1.55 m. from R1
Maximum S.F. (factored) = 5.61 kN at R1
Live load deflection = 2.40 x 10^6/EI at 1.55 m. from R1  (E in N/mm^2, I in cm^4)
Total deflection = 2.77 x 10^6/EI at 1.55 m. from R1
Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE: 203 x 133 x 30 UB  S275 (compact)

D=206.8 mm  B=133.9 mm  t=6.4 mm  T=9.6 mm  I_x=2,900 cm^4  r_y=3.17 cm  S_x=314 cm^3  x=21.5

Shear
Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 6.4 x 206.8/1000 = 218 kN (>=5.61) OK

Bending
Maximum moment = 4.349 kNm at 1.55 m. from R1
Moment capacity, M_c = p_y.S_x = 275 x 314/1000 = 86.35 kNm OK

Lateral-torsional buckling
Beam is laterally restrained at supports only: effective length = 1.0L
Bending strength, p_b = 183.2 N/mm^2
Maximum moment within segment, M_x = 4.349 kNm
Equivalent uniform moment factor, m_LT = 0.925  (M_2=3.26, M_3=4.35, M_4=3.26)
Equivalent uniform moment = 0.925 x 4.349 = 4.022 kNm
Buckling resistance moment, M_b = p_b.S_x = 183.2 x 314/1000 = 57.53 kNm OK

Web capacity
Check unstiffened web capacity with load of 5.611 kN
C1 = 60.5 kN;  C2 = 1.76 kN/mm;  C4 = 261;  K = min(0.5+(a_e/1.4d),1.0);  p_yw = 275N/mm^2
(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)
Bearing capacity, P_w = C1+b_1.C2  (b_e taken as zero)  Buckling capacity, P_x = K./C4.P_w
Unstiffened web bearing capacity, P_w = 60.5 kN: no minimum stiff bearing length required

Deflection
LL deflection = 2.405 x 1e8/205,000 x 2,900 = 0.4 mm  (L/7664) OK
TL deflection = 2.765 x 1e8/205,000 x 2,900 = 0.5 mm  (L/6664)
Beam: D - Stair Trimmer, Ground Floor

<table>
<thead>
<tr>
<th>Load name</th>
<th>Loading w1</th>
<th>Start x1</th>
<th>Loading w2</th>
<th>End x2</th>
<th>R1comp</th>
<th>R2comp</th>
</tr>
</thead>
<tbody>
<tr>
<td>U D o.w.</td>
<td>0.25</td>
<td>0</td>
<td>L</td>
<td>0.51</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>U D Floor SW</td>
<td>0.5x(1.2/2)</td>
<td>0</td>
<td>L</td>
<td>0.62</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>U L Floor SW</td>
<td>1.5x(1.2/2)</td>
<td>0</td>
<td>L</td>
<td>1.84</td>
<td>1.84</td>
<td></td>
</tr>
<tr>
<td>U D Balustrade SW</td>
<td>0.4</td>
<td>0</td>
<td>L</td>
<td>0.82</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>U L Balustrade Imposed</td>
<td>0.34</td>
<td>0</td>
<td>L</td>
<td>0.70</td>
<td>0.70</td>
<td></td>
</tr>
</tbody>
</table>

Unfactored reactions (kN) Total: 4.49
Dead: 1.95  Live: 2.54

Total load: 8.98/13.59 kN

Load types: U:UDL  D: Dead;  L: Live  (positions in m. from R1)

Maximum B.M. (factored) = 6.96 kNm at 2.05 m. from R1
Maximum S.F. (factored) = 6.79 kN at R1
Live load deflection = 4.56x10^8/El at 2.05 m. from R1 \((E \text{ in } N/mm^2, I \text{ in } cm^4)\)
Total deflection = 8.06x10^8/El at 2.05 m. from R1
Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : 150 x 90 x 24 PFC  S275 (compact)
D=150.0 mm  B=90.0 mm  t=6.5 mm  T=12.0 mm  \(I_x=1,160 \text{ cm}^4\)  \(r_y=2.89 \text{ cm}\)  \(S_x=179 \text{ cm}^3\)  \(x=10.8\)

Shear
Shear capacity = 0.6 \(p_y\cdot t\cdot D = 0.6 \times 275 \times 6.5 \times 150.0/1000 = 161 \text{ kN} \geq 6.79\) OK

Bending
Maximum moment = 6.964 kNm at 2.05 m. from R1
Moment capacity, \(M_c = p_y \cdot S_x = 275 \times 179/1000 = 49.23 \text{ kNm}\) OK

Lateral-torsional buckling
Beam is laterally restrained at supports only: effective length = 1.0L
Bending strength, \(p_b = 175.3 \text{ N/mm}^2\)
Maximum moment within segment, \(M_x = 6.964 \text{ kNm}\)
Equivalent uniform moment factor, \(m_{LT} = 0.925\)  \((M_2=5.22, M_3=6.96, M_4=5.22)\)
Equivalent uniform moment = 0.925 \times 6.964 = 6.441 kNm
Buckling resistance moment, \(M_b = p_b \cdot S_x = 175.3 \times 179/1000 = 31.38 \text{ kNm}\) OK
Web buckling and crushing have not been checked

Deflection
LL deflection = 4.562 \times 1e8/205,000 \times 1,160 = 1.9 mm  \((L/2137)\) OK
TL deflection = 8.057 \times 1e8/205,000 \times 1,160 = 3.4 mm  \((L/1210)\)
\[ E \text{ stress to } 200 \text{ Tonne} \]

\[ 200 \times 0.6 \times 0.6 \times 0.8 \text{ Ton} = 125 \text{ Ton} \]

\[ 200 \text{ Ton} = 14.3 \text{ kN/m} \]

\[ 40.26 \times 0.72 = 29.25 \text{ kN/m} \]

\[ 0.72 \times 0.72 = 0.52 \text{ kN/m} \]

\[ 40.26 \times 0.52 = 21.0 \text{ kN/m} \]

\[ 200 \times 0.6 \times 0.8 \text{ Ton} = 125 \text{ Ton} \]

\[ 29.25 \text{ kN/m} \]

\[ 0.52 \text{ kN/m} \]

\[ 21.0 \text{ kN/m} \]
Lettering Walls

- Join of existing foundations found at 545 to 592
  future levels between 600 - 1200mm.

- New foundations to be extended to found
  lower ground floor & base slab.

- Thickness of stem of wall unacceptable to match floor
  wall thickness and

- Ground floor the wall + bases have been considered
  independently as cantilevers however the actual
  construction will have bonded into all 3 stages with
  recess walls at each corner.

  & Design not possible due to pressure on
  all sides.

  & Cantilever not possible due to recess
  walls at continuous base.

  & Ready to attend stage 1-4 for internal
  wall detail.

  - Design modifications from site report.
IDEALISED STRUCTURE and FORCE DIAGRAMS

WARNING:
Passive pressure should only be considered if it can be guaranteed that there will be no future excavation in front of the wall.

DIMENSIONS (mm)

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>2800</td>
</tr>
<tr>
<td>B</td>
<td>1680</td>
</tr>
<tr>
<td>Tw</td>
<td>415</td>
</tr>
<tr>
<td>Hw</td>
<td>1000</td>
</tr>
<tr>
<td>Bi</td>
<td>1200</td>
</tr>
<tr>
<td>Tb</td>
<td>400</td>
</tr>
<tr>
<td>Hp</td>
<td>0</td>
</tr>
<tr>
<td>BN</td>
<td>0</td>
</tr>
<tr>
<td>TN</td>
<td>0</td>
</tr>
<tr>
<td>Hn</td>
<td>0</td>
</tr>
</tbody>
</table>

MATERIAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>fcu (N/mm²)</td>
<td>35</td>
</tr>
<tr>
<td>fy (N/mm²)</td>
<td>460</td>
</tr>
<tr>
<td>γm (concrete)</td>
<td>1.5</td>
</tr>
<tr>
<td>γm (steel)</td>
<td>1.05</td>
</tr>
<tr>
<td>Cover to tension steel = 50 mm</td>
<td></td>
</tr>
<tr>
<td>Max allowable design surface crack width (W) = 0.2 mm</td>
<td></td>
</tr>
<tr>
<td>Concrete density = 24 kN/m³</td>
<td></td>
</tr>
</tbody>
</table>

SOIL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design angle of int'l friction of retained mat'l (Ø) = 25 degree</td>
<td></td>
</tr>
<tr>
<td>Design cohesion of retained mat'l (C) = 18.5 kN/m²</td>
<td></td>
</tr>
<tr>
<td>Submerged Density of retained mat'l (qs) = 12.33 kN/m³</td>
<td></td>
</tr>
<tr>
<td>Design angle of int'l friction of base mat'l (Øb) = 25 degree</td>
<td></td>
</tr>
<tr>
<td>Design cohesion of base material (Cb) = 10 kN/m²</td>
<td></td>
</tr>
<tr>
<td>Density of base material (qb) = 18.5 kN/m³</td>
<td></td>
</tr>
<tr>
<td>Allowable gross ground bearing pressure (GBP) = 125 kN/m²</td>
<td></td>
</tr>
</tbody>
</table>

ASSUMPTIONS

a) Wall friction is zero
b) Minimum active earth pressure = 0.25qH
c) Granular backfill
d) Does not include check of rotational slide/slope failure

LOADINGS

<table>
<thead>
<tr>
<th>Load Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surcharge load -- live (SQK) = 5 kN/m²</td>
<td></td>
</tr>
<tr>
<td>Surcharge load -- dead (SGK) = 0</td>
<td></td>
</tr>
<tr>
<td>Line load -- live (LQK) = 0 kN/m</td>
<td></td>
</tr>
<tr>
<td>Line load -- dead (LDG) = 0 kN/m</td>
<td></td>
</tr>
<tr>
<td>Distance of line load from wall (X) = -150 mm</td>
<td></td>
</tr>
</tbody>
</table>

LATERAL FORCES (unfactored)

<table>
<thead>
<tr>
<th>Force</th>
<th>Lever arm (m)</th>
<th>Moment about TOE (kNm)</th>
<th>Fult (kN)</th>
<th>Mult (kNm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>28.18</td>
<td>0.960</td>
<td>27.05</td>
<td>1.40</td>
</tr>
<tr>
<td>PS(GK)</td>
<td>0.00</td>
<td>1.40</td>
<td>0.00</td>
<td>1.40</td>
</tr>
<tr>
<td>PS(QK)</td>
<td>5.68</td>
<td>1.40</td>
<td>7.95</td>
<td>1.60</td>
</tr>
<tr>
<td>PL(GK)</td>
<td>0.00</td>
<td>2.93</td>
<td>0.00</td>
<td>1.60</td>
</tr>
<tr>
<td>PL(QK)</td>
<td>0.00</td>
<td>2.93</td>
<td>0.00</td>
<td>1.60</td>
</tr>
<tr>
<td>PW</td>
<td>5.00</td>
<td>0.33</td>
<td>1.67</td>
<td>1.40</td>
</tr>
</tbody>
</table>

Total = 38.86  36.67  55.54  52.94

PP = 0.00  (LP-HN) = 0.00  0.00  1.00  0.00  0.00
EXTERNAL STABILITY

OVERTURNING about TOE
(Using overall factor of safety instead of partial safety factor)

<table>
<thead>
<tr>
<th>Lateral FORCE (kN)</th>
<th>Lever arm (m)</th>
<th>Moment (kNm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE = 28.18</td>
<td>LE = 0.93</td>
<td>26.30</td>
</tr>
<tr>
<td>PS(GK) = 0.00</td>
<td>LS = 1.40</td>
<td>0.00</td>
</tr>
<tr>
<td>PS(QK) = 5.68</td>
<td>LS = 1.40</td>
<td>7.95</td>
</tr>
<tr>
<td>PL(GK) = 0.00</td>
<td>LL = 2.93</td>
<td>0.00</td>
</tr>
<tr>
<td>PL(QK) = 0.00</td>
<td>LL = 2.93</td>
<td>0.00</td>
</tr>
<tr>
<td>PW = 5.00</td>
<td>LW = 0.33</td>
<td>1.67</td>
</tr>
</tbody>
</table>

\[ \Phi P = 38.86 \]
\[ \Phi P = 0.00 \]
\[ \Phi P = 0.00 \]
\[ G M = 35.92 \]

Restoring Moments

<table>
<thead>
<tr>
<th>Vertical FORCE (kN)</th>
<th>Lever arm (m)</th>
<th>Moment (kNm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall = 21.41</td>
<td>1.41</td>
<td>30.14</td>
</tr>
<tr>
<td>Base = 9.41</td>
<td>0.84</td>
<td>7.90</td>
</tr>
<tr>
<td>Nib = 0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Earth = 2.65</td>
<td>1.65</td>
<td>4.36</td>
</tr>
<tr>
<td>Water = 0.39</td>
<td>1.65</td>
<td>0.64</td>
</tr>
<tr>
<td>Surcharge = 0.33</td>
<td>1.65</td>
<td>0.54</td>
</tr>
<tr>
<td>Line load = 0.00</td>
<td>1.47</td>
<td>0.00</td>
</tr>
</tbody>
</table>

\[ \Phi V = 34.18 \]
\[ \Phi Mr = 43.58 \]

Factored of Safety, \[ \frac{Mr}{Mo} \] = 1.21<br/>OK

SLIDING
(Using overall factor of safety instead of partial safety factor)

F.O.S = 1.00

PASSIVE FORCE, \[ Pp \times \text{Red'n factor (1)} = 0.00 \] kN
Red'n factor for passive force = 1.00

BASE FRICTION (\[ \Phi V \tan \theta + B C_b \]) = -32.74 kN

Sum of FORCES RESISTING SLIDING, \[ Pr = -32.74 \] kN

Factor of Safety, \[ \frac{Pr}{P} \] = 0.84<br/>FAIL

GROUND BEARING FAILURE Taking moments about centre of base (anticlockwise "+"):

<table>
<thead>
<tr>
<th>additional vert.</th>
<th>Vertical FORCES (kN)</th>
<th>Lever arm (m)</th>
<th>Moment (kNm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall = 23.90</td>
<td>-0.57</td>
<td>-13.57</td>
<td></td>
</tr>
<tr>
<td>Base = 16.13</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Nib = 0.00</td>
<td>0.84</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Earth = 2.65</td>
<td>-0.81</td>
<td>-2.14</td>
<td></td>
</tr>
<tr>
<td>Water = 0.39</td>
<td>-0.81</td>
<td>-0.31</td>
<td></td>
</tr>
<tr>
<td>Surcharge = 0.33</td>
<td>-0.81</td>
<td>-0.26</td>
<td></td>
</tr>
<tr>
<td>Line load = 0.00</td>
<td>-0.63</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

\[ \Phi V = 43.39 \]
\[ \Phi Mr = -16.28 \]

Moment due to LATERAL FORCES, \[ M_o = 35.92 \] kNm

Resultant Moment, \[ M = Mr + Mo = 19.64 \] kNm

Eccentricity from base centre, \[ \frac{M}{V} = 0.57 \] m
Therefore, MAXIMUM Gross Bearing Pressure (GRP) = 86 kN/m² < 125<br/>OK
Selwood Terrace

Client: Wall A - Rear Elevation Wall Underpin

RETAILING WALL design to BS 8110:1997, BS 8002:1994. BS 8004:1

Location: Wall A - Rear Elevation Wall Underpin

Design Loads calculated including additional vertical load of: 0.00 kN

STRUCTURAL DESIGNS (ultimate)

WALL (per metre length)

<table>
<thead>
<tr>
<th>Force</th>
<th>Lever arm</th>
<th>Moment</th>
<th>γf</th>
<th>V ult</th>
<th>M ult</th>
</tr>
</thead>
<tbody>
<tr>
<td>EARTH</td>
<td>21.17</td>
<td>0.81</td>
<td>1.4</td>
<td>29.64</td>
<td>24.09</td>
</tr>
<tr>
<td>SURCHARGE(GK)</td>
<td>0.00</td>
<td>1.20</td>
<td>1.4</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>SURCHARGE(QK)</td>
<td>4.87</td>
<td>1.20</td>
<td>1.6</td>
<td>7.79</td>
<td>9.35</td>
</tr>
<tr>
<td>LINE LOAD(GK)</td>
<td>0.00</td>
<td>2.53</td>
<td>1.4</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>LINE LOAD(QK)</td>
<td>0.00</td>
<td>2.53</td>
<td>1.6</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>WATER</td>
<td>1.80</td>
<td>0.20</td>
<td>1.4</td>
<td>2.52</td>
<td>0.50</td>
</tr>
<tr>
<td>Total</td>
<td>27.84</td>
<td>23.41</td>
<td>39.96</td>
<td>33.95</td>
<td></td>
</tr>
</tbody>
</table>

BS8110 reference

MAIN REINFORCEMENT:
- Min. As = 540 mm²
- ϕ = 12 mm
- centres = 200 mm < 762 OK 3.12.11.2.7(b)
- Asprov = 565 mm² > 540 OK

MOMENT of RESISTANCE:
- d = 359 mm
- z = 341.05 mm 3.4.4.4
- As' = 0 mm²
- Mres = 84.49 kNm > 33.95 OK

SHEAR RESISTANCE:
- 100 As/bd = 0.16%
- vc = 0.39 N/mm² 3.5.5.2
- Vres = 140.83 kN > 39.96 OK

Ultimate Bending Moment Diagram

CHECK CRACK WIDTH TO BS8110/BS8007:
- X = 70.13 mm
- Acr = 108.61 mm
- W = -0.26 mm < 0.20 OK

NO CRACKING

REINFORCEMENT SUMMARY for WALL

<table>
<thead>
<tr>
<th>Type</th>
<th>φ</th>
<th>Centres</th>
<th>As</th>
<th>Min. As</th>
</tr>
</thead>
<tbody>
<tr>
<td>VERTICAL EXT. FACE</td>
<td>T</td>
<td>12</td>
<td>200</td>
<td>565</td>
</tr>
<tr>
<td>VERTICAL INT. FACE</td>
<td>T</td>
<td>12</td>
<td>200</td>
<td>565</td>
</tr>
<tr>
<td>TRANSVERSE</td>
<td>T</td>
<td>12</td>
<td>200</td>
<td>565</td>
</tr>
</tbody>
</table>
Design Loads calculated including additional vertical load of: 0.00 kN

OUTER BASE (per metre length)

\[ \gamma_f = 1.44 \] (default = ult mt / non-factored mt.1.44

\[ V_{ult} = 34.81 \text{ kN} \]
\[ M_{ult} = 44.73 \text{ kNm} (\text{`+ TENSION AT BOTTOM FACE}) \]

BOTTOM REINFORCEMENT:
- Min. As = 520 mm²
- \( \phi = 12 \) mm
- centres = 200 mm < 762 OK 3.12.11.2.7(b)
- Asprov = 565 mm² > 520 OK

MOMENT of RESISTANCE:
- \( d = 344 \) mm
- \( z = 326.80 \) mm 3.4.4.4
- \( A_s' = 0 \) mm²
- \( M_{res} = 80.96 \text{ kNm} > 44.73 \text{ OK} \)

SHEAR RESISTANCE:
- 100 As/bd = 0.16%
- \( v_c = 0.40 \) N/mm² Table 3.8
- \( V_{res} = 138.35 \text{ kN} > 34.81 \text{ OK} 3.5.5.2 \)

CHECK CRACK WIDTH TO BS8110/BS8007:
- (Temperature and shrinkage effects not included)
  - \( X = 68.49 \) mm
  - \( \varepsilon_m = -0.00074 \) BS8007
  - Acr = 108.61 mm
  - W = -0.18 mm < 0.20 OK App. B.2

NO CRACKING

INNER BASE (per metre length)

\[ V_{ult} = -5.44 \text{ kN} \]
\[ M_{ult} = -10.78 \text{ kNm} (\text{TENSION - TOP FACE}) \]

TOP REINFORCEMENT:
- Min. As = 520 mm²
- \( \phi = 12 \) mm
- centres = 200 mm < 762 OK 3.12.11.2.7(b)
- Asprov = 565 mm² > 520 OK

MOMENT RESISTANCE:
- \( d = 344 \) mm
- \( z = 326.80 \) mm 3.4.4.4
- \( A_s' = 0 \) mm²
- \( M_{res} = 80.96 \text{ kNm} > -10.78 \text{ OK} \)

SHEAR RESISTANCE:
- 100 As/bd = 0.16%
- \( v_c = 0.40 \) N/mm² Table 3.8
- \( V_{res} = 138.35 \text{ kN} > -5.44 \text{ OK} 3.5.5.2 \)

CHECK CRACK WIDTH TO BS8100/BS8007:
- (Temperature and shrinkage effects not included)
  - \( X = 68.49 \) mm
  - \( \varepsilon_m = -0.00201 \) BS8007
  - Acr = 108.61 mm
  - W = -0.48 mm < 0.20 OK App. B.2

REINFORCEMENT SUMMARY for BASE

<table>
<thead>
<tr>
<th>Type</th>
<th>( \phi )</th>
<th>Centers</th>
<th>As</th>
<th>Min. As</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOP (DESIGN)</td>
<td>T</td>
<td>12</td>
<td>200</td>
<td>565</td>
</tr>
<tr>
<td>BOTTOM (DESIGN)</td>
<td>T</td>
<td>12</td>
<td>200</td>
<td>565</td>
</tr>
<tr>
<td>TRANSVERSE</td>
<td>T</td>
<td>10</td>
<td>150</td>
<td>524</td>
</tr>
</tbody>
</table>
site investigation report 26185 R01(00), March 2013
typical underpinning construction sequence

(extract from RBKC town planning policy on subterranean development doc REP/123002/001 draft rev b, by Arup Geotechnics)
Stage 0: original foundation, typical of houses

Stage 1: exposure of original foundation by digging a short trench along a section of the wall to be underpinned

Stage 2: excavation of pit to form underpin: see Fig. 2.1b for details

Indicative, schematic sketches only. Actual dimensions are likely to vary. Not to scale.

RBKC SUBTERRANEAN DEVELOPMENT
Typical underpinning construction sequence
Stage 2a: excavation and concreting of initial section

Stage 2b: excavation and concreting of another section, not adjacent to first one

Stage 2c: excavation and concreting of an intermediate section, to form contiguous rows of underpin

Indicative, schematic sketches only. Actual dimensions are likely to vary. Not to scale.