16 Kensington Palace Gardens

Construction Method Statement

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Job Number: 23564

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Executive Summary

This report has been prepared following the process set out in The Royal Borough of Kensington and Chelsea “Basements Draft Supplementary Planning Document” of February 2015.

The structural engineers have the advantage of having worked on the building when it was last extensively refurbished to a scheme prepared by Alain Bouvier Associates in 2005 to 2007. An intrusive site investigation has confirmed the expected ground conditions and ground water level expected from this previous work.

The design process has considered the effect of the building work on nearby trees and a discussion with a specialist groundwork contractor has confirmed the proposed outline construction method.

Careful consideration has been given to the effect of the building project on the site ground water levels, the risk of any kind of flooding, and to ensuring that the design follows best practice in the application of sustainable urban drainage principles.

This report is based on an update to the ground movement analysis following comments from the Crown Estates’ engineers Alan Baxter Associates. The updated analysis includes changes to depths of existing footings used, which are now based on dimensions checked on site and not the previous conservative assumptions. As a result the predicted damage categories have changed, confirming that the proposed works will cause minimal damage to historic fabric.

As noted in the conclusions this work demonstrates that the basement can be safely built as required by Policy CL7 (n).
1 Introduction

This report forms part of a Planning Application for work to the house prepared by 6a architects. It should be read in conjunction with the following reports that provide further information about issues that affect the construction process:

- Highway Construction Traffic Management Plan prepared by Sizebreed Construction

The site is on the west side of Kensington Palace Gardens; with its rear, western garden backing onto the gardens of Palace Gardens Terrace; it can be described as “sensibly level”. There are no main utility services, tunnels or other infrastructure under the site.

An addition of a basement swimming pool is proposed along with other alterations generally to improve circulation within the building and between the house and the large garden. The pool is located to the south of the house within a concrete box formed with piled walls avoiding the need for any underpinning to the existing structure. The other principle structural alterations are enlarging the terrace to the side and rear, southern and western garden areas and forming openings in the ground floor of the northern wing of the house.

The house is understood, from The Survey of London to have been built between 1846 & 1849 for John Sperling to a design by T.H. Wyatt and J. Brandon; when Mr. Sperling took the lease of the plot he was granted an extension of the original site boundary to the south, resulting in the current large garden. Alterations were noted as being carried out internally & externally in 1903; then at some time the house was occupied by the Soviet Diplomatic Mission.

In 2005 to 2007 an extensive refurbishment and extension of the house was carried out to a design by Alain Bouvier Associates; with Price & Myers as the structural engineers.

The work carried out included:

- An extension to the lower ground floor at the south-west corner, with the formation of an enlarged terrace above.
- Forming an enlarged lower ground floor under the old “coach house” to the north to form a swimming pool with a garage above at ground floor. The upper part of the building was propped up and then re-supported on the new substructure.
- General extensive repairs and adjustments of openings within the main house; as well as replacement or renewal of much of the underground drainage.

Some subsequent minor alterations were carried out by the same design team in 2011.

2 Surveys and Ground Conditions

The ground conditions are expected to be made ground overlying a silty, sandy, clay above a sandy gravel of the Lynch Hill Gravel with London Clay at greater depth. During the work carried out in 2006 water was not encountered when excavating but there were problems with “rolling
gravel” when digging underpinning either for the existing house or the adjoining Party wall to the north.

A geotechnical site investigation, consisting of two boreholes in the area of garden where the basement is to be constructed, has been carried out by Geotechnical & Environmental Associates on 30th March & 1st April 2015. This has confirmed those expected ground conditions – in summary the boreholes show a made ground thickness of between 600mm & 1700mm from the garden level, with the silty, sandy, clay band between 1600mm & 3100mm thick. The Lynch Hill Gravel was found at depth of between 3300mm & 3700mm below garden level and the London Clay at about 10.5m below the garden level. Groundwater level readings were recently taken on the 29th August 2015 on both bore holes and found at 20.040mOD.

A full “final construction issue” set of Price & Myers structural drawings for the work in 2005 to 2007 shows where structural work was carried out at that time. A full list of these drawings is given in appendix B.

Land Contamination
The testing carried out as part of the 2015 site investigation showed elevated levels of lead in one sample within the made ground; the investigation in 2005 had several samples where an elevated levels of lead was noted. The made ground will be removed from site to an appropriate tip and any backfill to the basement will use natural ground and clean topsoil from site so over the area of new construction the existing contamination will be removed from site. The site investigation reports that no further action is needed to deal with the low level of contamination and that the waste should be classified as “non hazardous”.

3 Proposals

Introduction
All of the main ground work in this project is remote from any adjoining properties and so will not affect any neighbours. The location of the basement has been selected to minimise any potential effect of the work on the trees in the garden; for details of the criteria for this see the separate aboricultural report. Where demolition of any historic fabric is proposed the details of removal are shown on the architect’s set of demolition drawings:

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The potential effect on the neighbours from noise, dust and vibration caused by the alteration work, in particular the cutting of new openings in the 400mm thick solid reinforced concrete ground floor slab is discussed in detail in the separate environmental report.

Permanent Works
The proposed structural works are shown on the drawings listed in appendix D. In principle the main new structure is a cast in-situ reinforced concrete box constructed within a secant piled wall of cast in-situ reinforced concrete piles. For the rear terrace extension the proposed structure is similar to that from 2006; reinforced concrete walls, footings integral with the ground bearing slab, and a roof slab that acts as a transfer structure to support existing masonry walls above.
Within the listed building the structural alterations are limited to the creation of two new staircases to improve circulation within the house; and the addition of a new stair to allow the main stair to serve the lower ground floor. Details of the expected structural work are shown on drawings 23564/sk10, sk11 and sk12. In addition a section of wall within the coach house at mezzanine level is to be removed with a new support beam installed. Details of this work are shown on drawing 23564/sk11; with the required temporary support works shown on drawing 23564/SK-TW5.

**Basement Waterproofing**
The in-situ concrete walls will be designed to limit crack widths in accordance with Code of Practice requirements for water excluding structures and built with waterbars at construction joints which together with a slurry lining will form an integral Type B waterproofing to BS8102. In order then to create a Grade 3 basement, within the pool area, this will be lined with a drained cavity drainage system with a concrete topping slab and concrete or block lining walls; forming overall a BS8102 Type C waterproof structure. Careful detailing will be required by all members of the design team to co-ordinate the waterproofing to the top of the concrete box with this internal system. For the terrace extension semi-basement areas waterproofing will be provided, as existing, by the use of water resistant concrete plus a “waterproof” render.

Within this space the pool will be lined as required to suit specialist’s details that provide a pool that retains water within the pool.

**Temporary Works**
There are three distinct temporary works issues to consider in the construction work.

- **Main Swimming Pool Box**
The first and most important is the construction of the main swimming pool box, and associated underground services link passage. The expected temporary works and outline sequence of work for this element has been discussed and agreed with the Contractor as part of the design process. The plan outline of the basement will be formed using secant bored, cast in-situ concrete piles installed from garden level. The setting out of the extension allows for all piles to be installed without affecting the foundations of the existing listed house. On the garden side of the basement some of the piles need to be installed within the root protection area of tree 10; to allow this to happen a trench will be hand dug along the line of the piled wall in advance of the piling. This will allow the arboriculturalist to remove any roots in this zone; the trench will then be backfilled. When the piles have been installed the site will be excavated to a depth of about 1.5m to the formation level of the slab that forms the “lid” of the pool box; the piles will form the temporary retaining structure for this stage of the work. The “lid” will then be built and when the slab has gained sufficient strength to prop the top of the piles in place excavation of the basement volume will start. This method of construction with the top of the basement being propped before excavation starts and the bottom always fixed into the ground, as the piles extend below the basement level, will ensure the least possible movement of the ground during the work, minimising the effect of the work on the existing building.

When the piled walls are propped by the top slab the top section of piles on the garden side can be cut down and removed; this will be done as agreed with the project arboriculturalist to avoid any overdig where the piled wall is close to any root protection area.

For details of this work see sketch drawings: 23564-SK-TW1 & TW2.
• **Western Garden Extension of The Ground Floor Terrace**

As for the similar, but slightly smaller, extension built in 2006 this extension of the lower ground floor will be formed using an “open cut” excavation into the garden to form the new perimeter reinforced concrete retaining wall. This excavation is limited in nature and remote from the existing main building and its foundations so will not result in any movement of the existing structure. This work also requires propping some parts of the listed building in order to install the new concrete slab to replace that installed in 2006. This work will be carried out alongside the forming of the altered opening in the western, external wall of the house that was remodelled in 2006. The temporary supports to the existing masonry walls will be jacked into position with the permanent replacement work then jacked into place so that movement in the rear façade of the house is minimised. The new slab where it supports the house will also be designed with a pre-camber to minimise the effect of any creep in the concrete on the existing structure.

For details of this work see sketch drawings: 23564-SK-TW1, TW3, & TW4.

• **New Openings in “Coach House” Floor Slab**

The upper part of the northern wing of the house – the “coach house”; was all propped up during the 2006 alteration work and then re-supported on a 400 thick reinforced concrete transfer slab. The alterations propose forming five large holes in this important piece of structure; one for a new stair to link the upper and lower ground floors; two for pavement lights in the front garden and two for pavement lights in the rear garden. Temporary supports to the suspended slab can be supported on the new lower ground floor slab and if required the new openings can be cut as oversize holes that can be infilled with additional structure as needed to provide the required strengthening. In the case of the new stair opening the new masonry walls around the stair at lower ground floor can be built and pinned up to the slab before the opening is formed so that no temporary supports or strengthening will be needed.

4 **Site Drainage and Ground Water**

**Building Drainage**

The proposed building work has very little effect on the site drainage system. All roof drainage is unaltered and will continue to flow by gravity to the street sewers. There is no expected measurable increase in the foul drainage as the building occupancy is not expected to change.

The swimming pool has a balance storage tank and pumped drainage managed so that no water is pumped into the system during, or shortly after, a storm so that the pool drainage will not add to the peak drainage flow off the site.

**Site Drainage**

In accordance with Environment Agency (EA) guidelines, the Building Regulations, Water Authority’s advice and RBKC’s Consolidated Local Plan, in particular Policy CE2(e); an infiltration drainage system to the ground is the preferred method of surface water drainage for any new development, as this is the most sustainable solution. SUDS are an effective way to reduce the impact of urbanisation on watercourse flows, ensure the protection and enhancement of water quality and to encourage recharging of groundwater in a natural way. Drainage to public sewers should only be considered if all other options are proved to be unsuitable.

The enlarged terraces increase the overall impermeable area by 30m$^2$ to about 707m$^2$. The basement construction will not result in any change to the run-off rates as the soffit of the basement slab is 1.5m below ground level.
The existing and proposed run-off rates have been estimated for the 1 in 100 year storm event using WinDes software, based on the modified rational method.

\[ Q_{100} = 2.78 \times A \times i; \] where \( A \) is the catchment area in Hectares and \( i \) is the rainfall intensity in mm/hr

Existing: \[ Q_{100\text{ex}} = 2.78 \times 0.0677 \times 133.7 = 25.16 \text{ l/sec} \]
Proposed: \[ Q_{100\text{pr}} = 2.78 \times 0.0707 \times 133.7 = 26.28 \text{ l/sec} \]

The resulting increase in the surface water run-off as a result of the development proposals is thus 1.12 l/sec.

In response to the Council’s comments on the previous analysis the RBKC’s “Small Scale SuDS Tool” has been used to evaluate the surface water drainage proposals for this development; see Appendix C, where an attenuation storage volume of 1.5m\(^3\) is suggested to negate the effect of the calculated increase in the peak flow rate.

As noted in the table on page 2 of the “Small Scale SuDS Tool” some form of permeable pavement is a preferred SuDS solution to provision of an attenuation system. The proposal for draining the enlarged terrace is to replicate the current design where run-off from this terrace drains to the rear garden, acting as a large soakaway or permeable pavement.

Thus a storage volume is not provided as
- Firstly it is less preferable to infiltration
- Secondly, the joint Defra and EA Research & Development Technical Report “Preliminary Rainfall Runoff Management for Developments” sets the minimum limiting discharge for attenuation systems at 5 l/sec, as low flow rates require small diameter flow control devices which are at risk of blockages.

The run off from the enlarged terrace goes into the substantial garden area, underlain by free draining natural sands and gravels well above the level of any groundwater (9.5m below). This surface water flow will in the first instance water the planting bed it discharges into and any remaining run-off will infiltrate into the ground as existing.

**Swimming Pool Discharge**
The design of the pool includes the provision of a balance tank with pumps to lift the water from the pool base level to the main gravity drainage system. The pool system can be managed so that no water is pumped into the system during, or shortly after, a storm so that the pool drainage will not add to the peak drainage flow off the site.

**Groundwater**
As noted in the site investigation report groundwater was observed in the boreholes at a depth of 9.5m below the existing garden level; this is confirmed by the recent readings taken on the 29th August 2015 which indicates the groundwater to be at 20.040m OD. Therefore, the groundwater level is currently about half a meter above the future structural slab level, and appear to be at a consistent level. The small amount of water that may be displaced by the basement can be expected to have a minimal effect on groundwater flow.

**Basement Drainage**
The foul drainage from the new pool surround level and the sump to the drained cavity system will both be pumped to the existing building drainage where they will then drain by gravity to the public sewers. The design of the pump systems will include a non-return valve to prevent flooding of the basement from the sewer system.
5  Construction Methodology

Constructions Methods
As noted in section three the proposed “top down” method of construction for the basement, ensures the least possible movement of the ground during the work, minimising the effect of the work on the existing building. Temporary support systems for vertical propping will be jacked into place to minimise building movement; so that building damage will be limited to Category 0 or Category 1 of BRE Digest 251; see appendix G.

Ground Movement & Effect on Existing Buildings
The detailed geotechnical assessment of the potential ground movement as a result of pile installation and excavation for the basement box, generally uses the conservative assumption that the predicted total vertical movement ignores the beneficial effect of the clay heave that will occur as the basement is excavated. This report concludes that the proposed basement construction should have a negligible effect on the adjoining buildings at 15a & 17 Kensington Palace Gardens; although it shows that, at worst, some Very Slight damage may be caused to the single storey outbuilding to the rear of 15a; using these conservative assumptions. The detail within the report shows the of movement in this building is mostly as a result of ground heave during excavation of the basement piled wall; it is anticipated that it will be possible to minimise this movement by careful sequencing of the proposed basement construction work allowing any damage to be limited to at most Very Slight as the analysis predictions are always a worst case estimate.

The ground movement analysis conservatively estimates that as the garden elevation of the house settles during the excavation of the basement, some Slight damage as the to the front and rear elevations may result in this being at worst Category 2 as described in BRE Digest 251. This is on the basis, as noted above, that the beneficial predicted heave movement is ignored in making the assessment. This prediction is also likely to be conservative as the strains imposed on the front and rear elevations may in the first instance relieve those set up by excavation of the existing basement extension to the north in 2005. With conservative assumptions and the proposed monitoring and supervision in place it is expected that generally damage will only be very slight; and damage will never be more than category 2 as required by the planning guidance.

Movement Monitoring
It is essential to check that the effect of the construction work will have on the existing building. As stated above the work has been planned and will be supervised to minimise the potential for any movement in the building, the monitoring should demonstrate that the measures taken have performed as required; if however the trigger levels are reached it will allow the swiftest possible action to be taken to limit building movement.

The movement monitoring will be carried out by a specialist surveyor. The survey shall be to an array of targets fixed to the existing house, at locations to be agreed but at least three targets on each of the front, rear and flank elevations. The targets and surveying system will allow for measurement in three orthogonal directions.

Readings shall be taken weekly from the start of the work on site; the targets will be installed within a week of the work starting, until the major structural works start when monitoring shall be carried out twice a week. When the work to form the new basement pool and plant space, the enlargement of the rear and side terraces, and lower ground floor are complete the frequency of readings shall be reduced to fortnightly and when all the structural work on the house is complete the frequency of readings shall be reduced to monthly. A final set of readings should be taken after a further 6 months.
Reports recording the site readings in tabular and graphical format will be issued to all Parties within two days of the measurements being carried out. These will show the trend and size of any movements.

When there is a difference between two individual readings in excess of 4mm recorded and this shows a trend of increasing movement, or there is an overall trend of increasing movement in excess of 6mm, this is a “cause for concern” and the Contractor and Engineer are to assess the need to carry out any additional works to provide temporary support to the building or adjust the planned work sequence to reduce the potential for further movement. Where there is a “cause for concern” all Parties are to be informed of the result of the review and of any agreed additional works or adjustment to the planned work sequence.

When there is a difference between two individual readings in excess of 8mm recorded; work should be suspended as soon as practicable until all Parties agree on the action to take.

Material Selection
The selection of materials will be carried out to limit the environmental impact of the work in particular the “carbon footprint”. Use of the maximum practicable GGBS or PFA cement replacement materials will be specified at the detail design stage as this will have the greatest environmental impact.

Site Logistics: Health & Safety, Hoardings, Security & Traffic Management
Refer to the Highway Construction Traffic Management Plan prepared by Sizebreed
6 Conclusions

The proposed design, supervision and monitoring will, together, ensure that this house can be extended as proposed without

- causing damage to the existing listed structure,
- having any adverse effect on neighbouring houses,
- altering groundwater flow on the site
- any significant change to the site drainage
- any adverse effect on the trees in the garden.
Appendix A

Site Location Plan

Extract from “Survey of London”
Site Location Plan – from “Google”

Site Photograph – from “Google”
# Appendix B

## Final Construction Issue Drawings Project 14381

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SuDS Drainage Statement

Building & Ste Drainage
The proposed building work has very little effect on the site drainage system. All roof drainage is unaltered and will continue to flow by gravity to the street sewers. There is no expected measurable increase in the foul drainage as the building occupancy is not expected to change.

The swimming pool has a balance storage tank and pumped drainage managed so that no water is pumped into the system during, or shortly after, a storm so that the pool drainage will not add to the peak drainage flow off the site.

The small increase in external paved area of 30m² from the enlarged terraces will be drained into the either the existing garden area or the meter of backfill above the new pool and then into the garden. This surface water will infiltrate into the ground as existing, thus the drainage will continue to perform as if the site were a “green field”.

Emma Bailey
MSc CEng MICE
### Appendix D

**Proposed Drawings**

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<td>Lower Ground Floor Plan Sheet 2</td>
<td>23564/04</td>
<td>3</td>
</tr>
<tr>
<td>Ground Floor Plan Sheet 1</td>
<td>23564/05</td>
<td>3</td>
</tr>
<tr>
<td>Ground Floor Plan Sheet 2</td>
<td>23564/06</td>
<td>3</td>
</tr>
<tr>
<td>Overall Sections Sheet A &amp; B</td>
<td>23564/07</td>
<td>3</td>
</tr>
<tr>
<td>Overall Sections Sheet C</td>
<td>23564/08</td>
<td>3</td>
</tr>
<tr>
<td>Overall Sections Sheet D - F</td>
<td>23564/09</td>
<td>3</td>
</tr>
<tr>
<td>New Coach House Lower Ground Link Stair</td>
<td>23564/sk10</td>
<td>1</td>
</tr>
<tr>
<td>New Coach House Mezzanine Link Stair</td>
<td>23564/sk11</td>
<td>1</td>
</tr>
<tr>
<td>Main Staircase Extension</td>
<td>23564/sk12</td>
<td>2</td>
</tr>
</tbody>
</table>
Appendix E

Proposed Temporary Works Sequence Drawings

<table>
<thead>
<tr>
<th>Title</th>
<th>Number</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence of Construction (G.A)</td>
<td>23564-SK-TW1</td>
<td>E</td>
</tr>
<tr>
<td>Swimming Pool Box Construction</td>
<td>23564-SK-TW2</td>
<td>D</td>
</tr>
<tr>
<td>Section Q-Q, TW to Terrace Extension</td>
<td>23564-SK-TW3</td>
<td>B</td>
</tr>
<tr>
<td>Section L-L, TW to Terrace Extension</td>
<td>23564-SK-TW4</td>
<td>A</td>
</tr>
<tr>
<td>Section N-N, Coach House alterations</td>
<td>23564-SK-TW5</td>
<td>A</td>
</tr>
</tbody>
</table>
Appendix F

Outline Design Parameters

Loading

Design Loadpaths

**Vertical Loads**
The pool box loads are carried by the base raft slab

**Horizontal Loads & Overall Stability**
The pool box has stability inherent from its form; in the detailed design the rooflight openings will be checked to ensure they do not impact on the ability of the lid to prop the walls

**Robustness & Disproportionate Collapse**
There is no need to upgrade the existing building and the in-situ concrete pool box will meet the requirements of Building Regulations 2B.

**Design Loads**
To be assessed in accordance with: BS6399 Part 1 (1984) Dead & Imposed
Part 3 (1988) Roof Imposed

Dead Loads will be calculated to suit the materials used

**Imposed Loads**
Garden 5.0kN/m²
Domestic 1.5 kN/m²

**Other Loads**
Balusters 0.36kN/m

**Fire**
Design fire period for the structure will be 1 hour.

**Sound Resistance / Acoustics**

No special design requirements for the structure

**Movement Joints**
No structural movement joints are required
Concrete
To be designed in accordance with: BS8110 & BS8500.
The concrete in the ground is exposure class [Insert class].
Concrete finishes will generally be a plain finish

Steel
To be designed in accordance with: BS5950
The steel is to be grade S355 and bolts are all to be grade 8.8.
Steel to be corrosion protected by painting and fire protected by boarding

Masonry
To be designed in accordance with: BS5628.

Timber
To be designed in accordance with: BS5268.
<table>
<thead>
<tr>
<th>Category of damage</th>
<th>Description of typical damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Hairline cracks of less than about 0.1 mm which are classed as negligible. No action required.</td>
</tr>
<tr>
<td>1</td>
<td>Fine cracks which can be treated easily using normal decoration. Damage generally restricted to internal wall finishes; cracks rarely visible in external brickwork. Typical crack widths not more than 1 mm.</td>
</tr>
<tr>
<td>2</td>
<td>Cracks easily filled. Recurrent cracks can be masked by suitable linings. Cracks not necessarily visible externally; some external repointing may be required to ensure weather-tightness. Doors and windows may stick slightly and require easing and adjusting. Typical crack widths not more than 5 mm.</td>
</tr>
<tr>
<td>3</td>
<td>Cracks which require some opening up and can be patched by a mason. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weather-tightness often impaired. Typical crack widths are 5 to 15 mm, or several of, say, 3 mm.</td>
</tr>
<tr>
<td>4</td>
<td>Extensive damage which requires breaking-out and replacing sections of walls, especially over doors and windows. Windows and door frames distorted, floor sloping noticeably*. Walls leaning or bulging noticeably*, some loss of bearing in beams. Service pipes disrupted. Typical crack widths are 15 to 25 mm, but also depends on number of cracks.</td>
</tr>
<tr>
<td>5</td>
<td>Structural damage which requires a major repair job, involving partial or complete rebuilding. Beams lose bearing, walls lean badly and require shoring. Windows broken with distortion. Danger of instability. Typical crack widths are greater than 25 mm, but depends on number of cracks.</td>
</tr>
</tbody>
</table>
Appendix H

Structural Calculations – Terrace Extension

LOADS / ACTIONS

\( W_x = 0.225 \times 22 \times 4.6 \)  \( = 25 \text{ KN/m}^2 \)

DL (ON SLAB)  \( \text{KN/m}^2 \)

Self Weight (CSAV 293 mm)  \( = 0.275 \times 25 \)  \( = 6.91 \)

Screen + Pav.  \( = 0.1 \times 2.4 \)  \( = 2.4 \)

LL (ON SLAB)  \( \text{KN/m}^2 \)

Domestic  \( = 1.5 \)

COMBINATIONS

(i) ULS  \( 1.35G_e + 1.5Q_K \)

(ii) SLS  \( 1.6G_u + 1.5Q_K \)
ANALYSIS

(1) LLS

\[ P = \frac{1.35 \times 9.3 \times 6.6}{2} + (1.5 \times 1.5 \times 5.6) + (1.35 \times 2.3) - Q \]

\[ P = 113 \text{ kN} - Q \]

\[ M = 5.6P - (5.6 \times 148 \times 2.8) - (1.5 \times 31) = 0 \]

\[ Q = 63.3 \text{ kN} \]

\[ P = 113.74 \text{ kN} \]

SFD

BMD

\[ M_{\text{max}} = (49.7 \times 3.1) - (14.6 \times 5.1 \times 1.55) = 83 \text{ kNm} \]
FLEXURE

\[ M_{Ed} = 83.4 \text{kN} \text{m} \]
\[ V_{Ed} = 275 - 30 - 10 = 245 \]
\[ K = 0.044 \]
\[ z = 0.95d = 223 \text{mm} \]
\[ A_s = 850 \text{mm}^2 \]

PROVIDE HP2-125
\[ A_{psu} = 0.904 \text{mm}^2 \]

SHEAR

\[ V_{Ed} = 63.3 \text{kN} \]
\[ V_{Ed} = V_{Ed} / k = 0.27 \text{N/mm}^2 \]
\[ V_{وك} = 0.85 \text{N/mm}^2 \] (2.02%)

\[ V_{وك} > V_{Ed} \]

SHEAR OK

DEFLECTION

\[ \text{Actual } L/D = 5.6 / 0.245 = 20.4 \]
\[ \text{Basic } L/D = 1 [11 + 14 + 11] = 36 \]
\[ \text{Basic } L/D > \text{Actual } L/D \]

SPAN/DEFORM DEFLECTION OK
RETAINING WALL DESIGN

REF: DRAWING 23564-09(C1) SECTION E

\[ S_{LL} = 20 \text{ kN/m}^2 \]

\[ \phi = 25^\circ \]

\[ \rho = 1800 \text{ N/m}^2 \]

\[ K_a = \frac{1 - \sin \phi}{1 + \sin \phi} = 0.4 \]

SDL: \( 20 \text{ kN/m}^2 \times 0.4 = 8 \text{ kN/m}^2 \)

Un-Factored soil pressures

<table>
<thead>
<tr>
<th>Soil Layer</th>
<th>Level</th>
<th>Density</th>
<th>Fyd</th>
<th>Head</th>
<th>Pore pressure</th>
<th>Surcharge</th>
<th>Effective vertical direct</th>
<th>qv</th>
<th>K0</th>
<th>Active horizontal</th>
<th>( qh )</th>
<th>( qv )</th>
<th>( g_n )</th>
<th>( g_c )</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>0</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>20</td>
<td>25</td>
<td>0.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>18</td>
<td>9.8</td>
<td>2.6</td>
<td>25</td>
<td>20</td>
<td>20</td>
<td>25</td>
<td>0.4</td>
<td>0.52</td>
<td>0.52</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>F2</td>
<td>0.4</td>
<td>18</td>
<td>44.3</td>
<td>2.6</td>
<td>25</td>
<td>20</td>
<td>20</td>
<td>25</td>
<td>0.4</td>
<td>0.52</td>
<td>0.52</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

16 Kensington Palace Gardens
FLEXURE (STEM)

\[ M_{Ed} = 36.9 \text{ KN}\cdot\text{m} \]

\[ d = 250 - 30 - 10 = 210 \]

\[ k = \frac{M}{L_b d^2 f_c} = 0.02 \]

\[ z = 0.95 d = 194.5 \text{ mm} \]

\[ A_s = 427 \text{ mm}^2 \]

Provide H12-150

\[ A_s = 753 \text{ mm}^2 \]

FLEXURE (BASE)

\[ M_{Ed} = 52 \text{ KN}\cdot\text{m} \]

\[ d = 250 - 30 - 10 = 210 \]

\[ k = \frac{M}{L_b d^2 f_c} = 0.03 \]

\[ z = 0.95 d = 194.5 \text{ mm} \]

\[ A_s = 600 \text{ mm}^2 \]

Provide H12-150

\[ A_s = 753 \text{ mm}^2 \]

SHEAR

\[ V_{Ed} = \frac{V_{Ed}}{601} = 6.7 \text{ KN}/1000 \times 250 = 0.18 \text{ KN}/\text{mm}^2 \]

\[ V_{Edc} = 0.54 \text{ KN}/\text{mm}^2 \]

\[ V_e < V_{Edc} \quad \text{SHEAR OK} \]
COMBINATIONS

ULS (i) 1.35k + 1.5k
(ii) 1.0k + 1.3k

SLS (i) 1.0G + 1.0k

← WORST CASE

(BS EN 1990 Annex A)
TABLE 1.2

ANALYSIS

BMD
ULS(i)

SFD
ULS(i)

62 kN
52 kN

36.9 kN/m

~69 kN
DEFLECTION (SPAN/Depth Ratio)

\[ P = 0.11 \quad \text{<} \quad P_0 = 0.56 \]

\[ \frac{L}{D} = K \left[ 1 + \frac{1.5 \sqrt{P_0}}{P} + 3.2 \sqrt{P_0} \left( \frac{P_0}{P} - 1 \right)^{1.5} \right] \]

\[ = 1.0 \left[ 1 + 4.3 + 114.9 \right] \]

\[ = 203 \]

Actual \( \frac{L}{D} = \frac{3.5\text{m}}{0.3\text{m}} = 12 \]

SPAN/Depth OK
**Bearing Pressure on "Toe"**

**Working Load from Slats Above:** 36 kN/m²

**Soil of Wall:** 3.6 m × 0.75 m × 2.0 m = 62.25 m³

**Moment from Horizontal Soil Pressure + Suction:** +37 kN/m

\[ M = \frac{1250 \times 2}{2} = 625 \text{ mm} \]

\[ N = 22.5 \text{ kN/m} + 30 \text{ kN/m} = 58 \text{ kN/m} \]

\[ M = -36.25 \text{ kN/m} \]

\[ \text{Moments} = 43.5 \text{ kN/m} + (-36.25 \text{ kN/m}) \geq 0 \]

\[ \Rightarrow \text{Bearing Pressure} = 46 \text{ kN/m}² \text{ OK} \]