Eckersley O`Callaghan

The Honourable Society of Lincolns Inn Fields
East Terrace Basement Construction Plan

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1 Introduction

This report has been prepared for the East Terrace Extension, there is a separate report for the Library Extension. This report should be read in conjunction with the Structural Report and Basement Impact Assessment dated 27th July 2015.

1.1 Purpose of the Report

It should be noted that whilst this report mentions certain methods and sequences of construction that could be used to complete the works, there are other methods, techniques and sequences that could also be used. The contractor is responsible for the sequence of works and associated temporary works design including stability of the structure throughout the duration of the works. Their final method and sequence will take this report into account but will ultimately supersede this document.

The purpose of the report is to provide a concise plan for the construction of the basement for the East Terrace Extension. The report defines clear methods of ensuring that the adjacent Historic buildings are not damaged during the construction by carrying out condition surveys and monitoring the movement throughout the construction works. It also gives an overview of the construction sequence and proposed temporary works for the basement installation. Camden Planning Guidance document CPG4 suggests that the following list items are to be included within a basement construction plan:

— A method statement detailing the proposed method of ensuring the safety and stability of neighbouring properties throughout the construction phase including temporary works sequence drawings, appropriate monitoring including details of risk assessment thresholds and contingency measures, detail demonstrating that the basement has been designed using evidence of local factors including ground conditions, the local water environment and the structural condition of neighbouring properties, in order to minimise the impact on them.
— Provision to retain at the property throughout the construction phase a suitably qualified engineer from a recognised relevant professional body to monitor, inspect, and approve the permanent and temporary basement construction works, and measures to ensure the ongoing maintenance and upkeep of the basement.

The basement construction plan should ensure that:

— a suitably qualified and experienced engineer has agreed the design,
— the modelling of ground conditions and water environment is appropriately conservative; and
— best endeavours are undertaken to prevent any impact on the structural integrity of the neighbouring properties.

1.2 East Terrace Basement

The East Terrace basement will primarily be formed with a piled retaining wall to the perimeter and an internal concrete frame box construction. There is an approximate structural grid of 7.5x5m to the column layout, within the advocacy rooms, where columns can be situated within partition walls. The lecture hall at the north of the building has 13x9.5m open plan double height space. The piled basement retaining walls will be horizontally propped at pile cap level by the internal level 1 basement slab. In the lecture hall the double height wall will be retained by a 2m wide capping beam. The East Terrace ground water level recorded at from 14.1m-14.4m AOD has confirmed the requirement for a ‘secant’ interlocking piled wall construction. This will hold out the water in the temporary condition, whilst basement excavations progress.

The level 2 basement slab is designed as a suspended slab cast onto a heave mat. This will allow for the relief of overburden pressures associated with clay heave. The uplift effect of the water table has also been taken into account in the design of the basement slab and the piled foundations. Buoyancy uplift of ~10kPa will be counteracted by the structure self-weight and ground heave movements will be accounted for by the cellcore heave mat below the basement slab.

At the southern end of the east terrace there is a requirement for some underpinning to the existing building to allow excavations to progress. These underpins should not extend below the water table due to the shallower slab level in this area. Locally borehole #1 has shown a consistent water level of ~14.1m AOD over an extend period of time. The contractor may need to allow for permeation grouting in this area if water is found to be shallower than the stand pipe record has indicated. A trial pit will be carried out at the outset of the works to confirm the extent of the grouting required (if any).

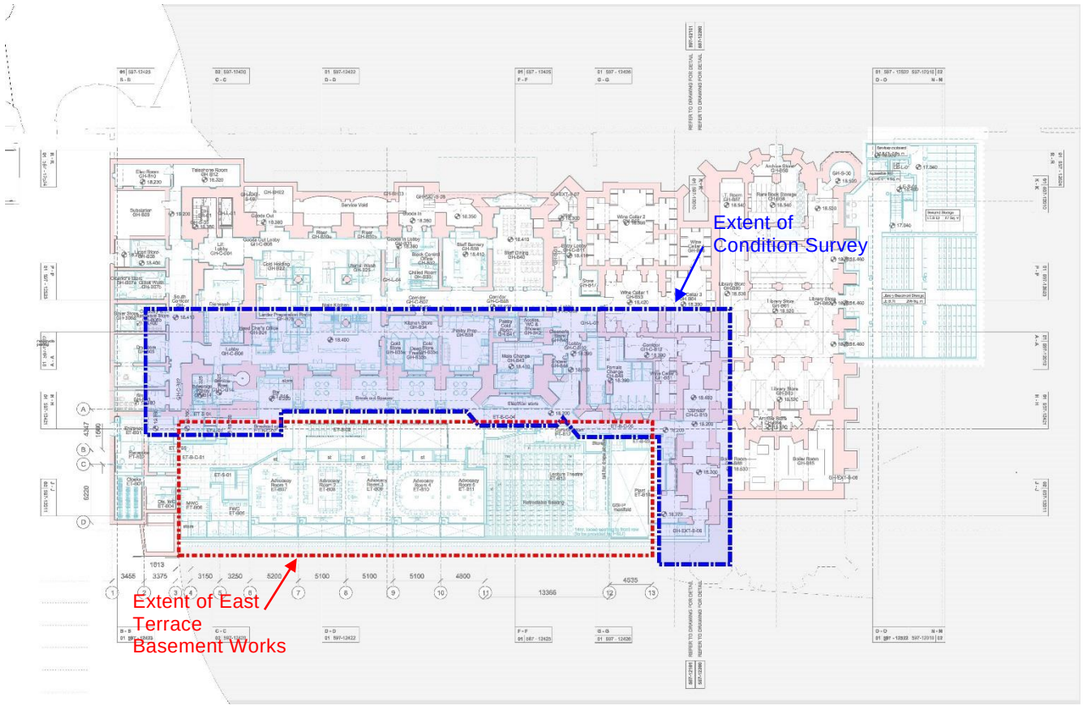


Figure 1 – Proposed Basement Developments Plan Drawing – Rick Mather Architects

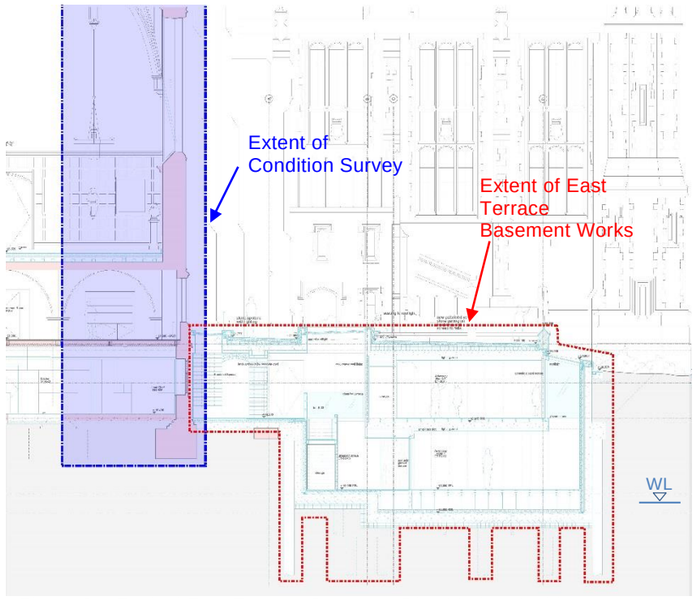


Figure 2 – Typical East Terrace Section – Rick Mather Architects

2 Existing Conditions

2.1 Site Access

There are several entrances to the site – one on Chancery Lane (to the east) and two directly from Newmans Row and Lincolns Inn Fields to the west. The chosen construction entrance to the proposed development will be the one adjacent to the existing under treasurer's residence building on Newmans Row, also known as the Captains Gate.

2.2 Existing Building

The existing Great Hall and Library buildings are listed by English Heritage as Grade II*. The Great Hall building runs north south along the west site boundary, parallel to Newmans Row. The existing under treasurer's residence building sits to the north of the existing library building. The proposed library extension will replace the current location of the under treasurers residence building, and a glazed structure will form a link and separation between the existing and the new library buildings.

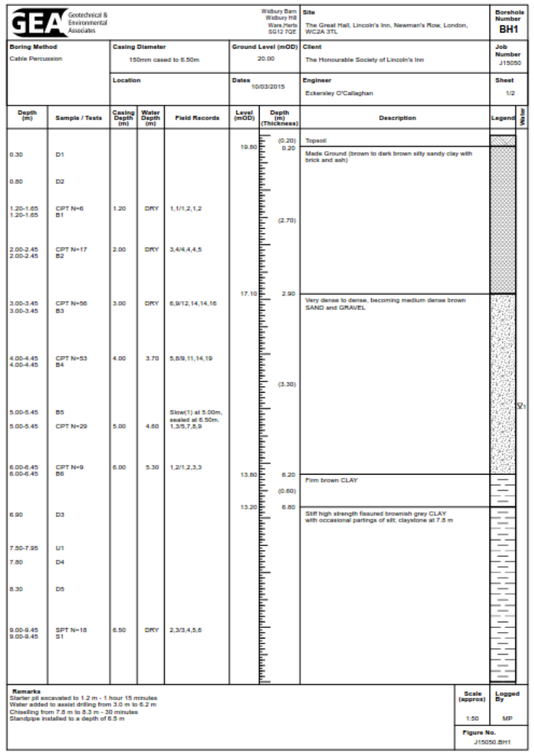
Figure 3 – Site Location

2.3 Existing Conditions

The British Geological Survey indicates that the site is located centrally in an area of Hackney Gravels over London Clay which is verified by the site investigations. Four deep boreholes were carried out across the site, two for each basement area as shown on the site investigation plan layout in Figure 6 overleaf. Boreholes indicated similar subsoil strata generally as follows:

Depth, bgl (m)			Soil Strata
0.0	to	3-4	Made Ground
3-4	to	6	Sand and Gravel
6m+			Firm London Clay

Standpipes were installed within all four boreholes and ongoing monitoring of water levels has identified the depth of the groundwater in the region 14.6m to 14.1m AOD, generally dropping from north to south across the site. Note the east terrace development is to be excavated to 13.5m AOD, i.e. slightly below the level of the measured water level. Figure 4 and Figure 5 show the Borehole logs for BH1 and BH2. These boreholes are adjacent to the propose East Terrace Basement, as shown in Figure 6


GEA Geotechnical & Environmental Associates — Wilbury Barn, Wilbury Hill, Ware,Herts SG12 7QE

Site: The Great Hall, Lincoln's Inn, Newman's Row, London, WC2A 3TL — Borehole Number: BH1

Boring Method: Cable Percussion — Casing Diameter: 150mm cased to 6.50m — Ground Level (mOD): 20.00 — Client: The Honourable Society of Lincoln's Inn — Job Number: J15050

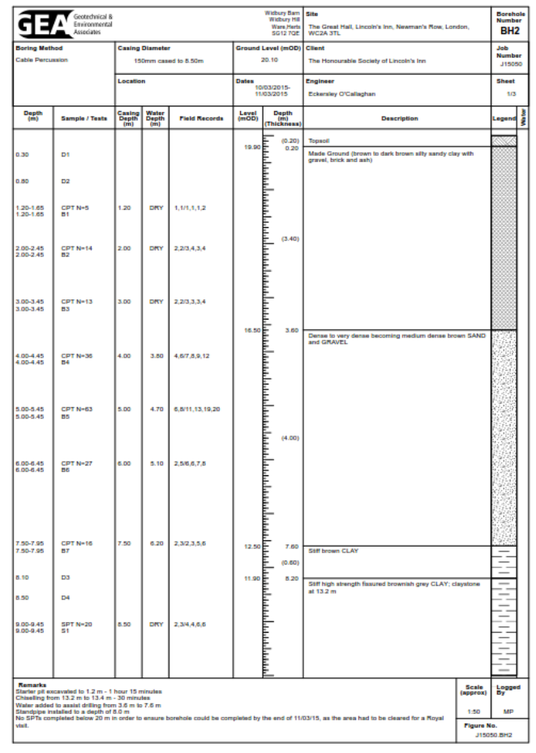
Location: — Dates: 10/03/2015 — Engineer: Eckersley O'Callaghan — Sheet: 1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.30	D1				19.80	(0.20) 0.20	Topsoil		
0.80	D2						Made Ground (brown to dark brown silty sandy clay with brick and ash)		
1.20-1.65	CPT N=6	1.20	DRY	1,1/1,2,1,2		(2.70)			
1.20-1.65	B1								
2.00-2.45	CPT N=17	2.00	DRY	3,4/4,4,4,5					
2.00-2.45	B2								
3.00-3.45	CPT N=56	3.00	DRY	6,9/12,14,14,16	17.10	2.90	Very dense to dense, becoming medium dense brown SAND and GRAVEL		
3.00-3.45	B3								
4.00-4.45	CPT N=53	4.00	3.70	5,8/9,11,14,19					
4.00-4.45	B4								
5.00-5.45	B5					(3.30)			
5.00-5.45	CPT N=29	5.00	4.60	Slow(1) at 5.00m, sealed at 6.50m, 1,3/5,7,8,9					
6.00-6.45	CPT N=9	6.00	5.30	1,2/1,2,3,3	13.80	6.20	Firm brown CLAY		
6.00-6.45	B6					(0.60)			
6.90	D3				13.20	6.80	Stiff high strength fissured brownish grey CLAY with occasional partings of silt; claystone at 7.8 m		
7.50-7.95	U1								
7.80	D4								
8.30	D5								
9.00-9.45	SPT N=18	6.50	DRY	2,3/3,4,5,6					
9.00-9.45	S1								

Remarks: Starter pit excavated to 1.2 m - 1 hour 15 minutes. Water added to assist drilling from 3.0 m to 6.2 m. Chiselling from 7.8 m to 8.3 m - 30 minutes. Standpipe installed to a depth of 6.5 m

Scale (approx): 1:50 — Logged By: MP — Figure No.: J15050.BH1

Figure 4 – Borehole Data for BH1


GEA Geotechnical & Environmental Associates — Wilbury Barn, Wilbury Hill, Ware,Herts SG12 7QE

Site: The Great Hall, Lincoln's Inn, Newman's Row, London, WC2A 3TL — Borehole Number: BH2

Boring Method: Cable Percussion — Casing Diameter: 150mm cased to 8.50m — Ground Level (mOD): 20.10 — Client: The Honourable Society of Lincoln's Inn — Job Number: J15050

Location: — Dates: 10/03/2015-11/03/2015 — Engineer: Eckersley O'Callaghan — Sheet: 1/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.30	D1				19.90	(0.20) 0.20	Topsoil		
0.80	D2						Made Ground (brown to dark brown silty sandy clay with gravel, brick and ash)		
1.20-1.65	CPT N=5	1.20	DRY	1,1/1,1,1,2		(3.40)			
1.20-1.65	B1								
2.00-2.45	CPT N=14	2.00	DRY	2,2/3,4,3,4					
2.00-2.45	B2								
3.00-3.45	CPT N=13	3.00	DRY	2,2/3,3,3,4	16.50	3.60	Dense to very dense becoming medium dense brown SAND and GRAVEL		
3.00-3.45	B3								
4.00-4.45	CPT N=36	4.00	3.80	4,6/7,8,9,12					
4.00-4.45	B4								
5.00-5.45	CPT N=63	5.00	4.70	6,8/11,13,19,20		(4.00)			
5.00-5.45	B5								
6.00-6.45	CPT N=27	6.00	5.10	2,5/6,6,7,8					
6.00-6.45	B6								
7.50-7.95	CPT N=16	7.50	6.20	2,3/2,3,5,6	12.50	7.60	Stiff brown CLAY		
7.50-7.95	B7					(0.60)			
8.10	D3				11.90	8.20	Stiff high strength fissured brownish grey CLAY; claystone at 13.2 m		
8.50	D4								
9.00-9.45	SPT N=20	8.50	DRY	2,3/4,4,6,6					
9.00-9.45	S1								

Remarks: Starter pit excavated to 1.2 m - 1 hour 15 minutes. Chiselling from 13.2 m to 13.4 m - 30 minutes. Water added to assist drilling from 3.6 m to 7.6 m. Standpipe installed to a depth of 8.0 m. No SPTs completed below 20 m in order to ensure borehole could be completed by the end of 11/03/15, as the area had to be cleared for a Royal visit.

Scale (approx): 1:50 — Logged By: MP — Figure No.: J15050.BH2

Figure 5 – Borehole Data for BH2

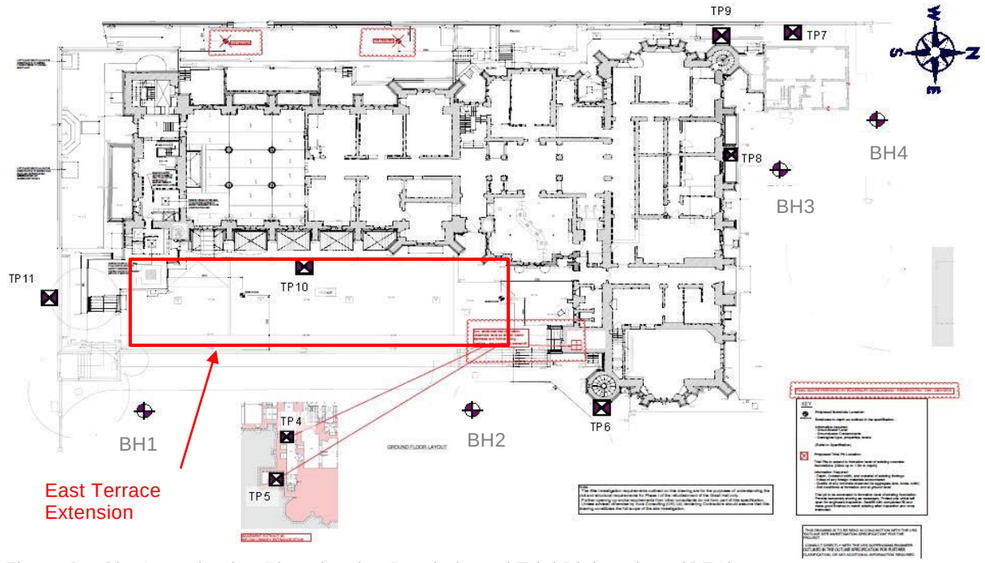


Figure 6 – Site Investigation Plan showing Borehole and Trial Pit locations (GEA)

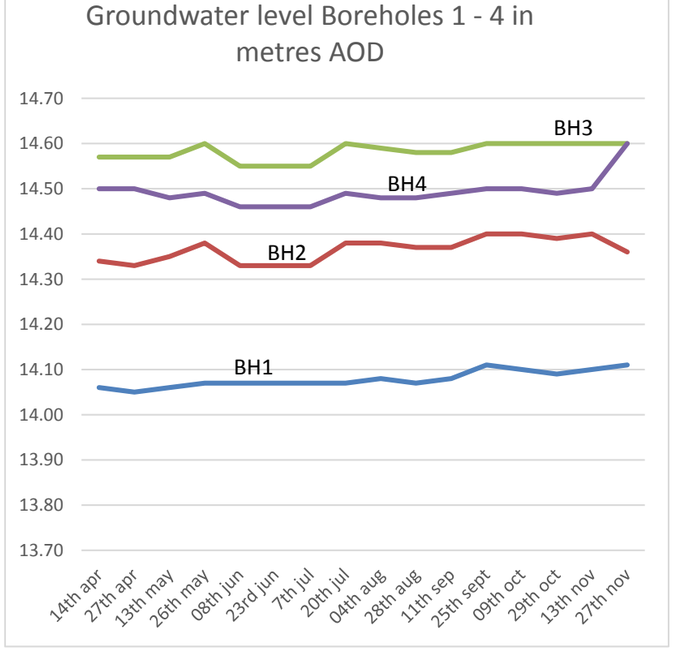


Figure 7 – Groundwater Monitoring from BH1 – BH4 during 2015

3 Condition Surveys

3.1 Condition Surveys

A Condition Survey of the existing Great Hall Building will be carried out prior to commencement of works. Photographic and descriptive records of the existing conditions must be provided including plans and elevation drawings including annotations of visible existing defects, such as length and width of cracks as necessary. This will form a record of the existing condition which can be referred back to during and after works have been completed. The client may request a post construction condition survey if they consider this necessary.

3.2 Extent of Condition Survey

The predicted ground movements in the revised ground movement assessment and the damage category assessment discussed in section 7 concludes that only the eastern frontage of the Great Hall and Library will be affected and therefore beyond this zone a condition survey is not required. The extent of the condition survey shall be carried out to a distance of 6m from the edge of the building as shown in Figure 8, 9 and 10.

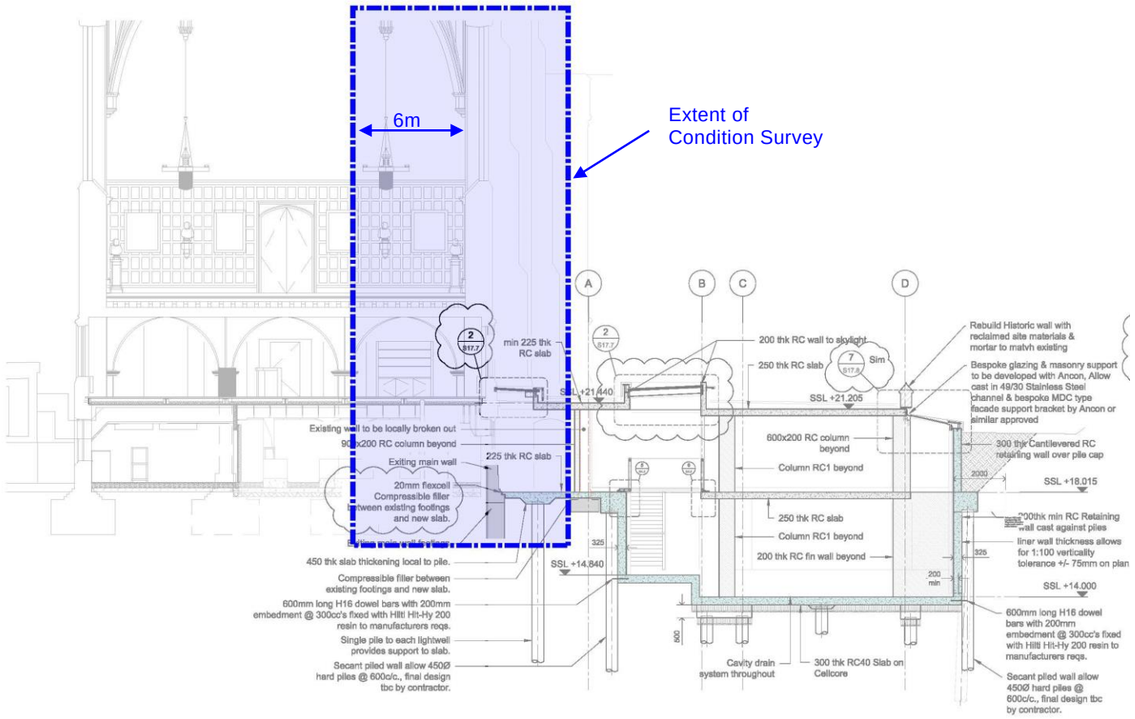


Figure 8 – Section showing Extent of Condition Survey

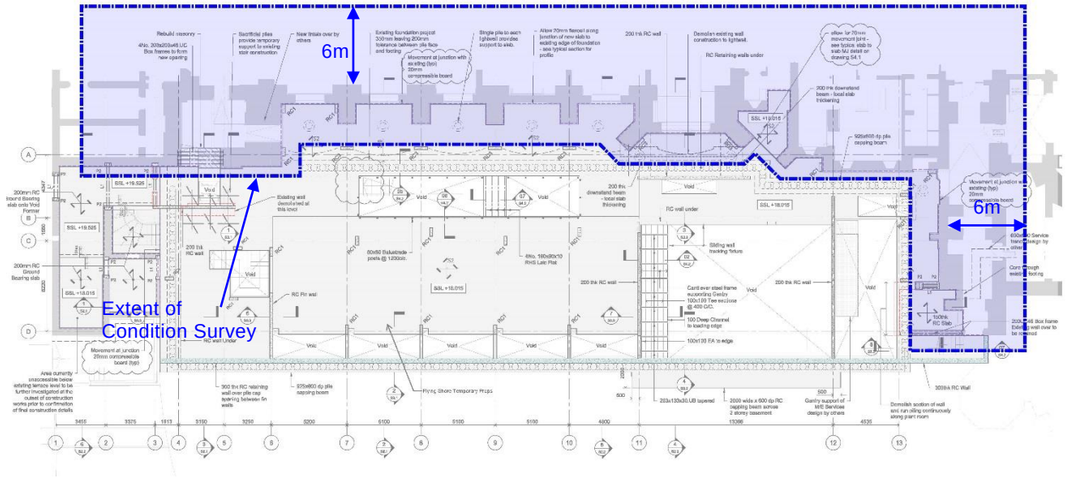


Figure 9 – Basement Plan showing Extent of Condition Survey

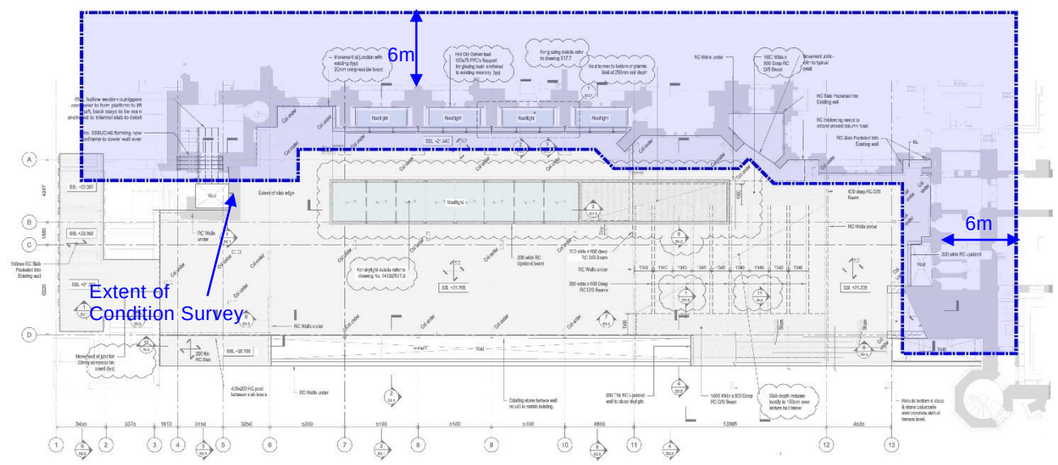


Figure 10 – Ground Floor Plan showing Extent of Condition Survey

4 Movement Monitoring Proposals

4.1 Monitoring

This section of the report provides the requisite information for the 3-dimensional monitoring of vertical and horizontal movement of the existing Historic Great Hall and Library Buildings at the site adjacent to the proposed basement excavation.

During the course of the piling and excavation works, reference should be made to the Ground Movement Assessment report appended to this report. Reference should also be made to the relevant clauses for monitoring within CIRIA Publication C579, Retention of Masonry Facades – Best Practice Guide.

4.2 Monitoring survey points

Façade survey points:

— A suggested arrangement of movement monitoring targets is indicated on engineering drawings appended to this report and Figure 11, 12 and 13.

— Establish an agreed number and location of survey points and record initial positions to enable monitoring of:

a) 3-dimensional movements: in accordance with trigger points as identified in section 4.6.

b) Crack widths: >1mm

c) Adjacent structure survey points: Before loading, establish and record initial positions to enable monitoring of adjacent building structures

d) Ensure datum for monitoring is on a solid structure away from building works and is not at risk of seasonal movement or damage from construction works.

4.3 Location of Monitoring Targets

The monitoring targets are to be located along the adjoining façades as indicated on the engineering sections/elevations above ground level in pairs at 5m horizontal centres with an approximate parallel spacing of 3m vertically to allow for 3-dimensional movement monitoring to the full extent of the affected areas. These locations are shown in Figure 11 and 12 adjacent.

Hilti nail targets are also to be provided along the pile capping beam at 5m centres to monitor 3-d movements; these locations are shown in Figure 13 adjacent. The targets are not to be obstructed and should be accessible for monitoring at all times during the construction works.

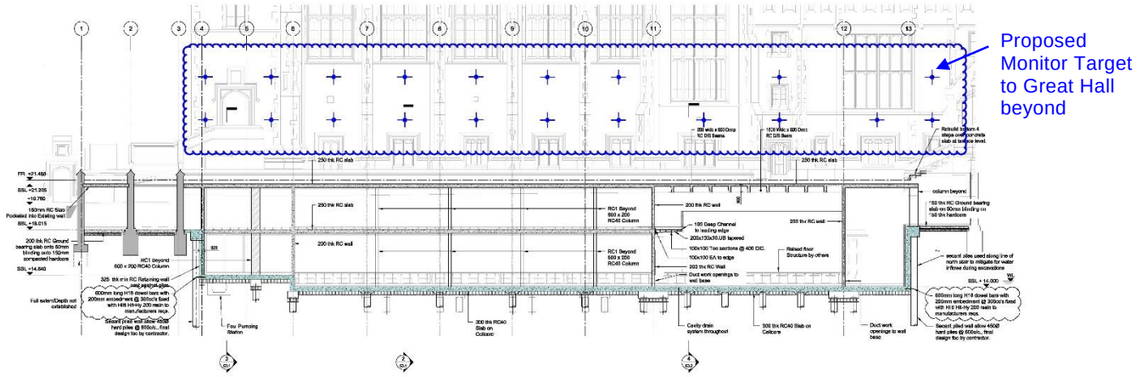


Figure 11 – Section showing proposed monitoring targets on the Great Hall East Elevation

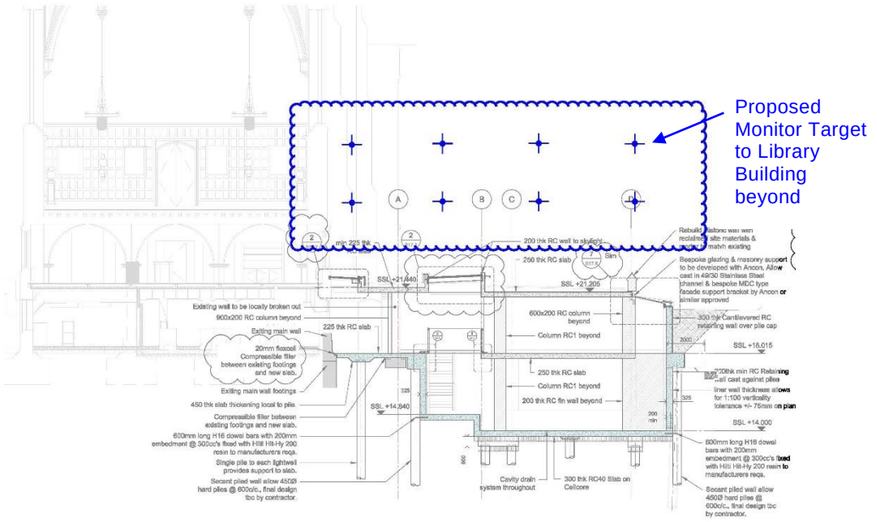


Figure 12 – Section showing proposed monitoring targets on the Library South Elevation Beyond

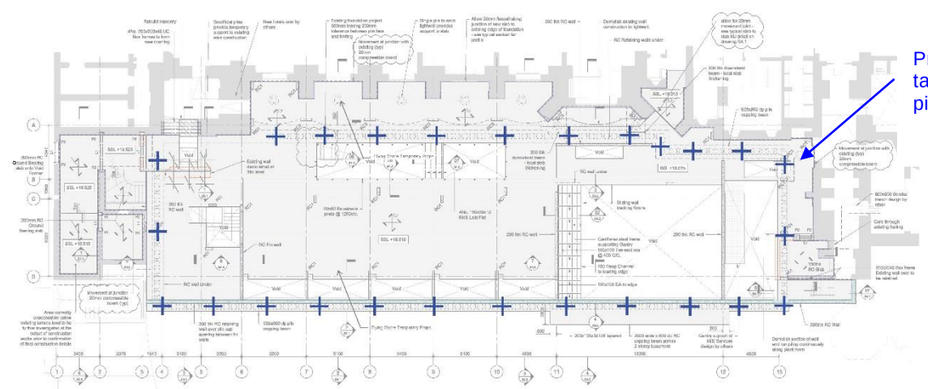


Figure 13 – Plan showing proposed monitoring targets at head of pile capping beam

4.4 Timing and Frequency of Monitoring

The proposed frequency of monitoring is as follows:

— The initial readings taken prior to work commencing on site should be stable and consistent. Inconsistencies should first be checked by repeating readings and checking the surveying instrumentation & method. The contractor should report on causes of all inconsistencies in readings and calibrate his monitoring equipment according to good practice.

— Prior to start of demolition: Three sets of readings taken over the duration of 3 weeks minimum before start of major structural intervention/demolition works commencing on site.

— During underpinning, piling and substructure works: full set of 3-D readings to be taken every week, for the duration of this period of work.

— A weekly information pack to be issued to Eckersley O'Callaghan within 24hrs of readings being carried out.

— Post basement works: façade readings to be taken monthly, for 3 months on completion of structural interventions (i.e. during the fit-out stage).

4.5 Method of Monitoring

The method of monitoring should comply with the requirements of CIRIA Publication C579. This includes consideration of accuracy of readings, location of site, position of fixed datum not affected by the works on site and weather conditions.

The contractor is to submit a detailed method statement of the proposed monitoring regime, including types of targets and monitoring equipment.

The contractor is expected to review monitoring results immediately after readings are taken and report any excessive and unexpected movements to the engineer. Results of monitoring are to be issued to Eckersley O'Callaghan within 24 hours of readings being taken.

The monitoring report is to include all previous monitoring records referenced according to the dates and times at which the readings were taken. These should be presented in graphical or tabular format.

4.6 Trigger Levels for Action

Based on the scale of allowable predicted movements within the Ground Movement Assessment report appended to this document the following "trigger levels" will be used for **vertical movements** at target locations:

Green	Amber	Red
>4mm	>8mm	>12mm

Based on the scale of allowable predicted movements within the Ground Movement Assessment report appended to this document the following "trigger levels" will be used for **horizontal movements** at target locations:

Green	Amber	Red
>4mm	>6mm	>9mm

The above scale of movements are to trigger the following proportionate actions:

Green: movement will be closely monitored to check if the structures are stable and movements are not accelerative.

Amber: above this limit a review of working procedures and assumptions will be conducted, to provide reassurance that the total movement will not be excessive, or to warrant modifying working methods.

Red: work to be stopped if this limit is exceeded until the reason for reaching the limit has been identified and any remedial action has been agreed.

— Note: for movement below Green trigger level no action is required.

— Accuracy of reading: to be agreed +/-2mm typically

5 Indicative Construction Sequence and Temporary Works

5.1 Construction Sequence of Basement

The following illustrative construction sequence is based on a traditional 'open excavation' using flying shores and bracers to prop the head of the retaining walls. There is an alternative to this known as 'top-down' construction, whereby the ground level slab is cast at the outset, before the basement excavations are commenced, and hence the need for flying shores is omitted. It is noted that a top-down sequence of works would not onerously affect the results of the Ground Movement Assessment discussed in section 7 and hence the calculated results contained are valid for both methods.

5.2 Site Set Up & Welfare

1. Carry out site topographic survey and set up benchmarks as required.
2. Terminate and divert existing services.
3. A hoarding will be constructed to site perimeter in line with CMP, to provide protection to passers-by
4. Install tree protection measures and temporary foundations for site facilities if required.
5. Set up site office and welfare facilities and Commence initial demolition and excavation works.
6. Access is only available from Newmans Rows so it is assumed that all deliveries, removals and access for operatives will be made from here.
7. This entrance will be manned by a banksman during operational hours to ensure construction deliveries do not pose potential risk to pedestrians and site operatives.
8. Install monitoring targets to adjacent listed building. Carry out baseline readings over period of two weeks to generate control readings.

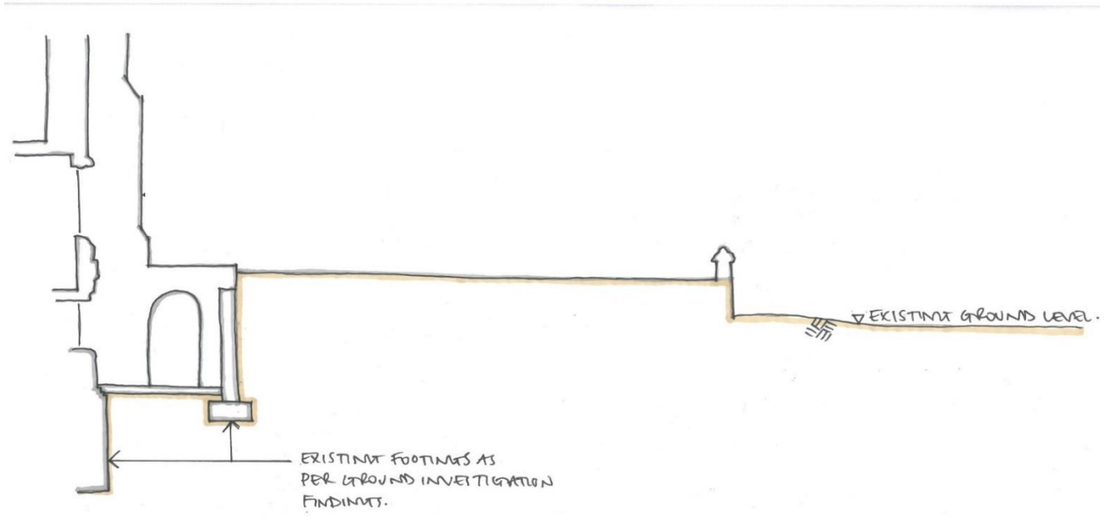


Figure 14 – Existing Condition

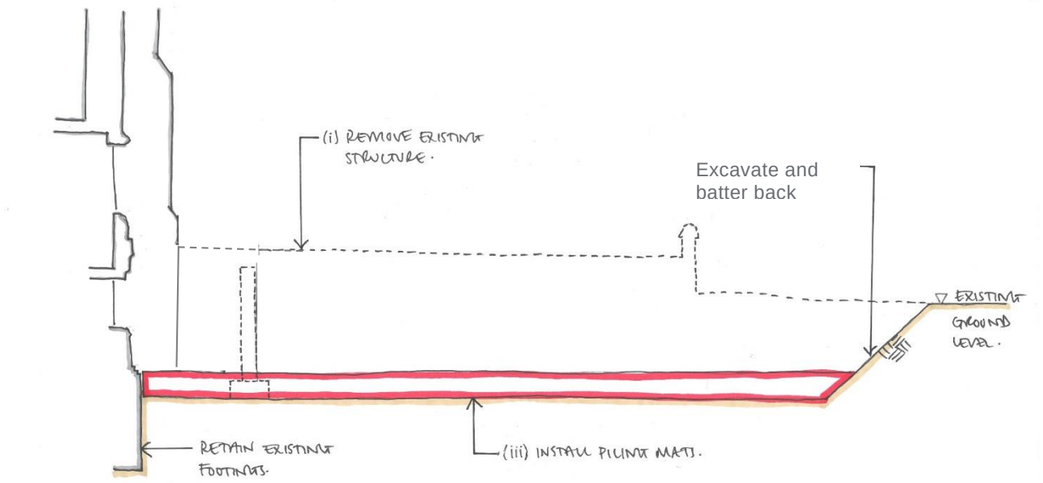


Figure 15 – Remove existing structure and start excavation to Pile Map level

5.3 Reduce Levels, Install Pile Mat & Commence Piling

1. Remove existing terrace wall and store safely for use in final construction.
2. Reduce levels, carefully demolish lightwell walls between buttresses using non-percussive methods.
3. Batter back and install piling mat.
4. Install guide wall & commence piling.
5. Install steel king posts into piles at maximum 6m centres to provide support for temporary flying shores.

5.4 Excavation of Basement (between 6 to 9 months duration)

1. Remove Piling Mat. Cast pile capping beams & carry out nominal dig to 1m below pile cap level.
2. Install flying shores to span full width of excavation propped from king post to king post across the excavation.
3. Commence excavation works of the basement.
4. It may be necessary to provide some limited groundwater control during the excavations to remove perched water within the made ground and gravel layers.
5. Install blinding layer on completion of excavation, followed by pouring of raft slab. The basement works will be completed in a 'bottom-up' sequence with perimeter liner walls, then column and wall column formwork installed and poured followed by ground floor slab installation.
6. The temporary props should remain installed until the ground floor slabs have been cast and adequately cured providing the permanent bracing system for the pile capping beams.

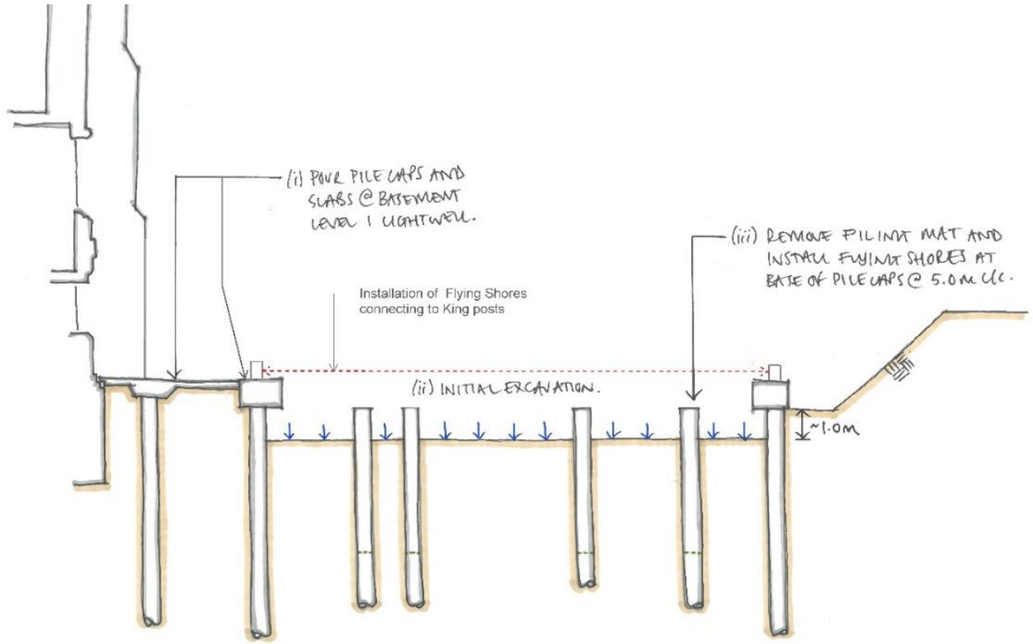


Figure 17 – Installation of Flying Shores

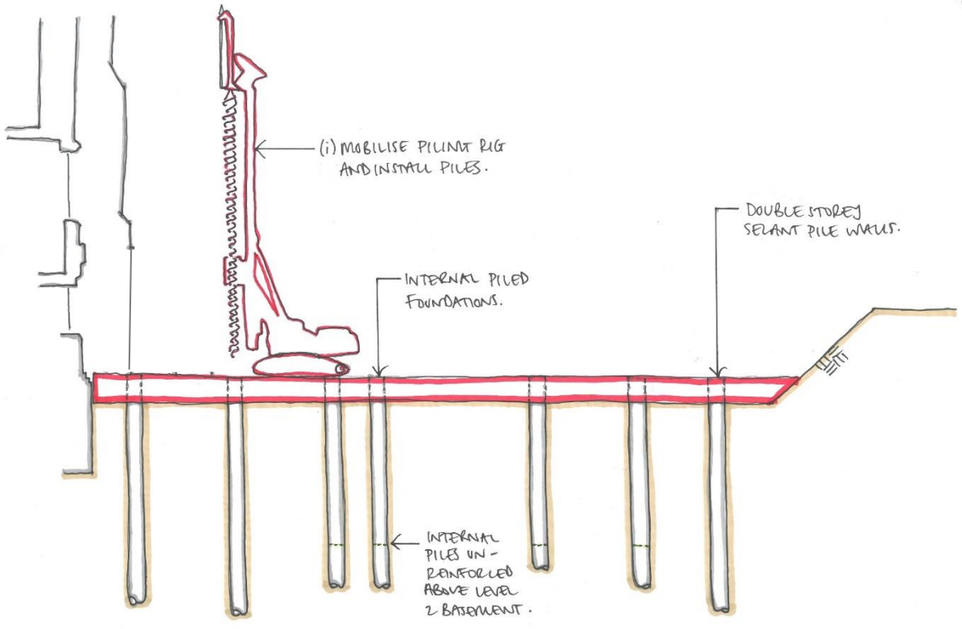


Figure 16 – Install Piles

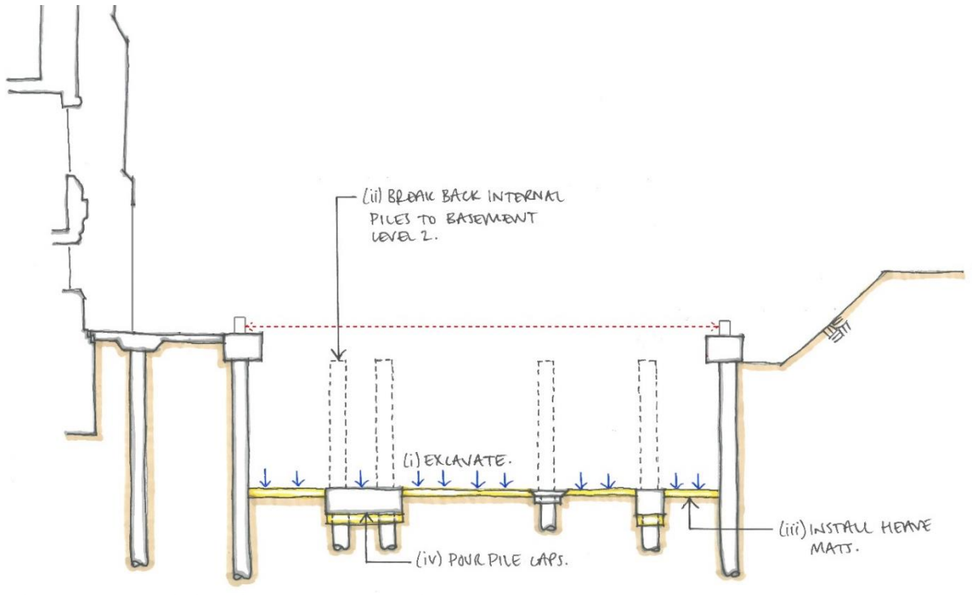


Figure 18 – Completion of Basement Excavation

5.5 Temporary Props

There are several ways in providing temporary supports for basements. The temporary works proposals for the basement construction of the East Terrace will be to use Groundforce or similar flying shores to provide a speedy installation and removal. Alternatively a 'top-down' construction may be preferable to tendering contractors and therefore the flying shores would not be required as the propping forces would be introduced into the ground floor slab from the outset.

The props span between steel kingposts which will be cast into the piles at 6m centres. King posts are required to provide a connection above the level of the ground floor slab, enabling easy removal of the props once slab has been poured. The posts are a 254UC steel sections with stiffener plates.

The connection between the props and the king post is a swivel end bearing plate which provides a zero moment end connection. The end bearing plate on the MP125 strut is 600mm wide x 500mm high and the connection is shown adjacent.

The props should be installed at 6m centres with diagonal braces at either end of the excavation, as shown adjacent. The props provided should be MP125 struts or similar approved, as these provide sufficient capacity for the maximum excavation length of 13m.

Figure 22 shows the capacities of the MP125 strut at lengths of up to 25m. The temporary propping force is calculated in the Wallap analysis as 35kN/m and therefore 210kN per strut as they are installed at 6m max centres. In Figure 22 the bright blue line represents the maximum capacity of a 13m long strut, giving 1250kN, hence a MP125 strut is adequate for this purpose.

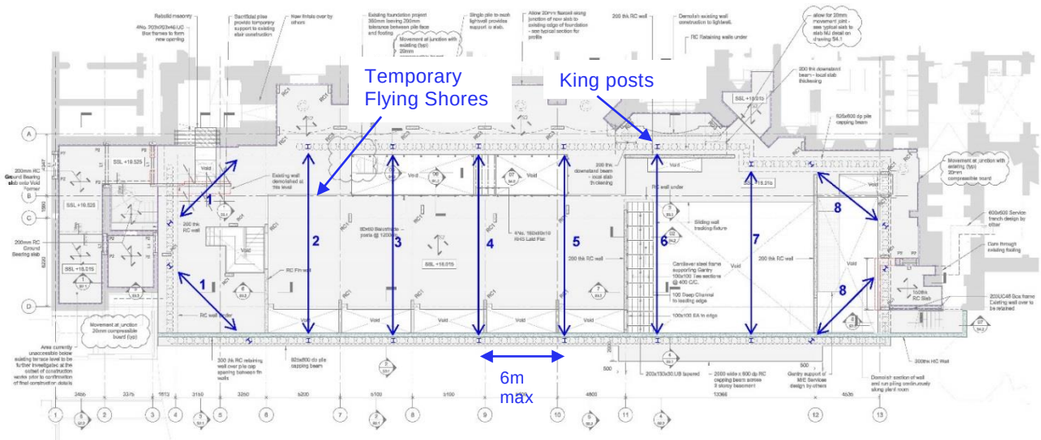


Figure 19 – Basement Plan showing indicative location of flying shoresand suggested sequence of installation

Figure 20 – Photo showing typical Groundforce struts spanning across a basement excavation © Groundforce &
Figure 21 – MP125 Groundforce Strut End Plate Connection to Kingpost © Groundforce

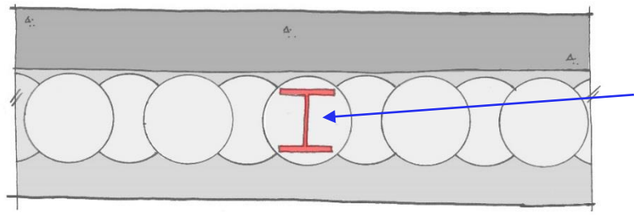


Figure 21 – Indicative view of 254 UC Kingpost installed within piled wall

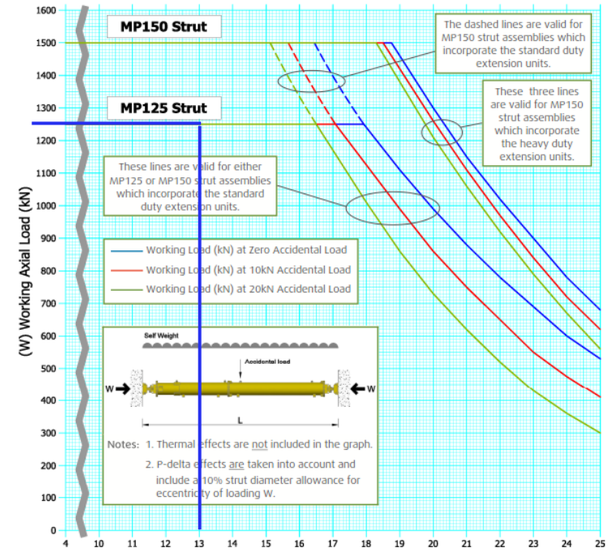


Figure 22 – Working Load Chart for Groundforce MP125 Hydraulic Strut

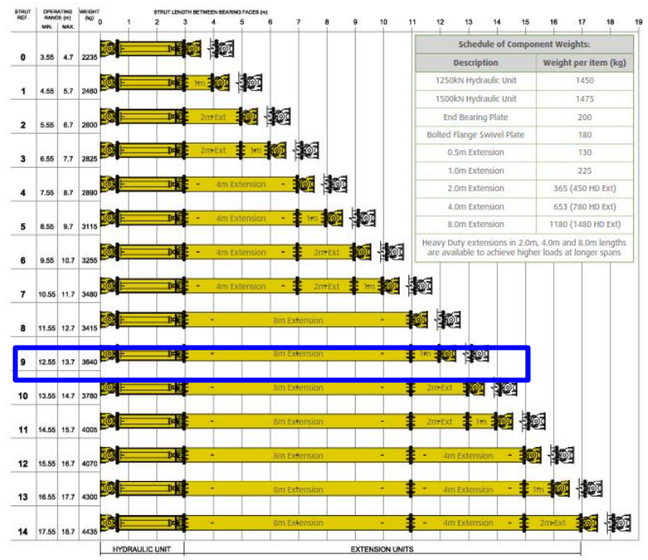


Figure 23 – MP125 Operating Range and Weight Chart

6 Underpinning Sequence

6.1 Methodology

In the first instance the contractor is to carry out full depth trial pit to confirm the flow rate, volume and depth of water. Dependent on the outcome of the trial hole, permeation grouting may be required to accommodate unforeseen water levels. For permeation grouting, the soil adjacent to the excavation is injected with cement or chemical-based grout to improve the strength and reduce the permeability of granular soils. An indicative construction sequence is shown in adjacent.

Underpinning should always be carried out in an agreed sequence and have maximum bays of 1.0m wide, as shown in Figure 24. The sequence is to be such that no two adjacent pins are cast within 48 hours of one another.

Typically underpins are cast in a 1 3 5 2 4 1 3 sequence to avoid the casting of adjacent bays in succession. This reduces the risk of delayed curing and settlement. Adjacent pins will be dowelled together to provide a shear connection.

Underpins are to extend to the underside of the proposed basement excavation level. To provide protection to operatives and retain stability to the ground during the excavation, Paceform or similar approved formwork system should be used to mitigate for ground loss within the excavations - see Figure 25.

The rear face of underpinning to be aligned with rear face of the re-supported footing. The front face of underpin is to align with internal face of the supported footing. Pins to be cast approximately 75mm below base of existing foundations to allow for adequate zone of dry-packing.

Dry-pack is to be installed tight between top of pins and underside of existing walls at least 24hours after casting. Excavations are to be back filled to the existing ground level.

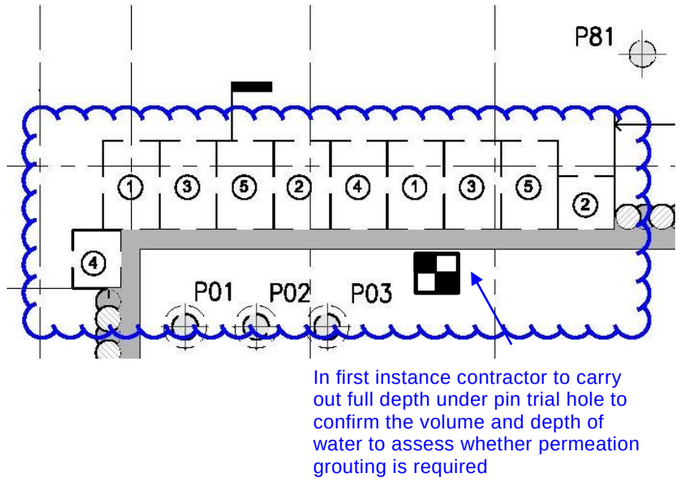


Figure 24 – Plan showing the sequence of bays to be underpinned

Figure 25 – Paceform Permanent Formwork System © Forcia

6.2 Construction Sequence of Underpins

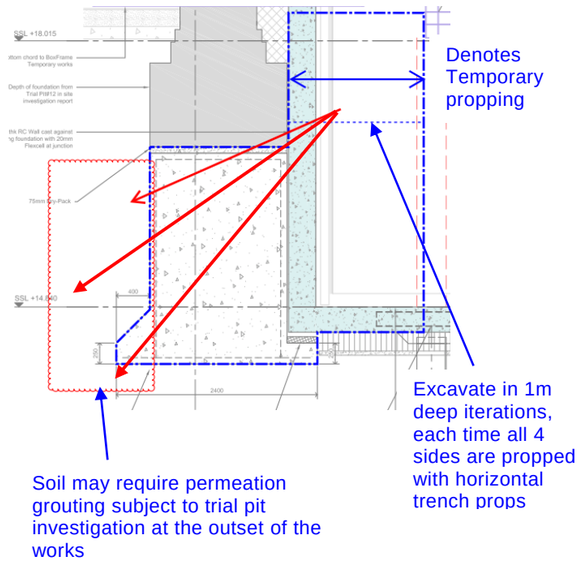


Figure 26 – Initial Dig Including Permeation Grouting Operation if required - tbc

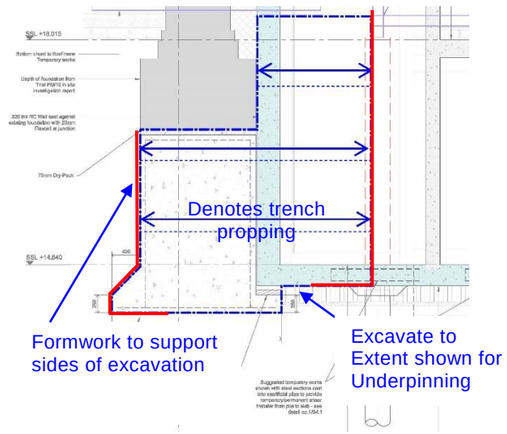


Figure 27 – Excavation of soil and Installation of trench propping to formation level

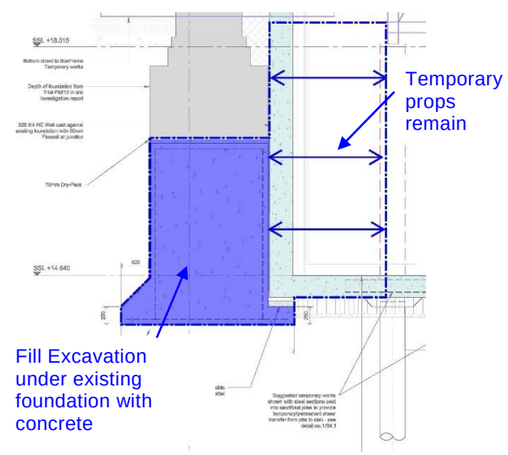


Figure 28 – Pour Underpin

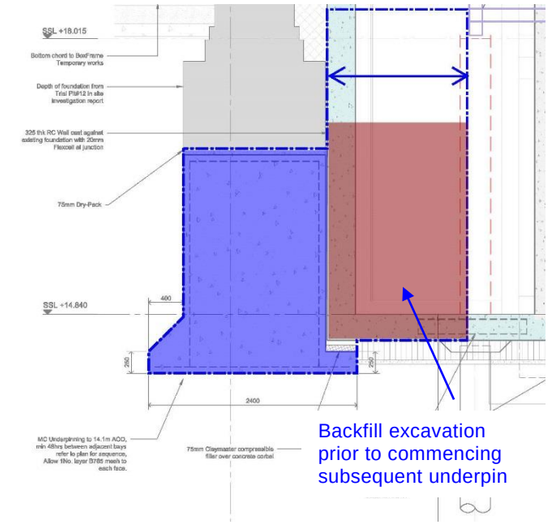


Figure 29 – Fill remaining excavation with backfill material

7 Ground Movement Assessment

This section summarises the results of the specialist Geotechnical design that has been carried out by GEA Ltd. The full version is appended to this report.

7.1 Ground Movement

A revised assessment of ground movements within and surrounding the excavation has been undertaken by *Geotechnical & Environmental Associates (GEA)* to predict the ground movements likely to arise from the construction of the proposed basement. This includes the settlement of the ground (vertical movement) and the lateral movement of soil behind the proposed retaining walls (horizontal movement). Refer to appended Ground Movement Assessment report for the results which includes the Wallap retaining wall analysis, X-disp and P-disp Oasys software outputs.

7.2 Damage Assessment

In addition to the above assessment of the likely movements that will result from the proposed development, some of the neighbouring structures have been considered as sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in the adjacent table. These include:

- The existing structures of the Great Hall (including East Terrace) and adjoining Library Building
- The boundary wall with Newman's Row

The combined movements resulting from both pile installation and basement excavation calculated using the X-Disp modelling software have been used to carry out an assessment of the likely damage to adjacent buildings and the results are summarised in Table 1 below.

The potential heave movements predicted by P-Disp have not been included in this assessment, which can therefore be considered as conservative, as these movements are likely to have a mitigating effect on the downward settlement predicted by X-Disp.

Table 1 – Building Damage Assessment for the Adjacent Structures

Sensitive Structure	Elevation	Category of Damage (as per adjacent table)
The Great Hall	East Terrace – Existing Vaults	Category 0 (Negligible) to Category 1 (Very Slight)
	Eastern – East Terrace Frontage	Category 0 (Negligible) to Category 1 (Very Slight)
	Western	Less than the limit of detection
	Southern	Category 0 (Negligible)
Library Building	Southern – East Terrace Frontage	Category 0 (Negligible) to Category 1 (Very Slight)
	Eastern	Category 0 (Negligible)

7.3 Conclusion & Mitigation Measures

The analysis has concluded that the predicted damage to the neighbouring properties would generally be 'Negligible', with some limited areas of 'Very Slight' along sections of the existing structures that adjoin the East Terrace. On this basis, the damage that would inevitably occur as a result of such an excavation would fall within the acceptable limits.

The sections of wall that are identified as being susceptible to 'very slight' damage will be identified and subject to close scrutiny during the monitoring process. Each of the piled walls that relate to these locations will be designed in detail in due course and will be subject to a specific propping arrangement which will be adjustable to that greater or lesser load can be applied depending on the performance of the piles at each location.

The separate phases of work, including piling / underpinning and subsequent excavation of the proposed basement structures, will in practice be separated by a number of weeks during which time construction of capping beams and pile curing will take place. This will provide an opportunity for the ground movements during and immediately after piling to be measured and the data acquired can be fed back into the design and compared with the predicted values. Such a comparison will allow the ground model to be reviewed and the predicted wall movements to be reassessed prior to the main excavation taking place so that propping arrangements can be adjusted if required. The Groundforce or similar hydraulic shoring will be adjustable during the course of the works and will also allow for real time loads to be compared with the predicted values.

Category of Damage	Description of typical damage	Approximate crack width (mm)	Limiting tensile strain ε_{lim} (%)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible	<0.1	0.0-0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection	<1	0.05-0.075
2 Slight	2 Slight Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weathertightness. Doors and windows may stick slightly.	<5	0.075-0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable lining. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5-15 or a number of cracks >3	0.15-0.3
4 Severe	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable lining. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	15-25 but also depends on number of cracks	>0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings,walls lean badly and require shoring. Windows broken with distortion, Danger of instability.	Usually >25 but depends on number of cracks	

7.4 Design Certification

In accordance with the requirements of CPG4 this BCP document has been approved and certified by an Associate level Chartered Structural Engineer with many years of experience in basement construction and design.

7.5 Design Changes

Any contractor proposals which fundamentally change the proposed temporary works, sequencing and basement construction methods contained within this report will require re-submission to Camden for approval.

Appendix 1 – Structural Drawings

Appendix 2 – Ground Movement Assessment by GEA Ltd