N.M.N PARTNERSHIP LMITED

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26 Amyand Park Road, Twickenham, TW1 3HE

CONSTRUCTION METHOD STATEMENT

November 2024

Project Ref: Nov/23 227

REVISION HISTORY

Rev	Purpose	Date	Issued By	Approved
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CONSTRUCTION METHOD STATEMENT

This Construction Method Statement is produced for submission to the London Borough of Richmond planning department for planning application purposes only and should not be used for any other purposes, e.g. Party Wall Awards.

SCOPE OF WORKS

A new basement will be excavated under the entire footprint of the property, with a 3m front extension and a 1m rear extension. A lightwell will be included at the bay window for natural light and ventilation, while the rear will feature walk-on glass panels instead of lightwells, allowing natural light to penetrate the basement below. The basement will house a 2m wide, 12.5m long swimming pool, as well as a utility room and storage areas.

The ground floor will feature an RC slab with openings for the lightwell, stairs, and walk-on glass panels, providing lateral support to retaining walls. The basement walls, including those for the swimming pool, will be constructed using RC retaining walls designed to resist earth pressures and surcharges. Waterproofing measures will ensure the basement and pool remain dry.

Key design elements include reinforced edges for openings in the slab, waterproofed concrete for the pool and retaining walls, and robust, safe walk-on glass installations for the rear area. The construction will comply with building regulations, ensuring structural integrity, effective ventilation, and natural lighting.

DESCRIPTION OF THE PROPERTY AND ADJOINING PROPERTIES

The property is a three-storey mid-terrace house, constructed with masonry walls, which provide a solid foundation for the structure. The foundations themselves are made from corbeling bricks, a traditional method where bricks are laid in a stepped, overhanging pattern to support the weight of the building. This type of foundation is common in older properties and is designed to bear the load of the walls above while ensuring stability over time.

Internally, the floors across all levels are timber, contributing to the house's period charm and warmth. The roof is supported by timber rafters, forming a traditional roof structure with a lean-to design at the rear of the house, which adds a unique architectural feature. An infill side extension has been added at the rear of the property, featuring skylights that help bring natural light into the space, creating a bright and airy atmosphere.

The property appears to be in sound structural condition. The adjoining properties are of similar construction, and a visual inspection suggests that they too are in good condition. The overall stability of the property and its neighboring buildings indicates that they are well-maintained and secure, offering a solid foundation for any future development or renovation plans.

SOIL CONDITIONS

This Construction Method Statement is supported by our previous successful subterranean developments in the vicinity of the property. The ground conditions in the area consist of Kempton Park Gravels (clayey sands and gravel) overlaying the London Clay. The depth to the London Clay is approximately 6.5 meters below ground level.

Our prior excavation work reached similar depths to those proposed for this project, and we can confirm that no groundwater was encountered during these operations. The new basement design will limit ground bearing pressure to 150 kN/m², ensuring that the existing geological conditions at the proposed depth can adequately support the new imposed loads.

Although no groundwater was encountered during the previous excavations, the basement will be designed in accordance with the recommendations of BS8102:1990, "Protection of structures against water from the ground." Specifically, Clause 3.4 indicates that a water table should be assumed to be at 1.0 meter below ground level, which will be considered in the basement's waterproofing and drainage design.

Additional Measures:

In addition to the water management measures already outlined, the new pumps in the basement will be fitted with non-return valves to prevent flooding in the event of pump failure or blockage. To minimize the discharge to the existing sewers, water-efficient fixtures and fittings will be installed throughout the basement to reduce the overall flow.

Construction Drawings:

Please refer to **Drawings SK 102** and the Appendices for the underpinning layout, sequencing, and sections related to the party walls of the property.

Construction Sequence:

- 1. **Excavation Start:** Excavation will begin at the spine wall of the property, progressing towards the rear and the new 3-meter rear extension. A light well will be incorporated at the rear, passing the 3-meter extension.
- 2. **Temporary Ground Floor Removal:** A portion of the existing timber ground floor will be temporarily removed to allow for the loading of excavated material onto skips using a conveyor belt system. This will provide access to the basement area.
- 3. **Conveyor Belt Setup:** A conveyor belt will be set up through the front room and window to move the spoil from the excavation to a skip placed on the driveway for disposal.
- 4. Underpinning Sequence: The existing property will be underpinned using a 1, 3, 5, 2,

and 4 "hit and miss" sequence, as shown in **Drawing NMN/SK 102**. This underpinning sequence will ensure proper support during the basement excavation process.

- 5. **Horizontal Propping for Underpins:** Horizontal propping will be required at the toe and high level of the underpins until the basement slab is completed, and the underpinning pins gain the required strength.
- 6. **Removal of Ground Floor Elements:** As excavation progresses, the remaining ground floor joists and concrete slabs will be broken out and removed. Any existing foundations encountered during excavation will also be removed to allow space for the new basement.
- 7. **Demolition of Internal Walls and Floor Support:** Internal walls will be demolished, and the floors above will be temporarily supported with steel beams and props to ensure stability during the excavation and construction phases. Temporary support will be provided for the floors above using a top-down sequence. The rear wall will receive moment frame support via temporary needles and props at 800mm centers, supported off the newly cast underpin toes (see **SK101**).
- 8. **Rear Wall Excavation and Retaining Wall Construction:** Once the rear wall is exposed, excavation and installation of the reinforced concrete (RC) retaining wall for the rear extension will follow. This will be carried out in a similar manner to the underpinning of the party walls, with a 1-meter wide section excavated at a time. Temporary lateral supports will be used during construction.
- 9. **Construction of Basement Slab:** Once the retaining walls with toes are completed, a 250mm thick suspended basement slab will be constructed, spanning between the retaining wall toes as detailed.
- 10. Ground Floor RC Slab for Patio: After the rear extension basement is formed with the temporary supports in place, the ground floor RC slab will be constructed to form the patio area.
- 11. **Rear Bi-Fold Door Opening and Roof Installation:** The rear bi-fold door opening will be supported by a torsion beam, as detailed in the construction drawings. A new timber roof with a skylight will be installed as per the design.
- 12. **Installation of Second Level of Props:** Once excavation reaches approximately 500mm above the proposed basement level, a second level of horizontal props will be installed if required by the design.
- 13. **Excavation to Formation Level:** Excavation will continue down to the formation level, as specified in the project design.
- 14. Drainage Installation: Below-slab drainage systems for both foul and ground water,

as well as sumps and pumps, will be installed. The pumps will discharge water into a silt tank, and once approved, it will be directed into the existing sewer system at the front of the property.

- 15. **Construction of New Basement RC Slab:** The new ground-bearing basement RC slab will be cast using A393 mesh at both the top and bottom of the slab. The extension basement slab will be cast between the retaining wall toes, with bent-up bars from the toes.
- 16. **Removal of Horizontal Propping:** Once the new basement slab has gained sufficient strength, horizontal propping across the basement level will be removed. However, the propping below the ground floor will remain in place until the ground floor slab is cast and has cured.
- 17. Excavation for Swimming Pool: Excavation for the swimming pool will commence along the No 28 party wall line, utilizing the underpinning method with toes, similar to the basement underpinning. Raking props will be installed from the basement level off the toe, while the opposite side of the pool will be cast as one continuous retaining wall.
- 18. **Drained Cavity Layer Installation:** After the basement slab has cured, a drained cavity layer will be installed on both the slab and the walls of the basement.
- 19. **Insulation Installation:** A layer of insulation will be placed on top of the drained cavity layer on the slab and along the walls in front of the drained cavity layer.
- 20. **Screed Layer for Finished Floor:** Finally, a screed layer will be applied to form the finished basement floor, providing a level surface for use and finishing.

This sequence ensures a systematic approach to excavating, underpinning, and constructing the basement, while maintaining the integrity of the existing structure and minimizing disruption during the process.

POTENTIAL IMPACT ON THE PROPERTY AND ADJOINING PROPERTIES

The proposed basement will be formed using an underpinning method, designed to ensure the structural integrity of both the existing property and neighbouring structures. The underpinning will be carried out in sections, with each pin being no wider than 1000mm to minimize disruption to the surrounding ground and foundations. Additionally, to further reduce the risk of ground movement, no adjacent underpins will be constructed within a 72-hour period from the time of dry packing between the top of the pin and the underside of the existing foundation. This phased approach ensures that the ground has sufficient time to settle and stabilise between operations, thereby minimizing any potential impact on the surrounding area.

By adopting this method of construction, the amount of potential ground movement is significantly reduced, which in turn minimizes the effects of settlement on both the property undergoing the works and any adjoining structures. The careful sequencing and controlled technique employed in this underpinning process are essential in preventing any unintended consequences, such as subsidence or structural instability.

Furthermore, the proposed works, if executed properly and in strict accordance with the appointed Engineer's detailed plans, guidelines, and procedures, will pose no significant threat to the structural stability of the property or the surrounding properties. The design has been specifically tailored to ensure that all potential risks are mitigated, and appropriate safeguards are put in place. With expert oversight and adherence to best practices, the works will proceed without compromising the safety and stability of the existing structures, ensuring a successful outcome for all parties involved.

POTENTIAL IMPACT ON EXISTING AND SURROUNDING UTILITIES, INFRASTRUCTURE AND MAN – MADE CAVITIES

Any local services that are located on the property's land will be carefully maintained throughout the construction process. In cases where it becomes necessary, these services will be rerouted to ensure their continued functionality and to prevent any disruption. While the exact location of these services will not be fully known until the works begin, we anticipate that any potential impact on these services will be negligible, as they will be properly managed and maintained during the course of construction.

In the event that it is required to relocate or divert any utilities, the Contractor and the Design Team will be legally bound to notify the relevant utility owners in advance of undertaking any work. This notification is crucial as it allows the utility owners to assess the potential impact of the works on their infrastructure. Following this assessment, the utility owner will have the authority to either approve or deny the proposed alterations based on their findings. This ensures that all utilities are properly managed and that their operation is not compromised during construction. Furthermore, it is important to note that there are no known man-made cavities, such as tunnels, in the vicinity of the proposed basement. This significantly reduces the likelihood of encountering unexpected underground voids or structures during excavation. The thorough planning and communication with utility owners, combined with the absence of known underground anomalies, ensure that the construction works can proceed without causing unforeseen complications related to services or sub-surface conditions.

POTENTIAL IMPACT ON DRAINAGE, SEWAGE, SURFACE AND GROUND WATER LEVELS AND FLOWS

All existing drainage and sewage connections will be meticulously maintained throughout the duration of the construction works, ensuring there is no disruption to the functionality of these vital systems. The proposed works are designed with minimal impact on the current infrastructure, and the property will remain a single residential unit throughout the construction process. As such, there will be no significant alteration to the existing drainage and sewage systems, and the overall discharge of wastewater to these systems will remain virtually unchanged. Consequently, the impact on the foul drainage system is expected to be minimal, with no major modifications or strain placed on it as a result of the basement construction.

Surface water management will also remain unaffected, as the scope of the proposed works is entirely subterranean, with no new "hard surfaces" being introduced at ground level. This means that the existing surface water drainage systems will continue to operate as originally designed, with no additional runoff generated from the proposed development. The absence of new impermeable surfaces ensures that there will be no significant increase in surface water discharge, thus minimizing the risk of localized flooding or overloading of the existing drainage systems.

The basement will be constructed at a level significantly above the local groundwater table, ensuring that the works will not impact or disrupt the natural flow of groundwater in the surrounding area, both during and after the construction process. The depth of the basement excavation has been carefully planned to avoid interference with any groundwater flows, and special attention will be given to ensuring that groundwater does not enter the excavation. In the rare event that any groundwater is encountered during excavation, measures will be taken to manage the situation appropriately. However, the pumping out of water will not be permitted on site. Instead, the procedure for managing any unexpected groundwater will involve the digging of containment holes to hold and manage the water until it can be safely addressed. This approach will ensure that the excavation process is managed responsibly, without any adverse impact on the surrounding environment or groundwater flow.

To ensure the potential risks associated with the construction works are fully understood and mitigated, a comprehensive Ground Investigation and Basement Impact Assessment has been carried out by Jomas Environmental Engineers. This thorough investigation has provided valuable insights into the local subsurface conditions, allowing for a detailed assessment of how the proposed works may interact with the existing infrastructure and environment. The findings from this assessment have been incorporated into the design and construction plans, ensuring that all necessary precautions and solutions are in place to prevent any unforeseen complications. The proactive approach taken in addressing groundwater, drainage, and other subsurface conditions guarantees that the construction will proceed smoothly, with minimal impact on the surrounding area and infrastructure.

Prepared By

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NMN Partnership Ltd

APPENDICES

The following appendices are included with this report.

Appendix A - NMN Partnership Proposed Drawings and Construction Sequence

Appendix B - Soil Investigation and BIA Report by Jomas Environmental Engineers

Appendix C – NMN Partnership Calculations







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Geotechnical Engineering and Environmental Services across the UK

GROUND INVESTIGATION & BASEMENT IMPACT ASSESSMENT REPORT

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EXECUTIVE SUMMARY

05 Group Ltd commissioned Jomas Associates Ltd to prepare a Geotechnical Ground Investigation and Basement Impact Assessment at the site located at 26 Amyand Park Road, Twickenham, TW1 3HE .

The principal objectives of the study were as follows:

- To establish the geotechnical conditions pertaining to the site;
- To assess the data from the investigation to inform preliminary design advice with respect to foundation design, concrete specification and excavation stability.
- To undertake a Basement Impact Assessment (BIA) based on the methodologies outlined in London Borough of Richmond on Thames "Planning Advice Note: Good Practice Guide on Basement Developments" (2015) and "Basement Assessment User Guide" (2021), with additional reference to the guidance given in the London Borough of Camden document "Camden Planning Guidance Basements" (CPGB) (January 2021).

It should be noted that the table below is an executive summary of the findings of this report and is for briefing purposes only. Reference should be made to the main report for detailed information and analysis.

	Site Information			
Current Site Use	Two-storey residential property undergoing refurbishment			
Proposed Site Use	The proposed development for this site is understood to comprise a rear-side extension and creation of basement beneath the entire building footprint and extending partially beneath the front garden.			
Summary of Stage 1 & 2 BIA	A Stage 1 & 2 Basement Impact Assessment report has been produced for the site and issued separately (Jomas, June 2024). A brief overview of the findings is presented below. Reference should be made to the full report for detailed information.			
	On the earliest available map (1865), the site is shown as largely vacant except for a small building shown to be extending into the site from the north-west. By the map dated 1912, the site is shown to be situated within a row of terraced housing. No observational changes then occur to the site until the most recent map dated 2024.			
	Historically, the surrounding area has comprised mainly residential properties, wit the only significant land use identified as a railway 80m north of site and the Rive Crane beyond at approximately 176m from site.			
	The British Geological Survey indicates that the site is directly underlain by superficial deposits of the Langley Silt Member. Superficial deposits of the Kempton Park Gravel Member are anticipated to underlie the Langley Silt Member. These superficial deposits overlie solid deposits of the London Clay Formation.			
	The underlying Langley Silt Member and the London Clay Formation are identified as Unproductive. The Kempton Park Gravel Member is reported (off-site) as a Principal Aquifer.			
	A review of the EnviroInsight Report indicates that there are no Environment Agency Zone 2 or Zone 3 flood zones within 250m of the site.			



	Site Information
	The River Crane is reported 176m north-west.
	The screening and scoping assessments concluded the following:
	 A ground investigation was recommended to confirm the ground conditions and groundwater levels (if any) beneath the site The ground investigation should also determine the presence of Made Ground and/or clay. Atterberg Limits of the underlying clay should be determined by the ground investigation to establish shrink/swell potential The proposed basement will underlie the existing building footprint/hardstanding; there will be no significant change in surface water run-off As SuDS will be required by NPPF, PPG and LLFA policy requirements, where practicable, the remaining hard surfaces will likely be replaced with permeable paving. This will ensure that the proposed development will not increase the potential risk of flooding A Ground Movement Assessment was considered prudent, but may not be a requirement of the London Borough of Richmond upon Thames
	Ground Investigation
Scope of Works	The ground investigation was undertaken on 10 October 2024, and consisted of the following:
	 1No cable percussive borehole, drilled to a depth of 10m below ground level (mbgl), with associated in-situ testing and sampling
	1No groundwater monitoring well, installed to 7.5mbgl
	Laboratory analysis for chemical and geotechnical purposes
	• 1No return visits to monitor groundwater levels has been carried out, and 1No further visit is due to be completed in February 2025
Ground Conditions	The results of the ground investigation revealed a ground profile comprising Made Ground to a depth of 1.9mbgl, underlain by granular deposits of the Kempton Park Gravel Member to 7.4mbgl, underlain by cohesive deposits of the London Clay Formation to a depth in excess of 10mbgl.
	During the investigation, groundwater was reported within the borehole at a depth of 6.2mbgl, and by the time the drilling had concluded, was sat at a level of 6.45mbgl.
	During return monitoring, groundwater was reported at 6.53mbgl. A second visit is due to take place in February 2025 and this report will be updated.
Foundations	Based upon the information obtained to date, it is considered that a cast in-situ cantilever retaining wall formed at approximately 3.5m below the existing ground level within the Kempton Park Gravel Member could be designed with an allowable bearing capacity of 200kPa. Total and differential settlements should be contained within tolerable limits.
	It is unlikely that the foundations would need to be deepened further due to NHBC building near trees requirements.



Site Information				
Sulphates	Based on the results of chemical testing, for foundations formed with the Kempton Park Gravel Member, the required concrete class for the site is DS-1 assuming an Aggressive Chemical Environment for Concrete classification of AC-1 in accordance with the procedures outlined in BRE Special Digest 1.			
	If foundations are to be formed within the London Clay Formation, higher concrete classes are considered necessary, as detailed in Section 6.4.			
Ground Floor Slabs	If a cantilever retaining wall is utilised, then a ground bearing floor slab could be used.			
	If a piled option is utilised then suspended floor slabs will be required.			
Excavations	Temporary excavations are unlikely to remain stable and some form of temporary support or battering back to a safe angle and dewatering are likely to be required. Subject to seasonal variations, surface water/groundwater encountered during site works could likely be dealt with by conventional pumping from a sump used to collate waters.			
Basement Impact Assessment				
Conclusions	The overall assessment of the site is that the creation of a basement for the proposed development should not adversely impact the site or its immediate environs, providing measures are taken to protect surrounding land and properties during construction.			
	The proposed basement excavation will be within 5m of a public pavement. It is also laterally within 5m of neighbouring properties.			
	Unavoidable lateral ground movements associated with the basement excavations must be controlled during temporary and permanent works so as not to impact adversely on the stability of the surrounding ground and any associated services.			
	During the construction phase careful and regular monitoring will need to be undertaken to ensure that the neighbouring properties are not adversely affected. This may mean that structures will need to be suitably propped and supported.			
	Recommended Further Works			
Recommendations	 A drainage/SuDS strategy report is recommended to outline how betterment of the flood risk will be achieved through development of the site A Ground Movement Assessment is also considered prudent, though may not be a specific requirement of the London Borough of Richmond upon Thames 			

1 INTRODUCTION

1.1 Terms of Reference

- 1.1.1 05 Group Ltd ("The Client") has commissioned Jomas Associates Ltd ('Jomas'), to undertake an investigation of the geotechnical factors pertaining to the proposed redevelopment and to prepare a Basement Impact Assessment at a site referred to as 26 Amyand Park Road, Twickenham, TW1 3HE.
- 1.1.2 To this end a Stage 1 & 2 (Screening and Scoping) Basement Impact Assessment has been produced for the site and issued separately (Jomas, June 2024), followed by an intrusive investigation (detailed in this report).
- 1.1.3 Details of the previous report are provided below in Table 1.1:

Table 1.1: Previous Reports - Jomas

Title	Author	Reference	Date
Stage 1 & 2 Basement Impact Assessment (Screening and Scoping) for 26 Amyand Park Road, Twickenham, TW1 3HE	Jomas Associates Ltd	Р5802Ј3027/НАН	20 June 2024

1.1.4The intrusive investigation was undertaken in accordance with Jomas' proposal dated
17 September 2024.

1.2 Proposed Development

- 1.2.1 The proposed development for this site is understood to comprise a rear-side extension and creation of basement beneath the entire building footprint and extending partially beneath the front garden.
- 1.2.2 Plans of the proposed development are included in Appendix 1.
- 1.2.3 For the purpose of geotechnical assessment, it is considered that the project could be classified as a Geotechnical Category (GC) 2 site in accordance with BS EN 1997.

1.3 Objectives

- 1.3.1 An intrusive investigation is proposed to establish geotechnical conditions pertaining to the site.
- 1.3.2 The data from the geotechnical investigation is to form the basis of preliminary design advice with respect to foundation design, concrete specification and excavation stability.
- 1.3.3 A Basement Impact Assessment will assess the potential impacts that the proposal may have on ground stability, the hydrogeology and hydrology on the site and its environs.



1.4 Scope of Works

- 1.4.1 The following tasks were undertaken to achieve the objectives listed above:
 - An intrusive investigation to assess the underlying ground conditions;
 - Undertaking of laboratory chemical and geotechnical testing upon samples obtained;
 - Return groundwater monitoring;
 - Carrying out a Basement Impact Assessment (BIA);
 - The compilation of this report, which collects and discusses the above data, and presents an assessment of the site conditions, conclusions and recommendations.

1.5 Scope of Basement Impact Assessment

- 1.5.1 The site lies within the remit of the London Borough of Richmond upon Thames. The council has published the documents "Planning Advice Note: Good Practice Guide on Basement Developments" (2015) and "Basement Assessment User Guide" (2021). These documents provide detail on the issues relevant to basements within London Borough of Richmond upon Thames and describe how these issues should be assessed.
- 1.5.2 Jomas has also used the guidance given in the London Borough of Camden document "Camden Planning Guidance Basements" (CPGB) (January 2021) as this is generally accepted as the best available guidance on the practicalities regarding how to undertake a BIA.
- 1.5.3 Jomas' BIA covers most items required under CPGB, with the exception of;
 - Plans and sections to show foundation details of adjacent structures.
 - Programme for enabling works, construction and restoration
 - Evidence of consultation with neighbours
 - Ground Movement Assessment (GMA), to include assessment of significant adverse impacts and Specific mitigation measures required, as well as a confirmatory and reasoned statement identifying likely damage to nearby properties according to Burland Scale
 - Construction Sequence Methodology
 - Proposals for monitoring during construction.
 - Drainage assessment



- 1.5.4 This Jomas BIA also takes into account the Campbell Reith pro forma BIA produced on behalf of and published by the London Borough of Camden as guidance for applicants to ensure that all of the required information is provided.
- 1.5.5 A number of the requirements set out in the London Borough of Camden document CPGB will need to be addressed in a construction management plan, this stage is not within the scope of work that Jomas Associates have been commissioned.

1.6 Supplied Documentation

1.6.1 Jomas Associates have not been supplied with any previously produced reports at the time of writing this report.

1.7 Limitations

- 1.7.1 Jomas Associates Ltd ('Jomas') has prepared this report for the sole use of 05 Group Ltd, in accordance with the generally accepted consulting practices and for the intended purposes as stated in the agreement under which this work was completed. This report may not be relied upon by any other party without the explicit written agreement of Jomas. No other third-party warranty, expressed or implied, is made as to the professional advice included in this report. This report must be used in its entirety.
- 1.7.2 The records search was limited to information available from public sources; this information is changing continually and frequently incomplete. Unless Jomas has actual knowledge to the contrary, information obtained from public sources or provided to Jomas by site personnel and other information sources, have been assumed to be correct. Jomas does not assume any liability for the misinterpretation of information or for items not visible, accessible or present on the subject property at the time of this study.
- 1.7.3 Whilst every effort has been made to ensure the accuracy of the data supplied, and any analysis derived from it, there may be conditions at the site that have not been disclosed by the investigation, and could not therefore be taken into account. As with any site, there may be differences in soil conditions between exploratory hole positions. Furthermore, it should be noted that groundwater conditions may vary due to seasonal and other effects and may at times be significantly different from those measured by the investigation. No liability can be accepted for any such variations in these conditions.
- 1.7.4 This report is not an engineering design and the figures and calculations contained in the report should be used by the Structural Engineer, taking note that variations may apply, depending on variations in design loading, in techniques used, and in site conditions. Our recommendations should therefore not supersede the Engineer's design.

2 EXISTING INFORMATION

2.1 Site Information

2.1.1 The site location plan is appended to this report in Appendix 1.

Name of Site	-
Address of Site	26 Amyand Park Road, Twickenham, Richmond upon Thames, TW1 3HE
Approx. National Grid Ref.	516307 173599
Site Area (Approx.)	0.01 hectares
Site Occupation	Residential
Local Authority	London Borough of Richmond upon Thames

Table 2.1: Site Information

2.2 Summary of Stage 1 & 2 Basement Impact Assessment

2.2.1 As detailed in Table 1.1, a report has been produced for the site by Jomas dated 20 June 2024, and issued separately. A brief overview of the findings is presented below. Reference should be made to the full report for detailed information.

Site Setting

- 2.2.2 On the earliest available map (1865), the site is shown as largely vacant except for a small building shown to be extending into the site from the north-west. By the map dated 1912, the site is shown to be situated within a row of terraced housing. No observational changes then occur to the site until the most recent map dated 2024.
- 2.2.3 Historically, the surrounding area has comprised mainly residential properties, with the only significant land use identified as a railway 80m north of site and the River Crane beyond at approximately 176m from site.
- 2.2.4 The British Geological Survey indicates that the site is directly underlain by superficial deposits of the Langley Silt Member. Superficial deposits of the Kempton Park Gravel Member are anticipated to underlie the Langley Silt Member. These superficial deposits overlie solid deposits of the London Clay Formation.
- 2.2.5 The underlying Langley Silt Member and the London Clay Formation are identified as Unproductive. The Kempton Park Gravel Member is reported (off-site) as a Principal Aquifer.
- 2.2.6 A review of the EnviroInsight Report indicates that there are no Environment Agency Zone 2 or Zone 3 flood zones within 250m of the site.
- 2.2.7 The River Crane is reported 176m north-west.



Basement Impact Assessment (Screening and Scoping)

- 2.2.8 Screening identifies the area that require further (usually intrusive) investigation whilst scoping is the activity of defining in further detail the matters to be investigated as part of the BIA process. Scoping comprises of the definition of the required investigation needed in order to determine in detail the nature and significance of the potential impacts identified during screening.
- 2.2.9 These issues are summarised below:
- 2.2.10 The site predominantly comprises hardstanding cover which includes the existing building on site, a driveway area and a rear external patio. Areas of gravel and small plants are present adjacent to the building. The proposed plans show that there will be a reduction in hardstanding area to the front of the building through provision of a new garden area, though the majority of this will be underlain by the basement.
- 2.2.11 The site was considered to be at low risk of flooding based on historic flooding.
- 2.2.12 No risk of flooding to the site from artificial sources was identified.
- 2.2.13 The published geological maps indicate that the site is directly underlain by superficial deposits of the Langley Silt Member and the Kempton Park Gravel Member. These superficial deposits are underlain by solid deposits of the London Clay Formation. This should be confirmed by an intrusive investigation. Geotechnical laboratory testing of soils should also be undertaken to establish their shrink/swell properties.
- 2.2.14 The proposed basement excavation will be within 5m of a public pavement, and within 5m of neighbouring properties.
- 2.2.15 Unavoidable lateral ground movements associated with the basement excavations must be controlled during temporary and permanent works so as not to impact adversely on the stability of the surrounding ground, any associated services and structures.
- 2.2.16 It is recommended that the site is supported by suitably designed temporary support with a basement box construction. This will ensure that the adjacent land is adequately supported in the temporary and permanent construction. Alternatively, the excavation should proceed in a manner that maintains the integrity of the ground on all sides.
- 2.2.17 Careful and regular monitoring of the structure will need to be undertaken during the construction phase to ensure that vertical movements do not adversely affect the above property and neighbouring structures. If necessary, the works may have to be carried out in stages with the above structure suitably propped and supported.
- 2.2.18 Full details of the suitable engineering design of the scheme in addition to an appropriate construction method statement should be submitted by the developer to the London Borough of Richmond upon Thames.



2.2.19 The overall assessment of the site is that the creation of a basement for the existing development will not adversely impact the site or its immediate environs, providing measures are taken to protect surrounding land and properties during construction.

2.3 Previous Ground Investigations

2.3.1 Jomas is not aware of any previous intrusive investigation works that have been undertaken on the site.

3 GROUND INVESTIGATION

3.1 Scope of Works

- 3.1.1 A ground investigation was undertaken on the 10 October 2024.
- 3.1.2 A summary of the fieldwork carried out at the site, with justifications for exploratory hole positions, is presented in Table 3.1 below.

Investigation Type	Number of Exploratory Holes Achieved	Exploratory Hole Designation	Depth Achieved	Justification	
Cable Percussion Borehole	1	BH1	10mbgl	Obtain samples for laboratory geotechnical testing. To allow in-situ geotechnical testing.	
Monitoring Well	1	BH1	7.5mbgl	Groundwater monitoring wells.	

Table 3.1: Scope of Intrusive Investigation

- 3.1.3 The ground investigation was undertaken in accordance with British Standard BS5930:2015+A1:2020 "Code of practice for ground investigations", British Standard BS10175:2011+A2:2017 "Investigation of potentially contaminated sites code of practice", NHBC Standards, Chapter 4.1 and AGS Guidelines for Good Practice in Site Investigations.
- The exploratory hole position is shown on the exploratory hole location plan presented in Figure 2, Appendix 1. The exploratory hole record is included in Appendix 2.

3.2 Geotechnical Testing

<u>In-situ</u>

3.2.1 In-situ geotechnical testing included Standard Penetration Tests (SPTs). The determined N-values have been used to determine the relative density of granular materials and have been used with standard correlations to infer various other derived geotechnical parameters including the undrained shear strength of the cohesive strata. The results of the individual tests are on the appropriate exploratory hole logs in Appendix 2.

Laboratory

- 3.2.2 Soil samples were obtained and submitted to the UKAS accredited laboratory of K4 Soils Ltd for a series of analyses.
- 3.2.3 This testing was designed to classify the samples; and to obtain parameters (either directly or sufficient to allow relevant correlations to be used) relevant to the technical objectives of the investigation.

3.2.4

The following laboratory geotechnical testing was carried out:

Methodology	Test Description	Number of tests
BS1377:1990	Moisture Content Determination	2
BS1377:1990	Liquid and Plastic Limit Determination (Atterberg Limits)	2
BS1377:1990	Particle Size Distribution - Sieving	3
BS1377:1990	Determination of the undrained shear strength in triaxial compression with single-stage loading and without measurement of pore pressure	1

Table 3.2 Laboratory Geotechnical Analysis

- 3.2.5 The geotechnical laboratory test results are included in Appendix 3.
- 3.2.6 In addition, 5No soil samples were sent to the UKAS and MCerts accredited laboratory of Derwentside Environmental Testing Services Ltd and analysed for a modified BRE Special Digest 1 suite (acid and water soluble sulphate, total sulphur and pH) to assist with the ACEC classification for buried concrete. The results of this chemical testing are included in Appendix 4.

4 ENCOUNTERED CONDITIONS

4.1 General

- 4.1.1 A factual record of the conditions encountered during the physical investigation of the site is presented in the following section.
- 4.1.2 For further details of the ground conditions, reference should be made to the exploratory hole location plan presented in Appendix 1, exploratory hole log presented in Appendix 2, and the laboratory testing results in Appendix 3 and 4.

4.2 Ground Conditions

4.2.1 The ground conditions encountered were broadly consistent with those anticipated, i.e. a thickness of Made Ground overlying the Langley Silt Member over the Kempton Park Gravel Member over the London Clay Formation, and are summarised in Table 4.1 below.

Stratum and Description	Encountered from (mbgl)	Base of strata (mbgl)	Thickness range (m)
Concrete over (dark) brown clayey silty gravelly sand. Sand is fine to coarse. Gravel consists of fine to coarse, angular to rounded flint, brick and concrete. (MADE GROUND)	0.0	1.9	1.9
Dense to very dense orangish brown slightly clayey very sandy GRAVEL. Sand is fine to coarse. Gravel consists of fine to coarse, angular to rounded flint. (KEMPTON PARK GARVEL MEMBER)	1.9	7.4	5.5
Firm to stiff consistency** dark grey CLAY. (LONDON CLAY FORMATION)	7.4	>10.0 [base not proven]	>2.6 [thickness not proven]

Table 4.1: Ground Conditions Encountered

**Consistency estimated using semi-empirical correlations with SPT N-values, Plasticity Indices and published literature

4.2.2 No visual or olfactory evidence of potential contamination was identified within the investigation positions.

4.3 Hydrogeology

4.3.1 Groundwater strikes and groundwater monitoring are summarised below.

Table 4.2: Groundwater Strikes During Investigation

Exploratory Hole ID	Depth Encountered (mbgl)	Depth Post- Drilling (mbgl)	Stratum
BH1	6.20	6.45	Kempton Park Gravel Member

4.3.2 1No return groundwater monitoring visit was undertaken on 18 October 2024, the results are presented in Appendix 5 and are summarised below. A second visit is due to take place in February 2025.

Exploratory Hole ID	Depth Encountered (mbgl)	Well response zone as installed (mbgl)	Depth base of well (mbgl)	Stratum targeted by response zone
BH1	6.53	1.00 - 7.50	8.02	Made Ground and Kempton Park Gravel Member

Table 4.3: Groundwater Monitoring Summary

- 4.3.3 While the monitoring well is understood to have been installed to 7.5mbgl, the depth to the base of the well measured during the return monitoring visit was 8.02mbgl. This is potentially due to an error when measuring the pipe for installation, and/or the top of the monitoring well being located below ground level.
- 4.3.4 It should be noted that changes in groundwater levels can occur for a number of reasons including seasonal effects and variations in drainage. Such fluctuations may only be recorded by the measurement of the groundwater level within a standpipe or piezometer installed within appropriate response zones. Changes in groundwater level can have a direct effect on excavation stability and dewatering requirements, and cohesive soils can soften under rising or high groundwater levels.

4.4 Limitations

4.4.1 During the intrusive ground investigation, no impenetrable obstructions were encountered. However, the possible presence of natural and/or manmade obstructions on site cannot be discounted.



5 DERIVATION OF GEOTECHNICAL PARAMETERS

5.1 Introduction

5.1.1 A summary of ground conditions obtained from the ground investigation and the derived geotechnical parameters is provided below.

5.2 Plasticity of Cohesive Materials

- 5.2.1 Atterberg Limit determination was undertaken on 1No sample of Made Ground at a depth of 1.7mbgl, and 1No sample of the London Clay Formation at a depth of 9.5mbgl.
- 5.2.2 Within the Made Ground, the plasticity index value was 8% and was indicative of low plasticity, as illustrated in Figure 5.1 below. The modified plasticity index value was 4.96%, indicating that these soils are non-shrinkable.
- 5.2.3 The plasticity index value within the London Clay Formation was 56% and was indicative of very high plasticity. The modified plasticity index value was 53.2%, indicating soils with high volume change potential.



Figure 5.1: Plasticity Chart



5.3 Standard Penetration Tests

- 5.3.1 Standard Penetration Tests were undertaken at regular intervals throughout the cable percussive borehole. The results of the SPTs are plotted against depth in Figure 5.2 below.
- 5.3.2 N_{equi} results have been calculated where the full 300mm of penetration could not be achieved for 50 or more blows



Figure 5.2: SPT N-Value v Depth

5.4 Undrained Shear Strength

5.4.1 As discussed above, the N values recorded in the clay vary with depth, this infers that the undrained shear strength of the clay similarly varies. Figure 5.3 below shows the undrained shear strength inferred by the correlation suggested by Stroud (1974);

 $c_u = f_1 \times N$ can be applied,

in which c_u = mass shear strength (kN) f_1 = constant N= SPT value achieved during boring operations



- 5.4.2 In the above equation f_1 is dependent on the plasticity of the material that the SPT is being carried out in. As the plasticity indices were shown to be greater than 25% a value for f_1 of 4.5 has been adopted after Tomlinson (2001).
- 5.4.3 The graph below shows the shear strength profile of the encountered cohesive materials at the site, based on the SPT to shear strength correlation described above, as well as the results of quick undrained triaxial (QUT) testing on undisturbed samples taken from the borehole.



Figure 5.3: Undrained Shear Strength v Depth

5.4.4 As shown above, a general trend of increasing undrained shear strength with depth can be seen within the limited results from the London Clay Formation.

5.5 Coefficient of Compressibility

5.5.1 Stroud and Butler (1974) developed a relationship between the coefficient of compressibility (m_v) and SPT N-value.

 $m_v = 1/f_2 \times N$ can be applied,

in which m_v = coefficient of compressibility (m²/MN)



- f_2 = constant dependent on the plasticity index
- N = SPT value achieved during boring operations
- 5.5.2 Using the plasticity indices obtained and the graphs provided in Tomlinson (2001) a value of f_2 of 0.45 has been taken and used with the SPT N-values to infer coefficient of compressibility (m_v).
- 5.5.3 Where the undrained shear strength of the clays was measured using the quick undrained triaxial methodology, the m_v value was calculated by rearranging the equations for f_1 and f_2 and substituting in the measured undrained shear strength.



Figure 5.4: Coefficient of Volume Compressibility (mv) v Depth

5.5.4 As shown above, the results from the London Clay Formation are of "medium compressibility".

5.6 Density

- 5.6.1 In order to calculate the undrained shear strength using the quick undrained triaxial methodology, the bulk density of the materials has to be calculated, which are provided on the testing certificates in Appendix 4. These values can be converted to a unit weight value in kN/m³.
- 5.6.2 In the absence of geotechnical laboratory test results, the correlations and suggested unit weight values for both cohesive and granular materials given in BS8004:2015 have been used.



5.6.3 The derived unit weights are summarised below in Table 5.1.

Table 5.1: Derived Unit Weights

Strata	Unit Weight (kN/m³)
Made Ground	17
Kempton Park Gravel Member	20
London Clay Formation	19.5

5.7 Effective Angle of Shearing Resistance / Angle of Friction

5.7.1 In cohesive soils, the effective angle of shearing resistance can be derived from the plasticity index of the soil, using the following equation presented in BS8004:2015.

$$\phi' = 42 - (12.5 x LOG10(PI))$$

Where PI = Plasticity Index.

5.7.2 Values have been calculated for all available Plasticity Index results and are presented in Table 5.2.

Sample	Stratum	Derived Angle of Shearing Resistance (°)
BH1 – 1.7m	Made Ground	30.7
BH1 – 9.5m	London Clay Formation	20.1

Table 5.2: Derived Angles of Shearing Resistance

5.7.3 In granular materials, the effective angle of friction can be derived directly from shear box testing, or indirectly using the methodology outlined in Table 1 of BS8004:2015, using a combination of the SPT N-values, Particle Size Distribution of the soil, and the field descriptions of angularity of the gravel fraction. This method assumes that the fines content of the material is less than 15%. An alternative method is to refer to the correlation between angle of friction and SPT N-values postulated by Peck *et al* (1967) and reproduced in Tomlinson (2001).

5.8 Stiffness Moduli

5.8.1 In cohesive soils of the London Clay Formation, the undrained stiffness modulus (Young's Modulus) can be derived using the correlation with undrained shear strength as postulated by Jardine et al. (1985):

 $\underline{Eu} = 400 * Cu(kPa)$

SECTION 5 DERIVATION OF GEOTECHNICAL PARAMETERS



5.8.2 The drained Young's Modulus for the London Clay Formation can then be derived from E_u, as follows:

 $\underline{E'} = 0.6 * \underline{Eu}$

5.8.3 In granular materials, the drained Young's Modulus can be derived using the following correlation:

E' = N

5.9 Summary of Derived General Properties

5.9.1 Based on the analysis of the ground investigation data and past experience with similar deposits, the following derived general parameters are given in Table 5.3.

Table 5.3: Derived General Parameters

Property	Made Ground	Kempton Park Gravel Member	London Clay Formation
Unit Weight	171)	20 ¹⁾	19.5 ²⁾
Drained Friction, ϕ' (°)	30.7 ³⁾	36 ⁴⁾	20.1 ³⁾
Drained Cohesion, c' (kPa)	0	-	0
SPT N-value	8	31 - 87	16 - 20
Undrained Young's Modulus, E _u (MPa) ⁵⁾	-	-	28.8 – 36
Drained Young's Modulus E' (MPa)	-	31.0 – 87.0 ⁶⁾	17.3 – 21.6 ⁷⁾
Undrained Shear Strength, c_u (kPa) ⁸⁾	-	-	72 – 90
Undrained Shear Strength, c_u (kPa) ⁹⁾	-	-	85
Plasticity Index (%)	8	-	56
Modified Plasticity Index (%)	5	-	53.2
Volume Change Potential [NHBC]	Non-shrinkable	-	High
Modulus of Volume Compressibility, m _v (m²/MN) ¹⁰⁾	-	-	0.111 - 0.139

 $^{\rm 1)}$ Derived from Figures 1 and 2 of BS8004:2015

 $^{\rm 2)}$ Calculated from bulk density, measured during quick undrained triaxial (QUT) testing

³⁾ Calculated from: $\phi' = (42^{\circ} - 12.5\log 10/_p)$ for 5% $\leq I_p \leq 100\%$ Where, I_p is the soil's plasticity index (BS8004:2015)

⁴⁾ Calculated from Table 1 of BS8004:2015

 $^{\rm 5)}$ Calculated from E_u = 0.4 x c_u MPa, based on the guidance given in Jardine et al 1985

 $^{\rm 6)}$ Calculated from: E' = 1.0 x N MPa, based on the guidance given in CIRIA Report 143

⁷⁾ Calculated from E' = $0.6 \times Eu$ MPa, based on the guidance given in Jardine et al 1985

⁸⁾ The undrained shear strength (c_u) of the cohesive soils was correlated to the SPT N-values using Stroud (1974), where c_u =f₁N and f₁ is factor related to the Plasticity Index (PI) of the clay (a value of f₁ equal to 5.0 for PI ≤ 25% and a value of f₁ value equal to 4.5 for PI>25)

⁹⁾ These values have been determined from the unconsolidated undrained triaxial compression testing in accordance with BS1377: Part 7: 1990, Clause 8

¹⁰⁾ Calculated from: $m_v = 1/f_2 N m^2/MN$, f_2 is a coefficient proposed by Stroud and Butler (1975) and varies with Plasticity Index (PI) as presented in Figure 27 of CIRIA Report 27 or $10/c_u$



6 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

6.1 General

- 6.1.1 Subsequent to intrusive investigation of the site and receipt of the laboratory test results, the following geotechnical assessments have been made.
- 6.2 Proposed Foundations

<u>General</u>

- 6.2.1 All topsoil is to be stripped from beneath proposed structures ahead of development.
- 6.2.2 The Made Ground is not considered to provide suitable bearing strata due to its variability and the unacceptable risk of total and differential settlement.
- 6.2.3 All foundations should be deepened beneath these deposits, soft clay, root or desiccated zones, or disturbed ground, and founded within underlying competent strata.

Conventional Foundations

- 6.2.4 Based on drawings provided, it is anticipated that the finished floor level of the basement would be approximately 3m below existing ground level and therefore formation level is anticipated to be ~3.5mbgl.
- 6.2.5 Based upon the information obtained to date, it is considered that a cast in-situ cantilever retaining wall formed at approximately 3.5m below the existing ground level within the Kempton Park Gravel Member could be designed with an allowable bearing capacity of 200kPa. Total and differential settlements should be contained within tolerable limits.
- 6.2.6 It is unlikely that the foundations would need to be deepened further due to NHBC building near trees requirements.
- 6.2.7 Where foundations need to change levels, the foundations should be stepped and reinforced. These steps should be no deeper than half of the width of the foundation and each step should not exceed 0.5m.
- 6.2.8 If foundations span different strata, e.g. sand and clay, they should either be deepened to terminate in a single soil stratum, or suitable reinforcement included (to be detailed by the Structural Engineer).
- 6.2.9 Foundations greater than 2.50m deep require structure-specific design by a structural engineer.
- 6.2.10 It is recommended that excavations to form the foundations should be undertaken using a toothless bucket to reduce the potential for disturbance of the underlying Kempton Park Gravel Member.


- 6.2.11 Foundations should not be formed in the granular materials until the granular materials have been proof compacted. Given the depth and likely size of these foundations, it is considered that this could be undertaken using a hydraulic "elephants foot" or if the whole basement founding layer is compacted at the same time a vibrating roller or "whacker plate" if the machinery can be easily taken into the excavation and the stability of the excavation/safety of any workers entering the excavation can be assured.
- 6.2.12 Where any unexpected or soft ground conditions are encountered during the groundworks, works in that area should cease and the advice of a suitably qualified geotechnical engineer sought.

6.3 Retaining Walls

- 6.3.1 It is anticipated that retaining structure(s) will be required.
- 6.3.2 Based on the analysis of the available site investigation data and past experience with similar deposits the parameters in Table 6.1 are considered appropriate for the potential retaining structure(s).

Table 6.1: Geotechnical Parameters for Retaining Wall Design

	Kempton Park Gravel Member	London Clay Formation
Critical state angle of shearing resistance $(\phi')^{\circ}$	36	20
Effective Cohesion kN/m ²	-	0
Saturated Bulk Weight (γ_{sat}) kN/m ³	21	19.5

- 6.3.3 In addition, the specialist contractor should ensure the stability of the cut-face during the temporary works.
- 6.3.4 As an alternative to cantilever retaining walls, fully embedded retaining walls comprising a contiguous/secant piled basement box could be formed. The piles would need to act as retaining walls as well as carry the structural loadings. The piles should be designed to withstand the earth pressures, and still meet the required structural requirements regarding issues such as deflection, deformation and bending.
- 6.3.5 To provide sufficient support for the excavation, it is recommended that un-propped piles are formed to at least three times the depth of excavation.
- 6.3.6 If these piles can be suitably propped, then this depth may be reduced. Suitable propping could be provided by the basement floor and the ground floor if they are suitably tied into the piles and suitably reinforced. This may require specialist construction techniques.



6.4 Aggressive Ground Conditions

- 6.4.1 Sulphate attack on building foundations occurs where sulphate solutions react with the various products of hydration in Ordinary Portland Cement (OPC) or converted High-Alumina Cement (HAC). The reaction is expansive, and therefore disruptive, not only due to the formation of minute cracks, but also due to loss of cohesion in the matrix.
- 6.4.2 In accordance with BRE Special Digest 1, the characteristic values of sulphate used to determine the concrete classification are determined using the methodology summarised in the table below.

Table 6.2: Concrete in the Ground Characteristic Value Determination

No Samples in the dataset	Method for determining the sulphate characteristic value
1 - 4	Highest value
5 - 9	Mean of the top 2No highest results
10 or greater	Mean of the top 20% highest results

6.4.3 Table 6.3 summarises the analysis of the aggressive nature of the ground for each of the strata encountered within the ground investigation.

Stratum	No Samples	pH range	Characteristic WS Sulphate (mg/l)	Characteristic Total Potential Sulphate (%) ¹⁾	Design Sulphate Class	ACEC Class
Made Ground	2	8-8.7	80	N/A	DS-1	AC-1
Kempton Park Gravel Member	2	8.4 - 8.7	<10	N/A	DS-1	AC-1
London Clay Formation	1	8.4	173	0.87	DS-3	AC-3

Table 6.3: Concrete in the Ground Classes

1) Applies to soils containing more than 0.3% of oxidisable sulphides, calculated in accordance with BRE SD-1

- 6.4.5 Where these deposits are not likely to be disturbed and exposed, but foundations are formed within them (such as piles), then a Design Class of DS-2 is recommended, with an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC-2.
- 6.4.6 The concrete structures, including foundations, will need to be designed in accordance with BS EN 1992-1-1:2004+A1:2014. It is recommended that the advice of this publication be taken for the design and specification of all sub-surface concrete.

^{6.4.4} Analysis of the results indicates that the London Clay Formation contains significant concentrations of oxidisable sulphides (e.g. pyrite), which can be oxidised to form additional sulphate on disturbance and exposure to air as outlined in BRE SD-1:2005. The total potential sulphate must therefore also be considered in the designation of a Design Class, in cases where the London Clay Formation is to be disturbed and exposed to air.



6.5 Floor Slabs

- 6.5.1 It is anticipated that finished floor level of the proposed basement will be approximately 3m below the existing ground floor level.
- 6.5.2 If a cantilever retaining wall is utilised, then a ground bearing floor slab could be used. Given the material at these depths, it is considered likely that such floor slabs could be constructed on the in-situ natural granular materials. In this case, formations of the structures should be inspected by a competent person. Any loose or soft material should be removed and replaced with well-graded, properly compacted granular fill or lean mix concrete. The formation should be blinded if left exposed for more than a few hours or if inclement weather is experienced.
- 6.5.3 If a piled option is utilised then suspended floor slabs will be required. The loadings from the suspended floor slab will need to be carried by the foundations, which will need to be designed to not only carry the structural loadings but the additional floor loadings.
- 6.5.4 All floor slabs would also need to be suitably reinforced, not only to distribute the structural loading but also to ensure that the floor slab can prop the retaining walls and does not buckle from the lateral pressures imposed by the cantilever retaining walls.
- 6.5.5The floor slab (and basement walls) would need to be constructed to conform to BS:
8102 (2009).

6.6 Excavations

- 6.6.1 Temporary excavations within the Made Ground and granular soils are unlikely to remain stable and some form of temporary support or battering back to a safe angle and dewatering are likely to be required.
- 6.6.2 Temporary excavations within the cohesive soils are likely to remain relatively stable in the short term though some spalling may be anticipated.
- 6.6.3 Cantilever retaining walls should be installed in short sections to aid stability of the excavation during construction of the basement.
- 6.6.4 Ground works should always be designed in such a manner to avoid entry into excavations by construction or maintenance personnel. However, in the event that such works cannot be avoided or designed out, they should only be undertaken in accordance with a safe system of work, following an appropriate risk assessment and in accordance with any legislative requirements, e.g. Confined Spaces Regulations.

6.7 Groundwater Control

6.7.1 During the investigation, groundwater was reported within the borehole at a depth of 6.2mbgl, and by the time the drilling had concluded, was sat at a level of 6.45mbgl.



- 6.7.2 During return monitoring, groundwater was reported at 6.53mbgl. A second visit is due to take place in February 2025 and this report will be updated.
- 6.7.3 Subject to seasonal variations, any groundwater encountered during site works could be readily dealt with by conventional pumping from a sump used to collate waters.
- 6.7.4 Surface water or rainfall ingress is likely to freely drain through the granular materials. If this does not occur, then they too could be dealt with by traditional sump and pump.



7 BASEMENT IMPACT ASSESSMENT

7.1 Geological Impact

- 7.1.1 The published geological maps indicate that the site is directly underlain solid deposits of the Langley Silt Member and Kempton Park Gravel Member. These superficial deposits are underlain by solid deposits of the London Clay Formation
- 7.1.2 The ground conditions were confirmed by a ground investigation and comprise Made Ground to a depth of 1.9mbgl, underlain by granular deposits of the Kempton Park Gravel Member to 7.4mbgl, underlain by cohesive deposits of the London Clay Formation to a depth in excess of 10mbgl. The proposed basement will be founded within the Kempton Park Gravel Member at a depth of ca. 3.5mbgl.
- 7.1.3 Laboratory testing indicates that the London Clay Formation is of high volume change potential. However, with consideration of the depth of these deposits, it is not considered that they will have an impact on the proposed basement.

7.2 Hydrology and Hydrogeology Impact

- 7.2.1 Based on all the information available at the time of writing, the risk of flooding from groundwater is considered to be low to moderate. The site was shown on mapping to not be located within an area where there is increased potential for elevated groundwater due to permeable surface deposits. The site was identified to be located within an area with a susceptibility to groundwater flooding of <25%.
- 7.2.2 During the investigation, groundwater was reported at depths of between 6.2mbgl and 6.53mbgl. At this stage, on this basis, it is considered that the proposed basement is unlikely to have a detectable impact on the groundwater regime. However, an additional groundwater monitoring visit is due to be conducted in February 2025, and this report will be updated on receipt of the results.
- 7.2.3 Appropriate water proofing measures should be included within the whole of the proposed basement wall/floor design as a precaution.
- 7.2.4 The Kempton Park Gravel Member is classed as a Secondary A Aquifer but the creation of the basement is considered unlikely to have any impact upon the hydrogeology of the area.
- 7.2.5 The proposed development will lie outside of flood risk zones and is therefore assessed as being at low probability of fluvial flooding.
- 7.2.6 The River Crane is reported 176m north-west of the site.
- 7.2.7 The information available suggests that the site lies in an area that is at low risk of surface water flooding.



- 7.2.8 The proposed basement construction is unlikely to result in an increase in impermeable areas in the post development scenario.
- 7.2.9 No risk of flooding to the site from artificial sources has been identified.

7.3 Other Impacts

- 7.3.1 Impacts such as changes to areas of external hardstanding, past flooding, and impacts to adjacent properties and pavement are addressed within the Stage 1 & 2 (Screening and Scoping) Basement Impact Assessment for 26 Amyand Park Road, Twickenham, TW1 3HE (Jomas Associates Ltd, P5802J3027/HAH, June 2024).
- 7.3.2 Full details of the suitable engineering design of the scheme in addition to an appropriate construction method statement should be submitted by the Developer to the London Borough of Richmond upon Thames.

7.4 Cumulative Impacts

- 7.4.1 The above individual effects could potentially interact to form a greater issue.
- 7.4.2 The site has been identified as being directly underlain by a Secondary A Aquifer (Kempton Park Gravel Member).
- 7.4.3 However, no sensitive uses have been identified in the surrounding area.
- 7.4.4 Furthermore, the modest size of the proposed basement will not significantly alter the existing groundwater regime.
- 7.4.5 The development of the basement will therefore not significantly affect the groundwater flow on or surrounding the site.

7.5 Conclusion

- 7.5.1 The overall assessment of the site is that the creation of a basement for the existing development will not adversely impact the site or its immediate environs, providing measures are taken to protect surrounding land and properties during construction.
- 7.5.2 The proposed development is not expected to cause significant problems to the subterranean drainage.

8 **REFERENCES**

AGS Guidelines for Good Practice in Geotechnical Ground Investigation, 2016

BRE Report BR 470: Working platforms for tracked plant, 2004. BRE: Watford

BRE Special Digest 1: Concrete in Aggressive Ground, 2005. BRE: Watford

British Standards Institution BS 10175:2011+A2:2017 Code of practice for the investigation of potentially contaminated sites. BSI: London

British Standards Institution BS 5930:2015+A1:2020 Code of practice for ground investigations. BSI:London

British Standards Institution BS 8002:2015 Code of practice for earth retaining structures. BSI: London

British Standards Institution BS 8004:2015 Code of practice for foundations. BSI: London

British Standards Institution BS EN 1997-1:2004+A1:2013 Eurocode 7. Geotechnical design. General rules. BSI: London

CIRIA Report R143 The standard penetration test (SPT): methods and use, 1995: CIRIA: London

Ministry of Housing, Communities & Local Government: National Planning Policy Framework. February 2019.

NHBC Standards 2023. NHBC, Milton Keynes

Tomlinson M.J (2001): Foundation Design and Construction 7th Edition. Pearson prentice Hall: Harlow



APPENDICES



APPENDIX 1 – FIGURES

JUMAS ENGINEERING LAND REMEDIATION

	6 Amyand Park Poad TW/1 2HE	CLIENT	05 Group Ltd
	ite Location Plan		P580213027
		FIGURE NO.	1
DATE	une 2024	FIGURE NO.	1
Posts Posts Posts Posts Posts Posts Posts Posts Posts Posts Posts Posts Posts Posts Posts	ups foreuning periods to the time of the t	20	

TITLE Completed Exploratory Hole Plan DATE October 2024 PIGURE NO. 2 FIGURE NO. 2 F		26 Amyand Park Road TW/1 3HE	CLIENT	05 Group Ltd
DATE October 2024 FIGURE NO. 2		Completed Exploratory Hole Plan		P580213027
DATE OCTOBEL2024 TIGORE HC. 2		October 2024	FIGURE NO	2
Posts 22 Posts 24 Posts	PROJECT NAME TITLE DATE	26 Amyand Park Road, TW1 3HE Completed Exploratory Hole Plan October 2024	CLIENT PROJECT NO. FIGURE NO.	05 Group Ltd P5802J3027 2
puelous uentre	Posts	BH1 R R Poouos Areunid Dougs Areunid Areunid Dougs Areunid Dougs Areunid A	20	A A A A A A A A A A A A A A A A A A A
	An	puelo siliena		P.



PROJECT NAME	26 Amyand Park Rd, TW1 3HE	CLIENT	05 Group Ltd
TITLE	Walkover Photo Plan	FIGURE	3
Photo 1: Overview of	f front of site.	Photo 2: Overview of	front garden of site.
	<image/>		<image/>



PROJECT NAME	26 Amyand Park Rd, TW1 3HE	CLIENT	05 Group Ltd
TITLE	Walkover Photo Plan	FIGURE	3
Photo 3: Main living room of site.		Photo 4: Site is connected to electrics.	







WE LISTEN, WE PLAN, WE DELIVER

PROJECT NAME	26 Amyand Park Rd, TW1 3HE	CLIENT	05 Group Ltd
TITLE	Walkover Photo Plan	FIGURE	3
Photo 5: Internal doo	prway leading to kitchen area of site.	Photo 6: Back doors o	f site.
	<image/>		



WE LISTEN, WE PLAN, WE DELIVER

PROJECT NAME	26 Amyand Park Rd, TW1 3HE	CLIENT	05 Group Ltd
TITLE	Walkover Photo Plan	FIGURE	3
Photo 7: Toilet of site	2.	Photo 8: Back garden	of site from the doorway.
			<image/>



PROJECT NAME	26 Amyand Park Rd, TW1 3HE	CLIENT	05 Group Ltd
TITLE	Walkover Photo Plan	FIGURE	3
Photo 9: Back garden of site from gate.		Photo 10: External wa	ter supply by front door.







WE LISTEN, WE PLAN, WE DELIVER

PROJECT NAME	26 Amyand Park Rd, TW1 3HE	CLIENT	05 Group Ltd
TITLE	Walkover Photo Plan	FIGURE	3
Photo 11: Drainage i	n back garden.	Photo 12: Alleyway lea	ading to back gate.
			<image/>



WE LISTEN, WE PLAN, WE DELIVER

PROJECT NAME	26 Amyand Park Rd, TW1 3HE	CLIENT	05 Group Ltd
TITLE	Walkover Photo Plan	FIGURE	3
Photo 13: Back gate	of site from alleyway.		

Figure 4: Proposed Development Plan (Basement and Ground Floors)



2. THIS DRAWING HAS BEEN DRAWN TO SCALE, AS SHOWN, FOR THE PURPOSE OF OBTAINING LOCAL AUTHORITY APPROVAL.

@ A3 1.0M 3.0M 1.0M 0 2.0M

4.0M

Property Address: Date: Scale @ A3: Drawing Number:

MAY 2024 1:100 SC 23111 / AP / BA01





APPENDIX 2 – EXPLORATORY HOLE RECORDS

		С		Ρ	FRC	רוו ר	SIO	N	RF		חצ	Boreho	le Numbo	er
	INMENTAL											D		
Project Na	ame: 26 Amy	and Park F	Road	Client	t: 05 Grou	p Ltd				Date: 10/10	/2024			
Location:	Twickenham	, TW1 3HE		Logge	ed by: HA	H/BD				Drilling Equipment: Cable Percussion Drilling				
	5. : P5802J30	J27 Hol	e Type	Crew	Name: R		Appro	ved B	v	Equipment Sc	ale	Page	Number	
F	INAL		CP		Lovor		S	C	y	1:	50	Shee	et 1 of 1	
Well Stri	ater Sam	ple and In	Situ Testing		Depth (m)	Level	Legend			Stratum	n Descriptior	ı		
	Depth	(m) Type	Results		()	(,		Concre	ete. (M	ADE GROUN	ID)		-	
	0.25	B B			0.20 0.40	-0.20 -0.40		Dark b Grave brick a Dark b Grave	orown s el consis and con brown c el consis rick (M	ilty gravelly s sts of fine to c icrete. (MADE layey gravelly sts of fine to c ADE GROUN	and. Sand is oarse, angu <u>E GROUND)</u> y sand. Sand oarse, angu	s fine to coars lar to rounde d is fine to me lar to rounde	se. d flint, edium. d flint	1
	1.00	D SPT	N=8 (1,0/1,2,	1,4)	1.40	-1.40		Brown	n clayey	slightly grave	elly sand. Sa	and is fine. G	ravel -	
	1.70 1.70	B D			1.90	-1.90		with or Dense sandy	e to very GRAV	al brick fragn y dense orang EL. Sand is fi	nents. (MAD gish brown s ne to coarse	E GROUND) lightly clayey . Gravel con:	very	2
	2.50 2.50 2.50	B D SPT	N=48 (3,5/9,11,14,	14)				of fine PARK	e to coa GRAVI	rse, angular t EL MEMBER	o rounded fli)	int. (KEMPTC	DN - - - - - - - - - - -	3
	3.50 3.50	B SPT	50 (7,11/50 172mm)	for										4
	4.50 4.50 4.50	B D SPT	50 (8,12/50 185mm)	for										5
	5.50 5.50	B SPT	N=33 (3,4/5,9,9,1	0)										6
	7.50 7.50 8.00	B SPT U	N=16 (2,3/3,4	.,4,5)	7.40	-7.40		Firm to CLAY	o stiff c FORM	onsistency** (ATION)	dark grey CL	AY. (LONDC		7
	9.50 9.50 9.50	B D SPT	N=20 (3,3/4,5	5,6)	10.00	-10.00				End of Bor	ehole at 10 (00m		9
Remarks:			1			I	Ca	sing Diar	meter by	Depth		Chiselling		
*Field descrip	tion			T.N. /		undin d	Depth Top	Dept	th Base	Diameter	Depth Top	Depth Base	Duratio	on
published liter	resurnated using s rature. reported at 6 2mb	emi-empirical (g and at 6.45mbol	oost-drii	ues, Plasticity lling	nuices and								
Groundwater	reported at 6.2mb	si uuring ariilin	6 anu at 0.45mbgl (pust-arii	JOM	AS ASSC	CIATES 11	 TD						
			Unit 24 S	arum	n Comple	x, Salist	oury Road	, Uxb	oridge	UB8 2RZ				
		14/14/	wiomasass	ociat	es com	0333-30	15-9054 ir	പ്രതി	iomas	associates	com			

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APPENDIX 3 – GEOTECHNICAL LABORATORY TEST RESULTS

K)	Summary of Natural Moisture Content, Liquid Limit and Plastic Limit Results											
Job No.			Project	ramme									
361	Q /I		26 A mu	and D	ark Dd TW/1 3HE					Samples r	eceived	14/10)/2024
301	04		20 Any							Schedule	received	14/10)/2024
Project No.			Client							Project sta	arted	15/10)/2024
J30	27		Jomas .	Associ	ates			1		Testing St	arted	23/10)/2024
Hole No.	Def	Sa	mple	Time	Soil Desc	ription	NMC	Passing 425µm	LL	PL	PI	Ren	narks
	Rei	m	m	туре			%	%	%	%	%		
BH1	-	1.70		в	Brown slightly gravelly CLAY (gravel is fmc a sub-rounded)	y very sandy silty and angular to	19	62	23	15	8	Sample w obtain tes	ashed to t fraction
BH1	-	9.50	-	U	High strength dark gro	ey silty CLAY	26	95	80	24	56		
	Test Natur Atterb	Method al Moistur berg Limit	Is: BS13 re Conten s: clause	77: P ation 1: Clau 4.3, 4.4	art 2: 1990: se 3.2 and 5.0 tems tested	Test U	Report by Init 8 Olds Watford	K4 SOILS Close Old Herts WI	S LABOR Is Appro D18 9RU	ATORY bach		Check App	ed and roved
	NOTE	: The rep	port shall r	not be r	eproduced except in full		Tel: Email: Ja	01923 711 mes@k4	1 288 soils.coi	m		Date:	25/10/2024
2519	without authority of the laboratory Approved Signatories: K.Phaure (Tech.Mgr) J.Phaure			(Lab.Mgr)	ab.Mgr) MSF-5-R1								











K		Unc	Unconsolidated Undrained Triaxial Compression tests without measurement of pore pressure Summary of Results														
			Tes	ts ca	arried out in accordar	nce w	ith B	51377	':Par	t7:1	990 c	laus	e 8 c	or 9 a	s ap	pro	priate to test
				26 Amyond Park Ed TW/1 3HE											rieceive	ograi ed	nme 14/10/2024
36184			26 Am	26 Amyand Park Rd TW1 3HE											receiv	ed	14/10/2024
Project N	0.		Client	Client											startec	1	15/10/2024
J3027			Jomas	Asso	ciates								Te	Started	k	21/10/2024	
		Sar	mple			Test	Dei	nsity	14/	Length	Diamete	π 3		At fail	ure		
Hole No.	Ref	Тор	Base	Туре	Soil Description	Туре	bulk	dry	**	Longa.	Diamoto	00	Axial strain 51 - c		σ; cu o		Remarks
		m	m				Mg	/m3	%	mm	mm	kPa	%	kPa	kPa	d e	
BH1	-	8.00	-	U	High strength dark grey silty CLAY	UU	1.97	1.56	26	198	102	190	20	170	85	с	
Logond		cinglo et	ogo tost	(cipal(a2	Colly	rocour				Mode	of foilu	ro :		Prittle	
Legena	UUM suffix	- Multist	age test age test oulded of	on a s r recor	and multiple specimens) single specimen mpacted	σ1 - σ3 cu	Maxi Undr	mum co ained sł	rrected	deviato ength, ½	r stress 2 (σ1 - c	τ3)		ie,	В-1 Р-1 С-(Plasti Comp	; pound
	S S S	π	nese result	ts only	Test Report by K4 Unit 8 Olds Close Olds App Tel: 01923 711 288 E Email: jam apply to the items tested. The report :	4 SOILS proach imail: ja es@k4 shall not f	S LABO Watfo ames@ soils.c	DRATC rd Her k4soi om	DRY ts WD ⁻ Is.com	18 9RU 1	J authoritv	of the la	aboraton	v	Che Initial Date:	ecke s:	d and Approved J.P 25/10/2024
2519	3	Appro	ved Sigi	natori	ies: K.Phaure (Tech.Mgr) J.P	haure (Lab.M	gr)									MSF-5-R7b





APPENDIX 4 – CHEMICAL LABORATORY TEST RESULTS



Hamza Hashi Jomas Associates Limited 24 Sarum Complex Salisbury Road Uxbrdge UB8 2RZ



Normec DETS Limited Unit 1 Rose Lane Industrial Estate Rose Lane Lenham Heath Kent ME17 2JN t: 01622 850410

DETS Report No: 24-12235

Site Reference:	26 Amvand Park Road, TW1 3HE
Project / Job Ref:	J3027
Order No:	P5802J3027.5
Sample Receipt Date:	15/10/2024
Sample Scheduled Date:	15/10/2024
Report Issue Number:	1
Reporting Date:	21/10/2024

Authorised by:

5.62

Steve Knight Customer Support Manager

Dates of laboratory activities for each tested analyte are available upon request.

Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation. I his certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.



Normec DETS Limited Unit 1, Rose Lane Industrial Estate **Rose Lane** Lenham Heath Maidstone Kent ME17 2JN Tel: 01622 850410

0.08

0.03

< 0.01



< 0.01

0.17

0.29

Soil Analysis Certificate								
DETS Report No: 24-12235		~	 Date Sampled 	10/10/24	10/10/24	10/10/24	10/10/24	10/10/24
Jomas Associates Limited	^	Time Sampled	None Supplied	None Supplied	None Supplied	None Supplied	None Supplied	
~Site Reference: 26 Amyand Park		~TP / BH No	BH1	BH1	BH1	BH1	BH1	
~Project / Job Ref: J3027		~	Additional Refs	Jar	Jar	Jar	Jar	Jar
~Order No: P5802J3027.5			~Depth (m)	1.00	1.70	2.50	4.50	9.50
Reporting Date: 21/10/2024	D	ETS Sample No	743975	743976	743977	743978	743979	
Determinand	Unit	RL	Accreditation			(n)	(n)	
pH	pH Units	N/a	MCERTS	8.7	8.0	8.7	8.4	8.4
Total Sulphate as SO ₄	mg/kg	< 200	MCERTS	1217	493	< 200	< 200	618
Total Sulphate as SO ₄	%	< 0.02	MCERTS	0.12	0.05	< 0.02	< 0.02	0.06
W/S Sulphate as SO ₄ (2:1)	mg/l	< 10	MCERTS	80	34	< 10	< 10	173

Total Sulphur < 0.02 NONE 0.05 0.03 < 0.02 < 0.02 Analytical results are expressed on a dry weight basis where samples are assisted-dried at less than 30°C. The Method Description page describes if the test is performed on the dried or as-received portion

MCERTS

W/S Sulphate as SO₄ (2:1)

Subcontracted analysis (S) ~Sample details provided by customer and can affect the validity of results (n) Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation

g/l

%

< 0.01



Normec DETS Limited Unit 1, Rose Lane Industrial Estate **Rose Lane** Lenham Heath Maidstone Kent ME17 2JN Tel : 01622 850410



Soil Analysis Certificate - Sample Descriptions
DETS Report No: 24-12235
Jomas Associates Limited
~Site Reference: 26 Amyand Park Road, TW1 3HE
~Project / Job Ref: J3027
~Order No: P5802J3027.5
Reporting Date: 21/10/2024

DETS Sample No	~TP / BH No	~Additional Refs	~Depth (m)	Moisture Content (%)	Sample Matrix Description
743975	BH1	Jar	1.00	13.4	Brown sandy clay with stones and brick
743976	BH1	Jar	1.70	15.9	Brown sandy clay with stones
743977	BH1	Jar	2.50	6.2	Brown sandy gravel with stones
743978	BH1	Jar	4.50	5.2	Brown sandy gravel with stones
743979	BH1	Jar	9.50	22	Brown clay

Moisture content is part of procedure E003 & is not an accredited test Insufficient Sample VS Unsuitable Sample US ~Sample details provided by customer and can affect the validity of results



Normec DETS Limited Unit 1, Rose Lane Industrial Estate Rose Lane Lenham Heath Maidstone Kent ME17 2JN Tel : 01622 850410



il Analysis Certificate - Methodology & Miscellaneous Information	
TS Report No: 24-12235	
mas Associates Limited	
ite Reference: 26 Amyand Park Road, TW1 3HE	
Project / Job Ref: J3027	
Order No: P5802J3027.5	
porting Date: 21/10/2024	

Soli 0 Boort Water Schlieb Design and schlar E001 Soli AR Bitter Schlar Bitter Schla	Matrix	Analysed	Determinand	Brief Method Description						
Sile AR Dots Effect Itelemination of Effect by Prantyspace (C-M) Itelemination of Effect by Prantyspace (C-M) Effect Soil D Chorida: Wate Soluble (C-L) Ottermination of Zhorida by extraction with water & analysed by incompany. E002 Soil AR Chorida: Wate Soluble (C-L) Ottermination of Zhorida by extraction with water & analysed by incompany. E003 Soil AR Chorida: Mate Soluble (C-L) Ottermination of Chorida by extraction with water & analysed by incompany. E015 Soil AR Chorida: The Difference of The Control by Addition followed by colorinetry. E015 Soil AR Chorida: The Difference of The Control by Addition followed by colorinetry. E015 Soil AR Desell Range Opanics (C): C - CA Itermination of electrical conductivity by addition of soluratic column by addition of soluraticol column by addition of soluratic column by addition of	Soil	D	Boron - Water Soluble	Determination of water soluble boron in soil by 2:1 bot water extract followed by ICP-OFS	F012					
Soil D Cations Determination of cations is soil by acat-acid departum followed by CPC OSS PEOP Soil AR Chromum - Heavwell Similar the environment of classics of controls with water a stanked by ion chromatography PEOP Soil AR Chromum - Heavwell Similar the environment of classics of controls with water a stanked by ion chromatography PEOP Soil AR Corande - Free Determination of the condex by colorimetry PEOI Soil AR Corande - Free Determination of the condex by colorimetry PEOI Soil AR Corande - Free Determination of the condex by colorimetry PEOI Soil AR Detectrical conductivity Detectrical conductivity PEOI PEOI Soil AR Electrical conductivity Detectrical conductivity PEOI PEO	Soil	AR	BTEX	Determination of BTEX by headspace GC-MS	E012					
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Soil AR Diesel Range Organics (C10 - C24) Determination of excitation conductivity by addition of sutrated calcum subpate followed by E002 Soil AR Electrical Conductivity Determination of excitation conductivity by addition of water followed by electrometric measurement E003 Soil D Electrical Conductivity Determination of elemental subpate hy solvent extraction followed by GC+ID E004 Soil AR Electrical Conductivity Determination of elemental subpate hy solvent extraction followed by GC+ID E004 Soil AR EPH Product ID Determination of action/hexane extractable hydrocarbons by GC+ID E004 Soil AR EPH rotact ID Determination of totic hydrocarbons by GC+ID for C to C40. C6 to C8 by E004 E004 Soil D Foraction (FGC) Determination of TCC by combustion analyser. E002 Soil D Foraction (FGC) Determination of TCC by combustion analyser. E002 Soil D FOC (Fraction Organic Carbon Carbon Determination of TCC by combustion analyser. E002 Soil D FOC (Fraction Organic Carbon Determination of TCC by combustion analyser. E003 Soil D FOC (Fraction Organic Carbon Determination of TCC by combustion analyser. E	Soil	D	Cyclohexane Extractable Matter (CEM)	Gravimetrically determined through extraction with cyclohexane	E011					
Sail AR Electrical Conductive, Determination of electrical conductively by addition of suturated calcium sulphate followed by Get22 E022 Soil AR Betcrinical Conductive, Determination of electrical conductively by addition of suturated calcium sulphate followed by GetFID E023 Soil AR Electrical Conductive, Determination of acentor/hexane extractable hydrocarbons by GetFID E004 Soil AR EPH (CL0 - C40) Determination of acentor/hexane extractable hydrocarbons by GetFID E004 Soil AR EPH (CL2 - C40) Determination of acentor/hexane extractable hydrocarbons by GetFID for C8 to C40. C6 to C8 by E004 Soil D Flatofide- Water Solid& Determination of TOCE by combustion analyser. E002 Soil D Flatofide- (CAD) Determination of TOCE by combustion analyser. E002 Soil D Flotofide- (CAD) Determination of TOCE by combustion analyser. E002 Soil D Loss on Ignition # 4500 Determination of roganic carbon by oxidiany with bates analysed by ion chromatography E003 Soil D Maneal Minition of Maneal Moletine magnetismine with analysed. E003 Soil D Maneal Minition Mistoland Minition Mistoland Minition Mistoland Mini	Soil	AR	Diesel Range Organics (C10 - C24)	Determination of hexane/acetone extractable hydrocarbons by GC-FID	E004					
Soll AR Electrical Conductivity Determination of electrical conductivity by addition of water followed by electrometric measurement E023 Soll D Elemental Subplus Electrical Conductivity Determination of electronal buscular by solvert extraction followed by (C-MS) E020 Soll AR EPH TEXAS (G-C8, CFCID, C10-C12) Determination of electron/heane extractable hydrocarbons by GC-HD for C8 to C40. C6 to C8 by E004 E004 Soll D Fibration C12-C43 Determination of textor productive extractable hydrocarbons by GC-HD for C8 to C40. C6 to C8 by E004 E004 Soll D Fibration C12-C43 Determination of TOC by combustion analyser. E022 Soll D Fibration Crash Carbon Determination of TOC by combustion analyser. E023 Soll D FOC (Fraction Organic Carbon Determination of Organic Carbon Dy obding with potassium dichromate followed by E023 E003 Soll D FOC (Fraction Organic Carbon Determination of organic Carbon Potasic Mission analyser. E023 Soll D FOC (Fraction Organic Carbon Determination of regaric Carbon Potasic Mission analyser. E023 Soll D FOC (Fraction Organic Carbon Potasic Carbon Potasicarbanalysei Potasic Potasicarban Potasic Potasicarban Pot	Soil	AR	Electrical Conductivity	Determination of electrical conductivity by addition of saturated calcium sulphate followed by electrometric measurement	E022					
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Soil AR EPH (10 – C40) Determination of action/heane extractable hydrocarbons by CG-FID EB04 Soil AR EPH TEXAS (CG-C3); EV-10, C10-C12. Determination of action/heane extractable hydrocarbons by CG-FID E004 Soil D Fracts (CG-C3); EV-10, C10-C12. Determination of action/heane extractable hydrocarbons by CG-FID E004 Soil D Fracts (CG-C3); EV-10, C10-C12. Determination of TOC by combustion analyser. E027 Soil D Fracts (CG-C3); EV-10, C10-C12. Determination of TOC by combustion analyser. E027 Soil D Fracts (CG-C3); EV-00, C10-C13. Determination of TOC by combustion analyser. E023 Soil D FOC (Fraction Organic Carbon) Determination of fraction of organic carbon by oxiding with potassium dichromate followed by ED-0ES E039 Soil D Loss on Liphtion @ 4500 E040 E002 E003 Soil AR Mineral OI (C10 - C40) Antil Determination of mater soluble magnesium by extraction with water followed by ICP-0ES E032 Soil AR Mineral OI (C10 - C40) Antil Determination of mater soluble magnesid digotin followed by ICP-0ES E033 </td <td>Soil</td> <td>D</td> <td>Elemental Sulphur</td> <td>Determination of elemental sulphur by solvent extraction followed by GC-MS</td> <td>E020</td>	Soil	D	Elemental Sulphur	Determination of elemental sulphur by solvent extraction followed by GC-MS	E020					
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Bot D Fractionality rates across potentiation of potentiation with additional water a analysed by on chronatography E037 Soil D Fractionality rates across potentiation of tools by consultation analyser. E037 Soil D Tool Cratal Grassic Cashon) Determination of Tools by combustion analyser. E037 Soil D FOC (Fraction Organic Carbon) Determination of Tocls by combustion analyser. E037 Soil D FOC (Fraction Organic Carbon) Determination of raction of organic carbon by oxidising with potassium dichromate followed by E010 Soil D Loss on Ignition @ 4500C Determination of matels by aquar-atoparising by carcaction with water followed by ICP-OES E002 Soil AR Mineral Oil (C10 - C40) Determination of matels by aquar-atoparising digestion followed by ICP-OES E002 Soil AR Mineral Oil (C10 - C40) Determination of natrate by extraction with water & analysed by ion chromatography E003 Soil AR Mineral Oil (C10 - C40) Determination of ratrate by extraction with moders & analysed by ion chromatography E003 Soil AR PAH - Speciated (PA L) Deteromination of ratrate by extraction	Coil	D	<u>C12-C16, C16-C21, C21-C40</u>) Elucrido Water Solublo	headspace GC-MS	E000					
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SoilDPetroleum ether extract (PEE) Gravimetrically determined through extraction with perfordum etherE011SoilARPhenols - Total (monohydrc)Determination of phenols by distillation followed by colorimetryE0037SoilDPhosphate - Water Soluble (2:1)Determination of phonols by distillation followed by colorimetryE009SoilDSulphate (as SO4) - Total Determination of total sulphate by extraction with 10% HCI followed by ICP-OESE013SoilDSulphate (as SO4) - Water Soluble (2:1)Determination of sulphate by extraction with water & analysed by ion chromatographyE009SoilDSulphate (as SO4) - Water Soluble (2:1)Determination of sulphate by extraction with aqua-regia followed by ICP-OESE014SoilARSulphate as SulphideDetermination of sulphate by extraction with aqua-regia followed by ICP-OESE018SoilARSulphur - TotalDetermination of sulphate-love at analysed followed by ICP-OESE014SoilARSulphur - TotalDetermination of sulphate-love at analysed compounds by extraction in acetone and hexane followed by GC-MSE017SoilARThiocyanate (as SCN)Determination of foric nitrate followed by colorimetryE017SoilDTotal Organic Carbon (TOC) addition of ferric nitrate followed by colorimetryE011SoilDTotal Organic Carbon (TOC) consci carbon (TOC)Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE arc: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C3, C12-C16, C16-C21, C21-C3, C35-C44, pet	Soll	AR	PCB - / Congeners	Determination of PCB by extraction with acetone and hexane followed by GC-MS	E008					
Soil AR Phenols - Total (monohydric) Determination of phenols by distillation followed by colorimetry E021 Soil D Phosphate - Water Soluble (2:1) Determination of phenols by distillation followed by colorimetry E021 Soil D Sulphate (as SO4) - Total (monohydric) Determination of sulphate by extraction with water & analysed by ion chromatography E009 Soil D Sulphate (as SO4) - Water Soluble (2:1) Determination of sulphate by extraction with water & analysed by ion chromatography E009 Soil D Sulphate (as SO4) - Water Soluble (2:1) Determination of sulphate by extraction with water & analysed by ion chromatography E009 Soil AR Sulphate (as SO4) - Water Soluble (2:1) Determination of sulphate by extraction with water & analysed by ion chromatography E009 Soil AR Sulphate - Total Determination of sulphate by extraction with aqua-regia followed by CD-OES E014 Soil AR Sulphate - Total Determination of sulphate-valphate organic compounds by extraction in acetone and hexane followed by CD-OES E018 Soil AR Thiocyanate (as SCN) Determination of funcyanate by extraction in caustic soda followed by caldification followed by CD-OES E017 Soil D Total O	Soll		Petroleum Ether Extract (PEE)	Gravimetrically determined through extraction with petroleum ether	E011					
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Soil D Subplate (as SO4) - Total Determination of total subplate by extraction with 10% HCI followed by ICP-OES E013 Soil D Sulphate (as SO4) - Water Soluble (2:1) Determination of sulphate by extraction with water & analysed by ion chromatography E009 Soil D Sulphate (as SO4) - Water Soluble (2:1) Determination of sulphate by extraction with water followed by ICP-OES E014 Soil AR Sulphate (as SO4) - Water Soluble (2:1) Determination of sulphate by extraction with aqua-regia followed by ICP-OES E014 Soil AR Sulphate (as SO4) - Water Soluble (2:1) Determination of sulphate by extraction with aqua-regia followed by ICP-OES E024 Soil AR Sulphate (as SO4) E014 E016 Soil AR Sulphate (as SO4) E014 E014 Soil AR Sulphate (as SO4) E014 E016 Soil AR Thiocyanate (as SCN) Determination of semi-volatile organic compounds by extraction in acustic soda followed by acidification followed by GC-MS E017 Soil D Toluene Extractable Matter (TEM) Gravimetrically determined through extraction with toluene E011 Soil D Total Organic Carbon (TOC) Craser (C1, C1	Soil	D	Phosphate - Water Soluble (2:1)	Determination of phosphate by extraction with water & analysed by ion chromatography	E021					
Soil D Sulphate (as SO4) - Water Soluble (2:1) Determination of sulphate by extraction with water & analysed by ion chromatography E009 Soil D Sulphate (as SO4) - Water Soluble (2:1) Determination of water soluble sulphate by extraction with water followed by ICP-OES E014 Soil AR Sulphur - Total Determination of sulphide by extraction with aqua-regia followed by ICP-OES E024 Soil AR Sulphur - Total Determination of semi-volatile organic compounds by extraction in acetone and hexane followed by GC-OES E024 Soil AR Svorc Determination of thiocyanate by extraction in caustic soda followed by acidification followed by acidification followed by addition of form-initrate followed by colorimetry. E016 Soil AR Thiocyanate (as SCN) Determination of thiocyanate by extraction in caustic soda followed by acidification followed by addition of form: nitrate followed by colorimetry. E017 Soil D Total Organic Carbon (TOC) Determination of organic matter by oxidising with potassium dichromate followed by titration with ion (II) sulphate E011 Soil D Total Organic Carbon (TOC) C10-C12, C12-C16, C16-C21, C21-C34, actridge for C8 to C35. C5 to C8 by headspace GC-MS E004 Soil AR C10-C12, C12-C16, C16-C21, C21-C34, cartridge for C8 to C	Soil	D	Sulphate (as SO4) - Total	Determination of total sulphate by extraction with 10% HCI followed by ICP-OES	E013					
SoilDSulphate (as SO4) - Water Soluble (2:1)Determination of water soluble sulphate by extraction with water followed by ICP-OESE014SoilARSulphideDetermination of sulphide by distillation followed by colorimetryE018SoilDSulphur - TotalDetermination of semi-volatile organic compounds by extraction in acetone and hexane followed byE004SoilARSVOCDetermination of semi-volatile organic compounds by extraction in acetone and hexane followed byE006SoilARThiocyanate (as SCN)Determination of ferric nitrate followed by colorimetryE006SoilDToluene Extractable Matter (TEM)Gravimetrically determined through extraction with tolueneE011SoilDTotal Organic Carbon (TOC)Determination of seane/acetone extractable hydrocarbons by GC-FID fractionating with SPEE004SoilARC10-C12, C12-C16, C16-C21, C21-C34, aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C34, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35E004SoilARTPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C34, cartridge for C8 to C44. C5 to C8 by headspace GC-MSE004SoilARVPH (C6-C8 & C8-C10, C10-C12, C12-C16, C16-C21, C21-C34, C12-C16, C16-C21, C21-C34E001SoilARVPH (C6-C8 & C8-C10) Determination of volatile	Soil	D	Sulphate (as SO4) - Water Soluble (2:1)	Determination of sulphate by extraction with water & analysed by ion chromatography	E009					
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SoilDSulphur - TotalDetermination of total sulphur by extraction with aqua-regia followed by ICP-OESE024SoilARSVOCDetermination of semi-volatile organic compounds by extraction in acetone and hexane followed by GC-MSE006SoilARThiocyanate (as SCN)Determination of thiocyanate by extraction in caustic soda followed by acidification followed by addition of ferric nitrate followed by colorimetry addition of ferric nitrate followed by colorimetry addition of ferric nitrate followed by colorimetry addition of organic matter by oxidising with potassium dichromate followed by titration with iron (II) sulphateE011SoilDTotal Organic Carbon (TOC) C10-C12, C12-C16, C16-C21, C21-C34, C10-C12, C12-C16, C16-C21, C21-C34, C12-C16, C16-C21, C21-C35, C12-C16, C16-C21, C21-C34, C12-C16, C16-C21, C21-C34, C12-C16, C16-C21, C21-C35, C12-C16, C16-C21, C21-C34, C12-C16, C16-C21, C21-C35, C12-C16, C16-C21, C21-C35, C12-C16, C16-C21, C21-C35, C12-C16, C16-C21, C21-C35, C12-C16, C16-C21, C21-C35, C12-C16, C16-C23, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge for C8 to C44. C5 to C8 by headspace GC-MSE004SoilARVPH (C6-C3 & C8-C10, D C12-C16, C16-C21, C21-C35, C35-C44, C12-C16, C16-C21, C21-C35, C35-C44, C12-C16, C16-C21, C21-C35, C35-C44, C12-C16, C16-C21, C21-C35, C35-C44,Determination of volatile	Soil	AR	Sulphide	Determination of sulphide by distillation followed by colorimetry	E018					
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SoilARThiocyanate (as SCN)Determination of thiocyanate by extraction in caustic soda followed by acidification followed by addition of ferric nitrate followed by colorimetryE017SoilDToluene Extractable Matter (TEM)Gravimetrically determined through extraction with tolueneE011SoilDTotal Organic Carbon (TOC)Determination of organic matter by oxidising with potassium dichromate followed by titration with iron (II) sulphateE010SoilARTPH CWG (ali: C5- C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C34, aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge for C8 to C35. C5 to C8 by headspace GC-MSE004SoilARTPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C35, C35-C44, aro: C5-C7, C7-C8, C8-C10, C10-C12, c12-C16, C16-C21, C21-C35, C35-C44Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE arridge for C8 to C44. C5 to C8 by headspace GC-MSE004SoilARVPH (C6-C8 & C8-C10, Determination of hoxane/acetone extractable hydrocarbons by GC-FID fractionating with SPE arridge for C8 to C44. C5 to C8 by headspace GC-MSE001SoilARVPH (C6-C8 & C8-C10, Determination of volatile organic compounds by headspace GC-MSE001	Soil	AR	SVOC	Determination of semi-volatile organic compounds by extraction in acetone and hexane followed by GC-MS	E006					
Soil D Toluene Extractable Matter (TEM) Gravimetrically determined through extraction with toluene E011 Soil D Total Organic Carbon (TOC) Determination of organic matter by oxidising with potassium dichromate followed by titration with iron (II) sulphate E010 Soil AR TPH CWG (ali: C5- C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C34, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE aro: C5-C7, C7-C8, C8-C10, C10-C12, cartridge for C8 to C35. C5 to C8 by headspace GC-MS E004 Soil AR TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, cartridge for C8 to C35. C5 to C8 by headspace GC-MS E004 Soil AR TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, cartridge for C8 to C44. C5 to C8 by headspace GC-MS E004 Soil AR TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, cartridge for C8 to C44. C5 to C8 by headspace GC-MS E004 Soil AR C10-C12, C12-C16, C16-C21, C21-C24, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE aro: C5-C7, C7-C8, C8-C10, C10-C12, cartridge for C8 to C44. C5 to C8 by headspace GC-MS E004 Soil AR C10-C12, C12-C13, C10-C12, cartridge for C8 to C44. C5 to C8 by headspace GC-MS E001 Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID E001	Soil	AR	Thiocyanate (as SCN)	Determination of thiocyanate by extraction in caustic soda followed by acidification followed by addition of ferric nitrate followed by colorimetry	E017					
Soil D Total Organic Carbon (TOC) Determination of organic matter by oxidising with potassium dichromate followed by titration with iron (II) sulphate E010 Soil AR TPH CWG (ali: C5- C6, C6-C8, C8-C10, C10-C12, C12-C15, C16-C21, C21-C34, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE arr: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE arr: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C35, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE arr: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C35, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE arr: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C35, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE arr: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35, C35-C44, Determination of hoxed pace GC-MS E004 Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS E001 Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID E001	Soil	D	Toluene Extractable Matter (TEM)	Gravimetrically determined through extraction with toluene	E011					
Soil AR TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C34, aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35) Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE E004 Soil AR TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35) Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE E004 Soil AR C10-C12, C12-C16, C16-C35, C35-C44, aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35, C35-C44) Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35, C35-C44) E004 Soil AR VPH (C6-C8 & C8-C10) Determination of volatile organic compounds by headspace GC-MS E001 Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID E001	Soil	р	Total Organic Carbon (TOC)	Determination of organic matter by oxidising with potassium dichromate followed by titration with	F010					
Soil AR C10-C12, C12-C16, C16-C21, C21-C34, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE aro: C5-C7, C7-C8, C8-C10, C10-C12, cartridge for C8 to C35. C5 to C8 by headspace GC-MS E004 Soil AR TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, cartridge for C8 to C35. C5 to C8 by headspace GC-MS E004 Soil AR TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, cartridge for C8 to C44. C5 to C8 by headspace GC-MS E004 Soil AR C10-C12, C12-C16, C16-C35, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE c12-C16, C16-C21, C21-C35, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE c12-C16, C16-C21, C21-C35, C35-C44, Determination of volatile organic compounds by headspace GC-MS E004 Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID E001	501	D	TPH CWG (ali: C5- C6, C6-C8, C8-C10,	iron (II) sulphate	2010					
Soil AR aro: C5-C7, C7-C8, C8-C10, C10-C12, (cartridge for C8 to C35. C5 to C8 by headspace GC-MS E004 Soil AR TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, C21-C35, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE aro: C5-C7, C7-C8, C8-C10, C10-C12, cartridge for C8 to C44. C5 to C8 by headspace GC-MS E004 Soil AR VOCS Determination of volatile organic compounds by headspace GC-MS & C8-C10 by GC-FID E001 Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID E001	Soil	AR	C10-C12, C12-C16, C16-C21, C21-C34,	Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE	E004					
Soil AR VPH (C6-C8 & C8-C10, C12-C135) E001 Soil AR VPH (C6-C8 & C8-C10, C10-C12, C12-C16, C16-C35, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE c12-C16, C16-C21, C12-C16, C16-C12, C12-C14, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE c12-C16, C16-C21, C12-C13, C10-C12, C12-C14, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE c12-C16, C16-C21, C12-C13, C35-C44) E001			aro: C5-C7, C7-C8, C8-C10, C10-C12,	cartridge for C8 to C35. C5 to C8 by headspace GC-MS						
SoilARTPH LQM (ali: C5-C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C35, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE aro: C5-C7, C7-C8, C8-C10, C10-C12, cartridge for C8 to C44. C5 to C8 by headspace GC-MSE004SoilARVOCsDetermination of volatile organic compounds by headspace GC-MSE001SoilARVPH (C6-C8 & C8-C10)Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FIDE001	L		C12-C16, C16-C21, C21-C35)							
Soil AR C10-C12, C12-C16, C16-C35, C35-C44, Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE aro: C5-C7, C7-C8, C8-C10, C10-C12, cartridge for C8 to C44. C5 to C8 by headspace GC-MS E004 Soil AR VOCs Determination of volatile organic compounds by headspace GC-MS E001 Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID E001			TPH LQM (ali: C5-C6, C6-C8, C8-C10,							
Soil AR VOCS Determination of volatile organic compounds by headspace GC-MS E001 Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID E001	Soil	٨D	C10-C12, C12-C16, C16-C35, C35-C44,	Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE	F004					
C12-C16, C16-C21, C21-C35, C35-C44) E001 Soil AR VOCs Determination of volatile organic compounds by headspace GC-MS E001 Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID E001	301	An	aro: C5-C7, C7-C8, C8-C10, C10-C12,	cartridge for C8 to C44. C5 to C8 by headspace GC-MS	LUUT					
Soil AR VOCs Determination of volatile organic compounds by headspace GC-MS E001 Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID E001			C12-C16, C16-C21, C21-C35, C35-C44)							
Soil AR VPH (C6-C8 & C8-C10) Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID E001	Soil	AR	VOCs	Determination of volatile organic compounds by headspace GC-MS	E001					
	Soil	AR	VPH (C6-C8 & C8-C10)	Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID	E001					

D Dried AR As Received

~Sample details provided by customer and can affect the validity of results


Normec DETS Limited Unit 1, Rose Lane Industrial Estate Rose Lane Lenham Heath Maidstone Kent ME17 2JN Tel : 01622 850410



List of HWOL Acronyms and Operators DETS Report No: 24-12235 Jomas Associates Limited ~Site Reference: 26 Amyand Park Road, TW1 3HE ~Project / Job Ref: J3027 ~Order No: P5802J3027.5 Reporting Date: 21/10/2024

Acronym	Description
HS	Headspace analysis
EH	Extractable Hydrocarbons - i.e. everything extracted by the solvent
CU	Clean-up - e.g. by florisil, silica gel
1D	GC - Single coil gas chromatography
2D	GC-GC - Double coil gas chromatography
Total	Aliphatics & Aromatics
AL	Aliphatics only
AR	Aromatics only
#1	EH_2D_Total but with humics mathematically subtracted
#2	EH_2D_Total but with fatty acids mathematically subtracted
_	Operator - underscore to separate acronyms (exception for +)
+	Operator to indicate cumulative eg. EH+HS_Total or EH_CU+HS_Total
~	Sample details provided by customer and can affect the validity of results

Det - Acronym



APPENDIX 5 – GROUNDWATER MONITORING RESULTS

GROUNDWATER MONITORING BOREHOLE RECORD SHEET									
Site: 26 Amyand Park Road	Operative(s):	DJH	Date: 18/10/2024	Time: 10:00		Round: 1	Page: 1		
	MONITORING EQUIPMENT								
Instrument Type	Instrument Ma	Instrument Make			Serial No. Date Last Calibrated				
Dip Meter – Interface Probe	In-Situ	In-Situ				-			
	MONITORING CONDITIONS								
Weather Conditions: Overcast Groun			d Conditions: Damp Temper		ature: 10°C				
Barometric Pressure (mbar): N/A		Baromet	Barometric Pressure Trend (24hr): Rising Ambier			nt Concentration: N/A	t Concentration: N/A		
			MONITORING RE	SULTS					
Monitoring Point Location	VOC (ppm)		Depth to product	Depth to wa	ater	Depth to base of well	Comments		
	Peak	Steady	(mbgl)	(mbgl)		(mbgl)			
BH1	-	-	-	6.53		8.02			

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Unit 24 Sarum Complex Salisbury Road Uxbridge UB8 2RZ

CONTACT US

Website: www.jomasassociates.com Tel: 0333 305 9054 Email: info@jomasassociates.com



N.M.N PARTNERSHIP LIMITED

Consulting Civil & Structural Engineers

9 Chamberlain Lane Pinner Middx HA5 2PH Tel: 07565979671 Email: nathanmasil@aol.com

Structural Calculation for Basement and swimming pool

RC retaining walls Basement slab Ground floor slab RC wals

Project26 Amyand Park RoadTwickenham TW1 3HE

Prepared By Nathan Masil BEng, MSc, ICIOB

Date: 04.05.2024

Document: Calculation 23 227-02

Codes and standards Used:

BS8110

BS8002

					NMN Pa	rtnership Ltd			
		Consul	ting Civi	& Structural Er	gineers	1			
NMN					Calc	ulation Sheet			
Project:	26 Amyand Park Road TV	V1 3HE					Date:	01.05.24	
Element:	Basement with swimming	pool					Sheet No:	1	
Ref	Existing and Proposed Dr	awings by Project A	Architect						Output
Load Assessment									
<u>Element</u>	Dead Load (Gk)				Imposed Lo	oad (Qk)		Reference	
				KN/m2			KN/m2		
Floor									
	Boards			0.1					
	Joist			0.2					
	Insulation			0.04					
	Ceiling and finishes			0.25					
	Total			0.59	Residential		1.	5	
Pitch Roof									
	Tiles			0.65					
	Rafter & Battens			0.22					
	Insulation			0.04					
	Ceiling & finishes			0.25					
	Total			1.16	No Access		0.7	5	
Loft Floor								_	
	Boards			0.1			_	-	
	Joist			0.1			_		
	Insulation			0.04					
	Ceiling & finishes			0.25	A '1 1 .		0	2	
	Total			0.49	Accessible		0.	3	
El-tf									
r tat rooj	Falt			0.08					
	Loist & firrings			0.08				-	
	Joist & Infings			0.22				-	
	Ply			0.04				-	
	Ceiling & finishes			0.15					
	Total			0.23	No Access		0	6	
	Total			0.72	NO ACCESS		0.	0	
Wall									
	0 1m single skin			2.2				+	
	render & finishes			0.25					
	Total			2.45				1	
				2.45					
	0.225 m solid wall			4 95				1	
	render & finishes			0.25				1	
	Total			5.2					
				0.2				1	
								1	

				NMN Pa	rtnership Ltd			
MMN			Consul	ing Civil &	Structural Engineers Eng	ineers		
NIVIN				Calc	ulation Sheet	D	01.05.04	
Project: Element:	26 Amyand Park Road T	w13HE				Date: Sheet No:	01.05.24	
Ref	Existing and Proposed Dr	awings by Project Architect				Sheet NO.	2	Output
	6 1	j j j						1.01
Member	Elements	Gk	KN/m	Qk		KN/m	Comments	
RWI	Lateral eth pressure only		62.2			0.2		
<u>aepin 4.0m</u>			02.2			9.3		
RW2	lateral earth pressure							
Depth	Wall	5.2x9	47					
RW3	I ateral earth pressure							
Depth 1.6m	basement slab	7.2x2/2	7.2		1.5x2/2	1.5		
RW4 Depth 3m	Wall	5.2x9	47					
<u>Depin Sm</u>	basement slab	7.2x2/2	7.2		1.5x2/2	1.5		
	Floors	2x0.59x5/2	2.95		2x1.5x5/2	6		
RW5	Wall	5.2x9	47		2-1.5-5/2			
Depui 4.6m	reaction B11	£x0.39X3/2	2.95		2x1.3x3/2	6 1/1 3		
		1	05.5			14.3		
RW6	Floors	2x0.59x5/2	2.95		2x1.5x5/2	6		
Depth 3m	Wall	5.2x9	47		1.5.0/2			
	basement floor	/.2x2/2	7.2		1.5x2/2	1.5		
							l	
RCW7	reaction B11		31.4			6		
Depth 3m								
PCW8	Wall	5.2x7	26		ddn windows 30%			
Depth 3m	Floors	2x0.59x4/2	2.36		2x15x4/2	6		
1	Roof	1.16x4/2cos30	2.68		0.75x4/2Cos30	1.73		
	Front ground floor slab 6	x4/2	12		5x4/2	10		
D12	Concernto amound floor	24-0 2-7 8/2	19 72		1 57 8/2	E 05		
Span 5m	Wall	5 2x2 4	12.48		1.3X7.8/2	3.83	PUDL.	
opun om	Reaction B10	0.2.12.1	62.2			9.3		
	Reaction B10		30.8			1.5		
D14		24.0.2.0.6/2			15.050	5.0		
B14 Span 3.7m	Concrete floor	24.0.2x9.6/2	23		1.5x9.6/2	1.2		
Span 5.7m								
B13	Concrete ground floor	24x0.2x7.5/2	18		1.5x7.5/2	5.62		
Span 5m	Partition	05x7.5/2	1.87					
B14								
Span 5m								
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Tekla. Tedds	Project	26 Amyand Parl	Job no. 23 227			
NMN Partnership	Calcs for RC wall 1 to extension of basement				Start page no./Revision RW1 3	
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
						-



Tekla Tedds	Project	26 Amyond Dor	Pood TM/1 2U	E	Job no.	227
NMN Partnershin	Color for	20 Amyanu Pan			23	221
	R	C wall 1 to exte	nsion of basem	ent	Start page no./Re	/1 4
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
Saturated density of retained ma	aterial	γs = 21.0 ki	N/m ³			
Design shear strength		φ' = 24.2 de	eg			
Angle of wall friction		δ = 0.0 deg	I			
Base material details						
Moist density		γ _{mb} = 18.0	۸/m³			
Design shear strength		φ' _b = 24.2 d	eg			
Design base friction		δ _b = 18.6 de	eg			
Allowable bearing pressure		Pbearing = 15	50 kN/m ²			
Using Coulomb theory						
Active pressure coefficient for re	etained material					
K _a = sin(α	+ $\phi')^2$ / (sin(α) ² ×	$\propto \sin(lpha$ - $\delta) imes$ [1 +	$\sqrt{(\sin(\phi' + \delta) \times s)}$	$\sin(\phi'$ - $eta)$ / (sin($lpha$	- δ) × sin(α + (3)))] ²) = 0.419
Passive pressure coefficient for	base material					
	K _p = sin(9	00 - φ'ь)² / (sin(90) - δ⊳) × [1 - √(sir	$h(\phi'_{P} + \delta_{P}) \times sin(\phi'_{P})$	») / (sin(90 + ծ	b)))] ²) = 4.187
At-rest pressure						
At-rest pressure for retained ma	iterial	K₀ = 1 – sir	n(φ') = 0.590			
Loading details						
Surcharge load on plan		Surcharge	= 10.0 kN/m ²			
Applied vertical dead load on wa	all	W _{dead} = 40 .	0 kN/m			
Applied vertical live load on wall	I	W _{live} = 5.0	kN/m			
Position of applied vertical load	on wall	l _{load} = 1675	mm			
Applied horizontal dead load on	wall	$F_{dead} = 0.0$	kN/m			
Height of applied horizontal load	vali 1 on wall	Flive = 0.0 K	n/111			
		45				
	21.4 Prop	Prop		4.7 9.8		
				Loads shown	in kN/m, pressure	es shown in kN/m²

Tekla Tedds	Project	26 Amvand Par	Job no. 23 227 Start page no./Revision RW1 5					
NMN Partnership	Calcs for	RC wall 1 to exte						
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date		
Vertical forces on wall Wall stem		w _{wall} = h _{sterr}	$h \times t_{wall} \times \gamma_{wall} =$	28.3 kN/m				
Wall base Applied vertical load Total vertical load		Wbase = Ibase W _v = W _{deac} W _{total} = Wwa	e × tbase × γbase 1 + W _{live} = 45 k 11 + Wbase + Wγ					
Horizontal forces on wall		Б - К . у	Surcharge - h	" – 18 kN/m				
Moist backfill above water table	Moist backfill above water table			$F_{m_a} = 0.5 \times K_a \times \gamma_m \times (h_{eff} - h_{water})^2 = 41 \text{ kN/m}$				
Moist backfill below water table		$F_{m_b} = K_a \times$	αγ _m × (h _{eff} - h _{wa}	_{ter}) × h _{water} = 24.9	kN/m			

Fprop = 60.6 kN/m

 $F_s = 0.5 \times K_a \times (\gamma_{s} - \gamma_{water}) \times h_{water}^2 = 2.3 \text{ kN/m}$

 $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 38.7 \text{ kNm/m}$

 $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 0.8 \text{ kNm/m}$

 $M_{wall} = W_{wall} \times (I_{toe} + t_{wall} / 2) = 46.7 \text{ kNm/m}$

Mrest = Mwall + Mbase + Mdead = 125.2 kNm/m

 $p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 47.8 \text{ kN/m}^2$

 $p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 47.8 \text{ kN/m}^2$

Mbase = Wbase × Ibase / 2 = 11.5 kNm/m

Mdead = Wdead × Iload = 67 kNm/m

e = abs((lbase / 2) - xbar) = 0 mm

R = W_{total} = 86.1 kN/m

 $x_{bar} = I_{base} / 2 = 900 \text{ mm}$

 $M_{m b} = F_{m b} \times (h_{water} - 2 \times d_{ds}) / 2 = 12.4 \text{ kNm/m}$

 $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 1.6 \text{ kNm/m}$

Mot = Msur + Mm a + Mm b + Ms + Mwater = 139.7 kNm/m

Ftotal = Fsur + Fm a + Fm b + Fs + Fwater = 91.1 kN/m

 $F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta_b), 0 \text{ kN/m})$

 $M_{m a} = F_{m a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 86.1 \text{ kNm/m}$

 $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.2 \text{ kN/m}$

 $F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 4.9 \text{ kN/m}$

Propping force to top of wall

Calculate propping forces to top and base of wall

Saturated backfill

Propping force

Surcharge

Water

Wall stem

Wall base

Saturated backfill

Total horizontal load

Overturning moments

Total overturning moment

Design vertical dead load

Check bearing pressure

Total restoring moment

Total vertical reaction

Bearing pressure at toe Bearing pressure at heel

Distance to reaction Eccentricity of reaction

Restoring moments

Calculate total propping force

Moist backfill above water table Moist backfill below water table

Passive resistance of soil in front of wall

Water

 $F_{prop_top} = (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = 19.962 \text{ kN/m}$ $F_{prop_base} = F_{prop} - F_{prop_top} = 40.664 \text{ kN/m}$

PASS - Maximum bearing pressure is less than allowable bearing pressure

Reaction acts within middle third of base

Propping force to base of wall

Tekla Tedds	Project	26 Amyand Par	k Road TW1 3F	ΗE	Job no. 23	227			
NMN Partnership	Calcs for	RC wall 1 to exte	nsion of basen	pent	Start page no./R	evision V1 6			
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date			
RETAINING WALL DESIGN (B	S 8002:1994	<u>+)</u>							
Ultimate limit state load facto	rs				IEDDS calculation	version 1.2.01.08			
Dead load factor		γ _{f_d} = 1.4							
Live load factor		γ _{f_l} = 1.6							
Earth and water pressure factor		γ _{f_e} = 1.4							
Factored vertical forces on wa	all								
Wall stem	~~~	Wwall f = γf d	\times h _{stem} \times t _{wall} \times '	wall = 39.6 kN/m	1				
Wall base		Whase $f = \gamma f_0$	t X Ibase X Ibase X	vbase = 17.8 kN/	m				
Applied vertical load		$W_{\rm V} f = v f d \lambda$	$W_{dead} + V_{f} + X$	$V_{\text{live}} = 64 \text{ kN/m}$					
Total vertical load		W total f = Wv	vall f + Wbase f + V	Vv f = 121.5 kN/r	n				
Eactored horizontal active for	cos on wall		<u>.</u>						
Surcharge		$F_{aut} f = \gamma f + \gamma$	K × Surchard	e v h _{off} = 28.8 kl	l/m				
Moist backfill above water table		$F_{m,o,f} = \gamma_{f,o}$	$\times 0.5 \times K_{o} \times v_{m}$	$\times (h_{\text{eff}} - h_{\text{water}})^2 =$	57 4 kN/m				
Moist backfill below water table		Fm_b_f = Vf o	\times K _a \times γ _m \times (h _a)	<pre>(Ten = Trwater) = f = hustor) × hustor :</pre>	= 34.8 kN/m				
Saturated backfill		$F_{n,f} = \gamma_{f,e}$	$0.5 \times K_{0} \times (v_{0} - v_{0})$	$(unter) \times hunter^2 = 3$	3 kN/m				
Water		$F_{\text{unitor } f} = \gamma_{f}$	$F_{\text{water}} = \frac{1}{2} \text{ from } 0.5 \times \text{hwater}^2 \times \text{water} = 6.9 \text{ kN/m}$						
Total horizontal load		$F_{total} = F_{su}$	f + Fm a f + Fm	$h f + F_s f + F_{water}$	 f = 131.2 kN/m				
Calculate total propping force									
Passive resistance of soil in from	, at of wall		$0.5 \times K_{-} \times \cos($	(d	$a + da - da ^2$	(Neck - 45			
kN/m		τ p_i — γi_e ×	0.5 × 10 × 003			(ymb - 4.5			
Propping force		F _{prop_f} = ma F _{prop_f} = 88 .	x(F _{total_f} - F _{p_f} - 5 kN/m	$(W_{total_f} - \gamma_{f_l} \times W)$	$_{ive}) imes tan(\delta_b), 0$	kN/m)			
Factored overturning moment	ts								
Surcharge		Msur_f = Fsur	$_f \times (h_{eff} - 2 \times d)$	_{ds}) / 2 = 61.9 kN	m/m				
Moist backfill above water table		$M_{m_a_f} = F_m$	$_a_f \times (h_{eff} + 2 \times$	hwater - $3 \times d_{ds}$) /	3 = 120.6 kNm	/m			
Moist backfill below water table		$M_{m_b_f} = F_m$	_b_f × (hwater - 2	× d _{ds}) / 2 = 17.4	kNm/m				
Saturated backfill		$M_{s_f} = F_{s_f}$	< (hwater - 3 $ imes$ dds	s) / 3 = 1.1 kNm/	m				
Water		$M_{water_f} = F_{v}$	vater_f × (hwater - 3	3 × d _{ds}) / 3 = 2.3	kNm/m				
Total overturning moment		$M_{ot_f} = M_{sur_f}$	_f + M _{m_a_f} + M _m	_b_f + Ms_f + M _{wate}	_{er_f} = 203.3 kNm	n/m			
Restoring moments									
Wall stem		$M_{wall_f} = w_{wall_f}$	$_{\text{all_f}} \times (I_{\text{toe}} + t_{\text{wall}})$	2) = 65.4 kNm/r	n				
Wall base		M _{base_f} = w _b	$_{ase_f} \times I_{base} / 2 =$	16.1 kNm/m					
Design vertical load		$M_{v_f} = W_{v_f}$	× I _{load} = 107.2 k	xNm/m					
Total restoring moment		$M_{rest_f} = M_{w}$	$_{all_f} + M_{base_f} + N$	l _{v_f} = 188.7 kNm	/m				
Factored bearing pressure									
Total vertical reaction		$R_f = W_{total_f}$	= 121.5 kN/m						
Distance to reaction		Xbar_f = Ibase	/ 2 = 900 mm						
Eccentricity of reaction		e _f = abs((I _{ba}	_{ase} / 2) - x _{bar_f}) =	0 mm					
				Reaction acts $2^{2} = 67$		third of base			
Bearing pressure at loe		$p_{\text{toe}_f} = (R_f / P_f)$	$(Dase) - (O \times Kf)$	$(ct / ibase^{-}) = 07.3$	$\sim \text{KIN/III}^{-}$				
Rate of change of base reaction	,	$p_{\text{heel}_f} = (\mathbf{R}_f)$	$i \text{ (base)} \neq (0 \times \text{Rf})$	$x = 0.00 \text{ kNl/m}^2/\text{m}^2$.⊎ KIN/III ⁻				
Bearing pressure at stem / toe	ı	naic - (ptoe)	$Iate - (Ptoe_f - Pheel_f) / Ibase = U.UU KIV/IIT/III Potom to f = max(Ptoe_f - (rate < b_c)) 0 kNI/m2) - 67.5 kNI/m2$						
		Pareiu_06_1 _			,				

Tekla Tedds						
	Project	26 Amvand Par	k Road TW1 3	HF	Job no.	3 227
NMN Partnership	Calcs for			··-	Start page no./F	Revision
		RC wall 1 to exte	ension of base	ment	R	N17
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
Bearing pressure at mid stem		Dstem mid f =	max(ptoe f - (ra	$te \times (I_{toe} + t_{wall} / 2)$)), 0 kN/m ²) = (67.5 kN/m ²
Bearing pressure at stem / heel		pstem_heel_f =	max(ptoe_f - (ra	ate \times (Itoe + twall)),	0 kN/m²) = 67.	5 kN/m ²
Calculate propping forces to a Propping force to top of wall	top and base	e of wall				
	Fprop_top_f	= (Mot_f - Mrest_f + R	f $ imes$ Ibase / 2 - Fpr	op_f × t base / 2) / (h	stem + t _{base} / 2) :	= 26.670 kN/m
Propping force to base of wall		Fprop_base_f =	= Fprop_f - Fprop_t	_{op_f} = 61.807 kN/r	n	
Design of reinforced concrete	e retaining w	all toe (BS 8002:1	994)			
Material properties		.				
Characteristic strength of concre	ete	fcu = 40 N/r	nm²			
Characteristic strength of reinfo	rcement	f _y = 500 N/	mm ²			
Base details		·				
Minimum area of reinforcement		k = 0.13 %				
Cover to reinforcement in toe		_{Ctoe} = 50 m	m			
Calculate shear for toe design	ı					
Shear from bearing pressure	-	V _{toe bear} = (Dtoe f + Dstem toe	f) × Itoe / 2 = 101.	2 kN/m	
Shear from weight of base		Vtoe wt base =	= γfd × γbase × It	_{oe} × t _{base} = 14.9 k	N/m	
Total shear for toe design		V _{toe} = V _{toe_t}	bear - Vtoe_wt_base	= 86.4 kN/m		
Calculate moment for toe des	ian					
Moment from bearing pressure	·J··	M _{toe bear} = ($2 \times p_{toe f} + p_{ster}$	m mid f) × (Itoe + twa	"/2) ² /6 = 91. 9	9 kNm/m
51		= (, ,	/ \ /	, , , , , , , , , , , , , ,	kNm/m
Moment from weight of base		Mtoe wt base	= ($\gamma_f d \times \gamma_{base} \times$	lbase × (Itoe + lwall /	$(2)^{2}/(2) = 13.5$	
Moment from weight of base Total moment for toe design		M _{toe_wt_base} M _{toe} = M _{toe}	= (γf_d × γbase × _bear - Mtoe_wt_bas	lbase × (Itoe + lwall / e = 78.4 kNm/m	2)² / 2) = 13.5	
Moment from weight of base Total moment for toe design	•	Mtoe_wt_base = Mtoe = Mtoe_	= (γf_d × γbase × bear - Mtoe_wt_bas	Lbase × (Itoe + Lwall / e = 78.4 kNm/m	•	
Moment from weight of base Total moment for toe design	-> ● ∢ 20	Mtoe_wt_base = Mtoe = Mtoe_ ●	= (γf_d × γbase × bear - Mtoe_wt_bas	Lbase × (Itoe + Lwall / e = 78.4 kNm/m	•	
Moment from weight of base Total moment for toe design	► ← 20	Mtoe_wt_base = Mtoe = Mtoe_ •	= (γf_d × γbase × bear - Mtoe_wt_bas	Lbase × (ltoe + Lwall / e = 78.4 kNm/m	•	
Moment from weight of base Total moment for toe design	► ← 201	Mtoe_wt_base = Mtoe = Mtoe_ 0 0 b = 1000 m	= (γf_d × γbase × bear - Mtoe_wt_bas	• 242.0 mm	•	
Moment from weight of base Total moment for toe design	► 4 20	Mtoe_wt_base = Mtoe = Mtoe_ 0 b = 1000 m dtoe = tbase -	Im/m Coto = - (φtoe / 2)	• • • •	•	
Moment from weight of base Total moment for toe design	► 4 201	Mtoe_wt_base = Mtoe = Mtoe_	mm/m - Ctoe - (φtoe / 2) / (b × dtoe ² × fcu	• • • • • • • • • • • • • •	•	s not required
Moment from weight of base Total moment for toe design	► 4 20	Mtoe_wt_base = Mtoe = Mtoe_	$m/m = (\phi_{1d} \times \gamma_{base} \times \phi_{bear} - M_{toe} + \phi_{tas})$	• • • • • • • • • • • • • • • • • • •	• • • • • • • • •	s not required
Moment from weight of base Total moment for toe design	- ● ← 201	Mtoe_wt_base = Mtoe = Mtoe_	$m/m = (\phi_{1d} \times \gamma_{base} \times \phi_{bear} - M_{toe} + \phi_{tase} \times \phi_{bear} - M_{toe} + \phi_{tase} \times \phi_{tas$	• • • • • • • • • • • • • • • • • • •	• • • • • • • • • • • • • • • • • • •	s not required
Moment from weight of base Total moment for toe design	► I a 201	Mtoe_wt_base = Mtoe = Mtoe_	$m/m = (\phi_{f_d} \times \gamma_{base} \times \phi_{bear} - M_{toe_wt_bas})$ \bullet \bullet $f_{toe_wt_bas}$ \bullet $f_{toe_wt_bas}$ \bullet $f_{toe_wt_bas}$ \bullet $f_{toe_wt_bas}$ $f_{toe_wt_bas}$ \bullet $f_{toe_wt_bas}$ $f_{toe_wt_bas}$ $f_{toe_wt_bas}$ $f_{toe_wt_bas}$ $f_{toe_wt_bas}$	• • • • • • • • • • • • • • • • • • •	• • • • • • • • • • • • • • • • • • •	s not required
Moment from weight of base Total moment for toe design	► • 201 equired rcement	Mtoe_wt_base = Mtoe = Mtoe_ Mtoe = Mtoe_ b = 1000 m dtoe = tbase - Ktoe = Mtoe d ztoe = min(0 ztoe = 230 m As_toe_des = As toe min =	$m/m = (\phi_{toe} - \phi_{toe} + \phi_{toe})$ $- Ctoe - (\phi_{toe} - 2)$ $/ (b \times dtoe^2 \times fou)$ $0.5 + \sqrt{(0.25 - (m))}$ $Mtoe / (0.87 \times fy)$ $k \times b \times toase = 3$	• • • • • • • • • • • • • • • • • • •	• • • • • • • • • • • • • • • • • • •	s not required
Moment from weight of base Total moment for toe design	► • <p< td=""><td>Mtoe_wt_base = Mtoe = Mtoe_ Mtoe = Mtoe_ b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = min(C Ztoe = 230 m As_toe_des = As_toe_min = As_toe_req = 1</td><td>$m/m = (\gamma f_d \times \gamma base \times bear - Mtoe_wt_base)$ $m/m = Ctoe - (\phi toe / 2)$ $/ (b \times dtoe^2 \times fcu)$ $(b \times dtoe^2 \times fcu)$ $(b \times dtoe^2 \times fcu)$ $Mtoe / (0.25 - (mm)$ $Mtoe / (0.87 \times fy)$ $k \times b \times tbase = 3$ $Max(As toe des, A)$</td><td>• • • • • • • • • • • • • • • • • • •</td><td>• • • • • • • • • • • • • • • • • • •</td><td>s not required</td></p<>	Mtoe_wt_base = Mtoe = Mtoe_ Mtoe = Mtoe_ b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = min(C Ztoe = 230 m As_toe_des = As_toe_min = As_toe_req = 1	$m/m = (\gamma f_d \times \gamma base \times bear - Mtoe_wt_base)$ $m/m = Ctoe - (\phi toe / 2)$ $/ (b \times dtoe^2 \times fcu)$ $(b \times dtoe^2 \times fcu)$ $(b \times dtoe^2 \times fcu)$ $Mtoe / (0.25 - (mm)$ $Mtoe / (0.87 \times fy)$ $k \times b \times tbase = 3$ $Max(As toe des, A)$	• • • • • • • • • • • • • • • • • • •	• • • • • • • • • • • • • • • • • • •	s not required
Moment from weight of base Total moment for toe design	≥ ● 4 20 equired treement equired	Mtoe_wt_base is $Mtoe = Mtoe_{add}$ b = 1000 m $dtoe = tbase - Ktoe = Mtoe_{add}$ $ztoe = mtoe_{add}$ $ztoe = mtoe_{add}$ ztoe = 230 m $As_toe_{add} = As_toe_{add}$ $As_toe_{add} = 1$ $As_toe_{add} = 1$	Im/m $- Ctoe - (\phi toe / 2)$ $/ (b \times dtoe^2 \times fcu)$ $Mtoe / (0.87 \times fy)$ $k \times b \times tbase = 3$ $Max(As_toe_des, A)$	• • • • • • • • • • • • • • • • • • •	<i>inforcement is</i> 0.9)),0.95) × d n ² /m nm ² /m	s not required
Moment from weight of base Total moment for toe design	■ </td <td>Mtoe_wt_base = Mtoe = Mtoe_ Mtoe = Mtoe_</td> <td>$(\gamma f_{-} d \times \gamma base \times bear - Mtoe_wt_base)$ $(\phi = 1)$ $(\phi = 1)$</td> <td>• • • • • • • • • • • • • • • • • • •</td> <td>• • • • • • • • • • • • • • • • • • •</td> <td>s not required</td>	Mtoe_wt_base = Mtoe = Mtoe_ Mtoe = Mtoe_	$(\gamma f_{-} d \times \gamma base \times bear - Mtoe_wt_base)$ $(\phi = 1)$	• • • • • • • • • • • • • • • • • • •	• • • • • • • • • • • • • • • • • • •	s not required

$\frac{1}{1 + 1} = \frac{1}{1 + 1} + \frac{1}{1 + 1} = $	Tekla Tedds	Project	26 Amyand Par	k Road TW/1 3	HE	Job no.	2 2 2 7			
$\begin{array}{ c c c c } \hline RC wall 1 to extension of basement \\ \hline Reviewed by \\ \hline RC wall 1 to extension of basement \\ \hline Reviewed by \\ \hline RC wall 1 to extension of basement \\ \hline Reviewed by \\ \hline Reviewed by \\ \hline RC wall 1 to extension of basement \\ \hline Reviewed by \\ \hline R$	NMN Partnership	Coloo for	20 Anyana i ai	Start page po //	Start page no /Revision					
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		Calcs IO	RC wall 1 to exte	ension of baser	nent	R	N18			
Check shear resistance at toe Design shear stress $v_{us} = V_{us} / (b \times d_{us}) = 0.357 \text{ Nmm}^2$ Allowable shear stress $v_{us} = min(0.8 \times (d_{us} / 1 \text{ Nmm}^2), 5) \times 1 \text{ Nmm}^2 = 5.000 \text{ Nmm}^2$ Allowable shear stress $v_{us} = min(0.8 \times (d_{us} / 1 \text{ Nmm}^2), 5) \times 1 \text{ Nmm}^2 = 5.000 \text{ Nmm}^2$ PASS - Design shear stress is less than maximum shear stress $V_{us} = 0.625 \text{ Nmm}^2$ Ver < v_{us} = 0.625 \text{ Nmm}^2 $V_{us} < v_{us} = 0.625 \text{ Nmm}^2$ Material propertiesCharacteristic strength of concrete $t_u = 40 \text{ Nmm}^2$ Characteristic strength of reinforcement $t_y = 500 \text{ Nmm}^2$ Wail dotalisMinimum area of reinforcement $t_y = 500 \text{ Nmm}^2$ Wail dotalisSurcharge $F_{us} x_{us} = 0.52 \text{ N/m}^2 \times t_{us} \times (hur - hus, - d_{us}) = 26.8 \text{ N/m}^2$ Surcharge $F_{us} x_{us} = 0.52 \text{ N/m}^2 \times t_{us} \times t_u \times (hur - hus, - d_{us}) = 26.8 \text{ N/m}^2$ Surcharge $F_{us} x_{us} = y_{us} \times K_u \times Surcharge \times (hur - hus, - d_{us}) = 26.8 \text{ N/m}^2$ Surcharge $F_{us} x_{us} = y_{us} \times K_u \times t_u \times (hur - hus, - d_{us}) = 26.8 \text{ N/m}^2$ Moist backfill above water table $F_{us} x_{us} = y_{us} \times K_u \times t_u \times (hur - hus, - d_{us}) = 26.8 \text{ N/m}^2$ Surcharge $V_{us} x_{us} = F_{us} x_{us} \times t_u \times (hur - hus, - d_{us}) = 26.8 \text{ N/m}^2$ Surcharge $V_{us} x_{us} = F_{us} x_{us} \times t_u \times (hur - hus, - d_{us}) = 26.8 \text{ N/m}^2$ Surcharge $V_{us} x_{us} = F_{us} x_{us} \times t_u \times (hur - hus, - d_{us}) = 26.8 \text{ N/m}^2$ Surcharge $V_{us} x_{us} = F_{us} x_{us} \times t_u \times (hur - hus, - d_{us}) = 26.8 \text{ N/m}^2$ Surcharge $V_{us} x_{us} = F_{us} x_{us} \times t_u$		Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date			
Check strear resistance at too Design share stress $v_{am} = V_{bm} / (b \times d_{am}) = 0.357 \text{ N/mm}^2$ Allowable shear stress $v_{am} = \text{min}(0.8 \times \langle f_{am} / 1 \text{ N/mm}^2), 5) \times 1 \text{ N/mm}^2 = 5.000 \text{ N/mm}^2$ PASS Design shore stress is less than maximum shear stress Prom BS8110:Part 1:1997 – Table 3.8 Design concrete shear stress $v_{am} = 0.625 \text{ N/mm}^2$ $v_{am} < v_{am} = 0.625 \text{ N/mm}^2$ $v_{am} < v_{am} = N_0 \text{ Stress}$ is less than maximum shear stress Prom BS8110:Part 1:1997 – Table 3.8 Design concrete shear stress $v_{am} = 0.625 \text{ N/mm}^2$ $v_{am} < v_{am} < N_0 \text{ Stress}$ is less than maximum shear stress $v_{am} = 0.625 \text{ N/mm}^2$ $v_{am} < v_{am} < N_0 \text{ Stress}$ is less than maximum shear stress $v_{am} = 0.625 \text{ N/mm}^2$ $V_{am} < v_{am} < N_0 \text{ Stress}$ is less than maximum shear stress $v_{am} = 0.625 \text{ N/mm}^2$ $V_{am} < v_{am} < N_m + N_mm^2$ Characteristic strength of concrete $f_m = 40 \text{ N/mm}^2$ $Core to reinforcement in stem c_{am} = 50 \text{ mm}Core to reinforcement in stem c_{am} = 50 \text{ mm}Core to reinforcement in stem c_{am} = 50 \text{ mm}Surcharge F_{am} = (-0.5 \times \gamma_{1} \times K_{3} \times \text{Surcharge} \times (har + haas - d_m) = 26.8 \text{ N/m}Moist backfill below water table F_{am} = (-0.5 \times \gamma_{1} \times K_{3} \times (hr - haas - d_m) = 26.4 \text{ kN/m}F_{am} = (-0.5 \times \gamma_{1} \times K_{3} \times \gamma_{1} \times (hm - ham - d_m) + hm = 24.4 \text{ kN/m}Surcharge V_{am} = F_{am} = (-0.5 \times \gamma_{1} \times K_{3} \times (hr - ham - d_m) + hm = 24.4 \text{ kN/m}Surcharge V_{am} = F_{am} = (-0.5 \times \gamma_{1} \times K_{3} \times (hr - ham) + hm = 24.4 \text{ kN/m}Surcharge V_{am} = (-5 \times \gamma_{1} \times K_{3} \times (hr - ham) + hm = 24.4 \text{ kN/m}V_{am} = F_{am} = (-0.5 \times \gamma_{1} \times K_{3} \times (hr - hm)) + hm = 24.4 \text{ kN/m}Surcharge V_{am} = F_{am} = (-1.6^{2} \times ((-1.1))) / (8 \times 2).9 \text{ N/m}Moist backfill below water table V_{am} = F_{am} = (-1.6^{2} \times ((-1.1))) / (8 \times 2).9 \text{ N/m}Moist backfill above water table V_{am} = F_{am} = (-1.6^{2} \times ((-1.1))) / (2 \times 2).9 \text{ N/m}Moist backfill below water table M_{am} = $	Charle shore registered at the									
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Design shear stress	1	$\gamma = \gamma = 1$	$(b \times d) = 0.3$	57 N/mm ²					
PASS - Design shear stress is less that maximum shear stressPASS - Design shear stress is less that maximum shear stressPASS - Design shear stress is less that maximum shear stressPASS - Design shear stress is less that maximum shear stressVex < ve_xe - No shear reinforcement requiredDesign of reinforcement requiredDesign of reinforcement requiredMaterial propertiesCharacteristic strength of reinforcementK = 0.825 N/mm²Wate < ve_xe - No shear reinforcement requiredWate < No shear reinforcement is stemCourt to reinforcement in stemCourt to reinforcement in stemCourt of reinforcem	Allowable aboar stress		Vtoe – Vtoe /	$(D \times U_{toe}) - U.3$	J/mm^2 E $\times 1$ N	/mm ² - E 000 N	1/mm ²			
From BS8110-Part 1:1997 – Table 3.8Design concrete shear stress $v_{n,tore} = 0.625$ N/mm²wee < v_{n,tore} - No shear reinforcement requiredDesign of reinforced concrete retaining wall stom (BS 8002:1994)Material propertiesCharacteristic strength of concrete $f_{tor} = 40$ N/mm²Characteristic strength of concrete $f_{tor} = 40$ N/mm²Wall detailsMinimum area of reinforcementk = 0.13 %Cover to reinforcement in stem $c_{outer} = 50$ mmCover to reinforcement in wall $c_{outer} = 50$ mmGotor to reinforcement in stemCover to reinforcement in wall $c_{outer} = 50$ mmGotor to reinforcement in wallMoist backfill above water table $F_{u,m,t,2} = \tau_{U,2} \times K_a \times \gamma_m \times (har - base - d_{ab} - has)^2 = 57.4 kN/mMoist backfill below water tableF_{u,m,t,2} = 0.5 \times \gamma_{U,8} \times K_a \times (\gamma_{UP Wall}) \times has = 24.4 kN/mSaturated backfillBastrated backfillV_{u,m,L,2} = F_{u,m,L,1} \times h \times ((5 \times L^2) - h^2) / (5 \times L^2) = 39.9 kN/mMoist backfill below water tableV_{u,m,L,2} = F_{u,m,L,1} \times h \times ((5 \times L^2) - h^2) / (5 \times L^2) = 39.9 kN/mMoist backfill below water tableV_{u,m,L,2} = F_{u,m,L,1} \times h \times ((5 \times L) - a) / (20 \times L^2))) = 3.3 kN/mSubtrated backfillV_{u,m,L,2} = F_{u,m,L,1} \times h \times ((5 \times L) - a) / (20 \times L^2))) = 3.3 kN/mMoist backfill below water tableN_{u,m,L,2} = F_{u,m,L,1} \times h \times ((5 \times L) - (3 \times D)) / ((5 \times L^2) = 39.2 kN/mMatterV_{u,m,L,2} + V_{u,m,L,2} + V_{u,m,L,2} + V_{u,m,L,2} = 0.4 kN/m$	Allowable shear stress		Vadm - IIIII(PASS -	Design shear	r stress is less t	han maximun	n shear stress			
Design concrete shear stress $v_{ijma} = 0.625$ N/mm ² New < v_{ijma} = No shear reinforcement required	From BS8110:Part 1:1997 – Ta	able 3.8		2 congin cincul						
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Design concrete shear stress		v _{c_toe} = 0.6 2	25 N/mm²						
Design of reinforced concrete retaining wall stem (BS 6002:1994)Material properties $f_{ss} = 40 \text{ N/mm}^2$ Characteristic strength of reinforcement $f_s = 500 \text{ N/mm}^2$ Wall detailsMinimum area of reinforcementk = 0.13 %Cover to reinforcement in stemCover to reinforcement in wall $Cover to reinforcement in wallCover to reinforcement in wallCover to reinforcement in wallCover to reinforcement in wallCover to reinforcement in wallSurchargeF_{x,m,1} = \gamma_{1,1} \times K_a \times Surcharge \times (her - base - da, - her)^2 = 57.4 \text{ K/m}Moist backfill above water tableF_{x,m,2} = 0.5 \times \gamma_{1,2} \times K_a \times \gamma_m \times (her - base - da, - her)^2 = 57.4 \text{ K/m}Saturated backfillF_{x,m,2} = 0.5 \times \gamma_{1,2} \times K_a \times \gamma_m \times (her - base - da, -her)^2 = 57.4 \text{ K/m}WalterF_{x,m,2} = 0.5 \times \gamma_{1,2} \times Y_{ax} \times (her - weater) + her² = 1.6 \text{ K/m}SurchargeV_{x,m,2} = 5 \times F_{x,m,2} / 8 = 16.7 \text{ K/m}WaterV_{x,m,2} = 5 \times \gamma_{1,2} \times \gamma_{1,2} \times (h = (h^2 \times (5 \times L^2) - 3)/(5 \times L^2) = 39.9 \text{ K/m}SurchargeV_{x,m,2} = F_{x,m,2} / 8 = 10.7 \text{ K/m}Moist backfill above water tableV_{x,m,2} = F_{x,m,2} / 8 = (h^2 \times (5 \times L^2) - a)/(20 \times L^2))WaterV_{x,m,2} = F_{x,m,2} / 1 - (a^2 \times (5 \times L) - a)/(20 \times L^2))Moist backfill above water tableV_{x,m,2} = F_{x,m,2} / x (1 - (a^2 \times (5 \times L) - a)/(20 \times L^2)))SurchargeM_{x,m} = F_{x,m,2} / x (1 - (a^2 \times (5 \times L) - a)/(20 \times L^2))Moist backfill above water tableM_{x,m} = F_{x,m,2} / x (1 - (a^2 \times (5 \times L) - a)/(20 \times L^2))SurchargeM_{x,m} = F_{x,m,2} / x (1 - (a^2 \times (5 \times L) -$				Vto	e < vc_toe - No sh	near reinforce	ment required			
Material propertiesCharacteristic strength of concrete $f_{sr} = 40 \text{ N/mm}^2$ Characteristic strength of reinforcement $f_y = 500 \text{ N/mm}^2$ Wall detailsMinimum area of reinforcementMinimum area of reinforcement in stem $C_{outm} = 50 \text{ mm}$ Cover to reinforcement in wall $C_{outm} = 50 \text{ mm}$ Factored horizontal active forces on stemSurcharge $F_{a,m,z,l} = \gamma_{L,2} \times K_a \times Surcharge \times (her - base - das) = 26.8 kN/mMoist backfill above water tableF_{a,m,z,l} = \gamma_{L,2} \times K_a \times \gamma_{ma} \times (her - base - das) = 26.8 kN/mSaturated backfillF_{a,m,z,l} = \gamma_{L,2} \times K_a \times \gamma_{ma} \times (her - base - das) + basl = 24.4 kN/mSaturated backfill below water tableF_{a,m,z,l} = 0.5 \times \gamma_{L,2} \times \gamma_{water} \times hasl = 1.6 kN/mWaterF_{a,m,z,l} = 0.5 \times \gamma_{L,2} \times \gamma_{water} \times hasl = 3.4 kN/mSurchargeV_{a,m,l,1} = 5 \times F_{a,m,z,l} \times 8 \times (\gamma_{a,masl}) \times hasl = 24.4 kN/mSurchargeV_{a,m,l,1} = 5 \times F_{a,m,z,l} \times 8 \times (\gamma_{a,masl}) \times hasl = 24.4 kN/mWaterF_{a,m,r,l} = 0.5 \times \gamma_{L,2} \times \gamma_{water} \times hasl = 3.4 kN/mSurchargeV_{a,m,l,1} = 5 \times F_{a,m,r,l} \times 8 \times (\gamma_{a,masl}) \times hasl = 24.4 kN/mSurchargeV_{a,m,l,1} = 5 \times F_{a,m,r,l} \times 8 \times (\gamma_{a,masl}) \times hasl = 24.4 kN/mWaterV_{a,m,l,1} = 5 \times F_{a,m,r,l} \times 8 \times (\gamma_{a,masl}) \times hasl = 24.4 kN/mSurchargeV_{a,m,l,1} = 5 \times F_{a,m,r,l} \times 8 \times (\gamma_{a,masl}) \times hasl = 24.4 kN/mSurchargeV_{a,m,l,1} = 5 \times F_{a,m,r,l} \times 8 \times (\gamma_{a,masl}) \times hasl = 24.4 kN/mSurchargeV_{a,m,l,1} = F_{a,m,l} \times 18 = 16.7 kN/mMoist backfill above water tableV_{a,m,l,1} = 5 \times F_{$	Design of reinforced concrete	retaining v	vall stem (BS 8002	:1994)						
Characteristic strength of concrete Characteristic strength of reinforcement $f_w = 40 \text{ N/mm}^2$ Wall detailsKMinimum area of reinforcementk = 0.13 % Cover to reinforcement in stem Catern = 50 mmSurcharge $F_{x_mx_1} = y_{12} \times K_x \times Surcharge \times (herr - base - des) = 26.8 kN/mFactored horizontal active forces on stemSurchargeF_{x_mx_1} = y_{12} \times K_x \times Surcharge \times (herr - base - des) = 26.8 kN/mFactored horizontal active forces on stemSurchargeF_{x_mx_1} = y_{12} \times K_x \times y_m \times (herr - base - des - heal) = 26.8 kN/mFactored horizontal active forces on stemSurchargeF_{x_mx_1} = y_{12} \times K_x \times y_m \times (herr - base - des - heal) = 26.8 kN/mFactored backfill above water tableFactored backfill above water tableF_{x_mx_1} = y_{12} \times K_x \times y_m \times (herr - base - des - heal) = 26.8 kN/mFactored backfill below water tableSurchargeV_{x,mx_1} = y_{12} \times K_x \times (y_{m} + base - des - heal) > 26.8 kN/mFactored backfill below water tableSurchargeV_{x,mx_1} = 5 \times y_{12} \times $	Material properties			<u>_</u>						
Characteristic strength of reinforcement $f_y = 500 \text{ N/mm}^2$ Wall detailsk = 0.13 %Minimum area of reinforcement in stemCover to reinforcement in stemCover to reinforcement in wallCount = 50 mmFactored horizontal active forces on stemFs_ms_1 = $\gamma_{1,2} \times K_n \times \text{Surcharge} \times (her - hans - dm) = 26.8 \text{ kN/m}$ Moist backfill above water table $F_{n,m,p,1} = 0.5 \times \gamma_{1,2} \times K_n \times \gamma_m \times (her - hans - dm) = 26.8 \text{ kN/m}$ Moist backfill above water table $F_{n,m,p,1} = 0.5 \times \gamma_{1,2} \times K_n \times \gamma_m \times (her - hans - dm) = 26.8 \text{ kN/m}$ Saturated backfill $F_{n,m,p,1} = 0.5 \times \gamma_{1,2} \times K_n \times (\gamma_n - \gamma_{mator}) \times han^2 = 1.6 \text{ kN/m}$ Water $F_{n,m,p,1} = 0.5 \times \gamma_{1,2} \times K_n \times (\gamma_n - \gamma_{mator}) \times han^2 = 1.6 \text{ kN/m}$ Surcharge $V_{n,m,1} = F_{n,m,p,1} \times 18 = 16.7 \text{ kN/m}$ Moist backfill above water table $V_{n,m,1} = F_{n,m,p,1} \times 18 = 16.7 \text{ kN/m}$ Moist backfill above water table $V_{n,m,1} = F_{n,m,p,1} \times 18 = 16.7 \text{ kN/m}$ Moist backfill above water table $V_{n,m,1} = F_{n,m,p,1} \times 18 = 13.9 \text{ kN/m}$ Muter $V_{n,m,1} = F_{n,m,p,1} \times 18 = 14.7 \text{ kN/m}$ Muter $V_{n,m,1} = F_{n,m,p,1} \times 18 = 14.7 \text{ kN/m}$ Muter $V_{n,m,n} = F_{n,m,p,1} \times 18 = 13.9 \text{ kN/m}$ Surcharge $M_{n,m,n} = F_{n,m,p,1} \times 18 = 13.9 \text{ kN/m}$ Moist backfill above water table $M_{n,m,n} = F_{n,m,p,1} \times 18 = 13.9 \text{ kN/m}$ Moist backfill above water table $M_{n,m,n} = F_{n,m,p,1} \times 18 = 13.9 \text{ kN/m}$ Moist backfill above water table $M_{n,m,n} = F_{n,m,p,1} \times 18 = 13.9 \text{ kN/m}$ Moist backfill above water table M_{n,m,n	Characteristic strength of concre	ete	fcu = 40 N/r	nm²						
Wall detailsMinimum area of reinforcementk = 0.13 %Cover to reinforcement in wallCover to reinforcement in wallCover to reinforcement in wallCover to reinforcement in wallSurcharge $F_{a,m,l} = \gamma_{1,1} \times K_a \times Surcharge \times (h_{eff} - b_{ass} - d_{as}) = 26.8 kN/mMoist backfill above water tableF_{a,m,k,l} = \gamma_{1,2} \times K_a \times \gamma_m \times (h_{eff} - b_{ass} - d_{as}) = 26.8 kN/mSaturated backfillF_{a,m,k,l} = 0.5 \times \gamma_{1,a} \times K_a \times \gamma_m \times (h_{eff} - b_{ass} - d_{as} - h_{as})^2 = 57.4 kN/mSaturated backfillF_{a,m,k,l} = 0.5 \times \gamma_{1,a} \times K_a \times \gamma_m \times (h_{eff} - b_{ass} - d_{as} - h_{as})^2 = 57.4 kN/mSaturated backfillF_{a,m,k,l} = 5 \times F_{a,m,l} / (h_{eff} - h_{ass}) - d_{as} - h_{ass})^2 = 57.4 kN/mSaturated backfillF_{a,m,k,l} = 5 \times F_{a,m,l} / (h_{eff} - h_{ass}) - d_{as} - h_{ass})^2 = 57.4 kN/mSaturated backfillF_{a,m,k,l} = 5 \times F_{a,m,k,l} / (h_{eff} - h_{ass})^2 = 1.6 kN/mWaterF_{a,m,k,l} = 5 \times F_{a,m,k,l} / (h_{eff} - h_{ass})^2 = 1.6 kN/mMoist backfill above water tableV_{a,m,k,l} = F_{a,m,k,l} / (h_{eff} - h_{ass})^2 = 1.6 kN/mWaterV_{a,m,k,l} = F_{a,m,k,l} \times (h_{eff} - h_{ass}) / (20 \times L^3)) = 1.6 kN/mVaterV_{a,m,k,l} = F_{a,m,k,l} + V_{a,m,k,l} + V_{a,$	Characteristic strength of reinfo	rcement	f _y = 500 N/	mm²						
Minimum area of reinforcementk = 0.13 % Cover to reinforcement in stemCourset = 50 mmCover to reinforcement in wallCourset = 50 mmSurchargeFactored horizontal active forces on stemSurchargeFactored horizontal active forces on stemMoist backfill below water tableFactored horizontal active forces on stemSaturated backfillFactored horizontal active forces on stemWaterFactored horizontal active forces on stemSurchargeVactored horizontal active forces on stemSurchargeMacored horizon	Wall details									
Cover to reinforcement in stem $c_{stem} = 50 \text{ mm}$ Cover to reinforcement in wall $c_{wall} = 50 \text{ mm}$ Factored horizontal active forces on stemSurcharge $F_{a_a,a,t} = \gamma_{1,2} \times K_a \times Surcharge \times (h_{at} - b_{ase} - d_{as} - h_{ast})^2 = 57.4 \text{ kN/m}$ Moist backfill above water table $F_{a_a,m,b,t} = \gamma_{1,2} \times K_a \times \gamma_m \times (h_{at} - b_{ase} - d_{as} - h_{ast})^2 = 57.4 \text{ kN/m}$ Saturated backfill $F_{a_a,m,b,t} = \gamma_{1,a} \times K_a \times \gamma_m \times (h_{at} - b_{ase} - d_{as} - h_{ast}) \times h_{ast} = 24.4 \text{ kN/m}$ Saturated backfill $F_{a_a,m,b,t} = 0.5 \times \gamma_{1,s} \times K_a \times (\gamma_{s-\gamma,water}) \times h_{ast}^2 = 3.4 \text{ kN/m}$ Calculate shear for stem designSaturated backfillSurcharge $V_{a_a,m,t} = 5 \times F_{a_a,m,t} / 8 = 16.7 \text{ kN/m}$ Moist backfill below water table $V_{a_a,m,t} = F_{a_a,m,k,t} \times b \times ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 \text{ kN/m}$ Moist backfill below water table $V_{a_a,m,t} = F_{a_a,m,k,t} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 1.6 \text{ kN/m}$ Water $V_{a_a,m,t} = F_{a_a,m,k,t} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 3.3 \text{ kN/m}$ Total shear for stem design $V_{a_a,m,t} = F_{a_a,m,k,t} \times ((5 \times L^2) - (3 \times L) / (20 \times L^3))) = 3.3 \text{ kN/m}$ Saturated backfill bove water table $M_{a_a,m} = F_{a_a,m,k,t} \times ((5 \times L^2) - (3 \times L) / (20 \times L^3))) = 3.3 \text{ kN/m}$ Moist backfill bove water table $M_{a_a,m,t} = F_{a_a,m,k,t} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 3.2 \text{ kN/m}$ Saturated backfill $M_{a_a,m} = F_{a_a,m,k,t} \times ((3 \times a^2)) + (5 \times a \times L) / (20 \times L^3)) = 3.2 \text{ kN/m}$ Moist backfill bove water table $M_{a_a,m,t} = F_{a_a,m,k,t} \times (a_a, (2 - n)^2 / a = 8.3 \text{ kN/m}$ Mois	Minimum area of reinforcement		k = 0.13 %							
Cover to reinforcement in wall $c_{wall} = 50 \text{ mm}$ Factored horizontal active forces on stem $F_{u_mu_n} = \gamma_{U,V} K_a \times Surcharge \times (herr - base - des) = 26.8 kV/m$ Moist backfill above water table $F_{u_mu_n} = 0.5 \times \gamma_{I,S} \times K_a \times \gamma_m \times (herr - base - des) - bast) = 57.4 kN/m$ Moist backfill below water table $F_{u_mu_n} = \gamma_{U,S} \times K_a \times \gamma_m \times (herr - base - des) - bast) = 57.4 kN/m$ Moist backfill below water table $F_{u_mu_n} = \gamma_{U,S} \times K_a \times \gamma_m \times (herr - base - des) - bast) = 57.4 kN/m$ Water $F_{u_mu_n} = \gamma_{U,S} \times K_a \times \gamma_m \times (nerr - base - des) - bast) = 24.4 kN/m$ Water $F_{u_mu_n} = \gamma_{U,S} \times K_a \times \gamma_m \times (herr - base - des) - bast) = 24.4 kN/m$ Calculate shear for stem design $S_{u_mu_n} = 5 \times \gamma_{U,S} \times \gamma_{water} \times h_{uell} = 3.4 kN/m$ Surcharge $V_{u_mu_n} = F_{u_mu_n} \times T_b \times ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 kN/m$ Moist backfill below water table $V_{u_mu_n} = F_{u_mu_n} \times T_b \times ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 kN/m$ Saturated backfill $V_{u_mu_n} = F_{u_mu_n} \times T_b \times ((5 \times L)^2 - a) / (20 \times L^3)) = 31.8 kN/m$ Water $V_{u_mun_n} = F_{u_mu_n} \times T_b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kN/m$ Total shear for stem design $M_{u_mu_n} = F_{u_mu_n} \times T_b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kN/m$ Sutcharge $M_{u_mu_n} = F_{u_mu_n} \times T_b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kN/m$ Moist backfill back water table $M_{u_mu_n} = F_{u_mu_n} \times L / 8 = 13.9 kNm/m$ Moist backfill back water table $M_{u_mu_n} = F_{u_mu_n} \times L / 8 = 13.9 kNm/m$ Moist backfill back water table $M_{u_mu_n} = F_{u_mu_n} \times M \times ((3 \times a^2) - (15 \times au L) + (20 \times L^2)) / (60 \times L^2) $	Cover to reinforcement in stem		c _{stem} = 50 n	nm						
Factored horizontal active forces on stemSurcharge $F_{s_s,ser,f} = \gamma_{t,j} \times K_s \times Surcharge \times (hst - base - das) = 26.8 kN/mMoist backfill above water tableF_{s_s,m,f} = 0.5 \times \gamma_{t,s} \times K_s \times \gamma_{m} \times (hst - base - das) = 26.8 kN/mMoist backfill below water tableF_{s_s,m,f} = 0.5 \times \gamma_{t,s} \times K_s \times \gamma_{m} \times (hst - base - das) = hast) \times hast = 24.4 kN/mSaturated backfillF_{s_s,sr,f} = 0.5 \times \gamma_{t,s} \times K_s \times (\gamma_{m} \vee (hst - base - das) + hast) \times hast = 24.4 kN/mWaterF_{s_s,sr,f} = 0.5 \times \gamma_{t,s} \times K_s \times (\gamma_{m} \vee (hst - base - das) + hast) \times hast = 24.4 kN/mCalculate shear for stem designV_{s,sr,f} = 5 \times F_{s_s,sr,f} / 8 = 16.7 kN/mSurchargeV_{s,sr,f} = 5 \times F_{s_s,sr,f} / 8 = 16.7 kN/mMoist backfill below water tableV_{s,m,f} = F_{s,m,h,t} \times b \times ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 kN/mSaturated backfill below water tableV_{s,m,f} = F_{s_s,m,f,t} / 1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 1.6 kN/mWaterV_{s,m,f} = F_{s,m,h,t} \times b \times ((5 \times L) - a) / (20 \times L^3)) = 3.3 kN/mTotal shear for stem designV_{s,m,f} = F_{s,m,h,t} / x b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kN/mSurchargeM_{s,m,s} = F_{s,m,h,t} / x b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kN/mMoist backfill below water tableM_{s,m,s} = F_{s,m,h,t} / x b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kN/mMoist backfill below water tableM_{s,m,s} = F_{s,m,h,t} / x b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kN/mMoist backfill below water tableM_{s,m,s} = F_{s,m,h,t} / x b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kN/mMoist backfill below water tableM_{s,m,s} = F_{s,m,s,t} / x L /$	Cover to reinforcement in wall		_{Cwall} = 50 m	m						
Surcharge $F_{u,uxr,t} = \gamma_{L,1} \times K_u \times Surcharge \times (h_{eff} - h_{uase} - d_{ub}) = 26.8 kN/mMoist backfill above water tableF_{u,m,h,t} = 0.5 \times \gamma_{L,0} \times K_u \times \gamma_m \times (h_{eff} - h_{uase} - d_{ub} - h_{eff})^2 = 57.4 kN/mMoist backfill below water tableF_{u,m,b,t} = \gamma_{L,0} \times K_u \times \gamma_m \times (h_{eff} - h_{uase} - d_{ub} - h_{eff})^2 = 57.4 kN/mSaturated backfillF_{u,m,b,t} = \gamma_{L,0} \times K_u \times \gamma_m \times (h_{eff} - h_{uase} - d_{ub} - h_{eff})^2 = 57.4 kN/mWaterF_{u,m,b,t} = \gamma_{L,0} \times K_u \times (\gamma_{eff} - \gamma_{water}) \times h_{uaft} = 24.4 kN/mWaterF_{u,m,t} = 0.5 \times \gamma_{L,0} \times K_u \times (\gamma_{eff} - \gamma_{water}) \times h_{uaft} = 24.4 kN/mCalculate shear for stem designSurchargeSurchargeV_{u,m,u,t} = f_{u,0} \times K_u \times (\gamma_{eff} - \gamma_{water}) \times h_{uat}^2 = 3.4 kN/mMoist backfill above water tableV_{u,m,u,t} = F_{u,m,u,t} \times (16 \times L^2) - b^2/ / (5 \times L^3) = 39.9 kN/mMoist backfill below water tableV_{u,m,u,t} = F_{u,m,u,t} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times 1^3))) = 1.6 kN/mWaterV_{u,water,t} = F_{u,uat} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times 1^3))) = 3.3 kN/mVaterV_{u,water,t} = F_{u,water,t} \times L / 8 = 13.9 kN/mMoist backfill above water tableM_{u,m,u} = F_{u,u,u,t} \times h \times ((5 \times L^2) - (3 \times h^2)) / (15 \times L^2) = 39.2 kNm/mMoist backfill above water tableM_{u,m,u} = F_{u,m,u,t} \times h \times ((5 \times L^2) - (3 \times h^2)) / (15 \times L^2) = 39.2 kNm/mMoist backfill above water tableM_{u,m,u} = F_{u,m,u,t} \times h \times ((5 \times L^2) - (3 \times h^2)) / (15 \times L^2) = 39.2 kNm/mMoist backfill above water tableM_{u,m,u} = F_{u,m,u,t} \times h \times ((5 \times L^2) - (3 \times h^2)) / (15 \times L^2) = 39.2 kNm/mMoist backfill above water tableM_{u,m,u} = F_$	Factored horizontal active for	ces on sten	n							
Moist backfill above water table $F_{k,m,n} = 0.5 \times \gamma_{k,0} \times K_n \times \gamma_m \times (herr - base - d_m - h_m)^2 = 57.4 kN/m$ Moist backfill below water table $F_{k,m,l} = 0.5 \times \gamma_{k,0} \times K_n \times \gamma_m \times (herr - base - d_m - h_m)^2 = 57.4 kN/m$ Saturated backfill $F_{k,m,l} = 0.5 \times \gamma_{k,0} \times K_n \times \gamma_m \times (herr - base - d_m - h_m)^2 = 57.4 kN/m$ Water $F_{k,m,l} = 0.5 \times \gamma_{k,0} \times K_n \times \gamma_m \times (herr - base - d_m - h_m)^2 = 57.4 kN/m$ Water $F_{k,m,l} = 0.5 \times \gamma_{k,0} \times K_n \times (\gamma_{kr} - \gamma_{unken}) \times h_{ant} = 24.4 kN/m$ Saturated backfill below water table $F_{k,m,l} = 5 \times F_{k,m,l} / K = 16.7 kN/m$ Moist backfill below water table $V_{k,m,l} = F_{k,m,l} \times h \times ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 kN/m$ Moist backfill below water table $V_{k,m,l} = F_{k,m,l} \times h \times ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 kN/m$ Saturated backfill $V_{k,m,l} = F_{k,m,l} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 1.6 kN/m$ Water $V_{k,m,l} = F_{k,m,l} \times h \times ((5 \times L^2) - a) / (20 \times L^3)) = 3.3 kN/m$ Total shear for stem design $V_{k,m,l} = F_{k,m,l} \times h \times ((5 \times L^2) - (3 \times h^2)) / (15 \times L^2) = 39.2 kNm/m$ Surcharge $M_{k,m} = F_{k,m,l} \times h \times ((5 \times L^2) - (15 \times a) \times 1) / (20 \times L^3)) = 0.4 kNm/m$ Moist backfill below water table $M_{k,m,h} = F_{k,m,h,l} \times h \times (2 - n)^2 / 8 = 8.3 kNm/m$ Moist backfill below water table $M_{k,m,k} = F_{k,m,h,l} \times a \times (2 - n)^2 / 15 \times a \times (10 \times (2)/) ((60 \times L^2) = 0.4 kNm/m$ Muter $M_{k,m,k} = F_{k,m,h,l} \times M_{k,m,k} + M_{k,m,k} + M_{k,m,k} = 62.6 kNm/m$ Moist backfill below water table $M_{k,m,k} = F_{k,m,h,l} \times 0.577 \times b \times (10^{2} + (0 \times (1)^{2} / (0 \times (2)^{2} - 0.577^{2} / 3] = 21.3 kNm/m$ Moist backfill below water	Surcharge		F _{s sur f} = γ _f	$I \times K_a \times Surcha$	$rge \times (h_{eff} - t_{base} \cdot$	- d _{ds}) = 26.8 kN	l/m			
Moist backfill below water table $F_{u,m,L,J} = \gamma_{L,e} \times K_a \times \gamma_m \times (herr - base - d_{ds} - h_{sal}) \times h_{sal} = 24.4 kN/m$ Saturated backfill $F_{u,m,L,J} = \gamma_{L,e} \times K_a \times \gamma_m \times (herr - base - d_{ds} - h_{sal}) \times h_{sal} = 24.4 kN/m$ Water $F_{u,m,L,J} = \gamma_{L,e} \times K_a \times (\gamma_{ber} \gamma_water) \times h_{sal}^2 = 1.6 kN/m$ Calculate shear for stem designSurchargeSurcharge $V_{u,m,L,J} = 5 \times F_{u,m,L,J} / 8 = 16.7 kN/m$ Moist backfill above water table $V_{u,m,L,J} = F_{u,m,L,J} \times b \times ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 kN/m$ Saturated backfill below water table $V_{u,m,L,J} = F_{u,m,L,J} \times b \times ((5 \times L^2) - a) / (20 \times L^3))) = 1.6 kN/m$ Water $V_{u,m,L,J} = F_{u,m,L,J} \times b \times ((5 \times L) - a) / (20 \times L^3))) = 1.6 kN/m$ Water $V_{u,m,L,J} = F_{u,m,L,J} \times b \times ((5 \times L) - a) / (20 \times L^3))) = 3.3 kN/m$ Total shear for stem design $V_{u,m,L,J} = F_{u,m,L,J} \times b \times ((5 \times L) - a) / (20 \times L^3))) = 3.3 kN/m$ Surcharge $M_{u,m,u} = F_{u,m,u,J} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kNm/m$ Moist backfill above water table $M_{u,m,u} = F_{u,m,u,J} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kNm/m$ Moist backfill above water table $M_{u,m,u} = F_{u,m,u,L} \times (2 \times h^2) \times (3 \times h^2) / (10 \times L^2) = 39.2 kNm/m$ Moist backfill above water table $M_{u,m,u} = F_{u,m,u,L} \times (2 \times h^2) \times (3 \times h^2) / (15 \times L^2) = 39.2 kNm/m$ Moist backfill above water table $M_{u,m,u} = F_{u,m,u,L} \times (2 \times h^2) \times (3 \times h^2) / (10 \times L^2) = 39.2 kNm/m$ Moist backfill above water table $M_{u,m,u} = F_{u,m,u,L} \times (3 \times a^2) - (15 \times a \times L) + (20 \times L^2) / (60 \times L^2) = 0.4 kNm/m$ Moist backfill below water table $M_{u,m,u} = F_{u,m,u,L} \times M_$	Moist backfill above water table		$F_{s_m_a_f} = 0.5 \times \gamma_{f_e} \times K_a \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2 = 57.4 \text{ kN/m}$							
Saturated backfill $F_{n_n,n_n} = 0.5 \times \gamma_{1,n} \times K_n \times (\gamma_{n-1} \vee_{name}) \times h_{na}^2 = 1.6 kN/m$ Water $F_{n_n,m_n} = 0.5 \times \gamma_{1,n} \times K_n \times (\gamma_{n-1} \vee_{name}) \times h_{na}^2 = 3.4 kN/m$ Calculate shear for stem design $V_{n_n,m_n} = 5 \times F_{n_n,m_n} f \times S_{n_n} \times V_{name} + N_{name} = 3.4 kN/m$ Moist backfill above water table $V_{n_n,m_n} = F_{n_n,m_n} f \times S_n \times ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 kN/m$ Moist backfill below water table $V_{n_n,m_n} = F_{n_n,m_n} f \times S_n \times ((5 \times L) - a) / (20 \times L^3))) = 1.6 kN/m$ Saturated backfill $V_{n_n,m_n} = F_{n_n,m_n} f \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3)))) = 1.6 kN/m$ Water $V_{n_n,m_n} = F_{n_n,m_n} f \times V_{n_n,m_n} + V_{n_n,m_n$	Moist backfill below water table		 Fsmbf=γf	$e \times K_a \times \gamma_m \times (l)$	h _{eff} - t _{base} - d _{ds} - h	Isat) × h _{sat} = 24.	4 kN/m			
Water $F_{s_water_t} = 0.5 \times \gamma_{t_e} \times \gamma_{water} \times hsat^{2} = 3.4 kN/m$ Calculate shear for stem designSurcharge $V_{s_war_t} = 5 \times F_{s_war_t} / 8 = 16.7 kN/m$ Moist backfill above water table $V_{s_m_s_t} = F_{s_m_s_t} \times h \times ((5 \times L^{2} - b^{2}) / (5 \times L^{3}) = 39.9 kN/m$ Moist backfill below water table $V_{s_m_s_t} = F_{s_m_s_t} \times (8 - (n^{2} \times (4 - n))) / 8 = 23.9 kN/m$ Saturated backfill $V_{s_s_t} = F_{s_s_t} \times (1 - (a^{2} \times ((5 \times L) - a) / (20 \times L^{3}))) = 1.6 kN/m$ Water $V_{s_water_t} = F_{s_water_t} \times (1 - (a^{2} \times ((5 \times L) - a)) / (20 \times L^{3}))) = 3.3 kN/m$ Total shear for stem design $V_{s_water_t} = F_{s_war_t} \times L / 8 = 13.9 kNm/m$ Surcharge $M_{s_war_t} = F_{s_w_t_t} \times L / 8 = 13.9 kNm/m$ Moist backfill above water table $M_{s_war_t} = F_{s_w_t_t} \times L / 8 = 13.9 kNm/m$ Moist backfill below water table $M_{s_war_t} = F_{s_w_t_t} \times L / 8 = 13.9 kNm/m$ Moist backfill below water table $M_{s_war_t} = F_{s_w_t_t} \times L / 8 = 13.9 kNm/m$ Moist backfill below water table $M_{s_war_t} = F_{s_w_t_t} \times (1 - (a^{2} \times ((2 \times L^{2}) - (3 \times b^{2}))) / (15 \times L^{2}) = 39.2 kNm/m$ Moist backfill below water table $M_{w_m_s} = F_{s_w_t_t} \times a \times (2 - n)^{2} / 8 = 8.3 kNm/m$ Moist backfill below water table $M_{s_w=t_m_t_t} \times a_{s_w=t_t_t} \times a_{s_w=t_t_t_t} + (2 \times a_{s_w_t_t_t_t] + (2 \times a_{s_w_t_t_t]}) / (60 \times L^{2}) = 0.4 kNm/m$ Water $M_{s_w=t_s_s_t_t_t_t_t_t_t_t_t_t] + M_{s_w=t_t_t_t_t_t_t_t_t_t_t_t] + M_{s_w=t_t_t_t_t_t_t_t_t] + M_{s_w=t_t_t_t_t_t_t_t_t_t]} = 5.5 \times S_{s_w=t_t_t_t_t_t_t_t_t_t_t] + 5.5 \times T_{s_w=t_t_t_t_t_t_t_t_t_t_t_t] = 5.5 \times T_{s_w=t_t_t_t_t_t_t_t_t_t_t_t_t_t_t_t_t_t_t$	Saturated backfill		$F_{s \ s \ f} = 0.5 \times \gamma_{f \ e} \times K_{a} \times (\gamma_{s} - \gamma_{water}) \times h_{sat}^{2} = 1.6 \text{ kN/m}$							
Calculate shear for stem designSurcharge $V_{s,sur_f} = 5 \times F_{s,sur_f} / 8 = 16.7 \text{ kN/m}$ Moist backfill above water table $V_{s,m,s,f} = F_{s,m,s,f} \times b_1 \times ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 \text{ kN/m}$ Moist backfill below water table $V_{s,m,s,f} = F_{s,s,n,s,f} \times (8 - (n^2 \times (4 - n))) / 8 = 23.9 \text{ kN/m}$ Saturated backfill $V_{s,s,f} = F_{s,s,f} \times (1 - (a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 1.6 \text{ kN/m}$ Water $V_{s,water,f} = F_{s,s,water,f} \times (1 - (a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 3.3 \text{ kN/m}$ Total shear for stem design $V_{s,sur_f} = F_{s,swater,f} \times (1 - (a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 3.3 \text{ kN/m}$ Surcharge $M_{s,sur} = F_{s,swater,f} \times L / 8 = 13.9 \text{ kNm/m}$ Moist backfill above water table $M_{s,sur_f} = F_{s,swater,f} \times 1 \times (5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 \text{ kNm/m}$ Moist backfill above water table $M_{s,m,a} = F_{s,m,a,f} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 \text{ kNm/m}$ Moist backfill above water table $M_{s,m,a} = F_{s,m,a,f} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 \text{ kNm/m}$ Moist backfill below water table $M_{s,m,a} = F_{s,m,a,f} \times a \times (2 - n)^2 / 8 = 8.3 \text{ kNm/m}$ Water $M_{s,m,a} = F_{s,swater,f} \times a \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 0.4 \text{ kNm/m}$ Water $M_{s,swater} = F_{s,swater,f} \times a \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 0.4 \text{ kNm/m}$ Water $M_{w,swater} = F_{s,swater,f} \times a \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 0.4 \text{ kNm/m}$ Moist backfill above water table $M_{w,swater} = 9 \times F_{s,swater,f} \times L / 128 = 7.8 \text{ kNm/m}$ Moist backfill above water table $M_{w,swat$	Water		$F_{s_water_f} = 0.5 \times \gamma_{f_e} \times \gamma_{water} \times h_{sat}^2 = 3.4 \text{ kN/m}$							
Surcharge $V_{s,sur_f} = 5 \times F_{s,sur_f} / 8 = 16.7 \text{ kN/m}$ Moist backfill above water table $V_{s,m,a,f} = F_{s,m,a,f} \times b_l \times ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 \text{ kN/m}$ Saturated backfill $V_{s,m,b,f} = F_{s,m,b,f} \times (8 - (n^2 \times (4 - n))) / 8 = 23.9 \text{ kN/m}$ Water $V_{s,m,b,f} = F_{s,s,f} \times (1 - (a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 1.6 \text{ kN/m}$ Water $V_{s,mater,f} = F_{s,s,mater,f} \times (1 - (a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 3.3 \text{ kN/m}$ Total shear for stem design $V_{s,mater,f} = F_{s,mater,f} \times V_{s,m,a,f} + V_{s,m,b,f} + V_{s,mater,f} = 85.4 \text{ kN/m}$ Calculate moment for stem design $W_{s,sur} = F_{s,mat,f} \times b_l \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 \text{ kNm/m}$ Moist backfill above water table $M_{s,m,a} = F_{s,m,a,f} \times b_l \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 \text{ kNm/m}$ Moist backfill above water table $M_{s,m,a} = F_{s,m,a,f} \times b_l \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 \text{ kNm/m}$ Moist backfill above water table $M_{s,m,a} = F_{s,m,a,f} \times b_l \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 \text{ kNm/m}$ Water $M_{s,m,a} = F_{s,m,a,f} \times b_l \times ((3 \times a^2) - (15 \times a_l \times L) + (20 \times L^2)) / (60 \times L^2) = 0.4 \text{ kNm/m}$ Water $M_{s,m,a} = F_{s,water,f} \times a_l \times (2 \cdot n)^2 / 8 = 8.3 \text{ kNm/m}$ Total moment for stem design $M_{m,s,sr} = 9 \times F_{s,sur,f} \times L / 128 = 7.8 \text{ kNm/m}$ Surcharge $M_{m,ssr} = 9 \times F_{s,sur,f} \times L / 128 = 7.8 \text{ kNm/m}$ Moist backfill above water table $M_{w,m,a} = F_{s,m,a,f} \times 0.577 \times b_{l} \times [(b^3 + 5 \cdot a_{l} \times 2) / (5 \times L^3) - 0.577^2 / 3] = 21.3 \text{ kNm/m}$ Moist backfill below water table $M_{w,m,a} = F_{s,m,a,f} \times a_{l} \times ((5 \times L) -a) / (20 \times L^3) - (0.577^2 $	Calculate shear for stem desig	an								
Moist backfill above water table $V_{s_m_a} r = F_{s_m_a} r = S_b x ((5 \times L^2) - b^2) / (5 \times L^3) = 39.9 kN/m$ Moist backfill below water table $V_{s_m_b} r = F_{s_m_b} r (1 - (a^2 \times (4 - n))) / 8 = 23.9 kN/m$ Saturated backfill $V_{s_m} r = F_{s_m} r (1 - (a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 1.6 kN/m$ Water $V_{s_water} r = F_{s_water} r + V_{s_m} r + V_{s_$	Surcharge	5	Vs sur f = 5	× Fs sur f / 8 = 1	6.7 kN/m					
Moist backfill below water table $V_{s,m_{s},b_{s}} = F_{s,m_{s},b_{s}} \times (8 - (n^{2} \times (4 - n)))/8 = 23.9 kN/m$ Saturated backfill $V_{s,m_{s},b_{s}} = F_{s,m_{s},b_{s}} \times (1 - (a^{2} \times ((5 \times L) - a))/(20 \times L^{3}))) = 1.6 kN/m$ Water $V_{s,water,f} = F_{s,mater,f} \times (1 - (a^{2} \times ((5 \times L) - a))/(20 \times L^{3}))) = 3.3 kN/m$ Total shear for stem design $V_{s,mar,b,f} + V_{s,m_{s},f} + V_{s,m_{s},f} + V_{s,m_{s},f} + V_{s,mater,f} = 85.4 kN/m$ Surcharge $M_{s,sur} = F_{s,mar,f} \times L/8 = 13.9 kN/m$ Moist backfill above water table $M_{s,m_{s}} = F_{s,m_{s},m_{s},f} \times L/8 = 13.9 kN/m$ Moist backfill below water table $M_{s,m_{s},m_{s}} = F_{s,m_{s},f} \times a \times (2 - n)^{2}/8 = 8.3 kNm/m$ Saturated backfill $M_{s,s} = F_{s,s,f} \times aix ((3 \times a^{2}) - (15 \times ai \times L) + (20 \times L^{2}))/(60 \times L^{2}) = 0.4 kNm/m$ Water $M_{s,mar} = F_{s,mar} \times a \times ((3 \times a^{2}) - (15 \times ai \times L) + (20 \times L^{2}))/(60 \times L^{2}) = 0.4 kNm/m$ Total moment for stem design $M_{s,s} = F_{s,s,st} \times ai \times ((3 \times a^{2}) - (15 \times ai \times L) + (20 \times L^{2}))/(60 \times L^{2}) = 0.4 kNm/m$ Surcharge $M_{w,mar} = M_{s,sur} + M_{s,m_{s}} + M_{s,m_{s}} + M_{s,s} + M_{s,water} = 62.6 kNm/m$ Moist backfill above water table $M_{w,mar} = 9 \times F_{s,sur,f} \times L / 128 = 7.8 kNm/m$ Moist backfill below water table $M_{w,mar} = F_{s,ma,m} \times 0.577 \times bix[(b^{3}+5 \times ai \times 2)/(5 \times L^{3})-0.577^{2}/3] = 21.3 kNm/m$ Moist backfill below water table $M_{w,mar} = F_{s,ma,m} \times a \times ((5 \times L)-a)/(20 \times L^{3}) - (x-b)^{3}/(3 \times a^{2})] = 0.1 kNm/m$ Moist backfill below water table $M_{w,mar} = F_{s,ma,m} \times ((5 \times L)-a)/(20 \times L^{3}) - (x-b)^{3}/(3 \times a^{2})] = 0.1 kNm/m$ Muter $M_{w,mar} = F_{s,ma,m} \times a \times ((5 \times L)-a)$	Moist backfill above water table		 V _{s_m_a_f} = F	s_m_a_f × bi × ((5	$5 \times L^2$) - b ²) / (5 ×	< L ³) = 39.9 kN/	'n			
Saturated backfill $V_{s_s_f} = F_{s_s_t} \times (1 - (at^2 \times ((5 \times L) - at))/(20 \times L^3))) = 1.6 kN/m$ Water $V_{s_water_f} = F_{s_water_t} \times (1 - (at^2 \times ((5 \times L) - at))/(20 \times L^3))) = 3.3 kN/m$ Total shear for stem design $V_{s_water_f} = F_{s_wat_t} + V_{s_m_b_t} + V_{s_m_b_t} + V_{s_m_t} = 85.4 kN/m$ Calculate moment for stem design $V_{s_w_t_f} = F_{s_wat_t_t} + V_{s_m_b_t} + V_{s_m_b_t} + V_{s_water_t} = 85.4 kN/m$ Surcharge $M_{s_w_n_a_t} + V_{s_m_b_t} + V_{s_m_b_t} + V_{s_m_b_t} + V_{s_water_t} = 85.4 kN/m$ Moist backfill above water table $M_{s_m_a_t} \times b \times ((5 \times L^2) - (3 \times b^2))/(15 \times L^2) = 39.2 kNm/m$ Moist backfill below water table $M_{s_m_b_t} \times a_{a} \times (2 - n)^2 / 8 = 8.3 kNm/m$ Saturated backfill $M_{s_m_b_t} = F_{s_m_t_t} \times a_{a} \times (2 - n)^2 / 8 = 8.3 kNm/m$ Water $M_{s_water} = F_{s_s_t_t} \times a_{a} \times (2 - n)^2 / 8 = 8.3 kNm/m$ Water $M_{s_water} = F_{s_m_t_t} \times a_{a} \times (3 \times a^2) - (15 \times a_{a} \times L) + (20 \times L^2))/(60 \times L^2) = 0.4 kNm/m$ Water $M_{s_water} = F_{s_m_t_t} \times a_{a} \times (2 - n)^2 / 8 = 8.3 kNm/m$ Total moment for stem design $M_{w_water} = F_{s_water_t} \times a_{a} \times (2 - n)^2 / 8 = 8.3 kNm/m$ Surcharge $M_{w_water} = F_{s_water_t} \times a_{a} \times (3 \times a^2) - (15 \times a_{a} \times L) + (20 \times L^2))/(60 \times L^2) = 0.4 kNm/m$ Moist backfill above water table $M_{w_water_s_t} \times a_{a} \times (1 - (a^2 \times x((5 \times L) - a))/(5 \times L^3) - 0.577^2/3] = 21.3 kNm/m$ Moist backfill below water table $M_{w_m_a_t} = F_{s_m_a_t} \times a_{a} \times ((5 \times L) - a)/(2 \times L^3) - 0.577^2/3] = 21.3 kNm/m$ Moist backfill below water table $M_{w_m_a_t} = F_{s_m_a_t} \times a_{a} \times ((5 \times L) - a)/(2 \times L^3) - 0.577^2/3] = 21.3 kNm/m$ Moist backfill bel	Moist backfill below water table		$V_{s_m_b_f} = F$	s_m_b_f × (8 - (n ²	$^{2} \times (4 - n))) / 8 =$	23.9 kN/m				
Water $V_{s_water_f} = F_{s_water_f} \times (1 - (al^2 \times ((5 \times L) - ai) / (20 \times L^3))) = 3.3 kN/m$ Total shear for stem design $V_{stem} = V_{s_sur_f} + V_{s_m_s,f} + V_{s_m,b_f} + V_{s_m,s,f} + V_{s_mater_f} = 85.4 kN/m$ Calculate moment for stem design $M_{s_sur} = F_{s_s,sur_f} \times L / 8 = 13.9 kNm/m$ Moist backfill above water table $M_{s_m,a} = F_{s_m,a_f} \times bi \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kNm/m$ Moist backfill below water table $M_{s_m,b} = F_{s_m,a_f} \times ai \times (2 - n)^2 / 8 = 8.3 kNm/m$ Saturated backfill $M_{s_m,b} = F_{s_s,m,s,f} \times ai \times (2 - n)^2 / 8 = 8.3 kNm/m$ Water $M_{s_m,b} = F_{s_s,m,s,f} \times ai \times ((3 \times a^2) - (15 \times ai \times L) + (20 \times L^2))/(60 \times L^2) = 0.4 kNm/m$ Water $M_{s_sur} = F_{s_s,water_f} \times ai \times ((3 \times a^2) - (15 \times ai \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 kNm/m$ Total moment for stem design $M_{w_sure} = F_{s_s,water_f} \times ai \times ((3 \times a^2) - (15 \times ai \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 kNm/m$ Surcharge $M_{w_sure} = 9 \times F_{s_ssur_f} \times L / 128 = 7.8 kNm/m$ Moist backfill above water table $M_{w_sur} = 9 \times F_{s_ssur_f} \times L / 128 = 7.8 kNm/m$ Moist backfill below water table $M_{w_sur} = F_{s_m,a_s} \times 0.577 \times bix[(b^3 + 5 \times ai \times 2)/(5 \times 1^3) - 0.577^2/3] = 21.3 kNm/m$ Moist backfill below water table $M_{w_m,a} = F_{s_m,b_s} \times ai \times [((8 - n^2 \times ((5 \times L) - ai))/(20 \times 1^3) - (x - b)^3/(3 \times a^2)] = 0.1 kNm/m$ Muster $M_{w_sure} = F_{s_s,st} \times [a^2 \times x \times (((5 \times L) - ai))/(20 \times 1^3) - (x - b)^3/(3 \times a^2)] = 0.1 kNm/m$ Water $M_{w_sure} = F_{s_s,water_f} \times [a^2 \times x \times (((5 \times L) - a))/(20 \times 1^3) - (x - b)^3/(3 \times a^2)] = 0.1 kNm/m$ Water $M_{w_sure} = M_{w_sur} + M_{w_m,a} + M_{w_m,b} + M_{w_s,water} = 30.8$	Saturated backfill		$V_{s_s_f} = F_{s_s}$	$s_{f} \times (1 - (a_{l}^{2} \times ($	(5 × L) - a _l) / (20	× L ³))) = 1.6 kM	N/m			
Total shear for stem design $V_{stem} = V_{s_sur_f} + V_{s_m_a_f} + V_{s_m_b_f} + V_{s_s_f} + V_{s_water_f} = 85.4 kN/m$ Calculate moment for stem design $M_{s_sur} = F_{s_sur_f} \times L / 8 = 13.9 kNm/m$ Moist backfill above water table $M_{s_m_a} = F_{s_m_a_f} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 kNm/m$ Moist backfill below water table $M_{s_m_a} = F_{s_m_b_f} \times a_1 \times (2 - n)^2 / 8 = 8.3 kNm/m$ Saturated backfill $M_{s_sur} = F_{s_s_f} \times a_1 \times (2 - n)^2 / 8 = 8.3 kNm/m$ Water $M_{s_water} = F_{s_s_f} \times a_1 \times ((3 \times a^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 0.4 kNm/m$ Total moment for stem design $M_{s_water} = F_{s_wate_f} \times a_1 \times ((3 \times a^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 kNm/m$ Surcharge $M_{w_water} = F_{s_wate_f} \times a_1 \times ((3 \times a^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 kNm/m$ Moist backfill above water table $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 7.8 kNm/m$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_{1} \times [(b^{13}+5 \times a_1 \times L^2)/(5 \times L^3) - 0.577^2/3] = 21.3 kNm/m$ Moist backfill below water table $M_{w_m_a} = F_{s_m_a_f} \times a_1 \times [((8-n^2 \times (4-n)))^2 / 16) - 4 + n \times (4-n)]/8 = 1.6 kNm/m$ Moist backfill below water table $M_{w_m_a} = F_{s_m_a_f} \times [a^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / ((3 \times a^2)] = 0.1 kNm/m$ Muter $M_{w_water} = F_{s_wate_f} + [a^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / ((3 \times a^2)] = 0.1 kNm/m$ Water $M_{w_water} = F_{s_wate_f} + [a^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / ((3 \times a^2)] = 0.1 kNm/m$ Total moment for wall design $M_{w=I} = M_{w_sur} + M_{w_m_a} + M_{w_m_b} + M_{w_s} + M_{w_water} = 30.8 kNm/m$	Water		$V_{s_water_f} = F$		$a_1^2 \times ((5 \times L) - a_1)$	$/(20 \times L^3))) = 1$	3.3 kN/m			
Calculate moment for stem designSurcharge $M_{s_sur} = F_{s_sur_f} \times L / 8 = 13.9 \text{ kNm/m}$ Moist backfill above water table $M_{s_u_a} = F_{s_u_a_f} \times b_i \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 \text{ kNm/m}$ Moist backfill below water table $M_{s_u_a} = F_{s_u_b_f} \times a_i \times (2 - n)^2 / 8 = 8.3 \text{ kNm/m}$ Saturated backfill $M_{s_u_b_F} = F_{s_u_b_f} \times a_i \times (2 - n)^2 / 8 = 8.3 \text{ kNm/m}$ Water $M_{s_u_a} = F_{s_u_b_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 0.4 \text{ kNm/m}$ Total moment for stem design $M_{s_uater} = F_{s_uater_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 \text{ kNm/m}$ Surcharge $M_{s_uater} = M_{s_sur_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 \text{ kNm/m}$ Moist backfill above water table abckfill $M_{s_uater} = F_{s_uater_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 \text{ kNm/m}$ Moist backfill above water table $M_{s_uater} = M_{s_sur_f} \times L / 128 = 7.8 \text{ kNm/m}$ Moist backfill above water table $M_{w_u_u_a} = F_{s_u_a_f} \times 0.577 \times b_i \times [(b^{i3}+5 \times a_i \times L^2)/(5 \times L^3) - 0.577^2/3] = 21.3 \text{ kNm/m}$ Moist backfill below water table $M_{w_u_u_b_f} \times a_i \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 1.6 \text{ kNm/m}$ Muter $M_{w_u_u_b_f} \times [a^{i2} \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_u_u=} = F_{s_u_u_f} \times [a^{i2} \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_u_u=} = M_{w_u_u=} + M_{w_u_u=} + M_{w_u_u=} + M_{w_u_u=} = 30.8 \text{ kNm/m}$ Water $M_{w_u_u=} = M_{u_u_u=} + M_{w_u_u=} + M_{w_u_u=} + M_{w_u_u=} = 30.8 \text{ kNm/m}$	Total shear for stem design		V _{stem} = V _{s_s}	ur_f + Vs_m_a_f +	$V_{s_m_b_f} + V_{s_s_f} +$	- Vs_water_f = 85.	4 kN/m			
Surcharge $M_{s_sur} = F_{s_sur_f} \times L / 8 = 13.9 \text{ kNm/m}$ Moist backfill above water table $M_{s_m_a} = F_{s_m_a_f} \times b_i \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 \text{ kNm/m}$ Moist backfill below water table $M_{s_m_b} = F_{s_m_b_f} \times a_i \times (2 - n)^2 / 8 = 8.3 \text{ kNm/m}$ Saturated backfill $M_{s_s} = F_{s_s_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 0.4 \text{ kNm/m}$ Water $M_{s_water} = F_{s_water_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 \text{ kNm/m}$ Total moment for stem design $M_{s_water} = F_{s_water_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 \text{ kNm/m}$ Surcharge $M_{w_s_ur} + M_{s_m_a} + M_{s_m_b} + M_{s_s} + M_{s_water} = 62.6 \text{ kNm/m}$ Moist backfill above water table $M_{w_s_ur} = 9 \times F_{s_s_ur_f} \times 1 / 128 = 7.8 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_i \times [(b^3 + 5 \times a_i \times L^2)/(5 \times L^3) - 0.577^2/3] = 21.3 \text{ kNm/m}$ Moist backfill below water table $M_{w_m_a} = F_{s_m_a_f} \times a_i \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 1.6 \text{ kNm/m}$ Moist backfill below water table $M_{w_m_b} = F_{s_m_a_f} \times [a^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a^2 \times x \times ((5 \times L) - a_i)/(20 \times 3) - (x - b_i)^3 / (3 \times a^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = M_{w_w=w} + M_{w_w=w} + M_{w_w=w} + M_{w_w=w} = 30.8 \text{ kNm/m}$	Calculate moment for stem de	esign								
Moist backfill above water table $M_{s_m_a} = F_{s_m_a,f} \times bl \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 39.2 \text{ kNm/m}$ Moist backfill below water table $M_{s_m_b} = F_{s_m,b_f} \times al \times (2 - n)^2 / 8 = 8.3 \text{ kNm/m}$ Saturated backfill $M_{s_s} = F_{s_s,f} \times al \times ((3 \times a^2) - (15 \times al \times L) + (20 \times L^2))/(60 \times L^2) = 0.4 \text{ kNm/m}$ Water $M_{s_water} = F_{s_water_f} \times al \times ((3 \times a^2) - (15 \times al \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 \text{ kNm/m}$ Total moment for stem design $M_{stem} = M_{s_sur} + M_{s_m_a} + M_{s_m_b} + M_{s_s} + M_{s_water} = 62.6 \text{ kNm/m}$ Surcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 7.8 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m,a_f} \times 0.577 \times blx[(b^3 + 5 \times al \times 2)/(5 \times L^3) - 0.577^2/3] = 21.3 \text{ kNm/m}$ Moist backfill below water table $M_{w_m_b} = F_{s_m_b} \times al \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 1.6 \text{ kNm/m}$ Moist backfill $M_{w_water} = F_{s_water_f} \times al \times [((5 \times L) - al)/(20 \times L^3) - (x - bl)^3 / ((3 \times al^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a^2 \times x \times ((5 \times L) - al)/(20 \times L^3) - (x - bl)^3 / ((3 \times al^2)] = 0.1 \text{ kNm/m}$ Water $M_{wall} = M_{w_sur} + M_{w_ma} + M_{w_mb} + M_{w_s} + M_{w_water} = 30.8 \text{ kNm/m}$	Surcharge	-	Ms_sur = Fs_	sur_f × L / 8 = 1 3	3.9 kNm/m					
Moist backfill below water table $M_{s_mb} = F_{s_mb_f} \times a_l \times (2 - n)^2 / 8 = 8.3 kNm/m$ Saturated backfill $M_{s_s} = F_{s_s f} \times a_l \times ((3 \times a^2) - (15 \times a_l \times L) + (20 \times L^2))/(60 \times L^2) = 0.4 kNm/m$ Water $M_{s_water} = F_{s_water_f} \times a_l \times ((3 \times a^2) - (15 \times a_l \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 kNm/m$ Total moment for stem design $M_{stem} = M_{s_sur} + M_{s_ma} + M_{s_mb} + M_{s_s} + M_{s_water} = 62.6 kNm/m$ Surcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 7.8 kNm/m$ Moist backfill above water table $M_{w_ma} = F_{s_ma_f} \times 0.577 \times b_l \times [(b^3 + 5 \times a_l \times 2)/(5 \times L^3) - 0.577^2/3] = 21.3 kNm/m$ Moist backfill below water table $M_{w_mb} = F_{s_mb_f} \times a_l \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 1.6 kNm/m$ Moist backfill below water table $M_{w_water} = F_{s_water_f} \times [a^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a^2)] = 0.1 kNm/m$ Water $M_{w_water} = F_{s_water_f} \times [a^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a^2)] = 0.1 kNm/m$ Water $M_{w_water} = M_{s_water} + M_{w_ma} + M_{w_mb} + M_{w_s} + M_{w_water} = 30.8 kNm/m$	Moist backfill above water table		Ms_m_a = Fs	_m_a_f × bı × ((5	\times L ²) - (3 \times bl ²))	/ (15 × L ²) = 39	.2 kNm/m			
Saturated backfill $M_{s_s} = F_{s_s} f \times alx((3\times al^2)-(15\times al\times L)+(20\times L^2))/(60\times L^2) = 0.4 \text{ kNm/m}$ Water $M_{s_water} = F_{s_water_f} \times alx((3\times al^2)-(15\times al\times L)+(20\times L^2))/(60\times L^2) = 0.8 \text{ kNm/m}$ Total moment for stem design $M_{stem} = M_{s_sur} + M_{s_m_a} + M_{s_m_b} + M_{s_s} + M_{s_water} = 62.6 \text{ kNm/m}$ Calculate moment for wall design $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 7.8 \text{ kNm/m}$ Surcharge $M_{w_m_a} = F_{s_m_a} \times 0.577 \times blx[(bl^3+5\times al\times L^2)/(5\times L^3)-0.577^2/3] = 21.3 \text{ kNm/m}$ Moist backfill below water table $M_{w_m_b} = F_{s_m_b} f \times alx [((8-n^2 \times (4-n))^2 / 16)-4+n \times (4-n)]/8 = 1.6 \text{ kNm/m}$ Moist backfill below water table $M_{w_water} = F_{s_s} f \times [al^2 \times x \times ((5\times L)-al)/(20\times L^3)-(x-bl)^3 / (3\times al^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [al^2 \times x \times ((5\times L)-al)/(20\times L^3)-(x-bl)^3 / (3\times al^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_all} = M_{w_sur} + M_{w_m_a} + M_{w_m_b} + M_{w_s} + M_{w_water} = 30.8 \text{ kNm/m}$	Moist backfill below water table		Ms_m_b = Fs	_m_b_f × a l × (2 -	- n)² / 8 = 8.3 kNi	m/m				
Water $M_{s_water} = F_{s_water_f} \times a_l \times ((3 \times a_l^2) - (15 \times a_l \times L) + (20 \times L^2))/(60 \times L^2) = 0.8 kNm/m$ Total moment for stem design $M_{stem} = M_{s_sur} + M_{s_m_a} + M_{s_m_b} + M_{s_s} + M_{s_water} = 62.6 kNm/m$ Calculate moment for wall design $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 7.8 kNm/m$ Surcharge $M_{w_wsur} = 9 \times F_{s_sur_f} \times 0.577 \times b_l \times (b^3 + 5 \times a_l \times L^2)/(5 \times L^3) - 0.577^2/3] = 21.3 kNm/m$ Moist backfill above water table $M_{w_m_a} = F_{s_m_af} \times 0.577 \times b_l \times ((b^3 + 5 \times a_l \times L^2)/(5 \times L^3) - 0.577^2/3] = 21.3 kNm/m$ Moist backfill below water table $M_{w_m_b} = F_{s_m_bf} \times a_l \times (((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 1.6 kNm/m$ Saturated backfill $M_{w_water} = F_{s_sf} \times [a^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a^2)] = 0.1 kNm/m$ Water $M_{w_water} = F_{s_water_f} \times [a^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a^2)] = 0.1 kNm/m$ Moment for wall design $M_{wall} = M_{w_ssur} + M_{w_ma} + M_{w_mb} + M_{w_ss} + M_{w_water} = 30.8 kNm/m$	Saturated backfill		Ms_s = Fs_s_	<u>_</u> f ×a⊨×((3×a⊧²)-(´	15×a⊧×L)+(20×L²)))/(60×L ²) = 0.4	kNm/m			
Total moment for stem design $M_{stem} = M_{s_sur} + M_{s_m_b} + M_{s_s} + M_{s_water} = 62.6 \text{ kNm/m}$ Calculate moment for wall design $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 7.8 \text{ kNm/m}$ Surcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 7.8 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_{lx}[(b_{l}^{3}+5\times a_{l}\times L^{2})/(5\times L^{3})-0.577^{2}/3] = 21.3$ kNm/mMoist backfill below water table $M_{w_m_b} = F_{s_m_b_f} \times a_{l} \times [((8-n^{2}\times(4-n))^{2}/16)-4+n\times(4-n)]/8 = 1.6 \text{ kNm/m}$ Saturated backfill $M_{w_s} = F_{s_s_f} \times [a_{l}^{2} \times x \times ((5\times L)-a_{l})/(20\times L^{3})-(x-b_{l})^{3}/(3\times a_{l}^{2})] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_{l}^{2} \times x \times ((5\times L)-a_{l})/(20\times L^{3})-(x-b_{l})^{3}/(3\times a_{l}^{2})] = 0.1 \text{ kNm/m}$ Total moment for wall design $M_{w_sur} + M_{w_m_a} + M_{w_m_b} + M_{w_s} + M_{w_water} = 30.8 \text{ kNm/m}$	Water		Ms_water = F	s_water_f × a l×((3×	aı²)-(15×aı×L)+(2	20×L²))/(60×L²)	= 0.8 kNm/m			
Calculate moment for wall designSurcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 7.8 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_l \times [(b_l^3 + 5 \times a_l \times L^2)/(5 \times L^3) - 0.577^2/3] = 21.3 \text{ kNm/m}$ Moist backfill below water table $M_{w_m_b} = F_{s_m_b_f} \times a_l \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 1.6 \text{ kNm/m}$ Saturated backfill $M_{w_m_b} = F_{s_s_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 0.1 \text{ kNm/m}$ Total moment for wall design $M_{w_sur} + M_{w_m_a} + M_{w_m_b} + M_{w_s} + M_{w_water} = 30.8 \text{ kNm/m}$	Total moment for stem design		M _{stem} = M _s _	_{sur} + M _{s_m_a} + N	/Is_m_b + Ms_s + M	s_water = 62.6 kN	lm/m			
Surcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 7.8 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_1 \times [(b_1^3 + 5 \times a_1 \times L^2)/(5 \times L^3) - 0.577^2/3] = 21.3$ kNm/mMoist backfill below water table $M_{w_m_b} = F_{s_m_b_f} \times a_1 \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 1.6 \text{ kNm/m}$ Saturated backfill $M_{w_m_b} = F_{s_s_f} \times [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 0.1 \text{ kNm/m}$ Total moment for wall design $M_{w_sur} + M_{w_m_a} + M_{w_m_b} + M_{w_s} + M_{w_water} = 30.8 \text{ kNm/m}$	Calculate moment for wall dea	sign								
Moist backfill above water table $M_{w_ma} = F_{s_ma_f} \times 0.577 \times b_l \times [(b_l^3 + 5 \times a_l \times L^2)/(5 \times L^3) - 0.577^2/3] = 21.3$ kNm/mMoist backfill below water table $M_{w_mb} = F_{s_mb_f} \times a_l \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 1.6$ kNm/mSaturated backfill $M_{w_mb} = F_{s_mb_f} \times a_l \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 1.6$ kNm/mWater $M_{w_water} = F_{s_water_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 0.1$ kNm/mWater $M_{w_water} = F_{s_water_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 0.1$ KNm/mTotal moment for wall designMwall = M_{w_water} + M_{w_ma} + M_{w_mb} + M_{w_water} = 30.8 kNm/m	Surcharge		M _{w_sur} = 9 >	$F_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_$	28 = 7.8 kNm/m					
kNm/mMw_m_b = $F_{s_m_b_f} \times a_i \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 1.6 \text{ kNm/m}$ Saturated backfill $M_{w_m} = F_{s_m_b_f} \times a_i \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 1.6 \text{ kNm/m}$ Saturated backfill $M_{w_m} = F_{s_m_b_f} \times a_i \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 1.6 \text{ kNm/m}$ Water $M_{w_m} = F_{s_m} \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a^2)] = 0.1 \text{ kNm/m}$ Womment for wall design $M_{wall} = M_{w_m} + M_{w_m_a} + M_{w_m_b} + M_{w_m} + M_{w_m_m} = 30.8 \text{ kNm/m}$	Moist backfill above water table		M _{w_m_a} = F _s	_m_a_f × 0.577×	bi×[(bi³+5×ai×L²)/	/(5×L³)-0.577²/3	3] = 21.3			
Moist backfill below water table $M_{w_mb} = F_{s_mb_f} \times a_l \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 1.6 \text{ kNm/m}$ Saturated backfill $M_{w_mb} = F_{s_mb_f} \times a_l \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 1.6 \text{ kNm/m}$ Water $M_{w_s} = F_{s_s f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 0.1$ kNm/m $M_{wall} = M_{w_sur} + M_{w_ma} + M_{w_mb} + M_{w_s} + M_{w_water} = 30.8 \text{ kNm/m}$	kNm/m									
Saturated backfill $M_{w_s} = F_{s_s_f} \times [al^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times al^2)] = 0.1 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [al^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times al^2)] = 0.1$ kNm/mTotal moment for wall designMwall = M_{w_sur} + M_{w_m_b} + M_{w_s} + M_{w_water} = 30.8 \text{ kNm/m}	Moist backfill below water table		$M_{w_m_b} = F_s$	_m_b_f × a l × [((8	3-n²×(4-n))² /16)-	4+n×(4-n)]/8 =	1.6 kNm/m			
Water $M_{w_water} = F_{s_water_f} \times [ai^2 \times x \times ((5 \times L) - ai)/(20 \times L^3) - (x - bi)^3 / (3 \times ai^2)] = 0.1$ kNm/mTotal moment for wall designMwall = $M_{w_sur} + M_{w_m_b} + M_{w_m_b} + M_{w_water} = 30.8$ kNm/m	Saturated backfill	Saturated backfill		$M_{w_s} = F_{s_s_f} \times [a_{l^2 \times X \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 0.1 \text{ kNm/m}$						
kNm/m Total moment for wall design $M_{wall} = M_{w_sur} + M_{w_m_a} + M_{w_m_b} + M_{w_s} + M_{w_water} = 30.8 \text{ kNm/m}$	Water		M _{w_water} = F	s_water_f × [al ² ×x	×((5×L)-aı)/(20×L	. ³)-(x-bı) ³ /(3×aı ²	²)] = 0.1			
Total moment for wall design $M_{wall} = M_{w_sur} + M_{w_m_a} + M_{w_m_b} + M_{w_s} + M_{w_water} = 30.8 \text{ kNm/m}$	kNm/m									
	Total moment for wall design		$M_{wall} = M_{w_s}$	sur + Mw_m_a + N	1w_m_b + Mw_s + M	w_water = 30.8 kl	Nm/m			



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Check retaining wall def	flection	
Basic span/effective deptl	n ratio	ratio _{bas} = 20
Design service stress		$f_s = 2 \times f_y \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = 274.6 \text{ N/mm}^2$
Modification factor	factor _{tens} = min(0	.55 + (477 N/mm ² - fs)/(120 × (0.9 N/mm ² + (M _{stem} /(b × d _{stem} ²)))),2) = 1.41
Maximum span/effective of	lepth ratio	ratio _{max} = ratio _{bas} × factor _{tens} = 28.28
Actual span/effective depth ratio		ratio _{act} = h _{stem} / d _{stem} = 16.39
		PASS - Span to depth ratio is acceptable

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NMN Partnership Calcs for Start page no./Revision RC wall 1 to extension of basement RW1 11 Calcs by Calcs date Checked by Checked date Approved by Approved
RC wall 1 to extension of basement RW1 11 Calcs by NM Calcs date 02/05/2024 Checked by Checked date Checked date Approved by Approved Approved by
Calcs by Calcs date Checked by Checked date Approved by Approved by NM 02/05/2024 Checked by Checked date Approved by Approved by
NM 02/05/2024
Indiantina antoinina wall uninforma mant dia man
Wal reinforcement
Toe bars - 16 mm dia.@ 200 mm centres - (1005 mm²/m) Wall bars - 10 mm dia.@ 200 mm centres - (393 mm²/m) Stem bars - 12 mm dia.@ 150 mm centres - (754 mm²/m)

Tekla. Tedds	Project	26 Amyand Park	Road TW1 3H	E	Job no. 23	227
NMN Partnership	Calcs for S RC wall 2 to extension of basement and wall above				Start page no./Re RW	evision 2 12
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	•					

RETAINING WALL ANALYSIS (BS 8002:1994) TEDDS calculation version 1.2.01.08 -1675-1500 -▶ 300 | 70 kN/m ⊥ 10 kN/m² Prop — 150.0 g Prop -×. Wall details Retaining wall type Cantilever propped at both hstem = 4500 mm Height of retaining wall stem t_{wall} = 300 mm Thickness of wall stem Itoe = **1500** mm Length of toe I_{heel} = 0 mm Length of heel Overall length of base Ibase = Itoe + Iheel + twall = 1800 mm Thickness of base t_{base} = **300** mm Depth of downstand d_{ds} = **0** mm I_{ds} = **200** mm Position of downstand Thickness of downstand t_{ds} = **300** mm Height of retaining wall $h_{wall} = h_{stem} + t_{base} + d_{ds} = 4800 \text{ mm}$ Depth of cover in front of wall d_{cover} = 0 mm $d_{exc} = 0 mm$ Depth of unplanned excavation h_{water} = **1000** mm Height of ground water behind wall $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 700 mm$ Height of saturated fill above base Density of wall construction γ_{wall} = 23.6 kN/m³ Density of base construction γ_{base} = 23.6 kN/m³ Angle of rear face of wall α = **90.0** deg Angle of soil surface behind wall $\beta = 0.0 \deg$ Effective height at virtual back of wall $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 4800 \text{ mm}$ **Retained material details**

Mobilisation factor Moist density of retained material M = **1.5** γ_m = **18.0** kN/m³

Tekla Tedds	Project Job no.					
NMN Partnershin	Calas far		Start page no /Povision			
	RC wall 2	to extension of	f basement and	l wall above	RW	2 13
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Saturated density of retained ma	aterial	γs = 21.0 kľ	N/m ³			
Design shear strength		∳' = 24.2 de	∋g			
Angle of wall friction		δ = 0.0 deg				
Base material details						
Moist density		γ _{mb} = 18.0 I	κN/m³			
Design shear strength		φ'₅ = 24.2 d	eg			
Design base friction		δ _b = 18.6 de	eg			
Allowable bearing pressure		Pbearing = 15	0 kN/m²			
Using Coulomb theory						
Active pressure coefficient for re	etained material					
$K_a = sin(\alpha)$	+ $\phi')^2$ / (sin(α) ² ×	$\sin(\alpha - \delta) \times [1 +$	$\cdot \sqrt{(\sin(\phi' + \delta) \times)}$	$\sin(\phi' - \beta) / (\sin(lpha$	- δ) × sin(α +	3)))]²) = 0.419
Passive pressure coefficient for	base material					
	K _p = sin(9	0 -) - δ⊳) × [1 - √(si	$n(\phi'_{b} + \delta_{b}) \times sin(\phi'_{b})$	թ) / (sin(90 + ծ	b)))] ²) = 4.187
At-rest pressure						
At-rest pressure for retained ma	terial	K₀ = 1 – sir	n(φ') = 0.590			
Loading details						
Surcharge load on plan		Surcharge	= 10.0 kN/m ²			
Applied vertical dead load on wa	all	W _{dead} = 65 .	0 kN/m			
Applied vertical live load on wall		W _{live} = 5.0	kN/m			
Position of applied vertical load	on wall	l _{load} = 1675	mm			
Applied horizontal dead load on	wall	$F_{dead} = 0.0$	KN/M			
Height of applied horizontal load	an Yon wall	Flive = 0.0 K	n/111			
		70 1 [10			
2	Prop 63.7	Prop -		4.7 9.8		
				Loads shown	in kN/m, pressure	s shown in kN/m²
Vertical forces on wall						
Wall stem		w _{wall} = h _{stem}	$\times t_{wall} \times \gamma_{wall} = 3$	31.9 kN/m		

Iekla. ledds	26 Amyand Park Road TW1 3HE 23 227						
NMN Partnership	Calcs for RC wal	12 to extension o	basement ar	nd wall above	Start page no./l	Revision N2 14	
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved of	
Wall base			× t	- 12 7 kN/m		ļ	
Applied vertical load		Wease - Ibase	+ \M/m - 70 k	- 12.7 NN/III			
Total vertical load		Wtotal = Wwa	+ W live - 70 K	= 114.6 kN/m			
Horizontal forces on wall							
Surcharge		F _{sur} = K _a ×	Surcharge × h	l _{eff} = 20.1 kN/m			
Moist backfill above water table		F _{m a} = 0.5 :	< K _a × γ _m × (h _e	_{ff} - h _{water}) ² = 54.4	kN/m		
Moist backfill below water table		F _{m b} = K _a ×	$\gamma_{\rm m} \times (h_{\rm eff} - h_{\rm was})$	$_{\text{iter}}$) × h _{water} = 28.6	kN/m		
Saturated backfill			Ka × (γs-γwater)	× h_{water}^2 = 2.3 kN/	/m		
Water		F _{water} = 0.5	$\times h_{water}^2 \times \gamma_{water}^2$	_{er} = 4.9 kN/m			
Total horizontal load		F _{total} = F _{sur}	+ F _{m_a} + F _{m_b} ·	+ F _s + F _{water} = 110).4 kN/m		
Calculate total propping force							
Passive resistance of soil in from	t of wall	$F_p = 0.5 \times H$	$K_{p} imes cos(\delta_{b}) imes$	(d _{cover} + t _{base} + d _d	s - $d_{exc})^2 \times \gamma_{mb}$ =	3.2 kN/m	
Propping force		$F_{\text{prop}} = \max(F_{\text{total}} - F_{\text{p}} - (W_{\text{total}} - W_{\text{live}}) \times \tan(\delta_{\text{b}}), 0 \text{ kN/m})$					
		F _{prop} = 70.3	kN/m				
Overturning moments							
Surcharge		M _{sur} = F _{sur} >	$<$ (h _{eff} - 2 \times d _d	s) / 2 = 48.2 kNm/	/m		
Moist backfill above water table		$M_{m_a} = F_{m_a}$	$h_{\rm a} \times ({\rm h_{eff}} + 2 \times {\rm h_{eff}})$	Nwater - $3 \times d_{ds}$) / 3	= 123.3 kNm/r	n	
Moist backfill below water table		$M_{m_b} = F_{m_t}$	h_{water} - 2 $ imes$	d _{ds}) / 2 = 14.3 kM	lm/m		
Saturated backfill		$M_s = F_s \times (H_s)$	n_{water} - $3 imes d_{ds}$)	/ 3 = 0.8 kNm/m			
Water		$M_{water} = F_{water}$	$_{ter} imes (h_{water} - 3)$	× d _{ds}) / 3 = 1.6 kM	Nm/m		
Total overturning moment		M _{ot} = M _{sur} +	Mm_a + Mm_b	+ Ms + M _{water} = 18	38.2 kNm/m		
Restoring moments							
Wall stem		M _{wall} = w _{wall}	\times (Itoe + t _{wall} / 2	2) = 52.6 kNm/m			
Wall base		Mbase = wbas	$se \times I_{base} / 2 = '$	11.5 kNm/m			
Design vertical dead load		M _{dead} = W _d	$aad \times I_{load} = 108$	3.9 kNm/m			
Total restoring moment		M _{rest} = M _{wall}	+ M _{base} + M _{de}	_{ad} = 172.9 kNm/n	า		
Check bearing pressure							
Total vertical reaction		R = W _{total} =	114.6 kN/m				
Distance to reaction		$x_{bar} = I_{base} /$	2 = 900 mm				
Eccentricity of reaction		e = abs((lba	se / 2) - Xbar) =	0 mm			
				Reaction acts	within middle	e third of b	
Bearing pressure at toe		$p_{toe} = (R / I_{t})$	$_{\rm ase}$) - (6 $ imes$ R $ imes$	e / I _{base} ²) = 63.7	kN/m²		
Bearing pressure at heel		$p_{heel} = (R /$	$_{base}) + (6 \times R)$	× e / I _{base} ²) = 63.7	′ kN/m²		
	D	ASS - Maximum h	opring proce	uro is loss than	allowable bea	rina nroce	

Propping force to base of wall

$$\begin{split} F_{prop_top} &= (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \textbf{23.208 kN/m} \\ F_{prop_base} &= F_{prop} - F_{prop_top} = \textbf{47.044 kN/m} \end{split}$$

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RETAINING WALL DESIGN (B	S 8002:1994)					
Ultimate limit state load facto	ſS				TEDDS calculation	version 1.2.01.08
Dead load factor		ν _{f d} = 1.4				
Live load factor		γ γ _{f I} = 1.6				
Earth and water pressure factor		γ _{f e} = 1.4				
Factored vertical forces on w	all	• –				
Wall stem		Wwall $f = \gamma f d$	× hetem × twall × '	$w_{\rm wall} = 44.6 \rm kN/m$	1	
Wall base		Where $f = \gamma f c$	X lbase X tbase X	$v_{\text{base}} = 17.8 \text{ kN}/$	m	
Applied vertical load		$W_{\rm M}$ f = M d X	$W_{doad} + v_{f} \downarrow \times V$	$M_{\rm live} = 99 \rm kN/m$		
Total vertical load		W total f = Ww	vall f + Wbase f + V	Vv f = 161.4 kN/r	n	
Eactored horizontal active for	cos on wall					
Surcharge		$F_{aut} f = \gamma f + \chi$	K _{a ×} Surchard	le ∨ h₀# = 32 1 kľ	l/m	
Moist backfill above water table		$F_{m,n} f = \gamma f_{m,n}$	$\times 0.5 \times K_{o} \times v_{m}$	$\times (h_{\text{eff}} - h_{\text{unitor}})^2 =$	76 1 kN/m	
Moist backfill below water table		$F_{m,a_1} = \gamma_{1,e}$	\times K ₂ \times V _m \times (hot	f = hwater) × hwater	= 40 1 kN/m	
Saturated backfill		$F_{n,f} = v_{f,n,X}$	$0.5 \times K_{0} \times (v_{c} - v_{c})$	$(water) \times h_{water}^2 = 3$	3 kN/m	
Water		$F_{water f} = v_{f, c}$	$\times 0.5 \times h_{water}^2$	\times Vwater = 6.9 kN	/m	
Total horizontal load		$F_{total f} = F_{sur}$	f + Fm a f + Fm	b f + Fs f + Fwater	 f = 158.5 kN/m	
Calculate total propring force						
Passive resistance of soil in from	nt of wall	$E_{\rm D} f = V f e X$	$0.5 \times K_{\rm p} \times \cos($	ίδη) x (dcover + thas	$a + dds - daxc)^2$	$v_{\rm mb} = 4.5$
kN/m		1 P_1 _ P_0 A				
Propping force		F _{prop f} = ma	x(F _{total f} - F _p f -	(W _{total} f - γf ι × Wι	$_{ive}) \times tan(\delta_b), 0$	kN/m)
		F _{prop_f} = 102	2.4 kN/m		, , ,,,	,
Factored overturning moment	s					
Surcharge		Msur_f = Fsur	$_f \times (h_{eff} - 2 \times d)$	_{ds}) / 2 = 77.1 kNi	m/m	
Moist backfill above water table		$M_{m_a_f} = F_{m_a}$	_a_f \times (heff + 2 \times	hwater - $3 \times d_{ds}$) /	3 = 172.6 kNm	/m
Moist backfill below water table		$M_{m_b_f} = F_{m_b}$	$_b_f \times (h_{water} - 2$	× d _{ds}) / 2 = 20 kN	lm/m	
Saturated backfill		$M_{s_f} = F_{s_f} \times$	\times (hwater - 3 $ imes$ dot	s) / 3 = 1.1 kNm/r	n	
Water		M _{water_f} = F _w	vater_f × (hwater - 3	8 × d _{ds}) / 3 = 2.3	kNm/m	
Total overturning moment		$M_{ot_f} = M_{sur_f}$	_f + M _{m_a_f} + M _m	_b_f + Ms_f + M _{wate}	_{er_f} = 273.2 kNm	n/m
Restoring moments						
Wall stem		$M_{wall_f} = w_{wall_f}$	$II_f \times (I_{toe} + t_{wall})$	2) = 73.6 kNm/r	n	
Wall base		$M_{base_f} = w_b$	$_{ase_f} \times I_{base} / 2 =$	16.1 kNm/m		
Design vertical load		$M_{v_f} = W_{v_f}$	× I _{load} = 165.8 k	(Nm/m		
Total restoring moment		M _{rest_f} = M _{wa}	$_{all_f} + M_{base_f} + N$	/lv_f = 255.5 kNm	/m	
Factored bearing pressure						
Total vertical reaction		$R_f = W_{total_f}$	= 161.4 kN/m			
Distance to reaction		$\mathbf{x}_{bar_f} = \mathbf{I}_{base}$	/ 2 = 900 mm			
Eccentricity of reaction		e _f = abs((I _{ba}	_{ase} / 2) - x _{bar_f}) =	0 mm		
Pooring process of the				Reaction acts $(2) = 20$	witnin middle 7 kN/m²	third of base
Bearing pressure at toe		$p_{toe_f} = (R_f / P_f)$	$(base) - (b \times Rf)$	$\langle ef / Ibase^{-} \rangle = \delta 9.1$		
Bate of change of bace reaction	1	$p_{\text{heel}_f} = (R_f)$	$i \text{ (base)} \neq (0 \times \text{Rf})$	$= 0.00 \text{ kN}/\text{m}^2/\text{m}$	• KIN/III ⁻	
Rearing pressure at stem / too	,	Determ tes f	n = Pneei_t) / Ibase max(ptoo f = (rot	= 0.00 KN/III /III e x $ _{toe}$) 0 kN/m ²) = 89 7 kN/m ²	
		Harein_ron_i _				

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	RC wall 2 to	extension of basement and wall above			RW	2 16
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	NM	02/05/2024				
Bearing pressure at mid stem		Dstem mid f =	max(ptoe f - (rate	$e \times (_{toe} + t_{wall} / 2))$. 0 kN/m ²) = 8	9.7 kN/m ²
Bearing pressure at stem / hee		pstem_heel_f =	max(ptoe_f - (rate	$e \times (I_{toe} + t_{wall})), 0$	kN/m ²) = 89.7	′ kN/m²
Calculate propping forces to	top and base of w	all				
Propping force to top of wall						
	Fprop_top_f = (Mot	_f - M _{rest_f} + Rf	× Ibase / 2 - Fprop	_f \times tbase / 2) / (hste	em + t _{base} / 2) =	31.748 kN/m
Propping force to base of wall		Fprop_base_f =	Fprop_f - Fprop_top	_f = 70.624 kN/m		
Design of reinforced concrete	e retaining wall to	e (BS 8002:1	994 <u>)</u>			
Material properties						
Characteristic strength of concr	ete	f _{cu} = 40 N/n	nm²			
Characteristic strength of reinfo	rcement	f _y = 500 N/r	nm²			
Base details						
Minimum area of reinforcement		k = 0.13 %				
Cover to reinforcement in toe		Ctoe = 50 MI	m			
Calculate shear for toe desig	1		- · · · · · · · · · · · · · · · · · · ·	1 10 424 5	1-11/	
Shear from bearing pressure		Vtoe_bear = (Dtoe_f + pstem_toe_f)	\times Itoe / 2 = 134.5	KIN/M	
Total shear for toe design		V toe_wt_base -	$-\gamma t_d \times \gamma base \times Itoe$	× lbase – 14.9 kN	/111	
Calculate moment for too des	ian		eai Vioe_wi_base			
Moment from bearing pressure	ign	Mtoe bear = (2 × Dtop f + Dstem	mid f) × (Itoe + twall /	$(2)^2 / 6 = 122$	1 kNm/m
Moment from weight of base		Mtoe wt base =	= (vf d × vbase × tb	x = x (Itoe + twall / 2	$(2^{2}/2) = 13.5 \text{ k}$	Nm/m
Total moment for toe design		Mtoe = Mtoe	bear - Mtoe wt base :	= 108.6 kNm/m	, , _,	
		_				
242-	>					
30					\leq	
	• •	•	• •	•	•	
<u>↓</u>						
	∢ — 150—▶					
Check toe in bending						
Width of toe		b = 1000 m	im/m			
Depth of reinforcement		dtoe = tbase -	- Ctoe — (φtoe / 2) =	= 242.0 mm		
Constant		Ktoe = IVItoe /	(D × Otoe ² × Tcu) =	= 0.046	forcomont is	not required
l ever arm		$z_{toe} = min(0)$	0.5 + √(0.25 - (m	in(K _{tos} 0 225) / 0	$(9)) 0.95) \times d_{t}$	notrequired
		Ztoe = 229 n	nm		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
Area of tension reinforcement r	equired	As_toe_des = I	Mtoe / (0.87 $ imes$ fy $ imes$	z _{toe}) = 1091 mm	² /m	
Minimum area of tension reinfo	rcement	As_toe_min = I	$\mathbf{x} \times \mathbf{b} \times \mathbf{t}_{base} = 39$	0 mm²/m		
Area of tension reinforcement r	equired	As_toe_req = N	Max(A _{s_toe_des} , A _s	_{_toe_min}) = 1091 m	ım²/m	
Reinforcement provided		16 mm dia	.bars @ 150 mr	n centres		
Area of reinforcement provided		As_toe_prov =	1340 mm²/m	rial and a total state	inin	
		rass - Rein	forcement prov	ridea at the reta	ining wall toe	is adequate

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NMN Partnership	Color for	20 Anyana i an			Ctart name no //	
	RC wall	2 to extension of	basement and	RV	V2 17	
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
Chack shoar resistance at too						
Design shear stress		Vtoo = Vtoo /	$(b \times d_{too}) = 0.4$	95 N/mm ²		
Allowable shear stress		$v_{ide} = v_{ide}$	(b ∧ dide) – 0. ∓ 0 8 × √(f _{ou} / 1 N	$\sqrt{(mm^2)}$ 5) \times 1 N/	/mm ² = 5 000 N	l/mm ²
Allowable sites sites		PASS -	Design shear	r stress is less f	han maximun	n shear stress
From BS8110:Part 1:1997 – Ta	ble 3.8		2 congin cincul			
Design concrete shear stress		v _{c_toe} = 0.68	88 N/mm ²			
			Vto	e < vc_toe - No sh	near reinforcei	ment required
Design of reinforced concrete	retaining wa	II stem (BS 8002	:1994)			
Material properties			<u></u>			
Characteristic strength of concre	ato	f – 40 N/n	nm ²			
Characteristic strength of reinfor	cement	$f_v = 500 \text{ N/r}$	mm ²			
Wall details	comon					
Minimum area of reinforcement		k - 0 13 %				
Cover to reinforcement in stem		K = 0.15 /0	nm			
Cover to reinforcement in wall		Cwall = 50 m	m			
Factored horizontal active for	res on stem					
Surcharge		$F_{s,sur} f = \gamma_{f}$	× K₂ × Surcha	arge × (h _{eff} - t _{base} -	- d _{ds}) = 30.1 kN	l/m
Moist backfill above water table		$F_{smat} = 0$	5 × Vf • × K• ×	$v_m \times (h_{eff} - t_{hase} - 0)$	$d_{ds} - h_{sat}^2 = 76$	1 kN/m
Moist backfill below water table		$F_{s,m,h,f} = v_{f}$	$a \times K_a \times v_m \times (l)$	heff - thase - dds - h	$(aus hat) \times h_{sat} = 28.2$	l kN/m
Saturated backfill		$F_{s,s,f} = 0.5$	× vf • × K• × (v	$(1 + 1) \times h_{sat}^2 = f$	1.6 kN/m	
Water		$F_{s,water,f} = 0$	$5 \times V_{\rm f} = X V_{\rm water}$	$r \times h_{sat}^2 = 3.4 \text{ kN}/$	/m	
Coloulate aboar for stom desig		· •	11_0 11			
Surcharge	Ju	V	E	88 kN/m		
Moist backfill above water table		Vs_sur_1 = 5 2	< r s_sur_1 / 0 - 1	5×1^{2}) - b^{2}) / (5 ×	, ³) = 53 9 kNl/	'n
Moist backfill below water table		Vs_m_a_i = F	$s_m_a \sim 0^{\circ} \wedge (0^{\circ})$	$(3 \times 10^{-1})^{-1}$	27 6 kN/m	
Saturated backfill		$V_{s,a,f} = F_{s,a}$	$s_{11} = 0^{-1} \times (0^{-1} \times 0^{-1})^{-1}$	(5 × L) - a) / (20	$\times ^{3}$)) = 1.6 kN	l/m
Water		$V_{s} = 1 = 1$	$\frac{1}{2} \times (1 - (a) \times (1 - (a)))$	(0 × 1) - a)) (20 a ² × ((5 × 1) - a)	$(20 \times 1^{3})) = 3$	3 3 kN/m
Total shear for stem design		Vstem = Vs s	$s_wallel_1 \wedge (1 - (1 - (1 - (1 - (1 - (1 - (1 - ($	Vs m h f + Vs s f +	· Vs water f = 105	5.3 kN/m
Calculate memory for stem de	cian	• • • • • • • • • • • • • • • • • • •			• •	
Surcharge	Sign	Ma aur = Fa	f = 17	7 5 kNm/m		
Moist backfill above water table		$Ms_{max} = Fs_{max}$	$m_{n} f \times h \times ((5))$	$(3 \times h^2) - (3 \times h^2))/$	$(15 \times 1^2) = 57$	8 kNm/m
Moist backfill below water table		$Ms_m h = Fs_m$	a_i × bi × ((0	$(0 \times 0^{1}))/(0 \times 0^{1})/(0 \times 0^{1}))/(0 \times 0^{1})/(0 \times 0^{1}))/(0 \times 0^{1})/(0 \times 0^{1}))/(0 \times 0^{1})/(0 \times 0^{1})/(0 \times 0^{1}))/(0 \times 0^{1})/(0 \times 0^{1})/(0 \times 0^{1}))/(0 \times 0^{1})/(0 \times 0^{1}$	(10 × ⊑) = 0 1	
Saturated backfill		$M_{s,s} = F_{s,s}$	₋ ııı_o_i × u × (2 - _{f ×} aı×((3×aı²)-(1	15×a×L)+(20×L ²)	$(0)/(60 \times 1^2) = 0.4$	kNm/m
Water		Ms_water = Fo	$\frac{1}{2} \operatorname{water} f \times \operatorname{Alx}((3))$	(a ²)-(15×a×L)+(2	?0×L ²))/(60×L ²)	= 0.8 kNm/m
Total moment for stem design		M _{stem} = M _s	sur + Ms m a + N	/ls m b + Ms s + Ms	s water = 86.4 kN	lm/m
Calculate moment for wall des	sian					
Surcharge	Jign	M _w our = 9 ×	$E_{s,surf} \times 1/1$	28 = 9 9 kNm/m		
Moist backfill above water table		Mw_sur 0 ×	m a f x 0 577 x	$b_{1} \times [(b_{1}^{3} + 5 \times a_{1} \times l^{2})]$	/(5×1 ³)-0 577 ² /3	31 = 30 2
kNm/m		ww_m_a = r s			(0~L)-0.011 /	-
Moist backfill below water table		Mwmb=Fs	m b f × a l × [((8	3-n²×(4-n))² /16)-	4+n×(4-n)1/8 =	1.7 kNm/m
Saturated backfill		Mw s = Fs s	$f \times [a ^2 \times \mathbf{x} \times ((5 \times 1)^2)]$	L)-aı)/(20×L³)-(x-t	$(3 \times a^2)$ = 0	kNm/m
Water		M _w water = F	s water f × la ² ×x	×((5×L)-aı)/(20×I	³)-(x-bi) ³ /(3×ai ²	²)] = 0.1
kNm/m					, , ., . (e. al	/



Tekla. Tedds	Project	26 Amyand Park	Road TW1 3H	E	Job no. 23 227	
NMN Partnership	Calcs for RC wall 2	to extension of	o extension of basement and wall above			evision 2 19
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Check retaining wall deflection	on	
Basic span/effective depth ratio)	ratio _{bas} = 20
Design service stress		$f_s = 2 \times f_y \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = 286.4 \text{ N/mm}^2$
Modification factor	factor _{tens} = min(0.55	+ (477 N/mm ² - f _s)/(120 × (0.9 N/mm ² + (M _{stem} /(b × d _{stem} ²)))),2) = 1.22
Maximum span/effective depth	ratio	ratio _{max} = ratio _{bas} × factor _{tens} = 24.37
Actual span/effective depth ratio	0	ratio _{act} = h _{stem} / d _{stem} = 18.60
		PASS - Span to depth ratio is acceptable

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NMN Partnership	Calcs for RC wall 2	to extension of	Start page no./Re RW	vision 2 20		
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Indicativo rotaining wall roinfe	rcomont diagr	am				
		II reinforcement	Stem re	einforcement		

Toe reinforcement

Toe bars - 16 mm dia.@ 150 mm centres - $(1340 \text{ mm}^2/\text{m})$ Wall bars - 12 mm dia.@ 200 mm centres - $(565 \text{ mm}^2/\text{m})$ Stem bars - 16 mm dia.@ 200 mm centres - $(1005 \text{ mm}^2/\text{m})$

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Moist density of retained material

γm = **18.0** kN/m³

P						
Tekla Tedds	Project	Job no.	Job no. 23 227			
		26 Amyand Pan	23	3 221		
	Calcs for RC	wall 3 to of bas	a pool	Start page no./F	Revision V3 21	
	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	NM	02/05/2024	Oneoked by		hppioved by	
			ļ			
Saturated density of retained ma	aterial	γs = 21.0 kM	N/m ³			
Design shear strength		φ' = 24.2 d€	eg			
Angle of wall friction		δ = 0.0 deg				
Base material details						
Moist density		γ _{mb} = 18.0 k	kN/m³			
Design shear strength		φ'₅ = 24.2 d	eg			
Design base friction		δ _b = 18.6 de	eg			
Allowable bearing pressure		Pbearing = 15	0 kN/m²			
Using Coulomb theory						
Active pressure coefficient for re	etained material					
K _a = sin(α	+ $\phi')^2$ / (sin(α) ² ×	$sin(\alpha - \delta) \times [1 + $	$\sqrt{(\sin(\phi' + \delta))}$	$\sin(\phi' - \beta) / (\sin$	$(\alpha - \delta) \times \sin(\alpha +$	$(\beta)))]^2) = 0.419$
Passive pressure coefficient for	base material					
	K _p = sin(9	0 - φ'ь)² / (sin(90) - δ⊳) × [1 - √(s	$in(\phi'_{P} + \delta_{P}) \times sin$	(¢'ь) / (sin(90 +	δ _b)))] ²) = 4.187
At-rest pressure						
At-rest pressure for retained ma	iterial	K₀ = 1 – sir	n(φ') = 0.590			
Loading details						
Surcharge load on plan		Surcharge	= 10.0 kN/m ²			
Applied vertical dead load on wa	all	W _{dead} = 0.0	kN/m			
Applied vertical live load on wall	I	W _{live} = 5.0	kN/m			
Position of applied vertical load	on wall	l _{load} = 1675	mm			
Applied horizontal dead load on	wall	F _{dead} = 0.0	kN/m			
Applied horizontal live load on w	vall	F _{live} = 0.0 k	N/m			
Height of applied horizontal load	d on wall	h _{load} = 0 mr	n			
			5 1	10		
			Y			
					A A	
Frop						
14.3			0.7	4.2 6.0	4.7 9.8	
				Loads sho	wn in kN/m, pressur	res shown in kN/m ²
Vertical forces on wall						
Wall stem		Wwall = hstem	\times t _{wall} \times γ_{wall} =	7.6 kN/m		

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NMN Partnership	Calcs for	RC wa	1.3 to of ba	isement swimir	na pool	Start page no./Revision RW3 22			
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Wall base			Whase = hase	e X thase X Vhase	= 8 kN/m				
Applied vertical load			$W_v = W_{deal}$	d + Wlive = 5 kN	/m				
Total vertical load			W _{total} = w _{wa}	all + Wbase + W_v	= 20.6 kN/m				
Horizontal forces on wall									
Surcharge			F _{sur} = K _a ×	Surcharge × h	_{eff} = 7.5 kN/m				
Moist backfill above water table			Fm a = 0.5	× K _a × γ _m × (h _{ef}	_f - h _{water}) ² = 2.4 kl	N/m			
Moist backfill below water table			$F_{m b} = K_a >$	<γ _m × (h _{eff} - h _{wat}	, ter) × h _{water} = 6 kN	/m			
Saturated backfill			$F_{s} = 0.5 \times$, Ka × (γs-γwater) >	× h _{water} ² = 2.3 kN/	'n			
Water			F _{water} = 0.5	$\times h_{water}^2 \times \gamma_{water}$	r = 4.9 kN/m				
Total horizontal load			F _{total} = F _{sur}	+ F _{m a} + F _{m b} +	- F _s + F _{water} = 23.	2 kN/m			
Calculate propping force									
Passive resistance of soil in from	t of wall		$F_{\rm D} = 0.5 \times$	$K_{\rm p} \times \cos(\delta_{\rm b}) \times (\delta_{\rm b})$	dcover + tbase + dds	$(-d_{exc})^2 \times \gamma_{mb} =$	1.4 kN/m		
Propping force			$F_{\text{prop}} = \max(F_{\text{total}} - F_{\text{p}} - (W_{\text{total}} - W_{\text{live}}) \times \tan(\delta h) = 0 \text{ kN/m})$						
			$F_{prop} = 16.5 \text{ kN/m}$						
Overturning moments									
Surcharge			M _{sur} = F _{sur}	imes (h _{eff} - 2 $ imes$ d _{ds}) / 2 = 6.8 kNm/n	n			
Moist backfill above water table			$M_{m_a} = F_{m_a}$	$a \times (h_{eff} + 2 \times h)$	water - $3 \times d_{ds}$) / 3	= 3.1 kNm/m			
Moist backfill below water table			$M_{m_b} = F_{m_b}$	_b × (h _{water} - 2 ×	d _{ds}) / 2 = 3 kNm/	m			
Saturated backfill			$M_s = F_s \times ($	h_{water} - 3 $ imes$ d _{ds})	/ 3 = 0.8 kNm/m				
Water			M_{water} = F _{water} × (h _{water} - 3 × d _{ds}) / 3 = 1.6 kNm/m						
Total overturning moment			$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 15.3 \text{ kNm/m}$						
Restoring moments									
Wall stem			Mwall = Wwal	$I \times (I_{\text{toe}} + t_{\text{wall}} / 2)$	2) = 12.1 kNm/m				
Wall base			Mbase = Wba	ase \times Ibase / 2 = 6	5.8 kNm/m				
Total restoring moment			M _{rest} = M _{wa}	II + M _{base} = 18.9	kNm/m				
Check bearing pressure									
Design vertical live load			M _{live} = W _{live}	e × I _{load} = 8.4 kN	lm/m				
Total moment for bearing			Mtotal = Mres	st - Mot + Mlive =	12 kNm/m				
Total vertical reaction			R = W _{total} =	= 20.6 kN/m					
Distance to reaction			x _{bar} = M _{total} / R = 584 mm						
Eccentricity of reaction			e = abs((l _b	_{ase} / 2) - x _{bar}) =	266 mm				
					Reaction acts	within middle	e third of ba		
Bearing pressure at toe			ptoe = (R / I	$(base) + (6 \times R \times R)$	$e / I_{base^2} = 23.5$	kN/m²			
Bearing pressure at heel		D 4 0 0	pheel = (R /	Ibase) - (6 × R ×	$e / I_{base^2} = 0.7 k$	N/m²			
	- F	- 65A-	waximum l	pearing pressi	ure is less than	allowable dea	iring pressu		

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NMN Partnership	Calcs for					Start page no./Re	evision
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	Calcs by NM	Calcs date 02/05/2)24	Checked by	Checked date	Approved by	Approved date
	1	ļ			1		1
RETAINING WALL DESIGN (B	S 8002:1994))					
					-	TEDDS calculation	version 1.2.01.08
Ultimate limit state load factor	rs						
Dead load factor		$\gamma_{f_d} = \gamma_{f_d}$	1.4				
Live load factor		γ _{f_l} = 1	.6				
Earth and water pressure factor		γ _{f_e} = '	1.4				
Factored vertical forces on wa	all						
Wall stem		Wwall_f	= γf_d	\times h _{stem} \times t _{wall} \times γ	wall = 10.6 kN/m		
Wall base		Wbase_f	= γ _{f_c}	$1 imes I_{base} imes t_{base} imes t_{base}$	_{γbase} = 11.2 kN/r	n	
Applied vertical load		W _{v_f} =	γf_d >	$\langle W_{dead} + \gamma_{f_l} \times W_{dead}$	/ _{live} = 8 kN/m		
Total vertical load		Wtotal_	= w _v	/all_f + Wbase_f + W	/ _{v_f} = 29.8 kN/m		
Factored horizontal active for	ces on wall						
Surcharge		F _{sur_f} =	= γ _{f_l} ×	$K_a \times Surcharge$	e × h _{eff} = 12.1 kN	/m	
Moist backfill above water table		$F_{m_a_f}$	= γ _{f_e}	$\times ~0.5 \times K_a \times \gamma_m$	\times (h _{eff} - h _{water}) ² =	3.4 kN/m	
Moist backfill below water table		$F_{m_b_f}$	= γ _{f_e}	$\times \ K_a \times \gamma_m \times (h_{\text{eff}}$	- h_{water}) × h_{water} =	8.4 kN/m	
Saturated backfill		$F_{s_f} =$	γf_e ×	$0.5 \times K_a \times (\gamma_{s} - \gamma_{v})$	water) \times h _{water} ² = 3.	. 3 kN/m	
Water		F _{water_1}	= γ _{f_}	$_{e} imes 0.5 imes h_{water}^{2} imes$	< γ _{water} = 6.9 kN/i	m	
Total horizontal load		Ftotal_f	= Fsur	$f + F_{m_a_f} + F_{m_t}$	b_f + Fs_f + Fwater_f	= 34 kN/m	
Calculate propping force							
Passive resistance of soil in fror	nt of wall	$F_{p_f} =$	γf_e ×	$0.5 \times K_p \times \cos(\delta)$	δ_b) × (d _{cover} + t _{base}	$e + d_{ds} - d_{exc})^2 \times$	$\gamma_{mb} = 2 \text{ kN/m}$
Propping force F _{prop_f} = ma:			$f = max(F_{total_f} - F_{p_f} - (W_{total_f} - \gamma_{f_l} \times W_{live}) \times tan(\delta_b), 0 \text{ kN/m})$				
		Fprop_f	= 24.	7 kN/m			
Factored overturning moment	ts						
Surcharge		Msur_f	= F _{sur}	$_{f} \times (h_{eff} - 2 \times d_{d})$	s) / 2 = 10.8 kNn	n/m	
Moist backfill above water table		M _{m_a_f}	= Fm	$_a_f \times (h_{eff} + 2 \times h)$	h _{water} - $3 \times d_{ds}$) / 3	8 = 4.3 kNm/m	
Moist backfill below water table		M _{m_b_f}	= Fm	$_{b_f} \times (h_{water} - 2 \times$	(d _{ds}) / 2 = 4.2 kN	lm/m	
Saturated backfill		$M_{s_f} =$	Fs_f ≻	\sim (h _{water} - 3 \times d _{ds})) / 3 = 1.1 kNm/m	า	
Water		M _{water} _	$f = F_v$	$_{vater_f} \times (h_{water} - 3)$	$\times d_{ds}) / 3 = 2.3 k$	Nm/m	
Total overturning moment		Mot_f =	Msur	_f + Mm_a_f + Mm_	b_f + Ms_f + Mwater	_f = 22.7 kNm/ı	n
Restoring moments							
Wall stem		Mwall_f	= Wwa	all_f \times (Itoe + twall / 2	2) = 16.9 kNm/m	1	
Wall base		Mbase_	= Wb	$ase_f \times I_{base} / 2 = 3$	9.5 kNm/m		
Design vertical load		Mv_f =	Wv_f	× Iload = 13.4 kN	m/m		
Total restoring moment		M _{rest_f}	= Mw	all_f + M _{base_f} + M	_{v_f} = 39.9 kNm/m	n	
Factored bearing pressure							
Total moment for bearing		Mtotal_f	= Mre	est_f - Mot_f = 17.1	kNm/m		
Total vertical reaction		R _f = V	/total_f	= 29.8 kN/m			
Distance to reaction		Xbar_f =	• M _{tota}	i_f / Rf = 575 mm	ן בבב		
Eccentricity of reaction		e _f = al	DS((Iba	ase / 2) - Xbar_f) = 1	275 mm	within middle	third of booo
Boaring prossure at too		D	(D,)		Reaction acts V	$k N m^2$	
Bearing pressure at loe			= (P	$(U \times IXI \times$	$(\Theta_f / _{hass}^2) = 0.5$	kN/m^2	
Rate of change of base reaction	1	rate =	(ptoe	$f = D_{heel} f / I_{hace} =$	= 20.01 kN/m ² /m		
Bearing pressure at stem / toe	-	Dstem to	ve f =	max(p _{toe f} - (rate	$a \times I_{toe}$), 0 kN/m ²)	= 4.5 kN/m ²	
		1.00011_0		(1 (,,,		

Tekla Tedds	Project Job 26 Amyand Park Road TW1 3HE					3 227
NMN Partnership	Calcs for	•			Start page no /	Revision
	R	C wall 3 to of bas	sement swimin	RW3 24		
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	NM	02/05/2024				
Bearing pressure at mid stem		pstem_mid_f =	max(p _{toe_f} - (ra	te $ imes$ (Itoe + t _{wall} / 2	2)), 0 kN/m²) = 2	2.5 kN/m ²
Bearing pressure at stem / heel		$p_{stem_heel_f} =$	max(p _{toe_f} - (ra	ate × (I _{toe} + t _{wall})),	0 kN/m²) = 0.5	kN/m ²
Design of reinforced concrete	retaining wa	ll toe (BS 8002:1	994 <u>)</u>			
Material properties						
Characteristic strength of concre	ete	f _{cu} = 40 N/r	nm²			
Characteristic strength of reinfo	rcement	fy = 500 N/r	mm²			
Base details						
Minimum area of reinforcement		k = 0.13 %				
Cover to reinforcement in toe		c _{toe} = 50 m	m			
Calculate shear for toe desigr	ı					
Shear from bearing pressure		V _{toe_bear} = (Otoe_f + Pstem_toe_	_f) × I _{toe} / 2 = 29.3	kN/m	
Shear from weight of base		Vtoe_wt_base =	= $\gamma f_d \times \gamma pase \times Ite$	$be \times tbase = 9.9 kN$	l/m	
Total shear for toe design		$V_{toe} = V_{toe_t}$	ear - Vtoe_wt_base	= 19.4 kN/m		
Calculate moment for toe des	ign		_			
Moment from bearing pressure		M _{toe_bear} = ($2 \times p_{toe_f} + p_{ster}$	n_mid_f) × (Itoe + t _{wa}	$(11.1)^2 / 6 = 30.$	6 kNm/m
Moment from weight of base		Mtoe_wt_base	= (γf_d × γbase ×	$t_{base} \times (I_{toe} + t_{wall})$	(2) ² / 2) = 8.5 k	(Nm/m
Total moment for toe design		Mtoe = Mtoe_	bear - Mtoe_wt_base	_e = 22.1 kNm/m		
	•	•	•	•	•	
	⊲ —200-					
Check toe in bending		h - 1000 m				
Depth of roinforcement		n 0001 – d	(h / 2)	- 111 0 mm		
		Utoe – Lbase –	$-Ctoe - (\psi toe / Z)$	- 144.0 mm		
CONSIGNI		Ntoe – Witoe /) – 0.021 Compression re	inforcement is	s not required
Lever arm		z _{toe} = min(0).5 + √(0.25 - (I	min(K _{toe} , 0.225)	(0.9)),0.95) × c	Itoe
	- au vince al	z _{toe} = 137 r	nm M ((0.07.5		-21	
Area of tension reinforcement re	equirea	As_toe_des =	Witce / (U.87 × Ty	$7 \times Z_{\text{toe}} = 371 \text{ mm}^2$	n-/m	
		As_toe_min -	$X \times D \times \text{Lbase} - 2$	(00 mm /m (00 mm /m	mm^2/m	
Reinforcement provided	equired	12 mm dia	hars @ 200 n	ns_toe_min) = 37 1 1		
Area of reinforcement provided		$A_{s \text{ toe prov}} =$	565 mm ² /m			
		PASS - Rein	forcement pro	ovided at the re	taining wall to	e is adequate
Check shear resistance at toe	•					
Design shear stress		v _{toe} = V _{toe} /	(b × d _{toe}) = 0.1	35 N/mm ²		
Allowable shear stress		v _{adm} = min(0.8 × √(fcu / 1 №	N/mm²), 5) × 1 N/	/mm² = 5.000 N	N/mm ²
		PASS -	Design shear	^r stress is less t	han maximun	n shear stress
From BS8110:Part 1:1997 – Ta	able 3.8					
Design concrete shear stress		v _{c_toe} = 0.6	99 N/mm ²			
			Vto	_e < v _{c_toe} - No sł	near reinforce	ment required

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NMN Partnership	Calcs for	C wall 3 to of bas	sement swimir	ng pool	Start page no./Re	evision 3 25			
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date			
Design of reinforced concrete	retaining wa	III stem (BS 8002	:1994)						
Material properties									
Characteristic strength of concre	ete	f _{cu} = 40 N/n	nm²						
Characteristic strength of reinfor	rcement	f _y = 500 N/r	mm²						
Wall details									
Minimum area of reinforcement		k = 0.13 %							
Cover to reinforcement in stem		c _{stem} = 50 n	nm						
Cover to reinforcement in wall		c _{wall} = 50 m	m						
Factored horizontal active for	ces on stem								
Surcharge		$F_{s_sur f} = \gamma_{f}$	\times K _a \times Surcha	$arge \times (h_{eff} - t_{base} -$	d _{ds}) = 10.7 kN/	m			
Moist backfill above water table		F _{smaf} = 0.	$.5 imes \gamma_{\rm fe} imes {\sf K}_{ m a} imes$	$\gamma_{\rm m} \times (h_{\rm eff} - t_{\rm base} - c$	l _{ds} - h _{sat}) ² = 3.4	kN/m			
Moist backfill below water table		$F_{smb}f = \gamma_f$	$e \times K_a \times \gamma_m \times ($	heff - tbase - dds - h	, sat) × hsat = 6.7 k	N/m			
Saturated backfill		$F_{s,s,f} = 0.5$,	s- v_{water} × h _{sat} ² = 2	2.1 kN/m				
Water		$F_{s_s} = 0.0$	$5 \times 1\% \times 1\%$	$r \times h_{act}^2 = 4.4 \text{ kN}/$	m				
			.o ~ n_e ~ nwate						
Calculate shear for stem desig	gn	.v. =				0.7.1.1.1			
Shear at base of stem		Vstem = Fs_s	ur_f + 	$Fs_m_b_f + Fs_s_f +$	Fs_water_f - Fprop_t	= 2.7 kin/m			
Calculate moment for stem de	esign								
Surcharge		$M_{s_{sur}} = F_{s_{s}}$	sur_f × (hstem + ti	_{base}) / 2 = 9.6 kNn	n/m				
Moist backfill above water table		Ms_m_a = Fs	$M_{s_m_a} = F_{s_m_a_f} \times (2 \times h_{sat} + h_{eff} - d_{ds} + t_{base} / 2) / 3 = 3.9 \text{ kNm/m}$						
Moist backfill below water table		$M_{s_m_b} = F_{s_b}$	_m_b_f \times hsat / 2	= 2.7 kNm/m					
Saturated backfill		$M_{s_s} = F_{s_s}$	f × h _{sat} / 3 = 0.	6 kNm/m					
Water		Ms_water = Fs	s_water_f × hsat / 3	3 = 1.2 kNm/m					
Total moment for stem design		M _{stem} = M _{s_}	_{sur} + M _{s_m_a} + N	$M_{s_m_b} + M_{s_s} + M_{s_s}$	_ _{water} = 18 kNm/	'n			
	•	•	•	•	•				
	∢ 200								
Check wall stem in bending									
		b = 1000 m	ım/m						
Width of wall stem	reinforcement								
Width of wall stem Depth of reinforcement		d _{stem} = t _{wall} -	− C _{stem} − (\$ _{stem} /	(2) = 144.0 mm					
Width of wall stem Depth of reinforcement Constant		d _{stem} = t _{wall} - K _{stem} = M _{ste}	– C _{stem} – (φ _{stem} / _m / (b × d _{stem} ² ×	′ 2) = 144.0 mm < f _{cu}) = 0.022					
Width of wall stem Depth of reinforcement Constant		d _{stem} = t _{wall} - K _{stem} = M _{ste}	– Cstem – (φstem / m / (b × dstem ² ×	(2) = 144.0 mm < f _{cu}) = 0.022 Compression rea	inforcement is	not required			
Width of wall stem Depth of reinforcement Constant Lever arm		d _{stem} = t _{wall} - K _{stem} = M _{ste} z _{stem} = min(- C _{stem} - (∮ _{stem} / m / (b × d _{stem} ² × (0.5 + √(0.25 -	(2) = 144.0 mm (f _{cu}) = 0.022 Compression rea (min(Kstem, 0.225)	i nforcement is) / 0.9)),0.95) ×	<i>not required</i> d _{stem}			
Width of wall stem Depth of reinforcement Constant Lever arm		d _{stem} = t _{wall} - K _{stem} = M _{ste} z _{stem} = min(z _{stem} = 137	- C _{stem} - (¢ _{stem} / m / (b × d _{stem} ² × (0.5 + √(0.25 - mm	(2) = 144.0 mm (f _{cu}) = 0.022 Compression rea (min(Kstem, 0.225	i nforcement is) / 0.9)),0.95) ×	<i>not required</i> d _{stem}			
Width of wall stem Depth of reinforcement Constant Lever arm Area of tension reinforcement re	equired	d _{stem} = t _{wall} - K _{stem} = M _{ste} Z _{stem} = min(Z _{stem} = 137 A _{s_stem_des} =	- C _{stem} - (¢ _{stem} / m / (b × d _{stem} ² × 0.5 + √(0.25 - mm Mstem / (0.87 >	(2) = 144.0 mm (f _{cu}) = 0.022 Compression rea (min(Kstem, 0.225) (f _y × z _{stem}) = 303	i nforcement is) / 0.9)),0.95) × mm²/m	<i>not required</i> d _{stem}			
Width of wall stem Depth of reinforcement Constant Lever arm Area of tension reinforcement re Minimum area of tension reinfor	equired cement	d _{stem} = t _{wall} - K _{stem} = M _{ste} z _{stem} = min(z _{stem} = 137 A _{s_stem_des} = A _{s_stem_min} =	- c _{stem} - (\$\$tem / m / (b × d _{stem} ² × 0.5 + √(0.25 - mm : M _{stem} / (0.87 × : k × b × t _{wall} = 2	⁽ 2) = 144.0 mm (f _{cu}) = 0.022 Compression re (min(Kstem, 0.225 (f _y × z _{stem}) = 303 260 mm ² /m	i nforcement is) / 0.9)),0.95) × mm²/m	<i>not required</i> d _{stem}			
Width of wall stem Depth of reinforcement Constant Lever arm Area of tension reinforcement re Minimum area of tension reinfor Area of tension reinforcement re	equired cement equired	d _{stem} = t _{wall} - K _{stem} = M _{ste} Z _{stem} = min(Z _{stem} = 137 A _{s_stem_des} = A _{s_stem_min} = A _{s_stem_req} =	- Cstem - (¢stem / m / (b × dstem ² × 0.5 + √(0.25 - mm Mstem / (0.87 × k × b × t _{wall} = 2 Max(As_stem_de	<pre>(2) = 144.0 mm (fcu) = 0.022 Compression red (min(Kstem, 0.225 (fy × Zstem) = 303 260 mm²/m s, As_stem_min) = 30</pre>	i nforcement is) / 0.9)),0.95) × mm²/m 3 mm²/m	<i>not required</i> d _{stem}			
Width of wall stem Depth of reinforcement Constant Lever arm Area of tension reinforcement re Minimum area of tension reinforcement re Reinforcement provided	equired cement equired	d _{stem} = t _{wall} - K _{stem} = M _{ste} Z _{stem} = min(Z _{stem} = 137 A _{s_stem_des} = A _{s_stem_min} = A _{s_stem_req} = 12 mm dia	- Cstem - (¢stem / m / (b × d _{stem} ² × 0.5 + √(0.25 - mm : M _{stem} / (0.87 × : k × b × t _{wall} = 2 Max(As_stem_de .bars @ 200 r	f 2) = 144.0 mm < f _{cu}) = 0.022 Compression rea (min(Kstem, 0.225 < f _y × Zstem) = 303 260 mm ² /m s, As_stem_min) = 30 mm centres	i nforcement is) / 0.9)),0.95) × mm²/m 3 mm²/m	<i>not required</i> d _{stem}			
Width of wall stem Depth of reinforcement Constant Lever arm Area of tension reinforcement re Minimum area of tension reinforcement re Area of tension reinforcement re Reinforcement provided Area of reinforcement provided	equired cement equired	d _{stem} = t _{wall} - K _{stem} = M _{ste} z _{stem} = min(z _{stem} = 137 A _{s_stem_des} = A _{s_stem_min} = A _{s_stem_req} = 12 mm dia A _{s_stem_prov} =	- Cstem - (¢stem / m / (b × dstem ² × (0.5 + √(0.25 - mm ≅ Mstem / (0.87 × k × b × twall = 2 Max(As_stem_de .bars @ 200 r = 565 mm ² /m	<pre>(2) = 144.0 mm (fcu) = 0.022 Compression red (min(Kstem, 0.225 (fy × Zstem) = 303 260 mm²/m s, As_stem_min) = 30 nm centres</pre>	i nforcement is) / 0.9)),0.95) × mm²/m 3 mm²/m	<i>not required</i> d _{stem}			

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Tekla Tedds	Project				Job no.	<u>-</u>
		26 Amyand Par	23	23 227		
NMN Partnership	Calcs for				Start page no./R	evision
	R	C wall 3 to of ba	sement swimiı	ıg pool	RM	/3 26
	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	NM	02/05/2024				
				I		
Check shear resistance at wa	II stem					
Design shear stress		V _{stem} = V _{sten}	_ / (b × d _{stem}) =	0 018 N/mm ²		
		vstem vstem	(0.9)	N/mm^2 E 1.1 N/	/mm2 - E 000 N	1/m m ²
Allowable shear stress		Vadm – IIIII	U.8 × V(Icu / I I	N/mm⁻), 5) × 1 N/	mm 5.000 iv	/mni-
		PASS -	Design snea	r stress is less t	han maximum	shear stress
From BS8110:Part 1:1997 – Ta	able 3.8					
Design concrete shear stress		Vc_stem = 0.6	699 N/mm²			
			Vstem	< Vc_stem - No sh	near reinforcen	nent required
Check retaining wall deflection	on					
Basic span/effective depth ratio		ratio _{bas} = 7				
Design service stress		$f_s = 2 \times f_y \times$	As_stem_req / (3	× As_stem_prov) = 17	78.4 N/mm ²	
Modification factor	factor _{tens} = mi	n(0.55 + (477 N/m	nm² - f₅)/(120 ×	: (0.9 N/mm ² + (N	$d_{\text{stem}}/(b \times d_{\text{stem}}^2)$))),2) = 1.96
Maximum span/effective depth	ratio	ratio _{max} = ra	$atio_{bas} imes factori$	_{iens} = 13.70		
Actual span/effective depth ratio	C	ratio _{act} = hs	stem / dstem = 11	.11		
				PASS - Span	to depth ratio	is acceptable

Tekla. Tedds	Project	26 Amyand Parl	Job no. 23 227			
NMN Partnership	Calcs for RC	Start page no./Revision RW3 27				
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
	•	•		•	•	



Toe bars - 12 mm dia.@ 200 mm centres - (565 mm²/m) Stem bars - 12 mm dia.@ 200 mm centres - (565 mm²/m)

Tekla. Tedds	Project	26 Amyand Parl	Job no. 23 227			
NMN Partnership	Calcs for RC	Start page no./Revision RW4 27				
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
	•	•		•	•	



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Tekla Tedds	S Project Job no. Job no.					
NMN Partnership	Calcs for				Start page no./Re	evision
	RC	RC wall 4 to of basement & Party wall				4 28
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
Caturated density of rateined m	otorial	24.0 kM	1/m3			
Saturated density of retained m	aterial	γs = 21.0 Kľ	N/M°			
Angle of wall friction		φ - 24.2 de	eg			
		o – 0.0 dey				
Base material details		49.01	(N1/m3			
		$\gamma_{mb} = 10.01$				
Design shear strength		φ _b = 24.2 d	eg			
Alloweble beering pressure		$O_{\rm b} = 10.0$ U				
Allowable bearing pressure		F bearing - 13				
Using Coulomb theory	to in a diverte vial					
Active pressure coefficient for fe	etained material $\frac{1}{2}$	oin($\sin(4! = 0)/(\sin(a))$	S) cip/a. l	0)))12) - 0 440
$\kappa_a = \sin(\alpha)$	+ φ)- / (Sin(α)- ×	$\sin(\alpha - \delta) \times [1 +$	$-\sqrt{(\sin(\phi + \delta) \times s)}$	sin(φ - β) / (sin(α	$- o) \times \sin(\alpha + \mu)$	()))] ⁻) = 0.419
rassive pressure coefficient for	$K_{\rm p} = \sin(9)$	በ _ ሐ' _ካ) ² / (sin/ዓር) - δ⊧) × [1 - √(sin	$a(a'_{b} + \delta_{b}) \times sin(a)$	'ь) / (sin(90 + δ	$(h)))(1^2) = 4.187$
						<i>s)))</i>])e.
At-rest pressure	atorial	K₀ = 1 _ sir	v(#') – 0 590			
	licitat	100 - 1 - 31	ι(φ) – 0.000			
Loading details		Surabarga	-10.0 kN/m ²			
Applied vertical dead load on w	all	W _{dood} = 75	0 kN/m			
Applied vertical live load on wal		Wive = 5.0	kN/m			
Position of applied vertical load	on wall	l _{load} = 1675	mm			
Applied horizontal dead load on	wall	F _{dead} = 0.0	kN/m			
Applied horizontal live load on v	vall	F _{live} = 0.0 k	N/m			
Height of applied horizontal load	d on wall	h _{load} = 0 mr	n			
			80 ↓ 10			
		Prop —				
21.4			4.2 1	7.3 4.7 9.8		
	63.3		63.3			
				Loads showr	ו in kN/m, pressure	es shown in kN/m²
Vertical forces on wall						
Wall stem		w _{wall} = h _{stem}	$\times t_{wall} \times \gamma_{wall}$ = 2	1.2 kN/m		

Tekla, Tedds	Project	26 Amyand Par	Job no. 23 227						
NMN Partnership	Calcs for				Start page no./F	Revision			
	R	C wall 4 to of ba	sement & Par	rty wall	RW4 29				
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date			
Wall base		Wbase = Ibase	$h \times t$ base $\times \gamma$ base	= 12.7 kN/m					
Applied vertical load		$W_v = W_{dead}$	i + W _{live} = 80 k	N/m					
Total vertical load	W_{total} = W_{wall} + W_{base} + W_v = 114 kN/m								
Horizontal forces on wall									
Surcharge		F_{sur} = $K_a imes$	Surcharge × h	_{eff} = 13.8 kN/m					
Moist backfill above water table		$F_{m_a} = 0.5$	$ imes$ Ka $ imes$ γ_m $ imes$ (h _{ef}	_{ff} - h _{water}) ² = 19.9 I	kN/m				
Moist backfill below water table		$F_{m_b} = K_a \times$	γ _m × (h _{eff} - h _{wa}	_{ter}) × h _{water} = 17.3	kN/m				
Saturated backfill		$F_s = 0.5 \times$	Ka × (γs- γwater) :	\times h _{water} ² = 2.3 kN/	′m				
Water		F _{water} = 0.5	$\times \ h_{water}{}^2 \times \gamma_{water}$	r = 4.9 kN/m					
Total horizontal load		$F_{total} = F_{sur}$	+ F _{m_a} + F _{m_b} +	+ F _s + F _{water} = 58.	3 kN/m				
Calculate total propping force)								
Passive resistance of soil in from	nt of wall	$F_p = 0.5 \times$	$F_{\text{P}} = 0.5 \times K_{\text{P}} \times \text{cos}(\delta_{\text{b}}) \times (d_{\text{cover}} + t_{\text{base}} + d_{\text{ds}} - d_{\text{exc}})^2 \times \gamma_{\text{mb}} = 3.2 \text{ kN/m}$						
Propping force	F _{prop} = max F _{prop} = 18.4	$F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta_b), 0 kN/m)$ $F_{prop} = 18.4 kN/m$							
Overturning moments									
Surcharge		$M_{sur} = F_{sur}$	× (h _{eff} - 2 × d _{ds}) / 2 = 22.8 kNm/	′m				
Moist backfill above water table		$M_{m_a} = F_{m_a}$	$_{a} \times (h_{eff} + 2 \times h)$	water - 3 × d _{ds}) / 3	= 35.2 kNm/m				
Moist backfill below water table		$M_{m_b} = F_{m_b}$	$M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 8.7 \text{ kNm/m}$						
Saturated backfill		$M_s = F_s \times ($	h_{water} - $3 imes d_{ds}$)	/ 3 = 0.8 kNm/m					
Water		M _{water} = F _{wa}	ater × (h _{water} - 3 :	× d _{ds}) / 3 = 1.6 kN	lm/m				
Total overturning moment		Mot = Msur -	+ Mm_a + Mm_b ·	+ Ms + M _{water} = 69).1 kNm/m				
Restoring moments									
Wall stem		M _{wall} = w _{wal}	\times (Itoe + t _{wall} / 2	2) = 35 kNm/m					
Wall base		M _{base} = w _{ba}	se × Ibase / 2 = 1	1 1.5 kNm/m					
Design vertical load		$M_v = W_v \times$	l _{load} = 134 kNm	ı/m	'n				
Total restoring moment		M _{rest} = M _{wa}	$H + M_{base} + M_v =$	= 180.5 kNm/m					
Check bearing pressure									
Total vertical reaction		R = W _{total} =	• 114.0 kN/m						
Distance to reaction		x _{bar} = I _{base} /	x _{bar} = I _{base} / 2 = 900 mm						
Eccentricity of reaction		e = abs((lba	ase / 2) - x _{bar}) =	0 mm					
				Reaction acts	within middle	e third of base			
Bearing pressure at toe		p _{toe} = (R / I	$_{base})$ - (6 $ imes$ R $ imes$	e / I _{base} ²) = 63.3 k	κN/m²				
Bearing pressure at heel		$p_{heel} = (R / $	I_{base}) + (6 × R $>$	× e / I _{base} ²) = 63.3	kN/m ²				
	PA	SS - Maximum L	pearing press	ure is less than	allowable bea	ring pressure			
Calculate propping forces to t	top and base o	of wall							
Propping force to top of wall									
	F _{prop_}	top = (Mot - Mrest +	$R \times I_{\text{base}}$ / 2 - F	$F_{prop} imes t_{base} / 2) / (I$	h _{stem} + t _{base} / 2)	= -3.690 kN/m			

Propping force to base of wall

 $F_{prop_top} = (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = -3.690 \text{ kN/m}$ $F_{prop_base} = F_{prop} - F_{prop_top} = 22.109 \text{ kN/m}$
Tekla Tedds	Project Job no. 26 Amyand Park Road TW1 3HE 23 227					
NMN Partnership	Calcs for F	RC wall 4 to of ba	sement & Part	v wall	Start page no./Re	evision 4 30
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
RETAINING WALL DESIGN (B	S 8002·1994	<u> </u>		-	1	•
	<u></u>	<u>-</u>		-	FEDDS calculation	version 1.2.01.08
Ultimate limit state load factor	S					
Live lead factor		γf_d - 1.4				
		$\gamma_{f} = 1.6$				
Earth and water pressure factor		γf_e - 1 .4				
Factored vertical forces on wa	all					
Wall stem		$W_{wall_f} = \gamma_{f_d}$	× hstem × twall × γ	wall = 29.7 kN/m		
Wall base		W base_f = γ f_c	$1 \times I_{\text{base}} \times \mathbf{t}_{\text{base}} \times t$	γ _{base} = 17.8 kN/n	n	
Applied vertical load		$W_{v_f} = \gamma_{f_d}$	$\langle W_{dead} + \gamma_{f_l} \times V$	V _{live} = 113 kN/m		
l otal vertical load		W total_f = Ww	/all_f + Wbase_f + V	Vv_f = 160.6 kN/m	1	
Factored horizontal active for	ces on wall					
Surcharge		$F_{sur_f} = \gamma_{f_l} \times$	$K_a \times Surcharge$	e × h _{eff} = 22.1 kN	/m	
Moist backfill above water table		$F_{m_a_f} = \gamma_{f_e}$	$\times 0.5 \times K_a \times \gamma_m$	$\times (h_{eff} - h_{water})^2 =$	27.9 kN/m	
Moist backfill below water table		$F_{m_b_f} = \gamma_{f_e}$	$\times \text{K}_{a} \times \gamma_{m} \times (h_{eff})$	- h _{water}) × h _{water} =	24.3 kN/m	
Saturated backfill		$F_{s_f} = \gamma_{f_e} \times$	0.5 × K _a × (γ _s - γ	$(water) \times h_{water}^2 = 3.$	3 kN/m	
Water		$F_{water_f} = \gamma_{f_e}$	$a \times 0.5 \times h_{water}^2$:	< γ _{water} = 6.9 kN/r	m	
Total horizontal load		F _{total_f} = F _{sur}	_f + Fm_a_f + Fm_	b_f + Fs_f + Fwater_f	= 84.4 kN/m	
Calculate total propping force						
Passive resistance of soil in fror kN/m	t of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 \times K_p \times \cos($	$\delta_{b}) imes (d_{cover} + t_{base})$	e + d _{ds} - d _{exc}) ² ×	: γ _{mb} = 4.5
Propping force		F _{prop_f} = ma F _{prop_f} = 28.	x(F _{total_f} - F _{p_f} - (5 kN/m	W_{total_f} - $\gamma_{f_l} \times W_{liv}$	$_{\sf re}) imes tan(\delta_{\sf b}), 0 {\sf I}$	κN/m)
Factored overturning moment	'e					
Surcharge		Msur f = Fsur	$f \times (h_{eff} - 2 \times d)$	ls) / 2 = 36.5 kNm	ı/m	
Moist backfill above water table		Mm a f = Fm		hwater - 3 × dds) / 3	 3 = 49.3 kNm/n	n
Moist backfill below water table		Mm b f = Fm	b f × (hwater - 2 >	< d _{ds}) / 2 = 12.1 k	Nm/m	-
Saturated backfill		Msf=Fsf×	(hwater - 3 × dds) / 3 = 1.1 kNm/m	1	
Water		 Mwater f = Fv	vater f × (hwater - 3	× d _{ds}) / 3 = 2.3 k	Nm/m	
Total overturning moment		M _{ot f} = M _{sur}	f + M _m a f + M _m	b f + Ms f + Mwater	_f = 101.3 kNm	/m
Restoring moments					-	
Wall stem		Mwall f = Wwa	$_{\rm H}$ f × ($I_{\rm toe}$ + t _{wall} /	2) = 49.1 kNm/m	1	
Wall base		$M_{\text{base f}} = W_{\text{b}}$	ase f × lbase / 2 =	16.1 kNm/m		
Design vertical load		$M_{\rm v}$ f = $W_{\rm v}$ f	× lload = 189.3 k	Nm/m		
Total restoring moment	storing moment $M_{rest f} = M_{wall f} + M_{have f} + M_v f = 254.4 \text{ kNm/m}$				m	
Factored bearing pressure		_		_		
Total vertical reaction		R _f = W _{total} f	= 160.6 kN/m			
Distance to reaction		\mathbf{X} bar f = \mathbf{I} base	/ 2 = 900 mm			
Eccentricity of reaction		e _f = abs((I _{ba}	_{ase} / 2) - x _{bar_f}) =	0 mm		
				Reaction acts w	vithin middle	third of base
Bearing pressure at toe		$p_{toe_f} = (R_f / $	Ibase) - ($6 \times R_f \times$	ef / Ibase ²) = 89.2	kN/m ²	
Bearing pressure at heel		$p_{\text{heel}_f} = (R_f)$	/ I _{base}) + (6 $ imes$ Rf	\times ef / I _{base} ²) = 89.	2 kN/m²	
Rate of change of base reaction		rate = (p _{toe} _	<code>f - p_{heel_f}) / I_{base} :</code>	= 0.00 kN/m²/m		
Bearing pressure at stem / toe		p _{stem_toe_f} =	max(p _{toe_f} - (rate	$e \times I_{toe}$), 0 kN/m ²)	= 89.2 kN/m ²	



Tekla Tedds 26 Amyand Park Road TW1 3HE 23						227	
NMN Partnership	Calcs for		Start page no./F	Revision			
	F	RC wall 4 to of ba	sement & Par	ty wall	RV	/4 32	
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date	
Check shear resistance at toe							
Design shear stress		v _{toe} = V _{toe} /	(b × d _{toe}) = 0.4	92 N/mm ²			
Allowable shear stress		v _{adm} = min(() 0.8 × √(f _{cu} / 1 N	N/mm²). 5) × 1 N/	/mm ² = 5.000 N	l/mm ²	
		PASS -	Design shear	r stress is less t	han maximum	shear stress	
From BS8110:Part 1:1997 – Ta	ble 3.8		-				
Design concrete shear stress		v _{c_toe} = 0.6 8	38 N/mm ²				
			Vto	oe < Vc_toe - No sh	near reinforcer	nent required	
Design of reinforced concrete	retaining w	all stem (BS 8002	:1994)				
Material properties		•	<u> </u>				
Characteristic strength of concre	ete	f _{cu} = 40 N/r	nm²				
Characteristic strength of reinfor	cement	f _v = 500 N/	mm²				
Wall details		,					
Minimum area of reinforcement		k = 0 13 %					
Cover to reinforcement in stem		C _{stem} = 50 n	nm				
Cover to reinforcement in wall		_{Cwall} = 50 m	ım				
Factored horizontal active for	ces on stem						
Surcharge		$F_{s,sur,f} = \gamma_{f}$	$I \times K_a \times Surcha$	arge × (h _{eff} - t _{base} -	- d _{ds}) = 20.1 kN	/m	
Moist backfill above water table		$F_{s,m,a,f} = 0$.5 × Vfe × Ka ×	$v_{\rm m} \times (h_{\rm eff} - t_{\rm base} - 0)$	d _{ds} - h _{sat}) ² = 27 .	9 kN/m	
Moist backfill below water table		$F_{s,m,b,f} = \gamma_f$	e × Ka × νm × (h _{eff} - t _{base} - d _{ds} - h	sat) × h _{sat} = 17 k	N/m	
Saturated backfill		$F_{s,s,f} = 0.5$	$\times \gamma_{fe} \times K_a \times (\gamma_{fe})$	s- γ_{water} × h _{sat} ² = '	1.6 kN/m		
Water		Fs water f = 0	$0.5 \times \gamma_{\rm fe} \times \gamma_{\rm wate}$	$r \times h_{sat}^2 = 3.4 \text{ kN/}$	'm		
Calculate shear for stem desir	n		1 - 1				
	J.,	$V_{c,sur} f = 5$	× Fs. sur. f / 8 = 1	2 6 kN/m			
Moist backfill above water table		Vs.m.a.f = F	s mafx bix ((5	5×1^{2}) - b^{2}) / (5 ×	(1 ³) = 18.2 kN/	m	
Moist backfill below water table		$V_{s_m b_f} = F$	's_m_b_f x (8 - (n ⁴	$2 \times (4 - n)) / 8 =$	16 4 kN/m		
Saturated backfill		Vs_f = Fs.	s_m_b_1 ^ (0 (1)	(5 × L) - a) / (20	$\times ^{3})) = 1.6 \text{ kN}$	l/m	
Water		$V_{s,water,f} = I$	= =	a ² × ((5 × 1) - a)	$(20 \times 1^3)) = 3$	3.3 kN/m	
Total shear for stem design		V _{stem} = V _s s	urf+Vsmaf+	Vs m b f + Vs s f +	- Vs water f = 52	kN/m	
Calculate moment for stem de	eian						
	Sign	Ma aur = Fa	surfy $1/8 = 7$	9 kNm/m			
Moist backfill above water table		Ms_sur = Fs	n n n n n n n_	$(x \mid 2) - (3 \times b^2))/$	$(15 \times 1^2) = 14$	5 kNm/m	
Moist backfill below water table		Ms_m_a = Fs	h f x a l x ((0	$(0 \times 0^{1})/(0 \times 0^{1})/(0 \times 0^{1})/(0 \times 0^{1}))/(0 \times 0^{1})/(0 $	(10 × ⊑) = 14		
Saturated backfill		Ms_n_b = Fs_s	_iii_0_i ∧ ai ∧ (∠ - ∉ ∨ai∨((3∨ai²)-(1	15×a×L)+(20×L ²)	$(1)/(60 \times 1^2) = 0.4$	kNm/m	
Water		Ms_s = 1 s_s_	$\sum_{i \to ai} ((0 \land ai))^{-1}$	(a ²)-(15×ai×L)+(2	?/\(00×L) = 0.4 ?/\×L ² \)/(60×L ²)	= 0.8 kNm/m	
Total moment for stem design		Mstem = Ms	sur + Ms m a + N	//smb+Mss+M	s water = 29 kNm	/m	
Calculate moment for wall dee	sian		u				
Surcharge	sign	M., our = 9 \	(Falour f x 1 / 1)	28 = 4 4 kNm/m			
Moist backfill above water table		$M_{\rm w} = 5$		$b_{1} \times [(b_{1}^{3} + 5 \times a_{1} \times 1^{2}))]$	(5×1 ³)-0 577 ² /3	3] = 8.8	
kNm/m		ww.m_a - 1 s	<u>, iii_a_i ^ 0.017</u> ^			, 	
Moist backfill below water table		Mwmb=Fa	smbf× a i× [//8	3-n ² ×(4-n)) ² /16)-	4+n×(4-n)1/8 =	1.3 kNm/m	
Saturated backfill		 Mw s = Fs s	$f \times [a]^2 \times x \times ((5 \times 1)^2)$	_)-aı)/(20×l ³)-(x-ł	$(3 \times a^2) = 0$	1 kNm/m	
Water		M _{w water} = F	$M_{w water} = F_{s water} f \times [a^{2} \times x \times ((5 \times L) - a)/(20 \times L^{3}) - (x - b)^{3} / (3 \times a^{2})] = 0.1$				
kNm/m					, <u>(</u> ,), (), (), (), (), (), (), (), (), (),	/	
		M – M		4, т М т М		line /ine	



Tekla. Tedds	Project	26 Amyand Parl	< Road TW1 3⊦	IE	Job no. 23 227	
NMN Partnership	Calcs for RC	Start page no./Re RW	evision 4 34			
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Check retaining wall def	lection	
Basic span/effective depth	i ratio	ratio _{bas} = 20
Design service stress		$f_s = 2 \times f_y \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = 229.9 \text{ N/mm}^2$
Modification factor	factor _{tens} = min(0.55	$5 + (477 \text{ N/mm}^2 - f_s)/(120 \times (0.9 \text{ N/mm}^2 + (M_{\text{stem}}/(b \times d_{\text{stem}}^2)))),2) = 2.00$
Maximum span/effective d	epth ratio	ratio _{max} = ratio _{bas} × factor _{tens} = 40.00
Actual span/effective dept	h ratio	ratio _{act} = h _{stem} / d _{stem} = 12.30
		PASS - Span to depth ratio is acceptable



Tekla. Tedds	Project	26 Amyand Park	Road TW1 3H	E	Job no. 23 227	
NMN Partnership	Calcs for RC	Start page no./Revision RW5 36				
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
	•	•		•	•	•

RETAINING WALL ANALYSIS (BS 8002:1994) TEDDS calculation version 1.2.01.08 1675-1500 ▶ 300 80 kN/m 10 kN/m² Prop — 60 g Prop 1800 -Wall details Retaining wall type Cantilever propped at both h_{stem} = **4600** mm Height of retaining wall stem Thickness of wall stem twall = 300 mm Itoe = **1500** mm Length of toe $I_{heel} = 0 \text{ mm}$ Length of heel Overall length of base $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1800 \text{ mm}$ t_{base} = **300** mm Thickness of base Depth of downstand d_{ds} = **0** mm lds = 200 mm Position of downstand t_{ds} = **300** mm Thickness of downstand Height of retaining wall hwall = hstem + tbase + dds = **4900** mm d_{cover} = 0 mm Depth of cover in front of wall $d_{exc} = 0 mm$ Depth of unplanned excavation Height of ground water behind wall h_{water} = **1000** mm Height of saturated fill above base hsat = max(hwater - tbase - dds, 0 mm) = 700 mm Density of wall construction ywall = 23.6 kN/m³ Density of base construction γbase = 23.6 kN/m³ Angle of rear face of wall α = **90.0** deg Angle of soil surface behind wall $\beta = 0.0 \deg$ Effective height at virtual back of wall $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 4900 \text{ mm}$ **Retained material details** M = 1.5 Mobilisation factor Moist density of retained material γm = 18.0 kN/m³

Tokla Todds	Project				Job no.	
		26 Amyand Parl	Road TW1 3H	E	23	227
NMN Partnership	Calcs for RC	wall 5 to of ba	sement & Party	wall	Start page no./Re RW	evision 5 37
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
Saturated density of retained ma	aterial	γs = 21.0 kM	N/m ³			
Design shear strength		φ' = 24.2 de	èg			
Angle of wall friction		δ = 0.0 deg				
Base material details						
Moist density		γ _{mb} = 18.0 Ι	N/m³			
Design shear strength		φ' _b = 24.2 d	eg			
Design base friction		δ _b = 18.6 de	eg			
Allowable bearing pressure		Pbearing = 15	0 kN/m ²			
Using Coulomb theory Active pressure coefficient for re $K_a = sin(\alpha + r)$ Passive pressure coefficient for	etained material + φ')² / (sin(α)² × base material	$a \sin(lpha - \delta) imes [1 +$	· √(sin(φ' + δ) × s	sin(φ' - β) / (sin(α	$-\delta$) × sin(α +	B)))] ²) = 0.419
	K _p = sin(9	0 - φ'ь)² / (sin(90) - δ⊳) × [1 - √(sin	$h(\phi'_{b} + \delta_{b}) \times sin(\phi'_{b})$	ь) / (sin(90 + δ	b)))] ²) = 4.187
At-rest pressure						
At-rest pressure for retained ma	terial	K₀ = 1 – sir	n(φ') = 0.590			
Loading details						
Surcharge load on plan		Surcharge	= 10.0 kN/m ²			
Applied vertical dead load on wa	all	W _{dead} = 75 .	0 kN/m			
Applied vertical live load on wall		W _{live} = 5.0 I	kN/m			
Position of applied vertical load	on wall	l _{load} = 1675	mm			
Applied horizontal dead load on	wall	F _{dead} = 0.0	kN/m			
Applied horizontal live load on w	vall	F _{live} = 0.0 k	N/m			
Height of applied horizontal load	d on wall	$h_{load} = 0 mr$	n			
			10			
2	Prop 69.6	Prop -		4.7 9.8		
				Loads shown	i in kN/m, pressure	es shown in kN/m ²

Tekla Tedds	Project	26 Amyand Pa	rk Road TW1 3	3HE	Job no.	3 227
NMN Partnership	Calcs for		Start page no./	Revision		
	RC wall 5 to of basement			rty wall	R	W5 38
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved da
Vertical forces on wall						
Wall stem		w _{wall} = h _{ste}	$_{\rm m} imes {t_{\rm wall}} imes \gamma_{\rm wall} =$	32.6 kN/m		
Wall base		w _{base} = I _{bas}	$t_{base} imes \gamma_{base}$	= 12.7 kN/m		
Applied vertical load		$W_v = W_{dea}$	ad + W _{live} = 80 k	κN/m		
Total vertical load		W _{total} = w _w	$_{rall}$ + $_{Wbase}$ + W_v	= 125.3 kN/m		
Horizontal forces on wall						
Surcharge		F _{sur} = K _a ×	Surcharge × h	n _{eff} = 20.5 kN/m		
Moist backfill above water table		F _{m_a} = 0.5	$\times \ \textbf{K}_{a} \times \gamma_{m} \times (\textbf{h}_{e}$	ff - h _{water}) ² = 57.3 k	κN/m	
Moist backfill below water table		F _{m_b} = K _a	$ imes \gamma_{m} imes$ (heff - hwa	h_{water} = 29.4	kN/m	
Saturated backfill		F_s = 0.5 \times	$K_{a} \times (\gamma_{s}\text{-} \gamma_{water})$	\times h _{water} ² = 2.3 kN/	m	
Water		F _{water} = 0.5	$5 \times h_{water}^2 \times \gamma_{water}^2$	_{er} = 4.9 kN/m		
Total horizontal load	F _{total} = F _{sur} + F _{m_a} + F _{m_b} + F _s + F _{water} = 114.4 kN/m					
Calculate total propping force						
Passive resistance of soil in fror	$F_p = 0.5 \times$	$K_p \times cos(\delta_b) \times$	(d _{cover} + t _{base} + d _{ds}	- $d_{exc})^2 \times \gamma_{mb}$ =	= 3.2 kN/m	
Propping force		F _{prop} = ma	x(Ftotal - Fp - (W	/total - Wlive) $ imes$ tan(δ	õ₅), 0 kN/m)	
		F _{prop} = 70 .	7 kN/m			
Overturning moments						
Surcharge		M _{sur} = F _{sur}	\times (h _{eff} - 2 \times d _d	s) / 2 = 50.2 kNm/	m	
Moist backfill above water table		M _{m_a} = F _m	$_a \times (h_{eff} + 2 \times h)$	Nwater - 3 × d _{ds}) / 3 =	= 131.8 kNm/r	m
Moist backfill below water table		$M_{m_b} = F_m$	$_{b} \times (h_{water} - 2 \times$	d _{ds}) / 2 = 14.7 kN	m/m	
Saturated backfill		$M_s = F_s \times$	$(h_{water} - 3 imes d_{ds})$	/ 3 = 0.8 kNm/m		
Water		M _{water} = F _v	_{vater} × (h _{water} - 3	× d _{ds}) / 3 = 1.6 kN	m/m	
Total overturning moment		$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 199.1 \text{ kNm/m}$				
Restoring moments						
Wall stem		Mwall = www	III × (Itoe + twall / 2	2) = 53.7 kNm/m		
Wall base		$M_{base} = W_{b}$	ase × Ibase / 2 = ′	11.5 kNm/m		
Design vertical load		$M_v = W_v \times$	l _{load} = 134 kNn	n/m		
Total restoring moment		M _{rest} = M _w	all + M _{base} + M _v :	= 199.2 kNm/m		
Check bearing pressure						
Total vertical reaction		R = W _{total}	= 125.3 kN/m			
Distance to reaction		$\mathbf{x}_{\text{bar}} = \mathbf{I}_{\text{base}}$	/ 2 = 900 mm			
Eccentricity of reaction		e = abs((l	oase / 2) - Xbar) =	0 mm		
				Reaction acts	within middl	e third of ba
Bearing pressure at toe		p _{toe} = (R /	I_{base}) - (6 × R ×	e / I _{base} ²) = 69.6 k	N/m ²	
Bearing pressure at heel		p _{heel} = (R /	I_{base}) + (6 × R	× e / I _{base} ²) = 69.6	kN/m ²	
	PA	ASS - Maximum	bearing press	ure is less than	allowable bea	aring pressu

Propping force to base of wall

 $\label{eq:Fprop_top} \begin{aligned} F_{prop_top} &= (M_{ot} - M_{rest} + R \times I_{base} \ / \ 2 - F_{prop} \times t_{base} \ / \ 2) \ / \ (h_{stem} + t_{base} \ / \ 2) = \textbf{21.491} \ kN/m \\ F_{prop_base} &= F_{prop} - F_{prop_top} = \textbf{49.230} \ kN/m \end{aligned}$

Tekla Tedds	Project	ject Job no. 26 Amyand Park Road TW1 3HE 23 227							
NMN Partnership	Calcs for				Start page no./Re	evision			
	F	C wall 5 to of ba	sement & Part	y wall	RW	5 39			
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date			
RETAINING WALL DESIGN (B	<u>S 8002:1994)</u>				TEDDS calculation	version 1.2.01.08			
Ultimate limit state load facto	rs								
Dead load factor		γ _{f_d} = 1.4							
Live load factor		γ _{f_l} = 1.6							
Earth and water pressure factor		γ _{f_e} = 1.4							
Factored vertical forces on wa	all								
Wall stem		$W_{wall_f} = \gamma_{f_d}$	imes h _{stem} $ imes$ t _{wall} $ imes$ $ imes$	_{ywall} = 45.6 kN/m	ı				
Wall base		$W_{base_f} = \gamma_{f_c}$	$ ext{d} imes ext{base} imes ext{base} imes$	γ _{base} = 17.8 kN/	'n				
Applied vertical load		$W_{v_f} = \gamma_{f_d}$	$<$ Wdead + $\gamma_{f_l} \times V$	N _{live} = 113 kN/m					
Total vertical load		W _{total_f} = w _w	vall_f + Wbase_f + V	V _{v_f} = 176.4 kN/r	n				
Factored horizontal active for	ces on wall								
Surcharge		$F_{sur_f} = \gamma_{f_l} \times$	$K K_a imes Surcharg$	e × h _{eff} = 32.8 kľ	N/m				
Moist backfill above water table		$F_{m_a_f} = \gamma_{f_e}$	$\times \ 0.5 \times K_a \times \gamma_m$	\times (h _{eff} - h _{water}) ² =	80.2 kN/m				
Moist backfill below water table		$F_{m_b_f} = \gamma_{f_e}$	$ imes$ K _a $ imes$ γ_m $ imes$ (her	f - h _{water}) × h _{water} :	= 41.1 kN/m				
Saturated backfill		F_{s_f} = γ_{f_e} ×	$F_{s_f} = \gamma_{f_e} \times 0.5 \times K_a \times (\gamma_{s} - \gamma_{water}) \times h_{water}^2 = 3.3 \text{ kN/m}$						
Water $F_{water_f} = \gamma_{f_e}$			$_{e} imes 0.5 imes h_{water}^{2}$	$\times \gamma_{water} = 6.9 \text{ kN}$	/m				
Total horizontal load		F _{total_f} = F _{sur}	r_f + Fm_a_f + Fm_	_b_f + Fs_f + Fwater_	_f = 164.3 kN/m				
Calculate total propping force)								
Passive resistance of soil in from kN/m	nt of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 imes K_p imes cos($	$(\delta b) \times (\mathbf{d}_{cover} + \mathbf{t}_{bas})$	se + dds - dexc) ² ×	: γ _{mb} = 4.5			
Propping force		F _{prop_f} = ma F _{prop_f} = 10 3	x(F _{total_f} - F _{p_f} - 3.1 kN/m	(W _{total_f} - $\gamma_{f_l} \times W_l$	$_{ive}) imes tan(\delta_b), 0$	κN/m)			
Factored overturning moment	te	F. F.							
Surcharge	.5	Mour f = Four	f × (hoff - 2 × d	(a)/2 = 804 kN	m/m				
Moist backfill above water table		$M_{m-a-f} = F_{m}$	2 × (heff + 2 × 4	hwater - 3 × dds) /	3 = 184.5 kNm	'm			
Moist backfill below water table		$M_{m,b,f} = F_{m,b}$	$\underline{a}_1 \times (h_{wator} - 2)$	(1000 das) / 2 = 20.6	kNm/m				
Saturated backfill		Msf=Fsf>	< (hwater - 3 × dds	(3 = 1.1 kNm/r)	m				
Water		Mwater f = Fv	vater f × (hwater - 3	$3 \times d_{ds}) / 3 = 2.3$	kNm/m				
Total overturning moment		M _{ot f} = M _{sur}	f + M _{m a f} + M _m	b f + Ms f + Mwate	er f = 288.8 kNm	ı/m			
Restoring moments					-				
Wall stem		Mwall f = Wwa	all f × (Itoe + twall /	2) = 75.2 kNm/r	n				
Wall base		$M_{\text{base f}} = W_{\text{b}}$	ase f×lbase/2=	16.1 kNm/m					
Design vertical load		$M_{\rm v} f = W_{\rm v} f$	× lload = 189.3 k	Nm/m					
Total restoring moment		Mrest f = Mw	all f + Mbase f + N	1 v f = 280.6 kNm	/m				
Factored bearing pressure									
Total vertical reaction		R _f = W _{total} f	= 176.4 kN/m						
Distance to reaction		Xbar_f = Ibase	/ 2 = 900 mm						
Eccentricity of reaction		e _f = abs((l _{ba}	_{ase} / 2) - x _{bar_f}) =	0 mm					
				Reaction acts	within middle	third of base			
Bearing pressure at toe		$p_{toe_f} = (R_f / $	Ibase) - ($6 \times R_f$ >	< ef / I _{base} ²) = 98	kN/m²				
Bearing pressure at heel		$p_{\text{heel}_f} = (R_f)$	/ Ibase) + ($6 \times R_f$	\times ef / Ibase ²) = 98	kN/m²				
Rate of change of base reactior	Rate of change of base reaction $rate = (p_{toe_f} - p_{heel_f}) / I_{base} = 0.00 \text{ kN/m}^2/\text{m}$								
Bearing pressure at stem / toe		$p_{stem_toe_f} =$	max(p _{toe_f} - (rat	$e \times I_{toe}$), 0 kN/m ²) = 98 kN/m²				



NMN Partnership C C C C C C C C C C C C C C C C C C C	alcs for F alcs by NM	C wall 5 to of ba	sement & Par	ty wall	Start page no./R	evision	
Ca Ca Check shear resistance at toe Design shear stress	R alcs by NM	C wall 5 to of ba	sement & Par	ty wall		Start page no./Revision	
C Check shear resistance at toe Design shear stress	NM	Calcs date 02/05/2024		RC wall 5 to of basement & Party wall			
Check shear resistance at toe Design shear stress		02/00/2021	Checked by	Checked date	Approved by	Approved date	
Design shear stress							
0		v _{toe} = V _{toe} /	(b × d _{toe}) = 0.5	46 N/mm ²			
Allowable shear stress		$v_{adm} = min($	0.8 × √(f _{cu} / 1 N	N/mm²). 5) × 1 N/	′mm² = 5.000 N	/mm²	
		PASS -	Design shear	r stress is less t	han maximum	shear stress	
From BS8110:Part 1:1997 – Tabl	e 3.8		0				
Design concrete shear stress		v _{c_toe} = 0.68	38 N/mm ²				
			Vto	e < vc_toe - No sh	ear reinforcen	nent required	
Design of reinforced concrete re	taining wa	all stem (BS 8002	:1994)				
Material properties			<u> </u>				
Characteristic strength of concrete		f _{ev} = 40 N/n	nm ²				
Characteristic strength of reinforce	ment	$f_v = 500 \text{ N/r}$	mm ²				
		ly 000 l.u.					
Minimum area of reinforcement		k - 0 13 %					
Cover to reinforcement in stem		K = 0.13 /0	nm				
Cover to reinforcement in wall		Cwall = 50 m	ım				
Eactored horizontal active force	e on etom						
Surcharge	s on stem	$F_{a,sur,f} = \gamma_{f,i}$	∟x K ₂ x Surcha	arge x (h _{off} - t _{hasa} -	. d _{de}) = 30 8 kN/	'm	
Moist backfill above water table		$F_{s_s} = 0$	5 × 1/6 × Ko ×	$\gamma_m \times (h_{\text{eff}} - t_{\text{hoose}} - t_{\text{hoose}})$	$d_{ds} = b_{ost}^2 = 80$	2 kN/m	
Moist backfill below water table		$F_{s} = h_{f} = v_{f}$		$h_{\text{eff}} = t_{\text{hase}} = d_{\text{da}} = h_{\text{base}}$	aus = Hsat = 28.8	kN/m	
Saturated backfill		$F_{s_1} = 0.5$	$\sim w \sim \mathbf{K} \sim \mathbf{K}$	$(1000 \pm 1000 \pm 1000 \pm 1000 \pm 1000 \pm 1000 \pm 1000 \pm 10000 \pm 10000 \pm 10000 \pm 10000 \pm 10000 \pm 10000 \pm 100000 \pm 100000000$	$sat) \times Hsat = 20.0$		
Water		$F_{s_s} = 0.5$	$\wedge \gamma_{1} e \wedge \eta_{a} \wedge (\gamma_{a})$	$s^2 \gamma \text{water} / \pi \text{ is at} = 2$	m		
		i s_water_i - C	.o ~ /i_e ~ /wate				
Calculate shear for stem design							
		$V_{s_sur_f} = 5$	$\times F_{s_{sur_f}} = 1$	19.3 KIN/M			
Moist backfill above water table		$V_{s_m_a_f} = F$	s_m_a_f × DI × ((5	$D \times L^2$) - Dl^2) / (5 ×	$(L^{\circ}) = 57 \text{ kin/m}$		
		$V_{s_m_b_f} = F$	s_m_b_f × (8 - (N	² × (4 - n))) / 8 = 2	28.4 KIN/M	l	
		$V_{s_s_f} = F_{s_s}$	s_f × (I - (ai ⁻ × ($(5 \times L) - a_1) / (20)$	$\times L^{\circ}))) = 1.6 \text{ kin}$	/m	
Total about for stom design		$V_{s}_{water_f} = f$	-s_water_f × (I - (ar × ((5 × L) - aı)	$7(20 \times L^{\circ})) = 3$	5.3 KIN/III	
		Vstem - Vs_s	ur_f Vs_m_a_f	Vs_m_b_f + Vs_s_f +	· Vs_water_t - 103	.5 KIN/III	
Calculate moment for stem desi	gn						
Surcharge		$Ms_sur = Fs_s$	$sur_f \times L / 8 = 10$	5.3 KNM/M		4 1 1 1	
Moist backfill above water table		$Ms_m_a = Fs_m$	_m_a_f × bi × ((5	$\times L^2$) - (3 × bi ²)) /	(15 × L²) = 62.	1 kNm/m	
Moist backfill below water table		$Ms_mb = Fs_m$	_m_b_f × a l × (2 ·	$(-n)^2 / 8 = 10.1 \text{ KM}$	$\frac{1}{2}$		
Saturated backfill		Ms_s = Fs_s_	f ×ai×((3×ai²)-('	15×ai×L)+(20×L²)	$(60 \times L^2) = 0.4$	KNM/M	
Water		Ms_water = F	s_water_f ×al×((3×	<a⊭)-(15×ai×l)+(2< td=""><td>(0×L²))/(60×L²)</td><td>= 0.8 KNM/M</td></a⊭)-(15×ai×l)+(2<>	(0×L²))/(60×L²)	= 0.8 KNM/M	
Total moment for stem design		IVIstem = IVIs_	sur + IVIs_m_a + IV	$/I_{s_m_b} + IVI_{s_s} + IVI_{s_s}$	s_water = 91.8 KIN	m/m	
Calculate moment for wall desig	n						
Surcharge		$M_{w_{sur}} = 9 \times$	<pre>Fs_sur_f × L / 12</pre>	28 = 10.3 kNm/m			
Moist backfill above water table		$M_{w_m_a} = F_s$	s_m_a_f × 0.577×	bi×[(bi³+5×ai×L²)/	(5×L³)-0.5772/3] = 32.2	
KINII/III Moist backfill balow water table				$p_{2}^{2}(A = 1)^{2} (A = 1)^{2}$	$(4 n)^{1/2} = 4$	1 7 kNm/m	
NUUSI DACKIIII DEIOW WATER TADIE			s_m_b_t × al × [((t	ס-וו־×(4-וו)/* / וט)-4) פי/(20 וויינא אינער אינער	+τι×(4-n)]/ð = '	kNm/m	
		IVIW_S = Fs_s_	_⊺ × [al⁻×x×((⊃×l	∟j-aij/(∠∪×Lč)-(X-ľ	אויית(ס×מ⊏)] = U 3) (ע ה∖3 //פי - ²⁾		
kNm/m		IVIw_water = F	s_water_t × [al-×X	×((0×L)-a)/(20×L))-(x-u)² /(3×al²)	nj – U.1	
Total moment for wall design			sur + Mw m a + M	Λwmb+ΝΛwα+ΝΛ	w water = 44 4 kN	lm/m	



Tekla. Tedds	Project	26 Amyand Parl	k Road TW1 3	HE	Job no. 23 227	
NMN Partnership	Calcs for RC	Start page no./Re RW	evision 5 43			
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date

Check retaining wall def	lection	
Basic span/effective depth	n ratio	ratio _{bas} = 20
Design service stress		$f_s = 2 \times f_y \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = 304.2 \text{ N/mm}^2$
Modification factor	factor _{tens} = min(0.5	5 + (477 N/mm ² - f _s)/(120 × (0.9 N/mm ² + (M _{stem} /(b × d _{stem} ²)))),2) = 1.13
Maximum span/effective of	lepth ratio	ratio _{max} = ratio _{bas} × factor _{tens} = 22.67
Actual span/effective dept	h ratio	ratio _{act} = h _{stem} / d _{stem} = 19.01
		PASS - Span to depth ratio is acceptable

Tekla Tedds	Project	26 Amyand Park	Road TW1 3HI	E	Job no. 23	227			
NMN Partnership	Calcs for RC	wall 5 to of bas	Start page no./Revision RW5 44						
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date			
Indicative retaining wall reinforcement diagram									
	Toe reinforcement	all reinforcement	Stem re	inforcement					
Toe bars - 16 mm dia.@ 150 m Wall bars - 12 mm dia.@ 200 m Stem bars - 16 mm dia.@ 200 n	n centres - (134 m centres - (56 nm centres - (10	40 mm²/m) 5 mm²/m) 005 mm²/m)							

Tekla. Tedds	Project	26 Amyand Parl	< Road TW1 3H	E	Job no. 23 227		
NMN Partnership	Calcs for RC	wall 6 to of ba	Start page no./Revision RW6 45				
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	•	•		•	•		



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Tekla Tedds	Project	26 Amvand Parl	k Road TW1 3H	E	Job no. 23	227
NMN Partnership	Calcs for				Start page no./Re	evision
	RC	wall 6 to of ba	sement & Party	' wall	RW	6 46
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
	atarial		1/1003			
Saturated density of retained ma	aterial	γs = 21.0 Kľ	N/m°			
Angle of wall friction		φ - 24.2 Ut	eg			
		o – 0.0 deg				
Base material details			(N1/m3			
		$\gamma_{mb} = 10.01$				
Design bass friction		φ _b – 24.2 d	eg			
Allowable bearing process		$O_{\rm b} = 10.0$ U				
Allowable bearing pressure		F bearing - 13				
Using Coulomb theory	to in ord words wind					
Active pressure coefficient for re	etained material	ain($\sin(4! = 0) / (\sin(a))$	s $ain(a, b)$	0)))12) - 0 440
$R_a = SIN(\alpha)$	+ φ)- / (Sin(α)- ×	$\sin(\alpha - \delta) \times [1 +$	$-\sqrt{(\sin(\phi + \delta) \times s)}$	sin(φ - β) / (sin(α	$- o) \times \sin(\alpha + \mu)$	()))] ⁻) = 0.419
rassive pressure coemcient for	$K_n = \sin(9)$	በ - ሐ' _ካ) ² / (sin/ዓር) - δ _b) × [1 - √(sin	ין (מיף אין	$_{\rm b}) / (\sin(90 + \delta$	$(h)))(1^2) = 4.187$
						<i>s)))</i>])e.
At-rest pressure	torial	K₀ = 1 _ sir	v(#') – 0 590			
	licitat	10 - 1 - 31	ι(φ) = 0.000			
Loading details		Surabarga	-10.0 kN/m ²			
Applied vertical dead load on wa	all	W _{dood} = 75	0 kN/m			
Applied vertical live load on wall		Wive = 5.0	kN/m			
Position of applied vertical load	on wall	$I_{load} = 1675$	mm			
Applied horizontal dead load on	wall	F _{dead} = 0.0	kN/m			
Applied horizontal live load on w	vall	F _{live} = 0.0 k	N/m			
Height of applied horizontal load	d on wall	h _{load} = 0 mr	n			
			80 ↓ 10			
		Prop —				
			- <u>-</u> -			
	Prop					
21.4	63.3		4.2 1 63.3	7.3 4.7 9.8		
				Loads shown	in kN/m, pressure	es shown in kN/m ²
Vertical forces on wall		ци <u>-</u> Е		4.9 1/1		
waii stelli		Wwall - Dstem	× twall × γwall = 2	1.4 KIN/III		

Tekla Tedds	Project	26 Amyand Pa	Park Road TW1 3HE 23 2				
NMN Partnership	Calcs for				Start page no./l	Revision	
	F				RV	10 47	
	NM	02/05/2024	Checked by	Checked date	Approved by	Approved date	
Wall base		Wbase = Iba	$he imes \mathbf{t}$ base $ imes \gamma$ base	= 12.7 kN/m			
Applied vertical load		$W_v = W_{des}$	_{ad} + W _{live} = 80 k	N/m			
Total vertical load		$W_{total} = W_{v}$	$_{rall}$ + $_{Wbase}$ + W_v	= 114 kN/m			
Horizontal forces on wall							
Surcharge		F _{sur} = K _a >	Surcharge \times h	_{eff} = 13.8 kN/m			
Moist backfill above water table		$F_{m_a} = 0.5$	$ imes$ Ka $ imes$ γ_m $ imes$ (here	ff - h _{water}) ² = 19.9	kN/m		
Moist backfill below water table		$F_{m_b} = K_a$	$\times \gamma_{m} \times (h_{eff} - h_{wa})$	ter) \times h _{water} = 17.3	kN/m		
Saturated backfill		$F_s = 0.5 \times$	$K_a \times (\gamma_s - \gamma_{water})$	\times h _{water} ² = 2.3 kN/	′m		
Water		F _{water} = 0.5	$5 imes h_{water}^2 imes \gamma_{water}^2$	r = 4.9 kN/m			
Total horizontal load		F _{total} = F _{su}	+ F _{m_a} + F _{m_b} +	+ F _s + F _{water} = 58.	3 kN/m		
Calculate total propping force)						
Passive resistance of soil in from	$F_p = 0.5 \times$	$F_{\text{P}} = 0.5 \times K_{\text{P}} \times \text{cos}(\delta_{\text{b}}) \times (d_{\text{cover}} + t_{\text{base}} + d_{\text{ds}} - d_{\text{exc}})^2 \times \gamma_{\text{mb}} = 3.2 \text{ kN/m}$					
Propping force	$\begin{array}{l} F_{prop} = \max(F_{total} - F_{p} - (W_{total} - W_{live}) \times \tan(\delta_{b}), \ 0 \ kN/m) \\ F_{prop} = 18.4 \ kN/m \end{array}$						
Overturning moments							
Surcharge		M _{sur} = F _{sur}	\times (h _{eff} - 2 \times d _{ds}	.) / 2 = 22.8 kNm/	′m		
Moist backfill above water table		$M_{m_a} = F_m$	$_a \times (h_{eff} + 2 \times h)$	water - $3 \times d_{ds}$) / 3	= 35.2 kNm/m		
Moist backfill below water table		$M_{m_b} = F_m$	$_{b} \times$ (h _{water} - 2 \times	d _{ds}) / 2 = 8.7 kNr	n/m		
Saturated backfill		M_s = $F_s \times$	$(h_{water} - 3 imes d_{ds})$	/ 3 = 0.8 kNm/m			
Water		$M_{water} = F_{v}$	_{vater} × (h _{water} - 3	× d _{ds}) / 3 = 1.6 kN	lm/m		
Total overturning moment		Mot = Msur	+ M _{m_a} + M _{m_b} ·	+ Ms + M _{water} = 69).1 kNm/m		
Restoring moments							
Wall stem		M _{wall} = w _{wa}	III $ imes$ (Itoe + t _{wall} / 2	2) = 35 kNm/m			
Wall base		M _{base} = w _b	$_{ m ase} imes {\sf I}_{ m base}$ / 2 = 1	l 1.5 kNm/m			
Design vertical load		$M_v = W_v \times$	l _{load} = 134 kNm	ı/m			
Total restoring moment		M _{rest} = M _w	all + M _{base} + M _v =	= 180.5 kNm/m			
Check bearing pressure							
Total vertical reaction		R = W _{total}	= 114.0 kN/m				
Distance to reaction		$x_{\text{bar}} = I_{\text{base}}$	/ 2 = 900 mm				
Eccentricity of reaction		e = abs((I	oase / 2) - x _{bar}) =	0 mm			
				Reaction acts	within middle	e third of base	
Bearing pressure at toe		p _{toe} = (R /	I_{base}) - (6 × R ×	e / I _{base²}) = 63.3 k	«N/m²		
Bearing pressure at heel	_	p _{heel} = (R	′ I _{base}) + (6 × R ∷ • • •	× e / I _{base} ²) = 63.3	kN/m ²		
	P/	ASS - Maximum	bearing press	ure is less than	allowable bea	arıng pressure	
Calculate propping forces to t	op and base	of wall					
Propping force to top of wall	_		_				
	Enror	ton = (Mot - Mrest	+ K X Ibasa / ソート	-prop X Ibase / 2) / (Netam + Ibasa / 2)	= -3.690 kN/n	

Propping force to base of wall

 $F_{prop_top} = (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = -3.690 \text{ kN/m}$ $F_{prop_base} = F_{prop} - F_{prop_top} = 22.109 \text{ kN/m}$

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NMN Partnership	Calcs for	-			Start page no./Re	evision		
	F	RC wall 6 to of ba	sement & Party	/ wall	RW	6 48		
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date		
	C 0002-4004							
RETAINING WALL DESIGN (B	5 8002:1994	<u>)</u>			TEDDS calculation	version 1.2.01.08		
Ultimate limit state load factor	ſS							
Dead load factor		γ _{f_d} = 1.4						
Live load factor		γ _{f_l} = 1.6						
Earth and water pressure factor		γ _{f_e} = 1.4						
Factored vertical forces on wa	all							
Wall stem		$\mathbf{W}_{wall_f} = \gamma_{f_d}$	$ imes$ h _{stem} $ imes$ t _{wall} $ imes$ γ	wall = 29.7 kN/m				
Wall base		$W_{base_f} = \gamma_{f_e}$	$1 imes I_{base} imes t_{base} imes t_{base}$	γbase = 17.8 kN/i	m			
Applied vertical load		$W_{v_f} = \gamma_{f_d}$	\times Wdead + $\gamma_{f_l} \times$ W	/ _{live} = 113 kN/m				
Total vertical load		W _{total_f} = w _v	vall_f + Wbase_f + W	/ _{v_f} = 160.6 kN/n	n			
Factored horizontal active for	ces on wall							
Surcharge		$F_{sur_f} = \gamma_{f_l}$	$K_a \times Surcharge$	e × h _{eff} = 22.1 kN	l/m			
Moist backfill above water table		$F_{m_a_f} = \gamma_{f_e}$	$\times ~0.5 \times K_a \times \gamma_m$	\times (h _{eff} - h _{water}) ² =	27.9 kN/m			
Moist backfill below water table		$F_{m_b_f} = \gamma_{f_e}$	$\times \ \textbf{K}_{a} \times \gamma_{m} \times (\textbf{h}_{\text{eff}}$	- h _{water}) × h _{water} =	= 24.3 kN/m			
Saturated backfill $F_{s_f} = \gamma_{f_e} \times 0.5 \times K_a \times (\gamma_{s_f} - \gamma_{s_f})$				$5 \times K_a \times (\gamma_{s^-} \gamma_{water}) \times h_{water}^2 = 3.3 \text{ kN/m}$				
Water $F_{water_f} = \gamma_{f_e} \times 0.5 \times h_{water}^2 \times \gamma_{water} = 6.9 \text{ kN/m}$								
Total horizontal load	$F_{total_f} = F_{sur_f} + F_{m_a_f} + F_{m_b_f} + F_{s_f} + F_{water_f} = 84.4 \text{ kN/m}$							
Calculate total propping force	ļ.							
Passive resistance of soil in fror kN/m	nt of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 imes K_p imes \cos(d)$	$\delta_b) imes (d_{cover} + t_{bas})$	$_{\rm e}$ + d _{ds} - d _{exc}) ² ×	γmb = 4.5		
Propping force		F _{prop_f} = ma	x(F _{total_f} - F _{p_f} - (W_{total_f} - $\gamma_{f_l} imes W_{li}$	ve) × tan(δ_b), 0 l	κN/m)		
		$F_{prop_f} = 28$	5 kN/m					
Factored overturning moment	S							
Surcharge		Msur_f = Fsur	$_f \times (h_{eff} - 2 \times d_{o})$	ls) / 2 = 36.5 kNr	n/m			
Moist backfill above water table		$M_{m_a_f} = F_m$	$_a_f \times (h_{eff} + 2 \times)$	hwater - $3 \times d_{ds}$) / 3	3 = 49.3 kNm/n	า		
Moist backfill below water table		$M_{m_b_f} = F_m$	_b_f × (hwater - 2 >	(dds) / 2 = 12.1	«Nm/m			
Saturated backfill		$M_{s_f} = F_{s_f}$	\times (hwater - 3 \times dds)) / 3 = 1.1 kNm/r	n			
Water		$M_{water_f} = F_v$	water_f \times (hwater - 3	× dds) / 3 = 2.3	«Nm/m			
Total overturning moment		$M_{ot_f} = M_{sur_f}$	$_{f}$ + M _{m_a_f} + M _{m_}	_b_f + Ms_f + M _{wate}	_{r_f} = 101.3 kNm	/m		
Restoring moments								
Wall stem		$M_{wall_f} = W_{wall_f}$	$I_{toe} + t_{wall}$	2) = 49.1 kNm/n	า			
Wall base		$M_{base_f} = W_b$	$_{ase_f} \times I_{base} / 2 =$	16.1 kNm/m				
Design vertical load	Design vertical load $M_{v_f} = W_{v_f} \times I_{load} = 189.3 \text{ kNm/m}$							
Total restoring moment		M _{rest_f} = M _w	$all_f + M_{base_f} + M$	_{v_f} = 254.4 kNm/	'n			
Factored bearing pressure								
Total vertical reaction		$R_f = W_{total_f}$	= 160.6 kN/m					
Distance to reaction		Xbar_f = Ibase	/ 2 = 900 mm	•				
Eccentricity of reaction		$e_f = abs((I_{bs}))$	ase / 2) - Xbar_f) =	Umm Reaction coto	within middl-	third of hear		
Rearing pressure at too		$\mathbf{D}_{\mathrm{max}} = (\mathbf{D}_{\mathrm{max}})$	lhaaa) _ (6 y Dr.y	reaction acts reaction acts	$k N/m^2$	uniu ui base		
Bearing pressure at heat		$p_{\text{toe}_t} = (\mathbf{R}_t)$	$(U \times Rf \times I) = (U \times Rf \times Pf)$	$\sqrt{\rho_f} / _{h=1}^{2} = 90$	$\frac{1}{2}$ kN/m ²			
Rate of change of hase reaction	1	$P^{\text{neel}_{I}} = (\mathbf{R})$	$f = D_{hecl} f / I_{hecc} =$	$= 0.00 \text{ kN/m}^2/\text{m}$	- IXIN/111			
Bearing pressure at stem / toe		Dstem top f =	max(ptoe f - (rate	$e \times I_{toe}$). 0 kN/m ²) = 89.2 kN/m ²			
		Potoni_too_i						



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NMN Partnership	Calcs for			Start page no./F	Revision			
, i	R	C wall 6 to of ba	sement & Par	ty wall	RV	V6 50		
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date		
0hh -h								
Check shear resistance at toe		$\gamma = \gamma = 1$	$(b \times d \cdot) = 0.4$	02 N/mm ²				
Allowable shear stress		$v_{toe} - v_{toe}$	$(D \times U_{toe}) = 0.4$	(92 N/IIIII)	mm ² - 5 000 N	1/mm ²		
Allowable shear stress		Vadm – IIIII(PASS -	Design shear	r stress is less t	han maximum	n shear stress		
From BS8110:Part 1:1997 – Ta	able 3.8	1,400 -	Design silea	311033 13 1033 1	nan maximan	Shear Stress		
Design concrete shear stress		v _{c_toe} = 0.68	38 N/mm ²					
			Vto	oe < Vc_toe - No sh	near reinforcei	ment required		
Design of reinforced concrete	e retaining wa	ll stem (BS 8002	:1994)					
Material properties	, otaning ita							
Characteristic strength of concr	oto	f 40 N/m	nm ²					
Characteristic strength of reinfo	rcement	$f_v = 500 \text{ N/r}$	mm ²					
Wall dataila		ly 000 l 41						
Minimum area of reinforcement		k = 0 13 %						
Cover to reinforcement in stem		C _{stem} = 50 n	nm					
Cover to reinforcement in wall		Cwall = 50 m	m					
Factored horizontal active for	ces on stem							
Surcharge		$F_{s,sur,f} = v_{f,i}$	× K₂ × Surcha	arge × (h _{eff} - t _{base} -	- d _{ds}) = 20.1 kN	/m		
Moist backfill above water table		$F_{smat} = 0$	5 × Vfe × Ka ×	$v_{\rm m} \times (h_{\rm eff} - t_{\rm base} - 0)$	d _{ds} - h _{sat}) ² = 27 .	9 kN/m		
Moist backfill below water table		$F_{smb}f = \gamma_f$	$e \times K_a \times \gamma_m \times ($	h _{eff} - t _{base} - d _{ds} - h	sat) × h _{sat} = 17 k	(N/m		
Saturated backfill		Fs s f = 0.5	$\times \gamma_{fe} \times K_a \times (\gamma_{e})$	s- γ_{water} × h _{sat} ² = '	1.6 kN/m			
Water		$F_{s water f} = 0$).5 × γfe × γwate	r × h _{sat} ² = 3.4 kN/	′m			
Calculate shear for stem desir	an		, <u> </u>					
Surcharge	9.1	$V_{s,sur} f = 5$	x Fs. sur. f / 8 = 1	12.6 kN/m				
Moist backfill above water table		Vsmaf=F	s m a f x b i x (({	5×1^{2}) - b ²) / (5 ×	(³) = 18.2 kN/	m		
Moist backfill below water table		Vs m b f = F	s m b f × (8 - (n	$^{2} \times (4 - n)) / 8 =$	16.4 kN/m			
Saturated backfill		Vs s f = Fs s	_{f ×} (1 - (a ² × ($(5 \times L) - a_1) / (20)$	× L ³))) = 1.6 kN	l/m		
Water		Vs water f = F	= s water f × (1 - (a ² × ((5 × L) - a _i)	$/(20 \times L^3))) = 3$	3.3 kN/m		
Total shear for stem design		V _{stem} = V _{s_s}	、、 ur_f + Vs_m_a_f +	$V_{s_m_b_f} + V_{s_s_f} +$	- V _{s_water_f} = 52	kN/m		
Calculate moment for stem de	esian							
Surcharge		Ms sur = Fs	sur f × L / 8 = 7 .	. 9 kNm/m				
Moist backfill above water table		 Ms_m_a = Fs		\times L ²) - (3 \times bi ²)) /	′ (15 × L²) = 14	. 5 kNm/m		
Moist backfill below water table		Msmb=Fs	(2. 	- n) ² / 8 = 5.4 kNr	m/m			
Saturated backfill		Ms_s = Fs_s	 _f ×a⊧×((3×a⊧²)-('	, 15×a⊧×L)+(20×L²))/(60×L ²) = 0.4	kNm/m		
Water		Ms_water = Fs	s_water_f × a l×((3>	√ (<a⊧²)-(15×a⊧×l)+(2< td=""><td>20×L²))/(60×L²)</td><td>= 0.8 kNm/m</td></a⊧²)-(15×a⊧×l)+(2<>	20×L ²))/(60×L ²)	= 0.8 kNm/m		
Total moment for stem design		M _{stem} = M _{s_}	_{sur} + M _{s_m_a} + N	M _{s_m_b} + M _{s_s} + M _s	_{s_water} = 29 kNm	ı/m		
Calculate moment for wall des	sign							
Surcharge	0	$M_{w_{sur}} = 9 \times$	$F_{s_{sur_f} \times L/1}$	28 = 4.4 kNm/m				
Moist backfill above water table		M _{w_m_a} = F _s	_m_a_f × 0.577×	⟨bı×[(bı³+5×aı×L²)/	/(5×L ³)-0.577 ² /3	8] = 8.8		
kNm/m								
Moist backfill below water table		$M_{w_m_b} = F_s$	_m_b_f × a I × [((8	8-n ² ×(4-n)) ² /16)-	4+n×(4-n)]/8 =	1.3 kNm/m		
Saturated backfill		$M_{w_s} = F_{s_s}$	$M_{w_s} = F_{s_sf} \times [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 0.1 \text{ kNm/m}$					
Water		M _{w_water} = F	$M_{w_water} = F_{s_water_f} \times [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 0.1$					
kNm/m								
Total moment for wall design		$M_{wall} = M_{w_s}$	_{ur} + M _{w_m_a} + N	/w_m_b + Mw_s + M	w_water = 14.8 ki	Nm/m		



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NMN Partnership	Calcs for RC	Start page no./Revision RW6 52				
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Check retaining wall de	flection	
Basic span/effective dept	h ratio	ratio _{bas} = 20
Design service stress		$f_s = 2 \times f_y \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = 229.9 \text{ N/mm}^2$
Modification factor	factortens = min(0.55	$5 + (477 \text{ N/mm}^2 - \text{fs})/(120 \times (0.9 \text{ N/mm}^2 + (\text{M}_{\text{stem}}/(\text{b} \times \text{d}_{\text{stem}}^2)))),2) = 2.00$
Maximum span/effective of	depth ratio	ratio _{max} = ratio _{bas} × factor _{tens} = 40.00
Actual span/effective dep	th ratio	ratio _{act} = h _{stem} / d _{stem} = 12.30
		PASS - Span to depth ratio is acceptable



	2	26 Amyand Park	Job no. 23 227			
NMN Partnership	Calcs for	Start page no./Revision RW7 54				
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Tekla Tedds	Project	26 Amvand Par	Jo	Job no. 23 227				
NMN Partnership	Calcs for	, ,		-		s	tart page no /Re	evision
·		RC wall 7 to	front base	ment			RW	7 55
	Calcs by NM	Calcs date 02/05/2024	Checked by	/ Ch	ecked d	ate A	pproved by	Approved date
Saturated density of retained ma	aterial	γs = 21.0 kl	N/m ³					
Design shear strength		φ' = 24.2 de	eg					
Angle of wall friction		δ = 0.0 deg	1					
Base material details								
Moist density		γ _{mb} = 18.0	kN/m³					
Design shear strength		φ' _b = 24.2 c	leg					
Design base friction		δ _b = 18.6 d	eg					
Allowable bearing pressure		Pbearing = 15	50 kN/m²					
Using Coulomb theory								
Active pressure coefficient for re	etained materia	al						
$K_a = sin(\alpha)$	+ $\phi')^2 / (\sin(\alpha)^2)$	$\times \sin(\alpha - \delta) \times [1 + $	- √(sin(φ' +	δ) × sin(¢	o' - β) /	(sin(α - δ	δ) × sin(α + β	3)))]²) = 0.419
Passive pressure coefficient for	base material							
	K _p = sin((90 - φ'♭)² / (sin(90) - δь) × [1 ·	- √(sin(φ'ь	+ δь) >	× sin(∳'♭)	/ (sin(90 + δ	b)))] ²) = 4.187
At-rest pressure								
At-rest pressure for retained ma	terial	K₀ = 1 – sir	n(φ') = 0.59	90				
Loading details								
Surcharge load on plan		Surcharge	= 10.0 kN/	/m²				
Applied vertical dead load on wa	all	W _{dead} = 0.0	kN/m					
Applied vertical live load on wall		W _{live} = 5.0	kN/m					
Position of applied vertical load	on wall	l _{load} = 1675	mm					
Applied horizontal dead load on	wall	$F_{dead} = 0.0$	KN/M					
Height of applied horizontal load	ali I on wall	Flive = 0.0 K	.in/iii m					
Theight of applied holizontal load			5					
	Prop	Prop		4.2 16.9	4.7	9.8		
					Load	ls shown in	kN/m, pressure	s shown in kN/m ²

Tekla. Tedds	Project	26 Amyand Par	Job no.	3 227			
NMN Partnership	Calcs for				Start page no./	Start page no./Revision	
		RC wall 7 to	R\	RW7 56			
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved da	
Vertical forces on wall							
Wall stem		w _{wall} = h _{sten}	$1 \times t_{wall} \times \gamma_{wall} =$	15.9 kN/m			
Wall base		w _{base} = I _{base}	$t \times t_{\text{base}} imes \gamma_{\text{base}}$	= 10.2 kN/m			
Applied vertical load		$W_v = W_{dead}$	1 + W _{live} = 5 kN	l/m			
Total vertical load		W _{total} = w _{wa}	III + Wbase + W_v	= 31.1 kN/m			
Horizontal forces on wall							
Surcharge		F_{sur} = K_a ×	Surcharge × h	_{eff} = 13.6 kN/m			
Moist backfill above water table		F _{m_a} = 0.5	$ imes K_a imes \gamma_m imes$ (he	ff - h _{water}) ² = 19.1	kN/m		
Moist backfill below water table		F _{m_b} = K _a ×	γ _m × (h _{eff} - h _{wa}	_{ter}) × h _{water} = 16.9	kN/m		
aturated backfill		$F_s = 0.5 \times K_a \times (\gamma_{s-} \gamma_{water}) \times h_{water}^2 = 2.3 \text{ kN/m}$					
Vater		$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 4.9 \text{ kN/m}$					
Total horizontal load		F _{total} = F _{sur}	+ Fm_a + Fm_b ·	+ Fs + F _{water} = 56.	9 kN/m		
Calculate total propping force)						
Passive resistance of soil in fror	nt of wall	$F_p = 0.5 \times$	$K_p \times \cos(\delta_b) \times$	(d _{cover} + t _{base} + d _d	s - dexc) ² × γmb =	2.2 kN/m	
Propping force		F _{prop} = max	(Ftotal - Fp - (W	` /total - Wlive) × tan(δь), 0 kN/m)		
		F _{prop} = 45.8	3 kN/m				
Overturning moments							
Surcharge		$M_{sur} = F_{sur}$	\times (h _{eff} - 2 \times d _{ds}	s) / 2 = 22.1 kNm	/m		
Moist backfill above water table		$M_{m_a} = F_{m_a}$	$_{a} \times (h_{eff} + 2 \times h)$	lwater - $3 \times d_{ds}$) / 3	= 33.4 kNm/m		
Moist backfill below water table		$M_{m_b} = F_{m_b}$	$_{b} imes$ (h _{water} - 2 $ imes$	d _{ds}) / 2 = 8.5 kNr	m/m		
Saturated backfill		$M_s = F_s \times ($	h_{water} - $3 imes d_{ds}$)	/ 3 = 0.8 kNm/m			
Water		M _{water} = F _{wa}	$_{ m ater} imes$ (h _{water} - 3	× d _{ds}) / 3 = 1.6 kN	Nm/m		
Total overturning moment		$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 66.4 \text{ kNm/m}$					
Restoring moments							
Wall stem		M _{wall} = w _{wal}	\times (Itoe + t _{wall} / 2	2) = 25.7 kNm/m			
Wall base		Mbase = Wba	se × I _{base} / 2 = 8	3.8 kNm/m			
Design vertical load		$M_v = W_v \times$	l _{load} = 8.4 kNm	/m			
Total restoring moment		M _{rest} = M _{wa}	I + M _{base} + M _v :	= 42.8 kNm/m			
Check bearing pressure							
Total ventical reaction		$D = M_{i}$	21 1 kN1/m				

Total vertical reaction	R = W _{total} = 31.1 kN/m
Distance to reaction	x _{bar} = I _{base} / 2 = 863 mm
Eccentricity of reaction	e = abs((l _{base} / 2) - x _{bar}) = 0 mm
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 18 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 18 \text{ kN/m}^2$
	PASS - Maximum bearing pressure is less than allowable bearing pressure

Calculate propping forces to top and base of wall

Propping force to top of wall

Propping force to base of wall

$$\begin{split} F_{prop_top} = (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \textbf{14.279 kN/m} \\ F_{prop_base} = F_{prop} - F_{prop_top} = \textbf{31.570 kN/m} \end{split}$$

		Job no. 26 Amyand Park Road TW1 3HE 23 227					
NMN Partnership Ca	llcs for				Start page no./Re	evision	
		RC wall 7 to	front basement	t	RW	7 57	
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RETAINING WALL DESIGN (BS 8	<u>8002:1994)</u>				TEDDS calculation	version 1.2.01.08	
Ultimate limit state load factors							
Dead load factor		$\gamma_{f_d} = 1.4$					
Live load factor		γ _{f_l} = 1.6					
Earth and water pressure factor		γ _{f_e} = 1.4					
Factored vertical forces on wall							
Wall stem		$\mathbf{W}_{wall_f} = \gamma_{f_d}$	\times hstem \times twall \times	_{γwall} = 22.3 kN/m			
Wall base		$W_{base_f} = \gamma_{f_e}$	d × Ibase × t base ×	γ _{base} = 14.2 kN/i	m		
Applied vertical load		$W_{v_f} = \gamma_{f_d}$	×Wdead +γf_l × \	W _{live} = 8 kN/m			
Total vertical load		W _{total_f} = w _v	vall_f + Wbase_f + \	<i>N</i> _{v_f} = 44.6 kN/m			
Factored horizontal active forces	s on wall						
Surcharge		$F_{sur f} = \gamma_{f}$	< K _a × Surchard	ae × h _{eff} = 21.8 k№	J/m		
Moist backfill above water table		 Fm_af=γfe	$\times 0.5 \times K_a \times \gamma_m$) n × (h _{eff} - h _{water}) ² =	26.7 kN/m		
Moist backfill below water table		$F_{m b f} = \gamma_{f e}$	$\times K_a \times \gamma_m \times (h_e)$, ff - h _{water}) × h _{water} =	= 23.7 kN/m		
Saturated backfill	$F_{s f} = \gamma_{f e} \times 0.5 \times K_a \times (\gamma_{s} - \gamma_{water}) \times h_{water}^2 = 3.3 \text{ kN/m}$						
Water	Water			× γ _{water} = 6.9 kN/	′m		
Total horizontal load $F_{total} = F_{sur} + F_{m,a} + F_{m,b} + F_{m,b}$, b f + Fs f + Fwater	f = 82.3 kN/m		
Calculate total propping force		_			-		
Passive resistance of soil in front o	fwall	$E_{\rm D} f = \gamma f e X$	$0.5 \times K_{\rm p} \times \cos \theta$	$(\delta_{\rm h}) \times (d_{\rm cover} + t_{\rm has})$	$a + d_{ds} - d_{avc})^2 $	vmb = 3.1	
kN/m	i man	i p_i _ p_c x					
Propping force		Fprop_f = ma	ax(Ftotal f - Fp f -	(Wtotal f - γf I × Wli	$_{ve}$) × tan(δ_{b}). 0	kN/m)	
		$F_{\text{prop} f} = 66.$.9 kN/m	(11.00		,	
Factored overturning moments							
Surcharge		Msur f = Fsur	r f x (h₀ff - 2 x d	lds) / 2 = 35.4 kNr	m/m		
Moist backfill above water table		$M_{m,a,f} = F_{m}$		hwater - 3 × dds) / 3	3 = 46.7 kNm/r	n	
Moist backfill below water table		$M_{m,b,f} = F_{m}$	$\underline{L} = \frac{L}{2} \times (h_{\text{water}} - 2)$	$\times d_{ds})/2 = 11.9$	«Nm/m		
Saturated backfill		$M_{n,f} = F_{n,f}$	$(h_{water} - 3 \times d_{d})$	(3 = 11 kNm/r)	n		
Water		$M_{water} f = F_{w}$	water $f \times (h_{water} - 3)$	$3 \times d_{12}$ / 3 = 2.3	«Nm/m		
Total overturning moment		$M_{ot f} = M_{sur}$	f + Mm a f + Mm	$h f + M_s f + M_{wate}$	r f = 97.3 kNm/	m	
Postoring momente							
		M		(2) - 36 k Nm/m			
		$V_{\text{IVIWall}_{f}} = V_{\text{VWall}_{f}}$		-123 kNm/m			
		$V_{\text{base}_{1}} = V_{\text{base}_{2}}$					
$Viv_f = VVv_f \times I_{load} = 13.4 \text{ KNM/M}$				n			
		TVIrest_1 - TVIW	all_i • Ivibase_i • Iv	₩_1 - 01. 7 KN11/11			
Factored bearing pressure		D = W					
		Rt - VV total_t	-44.0 KN/III				
Eccentricity of reaction		$Abar_1 - Base$	72 = 000 mm	• 0 mm			
				Reaction acts	within middle	third of base	
Bearing pressure at toe		$p_{\text{toe } f} = (R_f)$	/Ibase) - (6 × Rf >	$\times \text{e}_{\text{f}} / \text{I}_{\text{base}^2} = 25.8$	3 kN/m ²		
Bearing pressure at heel		pheel f = (Rf	/ Ibase) + (6 × R	$f \times e_f / I_{base}^2$) = 25	.8 kN/m²		
Rate of change of base reaction		rate = (p _{toe}	_f - p _{heel_f}) / I _{base}	, = 0.00 kN/m²/m			
Bearing pressure at stem / toe		p _{stem_toe_f} =	max(p _{toe_f} - (rat	$te \times I_{toe}$), 0 kN/m ²) = 25.8 kN/m²		

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NMN Partnership	Calcs for		Start page no./R	evision				
	RC wall 7 to front basement				RW	7 58		
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	NM	02/05/2024						
Bearing processrs at mid atom			may/n /rata		(1.0 kN) = 2	E 9 khl/m²		
Bearing pressure at this stem		pstem_mid_f =	max(ptoe_f - (late	$\times (\text{toe} + \text{twall}/2)$	(1, 0 KIN/III) - 2	J.O KIN/III		
bearing pressure at stem / neer		Pstem_heel_f −	max(ptoe_f - (rate	$e \times (\text{Itoe} + \text{Iwall})), U$	$(KIN/III^{-}) - 23.0$	KIN/III		
Calculate propping forces to t Propping force to top of wall	op and base o	f wall						
	$F_{prop_top_f} = ($	(Mot_f - Mrest_f + Rf	× Ibase / 2 - Fprop	_f $ imes$ tbase / 2) / (hs	_{tem} + t _{base} / 2) =	21.037 kN/m		
Propping force to base of wall		Fprop_base_f =	Fprop_f - Fprop_top_	_{.f} = 45.872 kN/m	ı			
Design of reinforced concrete	retaining wall	toe (BS 8002:1	994 <u>)</u>					
Material properties								
Characteristic strength of concre	ete	f _{cu} = 40 N/n	nm²					
Characteristic strength of reinfo	rcement	f _y = 500 N/r	nm²					
Base details								
Minimum area of reinforcement		k = 0.13 %						
Cover to reinforcement in toe		_{Ctoe} = 50 mi	m					
Calculate shear for toe desigr	ı							
Shear from bearing pressure		V _{toe_bear} = (p	Dtoe_f + pstem_toe_f)	× Itoe / 2 = 38.7	kN/m			
Shear from weight of base		V _{toe_wt_base} =	$V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times I_{toe} \times t_{base} = 12.4 \text{ kN/m}$					
Total shear for toe design	V _{toe} = V _{toe_bear} - V _{toe_wt_base} = 26.3 kN/m			26.3 kN/m				
Calculate moment for toe des	ian							
Moment from bearing pressure	0	M _{toe bear} = (2	2 × p _{toe f} + p _{stem i}	mid f) × (I_{toe} + t_{wall}	/ 2) ² / 6 = 33.6	kNm/m		
Moment from weight of base		M _{toe} wt base =	= ($\gamma_{f d} \times \gamma_{base} \times \mathbf{t}_{base}$	$_{ase} \times (I_{toe} + t_{wall} / 2)$	2) ² / 2) = 10.7	kNm/m		
Total moment for toe design		M _{toe} = M _{toe} _	bear - Mtoe_wt_base =	= 22.8 kNm/m	, ,			
	•	•	•	•	•			
	4 ——200—							
Check toe in bending								
Width of toe		b = 1000 m	ım/m					
Depth of reinforcement		d _{toe} = t _{base} –	d _{toe} = t _{base} - c _{toe} - (φ _{toe} / 2) = 194.0 mm					
Constant		K _{toe} = M _{toe} /	$(b \times d_{toe}^2 \times f_{cu}) =$	= 0.015				
			Co	mpression rei	nforcement is	not required		
Lever arm		$z_{toe} = min(0)$	0.5 + √(0.25 - (mi	in(K _{toe} , 0.225) / ($(0.9), 0.95) \times d_t$	oe		
		z _{toe} = 184 n	nm		D /			
Area of tension reinforcement re	required $A_{s_{toe_{des}}} = M_{toe} / (0.87 \times t_y \times z_{toe}) = 285 \text{ mm}^2/\text{m}$							
Minimum area of tension reinfor	rcement $A_{s_toe_min} = k \times b \times t_{base} = 325 \text{ mm}^2/\text{m}$							
Area of tension reinforcement re	equired	$A_{s_{toe_{req}}} = 1$	viax(As_toe_des, As	_toe_min) = 325 mi	m ⁻ /m			
Keinforcement provided		12 mm dia	.pars @ 200 mr	n centres				
Area or reiniorcement provided		PASS - Roin	forcement prov	vided at the retain	aining wall to	e is adequate		
		- AUU - NEIII				adoquale		

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		RC wall 7 to	front basement		RW	7 59	
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Check shear resistance at toe							
Design shear stress		$v_{toe} = V_{toe} /$	$(b \times d_{toe}) = 0.13$	36 N/mm ²			
Allowable shear stress		v _{adm} = min(0.8 × √(f _{cu} / 1 N	/mm²), 5) × 1 N/r	mm ² = 5.000 N	/mm ²	
		PASS -	Design shear	stress is less th	nan maximum	shear stress	
From BS8110:Part 1:1997 – Ta	ble 3.8		7 \mathbf{N}/mm^2				
Design concrete snear stress		Vc_toe - 0.50	07 IN/IIIII-	< Va tao - No shi	aar rainforcan	ont required	
			VIDE			ient required	
Design of reinforced concrete	retaining wa	all stem (BS 8002	:1994 <u>)</u>				
Material properties							
Characteristic strength of concre	ete	f _{cu} = 40 N/n	nm²				
Characteristic strength of reinfor	cement	f _y = 500 N/r	mm²				
Wall details							
Minimum area of reinforcement		k = 0.13 %					
Cover to reinforcement in stem		c _{stem} = 50 n	nm				
Cover to reinforcement in wall		Cwall = 50 M	m				
Factored horizontal active for	ces on stem						
Surcharge		$F_{s_sur_f} = \gamma_{f_i}$	\times K _a \times Surchar	$ge \times (h_{eff} - t_{base} - t_{base})$	d _{ds}) = 20.1 kN/	m	
Moist backfill above water table		$F_{s_m_a_f} = 0.$	$.5 imes \gamma_{f_e} imes K_a imes \gamma$	$m \times (h_{eff} - t_{base} - d)$	_{ds} - h _{sat}) ² = 26.	7 kN/m	
Moist backfill below water table		$F_{s_m_b_f} = \gamma_f$	$_{e} \times K_{a} \times \gamma_{m} \times (h)$	leff - t _{base} - d _{ds} - h _s	_{at}) × h _{sat} = 17.8	kN/m	
Saturated backfill	$F_{s_s_f} = 0.5$	$\times \gamma_{f_e} \times K_a \times (\gamma_{s})$	$-\gamma_{water}$) × h_{sat}^2 = 1	.8 kN/m			
Water		F _{s_water_f} = 0	$0.5 imes \gamma_{f_e} imes \gamma_{water}$	× h _{sat} ² = 3.9 kN/r	n		
Calculate shear for stem desig	gn						
Surcharge		$V_{s_sur_f} = 5$	× F _{s_sur_f} / 8 = 1 2	2.6 kN/m			
Moist backfill above water table		$V_{s_m_a_f} = F_{s_a}$	$s_m_a_f \times b_I \times ((5$	\times $L^2)$ - $b{\scriptscriptstyle I}^2)$ / (5 \times	L ³) = 17.2 kN/r	n	
Moist backfill below water table		$V_{s_m_b_f} = F_{f}$	s_m_b_f × (8 - (n ²	× (4 - n))) / 8 = 1	7.1 kN/m		
Saturated backfill		$V_{s_s_f} = F_{s_s}$	$_{f} \times (1 - (a_{l}^{2} \times ((a_{l}^{2} \times ((a_{l}^{2} \times ((a_{l}^{2} \times (a_{l}^{2} \times ($	5 × L) - aı) / (20 >	< L ³))) = 1.8 kN	/m	
Water		$V_{s_water_f} = F$	$V_{s_water_f} = F_{s_water_f} \times (1 - (a_1^2 \times ((5 \times L) - a_1) / (20 \times L^3))) = 3.8 \text{ kN}$				
Total shear for stem design		$V_{stem} = V_{s_sur_f} + V_{s_m_a_f} + V_{s_m_b_f} + V_{s_s_f} + V_{s_water_f} = 52.5 \text{ kN/m}$					
Calculate moment for stem de	sign						
Surcharge		$M_{s_sur} = F_{s_s}$	sur_f × L / 8 = 7.8	3 kNm/m			
Moist backfill above water table		Ms_m_a = Fs	_m_a_f × bi × ((5 >	\times L ²) - (3 \times bi ²)) /	$(15 \times L^2) = 13.3$	B kNm/m	
Moist backfill below water table		$M_{s_m_b} = F_{s_b}$	_m_b_f \times al \times (2 -	n)² / 8 = 5.8 kNm	ı/m		
Saturated backfill		$M_{s_s} = F_{s_s}$	_f ×a⊧×((3×a⊧²)-(1	5×a⊧×L)+(20×L²))	/(60×L ²) = 0.4	kNm/m	
Water		Ms_water = Fs	s_water_f × a l× ((3 × a	aı²)-(15×aı×L)+(20	0×L²))/(60×L²) :	= 0.9 kNm/m	
Total moment for stem design		M _{stem} = M _{s_s}	_{sur} + M _{s_m_a} + M	s_m_b + Ms_s + Ms_	_water = 28.7 kN	m/m	
Calculate moment for wall des	sign						
Surcharge		$M_{w_{sur}} = 9 \times$	$F_{s_sur_f} \times L / 12$	28 = 4.4 kNm/m			
Moist backfill above water table		$M_{w_m_a} = F_s$	_m_a_f × 0.577×b	o⊧×[(bi³+5×a⊧×L²)/(5×L ³)-0.577 ² /3] = 8.4	
kNm/m							
Moist backfill below water table		Mw_m_b = Fs	$_m_b_f \times a_I \times [((8)$	-n²×(4-n))² /16)-4	+n×(4-n)]/8 = 1	l .5 kNm/m	
Saturated backfill		$M_{w_s} = F_{s_s_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 0.1 \text{ kNm/m}$					
Water		M _{w_water} = F	s_water_f × [a l ² × x ×	((5×L)-a⊨)/(20×L³)-(x-bı) ³ /(3×aı²)] = 0.2	
kNm/m							
Total moment for wall design		$M_{wall} = M_{w_s}$	ur + Mw_m_a + M	w_m_b + Mw_s + Mw	/_water = 14.6 kN	lm/m	
۱ <u>ــــــــــــــــــــــــــــــــــــ</u>							



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Design service stress

 $f_{s} = 2 \times f_{y} \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = \textbf{242.5} \text{ N/mm}^{2}$

Modification factor

 $factor_{tens} = min(0.55 + (477 \text{ N/mm}^2 - f_s)/(120 \times (0.9 \text{ N/mm}^2 + (M_{stem}/(b \times d_{stem}^2)))), 2) = 1.58$

ratiomax = ratiobas × factortens = **31.50**

Maximum span/effective depth ratio Actual span/effective depth ratio

ratio_{act} = h_{stem} / d_{stem} = **17.75**

PASS - Span to depth ratio is acceptable



Toe bars - 12 mm dia.@ 200 mm centres - $(565 \text{ mm}^2/\text{m})$ Wall bars - 12 mm dia.@ 200 mm centres - $(565 \text{ mm}^2/\text{m})$ Stem bars - 12 mm dia.@ 200 mm centres - $(565 \text{ mm}^2/\text{m})$

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(assumed symmetric)

RC WALL DESIGN (BS8110) WALL DESIGN TO CL 3.9.3

WALL DEFINITION

Wall thickness h = **250** mm

Cover to tension reinforcement cw = 35 mm

Trial bar diameter Dtry = 12 mm

Depth to tension steel

h' = h - c_w - D_{try}/2 = **209** mm

Materials

Characteristic strength of reinforcement fy = 500 N/mm²

Characteristic strength of concrete fcu = 35 N/mm²

Braced Wall Design to cl 3.9.3 (Simply supported construction)

Stocky check for braced walls

Wall clear height Io = 3000 mm

Effective height factor for simply supported braced walls (assessed for a plain wall)

β **= 1.00**

 $I_e = \beta \times I_o = 3.000 \text{ m} I_e/h = 12.00$

The braced wall is stocky

Braced wall slenderness check

Effective wall height I_e = **3000** mm Slenderness limit I_{limit} = 40 × h = **10000** mm Slenderness limit I_{limit1} = 45 × h = **11250** mm TEDDS calculation version 1.0.04

Tekla. Tedds	Project 26 Amvard Park Road TW1 3HF				Job no. 23 227	
NMN Partnership	Calcs for				Start page no./Revision	
9 Chamberlain Lane Pinner	RC wal in basement			RC\	N7 64	
HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
					Wall slend	erness limit OK
Define wall reinforcement						
Main reinforcement in wall						
Provido 12 dia bara @ 200 aa	ntrop in pook	face				
Area of "tension" steel	$A_{st} = A_{svert} = 56$	5 mm²/m				
Area of compression st	eel A _{sc} = A _{st} = t	565 mm²/m				
Total area of steel Awa	⊫ = A _{st} + A _{sc} = 1 ′	130.0 mm²/m				
Percentage of steel $(A_{st} + A_{sc})$	/ h = 0.45 %					
, , , , , , , , , , , , , , , , , , ,						
HORIZONTAL WALL STEEL	mm					
Area of vertical steel provided	Δ	n^2/m				
Percentage of vertical steel now	$a_{\text{max}} = \mathbf{A}_{\text{max}} / \mathbf{h} = 0$	45 %				
Minimum diameter of horizonta	Isteel D _{min} = m	nax(D _{vert} /4 6 mm	n) = 6 mm			
Minimum area of horizontal stee			.)			
A _{⊎min} = If(f _v >=(460 N/mn	n²) if(n _{well} >2 %	0 13 % 0 25%) i	f(ກ _{າຫາຟ} ⊳2 % 0 2	4 % 0 30 %)) × ł	1/2	
$A_{Hmin} = 313 \text{ mm}^2/\text{m}$		on o /o,oo /o,,.				
				No	containment l	inks required
Define horizontal wall steel in or	ne face					
Provide 10 dia bars @ 200 cer	ntres in each i	face				
Stocky wall (simple construct	ion) - transver	se bending and	axial load			
Design ultimate loading						
Design ultimate axial loa	ad per m of wal	I n _w = 70 kN/m				
Design ultimate transve	rse moment pe	rm of wall m _w =	17.5 kNm/m			
Minimum design moments						
$m_{min} = min(0.05 \times h, 20)$	mm) × n _w = 0.9	kNm/m				
Design moments						
m _{design} = max(abs(m _w), r	m _{min})= 17.5 k	Nm/m				
CHECK OF DESIGN FORCES	- SYMMETRIC	ALLY REINFOR	CED WALL SE	ECTION		
NOTES						
h is the wall thickness						
h' is the depth from the	more highly cor	npressed face to	the "tension"	steel.		

Tekla. Tedds	Project 26 Amyard Park Road TW1 3HE Calcs for RC wal in basement				Job no. 23 227 Start page no./Revision RCW7 65	
NMN Partnership 9 Chamberlain Lane						
Pinner HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
<u>Tension steel yields</u> Determine correct moment of n _R = if(x _{calc} <h 0.9,="" n<sub="">R1 , r m_R = if(x_{calc}<h 0.9,="" m<sub="">R1 ,</h></h>	resistance n _{R2}) = 335.5 k m _{R2}) = 82.6	kN/m kNm/m				
Applied axial load						
n _w = ר ט.ט אוא/m Check for moment						
m _{design} = 17.5 kNm/m						
					Moment c	heck satisfie

The wall vertical reinforcement defined in each face is H12 dia bars @	200 centres
--	-------------

CHECK MIN AND MAX AREAS OF STEEL

Overall thickness of wall h = 250 mm

Vertical steel

Total area of concrete per m run of wall $A_c = h = 250000 \text{ mm}^2/\text{m}$

 $A_{st min} = 0.4\% \times A_c = 1000 \text{ mm}^2/\text{m}$

 $A_{st max} = 4 \% \times A_c = 10000 \text{ mm}^2/\text{m}$

Total vertical steel in wall Awall = 1130 mm²/m

Horizontal steel

Percentage of vertical steel pvwall = Awall / h = 0.45 %

Diameter of horizontal steel Dhor = 10 mm

Minimum diameter of horizontal steel $D_{min} = max(D_{vert}/4,6 mm) = 6 mm$

Diameter of horizontal steel in wall OK

Area of vertical steel in wall provided OK

Area of horizontal steel in one face Ashor = 393 mm²/m

Minimum area of horizontal steel

 $A_{Hmin} = If(f_y \ge (460 \text{ N/mm}^2), if(p_{vwall} \ge 2\%, 0.13\%, 0.25\%), if(p_{vwall} \ge 2\%, 0.24, 0.30\%)) \times h/2$

A_{Hmin} =313 mm²/m

Area of horizontal steel in wall provided OK

Shear Resistance of Concrete Walls - (cl 3.8.4.6)

Wall thickness h = 250 mmEffective depth to steel h' = 209 mm

Area of concrete A_{conc} = h = 250000 mm²/m
	Project				loh no		
ekia ledds		26 Amyard Park	HE	23	3 227		
NMN Partnership	Calcs for				Start page no./Revision		
9 Chamberlain Lane Pinner		RC wal in	basement	1	RC	RCW7 66	
HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date	
Design ultimate sh	ear force throu	gh thickness per	m of wall v _w =	= 6 kN/m			
Characteristic stre	ngth of concrete	e f _{cu} = 35 N/mm	2				
Is a check required? (3.8.4	4.6)						
Axial load per m of	wall n _w = 70.0	kN/m					
Major axis momen	t per m of wall	m _w = 17.5 kNm/i	m				
e = m _w / n _w = 250.0	e = m _w / n _w = 250.0 mm						
elimit = 0.6 × h = 15	e _{limit} = 0.6 × h = 150.0 mm						
Actual shear stress $v_x = v_w$	/ h' = 0.0 N/mm	2					
Allowable stress Vallowable = I	min ((0.8 N ^{1/2} /m	im) × $\sqrt{(f_{cu})}$, 5 N/	mm²) = 4.733	N/mm ²			
					Shear ch	neck required	
Design shear stress to cla	use 3.4.5.12						
$f_{cu_ratio} = if (f_{cu} > 40)$	N/mm² , 40/25	, f _{cu} /(25 N/mm²))	= 1.400				
Design concrete shear stres	SS						
$v_c = 0.79 \text{ N/mm}^2 \times$	min(3,100 \times A	_{st} / h') ^{1/3} × max(1	,(400 mm) / h') ^{1/4} / 1.25 * f _{cu_ratic}	,1/3		
v _c = 0.538 N/mm ²							
$v_{c}' = v_{c} + 0.6 \times n_{w} / c_{c}$	$h \times min(abs(v_{v}))$	") × h / m _w , 1.0) =	= 0.6 N/mm ²				
Vallowable = min ((0.8 N ^{1/2} /mm	i) $ imes \sqrt{({\sf f}_{\sf cu}}$), vc' , 5	5 N/mm²) = 0.55	2 N/mm ²				
Actual shear stress	6						
v _x = 0.0 N/mm ²							
					Shear re noi rea	einforcement t necessarily quired in wall	

Shear stress - OK

Check of nominal cover - (BS8110:Pt 1, Table 3.4)

Wall thickness h = 250 mm

Depth to tension steel from compression face h' = 209 mm

Diameter of vertical reinforcement Dvert = 12 mm

Diameter of links Ldia = 0 mm

Cover to tension reinforcement

c_{ten} = h - h' - D_{vert} / 2 = **35.0** mm

Nominal cover to links steel

Cnom = Cten - Ldia = **35.0** mm

Permissable minimum nominal cover to all reinforcement (Table 3.4)

c_{min} = **35** mm

Cover OK

Tekla. Tedds	Project 26 Amyard Park Road TW1 3HE				Job no. 23	Job no. 23 227		
NMN Partnership 9 Chamberlain Lane	Calcs for	RC wal ir	basement		Start page no./Revision RCW7 67			
HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Approved by	Approved date				
<u>SERVICEABILITY LIMIT STAT</u> (BS8110:Pt 2, Cl. 3.8 & BS800 ⁻	E - CRACKIN 7 Cl 2.6 & Apj	G IN WALLS pendix B)						

Design serviceability loading

For a conservative assessment of crack widths, the axial compression and the compression reinforcement in the wall will be ignored.

Serviceability transverse moment per m of wall msLs = 9 kNm/m

Wall thickness h = 250 mm

Depth to steel h' = 209 mm

Characteristic strength of concrete fcu = 35 N/mm²

Characteristic strength of reinforcement fy = 500 N/mm²

Diameter of wall vertical reinforcement Dvert = 12 mm

Spacing of vertical reinforcement bars svert = 200 mm

Area of vertical reinforcement in one face Ast = $\pi \times D_{vert}^2 / 4 / s_{vert} = 565 \text{ mm}^2/\text{m}$

Effective depth to tension reinforcement

h' = **209.0** mm

Cover to tension reinforcement

 c_{ten} = h - h' - D_{vert}/2 = **35** mm

Nominal cover to tension reinforcement

c_{nom} = c_{ten} = **35.0** mm

Tension bar centres

bar_{crs} = s_{vert} = **200.0** mm

MODULAR RATIO

Modulus of elasticity for reinforcement Es = 200 kN/mm²

Modulus of elasticity for concrete (half the instanteneous)

Ec = ((20 kN/mm²) + 200×fcu) / 2 = 14 kN/mm²

Modular ratio $m = E_s / E_c = 14.815$

NEUTRAL AXIS POSITION

For equilibrium Fst equates Fc

Therefore: $m \times A_{st} \times [f_c \times (h'-x)/x]$ equates to $0.5 \times f_c \times x$

BS8110:Pt 1:Cl 2.5.4

BS8110:Pt 2:Equation 17

BS8110:Pt 1:Table 3.1

Tekla Tedds	Project	26 Amyard Parl	< Road TW1 3	HE	Job no. 23	227
NMN Partnership	Calcs for				Start page no./Re	evision
9 Chamberlain Lane Pinner	Calco by	RC wal in	basement	Chasked data	RCV	V7 68
HA5 2PH	NM	02/05/2024	Checked by	Checked date	Approved by	Approved date
Solving for x gives the position	of the neutral a	axis in the section	:-			
$x = h' \times [-1 \times E_s \times A_{st}/(E_c \times A_{st})]$	h') + √(E _s ×A _{st} /	/(E₅×h') × (2+E₅×A	_{st} /(E _c ×h')))] = 5	1.4 mm		
Depth of concrete in compressi	on					
x = 51.4 mm						
CONCRETE AND STEEL STR	ESSES					
The serviceability limit state mo	ment per m of	wall m _{SLS} = 9 kN	m/m			
Taking moments about the cent	treline of the re	einforcement:-				
Moment of resistance of concre	ete is $0.5 \times f_c \times$	x × (h' - x/3)				
Solving for concrete stress $f_{\mbox{\tiny C}}$ gives	ves					
f_{c} = 2 \times m_{SLS} / (x \times (h' -	x/3)) = 1.83 N	/mm²				
Allowable stress 0.45 >	< f _{cu} = 15.75 N	/mm ²				
- 1					Concre	te stress OK
Taking moments about the cent	tre of action of	the concrete forc	e:-			
Moment of resistance of steel is	s fst × As × (h' -	x/3)				
Solving for steel stress Ist gives						
$f_{st} = m_{SLS} / (A_{st} \times (h' - x))$	(3)) = 82.95 N/	mm²				
CONCRETE AND STEEL STR	AINS					
Strain in the reinforcement						
εs = fst / Es = 414.7×10⁻⁶	i					
Allowable steel strain 0	0.8 × f _y / E _s = 2	.000×10 ⁻³			•	
					Ste	BS8007:App B.4
Strain in the concrete at the lev	el at which cra	ick width is require	ed			
Level of crack a' = h =	250 mm					
$\epsilon_1 = \epsilon_s \times (a' - x)/(h' - x) =$	⁻ 522.6×10⁻ ⁶					
Strain in the concrete at the leve	el at which cra	ick width is require	ed adjusted for	stiffening of the	concrete tensio	n zone
Allowable crack width	Crack _{Allowable} =	0.2 mm				
Factor for stiffening bas	ed on limitina	crack width			E	3S8007:Cl 2.2.3.3
factor = if(Crac	$k_{Allowable} == (0.2)$	2 mm). (1.0 N/mm	²). (1.5 N/mm ²)) = 1 N/mm ²		
ε _m = min(ε ₁ ,max(0, ε ₁ -	\cdot [factor \times (h -	x) × (a' - x) / (3×E	,, (()) = 0.0000		
		/ () - (-			E	3S8007:Cl 2.2.3.3
Distance from tension bar to cra	ack in tension	face between tens	sion bars			
$a_{cr} = \sqrt{(bar_{crs}/2)^2 + (c_{normalized})^2}$	om + Dvert/2) ²) -	D _{vert} /2 = 102.1 m	m			
Design crack width						

Tekla. Tedds	Project 26 Amyard Park Road TW1 3HE				Job no. 23 227	
NMN Partnership 9 Chamberlain Lane	Calcs for RC wal in basement				Start page no./Revision RCW7 69	
HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date

 $Crack_{\text{design}} = 3 \times a_{\text{cr}} \times \epsilon_{\text{m}} / (1 + 2 \times (a_{\text{cr}} - c_{\text{ten}}) / (h - x)) = 0.000 \text{ mm}$

BS8007:App B.3

Max allowable crack width

CrackAllowable = 0.20 mm

BS8007:Cl 2.2.3.3 Design Crack width OK

Tekla Tedds	Project J 26 Amyard Park Road TW1 3HE				Job no. 23 227	
NMN Partnership 9 Chamberlain Lane	Calcs for RC	wal in basemen	t to front wal sup	oport	Start page no./Re RCW	evision /8 70
HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date



(assumed symmetric)

RC WALL DESIGN (BS8110) WALL DESIGN TO CL 3.9.3

WALL DEFINITION

Wall thickness h = **300** mm

Cover to tension reinforcement cw = 35 mm

Trial bar diameter Dtry = 12 mm

Depth to tension steel

h' = h - c_w - D_{try}/2 = **259** mm

Materials

Characteristic strength of reinforcement fy = 500 N/mm²

Characteristic strength of concrete fcu = 35 N/mm²

Braced Wall Design to cl 3.9.3 (Simply supported construction)

Stocky check for braced walls

Wall clear height Io = 3000 mm

Effective height factor for simply supported braced walls (assessed for a plain wall)

β **= 1.00**

 $I_e = \beta \times I_o = 3.000 \text{ m} I_e/h = 10.00$

The braced wall is stocky

Braced wall slenderness check

Effective wall height I_e = **3000** mm Slenderness limit I_{limit} = 40 × h = **12000** mm Slenderness limit I_{limit1} = 45 × h = **13500** mm TEDDS calculation version 1.0.04

Tekla Tedds	Project Job no.					007
NMN Partnershin	Calcs for	26 Amyard Park	=	23 ZZ1		
9 Chamberlain Lane	RC	wal in basemen	t to front wal sup	oport	RCV	V8 71
Pinner HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
					Wall slend	erness limit OK
Define wall reinforcement						
Main reinforcement in wall						
<u>Provide 12 dia bars @ 200 cer</u> Area of "tension" steel	ntres <u>in each fa</u> A _{st} = A _{svert} = 565	ace mm²/m				
Area of compression ste	eel A _{sc} = A _{st} = 5	65 mm²/m				
Total area of steel Awai	= Ast + Asc = 11	30.0 mm²/m				
Percentage of steel $(A_{st} + A_{sc})$	/ h = 0.38 %					
HORIZONTAL WALL STEEL						
Wall thickness h = 300	mm					
Area of vertical steel provided	A _{wall} = 1130 mm	²/m				
Percentage of vertical steel pvvv	_{all} = A _{wall} / h = 0. 3	38 %				
Minimum diameter of horizonta	l steel D _{min} = ma	ax(D _{vert} /4 , 6 mm	n) = 6 mm			
Minimum area of horizontal stee	el					
$A_{Hmin} = If(f_y > = (460 \text{ N/mn})$	n²),if(p _{vwall} >2 %,0).13 %,0.25%),it	f(p _{vwall} >2 %,0.24	%, 0.30 %)) × h	/2	
A _{Hmin} = 375 mm ² /m						
				No c	ontainment l	inks required
Define horizontal wall steel in or	ne face					
Stocky wall (simple construct	ion) - transvers	a <u>ce</u> se bending and	axial load			
Design ultimate loading						
Design ultimate axial loa	ad per m of wall	n _w = 70 kN/m				
Design ultimate transve	rse moment per	m of wall m _w =	17.5 kNm/m			
Minimum design moments						
m_{min} = min(0.05 × h, 20	mm) × n _w = 1.1	kNm/m				
Design moments						
m _{design} = max(abs(m _w), r	n _{min})= 17.5 kN	lm/m				
CHECK OF DESIGN FORCES	- SYMMETRICA	LLY REINFOR	CED WALL SEC	CTION		
NOTES						
h is the wall thickness						
h' is the depth from the	more highly com	pressed face to	the "tension" st	eel.		

Tekla. Tedds	Project	Job no. 23 227				
NMN Partnership 9 Chamberlain Lane	Calcs for RC	wal in basemen	t to front wal su	pport	Start page no./Revision RCW8 72	
Pinner HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date

Tension	steel	yields
		-

Determine correct moment of resistance

n_R = if(x_{calc}<h/0.9, n_{R1} , n_{R2}) = **335.5** kN/m

mr = if(xcalc<h/0.9, mr1, mr2) = 103.2 kNm/m

Applied axial load

n_w = **70.0** kN/m

Check for moment

m_{design} = 17.5 kNm/m

Moment check satisfied

The wall vertical reinforcement defined in each face is H12 dia bars @ 200 centres

CHECK MIN AND MAX AREAS OF STEEL

Overall thickness of wall h = 300 mm

Vertical steel

Total area of concrete per m run of wall Ac = h = 300000 mm²/m

 $A_{st_{min}} = 0.4\% \times A_c = 1200 \text{ mm}^2/\text{m}$

 $A_{st_max} = 4 \% \times A_c = 12000 \text{ mm}^2/\text{m}$

Total vertical steel in wall Awall = 1130 mm²/m

Horizontal steel

Percentage of vertical steel pvwall = Awall / h = 0.38 %

Diameter of horizontal steel Dhor = 10 mm

Minimum diameter of horizontal steel $D_{min} = max(D_{vert}/4,6 mm) = 6 mm$

Diameter of horizontal steel in wall OK

Less than min area of vertical steel in wall - FAIL

Area of horizontal steel in one face A_{shor} = 393 mm²/m

Minimum area of horizontal steel

 $A_{Hmin} = If(f_y \ge (460 \text{ N/mm}^2), if(p_{vwall} \ge 2\%, 0.13\%, 0.25\%), if(p_{vwall} \ge 2\%, 0.24, 0.30\%)) \times h/2$

A_{Hmin} =375 mm²/m

Area of horizontal steel in wall provided OK

Shear Resistance of Concrete Walls - (cl 3.8.4.6)

Wall thickness h = **300** mm Effective depth to steel h' = **259** mm

Area of concrete A_{conc} = h = 300000 mm²/m

Tekla Tedds	Project	Project 26 Amyard Park Road TW1 3HE			Job no. 2	3 227	
9 Chamberlain Lane	RC	wal in basemer	nt to front wal s	support	RCW8 73		
Pinner HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date	
Design ultimate sh	ear force through	gh thickness pe	rmofwallv _w :	= 6 kN/m			
Characteristic stre	ngth of concrete	e f _{cu} = 35 N/mm	2				
Is a check required? (3.8.	4.6)						
Axial load per m o	f wall n _w = 70.0	kN/m					
Major axis momen	t per m of wall	m _w = 17.5 kNm/	m				
e = m _w / n _w = 250.0	0 mm						
elimit = 0.6 × h = 18	0.0 mm						
Actual shear stress $v_x = v_w$	/ h' = 0.0 N/mm	1 ²					
Allowable stress vallowable =	min ((0.8 N ^{1/2} /m	nm) × $\sqrt{(f_{cu})}$, 5 N	/mm²) = 4.733	N/mm ²			
					Shear cl	heck required	
Design shear stress to cla	ause 3.4.5.12						
$f_{cu_ratio} = if (f_{cu} > 40)$	N/mm ² , 40/25	, f _{cu} /(25 N/mm²)) = 1.400				
Design concrete shear stre	SS						
v_c = 0.79 N/mm ² ×	x min(3,100 \times A	a _{st} / h') ^{1/3} × max(*	l,(400 mm) / h'	') ^{1/4} / 1.25 * f _{cu_ration}	^{1/3}		
v _c = 0.474 N/mm ²							
v_c ' = v_c + 0.6 \times n_w /	h × min(abs(v	w) × h / mw, 1.0)	= 0.5 N/mm ²				
Vallowable = min ((0.8 N ^{1/2} /mm	n) $ imes \sqrt{({\sf f}_{\sf cu}}$), vc' , 5	5 N/mm²) = 0.48	9 N/mm²				
Actual shear stres	s						
v _x = 0.0 N/mm ²							
					Shear re	einforcement	

not necessarily required in wall

Shear stress - OK

Check of nominal cover - (BS8110:Pt 1, Table 3.4)

Wall thickness h = 300 mm

Depth to tension steel from compression face h' = 259 mm

Diameter of vertical reinforcement Dvert = 12 mm

Diameter of links Ldia = 0 mm

Cover to tension reinforcement

c_{ten} = h - h' - D_{vert} / 2 = **35.0** mm

Nominal cover to links steel

Cnom = Cten - Ldia = **35.0** mm

Permissable minimum nominal cover to all reinforcement (Table 3.4)

c_{min} = **35** mm

Cover OK

Tekla Tedds	Project	26 Amyard Park	<pre> Road TW1 3 </pre>	HE	Job no. 23	227	
NMN Partnership	Calcs for	alcs for Start page no./Revi					
9 Chamberlain Lane Pinner	RC	RC wal in basement to front wal support RCW8 74					
HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date	
SERVICEABILITY LIMIT STAT	E - CRACKING	IN WALLS					
(BS8110:Pt 2, Cl. 3.8 & BS800	7 CI 2.6 & Appe	endix B)					
Design serviceability loading							
For a conservative assessment be ignored.	of crack widths,	the axial compr	ression and the	e compression re	inforcement in	the wall will	
Serviceability transverse	e moment per m	of wall m _{SLS} =	9 kNm/m				
Wall thickness h = 300	mm						
Depth to steel	h' = 259 mm						
Characteristic strength	of concrete f _{cu} =	- 35 N/mm²					
Characteristic strength	of reinforcemen	t fy = 500 N/mm	2				
Diameter of wall vertica	l reinforcement	D _{vert} = 12 mm			BS8	110:Pt 1:Table 3.1	
Spacing of vertical reinf	orcement bars	s _{vert} = 200 mm					
Area of vertical reinforc	ement in one fa	ce $A_{st} = \pi \times D_{vert}$	t ² /4 / svert = 56	5 mm²/m			
Effective denth to tension reinfo	rcement						
h' = 259.0 mm							
Cover to tension reinforcement							
c _{ten} = h - h' - D _{vert} /2 = 35	mm						
Nominal cover to tension reinfor	rcement						
c _{nom} = c _{ten} = 35.0 mm							
Tension bar centres							
bar _{crs} = s _{vert} = 200.0 mr	n						
MODULAR RATIO							
Modulus of elasticity for	reinforcement	E₅ = 200 kN/mm	1 ²				
	· · · · · · · · · · · · · · · · · · ·	h . :			BS	68110:Pt 1:Cl 2.5.4	
			15)				
Ec = ((20 KN/Mr	11 ²) + 200×1cu) / 2	$2 = 14 \text{ km/mm}^2$			BS811	0:Pt 2:Equation 17	
Modular ratio $m = E_s / E_c = 14.8$	315					·	
NEUTRAL AXIS POSITION							
For equilibrium F_{st} equates F_c							
Therefore: $m \times A_{st} \times [f_c \times (h_{st})]$	'-x)/x] equates t	to $0.5 \times f_c \times x$					

Tekla Tedds	Project				Job no.	007
		26 Amyard Park	E	Z3 ZZ1		
9 Chamberlain Lane	Calcs for RC	wal in basemen	t to front wal su	ipport	RCW	/8 75
Pinner HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
Solving for x gives the position	of the neutral ax	kis in the section:	-			
$x = h' \times [-1 \times E_s \times A_{st}/(E_c \times A_{st})]$	h') + √(E₅×A₅t/(E	Ec×h') × (2+Es×As	t/(Ec×h')))] = 58	.0 mm		
Depth of concrete in compressi	on					
x = 58.0 mm						
CONCRETE AND STEEL STR	ESSES					
The serviceability limit state mo	oment per m of v	vall m _{sLs} = 9 kNr	m/m			
Taking moments about the cen	treline of the rei	nforcement:-				
Moment of resistance of concre	ete is $0.5 \times f_c \times c$	κ × (h' - x/3)				
Solving for concrete stress $f_{\mbox{\tiny C}}$ gi	ves					
f_{c} = 2 \times m_{SLS} / (x \times (h' -	x/3)) = 1.29 N/n	nm²				
Allowable stress 0.45	≺ f _{cu} = 15.75 N/m	nm²				
					Concre	te stress OK
Taking moments about the cen	tre of action of t	he concrete force	9:-			
Moment of resistance of steel is	$s f_{st} \times A_s \times (h' - x)$	/3)				
Solving for steel stress fst gives						
f_{st} = m_{SLS} / ($A_{st} \times (h' - x_{st})$	/3)) = 66.41 N/m	im ²				
CONCRETE AND STEEL STR	AINS					
Strain in the reinforcement						
εs = fst / Es = 332.0×10 -€	3					
Allowable steel strain (0.8 × f _y / E _s = 2.0	000×10 ⁻³				
					Ste	eel strain OK
Strain in the concrete at the lev	el at which crac	k width is require	d			Воосон лүр В.ч
Level of crack a' = h =	300 mm					
ε ₁ = ε _s × (a' - x)/(h' - x) =	= 399.8×10 ⁻⁶					
Strain in the concrete at the lev	el at which crac	k width is require	d adjusted for s	stiffening of the	concrete tensio	n zone
Allowable crack width	Crack _{Allowable} = 0	.2 mm				
					E	3S8007:Cl 2.2.3.3
Factor for stiffening bas	sed on limiting c	rack width				
factor = if(Crac	KAllowable == (0.2	mm), (1.0 N/mm ²	²), (1.5 N/mm ²))) = 1 N/mm ²		
$\varepsilon_m = \min(\varepsilon_1, \max(0, \varepsilon_1))$	- [factor × (h - x) × (a' - x) / (3×E₅	× A _{st} ×(h' - x))]))) = 0.0000	E	252007·CI 2 2 3 3
Distance from tension bar to cra	ack in tension fa	ice between tens	ion bars		E	330007:012.2.3.3
$a_{cr} = \sqrt{(bar_{crs}/2)^2 + (c_{nu})^2}$	om + Dvert/2) ²) - [Dvert/2 = 102.1 mi	n			

Tekla. Tedds	Project	Job no. 23 227				
NMN Partnership 9 Chamberlain Lane	Calcs for RC wal in basement to front wal support				Start page no./Revision RCW8 76	
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 $Crack_{\text{design}} = 3 \times a_{\text{cr}} \times \epsilon_{\text{m}} / (1 + 2 \times (a_{\text{cr}} - c_{\text{ten}}) / (h - x)) = 0.000 \text{ mm}$

BS8007:App B.3

Max allowable crack width

CrackAllowable = 0.20 mm

BS8007:Cl 2.2.3.3 Design Crack width OK

Tekla Tedds	Project	26 Amyard Parl	k Road TW1 3F	IE	Job no. 23	227
NMN Partnership	Calcs for				Start page no./Revision	
		Basement 1 wa	ay spanning sla	b	BSI	ab 77
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
RC SLAB DESIGN (BS8110:PA	ART1:1997)				TEDDS calculat	tion version 1.0.04
CONCRETE SLAB DESIGN (C	L 3.5.3 & 4)					
SIMPLE ONE WAY SPANNING	SLAB DEFIN	IITION				
Overall depth of slab h	= 150 mm					
Cover to tension reinfor	cement resistir	ng sagging c₀ = t	50 mm			
Trial bar diameter Dtryx	= 10 mm					
Depth to tension steel (r	resisting saggi	ng)				
$d_x = h - c_b - D_{tryx}$	/2 = 95 mm					
Characteristic strength of	of reinforceme	nt f _y = 500 N/mm	2			
Characteristic strength of	of concrete fcu	= 40 N/mm ²				
Asy On	Noi 1 e-wa	minal 1 m y spar (simple)	n width	∖ A slab	SX	
ONE WAY SPANNING SLAB (CL 3.5.4)					
MAXIMUM DESIGN MOMENTS	S IN SPAN					
Design sagging momen	t (per m width	of slab) m _{sx} = 6.0	0 kNm/m			
CONCRETE SLAB DESIGN - S	SAGGING – O	UTER LAYER OF	STEEL (CL 3.	5.4)		
Design sagging momen	t (per m width	of slab) m _{sx} = 6.	0 kNm/m	<u></u>		
Moment Redistribution I	=actor β _{bx} = 1 .	.0				
Area of reinforcement require	d					
$K_x = abs(m_{sx}) / (d_x^2 \times f_{cu})$,) = 0.017					
K' _x = min (0.156 , (0.402	$2 \times (\beta_{bx} - 0.4))$	- (0.18 × (β _{bx} - 0.4	() ²)) = 0.156			
<u>One-way Spanning Slab requi</u> $z_x = min ((0.95 \times d_x).(d_x))$	i <u>ring tension s</u> ×(0.5+√(0.25-ł	<u>steel only (saggi</u> ≺√0.9)))) = 90 mn	Outer compre i ng) - mesh n	ession steel not	required to re	esist sagging
Neutral axis depth $x_x =$	(d _x - z _x) / 0.45	= 11 mm				
Area of tension steel required	. , -					

	Project				loh no		
Iekla ledds	26 Amyard Park Road TW1 3HE 23 227						
NMN Partnership	Calcs for				Start page no./R	evision	
		Basement 1 wa	ay spanning sla	ab	BSI	ab 78	
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date	
A _{sx_req} = abs(m _{sx}) / (1/γ _m	$s \times f_y \times Z_x) = 1$	53 mm²/m					
Tension steel							
<u>Use A393 Mesh</u>							
$A_{sx_prov} = A_{sl} = 393 \text{ mm}^2$	$/m A_{sy_{prov}} = A$	_{Ast} = 393 mm²/m					
$D_x = d_{sl} = 10 \text{ mm} D_y = c$	d _{st} = 10 mm						
		Aı	rea of tension	steel provided	sufficient to re	sist sagging	
Check min and max areas of s	steel resisting	g sagging					
Total area of concrete $A_c = h =$	= 150000 mm²,	/m					
Minimum % reinforceme	ent k = 0.13 %	6					
A _{st_min} = k × A _c = 195 mi	m²/m						
$A_{st_max} = 4 \% \times A_c = 600$	0 mm²/m						
Steel defined:							
Outer steel resisting sa	gging Asx_prov :	= 393 mm²/m					
				Area of outer s	teel provided	(sagging) OK	
Inner steel resisting sag	ging Asy_prov =	= 393 mm²/m					
				Area of inner st	teel provided (sagging) OK	
SHEAR RESISTANCE OF COM	NCRETE SLAI	BS (CL 3.5.5)					
Outer tension steel resisting	sagging mom	ients					
Depth to tension steel f	rom compress	ion face d _x = 95 ı	mm				
Area of tension reinforc	ement provide	ed (per m width of	slab) A _{sx_prov} =	= 393 mm²/m			
Design ultimate shear fe	orce (per m wi	dth of slab) $V_x =$	12 kN/m				
Characteristic strength	of concrete f	, = 40 N/mm ²					
Applied shear stress							
$x = \frac{1}{2} \sqrt{\frac{1}{2}} = 0.13 \text{ N/mm}^2$							
$v_x = v_x / d_x = 0.13$ N/mm							
Check shear stress to clause	3.5.5.2						
Vallowable = min ((0.8 N ^{1/2} /mm) \times V	(fcu), 5 N/mm ²	²) = 5.00 N/mm ²					
Change of the state of the state of the					Shea	nr stress - OK	
Shear stresses to clause 5.5.	0.0						
Design shear stress							
f _{cu_ratio} = if (f _{cu} > 40 N/mr	m ² ,40/25,fcu/	/(25 N/mm²)) = 1 .0	600				
v_{cx} = 0.79 N/mm ² × min	(3,100 × Asx_p	orov / dx) ^{1/3} × max(0	.67,(400 mm /	$d_x)^{1/4}) / 1.25 \times f_{cu}$	_ratio ^{1/3}		
v _{cx} = 0.79 N/mm ²							
Applied shear stress							
v _x = 0.13 N/mm ²							
				No sh	ear reinforcen	nent required	

Tekla. Tedds	Project	26 Amyard Park	Road TW1 3HE	1	Job no. 23 227	
NMN Partnership	Calcs for	Basement 1 wa	ly spanning slab		Start page no./Re BSIa	evision ab 79
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CONCRETE SLAB DEFLECTION CHECK (CL 3.5.7)
Slab span length l _x = 2.000 m
Design ultimate moment in shorter span per m width $m_{sx} = 6$ kNm/m
Depth to outer tension steel $d_x = 95$ mm
Tension steel
Area of outer tension reinforcement provided Asx_prov = 393 mm ² /m
Area of tension reinforcement required $A_{sx_{req}} = 153 \text{ mm}^2/\text{m}$
Moment Redistribution Factor $\beta_{bx} = 1.00$
Modification Factors
Basic span / effective depth ratio (Table 3.9) ratio _{span_depth} = 20
The modification factor for spans in excess of 10m (ref. cl 3.4.6.4) has not been included.
$f_{s} = 2 \times f_{y} \times A_{sx_req} / (3 \times A_{sx_prov} \times \beta_{bx}) = 129.7 \text{ N/mm}^{2}$
factor _{tens} = min (2 , 0.55 + (477 N/mm ² - f _s) / ($120 \times (0.9 \text{ N/mm}^2 + m_{sx} / dx^2))) = 2.000$
Calculate Maximum Span
This is a simplified approach and further attention should be given where special circumstances exist. Refer to clauses 3.4.6.4 and 3.4.6.7.
Maximum span I_{max} = ratio _{span_depth} × factor _{tens} × d _x = 3.80 m
Check the actual beam span
Actual span/depth ratio $I_x / d_x = 21.05$

Span depth limit ratio_{span_depth} × factor_{tens} = 40.00

Span/Depth ratio check satisfied

CHECK OF NOMINAL COVER (SAGGING) - (BS8110:PT 1, TABLE 3.4)

Slab thickness h = 150 mm

Effective depth to bottom outer tension reinforcement $d_x = 95.0 \text{ mm}$

Diameter of tension reinforcement D_x = 10 mm

Diameter of links L_{diax} = 0 mm

Cover to outer tension reinforcement

c_{tenx} = h - d_x - D_x / 2 = **50.0** mm

Nominal cover to links steel

cnomx = ctenx - Ldiax = **50.0** mm

Permissable minimum nominal cover to all reinforcement (Table 3.4)

c_{min} = **50** mm

Cover over steel resisting sagging OK

Tekla. Tedds	Project	26 Amyard Park	E	Job no. 23 227		
NMN Partnership	Calcs for	Basement 1 wa	ly spanning slab		Start page no./Re BSIa	vision Ib 80
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date

Tekla. Tedds	Project	26 Amyard Park	Road TW1 3HE	E	Job no. 23 227	
NMN Partnership	Calcs for	Ground floor 2 w	ay spanning sla	b	Start page no./Re GSIa	evision ab 81
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date

RC SLAB DESIGN (BS8110:PART1:1997)

TWO WAY SPANNING SLAB DEFINITION – SIMPLY SUPPORTED Overall depth of slab h = 200 mm	
Outer sagging steel	
Cover to outer tension reinforcement resisting sagging csag = 35 mm	
Trial bar diameter D _{trvx} = 10 mm	
Depth to outer tension steel (resisting sagging)	
$d_x = h - c_{sag} - D_{tryx}/2 = 160 \text{ mm}$	
Inner sagging steel	
Trial bar diameter D _{tryy} = 10 mm	
Depth to inner tension steel (resisting sagging)	
dy = h - c _{sag} - D _{tryx} - D _{tryy} /2 = 150 mm	
Materials	
Characteristic strength of reinforcement $f_y = 500 \text{ N/mm}^2$	
Characteristic strength of concrete $f_{cu} = 40 \text{ N/mm}^2$	
h Asy Nominal 1 m width Asx Shorter Span	
$h \qquad \qquad h \qquad h \qquad \qquad h \qquad h \qquad \qquad h $	
l onger Span	
Longer Span	
Two-way spanning slab (simple)	
MAXIMUM DESIGN MOMENTS	
Length of shorter side of slab I _x = 3.400 m	
Length of longer side of slab $I_y = 5.000$ m	
Design ultimate load per unit area $n_s = 12.0 \text{ kN/m}^2$	

Tekla. Tedds	Project 26 Amyard Park Road TW1 3HE				Job no. 23 227	
NMN Partnership	Calcs for	Ground floor 2 w	ay spanning sla	b	Start page no./Re GSIa	vision ab 82
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Moment coefficients

 $\alpha_{sx} = (I_y / I_x)^4 / (8 \times (1 + (I_y / I_x)^4)) = 0.103$

 $\alpha_{sy} = (I_y / I_x)^2 / (8 \times (1 + (I_y / I_x)^4)) = 0.048$

Maximum moments per unit width - simply supported slabs

 $m_{sx} = \alpha_{sx} \times n_s \times l_x^2 = 14.3 \text{ kNm/m}$

 $m_{sy} = \alpha_{sy} \times n_s \times I_x^2 =$ 6.6 kNm/m

CONCRETE SLAB DESIGN - SAGGING - OUTER LAYER OF STEEL (CL 3.5.4)

Design sagging moment (per m width of slab) $m_{sx} = 14.3 \text{ kNm/m}$

Moment Redistribution Factor $\beta_{bx} = 1.0$

Area of reinforcement required

 $K_x = abs(m_{sx}) / (d_x^2 \times f_{cu}) = 0.014$

K'_x = min (0.156 , (0.402 × (β_{bx} - 0.4)) - (0.18 × (β_{bx} - 0.4)²)) = 0.156

Outer compression steel not required to resist sagging

Concrete Slab Design - Sagging - Inner layer of steel (cl. 3.5.4)

Design sagging moment (per m width of slab) $m_{sy} = 6.6 \text{ kNm/m}$

Moment Redistribution Factor $\beta_{by} = 1.0$

Area of reinforcement required

 $K_y = abs(m_{sy}) / (d_y^2 \times f_{cu}) = 0.007$

K'y = min (0.156 , (0.402 \times (β_{by} - 0.4)) - (0.18 \times (β_{by} - 0.4)^2)) = 0.156

Inner compression steel not required to resist sagging

Two way Spanning Slab requiring tension steel only - mesh (sagging)

z_x = min ((0.95 × d_x),(d_x×(0.5+√(0.25-K_x/0.9)))) = **152** mm

Neutral axis depth $x_x = (d_x - z_x) / 0.45 = 18 \text{ mm}$

 $z_y = \min ((0.95 \times d_y), (d_y \times (0.5 + \sqrt{(0.25 - K_y/0.9)}))) = 142 \text{ mm}$

Neutral axis depth $x_y = (d_y - z_y) / 0.45 = 17 \text{ mm}$

Area of outer tension steel required

 A_{sx_req} = abs(m_{sx}) / (1/ $\gamma_{ms} \times f_y \times z_x$) = 216 mm²/m

Area of inner tension steel required

 $A_{sy_req} = abs(m_{sy}) / (1/\gamma_{ms} \times f_y \times z_y) = 107 \text{ mm}^2/\text{m}$

Tension steel

Provide A393 Mesh tension steel resisting sagging

Asx_prov = Asl = **393** mm²/m Asy_prov = Ast = **393** mm²/m

Tekla Tedds	Project	26 Amyard Park	Pood TW1 3F	16	Job no.	227
NMN Partnership	Calcs for				2.3 Start page no./R	evision
		Ground floor 2 w	/ay spanning sl	ab	GSI	ab 83
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
$D_{\rm v} = d_{\rm el} = 10 \mathrm{mm}$	d _{et} = 10 mm					
2× 25, 10, 2, 1		Ar	ea of tension a	steel provided s	ufficient to re	sist sagging
Check min and max areas of	steel resisting	g sagging				
Total area of concrete $A_c = h =$	• 200000 mm²/	/m				
Minimum % reinforcem	ent k = 0.13 %	0				
A _{st_min} = k × A _c = 260 mi	n²/m					
A _{st_max} = 4 % × A _c = 800	0 mm²/m					
Steel defined:						
Outer steel resisting say	gging A _{sx_prov} =	= 393 mm²/m				
				Area of outer st	eel provided	(sagging) OK
Inner steel resisting sag	Iging A _{sy_prov} =	= 393 mm²/m		Aroo of innor of	ol providod (oogging) OK
				Area of inner su	eei provided (sagging) OK
SHEAR RESISTANCE OF CON	ICRETE SLAE	<u>3S (CL 3.5.5)</u>				
Depth to tension steel f	ayyiny mom	ion foco $d = 160$	mm			
Area of tancion reinfero	omont provide	$\frac{1}{2} \int dx = 100$		202 mm ² /m		
Area of tension remote	ernent provide	dth of alab) V = (SIDD) Asx_prov -	393 11111 /111		
	of concrete f	$= 40 \text{ N/mm}^2$	20 KIN/III			
		1 – 40 N/IIIII				
Applied silear stress $y_{1} = y_{1} / (d_{1} = 0.13) \text{ N/mm}^{2}$						
$v_x = v_x / u_x = 0.13 \text{ N/mm}^2$	2 5 5 2					
Check shear stress to clause	3.3.3.Z					
$V_{\text{allowable}} = \min((0.8 \text{ N}^{-7}) \times N)$	(Icu), 3 IN/MM ⁻) = 5.00 N/mm ⁻			Shoa	r stross - OK
Shear stresses to clause 3.5.	5.3				Uncu	
Design shear stress						
f _{cu_ratio} = if (f _{cu} > 40 N/mr	n² , 40/25 , f _{cu} /	/(25 N/mm²)) = 1.6	500			
v_{cx} = 0.79 N/mm ² × min	(3,100 × A _{sx_p}	$_{rov}$ / d _x) ^{1/3} × max(0	.67,(400 mm / d	d _x) ^{1/4}) / 1.25 × f _{cu} _	ratio ^{1/3}	
v _{cx} = 0.58 N/mm ²						
Applied shear stress						
v _x = 0.13 N/mm ²						
				No sh	ear reinforcen	nent required
SHEAR RESISTANCE OF COM		BS (CL 3.5.5)				
Inner tension steel resisting s	agging mom	ents				
Depth to tension steel f	rom compress	ion face d _y = 150	mm			
Area of tension reinforc	ement provide	d (per m width of	slab) A _{sy_prov} =	393 mm²/m		

Tekla Tedds	Project	26 Amyard Parl	Job no. 23 227			
NMN Partnership	Calcs for	Ground floor 2 v	vay spanning s	lab	Start page no./R GSI	evision ab 84
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
Design ultimate shear fo	orce (per m wic	th of slab) $V_y = 1$	30 kN/m			
Characteristic strength	of concrete fcu	= 40 N/mm ²				
Applied shear stress						
v _y = V _y / d _y = 0.20 N/mm ²						
Check shear stress to clause	3.5.5.2					
$v_{allowable}$ = min ((0.8 N ^{1/2} /mm) × $$	(f _{cu}), 5 N/mm ²) = 5.00 N/mm ²				
					Shea	r stress - OK
Shear stresses to clause 3.5.5	5.3					
Design shear stress						
$f_{cu_ratio} = if (f_{cu} > 40 N/mr)$	n² , 40/25 , f _{cu} /((25 N/mm²)) = 1 .0	600			
v_{cy} = 0.79 N/mm ² × min	$(3,100 \times A_{sy_pro}$	$_{vv} / d_{y})^{1/3} \times max(0)$	67,(400 mm) /	$d_y)^{1/4}$ / 1.25 × f _{cu_1}	ratio ^{1/3}	
v _{cy} = 0.60 N/mm ²						
Applied shear stress						
v _y = 0.20 N/mm ²						
				No she	ear reinforcem	ent required
CONCRETE SLAB DEFLECTION	ON CHECK (C	L 3.5.7)				
Slab span length $I_x = 3$.	.400 m					
Design ultimate momen	it in shorter spa	an per m width m	ı _{sx} = 14 kNm/m	1		
Depth to outer tension s	steel d _x = 160	mm				
Tension steel						
Area of outer tension re	inforcement pr	ovided A _{sx_prov} =	393 mm²/m			
Area of tension reinforc	ement required	Asx_req = 216 m	m²/m			
Moment Redistribution I	Factor $\beta_{bx} = 1$.	00				
Modification Factors						
Basic span / effective depth rat	io (Table 3.9)	ratio _{span_depth} = 26	i			
The modification factor for span	s in excess of	10m (ref. cl 3.4.6	.4) has not bee	en included.		
$f_{s} = 2 \times f_{y} \times A_{sx_req} / (3 \times A_{sx_prov})$	× β _{bx}) = 183.3	N/mm ²				
factor _{tens} = min(2,0.55 +(477	′ N/mm² - f _s) /	(120 × (0.9 N/m	m² + m _{sx} / d _x ²))) = 2.000		
Calculate Maximum Span						
This is a simplified approach an 3.4.6.4 and 3.4.6.7.	d further attent	tion should be giv	ven where spec	cial circumstance	s exist. Refer t	o clauses
Maximum span I _{max} = r	$\dot{tatio}_{span_depth} imes f$	actor _{tens} \times d _x = 8.	32 m			

Check the actual beam span

Actual span/depth ratio $I_x / d_x = 21.25$

Tekla Tedds	Project	26 Amvard Park	Job no.	Job no.		
NMN Barthorobin	<u></u>	20741194141			20	
Nini Farmership	Calcs for Ground floor 2 way spanning slab				Start page no./Revision GSIab 85	
	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date
Span depth limit ratio _{spar}	n_depth × factor	T _{tens} = 52.00		Span/I	Depth ratio ch	eck satisfied
CHECK OF NOMINAL COVER	(SAGGING) -	- (BS8110:PT 1, T	ABLE 3.4)			

Effective depth to bottom outer tension reinforcement $d_x = 160.0 \text{ mm}$

Diameter of tension reinforcement $D_x = 10 \text{ mm}$

Diameter of links L_{diax} = 0 mm

Cover to outer tension reinforcement

 $c_{tenx} = h - d_x - D_x / 2 = 35.0 \text{ mm}$

Nominal cover to links steel

 $c_{nomx} = c_{tenx}$ - $L_{diax} = 35.0 \text{ mm}$

Permissable minimum nominal cover to all reinforcement (Table 3.4)

c_{min} = **35** mm

Cover over steel resisting sagging OK





Support B

Support A

Applied loading

Roof Roof Frst floor Frst floor Wall con floor con floor

Load combinations

Load combination 1

Vertically restrained Rotationally free Vertically restrained Rotationally free

Imposed full UDL 1.73 kN/m Dead full UDL 2.78 kN/m Imposed full UDL 3 kN/m Dead full UDL 1.18 kN/m Dead full UDL 25 kN/m Imposed full UDL 8.75 kN/m Dead full UDL 10.5 kN/m Dead self weight of beam × 1

Support A

Span 1

Dead \times 1.40 Imposed \times 1.60 Dead \times 1.40 Imposed \times 1.60

Tekla Tedds	Project			Job no.		
	2	6 Amyard Pari	23	5 2 2 1		
NMN Partnersnip	Calcs for	Start page no./F	Revision			
Pinner						
HA5 2PH	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	INIVI	02/03/2024				
		Support B		Dead ×	1.40	
				Impose	d × 1.60	
Analysis results		Ma	kNm	Ma	0 kNm	
Maximum moment span 1 at 25	00 mm	$M_{A_max} = 0$ $M_{c1_max} = 2$	83 kNm	Ma_red =	= 283 kNm	
Maximum moment support B	00 11111	$M_{\rm R} = 0$	kNm	Me rod =	= 203 KNm	
Maximum shear support A		$V_{A} = 22$	6 kN	V _{A red} =	226 kN	
Maximum shear support A span	1 at 401 mm	$V_{A_{s1}}$ max =	185 kN	VA_s1_rec	= 185 kN	
Maximum shear support B		V _{B max} = -2:	26 kN	V _B red =	-226 kN	
Maximum shear support B span	1 at 4599 mm	$V_{B s1 max} =$	-185 kN	VB_s1_rec	= -185 kN	
Maximum reaction at support A		R _A = 226 k	N			
Unfactored dead load reaction a	at support A	R _{A Dead} = 1	23 kN			
Unfactored imposed load reaction	on at support A	_ RA Imposed =	34 kN			
Maximum reaction at support B		R _B = 226 k	N			
Unfactored dead load reaction a	at support B	RB_Dead = 1	$R_{B \text{ Dead}} = 123 \text{ kN}$			
Unfactored imposed load reaction	on at support B	R _{B_Imposed} =	R _{B_Imposed} = 34 kN			
Rectangular section details						
Section width		b = 900 mr	n			
Section depth		h = 450 mr	n			
450 051						
		Q	0			
		90				
Operational to the literation						
Concrete details		C22/40				
	o otropath	-40 M/m	nm²			
Moduluo of electicity of economic	e suengin	Icu = 40 IN/f	$mm^2 \pm 200 = f$	- 22000 NI/ma 2		
	;	$E_c = 20$ km/	mm² + 200 × 1	cu = 20000 N/mm²		
Maximum aggregate size		Nagg = 20 m	ITTI			
Reinforcement details			0			
Characteristic yield strength of r	einforcement	$f_y = 500 \text{ N/i}$	mm²			
Characteristic yield strength of s	snear reinforceme	ent t _{yv} = 500 N/	mm ^			
Nominal cover to reinforceme	nt					
Nominal cover to top reinforcem	ient	Cnom_t = 35	mm			
Nominal cover to bottom reinfor	cement	Cnom_b = 35	mm			
Nominal cover to side reinforcer	nent	Cnom_s = 35	mm			



Tekla Tedds	Project	26 Amyard Park Road TW1 3HE 23 227						
NMN Partnership	Calcs for	,			Start page no /	Revision		
9 Chamberlain Lane		RC beam und	ler bay windov	v	RC	B1 89		
Pinner HA5 2PH	Calcs by NM	Calcs date 02/05/2024	Checked by	Checked date	Approved by	Approved date		
			K' > K -	No compressio	n reinforceme	ent is required		
Lever arm		z = min(d ×	(0.5 + (0.25 -	κ / 0.9) ^{0.5}), 0.95	× d) = 374 mm	, 1		
Depth of neutral axis		x = (d - z) /	0.45 = 52 mm		,			
Area of tension reinforcement re	equired	$A_{s,req} = M /$	$(0.87 \times f_y \times z)$	= 1739 mm²				
Tension reinforcement provided		6 × 20ø bai	rs ,					
Area of tension reinforcement p	rovided	A _{s.prov} = 18	85 mm²					
Minimum area of reinforcement		$A_{s,min} = 0.00$	013 × b × h = 5	5 27 mm ²				
Maximum area of reinforcement		$A_{s,max} = 0.0$	$4 \times b \times b = 16$	200 mm ²				
	PASS - Area of	f reinforcement	t provided is a	greater than are	a of reinforce	ment requirec		
Rectangular section in shear								
Shear reinforcement provided		1 × 84 leas	at 200 c/c					
Area of shear reinforcement provided	wided	4 × 0φ iegs	$0.5 \text{ mm}^2/\text{m}$					
Minimum area of shear reinforce	ement (Table 3	$A_{\text{sv,prov}} = 1$	$N/mm^2 \times h / (($) 87 v f) – 828 j	mm²/m			
		$r_{\rm SS} = Area of sl$	hoar roinforce	ment provided	evcoeds mini	mum requirer		
Maximum longitudinal spacing (d 3455)	Sulmax = 0.7	$5 \times d = 298 \text{ m}$	m	exceeds minin	inum required		
Maximum longitadinal optioning (PASS - Longi	tudinal spacing	of shear reir	 oforcement prov	vided is less ti	han maximur		
Design concrete shear stress	PAGE Long	$v_c = 0.79 N/$	$mm^2 \times min(3)$	$100 \times A_{s prov} / (b)$	\times d)l ^{1/3}) \times max(1 (400mm		
Boolgi concrete chear creee		$(d)^{1/4}$ × (mi	$n(f_{\rm ou} = 10 \text{ N}/\text{mm}^2)$	2 / 25N/mm ²) ^{1/3}	$(v_m = 0.598 \text{ N/})$	mm^2		
Design shear resistance provide	$(d)^{(m)} \times (\Pi(\Pi(G_u, 40)) / 25N/\Pi(\Pi^{-})^{(m)} / \gamma_m = 0.550 N/\Pi(\Pi^{-})^{(m)}$							
Design shear stress provided		Verey = Veres	$y_{10} = 0.07 \times 100$	N/mm^2				
Design shear resistance		V prov – Vs,pro	$(h \times d) = 38$					
Shear link	s provided vali	d between 0 m	~ (0 ~ 0) - 30 m and 5000 m	m with tension	reinforcemen	t of 1885 mm ²		
Spacing of rainforcoment (al 3	2 4 2 4 4 V							
Actual distance between bars in	tension	s = (b - 2 ×	$(C_{nom s} + \phi_v + \phi_v)$	1) (Neat - 1)	- փոլ = 139 mm	n		
Minimum distance between b	ars in tonsion (ol 2 12 11 1)		, , , , , , , , , , , , , , , , , , ,	4500			
Minimum distance between bas	ars in tension	Smin = bagg =	⊦5 mm = 25 m	m				
		Smin – Hayy	PA S	SS - Satisfies th	e minimum sı	oacing criteria		
Maximum distance between b	are in tension	(c) 3 12 11 2)			,	J		
Design service stress		$f_{-} = (2 \times f_{-})$	<pre>/ (3 × A)</pre>	A	5 N/mm ²			
Maximum distance between bar	s in tension	$I_s = (Z \times I_s)$	$r = (2 \times ry \times As, req) / (3 \times As, prov \times pb) = 307.3 N/mm$					
		Smax – mini(47000 Ν/ΠΠΤ ΡΔ	SS - Satisfies the	e maximum sı	nacing criteria		
Chan to doubt notice (al. 2.4.0)						Juoning officine		
Span to depth ratio (cl. 3.4.6)	2.0)	444	th 00 0					
Basic span to depth ratio (Table	• 3.9)	span_to_d	$eptn_{basic} = 20.0$	0) 007	2			
Design service stress in tension	reinforcement	$T_s = (2 \times T_y)$	< As,req)/ (3 × As	s,prov × βb) = 307.	5 IN/MM ²			
	f	nin(200551)	177N1/mam2 f) / (120 (0 0NI/m	am ² I /M / /h	d2))))) - 1 02(
Modification for compression rei	Itens – I	nin(2.0, 0.55 + (4//IN/IIIII ⁻ - Is _,) / (120 × (0.9N/I	nni- + (w / (v ×	u-)))) - 1.030		
	f	$= \min(15 \ 1 + (1))$	100 × Δ	$(b \times d)) / (3 + (10))$)0 × Δ/ (b	<pre>< d)))) = 1 06(</pre>		
Modification for span length	Icomp	$f_{long} = 1 000$)	(b ^ u)) / (b + (10	vo ^ msz,prov / (D			
		snan to d	enthauau = enor	to dentheses y	ftons × form - 22	2.0		
Allowable span to depth ratio	Allowable span to depth ratio span_to_depthallow = span_to_depthbasic × ftens × fcomp = 22.0							
Allowable span to depth ratio	Actual span to depth ratio span to depth ratio span to depth ratio $z = L_{s1} / d = 12.6$							







 $\text{Dead} \times 1.40$

NMN Partnership 9 Chamberlain Lane Pinner HA5 2PH	Calcs for Calcs by	Ground foor RC	slab support b	eam	Start page no./F	Revision	
9 Chamberlain Lane Pinner HA5 2PH	Calcs by	Ground foor RC	slab support b	eam			
HA5 2PH	Calcs by	Calcs date			B	13 92	
	INIM	03/05/2024	Checked by	Checked date	Approved by	Approved da	
				Impos	ed × 1.60		
Analysis results							
Maximum moment		M _{max} = 128	5 .1 kNm	M _{min} =	0 kNm		
Maximum shear		V _{max} = 102	.5 kN	V _{min} =	V _{min} = -102.5 kN		
Deflection		δ _{max} = 11.9	mm	δ _{min} =	0 mm		
Maximum reaction at support A		R _{A_max} = 10	R _{A_max} = 102.5 kN R _{A_min} =				
Unfactored dead load reaction a	t support A	RA_Dead = 5	4.3 kN				
Unfactored imposed load reaction	on at support A	R _{A_Imposed} =	16.6 kN				
Maximum reaction at support B		R _{B_max} = 102.5 kN		RB_min	= 102.5 kN		
Unfactored dead load reaction a	t support B	R _{B_Dead} = 5	4.3 kN				
Unfactored imposed load reaction	on at support B	RB_Imposed =	R _{B_Imposed} = 16.6 kN				
Section details							
Section type		UKC 203x	203x86 (Tata	Steel Advance)			
Steel grade		S275					
From table 9: Design strength	р _у						
Thickness of element		max(T, t) =	20.5 mm				
Design strength		p _y = 265 N	/mm²				
Modulus of elasticity		E = 20500	0 N/mm²				

I atoral	restraint
Laterai	restraint

Span 1 has full lateral restraint

-

-209.1-

Effective length factors		
Effective length factor in major axis	K _x = 1.00	
Effective length factor in minor axis	K _y = 1.00	
Effective length factor for lateral-torsional buckling	K _{LT.A} = 1.00	
	K _{LT.B} = 1.00	
Classification of cross sections - Section 3.5		
	$\epsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]} = 1.02$	
Internal compression parts - Table 11		
Depth of section	d = 160.8 mm	
	d / t = 12.4 $\times \epsilon$ <= 80 $\times \epsilon$	Class 1 plastic

→ 20.5 →

Tekla Tedds	Project Job no.							
		26 Amyand Par	K Road TW13	HE	23	221		
NMN Partnership	Calcs for Start page no./Revision							
9 Chamberlain Lane Pinner		Ground foor RC	B13 93					
HA5 2PH	Calcs by NM	Calcs date 03/05/2024	Checked by	Checked date	Approved by	Approved date		
Outstand flanges - Table 11								
Width of section		b = B / 2 =	104.6 mm					
		b / T = 5.0	3 × θ => 3 ×	Class ?	plastic			
					Section is c	lass 1 plastic		
Shear capacity - Section 4.2.3								
Design shear force		F _v = max(a	F _v = max(abs(V _{max}), abs(V _{min})) = 102.5 kN					
		d / t < 70 × ε						
			Web does	not need to be a	hecked for sl	hear buckling		
Shear area		$A_v = t \times D =$	= 2822 mm ²					
Design shear resistance		$P_v = 0.6 \times I$	o _y × A _v = 448.7	7 kN				
		PAS	S - Design sl	near resistance e	xceeds desig	n shear force		
Moment capacity - Section 4.2	2.5							
Design bending moment		M = max(a	bs(M _{s1 max}), ab	os(M _{s1 min})) = 128.	1 kNm			
Moment capacity low shear - cl.	4.2.5.2	M _c = min(p	$M_c = min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) = 258.8 \text{ kNm}$					
	PASS - Moment capacity exceeds design bending					ding moment		
Check vertical deflection - Sec	ction 2.5.2							
Consider deflection due to dead	and imposed	loads						
Limiting deflection	,	$\delta_{\text{lim}} = L_{s1} / 3$	360 = 13.889 r	nm				
Maximum deflection span 1		$\delta = \max(ab)$	$s(\delta_{max})$. abs (δ_{r})	_{min})) = 11.904 mm				
······································		PAS	S - Maximum	deflection does	not exceed de	eflection limit		







Tekla. Tedds	Project	26 Amyand Par	Job no. 23 227							
NMN Partnership	Calcs for		Start page no./F	Start page no./Revision						
9 Chamberlain Lane		Ground foor RC	slab support b	eam	B12 96					
Pinner HA5 2PH	Calcs by NM	Calcs date 05/05/2024	Checked by	Checked date	Approved by	Approved date				
		K _{LT.B} = 1.00)							
Classification of cross section	ns - Section 3	3.5								
		ε = √[275 Ν	l/mm² / p _y] = 1	.02						
Internal compression parts - 1	able 11									
Depth of section		d = 160.8 r	nm							
·		d / t = 12.4	3 × 08 => 3 ×	Class ²	1 plastic					
Outstand flanges - Table 11										
Width of section		h = B / 2 =	b = B / 2 = 104.6 mm							
Width of Section	b = b/2 = b/T = 50	νε<= 9 ×ε	Class ?	s 1 plastic						
		571 - 0.0		Section is class 1 plastic						
Change annaite Continue 4.2.2										
Snear capacity - Section 4.2.3				(.)) - 400 0 (A)						
Design shear lorce		$F_v = \max(a$	$d/t < 70 \times c$							
		u/1<70×	8 Wah daaa	not nood to bo	hookod for a	hoor buckling				
Shear area			- 2822 mm ²	not need to be t	inecked for S	liear buckning				
Design shear resistance		$P_{v} = 0.6 \times t$	$\mathbf{P}_{\mathbf{v}} = 0 \mathbf{\beta}_{\mathbf{v}} \mathbf{p}_{\mathbf{v}} \mathbf{\gamma} \mathbf{A}_{\mathbf{v}} = 1 1 8 7 \mathbf{k} \mathbf{N}$							
Design shear resistance		PAS	S - Desian sh	nar resistance e	vceeds desir	n shear force				
	_	7.40	o - Design si			in Shear Toree				
Moment capacity - Section 4.2	5	N		- (14)) 450	4 I.h.I					
Design bending moment	M = max(a)	$W_1 = max(abs(W_{s1_max}), abs(W_{s1_min})) = 158.4 KNM$								
Moment capacity low snear - ci.	$f - CI.4.2.5.2 \qquad M_c = min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) = 258.8 \text{ kNm}$									
		PA	iss - woment	capacity exceed	is design ben	ung moment				
Check vertical deflection - Se	ction 2.5.2									
Consider deflection due to dead	and imposed	loads								
Limiting deflection	Limiting deflection $\delta_{lim} = L_{s1} / 360 = 12.222 \text{ mm}$									

Maximum deflection span 1 $\delta = \max(abs(\delta_{max}), abs(\delta_{min})) = 11.883 \text{ mm}$

PASS - Maximum deflection does not exceed deflection limit





 $\text{Dead} \times 1.40$

Tekla Tedds	ekla Tedds Project Job no. 23 227							
NIMN Partnership	Color for Color							
	Calcs for	Start page no./	B1/ 08					
Pinner					В	14 90		
HA5 2PH	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date		
	NM	05/05/2024						
				Impos	ed × 1.60			
Analysis results								
Maximum moment		M _{max} = 93.3	3 kNm	M _{min} =	0 kNm			
Maximum shear		V _{max} = 100 .	. 9 kN	V _{min} =	-100.9 kN			
Deflection		δ _{max} = 8.6 r	nm	δ _{min} = () mm			
Maximum reaction at support A		R _{A max} = 10	0.9 kN	R _{A min}	= 100.9 kN			
Unfactored dead load reaction a	at support A	$R_{A}Dead = 5$	6.8 kN	_				
Unfactored imposed load reaction	on at support A	R _{A_Imposed} =	13.3 kN					
Maximum reaction at support B		R _{B_max} = 10	0.9 kN	R _{B_min}	= 100.9 kN			
Unfactored dead load reaction a	at support B	R _{B_Dead} = 5	6.8 kN					
Unfactored imposed load reaction	on at support B	RB_Imposed =	13.3 kN					
Section details								
Section type		UKC 203x	203x52 (Tata	Steel Advance)				
Steel grade		S275		,				
From table 9: Design strength	1 Dv							
Thickness of element	.,	max(T, t) =	12.5 mm					
Design strength	$p_y = 275 \text{ N/mm}^2$							
Modulus of elasticity		E = 205000) N/mm ²					
	2.5							
	→							
	★							
			7.0					
	- 200		1.9					
	5.2							
	<u>↓</u>							
	± ₊							
	· 	204.3-		→				
	I			,				
Lateral restraint								
		Span 1 has	s full lateral res	straint				
Effective length factors								
Effective length factor in major a	axis	K _x = 1.00						
Effective length factor in minor a	axis	K _y = 1.00						
Effective length factor for lateral	-torsional bucklin	ig KLT.A = 1.00)					
-		K _{LT.B} = 1.00)					
Classification of cross section	ns - Section 3.5							
		ε = √[275 Ν	J/mm² / p _y] = 1	.00				
Internal compression parts - 1	Table 11							
Depth of section		d = 160 8 r	nm					
5 5 ptil 01 0000001		a – 100.0 I						

d / t = 20.4 $\times \epsilon$ <= 80 $\times \epsilon$

Class 1 plastic

Tekla Tedds	Project Job no.							
		26 Amyand Par	k Road TW1 3	HE	23	3 227		
NMN Partnership	Calcs for Start page no./Revision							
9 Chamberlain Lane		Ground foor RC	B1	B14 99				
HA5 2PH	Calcs by NM	Calcs date 05/05/2024	Checked by	Checked date	Approved by	Approved date		
Outstand flanges - Table 11								
Width of section		b = B / 2 =	102.2 mm					
		b / T = 8.2	3 × θ => 3 ×	Class	1 plastic			
					Section is a	lass 1 plastic		
Shear capacity - Section 4.2.3								
Design shear force		F _v = max(a	$F_v = max(abs(V_{max}), abs(V_{min})) = 100.9 \text{ kN}$					
		$d / t < 70 \times \varepsilon$						
			Web does	not need to be a	checked for s	hear buckling		
Shear area		$A_v = t \times D =$	= 1629 mm ²					
Design shear resistance		$P_v = 0.6 \times I$	o _y × A _v = 268.8	8 kN				
		PAS	S - Design sl	near resistance e	exceeds desig	In shear force		
Moment capacity - Section 4.2	2.5							
Design bending moment		M = max(a	bs(M _{s1_max}), ab	s(M _{s1_min})) = 93.3	kNm			
Moment capacity low shear - cl.	4.2.5.2	M₀ = min(p	$M_{c} = min(p_{y} \times S_{xx}, 1.2 \times p_{y} \times Z_{xx}) = 156 \text{ kNm}$					
	PASS - Moment capacity exceeds design bending					ding moment		
Check vertical deflection - Sec	ction 2.5.2							
Consider deflection due to dead	l and imposed	l loads						
Limiting deflection		$\delta_{\text{lim}} = L_{s1} / 3$	360 = 10.278 r	nm				
Maximum deflection span 1		δ = max(ab	$s(\delta_{max})$, abs(δr	_{nin})) = 8.581 mm				
PASS - Maximum deflection does not exc					not exceed d	eflection limit		



N.M.N PARTNERSHIP LIMITED

Consulting Civil & Structural Engineers

9 Chamberlain Lane Pinner Middx HA5 2PH Tel: 07565979671 Email: nathanmasil@aol.com

Structural Calculation for Temporary support to Party wall

Walling timber check Wind load check Soldier check Fixing check

Project 26 Amyand Park Road Twickenham TW1 3HE

Prepared By Nathan Masil BEng, MSc, ICIOB

Date: 09.05.2024

Document: Calculation 23 227-03

Codes and standards Used:

BS5268

BSEN 1991-01-4 2005

NMN Partnership

PROJECT

<mark>6 Amyand Road TW1 3H</mark>

Twickenham

23 227 NM

09.05.24

			TW1			Date			
Checker's comments	TITLE Wind load on façade								
commonito									
	Wind Calc to BS EN 1991-1-	4:2005-	+A1:2010						
	This spreadsheet performs ca	lculatio	ns in acco	rdance wi	ith the method	I described in Annex A	\		
	of BS EN 1991-1-4:2005+A1:	2010. D	ata from th	ne IStruct	E is binlinearly	/ interpolated to			
	calculate coefficient values fro	om the i	nputs give	n.					
	Location (first part of postcod	a)		Τ\Λ/1		London			
-	Height of structure above gro	und	7	6	3 m				
	Altitude of site		A	2	m AOD				
	Distance from open water			66.0	km				
	Distance within town terrain			2.0) km	Set to zero if in cou	untry		
	Reciprocal of annual probabil	ity	1/p	50) years	(ie. 1 in 2			
	of exceedence								
	Fundamental basic wind		V _{b,map}	22.5	5 m/s		Fig NA.1		
	Seasonal factor		C _{dir}	1					
-	Altitude factor		Call	1 002	x		NA 2a		
-	Probability factor			1.000)		4.2		
			piob			50			
	Basic Wind Velocity		$v_b = v_{b,ma}$	p.C _{alt} · C _{di}	$r \cdot c_{season} \cdot c_{pro}$	bb			
			Vb	22.55	5 m/s				
			- 0 C1	2 2					
	Reference basic velocity pres	sure	$q_b = 0.61$	3 X V _b	kN/m ²				
				0.312					
	Exposure factor		C _e (Z)	2.03	3		Fig NA.7		
	Town correction factor		C _{e,T}	0.82	2		Fig NA.8		
	Peak velocity pressure		$q_p(z) = c_e$	$\frac{1}{2}(z) \cdot q_b$ fo	or country terra	ain .	NA.3a		
			$q_p(z) = c_e$	e(Z) · C _{e,T} ·	q _b for town te		NA.3b		
Work to Cpi and Cpe			$q_{r}(z) =$	0.516	s kN/m ²				
From here			4 p(2) -	0.010					
	Panel length		1	8	3 m				
	Panel height		h	6	Sm				
			l/h	1.333	3				
			C _{pnet}	1.4	4		Tble 7.9		
L L	Wind pressure		$VV = q_p x$	C _{pnet}					
H			vv =	0.723					
⊢									
NMN Partnership Limited

NMR



NMN Partnership Limited Consulting Civil & Structural Engineers SHEET NO 02 JOB NO 23 227 Date 9 CALCS : NM JOB 26 Amyand Park Road TW1 3HE OUTPUT Temporary supports to Party wall ELEMENT Cheek welling timbers. spawhy = 1 m clc. looel = 0.73 × 1 = 0.73 KN/m. $\frac{5pon}{2m}$ 2 2 moment = 0.73×2/ - 0.37 knm. Zom rogund = 0.37×100 - 0.69×10mm³. Tumber to be used = 170x60 Clb 2x00 = bd? = 170x60 = 10xx10mm > 69cm Cheele botts in tension. Bott = 12mm of Studs bott tension capacity = 2. 4 km into Brich work. mans Tenson = 0.73 kr < 2.4 km Ohr Boott to be nes on anched to End work with Min &D = 96 mm. (Say loomm) Competion Slim Solder to Slim Soldner = 4NOM16 Timber to Timber - 2NO MIO Timber/soldeer to wall M12 bolts at incle.



SUPERSLIM SOLDIERS



1.1.3. Section Properties

Soldier characteristics

Area: Gross 26.06 cm² Area: Nett 19.64 cm² 1916 cm⁴ I xx 658 cm⁴ l yy 9.69 cm r xx 5.70 cm r yy Z xx 161 cm³ Ζ уу 61 cm³ El xx 4020 kNm² El yy 300 kNm² GAxx 17350 kN 40 kNm M max x 6.24 kNm M max y Max Joint Moment (4 M16 bolts) 12 kNm Max Joint Moment (6 M16 bolts) 18 kNm Max Joint Moment (stiffeners see 1.2.1. sheet 16) 20 kNm Max Joint Tension (4 M16 bolts) 100 kN Max Joint Tension (6 M16 bolts) 140 kN Max Joint Tension (4 M16 bolts and stiffeners) 150 kN 370 N/mm² Mean compressive yield stress Mean Self weight for Analysis 0.235 kN/m run*



* Self weight varies depending on makeup / length (see 1.1.1)

Effective area (Ae) for wind calculation purposes

	Direction A Direction B Direction C	0.177 m ² /m 0.130 m ² /m 0.286 m ² /m
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European Data

COMPONENTS

Date: 19/03/2015

lssue

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Sheet 8

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