CampbellReith
consulting engineers

71 Goldhurst Terrace, NW6 3HA

Basement Impact Assessment Audit

For

London Borough of Camden

Project Number: 12727-90
Revision: F1

June 2019

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Document History and Status

Revision	Date	Purpose/Status	File Ref	Author	Check	Review
D1	August 2018	Comment	12727-90-210818-71 Goldhurst Terrace-D1.doc	A Gleeson	G Kite	G Kite
F1	June 2019	Planning	GKemb12727-90-280619-71 Goldhurst Terrace-F1.doc	G Kite	E Brown	E Brown

Document Details

Last saved	28/06/2019 12:18
Path	GKemb12727-90-280619-71 Goldhurst Terrace-F1.doc
Author	G Kite
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Project Number	12727-90
Project Name	71 Goldhurst Terrace, NW6 3HA
Planning Reference	2018/1610/P

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Appendix

1.0 NON-TECHNICAL SUMMARY

1.1. CampbellReith was instructed by London Borough of Camden, (LBC) to carry out an audit on the Basement Impact Assessment submitted as part of the Planning Submission documentation for 71 Goldhurst Terrace, NW6 3HA (planning reference 2018/1610/P). The basement is considered to fall within Category B as defined by the Terms of Reference.

1.2. The Audit reviewed the Basement Impact Assessment for potential impact on land stability and local ground and surface water conditions arising from basement development in accordance with LBC's policies and technical procedures.

1.3. CampbellReith was able to access LBC's Planning Portal and gain access to the latest revision of submitted documentation and reviewed it against an agreed audit check list.

1.4. The qualifications of the authors of the BIA and the associated reports are in compliance with the requirements of CPG Basements.

1.5. The BIA Audit Instruction confirmed that the site is situated within the South Hampstead Conservation Area and that there are no listed building neighbouring the site.

1.6. The proposed works include the excavation of a new single storey basement to the full footprint of the existing building, extending to the front to form a lightwell. The basement will be formed using underpinning techniques. No transitional underpins will be constructed.

1.7. The ground conditions are indicated to be Made Ground over London Clay; designated unproductive strata. Groundwater was not encountered during the ground investigation. The BIA recommends allowance is made for temporary dewatering.

1.8. Whilst no trees are being felled, the screening and scoping identify that an aboricultural report should be provided as a tree exists some 10m from the basement. It is accepted that the basement is unlikely to have a significant impact on the root zone.

1.9. The structural report notes that the basement walls are designed as cantilevers. This is reflected in the revised calculations.

1.10. A ground movement assessment (GMA) has been undertaken which indicates the potential damage to neighbouring properties as no higher than Category 1 (Very Slight) on the Burland Scale.

1.11. Proposals are provided for a structural movement monitoring strategy during excavation and construction, including reasonable trigger values. The upstairs flats to 71 Goldhurst Terrace

should be included in the monitoring proposals which should be agreed with the Party Wall Engineer.

1.12. The site is within the Goldhurst Local Flood Risk Zone. The Flood Risk Assessment (FRA) report indicates the site to be at a very low risk of flooding. It is accepted that the increase to the hardstanding is negligible and that there will be no impacts to the wider hydrological environment.

1.13. It is accepted that there are no slope stability concerns regarding the proposed development.

1.14. In the revised submission, an outline construction programme for the primary structure is indicated.

1.15. Queries and requests for further information are discussed in Section 4 and summarised in Appendix 2. Considering the revised submission, the BIA meets the criteria of CPG Basements.

2.0 INTRODUCTION

2.1. CampbellReith was instructed by London Borough of Camden (LBC) on 03 July 2018 to carry out a Category B Audit on the Basement Impact Assessment (BIA) submitted as part of the Planning Submission documentation for 71 Goldhurst Terrace, NW6 3HA.

2.2. The Audit was carried out in accordance with the Terms of Reference set by LBC. It reviewed the Basement Impact Assessment for potential impact on land stability and local ground and surface water conditions arising from basement development.

2.3. A BIA is required for all planning applications with basements in Camden in general accordance with policies and technical procedures contained within:

- Guidance for Subterranean Development (GSD). Issue 01. November 2010. Ove Arup & Partners.
- Camden Planning Guidance: Basements. March 2018.
- Camden Development Policy (DP) 27: Basements and Lightwells.
- Camden Development Policy (DP) 23: Water.
- Local Plan Policy A5 Basements.

2.4. The BIA should demonstrate that schemes:

a) maintain the structural stability of the building and neighbouring properties;

b) avoid adversely affecting drainage and run off or causing other damage to the water environment;

c) avoid cumulative impacts upon structural stability or the water environment in the local area, and;

d) evaluate the impacts of the proposed basement considering the issues of hydrology, hydrogeology and land stability via the process described by the GSD and to make recommendations for the detailed design.

2.5. LBC's Audit Instruction described the planning proposal as *"Excavation of a basement and creation of lightwell to the front of the property, erection of a single storey infill extension and single storey rear extension and the repositioning of the railings to the front of the property."*

The Audit Instruction also confirms that the proposals for 71 Goldhurst Terrace does not involve any listed buildings, nor is it neighbour to a listed building.

2.6. CampbellReith accessed LBC's Planning Portal on 15 July 2018 and gained access to the following relevant documents for audit purposes:

- Basement Impact Assessment Engineering Method Statement dated March 2018 by Green Structural Engineering
- Basement Impact Assessment dated March 2018 by GabrielGeo Consulting (Parts 1-29)
- Floor Risk Assessment (FRA) by Opera Architects dated May 2018
- Planning Application Drawings by Opera Architects dated April 2018 consisting of:

  Site Location Plan

  Proposed Plans, Sections and Elevations
- Design & Access Statement
- Planning Comments and Response

2.7. CampbellReith was provided with the following submission in May 2019 (see Appendix 3):

- Basement Impact Assessment – Response to Audit, prepared by Opera Architects; undated.

3.0 BASEMENT IMPACT ASSESSMENT AUDIT CHECK LIST

Item	Yes/No/NA	Comment
Are BIA Author(s) credentials satisfactory?	Yes	
Is data required by Cl.233 of the GSD presented?	Yes	Programme of works indicated in revised submissions.
Does the description of the proposed development include all aspects of temporary and permanent works which might impact upon geology, hydrogeology and hydrology?	Yes	Structural proposals confirmed in revised submissions.
Are suitable plans/maps included?	Yes	
Do the plans/maps show the whole of the relevant area of study and do they show it in sufficient detail?	Yes	
Land Stability Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	
Hydrogeology Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	
Hydrology Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	
Is a conceptual model presented?	Yes	
Land Stability Scoping Provided? Is scoping consistent with screening outcome?	Yes	

Item	Yes/No/NA	Comment
Hydrogeology Scoping Provided? Is scoping consistent with screening outcome?	Yes	
Hydrology Scoping Provided? Is scoping consistent with screening outcome?	Yes	
Is factual ground investigation data provided?	Yes	
Is monitoring data presented?	Yes	
Is the ground investigation informed by a desk study?	Yes	
Has a site walkover been undertaken?	Yes	
Is the presence/absence of adjacent or nearby basements confirmed?	Yes	
Is a geotechnical interpretation presented?	Yes	
Does the geotechnical interpretation include information on retaining wall design?	Yes	
Are reports on other investigations required by screening and scoping presented?	No	Arboricultural report has been recommended but is not provided.
Are the baseline conditions described, based on the GSD?	Yes	
Do the base line conditions consider adjacent or nearby basements?	Yes	
Is an Impact Assessment provided?	Yes	

Item	Yes/No/NA	Comment
Are estimates of ground movement and structural impact presented?	Yes	
Is the Impact Assessment appropriate to the matters identified by screen and scoping?	Yes	
Has the need for mitigation been considered and are appropriate mitigation methods incorporated in the scheme?	Yes	Updated BIA confirms transitional underpins will not be constructed.
Has the need for monitoring during construction been considered?	Yes	Monitoring of upper flat to be agreed with Party Wall Engineer.
Have the residual (after mitigation) impacts been clearly identified?	Yes	
Has the scheme demonstrated that the structural stability of the building and neighbouring properties and infrastructure will be maintained?	Yes	
Has the scheme avoided adversely affecting drainage and run-off or causing other damage to the water environment?	Yes	
Has the scheme avoided cumulative impacts upon structural stability or the water environment in the local area?	Yes	
Does report state that damage to surrounding buildings will be no worse than Burland Category 1?	Yes	
Are non-technical summaries provided?	Yes	

4.0 DISCUSSION

4.1. The Basement Impact Assessment (BIA) has been carried out by Gabriel GeoConsulting, with the Structural Engineer's Method Statement carried out by Green Structural Engineering. The Flood Risk Assessment has been carried out by Opera Architects. The qualifications of the authors of the BIA and the associated reports are in compliance with the requirements of CPG Basements.

4.2. The BIA includes screening, scoping, site investigations and impact assessment stages as defined and required in the LBC Planning Guidance document 'CPG Basements' dated March 2018.

4.3. The existing building is of traditional masonry and timber construction. It has three storeys above ground with an existing lower ground floor cellar beneath part of the building. It forms part of a terrace of four houses constructed circa 1870. The house has previously been divided into flats. The property is situated mid terrace, to the east side of Goldhurst Terrace sharing party walls with No 69 to the north and No 73 to the south of the property.

4.4. The BIA Audit Instruction confirmed that the site is situated within the South Hampstead Conservation Area and that there are no listed buildings neighbouring the site.

4.5. The proposed works include the excavation of a new single storey basement across the full footprint of the existing building, extending into the hardstanding area to the front of the property to form a new lightwell. The depth of the proposed basement is approximately 3.8m below the existing ground floor level. It is proposed to construct the new basement by forming reinforced concrete underpins in a hit and miss sequence beneath the existing property. A new retaining wall is proposed to be constructed to form the lightwell structure. The basement slab is to be groundbearing.

4.6. The BIA indicates the existing footings as stepped, shallow strip footings bearing on the London Clay. However, the trial pit investigation indicates concrete footings to a depth of up to 680mm beneath the brick corbel. The revised submission indicates that the concrete footings encountered are considered to be part of the original structure.

4.7. A limited site investigation has been undertaken, which is not fully in accordance with LBC guidance (Guidance for Subterranean Development (GSD) Appendix G2). From a single borehole drilled on site, the ground conditions are indicated to be 0.7m of Made Ground overlying the London Clay; designated unproductive strata. Groundwater was not encountered during the ground investigation. One round of subsequent monitoring in March 2018 recorded groundwater at 3.7m bgl. It is accepted that there will be no impacts to the local or wider hydrogeological environment and the basement will not extend below the water table. The

interpreted geotechnical parameters are suitably conservative. The BIA recommends that the contractor make an allowance for temporary dewatering of any perched water encountered. The indicative retaining wall design has considered the groundwater rising to the top of the wall in line with best practice.

4.8. Whilst no trees are being felled, the screening and scoping identify that an aboricultural report should be provided as a tree exists some 10m from the basement. The basement excavation lies beyond the canopy of the tree and it is accepted that the basement is unlikely to have a significant impact on the root zone.

4.9. The BIA notes the high volume change potential of the London Clay. The proposed foundation depths are beyond the zone likely to be affected by shrink / swell movements. The structural proposals note that Cordex will be used to mitigate against clay heave.

4.10. The structural report notes that the basement walls are designed as cantilevers. The original calculations provided included for a prop to the top of the wall. The revised structural calculations include for a number of load cases and propped / un-propped scenarios.

4.11. A ground movement assessment (GMA) has been undertaken. The GMA indicates the potential damage to neighbouring properties as no higher than Category 1 (Very Slight) on the Burland Scale. The GMA is considered to be reasonably conservative and assumes low stiffness (cantilever) retaining walls. Reference has been made to settlement curves in section 10.6.8., used to derive maximum deflections, and these have been provided in the revised submission.

4.12. The original BIA suggested that transitional underpins may be required. The revised submission confirms that transitional underpins will not be constructed. This is reflected in the GMA.

4.13. Proposals are provided for a structural movement monitoring strategy during excavation and construction, including reasonable trigger values. However, the upstairs flats to 71 Goldhurst Terrace should also be included in the monitoring proposals. No additional monitoring information has been provided in the revised submission other than the confirmation that the monitoring will be agreed with the Party Wall Engineer. This is accepted and should be implemented.

4.14. It is noted that the proposed basement is situated within Flood Zone 1 (negligible risk of flooding) and Goldhurst Terrace is listed in the 'Floods in Camden' report as having flooded in both 1975 and 2002. The site is within the Goldhurst Local Flood Risk Zone. The Flood Risk Assessment (FRA) report indicates the site to be at a very low risk of flooding. Nevertheless, mitigation actions recommended within the BIA should be adopted, including raised threshold levels and upstands to lightwells.

4.15. An outline construction programme for the primary structure of 12 weeks is indicated in the revised submission. The fit out programme of the basement

4.16. It is accepted that the increase to the hardstanding is Negligible and that there will be no impact to the wider hydrological environment.

4.17. It is accepted that there are no slope stability concerns.

5.0 CONCLUSIONS

5.1. The qualifications of the authors of the BIA and the associated reports are in compliance with the requirements of CPG Basements.

5.2. The proposed works include the excavation of a new single storey basement to the full footprint of the existing building, extending to the front of the property to form a new lightwell.

5.3. A limited site investigation has Made Ground overlying the London Clay. Groundwater was not encountered during the ground investigation, nevertheless conservative assumptions have been made in respect of design and construction. It is accepted that there will be no impacts to the local and wider hydrogeological environment.

5.4. The BIA recommends that an aboricultural report should be provided, although it is accepted that there are unlikely to be any significant impacts to existing trees.

5.5. The structural proposals and calculations have been clarified in the revised submissions.

5.6. A ground movement assessment (GMA) has been undertaken. The GMA indicates the potential damage to neighbouring properties as no higher than Category 1 (Very Slight) on the Burland Scale.

5.7. A movement monitoring strategy has been provided. The upstairs flats to 71 Goldhurst Terrace should also be included in the monitoring proposals, in agreement with the Party Wall Engineer.

5.8. It is accepted that the risk of flooding is negligible. Nevertheless, mitigation actions recommended within the BIA should be adopted.

5.9. It is accepted that the increase to the hardstanding is negligible and that there will be no impacts to the local and wider hydrological environment.

5.10. An outline construction programme for the primary structure is indicated in the revised submissions.

5.11. Queries and requests for further information are summarised in Appendix 2. Considering the revised submission, the BIA meets the criteria of CPG Basements.

Appendix 1: Residents' Consultation Comments

Residents' Consultation Comments

Surname	Address	Date	Issue raised	Response
Spitzer		09/07/18	Stability of proposed basement and impact of movement on upper level flats at Goldhurst Terrace. Impact of proposed basement on local hydrology.	Queries addressed in Section 4.
CRASH		09/07/18	Cumulative impact of proposed basement on local hydrology and hydrogeology	BIA confirms the proposed development will not adversely impact the local hydrology and hydrogeology
Noel		08/07/18	Cumulative impact of proposed basement on ground stability	BIA addresses proposed construction methods and mitigation measures to maintain stability during and following construction.

Appendix 2: Audit Query Tracker

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Audit Query Tracker

Query No	Subject	Query	Status	Date closed out
1	Stability	Structural proposal to confirm if building is already underpinned and adapt design, as required.	Closed	June 2019
2	Stability	BIA recommends providing transitional underpins. This should be confirmed as part of the structural design with proposals revised, if required.	Closed	June 2019
3	Stability	Retaining wall design calculations to consider the walls as cantilever, as noted in BIA text / GMA.	Closed	June 2019
4	Stability	Settlement curves discussed in section 4.7 to be provided for reference.	Closed	June 2019
5	Stability	Monitoring proposals to be updated to include the upper floor flats at 71 Goldhurst Terrace.	Closed – contractor to liaise with Party Wall Engineer in regards flats within the same building and agree appropriate monitoring strategy.	June 2019
6	BIA	Arboricultural information to be provided to LBC to confirm impacts to root protection zones, as applicable.	Note – closest tree is 10m from proposed basement.	Note Only
7	BIA	An outline construction programme should be provided.	Closed	June 2019

Appendix 3: Supplementary Supporting Documents

1 Stability	Structural proposal to confirm if building is already underpinned and adapt design, as required.
GSE Response	It is not known if the building had been underpinned in the past. The "concrete footings" referred in Audit are thought to be the original footings, referred as "Brick Rubble concrete" in trial pit investigation at No 71. We found that a similar detail exists at No 67 too, referred to as "Crushed brick foundation". It is not unusual to have rubble concrete foundations in historical buildings. It is therefore assumed that foundations are original
2 Stability	BIA recommends providing transitional underpins. This should be confirmed as part of the structural design with proposals revised, if required.
GSE Response	It is proposed to underpin full perimeter of the building, including front lightwell. The new basement level will be the same throughout. It is not anticipated that transitional underpins will be required.
3 Stability	Retaining wall design calculations to consider the walls as cantilever, as noted in BIA text / GMA.
GSE Response	Our retaining wall calculations have been provided for 3 types of retaining walls: 1. Main House and Rear extension (Section R1) where significant vertical load exists, 2. New rear extension wall with little preload (Section R2) and 3. Underpinning to Cellar wall. All three typical walls have been designed for 3 load cases, out of which first two are permanent cases and the third case is a temporary case. The third case does not include ground water on assumption that the ground water during construction will find its way to open excavation and therefore will not be loading the retaining wall. In this case the prop to top of the wall have been designed out. We have revised our calculations to remove the prop. Please find attached revised calculations
4 Stability	Settlement curves discussed in section 4.7 to be provided for reference.
Gabriel GeoConsulting Ltd Response	The settlement curve required by Item 4 is attached. It was prepared when we wrote the BIA, but not presented because the PDISP element was zero so it is purely the curve given in the CIRIA reports, albeit with a slightly restricted length of wall. We have put it onto a figure sheet for presentation purposes.
5 Stability	Monitoring proposals to be updated to include the upper floor flats at 71 Goldhurst Terrace.
GSE Response	Monitoring proposals will be developed by contractor and submitted for Party Wall approval in due course.
6 BIA	Arboricultural information to be provided to LBC to confirm impacts to root protection zones, as applicable.
Opera Architecture	The arboricultural report has to be produced by xxx and submitted to LBC.
7 BIA	An outline construction programme should be provided.

GSE Response For the refurbishment development of this scale a 12 weeks construction programme can be anticipated, including structural works only. Fit out will be additional to this time and the time scale for this is unknow until contractor is appointed.

Attachements

GSE revised Calculations
Gabriel GeoConsulting Settlement curve

GSE GREEN STRUCTURAL ENGINEERING	Project: 71 GOLDHURST TERRACE		Job Ref: J000958	
	Drawing Ref:	Calculations by: J.S.	Checked by:	Sheet No.: 1
	Part of Structure: LOAD TAKE DOWN		Date: FEB '18	

WALL 1 + WALL 2 (MAIN HOUSE)

@ BOTTOM OF EXISTING FOOTINGS (ASSUMED -0.5m)

DEAD: BRICKWORK:

$9.6m \times 0,33m \times 19\ kN/m^3 = 60,2\ kN/m$

WALL 3 + WALL 4 (MAIN HOUSE)

DEAD: BRICKWORK

$9.6m \times 0,33m \times 19\ kN/m^3$ - 33% FOR WINDOWS = 40 kN/m

+ FLOOR LOAD (FLOOR SPAN FRONT-BACK ASSUMED)

3 FLOOR LEVELS + ROOF

ASSUME CENTRAL SPINE WALL. FLOOR SPAN: 4,5m

FLOOR DEAD LOAD:

$1,5\ kN/m^2$ (INCLUDING PARTITIONS)

FLOOR IMPOSED LOAD:

$1,5\ kN/m^2$

LOAD TO FRONT/REAR ELEVATION:

4.5m x 1,5 /2 = 3,4 kN/m PER LEVEL x 4 = 14 kN/m

TOTAL WALL 3 & 4 DEAD:

40 kN/m + 14 = 54 kN/m

IMPOSED: 14 kN/m

GSE GREEN STRUCTURAL ENGINEERING	Project: 71 GOLDHURST TERRACE		Job Ref: JOB 958	
	Drawing Ref:	Calculations by: J.S.	Checked by:	Sheet No.: 2
	Part of Structure: LOAD TAKE DOWN		Date: FEB '18	

WALL 5

DEAD: BRICKWORK:

$8{,}2m \times 0{,}22 \times 19\ kN/m^3 = 3.4\ kN/m$

FLOOR LOAD:

DEAD: $1{,}5\ kN/m^2 \times 3m = 4.5\ kN/m$ PER LEVEL INCL NEXT DOOR

IMPOSED: -"- $4{,}5\ kN/m$ PER LEVEL

× 4 LEVELS (INC ROOF) =

D: $4{,}5 \times 3{,}5 = 15{,}5\ kN/m$

I: -"- $15{,}5\ kN/m$

TOTAL DEAD: $3{,}4 + 15{,}5 = 49{,}5\ kN/m$ (conservative)

IMPOSED: $15{,}5\ kN/m$

WALL 6 – NOT GOING TO BASEMENT (SUPPORTED ON BEAMS, TRANSFERRING LOAD TO WALL 8)

WALL 7

DEAD: BRICKWORK

$3m \times 0{,}22 \times 19\ kN/m^3 = 12{,}5\ kN/m$

FLOORS (TIMBER) + ROOF

$1{,}5\ kN/m^2 \times 2{,}8m \times 2$ SIDES +

$0{,}75\ kN/m^2 \times 2{,}3m \times 2$ SIDES $= 11{,}85\ kN/m$

IMPOSED: $12\ kN/m$

TOTAL DEAD: $24{,}5\ kN/m$

IMPOSED: $12\ kN/m$

	Project		Job Ref	
GSE GREEN STRUCTURAL ENGINEERING	71 GOLDHURST TERRACE		J0000958	
	Drawing Ref	Calculations by	Checked by	Sheet No.
		J.S.		3
	Part of Structure		Date	
	LOAD TAKE DOWN		FEB'10	

WALL 8

DEAD: BRICKWORK:

3m x 0,22 x 19 kN/m³ - 20% WINDOWS = 10 kN/m

FLOORS:

1,5 kN/m² x 2,8m + ROOF=

0,75 kN/m² x 2,3m = 6 kN/m

IMPOSED: 6 kN/m

TOTAL DEAD: 16 kN/m

IMPOSED: 6 kN/m

GSE GREEN STRUCTURAL ENGINEERING	Project: 71 GOLDHURST TERRACE		Job Ref: JOB0958	
	Drawing Ref	Calculations by: J.S.	Checked by	Sheet No.
	Part of Structure: UNDERPINNING DESIGN		Date	

MAIN HOUSE AND REAR EXTENSION (SECTION R1)
UNDERPINNING (WALLS 2 & 5)

LOADS:

DEAD: 50 kN/m IMPOSED: 16 kN/m

SOIL: CLAY
UNIT WEIGHT: 20 kN/m³
ANGLE OF INT. FRICTION: 22°
$K_0 = 1,0 - 1,5$

ALLOWABLE BEARING PRESSURE: 100 kN/m²

HEIGHT OF THE WALL: 3,4m

WALL 8 UNDERPINNING (SECTION R2)

DEAD: 16 kN/m IMPOSED: 6 kN/m

WALL 1 UNDERPINNING:

ADD 2m OF MASONRY LOAD:

$2 \times 0,33 \times 19 kN/m^3 = 12,5$ kN/m

TOTAL DEAD: 50 + 12,5 = 62,5 kN/m
IMPOSED: 16 kN/m

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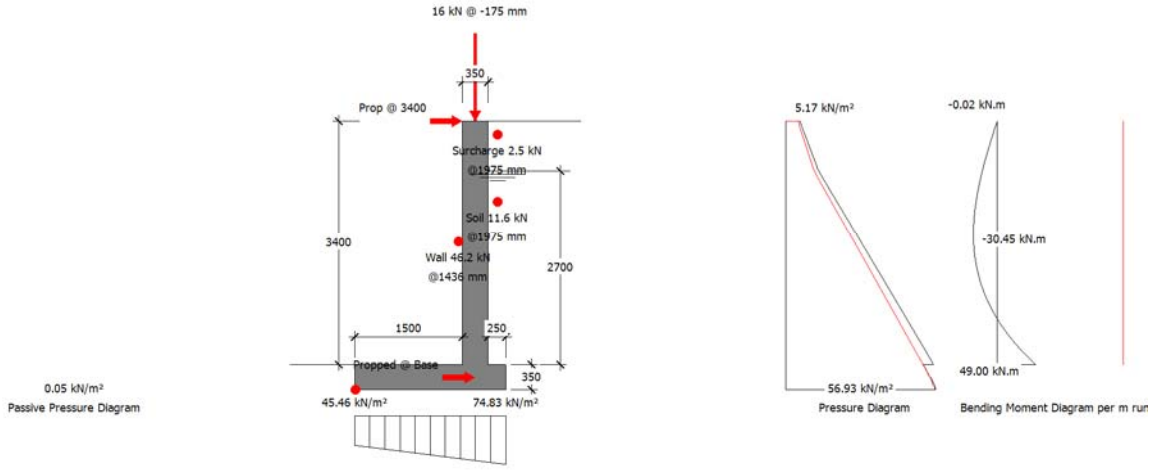
William Morris Way, Fulham, SW6 2UZ
Tel: (0203) 4053120
Email: info@gseltd.co.uk Web: www.gseltd.co.uk

25642

Job Ref :
Sheet : /10006
Made by :
Date : 03 September 2018 / Ver. 2017.10
Checked :
Approved :

MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R1 - L/C 1
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 10.00 kN/m², Water table level 2700 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 3.4 m
Vertical Line Loads	50 kN/m @ X -175 mm and Y 0 mm - Load type Dead
	16 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	140.161/283.570	0.494	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(31.893+0.000)	0.000	OK
Prop Reactions Case 2 (Service)	88.1 kN @ Base, 21.0 kN @ 3.750 m		

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Job Ref :
Sheet : /10007
Made by :
Date : 03 September 2018 / Ver. 2017.10
Checked :
Approved :

Soil Pressure

Virtual Back (No uplift)	Max(45.457/150, 74.829/150) kN/m²	0.499	OK
Wall Back (No uplift)	Max(52.770/150, 67.515/150) kN/m²	0.450	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\text{Sin}(\phi))\ x\sqrt{OCR} = (1+\text{Sin}(18.61)x\sqrt{1}$		1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	124.2 kN @ Base, 31.0 kN @ 3.400 m		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 49.0 kN.m, Mr 160.7 kN.m	0.305	OK
Shear Capacity Check	F 99.0 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.55	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1838 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 40.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 30.4 kN.m, Mr 68.2 kN.m	0.447	OK
Shear Capacity Check	F 0.7 kN, vc 0.431 N/mm², Fvr 135.9 kN	0.00	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1608 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 0.0 kN.m, Mr 63.8 kN.m	0.000	OK
Shear Capacity Check	F 0.0 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.00	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1608 mm², 500 N/mm², 40 N/mm²	272 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 44 mm, 0.15	190.6 kN.m	
Moment Capacity Check (M/Mr)	M 71.1 kN.m, Mr 190.6 kN.m	0.373	OK
Shear Capacity Check	F 102.3 kN, vc 0.656 N/mm², Fvr 191.4 kN	0.53	OK

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Made by :
Date : 03 September 2018 / Ver. 2017.10
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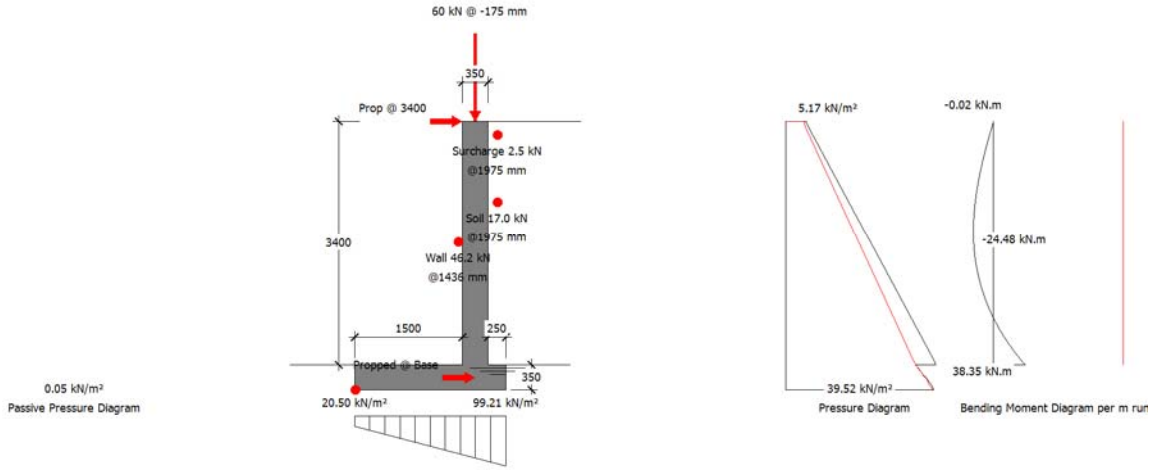
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R1 - L/C 2
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 30 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 10.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 3.4 m
Vertical Line Load	60 kN/m @ X -175 mm and Y 0 mm - Load type Dead
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	109.589/270.502	0.405	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(31.741+0.000)	0.000	OK
Prop Reactions Case 2 (Service)	62.1 kN @ Base, 17.4 kN @ 3.750 m		

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Soil Pressure

Virtual Back (No uplift)	Max(20.499/150, 99.215/150) kN/m²	0.661	OK
Wall Back (No uplift)	Max(29.758/150, 89.956/150) kN/m²	0.600	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\text{Sin}(\phi))\ x\sqrt{OCR} = (1+\text{Sin}(18.61)x\sqrt{1}$		1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	92.3 kN @ Base, 26.6 kN @ 3.400 m		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 30.0 N/mm²	270 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 48 mm, 0.17	157.6 kN.m	
Moment Capacity Check (M/Mr)	M 38.4 kN.m, Mr 157.6 kN.m	0.243	OK
Wall Axial Design (N/Ncap)	N 124.0 kN, Ncap 4200.0 kN	0.030	OK
Wall Slenderness λ	Leff/tk =0.96x3400.0/350.0	9.3	OK
Wall Axial-Mom Design (M/M_{1Axial})	M 38.4 kN, Mr_{Axial}173.4 kN.m	0.221	OK
Shear Capacity Check	F 75.2 kN, vc 0.560 N/mm², Fvr 163.7 kN	0.46	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1838 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 30.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 19 mm, 0.06	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 24.5 kN.m, Mr 68.2 kN.m	0.359	OK
Shear Capacity Check	F 0.8 kN, vc 0.392 N/mm², Fvr 123.5 kN	0.01	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 30 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 19 mm, 0.06	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 0.0 kN.m, Mr 63.8 kN.m	0.000	OK
Shear Capacity Check	F 0.0 kN, vc 0.407 N/mm², Fvr 120.1 kN	0.00	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 30 N/mm²	270 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 48 mm, 0.17	157.6 kN.m	
Moment Capacity Check (M/Mr)	M 52.8 kN.m, Mr 157.6 kN.m	0.335	OK
Shear Capacity Check	F 87.7 kN, vc 0.560 N/mm², Fvr 163.7 kN	0.54	OK

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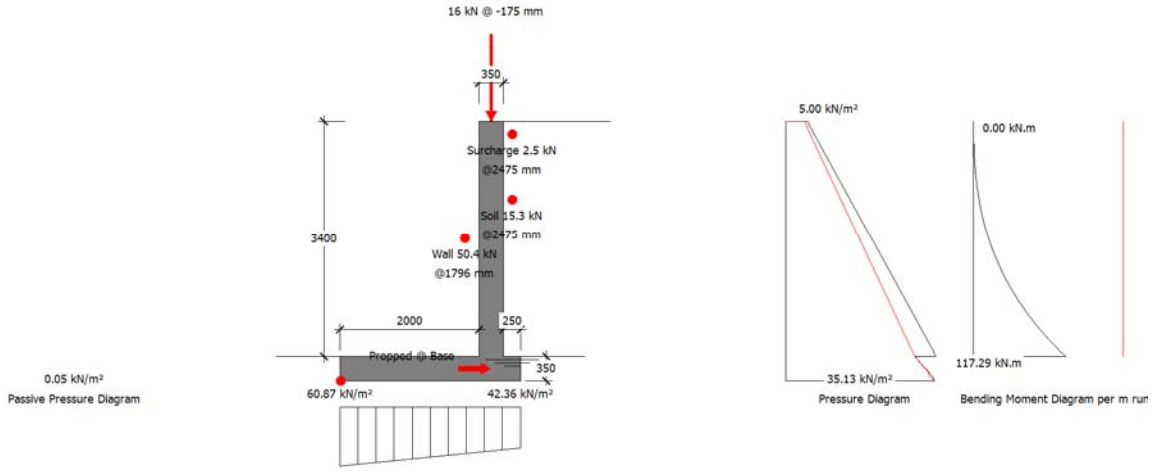
Job Ref :
Sheet : /10010
Made by :
Date : 03 September 2018 / Ver. 2017.10
Checked :
Approved :

MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R1 - L/C 3
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Dry Soil 18.00, Saturated Soil 20.80, Submerged Soil 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 10.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Vertical Line Loads	50 kN/m @ X -175 mm and Y 0 mm - Load type Dead 16 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(23)/1.2) = 19.48°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(23)/1.2))) = 14.86°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	98.074/278.115	0.353	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(35.603+0.000)	0.000	OK
Prop Reaction Case 2 (Service)	70.6 kN @ Base		

Soil Pressure

Virtual Back (No uplift)	Max(46.662/150, 56.569/150) kN/m²	0.377	OK

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Wall Back (No uplift)	Max(60.870/150, 42.360/150) kN/m²	0.406	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\text{Sin}(\phi))\ x\sqrt{OCR} = (1+\text{Sin}(19.48)x\sqrt{1}$		1.33

Prop Reaction

Maximum Prop Reaction (Ultimate)	107.3 kN @ Base		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	OK
Compression Steel Provided (Cover)	Main H10@300 (30 mm) Dist. H10@300 (40 mm)	262 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1608 mm², 500 N/mm², 40.0 N/mm²	272 mm	
Mr=fn(above,As',d',x,x/d)	262 mm², 35 mm, 44 mm, 0.15	190.6 kN.m	
Moment Capacity Check (M/Mr)	M 117.3 kN.m, Mr 190.6 kN.m	0.615	OK
Shear Capacity Check	F 91.9 kN, vc 0.656 N/mm², Fvr 191.4 kN	0.48	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1608 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 1.3 kN.m, Mr 63.8 kN.m	0.021	OK
Shear Capacity Check	F 10.7 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.08	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1608 mm², 500 N/mm², 40 N/mm²	272 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 44 mm, 0.15	190.6 kN.m	
Moment Capacity Check (M/Mr)	M 127.0 kN.m, Mr 190.6 kN.m	0.666	OK
Shear Capacity Check	F 125.3 kN, vc 0.656 N/mm², Fvr 191.4 kN	0.65	OK

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Sheet : /10024
Made by :
Date : 03 September 2018 / Ver. 2017.10
Checked :
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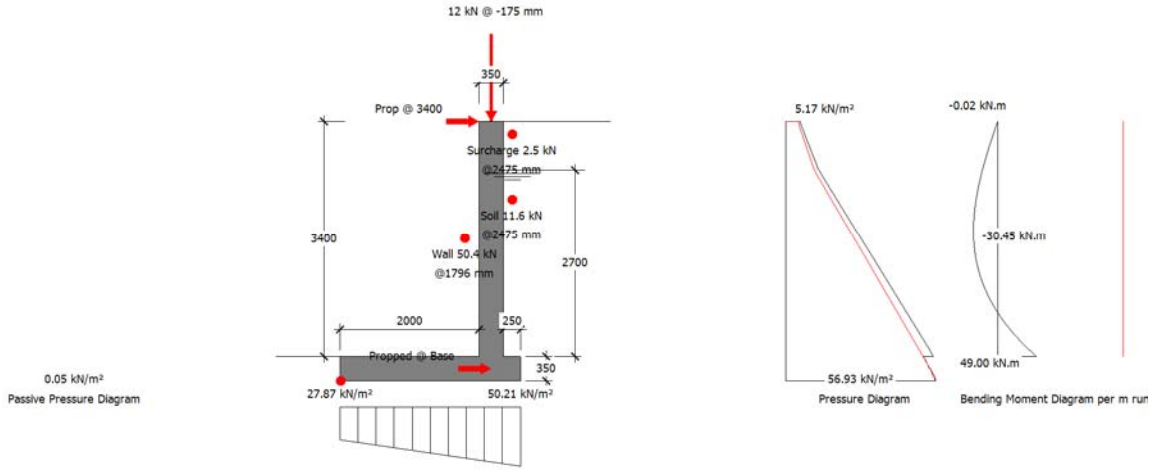
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R2 - L/C 1
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 30 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 10.00 kN/m², Water table level 2700 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 3.4 m
Vertical Line Loads	25 kN/m @ X -175 mm and Y 0 mm - Load type Dead
	12 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	140.161/284.695	0.492	OK

Wall Sliding - Virtual Back Pressure

Fx/($Rx_{Friction}$+ $Rx_{Passive}$)	0.000/(25.630+0.000)	0.000	OK
Prop Reactions Case 2 (Service)	88.1 kN @ Base, 21.0 kN @ 3.750 m		

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Soil Pressure

Virtual Back (No uplift)	Max(27.869/150, 50.208/150) kN/m²	0.335	OK
Wall Back (No uplift)	Max(32.640/150, 45.437/150) kN/m²	0.303	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\text{Sin}(\phi))\ x\sqrt{OCR} = (1+\text{Sin}(18.61)x\sqrt{1}$	1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	124.2 kN @ Base, 31.0 kN @ 3.400 m

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 30.0 N/mm²	270 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 48 mm, 0.17	157.6 kN.m	
Moment Capacity Check (M/Mr)	M 49.0 kN.m, Mr 157.6 kN.m	0.311	OK
Shear Capacity Check	F 99.0 kN, vc 0.560 N/mm², Fvr 163.7 kN	0.61	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1838 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 30.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 19 mm, 0.06	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 30.4 kN.m, Mr 68.2 kN.m	0.447	OK
Shear Capacity Check	F 0.7 kN, vc 0.392 N/mm², Fvr 123.5 kN	0.01	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 30 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1608 mm², 58 mm, 19 mm, 0.06	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 0.7 kN.m, Mr 63.8 kN.m	0.011	OK
Shear Capacity Check	F 5.6 kN, vc 0.407 N/mm², Fvr 120.1 kN	0.05	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1608 mm², 500 N/mm², 30 N/mm²	266 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 58 mm, 0.20	186.1 kN.m	
Moment Capacity Check (M/Mr)	M 72.3 kN.m, Mr 186.1 kN.m	0.389	OK
Shear Capacity Check	F 80.6 kN, vc 0.596 N/mm², Fvr 173.9 kN	0.46	OK

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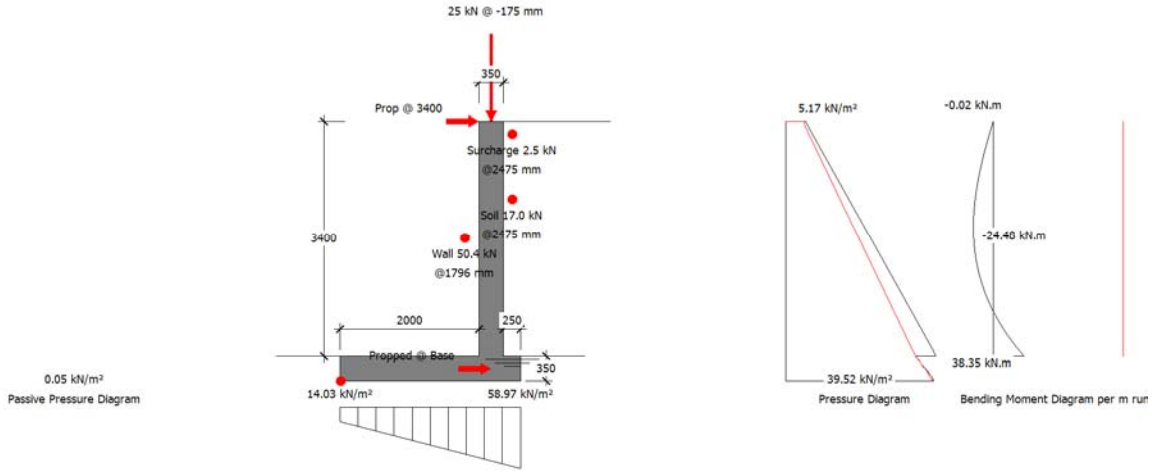
Job Ref :
Sheet : /10026
Made by :
Date : 03 September 2018 / Ver. 2017.10
Checked :
Approved :

MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R2 - L/C 2
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 10.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 3.4 m
Vertical Line Load	25 kN/m @ X -175 mm and Y 0 mm - Load type Dead
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	109.589/258.277	0.424	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(23.964+0.000)	0.000	OK
Prop Reactions Case 2 (Service)	62.1 kN @ Base, 17.4 kN @ 3.750 m		

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Soil Pressure

Virtual Back (No uplift)	Max(14.028/150, 58.972/150) kN/m²	0.393	OK
Wall Back (No uplift)	Max(20.069/150, 52.931/150) kN/m²	0.353	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\text{Sin}(\phi))\ x\sqrt{OCR} = (1+\text{Sin}(18.61)x\sqrt{1}$		1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	92.3 kN @ Base, 26.6 kN @ 3.400 m		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 38.4 kN.m, Mr 160.7 kN.m	0.239	OK
Shear Capacity Check	F 75.2 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.42	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1838 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 40.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 24.5 kN.m, Mr 68.2 kN.m	0.359	OK
Shear Capacity Check	F 0.8 kN, vc 0.431 N/mm², Fvr 135.9 kN	0.01	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 1.4 kN.m, Mr 63.8 kN.m	0.023	OK
Shear Capacity Check	F 11.8 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.09	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 52.6 kN.m, Mr 160.7 kN.m	0.327	OK
Shear Capacity Check	F 66.5 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.37	OK

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Made by :
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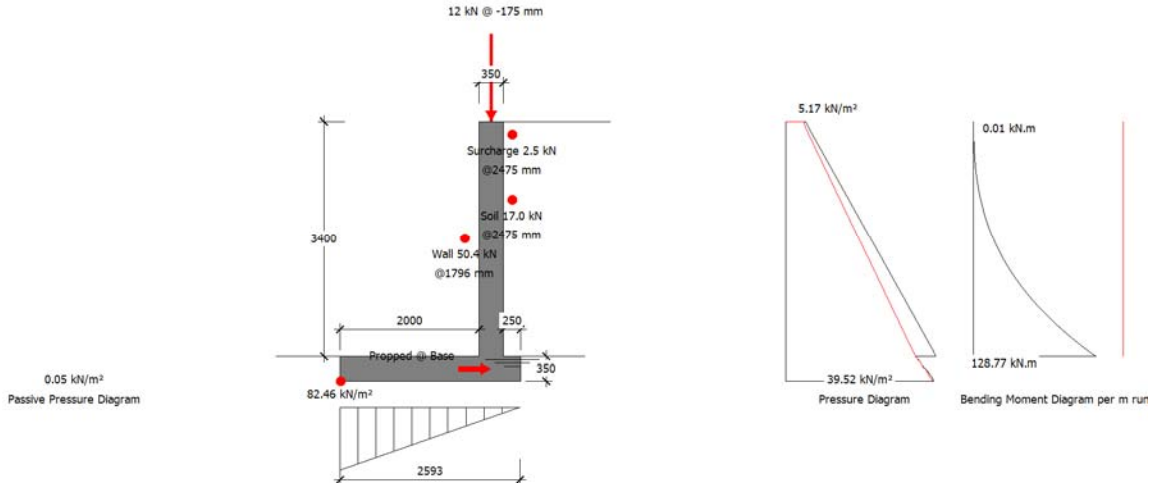
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R2 - L/C 3
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 30 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 10.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Vertical Line Loads	25 kN/m @ X -175 mm and Y 0 mm - Load type Dead
	12 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	109.589/219.247	0.500	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+ Rx_{Passive})$	0.000/(26.994+0.000)	0.000	OK
Prop Reaction Case 2 (Service)	79.5 kN @ Base		

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Soil Pressure

Virtual Back (No uplift)	Max(67.132/150, 15.099/150) kN/m²	0.448	OK
Wall Back	82.456/150 kN/m², Length under pressure 2.593 m	0.550	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\sin(\phi)) \times \sqrt{OCR} = (1+\sin(18.61)) \times \sqrt{1}$		1.32

Prop Reaction

Maximum Prop Reaction (Ultimate)	118.9 kN @ Base		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 30.0 N/mm²	270 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 48 mm, 0.17	157.6 kN.m	
Moment Capacity Check (M/Mr)	M 128.8 kN.m, Mr 157.6 kN.m	0.817	OK
Shear Capacity Check	F 101.8 kN, vc 0.560 N/mm², Fvr 163.7 kN	0.62	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 30 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 19 mm, 0.06	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 3.4 kN.m, Mr 63.8 kN.m	0.053	OK
Shear Capacity Check	F 26.6 kN, vc 0.407 N/mm², Fvr 120.1 kN	0.22	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 30 N/mm²	270 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 48 mm, 0.17	157.6 kN.m	
Moment Capacity Check (M/Mr)	M 139.0 kN.m, Mr 157.6 kN.m	0.882	OK
Shear Capacity Check	F 115.2 kN, vc 0.560 N/mm², Fvr 163.7 kN	0.70	OK

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Sheet : /10018
Made by :
Date : 03 September 2018 / Ver. 2017.10
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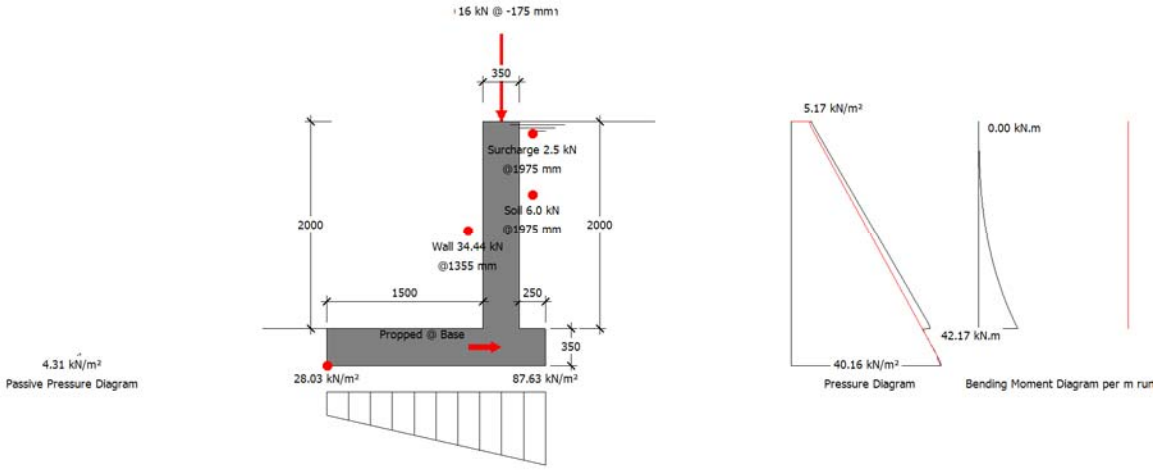
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R3 - L/C 1
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 10.00 kN/m², Water table level 2000 mm
Unplanned excavation depth	Front of wall 235 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Vertical Line Loads	62.5 kN/m @ X -175 mm and Y 0 mm - Load type Dead
	16 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge, P_p- Passive Earth Pressure

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$+1.00 P_p
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$+1.00 P_p

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	45.524/194.937	0.234	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(30.666+0.250)	0.000	OK
Prop Reaction Case 2 (Service)	52.8 kN @ Base		

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Soil Pressure

Virtual Back (No uplift)	Max(28.031/150, 87.626/150) kN/m²	0.584	OK
Wall Back (No uplift)	Max(32.936/150, 82.721/150) kN/m²	0.551	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\sin(\phi)) \times \sqrt{OCR} = (1+\sin(18.61)\times\sqrt{1}$	1.32

Prop Reaction

Maximum Prop Reaction (Ultimate)	73.6 kN @ Base

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 42.2 kN.m, Mr 160.7 kN.m	0.262	OK
Shear Capacity Check	F 56.2 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.31	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1608 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 0.0 kN.m, Mr 63.8 kN.m	0.000	OK
Shear Capacity Check	F 0.0 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.00	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1608 mm², 500 N/mm², 40 N/mm²	272 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 44 mm, 0.15	190.6 kN.m	
Moment Capacity Check (M/Mr)	M 54.1 kN.m, Mr 190.6 kN.m	0.284	OK
Shear Capacity Check	F 87.8 kN, vc 0.656 N/mm², Fvr 191.4 kN	0.46	OK

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Made by :
Date : 03 September 2018 / Ver. 2017.10
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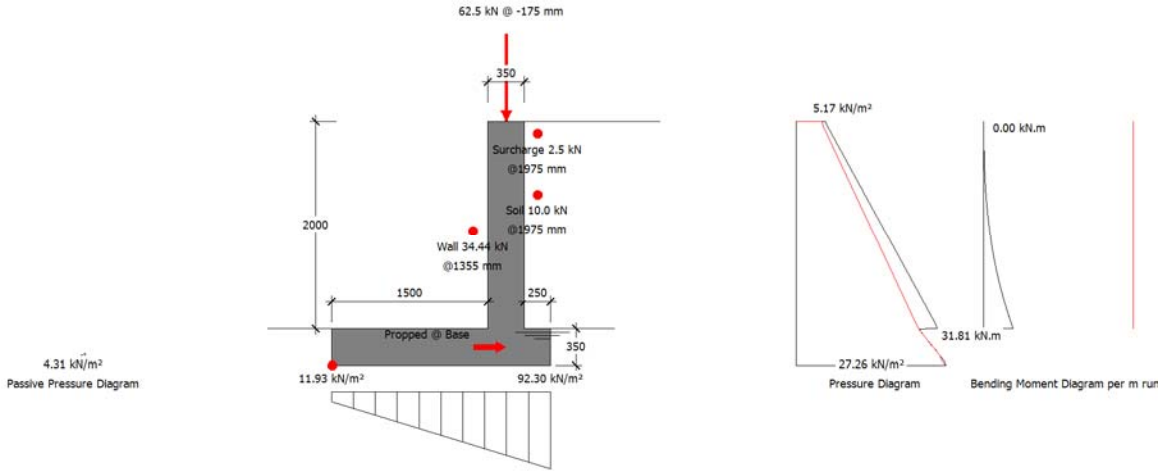
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R3 - L/C 2
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 10.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 235 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Vertical Line Load	62.5 kN/m @ X -175 mm and Y 0 mm - Load type Dead
† Dimensions	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge, P_p- Passive Earth Pressure

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$+1.00 P_p
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$+1.00 P_p

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	31.589/176.037	0.179	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+ Rx_{Passive})$	0.000/(27.635+0.250)	0.000	OK
Prop Reaction Case 2 (Service)	35.4 kN @ Base		

Soil Pressure

Virtual Back (No uplift)	Max(11.929/150, 92.299/150) kN/m²	0.615	OK

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Wall Back (No uplift)	Max(18.470/150, 85.758/150) kN/m²	0.572	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	(1+Sin(ϕ)) x$\sqrt{}$OCR = (1+Sin(18.61)x$\sqrt{}$1		1.32

Prop Reaction

Maximum Prop Reaction (Ultimate)	52.2 kN @ Base		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 31.8 kN.m, Mr 160.7 kN.m	0.198	OK
Shear Capacity Check	F 40.8 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.23	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 0.0 kN.m, Mr 63.8 kN.m	0.000	OK
Shear Capacity Check	F 0.0 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.00	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 38.6 kN.m, Mr 160.7 kN.m	0.240	OK
Shear Capacity Check	F 70.0 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.39	OK

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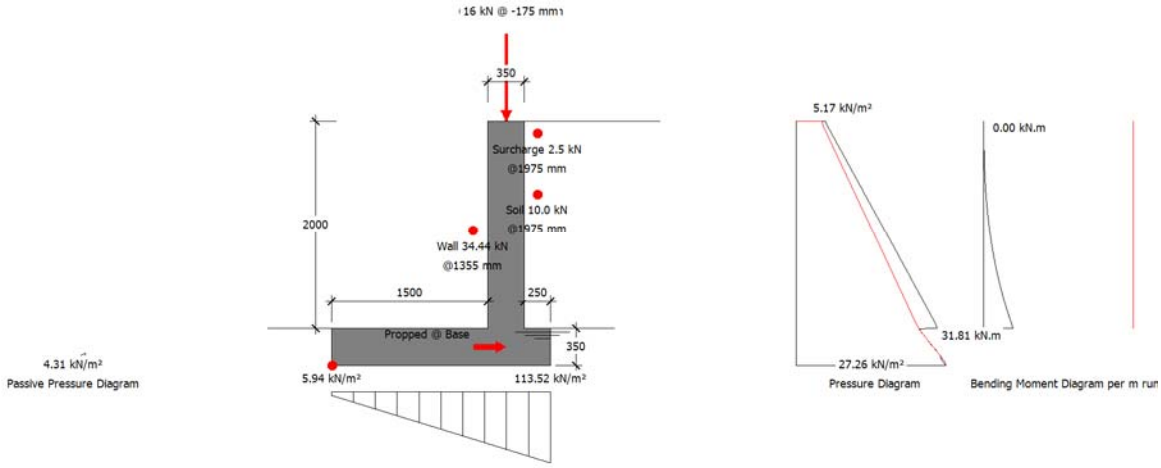
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R3 - L/C 3
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 10.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 235 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Vertical Line Loads	62.5 kN/m @ X -175 mm and Y 0 mm - Load type Dead
	16 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge, P_p- Passive Earth Pressure

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$+1.00 P_p
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$+1.00 P_p

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	31.589/202.837	0.156	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(31.676+0.250)	0.000	OK
Prop Reaction Case 2 (Service)	35.4 kN @ Base		

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Job Ref :
Sheet : /10023
Made by :
Date : 03 September 2018 / Ver. 2017.10
Checked :
Approved :

Soil Pressure

Virtual Back (No uplift)	Max(5.943/150, 113.524/150) kN/m²	0.757	OK
Wall Back (No uplift)	Max(12.484/150, 106.983/150) kN/m²	0.713	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\sin(\phi)) \times \sqrt{OCR} = (1+\sin(18.61)) \times \sqrt{1}$	1.32

Prop Reaction

Maximum Prop Reaction (Ultimate)	52.2 kN @ Base

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 31.8 kN.m, Mr 160.7 kN.m	0.198	OK
Shear Capacity Check	F 40.8 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.23	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 0.0 kN.m, Mr 63.8 kN.m	0.000	OK
Shear Capacity Check	F 0.0 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.00	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 39.5 kN.m, Mr 160.7 kN.m	0.246	OK
Shear Capacity Check	F 78.9 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.44	OK

Project:

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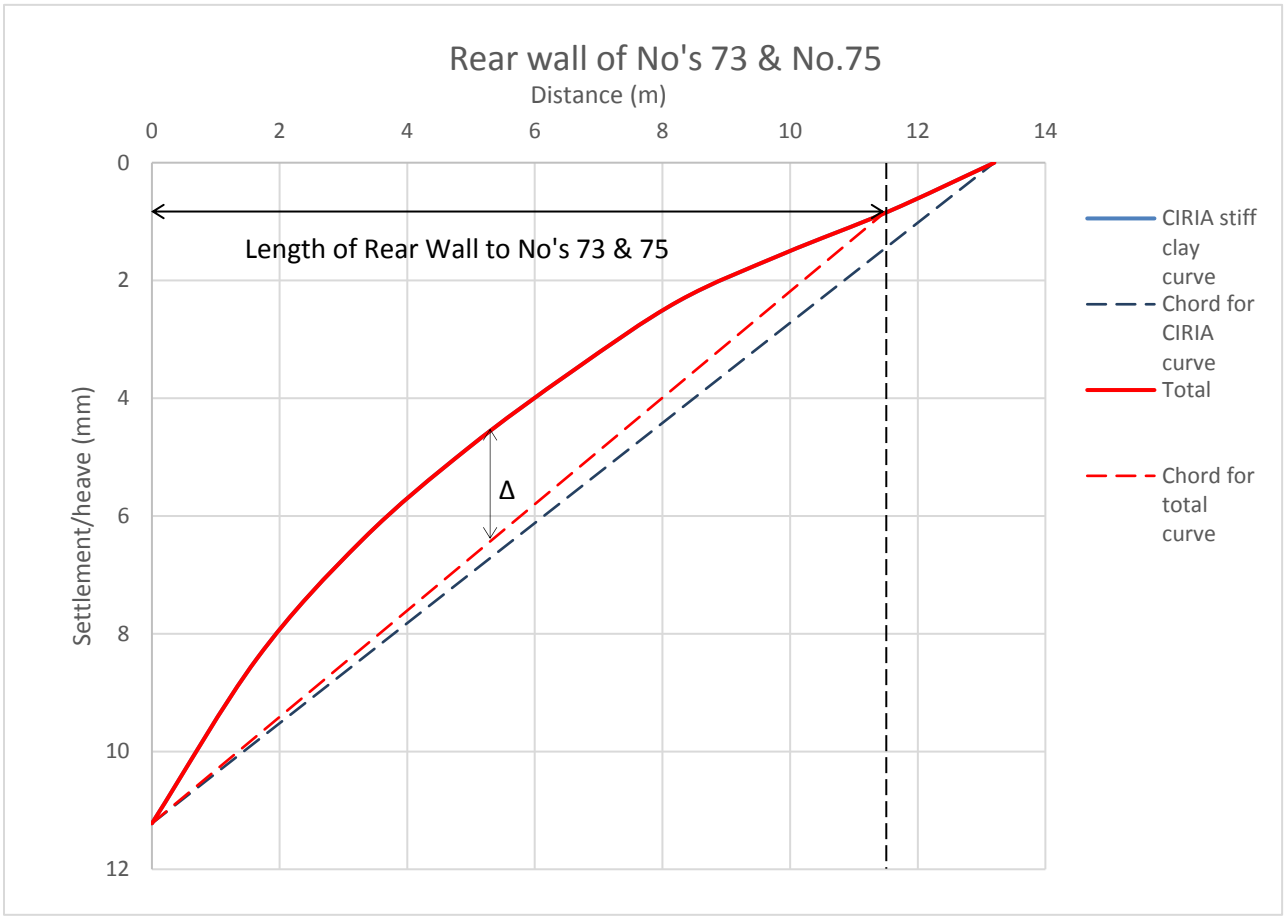
18672



Curve based on Figure 6.15 in the CIRIA Report C760 (which is identical to Figure 2.11(b) in the earlier CIRIA Report C580)

Title:	**GMA Displacement Graph - Rear wall of No's 73 & 75**					Figure:	-
Date:	5th October 2018	Checked:	AG	Approved:	KRG	Scale :	NTS

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