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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Job Ref :
Sheet : /10006
Made by :
Date : 03 September 2018 / Ver. 2017.10
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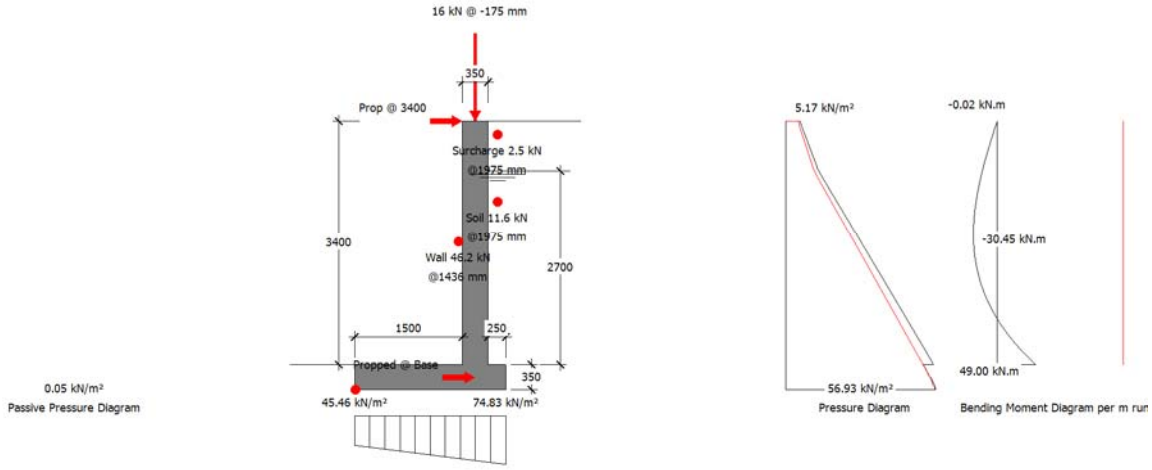
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R1 - L/C 1
Reinforced Concrete Retaining Wall with Reinforced Base



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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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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Job Ref :
Sheet : /10008
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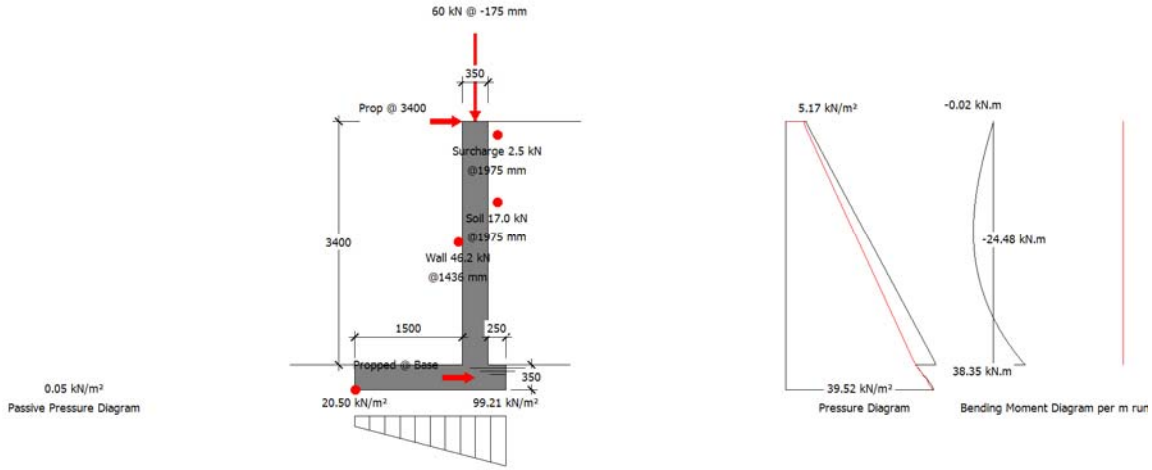
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R1 - L/C 2
Reinforced Concrete Retaining Wall with Reinforced Base



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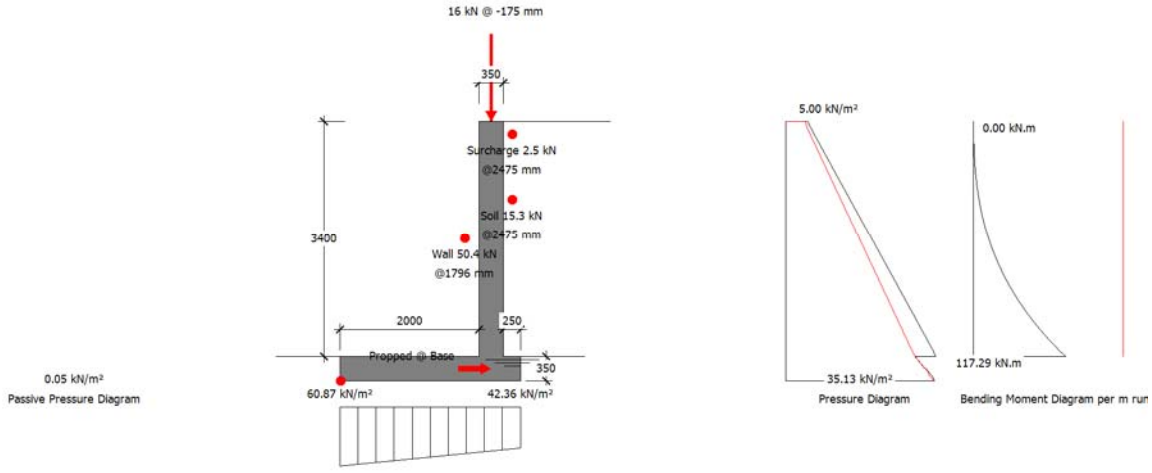
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R1 - L/C 3
Reinforced Concrete Retaining Wall with Reinforced Base



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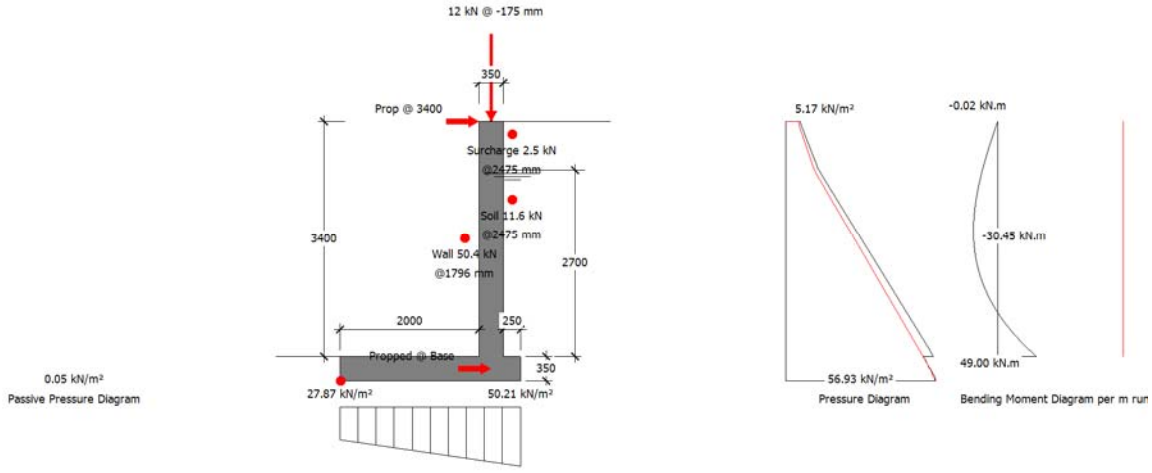
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R2 - L/C 1
Reinforced Concrete Retaining Wall with Reinforced Base



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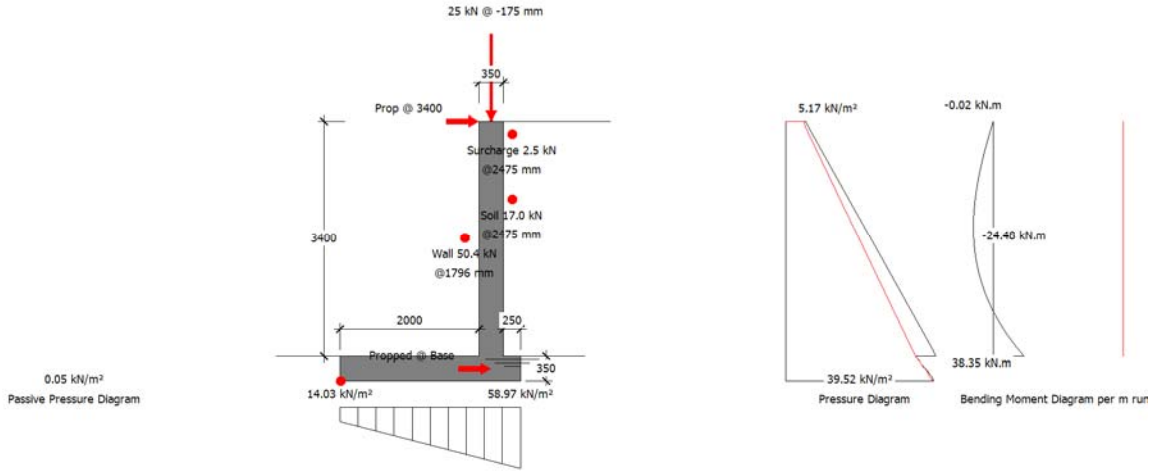
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R2 - L/C 2
Reinforced Concrete Retaining Wall with Reinforced Base



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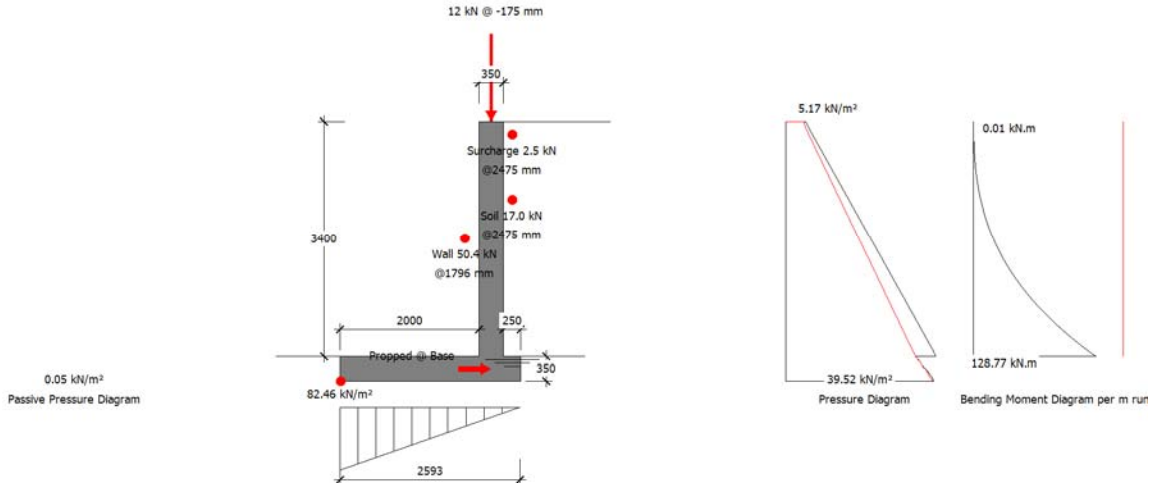
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R2 - L/C 3
Reinforced Concrete Retaining Wall with Reinforced Base



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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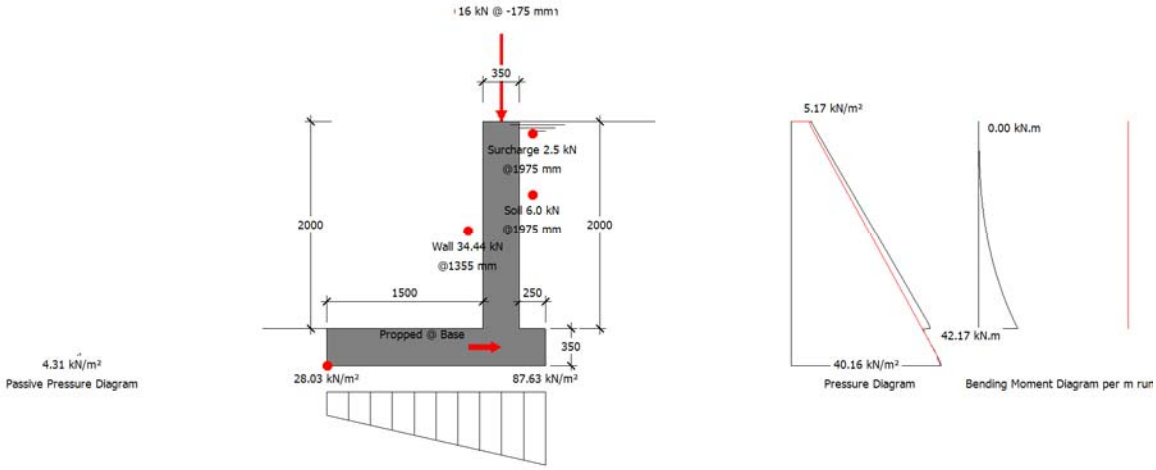
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R3 - L/C 1
Reinforced Concrete Retaining Wall with Reinforced Base



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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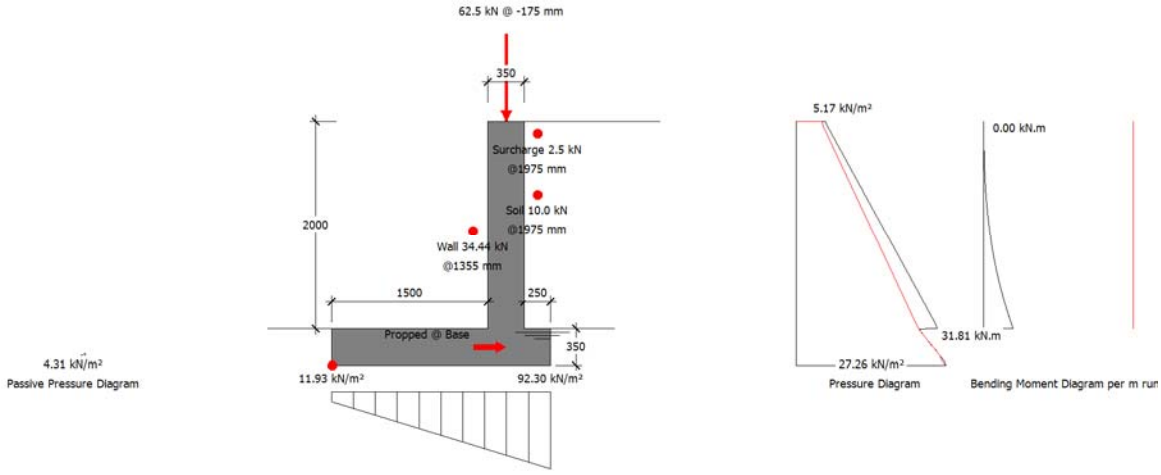
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R3 - L/C 2
Reinforced Concrete Retaining Wall with Reinforced Base



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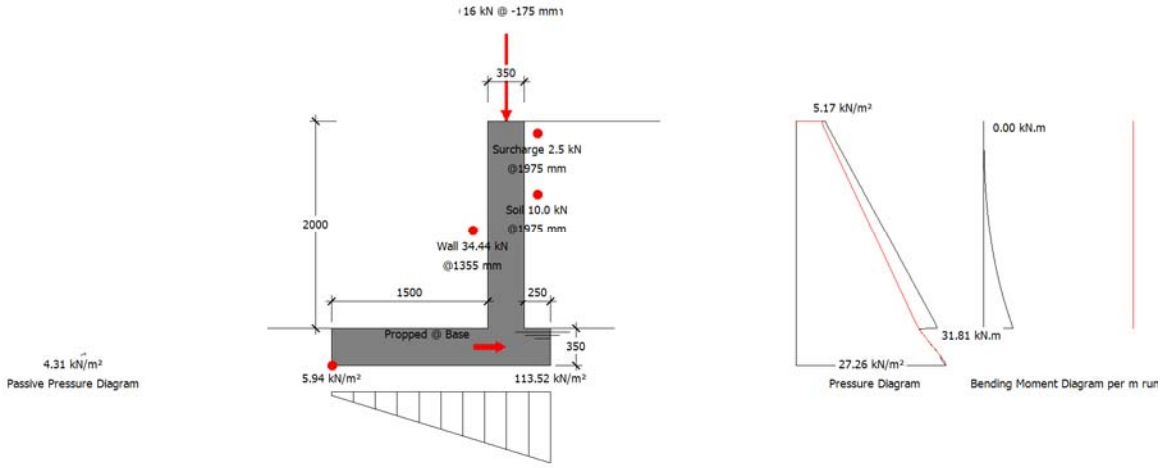
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall R3 - L/C 3
Reinforced Concrete Retaining Wall with Reinforced Base



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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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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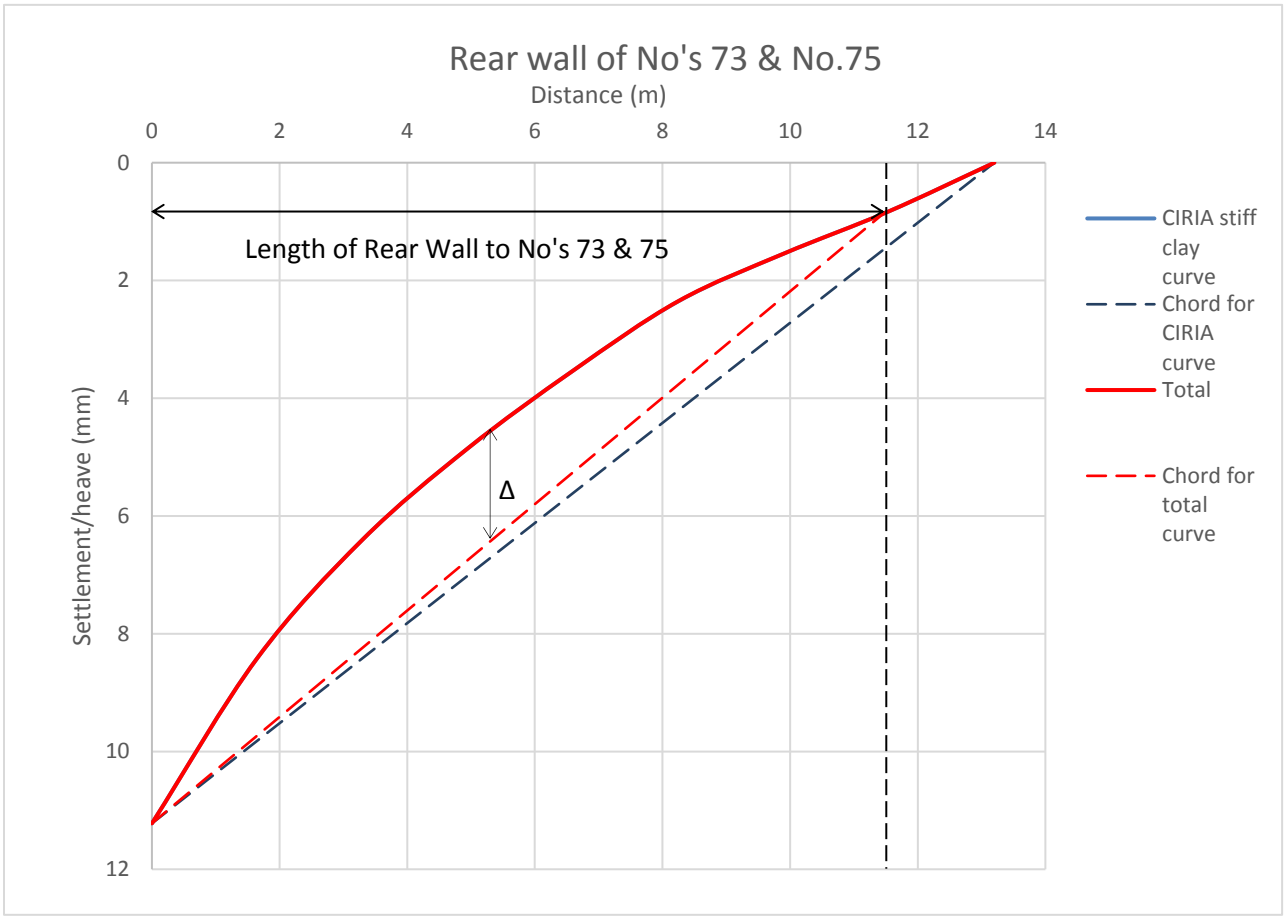
18672



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