6.6 Structure calculations

1) DESIGN COBDITON FOR VALVE CHAMBERS
2) WALL OF PADDLE FLANGE
3) ①VALVE CHAMBER (L2.7m×W2.2m×H3.0m)
4) ②VALVE CHAMBER (L4.87m×W4.15m×H3.0m, 2.5m)
5) ③VALVE CHAMBER (L2.9m×W2.6m×H3.0m)
6) ④VALVE CHAMBER(L3.95m×W3.45m×H3.0m)
7) ⑤VALVE CHAMBER(L4.25m×W3.55m×H3.0m)
8) ⑥VALVE CHAMBER(L2.95m×W2.35m×H3.0m)

1) DESIGN CONDITION FOR VALVE CHAMBERS

Design Condition For Valve Chambers

A- Stability check

- Over turning
  Over turning moment/stabilizing moment >1.5
- Sliding
  Sliding force/Resisting force >1.5

B- Design Codes

ACI-318-11

UBC-97

C- Design of structural members

- Material Strength

Concrete strength =25 MPa (cylinder)

Yield strength of steel =420 MPa

- Materials Unit weight
  Concrete =24 KN/m^3
  Soil =18 KN/m^3
  Water =10 KN/m^3
- Concrete Cover
  Severe condition (in contact to soil) =50 mm
  Severe condition (in contact to water) =75 mm
  Normal condition =40 mm

D- Loads

The following loads will be considered

- Dead load

Self-weight

Manhole cover weight=50 Kg

- Live load
  Traffic load 20 KN/m^2 or 145 KN whichever is greater
- Water pressure inside the valve chamber
  $P_w = \gamma_w H$
- Soil pressure outside the valve chamber
  $P_s = k_a ¥ \gamma_s H$

1

Where

$K_a = \frac{1-\sin \emptyset}{1+\sin \emptyset}$

And $\emptyset = 30^o$

- Hydrostatic pressure
  As per hydraulic design requirements, 12 bar water pressure was adopted to be applied on the contact area between the pipe line and the concrete structure.

E- Load combinations

According to UBC-97 code, the following load combination will be used in the analysis and design

- 1.4D+1.4F
- 1.2D+1.2F+1.6L+1.6H
- D+F+H
- D+L+F+H

Where

- D=Dead load
- L=Live loads
- F=Fluid pressure
- H=Soil Pressure

Both the service and ultimate load combinations stated here above are to be properly used as follows:

- Ultimate load combinations: for design purposes of all structural elements
- Allowable load combinations: for serviceability checks (deformation, deflection, stability and bearing pressure) and when working design method is required.
- The load cases H and F are added to all UBC Combination where H and F exist.

F- Bearing Capacity

Based on the soil investigation reports, it was recommended to adopt a soil bearing capacity of 100 KN/m² for all chambers.

G- Analysis and Design Software

The following software will be used to analyze and design the structure chamber members

- STAADPRO
- PROKON
- EXCEL

H- MODELING PROCESS

- The preliminary estimation for the chamber wall thickness has been done using PROKON. For
- Simplification purposes, a triangular soil pressure was applied on cantilever beam, it was concluded that a wall thickness of 250 mm is suitable for our case.
- After that, an accurate 3D model was created using the STAADPRO program, this is to represent the actual chamber dimensions and the structural element thicknesses.
- This analysis approach gave the structural designer more precise results, since all of the structural elements (walls, foundations and the top slab) are integrally working with each other.
- For the chamber, top slab and the raft foundation, the reactions of the different load combinations were imported from STAADPRO 3D model to a 2D models where the required analysis and designed were performed.
- Regarding the foundation system, strip foundation of 400 mm was used.
- Finally, regarding the chamber top slab, a flat slab of 250 mm thickness was found satisfying all of the strength and serviceability requirements.

I- OUTPUT DATA AND SAMPLE OF CALCULATIONS

After running the 3D STAADPRO model, the maximum reactions (moment & shear) in walls and slabs were read in both directions and the required

reinforcement was evaluated based on PROKON software for each member for all chambers as shown in output files.

J- Stability Analysis of thrust Blocks against surge forces

1- For the 1200 mm diameter pipe, the surge force is

$F=PA$

$F=12x10^5x1.2^2x\pi/4=12.96x10^5$ KN

Assuming the slope of the pipeline is 1%, the vertical component of the surge force is

$F_{vertical}=12.96x10^5x\sin 1\%=20.36$ KN

This force will transfer to chamber walls

2- Thrust blocks inside the chambers at washout lines

Thrust force at washout pipe line (Dia. =300mm)

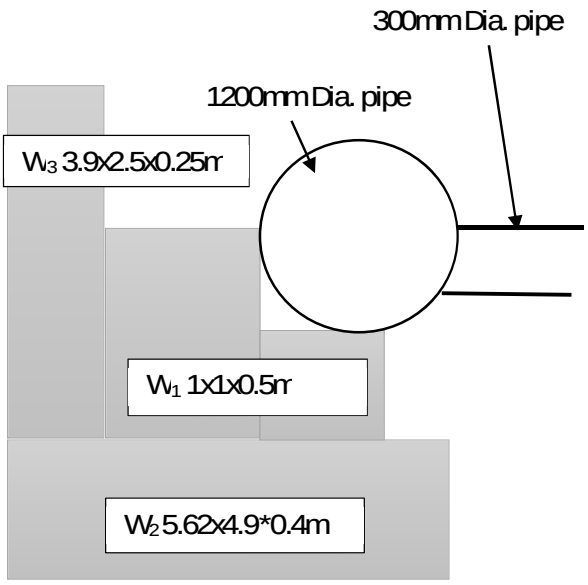
$F=12x10^5x0.3^2x\pi/4=84.82$ KN

Overturning moment

$M_0=82.82x0.85=72.1$ KN m

Stabilizing forces and moments

	W	X	M_s
w1	18.75	0.5	9.375
w2	161.7	1.95	315.315
w3	72.1875	0.125	9.023438
Sum	252.6375		333.7134

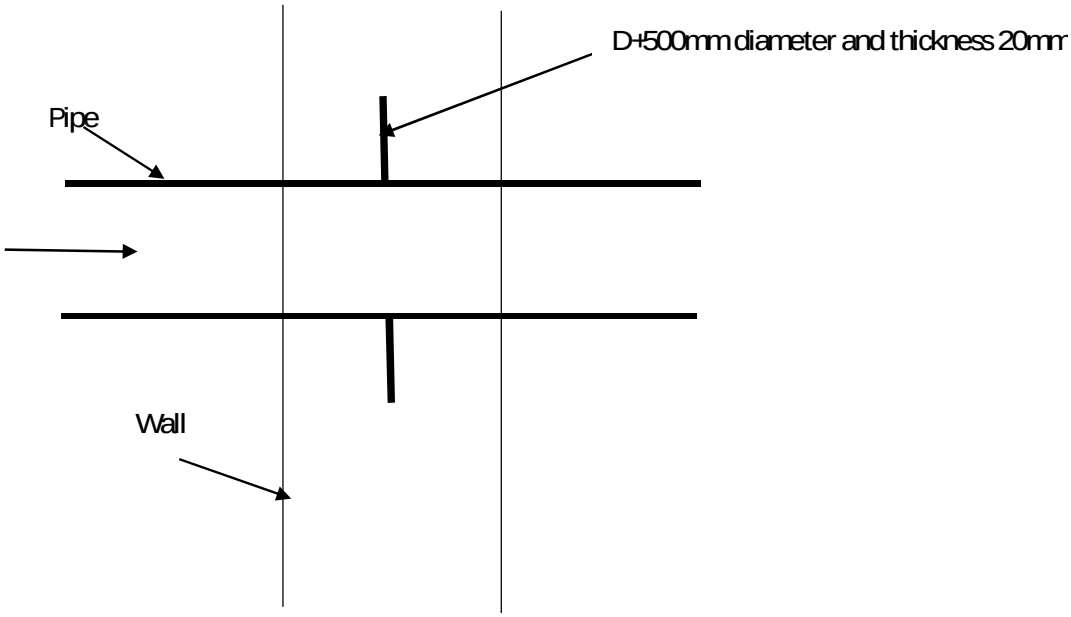


Factor of safety for overturning=M_s/M_o

$FS_o=333.71/72.1=4.63>1.5$ OK

$FS_s=252.6375x0.6/84.82=1.79>1.5$ OK

Puddle Flange Detail



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2) WALL OF PADDLE FLANGE

Continuous Beam: Beam at the top slab (Code of Practice : ACI 318 - 2005)

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Input Tables

Fc (MPa)	20
Fy (MPa)	420
Fyv (MPa)	250
% Redistribution	0
Downward/Optimized redistr.	D
Cover to centre top steel(mm)	40
Cover to centre bot.steel(mm)	40
Dead Load Factor	1.2
Live Load Factor	1.6
Density of concrete (kN/m3)	24
% Live load permanent	25
Ø (Creep coefficient)	2
Ecs (Free shrinkage strain)	300E-6

Sec No.	Bw (mm)	D (mm)	Bf-top (mm)	Hf-top (mm)	Bf-bot (mm)	Hf-bot (mm)	Y-offset (mm)	Web offset	Flange offset
1	250	650							

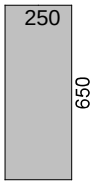
Span No	Section Length(m)	Sec No Left	Sec No Right
1	1	1	

Sup No.	Code C,F	Column Below			Code F,P	Column above			Code F,P
		D(mm)	B(mm)	H(m)		D(mm)	B(mm)	H(m)	
1	C								
2	F								

Case D,L	Span	Wleft (kN/m)	Wright (kN/m)	a (m)	b (m)	P (kN)	a (m)	M (kNm)	a (m)
D	1	0.3							
L	1	22							

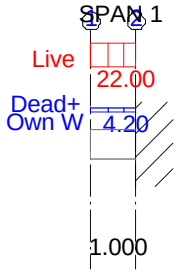
Span	M left (kNm)	M right (kNm)

Sections

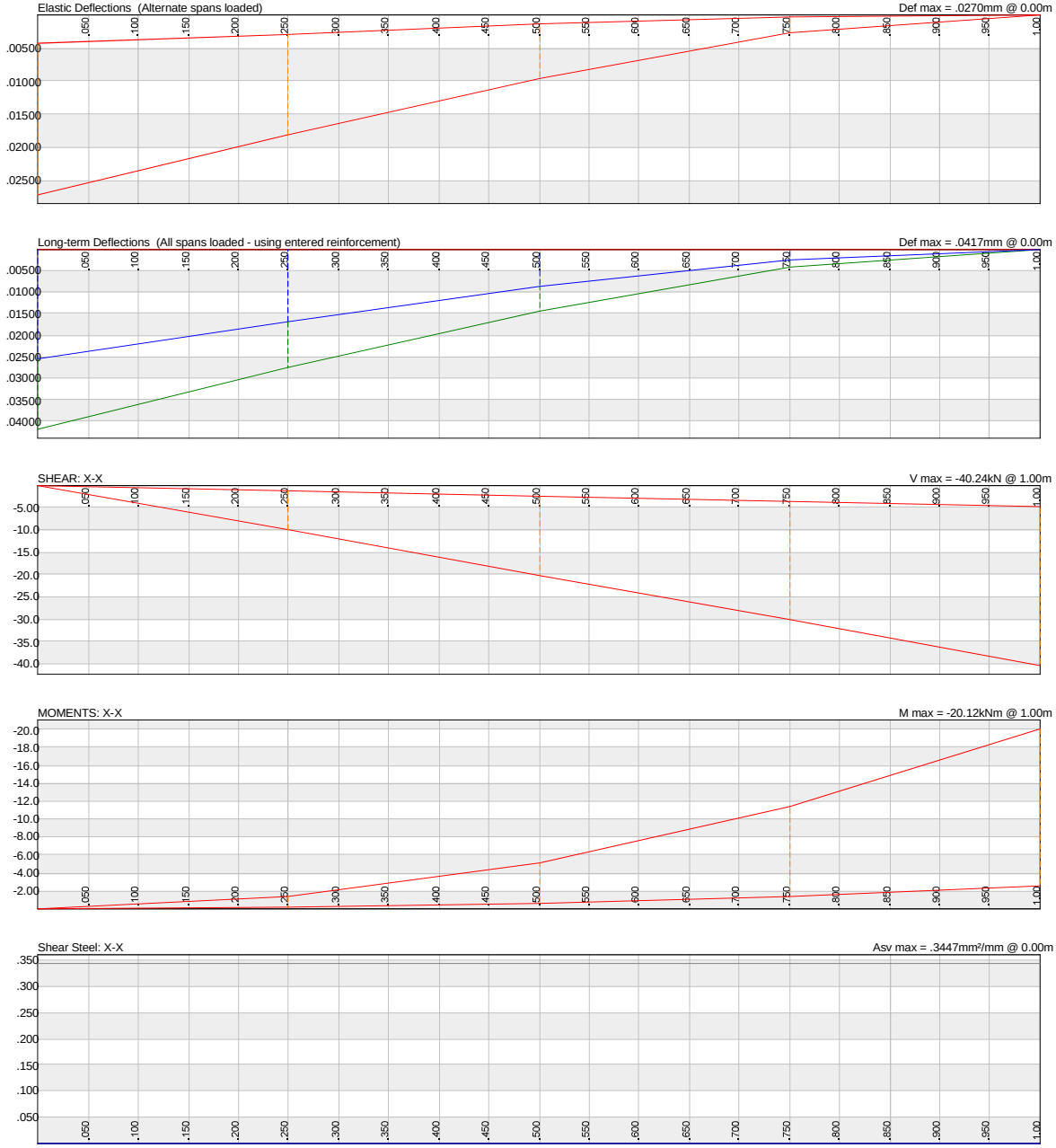


SECTION 1

Beam Elevation



Deflection, Shear, Moment and Steel diagrams. Span 1



Reinforcing Tables

Beam type	(1-5)	1
Maximum bar length	(m)	13
TOP: Minimum bar diameter	(mm)	12
Maximum bar diameter	(mm)	40
BOTTOM: Minimum bar diameter	(mm)	12
Maximum bar diameter	(mm)	40
STIRRUP: Minimum diameter	(mm)	8
Maximum diameter	(mm)	16
Stirrup shape code		72
First bar mark - top		A
First bar mark - mid.[optional]		
First bar mark - bot.[optional]		
Cover to stirrups - top	(mm)	30
Cover to stirrups - bot	(mm)	30
Cover to stirrups - sides	(mm)	25
Minimum stirrups as % of nominal		100
Loose method of detailing	(Y/N)	N
Exploded elevation	(Y/N)	Y
Bending schedule scale	1:	Auto
Number bars from left to right	(Y/N)	Y
Middle bar diameter	(mm)	Auto

Bars	Mark	SC	Span	Offset	Length	Hook	Layer
2Y12	A	34	1	0.025	1.515	L	T
2Y12	B	34	1	0.025	1.515	L	B

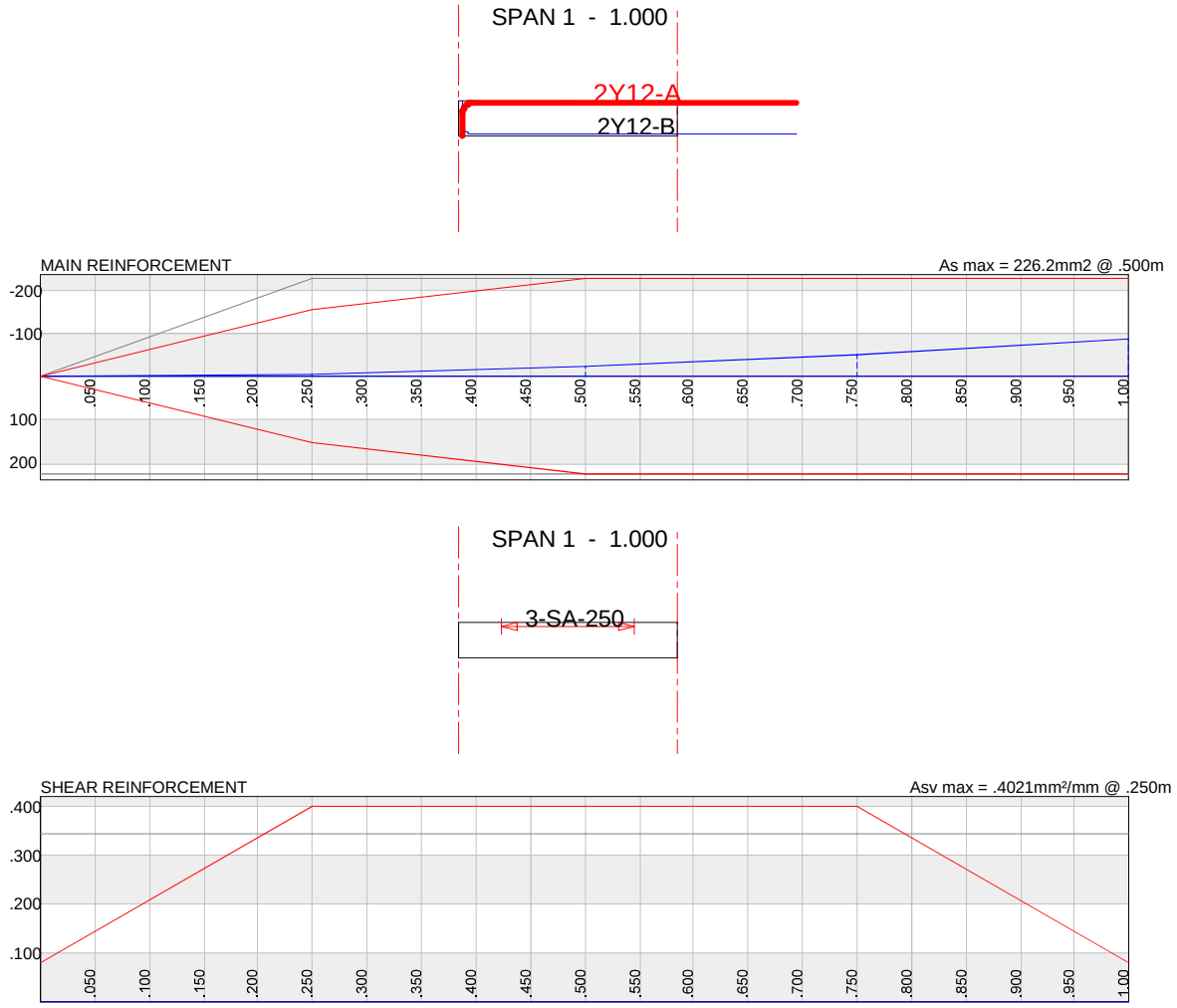
Stirrup Number	Section Number	Bar Type + Diameter	Mark	Shape Code	Top Offset	Top Flange	Bottom Flange
1	1	R8	SA1	72			
		R8	SA2	35			

Stirrup Number	Spacing	Span	Offset	Length (m)
1	250	1	0.20	0.60

Section positions		
Label	Span	Offset(m)
A	1	0.7

File name	CB.PAD
First span	1
Last span	1
Draw grid lines?(Y/N)	Y
Draw columns?(Y/N)	Y
Number/Letter of first grid	A
Number (U)p or (D)own	U
Drawing size?(A4 or A5)	A5
Height (normal text) mm	2
Height (title text) mm	2.5
Height (sec. bar mark)mm	1.8

Main and Shear Reinforcing diagrams. Span 1



3) ①VALVE CHAMBER

TOP SLAB (L2.7m×W2.2m)

Rectangular Slab Panel Design :

C04

Input Data

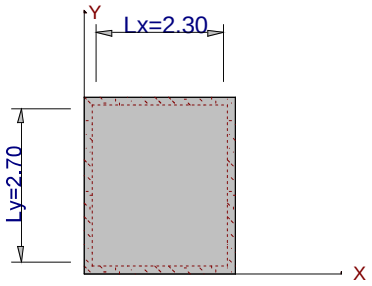
Lx	(m)	2.3
Ly	(m)	2.7
Slab depth	(mm)	200
deff X-dir	(mm)	175
deff Y-dir	(mm)	150
Poisson's ratio		0.2
fc' (MPa)		25
fy	(MPa)	420
Density	(kN/m^3)	24
Self weight LF		1.4
ε - time factor (ACI318 :9.5.2.5)		2

Load Cases

Unfactored Loads			Unfactored Point Loads			Unfactored Line Loads				
LC No.	Load fact	UDL kN/m²	P kN	x m	y m	L kN/m	x1 m	y1 m	x2 m	y2 m
1	1.4	2								
	1.6	25								

Sketch of slab

ACI 318 - 2005



Total UDL = 49.520 kN/m² (Incl self Wt)

Load Case 1 (factored)

Output

Wood-Armer Moments and reinforcement for each load case:
Wood-Armer moments were calculated using the 'Wood & Armer' theory.

LOAD CASE 1

Position		Wood-Armer Moments (kNm/m)				Reinforcement (mm²/m)			
		Top		Bottom		Top		Bottom	
X (m)	Y(m)	X	Y	X	Y	X	Y	X	Y
0.00	0.00	3.4	2.2	13.8	15.0	52	40	211	269
0.19	0.00	8.4	7.4	11.3	12.3	128	132	173	220
0.38	0.00	11.2	11.2	9.2	9.3	171	200	141	165
0.57	0.00	6.9	7.0	7.6	7.5	104	125	116	133
0.77	0.00	4.6	4.1	5.3	5.9	70	72	81	104
0.96	0.00	2.2	1.7	2.6	3.1	34	30	39	55
1.15	0.00	0.0	0.0	0.1	0.5	0	0	2	9
1.34	0.00	2.2	1.7	2.6	3.1	34	30	39	55
1.53	0.00	4.6	4.1	5.3	5.9	70	72	81	104
1.72	0.00	6.9	7.0	7.6	7.5	104	125	116	133
1.92	0.00	11.2	11.2	9.2	9.3	171	200	141	165
2.11	0.00	8.4	7.4	11.3	12.3	128	132	173	220
2.30	0.00	3.4	2.2	13.8	15.0	52	40	211	269
0.00	0.23	7.7	7.9	11.6	11.4	117	141	178	204
0.38	0.23	6.1	6.1	11.5	11.4	93	109	175	204
0.77	0.23	0.5	0.2	8.8	9.0	7	4	134	161
1.15	0.23	0.0	0.0	4.3	4.8	0	0	65	85
1.53	0.23	0.5	0.2	8.8	9.0	7	4	134	161
1.92	0.23	6.1	6.1	11.5	11.4	93	109	175	204
2.30	0.23	7.7	7.9	11.6	11.4	117	141	178	204
0.00	0.45	10.7	11.3	9.2	8.6	163	201	140	154
0.19	0.45	5.5	6.5	11.6	10.7	84	115	178	191
0.38	0.45	1.1	1.9	13.7	13.0	17	33	210	232
0.57	0.45	0.0	0.0	12.8	12.6	0	0	195	225
0.77	0.45	0.0	0.0	12.1	12.0	0	0	185	215
0.96	0.45	0.0	0.0	10.3	10.5	0	0	157	187
1.15	0.45	0.0	0.0	8.5	8.8	0	0	130	157
1.34	0.45	0.0	0.0	10.3	10.5	0	0	157	187
1.53	0.45	0.0	0.0	12.1	12.0	0	0	185	215
1.72	0.45	0.0	0.0	12.8	12.6	0	0	195	225
1.92	0.45	1.1	1.9	13.7	13.0	17	33	210	232
2.11	0.45	5.5	6.5	11.6	10.7	84	115	178	191
2.30	0.45	10.7	11.3	9.2	8.6	163	201	140	154
0.00	0.68	6.7	6.6	7.2	7.3	103	118	109	130
0.38	0.68	-0.0	-0.0	13.3	11.3	0	0	204	202
0.77	0.68	0.0	0.0	13.6	12.2	0	0	207	219
1.15	0.68	0.0	0.0	11.2	10.1	0	0	170	181
1.53	0.68	0.0	0.0	13.6	12.2	0	0	207	219
1.92	0.68	-0.0	-0.0	13.3	11.3	0	0	204	202
2.30	0.68	6.7	6.6	7.2	7.3	103	118	109	130
0.00	0.90	3.9	4.3	5.3	4.9	59	76	80	86
0.19	0.90	-0.0	0.6	9.2	7.6	0	11	139	135
0.38	0.90	0.0	0.0	12.9	10.2	0	0	198	183
0.57	0.90	0.0	0.0	13.9	11.3	0	0	213	202
0.77	0.90	0.0	0.0	15.0	12.5	0	0	230	223
0.96	0.90	0.0	0.0	14.4	12.0	0	0	220	215
1.15	0.90	0.0	0.0	13.8	11.5	0	0	211	206
1.34	0.90	0.0	0.0	14.4	12.0	0	0	220	215
1.53	0.90	0.0	0.0	15.0	12.5	0	0	230	223
1.72	0.90	0.0	0.0	13.9	11.3	0	0	213	202
1.92	0.90	0.0	0.0	12.9	10.2	0	0	198	183
2.11	0.90	-0.0	0.6	9.2	7.6	0	11	139	135
2.30	0.90	3.9	4.3	5.3	4.9	59	76	80	86
0.00	1.13	1.7	2.1	2.8	2.4	25	37	42	42
0.38	1.13	0.0	0.0	11.4	8.4	0	0	175	149
0.77	1.13	0.0	0.0	14.6	11.5	0	0	224	206
1.15	1.13	0.0	0.0	14.7	11.8	0	0	225	211
1.53	1.13	0.0	0.0	14.6	11.5	0	0	224	206

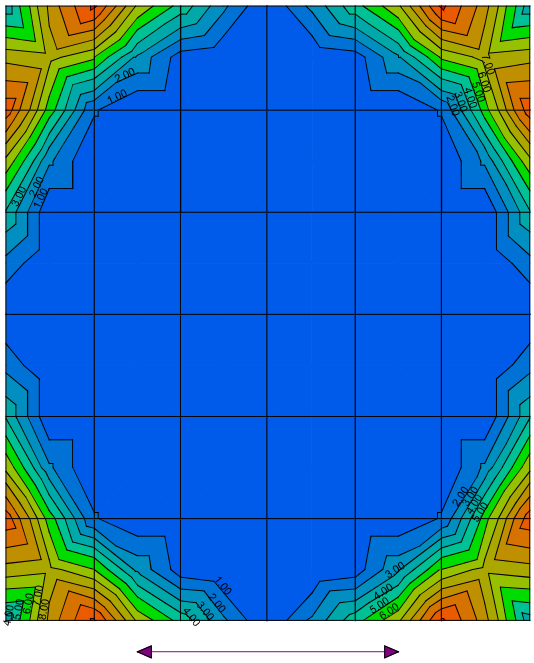
1.92	1.13	0.0	0.0	11.4	8.4	0	0	175	149
2.30	1.13	1.7	2.1	2.8	2.4	25	37	42	42
0.00	1.35	0.0	0.0	0.4	0.1	0	0	6	2
0.19	1.35	0.0	0.0	5.2	3.3	0	0	79	58
0.38	1.35	0.0	0.0	9.9	6.5	0	0	151	116
0.57	1.35	0.0	0.0	12.1	8.6	0	0	185	153
0.77	1.35	0.0	0.0	14.3	10.7	0	0	219	191
0.96	1.35	0.0	0.0	14.9	11.4	0	0	229	204
1.15	1.35	0.0	0.0	15.6	12.1	0	0	239	217
1.34	1.35	0.0	0.0	14.9	11.4	0	0	229	204
1.53	1.35	0.0	0.0	14.3	10.7	0	0	219	191
1.72	1.35	0.0	0.0	12.1	8.6	0	0	185	153
1.92	1.35	0.0	0.0	9.9	6.5	0	0	151	116
2.11	1.35	0.0	0.0	5.2	3.3	0	0	79	58
2.30	1.35	0.0	0.0	0.4	0.1	0	0	6	2
0.00	1.58	1.7	2.1	2.8	2.4	25	37	42	42
0.38	1.58	0.0	0.0	11.4	8.4	0	0	175	149
0.77	1.58	0.0	0.0	14.6	11.5	0	0	224	206
1.15	1.58	0.0	0.0	14.7	11.8	0	0	225	211
1.53	1.58	0.0	0.0	14.6	11.5	0	0	224	206
1.92	1.58	0.0	0.0	11.4	8.4	0	0	175	149
2.30	1.58	1.7	2.1	2.8	2.4	25	37	42	42
0.00	1.80	3.9	4.3	5.3	4.9	59	76	80	86
0.19	1.80	-0.0	0.6	9.2	7.6	0	11	139	135
0.38	1.80	0.0	0.0	12.9	10.2	0	0	198	183
0.57	1.80	0.0	0.0	13.9	11.3	0	0	213	202
0.77	1.80	0.0	0.0	15.0	12.5	0	0	230	223
0.96	1.80	0.0	0.0	14.4	12.0	0	0	220	215
1.15	1.80	0.0	0.0	13.8	11.5	0	0	211	206
1.34	1.80	0.0	0.0	14.4	12.0	0	0	220	215
1.53	1.80	0.0	0.0	15.0	12.5	0	0	230	223
1.72	1.80	0.0	0.0	13.9	11.3	0	0	213	202
1.92	1.80	0.0	0.0	12.9	10.2	0	0	198	183
2.11	1.80	-0.0	0.6	9.2	7.6	0	11	139	135
2.30	1.80	3.9	4.3	5.3	4.9	59	76	80	86
0.00	2.03	6.7	6.6	7.2	7.3	103	118	109	130
0.38	2.03	-0.0	-0.0	13.3	11.3	0	0	204	202
0.77	2.03	0.0	0.0	13.6	12.2	0	0	207	219
1.15	2.03	0.0	0.0	11.2	10.1	0	0	170	181
1.53	2.03	0.0	0.0	13.6	12.2	0	0	207	219
1.92	2.03	-0.0	-0.0	13.3	11.3	0	0	204	202
2.30	2.03	6.7	6.6	7.2	7.3	103	118	109	130
0.00	2.25	10.7	11.3	9.2	8.6	163	201	140	154
0.19	2.25	5.5	6.5	11.6	10.7	84	115	178	191
0.38	2.25	1.1	1.9	13.7	13.0	17	33	210	232
0.57	2.25	0.0	0.0	12.8	12.6	0	0	195	225
0.77	2.25	0.0	0.0	12.1	12.0	0	0	185	215
0.96	2.25	0.0	0.0	10.3	10.5	0	0	157	187
1.15	2.25	0.0	0.0	8.5	8.8	0	0	130	157
1.34	2.25	0.0	0.0	10.3	10.5	0	0	157	187
1.53	2.25	0.0	0.0	12.1	12.0	0	0	185	215
1.72	2.25	0.0	0.0	12.8	12.6	0	0	195	225
1.92	2.25	1.1	1.9	13.7	13.0	17	33	210	232
2.11	2.25	5.5	6.5	11.6	10.7	84	115	178	191
2.30	2.25	10.7	11.3	9.2	8.6	163	201	140	154
0.00	2.48	7.7	7.9	11.6	11.4	117	141	178	204
0.38	2.48	6.1	6.1	11.5	11.4	93	109	175	204
0.77	2.48	0.5	0.2	8.8	9.0	7	4	134	161
1.15	2.48	0.0	0.0	4.3	4.8	0	0	65	85
1.53	2.48	0.5	0.2	8.8	9.0	7	4	134	161
1.92	2.48	6.1	6.1	11.5	11.4	93	109	175	204
2.30	2.48	7.7	7.9	11.6	11.4	117	141	178	204
0.00	2.70	3.4	2.2	13.8	15.0	52	40	211	269
0.19	2.70	8.4	7.4	11.3	12.3	128	132	173	220
0.38	2.70	11.2	11.2	9.2	9.3	171	200	141	165
0.57	2.70	6.9	7.0	7.6	7.5	104	125	116	133
0.77	2.70	4.6	4.1	5.3	5.9	70	72	81	104
0.96	2.70	2.2	1.7	2.6	3.1	34	30	39	55
1.15	2.70	0.0	0.0	0.1	0.5	0	0	2	9

1.34	2.70	2.2	1.7	2.6	3.1	34	30	39	55
1.53	2.70	4.6	4.1	5.3	5.9	70	72	81	104
1.72	2.70	6.9	7.0	7.6	7.5	104	125	116	133
1.92	2.70	11.2	11.2	9.2	9.3	171	200	141	165
2.11	2.70	8.4	7.4	11.3	12.3	128	132	173	220
2.30	2.70	3.4	2.2	13.8	15.0	52	40	211	269

Wood-Armer Moments:

ACI 318 - 2005

Top:LC 1 (kNm/m)

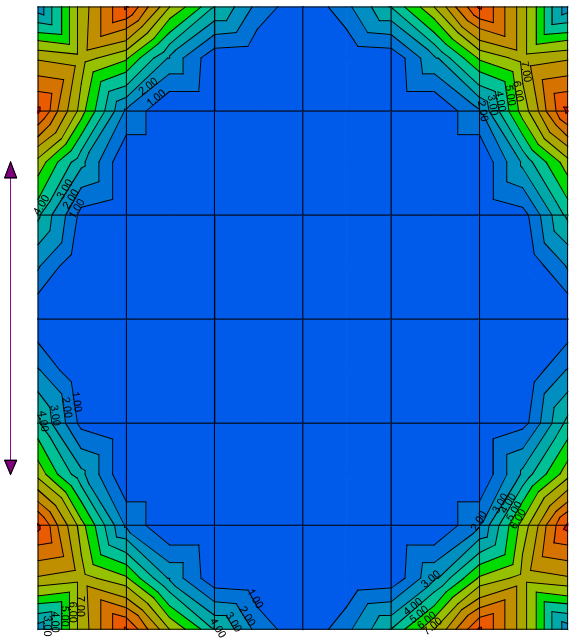


Max value:11.2 at X:1.9 Y:2.7

Wood-Armer Moments:

ACI 318 - 2005

Top:LC 1 (kNm/m)

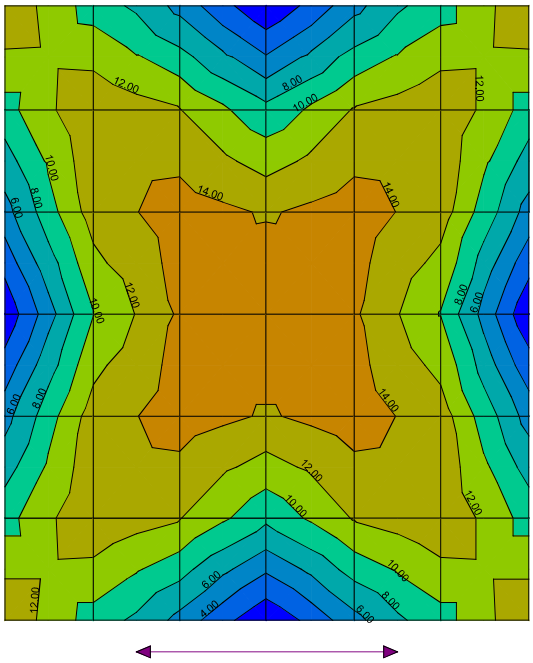


Max value:11.3 at X:2.3 Y:2.3

Wood-Armer Moments:

ACI 318 - 2005

Bot:LC 1 (kNm/m)

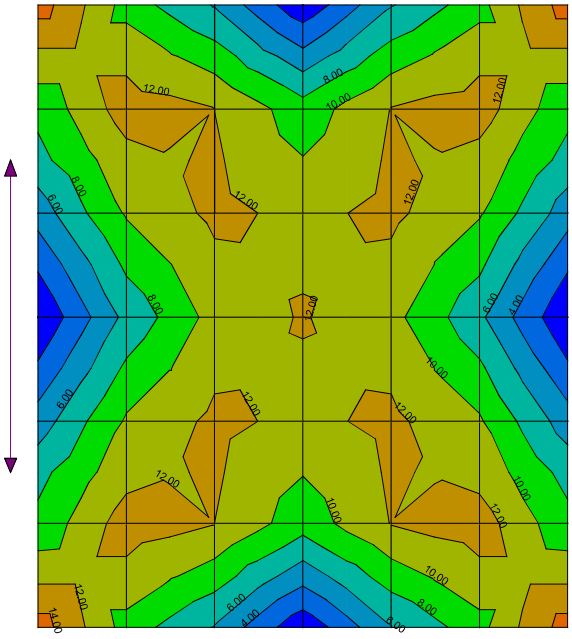


Max value:15.6 at X:1.1 Y:1.4

Wood-Armer Moments:

ACI 318 - 2005

Bot:LC 1 (kNm/m)

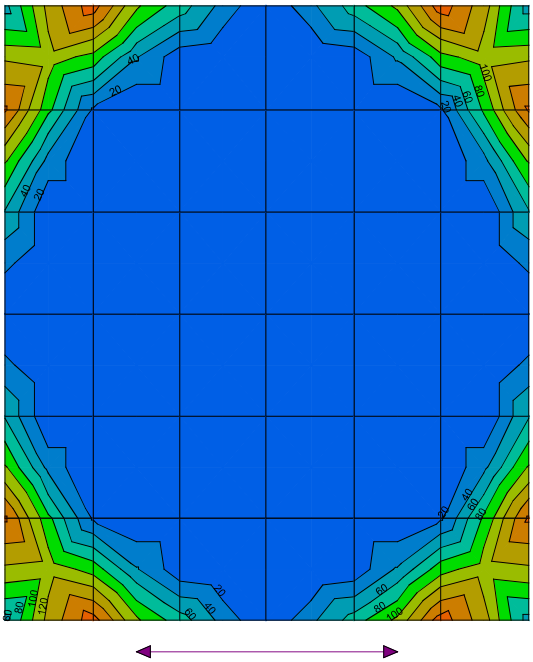


Max value:15.0 at X:2.3 Y:2.7

Reinforcement:

ACI 318 - 2005

Top:LC 1 (mm²/m)

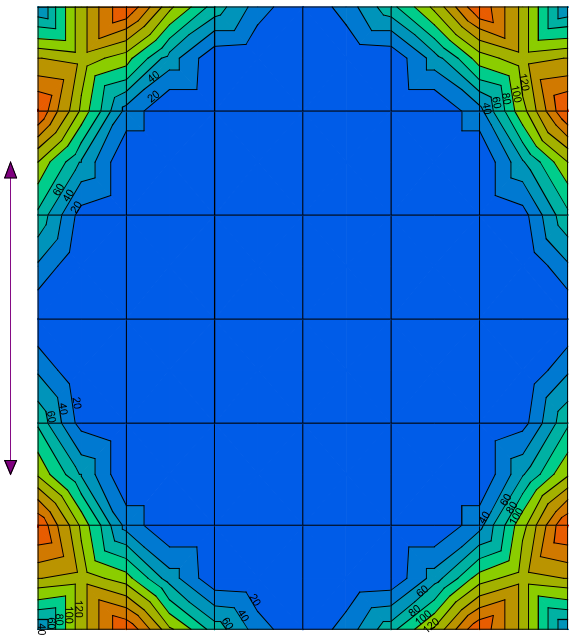


Max value:171.1 at X:1.9 Y:2.7

Reinforcement:

ACI 318 - 2005

Top:LC 1 (mm²/m)

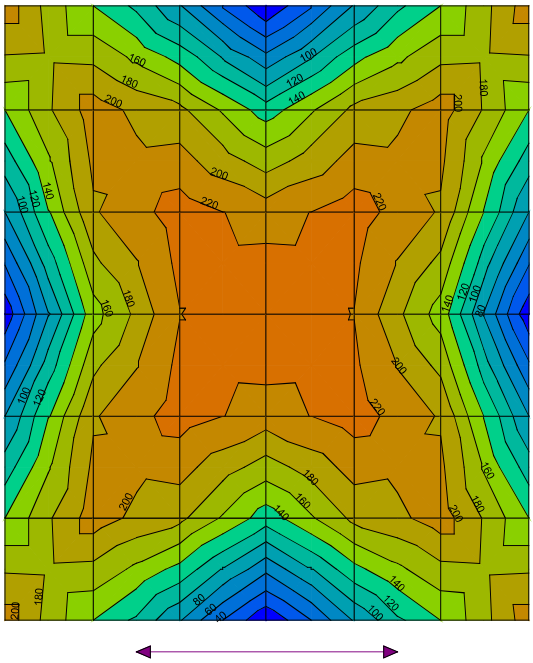


Max value:201.4 at X:2.3 Y:2.3

Reinforcement:

ACI 318 - 2005

Bot:LC 1 (mm²/m)

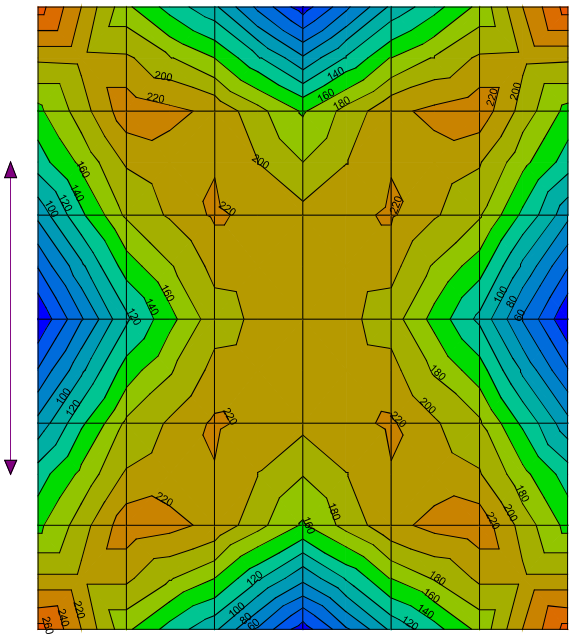


Max value:239.0 at X:1.1 Y:1.4

Reinforcement:

ACI 318 - 2005

Bot:LC 1 (mm²/m)

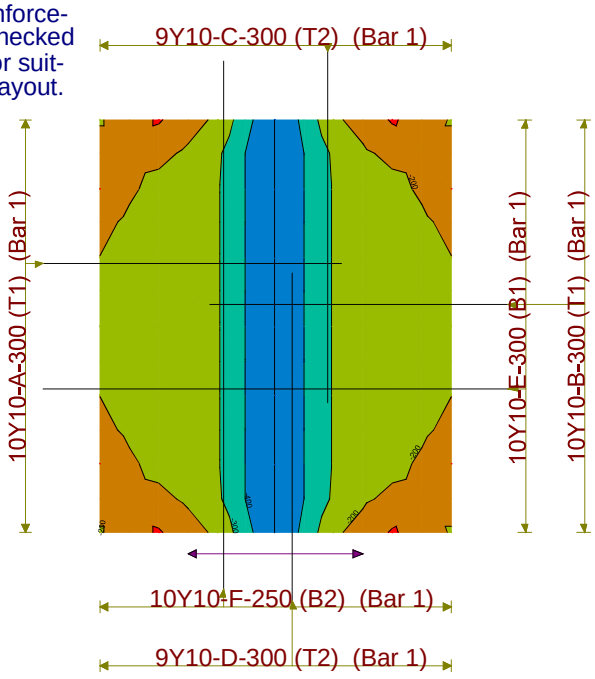


Max value:269.2 at X:2.3 Y:2.7

Rebar Excess:

Rebar Excess Top (mm²/m)

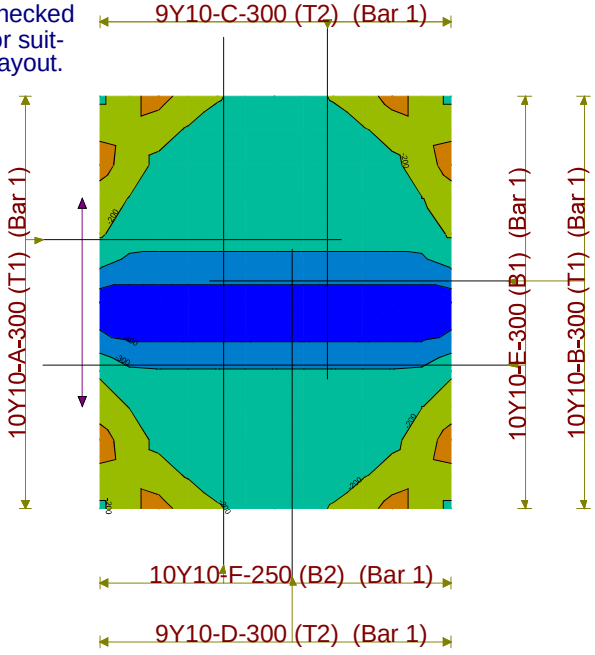
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Top (mm²/m)

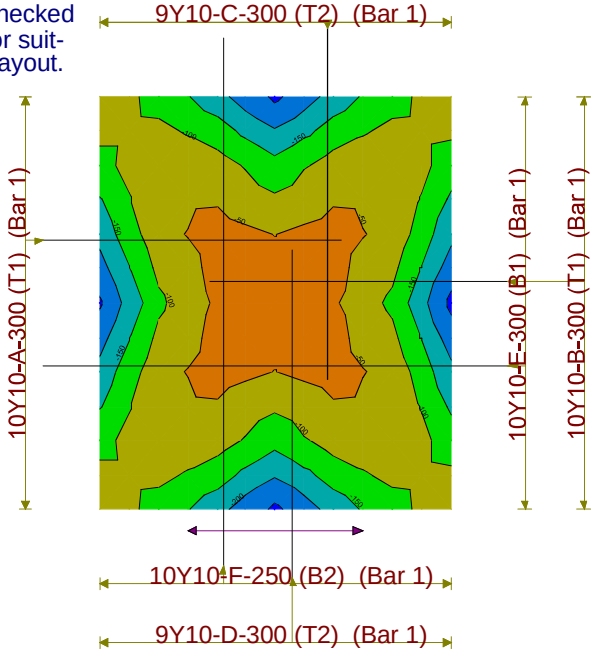
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Bot (mm²/m)

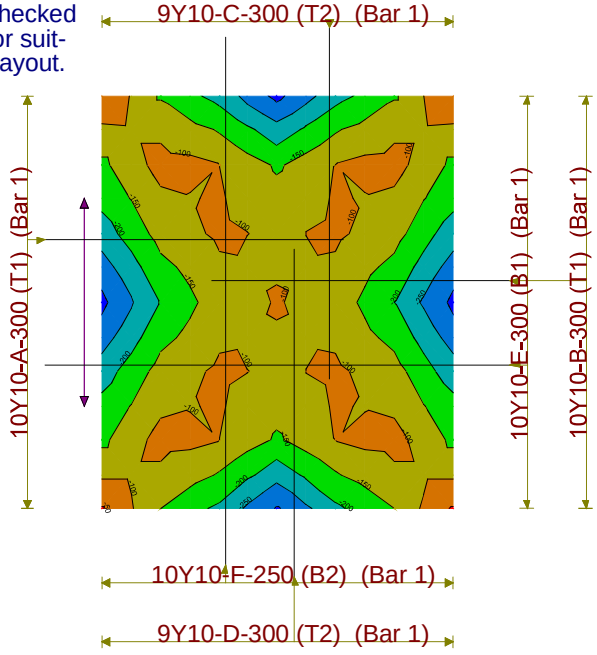
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Bot (mm²/m)

Note:Default reinforcement should be checked and adjusted for suitability and layout.



3) ①VALVE CHAMBER

WALL (H3.0m)

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Cantilever wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1	(m)	3	C	(m)	0.4	W	(kN/m²)	5	Soil frict ϕ	(°)	30	SF Overt.	1.5
H2	(m)	0.7	F	(m)	0	P	(kN)	0	Fill slope β	(°)	0	SF Slip	1.5
H3	(m)	0	xf	(m)	1	xp	(m)	1.30	Wall frict δ	(°)	20	ULS DL Factor	1.4
Hw	(m)	0	At	(m)	0.25	L	(kN/m)	20	ρ Conc	kN/m^3	25	ULS LL Factor	1.6
Hr	(m)	0.36	Ab	(m)	0.25	xl	(m)	2	ρ Soil	kN/m^3	18	Pmax (kPa)	400
B	(m)	0	Cov wall	mm	50	Lh	(kN/m)		fc'	(MPa)	25	Soil Poisson υ	0.5
D	(m)	2.7	Cov base	mm	50	x	(m)	0	fy	(MPa)	420	DL Factor Ovt.	0.9

Seepage allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:ON

Hor Accel. (g)	0.02
Vert Accel. (g)	0.01
Include LL's	Y

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.297
Passive Pressure coefficient Kp :6.105
Seismic Active Pressure coefficient Kas :0.313
Seismic Passive Pressure coefficient Kps :5.934
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	23.826	1.040	8.672	0.250
Siesmic component of Pa	1.195	1.800	0.435	0.250
As a result of surcharge w	4.368	1.500	1.590	0.250
As a result of Line Load L	5.044	1.611	0.000	0.250
Siesmic wall inertia	0.906	0.733		
Stabilizing forces:				
Passive pressure on base Pp	-26.171	0.228		
Siesmic component of Pp	0.754	0.420		
Weight of the wall + base			45.293	0.995
Weight of soil on the base			125.096	1.600
Line load of 20.00 kN/m on backfill			20.000	2.000
UDL of 5.0 kPa			13.365	1.600

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 312.19 kNm
      Destabilizing moment Mo : 37.56 kNm

Safety factor against overturning = Mr/Mo = 8.313

2.Force Equilibrium at SLS

    Sum of Vertical forces Pv : 213.82 kN
  Frictional resistance Pfric : 123.45 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base : 26.17 kN
=> Total Horiz. resistance Fr : 149.62 kN

     Horizontal sliding force on wall Fhw : 34.14 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh : 34.14 kN

Safety factor against overall sliding = Fr/Fh = 4.382

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

	FORCES (kN) and their LEVER ARMS (m)			
Description	F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	33.738	1.045	12.141	0.250
Siesmic component of Pa	1.913	1.800	0.696	0.250
As a result of surcharge w	6.989	1.500	2.544	0.250
As a result of Line Load L	8.070	1.611	0.000	0.250
Siesmic wall inertia	1.449	0.733		
Stabilizing forces:				
Passive pressure on base Pp	-23.554	0.228		
Siesmic component of Pp	0.678	0.420		
Weight of the wall + base			40.763	0.995
Weight of soil on the base			112.587	1.600
Line load of 18.00 kN/m on backfill			18.000	2.000
UDL of 4.5 kPa			12.029	1.600

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 280.97 kNm
      Destabilizing moment Mo : 56.14 kNm

Safety factor against overturning = Mr/Mo = 5.005

2.Force Equilibrium at ULS

    Sum of Vertical forces Pv : 192.43 kN

Frictional resistance Pfric : 111.10 kN
Passive Pressure on shear key : 0.00 kN
Passive pressure on base : 23.55 kN
=> Total Horiz. resistance Fr : 134.66 kN

Horizontal sliding force on wall Fhw : 50.25 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 50.25 kN

Safety factor against overall sliding = Fr/Fh = 2.680

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure :100.57 kPa
Minimum pressure : 44.39 kPa
Maximum pressure occurs at left hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Minimum (mm²/m)
0.00	40.25	0.00	577.82	623.81
0.05	38.54	0.00	552.55	623.81
0.10	36.79	0.00	526.66	623.81
0.16	35.01	0.00	500.46	623.81
0.21	33.22	0.00	474.25	623.81
0.26	31.45	0.00	448.32	623.81
0.31	29.71	0.00	422.97	623.81
0.36	28.02	0.00	398.37	623.81
0.42	26.38	0.00	374.55	623.81
0.47	24.78	0.00	351.48	623.81
0.52	23.23	0.00	329.14	623.81
0.57	21.73	0.00	307.51	623.81
0.62	20.28	0.00	286.58	623.81
0.68	18.86	0.00	266.32	623.81
0.73	17.49	0.00	246.73	623.81
0.78	16.16	0.00	227.77	623.81
0.83	14.88	0.00	209.45	623.81
0.88	13.63	0.00	191.73	623.81
0.94	12.43	0.00	174.60	623.81
0.99	11.26	0.00	158.06	623.81
1.04	10.13	0.00	142.07	623.81
1.09	9.03	0.00	126.63	623.81
1.14	7.98	0.00	111.71	623.81
1.20	6.95	0.00	97.32	623.81
1.25	5.97	0.00	83.42	623.81
1.30	5.31	0.00	74.23	623.81
1.35	4.81	0.00	67.17	623.81
1.40	4.33	0.00	60.54	623.81
1.46	3.89	0.00	54.35	623.81
1.51	3.48	0.00	48.57	623.81
1.56	3.10	0.00	43.19	623.81
1.61	2.74	0.00	38.21	623.81
1.66	2.41	0.00	33.60	623.81
1.72	2.10	0.00	29.35	623.81
1.77	1.83	0.00	25.45	623.81
1.82	1.57	0.00	21.89	623.81
1.87	1.34	0.00	18.65	623.81
1.92	1.13	0.00	15.72	623.81
1.98	0.94	0.00	13.09	623.81
2.03	0.77	0.00	10.74	623.81
2.08	0.62	0.00	8.66	623.81
2.13	0.49	0.00	6.85	623.81
2.18	0.38	0.00	5.27	623.81
2.24	0.28	0.00	3.93	623.81
2.29	0.20	0.00	2.81	623.81
2.34	0.14	0.00	1.90	623.81
2.39	0.08	0.00	1.18	623.81

2.44	0.05	0.00	0.65	623.81
2.50	0.02	0.00	0.28	623.81
2.55	0.00	0.00	0.07	623.81
2.60	0.00	0.00	0.00	623.81

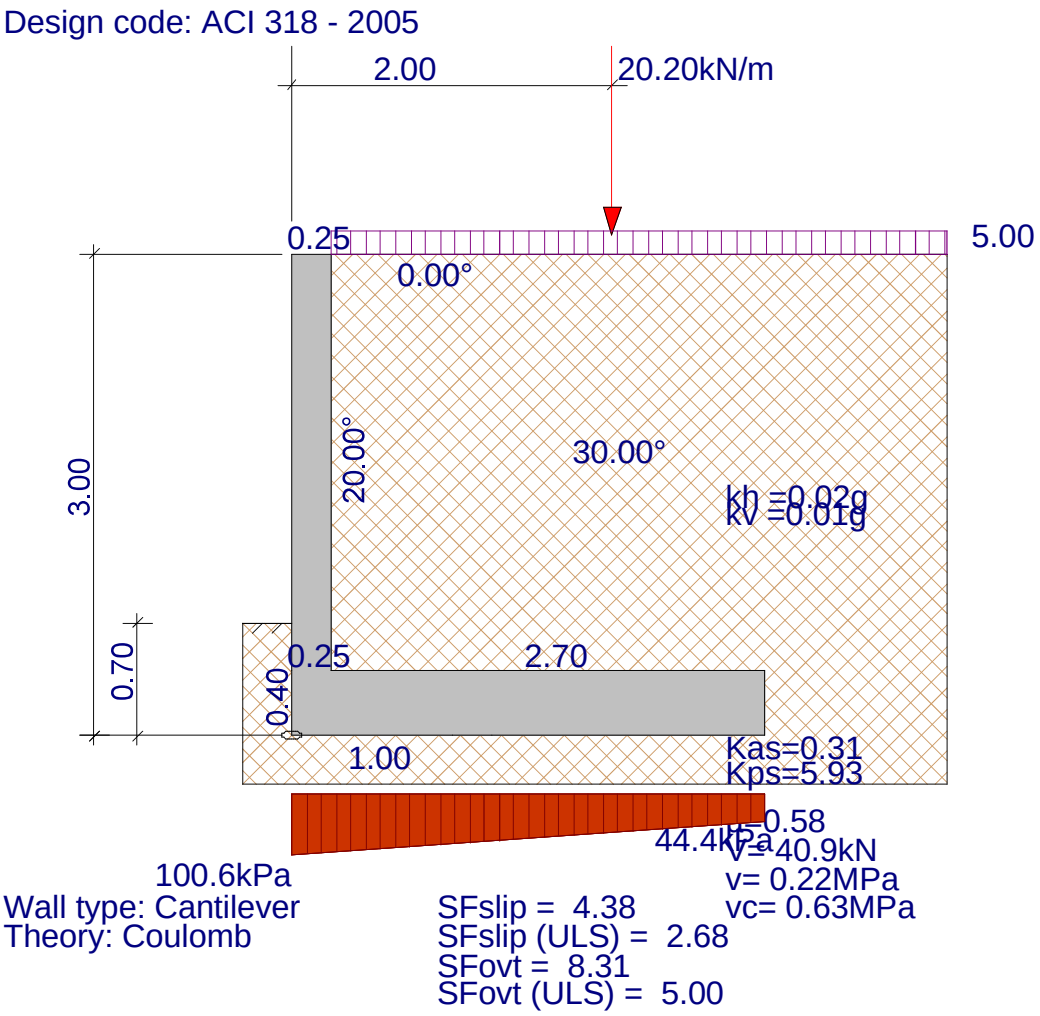
BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Minimum (mm^2/m)
0.00	-0.00	0.00	0.00	1116.29
0.06	-0.22	0.00	1.68	1116.29
0.12	-0.87	0.00	6.73	1116.29
0.18	-1.01	0.00	0.00	1116.29
0.24	48.25	0.00	0.00	1116.29
0.30	44.68	0.00	0.00	1116.29
0.35	42.80	336.31	0.00	1116.29
0.41	40.96	321.71	0.00	1116.29
0.47	39.16	307.44	0.00	1116.29
0.53	37.40	293.51	0.00	1116.29
0.59	35.68	279.90	0.00	1116.29
0.65	34.00	266.63	0.00	1116.29
0.71	32.36	253.69	0.00	1116.29
0.77	30.77	241.07	0.00	1116.29
0.83	29.21	228.79	0.00	1116.29
0.89	27.69	216.83	0.00	1116.29
0.94	26.21	205.19	0.00	1116.29
1.00	24.78	193.89	0.00	1116.29
1.06	23.38	182.91	0.00	1116.29
1.12	22.03	172.25	0.00	1116.29
1.18	20.71	161.92	0.00	1116.29
1.24	19.44	151.92	0.00	1116.29
1.30	18.20	142.23	0.00	1116.29
1.36	17.01	132.87	0.00	1116.29
1.42	15.86	123.84	0.00	1116.29
1.48	14.75	115.12	0.00	1116.29
1.53	13.67	106.72	0.00	1116.29
1.59	12.64	98.65	0.00	1116.29
1.65	11.65	90.89	0.00	1116.29
1.71	10.70	83.46	0.00	1116.29
1.77	9.79	76.34	0.00	1116.29
1.83	8.92	69.55	0.00	1116.29
1.89	8.09	63.07	0.00	1116.29
1.95	7.30	56.91	0.00	1116.29
2.01	6.55	51.07	0.00	1116.29
2.06	5.85	45.54	0.00	1116.29
2.12	5.18	40.34	0.00	1116.29
2.18	4.55	35.45	0.00	1116.29
2.24	3.96	30.88	0.00	1116.29
2.30	3.42	26.62	0.00	1116.29
2.36	2.91	22.68	0.00	1116.29
2.42	2.45	19.05	0.00	1116.29
2.48	2.02	15.75	0.00	1116.29
2.54	1.64	12.75	0.00	1116.29
2.60	1.29	10.08	0.00	1116.29
2.66	0.99	7.71	0.00	1116.29
2.71	0.73	5.67	0.00	1116.29
2.77	0.51	3.94	0.00	1116.29
2.83	0.32	2.52	0.00	1116.29
2.89	0.18	1.42	0.00	1116.29
2.95	0.08	0.63	0.00	1116.29

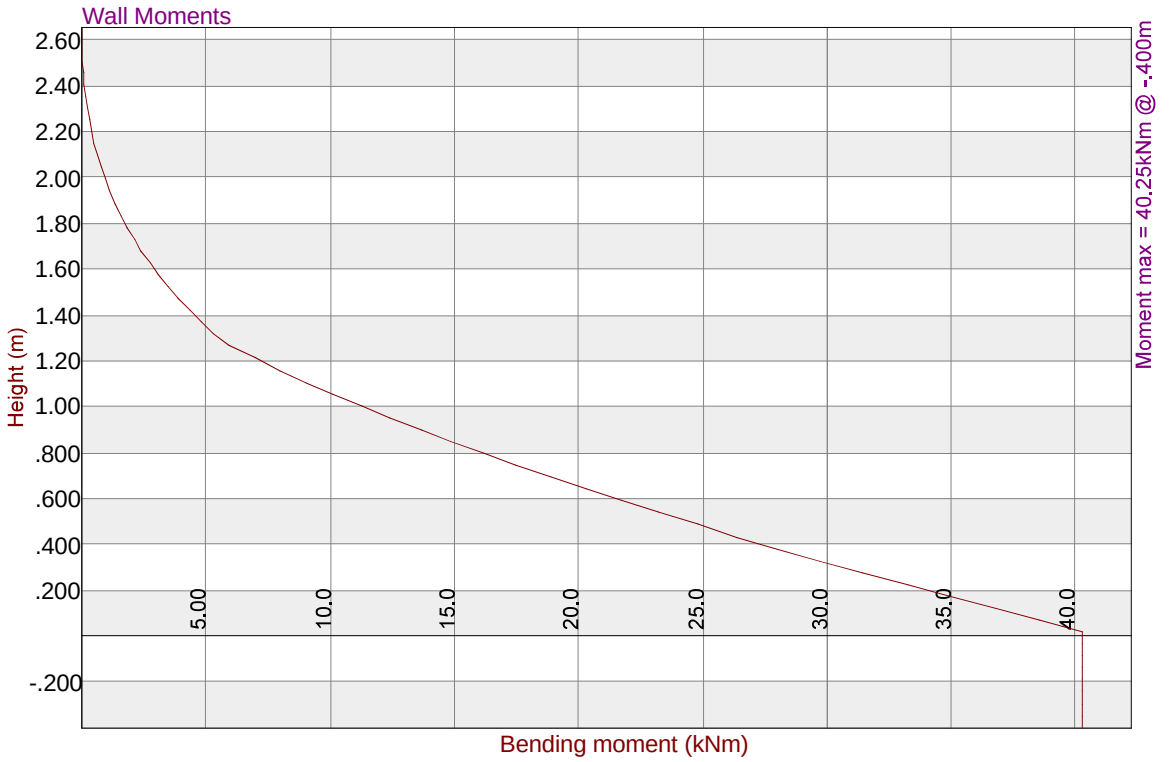
SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

Shear force at bottom of wall V = 40.9 kN
Shear stress at bottom of wall v = 0.22 MPa OK
Allowable shear stress vc = 0.63 MPa (based on Wall tensile reinf.)

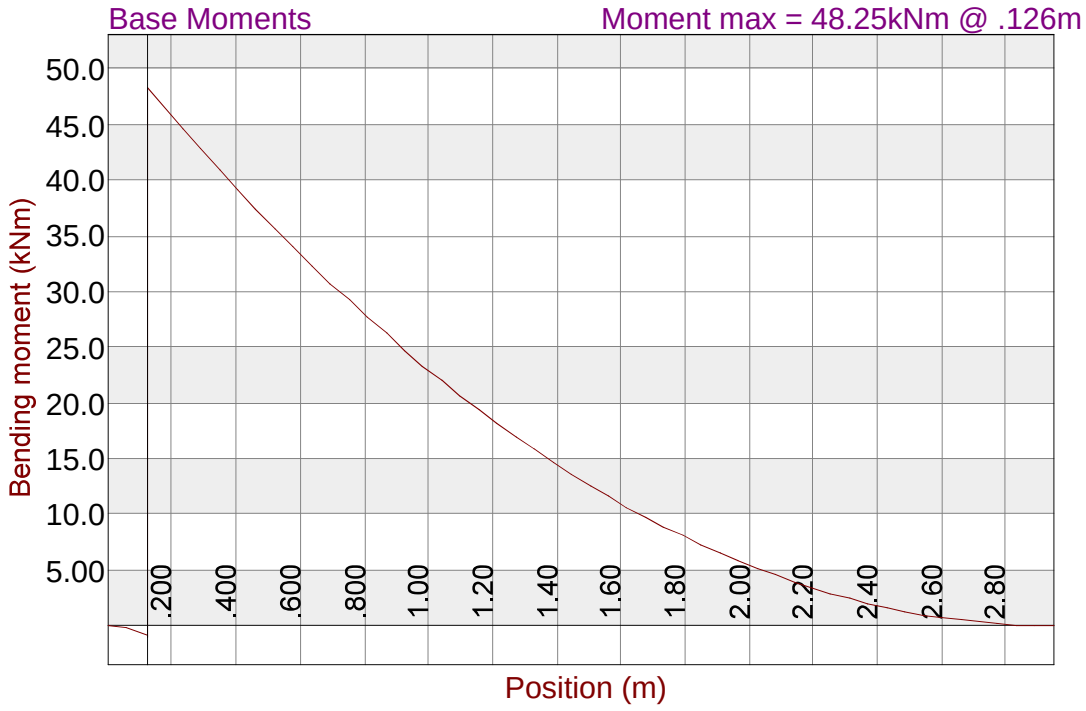
Sketch of Wall



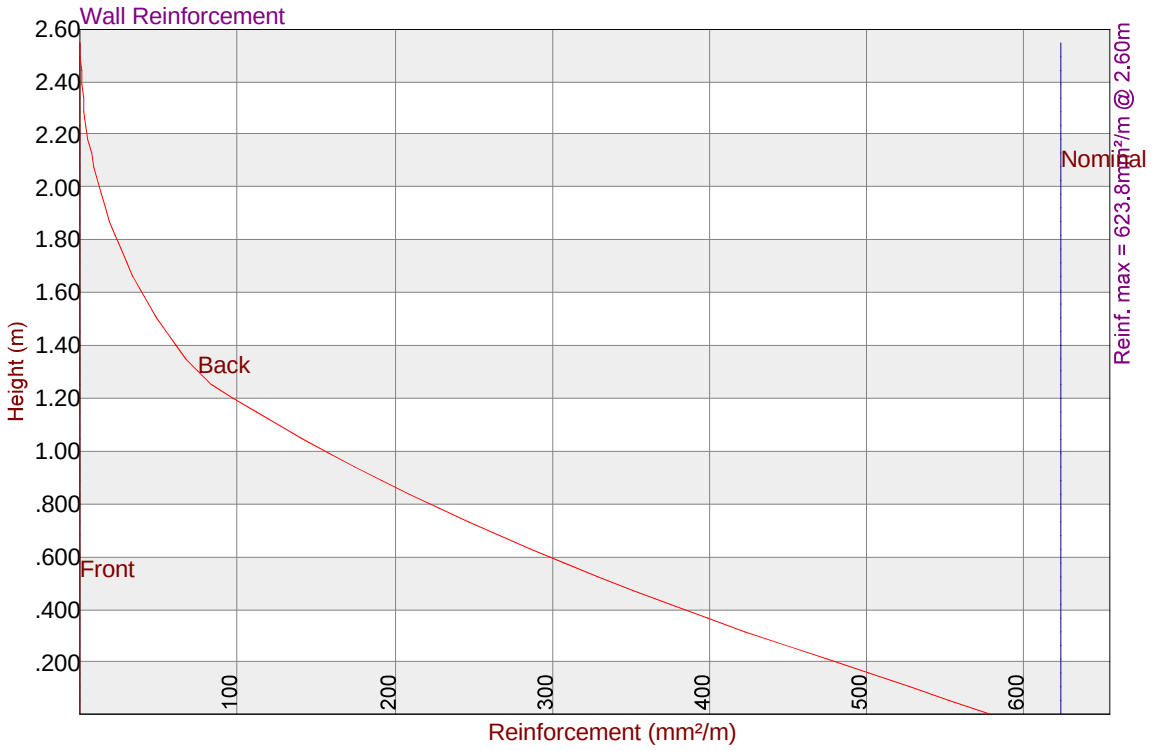
Wall Bending Moments



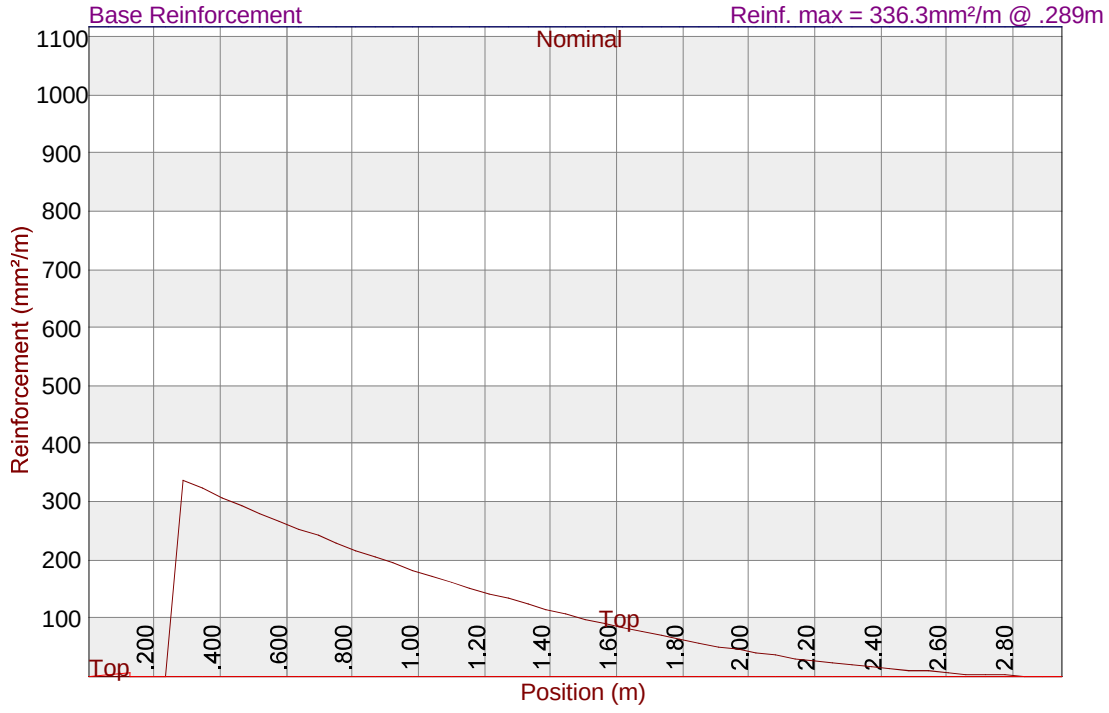
Base Bending Moments



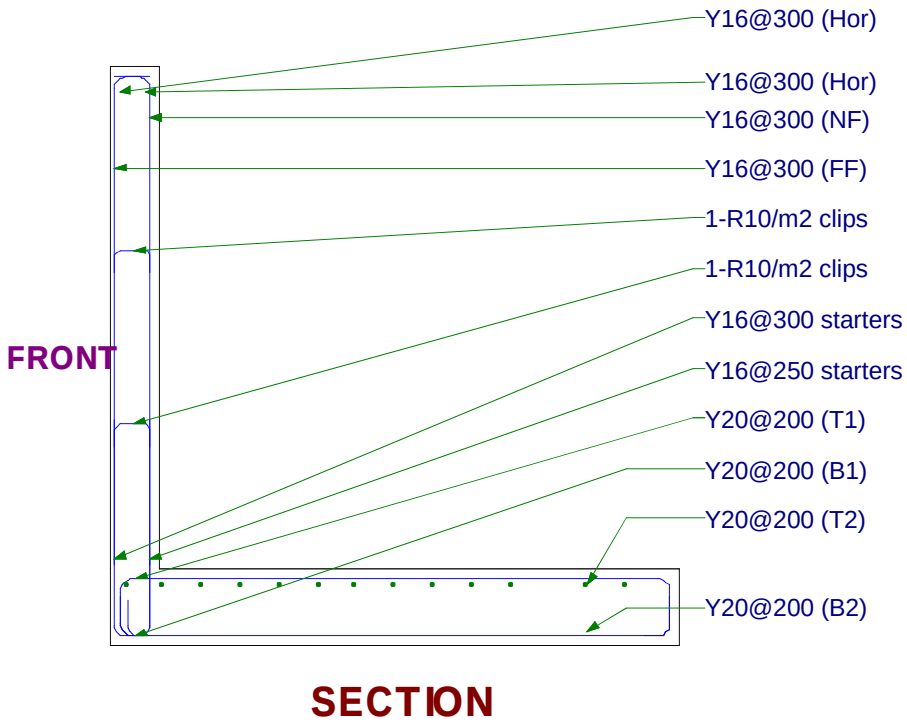
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



SECTION

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Reservoir wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1 (m)	3	C (m)	0.4	W	(kN/m²)		Soil frict ϕ	(°)	30	SF Overt.	1.5
H2 (m)	0.67	F (m)		P	(kN)		Fill slope β	(°)		SF Slip	1.5
H3 (m)	2.6	xf (m)		xp	(m)		Wall frict δ	(°)		ULS DL Factor	1.4
Hw (m)	2.6	At (m)	0.25	L	(kN/m)		ρ Conc	kN/m³	25	ULS LL Factor	1.6
Hr (m)	0.36	Ab (m)	0.25	xl	(m)		ρ Soil	kN/m³	18	Pmax (kPa)	400
B (m)		Cov wall	mm 50	Lh	(kN/m)		fcu	(MPa)	25	Soil Poisson υ	0.5
D (m)	2	Cov base	mm 50	x	(m)		fy	(MPa)	420	DL Factor Ovt.	0.9

Seepage not allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:OFF

Hor Accel. (g)	
Vert Accel. (g)	
Include LL's	

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.333
Passive Pressure coefficient Kp :3.000
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.480	0.133	0.000	0.250
Triangular W-table press Pw	0.523	0.133	0.000	0.250
W-table pr below free water	8.633	0.200	0.000	0.250
Free water pressure Pwf	23.740	1.133	0.000	0.250
Hydrostatic pressure on bot of base: uniform portion			0.000	1.125
Hydrostatic pressure on bot of base: triangular portion			0.000	1.500
Stabilizing forces:				
Passive pressure on base Pp	-12.120	0.223		
Weight of the wall + base			38.750	0.706
Weight of soil on the base			-0.000	1.250
Hydrostatic pressure on top of rear portion of base			43.164	1.250
Hydrostatic pressure on top of front portion of base			0.000	0.000

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 84.01 kNm
Destabilizing moment Mo : 28.77 kNm

Safety factor against overturning = Mr/Mo = 2.920

2.Force Equilibrium at SLS

Sum of Vertical forces Pv : 81.91 kN
Frictional resistance Pfric : 47.29 kN
Passive Pressure on shear key : 0.00 kN
Passive pressure on base : 12.12 kN
=> Total Horiz. resistance Fr : 59.41 kN

Horizontal sliding force on wall Fhw : 33.38 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 33.38 kN

Safety factor against overall sliding = Fr/Fh = 1.780

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.672	0.133	0.000	0.250
Triangular W-table press Pw	0.732	0.133	0.000	0.250
W-table pr below free water	12.086	0.200	0.000	0.250
Free water pressure Pwf	33.236	1.133	0.000	0.250
Hydrostatic pressure on bot of base: uniform portion			0.000	1.125
Hydrostatic pressure on bot of base: triangular portion			0.000	1.500
Stabilizing forces:				
Passive pressure on base Pp	-10.908	0.223		
Weight of the wall + base			34.875	0.706
Weight of soil on the base			-0.000	1.250
Hydrostatic pressure on top of rear portion of base			38.848	1.250
Hydrostatic pressure on top of front portion of base			0.000	0.000

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 75.61 kNm
Destabilizing moment Mo : 40.27 kNm

Safety factor against overturning = Mr/Mo = 1.877

2.Force Equilibrium at ULS

```
    Sum of Vertical forces Pv :  73.72 kN
  Frictional resistance Pfric :  42.56 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :  10.91 kN
=> Total Horiz. resistance Fr :  53.47 kN

     Horizontal sliding force on wall Fhw :  46.73 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh :  46.73 kN
```

Safety factor against overall sliding = Fr/Fh = 1.144

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure : 80.98 kPa
Minimum pressure : 0 kPa at 0.23 m from right hand side of base.
Maximum pressure occurs at left hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Nominal (0.13%) (mm²/m)
0.00	24.51	0.00	371.80	325.00
0.05	22.91	0.00	347.58	325.00
0.10	21.35	0.00	323.91	325.00
0.16	19.84	0.00	300.92	325.00
0.21	18.38	0.00	278.75	325.00
0.26	16.98	0.00	257.53	325.00
0.31	15.65	0.00	237.37	325.00
0.36	14.39	0.00	218.29	325.00
0.42	13.20	0.00	200.26	325.00
0.47	12.08	0.00	183.26	325.00
0.52	11.02	0.00	167.24	325.00
0.57	10.03	0.00	152.19	325.00
0.62	9.10	0.00	138.07	325.00
0.68	8.23	0.00	124.85	325.00
0.73	7.42	0.00	112.50	325.00
0.78	6.66	0.00	100.99	325.00
0.83	5.95	0.00	90.30	325.00
0.88	5.30	0.00	80.39	325.00
0.94	4.70	0.00	71.23	325.00
0.99	4.14	0.00	62.79	325.00
1.04	3.63	0.00	55.05	325.00
1.09	3.16	0.00	47.98	325.00
1.14	2.74	0.00	41.53	325.00
1.20	2.35	0.00	35.70	325.00
1.25	2.01	0.00	30.43	325.00
1.30	1.70	0.00	25.71	325.00
1.35	1.42	0.00	21.51	325.00
1.40	1.17	0.00	17.79	325.00
1.46	0.96	0.00	14.53	325.00
1.51	0.77	0.00	11.69	325.00
1.56	0.61	0.00	9.25	325.00
1.61	0.47	0.00	7.17	325.00
1.66	0.36	0.00	5.43	325.00
1.72	0.26	0.00	4.00	325.00
1.77	0.19	0.00	2.84	325.00
1.82	0.13	0.00	1.94	325.00
1.87	0.08	0.00	1.24	325.00
1.92	0.05	0.00	0.74	325.00
1.98	0.03	0.00	0.40	325.00
2.03	0.01	0.00	0.18	325.00
2.08	0.00	0.00	0.06	325.00

2.13	0.00	0.00	0.01	325.00
2.18	0.00	0.00	0.00	325.00
2.24	0.00	0.00	0.00	325.00
2.29	0.00	0.00	0.00	325.00
2.34	0.00	0.00	0.00	325.00
2.39	0.00	0.00	0.00	325.00
2.44	0.00	0.00	0.00	325.00
2.50	0.00	0.00	0.00	325.00
2.55	0.00	0.00	0.00	325.00
2.60	0.00	0.00	0.00	325.00

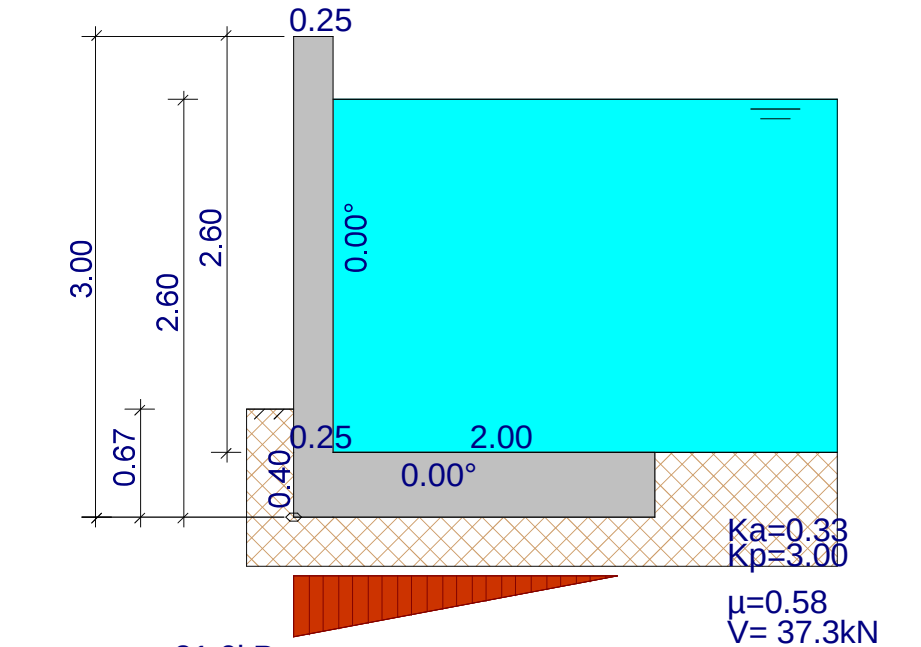
BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Nominal (0.13%) (mm^2/m)
0.00	-0.00	0.00	0.00	520.00
0.05	-0.09	0.00	0.80	520.00
0.09	-0.38	0.00	3.20	520.00
0.14	-0.76	0.00	0.00	520.00
0.18	36.26	0.00	0.00	520.00
0.23	34.53	0.00	0.00	520.00
0.27	33.07	0.00	0.00	520.00
0.32	31.65	268.30	0.00	520.00
0.36	30.26	256.51	0.00	520.00
0.41	28.90	244.98	0.00	520.00
0.45	27.57	233.72	0.00	520.00
0.50	26.27	222.72	0.00	520.00
0.54	25.01	211.99	0.00	520.00
0.58	23.77	201.53	0.00	520.00
0.63	22.57	191.32	0.00	520.00
0.68	21.40	181.39	0.00	520.00
0.72	20.26	171.71	0.00	520.00
0.77	19.15	162.31	0.00	520.00
0.81	18.07	153.16	0.00	520.00
0.85	17.02	144.29	0.00	520.00
0.90	16.00	135.68	0.00	520.00
0.94	15.02	127.33	0.00	520.00
0.99	14.07	119.25	0.00	520.00
1.03	13.14	111.43	0.00	520.00
1.08	12.25	103.88	0.00	520.00
1.13	11.39	96.59	0.00	520.00
1.17	10.57	89.57	0.00	520.00
1.22	9.77	82.81	0.00	520.00
1.26	9.00	76.32	0.00	520.00
1.30	8.27	70.09	0.00	520.00
1.35	7.56	64.13	0.00	520.00
1.40	6.89	58.43	0.00	520.00
1.44	6.25	53.00	0.00	520.00
1.49	5.64	47.83	0.00	520.00
1.53	5.06	42.93	0.00	520.00
1.57	4.52	38.29	0.00	520.00
1.62	4.00	33.92	0.00	520.00
1.67	3.52	29.81	0.00	520.00
1.71	3.06	25.97	0.00	520.00
1.75	2.64	22.39	0.00	520.00
1.80	2.25	19.08	0.00	520.00
1.84	1.89	16.03	0.00	520.00
1.89	1.56	13.25	0.00	520.00
1.94	1.27	10.73	0.00	520.00
1.98	1.00	8.48	0.00	520.00
2.02	0.77	6.49	0.00	520.00
2.07	0.56	4.77	0.00	520.00
2.12	0.39	3.31	0.00	520.00
2.16	0.25	2.12	0.00	520.00
2.21	0.14	1.19	0.00	520.00
2.25	0.06	0.53	0.00	520.00

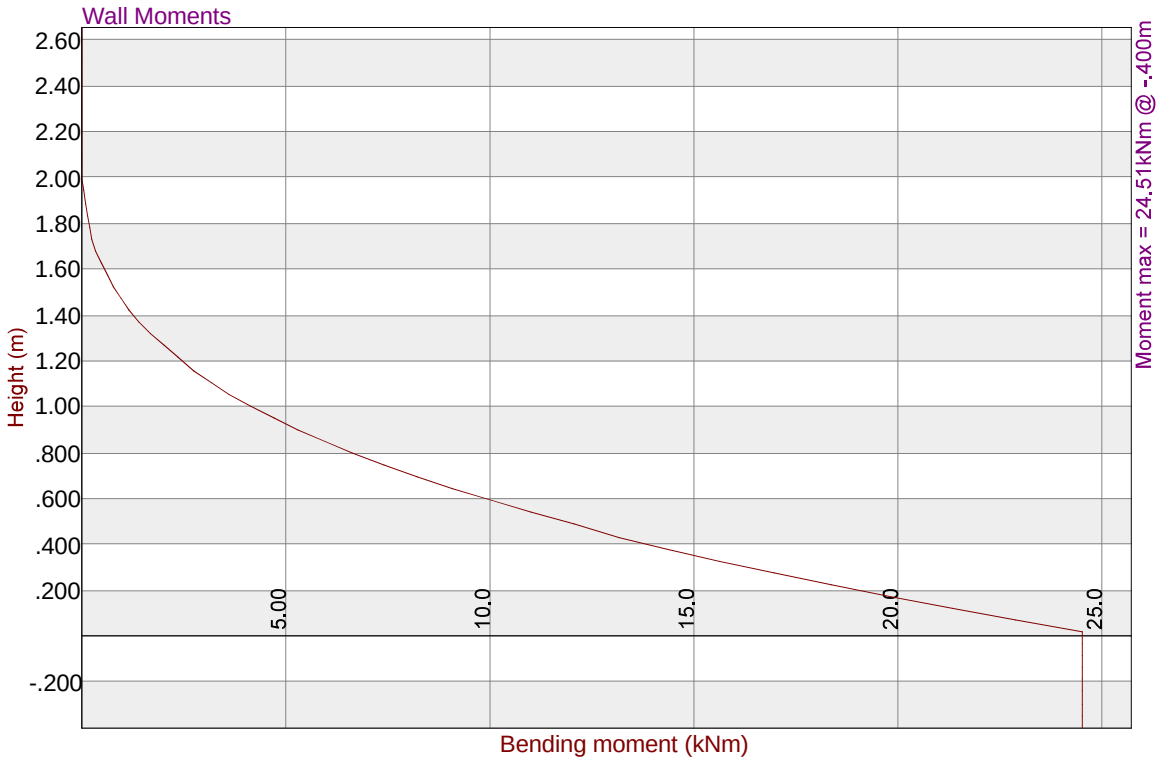
SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

```
 Shear force at bottom of wall V =  37.3 kN
Shear stress at bottom of wall v = 0.20 MPa OK
       Allowable shear stress vc = 0.43 MPa (based on Wall tensile reinf.)
```

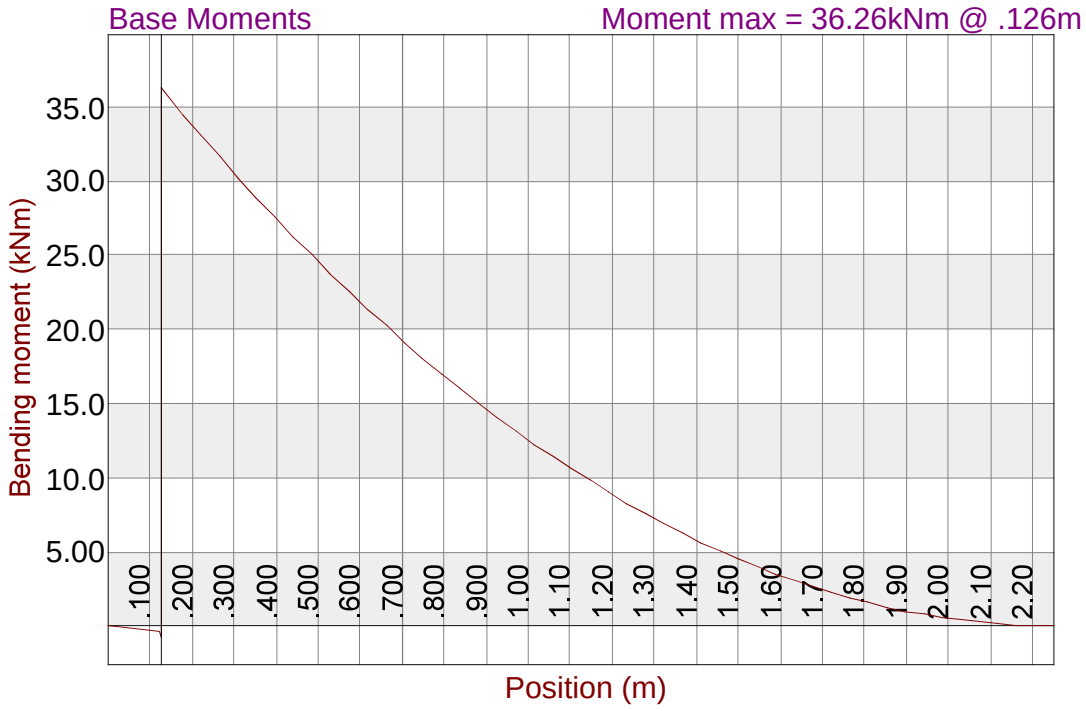
Sketch of Wall



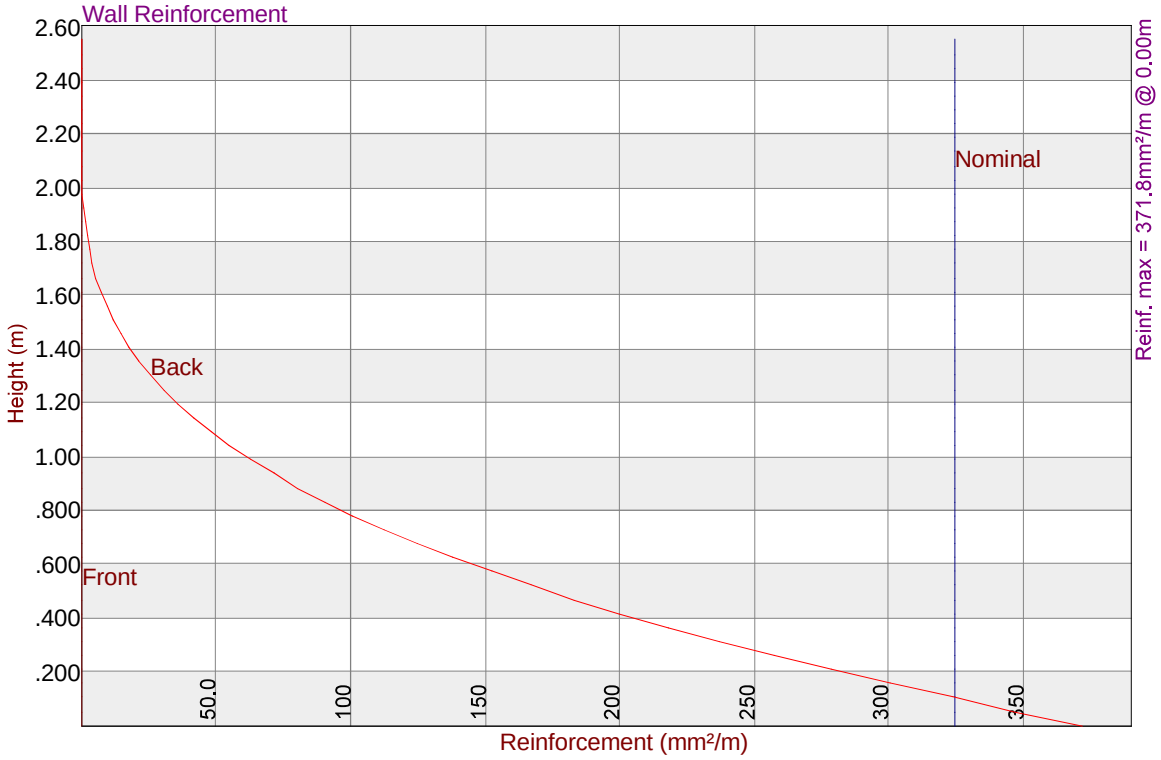
Wall Bending Moments



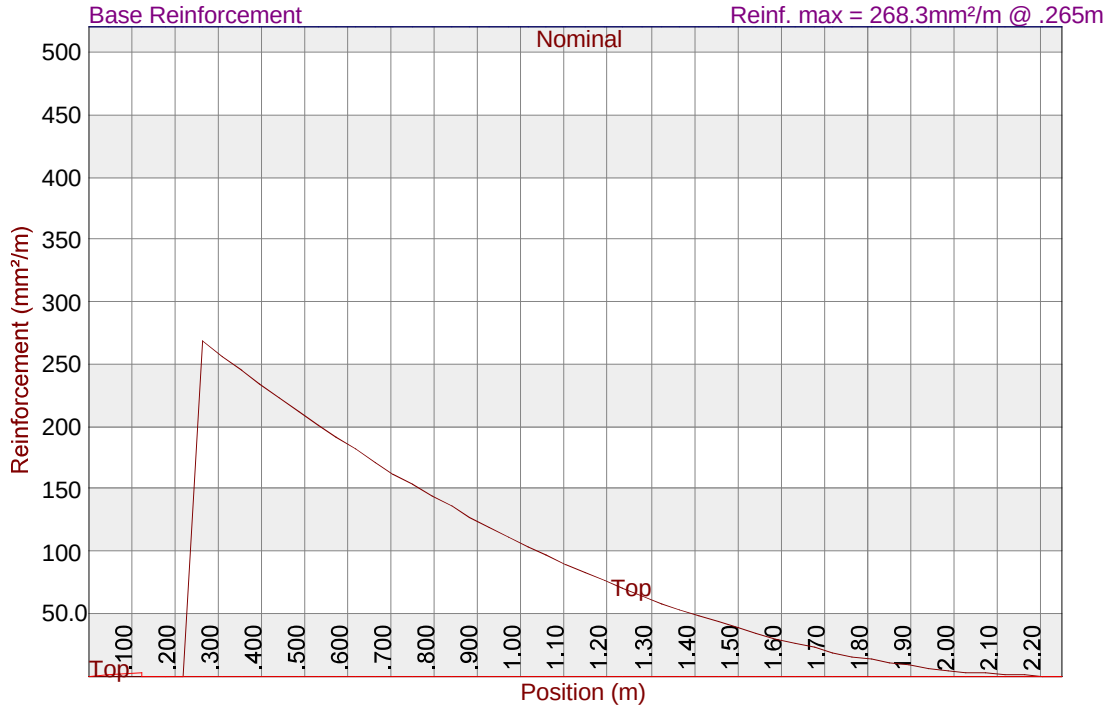
Base Bending Moments



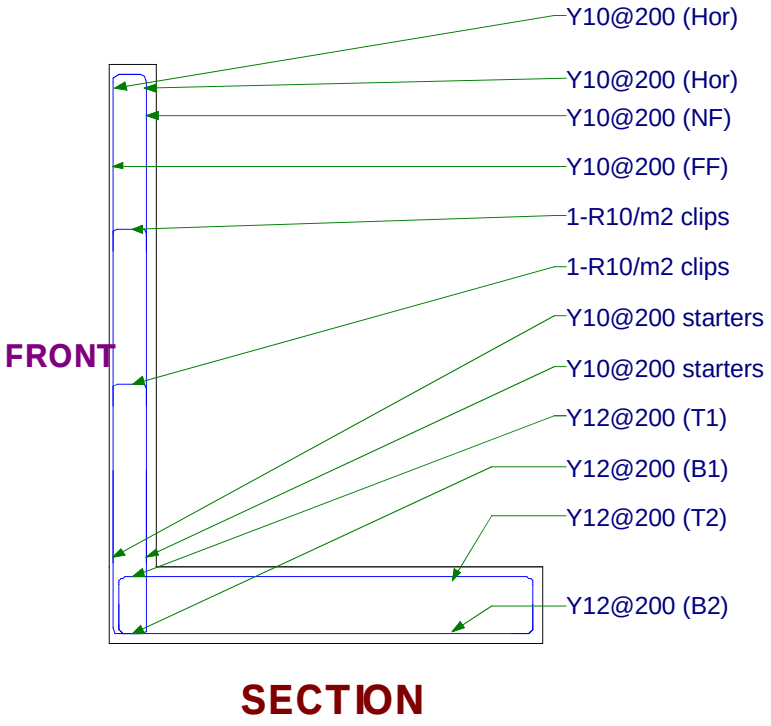
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



SECTION

4) ②VALVE CHAMBER

TOP SLAB (L4.87m×W4.15m)

Rectangular Slab Panel Design :

C04

Input Data

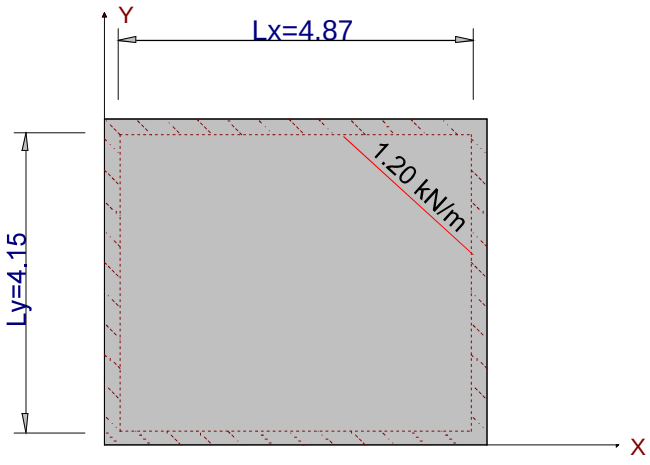
Lx (m)	4.87
Ly (m)	4.15
Slab depth (mm)	250
deff X-dir (mm)	200
deff Y-dir (mm)	220
Poisson's ratio	0.2
fc' (MPa)	25
fy (MPa)	420
Density (kN/m^3)	24
Self weight LF	1.4
ε - time factor (ACI318 :9.5.2.5)	2

Load Cases

Unfactored Loads			Unfactored Point Loads			Unfactored Line Loads				
LC No.	Load fact	UDL kN/m²	P kN	x m	y m	L kN/m	x1 m	y1 m	x2 m	y2 m
1	1.2	2				1	3.05	3.93	4.69	2.44
	1.6	2								
2	1.4	1								

Sketch of slab

ACI 318 - 2005



Total UDL = 14.000 kN/m²
(Incl self Wt)

Load Case 1 (factored)

Output

Wood-Armer Moments and reinforcement for each load case:
Wood-Armer moments were calculated using the 'Wood & Armer' theory.

LOAD CASE 1

Position		Wood-Armer Moments (kNm/m)				Reinforcement (mm²/m)			
		Top		Bottom		Top		Bottom	
X (m)	Y(m)	X	Y	X	Y	X	Y	X	Y
0.00	0.00	3.4	4.0	12.7	12.1	45	49	170	146
0.41	0.00	7.8	7.5	10.2	10.5	103	90	136	127
0.81	0.00	10.1	9.7	8.1	8.6	135	117	108	104
1.22	0.00	6.1	6.2	6.7	6.7	81	75	90	81
1.62	0.00	4.0	3.6	4.5	4.9	53	43	60	59
2.03	0.00	2.0	1.5	2.2	2.6	26	19	29	31
2.44	0.00	0.0	0.0	0.1	0.4	0	0	1	4
2.84	0.00	1.9	1.5	2.2	2.6	26	18	29	31
3.25	0.00	4.0	3.6	4.5	4.9	53	43	60	59
3.65	0.00	6.1	6.2	6.7	6.7	81	75	90	81
4.06	0.00	10.2	9.7	8.1	8.6	135	117	108	104
4.46	0.00	7.8	7.5	10.2	10.5	103	90	136	127
4.87	0.00	3.4	4.0	12.8	12.1	45	49	170	147
0.00	0.35	7.4	8.1	11.0	10.3	98	98	146	124
0.81	0.35	5.9	5.1	9.9	10.7	79	62	132	129
1.62	0.35	0.6	-0.0	7.0	8.5	8	0	94	103
2.44	0.35	0.0	0.0	3.0	4.8	0	0	40	58
3.25	0.35	0.6	-0.0	7.0	8.5	8	0	94	102
4.06	0.35	5.9	5.2	9.9	10.7	79	62	132	130
4.87	0.35	7.4	8.1	11.0	10.3	98	98	147	124
0.00	0.69	10.0	10.2	8.7	8.6	134	123	116	103
0.41	0.69	5.7	5.6	10.5	10.6	75	68	140	128
0.81	0.69	1.9	1.2	11.9	12.6	25	14	159	153
1.22	0.69	-0.0	-0.0	10.5	12.3	0	0	139	148
1.62	0.69	0.0	0.0	9.5	11.9	0	0	126	144
2.03	0.69	0.0	0.0	7.7	10.6	0	0	103	128
2.44	0.69	0.0	0.0	6.0	9.1	0	0	80	111
2.84	0.69	0.0	0.0	7.7	10.5	0	0	103	127
3.25	0.69	0.0	0.0	9.5	11.9	0	0	126	144
3.65	0.69	-0.0	-0.0	10.5	12.3	0	0	140	148
4.06	0.69	1.9	1.2	12.0	12.6	25	14	159	153
4.46	0.69	5.7	5.7	10.6	10.6	75	68	141	128
4.87	0.69	10.1	10.2	8.8	8.6	134	124	116	104
0.00	1.04	6.4	6.3	7.0	7.0	85	77	93	85
0.81	1.04	0.0	0.0	11.6	11.8	0	0	154	143
1.62	1.04	0.0	0.0	10.5	12.9	0	0	139	156
2.44	1.04	0.0	0.0	8.0	11.2	0	0	106	135
3.25	1.04	0.0	0.0	10.5	12.8	0	0	140	155
4.06	1.04	0.0	0.0	11.6	11.8	0	0	155	143
4.87	1.04	6.4	6.4	7.0	7.1	86	77	93	85
0.00	1.38	3.8	4.3	5.4	5.0	51	52	72	60
0.41	1.38	0.2	0.5	8.3	8.1	3	5	111	98
0.81	1.38	0.0	0.0	11.1	11.2	0	0	148	135
1.22	1.38	0.0	0.0	11.3	12.5	0	0	150	151
1.62	1.38	0.0	0.0	11.5	13.9	0	0	153	168
2.03	1.38	0.0	0.0	10.7	13.5	0	0	142	164
2.44	1.38	0.0	0.0	9.9	13.2	0	0	132	160
2.84	1.38	0.0	0.0	10.7	13.5	0	0	142	163
3.25	1.38	0.0	0.0	11.5	13.8	0	0	154	167
3.65	1.38	0.0	0.0	11.3	12.5	0	0	151	151
4.06	1.38	0.0	0.0	11.2	11.2	0	0	149	135
4.46	1.38	0.2	0.5	8.4	8.1	3	6	112	98
4.87	1.38	3.9	4.4	5.5	5.0	51	52	73	60
0.00	1.73	1.6	2.1	2.9	2.4	21	25	38	29
0.81	1.73	0.0	0.0	9.6	9.5	0	0	128	115
1.62	1.73	0.0	0.0	11.1	13.3	0	0	147	161
2.44	1.73	0.0	0.0	10.6	13.8	0	0	141	167
3.25	1.73	0.0	0.0	11.1	13.3	0	0	148	161

4.06	1.73	0.0	0.0	9.8	9.6	0	0	130	116
4.87	1.73	1.6	2.1	3.0	2.5	22	25	39	30
0.00	2.08	0.0	0.0	0.5	0.1	0	0	6	2
0.41	2.08	0.0	0.0	4.4	4.0	0	0	58	48
0.81	2.08	0.0	0.0	8.1	7.9	0	0	108	95
1.22	2.08	0.0	0.0	9.3	10.3	0	0	124	125
1.62	2.08	0.0	0.0	10.6	12.8	0	0	142	155
2.03	2.08	0.0	0.0	10.9	13.6	0	0	145	165
2.44	2.08	0.0	0.0	11.3	14.4	0	0	150	175
2.84	2.08	0.0	0.0	11.0	13.6	0	0	146	165
3.25	2.08	0.0	0.0	10.8	12.8	0	0	143	155
3.65	2.08	0.0	0.0	9.4	10.3	0	0	126	125
4.06	2.08	0.0	0.0	8.3	7.9	0	0	110	95
4.46	2.08	0.0	0.0	4.5	4.1	0	0	60	49
4.87	2.08	0.0	0.0	0.6	0.2	0	0	7	3
0.00	2.42	1.6	2.0	2.9	2.4	21	25	38	29
0.81	2.42	0.0	0.0	9.6	9.5	0	0	128	115
1.62	2.42	0.0	0.0	11.0	13.3	0	0	147	161
2.44	2.42	0.0	0.0	10.6	13.8	0	0	141	168
3.25	2.42	0.0	0.0	11.2	13.4	0	0	149	162
4.06	2.42	0.0	0.0	9.8	9.6	0	0	131	116
4.87	2.42	1.5	2.0	2.8	2.4	20	24	37	28
0.00	2.77	3.8	4.3	5.4	5.0	51	52	72	60
0.41	2.77	0.2	0.4	8.3	8.1	3	5	111	98
0.81	2.77	0.0	0.0	11.1	11.2	0	0	147	135
1.22	2.77	0.0	0.0	11.2	12.5	0	0	150	152
1.62	2.77	0.0	0.0	11.5	13.9	0	0	153	168
2.03	2.77	0.0	0.0	10.6	13.6	0	0	142	164
2.44	2.77	0.0	0.0	9.9	13.3	0	0	132	161
2.84	2.77	0.0	0.0	10.7	13.6	0	0	143	165
3.25	2.77	0.0	0.0	11.6	14.0	0	0	155	169
3.65	2.77	0.0	0.0	11.4	12.7	0	0	152	153
4.06	2.77	0.0	0.0	11.3	11.4	0	0	151	138
4.46	2.77	0.1	0.3	8.5	8.2	1	4	112	99
4.87	2.77	3.8	4.3	5.4	4.9	51	52	72	60
0.00	3.11	6.4	6.3	7.0	7.0	85	77	93	85
0.81	3.11	0.0	0.0	11.6	11.8	0	0	154	143
1.62	3.11	0.0	0.0	10.5	12.9	0	0	139	156
2.44	3.11	0.0	0.0	8.0	11.3	0	0	106	136
3.25	3.11	0.0	0.0	10.6	13.0	0	0	141	158
4.06	3.11	0.0	0.0	11.8	12.0	0	0	157	145
4.87	3.11	6.5	6.4	7.0	7.1	86	77	93	85
0.00	3.46	10.0	10.2	8.7	8.6	134	123	116	104
0.41	3.46	5.7	5.6	10.5	10.6	75	68	140	128
0.81	3.46	1.9	1.2	11.9	12.6	25	14	159	153
1.22	3.46	-0.0	-0.0	10.5	12.3	0	0	139	149
1.62	3.46	0.0	0.0	9.5	12.0	0	0	126	145
2.03	3.46	0.0	0.0	7.8	10.6	0	0	103	129
2.44	3.46	0.0	0.0	6.0	9.3	0	0	80	112
2.84	3.46	0.0	0.0	7.8	10.7	0	0	103	129
3.25	3.46	0.0	0.0	9.6	12.1	0	0	128	147
3.65	3.46	0.0	0.0	10.6	12.5	0	0	141	151
4.06	3.46	1.7	1.0	12.1	12.9	23	12	162	156
4.46	3.46	5.7	5.6	10.7	10.7	75	68	143	130
4.87	3.46	10.2	10.3	8.8	8.7	136	125	117	105
0.00	3.80	7.4	8.1	11.0	10.3	98	98	146	124
0.81	3.80	5.9	5.1	9.9	10.7	79	62	132	130
1.62	3.80	0.6	-0.0	7.1	8.5	9	0	94	103
2.44	3.80	0.0	0.0	3.1	4.9	0	0	41	59
3.25	3.80	0.4	-0.0	7.1	8.6	5	0	94	103
4.06	3.80	5.9	5.1	10.1	10.9	79	62	134	132
4.87	3.80	7.5	8.2	11.1	10.4	100	99	148	126
0.00	4.15	3.4	4.0	12.7	12.1	45	49	170	146
0.41	4.15	7.8	7.5	10.2	10.5	103	90	136	127
0.81	4.15	10.2	9.7	8.1	8.6	135	117	108	104
1.22	4.15	6.2	6.2	6.8	6.7	82	75	90	81
1.62	4.15	4.0	3.6	4.6	5.0	53	44	60	60
2.03	4.15	2.0	1.6	2.2	2.6	26	19	30	32
2.44	4.15	0.0	0.0	0.2	0.4	0	0	2	5

2.84	4.15	1.9	1.5	2.1	2.5	25	18	28	30
3.25	4.15	3.9	3.5	4.5	4.9	52	43	59	58
3.65	4.15	6.1	6.2	6.8	6.7	82	75	90	81
4.06	4.15	10.3	9.8	8.2	8.6	137	119	109	104
4.46	4.15	7.9	7.6	10.3	10.6	105	91	138	129
4.87	4.15	3.4	4.1	13.0	12.3	46	50	173	149

LOAD CASE 2

Position		Wood-Armer Moments (kNm/m)				Reinforcement (mm²/m)			
		Top		Bottom		Top		Bottom	
X (m)	Y(m)	X	Y	X	Y	X	Y	X	Y
0.00	0.00	2.4	2.8	8.9	8.4	31	34	118	102
0.41	0.00	5.4	5.2	7.1	7.3	72	63	94	88
0.81	0.00	7.1	6.8	5.7	6.0	94	82	75	72
1.22	0.00	4.3	4.3	4.7	4.7	57	52	62	56
1.62	0.00	2.8	2.5	3.1	3.4	37	30	42	41
2.03	0.00	1.4	1.1	1.5	1.8	18	13	20	22
2.44	0.00	0.0	0.0	0.1	0.2	0	0	1	3
2.84	0.00	1.4	1.1	1.5	1.8	18	13	20	22
3.25	0.00	2.8	2.5	3.1	3.4	37	30	42	41
3.65	0.00	4.3	4.3	4.7	4.7	57	52	62	56
4.06	0.00	7.1	6.8	5.7	6.0	94	82	75	72
4.46	0.00	5.4	5.2	7.1	7.3	72	63	94	88
4.87	0.00	2.4	2.8	8.9	8.4	31	34	118	102
0.00	0.35	5.2	5.7	7.7	7.2	68	68	102	86
0.81	0.35	4.1	3.6	6.9	7.5	55	43	92	90
1.62	0.35	0.4	-0.0	4.9	5.9	5	0	65	71
2.44	0.35	0.0	0.0	2.1	3.3	0	0	28	40
3.25	0.35	0.4	-0.0	4.9	5.9	5	0	65	71
4.06	0.35	4.1	3.6	6.9	7.5	55	43	92	90
4.87	0.35	5.2	5.7	7.7	7.2	68	68	102	86
0.00	0.69	7.0	7.1	6.1	6.0	93	86	81	72
0.41	0.69	3.9	3.9	7.3	7.4	52	47	98	89
0.81	0.69	1.3	0.8	8.3	8.8	17	10	111	106
1.22	0.69	-0.0	-0.0	7.3	8.6	0	0	97	103
1.62	0.69	0.0	0.0	6.6	8.3	0	0	88	100
2.03	0.69	0.0	0.0	5.4	7.4	0	0	72	89
2.44	0.69	0.0	0.0	4.2	6.4	0	0	56	77
2.84	0.69	0.0	0.0	5.4	7.4	0	0	72	89
3.25	0.69	0.0	0.0	6.6	8.3	0	0	88	100
3.65	0.69	-0.0	-0.0	7.3	8.6	0	0	97	103
4.06	0.69	1.3	0.8	8.3	8.8	17	10	111	106
4.46	0.69	3.9	3.9	7.3	7.4	52	47	98	89
4.87	0.69	7.0	7.1	6.1	6.0	93	86	81	72
0.00	1.04	4.5	4.4	4.9	4.9	59	53	64	59
0.81	1.04	0.0	0.0	8.1	8.2	0	0	107	99
1.62	1.04	0.0	0.0	7.3	9.0	0	0	97	108
2.44	1.04	0.0	0.0	5.5	7.8	0	0	74	94
3.25	1.04	0.0	0.0	7.3	9.0	0	0	97	108
4.06	1.04	0.0	0.0	8.1	8.2	0	0	107	99
4.87	1.04	4.5	4.4	4.9	4.9	59	53	64	59
0.00	1.38	2.7	3.0	3.8	3.5	35	36	50	42
0.41	1.38	0.1	0.3	5.8	5.7	2	4	77	68
0.81	1.38	0.0	0.0	7.7	7.8	0	0	103	94
1.22	1.38	0.0	0.0	7.9	8.7	0	0	105	105
1.62	1.38	0.0	0.0	8.0	9.7	0	0	107	117
2.03	1.38	0.0	0.0	7.4	9.4	0	0	99	114
2.44	1.38	0.0	0.0	6.9	9.2	0	0	92	111
2.84	1.38	0.0	0.0	7.4	9.4	0	0	99	114
3.25	1.38	0.0	0.0	8.0	9.7	0	0	107	117
3.65	1.38	0.0	0.0	7.9	8.7	0	0	105	105
4.06	1.38	0.0	0.0	7.7	7.8	0	0	103	94
4.46	1.38	0.1	0.3	5.8	5.7	2	4	77	68
4.87	1.38	2.7	3.0	3.8	3.5	35	36	50	42
0.00	1.73	1.1	1.4	2.0	1.7	14	17	27	20
0.81	1.73	0.0	0.0	6.7	6.6	0	0	89	80
1.62	1.73	0.0	0.0	7.7	9.3	0	0	103	112
2.44	1.73	0.0	0.0	7.4	9.6	0	0	98	116

3.25	1.73	0.0	0.0	7.7	9.3	0	0	103	112
4.06	1.73	0.0	0.0	6.7	6.6	0	0	89	80
4.87	1.73	1.1	1.4	2.0	1.7	14	17	27	20
0.00	2.08	0.0	0.0	0.3	0.1	0	0	4	1
0.41	2.08	0.0	0.0	3.1	2.8	0	0	41	33
0.81	2.08	0.0	0.0	5.7	5.5	0	0	75	66
1.22	2.08	0.0	0.0	6.5	7.2	0	0	87	87
1.62	2.08	0.0	0.0	7.4	8.9	0	0	99	107
2.03	2.08	0.0	0.0	7.6	9.5	0	0	101	114
2.44	2.08	0.0	0.0	7.8	10.0	0	0	104	121
2.84	2.08	0.0	0.0	7.6	9.5	0	0	101	114
3.25	2.08	0.0	0.0	7.4	8.9	0	0	99	107
3.65	2.08	0.0	0.0	6.5	7.2	0	0	87	87
4.06	2.08	0.0	0.0	5.7	5.5	0	0	75	66
4.46	2.08	0.0	0.0	3.1	2.8	0	0	41	33
4.87	2.08	0.0	0.0	0.3	0.1	0	0	4	1
0.00	2.42	1.1	1.4	2.0	1.7	14	17	27	20
0.81	2.42	0.0	0.0	6.7	6.6	0	0	89	80
1.62	2.42	0.0	0.0	7.7	9.3	0	0	103	112
2.44	2.42	0.0	0.0	7.4	9.6	0	0	98	116
3.25	2.42	0.0	0.0	7.7	9.3	0	0	103	112
4.06	2.42	0.0	0.0	6.7	6.6	0	0	89	80
4.87	2.42	1.1	1.4	2.0	1.7	14	17	27	20
0.00	2.77	2.7	3.0	3.8	3.5	35	36	50	42
0.41	2.77	0.1	0.3	5.8	5.7	2	4	77	68
0.81	2.77	0.0	0.0	7.7	7.8	0	0	103	94
1.22	2.77	0.0	0.0	7.9	8.7	0	0	105	105
1.62	2.77	0.0	0.0	8.0	9.7	0	0	107	117
2.03	2.77	0.0	0.0	7.4	9.4	0	0	99	114
2.44	2.77	0.0	0.0	6.9	9.2	0	0	92	111
2.84	2.77	0.0	0.0	7.4	9.4	0	0	99	114
3.25	2.77	0.0	0.0	8.0	9.7	0	0	107	117
3.65	2.77	0.0	0.0	7.9	8.7	0	0	105	105
4.06	2.77	0.0	0.0	7.7	7.8	0	0	103	94
4.46	2.77	0.1	0.3	5.8	5.7	2	4	77	68
4.87	2.77	2.7	3.0	3.8	3.5	35	36	50	42
0.00	3.11	4.5	4.4	4.9	4.9	59	53	64	59
0.81	3.11	0.0	0.0	8.1	8.2	0	0	107	99
1.62	3.11	0.0	0.0	7.3	9.0	0	0	97	108
2.44	3.11	0.0	0.0	5.5	7.8	0	0	74	94
3.25	3.11	0.0	0.0	7.3	9.0	0	0	97	108
4.06	3.11	0.0	0.0	8.1	8.2	0	0	107	99
4.87	3.11	4.5	4.4	4.9	4.9	59	53	64	59
0.00	3.46	7.0	7.1	6.1	6.0	93	86	81	72
0.41	3.46	3.9	3.9	7.3	7.4	52	47	98	89
0.81	3.46	1.3	0.8	8.3	8.8	17	10	111	106
1.22	3.46	-0.0	-0.0	7.3	8.6	0	0	97	103
1.62	3.46	0.0	0.0	6.6	8.3	0	0	88	100
2.03	3.46	0.0	0.0	5.4	7.4	0	0	72	89
2.44	3.46	0.0	0.0	4.2	6.4	0	0	56	77
2.84	3.46	0.0	0.0	5.4	7.4	0	0	72	89
3.25	3.46	0.0	0.0	6.6	8.3	0	0	88	100
3.65	3.46	-0.0	-0.0	7.3	8.6	0	0	97	103
4.06	3.46	1.3	0.8	8.3	8.8	17	10	111	106
4.46	3.46	3.9	3.9	7.3	7.4	52	47	98	89
4.87	3.46	7.0	7.1	6.1	6.0	93	86	81	72
0.00	3.80	5.2	5.7	7.7	7.2	68	68	102	86
0.81	3.80	4.1	3.6	6.9	7.5	55	43	92	90
1.62	3.80	0.4	-0.0	4.9	5.9	5	0	65	71
2.44	3.80	0.0	0.0	2.1	3.3	0	0	28	40
3.25	3.80	0.4	-0.0	4.9	5.9	5	0	65	71
4.06	3.80	4.1	3.6	6.9	7.5	55	43	92	90
4.87	3.80	5.2	5.7	7.7	7.2	68	68	102	86
0.00	4.15	2.4	2.8	8.9	8.4	31	34	118	102
0.41	4.15	5.4	5.2	7.1	7.3	72	63	94	88
0.81	4.15	7.1	6.8	5.7	6.0	94	82	75	72
1.22	4.15	4.3	4.3	4.7	4.7	57	52	62	56
1.62	4.15	2.8	2.5	3.1	3.4	37	30	42	41
2.03	4.15	1.4	1.1	1.5	1.8	18	13	20	22

2.44	4.15	0.0	0.0	0.1	0.2	0	0	1	3
2.84	4.15	1.4	1.1	1.5	1.8	18	13	20	22
3.25	4.15	2.8	2.5	3.1	3.4	37	30	42	41
3.65	4.15	4.3	4.3	4.7	4.7	57	52	62	56
4.06	4.15	7.1	6.8	5.7	6.0	94	82	75	72
4.46	4.15	5.4	5.2	7.1	7.3	72	63	94	88
4.87	4.15	2.4	2.8	8.9	8.4	31	34	118	102

ENVELOPE MAXIMUM

Position		Wood-Armer Moments (kNm/m)				Reinforcement (mm²/m)			
		Top		Bottom		Top		Bottom	
X (m)	Y(m)	X	Y	X	Y	X	Y	X	Y
0.00	0.00	3.4	4.0	12.7	12.1	45	49	170	146
0.41	0.00	7.8	7.5	10.2	10.5	103	90	136	127
0.81	0.00	10.1	9.7	8.1	8.6	135	117	108	104
1.22	0.00	6.1	6.2	6.7	6.7	81	75	90	81
1.62	0.00	4.0	3.6	4.5	4.9	53	43	60	59
2.03	0.00	2.0	1.5	2.2	2.6	26	19	29	31
2.44	0.00	0.0	0.0	0.1	0.4	0	0	1	4
2.84	0.00	1.9	1.5	2.2	2.6	26	18	29	31
3.25	0.00	4.0	3.6	4.5	4.9	53	43	60	59
3.65	0.00	6.1	6.2	6.7	6.7	81	75	90	81
4.06	0.00	10.2	9.7	8.1	8.6	135	117	108	104
4.46	0.00	7.8	7.5	10.2	10.5	103	90	136	127
4.87	0.00	3.4	4.0	12.8	12.1	45	49	170	147
0.00	0.35	7.4	8.1	11.0	10.3	98	98	146	124
0.81	0.35	5.9	5.1	9.9	10.7	79	62	132	129
1.62	0.35	0.6	-0.0	7.0	8.5	8	0	94	103
2.44	0.35	0.0	0.0	3.0	4.8	0	0	40	58
3.25	0.35	0.6	-0.0	7.0	8.5	8	0	94	102
4.06	0.35	5.9	5.2	9.9	10.7	79	62	132	130
4.87	0.35	7.4	8.1	11.0	10.3	98	98	147	124
0.00	0.69	10.0	10.2	8.7	8.6	134	123	116	103
0.41	0.69	5.7	5.6	10.5	10.6	75	68	140	128
0.81	0.69	1.9	1.2	11.9	12.6	25	14	159	153
1.22	0.69	-0.0	-0.0	10.5	12.3	0	0	139	148
1.62	0.69	0.0	0.0	9.5	11.9	0	0	126	144
2.03	0.69	0.0	0.0	7.7	10.6	0	0	103	128
2.44	0.69	0.0	0.0	6.0	9.1	0	0	80	111
2.84	0.69	0.0	0.0	7.7	10.5	0	0	103	127
3.25	0.69	0.0	0.0	9.5	11.9	0	0	126	144
3.65	0.69	-0.0	-0.0	10.5	12.3	0	0	140	148
4.06	0.69	1.9	1.2	12.0	12.6	25	14	159	153
4.46	0.69	5.7	5.7	10.6	10.6	75	68	141	128
4.87	0.69	10.1	10.2	8.8	8.6	134	124	116	104
0.00	1.04	6.4	6.3	7.0	7.0	85	77	93	85
0.81	1.04	0.0	0.0	11.6	11.8	0	0	154	143
1.62	1.04	0.0	0.0	10.5	12.9	0	0	139	156
2.44	1.04	0.0	0.0	8.0	11.2	0	0	106	135
3.25	1.04	0.0	0.0	10.5	12.8	0	0	140	155
4.06	1.04	0.0	0.0	11.6	11.8	0	0	155	143
4.87	1.04	6.4	6.4	7.0	7.1	86	77	93	85
0.00	1.38	3.8	4.3	5.4	5.0	51	52	72	60
0.41	1.38	0.2	0.5	8.3	8.1	3	5	111	98
0.81	1.38	0.0	0.0	11.1	11.2	0	0	148	135
1.22	1.38	0.0	0.0	11.3	12.5	0	0	150	151
1.62	1.38	0.0	0.0	11.5	13.9	0	0	153	168
2.03	1.38	0.0	0.0	10.7	13.5	0	0	142	164
2.44	1.38	0.0	0.0	9.9	13.2	0	0	132	160
2.84	1.38	0.0	0.0	10.7	13.5	0	0	142	163
3.25	1.38	0.0	0.0	11.5	13.8	0	0	154	167
3.65	1.38	0.0	0.0	11.3	12.5	0	0	151	151
4.06	1.38	0.0	0.0	11.2	11.2	0	0	149	135
4.46	1.38	0.2	0.5	8.4	8.1	3	6	112	98
4.87	1.38	3.9	4.4	5.5	5.0	51	52	73	60
0.00	1.73	1.6	2.1	2.9	2.4	21	25	38	29
0.81	1.73	0.0	0.0	9.6	9.5	0	0	128	115
1.62	1.73	0.0	0.0	11.1	13.3	0	0	147	161

2.44	1.73	0.0	0.0	10.6	13.8	0	0	141	167
3.25	1.73	0.0	0.0	11.1	13.3	0	0	148	161
4.06	1.73	0.0	0.0	9.8	9.6	0	0	130	116
4.87	1.73	1.6	2.1	3.0	2.5	22	25	39	30
0.00	2.08	0.0	0.0	0.5	0.1	0	0	6	2
0.41	2.08	0.0	0.0	4.4	4.0	0	0	58	48
0.81	2.08	0.0	0.0	8.1	7.9	0	0	108	95
1.22	2.08	0.0	0.0	9.3	10.3	0	0	124	125
1.62	2.08	0.0	0.0	10.6	12.8	0	0	142	155
2.03	2.08	0.0	0.0	10.9	13.6	0	0	145	165
2.44	2.08	0.0	0.0	11.3	14.4	0	0	150	175
2.84	2.08	0.0	0.0	11.0	13.6	0	0	146	165
3.25	2.08	0.0	0.0	10.8	12.8	0	0	143	155
3.65	2.08	0.0	0.0	9.4	10.3	0	0	126	125
4.06	2.08	0.0	0.0	8.3	7.9	0	0	110	95
4.46	2.08	0.0	0.0	4.5	4.1	0	0	60	49
4.87	2.08	0.0	0.0	0.6	0.2	0	0	7	3
0.00	2.42	1.6	2.0	2.9	2.4	21	25	38	29
0.81	2.42	0.0	0.0	9.6	9.5	0	0	128	115
1.62	2.42	0.0	0.0	11.0	13.3	0	0	147	161
2.44	2.42	0.0	0.0	10.6	13.8	0	0	141	168
3.25	2.42	0.0	0.0	11.2	13.4	0	0	149	162
4.06	2.42	0.0	0.0	9.8	9.6	0	0	131	116
4.87	2.42	1.5	2.0	2.8	2.4	20	24	37	28
0.00	2.77	3.8	4.3	5.4	5.0	51	52	72	60
0.41	2.77	0.2	0.4	8.3	8.1	3	5	111	98
0.81	2.77	0.0	0.0	11.1	11.2	0	0	147	135
1.22	2.77	0.0	0.0	11.2	12.5	0	0	150	152
1.62	2.77	0.0	0.0	11.5	13.9	0	0	153	168
2.03	2.77	0.0	0.0	10.6	13.6	0	0	142	164
2.44	2.77	0.0	0.0	9.9	13.3	0	0	132	161
2.84	2.77	0.0	0.0	10.7	13.6	0	0	143	165
3.25	2.77	0.0	0.0	11.6	14.0	0	0	155	169
3.65	2.77	0.0	0.0	11.4	12.7	0	0	152	153
4.06	2.77	0.0	0.0	11.3	11.4	0	0	151	138
4.46	2.77	0.1	0.3	8.5	8.2	2	4	112	99
4.87	2.77	3.8	4.3	5.4	4.9	51	52	72	60
0.00	3.11	6.4	6.3	7.0	7.0	85	77	93	85
0.81	3.11	0.0	0.0	11.6	11.8	0	0	154	143
1.62	3.11	0.0	0.0	10.5	12.9	0	0	139	156
2.44	3.11	0.0	0.0	8.0	11.3	0	0	106	136
3.25	3.11	0.0	0.0	10.6	13.0	0	0	141	158
4.06	3.11	0.0	0.0	11.8	12.0	0	0	157	145
4.87	3.11	6.5	6.4	7.0	7.1	86	77	93	85
0.00	3.46	10.0	10.2	8.7	8.6	134	123	116	104
0.41	3.46	5.7	5.6	10.5	10.6	75	68	140	128
0.81	3.46	1.9	1.2	11.9	12.6	25	14	159	153
1.22	3.46	-0.0	-0.0	10.5	12.3	0	0	139	149
1.62	3.46	0.0	0.0	9.5	12.0	0	0	126	145
2.03	3.46	0.0	0.0	7.8	10.6	0	0	103	129
2.44	3.46	0.0	0.0	6.0	9.3	0	0	80	112
2.84	3.46	0.0	0.0	7.8	10.7	0	0	103	129
3.25	3.46	0.0	0.0	9.6	12.1	0	0	128	147
3.65	3.46	-0.0	-0.0	10.6	12.5	0	0	141	151
4.06	3.46	1.7	1.0	12.1	12.9	23	12	162	156
4.46	3.46	5.7	5.6	10.7	10.7	75	68	143	130
4.87	3.46	10.2	10.3	8.8	8.7	136	125	117	105
0.00	3.80	7.4	8.1	11.0	10.3	98	98	146	124
0.81	3.80	5.9	5.1	9.9	10.7	79	62	132	130
1.62	3.80	0.6	-0.0	7.1	8.5	9	0	94	103
2.44	3.80	0.0	0.0	3.1	4.9	0	0	41	59
3.25	3.80	0.4	-0.0	7.1	8.6	5	0	94	103
4.06	3.80	5.9	5.1	10.1	10.9	79	62	134	132
4.87	3.80	7.5	8.2	11.1	10.4	100	99	148	126
0.00	4.15	3.4	4.0	12.7	12.1	45	49	170	146
0.41	4.15	7.8	7.5	10.2	10.5	103	90	136	127
0.81	4.15	10.2	9.7	8.1	8.6	135	117	108	104
1.22	4.15	6.2	6.2	6.8	6.7	82	75	90	81
1.62	4.15	4.0	3.6	4.6	5.0	53	44	60	60

2.03	4.15	2.0	1.6	2.2	2.6	26	19	30	32
2.44	4.15	0.0	0.0	0.2	0.4	0	0	2	5
2.84	4.15	1.9	1.5	2.1	2.5	25	18	28	30
3.25	4.15	3.9	3.5	4.5	4.9	52	43	59	58
3.65	4.15	6.1	6.2	6.8	6.7	82	75	90	81
4.06	4.15	10.3	9.8	8.2	8.6	137	119	109	104
4.46	4.15	7.9	7.6	10.3	10.6	105	91	138	129
4.87	4.15	3.4	4.1	13.0	12.3	46	50	173	149

ENVELOPE MINIMUM

Position		Wood-Armer Moments (kNm/m)				Reinforcement (mm²/m)			
		Top		Bottom		Top		Bottom	
X (m)	Y(m)	X	Y	X	Y	X	Y	X	Y
0.00	0.00	2.4	2.8	8.9	8.4	31	34	118	102
0.41	0.00	5.4	5.2	7.1	7.3	72	63	94	88
0.81	0.00	7.1	6.8	5.7	6.0	94	82	75	72
1.22	0.00	4.3	4.3	4.7	4.7	57	52	62	56
1.62	0.00	2.8	2.5	3.1	3.4	37	30	42	41
2.03	0.00	1.4	1.1	1.5	1.8	18	13	20	22
2.44	0.00	0.0	0.0	0.1	0.2	0	0	1	3
2.84	0.00	1.4	1.1	1.5	1.8	18	13	20	22
3.25	0.00	2.8	2.5	3.1	3.4	37	30	42	41
3.65	0.00	4.3	4.3	4.7	4.7	57	52	62	56
4.06	0.00	7.1	6.8	5.7	6.0	94	82	75	72
4.46	0.00	5.4	5.2	7.1	7.3	72	63	94	88
4.87	0.00	2.4	2.8	8.9	8.4	31	34	118	102
0.00	0.35	5.2	5.7	7.7	7.2	68	68	102	86
0.81	0.35	4.1	3.6	6.9	7.5	55	43	92	90
1.62	0.35	0.4	-0.0	4.9	5.9	5	0	65	71
2.44	0.35	0.0	0.0	2.1	3.3	0	0	28	40
3.25	0.35	0.4	-0.0	4.9	5.9	5	0	65	71
4.06	0.35	4.1	3.6	6.9	7.5	55	43	92	90
4.87	0.35	5.2	5.7	7.7	7.2	68	68	102	86
0.00	0.69	7.0	7.1	6.1	6.0	93	86	81	72
0.41	0.69	3.9	3.9	7.3	7.4	52	47	98	89
0.81	0.69	1.3	0.8	8.3	8.8	17	10	111	106
1.22	0.69	-0.0	-0.0	7.3	8.6	0	0	97	103
1.62	0.69	0.0	0.0	6.6	8.3	0	0	88	100
2.03	0.69	0.0	0.0	5.4	7.4	0	0	72	89
2.44	0.69	0.0	0.0	4.2	6.4	0	0	56	77
2.84	0.69	0.0	0.0	5.4	7.4	0	0	72	89
3.25	0.69	0.0	0.0	6.6	8.3	0	0	88	100
3.65	0.69	-0.0	-0.0	7.3	8.6	0	0	97	103
4.06	0.69	1.3	0.8	8.3	8.8	17	10	111	106
4.46	0.69	3.9	3.9	7.3	7.4	52	47	98	89
4.87	0.69	7.0	7.1	6.1	6.0	93	86	81	72
0.00	1.04	4.5	4.4	4.9	4.9	59	53	64	59
0.81	1.04	0.0	0.0	8.1	8.2	0	0	107	99
1.62	1.04	0.0	0.0	7.3	9.0	0	0	97	108
2.44	1.04	0.0	0.0	5.5	7.8	0	0	74	94
3.25	1.04	0.0	0.0	7.3	9.0	0	0	97	108
4.06	1.04	0.0	0.0	8.1	8.2	0	0	107	99
4.87	1.04	4.5	4.4	4.9	4.9	59	53	64	59
0.00	1.38	2.7	3.0	3.8	3.5	35	36	50	42
0.41	1.38	0.1	0.3	5.8	5.7	2	4	77	68
0.81	1.38	0.0	0.0	7.7	7.8	0	0	103	94
1.22	1.38	0.0	0.0	7.9	8.7	0	0	105	105
1.62	1.38	0.0	0.0	8.0	9.7	0	0	107	117
2.03	1.38	0.0	0.0	7.4	9.4	0	0	99	114
2.44	1.38	0.0	0.0	6.9	9.2	0	0	92	111
2.84	1.38	0.0	0.0	7.4	9.4	0	0	99	114
3.25	1.38	0.0	0.0	8.0	9.7	0	0	107	117
3.65	1.38	0.0	0.0	7.9	8.7	0	0	105	105
4.06	1.38	0.0	0.0	7.7	7.8	0	0	103	94
4.46	1.38	0.1	0.3	5.8	5.7	2	4	77	68
4.87	1.38	2.7	3.0	3.8	3.5	35	36	50	42
0.00	1.73	1.1	1.4	2.0	1.7	14	17	27	20
0.81	1.73	0.0	0.0	6.7	6.6	0	0	89	80

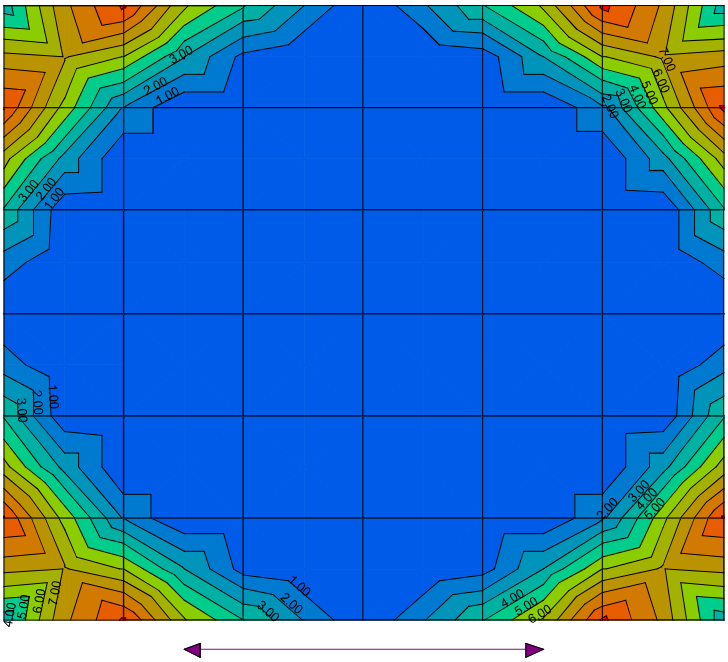
1.62	1.73	0.0	0.0	7.7	9.3	0	0	103	112
2.44	1.73	0.0	0.0	7.4	9.6	0	0	98	116
3.25	1.73	0.0	0.0	7.7	9.3	0	0	103	112
4.06	1.73	0.0	0.0	6.7	6.6	0	0	89	80
4.87	1.73	1.1	1.4	2.0	1.7	14	17	27	20
0.00	2.08	0.0	0.0	0.3	0.1	0	0	4	1
0.41	2.08	0.0	0.0	3.1	2.8	0	0	41	33
0.81	2.08	0.0	0.0	5.7	5.5	0	0	75	66
1.22	2.08	0.0	0.0	6.5	7.2	0	0	87	87
1.62	2.08	0.0	0.0	7.4	8.9	0	0	99	107
2.03	2.08	0.0	0.0	7.6	9.5	0	0	101	114
2.44	2.08	0.0	0.0	7.8	10.0	0	0	104	121
2.84	2.08	0.0	0.0	7.6	9.5	0	0	101	114
3.25	2.08	0.0	0.0	7.4	8.9	0	0	99	107
3.65	2.08	0.0	0.0	6.5	7.2	0	0	87	87
4.06	2.08	0.0	0.0	5.7	5.5	0	0	75	66
4.46	2.08	0.0	0.0	3.1	2.8	0	0	41	33
4.87	2.08	0.0	0.0	0.3	0.1	0	0	4	1
0.00	2.42	1.1	1.4	2.0	1.7	14	17	27	20
0.81	2.42	0.0	0.0	6.7	6.6	0	0	89	80
1.62	2.42	0.0	0.0	7.7	9.3	0	0	103	112
2.44	2.42	0.0	0.0	7.4	9.6	0	0	98	116
3.25	2.42	0.0	0.0	7.7	9.3	0	0	103	112
4.06	2.42	0.0	0.0	6.7	6.6	0	0	89	80
4.87	2.42	1.1	1.4	2.0	1.7	14	17	27	20
0.00	2.77	2.7	3.0	3.8	3.5	35	36	50	42
0.41	2.77	0.1	0.3	5.8	5.7	2	4	77	68
0.81	2.77	0.0	0.0	7.7	7.8	0	0	103	94
1.22	2.77	0.0	0.0	7.9	8.7	0	0	105	105
1.62	2.77	0.0	0.0	8.0	9.7	0	0	107	117
2.03	2.77	0.0	0.0	7.4	9.4	0	0	99	114
2.44	2.77	0.0	0.0	6.9	9.2	0	0	92	111
2.84	2.77	0.0	0.0	7.4	9.4	0	0	99	114
3.25	2.77	0.0	0.0	8.0	9.7	0	0	107	117
3.65	2.77	0.0	0.0	7.9	8.7	0	0	105	105
4.06	2.77	0.0	0.0	7.7	7.8	0	0	103	94
4.46	2.77	0.1	0.3	5.8	5.7	1	4	77	68
4.87	2.77	2.7	3.0	3.8	3.5	35	36	50	42
0.00	3.11	4.5	4.4	4.9	4.9	59	53	64	59
0.81	3.11	0.0	0.0	8.1	8.2	0	0	107	99
1.62	3.11	0.0	0.0	7.3	9.0	0	0	97	108
2.44	3.11	0.0	0.0	5.5	7.8	0	0	74	94
3.25	3.11	0.0	0.0	7.3	9.0	0	0	97	108
4.06	3.11	0.0	0.0	8.1	8.2	0	0	107	99
4.87	3.11	4.5	4.4	4.9	4.9	59	53	64	59
0.00	3.46	7.0	7.1	6.1	6.0	93	86	81	72
0.41	3.46	3.9	3.9	7.3	7.4	52	47	98	89
0.81	3.46	1.3	0.8	8.3	8.8	17	10	111	106
1.22	3.46	-0.0	-0.0	7.3	8.6	0	0	97	103
1.62	3.46	0.0	0.0	6.6	8.3	0	0	88	100
2.03	3.46	0.0	0.0	5.4	7.4	0	0	72	89
2.44	3.46	0.0	0.0	4.2	6.4	0	0	56	77
2.84	3.46	0.0	0.0	5.4	7.4	0	0	72	89
3.25	3.46	0.0	0.0	6.6	8.3	0	0	88	100
3.65	3.46	-0.0	-0.0	7.3	8.6	0	0	97	103
4.06	3.46	1.3	0.8	8.3	8.8	17	10	111	106
4.46	3.46	3.9	3.9	7.3	7.4	52	47	98	89
4.87	3.46	7.0	7.1	6.1	6.0	93	86	81	72
0.00	3.80	5.2	5.7	7.7	7.2	68	68	102	86
0.81	3.80	4.1	3.6	6.9	7.5	55	43	92	90
1.62	3.80	0.4	-0.0	4.9	5.9	5	0	65	71
2.44	3.80	0.0	0.0	2.1	3.3	0	0	28	40
3.25	3.80	0.4	-0.0	4.9	5.9	5	0	65	71
4.06	3.80	4.1	3.6	6.9	7.5	55	43	92	90
4.87	3.80	5.2	5.7	7.7	7.2	68	68	102	86
0.00	4.15	2.4	2.8	8.9	8.4	31	34	118	102
0.41	4.15	5.4	5.2	7.1	7.3	72	63	94	88
0.81	4.15	7.1	6.8	5.7	6.0	94	82	75	72
1.22	4.15	4.3	4.3	4.7	4.7	57	52	62	56

1.62	4.15	2.8	2.5	3.1	3.4	37	30	42	41
2.03	4.15	1.4	1.1	1.5	1.8	18	13	20	22
2.44	4.15	0.0	0.0	0.1	0.2	0	0	1	3
2.84	4.15	1.4	1.1	1.5	1.8	18	13	20	22
3.25	4.15	2.8	2.5	3.1	3.4	37	30	42	41
3.65	4.15	4.3	4.3	4.7	4.7	57	52	62	56
4.06	4.15	7.1	6.8	5.7	6.0	94	82	75	72
4.46	4.15	5.4	5.2	7.1	7.3	72	63	94	88
4.87	4.15	2.4	2.8	8.9	8.4	31	34	118	102

Wood-Armer Moments:

ACI 318 - 2005

Top:LC 1 (kNm/m)

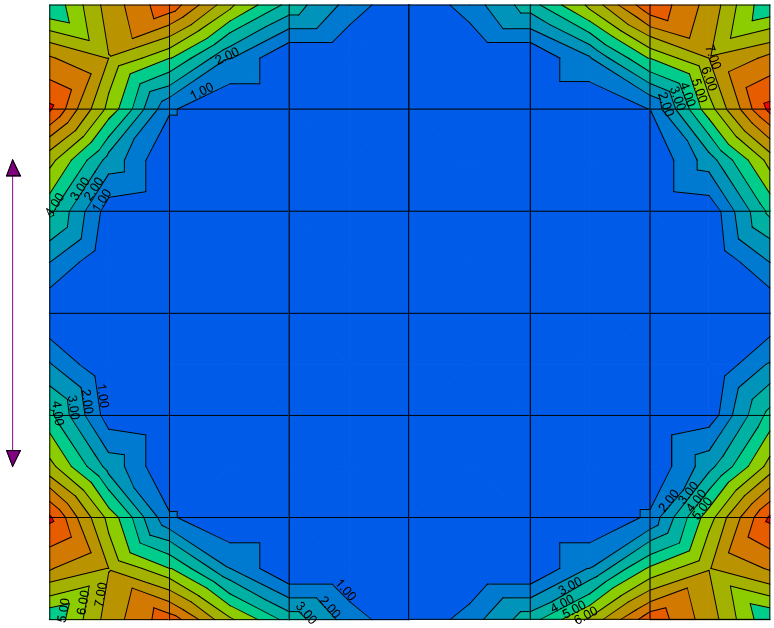


Max value:10.3 at X:4.1 Y:4.2

Wood-Armer Moments:

ACI 318 - 2005

Top:LC 1 (kNm/m)

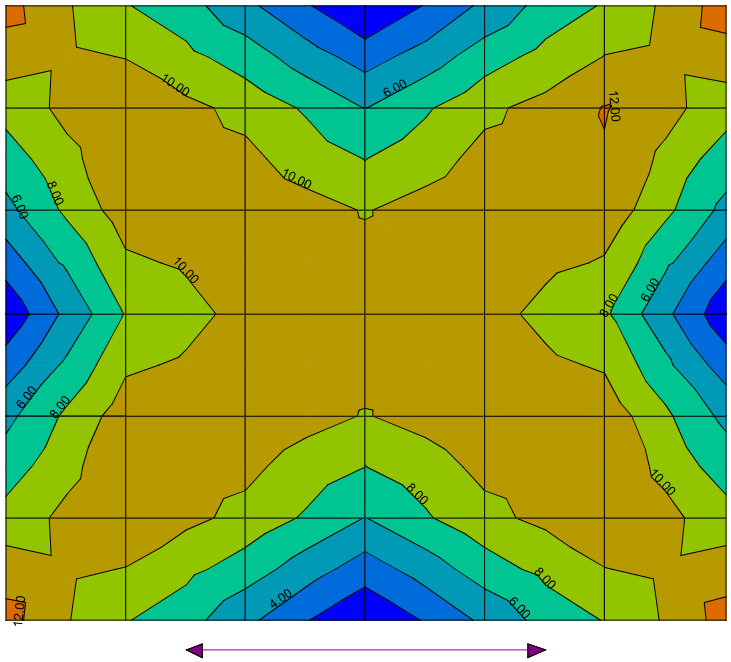


Max value:10.3 at X:4.9 Y:3.5

Wood-Armer Moments:

ACI 318 - 2005

Bot:LC 1 (kNm/m)

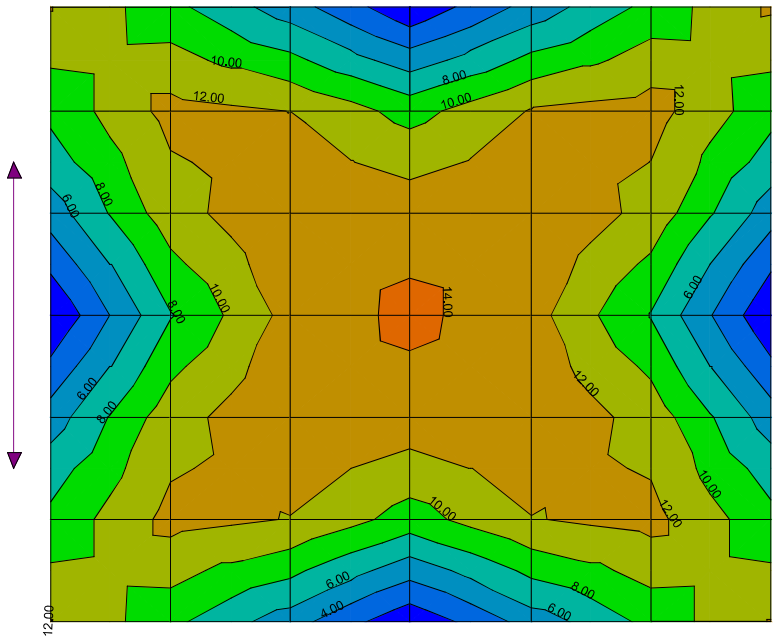


Max value:13.0 at X:4.9 Y:4.2

Wood-Armer Moments:

ACI 318 - 2005

Bot:LC 1 (kNm/m)

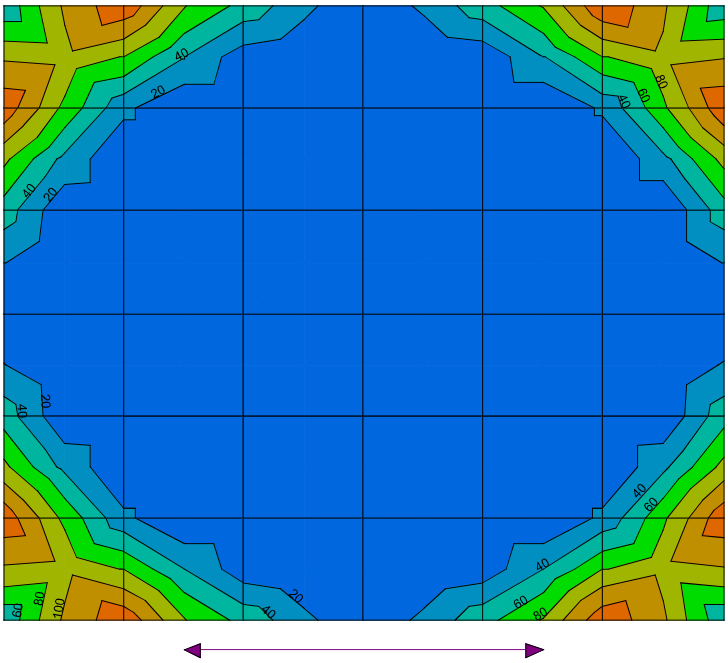


Max value:14.4 at X:2.4 Y:2.1

Reinforcement:

ACI 318 - 2005

Top:LC 1 (mm²/m)

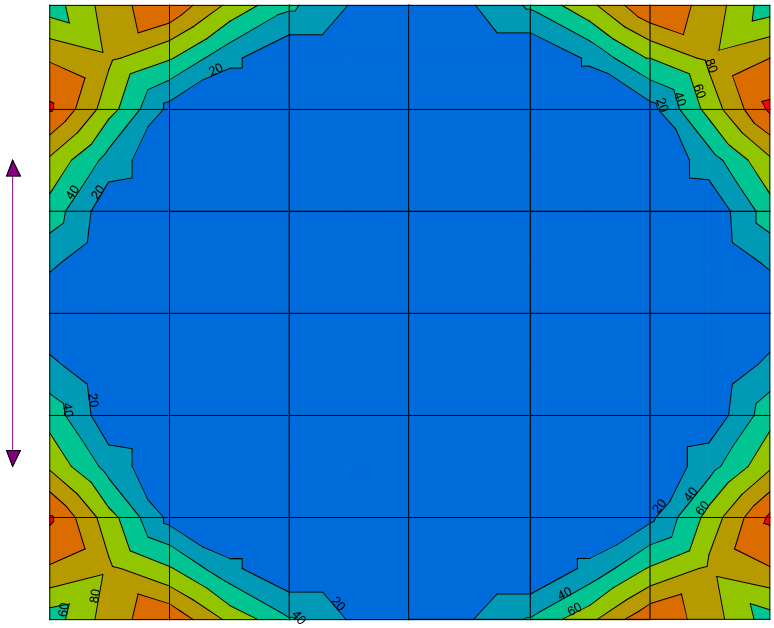


Max value:136.7 at X:4.1 Y:4.2

Reinforcement:

ACI 318 - 2005

Top:LC 1 (mm²/m)

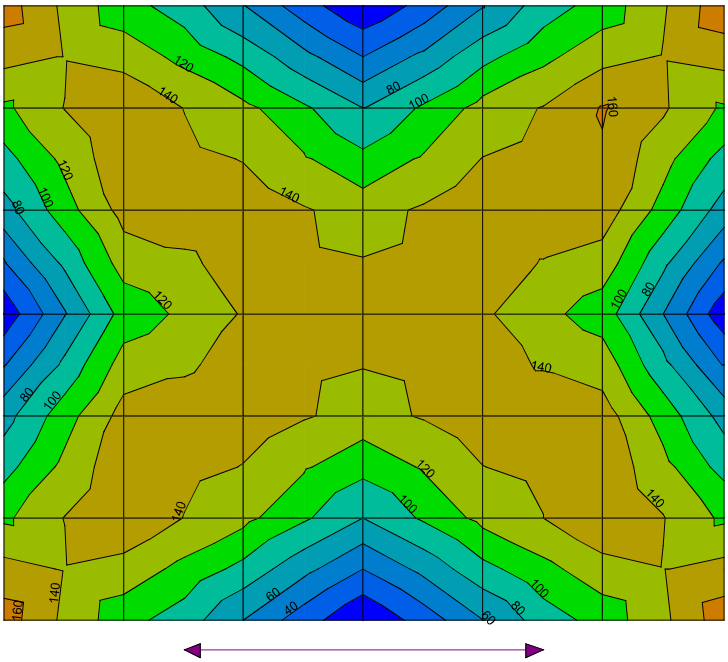


Max value:124.8 at X:4.9 Y:3.5

Reinforcement:

ACI 318 - 2005

Bot:LC 1 (mm²/m)

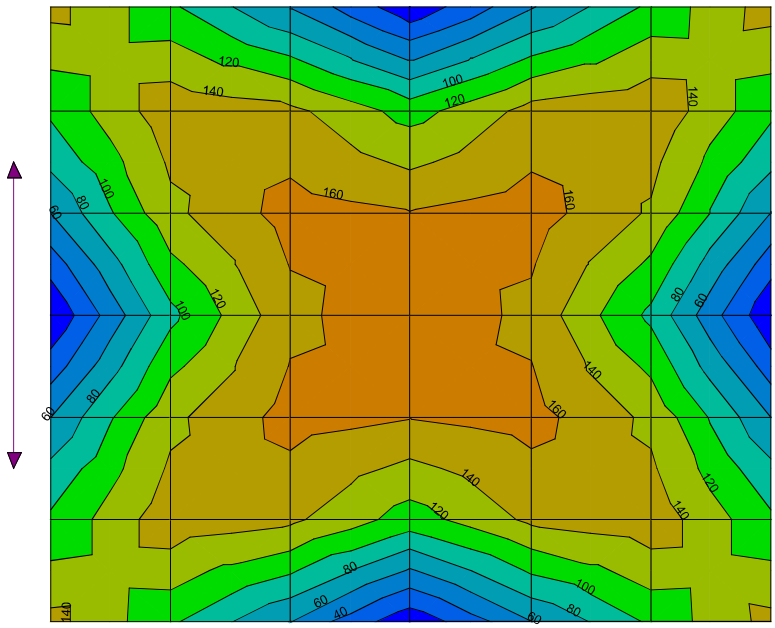


Max value:172.8 at X:4.9 Y:4.2

Reinforcement:

ACI 318 - 2005

Bot:LC 1 (mm²/m)

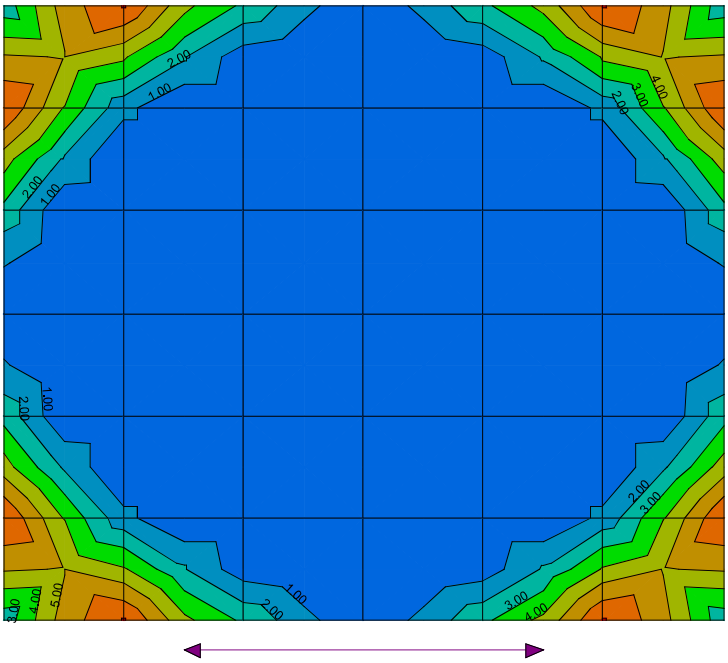


Max value:175.1 at X:2.4 Y:2.1

Wood-Armer Moments:

ACI 318 - 2005

Top:LC 2 (kNm/m)

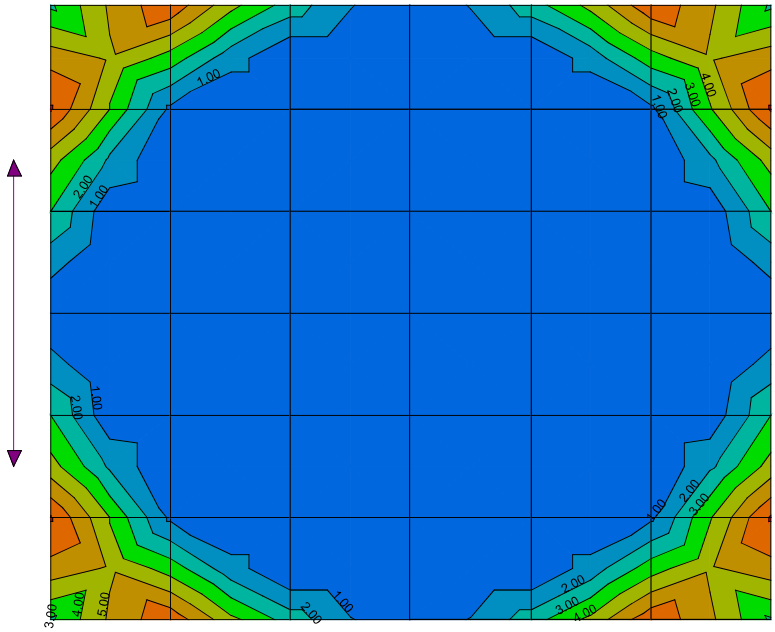


Max value:7.1 at X:4.1 Y:4.2

Wood-Armer Moments:

ACI 318 - 2005

Top:LC 2 (kNm/m)

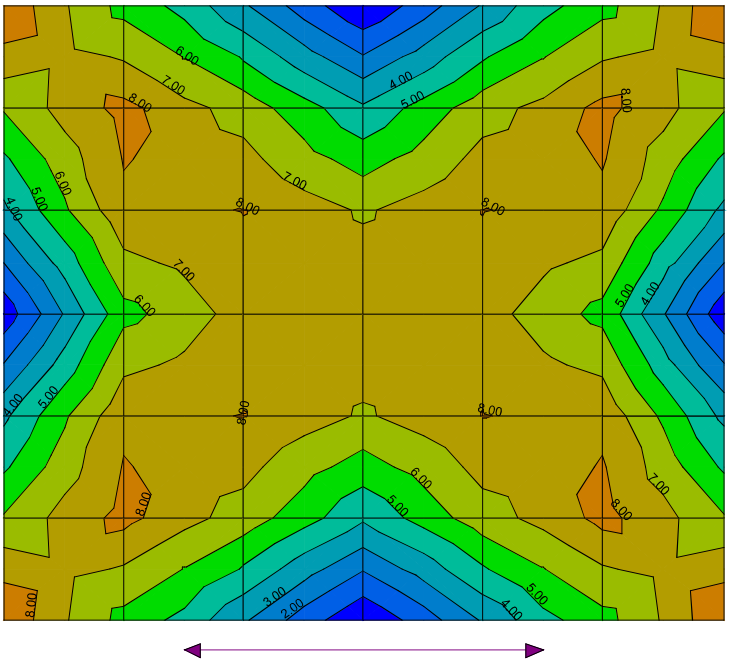


Max value:7.1 at X:4.9 Y:3.5

Wood-Armer Moments:

ACI 318 - 2005

Bot:LC 2 (kNm/m)

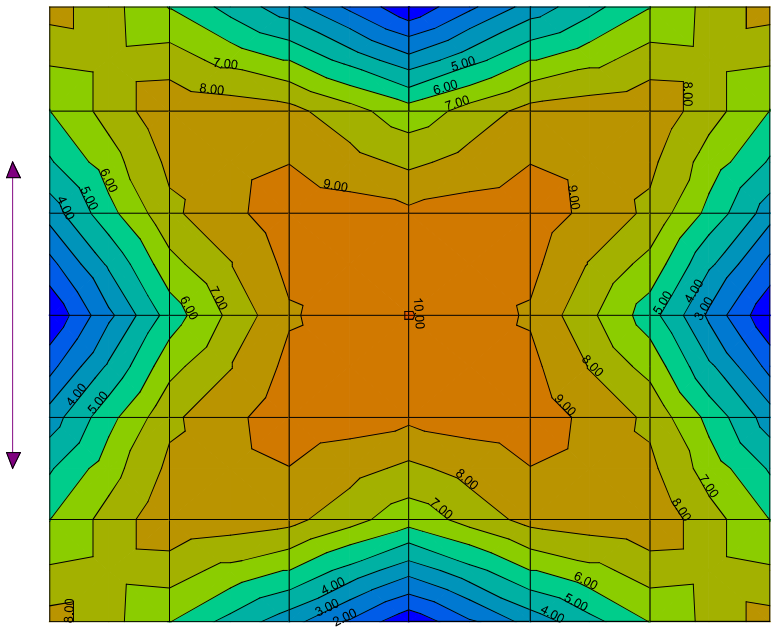


Max value:8.9 at X:4.9 Y:4.2

Wood-Armer Moments:

ACI 318 - 2005

Bot:LC 2 (kNm/m)

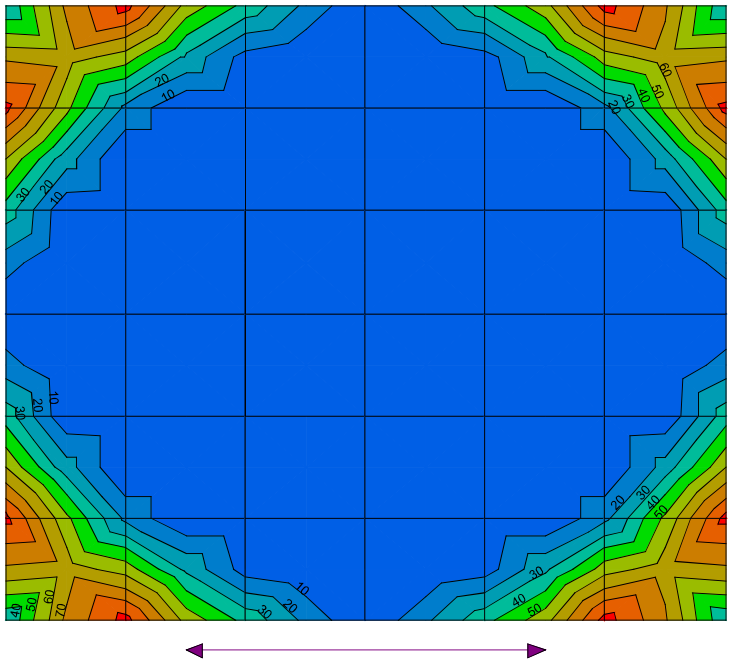


Max value:10.0 at X:2.4 Y:2.1

Reinforcement:

ACI 318 - 2005

Top:LC 2 (mm²/m)

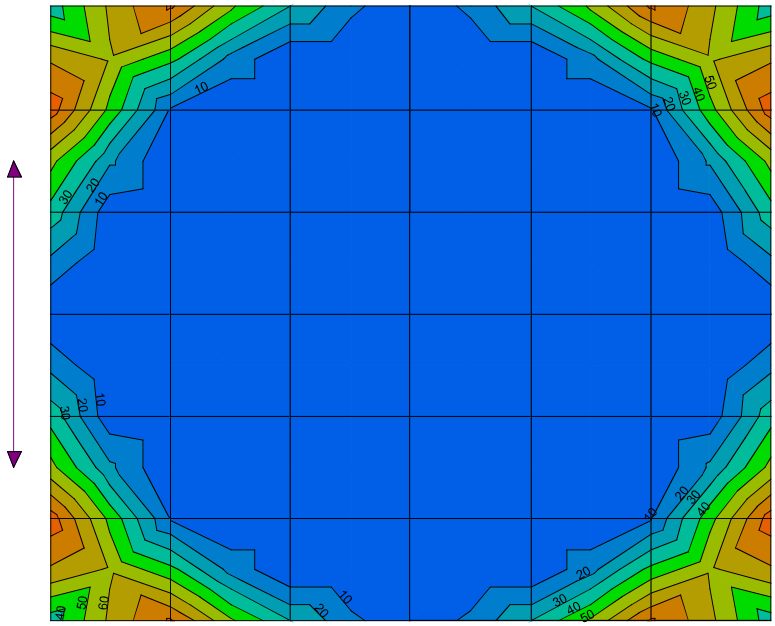


Max value:94.0 at X:4.1 Y:4.2

Reinforcement:

ACI 318 - 2005

Top:LC 2 (mm²/m)

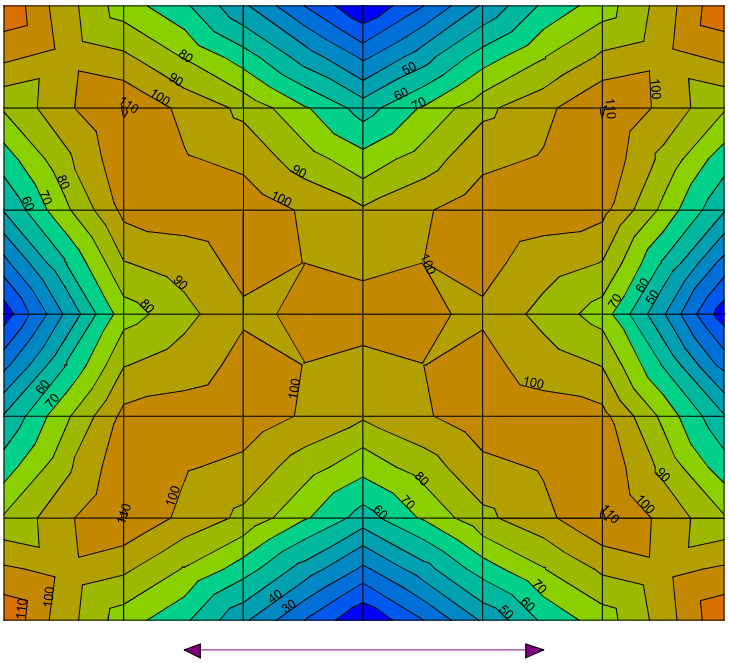


Max value:85.8 at X:4.9 Y:3.5

Reinforcement:

ACI 318 - 2005

Bot:LC 2 (mm²/m)

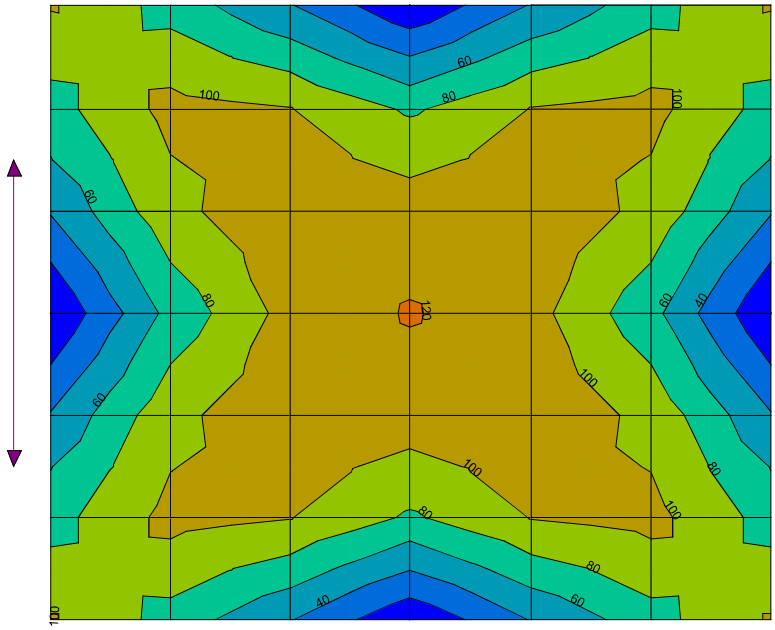


Max value:118.3 at X:4.9 Y:4.2

Reinforcement:

ACI 318 - 2005

Bot:LC 2 (mm²/m)

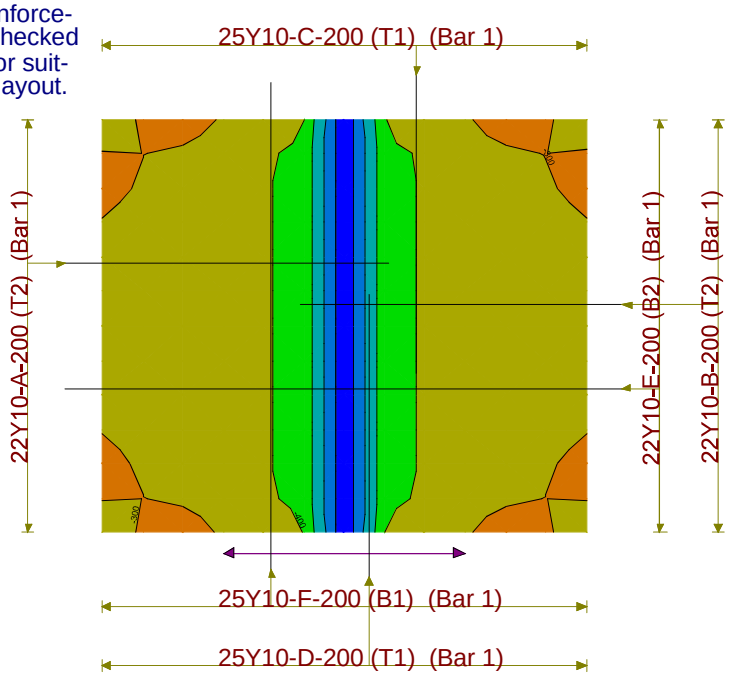


Max value:121.4 at X:2.4 Y:2.1

Rebar Excess:

Rebar Excess Top (mm²/m)

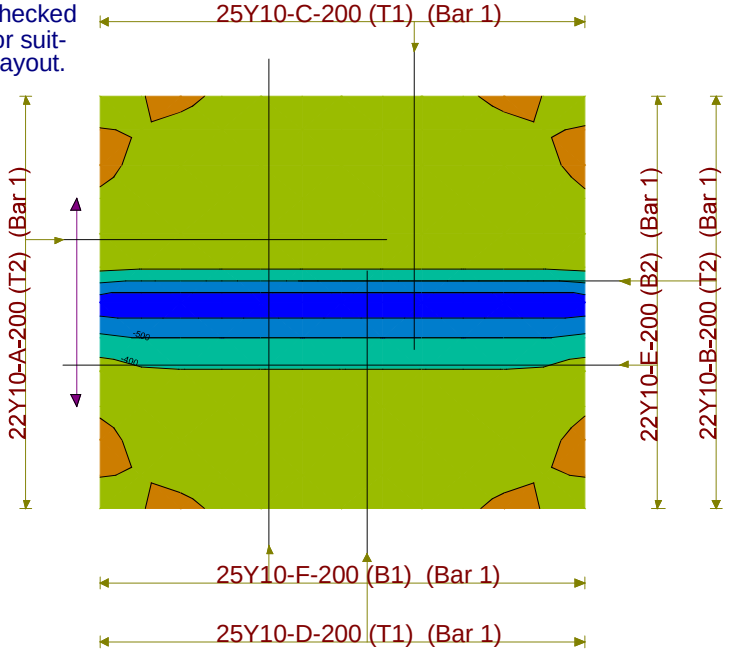
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Top (mm²/m)

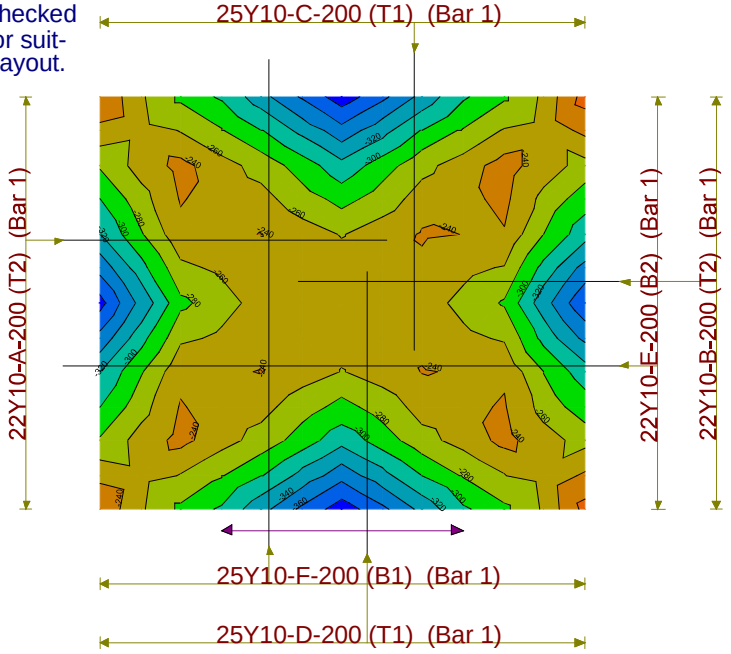
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Bot (mm²/m)

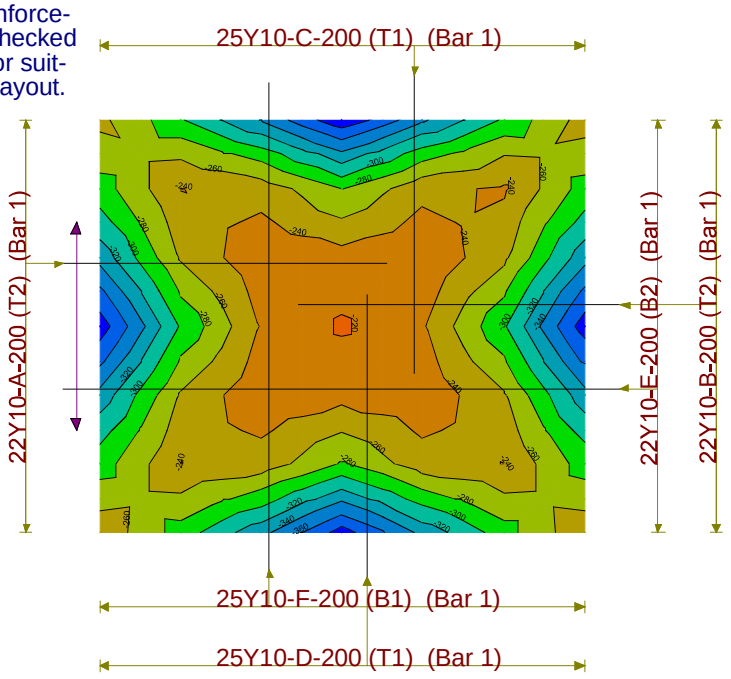
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Bot (mm²/m)

Note:Default reinforcement should be checked and adjusted for suitability and layout.



4) ②VALVE CHAMBER

WALL (H3.0m)

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Propped cantilever exam

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1 (m)	3	C (m)	0.4	W (kN/m²)	20	Soil frict ϕ (°)	30	SF Overt.	1.5
H2 (m)	0.7	F (m)	0	P (kN)	0	Fill slope β (°)	0	SF Slip	1.5
H3 (m)	0	xf (m)	1	xp (m)	0	Wall frict δ (°)	15	ULS DL Factor	1.4
Hw (m)	0	At (m)	.25	L (kN/m)	5	ρ Conc kN/m^3	25	ULS LL Factor	1.6
Hr (m)	0	Ab (m)	.25	xl (m)	2	ρ Soil kN/m^3	18	Pmax (kPa)	400
B (m)	0	Cov wall mm	50	Lh (kN/m)	0	fc' (MPa)	25	Soil Poisson υ	0.5
D (m)	2	Cov base mm	50	x (m)	0	fy (MPa)	420	DL Factor Ovt.	0.9

Seepage allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Propped cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:ON

Hor Accel. (g)	0.1
Vert Accel. (g)	0.01
Include LL's	Y

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.301
Passive Pressure coefficient Kp :4.977
Seismic Active Pressure coefficient Kas :0.372
Seismic Passive Pressure coefficient Kps :4.512
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

	FORCES (kN) and their LEVER ARMS (m)			
Description	F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	29.132	1.152	7.806	0.250
Siesmic component of Pa	5.549	1.800	1.487	0.250
As a result of surcharge w	21.363	1.500	5.724	0.250
As a result of Line Load L	1.480	1.611	0.000	0.250
Siesmic wall inertia	3.836	0.829		
Stabilizing forces:				
Passive pressure on base Pp	-19.897	0.214		
Siesmic component of Pp	2.050	0.420		
Weight of the wall + base			38.362	0.706
Weight of soil on the base			92.664	1.250
Line load of 4.95 kN/m on backfill			4.950	2.000
UDL of 19.8 kPa			39.600	1.250

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Force Equilibrium at SLS

Sum of Vertical forces Pv : 189.11 kN

```
  Frictional resistance Pfric : 109.18 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :  19.90 kN
   Horizontal reaction at top :  15.53 kN
=> Total Horiz. resistance Fr : 144.60 kN

  => Horizontal resistance at base Fr(base) : 129.08 kN
  Reaction at base                          :  40.28 kN
Safety factor against base sliding = Fr(base)/Reaction(base) = 3.204
```

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
	FORCES (kN) and their LEVER ARMS (m)			
Destabilizing forces:				
Total Active pressure Pa	42.560	1.167	10.928	0.250
Siesmic component of Pa	8.879	1.800	2.379	0.250
As a result of surcharge w	34.181	1.500	9.159	0.250
As a result of Line Load L	2.367	1.611	0.000	0.250
Siesmic wall inertia	6.138	0.829		
Stabilizing forces:				
Passive pressure on base Pp	-17.907	0.214		
Siesmic component of Pp	1.845	0.420		
Weight of the wall + base			34.526	0.706
Weight of soil on the base			83.398	1.250
Line load of 4.46 kN/m on backfill			4.455	2.000
UDL of 17.8 kPa			35.640	1.250

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Force Equilibrium at ULS

```
    Sum of Vertical forces Pv : 170.20 kN
  Frictional resistance Pfric :  98.26 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :  17.91 kN
   Horizontal reaction at top :  23.98 kN
=> Total Horiz. resistance Fr : 140.15 kN

  => Horizontal resistance at base Fr(base) : 116.17 kN
  Reaction at base                          :  61.26 kN
Safety factor against base sliding = Fr(base)/Reaction(base) = 1.896
```

SOIL PRESSURES UNDER BASE AT SLS

```
Maximum pressure :116.52 kPa
Minimum pressure : 51.57 kPa
Maximum pressure occurs at left hand side of base
```

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Minimum (mm²/m)
0.00	14.15	0.00	199.08	623.81
0.05	12.22	0.00	171.72	623.81
0.10	10.31	0.00	144.58	623.81
0.16	8.41	0.00	117.88	623.81
0.21	6.56	0.00	91.83	623.81
0.26	4.77	0.00	66.63	623.81
0.31	3.04	0.00	42.48	623.81
0.36	1.40	0.00	19.53	623.81
0.42	-0.16	2.23	0.00	623.81
0.47	-1.64	22.87	0.00	623.81

0.52	-3.04	42.45	0.00	623.81
0.57	-4.36	60.95	0.00	623.81
0.62	-5.61	78.40	0.00	623.81
0.68	-6.77	94.78	0.00	623.81
0.73	-7.86	110.12	0.00	623.81
0.78	-8.88	124.42	0.00	623.81
0.83	-9.82	137.69	0.00	623.81
0.88	-10.68	149.92	0.00	623.81
0.94	-11.48	161.14	0.00	623.81
0.99	-12.20	171.34	0.00	623.81
1.04	-12.85	180.55	0.00	623.81
1.09	-13.42	188.76	0.00	623.81
1.14	-13.93	195.98	0.00	623.81
1.20	-14.37	202.24	0.00	623.81
1.25	-14.66	206.27	0.00	623.81
1.30	-14.84	208.85	0.00	623.81
1.35	-14.95	210.48	0.00	623.81
1.40	-15.00	211.19	0.00	623.81
1.46	-14.99	210.97	0.00	623.81
1.51	-14.91	209.85	0.00	623.81
1.56	-14.77	207.83	0.00	623.81
1.61	-14.56	204.93	0.00	623.81
1.66	-14.30	201.15	0.00	623.81
1.72	-13.97	196.52	0.00	623.81
1.77	-13.58	191.04	0.00	623.81
1.82	-13.14	184.74	0.00	623.81
1.87	-12.64	177.61	0.00	623.81
1.92	-12.08	169.68	0.00	623.81
1.98	-11.46	160.96	0.00	623.81
2.03	-10.79	151.47	0.00	623.81
2.08	-10.07	141.21	0.00	623.81
2.13	-9.29	130.21	0.00	623.81
2.18	-8.46	118.48	0.00	623.81
2.24	-7.57	106.03	0.00	623.81
2.29	-6.64	92.87	0.00	623.81
2.34	-5.65	79.03	0.00	623.81
2.39	-4.62	64.51	0.00	623.81
2.44	-3.53	49.33	0.00	623.81
2.50	-2.40	33.51	0.00	623.81
2.55	-1.22	17.06	0.00	623.81
2.60	0.00	0.00	0.00	623.81

BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from left (m)	Moment (kNm)	Top Reinforcing (mm²/m)	Bot Reinforcing (mm²/m)	Minimum (mm²/m)
0.00	-0.00	0.00	0.00	1116.29
0.05	-0.15	0.00	1.17	1116.29
0.09	-0.60	0.00	4.67	1116.29
0.14	-1.21	0.00	0.00	1116.29
0.18	26.48	0.00	0.00	1116.29
0.23	25.21	0.00	0.00	1116.29
0.27	24.15	0.00	0.00	1116.29
0.32	23.11	180.79	0.00	1116.29
0.36	22.10	172.80	0.00	1116.29
0.41	21.10	165.00	0.00	1116.29
0.45	20.13	157.38	0.00	1116.29
0.50	19.19	149.94	0.00	1116.29
0.54	18.26	142.69	0.00	1116.29
0.58	17.36	135.61	0.00	1116.29
0.63	16.48	128.72	0.00	1116.29
0.68	15.63	122.01	0.00	1116.29
0.72	14.79	115.48	0.00	1116.29
0.77	13.98	109.14	0.00	1116.29
0.81	13.19	102.97	0.00	1116.29
0.85	12.43	96.99	0.00	1116.29
0.90	11.69	91.18	0.00	1116.29
0.94	10.97	85.56	0.00	1116.29

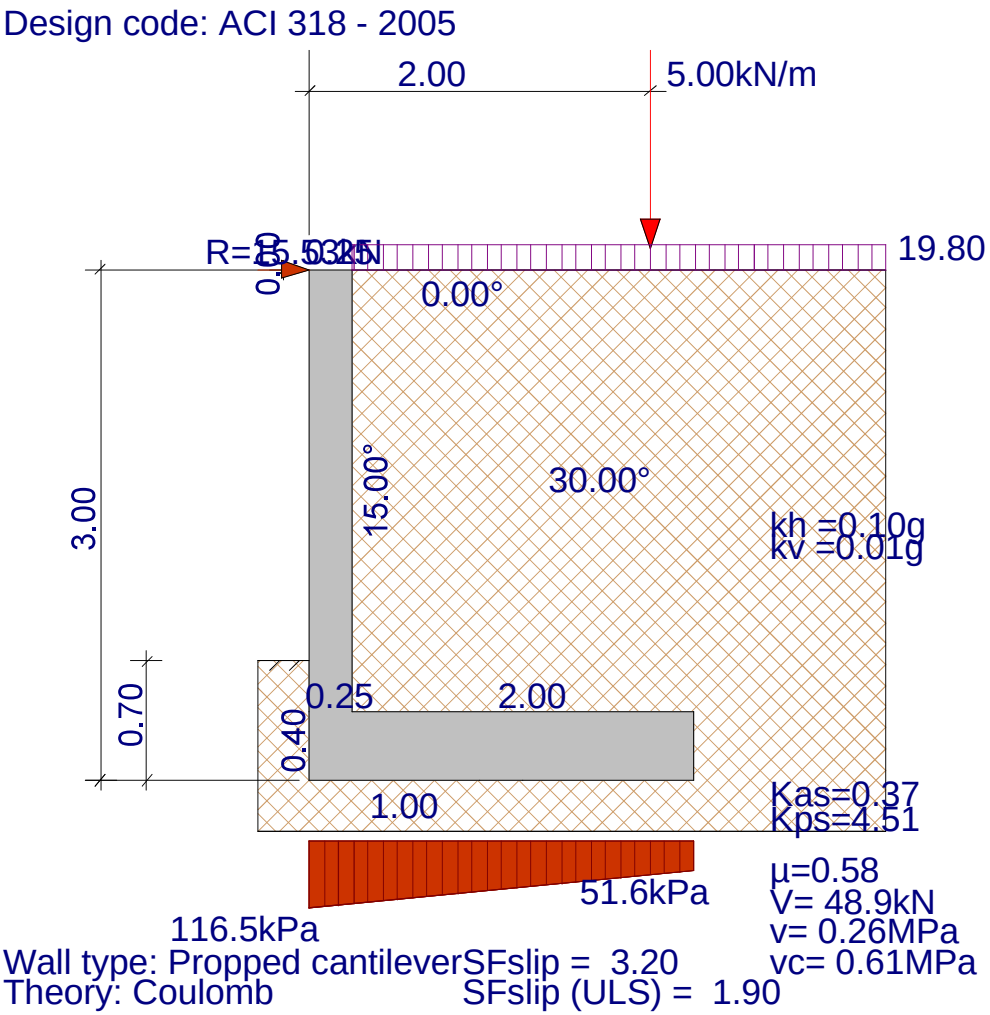
0.99	10.27	80.11	0.00	1116.29
1.03	9.60	74.85	0.00	1116.29
1.08	8.95	69.77	0.00	1116.29
1.13	8.32	64.86	0.00	1116.29
1.17	7.72	60.14	0.00	1116.29
1.22	7.13	55.60	0.00	1116.29
1.26	6.57	51.23	0.00	1116.29
1.30	6.04	47.04	0.00	1116.29
1.35	5.52	43.04	0.00	1116.29
1.40	5.03	39.21	0.00	1116.29
1.44	4.57	35.56	0.00	1116.29
1.49	4.12	32.09	0.00	1116.29
1.53	3.70	28.80	0.00	1116.29
1.57	3.30	25.68	0.00	1116.29
1.62	2.92	22.75	0.00	1116.29
1.67	2.57	19.99	0.00	1116.29
1.71	2.24	17.42	0.00	1116.29
1.75	1.93	15.02	0.00	1116.29
1.80	1.64	12.79	0.00	1116.29
1.84	1.38	10.75	0.00	1116.29
1.89	1.14	8.88	0.00	1116.29
1.94	0.92	7.20	0.00	1116.29
1.98	0.73	5.68	0.00	1116.29
2.02	0.56	4.35	0.00	1116.29
2.07	0.41	3.20	0.00	1116.29
2.12	0.29	2.22	0.00	1116.29
2.16	0.18	1.42	0.00	1116.29
2.21	0.10	0.80	0.00	1116.29
2.25	0.05	0.36	0.00	1116.29

SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

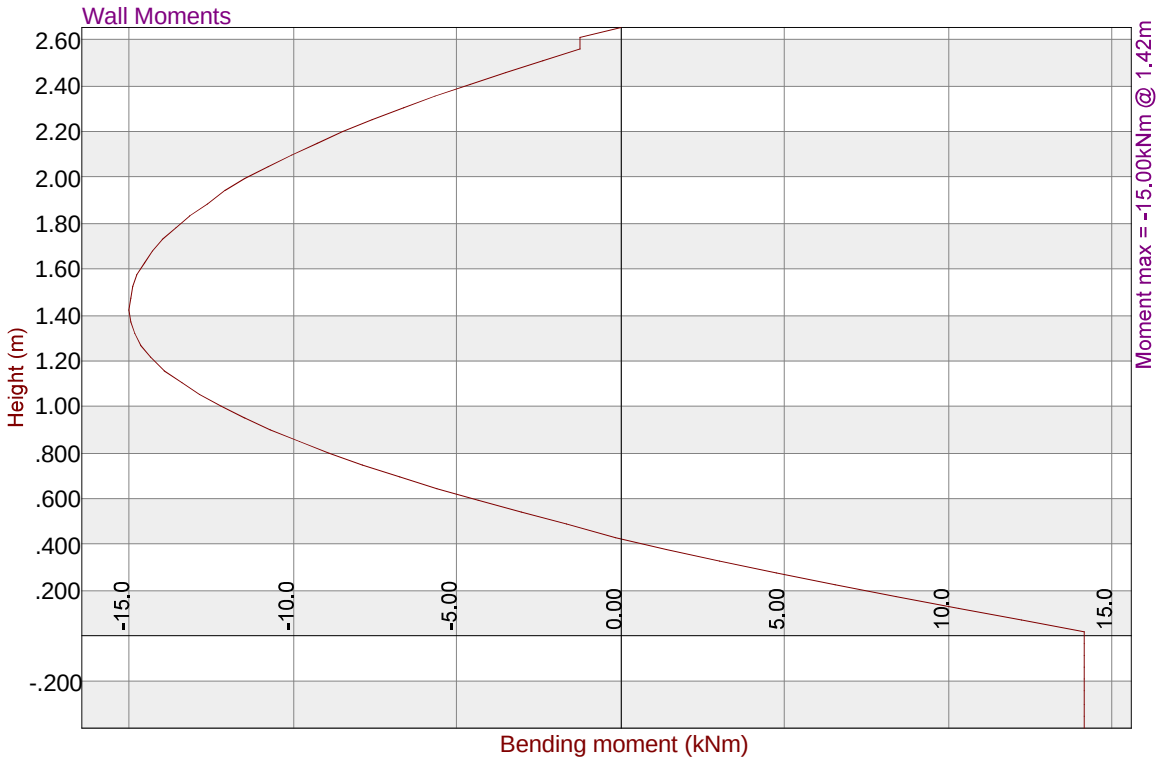
Shear force at bottom of wall V = 48.9 kN
Shear stress at bottom of wall v = 0.26 MPa OK
Allowable shear stress vc = 0.61 MPa (based on Wall tensile reinf.)

PROKON Software Consultants (Pty) Ltd Internet: http://www.prokon.com E-Mail : mail@prokon.com	Job Number		Sheet
	Job Title		
	Client		
	Calcs by	Checked by	Date

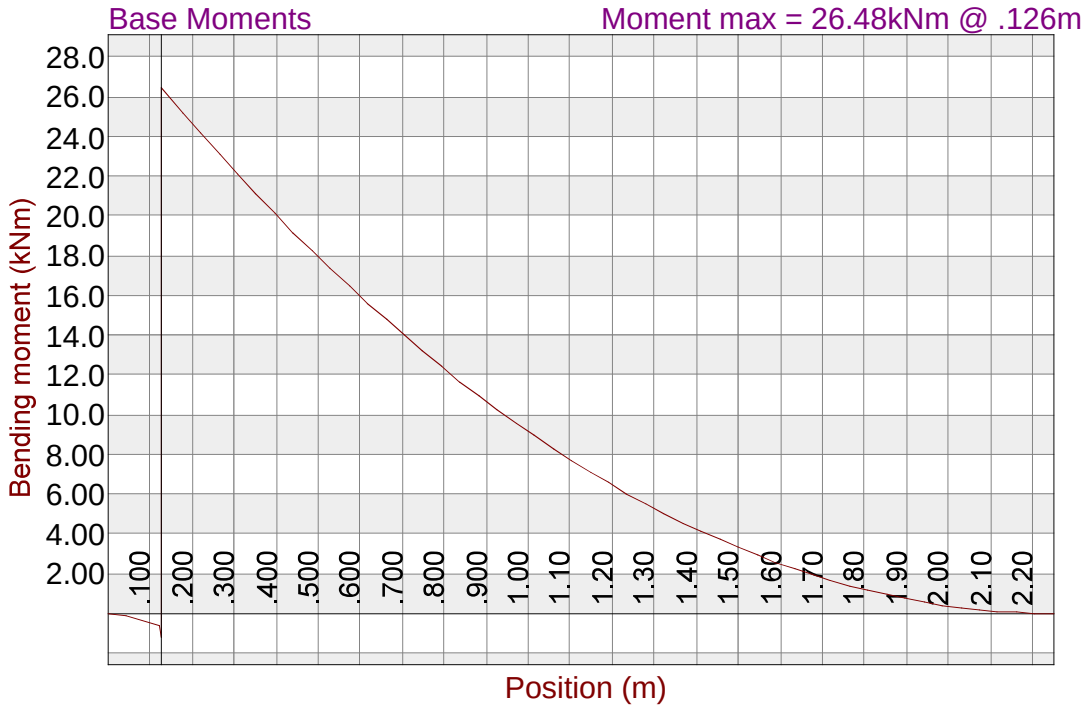
Sketch of Wall



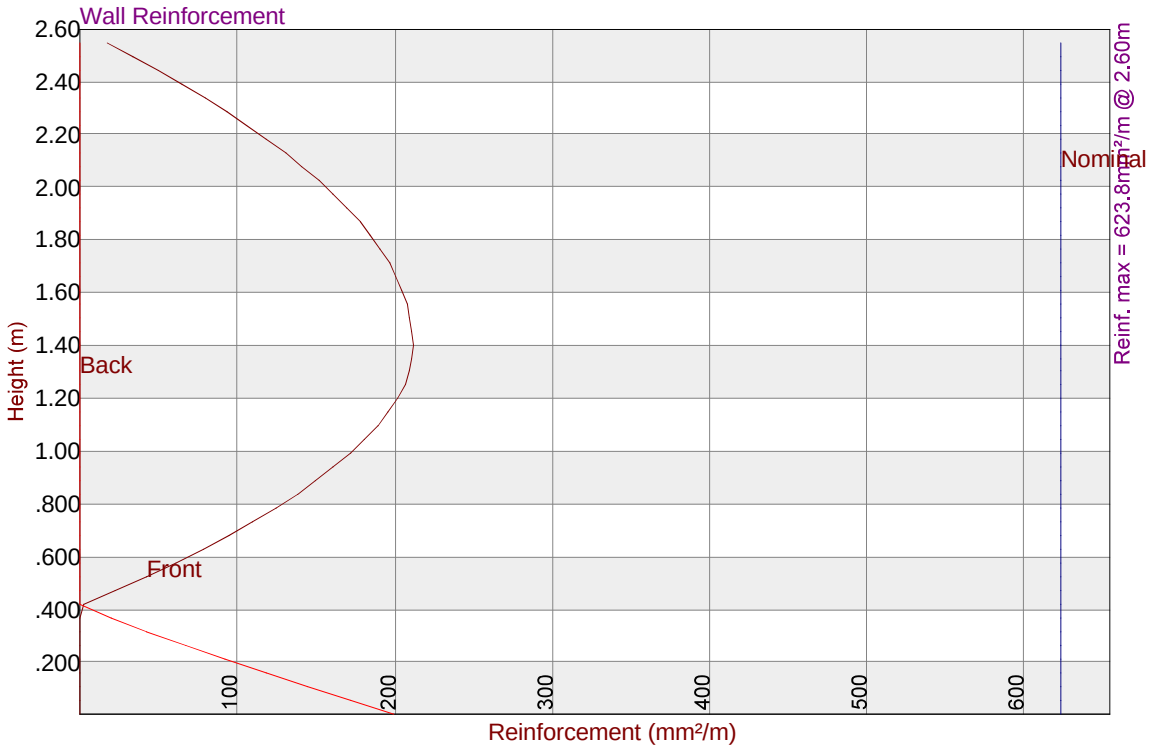
Wall Bending Moments



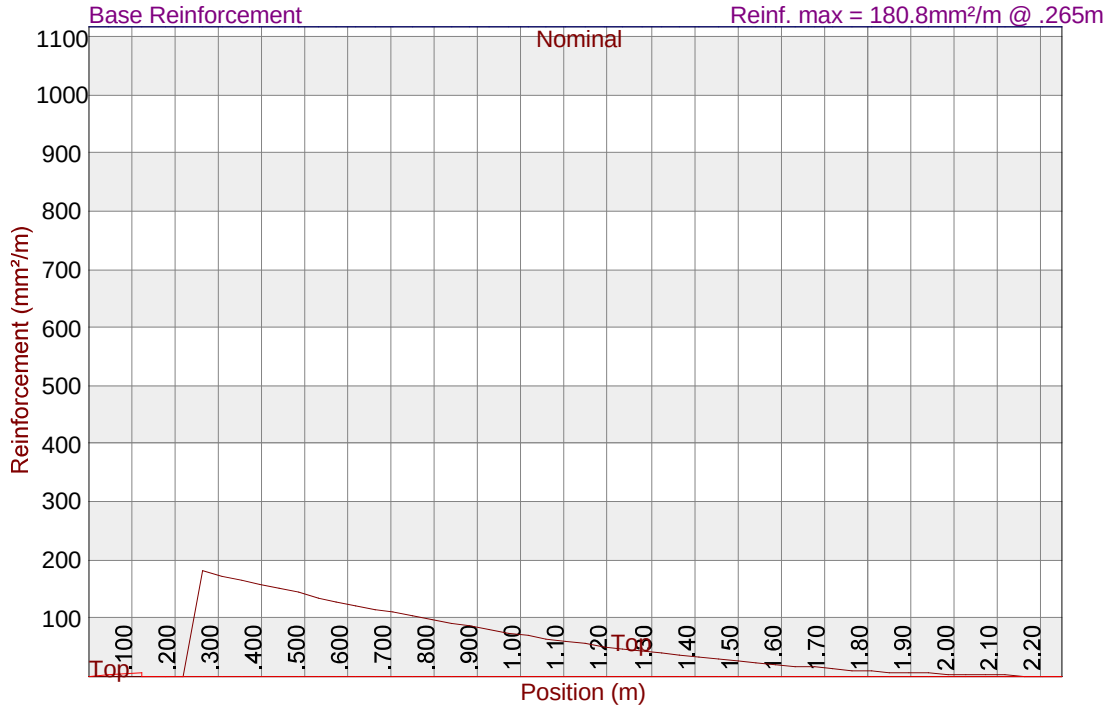
Base Bending Moments



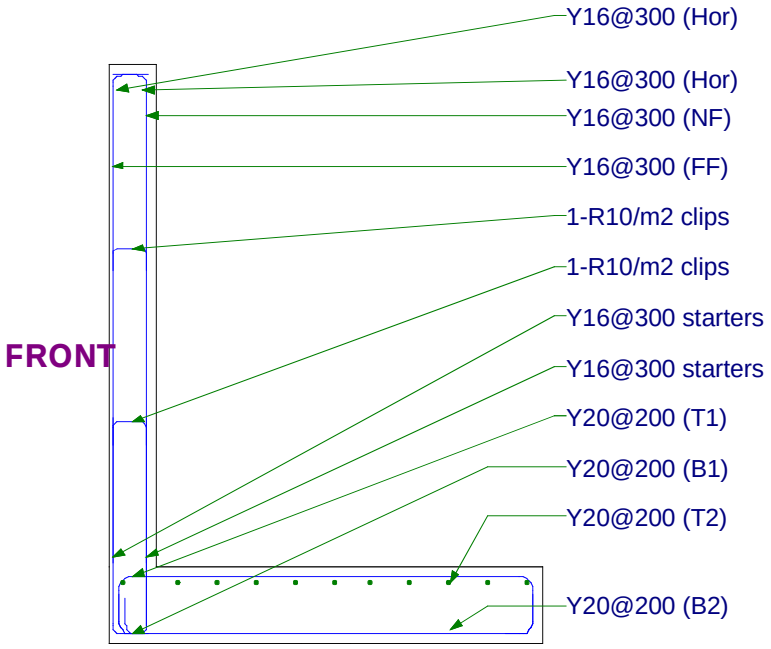
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



SECTION

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Reservoir wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1	(m)	3	C	(m)	0.4	W	(kN/m²)		Soil frict ϕ	(°)	25	SF Overt.	1.5
H2	(m)	0.67	F	(m)		P	(kN)	85	Fill slope β	(°)		SF Slip	1.5
H3	(m)	2.6	xf	(m)		xp	(m)	1	Wall frict δ	(°)		ULS DL Factor	1.4
Hw	(m)	2.6	At	(m)	0.25	L	(kN/m)		ρ Conc	kN/m³	25	ULS LL Factor	1.6
Hr	(m)	0.36	Ab	(m)	0.25	xl	(m)		ρ Soil	kN/m³	18	Pmax (kPa)	100
B	(m)		Cov wall	mm	50	Lh	(kN/m)		fcu	(MPa)	25	Soil Poisson υ	0.5
D	(m)	4.4	Cov base	mm	50	x	(m)		fy	(MPa)	420	DL Factor Ovt.	0.9

Seepage not allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:OFF

Hor Accel. (g)	
Vert Accel. (g)	
Include LL's	

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.406
Passive Pressure coefficient Kp :2.464
Base frictional constant μ :0.466

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.584	0.133	0.000	0.250
Triangular W-table press Pw	0.466	0.133	0.000	0.250
W-table pr below free water	8.633	0.200	0.000	0.250
Free water pressure Pwf	23.740	1.133	0.000	0.250
Hydrostatic pressure on bot of base: uniform portion			0.000	2.325
Hydrostatic pressure on bot of base: triangular portion			0.000	3.100
As a result of Point load P	0.000	0.400	0.000	0.250
Stabilizing forces:				
Passive pressure on base Pp	-9.954	0.223		
Weight of the wall + base			62.750	1.755
Weight of soil on the base			-0.000	2.450
Hydrostatic pressure on top of rear portion of base			94.961	2.450
Hydrostatic pressure on top of front portion of base			0.000	0.000
Point load of 85.00 kN on backfill			106.250	1.000

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 451.27 kNm
      Destabilizing moment Mo : 28.77 kNm

Safety factor against overturning = Mr/Mo = 15.684

2.Force Equilibrium at SLS

    Sum of Vertical forces Pv : 263.96 kN
  Frictional resistance Pfric : 123.09 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :   9.95 kN
=> Total Horiz. resistance Fr : 133.04 kN

     Horizontal sliding force on wall Fhw : 33.42 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh : 33.42 kN

Safety factor against overall sliding = Fr/Fh = 3.980

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.818	0.133	0.000	0.250
Triangular W-table press Pw	0.653	0.133	0.000	0.250
W-table pr below free water	12.086	0.200	0.000	0.250
Free water pressure Pwf	33.236	1.133	0.000	0.250
Hydrostatic pressure on bot of base: uniform portion			0.000	2.325
Hydrostatic pressure on bot of base: triangular portion			0.000	3.100
As a result of Point load P	0.000	0.400	0.000	0.250
Stabilizing forces:				
Passive pressure on base Pp	-8.959	0.223		
Weight of the wall + base			56.475	1.755
Weight of soil on the base			-0.000	2.450
Hydrostatic pressure on top of rear portion of base			85.465	2.450
Hydrostatic pressure on top of front portion of base			0.000	0.000
Point load of 76.50 kN on backfill			95.625	1.000

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)

where l.a. = lever arm of each force.

Stabilizing moment Mr : 406.14 kNm
Destabilizing moment Mo : 40.28 kNm

Safety factor against overturning = Mr/Mo = 10.083

2.Force Equilibrium at ULS

Sum of Vertical forces Pv : 237.56 kN
Frictional resistance Pfric : 110.78 kN
Passive Pressure on shear key : 0.00 kN
Passive pressure on base : 8.96 kN
=> Total Horiz. resistance Fr : 119.74 kN

Horizontal sliding force on wall Fhw : 46.79 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 46.79 kN

Safety factor against overall sliding = Fr/Fh = 2.559

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure :109.82 kPa
Minimum pressure : 3.71 kPa
Maximum pressure occurs at left hand side of base

***** MAXIMUM PRESSURE EXCEEDS SPECIFIED ALLOWABLE PRESSURE BY 9.8 kPa *****

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Nominal (0.13%) (mm²/m)
0.00	24.51	0.00	371.84	325.00
0.05	22.90	0.00	347.34	325.00
0.10	21.33	0.00	323.51	325.00
0.16	19.81	0.00	300.46	325.00
0.21	18.35	0.00	278.29	325.00
0.26	16.95	0.00	257.09	325.00
0.31	15.62	0.00	236.97	325.00
0.36	14.37	0.00	217.92	325.00
0.42	13.18	0.00	199.92	325.00
0.47	12.06	0.00	182.95	325.00
0.52	11.01	0.00	166.96	325.00
0.57	10.02	0.00	151.93	325.00
0.62	9.09	0.00	137.83	325.00
0.68	8.22	0.00	124.63	325.00
0.73	7.40	0.00	112.31	325.00
0.78	6.65	0.00	100.82	325.00
0.83	5.94	0.00	90.14	325.00
0.88	5.29	0.00	80.25	325.00
0.94	4.69	0.00	71.11	325.00
0.99	4.13	0.00	62.69	325.00
1.04	3.62	0.00	54.96	325.00
1.09	3.16	0.00	47.90	325.00
1.14	2.73	0.00	41.46	325.00
1.20	2.35	0.00	35.64	325.00
1.25	2.00	0.00	30.38	325.00
1.30	1.69	0.00	25.67	325.00
1.35	1.42	0.00	21.47	325.00
1.40	1.17	0.00	17.76	325.00
1.46	0.96	0.00	14.50	325.00
1.51	0.77	0.00	11.67	325.00
1.56	0.61	0.00	9.23	325.00
1.61	0.47	0.00	7.16	325.00
1.66	0.36	0.00	5.42	325.00
1.72	0.26	0.00	3.99	325.00
1.77	0.19	0.00	2.84	325.00

1.82	0.13	0.00	1.93	325.00
1.87	0.08	0.00	1.24	325.00
1.92	0.05	0.00	0.74	325.00
1.98	0.03	0.00	0.40	325.00
2.03	0.01	0.00	0.18	325.00
2.08	0.00	0.00	0.06	325.00
2.13	0.00	0.00	0.01	325.00
2.18	0.00	0.00	0.00	325.00
2.24	0.00	0.00	0.00	325.00
2.29	0.00	0.00	0.00	325.00
2.34	0.00	0.00	0.00	325.00
2.39	0.00	0.00	0.00	325.00
2.44	0.00	0.00	0.00	325.00
2.50	0.00	0.00	0.00	325.00
2.55	0.00	0.00	0.00	325.00
2.60	0.00	0.00	0.00	325.00

BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

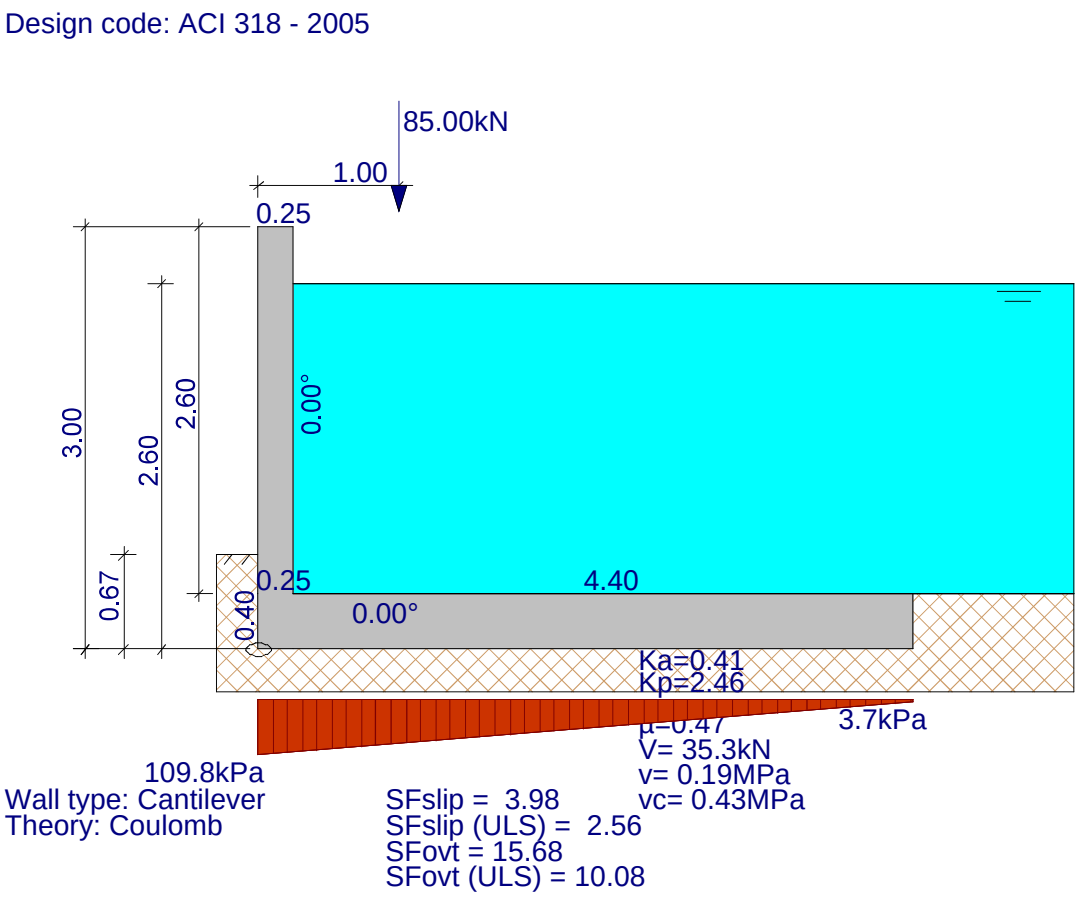
Position from left (m)	Moment (kNm)	Top Reinforcing (mm²/m)	Bot Reinforcing (mm²/m)	Nominal (0.13%) (mm²/m)
0.00	-0.00	0.00	0.00	520.00
0.09	-0.63	0.00	5.31	520.00
0.19	-1.18	0.00	0.00	520.00
0.28	36.47	0.00	0.00	520.00
0.37	34.12	289.20	0.00	520.00
0.47	32.71	277.27	0.00	520.00
0.56	31.33	265.60	0.00	520.00
0.65	29.98	254.18	0.00	520.00
0.74	28.67	243.01	0.00	520.00
0.84	27.38	232.09	0.00	520.00
0.93	26.12	221.42	0.00	520.00
1.02	24.89	211.00	0.00	520.00
1.12	23.69	200.83	0.00	520.00
1.21	22.52	190.92	0.00	520.00
1.30	21.38	181.25	0.00	520.00
1.40	20.27	171.84	0.00	520.00
1.49	19.19	162.67	0.00	520.00
1.58	18.14	153.76	0.00	520.00
1.67	17.12	145.10	0.00	520.00
1.77	16.12	136.69	0.00	520.00
1.86	15.16	128.53	0.00	520.00
1.95	14.23	120.62	0.00	520.00
2.05	13.33	112.97	0.00	520.00
2.14	12.45	105.56	0.00	520.00
2.23	11.61	98.41	0.00	520.00
2.33	10.79	91.50	0.00	520.00
2.42	10.01	84.85	0.00	520.00
2.51	9.25	78.45	0.00	520.00
2.60	8.53	72.30	0.00	520.00
2.70	7.83	66.40	0.00	520.00
2.79	7.17	60.75	0.00	520.00
2.88	6.53	55.35	0.00	520.00
2.98	5.92	50.21	0.00	520.00
3.07	5.35	45.31	0.00	520.00
3.16	4.80	40.67	0.00	520.00
3.26	4.28	36.28	0.00	520.00
3.35	3.79	32.13	0.00	520.00
3.44	3.33	28.24	0.00	520.00
3.53	2.90	24.60	0.00	520.00
3.63	2.50	21.21	0.00	520.00
3.72	2.13	18.07	0.00	520.00
3.81	1.79	15.19	0.00	520.00
3.91	1.48	12.55	0.00	520.00
4.00	1.20	10.17	0.00	520.00
4.09	0.95	8.03	0.00	520.00
4.19	0.73	6.15	0.00	520.00
4.28	0.53	4.52	0.00	520.00

4.37	0.37	3.14	0.00	520.00
4.46	0.24	2.01	0.00	520.00
4.56	0.13	1.13	0.00	520.00
4.65	0.06	0.50	0.00	520.00

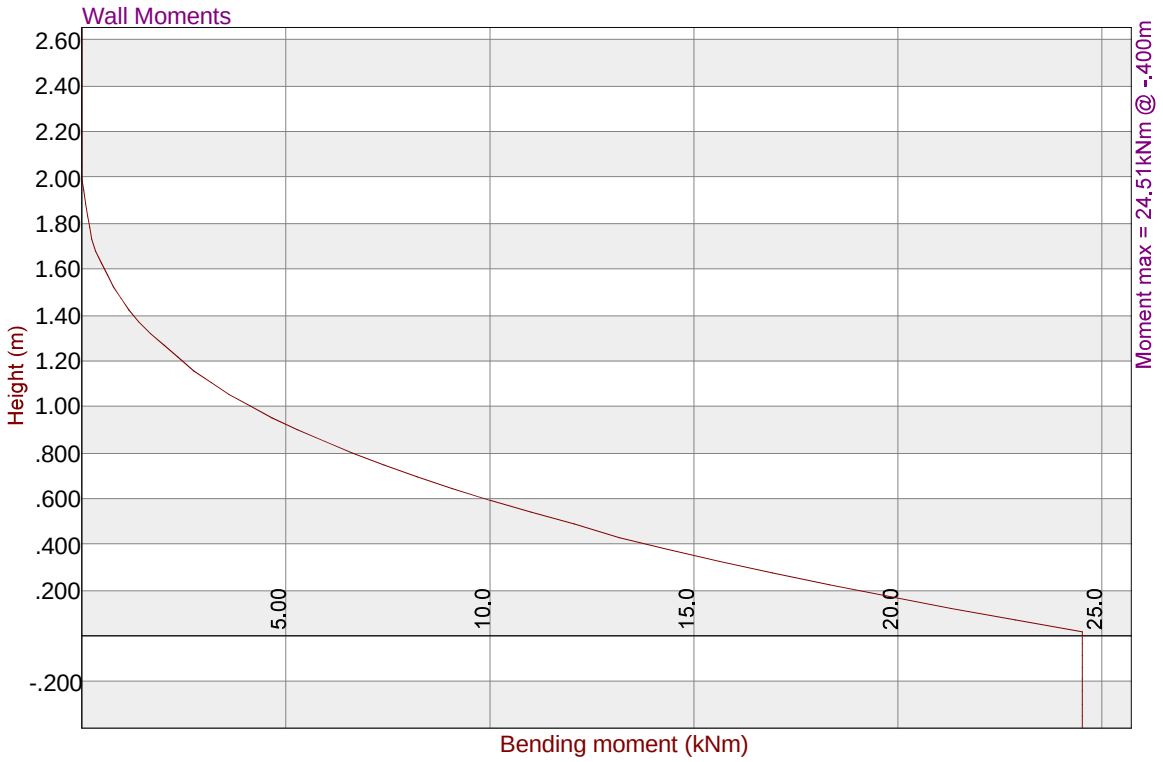
SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

```
 Shear force at bottom of wall V =  35.3 kN
Shear stress at bottom of wall v = 0.19 MPa OK
       Allowable shear stress vc = 0.43 MPa (based on Wall tensile reinf.)
```

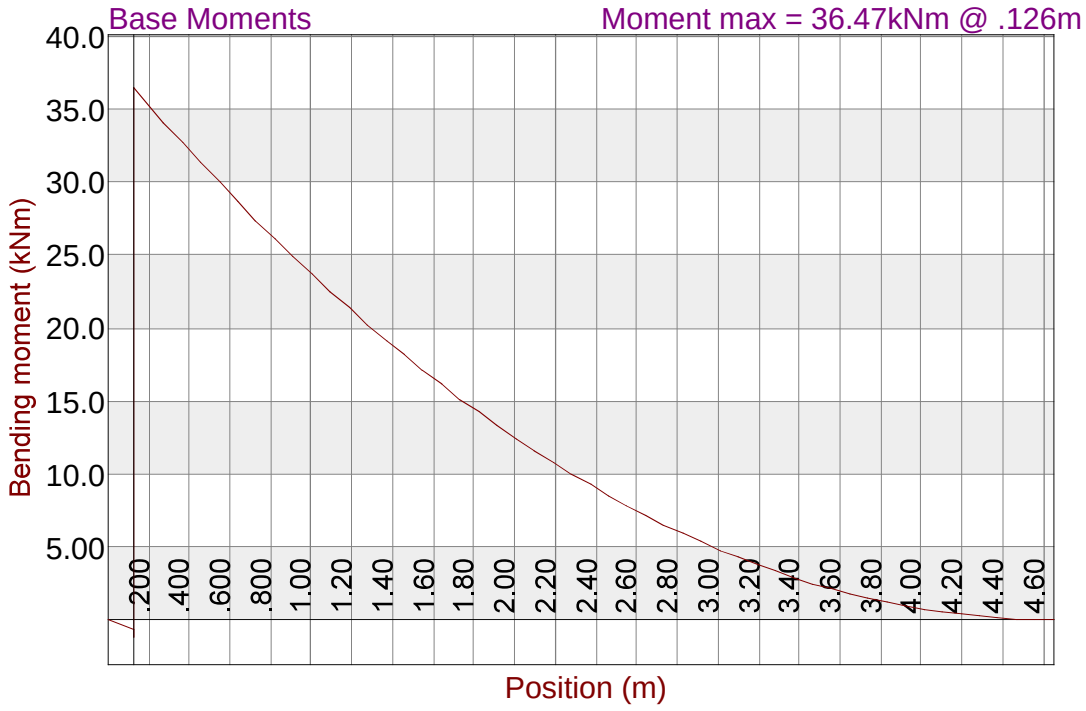
Sketch of Wall



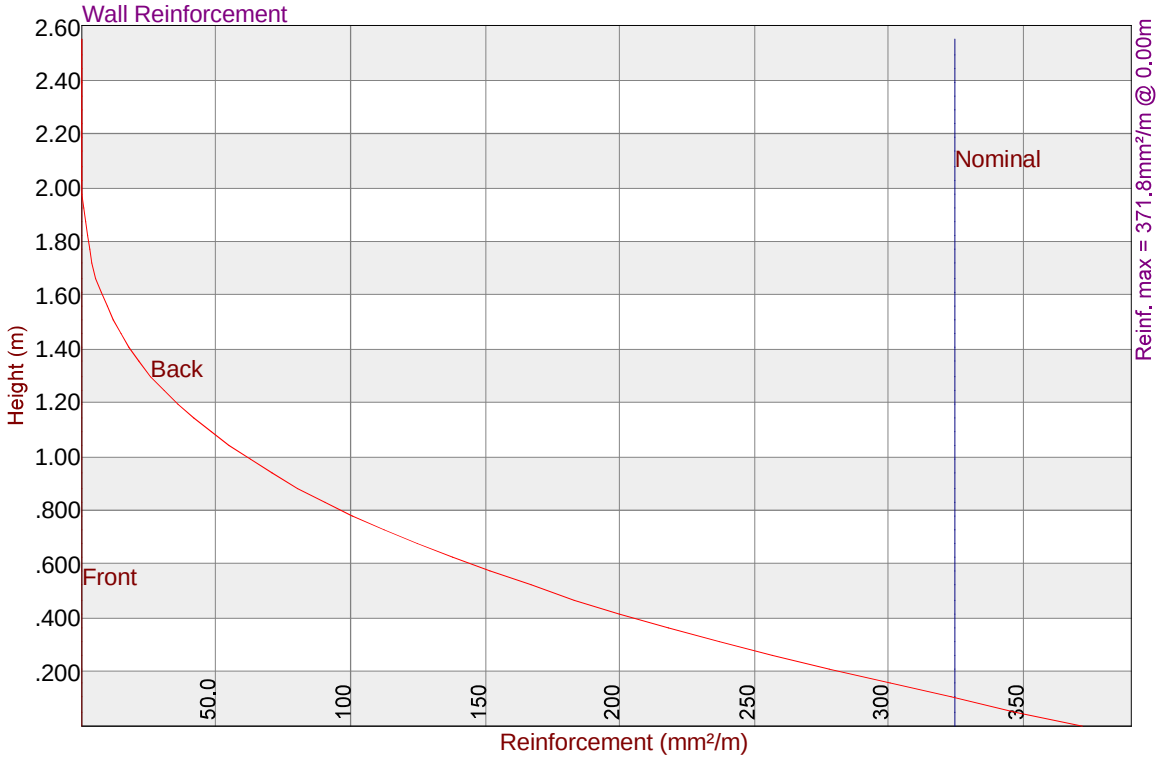
Wall Bending Moments



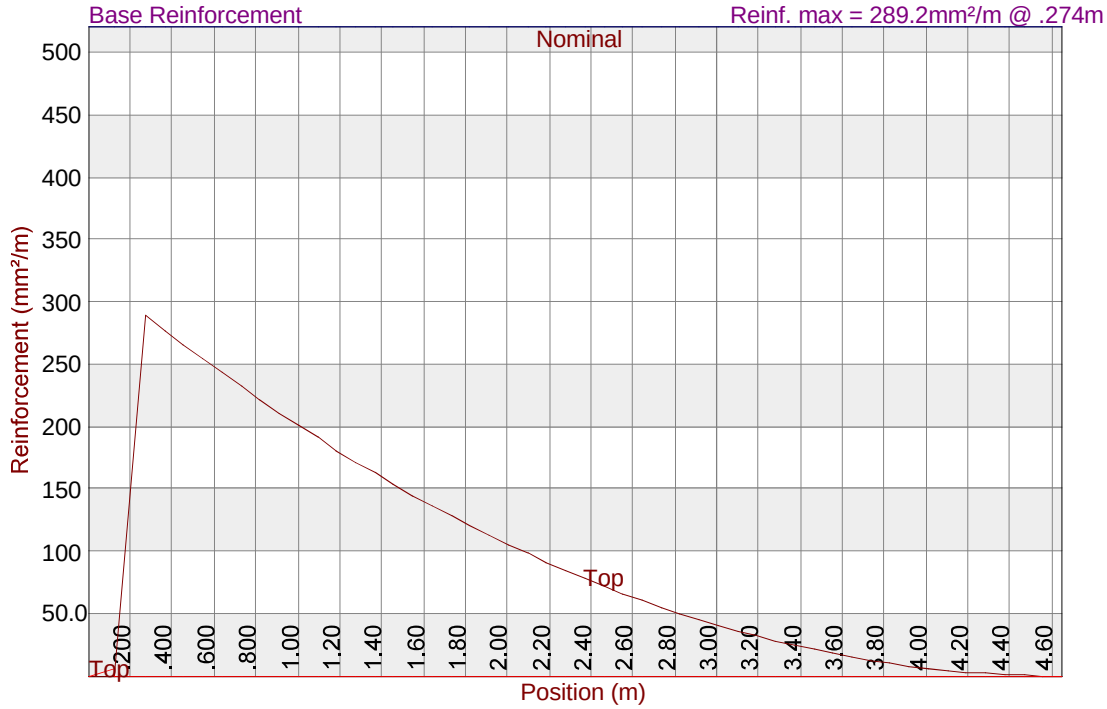
Base Bending Moments



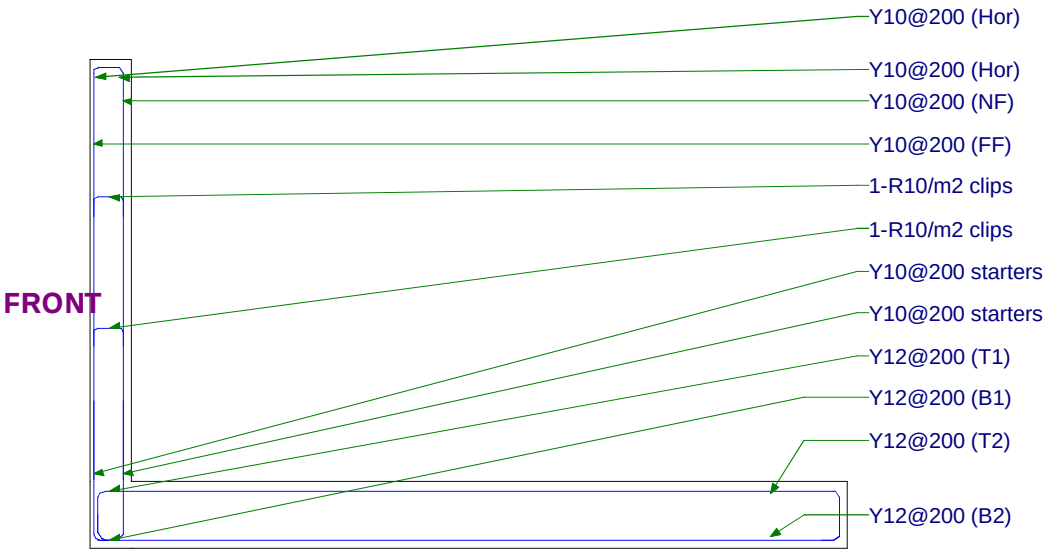
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



SECTION

4) ②VALVE CHAMBER

WALL (H2.5m)

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Propped cantilever exam

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1 (m)	2.5	C (m)	0.4	W (kN/m²)	20	Soil frict ϕ (°)	30	SF Overt.	1.5
H2 (m)	0.6	F (m)	0	P (kN)	85	Fill slope β (°)	0	SF Slip	1.5
H3 (m)	0	xf (m)	0	xp (m)	1	Wall frict δ (°)	15	ULS DL Factor	1.4
Hw (m)	0	At (m)	0.25	L (kN/m)	0	ρ Conc kN/m³	25	ULS LL Factor	1.6
Hr (m)	0	Ab (m)	0.25	xl (m)	0	ρ Soil kN/m³	18	Pmax (kPa)	100
B (m)	0	Cov wall mm	50	Lh (kN/m)	1	fcu (MPa)	25	Soil Poisson υ	0.5
D (m)	4.4	Cov base mm	50	x (m)	0	fy (MPa)	420	DL Factor Ovt.	0.9

Seepage allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Propped cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:ON

Hor Accel. (g)	0.02
Vert Accel. (g)	0.01
Include LL's	Y

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.301
Passive Pressure coefficient Kp :4.977
Seismic Active Pressure coefficient Kas :0.317
Seismic Passive Pressure coefficient Kps :4.845
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

	FORCES (kN) and their LEVER ARMS (m)			
Description	F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	17.215	0.866	4.613	0.250
Siesmic component of Pa	0.838	1.500	0.225	0.250
As a result of surcharge w	15.149	1.250	4.059	0.250
As a result of Point load P	7.217	1.689	0.000	0.250
Siesmic wall inertia	1.181	0.475		
Stabilizing forces:				
Passive pressure on base Pp	-15.697	0.196		
Siesmic component of Pp	0.426	0.360		
Weight of the wall + base			59.029	1.841
Weight of soil on the base			164.657	2.450
Point load of 85.00 kN on backfill			17.000	1.000
UDL of 20.0 kPa			87.120	2.450
Applied horiz. Line Load	1.000	2.500		

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Force Equilibrium at SLS

```
    Sum of Vertical forces Pv : 336.31 kN
  Frictional resistance Pfric : 194.17 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :  15.70 kN
   Horizontal reaction at top :   9.08 kN
=> Total Horiz. resistance Fr : 218.95 kN

  => Horizontal resistance at base Fr(base) : 210.86 kN
  Reaction at base                          :  31.68 kN
Safety factor against base sliding = Fr(base)/Reaction(base) = 6.656
```

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
	FORCES (kN) and their LEVER ARMS (m)			
Destabilizing forces:				
Total Active pressure Pa	24.369	0.870	6.458	0.250
Siesmic component of Pa	1.341	1.500	0.359	0.250
As a result of surcharge w	24.239	1.250	6.495	0.250
As a result of Point load P	11.547	1.689	0.000	0.250
Siesmic wall inertia	1.889	0.475		
Stabilizing forces:				
Passive pressure on base Pp	-14.128	0.196		
Siesmic component of Pp	0.384	0.360		
Weight of the wall + base			53.126	1.841
Weight of soil on the base			148.191	2.450
Point load of 76.50 kN on backfill			15.300	1.000
UDL of 18.0 kPa			78.408	2.450
Applied horiz. Line Load	0.900	2.500		

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Force Equilibrium at ULS

```
    Sum of Vertical forces Pv : 302.68 kN
  Frictional resistance Pfric : 174.75 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :  14.13 kN
   Horizontal reaction at top :  13.94 kN
=> Total Horiz. resistance Fr : 202.82 kN

  => Horizontal resistance at base Fr(base) : 189.78 kN
  Reaction at base                          :  48.10 kN
Safety factor against base sliding = Fr(base)/Reaction(base) = 3.945
```

SOIL PRESSURES UNDER BASE AT SLS

```
Maximum pressure : 87.79 kPa
Minimum pressure : 56.86 kPa
Maximum pressure occurs at left hand side of base
```

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Nominal (0.13%) (mm²/m)
0.00	15.66	0.00	237.55	325.00
0.04	14.38	0.00	218.12	325.00
0.08	13.11	0.00	198.82	325.00
0.13	11.85	0.00	179.80	325.00
0.17	10.62	0.00	161.17	325.00
0.21	9.43	0.00	143.07	325.00
0.25	8.28	0.00	125.58	325.00
0.29	7.17	0.00	108.71	325.00

0.34	6.09	0.00	92.45	325.00
0.38	5.06	0.00	76.79	325.00
0.42	4.07	0.00	61.72	325.00
0.46	3.11	0.00	47.24	325.00
0.50	2.20	0.00	33.34	325.00
0.55	1.32	0.00	20.01	325.00
0.59	0.48	0.00	7.24	325.00
0.63	-0.33	4.98	0.00	325.00
0.67	-1.10	16.64	0.00	325.00
0.71	-1.83	27.77	0.00	325.00
0.76	-2.53	38.36	0.00	325.00
0.80	-3.19	48.43	0.00	325.00
0.84	-3.82	57.98	0.00	325.00
0.88	-4.42	67.03	0.00	325.00
0.92	-4.98	75.57	0.00	325.00
0.97	-5.51	83.62	0.00	325.00
1.01	-6.01	91.18	0.00	325.00
1.05	-6.48	98.26	0.00	325.00
1.09	-6.91	104.87	0.00	325.00
1.13	-7.32	111.02	0.00	325.00
1.18	-7.69	116.71	0.00	325.00
1.22	-8.04	121.95	0.00	325.00
1.26	-8.36	126.75	0.00	325.00
1.30	-8.49	128.86	0.00	325.00
1.34	-8.27	125.45	0.00	325.00
1.39	-8.02	121.62	0.00	325.00
1.43	-7.74	117.38	0.00	325.00
1.47	-7.43	112.73	0.00	325.00
1.51	-7.10	107.70	0.00	325.00
1.55	-6.74	102.27	0.00	325.00
1.60	-6.36	96.47	0.00	325.00
1.64	-5.95	90.29	0.00	325.00
1.68	-5.52	83.75	0.00	325.00
1.72	-5.07	76.85	0.00	325.00
1.76	-4.59	69.61	0.00	325.00
1.81	-4.09	62.02	0.00	325.00
1.85	-3.57	54.10	0.00	325.00
1.89	-3.02	45.85	0.00	325.00
1.93	-2.46	37.29	0.00	325.00
1.97	-1.87	28.41	0.00	325.00
2.02	-1.27	19.24	0.00	325.00
2.06	-0.64	9.76	0.00	325.00
2.10	0.00	0.00	0.00	325.00

BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Nominal (0.13%) (mm^2/m)
0.00	-0.00	0.00	0.00	520.00
0.09	-0.48	0.00	4.06	520.00
0.19	-0.90	0.00	0.00	520.00
0.28	25.77	0.00	0.00	520.00
0.37	24.11	204.37	0.00	520.00
0.47	23.11	195.94	0.00	520.00
0.56	22.14	187.69	0.00	520.00
0.65	21.19	179.62	0.00	520.00
0.74	20.26	171.73	0.00	520.00
0.84	19.35	164.01	0.00	520.00
0.93	18.46	156.47	0.00	520.00
1.02	17.59	149.11	0.00	520.00
1.12	16.74	141.92	0.00	520.00
1.21	15.92	134.92	0.00	520.00
1.30	15.11	128.09	0.00	520.00
1.40	14.32	121.43	0.00	520.00
1.49	13.56	114.96	0.00	520.00
1.58	12.82	108.66	0.00	520.00
1.67	12.10	102.54	0.00	520.00
1.77	11.39	96.60	0.00	520.00

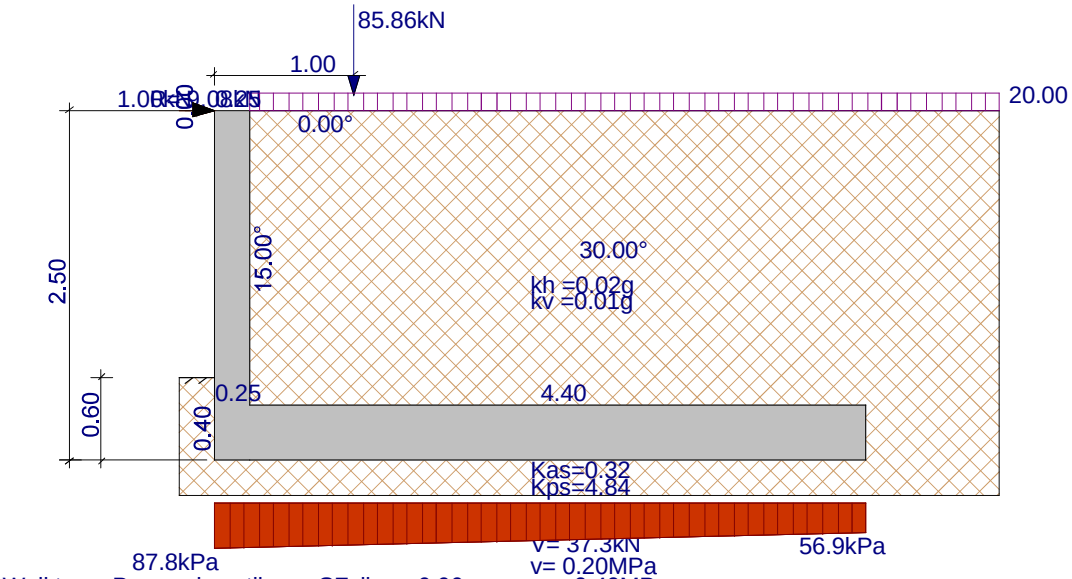
1.86	10.71	90.83	0.00	520.00
1.95	10.06	85.24	0.00	520.00
2.05	9.42	79.83	0.00	520.00
2.14	8.80	74.60	0.00	520.00
2.23	8.20	69.54	0.00	520.00
2.33	7.63	64.66	0.00	520.00
2.42	7.07	59.96	0.00	520.00
2.51	6.54	55.44	0.00	520.00
2.60	6.03	51.09	0.00	520.00
2.70	5.54	46.92	0.00	520.00
2.79	5.06	42.93	0.00	520.00
2.88	4.61	39.12	0.00	520.00
2.98	4.19	35.48	0.00	520.00
3.07	3.78	32.02	0.00	520.00
3.16	3.39	28.74	0.00	520.00
3.26	3.02	25.63	0.00	520.00
3.35	2.68	22.71	0.00	520.00
3.44	2.35	19.96	0.00	520.00
3.53	2.05	17.39	0.00	520.00
3.63	1.77	14.99	0.00	520.00
3.72	1.51	12.77	0.00	520.00
3.81	1.27	10.73	0.00	520.00
3.91	1.05	8.87	0.00	520.00
4.00	0.85	7.18	0.00	520.00
4.09	0.67	5.68	0.00	520.00
4.19	0.51	4.35	0.00	520.00
4.28	0.38	3.19	0.00	520.00
4.37	0.26	2.22	0.00	520.00
4.46	0.17	1.42	0.00	520.00
4.56	0.09	0.80	0.00	520.00
4.65	0.04	0.35	0.00	520.00

SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

Shear force at bottom of wall V = 37.3 kN
Shear stress at bottom of wall v = 0.20 MPa OK
Allowable shear stress vc = 0.40 MPa (based on Wall tensile reinf.)

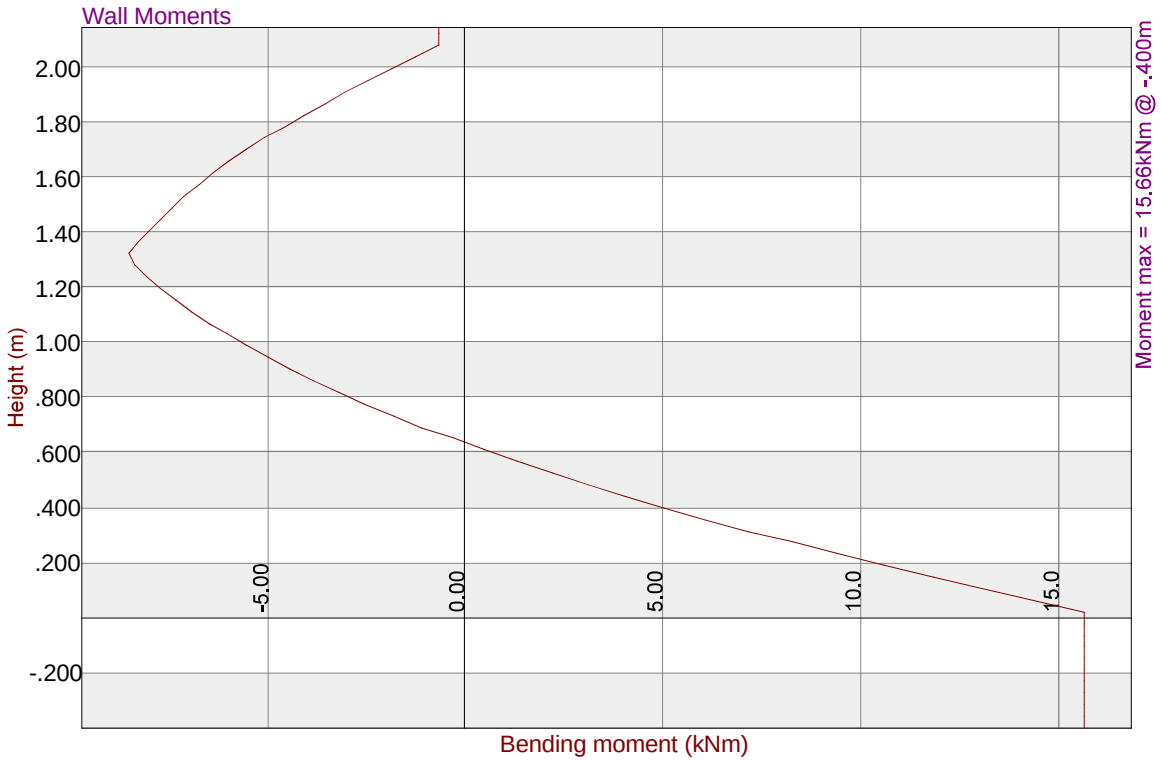
Sketch of Wall

Design code: ACI 318 - 2005

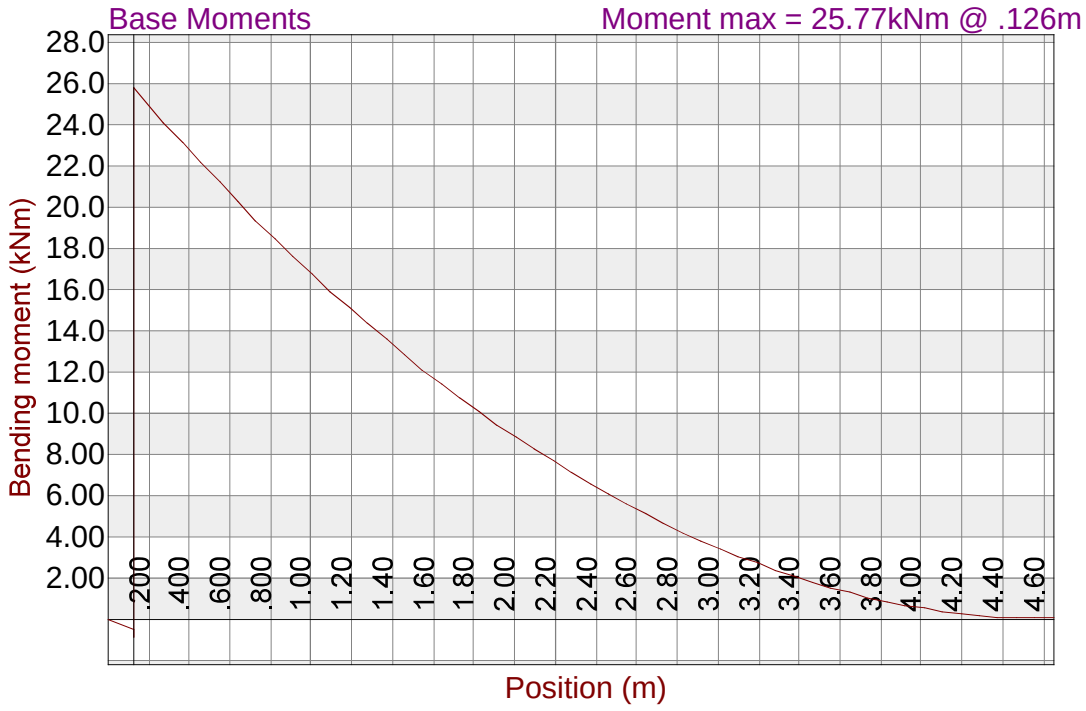


Wall type: Propped cantilever SFslip = 6.66
Theory: Coulomb SFslip (ULS) = 3.95

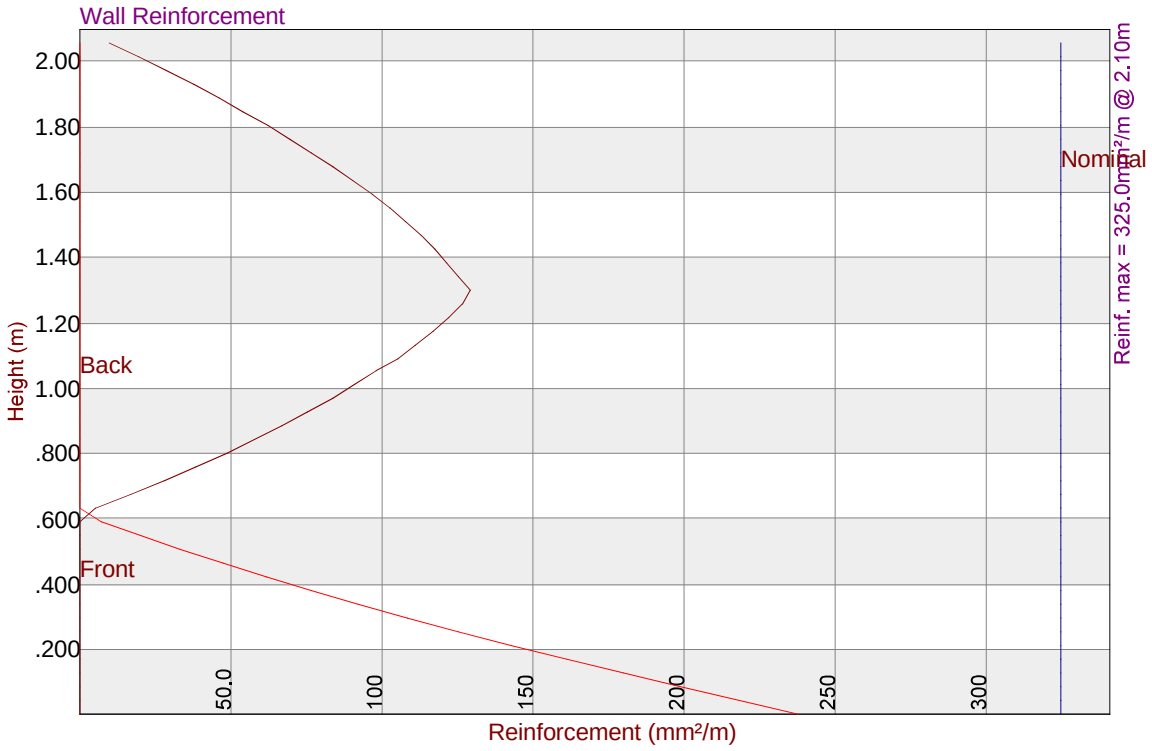
Wall Bending Moments



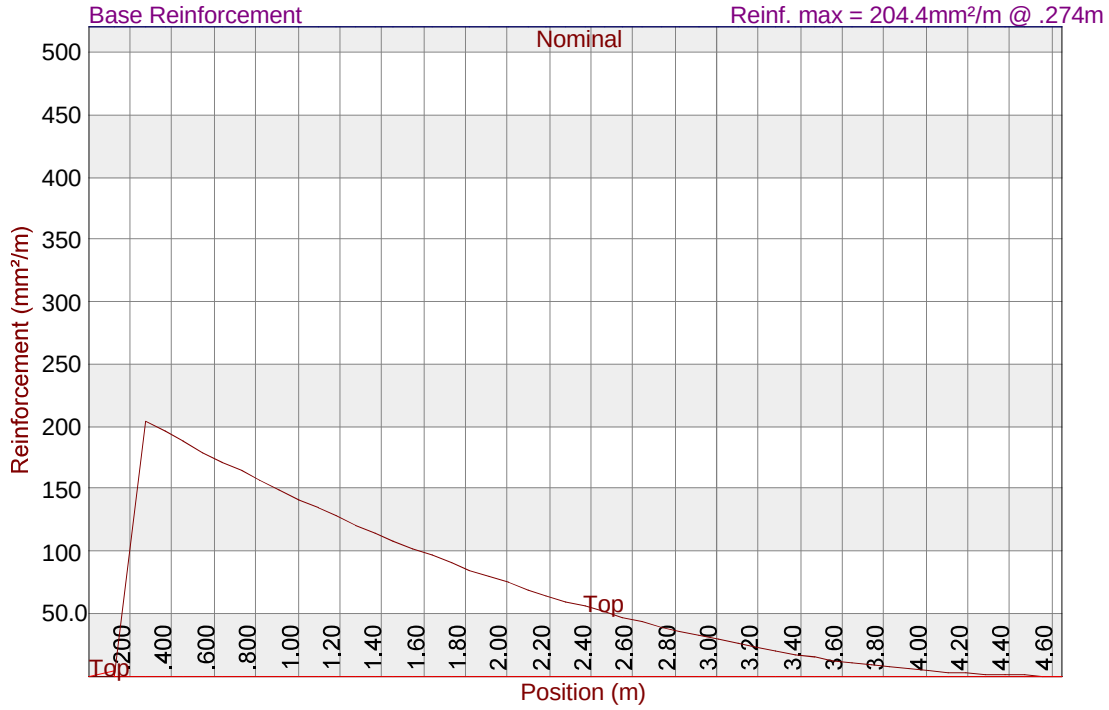
Base Bending Moments



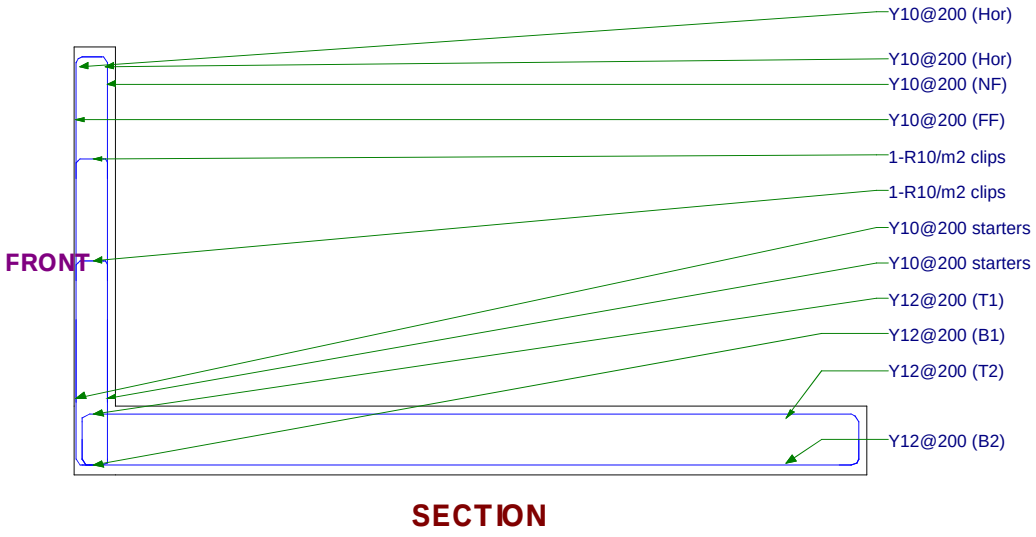
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



SECTION

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Cantilever wall example

Input Data

C14

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1 (m)	2.5	C (m)	0.6	W	(kN/m²)	20	Soil frict ϕ	(°)	30	SF Overt.	1.5
H2 (m)	0	F (m)	0	P	(kN)		Fill slope β	(°)	0	SF Slip	1.5
H3 (m)	0	xf (m)	1.5	xp	(m)		Wall frict δ	(°)	20	ULS DL Factor	1.2
Hw (m)	0	At (m)	0.5	L	(kN/m)		ρ Conc	kN/m³	25	ULS LL Factor	1.6
Hr (m)	0.36	Ab (m)	0.5	xl	(m)		ρ Soil	kN/m³	18	Pmax (kPa)	100
B (m)	4.4	Cov wall	mm	50	Lh	(kN/m)	0	fcu	(MPa)	25	Soil Poisson υ	0.5
D (m)	0	Cov base	mm	50	x	(m)	0	fy	(MPa)	420	DL Factor Ovt.	0.9

Seepage allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:ON

Hor Accel. (g)	0.02
Vert Accel. (g)	0.01
Include LL's	Y

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.297
Passive Pressure coefficient Kp :6.105
Seismic Active Pressure coefficient Kas :0.313
Seismic Passive Pressure coefficient Kps :5.934
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	16.546	0.867	6.022	4.900
Siesmic component of Pa	0.830	1.500	0.302	4.900
As a result of surcharge w	14.560	1.250	5.299	4.900
Siesmic wall inertia	1.926	0.605		
Stabilizing forces:				
Passive pressure on base Pp	-0.000	0.000		
Siesmic component of Pp	-0.000	0.000		
Weight of the wall + base			96.278	2.987
Weight of soil on the base			0.000	0.000
UDL of 19.8 kPa			0.000	4.900

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:

Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 287.61 kNm
Destabilizing moment Mo : -21.77 kNm

Safety factor against overturning = Mr/Mo = -13.212

***** SAFETY FACTOR IS LOWER THAN SPECIFIED MINIMUM OF 1.5 *****

2.Force Equilibrium at SLS

Sum of Vertical forces Pv : 107.60 kN
Frictional resistance Pfric : 62.12 kN
Passive Pressure on shear key : 0.00 kN
Passive pressure on base : 0.00 kN
=> Total Horiz. resistance Fr : 62.12 kN

Horizontal sliding force on wall Fhw : 33.03 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 33.03 kN

Safety factor against overall sliding = Fr/Fh = 1.881

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	20.386	0.877	7.226	4.900
Siesmic component of Pa	1.328	1.500	0.483	4.900
As a result of surcharge w	23.296	1.250	8.479	4.900
Siesmic wall inertia	3.081	0.605		
Stabilizing forces:				
Passive pressure on base Pp	-0.000	0.000		
Siesmic component of Pp	-0.000	0.000		
Weight of the wall + base			86.650	2.987
Weight of soil on the base			0.000	0.000
UDL of 17.8 kPa			0.000	4.900

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 258.85 kNm
Destabilizing moment Mo : -28.10 kNm

Safety factor against overturning = Mr/Mo = -9.212

***** SAFETY FACTOR IS LOWER THAN 1.00 *****

2.Force Equilibrium at ULS

Sum of Vertical forces Pv : 96.84 kN

Frictional resistance Pfric : 55.91 kN
Passive Pressure on shear key : 0.00 kN
Passive pressure on base : 0.00 kN
=> Total Horiz. resistance Fr : 55.91 kN

Horizontal sliding force on wall Fhw : 46.76 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 46.76 kN

Safety factor against overall sliding = Fr/Fh = 1.196

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure : 33.39 kPa
Minimum pressure : 10.52 kPa
Maximum pressure occurs at right hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Nominal (0.13%) (mm²/m)
0.00	23.73	0.00	155.45	650.00
0.04	22.68	0.00	148.56	650.00
0.08	21.65	0.00	141.84	650.00
0.11	20.66	0.00	135.31	650.00
0.15	19.69	0.00	128.96	650.00
0.19	18.75	0.00	122.79	650.00
0.23	17.83	0.00	116.80	650.00
0.27	16.94	0.00	110.98	650.00
0.30	16.08	0.00	105.33	650.00
0.34	15.24	0.00	99.86	650.00
0.38	14.43	0.00	94.55	650.00
0.42	13.65	0.00	89.42	650.00
0.46	12.89	0.00	84.44	650.00
0.49	12.16	0.00	79.64	650.00
0.53	11.45	0.00	74.99	650.00
0.57	10.76	0.00	70.50	650.00
0.61	10.10	0.00	66.18	650.00
0.65	9.47	0.00	62.00	650.00
0.68	8.85	0.00	57.99	650.00
0.72	8.26	0.00	54.12	650.00
0.76	7.70	0.00	50.41	650.00
0.80	7.15	0.00	46.85	650.00
0.84	6.63	0.00	43.43	650.00
0.87	6.13	0.00	40.16	650.00
0.91	5.65	0.00	37.03	650.00
0.95	5.20	0.00	34.04	650.00
0.99	4.76	0.00	31.20	650.00
1.03	4.35	0.00	28.49	650.00
1.06	3.96	0.00	25.91	650.00
1.10	3.58	0.00	23.48	650.00
1.14	3.23	0.00	21.17	650.00
1.18	2.90	0.00	18.99	650.00
1.22	2.59	0.00	16.95	650.00
1.25	2.29	0.00	15.03	650.00
1.29	2.02	0.00	13.23	650.00
1.33	1.76	0.00	11.56	650.00
1.37	1.53	0.00	10.01	650.00
1.41	1.31	0.00	8.58	650.00
1.44	1.11	0.00	7.27	650.00
1.48	0.93	0.00	6.07	650.00
1.52	0.76	0.00	4.98	650.00
1.56	0.61	0.00	4.01	650.00
1.60	0.48	0.00	3.15	650.00
1.63	0.37	0.00	2.40	650.00
1.67	0.27	0.00	1.75	650.00
1.71	0.18	0.00	1.21	650.00
1.75	0.12	0.00	0.77	650.00

1.79	0.07	0.00	0.43	650.00
1.82	0.03	0.00	0.19	650.00
1.86	0.01	0.00	0.05	650.00
1.90	0.00	0.00	0.00	650.00

BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

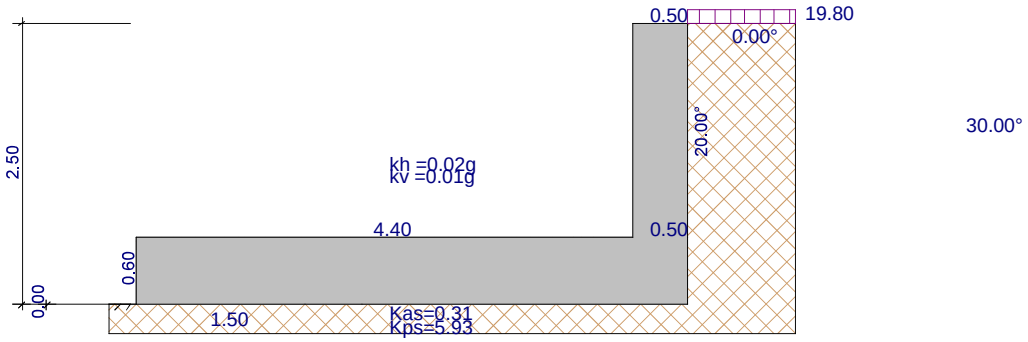
Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Nominal (0.13%) (mm^2/m)
0.00	-0.00	0.00	0.00	780.00
0.10	-0.02	0.00	0.10	780.00
0.20	-0.08	0.00	0.42	780.00
0.29	-0.18	0.00	0.94	780.00
0.39	-0.31	0.00	1.66	780.00
0.49	-0.49	0.00	2.60	780.00
0.59	-0.70	0.00	3.74	780.00
0.69	-0.95	0.00	5.09	780.00
0.78	-1.25	0.00	6.65	780.00
0.88	-1.58	0.00	8.42	780.00
0.98	-1.95	0.00	10.39	780.00
1.08	-2.36	0.00	12.57	780.00
1.18	-2.80	0.00	14.96	780.00
1.27	-3.29	0.00	17.56	780.00
1.37	-3.82	0.00	20.37	780.00
1.47	-4.38	0.00	23.38	780.00
1.57	-4.98	0.00	26.60	780.00
1.67	-5.63	0.00	30.03	780.00
1.76	-6.31	0.00	33.67	780.00
1.86	-7.03	0.00	37.51	780.00
1.96	-7.79	0.00	41.56	780.00
2.06	-8.59	0.00	45.83	780.00
2.16	-9.42	0.00	50.29	780.00
2.25	-10.30	0.00	54.97	780.00
2.35	-11.21	0.00	59.85	780.00
2.45	-12.17	0.00	64.94	780.00
2.55	-13.16	0.00	70.24	780.00
2.65	-14.19	0.00	75.75	780.00
2.74	-15.26	0.00	81.47	780.00
2.84	-16.37	0.00	87.39	780.00
2.94	-17.52	0.00	93.52	780.00
3.04	-18.71	0.00	99.86	780.00
3.14	-19.94	0.00	106.41	780.00
3.23	-21.20	0.00	113.16	780.00
3.33	-22.51	0.00	120.12	780.00
3.43	-23.85	0.00	127.29	780.00
3.53	-25.23	0.00	134.67	780.00
3.63	-26.65	0.00	142.26	780.00
3.72	-28.11	0.00	150.05	780.00
3.82	-29.61	0.00	158.05	780.00
3.92	-31.15	0.00	166.26	780.00
4.02	-32.73	0.00	174.68	780.00
4.12	-34.34	0.00	183.30	780.00
4.21	-36.00	0.00	192.13	780.00
4.31	-37.69	0.00	201.17	780.00
4.41	-39.42	0.00	210.42	780.00
4.51	-41.20	0.00	219.88	780.00
4.61	-43.01	0.00	229.54	780.00
4.70	-44.86	0.00	239.41	780.00
4.80	-45.60	0.00	0.00	780.00
4.90	-1.30	0.00	0.00	780.00

SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

Shear force at bottom of wall V = 32.6 kN
Shear stress at bottom of wall v = 0.07 MPa OK
Allowable shear stress vc = 0.34 MPa (based on Wall tensile reinf.)

Sketch of Wall

Design code: ACI 318 - 2005

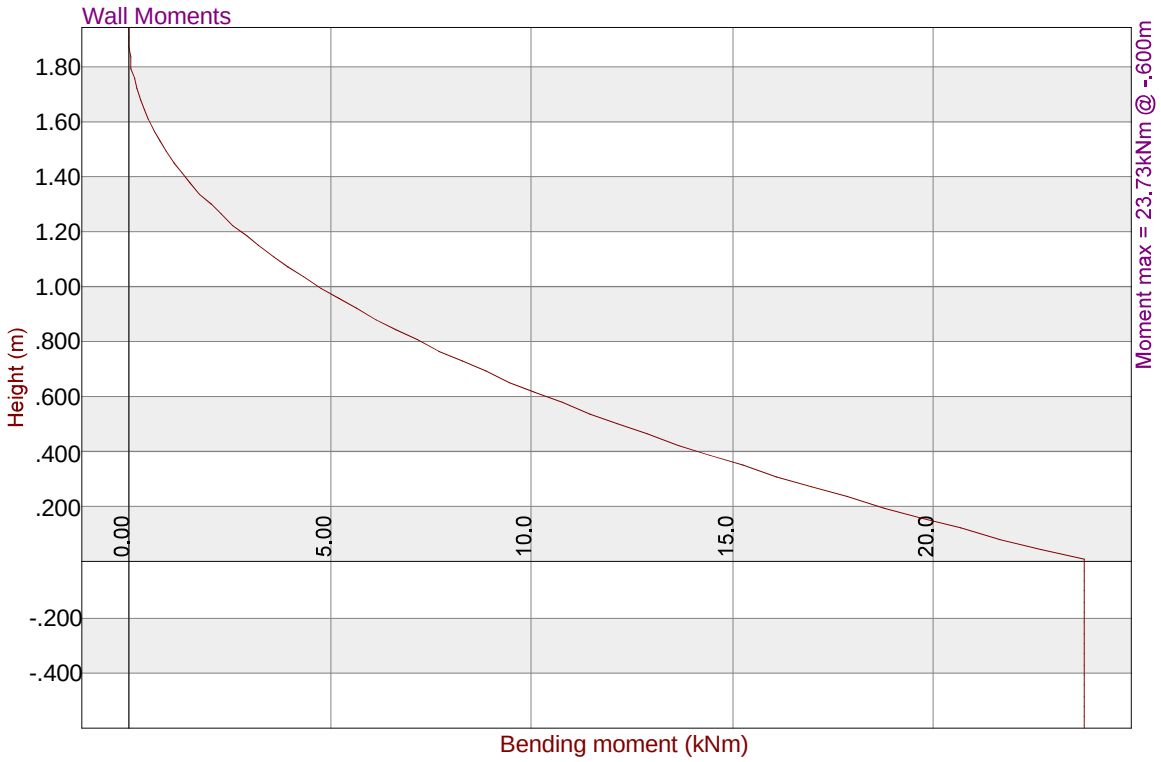


Wall type: Cantilever
Theory: Coulomb

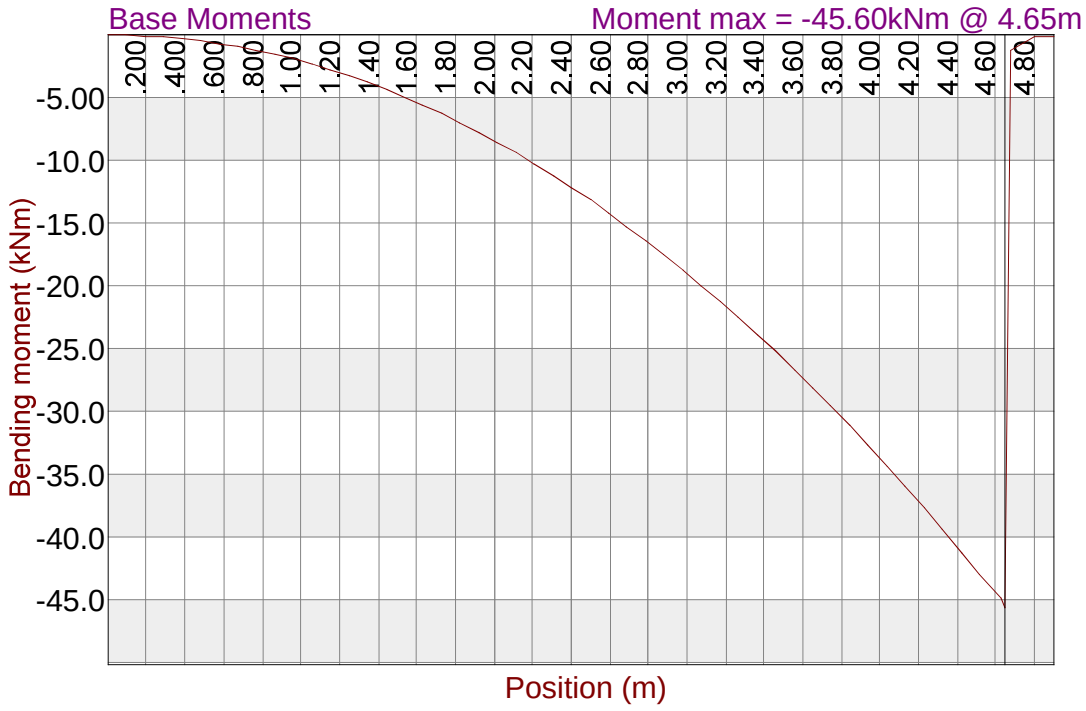
SFslip = 1.88
SFslip (ULS) = 1.20
SFovt = -13.21
SFovt (ULS) = -9.21

SF Ovt<0 :No Overturning posssible

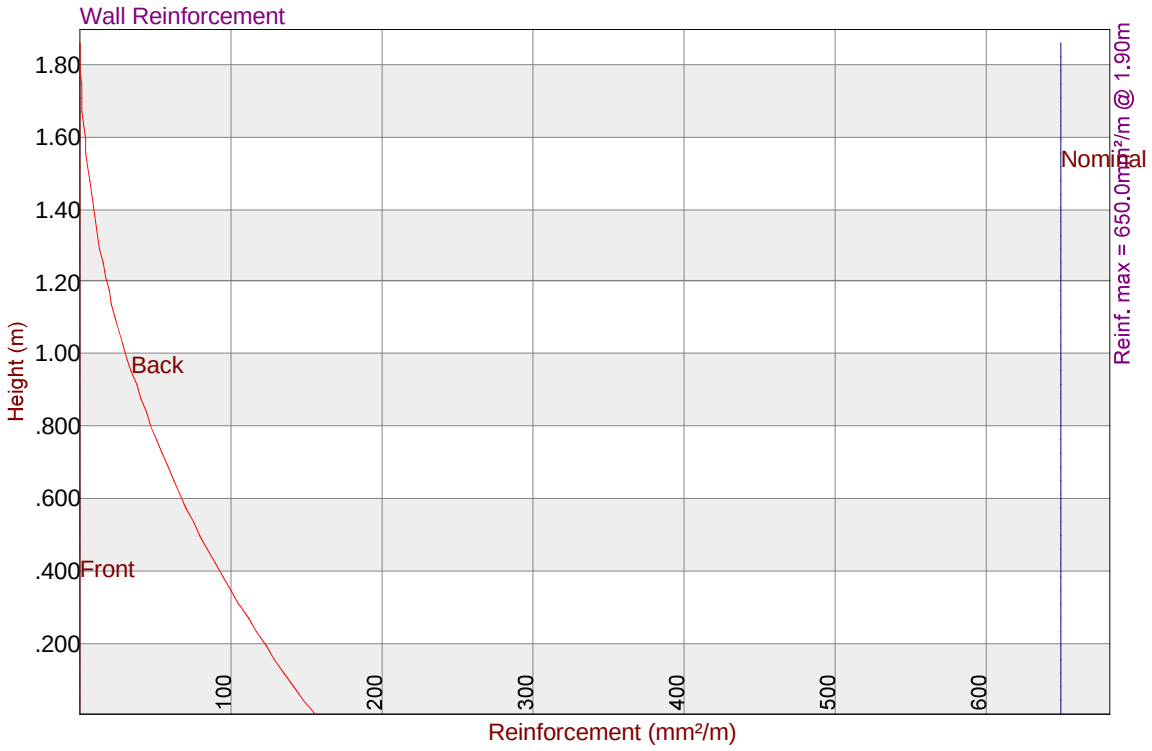
Wall Bending Moments



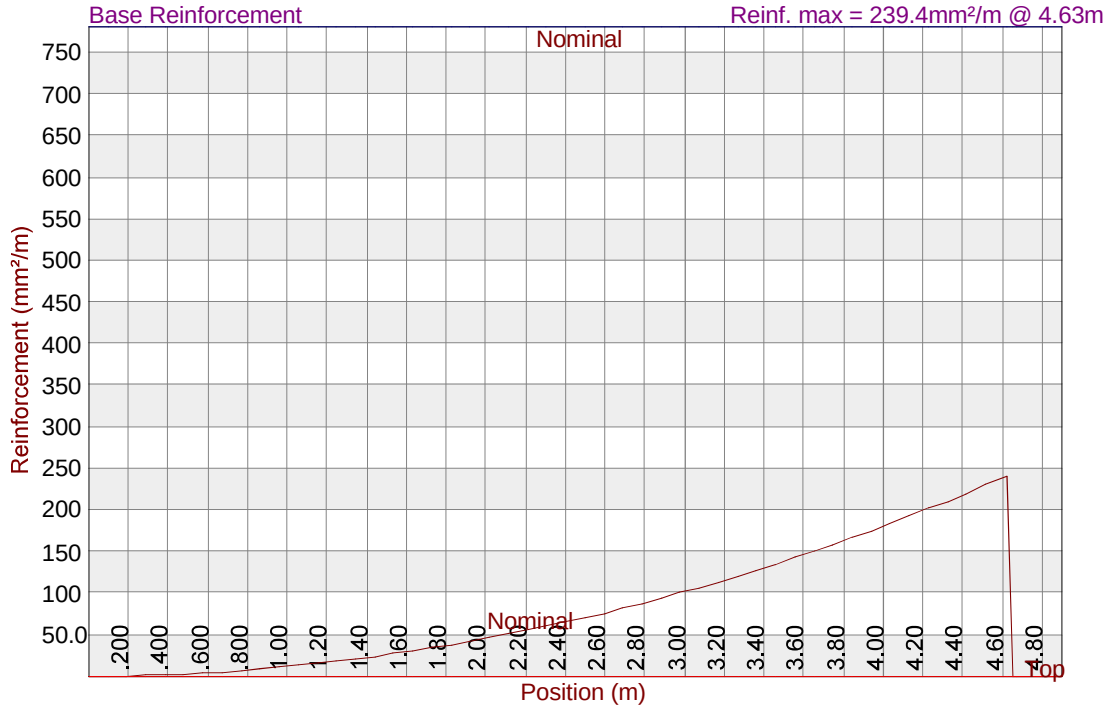
Base Bending Moments



Wall Reinforcement



Base Reinforcement



Schematic Reinforcement

SECTION

5) ③VALVE CHAMBER

TOP SLAB (L2.9m×W2.6m)

Rectangular Slab Panel Design :

C04

Input Data

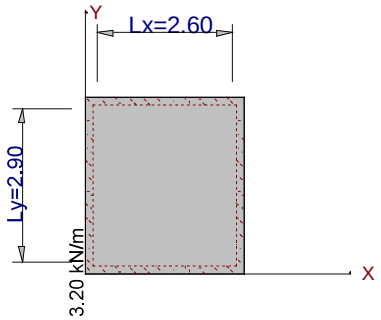
Lx	(m)	2.6
Ly	(m)	2.9
Slab depth	(mm)	250
deff X-dir	(mm)	200
deff Y-dir	(mm)	220
Poisson's ratio		0.2
fcu	(MPa)	25
fy	(MPa)	420
Density	(kN/m^3)	24
Self weight LF		1.4
ε - time factor (ACI318 :9.5.2.5)		2

Load Cases

Unfactored Loads			Unfactored Point Loads			Unfactored Line Loads				
LC No.	Load fact	UDL kN/m²	P kN	x m	y m	L kN/m	x1 m	y1 m	x2 m	y2 m
1	1.4	0.3								
	1.6	20				2				

Sketch of slab

BS8110 - 1997



Total UDL = 40.820 kN/m² (Incl self Wt)

Load Case 1 (factored)

Output

Wood-Armer Moments and reinforcement for each load case:
Wood-Armer moments were calculated using the 'Wood & Armer' theory.

LOAD CASE 1

Position		Wood-Armer Moments (kNm/m)				Reinforcement (mm²/m)			
		Top		Bottom		Top		Bottom	
X (m)	Y(m)	X	Y	X	Y	X	Y	X	Y
0.00	0.00	3.0	2.1	14.5	15.4	44	27	209	202
0.22	0.00	8.3	7.4	11.6	12.5	120	97	167	164
0.43	0.00	11.4	11.3	9.2	9.3	165	149	133	122
0.65	0.00	6.9	7.1	7.7	7.5	100	93	111	98
0.87	0.00	4.6	4.1	5.3	5.9	66	54	77	77
1.08	0.00	2.3	1.7	2.6	3.1	32	23	38	41
1.30	0.00	0.0	0.0	0.1	0.5	0	0	2	6
1.52	0.00	2.3	1.7	2.6	3.1	32	23	38	41
1.73	0.00	4.6	4.1	5.3	5.9	66	54	77	77
1.95	0.00	6.9	7.1	7.7	7.5	100	93	111	98
2.17	0.00	11.4	11.3	9.2	9.3	165	149	133	122
2.38	0.00	8.3	7.4	11.6	12.5	120	97	167	164
2.60	0.00	3.0	2.1	14.5	15.4	44	27	209	202
0.00	0.24	7.6	8.0	12.0	11.7	110	104	173	153
0.43	0.24	6.3	6.2	11.5	11.6	90	81	165	151
0.87	0.24	0.6	0.2	8.7	9.1	9	2	125	120
1.30	0.24	0.0	0.0	4.2	4.9	0	0	60	64
1.73	0.24	0.6	0.2	8.7	9.1	9	2	125	120
2.17	0.24	6.3	6.2	11.5	11.6	90	81	165	151
2.60	0.24	7.6	8.0	12.0	11.7	110	104	173	153
0.00	0.48	11.0	11.5	9.3	8.8	158	151	134	115
0.22	0.48	5.7	6.5	11.7	10.9	83	86	169	143
0.43	0.48	1.3	1.8	13.8	13.3	19	24	199	174
0.65	0.48	0.0	0.0	12.7	12.9	0	0	183	168
0.87	0.48	0.0	0.0	11.9	12.3	0	0	172	161
1.08	0.48	0.0	0.0	10.1	10.7	0	0	146	140
1.30	0.48	0.0	0.0	8.2	9.1	0	0	119	119
1.52	0.48	0.0	0.0	10.1	10.7	0	0	146	140
1.73	0.48	0.0	0.0	11.9	12.3	0	0	172	161
1.95	0.48	0.0	0.0	12.7	12.9	0	0	183	168
2.17	0.48	1.3	1.8	13.8	13.3	19	24	199	174
2.38	0.48	5.7	6.5	11.7	10.9	83	86	169	143
2.60	0.48	11.0	11.5	9.3	8.8	158	151	134	115
0.00	0.72	6.9	6.8	7.3	7.5	100	89	105	98
0.43	0.72	-0.0	-0.0	13.4	11.7	0	0	192	153
0.87	0.72	0.0	0.0	13.3	12.6	0	0	192	166
1.30	0.72	0.0	0.0	10.8	10.5	0	0	156	138
1.73	0.72	0.0	0.0	13.3	12.6	0	0	192	166
2.17	0.72	-0.0	-0.0	13.4	11.7	0	0	192	153
2.60	0.72	6.9	6.8	7.3	7.5	100	89	105	98
0.00	0.97	4.0	4.4	5.4	5.0	57	58	78	66
0.22	0.97	-0.0	0.7	9.2	7.9	0	10	133	103
0.43	0.97	0.0	0.0	12.9	10.7	0	0	186	140
0.65	0.97	0.0	0.0	13.8	11.8	0	0	199	155
0.87	0.97	0.0	0.0	14.8	13.0	0	0	213	170
1.08	0.97	0.0	0.0	14.1	12.5	0	0	203	164
1.30	0.97	0.0	0.0	13.4	12.1	0	0	194	158
1.52	0.97	0.0	0.0	14.1	12.5	0	0	203	164
1.73	0.97	0.0	0.0	14.8	13.0	0	0	213	170
1.95	0.97	0.0	0.0	13.8	11.8	0	0	199	155
2.17	0.97	0.0	0.0	12.9	10.7	0	0	186	140
2.38	0.97	-0.0	0.7	9.2	7.9	0	10	133	103
2.60	0.97	4.0	4.4	5.4	5.0	57	58	78	66
0.00	1.21	1.7	2.2	2.9	2.4	25	28	42	32
0.43	1.21	0.0	0.0	11.4	8.8	0	0	164	115
0.87	1.21	0.0	0.0	14.4	12.1	0	0	207	158
1.30	1.21	0.0	0.0	14.3	12.4	0	0	206	162
1.73	1.21	0.0	0.0	14.4	12.1	0	0	207	158

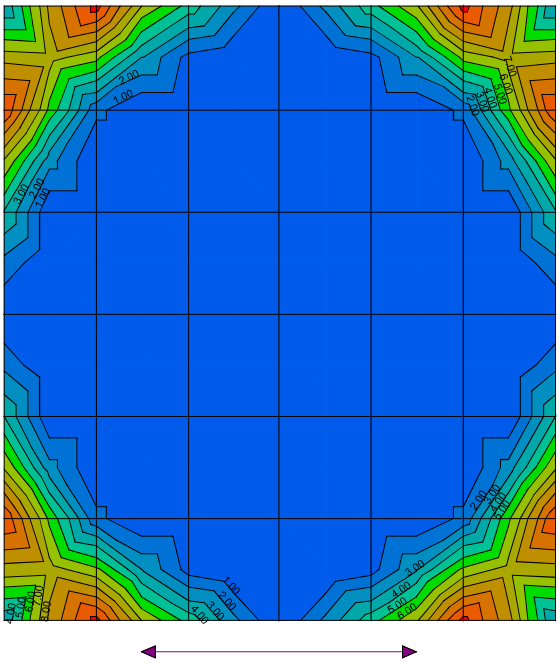
2.17	1.21	0.0	0.0	11.4	8.8	0	0	164	115
2.60	1.21	1.7	2.2	2.9	2.4	25	28	42	32
0.00	1.45	0.0	0.0	0.4	0.1	0	0	6	1
0.22	1.45	0.0	0.0	5.2	3.5	0	0	75	45
0.43	1.45	0.0	0.0	9.8	6.9	0	0	141	90
0.65	1.45	0.0	0.0	11.9	9.1	0	0	171	119
0.87	1.45	0.0	0.0	14.0	11.3	0	0	202	148
1.08	1.45	0.0	0.0	14.6	12.1	0	0	210	158
1.30	1.45	0.0	0.0	15.2	12.8	0	0	219	168
1.52	1.45	0.0	0.0	14.6	12.1	0	0	210	158
1.73	1.45	0.0	0.0	14.0	11.3	0	0	202	148
1.95	1.45	0.0	0.0	11.9	9.1	0	0	171	119
2.17	1.45	0.0	0.0	9.8	6.9	0	0	141	90
2.38	1.45	0.0	0.0	5.2	3.5	0	0	75	45
2.60	1.45	0.0	0.0	0.4	0.1	0	0	6	1
0.00	1.69	1.7	2.2	2.9	2.4	25	28	42	32
0.43	1.69	0.0	0.0	11.4	8.8	0	0	164	115
0.87	1.69	0.0	0.0	14.4	12.1	0	0	207	158
1.30	1.69	0.0	0.0	14.3	12.4	0	0	206	162
1.73	1.69	0.0	0.0	14.4	12.1	0	0	207	158
2.17	1.69	0.0	0.0	11.4	8.8	0	0	164	115
2.60	1.69	1.7	2.2	2.9	2.4	25	28	42	32
0.00	1.93	4.0	4.4	5.4	5.0	57	58	78	66
0.22	1.93	-0.0	0.7	9.2	7.9	0	10	133	103
0.43	1.93	0.0	0.0	12.9	10.7	0	0	186	140
0.65	1.93	0.0	0.0	13.8	11.8	0	0	199	155
0.87	1.93	0.0	0.0	14.8	13.0	0	0	213	170
1.08	1.93	0.0	0.0	14.1	12.5	0	0	203	164
1.30	1.93	0.0	0.0	13.4	12.1	0	0	194	158
1.52	1.93	0.0	0.0	14.1	12.5	0	0	203	164
1.73	1.93	0.0	0.0	14.8	13.0	0	0	213	170
1.95	1.93	0.0	0.0	13.8	11.8	0	0	199	155
2.17	1.93	0.0	0.0	12.9	10.7	0	0	186	140
2.38	1.93	-0.0	0.7	9.2	7.9	0	10	133	103
2.60	1.93	4.0	4.4	5.4	5.0	57	58	78	66
0.00	2.17	6.9	6.8	7.3	7.5	100	89	105	98
0.43	2.17	-0.0	-0.0	13.4	11.7	0	0	192	153
0.87	2.17	0.0	0.0	13.3	12.6	0	0	192	166
1.30	2.17	0.0	0.0	10.8	10.5	0	0	156	138
1.73	2.17	0.0	0.0	13.3	12.6	0	0	192	166
2.17	2.17	-0.0	-0.0	13.4	11.7	0	0	192	153
2.60	2.17	6.9	6.8	7.3	7.5	100	89	105	98
0.00	2.42	11.0	11.5	9.3	8.8	158	151	134	115
0.22	2.42	5.7	6.5	11.7	10.9	83	86	169	143
0.43	2.42	1.3	1.8	13.8	13.3	19	24	199	174
0.65	2.42	0.0	0.0	12.7	12.9	0	0	183	168
0.87	2.42	0.0	0.0	11.9	12.3	0	0	172	161
1.08	2.42	0.0	0.0	10.1	10.7	0	0	146	140
1.30	2.42	0.0	0.0	8.2	9.1	0	0	119	119
1.52	2.42	0.0	0.0	10.1	10.7	0	0	146	140
1.73	2.42	0.0	0.0	11.9	12.3	0	0	172	161
1.95	2.42	0.0	0.0	12.7	12.9	0	0	183	168
2.17	2.42	1.3	1.8	13.8	13.3	19	24	199	174
2.38	2.42	5.7	6.5	11.7	10.9	83	86	169	143
2.60	2.42	11.0	11.5	9.3	8.8	158	151	134	115
0.00	2.66	7.6	8.0	12.0	11.7	110	104	173	153
0.43	2.66	6.3	6.2	11.5	11.6	90	81	165	151
0.87	2.66	0.6	0.2	8.7	9.1	9	2	125	120
1.30	2.66	0.0	0.0	4.2	4.9	0	0	60	64
1.73	2.66	0.6	0.2	8.7	9.1	9	2	125	120
2.17	2.66	6.3	6.2	11.5	11.6	90	81	165	151
2.60	2.66	7.6	8.0	12.0	11.7	110	104	173	153
0.00	2.90	3.0	2.1	14.5	15.4	44	27	209	202
0.22	2.90	8.3	7.4	11.6	12.5	120	97	167	164
0.43	2.90	11.4	11.3	9.2	9.3	165	149	133	122
0.65	2.90	6.9	7.1	7.7	7.5	100	93	111	98
0.87	2.90	4.6	4.1	5.3	5.9	66	54	77	77
1.08	2.90	2.3	1.7	2.6	3.1	32	23	38	41
1.30	2.90	0.0	0.0	0.1	0.5	0	0	2	6

1.52	2.90	2.3	1.7	2.6	3.1	32	23	38	41
1.73	2.90	4.6	4.1	5.3	5.9	66	54	77	77
1.95	2.90	6.9	7.1	7.7	7.5	100	93	111	98
2.17	2.90	11.4	11.3	9.2	9.3	165	149	133	122
2.38	2.90	8.3	7.4	11.6	12.5	120	97	167	164
2.60	2.90	3.0	2.1	14.5	15.4	44	27	209	202

Wood-Armer Moments:

BS8110 - 1997

Top:LC 1 (kNm/m)

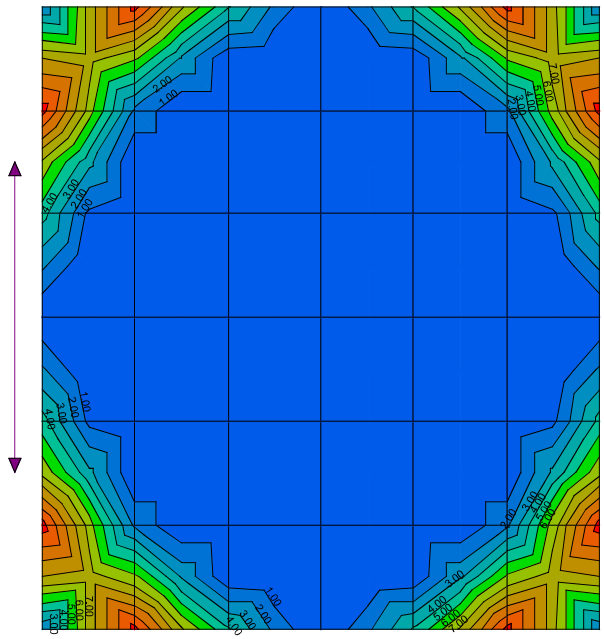


Max value:11.4 at X:2.2 Y:2.9

Wood-Armer Moments:

BS8110 - 1997

Top:LC 1 (kNm/m)

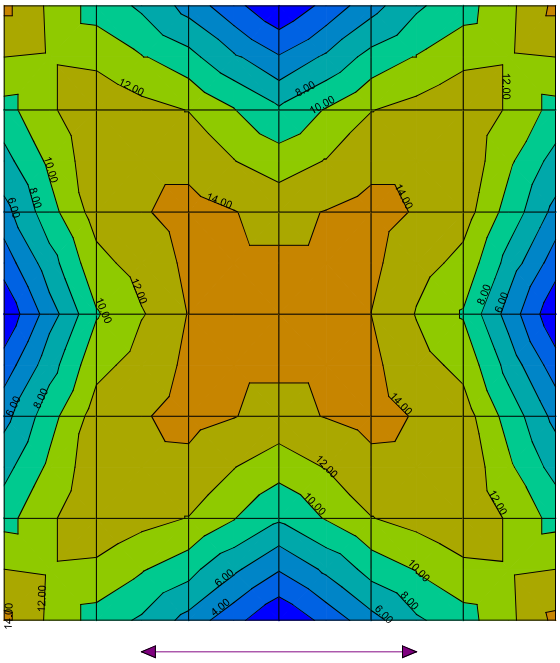


Max value:11.5 at X:2.6 Y:2.4

Wood-Armer Moments:

BS8110 - 1997

Bot:LC 1 (kNm/m)

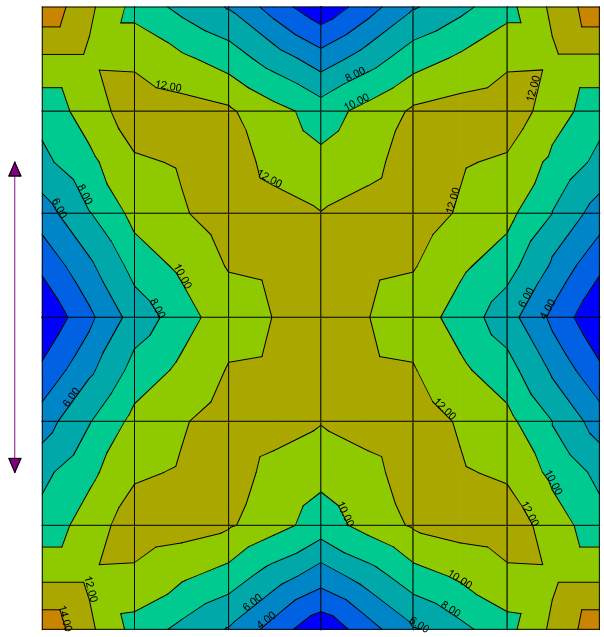


Max value:15.2 at X:1.3 Y:1.4

Wood-Armer Moments:

BS8110 - 1997

Bot:LC 1 (kNm/m)

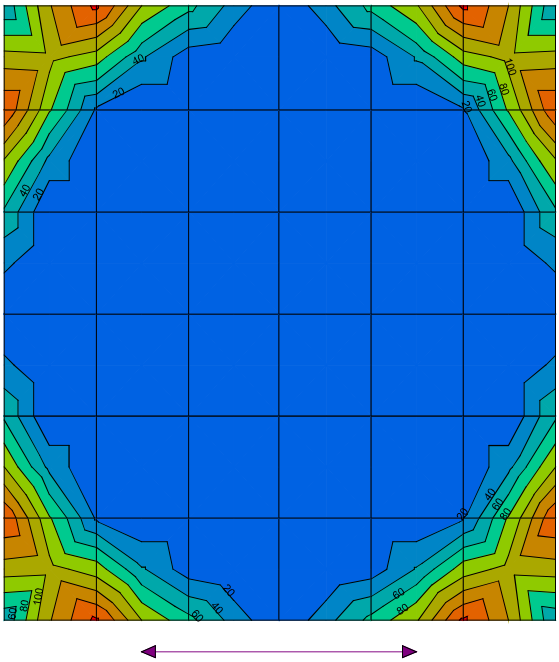


Max value:15.4 at X:2.6 Y:2.9

Reinforcement:

BS8110 - 1997

Top:LC 1 (mm²/m)

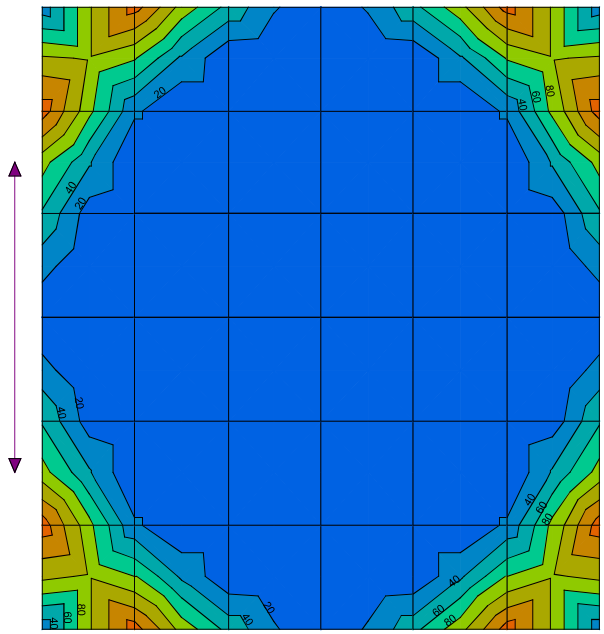


Max value:164.5 at X:2.2 Y:2.9

Reinforcement:

BS8110 - 1997

Top:LC 1 (mm²/m)

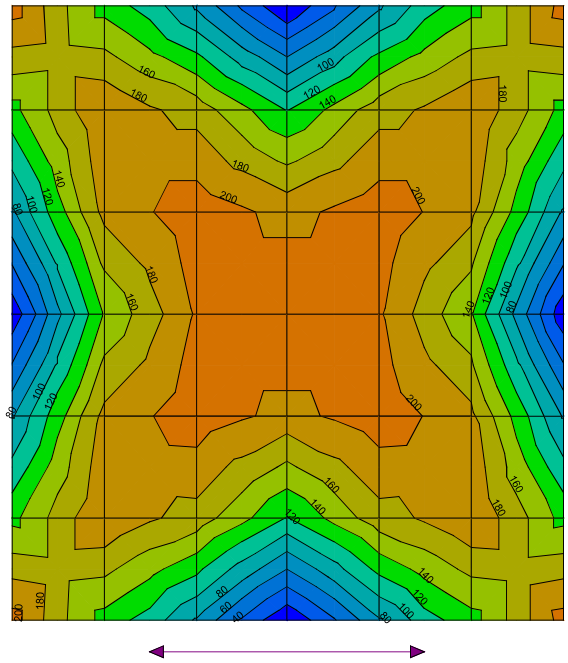


Max value:150.5 at X:2.6 Y:2.4

Reinforcement:

BS8110 - 1997

Bot:LC 1 (mm²/m)

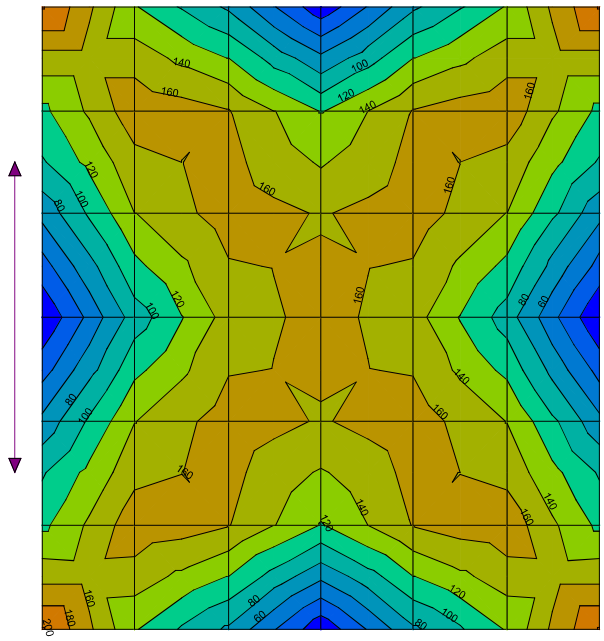


Max value:218.9 at X:1.3 Y:1.4

Reinforcement:

BS8110 - 1997

Bot:LC 1 (mm²/m)

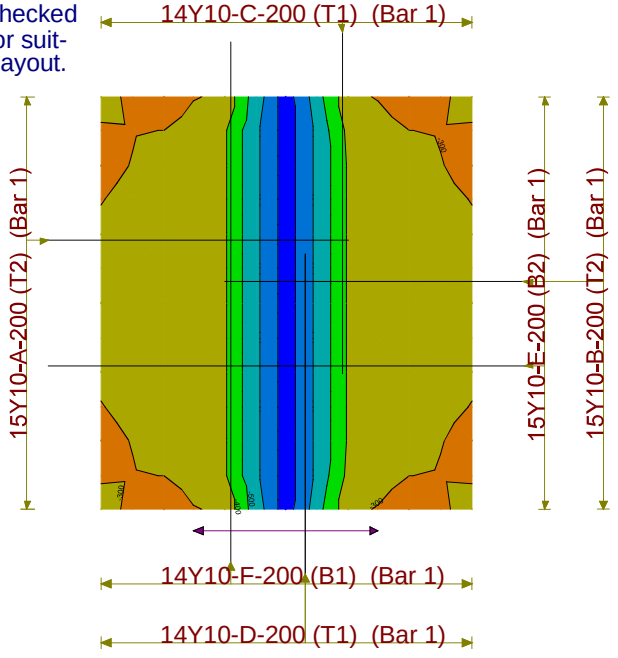


Max value:202.0 at X:2.6 Y:2.9

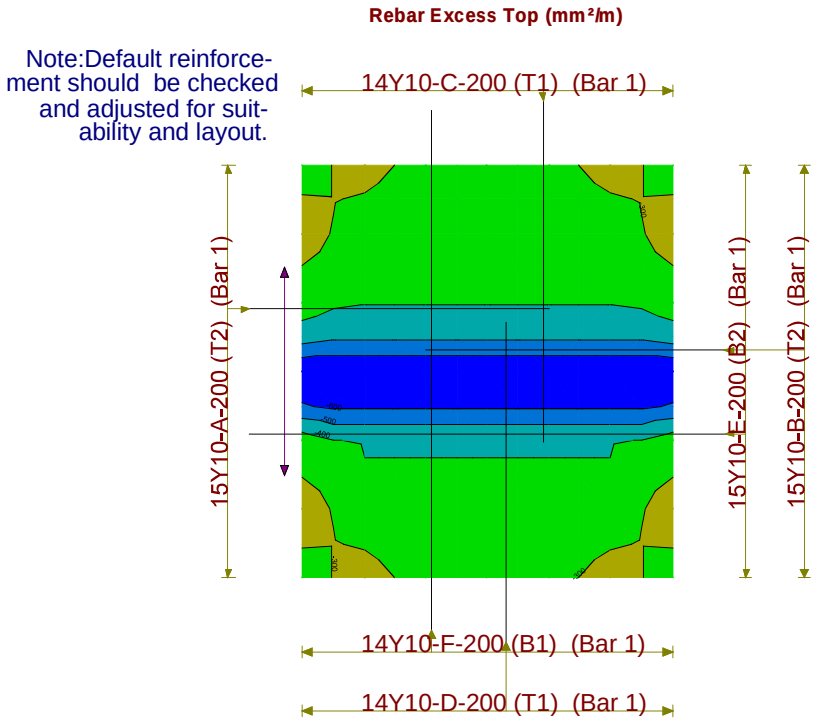
Rebar Excess:

Rebar Excess Top (mm²/m)

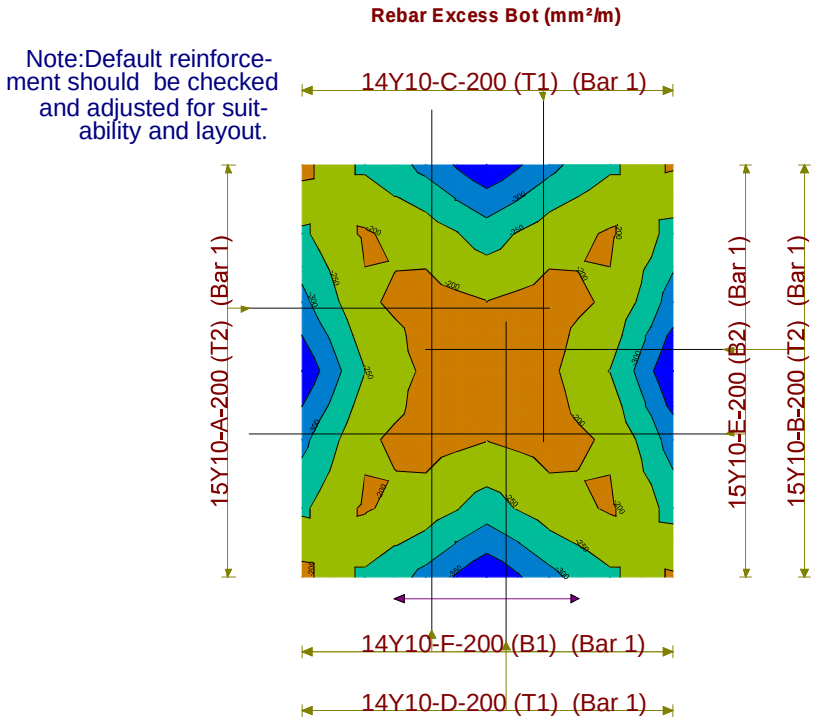
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:



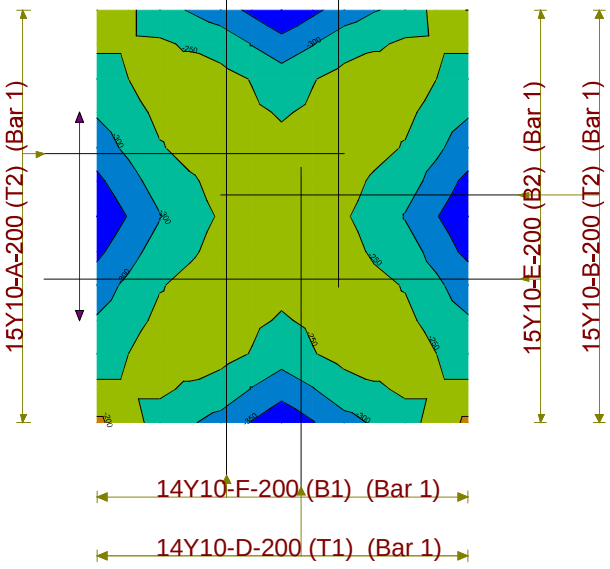
Rebar Excess:



Rebar Excess:

Rebar Excess Bot (mm²/m)

Note:Default reinforcement should be checked and adjusted for suitability and layout.



5) ③VALVE CHAMBER

WALL (H3.0m)

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Reservoir wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1	(m)	3	C	(m)	0.4	W	(kN/m²)		Soil frict ϕ	(°)	25	SF Overt.	1.5
H2	(m)	0.67	F	(m)		P	(kN)		Fill slope β	(°)		SF Slip	1.5
H3	(m)	2.6	xf	(m)		xp	(m)		Wall frict δ	(°)		ULS DL Factor	1.4
Hw	(m)	2.6	At	(m)	0.25	L	(kN/m)		ρ Conc	kN/m³	25	ULS LL Factor	1.6
Hr	(m)	0.36	Ab	(m)	0.25	xl	(m)		ρ Soil	kN/m³	18	Pmax (kPa)	100
B	(m)		Cov wall	mm	50	Lh	(kN/m)		fcu	(MPa)	25	Soil Poisson υ	0.5
D	(m)	2.35	Cov base	mm	50	x	(m)		fy	(MPa)	450	DL Factor Ovt.	0.9

Seepage not allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:OFF

Hor Accel. (g)	
Vert Accel. (g)	
Include LL's	

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.406
Passive Pressure coefficient Kp :2.464
Base frictional constant μ :0.466

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.584	0.133	0.000	0.250
Triangular W-table press Pw	0.466	0.133	0.000	0.250
W-table pr below free water	8.633	0.200	0.000	0.250
Free water pressure Pwf	23.740	1.133	0.000	0.250
Hydrostatic pressure on bot of base: uniform portion			0.000	1.300
Hydrostatic pressure on bot of base: triangular portion			0.000	1.733
Stabilizing forces:				
Passive pressure on base Pp	-9.954	0.223		
Weight of the wall + base			42.250	0.848
Weight of soil on the base			-0.000	1.425
Hydrostatic pressure on top of rear portion of base			50.718	1.425
Hydrostatic pressure on top of front portion of base			0.000	0.000

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 110.33 kNm
      Destabilizing moment Mo : 28.77 kNm

Safety factor against overturning = Mr/Mo = 3.835

2.Force Equilibrium at SLS

    Sum of Vertical forces Pv : 92.97 kN
  Frictional resistance Pfric : 43.35 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :   9.95 kN
=> Total Horiz. resistance Fr : 53.31 kN

     Horizontal sliding force on wall Fhw : 33.42 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh : 33.42 kN

Safety factor against overall sliding = Fr/Fh = 1.595

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.818	0.133	0.000	0.250
Triangular W-table press Pw	0.653	0.133	0.000	0.250
W-table pr below free water	12.086	0.200	0.000	0.250
Free water pressure Pwf	33.236	1.133	0.000	0.250
Hydrostatic pressure on bot of base: uniform portion			0.000	1.300
Hydrostatic pressure on bot of base: triangular portion			0.000	1.733
Stabilizing forces:				
Passive pressure on base Pp	-8.959	0.223		
Weight of the wall + base			38.025	0.848
Weight of soil on the base			-0.000	1.425
Hydrostatic pressure on top of rear portion of base			45.646	1.425
Hydrostatic pressure on top of front portion of base			0.000	0.000

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 99.29 kNm
      Destabilizing moment Mo : 40.28 kNm

Safety factor against overturning = Mr/Mo = 2.465

2.Force Equilibrium at ULS

```
    Sum of Vertical forces Pv :  83.67 kN
  Frictional resistance Pfric :  39.02 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :   8.96 kN
=> Total Horiz. resistance Fr :  47.98 kN

     Horizontal sliding force on wall Fhw :  46.79 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh :  46.79 kN
```

Safety factor against overall sliding = Fr/Fh = 1.025

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure : 70.64 kPa
Minimum pressure : 0.87 kPa
Maximum pressure occurs at left hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Nominal (0.13%) (mm²/m)
0.00	24.51	0.00	347.05	325.00
0.05	22.90	0.00	324.18	325.00
0.10	21.33	0.00	301.95	325.00
0.16	19.81	0.00	280.43	325.00
0.21	18.35	0.00	259.73	325.00
0.26	16.95	0.00	239.95	325.00
0.31	15.62	0.00	221.17	325.00
0.36	14.37	0.00	203.39	325.00
0.42	13.18	0.00	186.60	325.00
0.47	12.06	0.00	170.75	325.00
0.52	11.01	0.00	155.83	325.00
0.57	10.02	0.00	141.80	325.00
0.62	9.09	0.00	128.64	325.00
0.68	8.22	0.00	116.33	325.00
0.73	7.40	0.00	104.82	325.00
0.78	6.65	0.00	94.10	325.00
0.83	5.94	0.00	84.14	325.00
0.88	5.29	0.00	74.90	325.00
0.94	4.69	0.00	66.37	325.00
0.99	4.13	0.00	58.51	325.00
1.04	3.62	0.00	51.30	325.00
1.09	3.16	0.00	44.70	325.00
1.14	2.73	0.00	38.70	325.00
1.20	2.35	0.00	33.26	325.00
1.25	2.00	0.00	28.35	325.00
1.30	1.69	0.00	23.96	325.00
1.35	1.42	0.00	20.04	325.00
1.40	1.17	0.00	16.58	325.00
1.46	0.96	0.00	13.53	325.00
1.51	0.77	0.00	10.89	325.00
1.56	0.61	0.00	8.62	325.00
1.61	0.47	0.00	6.68	325.00
1.66	0.36	0.00	5.06	325.00
1.72	0.26	0.00	3.73	325.00
1.77	0.19	0.00	2.65	325.00
1.82	0.13	0.00	1.80	325.00
1.87	0.08	0.00	1.16	325.00
1.92	0.05	0.00	0.69	325.00
1.98	0.03	0.00	0.37	325.00
2.03	0.01	0.00	0.17	325.00
2.08	0.00	0.00	0.06	325.00

2.13	0.00	0.00	0.01	325.00
2.18	0.00	0.00	0.00	325.00
2.24	0.00	0.00	0.00	325.00
2.29	0.00	0.00	0.00	325.00
2.34	0.00	0.00	0.00	325.00
2.39	0.00	0.00	0.00	325.00
2.44	0.00	0.00	0.00	325.00
2.50	0.00	0.00	0.00	325.00
2.55	0.00	0.00	0.00	325.00
2.60	0.00	0.00	0.00	325.00

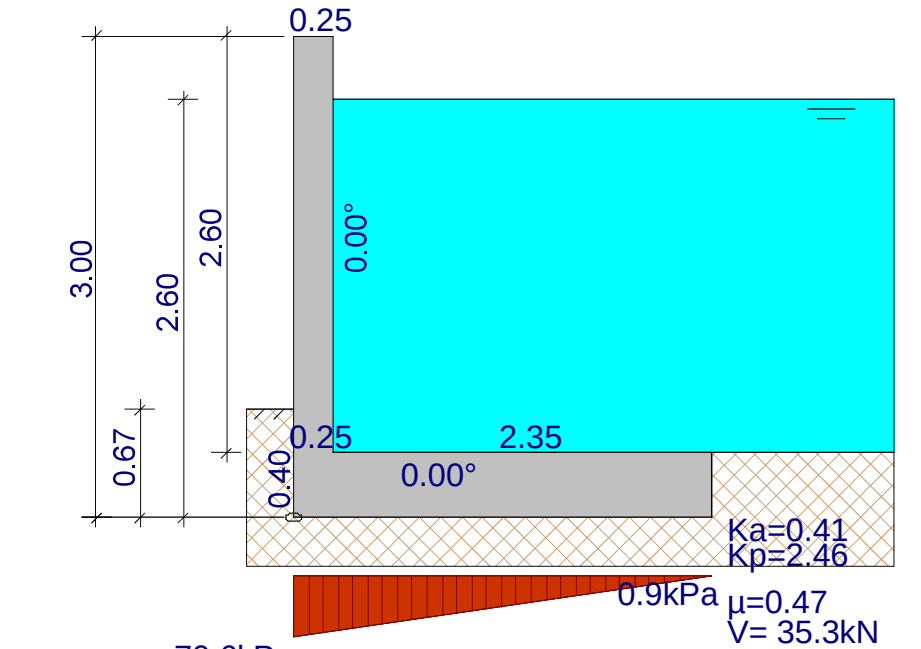
BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Nominal (0.13%) (mm^2/m)
0.00	-0.00	0.00	0.00	520.00
0.05	-0.11	0.00	0.86	520.00
0.10	-0.43	0.00	3.43	520.00
0.16	-0.65	0.00	0.00	520.00
0.21	37.00	0.00	0.00	520.00
0.26	34.67	0.00	0.00	520.00
0.31	33.21	262.79	0.00	520.00
0.36	31.79	251.49	0.00	520.00
0.42	30.39	240.44	0.00	520.00
0.47	29.02	229.63	0.00	520.00
0.52	27.69	219.08	0.00	520.00
0.57	26.39	208.77	0.00	520.00
0.62	25.12	198.71	0.00	520.00
0.68	23.88	188.90	0.00	520.00
0.73	22.67	179.33	0.00	520.00
0.78	21.49	170.02	0.00	520.00
0.83	20.34	160.95	0.00	520.00
0.88	19.23	152.14	0.00	520.00
0.94	18.15	143.57	0.00	520.00
0.99	17.09	135.25	0.00	520.00
1.04	16.07	127.17	0.00	520.00
1.09	15.08	119.35	0.00	520.00
1.14	14.13	111.77	0.00	520.00
1.20	13.20	104.45	0.00	520.00
1.25	12.31	97.37	0.00	520.00
1.30	11.44	90.54	0.00	520.00
1.35	10.61	83.95	0.00	520.00
1.40	9.81	77.62	0.00	520.00
1.46	9.04	71.54	0.00	520.00
1.51	8.30	65.70	0.00	520.00
1.56	7.60	60.11	0.00	520.00
1.61	6.92	54.77	0.00	520.00
1.66	6.28	49.68	0.00	520.00
1.72	5.67	44.83	0.00	520.00
1.77	5.09	40.24	0.00	520.00
1.82	4.54	35.89	0.00	520.00
1.87	4.02	31.79	0.00	520.00
1.92	3.53	27.94	0.00	520.00
1.98	3.08	24.34	0.00	520.00
2.03	2.65	20.99	0.00	520.00
2.08	2.26	17.88	0.00	520.00
2.13	1.90	15.03	0.00	520.00
2.18	1.57	12.42	0.00	520.00
2.24	1.27	10.06	0.00	520.00
2.29	1.00	7.95	0.00	520.00
2.34	0.77	6.09	0.00	520.00
2.39	0.57	4.47	0.00	520.00
2.44	0.39	3.10	0.00	520.00
2.50	0.25	1.99	0.00	520.00
2.55	0.14	1.12	0.00	520.00
2.60	0.06	0.50	0.00	520.00

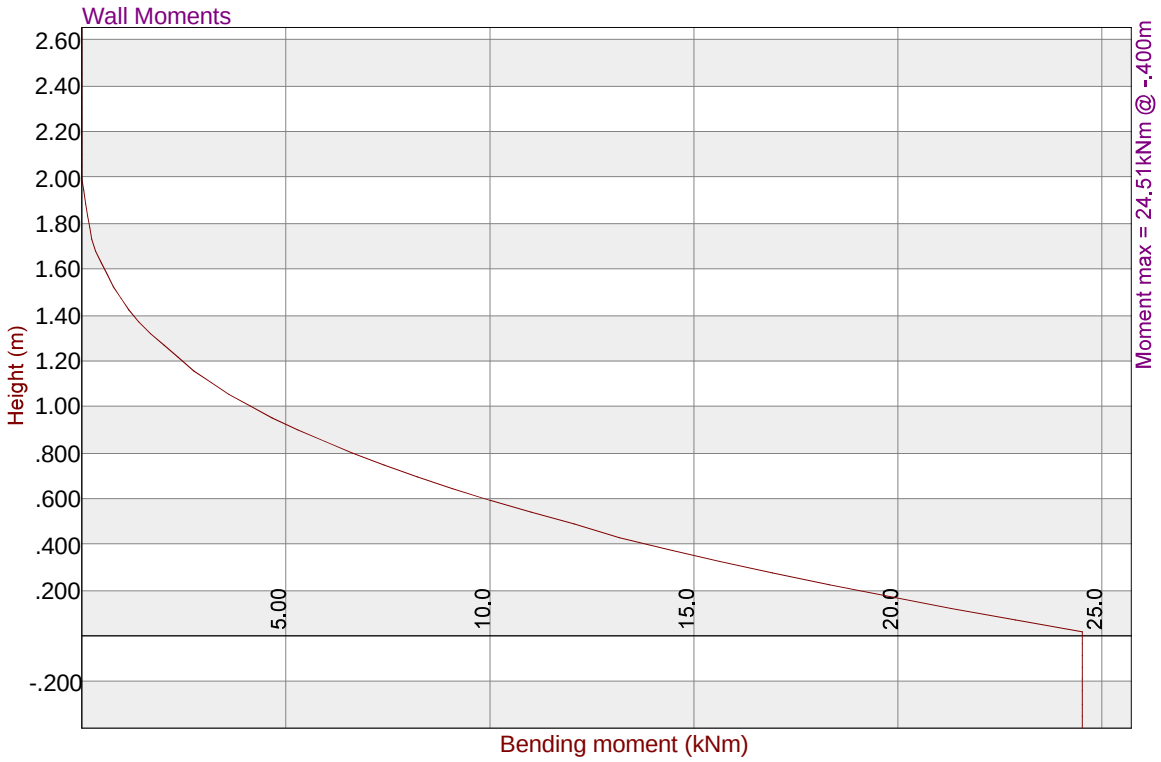
SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

```
 Shear force at bottom of wall V =  35.3 kN
Shear stress at bottom of wall v = 0.19 MPa OK
       Allowable shear stress vc = 0.42 MPa (based on Wall tensile reinf.)
```

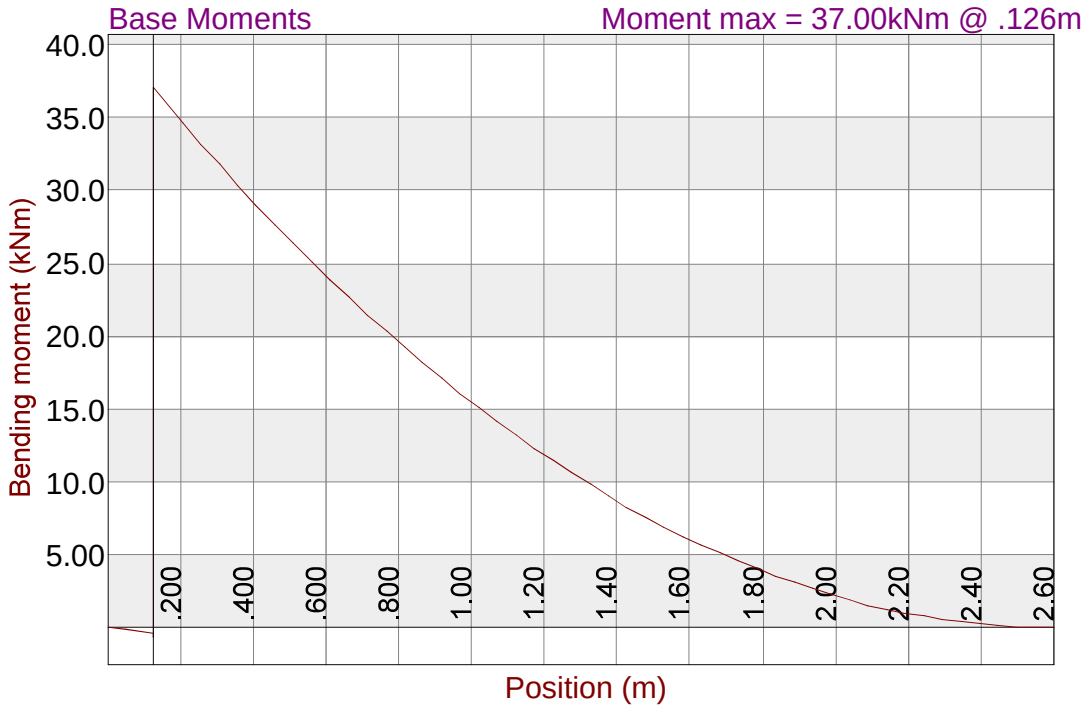
Sketch of Wall



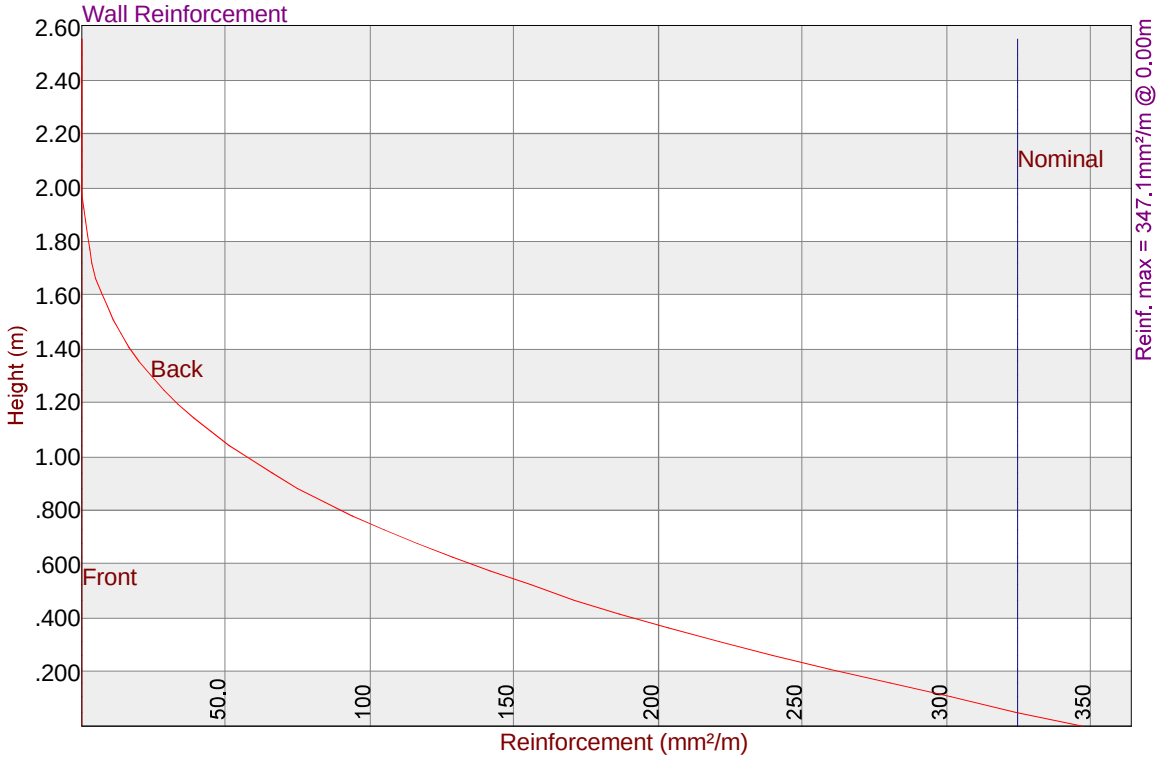
Wall Bending Moments



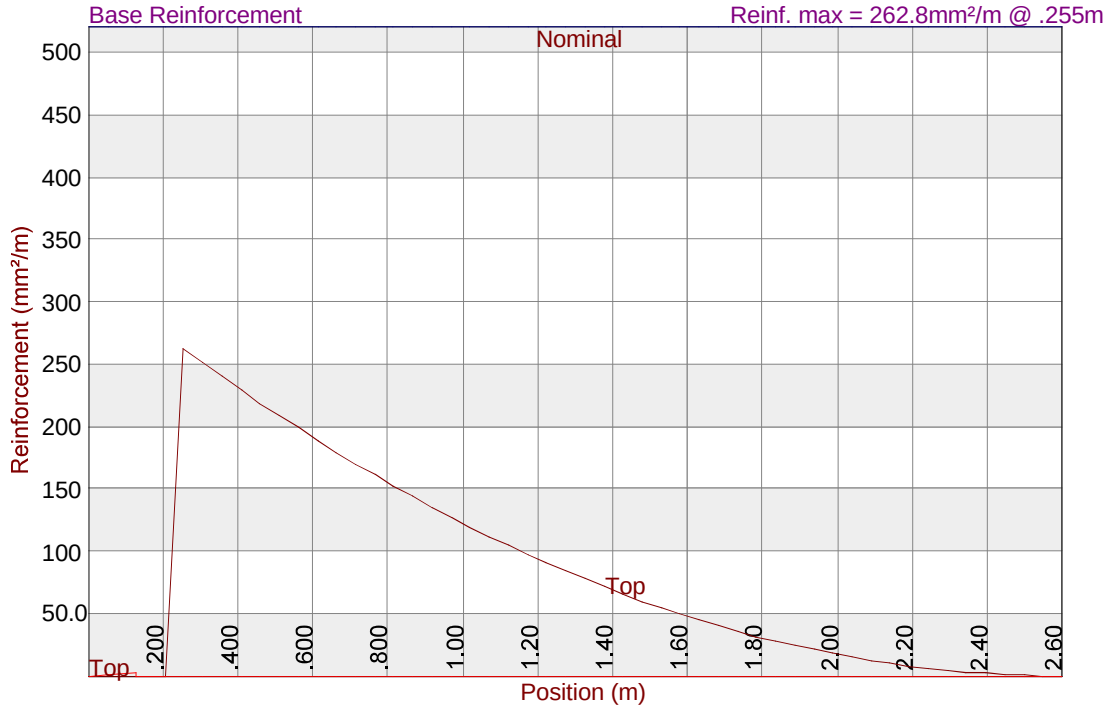
Base Bending Moments



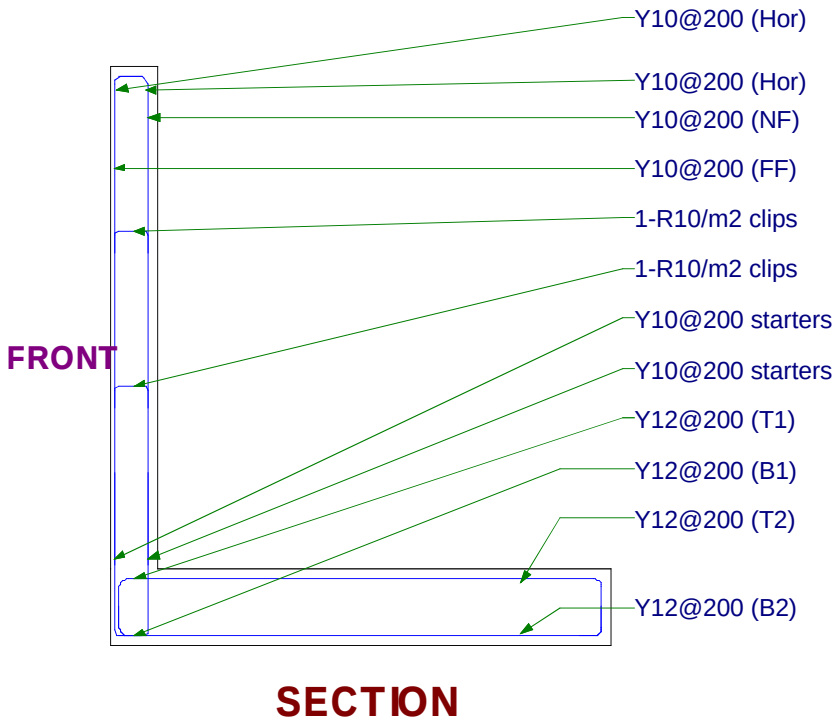
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



SECTION

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Cantilever wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1 (m)	3	C	(m)	0.4	W	(kN/m²)	1	Soil frict ϕ	(°)	30	SF Overt.	1.5
H2 (m)	0.7	F	(m)	0	P	(kN)	0	Fill slope β	(°)	0	SF Slip	1.5
H3 (m)	0	xf	(m)	2	xp	(m)	0	Wall frict δ	(°)	20	ULS DL Factor	1.4
Hw (m)	0	At	(m)	.25	L	(kN/m)	20	ρ Conc	kN/m^3	25	ULS LL Factor	1.6
Hr (m)	0.36	Ab	(m)	.25	xl	(m)	1.5	ρ Soil	kN/m^3	18	Pmax (kPa)	100
B (m)	2.6	Cov wall	mm	50	Lh	(kN/m)		fcu	(MPa)	25	Soil Poisson υ	0.5
D (m)	0	Cov base	mm	50	x	(m)	0	fy	(MPa)	450	DL Factor Ovt.	0.9

Seepage allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:ON

Hor Accel. (g)	0.02
Vert Accel. (g)	0.01
Include LL's	Y

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.297
Passive Pressure coefficient Kp :6.105
Seismic Active Pressure coefficient Kas :0.313
Seismic Passive Pressure coefficient Kps :5.934
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	23.826	1.040	8.672	2.850
Siesmic component of Pa	1.195	1.800	0.435	2.850
As a result of surcharge w	0.874	1.500	0.318	2.850
As a result of Line Load L	6.270	1.742	0.000	2.850
Siesmic wall inertia	0.886	0.745		
Stabilizing forces:				
Passive pressure on base Pp	-26.171	0.228		
Siesmic component of Pp	0.754	0.420		
Weight of the wall + base			44.303	1.897
Weight of soil on the base			13.900	1.300
UDL of 1.0 kPa			0.000	2.850

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 108.08 kNm
Destabilizing moment Mo : 12.05 kNm

Safety factor against overturning = Mr/Mo = 8.969

2.Force Equilibrium at SLS

Sum of Vertical forces Pv : 67.19 kN
Frictional resistance Pfric : 38.79 kN
Passive Pressure on shear key : 0.00 kN
Passive pressure on base : 26.17 kN
=> Total Horiz. resistance Fr : 64.96 kN

Horizontal sliding force on wall Fhw : 31.86 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 31.86 kN

Safety factor against overall sliding = Fr/Fh = 2.039

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	33.738	1.045	12.141	2.850
Siesmic component of Pa	1.913	1.800	0.696	2.850
As a result of surcharge w	1.398	1.500	0.509	2.850
As a result of Line Load L	10.032	1.742	0.000	2.850
Siesmic wall inertia	1.418	0.745		
Stabilizing forces:				
Passive pressure on base Pp	-23.554	0.228		
Siesmic component of Pp	0.678	0.420		
Weight of the wall + base			39.872	1.897
Weight of soil on the base			12.510	1.300
UDL of 0.9 kPa			0.000	2.850

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 97.27 kNm
Destabilizing moment Mo : 19.84 kNm

Safety factor against overturning = Mr/Mo = 4.902

2.Force Equilibrium at ULS

Sum of Vertical forces Pv : 60.47 kN
Frictional resistance Pfric : 34.91 kN
Passive Pressure on shear key : 0.00 kN

Passive pressure on base : 23.55 kN
=> Total Horiz. resistance Fr : 58.47 kN

Horizontal sliding force on wall Fhw : 46.59 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 46.59 kN

Safety factor against overall sliding = Fr/Fh = 1.255

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure : 23.78 kPa
Minimum pressure : 23.37 kPa
Maximum pressure occurs at right hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Nominal (0.13%) (mm²/m)
0.00	37.93	0.00	537.07	325.00
0.05	36.36	0.00	514.86	325.00
0.10	34.75	0.00	491.93	325.00
0.16	33.09	0.00	468.56	325.00
0.21	31.43	0.00	445.03	325.00
0.26	29.78	0.00	421.63	325.00
0.31	28.16	0.00	398.65	325.00
0.36	26.58	0.00	376.28	325.00
0.42	25.04	0.00	354.52	325.00
0.47	23.55	0.00	333.38	325.00
0.52	22.09	0.00	312.82	325.00
0.57	20.68	0.00	292.85	325.00
0.62	19.31	0.00	273.44	325.00
0.68	17.98	0.00	254.58	325.00
0.73	16.69	0.00	236.27	325.00
0.78	15.43	0.00	218.49	325.00
0.83	14.21	0.00	201.22	325.00
0.88	13.03	0.00	184.45	325.00
0.94	11.88	0.00	168.17	325.00
0.99	10.76	0.00	152.37	325.00
1.04	9.68	0.00	137.04	325.00
1.09	8.63	0.00	122.15	325.00
1.14	7.61	0.00	107.71	325.00
1.20	6.62	0.00	93.68	325.00
1.25	5.66	0.00	80.07	325.00
1.30	4.72	0.00	66.86	325.00
1.35	3.82	0.00	54.04	325.00
1.40	3.04	0.00	43.07	325.00
1.46	2.71	0.00	38.36	325.00
1.51	2.40	0.00	34.01	325.00
1.56	2.12	0.00	29.99	325.00
1.61	1.86	0.00	26.29	325.00
1.66	1.62	0.00	22.90	325.00
1.72	1.40	0.00	19.80	325.00
1.77	1.20	0.00	16.99	325.00
1.82	1.02	0.00	14.45	325.00
1.87	0.86	0.00	12.16	325.00
1.92	0.72	0.00	10.13	325.00
1.98	0.59	0.00	8.32	325.00
2.03	0.48	0.00	6.73	325.00
2.08	0.38	0.00	5.35	325.00
2.13	0.29	0.00	4.16	325.00
2.18	0.22	0.00	3.15	325.00
2.24	0.16	0.00	2.30	325.00
2.29	0.11	0.00	1.62	325.00
2.34	0.08	0.00	1.07	325.00
2.39	0.05	0.00	0.65	325.00
2.44	0.02	0.00	0.35	325.00
2.50	0.01	0.00	0.15	325.00

2.55	0.00	0.00	0.03	325.00
2.60	0.00	0.00	0.00	325.00

BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

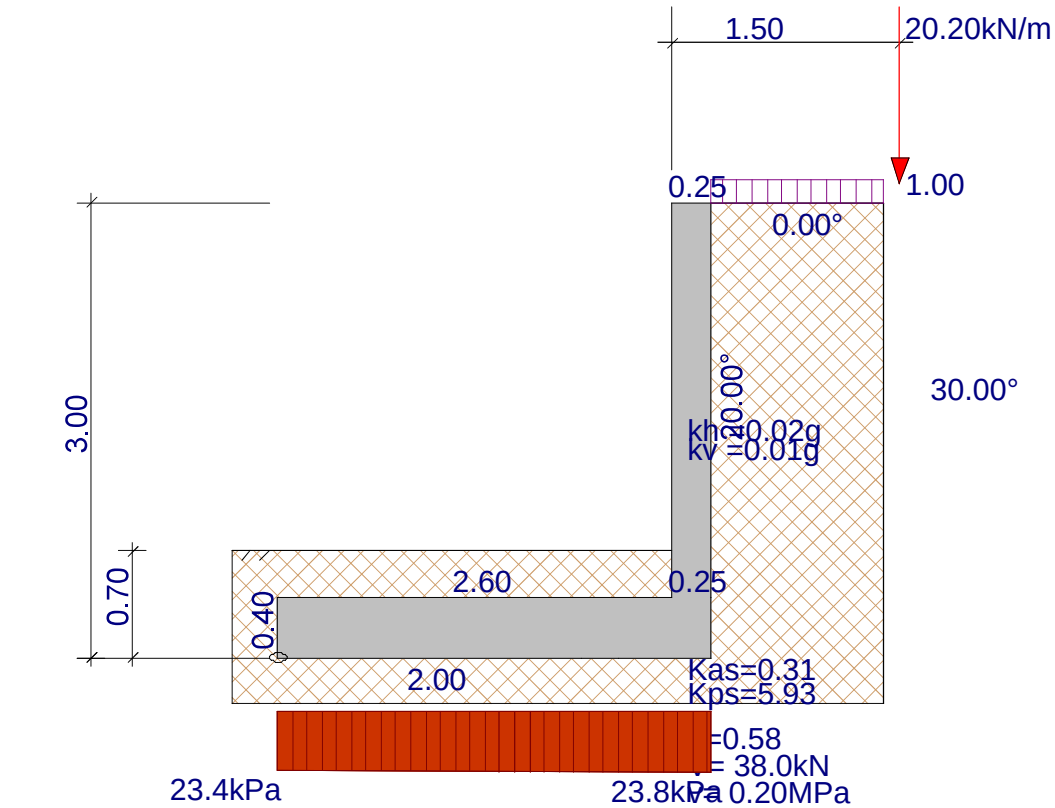
Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Nominal (0.13%) (mm^2/m)
0.00	-0.00	0.00	0.00	520.00
0.06	-0.02	0.00	0.15	520.00
0.11	-0.08	0.00	0.61	520.00
0.17	-0.17	0.00	1.38	520.00
0.23	-0.31	0.00	2.45	520.00
0.29	-0.48	0.00	3.83	520.00
0.34	-0.70	0.00	5.52	520.00
0.40	-0.95	0.00	7.52	520.00
0.46	-1.24	0.00	9.82	520.00
0.51	-1.57	0.00	12.42	520.00
0.57	-1.94	0.00	15.34	520.00
0.63	-2.35	0.00	18.56	520.00
0.68	-2.79	0.00	22.09	520.00
0.74	-3.28	0.00	25.92	520.00
0.80	-3.80	0.00	30.06	520.00
0.85	-4.36	0.00	34.51	520.00
0.91	-4.96	0.00	39.26	520.00
0.97	-5.60	0.00	44.32	520.00
1.03	-6.28	0.00	49.69	520.00
1.08	-7.00	0.00	55.37	520.00
1.14	-7.75	0.00	61.35	520.00
1.20	-8.55	0.00	67.64	520.00
1.25	-9.38	0.00	74.23	520.00
1.31	-10.25	0.00	81.13	520.00
1.37	-11.17	0.00	88.34	520.00
1.43	-12.12	0.00	95.86	520.00
1.48	-13.10	0.00	103.68	520.00
1.54	-14.13	0.00	111.81	520.00
1.60	-15.20	0.00	120.24	520.00
1.65	-16.30	0.00	128.98	520.00
1.71	-17.45	0.00	138.03	520.00
1.77	-18.63	0.00	147.39	520.00
1.82	-19.85	0.00	157.05	520.00
1.88	-21.11	0.00	167.02	520.00
1.94	-22.41	0.00	177.29	520.00
2.00	-23.75	0.00	187.88	520.00
2.05	-25.12	0.00	198.77	520.00
2.11	-26.54	0.00	209.96	520.00
2.17	-27.99	0.00	221.46	520.00
2.22	-29.48	0.00	233.27	520.00
2.28	-31.02	0.00	245.39	520.00
2.34	-32.59	0.00	257.81	520.00
2.39	-34.19	0.00	270.54	520.00
2.45	-35.84	0.00	283.58	520.00
2.51	-37.53	0.00	296.92	520.00
2.56	-39.25	0.00	310.57	520.00
2.62	-41.02	0.00	324.53	520.00
2.68	-42.82	0.00	338.79	520.00
2.74	-44.66	0.00	353.36	520.00
2.79	-46.09	0.00	0.00	520.00
2.85	-0.50	0.00	0.00	520.00

SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

Shear force at bottom of wall V = 38.0 kN
Shear stress at bottom of wall v = 0.20 MPa OK
Allowable shear stress vc = 0.49 MPa (based on Wall tensile reinf.)

Sketch of Wall

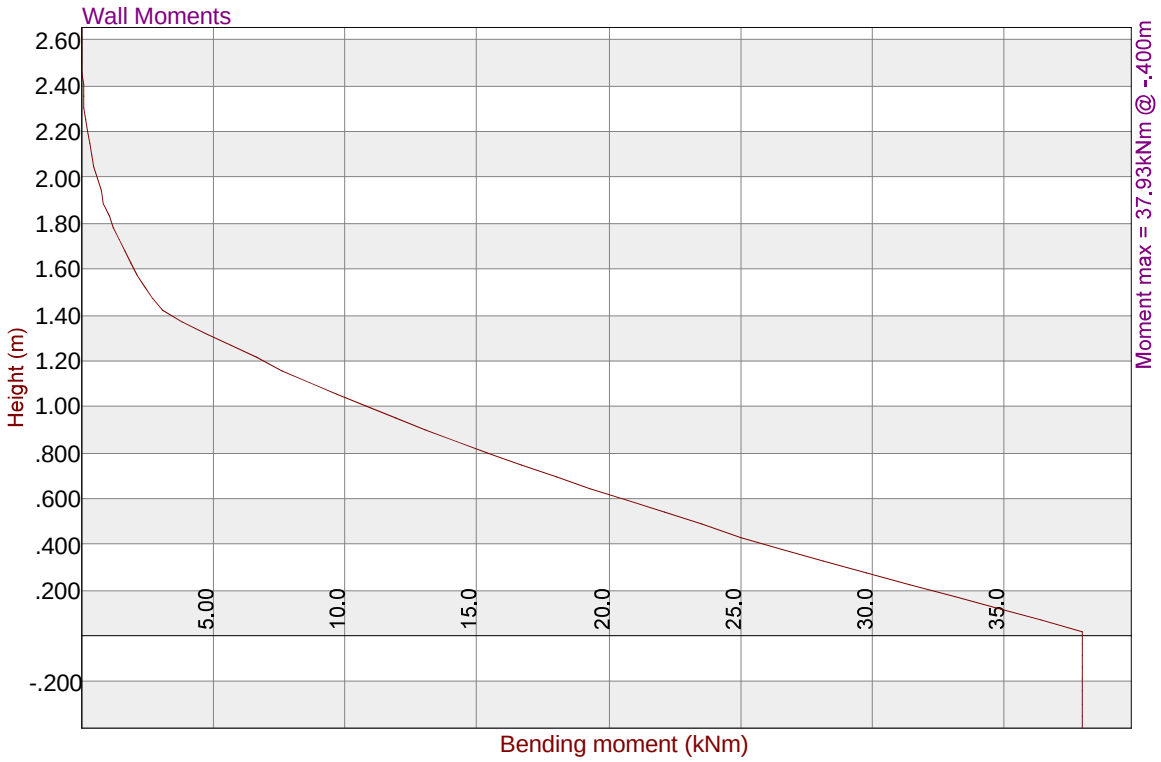
Design code: ACI 318 - 2005



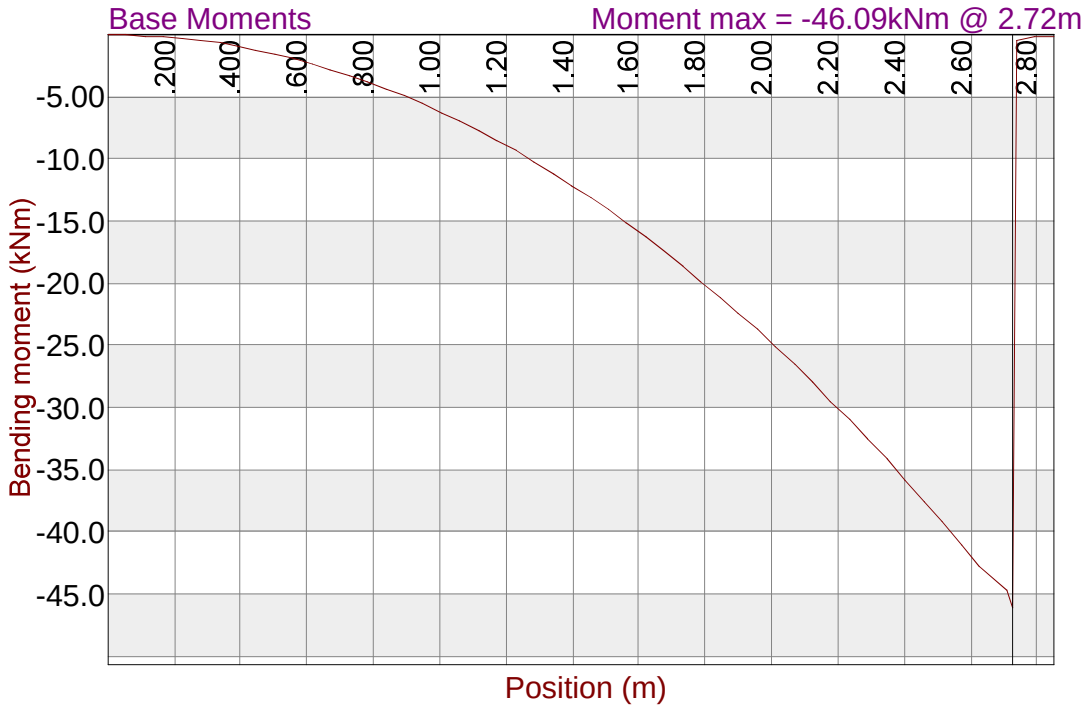
Wall type: Cantilever
Theory: Coulomb

SFslip = 2.04
SFslip (ULS) = 1.26
SFovt = 8.97
SFovt (ULS) = 4.90

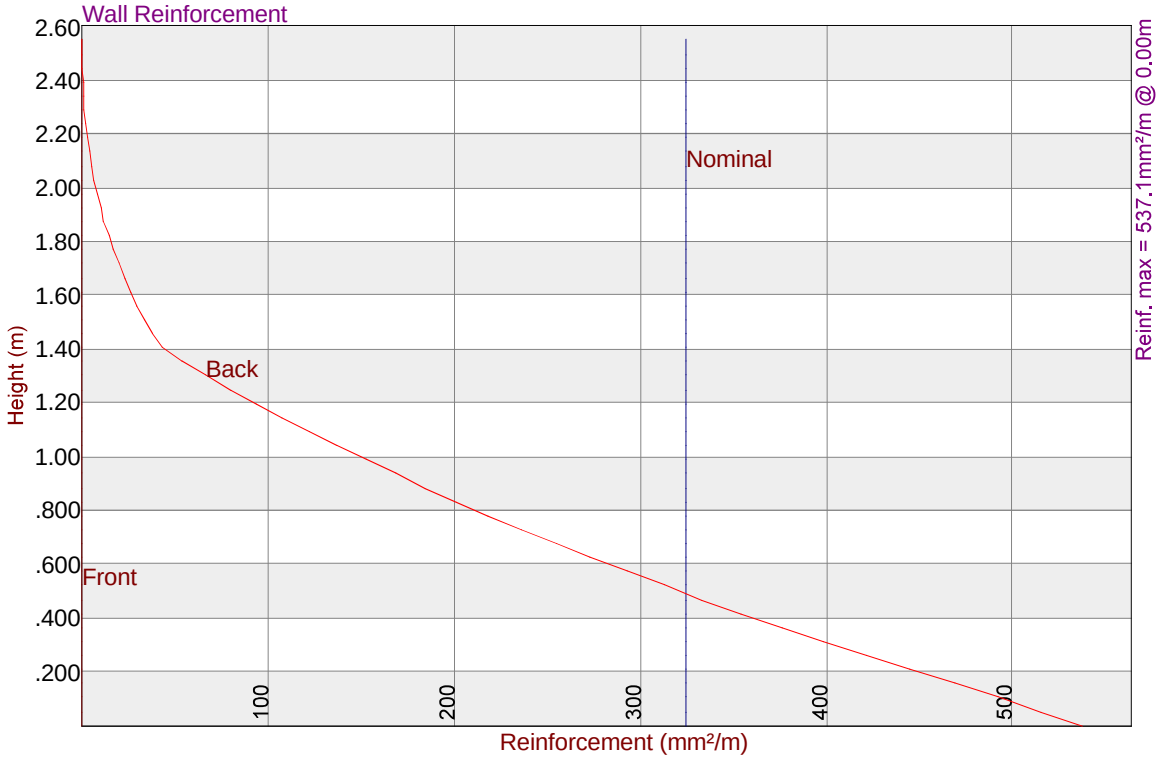
Wall Bending Moments



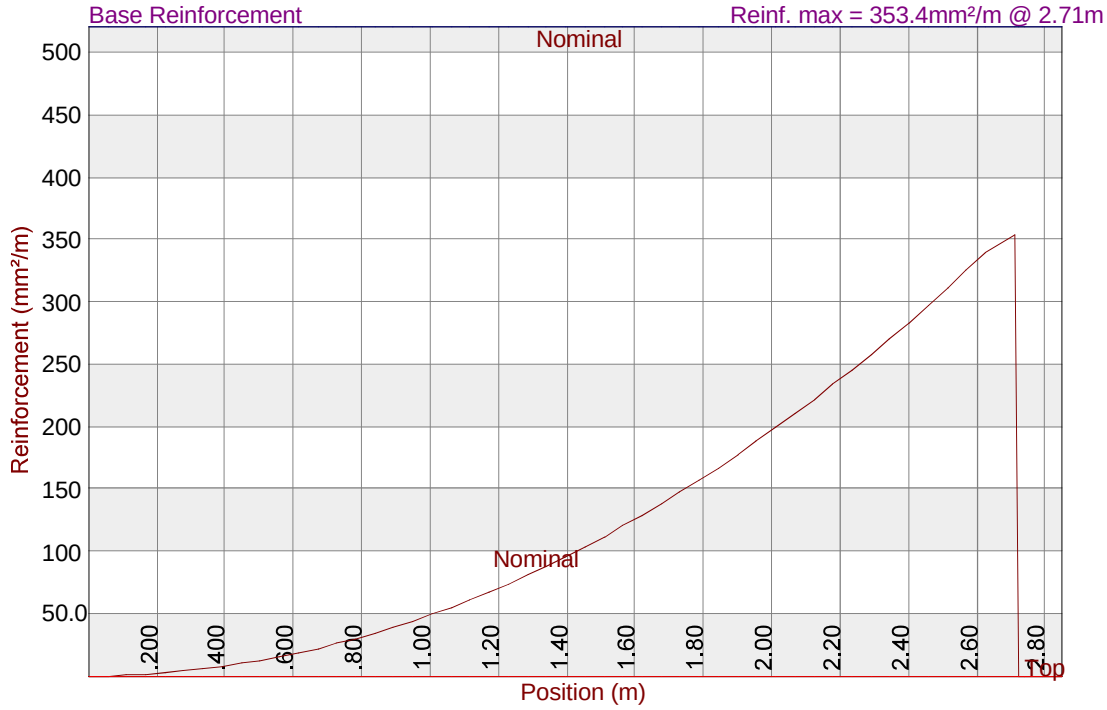
Base Bending Moments



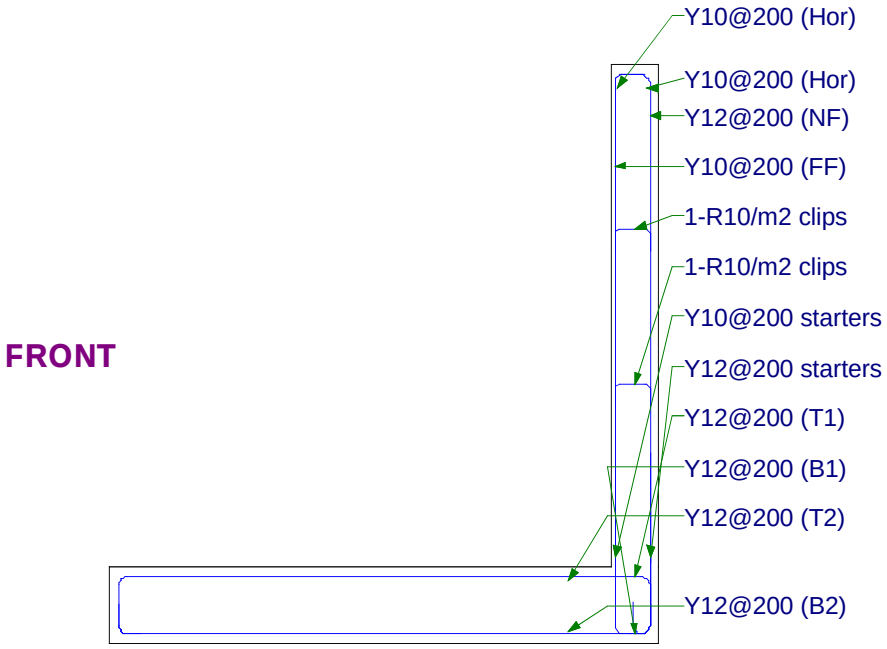
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



SECTION

6) ④VALVE CHAMBER

TOP SLAB (L3.95m×W3.45m)

Rectangular Slab Panel Design :

C04

Input Data

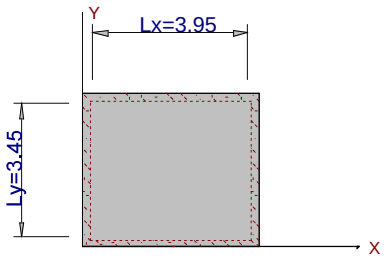
Lx	(m)	3.95
Ly	(m)	3.45
Slab depth	(mm)	250
deff X-dir	(mm)	200
deff Y-dir	(mm)	220
Poisson's ratio		0.2
fcu	(MPa)	25
fy	(MPa)	420
Density	(kN/m^3)	24
Self weight LF		1.4
ε - time factor (ACI318 :9.5.2.5)		2

Load Cases

Unfactored Loads			Unfactored Point Loads			Unfactored Line Loads				
LC No.	Load fact	UDL kN/m²	P kN	x m	y m	L kN/m	x1 m	y1 m	x2 m	y2 m
1	1.4	0.3								
	1.6	20								

Sketch of slab

BS8110 - 1997



Total UDL = 40.820 kN/m² (Incl self Wt)

Load Case 1 (factored)

Output

Wood-Armer Moments and reinforcement for each load case:
Wood-Armer moments were calculated using the 'Wood & Armer' theory.

LOAD CASE 1

Position		Wood-Armer Moments (kNm/m)				Reinforcement (mm²/m)			
		Top		Bottom		Top		Bottom	
X (m)	Y(m)	X	Y	X	Y	X	Y	X	Y
0.00	0.00	5.3	6.8	26.2	24.7	77	90	377	323
0.33	0.00	14.9	14.3	20.4	21.0	214	187	295	276
0.66	0.00	20.3	19.4	15.9	16.8	292	254	229	221
0.99	0.00	12.1	12.3	13.3	13.2	174	161	192	172
1.32	0.00	7.9	7.1	9.0	9.7	113	93	129	127
1.65	0.00	3.9	3.0	4.3	5.1	56	40	62	67
1.98	0.00	0.0	0.0	0.2	0.7	0	0	2	9
2.30	0.00	3.9	3.0	4.3	5.1	56	40	62	67
2.63	0.00	7.9	7.1	9.0	9.7	113	93	129	127
2.96	0.00	12.1	12.3	13.3	13.2	174	161	192	172
3.29	0.00	20.3	19.4	15.9	16.8	292	254	229	221
3.62	0.00	14.9	14.3	20.4	21.0	214	187	295	276
3.95	0.00	5.3	6.8	26.2	24.7	77	90	377	323
0.00	0.29	14.0	15.5	22.0	20.4	202	203	317	268
0.66	0.29	11.7	10.2	19.6	21.1	169	134	282	277
1.32	0.29	1.2	-0.0	14.0	16.7	18	0	202	218
1.98	0.29	0.0	0.0	6.1	9.4	0	0	88	123
2.63	0.29	1.2	-0.0	14.0	16.7	18	0	202	218
3.29	0.29	11.7	10.2	19.6	21.1	169	134	282	277
3.95	0.29	14.0	15.5	22.0	20.4	202	203	317	268
0.00	0.58	20.0	20.3	17.0	16.7	289	266	245	219
0.33	0.58	11.1	11.2	20.8	20.7	160	146	300	272
0.66	0.58	3.5	2.3	23.7	24.8	50	30	341	325
0.99	0.58	-0.0	-0.0	20.8	24.1	0	0	300	316
1.32	0.58	0.0	0.0	18.9	23.4	0	0	272	306
1.65	0.58	0.0	0.0	15.5	20.6	0	0	223	270
1.98	0.58	0.0	0.0	12.1	17.8	0	0	174	234
2.30	0.58	0.0	0.0	15.5	20.6	0	0	223	270
2.63	0.58	0.0	0.0	18.9	23.4	0	0	272	306
2.96	0.58	-0.0	-0.0	20.8	24.1	0	0	300	316
3.29	0.58	3.5	2.3	23.7	24.8	50	30	341	325
3.62	0.58	11.1	11.2	20.8	20.7	160	146	300	272
3.95	0.58	20.0	20.3	17.0	16.7	289	266	245	219
0.00	0.86	12.7	12.5	13.6	13.8	182	163	196	181
0.66	0.86	0.0	0.0	23.0	23.0	0	0	331	302
1.32	0.86	0.0	0.0	20.9	25.1	0	0	301	329
1.98	0.86	0.0	0.0	16.0	21.7	0	0	230	284
2.63	0.86	0.0	0.0	20.9	25.1	0	0	301	329
3.29	0.86	0.0	0.0	23.0	23.0	0	0	331	302
3.95	0.86	12.7	12.5	13.6	13.8	182	163	196	181
0.00	1.15	7.4	8.4	10.6	9.7	107	110	153	127
0.33	1.15	0.3	1.0	16.4	15.8	5	13	237	207
0.66	1.15	0.0	0.0	22.0	21.8	0	0	317	285
0.99	1.15	0.0	0.0	22.4	24.3	0	0	324	319
1.32	1.15	0.0	0.0	23.0	26.9	0	0	332	353
1.65	1.15	0.0	0.0	21.4	26.2	0	0	308	344
1.98	1.15	0.0	0.0	19.8	25.6	0	0	286	336
2.30	1.15	0.0	0.0	21.4	26.2	0	0	308	344
2.63	1.15	0.0	0.0	23.0	26.9	0	0	332	353
2.96	1.15	0.0	0.0	22.4	24.3	0	0	324	319
3.29	1.15	0.0	0.0	22.0	21.8	0	0	317	285
3.62	1.15	0.3	1.0	16.4	15.8	5	13	237	207
3.95	1.15	7.4	8.4	10.6	9.7	107	110	153	127
0.00	1.44	3.1	4.0	5.6	4.7	45	53	81	62
0.66	1.44	0.0	0.0	19.1	18.5	0	0	276	242
1.32	1.44	0.0	0.0	22.2	25.7	0	0	319	337
1.98	1.44	0.0	0.0	21.2	26.7	0	0	306	349
2.63	1.44	0.0	0.0	22.2	25.7	0	0	319	337

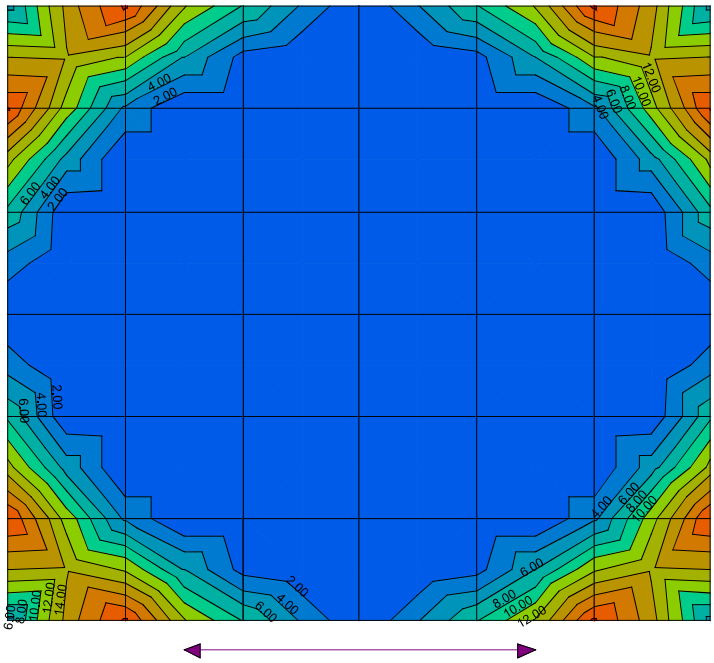
3.29	1.44	0.0	0.0	19.1	18.5	0	0	276	242
3.95	1.44	3.1	4.0	5.6	4.7	45	53	81	62
0.00	1.73	0.0	0.0	0.9	0.3	0	0	13	3
0.33	1.73	0.0	0.0	8.7	7.7	0	0	126	101
0.66	1.73	0.0	0.0	16.2	15.2	0	0	233	199
0.99	1.73	0.0	0.0	18.6	19.9	0	0	269	261
1.32	1.73	0.0	0.0	21.4	24.6	0	0	308	323
1.65	1.73	0.0	0.0	21.9	26.3	0	0	315	344
1.98	1.73	0.0	0.0	22.5	27.8	0	0	325	365
2.30	1.73	0.0	0.0	21.9	26.3	0	0	315	344
2.63	1.73	0.0	0.0	21.4	24.6	0	0	308	323
2.96	1.73	0.0	0.0	18.6	19.9	0	0	269	261
3.29	1.73	0.0	0.0	16.2	15.2	0	0	233	199
3.62	1.73	0.0	0.0	8.7	7.7	0	0	126	101
3.95	1.73	0.0	0.0	0.9	0.3	0	0	13	3
0.00	2.01	3.1	4.0	5.6	4.7	45	53	81	62
0.66	2.01	0.0	0.0	19.1	18.5	0	0	276	242
1.32	2.01	0.0	0.0	22.2	25.7	0	0	319	337
1.98	2.01	0.0	0.0	21.2	26.7	0	0	306	349
2.63	2.01	0.0	0.0	22.2	25.7	0	0	319	337
3.29	2.01	0.0	0.0	19.1	18.5	0	0	276	242
3.95	2.01	3.1	4.0	5.6	4.7	45	53	81	62
0.00	2.30	7.4	8.4	10.6	9.7	107	110	153	127
0.33	2.30	0.3	1.0	16.4	15.8	5	13	237	207
0.66	2.30	0.0	0.0	22.0	21.8	0	0	317	285
0.99	2.30	0.0	0.0	22.4	24.3	0	0	324	319
1.32	2.30	0.0	0.0	23.0	26.9	0	0	332	353
1.65	2.30	0.0	0.0	21.4	26.2	0	0	308	344
1.98	2.30	0.0	0.0	19.8	25.6	0	0	286	336
2.30	2.30	0.0	0.0	21.4	26.2	0	0	308	344
2.63	2.30	0.0	0.0	23.0	26.9	0	0	332	353
2.96	2.30	0.0	0.0	22.4	24.3	0	0	324	319
3.29	2.30	0.0	0.0	22.0	21.8	0	0	317	285
3.62	2.30	0.3	1.0	16.4	15.8	5	13	237	207
3.95	2.30	7.4	8.4	10.6	9.7	107	110	153	127
0.00	2.59	12.7	12.5	13.6	13.8	182	163	196	181
0.66	2.59	0.0	0.0	23.0	23.0	0	0	331	302
1.32	2.59	0.0	0.0	20.9	25.1	0	0	301	329
1.98	2.59	0.0	0.0	16.0	21.7	0	0	230	284
2.63	2.59	0.0	0.0	20.9	25.1	0	0	301	329
3.29	2.59	0.0	0.0	23.0	23.0	0	0	331	302
3.95	2.59	12.7	12.5	13.6	13.8	182	163	196	181
0.00	2.88	20.0	20.3	17.0	16.7	289	266	245	219
0.33	2.88	11.1	11.2	20.8	20.7	160	146	300	272
0.66	2.88	3.5	2.3	23.7	24.8	50	30	341	325
0.99	2.88	-0.0	-0.0	20.8	24.1	0	0	300	316
1.32	2.88	0.0	0.0	18.9	23.4	0	0	272	306
1.65	2.88	0.0	0.0	15.5	20.6	0	0	223	270
1.98	2.88	0.0	0.0	12.1	17.8	0	0	174	234
2.30	2.88	0.0	0.0	15.5	20.6	0	0	223	270
2.63	2.88	0.0	0.0	18.9	23.4	0	0	272	306
2.96	2.88	-0.0	-0.0	20.8	24.1	0	0	300	316
3.29	2.88	3.5	2.3	23.7	24.8	50	30	341	325
3.62	2.88	11.1	11.2	20.8	20.7	160	146	300	272
3.95	2.88	20.0	20.3	17.0	16.7	289	266	245	219
0.00	3.16	14.0	15.5	22.0	20.4	202	203	317	268
0.66	3.16	11.7	10.2	19.6	21.1	169	134	282	277
1.32	3.16	1.2	-0.0	14.0	16.7	18	0	202	218
1.98	3.16	0.0	0.0	6.1	9.4	0	0	88	123
2.63	3.16	1.2	-0.0	14.0	16.7	18	0	202	218
3.29	3.16	11.7	10.2	19.6	21.1	169	134	282	277
3.95	3.16	14.0	15.5	22.0	20.4	202	203	317	268
0.00	3.45	5.3	6.8	26.2	24.7	77	90	377	323
0.33	3.45	14.9	14.3	20.4	21.0	214	187	295	276
0.66	3.45	20.3	19.4	15.9	16.8	292	254	229	221
0.99	3.45	12.1	12.3	13.3	13.2	174	161	192	172
1.32	3.45	7.9	7.1	9.0	9.7	113	93	129	127
1.65	3.45	3.9	3.0	4.3	5.1	56	40	62	67
1.98	3.45	0.0	0.0	0.2	0.7	0	0	2	9

2.30	3.45	3.9	3.0	4.3	5.1	56	40	62	67
2.63	3.45	7.9	7.1	9.0	9.7	113	93	129	127
2.96	3.45	12.1	12.3	13.3	13.2	174	161	192	172
3.29	3.45	20.3	19.4	15.9	16.8	292	254	229	221
3.62	3.45	14.9	14.3	20.4	21.0	214	187	295	276
3.95	3.45	5.3	6.8	26.2	24.7	77	90	377	323

Wood-Armer Moments:

BS8110 - 1997

Top:LC 1 (kNm/m)

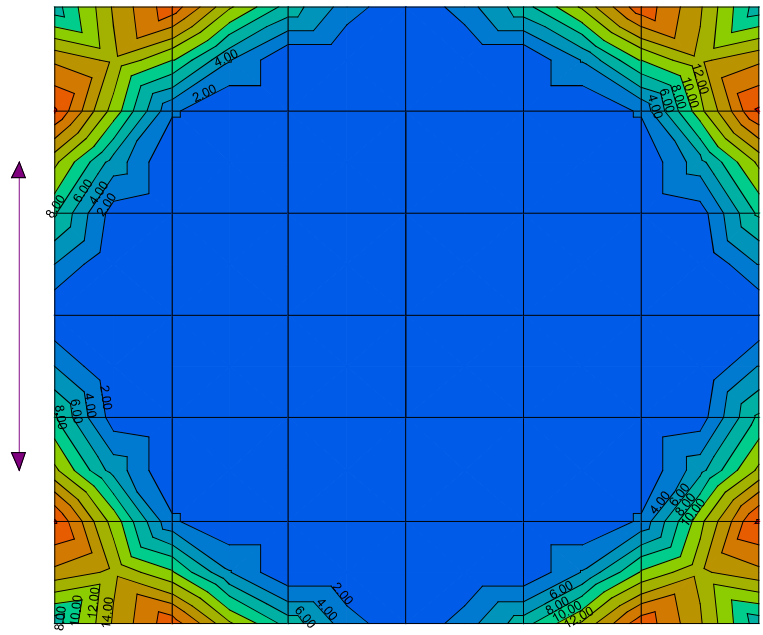


Max value:20.3 at X:3.3 Y:3.5

Wood-Armer Moments:

BS8110 - 1997

Top:LC 1 (kNm/m)

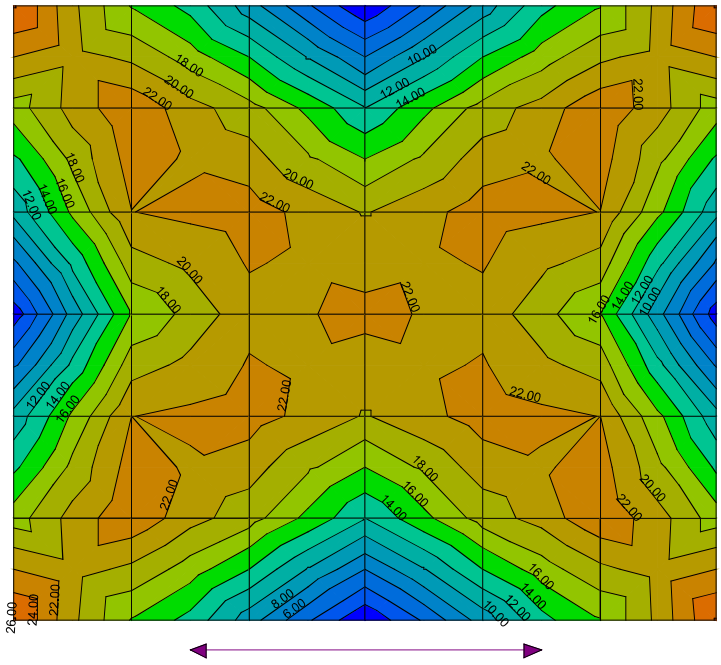


Max value:20.3 at X:4.0 Y:2.9

Wood-Armer Moments:

BS8110 - 1997

Bot:LC 1 (kNm/m)

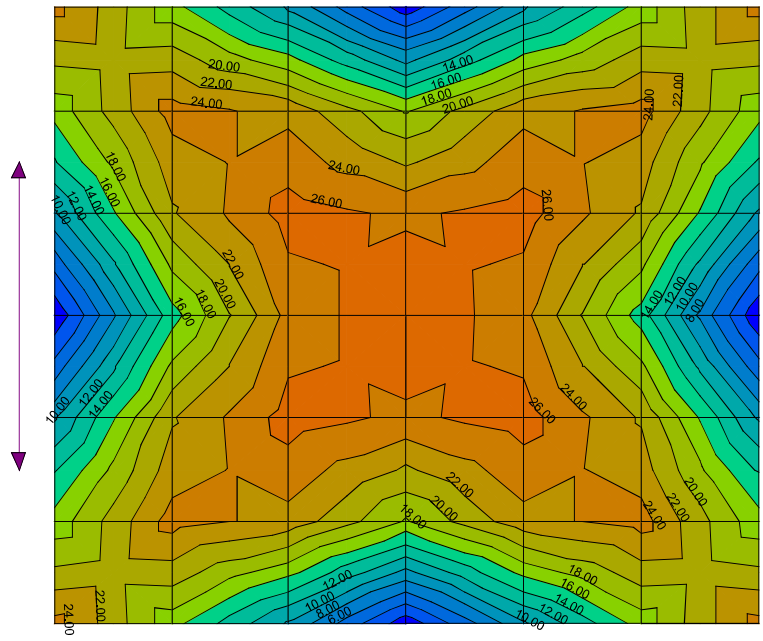


Max value:26.2 at X:4.0 Y:3.5

Wood-Armer Moments:

BS8110 - 1997

Bot:LC 1 (kNm/m)

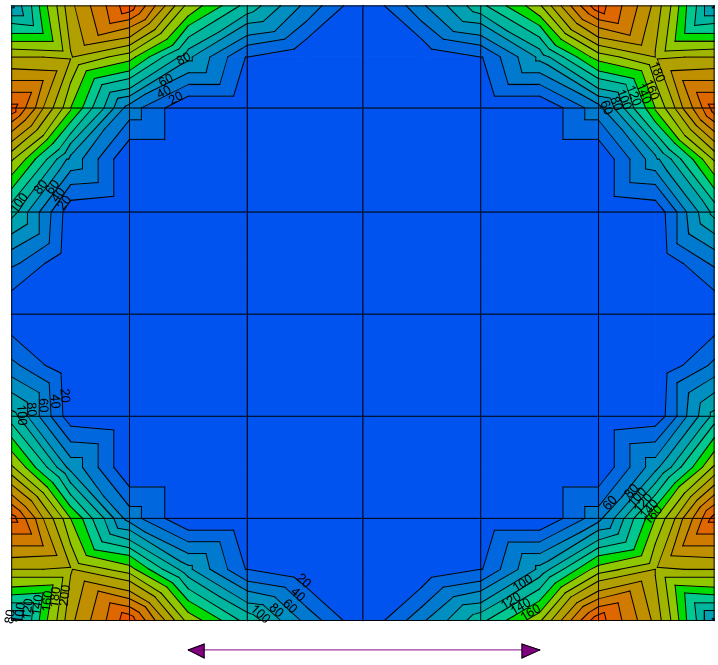


Max value:27.8 at X:2.0 Y:1.7

Reinforcement:

BS8110 - 1997

Top:LC 1 (mm²/m)

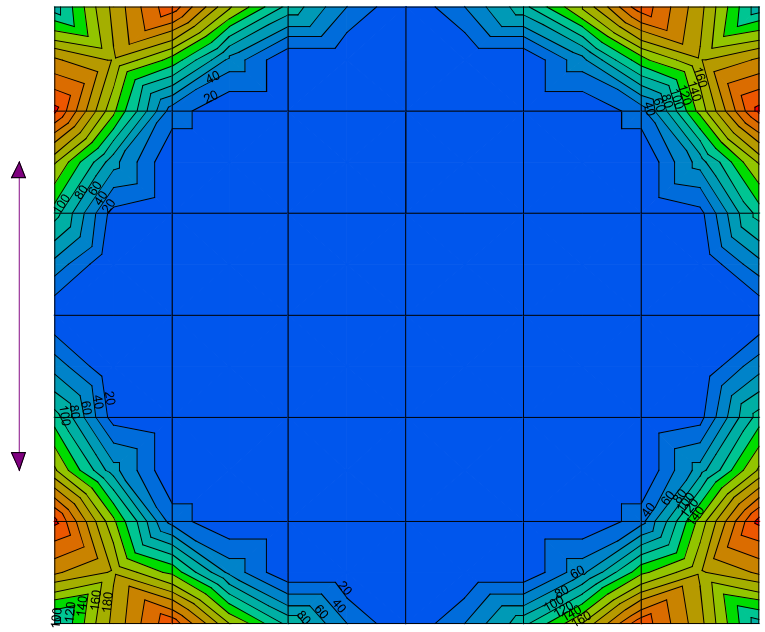


Max value:292.4 at X:3.3 Y:3.5

Reinforcement:

BS8110 - 1997

Top:LC 1 (mm²/m)

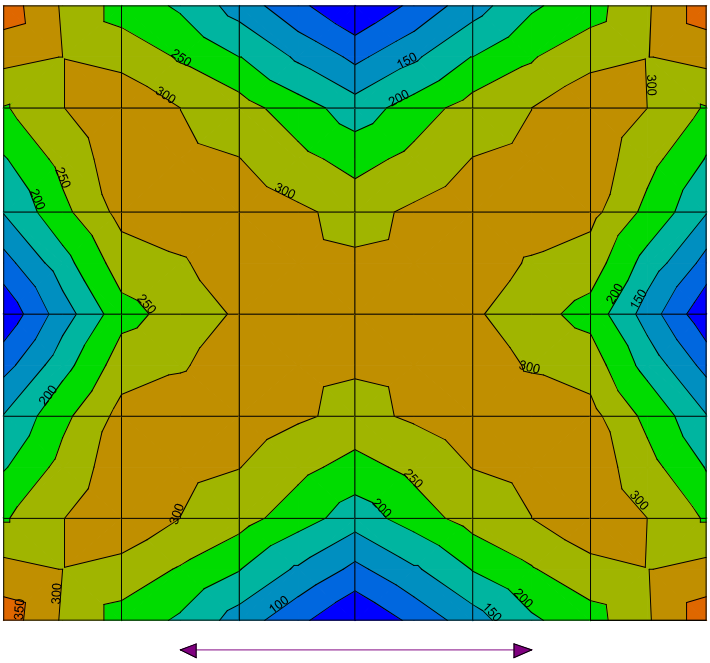


Max value:265.7 at X:4.0 Y:2.9

Reinforcement:

BS8110 - 1997

Bot:LC 1 (mm²/m)

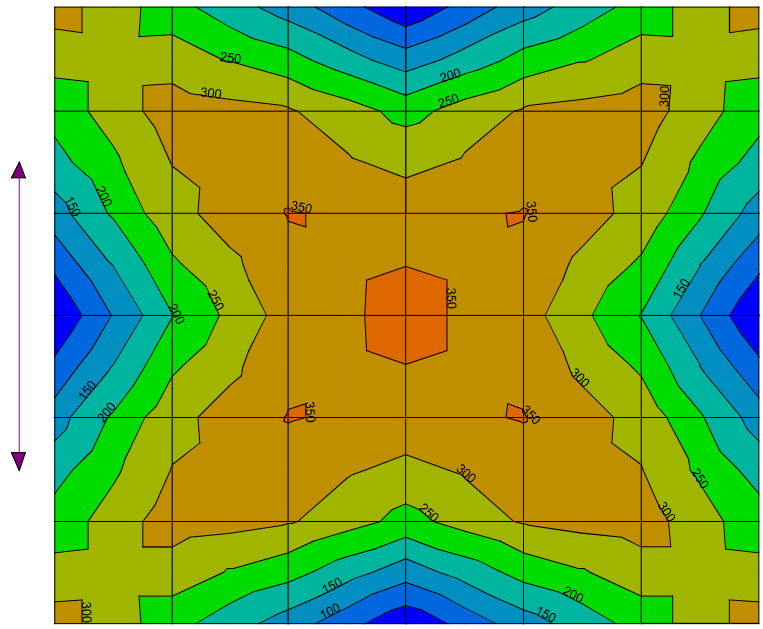


Max value:377.1 at X:4.0 Y:3.5

Reinforcement:

BS8110 - 1997

Bot:LC 1 (mm²/m)

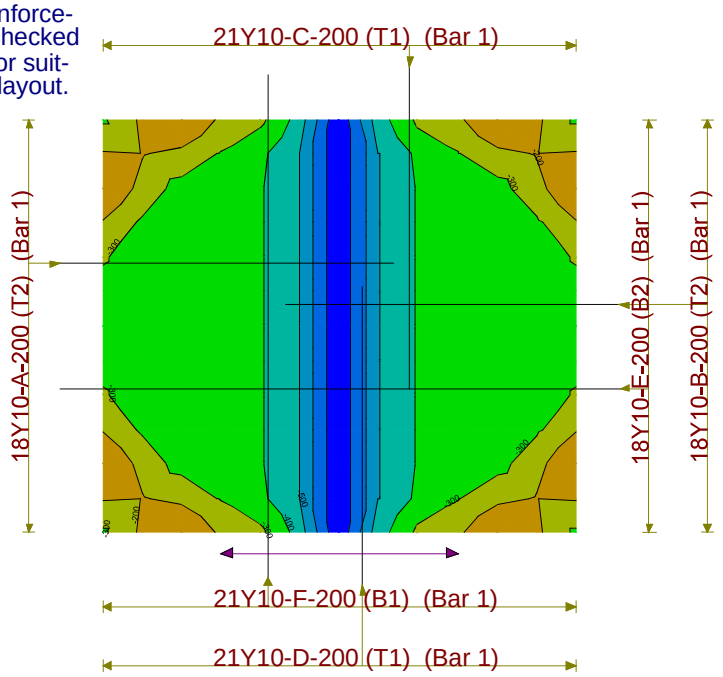


Max value:364.9 at X:2.0 Y:1.7

Rebar Excess:

Rebar Excess Top (mm²/m)

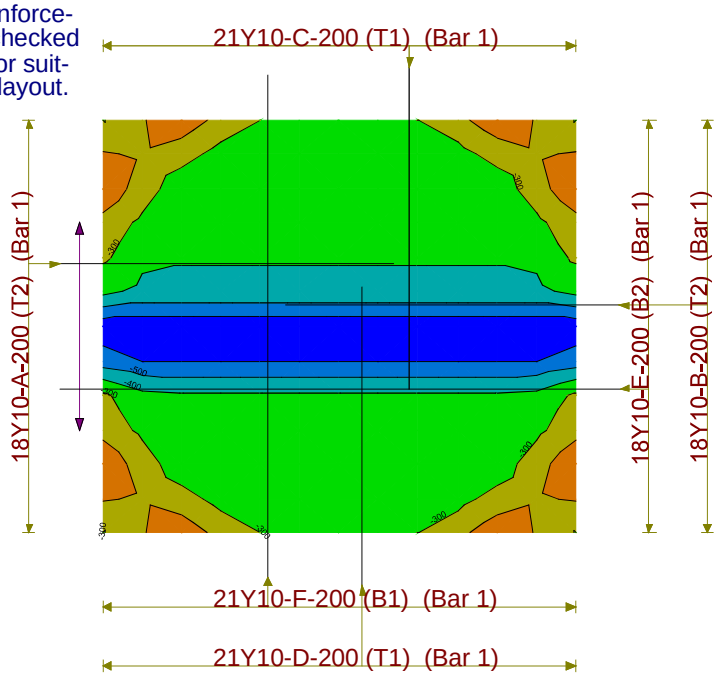
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Top (mm²/m)

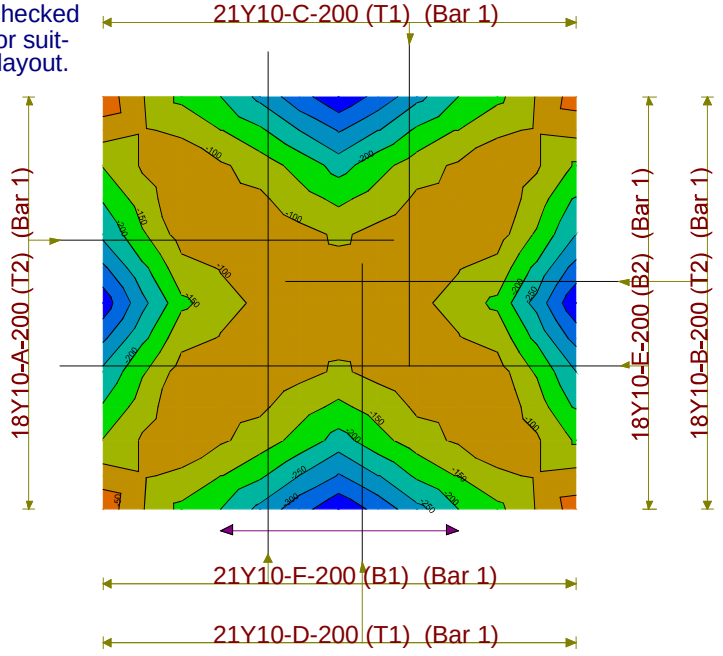
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Bot (mm²/m)

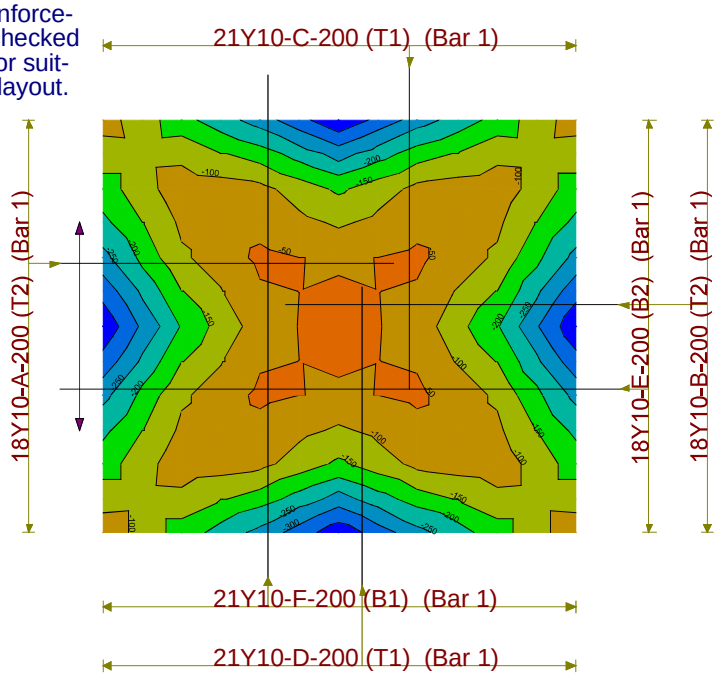
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Bot (mm²/m)

Note:Default reinforcement should be checked and adjusted for suitability and layout.



6) ④VALVE CHAMBER

WALL (H3.0m)

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Cantilever wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1 (m)	3	C (m)	0.6	W	(kN/m²)	1	Soil frict ϕ	(°)	30	SF Overt.	1.5
H2 (m)	0	F (m)	0	P	(kN)	0	Fill slope β	(°)	0	SF Slip	1.5
H3 (m)	0	xf (m)	2	xp	(m)	0	Wall frict δ	(°)	20	ULS DL Factor	1.4
Hw (m)	0	At (m)	.4	L	(kN/m)	20	ρ Conc	kN/m³	25	ULS LL Factor	1.6
Hr (m)	0.36	Ab (m)	.4	xl	(m)	2	ρ Soil	kN/m³	18	Pmax (kPa)	100
B (m)	3.45	Cov wall	mm	50	Lh	(kN/m)		fcu	(MPa)	25	Soil Poisson υ	0.5
D (m)	0	Cov base	mm	50	x	(m)	0	fy	(MPa)	420	DL Factor Ovt.	0.9

Seepage allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:ON

Hor Accel. (g)	0.02
Vert Accel. (g)	0.01
Include LL's	Y

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.297
Passive Pressure coefficient Kp :6.105
Seismic Active Pressure coefficient Kas :0.313
Seismic Passive Pressure coefficient Kps :5.934
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	23.826	1.040	8.672	3.850
Siesmic component of Pa	1.195	1.800	0.435	3.850
As a result of surcharge w	0.874	1.500	0.318	3.850
As a result of Line Load L	4.721	1.686	0.000	3.850
Siesmic wall inertia	1.619	0.740		
Stabilizing forces:				
Passive pressure on base Pp	-0.000	0.000		
Siesmic component of Pp	-0.000	0.000		
Weight of the wall + base			80.933	2.431
Weight of soil on the base			0.000	0.000
UDL of 1.0 kPa			0.000	3.850

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 196.78 kNm
Destabilizing moment Mo : 0.64 kNm

Safety factor against overturning = Mr/Mo = 308.282

2.Force Equilibrium at SLS

Sum of Vertical forces Pv : 89.92 kN
Frictional resistance Pfric : 51.92 kN
Passive Pressure on shear key : 0.00 kN
Passive pressure on base : 0.00 kN
=> Total Horiz. resistance Fr : 51.92 kN

Horizontal sliding force on wall Fhw : 31.04 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 31.04 kN

Safety factor against overall sliding = Fr/Fh = 1.673

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	33.738	1.045	12.141	3.850
Siesmic component of Pa	1.913	1.800	0.696	3.850
As a result of surcharge w	1.398	1.500	0.509	3.850
As a result of Line Load L	7.553	1.686	0.000	3.850
Siesmic wall inertia	2.590	0.740		
Stabilizing forces:				
Passive pressure on base Pp	-0.000	0.000		
Siesmic component of Pp	-0.000	0.000		
Weight of the wall + base			72.839	2.431
Weight of soil on the base			0.000	0.000
UDL of 0.9 kPa			0.000	3.850

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 177.10 kNm
Destabilizing moment Mo : 3.32 kNm

Safety factor against overturning = Mr/Mo = 53.408

2.Force Equilibrium at ULS

Sum of Vertical forces Pv : 80.93 kN
Frictional resistance Pfric : 46.72 kN
Passive Pressure on shear key : 0.00 kN

Passive pressure on base : 0.00 kN
=> Total Horiz. resistance Fr : 46.72 kN

Horizontal sliding force on wall Fhw : 45.28 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 45.28 kN

Safety factor against overall sliding = Fr/Fh = 1.032

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure : 32.68 kPa
Minimum pressure : 14.03 kPa
Maximum pressure occurs at right hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Nominal (0.13%) (mm²/m)
0.00	28.15	0.00	238.67	520.00
0.05	26.74	0.00	226.66	520.00
0.10	25.36	0.00	214.98	520.00
0.14	24.02	0.00	203.62	520.00
0.19	22.72	0.00	192.56	520.00
0.24	21.45	0.00	181.82	520.00
0.29	20.22	0.00	171.37	520.00
0.34	19.02	0.00	161.21	520.00
0.38	17.85	0.00	151.35	520.00
0.43	16.72	0.00	141.76	520.00
0.48	15.62	0.00	132.45	520.00
0.53	14.56	0.00	123.41	520.00
0.58	13.52	0.00	114.64	520.00
0.62	12.52	0.00	106.12	520.00
0.67	11.54	0.00	97.86	520.00
0.72	10.60	0.00	89.84	520.00
0.77	9.68	0.00	82.07	520.00
0.82	8.79	0.00	74.53	520.00
0.86	7.93	0.00	67.22	520.00
0.91	7.09	0.00	60.13	520.00
0.96	6.28	0.00	53.26	520.00
1.01	5.50	0.00	46.59	520.00
1.06	4.74	0.00	40.14	520.00
1.10	4.00	0.00	33.88	520.00
1.15	3.42	0.00	28.99	520.00
1.20	3.09	0.00	26.19	520.00
1.25	2.78	0.00	23.57	520.00
1.30	2.49	0.00	21.13	520.00
1.34	2.22	0.00	18.86	520.00
1.39	1.98	0.00	16.75	520.00
1.44	1.75	0.00	14.80	520.00
1.49	1.53	0.00	13.00	520.00
1.54	1.34	0.00	11.35	520.00
1.58	1.16	0.00	9.84	520.00
1.63	1.00	0.00	8.47	520.00
1.68	0.85	0.00	7.22	520.00
1.73	0.72	0.00	6.10	520.00
1.78	0.60	0.00	5.09	520.00
1.82	0.50	0.00	4.20	520.00
1.87	0.40	0.00	3.41	520.00
1.92	0.32	0.00	2.72	520.00
1.97	0.25	0.00	2.12	520.00
2.02	0.19	0.00	1.61	520.00
2.06	0.14	0.00	1.19	520.00
2.11	0.10	0.00	0.84	520.00
2.16	0.07	0.00	0.56	520.00
2.21	0.04	0.00	0.34	520.00
2.26	0.02	0.00	0.18	520.00
2.30	0.01	0.00	0.08	520.00

2.35	0.00	0.00	0.02	520.00
2.40	0.00	0.00	0.00	520.00

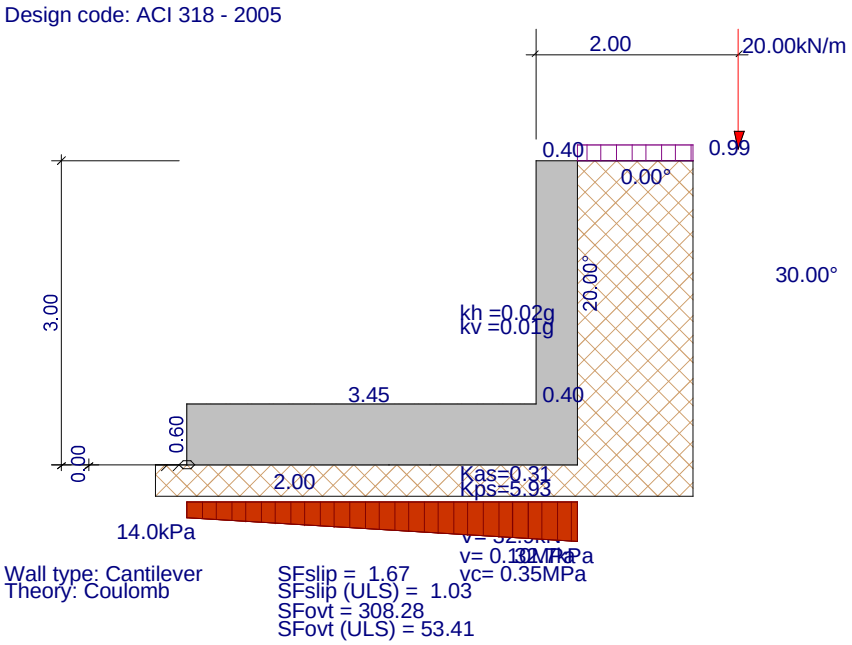
BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Nominal (0.13%) (mm^2/m)
0.00	-0.00	0.00	0.00	780.00
0.08	-0.02	0.00	0.11	780.00
0.15	-0.09	0.00	0.46	780.00
0.23	-0.19	0.00	1.03	780.00
0.31	-0.34	0.00	1.82	780.00
0.39	-0.53	0.00	2.85	780.00
0.46	-0.77	0.00	4.11	780.00
0.54	-1.05	0.00	5.59	780.00
0.62	-1.37	0.00	7.30	780.00
0.69	-1.73	0.00	9.24	780.00
0.77	-2.14	0.00	11.41	780.00
0.85	-2.59	0.00	13.80	780.00
0.92	-3.08	0.00	16.42	780.00
1.00	-3.61	0.00	19.28	780.00
1.08	-4.19	0.00	22.36	780.00
1.16	-4.81	0.00	25.66	780.00
1.23	-5.47	0.00	29.20	780.00
1.31	-6.18	0.00	32.96	780.00
1.39	-6.92	0.00	36.95	780.00
1.46	-7.71	0.00	41.17	780.00
1.54	-8.55	0.00	45.62	780.00
1.62	-9.42	0.00	50.30	780.00
1.69	-10.34	0.00	55.20	780.00
1.77	-11.30	0.00	60.34	780.00
1.85	-12.31	0.00	65.70	780.00
1.93	-13.36	0.00	71.29	780.00
2.00	-14.45	0.00	77.10	780.00
2.08	-15.58	0.00	83.15	780.00
2.16	-16.75	0.00	89.42	780.00
2.23	-17.97	0.00	95.92	780.00
2.31	-19.23	0.00	102.65	780.00
2.39	-20.54	0.00	109.61	780.00
2.46	-21.88	0.00	116.79	780.00
2.54	-23.27	0.00	124.21	780.00
2.62	-24.70	0.00	131.85	780.00
2.70	-26.18	0.00	139.72	780.00
2.77	-27.69	0.00	147.82	780.00
2.85	-29.25	0.00	156.14	780.00
2.93	-30.86	0.00	164.70	780.00
3.00	-32.50	0.00	173.48	780.00
3.08	-34.19	0.00	182.49	780.00
3.16	-35.92	0.00	191.73	780.00
3.23	-37.70	0.00	201.20	780.00
3.31	-39.51	0.00	210.89	780.00
3.39	-41.37	0.00	220.81	780.00
3.46	-43.27	0.00	230.96	780.00
3.54	-45.22	0.00	241.34	780.00
3.62	-47.20	0.00	251.95	780.00
3.70	-49.23	0.00	262.79	780.00
3.77	-49.96	0.00	0.00	780.00
3.85	-0.96	0.00	0.00	780.00

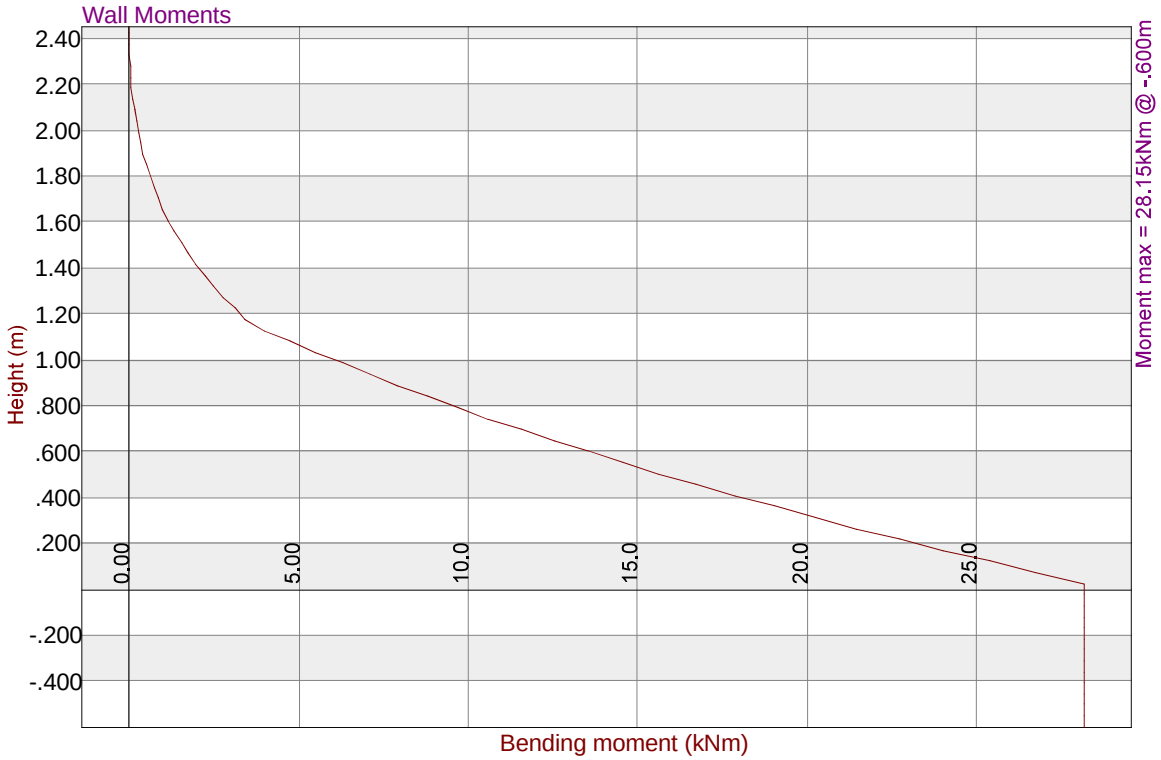
SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

Shear force at bottom of wall V = 32.9 kN
Shear stress at bottom of wall v = 0.10 MPa OK
Allowable shear stress vc = 0.35 MPa (based on Wall tensile reinf.)

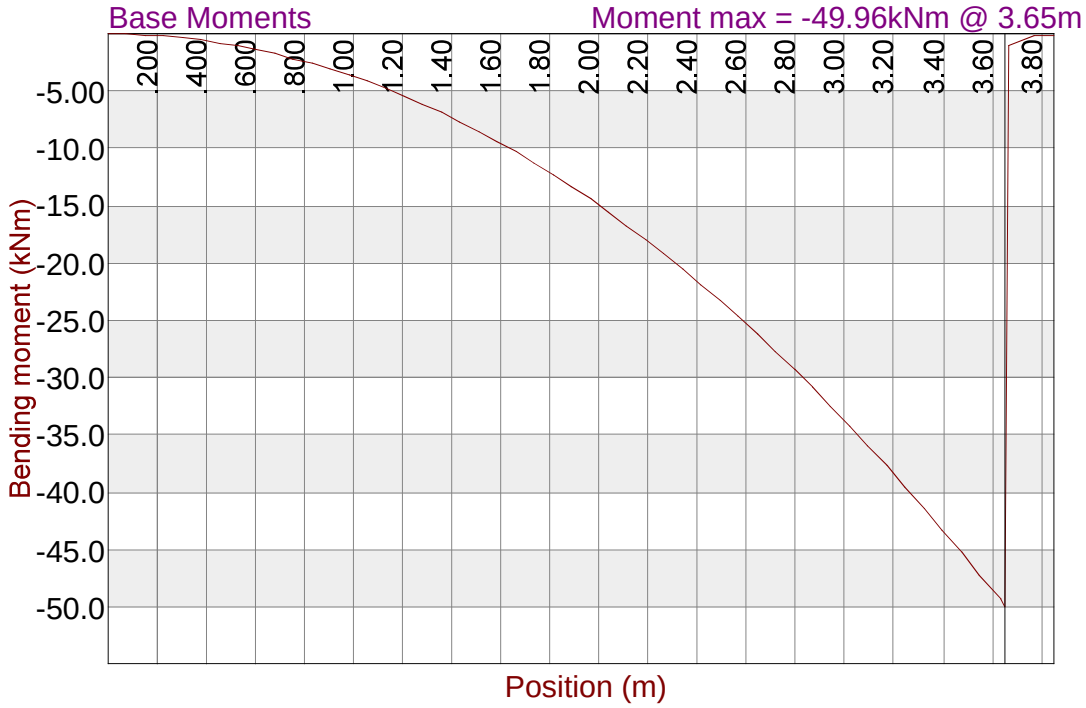
Sketch of Wall



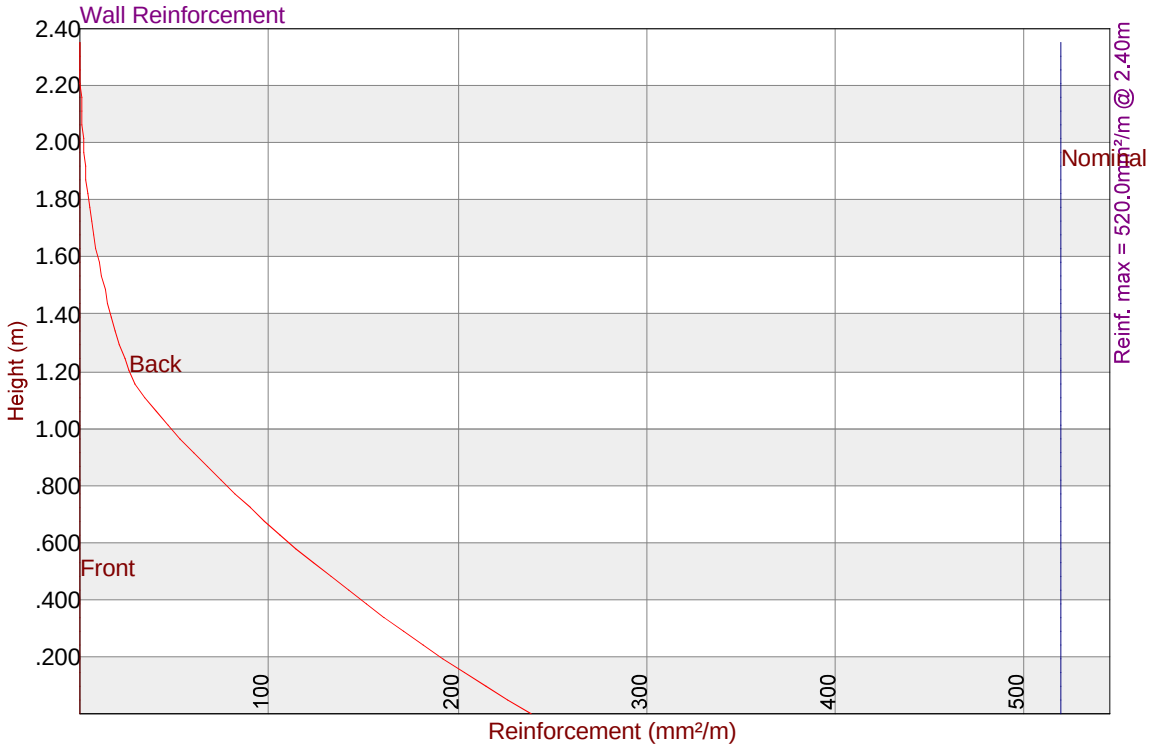
Wall Bending Moments



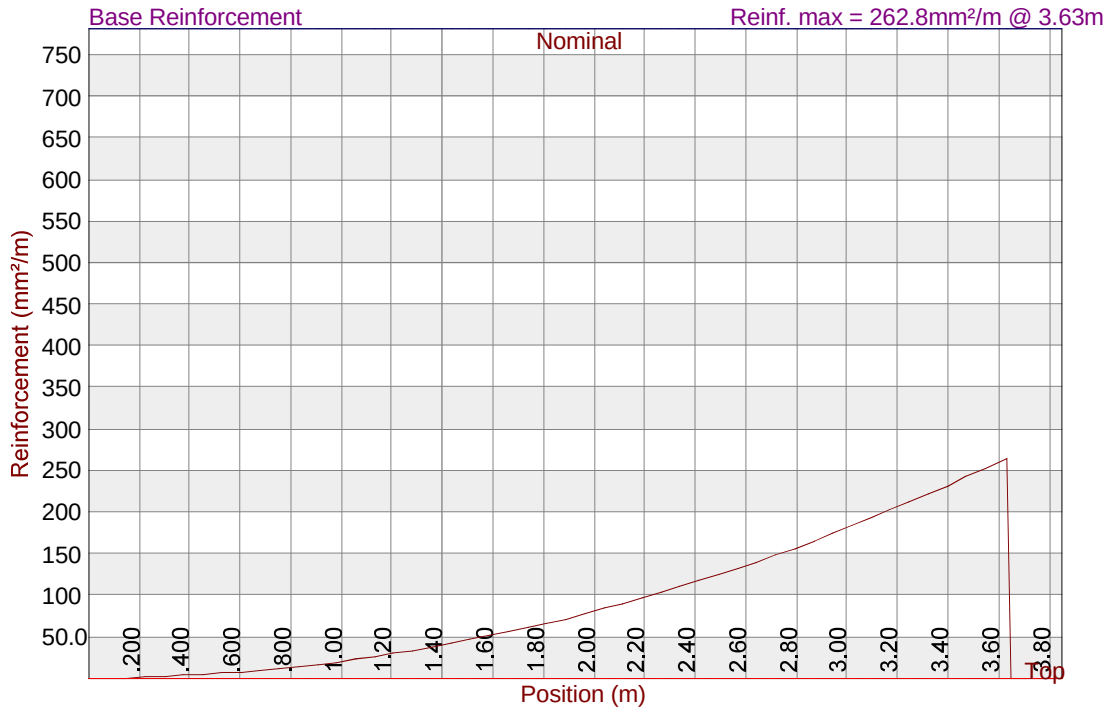
Base Bending Moments



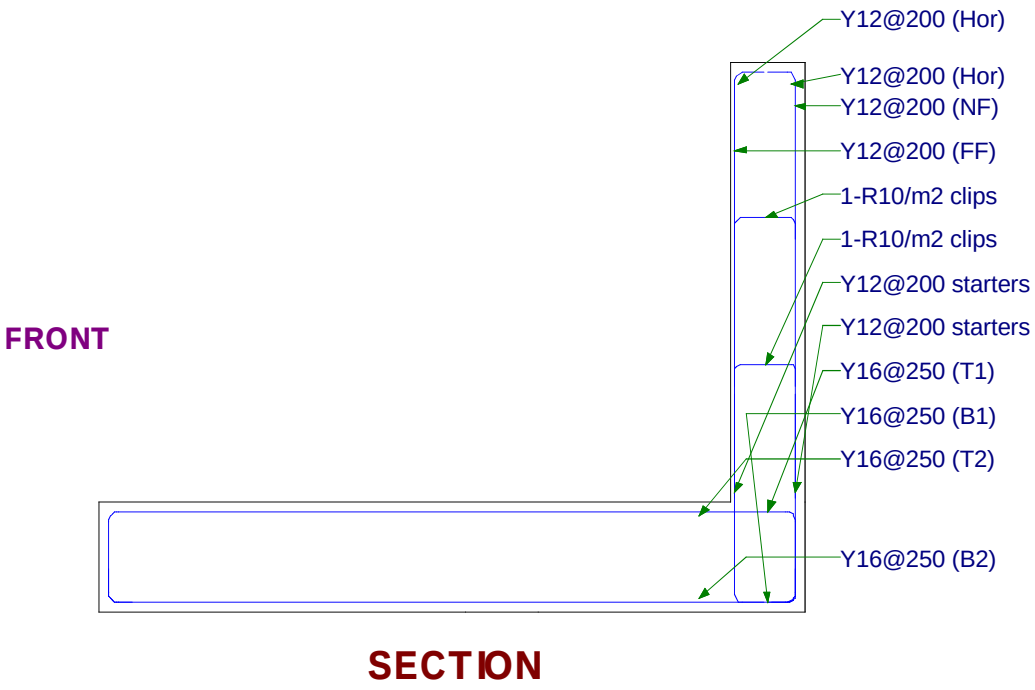
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



SECTION

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Reservoir wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1 (m)	3	C (m)	.6	W	(kN/m²)		Soil frict ϕ	(°)	30	SF Overt.	1.5
H2 (m)	0.67	F (m)		P	(kN)		Fill slope β	(°)		SF Slip	1.5
H3 (m)	2.6	xf (m)		xp	(m)		Wall frict δ	(°)		ULS DL Factor	1.4
Hw (m)	2.6	At (m)	.4	L	(kN/m)		ρ Conc	kN/m³	25	ULS LL Factor	1.6
Hr (m)	0.36	Ab (m)	.4	xl	(m)		ρ Soil	kN/m³	18	Pmax (kPa)	100
B (m)		Cov wall	mm 50	Lh	(kN/m)		fcu	(MPa)	25	Soil Poisson υ	0.5
D (m)	3.45	Cov base	mm 50	x	(m)		fy	(MPa)	450	DL Factor Ovt.	0.9

Seepage not allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:OFF

Hor Accel. (g)	
Vert Accel. (g)	
Include LL's	

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.333
Passive Pressure coefficient Kp :3.000
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.480	0.133	0.000	0.400
Triangular W-table press Pw	0.523	0.133	0.000	0.400
W-table pr below free water	8.633	0.200	0.000	0.400
Free water pressure Pwf	23.740	1.133	0.000	0.400
Hydrostatic pressure on bot of base: uniform portion			0.000	1.925
Hydrostatic pressure on bot of base: triangular portion			0.000	2.567
Stabilizing forces:				
Passive pressure on base Pp	-12.120	0.223		
Weight of the wall + base			81.750	1.419
Weight of soil on the base			-5.651	2.125
Hydrostatic pressure on top of rear portion of base			67.689	2.125
Hydrostatic pressure on top of front portion of base			0.000	0.000

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 250.51 kNm
      Destabilizing moment Mo : 28.77 kNm

Safety factor against overturning = Mr/Mo = 8.708

2.Force Equilibrium at SLS

    Sum of Vertical forces Pv : 143.79 kN
  Frictional resistance Pfric : 83.02 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base : 12.12 kN
=> Total Horiz. resistance Fr : 95.14 kN

     Horizontal sliding force on wall Fhw : 33.38 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh : 33.38 kN

Safety factor against overall sliding = Fr/Fh = 2.850

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.672	0.133	0.000	0.400
Triangular W-table press Pw	0.732	0.133	0.000	0.400
W-table pr below free water	12.086	0.200	0.000	0.400
Free water pressure Pwf	33.236	1.133	0.000	0.400
Hydrostatic pressure on bot of base: uniform portion			0.000	1.925
Hydrostatic pressure on bot of base: triangular portion			0.000	2.567
Stabilizing forces:				
Passive pressure on base Pp	-10.908	0.223		
Weight of the wall + base			73.575	1.419
Weight of soil on the base			-5.086	2.125
Hydrostatic pressure on top of rear portion of base			60.920	2.125
Hydrostatic pressure on top of front portion of base			0.000	0.000

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 225.46 kNm
      Destabilizing moment Mo : 40.27 kNm

Safety factor against overturning = Mr/Mo = 5.598

2.Force Equilibrium at ULS

```
    Sum of Vertical forces Pv : 129.41 kN
  Frictional resistance Pfric :  74.71 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :  10.91 kN
=> Total Horiz. resistance Fr :  85.62 kN

     Horizontal sliding force on wall Fhw :  46.73 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh :  46.73 kN
```

Safety factor against overall sliding = Fr/Fh = 1.832

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure : 59.63 kPa
Minimum pressure : 15.06 kPa
Maximum pressure occurs at left hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Nominal (0.13%) (mm²/m)
0.00	18.60	0.00	147.14	520.00
0.05	17.29	0.00	136.82	520.00
0.10	16.05	0.00	126.98	520.00
0.14	14.87	0.00	117.61	520.00
0.19	13.74	0.00	108.72	520.00
0.24	12.68	0.00	100.29	520.00
0.29	11.67	0.00	92.31	520.00
0.34	10.71	0.00	84.76	520.00
0.38	9.81	0.00	77.63	520.00
0.43	8.96	0.00	70.92	520.00
0.48	8.17	0.00	64.60	520.00
0.53	7.42	0.00	58.67	520.00
0.58	6.71	0.00	53.12	520.00
0.62	6.06	0.00	47.93	520.00
0.67	5.45	0.00	43.08	520.00
0.72	4.88	0.00	38.58	520.00
0.77	4.35	0.00	34.40	520.00
0.82	3.86	0.00	30.53	520.00
0.86	3.41	0.00	26.97	520.00
0.91	2.99	0.00	23.69	520.00
0.96	2.62	0.00	20.69	520.00
1.01	2.27	0.00	17.96	520.00
1.06	1.96	0.00	15.48	520.00
1.10	1.67	0.00	13.23	520.00
1.15	1.42	0.00	11.22	520.00
1.20	1.19	0.00	9.42	520.00
1.25	0.99	0.00	7.82	520.00
1.30	0.81	0.00	6.42	520.00
1.34	0.66	0.00	5.19	520.00
1.39	0.52	0.00	4.13	520.00
1.44	0.41	0.00	3.23	520.00
1.49	0.31	0.00	2.47	520.00
1.54	0.23	0.00	1.84	520.00
1.58	0.17	0.00	1.32	520.00
1.63	0.12	0.00	0.92	520.00
1.68	0.08	0.00	0.60	520.00
1.73	0.05	0.00	0.37	520.00
1.78	0.03	0.00	0.21	520.00
1.82	0.01	0.00	0.10	520.00
1.87	0.00	0.00	0.04	520.00
1.92	0.00	0.00	0.01	520.00

1.97	0.00	0.00	0.00	520.00
2.02	0.00	0.00	0.00	520.00
2.06	0.00	0.00	0.00	520.00
2.11	0.00	0.00	0.00	520.00
2.16	0.00	0.00	0.00	520.00
2.21	0.00	0.00	0.00	520.00
2.26	0.00	0.00	0.00	520.00
2.30	0.00	0.00	0.00	520.00
2.35	0.00	0.00	0.00	520.00
2.40	0.00	0.00	0.00	520.00

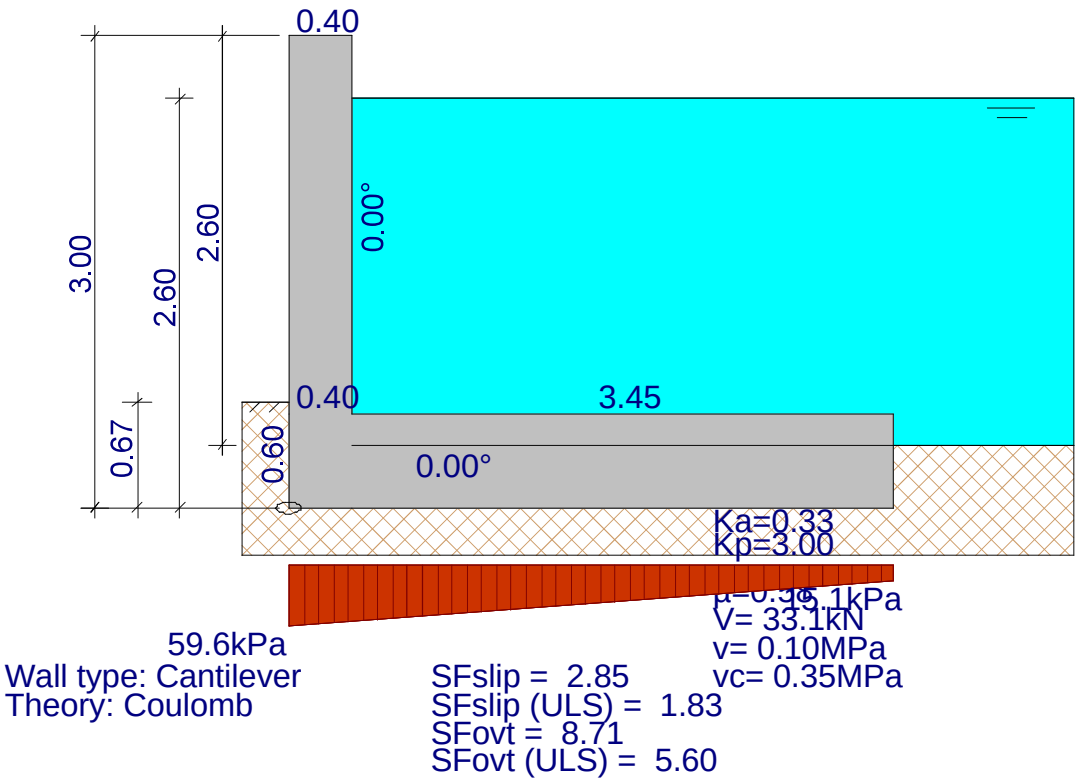
BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Nominal (0.13%) (mm^2/m)
0.00	-0.00	0.00	0.00	780.00
0.08	-0.17	0.00	0.87	780.00
0.15	-0.70	0.00	3.49	780.00
0.23	-1.23	0.00	0.00	780.00
0.31	35.79	0.00	0.00	780.00
0.39	33.82	0.00	0.00	780.00
0.46	32.40	0.00	0.00	780.00
0.54	31.00	154.44	0.00	780.00
0.62	29.64	147.66	0.00	780.00
0.69	28.31	141.02	0.00	780.00
0.77	27.01	134.54	0.00	780.00
0.85	25.74	128.21	0.00	780.00
0.92	24.50	122.03	0.00	780.00
1.00	23.29	116.00	0.00	780.00
1.08	22.11	110.13	0.00	780.00
1.16	20.96	104.41	0.00	780.00
1.23	19.84	98.84	0.00	780.00
1.31	18.75	93.43	0.00	780.00
1.39	17.70	88.17	0.00	780.00
1.46	16.67	83.06	0.00	780.00
1.54	15.68	78.10	0.00	780.00
1.62	14.71	73.29	0.00	780.00
1.69	13.78	68.64	0.00	780.00
1.77	12.88	64.14	0.00	780.00
1.85	12.00	59.79	0.00	780.00
1.93	11.16	55.60	0.00	780.00
2.00	10.35	51.56	0.00	780.00
2.08	9.57	47.67	0.00	780.00
2.16	8.82	43.93	0.00	780.00
2.23	8.10	40.35	0.00	780.00
2.31	7.41	36.91	0.00	780.00
2.39	6.75	33.63	0.00	780.00
2.46	6.12	30.51	0.00	780.00
2.54	5.53	27.53	0.00	780.00
2.62	4.96	24.71	0.00	780.00
2.70	4.42	22.04	0.00	780.00
2.77	3.92	19.52	0.00	780.00
2.85	3.44	17.16	0.00	780.00
2.93	3.00	14.95	0.00	780.00
3.00	2.59	12.89	0.00	780.00
3.08	2.20	10.98	0.00	780.00
3.16	1.85	9.23	0.00	780.00
3.23	1.53	7.63	0.00	780.00
3.31	1.24	6.18	0.00	780.00
3.39	0.98	4.88	0.00	780.00
3.46	0.75	3.74	0.00	780.00
3.54	0.55	2.75	0.00	780.00
3.62	0.38	1.91	0.00	780.00
3.70	0.24	1.22	0.00	780.00
3.77	0.14	0.69	0.00	780.00
3.85	0.06	0.31	0.00	780.00

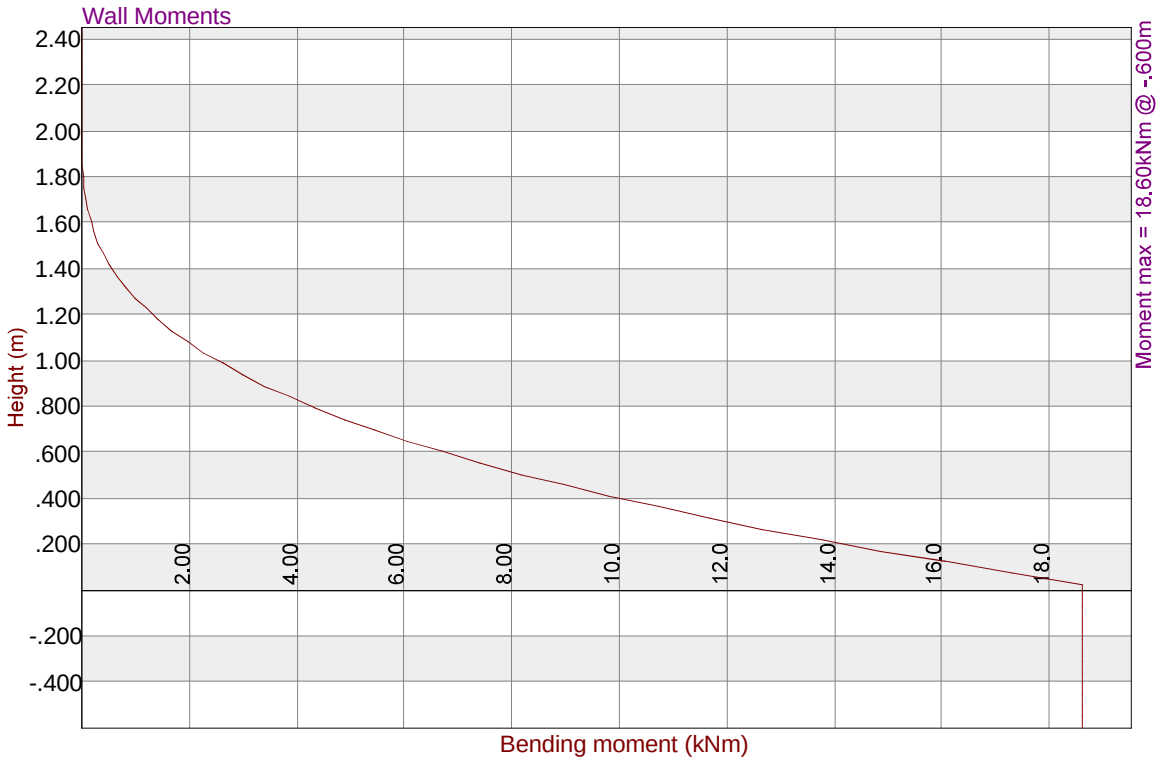
SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

```
 Shear force at bottom of wall V =  33.1 kN
Shear stress at bottom of wall v = 0.10 MPa OK
       Allowable shear stress vc = 0.35 MPa (based on Wall tensile reinf.)
```

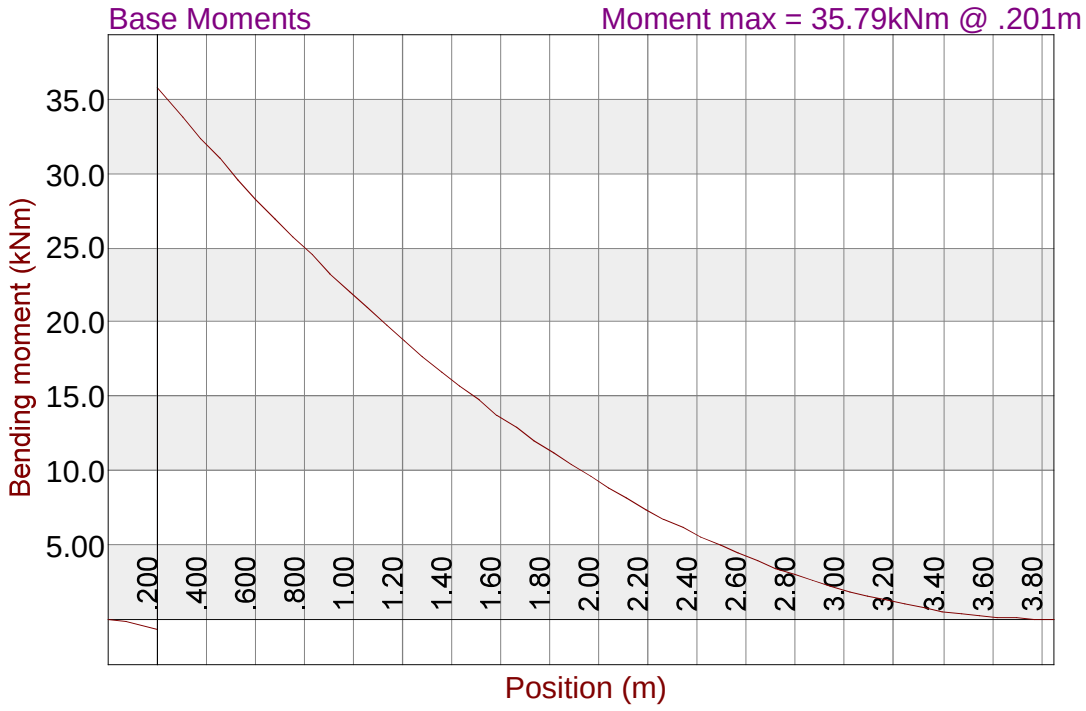
Sketch of Wall



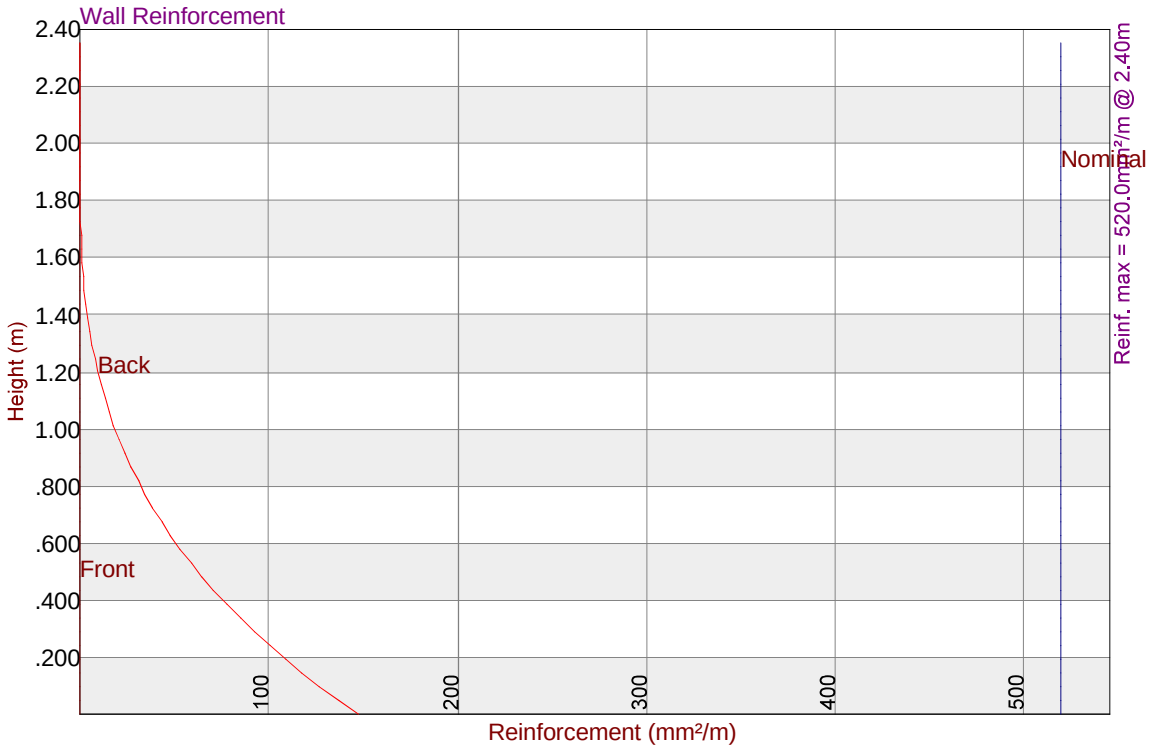
Wall Bending Moments



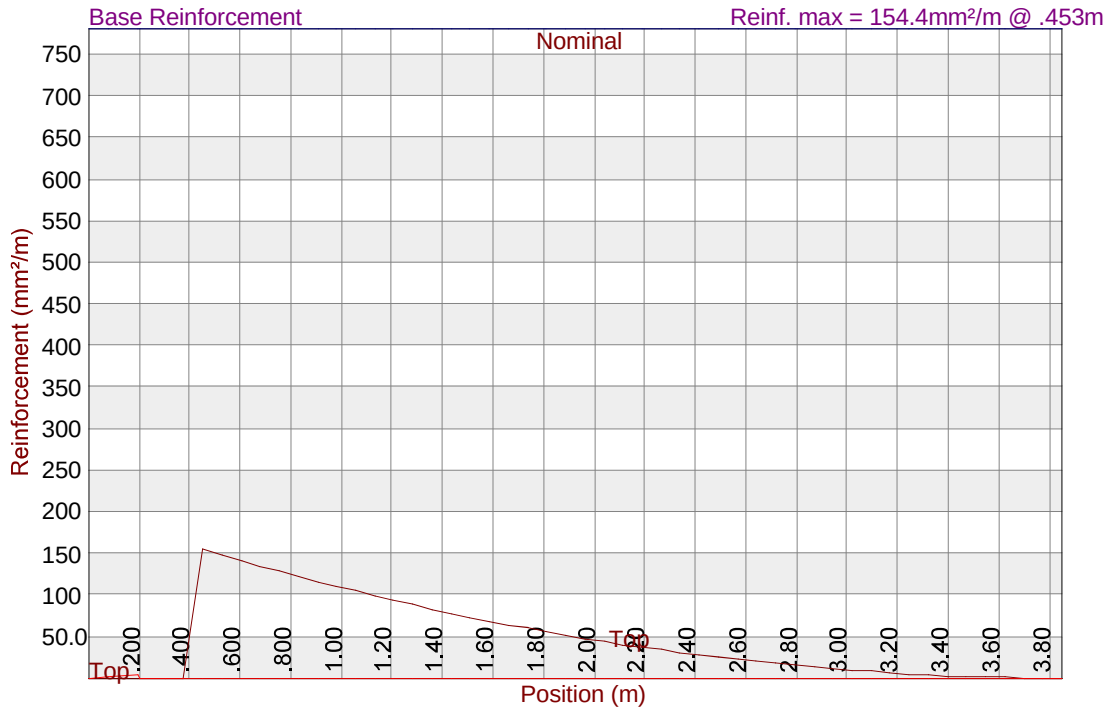
Base Bending Moments



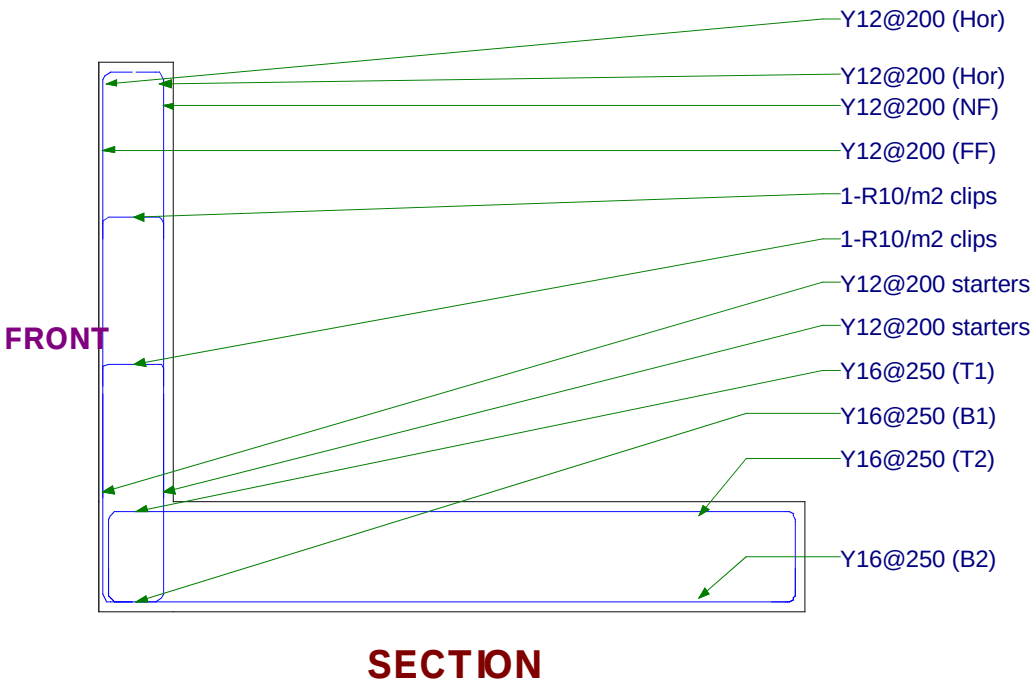
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



SECTION

7) ⑤VALVE CHAMBER

TOP SLAB (L4.25m×W3.55m)

Rectangular Slab Panel Design :

C04

Input Data

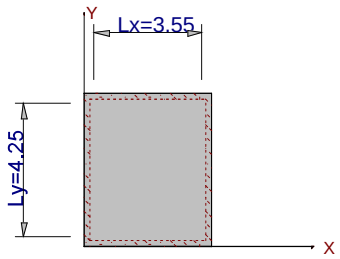
Lx	(m)	3.55
Ly	(m)	4.25
Slab depth	(mm)	250
deff X-dir	(mm)	200
deff Y-dir	(mm)	220
Poisson's ratio		0.2
fcu	(MPa)	25
fy	(MPa)	420
Density	(kN/m^3)	24
Self weight LF		1.4
ε - time factor (ACI318 :9.5.2.5)		2

Load Cases

Unfactored Loads			Unfactored Point Loads			Unfactored Line Loads				
LC No.	Load fact	UDL kN/m²	P kN	x m	y m	L kN/m	x1 m	y1 m	x2 m	y2 m
1	1.4	0.3								
	1.6	20								

Sketch of slab

BS8110 - 1997



Total UDL = 40.820 kN/m² (Incl self Wt) Load Case 1 (factored)

Output

Wood-Armer Moments and reinforcement for each load case:
Wood-Armer moments were calculated using the 'Wood & Armer' theory.

LOAD CASE 1

Position		Wood-Armer Moments (kNm/m)				Reinforcement (mm²/m)			
		Top		Bottom		Top		Bottom	
X (m)	Y(m)	X	Y	X	Y	X	Y	X	Y
0.00	0.00	8.0	6.0	26.5	28.5	115	78	382	373
0.30	0.00	17.2	15.4	22.3	24.1	248	202	321	315
0.59	0.00	22.1	21.9	18.5	18.7	319	287	267	245
0.89	0.00	13.7	13.9	15.2	15.0	197	182	219	196
1.18	0.00	9.2	8.2	10.7	11.8	133	107	154	154
1.48	0.00	4.4	3.4	5.2	6.3	64	44	75	82
1.77	0.00	0.0	0.0	0.3	1.0	0	0	4	13
2.07	0.00	4.4	3.4	5.2	6.3	64	44	75	82
2.37	0.00	9.2	8.2	10.7	11.8	133	107	154	154
2.66	0.00	13.7	13.9	15.2	15.0	197	182	219	196
2.96	0.00	22.1	21.9	18.5	18.7	319	287	267	245
3.25	0.00	17.2	15.4	22.3	24.1	248	202	321	315
3.55	0.00	8.0	6.0	26.5	28.5	115	78	382	373
0.00	0.35	15.7	16.3	22.8	22.2	227	213	328	291
0.59	0.35	12.1	12.3	22.9	22.7	174	161	330	298
1.18	0.35	0.8	0.5	17.6	18.0	12	6	254	236
1.77	0.35	0.0	0.0	8.7	9.5	0	0	126	124
2.37	0.35	0.8	0.5	17.6	18.0	12	6	254	236
2.96	0.35	12.1	12.3	22.9	22.7	174	161	330	298
3.55	0.35	15.7	16.3	22.8	22.2	227	213	328	291
0.00	0.71	21.0	22.1	18.4	17.3	302	289	266	227
0.30	0.71	10.9	12.8	23.2	21.3	158	168	334	279
0.59	0.71	2.2	3.9	27.4	25.7	32	52	395	336
0.89	0.71	0.0	0.0	25.6	24.9	0	0	369	327
1.18	0.71	0.0	0.0	24.4	23.9	0	0	351	313
1.48	0.71	0.0	0.0	20.8	20.8	0	0	300	272
1.77	0.71	0.0	0.0	17.2	17.5	0	0	248	229
2.07	0.71	0.0	0.0	20.8	20.8	0	0	300	272
2.37	0.71	0.0	0.0	24.4	23.9	0	0	351	313
2.66	0.71	0.0	0.0	25.6	24.9	0	0	369	327
2.96	0.71	2.2	3.9	27.4	25.7	32	52	395	336
3.25	0.71	10.9	12.8	23.2	21.3	158	168	334	279
3.55	0.71	21.0	22.1	18.4	17.3	302	289	266	227
0.00	1.06	13.3	13.1	14.3	14.5	192	172	206	190
0.59	1.06	-0.0	-0.0	26.6	22.4	0	0	383	293
1.18	1.06	0.0	0.0	27.3	24.1	0	0	393	316
1.77	1.06	0.0	0.0	22.6	20.0	0	0	325	261
2.37	1.06	0.0	0.0	27.3	24.1	0	0	393	316
2.96	1.06	-0.0	-0.0	26.6	22.4	0	0	383	293
3.55	1.06	13.3	13.1	14.3	14.5	192	172	206	190
0.00	1.42	7.7	8.5	10.5	9.6	110	111	151	126
0.30	1.42	-0.0	1.2	18.3	15.0	0	16	264	197
0.59	1.42	0.0	0.0	25.9	20.2	0	0	373	265
0.89	1.42	0.0	0.0	28.0	22.3	0	0	403	292
1.18	1.42	0.0	0.0	30.2	24.5	0	0	435	321
1.48	1.42	0.0	0.0	29.0	23.6	0	0	418	309
1.77	1.42	0.0	0.0	27.9	22.7	0	0	402	297
2.07	1.42	0.0	0.0	29.0	23.6	0	0	418	309
2.37	1.42	0.0	0.0	30.2	24.5	0	0	435	321
2.66	1.42	0.0	0.0	28.0	22.3	0	0	403	292
2.96	1.42	0.0	0.0	25.9	20.2	0	0	373	265
3.25	1.42	-0.0	1.2	18.3	15.0	0	16	264	197
3.55	1.42	7.7	8.5	10.5	9.6	110	111	151	126
0.00	1.77	3.3	4.2	5.5	4.6	47	54	80	61
0.59	1.77	0.0	0.0	22.9	16.5	0	0	331	216
1.18	1.77	0.0	0.0	29.5	22.7	0	0	425	297
1.77	1.77	0.0	0.0	29.7	23.2	0	0	428	303
2.37	1.77	0.0	0.0	29.5	22.7	0	0	425	297

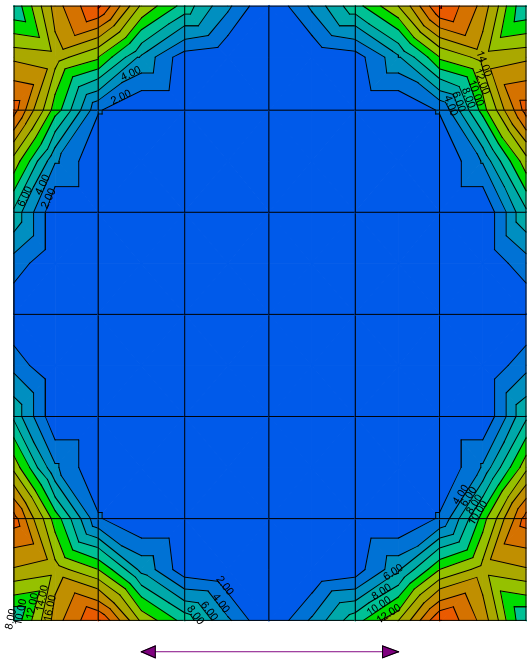
2.96	1.77	0.0	0.0	22.9	16.5	0	0	331	216
3.55	1.77	3.3	4.2	5.5	4.6	47	54	80	61
0.00	2.13	0.0	0.0	0.8	0.2	0	0	11	2
0.30	2.13	0.0	0.0	10.4	6.4	0	0	151	84
0.59	2.13	0.0	0.0	19.9	12.8	0	0	287	167
0.89	2.13	0.0	0.0	24.4	16.9	0	0	351	221
1.18	2.13	0.0	0.0	28.9	21.0	0	0	417	275
1.48	2.13	0.0	0.0	30.1	22.4	0	0	434	293
1.77	2.13	0.0	0.0	31.5	23.8	0	0	454	312
2.07	2.13	0.0	0.0	30.1	22.4	0	0	434	293
2.37	2.13	0.0	0.0	28.9	21.0	0	0	417	275
2.66	2.13	0.0	0.0	24.4	16.9	0	0	351	221
2.96	2.13	0.0	0.0	19.9	12.8	0	0	287	167
3.25	2.13	0.0	0.0	10.4	6.4	0	0	151	84
3.55	2.13	0.0	0.0	0.8	0.2	0	0	11	2
0.00	2.48	3.3	4.2	5.5	4.6	47	54	80	61
0.59	2.48	0.0	0.0	22.9	16.5	0	0	331	216
1.18	2.48	0.0	0.0	29.5	22.7	0	0	425	297
1.77	2.48	0.0	0.0	29.7	23.2	0	0	428	303
2.37	2.48	0.0	0.0	29.5	22.7	0	0	425	297
2.96	2.48	0.0	0.0	22.9	16.5	0	0	331	216
3.55	2.48	3.3	4.2	5.5	4.6	47	54	80	61
0.00	2.83	7.7	8.5	10.5	9.6	110	111	151	126
0.30	2.83	-0.0	1.2	18.3	15.0	0	16	264	197
0.59	2.83	0.0	0.0	25.9	20.2	0	0	373	265
0.89	2.83	0.0	0.0	28.0	22.3	0	0	403	292
1.18	2.83	0.0	0.0	30.2	24.5	0	0	435	321
1.48	2.83	0.0	0.0	29.0	23.6	0	0	418	309
1.77	2.83	0.0	0.0	27.9	22.7	0	0	402	297
2.07	2.83	0.0	0.0	29.0	23.6	0	0	418	309
2.37	2.83	0.0	0.0	30.2	24.5	0	0	435	321
2.66	2.83	0.0	0.0	28.0	22.3	0	0	403	292
2.96	2.83	0.0	0.0	25.9	20.2	0	0	373	265
3.25	2.83	-0.0	1.2	18.3	15.0	0	16	264	197
3.55	2.83	7.7	8.5	10.5	9.6	110	111	151	126
0.00	3.19	13.3	13.1	14.3	14.5	192	172	206	190
0.59	3.19	-0.0	-0.0	26.6	22.4	0	0	383	293
1.18	3.19	0.0	0.0	27.3	24.1	0	0	393	316
1.77	3.19	0.0	0.0	22.6	20.0	0	0	325	261
2.37	3.19	0.0	0.0	27.3	24.1	0	0	393	316
2.96	3.19	-0.0	-0.0	26.6	22.4	0	0	383	293
3.55	3.19	13.3	13.1	14.3	14.5	192	172	206	190
0.00	3.54	21.0	22.1	18.4	17.3	302	289	266	227
0.30	3.54	10.9	12.8	23.2	21.3	158	168	334	279
0.59	3.54	2.2	3.9	27.4	25.7	32	52	395	336
0.89	3.54	0.0	0.0	25.6	24.9	0	0	369	327
1.18	3.54	0.0	0.0	24.4	23.9	0	0	351	313
1.48	3.54	0.0	0.0	20.8	20.8	0	0	300	272
1.77	3.54	0.0	0.0	17.2	17.5	0	0	248	229
2.07	3.54	0.0	0.0	20.8	20.8	0	0	300	272
2.37	3.54	0.0	0.0	24.4	23.9	0	0	351	313
2.66	3.54	0.0	0.0	25.6	24.9	0	0	369	327
2.96	3.54	2.2	3.9	27.4	25.7	32	52	395	336
3.25	3.54	10.9	12.8	23.2	21.3	158	168	334	279
3.55	3.54	21.0	22.1	18.4	17.3	302	289	266	227
0.00	3.90	15.7	16.3	22.8	22.2	227	213	328	291
0.59	3.90	12.1	12.3	22.9	22.7	174	161	330	298
1.18	3.90	0.8	0.5	17.6	18.0	12	6	254	236
1.77	3.90	0.0	0.0	8.7	9.5	0	0	126	124
2.37	3.90	0.8	0.5	17.6	18.0	12	6	254	236
2.96	3.90	12.1	12.3	22.9	22.7	174	161	330	298
3.55	3.90	15.7	16.3	22.8	22.2	227	213	328	291
0.00	4.25	8.0	6.0	26.5	28.5	115	78	382	373
0.30	4.25	17.2	15.4	22.3	24.1	248	202	321	315
0.59	4.25	22.1	21.9	18.5	18.7	319	287	267	245
0.89	4.25	13.7	13.9	15.2	15.0	197	182	219	196
1.18	4.25	9.2	8.2	10.7	11.8	133	107	154	154
1.48	4.25	4.4	3.4	5.2	6.3	64	44	75	82
1.77	4.25	0.0	0.0	0.3	1.0	0	0	4	13

2.07	4.25	4.4	3.4	5.2	6.3	64	44	75	82
2.37	4.25	9.2	8.2	10.7	11.8	133	107	154	154
2.66	4.25	13.7	13.9	15.2	15.0	197	182	219	196
2.96	4.25	22.1	21.9	18.5	18.7	319	287	267	245
3.25	4.25	17.2	15.4	22.3	24.1	248	202	321	315
3.55	4.25	8.0	6.0	26.5	28.5	115	78	382	373

Wood-Armer Moments:

BS8110 - 1997

Top:LC 1 (kNm/m)

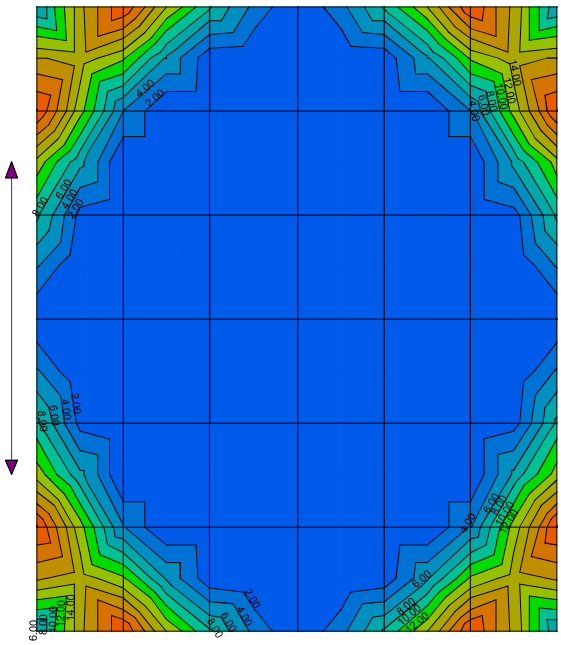


Max value:22.1 at X:3.0 Y:4.3

Wood-Armer Moments:

BS8110 - 1997

Top:LC 1 (kNm/m)

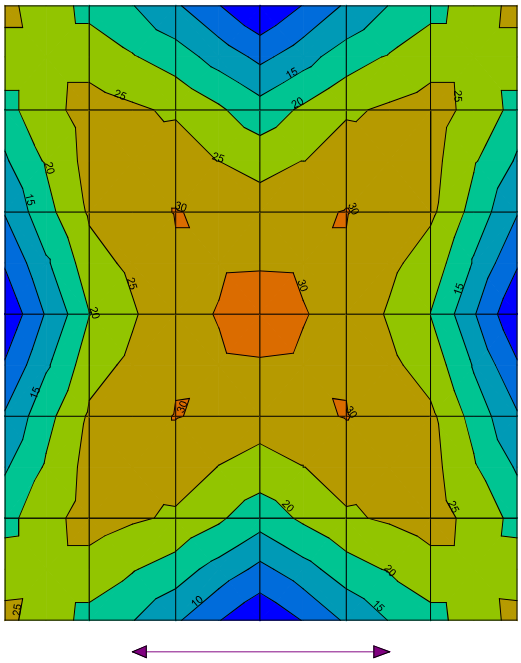


Max value:22.1 at X:3.5 Y:3.5

Wood-Armer Moments:

BS8110 - 1997

Bot:LC 1 (kNm/m)

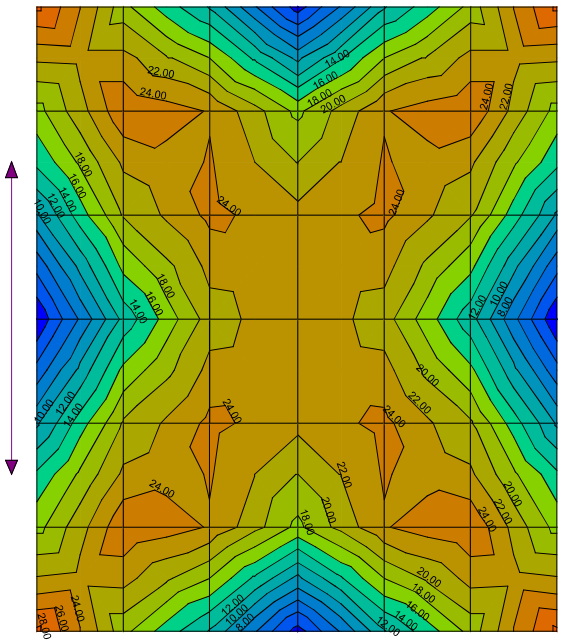


Max value:31.5 at X:1.8 Y:2.1

Wood-Armer Moments:

BS8110 - 1997

Bot:LC 1 (kNm/m)

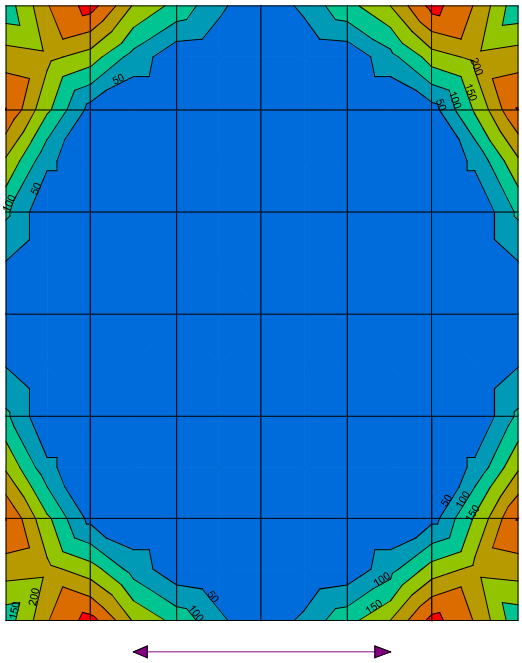


Max value:28.5 at X:3.5 Y:4.3

Reinforcement:

BS8110 - 1997

Top:LC 1 (mm²/m)

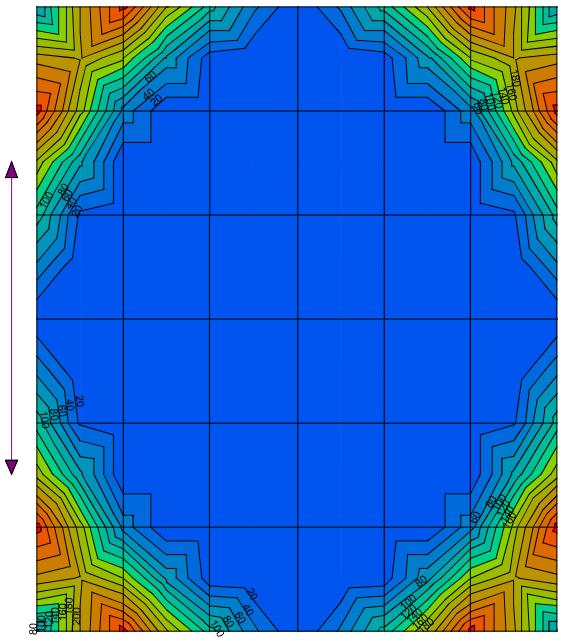


Max value:318.7 at X:3.0 Y:4.3

Reinforcement:

BS8110 - 1997

Top:LC 1 (mm²/m)

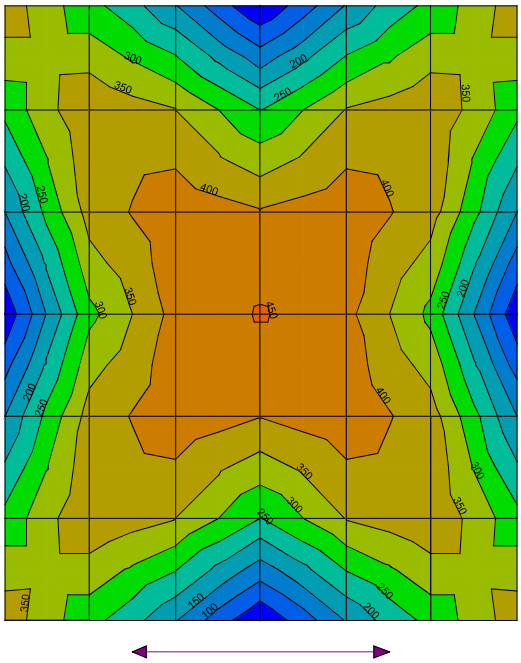


Max value:289.5 at X:3.5 Y:3.5

Reinforcement:

BS8110 - 1997

Bot:LC 1 (mm²/m)

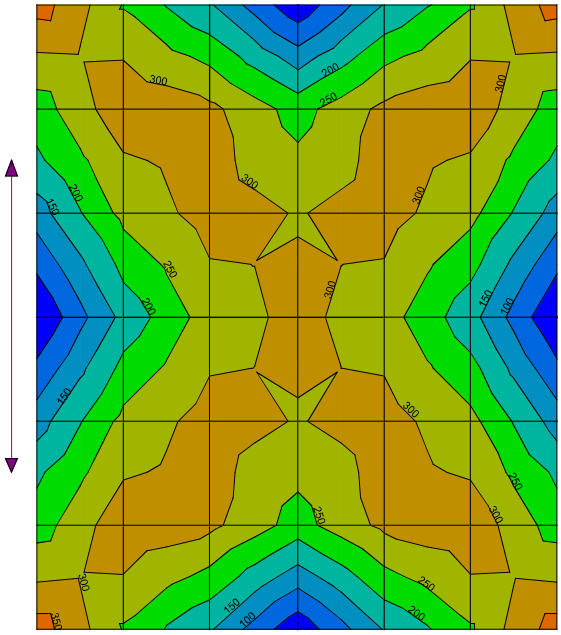


Max value:454.3 at X:1.8 Y:2.1

Reinforcement:

BS8110 - 1997

Bot:LC 1 (mm²/m)

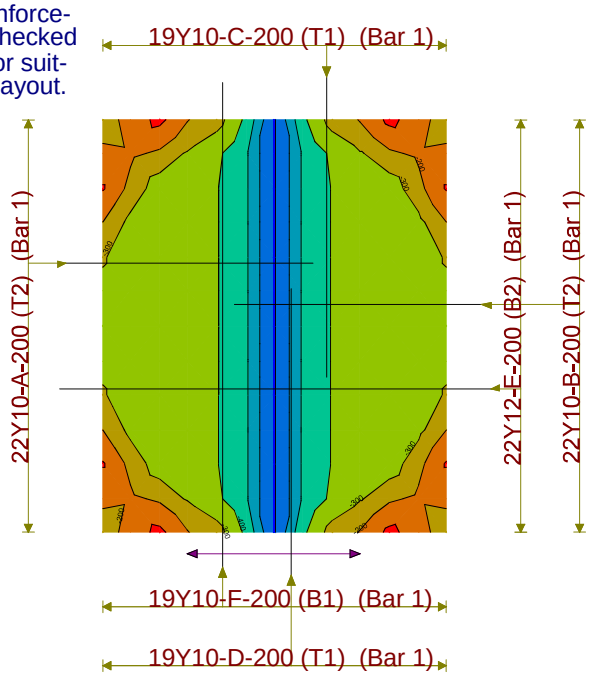


Max value:373.2 at X:3.5 Y:4.3

Rebar Excess:

Rebar Excess Top (mm²/m)

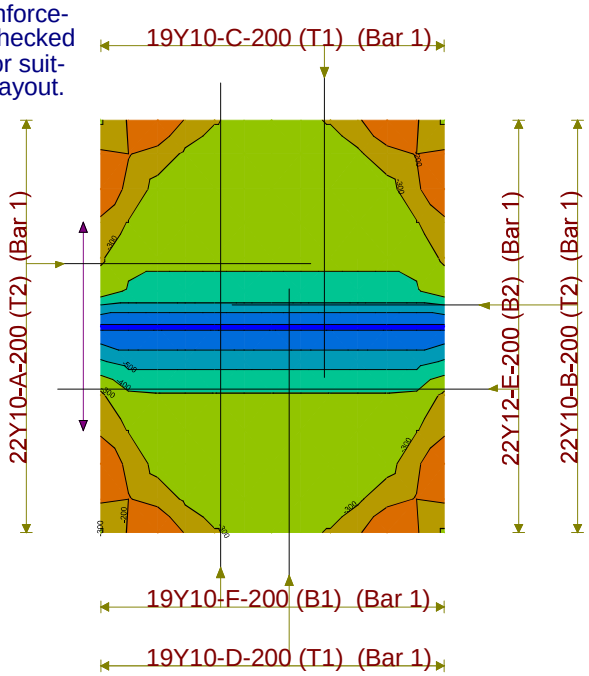
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Top (mm²/m)

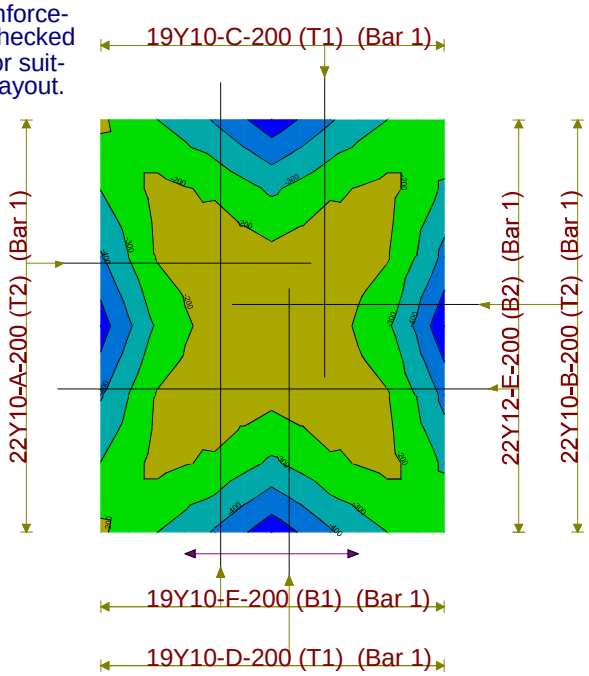
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Bot (mm²/m)

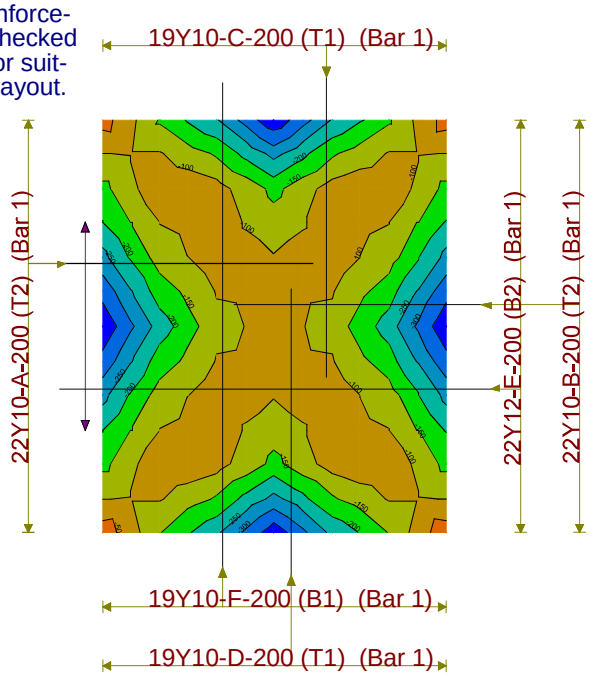
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:

Rebar Excess Bot (mm²/m)

Note:Default reinforcement should be checked and adjusted for suitability and layout.



7) ⑤VALVE CHAMBER

WALL (H3.0m)

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Cantilever wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1	(m)	3	C	(m)	0.6	W	(kN/m²)	1	Soil frict ϕ	(°)	30	SF Overt.	1.5
H2	(m)	0	F	(m)	0	P	(kN)	0	Fill slope β	(°)	0	SF Slip	1.5
H3	(m)	0	xf	(m)	2	xp	(m)	0	Wall frict δ	(°)	20	ULS DL Factor	1.4
Hw	(m)	0	At	(m)	0.4	L	(kN/m)	20	ρ Conc	kN/m^3	25	ULS LL Factor	1.6
Hr	(m)	0.36	Ab	(m)	0.4	xl	(m)	2	ρ Soil	kN/m^3	18	Pmax (kPa)	100
B	(m)	3.44	Cov wall	mm	50	Lh	(kN/m)		fc'	(MPa)	25	Soil Poisson υ	0.5
D	(m)	0	Cov base	mm	50	x	(m)	0	fy	(MPa)	420	DL Factor Ovt.	0.9

Seepage allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:ON

Hor Accel. (g)	0.02
Vert Accel. (g)	0.01
Include LL's	Y

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.297
Passive Pressure coefficient Kp :6.105
Seismic Active Pressure coefficient Kas :0.313
Seismic Passive Pressure coefficient Kps :5.934
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	23.826	1.040	8.672	3.840
Siesmic component of Pa	1.195	1.800	0.435	3.840
As a result of surcharge w	0.874	1.500	0.318	3.840
As a result of Line Load L	4.721	1.686	0.000	3.840
Siesmic wall inertia	1.616	0.741		
Stabilizing forces:				
Passive pressure on base Pp	-0.000	0.000		
Siesmic component of Pp	-0.000	0.000		
Weight of the wall + base			80.784	2.426
Weight of soil on the base			0.000	0.000
UDL of 1.0 kPa			0.000	3.840

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 195.97 kNm
Destabilizing moment Mo : 0.73 kNm

Safety factor against overturning = Mr/Mo = 269.444

2.Force Equilibrium at SLS

Sum of Vertical forces Pv : 89.77 kN
Frictional resistance Pfric : 51.83 kN
Passive Pressure on shear key : 0.00 kN
Passive pressure on base : 0.00 kN
=> Total Horiz. resistance Fr : 51.83 kN

Horizontal sliding force on wall Fhw : 31.04 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 31.04 kN

Safety factor against overall sliding = Fr/Fh = 1.670

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	33.738	1.045	12.141	3.840
Siesmic component of Pa	1.913	1.800	0.696	3.840
As a result of surcharge w	1.398	1.500	0.509	3.840
As a result of Line Load L	7.553	1.686	0.000	3.840
Siesmic wall inertia	2.585	0.741		
Stabilizing forces:				
Passive pressure on base Pp	-0.000	0.000		
Siesmic component of Pp	-0.000	0.000		
Weight of the wall + base			72.706	2.426
Weight of soil on the base			0.000	0.000
UDL of 0.9 kPa			0.000	3.840

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 176.38 kNm
Destabilizing moment Mo : 3.44 kNm

Safety factor against overturning = Mr/Mo = 51.256

2.Force Equilibrium at ULS

Sum of Vertical forces Pv : 80.80 kN
Frictional resistance Pfric : 46.65 kN
Passive Pressure on shear key : 0.00 kN

Passive pressure on base : 0.00 kN
=> Total Horiz. resistance Fr : 46.65 kN

Horizontal sliding force on wall Fhw : 45.27 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 45.27 kN

Safety factor against overall sliding = Fr/Fh = 1.030

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure : 32.69 kPa
Minimum pressure : 14.07 kPa
Maximum pressure occurs at right hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Minimum (mm²/m)
0.00	28.15	0.00	220.48	1116.29
0.05	26.74	0.00	209.32	1116.29
0.10	25.36	0.00	198.47	1116.29
0.14	24.02	0.00	187.92	1116.29
0.19	22.72	0.00	177.67	1116.29
0.24	21.45	0.00	167.70	1116.29
0.29	20.22	0.00	158.02	1116.29
0.34	19.02	0.00	148.61	1116.29
0.38	17.85	0.00	139.48	1116.29
0.43	16.72	0.00	130.61	1116.29
0.48	15.62	0.00	122.01	1116.29
0.53	14.56	0.00	113.65	1116.29
0.58	13.52	0.00	105.55	1116.29
0.62	12.52	0.00	97.69	1116.29
0.67	11.54	0.00	90.06	1116.29
0.72	10.60	0.00	82.66	1116.29
0.77	9.68	0.00	75.49	1116.29
0.82	8.79	0.00	68.54	1116.29
0.86	7.93	0.00	61.81	1116.29
0.91	7.09	0.00	55.28	1116.29
0.96	6.28	0.00	48.95	1116.29
1.01	5.50	0.00	42.82	1116.29
1.06	4.74	0.00	36.88	1116.29
1.10	4.00	0.00	31.13	1116.29
1.15	3.42	0.00	26.63	1116.29
1.20	3.09	0.00	24.06	1116.29
1.25	2.78	0.00	21.65	1116.29
1.30	2.49	0.00	19.41	1116.29
1.34	2.22	0.00	17.32	1116.29
1.39	1.98	0.00	15.38	1116.29
1.44	1.75	0.00	13.59	1116.29
1.49	1.53	0.00	11.94	1116.29
1.54	1.34	0.00	10.42	1116.29
1.58	1.16	0.00	9.04	1116.29
1.63	1.00	0.00	7.77	1116.29
1.68	0.85	0.00	6.63	1116.29
1.73	0.72	0.00	5.60	1116.29
1.78	0.60	0.00	4.68	1116.29
1.82	0.50	0.00	3.85	1116.29
1.87	0.40	0.00	3.13	1116.29
1.92	0.32	0.00	2.50	1116.29
1.97	0.25	0.00	1.95	1116.29
2.02	0.19	0.00	1.48	1116.29
2.06	0.14	0.00	1.09	1116.29
2.11	0.10	0.00	0.77	1116.29
2.16	0.07	0.00	0.51	1116.29
2.21	0.04	0.00	0.31	1116.29
2.26	0.02	0.00	0.17	1116.29
2.30	0.01	0.00	0.07	1116.29

2.35	0.00	0.00	0.02	1116.29
2.40	0.00	0.00	0.00	1116.29

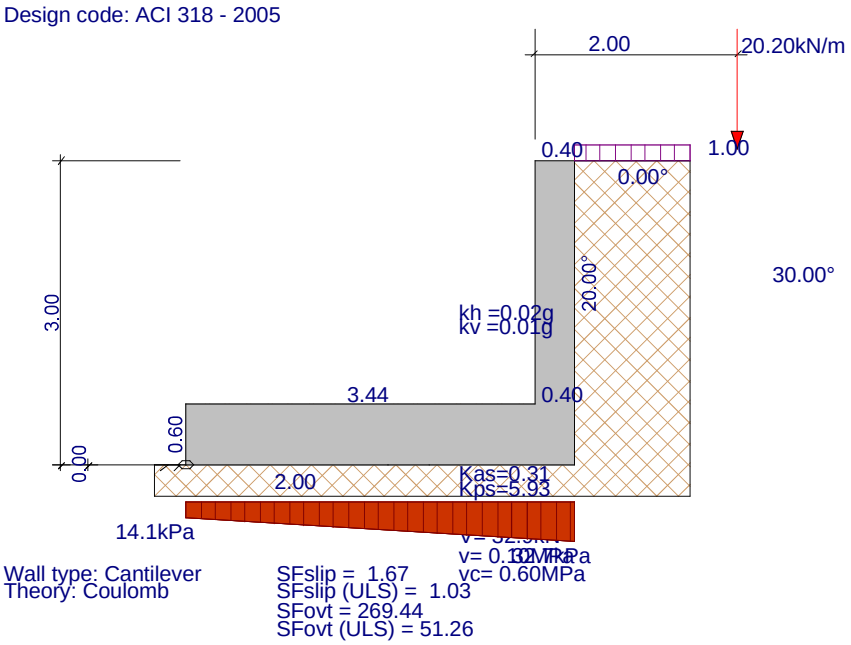
BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Minimum (mm^2/m)
0.00	-0.00	0.00	0.00	1772.94
0.08	-0.02	0.00	0.10	1772.94
0.15	-0.09	0.00	0.42	1772.94
0.23	-0.19	0.00	0.94	1772.94
0.31	-0.34	0.00	1.68	1772.94
0.38	-0.53	0.00	2.62	1772.94
0.46	-0.77	0.00	3.77	1772.94
0.54	-1.05	0.00	5.13	1772.94
0.61	-1.37	0.00	6.70	1772.94
0.69	-1.73	0.00	8.48	1772.94
0.77	-2.14	0.00	10.47	1772.94
0.84	-2.59	0.00	12.67	1772.94
0.92	-3.08	0.00	15.08	1772.94
1.00	-3.61	0.00	17.70	1772.94
1.08	-4.19	0.00	20.53	1772.94
1.15	-4.81	0.00	23.57	1772.94
1.23	-5.47	0.00	26.82	1772.94
1.31	-6.18	0.00	30.28	1772.94
1.38	-6.93	0.00	33.95	1772.94
1.46	-7.72	0.00	37.83	1772.94
1.54	-8.55	0.00	41.92	1772.94
1.61	-9.43	0.00	46.22	1772.94
1.69	-10.35	0.00	50.73	1772.94
1.77	-11.31	0.00	55.45	1772.94
1.84	-12.31	0.00	60.38	1772.94
1.92	-13.36	0.00	65.53	1772.94
2.00	-14.45	0.00	70.88	1772.94
2.07	-15.58	0.00	76.45	1772.94
2.15	-16.76	0.00	82.22	1772.94
2.23	-17.98	0.00	88.21	1772.94
2.30	-19.24	0.00	94.41	1772.94
2.38	-20.54	0.00	100.82	1772.94
2.46	-21.89	0.00	107.44	1772.94
2.53	-23.28	0.00	114.27	1772.94
2.61	-24.71	0.00	121.32	1772.94
2.69	-26.18	0.00	128.58	1772.94
2.76	-27.70	0.00	136.05	1772.94
2.84	-29.26	0.00	143.73	1772.94
2.92	-30.87	0.00	151.63	1772.94
3.00	-32.51	0.00	159.74	1772.94
3.07	-34.20	0.00	168.06	1772.94
3.15	-35.93	0.00	176.60	1772.94
3.23	-37.70	0.00	185.35	1772.94
3.30	-39.52	0.00	194.31	1772.94
3.38	-41.38	0.00	203.49	1772.94
3.46	-43.28	0.00	212.88	1772.94
3.53	-45.23	0.00	222.49	1772.94
3.61	-47.22	0.00	232.31	1772.94
3.69	-49.25	0.00	242.34	1772.94
3.76	-49.96	0.00	0.00	1772.94
3.84	-0.96	0.00	0.00	1772.94

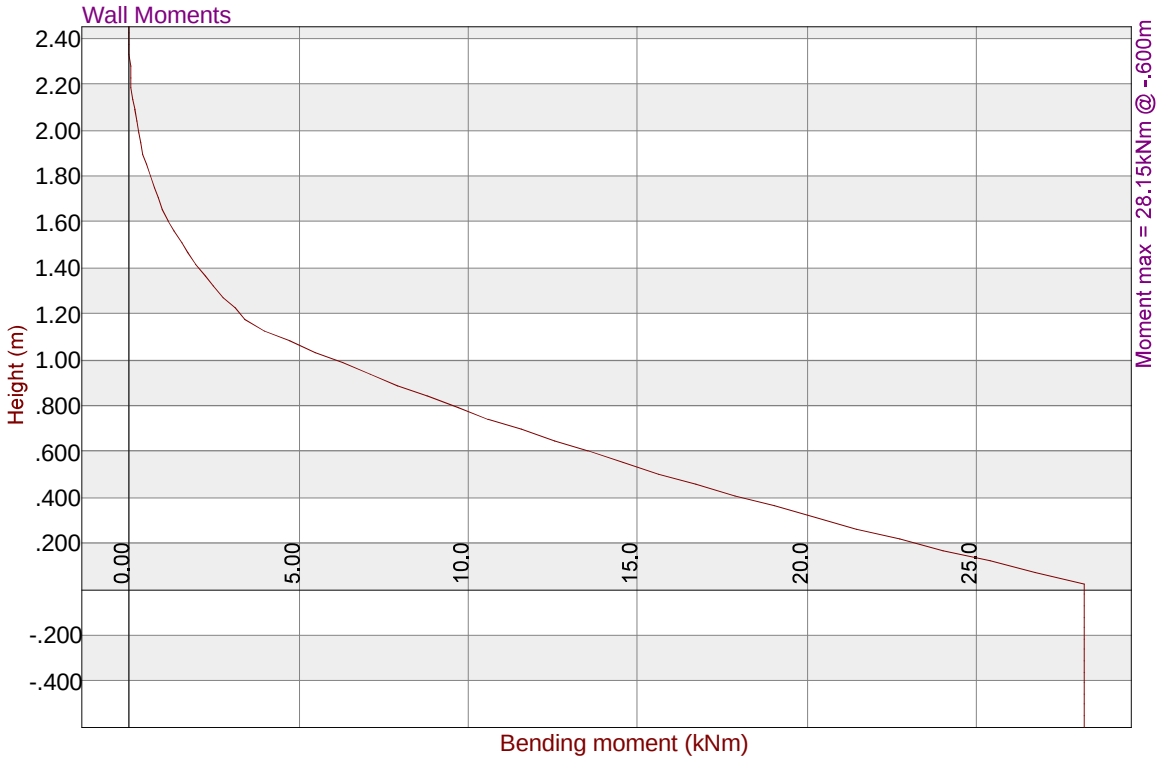
SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

Shear force at bottom of wall V = 32.9 kN
Shear stress at bottom of wall v = 0.10 MPa OK
Allowable shear stress vc = 0.60 MPa (based on Wall tensile reinf.)

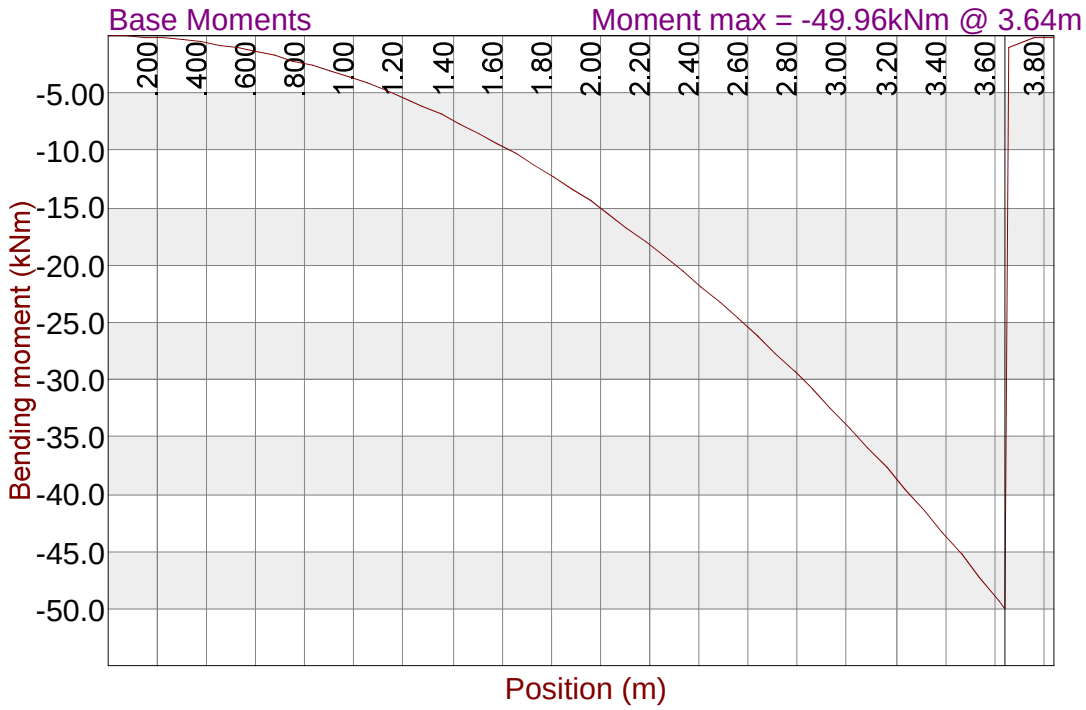
Sketch of Wall



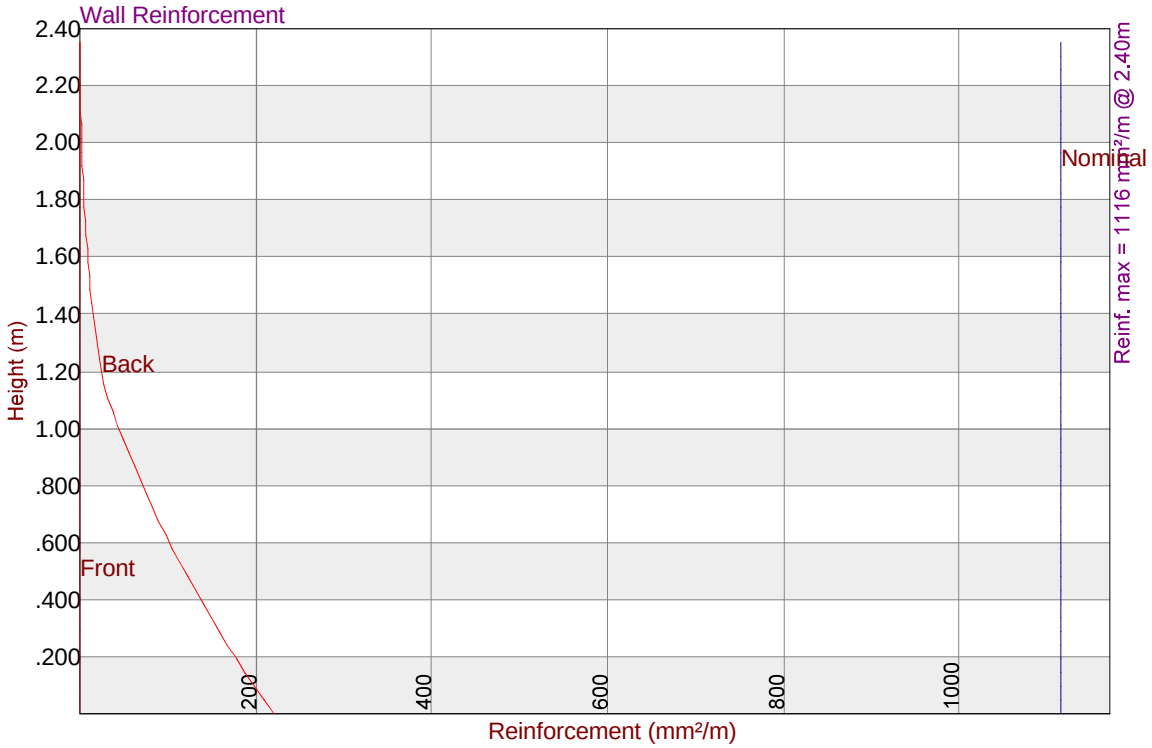
Wall Bending Moments



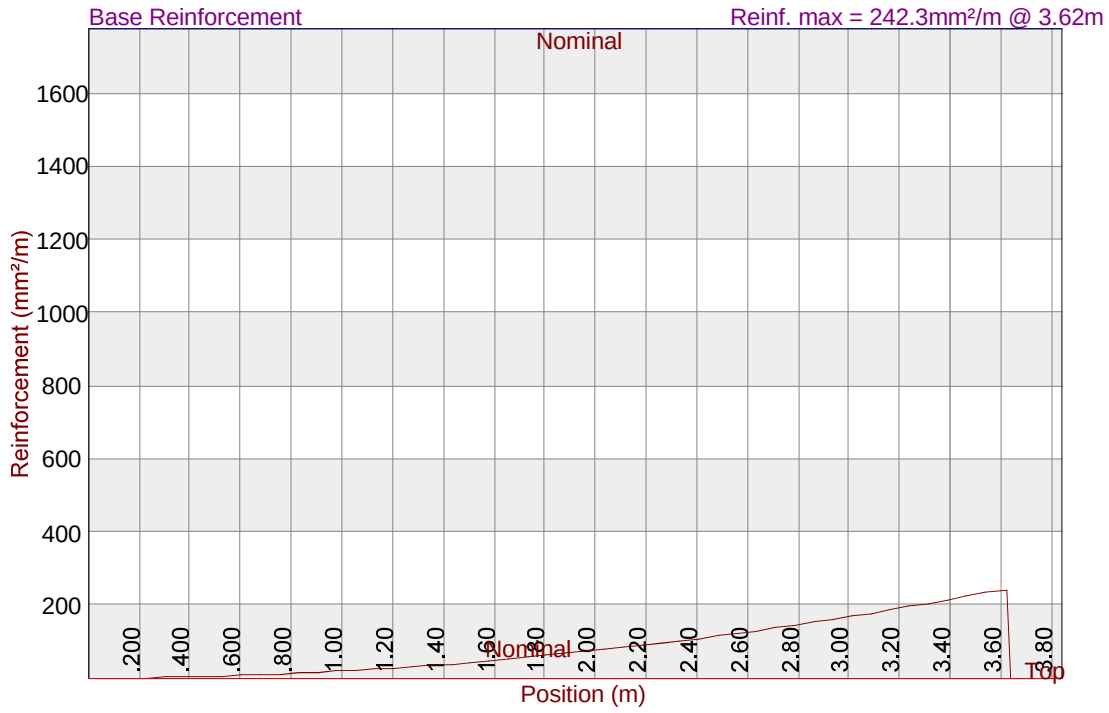
Base Bending Moments



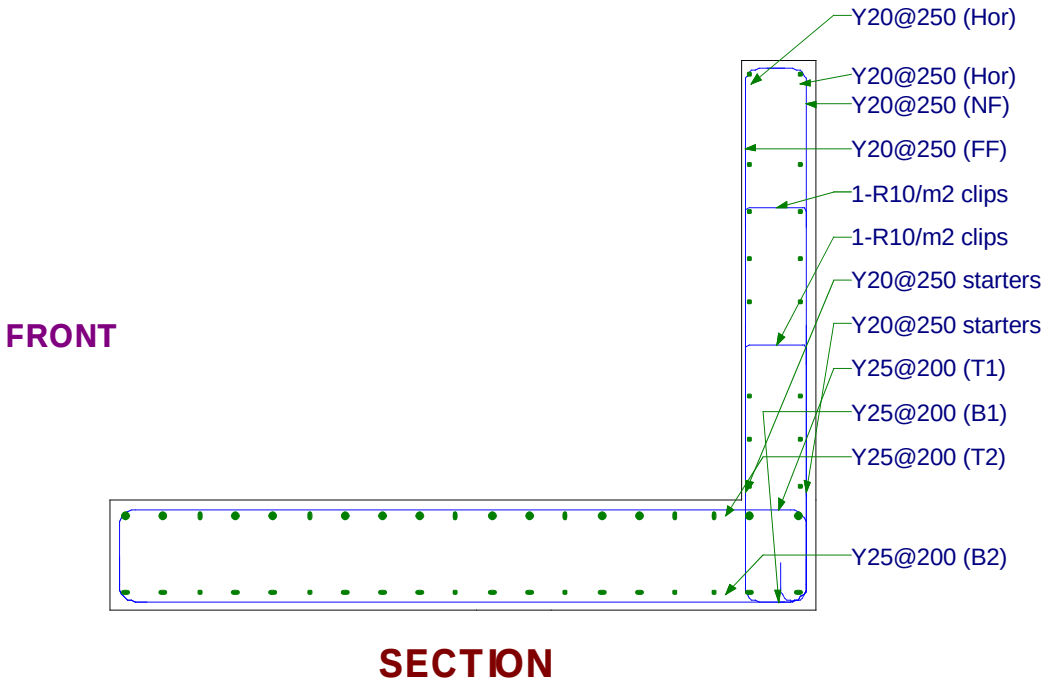
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Reservoir wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads		General Parameters			Design Parameters	
H1 (m)	3	C (m)	0.6	W	(kN/m²)		Soil frict ϕ	(°)	25	SF Overt.		1.5
H2 (m)	0.67	F (m)		P	(kN)		Fill slope β	(°)		SF Slip		1.5
H3 (m)	2.6	xf (m)		xp	(m)		Wall frict δ	(°)		ULS DL Factor		1.4
Hw (m)	2.6	At (m)	0.4	L	(kN/m)		ρ Conc	kN/m³	25	ULS LL Factor		1.6
Hr (m)	0.36	Ab (m)	0.4	xl	(m)		ρ Soil	kN/m³	18	Pmax (kPa)		100
B (m)		Cov wall	mm 50	Lh	(kN/m)		fc'	(MPa)	25	Soil Poisson υ		0.5
D (m)	3.55	Cov base	mm 50	x	(m)		fy	(MPa)	420	DL Factor Ovt.		0.9

Seepage not allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:OFF

Hor Accel. (g)	
Vert Accel. (g)	
Include LL's	

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.406
Passive Pressure coefficient Kp :2.464
Base frictional constant μ :0.466

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.584	0.133	0.000	0.400
Triangular W-table press Pw	0.466	0.133	0.000	0.400
W-table pr below free water	8.633	0.200	0.000	0.400
Free water pressure Pwf	23.740	1.133	0.000	0.400
Hydrostatic pressure on bot of base: uniform portion			0.000	1.975
Hydrostatic pressure on bot of base: triangular portion			0.000	2.633
Stabilizing forces:				
Passive pressure on base Pp	-9.954	0.223		
Weight of the wall + base			83.250	1.463
Weight of soil on the base			-5.815	2.175
Hydrostatic pressure on top of rear portion of base			69.651	2.175
Hydrostatic pressure on top of front portion of base			0.000	0.000

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 262.89 kNm
      Destabilizing moment Mo : 28.77 kNm

Safety factor against overturning = Mr/Mo = 9.137

2.Force Equilibrium at SLS

    Sum of Vertical forces Pv : 147.09 kN
  Frictional resistance Pfric : 68.59 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :   9.95 kN
=> Total Horiz. resistance Fr : 78.54 kN

     Horizontal sliding force on wall Fhw : 33.42 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh : 33.42 kN

Safety factor against overall sliding = Fr/Fh = 2.350

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.818	0.133	0.000	0.400
Triangular W-table press Pw	0.653	0.133	0.000	0.400
W-table pr below free water	12.086	0.200	0.000	0.400
Free water pressure Pwf	33.236	1.133	0.000	0.400
Hydrostatic pressure on bot of base: uniform portion			0.000	1.975
Hydrostatic pressure on bot of base: triangular portion			0.000	2.633
Stabilizing forces:				
Passive pressure on base Pp	-8.959	0.223		
Weight of the wall + base			74.925	1.463
Weight of soil on the base			-5.233	2.175
Hydrostatic pressure on top of rear portion of base			62.686	2.175
Hydrostatic pressure on top of front portion of base			0.000	0.000

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 236.60 kNm
      Destabilizing moment Mo : 40.28 kNm

Safety factor against overturning = Mr/Mo = 5.874

2.Force Equilibrium at ULS

```
    Sum of Vertical forces Pv : 132.38 kN
  Frictional resistance Pfric :  61.73 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :   8.96 kN
=> Total Horiz. resistance Fr :  70.69 kN

     Horizontal sliding force on wall Fhw :  46.79 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh :  46.79 kN
```

Safety factor against overall sliding = Fr/Fh = 1.511

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure : 58.92 kPa
Minimum pressure : 15.56 kPa
Maximum pressure occurs at left hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Minimum (mm²/m)
0.00	18.57	0.00	145.07	1116.29
0.05	17.26	0.00	134.86	1116.29
0.10	16.02	0.00	125.12	1116.29
0.14	14.84	0.00	115.86	1116.29
0.19	13.72	0.00	107.08	1116.29
0.24	12.65	0.00	98.75	1116.29
0.29	11.65	0.00	90.87	1116.29
0.34	10.69	0.00	83.42	1116.29
0.38	9.80	0.00	76.39	1116.29
0.43	8.95	0.00	69.77	1116.29
0.48	8.15	0.00	63.54	1116.29
0.53	7.40	0.00	57.70	1116.29
0.58	6.70	0.00	52.23	1116.29
0.62	6.05	0.00	47.12	1116.29
0.67	5.44	0.00	42.35	1116.29
0.72	4.87	0.00	37.92	1116.29
0.77	4.34	0.00	33.81	1116.29
0.82	3.85	0.00	30.00	1116.29
0.86	3.40	0.00	26.50	1116.29
0.91	2.99	0.00	23.28	1116.29
0.96	2.61	0.00	20.33	1116.29
1.01	2.27	0.00	17.64	1116.29
1.06	1.95	0.00	15.20	1116.29
1.10	1.67	0.00	13.00	1116.29
1.15	1.42	0.00	11.02	1116.29
1.20	1.19	0.00	9.25	1116.29
1.25	0.99	0.00	7.68	1116.29
1.30	0.81	0.00	6.30	1116.29
1.34	0.66	0.00	5.10	1116.29
1.39	0.52	0.00	4.06	1116.29
1.44	0.41	0.00	3.17	1116.29
1.49	0.31	0.00	2.42	1116.29
1.54	0.23	0.00	1.80	1116.29
1.58	0.17	0.00	1.30	1116.29
1.63	0.12	0.00	0.90	1116.29
1.68	0.08	0.00	0.59	1116.29
1.73	0.05	0.00	0.36	1116.29
1.78	0.03	0.00	0.20	1116.29
1.82	0.01	0.00	0.10	1116.29
1.87	0.00	0.00	0.04	1116.29
1.92	0.00	0.00	0.01	1116.29

1.97	0.00	0.00	0.00	1116.29
2.02	0.00	0.00	0.00	1116.29
2.06	0.00	0.00	0.00	1116.29
2.11	0.00	0.00	0.00	1116.29
2.16	0.00	0.00	0.00	1116.29
2.21	0.00	0.00	0.00	1116.29
2.26	0.00	0.00	0.00	1116.29
2.30	0.00	0.00	0.00	1116.29
2.35	0.00	0.00	0.00	1116.29
2.40	0.00	0.00	0.00	1116.29

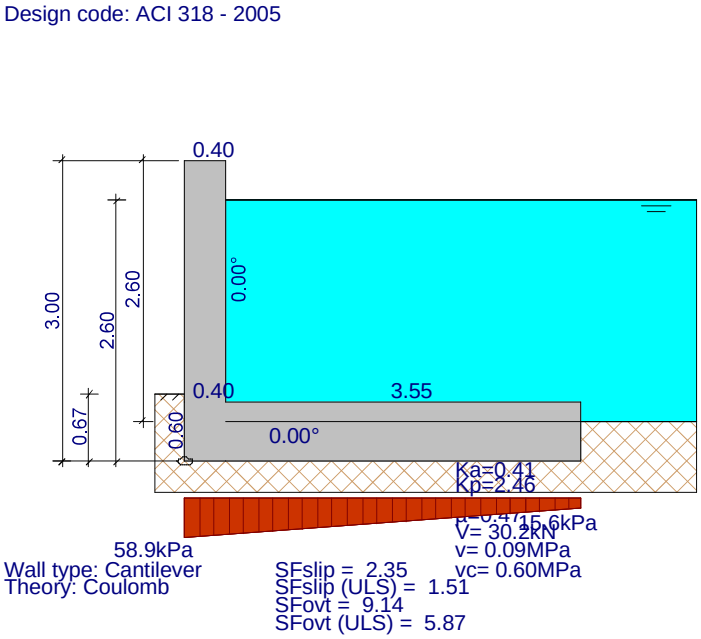
BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Minimum (mm^2/m)
0.00	-0.00	0.00	0.00	1772.94
0.08	-0.18	0.00	0.89	1772.94
0.16	-0.73	0.00	3.55	1772.94
0.24	-1.21	0.00	0.00	1772.94
0.32	36.44	0.00	0.00	1772.94
0.39	34.34	0.00	0.00	1772.94
0.47	32.89	0.00	0.00	1772.94
0.55	31.48	154.64	0.00	1772.94
0.63	30.09	147.82	0.00	1772.94
0.71	28.74	141.16	0.00	1772.94
0.79	27.42	134.66	0.00	1772.94
0.87	26.13	128.31	0.00	1772.94
0.95	24.87	122.11	0.00	1772.94
1.03	23.64	116.07	0.00	1772.94
1.11	22.44	110.18	0.00	1772.94
1.18	21.28	104.45	0.00	1772.94
1.26	20.14	98.87	0.00	1772.94
1.34	19.04	93.44	0.00	1772.94
1.42	17.97	88.17	0.00	1772.94
1.50	16.93	83.05	0.00	1772.94
1.58	15.92	78.09	0.00	1772.94
1.66	14.94	73.28	0.00	1772.94
1.74	13.99	68.62	0.00	1772.94
1.82	13.07	64.12	0.00	1772.94
1.90	12.19	59.77	0.00	1772.94
1.97	11.33	55.57	0.00	1772.94
2.05	10.51	51.53	0.00	1772.94
2.13	9.71	47.63	0.00	1772.94
2.21	8.95	43.90	0.00	1772.94
2.29	8.22	40.31	0.00	1772.94
2.37	7.52	36.88	0.00	1772.94
2.45	6.85	33.60	0.00	1772.94
2.53	6.22	30.48	0.00	1772.94
2.61	5.61	27.50	0.00	1772.94
2.69	5.04	24.68	0.00	1772.94
2.76	4.49	22.02	0.00	1772.94
2.84	3.98	19.50	0.00	1772.94
2.92	3.50	17.14	0.00	1772.94
3.00	3.05	14.93	0.00	1772.94
3.08	2.63	12.87	0.00	1772.94
3.16	2.24	10.97	0.00	1772.94
3.24	1.88	9.22	0.00	1772.94
3.32	1.55	7.62	0.00	1772.94
3.40	1.26	6.17	0.00	1772.94
3.48	0.99	4.87	0.00	1772.94
3.55	0.76	3.73	0.00	1772.94
3.63	0.56	2.74	0.00	1772.94
3.71	0.39	1.90	0.00	1772.94
3.79	0.25	1.22	0.00	1772.94
3.87	0.14	0.69	0.00	1772.94
3.95	0.06	0.30	0.00	1772.94

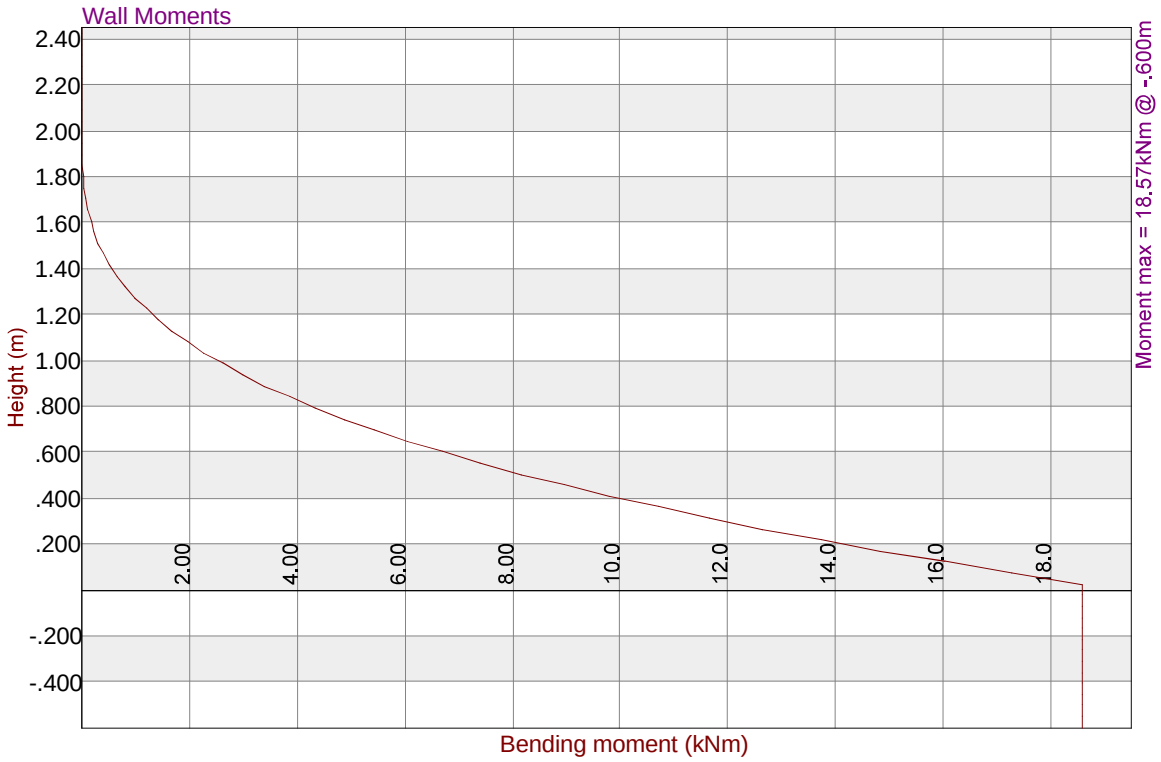
SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

```
 Shear force at bottom of wall V =  30.2 kN
Shear stress at bottom of wall v = 0.09 MPa OK
       Allowable shear stress vc = 0.60 MPa (based on Wall tensile reinf.)
```

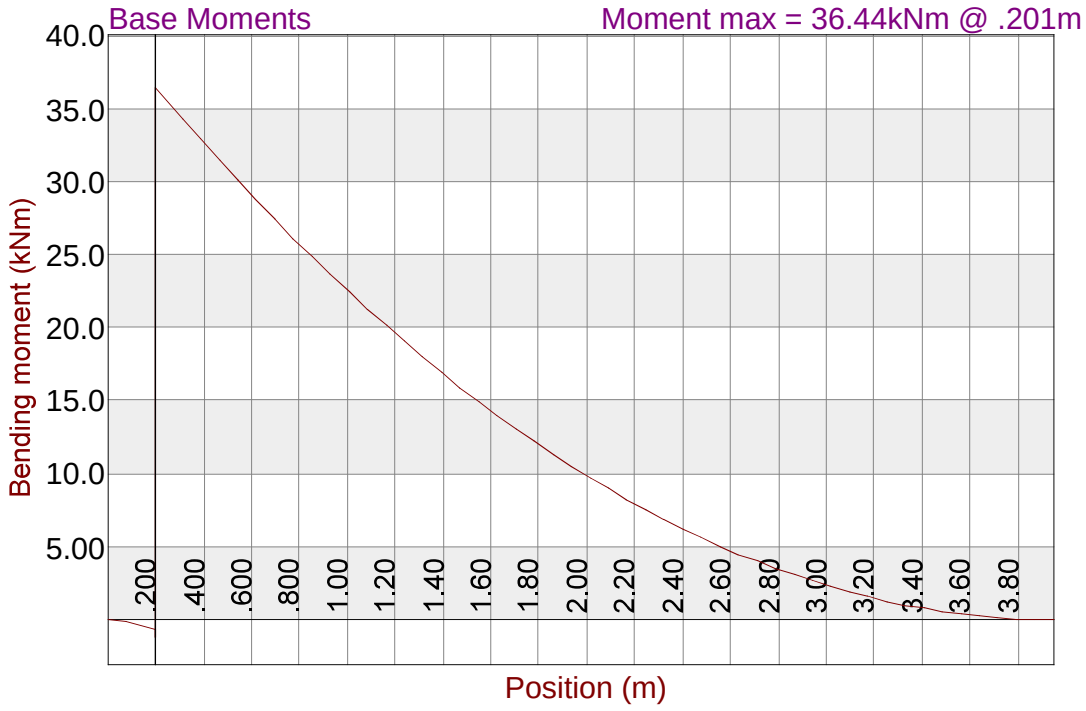
Sketch of Wall



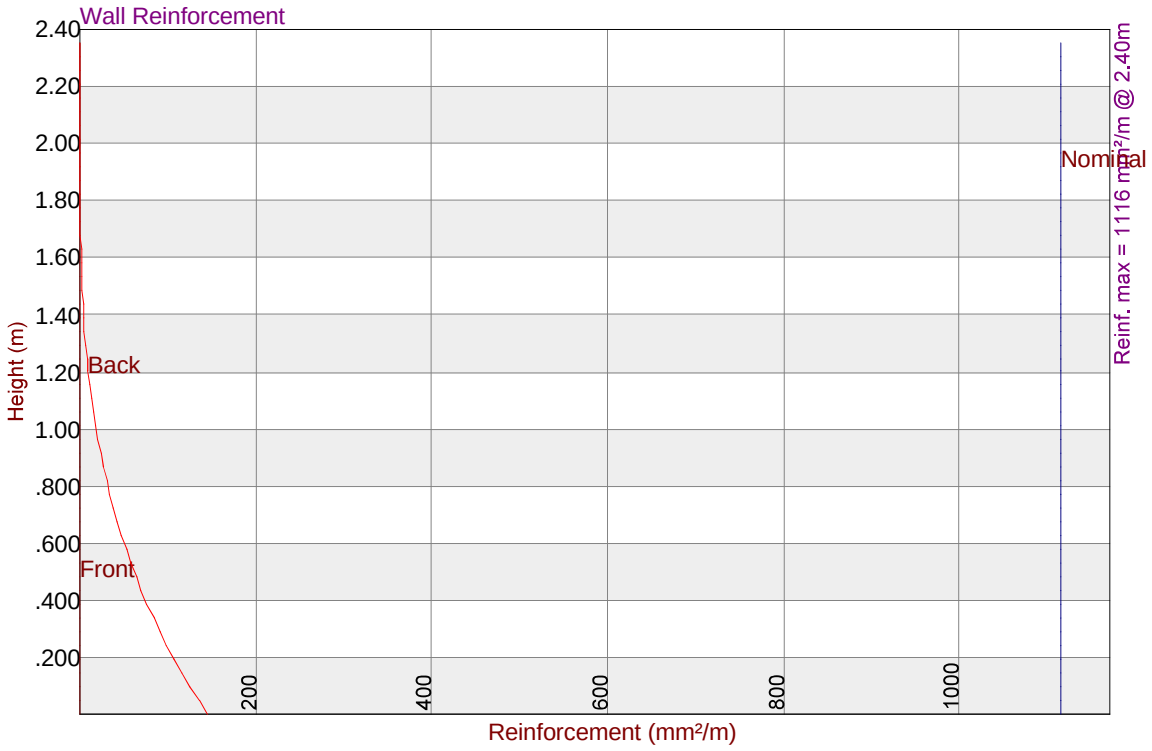
Wall Bending Moments



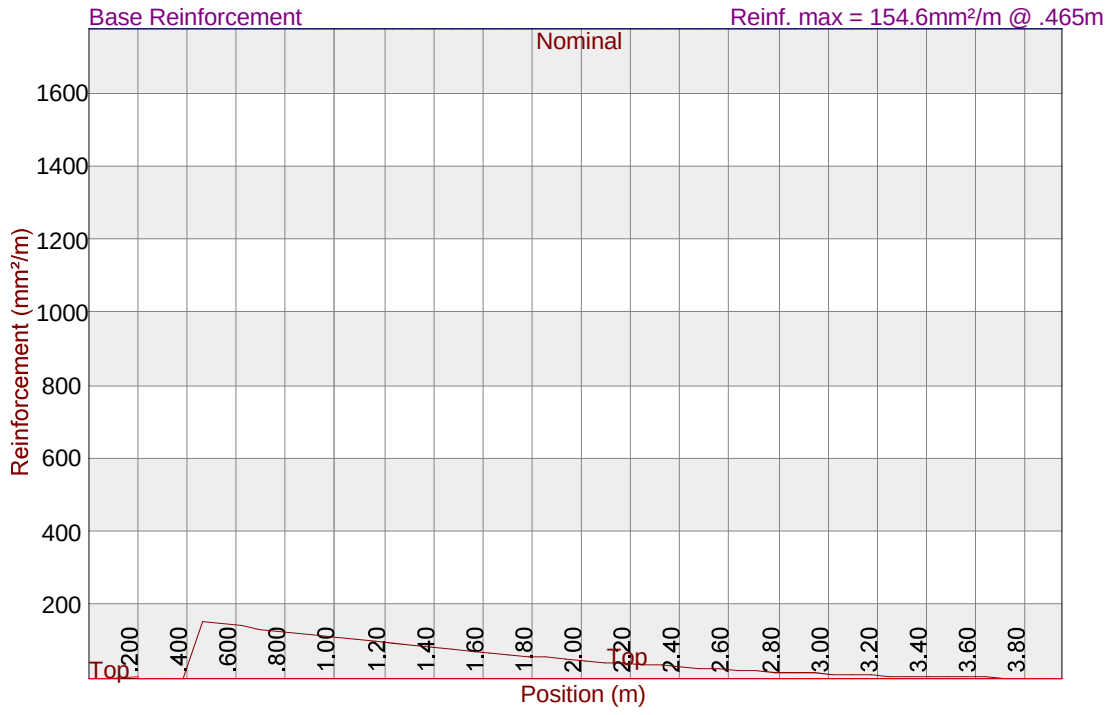
Base Bending Moments



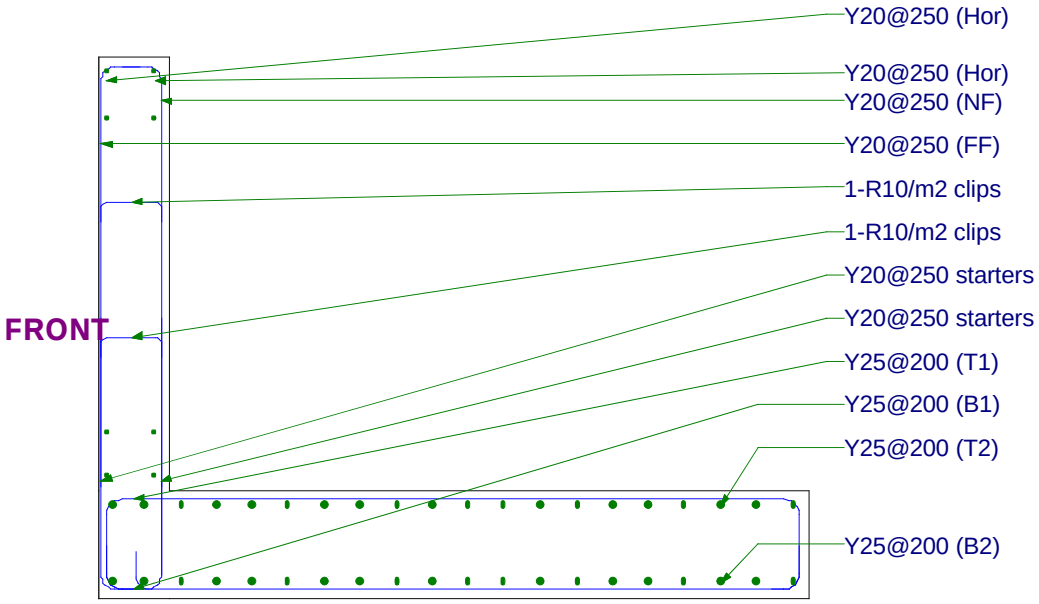
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



SECTION

8) ⑥VALVE CHAMBER

TOP SLAB (L2.95m×W2.35m)

Rectangular Slab Panel Design :

C04

Input Data

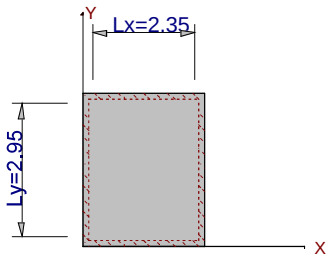
Lx	(m)	2.35
Ly	(m)	2.95
Slab depth	(mm)	250
deff X-dir	(mm)	200
deff Y-dir	(mm)	220
Poisson's ratio		0.2
fc' (MPa)		25
fy	(MPa)	420
Density	(kN/m^3)	24
Self weight LF		1.4
ε - time factor (ACI318 :9.5.2.5)		2

Load Cases

Unfactored Loads			Unfactored Point Loads			Unfactored Line Loads				
LC No.	Load fact	UDL kN/m²	P kN	x m	y m	L kN/m	x1 m	y1 m	x2 m	y2 m
1	1.4	0.3								
	1.6	20								

Sketch of slab

ACI 318 - 2005



Total UDL =
40.820 kN/m² Load Case 1 (factored)
(Incl self Wt)

Output

Wood-Armer Moments and reinforcement for each load case:
Wood-Armer moments were calculated using the 'Wood & Armer' theory.

LOAD CASE 1

Position		Wood-Armer Moments (kNm/m)				Reinforcement (mm²/m)			
		Top		Bottom		Top		Bottom	
X (m)	Y(m)	X	Y	X	Y	X	Y	X	Y
0.00	0.00	3.0	1.2	12.4	14.2	40	15	165	172
0.20	0.00	7.5	6.4	10.3	11.4	100	77	137	138
0.39	0.00	10.1	10.3	8.4	8.3	135	124	112	100
0.59	0.00	6.2	6.4	6.9	6.8	82	77	92	81
0.78	0.00	4.2	3.6	4.9	5.4	55	44	65	65
0.98	0.00	2.0	1.5	2.4	2.9	27	18	32	35
1.18	0.00	0.0	0.0	0.1	0.5	0	0	2	6
1.37	0.00	2.0	1.5	2.4	2.9	27	18	32	35
1.57	0.00	4.2	3.6	4.9	5.4	55	44	65	65
1.76	0.00	6.2	6.4	6.9	6.8	82	77	92	81
1.96	0.00	10.1	10.3	8.4	8.3	135	124	112	100
2.15	0.00	7.5	6.4	10.3	11.4	100	77	137	138
2.35	0.00	3.0	1.2	12.4	14.2	40	15	165	172
0.00	0.25	6.8	6.8	10.4	10.4	91	82	139	126
0.39	0.25	5.3	5.6	10.5	10.2	71	67	140	124
0.78	0.25	0.2	0.2	8.1	8.1	3	3	108	98
1.18	0.25	0.0	0.0	4.1	4.3	0	0	55	52
1.57	0.25	0.2	0.2	8.1	8.1	3	3	108	98
1.96	0.25	5.3	5.6	10.5	10.2	71	67	140	124
2.35	0.25	6.8	6.8	10.4	10.4	91	82	139	126
0.00	0.49	9.6	10.2	8.3	7.6	127	124	110	92
0.20	0.49	4.8	5.9	10.5	9.5	64	71	140	115
0.39	0.49	0.7	1.7	12.6	11.6	10	20	167	140
0.59	0.49	0.0	0.0	11.8	11.3	0	0	157	136
0.78	0.49	0.0	0.0	11.3	10.7	0	0	151	130
0.98	0.49	0.0	0.0	9.7	9.3	0	0	129	112
1.18	0.49	0.0	0.0	8.1	7.8	0	0	108	95
1.37	0.49	0.0	0.0	9.7	9.3	0	0	129	112
1.57	0.49	0.0	0.0	11.3	10.7	0	0	151	130
1.76	0.49	0.0	0.0	11.8	11.3	0	0	157	136
1.96	0.49	0.7	1.7	12.6	11.6	10	20	167	140
2.15	0.49	4.8	5.9	10.5	9.5	64	71	140	115
2.35	0.49	9.6	10.2	8.3	7.6	127	124	110	92
0.00	0.74	6.0	5.9	6.4	6.5	80	71	85	79
0.39	0.74	-0.0	-0.0	12.2	9.9	0	0	162	120
0.78	0.74	0.0	0.0	12.7	10.7	0	0	169	130
1.18	0.74	0.0	0.0	10.6	8.8	0	0	141	107
1.57	0.74	0.0	0.0	12.7	10.7	0	0	169	130
1.96	0.74	-0.0	-0.0	12.2	9.9	0	0	162	120
2.35	0.74	6.0	5.9	6.4	6.5	80	71	85	79
0.00	0.98	3.4	3.7	4.6	4.3	45	45	61	51
0.20	0.98	-0.0	0.5	8.3	6.6	0	6	110	80
0.39	0.98	0.0	0.0	11.8	8.9	0	0	158	108
0.59	0.98	0.0	0.0	12.9	9.8	0	0	173	119
0.78	0.98	0.0	0.0	14.1	10.8	0	0	188	131
0.98	0.98	0.0	0.0	13.6	10.4	0	0	181	125
1.18	0.98	0.0	0.0	13.1	10.0	0	0	175	120
1.37	0.98	0.0	0.0	13.6	10.4	0	0	181	125
1.57	0.98	0.0	0.0	14.1	10.8	0	0	188	131
1.76	0.98	0.0	0.0	12.9	9.8	0	0	173	119
1.96	0.98	0.0	0.0	11.8	8.9	0	0	158	108
2.15	0.98	-0.0	0.5	8.3	6.6	0	6	110	80
2.35	0.98	3.4	3.7	4.6	4.3	45	45	61	51
0.00	1.23	1.5	1.9	2.5	2.1	19	22	32	25
0.39	1.23	0.0	0.0	10.5	7.2	0	0	140	87
0.78	1.23	0.0	0.0	13.8	9.9	0	0	184	120
1.18	1.23	0.0	0.0	13.9	10.1	0	0	186	122
1.57	1.23	0.0	0.0	13.8	9.9	0	0	184	120

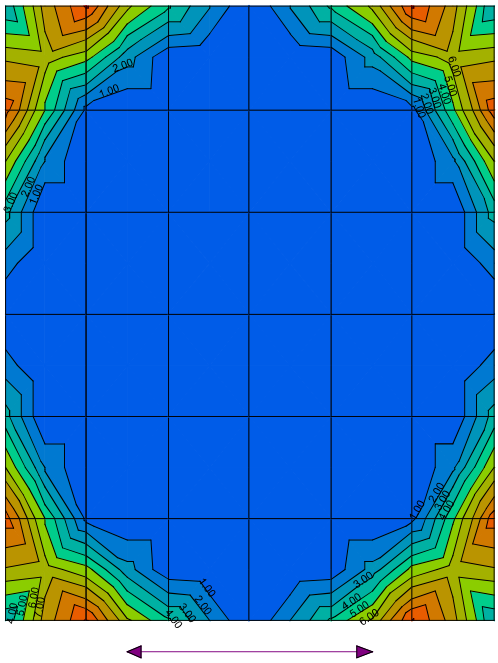
1.96	1.23	0.0	0.0	10.5	7.2	0	0	140	87
2.35	1.23	1.5	1.9	2.5	2.1	19	22	32	25
0.00	1.48	0.0	0.0	0.4	0.1	0	0	5	1
0.20	1.48	0.0	0.0	4.8	2.8	0	0	64	34
0.39	1.48	0.0	0.0	9.2	5.6	0	0	122	67
0.59	1.48	0.0	0.0	11.3	7.3	0	0	151	89
0.78	1.48	0.0	0.0	13.5	9.1	0	0	180	110
0.98	1.48	0.0	0.0	14.1	9.8	0	0	188	118
1.18	1.48	0.0	0.0	14.8	10.4	0	0	197	125
1.37	1.48	0.0	0.0	14.1	9.8	0	0	188	118
1.57	1.48	0.0	0.0	13.5	9.1	0	0	180	110
1.76	1.48	0.0	0.0	11.3	7.3	0	0	151	89
1.96	1.48	0.0	0.0	9.2	5.6	0	0	122	67
2.15	1.48	0.0	0.0	4.8	2.8	0	0	64	34
2.35	1.48	0.0	0.0	0.4	0.1	0	0	5	1
0.00	1.72	1.5	1.9	2.5	2.1	19	22	32	25
0.39	1.72	0.0	0.0	10.5	7.2	0	0	140	87
0.78	1.72	0.0	0.0	13.8	9.9	0	0	184	120
1.18	1.72	0.0	0.0	13.9	10.1	0	0	186	122
1.57	1.72	0.0	0.0	13.8	9.9	0	0	184	120
1.96	1.72	0.0	0.0	10.5	7.2	0	0	140	87
2.35	1.72	1.5	1.9	2.5	2.1	19	22	32	25
0.00	1.97	3.4	3.7	4.6	4.3	45	45	61	51
0.20	1.97	-0.0	0.5	8.3	6.6	0	6	110	80
0.39	1.97	0.0	0.0	11.8	8.9	0	0	158	108
0.59	1.97	0.0	0.0	12.9	9.8	0	0	173	119
0.78	1.97	0.0	0.0	14.1	10.8	0	0	188	131
0.98	1.97	0.0	0.0	13.6	10.4	0	0	181	125
1.18	1.97	0.0	0.0	13.1	10.0	0	0	175	120
1.37	1.97	0.0	0.0	13.6	10.4	0	0	181	125
1.57	1.97	0.0	0.0	14.1	10.8	0	0	188	131
1.76	1.97	0.0	0.0	12.9	9.8	0	0	173	119
1.96	1.97	0.0	0.0	11.8	8.9	0	0	158	108
2.15	1.97	-0.0	0.5	8.3	6.6	0	6	110	80
2.35	1.97	3.4	3.7	4.6	4.3	45	45	61	51
0.00	2.21	6.0	5.9	6.4	6.5	80	71	85	79
0.39	2.21	-0.0	-0.0	12.2	9.9	0	0	162	120
0.78	2.21	0.0	0.0	12.7	10.7	0	0	169	130
1.18	2.21	0.0	0.0	10.6	8.8	0	0	141	107
1.57	2.21	0.0	0.0	12.7	10.7	0	0	169	130
1.96	2.21	-0.0	-0.0	12.2	9.9	0	0	162	120
2.35	2.21	6.0	5.9	6.4	6.5	80	71	85	79
0.00	2.46	9.6	10.2	8.3	7.6	127	124	110	92
0.20	2.46	4.8	5.9	10.5	9.5	64	71	140	115
0.39	2.46	0.7	1.7	12.6	11.6	10	20	167	140
0.59	2.46	0.0	0.0	11.8	11.3	0	0	157	136
0.78	2.46	0.0	0.0	11.3	10.7	0	0	151	130
0.98	2.46	0.0	0.0	9.7	9.3	0	0	129	112
1.18	2.46	0.0	0.0	8.1	7.8	0	0	108	95
1.37	2.46	0.0	0.0	9.7	9.3	0	0	129	112
1.57	2.46	0.0	0.0	11.3	10.7	0	0	151	130
1.76	2.46	0.0	0.0	11.8	11.3	0	0	157	136
1.96	2.46	0.7	1.7	12.6	11.6	10	20	167	140
2.15	2.46	4.8	5.9	10.5	9.5	64	71	140	115
2.35	2.46	9.6	10.2	8.3	7.6	127	124	110	92
0.00	2.70	6.8	6.8	10.4	10.4	91	82	139	126
0.39	2.70	5.3	5.6	10.5	10.2	71	67	140	124
0.78	2.70	0.2	0.2	8.1	8.1	3	3	108	98
1.18	2.70	0.0	0.0	4.1	4.3	0	0	55	52
1.57	2.70	0.2	0.2	8.1	8.1	3	3	108	98
1.96	2.70	5.3	5.6	10.5	10.2	71	67	140	124
2.35	2.70	6.8	6.8	10.4	10.4	91	82	139	126
0.00	2.95	3.0	1.2	12.4	14.2	40	15	165	172
0.20	2.95	7.5	6.4	10.3	11.4	100	77	137	138
0.39	2.95	10.1	10.3	8.4	8.3	135	124	112	100
0.59	2.95	6.2	6.4	6.9	6.8	82	77	92	81
0.78	2.95	4.2	3.6	4.9	5.4	55	44	65	65
0.98	2.95	2.0	1.5	2.4	2.9	27	18	32	35
1.18	2.95	0.0	0.0	0.1	0.5	0	0	2	6

1.37	2.95	2.0	1.5	2.4	2.9	27	18	32	35
1.57	2.95	4.2	3.6	4.9	5.4	55	44	65	65
1.76	2.95	6.2	6.4	6.9	6.8	82	77	92	81
1.96	2.95	10.1	10.3	8.4	8.3	135	124	112	100
2.15	2.95	7.5	6.4	10.3	11.4	100	77	137	138
2.35	2.95	3.0	1.2	12.4	14.2	40	15	165	172

Wood-Armer Moments:

ACI 318 - 2005

Top:LC 1 (kNm/m)

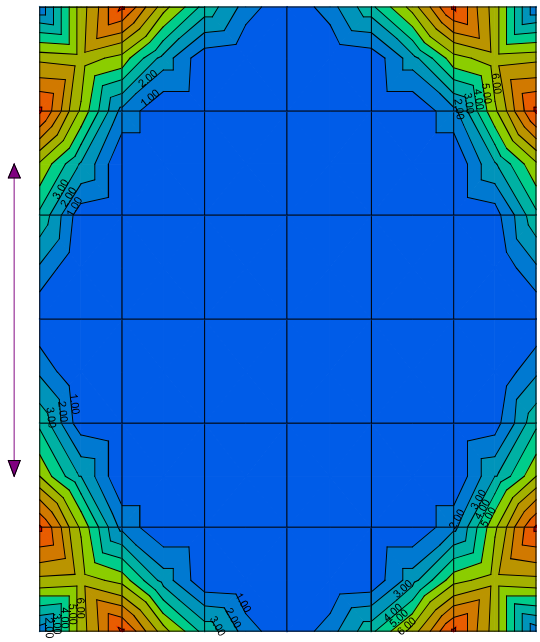


Max value:10.1 at X:2.0 Y:3.0

Wood-Armer Moments:

ACI 318 - 2005

Top:LC 1 (kNm/m)



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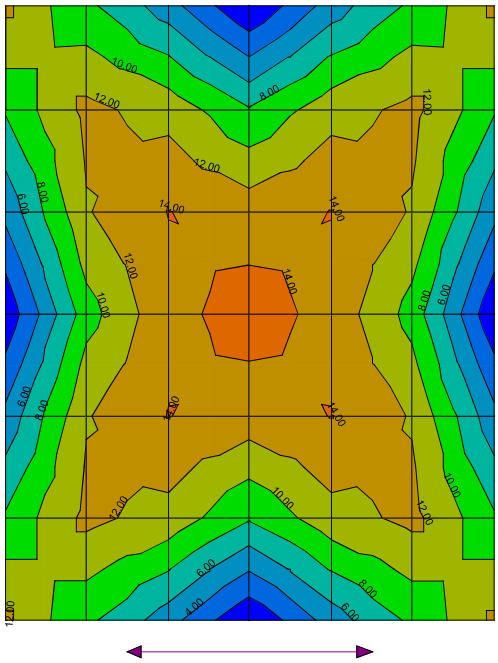
Wood-Armer Moments:

ACI 318 - 2005

Bot:LC 1 (kNm/m)



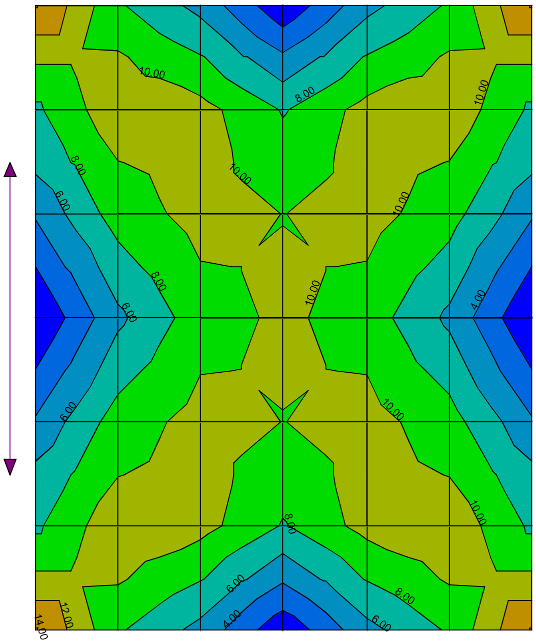
Max value:14.8 at X:1.2 Y:1.5

PROKON Software Consultants (Pty) Ltd Internet: http://www.prokon.com E-Mail : mail@prokon.com	Job Number		Sheet
	Job Title		
	Client		
	Calcs by	Checked by	Date

Wood-Armer Moments:

ACI 318 - 2005

Bot:LC 1 (kNm/m)

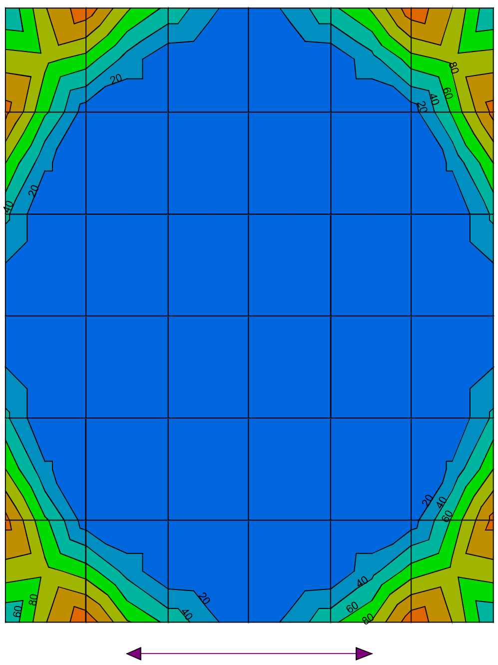


Max value:14.2 at X:2.4 Y:3.0

Reinforcement:

ACI 318 - 2005

Top:LC 1 (mm²/m)

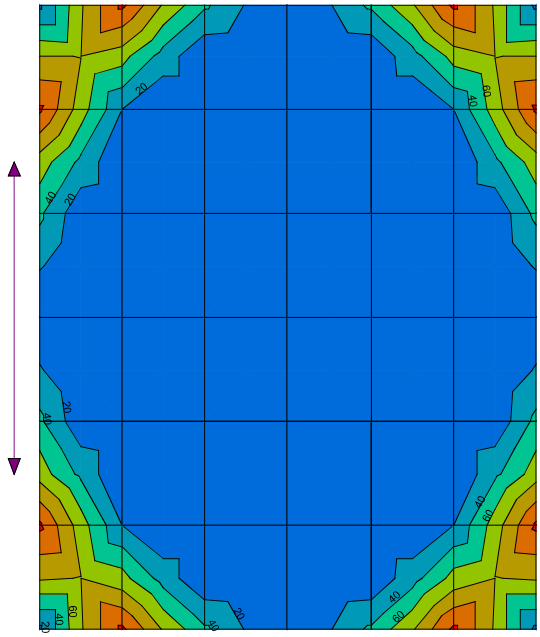


Max value:134.5 at X:2.0 Y:3.0

Reinforcement:

ACI 318 - 2005

Top:LC 1 (mm²/m)

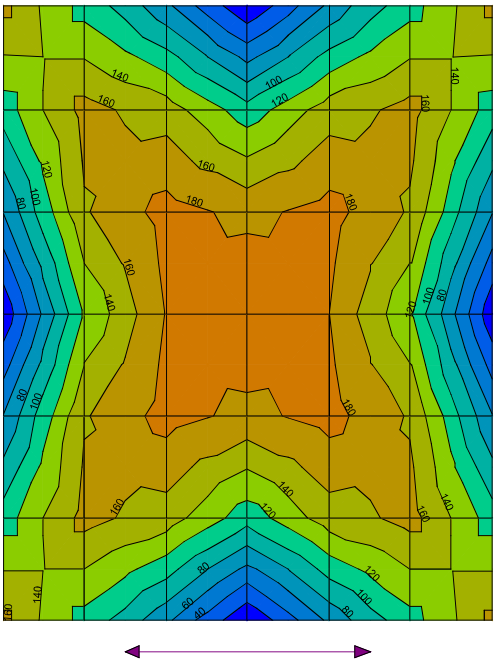


Max value:124.1 at X:2.0 Y:3.0

Reinforcement:

ACI 318 - 2005

Bot:LC 1 (mm²/m)

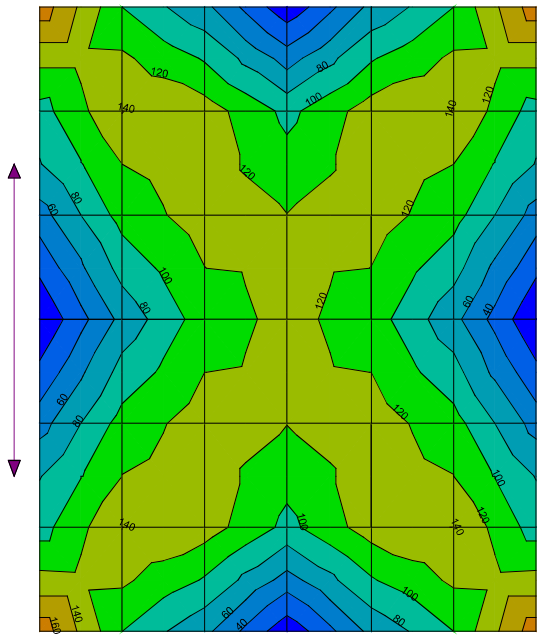


Max value:197.4 at X:1.2 Y:1.5

Reinforcement:

ACI 318 - 2005

Bot:LC 1 (mm²/m)

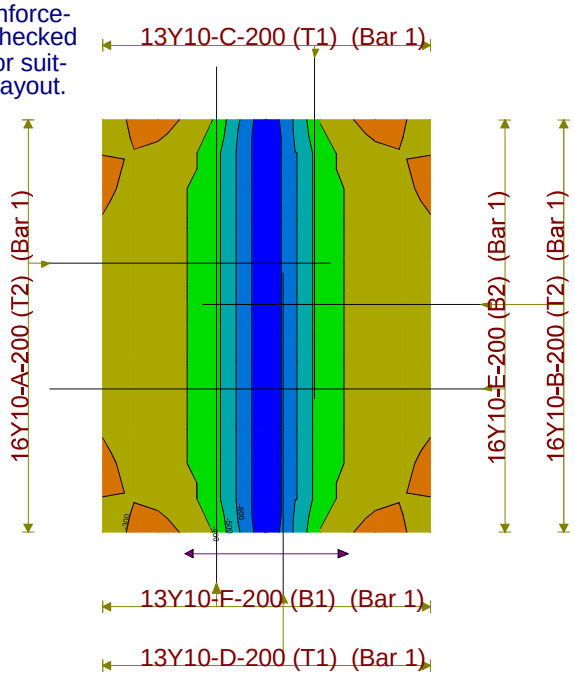


Max value:172.1 at X:2.4 Y:3.0

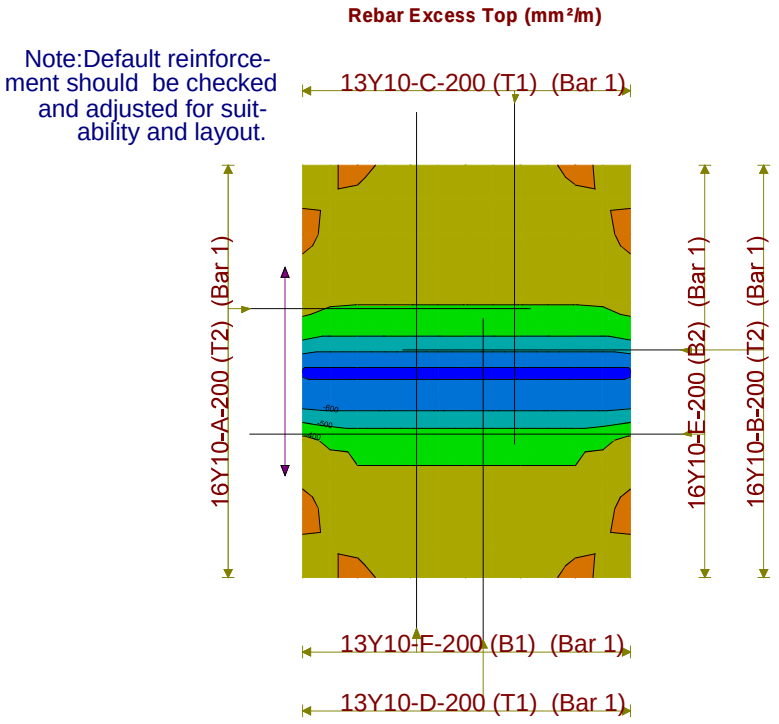
Rebar Excess:

Rebar Excess Top (mm²/m)

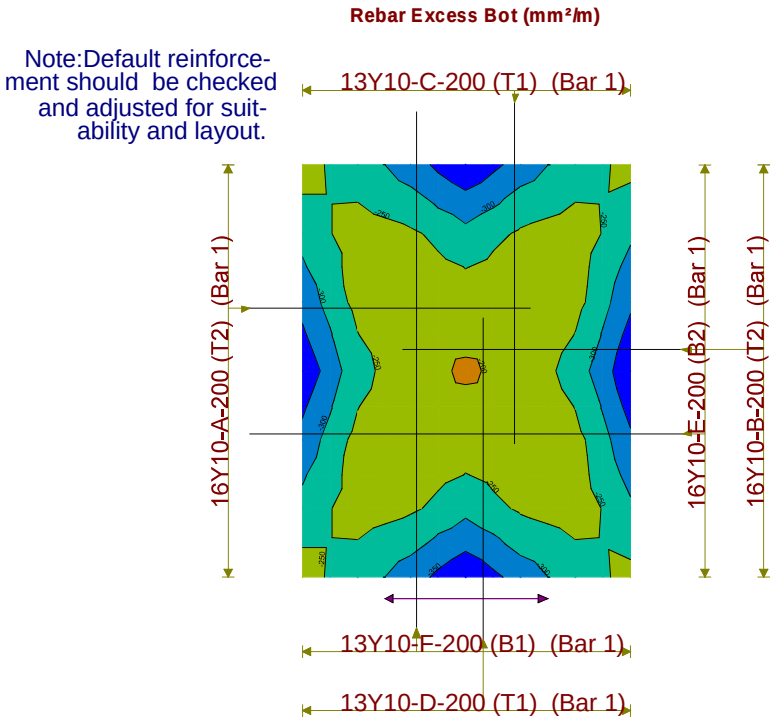
Note:Default reinforcement should be checked and adjusted for suitability and layout.



Rebar Excess:



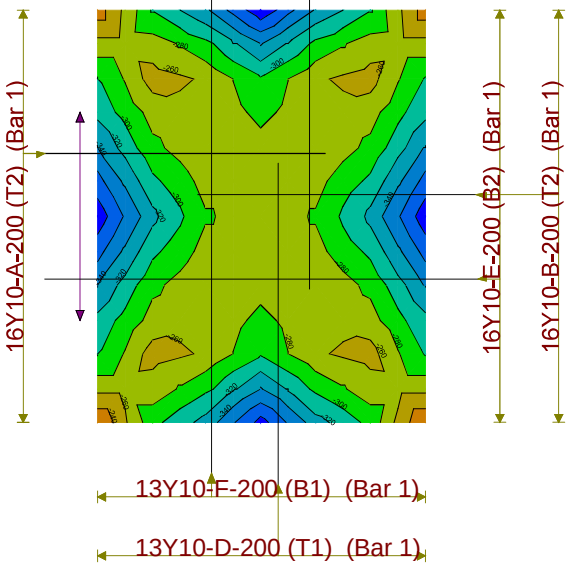
Rebar Excess:



Rebar Excess:

Rebar Excess Bot (mm²/m)

Note:Default reinforcement should be checked and adjusted for suitability and layout.



8) ⑥VALVE CHAMBER

WALL (H3.0m)

Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Cantilever wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1 (m)	3	C (m)	0.6	W	(kN/m²)	1	Soil frict ϕ	(°)	30	SF Overt.	1.5
H2 (m)	0	F (m)	0	P	(kN)	0	Fill slope β	(°)	0	SF Slip	1.5
H3 (m)	0	xf (m)	0	xp	(m)		Wall frict δ	(°)	20	ULS DL Factor	1.4
Hw (m)		At (m)	0.6	L	(kN/m)	20	ρ Conc	kN/m³	25	ULS LL Factor	1.6
Hr (m)	0.36	Ab (m)	0.6	xl	(m)	2	ρ Soil	kN/m³	18	Pmax (kPa)	100
B (m)	2.35	Cov wall	mm 50	Lh	(kN/m)		fc'	(MPa)	25	Soil Poisson υ	0.5
D (m)	0	Cov base	mm 50	x	(m)	0	fy	(MPa)	420	DL Factor Ovt.	0.9

Seepage allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:ON

Hor Accel. (g)	0.02
Vert Accel. (g)	0.01
Include LL's	Y

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.297
Passive Pressure coefficient Kp :6.105
Seismic Active Pressure coefficient Kas :0.313
Seismic Passive Pressure coefficient Kps :5.934
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	23.826	1.040	8.672	2.950
Siesmic component of Pa	1.195	1.800	0.435	2.950
As a result of surcharge w	0.874	1.500	0.318	2.950
As a result of Line Load L	4.721	1.686	0.000	2.950
Siesmic wall inertia	1.589	0.973		
Stabilizing forces:				
Passive pressure on base Pp	-0.000	0.000		
Siesmic component of Pp	-0.000	0.000		
Weight of the wall + base			79.447	2.002
Weight of soil on the base			0.000	0.000
UDL of 1.0 kPa			0.000	2.950

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 159.06 kNm
Destabilizing moment Mo : 9.08 kNm

Safety factor against overturning = Mr/Mo = 17.524

2.Force Equilibrium at SLS

Sum of Vertical forces Pv : 88.44 kN
Frictional resistance Pfric : 51.06 kN
Passive Pressure on shear key : 0.00 kN
Passive pressure on base : 0.00 kN
=> Total Horiz. resistance Fr : 51.06 kN

Horizontal sliding force on wall Fhw : 31.01 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 31.01 kN

Safety factor against overall sliding = Fr/Fh = 1.647

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	33.738	1.045	12.141	2.950
Siesmic component of Pa	1.913	1.800	0.696	2.950
As a result of surcharge w	1.398	1.500	0.509	2.950
As a result of Line Load L	7.553	1.686	0.000	2.950
Siesmic wall inertia	2.542	0.973		
Stabilizing forces:				
Passive pressure on base Pp	-0.000	0.000		
Siesmic component of Pp	-0.000	0.000		
Weight of the wall + base			71.503	2.002
Weight of soil on the base			0.000	0.000
UDL of 0.9 kPa			0.000	2.950

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

Stabilizing moment Mr : 143.16 kNm
Destabilizing moment Mo : 15.26 kNm

Safety factor against overturning = Mr/Mo = 9.383

2.Force Equilibrium at ULS

Sum of Vertical forces Pv : 79.59 kN
Frictional resistance Pfric : 45.95 kN
Passive Pressure on shear key : 0.00 kN

Passive pressure on base : 0.00 kN
=> Total Horiz. resistance Fr : 45.95 kN

Horizontal sliding force on wall Fhw : 45.23 kN
Horizontal sliding force on shear key Fht : 0.00 kN
=> Total Horizontal sliding force Fh : 45.23 kN

Safety factor against overall sliding = Fr/Fh = 1.016

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure : 43.45 kPa
Minimum pressure : 16.51 kPa
Maximum pressure occurs at right hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Minimum (mm²/m)
0.00	27.96	0.00	137.31	1772.94
0.05	26.56	0.00	130.43	1772.94
0.10	25.20	0.00	123.74	1772.94
0.14	23.88	0.00	117.23	1772.94
0.19	22.59	0.00	110.90	1772.94
0.24	21.34	0.00	104.74	1772.94
0.29	20.12	0.00	98.75	1772.94
0.34	18.94	0.00	92.92	1772.94
0.38	17.78	0.00	87.26	1772.94
0.43	16.67	0.00	81.77	1772.94
0.48	15.58	0.00	76.42	1772.94
0.53	14.52	0.00	71.23	1772.94
0.58	13.50	0.00	66.20	1772.94
0.62	12.50	0.00	61.30	1772.94
0.67	11.53	0.00	56.55	1772.94
0.72	10.59	0.00	51.94	1772.94
0.77	9.68	0.00	47.47	1772.94
0.82	8.80	0.00	43.13	1772.94
0.86	7.94	0.00	38.92	1772.94
0.91	7.11	0.00	34.84	1772.94
0.96	6.30	0.00	30.88	1772.94
1.01	5.52	0.00	27.05	1772.94
1.06	4.76	0.00	23.32	1772.94
1.10	4.02	0.00	19.72	1772.94
1.15	3.45	0.00	16.89	1772.94
1.20	3.12	0.00	15.28	1772.94
1.25	2.81	0.00	13.77	1772.94
1.30	2.52	0.00	12.36	1772.94
1.34	2.25	0.00	11.04	1772.94
1.39	2.00	0.00	9.82	1772.94
1.44	1.77	0.00	8.69	1772.94
1.49	1.56	0.00	7.65	1772.94
1.54	1.37	0.00	6.69	1772.94
1.58	1.19	0.00	5.81	1772.94
1.63	1.02	0.00	5.01	1772.94
1.68	0.87	0.00	4.28	1772.94
1.73	0.74	0.00	3.62	1772.94
1.78	0.62	0.00	3.03	1772.94
1.82	0.51	0.00	2.50	1772.94
1.87	0.42	0.00	2.04	1772.94
1.92	0.33	0.00	1.63	1772.94
1.97	0.26	0.00	1.28	1772.94
2.02	0.20	0.00	0.97	1772.94
2.06	0.15	0.00	0.72	1772.94
2.11	0.10	0.00	0.51	1772.94
2.16	0.07	0.00	0.34	1772.94
2.21	0.04	0.00	0.21	1772.94
2.26	0.02	0.00	0.11	1772.94
2.30	0.01	0.00	0.05	1772.94

2.35	0.00	0.00	0.01	1772.94
2.40	0.00	0.00	0.00	1772.94

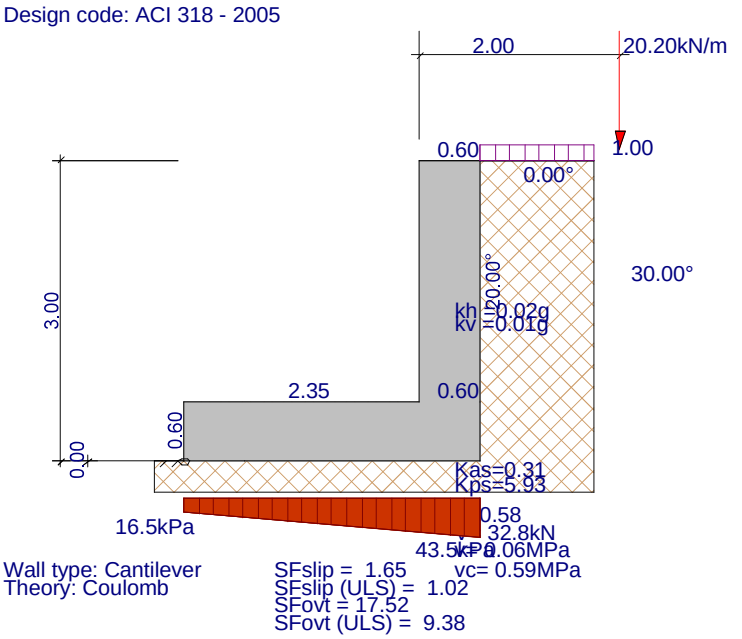
BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Minimum (mm^2/m)
0.00	-0.00	0.00	0.00	1772.94
0.06	-0.02	0.00	0.12	1772.94
0.12	-0.10	0.00	0.47	1772.94
0.18	-0.22	0.00	1.06	1772.94
0.24	-0.38	0.00	1.88	1772.94
0.30	-0.60	0.00	2.94	1772.94
0.35	-0.87	0.00	4.24	1772.94
0.41	-1.18	0.00	5.77	1772.94
0.47	-1.54	0.00	7.54	1772.94
0.53	-1.95	0.00	9.54	1772.94
0.59	-2.40	0.00	11.78	1772.94
0.65	-2.91	0.00	14.25	1772.94
0.71	-3.46	0.00	16.96	1772.94
0.77	-4.06	0.00	19.91	1772.94
0.83	-4.71	0.00	23.09	1772.94
0.89	-5.41	0.00	26.51	1772.94
0.94	-6.15	0.00	30.16	1772.94
1.00	-6.95	0.00	34.05	1772.94
1.06	-7.79	0.00	38.18	1772.94
1.12	-8.68	0.00	42.54	1772.94
1.18	-9.61	0.00	47.14	1772.94
1.24	-10.60	0.00	51.98	1772.94
1.30	-11.63	0.00	57.05	1772.94
1.36	-12.71	0.00	62.36	1772.94
1.42	-13.84	0.00	67.91	1772.94
1.48	-15.02	0.00	73.69	1772.94
1.53	-16.25	0.00	79.71	1772.94
1.59	-17.52	0.00	85.97	1772.94
1.65	-18.84	0.00	92.47	1772.94
1.71	-20.21	0.00	99.21	1772.94
1.77	-21.63	0.00	106.18	1772.94
1.83	-23.10	0.00	113.39	1772.94
1.89	-24.61	0.00	120.84	1772.94
1.95	-26.17	0.00	128.53	1772.94
2.01	-27.78	0.00	136.46	1772.94
2.06	-29.44	0.00	144.62	1772.94
2.12	-31.15	0.00	153.03	1772.94
2.18	-32.90	0.00	161.67	1772.94
2.24	-34.71	0.00	170.56	1772.94
2.30	-36.56	0.00	179.68	1772.94
2.36	-38.46	0.00	189.05	1772.94
2.42	-40.40	0.00	198.66	1772.94
2.48	-42.40	0.00	208.50	1772.94
2.54	-44.44	0.00	218.59	1772.94
2.60	-46.53	0.00	228.92	1772.94
2.66	-48.67	0.00	239.49	1772.94
2.71	-50.45	0.00	248.27	1772.94
2.77	-2.00	0.00	0.00	1772.94
2.83	-1.19	0.00	0.00	1772.94
2.89	-0.67	0.00	0.00	1772.94
2.95	-0.30	0.00	0.00	1772.94

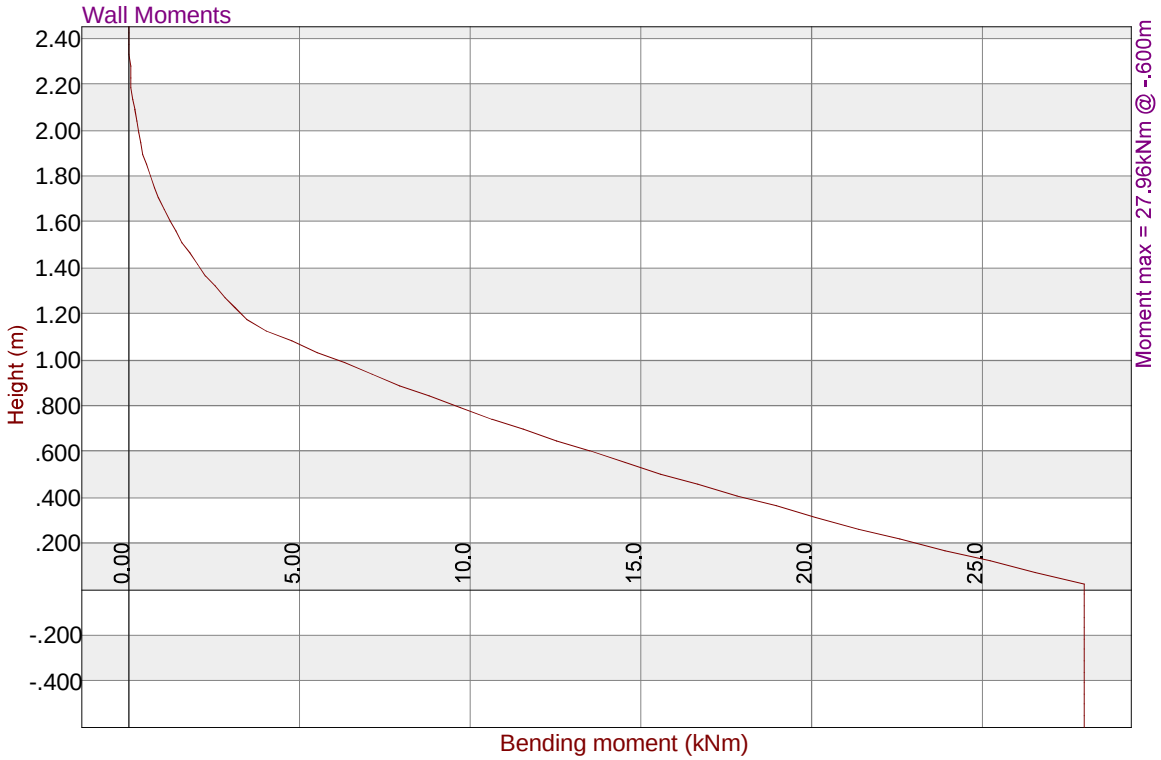
SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

Shear force at bottom of wall V = 32.8 kN
Shear stress at bottom of wall v = 0.06 MPa OK
Allowable shear stress vc = 0.59 MPa (based on Wall tensile reinf.)

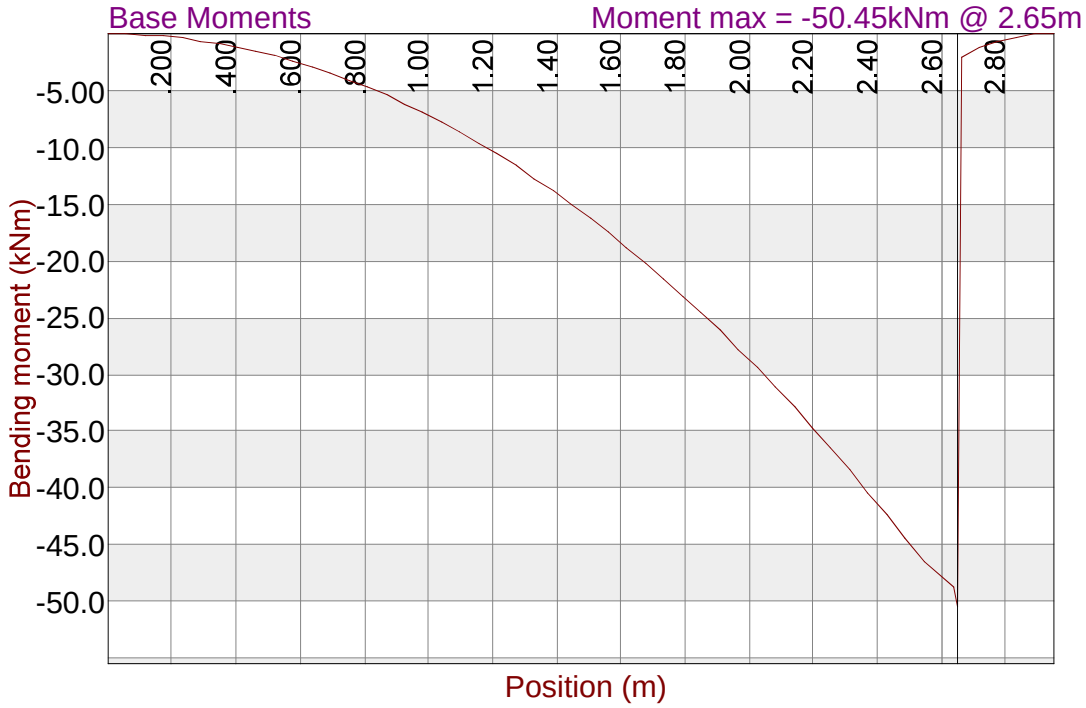
Sketch of Wall



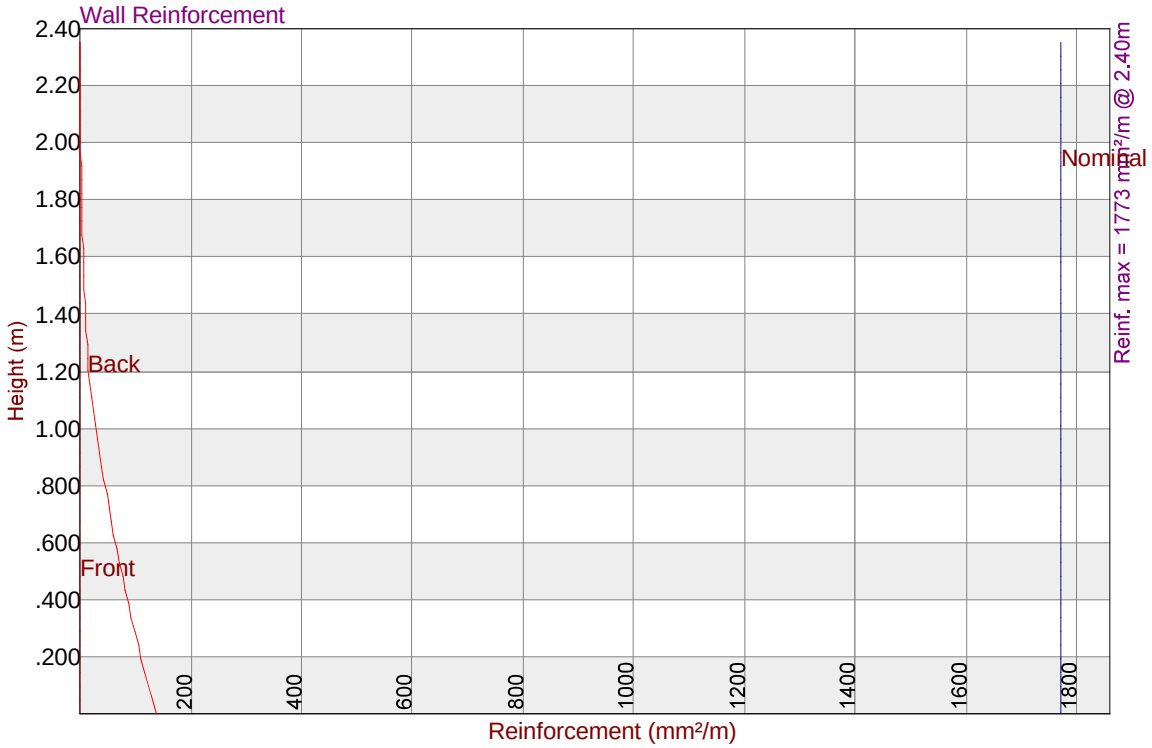
Wall Bending Moments



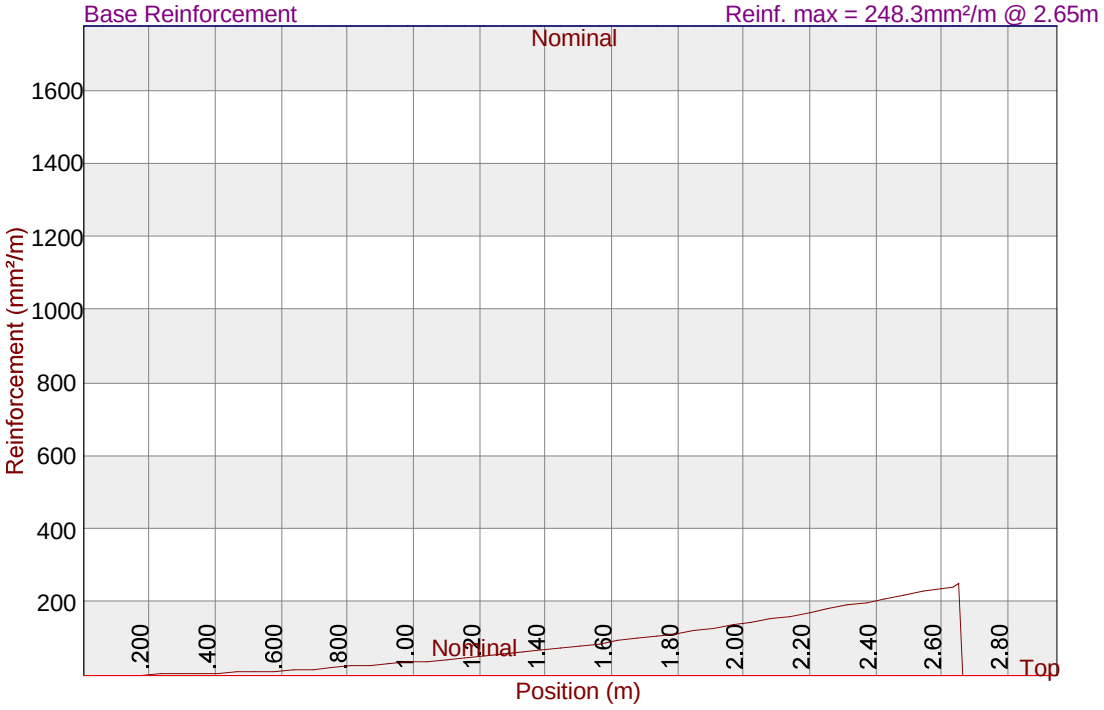
Base Bending Moments



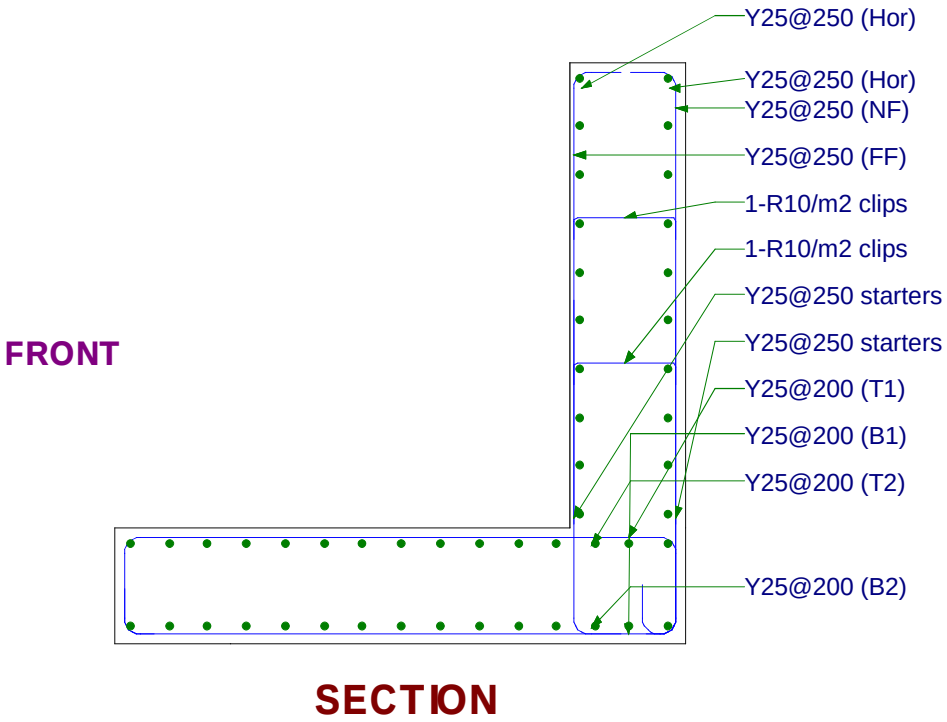
Wall Reinforcement



Base Reinforcement



Schematic Reinforcement



Retaining Wall Design : Ver W2.4.01 - 01 Apr 2008
Title : Reservoir wall example

C14

Input Data

Wall Dimensions						Unfactored Live Loads			General Parameters			Design Parameters	
H1	(m)	3	C	(m)	0.6	W	(kN/m²)		Soil frict ϕ	(°)	30	SF Overt.	1.5
H2	(m)	0.67	F	(m)		P	(kN)		Fill slope β	(°)		SF Slip	1.5
H3	(m)	2.6	xf	(m)		xp	(m)		Wall frict δ	(°)		ULS DL Factor	1.4
Hw	(m)	2.6	At	(m)	0.6	L	(kN/m)		ρ Conc	kN/m^3	25	ULS LL Factor	1.6
Hr	(m)	0.36	Ab	(m)	0.6	xl	(m)		ρ Soil	kN/m^3	18	Pmax (kPa)	100
B	(m)		Cov wall	mm	50	Lh	(kN/m)		fc'	(MPa)	25	Soil Poisson υ	0.5
D	(m)	2.35	Cov base	mm	50	x	(m)		fy	(MPa)	420	DL Factor Ovt.	0.9

Seepage not allowed
Active pressure applied on back of shear key for sliding

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:OFF

Hor Accel. (g)	
Vert Accel. (g)	
Include LL's	

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka :0.333
Passive Pressure coefficient Kp :3.000
Base frictional constant μ :0.577

FORCES ACTING ON THE WALL AT SLS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.480	0.133	0.000	0.600
Triangular W-table press Pw	0.523	0.133	0.000	0.600
W-table pr below free water	8.633	0.200	0.000	0.600
Free water pressure Pwf	23.740	1.133	0.000	0.600
Hydrostatic pressure on bot of base: uniform portion			0.000	1.475
Hydrostatic pressure on bot of base: triangular portion			0.000	1.967
Stabilizing forces:				
Passive pressure on base Pp	-12.120	0.223		
Weight of the wall + base			80.250	0.948
Weight of soil on the base			-3.849	1.775
Hydrostatic pressure on top of rear portion of base			46.107	1.775
Hydrostatic pressure on top of front portion of base			0.000	0.000

EQUILIBRIUM CALCULATIONS AT SLS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 153.78 kNm
      Destabilizing moment Mo : 28.77 kNm

Safety factor against overturning = Mr/Mo = 5.346

2.Force Equilibrium at SLS

    Sum of Vertical forces Pv : 122.51 kN
  Frictional resistance Pfric : 70.73 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base : 12.12 kN
=> Total Horiz. resistance Fr : 82.85 kN

     Horizontal sliding force on wall Fhw : 33.38 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh : 33.38 kN

Safety factor against overall sliding = Fr/Fh = 2.482

FORCES ACTING ON THE WALL AT ULS:
All forces/moments are per m width

Description	FORCES (kN) and their LEVER ARMS (m) F Horizontal left (+)	Lever arm	F Vertical down (+)	Lever arm
Destabilizing forces:				
Total Active pressure Pa	0.672	0.133	0.000	0.600
Triangular W-table press Pw	0.732	0.133	0.000	0.600
W-table pr below free water	12.086	0.200	0.000	0.600
Free water pressure Pwf	33.236	1.133	0.000	0.600
Hydrostatic pressure on bot of base: uniform portion			0.000	1.475
Hydrostatic pressure on bot of base: triangular portion			0.000	1.967
Stabilizing forces:				
Passive pressure on base Pp	-10.908	0.223		
Weight of the wall + base			72.225	0.948
Weight of soil on the base			-3.464	1.775
Hydrostatic pressure on top of rear portion of base			41.496	1.775
Hydrostatic pressure on top of front portion of base			0.000	0.000

EQUILIBRIUM CALCULATIONS AT ULS
All forces/moments are per m width

1.Moment Equilibrium

Point of rotation: bottom front corner of base.

For Overturning moment Mo calculate as follows:
  Mo = Sum(hor. forces x l.a.) - Sum(vert. forces x l.a.)
For Stabilizing moment Mr calculate as follows:
  Mr = -Sum(hor. forces x l.a.) + Sum(vert. forces x l.a.)
where l.a. = lever arm of each force.

        Stabilizing moment Mr : 138.40 kNm
      Destabilizing moment Mo : 40.27 kNm

Safety factor against overturning = Mr/Mo = 3.437

2.Force Equilibrium at ULS

```
    Sum of Vertical forces Pv : 110.26 kN
  Frictional resistance Pfric :  63.66 kN
Passive Pressure on shear key :   0.00 kN
     Passive pressure on base :  10.91 kN
=> Total Horiz. resistance Fr :  74.57 kN

     Horizontal sliding force on wall Fhw :  46.73 kN
Horizontal sliding force on shear key Fht :   0.00 kN
     => Total Horizontal sliding force Fh :  46.73 kN
```

Safety factor against overall sliding = Fr/Fh = 1.596

SOIL PRESSURES UNDER BASE AT SLS

Maximum pressure : 79.92 kPa
Minimum pressure : 3.14 kPa
Maximum pressure occurs at left hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm²/m)	Back Reinforcing (mm²/m)	Minimum (mm²/m)
0.00	18.60	0.00	91.26	1772.94
0.05	17.29	0.00	84.85	1772.94
0.10	16.05	0.00	78.74	1772.94
0.14	14.87	0.00	72.92	1772.94
0.19	13.74	0.00	67.40	1772.94
0.24	12.68	0.00	62.17	1772.94
0.29	11.67	0.00	57.22	1772.94
0.34	10.71	0.00	52.53	1772.94
0.38	9.81	0.00	48.11	1772.94
0.43	8.96	0.00	43.95	1772.94
0.48	8.17	0.00	40.03	1772.94
0.53	7.42	0.00	36.36	1772.94
0.58	6.71	0.00	32.91	1772.94
0.62	6.06	0.00	29.69	1772.94
0.67	5.45	0.00	26.69	1772.94
0.72	4.88	0.00	23.90	1772.94
0.77	4.35	0.00	21.31	1772.94
0.82	3.86	0.00	18.91	1772.94
0.86	3.41	0.00	16.70	1772.94
0.91	2.99	0.00	14.67	1772.94
0.96	2.62	0.00	12.82	1772.94
1.01	2.27	0.00	11.12	1772.94
1.06	1.96	0.00	9.58	1772.94
1.10	1.67	0.00	8.19	1772.94
1.15	1.42	0.00	6.95	1772.94
1.20	1.19	0.00	5.83	1772.94
1.25	0.99	0.00	4.84	1772.94
1.30	0.81	0.00	3.97	1772.94
1.34	0.66	0.00	3.22	1772.94
1.39	0.52	0.00	2.56	1772.94
1.44	0.41	0.00	2.00	1772.94
1.49	0.31	0.00	1.53	1772.94
1.54	0.23	0.00	1.14	1772.94
1.58	0.17	0.00	0.82	1772.94
1.63	0.12	0.00	0.57	1772.94
1.68	0.08	0.00	0.37	1772.94
1.73	0.05	0.00	0.23	1772.94
1.78	0.03	0.00	0.13	1772.94
1.82	0.01	0.00	0.06	1772.94
1.87	0.00	0.00	0.02	1772.94
1.92	0.00	0.00	0.01	1772.94

1.97	0.00	0.00	0.00	1772.94
2.02	0.00	0.00	0.00	1772.94
2.06	0.00	0.00	0.00	1772.94
2.11	0.00	0.00	0.00	1772.94
2.16	0.00	0.00	0.00	1772.94
2.21	0.00	0.00	0.00	1772.94
2.26	0.00	0.00	0.00	1772.94
2.30	0.00	0.00	0.00	1772.94
2.35	0.00	0.00	0.00	1772.94
2.40	0.00	0.00	0.00	1772.94

BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 2005

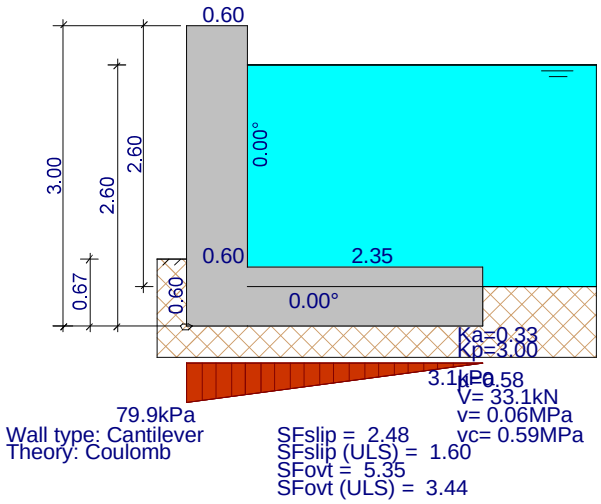
Position from left (m)	Moment (kNm)	Top Reinforcing (mm^2/m)	Bot Reinforcing (mm^2/m)	Minimum (mm^2/m)
0.00	-0.00	0.00	0.00	1772.94
0.06	-0.15	0.00	0.72	1772.94
0.12	-0.58	0.00	2.86	1772.94
0.18	-1.31	0.00	6.44	1772.94
0.24	-2.34	0.00	11.44	1772.94
0.30	-3.65	0.00	17.88	1772.94
0.35	-3.93	0.00	0.00	1772.94
0.41	33.09	0.00	0.00	1772.94
0.47	30.53	0.00	0.00	1772.94
0.53	29.15	0.00	0.00	1772.94
0.59	27.81	0.00	0.00	1772.94
0.65	26.50	0.00	0.00	1772.94
0.71	25.23	123.87	0.00	1772.94
0.77	23.98	117.74	0.00	1772.94
0.83	22.77	111.77	0.00	1772.94
0.89	21.59	105.95	0.00	1772.94
0.94	20.43	100.29	0.00	1772.94
1.00	19.32	94.79	0.00	1772.94
1.06	18.23	89.44	0.00	1772.94
1.12	17.17	84.25	0.00	1772.94
1.18	16.15	79.21	0.00	1772.94
1.24	15.15	74.33	0.00	1772.94
1.30	14.19	69.61	0.00	1772.94
1.36	13.26	65.04	0.00	1772.94
1.42	12.36	60.63	0.00	1772.94
1.48	11.49	56.37	0.00	1772.94
1.53	10.66	52.27	0.00	1772.94
1.59	9.85	48.32	0.00	1772.94
1.65	9.08	44.53	0.00	1772.94
1.71	8.34	40.89	0.00	1772.94
1.77	7.63	37.41	0.00	1772.94
1.83	6.95	34.09	0.00	1772.94
1.89	6.31	30.92	0.00	1772.94
1.95	5.69	27.90	0.00	1772.94
2.01	5.11	25.04	0.00	1772.94
2.06	4.56	22.33	0.00	1772.94
2.12	4.04	19.78	0.00	1772.94
2.18	3.55	17.39	0.00	1772.94
2.24	3.09	15.14	0.00	1772.94
2.30	2.66	13.06	0.00	1772.94
2.36	2.27	11.13	0.00	1772.94
2.42	1.91	9.35	0.00	1772.94
2.48	1.58	7.73	0.00	1772.94
2.54	1.28	6.26	0.00	1772.94
2.60	1.01	4.94	0.00	1772.94
2.66	0.77	3.79	0.00	1772.94
2.71	0.57	2.78	0.00	1772.94
2.77	0.39	1.93	0.00	1772.94
2.83	0.25	1.24	0.00	1772.94
2.89	0.14	0.70	0.00	1772.94
2.95	0.06	0.31	0.00	1772.94

SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 2005

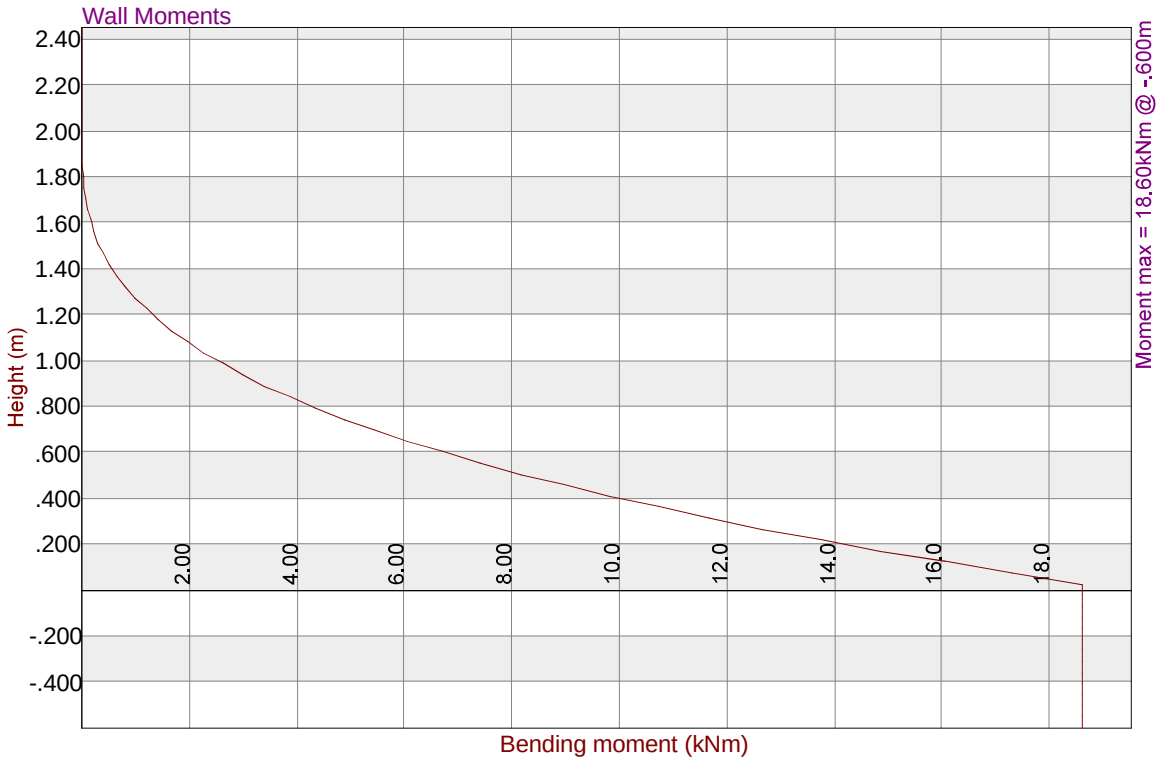
```
 Shear force at bottom of wall V =  33.1 kN
Shear stress at bottom of wall v = 0.06 MPa OK
       Allowable shear stress vc = 0.59 MPa (based on Wall tensile reinf.)
```

Sketch of Wall

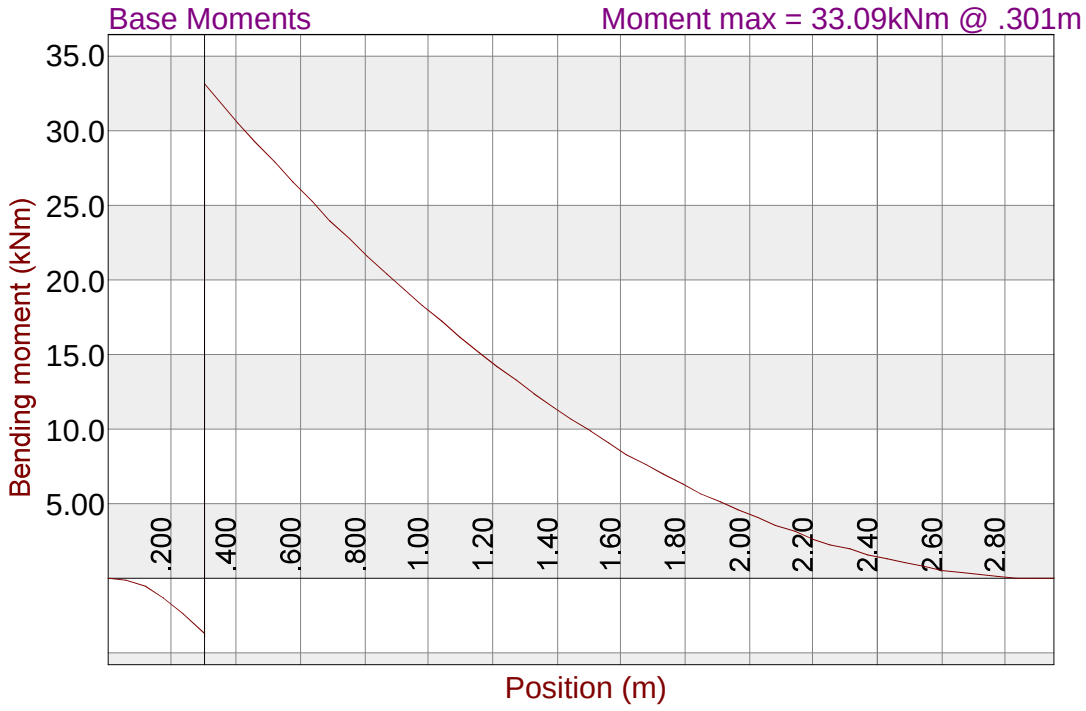
Design code: ACI 318 - 2005



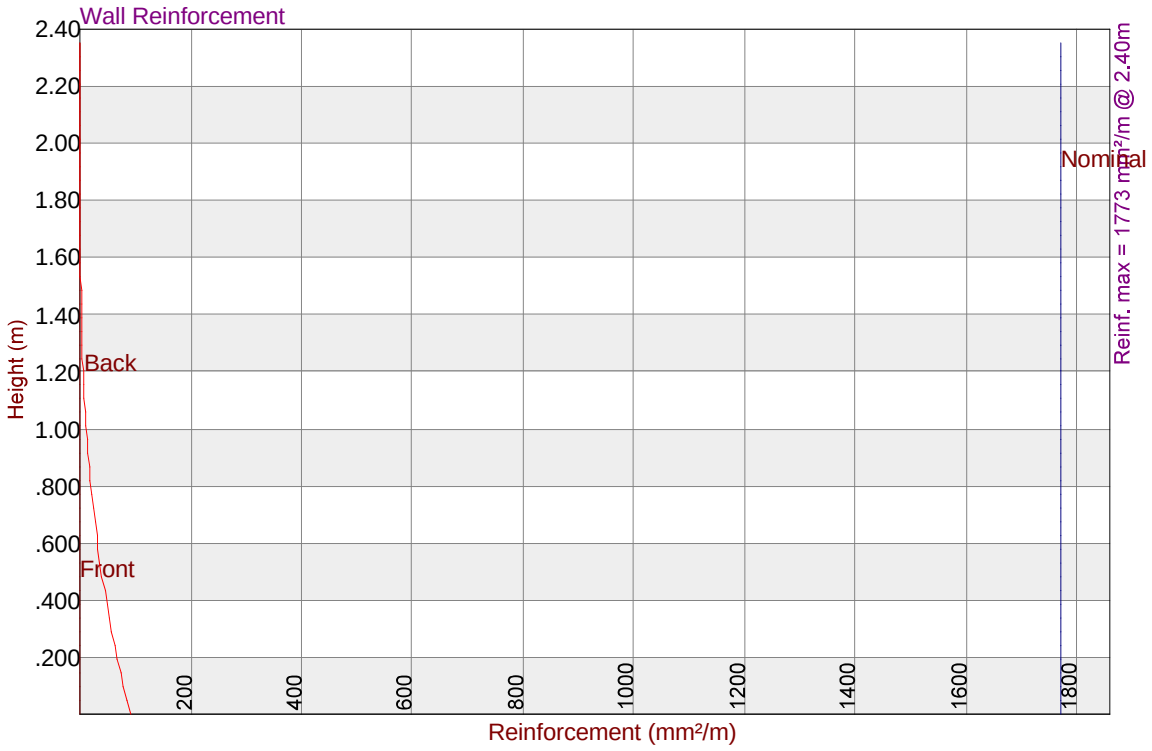
Wall Bending Moments



Base Bending Moments



Wall Reinforcement



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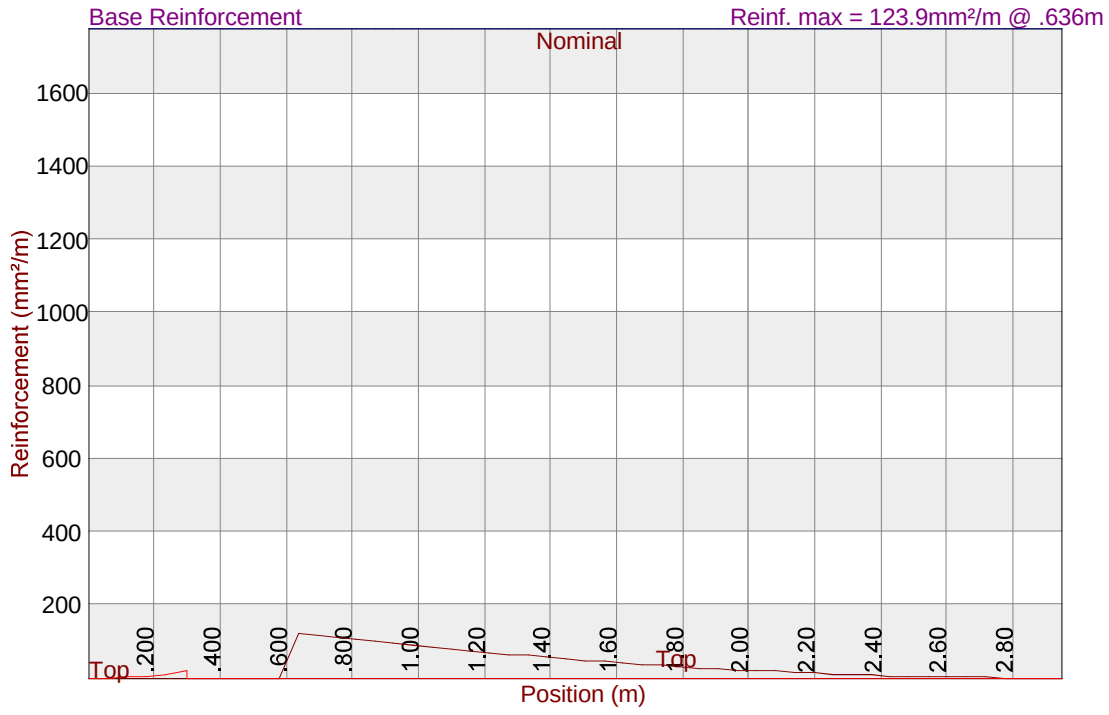
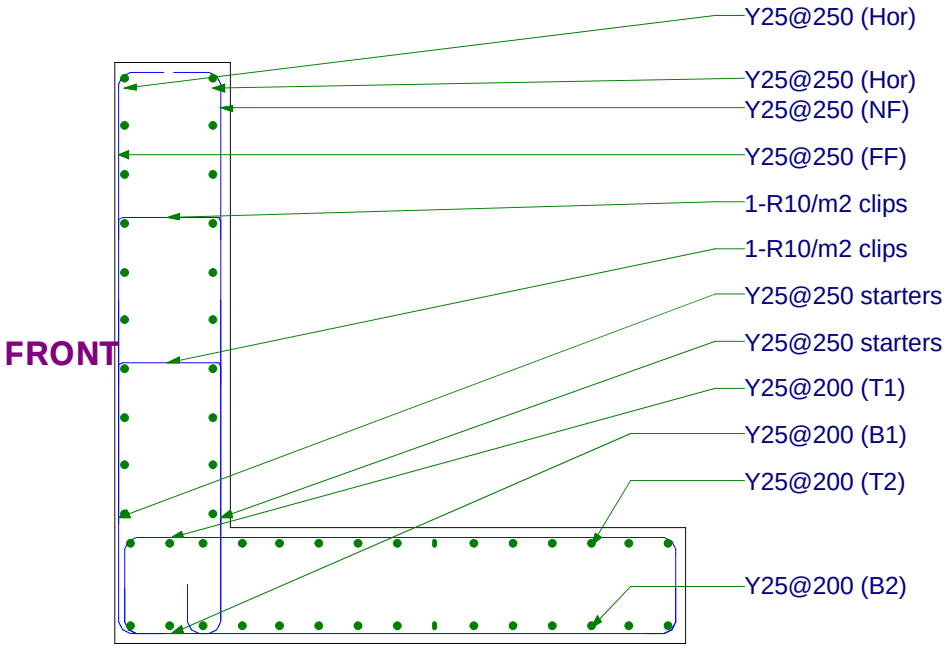


Schematic Reinforcement



SECTION

6.7 Topographic Survey Report

Contents

1. INTRODUCTION

According to the agreement with Arabtech Jardaneh Engineers & Architects(AJ) to carry out the survey works of Improvement and Expansion of the Water Distribution Network in Irbed which include 73 km the survey work as of Irbed District include :-

1. Longitudinal and topographic Survey works for alignment of the water pipes along the proposed alignment

2. Plan table survey for Existing pumping station and reservoir

2. DATUM OF ELEVATION:-

Datum of The Elevation Taken from Royal Jordanian Geographic Centre level point :-

DESCRIPTIN	ELEVATION	Point No.
BH 3	553.221	In Irbid –Al-mafraq road
BH 4	579.977	In Irbid - Alstklal Street

بسم الله الرحمن الرحيم

Levelling Point نقطة تسوية

Order .... الدرجة .... Loop B H اسم الحلقة .... Point Number B H3 رقم النقطة

X 35 54.01 الشرقيات Y 32 31.59 الشمّاليات	نظام الاحداثيات (Coordinates.S)	(M.No.) .... رقم الخريطة
M.Name .... اسم الخريطة	Date ٧/٧/٢٠٠١م تاريخ صب النقطة	
Scale .... مقياس الخريطة	Road المزرعة/اربد/الشونة الطريق	District اربد المحافظة

Altitude 553.221 ارتفاع النقطة النهائي

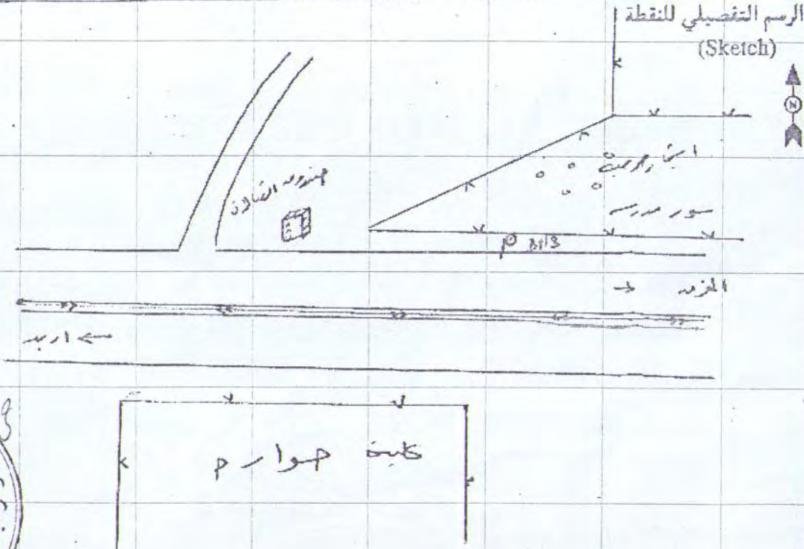
وصف صب النقطة (Description)

[illegible]

وصف الوصول الى النقطة (Destination)

[illegible]

الرسم التفصيلي للنقطة (Sketch)



form # qpo92-8.rev.a

بسم الله الرحمن الرحيم

Levelling Point

نقطة تسوية

Order	الدرجة	Loop	اسم الحلقة	Point Number	رقم النقطة

X	الشرقيات	M.Name	اسم الخريطة	Date	تاريخ صب النقطة
Y	الشماليات	نظام الاحداثيات (Coordinates S)	(M.No.) رقم الخريطة	Road	الطريق
		Scale	مقياس الخريطة	District	المحافظة

Altitude الارتفاع النهائي

الرسم التفصيلي للنقطة (Sketch)

وصف صب النقطة (Description)

وصف الوصول الى النقطة (Destination)

3. METHOD OF WORK

Survey works start by checking the Land Department Points and the Royal Jordanian Center Bench Marks using **Topcon Duel Frequency GPS** with RTK and making localization to reach an accuracy of 1cm + 1ppm horizontally and vertically.

Establishing Traverse Points along the proposed line and inside the served areas Based on the control points full survey taken by Total Station equipments.

List of Reference Point according to Department of Land and survey:-

Point No.	EASTING	NORTHING
IR35	225922.434	223179.297
IR40	231053.835	223000.749
IR41	232240.492	222816.731
IR71	228972.164	221045.08
IR91	230141.041	219854.667
IR93	228037.112	220076.028
IR181	229939.78	214819.71

New control points checked by the GPS
List Of The control points coordinates and elevations:-

list of benchmarks-Irbed Water				
Point	Easting	Northing	Elevation	Name
1	232741.52	215386.15	579.66	I98
2	232747.73	214954.25	581.06	I97
3	232876.54	216394.14	568.5	I101
4	233105.99	217551.75	558.82	T3
5	232362.49	218445.04	560.04	T17
6	231604.04	217290.22	564.04	T22
7	231945.32	215613.68	587.34	T27
8	232016.57	215208.62	592.94	T28
9	227727.89	216256.82	558.11	WA34
10	227505.34	216105.64	569.79	WA35
11	228492.85	216301.25	592.99	WA36
12	231922.42	215212.04	594.55	A1
13	231801.15	215556.47	589.49	A2
14	231565.21	216434.35	581.33	A5
15	231567.45	215998.65	588.28	A5-
16	231350.44	216421.32	583.99	A7
17	232067.22	215627.26	584.36	A8
18	227847.05	215767.96	623.43	AM1
19	228202.9	215814.96	601.41	AM2
20	228525.36	215853.96	625.27	AM3
21	228259.36	216095.06	604.04	AM4
22	228338.64	216080.98	607.57	AM5
23	228309.68	215966.43	611.38	AM6
24	228375.32	215963.93	615.3	AM7
25	231693.77	220788.52	547.77	AA1
26	231309.65	221915.4	579.73	B29
27	231066.03	222388.24	590.32	B34
28	231057.29	214263.28	624.76	M1
29	231057.81	214625.48	621.41	M2
30	231085.7	214908.68	633.75	M3
31	231176.19	214945.46	630.38	M4
32	231363.61	214985.76	623.45	M5
33	231367.96	214841.78	629.77	M6
34	231359.7	214701.45	625.01	M7

35	231618.62	214378.53	604.77	M8
36	231861.35	214470.73	599.9	M9
37	230994.9	215161.13	627.54	M10
38	231298.23	215301.87	609.34	M11
39	230909.59	215081.35	636.1	M12
40	230834.09	215283.44	624.17	M13
41	230716.94	215547.13	613.2	M14
42	230543.31	215474.31	620.18	M15
43	230616.72	215254.57	627.68	M16
44	230317.51	215448.12	626.82	M17
45	230202.07	215423.32	632.42	M18
46	230121.56	215495.3	627.16	M19
47	229650.17	215571.39	635.42	M20
48	229444.58	215619.78	635.81	M21
49	229291.22	215644.98	629.41	M22
50	229104.48	215672.58	621.84	M23
51	229064.71	215535.89	627.44	M24
52	228889.39	215566.91	612.67	M25
53	228749.64	215337.3	643.82	M26
54	228619.03	215356.88	645.35	M27
55	228416.56	215378.04	635.28	M28
56	228364.91	215506.92	628.93	M29
57	228378.32	215623.73	631.24	M30
58	228243.38	215699.59	614.85	M31
59	228121.36	215581.33	613.29	M32
60	228507.49	215697.68	638.75	M33
61	228582.91	215684.86	636.93	M34
62	228701.1	215692.63	626.91	M35
63	228817.4	215741.51	611.69	M36
64	228455.78	216044.3	609.93	M37
65	228471.05	216177.46	600.31	M38
66	228567.64	216007.44	609.52	M39
67	228700.51	215926.05	609.87	M40
68	228829.64	215949.12	600.66	M41
69	228971.13	215965.6	584.93	M42
70	229191.44	216028.25	597.96	M43
71	229204.14	216086.82	594.21	M44
72	229428.11	216071.36	590.03	M45
73	229744.2	216040.77	599.16	M46
74	229808.93	216075.57	599.05	M47
75	230120.85	216200.09	587.88	M48
76	230009.1	216176.63	588.92	M49

77	229769.06	216160.92	590.05	M50
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81	229343.58	216408.95	567.67	M54
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83	228894.93	216260.79	573.93	M56
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85	228835.73	216650.87	553.63	M58
86	228656.98	216355.33	581.67	M59
87	228522.32	216408.6	590.57	M60
88	228392.38	216362.75	593.93	M61
89	228305.64	216406.08	584.72	M62
90	227904.97	216365.18	573.34	M63
91	227963.88	216747.69	578.37	M64
92	228158.94	217057.31	546.47	M65
93	229564.24	216539.53	575.41	M66
94	229339.65	216599.68	568.94	M67
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107	228486.08	218242.57	554.44	M80
108	228500.79	218360.06	541.7	M81
109	228082.72	218308.75	553.59	M82
110	227938.98	218344.84	547.55	M83
111	227721.19	218386.32	529.61	M84
112	227796.46	218473.89	536.05	M85
113	227901.2	218542.13	532.93	M86
114	228028.34	218657.61	521.84	M87
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116	227948.85	218762.12	516.6	M89
117	227688.41	218803.13	516.96	M90
118	227665.74	218214.55	515.68	M91

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121	229653.27	216585.13	578.78	M94
122	229637.01	216734.5	585.72	M95
123	229614.17	216923.16	588.36	M96
124	229593.93	217016.63	584.94	M97
125	229662.58	217034.53	583.58	M98
126	229659.65	217114.9	578.61	M99
127	229822.54	217129.62	579.57	M100
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185	230874.99	219645.51	543.53	M159
186	230705.23	219495.1	540.17	M160
187	230581.49	219377.5	538.46	M161
188	230542.29	219165.47	538.3	M162
189	230501.11	218894.03	547.75	M163
190	230360.05	218713.88	552.38	M164
191	230281.67	218615.7	558.05	M165
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208	227561.27	220319.09	519.86	M182
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213	226830.6	221115.04	477.17	M187
214	226670.38	221282.77	467.64	M188
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217	228117.13	220136.98	507.09	M191
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220	229177.01	220204.22	482.22	M194
221	229216.11	220237.44	481.64	M195
222	229165.86	220480.99	475.56	M196
223	228959.74	220706.54	476.94	M197
224	228826.95	220926.09	483.64	M198
225	228698.01	221071.41	484.75	M199
226	228417.04	221241.47	487.19	M200
227	228131.95	221472.61	484.74	M201
228	230883.4	220235.96	527.74	M202
229	230964.94	220266.5	534.33	M203
230	230974.64	220097.72	535.62	M204
231	231005.21	219854.32	531.97	M205
232	230884.6	220411.57	540.06	M206
233	230882.88	220610.04	554.68	M207
234	231296.6	220362.12	548.62	M208
235	231471.11	220362.35	547.6	M209
236	231744.02	220360.88	543.72	M210
237	231878.62	220402.89	541.57	M211
238	232498.51	220463.11	534.79	M212
239	232571.82	220149.19	537.17	M213
240	232625.38	219862.82	540.97	M214
241	230931.78	218272.42	564.55	M215
242	231197.17	218296.5	565.41	M216
243	231319.94	218310.03	566.11	M217
244	231263.66	218346.44	565.89	M218

245	231241.29	218566.76	563.43	M219
246	231467.65	218326.66	564.54	M220
247	231726.28	218366.7	560.98	M221
248	232326.36	218521.66	558.08	M222
249	232308.02	218698.03	555.44	M223
250	232395.08	219095.27	553.12	M224
251	232645.98	219209.39	550.26	M225
252	232686.42	218370.81	561.81	M226
253	232691.59	218279.95	561.85	M227
254	231720.68	218265.29	560.66	M228
255	231503.92	218235.22	563.14	M229
256	231334.48	218220.42	566.28	M230
257	231289.27	217967.2	567.93	M231
258	231259.49	217715	567.48	M232
259	231224.82	217812.95	569.29	M233
260	231476.19	217387.6	564.36	M234
261	231242.38	217492.37	566.25	M235
262	231042.32	217611.81	569.93	M236
263	230754.09	217797.05	567.85	M237
264	230614.95	217863.99	566.69	M238
265	230471.43	217954.6	564.77	M239
266	230082.45	218027.11	557	M240
267	231006.99	217452.63	571.26	M241
268	230982.23	217146.13	575.13	M242
269	230780.93	216643.69	585.4	M243
270	230601.29	216641.13	587.81	M244
271	230187.05	216516.63	593.31	M245
272	230229.14	216404.24	596.21	M246
273	231510.29	213722.11	618.79	M247
274	231589.68	213446.91	630.46	M248
275	231866.37	213532.05	617.69	M249
276	227201.55	219505.65	507.41	M250
277	227018.72	219540.33	498.29	M251

3. EQUIPMENTS AND INSTRUMENTS:-

The following equipment was used for the topographic survey

4-1. **Topcon Duel Frequency GPS**

Instrument	*Type*	*Model*
HIPER	TOPCON	GR3
RECEVER	TOPCON	GB1000
ANTINA	TOPCON	PG-A1
CONTOLER	TOPCON	FC-2000
RADIO	PACIFIC CREST	PDL

4-2. **Topcon total station GPT 7000i**
4-3. **Topcon total station GTS-601C**
4-4. **Leica total station TC 1800**
4-5. **Leica Automatic Level NA730**

GR-3 Topcon GPS Reserve

G3 Enabled GNSS Receiver GR-3

G3 ENABLED GNSS RECEIVER

GR-3

The GR-3 is the next generation RTK GPS system from Topcon. This exciting new system incorporates G3 tracking technology to track all three satellite positioning systems as well as new design features not found in any other system.

- G3 Satellite Tracking (GPS,Glonass,Galileo)
- Advanced Rugged System Design
- Bluetooth Wireless Technology
- 72 Universal Tracking Channels
- Optional Internal GSM/GPRS Cellular Communication

Topcon Total Station GTS – 721

Topcon, the world leader in Precise Positioning Solutions, is now proud to announce the launch of the next generation of total station GTS-720 series, which features built-in Windows® CE.NET operating system, large & full color graphic display with touch pad, lithium-ion battery which assures the long time operation, and powerful on-board software. You can get all you need in this Total Stations.


TOPCON
IMAGING TOTAL STATION
GPT-7000i series
GPT-7001i/7002i/7003i/7005i
CAPTURE REALITY
Capturing The Reality
With New Revolutionary Technology
"Topcon revolutionizes surveying work with a world's first new Total Station. Featuring built-in Digital camera for capturing digital images, precise and long range EDM, TFT colour graphic display, the newest Windows® CE and much more, the GPT-7000i provides you the best performance and most efficient survey work with the addition of image information."
[MAIN FEATURES]
Built-in Digital Camera (Wide and finder view)
The field Images are recorded with field coordinates data
Graphical Display Boosts your productivity
Precise and long range Non Prism EDM
Supporting the strong and versatile software TopSURV OnBoard


LEICA TCA1800 • TCA2003 • TC2003
High-performance total station robust, precise and universally useful
The high-performance total stations have unique precision. You can tackle demanding tasks in engineering surveying, in tunnel building as well as structural work above and below ground both reliably and with very high precision. The total stations are extremely robust and are excellently suited to continuous applications such as permanent structure monitoring or for controlling machines.
LEICA SYSTEM 2000
TC2003 • TCA 2003
Robust precision total station for the highest requirements in surveying with an angle measuring accuracy of 0.5" (0.15 mgon) (ISO 17123-3)
TCA 1800
Universal total station for demanding surveying tasks with high accuracy requirements. Angle measuring accuracy of 1" (0.3 mgon) (ISO 17123-3)

Topcon Total Station GTS – 601 C

A NEW LINEUP FOR TOPCON TOTAL STATION, GTS-600C SERIES !!

TOPCON, a leader in the surveying instruments field, now offers the most advanced technology that provides significant measuring performance and built-in MS-DOS® operating system in Pulse Total Station.

6.8 Soil Survey Report

Attached in the Draft Bidding Documents.