

A. DESIGN CALCULATION SHEETS

STRUCTURE

 Tibah Consultants Amman - Jordan E-Mail: tibah@go.com.jo	Job Number		Sheet
	Job Title		
	Client		
	Calcs by	Checked by	Date

Retaining Wall Design :

Input Data

C14


H1	3.0	C	0.25		Soil Frict.	30	FSOT	1.5
H2	0.5				Wall Frict	27	F.S. Sh	1.5
		Ah	0.3		conc	24	Pl. Frict	1.5
		At	0.2		Soil	20	LL Frict	1.7
		COV. Wall	5m		ty	24	Bearing Cap	200
D	1.0	COV. Date	5m			Y25		

Seepage allowed

Theory : Coulomb
 Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:OFF

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka : 0.312
 Passive Pressure coefficient Kp : 8.539
 Base frictional constant μ : 0.577

FORCES ACTING ON THE WALL:

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	24.551	1.000	13.655	0.217
Stabilizing forces:				
Passive pressure on base Pp	-21.347	0.167		
Weight of the wall + base			22.350	0.269
Weight of soil on the base			57.740	0.725

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:
 $M_o = \text{Sum}(\text{hor. forces} \times \text{l.a.}) - \text{Sum}(\text{vert. forces} \times \text{l.a.})$
 For Stabilizing moment Mr calculate as follows:
 $M_r = -\text{Sum}(\text{hor. forces} \times \text{l.a.}) + \text{Sum}(\text{vert. forces} \times \text{l.a.})$
 where l.a. = lever arm of each force.

Stabilizing moment Mr : 51.41 kNm
 Destabilizing moment Mo : 21.59 kNm

Safety factor against overturning = $M_r/M_o = 2.381$

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	Job Title		
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	Calcs by	Checked by	Date

2. Force Equilibrium

Sum of Vertical forces Pv : 93.74 kN
 Frictional resistance Pfric : 54.12 kN
 Passive Pressure on shear key : 0.00 kN
 Passive pressure on base : 21.35 kN
 => Horizontal resistance Fr : 75.47 kN
 Horizontal sliding force Fh : 24.55 kN

Safety factor against overall sliding = $Fr/Fh = 3.074$

SOIL PRESSURES UNDER BASE

Maximum pressure : 196.48 kPa
 Minimum pressure : 0 kPa at 0.30 m from right hand side of base.
 Maximum pressure occurs at left hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO BS8110 - 1997

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm ² /m)	Back Reinforcing (mm ² /m)	Nominal (0.13%) (mm ² /m)
0.00	24.50	0.00	334.46	326.30
0.06	23.89	0.00	327.79	325.00
0.11	22.64	0.00	312.27	323.70
0.17	21.34	0.00	295.98	322.40
0.22	20.04	0.00	279.45	321.10
0.28	18.78	0.00	263.22	319.80
0.33	17.57	0.00	247.56	318.50
0.39	16.41	0.00	232.49	317.20
0.44	15.30	0.00	217.99	315.90
0.50	14.25	0.00	204.07	314.60
0.55	13.24	0.00	190.70	313.30
0.61	12.28	0.00	177.90	312.00
0.66	11.37	0.00	165.64	310.70
0.72	10.51	0.00	153.91	309.40
0.77	9.69	0.00	142.72	308.10
0.83	8.91	0.00	132.04	306.80
0.88	8.18	0.00	121.88	305.50
0.94	7.49	0.00	112.22	304.20
0.99	6.84	0.00	103.05	302.90
1.05	6.23	0.00	94.37	301.60
1.10	5.65	0.00	86.16	300.30
1.16	5.11	0.00	78.41	299.00
1.21	4.61	0.00	71.12	297.70
1.27	4.14	0.00	64.27	296.40
1.32	3.71	0.00	57.85	295.10
1.38	3.30	0.00	51.86	293.80
1.43	2.93	0.00	46.27	292.50
1.49	2.58	0.00	41.08	291.20
1.54	2.27	0.00	36.27	289.90
1.60	1.98	0.00	31.84	288.60
1.65	1.72	0.00	27.78	287.30
1.71	1.48	0.00	24.06	286.00
1.76	1.26	0.00	20.67	284.70
1.82	1.07	0.00	17.61	283.40
1.87	0.89	0.00	14.86	282.10
1.93	0.74	0.00	12.40	280.80
1.98	0.61	0.00	10.22	279.50
2.04	0.49	0.00	8.31	278.20
2.09	0.39	0.00	6.64	276.90
2.15	0.30	0.00	5.21	275.60
2.20	0.23	0.00	4.00	274.30
2.26	0.17	0.00	2.99	273.00
2.31	0.12	0.00	2.16	271.70
2.37	0.09	0.00	1.50	270.40
2.42	0.06	0.00	0.99	269.10
2.48	0.03	0.00	0.61	267.80

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	Calcs by	Checked by	Date

2.53	0.02	0.00	0.35	266.50
2.59	0.01	0.00	0.17	265.20
2.64	0.00	0.00	0.07	263.90
2.70	0.00	0.00	0.02	262.60
2.75	0.00	0.00	0.00	261.30

BASE MOMENTS (ULS) AND REINFORCEMENT TO BS8110 - 1997

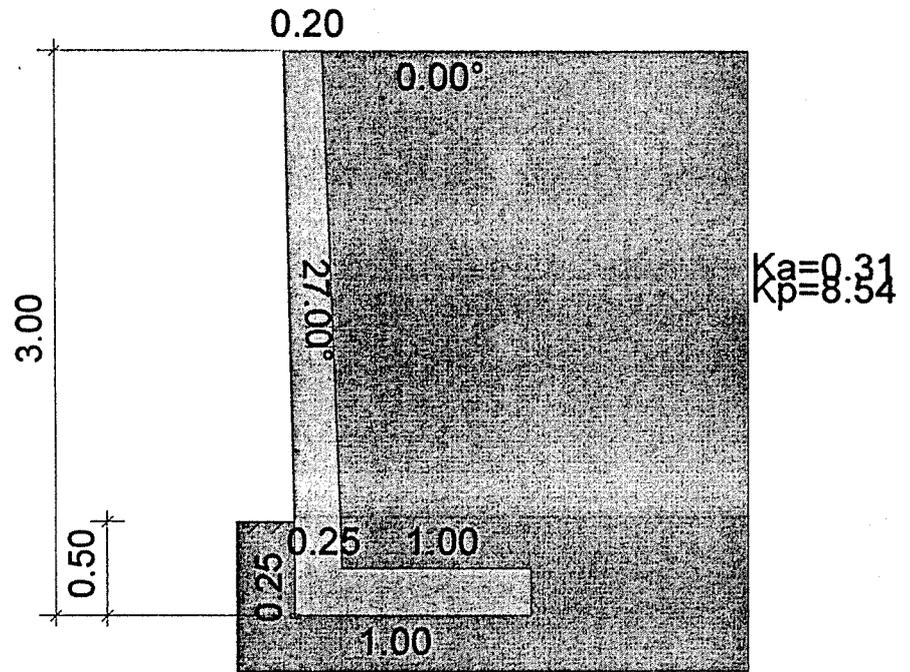
Position from left (m)	Moment (kNm)	Top Reinforcing (mm ² /m)	Bot Reinforcing (mm ² /m)	Nominal (0.13%) (mm ² /m)
0.03	-0.00	0.00	0.00	325.00
0.05	-0.08	0.00	1.09	325.00
0.08	-0.32	0.00	4.37	325.00
0.10	-0.72	0.00	9.84	325.00
0.13	-1.27	0.00	17.49	325.00
0.15	-1.99	27.33	0.00	325.00
0.17	26.18	359.28	0.00	325.00
0.20	-1.99	0.00	27.33	325.00
0.23	-1.99	27.33	0.00	325.00
0.25	26.18	359.28	0.00	325.00
0.28	25.03	343.49	0.00	325.00
0.30	23.91	328.05	0.00	325.00
0.33	22.81	312.97	0.00	325.00
0.35	21.74	298.25	0.00	325.00
0.38	20.69	283.88	0.00	325.00
0.40	19.67	269.86	0.00	325.00
0.42	18.67	256.20	0.00	325.00
0.45	17.70	242.89	0.00	325.00
0.47	16.76	229.94	0.00	325.00
0.50	15.84	217.34	0.00	325.00
0.53	14.95	205.10	0.00	325.00
0.55	14.08	193.21	0.00	325.00
0.57	13.24	181.68	0.00	325.00
0.60	12.43	170.50	0.00	325.00
0.63	11.64	159.68	0.00	325.00
0.65	10.87	149.21	0.00	325.00
0.68	10.14	139.10	0.00	325.00
0.70	9.43	129.34	0.00	325.00
0.72	8.74	119.94	0.00	325.00
0.75	8.08	110.89	0.00	325.00
0.78	7.45	102.20	0.00	325.00
0.80	6.84	93.86	0.00	325.00
0.82	6.26	85.87	0.00	325.00
0.85	5.70	78.24	0.00	325.00
0.88	5.17	70.97	0.00	325.00
0.90	4.67	64.05	0.00	325.00
0.93	4.19	57.48	0.00	325.00
0.95	3.74	51.28	0.00	325.00
0.97	3.31	45.42	0.00	325.00
1.00	2.91	39.92	0.00	325.00
1.02	2.53	34.77	0.00	325.00
1.05	2.19	29.98	0.00	325.00
1.07	1.86	25.55	0.00	325.00
1.10	1.56	21.47	0.00	325.00
1.13	1.29	17.74	0.00	325.00
1.15	1.05	14.37	0.00	325.00
1.18	0.83	11.36	0.00	325.00
1.20	0.63	8.69	0.00	325.00
1.23	0.47	6.39	0.00	325.00
1.25	0.32	4.44	0.00	325.00

SHEAR CHECK AT WALL-BASE JUNCTION TO BS8110 - 1997

Shear force at bottom of wall V = 34.4 kN
 Shear stress at bottom of wall v = 0.26 MPa OK
 Allowable shear stress v_c = 0.52 MPa (based on Wall tensile reinf.)

Sketch of Wall

Design code: BS8110 - 1997



196.5kPa
 Wall type: Cantilever
 Theory: Coulomb

SFslip = 3.07
 SFovt = 2.38

$\mu=0.58$
 $V= 34.4kN$
 $v= 0.26MPa$
 $vc= 0.52MPa$



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Job Number

Sheet

Job Title

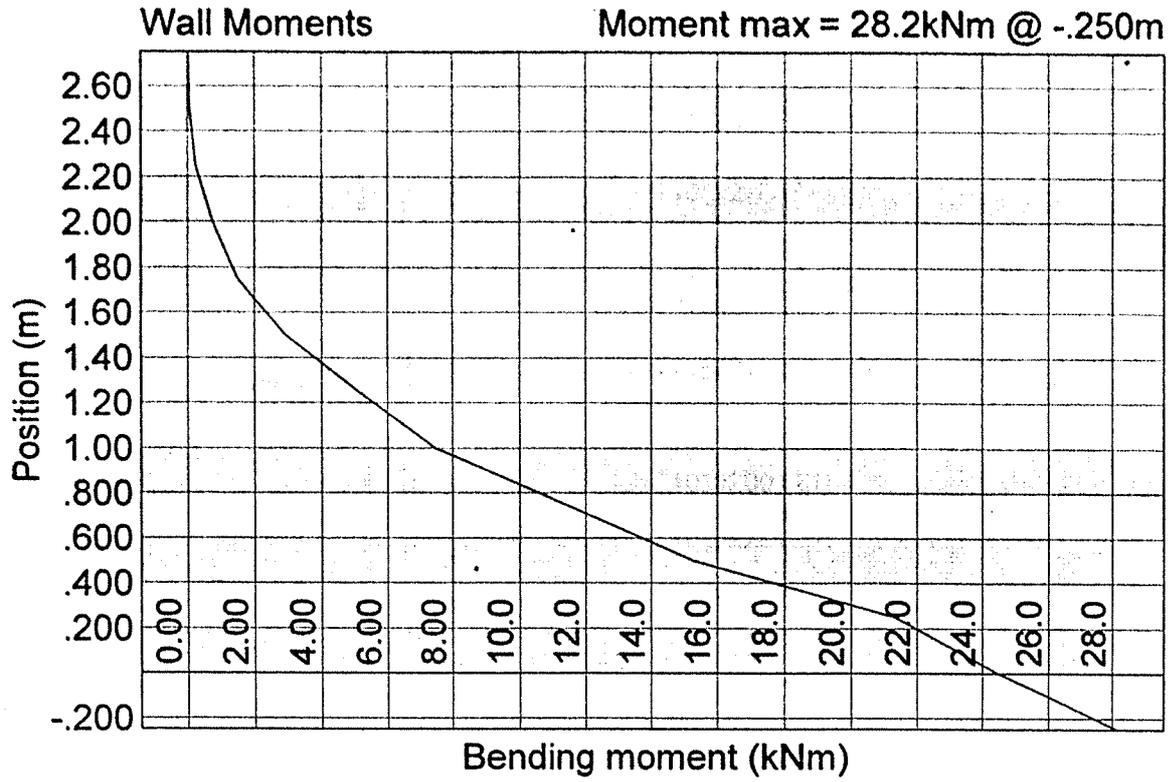
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Calcs by

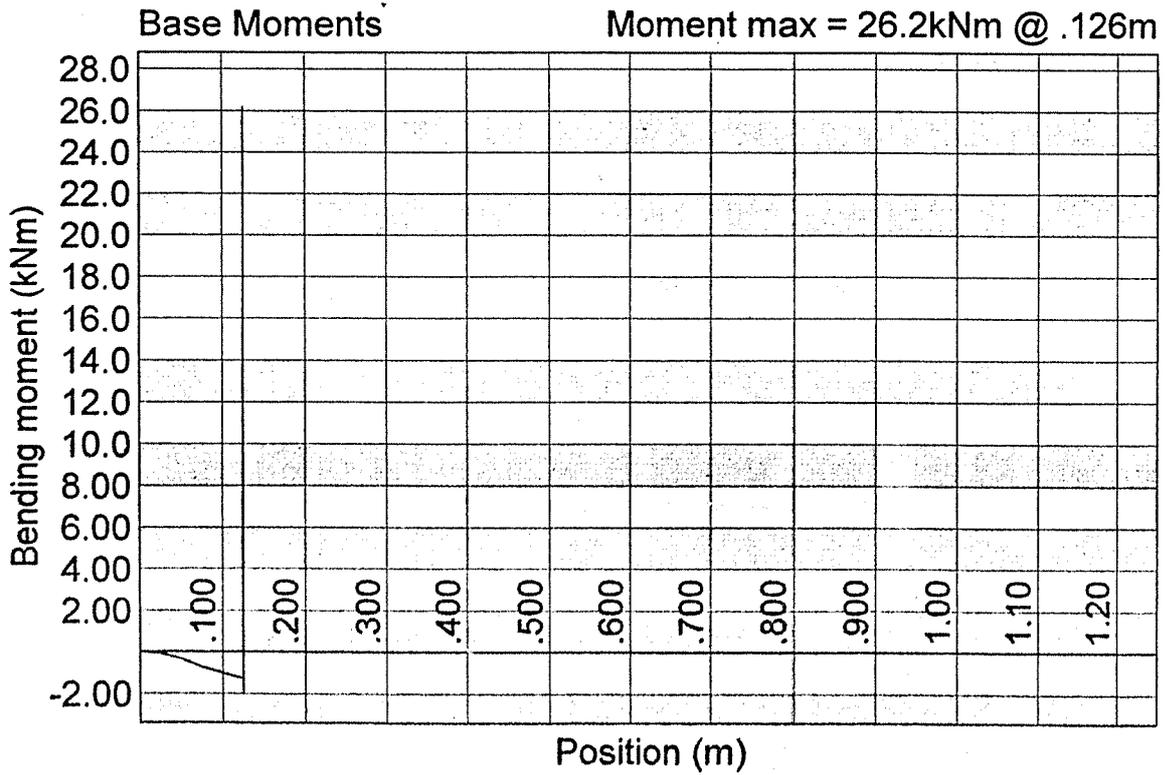
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Date

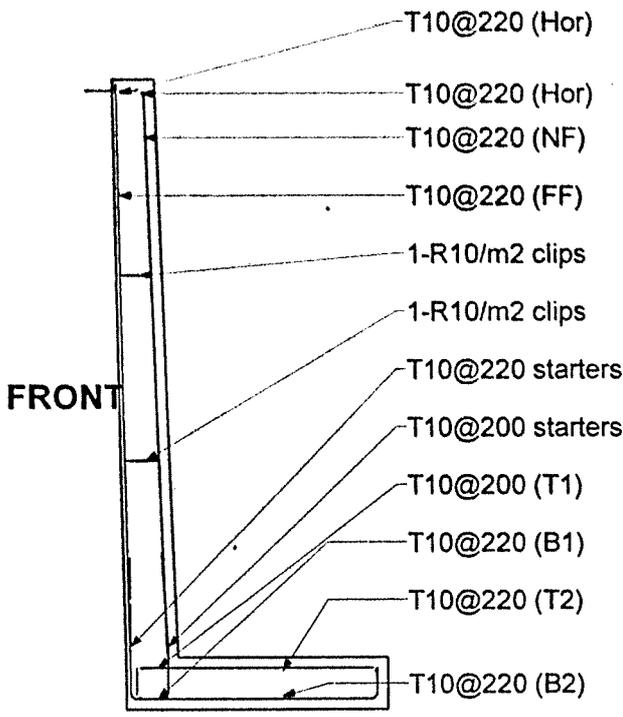
Wall Bending Moments



Base Bending Moments



Schematic Reinforcement



SECTION

Retaining Wall Design : Al Jada' Lookout / Type B

Input Data

H ₁	3.0	Cover (H)	5 mm	F.S.O.T	1.5				
H ₂	0.0	Cover (b)	5 mm	F.S.Sl.	1.5				
B	0.6	Soil Friction	25	DL Factor	1.4				
D	0.9	Wall Friction	26	LL Factor	1.7				
C	0.2	Spil. Density	20 KN/m ³	Soil B.C	200				
At	0.2	c (MPa)	20	C (KPa)					
Ab	0.3	γ _s (MPa)	425						

Seepage not allowed

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:OFF

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient K_a : 0.372
Passive Pressure coefficient K_p : 5.842
Base frictional constant μ : 0.466

FORCES ACTING ON THE WALL:

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	29.497	1.000	15.764	0.867
Stabilizing forces:				
Passive pressure on base Pp	-0.000	0.000		
Weight of the wall + base			29.160	0.804
Weight of soil on the base			51.300	1.325

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 M_o calculate as follows:

$$M_o = \text{Sum}(\text{hor. forces} \times \text{l.a.}) - \text{Sum}(\text{vert. forces} \times \text{l.a.})$$

For Stabilizing moment M_r calculate as follows:

$$M_r = -\text{Sum}(\text{hor. forces} \times \text{l.a.}) + \text{Sum}(\text{vert. forces} \times \text{l.a.})$$

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

Stabilizing moment M_r : 91.39 kNm
Destabilizing moment M_o : 15.83 kNm

Safety factor against overturning = M_r/M_o = 5.771

2. Force Equilibrium

Sum of Vertical forces P_v : 96.22 kN
 Frictional resistance F_{fric} : 44.87 kN
 Passive Pressure on shear key : 0.00 kN
 Passive pressure on base : 0.00 kN
 => Horizontal resistance F_r : 44.87 kN
 Horizontal sliding force F_h : 29.50 kN

Safety factor against overall sliding = $F_r/F_h = 1.521$

SOIL PRESSURES UNDER BASE

Maximum pressure : 73.92 kPa
 Minimum pressure : 32.99 kPa
 Maximum pressure occurs at left hand side of base

WALL MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 1993

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm ² /m)	Back Reinforcing (mm ² /m)	Nominal (0.13%) (mm ² /m)
0.00	28.23	0.00	309.91	979.87
0.05	26.95	0.00	298.15	973.38
0.11	25.34	0.00	282.57	966.89
0.16	23.80	0.00	267.48	960.40
0.22	22.33	0.00	252.88	953.91
0.27	20.92	0.00	238.77	947.42
0.32	19.56	0.00	225.14	940.93
0.38	18.27	0.00	211.98	934.44
0.43	17.04	0.00	199.29	927.95
0.49	15.86	0.00	187.07	921.46
0.54	14.74	0.00	175.31	914.97
0.59	13.67	0.00	164.00	908.49
0.65	12.66	0.00	153.14	902.00
0.70	11.69	0.00	142.72	895.51
0.76	10.78	0.00	132.74	889.02
0.81	9.92	0.00	123.19	882.53
0.86	9.10	0.00	114.07	876.04
0.92	8.33	0.00	105.37	869.55
0.97	7.60	0.00	97.08	863.06
1.03	6.92	0.00	89.20	856.57
1.08	6.28	0.00	81.72	850.08
1.13	5.68	0.00	74.63	843.59
1.19	5.12	0.00	67.93	837.10
1.24	4.60	0.00	61.61	830.62
1.30	4.12	0.00	55.66	824.13
1.35	3.67	0.00	50.08	817.64
1.40	3.25	0.00	44.85	811.15
1.46	2.87	0.00	39.98	804.66
1.51	2.52	0.00	35.44	798.17
1.57	2.19	0.00	31.24	791.68
1.62	1.90	0.00	27.36	785.19
1.67	1.64	0.00	23.79	778.70
1.73	1.40	0.00	20.53	772.21
1.78	1.18	0.00	17.56	765.72
1.84	0.99	0.00	14.88	759.23
1.89	0.82	0.00	12.47	752.75
1.94	0.67	0.00	10.32	746.26
2.00	0.54	0.00	8.42	739.77
2.05	0.43	0.00	6.76	733.28
2.11	0.33	0.00	5.33	726.79
2.16	0.25	0.00	4.11	720.30
2.21	0.19	0.00	3.08	713.81
2.27	0.14	0.00	2.23	707.32
2.32	0.09	0.00	1.56	700.83
2.38	0.06	0.00	1.03	694.34
2.43	0.04	0.00	0.64	687.85

Sari Zuayter

Nov. 1999

2.48	0.02	0.00	0.36	681.36
2.54	0.01	0.00	0.18	674.68
2.59	0.00	0.00	0.07	668.39
2.65	0.00	0.00	0.02	661.90
2.70	0.00	0.00	0.00	655.41

BASE MOMENTS (ULS) AND REINFORCEMENT TO ACI 318 - 1993

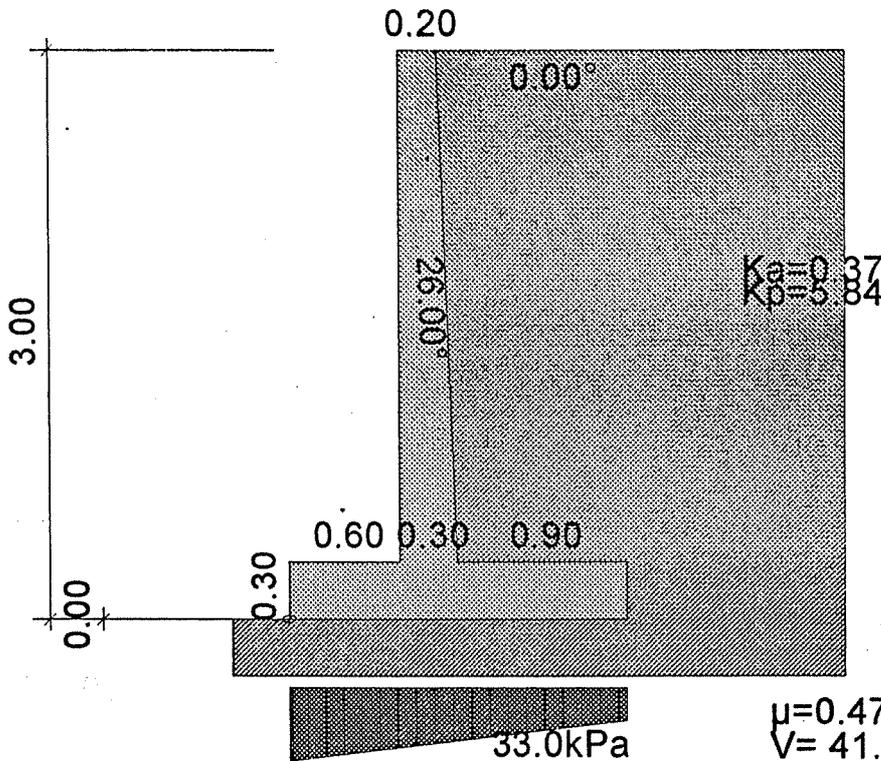
Position from left (m)	Moment (kNm)	Top Reinforcing (mm ² /m)	Bot Reinforcing (mm ² /m)	Nominal (0.13%) (mm ² /m)
0.04	-0.00	0.00	0.00	973.38
0.07	-0.06	0.00	0.60	973.38
0.11	-0.22	0.00	2.41	973.38
0.14	-0.50	0.00	5.43	973.38
0.18	-0.89	0.00	9.66	973.38
0.22	-1.38	0.00	15.09	973.38
0.25	-1.99	0.00	21.74	973.38
0.29	-2.71	0.00	29.60	973.38
0.32	-3.54	0.00	38.68	973.38
0.36	-4.49	0.00	48.98	973.38
0.40	-5.54	0.00	60.51	973.38
0.43	-6.70	0.00	73.26	973.38
0.47	-7.97	0.00	87.25	973.38
0.50	-9.36	0.00	102.49	973.38
0.54	-10.85	0.00	118.96	973.38
0.58	-12.46	0.00	136.69	973.38
0.61	-14.18	0.00	155.68	973.38
0.65	-16.00	0.00	175.93	973.38
0.68	-17.94	0.00	197.46	973.38
0.72	-19.99	0.00	220.28	973.38
0.76	-22.15	0.00	244.38	973.38
0.79	-24.03	265.47	0.00	973.38
0.83	15.07	165.54	0.00	973.38
0.86	14.89	163.64	0.00	973.38
0.90	13.88	152.46	0.00	973.38
0.94	12.91	141.68	0.00	973.38
0.97	11.97	131.31	0.00	973.38
1.01	11.07	121.34	0.00	973.38
1.04	10.20	111.77	0.00	973.38
1.08	9.37	102.60	0.00	973.38
1.12	8.57	93.83	0.00	973.38
1.15	7.81	85.46	0.00	973.38
1.19	7.08	77.48	0.00	973.38
1.22	6.39	69.90	0.00	973.38
1.26	5.74	62.71	0.00	973.38
1.30	5.12	55.91	0.00	973.38
1.33	4.53	49.51	0.00	973.38
1.37	3.98	43.50	0.00	973.38
1.40	3.47	37.89	0.00	973.38
1.44	2.99	32.66	0.00	973.38
1.48	2.55	27.82	0.00	973.38
1.51	2.14	23.37	0.00	973.38
1.55	1.77	19.31	0.00	973.38
1.58	1.43	15.64	0.00	973.38
1.62	1.13	12.35	0.00	973.38
1.66	0.87	9.46	0.00	973.38
1.69	0.64	6.95	0.00	973.38
1.73	0.44	4.82	0.00	973.38
1.76	0.28	3.09	0.00	973.38
1.80	0.16	1.74	0.00	973.38

SHEAR CHECK AT WALL-BASE JUNCTION TO ACI 318 - 1993

Shear force at bottom of wall V = 41.3 kN
 Shear stress at bottom of wall v = 0.23 MPa OK
 Allowable shear stress vc = 0.61 MPa (based on Wall tensile reinf.)

Sketch of Wall

Design code: ACI 318 - 1993

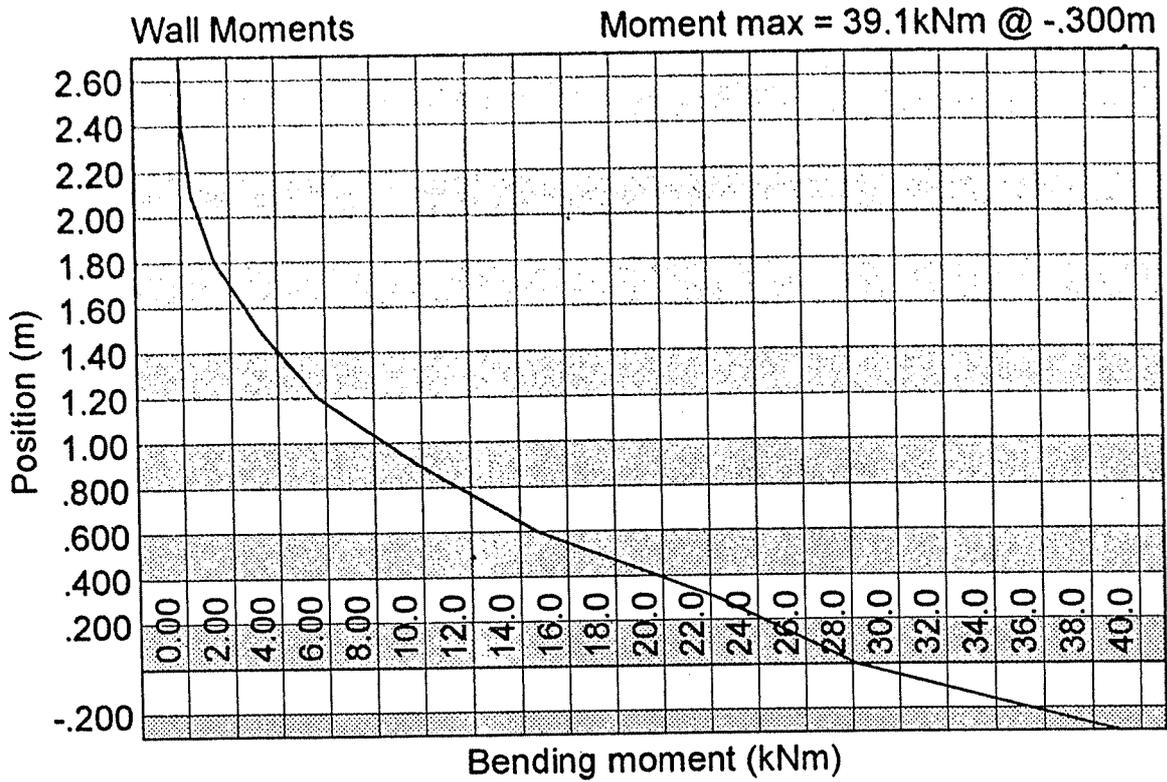


73.9kPa
Wall type: Cantilever
Theory: Coulomb

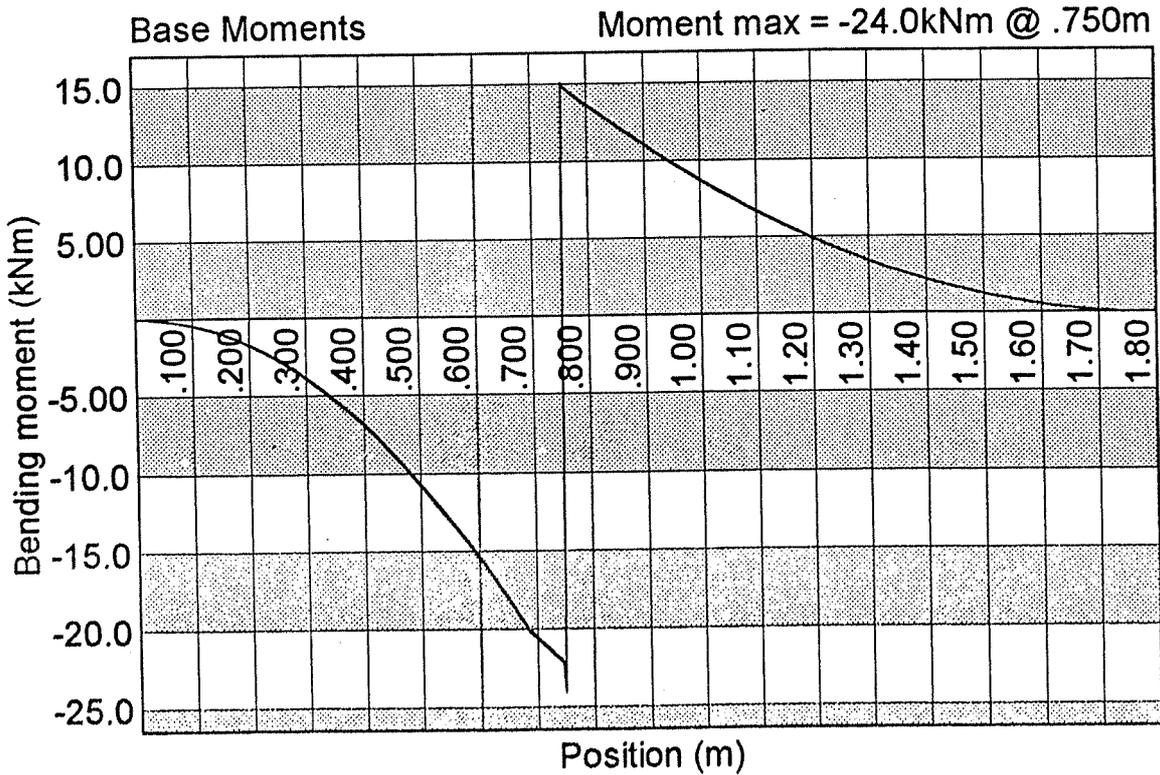
SFslip = 1.52
SFovt = 5.77

$\mu=0.47$
 $V= 41.3\text{kN}$
 $v= 0.23\text{MPa}$
 $vc= 0.61\text{MPa}$

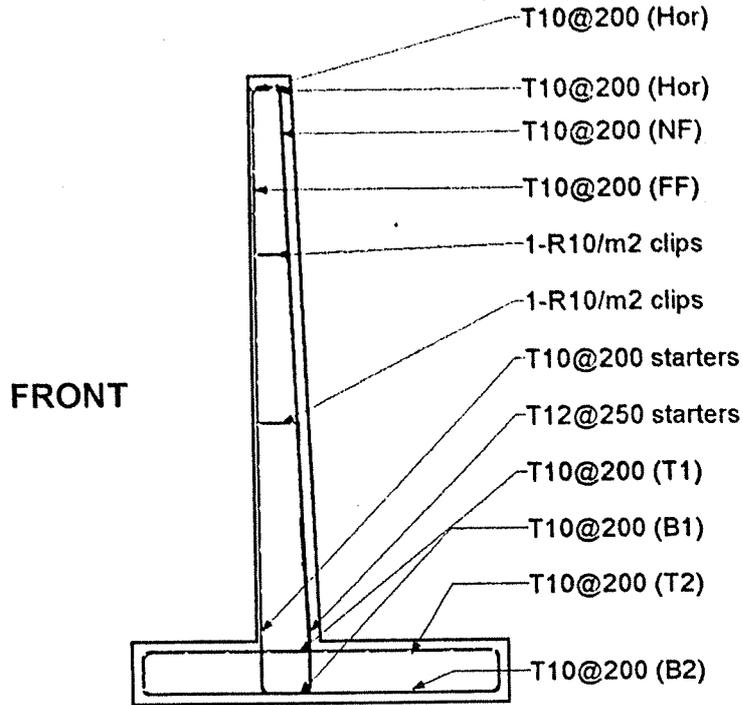
Wall Bending Moments



Base Bending Moments



Schematic Reinforcement





Tibah Consultants
Amman - Jordan
E-Mail: tibah@go.com.jo

Job Number _____
Job Title _____
Client _____
Calcs by **S.Z** Checked by _____ Date **23/3/2000**

Retaining Wall Design :

(L shape)

C14

Input Data



H	1.3m	C	0.3		Soil Frict.	30°	S.F. OT	1.5
H2	0.5m	F	0.3		Wall Fric	27°	S.F. Slid	1.5
		X ₁	1.3		Plane (kN/m ³)	24	DL Factor	1.4
		At	0.2		Soil (kN/m ³)	20	IL Factor	1.7
		Ab	0.3		γ _{cy} (kPa)	24	Bearing Cap.	200 (kPa)
D	1.3m	COV. (no.)	5cm		γ _p (kPa)	25		
		" (base)	5cm					

Seepage allowed

Theory : Coulomb
Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF:OFF

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka : 0.308
Passive Pressure coefficient Kp : 8.539
Base frictional constant μ : 0.577

FORCES ACTING ON THE WALL:

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	43.283	1.333	23.548	0.267
Stabilizing forces:				
Passive pressure on base Pp	-21.347	0.167		
Weight of the wall + base			35.880	0.423
Weight of soil on the base			99.900	0.925

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:

$$M_o = \text{Sum}(\text{hor. forces} \times \text{l.a.}) - \text{Sum}(\text{vert. forces} \times \text{l.a.})$$

For Stabilizing moment Mr calculate as follows:

$$M_r = -\text{Sum}(\text{hor. forces} \times \text{l.a.}) + \text{Sum}(\text{vert. forces} \times \text{l.a.})$$

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

Stabilizing moment Mr : 111.09 kNm
Destabilizing moment Mo : 51.43 kNm

Safety factor against overturning = Mr/Mo = 2.160

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	Job Title		
	Client		
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2. Force Equilibrium

Sum of Vertical forces P_v : 159.33 kN
 Frictional resistance P_{fric} : 91.99 kN
 Passive Pressure on shear key : 33.30 kN
 Passive pressure on base : 21.35 kN
 => Horizontal resistance F_r : 146.64 kN
 Horizontal sliding force F_h : 43.28 kN

Safety factor against overall sliding = $F_r/F_h = 3.388$

SOIL PRESSURES UNDER BASE

Maximum pressure : 283.65 kPa
 Minimum pressure : 0 kPa at 0.48 m from right hand side of base.
 Maximum pressure occurs at left hand side of base

*** MAXIMUM PRESSURE EXCEEDS SPECIFIED ALLOWABLE PRESSURE BY 83.7 kPa ***

WALL MOMENTS (ULS) AND REINFORCEMENT TO BS8110 - 1997

Position from base top (m)	Moment (kNm)	Front Reinforcing (mm ² /m)	Back Reinforcing (mm ² /m)	Nominal (0.13%) (mm ² /m)
0.00	60.58	0.00	653.43	392.60
0.07	57.76	0.00	627.43	390.00
0.15	54.38	0.00	595.70	387.40
0.22	51.07	0.00	564.23	384.80
0.30	47.90	0.00	533.69	382.20
0.37	44.86	0.00	504.13	379.60
0.44	41.95	0.00	475.54	377.00
0.52	39.17	0.00	447.93	374.40
0.59	36.52	0.00	421.27	371.80
0.67	33.99	0.00	395.57	369.20
0.74	31.57	0.00	370.81	366.60
0.81	29.28	0.00	346.98	364.00
0.89	27.10	0.00	324.08	361.40
0.96	25.03	0.00	302.10	358.80
1.04	23.07	0.00	281.03	356.20
1.11	21.21	0.00	260.85	353.60
1.18	19.46	0.00	241.56	351.00
1.26	17.80	0.00	223.15	348.40
1.33	16.25	0.00	205.60	345.80
1.41	14.78	0.00	188.91	343.20
1.48	13.41	0.00	173.05	340.60
1.55	12.12	0.00	158.02	338.00
1.63	10.92	0.00	143.81	335.40
1.70	9.80	0.00	130.40	332.80
1.78	8.76	0.00	117.78	330.20
1.85	7.80	0.00	105.93	327.60
1.92	6.91	0.00	94.83	325.00
2.00	6.09	0.00	84.48	322.40
2.07	5.34	0.00	74.85	319.80
2.15	4.65	0.00	65.92	317.20
2.22	4.03	0.00	57.69	314.60
2.29	3.46	0.00	50.12	312.00
2.37	2.95	0.00	43.20	309.40
2.44	2.49	0.00	36.91	306.80
2.52	2.08	0.00	31.22	304.20
2.59	1.72	0.00	26.12	301.60
2.66	1.41	0.00	21.58	299.00
2.74	1.13	0.00	17.57	296.40
2.81	0.90	0.00	14.06	293.80
2.89	0.69	0.00	11.04	291.20
2.96	0.53	0.00	8.47	288.60
3.03	0.39	0.00	6.32	286.00
3.11	0.28	0.00	4.56	283.40
3.18	0.19	0.00	3.15	280.80

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3.26	0.12	0.00	2.06	278.20
3.33	0.07	0.00	1.25	275.60
3.40	0.04	0.00	0.69	273.00
3.48	0.02	0.00	0.33	270.40
3.55	0.01	0.00	0.13	267.80
3.63	0.00	0.00	0.03	265.20
3.70	0.00	0.00	0.01	262.60

BASE MOMENTS (ULS) AND REINFORCEMENT TO BS8110 - 1997

Position from left (m)	Moment (kNm)	Top Reinforcing (mm ² /m)	Bot Reinforcing (mm ² /m)	Nominal (0.13%) (mm ² /m)
0.03	-0.00	0.00	0.00	390.00
0.06	-0.37	0.00	4.00	390.00
0.10	-1.47	0.00	15.99	390.00
0.13	-3.31	0.00	35.98	390.00
0.16	-5.89	0.00	63.97	390.00
0.19	-8.09	87.84	0.00	390.00
0.22	64.40	703.64	0.00	390.00
0.26	63.51	693.37	0.00	390.00
0.29	60.72	661.12	0.00	390.00
0.32	57.99	629.99	0.00	390.00
0.35	55.33	601.03	0.00	390.00
0.38	52.72	572.75	0.00	390.00
0.42	50.18	545.15	0.00	390.00
0.45	47.71	518.24	0.00	390.00
0.48	45.29	492.00	0.00	390.00
0.51	42.94	466.45	0.00	390.00
0.54	40.65	441.57	0.00	390.00
0.58	38.42	417.38	0.00	390.00
0.61	36.26	393.87	0.00	390.00
0.64	34.16	371.04	0.00	390.00
0.67	32.12	348.90	0.00	390.00
0.70	30.14	327.43	0.00	390.00
0.74	28.23	306.65	0.00	390.00
0.77	26.38	286.55	0.00	390.00
0.80	24.59	267.12	0.00	390.00
0.83	22.87	248.38	0.00	390.00
0.86	21.20	230.33	0.00	390.00
0.90	19.60	212.95	0.00	390.00
0.93	18.07	196.25	0.00	390.00
0.96	16.59	180.24	0.00	390.00
0.99	15.18	164.91	0.00	390.00
1.02	13.83	150.26	0.00	390.00
1.06	12.55	136.29	0.00	390.00
1.09	11.32	123.00	0.00	390.00
1.12	10.16	110.39	0.00	390.00
1.15	9.06	98.47	0.00	390.00
1.18	8.03	87.22	0.00	390.00
1.22	7.06	76.66	0.00	390.00
1.25	6.15	66.78	0.00	390.00
1.28	5.30	57.58	0.00	390.00
1.31	4.52	49.06	0.00	390.00
1.34	3.80	41.23	0.00	390.00
1.38	3.14	34.07	0.00	390.00
1.41	2.54	27.60	0.00	390.00
1.44	2.01	21.81	0.00	390.00
1.47	1.54	16.70	0.00	390.00
1.50	1.13	12.27	0.00	390.00
1.54	0.78	8.52	0.00	390.00
1.57	0.50	5.45	0.00	390.00
1.60	0.28	3.07	0.00	390.00

SHEAR CHECK AT WALL-BASE JUNCTION TO BS8110 - 1997

Shear force at bottom of wall $V = 60.6$ kN
 Shear stress at bottom of wall $v = 0.34$ MPa OK
 Allowable shear stress $v_c = 0.54$ MPa (based on Wall tensile reinf.)



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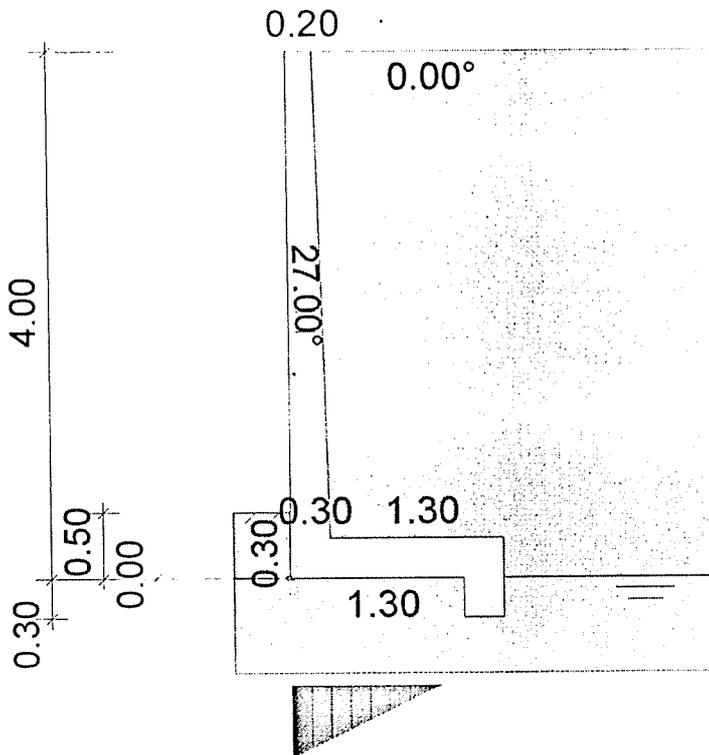
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Sketch of Wall

Design code: BS8110 - 1997



$K_a = 0.31$
 $K_p = 8.54$

$\mu = 0.58$
 $V = 60.6 \text{ kN}$
 $v = 0.34 \text{ MPa}$
 $vc = 0.54 \text{ MPa}$

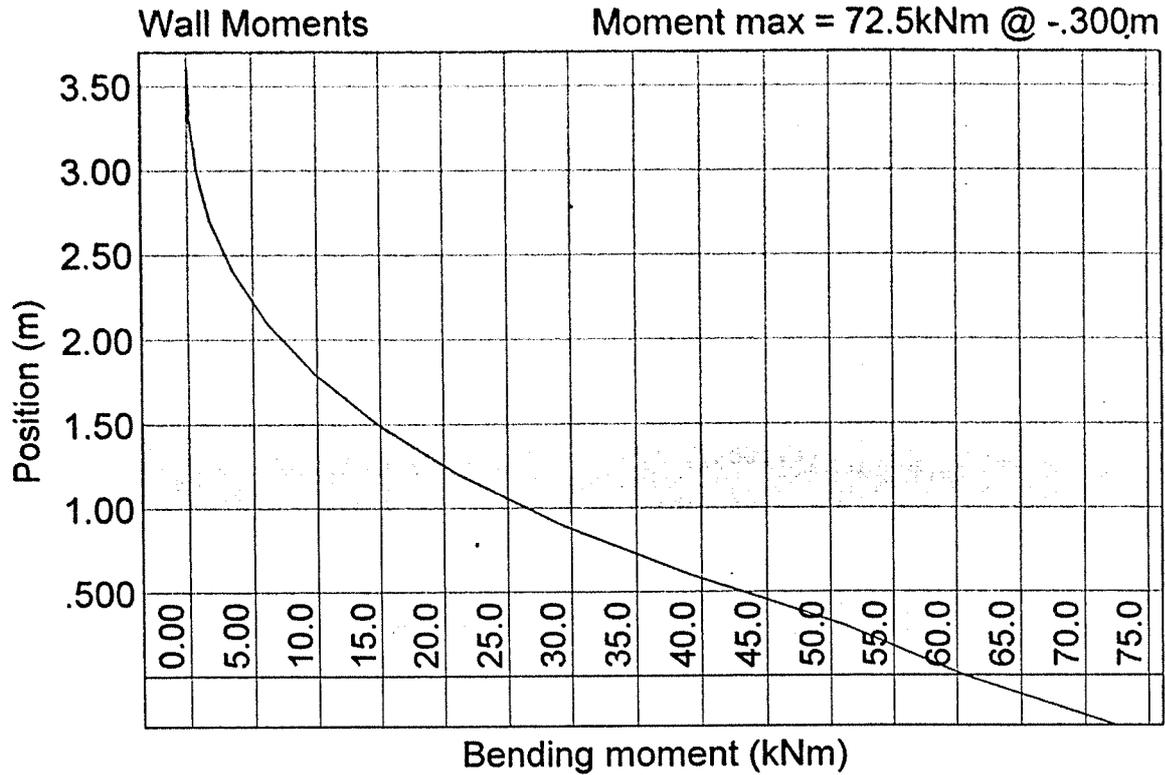
283.7kPa
Wall type: Cantilever
Theory: Coulomb
SFslip = 3.39
SFovt = 2.16



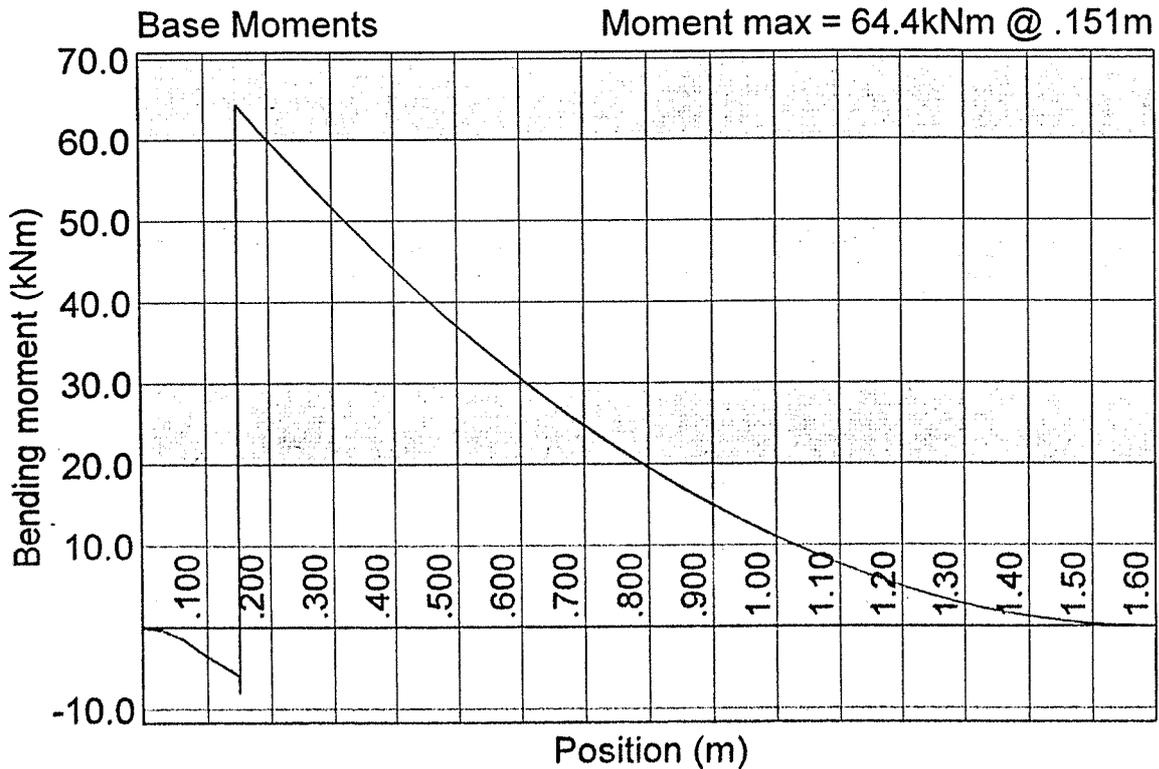
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Wall Bending Moments

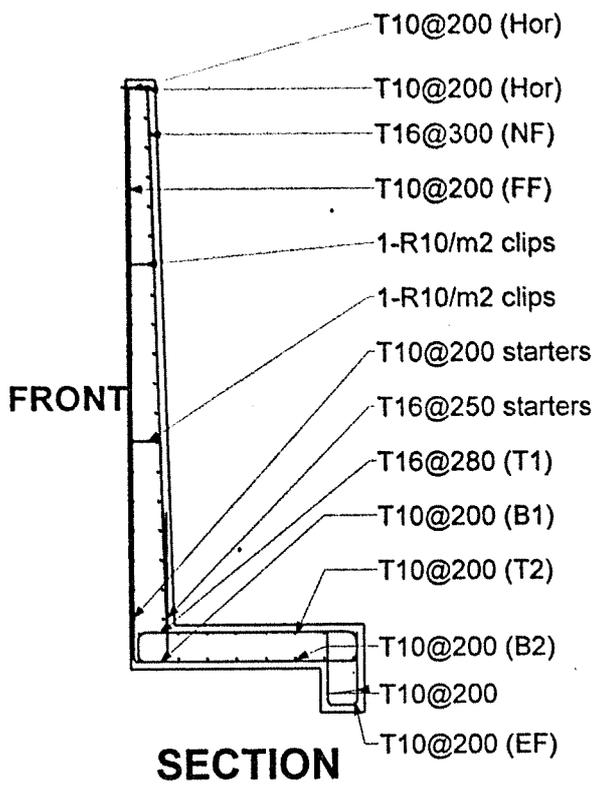


Base Bending Moments



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Schematic Reinforcement



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	Client	
Drawn by	Sari Zuayter	Checked by
		Date 28/11/99

Retaining Wall Design :

Input Data

C14


H1	2.0m	C	0.2m	Soil fric	30		SF. ovt.	1.5
H2	0.0m			wall fric	27		SF. slid.	1.5
		AK	0.2m	P. conc	24 KN/m ³		DL Fact.	1.4
		Ah	0.2m	P. soil	20 KN/m ³		UL Fact.	1.7
B	0.4m	con. wall	50mm	PC	20 MPa		Bearing Cap	200 kPa
D	0.5m	con. Bas	50mm	PC	425 MPa			

Seepage allowed

Theory : Coulomb
 Wall type : Cantilever

SEISMIC ANALYSIS SETTINGS:

Seismic Analysis ON/OFF: OFF

VALUES OF PRESSURE COEFFICIENTS:

Active Pressure coefficient Ka : 0.296
 Passive Pressure coefficient Kp : 8.539
 Base frictional constant μ : 0.577

FORCES ACTING ON THE WALL:

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	10.553	0.667	5.377	0.600
Stabilizing forces:				
Passive pressure on base Pp	-0.000	0.000		
Weight of the wall + base			13.920	0.519
Weight of soil on the base			18.000	0.850

EQUILIBRIUM CALCULATIONS AT SLS

All forces/moments are per m width

1. Moment Equilibrium

Point of rotation: bottom front corner of base.

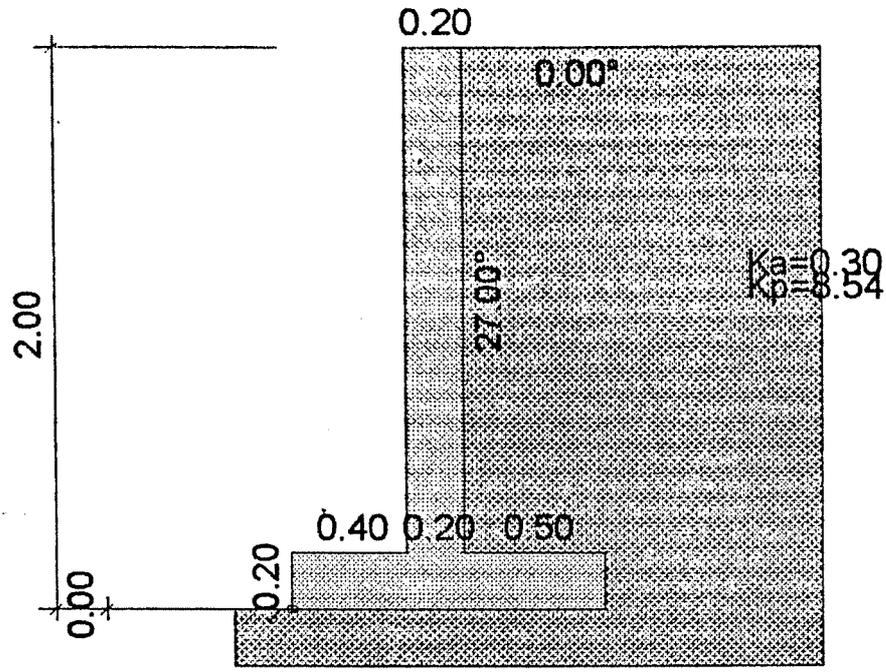
For Overturning moment Mo calculate as follows:
 $M_o = \text{Sum}(\text{hor. forces} \times \text{l.a.}) - \text{Sum}(\text{vert. forces} \times \text{l.a.})$
 For Stabilizing moment Mr calculate as follows:
 $M_r = -\text{Sum}(\text{hor. forces} \times \text{l.a.}) + \text{Sum}(\text{vert. forces} \times \text{l.a.})$
 where l.a. = lever arm of each force.

Stabilizing moment Mr : 22.52 kNm
 Destabilizing moment Mo : 3.81 kNm

Safety factor against overturning = Mr/Mo = 5.913

Sketch of Wall

Design code: ACI 318 - 1993



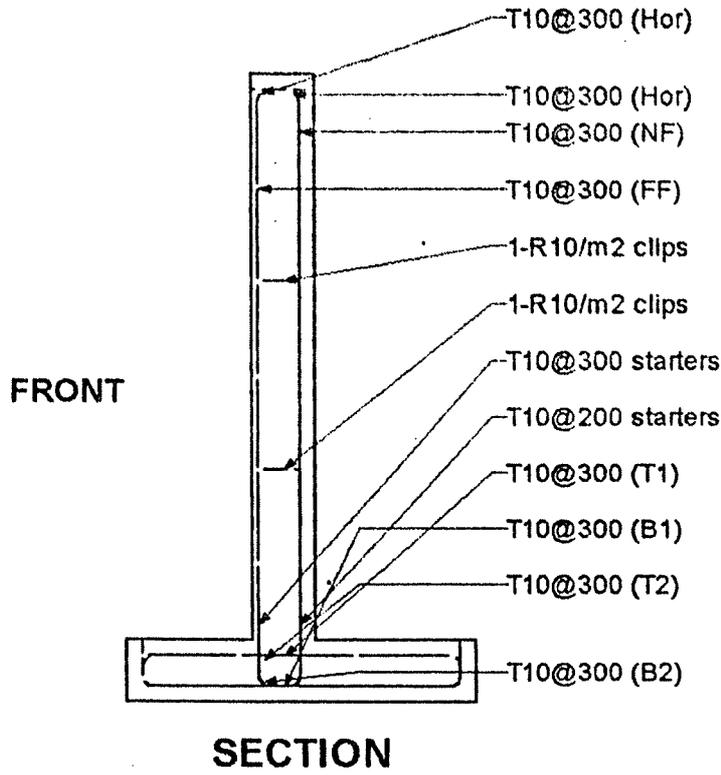
Wall type: Cantilever Theory: Coulomb	42.8 kPa 25.0 kPa $SF_{\text{slip}} = 2.04$ $SF_{\text{ovt}} = 5.91$	$\mu = 0.58$ $V = 14.8 \text{ kN}$ $v = 0.18 \text{ MPa}$ $vc = 0.60 \text{ MPa}$
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Schematic Reinforcement



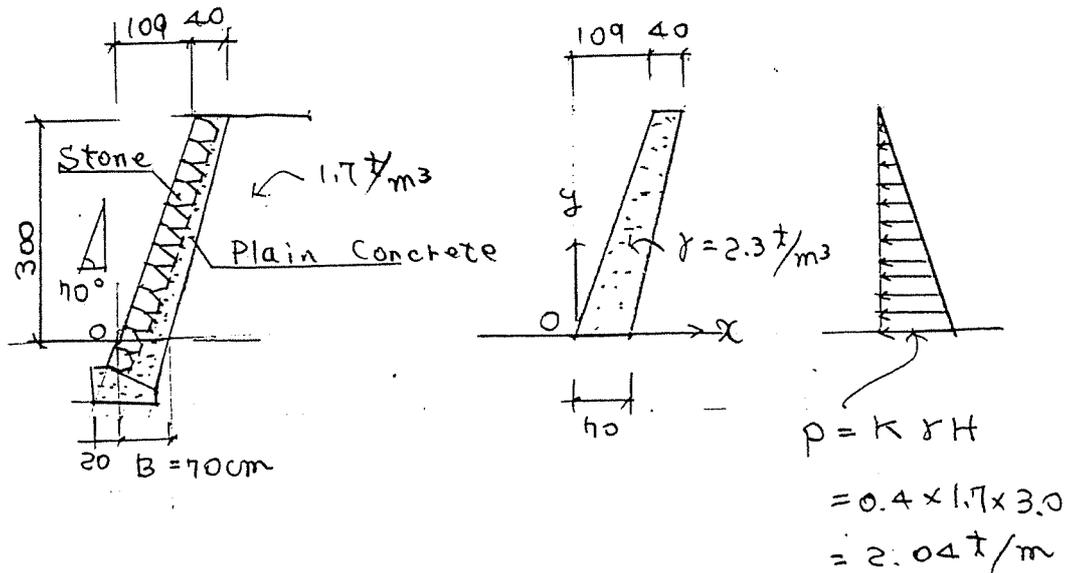
Historic Old Salt Development Trails, Lookouts & Plazas

Calculations of Stone Retaining Walls

JICA Study Team

Structural Drawing No. SD.ST-002

(1) Outline of Retaining Wall



(2) Over Turning about O Point

① Over turning Moment by Self Weight of Wall (1.0m width)

$$W_1 = 2.3 \frac{t}{m^3} \times 0.4 \text{m} \times 3.0 \text{m} \times 1.0 \text{m} = 2.76 \text{t}$$

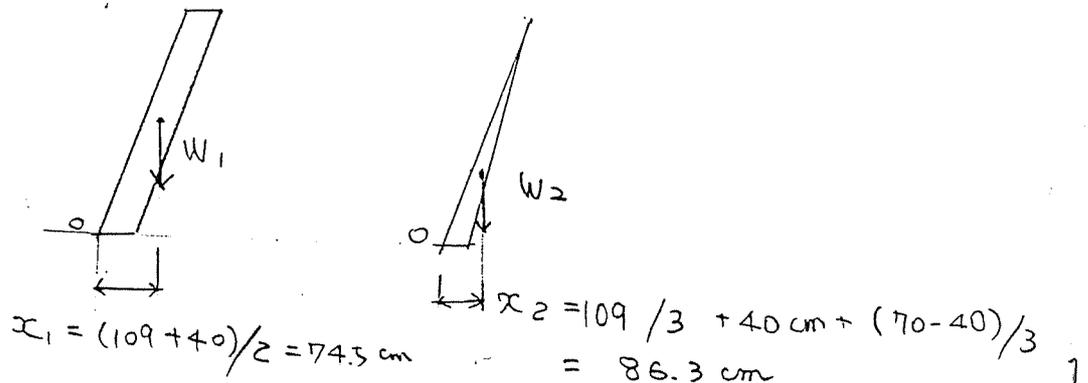
$$W_2 = 2.3 \frac{t}{m^3} \times (0.7 - 0.4) \text{m} \times 3 \text{m} \times 1 \text{m} / 2 = 1.03 \text{t}$$

$$\Sigma W = 3.79 \text{t}$$

$$x_1 = (1.09 + 0.4) / 2 = 0.745 \text{m}$$

$$x_2 = 1.09 / 3 + 0.4 + (0.7 - 0.4) / 3 = 0.863 \text{m}$$

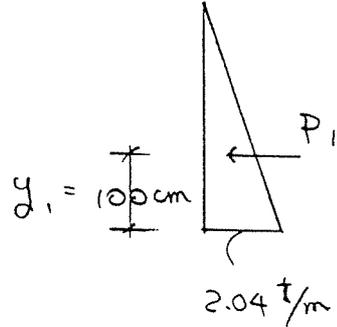
$$\Sigma M_w = -(W_1 \times x_1 + W_2 \times x_2) = -(2.76 \times 0.745 + 1.03 \times 0.863) = -2.94 \text{t}$$



② Over Turning Moment by Soil Pressure

$$P=2.04 \times 3\text{m}/2=3.06\text{t}$$

$$M_p=3.06 \times 3\text{m}/3=3.06\text{tm}$$



③ Total Over Turning Moment

$$\Sigma M = \Sigma M_w + M_p = -2.94 + 3.06 = 0.12\text{tm}$$

④ Eccentricity

$$e = \Sigma M / \Sigma W = 0.12 / 3.79\text{t} = 0.03\text{m} < B/6 = 0.7\text{m}/6 = 0.116\text{m} \quad \text{OK}$$

Retaining wall is safety because eccentricity is very small.

(3) Sliding

① Friction coefficient μ of upper stone and under stone is 0.7 according to experiment in Japan.

② Allowable shear stress of plain concrete τ is 5kg/cm².

③ Allowable Safety factor of sliding aF_s is 1.5.

$$\begin{aligned} \text{④ Safety factor } F_s &= (\Sigma W \times \mu + \tau \times B') / P \\ &= (3.8\text{t} \times 0.7 + 5\text{kg/cm}^2 \times 60\text{cm} \times 100\text{cm}/1000) / 3.06 \\ &= (2.66\text{t} + 30\text{t}) / 3.06 = 10.6 > aF_s = 1.5 \quad \text{OK} \end{aligned}$$

(4) Vertical loading

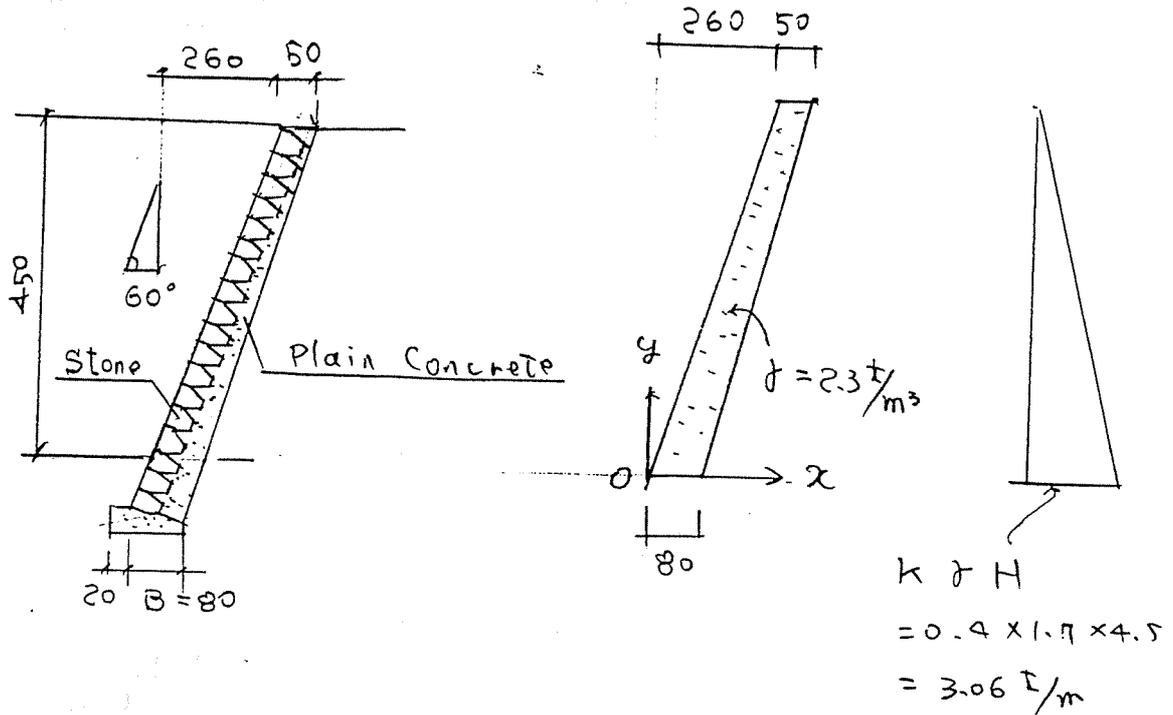
① Allowable Bearing Capacity = 15t/m²

② Total Weight of Wall = 3.79 + 2.3 × 1.0 × 1.0 = 6.09t

$$w = 6.09 / (0.9\text{m} \times 1.0\text{m}) = 6.8\text{t/m}^2 < 15\text{t/m}^2 \quad \text{OK}$$

Structural Drawing No. SD. ST-002

(1) Outline of Retaining Wall



(2) Over turning about O Point (1.0m width)

① Over turning Moment By Self Weight of Wall

$$W_1 = 2.3 \text{ t/m}^3 \times 0.5 \text{ m} \times 4.5 \text{ m} \times 1.0 \text{ m} = 5.18 \text{ t}$$

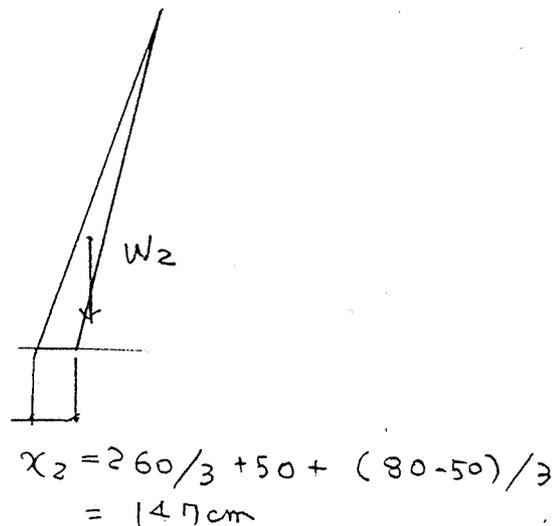
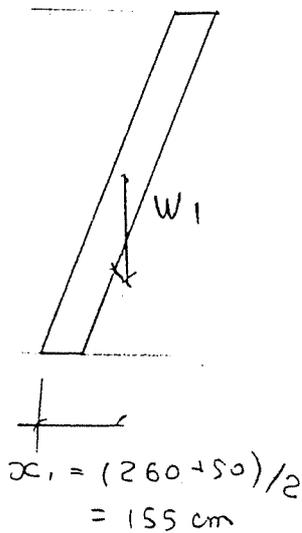
$$W_2 = 2.3 \text{ t/m}^3 \times (0.8 - 0.5) \text{ m} \times 4.5 \text{ m} \times 1 \text{ m} / 2 = 1.55 \text{ t}$$

$$\Sigma W = 6.73 \text{ t}$$

$$x_1 = (2.6 + 0.5) / 2 = 1.55 \text{ m}$$

$$x_2 = 2.6 / 3 + 0.5 + (0.8 - 0.5) / 3 = 1.47 \text{ m}$$

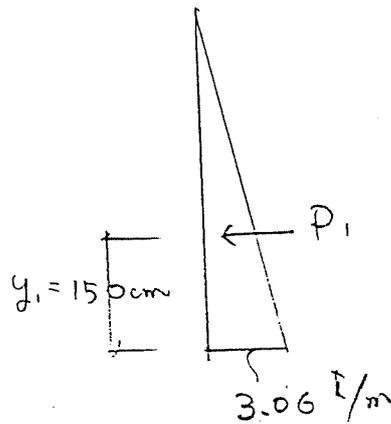
$$\Sigma M_w = - (W_1 \times x_1 + W_2 \times x_2) = - (5.18 \times 1.55 + 1.55 \times 1.47) = -10.3 \text{ tm}$$



② Over Turning Moment by Soil Pressure

$$P = 3.06 \times 4.5 / 2 = 6.9t$$

$$M_p = 6.9 \times 4.5 / 3 = 10.35tm$$



③ Total Over Turning Moment

$$\Sigma = \Sigma M_w + M_p = -10.3 + 10.35 = 0.05tm$$

④ Eccentricity

$$e = \Sigma M / \Sigma W = 0.05 / 6.73 = 0.007 < B/6 = 0.8/6 = 0.13 \quad \underline{OK}$$

(3) Sliding

$$\text{Safety Factor } F_s = (\Sigma W \times \mu + \tau \times B) / P$$

$$= (6.73 \times 0.7 + 5 \text{kg/cm}^2 \times 60 \text{cm} \times 100 \text{cm} / 1000) / 6.9$$

$$= (4.71 + 30t) / 6.9 = 5.0 > a F_s = 1.5 \quad \underline{OK}$$

(4) Vertical Loading

$$\text{Total Weight of Wall} = 6.73 + 2.3 \times 1.0 \times 1.0 \times 1.0 = 8.93t$$

$$w = 8.93 / (1.0 \text{m} \times 1.0 \text{m}) = 8.93 < 15t/\text{m}^2 \quad \underline{OK}$$