GOVERNMENT OF ORISSA

WORKS DEPARTMENT

ORISSA STATE ROAD PROJECT

FINAL DETAILED ENGINEERING REPORT FOR PHASE-I ROADS

DESIGN REPORT OF CULVERTS (BERHAMPUR TO BANGI JUNCTION) (0.0 TO 41.0)

C O N S U L T I N G

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INTRODUCTION

INTRODUCTION

The culverts have been categorized on the basis of detailed inventory and condition survey, hydrological study, horizontal & vertical profile of highway.

The following criterion has been taken while deciding the culverts :

i. The width of culvert shall be 12.0m
ii. NP-3/NP-4 pipe culverts in good condition and hydrologically adequate shall be retained
iii. Slab culverts structurally in good condition and hydrologically adequate having width less than 10.0m shall be widened as per approved alignment.
iv. All arch type culverts shall be reconstructed.
v. All new pipe culverts shall have minimum dia. of 1.0m and box culverts of minimum span 2.0m and height 1.5m.
vi. RR stone masonry culverts shall be reconstructed.
vii. Additional culverts as per site investigation has been identified and included in this report.

On the basis of above, all culverts lies in the following category :

i. Single Pipe Culverts of 1.0m dia
ii. Double Pipe Culverts of 1.0m dia
iii. Extension of Pipe Culverts with existing pipe dia
iv. Single Cell box Culverts upto span of 6.0m
v. Widening of Slab Culverts

On the basis of above, all culverts in this stretch lies the following category

Summary of Proposed Culverts

Type of Culvert	**Nos.**
Culverts Retained	Nil
Culverts Widened	
Pipe extension	5
Slab widening	12
Culverts Replaced	
New Single Pipe	51
New Double Pipe	9
New Single Box of 1/22/0	21
New Single Box of 1/22/1	1
New Single Box of 1/23/0	22
New Single Box of 1/33/0	12
New Single Box of 1/34/0	1
New Single Box of 1/43/0	2
New Single Box of 1/44/0	1
Total	**137**

The drawings of Pipe Culverts for height of fill from 0.6 to 4.0m has been taken from SP-13.For Box Culverts with different clear heights MOST Standard Drawings has been taken.

Bed levels, Formation levels, Super-elevation/Camber has been taken from highway plan & profile drawings and data has been analysed by using Microsoft Excel Sheet.

In Box Culverts, the retaining wall is kept along the road instead of splayed Wing Wall mentioned in MOST Drawings. These Walls has been designed by using Microsoft Excel Sheet for the height varying from 2.0 to 6.0m.

Reference codes:

IRC – 6 – 2000
IRC – 21 – 2000
IRC – 78 – 2000

Proposed Culverts

S. No.	Location/ Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
1	0/190	213.0	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent
2	0/350	369.0	1 x 1.75	Slab	1 x 1.75	-	Good, to be widened
3	0/830	847.0	1 x 2.0	Slab	1 x 2.0	-	Good, to be widened
4	0/950	975.0	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent
5	1/150	1146.0	1 x 1.5	Slab	1/23/0	RCC Box	Replaced due to poor condition
6	1/310	1310.0	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to raising in road level
7	1/785	1781.0	1 x 1.5	Slab	1/23/0	RCC Box	Replaced due to poor condition
8	2/140	2137.0	1 x 1.5	Slab	1/23/0	RCC Box	**Replaced due to poor condition, to be used as Wild Life Under Pass**
9	2/285	2332.0	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to insufficient vent
10	2/515	2515.0	3 x 0.9	Slab	1/43/0	RCC Box	Replaced due to poor condition
11	2/630	2629.0	1 x 1.5	Slab	1 x 1.5	-	Good, to be widened
12	2/745	2742.0	1 x 2.5	Slab	1/33/0	RCC Box	Replaced due to raising in road level
13	3/105	3095.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to insufficient vent
14	3/265	3259.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
15	3/390	3382.0	1 x 1.4	Slab	1/23/0	RCC Box	Replaced due to poor condition
16	3/505	3498.0	1 x 2.5	Slab	1/33/0	RCC Box	Replaced due to raising in road level
17	3/775	3765.0	1 x 0.7	Stone Slab	1 x 1.0	Pipe	Replaced due to poor condition

S. No.	Location/ Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
18	3/895	3890.0	1 x 0.7	Stone Slab	2 x 1.0	Pipe	Replaced due to insufficient vent
19	4/115	4115.0	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to raising in road level
20	5/145	5127.0	1 x 1.5	Slab	1 x 1.5	-	Good, to be widened
21	5/230	5215.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to poor condition
22	5/535	5521.0	2 x 1.5	Arch	1/33/0	RCC Box	Replaced due to poor condition
23	5/775	5761.0	1 x 2.5	Slab	1/33/0	RCC Box	Replaced due to poor condition
24	6/090	6069.0	1 x 0.8	Pipe	1/22/0	RCC Box	Replaced due to poor condition
25	6/555	6497.0	-	Choked	1 x 1.0	Pipe	Replaced due to insufficient vent
26	6/590	6573.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to poor condition
27	7/020	7000.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to poor condition
28	7/240	7217.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
29	7/540	7520.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to poor condition
30	7/630	7605.0	1 x 1.5	Slab	1 x 1.5	-	Good, to be widened
31	7/795	7769.0	1 x 1.5	Slab	1 x 1.5	-	Good, to be widened
32	8/030	8008.0	1 x 2.0	Slab	1/23/0	RCC Box	Replaced due to raising in road level
33	8/210	8193.0	2 x 1.0	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
34	8/385	8363.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to poor condition
35	8/550	8530.0	1 x 3.0	Slab	1/33/0	RCC Box	Replaced due to poor condition
36	8/700	8685.0	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent
37	9/175	9152.0	1 x 1.5	Slab	1/23/0	RCC Box	Replaced due to raising in road level
38	9/600	9538.0	1 x 0.5	Stone Slab	2 x 1.0	Pipe	Replaced due to poor condition
39	9/810	9786.0	1 x 1.5	Slab	1/23/0	RCC Box	**Replaced due to raising in road level, to be used as Wild Life Under Pass**
40	10/370	10340.0	-	Choked	1/22/0	RCC Box	Replaced due to insufficient vent
41	10/965	10933.0	2 x 1.5	Slab	2 x 1.5	-	Good, to be widened
42	11/120	11120.0	1 x 0.9	Arch	2 x 1.0	Pipe	Replaced due to poor condition
43	11/500	11500.0	1 x 1.5	Slab	1/23/0	RCC Box	Replaced due to poor condition
44	12/040	12065.0	2 x 0.8	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent

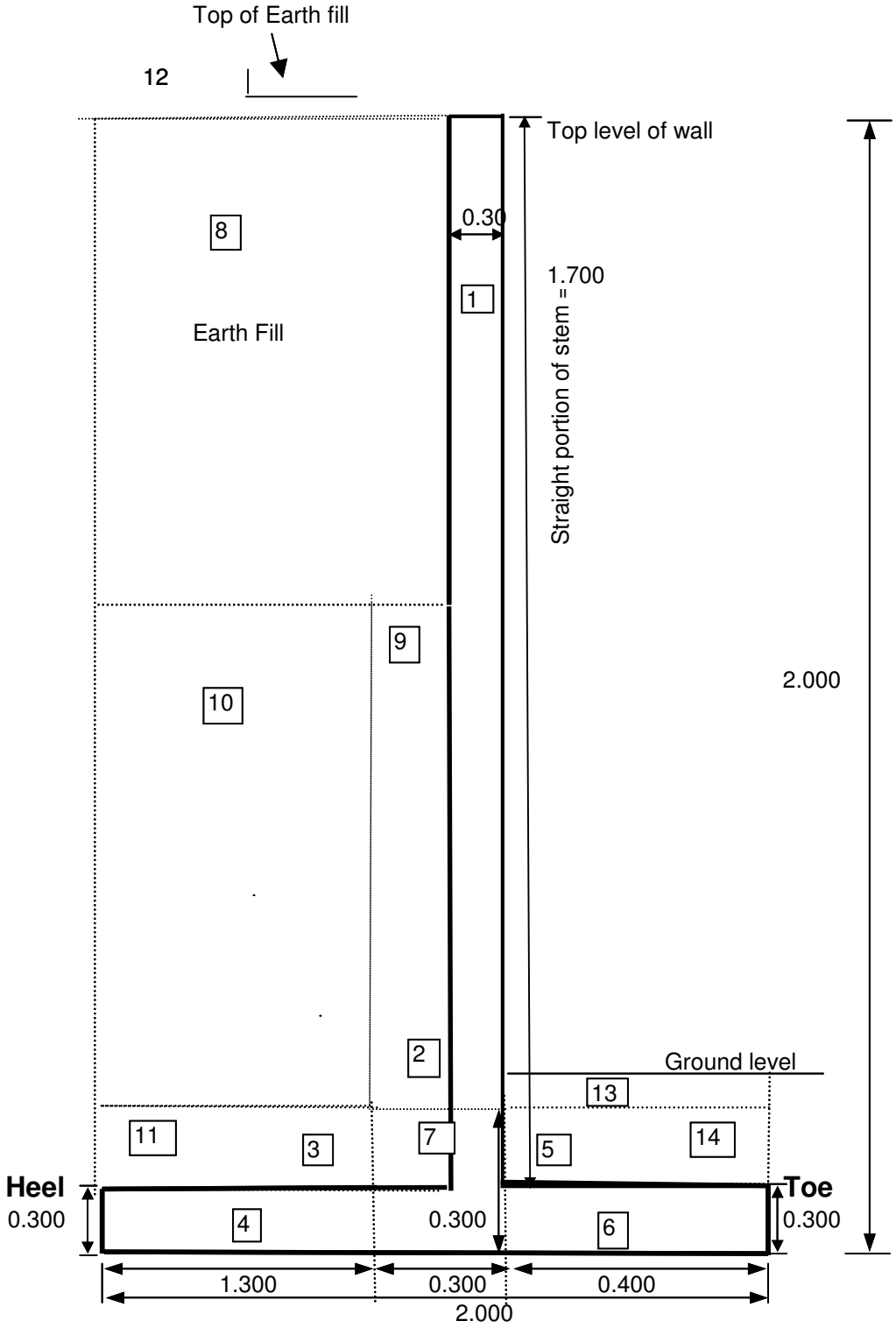
S. No.	Location/ Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
45	12/380	12407.0	1 x 1.0	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
46	12/585	12611.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
47	12/810	12836.0	3 x 1.2	Pipe	1/33/0	RCC Box	Replaced due to poor condition
48	12/880	12907.0	1 x 0.9	Pipe	1 x 0.9	-	Good, to be extended
49	13/110	13132.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to poor condition
50	13/265	13288.0	1 x 1.5	Slab	1/23/0	RCC Box	Replaced due to poor condition
51	13/450	13470.0	1 x 3.0	Slab	1/33/0	RCC Box	Replaced due to raising in road level
52	13/600	13619.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
53	13/790	13809.0	1 x 1.2	Pipe	1/22/0	RCC Box	Replaced due to poor condition
54	13/895	13916.0	1 x 1.0	Pipe	1 x 1.0	-	Good, to be extended
55	14/135	14157.0	1 x 3.0	Slab	1 x 3.0	-	Good, to be widened
56	14/510	14531.0	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
57	14/855	14877.0	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to poor condition
58	15/430	15440.0	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
59	15/880	15897.0	NV	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
60	16/050	16068.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
61	16/400	16417.0	1 x 2.3	Slab	1/33/0	RCC Box	Replaced due to poor condition
62	16/505	16521.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
63	16/750	16770.0	NV	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
64	16/950	16970.0	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to submergence
65	17/650	17666.0	1 x 0.9	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
66	18/020	18028.0	2 x 1.7	Slab	1/43/0	RCC Box	Replaced due to raising in road level
67	18/105	18115.0	1 x 1.0	Slab	1/22/0	RCC Box	Replaced due to poor condition
68	18/470	18480.0	1 x 0.6	Stone Slab	1 x 1.0	Pipe	Replaced due to poor condition
69	19/240	19192.0	1 x 0.9	Slab	2 x 1.0	Pipe	Replaced due to poor condition
70	19/430	19382.0	1 x 0.6	Slab	1 x 1.0	Pipe	Replaced due to poor condition
71	19/570	19530.0	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to raising in road level
72	19/845	19799.0	1 x 1.0	Pipe	1 x 1.0	-	Good, to be extended

S. No.	Location/ Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
73	20/355	20361.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
74	20/610	20614.0	1 x 0.5	Slab	1 x 1.0	Pipe	Replaced due to insufficient vent
75	20/930	20935.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
76	21/015	21005.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to insufficient vent
77	21/230	21224.0	1 x 0.45	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
78	21/420	21411.0	1 x 1.0	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
79	21/875	21865.0	1 x 1.2	Pipe	1 x 1.2	-	Good, to be extended
80	22/210	22189.0	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
81	22/605	22582.0	1 x 1.6	Slab	1 x 1.6	-	Good, to be widened
82	22/790	22761.0	1 x 1.0	Pipe	1 x 1.0	-	Good, to be extended
83	22/985	22961.0	1 x 0.9	Stone Slab	1 x 1.0	Pipe	Replaced due to poor condition
84	23/180	23147.0	1 x 0.7	Stone Slab	1 x 1.0	Pipe	Replaced due to insufficient vent
85	23/300	23255.0		Choked	1/22/0	RCC Box	Replaced due to insufficient vent
86	23/515	23484.0	1 x 0.3	Pipe	1/22/0	RCC Box	Replaced due to insufficient vent
87	23/750	23713.0		Choked	1/22/0	RCC Box	Replaced due to insufficient vent
88	23/850	23821.0	1 x 1.5	Slab	1/23/0	RCC Box	Replaced due to raising in road level
89	24/365	24351.0	1 x 0.6	Pipe	1/34/0	RCC Box	Replaced due to insufficient vent
90	24/650	24636.0	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to poor condition
91	24/1020	25106.0	1 x 1.8	Arch	1/23/0	RCC Box	Replaced due to poor condition
92	25/050	25214.0	1 x 4.7	Slab	1 x 1.5	-	Good, to be widened
93	25/695	25861.0	1 x 1.85	Slab	1/22/0	RCC Box	Replaced due to poor condition
94	25/905	26072.0	1 x 0.95	Arch	1/22/0	RCC Box	Replaced due to poor condition
95	26/150	26314.0	1 x 0.5	Stone Slab	1/23/0	RCC Box	Replaced due to insufficient vent
96	26/430	26612.0	1 x 3.1	Slab	1/44/0	RCC Box	Replaced due to poor condition
97	26/850	27026.0	1 x 1.0	Arch	1/22/1	RCC Box	**Replaced due to poor condition, to be used as Bear Under Pass**
98	27/600	27743.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
99	27/850	28008.0	1 x 0.65	Stone Slab	1/23/0	RCC Box	Replaced due to insufficient vent

S. No.	Location/ Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
100	28/375	28547.0		Choked	1 x 1.0	Pipe	Replaced due to insufficient vent
101	28/800	28954.0	3 x 1.2	Pipe	1/33/0	RCC Box	Replaced due to poor condition
102	30/060	30241.0	1 x 3.0	Slab	1/33/0	RCC Box	Replaced due to raising in road level
103	30/460	30637.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
104	30/720	30889.0	1 x 1.8	Slab	1/23/0	RCC Box	Replaced due to raising in road level
105	31/960	32128.0	1 x 0.8	Stone Slab	1/22/0	RCC Box	Replaced due to poor condition
106	32/300	32465.0	NV	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
107	33/220	33402.0	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to poor condition
108	33/310	33476.0	1 x 1.6	Slab	1/22/0	RCC Box	Replaced due to poor condition
109	33/806	33976.0	NV	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
110	33/900	34069.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
111	34/250	34463.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
112	34/525	34670.0	1 x 2.9	Slab	1/33/0	RCC Box	Replaced due to poor condition
113	34/640	34813.0	2 x 0.9	Pipe	1/23/0	RCC Box	Replaced due to insufficient vent
114	34/675	34858.0	1 x 2.1	Arch	1/33/0	RCC Box	Replaced due to poor condition
115	35/204	35378.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to insufficient vent
116	35/350	35533.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to insufficient vent
117	35/825	36003.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to insufficient vent
118	36/060	36238.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to insufficient vent
119	36/220	36358.0	-	Choked	1 x 1.0	Pipe	Replaced due to insufficient vent
120	36/500	36594.0	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
121	36/575	36758.0	1 x 0.8	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
122	36/800	36961.0	NV	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
123	36/990	37164.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to insufficient vent
124	37/440	37619.0	1 x 0.8	Arch	1/23/0	RCC Box	Replaced due to poor condition
125	37/985	38157.0	1 x 0.5	Stone Slab	1 x 1.0	Pipe	Replaced due to insufficient vent
126	38/450	38483.0	1 x 1.5	Slab	1 x 1.5	-	Good, to be widened
127	38/600	38746.0	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to poor condition

S. No.	Location/ Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
128	38/810	39002.0	NV	Choked	1 x 1.0	Pipe	Replaced due to insufficient vent
129	38/960	39118.0	1 x 0.8	Arch	1/23/0	RCC Box	Replaced due to poor condition
130	39/195	39375.0	1 x 1.8	Arch	1/23/0	RCC Box	Replaced due to poor condition
131	39/340	39517.0	1 x 3.2	Slab	1 x 3.2	-	Good, to be widened
132	39/455	39671.0	1 x 0.8	Arch	1/23/0	RCC Box	Replaced due to poor condition
133	39/900	40090.0	1 x 0.85	Arch	1/23/0	RCC Box	Replaced due to poor condition
134	40/100	40280.0	1 x 1.35	Slab	1/22/0	RCC Box	Replaced due to poor condition
135	40/240	40437.0	2 x 0.45	Stone Slab	1/22/0	RCC Box	Replaced due to insufficient vent
136	40/420	40610.0	1 x 1.5	Slab	1/23/0	RCC Box	Replaced due to poor condition
137	40/815	41000.0	1 x 1.5	Slab	1/23/0	RCC Box	Replaced due to poor condition

DESIGN OF RETURN WALL


Top of Earth fill
12
Top level of wall
0.30
8
1
1.700
Straight portion of stem =
Earth Fill
9
10
2.000
2
Ground level
13
11
3
7
5
14
Heel
0.300
4
0.300
6
Toe
0.300
1.300
0.300
0.400
2.000

DESIGN OF RETAINING WALL FOR 2.000 m HEIGHT

DESIGN DATA:

Top level of retaining wall	=	2.000	m
Ground level	=	1.000	m
Founding Level	=	0.000	m
Total Height from top of wall to founding level	=	**2.000**	m
Density of earth	=	1.8	t/m^3
Density of concrete	=	2.4	t/m^3
Clear cover to Reinforcement	=	0.05	m
Clear cover to Reinforcement for foundations	=	0.075	m
Grade of concrete	=	20	
Allowable stress in steel	=	20380	
Safe bearing capacity	=	20	t/m^2
Safety factor against overturning	=	2.0	
Safety factor against sliding	=	1.5	
Depth of L.L.Surcharge	=	1.2	m
L.L.Surcharge on wall	=	0	t/m^2
ActiveEarthPressure			
For Grade of concrete	= M	20	& HYSD reinf. with Fe 415
Lever arm factor j	=	0.916	
Moment of resistance factor Q	=	78.54	

DIMENSIONS :

Length of Base of Retaining wall	=	2.000	m
Section modulus	=	0.667	m^3
Length of Toe	=	0.400	m
Length of Heel	=	1.300	m
Thickness of Stem at base	=	0.300	m
Thickness of straight portion of stem	=	0.300	m
Ht. of straight portion of stem	=	1.700	m
Minimum thickness of Toe slab	=	0.300	m
Thickness of Toe slab at junction with stem	=	0.300	m
Minimum thickness of heel slab	=	0.300	m
Thickness of heel slab at junction with stem	=	0.300	m
Angle of inclined stem with vertical	=	0.000	
Ht.of inclined potion of stem to base of footing	=	0.300	m
Ht.of inclined potion of stem to top of footing	=	0.000	m

Calculation of Earth pressure coefficients =

Angle of internal friction of soil ϕ	=	30	deg	=	0.524 rad
Angle of wall friction δ	=	20	deg	=	0.349 rad
Angle of incli . of soil at back i	=	0	deg	=	0.000 rad
Angle of incli . of stem at back α	=	90	deg	=	1.571 rad
Coefficient of active earth pressure k_a	=	0.297			
Coefficient of horz.active earth pressure K_{ah}	=	0.279			

Calculation of Forces & moments due to Vertical Forces

S.No.	Description	Area Factor	width	Depth	Density	Weight	C.G. from Toe	Moment about toe
1	Wt of stem	1.0	0.300	1.7	2.4	1.224	0.550	0.673
2		0.5	0.000	0	2.4	0.000	0.700	0.000
3	Wt of heel slab	0.5	1.300	0	2.4	0.000	1.133	0.000
4		1.0	1.300	0.3	2.4	0.936	1.350	1.264
5	Wt of toe slab	0.5	0.400	0	2.4	0.000	0.267	0.000
6		1.0	0.400	0.3	2.4	0.288	0.200	0.058
7	Wt.of intmdt.portion	1.0	0.300	0.3	2.4	0.216	0.550	0.119
8	Wt. of soil above heel slab	1.0	1.300	1.7	1.8	3.978	1.35	5.370
9		0.5	0.000	0	1.8	0.000	0.700	0.000
10		1.0	1.300	0	1.8	0.000	1.350	0.000
11		0.5	1.300	0	1.8	0.000	1.567	0.000
12		0.0	1.300	0.65	1.8	0.000	1.567	0.000
13	Wt. of soil above toe slab	0.0	0.4	0.7	1.8	0.000	0.200	0.000
14		0.0	0.4	0	1.8	0.000	0.133	0.000
15	L.L.Surcharge	0.0	1.3	1.2	1.8	0.000	1.350	0.000
			Total forces =			**6.642**		**7.48**

Total Vertical load = **6.64** Total Restoring moment = **7.48**

Horz. components of Earth Pressure

S.No.	Horz. Press due to	Area factor	Pressure $k_{ah}\gamma h$	Height	Horz. Force	C.G. from Toe	Moment about toe
1	Active Earth Pressure	0.5	1.006	2	1.006	0.840	0.84
2	L.L.Surcharge	1	0.603	2	1.207	1.000	1.21
			Total forces =		2.213		2.05

Total overturning moment Mo = 2.05 tm Total vertical load V = 6.642 t
Total restoring moment Mr = 7.48 tm Total Horz. Force = 2.213 t

Factor of safety against overturning Mr/Mo = 3.65 **OK** > 2

Check for sliding :

Coefficient of base friction = 0.500
Total vertical force = 6.642 t
Resisting force = 3.32 t
F.O.S 1.501 **OK** > 1.5
C.G. of loads from toe = Mr/V = 1.127 m
Eccentricity of loads w.r.t. c/l raft = 0.127 m
Moment about c/l raft = 0.842 t-m
Net moment about base M = 1.210 t-m

Calculation of Base Pressure

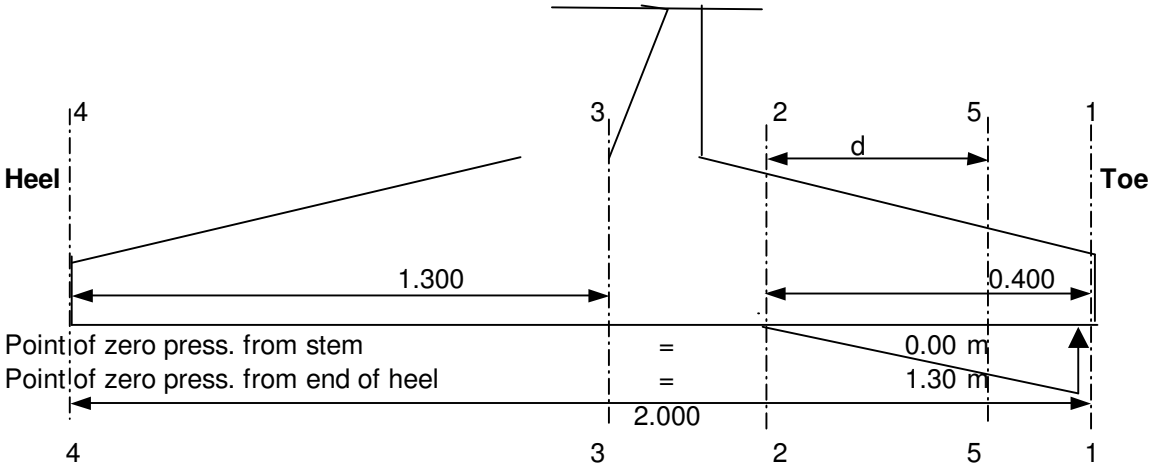
Base pressure due to vertical load V/A = 3.32 Pressure at toe = **5.14** t/m^2

Base pressure due to moment Mn/Z = 1.815 Pressure at heel= **1.51** t/m^2

CALCULATION OF DESIGN PRESSURES

Section	1-1	2-2	3-3	4-4	5-5
Upward pressure	5.136	4.410	3.866	1.506	4.742
Downward Pressure	0.720	0.720	3.780	3.780	0.720
Net pressure	4.416	3.690	0.086	-2.274	4.022

** Positive net pressure means upward pressure & negative net pressure means downward pressure



Point of zero press. from stem = 0.00 m
Point of zero press. from end of heel = 1.30 m

DESIGN OF TOE SLAB

Reinforcement calculation

Bending Moment at face of stem	=	0.33	t-m	
Effective depth required	=	0.065	m	
Effective depth provided at face of stem	=	0.217	> reqd	0.065
Area of Reinforcement reqd.at bottom	=	**0.82**	cm^2	**HENCE SAFE**

Shear check:

Shear force at distance d from stem	=	0.77	t	
Bending moment at sec 5-5 =		0.07	t-m	
Net shear force at sec 5-5=S-Ms*tanβ/d_1 =		0.77	t	
Depth of slab at section 5-5 =		0.300	Effective depth d_1 =	0.215 m

Nominal Shear stress = 2.57 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.038 %
Therefore Permissible shear strsss = 18.36 t/m^2 **HENCE SAFE**

DESIGN OF HEEL SLAB

Bending Moment at face of stem =		1.26	t-m
Effective depth required	=	0.127	m
Effective depth of slab at face of stem =		0.215	m
Reinforcement reqd.at top =		**3.13**	cm^2

Shear check:

Shear force at face of stem S =		1.42	t
Bending moment at face Ms =		1.26	t-m
Net shear force =S-Ms*tanβ/d_1 =		1.42	t

Nominal Shear stress = 6.62 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.146 %
Therefore Permissible shear strsss = 18.36 t/m^2 **HENCE SAFE**

DESIGN OF STEM BASE

Section A

Height of Base of stem from top of earth fill = 2.7 m

Height of Base of stem below straight portion = 0.3 m

S.No.	Horz. Press due to	Area factor	Pressure k_a.g.h	Height	Horz. Force	C.G. from base	Moment about base
1	Active Earth Pressure	0.5	1.358	2.7	1.833	1.134	2.08
2	L.L.Surcharge	1	0.603	2.7	1.629	1.350	2.20
			Total =		3.46		4.28

Total Horizontal Force	3.46	t		
Total Moment about base	4.28	tm		
Design bending moment	4.28	t-m		
Effective depth required	0.195	m		
Thickness of stem at base	0.300	m		
Effective depth provided	0.238	>	0.195	**HENCE SAFE**
Area of steel reqd.	**9.80**	cm^2		

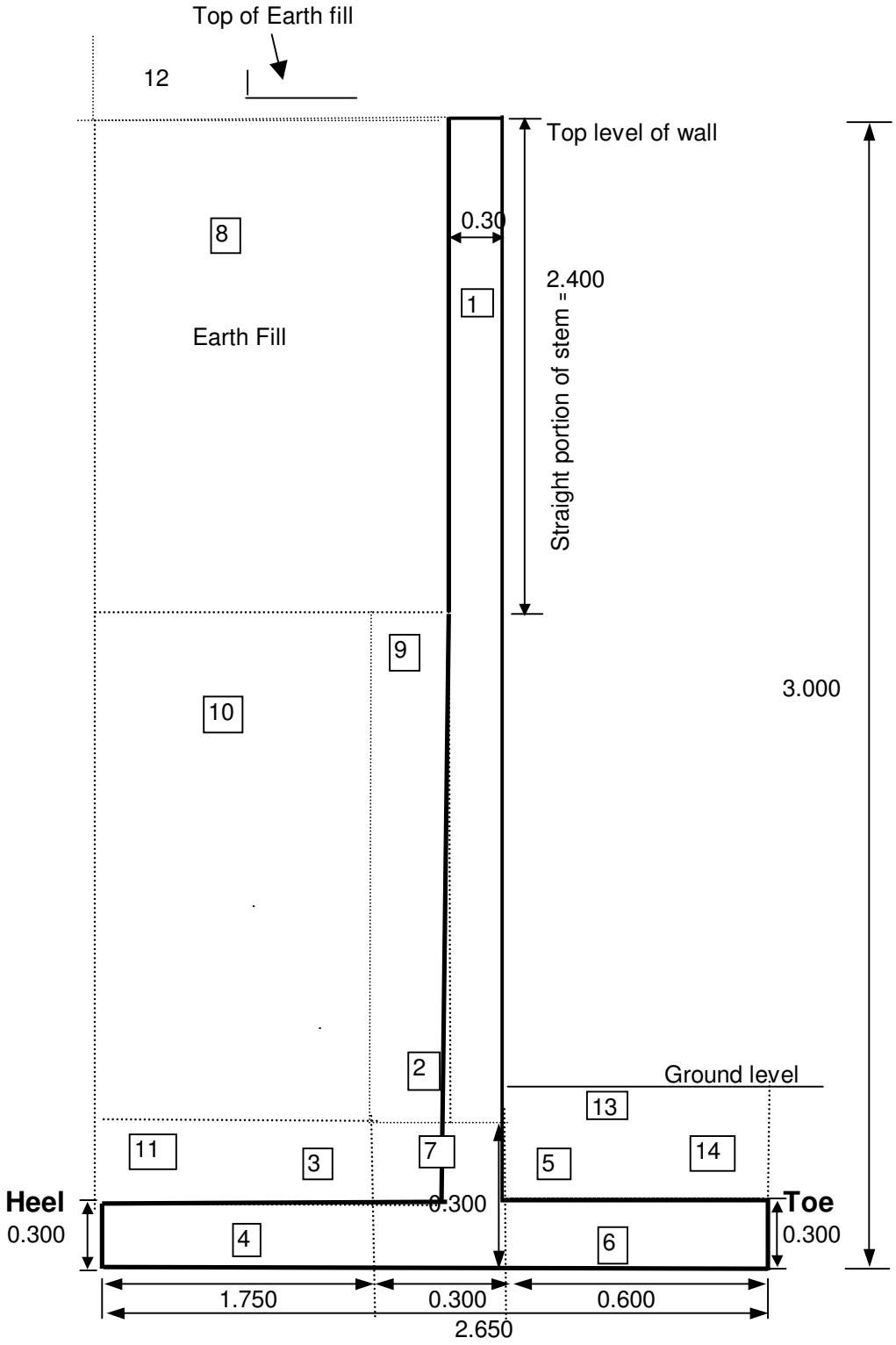
Shear check:

Shear force at base of stem	3.46	t
Bending moment at base	4.28	t-m
Net shear force	3.46	t
Nominal Shear stress	14.58	t/m^2

Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000

100As/bd = 0.41 %

Therefore Permissible shear strsss 27.75 t/m^2 **HENCE SAFE**


Top of Earth fill
12
Top level of wall
0.30
2.400
Straight portion of stem =
8
1
Earth Fill
9
3.000
10
2
Ground level
13
11
3
7
5
14
Heel
0.300
0.300
Toe
0.300
4
6
1.750
0.300
0.600
2.650

DESIGN OF RETAINING WALL FOR 3.000 m HEIGHT

DESIGN DATA:

Top level of retaining wall	=	3.000	m
Ground level	=	1.200	m
Founding Level	=	0.000	m
Total Height from top of wall to founding level	=	**3.000**	m
Density of earth	=	1.8	t/m^3
Density of concrete	=	2.4	t/m^3
Clear cover to Reinforcement	=	0.05	m
Clear cover to Reinforcement for foundations	=	0.075	m
Grade of concrete	=	25	
Allowable stress in steel	=	20380	
Safe bearing capacity	=	20	t/m^2
Safety factor against overturning	=	2.0	
Safety factor against sliding	=	1.5	
Depth of L.L.Surcharge	=	1.2	m
L.L.Surcharge on wall	=	0	t/m^2

DESIGN CONSTANTS:

For Grade of concrete	= M	25	& HYSD reinf. with Fe 415
Lever arm factor j	=	0.902	
Moment of resistance factor Q	=	111.996	

DIMENSIONS :

Length of Base of Retaining wall	=	2.650	m
Section modulus	=	1.170	m^3
Length of Toe	=	0.600	m
Length of Heel	=	1.750	m
Thickness of Stem at base	=	0.300	m
Thickness of straight portion of stem	=	0.300	m
Ht. of straight portion of stem	=	2.400	m
Minimum thickness of Toe slab	=	0.300	m
Thickness of Toe slab at junction with stem	=	0.300	m
Minimum thickness of heel slab	=	0.300	m
Thickness of heel slab at junction with stem	=	0.300	m
Angle of inclined stem with vertical	=	0.000	
Ht.of inclined potion of stem to base of footing	=	0.600	m
Ht.of inclined potion of stem to top of footing	=	0.300	m

Calculation of Earth pressure coefficients =

Angle of internal friction of soil ϕ	=	30	deg	=	0.5236 rad
Angle of wall friction δ	=	20	deg	=	0.3491 rad
Angle of incli . of soil at back i	=	0	deg	=	0.0000 rad
Angle of incli . of stem at back α	=	90	deg	=	1.570796 rad
Coefficient of active earth pressure k_a	=	0.297			
Coefficient of horz.active earth pressure K_{ah}	=	0.279			

Calculation of Forces & moments due to Vertical Forces

S.No.	Description	Area Factor	width	Depth	Density	Weight	C.G. from Toe	Moment about toe
1	Wt of stem	1.0	0.300	2.7	2.4	1.944	0.750	1.458
2		0.5	0.000	0.3	2.4	0.000	0.900	0.000
3	Wt of heel slab	0.5	1.750	0	2.4	0.000	1.483	0.000
4		1.0	1.750	0.3	2.4	1.260	1.775	2.237
5	Wt of toe slab	0.5	0.600	0	2.4	0.000	0.400	0.000
6		1.0	0.600	0.3	2.4	0.432	0.300	0.130
7	Wt.of intmdt.portion	1.0	0.300	0.3	2.4	0.216	0.750	0.162
8	Wt. of soil above heel slab	1.0	1.750	2.4	1.8	7.560	1.775	13.419
9		0.5	0.000	0.3	1.8	0.000	0.900	0.000
10		1.0	1.750	0.3	1.8	0.945	1.775	1.677
11		0.5	1.750	0	1.8	0.000	2.067	0.000
12		0.0	1.750	0.875	1.8	0.000	2.067	0.000
13	Wt. of soil above toe slab	0.0	0.6	0.9	1.8	0.000	0.300	0.000
14		0.0	0.6	0	1.8	0.000	0.200	0.000
15	L.L.Surcharge	0.0	1.75	1.2	1.8	0.000	1.775	0.000
				Total forces =		**12.357**		**19.08**

Total Vertical load = **12.36** Total Restoring moment = **19.08**

Horz. components of Earth Pressure

S.No.	Horz. Press due to		Area factor	Pressure $k_{ah}\gamma h$	Height	Horz. Force	C.G. from Toe	Moment about toe
1	Active Earth Pressure		0.5	1.509	3	2.263	1.260	2.85
2	L.L.Surcharge		1	0.603	3	1.810	1.500	2.72
				Total forces =		4.073		5.57

Total overturning moment Mo = 5.57 tm Total vertical load V = 12.357 t
Total restoring moment Mr = 19.08 tm Total Horz. Force = 4.073 t

Factor of safety against overturning Mr/Mo = 3.43 **OK** > 2

Check for sliding :

Coefficient of base friction = 0.500
Total vertical force = 12.357 t
Resisting force = 6.18 t
F.O.S 1.52 **OK** > 1.5

C.G. of loads from toe = Mr/V = 1.544 m
Eccentricity of loads w.r.t. c/l raft = 0.219 m
Moment about c/l raft = 2.709 t-m
Net moment about base Mn = 2.858 t-m

Calculation of Base Pressure

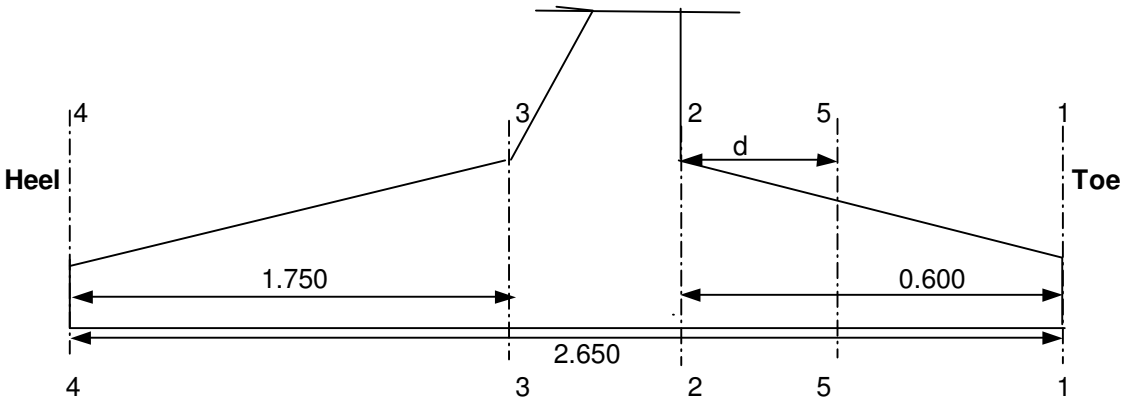
Base pressure due to vertical load V/A = 4.66 Pressure at toe = **7.10** t/m^2

Base pressure due to moment Mn/Z = 2.441 Pressure at heel= **2.22** t/m^2

CALCULATION OF DESIGN PRESSURES

Section	1-1	2-2	3-3	4-4	5-5
Upward pressure	7.104	5.999	5.446	2.222	6.705
Downward Pressure	0.720	0.720	5.580	5.580	0.720
Net pressure	6.384	5.279	-0.134	-3.358	5.985

** Positive net pressure means upward pressure & negative net pressure means downward pressure



DESIGN OF TOE SLAB

Reinforcement calculation

Bending Moment at face of stem = 1.08 t-m
Effective depth required = 0.098 m
Effective depth provided at face of stem = 0.217 > reqd 0.098
Area of Reinforcement reqd.at bottom = **2.71** cm^2 **HENCE SAFE**

Shear check:

Shear force at distance d from stem = 2.37 t
Bending moment at sec 5-5 = 0.46 t-m
Net shear force at sec 5-5=S-Ms*tanβ/d_1 = 2.37 t
Depth of slab at section 5-5 = 0.300 Effective depth d_1 = 0.215 m
Nominal Shear stress = 7.90 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.126 %
Therefore Permissible shear strsss = 18.36 t/m^2 **HENCE SAFE**

DESIGN OF HEEL SLAB

Bending Moment at face of stem = 3.50 t-m
Effective depth required = 0.177 m
Effective depth of slab at face of stem = 0.215 m
Reinforcement reqd.at top = **8.85** cm^2

Shear check:

Shear force at face of stem S = 3.06 t
Bending moment at face Ms = 3.50 t-m
Net shear force =S-Ms*tanβ/d_1 = 3.06 t
Nominal Shear stress = 14.21 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.412 %
Therefore Permissible shear strsss = 27.71 t/m^2 **HENCE SAFE**

DESIGN OF STEM BASE

Section A

Height of Base of stem from top of earth fill = 2.7 m

Height of Base of stem below straight portion = 0.3 m

S.No.	Horz. Press due to	Area factor	Pressure k_a.g.h	Height	Horz. Force	C.G. from base	Moment about base
1	Active Earth Pressure	0.5	1.358	2.7	1.833	1.134	2.08
2	L.L.Surcharge	1	0.603	2.7	1.629	1.350	2.20
			Total =		3.46		4.28

Total Horizontal Force	3.46	t		
Total Moment about base	4.28	tm		
Design bending moment	4.28	t-m		
Effective depth required	0.195	m		
Thickness of stem at base	0.300	m		
Effective depth provided	0.238	>	0.195	**HENCE SAFE**
Area of steel reqd.	**9.80**	cm^2		

Shear check:

Shear force at base of stem	3.46	t
Bending moment at base	4.28	t-m
Net shear force	3.46	t
Nominal Shear stress	14.58	t/m^2

Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000

100As/bd = 0.41 %

Therefore Permissible shear strsss 27.75 t/m^2 **HENCE SAFE**


Top of Earth fill
12
Top level of wall
0.30
2.400
Straight portion of stem =
8
1
Earth Fill
9
4.000
10
2
Ground level
13
11
3
7
5
14
Heel
0.300
0.450
Toe
0.300
4
6
2.040
0.410
0.700
3.150

DESIGN OF RETAINING WALL FOR 4.000 m HEIGHT

DESIGN DATA:

Top level of retaining wall	=	4.000	m
Ground level	=	1.500	m
Founding Level	=	0.000	m
Total Height from top of wall to founding level	=	**4.000**	m
Density of earth	=	1.8	t/m^3
Density of concrete	=	2.4	t/m^3
Clear cover to Reinforcement	=	0.05	m
Clear cover to Reinforcement for foundations	=	0.075	m
Grade of concrete	=	20	
Allowable stress in steel	=	20380	
Safe bearing capacity	=	20	t/m^2
Safety factor against overturning	=	2.0	
Safety factor against sliding	=	1.5	
Depth of L.L.Surcharge	=	1.2	m
L.L.Surcharge on wall	=	0	t/m^2

DESIGN CONSTANTS:

For Grade of concrete	= M 20		& HYSD reinf. with Fe 415
Lever arm factor j	=	0.916	
Moment of resistance factor Q	=	78.54	

DIMENSIONS :

Length of Base of Retaining wall	=	3.150	m
Section modulus	=	1.654	m^3
Length of Toe	=	0.700	m
Length of Heel	=	2.040	m
Thickness of Stem at base	=	0.410	m
Thickness of straight portion of stem	=	0.300	m
Ht. of straight portion of stem	=	2.400	m
Minimum thickness of Toe slab	=	0.300	m
Thickness of Toe slab at junction with stem	=	0.450	m
Minimum thickness of heel slab	=	0.300	m
Thickness of heel slab at junction with stem	=	0.450	m
Angle of inclined stem with vertical	=	0.096	
Ht.of inclined potion of stem to base of footing	=	1.600	m
Ht.of inclined potion of stem to top of footing	=	1.150	m

Calculation of Earth pressure coefficients =

Angle of internal friction of soil ϕ	=	30	deg	=	0.524 rad
Angle of wall friction δ	=	20	deg	=	0.349 rad
Angle of incli . of soil at back i	=	0	deg	=	0.000 rad
Angle of incli . of stem at back α	=	90	deg	=	1.57080 rad
Coefficient of active earth pressure k_a	=	0.297			
Coefficient of horz.active earth pressure K_{ah}	=	0.279			

Calculation of Forces & moments due to Vertical Forces

S.No.	Description	Area Factor	width	Depth	Density	Weight	C.G. from Toe	Moment about toe
1	Wt of stem	1.0	0.300	3.55	2.4	2.556	0.850	2.173
2		0.5	0.110	1.15	2.4	0.152	1.037	0.157
3	Wt of heel slab	0.5	2.040	0.15	2.4	0.367	1.790	0.657
4		1.0	2.040	0.3	2.4	1.469	2.130	3.129
5	Wt of toe slab	0.5	0.700	0.15	2.4	0.126	0.467	0.059
6		1.0	0.700	0.3	2.4	0.504	0.350	0.176
7	Wt.of intmdt.portion	1.0	0.410	0.45	2.4	0.443	0.905	0.401
8	Wt. of soil above heel slab	1.0	2.150	2.4	1.8	9.288	2.075	19.273
9		0.5	0.110	1.15	1.8	0.114	1.073	0.122
10		1.0	2.040	1.15	1.8	4.223	2.130	8.995
11		0.5	2.040	0.15	1.8	0.275	2.470	0.680
12		0.0	2.150	1.075	1.8	0.000	2.434	0.000
13	Wt. of soil above toe slab	0.0	0.7	1.1	1.8	0.000	0.350	0.000
14		0.0	0.7	0.15	1.8	0.000	0.233	0.000
15	L.L.Surcharge	0.0	2.15	1.2	1.8	0.000	2.075	0.000
			Total forces =			**19.517**		**35.82**

Total Vertical load = **19.52** Total Restoring moment = **35.82**

Horz. components of Earth Pressure

S.No.	Horz. Press due to		Area factor	Pressure $k_{ah}\gamma h$	Height	Horz. Force	C.G. from Toe	Moment about toe
1	Active Earth Pressure		0.5	2.012	4	4.023	1.680	6.76
2	L.L.Surcharge		1	0.603	4	2.414	2.000	4.83
				Total forces =		6.437		11.59

Total overturning moment Mo = 11.59 tm Total vertical load V = 19.517 t
Total restoring moment Mr = 35.82 tm Total Horz. Force = 6.437 t

Factor of safety against overturning Mr/Mo = 3.09 **OK** > 2

Check for sliding :

Coefficient of base friction = 0.500
Total vertical force = 19.517 t
Resisting force = 9.76 t
F.O.S 1.52 **OK** > 1.5
C.G. of loads from toe = Mr/V = 1.835 m
Eccentricity of loads w.r.t. c/l raft = 0.260 m
Moment about c/l raft = 5.083 t-m
Net moment about base Mn = 6.504 t-m

Calculation of Base Pressure

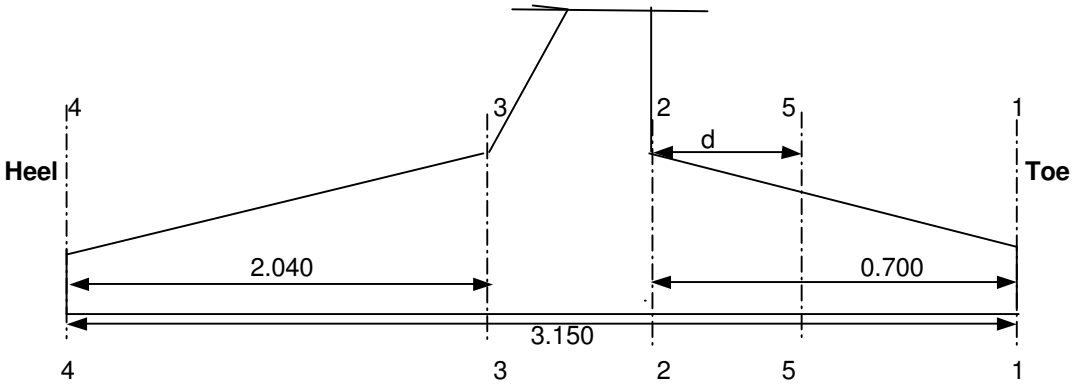
Base pressure due to vertical load V/A = 6.20 Pressure at toe = **10.13** t/m^2

Base pressure due to moment Mn/Z = 3.933 Pressure at heel= **2.26** t/m^2

CALCULATION OF DESIGN PRESSURES

Section	1-1	2-2	3-3	4-4	5-5
Upward pressure	10.129	8.381	7.357	2.263	9.212
Downward Pressure	0.720	1.080	7.470	7.380	0.891
Net pressure	9.409	7.301	-0.113	-5.117	8.321

** Positive net pressure means upward pressure & negative net pressure means downward pressure



DESIGN OF TOE SLAB

Reinforcement calculation

Bending Moment at face of stem = 2.13 t-m
Effective depth required = 0.165 m
Effective depth provided at face of stem = 0.367 > reqd 0.165
Area of Reinforcement reqd.at bottom = **3.11** cm^2 **HENCE SAFE**

Shear check:

Shear force at distance d from stem = 2.95 t
Bending moment at sec 5-5 = 0.50 t-m
Net shear force at sec 5-5=S-Ms*tanβ/d_1 = 2.58 t
Depth of slab at section 5-5 = 0.371 Effective depth d_1 = 0.286 m
Nominal Shear stress = 6.94 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.109 %
Therefore Permissible shear strsss = 18.36 t/m^2 **HENCE SAFE**

DESIGN OF HEEL SLAB

Bending Moment at face of stem = 7.18 t-m
Effective depth required = 0.302 m
Effective depth of slab at face of stem = 0.365 m
Reinforcement reqd.at top = **10.53** cm^2

Shear check:

Shear force at face of stem S = 5.33 t
Bending moment at face Ms = 7.18 t-m
Net shear force =S-Ms*tanβ/d_1 = 3.89 t
Nominal Shear stress = 10.65 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.289 %
Therefore Permissible shear strsss = 23.70 t/m^2 **HENCE SAFE**

FOR CURTAILMENT

Shear Force at distance from stem = 123.873
Bending Moment at distance 2.000 m from face of stem = 0.00
Effective depth required = 0.007 m
Effective depth provided = 0.220 > reqd 0.007
Curtailment Length = 2.220
Area of Reinforcement reqd.at bottom = **0.01** cm^2

DESIGN OF STEM BASE

Section A

Height of Base of stem from top of earth fill = 3.55 m

Height of Base of stem below straight portion = 1.15 m

S.No.	Horz. Press due to	Area factor	Pressure $k_a.g.h$	Height	Horz. Force	C.G. from base	Moment about base
1	ActiveEarthPressure	0.5	1.785	3.55	3.169	1.491	4.72
2	L.L.Surcharge	1	0.603	3.55	2.142	1.775	3.80
			Total =		5.31		8.53

Total Horizontal Force	5.31	t	
Total Moment about base	8.53	tm	
Design bending moment	8.53	t-m	
Effective depth required	0.330	m	
Thickness of stem at base	0.410	m	
Effective depth provided	0.348	> 0.330	**HENCE SAFE**
Area of steel reqd.	**13.14**	cm^2	

Shear check:

Shear force at base of stem	5.31	t
Bending moment at base	8.53	t-m
Net shear force	2.96	t
Nominal Shear stress	8.53	t/m^2

Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000

100As/bd = 0.38 %

Therefore Permissible shear strsss 26.63 t/m^2 **HENCE SAFE**


Top of Earth fill
12
Top level of wall
0.30
2.400
Straight portion of stem =
Earth Fill
5.000
Ground level
Heel
0.300
0.500
Toe
0.300
2.680
0.550
1.000
4.230

DESIGN OF RETAINING WALL FOR 5.000 m HEIGHT

DESIGN DATA:

Top level of retaining wall	=	5.000	m
Ground level	=	1.500	m
Founding Level	=	0.000	m
Total Height from top of wall to founding level	=	**5.000**	m
Density of earth	=	1.8	t/m^3
Density of concrete	=	2.4	t/m^3
Clear cover to Reinforcement	=	0.05	m
Clear cover to Reinforcement for foundations	=	0.075	m
Grade of concrete	=	20	.
Allowable stress in steel	=	20380	
Safe bearing capacity	=	20	t/m^2
Safety factor against overturning	=	2.0	
Safety factor against sliding	=	1.5	
Depth of L.L.Surcharge	=	1.2	m
L.L.Surcharge on wall	=	0	t/m^2

DESIGN CONSTANTS:

For Grade of concrete	= M 20		& HYSD reinf. with Fe 415
Lever arm factor j	=	0.916	
Moment of resistance factor Q	=	78.54	

DIMENSIONS :

Length of Base of Retaining wall	=	4.230	m
Section modulus	=	2.982	m^3
Length of Toe	=	1.000	m
Length of Heel	=	2.680	m
Thickness of Stem at base	=	0.550	m
Thickness of straight portion of stem	=	0.300	m
Ht. of straight portion of stem	=	2.400	m
Minimum thickness of Toe slab	=	0.300	m
Thickness of Toe slab at junction with stem	=	0.500	m
Minimum thickness of heel slab	=	0.300	m
Thickness of heel slab at junction with stem	=	0.500	m
Angle of inclined stem with vertical	=	0.119	
Ht.of inclined potion of stem to base of footing	=	2.600	m
Ht.of inclined potion of stem to top of footing	=	2.100	m

Calculation of Earth pressure coefficients =

Angle of internal friction of soil ϕ	=	30	deg	=	0.524 rad
Angle of wall friction δ	=	20	deg	=	0.349 rad
Angle of incli . of soil at back i	=	0	deg	=	0.000 rad
Angle of incli . of stem at back α	=	90	deg	=	1.571 rad
Coefficient of active earth pressure k_a	=	0.297			
Coefficient of horz.active earth pressure K_{ah}	=	0.279			

Calculation of Forces & moments due to Vertical Forces

S.No.	Description	Area Factor	width	Depth	Density	Weight	C.G. from Toe	Moment about toe
1	Wt of stem	1.0	0.300	4.5	2.4	3.240	1.150	3.726
2		0.5	0.250	2.1	2.4	0.630	1.383	0.871
3	Wt of heel slab	0.5	2.680	0.2	2.4	0.643	2.443	1.572
4		1.0	2.680	0.3	2.4	1.930	2.890	5.577
5	Wt of toe slab	0.5	1.000	0.2	2.4	0.240	0.667	0.160
6		1.0	1.000	0.3	2.4	0.720	0.500	0.360
7	Wt.of intmdt.portion	1.0	0.550	0.5	2.4	0.660	1.275	0.842
8	Wt. of soil above heel slab	1.0	2.930	2.4	1.8	12.658	2.765	34.998
9		0.5	0.250	2.1	1.8	0.473	1.467	0.693
10		1.0	2.680	2.1	1.8	10.130	2.890	29.277
11		0.5	2.680	0.2	1.8	0.482	3.337	1.610
12		0.0	2.930	1.465	1.8	0.000	3.254	0.000
13	Wt. of soil above toe slab	0.0	1	1.0	1.8	0.000	0.500	0.000
14		0.0	1	0.2	1.8	0.000	0.333	0.000
15	L.L.Surcharge	0.0	2.93	1.2	1.8	0.000	2.765	0.000
			Total forces =			**31.806**		**79.68**
	Total Vertical load =	**31.81**			Total Restoring moment =			**79.68**

Horz. components of Earth Pressure

S.No.	Horz. Press due to		Area factor	Pressure $k_{ah}\gamma h$	Height	Horz. Force	C.G. from Toe	Moment about toe
1	Active Earth Pressure		0.5	2.514	5	6.286	2.100	13.20
2	L.L.Surcharge		1	0.603	5	3.017	2.500	7.54
				Total forces =		9.303		20.74

Total overturning moment Mo = 20.74 tm
Total restoring moment Mr = 79.68 tm
Total vertical load V = 31.806 t
Total Horz. Force = 9.303 t

Factor of safety against overturning Mr/Mo = 3.84 **OK** > 2

Check for sliding :

Coefficient of base friction = 0.500
Total vertical force = 31.806 t
Resisting force = 15.90 t
F.O.S 1.71 **OK** > 1.5
C.G. of loads from toe = Mr/V = 2.505 m
Eccentricity of loads w.r.t. c/l raft = 0.390 m
Moment about c/l raft = 12.416 t-m
Net moment about base Mn = 8.328 t-m

Calculation of Base Pressure

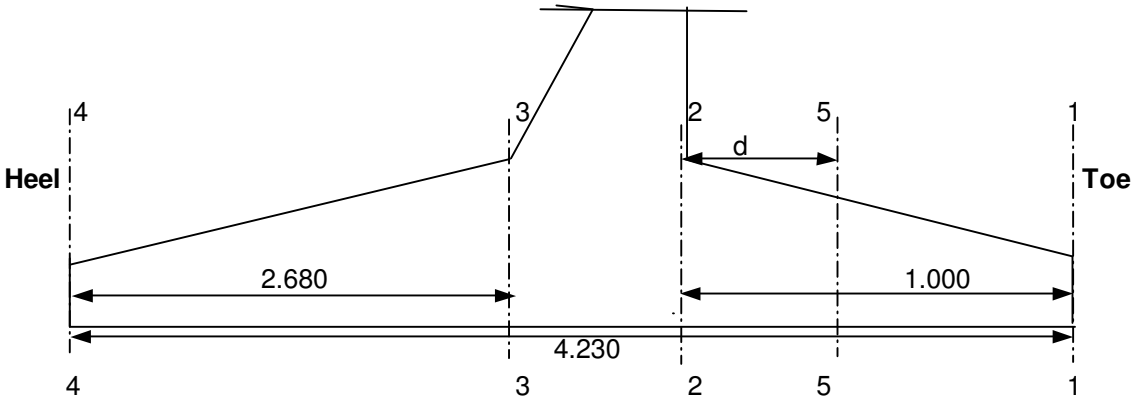
Base pressure due to vertical load V/A = 7.52
Pressure at toe = **10.31** t/m^2

Base pressure due to moment Mn/Z = 2.793
Pressure at heel= **4.73** t/m^2

CALCULATION OF DESIGN PRESSURES

Section	1-1	2-2	3-3	4-4	5-5
Upward pressure	10.312	8.991	8.265	4.726	9.761
Downward Pressure	0.720	1.200	9.300	9.180	1.000
Net pressure	9.592	7.791	-1.035	-4.454	8.761

** Positive net pressure means upward pressure & negative net pressure means downward pressure



DESIGN OF TOE SLAB

Reinforcement calculation

Bending Moment at face of stem = 4.50 t-m
Effective depth required = 0.239 m
Effective depth provided at face of stem = 0.417 > reqd 0.239
Area of Reinforcement reqd.at bottom = **5.78** cm^2 **HENCE SAFE**

Shear check:

Shear force at distance d from stem = 5.35 t
Bending moment at sec 5-5 = 1.58 t-m
Net shear force at sec 5-5=S-Ms*tanβ/d_1 = 4.40 t
Depth of slab at section 5-5 = 0.417 Effective depth d_1 = 0.332 m
Nominal Shear stress = 10.55 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.174 %
Therefore Permissible shear strsss = 19.35 t/m^2 **HENCE SAFE**

DESIGN OF HEEL SLAB

Bending Moment at face of stem = 11.90 t-m
Effective depth required = 0.389 m
Effective depth of slab at face of stem = 0.415 m
Reinforcement reqd.at top = **15.36** cm^2

Shear check:

Shear force at face of stem S = 7.35 t
Bending moment at face Ms = 11.90 t-m
Net shear force =S-Ms*tanβ/d_1 = 5.21 t
Nominal Shear stress = 12.57 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.370 %
Therefore Permissible shear strsss = 26.36 t/m^2 **HENCE SAFE**

FOR CURTAILMENT

Shear Force at distance from stem = 2.259
Bending Moment at distance 1.500 m from face of stem = 2.27
Effective depth required = 0.170 m
Effective depth provided = 0.305 > reqd 0.170
Curtailment Length = 1.805
Area of Reinforcement reqd.at bottom = **3.99** cm^2

DESIGN OF STEM BASE

Section A

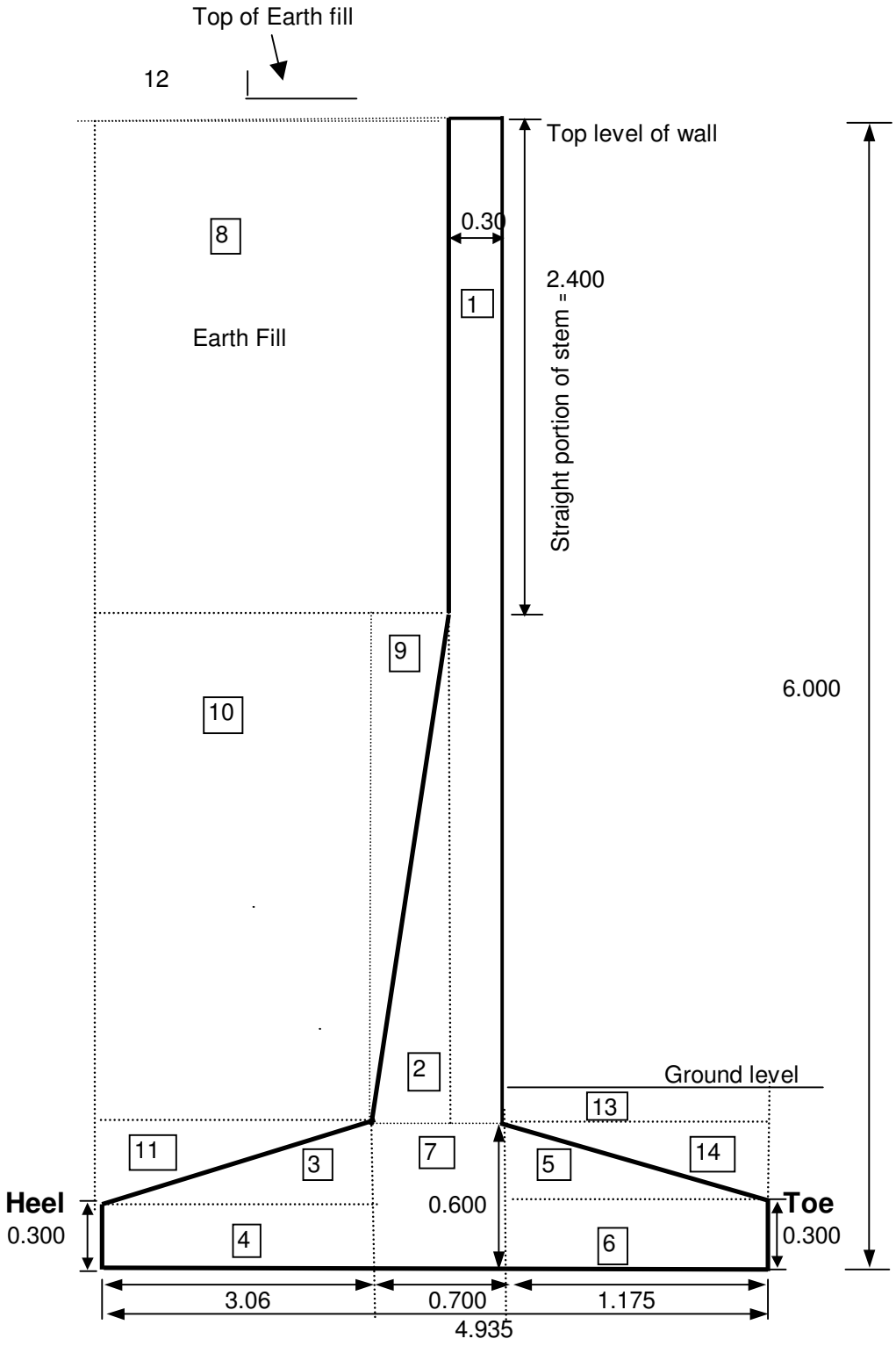
Height of Base of stem from top of earth fill = 4.5 m
Height of Base of stem below straight portion = 2.1 m

S.No.	Horz. Press due to	Area factor	Pressure k_a.g.h	Height	Horz. Force	C.G. from base	Moment about base
1	ActiveEarthPressure	0.5	2.263	4.5	5.092	1.890	9.62
2	L.L.Surcharge	1	0.603	4.5	2.716	2.250	6.11
			Total =		7.81		15.73

Total Horizontal Force	7.81	t		
Total Moment about base	15.73	tm		
Design bending moment	15.73	t-m		
Effective depth required	0.448	m		
Thickness of stem at base	0.550	m		
Effective depth provided	0.488	>	0.448	**HENCE SAFE**
Area of steel reqd.	**17.29**	cm^2		

Shear check:

Shear force at base of stem	7.81	t		
Bending moment at base	15.73	t-m		
Net shear force	3.97	t		
Nominal Shear stress	8.13	t/m^2		
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000				
100As/bd =	0.35	%		
Therefore Permissible shear strsss		25.86	t/m^2	**HENCE SAFE**


Top of Earth fill
12
Top level of wall
0.30
2.400
Straight portion of stem =
8
1
Earth Fill
9
10
6.000
2
Ground level
13
11
3
7
5
14
Heel
0.300
0.600
Toe
0.300
4
6
3.06
0.700
1.175
4.935

DESIGN OF RETAINING WALL FOR 6.000 m HEIGHT

DESIGN DATA:

Top level of retaining wall	=	6.000	m
Ground level	=	1.500	m
Founding Level	=	0.000	m
Total Height from top of wall to founding level	=	**6.000**	m
Density of earth	=	1.8	t/m^3
Density of concrete	=	2.4	t/m^3
Clear cover to Reinforcement	=	0.05	m
Clear cover to Reinforcement for foundations	=	0.075	m
Grade of concrete	=	20	
Allowable stress in steel	=	20380	
Safe bearing capacity	=	20	t/m^2
Safety factor against overturning	=	2.0	
Safety factor against sliding	=	1.5	
Depth of L.L.Surcharge	=	1.2	m
L.L.Surcharge on wall	=	0	t/m^2

DESIGN CONSTANTS:

For Grade of concrete	= M	20	& HYSD reinf. with Fe 415
Lever arm factor j	=	0.916	
Moment of resistance factor Q	=	78.54	

DIMENSIONS :

Length of Base of Retaining wall	=	4.935	m
Section modulus	=	4.059	m^3
Length of Toe	=	1.175	m
Length of Heel	=	3.060	m
Thickness of Stem at base	=	0.700	m
Thickness of straight portion of stem	=	0.300	m
Ht. of straight portion of stem	=	2.400	m
Minimum thickness of Toe slab	=	0.300	m
Thickness of Toe slab at junction with stem	=	0.600	m
Minimum thickness of heel slab	=	0.300	m
Thickness of heel slab at junction with stem	=	0.600	m
Angle of inclined stem with vertical	=	0.133	
Ht.of inclined potion of stem to base of footing	=	3.600	m
Ht.of inclined potion of stem to top of footing	=	3.000	m

Calculation of Earth pressure coefficients

	=				
Angle of internal friction of soil ϕ	=	30	deg	=	0.524 rad
Angle of wall friction δ	=	20	deg	=	0.349 rad
Angle of incli . of soil at back i	=	0	deg	=	0.000 rad
Angle of incli . of stem at back α	=	90	deg	=	1.571 rad
Coefficient of active earth pressure k_a	=	0.297			
Coefficient of horz.active earth pressure K_{ah}	=	0.279			

Calculation of Forces & moments due to Vertical Forces

S.No.	Description	Area Factor	width	Depth	Density	Weight	C.G. from Toe	Moment about toe
1	Wt of stem	1.0	0.300	5.4	2.4	3.888	1.325	5.152
2		0.5	0.400	3	2.4	1.440	1.608	2.316
3	Wt of heel slab	0.5	3.060	0.3	2.4	1.102	2.895	3.189
4		1.0	3.060	0.3	2.4	2.203	3.405	7.502
5	Wt of toe slab	0.5	1.175	0.3	2.4	0.423	0.783	0.331
6		1.0	1.175	0.3	2.4	0.846	0.588	0.497
7	Wt.of intmdt.portion	1.0	0.700	0.6	2.4	1.008	1.525	1.537
8	Wt. of soil above heel slab	1.0	3.460	2.4	1.8	14.947	3.205	47.906
9		0.5	0.400	3	1.8	1.080	1.742	1.881
10		1.0	3.060	3	1.8	16.524	3.405	56.264
11		0.5	3.060	0.3	1.8	0.826	3.915	3.235
12		0.0	3.460	1.73	1.8	0.000	3.783	0.000
13	Wt. of soil above toe slab	0.0	1.175	0.9	1.8	0.000	0.588	0.000
14		0.0	1.175	0.3	1.8	0.000	0.392	0.000
15	L.L.Surcharge	0.0	3.46	1.2	1.8	0.000	3.205	0.000
			Total forces =			**44.287**		**129.81**

Total Vertical load = **44.29** Total Restoring moment = **129.81**

Horz. components of Earth Pressure

S.No.	Horz. Press due to	Area factor	Pressure $k_{ah}\gamma h$	Height	Horz. Force	C.G. from Toe	Moment about toe
1	Active Earth Pressure	0.5	3.017	6	9.052	2.520	22.81
2	L.L.Surcharge	1	0.603	6	3.621	3.000	10.86
			Total forces =		12.673		33.67

Total overturning moment Mo = 33.67 tm Total vertical load V = 44.287 t

Total restoring moment Mr = 129.81 tm Total Horz. Force = 12.673 t

Factor of safety against overturning Mr/Mo = 3.85 **OK** > 2

Check for sliding :

Coefficient of base friction = 0.500

Total vertical force = 44.287 t

Resisting force = 22.14 t

F.O.S 1.75 **OK** > 1.5

C.G. of loads from toe = Mr/V = 2.931 m

Eccentricity of loads w.r.t. c/l raft = 0.464 m

Moment about c/l raft = 20.531 t-m

Net moment about base Mn = 13.142 t-m

Calculation of Base Pressure

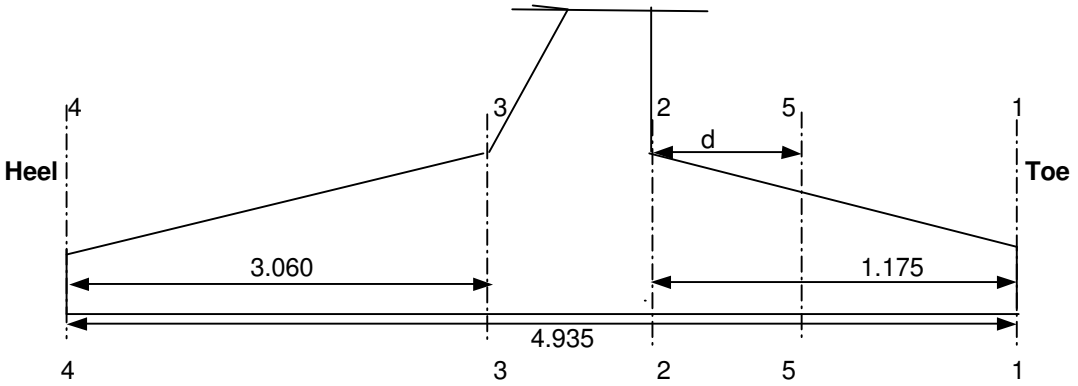
Base pressure due to vertical load V/A = 8.97 Pressure at toe = **12.21** t/m^2

Base pressure due to moment Mn/Z = 3.238 Pressure at heel= **5.74** t/m^2

CALCULATION OF DESIGN PRESSURES

Section	1-1	2-2	3-3	4-4	5-5
Upward pressure	12.212	10.670	9.752	5.736	11.531
Downward Pressure	0.720	1.440	11.160	10.980	1.122
Net pressure	11.492	9.230	-1.408	-5.244	10.409

** Positive net pressure means upward pressure & negative net pressure means downward pressure



DESIGN OF TOE SLAB

Reinforcement calculation

Bending Moment at face of stem = 7.41 t-m
Effective depth required = 0.307 m
Effective depth provided at face of stem = 0.519 > reqd 0.307
Area of Reinforcement reqd.at bottom = **7.65** cm^2 **HENCE SAFE**

Shear check:

Shear force at distance d from stem = 7.18 t
Bending moment at sec 5-5 = 2.40 t-m
Net shear force at sec 5-5=S-Ms*tanβ/d_1 = 5.58 t
Depth of slab at section 5-5 = 0.467 Effective depth d_1 = 0.382 m
Nominal Shear stress = 11.95 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.200 %
Therefore Permissible shear strsss = 20.40 t/m^2 **HENCE SAFE**

DESIGN OF HEEL SLAB

Bending Moment at face of stem = 18.56 t-m
Effective depth required = 0.486 m
Effective depth of slab at face of stem = 0.517 m
Reinforcement reqd.at top = **19.24** cm^2

Shear check:

Shear force at face of stem S = 10.18 t
Bending moment at face Ms = 18.56 t-m
Net shear force =S-Ms*tanβ/d_1 = 6.66 t
Nominal Shear stress = 12.88 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.372 %
Therefore Permissible shear strsss = 26.42 t/m^2 **HENCE SAFE**

FOR CURTAILMENT

Shear Force at distance from stem = 2.991
Bending Moment at distance 2.000 m from face of stem = 2.17
Effective depth required = 0.166 m
Effective depth provided = 0.321 > reqd 0.166
Curtailment Length = 2.321
Area of Reinforcement reqd.at bottom = **3.62** cm^2

DESIGN OF STEM BASE

Section A

Height of Base of stem from top of earth fill = 5.4 m
Height of Base of stem below straight portion = 3 m

S.No.	Horz. Press due to	Area factor	Pressure $k_a.g.h$	Height	Horz. Force	C.G. from base	Moment about base
1	ActiveEarthPressure	0.5	2.716	5.4	7.332	2.268	16.63
2	L.L.Surcharge	1	0.603	5.4	3.259	2.700	8.80
			Total =		10.59		25.43

Total Horizontal Force	10.59	t		
Total Moment about base	25.43	tm		
Design bending moment	25.43	t-m		
Effective depth required	0.569	m		
Thickness of stem at base	0.700	m		
Effective depth provided	0.640	>	0.569	**HENCE SAFE**
Area of steel reqd.	**21.28**	cm^2		

Shear check:

Shear force at base of stem	10.59	t
Bending moment at base	25.43	t-m
Net shear force	5.29	t
Nominal Shear stress	8.27	t/m^2

Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000

100As/bd = 0.33 %

Therefore Permissible shear strsss 25.13 t/m^2 **HENCE SAFE**