GOVERNMENT OF ORISSA

WORKS DEPARTMENT

ORISSA STATE ROAD PROJECT

FINAL DETAIL ENGINEERING REPORT FOR PHASE-I ROADS

DESIGN REPORT OF CULVERTS

BHADRAK TO CHANDBALI (0 - 45 km)
&
BHADRAK TO ANANDPUR (0 - 50 km)

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INTRODUCTION

INTRODUCTION

This report presents the design of culverts.

In **Bhadrak – Chandbali** stretch there are 52 Nos. of culverts and 20 Nos. of culverts has been proposed as additional as per site condition.
In **Bhadrak –Anandpur** stretch there are 99 Nos. of culverts and 7 Nos. of culverts has been introduced as additional.
The total No of culverts recommended has been presented in the subsequent pages for Bhadrak – Chandbali & Bhadrak – Anandpur stretches.

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 in good condition has been retained if horizontal & vertical profile permits.
vii. Additional culverts as per site investigation has been identified and included in this report.

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

Summary of Culverts in the stretch Bhadrak – Chandbali

Type of Culvert	**Nos.**
Culverts Widened	
Slab widening	3
Culverts Replaced	
New Single Box of 1/22/0	33
New Single Box of 1/23/0	8
New Single Box of 1/33/0	1
New Single Box of 1/34/0	1
New Single Box of 1/43/0	3
New Single Box of 1/63/0	1
New Single Box of 1/64/0	1
Additional Culverts proposed	
Single Cell Box of 1/23/0	1
New Single Box of 1/43/0	14
New Single Box of 1/44/0	5
Total	**71**

Summary of Culverts in the stretch Bhadrak – Anandpur

Type of Culvert	Nos.
Culverts Widened	
Pipe extension	12
Culverts Replaced	
New Single Pipe	13
New Double Pipe	22
New Single Box of 1/22/0	15
New Single Box of 1/23/0	10
New Single Box of 1/33/0	10
New Single Box of 1/34/0	7
New Single Box of 1/43/0	3
New Single Box of 1/44/0	2
New Single Box of 1/63/0	1
Additional Culverts proposed	
Single Cell Box of 1/22/0	1
Single Cell Box of 1/23/0	3
Single Cell Box of 1/34/0	3
Total	**102**

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

Summary of recommended Culverts for the stretch Bhadrak – Chandbali

S. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
1	**-**	**0/0**	**-**	**-**	**1/23/0**	**RCC Box**	**Additional structure**
2	2/500	2/507	1 x 3.0	Slab	-	-	To be widened
3	2/800	2/865	1 x 3.0	Slab	-	-	To be widened
4	4/300	4/350	2 x 1.0	Pipe	1/23/0	RCC Box	Replaced due to poor condition
5	4/900	4/935	1 x 2.0	Arch	1/23/0	RCC Box	Replaced due to poor condition
6	**-**	**5/705**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
7	**-**	**5/740**	**-**	**-**	**1/44/0**	**RCC Box**	**Additional structure**
8	6/990	7/001	1 x 0.9	Pipe	1/22/0	RCC Box	Replaced due to poor condition
9	7/900	7/927	1 x 0.9	Pipe	1/22/0	RCC Box	Replaced due to poor condition
10	8/900	8/939	1 x 4.5	Slab	1/64/0	RCC Box	Replaced due to poor condition
11	9/500	9/602	1 x 2.0	Slab	1/23/0	RCC Box	Replaced due to poor condition
12	9/900	9/902	1 x 4.5	Slab	1/63/0	RCC Box	Replaced due to poor condition
13	10/250	10/260	1 x 1.4	Slab	1/22/0	RCC Box	Replaced due to poor condition
14	11/100	11/142	1 x 1.4	Slab	1/23/0	RCC Box	Replaced due to poor condition
15	11/650	11/535	2 x 0.3	Pipe	1/22/0	RCC Box	Replaced due to poor condition
16	12/600	12/397	1 x 0.3	Pipe	1/22/0	RCC Box	Replaced due to poor condition
17	12/900	12/923	1 x 0.9	Pipe	1/22/0	RCC Box	Replaced due to poor condition
18	13/150	13/132	1 x 1.4	Slab	1/23/0	RCC Box	Replaced due to poor condition
19	14/800	14/791	1 x 0.3	Pipe	1/22/0	RCC Box	Replaced due to poor condition
20	**-**	**15/125**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
21	15/600	15/360	1 x 0.3	Pipe	1/22/0	RCC Box	Replaced due to poor condition
22	**-**	**15/425**			**1/43/0**	**RCC Box**	**Additional structure**
23	15/700	15/714	1 x 3.2	Slab	1/43/0	RCC Box	Replaced due to poor condition
24	**-**	**15/750**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
25	**-**	**15/850**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
26	16/500	16/509	1 x 0.6	Pipe	1/23/0	RCC Box	Replaced due to poor condition
27	16/700	16/733	1 x 0.6	Pipe	1/22/0	RCC Box	Replaced due to poor condition

S. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
28	17/100	17/078	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to poor condition
29	17/700	17/666	1 x 0.9	Pipe	1/22/0	RCC Box	Replaced due to poor condition
30	17/900	17/928	1 x 1.0	Pipe	1/22/0	RCC Box	Replaced due to poor condition
31	18/200	18/195	1 x 1.0	Pipe	1/22/0	RCC Box	Replaced due to poor condition
32	18/600	18/627	1 x 1.0	Pipe	1/22/0	RCC Box	Replaced due to poor condition
33	19/100	19/096	1 x 1.0	Pipe	1/22/0	RCC Box	Replaced due to poor condition
34	19/400	19/367	2 x 1.5	Slab	1/33/0	RCC Box	Replaced due to poor condition
35	19/900	19/888	2 x 2.3	Slab	-	-	To be widened
36	20/100	20/144	1 x 1.4	Slab	1/22/0	RCC Box	Replaced due to poor condition
37	20/200	20/365	1 x 0.6	Pipe	1/22/0	RCC Box	Replaced due to poor condition
38	20/700	20/691	1 x 0.6	Pipe	1/22/0	RCC Box	Replaced due to poor condition
39	21/050	21/074	1 x 0.45	Pipe	1/22/0	RCC Box	Replaced due to poor condition
40	21/150	21/235	1 x 0.45	Pipe	1/22/0	RCC Box	Replaced due to poor condition
41	21/400	21/490	1 x 0.6	Pipe	1/22/0	RCC Box	Replaced due to poor condition
42	21/700	21/829	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to poor condition
43	22/700	22/570	1 x 0.9	Pipe	1/22/0	RCC Box	Replaced due to poor condition
44	23/150	23/240	1 x 3.2	Slab	1/43/0	RCC Box	Replaced due to poor condition
45	24/050	24/096	1 x 0.9	Arch	1/22/0	RCC Box	Replaced due to poor condition
46	24/350	24/478	1 x 0.8	Pipe	1/22/0	RCC Box	Replaced due to poor condition
47	24/500	24/770	1 x 1.2	Slab	1/22/0	RCC Box	Replaced due to poor condition
48	25/200	25/249	1 x 1.0	Pipe	1/22/0	RCC Box	Replaced due to poor condition
49	26/400	26/430	-	Choked	1/22/0	RCC Box	**Replaced due to insufficient vent, to be used for Environmental purpose**
50	**-**	**28/225**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
51	**-**	**30/075**	**-**	**-**	**1/44/0**	**RCC Box**	**Additional structure**
52	30/600	30/821	1 x 0.5	Arch	1/22/0	RCC Box	Replaced due to poor condition
53	**-**	**31/400**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
54	**-**	**31/700**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**

S. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
55	**-**	**36/775**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
56	**-**	**36/850**	**-**	**-**	**1/44/0**	**RCC Box**	**Additional structure**
57	**-**	**37/850**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
58	39/300	39/387	2 x 0.45	Pipe	1/22/0	RCC Box	Replaced due to poor condition
59	39/800	39/837	1 x 0.8	Pipe	1/22/0	RCC Box	Replaced due to poor condition
60	40/350	40/310	1 x 0.6	Pipe	1/22/0	RCC Box	Replaced due to poor condition
61	40/950	40/974	1 x 0.9	Pipe	1/23/0	RCC Box	**Replaced due to insufficient vent, to be used for Environmental purpose**
62	**-**	**41/125**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
63	**-**	**41/275**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
64	**-**	**41/375**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
65	**-**	**41/550**	**-**	**-**	**1/43/0**	**RCC Box**	**Additional structure**
66	41/990	41/996	2 x 1.5	Slab	1/34/0	RCC Box	Replaced due to poor condition
67	**-**	**42/225**	**-**	**-**	**1/44/0**	**RCC Box**	**Additional structure**
68	**-**	**42/400**	**-**	**-**	**1/44/0**	**RCC Box**	**Additional structure**
69	43/050	43/061	1 x 0.6	Arch	1/22/0	RCC Box	Replaced due to poor condition
70	43/600	43/771	1 x 4.8	Slab	1/43/0	RCC Box	Replaced due to poor condition
71	44/400	44/315	1 x 1.8	Slab	1/23/0	RCC Box	Replaced due to raising of road level

Summary of recommended Culverts for the stretch Bhadrak – Anandpur

Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
1	1/010	1165	1 x 0.9	Pipe	1/23/0	Box Cell	Replaced due to poor condition
2	1/275	1328	-	Choked	1/23/0	Box Cell	Replaced due to insufficient vent
3	1/900	2010	1 x 0.9	Pipe	1/34/0	Box Cell	Replaced due to insufficient vent
4	2/150	2201	3 x 1.5	Slab	1/44/0	Box Cell	Replaced due to poor condition
5	2/400	2354	3 x 0.9	Pipe	1/23/0	Box Cell	Replaced due to poor condition
6	2/600	2668	1 x 1.8	Slab	1/34/0	Box Cell	Replaced due to poor condition

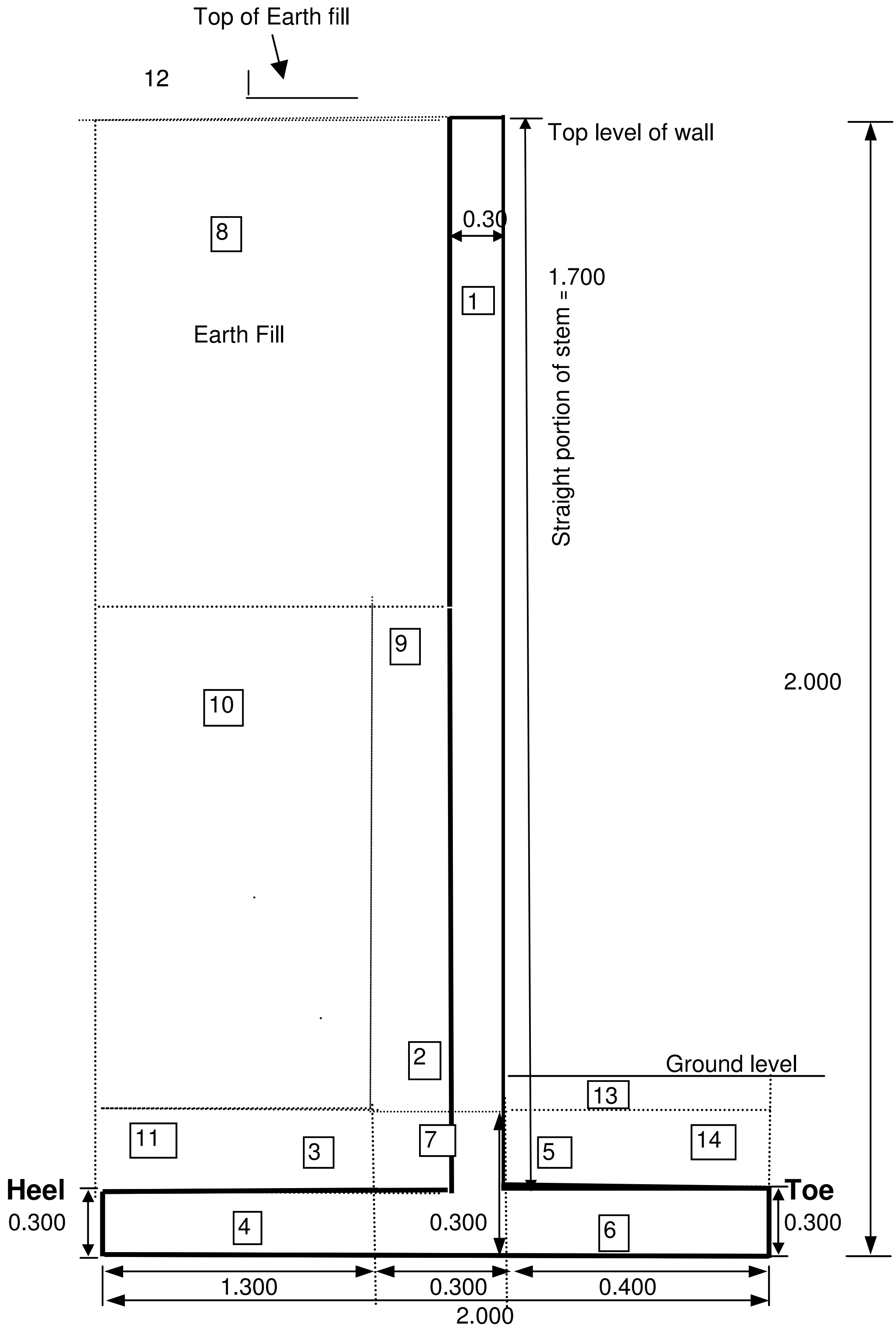
Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
7	3/700	3604	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to poor condition
8	3/900	3979	-	Choked	1/22/0	Box Cell	Replaced due to insufficient vent
9	4/500	4411	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to poor condition
10	5/010	5122	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to raise in road level
11	6/800	6675	1 x 1.5	Slab	2 x 1.0	Pipe	Replaced due to poor condition
12	7/880	7785	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to less carriage way width
13	8/300	8498	1 x 2.7	Slab	2 x 1.0	Pipe	Replaced due to poor condition
14	8/750	8958	1 x 0.6	Pipe	1/23/0	Box Cell	Replaced due to poor condition
15	8/850	9027	2 x 0.9	Pipe	2 x 0.9	-	To be extended
16	10/600	10699	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to less carriage way width
17	11/150	10975	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to poor condition
18	**-**	**11249**	**-**	**-**	**1/22/0**	**Box Cell**	**Additional structure**
19	**-**	**11500**	**-**	**-**	**1/23/0**	**Box Cell**	**Additional structure**
20	12/200	11869	1 x 0.6	Pipe	1 x 1.0	Pipe	**Replaced due to poor condition, to be used for Environmental purpose**
21	13/110	12809	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
22	13/800	13507	1 x 0.6	Pipe	1 x 1.0	Pipe	**Replaced due to poor condition, to be used for Environmental purpose**
23	14/200	13909	1 x 0.9	Pipe	1 x 0.9	-	To be extended
24	14/400	14166	1 x 1.8	Slab	1/22/0	Box Cell	Replaced due to poor condition
25	14/600	14300	1 x 2.4	Slab	1/33/0	Box Cell	Replaced due to raise in road level
26	15/500	15110	2 x 0.9	Pipe	2 x 0.9	-	To be extended
27	17/200	17002	1 x 1.5	Slab	1/22/0	Box Cell	**Replaced due to poor condition, to be used for Environmental purpose**
28	17/300	17123	2 x 0.9	Pipe	1/22/0	Box Cell	Replaced due to poor condition
29	**-**	**17500**	**-**	**-**	**1/34/0**	**Box Cell**	**Additional structure**
30	18/500	17954	2 x 0.9	Pipe	2 x 0.9	-	To be extended
31	18/700	18261	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent

Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
32	18/800	18444	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
33	18/850	18486	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
34	19/250	18902	1 x 0.3	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
35	20/100	19695	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
36	20/800	20426	4 x 0.45	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
37	20/825	20450	1 x 1.3	Slab	1/22/0	Box Cell	Replaced due to poor condition
38	21/050	20648	1 x 4.6	Slab	1/43/0	Box Cell	Replaced due to poor condition
39	21/750	21024	1 x 0.8	Pipe	2 x 1.0	Pipe	**Replaced due to insufficient vent, to be used for Environmental purpose**
40	22/800	22225	2 x 0.6	Pipe	1/34/0	Box Cell	Replaced due to insufficient vent
41	23/600	22794	1 x 0.6	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
42	24/150	23700	1 x 0.3	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
43	24/700	24205	1 x 0.6	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
44	24/750	24375	1 x 0.6	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
45	25/700	25253	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to raise in road level
46	25/710	25265	1 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
47	25/990	25571	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent
48	26/450	26025	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent
49	26/700	26351	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
50	27/050	26645	1 x 0.45	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
51	27/100	26699	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
52	27/800	27440	2 x 0.9	Pipe	2 x 0.9	-	To be extended
53	28/200	27733	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
54	28/950	28531	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
55	29/100	28684	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
56	29/650	29159	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
57	29/700	29250	1 x 0.45	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
58	29/800	29374	2 x 0.9	Pipe	2 x 0.9	-	To be extended

Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
59	30/150	29601	2 x 0.9	Pipe	2 x 0.9	-	To be extended
60	30/500	29984	2 x 0.9	Pipe	2 x 0.9	-	To be extended
61	30/900	30501	2 x 0.9	Pipe	2 x 0.9	-	To be extended
62	31/100	30684	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
63	31/500	31097	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to raise in road level
64	31/800	31353	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent
65	31/900	31484	2 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
66	32/200	31776	4 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to change in alignment
67	32/400	32108	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to change in alignment
68	33/050	32528	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to change in alignment
69	33/450	32964	1 x 3.0	Slab	2 x 1.0	Pipe	Replaced due to poor condition
70	33/500	33013	2 x 0.9	Pipe	1/22/0	Box Cell	Replaced due to change in alignment
71	34/400	33760	1 x 0.9	Pipe	1 x 0.9	-	To be extended
72	34/750	34204	2 x 1.0	Pipe	2 x 1.0	-	To be extended
73	35/300	34662	2 x 1.1	Pipe	2 x 1.0	-	To be extended
74	35/700	34935	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
75	35/900	35281	1 x 1.0	Slab	1/63/0	Box Cell	Replaced due to insufficient vent
76	36/100	35444	1 x 1.0	Slab	1/23/0	Box Cell	Replaced due to poor condition
77	36/250	35495	1 x 1.0	Slab	1/34/0	Box Cell	Replaced due to poor condition
78	36/600	35998	2 x 1.0	Slab	1/34/0	Box Cell	Replaced due to poor condition
79	37/150	36430	1 x 0.6	Pipe	1/23/0	Box Cell	Replaced due to poor condition
80	37/200	36510	1 x 0.6	Pipe	1/34/0	Box Cell	Replaced due to poor condition
81	37/300	36624	1 x 3.15	Slab	1/44/0	Box Cell	Replaced due to raise in road level
82	**-**	**38300**	**-**	**-**	**1/34/0**	**Box Cell**	**Additional structure**
83	38/900	38088	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to change in alignment
84	39/450	38665	2 x 2.5	Arch	1/43/0	Box Cell	Replaced due to poor condition
85	40/500	39657	1 x 0.9	Arch	1/22/0	Box Cell	Replaced due to poor condition
86	40/850	40017	1 x 0.9	Arch	1/22/0	Box Cell	Replaced due to poor condition

Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
87	41/100	40242	2 x 1.8	Arch	1/43/0	Box Cell	**Replaced due to poor condition, to be used for Environmental purpose**
88	41/700	40808	2 x 1.2	Slab	1/33/0	Box Cell	Replaced due to poor condition
89	**-**	**42425**	**-**	**-**	**1/23/0**	**Box Cell**	**Additional structure**
90	43/200	42191	1 x 0.9	Pipe	1/33/0	Box Cell	Replaced due to change in alignment
91	**-**	**43500**	**-**	**-**	**1/34/0**	**Box Cell**	**Additional structure**
92	**-**	**44400**	**-**	**-**	**1/23/0**	**Box Cell**	**Additional structure**
93	45/500	44680	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to poor condition
94	45/700	45094	1 x 1.5	Slab	1/23/0	Box Cell	Replaced due to raise in road level
95	45/900	45275	1 x 1.6	Slab	1/22/0	Box Cell	Replaced due to raise in road level
96	45/990	45395	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to raise in road level
97	46/600	45720	1 x 1.5	Slab	1/23/0	Box Cell	Replaced due to raise in road level
98	46/900	46032	1 x 1.6	Slab	1/23/0	Box Cell	Replaced due to raise in road level
99	47/300	46311	1 x 1.6	Slab	1/23/0	Box Cell	Replaced due to change in alignment
100	47/800	47246	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to raise in road level
101	48/550	47931	1 x 1.5	Slab	1/34/0	Box Cell	Replaced due to raise in road level
102	49/100	48530	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to raise in road level

DESIGN OF RETURN WALL



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

<u>Check for sliding :</u>

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 Mn = 1.210 t-m

<u>Calculation of Base Pressure</u>

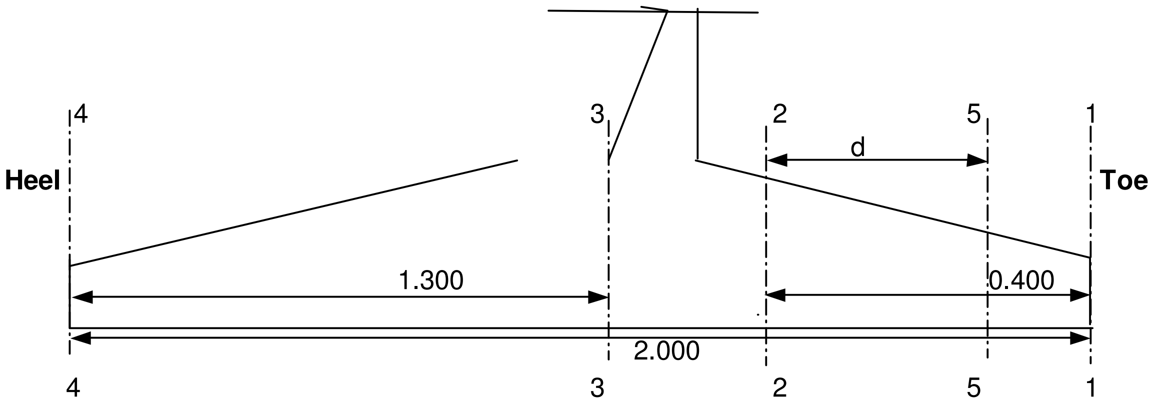
Base pressure due to vertical load V/A = 3.32   Pressure at toe = **5.14** t/m^2

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



DESIGN OF TOE SLAB

Reinforcement calculation

Bending Moment at face of stem	=	0.33	t-m		
Effective depth required	=	0.055	m		
Effective depth provided at face of stem	=	0.217	> reqd	0.055	
Area of Reinforcement reqd.at bottom	=	**0.84**	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	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 = 0.039 %

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	=	0.106	m
Effective depth of slab at face of stem =		0.215	m
Reinforcement reqd.at top =		**3.18**	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 = 0.148 %

Therefore Permissible shear strsss = 18.36 t/m^2 **HENCE SAFE**

DESIGN OF STEM BASE

Section A

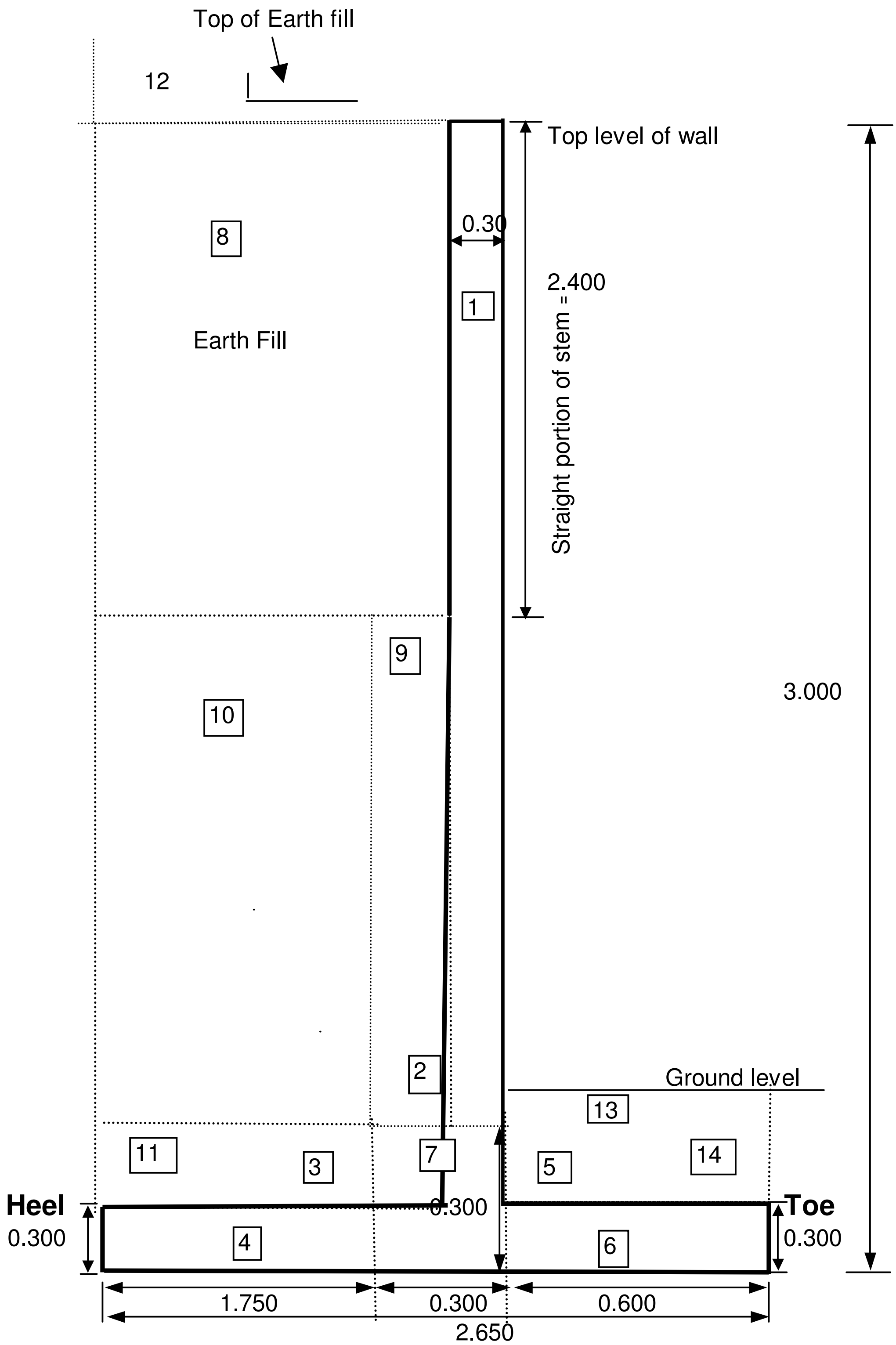
Height of Base of stem from top of earth fill = 1.7 m
Height of Base of stem below straight portion = 5.6E-17 m

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	0.855	1.7	0.727	0.714	0.52
2	L.L.Surcharge	1	0.603	1.7	1.026	0.850	0.87
			Total =		1.75		1.39

Total Horizontal Force 1.75 t
Total Moment about base 1.39 tm
Design bending moment 1.39 t-m
Effective depth required 0.111 m
Thickness of stem at base 0.300 m
Effective depth provided 0.238 > 0.111 **HENCE SAFE**
Area of steel reqd. **3.19** cm^2

Shear check:

Shear force at base of stem 1.75 t
Bending moment at base 1.39 t-m
Net shear force 1.75 t
Nominal Shear stress 7.38 t/m^2
Permissible shear strsss is calculated as per cl.304.7.1.3 of IRC:21-2000
100As/bd = 0.15 %
ActiveEarthPressure 18.40 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
3.000
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	=	1.000	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	0.7	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

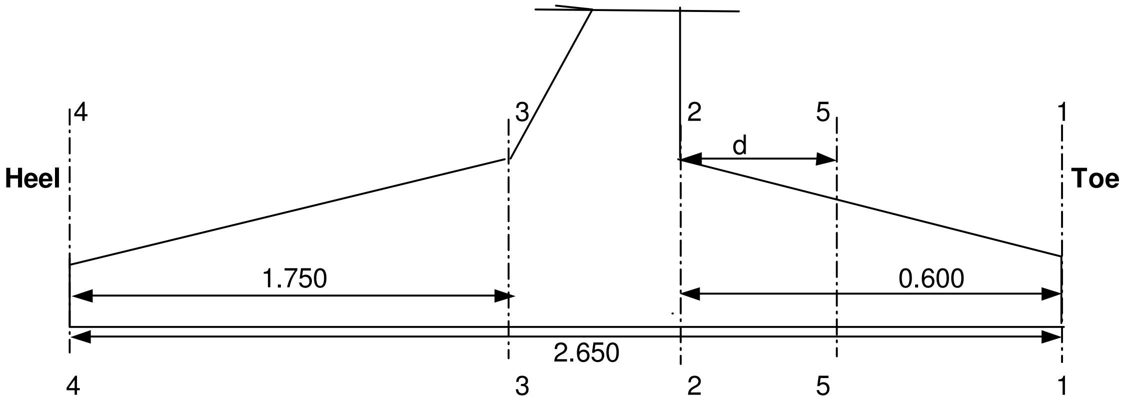
Base pressure due to vertical load V/A = 4.66 Pressure at toe = **7.10** t/m^2

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

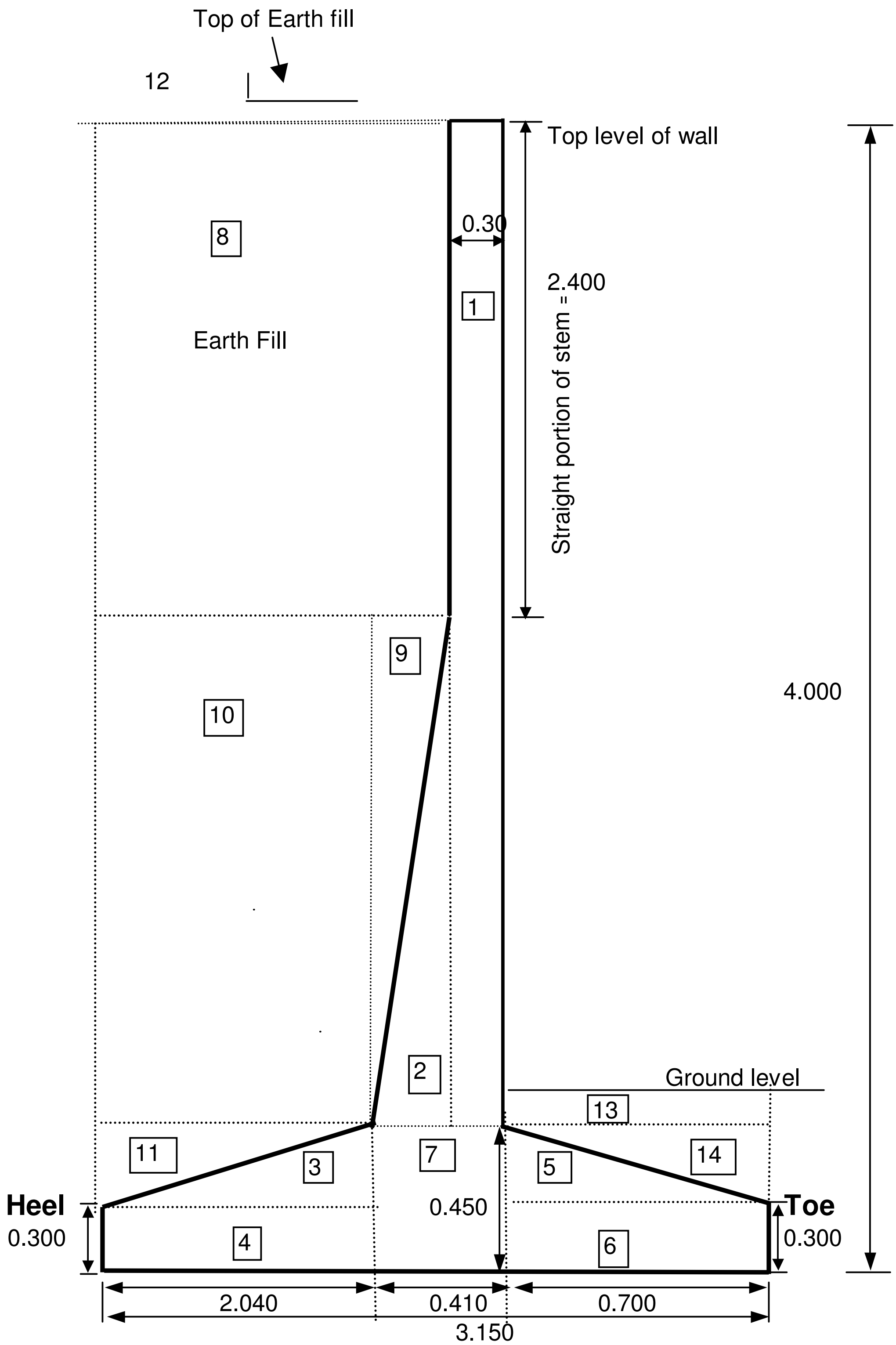
Height of Base of stem from top of earth fill = 2.7 m
Height of Base of stem below straight portion = 0.3 m

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
10
4.000
2
Ground level
13
11
3
7
5
14
Heel
Toe
0.450
0.300
4
6
0.300
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	=	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	=	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

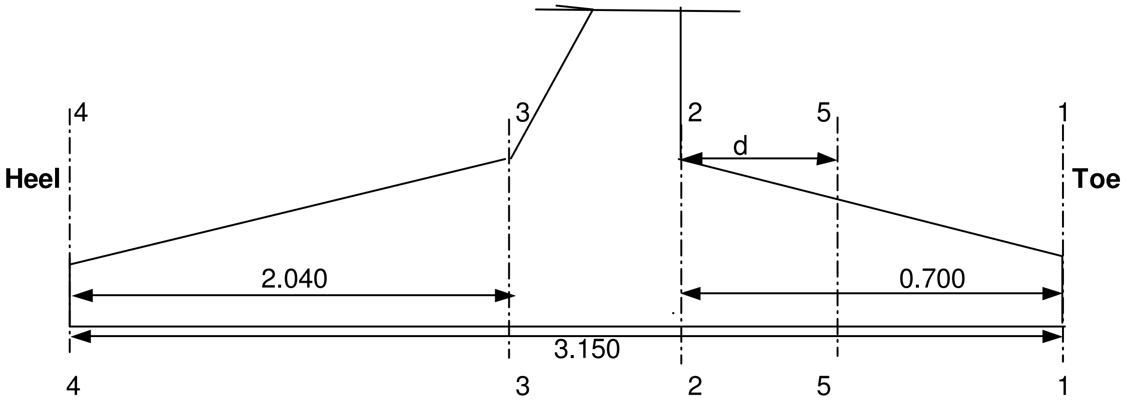
Base pressure due to vertical load V/A = 6.20 Pressure at toe = **10.13** t/m^2

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 = 0.138 m
Effective depth provided at face of stem = 0.367 > reqd 0.138
Area of Reinforcement reqd.at bottom = **3.16** 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 = 0.110 %
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 = 0.253 m
Effective depth of slab at face of stem = 0.365 m
Reinforcement reqd.at top = **10.70** 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 = 0.293 %
Therefore Permissible shear strsss = 23.85 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 = 0.006 m
Effective depth provided = 0.220 > reqd 0.006
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 0.276 m
Thickness of stem at base 0.410 m
Effective depth provided 0.348 > 0.276 **HENCE SAFE**
Area of steel reqd. **13.35** 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 26.82 t/m^2 **HENCE SAFE**


Top of Earth fill
12
Top level of wall
0.30
8
2.400
1
Earth Fill
Straight portion of stem =
9
10
5.000
2
Ground level
13
11
7
14
3
5
Heel
0.500
Toe
0.300
4
6
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	=	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	=	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 vertical load V = 31.806 t
Total restoring moment Mr = 79.68 tm   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

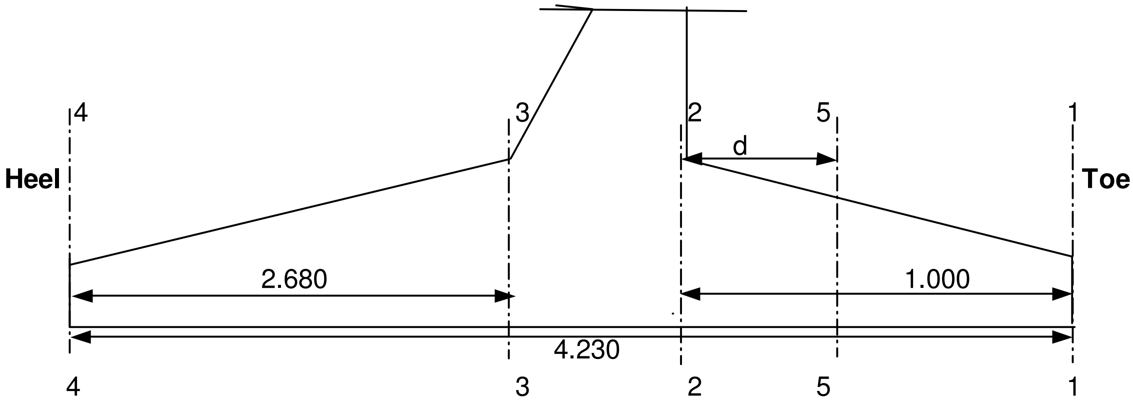
Base pressure due to vertical load V/A = 7.52   Pressure at toe = **10.31** t/m^2

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	=	0.200	m	
Effective depth provided at face of stem	=	0.417	> reqd	0.200
Area of Reinforcement reqd.at bottom	=	**5.86**	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 = 0.177 %

Therefore Permissible shear strsss = 19.46 t/m^2 **HENCE SAFE**

DESIGN OF HEEL SLAB

Bending Moment at face of stem = 11.90 t-m

Effective depth required = 0.326 m

Effective depth of slab at face of stem = 0.415 m

Reinforcement reqd.at top = **15.60** 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 = 0.376 %

Therefore Permissible shear strsss = 26.55 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 = 0.142 m

Effective depth provided = 0.305 > reqd 0.142

Curtailment Length = 1.805

Area of Reinforcement reqd.at bottom = **4.05** cm^2

DESIGN OF STEM BASE

Section A

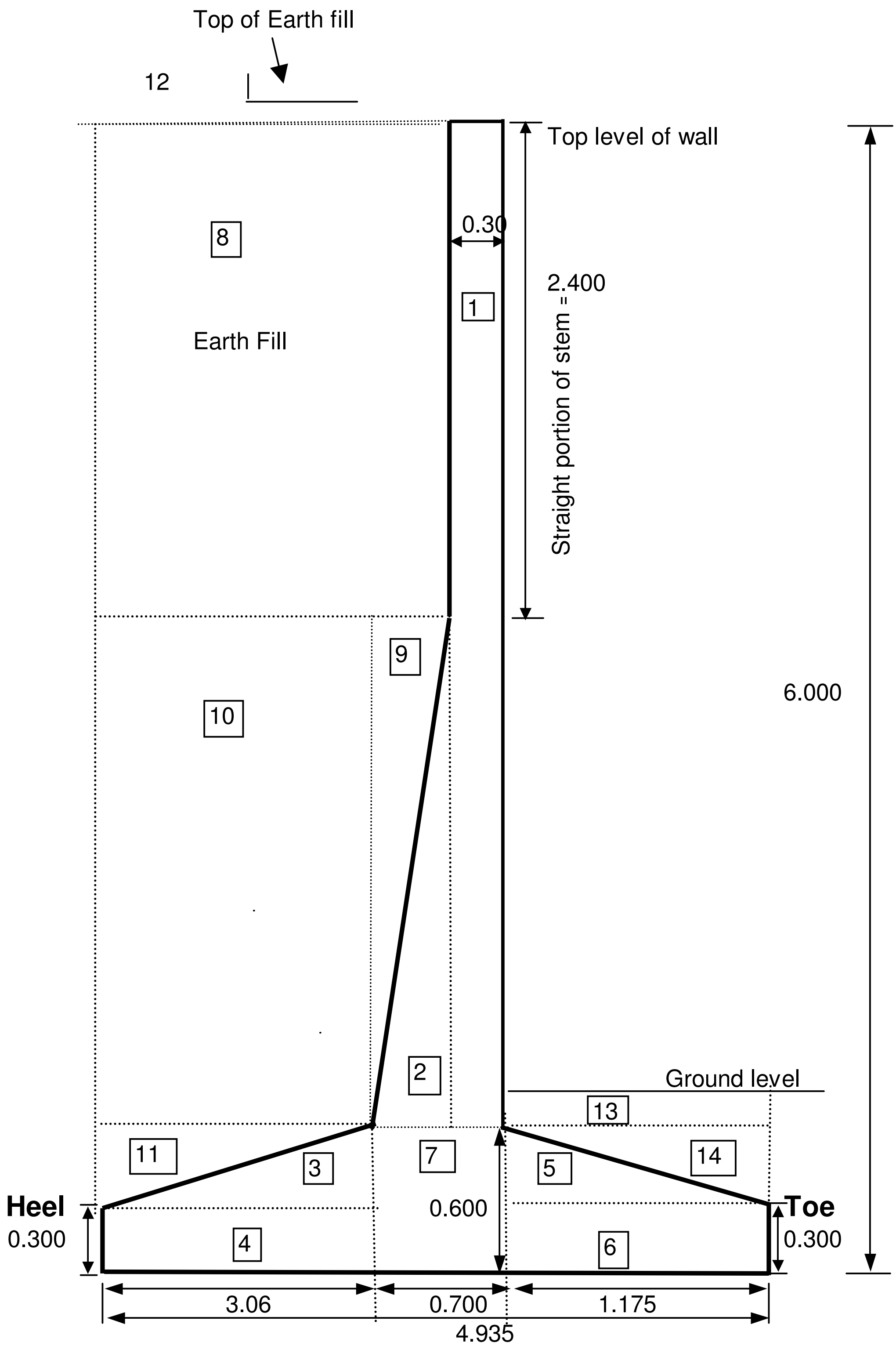
Height of Base of stem from top of earth fill = 4.5 m
Height of Base of stem below straight portion = 2.1 m

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 0.375 m
Thickness of stem at base 0.550 m
Effective depth provided 0.488 > 0.375 **HENCE SAFE**
Area of steel reqd. **17.56** 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 = 0.36 %
Therefore Permissible shear strsss 26.03 t/m^2 **HENCE SAFE**


Top of Earth fill
12
Top level of wall
0.30
8
1
2.400
Straight portion of stem =
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	=	2.000	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	=	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	=	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	1.4	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

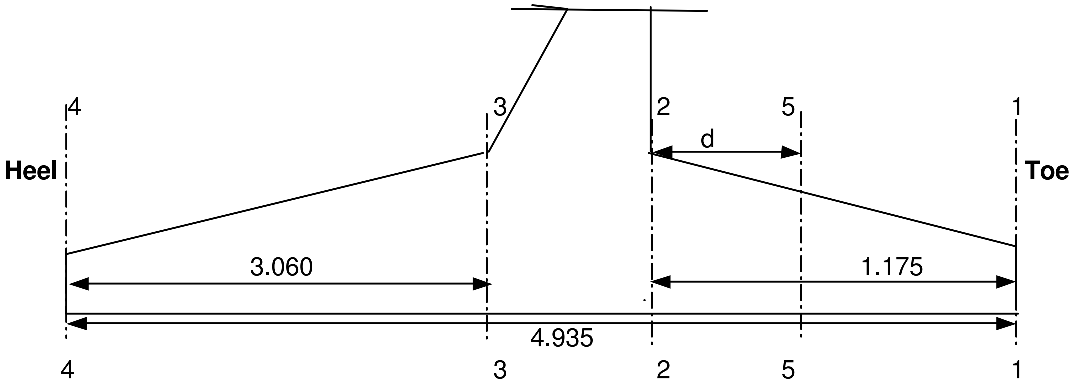
Base pressure due to vertical load V/A = 8.97 Pressure at toe = **12.21** t/m^2

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 = 0.257 m
Effective depth provided at face of stem = 0.519 > reqd 0.257
Area of Reinforcement reqd.at bottom = **7.77** 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 = 0.203 %
Therefore Permissible shear strsss = 20.53 t/m^2 **HENCE SAFE**

DESIGN OF HEEL SLAB

Bending Moment at face of stem = 18.56 t-m
Effective depth required = 0.407 m
Effective depth of slab at face of stem = 0.517 m
Reinforcement reqd.at top = **19.53** 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 = 0.378 %
Therefore Permissible shear strsss = 26.61 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 = 0.139 m
Effective depth provided = 0.321 > reqd 0.139
Curtailment Length = 2.321
Area of Reinforcement reqd.at bottom = **3.68** 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 0.476 m
Thickness of stem at base 0.700 m
Effective depth provided 0.640 > 0.476 **HENCE SAFE**
Area of steel reqd. **21.61** 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 = 0.34 %

Therefore Permissible shear strsss 25.30 t/m^2 **HENCE SAFE**