GOTHATUWA TRANSMISSION MAIN

GREATER COLOMBO NRW PROJECT

Design of Nominal Thrust Blocks and restraint pipe lengths for the transmission main

Comp. By: A. P.	*Check By:*	*Date:* 2/10/00

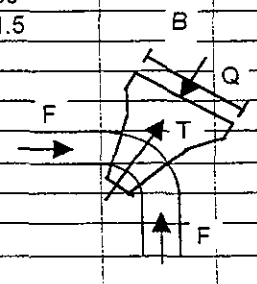
1. DESIGN APPROACH

In situations where subsoil conditions are bad, it would be advisable to provide restrained joints along *the pipe to resist unbalanced thrust at the bends, tees and other specials. It is also prposed to apply* restrained joints at locations with restricted space for a conventional thrust block. However, it would be preferable to provide a thrust block of nominal size at bends and tees with restrained as an added precaution. These nominal sized thrust blocks are designed for 30% of the test pressure, I.e. 5 bar.

2. HORIZONTAL BENDS

2.1 DATA

Pipe material	:	DI/PVC
Design Hydrostatic Pressure, p in N/sq.mm	:	0.5 → Max Hydrostatic Test Press.
Density of soil ρ in kN/m³	:	20
Angle of internal friction "θ" in degrees	:	30
Factor of safety	:	1.5



PLAN

2.2 CALCULATIONS

Hydrostatic force $F = \frac{(\pi/4 * D^2 x p)}{1000}$ kN

Unbalanced Thrust T $2*F*\sin(\alpha/_2 * \pi/_{180})$ kN

Where α = angle of bend in degrees

Soil Constant for passive resistance, $k = \frac{\rho*(1+\sin\theta)}{(1-\sin\theta)}$

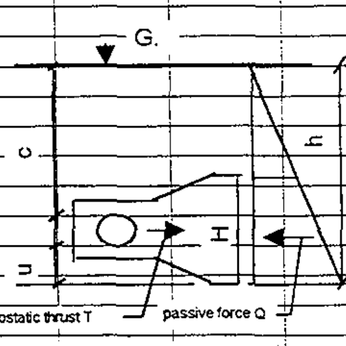
= 60

As an approximation, passive pressure at the bottom is assumed to act uniformly through the entire height of the thrust block based on effective depth of (c+D/2).

Passive pressure, q = k*(c+D/2) kN/sq m

Therefore area required for the thrust block=

=(T/(q))*f sq m



SECTION

	>110	90	
Clear cover c shall be taken as	1	0.75	m and u shall be taken as = 0.5*D

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2.3 RESULTS

On the basis of above approach the following table gives lateral surface areas required for the thrust blocks, for different pipe diameters.

D	c+D/2	q	Lateral Area required in sq.m			
mm	m	kN/m²	$11^1/_4$	$22^1/_2$	45	90
50	0.78	46.50	0.01	0.01	0.02	0.04
90	1.05	62.70	0.01	0.03	0.06	0.11
100	1.05	63.00	0.02	0.04	0.07	0.13
150	1.08	64.50	0.04	0.08	0.16	0.29
200	1.10	66.00	0.07	0.14	0.27	0.51
250	1.13	67.50	0.11	0.21	0.42	0.77
300	1.15	69.00	0.15	0.30	0.59	1.09
350	1.18	70.50	0.20	0.40	0.78	1.45
500	1.25	75.00	0.39	0.77	1.50	2.78
600	1.30	78.00	0.53	1.06	2.08	3.85
800	1.40	84.00	0.88	1.75	3.44	6.35

Estimated size of thrust blocks

D mm	Dimensions of thrust blocks in m. for different horizontal angles							
	111/4		221/2		45		90	
	B	H	B	H	B	H	B	H
50	0.08	0.08	0.11	0.11	0.16	0.16	0.21	0.21
90	0.12	0.12	0.17	0.17	0.24	0.24	0.33	0.33
100	0.14	0.14	0.19	0.19	0.27	0.27	0.36	0.36
150	0.20	0.20	0.28	0.28	0.40	0.40	0.54	0.54
200	0.26	0.26	0.37	0.37	0.52	0.52	0.71	0.71
250	0.33	0.33	0.46	0.46	0.65	0.65	0.88	0.88
300	0.39	0.39	0.55	0.55	0.77	0.77	1.04	1.04
350	0.45	0.45	0.63	0.63	0.89	0.89	1.20	1.20
500	0.62	0.62	0.88	0.88	1.23	1.23	1.67	1.67
600	0.73	0.73	1.03	1.03	1.44	1.44	1.96	1.96
800	0.94	0.94	1.32	1.32	1.85	1.85	2.52	2.52

NOTE:- The above table indicates the practically feasible minimum dimensions to suit the type of bend

3.TEES

3.1 CALCULATIONS

In the case of tees, full hydrostatic force F acting from the direction of lateral pipe needs to be counter balanced by the thrust block, as shown in the figure.

Following the same procedure as above

Area required for the thrust block =(F/q)*f sq m

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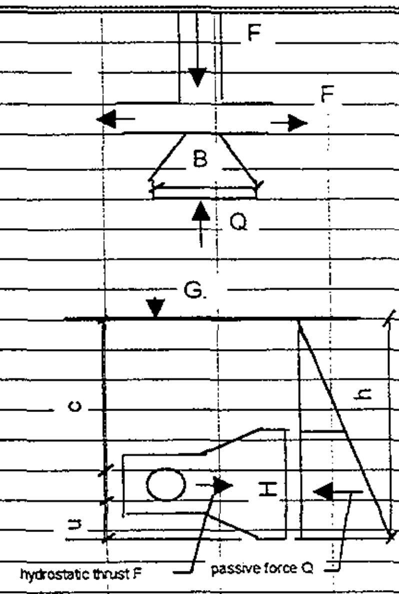
Comp. By: A. P. | *Check By:* | *Date:* 2/10/00

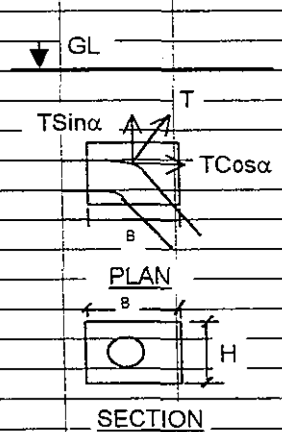
3.2 RESULTS

D	c+D/2	q	Area	B	H
mm	m	kN/m²	sq m	m	m
50	0.78	46.50	0.03	0.18	0.18
90	1.05	62.70	0.08	0.28	0.28
100	1.05	63.00	0.09	0.31	0.31
150	1.08	64.50	0.21	0.45	0.45
200	1.10	66.00	0.36	0.60	0.60
250	1.13	67.50	0.55	0.74	0.74
300	1.15	69.00	0.77	0.88	0.88
350	1.18	70.50	1.02	1.01	1.01
500	1.25	75.00	1.96	1.40	1.40
600	1.30	78.00	2.72	1.65	1.65
800	1.40	84.00	4.49	2.12	2.12



4.VERTICAL UPWARD BEND

4.1 DESIGN APPROACH



In the case of vertical upward bend, unbalanced thrust T acts upwards as shown in the figure. In order to keep the bend in place, this thrust will have to be balanced using either of the following methods;

(1) provision of a thrust block so that its weight plus the soil overburden on top balances the vertical force component TSinα.

(2) provision of restrained joints at the bend plus a number of restrained joints along the pipeline on both sides of the bend.

For larger diameter pipes the method (1) may turn out to be impracticable because, prohibitively large thrust block is required to balance the thrust.

Therefore method (2) is recommended for upward vertical bends. Provide restrained joints on both sides of the bend together with a nominal sized thrust block. Recommended sizes of thrust blocks are given in the following table. The size of thrust block may be adjusted to suit available space.

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Design of Nominal Thrust Blocks and restraint pipe lengths for the transmission main

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D mm	Dimensions of thrust blocks in m. for different vertical angles							
	11 1/4		22 1/2		45		90	
	B	H	B	H	B	H	B	H
50	0.08	0.08	0.09	0.09	0.10	0.10	0.13	0.13
90	0.14	0.14	0.16	0.16	0.18	0.18	0.23	0.23
100	0.15	0.15	0.18	0.18	0.20	0.20	0.25	0.25
150	0.23	0.23	0.26	0.26	0.30	0.30	0.38	0.38
200	0.30	0.30	0.35	0.35	0.40	0.40	0.50	0.50
250	0.38	0.38	0.44	0.44	0.50	0.50	0.63	0.63
300	0.45	0.45	0.53	0.53	0.60	0.60	0.75	0.75
350	0.53	0.53	0.61	0.61	0.70	0.70	0.88	0.88
500	0.75	0.75	0.88	0.88	1.00	1.00	1.25	1.25
600	0.90	0.90	1.05	1.05	1.20	1.20	1.50	1.50
800	1.20	1.20	1.40	1.40	1.60	1.60	2.00	2.00

5. VERTICAL DOWNWARD BEND

As in the case of vertical upward bends, provide restrained joints along the pipeline on both sides of the bend. A nominal size thrust block may be provided merely to keep the bend in place using the same dimensions as indicated above.

6. REQUIRED LENGTHS FOR RESTRAINT

The length of pipeline required to be restrained on each side of the bend is given by;

$L = P*A*(1-\cos \alpha)/\mu*(We+Ww+Wp)$

L = Length of restrained joints on each side of the bend (m)
P = Internal Pressure in N/sq mm
A = Cross-sectional area of the pipe in sq mm
α = Bend deflection in degrees
μ = Coefficient of friction between the pipe and the soil = 0.3
We = Weight of the prism of soil over the pipe (kN/m length of pipe)
Ww = Weight of the contained water (kN/m length of pipe)
Wp = Weight of the pipe (kN/m length of pipe)

D mm	P	A	We	Ww	Wp	L			
	N					11 1/4	22 1/2	45	90
50	1.00	1963	0.75	0.02		0.16	0.65	2.36	8.50
90	1.00	6362	1.35	0.06		0.29	1.14	4.34	15.00
100	1.00	7854	2.00	0.08		0.24	0.96	6.39	12.60
150	1.00	17671	3.00	0.18		0.36	1.41	9.76	18.54
200	1.00	31416	4.00	0.31		0.47	1.85	13.25	24.27
250	1.00	49087	5.00	0.49	0.52	0.52	2.07	15.40	27.24
300	1.00	70686	6.00	0.71	0.68	0.61	2.43	18.56	31.92
350	1.00	96211	7.00	0.96	0.83	0.70	2.78	21.80	36.46
500	1.00	196350	10.00	1.96	0.98	0.97	3.85	33.04	50.55
600	1.00	282743	12.00	2.83	1.34	1.12	4.44	40.04	58.31
800	1.00	502655	16.00	5.03	1.73	1.41	5.61	56.11	73.64

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7. THRUSTBLOCKS FOR TAPERS

The same design concept is applied to size the thrust blocks for tapers. In the case of tapers, resulting differentilal force is balanced by the passive resistence of soil.

Taper size in mm		Force F	c+D/2	q	A	Thrust Block size	
d1	d2	kN	m	kN/sq m	sq m	H m	B m
uPVC							
110	90	1.5708	1.06	63.30	0.03432	0.19	0.19
225	160	9.82729	1.11	66.75	0.18699	0.43	0.43
160	110	5.30144	1.08	64.80	0.10192	0.32	0.32
DI							
250	150	15.708	1.13	67.50	0.2818	0.53	0.53
300	150	26.5072	1.15	69.00	0.45485	0.67	0.67
300	200	19.635	1.15	69.00	0.35525	0.60	0.60
300	250	10.7992	1.15	69.00	0.2272	0.48	0.48
400	200	47.1239	1.20	72.00	0.78016	0.88	0.88
400	250	38.2882	1.20	72.00	0.65744	0.81	0.81
400	300	27.4889	1.20	72.00	0.50745	0.71	0.71
450	300	44.1786	1.23	73.50	0.76011	0.87	0.87
450	400	16.6897	1.23	73.50	0.38611	0.62	0.62
500	300	62.8319	1.25	75.00	1.03411	1.02	1.02
500	400	35.3429	1.25	75.00	0.66759	0.82	0.82
500	450	18.6532	1.25	75.00	0.44506	0.67	0.67
600	300	106.029	1.30	78.00	1.64209	1.28	1.28
600	400	78.5398	1.30	78.00	1.28966	1.14	1.14
600	500	43.1969	1.30	78.00	0.83655	0.91	0.91
700	500	94.2478	1.35	81.00	1.5484	1.24	1.24
700	600	51.0509	1.35	81.00	1.0151	1.01	1.01

GOTHATUWA GROUND RESERVOIR
AND PUMP HOUSE

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW.	JOB NO.
	CALCULATIONS BY Mohd. Luthfy.	SHEET 01 OF ......
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & P. HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT
1.	DATA.	

A). DEAD LOADS:

STAGING AREA SLAB 200mm THK. = 4.8 kN/m²
AVE. 100MM THICK BENCHING ON ROOF = 2.4 "
SCREED & TERRAZZO = 1.8 "
RESERVOIR ROOF SLAB 250mm = 6.0 "
100mm THICK BENCHING CONC. = 2.4 "
200 mm PEBBLE LAYER = 4.8 "
ZINC ALUMINIUM ROOFING WITH PURLINS ETC. = 0.5 "
200mm BLOCK WALL = 3.2 "
DENSITY OF CONCRETE = 24.0 kN/m³
DENSITY OF WATER = 10.0 "

B). LIVE LOADS.

INACCESSIBLE ROOF = 1.0 kN/m²
ON STAGING AREA SLAB = 10.0 "
ON RESERVOIR ROOF = 2.5 "

C). WIND FORCES.

BASIC WIND SPEED = 34.0 m/s.

CHARACTERISTIC WIND PRESSURE
$W_K = 0.613\ V_s^2$ N/m².

WHERE $V_S = S_1 S_2 S_3 V$
$S_1 = 1.0$, $S_3 = 1.0$ & $S_2 = 0.83$ for H = 5.0m.

D). ALLOWABLE SOIL BEARING PRESSURE
= 250.0 kN/m².

CONCRETE f_{cu} = 35.0 N/mm².

REINFORCEMENT f_y = 460.0 "

MILD STEEL = 250.0 "

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW.	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 02 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT
2.	CALCULATION OF WIND FORCES.	
	$W_k = 0.613\, V_s^2$	
	$= 0.613 \times (1.0 \times 0.83 \times 1.0 \times 34)^2$	$W_k = 0.488$ kN/m².
	$= 0.488$ kN/m²	
	BUILDING DIMENSIONS.	
	$l = 24.5\,m,\ b = 11.5\,m\quad h = 5.0$	
	$h \not> \frac{1}{2} b.$	
	ROOF SLOPE $= 15^\circ$.	
	WIND AT RIGHT ANGLE TO BUILDING	
	$C_{pe} = -0.8$ & -0.4	
	WIND PARALLEL TO BUILDING.	
	$C_{pe} = -0.8$ & -0.6	
	TOTAL WIND FORCE F PER FRAME	
	$F = W_k \cdot A\,(C_{pe_1} - C_{pe_2})$	
	$= 0.488 \times 4.0 \times h \times (-0.8 - (-0.4))$	
	$= -0.78\,h$ kN. (SUCTION).	
	WIND FORCE UDL ON FRAME	WIND FORCE
	$= 0.78$ kN/m.	$F = -0.78$ kN/m.

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 03 OF ....
	SCHEME COMPONENT KMU - GOTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

3) DESIGN OF RESERVOIR ROOF SLAB.

BS 8110 : PART 1 : 1985 FOR FLAT SLAB

ULTIMATE DESIGN LOAD ON ROOF SLAB

$$n = 1.4G_k + 1.6Q_k$$

$$= 1.4(6.0+4.8+2.4)+1.6\times2.5$$

$$= 22.48 \ kN/m^2$$

DESIGN LOAD $n = 22.48 \ kN/m^2$

ROOF SLAB ANALYSED IN TWO RIGHT ANGULAR DIRECTION AS FLAT SLAB SUPPORTED ON SET OF COLUMNS WITH UNIFORM GRIDS.

SLAB WIDTH = 5442 mm.

D = 250 mm.

$$\therefore I = \frac{1}{12} bh^3$$

$$= \frac{1}{12} \times 5442 \times 250^3$$

$$= 7.0861 E9 \ mm^4.$$

SLAB WIDTH = 5330 mm.

$$\therefore I = \frac{1}{12} \times 5330 \times 250^3$$

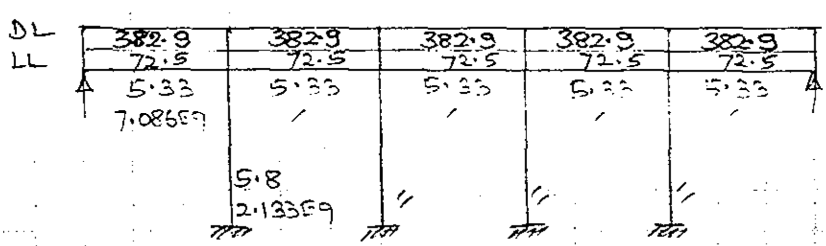
$$= 6.940 E9 \ mm^4.$$

COLUMNS 400 × 400 → $I = \frac{1}{12} \times 400^4$

$= 2.133E9 \ mm^4$.

SLAB MOMENTS & SHEAR ANALYSED USING COMPUTER. BASED ON SLAB-COLUMN FRAME.

FRAME 1 (ALONG THE RESERVOIR PARALLEL TO MIDDLE WALL.



TITLE ROOF FRAME 1

F.O.S FOR DL= 1.4 ***F.O.S. FOR IMPL= 1.6
STRUCTURE INFORMATION NO.OF SPANS= 5

SPAN NO	SPAN LTH-m	Iz- mm^4
1	5.33	7.086E+09
2	5.33	7.086E+09
3	5.33	7.086E+09
4	5.33	7.086E+09
5	5.33	7.086E+09

COLUMN ROW	LENGTH(m)	2ND MOMENT OF AREA(mm^4)	
1.00	0.00	0.00	ABOVE
1.00	0.00	0.00	BELOW
2.00	0.00	0.00	ABOVE
2.00	5.80	%2133000000.00	BELOW
3.00	0.00	0.00	ABOVE
3.00	5.80	%2133000000.00	BELOW
4.00	0.00	0.00	ABOVE
4.00	5.80	%2133000000.00	BELOW
5.00	0.00	0.00	ABOVE
5.00	5.80	%2133000000.00	BELOW
6.00	0.00	0.00	ABOVE
6.00	0.00	0.00	BELOW

******LOADING INFORMATION******

SP.NO	LOAD-kN	ST.DIST-m	COV.DIST-m	DD/IMP
1	382.90	0.00	5.33	D
1	72.50	0.00	5.33	I
2	382.90	0.00	5.33	D
2	72.50	0.00	5.33	I
3	382.90	0.00	5.33	D
3	72.50	0.00	5.33	I
4	382.90	0.00	5.33	D
4	72.50	0.00	5.33	I
5	382.90	0.00	5.33	D
5	72.50	0.00	5.33	I

CANT.CHR.D.MT LHS= 0 kNm CANT.CHR.IMP.MT.LHS = 0 kNm
CANT.CHR.D.MT RHS= 0 kNm CANT.CHR.IMP.MT.RHS = 0 kNm

MAX.SHEARS AND MOMENTS. SF-kN BM-kNm

SPAN NO.	SHEAR	HOG.MT	SAG.MT
1			
	266.76	-0.03	0.00
	-396.73	-376.84	0.00

MAX.SPAN MNT= 290.67 kNm AT A DISTANCE= 2.13 m

SPAN NO.	SHEAR	HOG.MT	SAG.MT
2			
	341.56	-355.60	0.00
	-314.40	-272.84	0.00

MAX.SPAN MNT= 173.21 kNm AT A DISTANCE= 2.66 m

SPAN NO.	SHEAR	HOG.MT	SAG.MT
3			
	326.03	-278.82	0.00

(5)

	-326.03	-278.82	0.00

MAX.SPAN MNT= 200.69 kNm AT A DISTANCE= 2.66 m

4			
	314.40	-272.84	0.00
	-341.56	-355.60	0.00

MAX.SPAN MNT= 173.21 kNm AT A DISTANCE= 2.66 m

5			
	396.73	-376.85	0.00
	-266.76	0.00	0.00

MAX.SPAN MNT= 290.68 kNm AT A DISTANCE= 3.19 m

COLUMN MOMENTS, kN.m

COLUMN ROW	COLUMN MOMENTS ABOVE	BELOW
1.00	0.00	0.00
2.00	0.00	-43.71
3.00	0.00	30.92
4.00	0.00	-30.92
5.00	0.00	43.71
6.00	0.00	0.00

(6)

ITLE ROOF FRAME 2

.O.S FOR DL= 1.4 ***F.O.S. FOR IMPL= 1.6
STRUCTURE INFORMATION* NO.OF SPANS= 6

PAN NO	SPAN LTH-m	Iz- mm^4
1	5.44	6.940001E+09
2	5.44	6.940001E+09
3	5.44	6.940001E+09
4	5.44	6.940001E+09
5	5.44	6.940001E+09
6	5.44	6.940001E+09

OLUMN OW	LENGTH(m)	2ND MOMENT OF AREA(mm^4)	
1.00	0.00	0.00	ABOVE
1.00	0.00	0.00	BELOW
2.00	0.00	0.00	ABOVE
2.00	5.80	%2133000000.00	BELOW
3.00	0.00	0.00	ABOVE
3.00	5.80	%2133000000.00	BELOW
4.00	0.00	0.00	ABOVE
4.00	0.00	0.00	BELOW
5.00	0.00	0.00	ABOVE
5.00	5.80	%2133000000.00	BELOW
6.00	0.00	0.00	ABOVE
6.00	5.80	%2133000000.00	BELOW
7.00	0.00	0.00	ABOVE
7.00	0.00	0.00	BELOW

*****LOADING INFORMATION******

P.NO	LOAD-kN	ST.DIST-m	COV.DIST-m	DD/IMP
1	382.90	0.00	5.44	D
1	72.50	0.00	5.44	I
2	382.90	0.00	5.44	D
2	72.50	0.00	5.44	I
3	382.90	0.00	5.44	D
3	72.50	0.00	5.44	I
4	382.90	0.00	5.44	D
4	72.50	0.00	5.44	I
5	382.90	0.00	5.44	D
5	72.50	0.00	5.44	I
6	382.90	0.00	5.44	D
6	72.50	0.00	5.44	I

ANT.CHR.D.MT LHS= 0 kNm CANT.CHR.IMP.MT.LHS = 0 kNm
ANT.CHR.D.MT RHS= 0 kNm CANT.CHR.IMP.MT.RHS = 0 kNm

IAX.SHEARS AND MOMENTS. SF-kN BM-kNm

PAN NO.	SHEAR	HOG.MT	SAG.MT
1			
	266.56	-0.03	0.04
	-396.98	-386.09	0.00

MAX.SPAN MNT= 296.41 kNm AT A DISTANCE= 2.17 m

PAN NO.	SHEAR	HOG.MT	SAG.MT
2			
	342.54	-363.98	0.00

(7)

	-312.93	-274.13	0.00

MAX.SPAN MNT= 178.91 kNm AT A DISTANCE= 2.72 m

3			
	325.52	-278.96	0.00
	-330.65	-304.08	0.00

MAX.SPAN MNT= 203.62 kNm AT A DISTANCE= 2.72 m

4			
	330.65	-304.08	0.00
	-325.52	-278.96	0.00

MAX.SPAN MNT= 203.62 kNm AT A DISTANCE= 2.72 m

5			
	312.93	-274.13	0.00
	-342.54	-363.98	0.00

MAX.SPAN MNT= 178.91 kNm AT A DISTANCE= 2.72 m

6			
	396.97	-386.08	0.00
	-266.57	-0.00	0.00

MAX.SPAN MNT= 296.39 kNm AT A DISTANCE= 3.26 m

COLUMN MOMENTS, kN.m

COLUMN ROW	COLUMN MOMENTS ABOVE	BELOW
1.00	0.00	0.00
2.00	0.00	-46.15
3.00	0.00	32.44
4.00	0.00	0.00
5.00	0.00	-32.43
6.00	0.00	46.14
7.00	0.00	0.00

'ITLE ROOF FRAME 1 SERVICE LOAD

'.O.S FOR DL= 1 ***F.O.S. FOR IMPL= 1
'**STRUCTURE INFORMATION*** NO.OF SPANS= 5

SPAN NO	SPAN LTH-m	Iz- mm^4
1	5.33	7.086E+09
2	5.33	7.086E+09
3	5.33	7.086E+09
4	5.33	7.086E+09
5	5.33	7.086E+09

COLUMN ROW	LENGTH(m)	2ND MOMENT OF AREA(mm^4)	
1.00	0.00	0.00	ABOVE
1.00	0.00	0.00	BELOW
2.00	0.00	0.00	ABOVE
2.00	5.80	%2133000000.00	BELOW
3.00	0.00	0.00	ABOVE
3.00	5.80	%2133000000.00	BELOW
4.00	0.00	0.00	ABOVE
4.00	5.80	%2133000000.00	BELOW
5.00	0.00	0.00	ABOVE
5.00	5.80	%2133000000.00	BELOW
6.00	0.00	0.00	ABOVE
6.00	0.00	0.00	BELOW

*****LOADING INFORMATION******

SP.NO	LOAD-kN	ST.DIST-m	COV.DIST-m	DD/IMP
1	382.90	0.00	5.33	D
1	72.50	0.00	5.33	I
2	382.90	0.00	5.33	D
2	72.50	0.00	5.33	I
3	382.90	0.00	5.33	D
3	72.50	0.00	5.33	I
4	382.90	0.00	5.33	D
4	72.50	0.00	5.33	I
5	382.90	0.00	5.33	D
5	72.50	0.00	5.33	I

CANT.CHR.D.MT LHS= 0 kNm CANT.CHR.IMP.MT.LHS = 0 kNm
CANT.CHR.D.MT RHS= 0 kNm CANT.CHR.IMP.MT.RHS = 0 kNm

MAX.SHEARS AND MOMENTS. SF-kN BM-kNm

SPAN NO.	SHEAR	HOG.MT	SAG.MT
1			
	181.40	-0.01	0.00
	-277.08	-263.19	0.00

MAX.SPAN MNT= 192.55 kNm AT A DISTANCE= 2.13 m

SPAN NO.	SHEAR	HOG.MT	SAG.MT
2			
	238.54	-248.35	0.00
	-217.91	-190.55	0.00

MAX.SPAN MNT= 98.23001 kNm AT A DISTANCE= 2.66 m

SPAN NO.	SHEAR	HOG.MT	SAG.MT
3			
	227.70	-194.73	0.00

-227.70 -194.73 0.00 (9)

MAX.SPAN MNT= 120.82 kNm AT A DISTANCE= 2.66 m

4

217.91 -190.55 0.00
-238.54 -248.35 0.00

MAX.SPAN MNT= 98.23001 kNm AT A DISTANCE= 2.66 m

5

277.08 -263.19 0.00
-181.40 0.00 0.00

MAX.SPAN MNT= 192.56 kNm AT A DISTANCE= 3.19 m

COLUMN MOMENTS, kN.m

COLUMN ROW	COLUMN MOMENTS ABOVE	BELOW
1.00	0.00	0.00
2.00	0.00	-20.89
3.00	0.00	10.89
4.00	0.00	-10.89
5.00	0.00	20.89
6.00	0.00	0.00

'ITLE ROOF FRAME 2 SERVICE LOAD

'.O.S FOR DL= 1 ***F.O.S. FOR IMPL= 1
:**STRUCTURE INFORMATION*** NO.OF SPANS= 6

;PAN NO	SPAN LTH-m	Iz- mm^4
1	5.44	6.940001E+09
2	5.44	6.940001E+09
3	5.44	6.940001E+09
4	5.44	6.940001E+09
5	5.44	6.940001E+09
6	5.44	6.940001E+09

OLUMN OW	LENGTH(m)	2ND MOMENT OF AREA(mm^4)	
1.00	0.00	0.00	ABOVE
1.00	0.00	0.00	BELOW
2.00	0.00	0.00	ABOVE
2.00	5.80	%2133000000.00	BELOW
3.00	0.00	0.00	ABOVE
3.00	5.80	%2133000000.00	BELOW
4.00	0.00	0.00	ABOVE
4.00	0.00	0.00	BELOW
5.00	0.00	0.00	ABOVE
5.00	5.80	%2133000000.00	BELOW
6.00	0.00	0.00	ABOVE
6.00	5.80	%2133000000.00	BELOW
7.00	0.00	0.00	ABOVE
7.00	0.00	0.00	BELOW

*****LOADING INFORMATION******

P.NO	LOAD-kN	ST.DIST-m	COV.DIST-m	DD/IMP
1	382.90	0.00	5.44	D
1	72.50	0.00	5.44	I
2	382.90	0.00	5.44	D
2	72.50	0.00	5.44	I
3	382.90	0.00	5.44	D
3	72.50	0.00	5.44	I
4	382.90	0.00	5.44	D
4	72.50	0.00	5.44	I
5	382.90	0.00	5.44	D
5	72.50	0.00	5.44	I
6	382.90	0.00	5.44	D
6	72.50	0.00	5.44	I

\NT.CHR.D.MT LHS= 0 kNm CANT.CHR.IMP.MT.LHS = 0 kNm
\NT.CHR.D.MT RHS= 0 kNm CANT.CHR.IMP.MT.RHS = 0 kNm

.X.SHEARS AND MOMENTS. SF-kN BM-kNm

'AN NO.	SHEAR	HOG.MT	SAG.MT
1			
	181.25	0.00	0.02
	-277.25	-269.65	0.00

MAX.SPAN MNT= 196.27 kNm AT A DISTANCE= 2.17 m

2			
	239.23	-254.21	0.00

	-217.09	-191.45	0.00

MAX.SPAN MNT= 101.61 kNm AT A DISTANCE= 2.72 m

3			
	225.58	-194.83	0.00
	-230.92	-212.37	0.00

MAX.SPAN MNT= 120.08 kNm AT A DISTANCE= 2.72 m

4			
	230.92	-212.37	0.00
	-225.58	-194.83	0.00

MAX.SPAN MNT= 120.08 kNm AT A DISTANCE= 2.72 m

5			
	217.09	-191.46	0.00
	-239.23	-254.20	0.00

MAX.SPAN MNT= 101.61 kNm AT A DISTANCE= 2.72 m

6			
	277.25	-269.64	0.00
	-181.25	-0.00	0.00

MAX.SPAN MNT= 196.27 kNm AT A DISTANCE= 3.26 m

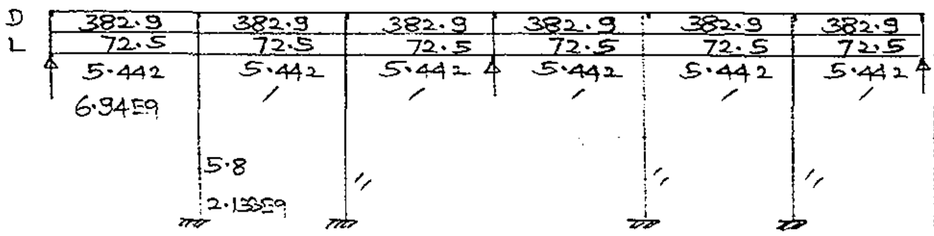
COLUMN MOMENTS, kN.m

COLUMN	COLUMN MOMENTS	
ROW	ABOVE	BELOW
1.00	0.00	0.00
2.00	0.00	-21.91
3.00	0.00	10.81
4.00	0.00	0.00
5.00	0.00	-10.81
6.00	0.00	21.91
7.00	0.00	0.00

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY	SHEET 12 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

FRAME 2. (ACCROSS THE RESERVOIR).



FRAME ①. - DESIGN BASED ON BS8110 - 3.7.

MAX. SUPPORT BM (-)VE = 376.84 KNm.

TABLE 3.20 BS 8110.

∴ COLUMN STRIP 75% = 282.63 KNm.

MIDDLE STRIP 25% = 94.21 "

MAX. SPAN BM (+VE) = 290.67 KNm.

COLUMN STRIP 55% = 159.9 KNm.

MIDDLE STRIP 45% = 130.8 "

WIDTH OF COLUMN STRIP $= 2 \times \frac{l}{4} = 2 \times \frac{5.33}{4}$

$= \underline{\underline{2.665}}$ m.

WIDTH OF MIDDLE STRIP = 5.442 - 2.665

$= \underline{\underline{2.777}}$ m.

REINFORCEMENT.

NEGATIVE - OVER THE SUPPORT

TOP BAR.

$d = 250 - 40 - \frac{16}{2} = 202$ mm.

BM = 282.63 KNm.

$$\frac{M}{bd^2} = \frac{282.63 \times 10^6}{2665 \times 202^2} = 2.6$$

$$\therefore \frac{100 A_s}{bd} = 0.72 \Rightarrow A_s = \frac{0.72}{100} \times 2665 \times 202$$

$= 3876.0$ mm²

$\frac{2}{3} A_s = 2584.0$ mm² — T16@100 - over 1333 CENTRE COL.W

$\frac{1}{3} A_s = 1292.0$ mm² — T16@200 - over 1333 REST OF COL.W

OUT PUT: PROVIDE T16@200 OVER 2665 & T16@200 OVER 1333 - COLUMN WIDTH - MID.

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 13 OF ......
	SCHEME COMPONENT KMU- GOTHTHATUWA RESERVOIR & PUMP HOUSE	DATE

ITEM	CALCULATIONS	OUT PUT

NEGATIVE → MIDDLE STRIP TOP BAR.

BM = 94.21 kNm.
d = 205.0 mm. & b = 2777 mm.

$\frac{M}{bd^2} = \frac{94.21 \times 10^6}{2777 \times 205^2} = 0.81$

$\frac{100A_s}{bd} = 0.22.$

$\therefore A_s = \frac{0.22 \times 2777 \times 205}{100} = 1252.4 \text{ mm}^2$

$= \frac{1252.4}{2.777} = 451.0 \text{ mm}^2/\text{m}.$

PROVIDE T10 @ 150 c/c → $A_s = 523.0 \text{ mm}^2/\text{m}$ — MIDDLE STRIP TOP BAR T10 @ 150 c/c

POSITIVE BM – COLUMN STRIP BOTTOM BAR.

M = 159.9 kNm.
b = 2665 mm
d = 250 − 40 − $\frac{12}{2}$ = 204.0 mm.

$\frac{M}{bd^2} = \frac{159.9 \times 10^6}{2665 \times 204^2} = 1.44$

$\frac{100A_s}{bd} = 0.39 \Rightarrow A_s = \frac{0.39 \times 2665 \times 204}{100}$

$= 2120.3 \text{ mm}^2$

$= \frac{2120.3}{2.665} = 795.6 \text{ mm}^2/\text{m}$

PROVIDE T12 @ 125 c/c → $A_s = 904.0 \text{ mm}^2$ — COLUMN STRIP BOTTOM BAR T12 @ 125 c/c.

POSITIVE BM – MIDDLE STRIP BOTTOM BAR.

M = 130.8 kNm.
b = 2777 mm & d = 204 mm.

$\frac{M}{bd^2} = \frac{130.8 \times 10^6}{2777 \times 204^2} = 1.13$

$\frac{100A_s}{bd} = 0.31 \rightarrow A_s = \frac{0.31 \times 2777 \times 204}{100}$

$= 1756.2 \text{ mm}^2$

$= 632.4 \text{ mm}^2/\text{m}.$ — MIDDLE STRIP BOTTOM BAR

PROVIDE T12 @ 175 → $A_s = 646.0 \text{ mm}^2/\text{m}$ — T12 @ 175 c/c.

CEYWATER CONSULTANT (PVT) LTD.	PROJECT NRW.	JOB NO.
INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	CALCULATIONS BY MOHD. LUTHFY.	SHEET 14 OF ......
	SCHEME KMU - GOTHTHATUWA RESERVOIR COMPONENT - PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT
	FRAME (2).	
	MAX^M. SUPPORT BM (-VE) = 386.09 kNm.	
	COLUMN STRIP 75% = 289.6 kNm. MIDDLE STRIP 25% = 96.5 kNm.	
	MAX^M. SPAN BM (+VE) = 296.41 kNm.	
	COLUMN STRIP 55% = 163.0 kNm. MIDDLE STRIP 45% = 133.4 "	
	WIDTH OF COLUMN STRIP = 2665.0mm. WIDTH OF MIDDLE STRIP = 5330 - 2665 = 2665.0 mm.	
	REINFORCEMENT.	
	NEGATIVE OVER THE SUPPORT (TOP BAR)	
	$M = 289.6$ kNm. $d = 250 - 40 - \frac{16}{2} = 202$ mm. $b = 2665.0$ mm.	
	$\frac{M}{bd^2} = \frac{289.6 \times 10^6}{2665.0 \times 202.0^2} = 2.66$	
	$\frac{100 A_s}{bd} = 0.74 \rightarrow A_s = \frac{0.74 \times 2665.0 \times 202}{100}$ $= 3983.6 \text{ mm}^2$	
	$\frac{2}{3} A_s = 2655.7 \text{ mm}^2$ over 1333.0 mm (MID)	
	$\frac{1}{3} A_s = 1327.9 \text{ mm}^2$ over 1333.0 (REST)	
	∴ PROVIDE T16@100 OVER 1333.0 mm $= 2010.0 \text{ mm}^2/\text{m}$ MID OF MIDDLE STRIP.	PROVIDE
	T16@200 OVER REST OF 1333.0 mm $= 1005.0 \text{ mm}^2/\text{m}$.	T16@200 OVER 2665.0 mm WIDTH & T16@200 ADD^L OVER 1333.0 MIDDLE AREA OF COL. STRIP

ITEM	CALCULATIONS	OUT PUT
	NEGATIVE - MIDDLE STRIP - TOP BAR.	
	$M = 96.5$ kNm. $b = 2665.0$ mm $d = 205.0$ mm.	
	$\frac{M}{bd^2} = \frac{96.5 \times 10^6}{2665.0 \times 205.0^2} = 0.86$	
	$\frac{100A_s}{bd} = 0.23 \rightarrow A_s = \frac{0.23 \times 2665.0 \times 205.0}{100}$ $= 1256.5\ mm^2$ $= 471.5\ mm^2/m$.	
	PROVIDE T10@ 150 c/c $\rightarrow A_s = 523.0\ mm^2/m$	MIDDLE STRIP TOP BAR T10 @ 150 c/c.
	POSITIVE BM. COLUMN STRIP BOTTOM BAR	
	$M = 163.0$ kNm. $b = 2665.0$ mm. $d = 204.0$ mm.	
	$\frac{M}{bd^2} = \frac{163.0 \times 10^6}{2665.0 \times 204.0^2} = 1.47$	
	$\frac{100A_s}{bd} = 0.4 \rightarrow A_s = \frac{0.4 \times 2665.0 \times 204.0}{100}$ $= 2174.6\ mm^2$ $= 816.0\ mm^2/m$.	
	PROVIDE T12 @ 125 c/c $\rightarrow A_s = 904.0\ mm^2/m$	COLUMN STRIP BOTTOM BAR T12 @ 125 c/c.
	POSITIVE BM - MIDDLE STRIP - BOTTOM BAR. $M = 133.4$ kNm. $b = 2665.0$ mm , $d = 204.0$ mm.	
	$\frac{M}{bd^2} = \frac{133.4 \times 10^6}{2665.0 \times 204.0^2} = 1.2$	
	$\frac{100A_s}{bd} = 0.33 \rightarrow A_s = \frac{0.33 \times 2665.0 \times 204.0}{100}$ $= 1794.1\ mm^2 \rightarrow 673.2\ mm^2/m$	
	PROVIDE T12@ 150 c/c $\rightarrow A_s = 753.0\ mm^2$	MIDDLE STRIP BOTTOM BAR T12 @150 c/c.

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 16 OF ....
	SCHEME COMPONENT KMU - GOTHTUATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT
	CHECK FOR DEFLECTION.	
	BS 8110 : PART 1 : 1985 CLAUSE 3.7.8 & 3.4.6	
	$\frac{l}{d} = 26$ CONTINUOUS SPANS	
	FACTOR = 0.9 FOR DROPS < $\frac{1}{3}$ x SPAN.	
	$\frac{M}{bd^2} = 1.47$	
	MODIFICATION FACTOR = 1.2202.	
	∴ ALLOWABLE SPAN = 26 x 1.2202 x 0.9 x 204	
	= 5825.0 mm > 5442.0 mm.	DEFLECTION OK
	∴ DEFLECTION CRITERIA SATISFACTORY.	

DESIGN OF CRACK.

BS 8007 : 1987

Reservoir Roof Slab

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3acr.Em}{1+2\left(\dfrac{acr - Cmin}{(h-x)}\right)}$

$$\mathcal{E}m = \mathcal{E}_1 - \frac{bt\,(h-x)(a'-x)}{3Es.\,As\,(d-x)}$$

SERVICE MOMENT M = 75.9 KNM/M

h (mm) = 250 Cmin = 40 (mm) Φ = 16.00 mm

d = h - Cmin - Φ/2 d = 202.00 mm

CONCRETE f cu = 35 N/mm^2

fy = 460 N/mm^2

REINFORCEMENT PROVIDED BAR DIAMETER Φ = 16 mm

BAR SPACING S = 100 mm

Asp = 2010.62 mm^2

Ec = 28 KN/mm^2

Es = 200 KN/mm^2

$\alpha e = Es/\ 1/2Ec$ = 14.29

ρ = 0.00995

$\alpha e.\rho$ = 0.142

THEREFORE $\dfrac{x}{d} = -\alpha e\,(\rho + \rho') + \sqrt{\alpha e^2\,(\rho + \rho')^2 + 2\alpha e\,(\rho + \dfrac{d'}{d}\rho')}$ = 0.410

CONSIDERING $\rho' = 0$

THEREFORE x = 82.76 mm

z = d - 1/3 x = 174.41 mm

$fs = \dfrac{M}{Asp.z}$ = 216.44 N/mm^2

$\mathcal{E}s = \dfrac{fs}{Es \times 1000}$ = 0.0010822

(18)

$$\varepsilon_1 = \frac{(h - x)}{(d - x)} * \varepsilon_s = 0.001518$$

ε_m = 0.0013234

1) <u>CRACK UNDER THE BAR DIRECTLY</u>

acr = Cmin = 40 mm

ω = 3.acr.ε_m = **0.159 mm**

< **0.2mm** O.K

2) <u>CRACK AT MIDWAY BETWEEN TWO BARS</u>

$$acr + \phi/2 = \sqrt{(S/2)^2 + (\phi/2 + Cmin)^2} = 69.31$$

acr = 61.31 mm

ω = **0.194 mm**

< **0.2mm** O.K

THERFORE BARS T16 @ 100 C/C O.K

DESIGN OF CRACK.

BS 8007 : 1987

Reservoir Roof Slab - Middle strip Bottom

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3acr.Em}{1+2\left(\dfrac{acr - Cmin}{h - x}\right)}$

$$\varepsilon m = \varepsilon_1 - \frac{bt\,(h - x)(a' - x)}{3Es.\,As\,(d - x)}$$

SERVICE MOMENT M = 33.1 KNM/M

h (mm) = 250 Cmin = 40 (mm) Φ = 12.00 mm

d = h - Cmin - Φ/2 d = 204.00 mm

CONCRETE f cu = 35 N/mm^2

fy = 460 N/mm^2

REINFORCEMENT PROVIDED BAR DIAMETER Φ = 12 mm

BAR SPACING S = 150 mm

Asp = 753.98 mm^2

Ec = 28 KN/mm^2

Es = 200 KN/mm^2

αe = Es/ 1/2Ec = 14.29

ρ = 0.00370

$\alpha e.\rho$ = 0.053

THEREFORE $\dfrac{x}{d} = -\alpha e\,(\rho + \rho') + \sqrt{\alpha e^2\,(\rho + \rho')^2 + 2\alpha e\left(\rho + \dfrac{d'}{d}\rho'\right)}$ = 0.276

CONSIDERING $\rho' = 0$

THEREFORE x = 56.39 mm

z = d - 1/3 x = 185.20 mm

$fs = \dfrac{M}{Asp.z}$ = 237.04 N/mm^2

$\varepsilon s = \dfrac{fs}{Es \times 1000}$ = 0.0011852

$$\varepsilon_1 = \frac{(h-x)}{(d-x)} * \varepsilon_s = 0.001555$$

$$\varepsilon_m = 0.0009932$$

1) CRACK UNDER THE BAR DIRECTLY

$acr = C_{min} = 40$ mm

$\omega = 3.acr.\varepsilon_m = 0.119$ mm

< 0.2mm O.K

2) CRACK AT MIDWAY BETWEEN TWO BARS

$$acr + \phi/2 = \sqrt{(S/2)^2 + (\phi/2 + C_{min})^2} = 87.98$$

$acr = 81.98$ mm

$\omega = 0.170$ mm

< 0.2mm O.K

THEREFORE BARS T12 @ 150 C/C O.K

CHECK FOR THERMAL CRACK
Reservoir Roof Slab
BS 8007, APPENDIX A.3

CRACK SPACING $S_{max} = \frac{f_{ct}}{f_b} \times \frac{\Phi}{2\rho}$

FROM TABLE A.1 $\frac{f_{ct}}{f_b}$ = 0.67

FOR R/F PROVIDED

BAR DIAMETER Φ = 10 mm

BAR SPACING S = 150 mm

Asp = 523.81 mm^2

USING SURFACE ZONES AS PER FIG A.2 BS 8007 h = 125 mm

$\rho = \frac{Asp}{1000 \cdot h}$ = 0.0041905

Smax = 799.43 mm

MAXIMUM CRACK WIDTH DUE TO CHANGE IN TEMPERATURE T1 & T2

BS 8007 - APPENDIX A.3 $\omega_{max} = S_{max} \cdot \frac{\alpha(T1+T2)}{2}$

α = 0.00001 /°C

T1= 25°C FOR WALL OF 250mm THICK

THEREFORE

T1 = 25 °C
T2 = 15 °C

ω_{max} = **0.1598864 mm** **< 0.2mm**

THERMAL CRACK OK

CHECK FOR THERMAL CRACK

Reservoir Roof Slab

BS 8007, APPENDIX A.3

CRACK SPACING $S_{max} = \frac{f_{ct}}{f_b} \times \frac{\Phi}{2\rho}$

FROM TABLE A.1 $\frac{f_{ct}}{f_b}$ = 0.67

FOR R/F PROVIDED BAR DIAMETER Φ = 16 mm

BAR SPACING S = 200 mm

Asp = 1005.71 mm^2

USING SURFACE ZONES AS PER FIG A.2 BS 8007 h = 125 mm

$\rho = \frac{Asp}{1000 \cdot h}$ = 0.0080457

Smax = 666.19 mm

MAXIMUM CRACK WIDTH DUE TO CHANGE IN TEMPERATURE T1 & T2

BS 8007 - APPENDIX A.3 $\omega max = Smax \cdot \frac{\alpha(T1+T2)}{2}$

α = 0.00001 / °C

T1= 25°C FOR WALL OF 250mm THICK

THEREFORE T1 = 25 °C

T2 = 15 °C

ωmax = **0.1332386 mm** **< 0.2mm**

THERMAL CRACK OK

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW.	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY	SHEET 23 OF ....
	SCHEME COMPONENT KMU - GOTTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT
	DESIGN OF STAGING AREA SLAB.	
	ULTIMATE DESIGN LOAD ON SLAB BS 8110 : PART I : 1985.	
	$n = 1.4 G_k + 1.6 Q_k$ $= 1.4(4.8+1.8) + 1.6 \times 10.0$ $= 25.24$ kN/m².	n = 25.24 kN/m²
	MAXIMUM SPAN = 4.125 m. SLAB DESIGNED AS ONE WAY SPANNING. ULTIMATE — ∴ Max^m BM $= \frac{wl^2}{8} = \frac{25.24 \times 4.125^2}{8}$ = 53.7 kNm /m.	ULTIMATE BM = 53.7 kNm.
	SF $= \frac{wl}{2} = \frac{25.24 \times 4.125}{2}$ = 52.06 kN /m.	
	SERVICE → BM $= \frac{16.6 \times 4.125^2}{8}$ = 35.3 kNm /m.	SERVICE BM = 35.3 kNm.
	REINFORCEMENT. BS 8110 : PART I ; 1985, CLAUSE 3.5.4 & CLAUSE 3.4.4. SLAB THICKNESS = 200 mm. EFFECTIVE d = 200 − 40 − $\frac{12}{2}$ = 154 mm. $\frac{M}{bd^2} = \frac{53.7 \times 10^6}{1000 \times 154^2} = 2.26$ $\frac{100 A_s}{bd} = 0.63$. ∴ $A_s = \frac{0.63 \times 1000 \times 154}{100}$ = 970.2 mm².	
	PROVIDE T12 @ 100 c/c → As = 1130.0 mm²	SLAB BOTTOM BARS T12 @ 100 c/c
	DISTRIBUTION BARS & SLAB TOP BARS BASED ON THERMAL CRACK.	

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 24 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

DEFLECTION.

BS 8110 : PART 1 : 1985, CLAUSE 3.5.7 & TABLE : 3.10, 3.11.

BASIC $l/d = 20$ S/S CONDITION.

MODIFICATION FACTOR FOR TENSION REINFORCEMENT →

$$f_s = \frac{5}{8} f_y \times \frac{A_{s\,req}}{A_{s\,pro}} \times \frac{1}{\beta_b} \rightarrow \beta_b = 1.0$$

$$= \frac{5}{8} \times 460 \times \frac{970.2}{1130.0}$$

$$= 246.8 \text{ N/mm}^2$$

∴ MOD. FACTOR $= 0.55 + \frac{(477 - 246.8)}{120(0.9 + 2.26)}$

$= 1.157.$

MODIFICATION FACTOR DUE TO TOP BARS (COMPRESSION AREA RFT).

$$= 1 + \frac{100 A_s' \,pro.}{bd} \Big/ \left(3 + \frac{100 A_s' \,pro}{bd}\right) \leq 1.5$$

CONSIDERING T12 @ 100 c/c.

$A_s = 1130.0 \text{ mm}^2.$

MOD. FACTOR $= 1 + \frac{100 \times 1130.0}{1000 \times 154} \Big/ \left(3 + \frac{100 \times 1130}{1000 \times 154}\right)$

$= 1.197$

∴ ALLOWABLE SPAN

$= 20 \times 1.157 \times 1.197 \times 154$

$= 4265.6 \text{ mm} > 4125 \text{ mm}.$ — DEFLECTION OK.

∴ DEFLECTION OK.

DESIGN OF CRACK.

BS 8007 : 1987

Staging Area Slab

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3a_{cr}.\varepsilon_m}{1+2\left(\dfrac{a_{cr} - C_{min}}{(h-x)}\right)}$

$$\varepsilon_m = \varepsilon_1 - \frac{b_t(h-x)(a'-x)}{3E_s.A_s(d-x)}$$

SERVICE MOMENT M = 35.3 KNM/M

h (mm) = 200 Cmin = 40 (mm) Φ = 12.00 mm

$d = h - C_{min} - \Phi/2$ d = 154.00 mm

CONCRETE f_{cu} = 35 N/mm^2

f_y = 460 N/mm^2

REINFORCEMENT PROVIDED BAR DIAMETER Φ = 12 mm

BAR SPACING S = 100 mm

Asp = 1130.97 mm^2

Ec = 28 KN/mm^2

Es = 200 KN/mm^2

$\alpha e = Es/.1/2Ec$ = 14.29

ρ = 0.00734

$\alpha e.\rho$ = 0.105

THEREFORE $\dfrac{x}{d} = -\alpha e(\rho + \rho') + \sqrt{\alpha e^2(\rho + \rho')^2 + 2\alpha e\left(\rho + \dfrac{d'}{d}\rho'\right)}$ = 0.365

CONSIDERING $\rho' = 0$

THEREFORE x = 56.21 mm

$z = d - 1/3\,x$ = 135.26 mm

$f_s = \dfrac{M}{Asp.z}$ = 230.75 N/mm^2

$\varepsilon_s = \dfrac{f_s}{E_s \times 1000}$ = 0.0011538

$$\mathcal{E}1 = \frac{(h - x)}{(d - x)} * \mathcal{E}s = 0.001696$$

$$\mathcal{E}m = 0.0013849$$

1) <u>CRACK UNDER THE BAR DIRECTLY</u>

acr = Cmin = 40 mm

$\omega = 3.acr.\mathcal{E}m =$ **0.166 mm**

< **0.2mm** O.K

2) <u>CRACK AT MIDWAY BETWEEN TWO BARS</u>

$$acr + \phi/2 = \sqrt{(S/2)^2 + (\phi/2 + Cmin)^2} = 67.94$$

acr = 61.94 mm

$\omega =$ **0.197 mm**

< **0.2mm** O.K

THERFORE BARS T12 @ 100 C/C O.K

(27)

CHECK FOR THERMAL CRACK

Staging area Slab

BS 8007, APPENDIX A.3

CRACK SPACING $S_{max} = \frac{f_{ct}}{f_b} \times \frac{\Phi}{2\rho}$

FROM TABLE A.1 $\frac{f_{ct}}{f_b}$ = 0.67

FOR R/F PROVIDED

BAR DIAMETER Φ = 12 mm

BAR SPACING S = 100 mm

Asp = 1131.43 mm^2

USING SURFACE ZONES AS PER FIG A.2 BS 8007 h = 100 mm

$\rho = \frac{Asp}{1000*h}$ = 0.0113143

Smax = 355.30 mm

MAXIMUM CRACK WIDTH DUE TO CHANGE IN TEMPERATURE T1 & T2

BS 8007 - APPENDIX A.3 $\omega max = Smax \cdot \frac{\alpha(T1+T2)}{2}$

α = 0.00001 /°C

T1= 25°C FOR WALL OF 200mm THICK

THEREFORE

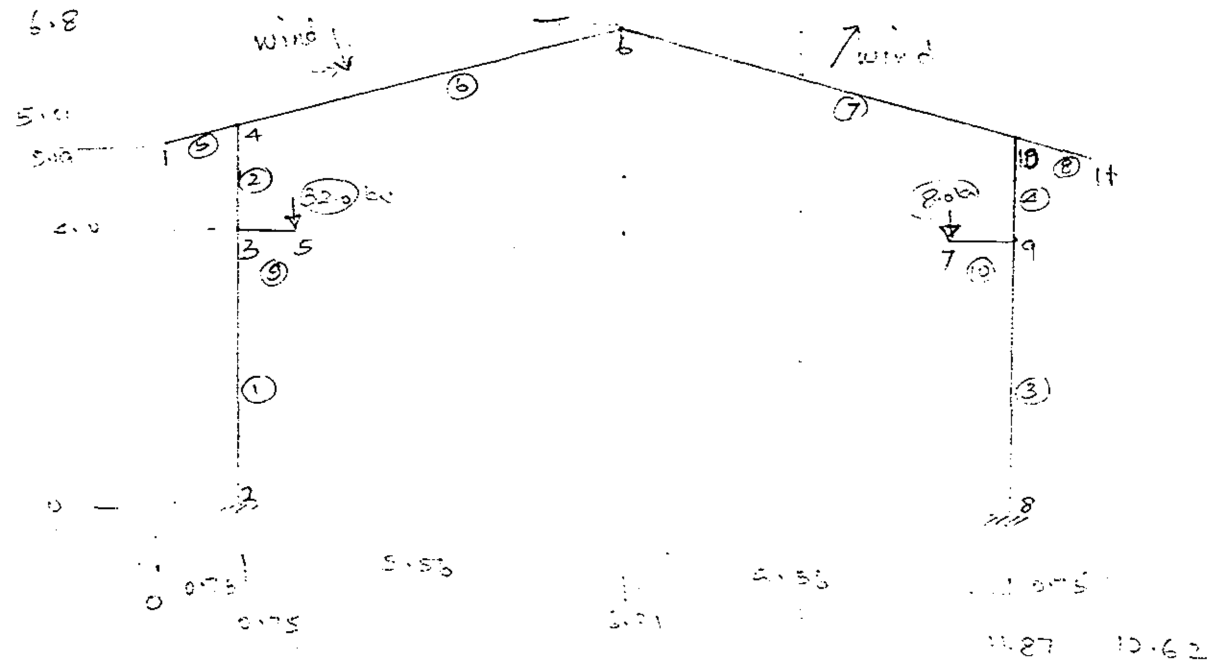
T1 = 25 °C

T2 = 15 °C

ωmax = **0.0710606 mm** **< 0.2mm**

THERMAL CRACK OK

Gotharum Pump House frame.



No of Nodes = 11.

No. of elements = 10

		A	I	Elem
No of Materials = 3	1 - 300×500.	0.15	3.125E-3	1, 3
	2 - 300×400	0.12	1.6E-3	5, 8
	3 - 300×800.	0.24	1.28E-2	9, 10

Loads :

DL → - 4.88 kN/m 5, 6, 7, 8 -92.0 kN/m → 9, 10

LL → - 4.0 " "

WL → - 0.78 ↓, → +0.21 5, 6

+ 0.78 ↑, → 0.21 7, 8

Crane Node 5 → - 32.0 ↓ & Node 7 . - 8.0 ↓

Node 5 → - 8.0 ↓ & Node 7, - 32.0 ↓.

MICROFEAP-P1 DATE: 09-22-2000 <DATA> P.1
ROJECT : GOTHATUWA PUMP HOUSE ROOF FRAME FILENAME: GOTHFR1
JTHORITY: KANDIAH SRIBALASKANDARAJAH ENGINEER: MOHD. LUTHFY

STRUCTURE DATA

*COORDINATE DATA (m)** **BOUNDARY DATA**

ODE	1-COOR	2-COOR	1-B	2-B	3-B
1	0.00	5.19			
2	0.75	0.00	L	L	F
3	0.75	4.00			
4	0.75	5.40			
5	1.40	4.00			
6	6.31	6.80			
7	11.22	4.00			
8	11.87	0.00	L	L	F
9	11.87	4.00			
10	11.87	5.40			
11	12.62	5.19			

*ELEMENT DATA**

LEM	1-NODE	2-NODE	HINGE	MATERIAL
1	2	3		1
2	3	4		1
3	8	9		1
4	9	10		1
5	1	4		2
6	4	6		2
7	6	10		2
8	10	11		2
9	3	5		3
10	7	9		3

MATERIAL DATA

MATE	E-MODULUS (KN/m^2)	AXIAL-AREA (m^2)	INERTIA (m^4)
1	2.100D+07	1.500D-01	3.125D-03
2	2.100D+07	1.200D-01	1.600D-03
3	2.100D+07	2.400D-01	1.280D-02

LOAD CASE #1 : DEAD LOAD
UNIFORM LOAD DATA

ELEM	1-UNIFORM (KN/m)	2-UNIFORM (KN/m)

)AD CASE #1 : DEAD LOAD
·UNIFORM LOAD DATA**

.EM	1-UNIFORM (KN/m)	2-UNIFORM (KN/m)
5	0.000D+00	-4.880D+00
6	0.000D+00	-4.880D+00
7	0.000D+00	-4.880D+00
8	0.000D+00	-4.880D+00
9	0.000D+00	-9.200D+01
10	0.000D+00	-9.200D+01

)AD CASE #2 : LIVE LOAD
*NODAL FORCE DATA**

)DE	1-FORC (KN)	2-FORC (KN)	3-FORC (KN-m)
5	0.000D+00	-3.200D+01	0.000D+00
7	0.000D+00	-8.000D+00	0.000D+00

OAD CASE #2 : LIVE LOAD
*UNIFORM LOAD DATA**

LEM	1-UNIFORM (KN/m)	2-UNIFORM (KN/m)
5	0.000D+00	-4.000D+00
6	0.000D+00	-4.000D+00
7	0.000D+00	-4.000D+00
8	0.000D+00	-4.000D+00

.OAD CASE #3 : WIND LOAD
·*UNIFORM LOAD DATA**

:LEM	1-UNIFORM (KN/m)	2-UNIFORM (KN/m)
5	2.100D-01	-7.800D-01
6	2.100D-01	-7.800D-01
7	2.100D-01	7.800D-01
8	2.100D-01	7.800D-01

COMBINATION

DISPLACEMENT COMBINATION <2D-FRAME SYSTEM>
LOAD FACTOR : 1.4/1.6/0

NODE	1-DISP (m)	2-DISP (m)	3-DISP (Rad)
1	-3.8035D-04	1.9109D-03	-2.9549D-03
2	0.0000D+00	0.0000D+00	1.8189D-03
3	-2.8179D-03	-2.7450D-04	-1.5243D-03
4	2.4209D-04	-3.1061D-04	-2.9837D-03
5	-2.8179D-03	-1.2934D-03	-1.5865D-03
6	5.0612D-03	-1.9776D-02	3.5858D-04
7	1.0598D-02	2.6947D-05	-3.8868D-04
8	0.0000D+00	0.0000D+00	-3.7639D-03
9	1.0598D-02	-2.3144D-04	-4.2067D-04
10	9.8881D-03	-2.6955D-04	1.5712D-03
11	1.0214D-02	8.9254D-04	1.5424D-03

STRESS COMBINATION <2D-FRAME SYSTEM>
LOAD FACTOR : 1.4/1.6/0

ELEM	MA	HINGE	SECTION (m)	AXIAL F. (KN)	SHEAR (KN)	MOMENT (KN-m)
1	1		0.00	-2.1617D+02	-2.7425D+01	0.0000D+00
			4.00	-2.1617D+02	-2.7425D+01	-1.0970D+02
2	1		0.00	-8.1249D+01	-2.7425D+01	-4.9209D+01
			1.40	-8.1249D+01	-2.7425D+01	-8.7604D+01
3	1		0.00	-1.8226D+02	2.7425D+01	9.5367D-06
			4.00	-1.8226D+02	2.7425D+01	1.0970D+02
4	1		0.00	-8.5739D+01	2.7425D+01	7.4170D+01
			1.40	-8.5739D+01	2.7425D+01	1.1256D+02
5	2		0.00	-1.6600D-04	2.9325D-05	1.9729D-05
			0.19	6.6879D-01	-2.3891D+00	-2.3260D-01
			0.39	1.3377D+00	-4.7782D+00	-9.3040D-01
			0.58	2.0067D+00	-7.1673D+00	-2.0934D+00
			0.78	2.6756D+00	-9.5564D+00	-3.7216D+00

TRESS COMBINATION <2D-FRAME SYSTEM>
DAD FACTOR : 1.4/1.6/0

LEM	MA HINGE	SECTION (m)	AXIAL F. (KN)	SHEAR (KN)	MOMENT (KN-m)
6	2	0.00	-4.4011D+01	6.2470D+01	-9.1326D+01
		1.43	-3.9520D+01	4.4634D+01	-1.4565D+01
		2.87	-3.5029D+01	2.6798D+01	3.6630D+01
		4.30	-3.0538D+01	8.9625D+00	6.2260D+01
		5.73	-2.6047D+01	-8.8733D+00	6.2324D+01
7	2	0.00	-2.7143D+01	4.5198D+00	6.2324D+01
		1.43	-3.1634D+01	-1.3316D+01	5.6019D+01
		2.87	-3.6125D+01	-3.1152D+01	2.4150D+01
		4.30	-4.0616D+01	-4.8987D+01	-3.3286D+01
		5.73	-4.5107D+01	-6.6823D+01	-1.1629D+02
8	2	0.00	2.6749D+00	9.5565D+00	-3.7215D+00
		0.19	2.0060D+00	7.1674D+00	-2.0934D+00
		0.39	1.3370D+00	4.7783D+00	-9.3040D-01
		0.58	6.6808D-01	2.3891D+00	-2.3261D-01
		0.78	-8.6790D-04	3.1710D-05	-1.0788D-05
9	3	0.00	0.0000D+00	1.3492D+02	-6.0490D+01
		0.65	0.0000D+00	5.1201D+01	3.2330D-04
10	3	0.00	0.0000D+00	-1.2800D+01	2.3365D-05
		0.65	0.0000D+00	-9.6520D+01	-3.5529D+01

SUPPORT REACTIONS <2D-FRAME SYSTEM>
LOAD FACTOR : 1.4/1.6/0

NODE	1-REACTION (KN)	2-REACTION (KN)	3-REACTION (KN-m)
2	2.7425D+01	2.1617D+02	0.0000D+00
8	-2.7425D+01	1.8226D+02	0.0000D+00

COMBINATION

ISPLACEMENT COMBINATION <2D-FRAME SYSTEM>
OAD FACTOR : 1.2/1.2/1.2

ODE	1-DISP (m)	2-DISP (m)	3-DISP (Rad)
1	1.3954D-03	1.7405D-03	-2.6576D-03
2	0.0000D+00	0.0000D+00	1.1130D-03
3	-9.2155D-04	-2.2683D-04	-1.5349D-03
4	1.9551D-03	-2.5726D-04	-2.6828D-03
5	-9.2155D-04	-1.2468D-03	-1.5839D-03
6	5.8354D-03	-1.5928D-02	5.3372D-04
7	9.8874D-03	2.1683D-04	-6.1427D-04
8	0.0000D+00	0.0000D+00	-3.3875D-03
9	9.8874D-03	-1.8714D-04	-6.4061D-04
10	9.7227D-03	-2.1647D-04	9.8801D-04
11	9.9272D-03	5.1259D-04	9.6693D-04

TRESS COMBINATION <2D-FRAME SYSTEM>
LOAD FACTOR : 1.2/1.2/1.2

ELEM	MA	HINGE	SECTION (m)	AXIAL F. (KN)	SHEAR (KN)	MOMENT (KN-m)
1	1		0.00	-1.7863D+02	-2.1721D+01	-3.8147D-06
			4.00	-1.7863D+02	-2.1721D+01	-8.6885D+01
2	1		0.00	-6.8470D+01	-2.1721D+01	-3.8602D+01
			1.40	-6.8470D+01	-2.1721D+01	-6.9012D+01
3	1		0.00	-1.4737D+02	2.2533D+01	-7.6294D-06
			4.00	-1.4737D+02	2.2533D+01	9.0131D+01
4	1		0.00	-6.6009D+01	2.2533D+01	6.0569D+01
			1.40	-6.6009D+01	2.2533D+01	9.2114D+01
5	2		0.00	2.3375D-04	2.4110D-05	-4.8801D-06
			0.19	5.7353D-01	-2.0965D+00	-2.0412D-01
			0.39	1.1468D+00	-4.1931D+00	-8.1646D-01
			0.58	1.7201D+00	-6.2897D+00	-1.8370D+00
			0.78	2.2934D+00	-8.3863D+00	-3.2658D+00

MICROFEAP-P1 DATE: 09-22-2000 <COMB> P.2
OJECT : GOTHATUWA PUMP HOUSE ROOF FRAME FILENAME: GOTHFR1
THORITY: KANDIAH SRIBALASKANDARAJAH ENGINEER: MOHD. LUTHFY

RESS COMBINATION <2D-FRAME SYSTEM>
AD FACTOR : 1.2/1.2/1.2

EM	MA HINGE	SECTION (m)	AXIAL F. (KN)	SHEAR (KN)	MOMENT (KN-m)
6	2	0.00	-3.5711D+01	5.2650D+01	-7.2278D+01
		1.43	-3.1862D+01	3.7003D+01	-8.0244D+00
		2.87	-2.8013D+01	2.1356D+01	3.3801D+01
		4.30	-2.4164D+01	5.7096D+00	5.3199D+01
		5.73	-2.0315D+01	-9.9371D+00	5.0169D+01
7	2	0.00	-2.2599D+01	8.6875D-01	5.0169D+01
		1.43	-2.5983D+01	-1.2212D+01	4.2040D+01
		2.87	-2.9368D+01	-2.5292D+01	1.5162D+01
		4.30	-3.2752D+01	-3.8372D+01	-3.0466D+01
		5.73	-3.6137D+01	-5.1452D+01	-9.4843D+01
8	2	0.00	2.0179D+00	7.0057D+00	-2.7282D+00
		0.19	1.5138D+00	5.2542D+00	-1.5346D+00
		0.39	1.0096D+00	3.5028D+00	-6.8206D-01
		0.58	5.0550D-01	1.7514D+00	-1.7053D-01
		0.78	1.3622D-03	-6.2197D-05	-1.7561D-05
9	3	0.00	0.0000D+00	1.1016D+02	-4.8283D+01
		0.65	0.0000D+00	3.8400D+01	-3.6955D-05
10	3	0.00	0.0000D+00	-9.6002D+00	2.8610D-05
		0.65	0.0000D+00	-8.1360D+01	-2.9562D+01

PPORT REACTIONS <2D-FRAME SYSTEM>
AD FACTOR : 1.2/1.2/1.2

DE	1-REACTION (KN)	2-REACTION (KN)	3-REACTION (KN-m)
2	2.1721D+01	1.7863D+02	0.0000D+00
8	-2.2533D+01	1.4737D+02	0.0000D+00

COMBINATION

ISPLACEMENT COMBINATION <2D-FRAME SYSTEM>
OAD FACTOR : 1/0/1.4

ODE	1-DISP (m)	2-DISP (m)	3-DISP (Rad)
1	3.4915D-04	7.7273D-04	-1.2065D-03
2	0.0000D+00	0.0000D+00	5.6886D-04
3	-6.6371D-04	-1.1936D-04	-6.3993D-04
4	6.0338D-04	-1.3455D-04	-1.2195D-03
5	-6.6371D-04	-5.4295D-04	-6.5560D-04
6	2.3794D-03	-7.3098D-03	3.0891D-04
7	4.3164D-03	9.2420D-06	-1.8064D-04
8	0.0000D+00	0.0000D+00	-1.5205D-03
9	4.3164D-03	-1.1072D-04	-1.9631D-04
10	4.1569D-03	-1.2290D-04	4.7823D-04
11	4.2562D-03	2.3114D-04	4.7005D-04

STRESS COMBINATION <2D-FRAME SYSTEM>
LOAD FACTOR : 1/0/1.4

ELEM	MA	HINGE	SECTION (m)	AXIAL F. (KN)	SHEAR (KN)	MOMENT (KN-m)
1	1		0.00	-9.3992D+01	-9.9159D+00	-1.9073D-06
			4.00	-9.3992D+01	-9.9159D+00	-3.9663D+01
2	1		0.00	-3.4192D+01	-9.9158D+00	-2.0228D+01
			1.40	-3.4192D+01	-9.9158D+00	-3.4110D+01
3	1		0.00	-8.7193D+01	1.0863D+01	-1.9073D-06
			4.00	-8.7193D+01	1.0863D+01	4.3450D+01
4	1		0.00	-2.7393D+01	1.0863D+01	2.4015D+01
			1.40	-2.7393D+01	1.0863D+01	3.9223D+01
5	2		0.00	1.3198D-04	5.6088D-05	3.1404D-06
			0.19	2.8719D-01	-1.0824D+00	-1.0539D-01
			0.39	5.7424D-01	-2.1648D+00	-4.2154D-01
			0.58	8.6130D-01	-3.2473D+00	-9.4846D-01
			0.78	1.1484D+00	-4.3297D+00	-1.6861D+00

RESS COMBINATION <2D-FRAME SYSTEM>
AD FACTOR : 1/0/1.4

EM	MA HINGE	SECTION (m)	AXIAL F. (KN)	SHEAR (KN)	MOMENT (KN-m)
6	2	0.00	-1.6931D+01	2.6378D+01	-3.5796D+01
		1.43	-1.5004D+01	1.8303D+01	-3.7742D+00
		2.87	-1.3077D+01	1.0228D+01	1.6673D+01
		4.30	-1.1150D+01	2.1529D+00	2.5547D+01
		5.73	-9.2224D+00	-5.9221D+00	2.2845D+01
7	2	0.00	-1.0927D+01	-8.4844D-01	2.2845D+01
		1.43	-1.2313D+01	-5.9293D+00	1.7988D+01
		2.87	-1.3698D+01	-1.1010D+01	5.8474D+00
		4.30	-1.5083D+01	-1.6091D+01	-1.3576D+01
		5.73	-1.6469D+01	-2.1172D+01	-4.0282D+01
8	2	0.00	8.2453D-01	2.7192D+00	-1.0589D+00
		0.19	6.1816D-01	2.0394D+00	-5.9565D-01
		0.39	4.1179D-01	1.3596D+00	-2.6473D-01
		0.58	2.0542D-01	6.7981D-01	-6.6166D-02
		0.78	-9.4719D-04	2.1517D-05	3.1579D-05
9	3	0.00	0.0000D+00	5.9800D+01	-1.9436D+01
		0.65	0.0000D+00	3.9101D-04	9.1314D-05
10	3	0.00	0.0000D+00	8.0109D-05	3.5763D-06
		0.65	0.0000D+00	-5.9800D+01	-1.9435D+01

UPPORT REACTIONS <2D-FRAME SYSTEM>
OAD FACTOR : 1/0/1.4

ODE	1-REACTION (KN)	2-REACTION (KN)	3-REACTION (KN-m)
2	9.9159D+00	9.3992D+01	0.0000D+00
8	-1.0863D+01	8.7193D+01	0.0000D+00

Design of Reinforcements.

Elements 5, 6, 7 & 8.

Max^m. BM = 116.3 kNm.

Max^m SF = 66.8 kN

Beam Section 300 × 400.

Using BS 8110 design charts.

$$\frac{M}{bd^2} = \frac{116.3 \times 10^6}{300 \times 352^2} = 3.13.$$

$$\frac{100 A_s}{bd} = 0.89.$$

$$\therefore A_s = 0.89 \times 300 \times 352/_{100} = 939.8 \text{ mm}^2.$$

Provide 3T20 → A_s = **942.5 mm²**

Shear:

$$v = \frac{66.8 \times 10^3}{300 \times 352} = 0.633 \text{ N/mm}^2.$$

$$v_c = 0.675 \text{ N/mm}^2.$$

$$\frac{1}{2} v_c < v < v_c + 0.4$$

∴ Nominal shear links.

$$\frac{A_{sv}}{S_v} \geq \frac{0.4\, b_v}{0.87\, f_{yv}}$$

$$\therefore S_v \leq \frac{0.87 \times 460}{0.4 \times 300} \times A_{sv}$$

$$\leq 3.335 A_{sv}.$$

Using T8 bars 2 legs A_{sv} = 100.5 mm².

$$\therefore S_v \leq 335.2 \text{ mm}.$$

Provide **T8 @ 200** links.

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 38 OF ....
	SCHEME COMPONENT KMU - GOTHTHATOWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

RESERVOIR BASE SLAB.

IN THIS ANAYSIS RESERVOIR STRUCTURE SEPERATELY CONSIDERED IN CALCULATION OF BEARING PRESSURE UNDER THE BASE SLAB. PUMP HOUSE BASE SLAB ANALYSED SEPERATELY.

TOTAL LOADS ON THE BASE SLAB

DEAD LOAD ON THE ROOF $= (6.0 + 2.4 + 4.8)$
$= 13.2$ kN/m²

LIVE LOAD ON ROOF $= 2.5$ "

SELF WEIGHT OF BASE SLAB $= 0.6 \times 24$
$= 14.4$ kN/m²

WATER LOAD $(26.55 - 21.0)$ $= 55.5$ kN/m².

CONTRIBUTION COLUMN LOAD AS UDL $= 1.0$ kN/m²

WHEN WATER AT FULL HEIGHT (26.55 MSL)

BEARING PRESSURE ON SOIL
$= (13.2 + 2.5 + 14.4 + 55.5 + 1.0)$
$= \underline{86.6}$ kN/m² < 250.0 kN/m².

∴ ULTIMATE BP $= 1.4 \times 86.6$
$= \underline{121.24}$ kN/m²

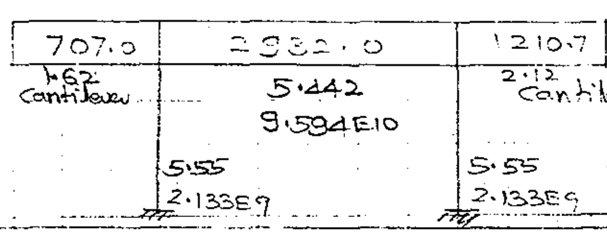
BASE SLAB ANAYSED AS INVERTED FLOOR SLAB FRAMING WITH COLUMN.

ULTIMATE LOAD DUE TO

SELF WEIGHT OF SLAB $= 1.4 \times 0.6 \times 24.0$
$= 20.16$ kN/m²

NET PRESSURE ON SLAB $= 121.24 - 20.16$
$= \underline{101.08}$ kN/m²

CONSIDER FRAME ON GRID 6 or 7.



TITLE BASE SLAB FRAME ON GRID 7

F.O.S FOR DL= 1 ***F.O.S. FOR IMPL= 1
STRUCTURE INFORMATION NO.OF SPANS= 1

SPAN NO	SPAN LTH-m	Iz- mm^4
1	5.44	9.594001E+10

COLUMN ROW	LENGTH(m)	2ND MOMENT OF AREA(mm^4)	
1.00	0.00	0.00	ABOVE
1.00	5.55	%2133000000.00	BELOW
2.00	0.00	0.00	ABOVE
2.00	5.55	%2133000000.00	BELOW

******LOADING INFORMATION******

SP.NO	LOAD-kN	ST.DIST-m	COV.DIST-m	DD/IMP
1	2932.00	0.00	5.44	D

CANT.CHR.D.MT LHS= 707 kNm CANT.CHR.IMP.MT.LHS = 0 kNm
CANT.CHR.D.MT RHS= 1210.7 kNm CANT.CHR.IMP.MT.RHS = 0 kNm

MAX.SHEARS AND MOMENTS. SF-kN BM-kNm

SPAN NO.	SHEAR	HOG.MT	SAG.MT
1			
	1374.77	-726.10	0.00
	%-1557.23	%-1222.58	0.00

MAX.SPAN MNT= 1025.03 kNm AT A DISTANCE= 2.44 m

COLUMN MOMENTS, kN.m

COLUMN ROW	COLUMN MOMENTS ABOVE	BELOW
1.00	0.00	19.10
2.00	0.00	-11.88

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 40 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

MAX^{M}. BM AT COLUMN LOCATION.
= 1222.58 kNm.

COLUMN STRIP 75% = 917.0 kNm.

MIDDLE STRIP 25% = 305.6 "

WIDTH OF COLUMN STRIP = 2665 mm
WIDTH OF MIDDLE STRIP = 2665 mm.

MAX^{M}. SPAN BM = 1025.03 kNm.

COLUMN STRIP 55% = 563.8 kNm.

MIDDLE STRIP 45% = 461.3 kNm.

REINFORCEMENT.
COLUMN STRIP (-)VE BM = 917.0 kNm.
b = 2665 mm.
$d = 600 - 50 - \frac{20}{2}$
= 540 mm.

$$\frac{M}{bd^2} = \frac{917.0 \times 10^6}{2665 \times 540^2} = 1.18$$

$$\therefore \frac{100A_s}{bd} = 0.32$$

$$\therefore A_s = \frac{0.32 \times 2665 \times 540}{100} = 4605.1\ mm^2$$
$= 1728.0\ mm^2/m$

PROVIDE T20 @ 150 → A_s = 2094.0 mm^2/m.

PROVIDE BOTTOM BAR T20 @ 150 c/c

REST OF THE BM < 917.0 kNm.

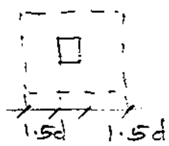
∴ FOR SIMPLICITY ADOPT T20 @ 150 c/c BOTHWAY.

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 41 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

PUNCHING SHEAR AT COLUMN.

ULTIMATE COLUMN LOAD = 739.5 kN.



$1.5d = 1.5 \times 540 = 810$ mm.

∴ SHEAR PERIMETER

$= 4(2 \times 810 + 400)$

$= \underline{8080}$ mm.

AREA WITHIN SHEAR PERIMETER

$= 2.02 \times 2.02$

$= 4.08\ m^2$.

∴ UPWARD FORCE $= 4.08 \times 121.24$

$= \underline{494.6}$ kN.

∴ PUNCHING LOAD $= 739.5 - 494.6$

$= \underline{244.9}$ kN.

PUNCHING SHEAR STRESS

$$v = \frac{244.9 \times 10^3}{8080 \times 540}$$

$= 0.06\ N/mm^2$.

DESIGN SHEAR STRESS v_c

$$\frac{100 A_s}{bd} = \frac{100 \times 2094}{1000 \times 540} = 0.39$$

∴ $v_c = 0.51\ N/mm^2$

$v < v_c$

∴ NO SHEAR REINFORCEMENT NECESSARY.

DESIGN OF CRACK.

BS 8007 : 1987

Reservoir Area Base Slab

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3acr.Em}{1+2\dfrac{(acr - Cmin)}{(h - x)}}$

$$\varepsilon m = \varepsilon_1 - \frac{b(h - x)(a' - x)}{3Es.As(d - x)}$$

SERVICE MOMENT M = 245.8 KNM/M

h (mm) = 600 Cmin = 50 (mm) Φ = 20.00 mm

d = h - Cmin - Φ/2 d = 540.00 mm

CONCRETE f cu = 35 N/mm^2

fy = 460 N/mm^2

REINFORCEMENT PROVIDED BAR DIAMETER Φ = 20 mm

BAR SPACING S = 125 mm

Asp = 2513.27 mm^2

Ec = 28 KN/mm^2

Es = 200 KN/mm^2

αe = Es/ 1/2Ec = 14.29

ρ = 0.00465

$\alpha e.\rho$ = 0.066

THEREFORE $\dfrac{x}{d} = -\alpha e(\rho + \rho') + \sqrt{\alpha e^2(\rho + \rho')^2 + 2\alpha e\left(\rho + \dfrac{d'}{d}\rho'\right)}$ = 0.304

CONSIDERING $\rho' = 0$

THEREFORE x = 164.26 mm

z = d - 1/3 x = 485.25 mm

$fs = \dfrac{M}{Asp.z}$ = 201.55 N/mm^2

$\varepsilon s = \dfrac{fs}{Es \times 1000}$ = 0.0010077

$$\varepsilon 1 = \frac{(h - x)}{(d - x)} * \varepsilon s = 0.001169$$

$$\varepsilon m = 0.0008336$$

1) CRACK UNDER THE BAR DIRECTLY

acr = Cmin = 50 mm

$\omega = 3.acr.\varepsilon m =$ **0.125 mm**

< **0.2mm** O.K

2) CRACK AT MIDWAY BETWEEN TWO BARS

$$acr + \phi/2 = \sqrt{(S/2)^2 + (\phi/2 + Cmin)^2} = 86.64$$

acr = 76.64 mm

$\omega =$ **0.171 mm**

< **0.2mm** O.K

THEREFORE REINFORCEMENT T20 @ 125 C/C O.K

CHECK FOR THERMAL CRACK

Reservoir Base Slab

BS 8007, APPENDIX A.3

CRACK SPACING $S_{max} = \frac{f_{ct}}{f_b} \times \frac{\Phi}{2\rho}$

FROM TABLE A.1 $\frac{f_{ct}}{f_b}$ = 0.67

FOR R/F PROVIDED

BAR DIAMETER Φ = 20 mm

BAR SPACING S = 125 mm

Asp = 2514.29 mm^2

USING SURFACE ZONES AS PER FIG A.2 BS 8007 h = 250 mm

$\rho = \frac{Asp}{1000*h}$ = 0.0100571

Smax = 666.19 mm

MAXIMUM CRACK WIDTH DUE TO CHANGE IN TEMPERATURE T1 & T2

BS 8007 - APPENDIX A.3 $\omega max = Smax . \frac{\alpha(T1+T2)}{2}$

α = 0.00001 /°C

T1= 42°C FOR WALL OF 600mm THICK

THEREFORE T1 = 42 °C

T2 = 15 °C

ωmax = **0.1898651 mm** **< 0.2mm**

THERMAL CRACK OK

CEYWATER CONSULTANT (PVT) LTD.	PROJECT NRW	JOB NO.
INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	CALCULATIONS BY MOHD. LUTHFY.	SHEET 45 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

PUMP HOUSE BASE SLAB DESIGN.

LOADS : ULTIMATE COLUMN REACTION AT THE LEVEL OF STAGING SLAB = 216.2 kN.

∴ SERVICE LOAD = $\frac{216.2}{1.45}$ - AVE. FOS.

= 149.1 kN.

STAGING AREA SLAB = (4.8 + 1.8 + 10)

= 16.6 kN/m².

BASE SLAB (0.6) = 14.4 kN/m².

BASE SLAB LIVE LOAD = 10.0 kN/m².

RC WALLS (26.25 - 19.5) 650mm THICK = 105.3 kN/m.

BLOCK WALL 4.0m HIGH = 4 × 3.3

= 13.2 kN/m.

TOTAL WALL LOAD AS PRESSURE ON THE GROUND

$$= \frac{(105.3 + 13.2) \times 2(20 + 11.175)}{20 \times 11.175}$$

= 33.06 kN/m².

PRESSURE DUE TO TOTAL COLUMN LOADS = $\frac{12 \times 149.1}{20 \times 11.175}$

= 8.0 kN/m².

∴ TOTAL PRESSURE ON THE GROUND

= (16.6 + 14.4 + 10 + 33.06 + 8)

= 82.06 kN/m² < 250.0

∴ ok.

∴ ULTIMATE DESIGN PRESSURE

= 1.4 × 82.06

= 114.9 kN/m².

PRESSURE DUE TO BASE SLAB

= 0.6 × 24 × 1.4

= 20.16 kN/m².

∴ NET PRESSURE = 114.9 - 20.16

= 94.74 kN/m².

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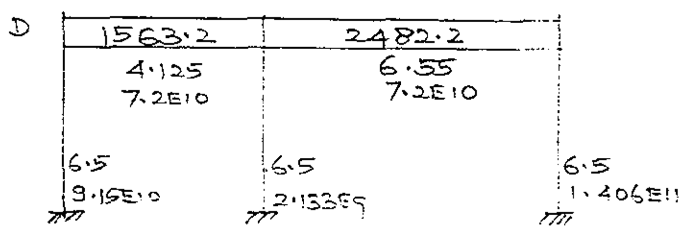
CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 46 OF ....
	SCHEME COMPONENT KMU - GOTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

PUMP HOUSE BASE SLAB ANALYSED AS INVERTED FLOOR SLAB FRAMING WITH COLUMN & RC WALLS.

CONSIDER A TYPICAL STRIP → GRID 'G'.



REINFORCEMENT

AT SUPPORT MAX^M BM = 1228.08 KNm.

COLUMN STRIP 75% = 921.1 KNm

MIDDLE STRIP 25% = 307.0 "

AT MID SPAN MAX^M BM = 904.82 KNm.

COLUMN STRIP 55% = 497.7 KNm

MIDDLE STRIP 45% = 407.2 "

WIDTH OF COLUMN STRIP = 2000. mm.

WIDTH OF MIDDLE STRIP = 2000. mm.

AT SUPPORT (-)VE RFT

$M = 921.1$ KNm.

$b = 2000$ mm.

$d = 600 - 50 - \frac{20}{2} = 540$ mm.

$$\frac{M}{bd^2} = \frac{921.1 \times 10^6}{2000 \times 540^2} = 1.58.$$

$$\therefore \frac{100 A_s}{bd} = 0.42 \rightarrow A_s = \frac{0.42 \times 2000 \times 540}{100}$$

$= 4536.0 \text{ mm}^2$

$= 2268.0 \text{ mm}^2/\text{m}.$

PROVIDE T20@125 → $A_s = 2513.0 \text{ mm}^2/\text{m}$

OUTPUT: BOTTOM BARS T20@125

TITLE BASE SLAB GRID G

F.O.S FOR DL= 1 ***F.O.S. FOR IMPL= 1
STRUCTURE INFORMATION NO.OF SPANS= 2

SPAN NO	SPAN LTH-m	Iz- mm^4
1	4.12	7.200001E+10
2	6.55	7.200001E+10

COLUMN ROW	LENGTH(m)	2ND MOMENT OF AREA(mm^4)	
1.00	0.00	0.00	ABOVE
1.00	6.50	%91500010000.00	BELOW
2.00	0.00	0.00	ABOVE
2.00	6.50	%2133000000.00	BELOW
3.00	0.00	0.00	ABOVE
3.00	6.50	%140600000000.00	BELOW

******LOADING INFORMATION******

SP.NO	LOAD-kN	ST.DIST-m	COV.DIST-m	DD/IMP
1	1563.20	0.00	4.13	D
2	2482.20	0.00	6.55	D

CANT.CHR.D.MT LHS= 0 kNm CANT.CHR.IMP.MT.LHS = 0 kNm
CANT.CHR.D.MT RHS= 0 kNm CANT.CHR.IMP.MT.RHS = 0 kNm

MAX.SHEARS AND MOMENTS. SF-kN BM-kNm

SPAN NO.	SHEAR	HOG.MT	SAG.MT
1			
	511.53	-102.47	0.00
	%-1051.67	%-1216.51	0.00

MAX.SPAN MNT= 241.09 kNm AT A DISTANCE= 1.44 m

SPAN NO.	SHEAR	HOG.MT	SAG.MT
2			
	1271.82	%-1228.08	0.00
	%-1210.38	%-1026.88	0.00

MAX.SPAN MNT= 904.82 kNm AT A DISTANCE= 3.27 m

COLUMN MOMENTS, kN.m

COLUMN ROW	COLUMN MOMENTS ABOVE	BELOW
1.00	0.00	102.47
2.00	0.00	11.57
3.00	0.00	-1026.88

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 48 OF
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

MIDDLE STRIP BOTTOM BARS

$M = 307.0$ kNm.
$b = 2000$ mm
$d = 540$ mm.

$$\frac{M}{bd^2} = \frac{307.0 \times 10^6}{2000 \times 540^2} = 0.53.$$

$$\frac{100 A_s}{bd} = 0.15 \rightarrow A_s = \frac{0.15 \times 2000 \times 540}{100}$$

$= 1620.0$ mm².
$= 810.0$ mm²/m..

NOMINAL BARS AS PER BS 8007

$\rho_{crit} = 0.35\%$.

$$\therefore \frac{100 A_s}{bh} = 0.35$$

$$\therefore A_s = \frac{0.35 \times 1000 \times 600}{100}$$

$= 2100.0$ mm².

$\therefore$ T20 @ 125 $\rightarrow$ $A_s = 2513.0$ mm².

COLUMN STRIP TOP BARS & MIDDLE STRIP TOP BARS ADOPT T20 @ 125 c/c. As BM < 321.1 kNm.

OUT PUT: PROVIDE T20 @ 125 c/c TOP & BOTTOM.

SHEAR CHECK.

PUNCHING SHEAR AT COLUMNS NOMINAL. (CALC^S SIMILAR TO RESERVOIR BASE SLAB).

(49)

DESIGN OF CRACK

BS 8007 : 1987

Pump House Area Base Slab

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3a_{cr}.\varepsilon_m}{1+2\left(\dfrac{a_{cr} - C_{min}}{h - x}\right)}$

$$\varepsilon_m = \varepsilon_1 - \frac{b_t (h - x)(a' - x)}{3E_s.A_s(d - x)}$$

		SERVICE MOMENT M	=	329 KNM/M	
h (mm) = 600	Cmin =	50 (mm) ϕ	=	20.00 mm	
d = h - Cmin - ϕ/2		d	=	540.00 mm	
		CONCRETE f cu	=	35 N/mm^2	
		fy	=	460 N/mm^2	
REINFORCEMENT PROVIDED		BAR DIAMETER ϕ	=	20 mm	
		BAR SPACING S	=	100 mm	
		Asp	=	3141.59 mm^2	
		Ec	=	28 KN/mm^2	
		Es	=	200 KN/mm^2	
		$\alpha e = Es/\ {}_{1/2}Ec$	=	14.29	
		ρ	=	0.00582	
		$\alpha e.\rho$	=	0.083	

THEREFORE $\dfrac{x}{d} = -\alpha e(\rho + \rho') + \sqrt{\alpha e^2(\rho + \rho')^2 + 2\alpha e\left(\rho + \dfrac{d'}{d}\rho'\right)}$ = 0.333

CONSIDERING $\rho' = 0$

THEREFORE x = 179.81 mm

z = d - 1/3 x = 480.06 mm

$fs = \dfrac{M}{Asp.z}$ = 218.15 N/mm^2

$\varepsilon s = \dfrac{fs}{Es \times 1000}$ = 0.0010907

(50)

$$\varepsilon 1 = \frac{(h - x)}{(d - x)} * \varepsilon s = 0.001272$$

$$\varepsilon m = 0.0010124$$

1) CRACK UNDER THE BAR DIRECTLY

$acr = C_{min} =$ 50 mm

$\omega = 3.acr.\varepsilon m =$ **0.152 mm**

$<$ **0.2mm** O.K

2) CRACK AT MIDWAY BETWEEN TWO BARS

$$acr + \Phi/2 = \sqrt{(S/2)^2 + (\Phi/2 + C_{min})^2} = 78.10$$

$acr =$ 68.10 mm

$\omega =$ **0.190 mm**

$<$ **0.2mm** O.K

THEREFORE REINFORCEMENT T20 @ 100 C/C O.K

(51)

CHECK FOR THERMAL CRACK

PUMP HOUSE BASE SLAB

BS 8007, APPENDIX A.3

CRACK SPACING $S_{max} = \frac{f_{ct}}{f_b} \times \frac{\Phi}{2\rho}$

FROM TABLE A.1 $\frac{f_{ct}}{f_b}$ = 0.67

FOR BASE SLAB R/F PROVIDED — BAR DIAMETER Φ = 20 mm

BAR SPACING S = 100 mm

Asp = 3142.86 mm^2

USING SURFACE ZONES AS PER FIG A.2 BS 8007

$\rho = \frac{Asp}{1000*250}$ = 0.0125714

Smax = 532.95 mm

MAXIMUM CRACK WIDTH DUE TO CHANGE IN TEMPERATURE T1 & T2

BS 8007 - APPENDIX A.3 — $\omega_{max} = S_{max} \cdot \frac{\alpha(T1+T2)}{2}$

α = 0.00001 $/^{0}C$

T1= 28^{0}C FOR GROUND SLAB WITH 600mm THICK

USE AS PER DESIGN CRITERIA — T1 = 35 ^{0}C

T2 = 15 ^{0}C

ω_{max} = **0.13 mm** O.K

(52)

ESERVOIR AREA COLUMN

ONCRETE GRADE fcu = 30 N/mm^2
HARACTERISTIC STRENGTH OF REINFORCEMENT fy = 460 N/mm^2
OLUMN BREADTH = 400 AND DEPTH = 400 mm
EPTH TO STEEL = 68 mm

XIAL LOAD N = 740 kN
OMENTS = 46.15 & 0 kNm
FFECTIVE LENGTHS = 7.17 & 7.17 meters
STRUCTURE IS UNBRACED

OTAL STEEL AREA = 0 mm^2 = 0 %
INIMUM STEEL AREA REQUIRED = .4% OF B*H = 640 mm^2

PROVIDE 8T16
MAIN BAR.

RESERVOIR AREA COLUMN

CONCRETE GRADE fcu = 35 N/mm^2
CHARACTERISTIC STRENGTH OF REINFORCEMENT fy = 460 N/mm^2
COLUMN BREADTH = 400 AND DEPTH = 400 mm
DEPTH TO STEEL = 68 mm

AXIAL LOAD N = 740 kN
MOMENTS = 46.15 & 0 kNm
EFFECTIVE LENGTHS = 9.560001 & 9.560001 meters
STRUCTURE IS UNBRACED

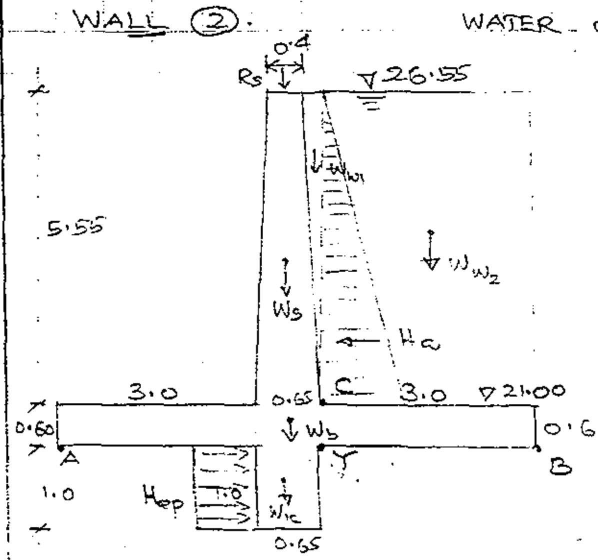
PROVIDE 8T16.
MAIN BAR

TOTAL STEEL AREA = 505.99 mm^2 = .31 %
MINIMUM STEEL AREA REQUIRED = .4% OF B*H = 640 mm^2

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW.	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 53 OF ....
	SCHEME KMU - GOTHTHATUWA RESERVOR COMPONENT 2 PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

WALL (2). WATER ONE SIDE FULL.



SELF WEIGHT OF COMPONENTS.

$W_s = \left(\frac{0.4+0.65}{2}\right) \times 5.55 \times 24.0 = 69.93$ kN/m
$W_b = 6.65 \times 0.6 \times 24.0 = 95.76$ "
$W_k = 0.65 \times 1.0 \times 24.0 = 15.60$ "
$W_{w1} = \frac{1}{2} \times 0.125 \times 5.55 \times 10.0 = 3.50$ "
$W_{w2} = 3.0 \times 5.55 \times 10 = 166.50$ "
$H_a = \frac{1}{2} \times 55.5 \times 5.55 = 154.01$ "
$H_{ep} = 3.0 \times 1.0 \times 20 = 60.00$ "
$R_s = 84.9 = 84.9$ kN/m.

1). CHECK FOR OVERTURNING.

Over turning about A.

$OT.M = 152.01 \times \frac{5.55}{3}$

$= 284.9$ kNm/m.

Restoring Moment

$= (69.93 + 95.76 + 15.60 + 84.9) \times \frac{6.65}{2}$
$+ 3.5 \times (3.65 - \frac{0.125}{3})$
$+ 166.5 \times (3.65 + \frac{3.0}{2})$

$= 1755.2$ kNm.

FOS Against Overturning $= \frac{1755.2}{284.9} = 6.16$

> 2.0

∴ ok//

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW.	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 54 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

2). SLIDING.

Total Vertical Loads = 69.93 + 95.76 + 15.60 + 84.9 + 3.50 + 166.50

= 436.2 kN/m.

Resisting forces

= 436.2 tan 26° + 60.0

= 272.7 kN/m.

∴ FOS = $\frac{272.7}{154.01}$ = 1.77 > 1.50.

∴ ok.

3). EARTH PRESSURE UNDER THE BASE.

From A,

$\bar{x} = \frac{(1755.2 - 284.9)}{436.2}$

= 3.371 m.

∴ Eccentricity of Loads

$e = \bar{x} - \frac{6.65}{2}$

= 3.371 − 3.325

= 0.046 < $\frac{L}{6} = \frac{6.65}{6}$ = 1.108

∴ ok.

Maximum Earth Pressure

$\sigma_{max} = \frac{436.2}{6.65}\left(1 + \frac{6 \times 0.046}{6.65}\right)$

= 68.3 kN/m² < 250.0

ok.

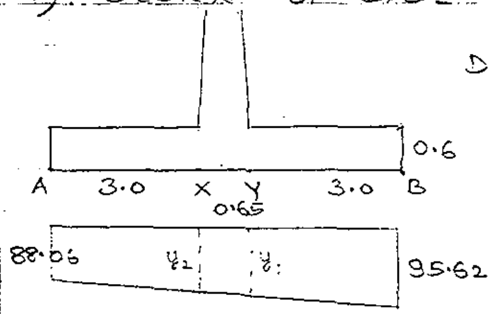
$\sigma_{min} = \frac{436.2}{6.65}\left(1 - \frac{6 \times 0.046}{6.65}\right)$

= 62.9 kN/m² > 0.

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW.	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 55 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

4) DESIGN OF BASE SLAB.



Design $f_{max} = 1.4 \times 68.3$
$= 95.62$ kN/m²

$f_{min} = 1.4 \times 62.9$
$= 88.06$ kN/m²

$y_1 = 88.06 + \left(\frac{95.62 - 88.06}{6.65}\right) \times 3.65$

$= 92.2$ kN/m²

$y_2 = 88.06 + \left(\frac{95.62 - 88.06}{6.65}\right) \times 3.0$

$= 91.5$ kN/m².

Pressure due to base slab
$= 0.6 \times 24 \times 1.4 = 20.16$ kN/m².

SLAB AX.

BM at X $= 88.06 \times \frac{3.0^2}{2} + \frac{1}{2}(91.5 - 88.06) \times \frac{3^2}{3}$
$- 20.16 \times 3^2/2$
$= 310.7$ kNm./m. – Bottom Tension.

SF $= 88.06 \times 3 + \frac{1}{2}(91.5 - 88.06) \times 3.0$
$- 20.16 \times 3$
$= 208.9$ kN/m.

REINFORCEMENT.

$M = 310.7$ kNm/m.
$b = 1000$ mm
$d = 600 - 50 - \frac{20}{2} = 540$ mm.

$\frac{M}{bd^2} = \frac{310.7 \times 10^6}{1000 \times 540^2} \doteq 1.07.$

$\frac{100 A_s}{bd} = 0.28 \rightarrow A_s = \frac{0.28 \times 1000 \times 540}{100}$

$= 1512.0$ mm²/m.

Nominal Reinforcement as per BS 8007

$\frac{100 A_s}{bh} = 0.35 \rightarrow A_s = 2100.0$ mm²/m.

Provide
T20@125 c/c
$A_s = 2513.0$ mm²

DESIGN OF CRACK.

BS 8007 : 1987

Reservoir Wall No. 2- Base Slab

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3acr.Em}{1+2\dfrac{(acr - Cmin)}{(h - x)}}$

$$\varepsilon m = \varepsilon_1 - \frac{bt(h - x)(a' - x)}{3Es.As(d - x)}$$

SERVICE MOMENT M = 222 KNM/M

h (mm) = 600 Cmin = 50 (mm) Φ = 20.00 mm

d = h - Cmin - Φ/2 d = 540.00 mm

CONCRETE f cu = 35 N/mm^2

fy = 460 N/mm^2

REINFORCEMENT PROVIDED BAR DIAMETER Φ = 20 mm

BAR SPACING S = 125 mm

Asp = 2513.27 mm^2

Ec = 28 KN/mm^2

Es = 200 KN/mm^2

αe = Es/ 1/2Ec = 14.29

ρ = 0.00465

$\alpha e.\rho$ = 0.066

THEREFORE $\dfrac{x}{d} = -\alpha e(\rho + \rho') + \sqrt{\alpha e^2(\rho + \rho')^2 + 2\alpha e\left(\rho + \dfrac{d'}{d}\rho'\right)}$ = 0.304

CONSIDERING $\rho' = 0$

THEREFORE x = 164.26 mm

z = d - 1/3 x = 485.25 mm

fs = $\dfrac{M}{Asp.z}$ = 182.03 N/mm^2

$\varepsilon s = \dfrac{fs}{Es \times 1000}$ = 0.0009102

$$\varepsilon_1 = \frac{(h - x)}{(d - x)} * \varepsilon_s = 0.001056$$

$$\varepsilon_m = 0.0007204$$

1) CRACK UNDER THE BAR DIRECTLY

$a_{cr} = C_{min} = 50$ mm

$\omega = 3.a_{cr}.\varepsilon_m =$ **0.108 mm**

< **0.2mm** O.K

2) CRACK AT MIDWAY BETWEEN TWO BARS

$$a_{cr} + \phi/2 = \sqrt{(S/2)^2 + (\phi/2 + C_{min})^2} = 86.64$$

$a_{cr} =$ 76.64 mm

$\omega =$ **0.148 mm**

< **0.2mm** O.K

THEREFORE REINFORCEMENT T20 @ 125 C/C O.K

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	CALCULATIONS BY MOH'D. LUTHFY.	SHEET 58 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

SHEAR $v = \frac{208.9 \times 10^3}{1000 \times 540} = 0.387\ N/mm^2.$

v_c for T20 @ 125 c/c.

$v_c = 0.544\ N/mm^2 > v.$

No Shear Reinforcement Necessary.

SLAB - BY.

$BM \text{ at } Y = 92.2 \times \frac{3^2}{2} + \frac{1}{2}(95.62 - 92.2) \times \frac{2 \times 3^2}{3}$

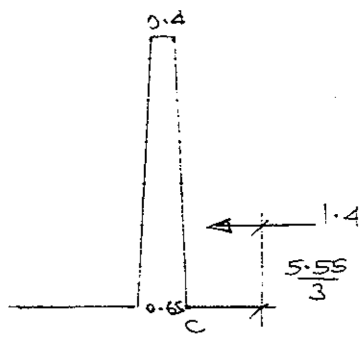
$- 1.4 \times 166.5 \times \frac{3}{2} - 20.16 \times \frac{3^2}{2}$

$= -15.21\ kNm/m.$ Top tension.

Shear Nominal.

Provide T20 @ 125 c/c. — Top bar T20 @ 125c/c

5). DESIGN OF WALL STEM.



$BM \text{ at } C = 215.6 \times \frac{5.55}{3} = 398.9\ kNm/m$

Shear at C = 215.6 kN/m.

Reinforcement

$M = 398.9\ kNm$

$b = 1000.0\ mm$

$d = 650 - 50 - \frac{20}{2} = 590.0\ mm.$

$\frac{M}{bd^2} = \frac{398.9 \times 10^6}{1000 \times 590^2} = 1.15$

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW.	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 59 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT
	$\frac{100A_s}{bd} = 0.31$	
	Minimum Required $\frac{100A_s}{bh} = 0.35$	
	$\therefore A_s = \frac{0.35 \times 1000 \times 650}{100}$	
	$= 2275.0 \text{ mm}^2$.	
	Provide T20 @ 125 c/c.	WALL RFT.
	$A_s = 2513.0 \text{ mm}^2$.	T20 @ 125 c/c.
	Shear $v = \frac{215.6 \times 10^3}{1000 \times 590} = 0.365 \text{ N/mm}^2$.	
	$v_c = 0.54 \text{ N/mm}^2 > v$	
	$\therefore$ No shear Reinforcement Necessary.	

(60)

DESIGN OF CRACK.

BS 8007 : 1987

Reservoir Wall No. 2- Wall Stem

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3acr.Em}{1+2\dfrac{(acr - Cmin)}{(h - x)}}$

$$\varepsilon m = \varepsilon_1 - \frac{bt\,(h - x)(a' - x)}{3Es.\,As\,(d - x)}$$

SERVICE MOMENT M =	284.9 KNM/M
h (mm) = 650 Cmin = 50 (mm) Φ =	20.00 mm
d = h - Cmin - Φ/2 d =	590.00 mm
CONCRETE f cu =	35 N/mm^2
fy =	460 N/mm^2
REINFORCEMENT PROVIDED BAR DIAMETER Φ =	20 mm
BAR SPACING S =	125 mm
Asp =	2513.27 mm^2
Ec =	28 KN/mm^2
Es =	200 KN/mm^2
αe = Es/ 1/2Ec =	14.29
ρ =	0.00426
$\alpha e.\rho$ =	0.061

THEREFORE $\dfrac{x}{d} = -\alpha e\,(\rho + \rho') + \sqrt{\alpha e^2\,(\rho + \rho')^2 + 2\alpha e\,(\rho + \dfrac{d'}{d}\rho')}$ = 0.293

CONSIDERING $\rho' = 0$

THEREFORE x =	173.04 mm
z = d - 1/3 x =	532.32 mm
$fs = \dfrac{M}{Asp.z}$ =	212.95 N/mm^2
$\varepsilon s = \dfrac{fs}{Es \times 1000}$ =	0.0010648

$$\varepsilon 1 = \frac{(h - x)}{(d - x)} * \varepsilon s = 0.001218$$

$$\varepsilon m = 0.0008562$$

1) <u>CRACK UNDER THE BAR DIRECTLY</u>

acr = Cmin = 50 mm

$\omega = 3.acr.\varepsilon m =$ **0.128 mm**

< **0.2mm** O.K

2) <u>CRACK AT MIDWAY BETWEEN TWO BARS</u>

$$acr + \phi/2 = \sqrt{(S/2)^2 + (\phi/2 + Cmin)^2} = 86.64$$

acr = 76.64 mm

$\omega =$ **0.177 mm**

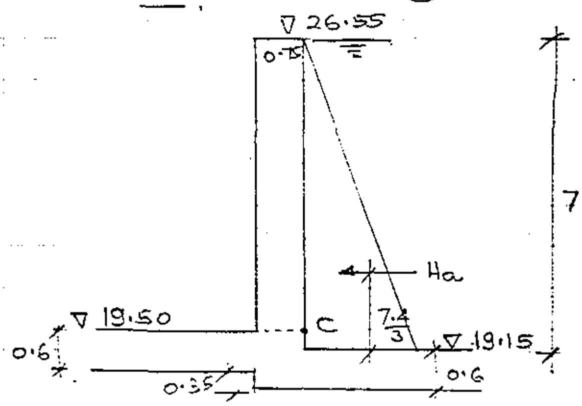
< **0.2mm** O.K

THEREFORE REINFORCEMENT T20 @ 125 C/C O.K

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW.	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 62 OF ......
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

DESIGN OF WALL (6).



Water at full level.

$Ha = \frac{1}{2} \times 74 \times 7.4 = 273.8$ kN/m.

Service BM at C $= 273.8 \times \left(\frac{7.4}{3} - 0.35\right)$
$= 579.5$ kNm.

Ultimate BM $= 1.4 \times 579.5$
$= 811.3$ kNm.

Ultimate Shear at C $= 273.8 \times 1.4$
$= 383.3$ kN/m.

Wall Reinforcement.

$M = 811.3$ kNm.
$b = 1000$ mm
$d = 750 - 50 - \frac{25}{2} = 687.5$ mm.

$\frac{M}{bd^2} = \frac{811.3 \times 10^6}{1000 \times 687.5^2} = 1.72.$

$\frac{100 As}{bd} = 0.48 \rightarrow As = \frac{0.48 \times 1000 \times 687.5}{100}$

$= 3300.0 \; mm^2$

Nominal R/f

$\frac{100 As}{bh} = 0.35$

$As = 3.5 \times 750 = 2625.0 \; mm^2$

Provide T25 @ 125 c/c.
∴ $As = 3926.0 \; mm^2$

Wall R/f
T25 @ 125 c/c

DESIGN OF CRACK.

BS 8007 : 1987

Reservoir Wall No. 6 - Wall Stem

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3acr.Em}{1+2\left(\dfrac{acr - Cmin}{h - x}\right)}$

$$\varepsilon m = \varepsilon_1 - \frac{bt\,(h - x)(a' - x)}{3Es.\,As\,(d - x)}$$

SERVICE MOMENT M = 579.5 KNM/M

h (mm) = 750 Cmin = 50 (mm) Φ = 25.00 mm

d = h - Cmin - Φ/2 d = 687.50 mm

CONCRETE f cu = 35 N/mm^2

fy = 460 N/mm^2

REINFORCEMENT PROVIDED BAR DIAMETER Φ = 25 mm

BAR SPACING S = 100 mm

Asp = 4908.74 mm^2

Ec = 28 KN/mm^2

Es = 200 KN/mm^2

$\alpha e = Es/\ 1/2Ec$ = 14.29

ρ = 0.00714

$\alpha e.\rho$ = 0.102

THEREFORE $\dfrac{x}{d} = -\alpha e\,(\rho + \rho') + \sqrt{\alpha e^2\,(\rho + \rho')^2 + 2\alpha e\,(\rho + \dfrac{d'}{d}\rho')}$ = 0.361

CONSIDERING $\rho' = 0$

THEREFORE x = 248.21 mm

z = d - 1/3 x = 604.76 mm

$fs = \dfrac{M}{Asp.z}$ = 195.21 N/mm^2

$\varepsilon s = \dfrac{fs}{Es \times 1000}$ = 0.000976

64

$$\varepsilon_1 = \frac{(h - x)}{(d - x)} * \varepsilon_s = 0.001115$$

ε_m = 0.0009203

1) <u>CRACK UNDER THE BAR DIRECTLY</u>

acr = Cmin = 50 mm

$\omega = 3.acr.\varepsilon_m$ = **0.138 mm**

< **0.2mm** O.K

2) <u>CRACK AT MIDWAY BETWEEN TWO BARS</u>

$$acr + \phi/2 = \sqrt{(S/2)^2 + (\phi/2 + Cmin)^2} = 80.04$$

acr = 67.54 mm

ω = **0.174 mm**

< **0.2mm** O.K

THEREFORE REINFORCEMENT T25 @ 100 C/C O.K

(65)

CHECK FOR THERMAL CRACK
Reservoir Wall 6 - Stem
BS 8007, APPENDIX A.3

CRACK SPACING $S_{max} = \frac{f_{ct}}{f_b} \times \frac{\Phi}{2\rho}$

FROM TABLE A.1 $\frac{f_{ct}}{f_b}$ = 0.67

FOR R/F PROVIDED

BAR DIAMETER Φ = 25 mm

BAR SPACING S = 125 mm

Asp = 3928.57 mm^2

USING SURFACE ZONES AS PER FIG A.2 BS 8007 h = 250 mm

$\rho = \frac{Asp}{1000*h}$ = 0.0157143

Smax = 532.95 mm

MAXIMUM CRACK WIDTH DUE TO CHANGE IN TEMPERATURE T1 & T2

BS 8007 - APPENDIX A.3 $\omega max = Smax \cdot \frac{\alpha(T1+T2)}{2}$

α = 0.00001 /°C

T1= 42°C FOR WALL OF 750mm THICK

THEREFORE T1 = 42 °C

T2 = 15 °C

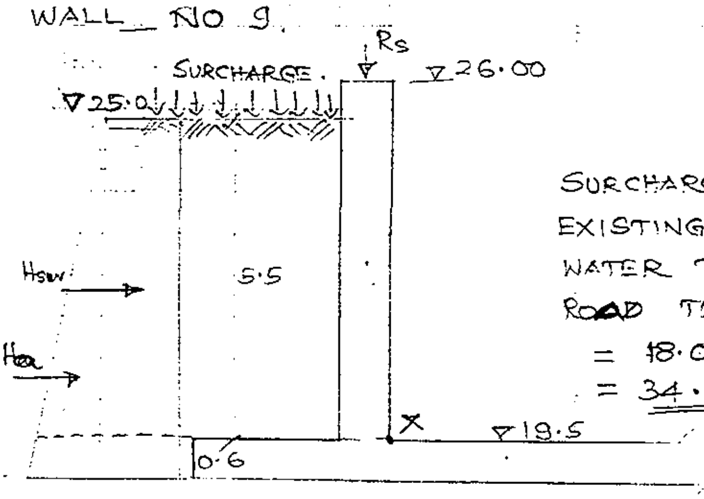
ωmax = **0.151892 mm** **< 0.2mm**

THERMAL CRACK OK

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY	SHEET 66 OF ....
	SCHEME KMU - GOTHTHATUWA RESERVOIR COMPONENT & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

WALL NO 9.



SURCHARGE DUE TO EXISTING & NEW WATER TOWER & ROAD TRAFFIC.

$= 18.0 + 16.5$

$= 34.5$ kN/m²

FOR THE WALL STEM.

$H_a = 0.333 \times 20 \times \frac{5.5^2}{2}$

$= 100.7$ kN.

$H_{sw} = 34.5 \times 5.5 = 189.75$ kN.

OVERTURNING & SLIDING RESISTED BY LARGE BASE SLAB.

BM DUE TO EARTH PRESSURE & SURCHARGE (SERVICE) AT 'X'

$= 100.7 \times \frac{5.5}{3} + 189.75 \times \frac{5.5}{2}$

$= 706.4$ kNm.

ULTIMATE BM $= 1.4 \times 706.4 = 989.0$ kNm.

SF $= 1.4 \times (100.7 + 189.75)$

$= 406.6$ kN.

REINFORCEMENT.

$d = 650 - 50 - \frac{25}{2}$

$=$

$\frac{M}{bd^2} = \frac{989.0 \times 10^6}{1000 \times 587.5^2}$

$= 2.87$.

$\frac{100 A_s}{bd} = 0.81 \rightarrow A_s = \frac{0.81 \times 1000 \times 587.5}{100}$

$= 4758.8$ mm²

PROVIDE T25 @ 100 c/c → $A_s = 4908.0$ mm².

WALL VERTICAL BARS
T25@100 c/c
EARTH FACE.

DESIGN OF CRACK

BS 8007 : 1987

Reservoir Wall No. 9 - Wall Stem

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3acr.Em}{1+2\dfrac{(acr - Cmin)}{(h - x)}}$

$$\mathcal{E}m = \mathcal{E}_1 - \frac{bt\,(h - x)(a' - x)}{3Es.\,As\,(d - x)}$$

SERVICE MOMENT M = 706.4 KNM/M

h (mm) = 650 Cmin = 50 (mm) Φ = 32.00 mm

d = h - Cmin - Φ/2 d = 584.00 mm

CONCRETE f cu = 35 N/mm^2

fy = 460 N/mm^2

REINFORCEMENT PROVIDED BAR DIAMETER Φ = 32 mm

BAR SPACING S = 100 mm

Asp = 8042.48 mm^2

Ec = 28 KN/mm^2

Es = 200 KN/mm^2

$\alpha e = Es/\,1/2Ec$ = 14.29

ρ = 0.01377

$\alpha e.\rho$ = 0.197

THEREFORE $\dfrac{x}{d} = -\alpha e\,(\rho + \rho') + \sqrt{\alpha e^2\,(\rho + \rho')^2 + 2\alpha e\,(\rho + \dfrac{d'}{d}\rho')}$ = 0.461

CONSIDERING $\rho' = 0$

THEREFORE x = 269.03 mm

z = d - 1/3 x = 494.32 mm

$fs = \dfrac{M}{Asp.z}$ = 177.68 N/mm^2

$\mathcal{E}s = \dfrac{fs}{Es \times 1000}$ = 0.0008884

(68)

$$\varepsilon 1 = \frac{(h - x)}{(d - x)} * \varepsilon s = 0.001075$$

$$\varepsilon m = 0.0009791$$

1) <u>CRACK UNDER THE BAR DIRECTLY</u>

acr = Cmin = 50 mm

$\omega = 3.acr.\varepsilon m =$ **0.147 mm**

< **0.2mm** O.K

2) <u>CRACK AT MIDWAY BETWEEN TWO BARS</u>

$$acr + \phi/2 = \sqrt{(S/2)^2 + (\phi/2 + Cmin)^2} = 82.80$$

acr = 66.80 mm

$\omega =$ **0.180 mm**

< **0.2mm** O.K

THEREFORE REINFORCEMENT T32 @ 100 C/C O.K

CHECK FOR THERMAL CRACK

Wall No. 9

BS 8007, APPENDIX A.3

CRACK SPACING $S_{max} = \frac{f_{ct}}{f_b} \times \frac{\Phi}{2\rho}$

FROM TABLE A.1 $\frac{f_{ct}}{f_b}$ = 0.67

FOR R/F PROVIDED BAR DIAMETER Φ = 25 mm

BAR SPACING S = 100 mm

Asp = 4910.71 mm^2

USING SURFACE ZONES AS PER FIG A.2 BS 8007 h = 250 mm

$\rho = \frac{Asp}{1000*250}$ = 0.0196429

Smax = 426.36 mm

MAXIMUM CRACK WIDTH DUE TO CHANGE IN TEMPERATURE T1 & T2

BS 8007 - APPENDIX A.3 $\omega max = Smax \cdot \frac{\alpha(T1+T2)}{2}$

α = 0.00001 $/^{\circ}C$

T1= 42^{0}C FOR WALL OF 650mm THICK

THEREFORE T1 = 42 ^{0}C

T2 = 15 $^{\circ}C$

ωmax = ***0.1215136 mm*** ***< 0.2mm***

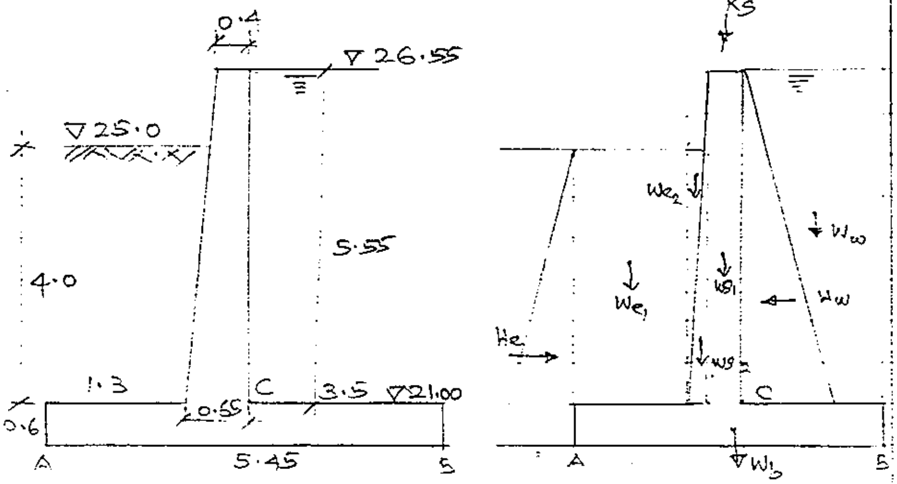
THERMAL CRACK OK

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW.	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 70 OF ....
	SCHEME COMPONENT KMU. GOTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

RESERVOR WALLS.

WALL ①, ③ & ④.



Self weight of component's contributing to forces.

$W_{S_1} = 0.4 \times 5.55 \times 24.0 = 53.28$ kN/m.

$W_{S_2} = \frac{1}{2} \times 0.25 \times 5.5 \times 24.0 = 16.50$ "

$W_{e_1} = 1.3 \times 4.0 \times 20.0 = 104.00$ "

$W_{e_2} = \frac{1}{2} \times 0.18 \times 4.0 \times 20.0 = 7.20$ "

$W_b = 0.6 \times 5.45 \times 24.0 = 78.48$ "

$W_w = 3.5 \times 5.55 \times 10.0 = 194.25$ "

$H_e = 0.333 \times 20 \times \frac{4.6^2}{2} = 70.46$ "

Slab React. $R_s = (6 + 4.8 + 2.4 + 2.5) \times \frac{5.442}{2} = 42.72$ "

$H_w = \frac{1}{2} \times 5.55 \times 10 \times 5.5 = 154.0$ "

CASE OF WATER FULL LEVEL.

IGNORING EARTH SUPPORT

1). OVERTURNING

About Point 'A'

Overturning Moment $= 154.0 \times \left(\frac{5.55}{3} + 0.6\right)$

$= \underline{377.3}$ kNm.

Restoring Moment

$= 53.28 \times 1.75 + 16.5 \times (1.3 + \frac{2}{3} \times 0.25)$

$+ 194.25 \times (1.95 + \frac{3.5}{2}) + 78.48 \times \frac{5.45}{2}$

$+ 42.72 \times 1.75$

$= 1124.8$ kNm.

FOS Against overturning $= \frac{1124.8}{377.3} = 2.98 > 2.0$

OK.

ITEM	CALCULATIONS	OUT PUT

2). SLIDING.

TOTAL VERTICAL LOADS

$= 53.28 + 16.50 + 194.25 + 78.48 + 42.72$

$= \underline{385.23}$ kN.

Frictional Resistance at the base

$= 385.23 \tan 26°$

$= 187.9$ kN.

$\therefore$ FOS $= \frac{187.9}{154.0} = 1.22$

Considering the passive earth resistance on the outer face FOS against sliding would reach around 3.0.

$\therefore$ ok.

3) EARTH PRESSURE UNDER THE BASE SLAB.

From A, $\bar{x} = \frac{(1124.8 - 377.3)}{385.23}$

$= 1.94$ m.

$\therefore$ Eccentricity $e = \bar{x} - \frac{L}{2} = 1.94 - \frac{5.45}{2}$

$= -0.785 < 0.908 = L/6$

Maximum Earth pressure

$\sigma_{max} = \frac{385.23}{5.45}\left(1 + \frac{6 \times 0.785}{5.45}\right)$

$= 131.8$ kN/m² < 250.0 ok.

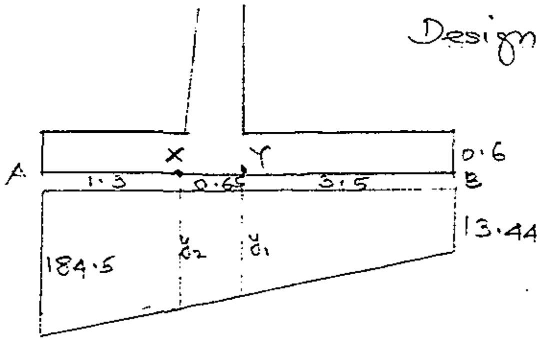
$\sigma_{min} = \frac{385.23}{5.45}\left(1 - \frac{6 \times 0.785}{5.45}\right)$

$= 9.6$ kN/m² > 0. ok.

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 72 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

4). DESIGN OF BASE SLAB.



Design $\sigma_{max} = 1.4 \times 131.8$
$= 184.5$ kN/m²

$\sigma_{min} = 1.4 \times 9.6$
$= 13.44$ kN/m²

$y_1 = 13.44 + \left(\frac{184.5 - 13.44}{5.45}\right) \times 3.5$

$= 13.44 + 109.9$
$= 123.3$ kN/m²

$y_2 = 13.44 + \left(\frac{184.5 - 13.44}{5.45}\right) \times 4.15$

$= 13.44 + 130.26$
$= 143.7$ kN/m².

Pressure due to base Slab
$= 0.6 \times 24 \times 1.4 = 20.16$ kN/m².

SLAB AX

Ult. BM at X $= 143.7 \times \frac{1.3^2}{2} +$
$\frac{1}{2}(184.5 - 143.7) \times \frac{2}{3} \times 1.3^2 - 20.16 \times \frac{1.3^2}{2}$

$= 127.4$ kNm.

Ult. SF $= 143.7 \times 1.3 + \frac{1}{2}(184.5 - 143.7) \times 1.3$
$= 213.3$ kN $- 20.16 \times 1.3$
$= 187.1$ kN.

Reinforcement

$M = 144.4$ kNm.
$b = 1000$ mm
$d = 600 - 50 - \frac{20}{2} = 540$ mm.

$\frac{M}{bd^2} = \frac{127.4 \times 10^6}{1000 \times 540^2} = 0.44$.

Nominal $\frac{100 A_s}{bh} = 0.35 \rightarrow A_s = \frac{0.35 \times 1000 \times 600}{100}$
$= 2100.0$ mm².

Provide T20 @ 125 c/c
$\rightarrow A_s = 2513.0$ mm².

OUT PUT: T20 @ 125 c/c

DESIGN OF CRACK.

BS 8007 : 1987

Wall 1,3 & 4 Base Slab

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3a_{cr}.E_m}{1+2\left(\dfrac{a_{cr} - C_{min}}{h - x}\right)}$

$$\varepsilon_m = \varepsilon_1 - \frac{b_t\,(h - x)(a' - x)}{3E_s.\,A_s\,(d - x)}$$

SERVICE MOMENT M = 91 KNM/M

h (mm) = 600 Cmin = 50 (mm) Φ = 20.00 mm

$d = h - C_{min} - \Phi/2$ d = 540.00 mm

CONCRETE f_{cu} = 35 N/mm^2

f_y = 460 N/mm^2

REINFORCEMENT PROVIDED BAR DIAMETER Φ = 20 mm

BAR SPACING S = 125 mm

Asp = 2513.27 mm^2

Ec = 28 KN/mm^2

Es = 200 KN/mm^2

$\alpha_e = E_s / \tfrac{1}{2}E_c$ = 14.29

ρ = 0.00465

$\alpha_e.\rho$ = 0.066

THEREFORE $\dfrac{x}{d} = -\alpha_e(\rho + \rho') + \sqrt{\alpha_e^2(\rho + \rho')^2 + 2\alpha_e\left(\rho + \dfrac{d'}{d}\rho'\right)}$ = 0.304

CONSIDERING $\rho' = 0$

THEREFORE x = 164.26 mm

$z = d - 1/3\,x$ = 485.25 mm

$f_s = \dfrac{M}{A_{sp}.z}$ = 74.62 N/mm^2

$\varepsilon_s = \dfrac{f_s}{E_s \times 1000}$ = 0.0003731

$$\varepsilon 1 = \frac{(h - x)}{(d - x)} * \varepsilon s = 0.000433$$

$$\varepsilon m = 9.756E\text{-}05$$

1) CRACK UNDER THE BAR DIRECTLY

acr = Cmin = 50 mm

$\omega = 3.acr.\varepsilon m =$ **0.015 mm**

< **0.2mm** O.K

2) CRACK AT MIDWAY BETWEEN TWO BARS

$$acr + \phi/2 = \sqrt{(S/2)^2 + (\phi/2 + Cmin)^2} = 86.64$$

acr = 76.64 mm

$\omega =$ **0.020 mm**

< **0.2mm** O.K

THEREFORE REINFORCEMENT T20 @ 1250C/C O.K

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 75 OF ....
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

SLAB BY.

$$\text{Ult BM at Y} = 13.44 \times \frac{3.5^2}{2} + \frac{1}{2}(123.3 - 13.44) \times 3.5 \times \frac{1}{3} \times 3.5$$

$$= -166.5 \times \frac{3.5}{2} - 20.16 \times \frac{3.5^2}{2}$$

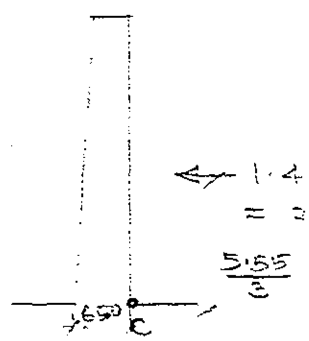
$$= -108.2 \text{ kNm} - \text{Top Tension.}$$

BM $108.2 < 127.4$ (Slab Ax)

∴ Provide Nominal T20 @ 125 c/c.

Provide T20 @ 125 c/c

5). DESIGN OF STEM.



$$\text{BM at C} = 215.6 \times \frac{5.55}{3} = 398.9 \text{ kNm}$$

$$\text{SF} = 215.6 \text{ kN.}$$

Reinforcement

$M = 398.9$ kNm.

$b = 1000$ mm

$d = 650 - 50 - \frac{20}{2} = 590$ mm.

$$\frac{M}{bd^2} = \frac{398.9 \times 10^6}{1000 \times 590^2} = 1.15$$

$$\frac{100A_s}{bd} = 0.3.$$

Nominal $\frac{100A_s}{bh} = 0.35$

$$\therefore A_s = 0.35 \times 1000 \times \frac{650}{100}$$

$$= 2275.0 \text{ mm}^2$$

Provide T20 @ 125 → $A_s = 2513$

Wall T20 @ 125 c/c.

DESIGN OF CRACK.

BS 8007 : 1987

Wall 1,3 & 4 Wall Stem

DESIGN SURFACE CRACK WIDTH $\omega = \dfrac{3acr.Em}{1+2\dfrac{(acr - Cmin)}{(h-x)}}$

$$\varepsilon m = \varepsilon_1 - \frac{bt\,(h-x)(a'-x)}{3Es.\,As\,(d-x)}$$

SERVICE MOMENT M = 284.9 KNM/M

h (mm) = 650 Cmin = 50 (mm) Φ = 20.00 mm

d = h - Cmin - Φ/2 d = 590.00 mm

CONCRETE f cu = 35 N/mm^2

fy = 460 N/mm^2

REINFORCEMENT PROVIDED BAR DIAMETER Φ = 20 mm

BAR SPACING S = 125 mm

Asp = 2513.27 mm^2

Ec = 28 KN/mm^2

Es = 200 KN/mm^2

αe = Es/ 1/2Ec = 14.29

ρ = 0.00426

$\alpha e.\rho$ = 0.061

THEREFORE $\dfrac{x}{d} = -\alpha e\,(\rho + \rho') + \sqrt{\alpha e^2\,(\rho+\rho')^2 + 2\alpha e\,(\rho + \dfrac{d'}{d}\rho')}$ = 0.293

CONSIDERING $\rho' = 0$

THEREFORE x = 173.04 mm

z = d - 1/3 x = 532.32 mm

$fs = \dfrac{M}{Asp.z}$ = 212.95 N/mm^2

$\varepsilon s = \dfrac{fs}{Es \times 1000}$ = 0.0010648

$$\varepsilon_1 = \frac{(h - x)}{(d - x)} * \varepsilon_s = 0.001218$$

$$\varepsilon_m = 0.0008562$$

1) <u>CRACK UNDER THE BAR DIRECTLY</u>

$a_{cr} = C_{min} =$ 50 mm

$\omega = 3.a_{cr}.\varepsilon_m =$ **0.128 mm**

< **0.2mm** O.K

2) <u>CRACK AT MIDWAY BETWEEN TWO BARS</u>

$$a_{cr} + \phi/2 = \sqrt{(S/2)^2 + (\phi/2 + C_{min})^2} = 86.64$$

$a_{cr} =$ 76.64 mm

$\omega =$ **0.177 mm**

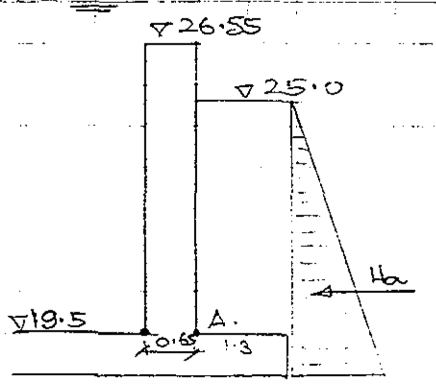
< **0.2mm** O.K

THEREFORE REINFORCEMENT T20 @ 125C/C O.K

CEYWATER CONSULTANT (PVT) LTD. INFRASTRUCTURE & ENVIRONMENTAL ENGINEERS AND PLANNERS	PROJECT NRW.	JOB NO.
	CALCULATIONS BY MOHD. LUTHFY.	SHEET 78 OF ......
	SCHEME COMPONENT KMU - GOTHTHATUWA RESERVOIR & PUMP HOUSE.	DATE

ITEM	CALCULATIONS	OUT PUT

WALL 10 & 11.



$$H_a = 0.333 \times 20 \times \frac{5.5^2}{2}$$

$$= 100.7 \text{ kN}.$$

Overturning & sliding resisted by the large base slab.

WALL.

Service BM at A $= 100.7 \times \left(\frac{5.5}{3} - 0.6\right)$
$= 124.2$ kNm/m.

Ultimate BM at A $= 1.4 \times 124.2$
$= \underline{173.9}$ kNm/m.

Ultimate shear at A $= 1.4 \times 100.7$
$= \underline{141.0}$ kN

Reinforcement.

$M = 173.9$ kNm.
$b = 1000.0$ mm.
$d = 650 - 50 - \frac{20}{2} = 590$ mm.

$$\frac{M}{bd^2} = \frac{173.9 \times 10^6}{1000 \times 590^2} = 0.5.$$

Nominal Reinforcement.

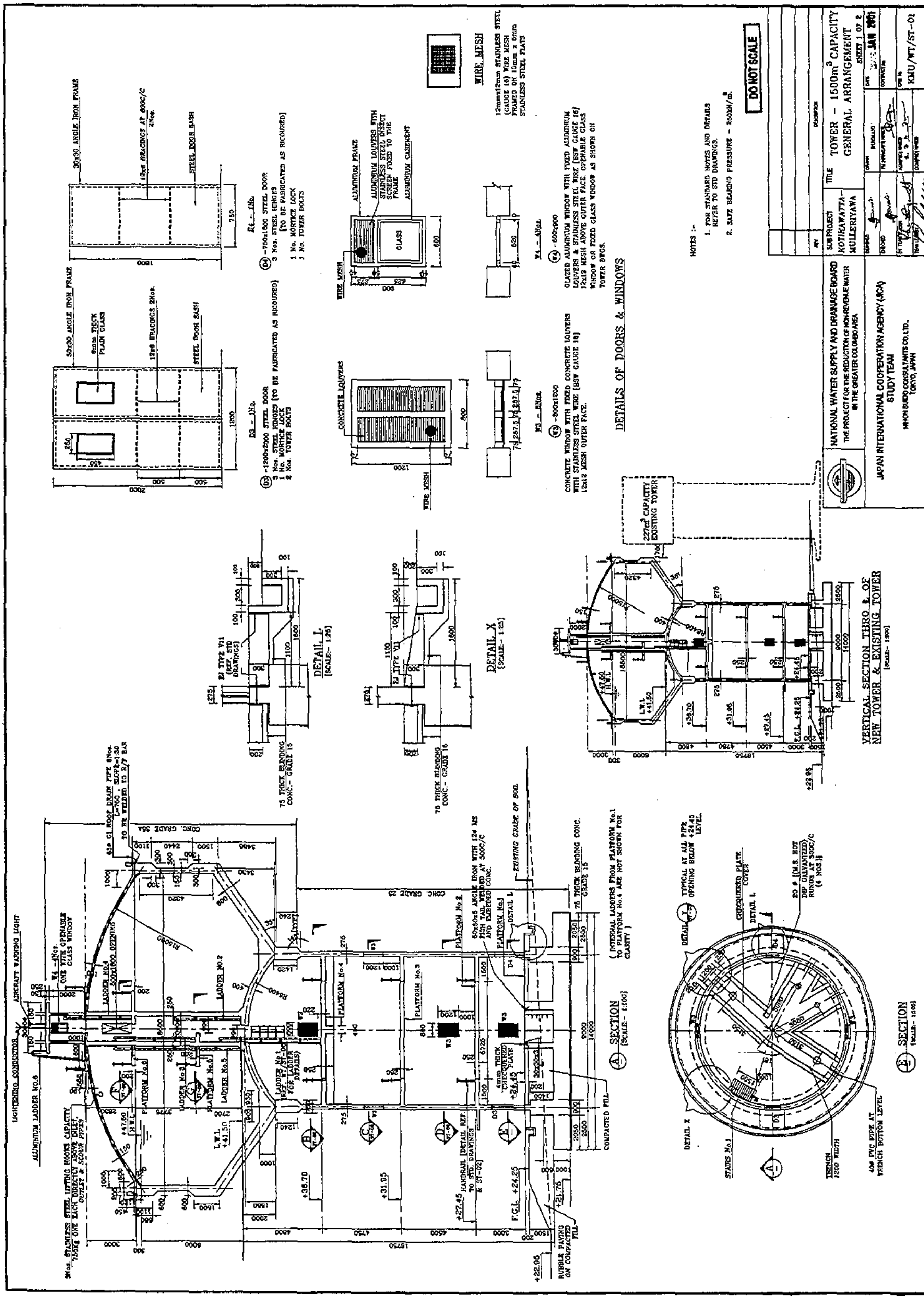
$$\frac{100 A_s}{bh} = 0.35 \rightarrow A_s = \frac{0.35 \times 1000 \times 650}{100}$$
$$= 2275.0 \text{ mm}^2.$$

Provide T20 @ 125 c/c.
$A_s = 2513.0$ mm^2

Vertical Bars
T20 @ 125 c/c

FLEXURAL CRACKS & THERMAL CRACKS SATISFACTORY.

GOTHATUWA NEW WATER TOWER


DO NOT SCALE
TOWER - 1500m3 CAPACITY
GENERAL ARRANGEMENT
KMU/WT/ST-01
NATIONAL WATER SUPPLY AND DRAINAGE BOARD
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
STUDY TEAM
DETAILS OF DOORS & WINDOWS
VERTICAL SECTION THRO & OF NEW TOWER & EXISTING TOWER
DETAIL L
DETAIL X
SECTION
WIRE MESH

PROJECT	Reduction of non-revenue water in the Greater Colombo Area
PART OF STRUCTURE	kotikawatta-Mulleriyawa -tower -1500 m^3

REF	CALCULATIONS	OUT PUT

Load cases

1 - $1.2w_d + 1.2w_s . 1.2w_w$

2 - $1.4w_d . 1.4w_w$

3 - $1.0w_d . 1.4w_w$

4 - $1.4w_d + 1.6w_s$

Wind speed = 45 m/s

w_k = 1.53 kN/m^2

Weight of shaft (1.5+16.5)xpix9.x0.275x24

3360 kN

Total dead load allowing for 50% = 204*60+3350*1.5

for platforms etc = 17265 kN

OUTPUT: dead load 204x60 kN

Load case (2)

dead load = 17265*1.4

= 24171 kN

moment @ foundation level

= (1.53*19.5*11.0*23.25+1.53*9.275*15.25*10.125)*1.4

= 13750 kNm

e = 13750/24171

= 0.57 m

e/D = 0.57/14

= 0.0406 (<0.125)

f_c = {24171/[(π/4)*14.00^2]} * (1+0.0406/0.125)

or

{24171/[(π/4)*14.00^2]} * (1-0.0406/0.125)

f_c = 208 or 106 kN/m^2 < 250*1.4

Similiarly for load case (3),

dead load = 17265 kN

moment @ foundation level = 13750 kNm

e = 13750/17265

= 0.8 m

e/D = 0.80/14.00

= 0.057 (<0.125)

f_c = {17265/[(π/4)*14.00^2]} * (1+0.057/0.125)

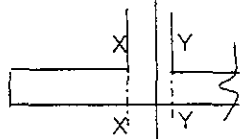
or

{17265/[(π/4)*14.00^2]} * (1-0.057/0.125)

f_c = 163 or 61 kN/m^2 < 250*1.4

PROJECT	Reduction of non-revenue water in the Greater Colombo Area
PART OF STRUCTURE	kotikawatta-Mulleriyawa -tower -1500 m^3

REF	CALCULATIONS				OUT PUT
	Loading case 4				
	Load due to tank & water		=	34320 kN	572x60 kN
	Weight of shaft		=	3360 kN	SLS
	allowing 50% for platforms & etc,				
	Total load at foundation level		=	34320+3360x1.5 kN	
				39360 kN	
	with safe bearing pressure of 250 kN/m^2				
		A	=	39360/250	
			=	157.44 m2	
	14.0 m dia base max pressure fc		=	39360/(PIx14^2/4)	
			=	255 kN/m2	
	vu @ 1.5d away from x-x		=	255*(14^2-12.7^2)*p*1.4/(p*4*12.7)	
			=	244.6 kN/m	
		vu	=	244.6*10^3/(10^3*935)	
			=	0.26 N/mm2	
	Provide Y25-200c/c		=	2454 mm2/m	
	vu @ 1.5d away from y-y		=	255*5.32*p*1.4/(p*4*5.3)	
			=	473 kN/m	
		vu	=	473.*10^3/935*10^3	
			=	0.5 N/mm2	
		Ast	=	0.50*10^3*935/100	
			=	4675 mm2/m r/f for shear predominates	
	Provide Y25-100c/c			4909 mm^y/m	
	Moment @ x-x	Mxx	=	255{(2.05^2/2)+(0.414*2.05^2*2/2/3)}*1.4	
			=	957.19 kNm	
		Ast	=	2756 mm2/m	
	provide Y25-150c/c bottom		=	3273 mm2/m	
	Moment @ center	Mc	=	(255*9.9^2*1.4/20)- (255*2.05^2/2)	
			=	999.47 kNm	
		Ast	=	2974 mm2/m	
	Provide Y25-150c/c top		=	3273 mm2/m	



PROJECT	Reduction of non-revenue water in the Greater Colombo Area
PART OF STRUCTURE	kotikawatta-Mulleriyawa -tower -1500 m^3

REF	CALCULATIONS	OUT PUT
	RC wall which supports the Tank	
	thickness = 275 mm	
	f_c = 39360*1.4*10^3/(π*9000*275)	
	= 7.09 N/mm^2	
	≤ 0.40*25 = 10 N/mm^2	
	Vertical r/f = provide 0.4%	
	= 0.4*10^3*275/100	
	= 1100	
	Provide Y12-150c/c both faces (= 754*2 = 1508mm^2)	o.k
	Hoop R/F = 0.25*10^3*275/100 = 688 mm^2	
	Provide Y10-200c/c both faces (= 392*2 = 784mm^2)	
	Distribution r/f for base = 0.13*10^3*1000/100	
	= 1300 mm^2/m	
	Provide Y16-150c/c both faces (= 1340mm^2)	
	Reinforcement of the circular ring beam which supports the circular shaft this is nominal	
	$(A_{st})_{-min}$ = 0.13*900*2400/100	
	= 2400 mm^2	
	Provide 5Y25 (2454mm^2) Top & bottom	o.k
	Vertical r/f for base beam (0.4%) = 0.4*900*10^3/100	
	= 3600 mm2/m	
	provide Y16-110c/c both faces (= 3656 mm2)	o.k

PROJECT	Reduction of non-revenue water in the Greater Colombo Area
PART OF STRUCTURE	kotikawatta-Mulleriyawa -tower -1500 m^3

REF	CALCULATIONS	OUT PUT
	Ring beam at top 600x1100 mm	600X 1100 deep
	F_x = 311.30x0.6x1.1 = 205.46 kN -tensile	
	f_{st} = $205.46\times10^3/(3141\times2\times1.1)$	
	= 29.73 N/mm^2	
	ε_{st} = $29.73/200*10^3$	
	= 1.49×10^{-4}	
	e_m = $2*600*1100/(3*200*10^3*3141\times2\times1.1)$	
	= 3.18×10^{-4} < ε_{st}	
	nominal r/f is ok	
	nominal = 1 ϕ	
	600 section A_{st}-min = Y20-100c/c = 3141 mm^2/m	o.k
	300mm thick tank wall	
	F_x = 1237*0.3 kN/m = 371 kN/m	
	f_{st} = $371\times10^3/(1340\times2)$	
	= 138 N/mm^2	
	A_{st}-min = $1*10^{-5}*150*10^3*(29+14)\phi$	
	= 64.5 ϕ - per face	
	ϕ(mm) $A_{st}(mm^2)$	
	16 1032 → Y16-150c/c 1340	
	f_{st} = $371*10^3/(1340*2)$	
	= 138 N/mm^2	
	ε_{st} = $138/200*10^3$	
	= $6.92*10^{-4}$	
	a_{cr} = 85.6 mm	
	w_{cr} = $3*85.6*6.92*10^{-4}$	
	Crackwidth 0.18 mm < 0.2 mm	o.k
	Tank bottom ring beam at conical top	600x1400
	Tensile force (F_x) = 1364x0.6x1.4	
	= 1145 kN	
	A_{st}-min = $1*10^{-5}*250*10^3*(49+14)\phi$	
	157.5 ϕ → Y25-125c/c hoop	

PROJECT	Reduction of non-revenue water in the Greater Colombo Area
PART OF STRUCTURE	kotikawatta-Mulleriyawa -tower -1500 m^3

REF	CALCULATIONS	OUT PUT
	f_{st} = 1145*10³/(18*490)	cover =
	= 129.82 N/mm²	50+10 =
	ε_{st} = 129.82/200*10³	60mm
	= 6.49*10⁻⁴	
	a_{cr} = 91 mm	
	w_{cr} = 3*91*6.49*10⁻⁴	
	Crackwidth < 0.18 mm < 0.2 mm	o.k
	Maximum tension in conical bottom	600 mm
	F_x = 1452x0.6 kN/m = 871.2 kN/m	section
	A_{st}-min = 1*10⁻⁵*250*10³*(44+14)ϕ	
	= 145 ϕ	
	ϕ(mm) A_{st}(mm²)	
	16 2320	
	20 2900 → Y20-100c/c hoop	
	A_{st} = 3141x2 mm²/m	
	f_{st} = 871.2x10³/(3141x2)	run worksh
	= 133.68 N/mm²	
	ε_{st} = 133.68/200*10³	
	= 6.93x10⁻⁴	
	e_m = 2*600*1000/(3*200*10³*3141*2)	
	= 3.18*10⁻⁴	
	a_{cr} = 84.34 mm	
	w_{cr} = 3*84.34*(6.93*10⁻⁴-3.18*10⁻⁴)	
	Crackwidth = 0.09 mm < 0.2 mm	
	Conical bottom - near bottom ring 1000mm thick	
	Q_y = 288x1.4x1.00 = 288 kN/m	
	F_x = -560.99x0.9 = -504.90 kN/m	
	F_y = -134.71x0.9 = -1021.24 kN/m	
	v_u = 288x10³/(10³*940)	h=1000
	= 0.31 N/mm²	d=
	A_{st}-min = 1*10⁻⁵*250*10³*(52+14)ϕ	(1000-50-10)
	= 165 ϕ	=940mm
	ϕ(mm) A_{st}(mm²)	
	20 3300	
	25 4125 → Y25-120c/c	

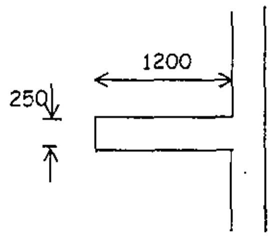
PROJECT	Reduction of non-revenue water in the Greater Colombo Area
PART OF STRUCTURE	kotikawatta-Mulleriyawa -tower -1500 m^3

REF	CALCULATIONS	OUT PUT
	Bottom dome of tank	
	Maximum compression,	
	F_y = -2186*0.4 kN/m	
	= -874.4 kN/m	
	$\therefore f_c$ = $874.4*10^3/(400*10^3)$	
	= 2.2 N/mm^2 < 35*0.35/1.4	
	= 8.75 N/mm^2	o.k
	A_{st}-min = $1*10^{-5}*200*10^3*(35+14)\phi$	
	= 98 ϕ	
	ϕ(mm) A_{st}(mm^2)	
	16 1568 → Y16-125c/c	
	Ring beam at 9.0 dia rc shaft top	750 x
	Fx = 1642x0.75x1.24 = 1527.00 kN -compressive	1240 secti
	$\therefore f_c$ = $1527x10^3/(750x1240)$	
	= 1.64 N/mm^2	ok
	A_{st}-min = $1*10^{-5}*250*10^3*(49+14)\phi$	
	= 15.75 ϕ → Y25-125c/c	
	nominal links = $0.0035*600*10^3/2$ per face	
	= 1050 mm^2 → Y16-150c/c links	o.k
	Tank Inner shaft (250 mm)	
	A_{st}-min = $1*10^{-5}*125*10^3*30\phi$	
	= 37.5 ϕ	
	ϕ(mm) A_{st}(mm^2)	
	10 375	
	12 450 → Y10-150c/c (523mm^2)	
	both ways	

PROJECT	Reduction of non-revenue water in the Greater Colombo Area
PART OF STRUCTURE	kotikawatta-Mulleriyawa -tower -1500 m^3

REF	CALCULATIONS	OUT PUT

Circulart platform inside the tower



Loading

super = 5 kN/m^2

slab = 0.25*24 kN/m^2

U_{sls} = 11 kN/m^2

Uu_{lt} = 5*1.6 + 6*1.4

= 16.4 kN/m^2

M_{sls} = (11*1.2^2)/2 + (11*1.2*2*1.2)/(2*3)

= 13.2 kN/m

V_u = 16.4*1*1.2 + 16.4*1*2.2/2

= 37.72 kN

v_u = 37.72*10^3/194

= 0.19 N/mm^2

M_{ult} = 13.2*16.4/11

= 19.68 kN/m → Y12-100c/c

v_c = 0.71 N/mm^2 > v_u

Circulart platform inside the rc shaft

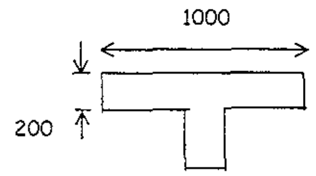
	Uu_{lt} = 5*1.6 + 0.3*24*1.4	h=250
	= 18.08 kN/m^2	d=
	M_{cant} = 18.08*1.5^2/2	(250-40-6)
	= 20.34 kNm	=204 mm
	A_{st} = 266 mm^2 → Provide Y12-200c/c(565mm^2)	
	γ_{st} = 2	
	d ≥ 1.5*10^3/(7*2)	
	≥ 107 mm	o.k

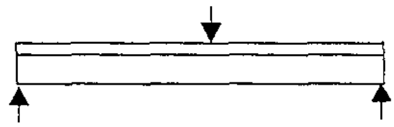
WT-09

PROJECT	Reduction of non-revenue water in the Greater Colombo Area
PART OF STRUCTURE	kotikawatta-Mulleriyawa -tower -1500 m^3

REF	CALCULATIONS	OUT PUT

Tie beam at top platform level within the shaft





Loading

slab = 0.25*24*1.4 = 8.4 kN/m

super = 2*1.6 = 3.2 kN/m

point load = 100*1.6 = 160 kN

(allow for 10 tonnes pt. Load)

Moment at centre = $11.6*8.25^2/8 + 160*8.25/4$

= 429 kNm

450 x750 deep

$d \geq \sqrt{[429*10^6/(0.156*25*450)]}$

$\geq$ 495 mm

d = 750-40-10-10

= 690 mm

450*750 beam

A_{st} = 2069 mm^2 → 5Y25 (=2454 mm^2)

ELEMENT FORCES FORCE,LENGTH UNITS= KNS METE
FORCE OR STRESS = FORCE/WIDTH/THICK, MOMENT = FORCE-LENGTH/WIDTH

ELEMENT	LOAD	QX VONT	QY VONE	MX FX	MY FY	MXY FXY
1	3	.[illegible]	-251.[illegible]6	-13.11	-97.[illegible]6	.[illegible]
		1151.67	1313.68	-1641.1[illegible]	-1611.[illegible]3	-.1[illegible]
[illegible]	3	.01	-251.04	-13.1[illegible]	-97.15	.00
		1151.65	1303.57	-1641.14	-1601.31	-.08
61	3	.01	208.06	-95.44	-144.78	.01
		1933.10	213.69	-545.99	-1153.87	.07
121	3	-.01	80.31	-76.76	-23.96	.00
		1007.77	1379.41	251.77	-951.77	.01
181	3	-.11	49.78	-15.00	19.18	.0[illegible]
		1151.10	1140.11	616.87	-1166.54	-.01
241	3	.0[illegible]	23.30	-7.36	35.18	.[illegible]
		1193.13	2336.51	1206.86	-778.66	-.01
301	3	.0[illegible]	19.31	-.91	43.11	.00
		1304.84	2298.20	1416.36	-498.89	.00
361	3	.00	21.72	5.30	51.65	.00
		1344.83	2153.43	1451.46	-257.61	.00
62	3	.01	208.06	-95.44	-144.79	.03
		1933.14	213.75	-545.99	-1153.88	.22
122	3	-.02	80.31	-76.77	-23.98	.01
		1007.81	1379.40	250.90	-950.77	.02

ELEMENT	LOAD	QX	QY	MX	MY	MXY
182	3	-.11	49.78	-15.00	19.19	.0[illegible]
		1151.15	1140.19	616.88	-1166.53	-.01
242	3	.00	23.30	-7.36	35.16	.00
		1193.13	2336.52	1208.85	-778.66	-.02
302	3	.00	19.31	-.92	43.12	.00
		1304.83	2298.20	1416.35	-498.90	-.01
362	3	.01	21.73	5.30	51.65	.00
		1344.81	2153.44	1452.46	-257.61	.00

ELEMENT	LOAD	QX	QY	MX	MY	MXY
421	3	.00	-58.93	1.68	17.58	.00
		1317.32	1549.44	1364.68	-98.43	.00
422	3	-.01	-58.93	1.69	17.58	.00
		1317.31	1549.44	1364.67	-98.43	.01

ELEMENT	LOAD	QX VONT	QY VONE	MX FX	MY FY	MXY FXY
481	3	.00	-19.36	.84	5.63	.00
		1163.39	1474.96	1208.49	-134.96	.01
541	3	.00	-16.68	.44	2.94	.00
		1064.19	1230.93	1069.55	-122.78	.01
601	3	.00	-13.41	.11	.76	.00
		929.31	973.31	990.44	-110.29	.01
661	3	.[illegible]	-10.04	-.13	-.91	.0[illegible]
		783.46	750.63	701.64	-97.91	.01
721	3	.[illegible]	-8.04	-.32	-2.16	.00
		648.11	518.7[illegible]	513.94	-88.33	.01
482	3	.00	-19.36	.84	5.63	.00
		1163.37	1474.97	1208.49	-134.97	.02
542	3	.00	-16.68	.44	2.94	.00
		1064.19	1230.94	1069.55	-122.76	.02
6[illegible]	3	.00	-13.41	.11	.76	.00
		929.31	973.31	990.44	-110.24	.01
662	3	.00	-10.04	-.13	-.91	.[illegible]
		783.47	750.64	701.64	-97.91	.01
722	3	.00	-8.04	-.32	-2.16	.0[illegible]
		648.12	518.74	513.96	-88.33	.0[illegible]

781	3	.[illegible]	7.74	-.14	-1.61	.[illegible]
		339.04	315.92	311.29	-17.91	.[illegible]
782	3	.[illegible]	7.74	-.14	-1.61	.[illegible]
		338.04	315.83	311.31	-17.91	.[illegible]

ELEMENT	LOAD	QX VONT	QY VONB	MX FX	MY FY	MXY FXY
941	3	.[illegible]	-15.35	-.15	.45	.[illegible]
		85.[illegible]	111.35	97.51	-66.7[illegible]	.[illegible]
901	3	.[illegible]	4.26	-.16	-.71	.[illegible]
		238.27	151.96	-110.74	-93.94	-.01
961	3	.00	1.68	.00	-.04	.00
		147.30	150.54	-167.79	-52.87	-.05
1021	3	.[illegible]	.31	.01	.11	.00
		197.79	177.58	-189.77	-7.49	-.09
1081	3	-.04	-4.74	-.11	-.1[illegible]	.[illegible]
		263.79	352.66	-271.54	73.39	-.[illegible]
1141	3	.[illegible]	-14.14	.14	-1.46	.00
		367.90	1052.70	-203.08	137.94	-.39
1201	3	-.91	100.28	1.91	1.41	.01
		738.94	313.84	[illegible].98	398.51	.50
942	3	.[illegible]	-15.35	-.15	.45	.00
		[illegible]	111.36	97.51	-[illegible]	-.[illegible]
902	3	.[illegible]	4.16	-.16	-.71	.[illegible]
		239.16	151.94	-11[illegible].74	-93.94	-.04
962	3	.00	1.69	.[illegible]	-.04	.00
		147.29	150.52	-167.77	-52.98	-.09
1022	3	.01	.01	.01	.11	.00
		197.73	177.64	-189.74	-7.93	-.24
1082	3	-.11	-4.74	-.[illegible]	-.[illegible]	.[illegible]
		[illegible]	352.4[illegible]	-[illegible]	73.2[illegible]	-.67
1142	3	.6[illegible]	-14.15	.[illegible]	-1.45	.[illegible]
		367.72	1052.11	-[illegible]	137.7[illegible]	-1.15
1202	3	-1.67	101.1[illegible]	1.9[illegible]	1.41	.01
		737.63	315.16	[illegible].81	398.4[illegible]	1.49
1261	3	.07	28.25	7.57	24.71	.02
		184.43	1914.95	-516.59	-1246.49	-.99
1321	3	-.16	-14.44	1.26	3[illegible].66	.07
		199.78	1497.56	-6.73	-1391.39	-1.91
1381	3	-.15	1.34	-9.79	39.49	.11
		554.91	3195.06	-271.15	-1768.19	-1.35
1441	4	-1.67	-357.67	-43.16	9.91	.19
		1779.41	2627.67	-1575.11	-2136.19	.19
1262	3	.20	28.23	7.57	24.74	.05
		184.02	1906.12	-506.40	-1246.47	-2.91
1322	3	-.19	-14.44	1.24	30.69	.12
		189.01	1499.94	-6.93	-1395.19	-5.35

GOTHATUWA DISTRIBUTION MAINS

GREATER COLOMBO NRW PROJECT

Design of Thrust Blocks for Distribution Systems T.P. 7.5 bar (submerged conditions)

Comp. By: A. P.	*Check By:*	*Date:* 2/10/00

1. DESIGN APPROACH

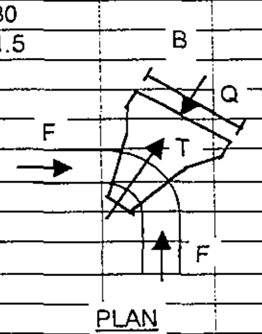
An unbalanced thrust is developed whenever there is a change in direction of a pressure pipe. This thrust is caused by (a) dynamic forces *due to change in momentum, if there is fluid flow within the pipeline.* (b) static force due to internal pressure. Dynamic force is negligible compared to static force. Therefore only static force will be considered for calculation of unbalanced force. The design is based on the principle that so called unbalanced force is transferred on to concrete thrust block which is pressing against natural earth which in turn develops passive resistance to counter balance the force. All thrust blocks and required restrained lengths are designed for fully submerged conditions.

2. HORIZONTAL BENDS

2.1 DATA

Pipe material	:	DI/PVC
Design Hydrostatic Pressure, p in N/sq.mm	:	0.75 ⟶ Max Hydrostatic Test Press.
Density of soil ρ in kN/m^3	:	20
Density of water w in kN/m3	:	9.81
Angle of internal friction "θ" in degrees	:	30
Factor of safety	:	1.5

2.2 CALCULATIONS



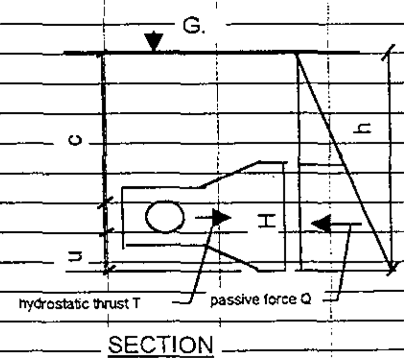
Hydrostatic force F = $\frac{(\pi/4 * D^2 x p)}{1000}$ kN

Unbalanced Thrust T $2*F*\sin(\alpha/_2*\pi/_{180})$ kN

Where α = angle of bend in degrees

Soil Constant for passive resistance, k = $\frac{(\rho-\omega)*(1+\sin\theta)}{(1-\sin\theta)}$

= 30.57



As an approximation, passive pressure at the bottom is assumed to act uniformly through the entire height of the thrust block based on effective depth of (c+D/2).

Passive pressure, q = k*(c+D/2) kN/sq m

Therefore area required for the thrust block=

=(T/(q))*f sq m

	>110	90	
Clear cover c shall be taken as	1	0.75	m and u shall be taken as = 0.5*D

GREATER COLOMBO NRW PROJECT

Design of Thrust Blocks for Distribution Systems T.P. 7.5 bar (submerged conditions)

Comp. By: A. P. | *Check By:* | *Date:* 2/10/00

2.3 RESULTS

On the basis of above approach the following table gives lateral surface areas required for the thrust blocks, for different pipe diameters.

D	c+D/2	q	Lateral Area required in sq.m			
mm	m	kN/m^2	$11^1/_4$	$22^1/_2$	45	90
50	0.78	31.29	0.01	0.03	0.05	0.10
90	1.05	42.20	0.03	0.07	0.13	0.24
100	1.05	42.40	0.04	0.08	0.16	0.29
150	1.08	43.41	0.09	0.18	0.35	0.65
200	1.10	44.42	0.16	0.31	0.61	1.13
250	1.13	45.43	0.24	0.47	0.93	1.72
300	1.15	46.44	0.34	0.67	1.31	2.42
350	1.18	47.45	0.45	0.89	1.75	3.23
500	1.25	50.48	0.86	1.71	3.35	6.19
600	1.30	52.49	1.19	2.37	4.64	8.57
800	1.40	56.53	1.96	3.90	7.66	14.15

<u>Estimated size of thrust blocks</u>

D mm	Dimensions of thrust blocks in m. for different horizontal angles							
	111/4		221/2		45		90	
	B	H	B	H	B	H	B	H
50	0.12	0.12	0.17	0.17	0.23	0.23	0.32	0.32
90	0.18	0.18	0.26	0.26	0.36	0.36	0.49	0.49
100	0.20	0.20	0.29	0.29	0.40	0.40	0.54	0.54
150	0.30	0.30	0.42	0.42	0.59	0.59	0.80	0.80
200	0.40	0.40	0.56	0.56	0.78	0.78	1.06	1.06
250	0.49	0.49	0.69	0.69	0.96	0.96	1.31	1.31
300	0.58	0.58	0.82	0.82	1.15	1.15	1.56	1.56
350	0.67	0.67	0.94	0.94	1.32	1.32	1.80	1.80
500	0.93	0.93	1.31	1.31	1.83	1.83	2.49	2.49
600	1.09	1.09	1.54	1.54	2.15	2.15	3.30	2.60
800	1.40	1.40	1.98	1.98	2.77	2.77	5.05	2.80

NOTE:- The above table indicates the practically feasible minimum dimensions to suit the type of bend

3.TEES

3.1 CALCULATIONS

In the case of tees, full hydrostatic force F acting from the direction of lateral pipe needs to be counter balanced by the thrust block, as shown in the figure.

Following the same procedure as above

Area required for the thrust block =(F/q)*f sq m

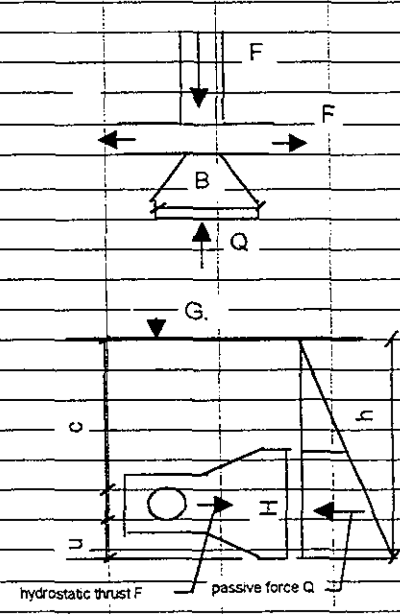
GREATER COLOMBO NRW PROJECT

Design of Thrust Blocks for Distribution Systems T.P. 7.5 bar (submerged conditions)

Comp. By: A. P.	*Check By:*	*Date:* 2/10/00

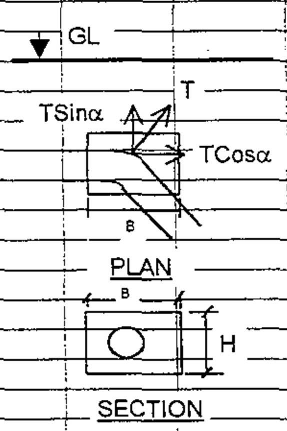
3.2 RESULTS

D	c+D/2	q	Area	B	H
mm	m	kN/m^2	sq m	m	m
50	0.78	31.29	0.07	0.27	0.27
90	1.05	42.20	*0.17*	*0.41*	*0.41*
100	1.05	42.40	0.21	0.46	0.46
150	1.08	43.41	0.46	0.68	0.68
200	1.10	44.42	0.80	0.89	0.89
250	1.13	45.43	1.22	1.10	1.10
300	1.15	46.44	1.71	1.31	1.31
350	1.18	47.45	2.28	1.51	1.51
500	1.25	50.48	4.38	2.09	2.09
600	1.30	52.49	6.06	2.46	2.46
800	1.40	56.53	10.00	3.16	3.16



4.VERTICAL UPWARD BEND

4.1 DESIGN APPROACH



In the case of vertical upward bend, unbalanced thrust T acts upwards as shown in the figure. In order to keep the bend in place, this thrust will have to be balanced using either of the following methods;
(1) provision of a thrust block so that its weight plus the soil overburden on top balances the vertical force component *TSinα*.
(2) provision of restrained joints at the bend plus a number of restrained joints along the pipeline on both sides of the bend.

For larger diameter pipes the method (1) may turn out to be impracticable because, prohibitively large thrust block is required to balance the thrust.

Therefore method (2) is recommended for upward vertical bends. Provide restrained joints on both sides of the bend together with a nominal sized thrust block. Recommended sizes of thrust blocks are given in the following table. The size of thrust block may be adjusted to suit available space.

A	B	C	D	E	F	G	H	I	J

GREATER COLOMBO NRW PROJECT

Design of Thrust Blocks for Distribution Systems T.P. 7.5 bar (submerged conditions)

Comp. By: A. P.	*Check By:*	*Date:* 2/10/00

	Dimensions of thrust blocks in m. for different vertical angles							
D mm	11 1/4		22 1/2		45		90	
	B	H	B	H	B	H	B	H
50	0.08	0.08	0.09	0.09	0.10	0.10	0.13	0.13
90	0.14	0.14	0.16	0.16	0.18	0.18	0.23	0.23
100	0.15	0.15	0.18	0.18	0.20	0.20	0.25	0.25
150	0.23	0.23	0.26	0.26	0.30	0.30	0.38	0.38
200	0.30	.0.30	0.35	0.35	0.40	0.40	0.50	0.50
250	0.38	0.38	0.44	0.44	0.50	0.50	0.63	0.63
300	0.45	0.45	0.53	0.53	0.60	0.60	0.75	0.75
350	0.53	0.53	0.61	0.61	0.70	0.70	0.88	0.88
500	0.75	0.75	0.88	0.88	1.00	1.00	1.25	1.25
600	0.90	0.90	1.05	1.05	1.20	1.20	1.50	1.50
800	1.20	1.20	1.40	1.40	1.60	1.60	2.00	2.00

5. VERTICAL DOWNWARD BEND

As in the case of vertical upward bends, provide restrained joints along the pipeline on
both sides of the bend. A nominal size thrust block may be provided merely to keep the bend
in place using the same dimensions as indicated above.

6. REQUIRED LENGTHS FOR RESTRAINT

The length of pipeline required to be restrained on each side of the bend is given by;

$L = P*A*(1-\cos\alpha)/\mu*(We+Ww+Wp)$

L = Length of restrained joints on each side of the bend (m)
P = Internal Pressure in N/sq mm
A = Cross-sectional area of the pipe in sq mm
α = Bend deflection in degrees
μ = Coefficient of friction between the pipe and the soil = 0.3
We = Weight of the prism of soil over the pipe (kN/m length of pipe)
Ww = Weight of the contained water (kN/m length of pipe)
Wp = Weight of the pipe (kN/m length of pipe)

D mm	P	A	We	Ww	Wp	L			
	N					11 1/4	22 1/2	45	90
50	0.75	1963	0.75	0.02		0.12	0.49	2.36	6.38
90	0.75	6362	1.35	0.06		0.22	0.86	4.34	11.25
100	0.75	7854	1.50	0.08		0.24	0.95	4.85	12.44
150	0.75	17671	2.25	0.18		0.35	1.39	7.46	18.21
200	0.75	31416	3.00	0.31		0.46	1.80	10.18	23.70
250	0.75	49087	3.75	0.49	0.52	0.50	1.96	12.08	25.80
300	0.75	70686	4.50	0.71	0.68	0.58	2.29	14.62	30.04
350	0.75	96211	5.25	0.96	0.83	0.66	2.60	17.23	34.14
500	0.75	196350	7.50	1.96	0.98	0.90	3.58	26.32	46.99
600	0.75	282743	9.00	2.83	1.34	1.03	4.09	32.07	53.70
800	0.75	502655	12.00	5.03	1.73	1.29	5.10	45.36	67.01

	A	B	C	D	E	F	G	H	I	J
1										
2	**GREATER COLOMBO NRW PROJECT**									
3										
4	**Design of Thrust Blocks for Distribution Systems T.P. 7.5 bar (submerged conditions)**									
5										
6	*Comp. By:* A. P.				*Check By:*				*Date:*	2/10/00
7										
228										
229										
230	**7. THRUSTBLOCKS FOR TAPERS**									
231										
232	The same design concept is applied to size the thrust blocks for tapers. In the case of tapers, resulting									
233	differentilal force is balanced by the passive resistence of soil.									
234										
235	Taper size in mm		Force F	c+D/2	q	A	Thrust Block size			
236	d1	d2	kN	m	kN/sq m	sq m	H m	B m		
237	uPVC									
238	110	90	2.35619	1.06	42.60	0.06481	0.25	0.25		
239	225	160	14.7409	1.11	44.92	0.3679	0.61	0.61		
240	160	110	7.95216	1.08	43.61	0.20245	0.45	0.45		
241	DI				0.00					
242	250	150	23.5619	1.13	45.43	0.56776	0.75	0.75		
243	300	150	39.7608	1.15	46.44	0.92692	0.96	0.96		
244	300	200	29.4524	1.15	46.44	0.70493	0.84	0.84		
245	300	250	16.1988	1.15	46.44	0.41952	0.65	0.65		
246	400	200	70.6858	1.20	48.46	1.58443	1.26	1.26		
247	400	250	57.4322	1.20	48.46	1.31091	1.14	1.14		
248	400	300	41.2334	1.20	48.46	0.97661	0.99	0.99		
249	450	300	66.268	1.23	49.47	1.49872	1.22	1.22		
250	450	400	25.0346	1.23	49.47	0.66514	0.82	0.82		
251	500	300	94.2478	1.25	50.48	2.06357	1.44	1.44		
252	500	400	53.0144	1.25	50.48	1.24666	1.12	1.12		
253	500	450	27.9798	1.25	50.48	0.75068	0.87	0.87		
254	600	300	159.043	1.30	52.49	3.31248	1.82	1.82		
255	600	400	117.81	1.30	52.49	2.52699	1.59	1.59		
256	600	500	64.7953	1.30	52.49	1.51708	1.23	1.23		
257	700	500	141.372	1.35	54.51	2.9782	1.73	1.73		
258	700	600	76.5763	1.35	54.51	1.78958	1.34	1.34		