International Journal of Research in Engineering, Science and Management
Volume 6, Issue 3, March 2023
https://www.ijresm.com | ISSN (Online): 2581-5792

Structural Design Report of a Typical Jackwell Cum Pump House

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***Abstract*: Drought prone districts in the eastern part of Karnataka are frequently affected due to erratic rainfall. It is a long-standing demand of the people in the region that a permanent and dependable source need to be identified and these areas are supplied with drinking water. Government of Karnataka initiated Yettinahole Project for mitigating the problem faced by the people by harnessing Yettinahole and other streams originating in the upper reaches of Western Ghats near Sakleshpura and has directed Visvesvaraya Jala Nigam Limited for implementation of the project.**

***Keywords*: Structural design, Jackwell.**

1. Introduction

The jack well cum pump house under the scheme proposes accommodate 3 VT Pumps. The Dimensional details of Jackwell are as shown below. The Jack Well is proposed with Reinforced Concrete - cast insitu construction. The Super Structure for pump room is RC Framed Structure and Brick wall Masonry .The roof of the pump room is Structural Steel Structure with appropriate Roof Covering.

Aims and Objectives of Project:

It is proposed to take up the work of "survey, investigation, design and construction of diversion weir-2 across yettinahole tributary-1, weir-6 across kerihole stream, and weir-7 across hongadahalla stream & weir-8 across yettinahole river with one no. of river sluice for each weir including protection works and energy dissipating arrangements, and necessary allied works including construction of approach road and construction of lift scheme comprising of intake fore bay, jack well cum pump house on u/s of respective weirs for housing vertical turbine pumps, pumping machinery, pump house electrical works, electrical substation, raising main from weir-2 and delivering the water to dc-5 for discharging the water to natural nala feeding to weir-8, independent rising mains from weir-6,7,8 upto receiving chamber for discharging the water to intermediate pumping station near weir-1, in a common corridor for pumping 44.0 cumecs of water up to dc 1".

2. Jackwell Cum Pump House

It is a type of intake Structure within which the water level is practically similar to the level of the sources of supply. It is known as Jackwell and is most commonly used. Jackwell structures are used for accumulating water from the surface sources like a river, lake, and reservoir. It is then further transferred to the water treatment plant. These Jackwell Designs and Constructions are masonry or concrete structures. Its function is to provide clean water. The of the Weir 6 for the Yettinahole project is given below.

A. Yettinahole Project

Name of the project: Yettinahole Project-Package IV
Type of project: Drinking Water
Location: Jackwell near Kadagarahalli Village,
Longitude: 75°43'04"E Latitude: 12°50'00"N
River Basin: Yettinahole
a) Name: Yettinahole
b) Located in i) State (s) Karnataka State
State(s)/District(s) or Taluk:
Karnataka/Hassan/Akalaeshapura

Table 1
Jackwell and Pump house-levels

S. No.	Particulars	Jackwell and Pump house
1	Shape	Rectangular
2	Ground level at site	RL 784.032 m
3	Sump Bed Level	RL 772.117 m
4	Minimum water level/Intake level	RL 779.500 m
5	Delivery floor level	RL 784.200 m
6	Motor floor level	RL 788.050 m
7	Gantry level	EL. 794.300 m
8	Roof level	EL. 797.450 m
9	Number of Pump Chambers	3
10	Dimension of Each chamber	3.00 m x 8.50 m
11	Overall size	17.25 m x 20.00 m

Method of Analysis:

3D Analysis is carried out using Staad pro software. The R.C. walls and Raft is idealized as plate elements with aspect ratio< 2. The plate elements are given appropriate physical member thickness. Columns, tie beams are idealized as beam elements. Supports are assigned as Elastic mat with appropriate subgrade modulus. The detail of Analysis is elaborated in the following pages.

Soil Parameters:

$\varnothing = 30^0$
$\delta = (2/3) \times 30^0 = 20^0$
$\alpha = 90^0$
$\beta = 0^0$

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ϒ = Density of soil = 20kN/m^3
Density of water = 10kN/m^3

Materials:

a) Grade of concrete M = 30
b) Grade of steel = Fe 500

Clear Cover:

i. Raft: 75mm
ii. Wall (Earth Face): 50mm
iii. Wall (Water Face): 40mm
iv. Columns: 40mm

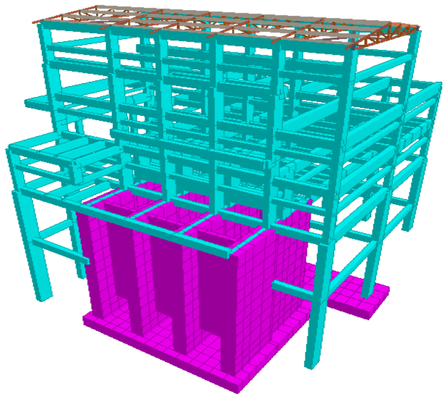


Fig. 1.

Permissible Stresses and Design Constants (Working Stress Method):

(Ref. Table 2, Page No. 8, IS 3370–1965, (Part-2 Reinforced concrete structure) code for practice for concrete structure for the storage of liquids

a) Water face: 130 N/mm^2

b) Away from water face: 130 N/mm^2

$\sigma cbc = 10.0$
$m = 280 / (3\sigma cbc) = 280/(3*10) = 9.333$
$k = (m*\sigma cbc)/((m*\sigma cbc)+\sigma st) = (9.333*10.0)/((9.333*10.00)+130) = 0.418$
$j = 1-(k/3) = 0.861$
$Q = 0.5*j*k*\sigma cbc = 0.5*0.861*0.418*10.0 = 1.798$

Check for Minimum Ast required:

Refer Cl. 7. 1.1, page no. 13 IS 3370 – (Part-2 Reinforced concrete structure) code for practice for concrete structure for the storage of liquids. 0.24 % Steel is provided by taking the Zone into consideration.

Loads:

Following loads are considered for design of raft, walls, columns and beams.

1. LOAD 1 LOADTYPE None TITLE SES +X
2. LOAD 2 LOADTYPE None TITLE SES -X
3. LOAD 3 LOADTYPE None TITLE SES +Z
4. LOAD 4 LOADTYPE None TITLE SES -Z
5. LOAD 5 LOADTYPE None TITLE DL
6. LOAD 6 LOADTYPE None TITLE LL
7. LOAD 7 LOADTYPE None TITLE AEP DRY
8. LOAD 8 LOADTYPE None TITLE AEP SUB
9. LOAD 9 LOADTYPE None TITLE WATER FULL SUMP1
10. LOAD 10 LOADTYPE None TITLE WATER FULL SUMP2
11. LOAD 11 LOADTYPE None TITLE WATER FULL SUMP3
12. LOAD 12 LOADTYPE None TITLE WATER PRESSURE ON BREAST WALL
13. LOAD 13 LOADTYPE None TITLE PUMP-MOTOR-VER-S1
14. LOAD 14 LOADTYPE None TITLE PUMP-MOTOR-VER-S2
15. LOAD 15 LOADTYPE None TITLE PUMP-MOTOR-VER-S3
16. LOAD 16 LOADTYPE None TITLE PUMP RUNNING (VER) SUMP-1 (DAF 25% CONSIDERED)
17. LOAD 17 LOADTYPE None TITLE PUMP RUNNING (VER) SUMP-2 (DAF 25% CONSIDERED)
18. LOAD 18 LOADTYPE None TITLE PUMP RUNNING (VER) SUMP-3 (DAF 25% CONSIDERED)
19. LOAD 19 LOADTYPE None TITLE PUMP RUNNING (HOR) SUMP-1 (DAF 25% CONSIDERED)
20. LOAD 20 LOADTYPE None TITLE PUMP RUNNING (HOR) SUMP-2 (DAF 25% CONSIDERED)
21. LOAD 21 LOADTYPE None TITLE PUMP RUNNING (HOR) SUMP-3 (DAF 25% CONSIDERED)
22. LOAD 22 LOADTYPE None TITLE PUMP SHUTDOWN (VER) SUMP-1 (DAF 25% CONSIDERED)
23. LOAD 23 LOADTYPE None TITLE PUMP SHUTDOWN (VER) SUMP-2 (DAF 25% CONSIDERED)
24. LOAD 24 LOADTYPE None TITLE PUMP SHUTDOWN (VER) SUMP-3 (DAF 25% CONSIDERED)
25. LOAD 25 LOADTYPE None TITLE PUMP SHUTDOWN (HOR) SUMP-1 (DAF 25% CONSIDERED)
26. LOAD 26 LOADTYPE None TITLE PUMP SHUTDOWN (HOR) SUMP-2 (DAF 25% CONSIDERED)
27. LOAD 27 LOADTYPE None TITLE PUMP SHUTDOWN (HOR) SUMP-3 (DAF 25% CONSIDERED)
28. LOAD 28 LOADTYPE None TITLE CRANE LOAD 5.5 MTR BAY
29. LOAD 29 LOADTYPE None TITLE CRANE LOAD 5.5 MTR BAY NODE
30. LOAD 30 LOADTYPE None TITLE CRANE LOAD

3.5 MTR BAY

31. LOAD 31 LOADTYPE None TITLE CRANE LOAD 3.5 MTR BAYNODE
32. LOAD 32 LOADTYPE None TITLE WIND +X
33. LOAD 33 LOADTYPE None TITLE WIND -X
34. LOAD 34 LOADTYPE None TITLE WIND +Z
35. LOAD 35 LOADTYPE None TITLE WIND –Z

Load Calculation:

Dead Load:

Self-weight Y -1

Self-weight is generated using – self weight command in STAAD Pro.

Slab Load:

Slab Load: @784.200 LVL, 788.050 LVL791.550 LVL:

Slab Thickness = 0.2x25 = 5.00kN/m^2

Total = 5.05kN/m^2

Pump and Motor Load:

1) Static Load on foundation due to pump and motor set - 27900 Kgs
2) Dynamic Load on foundation due to pump and motor set - 41875 Kgs
3) Horizontal Thrust (H) at duty point -367250 Kgs
4) Horizontal Thrust (H) at Shut off point - 55570 Kgs
5) Crane load considered for design - 30.00 Tonnes.

Active Earth Pressure:

Calculation of Ka value for Wall:

Ka = coefficient of active earth pressure

$Ka = \sin^2(\alpha+\Phi) / \{(\sin^2\alpha * \sin(\alpha-\delta)*[1-\sqrt{(\sin\Phi+\delta)\sin(\Phi-\beta)/(\sin\alpha-\delta)\sin(\alpha+\beta)}]\}$

Soil parameters:

$\varnothing = 30^0$

$\delta = (2/3) \times 30^0 = 20^0$

$\alpha = 90^0$

$\beta = 0^0$

ϒ = Density of soil = 20kN/m^3

Ka = 0.333 (Refer Foundation analysis & Design - By Joseph E. Bowles, Table 11-1, pg. 597)

Raft Bot level = EL: +771.117 m

Delivery Floor Level = EL: +784.20 m

Thickness of Raft is considered as 1000mm

Height = 784.200 – 771.117 = 13.083 m

AEP = Ka x ϒ x h

Wind Load:

Table 2

Basic wind speed V_b	39	m/sec
K1	1.00	
K2	1.13	
K3	1	
Design Wind Speed	44.07	m/sec
Design Wind Pressure	1.165	KN/m^2

The Wind Load is applied in +X, -X, +Z, -Z direction.

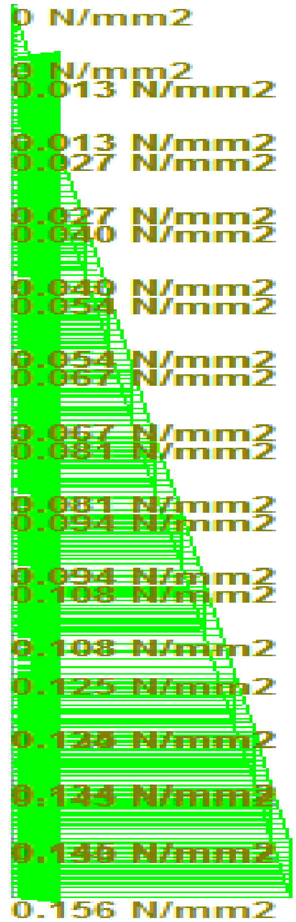


Fig. 2. Active earth pressure

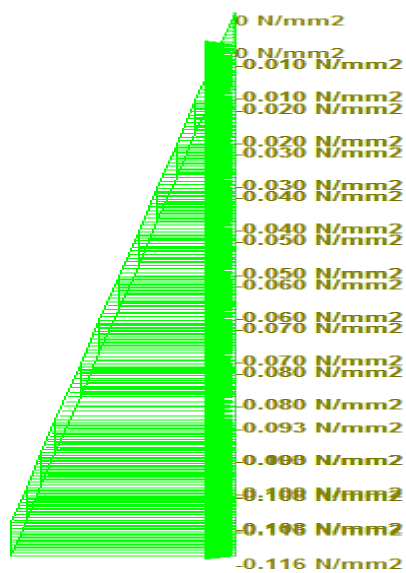


Fig. 3. Water pressure

Seismic Load:

The Seismic Load are taken by performing a hinge analysis in Staad Pro. The Weight of each joint in the Y- Direction is the Lumped mass as per IS 1893 Part-1

1. WEIGHT 0.199
2. WEIGHT 0.289

The Weight is in KN as specified in the above figures.

Table 3
Stability analysis of Jackwell

Weir 6 Jack Well Stabilty at water empty Condition											
Component	**No.**	**L, m**	**B, m**	**D, m**	**Density, kN/m3**	**Per pump, kN**	**Vertical, kN**	**Horizontal, kN**	**Lever Arm, m**	**Moment(RM), kN-m**	**Moment(OM), kN-m**
Raft-1	1	10.9	13.5	1	25		3678.75		5.45	20049.19	
Piers	4	12.083	1	4.1	25		4954.03		2.55	12632.78	
Piers Height 5.0	0	5	1	1.8	25		0		1.65	0.00	
Baffel Walls	2	4.4	0.5	12.083	25		1329.13		6.8	9038.08	
Baffel Walls	2	4.4	0.5	12.083	25		1329.13		6.8	9038.08	
Back Wall	1	11.5	0.5	12.083	25		1736.931		9.25	16066.61	
Breast Wall-1	3	3.5	0.3	9.85	25		775.6875		1.525	1182.92	
Breast Wall-2	0	14.2	0.3	5	25		0		14	0.00	
Horizonal Force of Soil on Back Wall 1/2*Ka*w*H^2	1							411.94	4.03		1659.14
Horizonal Force of Water on Back Wall 1/2*w*H^2	1									0.00	
Horizonal Force of Water on Breast Wall 1/2*w*H^2	1									0.00	
Pump Running Vertical	-3									0.00	
Pump Running Horizontal	3										0.00
Total							**13803.66**	**411.93587**		**68007.6695**	**1659.140354**
Factor of safety Sliding (0.6 friction factor)	=	0.6 x0.9x13803.66 / 411.9358653		=	18.09	>>1.5	Hence safe				
Factor of safety Against Over Turning	=	0.9x68007.6695 / 1659.140354		=	36.89	>>1.5	Hence safe				

3. Result Analysis and Design

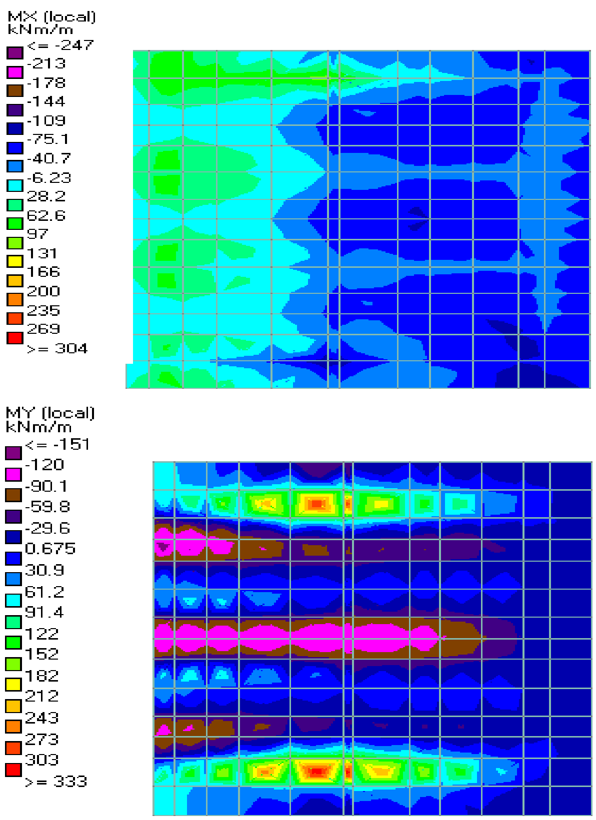
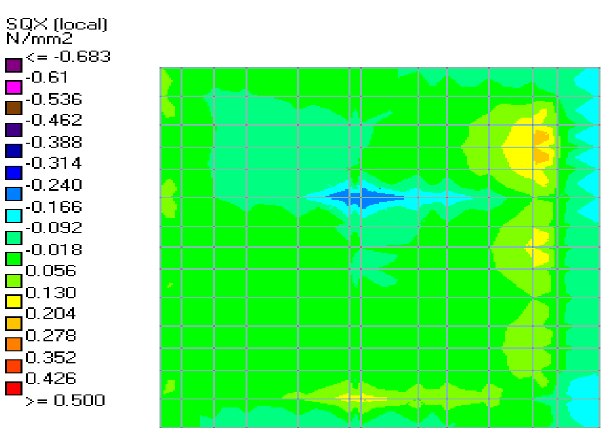


Fig. 4. Design of Raft-01 bending moment in Mx and My



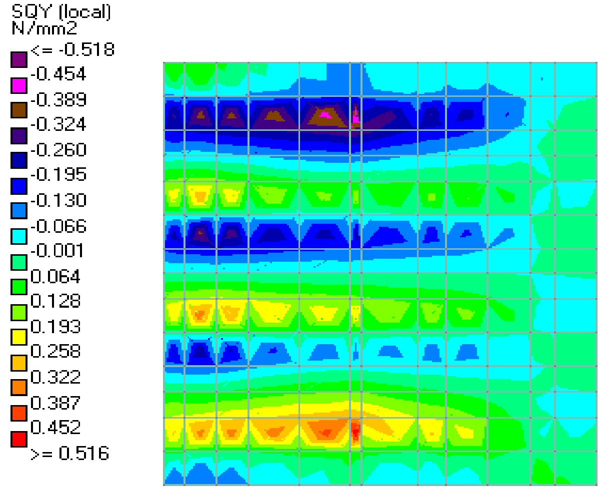


Fig. 5. Shear Force in SQx and SQy directions

Table 4
Raff design

MATERIAL DATA

DENSITY OF CONCRETE = Dc =		25	KN/M^3
DENSITY OF WATER = Dw =		10	KN/M^3
DENSITY OF BBM = Dbbm		20	KN/M^3
GRADE OF CONCRETE =	fck	30	N/MM^2
GRADE OF STEEL =	fy	500	N/MM^2

	WET PORTION	
σcbc	10.0	N/MM^2
σst	130	N/MM^2

DESIGN METHOD :-WORKING STRESS METHOD

	WET PORTION
Q	1.798
m	9.333
k	0.418
j	0.861

DESIGN OF BASE RAFT - 1

THE MAXIMUM MOMENT IS CONSIDERED FROM WORST COMBINATIONS

AND THE RAFT IS DESIGNED IN WORKING STRESS METHOD :

			Mx		My	
THICKNESS OF RAFT =	1.00m	L/C	201	87	104	137
MX, MY --------->	*kN-m/m*	PLATE NO.	933	900	1713	915
			-109.201	104.45	-228.24	333.45
			TOP	BOTTOM	TOP	BOTTOM

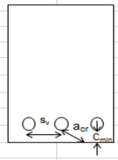
DEPTH & REINFORCEMENT CLACULATION

		Mx		My		
		TOP	**BOTTOM**	**TOP**	**BOTTOM**	
MAX. BM/ M WIDTH =M1 =		**109**	**104**	**228**	**333**	*kN-m*
EFFECTIVE COVER = Cc =		87.5	87.5	87.5	87.5	*MM*
EFFECTIVE DEPTH = Trieff =		912.5	912.5	912.5	912.5	*MM*
AST REQD. FOR MOMENT =		1070	1023	2235	3266	*MM^2*
Pt -MIN =		0.20	0.20	0.20	0.20	*%*
AST-MIN/FACE =		2000	2000	2000	2000	*MM^2*
Design AST=		2000	2000	2235	3266	
DIA OF BAR =		25.00	25.00	25.00	25.00	*MM*
SPACING (MM) REQ.D FOR MOMENT =		245.44	245.44	219.58	150.30	*MM*
	PROVIDE	*150 MM*	*150 MM*	*150 MM*	*150 MM*	*C/C*
Pt(%) provided	=	0.359	0.359	0.359	0.359	

SHEAR CLACULATION

	SQX		SQY		
L/C	79		137		
PLATE NO.	1705		912		
SHEAR STESS	247		517		
Haunch Bar	16	150	20	100	
Shear Capacity of Haunch Bar	121.916		285.740		
Net Shear Force V	125.084		231.260		
Tv	0.14		0.25		*N/MM^2*
Tc, (Enhanced by 33% for transient loads)	0.352184		0.352184		*N/MM^2*
	SAFE		**SAFE**		

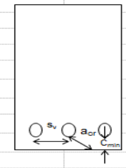
Table 5



Crack width due to flexure at inner face in Raft 1				
References:				
IS 456-2000 P 95				
Reinforced Concrete Design -by Pillai and Menon				
a_{cr}	=	**96**	mm	
C_{min}	=	**75**	mm	
D	=	**1000**	mm	
ϵ_m	=	**ϵ_1-ϵ_2**		
b_t	=	**1000**	mm	
m	=	**9.3**		
k	=	**0.2**		
d	=	**908**	mm	
x	=	**414**	mm	
E_c		**27386**	N/mm^2	
Es	=	**200000**	N/mm^2	
A_s	=	**3266.00**	mm^2	for inner face
moment of inertia of cracked section	=	**31051043896**	mm4	
moment at the section	=	**580**	kNm	
fst	=	**86.07**	N/mm^2	
ϵ_1	=	**0.00051**		p 401
a'	=	**1000**	mm	
for 0.2mm crack width - IS 456				
ϵ_2	=	**0.0004**		
Design crack width for limiting value of 0.2mm				
ϵ_m		0.00016		
Design crack width	w	**0.04**	mm	

				45.3125	
Cracking moment					
(fcr*Igr)/Yt	(IS:456)				
fcr=	Modulus of rupture of concrete			=	3.834057903
	=	0.7*Sqrt(fck)			
Igr	=	moment of inertia of section		=	7.07738E+11
Yt	=	Distance of centroidal axial of gross section neglecting reinforcements upto extreme fibre		=	486
Mcr	**=**	**5581.27968**	kN m	**> Mu**	**Hence safe**

Table 6



Crack width due to flexure at inner face in Raft 2				
References:				
IS 456-2000 P 95				
Reinforced Concrete Design -by Pillai and Menon				
a_{cr}	=	**96**	mm	
C_{min}	=	**75**	mm	
D	=	**1000**	mm	
ϵ_m	=	**ϵ_1-ϵ_2**		
b_t	=	**1000**	mm	
m	=	**9.3**		
k	=	**0.2**		
d	=	**908**	mm	
x	=	**414**	mm	
E_c		**27386**	N/mm^2	
Es	=	**200000**	N/mm^2	
A_s	=	**3266.00**	mm^2	for inner face
moment of inertia of cracked section	=	**31051043896**	mm4	
moment at the section	=	**601**	kNm	
fst	=	**89.18**	N/mm^2	
ϵ_1	=	**0.00053**		p 401
a'	=	**1000**	mm	
for 0.2mm crack width - IS 456				
ϵ_2	=	**0.0004**		
Design crack width for limiting value of 0.2mm				
ϵ_m		0.00017		
Design crack width	w	**0.05**	mm	

				45.3125
Cracking moment				
(fcr*Igr)/Yt	(IS:456)			
fcr=	Modulus of rupture of concrete		=	3.834058
	=	0.7*Sqrt(fck)		
Igr	=	moment of inertia of section	=	7.08E+11
Yt	=	Distance of centroidal axial of gross section neglecting reinforcements upto extreme fibre	=	486
Mcr	**=**	**5581.27968** kN m	>	M

Table 5

MATERIAL DATA			
DENSITY OF CONCRETE = Dc =		25	KN/M^3
DENSITY OF WATER = Dw =		10	KN/M^3
DENSITY OF BBM = Dbbm		20	KN/M^3
GRADE OF CONCRETE =	fck	30	N/MM^2
GRADE OF STEEL =	fy	500	N/MM^2

	WET PORTION	
σcbc	10.0	N/MM^2
σst	130	N/MM^2

DESIGN METHOD :-WORKING STRESS METHOD

	WET PORTION
Q	1.798
m	9.333
k	0.418
j	0.861

DESIGN OF BASE RAFT - 2

THE MAXIMUM MOMENT IS CONSIDERED FROM WORST COMBINATIONS
AND THE RAFT IS DESIGNED IN WORKING STRESS METHOD :

			Mx		My	
THICKNESS OF RAFT =	1.00m	L/C	96	41	205	73
MX, MY --------->	*kN-m/m*	PLATE NO.	2268	2334	2778	2314
			15.283	**414.28**	**-146.81**	**139.96**
			TOP	BOTTOM	TOP	BOTTOM

DEPTH & REINFORCEMENT CLACULATION		Mx		My		
		TOP	**BOTTOM**	**TOP**	**BOTTOM**	
MAX. BM/ M WIDTH =M1 =		**15**	**414**	**147**	**140**	*kN-m*
EFFECTIVE COVER = Cc =		87.5	87.5	85	85	*MM*
EFFECTIVE DEPTH = Trieff =		912.5	912.5	915	915	*MM*
AST REQD. FOR MOMENT =		150	4058	1434	1367	*MM^2*
Pt -MIN =		0.20	0.20	0.20	0.20	%
AST-MIN/FACE =		2000	2000	2000	2000	*MM^2*
Design AST=		2000	4058	2000	2000	
DIA OF BAR =		25.00	25.00	20.00	20.00	*MM*
SPACING (MM) REQ.D FOR MOMENT =		245.44	120.98	157.08	157.08	*MM*
	PROVIDE	*125 MM*	*125 MM*	*125 MM*	*125 MM*	C/C
Pt(%) provided	=	0.430	0.430	0.275	0.275	

SHEAR CLACULATION			
	SQX	**SQY**	
L/C	201	41	
PLATE NO.	2270	2330	
SHEAR STESS	70	181	
Net Shear Force V	70.000	181.000	
Tv	0.08	0.20	*N/MM^2*
Tc	0.238	0.2876	*N/MM^2*
	SAFE	**SAFE**	

Table 7

MATERIAL DATA			
DENSITY OF CONCRETE = Dc =		25	KN/M^3
DENSITY OF WATER = Dw =		10	KN/M^3
DENSITY OF BBM = Dbbm		20	KN/M^3
GRADE OF CONCRETE =	fck	30	N/MM^2
GRADE OF STEEL =	fy	500	N/MM^2

DESIGN OF END PIER

THE MAXIMUM MOMENT IS CONSIDERED FROM WORST COMBINATIONS
AND THE PIER IS DESIGNED IN LIMIT STATE METHOD :

			Mx		My	
THICKNESS =	1.00m	L/C	137		160	
MX, MY ---------->	*kN-m/m*	PLATE NO.	2157		389	
			330.000		**-180.98**	

DEPTH & REINFORCEMENT CALCULATIO		Mx		My		
MAX. BM/ M WIDTH =M1 =		**495**		**271**		*kN-m*
Mu limit=		**3990**	**3990**	**3990**	**3990**	*kN-m*
		Mu<Mu limit hence under reinforced				
EFFECTIVE COVER = Cc =		62.5		62.5		*MM*
EFFECTIVE DEPTH = Trieff =		937.5		937.5		*MM*
AST REQD. FOR MOMENT =		1277		693		*MM^2*
Pt -MIN =		0.20		0.20		%
AST-MIN/FACE =		2000		2000		*MM^2*
Design AST=		2000		2000		
DIA OF BAR =		25.00		25.00		*MM*
SPACING (MM) REQ.D FOR MOMENT =		245.44		245.44		*MM*
	PROVIDE	*150 MM*		*150 MM*		C/C
Pt(%) provided	=	0.349		0.349		%

SHEAR CALCULATION			
	SQX	**SQY**	
L/C	137	158	
PLATE NO.	2163	389	
SHEAR STESS(At 'd' Away from Support)	0.307	0.3	*N/MM^2*
SHEAR FORCE V	307	300	*kN*
Tv	0.33	0.32	*N/MM^2*
Tc, (Enhanced by 33% for transient loads)	0.4197	0.4197	*N/MM^2*
	SAFE	**SAFE**	

Table 6

Crack width due to flexure at inner face in piers				
References:				
IS 456-2000 P 95				
Reinforced Concrete Design -by Pillai and Menon				
a_{cr}	=	**63**	mm	
C_{min}	=	**50**	mm	
D	=	**1000**	mm	
ϵ_m	=	**ϵ_1-ϵ_2**		
b_t	=	**1000**	mm	
m	=	**9.3**		
k	=	**0.2**		
d	=	**938**	mm	
x	=	**428**	mm	
E_c		**27386**	N/mm^2	
Es	=	**200000**	N/mm^2	
A_s	=	**3266.00**	mm^2	for inner face
moment of inertia of cracked section	=	**33971307225**	mm4	
moment at the section	=	**618**	kNm	
fst	=	**86.59**	N/mm^2	
ϵ_1	=	**0.00049**		p 401
a'	=	**1000**	mm	
for 0.2mm crack width - IS 456				
ϵ_2	=	**0.0003**		
Design crack width for limiting value of 0.2mm				
ϵ_m		0.00016		
Design crack width	w	**0.03**	mm	

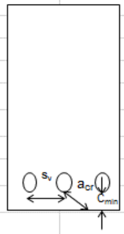


Table 8

Crack width due to flexure at inner face in piers				
References:				
IS 456-2000 P 95				
Reinforced Concrete Design -by Pillai and Menon				
a_{cr}	=	**63**	mm	
C_{min}	=	**50**	mm	
D	=	**1000**	mm	
ϵ_m	=	**ϵ_1-ϵ_2**		
b_t	=	**1000**	mm	
m	=	**9.3**		
k	=	**0.2**		
d	=	**938**	mm	
x	=	**428**	mm	
E_c		**27386**	N/mm^2	
Es	=	**200000**	N/mm^2	
A_s	=	**3266.00**	mm^2	for inner face
moment of inertia of cracked section	=	**33971307225**	mm4	
moment at the section	=	**465**	kNm	
fst	=	**65.15**	N/mm^2	
ϵ_1	=	**0.00037**		p 401
a'	=	**1000**	mm	
for 0.2mm crack width - IS 456				
ϵ_2	=	**0.0003**		
Design crack width for limiting value of 0.2mm				
ϵ_m		0.00004		
Design crack width	w	**0.01**	mm	

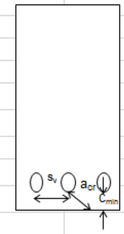


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Table 7

MATERIAL DATA

DENSITY OF CONCRETE = Dc =		25 KN/M^3
DENSITY OF WATER = Dw =		10 KN/M^3
DENSITY OF BBM = Dbbm		20 KN/M^3
GRADE OF CONCRETE =	fck	30 N/MM^2
GRADE OF STEEL =	fy	500 N/MM^2

	WET PORTION	
σcbc	10.0	N/MM^2
σst	130	N/MM^2

DESIGN METHOD :-WORKING STRESS METHOD

	WET PORTION
Q	1.798
m	9.333
k	0.418
j	0.861

DESIGN OF INTERMEDIATE PIER

THE MAXIMUM MOMENT IS CONSIDERED FROM WORST COMBINATIONS
AND THE RAFT IS DESIGNED IN WORKING STRESS METHOD :

			Mx		My	
THICKNESS OF PIER =	1.00m	L/C	231		209	
MX, MY --------->	*kN-m/m*	PLATE NO.	2159		367	
			423.907		**168.78**	

DEPTH & REINFORCEMENT CLACULATION

		Mx		My		
MAX. BM/ M WIDTH =M1 =		**424**		**169**		*kN-m*
EFFECTIVE COVER = Cc =		62.5		62.5		*MM*
EFFECTIVE DEPTH = Trieff =		937.5		937.5		*MM*
AST REQD. FOR MOMENT =		4041		1609		*MM*^{2}
Pt -MIN =		0.20		0.20		%
AST-MIN/FACE =		2000		2000		*MM*^{2}
Design AST=		4041		2000		
DIA OF BAR =		25.00		25.00		*MM*
SPACING (MM) REQ.D FOR MOMENT =		121.47		245.44		*MM*
	PROVIDE	*150 MM*		*150 MM*		*C/C*
Pt(%) provided	=	0.349		0.349		

SHEAR CLACULATION

	SQX	SQY	
L/C	123	157	
PLATE NO.	2161	365	
SHEAR STRESS(At 'd' Away from Support)	0.309	0.32	
SHEAR FORCE V	309	320	*kN*
Tv	0.33	0.34	*N/MM*^{2}
Tc, (Enhanced by 33% for transient loads)	0.3487	0.3487	*N/MM*^{2}
	SAFE	**SAFE**	

Table 9

MATERIAL DATA

DENSITY OF CONCRETE = Dc =		25 KN/M^3
DENSITY OF WATER = Dw =		10 KN/M^3
DENSITY OF BBM = Dbbm		20 KN/M^3
GRADE OF CONCRETE =	fck	30 N/MM^2
GRADE OF STEEL =	fy	500 N/MM^2

	WET PORTION	
σcbc	10.0	N/MM^2
σst	130	N/MM^2

DESIGN METHOD :-WORKING STRESS METHOD

	WET PORTION
Q	1.798
m	9.333
k	0.418
j	0.861

DESIGN OF BACKWALL

THE MAXIMUM MOMENT IS CONSIDERED FROM WORST COMBINATIONS
AND THE RAFT IS DESIGNED IN WORKING STRESS METHOD :

			Mx		My	
THICKNESS OF RAFT =	0.50m	L/C	44	137	137	137
MX, MY --------->	*kN-m/m*	PLATE NO.	679	2239	1790	661
			-229.544	**66.74**	**-57.21**	**130.30**
			TOP	BOTTOM	TOP	BOTTOM

DEPTH & REINFORCEMENT CLACULATION

		Mx		My		
		TOP	**BOTTOM**	**TOP**	**BOTTOM**	
MAX. BM/ M WIDTH =M1 =		**230**	**67**	**57**	**130**	*kN-m*
EFFECTIVE COVER = Cc =		87.5	87.5	87.5	87.5	*MM*
EFFECTIVE DEPTH = Trieff =		412.5	412.5	412.5	412.5	*MM*
AST REQD. FOR MOMENT =		4973	1446	932	2123	*MM*^{2}
Pt -MIN =		0.20	0.20	0.20	0.20	%
AST-MIN/FACE =		1000	1000	1000	1000	*MM*^{2}
Design AST=		4973	1446	1000	2123	
DIA OF BAR =		25.00	25.00	25.00	25.00	*MM*
Additional Bar at High Moments		20.00				
SPACING (MM) REQ.D FOR MOMENT =		161.87	339.50	490.87	231.26	*MM*
	PROVIDE	*150 MM*	*150 MM*	*150 MM*	*150 MM*	*C/C*
Pt(%) provided	=	0.793	0.793	0.793	0.793	

SHEAR CLACULATION

	SQX		SQY		
L/C	44		231		
PLATE NO.	1820		658		
SHEAR STESS	964		370		
Haunch Bar	20	100	16	150	
Shear Capacity of Haunch Bar	285.740		121.916		
Net Shear Force V	196.260		63.084		
Tv	0.48		0.15		*N/MM*^{2}
Tc, (Enhanced by 33% for transient loads)	0.5013		0.5013		*N/MM*^{2}
	SAFE		**SAFE**		

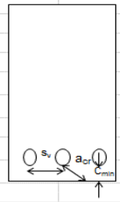
Table 10

Crack width due to flexure at inner face in Back walls

References:

IS 456-2000 P 95

Reinforced Concrete Design -by Pillai and Menon



a_{cr}	=	**63**	mm	
C_{min}	=	**50**	mm	
D	=	**1000**	mm	
ϵ_m	=	**ϵ_1-ϵ_2**		
b_t	=	**1000**	mm	
m	=	**9.3**		
k	=	**0.2**		
d	=	**938**	mm	
x	=	**428**	mm	
E_c		**27386**	N/mm^2	
Es	=	**200000**	N/mm^2	
A_s	=	**3266.00**	mm^2	for inner face
moment of inertia of cracked section	=	**33971307225**	mm4	
moment at the section	=	**438**	kNm	
fst	=	**61.37**	N/mm^2	
ϵ_1	=	**0.00034**		p 401
a'	=	**1000**	mm	
for 0.2mm crack width - IS 456				
ϵ_2	=	**0.0003**		
Design crack width for limiting value of 0.2mm				
ϵ_m		0.00002		
Design crack width	w	**0.00**	mm	

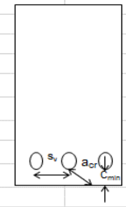
Table 12

Crack width due to flexure at inner face in end walls

References:

IS 456-2000 P 95

Reinforced Concrete Design -by Pillai and Menon



a_{cr}	=	**63**	mm	
C_{min}	=	**50**	mm	
D	=	**750**	mm	
ϵ_m	=	**ϵ_1-ϵ_2**		
b_t	=	**1000**	mm	
m	=	**9.3**		
k	=	**0.2**		
d	=	**688**	mm	
x	=	**314**	mm	
E_c		**27386**	N/mm^2	
Es	=	**200000**	N/mm^2	
A_s	=	**3266.00**	mm^2	for inner face
moment of inertia of cracked section		**14534288608**	mm4	
moment at the section	=	**496**	kNm	
fst	=	**119.12**	N/mm^2	
ϵ_1	=	**0.00070**		p 401
a'	=	**750**	mm	
for 0.2mm crack width - IS 456				
ϵ_2	=	**0.0003**		
Design crack width for limiting value of 0.2mm				
ϵ_m		0.00044		
Design crack width	w	**0.08**	mm	

Table 11

MATERIAL DATA

DENSITY OF CONCRETE = Dc =		25	KN/M^3
DENSITY OF WATER = Dw =		10	KN/M^3
DENSITY OF BBM = Dbbm		20	KN/M^3
GRADE OF CONCRETE =	fck	30	N/MM^2
GRADE OF STEEL =	fy	500	N/MM^2

	WET PORTION	
σcbc	10.0	N/MM^2
σst	130	N/MM^2

DESIGN METHOD :-WORKING STRESS METHOD

	WET PORTION
Q	1.798
m	9.333
k	0.418
j	0.861

DESIGN OF ENDWALL

THE MAXIMUM MOMENT IS CONSIDERED FROM WORST COMBINATIONS AND THE RAFT IS DESIGNED IN WORKING STRESS METHOD :

THICKNESS OF RAFT = 0.50m

MX, MY ---------> *kN-m/m*

	Mx		My	
L/C	137	137	137	167
PLATE NO.	2217	2199	422	550
	-171.100	**177.62**	**-150.59**	**150.31**
	TOP	BOTTOM	TOP	BOTTOM

DEPTH & REINFORCEMENT CLACULATION

		Mx		My		
		TOP	**BOTTOM**	**TOP**	**BOTTOM**	
MAX. BM/ M WIDTH =M1 =		**171**	**178**	**151**	**150**	*kN-m*
EFFECTIVE COVER = Cc =		87.5	87.5	87.5	87.5	*MM*
EFFECTIVE DEPTH = Trieff =		412.5	412.5	412.5	412.5	*MM*
AST REQD. FOR MOMENT =		3707	3848	3263	3257	*MM^2*
Pt -MIN =		0.20	0.20	0.20	0.20	*%*
AST-MIN/FACE =		1000	1000	1000	1000	*MM^2*
Design AST=		3707	3848	3263	3257	
DIA OF BAR =		25.00	25.00	25.00	25.00	*MM*
SPACING (MM) REQ.D FOR MOMENT =		132.42	127.56	150.45	150.73	*MM*
	PROVIDE	*125 MM*	*125 MM*	*125 MM*	*125 MM*	*C/C*
Pt(%) provided	=	0.952	0.952	0.952	0.952	

SHEAR CLACULATION

	SQX		**SQY**		
L/C	137		137		
PLATE NO.	2217		420		
SHEAR STESS	607		518		
Haunch Bar	16	150	16	150	
Shear Capacity of Haunch Bar	121.916		121.916		
Net Shear Force V	181.584		137.084		
Tv	0.44		0.33		*N/MM^2*
Tc, (Enhanced by 33% for transient loads)	0.5363		0.5363		*N/MM^2*
	SAFE		**SAFE**		

Table 13

MATERIAL DATA

DENSITY OF CONCRETE = Dc =		25	KN/M^3
DENSITY OF WATER = Dw =		10	KN/M^3
DENSITY OF BBM = Dbbm		20	KN/M^3
GRADE OF CONCRETE =	fck	30	N/MM^2
GRADE OF STEEL =	fy	500	N/MM^2

	WET PORTION	
σcbc	10.0	N/MM^2
σst	130	N/MM^2

DESIGN METHOD :-WORKING STRESS METHOD

	WET PORTION
Q	1.798
m	9.333
k	0.418
j	0.861

DESIGN OFINTERMEDIATE WALL

THE MAXIMUM MOMENT IS CONSIDERED FROM WORST COMBINATIONS AND THE RAFT IS DESIGNED IN WORKING STRESS METHOD :

THICKNESS OF RAFT = 0.50m

MX, MY ---------> *kN-m/m*

	Mx		My	
L/C	123	231	225	180
PLATE NO.	2211	2205	508	464
	-117.031	**114.19**	**-124.76**	**127.28**
	TOP	BOTTOM	TOP	BOTTOM

DEPTH & REINFORCEMENT CLACULATION

		Mx		My		
		TOP	**BOTTOM**	**TOP**	**BOTTOM**	
MAX. BM/ M WIDTH =M1 =		**117**	**114**	**125**	**127**	*kN-m*
EFFECTIVE COVER = Cc =		87.5	87.5	87.5	87.5	*MM*
EFFECTIVE DEPTH = Trieff =		412.5	412.5	412.5	412.5	*MM*
AST REQD. FOR MOMENT =		2536	2474	2703	2758	*MM^2*
Pt -MIN =		0.20	0.20	0.20	0.20	*%*
AST-MIN/FACE =		1000	1000	1000	1000	*MM^2*
Design AST=		2536	2474	2703	2758	
DIA OF BAR =		25.00	25.00	25.00	25.00	*MM*
SPACING (MM) REQ.D FOR MOMENT =		193.59	198.41	181.60	178.01	*MM*
	PROVIDE	*150 MM*	*150 MM*	*150 MM*	*150 MM*	*C/C*
Pt(%) provided	=	0.793	0.793	0.793	0.793	

SHEAR CLACULATION

	SQX		**SQY**		
L/C	55		61		
PLATE NO.	2211		512		
SHEAR STESS	430		398		
Haunch Bar	16	150	16	150	
Shear Capacity of Haunch Bar	121.916		121.916		
Net Shear Force V	93.084		77.084		
Tv	0.23		0.00		*N/MM^2*
Tc, (Enhanced by 33% for transient loads)	0.501144		0.501144		*N/MM^2*
	SAFE		**SAFE**		

Table 14

Crack width due to flexure at inner face in intermediate walls				
References:				
IS 456-2000 P 95				
Reinforced Concrete Design -by Pillai and Menon				
a_{cr}	=	**63**	mm	
C_{min}	=	**50**	mm	
D	=	**1000**	mm	
ϵ_m	=	**ϵ_1-ϵ_2**		
b_t	=	**1000**	mm	
m	=	**9.3**		
k	=	**0.2**		
d	=	**938**	mm	
x	=	**428**	mm	
E_c		**27386**	N/mm^2	
Es	=	**200000**	N/mm^2	
A_s	=	**3266.00**	mm^2	for inner face
moment of inertia of cracked section	=	**33971307225**	mm4	
moment at the section	=	**397**	kNm	
fst	=	**55.63**	N/mm^2	
ϵ_1	=	**0.00031**		p 401
a'	=	**1000**	mm	
for 0.2mm crack width - IS 456				
ϵ_2	=	**0.0003**		
Design crack width for limiting value of 0.2mm				
ϵ_m		-0.00002		
Design crack width	w	**0.00**	mm	

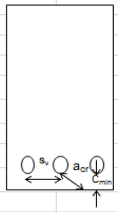


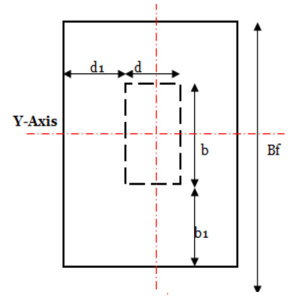
Table 15
Typical column design

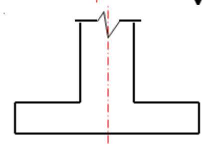
Design of Column C-1									
Data:									
Pu=	919.717	kN							
Mu=	182.284	Knm							
Fck	30								
Fy	500								
Column Dimesion									
B	500	mm							
D	1000	mm							
d=	950	mm							
Nominal Cover=		40							
Pu/(Fck*B*D)=		0.0613							
Mu/(Fck*b*d2)=		0.01347							
d'/D=		0.05							
Ast as per Chart-47 of SP-16, Min Reinforcment governs									
P/fck=	0.02								
P=	0.6								
As=pbD/100=		3000	mm2						
Min Ast=	0.8% of Area								
=	4000	mm2							
using	20	mm bars							
Area of one Bar	=	$\frac{3.14 x dia^2}{4}$							
	=	$\frac{3.14 x 20 X 20}{4}$	=	314	mm^2				
Number of Bars	=	$\frac{A_{st}}{A}$	=	$\frac{4000.00}{314.00}$	=	12.74			
			say	=	14	No.			
Hence Provided		14	bars of	20	mm Φ bar,				
		having, Ast	=	14	x	314	=	4396.00	mm^2
		Keeping	=	40	mm nominal side cover				
Design of ties:-									
Diameter of ties should be 1/4 of the diameter of longitudinal reinforcement subject to minimum 6 mm.									
However use		8	mm ϕ bars of ties.						
The spacing of the ties should not exceed least of the following.									
(I)	Least lateral diamension.						=	**500**	mm
(II)	16 x Diameter of main bars			16	x	20	=	**320**	mm
(III)	48 x dia of ties			48	x	8	=	**384**	mm
	Hence provided the ties @					=	**250**	mm c/c.	

Table 16
Typical footing design

DESIGN OF ISOLATED FOOTING (F1)

Data:	Column no.	C-1	
	load case		
	Concrete grade, M	30	
	Steel grade, Fe	500	
	Axial load, kN	919.177	kN
	My, kNm	12.811	kNm
	Mz, kNm	182.284	kNm
	Column size, b	500	mm
	Column size, d	1000	mm
	SBC of soil, kN/m2	300	kN/m^2
	Design factor	1.5	
Pressure:	Axial load	919.177	kN
	App. Self weight	91.9177	kN
	Total weight	1011.0947	kN
	Area of footing	3.37	m2
	size of footing, Bf	2	mt
	size of footing, Df	2.5	mt
	Projection, b1	0.750	mt
	Projection, d1	0.750	mt





A= 5 m2

Zb = 1.666666667

Zd = 1.666666667

Footing Pressure,

Pmax = P/A + My/Zb + Mz/Zd

= 134.8126267 + 5.1244 + 72.9136

Pmax = 212.85 kN/m^2

Pmin = P/A - My/Zy - Mz/Zz

Pmin = 56.77 kN/m^2

Flexure design:

The foundation is designed for full SBC = 300 kN/m^2

BM along e-g= 84.375 kN-m/m

BM along a-d= 84.375 kN-m/m

Footing is Designed for Maximum of BM= 84.375 kN-m/m

Footing Depth= 750.00 mm

deff= 650.00 mm

j= 0.8

σst= 230 N/mm2

Ast Required= M / (σst x j x d) = 705.4765886 mm^2

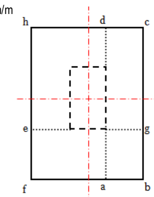
Ast Minimum= 0.2 % / 2 of Ast per face = 650 mm^2

Ast Required= 705.48 mm^2

provide 16# @200c/c

Ast Provided **904** mm^2

Provide **16#** @200c/c as Top and Bottom Reinforcment



Shear Chk.

One way Shear : At distance d from face of column.

Pt Provided= 0.139 %

Shear stress, Tc = 0.222 N/mm^2

V = 30 Kn

Shear Stress, Tv= 0.046 N/mm2

Tc > Tv, OK

Table 17

WEIR 6 JACKWELL BEAM DESIGN

Project Title :

BEAM DESIGN

2L	8	100.52	2L	10	157.08
4L	8	201.04	4L	10	314.15
6L	8	301.62	6L	10	471
				3.5	

Grade of concrete, Fck = 30

d/d1= 0.5

Fy = 500

500

BEAM AT 784.2

Beam No	b	D	d	FM	T	Eq BM	Mu	Mu/(b*d*d)	Pt	Pt Min	Pt Doubly	Pc	Ast	Ast provided	Asc	WV	Eq Shear	tv=Vu/(b*d)	tc	Vus	Vus/d	Spacing	Spacing	Spacing	Spacing	Spacing
	mm	mm	mm	kN-m	kN	kN-m	kN-m	----	----			----	mm^2	mm^2	mm^2	kN	kN	N/mm^2	N/mm^2	kN	KN/cm	mm	mm	mm	mm	mm
			750																				*2LY8*	*2LY10*	*6Ly8*	*6Ly10*
B1	350	650	615	**451.63**	32.89	55.28	506.91	3.82922	**1.072**	1.072	1.072	0.000	2308.3	4780	0	269.54	150.3542857	1.9507052	0.6735	274914.38	4.4702	97.8181	98	153	294	458
B2	350	600	565	**376.44**	27.53	43.95	420.38	3.762527	**1.049**	1.049	1.049	0.000	2073.7	4780	0	278.93	125.8285714	2.0468196	0.6678	272698.45	4.8265	90.5957	91	142	272	424
B3	350	600	565	**212.30**	24.38	38.93	251.22	2.248491	**0.572**	0.572	0.572	0.000	1130.4	4378	0	219.92	111.4514286	1.6756937	0.525	227549.98	4.0274	108.571	109	170	326	509
B4	400	400	365	**49.93**	9.496	11.17	61.106	1.146665	**0.276**	0.276	0.276	0.000	403.65	1608	0	53.71	37.984	0.6280685	0.3856	35403.379	0.97	450.806	250	704	1353	2112
B5	350	600	565	**369.45**	14.89	23.77	393.22	3.51945	**0.965**	0.965	0.965	0.000	1907.3	4780	0	299.82	68.05942857	1.8603208	0.6468	239983.33	4.2475	102.946	103	161	309	482
B6	400	400	365	70.06	14.44	16.99	87.049	1.633488	**0.403**	0.403	0.403	0.000	587.99	1608	0	52.18	57.768	0.7530411	0.4535	43732.143	1.1981	364.95	250	570	1095	1710
B7	350	600	565	226.29	34.3	54.76	281.05	2.515425	**0.649**	0.649	0.649	0.000	1282.8	3366	0	238.94	156.7817143	2.001106	0.5528	286400.89	5.069	86.2613	86	135	259	404
B8	350	600	565	44.54	7.303	11.66	56.199	0.502997	**0.118**	.2	0.118	0.000	395.5	2060	0	37.45	33.38514286	0.3582258	0.2631	18811.964	0.333	1313.28	250	2052	3941	6154
B9	350	600	565	**45.95**	8.593	13.72	59.67	0.534061	**0.125**	.2	0.125	0.000	395.5	2060	0	46.52	39.28228571	0.4338725	0.2706	32291.236	0.5715	765.078	250	1196	2296	3585
B10	350	600	565	**366.74**	14.38	22.97	389.71	3.487966	**0.954**	0.954	0.954	0.000	1886.3	4378	0	273.07	65.75542857	1.713413	0.644	211478.69	3.743	116.822	117	183	351	547
B11,11a,11b,	350	600	565	**180.87**	21.35	34.09	214.96	1.923969	**0.481**	0.481	0.481	0.000	951.35	2964	0	143.56	97.61828571	1.2196121	0.4888	144520	2.5579	170.947	171	267	513	801
B12	350	900	865	**782.85**	110.5	232.1	1015	3.875812	**1.089**	1.089	1.089	0.000	3297.4	6568	0	457.20	505.1428571	3.1786717	0.6775	757233.28	8.7541	49.9492	~~50~~	~~78~~	150	234
B13,13a	350	600	565	41.07	111.3	177.7	218.77	1.958063	**0.490**	0.490	0.490	0.000	969.85	2964	0	111.30	508.8	3.1357775	0.4927	522661	9.2506	47.2683	~~47~~	~~74~~	142	221
B14,14a,14b, 14c	350	1000	965	1134.24	56.34	127.8	1262.1	3.872207	**1.088**	1.088	1.088	0.000	3674.2	6793	0	680.72	257.5405714	2.7779736	0.6772	709542.51	7.3528	59.469	~~59~~	93	178	279
B15	400	400	365	21.86	8.011	9.425	31.281	0.58699	**0.138**	.2	0.138	0.000	292	1608	0	67.12	32.044	0.6792055	0.6535	3748.8861	0.1027	4257.28	250	6653	12774	19948
B16	350	950	915	**1036.00**	8.261	18.05	1054	3.597085	**0.991**	0.991	0.991	0.000	3173.7	6568	0	417.12	37.76457143	1.4204046	0.6535	245592.17	2.6841	162.91	163	255	489	763

TOP		**25.000**	**6.000**		**2945.243**
		20.000	**4.000**		**1256.637**
		25.000	**4.000**		**1963.495**
		32.000	**4.000**		**3216.991**
BOT		**25.000**	**6.000**		**2945.243**
		20.000	**4.000**		**1256.637**
		25.000	**4.000**		**1963.495**

4. Conclusion

The structural design and drawings for Jack well cum pump house, based on approved General Arrangement Drawing is based on the detailed structural analysis. The Structure is now fit for Construction.

Abbreviations

VJNL	Visvesvaraya Jala Nigam Ltd
DGPS	Dual frequency Global Positioning System
GoK	Government of Karnataka
DC	Delivery Chamber
TBM	Temporary Bench Mark
ft	Feet
mts	Meters
mm	Millimeters
kms	Kilometers
sq.kms.	Square Kilometers
MCum	Million Cubic Meters
TM Cft	Thousand Million Cubic Feet
Ha	Hectares
Cm/hr	Centimeter per hour
MSL	Mean Sea Level
AMSL	Above Mean Sea Level
TMC	Thousand Million Cubic Feet
MS	Mild Steel
CD	Cross Drainage
m/s	meters per second
SR	Schedule of Rates
WRD	Water Resources Department
MW	Megawatt
GPS	Global Positioning System

References

[1] IS 3370–1965, (Part-1 General requirements) code for practice for concrete structure for the storage of liquids.

[2] IS 3370–1965, (Part-2 Reinforced concrete structure) code for practice for concrete structure for the storage of liquids.

[3] IS 3370–1965, (Part-4 Design tables) code for practice for concrete structure for the storage of liquids.

[4] Design Aid to water retaining structure by M/s Tor Steel Research Foundation.

[5] IS 456: 2000, Plain and reinforced concrete code practice.

[6] Joseph E. Bowles, "Foundation analysis and design."