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Innovative Construction of Combined Ground and Elevated Level Service Reservoir in Monolithic Structure

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Abstract
This paper presents a combined R.C.C ground level service reservoir and elevated level service reservoirs for a capacity of 5 million gallon(1800 Cum), 20 million gallon(1710 Cum) respectively store fully treated portable water close to the point of distribution with the help of rising main (different DIA) pipe line. The best way is to select this type of combined structure depending on the circumstances and site. The aim of this paper design large capacity of combined R.C.C water tanks in a monolithic structure. The idea is to reach a definite conclusion regarding the superiority of the two techniques over one another for specified capacity. This research gives in brief about service reservoirs, service reservoirs requirement as per IS provisions and particular for ground and elevated level reservoir by carried out the analysis and studying different types of water towers in to get idea of service reservoir with help of basic by STAAD pro design calculation. The main concept of designing combined service reservoir in one monolithic structure is to increase storage capacity and improve pressure without affecting environmental and ecological assets in the area. In addition, to get the high or maximum water pressure to both nearby and more distant residents. In this paper carried out the conclusion is designing a single tower with two separate reservoirs. Different pressure zones had the operational costs were 35% lower, which offset higher capital costs.
Keywords: *Ground and Elevated Level Service Reservoir, STAAD pro.*

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I. INTRODUCTION

Water is generally stored in concrete containers and later on, it is pumped to altered areas to serve the community. Water reservoirs can be classified as overhead, resting on ground or underground depending on their location. The containers can be made of steel or concrete. Service reservoirs resting on ground are normally of smaller capacity as the overhead water reservoirs are open to public view. Their shape is influenced by the appealing view in the surroundings. Storage reservoirs are used to store water, petroleum products and similar liquids. Most water resource systems in developing countries such as India, where urbanizing is increasing day by day hence there is need to construct a greater number of water reservoirs are designed as crack free structures to reduce any leakage. Water or raw petroleum retaining slab and walls can be of reinforced concrete with adequate cover to the reinforcement. The walls of water reservoirs are exposed to water pressure from inside and earth pressure from outside. The base of these service reservoirs is subjected to water pressure from inside and soil reaction from underneath.

i) This paper also enlarges the comparison the analysis results between Elevated Level Service Reservoir, Ground Level Service Reservoir and Combined Structure of Elevated Level Service Reservoir and Ground Level Service Reservoir.
ii) This Paper concludes that there are three of vision on the construction technique of combined structure.
iii) The estimate and other design methodology ensure that this technology is more efficient.

1.1.1 General Consideration

We have considered a site in North Dum Dum, Kolkata, and West Bengal. The approximate population of this area is 2,49,142 No's as per 2011 census. There have airport area and commercial area also, so supply water would be used as many purpose as well as family. For that we have taken a per capita water demand of 150 Littre per capita per day (approx.) but existing water demand is 85 Littre per capita per day.

1.1.2 Scope of work

1 To study about the analysis and design of service reservoirs.
2 To create the guidelines for the design of liquid retaining structure According to IS code.

3 To identify about design philosophy for safe design of service reservoirs. Staad pro analysis for ground and elevated service reservoirs.
4 To create maximum Water, minimum impact. With two reservoirs stacked atop one another.
5 This paper also enlarges the comparison the analysis results between Elevated Level Service Reservoir, Ground Level Service Reservoir and Combined Structure of Elevated Level Service Reservoir and Ground Level Service Reservoir.

1.2 Objective

This Project report developes the aspect and design consideration based on IS code to produce a large number of quantity water or any kind of liquid through monolithic structure construction and study on its different parameters through its analysis which is based on STAAD PRO software.

1.2.1 Methodology

The elevated water tank is carried by 36 columns and founded on a square mat foundation having
a side length of 35.5 m. Because of symmetric conditions, only one quarter of the mat and the underlying soil layers is considered. Three-dimensional finite element mesh containing 1135 solid elements was used to model the raft and the supporting soils. The mat is represented by 121 elements 1.25-m thick.
1. The Structure is consolidated and designed by the staad pro software.
This is almost considered as combined structure and also designed as single structure in the form of Elevated Level Service Reservoir and Ground Level Service Reservoir. Elevated Level Service reservoir is mainly main structure with one at stack with Ground Level Service Reservoir.
2. Step for construction of Elevated Level Service Reservoir.
a. Survey of suitable site
b. Selection of the site which permit more stabilized condition for Elevated Storage tank.
c. Estimate the proper population to serve .
d. Selection for zoning of water vated area (Pressure zone)
e. Estimate the cost of construction.
f. Preparation of structural drawing of the structure.
g. Design the whole structure with its various components.

1.2.2 Step for construction of Ground Level Service Reservoir.

a. Survey of Suitable site.
b. Selection of the site which permit more stabilized condition for Ground Elevated Storage tank.
c. Estimate the proper population to serve.
d. Selection for zoning of water vated area (Pressure zone)
e. Estimate the cost of construction.
f. Preparation of structural drawing of the structure.
g. Design the foundation of this structure.
h. Design the whole structure with its various components.

1.2.3 Step for construction of Combined (Monolithic Structure) of Ground Level Service Reservoir and Elevated Level Service Reservoir.

a. Survey of Suitable site.
b. Selection of the site which permit more stabilized condition for combined Ground Elevated Storage tank and Elevated Storage tank in monolithic structure.
c. Estimate the proper population to serve.
d. Selection for zoning of water vated area (Pressure zone)
e. Estimate the cost of construction.
f. Preparation of structural drawing of the structure.
g. Design the foundation of this structure.
h. Design the whole structure with its various components.
i. Check the feasibility of this combined structure.

3. First in this paper the size of tank is taken as 25 mg (million gallon) and this is not expected that this capacity of tank is enough for serviceability of the population then we design the whole things in manual and software both.
4. The single structure capacity have analysis of Seismic, Wind, Time History Analysis and different displacement graph and mode shape is shown by picture.
Compare the analyzed result for Elevated Level Service Reservoir, Ground Level Service Reservoir and combined structure of Elevated Level Service Reservoir and Ground Level Service Reservoir.

1.2.2 Parametric Study

Due to this unconventional method of differentiating the both Water reservoir with combined structure of two structures reflect everything, which is more economical structure than other two single structures individually.

1.2.3 Design Result

Volume Calculation

Dimensions of Tank Proper
Inner Radius of Monitor = 0.45000 m
Clear Height of Monitor = 0.60000 m
Free Boar = 0.30000 m
Horizontal Radius of Top Dome = 4.20000 m
Height of Top Dome = 1.20000 m
Radius of Curvature of Top Dome = $(4.200^2+1.200^2)/(2X1.200)$ = 7.95000 m
Radius of Cylindrical Shell = 6.60000 m
Height of Cylindrical Shell = 5.05000 m
Top Horizontal Radius of Conical Shell = 6.60000 m
Bottom Horizontal Radius of Conical Shell = 4.20000 m
Height of Conical Shell = 2.40000 m
Horizontal Radius of Bottom Dome = 4.20000 m
Height of Bottom Dome = 1.20000 m
Radius of Curvature of Bottom Dome = $(4.200^2+1.200^2)/(2X1.200)$ = 7.95000 m
Radius of Staging= 4.20000 m

Volume of Water in Cylindrical Shell

Clear Height of Water in Cylindrical Shell = 4.750 m
Volume of Water = **650.02694 m^3**
CG above Tank Bottom = 4.775 m

Volume of Water in Conical Shell

Clear Height of Water = 2.400 m
Clear Top Horizontal Radius = 6.600 m
Clear Bottom Horizontal Radius = 4.200 m
Volume of Water = **223.480 m^3**
CG above Tank Bottom = 1.37490 m

Deduction for Bottom Dome
Clear Horizontal Radius of Bottom Dome = 4.200 m
Total Height of Bottom Dome = 1.200 m
Radius of Curvature of Bottom Dome = 7.95000 m
Deduction = **34.15540 m^3**
CG above Tank Bottom = 0.40530 m

Deduction for Column
Deduction = **6.43500 m^3**
CG above Tank Bottom = 3.575 m

Combined CG from Tank Bottom = 4.05118 m
Basic Parameters
A) Grade of Concrete = M–25, Grade of Steel = Fe–500, σ_{cbc} = 8.5 N/mm^2
m = 10.98039
σ_{st} = 275.00 N/mm^2 = 2803.262 Kg/cm^2
K = 0.25339
j = 0.91554
Q = 10.05046 Kg/cm^2

B) Grade of Concrete = M–30, Grade of Steel = Fe–500, σ_{cbc} = 10.0 N/mm^2
m = 9.33333
σ_{st} = 2803.262 Kg/cm^2
K = 0.25339
j = 0.91554
Q = 11.82406 Kg/cm^2

C) For Water Retaining Structure,
σ_{st} = 1325.178 Kg/cm^2 [Ref. : Table 4 of IS: 3370 (Part–II)]
K = 0.41791
j = 0.86070
Permissible Bending Tensile Stress in Concrete = 2.0 N/mm^2 = 20.387 Kg/cm^2

Design of Monitor Roof (75 mm to 100 mm Thick)
Loading
1) Self weight of Slab = 0.22295 T/m^2
2) Weight of Plaster = 0.04160 T/m^2
Total Dead Load = 0.26455 T/m^2
3) Live Load = 0.07645 T/m^2
Total Vertical Load = 0.34100 T/m^2
[Ref. : Case–2l, 10a & 13a Table–24 of "ROARK'S Formulas for Stress & Strain" by W. C. Young]

Cantilever Moment at CL of Monitor Column = –0.03420 Tm
Design Moment at Centre = –0.01481 Tm (Nominal)
Cantilever Moment at Face of Monitor Column = –0.02044 Tm
d = 4.600 cm
Ast = 0.173 cm^2
Provide 8 Tor @ 150 mm C/C on both ways centrally placed, Ast provided = 3.351 cm^2
Design of Monitor Column (4 Nos. 150mm X 150mm)

Loading
1) Self weight of Column = 0.03440 T
2) Weight of Plaster = 0.00749 T
3) Dead Load from Roof/Column = 0.16830 T
Total Dead Load = 0.21019 T
4) Live Load from Roof/Column = 0.04864 T
Total Vertical Load = 0.25883 T
Compressive Stress = 1.150 Kg/cm^2<< 6X100/9.81= 61.162 Kg/cm^2

Provide 4 Nos 12 Tor Vertical Reinforcement with 8 Tor Transverse Reinforcement @ 150 mm C/C.
To distribute the negligible column loads on Top Dome, we shall provide 150mmX150mm Ring beam below columns with 4 Nos. 8 Tor Ring and 2 Legged 8 Tor Stirrups @ 75 mm C/C.

Design of Top Dome (100 mm Thick)

Dead Load Calculations from Monitor
1) Weight of Monitor Slab = 0.67320 T
2) Weight of Monitor Column = 0.16756 T
3) Weight of Monitor Ring Beam = 0.22244 T
Total Dead Load = 1.06320 T

CG above Tank Bottom = 9.23920 m

4) Live Load from Monitor Roof = 0.19456 T

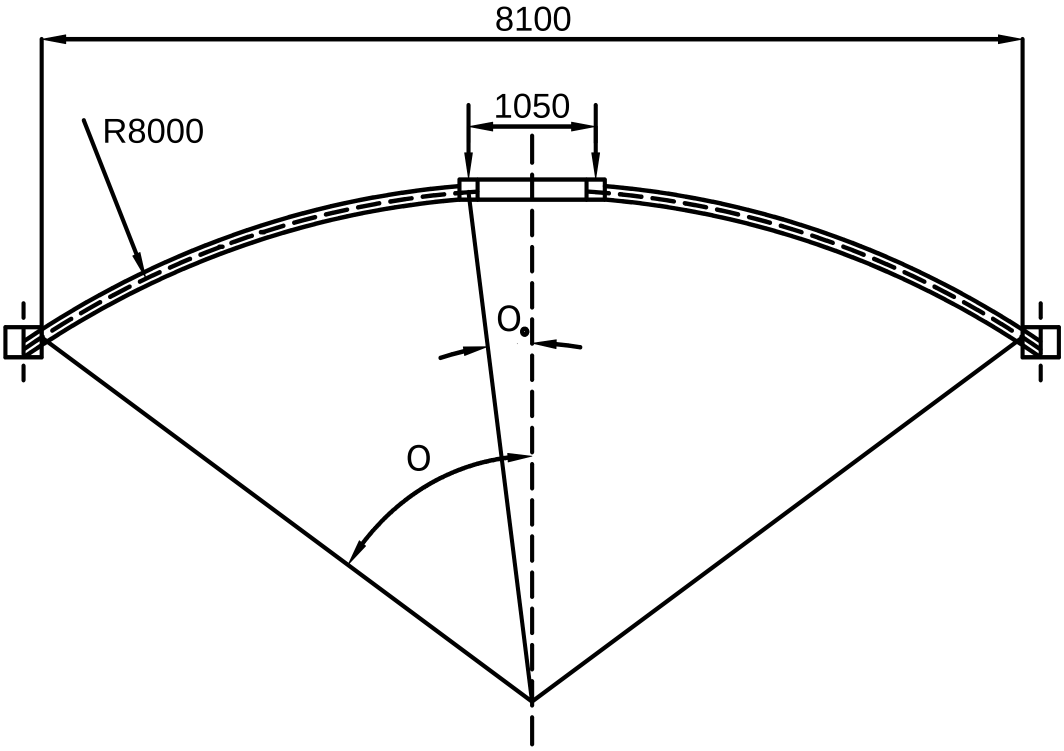
CG above Tank Bottom = 9.4875 m

5) Weight of Top Dome = 16.06690 T

CG Calculation for Top Dome
Inner dome volume = 29.28878 m^3
Inner dome CG = 0.46522 m
Outer dome volume = 28.84508 m^3
Outer dome CG = 0.57566 m
Volume = 5.97748 m^3
CG = 0.14905 m
Opening Volume = 0.11310 m^3
Opening CG = 1.250 m
CG above Tank Bottom = 8.13788 m

7) Live load from Top Dome = 3.74492 T
CG above Tank Bottom = 8.02566 m

Total Load from Monitor Ring Beam = 1.25776 T
This load will be transmitted to the dome as ring load, p = 0.38129 T/m
Total Vertical Load from Top Dome = 19.81182 T
Load per unit area, w = 0.36546 T/m²
[Ref. : Clause 2.2.1.1 of "Storage Structures" by K. Rajagopalan]



Provide 8 Tor @ 200 mm C/C Radially at top and 8 Tor @ 200 mm C/C Circumferentially at top
Design of Top Slab (100 mm Thick)
[Ref. : Case–2h, Table–24 of "ROARK'S Formulas for Stress & Strain" by W. C. Young]
Provide 8 Tor @ 150 mm C/C Radialy at centrally placed, Ast provided = 3.351 cm²
Provide 8 Tor @ 200 mm C/C Circumferentially at centrally placed, Ast provided = 2.513 cm²

Load Calculations
Weight of Top Slab = 28.39068 T
CG from Tank Bottom = 7.500 m
Live Load on Top Slab = 6.47946 T
CG from Tank Bottom = 7.550 m
Weight of Top Ring Beam = 4.99155 T
CG above Tank Bottom = 7.5625 m
Love Load on Ring Beam = 0.45393 T
CG above Tank Bottom = 7.675 m
Weight of Top Dome Supporting Column = 17.08434 T
CG above Tank Bottom = 3.725 m
Design of Top Ring Beam (300 mm X 225 mm)
Hoop tension = F_t = 5.95036 T
Total Load on Top ring Beam = 43.95013 T
Udl on Top ring Beam = 1.66545 T/m

Design of Column (300 mm X 300 mm)
Provide 8 Nos 12 Tor with 2 Legged 8 Tor Stirrups @ 150 mm C/C.

1.3.1 Design Philosophy.

Monolithic Structure of Elevated Level Service Reservoir and Ground Level Service Reservoir in combined form will serve the area with an increasing pressure zone.
Firstly there are design of different Structure of Elevated Level Service Reservoir with a 20 cum capacity and Ground Level Service Reservoir with a 5 cum capacity and we calculate the pressure zone for both water retaining structure and after the calculate of pressure zone the staging height of both Storage tank was calculated. In future would be developed the monolithic structure with different pressure zone with staging height.
However this is purely contains one or more structure in a form of monolithic structure in design purpose.

1.3.2 Design Methodology

All the modules of the Service Reservoirs are analyzed. Considering Dead load, Live load ,Wind load and Earthquake forces and their various combinations, In addition, the service reservoirs is analyzed for the tank full and tank empty conditions. The permissible stresses in material are increased by 35% for wind force. Whenever the effect of wind and seismic forces together are taken into account, the safe bearing capacity of soil is increased by 20%. The design is done in accordance with the procedure laid down in I.S: 3370-1967 Part I-IV (1). 4

The connections between wall-wall and wall-slab are considered as either fixed or pinned . For given cases displacements, stresses and bending moment calculations are done . In addition to that the design made as per IS (Indian standards) with the use of STAAD Pro software. By use of software, the cases are carried out and the conclusion is given.

1.3.3Tabulation of Result

We shall design the wall following Membrane Analysis.
DESIGN OF CYLINDRICAL WALL (175 mm thick with a haunch 50 mm X 300 mm)

Table 1: SWD (m) =4.550 Radius (m) =6.6

Depth below TWL in m	Hoop Tension in T	Total A_{SREQD} in cm^2	Thick Prov. in cm	A_{SMIN} in cm^2	A_{SDIA} in mm	Spacing of A_S in mm	Actual A_{SPROV} in cm^2	Hoop Stress in Kg/cm^2
0.0000	0.00000	0.000	17.500	4.200	10	175	8.976	0.00000
0.4000	2.64000	1.992	17.500	4.200	10	175	8.976	1.44673
0.4750	3.13500	2.366	17.500	4.200	10	175	8.976	1.71800
0.5500	3.63000	2.739	17.500	4.200	10	175	8.976	1.98926
0.6250	4.12500	3.113	17.500	4.200	10	175	8.976	2.26052
0.7000	4.62000	3.486	17.500	4.200	10	175	8.976	2.53178
0.7750	5.11500	3.860	17.500	4.200	10	175	8.976	2.80305
0.8500	5.61000	4.233	17.500	4.200	10	175	8.976	3.07431
0.9250	6.10500	4.607	17.500	4.200	10	175	8.976	3.34557
1.0000	6.60000	4.980	17.500	4.200	10	175	8.976	3.61683
1.0750	7.09500	5.354	17.500	4.200	10	175	8.976	3.88810
1.1500	7.59000	5.728	17.500	4.200	10	175	8.976	4.15936
1.2250	8.08500	6.101	17.500	4.200	10	175	8.976	4.43062
1.3000	8.58000	6.475	17.500	4.200	10	175	8.976	4.70189
1.3750	9.07500	6.848	17.500	4.200	10	175	8.976	4.97315
1.4500	9.57000	7.222	17.500	4.200	10	175	8.976	5.24441
1.5250	10.06500	7.595	17.500	4.200	10	175	8.976	5.51567
1.6000	10.56000	7.969	17.500	4.200	10	175	8.976	5.78694
1.6750	11.05500	8.342	17.500	4.200	10	175	8.976	6.05820
1.7500	11.55000	8.716	17.500	4.200	10	175	8.976	6.32946
1.8250	12.04500	9.089	17.500	4.200	10	150	10.472	6.55593
1.9000	12.54000	9.463	17.500	4.200	10	150	10.472	6.82536
1.9750	13.03500	9.836	17.500	4.200	10	150	10.472	7.09478
2.0500	13.53000	10.210	17.500	4.200	10	150	10.472	7.36420
2.1250	14.02500	10.583	17.500	4.200	10	125	12.566	7.56180
2.2000	14.52000	10.957	17.500	4.200	10	125	12.566	7.82869
2.2750	15.01500	11.331	17.500	4.200	10	125	12.566	8.09558
2.3500	15.51000	11.704	17.500	4.200	10	125	12.566	8.36246
2.4250	16.00500	12.078	17.500	4.200	10	125	12.566	8.62935
2.5000	16.50000	12.451	17.500	4.200	10	125	12.566	8.89624
2.5750	16.99500	12.825	17.500	4.200	10	100	15.708	9.03557
2.6500	17.49000	13.198	17.500	4.200	10	100	15.708	9.29874
2.7250	17.98500	13.572	17.500	4.200	10	100	15.708	9.56191
2.8000	18.48000	13.945	17.500	4.200	10	100	15.708	9.82508
2.8750	18.97500	14.319	17.500	4.200	10	100	15.708	10.08826
2.9500	19.47000	14.692	17.500	4.200	10	100	15.708	10.35143
3.0250	19.96500	15.066	17.500	4.200	10	100	15.708	10.61460
3.1000	20.46000	15.439	17.500	4.200	10	100	15.708	10.87777
3.1750	20.95500	15.813	17.500	4.200	10	75	20.944	10.88835
3.2500	21.45000	16.187	17.500	4.200	10	75	20.944	11.14556
3.3250	21.94500	16.560	17.500	4.200	10	75	20.944	11.40276
3.4000	22.44000	16.934	17.500	4.200	10	75	20.944	11.65997

3.4750	22.93500	17.307	17.500	4.200	10	75	20.944	11.91718
3.5500	23.43000	17.681	17.500	4.200	10	75	20.944	12.17438
3.6250	23.92500	18.054	17.500	4.200	10	75	20.944	12.43159
3.7000	24.42000	18.428	17.500	4.200	10	75	20.944	12.68879
3.7750	24.91500	18.801	17.500	4.200	10	75	20.944	12.94600
3.8500	25.41000	19.175	17.500	4.200	10	75	20.944	13.20320
3.9250	25.90500	19.548	17.500	4.200	10	75	20.944	13.46041
4.0000	26.40000	19.922	17.500	4.200	10	75	20.944	13.71761
4.0750	26.89500	20.295	17.500	4.200	10	75	20.944	13.97482
4.1500	27.39000	20.669	17.500	4.200	10	75	20.944	14.23202
4.2250	27.88500	21.042	17.083	4.100	10	65	24.166	14.60164
4.3000	28.38000	21.416	18.333	4.400	10	65	24.166	13.94789
4.3750	28.87500	21.790	19.583	4.700	10	65	24.166	13.36981
4.4500	29.37000	22.163	20.833	5.000	10	65	24.166	12.85499
4.5500	30.03000	22.661	22.500	5.400	10	65	24.166	12.25023

Table 2:

Calculation of Moment on Wall due to Water							
[Ref. : Table 10 of IS : 3370 (Part-IV)]						w in T/m^3=	1.00000
D in m =		13.200		H in m =	4.5500	t in m =	0.175
H^2/Dt =		8.96212		Edge Condition : Top Free & Bottom Fixed			
Moment at		**RL at**		**Coefficient for H^2/Dt**			**Moment in Tm**
				8.00000	**10.00000**	**8.96212**	
0.0	H	27.15000	m	0.00000	0.00000	0.00000	0.00000
0.1	H	26.69500	m	0.00000	0.00000	0.00000	0.00000
0.2	H	26.24000	m	0.00010	0.00000	0.00005	0.00471
0.3	H	25.78500	m	0.00020	0.00010	0.00015	0.01413
0.4	H	25.33000	m	0.00080	0.00040	0.00061	0.05746
0.5	H	24.87500	m	0.00160	0.00070	0.00117	0.11021
0.6	H	24.42000	m	0.00280	0.00190	0.00237	0.22325
0.7	H	23.96500	m	0.00380	0.00290	0.00337	0.31744
0.8	H	23.51000	m	0.00290	0.00280	0.00285	0.26846
0.9	H	23.05500	m	-0.00220	-0.00120	-0.00172	-0.16202
1.0	H	22.60000	m	-0.01460	-0.01220	-0.01345	-1.26694

Summary of Vertical Loads

Table 3:-

CALCULATIONS FOR DEAD LOAD					
SN	**Description of items**	**Weight (T)**	**LA from LWL (m)**	**Staging Ht. (m)**	**Moment at FGL (Tm)**
1	Monitor	1.06320	9.23920	20.000	31.08712
2	Top Dome	16.06690	8.13788	20.000	452.08850
3	Top Slab	28.39068	7.50000	20.000	780.74370
4	Top Ring Beam with Railing	4.99155	7.56250	20.000	137.57960
5	300 mm X 300 mm Column	17.08434	3.72500	20.000	405.32597
6	Cylindrical Wall	97.94228	5.05523	20.000	2453.96635
7	Middle Ring Beam with Walkway	37.23497	2.43897	20.000	835.51437
8	Conical Shell	87.39077	1.19204	20.000	1851.98869
9	Bottom Dome	22.35008	0.56346	20.000	459.59498
10	Screed Concrete	0.73626	0.10000	20.000	14.79883
	Total Weight =	**313.25103**	**Total Moment at FGL =**		**7422.68811**
				CG from FGL =	**23.69565**
SN	**Description of items**	**Weight (T)**	**LA from LWL (m)**	**Staging Ht. (m)**	**Moment at FGL (Tm)**

1	Monitor	0.19456	9.48750	20.000	5.73709
2	Top Dome	3.74492	8.02566	20.000	104.95385
3	Top Slab	6.47946	7.55000	20.000	178.50912
4	Top Ring Beam	0.45393	7.67500	20.000	12.56251
5	Middle Ring Beam with Walkway	6.98954	2.60000	20.000	157.96360
	Total Weight =	**17.86241**		**Total Moment at FGL =**	**459.72617**
				CG from FGL =	**25.73707**
1	**Water Load**	**832.91654**	**4.05118**	**20.000**	**20032.62563**
2	**Nonseismic with DL+WL+LL**	**1164.02998**		**CG from FGL =**	**NA**
3	**Seismic with DL only**	**313.25103**		**CG from FGL =**	**23.69565**
4	**Seismic with DL+WL+LL**	**1150.63317**		**CG from FGL =**	**23.96093**

Table 4:-

DETERMINATION OF LATERAL PILE CAPACITY [Ref : IS : 2911 (Part I/Sec 2) - 2010, Appendix - C]		
Grade of Concrete	=	M-25
f_{ck} in N/mm^2	=	25
E in MN/m^2	=	25000
Dia of Pile in m	=	0.500
I in m^4	=	0.003068
EI in MNm^2	=	76.7
Type of Pile Head	=	Fixed
Unsupported Length of Pile, L_1 in m	=	0.000
For Cohesive Soil, C in T/m^2	=	**1.830**
For Cohesive Soil, q_u in KN/m^2 [q_u = 2XCX9.81]	=	35.90460
For Cohesive Soil, k_1 in MN/m^2	=	6.463
For Cohesive Soil, K in MN/m^2 [K = K1X0.3/(1.5XD]	=	2.58520
For Cohesive Soil, R in m [R = $^{4Square Root of}$(EI/KD)]	=	2.77500
Reduction Factor	=	2.17000
L_f in m	=	6.02200
L1+Lf in m	=	6.02200
Deflection "□" in m	=	0.005
Allowable Horizontal Force, H in KN	=	21.073
Allowable Horizontal Force, H in T	=	**2.148**

Table 5:-

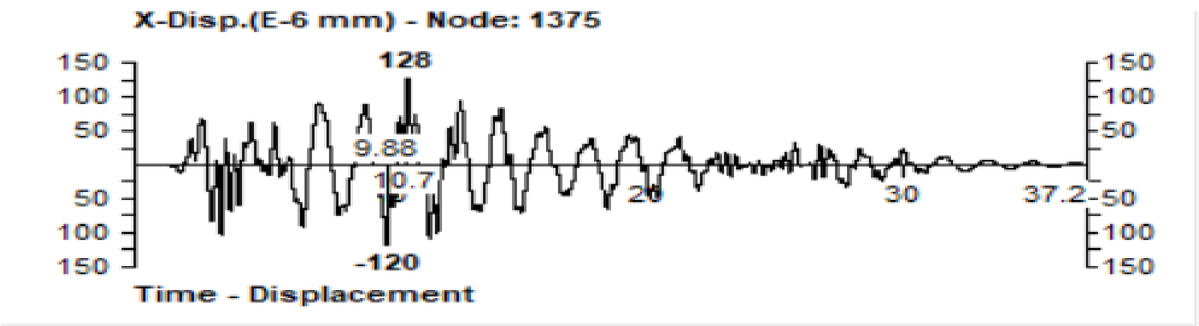
VERTICAL LOAD CARRYING CAPACITY CALCULATION		
Length of Shaft in m	=	26.000
RL at EGL in m	=	**0.000**
RL at Pile Cut-off Level in m	=	-0.600
RL at Pile Termination Level in m	=	-26.600
Diameter of Pile in m	=	0.500
Cross Sectional Area of Pile Tip, A_p in m^2	=	0.19635
Bearing Capacity Factor for Cohesive Soil, N_c	=	9
Factor of Safety for Adhesion/Skin Friction (Downward Load Capacity)	=	2.5
Factor of Safety for Adhesion/Skin Friction (Upward Load Capacity)	=	3.0
Factor of Safety for End Bearing Capacity	=	3.0
Stratum-I		
RL at start of layer in m	=	0.000

RL at end of layer in m	=	-4.000
Depth of layer in m	=	4.000
Depth of Pile in this layer in m	=	3.400
Submerged Density = g_{sub} in T/m^3	=	0.810
Total Overburden Pressure up to this layer in T/m^2	=	2.75400
Cohesion = C_i in T/m^2	=	1.830
Adhesion Factor, a_i	=	1.000
Surface Area, A_{si} in m^2	=	5.34071
Ultimate Adhesion, $a_iC_iA_{si}$ in T	=	9.77350
Ultimate End Bearing Capacity of Pile, $A_pN_cC_p$ in T	=	0.00000
Safe Vertical Load Capacity of Pile up to this layer in T	=	3.90940

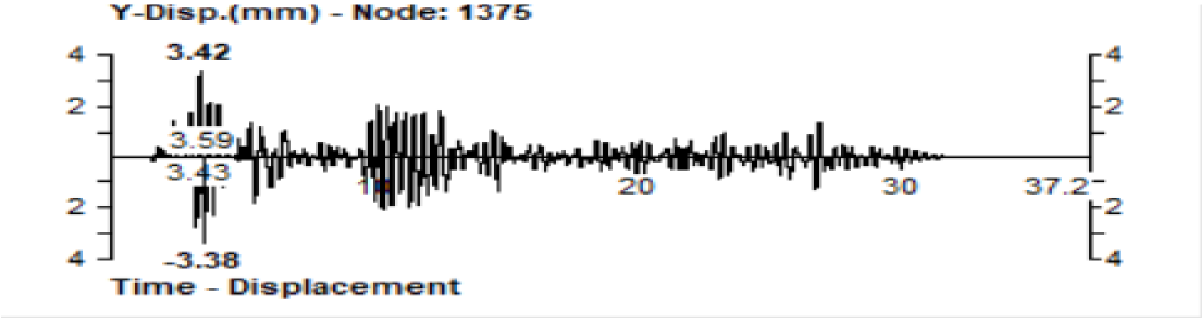
Table 6:-

Stratum-I		
RL at start of layer in m	=	0.000
RL at end of layer in m	=	-4.000
Depth of layer in m	=	4.000
Depth of Pile in this layer in m	=	3.400
Submerged Density = g_{sub} in T/m^3	=	0.810
Total Overburden Pressure upto this layer in T/m^2	=	2.75400
Cohesion = C_i in T/m^2	=	1.830
Adhesion Factor, a_i	=	1.000
Surface Area, A_{si} in m^2	=	5.34071
Ultimate Adhesion, $a_iC_iA_{si}$ in T	=	9.77350
Ultimate End Bearing Capacity of Pile, $A_pN_cC_p$ in T	=	0.00000
Safe Vertical Load Capacity of Pile upto this layer in T	=	3.90940
Stratum-II		
RL at start of layer in m	=	-4.000
RL at end of layer in m	=	-12.000
Depth of layer in m	=	8.000
Depth of Pile in this layer in m	=	8.000

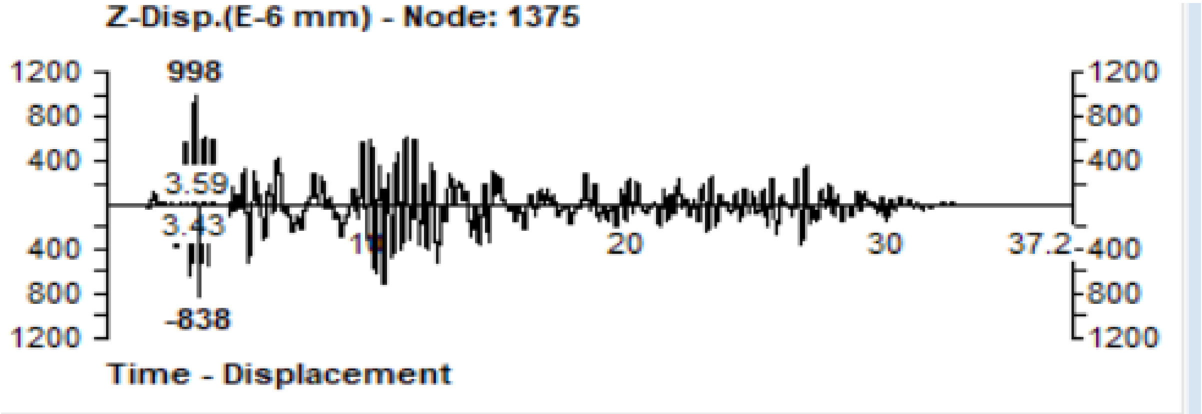
2.1Time History Analysis at X- Displacement



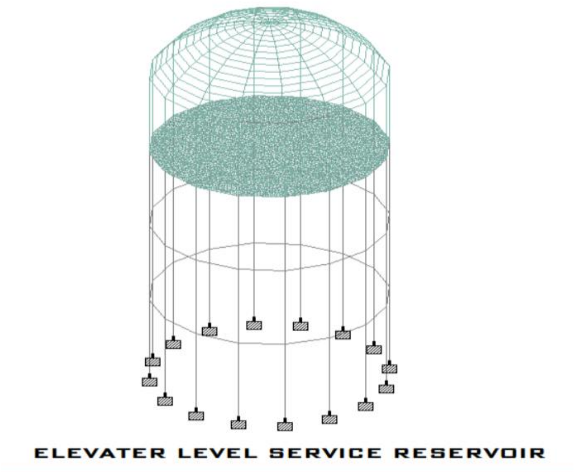
Time History Analysis at Y- Displacement

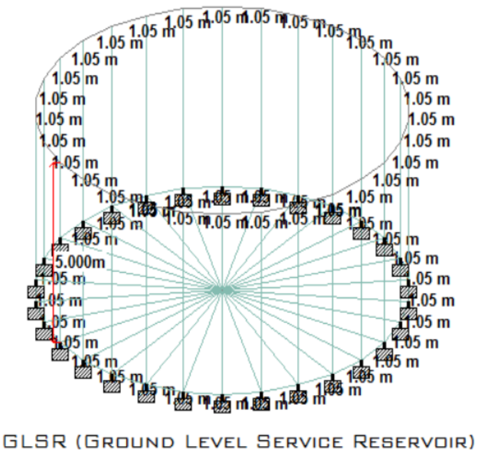


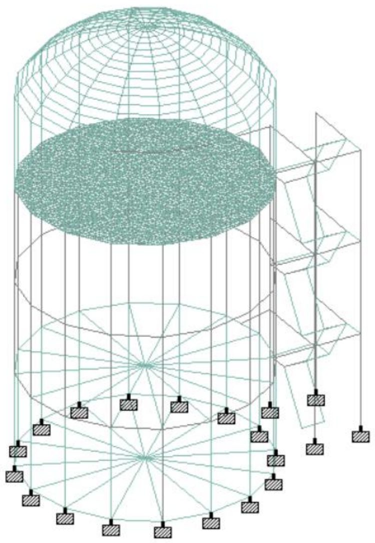
Time History Analysis at Z- Displacement



2.1.1 Whole Structure View of Elevated Level Service Reservoir and Ground Level Service Reservoir

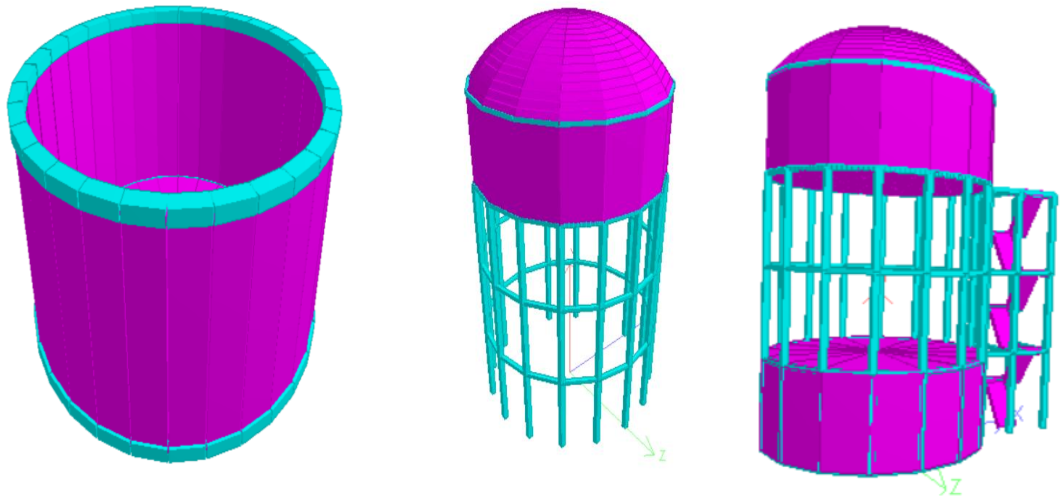






Whole Structure View of Combined Structure of Elevated Level Service Reservoir and Ground Level Service Reservoir.

2.1.2 **3D Rendered View of Ground Level Service Reservoir and Elevated Level Service Reservoir and Combined Structure.**



3D Rendered view of GLSR and ELSR shown that the complete things of the views of this combined monolithic construction process.

STAAD Pro design give us the proper analysis result

2.1.3 Estimate to be differentiate :-

Details	Ground Level Service Reservoir (GLSR) (Rs)	Elevated Level Service Reservoir (ELSR) (Rs)	Combined GLSR & ELSR (Rs)
Excavation Works	707800	820050	1217696
Centering& Shuttering	530450	788750	1051402
RCC Work	7161738	9347408	13157789
Concreting With RMC	2869120	4966520	6245005
Plastering(Inner Surface)	718250	958750	1336569
Water Proofing	668870	995850	1326782

Plasterin(Outer Surface)	757680	947800	1359268
Labour Charges	1525000	2505000	3211910
Plumbing	700500	958000	1321825
Miscellaneous	1560500	2612737	3326070
Total	**14617700**	**24900865**	**33554316**
Total estimated cost of each service reservoir ELSR + GLSR	**14617700 + 24900865 = 39518565**		**33554316**

As per the above comparison we can surely conclude that the combined structure is not economical structure than Elevated Level Service Reservoir but just higher cost than Ground Level Service Reservoir.

The design of Single structure like GLSR (Ground Level Service Reservoir) & ELSR (Elevated Level Service Reservoir) have their different capacity. When they are combined in a monolithic structure, it is economical than each of the single structure as per prevailing cost.

Like total estimated cost of Elevated Level Service Reservoir (ELSR) is Rs. 24900865 and the total estimated cost of Ground Level Service Reservoir (GLSR) is Rs. 14617700 while the cost of combined structure is Rs. 33554316.

If we add the two service reservoir cost and compare with combined structure cost we surely conclude that the construction cost of combined structure is economical.

II. CONCLUSION

Design of water tank is a very monotonous method. Overhead tanks serving of water to entire area under gravity. However, source of water may be a confined aquifer or unconfined aquifer and after that pumping the water from this source to combined structure. As compared to both GLSR and ELSR is economical and used for larger diameter. The main usage of such structure is that the store large amount of capacity of water in monolithic body. The conclusion is the above method or design of two single structure in a monolithic structure is economical, large amount capacitate liquid retaining structure. And the construction cost is estimated to be lesser than the summation of cost of two single structures.

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