Analysis and Design of Sump and Overhead Tank and Usage of Sensors in Residential Apartment in Nanganallur, Chennai.

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Abstract- **The Sumps and Overhead tanks are those Hydraulic structures that are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the tanks is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage. These structures plays a crucial role in storing water which can be used in various day-to-day activities mostly in urban regions especially in Residential apartments which happens to be this project.**

The Float Sensor unit is responsible for sensing the level of water and sound the alarm when the level of water is about to over flow or the tank is nearly empty. The presence of sensor unit helps in maintaining the level of water throughout the day and it also helps in uninterrupted supply of water in many commercial buildings and residential apartments.

The necessity of water is rapidly increasing now-a-days and this situation cannot be helped only by increasing the source but also by saving the water from wastage. More water is wasted by over flow from tanks and this is due to human negligence. This can be avoided by the implementation of sensors. This is a small step towards the bright future.

Keywords- Hydraulic Structures; leakage; force analysis; Float Sensor Unit; sensors; crack free structures

INTRODUCTION

The Sumps and Overhead tanks are those Hydraulic structures that are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the tanks is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage. These structures plays a crucial role in storing water which can be used in various day-to-day activities mostly in urban regions especially in Residential apartments which happens to be this project.

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A water tank is used to store water to tide over the daily requirement. In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential .The permeability of any uniform and thoroughly compacted concrete of given mix proportions is mainly dependent on water cement ratio .The increase in water cement ratio results in increase in the permeability .The decrease in water cement ratio will therefore be desirable to decrease the permeability, but very much reduced water cement ratio may cause compaction difficulties and prove to be harmful also. Design of liquid retaining structure has to be based on the avoidance of cracking in the concrete having regard to its tensile strength. The risk of cracking can also be minimized by reducing the restraints on free expansion or contraction of the structure. And the usage of sensors will help to avoid the wastage of water which is more important now-a-days.

OBJECTIVES

- To make a study about the design and analysis of water tanks.
- To make a study about the guidelines for the design of liquid retaining structure according to IS Code.
- To know about the design philosophy for the safe and economical design of water tank and sump and applying a circuit in it.
- To develop programs for the design of water tank of flexible base and rigid bae and the underground tank to avoid the tedious calculations.
- In the end, the usage of sensors and circuit board for the prevention of water wastage.

SCOPE

- It helps us to design and analyze overhead tank or a sump of any dimension for any residential or commercial building.
- It helps us to find the overall demand and per capita demand for a particular area.
- And the implementation of sensors and circuit boards helps us to gain few knowledge about application of sensors.
- Wastage of water can be avoided and enables the usage of water only for appropriate needs.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

METHODOLOGY

Here, the methodology consists of various steps where we understand the process from planning the project, analysis and the design. The methodology of the project is shown as a flow chart in the below figure.

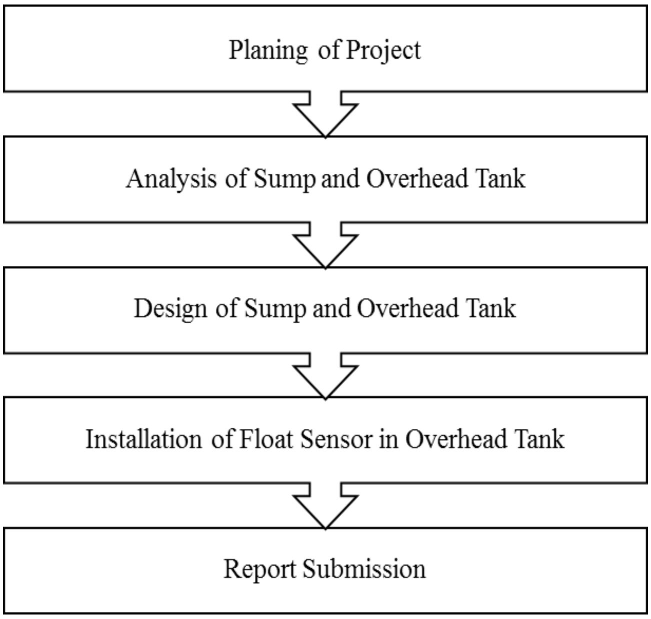

Fig: Flow chart of Methodology

SOFTWARES/EQUIPMENT USED

The software / equipment used in the project work is:

- AutoCAD 2016: Overviews of overhead tanks and sumps have been drawn with the help of this software. This software will help us to observe the overhead tank and sump from the top and will make sure that the dimensions of these tanks are correct.
- STAAD Pro: Analysis of overhead tanks and sump has been done with the help of this software. The bending moment and shear force diagrams are the outcomes and they have been studied.

GENERAL

This project is done according to the Indian Standards and the requirements regarding the project should be kept in mind. The average annual daily consumption for the people living in Kadhirkamam apartments has been calculated. And with the help of STAAD Pro analysis of sump and overhead tank is done and bending moment and shear force analysis has been studied. Design of overhead tank and sump has been done according to the obtained analysis report.

Building Description: The proposed overhead tank and sump is in Kadhirkamam apartments situated at Nanganallur, Chennai. The dimensions of the sump and overhead tank are shown in following table.

Table 1 Structure Descriptions

SUMP	DIMENSIONS
Length	4 m
Breadth	3 m
Height	3 m
OVERHEAD TANK	DIMENSIONS
Length	4 m
Breadth	2 m
Height	5 m

Per Capita Demand: Per Capita Demand is defined as the average annual consumption of water for a particular population in particular area. It includes domestic, industrial, fire and theft demands.

$$\text{P.C.D} = \frac{\text{Total annual Consumption}}{\text{Population}} X\ 365$$

From the above formula we found the total annual consumption of water in Kadhirkammam Apartments to be 19710 *l* per day.

ANALYSIS AND DESIGN OF SUMP

With respect to the plan of the sump, structure is made with the help of nodes, beams, plates and surface elements.

Loads which are acting on the sump are Dead Load, Hydraulic Load and Soil Load.

AutoCAD Diagram: The following AutoCAD diagram shows the overview of Sump in the below figure.

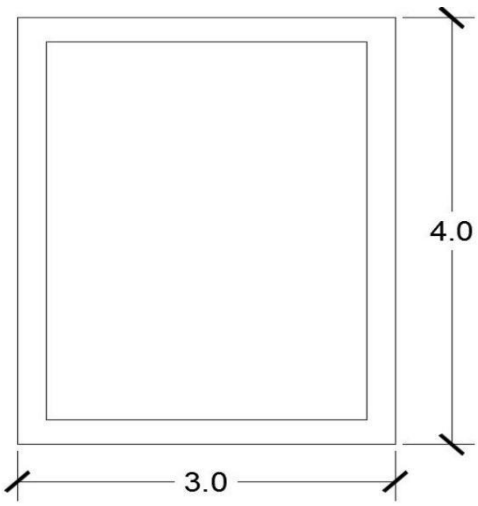

Fig.2. Overview of Sump

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

Analysis Results: The following results include the 3-dimensional diagram of the sump and diagram explaining dead load and hydraulic load acting on the sump.

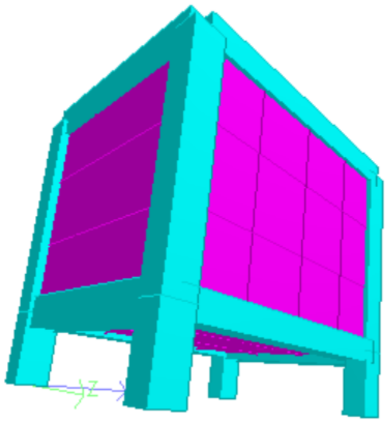

Fig.4. 3-D view of Sump

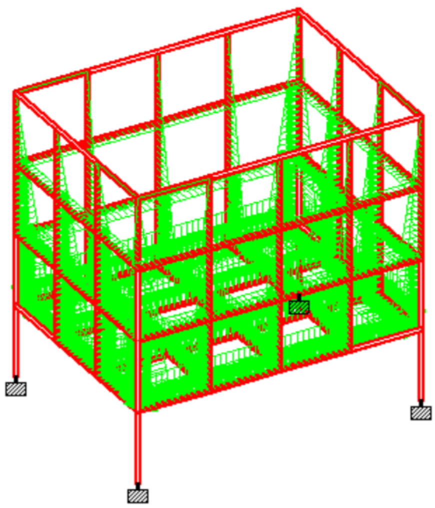

Fig.3. Dead and Hydraulic Load acting

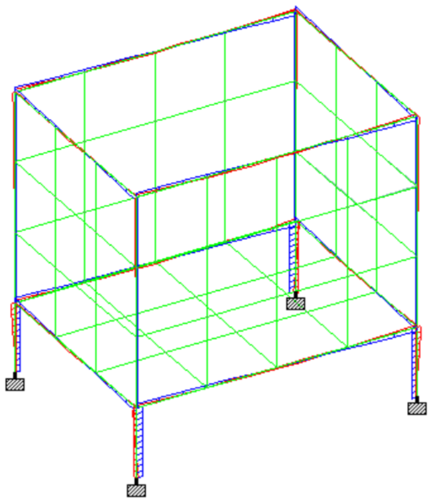

Fig.5. Deflection and Shear on y and z

Design of Sump

Given

Capacity of the tank	=	24000	litres
	=	24	m^3
Free board	=	0.2	m
Depth of tank	=	3	m
Length of tank	=	4	m
Height of tank	=	3	m
Storage height	=	3 - 0.2	
		=	2.8 m

Area $= \frac{Capacity}{Storage\ Height}$

$= \frac{24}{2.8}$

Two Conditions

1. Tank Full

M $= \frac{\gamma w H^3}{6}$

H = 2.8 m

Y = 10 m

M $= \frac{10*2.8^3}{6}$

= 36.586 KNm

T $= \frac{(\gamma H)B}{2}$

$= \frac{10*2.8*3}{2}$

= 42 KN

For M 20 and Fe 415

⇨ Q = 1.16 , j = 0.87

M = Qbd^2

36.586 x 10^6 = 1.16 x 1000 x d^2

d = 177.45 mm

= 178 mm (approx.)

D = d + cover(30 mm) + $\frac{Diameter\ of\ Bar}{2}$

= 178 + 30 + $\frac{12}{2}$

= 214 mm

Ast = $\frac{M}{\sigma j d}$ 36.586 x 10^6

$= \frac{36.586 \times 10^6}{0.87 \times 178 \times 150}$

= 1575.01 mm^2

Using 12 mm bars

Spacing $= \frac{1000}{Ast/113}$

$= \frac{1000}{13.938}$

= 71.74

= 70 mm c/c

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

Minimum requirements

Ast (min) = $\frac{0.24 \times 1000 \times 214}{100}$

= 513.6 mm^2

Proving 8 mm bars for distribution

= $\frac{1000}{513.6/71.74}$

= 139.68

= 140 mm

Check for Tension (T)

Consider 1 m height of the well,

Tensile stress induced = $\frac{T}{Area}$

= $\frac{42 \times 1000}{1000 \times 214}$

= 0.19 N/mm^2 < 1.2 N/mm^2

Hence Safe.

2. Tank Empty

M = $\frac{K_a \times V_{soil} \times H^3}{6}$

$K_a = \frac{1-\sin\phi}{1+\sin\phi}$ (Ø = angle of repose)

= $\frac{1-\sin 30}{1+\sin 30}$

= $\frac{\frac{1}{3} \times 15 \times 2.8^3}{6}$ = 18.29 KNm

Ast = $\frac{M}{\sigma\, j\, d}$

= $\frac{36.586 \times 10^6}{150 \times 0.87 \times 178}$

= 1575.01 mm^2

Using 12 mm bars

Spacing = $\frac{1000}{1575/71.74}$

= 71.74 mm

Provide distribution reinforcement horizontally in both faces @ 140 mm.

Spacing = 2 x 140

= 280 mm

Provide 8 mm bars @ 250 mm.

ANALYSIS AND DESIGN OF O.H TANK

With respect to the plan of the overhead tank structure is made with the help of nodes, beams, plates and surface elements.

Loads which are acting on the sump are Dead Load, Hydraulic Load and Wind Load.

AutoCAD Diagram: The following AutoCAD diagram shows the overview of Overhead tank in the below figure.

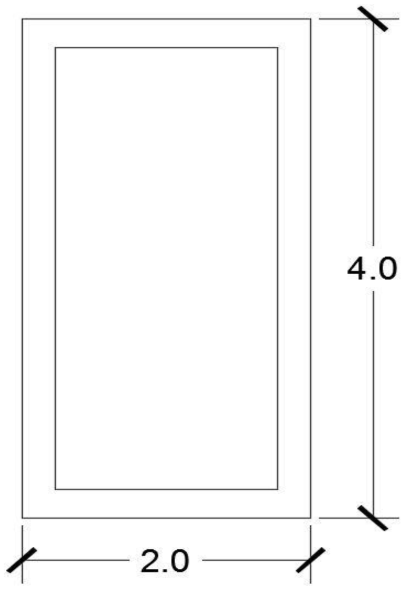

Fig.6. Overview of Overhead Tank

Analysis Results: The following results includes the 3-dimensional diagram of the sump and diagram explaining wind load acting on the sump.

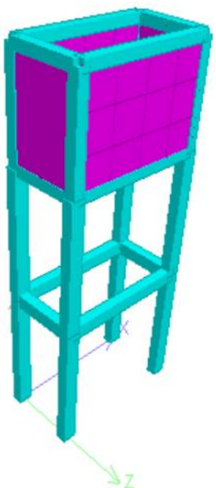

Fig.8. 3-D view of Overhead Tank

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

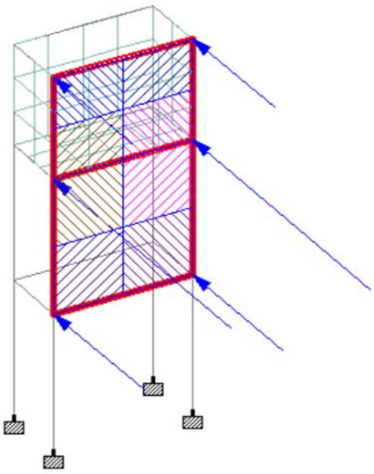

Fig.7. Wind load acting on Z- direction

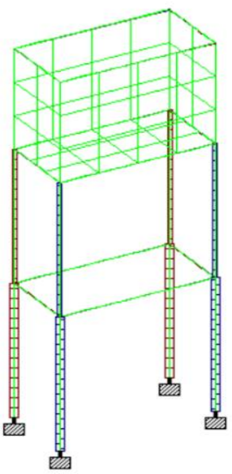

Fig.9. Deflection and axial force on Tank

Design of Overhead Tank

Given

Capacity of the tank = 24000 litres

= 24 m^3

Free board = 0.2 m

Depth of tank = 2 m

Length of tank = 4 m

Height of tank = 3 m

Grade of concrete = M20 grade

Permissible Stress

σ_{cbc} = 8.33 N/mm^2

σ_{st} = 200 N/mm^2

Modular ratio, m = $\frac{m\sigma_{cbc}}{m\sigma_{cbc}+\sigma_n}$

= $\frac{11 \times 8.33}{11 \times 8.33 + 200}$

= 0.314

j = $1-\frac{n}{3}$

= 1 – 0.314/3

= 0.895

k = 0.5(σ_{cbc} x n x j)

= 1.1708

Dimensions of Tank

Height = 3 + 0.2

= 3.2 m

(L\B) = 2 m

Long walls are designed at vertical cantilevers and short walls as spanning horizontally between long walls.

Maximum bending moment at base of,

Long walls = $\frac{\gamma H^3}{6}$

= $\frac{9.8 * 3.2^3}{6}$

= 53.52 KNm

d = $\frac{\sqrt{M}}{\sqrt{Qb}}$

= $\frac{\sqrt{53.52 * 10^6}}{\sqrt{1000 * 1.1708}}$

= 213 mm

Use 16 mm diameter bars and 25 mm clear cover

Overall depth = 246 mm

Effective depth = 213 mm

Therefore,

A_{st} = $\frac{53.52 * 10^6}{98 * 0.895 * 213}$

= 4454 mm

Spacing of 16 mm bars = $\frac{98 * 201}{4454}$

= 93.2 mm

Adopt 16 mm diameter bars at 95 mm c\c. Spacing towards the top is increased to 170 mm c\c for the top 1 m.

Intensity of pressure 1 m above base is:

p = $\gamma(H-h)$

= 9.8(3-1)

= 19.61 KN/m^2

Direct tension in long walls ,

T = $\frac{19.6 * B}{2}$

= 19.6 KN

A_{st} = $\frac{19.6 * 10^3}{100}$ =

196 mm^2

But minimum area

= 0.3% = ($\frac{0.3}{100}$ x 246 x 1000)

= 738 mm^2

Spacing of 10 mm diameter bars =

($\frac{1000 * 79}{738}$) = 108 mm

Provide 10 mm diameter bars at 200 mm c\c on both faces.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

Design of Short Walls

p = 19.6 KN/m^2

Effective span of horizontally spanning slab

= (2 + 0.24)

= 2.24 m

Bending moment (Corner section)

$= \frac{pL^2}{12}$

$= \frac{19.6 * 2.26^2}{12}$

= 8.342 KNm

Tension transferred per metre height of short wall

= (19.6 x 1)

= 19.6 KN

Therefore,

$A_{st} = [\frac{M-Tx}{\sigma_{st}\, j\, d} + \frac{T}{\sigma_{st}}]$

$= [\frac{8.342 * 10^6 - (196 * 1000)(213 - 95)}{200 * 0.95 * 213} + \frac{19.6 * 1000}{100}]$

= 345 mm^2

Spacing of 10 mm bars $= \frac{1000 * 79}{345}$

= 228 mm

Adopt 16 mm bars at 230 mm centres. At mid span section the bending moment is ($PL^2/24$) and hence provide 10 mm diameter bars at 460 mm centres away from the water face.

Design for Cantilever effect of Short wall

Maximum Bending moment

= (0.5 x 10 x 3 x 1/3)

= 5 KNm

Effective depth (using 10 mm bars)

= (213 – 25 – 10 – 5)

= 173 mm

Therefore,

$A_{st} = \frac{5 * 1000}{100 * 173 * 0.95}$

= 304 mm^2

But 0.3% of gross area $= (\frac{0.3}{100}$ x 1000 x 246)

= 738 mm^2

Therefore,

Spacing of 10 mm diameter bars $= \frac{1000 * 79}{738}$

= 108 mm

Adopt 10 mm diameter bars at 200 mm c\c on both faces in the vertical direction.

INSTALLATION OF SENSOR

The Sensor used to fine the level of water is Float Sensor. Detectors are place near the bottom of the tank and almost at the top of the tank.

Fig.10. Float switch in OFF condition

Fig.11. Float switch in ON condition

A ball will be allowed to float in water and ball floats at the surface of the water. If the level of water gets changed, the position of ball changes too. By that way, if the water either goes below the detector level or increases above the detector in the top, the sensor will sound alarm. So that the wastage of water can be prevented by overflowing and always to keep a constant amount of water in the tank always which helps in uninterrupted supply.

CONCLUSION

During the course of the research, sufficient knowledge on planning and designing the Overhead tank and Sump on different software such as STAAD. Pro and AUTOCAD have been implemented. This particular knowledge enriched us in various circumstances and taught us varied methods to look into this study. The Standard codes required for the design of Overhead tank and Sump have been obtained from Indian

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

Standard Provisions. Per capita demand has been calculated which helped us know about the water consumption in a residential apartment and further helped in designing the tank and sump. Sensors' applications and their wide varieties have been studied and conclusion has been made regarding the correct use of sensors in a particular situation. Usage of sensors has reduced many difficulties that arose during earlier circumstances.

ACKNOWLEDGMENTS

The authors would like to place on record, our grateful thanks to the Department of Civil Engineering, SRM University Kattankulathur for providing all facilities and help in carrying out this project. The authors are also grateful for their encouragement and support during the course of this research.

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