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Analysis of Rectangular Water Tank Using Fem Method

Shital Naghate[1], Dr. A. R. Gupta[2]
[1] M.E Student, Department of Structural Engineering, College of Engineering and Technology Akola, India
[2] Guide, Department of Structural Engineering, College of Engineering and Technology Akola, India
Sant Gadge Baba Amravati University

***Abstract:** All know that water is the most vital requirement of human beings for better livelihood. As the population is growing day by day in our country with rapid speed it is the need of time to study storage capacity and shapes of storage tanks. These tanks are very useful in such areas where rivers do not flow for the whole year and water available only during monsoon season through rainfall. Present study deals with the analysis of water tanks using the FEM method using Staad pro software. The finite-element method is a computational method that subdivides a CAD model into very small but finite-sized elements of geometrically simple shapes. The collection of all these simple shapes constitutes the so-called finite-element mesh.*
***Index Terms:** Water tank, finite element method (FEM), Displacements, Staad pro, a baffle wall.*

I. INTRODUCTION

Water is the basic need for all the living organisms to survive. Portable water is essential for the good health of human beings [1]. A water tank is a container for storing liquid. The need for a water tank is as old as civilization, to provide storage of water for use in many applications, drinking water, irrigation, agriculture, fire suppression, agricultural farming, both for plants and livestock, chemical manufacturing, food preparation as well as many other uses [2][3]. A water tank is a structure used to store water to tide over the daily requirement. Need for water tanks is necessary since civil engineers construct water tanks for irrigation, home purposes etc. Water tanks are the storage units of water which are used for distribution. Water tanks are constructed at high heads to distribute the water with the effect of gravity [4].

In this paper, we are studying only the rectangular water tank resting on ground using the FEM method. The walls of these tanks are subjected to pressure and the base is subjected to the weight of water. These tanks are rectangular in their shape. The walls of the rectangular tank are subjected to bending moments both in horizontal as well as in vertical direction [5]. The analysis of moments in the wall is difficult since water pressure results in a triangular load on them. The magnitude of the moment will depend upon several factors such as length, breadth and height of the tank, and conditions of the support of the wall at the top and bottom edge. If the length of the wall is more in compression to its height the moment will be mainly in vertical direction i.eThe panel will bend as a cantilever [6]. If, however, height is larger in comparison to length, the moments will be in horizontal direction, and the panel will bend as a thin slab supported on the edges [7].

II. LITERATURE REVIEW

ShiljaSureshkumar*et. al.* [1] proposed design of liquid storage tanks are used to store different types of materials such as water, oil and gas etc… damaged tanks containing any dangerous chemical leads to environmental pollution. There will be a great loss of life and property of any failure of tanks. Fluid inside the tank is divided as impulsive. Tank performance also depends mainly on soil structure interaction of the tank with surrounding soil structure will be different, based on soil properties such as elastic properties, cohesion, angle of friction etc…based on support condition provided behaviour of water tanks and ground supported tanks are different, variation in the structural performance of water tanks.

George *et. al.* [2]analyse the response behaviour of an RCC elevated rectangular water tank. The static structural, modal and transient analyses were carried out using the ANSYS 15 WORKBENCH. The effect of water height on the tank response was studied by using 100%, 75%, 50% and 25% water fill conditions. Hence seismic behaviour of these structures during the earthquakes has to be investigated in detail in order to meet the safety objectives while containing construction and maintenance costs. In the present study, an elevated RCC rectangular water tank was modelled and analysed using the ANSYS software. The static structural, modal and transient analyses were conducted. It was observed that the responses of the tanks elevated with an increase in the water heights.

VeereshVarur*et. al.* [3] water tanks may consist of three types such as 1) Tanks rested on ground, 2) Underground tanks, 3) Elevated or overhead tanks. In this project may be studied tanks resting on ground such as whole storage reservoirs, settling tanks and aeration tanks are directly supported on ground. Designs are considered by the total cost of the tank. The water tanks include measurements and capacity. Considering the properties of tanks such as capacity and volume. This project gives the result for safe design with minimum cost of construction, it is more economical, reliable and simple. This literature gives the idea in design philosophy for safety and economics. The wall of tanks subjected to force and weight of water and its results are made optimum.

ltaly*et. al.* [4]current research is based on the verification of previous analytical approaches that were used to obtain modal parameters of water tanks as a basic step to study the behaviour of these structures under seismic loads. Due to the complex nature of theoretical approaches especially when considering the dynamic nature of structure, ANSYS finite element software was used. Houser method was adopted to represent the dynamic behaviour of a water elevated tank subjected to horizontal base excitation. Two cases of tanks were studied, and their validated 3D models showed quite good agreement with the experimental modal results. The analytical approach efficiently simulated the dynamic behaviour of all tanks in the current study.

Vajir*et. al.* [5] studied an Analytical and numerical analysis of composite material storage tanks under seismic loading. Dynamic characteristics of industrial equipment, as for example pressurized vertical tanks, are taken for study. An evaluation of existing technical solutions and design guidelines apropos composite material pressure vessel under seismic loading has been carried out. In particular, attention has been focused on the seismic design and analysis of tanks for storage of hazardous and corrosive materials. They are very common worldwide and can help to develop methods of seismic analysis able to take account of composite material orthotropic behavior. Advanced FEM analyses have been carried out and a comparison between procedures of ASME RTP-1 & FEM has been discussed. A satisfactory capacity of simplified models to fit the overall response of tanks has been shown.

Sarokolayi*et. al.* [6] present study investigated the effect of the rotational ground motion correlated components on the linear dynamic response of a water storage tank. The finite element method with Lagrangian approach to model the fluid structure interaction is used. The rotational components of the ground motion are deduced from the translational components by solving the wave propagation equations in 3D. The parametric study included the analyses of a water tank subjected to four earthquake records and considered empty, 40 and 80 % full tanks.

Dhumal *et. al.* [7]studied FEA model of rectangular elevated water tank with baffle wall is model using ANYSIS 16.0 sloshing effect is a major problem encountered in the analysis of design of reinforced concrete rectangular elevated water tank. In this paper study of baffle walls is done with varying parameters such as thickness, spacing of baffle wall. In the second stage opening effects are studied in baffle walls. Present study is based on Finite Element Simulation of elevated RCC water tank in ANSYS workbench In first stage pressure and loads are calculated in accordance with IS 1893:2002 part-2. Later comparison is made between a water tank with a baffle wall and without a baffle wall. Deformation and shear stress along a long wall is considerably reduced by using baffle walls.

Hassan Jasim Mohammed *et. al.* [8] studied the economical design of concrete water Tanks by optimization method. He applied the optimization technique to the structural design of concrete rectangular and circular water tanks, considering the total cost of the tank as an objective function with the properties of the tank viz. tank capacity, width and length of the tank, unit weight of water and tank floor slab thickness as design variables. From the study he concluded that an increased tank capacity leads to increased minimum total cost of the rectangular tank but decreased minimum total cost for the circular tank. The tank floor slab thickness constitutes the minimum total cost for two types of tanks. The minimum cost is more sensitive to changes in tank capacity and floor slab thickness of the rectangular tank but in circular type is more sensitive to change in all variables. Increased tank capacity leads to increase in minimum total cost. Increase in water depth in circular tanks leads to an increase in minimum total cost.

III. METHODOLOGY

The whole project work is divided into various sub phases which is as elaborated below:

A. *Phase-I*

1) *Aim, Objective and Need of Work:* Comparative analysis for rectangular water tanks resting over ground using FEM method. To understand the concept of a rectangular water tank using the FEM method. Water tanks are constructed at high heads to distribute the water with the effect of gravity. These are mainly used for serving drinking water for highly populated areas of metropolitan urban communities in cities and towns. Water is the basic essential requirement for all living organisms in the world. Frameworks, transportation of Inflammable fluids and chemicals. After tanks are used for water supply and firing. In this regard water tanks play an indispensable role in day-to-day life.

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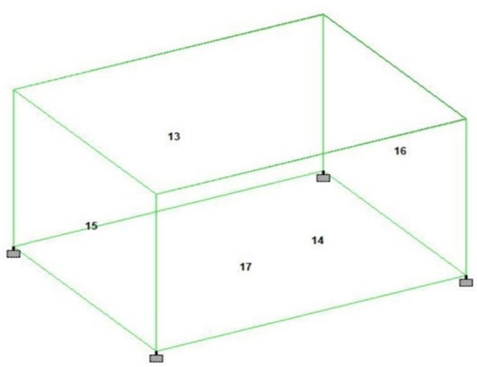
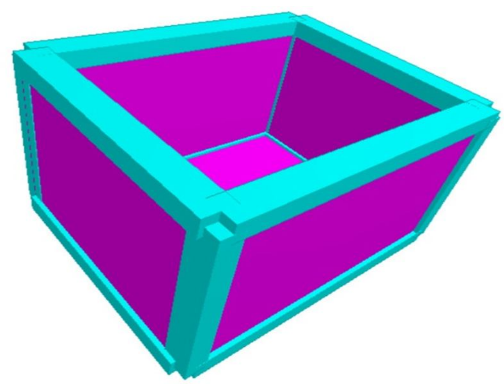
2) *To decide the flow of work i,e Methodology:* To complete the work in an efficient form this work is divided into various standard phases to easily complete the work with high efficiency and with more precision.

B. Phase-II

1) *Detail Study:* Finite-element Method (FEM): The finite-element method is a computational method that subdivides a CAD model into very small but finite-sized elements of geometrically simple shapes. The collection of all these simple shapes constitutes the so-called finite-element mesh. The next step is to take a system of field equations, mathematically represented by partial differential equations (PDEs) that describe the physics you are interested in, and formulate these equations for each element. This is handled by approximating the fields within each element as a simple function, such as a linear or quadratic polynomial, with a finite number of degrees of freedom (DOFs). This gives an approximate local description of the physics by a set of simple linear (but sometimes nonlinear) equations. When the contributions from all elements are assembled you end up with a large sparse matrix equation system that can be solved by any of a number of well-known sparse matrix solvers. The type of solver used depends on the original physics, since each type of physics gives its unique imprint on the structure of the matrix. To speed things up, this structure is exploited by using a tailored numerical method. A method may be suitable for structural mechanics but not for electromagnetics, and vice versa. Historically, the method was first applied to structural analysis. Over the last ten years or so, it has been realized that the finite element method is also suitable for a large class of multi-physics problems.
2) *Design of Rectangular water tank using FEM method using Staad pro software:* Design a rectangular water tank 5m x 4m with depth of storage 3m, resting on ground and whose walls are rigidly joined at vertical and horizontal edges. Assume M20 concrete and Fe415 grade steel.





IV. RESULT AND DISCUSSION

A. Reaction of Rectangular water Tank

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B. Center and Corner Displacement:

Plate No.13

STAAD.Pro Query Stresses

Element no 13

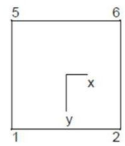

Plate Center Stresses

SQX (local) (N/mm2)	SQY (local) (N/mm2)	SX (local) (N/mm2)	SY (local) (N/mm2)
-0.000000	0.001349	-0.008588	-0.051429
SXY (local) (N/mm2)	MX (local) (kNm/m)	MY (local) (kNm/m)	MXY (local) (kNm/m)
-0.000000	-0.030401	-0.280666	0.000000

Principal / Von Mises / Tresca

	Principal	Von Mis	Tresca
Top (N/mm2)	-0.032718	0.065481	0.070140
Bottom (N/mm2)	-0.006561	0.029981	0.032718

Element no 13

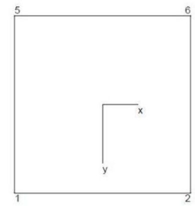

Plate Corner Stress For Load Case 3

Node	5	6	2	1
Max Top (Principal Major Stress)(N/mm2)	0.101205	0.101205	0.107955	0.107955
Max Bottom (Principal Major Stress)(N/mm2)	0.071935	0.071935	0.116903	0.116903
SX (local)(N/mm2)	0.031787	0.031787	-0.048962	-0.048962
SY (local)(N/mm2)	-0.024207	-0.024207	-0.078651	-0.078651
SXY (local)(N/mm2)	-0.045370	0.045370	0.045370	-0.045370
MX (local)(kNm/m)	-0.103898	-0.103898	0.043096	0.043096
MY (local)(kNm/m)	-0.814839	-0.814839	0.253506	0.253506
MXY (local)(kNm/m)	-0.121433	0.121433	0.121433	-0.121433
SQX (local)(N/mm2)	-0.000000	-0.000000	-0.000000	0.000000
SQY (local)(N/mm2)	0.001349	0.001349	0.001349	0.001349
Von Mis Top(N/mm2)	0.131578	0.131578	0.108013	0.108013
Von Mis Bottom(N/mm2)	0.073538	0.073538	0.105034	0.105034

Plate No.14

Element no 14

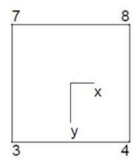

Plate Center Stresses

SQX (local) (N/mm2)	SQY (local) (N/mm2)	SX (local) (N/mm2)	SY (local) (N/mm2)
0.000000	-0.001349	-0.008588	-0.051429
SXY (local) (N/mm2)	MX (local) (kNm/m)	MY (local) (kNm/m)	MXY (local) (kNm/m)
-0.000000	0.030401	0.280666	0.000000

Principal / Von Mises / Tresca

	Principal	Von Mis	Tresca
Top (N/mm2)	-0.070140	0.029981	0.032718
Bottom (N/mm2)	-0.010614	0.065481	0.070140

Element no 14

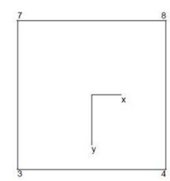

Plate Corner Stress For Load Case 3

Node	7	8	4	3
Max Top (Principal Major Stress)(N/mm2)	0.071935	0.071935	0.116903	0.116903
Max Bottom (Principal Major Stress)(N/mm2)	0.101205	0.101205	0.107955	0.107955
SX (local)(N/mm2)	0.031787	0.031787	-0.048962	-0.048962
SY (local)(N/mm2)	-0.024207	-0.024207	-0.078651	-0.078651
SXY (local)(N/mm2)	-0.045370	0.045370	0.045370	-0.045370
MX (local)(kNm/m)	0.103898	0.103898	-0.043096	-0.043096
MY (local)(kNm/m)	0.814839	0.814839	-0.253506	-0.253506
MXY (local)(kNm/m)	0.121433	-0.121433	-0.121433	0.121433
SQX (local)(N/mm2)	0.000000	0.000000	0.000000	-0.000000
SQY (local)(N/mm2)	-0.001349	-0.001349	-0.001349	-0.001349
Von Mis Top(N/mm2)	0.073538	0.073538	0.105034	0.105034
Von Mis Bottom(N/mm2)	0.131578	0.131578	0.108013	0.108013

Plate No.15

Element no 15

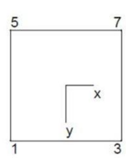

Plate Center Stresses

SQX (local) (N/mm2)	SQY (local) (N/mm2)	SX (local) (N/mm2)	SY (local) (N/mm2)
-0.000000	-0.001594	-0.017424	-0.070167
SXY (local) (N/mm2)	MX (local) (kNm/m)	MY (local) (kNm/m)	MXY (local) (kNm/m)
0.000000	0.069014	0.278668	-0.000000

Principal / Von Mises / Tresca

	Principal	Von Mis	Tresca
Top (N/mm2)	-0.088745	0.046523	0.051589
Bottom (N/mm2)	-0.022025	0.080039	0.088745

Element no 15

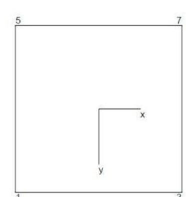

Plate Corner Stress For Load Case 3

Node	5	7	3	1
Max Top (Principal Major Stress)(N/mm2)	0.067127	0.067127	0.140746	0.140746
Max Bottom (Principal Major Stress)(N/mm2)	0.118220	0.118220	0.133693	0.133693
SX (local)(N/mm2)	0.028956	0.028956	-0.063805	-0.063805
SY (local)(N/mm2)	-0.035107	-0.035107	-0.105228	-0.105228
SXY (local)(N/mm2)	-0.046748	0.046748	0.046748	-0.046748
MX (local)(kNm/m)	0.188350	0.188350	-0.050323	-0.050323
MY (local)(kNm/m)	0.853353	0.853353	-0.296016	-0.296016
MXY (local)(kNm/m)	0.190022	-0.190022	-0.190022	0.190022
SQX (local)(N/mm2)	-0.000000	0.000000	0.000000	-0.000000
SQY (local)(N/mm2)	-0.001594	-0.001594	-0.001594	-0.001594
Von Mis Top(N/mm2)	0.069122	0.069122	0.123361	0.123361
Von Mis Bottom(N/mm2)	0.144332	0.144332	0.128008	0.128008

Plate No.16

Element no 16

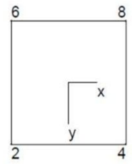

Plate Center Stresses

SQX (local) (N/mm2)	SQY (local) (N/mm2)	SX (local) (N/mm2)	SY (local) (N/mm2)
0.000000	0.001594	-0.017424	-0.070167
SXY (local) (N/mm2)	MX (local) (kNm/m)	MY (local) (kNm/m)	MXY (local) (kNm/m)
0.000000	-0.069014	-0.278668	-0.000000

Principal / Von Mises / Tresca

	Principal	Von Mis	Tresca
Top (N/mm2)	-0.051589	0.080039	0.088745
Bottom (N/mm2)	-0.012823	0.046523	0.051589

Element no 16

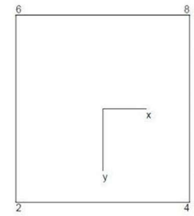

Plate Corner Stress For Load Case 3

Node	6	8	4	2
Max Top (Principal Major Stress)(N/mm2)	0.118220	0.118220	0.133693	0.133693
Max Bottom (Principal Major Stress)(N/mm2)	0.067127	0.067127	0.140746	0.140746
SX (local)(N/mm2)	0.028956	0.028956	-0.063805	-0.063805
SY (local)(N/mm2)	-0.035107	-0.035107	-0.105228	-0.105228
SXY (local)(N/mm2)	-0.046748	0.046748	0.046748	-0.046748
MX (local)(kNm/m)	-0.188350	-0.188350	0.050323	0.050323
MY (local)(kNm/m)	-0.853353	-0.853353	0.296016	0.296016
MXY (local)(kNm/m)	-0.190022	0.190022	0.190022	-0.190022
SQX (local)(N/mm2)	0.000000	-0.000000	-0.000000	0.000000
SQY (local)(N/mm2)	0.001594	0.001594	0.001594	0.001594
Von Mis Top(N/mm2)	0.144332	0.144332	0.128008	0.128008
Von Mis Bottom(N/mm2)	0.069122	0.069122	0.123361	0.123361

Plate No. 17

Element no 17

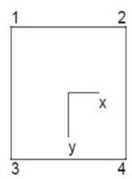

Plate Center Stresses

SQX (local) (N/mm2)	SQY (local) (N/mm2)	SX (local) (N/mm2)	SY (local) (N/mm2)
0.000000	0.000000	0.000000	0.000000
SXY (local) (N/mm2)	MX (local) (kNm/m)	MY (local) (kNm/m)	MXY (local) (kNm/m)
0.000000	0.000000	0.000000	0.000000

Principal / Von Mises / Tresca

	Principal	Von Mis	Tresca
Top (N/mm2)	0.000000	0.000000	0.000000
Bottom (N/mm2)	0.000000	0.000000	0.000000

Element no 17

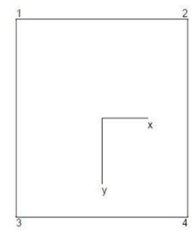

Plate Corner Stress For Load Case 1

Node	1	2	4	3
Max Top (Principal Major Stress)(N/mm2)	0.000000	0.000000	0.000000	0.000000
Max Bottom (Principal Major Stress)(N/mm2)	0.000000	0.000000	0.000000	0.000000
SX (local)(N/mm2)	0.000000	0.000000	0.000000	0.000000
SY (local)(N/mm2)	0.000000	0.000000	0.000000	0.000000
SXY (local)(N/mm2)	0.000000	0.000000	0.000000	0.000000
MX (local)(kNm/m)	0.000000	0.000000	0.000000	0.000000
MY (local)(kNm/m)	0.000000	0.000000	0.000000	0.000000
MXY (local)(kNm/m)	0.000000	0.000000	0.000000	0.000000
SQX (local)(N/mm2)	0.000000	0.000000	0.000000	0.000000
SQY (local)(N/mm2)	0.000000	0.000000	0.000000	0.000000
Von Mis Top(N/mm2)	0.000000	0.000000	0.000000	0.000000
Von Mis Bottom(N/mm2)	0.000000	0.000000	0.000000	0.000000

V. CONCLUSION

This paper deals with the analysis of rectangular water tanks using the FEM method using staad pro software. From these designs it is shown that reaction, center and corner displacements. According to the analysis from the above paper it is concluded that the moments from FEM are more accurate than calculated manually. By using Staad pro, the results obtained will be more accurate than conventional results. By using FEM, in case of square tanks the moments match with the exact solution but in case of rectangular tank moments have 3% to 4% error. This paper is an application of optimization methods to the structural Analysis and design of circular elevated water tanks.

VI. ACKNOWLEDGEMENT

It gives me immense pleasure to express my gratitude to Dr. A. R. Gupta, my Supervisor who provided me constructive criticism and positive feedback during the preparation of this Research Paper. I am indebted to Dr. A.R. Gupta, who was always there whenever I needed any help. Without them and their cooperation, completion of this research work would have been inevitable and their presence behind me is totally indispensable.

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