International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 10 ǁ October 2023 ǁ PP. 156-162

Effects of Sloping Ground on Analysis of Cicular Water Tank

[1] Mr. Meet Dama, [2]Prof. Ayyazoddin Shaikh
[1] P.G. Student, Department of Civil Engineering, M.S. Bidve Engineering College, Latur, Maharashtra, India
[2] Assistant Professor, Department of Civil Engineering, M.S. Bidve Engineering College, Latur, Maharashtra, India

Abstract
There are various types of storage tanks for example over headed tank, ground resting, flat bottomed, tanks are used for storage of petroleum, liquefied gases, water, oil, etc. Generally over-headed tanks are used to store water. The trend in recent years is for the seismic, wind and blast design of large storage water tanks for considerance of safety of life and environmental impact as well as society as whole.
In this work, attempt has been made to analyse a circular water tank on sloping ground for height 12m for considering wind loads of 39 m/s, 44m/s. Deflection, Shear Force, Bending Moment is calculated for seismic zones- V, according to Indian Standard Code –IS 1893:2016 and IS 875:2015 (Part 3) by using STAAD PRO V8i software.
Keywords: *circular water tank, Slope of ground, Response spectrum analysis.*

Date of Submission: 02-10-2023 Date of acceptance: 13-10-2023

I. INTRODUCTION

Water tanks are used to provide storage of water for use in many applications like drinking, irrigation, agriculture, fire suppression, farming for both live stocks and plants, chemical manufacturing, food preparation and various other uses. Design of water tank plays an important role as it considers the scope of future requirement of water as per population growth of that region , the life of overhead water tank is generally of about 20-30 years, so the design of water tank plays an important role as it considers rate of future growth, shape of tank, material used to make water tank like steel, reinforced concrete .Water tanks are an efficient way to help developing countries to solve clean drinking water problems for drinking and other uses.Load's acting on water tank are designed by keeping the projection of future population forecast in mind, so Water Tank is designed by applying the loads like Dead Load (Self Weight), Live Loads which depends upon the water capacity like empty, half filled, full filled and over flow condition as well as the water pressure is considered. As structural design of a R.C.C structure the loads like seismic and wind are also considered for the design of structure which depends on the zone as per IS-Codes in which it is constructed.

OBJECTIVE AND SCOPE OF WORK:

- To study the various forces acting on a circular water tank
- To perform seismic analysis of circular water tank as per IS Code 1893:2016 by using STAAD-Pro V8i software and obtain the results in terms of bending moment, shear force and deflection.
- To compare the results obtained of circular water tank on level ground and sloping ground.
- To study the design philosophies of water tank design on sloping ground in seismic zones and wind pressure.

II. LITERATURE SURVERY

1. **M.Ravikanth et.al (2019)** they studied "Design and Analysis of Hydraulic Water Tank by using STAAD-Pro", in this project an application was made, in which economy of tank was an objective function with the properties of that optimization method to the structural analysis and design of circular water tank . water depth, unit weight of water and tank floor to floor height and tank slab thickness as designed by considering the total tank capacity .To consider dead load, live load, seismic load a computer program has been developed to solve the numerical example the load calculations are done through known data. The aim of the project was to apply seismic loading for different zones-II,III,IV,V and assess the varying steel & concrete in seismic zones there design concluded that Design of water tank in Zone –V is highly expensive

2. **Shreya Salunke et.al (2017)** they studied "Analysis of solid and hollow wall of circular steel petroleum tank for stress in STAAD-Pro". In this work attempt has made to analyses a storage tank holding a capacity of 1.5 lakh hazardous petroleum liquid. Appropriate standards and design codes are used, material selection is done in accordance with the requirements of the recent edition IS codes and an adequate design method is chosen. Design specifications of the storage tanks were presented. Two tanks, a hollow and solid are considered having the same thickness, the tank was designed according to the IS-codes and the nominal diameter was kept 12m without space constraint, height was 14.1m number of course is: the bottom thickness is 8mm, carbon-steel according to IS 2062:1969 was selected for design, they saw the maximum absolute stress of the solid tank is less as compared to hollow section, as the theory states with the increasing. Hence, the deformation goes on increasing; hence the deformation of hollow tank is more as compared to solid tank.

3. **Prof. Patel Nikunj R et.al (2016)** they worked on "Analysis of rectangular water tank and its behavior under different types of loading by using STAAD Pro." In this paper they presented a parametric study concerning behavior and design of overhead rectangular concrete tank subjected to static loading conditions with special emphasis on IS:3370 PCA and STAAD Pro, the effect of the different tanks aspect ratio, end condition for same capacity is reviewed and considered in the analysis and design, here they concluded that deflection is high due to settlement of support, the stability of water tank gets affected by intensity of wind load. The mid span of top portion gets maximum bending moment. Fluid density must be considered in design and the connected beam get maximum axial force due to load combination as per IS-875 part-3.

4. **Issar Kapadia et al (2018)** here they "Designed Analysis and Study of the combined Rectangular Water tank: Combination of the rectangular overhead water tank and the rectangular surface water tank in combination by using Staad-Pro" in this research they considered a new idea that is combined rectangular water tank in which over rectangular overhead water tank and rectangular surface tank are taken as together as one structure for this water tank design was done using STAAD-Pro software. They concluded that, from the performance we came to know that the absolute pressure is less compared to the general one. The Hydrostatic pressure assumed ass for overhead was 200KN\m3 and for Ground tank 300Kn\m3, the deflection here was less as compared to normal tank.

5. **M.Bhandari et al (2014)** they tried to figure out "Economical design of water tank of different shapes with reference to IS-3370 2009" so here they designed water tanks of different shapes and volume like 100000,150000,200000 by limit state method, the results were presented in form of graphs and table it has been observed that circular shaped tank consumed lesser of each material as compared to square, rectangular, intze ones. The amount of formwork required for circular tanks is also less than that for square, rectangular and intze tank. There by they concluded that circular shaped tanks are more favorable over rectangular square and intze tanks.

6. **Mareddy Arunkumar et al (2018)** they did "Planning, Analysis and design of a overhead circular water tank in N.B.K.R.I.S.T using STAAD Pro Software." The main objective of their paper was to design a safe overhead circular water tank which is crack free by using STAAD Pro Software for a 15 lakh liter of water capacity at the height of 15 meters.

7. **Yogeshkumar Bajpai et al (2009)** they made a "Comparison of design of water tank as per IS 3370 (1967) and IS 3370 (2009)", Indian standards for design of liquid retaining structures have been revised in year 2009.The earlier version allowed the design of water retaining structures by working stress method only but the revision of the code allowed the use of working stress method as well as limit state method for design of R.C.C Tanks. The major modification in the revision is the introduction of limit state design method foe water tank which was recommended by BIS in order to avoid cracks. Also the permissible stresses in steel were reduced to 135 MPA and the clause for minimum steel has also been modified.

8. **Thalapathy.M (2016)** They did the study of Analysis and economical Design of water tank" in this study they made a comparison of water tanks based on its position – a)Underground Tank 2)Tank resting on ground 3)Overhead Water tank, in this paper they concluded that the height to diameter ratio 0.45 is safest and provides economical design. The rectangular tank resting on ground (8x5x2.5) have moderate shear, deflection, bending moment , cost wise 8x5x2.5 section is more economical in tank resting on ground. Increase in shear force and bending moment becomes milder as one goes towards downwards side of slope. The circular shaped tank requires minimum formwork. Limit state method was found to be most economical for design of water tank as the quantity of steel requires is less as compared to working state method.

9. **Shriram Nagorao Bengal(2017)** in this paper "Seismic analysis of elevated water tank with variation in H/D ratio and container shape" here they studied seismic forces acting on an elevated water tank like circular tank and rectangular tank with a fixed height for seismic forces by using STAAD-Pro here they concluded the base shear of full water tank and empty water tank are increased with seismic zone II-V because of zone factor.

III. METHODOLOGY

Force Based analysis a traditional approach to Seismic and wind analysis of a water tank . Analysis is done by using response spectrum analysis with wind load and seismic load condition. there is comparison of structure with ground slope 0 degree , 5 degree, 10 degree, 15 degree . the comparatively parameter are shear force, bending moment , deflection .

For seismic analysis used zone V . and wind speed 39km/hr and 44km/hr.

Geometrical Data:

- Shape of tank: - circular water tank with on ground condition which have :

Radius of Tank – 3.35 m
Height of tank – 4.769 m
Clear height of tank – 12m
Property details:
Column size :- (circular column)
0.45 m radius of column
Beam size :-
0.23m x0.45 m
Plate Thickness :-
0.2 m

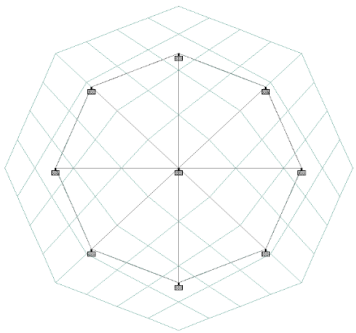


FIG: TOP VIEW OF GRID OF WATER TANK

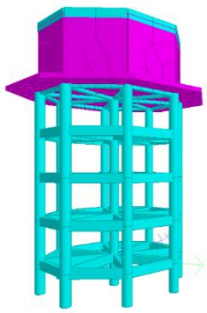


FIG : 3D VIEW OF WATER TANK

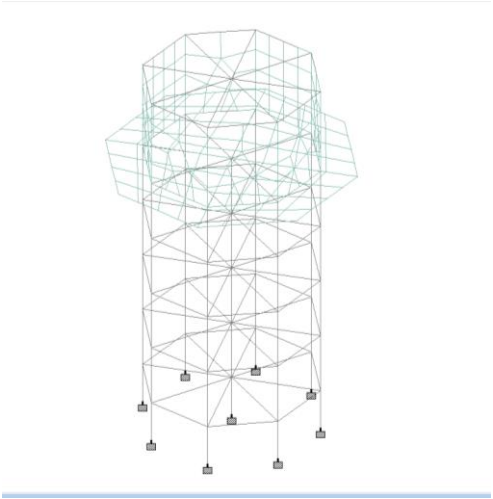


FIG : 0 DEGREE SLOPE MODEL

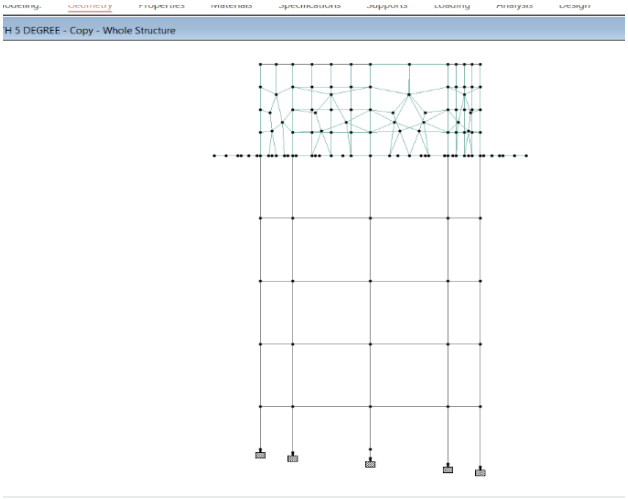


FIG : 5 DEGREE SLOPE MODEL

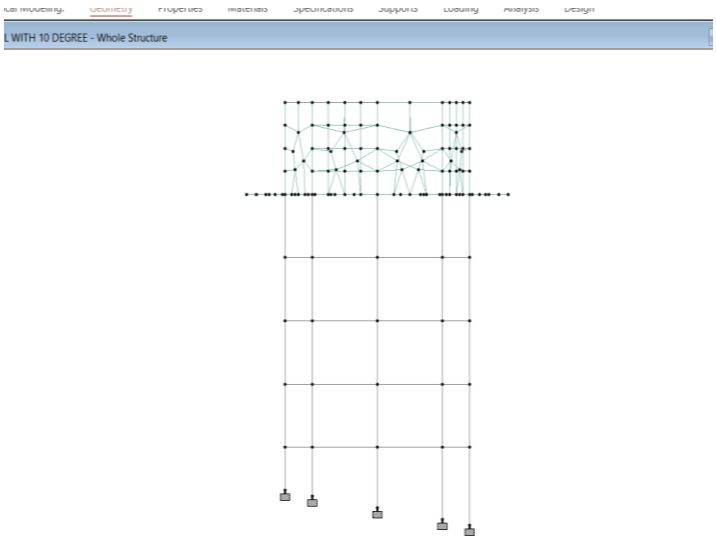


FIG : 10 DEGREE SLOPE MODEL

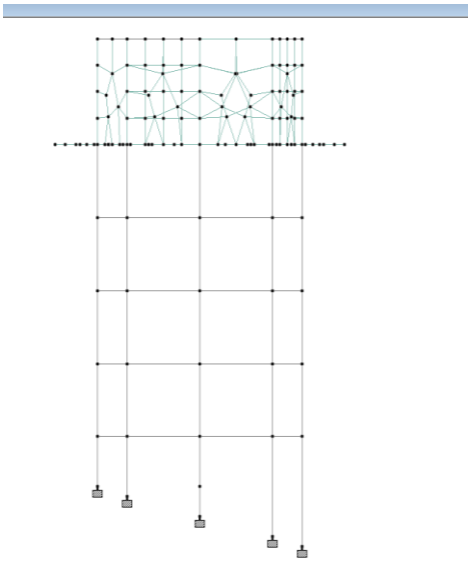
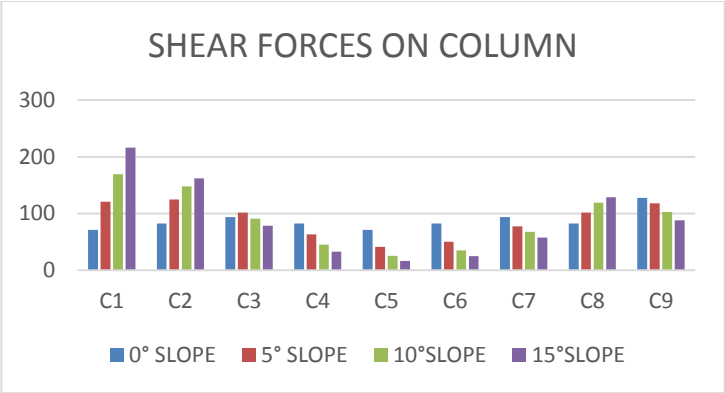


FIG : 15 DEGREE SLOPE MODEL

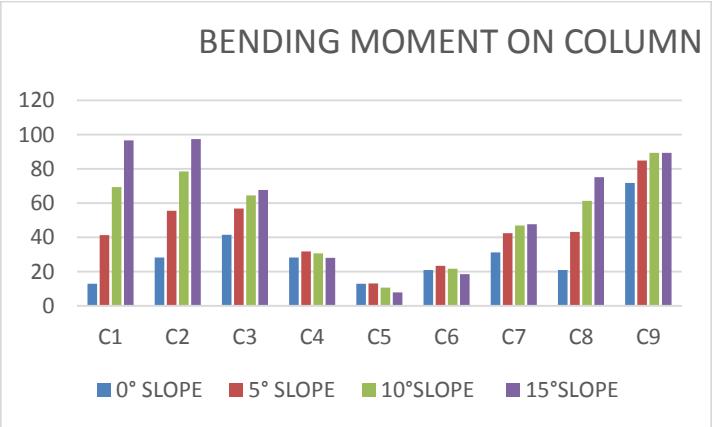
IV. RESULT :

Seismic response has been studied with respect shear forces and bending moment on column of water tank for different type of sloping ground like 0 degree , 5 degree, 10 degree, and 15 degree for both zone V And the results obtained are compared by using table and graphs .

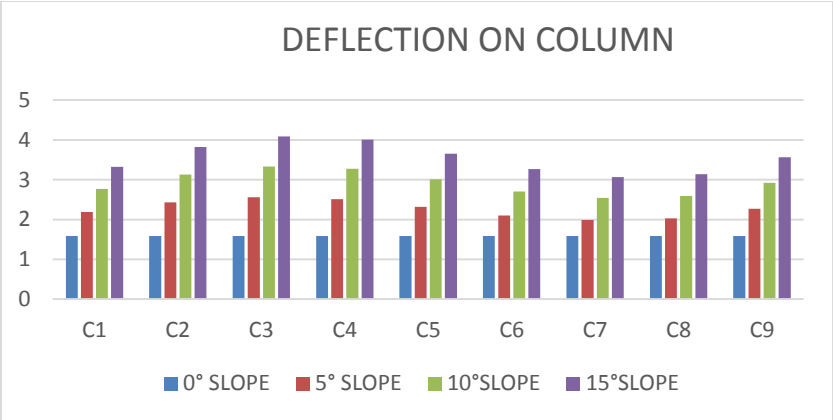
RESULT FOR ZONE V AND WIND SPEED 39KM/HR				
COLUMN	SHEAR FORCES ON COLUMN			
	0° SLOPE	**5° SLOPE**	**10°SLOPE**	**15°SLOPE**
C1	71.35	120.98	169.46	216.369
C2	82.69	125.06	147.77	162.262
C3	94.02	101.86	91.19	78.781
C4	82.68	63.5	45.17	33.13
C5	71.36	41.33	25.61	16.749
C6	82.68	50.66	35.13	24.918
C7	94.01	77.64	68.1	57.933
C8	82.68	101.7	119.14	128.927
C9	127.84	118.18	102.92	88.016



RESULT FOR ZONE V AND WIND SPEED 39KM/HR				
COLUMN	BENDING MOMENT ON COLUMN			
	0° SLOPE	**5° SLOPE**	**10°SLOPE**	**15°SLOPE**
C1	12.924	41.286	69.435	96.761
C2	28.352	55.598	78.581	97.51
C3	41.638	56.869	64.55	67.786
C4	28.35	31.889	30.744	28.068
C5	12.921	13.166	10.678	7.826
C6	21.021	23.395	21.676	18.635
C7	31.27	42.437	47.029	47.736
C8	21.021	43.317	61.28	75.121
C9	71.774	84.939	89.42	89.392

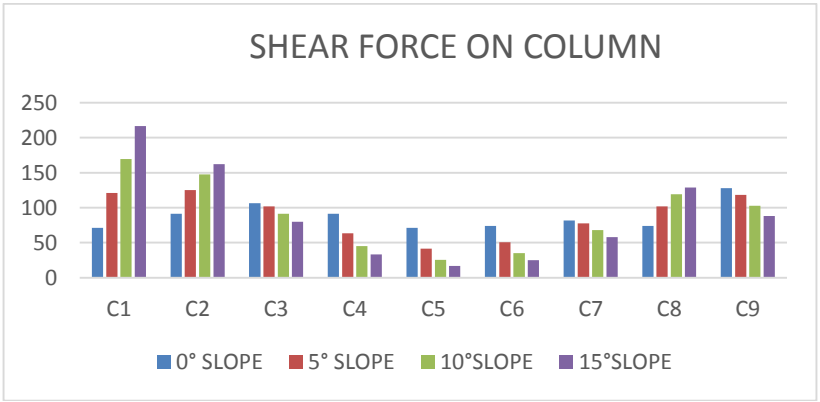


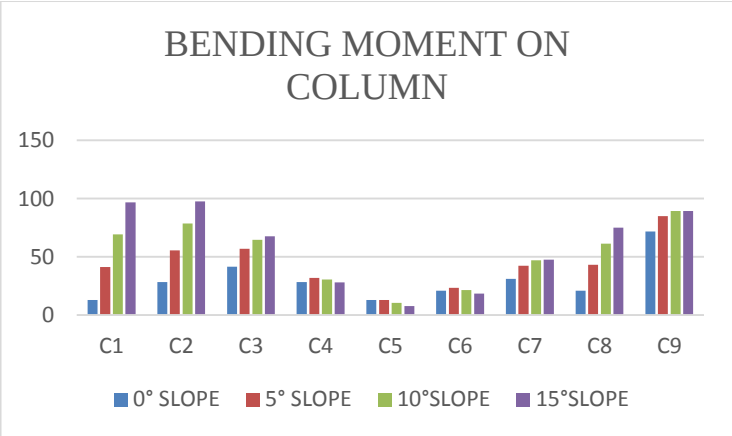
RESULT FOR ZONE V AND WIND SPEED 39KM/HR				
COLUMN	DEFLECTION ON COLUMN			
	0°SLOPE	**5°SLOPE**	**10°SLOPE**	**15°SLOPE**
C1	1.585	2.189	2.768	3.325
C2	1.587	2.43	3.129	3.824
C3	1.589	2.562	3.33	4.089
C4	1.587	2.512	3.272	4.007
C5	1.587	2.321	3.007	3.657
C6	1.587	2.098	2.704	3.267
C7	1.589	1.987	2.546	3.067
C8	1.587	2.032	2.592	3.137
C9	1.589	2.27	2.922	3.567

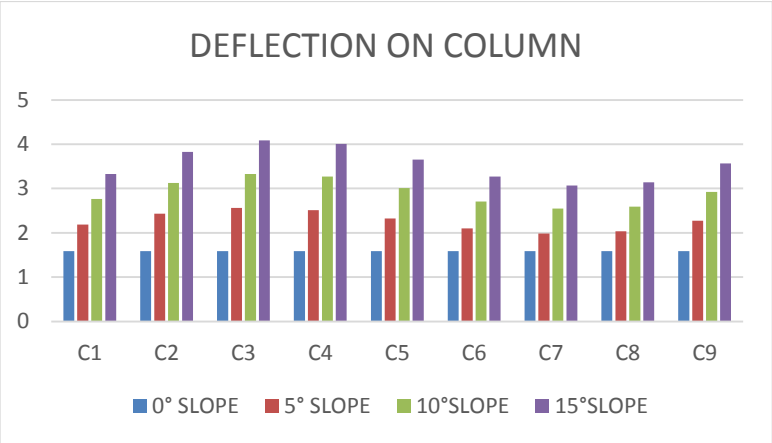


RESULT FOR ZONE V AND WIND SPEED 44KM/HR				
COLUMN	SHEAR FORCE ON COLUMN			
	0°SLOPE	**5°SLOPE**	**10°SLOPE**	**15°SLOPE**
C1	71.356	120.981	169.41	216.369
C2	91.357	125.062	147.77	162.262
C3	106.284	101.861	91.199	79.781
C4	91.355	63.508	45.17	33.13
C5	71.353	41.332	25.615	16.749
C6	74.014	50.668	35.136	24.918
C7	81.759	77.645	68.102	57.933
C8	74.015	101.701	119.144	128.927
C9	127.842	118.187	102.925	88.016

RESULT FOR ZONE IV AND WIND SPEED 44KM/HR				
COLUMN	BENDING MOMENT ON COLUMN			
	0°SLOPE	**5°SLOPE**	**10°SLOPE**	**15°SLOPE**
C1	12.924	41.286	69.435	96.761
C2	28.352	55.598	78.581	97.51
C3	41.638	56.869	64.55	67.786
C4	28.35	31.889	30.744	28.068
C5	12.921	13.166	10.678	7.826
C6	21.021	23.395	21.676	18.635
C7	31.27	42.437	47.029	47.736
C8	21.021	43.317	61.28	75.121
C9	71.774	84.939	89.42	89.392







V. CONCLUSION

- In this , work done to study the analysis and comparatively result of water tank with different slope condition of ground. This study has been mainly carried out to determine the change in various seismic response quantities due to consideration slope of ground and the effect of seismic zones.
- C1 is have zero degree slope in all condition , so slope changes from C2 . shear forces on column is vary with slope. Value at zero slope is less than 5 and 10 degree but greater than both .
- Bending moment in all column vary , height of C5 is increase gradually with increase slope so bending moment is decreases. And in other , bending moment is also vary with height.
- Deflection of column is increased with increased slope of ground in all ground condition .

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