Study of Floods and Flood Protection System in Maharashtra: Analysis of Flood Preventing Water Tank Using STAAD. Pro Software

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ABSTRACT

Flooding could occur as an overflow of water from water bodies, like a watercourse, lake, or ocean, within which the water overtops or breaks levees, leading to a number of that water escaping its usual boundaries. specifically climate change's increased downfall and extreme weather events will increase the severity of alternative causes for flooding, leading to additional intense floods and increased flood risk. This paper describes that to avoid the flood scenario capital of Japan and urban center construct the underground flood preventing storage tank that store great amount of flood water in it. thanks to that flooding can minimize. Maharashtra saw significant downfall in several of its western districts within which Kolhapur additionally faces massive flood scenario and additionally type some flood preventing system for that however temperature change might have completed a very important role in inflicting large-scale floods across Maharashtra, thus construction of underground flood preventing storage tank for Kolhapur, Maharashtra is one amongst the most effective flood preventing live. This project includes Case study of underground flood preventing storage tank in capital of Japan and urban center, Analysis of underground flood preventing storage tank desires to be construct for Kolhapur and style of underground flood preventing storage tank for Kolhapur.

Keywords: Flood, Flood Preventing Measures, Underground Flood Preventing Water Tank, Rainfall, Rainfall Data, etc.

INTRODUCTION

Underground flood storage is one of the flow regulation techniques in reducing flood risk. Failure of levees and dams inadequate drainage in urban areas can also result in flooding. The area repeatedly became the victim of serious flooding, causing huge financial losses for a vital part of the economy for that something had to be done. Thus, construction of flood preventing underground water tank is most preferable solution to overcome the flooding condition in heavy rainfall cities. In the world at Tokyo and Hong Kong there is already construction of underground flood preventing water tank.

K. History of Underground Flood Preventing Water Tank in Tokyo

In Japan, people recognized the need for preventative technology to ensure the safety of its inhabitants.TheMetropolitan Area Outer Discharge Channel is an underground water infrastructure project in Kasukabe, Saitama, Japan. Work on the project started in 1992 and was completed by early 2006, at the cost of $3 billion. The official name of these long, underground tunnels is the “Metropolitan Area Outer Underground Discharge Channel”, but is more commonly called G-Cans. It is the world's largest underground flood water diversion facility.

Figure 1. **Underground flood preventing water tank in Tokyo**

L. History of Underground Flood Preventing Water Tank in Hong Kong

Figure 2. **Underground flood preventing water tank in Hong Kong**

The Hong Kong government's Drainage Services Department's (DSD's) trio storm water scheme was designed to combat rainy season flooding. The project was innovative as it included the storage of storm water. The scheme included the construction of a gigantic underground storage tank**.** The contract is worth HK$678m ($87.4m). The entire project will be released by 2018. The project won the International Water Association's (IWA) Project Innovation Award for the East Asia region in the Planning Category in 2012.

M. Flood in Maharashtra

Figure 3.**Flood in Maharashtra**

A series of floods took place across the Maharashtra in 2021. The most affected regions are the districts of Raigad, Ratnagiri, Sindhudurg, Satara, Sangli and Kolhapur. Due to heavy rains, more than 1,020 villages are affected in these districts. Over 375,000 people have been evacuated, of whom around 206,000 are from Sangli district and around 150,000 from Kolhapur district. There have been more than 28,700 poultry deaths and around 300 other animal deaths in Kolhapur, Sangli, Satara and Sindhudurg districts. Initial estimates state that over 2 lakh (200,000) hectares of crops have been damaged in the floods.

N. Flood Preventing Measures in Maharashtra

Following are the flood preventing measures taken by Maharashtra before or at the time of flood situation in the various districts of Maharashtra.

1. **State Disaster Management Plan:**Disasters disrupt progress and destroy the hard-earned fruits of painstaking developmental efforts in quest for progress. Maharashtra state has a profile of varied hazards and was first in India to start a Disaster Management Unit (DMU)after the Latur earthquake.Considering the consequences of past disasters priority has been given to preventive, mitigation and preparedness measures. Preparation of State Disaster Management Plan (SDMP) is a part of it. In the mean while the state based on its disaster experience has improved a lot in institutional, legal, financial and disaster infrastructures in the state.

2. **Flood Forecasting Method Modernization:**Flood forecasting methods will be modernized to mitigate their impact and a management strategy will be devised by setting up a real-time data acquisition system and forecasting models. Flood inundation maps will be prepared to evolve management strategies and an emergency plan will be devised for mitigation of floods and management of each flood-prone area. At the same time to alert local residents about the possibility of floods, the policy stated by Maharashtra government. An SMS-based flood alert system must be developed in flood-prone areas.

METHODOLOGY

A. Problem Statement

Floods are caused by many different phenomena including natural process such as heavy rain. Disaster authorities in India report thatupto 24 July 2021 around 192 people was died in floods and landslides in the western state of Maharashtra since record heavy rainfall from 22 July 2021.The heavy rain brought floods and landslides affected 1028 villages across the districts of Ratnagiri, Raigad, Kolhapur, Thane, Sangli, Satara, Sindhudurg, Pune, Wardha and suburban areas of Mumbai. Over 40 roads were submerged and a bridge on the Vashishti river at Chiplun was severely damaged. At one point at total of 375,178 people were displaced from their homes, most recently in low-lying areas of Kolhapur District along the Panchganga River which overflowed after heavy rain and releases from the Koyna dam.

Kolhapur is one of the district where major rainfall occur this year almost after 15 years this kind of major flood situation is arise. According to reports in 2005 their was major flood occur in Maharashtra but as compare to 2021 that flood was not major. India’s National Disaster Response Force (NDRF)and military have carried out massive search and rescue (SAR) efforts over their. NDRF teams alone rescued 3,804 people from flood waters. Flood situation is very hard to handle in Maharashtra due to which several lives was in danger at that time. To overcome this problem there is requirement of permanent solution. Construction of underground flood preventing water tank is one of the preventing measure for flood.

B. Aim of the Study

a) Minimize the harm occur due to flooding:-Faulty or leaky appliances, burst pipes, and damages which are not repaired promptly are all causes of flooding. The low-lying areas in your home such as foundation or basement are often more susceptible to flooding. Even after water removal, the effect of flooding can appear in the form of damaged floors, mold growth, and discoloration. businesses can be forced to shut down services such as hospitals and schools can close transport networks can be affected, such as flood damage to bridges, railways and roads. To minimizing this causes the study and design of underground flood preventing water tank is important.

b) To secure several lives which is in danger during flood:-People can be injured or killed by flooding and for instance when the house is swept by the floods we imagine of the physical exposure to harsh weather conditions and the health challenges that one is exposed to. The psychological mishap and the loss in monetary terms since one will have to incur cost in rebuilding. The worst will happen when oneloses property and all the investments. This has seen many people lose the meaning of life and end up committing the worst crime, suicide, hence to secure the lives of many people from flooding the study of flood preventing water tank is important.

c) Study how to use this stored water after weather change:-At the time of flood the water get stored in the underground flood preventing water tank then at the time of summer season this water will be use after treating or it may be supply to the draught prone areas also. This management of stored water is important.

C. Objective of the Study

a) Study the rainfall data of Maharashtra.
b) Detail study of rainfall data of heavy rainfall city Kolhapur.
c) Case study of underground flood preventing water tanks constructed in Tokyo, Melbourne and Hong Kong.
d) Analysis of underground flood preventing water tank for tank full and tank half condition.

e) Comparative analysis of different parameters.

D. Scope of the Study

In many developed countries underground flood preventing water tank is already constructed and in other countries there is requirement of this water tank due to harmful effects of flood.

a) In this year Kolhapur, Sangli and Satara districts in Maharashtra are facing flood like situation due to rise in water level in rivers in rainy season. To control this kind of situation due to which lots of cities are facing many problem at the time of heavy rainfall so there is need to construct the underground flood preventing water tank to reduce effect of flood in India.
b) Maintain general lifestyle during the heavy rainfall condition also without worry about flood.
c) Reuse the water stored in underground water tank after rainy season for agricultural, industrial and domestic purpose after treating water.
d) Use the stored water in tank at drought prone areas by providing connectivity with this underground water tank.
e) The storage water in tank used for improves the ecosystem; new predators and prey are introduced to the areas, balancing the aquatic population.
f) Study work related to underground flood preventing water tank is less in India hence this concept gives more information related to this tank.
g) Knowledge related to STAAD.Pro software increase.

E. Methodology of the Work

a) Case study of underground flood preventing water tank in Tokyo and Hong Kong.
b) Case study about constructing underground flood preventing water tank for Kolhapur.
c) Analysis of underground flood preventing water tank wants to be construct.
d) Result and conclusion.

F. Case Study of Rainfall Data

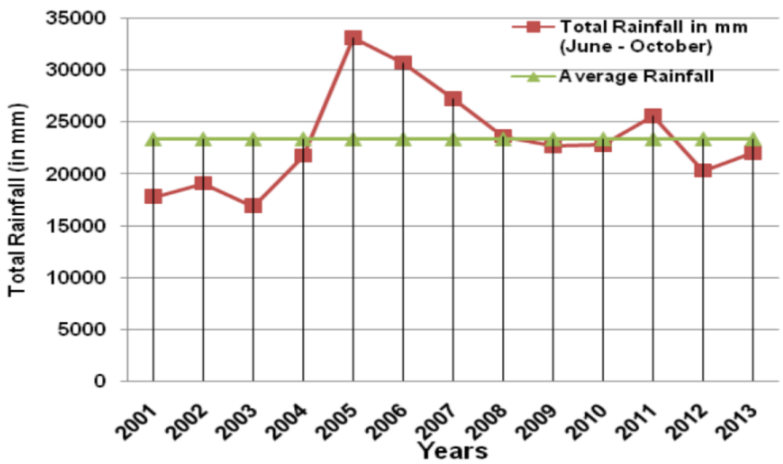


Figure 4.Annual Rainfall Trend in the Thirteen Years (2001-2013)in Kolhapur District

The rising water levels in the Krishna basin due to incessant rainfall has led to floods in several cities and villages. The flood situation in Kolhapur is likely to aggravate further. Due to the overnight rains, water discharge from Koyna dam has been increased to 10,000. The water discharge from Warna dam is 32,000 cusecs. Koyna has received 704 mm rainfall so far. According to monsoon 2020: district wise rainfall in 2019 Madhya Maharashtra had 1166.9 mm rainfall during the monsoon, 55% above normal. Five of the ten districts here had above 1000 mm rainfall. Kolhapur with 2927.5 mm (69% above normal) rainfall, had the highest rainfall. in 2020 also Madhya Maharashtra had 966.6 mm rainfall, 29% above normal. Kolhapur had the highest rainfall at 2132.3 mm, 23% above. In 2021Kolhapur had the rainfall at around 1000mm.

Result and Discussion

A. Modeling of Structure in STAAD.Pro Software

Model 1: Rectangular Underground Water Tank (Tank Full Condition)

Model 2: Rectangular Underground Water Tank (Tank Half Condition)

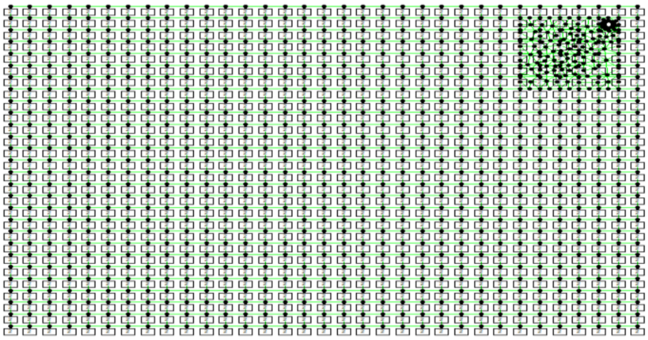


Figure 5.Plan of Model 1 and Model 2 - Rectangular Underground Flood Preventing Water Tank

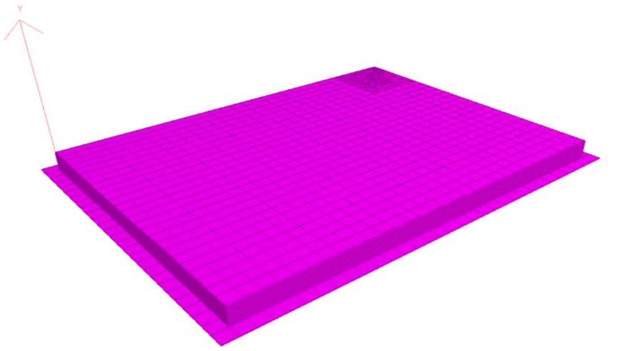


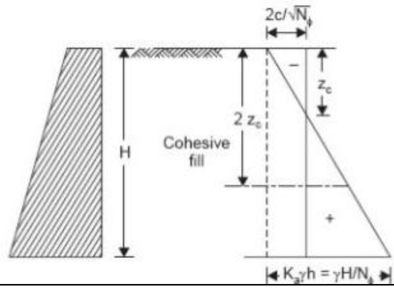
Figure 6.Rendered View of Model 1 and Model 2 - Rectangular Underground Flood Preventing Water Tank

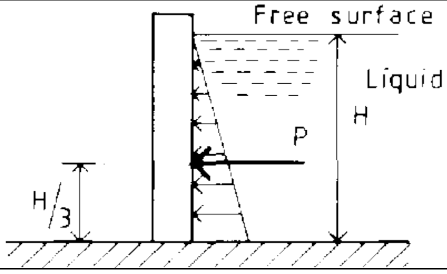
B. Loading on Model

Loads considered for analysis are as follows:

a) Dead Load (DL)
b) Live Load (Water Load)
c) Active Earth Pressure
d) Earthquake Load (EL)

Table 1: Loads Consider for Analysis

Sr. No.	Loads	Specifications
1	Self-Weight of the Frame Elements & Slabs	It is calculated & used automatically during analysis by the STAAD.Pro software
2	Super-Imposed Dead Load (IS 875 Part I: 1987)	Floor Finish = 1.5 kN/m^2
3	Active Earth Pressure (IS 875 Part III: 2015)	Ps= 1/3 x Ka x Ɣs x h = 1/3 x 0.333 x 18 x 6.3 =12.58 kN/m^3 
4	Live Load (Water Load) (IS 3370 Part I and II: 2009)	a) Height of Tank Wall = 6.3 m b) Unit weight of Water = 9.81 kN/m^3 c) Water Load at top of Wall = 9.81 x 0 = 0 kN/m^2 d) Water Load at bottom of Wall = Ɣh = 9.81 x 6.3 = 61.80 kN/m^2 acting inclined to surface of wall

Sr. No.	Loads	Specifications
		
5	Earthquake Load or Seismic Load (IS 1893 Part I: 2016)	a) Seismic Zone = Zone III (Moderate Zone) For Kolhapur City b) Zone Factor, *Z* = 0.16 c) Importance Factor, *I* = 1.2 d) Damping Ratio = 0.05 (5%) e) Response reduction Factor, *R* = 5 (SMRF) f) Soil Type = II, Brown Soil g) Seismic Source Type = B h) Period in *X – direction = 0.09h / √dx* seconds = 0.442 seconds i) Period in *Y – direction = 0.09h / √dy* seconds = 0.625 seconds Where, *h* = height of the building *dx* = length of building in x direction *dy* = length of building in y direction

M. Analysis Results of Model 1: Rectangular Underground Water Tank (Tank Full Condition)

The results obtained for Model 1: Rectangular Underground Water Tank with tank full condition is as follows:

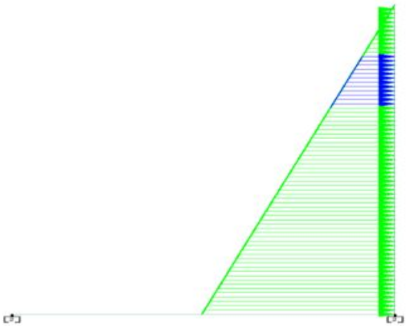


Figure 7.Loading under Tank Full Condition

1. Maximum Absolute Stresses

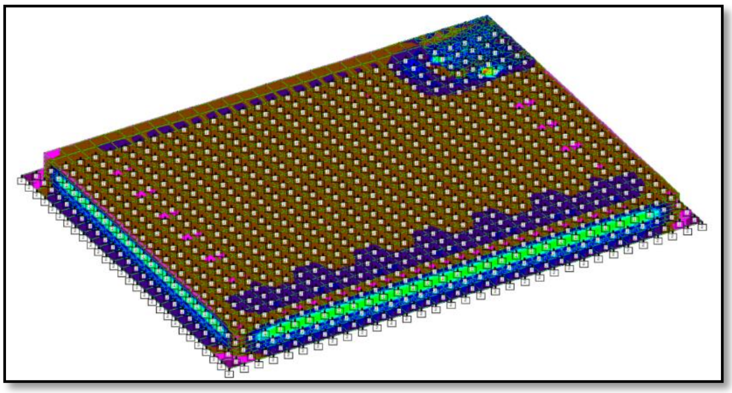


Figure 8. Analysis Results of Maximum Absolute Stresses in Model 1

Table 2: Analysis Results of Stresses in Model 1

Sr. No.	Type	Values
1	Maximum Absolute Stresses	12.18 /mm^2

2. Maximum Principle Major Stresses

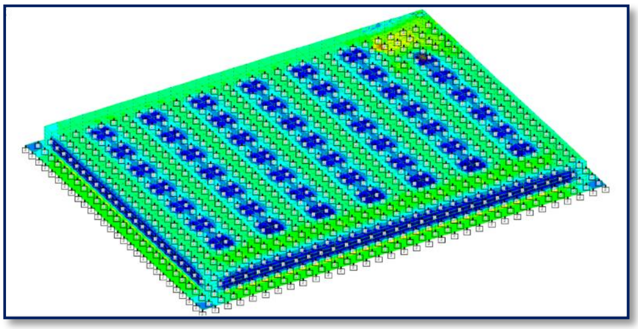


Figure 9. Analysis Results of Maximum Principle Major Stresses in Model 1

Table 3: Analysis Results of Stresses in Model 1

Sr. No.	Type	Values
1	Maximum Principle Major Stresses	8.25 N/mm^2

3. Maximum Active Earth Pressure

Table 4: Analysis Results of Stresses in Model 1

Sr. No.	Type	Values
1	Maximum Active Earth Pressure	0.15 N/mm^2

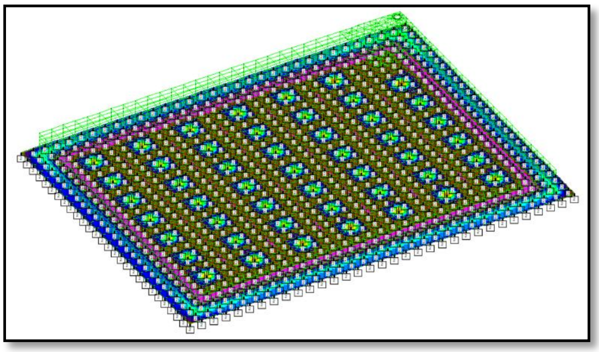


Figure 10. Analysis Results of Maximum Active Earth Pressure in Model 1

4. Maximum Bending Moment

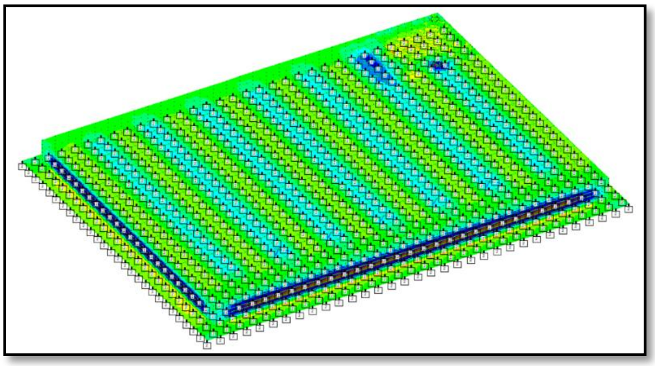


Figure 11.Analysis Results of Bending Moment in Model 1

Table5: Analysis Results of Bending Moment in Model 1

Sr. No.	Plate	L/C	Mx(kN m)	My(kN m)
1	910	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	3.211	0.559
2	2633	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	-4.002	-2.172
3	2628	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	0.0718	2.187
4	2674	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	-2.063	-4.014

4. Maximum Shear Stress

Table 6: Analysis Results of Shear Stress in Model 1

Sr. No.	Plate	L/C	SQX(N/mm^2)	SQY(N/mm^2)
1	2531	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	-0.0671	-0.1535
2	2537	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	-0.0813	-0.0286
3	2628	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	0.0942	-0.1361
4	2669	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	0.3034	-0.3560

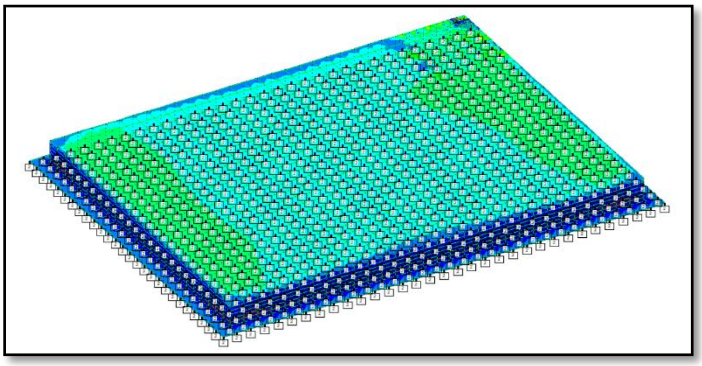


Figure 12: Analysis Results of Shear Stress in Model 1

5. Maximum Displacement

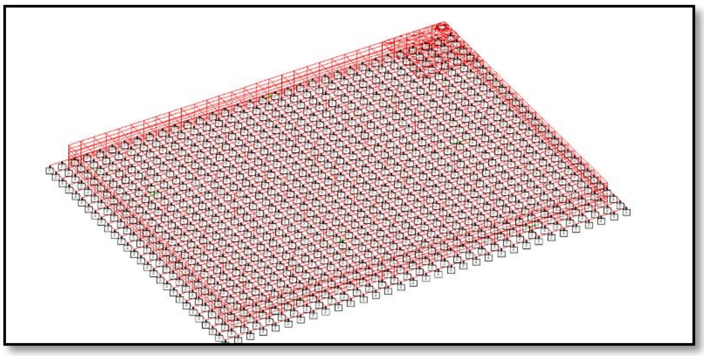


Figure 13.Analysis Results of Displacement in Model 1

Table 7: Analysis Results of Displacement in Model 1

Sr. No.	Plate	L/C	X (mm)	Y (mm)	Z (mm)
Max X	1375	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	12.03	-5.130	-0.0762
Min X	1121	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	-7.5946	-5.156	0.0762
Max Y	2556	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	0.0762	1.778	0.050
Min Y	2534	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	0.254	-61.823	-0.203
Max Z	1642	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	-0.0508	-5.181	8.178

Sr. No.	Plate	L/C	X (mm)	Y (mm)	Z (mm)
Min Z	971	1.2 DEAD + 1.6 LIVE + 1.6 SOIL	0.0762	-5.283	-9.372

N. Analysis Results of Model 2:Rectangular Underground Water Tank (Tank Half Condition)

The results obtained for Model 2: Rectangular Underground Water Tank with tank half condition is as follows:

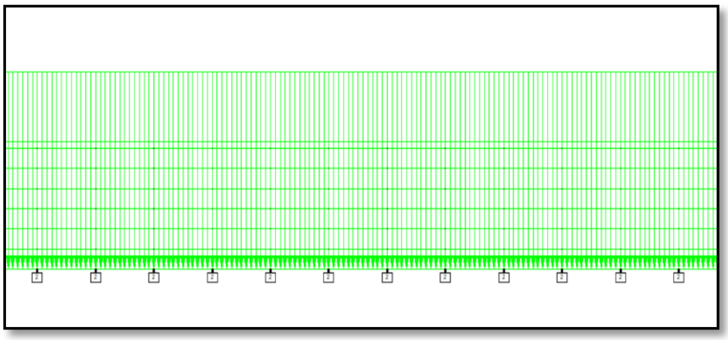


Figure 14.Loading Under Tank Full Condition

1. Maximum Absolute Stresses

Table 8: Analysis Results of Stresses in Model 2

Sr. No.	Type	Values
1	Maximum Absolute Stresses	5.92 N/mm^2

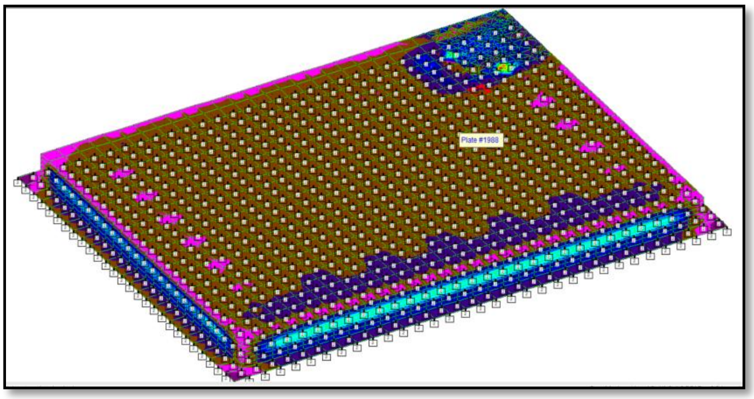


Figure 15.Analysis Results of Maximum Absolute Stresses in Model 2

2. Maximum Principle Major Stresses

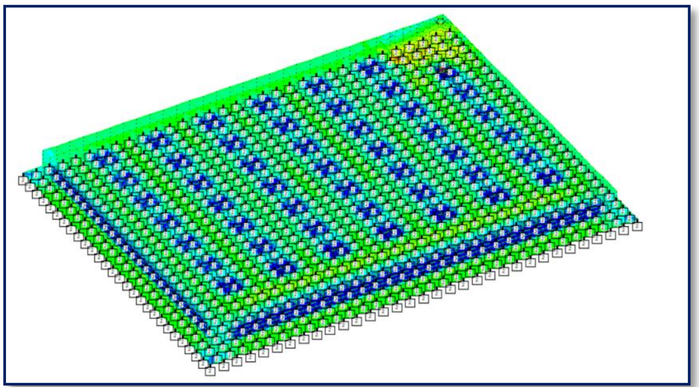


Figure 16. Analysis Results of Maximum Principle Major Stresses in Model 2

Table 9: Analysis Results of Stresses in Model 2

Sr. No.	Type	Values
1	Maximum Principle Major Stresses	3.59N/mm^2

3. Maximum Active Earth Pressure

Table 10: Analysis Results of Stresses in Model 2

Sr. No.	Type	Values
1	Maximum Active Earth Pressure	0.083 N/mm^2

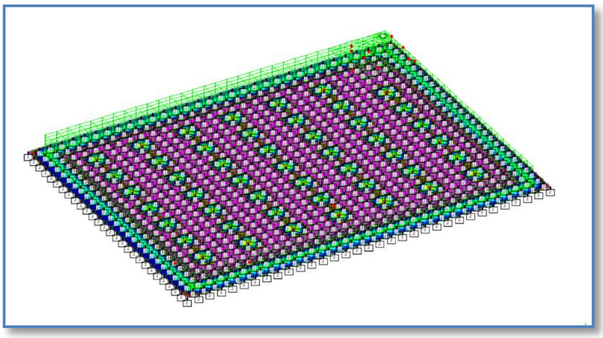


Figure 17. Analysis Results of Maximum Active Earth Pressure in Model 2

4. Maximum Bending Moment

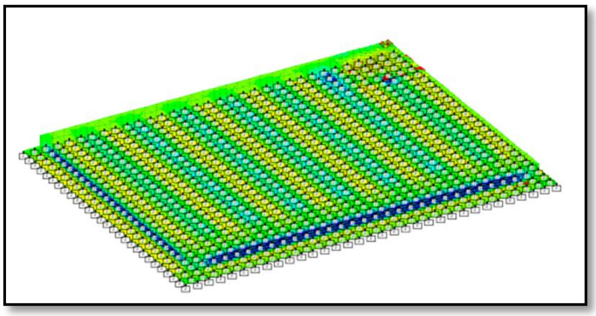


Figure 18.Analysis Results of Bending Moment in Model 2

Table 11: Analysis Results of Bending Moment in Model 2

Sr. No.	Plate	L/C	Mx(kNm)	My(kNm)
Max Mx	910	1.2 DEAD + 1 LIVE	2.406	0.416
Min Mx	2633	1.2 DEAD + 1 LIVE	-2.565	-1.371
Max My	2628	1.2 DEAD + 1 LIVE	0.043	1.384
Min My	2674	1.2 DEAD + 1 LIVE	-1.334	-2.586

5. Maximum Shear Stress

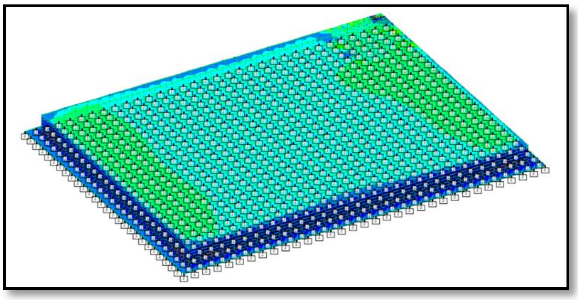


Figure 19.Analysis Results of Shear Stress in Model 2

Table 12: Analysis Results of Shear Stress in Model 2

Sr. No.	Plate	L/C	SQX(N/mm^2)	SQY(N/mm^2)
Max Sx	2531	1.2 DEAD + 1 LIVE	-0.0481	-0.1022
Min Sx	2537	2 LL (WL)	-0.0497	-0.0295
Max Sy	2628	1.2 DEAD + 1 LIVE	0.0596	-0.0863
Min Sy	2669	2 LL (WL)	0.2030	-0.2314

6. Maximum Displacement

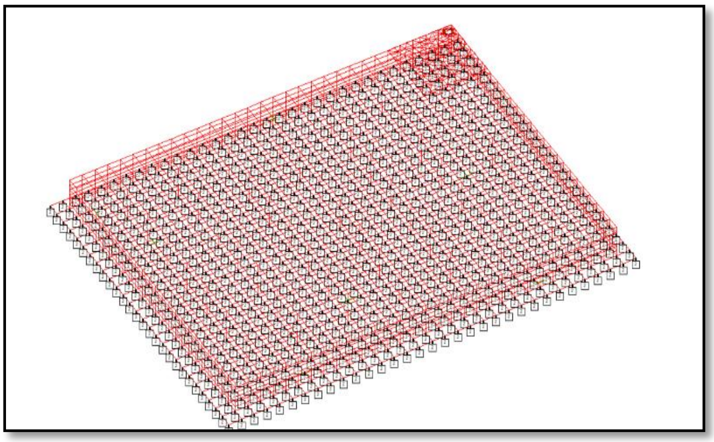


Figure 20. Analysis Results of Displacement in Model 2

Table 13: Analysis Results of Displacement in Model 2

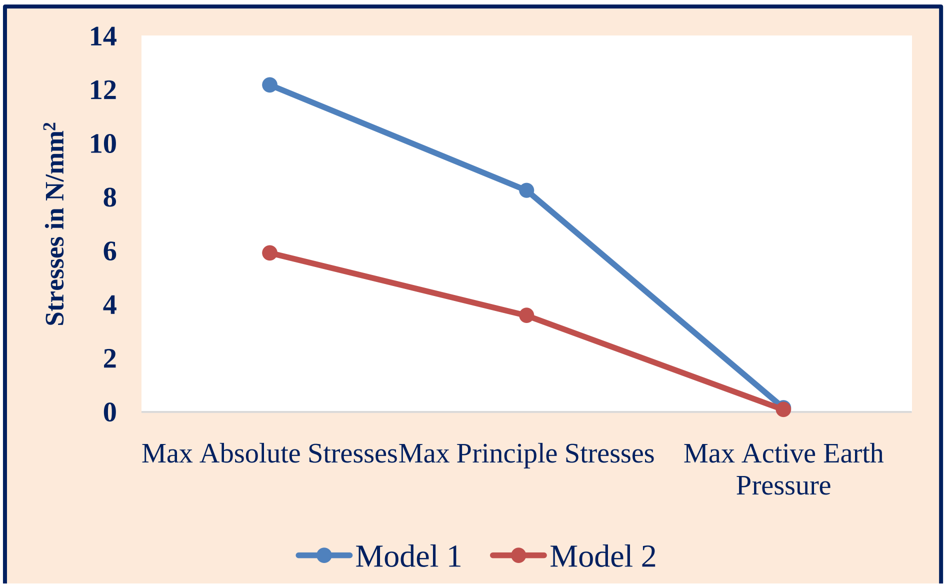
Sr. No.	Plate	L/C	X (mm)	Y (mm)	Z (mm)
Max X	1375	1.2 DEAD + 1 LIVE	9.271	-3.556	-0.076
Min X	1121	1.2 DEAD + 1 LIVE	-5.8928	-3.581	0.0762
Max Y	2556	0.9 DEAD + 1.6 SOIL	-0.0762	1.778	0.0508
Min Y	2591	1.2 DEAD + 1 LIVE	0.2032	-40.360	-0.1524
Max Z	1642	1.2 DEAD + 1 LIVE	-0.0254	-3.6068	6.2484
Min Z	971	1.2 DEAD + 1 LIVE	0.07623	-3.6576	-7.0358

O. *Comparative Analysis of Model 1 and Model 2*

a) Comparative Analysis of Model 1 and Model 2: Maximum Absolute Stresses, Maximum Principle Major Stresses and Maximum Base Pressure

Table 14: Maximum Absolute Stresses, Maximum Principle Major Stresses and Maximum Base Pressure for Tank Full and Tank Half Condition

Model	Max Absolute Stresses (N/mm^2)	Max Principle Stresses (N/mm^2)	Max Active Earth Pressure (N/mm^2)
Model 1	12.18	8.25	0.15
Model 2	5.92	3.59	0.083

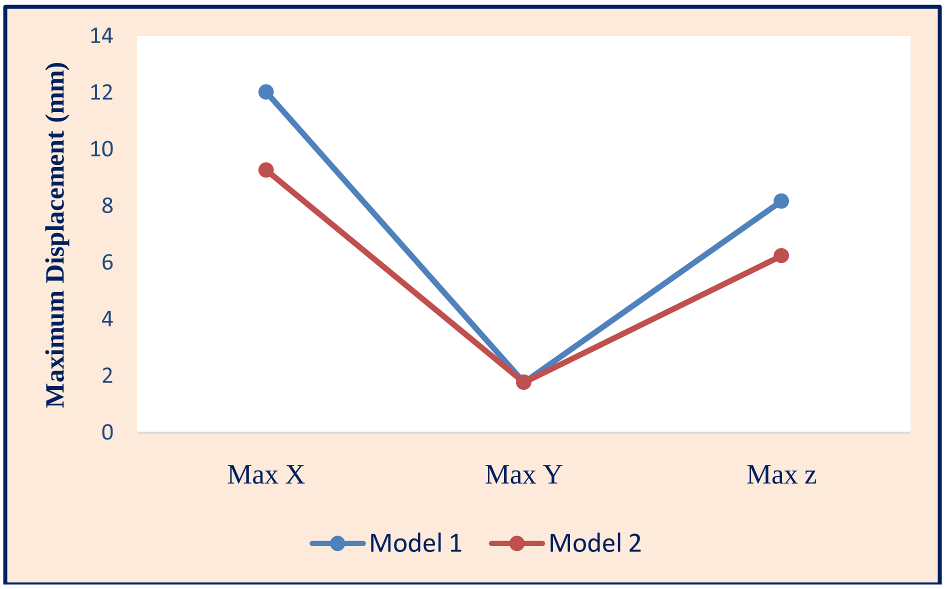


Graph 21. Maximum Absolute Stresses, Maximum Principle Major Stresses and Maximum Base Pressure

b) Comparative Analysis of Model 1 and Model 2: Maximum Displacement

Table 15: Maximum Displacement towards X, Y and Z Direction for Tank Full and Tank Half Condition

Model	Max X (mm)	Max Y (mm)	Max Z (mm)
Model 1	12.03	1.778	8.178
Model 2	9.271	1.778	6.2484



Graph 22. Maximum Displacement

CONCLUSION

Maximum absolute stress for full tank condition is 12.18 N/mm^2 and for half tank condition is 5.92 N/mm^2 in the analysis of underground flood preventing water tank and maximum major principle stress for full tank condition is 8.25 N/mm^2 and for half tank condition is 3.59 N/mm^2 in the analysis of underground flood preventing water tank. The maximum base pressure for tank full condition is 0.15 N/mm^2 and for half tank condition 0.083 N/mm^2 in the analysis of underground flood preventing water tank. Maximum and minimum bending moment is calculated towards X axis and Y axis is 195.9 N/mm^2 and 4.38 N/mm^2 respectively for full tank condition and maximum and minimum bending moment is calculated towards X axis and Y axis is 146.85 N/mm^2 and 25.400 N/mm^2 respectively for half tank condition.

Maximum and minimum shear force is calculated towards X axis and Y axis is 0.067 N/mm^2 and 0.094 N/mm^2 respectively for full tank condition and maximum and minimum shear force is calculated towards X axis and Y axis is 0.048 N/mm^2 and 0.059 N/mm^2 respectively for half tank condition.Maximum and minimum displacement is calculated towards X axis, Y axis and Z are 0.0032 N/mm^2, 0.00048 N/mm^2 and 0.002 N/mm^{2}respectively for full tank condition and maximum and minimum displacement is calculated towards X axis, Y axis and Z axis are 0.0025 N/mm^2, 0.00048 N/mm^2 and 0.0016 N/mm^2 respectively for half tank condition.

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