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Seismic Analysis of Various Capacities of Over Head Tanks Considering Soil Structure Interaction

[1]Ajinkya A.Gulhane , [2]Prof. Sandeep Gaikwad, [3]Ms. Divyani Harpal

[1]Post Graduate Student, [2]Assistant Professor, [3]Assistant.Professor
[1]Department of Structural Engineering ,
[1]Tulsiramji Gaikwad Patil College of Engineering and Technology, Nagpur, India.

Abstract : We have attempted to investigate the effect of soil structure interaction on the structural behaviour of a building in this research. When seismic loads are applied to a structure supported on a mat foundation. When considering actual support flexibility during dynamic loading, the overall stiffness of the structure is reduced. As a result, research into dynamic soil structure interaction is required. The primary goal of this research is to examine a building supported on a mat foundation for various soil conditions and compare the results of storey displacement, column end forces, and beam bending moments. The soil structure is analysed using the STAAD PRO analytical programme.

***IndexTerms* – Soil-Structure Interaction, Sub-grade Modulus, Story Drift.**

I. INTRODUCTION

When selecting the foundation type for the upper groundwater reservoir, several options such as shallow foundations and pile foundations can be considered by design engineers to perform both gravity and seismic load analysis. However, different types of supporting assumptions behave differently during earthquakes when it comes to structure-soil interactions (SSI) that can influence the seismic behaviour of superstructures. This project aims at structural analysis taking into account the interaction of soil structure under different seismic zones. The analysis will be performed considering a fixed base and a spring-loaded stand with a capacity of a water tank of 1500 KL, 2000 KL and 3000 KL. The effects of different soil types are considered in terms of soil resources provided by WINKLER. Three values of foundation modulus are considered to interpret different soils to determine the effect of SSI on floor drift, forces on columns and beams, and bending moments in raft slabs. The goal was to identify good practices that would be applied to account for handling in the case of aerial tanks.

II. PROPOSED WORK

The goal of this study is to examine a structure while taking into account the interaction of soil and structure under seismic loads. With a 1500KL, 2000KL & 3000KL super-structure, analyse the structure using a fixed base and spring support. Different soil types' effects are considered in the form of soil springs. WINKLER proposed it. For the interpretation of different types of soils, three Subgrade Modulus values are used to determine the influence of SSI on story drift, forces on columns, and beams. To determine the optimum practise for taking into account supports.

Table 1. Details of Modelling for 1500KL water Tank in Zone IV

LATERAL FORCE ON WATER TANK (IS:1893-1984)			
MODEL	1500 FIXED		
CAPACITY	1500	KL	
SEISMIC ZONE	IV		
SUPPORT CONDITION	FIXED		
HT. OF CONTAINER	5	M	
WT. OF CONTAINER + 1/3 WT. OF STAGGING + WT. OF WATER **(W FULL)**	21436	KN	
WT. OF CONTAINER + 1/3 WT. OF STAGGING **(W EMPTY)**	6866	KN	
COFFICIENT OF SOIL FOUNDATION($_\beta$)	1	TYPE I	IS 1893:1984 (TABLE-3)
IMPORTANCE FACTOR(I)	1.5		IS 1893:1984 (TABLE-4)
SESMIC ZONE FACTOR(F0)	0.25	IV	IS 1893:1984 (TABLE-2)
AVRAGE ACCELERATION COFFIENT(Sa/g)	0.2		IS 1893:1984 (FIG-2)
DESIGN HORIZONTAL SEISMIC COEFFICIENT	0.075		IS 1893:1984 (3.4.2.3(b))
LATERAL FORCE **(TANK FULL)**	**1608**	KN	IS 1893:1984 (5.2.6)
LATERAL FORCE **(TANK EMPTY)**	**515**	KN	IS 1893:1984 (5.2.6)
WT OF WATER	**49.1**	KN/M2	

Table 2. Details of Modelling for 2000KL water Tank in Zone VI

LATERAL FORCE ON WATER TANK (IS:1893-1984)			
MODEL	2000		
CAPACITY	2000	KL	
SEISMIC ZONE	IV		
SUPPORT CONDITION	FIXED		
HT. OF CONTAINER	5	M	
WT. OF CONTAINER + 1/3 WT. OF STAGGING + WT. OF WATER **(W FULL)**	29864	KN	
WT. OF CONTAINER + 1/3 WT. OF STAGGING **(W EMPTY)**	10286	KN	
COFFICIENT OF SOIL FOUNDATION($_\beta$)	1	TYPE I	IS 1893:1984 (TABLE-3)
IMPORTANCE FACTOR(I)	1.5		IS 1893:1984 (TABLE-4)
SESMIC ZONE FACTOR(F0)	0.25	IV	IS 1893:1984 (TABLE-2)
AVRAGE ACCELERATION COFFIENT(Sa/g)	0.2		IS 1893:1984 (FIG-2)
DESIGN HORIZONTAL SEISMIC COEFFICIENT	0.075		IS 1893:1984 (3.4.2.3(b))
LATERAL FORCE **(TANK FULL)**	**2240**	KN	IS 1893:1984 (5.2.6)
LATERAL FORCE **(TANK EMPTY)**	**771**	KN	IS 1893:1984 (5.2.6)
WT OF WATER	**49.1**	KN/M2	

Table 3. Details of Modelling for 3000KL water Tank in Zone VI

LATERAL FORCE ON WATER TANK (IS:1893-1984)			
MODEL	3000		
CAPACITY	3000	KL	
SEISMIC ZONE	IV		
SUPPORT CONDITION	FIXED		
HT. OF CONTAINER	5	M	
WT. OF CONTAINER + 1/3 WT. OF STAGGING + WT. OF WATER **(W FULL)**	45270	KN	
WT. OF CONTAINER + 1/3 WT. OF STAGGING **(W EMPTY)**	14808	KN	
COFFICIENT OF SOIL FOUNDATION($_\beta$)	1	TYPE I	IS 1893:1984 (TABLE-3)
IMPORTANCE FACTOR(I)	1.5		IS 1893:1984 (TABLE-4)
SESMIC ZONE FACTOR(F0)	0.25	IV	IS 1893:1984 (TABLE-2)
AVRAGE ACCELERATION COFFIENT(Sa/g)	0.2		IS 1893:1984 (FIG-2)
DESIGN HORIZONTAL SEISMIC COEFFICIENT	0.075		IS 1893:1984 (3.4.2.3(b))
LATERAL FORCE **(TANK FULL)**	**3395**	KN	IS 1893:1984 (5.2.6)
LATERAL FORCE **(TANK EMPTY)**	**1111**	KN	IS 1893:1984 (5.2.6)
WT OF WATER	**49.1**	KN/M2	

Table 4. Details of Modelling for 1500KL water Tank in Zone V

LATERAL FORCE ON WATER TANK (IS:1893-1984)			
MODEL	1500,18M		
CAPACITY	1500	KL	
SEISMIC ZONE	V		
SUPPORT CONDITION	FIXED		
HT. OF CONTAINER	5	M	
WT. OF CONTAINER + 1/3 WT. OF STAGGING + WT. OF WATER **(W FULL)**	21436	KN	
WT. OF CONTAINER + 1/3 WT. OF STAGGING **(W EMPTY)**	6866	KN	
COFFICIENT OF SOIL FOUNDATION(β)	1	TYPE I	IS 1893:1984 (TABLE-3)
IMPORTANCE FACTOR(I)	1.5		IS 1893:1984 (TABLE-4)
SESMIC ZONE FACTOR(F0)	0.4	V	IS 1893:1984 (TABLE-2)
AVRAGE ACCELERATION COFFIENT(Sa/g)	0.2		IS 1893:1984 (FIG-2)
DESIGN HORIZONTAL SEISMIC COEFFICIEN	0.12		IS 1893:1984 (3.4.2.3(b))
LATERAL FORCE **(TANK FULL)**	**2572**	KN	IS 1893:1984 (5.2.6)
LATERAL FORCE **(TANK EMPTY)**	**824**	KN	IS 1893:1984 (5.2.6)
WT OF WATER	**49.1**	KN/M2	

Table 5. Details of Modelling for 2000KL water Tank in Zone V

LATERAL FORCE ON WATER TANK (IS:1893-1984)			
MODEL	2000, 18M		
CAPACITY	2000	KL	
SEISMIC ZONE	V		
SUPPORT CONDITION	FIXED		
HT. OF CONTAINER	5	M	
WT. OF CONTAINER + 1/3 WT. OF STAGGING + WT. OF WATER **(W FULL)**	29864	KN	
WT. OF CONTAINER + 1/3 WT. OF STAGGING **(W EMPTY)**	10286	KN	
COFFICIENT OF SOIL FOUNDATION(β)	1	TYPE I	IS 1893:1984 (TABLE-3)
IMPORTANCE FACTOR(I)	1.5		IS 1893:1984 (TABLE-4)
SESMIC ZONE FACTOR(F0)	0.4	V	IS 1893:1984 (TABLE-2)
AVRAGE ACCELERATION COFFIENT(Sa/g)	0.2		IS 1893:1984 (FIG-2)
DESIGN HORIZONTAL SEISMIC COEFFICIEN	0.12		IS 1893:1984 (3.4.2.3(b))
LATERAL FORCE **(TANK FULL)**	**3584**	KN	IS 1893:1984 (5.2.6)
LATERAL FORCE **(TANK EMPTY)**	**1234**	KN	IS 1893:1984 (5.2.6)
WT OF WATER	**49.1**	KN/M2	

Table 6. Details of Modelling for 3000KL water Tank in Zone V

Table 7.

LATERAL FORCE ON WATER TANK (IS:1893-1984)			
MODEL	3000, 18M		
CAPACITY	3000	KL	
SEISMIC ZONE	V		
SUPPORT CONDITION	FIXED		
HT. OF CONTAINER	5	M	
WT. OF CONTAINER + 1/3 WT. OF STAGGING + WT. OF WATER **(W FULL)**	45270	KN	
WT. OF CONTAINER + 1/3 WT. OF STAGGING **(W EMPTY)**	14808	KN	
COFFICIENT OF SOIL FOUNDATION(β)	1	TYPE I	IS 1893:1984 (TABLE-3)
IMPORTANCE FACTOR(I)	1.5		IS 1893:1984 (TABLE-4)
SESMIC ZONE FACTOR(F0)	0.4	V	IS 1893:1984 (TABLE-2)
AVRAGE ACCELERATION COFFIENT(Sa/g)	0.2		IS 1893:1984 (FIG-2)
DESIGN HORIZONTAL SEISMIC COEFFICIEN	0.12		IS 1893:1984 (3.4.2.3(b))
LATERAL FORCE **(TANK FULL)**	**5432**	KN	IS 1893:1984 (5.2.6)
LATERAL FORCE **(TANK EMPTY)**	**1777**	KN	IS 1893:1984 (5.2.6)
WT OF WATER	**49.1**	KN/M2	

Table 8. Modulus of Sub-grade Reactions considered

Type of soil	Soft	Medium	Hard
Subgrade Reaction kN/m3	10000	45000	95000

2.1 Load Combinations

1) EQX Tank Full,
2) WQX Tank Empty.

2.2 Seismic Zones Considered

1) Zone VI,
2) Zone V.

2.3 Models Analysed

1. 1500 KL Fixed Base 18m Zone IV,
2. 1500 KL Mat Base K=10,000 (Soft Soil) Zone IV,
3. 1500 KL Mat Base K=45,000 (Medium Soil) Zone IV,
4. 1500 KL Mat Base K=95,000 (Hard Soil) Zone IV,
5. 2000 KL Fixed Base 18m Zone IV,
6. 2000 KL Mat Base K=10,000 (Soft Soil) Zone IV,
7. 2000 KL Mat Base K=45,000 (Medium Soil) Zone IV,
8. 2000 KL Mat Base K=95,000 (Hard Soil) Zone IV,
9. 3000 KL Fixed Base 18m Zone IV,
10. 3000 KL Mat Base K=10,000 (Soft Soil) Zone IV,
11. 3000 KL Mat Base K=45,000 (Medium Soil) Zone IV,
12. 3000 KL Mat Base K=95,000 (Hard Soil) Zone IV,
13. 1500 KL Fixed Base 18m Zone V,
14. 1500 KL Mat Base K=10,000 (Soft Soil) Zone V,
15. 1500 KL Mat Base K=45,000 (Medium Soil) Zone V,
16. 1500 KL Mat Base K=95,000 (Hard Soil) Zone V,
17. 2000 KL Fixed Base 18m Zone V,
18. 2000 KL Mat Base K=10,000 (Soft Soil) Zone V,
19. 2000 KL Mat Base K=45,000 (Medium Soil) Zone V,
20. 2000 KL Mat Base K=95,000 (Hard Soil) Zone V,
21. 3000 KL Fixed Base 18m Zone V,
22. 3000 KL Mat Base K=10,000 (Soft Soil) Zone V,
23. 3000 KL Mat Base K=45,000 (Medium Soil) Zone V,
24. 3000 KL Mat Base K=95,000 (Hard Soil) Zone V.

III. Results

Table 9. Graphic Representation of Story Displacement for Water tanks in Zone VI

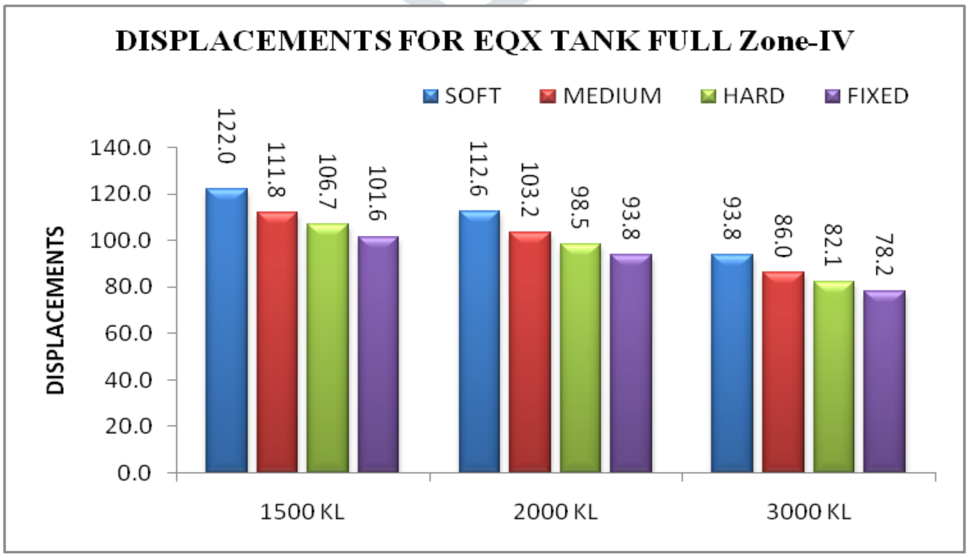
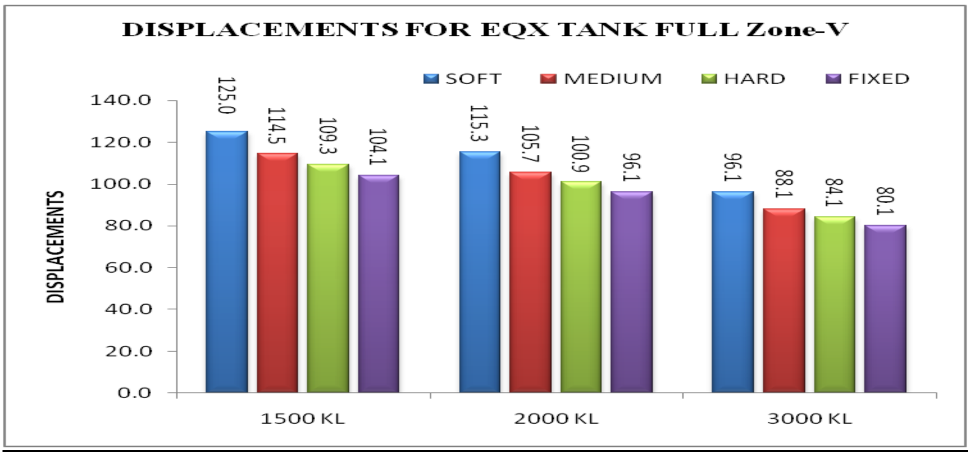


Table 10. Graphic Representation of Story Displacement for Water tanks in Zone V



IV. Conclusions

Analysis of the response spectra of 1500 KL, 2000 KL, and 3000 KL overhead tanks, taking into account soil-structure interactions, concludes:

1. Consideration of realistic support condition changes the column and beams bending moments.
2. The structure on soft soil deflects as a whole body. The effect of SSI in soft soils is more as compared to medium and hard.
3. As the stiffness of the soil strata increased, structure behaviour became closer to that observed for fixed supports.
4. The water tanks with 18m & above height, located in any soil conditions significant effect of SSI is seen.
5. Therefore, in such case one should not assume the support as fixed, The actual subgrade modulus should be obtained by plate load test and by applying soil springs the structure should be analysed.
6. With the use of software power one can incorporate the elasticity of soil that will provide approximate solutions as close to the exact solutions.

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