QUANTIFYING THE EFFECT OF SOIL FLEXIBILITY FOR ELEVATED STORAGE RESERVOIR BY PUSHOVER ANALYSIS

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Abstract: Since last some years the structures is getting critical damage during the earthquake because of the absence of the calculation of soil flexibility during the analysis and design. Many water tanks had been collapsed in last few earthquakes where water tank is an important lifeline structure. The multiple base motion effect on hydrodynamic pressure, acceleration of tank and fluid surface elevation problem in Elevated water tank is understood as Soil structure Interaction problem. Where, Soil-Structure interaction causes rocking motion and soil Structure interaction causes the hydrodynamic behaviour of water tank. According to the available literature, substantial amount of study has been done on behaviour of elevated steel water tank under pure rocking, but very few study is done on water tanks with soil structure interaction effect with various heights. The main objective of this study is to compare the time period, maximum displacement, base shear and performance point of an elevated water tank with various height.

Key Words: Key word1, Key word2, Key word3, and Key word4 etc…

1. INTRODUCTION

The forces due to earthquake-induced sloshing in fluid-filled water tanks are important considerations in the design of civil engineering structures. Seismic safety of elevated liquid-filled containers is of great concern because of the potential adverse economic and environmental impacts associated with failure of the container and liquid spillage on the surrounding area. As a result, a considerable amount of research effort has been devoted to a better determination of the seismic behaviour of liquid tanks and reservoirs and the improvement of associated design codes. In spite of this, there have been relatively few studies on the seismic behaviour of elevated water tank with soil flexibility. Static push-over analysis is a simplified nonlinear analysis technique in which a structure modeled with non-linear properties (such as plastic hinge properties) and permanent gravity loads is subjected to an incremental lateral load from zero to a prescribed ultimate displacement or until the structure is unable to resist further loads. The sequence of yielding, plastic hinge formation and failure of various structural components are noted and the total force is plotted against displacement to define a capacity curve. In the pushover analysis it is assumed that the target displacement for MDOF structure can be estimated as the displacement demand for the corresponding equivalent SDOF system transformed the MDOF through the shape vector. This assumption which is an always an approximation, can only be accepted within limitation and only if great care is taken in incorporating in the predicted SDOF displacement demand all the important ground motion and structural response characteristic that significantly affect the maximum displacement of the MDOF structure.

1.1 Need of pushover analysis

The realistic force demands on potentially brittle elements, such as axial force on columns, force on braced connections, moment on beam column connections. Estimates of the deformation demands for elements that have to form inelastically in order to dissipate the energy imparted to the structure. Estimates of the inner storey drifts that account for strength discontinuities and that may be used to control the damages and to evaluate P-Delta effects. Identification of the strength discontinuous in plan elevation that will lead to change in the dynamic characteristics in elastic range.

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2. OBJECTIVE

The objective of this paper is to highlight the effect of the soil flexibility for the elevated storage water tank with various height by performing a nonlinear static pushover analysis. In general, to ensure stability of ESR in earthquake event by adopting SSI effects in seismic analysis.

To reveal the effect of soil flexibility for elevated storage tank an existing water tank is considered which is located at Bhuj. A water tank is frame staging and having various components as given in the table no-2. A nonlinear static analysis for the tank with various height like 18m and 21m and with the various soils is to be carried out in SAP2000 v14. Also response reduction factor for each tank with each soil type is to be carried out. The soil parameters which is considered in this study is as tabulated below. Total eight analysis is carried out to evaluate the soil flexibility effect for water tank.

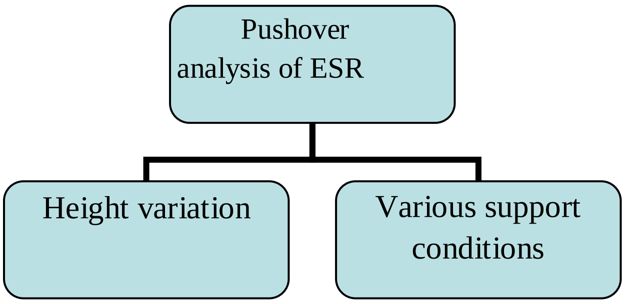

Table -1: Soil parameters for the study

Type of soil	**shear wave velocity (m/sec)**	**Poisson's ratio**	**Density of soil**	**modulus of elasticity**
HARD	90 sec	0.38	21	200000
MEDIUM	200 sec	0.32	18.5	60000
SOFT	1000 sec	0.30	17	15000

To assign the soil flexibility, a spring support has taken for a different soils the equation to find the soil stiffness has been taken from FEMA-356.

2.1 Procedure for pushover analysis

1. Create three dimensional model of tank.
2. Implementation and application of gravity loads, live loads, and water load, etc.
3. Define properties and acceptance criteria for the pushover hinges .The program includes several built-in default hinge properties that are based on average values from ATC-40 for concrete members and average values from FEMA-356 for steel members.
4. Locate the pushover hinges on the model by selecting one or more frame members and assigning them one or more hinge properties and define the pushover load case.
5. Push the structure using the load patterns of static lateral loads, to displacements larger than those associated with target displacement using static pushover analysis.
6. Plastic hinge will form at a various levels like immediate occupancy, life safety collapse prevention etc.
7. The lateral load is applied on the frame, which when deflected forms hinges. The plastic hinge formation at the yielding and significant difference in the hinging patterns at the ultimate state.
8. Developing a pushover curve and estimating the force and deformations in each element at the level of displacement corresponding to target displacement.
9. The node associated at CG of container is the target point/node selected for comparison with target displacement. The maximum limit for roof displacement is given as 0.004H, where H is the height of the structure.
10. The equivalent static methods adopt seismic coefficient, which depends on the natural time period of their vibration of the structure, the time period is required for earthquake resistance design of the structures and to calculate the base shear. Time period of the structure is been taken from the software SAP2000.

3. METHODOLOGY

In this study to quantifying the effect of soil flexibility a spring support has been assigned instead of fixed support and the spring constant is taken from the FEMA-356 as tabulated below.

Table -2: Geometrical data for a tank

Column	350 x 350 mm
Beam	350 x 350 mm

Tie beam	3m c/c + plinth beam
Side wall thickness	230 mm
Top slab thickness	120 mm
Bottom slab thickness	230 mm

4. RESULTS

4.1 Analytical results for 15 m height tank:

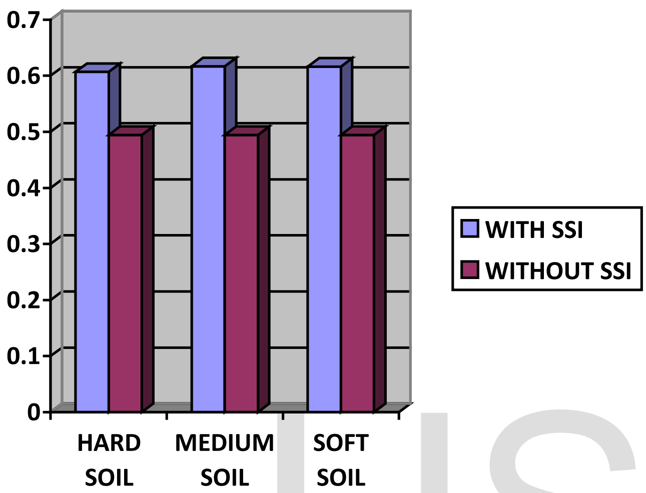

Chart -1: Time period for 15 m height tank

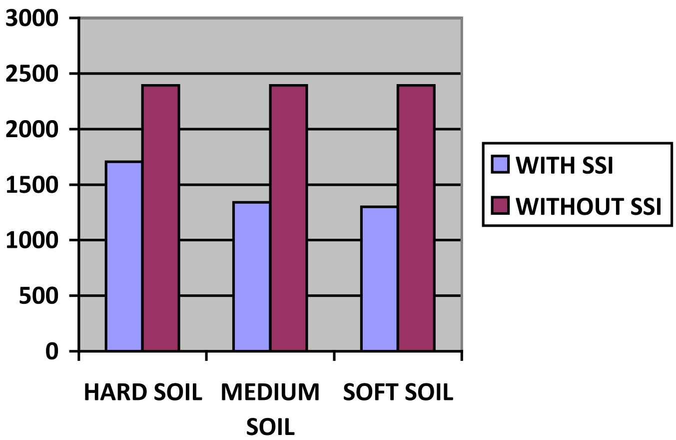

Chart -2: Base shear for 15 m height tank

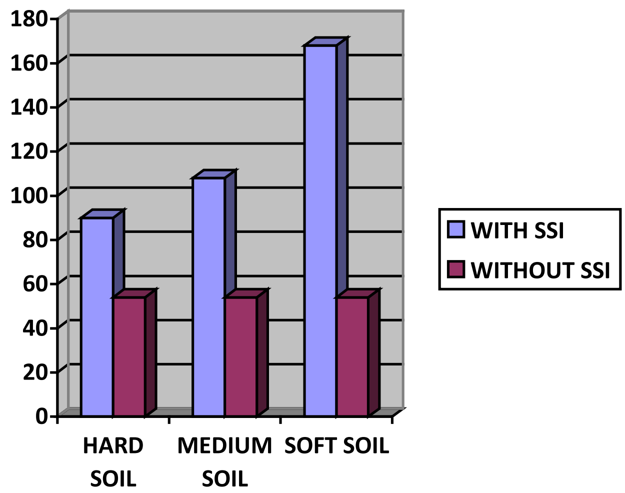

Chart -3: Target displacement for 15 m height tank

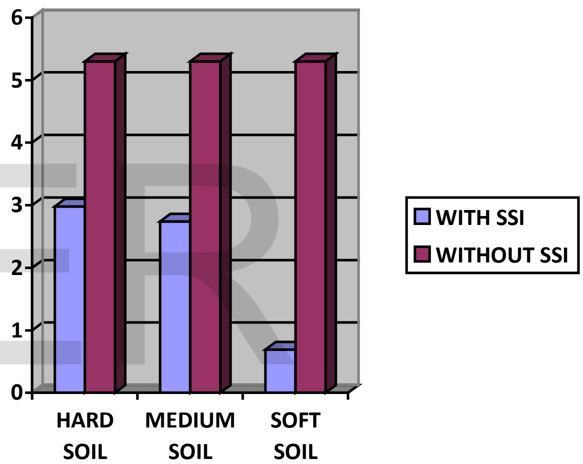

Chart -4: Response reduction factor for 15 m height tank

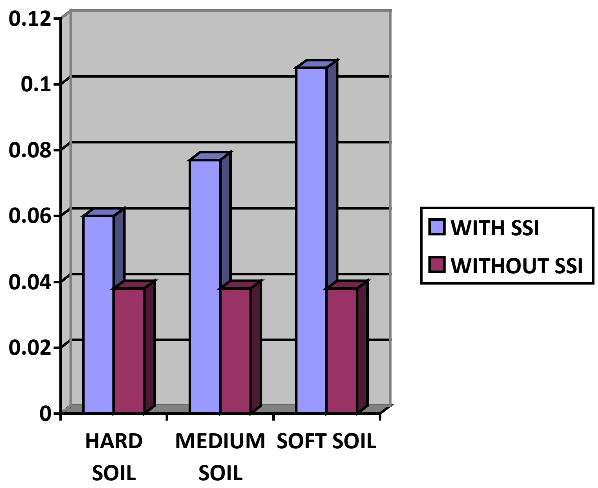

Chart -5: Performance point for 15 m height tank

4.2 analytical results for 18m height tank:

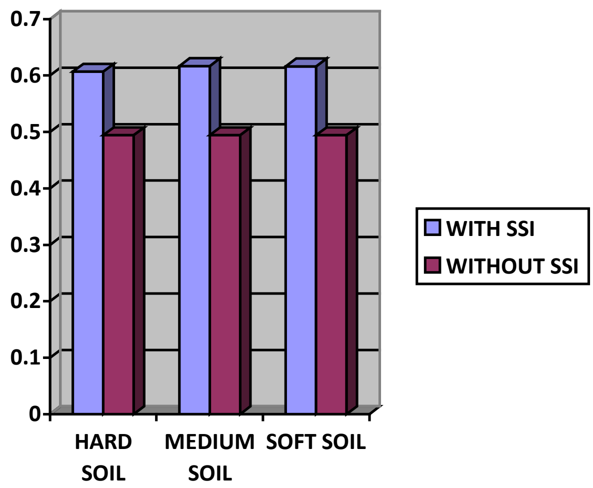

Chart -6: Time period for 18 m height tank

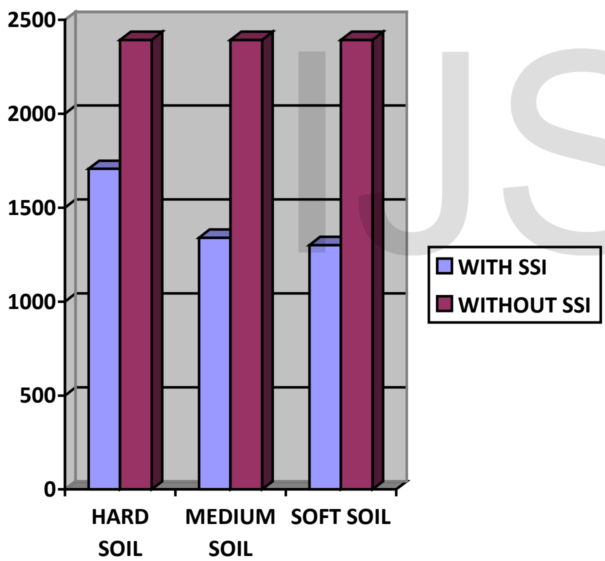

Chart -7: Base shear for 18 m height tank

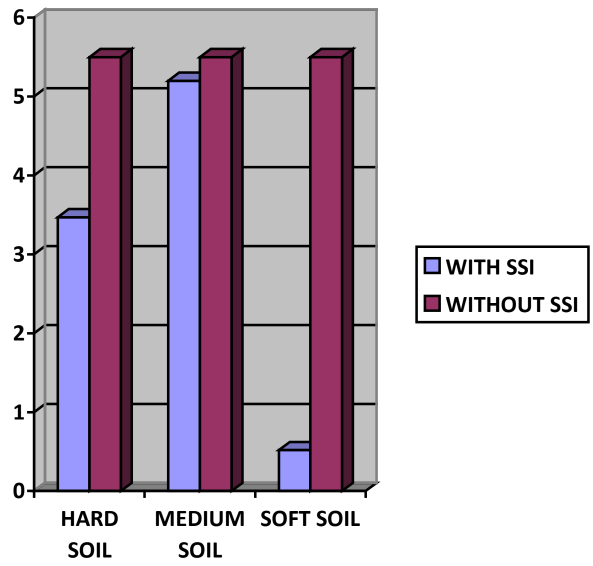

Chart -8: Response reduction factor for 18 m height tank

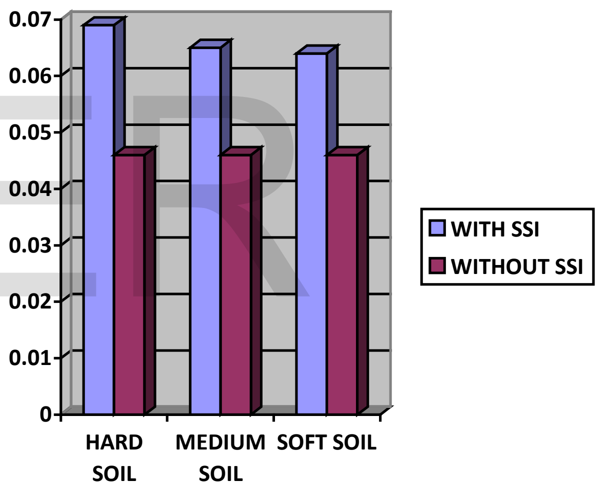

Chart -9: performance point factor for 18 m height tank

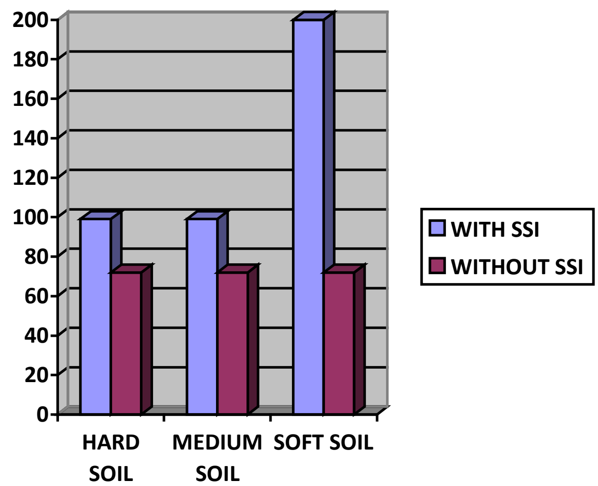

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Chart -10: Target displacement for 18 m height tank

4.3 analytical results for 21m height tank:

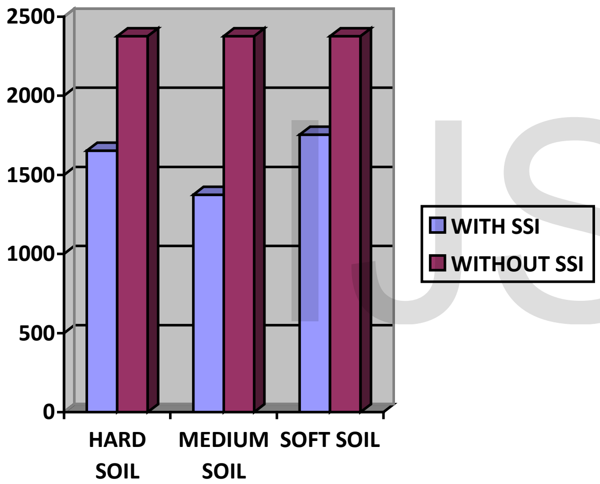

Chart -11: Base shear for 21 m height tank

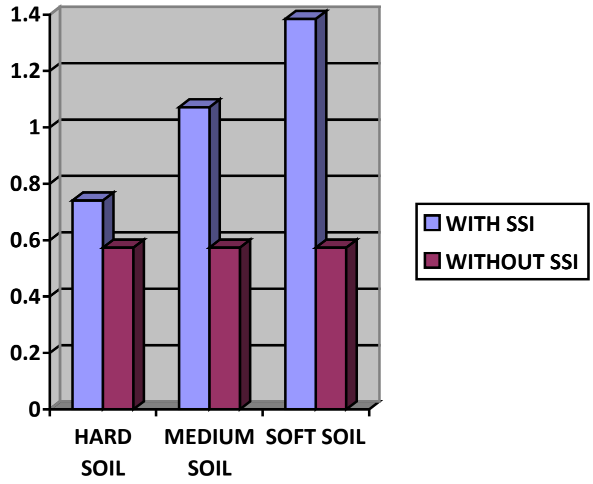

Chart -12: Time period for 21 m height tank

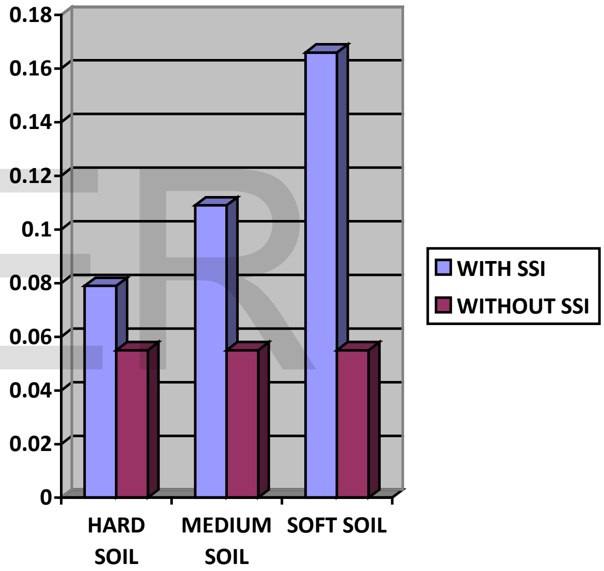

Chart -13: performance point for 21 m height tank

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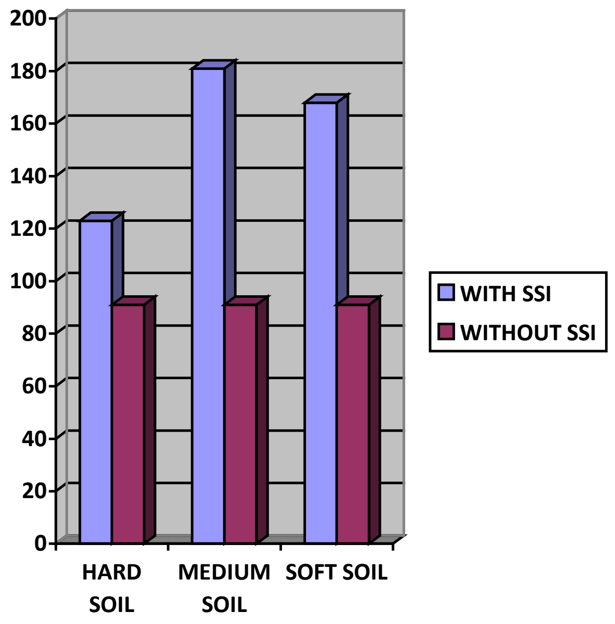

Chart -14: Target displacement for 21 m height tank

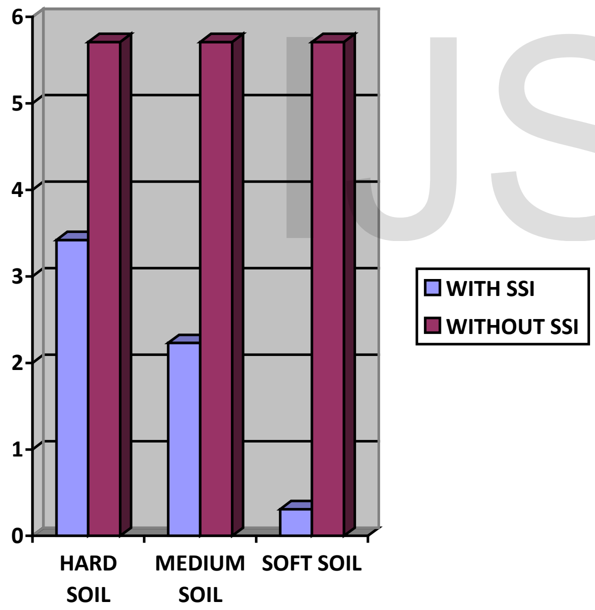

Chart -15: Response reduction factor for 21 m height tank

Fig -1: Existing water tank at Bhuj

After performing a nonlinear static pushover analysis we came to know that to performing a pushover analysis on the shaft staging tank is very difficult and when it is necessary to include the soil flexibility effect during the analysis then a spring support has to be assigned instead of fixed support.

3. CONCLUSIONS

From the above results significant outcomes of present study are summarized as follows:

1. The response reduction factor is decreases while time period is increases from fixed base to flexible base and maximum time period achieved in the soft soil. So it can observed that avoidance of soil flexibility effect might lead to mistaken and poor results of RC frame structures.

2. The values of response reduction factor decreases when the height is increases for the flexible base and it will goes beyond the minus which shows that the building has become so flexible with more time period.

3. The values of base shear is decreases from fixed base to flexible base because of aggregation of time period at all.

4. The minimum value of response reduction factor is observed in soft soil so it can be conclude that avoidance of soil flexibility effect might lead to inappropriate ductile detailing.

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BIOGRAPHIES

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