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EFFECT OF STAGGING HEIGHT ON THE SEISMIC PERFORMANCE OF RC ELEVATED WATER TANK

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ABSTRACT

Elevated water tanks are integral part of lifeline facilities in any town/city. They are used to store water for various purposes like drinking, fire fighting, etc and are vulnerable in resisting earthquake forces due to presence of large mass on a slender staging.. Further, the supporting structures i.e. the staggings have been found to be extremely susceptible to earthquake forces, sometimes leading to collapse of water tanks. Bhuj earthquake is an epitome of this hazard. Further, in view of the limitations of IS 1893-part2 with respect to the international practice for seismic resistant design of water tanks, IITK-GSDMA has presented certain additional guidelines. This study is mainly focused in understanding the seismic behaviour and vulnerability of elevated reinforced concrete water tanks and supporting structures for various seismic intensities, soil conditions, staging heights etc. with respect to the provisions of IS1893 Part2 and guidelines proposed by IITK-GSDMA.

Finite element modelling and dynamic analysis of elevated water tanks has been performed using SAP2000. Since available earthquake data is not adequate, response spectrum analysis has been carried out to understand the seismic behaviour of water tanks. Further, Nonlinear static analysis has been performed to assess the ductility characteristics of the water tank for varying staging heights, for a given capacity of water tank (Empty and Full water level conditions). In this study Circular water tank has been chosen as a case study and analysed for staging heights 5, 8,11,14,17,20,23 & 26, for an interval of 3 meters.
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KEYWORDS: Elevated water tanks, Seismic, SAP2000, Response spectrum analysis, Nonlinear static analysis..

INTRODUCTION

Losses inflicted on modern buildings from recent earthquakes have shown the pressing need for investigation of the seismic safety of code-compliant buildings at various performance limit states. This need has stimulated significant research to develop methodologies for deriving fragility relationships, which are a key component in seismic loss assessment . The seismic vulnerability of a structure can be described as its susceptibility to damage by ground shaking of a given intensity. The aim of a vulnerability assessment is to obtain the probability of a given level of damage to a given building type due to a scenario earthquake. The level of damage is directly associated with deaths, injuries, economic losses. Damage functions are to be developed to assess the damage level for given level of earthquake. The outcome of vulnerability assessment can be used in loss estimation. Loss estimation is essential in disaster mitigation, emergency preparedness .

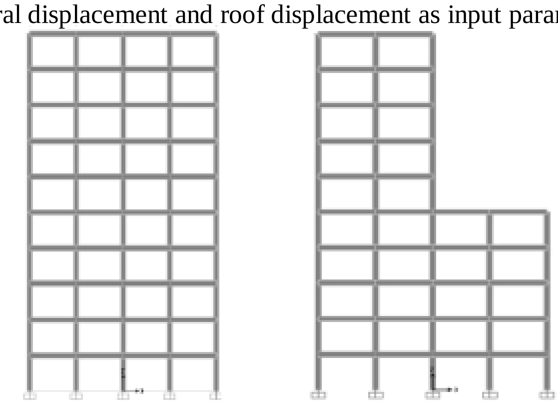
The aim of seismic performance of buildings is to estimate and depict the damage in structures due to a specified earthquake at a specific location. Various methodologies exist for estimating the seismic vulnerability and subsequent damage in seismic areas.The methodologies are used to develop various tools such as Damage probability matrices, vulnerability functions and fragility curves, from structural damages observed during earthquakes. A complete observed damage database would be necessary for developing such tools possible in high seismicity areas where post-earthquake surveys are available. In areas where the data is limited or incomplete, local expert opinion will be used to support observed data. Building modeling and non-linear structural analysis are other methods to stand in for the shortage of data. In areas without any available damage database, the information obtained in other similar areas was applied, but at the same time using an expert judgment. Accordingly, the probabilistic analysis of computer- generated structural responses, obtained by using nonlinear analysis procedures of representative buildings, has provided fragility functions .

The present study focuses on seismic performance evaluation in various regular and vertical setback RC buildings located on zone V seismically high intensity area. Response spectrum analysis has been performed for these buildings due to lack of previous earthquake data. Response spectrum data in IS 1893:2002 has been considered for RC buildings situated on hard soil and belongs to zone V

METHODOLOGY

Seismic Fragility Analysis of 10 Story Regular Bare Frame and Vertical Setback Frame

The seismic fragility analysis of 10-storey regular bare frame and vertical setback frame is performed and damage probability matrix is developed. Each fragility curve is defined by a median value of the demand parameter (e.g., spectral displacement, roof displacement, PGA) that corresponds to the threshold of that damage state and by the variability associated with that damage state. The damage state variability values are taken from HAZUS for C1H, high code design structure. The fragility curves can be developed for varied input parameters representing the damage state (Spectral displacement, roof displacement, Spectral acceleration, Peak ground acceleration). Here the fragility curves are developed for spectral displacement and roof displacement as input parameter.

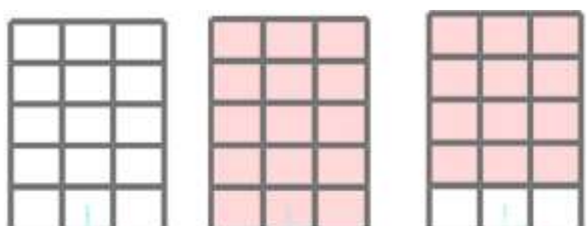


(a) **(b)**

Figure 2.1 Modelling in SAP2000: (a) Regular 10 SBF (b) Vertical setback of 10 SBF

Seismic Fragility Analysis of 5 Storey Buildings with and without Infill walls

Three models were used to differentiate the effect of infill walls on seismic fragility analysis results. Three models are developed in SAP2000 of equal storey heights and bay widths. For all these models pushover analysis is carried out and the fragility curves are drawn for different damage states (i.e.., slight, moderate, extensive and collapse). In first model there is no infill material it is simply bare frame denoted as SBF. In Second model infill is provided in every storey denoted by SIF1. In third model infill is not provided in ground storey and denoted by SIF2. All these models are clearly shown in figure 2.2



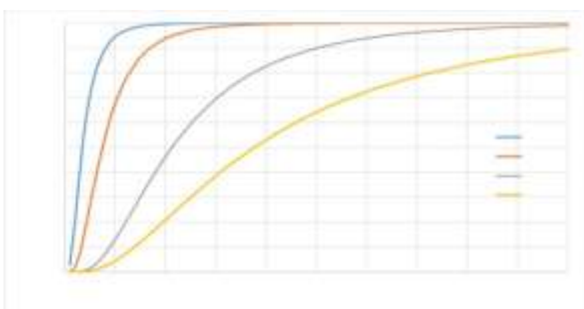
(I) SBF **(II) SIF 1** **(III) SIF 2**

Figure 2.2 SAP models showing with and without infill walls

RESULTS AND DISCUSSIONS

For these buildings modal analysis were carried out and the Modal characteristics of regular and setback buildings are as shown in table 3.1

	Regular Building			Vertical Setback building		
Mode No. Unitless	Period Sec	UX Unitless	UY Unitless	Period Sec	UX Unitless	UY Unitless
1	0.734	0.792	2.348E-11	0.676	0	0.553
2	0.734	2.348E-11	0.792	0.634	0.707	1.83E-20
3	0.678	7.193E-20	4.583E-20	0.495	0	0.168
4	0.239	0.098	0.001	0.264	2.849 E-19	0.100
5	0.239	0.001	0.098	0.263	0.154	1.021E-17
6	0.222	5.568E-18	6.703E-18	0.234	1.498 E-19	0.042
7	0.136	0.033	0.002	0.135	0.042	2.048E-16
8	0.136	0.002	0.033	0.132	3.042 E-17	0.034
9				0.121	1.582 E-16	0.008
Total	-	0.927	0.927	-	0.904	0.907



Graph 3.1 Seismic fragility curves for regular 10 SBF in terms of spectral displacement

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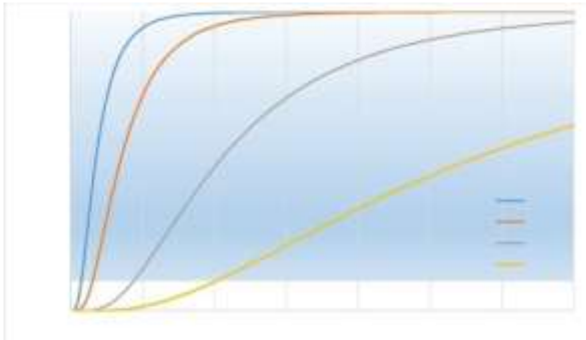
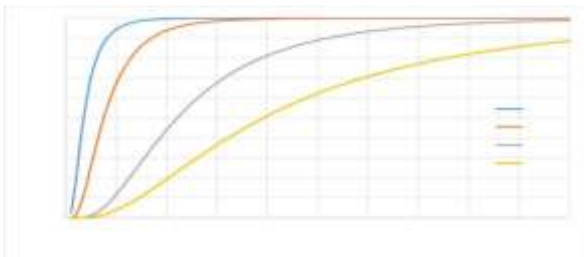
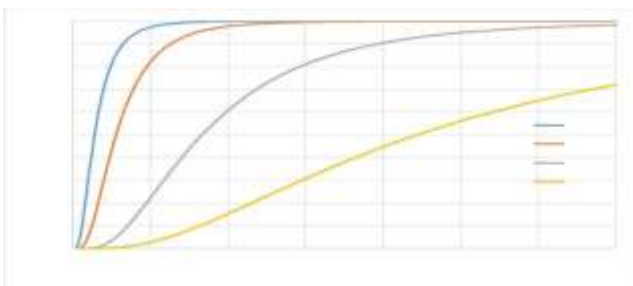


Graph 3.2 Seismic fragility curves for regular 10 SBF in terms of roof displacement



Graph 3.3 Seismic fragility curves for vertical setback 10 SBF in terms of spectral displacement



Graph 3.4 Seismic fragility curves for vertical setback 10 SBF in terms of roof displacement

Modal analysis is carried out for three buildings (i.e.., SBF, SIF1 and SIF2) and their results were shown in table 3.2

Mode no.	SBF			SIF1			SIF 2		
	Period Sec	**UX** Unitless	**UY** Unitless	**Period** Sec	**UX** Unitless	**UY** Unitless	**Period** Sec	**UX** Unitless	**UY** Unitless
1	0.357	0.614	0.357	0.186	0.753	0	0.257	0.917	0

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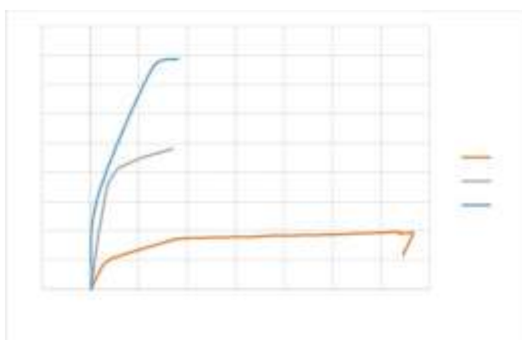
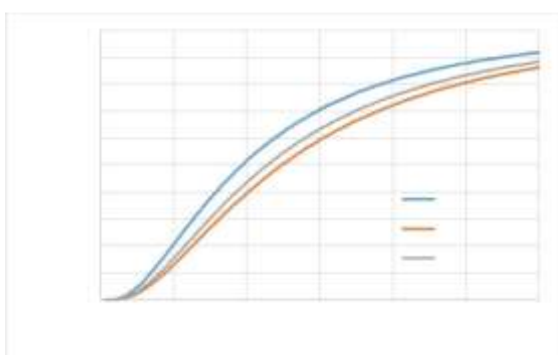
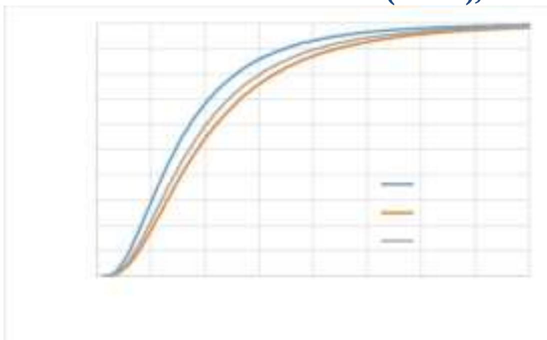
2	0.357	0.162	0.357	0.186	0	0.753	0.257	0	0.917
3	0.328	0.009	0.328	0.135	0	0	0.231	0	0
4	0.112	0.001	0.112	0.057	0.143	0.026			
5	0.111	0.098	0.111	0.057	0.026	0.143			
6	0.103	0.001	0.103						
7	0.069	0	0.069						
8	0.061	0	0.061						
9	0.061	0.041	0						
Total	-	0.931	0.932	-	0.923	0.923	-	0.917	0.917



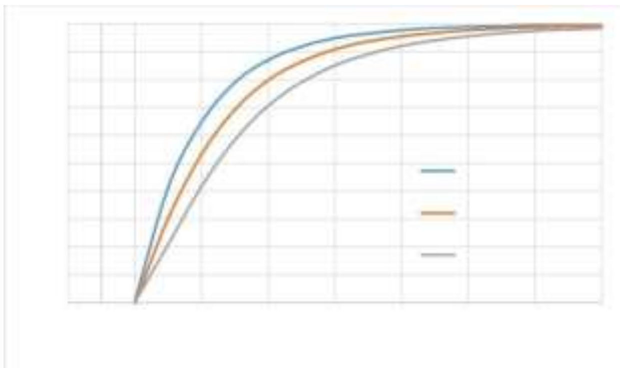
Graph 3.5 Comparison of capacity curves with and without infill walls



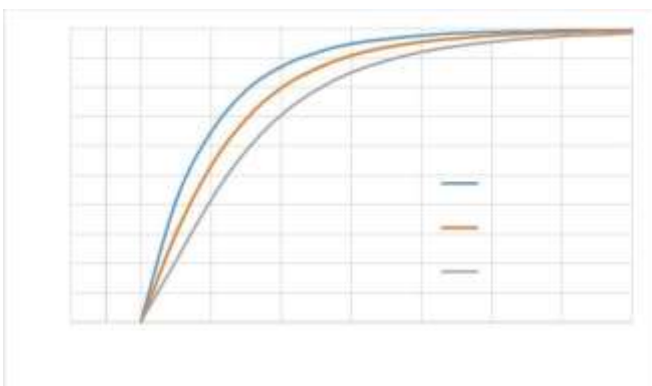
Graph 3.6Comparision of fragility curves of collapse damage state for buildings with and without infill walls



Graph 3.7 Comparison of fragility curves of extensive damage state for buildings with and without infill walls



Graph 3.8 Comparison of fragility curves of moderate damage state for buildings with and without infill walls



Graph 3.9 Comparison of fragility curves of slight damage state for buildings with and without infill walls

CONCLUSIONS

1. The regular RC buildings located on soft soils have been found more vulnerable when compared to medium and hard soils due to amplification of waves in soft soil.
2. The probability of damage in RC buildings is found to be high when setbacks were introduced at middle storey compared with RC buildings with setbacks at other stories.
3. Also it is observed that setbacks introduced at middle storey of RC buildings the probability of damage is 20% more than the RC buildings without infills.
4. Further it can be observed that RC buildings with infill walls are seismically more resistant than RC buildings without infill walls for all damage states.

5. The seismic resistance of the setback buildings having setback at middle storey can be improved similar to that of regular RC building by providing infill to the setback walls.

REFERENCES

1. Alexandra Papailia.,(2011). "Seismic fragility curves for reinforced concrete buildings", *M.Tech Dissertation*, University of Patras, Greece.
2. Applied Technology Council, (1996). "Recommended methodology for seismic evaluation and retrofitting of buildings." *ReportNo.ATC-40*, Redwood City, California.
3. Barbat A.H.,LagomarsinoS.,andPujades L.G.,(2002). "Vulnerability assessment of dwelling buildings".projects,REN 2001-2418-C04-01 and REN2002-03365/RIES UniversitatPolitdecnicadeCatalunya, Barcelona, Spain, University of Genoa, Italy.
4. Barbat A. H., Pujades L.G., and Lantada N., (2008).Seismic" damage evaluation in urban areas using capacity spectrum method: Application to Barcelona".*Soil dynamics and EarthquakeEngineering*,28,851-865.
5. Bureau of Indian Standards. (2000). "Plain and Reinforced Concrete –Code of Practice *IS456:2000*.,"New Delhi.
6. Bureau of Indian Standards. (2002). "Criteria for Earthquake Resistant Design of Structures *IS1893(Part.I):2002*", New Delhi.
7. Chopra A.K., (2007). "Dynamics of Structures-Theory and Application to Earthquake Engineering", Prentice Hall, New Jersey.
8. Chopra, A.K. and Goel, R.K. (2002). "A modal pushover analysis procedure to estimate seismic demands for buildings," Earthquake Engineering and Structural Dynamics,31,561-582.
9. Federal Emergency Management Agency. (1997). "NEHRP guidelines for the seismic rehabilitation of buildings" *Report No. FEMA 273*, Washington, D. C.
10. Federal Emergency Management Agency. (2000). "Prestandard and commentary for the seismic rehabilitation of buildings." *Report No. FEMA 356*, Washington, D. C.

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