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Comparative study on Seismic fragility analysis of RCC building in different soil conditions

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Abstract: Human and economic losses due to natural calamities that occurred in past many decades increased the researchers concern to revaluate the building stock to decrease these casualties. After experiencing few vulnerable earthquakes seismic evaluation of structure has become vital even post-earthquake assessment are emphasized. This study will cover an approach to assess a seismic vulnerability of earthquake. Seismic fragility curves are developed based on nonlinear dynamic analysis considering appropriate failure mechanisms. Seismic fragility curves are used mainly by decision makers for the assessment of seismic losses both for pre-earthquake disaster planning as well as post-earthquake recovery programs. Fragility curves - show the probability of failure versus peak ground acceleration. The primary motivation of seismic fragility assessment is to obtain an estimate of the probability of exceedance of a given damage level in a building due to a seismic hazard to predict its vulnerability. Seismic behaviour of structure that is built on soft soils is mainly influenced by the soil properties, and the structural response is considerably different from the fixed base condition beholding to the interaction between the structures and the ground.

Keywords: Fragility curves, seismic parameters, Pushover analysis, Seismic Vulnerability.

I. Introduction

The seismic vulnerability assessment of R/C buildings is extremely important in the mitigation of the earthquake effects, in order to reduce their consequences. Fragility analysis is an exercise to determine the damage thresholds which usually are classified as slight, moderate, extensive and collapse on some prefixed performance levels. Probabilities of exceeding a particular damage level plotted against damage measure provide the fragility curve. Seismic fragility curves are developed based on nonlinear dynamic analysis considering appropriate failure mechanisms. Probabilities of exceeding a particular damage level plotted against damage measure provide the fragility curve. These curves are of immense help in assessing structural safety or probable seismic damages. Seismic behavior of structure that is built on soft soils is mainly influenced by the soil properties, and the structural response is considerably different from the fixed base condition beholding to the interaction between the structures and the ground.

II. Data of Building & Model Generation

Story no	4	Steel	Fe415
Storey height	3.5m Ground, 3m rest all	Live load	2.5 kN/m2
Bay width	4m in both X & Y	Roof Live load	3 kN/m2
No. of Bay	5 in X and 4 in Y	FF	0.75 kN/m2
Beam	250 x450 mm	Wall Load	15 kN/m
Column	400 x400 mm	Partition Wall Load	7.8 kN/m
Slab	150mm thick	Parapet Wall Load	5.75 kN/m
Concrete	M25	Earthquake load	As per IS-1893 (Part 1) – 2016

For consideration of soil parameters we take 5 different types soil which are soft soil, medium soil, stiff soil, very stiff soil, hard soil.

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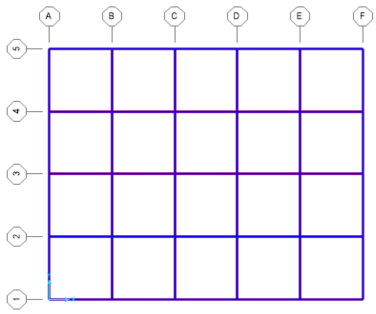
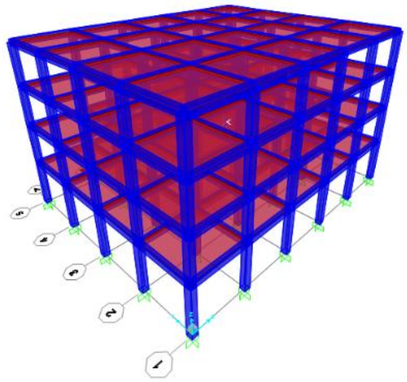
III. MODELLING & RESULT



Plan



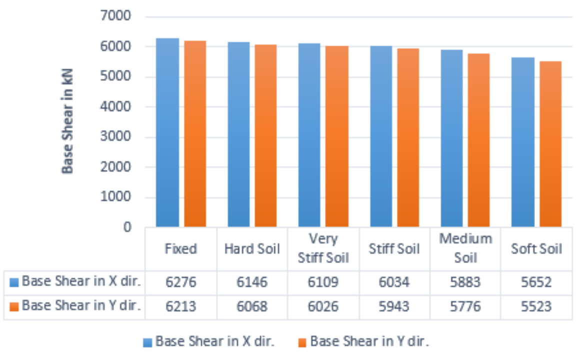
3D view

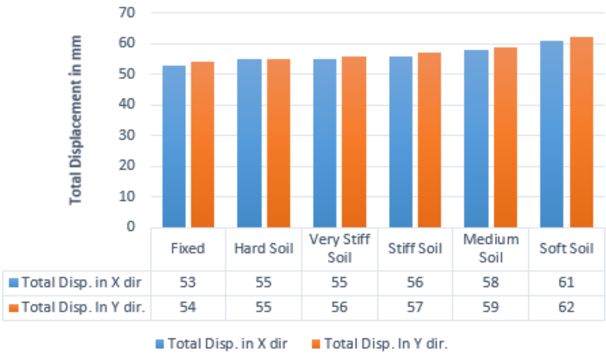
To take the effect of Soil condition into account in analysis, these buildings are considered to be supported by raft foundations. Soil springs are considered to represent the soil medium below the foundation. •To obtain the values of stiffness of the springs for varieties of clayey soil, values of shear modulus (G) of soil have been estimated following the empirical relationship G= 120*N^0.8 (T/ft2) (Ohsaki and Ishwaki ,1973), where N is the number of blows to be applied in Standard Penetration Test (SPT) of the soil and Poisson's ratio (μ)of soil has been taken to be equal to 0.5 for all types of clay (IS 5249:1992, 1992),and Stiffness can calculate by Gazetas (1991) formula given in FEMA code.

N is taken as 3, 6, 12, 2 and 28 for soft, medium, stiff; very stiff and hard soil, respectively.

Soil Type	N value	G (Shear Modulas)	Kx (kN/m)	Ky (kN/m)	Kz (kN/m)	Krx (kN*m/rad)	Kry (kN*m/rad)	Krz (kN*m/rad)
Soft Soil	3	288.99	30425.13	31349.89	46993.47	10281117	15054888	14066394
Medium Soil	6	503.16	52973.23	54583.33	81820.39	17900463.93	26212082.63	24491014.52
Stiff Soil	12	876.04	92231.76	95035.1	142457.57	31166517.91	45637886.6	42641332.96
Very Stiff Soil	20	1318.27	138790.42	143008.89	214370.26	46899399.61	68675926.1	64166709.93
Hard Soil	28	1725.47	181661.09	187182.59	280586.63	61386053.22	89889083.65	83987025.5

Pushover Result:
From the push over analysis we get performance point in terms of Base Shear force and Total Displacements





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Deriving Fragility Curve:

In the present study, the capacity spectrum method is used to evaluate the probable vulnerability of the buildings. Fragility curves are developed using the procedure mentioned in HAZUS for all the cases considered in this study. The probability of being in or exceeding a given damage state is modelled as a cumulative lognormal distribution. For structural damage, given the spectral displacement, Sd, the probability of being in or exceeding a damage state, ds, is modelled as:

$$P[ds|S_d] = \Phi\left[\frac{1}{\beta_{ds}}\ln\left(\frac{S_d}{\bar{S}_{d,ds}}\right)\right]$$

$\bar{S}_{d,ds}$ is the median value of spectral displacement at which the building reaches the threshold of damage state, ds,

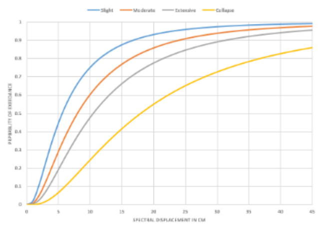
βds is the standard deviation of the natural logarithm of spectral displacement for damage state, ds, and

Φ is the standard normal cumulative distribution function.

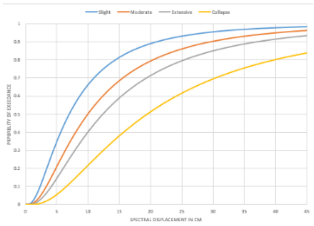
Damage states	Spectral displacements (sd,ds)
Slight	0.7Dy
Moderate	Dy
Extensive	Dy + 0.25(Du-Dy)
Collapse	Du

Fragility Curve

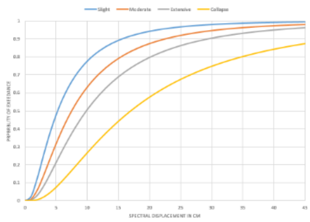
Building fragility curves are lognormal functions that describe the probability of reaching, or exceeding, structural and non-structural damage states, given median estimates of spectral displacement



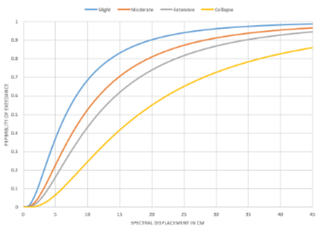
Fragility curve for Rigid Support condition in X dir.



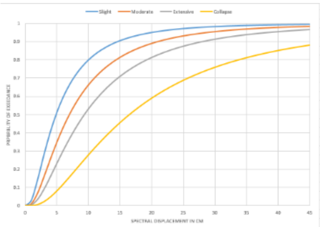
Fragility curve for Rigid Support condition in Y dir.



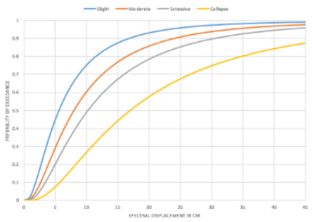
Fragility curve for Hard Soil condition in X dir.



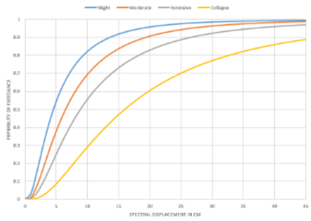
Fragility curve for Hard Soil condition in Y dir.



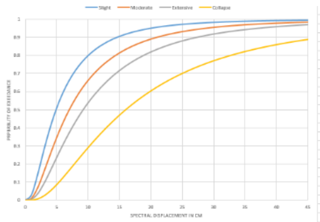
Fragility curve for Very Stiff soil condition in X dir.



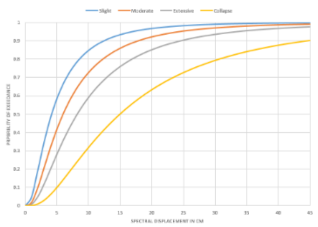
Fragility curve for Very stiff soil in Y dir.



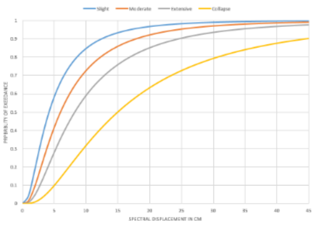
Fragility curve for Stiff soil condition in X dir.



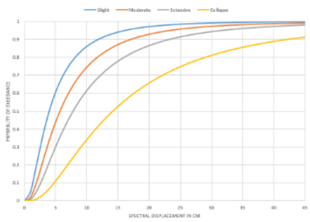
Fragility curve for Stiff soil condition in Y dir.



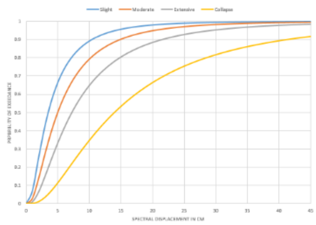
Fragility curve for Medium soil condition in X dir.



Fragility curve for Medium soil condition in Y dir.



Fragility curve for Soft soil condition in X dir.



Fragility curve for Soft soil condition in Y dir.

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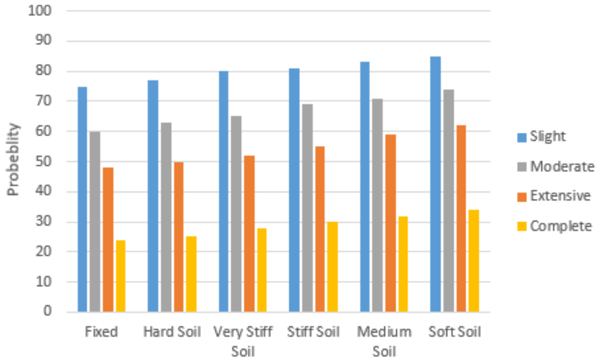
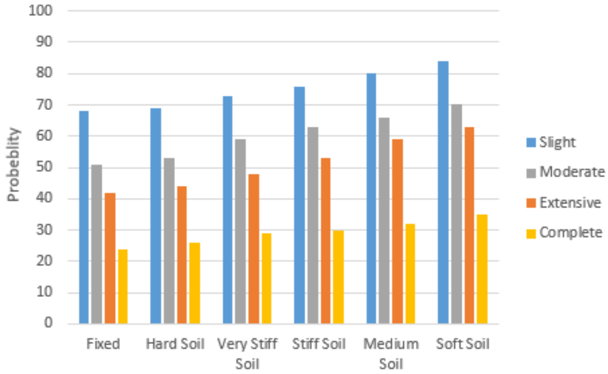
Fragility Curve Comparison

Here we are comparing Results from the plotted fragility curves of probability for 100mm Spectral Displacement.



Fragility curve Comparison in X dir.



Fragility curve Comparison in Y dir.

IV. CONCLUSION

From Pushover Curve comparison, it is observed that the Capacity of building decrease with decrease in soil stiffness and the difference observed between Rigid support condition and soft is within 10% and 11% in X and Y Direction respectively. The total displacement at performance Point is approximately 15% increase with decrease in soil stiffness in both direction. The probability of failure also increase with decrease in soil stiffness for all 4 damage state in both direction. The results represented in fragility analysis show that consideration of the Soil stiffness effects induces a higher fragility than that of the fixed-base models. So soil condition degrades from hard to soft, the vulnerability to seismic threat increases. Therefore, the Soil effects should not be neglected in the structural fragility analysis.

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