CONSOLIDATION OF STRUCTURE DUE TO SEISMIC BEHAVIOUR OF SOIL

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Abstract : Now a days all the structure around the world is designed considering permissible settlement of structure throughout its life span. But according to intensity of earthquake settlement of structure may exceed permissible settlement so the structure damages. Depending on the various data available in past earthquake zone are classified. In India in past few years earthquake has increased drastically causing various damages. Depending on intensity of earthquake damages occurs Also with variation in type of soil the amount of consolidation changes so it is important to test all the properties of soil before making any structure. Our project is about understanding how the consolidation of structure will vary with varying intensity of earthquake. In Mumbai, Bhayander area which comes under the ZONE-2 of earthquake zone. We designed the model of existing building of Bhayander area in ETABS software and we have analyzed its consolidation in SAFE software. We have tested the model with varying intensity of earthquake, then depending on results obtained from our studies we have given the control measures that can be adopted for reducing the settlement of structure.

Index Terms **- Permissible settlement, ETABS, SAFE.**

I. INTRODUCTION

A. BACKGROUND

In past few years no of earthquakes in India has increased drastically. Depending on intensity of earthquake the damage to structure changes. According to geographical statistics of India almost 54% of Indian land is vulnerable to earthquakes. Depending on the various data available in past earthquake zone are classified.

If the intensity of earthquake is 2.5 or less than this intensity earthquake doesn't affects the structure. The estimated quantity of this intensity of earthquake in a year is 900000. If the intensity of earthquake is between 2.5 to 5.4 this intensity earthquake often felt, but only causes minor damage. The estimated quantity of this intensity of earthquake in a year is30,000. If the intensity of earthquake is between 5.5 to 6 it slightly damages the structures. The estimated quantity of this intensity of earthquake in a year is 500. If the intensity of earthquake is between 6.1 to 6.9 it may cause a lot of damages in very populated area. The estimated quantity of this intensity of earthquake in a year is 100. If the intensity of earthquake is between 7.0 to 7.9 it seriously damages the structures. The estimated quantity of this intensity of earthquake in a year is 20. If the intensity of earthquake is 8 or more than 8 then it is major earthquake which occurs only once or twice in 5 to 10 years. Below is the table showing zone and intensity of earthquake in India.

Table 1.1 zones and intensity of earthquakes in India

Seismic zone	Intensity onMMI scale	% of Total Area
2 (Low Intensity Zone)	6 (or less)	43%
3 (Moderate Intensity Zone)	7	27%
4 (Severe Intensity Zone)	8	18%
5 (Very Severe Intensity Zone)	9 (and above)	12%

II. CONSOLIDATION OF SOIL

According to Karl Von Terzaghi "consolidation is any process which involves the decrease in water content of saturated soil without replacement of water by air". There are two types of consolidation, 1. Primary consolidation, 2. Secondary consolidation. Primary consolidation is reduction in volume of soil with removal of water. Secondary consolidation occurs by plastic rearrangement of soil particle with passage of time. The magnitude of consolidation can be measured by classical method given by Terzaghi i.e. Odometer test. Consolidation process can be explained by spring analogy. It is assumed that consolidation will take place only in one direction. Consolidation of structure depends on types of soil. With change in state the type of soil in India changes below is the graph showing different types of soil present in different parts of India.

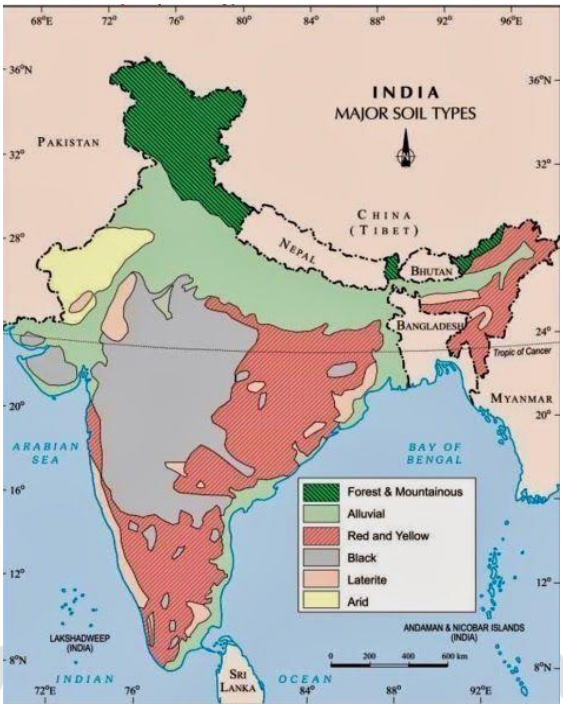


Figure (1) different types of soil in India

III. BEHAVIOUR OF SOIL UNDER SEISMIC ACTIVITY

Depending upon types of soil structure behave differently under seismic activity. If the intensity of earth quake is between 5.5 to 6, this intensity earth quake settles the structure or it develops the crack in the structure but it does not harm the structure severely. Our area of study is in zone 2 with variation in types of soil the amount of settlement will vary. Different types of strata like hard, medium, soft strata exist inside the ground with variation of strata the settlement of structure changes it has been found that in previous studies with change of soil strata from hard to medium and from hard to soft deflection has increased by 53.33% and 60.25% respectively. From change of soil strata from hard to medium and from hard to soft the base shear has increased by 26.85% and 43.25% respectively for flexible bases below is the graph showing different earthquake zones in India.

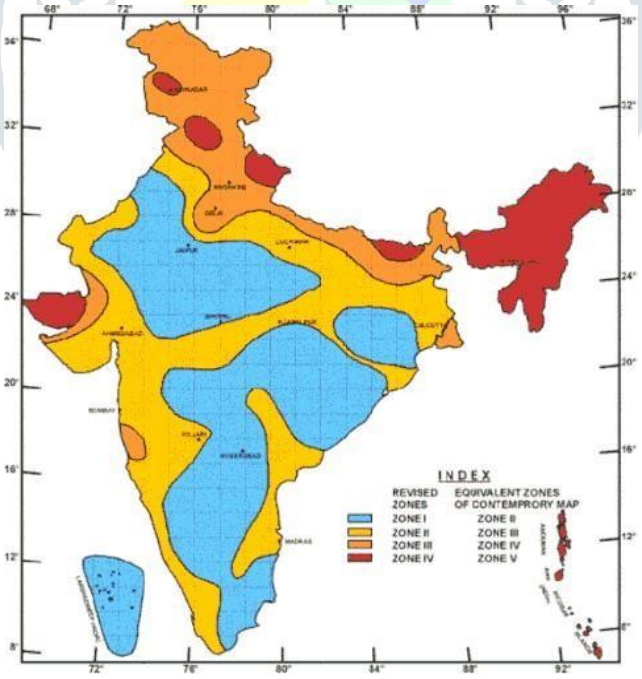


Figure (2) seismic zones in India

IV. METHODOLOGY

4.1 Soil Testing

We have taken a case study of the existing building located in Mira Road (Mumbai). We collected around 30 kg of soil sample including ground surface soil and below ground surface soil. At the site they have prepared the borehole for testing BH-1, BH-2, BH-3 and they have excavated the soil till 15 m of depth they have performed various tests on the sample collected from each Borehole according to their testing they have found that any building of G+7 and above can be created by excavating till 7.5 m depth. We have collected the sample from BH-1 for testing and comparing theirs laboratory results with our laboratory results.

Table 4.1 test results

Tests	Test at site lab	Test at our laboratory
Crushing load(kg)	2400	2430
UCS	110.10	112.30
Water absorption(%)	2.40	2.38
Porosity	6.53	6.52
Dry Density	2.07	2.21
Rock type	breccia	breccia
H/D	1.94	1.94
Height(cm)	10.20	10.20
Diameter (cm)	5.25	5.25

4.2 Model Testing and Analysis in ETABS

We have collected the site plans, floor plans, beam and column sizes foundation details from site office and we have designed the building in ETABS to calculate its total load acting on a soil.

DATA COLLECTED

G+4 story building with 2.9 m floor to floor height.

1.5 m height from base of foundation to ground story

Beams & columns sizes:

BEAMS- 260mm*450mm

COLUMNS - 250mm*350mm

Slab thickness- 160mm

Wall thickness - 230 mm

FOUNDATION DETAILS

Raft foundation of 2.5 m at 1.5 m below the ground level.

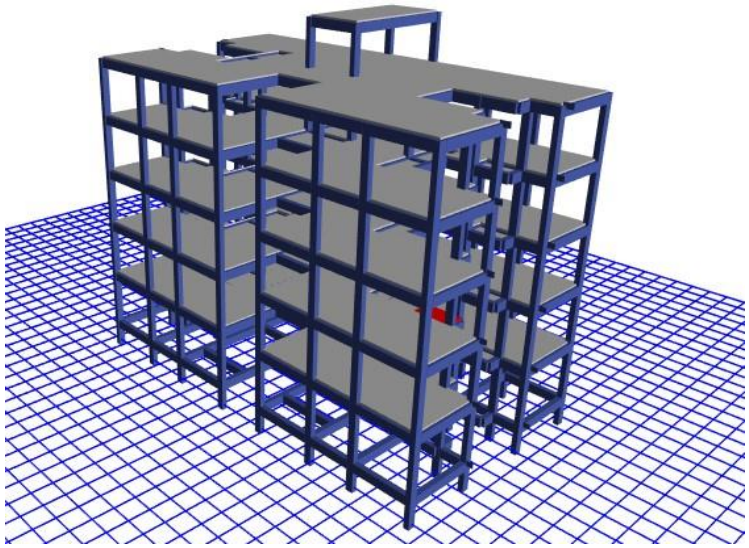


Figure (3)

1.We applied various loading parameters like dead load, live load and earthquake load as per the zone and their various combinations as per IS 456:2000 in ETABS.

2.We analysed the structure and made sure that structure is safe for all those loads.

3.We found the reactions coming on all columns in ETABS.

4.We design the raft foundation in SAFE Software.

5.We import the column reaction from ETABS and SAFE.

6.As per soil properties we have already determined in laboratory we put that in SAFE and found out that our model is safe for design.

7.By putting the depth of soil strata below footing in SAFE.

8.The settlement of structure due the seismic load reaction in SAFE are analysed.

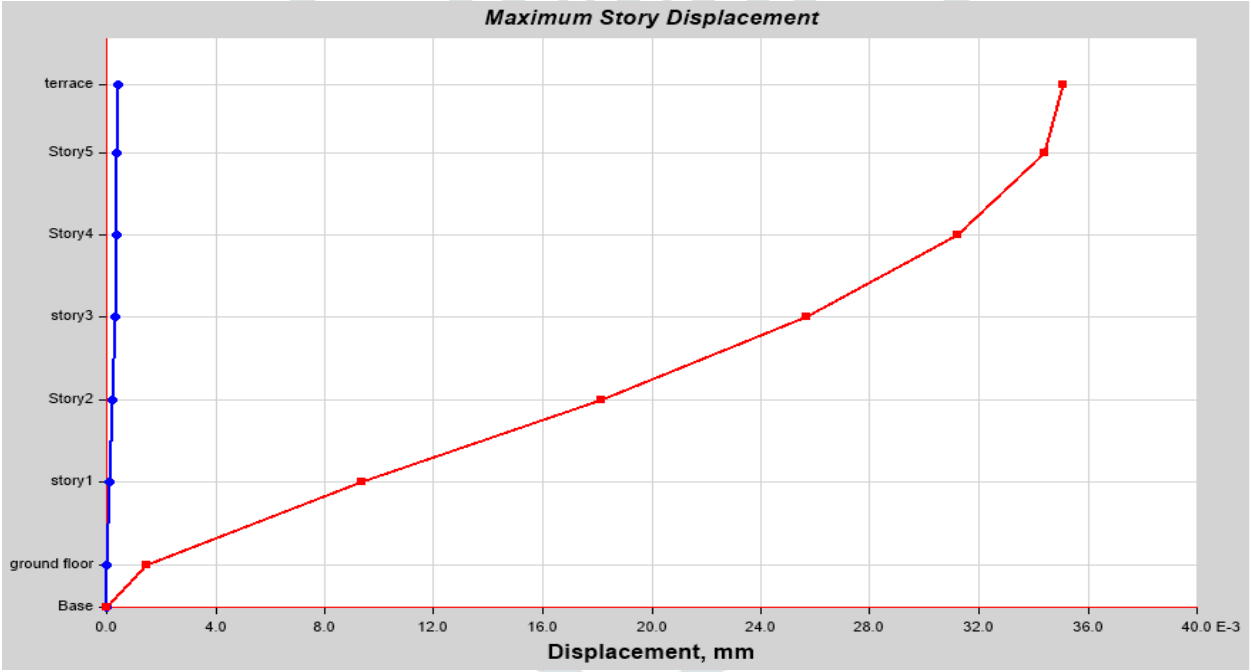
9.In SAFE we have provided the Raft foundation of 250 mm.

Table 4.2 loads applied

Name	Type	Self-weight Multiplier	Auto Load
Dead	Dead	1	
Live	Live	0	
Masonry	Superimposed load	0	
Parapet	Superimposed load	0	
Internal walls	Superimposed load	0	
Stair wall	Superimposed load	0	
Point	Other	0	
Ex	Seismic	0	IS 1893 2002
Ey	Seismic	0	IS 1893 2002

V. RESULTS AND DISCUSSION

5.1 Graph of displacement of stories



5.2 Base Reaction

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m	X m	Y m	Z m
Dead	0	0	8971.9755	46095.7861	-87964.2331	0	0	0	0
Live	0	0	1775.9367	8970.4418	-17413.0593	0	0	0	0
masonry	0	0	7316.8	40387.084	-71679.68	0	0	0	0
parapet	0	0	759.118	4190.16	-7436.7668	0	0	0	0
internal walls	0	0	4660.84	22641.2565	-45699.5362	0	0	0	0
stairwall	0	0	210.41	558.6386	-2063.07	0	0	0	0
point	0	0	100	265.5	-980.5	0	0	0	0
Ex	-212.9951	0	0	0	-2741.0403	1181.051	0	0	0
Ey 1	-212.9951	0	0	0	-2741.0403	1100.2917	0	0	0
Ey 2	0	-159.2068	0	2048.8363	0	-1672.0354	0	0	0
Comb1	0	0	35542.6204	184265.0505	-348385	0	0	0	0
Comb2	-255.5941	0	28434.0963	147412.0404	-281997	1417.2612	0	0	0
Comb3	255.5941	0	28434.0963	147412.0404	-275418	-1417.2612	0	0	0
Comb4 Max	0	0	28434.0963	149870.644	-278708	1320.3501	0	0	0
Comb4 Min	-255.5941	-191.0481	28434.0963	147412.0404	-281997	-2006.4425	0	0	0
Comb5 Max	255.5941	191.0481	28434.0963	147412.0404	-275418	2006.4425	0	0	0
Comb5 Min	0	0	28434.0963	144953.4368	-278708	-1320.3501	0	0	0
Comb6	-319.4927	0	32878.7153	170809.3877	-326376	1771.5764	0	0	0
Comb7	319.4927	0	32878.7153	170809.3877	-318153	-1771.5764	0	0	0
Comb8 Max	0	0	32878.7153	173882.6422	-322265	1650.4376	0	0	0
Comb8 Min	-319.4927	-238.8101	32878.7153	170809.3877	-326376	-2508.0531	0	0	0
Comb9 Max	0	0	32878.7153	173882.6422	-322265	1650.4376	0	0	0
Comb9 Min	-319.4927	-238.8101	32878.7153	170809.3877	-326376	-2508.0531	0	0	0
Comb10 Max	319.4927	191.0481	35542.6204	184265.0505	-275418	2006.4425	0	0	0
Comb10 Min	-319.4927	-238.8101	28434.0963	144953.4368	-348385	-2508.0531	0	0	0

5.3 Discussion

1. The building was designed for the permissible settlement of 40mm and by safe we obtain the settlement to be 35mm.As settlement of a structure is less than permissible settlement and hence the structure is safe against seismic load.
2. We can reduce the settlement of structure by extracting the water from soil thereby reducing the water content of soil.
3. Use of Geosynthetic materials, retrofitting and other modern method to change the properties of soil and to prevent the settlement.
4. Compacting the soil in order to reduce the void and being the water content of soil up to the OMC before construction of structure.
5.Depending on the results we will give the necessary methods to be adopted for existing buildings.

VI. OUTCOME AND CONCLUSION

1.Settlement of structure at a time of earthquake of different intensities.
2.Intensity of damage to the structure with varying intensity of earthquake.
3.With change in soil properties how settlement of structure changes.
4. Prevention method of reducing the settlement of existing structure so increasing the life span of structures.

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