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RESPONSE SPECTRAM ANALYSIS OF HIGH RISE BUILDING IN DIFFERENT TYPES OF SOIL CONDITION

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Abstract - In urban areas, increase in population and scarcity of land, the horizontal development gets restricted that's why most of the owners, building contractors, engineers are adopting vertical development of buildings for the construction. Natural hazard like earthquake affects the stability of such structures. Therefore, it is need of time to analyses & designs such hazard resisting structures so as to save human life and avoid property damage. The behavior of a building during earthquakes depends critically on its overall shape, size and geometry. In this Study, a high rise reinforced concrete building has been modelled and performed by using software STAAD Pro V8i program with hard soil and soft soil and plane dimension (12X12) m with G+20 storeys resting on plan ground. The models have been conducted and analyzed by using response spectrum method for comparing and investigating the changes in structural behavior and the irregularity effect in plan.

Key Words: *Response Spectrum Analysis, peak story shear, base shear, time period*

1.INTRODUCTION

Earthquake causes the random ground motions in all directions, radiating from the epicenter. These ground motions causes structure to vibrate and induces inertia forces in them. For the structure to perform better during the earthquakes, it must be analyzed and designed as per the Indian seismic code IS 1893 (Part 1) 2016. In the past, several major earthquakes have exposed the shortcomings in buildings, which had caused them to damage or collapse. It has been found that regular shaped buildings perform better during earthquakes. Earthquakes causes ground to vibrate and structures supported on ground are subjected to this motion. Thus the dynamic loading on the structure during an earthquake is not an external loading, but due to motion of support. The building can be designed to resist earthquake with certain amount of damage, but without causing the collapse and affecting the livelihood. The response spectrum represents an interaction between ground acceleration and the structural system, by envelope of several different ground motion records. For the purpose of the seismic analysis the design spectrum given in fig.2 of IS 1893(Part 1): 2016 is used. Response spectrum analysis of the building model is performed using STAADPRO. The lateral loads generated by STAADPRO correspond to the seismic zone v and 5% damped response spectrum given in IS 1893 (Part1): 2016.

Response Spectrum Analysis

The response spectrum method (RSM) was introduced in 1932 in the doctoral dissertation of Maurice Anthony Biot at Caltech University. It is a scientific approach to estimate earthquake response of structures using waves and vibration mode shapes. The concept of the "response spectrum" was realistically put to use in design requirements only in the mid-20th century in building codes of various countries. The biggest computational advantage in using the response spectrum method of seismic analysis is the prediction of displacement and member forces in structural systems. The method comprises of calculation of only max values of the displacement and member forces in each mode using smooth design spectra that are the average of several earthquake motions

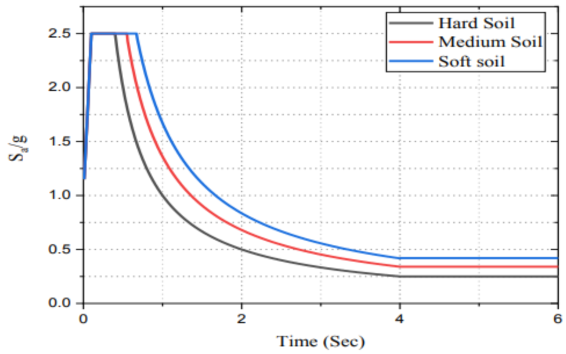

Figure 1. Design Response Spectrum for different soil (5% damping)

2.LITERATURE REVIEW

Sunil Rathore , Ankit Pal , Arvind Vishwakarma (2020) "This paper is based on the study of different research paper of different researchers which are used different soil types. On the bases of hard, medium and soft soil different researchers used in various building construction so that it get re action against the lateral loads. Based on the study it concluded that the maximum researcher is worked on the medium soil taken as a reference. The maximum amounts of research are earthquake basis in it and few are also wind parameter basis. Under building design somehow focused on the grade of concrete. The stability is more in hard soil and moderate in medium soil and the foundation adoptability is more required in soft soil"

Vinay K. Gupta, (2002) "This article comprises of a review of alternative strategies which have been developed over the course of time since 1970's to give realistic estimates of response peaks, while continuing to use the information available through response spectrum. These methods have the convenience of being applied in a different situations, do not usually suffer from the inaccuracies associated with the use of modal combination rules, and present state-of-the-art methodology in linear seismic response analysis. The limitations of various formulations proposed under these methods are identified, and future directions of required work are suggested."

M. Firoj and S. K. Singh (2008) "In this paper, a G+10 storied building was analyzed through the response spectrum analysis using three different computer software i.e. ETABS, STAD PRO and SAP2000. The displacements of joints, axial forces, time period and mass participating factors were studied. The design response spectrum curve suggested by the IS: 1893 Part-1 for seismic design is utilized to perform the dynamic analysis"

E. Hassaballa, Fathelrahman, M. Adam, M. A. Ismaeil (2013) " in this paper Seismic analysis of a multi-story RC frame in Khartoum city was analyzed under moderate earthquake loads as an application of seismic hazard, and in accordance with the seismic provisions proposed for Sudan to investigate the performance of existing buildings if exposed to seismic loads. The frame was analyzed using the response spectrum method to calculate the seismic displacements and stresses. The results obtained, clearly, show that the nodal displacements caused drifts in excess of approximately 2 to 3 times the allowable drifts."

3.OBJECTIVE

1. To determine dynamic response of multi-story building for earthquake load.

2. To study response spectrum analysis of regular multi story building using computer programs (STAADPRO).

4.METHODOLOGY

The STAADPRO software is used for modelling as well as analysis of the structure. A symmetrical plan of reinforced concrete structure having G+20 storeys is considered. First the Earthquake loads are considered as per IS 1893- 2016, Part-1 are applied for structure located in zone V. And response spectrum method of analysis is carried out for 5% damping and scale factor considered as per IS code in both X and Z directions. Assuming that material property is linear static and Response spectrum analysis is performed.

Loadings and material properties M25 grade of concrete and Fe 500 grade of Steel are used for all slabs and beams of the building whereas M30 is used for columns with same grade of Steel. Elastic material properties of these materials are taken as per IS 456- 2000. The short-term modulus of elasticity (EC) of concrete is taken as

$$EC = 5000\sqrt{fck} \text{ Mpa}$$

fck =characteristic compressive strength of concrete cube For the Steel rebar with stress and modulus of elasticity is taken as per IS 456-2000. While applying the loads to the structure we consider only the external loads which are actually acting on the members neglecting its self-weight because STAADPRO automatically takes the members' self weight. The Seismic loads EQ X and EQ Z are given in Load patterns directly using Code IS1893:2016

Table1: Structural property of building

PARTICULAR OF ITEMS	PROPERTIES
Dimension of beam	400mmx400mm
Dimension of column	600mmx600mm
Thickness of Slab	125mm
Height of one story	3m
No of storey	G+20
Live Load	3kN/m2
Grade of reinforcing steel	Fe415
Grade of concrete	M25
Density of concrete	25kN/m3
Seismic Zone	V
Importance factor	1
Zone factor	0.36
Damping ratio	5%

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The MODEL of building is given below:-

1. G+20 Building .

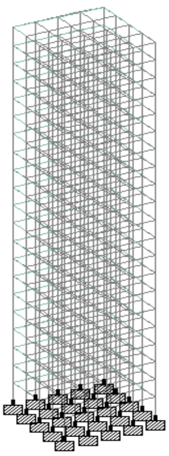

Figure 2: G+20 Structure

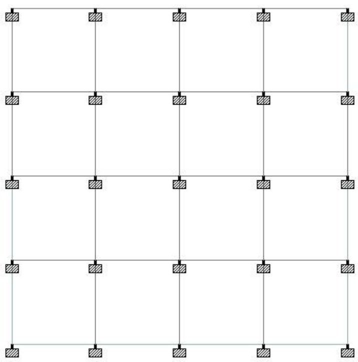

Figure 3: base plan view

5.Results

Result obtain from the analysis are recorded for the different type of soil . And for the three different parameters the graphs are plotted:

Base Shear :

1. In X Direction

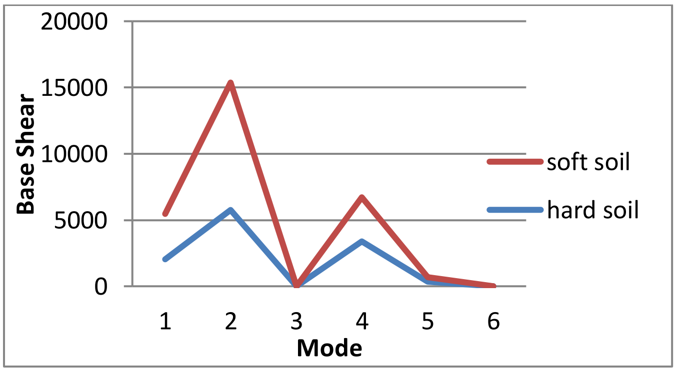

Figure 4: Base Shear in X direction

2. In Z Direction

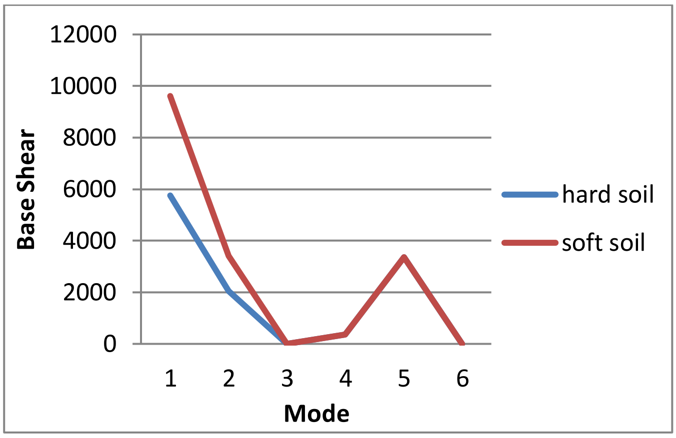

Figure 4: Base Shear in Z direction

For Hard Soil :

1. MASS PARTICIPATION FACTORS:

MODE	MASS PARTICIPATION FACTORS IN PERCENT					
	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z
1	20.24	0	56.9	20.244	0	56.899
2	56.9	0	20.24	77.144	0	77.144
3	0	0	0	77.144	0	77.144
4	10.79	0	1.13	87.935	0	78.274
5	1.13	0	10.79	89.065	0	89.065
6	0	0	0	89.065	0	89.065

2. CALCULATED FREQUENCIES FOR LOAD CASE 1

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	0.812	1.23173
2	0.812	1.23173
3	0.957	1.04527
4	2.539	0.39389
5	2.539	0.39389
6	2.904	0.34432

3. 1893 RESPONSE SPECTRUM LOAD

MODE	SPECTRAL ACCELERATION	DESIGN SEISMIC COEFFICIENT		
		X	Y	Z
1	0.81186	0.8119	0.0000	0.8119
2	0.81186	0.8119	0.0000	0.8119
3	0.95669	0.9567	0.0000	0.9567
4	2.50000	2.5000	0.0000	2.5000
5	2.50000	2.5000	0.0000	2.5000
6	2.50000	2.5000	0.0000	2.5000

For Soft Soil :

1. MASS PARTICIPATION FACTORS:

MODE	MASS PARTICIPATION FACTORS IN PERCENT					
	X	Y	Z	SUM M-X	SUM M-Y	SUM M-Z
1	20.24	0	56.9	20.244	0	56.899
2	56.9	0	20.24	77.144	0	77.144
3	0	0	0	77.144	0	77.144
4	10.79	0	1.13	87.935	0	78.274
5	1.13	0	10.79	89.065	0	89.065
6	0	0	0	89.065	0	89.065

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MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	0.812	1.23173
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3	0.957	1.04527
4	2.539	0.39389
5	2.539	0.39389
6	2.904	0.34432

3. 1893 RESPONSE SPECTRUM LOAD

MODE	SPECTRAL ACCELERATION	DESIGN SEISMIC COEFFICIENT		
		X	Y	Z
1	1.35581	1.3558	0	1.3558
2	1.35581	1.3558	0	1.3558
3	1.59768	1.5977	0	1.5977
4	2.50000	2.5000	0	2.5000
5	2.50000	2.5000	0	2.5000
6	2.50000	2.5000	0	2.5000

6.Conclusions

Based on the response spectra study on high rise RC structure, following points are concluded:

1. As the modal mass participating factor is more than 75% in the higher mode, the considered structure is stiff for earthquake excitation.
2. The stability is more in hard soil and the foundation adoptability is more required in soft soil.
3. It was observed that there was an increase in base shear in soft soil condition compare to hard soil condition.
4. The value of spectral acceleration coefficient is more in soft soil condition whereas it decreases in hard soil condition.
5. Response spectrum analysis was performed on G+20 RC structure on STAAD pro V8i from this analysis we conclude that the structure is stiff and good to rasist small earthquakes of modrate magnitude.

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