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Dynamic Analysis of R.C. Framed Buildings with Finite Element Method Using Site-Specific Response Spectra

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Abstract:

For earthquake resistant design of the structure, proper dynamic analysis is very much necessary. In the present study, an attempt has been made to carry out the nonlinear dynamic analysis of R. C. framed buildings of different heights. The buildings have been analyzed by nonlinear dynamic method using finite element software-ABAQUS considering a site-specific response spectrum of the Kolkata region. Linear dynamic analysis has also been carried out by STAAD-Pro v8i. These results have been compared in terms of story drift and shear. The results show significance. The differences of the two different software packages for the different story buildings.

Keywords:
Nonlinear dynamic analysis, linear dynamic analysis, site-specific response spectra.

I. INTRODUCTION

Reinforced concrete (RC) frame buildings are the most common type of constructions in urban India, subjected to several types of forces during their lifetimes, such as static forces due to dead and live loads and dynamic forces due to wind earthquakes. The behavior of buildings under dynamic forces depends on the dynamic characteristics of buildings controlled by both their mass and stiffness properties.

The performance of buildings largely depends on constituent members' strength and deformability, which is further linked to the internal design forces for the members. The internal design forces depend upon the accuracy of the method employed in their analytical determination

Kolkata city, India's former capital and the present capital of state West Bengal is situated on a soft, deep alluvial soil deposit. Thus, the seismic wave may amplify during propagation in the soil layers. Therefore, the structures designed by following Indian code (IS 1893(Part- I):2002) may not perform their desired level during the earthquake. The site-specific ground motion has been studied, and its consequences have been found in any literature ([1],[2],[3],[4],[5],[6],[7],[8]).

The important objective of dynamic analysis of a building is to observe the building's dynamic behavior [9]. This report aims towards the nonlinear dynamic analysis of multistory R.C. buildings with symmetrical configuration. In the present study, nonlinear dynamic analysis of symmetrically planned three and five-story R.C. framed building have been carried out using finite element based software ABAQUS. Site-specific response spectra of two different Kolkata city locations and IS: 1893 -2002 zone III response spectra for soft soil have been used to conduct the analysis. Various response parameters such as lateral force, base shear, story drift have been obtained. A comparative study has also been performed by linear dynamic analysis using STAAD.

II. DETERMINATION OF SITE SPECIFIC RESPONSE SPECTRA

The buildings' performance analysis has been conducted using the site specific response spectra for Tollygungue metro area, Kolkata, which DSHA obtained. In the response spectra analysis, the Peak Ground Acceleration (PGA) for Maximum Considerable Earthquake (MCE) has been estimated as 0.184 g (g=acceleration of gravity) at bedrock level using the attenuation relationship developed by Artificial Neural Network (ANN). The time history compatible with Indian standard has been determined at the bedrock level. Finally, it has been transformed at the surface level using 1-D wave propagation software SHAKE 2000. The Site-specific response spectra at the surface level of each of the three locations have been determined. Fig 1 shows the borehole details of the Tollygunge area.

Depth	Strata	Soil Description
1.2m		Fill and top soil brownish grey silty clay (N=2, D=1.41)
4.9m		Brownish silty fine sand with mica (N=16, D=1.64)
11.2m		Grey silty fine sand with mica (N=17, D=1.85)
14.9m		Grey silty medium sand with mica (N=32, D=1.9)
18.1m		Dense grey laminated silt pockets of grey silty clay with traces of very fine sand (N=36, D=1.9)
30.5m		Dense grey very fine silty sand with mica (N=48, D=1.9)
32.4m		Very stiff mottled brown/grey silty clay (N=30, D=1.9)
37.1m		Stiff grey silty clay with yellowish/rusty brown spots (N=29, D=1.95)
40.0m		Stiff yellowish brown silty clay with black spots(N=40, D=1.98)
45.7m		Stiff to very stiff silty clay with some black spots (N=50, D=1.9)
48.5m		Stiff grey sandy clay with rusty brown spots of silt (N=54, D=2.03)
50.0m		Brown mottled yellowish brown grey clayey sand (N=67, D=2.1)

1) Borehole location of Tollygaunge metro

III. PROBLEM FORMULATION

Numerical modeling has been conducted

For a typical G+2 story and G+4 story buildings by STAAD Pro and ABAQUS (Fig. 2-5). Details of G+2 and G+4 storied buildings are presented in Table1 and Table 2, respectively.

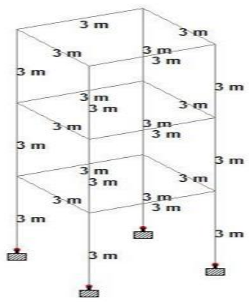

Figure 2: Elevation of G+2 Building

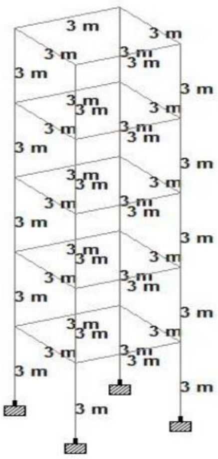

Figure 3: Elevation of G+4 Building

Figure 4: 3D Elevation of G+2 Building

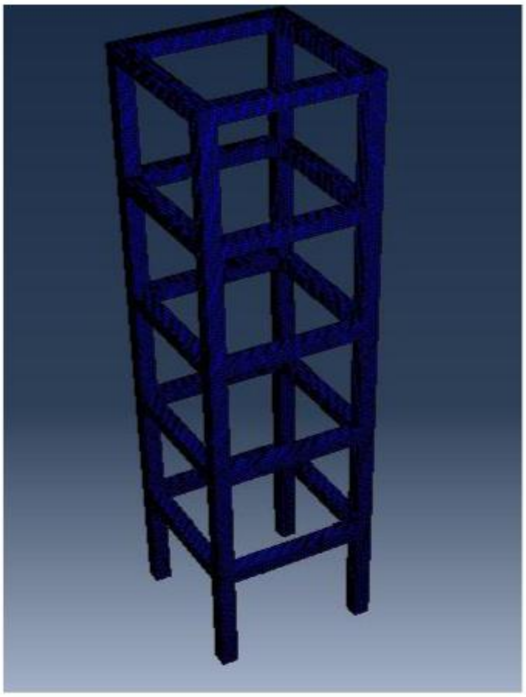

Figure 5: 3D Elevation of G+4 Building

Table 1:The details of the G+2 buildings.

Grade of concrete	M 20
Grade of steel	Fe 500
Floor to floor height	3.0m
Parapet height	0.5m
External wall thickness	250mm
Internal wall thickness	150mm
Live Load	4 KN/m2
Floor finish	1 KN/m2
The building is resting on	soft soil
Density of concrete	25 KN/m3
Density of masonry	20 KN/m3
Building Frame Size	3 m X 3 m
Size of Column	250X250 mm
Size of Beam	250X250 mm

Table 2: The details of the G+4 buildings.

Grade of concrete	M 20
Grade of steel	Fe 500
Floor to floor height	3.0m
Parapet height	0.5m
External wall thickness	250mm
Internal wall thickness	150mm
Live Load	4 KN/m^2
Floor finish	1 KN/m^2
The building is resting on	medium soil
Density of concrete	25 KN/m^3
Density of masonry	20 KN/m^3
Building Frame Size	3 m X 3 m
Size of Column	350X350 mm
Size of Beam	250X350 mm

Nonlinear dynamic analysis has been carried out by ABAQUS using the site-specific ground motion. The proper interface has been considered between the reinforcement and concrete.

IV. RESULTS AND DISCUSSION

The results obtained from the G+2 and G+4 models for Response Spectra Analysis and Modal Analysis using STTAD Pro software are tabulated in Table 3 and Table 4, respectively. Magnitudes of design lateral forces at different floor levels and base shear of G+2 and G+4 buildings are shown in Table 3 and Table 4. These two tables signify that for both G+2 and G+4 storied buildings, the base shear and storey shear obtained in the modal analysis are greater

Then response spectrum analysis, however, for nonlinear dynamic analysis performed by ABAQUS, the storey shear, and base shear are larger than both response spectrum and modal analysis method.

Table 3 Lateral load and base shear of G+2 storied building

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Floor Level	STAAD		ABAQUS
	Response Spectrum Method	Modal Analysis Method	
Roof	469.6 KN	317 KN	357.49
2	277.8 KN	402 KN	234.25
1	165.25 KN	307 KN	151.48
Base Shear	912.65 KN	1026 KN	743.22

Table 4 Lateral load and base shear of G+4 storied building.

Floor Level	STAAD		ABAQUS
	Response Spectrum Method	Modal Analysis Method	
Roof	316.71 KN	381 KN	448.32
4	227.3 KN	316 KN	401.11
3	150.4 KN	232 KN	386.21
2	128.58 KN	168 KN	287.90
1	74 KN	52 KN	124.05
Base Shear	897 KN	1149 KN	1647.59

The storey drift obtained by nonlinear dynamic analysis using ABAQUS and linear dynamic analysis using STAAD for G+2, and G+4 storied building is tabulated in table 5. The graphical representation of story drift obtained by ABAQUS for G+2 building, and G+4 storied building is shown in Fig. 6 and Fig. 7, respectively.

Table 5 Storey drift obtained of G+2 and G+4 storey building

Storey No.	STAAD		ABAQUS	
	G+2	G+4	G+2	G+4
4		8.9		4.587
3		8.12		3.244
2	1.6	7.62	1.489	1.956
1	1.57	6.5	1.648	1.623
GF	1.57	5.17	0.955	0.927

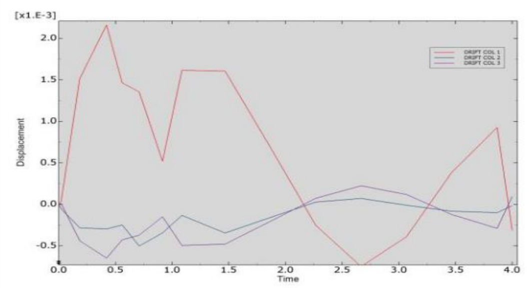

Figure 6: Story Drift of G+2 storied building.

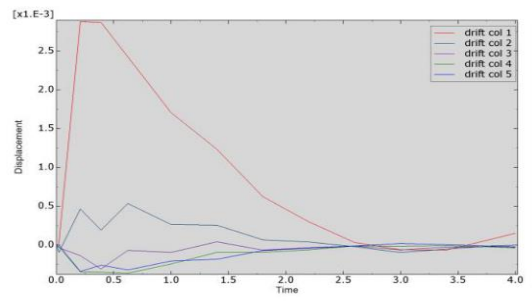

Figure 7: Story Drift of G+4 storied building.

V. CONCLUSION

In the present study, linear dynamic analysis and nonlinear dynamic analysis have been performed for G+2 and G+ 4 storied building using the Kolkata region's site-specific ground motion. For this purpose, the software package STAAD and ABAQUS have been used. The present study signifies that nonlinear dynamic analysis performed by ABAQUS, the storey shear, and base shear are larger than linear dynamic analysis. However, for linear dynamic analyses, the story drift is larger than the drift obtained by nonlinear dynamic analysis.

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