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Time History Analysis of Irregular Shape Concrete Building in SAP2000

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In the present paper study of nonlinear dynamic analysis of Ten storied RCC building considering different seismic intensities is carried out and seismic responses of such building are studied. The building under consideration is modeled with the help of SAP2000 software. Five different time histories have been used considering seismic intensities V, VI, VII, VIII, IX and X on Modified Mercalli's Intensity scale (MMI) for establishment of relationship between seismic intensities and seismic responses. The results of the study show similar variations pattern in Seismic responses such as base shear and storey displacements with intensities V to X. From the study it is recommended that analysis of multistoried RCC building using Time History method becomes necessary to ensure safety against earthquake force.

Keywords: Time History Analysis, Seismic responses, Multistoried buildings, Scaling

INTRODUCTION

All over world, there is high demand for construction of tall buildings due to increasing urbanization and spiraling population, and earthquakes have the potential for causing the greatest damages to those tall structures. Since earthquake forces are random in nature and unpredictable, the engineering tools need to be sharpened for analyzing structures under the action of these forces. Earthquake loads are required to be carefully modeled so as to assess the real behavior of structure with a clear understanding that damage is expected but it should be regulated. Analyzing the structure for various earthquake intensities and checking for multiple criteria at each level has become an essential exercise for the last couple of decades (Romy and Prabha, 2011).

Earthquake causes different shaking intensities at different locations and the damage induced in buildings at these locations is also different. Thus, there is necessary to construct a structure which is earthquake resistance at a particular level of intensity of shaking a structure, and not so much the magnitude of an earthquake. Even though same magnitudes of earthquakes are occurring due to its varying intensity, it results into dissimilar damaging effects in different regions. Therefore, it is necessary to study variations in seismic behavior of multistoried RC framed building for different seismic intensities in terms of various responses such as lateral displacements and base shear. It is necessary to understand the seismic behavior of buildings having similar layout under different intensities of earthquake. For determination of seismic responses, it is necessary to carry out seismic analysis of the structure using different available methods (Duggal, 2010).

OBJECTIVES

1. To analyze a multistoried RC framed building (10 Storey) for available earthquake time histories considering different earthquake intensities (i.e., V, VI, VII, VIII, IX and X).
2. To compare seismic behavior of multistoried RC framed building for different earthquake intensities in terms of various responses such as, base shear and displacements.
3. To find the relationship between earthquake intensities and responses.

SEISMIC ANALYSIS

For the determination of seismic responses there is necessary to carry out seismic analysis of structure. The analysis can be performed on the basis of external action, the behavior of structure or structural materials, and the type of structural model selected. Based on the type of external action and behavior of structure, the analysis can be further classified as: (1) Linear Static Analysis, (2) Nonlinear Static Analysis, (3) Linear Dynamic Analysis; and (4) Nonlinear Dynamic Analysis. Linear static analysis or equivalent static method can be used for regular structure with limited height. Linear dynamic analysis can be performed by response spectrum method. The significant difference between linear static and linear dynamic analysis is the level of the forces and their distribution along the height of structure. Nonlinear static analysis is an improvement over linear static or dynamic analysis in the sense that it allows inelastic behavior of structure. A nonlinear dynamic analysis is the only method to describe the actual behavior of a structure during an earthquake. The method is based on the direct numerical integration of the differential equations of motion by considering the elasto-plastic deformation of the structural element.

Equivalent Static Analysis

This procedure does not require dynamic analysis, however, it account for the dynamics of building in an approximate manner. The static method is the simplest one-it requires less computational efforts and is based on formulate given in the code of practice. First, the design base shear is computed for the whole building, and it is then distributed along the height of the building. The lateral forces at each floor levels thus obtained are distributed to individuals lateral load resisting elements (Duggal, 2010).

Nonlinear Static Analysis

It is practical method in which analysis is carried out under permanent vertical loads and gradually increasing lateral loads to estimate deformation and damage pattern of structure.

Non linear static analysis is the method of seismic analysis in which behavior of the structure is characterized by capacity curve that represents the relation between the base shear force and the displacement of the roof. It is also known as Pushover Analysis.

Linear Dynamic Analysis

Response spectrum method is the linear dynamic analysis method. In that method the peak response of structure during an earthquake is obtained directly from the earthquake response, but this is quite accurate for structural design applications (Duggal, 2010).

Nonlinear Dynamic Analysis

It is known as Time history analysis. It is an important technique for structural seismic analysis especially when the evaluated structural response is nonlinear. To perform such an analysis, a representative earthquake time history is required for a structure being evaluated. Time history analysis is a step-by-step analysis of the dynamic response of a structure to a specified loading that may vary with time. Time history analysis is used to determine the seismic response of a structure under dynamic loading of representative earthquake (Wilkinson and Hiley, 2006) (Tables 1 and 2)..

STRUCTURAL MODELING AND ANALYSIS

The finite element analysis software SAP 2000 Nonlinear is utilized to create 3D model and run all analyses. The software is able to predict the geometric nonlinear behavior of space frames under static or dynamic loadings, taking into account both geometric nonlinearity and material inelasticity.

Problem Statements

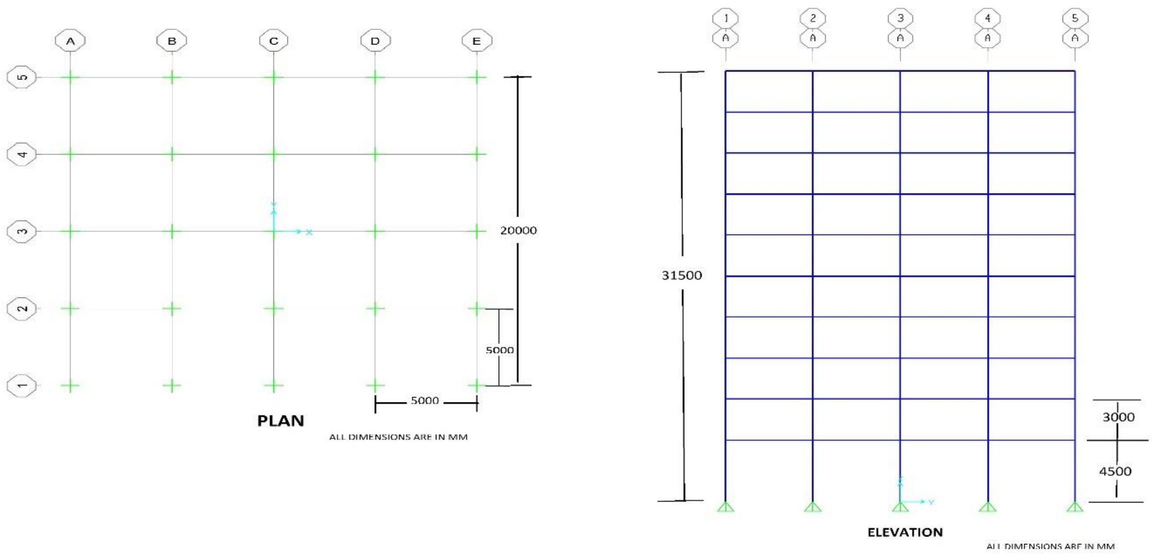

Figure 1: Plan & Elevation

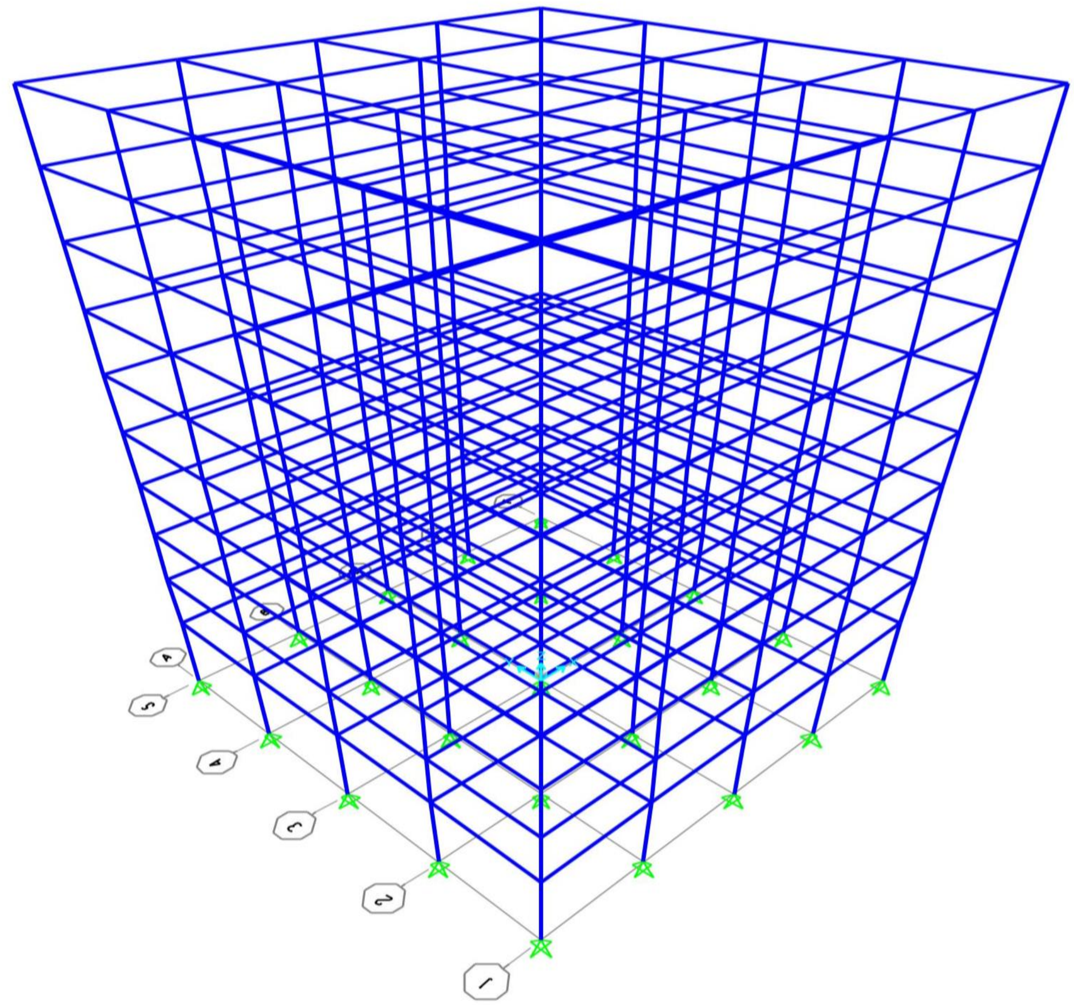

Figure 2 3D View in SAP2000

For the study ten storied masonry in filled RCC building is considered. The geometry and dimensions of plan are shown in Figure 1.

Live Load on Typical floors – 3.0 KN/m^2

Live Load on Terrace - 2 KN/m^2

Column size - 0.5 m X 0.5 m

Beams size - 0.23 m X 0.45 m

Slab Thickness - 0.150 m

Brick wall Thickness -0.230 m

Density of Concrete - 25 KN/m^2

Density of Brickwall - 20 N/m^2

Modulus of Elasticity for Concrete - 25 KN/ m^2

Modulus of Elasticity for Brick wall - 10.5 KN/m^2

Table 1: Different Time Histories Considered for Study

S. No.	EQ	Date	Magnitude Richter Scale	P. G. A.g
1.	Bhuj, India	Jan 26, 2001	6.9	0.110
2.	Koyana, India	Dec 11, 1964	6.5	0.489
3.	Anza, USA	Feb 25, 1980	4.7	0.110
4.	Nahanni, Canada	Dec 23, 1985	6.9	0.489
5.	Northridge, USA	Jan 17, 1994	6.7	0.489

Table 2: Different Seismic Intensities Considered for Study

S. No.	Intensity MMI	PGA g	Seismic Zones as per IS:1893-2002
1.	V	0.03-0.04	-
2.	VI	0.06-0.07	II (second)
3.	VII	0.10-0.15	III(third)
4.	VIII	0.25-0.30	IV(fourth)
5.	IX	0.50-0.55	V(fifth)
6.	X	>0.60	-

Table: 3 Variations in Base Shears for X Direction

S. No.	Intensity MMI	Base Shears kN				
		Bhuj	Koyana	Anza	Nahanni	Northridge
1.	V	40.268	56.87	96.479	145.774	106.544
2.	VI	74.786	105.615	179.153	270.746	197.897
3.	VII	143.801	203.112	344.554	520.643	380.542
4.	VIII	316.37	446.84	757.985	1145.45	837.214
5.	IX	603.975	853.056	1447.07	2186.74	1598.34
6.	X	690.247	974.926	1653.8	2499.11	1826.66

Figure 3: Variations in Base Shears for X Directions

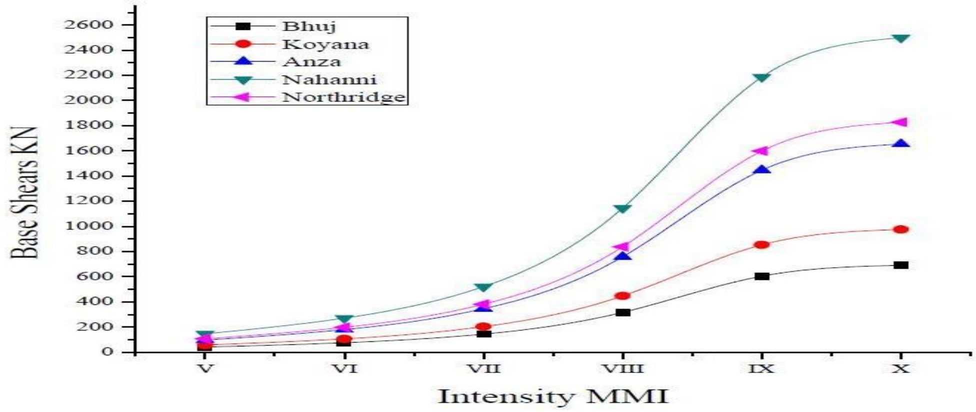

Table 4: Variations in Base Shears for Y Direction

S. No.	Intensity MMI	Base Shears kN				
		Bhuj	Koyana	Anza	Nahanni	Northridge
1.	V	47.932	54.299	124.994	71.536	79.959
2.	VI	89.028	100.874	232.111	132.834	148.504
3.	VII	171.182	139.969	446.395	255.429	285.609
4.	VIII	376.609	426.722	982.029	561.973	628.304
5.	IX	718.996	817.659	1874.78	1072.83	1199.49
6.	X	821.7	931.041	2142.61	1226.1	1370.82

Table 5: Variations in Roof Displacements for X Direction

S. No.	Intensity MMI	Displacements mm				
		Bhuj	Koyana	Anza	Nahanni	Northridge
1.	V	0.027	0.031	0.044	0.052	0.05
2.	VI	0.05	0.058	0.082	0.097	0.093
3.	VII	0.097	0.111	0.159	0.186	0.18
4.	VIII	0.213	0.245	0.349	0.41	0.395
5.	IX	0.407	0.467	0.666	0.782	0.755
6.	X	0.465	0.534	0.762	0.894	0.863

Table: 6 Variations in Roof Displacements for Y direction

S. No.	Intensity MMI	Displacements mm				
		Bhuj	Koyana	Anza	Nahanni	Northridge
1.	V	0.056	0.073	0.162	0.1	0.076
2.	VI	0.104	0.135	0.3	0.186	0.141
3.	VII	0.201	0.259	0.578	0.357	0.272
4.	VIII	0.442	0.57	1.271	0.786	0.598
5.	IX	0.843	1.088	2.426	1.5	1.141
6.	X	0.963	1.244	2.772	1.715	1.304

RESULTS AND DISCUSSION

Results obtained from the analysis are tabulated in Tables 3 to 6.

Graphical representations of variations in results are shown in Figures 3. The graph shows that similar variations in seismic responses namely base shears and displacements with intensities V to X.

CONCLUSION

1. The seismic responses namely base shear, storey displacements and storey drifts in both the directions are found to vary in similar pattern with intensities (V to X) for all the Time Histories and both the models considered for the study.
2. The values of seismic responses namely base shear, storey displacement and storey drifts for all the Time Histories and both the models are found to be of the increased order for seismic intensities varying from V to X.
3. The values of base shear, storey displacements and storey drifts (X and Y directions) for seismic intensities of VI, VII, VIII, IX and X are found to be more by 1.85, 3.56, 7.86, 15.1, and 17.15 times, respectively as compared to seismic intensity of V for both the models (i.e., with and without soft story) and for all the time histories.
4. As Time History is realistic method, used for seismic analysis, it provides a better check to the safety of structures analyzed and designed by method specified by IS code.

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