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Analysis Of RCC Building In Sloping Ground With Various Heights

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Abstract

During the last two decades, metropolitan cities have attempted to develop vertically to meet the building requirement of large influxes of population into urban areas. Having faced the problems of urban population explosion, lack of land, high land prices and unwieldy slump of cities and towns, attempts have been made in our major cities to provide more built up space vertically for both working and living. The structures are generally constructed on level ground; however, due to scarcity of level grounds the construction activities have been started on sloping grounds. In this study, G+ 11,G+15,G+20 storey's RCC building and the ground slope varying from 5 to 8m have been considered for the analysis. A comparison has been made with the building resting on level ground. The modelling and analysis of the building has been done by using structure analysis tool ETAB 2016, to study the effect of varying height of the column in bottom storey at different position during the earthquake. The aim of present study is to compare seismic performance of G+11, G+15, G+20 structures situated in earthquake zones II & zone IV. All frames are designed under same gravity loading. Time history method of analysis used for seismic analysis. ETABS software is used and the results are compared. The results were obtained in the form of top storey displacement, Storey drift, Base shear and displacement. It is observed that short column is affected more during the earthquake.

Keywords— ETABS, Earthquake, Sloping ground building, Time history analysis

I. INTRODUCTION

General Introduction

In India most of the structures are low rise buildings. Now a day due to greater migration towards cities, results in increase in the population in most of the major cities. In order to fulfil the requirement of this increased population in limited land the height of building becomes medium to high rise buildings Structural planning and design is an art and science of designing with economy and elegance, serviceable and durable structure. The entire process of structural planning and designing requires not only

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imagination and conceptual thinking but also sound knowledge of science of structural engineering besides knowledge of practical aspects, such as relevant design codes and byelaws backed up by example experience. The one of the most sensitive issues that the Structural Engineers face is the selection of proper procedure for estimating the seismic performance of the structure. This is very important when they are dealing with high rise structures as the improper selection of the method ultimately leads to the results which are far away from the correct results. Time history analysis is one of the effective procedures for evaluating the seismic performance of the building. The damage control is one of important design considerations which is increasing its influence and can be achieved only by introducing dynamic analysis in the design. The dynamic analysis can be done by software's like Etabs, Staad Pro, and SAP. Etabs is one of the leading software which is presently using by many companies and Structural Engineers for their projects. Etabs is used for the dynamic analysis of the multi-storey building. The methodology followed in Etabs for the analysis is as follows modelling of the multi-storey building, static analysis, and designing and dynamic analysis. And design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, Etabs 2016 is the professional's choice for steel, concrete, timber, aluminium and cold-formed steel design of low and high-rise buildings for structural analysis and integrated Steel, Concrete, Timber and Aluminium design.

To perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. Advanced structural analysis may examine.

Dynamic response, stability and non-linear behaviour. The aim of design is the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and adequate resistance to the effects of seismic and wind. Structure and structural elements shall normally be designed by Limit State Method. Account should be taken of accepted theories, experiment and experience and the need to design for durability. Design, including design for durability, construction and use in service should be considered as a whole. The realization of design objectives requires compliance with clearly defined standards for materials, production, workmanship and also maintenance and use of structure in service. The design of the building is dependent upon the minimum requirements as the minimum requirements pertaining to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed Loads, and other external loads, the structure would be required to bear. Strict conformity to loading standards recommended in this code, it is hoped, will not only ensure the structural safety of the buildings which are being designed.

II. RESEARCH METHODOLOGY

Non- Linear Dynamic Method (Time History Method):

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1. Nonlinear dynamic analysis is most accurate method to determine the seismic responses of structures.
2. To perform such an analysis, a representative earthquake time history is required for a structure being evaluated.
3. In this method the structure is subjected to actual ground motion which is the representation of the ground acceleration versus time. The ground acceleration is determined at small time step to give the ground motion record.
4. Then the structural response is calculated at every time instant to know its time history and the peak value of this time history is chosen to be design demand. Hence, a mathematical model directly incorporating the nonlinear characteristic of individual component and element of the building shall be subjected to earthquake shaking represented by ground motion time history to obtain forces and the displacement.
5. Since numerical model directly accounts for the effect of material nonlinearity, inelastic responses and calculated internal forces will be reasonably approximate to those expected during the design earthquake.

III. PROBLEM FORMULATION

In G+11, G+15 and G+20 story reinforced concrete moment resisting space frame have been analyzed using professional software. Model G+11, G+15 and G+20 story building is analyzed by response spectrum method. The plan dimensions of buildings are shown in table below. The plan view of building, elevation of different frames is shown in figures below.

Table No I: Detail Features Of Building

Sr. No	Parameters	Values
1	Material Used	Concrete-M30 Reinforcement Fe500&Fe415MPA
3	Height Of Each Storey	3.0m
4	Height Of Ground Storey	3.0m
5	Density Of Concrete	25KN/M3
6	Poisson Ratio	0.2-Concrete And 0.15-Steel
9	Code Of Practice Adopted	IS456:2000 , IS1893:2016
10	Seismic Zone For IS1893:2016	III & IV
12	Importance Factor	1.5
13	Response Reduction Factor	5
14	Foundation Soil	Medium
15	Slab Thickness	150mm
16	Wall Thickness	150mm

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17	Floor Finish	1KN/M2
18	Live Load	2.5KN/M2
19	Earthquake Load	As Per IS 1893-2016
20	Size Of Beam	430mmx230mm
21	Size Of Column	530mmx230mm
23	Model To Be Analyzed	G+11 And G+15 and G+20 Building
24	Ductility Class	IS1893:2016 SMRF

1. *G+11 Building 3d Model:*

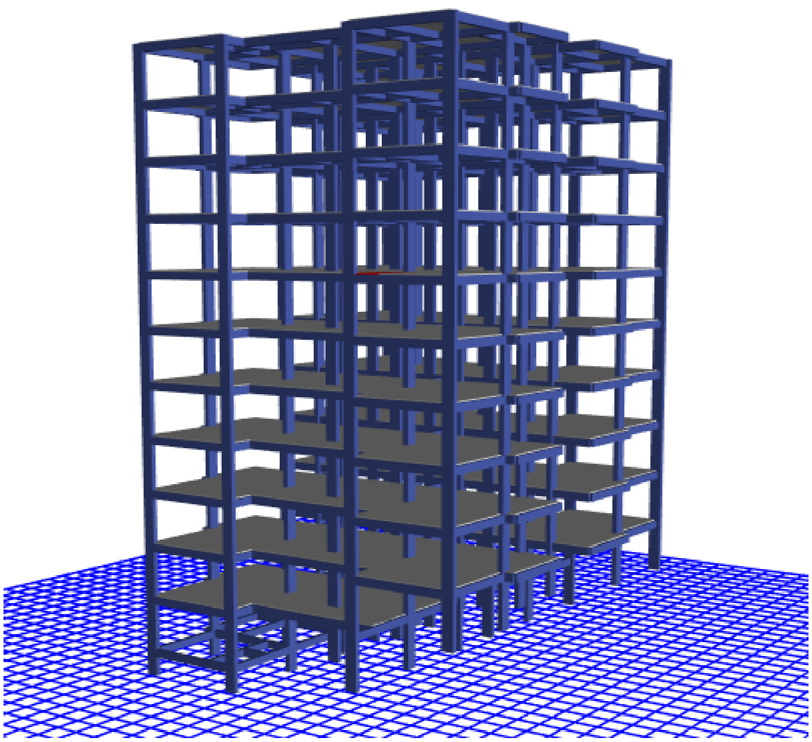

Fig. G+11 Building Software Rendering Model

2. *G+15 Building 3d Model:*

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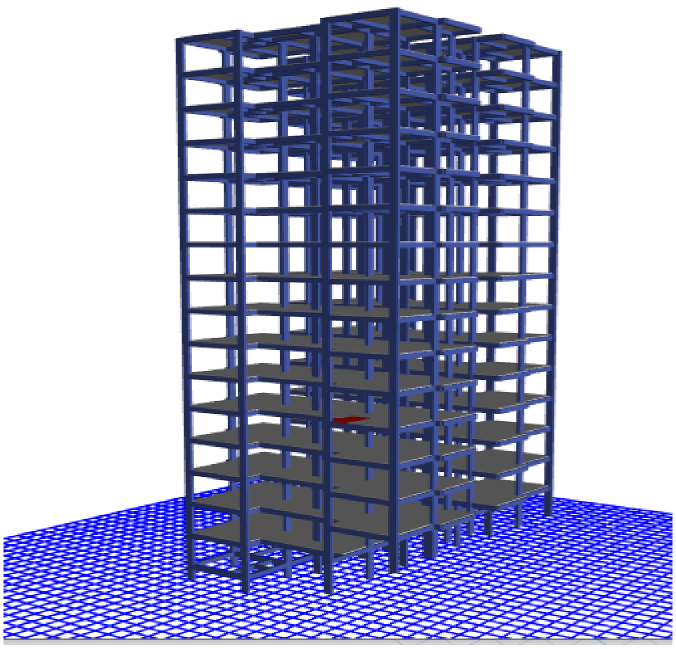

Fig. G+15 Building Software Rendering Model

1. *G+20 Building Software Rendering Model:*

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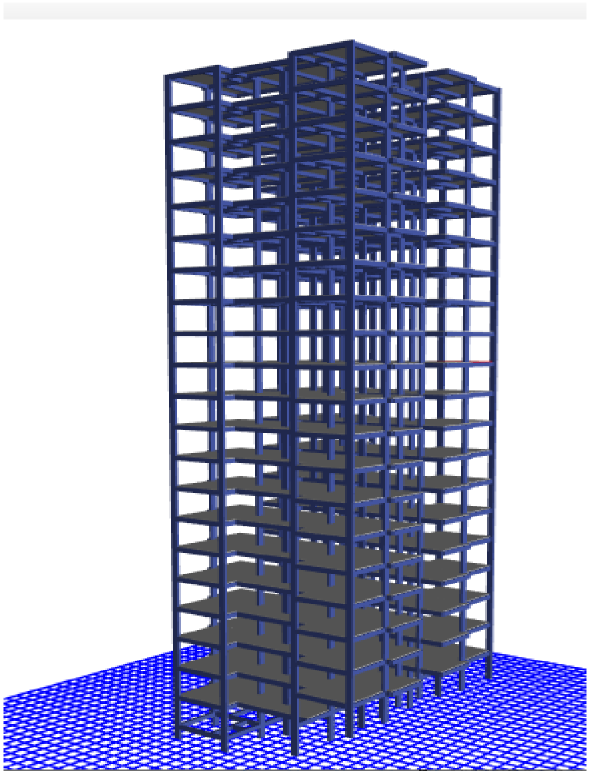

Fig. G+20 Building Software Rendering Model

IV. RESULTS

Table No. 1: Base Shear G+11 Story Building

Table: Auto Seismic - Is 1893:2002				
Load Pattern	Time Period	Coeff Used	Weight Used	Base Shear
	sec		kN	kN
EQ+X	3.671	0.013337	65560.5134	874.3539
EQ-X	3.671	0.013337	65560.5134	874.3539
EQ+Y	3.352	0.009737	65560.5134	638.3421
EQ-Y	3.352	0.014605	65560.5134	957.5131

Table No. 2: Base Shear G+15 Story Building

Table: Auto Seismic - Is 1893:2002				
Load Pattern	Time Period	Coeff Used	Weight Used	Base Shear

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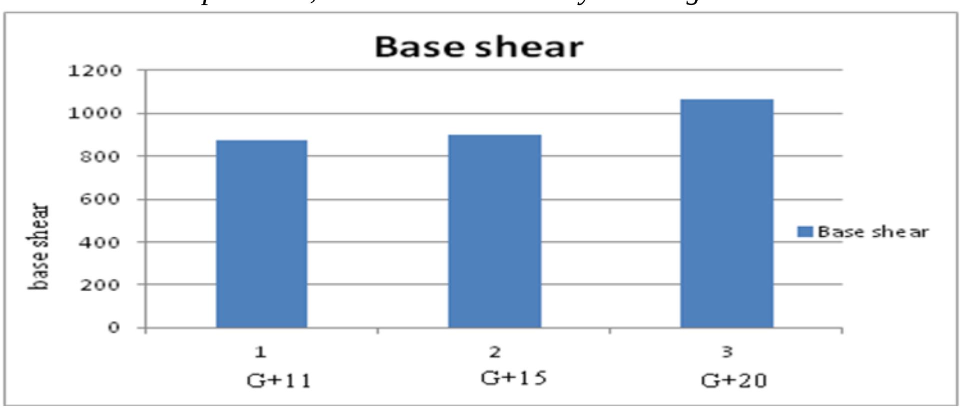
	sec		kN	kN
EQ+X	2.642	0.018533	48420.6466	897.372
EQ-X	2.642	0.018533	48420.6466	897.372
EQ+Y	2.434	0.020114	48420.6466	973.9552
EQ-Y	2.434	0.020114	48420.6466	973.9552

Table No. 3: Base Shear G+20 Story Building

Table: Auto Seismic - Is 1893:2002				
Load Pattern	Period Used	Coeff Used	Weight Used	Base Shear
	sec		kN	kN
EQ+X	5.061	0.01224	86976.4528	1064.5918
EQ-X	5.061	0.01224	86976.4528	1064.5918
EQ+Y	4.582	0.01224	86976.4528	1064.5918
EQ-Y	4.582	0.01224	86976.4528	1064.5918

Graph: I Base Shear Graph G+11, G+15 and G+20 Story Building



Graph: Story vs. Base Shear

Earthquake Displacement

Table No: 4 earthquake displacement G+11 story building

Table: Diaphragm Centre of Mass Displacements			
Story	Load Case/Combo	UX	UY
		m	m
Story12	Bhuj ground motion+X	0.331398	0.000055

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Story11	Bhuj ground motion+X	0.301458	0.000052
Story10	Bhuj ground motion+X	0.269539	0.000048
Story9	Bhuj ground motion+X	0.236139	0.000044
Story8	Bhuj ground motion+X	0.201816	0.000039
Story7	Bhuj ground motion+X	0.167179	0.000034
Story6	Bhuj ground motion+X	0.132898	0.000029
Story5	Bhuj ground motion +X	0.099727	0.000023
Story3	Bhuj ground motion +X	0.040534	0.000012
Story2	Bhuj ground motion +X	0.017314	0.000005
Story1	Bhuj ground motion +X	0.002048	4.399E-10
Base	Bhuj ground motion +X	0	0

Table No: 5 earthquake displacement G+15 story building

Table: diaphragm centre of mass displacements			
Story	Load Case/Combo	UX	UY
		m	m
Story17	Bhuj ground motion +X	0.268317	0.000202
Story16	Bhuj ground motion +X	0.25892	-3.535E-08
Story15	Bhuj ground motion +X	0.24916	0.000542
Story14	Bhuj ground motion +X	0.236205	0.00053
Story13	Bhuj ground motion +X	0.221276	0.000511
Story12	Bhuj ground motion +X	0.204525	0.000487
Story11	Bhuj ground motion +X	0.186222	0.000458
Story10	Bhuj ground motion +X	0.166673	0.000425
Story9	Bhuj ground motion +X	0.146214	0.000388
Story8	Bhuj ground motion +X	0.1252	0.000348
Story7	Bhuj ground motion +X	0.104005	0.000306
Story6	Bhuj ground motion +X	0.083035	0.000262
Story5	Bhuj ground motion +X	0.062739	0.000215
Story4	Bhuj ground motion +X	0.043645	0.000165
Story3	Bhuj ground motion +X	0.026426	0.000113
Story2	Bhuj ground motion +X	0.012031	0.00006
Story1	Bhuj ground motion +X	0.00207	-4.177E-10

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Base	Bhuj ground motion +X	0	0

Table No: 6 Earthquake displacements G+20 story building

Table: Diaphragm Centre of Mass Displacements			
Story	Load Case/Combo	UX	UY
		m	m
Story22	Bhuj ground motion +X	0.512216	0.000328
Story21	Bhuj ground motion +X	0.501512	0.000329
Story20	Bhuj ground motion +X	0.490475	0.00033
Story19	Bhuj ground motion +X	0.478964	0.000332
Story18	Bhuj ground motion +X	0.466767	0.000334
Story17	Bhuj ground motion +X	0.453542	0.000336
Story16	Bhuj ground motion +X	0.437899	-1.815E-07
Story15	Bhuj ground motion +X	0.421501	0.000902
Story14	Bhuj ground motion +X	0.399635	0.00088
Story13	Bhuj ground motion +X	0.374349	0.000848
Story12	Bhuj ground motion +X	0.345915	0.000806
Story11	Bhuj ground motion +X	0.314796	0.000756
Story10	Bhuj ground motion +X	0.281526	0.0007
Story9	Bhuj ground motion +X	0.24668	0.000637
Story8	Bhuj ground motion +X	0.210868	0.000569
Story7	Bhuj ground motion +X	0.174736	0.000497
Story6	Bhuj ground motion +X	0.138979	0.000421
Story5	Bhuj ground motion +X	0.104374	0.000341
Story4	Bhuj ground motion +X	0.071832	0.000256
Story3	Bhuj ground motion +X	0.042539	0.000168
Story2	Bhuj ground motion +X	0.018203	0.000079
Story1	Bhuj ground motion +X	0.002107	-8.104E-10
Base	Bhuj ground motion +X	0	0

Graph: 2 Story vs. Earthquake Displacement in X- direction (G+11, G+15 and G+20) story buildings

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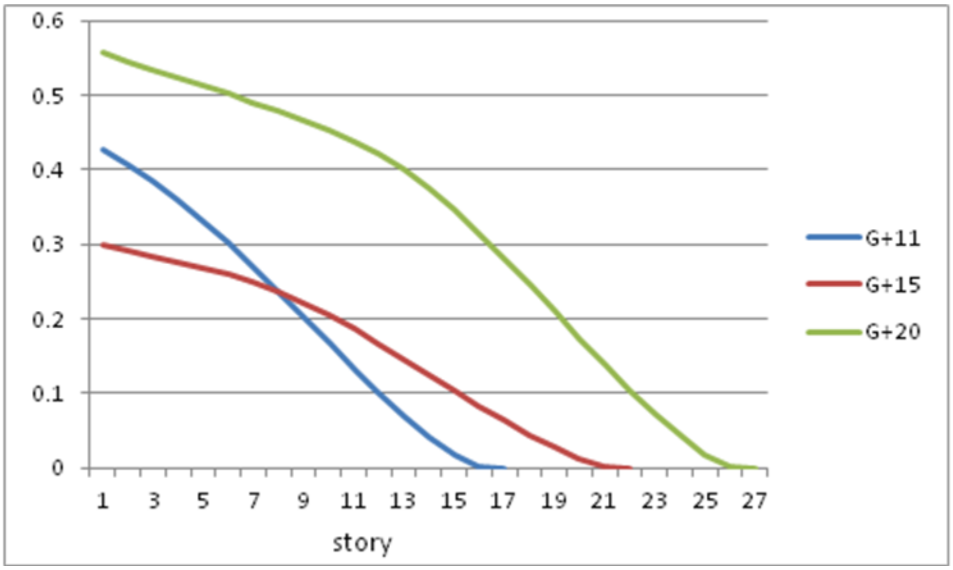
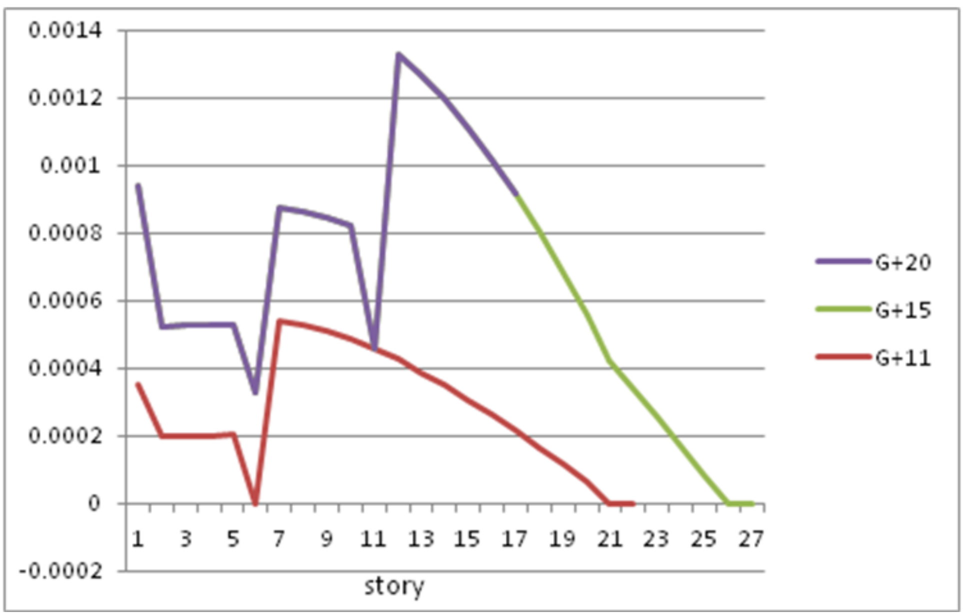


Graph: story vs. earthquake displacement graph

Graph: 3 Story vs. Earthquake Displacement in Y- direction (G+11, G+15 and G+20) story buildings



Graph: story vs. earthquake displacement graph

1. For above Table No. I, II, and III all the RCC building in bhuj ground motion, base shear increases as the height increases. This increase in base shear shows similar variations in G+11, G+15 and G+20 story building.

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2. From Table No. IV, V and VI Displacements obtained from the (bhuj ground motion) time history analysis are much less than the allowable limit for all the Models. The difference of displacement values among all different heights of building is insignificant in lower stories but it increased in higher stories and reached peak at top stories.

V. CONCLUSION

In the present study, comparative evaluation of high rise building with sloping ground with medium soils has been carried out for different number of storey. The buildings are analyses for earthquake load (bhuj ground motion). Comparison has been made on different structural parameters viz. base shear, Earthquake displacement etc.

Based on the analysis results following conclusions have been drawn

1. Base shear is maximum in X-direction at G+11, G+15 and G+20 stories building in bhuj ground motion. Also in G+ 11 stories building base shear are increases 1.24 times as compare to G+15 story building and also 1.3 times increases in G+20 stories building in zone IV in medium soil.

2. In G+11, G+15 and G+20 Story building due to earthquake loading, the displacement in X-direction is maximum in G+ 20 stories building as compare to G+11 & G+15 stories in bhuj ground motion.

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