

# Seismic Analysis of Regular Configuration of Multi Storey Building with Rigid and Flexible Base under Different Soil Conditions

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**Abstract:** The supporting soil influences the behaviour of the structure due to its ability to deform. The rigid support neglects all these deformations. The response of the structure with flexible foundation has been done in this study. The difference in behaviour between rigid and flexible support structure if not taken into account could lead to inaccuracy in assessing the structural safety. Time history analysis is done to consider the seismic forces. The analysis of the buildings is carried out in ETAB 2016. All the soil parameters required which defines the classification of soil has been together computed from IS 1893(II). The influence of different soil conditions, number of stories, and type of footing has been taken to observe the change in the structural behaviour of the structure. The seismic response of structure due to the effect of soil flexibility depends on both the soil property and structural property.

**KEY WORDS:** Time history, Storey drift, max/avg drift ratio, ETAB etc

## INTRODUCTION

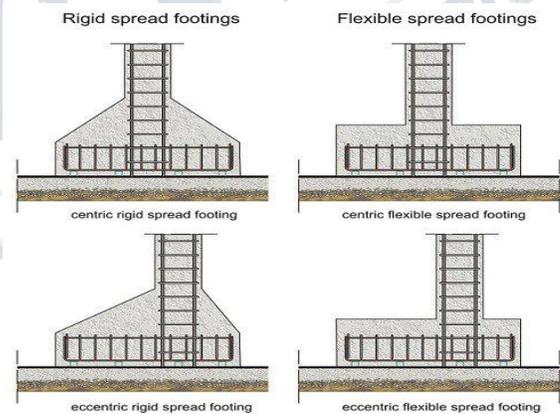
### 1.1 General:

Vibrations which disturb the earth's surface caused by waves generated inside the earth are termed as earthquakes. It is said that earthquake will not kill the life of human but structures which are not constructed in considering the earthquake forces do. At present a major importance has given to earthquake resistant structures in India for human safety.

As waves from an earthquake reach a structure, they produce motion in the structure. These motion depends on the structure's vibrational characteristics and the layout of the structure. For the structure react to the motion, it needs to overcome its own inertia force, which results in an interaction between the structure and the soil.

### 1.2 Rigid and Flexible footing:

The basic difference between the rigid footing and flexible footing is that, the flexible footing undergoes differential settlement while a rigid footing will undergo uniform settlement i.e. at every point settlement will be same in case of rigid footing while in flexible footing it will vary.

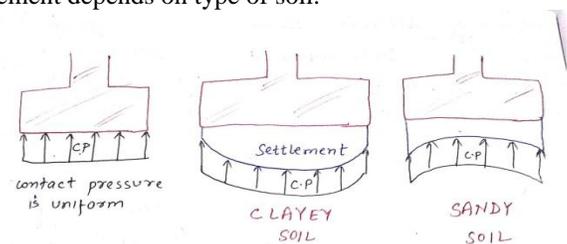


**Figure 1. Rigid and Flexible Footing.**

### 1.3 Footing settlement on type of soil:

#### 1.3.1 Flexible Footing:

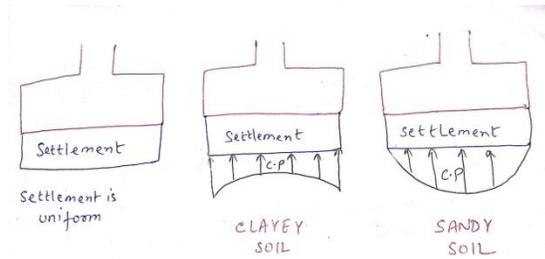
Contact pressure for all types of soil is nearly uniform but settlement depends on type of soil.



**Figure 2. Contact pressure and settlement in flexible footing.**

### 1.3.2 Rigid Footing:

In rigid footing settlement for all types of soil is nearly uniform but contact pressure depends upon type of soil.



**Figure 3. Contact pressure and settlement in rigid footing.**

## II. LITERATURE REVIEW

Many researchers have studied on different soil conditions. Anand[4] studied the seismic behaviour of RCC buildings with and without shear wall under different soil conditions. One to fifteen storied spaced frame with and without shear wall were analyzed using ETAB software for different soil conditions (i.e. hard, medium and soft). The values of base shear, axial force and lateral displacement were compared between two frames. Which results in an interaction between structure and the soil.

Jenifer Priyanaka[5] studied the effect of lateral force on tall building with different type of irregularities. It was found that building with soft soil gives more deflection as compared to medium and hard soil for all types of building. Building with stiffness irregularity gives more deflection as compared to other type of buildings with different irregularity.

Whiteman[6] After Killari(1993)[4] Jablpur(1997) and Bhuj(2001) earthquake, it is well organized that no part of India can be considered to be seismic hazard. Subsequently, IS-1893 code was modified in 2002 deleting zone-I from seismic zone map of India. Influence of soil-structure interaction plays, vital role when structure with different configurations under different soil conditions are subjected to earthquake forces.

M.jeelani[7] studied that Most of structures in urban India are made up of RCC which are to be seismically analyzed because of frequent earthquakes. Structures subjected to dynamic forces such as wind and earthquake can be analyzed

by different methods of seismic analysis. Generally flexibility of soil is not considered while analyzing the structure in seismic, adopting the base as fixed one.

## III. OBJECTIVE OF WORK

The major objectives of the work are as follows.

1. Design of G+15 storied building models and time history analysis subjected to intermediate frequency ground motion for the response of regular buildings with ETAB 2016.
2. To study the response of buildings with rigid and flexible base under different soil conditions.
3. To compare seismic performance of rigid and flexible base building models with respect to following aspects Max storey drift and max/avg storey drift ratio.
4. To analyze the RCC multi-storey building for seismic forces.

## IV. METHODOLOGY

The seismic analysis should be carried out for the buildings lacks resistant to earthquake forces. Seismic analysis will consider dynamic effects hence the exact analysis sometimes become complex. However there are two methods for the analysis of the structure, linear analysis and nonlinear analysis. The linear analysis is used to know the behaviour of building in elastic limit whereas to know the behaviour of building in plastic limit nonlinear analysis used.

### A. Time History Analysis

Time history analysis is a dynamic analysis which is used to predict linear and nonlinear behaviour of the structures. Time histories of earthquake accelerations are in general random function of time. However, considerable insight into the response of structures can be gained by considering the response characteristics of structures to two basic dynamic loading. Time history analysis is a step by step analysis of dynamic response of a structure to a specified loading that may vary with time. This method is used to determine the seismic response of a structure under dynamic loading of representative earthquake.

## V. MODELLING OF BUILDING

The G+15 RC multi storey framed building considered for structural analysis with rigid and flexible base under different soil conditions (i.e. hard medium and soft) is done with the

help of ETAB software. The building is assumed as commercial building. Regular plan dimensions in X and Y direction are 25m and 25m respectively.. The structure is assumed to be located in seismic zone IV. The height of all floors is 3m and height of plinth is 3.5m.

**Table 1. DESCRIPTION OF THE BUILDING**

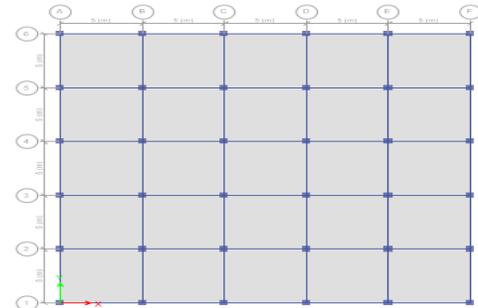
S No.	Structural Part	Dimension
1.	Length in X-direction	25 m, No. of bays 5@5m each
2.	Length in Y-direction	25 m, No. of bays 5@5m each
3.	No. of story	16 story (G+15)
4.	Height of first story	3.5m
6.	Floor to floor height	3m
7.	Total height of building	48.5m
8.	Column size	500x500mm
9.	Beam size	350x450mm
10.	Slab thickness	150 mm
11.	Type of building	Commercial
12.	Soil types	Hard, medium and soft

**Table 2. MATERIAL PROPERTIES:**

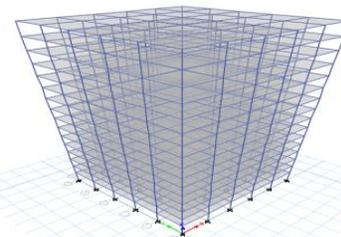
S No.	Material	Grade
1.	Concrete(Beam, slab)	M25
2.	Concrete(Column)	M30
3.	Rebar	HYSD-415

**Table 3. SEISMIC DATA:**

1.	Seismic zone	IV
2.	Damping ratio	5%
3.	Importance Factor	1
4.	Response reduction factor	3
5.	Time period	Program calculated



**Figure 4: Plan View**



**Figure 5: 3D View**

**1. LOADING:**

a. Live load- 3.5 kN/m<sup>2</sup>

b. Load combination:

1. 1.5(DL+LL)
2. 1.2(DL+LL+ELX)
3. 1.2(DL+LL-ELX)
4. 1.2(DL+LL+ELY)
5. 1.2(DL+LL-ELY)
6. 1.5(DL+ELX)
7. 1.5(DL-ELX)
8. 1.5(DL+ELY)
9. 1.5(DL-ELY)
10. 0.9DL+1.5ELX
11. 0.9DL-1.5ELX
12. 0.9DL+1.5ELY
13. 0.9DL-1.5ELY

**Table 4 . BUILDING MODELS:**

Type of Soil	Hard	Medium	Soft
<b>Rigid Base</b>	Model 1	Model 2	Model 3
<b>Flexible Base</b>	Model 4	Model 5	Model 6

**VI. RESULTS AND DISCUSSIONS**

The analysis of all the six models with Flexible and rigid base under different soil conditions (i.e. Hard, medium and soft) was done by using ETABS and results are shown below. The parameters which are to be studied are story drift and max/avg. Story drift ratio.

**1. STORY DRIFT:**

The storey drift is defined as the displacement of the storey with respect to its adjacent upper storey. Storey drift is an important criteria to represent the performance of the structure as per IS 1893:2002 Part 1, Clause 7.11.1, page 28, the storey drift should be less than 0.004 times the height of the storey under consideration.

The limited value as per IS 1893-2002 Storey Drift in 2nd to 16 storey,  $0.004 \times 3000 = 12\text{mm}$ .

The limited value as per IS 1893-2002 storey drift in 1st storey,  $0.004 \times 3500 = 14\text{mm}$ .

**Table 5: Maximum Storey Drift in 'X' Direction:  
Storey**

Storey	Rigid Base			Flexible Base			Max Drift allowed IS 1893(2002)Code
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	
	Hard soil	Medium Soil	Soft Soil	Hard Soil	Medium Soil	Soft Soil	
	mm	mm	mm	mm	mm	mm	
Storey16	0.657	0.984	1.097	0.581	1.017	0.97	12
Storey15	1.006	1.51	1.679	0.888	1.576	1.482	12
Storey14	1.351	2.033	2.256	1.192	2.112	1.99	12
Storey13	1.657	2.496	2.767	1.461	2.581	2.44	12

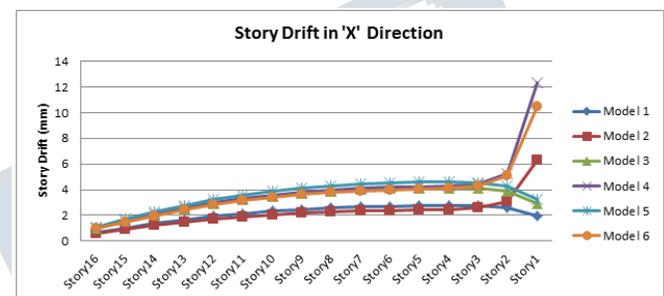
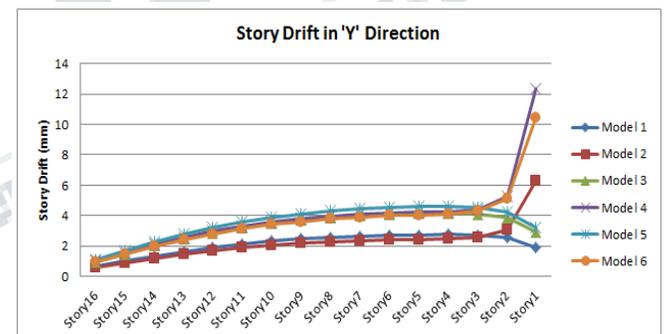
Storey12	1.919	2.893	3.205	1.692	2.98	2.825	12
Storey11	2.139	3.226	3.572	1.885	3.314	3.149	12
Storey10	2.319	3.499	3.873	2.044	3.588	3.414	12
Storey9	2.464	3.718	4.114	2.171	3.806	3.626	12
Storey8	2.575	3.887	4.301	2.27	3.974	3.79	12
Storey7	2.658	4.012	4.438	2.342	4.097	3.912	12
Storey6	2.714	4.097	4.532	2.393	4.181	3.997	12
Storey5	2.746	4.146	4.586	2.429	4.233	4.056	12
Storey4	2.754	4.159	4.667	2.467	4.276	4.119	12
Storey3	2.721	4.108	4.544	2.573	4.41	4.298	12
Storey2	2.56	3.865	4.274	3.05	5.235	5.093	12
Storey1	1.933	2.919	3.228	6.259	12.313	10.453	14

**Table 6: Maximum Storey Drift in 'Y' Direction:  
Storey**

Storey	Rigid Base	Flexible Base	Max Drift Allowed IS 1893(2002)Code
Storey1	1.933	2.919	14
Storey2	2.56	3.865	12
Storey3	2.721	4.108	12
Storey4	2.754	4.159	12
Storey5	2.746	4.146	12
Storey6	2.714	4.097	12
Storey7	2.658	4.012	12
Storey8	2.575	3.887	12
Storey9	2.464	3.718	12
Storey10	2.319	3.499	12
Storey11	2.139	3.226	12
Storey12	1.919	2.893	12

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	mm
	Hard soil	Medium Soil	Soft Soil	Hard Soil	Medium Soil	Soft Soil	
	mm	mm	mm	mm	mm	mm	
Story16	0.657	0.984	1.097	0.581	1.017	0.977	12
Story15	1.006	1.51	1.679	0.888	1.576	1.482	12
Story14	1.351	2.033	2.256	1.192	2.112	1.979	12
Story13	1.657	2.496	2.767	1.461	2.581	2.474	12
Story12	1.919	2.893	3.205	1.692	2.982	2.825	12
Story11	2.139	3.226	3.572	1.885	3.314	3.149	12
Story10	2.319	3.499	3.873	2.044	3.588	3.414	12
Story9	2.464	3.718	4.114	2.171	3.806	3.626	12
Story8	2.575	3.887	4.301	2.277	3.974	3.779	12
Story7	2.658	4.012	4.438	2.342	4.097	3.912	12
Story6	2.714	4.097	4.532	2.393	4.181	3.997	12
Story5	2.746	4.146	4.586	2.429	4.233	4.056	12
Story4	2.754	4.159	4.646	2.467	4.276	4.119	12

Story3	2.721	4.108	4.544	2.573	4.41	4.298	12
Story2	2.56	3.865	4.274	3.05	5.235	5.093	12
Story1	1.933	2.919	3.228	6.259	12.313	10.453	14


**Graph 1: Maximum Storey Drift in 'X' Direction:**

**Graph 2: Maximum Storey Drift in 'Y' Direction:**

## 2. MAX/AVG STOREY DRIFT RATIO:

As per IS 1893:2002 Code describe that the torsional irregularity will be occur when mass story drift/avg story drift is more than 1.2

As per IS 1893:2002 The maximum horizontal displacement of any floor in the direction of the lateral force at one end of the floor is more than 1.5 times its minimum horizontal displacement at the far end of the same floor in that direction.

**Table 7: Maximum / Average Storey Drift ratio in X-Direction:**

Storey	Rigid Base			Flexible Base			Allowed value IS 1893:2002
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	
	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	
Story 16	1.082	1.081	1.082	1.081	1.081	1.081	1.2
Story 15	1.089	1.089	1.089	1.089	1.088	1.089	1.2
Story 14	1.093	1.093	1.093	1.093	1.093	1.093	1.2
Story 13	1.095	1.095	1.095	1.095	1.095	1.095	1.2
Story 12	1.096	1.096	1.096	1.096	1.096	1.096	1.2
Story 11	1.097	1.097	1.097	1.097	1.097	1.097	1.2
Story 10	1.098	1.098	1.098	1.098	1.098	1.098	1.2
Story 9	1.099	1.099	1.099	1.099	1.099	1.099	1.2
Story 8	1.099	1.099	1.099	1.099	1.099	1.099	1.2
Story 7	1.1	1.1	1.1	1.1	1.1	1.1	1.2
Story 6	1.1	1.1	1.1	1.1	1.1	1.1	1.2
Story	1.10	1.10	1.10	1.10	1.10	1.10	1.2

5	1	1	1	1	1	1	
Story 4	1.101	1.101	1.101	1.101	1.102	1.101	1.2
Story 3	1.102	1.102	1.102	1.102	1.102	1.102	1.2
Story 2	1.103	1.103	1.103	1.103	1.103	1.103	1.2
Story 1	1.104	1.104	1.104	1.104	1.106	1.105	1.2

**Table 8: Maximum / Average Storey Drift ratio in Y-Direction:**

Storey	Rigid Base			Flexible Base			Allowed value IS 1893:2002
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	
	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	
Story 16	1.082	1.081	1.082	1.081	1.081	1.081	1.2
Story 15	1.089	1.089	1.089	1.089	1.088	1.089	1.2
Story 14	1.093	1.093	1.093	1.093	1.093	1.093	1.2
Story 13	1.095	1.095	1.095	1.095	1.095	1.095	1.2
Story 12	1.096	1.096	1.096	1.096	1.096	1.096	1.2
Story 11	1.097	1.097	1.097	1.097	1.097	1.097	1.2
Story 10	1.098	1.098	1.098	1.098	1.098	1.098	1.2
Story	1.09	1.09	1.09	1.09	1.09	1.09	1.2

9	9	9	9	9	9	9	
Story 8	1.09 9	1.09 9	1.09 9	1.09 9	1.09 9	1.09 9	1.2
Story 7	1.1	1.1	1.1	1.1	1.1	1.1	1.2
Story 6	1.1	1.1	1.1	1.1	1.1	1.1	1.2
Story 5	1.10 1	1.10 1	1.10 1	1.10 1	1.10 1	1.10 1	1.2
Story 4	1.10 1	1.10 1	1.10 1	1.10 1	1.10 2	1.10 1	1.2
Story 3	1.10 2	1.10 2	1.10 2	1.10 2	1.10 2	1.10 2	1.2
Story 2	1.10 3	1.10 3	1.10 3	1.10 3	1.10 3	1.10 3	1.2
Story 1	1.10 4	1.10 4	1.10 4	1.10 4	1.10 6	1.10 5	1.2

## VI. CONCLUSION:

1. With reference to the output values of maximum storey drift in all six models, it lies within the allowable limit as per IS 1893-2002, from the analysis regular structure max storey drift variation exit in soil conditions (i.e. Hard, Medium and Soft).

2. It can be observed that Story Drift values increase from 16th storey to 4th storey and then suddenly decrease.

3. Max/avg drift ratio is a major factor in order to determine torsional irregularity in the structure. According to IS 1893-2002 All values lie within permissible limits.

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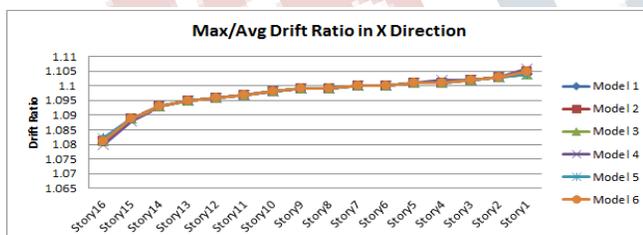
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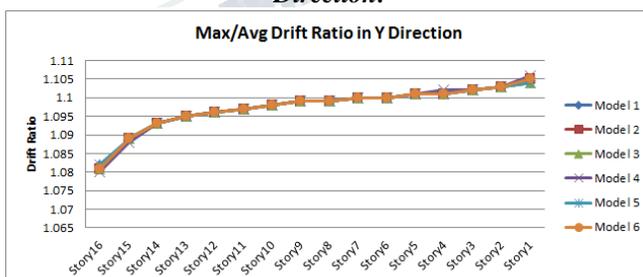
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**Graph 3: Maximum / Average Storey Drift Ratio in X-Direction:**



**Graph 4: Maximum / Average Storey Drift in Y-Direction**

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