

# ANALYSIS AND DESIGN OF G+7 RC BUILDING IN SEISMIC ZONE III AND IV OF INDIA

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**Abstract:** To know the behaviour of structure we analysis a G+7 RC building of same size and dimensions in two different earthquake zone III & IV of India by using Indian earthquake code IS 1893:2002 and Indian concrete design code IS 456:2000 and SAP2000 v23.1.0 software was used to analysis and design this model. After analysis two model of same dimension in two different seismic zone we compared the results of both of the structures and found that the structure which analysis in higher earthquake zone has more impact of earthquake forces due to high intensity of earthquake forces and due to which the model in higher earthquake zone contains increased in forces in members, increased in base reactions etc.

**Keywords:** SAP2000 v23.1.0, Steel percentage, Bending moments & Shear forces, maximum deflections, seismic zone III & IV

## I. INTRODUCTION

When a structure is design then it should be very safe for all load and also economical in cost. The load which are considered in design purpose are dead load, live load, wind load, seismic load, equipment load, dynamic motor load etc. dead loads are mostly gravity loads and these are due to self-weight of the structure and dead weight of the other items like floor tiles, furniture, partitions, walls, equipment dead weight, fall ceiling, etc are included in dead load or gravity load. Live load are also considered in gravity load if these act towards the gravity, mostly live loads are gravity load like live load of human at different locations, equipment operating load, tank full load, stairs load etc are considered in live load. Horizontal loads are due to the earthquake forces and wind forces at different locations of earth territory. In India, the earthquake zones are divided into five numbers and similarly the wind zones are also divided into different zones. So, when a building designed then it should carry all load and should be safe against these forces and it should be also economical in cost of the building. We have also considered live load and dead load due to self-weight of the building and due to concrete floor slab. In this study we analysis a G+7 RC structure in SAP2000 software by using Indian seismic code and Indian concrete design code and we analysis two structures of same size and dimensions in two different earthquake zone III & IV of India and after analysis we compared the results of both the models in different earthquake zones. By comparing results of the structures, we observed that the structure which are designed in higher earthquake zone carry more forces in place of which are designed in lower seismic zone. It is due to the high intensity of the earthquake forces in high earthquake zone and due to high forces, the size of the members got increased in higher seismic zone, the steel percentage also got increased in higher zone, base reactions also got increased in higher zone and the overall cost of the structure also affected due to high intensity of earthquake forces and it got increased.

*The basic objectives of the present study:* there are the following the basic objectives of the present study which helps to understand the aim of the present research.

- 1). To observe the performance of structure by analysis the structure in SAP2000 and by response spectrum method of earthquake analysis
- 2). To compare the results of shear force and bending moment in both RC structure by analysis in SAP2000.
- 3). To record the difference between variations in deflections & drifts in members by analysis RC structure in two different earthquake zone III & IV.
- 4). To compare the overall cost of the both the structures by analysis structure in two different seismic zone of India.
- 5). To check the change in steel percentage or reinforcement in members when analysis the same model in different earthquake zones.
- 6). To know the change in base reactions of structure when analysis the structure in different earthquake zones of India.

*The basic scope of the present study:* we have also discussed the basic scope of the present study which are given and discussed below. There are so many studies done related to this topic and we have also reviewed some related literatures to know the basic scope of this topic. In general, we had analysis a G+7 RC structure having seven storeys in SAP2000 software and symmetrical in shape of structure, same size, same dimension. We have modelled two structure in SAP2000 having same size and shape and analysis both in two different earthquake zones by using seismic code IS 1893:2002 & concrete code.

*Methodology of present study:* the basic methodology of this present study are given below and discussed below.

- 1). To model the structure in SAP 2000 & earthquake zone three of India.
- 2). To model the same dimensions and same size structure in zone four of India.
- 3). To design and analysis these structures, response spectrum analysis method of earthquake analysis was used.
- 4). And last after design and analysis we compared the results of both models and their forces that how much change occurred between both the models.

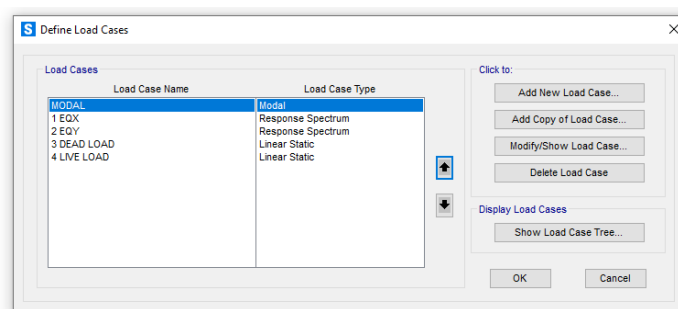
## II. MODELLING AND ANALYSIS

The software SAP2000 v23.1.0 is used to perform response spectrum analysis of the models. There are so many software used for design the building but this software gives accurate results that why we used this software for design this structure. We have to draw the model step by step in this software. We have to draw the coordinate axis and geometry of the structure like dimensions, length, width, height, number of bay etc then start to draw nodes. After drawing node we have to joined those all nodes by using element draw command. After this select the area draw command and start to draw the area which required for slab and roof. After drawing all the complete we have to provide properties of member and sizes of member like beam and column and area of slab. We define the material also for concrete and steel. Select the property define command and provide the required material. After that select the size of the member and assign the material also to that member. There are two windows exist in this software, one is for three dimension and another for 2d work. We can choose one window also. In SAP 2000 select the top command “define” which includes so many points which we have to draw or use to draw the structure. There are the following commands which “define” command contains like, materials, section properties, soil profile, mass source, load cases, load pattern, load combinations, moving load, fundamental properties, joint groups, joint constraint, section cuts, fundamental properties, fundamental assemblies etc. after draw the structure we have to provide properties of member and after that we have to define the load pattern. The load pattern contains number of load types which we want to apply on the structure, so we have to define all of them. Load pattern contains load like dead load, imposed load, notional load in x & y direction, equipment load etc. there are so many types of load like gravity load and horizontal direction load. So we have to define them in load pattern. After defining load pattern we should define load case. Load case means which types of load contains for combination purpose. After define the load case we should define load combination according to Indian code IS 456:2000. Load combinations are two type, one for design of strength and another for crack width and deflection check, or we can say one for limit state and another for serviceability design. The structural calculation is in agreement, by means of a three-dimensional model, with the structural design software SAP2000 v23.1.0. After defining the load combination according to Indian code we should define the types of support which we are going to provide to our structure like pinned or fixed support. For this select the assign command and go to the joint command, from where select the restrained command, after selected the restrained command, there are four types of options we have like pinned support, semi pinned support, fixed support and partially fixed. So mostly we selected pinned and fixed support. For R C structure we chose fixed support and for steel structure we can choose fixed and pinned according to design criteria and requirement. So, this is a R C structure and we choose fixed support for column and the bottom of column or can say that top of foundation slab. After provided support, check secondary beams provided hinged at end. The secondary beams need to provide moment release from both end and torsion release from one end. If we provide torsion release from both the end then our member becomes unstable and it fails in deflection and does not gives us accurate result. for accurate result we have to provide only one end torsion release and another end no release. But moment of both the end should be released because secondary beams are pinned type beam and in pinned type beams no moment exist in the structure. After this we should checked that the column unsupported length are provided or not. Its very important to provide columns unsupported length, for this we check from how many directions column is tied that in x- direction and y-direction, then calculate unsupported length in both direction of column in x & y direction. After this provide the area element for slab on different floors and meshed that area slab. After mesh area section not more than the size of mesh 500mm x 500mm provide the thickness of slab to this meshed area section and also select the material of concrete for this slab. This software uses. The program is based on techniques of matrix calculation and finite elements under the habitual hypotheses of the linear elasticity:

- Proportionality between stress and deformations.
- Structural elements compatibility.
- Local and global static balance of each one of the parts of the structure.

The model is discretized into frame elements to represent the beams and columns of the structure. Below, the different types of elements used in the calculation model are explained:

*Procedure of modelling in SAP2000:* To study seismic effect in different zone of India a seven storied RC building is being considered. The detail of the building dimensions is shown below. To study seismic effect in different zone of India a seven storied RC building is being considered. The detail of the building dimensions is shown below. We draw the grid system and after that we develop the member properties. Concrete properties are also provided and after that the sizes of beam and columns are also provided. Slab thickness also provided by using shell command and shell quantities also provided.





On defining the dead load self-weight multiplier is given as. Live loads and earthquake load case are also defining the load pattern command are available in define command and we have to define all the load pattern which are used to design this structure like gravity and horizontal load

In SAP 2000 software, this command is available in define command on the top of the window and we can choose this for defining the types of seismic method for which we are going to design the structure. In this command we have to provide all the data given in the seismic code. This building is designed by above method of earthquake. If the gravity load are more than the base reaction due to gravity load are also more and the horizontal reaction for seismic are also more. Base reactions are directly depend on the total load provided on the building for design.

### III. RESULTS

*Base reactions:* By analysing same structure in different two seismic zones III & IV, it is observed that there is 1.5 times increase in base reactions in seismic zone IV as compared to seismic zone III. These values are in mm and less than permissible value. These values obtained under load cases limit of serviceability. Indian RC design code IS 456:2000 is used for reference purpose. Two different model are analysed to compare the results between the seismic zone III & zone IV. SAP 2000 used for designed this structure.

TABLE: Base Reactions								
OutputCase	CaseType	StepType	GlobalFX	GlobalFY	GlobalFZ	GlobalMX	GlobalMY	GlobalMZ
Text	Text	Text	KN	KN	KN	KN-m	KN-m	KN-m
1 EQX	LinRespSpec	Max	825.663	0.0001118	0.000513	0.0018	10744.0362	3302.6531
2 EQY	LinRespSpec	Max	0.0001379	825.692	0.0005474	10704.4958	0.0072	8256.9183
3 DEAD LOAD	LinStatic		6.661E-14	-6.839E-14	17447.245	69788.9796	-174472.449	-4.476E-13
4 LIVE LOAD	LinStatic		1.926E-14	-7.522E-15	3120	12480	-31200	-1.821E-14

Fig. Structure in zone III

TABLE: Base Reactions								
OutputCase	CaseType	StepType	GlobalFX	GlobalFY	GlobalFZ	GlobalMX	GlobalMY	GlobalMZ
Text	Text	Text	KN	KN	KN	KN-m	KN-m	KN-m
1 EQX	LinRespSpec	Max	1238.495	0.0001677	0.0007694	0.0028	16116.0543	4953.9796
2 EQY	LinRespSpec	Max	0.0002068	1238.538	0.0008211	16056.7437	0.0109	12385.3775
3 DEAD LOAD	LinStatic		8.793E-14	-1.723E-13	17447.245	69788.9796	-174472.449	-1.961E-12
4 LIVE LOAD	LinStatic		1.563E-14	-3.608E-14	3120	12480	-31200	-3.961E-13

Fig. Structure in zone IV



**Drifts & deflections:** When model is analysed in zone IV, the columns maximum drift ( $U_2 = -30.17$  &  $U_1 = -26.09$ ) is observed in joint number 20 & 38 with load case 108(DL+EQZ) & 102(DL+50%LL+EQX). These values are in mm and less than permissible value. These values obtained under load cases limit of serviceability. Indian RC design code IS 456:2000 is used for reference purpose. Two different model are analysed to compare the results between the seismic zone III & zone IV.

By analysing same structure in different two seismic zones III & IV, it is observed that there is 1.5 times increase in columns top drifts in seismic zone IV as compared to seismic zone III.

Joint Text	Output Case Text	Case Type	Step Type	U1 mm	U2 mm	U3 mm	R1 Radians	R2 Radians	R3 Radians
102 10L+50%LL+EQX	Combination	Min	-26.09054	0.002587	-2.567364	-6.96-05	-0.000336	-5.7985-07	
103 10L+50%LL+EQX	Combination	Min	-26.09054	0.002587	-2.567364	-6.96-05	-0.000336	-5.7985-07	
39 102 10L+50%LL+EQX	Combination	Min	-26.09054	-0.003054	-2.567364	6.45-05	-0.000336	1.3225-07	
39 103 10L+50%LL+EQX	Combination	Min	-26.09054	-0.003054	-2.567364	6.45-05	-0.000336	1.3225-07	
38 106 10L+EQX	Combination	Min	-26.094272	0.002312	-2.331576	-5.55-05	-0.000321	-5.5305-07	
38 107 10L+EQX	Combination	Min	-26.094272	0.002312	-2.331576	-5.55-05	-0.000321	-5.5305-07	
38 108 10L+EQX	Combination	Min	-26.094272	-0.002779	-2.331576	56-05	-0.000321	1.0745-07	
38 107 10L+EQX	Combination	Min	-26.094272	-0.002779	-2.331576	56-05	-0.000321	1.0745-07	
42 102 10L+50%LL+EQX	Combination	Min	-26.09423	-1.4375-07	-2.995811	-8.9135-11	-0.000318	-2.3295-11	
42 103 10L+50%LL+EQX	Combination	Min	-26.09423	-1.4375-07	-2.995811	-8.9135-11	-0.000318	-2.3295-11	
38 110 10L+EQX	Combination	Min	-26.093405	0.002057	-2.142508	-4.95-05	-0.000315	-5.2075-07	
38 111 10L+EQX	Combination	Min	-26.093405	0.002057	-2.142508	-4.95-05	-0.000315	-5.2075-07	
38 110 10L+EQX	Combination	Min	-26.093405	-0.002525	-2.142508	4.95-05	-0.000315	7.4345-08	
38 111 10L+EQX	Combination	Min	-26.093405	-0.002525	-2.142508	4.95-05	-0.000315	7.4345-08	
42 106 10L+EQX	Combination	Min	-26.092486	-1.4375-07	-2.581781	-8.9135-11	-0.000296	-2.3295-11	
42 107 10L+EQX	Combination	Min	-26.092486	-1.4375-07	-2.581781	-8.9135-11	-0.000296	-2.3295-11	
42 110 10L+EQX	Combination	Min	-26.091885	-1.4375-07	-2.368862	-8.9135-11	-0.000292	-2.3295-11	
42 111 10L+EQX	Combination	Min	-26.091885	-1.4375-07	-2.368862	-8.9135-11	-0.000292	-2.3295-11	
33 102 10L+50%LL+EQX	Combination	Min	-26.091056	-7.1035-08	-3.212335	-2.8245-11	-0.00023	-2.2215-11	
33 103 10L+50%LL+EQX	Combination	Min	-26.091056	-7.1035-08	-3.212335	-2.8245-11	-0.00023	-2.2215-11	
33 106 10L+EQX	Combination	Min	-26.089933	-7.1035-08	-2.549752	-2.8245-11	-0.000213	-2.2215-11	
33 107 10L+EQX	Combination	Min	-26.089933	-7.1035-08	-2.549752	-2.8245-11	-0.000213	-2.2215-11	
29 102 10L+50%LL+EQX	Combination	Min	-26.089865	8.15-05	-2.868861	-4.45-05	-0.000254	2.0915-08	

Fig. Structure in zone IV

## IV. CONCLUSIONS

In this project we studied the behaviour of RC G+7 Building in two different seismic zones III & IV of India by following Indian seismic code IS 1893:2016 & SAP 2000 software. We analysed the structure first in seismic zone III and then the same structure in seismic zone IV and we compared the following results between zones III & IV

- The base reactions of structure are increased 1.5 times in seismic zone IV as compared to seismic zone III of India.
- The drifts & deflections are also found to be increased 1.5 times in zone IV as compared to zone III.
- The bending moment of columns are also increased 1.5 times in zone IV as compared to zone III and bending moment of beams increased more than 1.5 time in zone IV as compared to zone III.
- It was found that the shear force of beams and column are also increased in seismic zone IV as compared to zone III.
- By analyzing same structure in different two seismic zones III & IV, it is observed that there is increase in percentage of steel in columns & beams in seismic zone IV as compared to seismic zone III.
- It was studied that there is approx. 1.3 times increase in columns P-M-M Interaction Ratio in seismic zone IV in place of III.

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