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Influence of the Seismic Variational Parameters on the RC Building With and Without Use of Master-Slave

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Abstract: -- **Earthquake is a natural and unpredictable calamity. It leads to loss of precious human life and property and at the same time pushes the national economy in the backward direction. As we know occurrence and magnitude of an earthquake are unpredictable. So, codes need regular updating to provide safety to the structures and human lives as well. These codal provisions are based on the return period of the earthquake and its magnitude. By employing these magnitudes into considerations, codal provisions have been revised regularly and has a different significance based on the earthquake zones. The prime objective of this investigation is to study the influence of seismic parameters if a building existing in zones with less seismic probability, experienced severe earthquake shakings and what should be the safety measures we need to provide for the safety of the structure and human life as well in such cases? To understand this, a G+6 storied reinforced concrete building is modelled using commercially available 3-Dimensional Structural Analysis and Design Software (STAAD.Pro) and then analysed for the different zones against earthquake forces. Seismic analysis has been done with dynamic linear analysis by using response spectrum analysis method by taking the significance of all the zones in India. Use of master-slave has shown the reduction in nodal displacements. Based on this study, it is concluded that analysis with master-slave results in economical design in comparison with design without considering master-slave.**

***Keywords*: Seismic loads, STAAD.Pro, Dynamic linear analysis, Response spectrum analysis method.**

I. INTRODUCTION

In recent times, people are aware about the earthquake, its occurrence and the reason behind it. Despite all the technological advancement, it earthquake occurrence cannot be predicted. So, whenever it occurs, depending on its magnitude, it results in disastrous effects to the structures as well as loss of precious human life. Till now, for analysis purpose codes haven been developed based on the data of previously occurred earthquakes. The whole world is divided in different zones considering the data of the past earthquakes and other related activities leading to earthquake. But threat still exists that higher magnitude earthquake can occur at a zone where the structures are not designed to sustain that much seismic forces. This ultimately results in more loss of human lives and structures too. The objective of this investigation is to study the influence of seismic parameters if building existing in the zones with lower seismic probability experienced the higher magnitude earthquake and safety measures need to be provided for the safety of the structure and the human life under such events. For the analysis, a G+6 storeyed RC building has been taken and modelled by the use of 3-Dimesnional Structural Analysis and Design Software (STAAD.Pro). IS:1893 Part 1, 2016 is used to analyse the building against the earthquake loadings [1]. Use of dynamic linear analysis by using response spectrum analysis method has been carried out. Use of master-slave in the structure to provide same rigidity for the specific floor levels has been explained so that the results which we get from the analysis will converged to more reliable results.

II. MODELLING OF BUILDING

G+6 storeyed building of 35 m × 30 m ×18 m dimension is modelled in commercially available 3-Dimesnional Structural Analysis and Design Software (STAAD.Pro). The plan, elevation and 3-D view of building is shown in Fig. 1, Fig. 2 and Fig. 3, respectively.

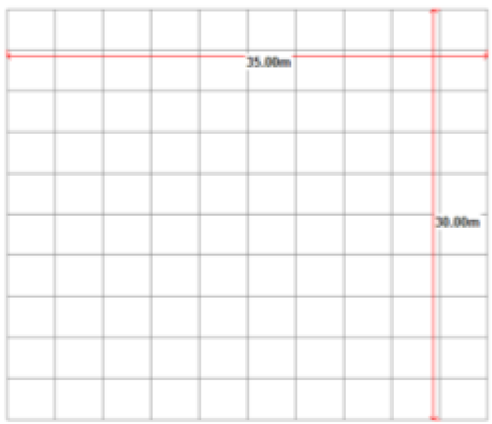

Fig. 1: Plan of RC building

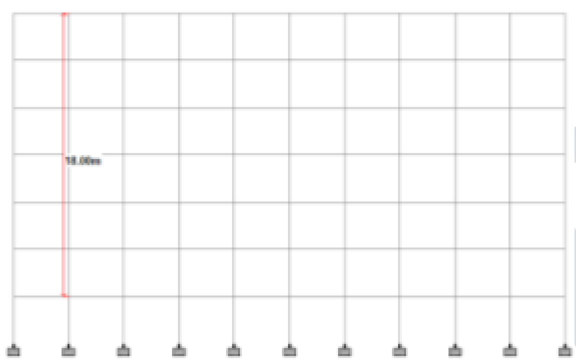

Fig. 2: Elevation of RC building

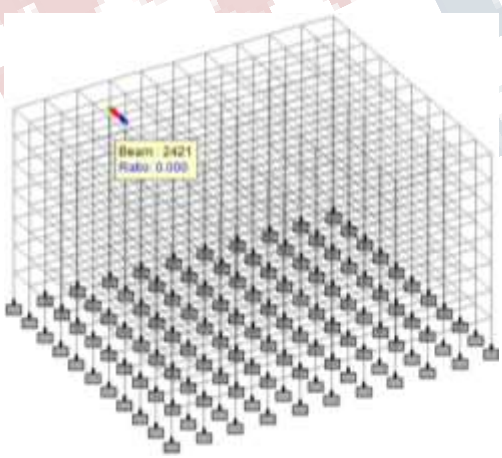

Fig. 3: 3-D view of RC building

The properties of the beam and column is taken as per the length to depth ratios given in IS:456-2000 [2] and by taking into considerations the clauses given for the minimum sizes of members in IS:13920-2016 [3]. The property assigned to columns are 600 mm × 300 mm and that to the beams are 450 mm × 230 mm as shown in Fig. 4. As per the IS:1893 Part 1, 2016 [1], it is specified that we need to consider only 70% inertia of column and 35% inertia of beam.

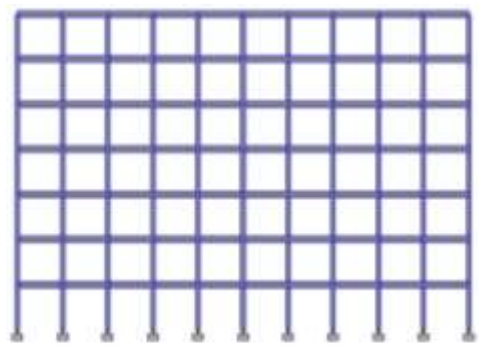

Fig. 4: Assigned properties

III. LOADING CALCULATIONS

Based on the specified code, loading is applied and the same is reported in next section.

3.1 DEAD LOAD

Self-weight of the building will automatically be calculated based on the sizes by the STAAD.Pro. Dead load including wall load (WL), parapet load (PL), slab load (SL), and floor finish (FF) are as shown in Table 1.

Table 1: Dead load calculations

	Height (m)	Thickness (m)	γ (kN/m3)	Loading (kN/m)
WL	3	0.23	20	13.8
PL	1	0.15	20	3
SL	-	0.125	25	3.125
FF	-	-	-	1

3.2 LIVE LOAD

IS:875- Part 2 is used to consider the live loads which will be applied to the building [4]. These live loads are based on the use of the building. To get the higher side effects, this building is considered as a commercial building and a live load of 4kN/m2 is assumed as per code. After assigning these gravity loads, it gets distributed from floor loads to beams shown in Fig. 5.

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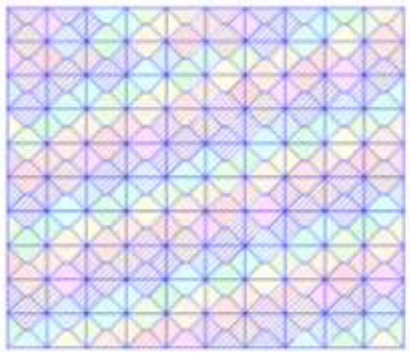

Fig. 5: Distribution of loads

3.5 SEISMIC LOAD

For the calculation of seismic forces directly by STAAD-Pro, customised support at the joints of beam and column were assigned. Assignment of the supports at the joints will provide the shear forces at that joint where earthquake occurs. This due to the reason that at the joints the earthquake affects more. Further, as per IS: 1893 Part 1, 2016, if live load is up to 3 kN/m2 then only 25% live load should be taken for the earthquake analysis and, if live load is greater than 3kN/m2, then 50% of live load should be taken for the earthquake analysis and the same is applied in the present investigation. Dead load has to be considered fully, no reduction in dead load is needed as it is rigidly connected to the other components even at the time of earthquake. So, after assigning the customized supports, the structure is analysed for the seismic combination of 0.5 LL + DL to get the forces at the joint at the time of earthquake.

3.5.1 FACTORS CONSIDERED FOR EARTHQUAKE

IS:1893 Part 1, 2016 has given some parameters depends on the zone of the structure, type of building, type of soil and fundamental natural period which we need to consider while analysing the building against earthquake. Table 2 shows the zone factor (z), importance factor (I) and response reduction factor (R) for the different zones in India. Table 3 shows the calculation of fundamental natural period respectively. Fundamental natural period is given as,

$$T = \frac{0.09h}{\sqrt{d}} \qquad (1)$$

Table 2: Fundamental natural period

Natural Fundamental Periods	
Tx	Tz
0.27	0.298

Table 3: Factors to define seismic loadings

Zone	Z	I	R
II	0.1	1	5
III	0.16	1	5
IV	0.24	1	5
V	0.36	1	5

3.5.2 RESPONSE SPECTRUM ANALYSIS

To analyse the structure with dynamic linear analysis, modal analysis need to be carried out. Thereafter, spectra need to be defined as per IS:1893 Part 1, 2016 [1]. To define the spectra, we needed to define the value of horizontal acceleration coefficient by using the Eq. 2. Then, the earthquake forces which has been calculated for earthquake combination of 0.5LL+DL, will be assigned to same joints in both the lateral directions and same forces in Y-direction, shall need to be assigned as seismic weight. Fig. 6 shows the forces assigned at some of the joints.

$$A_h = \frac{z}{2} \times \frac{I}{R} \times \frac{S_a}{g} \qquad (2)$$

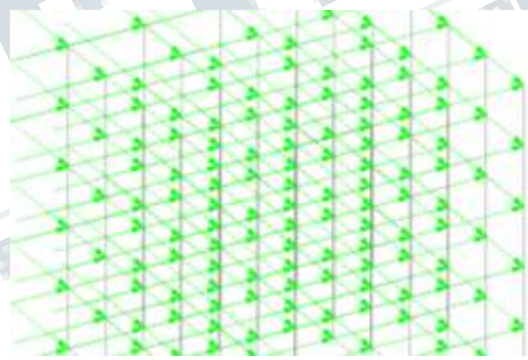

Fig. 6: Forces assigned at beam - column joints

While defining the horizontal acceleration coefficient in software, the value of Sa/g will be taken by the STAAD.Pro according to the value of time period. The structure which is in zone IV and V, we need to consider the vertical motions as well. Values of the factor to be defined in analysis for the different zones are given in Table 4.

Table 4: Factor for RSA

Sr. No.	Zone	Factor $(\frac{z}{2} \times \frac{I}{R})$	Vertical Vibration
1	I	0.01	-
2	II	0.016	-
3	III	0.024	0.016
4	IV	0.036	0.024

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3.5.3 LOAD COMBINATIONS

We need to consider some of the factors with consideration of several combinations for the future uncertainties. The combinations to be taken into considerations is shown in Table 4 based on IS:1893 part 1, 2016 [1].

Table 5: Load Combinations

Sr. No.	Combinations
1	1.5DL+1.5LL
2	1.5DL+1.5(0.9LL)
3	1.5DL+1.5(0.8LL)
4	1.5DL+1.5(0.7LL)
5	1.5DL+1.5(0.6LL)
6	1.5DL+1.5(0.5LL)
7	1.2DL+1.2LL+1.2EQX
8	1.2DL+1.2LL+1.2EQZ
9	1.2DL+1.2LL-1.2EQX
10	1.2DL+1.2LL-1.2EQZ
11	1.5DL+1.5EQX
12	1.5DL+1.5EQZ
13	1.5DL-1.5EQX
14	1.5DL-1.5EQZ
15	0.9DL+1.5EQX
16	0.9DL+1.5EQZ
17	0.9DL-1.5EQX
18	0.9DL-1.5EQZ
19	$1.2[DL + IL \pm (EL_X \pm 0.3EL_Y \pm 0.3EL_Z)]$
20	$1.2[DL + IL \pm (EL_Y \pm 0.3EL_X \pm 0.3EL_Z)$
21	$1.5[DL \pm (EL_X \pm 0.3EL_Y \pm 0.3EL_Z)]$
22	$1.5[DL \pm (EL_Y \pm 0.3EL_X \pm 0.3EL_Z)]$
23	$0.9DL \pm 1.5(EL_X \pm 0.3EL_Y \pm 0.3EL_Z)$
24	$0.9DL \pm 1.5(EL_X \pm 0.3EL_Y \pm 0.3EL_Z)]$

IV. USE OF MASTER-SLAVE

In reality, the members of each floor are rigidly connected to each other. So we need to take into consideration the rigidity of slab. While modelling any RC structure in STAAD-Pro, the provided rigidity is substantial. So, by using master-slave combination, we are basically forcing the nodes on each floor to behave in the same manner as of master node. So we need to take a single node at each floor which will govern the behaviour of all other nodes on the each floor. So, by the use of master-slave, the results on the structure will converge towards the practical behaviour of the structure. Fig. 6 shows the assigned master slave on the floor in STAAD-Pro. The analysis results of the building has been compared with and without use of master-slave. Comparison is plotted and shown in graphs.

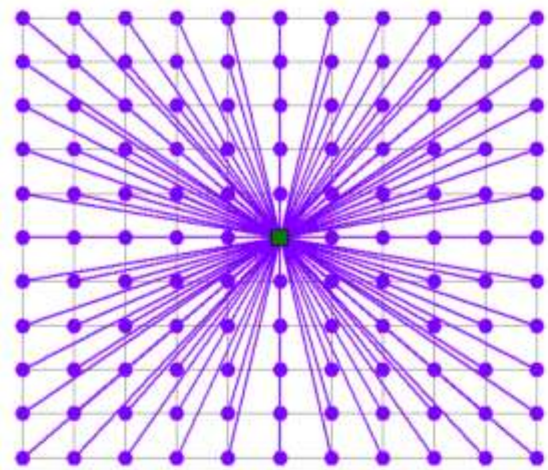

Fig. 7: Assigned master-slave in STAAD-Pro

V. ANALYSIS RESULTS

The graphs has been plotted for the analysis results for all the seismic zones and compared with the analysis done by using master-slave command. By the use of bar charts, comparison amongst the analysis results of node displacements, shear force Fx, shear force Fz, bending moment My, bending moment Mz and axial forces for different seismic zones are shown in Fig. 8, Fig. 9, Fig. 10, Fig. 11, Fig. 12 and Fig. 13, respectively.

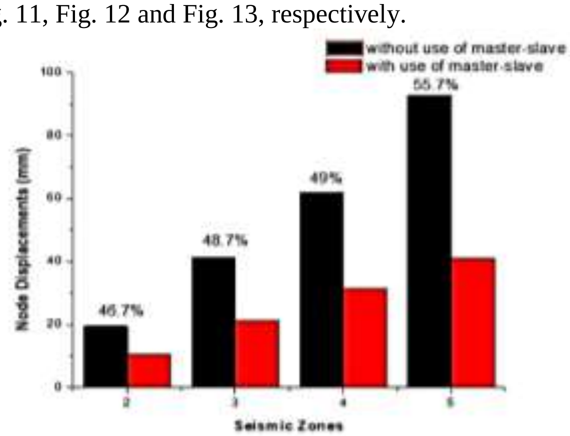

Fig. 8: Node displacements

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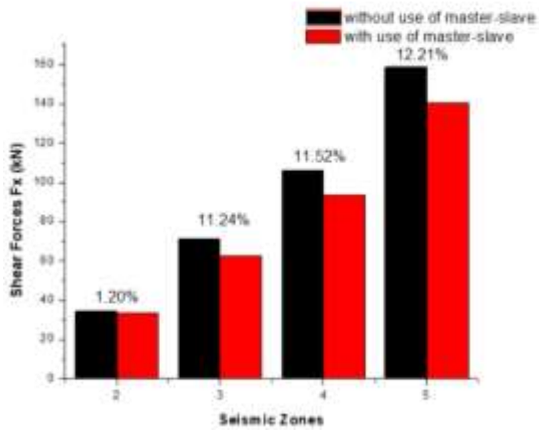

Fig. 9: Shear forces Fx (kN)

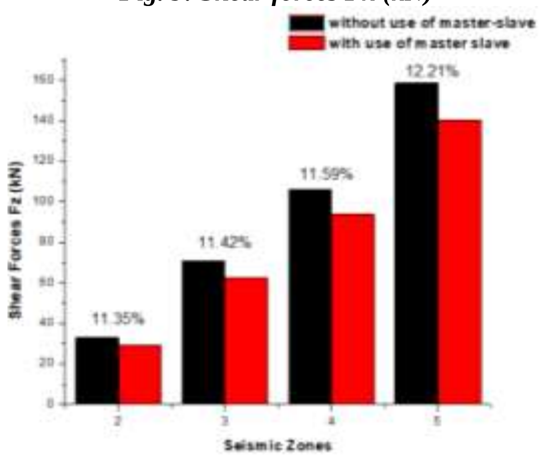

Fig. 10: Shear forces Fy (kN)

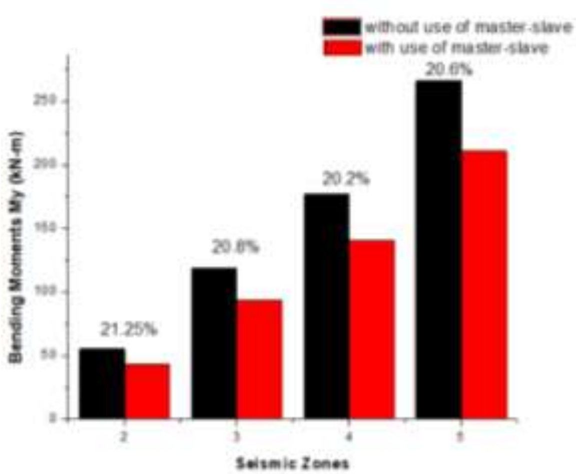

Fig. 11: Bending Moment My (kN-m)

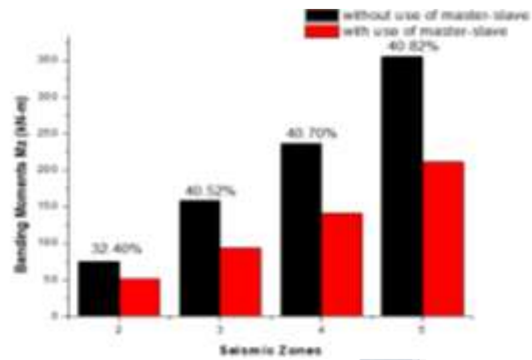

Fig. 12: Bending Moment Mz (kN-m)

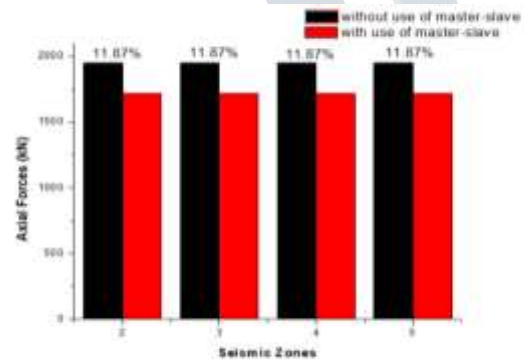

Fig. 13: Axial Forces (kN)

VI. RESULTS AND DISCUSSIONS

While comparing the results as per the seismic zones, it is observed that the results we are getting for the analysis without using the same rigidity to the floor are higher than the results we get with the use of master-slave, which leads to unnecessary increase in the requirement of reinforcement. So, better to give the same rigidity to each of the floor to converge towards more realistic behaviour of the structure, this is possible only by the use of master-slave or by providing the diaphragm action to each of the floor so that it will behave in the same manner leads to more conservative results.

REFERENCES

1. IS 1893 (Part 1) (2016). "Criteria for Earthquake Resistant Design of Structures- Part 1 general provision and buildings", Bureau of Indian Standards, New Delhi, India

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International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

2. IS 456 (2016). “Plain and Reinforced concrete Structures”, Bureau of Indian Standards, New Delhi, India.

3. IS 13920 (2016). “Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces - Code of Practice” Bureau of Indian Standards, New Delhi, India

4. IS 875 Part 3 (1987). “Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures- Wind Loads” Bureau of Indian Standards, New Delhi, India