Comparison of IS 1893 (2002) and IS 1893 (2016) Draft in Multistoreyed Building Design

Zeeshan Farooque[1], A K L Srivastava[2], Md Mozaffar Masud[3]

[1]*Assistant Professor, Department of Civil Engineering, MACET, Patna*
[2] *Professor, Department of Civil Engineering, NIT Jamshedpur*
[3]*Research Scholar, Department of Civil Engineering, NIT Jamshedpur*

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Abstract - This Ground motion occurs in a random pattern both horizontally and vertically in all directions radiating from the epicentre during an earthquake. Structures vibrate and are subjected to inertial forces as a result of ground accelerations. As a result, structures in such locations must be properly designed and detailed to ensure stability, strength, and serviceability while maintaining an acceptable levels of safety when subjected to seismic forces.

In this study, a comparison of IS 1893 Part 1 (2002) and IS 1893 Part 1(2016) Draft was developed, as well as their application in earthquake resistance multi-storeyed frame analysis. According to IS 1893 (2016 draft), a dynamic analysis is required for the design of any unsymmetrical building subjected to earthquake loading. This study used static and dynamic (Response Spectrum Method) earthquake analysis to examine G+9 symmetric and unsymmetrical buildings. On the ground floor columns, we also compared changes in axial load, moment, and torsion.

***Key Words*:** Is 1893 (2016) draft, static method, dynamic method, symmetric building, asymmetric building

1.INTRODUCTION *(Size 11, Times New roman)*

Natural disasters such as earthquakes, tsunamis, landslides, flooding, and other natural disasters cause significant harm and suffering to humans by collapsing many buildings, trapping or killing people, cutting off transportation systems, blocking navigation systems, and causing animal hazards, among other things. Such natural disasters are significant challenges to the progress of development. However, civil engineers play a significant role in minimizing the damages by adequately designing the structures or proper material selections or proper construction procedures and making other valuable decisions. This includes understanding the earthquakes, behaviour of the materials of construction and structures and the extent to which structural engineers use the knowledge in taking proper decisions in designing the structures made of reinforced concrete.

Earthquakes are characterised as a vibration of the earth's surface caused by the release of energy from the crust. Vibrations can occur because the earth's crust is made up of many plates that are continuously moving slowly, resulting in small earthquakes. Most earthquakes are small but are not readily felt. Larger and violent earthquakes occur in a release of energy as the plates slide past or collide into one another. The magnitude of an earthquake, its depth of focus, distance from the epicentre, characteristics of the direction along which the seismic waves pass, and the soil strata on which the structure stands all influence the strength, length, and other characteristics of seismic ground vibrations predicted at any site. Ground vibrations normally travel in a horizontal direction.

In seismic analysis, E. L. Wilson et al.[1] proposed an improved technique to replace the SRSS method. In the examples reviewed, a Complete Quadratic Combination (CQC) approach was suggested, which reduced errors in modal combination. The CQC method degenerates into the SRSS method for systems with well-spaced natural frequencies. Since the CQC method only involves a slight increase in numerical effort, it was recommended that the new approach is used as a replacement for the SRSS Method in all response spectrum calculations. The "characteristic intensity" of ground motions can be expressed in terms of structural damage, and the "damage index" can be expressed in terms of the destructiveness of the ground motions [2]. The conventional 3-D inelastic model enabled the engineer to try different structural configurations and thus, produced designs that had the desired seismic behaviour and are cost-effective [3].

The classical static approach of treating P-delta using amplification factors was not well suited for considering second-order effects during severe seismic excitation. A rational approach was used to estimate the strength level associated with the instability threshold and to ensure that the strength level provided exceeded the required limit by an appropriate safety margin. Guidelines for carrying out an explicit stability check based on this strategy were presented by D bernal et. al.[4]. Pushover analysis could provide insight into the elastic as well as the inelastic response of buildings when subjected to earthquake ground motions. Static pushover analysis was a more appropriate method for low rise and short period frame structures. For well-designed buildings but with structural irregularities, the results of the procedure also showed a good correlation with the dynamic analysis [5]. A superposition-based analysis procedure was proposed to implement code-specified torsional provisions for buildings with flexible floor diaphragms. The procedure suggested considered amplification of static eccentricity as well as accidental eccentricity. The proposed approach was applicable to orthogonal and nonorthogonal unsymmetrical buildings and accounted for all possible definitions of the center of rigidity [6]. There was certainly room for further improvement in all the methods, and time showed which the right option is for each particular class of structures [7]. IS code depicted the higher values of base shear for similar ground types defined in the other codes, which led to overestimate the overturning moment and could result in heavier structural members in the building. For the buildings, the UBC code gave the maximum and IS code gave the minimum displacement values [8]. The columns at the external frame, where there is a sudden change of floor area are taken care in design with some modification

[9]. The special moment of resisting frame structured shows good agreement in resisting the seismic loads than ordinary moment-resisting frame [10]. As compared to static loads, seismic excitation causes even greater nodal displacements and bending moments in beams and columns [11].

2. Methodology

The dynamic analysis of the structure is done through the response spectrum (SRSS) method. Both symmetric and unsymmetrical building is analyzed by the static and dynamic method. Also charges of axial load, moment and torsion in the ground floor column are compared in both static and dynamic loading for both types of building.

The other member forces i.e., axial force, torsion *and* major/minor axis moment for some selected ground floor columns shown in the figure below, are shown in Table 1 and 2 for symmetrical building and in Table 7 and 8 for asymmetrical building.

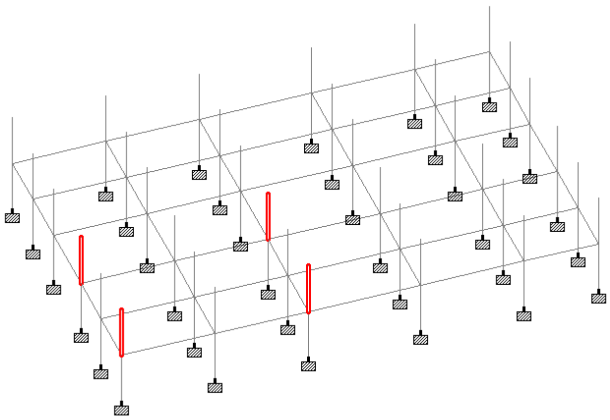

Fig -1: Four columns for which member forces are calculated

3. RESULTS AND DISCUSSION

3.1 Symmetrical Building

Table-1: Member forces (Axial force, Lateral force, Torsion and Moment) in Symmetrical Building model (Static Analysis).

STATIC SYMMETRICAL								
CO L.	LOAD CASE	DIS T	FX KN	FY KN	FZ KN	MX KN m	MY KN m	MZ KNm
601	1.2(DL+LL+E Q)	331	142 9	72.402	- 6.69 2	0.09 6	9.87 9	163.62 8
603	1.2(DL+LL+E Q)	333	262 2	151.07 2	- 6.57 1	- 0.16 4	8.27 2	272.70 1
381	1.2(DL+LL+E Q)	199	166 7	76.389	- 0.48 1	- 0.00 5	0.54 2	168.67 4
383	1.2(DL+LL+E Q)	201	289 1	76.389	- 0.48 1	0.04 3	0.71 8	170.84 4

Table-2: Member forces (Axial force, Lateral force, Torsion and Moment) in Symmetrical Building model (Dynamic Analysis).

DYNAMIC SYMMETRICAL								
CO L.	LOAD CASE	DIS T	FX KN	FY KN	FZ KN	MX KNm	MY KNm	MZ KNm
601	1.2(DL+LL+ EQ)	331	2526. 6	76.47 7	6.18 4	0.098	11.20 6	163.9 14
603	1.2(DL+LL+ EQ)	333	2605. 3	153.3 4	5.55 8	0.164	7.808	272.7 53
381	1.2(DL+LL+ EQ)	199	2789. 8	81.91 6	0.48 8	0.005 1	0.633	169.3 2
383	1.2(DL+LL+ EQ)	201	2859. 8	82.51 2	0.63 3	0.004 5	0.739	172.0 38

The comparison between member forces obtained from static and dynamic analysis are given below in the Table 3, 4 , 5 and 6.

Table -3: Comparison between Axial Compressive Forces

COL.	FY STAT	FY DYN	FY %CHANGE
601	72.402	76.477	5.63
603	151.072	153.34	1.50
381	76.389	81.916	7.24
383	76.389	82.512	8.01

Table -4: Comparison between Torsional Moments

COL.	MX	MX	MX
	STAT	DYN	%CHANGE
601	0.096	0.098	1.03
603	-0.164	0.164	0.00
381	-0.005	-0.0051	2.00
383	-0.043	0.0045	4.65

Table -5: Comparison between Moments (minor axis)

COL.	MY	MY	MY
	STAT	DYN	% CHANGE
601	9.612	11.206	13.43
603	7.756	7.808	5.61
381	0.559	0.633	13.24

383	0.718	0.739	11.80

Table -6: Comparison between Moments (major axis)

COL.	MZ	MZ	MZ
	STAT	DYN	% CHANGE
601	163.628	163.914	0.17
603	272.701	272.753	0.02
381	168.674	169.32	0.38
383	168.674	170.844	1.28

Table – 1 and table -2 shows the static and dynamic analysis result of a symmetric building. Table -3 shows that the percentage of axial load increment in static loading of a symmetric building with respect to dynamic loading is around six percentages. Also the enhancement of torsional moment, major axis and minor axis moment is about 2%, 11% and 5% respectively with respect to static loading in a symmetric building has been noted in Table – 4, 5 and 6. These results are compared with asymmetric building with both static and dynamic loading.

3.2 Asymmetrical Building

Table-7: Member forces (Axial force, Lateral force, Torsion and Moment) in Asymmetrical Building model (Static Analysis).

STATIC ASYMMETRIC								
COL.	LOAD CASE	DIST	FX KN	FY KN	FZ KN	MX KNm	MY KNm	MZ KNm
601	1.2(DL+LL+EQX)	331	1509.3	53.197	-7.134	0.084	10.139	121.145
603	1.2(DL+LL+EQX)	333	2710.4	107.445	-6.749	0.161	8.305	195.206
381	1.2(DL+LL+EQX)	199	1865.9	56.685	-5.863	0.061	8.112	126.251
383	1.2(DL+LL+EQX)	201	3131.8	110.258	-5.745	-0.02	7.12	197.106

Table-8: Member forces (Axial force, Lateral force, Torsion and Moment) in Asymmetrical Building model (Dynamic Analysis).

DYNAMIC ASYMMETRIC								
COL.	LOAD CASE	DIST	FX KN	FY KN	FZ KN	MX KNm	MY KNm	MZ KNm
601	1.2(DL+LL+DYN)	331	2552.9	66.352	-7.043	0.098	11.564	141.924
603	1.2(DL+LL+DYN)	333	2717.1	126.38	-6.784	0.186	11.072	224.418
381	1.2(DL+LL+DYN)	199	2947.5	69.989	-5.859	0.064	9.494	146.909
383	1.2(DL+LL+DYN)	201	3147.1	129.44	-5.708	0.017	10.208	226.238

The comparison between member forces obtained from static and dynamic analysis are given below in the Table 9, 10 , 11 and 12.

Table -9: Comparison between Axial Compressive Forces

COL.	FY	FY	FY
	STAT	DYN	%CHANGE
601	53.197	66.352	24.72
603	107.445	126.38	17.62
381	56.685	69.989	23.47
383	110.258	129.44	17.39

Table -10: Comparison between Torsional Moments

COL.	MX	MX	MX
	STAT	DYN	%CHANGE
601	0.084	0.098	16.66
603	0.161	0.186	15.53
381	0.061	0.064	4.92
383	0.02	0.017	15.00

Table -11: Comparison between Moments (minor axis)

COL.	MY	MY	MY
	STAT	DYN	% CHANGE
601	10.139	11.564	14.05
603	8.305	11.072	33.33
381	8.112	9.494	17.13
383	7.12	10.208	43.40

Table -12: Comparison between Moments (major axis)

COL.	MZ	MZ	MZ
	STAT	DYN	% CHANGE
601	38.446	57.536	49.65

603	127.13	154.831	21.79
381	43.805	63.432	44.81
383	133.667	162.189	21.34

Table 7 and 8 show the axial load and moments of both internal and external ground floor columns of an asymmetric building in static and dynamic loading. It has been noted in Table 9 that due to dynamic loading, about 20 % enhancement of axial loading in column with respect to static loading. Similar results have been observed in the case of torsional moment, major axis moment and minor axis moment. It has also been noted that the percentage of enhancement axial load in the asymmetric building during dynamic loading is about three times more than in symmetric building. In the case of an asymmetric building, torsional moment and axial moments (major and minor axis), it has been noted that it is about 3 to 5 times higher than the symmetric building with dynamic loading.

In the case of dynamic analysis, the vertical load and moments are increased due to the changes of a dynamic amplification factor (DAF), which is defined as the ratio between the dynamic displacement response of a single elastic degree of freedom system and its static displacement response under the same loading.

4. CONCLUSIONS

From the results obtained from the detailed static and dynamic analysis of symmetric and asymmetric building following conclusions are made:

SYMMETRIC BUILDINGS

- More than 6.60% increase in axial force (FY) in dynamic analysis with respect to static analysis.
- More than 5% increase in the moment about Z-axis and more than 11% increase in the moment about Y-axis in dynamic analysis.
- More than 2.0 % change in the torsional moment in dynamic analysis though the numerical values are small.

ASYMMETRIC BUILDINGS

- More than 25% increase in axial force (FY) in dynamic analysis with respect to static earthquake loading.
- 30 % increase in the moment about Z-axis and up to 25% increase in the moment about Y-axis in dynamic analysis.
- 13% increase in the torsional moment in dynamic analysis.

It has been observed in the present study that for symmetric building column with static and dynamic loading, the percentage of changes in axial compression load and moment (torsional and axial moment) is significantly less. In the case of an asymmetric building due to dynamic loading, significant changes have been noticed for both axial load and moment. In the case of asymmetric bulling axial moment value is more than three times (in dynamic loading) than that of symmetric building, which is a critical load and in the design aspect. As per changes in the IS 1893 (2016) draft, any asymmetric bulling during earthquake analysis has to perform dynamic analysis. Our results show that the design of earthquake resistance building with asymmetric dynamic load is critical for design , which is satisfied with the new changes in the IS 1893 (2016) draft.

REFERENCES

1. Wilson, E. L., Kiureghian, A. D., Bayo, E. P.: A replacement for the SRSS method in seismic analysis. Earthquake Engineering and Structural Dynamics, Vol. 9 (1981), 187-194.

2. Park ,Y.J., Ang, A. H.-S., Wen ,Y. K.: Seismic damage analysis of reinforced concrete buildings. M. ASCE(1985).

3. La llera ,J. C. D., Chopra, A. K. : A simplified model for analysis and design of asymmetric-plan buildings. Earthquake Engineering and Structural Dynamics, Vol. 24(1995), 573- 594.

4.Bernal, D.: Instability of buildings during seismic response. Engineering Structures, Vol. 20 (1998), 496-502.

5. Mwafy, A.M., Elnashai ,A.S.: Static pushover versus dynamic collapse analysis of RC buildings(2000).

6. Basu, D., Jain, S.K.: Seismic Analysis of Asymmetric Buildings with Flexible Floor Diaphragms. J. Struct. Eng.,(2004)130,1169-1176.

7. Kappos, A. J., Panagopoulos, G.: Performance-based seismic design of 3d r/c buildings using inelastic static and dynamic analysis procedures. ISET Journal of Earthquake Technology, Paper No. 444, Vol. 41, No. 1, March (2004), 141-158.

8. Shirule, P.A., Mahajan, B.V.:Response Spectrum Analysis of Asymmetrical Building. PRATIBHA: International Journal of Science, Spirituality, Business and Technology (IJSSBT), Vol. 1, No.2, February (2013).

9. Tande, S. N., Patil, S. J.: Seismic Response of Asymmetric Buildings. International Journal of Latest Trends in Engineering and Technology (IJLTET), (2013).

10. Pavan Kumar, E., Naresh ,A., Nagajyothi, M. Rajasekhar, M.: Earthquake Analysis of Multi Storied Residential Building. Int.Journal of Engineering Research and Applications. Vol. 4, Issue 11(Version 1), November (2014).

11. Yajdhani, Dr. S.: Comparative Study of Static and Dynamic Seismic Analysis of a Multistoried Building. IJSTE - International Journal of Science Technology & Engineering, Vol. 2, Issue 01, July (2015).