Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 7, Issue 2; April-June 2020, pp. 141-146

http://www.krishisanskriti.org/Publication.html

Study of RC Plan Irregular Multi-Storey Building with IS 1893(Part-1):2002 and IS 1893 (Part-1):2016 using Response Spectrum Analysis

Shariqa Ali[1] and Anjali Rai[2]

[1]*M.Tech Student, Department of Civil Engineering, IET, Lucknow*
[2]*Assistant Professor, Department of Civil Engineering, IET, Lucknow*

Abstract—*From the past evaluation and trend in technologies many changes have been done for improving the performance of high rise buildings in most seismic prone areas .The national building codes which released by bureau of Indian standards during December 2016/January 2017 undergoes many changes as per latest technology and requirement. It is necessary to evaluate the performance of structures on the basis of both new and the existing one code. This paper analyses the performance of RCC plan irregular building in zone III having medium soil with both codes , as the evaluation of irregularity is important because it tends to decrease the seismic performance of structures. This study highlights the significance differences in various provisions and parameters of both codes specially related to irregularity and dynamic analysis. A G+15 RCC multi-story building with H, L and T shape is modeled and analyzed with IS 1893(Part-1):2002 and IS 1893(Part-1):2016 to find out the effect of irregularity on RCC structures using ETABS 2017 software. In this study, the parameters i.e. store displacement, base shear, fundamental time-period for all models are considered and compared using Response spectrum method of analysis. The results show higher values of storey displacement, base shear in case of models analyzed with IS 1893(Part-1):2016 but the time period values are same from both the codes and the L shape shows more variation when compared with other models.*

Keywords: *Storey displacement, Base shear, Fundamental time period, Response spectrum analysis, Plan irregularity, IS 1893(Part-1):2002 and 2016.*

1. INTRODUCTION

Due to the rapid development in the earthquake engineering practices during last several years, the seismic codes are becoming more refined. Firstly, the seismic codes are based on extensive information of ground's motions that are irregular in magnitude, in direction and also in sequences. This research focuses on the outcomes of the different ground's motion on the structures under seismic forces. And also study the reason behind their variation.

In India, the first seismic code was published in year 1962 and after that it is revised in years 1966, 1970, 1975, 1984 and after the devastating Bhuj earthquake in 2001 and as a fifth revision in 2002. The actual progress in the understanding of earthquake , the responses of different kinds of structures and many more modifications in the literature have been witnessed in last few years. Due to several earthquakes the building code is again revised in 2016 and this is the latest version of the code. As all know that the major issue on designing a multistory structure is its lateral instability due to which structure may collapse. So, seismic zones are also considered while designing a multistory building. For fulfilling the needs and providing the habitat to every individual we need to make the buildings in various kinds of shapes and also in various heights which are called high-rise. So, various kinds of irregular shapes of high rise building are provided due to limitation of space and also for the aesthetic appearance. But the irregularity in structures decreases the seismic performance of multi-storey buildings when seismic analysis is done.

In the research, we try to understand the changes in both codes by doing analysis with the help of software on a RCC building with irregular configuration. Most of construction in recent time consist of poorly design and constructed building in urban areas. The older buildings may not comply with the more stringent specifications of the latest standards of IS 1893(Part-1):2016, even if constructed with the most popular code.

Table 1: Comparison between IS 1893(Part-1):2002 and IS 1893(Part-1):2016 in terms of irregularity

Sr. no.	IS 1893(PART-1):2002	IS 1893(PART-1):2016
1.	Torsion irregularity: it is came when the maximum storey drift at one end of the structure transverse to the axis is greater than 1.2 times of the average of drift at two ends.	Torsion irregularity: it is came when the maximum horizontal displacement at one end of floor is greater than 1.5 times of minimum horizontal displacement at far end of same floor.
2.	Re-entrant corners: For this case, the ratio	Re-entrant Corners: It is more accurate as the ratio

	of A/L should be greater than 0.15-0.20.	of A/L should be greater than 0.15.
3.	Diaphragm: If cut out area is greater than 0.5 times of the total area than called discontinuous diaphragm.	Diaphragm: If cut out area is greater than 0.5 times of total area called flexible diaphragm. If cut out area is less than 0.5 times of total area called rigid diaphragm.
4.	Soft storey: If the lateral stiffness of any floor is less than 70% of that in the floor above or is less than 80% of the average lateral stiffness of the three floor above.	Soft storey: A building is said to have a soft storey if lateral stiffness of any floor is less than the floor above.
5.	Mass Irregularity: If seismic weight of any floor is more than 200% to that of the floor above or below then mass irregularity is considered to exist.	Mass Irregularity: If seismic weight of any floor is more than 150% to that of the floor below then mass irregularity is considered to exist.
6.	Vertical Geometric irregularity: This type of irregularity will be considered to exist, when the horizontal dimension of the horizontal force resisting system in any floor is more than 150 % of that the floor below or above. The value of L_2 should be greater than 1.5 times of the value of L_1.	Vertical Geometric Irregularity: this type of irregularity will be considered to exist, when the horizontal dimension of the horizontal force resisting system in any story is more than 125 % of that the storey below. The value of L_2 should be greater than 1.25 times of the value of L_1.
7.	Weak storey: According to older one, It is that storey whose lateral strength is less than 80% of that in the floor above.	Weak storey: According to new revision, It is that storey whose lateral strength is less than that in the floor above

In the present study the objectives of this paper are shown below:

1) To study changes and adaptation of new provisions and clauses in IS 1893 (Part-1): 2016 with respect to previous IS 1893 (Part-1): 2002 and their effect.
2) To analyze the RC multi-story building (G+15) having plan shape H, L and T with IS 1893(Part-1):2002 and IS 1893(Part1):2016 in seismic zones III by using ETABs 2017 software.
3) To find the parameters i.e. storey displacement, base shear and fundamental time-period with response spectrum method using both codes
4) Plot the comparison curves of the parameter resulted after analysis with both codes.

2. METHODOLOGY

2.1 As Per IS 1893(Part-1):2016

From both the codes, the calculation procedure of finding seismic loading is somehow similar. The only difference is that in new code now we have the clarity about the vertical e9arthquake load as compared to previous one. So we considered the vertical earthquake load also with the lateral earthquake load, so there is a difference of load combination in both methods

Finding of design earthquake load:

The design earthquake load effect can be found out by two methods: static equivalent method and dynamic analysis method.

But according to draft code, the irregular buildings which are in seismic zone III, IV and V having height taller than 12m and in seismic zone II having height more than 48m, dynamic analysis procedure is applicable rather than equivalent static method. So we are performing dynamic analysis as the building's height is 48.5 m and have H, L and T configuration.

Dynamic analysis method-

Dynamic analysis method can be done in the following ways:

(i) Response spectrum analysis
(ii) Model time history method
(iii) Time history method

Here, model time history method is newly added in the draft code for the calculation of lateral seismic forces.

Response spectrum analysis: This method is alsoknown as the mode superposition method. Whenever the modes other than the fundamental one affect the response of the structure, this method is used in that structure. Generally, for finding dynamic response of an asymmetrical buildings or the buiding having area of discontinuity or having irregularity in their linear response this method is used. When medium ground shaking causes moderately large deformation which results in essential linear response in sructure, then the respnse spectrum method is purposely used to analyse deformation and forces in that structure. In this approach multiple mode of responses are taken into account.

Here, the separate spectrum are defined up to 6 seconds natural period for both static equivalent method and response spectrum analysis method. The Figures below show these graphs of design acceleration coefficient corresponding to 5% damping. Hence, the clause 6.4.2 mentioned in code IS 1893(part-1):2016 gives the expression to determine the Sa /g value for equivalent static method as well as for response spectrum method. The table 4 in new code tells about the classification of different type of soil.

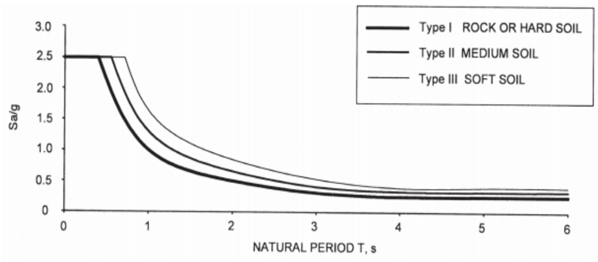

Fig.1: For Equivalent static method

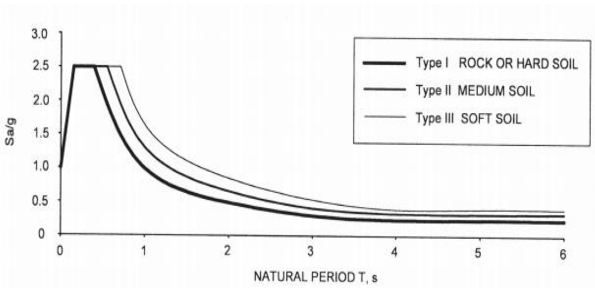

Fig.2: For Response spectrum method

2.2 As Per IS 1893(Part-1):2002

Seismic load calculation is similar to the new code but there is no clarity about the vertical earthquake load in this code, therefore the vertical earthquake load is not considered in this method so the load combination only contain the x and y part of earthquake load.

Finding of design earthquake load:

It can be found out by two ways: Static equivalent method and dynamic analysis method. Here the dynamic analysis is done as our building is irregular having 48.5m height and the response spectrum analysis adopted for dynamic analysis.

Response spectrum analysis:

The combined design spectrum is defined up to 4 seconds natural period for both equivalent static method & response spectrum method.

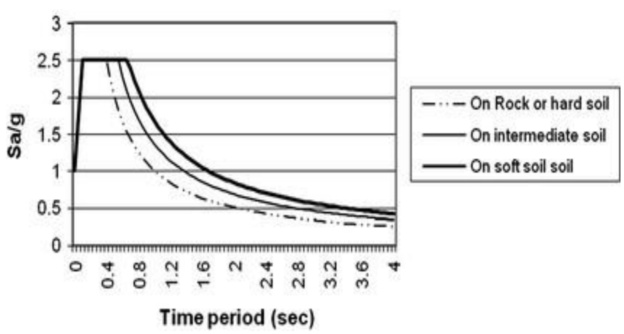

Fig. 3: For Response Spectra (Rock and Soil sites, 5% Damping)

The Figure 3 shows the graph of design acceleration coefficient corresponding to 5% damping. Hence, the clause 6.4.5 in IS 1893(part-1):2002 mentions the expressions to determine the Sa /g value using equivalent static method as well as response spectrum method. The table 1 in the previous code tells about the classification of various type of soil.

3. PROBLEM STATEMENT

In this work, we study the major changes in some provisions of the IS 1893(Part-1):2002 and analyze the special moment resisting RC irregular building in plan with both the codes and compare the values of the results. Different plan irregular building (G+15) like H, L and T shape having re-entrant corner has been considered for the present study. ETABs 2017 FEM based software is used for modeling and analysis. Building is considered having 14KN/m load bearing wall load, 7 KN/m partition wall load and 3KN/m^2 live load as per the code. Building is a commercial building located on medium soil in zone III.

Table 2: Description of Building

S. No	Name of parameter	Value
1.	Building type	Commercial
2.	Number of storey	G+15
3.	Bottom storey height	3.5m
4.	Total height	48.5m
5.	Floor height	3m
6.	Size of column	450×550mm(for external column) 400×500mm(for internal column)
7.	Size of beam	350×450mm(for external beam) 300×400mm(for internal beam)
8.	Thickness of slab	130mm

Table 3: Material Properties

S. No	Material	Grade
1.	Concrete	M30(column) M25(Beam and slab)
2.	Steel reinforcement	Fe250 and HYSD 500

Table 4: Seismic Data

1.	Earthquake Zone	III
2.	Zone factor(Z)	0.16
3.	Damping Ratio	5%
4.	Importance Factor(I)	1{as per IS 1893(Part1):2002} 1.2{as per IS 1893(Part1):2016}
5.	Response Reduction Factor (R)	5
6.	Type of soil	Medium soil

4. STRUCTURAL MODELING

For the purpose of this study, three models of (G+15) high rise RC framed irregular building with H, L and T configuration having re-entrant corner were selected in order to determine the seismic performance of the building. The columns are taken as restrain and fixed at the ground. The building height is 48.5m with base storey height 3.5 and floor height 3m.Figure 4, 5 and 6 shows the geometrical configuration of the building. The no. of bays in X and Y direction are15.Software ETABs is used for modeling and seismic analysis. To study the seismic behaviour, models are compared with different parametres of analysis.

Model 1: G+15 H shape

Model 2: G+15 L shape

Model 3: G+15 T shape

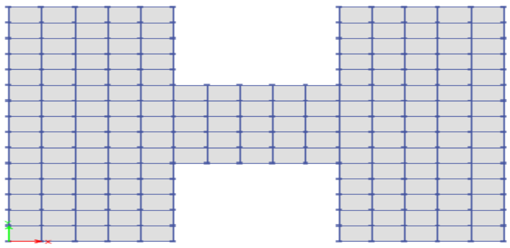

Fig. 4: Plan view of Model 1

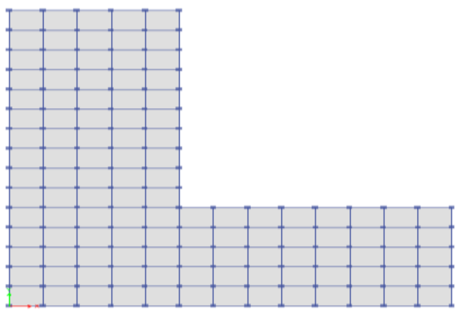

Fig. 5: Plan view of Model 2

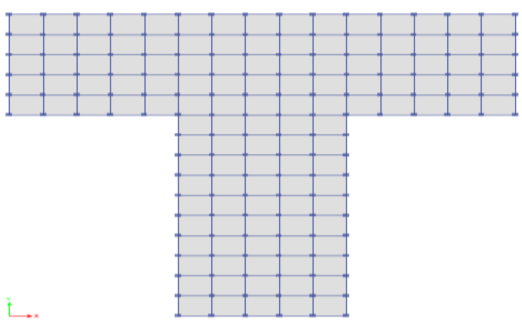

Fig. 6: Plan view of Model 3

5. RESULT AND DISCUSSION

5.1 Storey Displacement

The models analysed with new code showing higher value of storey displacement compared with old code analysis. The table and the graph below is showing the maximum storey displacement values of all models in X and Y direction with both the codes.

Table 5: Max. Storey Displacement (mm) comparison in X direction

Model	IS 1893(Part-1):2002	IS 1893(Part -1):2016
H Shape	14.89	17.868
L Shape	15.189	21.515
T Shape	18.581	22.311

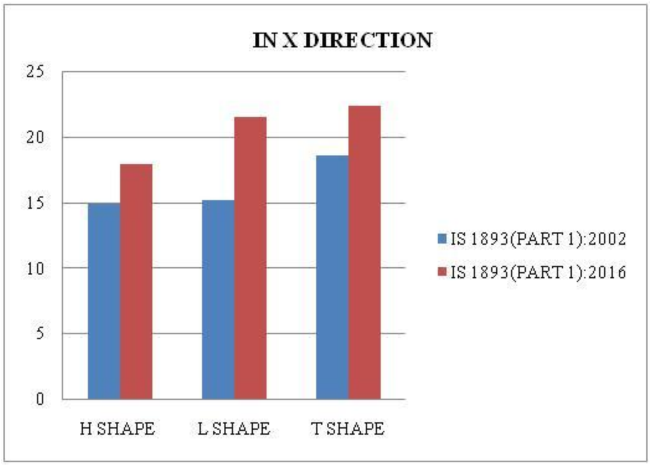

Fig. 7: Max. Storey Displacement (mm) comparison in X direction

Figure 7 shows graphical representation between storey displacements in X direction with plan irregularity by response spectrum method using IS 1893:2002 and IS 1893:2016. It shows that the storey displacement in X direction is increases by 20% in H shape, 42% in L shape and 20% in T shape but didn't exceed the permissible limit.

Table 6: Max. Storey Displacement (mm) comparison in Y direction

Model	**IS 1893(Part -1):2002**	**IS 1893(Part -1):2016**
H Shape	14.906	17.887
L Shape	15.827	21.734
T Shape	15.376	18.451

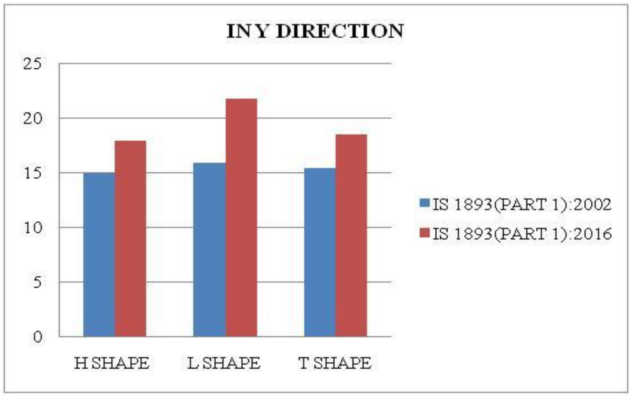

Fig. 8: Max. Storey Displacement (mm) comparison in Y direction

Figure 8 shows graphical representation between storey displacements in Y direction with plan irregularity by response spectrum method using IS 1893:2002 and IS 1893:2016. It shows that the storey displacement in Y direction is increases by 20% in H shape, 37% in L shape and 20% in T shape but didn't exceed the permissible limit.

5.2 Base shear

It is the total design lateral force which acts at the base of the structure. The base shear value for all 3 models is tabulated in the table 8 below. The models when analysed as per IS 1893-2016 gives higher values of base shear in both X and Y direction than the models analysed as per IS 1893-2002. For vertical earthquake load, the base shear is computed for the models according to IS 1893(part-1)-2016. According to the clause in code 2/3rd of the lateral load which acts on structure due to earthquake considered as vertical load and should be analysed. The values of the base shear due to vertical earthquake load are too less than the gravity loads and hence they are ignored and not mention here. They are also ignored in the design.

Table 7: Base shear (KN) comparison in X direction

Model	IS 1893(Part - 1):2002	IS 1893(Part-1):2016
H Shape	4272.4595	5126.9607
L Shape	2391.2651	3384.4653
T Shape	3248.1126	3897.3599

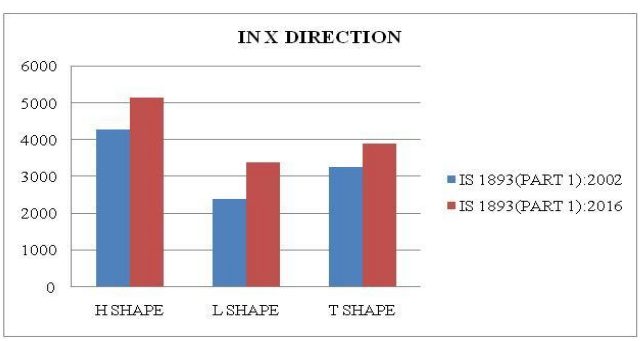

Fig. 9: Base shear (KN) comparison in X direction

Figure 9 shows graphical representation between base shear in X direction with plan irregularity by response spectrum method using IS 1893:2002 and IS 1893:2016. It shows that the base shear in X direction is increases by 20% in H shape, 42% in L shape and 20% in T shape.

Table 8: Base shear (KN) comparison in Y direction

Model	IS 1893(Part-1):2002	IS 1893(Part-1):2016
H Shape	4178.222	5013.871
L Shape	2363.1519	3243.6082
T Shape	2936.3599	3523.5428

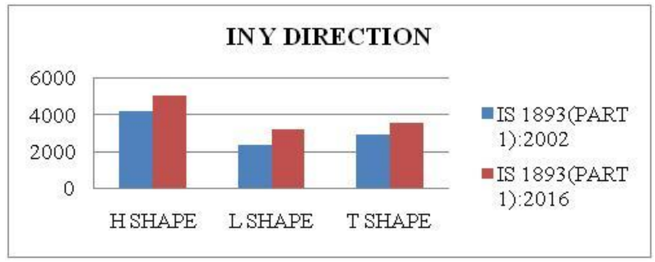

Fig.10: Base shear (KN) comparison in Y direction

Figure 10 shows graphical representation between base shear in Y direction with plan irregularity by response spectrum method using IS 1893:2002 and IS 1893:2016. It shows that the base shear in Y direction is increases by 20% in H shape, 37% in L shape and 20% in T shape.

5.3 Fundamental Time Period

According to IS 1893(Part 1), it is the first longest (in seconds) modal time period of vibration. The time period values are same from both the codes for all models because the stiffness is same. The table 9 is showing the maximum value of time period which is coming at mode 1for all the models.

Table 9: Fundamental Time Period (sec)

Model	IS 1893(Part-1):2002	IS 1893(Part-1):2016
H Shape	1.896	1.896
L Shape	1.948	1.948
T Shape	1.944	1.944

The L shape models shows high value of time period among all three models.

6. CONCLUSION

Based on the Response spectrum study on plan irregular multi-storey building, following points are concluded:

- The value of time period, importance factor of building, the response reduction factor and the design acceleration coefficient have more realistic value in new code.

Therefore, new code is more refined as compared to old code.

- For any type of irregularity in structural system, we got clarity in new code and got more realistic approach of analysis for regular and irregular buildings.
- Depending upon occupancy and location, new code proposed more fractional approach in seismic design. It gives the clarity for vertical earthquake load as compare to old code as all conditions are specified in which vertical earthquake load could come.
- Method of liquefaction, potential analysis in simplified form is carried out to be extra items in new code. Torsional provisions were also added.
- The models analyzed as per the IS 1893(Part-1):2016 showing approximately 20%,40% and 20% higher values of storey displacement in H, L and T shape respectively than the models analyzed as per IS 1893(Part-1):2002, this is due to reduction of moment of inertia and the higher factor of safety considered in new code of practice.
- The models analysed as per IS 1893(Part-1):2016 showing approximately 20%,40% and 20% higher values of base shear in H, L and T shape respectively than models analysed as per IS 1893(Part-1):2002.The values of base shear under vertical earthquake load found too less than the gravity loads and hence they are not mentioned here. They are ignored in the design.
- The time period values obtained from analysis as per IS 1893(Part-1):2016 gave the same values as compared to when the models analysed as per IS 1893(Part-1):2002 because the stiffness values are same when all models analysed with both code. As In analytical method time period depends upon mass and stiffness.
- The L shape is showing the maximum variation among all three models.
- According to revised code the building is safe and not structurally deficient. Hence, there is no requirement of retrofitting this building to ensure safety against design seismic vibration.

References

[1] Rita Debnath "*A Comparative Study of the Seismic Provisions of Indian Seismic Code IS 1893-2002 and Draft Indian code IS 1893:2016",* NIT Agartala; Springer (2019)

[2] Ajay Kumar "*A comparative study of static analysis (as per is: 1893-2002) & dynamic analysis (as per is:1893-2016) of a building for zone v"*. International Journal of Civil Engineering and Technology (IJCIET) Volume 10, Issue 03, March 2019

[3] Vikas Siddesh "*Codal comparison of is-1893 (part 1)2002 and is-1893 (part 1) 2016 for seismic analysis of high rise building with raft foundation using etabs and safe software",* IRJET Volume: 06 Issue: 07 July 2019

[4] Snehal D.Channe "*Seismic Analysis of High Rise Building with IS Code 1893:2016*", IOSR Journal of Engineering(IOSRJEN)(2019)

[5] Sanyogita and Babita Saini, "*Seismic Analysis of Vertical Irregularities in Buildings*". Department of Civil Engineering, National Institute of Technology, Springer (2019)

[6] Anoj Surwase *"Seismic analysis and comparison of is 1893 (part-1) 2002 and 2016 of (g+4) residential building",* Global Journal of Engineering Science and Researches ISSN 2348 – 8034.

[7] Rakeshkumar Gupta Prof. D.L.Budhlani2 *"Review of IS 1893:2016 with IS1893:2002 for high rise structure with irregularities",* International Journal of Innovations in Engineering and Science, IJIES Vol. 3, No.7 2018 e-ISSN: 2456-3463.

[8] IS:1893(Part-1) (2002)"*Criteria for Earthquake Resistant Design of Structures*", Bureau of Indian Standards, New Delhi.

[9] IS:1893(Part-1) (2016)"*Criteria for Earthquake Resistant Design of Structures*", Bureau of Indian Standards, New Delhi.

[10] IS 456:2000, "*Code of Practice for Plain and Reinforced Concrete*", Bureau of Indian Standards, New Delhi, 2000.