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Review of IS 1893:2016 with IS1893:2002 for high rise structure with irregularities

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Abstract *–The national building code of India(NBC)2015 was released by bureau of Indian standards during December 2016/january2017. The various sections of this NBC have undergone changes as per latest technologies and user requirements. It is necessary to identify the performance of the structures to withstand against disaster for both new and existing one. The paper discusses the performance evaluation of RC (Reinforced Concrete) Buildings with various irregularities. Structural irregularities are important factors which decrease the seismic performance of the structures. This study as a whole makes an effort to evaluate the effect of various irregularities on RC buildings using IS 1893:2002 and IS 1893:2016 in terms of dynamic characteristics.*

Keywords-Seismic performance, Plan, vertical, mass, stiffness, weak storey irregularities, IS 1893:2002, IS1893:2016.

INTRODUCTION

Earthquake is known to be one of the most destructive phenomenons experienced on earth. It is caused due to a sudden release of energy in the earth's crust which results in seismic waves. When the seismic waves reach the foundation level of the structure, it experiences horizontal and vertical motion at ground surface level. Due to this, earthquake is responsible for the damage to various man-made structures like buildings, bridges, roads, dams, etc. It also causes landslides, liquefaction, slope-instability and overall loss of life and property.

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building.

IS 1893 definition of Vertically Irregular structures: The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated.

There are two types of irregularities-
1. Plan Irregularities
2. Vertical Irregularities.

Vertical Irregularities are mainly of five types

i a) Stiffness Irregularity — Soft Storey-A soft storey is one in which the lateral stiffness is less than 70 percent of the storey above or less than 80 percent of the average lateral stiffness of the three storeys above.
b) Stiffness Irregularity — Extreme Soft Storey-An extreme soft storey is one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of the average stiffness of the three storeys above.

ii) Mass Irregularity-Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storeys. In case of roofs irregularity need not be considered.
iii) Vertical Geometric Irregularity- A structure is considered to be Vertical geometric irregular when the horizontal dimension of the lateral force resisting system

in any storey is more 2 than 150 percent of that in its adjacent storey.
iv) In-Plane Discontinuity in Vertical Elements Resisting Lateral Force-An in-plane offset of the lateral force resisting elements greater than the length of those elements.
v) Discontinuity in Capacity — Weak Storey-A weak storey is one in which the storey lateral strength is less than 80 percent of that in the storey above.

METHODOLOGY

RCC Frames with G+10 is considered in the study. Fundamental period of vibration of the frame with fixed support using codal formula in IS 1893(Part I):2002 and IS 1893(Part I):2016 and model analysis is evaluated. In order to understand the effect of irregularities in structures, modeling is done using STAAD. Pro software. Response spectrum methods of seismic analysis of the models are performed using STAADPro.

PROBLEM STATEMENT

The building is analyzed is G+10 R.C framed building of symmetrical rectangular plan configuration. Complete analysis is carried out for dead load, live load & seismic load using STAAD-Pro software. Response Spectrum Method of seismic analysis is used. All combinations are considered as per IS 1893-(part I).

Site Properties:
Details of building:: G+10 RC framed structure
Plan Dimension:: 35m x 20m , 5m span in each direction.
Outer wall thickness:: 230mm
Inner wall thickness:: 230mm
Floor height ::3 m
Parking floor height :: 3m
Material Properties
Material grades of M35 & Fe500 is used for the design.
Loading on structure
Dead load :: self-weight of structure
Weight of 230mm wall :: 13.8 kN/m²
Live load:: Floor:: 2.5 kN/m²
Roof :: 1.5 kN/m²
Seismic load:: Seismic Zone IV

Table 1- Preliminary Geometric & Seismic data

	As per IS 1893:2002	As per IS 1893:2016
Column size	850mmX400mm	950mmX400mm
Beam size	600mmX300mm	600mmX300mm
Slab thickness	120mm	120mm
Seismic Zone Z	IV=0.24	IV=0.24
Importance factor I	1.0	1.2
Response Reduction factor R	5	5

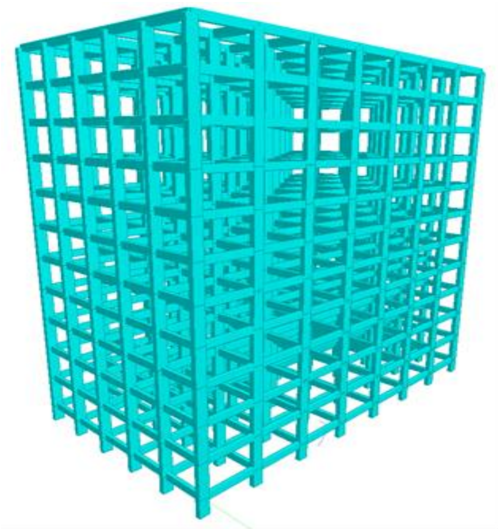

Fig.1- 3D view of G+10 RC building

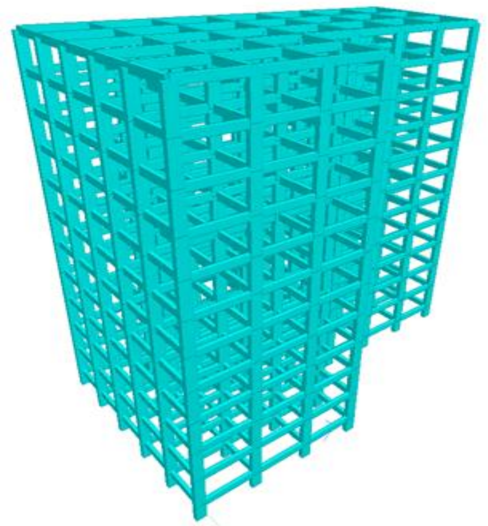

Fig.2- 3D view of G+10 RC building with plan irregularity

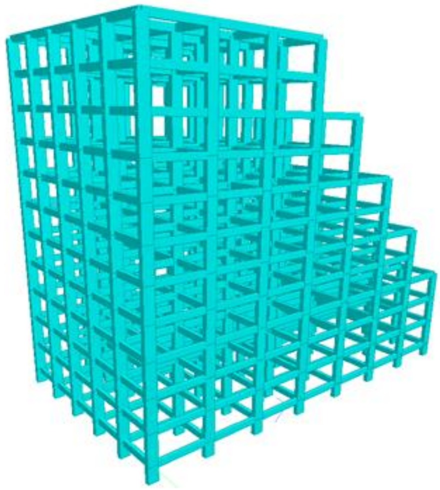

Fig.3- 3D view of G+10 RC building with vertical irregularity

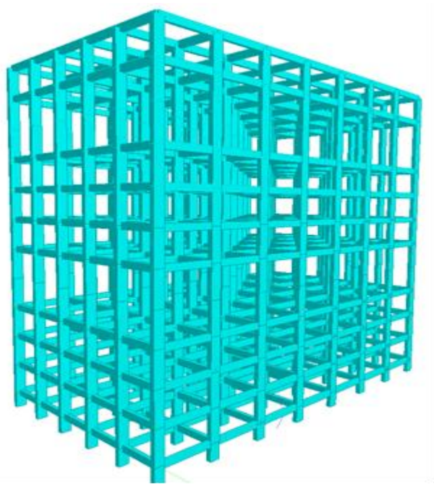

Fig.4- 3D view of G+10 RC building with stiffness irregularity

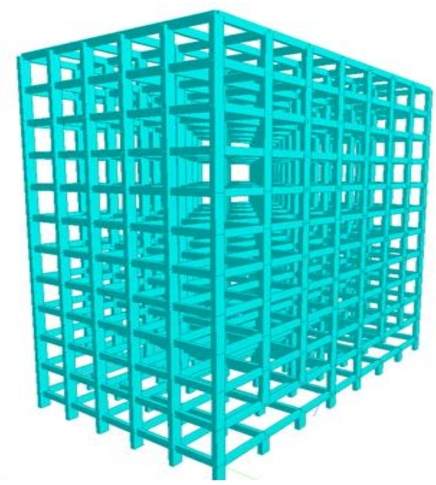

Fig.5- 3D view of G+10 RC building with weak storey irregularity

RESULTS

Table 2- Base shear (kN) in X-direction

Type of Model	IS 1893:2002	IS 1893:2016
Regular	5786.01	8307.57
Plan Irregularity	5465.6	6634.29
Vertical Irregularity	5084.51	6152.26
Mass Irregularity	6909.64	8389.46
Stiffness Irregularity	5657.1	6975.1
Weak storey	6769.97	8423.52

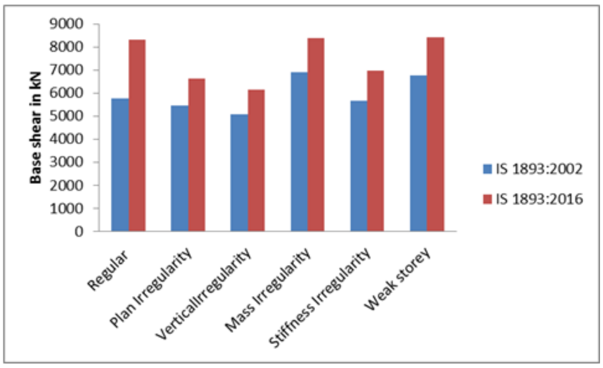

Fig.6-Base shear (kN) in X-direction

Table 3- Base shear (kN) in Z-direction

Type of Model	IS 1893:2002	IS 1893:2016
Regular	5722.98	6944.72
Plan Irregularity	5007.98	6062.15
Vertical Irregularity	4507.57	5651.94
Mass Irregularity	6319.35	7678.22
Stiffness Irregularity	5226.11	6365.39
Weak storey	6219.56	7640.47

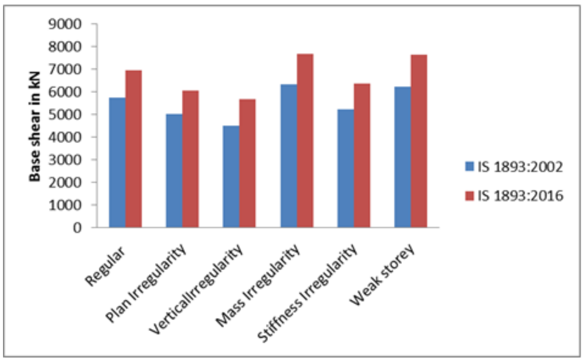

Fig.7-Base shear (kN) in Z-direction

Table 4- Maximum Lateral Displacement (mm) in X-direction

Type of Model	IS 1893:2002	IS 1893:2016
Regular	49.85	81.326
Plan Irregularity	49.863	84.244
Vertical Irregularity	42.462	73.704
Mass Irregularity	50.453	84.926
Stiffness Irregularity	54.486	92.734
Weak storey	53.037	93.968

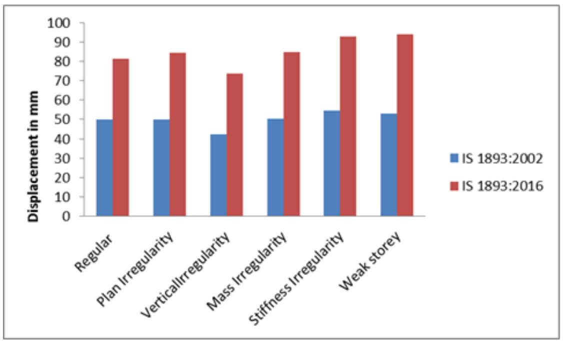

Fig.8-Maximum Lateral Displacement (mm) in X-direction

Table 5- Maximum Lateral Displacement (mm) in Z-direction

Type of Model	IS 1893:2002	IS 1893:2016
Regular	65.255	110.531
Plan Irregularity	72.907	128.677
Vertical Irregularity	81.001	136.697
Mass Irregularity	66.083	115.905
Stiffness Irregularity	81.426	146.157
Weak storey	89.414	170.734

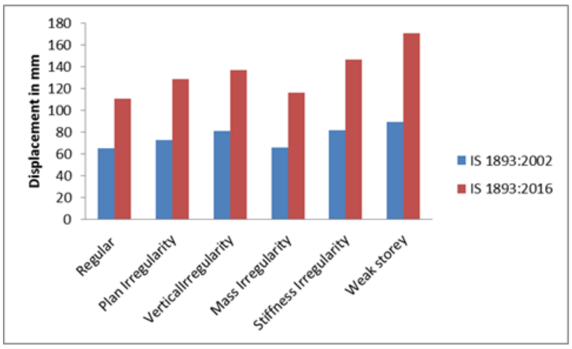

Fig.9-Maximum Lateral Displacement (mm) in Z-direction

Table 6- Maximum axial force (kN) in columns

Type of Model	IS 1893:2002	IS 1893:2016
Regular	4409.52	5452.28
Plan Irregularity	4524.18	5755.75
Vertical Irregularity	4450.9	5657.1
Mass Irregularity	4426.21	5563.72
Stiffness Irregularity	3674.96	4718.07
Weak storey	8721	11045.2

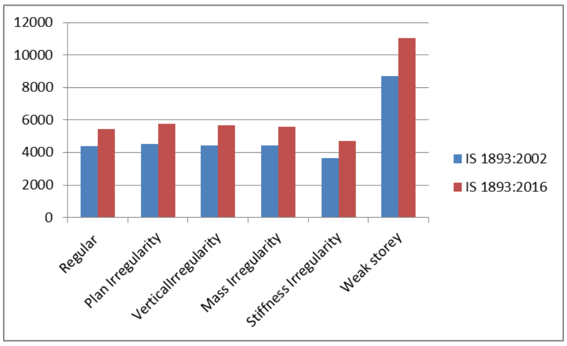

Fig.10- Maximum axial force (kN) in columns

Table 7- Maximum shear force Y (kN) in columns

Type of Model	IS 1893:2002	IS 1893:2016
Regular	244.721	432.068
Plan Irregularity	243.969	356.98
Vertical Irregularity	200.185	438.581
Mass Irregularity	248.922	375.499
Stiffness Irregularity	207.338	1080.05
Weak storey	801.195	423.661

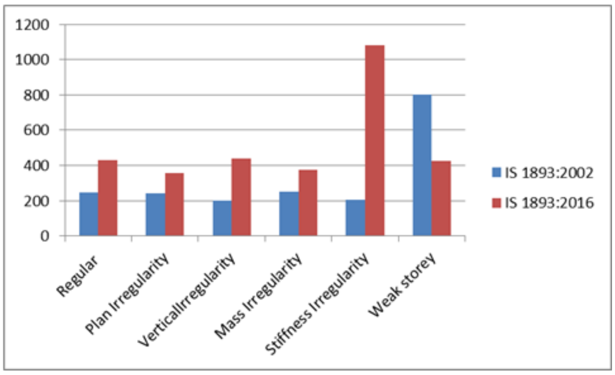

Fig.11-Maximum shear force Y (kN) in columns

Table 8- Maximum shear force Z (kN) in columns

Type of Model	IS 1893:2002	IS 1893:2016
Regular	239.06	475.381
Plan Irregularity	255.938	531.566
VerticalIrregularity	302.143	445.811
Mass Irregularity	242.986	379.235
Stiffness Irregularity	201.316	904.912
Weak storey	455.708	666.208

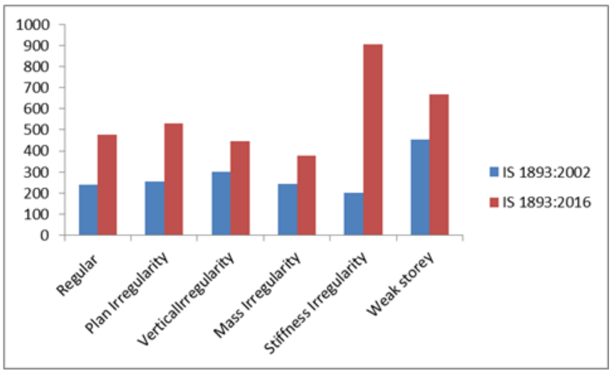

Fig.12-Maximum shear force Z (kN) in columns

Table 9- Maximum moment Y (kNm) in columns

Type of Model	IS 1893:2002	IS 1893:2016
Regular	370.935	666.208
Plan Irregularity	392.576	736.731
Vertical Irregularity	468.698	834.926
Mass Irregularity	377.129	701.31
Stiffness Irregularity	488.377	934.892
Weak storey	709.518	1423.33

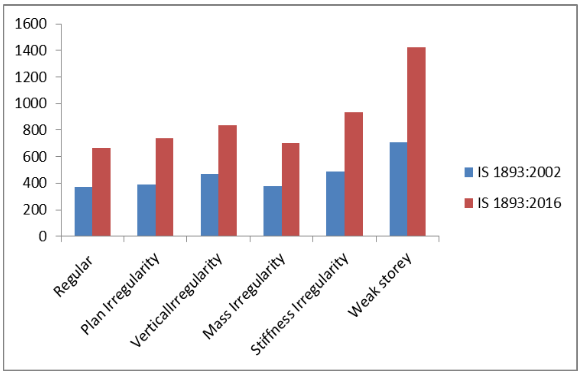

Fig.13-Maximum moment Y(kNm) in columns

Table 10- Maximum moment Z (kNm) in columns

Type of Model	IS 1893:2002	IS 1893:2016
Regular	537.995	1082.54
Plan Irregularity	536.513	1120.87
Vertical Irregularity	408.965	871.491
Mass Irregularity	546.83	1135.72
Stiffness Irregularity	545.523	1006.91
Weak storey	1466.03	2017.62

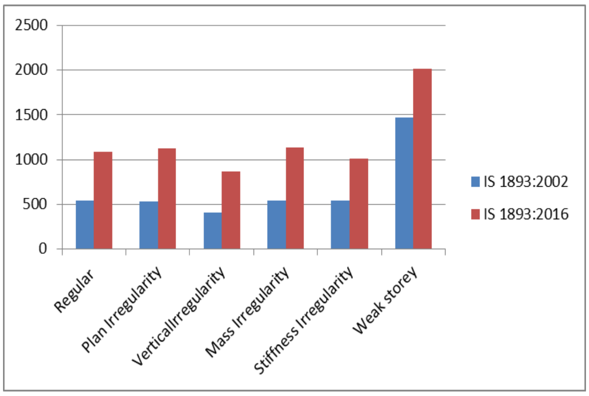

Fig.14-Maximum moment Z (kNm) in columns

CONCLUSIONS

- Base shear for mass irregularity is highest Approximately 20% increase in base shear is calculated after using IS 1893:2016.
- Storeyshearandbaseshearinboththedirectionsi.e .alongX-directionand along Z-direction are increased by nearly same amount i.e. approximately20%when using IS 1893:2016.
- Models using IS 1893:2016shows 10%-20%riseinaxialforce in columns whencompared with models using IS 1893:2000.
- Models using IS 1893:2016shows 15%-25%riseinshearforce in columns whencompared with models using IS 1893:2000.
- Models using IS 1893:2016shows30%riseinmoments in columnswhencompared with models using IS 1893:2000.

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