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Comparative study of typical R.C. Building using IS Standard and IBC (ASCE)

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Abstract - *This study focuses on the comparison of the Indian Code (IS) and International Building Codes (IBC) in relation to the seismic analysis of Ordinary RC moment resisting frame (OMRF) and Special RC moment-resting frame (SMRF) on medium soil. The analytical results of the model buildings are then compared and analysed taking note of any significant differences. The study also helps in understanding the main contributing factors such as base shear, displacement, storey drift which lead to poor performance of Structure during the earthquake, so as to achieve their adequate safe behaviour under future earthquakes. The structure analysed is symmetrical. Modelling of the structure is done as per ETABS. The Lateral seismic forces are calculated manually. The Lateral seismic forces are calculated per floor as per different codes are applied to the Centre of gravity of the structure. The analytical results of the model buildings are then represented graphically and in tabular form, it is compared and analysed taking note of any significant differences. This study focuses on exploring variations in the results obtained using the both codes i.e. IBC (ASCE) and Indian code (IS 1893-2002 and IS 1893-2016). This work aims at the comparison of various provisions for earthquake analysis as given in building codes of Indian Code and International Building Codes.*

Key Words: IS 1893:2002, IS 1893:2016, IBC, ASCE, Base shear, Storey displacement, Storey drift, Comparison.

1.INTRODUCTION

Natural disaster such as Earthquakes, Tsunamis, Landslides, Floods etc. causes severe damages and suffering to human being by collapsing many structures, killing persons, animal hazards etc. Such natural disasters are big challenges to the progress of development. Civil engineers plays an important role in minimizing the damages by proper designing the structures or by proper construction procedure or taking other useful decisions.

India is prone to strong earthquake shaking, and hence it is necessary to design earthquake resistance structure. The Engineers do not attempt to make an earthquake proof buildings that will not damaged even during strong earthquake. Such buildings will be too strong and also to expensive. Earthquakes are defined as a vibration of the earth's surface that occurs after a release of energy in the earth's crust. The purpose of earthquake resistance design is to erect structure that perform better during seismic activity. The aim of the earthquake resistant design is to have structures that will behave elastically and survive without collapse under major earthquakes that might occur during the life of the structure. To avoid collapse during a major earthquake, structural members must be ductile enough to adsorb and dissipate energy.

1.1 Indian standards IS-1893:2002

IS 1893:2002 is denoted as "Criteria for earthquake resistant Design of structures" Part 1 General provisions and buildings. Vertical Distribution of Base Shear to Different Floor Levels is stated in IS 1893:2002.The design lateral force shall first be computed for the building as a whole. The design lateral force shall then be distributed to the various floor levels. This overall design seismic force thus obtained at each floor level shall then be distributed to individual lateral load resisting elements depending on the floor diaphragm action. The design base shear calculated shall be distributed along the height of the building as per the following expression:

$$Q_i = V_B \frac{W_i {h_i}^k}{\sum_{j=1}^{n} W_j {h_j}^k}$$

1.2 IBC (ASCE – 7)

ASCE is American Society of Civil Engineers and ASCE -7 "Minimum Design Loads for Buildings and Other Structures" is the Standard which provides requirements for dead, live, soil, Flood, wind, snow, rain, ice, and earthquake loads, and their combinations that are suitable for inclusion in building codes and is used in design of building. Seismic Base Shear is calculated as per Eq. 9.5.5.2-1 of ASCE-7. And the lateral seismic force *(Fx)* (in kN) induced at any level is determined from the following equations:

$$F_x = C_{vx} V$$

And,

$$C_{vx} = \frac{w_x {h_x}^k}{\sum_{i=1}^{n} w_i {h_i}^k}$$

2. ANALYSIS AND METHODOLOGY

An RCC building with Ground + 12 floors is considered for analysis and comparison. The building is a residential building situated in zone V. The type of soil is taken as medium soil. The live load value is taken as 3 KN/m^2. The dimensions of the building are 27 m X 17 m in Plan and height is 36 m. The column sizes are 300 mm X 450 mm and beams are 450 mm X 450 mm. The time period values for each codes is calculated and applied in the software. The analysis is done using Equivalent Static Method of analysis (ESM) in STAAD PRO software. The ESM is the very basic method of analysis.

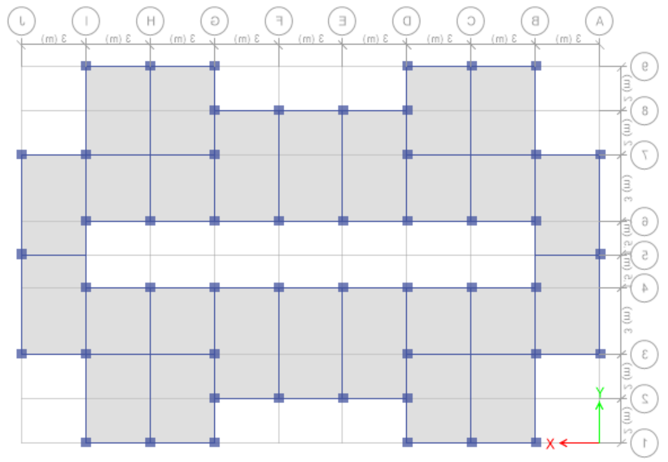

Fig -1: PLAN

Table -1: Base shear calculation

Seismic Parameters		
IS 1893 – 2002	**IS 1893:2016**	**IBC**
Z = 0.36 Sa/g = 1.25 I = 1.0 R = 3 (For OMRF) R = 5 (For SMRF)	Z = 0.36 Sa/g = 1.25 I = 1.2 R = 3 (For OMRF) R = 5 (For SMRF)	S_S = 1.4 F_a = 1 I = 1.0 R = 3 (For OMRF) R = 8 (For SMRF)
For OMRF $A_h = \frac{Z}{2} * \frac{I}{R} * \frac{S_a}{g}$ A_h = 0.075	For OMRF $A_h = \frac{Z}{2} * \frac{I}{R} * \frac{S_a}{g}$ A_h = 0.090	For OMRF $C_s = \frac{2}{3} F_a * S_s * \frac{I}{R}$ C_S = 0.1225
Seismic weight W = (Dead load + 25% live load) = 71441 KN	Seismic weight W =(Dead load + 25% live load) = 71441 KN	Seismic weight W = (Dead load + 0 live load) = 68066 KN
Base shear $V_B = A_h * W$ = 0.045 * 71441 = 3217 KN	Base shear $V_B = A_h * W$ = 0.054 * 71441 = 3861 KN	Base shear $V_B = C_s * W$ = 0.0459 * 68066 = 3124 KN

3. RESULT

Table -2: Base shear

Different code	OMRF	SMRF
IS 1893:2002	5372	3223
IS 1893:2016	6446	3868
IBC	8168	3063

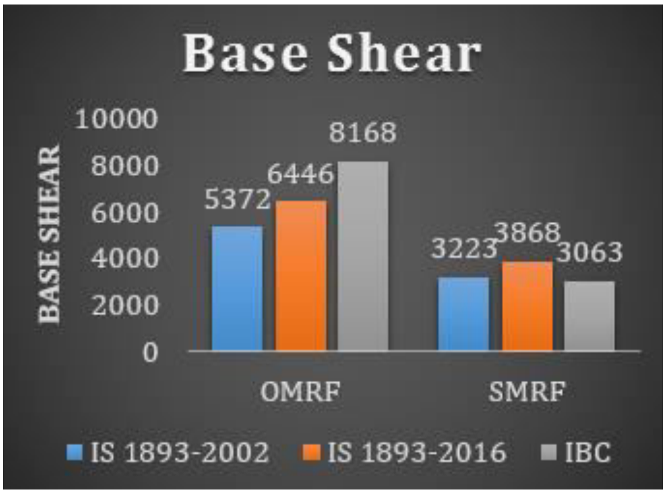

Chart – 1: Base shear

Table -3: Storey displacement for OMRF

Storey	IS 1893:2002	IS 1893:2016	IBC
Base	0	0	0
Storey 1	9.98	11.976	15.207
Storey 2	26.78	32.136	40.653
Storey 3	44.894	53.873	67.787
Storey 4	63.128	75.754	94.676
Storey 5	81.046	97.255	120.582
Storey 6	98.302	117.962	144.973
Storey 7	114.524	137.428	167.336
Storey 8	129.29	155.148	187.15
Storey 9	142.126	170.551	203.88
Storey 10	152.517	183.02	217.004
Storey 11	159.948	191.937	226.089
Storey 12	164.293	197.152	231.315

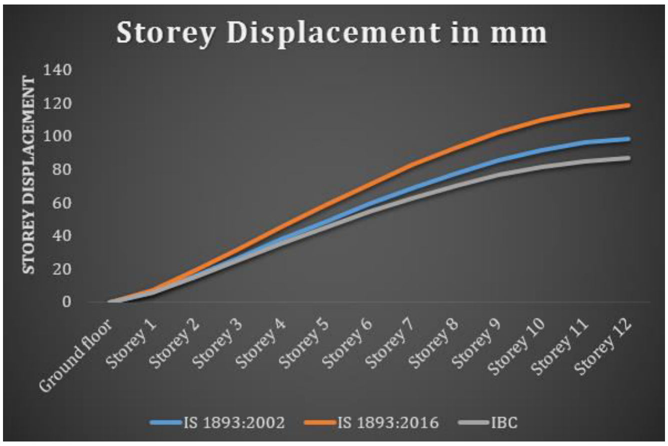

Chart – 2: Storey displacement for OMRF

Table -4: Storey displacement for SMRF

Storey	IS 1893:2002	IS 1893:2016	IBC
Base	0	0	0
Storey 1	5.988	7.185	5.703
Storey 2	16.068	19.281	15.245
Storey 3	26.936	32.324	25.42
Storey 4	37.877	45.452	35.502
Storey 5	48.628	58.353	45.218
Storey 6	58.981	70.777	54.365
Storey 7	68.714	82.457	62.751
Storey 8	77.574	93.089	70.181
Storey 9	85.276	102.231	76.455
Storey 10	91.51	109.812	81.376
Storey 11	95.969	115.162	84.783
Storey 12	98.576	118.291	86.743

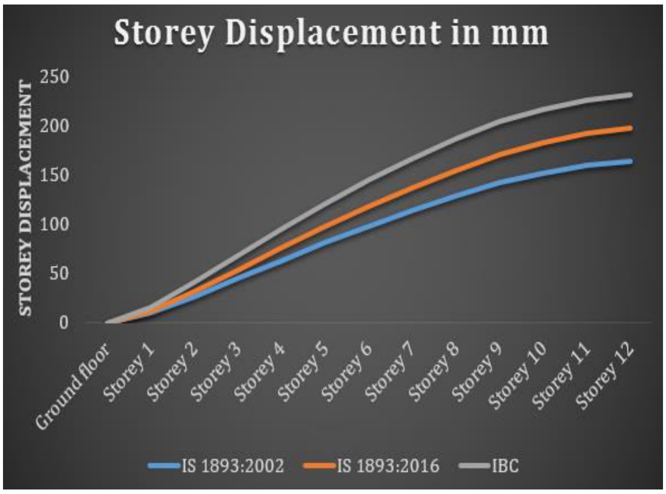

Chart – 3: Storey displacement for SMRF

Table -5: Maximum storey displacement

Different code	OMRF	SMRF
IS 1893:2002	164.293	98.576
IS 1893:2016	197.152	118.291
IBC	231.315	86.743

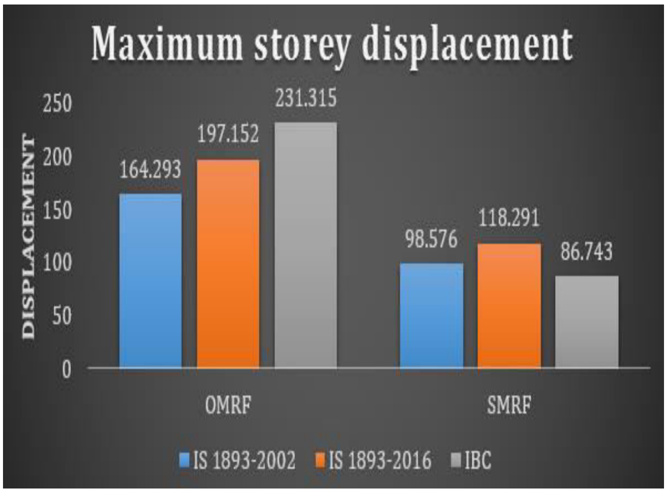

Chart – 4: Maximum storey displacement

Table -6: Storey drift for OMRF

Storey	IS 1893:2002	IS 1893:2016	IBC
Base	0	0	0
Storey 1	0.003327	0.003992	0.005069
Storey 2	0.005608	0.00673	0.008495
Storey 3	0.006039	0.007247	0.009046
Storey 4	0.006079	0.007295	0.008963
Storey 5	0.005973	0.007167	0.008963
Storey 6	0.005752	0.006902	0.008130
Storey 7	0.005407	0.006489	0.007454
Storey 8	0.004922	0.005906	0.006604
Storey 9	0.004279	0.005135	0.005577
Storey 10	0.003464	0.004156	0.004375
Storey 11	0.002479	0.002974	0.003031
Storey 12	0.001451	0.001742	0.001745

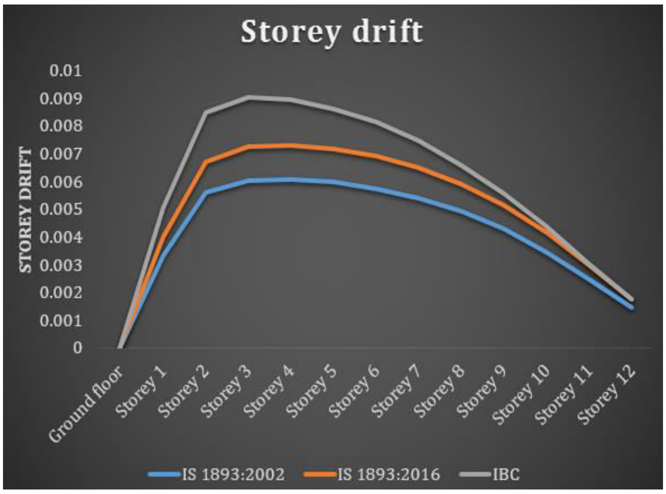

Chart – 5: Storey drift for OMRF

Table -7: Storey drift for SMRF

Storey	IS 1893:2002	IS 1893:2016	IBC
Base	0	0	0
Storey 1	0.001996	0.002395	0.001901
Storey 2	0.003365	0.004038	0.003186
Storey 3	0.003623	0.004348	0.003392
Storey 4	0.003647	0.004377	0.003361
Storey 5	0.003584	0.004300	0.003238
Storey 6	0.003451	0.004141	0.003049
Storey 7	0.003244	0.003893	0.002795
Storey 8	0.002953	0.003544	0.002477
Storey 9	0.002567	0.003081	0.002091
Storey 10	0.002078	0.002494	0.001640
Storey 11	0.001487	0.001785	0.001137
Storey 12	0.000871	0.001045	0.000654

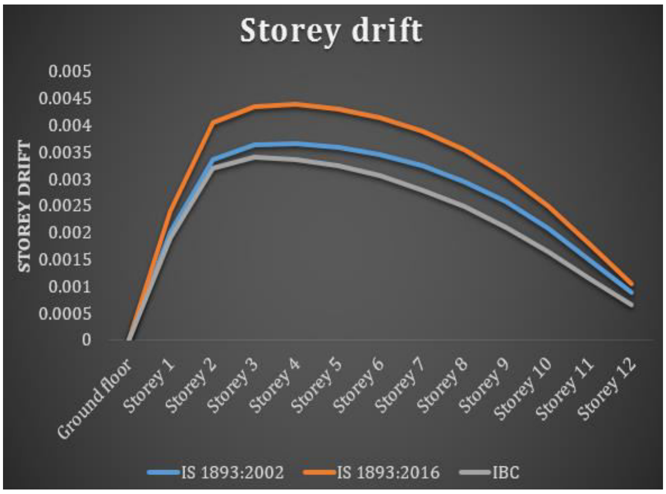

Chart – 6: Storey drift for SMRF

4. CONCLUSION

The results of the ETABS software on base shear, storey displacement, and storey drift are different for each codes which are discussed below,

1. Base shear in OMRF structure, compared to IS 1893:2016, IBC shows 21.08% more base shear and IS 1893:2002 shows 19.99 % less base shear.
2. Base shear in SMRF structure, compared to IS 1893:2016, IBC shows 26.28 % less base shear and IS 1893:2002 shows 20.01 % less base shear.
3. Maximum displacement in case of OMRF structure as per IBC is maximum compared to other codes, displacement as per IBC 14.77 % more and as per IS 1893:2002 20% less value than the IS 1893:2016.
4. Maximum displacement in case of SMRF structure as per IS 1893:2016 is maximum compared to other codes, displacement as per IBC 11.61 % less and as per IS 1893:2002 19.98 % more value than the IS 1893:2016.
5. Storey drift for OMRF structure is more as per IBC than the Indian standard.
6. Storey drift for SMRF structure is less as per IBC than the Indian standard.

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