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A Comparative Study of Seismic behaviour on Multistoreyed RC Buildings by the Provisions Made in Indian and other International Building Codes

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***Abstract* - In this paper a comparative study of the seismic provisions of Indian, American and Australian code has presented. The structure being a residential Regular RCC framed building with Ground and Five Floors. Various seismic parameters has been considered for analysis. The Equivalent Static Method Analysis has performed using STAAD PRO software. The building frame is an Ordinary Moment Resisting Frame (OMRF). The values of Base Shear, Column's moments & axial forces, Beam's moments Lateral displacements and Storey drifts coming out from the analysis are compared for IS1893-2002, IBC-2006 & AS 1170-2007. Comparing the results the IBC code is found to be more conservative than the IS 1893 & AS 1170**

***Index Terms* - IS1893 2002, IBC, AS1170, Base Shear**

I. INTRODUCTION

All over the world , earthquakes are occurring at an interval of time. People are understanding the severity of earthquakes. Thus the proper use of methods for earthquake resistant design and construction is important for countries that are at high risk of being subjected to earthquake. earthquake is a phononmenon due to tectonic activity. It is very important to investigate and understand the reasons for earthquake disasters and to take necessary steps to eliminate the catastrophic consequences Most of the human and other losses resulting due to earthquake are due to failure of human made facilities such as buildings and other structures.

The severity or the earthauake disaster depends on four factors. Firstly the magnitude of the earthquake is a major factor. The more the magnitude of the earthquake more will be the groundshaking. The distance between the earthquake origin and the region of population is the second factor. The more the distance lesser will be the intensity of ground motion. The third factor is the population and the development in the particular region. The fouth one is the quality of the construction of the structures or the methods of design and construction. Many buildings may be able to resist the moderate groundshaking though they are not as per the requirements of the design for seismic conditions. This is because of the masonary infilled walls. However for a building to resist a severe earthquake it has to be designed considering all the aspects of earthquake resistant design. Mostly the design and construction of seismic resistant structure follows the provisions of the seismic codes. Though the effects of the earthquake groundshaking and the basic concepts in the design of earthquake resistant structures are same everywhere, the seismic codal provisions in different countries are different. This difference in the seismic codes is due to the application of basic concepts as per the seismic activity of that particular country, the design methodology, the experiences of the professionals and their educations.

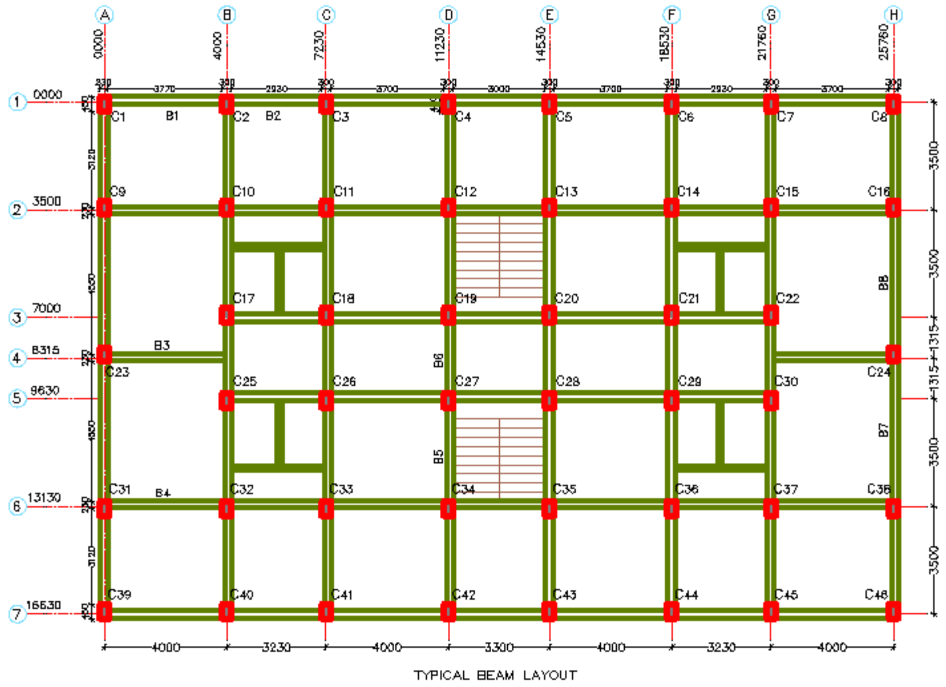
The scope of this paper is to apply the seismic codal provisions and compare the results using three different codes for the RCC building of same specifications for OMR frame. In this paper following codes are compared 1. Indian Standard i.e, IS 1893 2002, American i.e., IBC 2006 & Australian code i.e.,AS 1170 2007

II. ANALYSIS AND METHODOLOGY

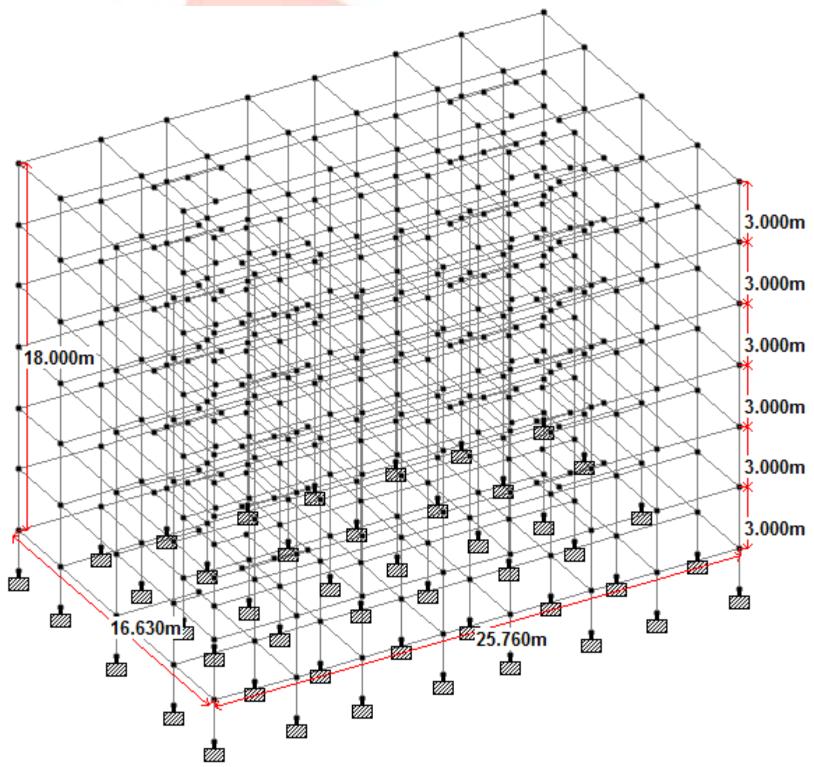
An RCC building with Gound + 5 floors is considerd for analysis and comparision. The building is a residential builing. The live load value is taken as 2 Kn/sq.m. The dimension of the building are 25.76 m X 16.63 m in Plan and height is 18m. The RCC frame is a OMRF. The column sizes are 300X450 mm and beams are 230X450mm. The time period values for each of the three codes is calculated then the base shear values are calculated. The storey forces are calculated for each floor level for each of the three codes and apllied in the software. The analysis is done using Eqivalent Static Method of analysis(ESM) in STAAD PRO software. The ESM is the very basic method of analysis.

Building geometry

Building Plan



Building Dimensions

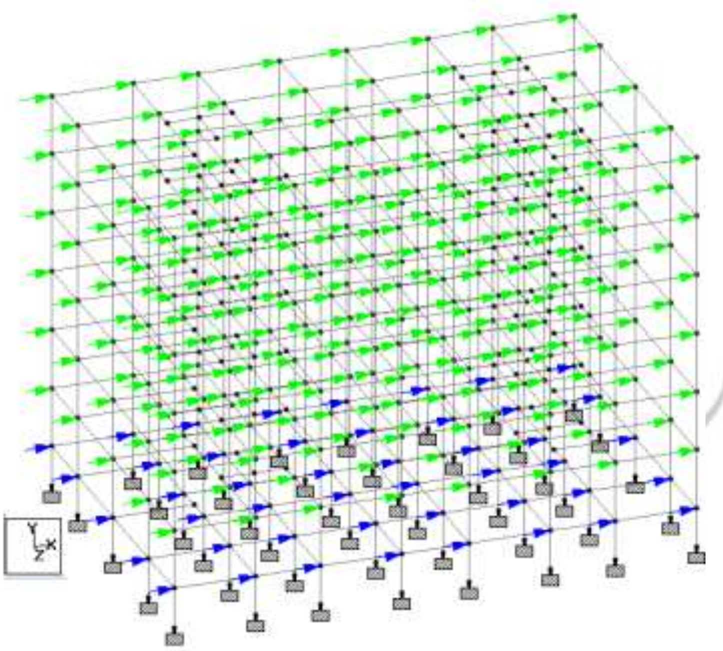


III. SEISMIC COEFFICIENTS

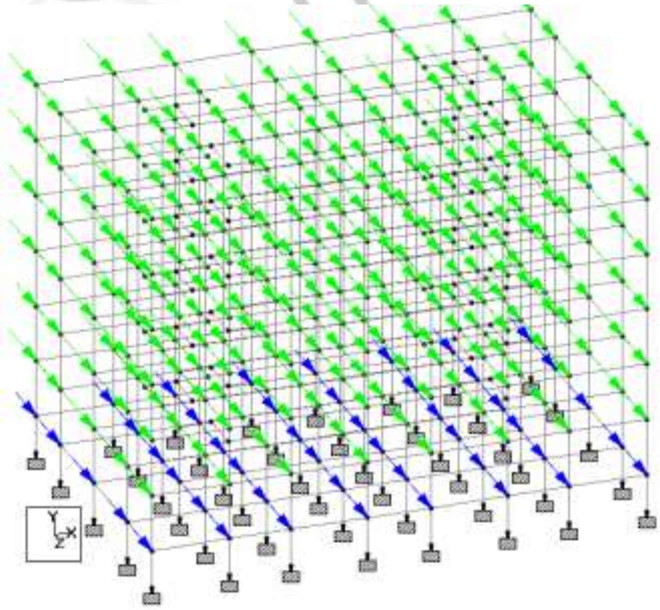
IS 1893	IBC 2006	AS 1170
For Low Inensity Zone	For Low Inensity Zone	For Low Inensity Zone
Z = 0.1	Ss = 0.25	Z = 0.1
Sa/g= 2.5	Fa = 1.600	Probability factor kp = 0.5
	SMS = Fa . Ss = 0.400	Sp = Structural Performance
	S DS = 2/3 SMS = 0.267	μ = Structural Ductility factor
I = 1.00	I = 1.00	
R= 3 for OMRF	R= 3 for OMRF	Sp/μ = 0.38 for OMRF
Ah = Z/2 . Sa/g . I/R	Cs = S DS . I/R	$C_d(T_1)$ = kp. Z . Ch (T1) . Sp/μ

Comparision of Base Shear		
IS 1893	IBC 2006	AS 1170
1. Total Weight W (Dead Load + 25% Live Load) W= 29804 KN	1. Total Weight W (Dead Load + 0 Live Load) W= 28734 KN	1. Total Weight W (Dead Load + 30% Live Load) W= 30019 KN
Base Shear = Ah . W Ah = Z/2 . Sa/g . I/R = 0.1/2 x 2.5 x I/R = 0.125 x I/R = 0.125 x 1.0/3 = 0.042 Base Shear = Ah . W 0.042 x 29804 1242 KN	Base Shear = Cs . W Cs = SDS . I/R 2/3 SMS I/R 2/3 (Fa x Ss) I/R 2/3 (1.600 x 0.25) I/R 2/3 x 0.400 x I/R 0.267 x 1.0/3 0.089 Base Shear = Cs . W 0.089 x 28734 2554 KN	Base Shear = Cd(T1) . W $C_d(T_1)$ = kp. Z . Ch (T1) . Sp/μ 0.5 x 0.1 x Ch(T1) . Sp/μ 0.05 x 1.49 x 0.38 0.075 x 0.38 0.029 Base Shear = Cd(T1) . W 0.029 x 30019 871 KN

Earthquake Load in X-direction



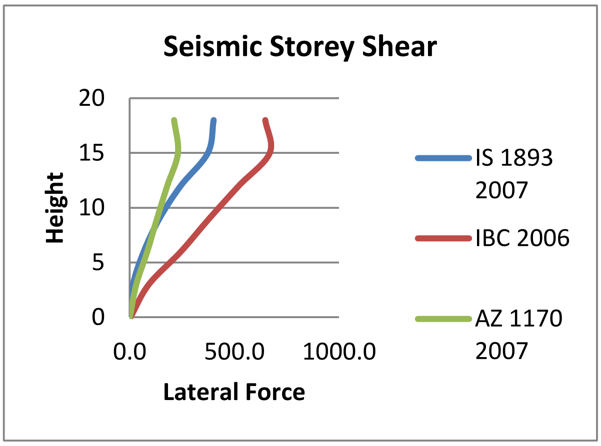
Earthquake Load in Z-direction



IV. RESULTS

1. Comparision of Storey Shear & Base Shear

S.no.	Floor Lvl		IS 1893 2007	IBC 2006	AZ 1170 2007
	Floor	Height	Lateral Force Q (KN)	Lateral Force Fx (KN)	Lateral Force Fx (KN)
1	Plinth	0	0.1	3	1
2	1st FL.	3	15	91	32
3	2nd FL.	6	67	245	84
4	3rd FL.	9	141	379	131
6	4th FL.	12	244	521	180
7	5th FL.	15	373	669	231
8	TERR.	18	401	648	212
TOTAL			1242	2557	871

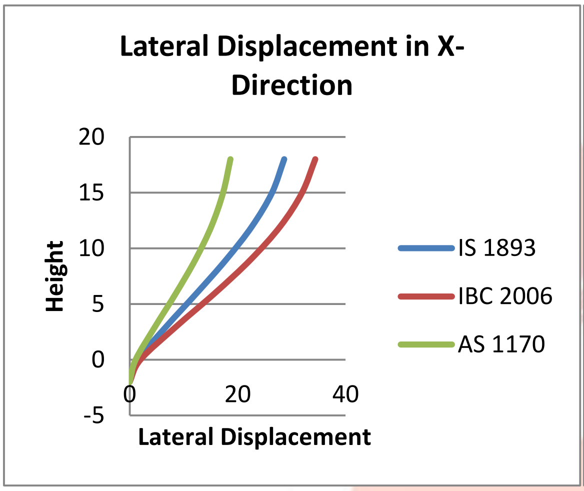


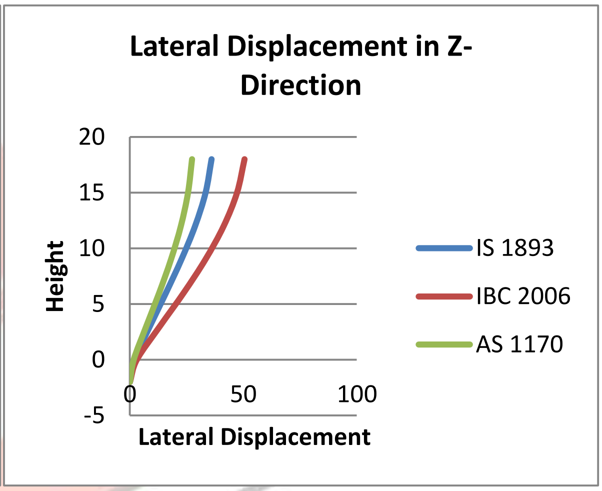
2. Columns Moments & Axial Loads

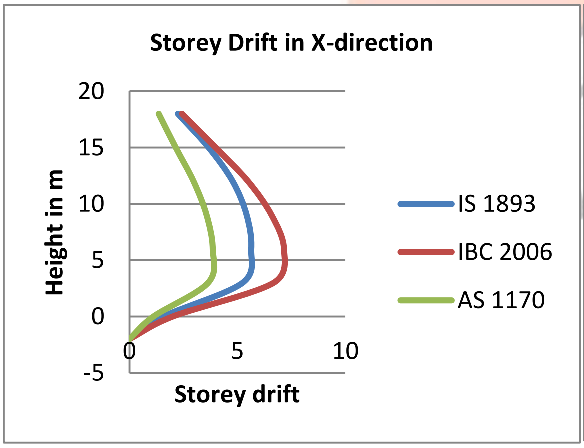
column's moment & axial load	IS 1893				column's moment & axial load	IBC 2006				column's moment & axial load	AS 1170			
	moment knm		axial load kn			moment knm		axial load kn			moment knm		axial load kn	
columns below plinth					columns below plinth					columns below plinth				
corner columns	41.6	100 %	914	100 %	corner columns	64.1	154 %	874	96 %	corner columns	34.8	84 %	722	79 %
pheripheral columns	40.1	100 %	1100	100 %	pheripheral columns	65.1	162 %	1071	97 %	pheripheral columns	34.5	86 %	894	81 %
central columns	51.23	100 %	1198	100 %	central columns	76.17	149 %	1147	96 %	central columns	41.00	80 %	958	80 %
columns gr. floor					columns gr. floor					columns gr. floor				
corner columns	50.7	100 %	837	100 %	corner columns	73.0	144 %	785	94 %	corner columns	40.8	80 %	673	80 %
pheripheral columns	47.3	100 %	1050	100 %	pheripheral columns	73.8	156 %	1008	96 %	pheripheral columns	39.0	83 %	892	85 %
central columns	69.8	100 %	1075	100 %	central columns	101.9	146 %	1029	96 %	central columns	55.9	80 %	927	86 %
columns 2nd floor					columns 2nd floor					columns 2nd floor				
corner columns	52.2	100 %	521	100 %	corner columns	65.0	124 %	474	91 %	corner columns	40.2	77 %	419	80 %
pheripheral columns	44.6	100 %	664	100 %	pheripheral columns	61.3	137 %	628	95 %	pheripheral columns	37.4	84 %	563	85 %
central columns	70.3	100 %	693	100 %	central columns	93.5	133 %	663	96 %	central columns	53.7	76 %	597	86 %
columns 5th floor					columns 5th floor					columns 5th floor				
corner columns	28.7	100 %	81	100 %	corner columns	28.5	99 %	75	93 %	corner columns	20.9	73 %	67	83 %
pheripheral columns	24.7	100 %	111	100 %	pheripheral columns	29.4	119 %	106	95 %	pheripheral columns	20.3	82 %	95	86 %
central columns	30.2	100 %	114	100 %	central columns	34.3	113 %	109	95 %	central columns	20.1	67 %	98	86 %

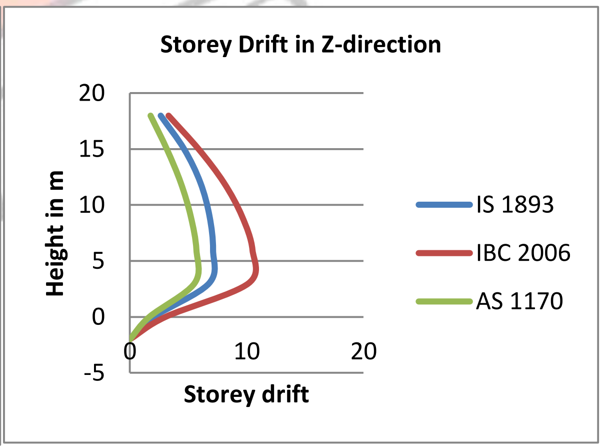
3. Lateral Displacement and Storey Drift

floor	ht. (m)	IS 1893				IBC 2006				AS 1170			
		lateреal displ.		storey drift		lateral displ.		storey drift		lateral displ.		storey drift	
		x direc	z direc	x direc	z direc	x direc	z direc	x direc	z direc	x direc	z direc	x direc	z direc
		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
footing lvl	-2	**0**	**0**	**0**	**0**	**0**	**0**	0	0	**0**	**0**	0	0
plinth lvl	0	**1.572**	**2.031**	**1.572**	**2.031**	**2.002**	**3.043**	2.002	3.043	**1.113**	**1.664**	1.113	1.664
1st fl lvl	3	**6.819**	**8.811**	**5.247**	**6.78**	**8.684**	**13.191**	6.682	10.148	**4.762**	**7.194**	3.649	5.53
2nd fl lvl	6	**12.464**	**15.936**	**5.645**	**7.125**	**15.843**	**23.681**	7.159	10.49	**8.625**	**12.893**	3.863	5.699
3rd fl lvl	9	**17.899**	**22.76**	**5.435**	**6.824**	**22.429**	**33.277**	6.586	9.596	**12.204**	**18.106**	3.579	5.213
4th fl lvl	12	**22.686**	**28.803**	**4.787**	**6.043**	**27.926**	**41.324**	5.497	8.047	**15.179**	**22.463**	2.975	4.357
5th fl lvl	15	**26.359**	**33.453**	**3.673**	**4.65**	**31.921**	**47.21**	3.995	5.886	**17.328**	**25.629**	2.149	3.166
terrace lvl	18	**28.607**	**36.089**	**2.248**	**2.636**	**34.358**	**50.514**	2.437	3.304	**18.686**	**27.396**	1.358	1.767









4. Beams Moments & Shear Forces

plinth	IS 1893				plinth	IBC 2006				plinth	AS 1170			
beam nos.	moment		shear force		beam nos.	moment		shear force		beam nos.	moment		shear force	
b 1	68	100 %	43	100 %	b 1	84	125 %	52	119 %	b 1	44	66 %	26	59 %
b 2	63	100 %	46	100 %	b 2	80	127 %	57	122 %	b 2	42	66 %	29	63 %
b 3	57	100 %	46	100 %	b 3	80	140 %	53	117 %	b 3	35	61 %	18	40 %
b 4	61	100 %	48	100 %	b 4	92	152 %	64	132 %	b 4	44	72 %	25	53 %

b 5	59	100 %	48	100 %	b 5	83	140 %	63	131 %	b 5	41	69 %	27	57 %
b 6	62	100 %	55	100 %	b 6	90	144 %	76	139 %	b 6	46	74 %	38	69 %
b 7	73	100 %	44	100 %	b 7	84	114 %	49	110 %	b 7	39	53 %	21	48 %
b 8	73	100 %	44	100 %	b 8	84	114 %	49	110 %	b 8	39	53 %	21	48 %
1st fl	IS 1893				1st fl	IBC 2006				1st fl	AS 1170			
beam nos.	moment		shear force		beam nos.	moment		shear force		beam nos.	moment		shear force	
b 1	107	100 %	87	100 %	b 1	125	117 %	91	104 %	b 1	81	75 %	70	80 %
b 2	97	100 %	86	100 %	b 2	115	119 %	94	108 %	b 2	72	74 %	67	77 %
b 3	70	100 %	49	100 %	b 3	101	145 %	60	123 %	b 3	62	89 %	43	88 %
b 4	82	100 %	72	100 %	b 4	125	151 %	89	123 %	b 4	77	94 %	65	91 %
b 5	86	100 %	89	100 %	b 5	113	131 %	100	113 %	b 5	71	82 %	75	85 %
b 6	80	100 %	65	100 %	b 6	112	140 %	90	139 %	b 6	66	82 %	54	83 %
b 7	128	100 %	95	100 %	b 7	129	101 %	91	95 %	b 7	92	72 %	75	79 %
b 8	128	100 %	95	100 %	b 8	129	101 %	91	95 %	b 8	92	72 %	75	79 %
3rd fl	IS 1893				3rd fl	IBC 2006				3rd fl	AS 1170			
beam nos.	moment		shear force		beam nos.	moment		shear force		beam nos.	moment		shear force	
b 1	102	100 %	85	100 %	b 1	111	109 %	84	100 %	b 1	75	73 %	67	78 %
b 2	89	100 %	81	100 %	b 2	99	111 %	83	102 %	b 2	63	71 %	61	75 %
b 3	66	100 %	48	100 %	b 3	89	136 %	56	117 %	b 3	56	85 %	41	86 %
b 4	78	100 %	69	100 %	b 4	110	140 %	81	117 %	b 4	70	89 %	60	87 %
b 5	85	100 %	86	100 %	b 5	103	121 %	92	107 %	b 5	66	78 %	71	82 %
b 6	71	100 %	58	100 %	b 6	91	128 %	74	127 %	b 6	54	76 %	45	77 %
b 7	121	100 %	93	100 %	b 7	118	97 %	86	93 %	b 7	85	70 %	73	78 %
b 8	121	100 %	93	100 %	b 8	118	97 %	86	93 %	b 8	85	70 %	73	78 %
ter.	IS 1893				ter.	IBC 2006				ter.	AS 1170			
beam nos.	moment		shear force		beam nos.	moment		shear force		beam nos.	moment		shear force	
b 1	37	100 %	39	100 %	b 1	35	96 %	35	91 %	b 1	27	74 %	31	80 %
b 2	27	100 %	33	100 %	b 2	26	96 %	29	90 %	b 2	19	71 %	25	78 %
b 3	26	100 %	33	100 %	b 3	33	130 %	33	100 %	b 3	24	92 %	30	89 %
b 4	26	100 %	34	100 %	b 4	34	133 %	34	100 %	b 4	24	94 %	29	85 %
b 5	31	100 %	31	100 %	b 5	35	110 %	32	104 %	b 5	24	76 %	26	82 %
b 6	17	100 %	19	100 %	b 6	18	102 %	19	98 %	b 6	13	74 %	15	78 %
b 7	53	100 %	48	100 %	b 7	46	88 %	43	89 %	b 7	39	73 %	39	81 %
b 8	53	100 %	48	100 %	b 8	46	88 %	43	89 %	b 8	39	73 %	39	81 %

V. CONCLUSION

- The value of base shear for IBC code is more than IS 1893 and AS 1170. Its value for IBC code is nearly double than that of IS 1893 and its value for AS 1170 is 70% than that of IS 1893
- The values of Column moments for IBC code are nearly 150% for below plinth & Gr. Floor, 130% for 2nd floor and 110% for top floor than that of IS 1893 and for AS 1170 its values are nearly 80 - 85% than that of IS 1893
- The values of Axial Loads on Columns for IBC code are nearly 95% than that of IS 1893 and for AS 1170 its values are nearly 83% than that of IS 1893
- The values of Beam moments for IBC code are nearly 125% than that of IS 1893 and for AS 1170 its values are nearly 80% than that of IS 1893
- The values of Beam shear forces for IBC code are nearly 120% than that of IS 1893 and for AS 1170 its values are nearly 80% than that of IS 1893
- The Lateral displacement and storey drift values are more in IBC code

- The building design using IBC code would be more conservative than that of IS 1893 and AS 1170 codes
- The area of steel required for the RCC members for IBC code would be more than that of IS 1893 and AS 1170 codes

VI. ACKNOWLEDGMENT

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