Comparative Seismic Analysis of Multi-Storey Buildings Using Indian, Canadian and Japanese Regulations

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ABSTRACT: - The seismic structure can resist vertical and lateral forces acting on the structure. However, no structure can completely resist an earthquake without a refund, since a damage-free design structure is very profitable. According to the code, the seismic structure is designed to withstand at least one earthquake expected during the life of the structure. Many countries have their own codes of conduct when designing seismic structures. Analyze and design reinforced concrete buildings according to the code requirements. These buildings designed in accordance with the provisions of the "Code" can survive the entire earthquake, with little damage to the structural elements and there is enough time or warning to escape the structure.

There are differences in anti-seismic building codes in different countries because they all take into account different factors such as strength, size, area factor and importance factor, which is why it is difficult to determine them. In this project, various international design codes were used to conduct comparative analysis and research on RCC buildings. The comparison carried out in this project provides for the maximum cutting force, the maximum bending moment, the maximum bending, etc.

This comparative study shows the impact of different codes on these parameters and the economic design of the building. In this project, a G+11 building is planned and analysed. The design and analysis is carried out using three International Seismic Standards IS: 1893 –Criteria for earthquake resistant design of structures Part 1, Japanese seismic Design codes, AIJ, BSLJ, Canada code NBCC 2005, CSA Standards A23.3-94.

Keywords: Earthquake resistant structures, Intensity, Magnitude, Zone factors, Maximum Shear force, Maximum Bending Moment, Maximum Deflection.

I. INTRODUCTION

The analysis of a structure is to discover the behavior of a structure when it is exposed to some type of action. These actions can take the form of a load due to the weight of furniture, people, wind, snow, etc. it happens, a building experiences a dynamic movement. This is because the earthquake causes the earthquake in the ground, causing the building to move there at its base. According to Newton's first law of movement, the roof remains in its original position, although the base of the building moves with the floor. But since the columns and walls are connected to it, they pull the roof with them. This tendency to remain in its original place is called inertia.

As a result, the building is exposed to inertial forces that counteract the acceleration of seismic excitation. These inertial forces are called seismic loads. These seismic loads are believed to be forces outside the building. Not only will the imposed load and therefore the burden, or we are able to say gravitational loads, but the structure will also be subject to large lateral forces of considerable magnitude during the earthquake. When planning the anti-seismic structure, these lateral forces must be estimated and specified in order that the building can safely resist the earthquake. It's rightly said that "the earthquake doesn't kill people, but buildings". This implies that earthquakes don't actually kill people. This can be all the damage and collapse of the building during the earthquake. Buildings collapse and fall, avalanches and landslides occur roads and bridges can collapse. Falling objects may also injure people during an earthquake, as objects are shaken by walls, shelves and buildings.

Anti-seismic structures are able to resist vertical and lateral forces acting on the structures. However, no structure can fully survive an earthquake without a refund because the design of damage-free structures is very profitable. According to the codes, the anti-seismic structures are designed to withstand the expected earthquake at least once during the life of the structure. Many countries have their own rules of conduct for the design of seismic structures. Analyze and design reinforced concrete buildings according to the code requirements. These buildings designed in accordance with the provisions of the "Code" can survive the entire earthquake, with little damage to the structural elements and there is enough time or warning to escape the structure.

Various international design codes have been used in this project to conduct comparative analysis and research on RCC buildings. The comparison in this project is the comparison between the maximum cutting force, the maximum bending moment, the maximum bending and the maximum axial force on some key components according to different specifications.

Most seismic codes require structures that must be designed to withstand certain static lateral forces associated with the structure and seismicity of the area. On the basis of the estimate of the basic natural period of the structure, some formulas are determined for the basic cut and the distribution of lateral forces on the height of the buildings.

In fact, with all the coding comparisons, the point is that the overall cut is different due to the microzonation of the seismic areas and the way the structural response has been considered. In addition to the period of oscillation, which is greater than the period of oscillation, and the relationship with the spectral acceleration, the calculation of the basic cut is also affected.

Natural disasters such as earthquakes, landslides, tsunamis, floods, etc. They cause serious harm and misery for people. Tragedies are poorly reflected in the economy and can pose a great challenge for further development. Civil engineers participate in an important damage mitigation task by properly designing the structures or using the right construction method and making other useful decisions. This includes understanding earthquakes, the performance of building materials and structures as a whole.

`The earthquake is the result of tensions along the edges of the plates on the earth. Because the earth's crust is made up of different plates that move slowly and continuously. Sometimes they move enough to squeeze or separate. Compression stress occurs when the stones are pressed against each other - they are pressed into each other. Tension occurs when the stones are separated: they are stretched beyond their original position. Shear stress occurs when the stones slide over each other in opposite directions - It's like rubbing your hands. They don't push or pull, but there is a lot of friction there.

II. METHDOLOGY

This section introduces the various codes selected for this study and describes the design process of these three codes. To subsequently calculate the seismic load in each code, the basic shear coefficient, the spectral content, the seismic zone, the base period, the important factors, the structural behavior coefficient, the soil profile and the soil are discussed. Influence of the foundation and the influence of the weight of the building. The difference is mentioned. After calculating the seismic force, the method of distributing the height of the building was also compared.

The purpose is to understand the performance of RCC buildings under seismic loads. In this project, different country codes were subsequently applied to the same structure and the different results were compared.

Description of the Building

A reinforced concrete structure was selected for this study. It is arranged symmetrically and consists of 12 floors with a floor height of 4 m. The plan of all floors is square with a length of 18 m in the X direction and a length of 18 m in the Z direction. The number of slots in the X direction is 3 and the number of fields in the Z direction is 3. The width of each housing is 6 m in both the X and Z directions. All the pillars of the building are located at the intersection of the axes.

Building details are as follows:

- Building frame type is Special Moment Resisting Frame (SMRF) which is fixed at base.
- Building is found in Seismic Zone IV.
- Number of storey is G+11.
- Spacing between bays is 4 m in both X and Z-directions.
- Number of bays in X and Z-directions 3.
- Floor height is 4 m.
- Parapet wall height is 1 m.
- Parapet wall thickness is 230 mm.
- Slab depth is 150 mm.
- Thickness of external wall is 230 mm and thickness of internal wall is 115 mm.
- Column size is 300 mm x 450 mm.
- Size of beams is 450 mm x 300 mm.
- Live load on floors is 4 KN/m2.
- Live roof load is 1.5 KN/m2.

- Floor finish load is 1 KN/m2.
- Building is resting on medium soil.
- Importance factor is taken as 1.
- Unit weight of RCC is 25 KN/m3.
- Unit weight of masonry wall is taken as 20 KN/m3.
- Elastic modulus of brick masonry wall is 22360 MPa.
- Elastic modulus of concrete is 30000 MPa.
- Response Spectra are taken as per IS 1893 (Part-1): 2002.
- Damping of structure is taken as 5 percent.

Modeling Assumptions

All the models developed to work out the performance of the building were created in STAAD. ProV8i. During the creation of 3D models, some basic assumptions were made to cut back the complexity of the program and also the time taken to perform the analysis. It's also known that a lot of parameters influence the behavior of the development system under load, in particularly lateral load. The material properties of concrete and masonry are always defined.

III. STRUCTURAL ANALYSIS PROCEDURE

For Modeling of structure use STAAD. Pro can be defined in the following steps:

1. Pre-processing
2. Post- processing
3. Analysis and design of the model
4. Results

Pre-processing

In this initiative we define the prototype model, the materials and properties of the support, the column and therefore the masonry. We also define the support conditions and load cases.

Define Prototype model data

First, let's start with a replacement model during which force units are used as kilo-Newtons and length units as meters. Then select the sort of manhole frame by opening the structural assistant option in STAAD. Pro and so set the length, height and width within the X, Y and Z directions by entering the sufficient number of fields within the X, Y and Z directions as shown in figure 3 and 4.

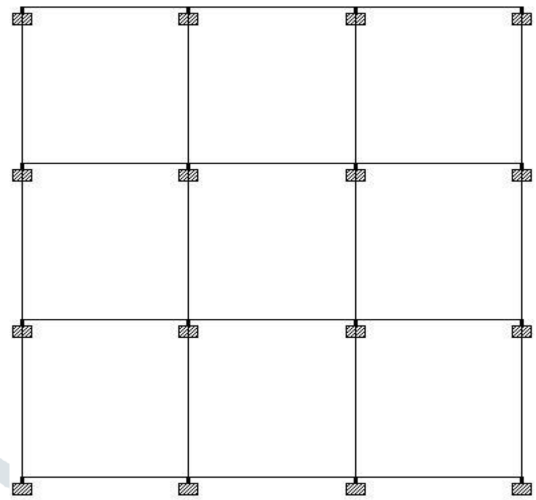

Figure 1: Plan of the Building

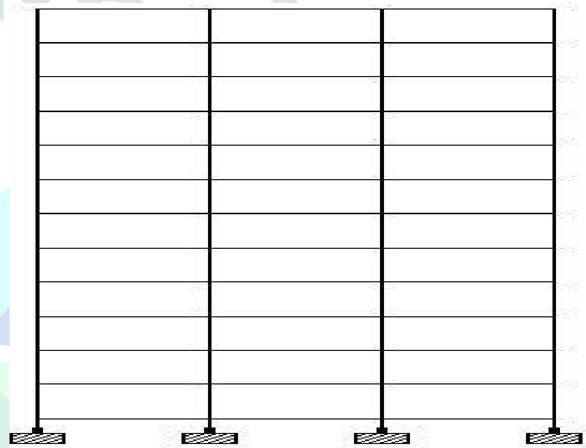

Figure 2: Elevation of the Building

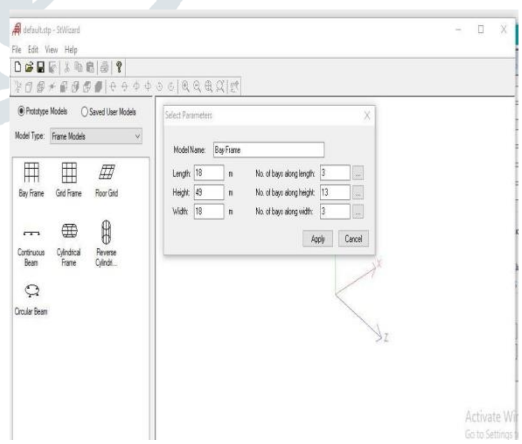

Figure 3: Define Frame Type and Dimensions

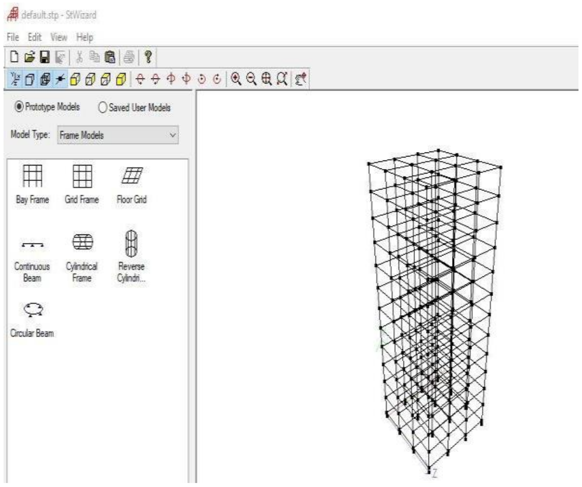

Figure 4: Define Wire Frame Model

Same load combination and data has been used for Japanese as well as Canada model.

Post -processing

In this step, differing kinds of loads are assigned to different parts of the building. Assign a load to the structure Loads play a necessary role in building planning, in order that they must be carefully applied to the building. All loads are assigned to the ability.

Analysis and design of the model

Model analysis is performed for all static load cases. The model must be analyzed before it's conceived. All load combinations are selected for design. STAAD Pro V8i designs the frame elements (eg beams and columns) for the foremost critical load combination.

IV. RESULT

After the analysis is performed, results will be easily obtained. The result from all the three countries models are here given below.

Table 1- Maximum lateral Displacement along X-Direction (mm)

Max Lateral displacement in X direction			
Storey No.	India	Canada	Japan
12	338.05	196.781	718.248
11	329.724	190.415	698.584
10	315.31	181.566	667.236
9	295.447	170.486	626.072
8	271.144	157.414	576.62
7	243.321	142.569	520.042
6	212.809	126.18	457.352
5	180.344	108.486	389.482
4	146.563	89.726	317.316
3	112.005	70.143	241.714
2	77.131	50.003	163.577
1	42.471	29.633	84.255
G	12.455	11.833	14.321

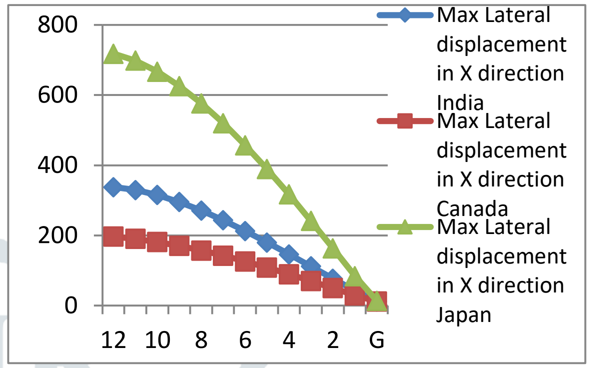

Figure 5: Maximum Lateral Displacements In X Direction (Mm)

Table 2 Maximum Lateral Displacement in Z Direction

Max Lateral displacement in Z direction			
Storey No.	India	Canada	Japan
12	247.469	142.663	521.682
11	240.785	137.8	506.408
10	230.083	131.332	483.199
9	215.49	123.259	452.887
8	197.708	113.797	416.566
7	177.385	103.099	375.088
6	155.12	91.331	329.207
5	131.447	78.662	279.616
4	106.833	65.266	226.977
3	81.678	51.323	171.949
2	56.383	37.062	115.34
1	31.676	22.896	58.961
G	12.115	11.61	13.547

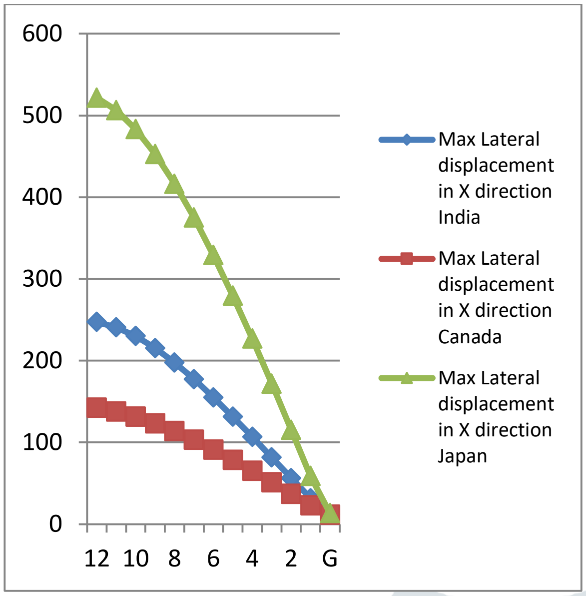

Figure 6 Maximum Lateral Displacements along Z-Direction (Mm)

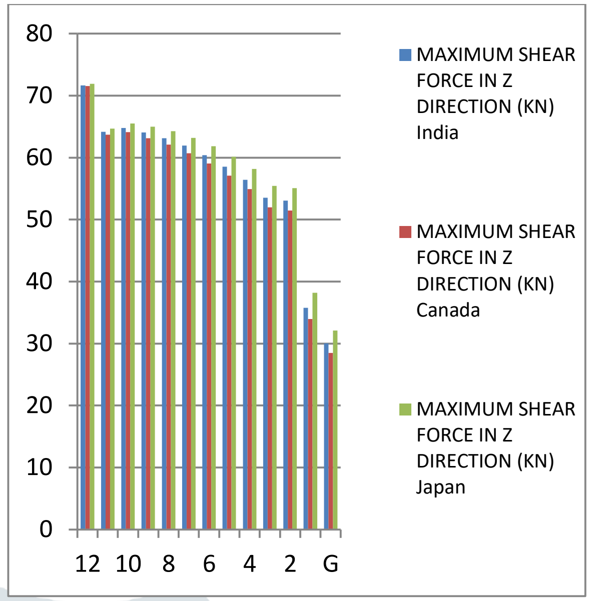

Figure 7 Comparison of Maximum Shear Force in Z Direction (KN)

Table 3– Comparison of Maximum Shear Force in Z Direction (KN)

Maximum Shear Force In Z Direction (KN)			
Storey	India	Canada	Japan
12	71.671	71.536	71.913
11	64.154	63.698	64.691
10	64.791	64.098	65.525
9	64.055	63.153	64.98
8	63.155	62.08	64.261
7	61.928	60.713	63.209
6	60.393	59.066	61.846
5	58.529	57.114	60.146
4	56.412	54.928	58.186
3	53.531	51.986	55.457
2	53.051	51.468	55.092
1	35.763	33.931	38.181
G	30.034	28.477	32.086

Table 4– Comparison of Maximum Shear Force in X Direction (KN)

Maximum Shear Force in X Direction (KN)			
Storey	India	Canada	Japan
12	412.706	415.77	407.106
11	927.619	933.262	917.192
10	1447.96	1454.45	1434.88
9	1972.02	1978.24	1957.93
8	2500.37	2505.44	2486.99
7	3033.45	3036.71	3022.61
6	3571.82	3572.76	3565.47
5	4116.12	4114.32	4116.39
4	4667.1	4662.18	4676.25
3	5225.66	5217.22	5246.17
2	5792.23	5779.86	5826.5
1	6371.88	6354.69	6423.95
G	6542.09	6523.44	6599.68

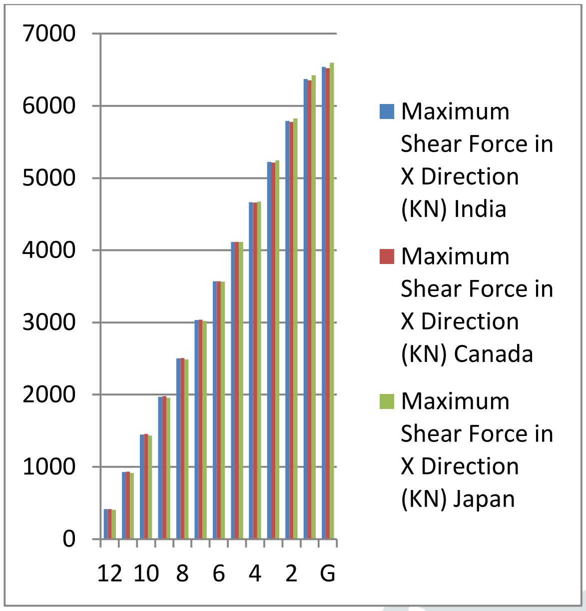

Figure 8 Comparison of Maximum Shear Force in X Direction (KN)

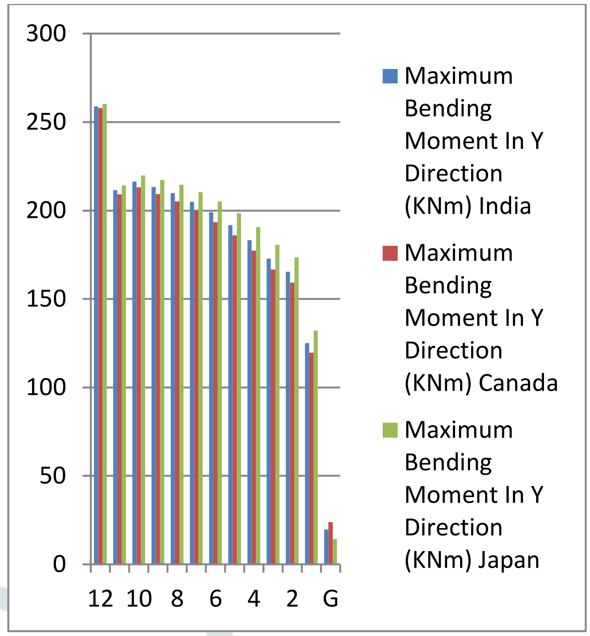

Figure 9 Comparison of Maximum Bending Moment in Y Direction(Knm)

Table 5 - Comparison of Maximum bending moment in Y direction(KNm)

Maximum Bending Moment In Y Direction (KNm)			
Storey	India	Canada	Japan
12	258.886	257.928	260.31
11	211.478	209.086	214.138
10	216.39	213.126	219.756
9	213.254	209.232	217.352
8	209.802	205.172	214.598
7	205.002	199.888	210.482
6	198.99	193.498	205.13
5	191.704	185.918	198.474
4	183.26	177.248	190.616
3	172.756	166.574	180.622
2	165.398	159.254	173.452
1	125.004	119.682	132.106
G	19.69	23.804	14.28

Table 6 - Comparison of Maximum Bending Moment in Z Direction (Knm)

Maximum Bending Moment in Z Direction			
storey	India	Canada	Japan
12	160.441	158.913	193.928
11	278.772	264.403	346.382
10	309.699	274.42	404.607
9	336.374	284.788	453.475
8	355.942	292.505	494.232
7	369.456	297.975	528.549
6	377.539	301.099	557.06
5	380.817	301.838	580.13
4	379.89	300.158	597.967
3	375.065	295.788	610.313
2	366.44	288.794	614.767
1	338.924	266.692	584.234
G	135.37	103.936	245.328

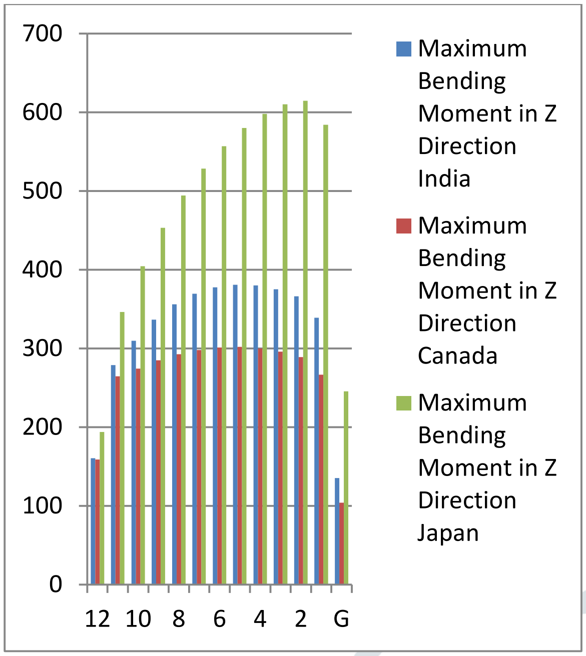

Figure 10 Comparison of Maximum Bending Moment in Z Direction (Knm)

For further studies four columns have been selected in the models to compare the results. These columns are C1, C2, C5, and C6 shown in the figure11 below.

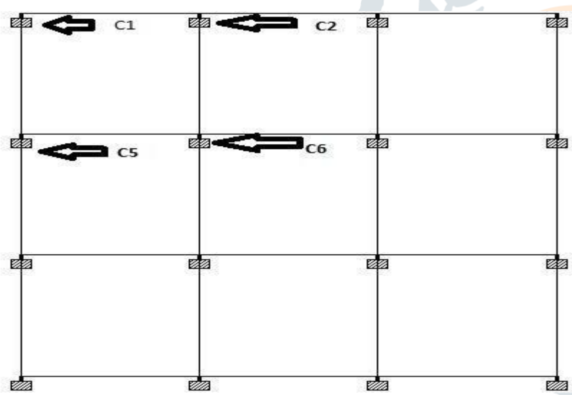

Figure 11 Plan of Model Showing Selected Column

Table 7 - Maximum Displacement on Each Selected Column in X Direction (Mm)

Maximum Displacement On Each Selected Column in X Direction			
No. Of Column	Max Displacement		
	Indian	Canada	Japan
C1	295.973	193.843	627.059
C2	295.889	193.761	626.971
C5	314.599	196.891	667.742
C6	314.498	196.792	667.64

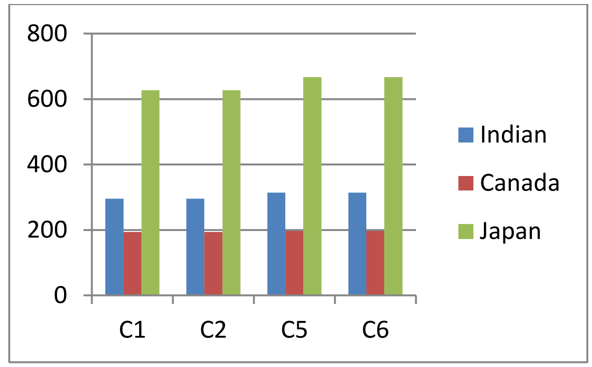

Figure 12 Maximum Displacements on Each Selected Column in X Direction (mm)

Table 8- Maximum Displacement on Each Selected Column in Z Direction (mm)

Maximum Displacement On Each Selected Column in Z Direction			
No. of Column	Max Displacement (mm)		
	Indian	Canada	Japan
C1	206.185	139.866	432.243
C2	224.523	142.773	472.066
C5	206.081	139.763	432.132
C6	224.394	142.647	471.932
Max Displacement	224.523	142.773	472.066

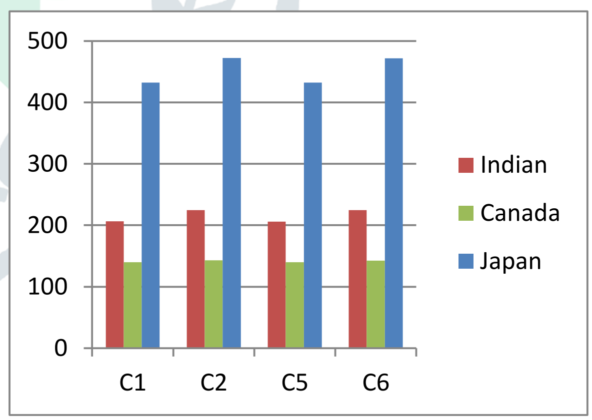

Figure 13 Maximum Displacements on Each Selected Column in Z Direction (mm)

Table 9 - Maximum Moment Y on Each Selected Column (Knm)

Maximum Moment Y On Each Column			
No. Of Column	Max Moment		
	Indian	Canada	Japan
C1	110.407	112.378	265.31

C2	139.58	140.074	298.303
C5	168.332	120.972	376.771
C6	181.781	122.516	413.33
Max Moment	181.781	140.074	413.33

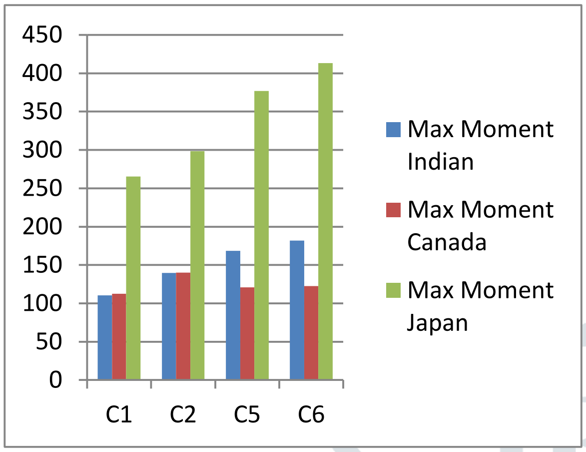

Figure 14 Maximum Moments Y on Each Selected Column (Knm)

Table 10- Maximum Moment Z on Each selected Column (KNm)

Maximum Moment Z On Each Column			
No. of Column	Max Moment		
	Indian	Canada	Japan
C1	88.888	87.37	256.303
C2	165.312	114.756	362.378
C5	109.393	109.758	277.058
C6	174.539	116.13	384.858
max Moment	174.539	116.13	384.858

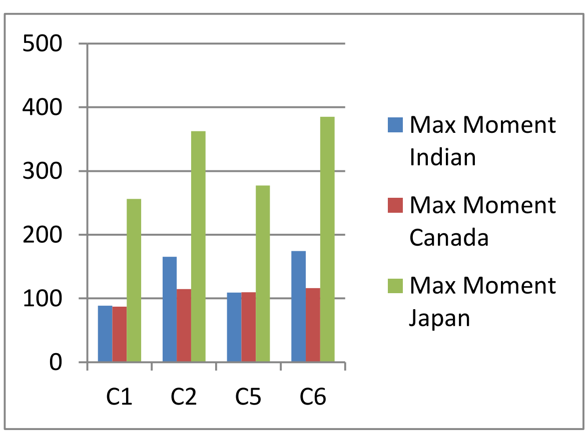

Figure 15 Maximum Moment Z on Each selected Column (KNm)

Table 11-Maximum Base Shear In X Direction in selected columns (KN)

Maximum Base Shear In X Direction			
No. Of Column	Max Shear (KN)		
	Indian	Canada	Japan
C1	2765.65	3000.689	2103.45
C2	4885.69	4888.148	4917.8
C5	4153.81	4365.009	3513.96
C6	6540.12	6523.548	6595.28
Max Base Shear	6540.12	6523.548	6595.28

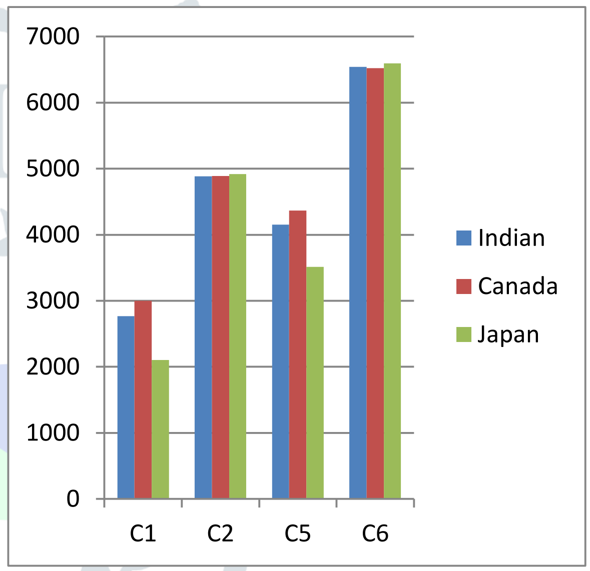

Figure 16 Maximum Base Shear In X Direction in selected columns (KN)

Table 12-Maximum Base Shear In X Direction (KN)

Maximum Base Shear In X Direction			
Name of Country	Max Shear (KN)		
	Indian	Canada	Japan
Max Base Shear	6540.12	6523.55	6595.28

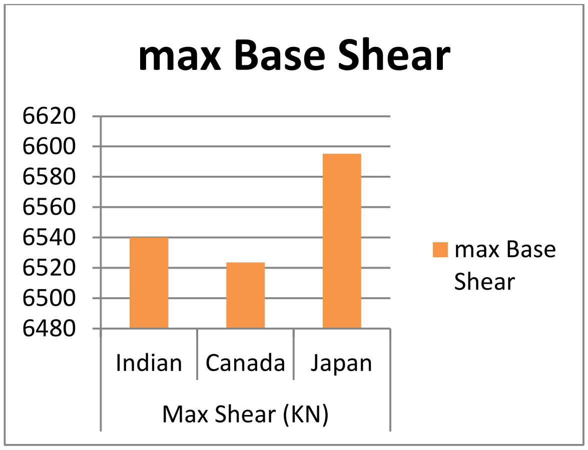

Figure 17 Maximum Base Shears In X Direction (KN)

Table 13-Maximum Base Shear in Z Direction in selected columns (KN)

Maximum Base Shear In Z Direction			
No. Of Column	Max Shear (N)		
	Indian	Canada	Japan
C1	58.546	59.173	102.945
C2	71.503	71.646	113.982
C5	90.726	67.936	193.139
C6	91.751	62.925	205.94
max Base Shear	91.751	71.646	205.94

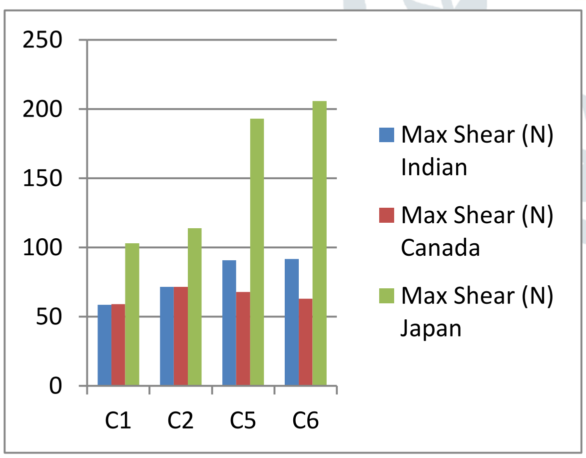

Figure 18 Maximum Base Shear in Z Direction in selected columns (KN)

Table 14 -Maximum Base Shear in Z Direction (KN)

Maximum Base Shear In Z Direction			
Name of Country	Max Shear (KN)		
	Indian	Canada	Japan
Max Base Shear	91.751	71.646	205.94

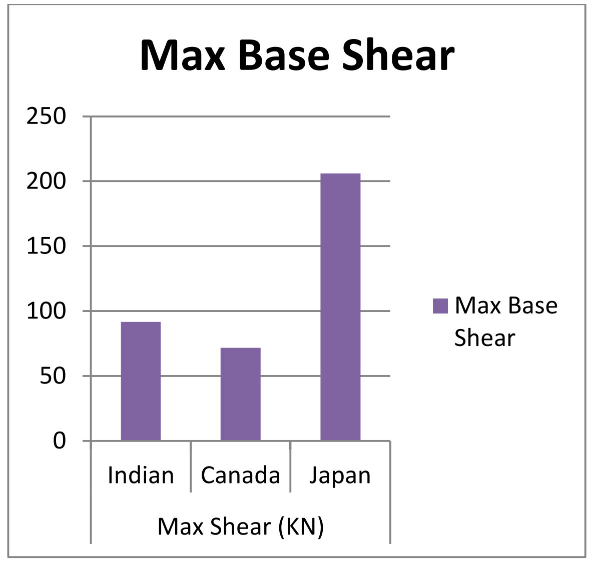

Figure 19 Maximum Base Shears in Z Direction (KN)

V. CONCLUSION

The main factors making up the SI, BSLJ and NBCC seismic load arrangements were presented and compared in this study. Although the three codes differ in detail, they have essential common characteristics and are comparable. All include the effects of seismic risk, the spectral content, the structural behavior and the soil / foundation of the seismic load. The meaning of a building is contained in IS and NBCC, but not in BSLJ. Because BSLJ sets the minimum standards that apply to all buildings.

- According to the results obtained, it can be seen that the Canadian code causes the GF and the upper floors to have a small lateral offset, while the Japanese code causes the upper and lower floors to have the largest offset.
- It can be seen that in the upper layer, the Japanese code represents the maximum cutting force, followed by the Indian code and the Canadian code.
- We noticed that the Japanese code on the upper level indicates the maximum moment of bending in the Y direction, followed by the Indian code and the Canadian code.
- According to the results obtained, it can be seen that the Japanese code represents the maximum bending moment in the Z direction in the second stage, while the upper part represents the minimum bending moment in the Z direction, while the Canadian code and the Indian code represent the maximum in the Z direction on the 5th floor Bending moment and minimum bending moment in the Z direction of the first floor.
- According to the results obtained, it is observed that, compared to the Indian code and the Japanese code, the Japanese code on the ground represents the largest basic cut, while the Canadian code represents the smallest basic cut.
- Results of the manual calculation of the lateral distribution of

the seismic force show that the Japanese code represents the maximum force in the first phase, followed by the Indian code and the Canadian code.

Regardless of the values obtained for different structural parameters in the structural analysis process, it is obvious that the deviation of the values is due to the independent constant, the load and the microzone of the seismic zone of different countries and their influence on the earthquake to calculate the shear coefficient Basic.

REFERENCES

1. Faizian, Marjan, and Yuji Ishiyama. "COMPARISON OF SEISMIC CODES OF 1981 JAPAN (BSLJ), 2000 USA (IBC) AND 1999 IRAN (ICS)." 10th World Conference on Earthquake Engineering. 2004.
2. Mitchell, Denis, et al. "Evolution of seismic design provisions in the National building code of Canada." Canadian Journal of Civil Engineering 37.9 (2010): 1157- 1170.
3. Santos, Sergio Hampshire De C., et al. "Comparative study of codes for seismic design of structures." Mathematical Modelling in Civil Engineering 9.1 (2013): 1-12.
4. Khose, Vijay Namdev, Yogendra Singh, and Dominik H. Lang. "A comparative study of design base shear for RC buildings in selected seismic design codes." Earthquake Spectra 28.3 (2012): 1047-1070.
5. Dhanvijay, Vinit, Deepa Telang, and Vikrant Nair. "Comparative study of different codes in seismic assessment." International Research Journal of Engineering and Technology2.04 (2015).
6. Tremblay, R., et al. "Comparison of seismic design provisions for buckling restrained braced frames in Canada, United States, Chile, and New Zealand." Structures. Vol. 8. Elsevier, 2016.
7. Karthiga, S., et al. "Design and comparison of a residential building (G+ 10) for seismic forces using the codes: IS1893, Euro code 8, ASCE 7-10 and British code." Int. J. Res. Eng. Technol 5 (2015): 205-09.
8. Singh, Yogendra, Vijay Namdev Khose, and Dominik H. Lang. "A comparative study of code provisions for ductile RC frame buildings." Proceedings of the 15th World Conference on Earthquake Engineering. 2012.
9. Karthik N, Varuna Koti "Comparative Analysis of a High-Rise Structure using Various International Codes" International Journal for Innovative Research in Science & Technology 4.06 (2017)
10. Sajid Ali Khan, Prof. R.V.R.K. Prasad "A Comparative Study of Seismic behavior on Multistoried RC Buildings by the Provisions Made in Indian and other International Building Codes" International Journal of Engineering Development and Research 4.02 (2016)
11. Asmita Ravindra agh, Prof. P. J. Salunke and Prof. T. N. Narkhede " Review on Seismic Design and Assessment of High-Rise Structures using various International Codes" International Journal for Scientific Research & Development4.03 (2016)
12. Pamela Jennifer J P, Jegidha K J, "Review on Seismic Design on Multistoreyed RC Building Using Various Codes", IJISET Volume:02 Issue:10 October- 2015
13. Mr. Mehul J Bhavsar, Mr. Shrenik K Shah, Miss Khyati K Choksi, "Comparative Study of Typical RC Building using Indian Standards and Euro Standards under Seismic Forces", GRD Journals March-2016.
14. Landingin, Jaime, et al. "Comparative analysis of RC irregular buildings designed according to different seismic design codes." 15th International Conference on Experimental Mechanics (ICEM15). Faculty of Engineering, University of Porto, 2012.
15. Kaur, Kamaldeep, and Jaspal Singh. "A Review on Comparison of Seismic Behavior of RC Structures Using Various Codes." International Journal of Agriculture, Environment and Biotechnology 10.6 (2017): 703-707.
16. Kakpure, Gauri G., and Ashok R. Mundhada. "Comparative Study of Static and Dynamic Seismic Analysis of Multistoried RCC Building by ETAB: A Review." International Journal of Emerging Research in Management &Technology 5 (2016).
17. Raju, K. Rama, et al. "Analysis and design of RC tall building subjected to wind and earthquake loads." Proc. of the 8th Asia-Pacific Conference on Wind Engineering (APCWE-VIII), ISBN. 2013
18. Ishiyama, Yuji. "Introduction to Earthquake Engineering and Seismic Codes in the World." Hokkaido University, Hokkaido, Japan (2011).
19. Bose, P. R., R. Dubey, and M. A. Yazdi. "Comparison of codal provisions suggested by various countries." Earthquake Engineering, Tenth World Conference. 1992.
20. Ishiyama Y. and Rainer J. Hans. Comparison of seismic provisions of 1985 NBC of Canada,1981 BSL of Japan and 1985 NEHRP of the USA. 5th Canadian conference, earthquake engineering, Ottawa, 1987.
21. Ishiyama Y. Seismic Design Method for Buildings in Japan. Comparison of building design practices in the U.S. and Japan, ATC 15, Applied Technology Council, 1984.