Seismic Analysis of A G+20 Building Using Different Country Codes

Ankush Rajabhau Kene[1], Prof. Ashok R.Mundhada[2]
[1,2]*Department of Civil Engineering, Prof. Ram Meghe Institute of Technology & Research, Badnera-444701, Maharashtra, India*

***Abstract*- Earthquake is a natural calamity that has killed millions of peoples through the ages. Every earthquake leaves a trail of misery because of the loss of life and destruction.**

Seismic codes are very important in the designing of multistoried buildings. In order to design an earthquake resistant building, structural engineers must have good knowledge of the various seismic codes. In this study, seismic design provisions in three building codes, IS 1893-2002, 1997 USA (UBC)& Canadian (NRC 2005) are studied. Factors like Importance factor, response reduction factor, seismic zones, soil profile, and Fundamental time period were compared. Recommendations provided by seismic codes help the designer to improve the behavior of structures so that they may withstand the earthquake effects without significant loss. Seismic codes are unique to a particular region or country. They take into account the local seismology, accepted level of seismic risk, properties of available materials, methods used in construction and building typologies.

In this study, a symmetrical G+20 multistoried building was analyzed & designed by computer software Staad Pro using the above mentioned three seismic codes. It was found that the Indian Standard code gave the most economical design whereas the UBC code consumed more steel.

***Keywords*- Earthquake, Seismic Code, Seismic analysis**

I. INTRODUCTION

A. General

Natural calamities such as earthquakes, tsunamis, landslides, floods etc. cause severe damage and suffering to human beings by collapsing many structures, trapping or killing persons, cutting off transport systems, blocking of navigation systems, animal deaths etc. Such natural disasters are big challenges to the progress of development. However, civil engineers play a major role in minimizing the damages by properly designing the structures or by proper material selection or proper construction procedure and taking other appropriate decisions. This includes understanding the earthquakes, behavior of the materials of construction and structures and the extent to which structural engineers make use of the knowledge in taking proper decisions in designing the structures made of reinforced concrete.

The first code was introduced in 1927 in the USA for the Californian earthquakes. Following this code, the effort to elaborate codes was extended to all the world's seismic zones. For these codes, the current set of seismic design factors found in national standards is based on a measured combination of history of seismic events, state of- the art of research works and engineering judgments, very different in each country as a function of its experience of construction in seismic areas, coming from the nature and characteristics of ground motions, traditions and jurisdictions. Therefore, it is very important to analyze the evolution of seismic codes in the world's main seismic areas, in the context of the above-mentioned factors. Earthquakes all over the world have affected the seismic resistant design in different countries and made a revision necessary in many areas. Great Improvements during last 50 years in Japan and USA make a comparison between their codes and other Countries inevitable. The Building Standard Law in Japan (AIJ) has been in force since 1950.

Tall structures and buildings are now adopted in India. Analysis of such a complex structure is too hectic & time consuming. It is tried since long time to find the solution to this problem. Wind & seismic analysis of the structures can be done by the advance software Staad Pro, SAP or ETABS.

B. Objectives And Scope

The purpose of this research is to study seismic codes of different countries which are very important in the designing of multistoried buildings. Objectives of this study are as follows:

1) To study codes which differ in details but they have a lot of common features which can be compared.
2) To study the different parameters of the different country codes.
3) To analyze the results obtained by the software Staad Pro.
4) To study and differentiate the highlights and recommendations in codes.
5) To design high rise building with different codes and to compare seismic response of buildings designed with different codes.
6) To study results of seismic behavior of buildings in terms of stress and deflection.
7) To compare buildings designed with 3 different international codes.

C. Methodology

The whole purpose of this study is to design building model based on literature survey, carry out model testing over Staad Pro, analyze the results and finally come to a conclusion.

The steps to be followed are listed below,

1) Preparation of the model in Staad Pro software.
2) Calculation for loads on the structure.
3) Assigning properties and load to the model.
4) Applying earthquake parameter to the building and analyzing the structure.
5) The findings of the study are obtained and same process is done for the rest of the codes.
6) Observe the findings/results of the Staad file.
7) Compare the results of the various models and check the efficiency.

D. Building Parameters:

All the parameters shown below are the same for every model.

Table1: Structural Data of Model

Coloumn	450 x 450 mm 600 x 600 mm 750 x 750 mm
Beam	380 x 230 mm 530 x 380 mm 750 x 380 mm
Material used	Reinforced Cement Concrete
Concrete Frame	SMRF
Main wall	230 mm
Reinforcement used	HYSD
Slab thickness	150 mm
Unit weight of concrete	25 KN/cum.
Concrete Grade	M 60
Steel Grade	Fy500

Table2: Parameters Adopted For The Model.

Parameter	Units
Total Building height	66.50 m
Floor to floor height	3.2 m
No. of floors	G+20
No. of columns	49
Length of plan in X-direction	27.6 m
Length of plan in z-direction	27.6 m

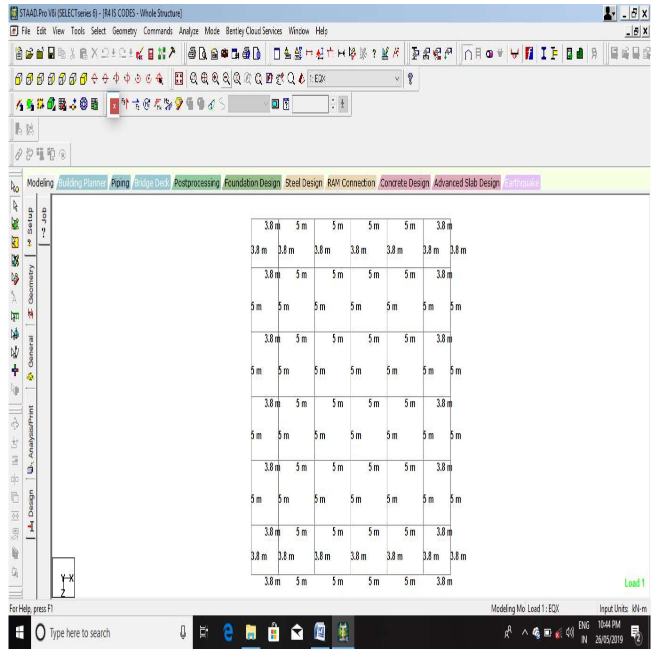

Figure1: Geometry of Approved Plan in Staad Pro for All Standards.

II. RESULTS OBTAINED FROM THE STUDY

In this paper the various parameters are compared with the beam and Coloumn as per their position according to the different international standards used in the staad pro.

Table3: Displacement According To International Standards.

Storey	Displacement IS 1893	Displacement CANADIAN	Displacement UBC (USA)
G	2.365	2.282	3.480
1	8.425	8.071	12.479
2	15.236	14.543	22.631
3	22.338	21.241	33.172
4	29.616	28.044	43.893
5	36.998	34.888	54.652
6	44.416	41.654	65.337
7	51.820	48.348	75.857
8	59.858	54.907	86.131
9	66.377	61.291	96.088
10	73.427	67.461	105.659
11	80.248	73.379	114.781
12	86.784	79.011	123.392
13	92.973	84.321	131.433
14	98.652	89.275	138.850
15	104.054	93.840	145.593
16	108.813	97.981	154.614
17	112.965	101.666	156.887
18	116.447	104.859	161.352
19	119.214	107.527	165.045
20	121.251	109.555	167.936

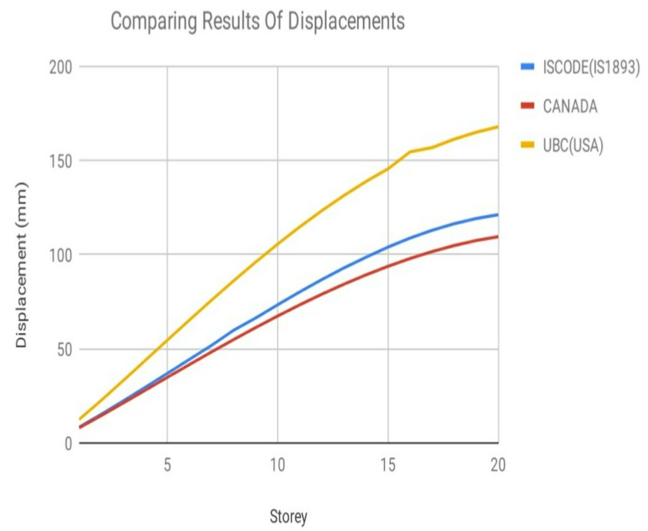

Fig.2: Comparing the Result of Displacement on Each Floor.

Table4: Fundamental Time Period According To International Standards.

International Standards.	Fundamental Time Period (sec.)
IS1893	1.13
CANADA	1.74
UBC (USA)	0.6986

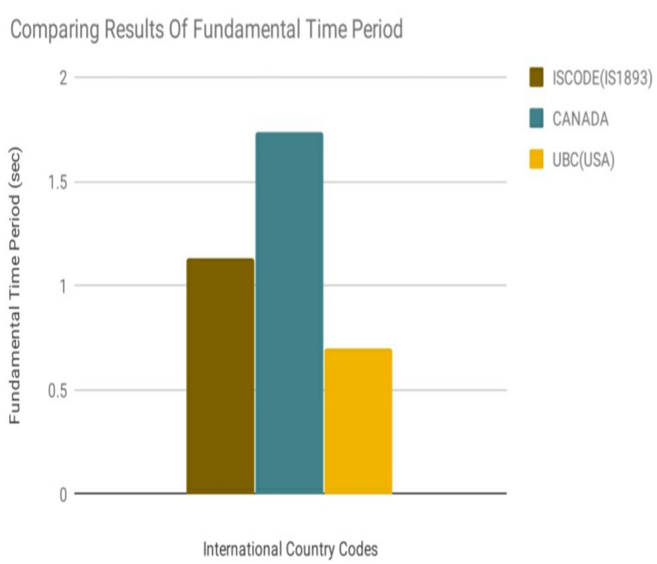

Fig3: Comparing the Result of Fundamental Time Period

Table5: Maximum Moment-Y on Beam End Span Peripheral Bay

International CountryCode	First Floor My(KN.m)	Top Floor My(KN.m)
IS CODE(IS 1893)	1.980	4.634
CANADA	1.263	3.203
UBC (USA)	1.268	3.729

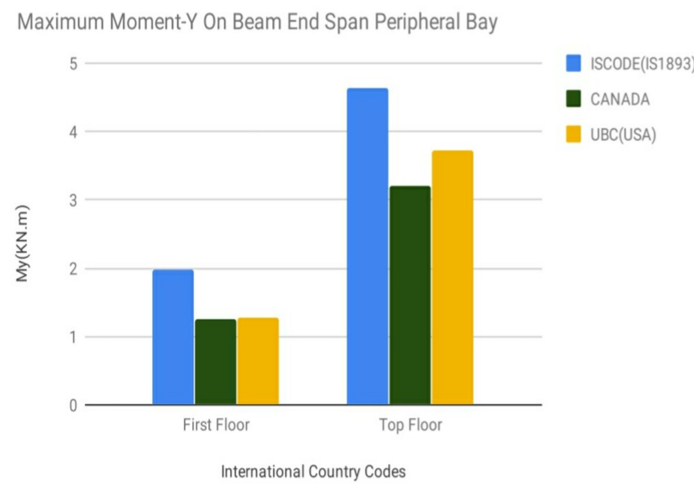

Fig.4: Maximum Moment-Yon End Span Peripheral Bay Beam.

Table6: Maximum Moment-Z on Beam End Span Peripheral Bay.

International Country Code	First Floor Mz (KN.m)	Top Floor Mz (KN.m)
IS CODE(IS 1893)	97.645	69.892
CANADA	60.956	44.263
UBC (USA)	93.317	84.503

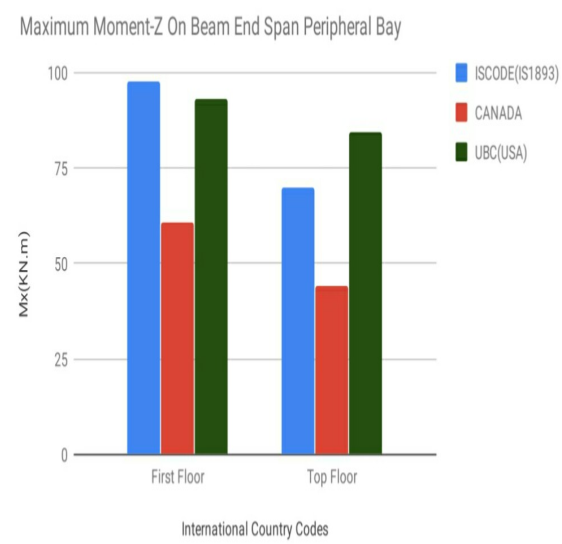

Fig.5: Maximum Moment-Z on End Span Peripheral Bay Beam.

Table7: Maximum Moment-Yon Beam Interior Span Peripheral Bay.

International Country Code	First Floor My(KN-m)	Top Floor My(KN-m)
IS CODE(IS 1893)	5.240	23.512
CANADA	3.242	15.145
UBC (USA)	4.911	13.950

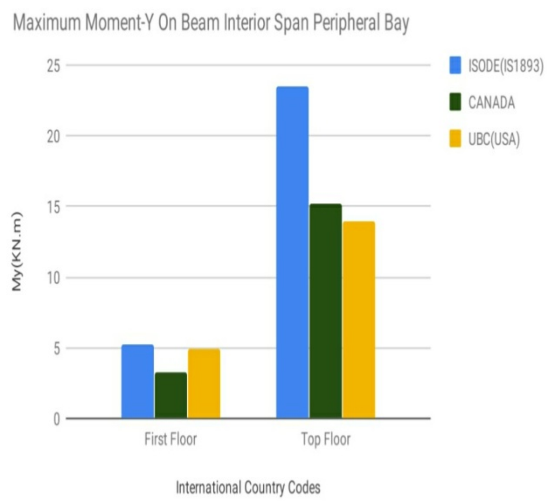

Fig.6: Maximum Moment-Y on Interior Span Peripheral Bay Beam.

Table 8: Maximum Moment-Z on Beam Interior Span Peripheral Bay

International Country Code	First Floor Mz (KN.m)	Top Floor Mz (KN.m)
IS CODE(IS 1893)	480.989	177.484
CANADA	307.561	99.255
UBC (USA)	457.810	130.827

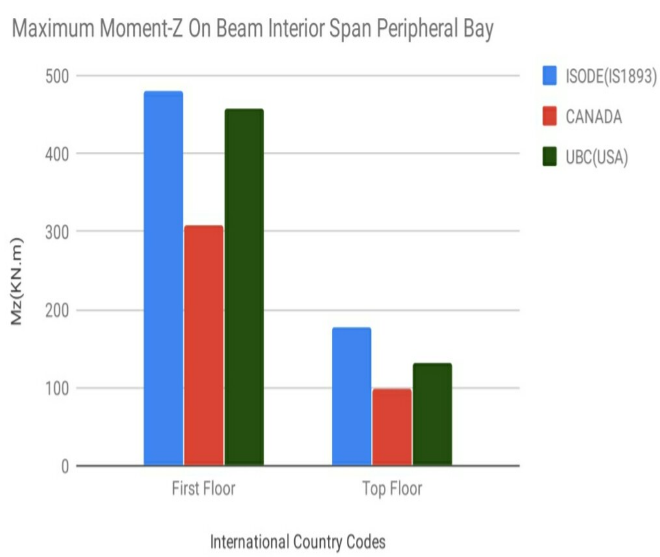

Fig.7: Maximum Moment-Z on Interior Span Peripheral Bay Beam.

Table9: Maximum Moment-Yon Beam End Span Interior Bay.

International Country Code	First Floor My(KN.m)	Top Floor My(KN.m)
IS CODE(IS 1893)	11.365	44.217
CANADA	7.078	29.066
UBC (USA)	7.320	30.262

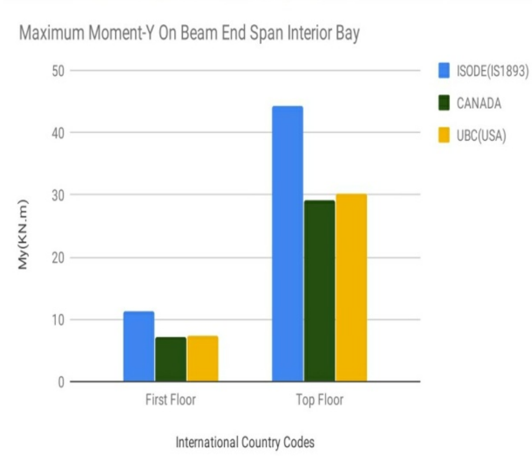

Fig.8: Maximum Moment-Y on End Span Interior Bay Beam.

Table10: Maximum Moment-Z on Beam End Span Interior Bay.

International Country Code	First Floor Mz (KN.m)	Top Floor Mz (KN.m)
IS CODE(IS 1893)	274.183	83.207
CANADA	177.323	63.053
UBC (USA)	252.102	114.142

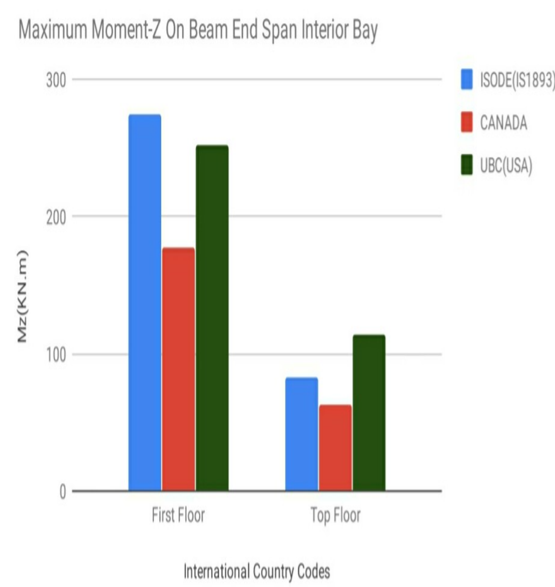

Fig.9: Maximum Moment-Y on End Span Interior Bay Beam.

Table11: Maximum Moment-Yon Beam Interior Span Interior Bay.

International Country Code	First Floor My(KN.m)	Top Floor My(KN.m)
IS CODE(IS 1893)	0.074	7.848
CANADA	0.048	4.59
UBC (USA)	0.132	3.914

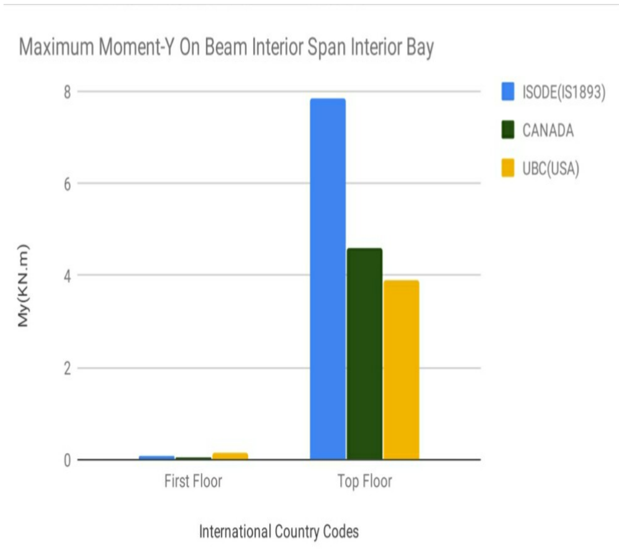

Fig.10: Maximum Moment-Y on Interior Span Interior Bay Beam.

Table12: Maximum Moment-Z on Beam Interior Span Interior Bay.

International Country Code	First Floor Mz (KN.m)	Top Floor Mz (KN.m)
IS CODE(IS 1893)	269.714	196.711
CANADA	174.556	137.353
UBC (USA)	262.107	158.130

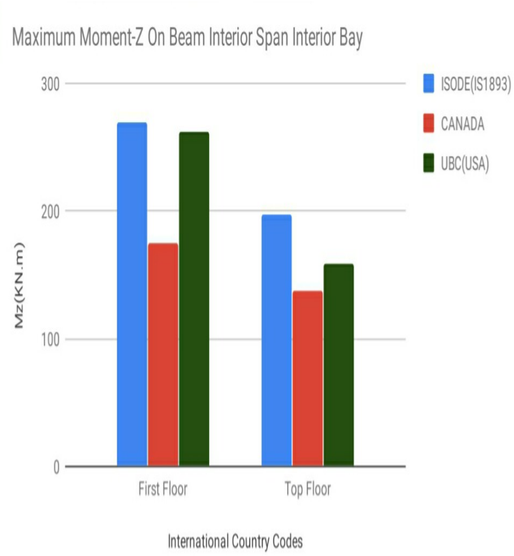

Fig.11: Maximum Moment-Z on Interior Span Interior Bay Beam

Table13: % of Steel in Exterior Column at Top Floor International Code.

International code	% steel
IS 1893	0.89
CANADA	1.18
UBC (USA)	1.17

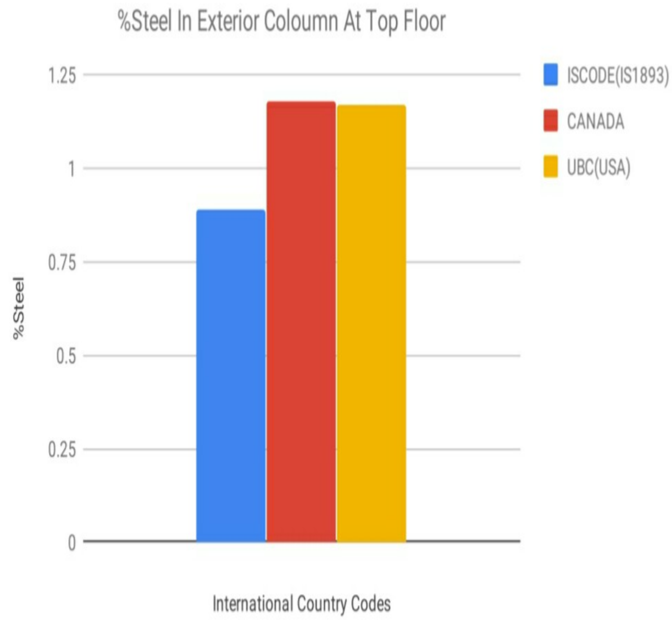

Fig.12: Comparing Result Of % Steel In Column At Top Floor Provided.

Table14: Steel Quantity for Entire Building According to various Codes

International Code	Steel Quantity (N)
IS 1893	2426266
CANADA	-
UBC (USA)	3070758.61

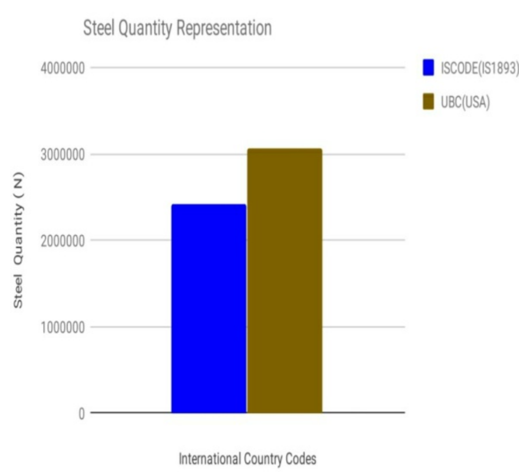

Fig.13: Comparing the Result of Steel Quantity Used In International Code

Table15: Axial Forces Used In International Code.

International Code	Axial Forces
IS 1893	3265.61
CANADA	2890.957
UBC (USA)	3538.721

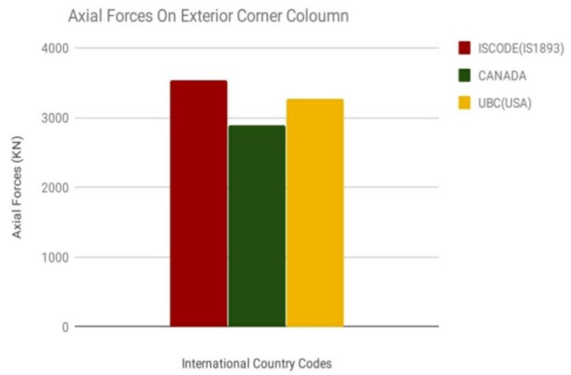

Fig.14: Comparing the Result of Axial Forces on Exterior Corner Column.

III. CONCLUSIONS

Based on the overall results, analysis and comparison, the conclusion can be drawn are as following:

1) Maximum quantity of steel is required in UBC standard.
2) Minimum quantity of steel is required in IS standard.
3) The Canadian standard does not show the steel quantity obtained through the Staad Pro software hence the conclusion cannot be drawn for the CANADIAN CODE.
4) The largest load combination was of UNIFORM BUILDING CODE (USA).
5) Time period of the structure both in x and z direction is highest for IS and minimum for UNIFORM BUILDING CODE (USA).
6) Higher axial forces were observed in IS: 1893 standard and subsequently in CANADIAN CODE and UBC standard.
7) Finally, it can be summarized that the variations in values is due to the independent constants, loading and load combinations of their respective International Standard codes.

REFERENCES

[1]. NimitaGautam, T. P. (2017). Critical Study and Comparison of Earthquake. International Journal of Research in Engineering, Science and Technologies, 03 (06), 15-21.
[2]. Dr. S.V. Itti, P. A. (n.d.). A Comparative Study on Seismic Provisions Made in Indian and International Building Code for RC Building.
[3]. P.R.Bose, R. M. (1992). Comparison of Codal Provisions Suggested by Various Countries. University of Roorkee, India, Earthquake Engineering Department. Rotterdam: Earthquake Engineering, Tenth World Conference.International Building Code 2009 (USA).
[4]. IS 1893-2002- Indian Standard, Criteria for Earthquake Resistant Design of Structures, Part 1 General Provisions and Buildings.
[5]. Uniform Building Code 1997 (USA)
[6]. National Building Code of Canada (2005), Published by National Research Council of Canada.