Comparative Analysis of a High-Rise Structure using Various International Codes

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Abstract

Most of the population of world is being concentrated in the metropolitan cities. Since the land areas of metropolitan cities are scarce with the high number of population, to counteract this problem, the structures which are being used as both commercial and residential purposes must grow vertically instead of growing horizontally. This vertical growth must be implemented to counteract the recurring growth of the population in most of the parts in the world. In this study, the vertical growth is referred to a high-rise building, and a comparative analysis of dynamic loads are carried out on these high-rise structures using various International Standard Codes (American, European and Indian), with the inclusive of recently developed IS 1893:2016.
Keywords: Population, Metropolitan Cities, Recurring, High-Rise Buildings, Dynamic Loads, IS 1893:2016

I. INTRODUCTION

Our planet, Earth is the 3rd planet in the solar system, and this is the only planet that supports life. The area of Earth is 510.072 million sq. km out of which 29.1% is land i.e., 148.940 million sq. km and 70.9% is covered by water i.e., 361.132 million sq. km. In the given land mass of 148.940 million sq. km is the home for human population of about 7.5 billion people, according to the United Nations estimates, here the land mass remains constant and the population keeps on increasing. Due to this constant land mass and growing population there is a scarcity of land. Most of the population of world is being concentrated in the metropolitan cities. As the structure grows in height it must satisfy many conditions, like to carry the earthquake loads safely, counteract the wind loads and stability of the structure must also be maintained in other words the structure must be in Equilibrium during the forces acting on it.

II. LITERATURE REVIEW

Maria A Parisi [2] [2008] This forum issues a profile of the EUROCODE, the European system of codes for structural design. It is notable that EUROCODE 8 which is meant for tremor convulsion proposition and the most noteworthy affair associated to the seismic design of buildings are scrutinized. A thorough juxtaposition is carried out by considering the total design process. The nature of two standards ASCE and EN seems quite unalike, The EUROCODE aims more at interpreting ideas and hold up resolutions by describing the design philosophy, whereas the ASCE code seems user affable and more exercise aligned, conducting the design process with comprehensive details. Vijay Namdev Khose, et.al. [3] [2012] This article presents a juxtapose study of the seismic performances of 8 story building designed according to U.S.A (ASCE 7-10 2010) and Indian (IS1893:2002) seismic design codes for a given value of PGA corresponding to the maximum credible earthquake (MCE) platform used for modelling is SAP 2000. A comparison of seismic performance of 8 storey RC frame building designed are quite close. Both the buildings have attained better than the deliberate performance for subside impairment. However, the pear interstorey drift ratio in case of the building designed for IS 1893 exceeds the deliberate limits, Due to gross section stiffness in design. Hanna Elza Titus, et.al. [8] [2015] This paper presents with the analysis and design of a G+10 for seismic forces using four international building std. IS 1893:2002, EUROCODE 8, ASCE 7-10 and British codes. The analysis of the building was done using Staad-pro V8i. and was designed using afore mentioned codes, once analysis was done pushover analysis was done is SAP 2000 to check seismic performance of the building. Building analysed is G+10 building. After analysis it is seen that EUROCODE standards serves to be most in-expensive design and Indian standards were least in-expensive. During pushover analysis IS had max. shear value, compared to IS 3.05% euro less,11.10% (ASCE) and 12.24% (BS). For displacement IS has lesser displacement whereas EURO standard has 22% more when compared to IS, ASCE 20% & BS 19% It can thus be inferred that building designed according to the IS are more rigid and thus it attracts more seismic forces. Asmita Ravindra Wagh, et.al. [12] [2016] This study focuses on juxtaposition of global standard. An illustrative study of seismic design and gauging of sky-scraping structure utilizing diverse International code is executed. The objective of this paper is to examine the contrast being provoked by the use of diverse codes in the analysis of high rise building. The parameters such as displacement, base shear, storey drift, time period, axial force and shear force, bending moment are studied to figure out the disparity that occur while using different codes. This paper is deliberate to contrast the design of high rise edifice with various International codes. This advancement of contrasted study based on the design and seismic analysis of the building will act as check as to which code serves to be the most economical.

III. OBJECTIVES

- To study and understand various International standard codes, which are being used in this thesis. (American, European and Indian)
- To assign the loading values and other parameters to the structure according to the codes of the respective Countries.
- To analyze the structure for Response Spectrum Analysis (RSA) or Dynamic Analysis.
- To obtain the structural parameters of the structure and generate the graphs.
- To compare the graphs and decide which International code parameters give good results regarding the strength, durability and stability of the structure.

IV. METHODOLOGY

A. *Model Description:*

- A Reinforced concrete building of 25 floors has been considered for this project.
- The proposed structure is irregular in shape, which resembles the '+' shape.
- The structure has voids in the upper block and the adjacent block to its left to provide ventilation, plumbing accessories and electrical lines etc.,
- Shear wall is provided for the lifts, there are two lifts, one for the main use and another is used are service lift, where it is used in case of failure or maintenance of the main lift.
- Each floor consists of 8 units with 2 stair cases and lift services.
- Marble and Granite finish is given for the structure for interiors, parapet walls are provided for balconies and terrace.
- Proposed area for the construction of the Edifice is 2320.34 m2, Carpet area is 1337.89 m^2.

B. *Structural Data of the Building:*

Structural Elements	*Description*
Column	*450 x 1500 mm* *450 x 1800 mm* *450 x 2400 mm*
Beam	*300 x 750 mm* *300 x 900 mm*
Slab	*150 mm*
Shear wall	*200 mm*
Main wall	*230 mm*
Partition wall	*115 mm*
Parapet wall	*115 mm*
Height of parapet wall	*1300 mm*
Height of the structure	*75400 mm*
Floor-to-floor height	*2900 mm*
No. of stories	*25 nos.*
Material used	*Reinforced Cement Concrete*
Concrete Frame	*SMRF*
Reinforcement used	*HYSD Rebar*
Purpose of Structure	*Residential use*

C. *Model:*

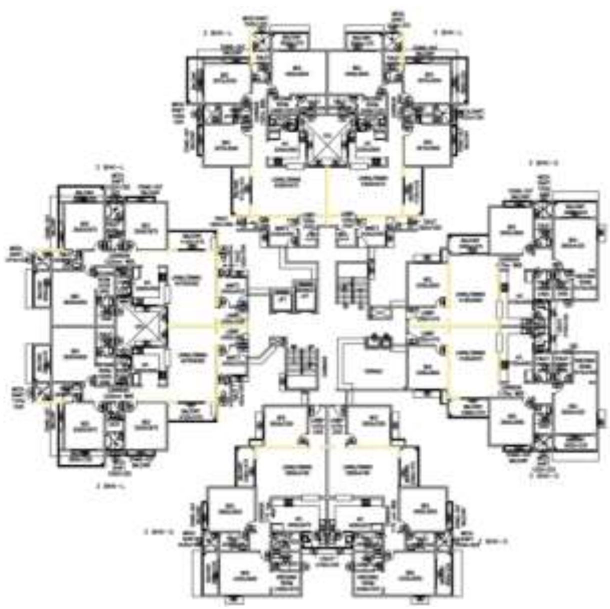

Fig. 1: Plan of the model

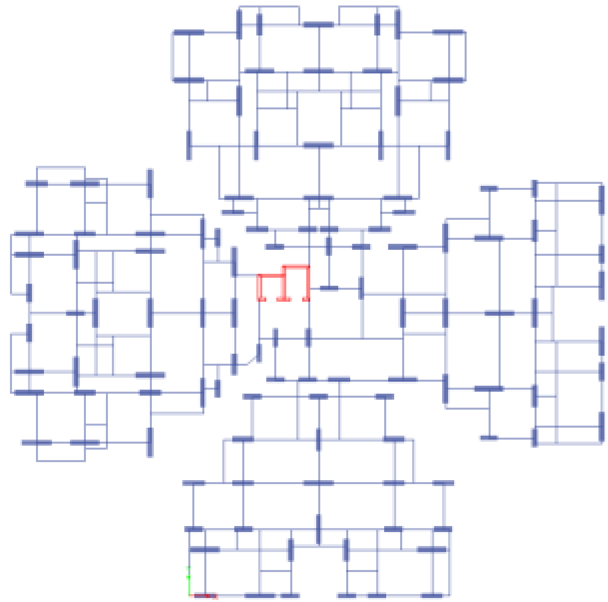

Fig. 2: Column beam layout of the model

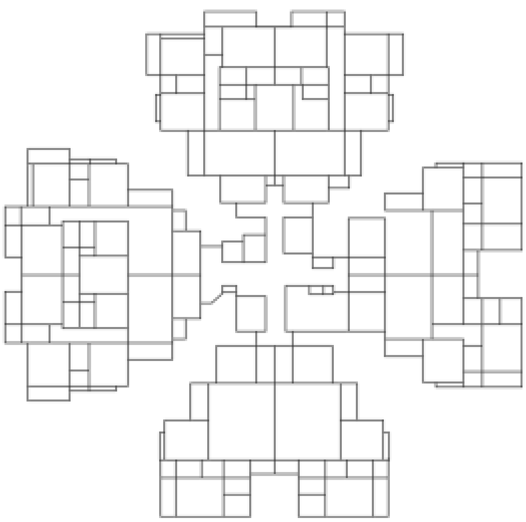

Fig. 3: Centre line plan of the structure

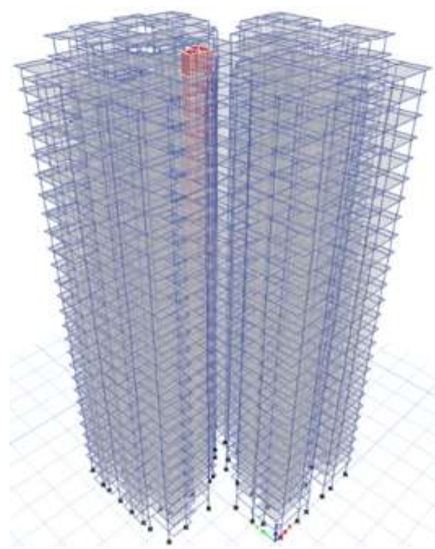

Fig. 4: 3D line diagram of the structure

Fig. 5: 3D Rendered View of the structure

D. Results of Analysis:

Structural parameter = Storey shear

Case Combo, SPEC X	*Storey Shear*
ASCE 7-05	*4513.53*
IS 1893:2016	*6951.09*
IS 1893:2002	*10609.26*
EN 8	*14928.20*

1) Storey Shear values for case combo SPEC X for various International Standard Codes

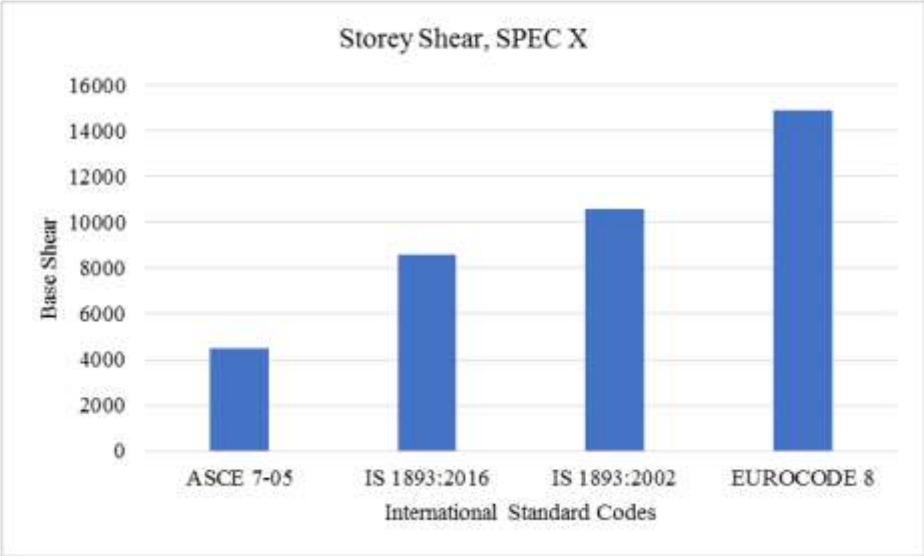

Fig. 6: Graphical representation of Storey shear results for SPEC X of various codes.

Case Combo, SPEC Y	*Storey Shear*
ASCE 7-05	*4512.85*
IS 1893:2016	*8583.03*
IS 1893:2002	*10715.61*
EN 8	*14894.07*

2) Storey Shear values for case combo SPEC Y for various International Standard Codes

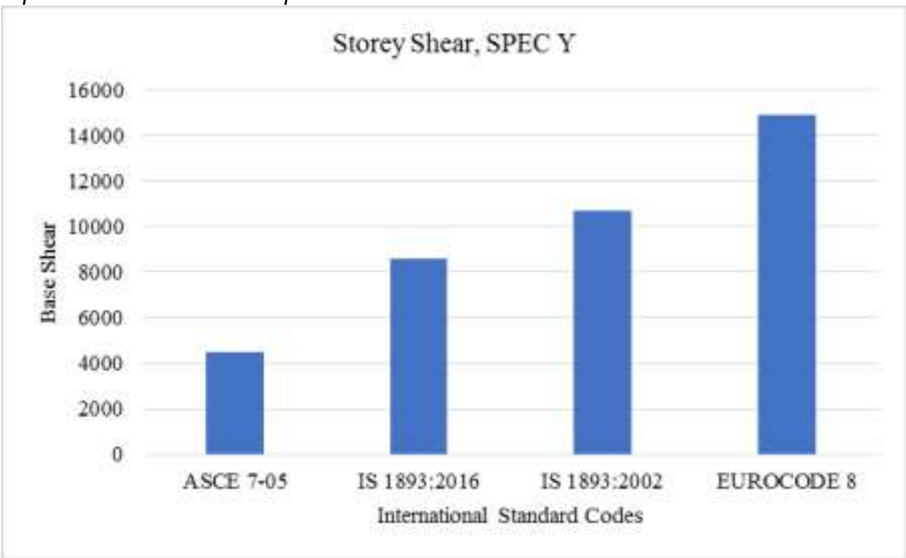

Fig. 7: Graphical representation of Storey shear results for SPEC Y of various codes.

Structural Parameter = Maximum storey displacement

Case Combo, SPEC X	*Maximum Storey Displacement (mm)*
ASCE 7-05	*10.33*
IS 1893:2002	*21.69*
IS 1893:2016	*14.21*
EN 8	*28.79*

3) *Max. Storey Displacement values for case combo SPEC Y for various International Standard Codes.*

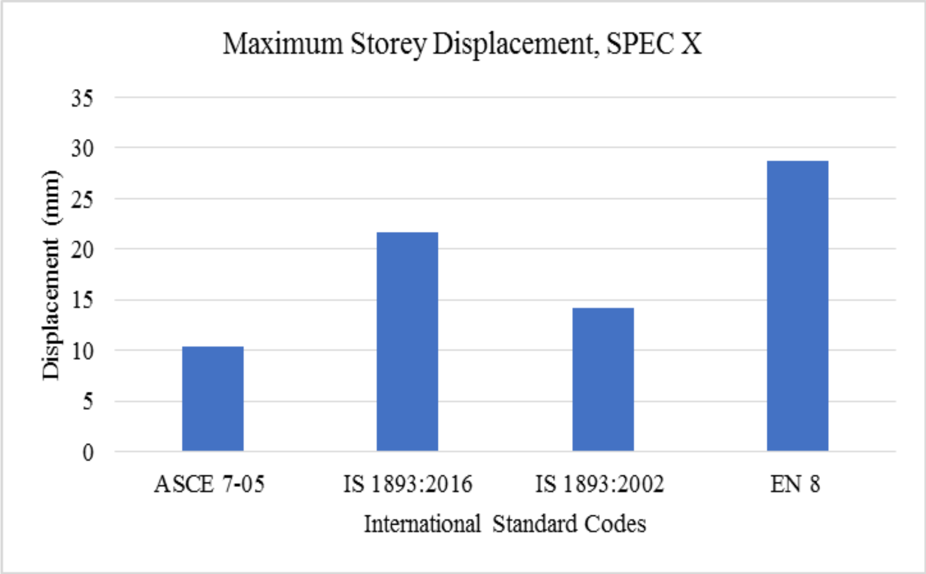

Fig. 8: Graphical representation of Max. Storey Displacement results for SPEC X of various codes.

Case Combo, SPEC Y	*Maximum Storey Displacement (mm)*
ASCE 7-05	*11.05*
IS 1893:2002	*21.15*
IS 1893:2016	*11.05*
EN 8	*31.82*

4) *Max. Storey Displacement values for case combo SPEC Y for various International Standard Codes.*

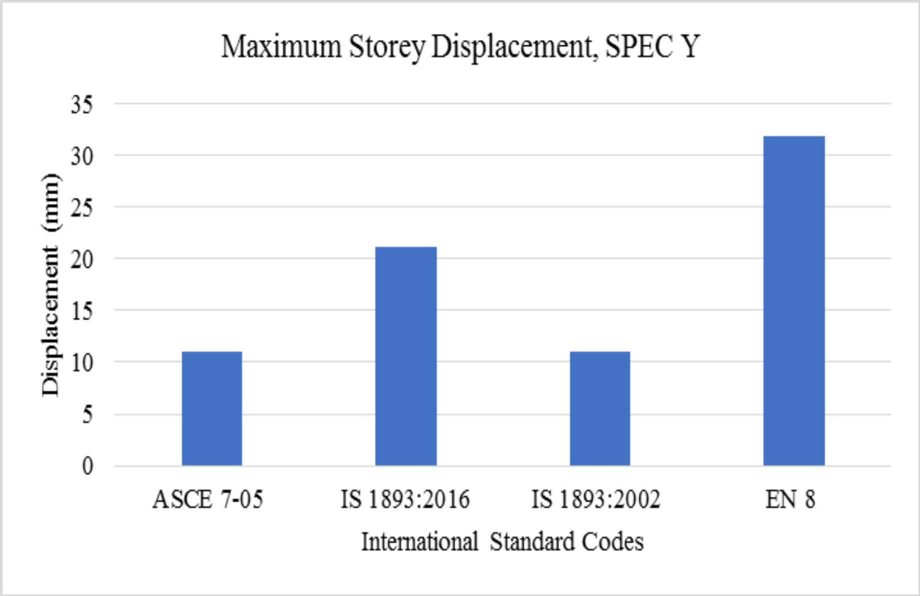

Fig. 9: Graphical representation of Max. Storey Displacement results for SPEC Y of various codes.

Structural Parameter = Maximum Storey Drift

Case Combo, SPEC X	*Maximum Storey Drift*
ASCE 7-05	*0.000171*
IS 1893:2016	*0.000244*
IS 1893:2002	*0.000373*
EN 8	*0.000482*

5) Max. Storey drift values for case combo SPEC X for various International Standard Codes

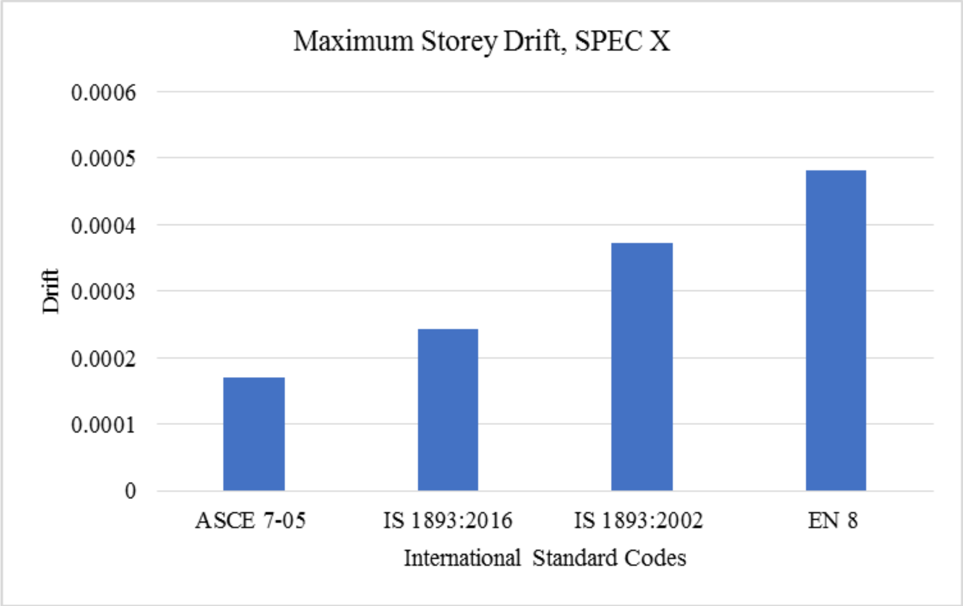

Fig. 10: Graphical representation of Max. Storey Drift results for SPEC X of various codes.

Case Combo, SPEC Y	*Maximum Storey Drift*
ASCE 7-05	*0.000183*
IS 1893:2016	*0.000296*
IS 1893:2002	*0.000369*
EN 8	*0.000531*

6) Max. Storey Drift Values For Case Combo SPEC Y for Various International Standard Codes

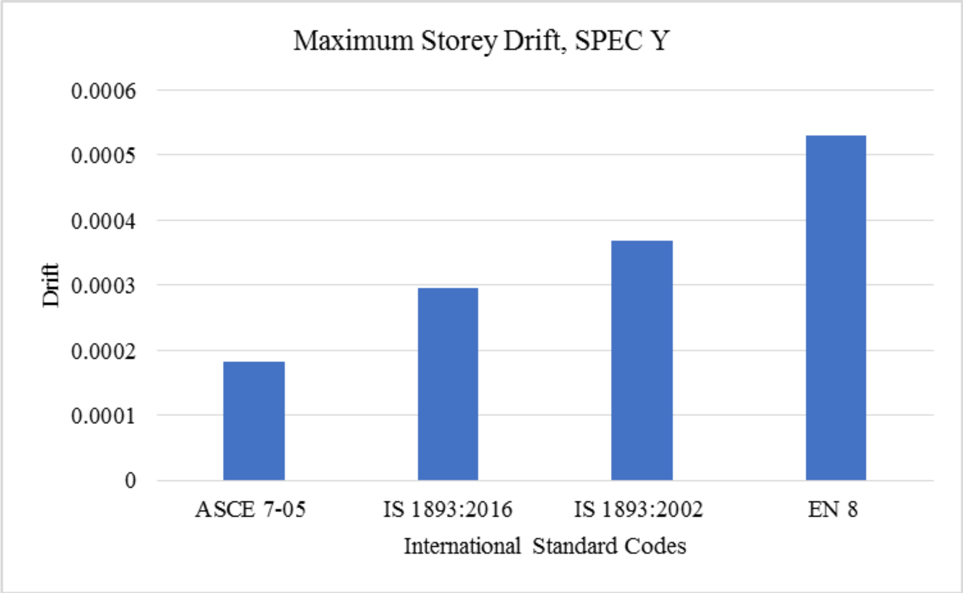

Fig. 11: Graphical representation of Max. Storey Drift results for SPEC Y of various codes.

Structural Parameter = Storey Overturning Moment.

Case Combo, SPEC X	*Storey Overturning Moment (kN-m)*
ASCE 7-05	*202970*
IS 1893:2016	*326593*
IS 1893:2002	*494870*
EN 8	*695532*

7) Overturning Moment values for case combo SPEC X for various International Standard Codes

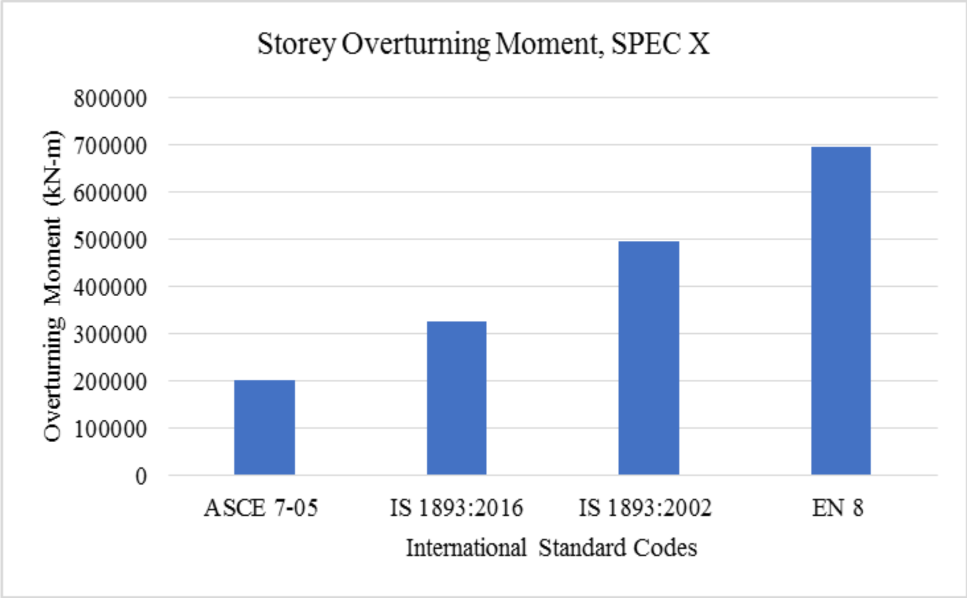

Fig. 12: Graphical representation of Overturning Moment results for SPEC X of various codes.

Case Combo, SPEC Y	*Storey Overturning Moment (kN-m)*
ASCE 7-05	*200144*
IS 1893:2016	*401117*
IS 1893:2002	*500781*
EN 8	*685591*

Overturning Moment values for case combo SPEC Y for various International Standard Codes

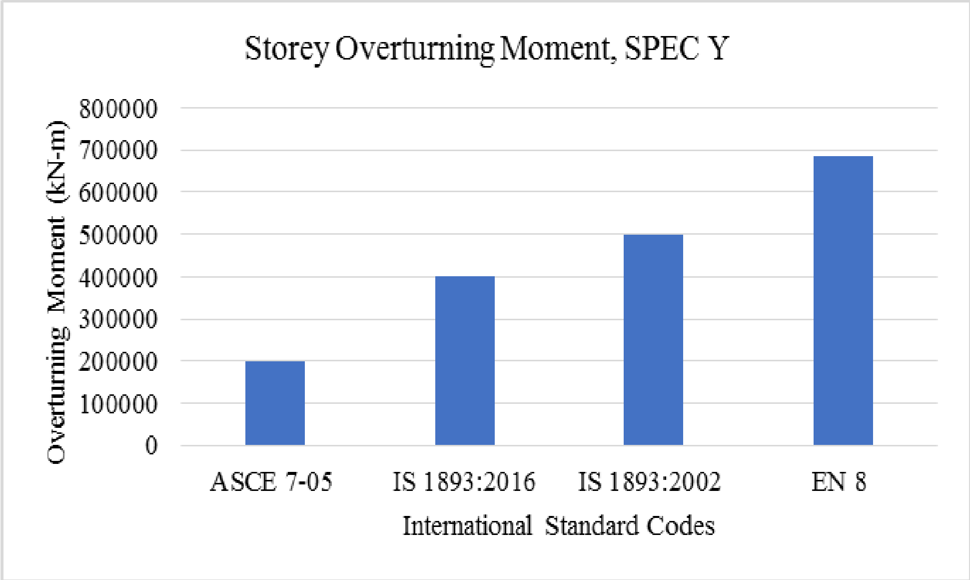

Fig. 13: Graphical representation of Overturning Moment results for SPEC Y of various codes.

V. CONCLUSION

In this present study, the dynamic analysis for various structural parameters which governs the stability, durability and safety of the structure was carried on a high-rise structure for various International Standard Codes. Based on the results attained after the dynamic analysis of structure, following conclusions can be drawn.

- It is apparent that the United States of American code has low values and also well within the permissible limit for the various structural parameters analysed for the spectrum load cases when compared with other International Standards. Hence the structure analysed for the American code performs well when compared with the other codes.

- The structure analysed for IS 1893:2016 has shown better values for all the structural parameters considered, when compared to its previous code IS 1893:2002. Hence IS 1893:2016, the 6th revision is better in terms of structural parameters and structural safety in contrast to IS 1893:2002.
- Since EUROCODE surpasses all the other codes when compared in terms of values obtained for structural parameters, hence during the design, EUROCODE needs more reinforcement area when compared to other codes, due to the increased reinforcement area with contrast to other International Standard codes, the structure analysed for EUROCODE is comparatively ductile.
- IS 1893:2002 and IS 1893:2016 has less base shear when compared with the EUROCODE, hence it is evident that, Structure analysed for IS 1893:2002 and IS1893:2016 is more rigid, while the structure analysed for EUROCODE is more ductile.
- However, what so ever the values obtained during the analysis of the structure for various structural parameters, it is obvious that the variations of values are due to the independent constants, loading and load combinations of their respective International Standard codes.

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, and during the design process of these structures it can be designed in such a way that it serves it service period without any complications and made safe and durable.

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