Role of Seismic Codal Provisions in Seismic Study of the RCC Structures-Review

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ABSTRACT

The earthquake resistance design of a structures is highly important and are still a challenge for designers. Present study is a review on comparison of Indian and American seismic codes based on seismic performance of RCC structure. the codes which are under study are IS1893;2016 and ASCE/SEI7-10. The results which come out from the literatures are that the building which will design as per IS1893;2016 will show more base shear in comparison with ASCE/SEI7-10 American standard. But in case of story drift the Indian standard will show less story drift it means the displacement of a building which is designed by Indian code will be minimum.

Keywords, IS Indian code, ASCE American code, Base shear, story drift, displacement.

1. INTRODUCTION

Earthquake is an unpredictable disaster which happens in the earth and cause ground motions with various magnitude and intensities and may cause huge damage to structures and human's lives, that's why each developed country has a specific seismic code, but there are some countries which have no seismic code so they have used the codes of developed countries, because of these demands this paper has been provided for better understanding of Indian and American seismic codes.

1.1.1 Criteria for Earthquake Resistant Design of Structures

IS1893;2016

IS1893 Indian code has been published at the year 1964 and the first time this code was revised at the year 1984, this code contains all provisions regarding design of earthquake resistant structures, and the latest edit was happened in the year 2016 after 2002 and there was a gap of 18 years for revise the code.

1.1.2 The Major Factor which are suggested at IS 1892;2016 code are as fallows.

a) Seismic zones

Each country which are under seismic regions are classified into number of seismic zones, based on IS1893;2016 Indian seismic code India is classified into for major seismic zones which are mentioned as roman numbers in below table.

Zone factor	II	III	IV	V
Z	0.10	0.16	0.24	0.36

Table 1

b) Importance factor

This is the factor which is under consideration for computing design lateral force Vb, based on code provisions this factor shall be taken as per below table.

No	structures	Factor (I)
1	All-important buildings for instant(hospital , schools, critical governmental buildings and all building which	1.5

	more than 200 persons are occupied with,…	
2	Residential buildings which less than 200 persons are involved	1.2
3	All other buildings	1.0

Table 2

c) **Response reduction factor (R)**

This factor demonstrates the radio of the maximum lateral force Ve to lateral force Vb under a specific ground motion, many seismic code recommend different values for reduction factor this values depend on building systems, according IS1893;2016 these values are mentioned in IS1893;2016 part-1, table number 9.

1.1.3 Method of Analysis

- Equivalent static analysis
- Dynamic analysis of a structures.

1.1.4 Major Steps to calculate base shear of a structure

- Determination of masses to various floor levels
- Calculation of natural period
- Estimation of design horizontal seismic coefficient A_h
- Determination of base shear
- Vertical distribution of base shear

1.2.1 American Society of Civil Engineering(ASCE)

Minimum design loads for buildings and other structures, ASCE/SEI 7-10, have provisions and guidance for structural design and contains means for estimating all kind of load such as dead load, live load, floods, snow loads, rain loads, ice loads, wind loads and earthquake loads, and their combinations.

For the designing of earthquake resistant structure this standard has considered the most sever effects of earthquake.

1.2.2 Steps for Determining Design Force

- Definition of maximum considered earthquake.
- Soil site classification.
- Spectral response acceleration and design response acceleration.
- Risk and importance factor.
- Seismic design category.
- Seismic design load.

1.2.3 Soil Site Classification

The soil sites are divided into soil site class A through F as mentioned in Table 20.3-1 and Section 20.3 of ASCE/SEI 7, in the lack of exact information of soil site, site class D should be used unless the authority having jurisdiction or geotechnical data determines that site class E or F is appropriate.

1.2.4 Risk and Importance Factor

The risk and importance factors depend on amount of damages and its effects on humans lives, as we all know that a school is more important than a form so its importance factor is also high. Chapter 1 of ASCE/SEI 7 lists four risk categories in Table 1.5-1. These risk categories are correlated to importance factors that range from 1.0 to 1.5 (ASCE/SEI 7-10, Table 11.5-2)

2. LITERATURE REVIEW

(Patil et al., 2008)The aims of this article was the comparison of seismic assessment Parameters using different international standards. The chosen standards are Euro code, ACI and Indian code i.e. IS 1893:2016. The authors considered G+20, Special RC moment-resting frame (SMRF). Modelling of the structure has been done in ETABS 2015 software., Calculated Base shear in X direction, compared to Indian code, Euro code shows 16.70 % more base shear and ACI shows 10.05 % less base shear**.** Story Drift as seen in the graph, in the case of Euro code has fluctuating values with a drastic heave. And

Indian Code, ACI represent a graph having lesser fluctuating values than the former one.

(Charavande & Maru, 2019)The title of this article is Earthquake Analysis, of RC Structure using Different Codes and Different Countries.

The author concluded the results of this project as follows. 1. Conclusions for Base Shear for G+5 When base shear was Calculated in X-Y direction, American code showed better results than Indian code, For G+11 When base shear was Calculated in X-Y direction, Indian code showed better results than American code, For G+21 When base shear was Calculated in X-Y direction, Indian code showed better results than American code. 2. Conclusions for Story Drift for G+5 When Story Drift was Calculated, Indian code showed better results than American code, For G+11 and G+21 When Story Drifts Were Calculated, Indian code showed better results than American code,

(S.Karthiga1, 2015)The authors have done a comparative study over international seismic codes, namely IS1893, euro code and ASCE7-10. And finally the authors concluded that based on Indian standard base shear has high value than Euro and American standards, according to percentage Euro standard has 3.05% less value and American standard has 11.10% less value compared to Indian standard. And also the authors concluded that Indian standard has minimum displacement as compared to Euro and American standards. (Varsha & Hirde, 2020)this paper is a comparative study of Indian seismic code and American code and the author considered both IS1893;2002 and IS1893;2016 for comparing with ASCE/SEI 7-10, in this article three special moment resisting frames were under study. The author concluded that American code had high shear value than Indian standards, and also the author added that the Data shown in table represents base shear values for the structure designed according to IS 1893: 2002 are higher than IS 1893: 2016 It shows American code has maximum story response value than Indian code and RC frame designed according to IS 1893: 2016 show nearly similar values than ASCE 7-10. The third thing that the author was concluded is that as per IS 1893: 2002 the RCC frames show less story drift than designed with IS 1893: 2016 and ASCE 7-10. story Drift of the structures were approximately same according to IS 1893: 2016 and ASCE7-10.

(Mostafijur Rahman et al., 2018) The article is a comparative study of IS Indian code, American ASCE/SEI 7-10 and Bangladesh building code(BNBC). In this study the comparison of building has been done based on 12-story special moment resistant frame. The author aggregated the conclusion and has written that the structure designed according to the Indian code performed better when subjected to the ground motion that is intended to represent the Indian design response spectrum. Although the drift limits were met, slightly larger members would have made the stiffness of the IS building comparable to the ASCE building.

(P. G. Student & Koti, 2017)This article is a comparative study which include different international codes (American, European and Indian), with the inclusive of recently developed IS 1893:2016. In this research article an RC structure has been considered with 25 floors and it is a high rise building. The author concluded the result of this article after its dynamic analysis as follows. 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 analyzed for the spectrum load cases when compared with other International Standards. Hence the structure analyzed for the American code performs well when compared with the other codes. The structure analyzed 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. IS 1893:2002 and IS 1893:2016 has less base shear when compared with the EUROCODE, hence it is evident that, Structure analyzed for IS 1893:2002 and IS1893:2016 is more rigid, while the structure analyzed for EUROCODE is more ductile.

(Singh et al., 2012) The authors of this research paper have done a comparative study of difference building codes like ASCE7 (United States), EN1998-1 (Europe), NZS 1170.5 (New Zealand) and IS Indian code. After analyzing of the results of this paper the authors have concluded that The design base shear as per Euro code 8 is close to that of NZS 1170.5, while IS 1893 results in the lowest design base shear for a given hazard. The codes also differ significantly on the issue of minimum design base shear, and Euro code 8 and IS 1893 have no minimum limit on design base shear. However, the interstory drift ratio for most of the code designed buildings is greater than 2.5% (the highest limit on design drift among all the considered codes) for DBE. In case of MCE, the peak interstory drift ratio reaches up to or exceeds 4% for most of the codes.

(Malviya et al., 2017) In this paper the comparison of two Indian seismic code has been done, the author of this research paper considered an RCC structure with G+50 floors and the main objective of this research paper was to define the code differences regarding seismic performance of high rise structure, this paper has been concluded by author that the maximum deflection which are found by both old and new seismic codes are 1.0865 Meter and 0.161888 from old and new Indian code respectively ,the shear force resulted are 334.178 KN from IS1893;2002 and 188.483 KN from IS1893;2016.

(Izhar et al., 2019)this research paper is a comparative study of four seismic codes (IS 1893:2002, Euro code 8, Japan-2007 and ASCE 7-10) in this paper the author considered a 10 story building and the design has been done by staad pro software and the author concluded the result of this article that for beams the shear force is maximum as per ASCE 7-10 but the percentage of steel required was maximum as per IS standard and for column the base shear was maximum as per IS and minimum as per ASCE 7-10.

(Khose et al., 2012) The title of this research paper is “COMPARATIVE SEISMIC PERFORMANCE OF RC FRAME BUILDINGS DESIGNED FOR ASCE 7 AND IS 1893” the authors have considered an RC frame of 8-story, the authors concluded the results of the research paper that the, the final design base shear is identical in the two codes. The capacity curves of the buildings designed for ASCE 7 and IS 1893 are quite close, and the peak understory drift ratio in case of the building designed for IS 1893 exceeds the intended limits, due to use of gross-section stiffness in design.

(Velayutham & Subramanian, 2020)In the present study, the main factors constitute the seismic load have been studied and dynamic analysis results for various structural systems with various zone factors are compared using in IS 1893 (Part 1):2002, UBC 1997, NZS 1170.5 – 2004 and BS EN 1998-1-2004. Even though various codes differ in detail, they have essential common features and are comparable. All codes of practices include the effect of seismic risk, spectral content, importance of building, structural behavior and soil/foundation for seismic load. To illustrate the various seismic parameters governing the seismic forces on the building, analytical study is carried out using the modernized structural engineering software package ETABS for various structural systems and the similarities and differences are presented for all four codes of practices. The presented approach enables engineers to understand the codal provisions given in IS 1893 (Part 1):2002, UBC 1997, NZS 1170.5 – 2004 and BS EN 1998-1-2004 in relative to another and the influence of zone factor on the effect of seismic forces are discussed when the same building to be located in different regions.

(Bhusal & Paudel, 2021)Comparative study of existing and revised codal provisions adopted in

Nepal for analysis and design of Reinforced concrete structure., A study is performed in evaluation of a G+6 Building located in Kathmandu, Nepal with Nepalese.

A study of fundamental period of vibration, inter story drift, base shear etc., is performed for the studied prototype building using linear static and dynamic approaches. The important conclusion as obtained can be enumerated as below: ¬ All of the response parameters were observed to be predicted greater from the revised NBC 105:2019 as compared to other studied codal provisions. The major reason behind this is the adoption of the latest seismic catalogue in estimation of the hazard. ¬ Although the response parameters were observed maximum in NBC 105:2019 the longitudinal rebar percent in column was observed to be almost similar for NBC 105:2019 and IS 1893:2016 followed by IS 1893:2002 with least that of NBC 105:1994. The reason might be due to load combination. ¬ The period of vibration predicted by the revised code is higher than the existing ones since the reduced stiffness (considering crack section) is adopted in both revised IS 1893:2016 and NBC 105:2019.

(Wagh, 2018)The title of this project is Codal Comparison of Seismic Analysis of a High-rise Str. This paper depicts the study carried out on comparison of International standards for seismic behavior of a high-rise structure when designed and analyzed by three International Seismic Codes namely, Indian, European & New Zealand Codes. From the graphical representation depicting the base shear values obtained; it is noticed that the base shear is lowest as per the Indian Code when compared to the Euro and New Zealand Codes, Design Base Shear calculated according to Euro Code 8 is higher than IS - 1893 by up to 79% whereas Design Base Shear calculated according to the New Zealand standards NZS 1170.5 is higher than IS 1893 by up to 44%. This is on account of the high value of Response Reduction Factor specified by the Indian Code. Due to higher design base shear values, the story displacements at top and story drifts for Euro Code are lowest as compared to the Indian Code and New Zealand Code.

(Rajeev & Meena, 2019)Comparative Study of Seismic Design and Performance of OMRF Building Using Indian, British, and European Codes. The present study compared the performance of six buildings designed using three codal provisions namely, Indian, British, and European. Six four-storied typical ordinary moment resistant frame buildings were designed with, and without, earthquake loading conditions. The following conclusions can be drawn.

• For the WoEQ loading condition, the amount of steel required to comply with the Indian code is 40.6% and 35.1% more than the British, and Euro code, respectively. Further, for buildings designed with WiEQ, the amount for steel required to comply with the Indian code is 66.5% and 43.5% more than the British code, and European code, respectively. This may be due to various safety factors applied on materials, ductility provisions, and the minimum criteria of reinforcement in the various codes.

• The pushover analysis results show that buildings designed in accordance with the Indian code perform significantly better in a seismic environment compared with the British and European codes. In the case of WoEQ loading, there is an increase in the load capacity of 95% and 279%, and for WiEQ loading, the corresponding increases are about 17% and 23.42% over the British code, and Euro code, respectively. Further, for WoEQ loading case, the Indian code gives a 19% and 26% increase in displacement capacity compared to the British code, and Euro code, respectively. Whereas, for WiEQ loading, the increase is about 11.68% w.r.t the Euro code and is almost comparable w.r.t the British code.

• It is also observed that for a large displacement capacity without strength and stiffness degradation, the Indian code provides a 19% and 26% increase in displacement capacity compared to the British code, and Euro code, respectively for WoEQ loading.

• The study also concludes that, for the same level of hazard at different places on earth, one should have a uniform design and detailing provisions.

(Maiti & Gautam, 2021)Effect of Lintel Beam on Seismic Response of Reinforced Concrete Buildings with Semi-Interlocked and Unreinforced Brick Masonry Infills. The primary focus of this study is to evaluate the nonlinear response of reinforced concrete (RC) frames with two types of brick infills viz., unreinforced brick masonry infill (URM) and semi interlocked brick masonry infill (SIM) together with lintel beams, subjected to seismic load., this study assesses the variation in the seismic performance for several analysis scenarios. The average base shear value was 1.41 times greater in the case of the full RC-SIM infilled frame with lintel beam when compared to the full RC-URM infilled frame with lintel beam. The average response reduction factor was 1.31 times greater in the full RC-SIM infilled frame with lintel beam when compared to the full RC-URM infilled frame with lintel beam because the SIM panels have the potential to dissipate more amount of energy due to the shear sliding mechanism in the brick units.

(Askouni & Papagiannopoulos, 2021)The title of this article is “Seismic Behavior of a Class of Mixed Reinforced Concrete-Steel Buildings Subjected to Near-Fault Motions”: This paper investigates the seismic behavior of a class of mixed reinforced concrete-steel buildings. The author concluded the results of this as follows, 1. Near-fault seismic motions induce, as expected, large maximum IDRs and PFA amplifications, which in turn lead to large RIDR. 2. The maximum values of IDR and RIDR take place at the r/c part of the mixed building, whereas maximum PFA almost always occurs at the steel part. 3. The large RIDRs are always accompanied by the formation of plastic hinges at the ends of the lower r/c stories, thus rendering the capacity design performed to the r/c part of the mixed building defective. 4. The steel columns of the mixed building almost always exhibit elastic behavior and, thus, the capacity design performed to the steel part of the mixed building is in all likelihood effective. 5. The type of support condition of the steel structure to the r/c one does not seem to heavily influence the maximum IDR, RDIR and PFA values induced to the mixed building

(Science, n.d.)Comparative Study of Seismic Analysis of Vertically Irregular R.C. Frame using INDIAN and EURO Code. In this study, the dynamic analysis for structural parameters which govern the durability, stability, and safety of the building for various International Standard Codes. The following conclusions may be derived based on the results of the dynamic study of structure. 1. Because of the high values of response reduction factors defined by EURO code, the computed design base shear according to Euro code 8 is up to 67 percent greater than IS 1893, and the values for story shear along the X-direction and Y-direction are practically identical. 2. Because of higher base shear design, the story displacement at top is high for Euro code-based design and the displacements are varying on higher side as height of structure is increases. 3. The calculated story drift according to Euro code 8 is up to 65 percent higher than IS 1893 due to increased design base shear. 4. The structure analyzed for IS 1893:2016 has shown better values for the structural parameters considered, when compared to the Euro code 8. Hence Indian Code is better in terms of structural parameters and structural safety.

(Bohara et al., 2021)Seismic Analysis of Retrofitting of RC Regular Frame with V-Braced Frame. Four-story regular RC buildings with and without V shape steel braced frames are analyzed by using the RSM and pushover analysis to understand the seismic behaviors of the buildings. The results of the analysis show that the thickness of steel bracings significantly affect the RC frames. • This study shows that the bracings improve the seismic behaviors of the structures effectively, which implies that adding the steel bracings in the RC frame improves the strength and stiffness of the structures. • Base shear contribution in different building with base shear and FTP indicates that increasing the thickness of the steel bracing in low-rise buildings increases the base shear, shear resisting strength and stiffness of the buildings. • Among all the building stories considered, retrofitting of the 4-storey RC building by using the V shape steel bracings, is found to be most effective in reducing the maximum story displacement, FTP, and drift. • For the thickness of bracings ranging from 2.5 to 6mm, columns show the main line of defense while for the thickness of bracings more than 6mm, the steel bracing becomes the main line of defense. Provided that the size of bracings is kept constant. • From pushover analysis it can be concluded that for expected failure mechanism (strong columns, weak beams and weaker bracings), the columns should resist at least 50% lateral base shear capacity.

3. CONCLUSION

Based on this review paper the results which are related to our topic can be summarized as follows.

- building which will design as per IS1893;2016 will show more base shear in comparison with ASCE/SEI7-10 American standard.
- the Indian standard will show less story drift it means the displacement of a building which is designed by Indian code will be minimum.
- According to high base shear the demand of steel for building which will be designed as per IS1893(2016) will be more than ASCE/SEI7-10.

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