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A REVIEW ON COMPARATIVE PERFORMANCE OF SEISMIC DESIGN OF TALL STRUCTURE USING IS AND EURO CODES

Vatsal patel[1], Palak Trivedi[2], Anuj Chandiwala[3]

[1]*Post Graduation Student, Department of Civil Engineering, CGPIT, Uka Tarsadia University, Bardoli, Gujarat, India.*
[2]*Assistant Professor, Department of Civil Engineering, CGPIT, Uka Tarsadia University, Bardoli, Gujarat, India.*
[3]*Assistant Professor, Department of Civil Engineering, CGPIT, Uka Tarsadia University, Bardoli, Gujarat, India.*

Abstract—In Reinforced building, frames are major parts since it opposes Shear force, bending moment, torsion and furthermore subjected to variety of loads in which seismic loads are dominating. Developing nations like India we need to adopt some standards. The BIS recommended IS 456:2000 and IS 1893(Part-1)2002 likewise European standard recommended EC2 and EC8 for Design of concrete structures and Design of earthquake resi stant structures respectively. The study focuses on the comparison of certain critical points: recurrence periods; seismic zonation & ground motion parameter values; shape of the response spectrum; soil amplification; seismic force-resisting system; story drift limits; procedures for seismic analysis. The response spectrum and seismic parameters of IS 1893 (part-1)2002 & EC8 were considered for the horizontal load action with different load combinations. Response spectrum analysis and equivalent lateral force analysis were performed using "ETABS 2016" software package. Different seismic codes determines distinctive parameters so that clearly, it's performance differs as per different codes. Hence, it is important to do comparison in order to assess which building performs better. However, EC8 provisions were considered to be safer.

Keywords— Shear force, Bending moment, Torsion, IS 457-2000, IS 1893(Part-1), Euro code 2, Euro code 8, Response spectrum, Story drift.

I. INTRODUCTION

In India the standard for RC buildings were presented in 1953, which was additionally revised and executed with the course of time. For Earthquake load, Indian Bureau Standard has recommended the criteria for earthquake resist design of structures in 1983. This paper incorporated the IS 456:2000: Code of Practice for Plain and Reinforced Concrete and IS 1983(Part-1):2002: Criteria for Earthquake Resistant Design of Structures. In the present situation there is a requirement for convergence of design philosophies to bring out structures with uniform danger of collapse and least level of harm or damage and need to look at the expected seismic performance of building designed on various codes. Indian codes are adequate for design but there are different parameters in some global norms which are not adopted in Indian code, so to improve our design there is requirement for selection for the best practice of design. The developing nations like India it is desirable to adopt the standard like Euro standard.

The European Committee for Standardization (CEN, French: Comité European de Normalization) is guidelines board. The main commitment of CEN is to provide an efficient and reliable structures for development of nation, to maintain a standard set of specifications. The current CEN Members are:

- All member states of the European Union: Germany, Poland, United Kingdom, France, Italy etc.
- 3 of EFTA members: Iceland, Norway, Switzerland
- Other states: Macedonia, Turkey, Serbia.

An ordinary reinforced concrete building ("Model building") has been selected for the comparative analysis of the codes. This building has been modelled using ETABS2016. Each model is subjected to the seismic input according to the IS & EURO codes and obtained results were compared.

II. LITERATURE REVIEW

A) ANALYSIS AND COMPARISON OF TALL BUILDING USING INDIAN AND EURO CODE OF STANDARDS

Anupkumar S Karadi, B S Suresh Chandra: The research work was performed using ETABS 2016 software, the analysis is done under static and dynamic loads on structure using Indian and Euro code of standards for a 30-storey building. The site conditions are as follows: Soil profile: Medium Soil, Location-Bengaluru, Seismic Zone-II, Zone factor-0.1, Wind Speed-33 m/s.

Despite the design principles and standards contained in both codes IS and Euro standards codes are same, but they vary in configuration, design criteria, detailing and also different seismic factors that governs the design strengths on the structure. The investigation focuses on the factors which contributes to the poor performance of structure during earthquake. The current research is to compare the performance of 3D strengthened structure under both static and dynamic strategies. Modelling and research are done in ETABS. The structure is analysed under static and dynamic load cases. Different seismic codes specify different parameters so than clearly, it's performance also varies. Thus, it is important to do a relative report in order to conclude which building performs better. Results are organized by tables and relating graphs are plotted.

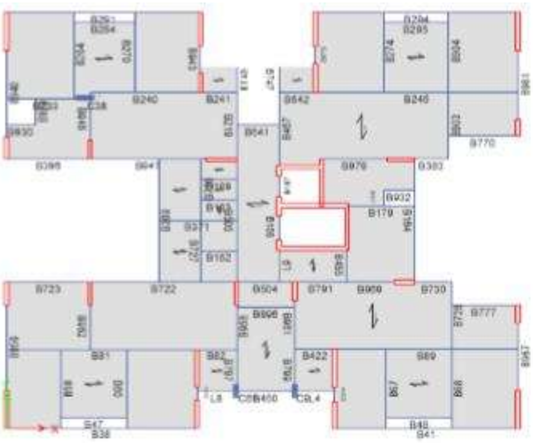

Figure 1: Typical plan layout of building model

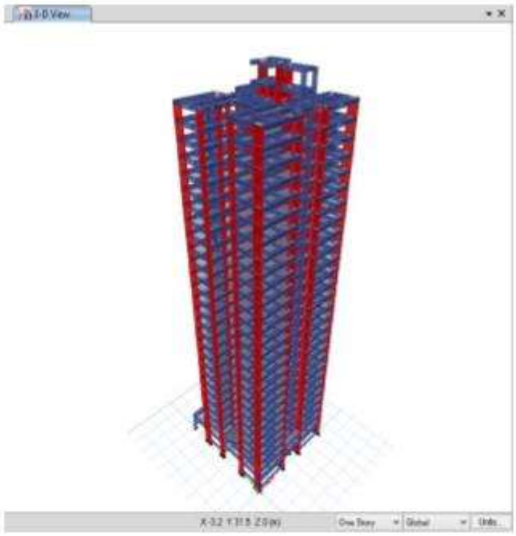

Figure 2: 3-D view of building model

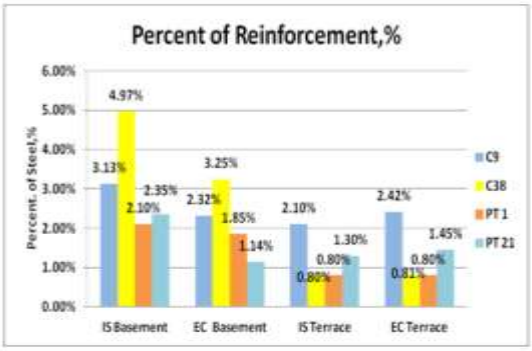

Figure 3: Longitudinal reinforcement for selected columns Due to dynamic loading

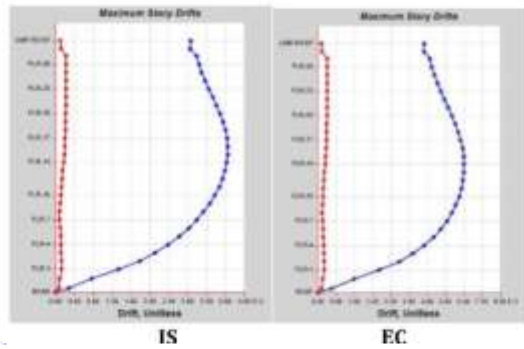

Figure 4: Story displacement due to EQ load

B) COMPARATIVE STUDY OF SET OF CODES FOR THE SEISMIC DESIGN OF BUILDING

S.H. Santos, C. Giarlelis: The elastic response spectrum of EC8, as well as in elastic spectra of all the other analysed standards, the accelerations (S_e) are given as a function of structural time periods (T). The spectra vary proportionally to the peak ground acceleration (a_g), soil co-efficient S, related to the soil amplification and parameter η, correction factor for damping values different from 5%.

The region between reference periods T_B and T_C is controlled by acceleration (constant acceleration); the region between periods T_C and T_D is controlled by velocity (accelerations varying with the inverse of T); the region superior to T_D is governed by displacement (acceleration varying with inverse of T2). The region between ZPA (zero period acceleration) and TB is transition region between peak ground acceleration and the maximum spectral acceleration. For EC8, the values of S, T_B, T_C and T_D are defined as a function of the type of subsoil in two spectral types defined in the code; type 1 or 2, related respectively higher and lower seismicity regions.

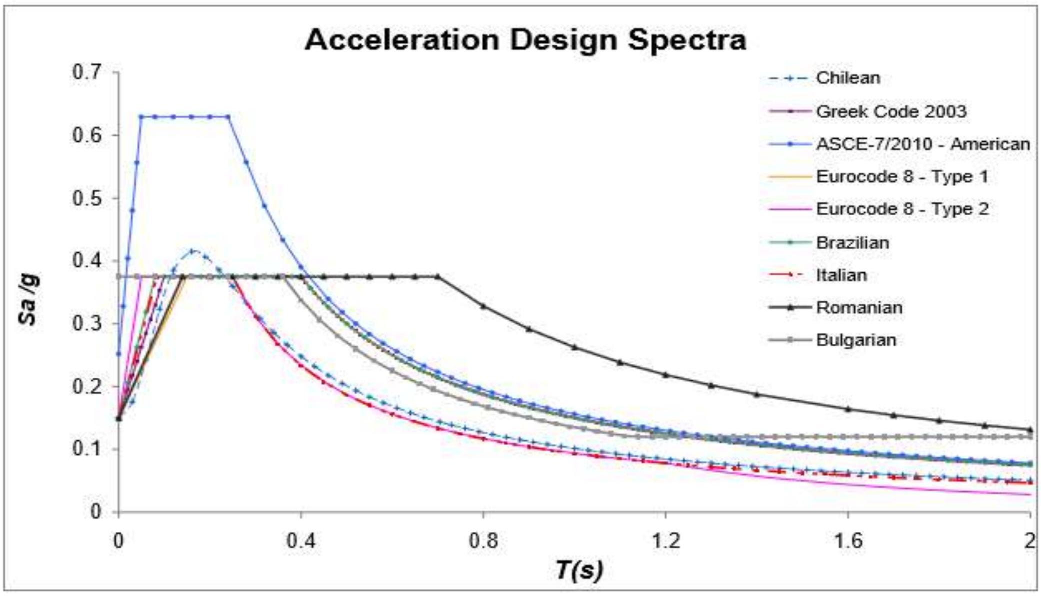

Figure 5: Elastic response spectra for the analysed building according to the standards.

C) A COMPARATIVE STUDY OF DESIGN BASE SHEAR FOR RC BUILDINGS IN SELECTED SEISMIC DESIGN CODES

Vijay Namdev Khose, Dominik H. Lang: This article presents a comparative study of selected major national codes by studying the independent and compounded effects of different code provisions governing the design base shear. The issues examined in the study include seismic hazard, site classification, design response spectrum, design period of vibration, ductility classes, and response reduction factors. Further, it is noted that different codes employ different load factors and different material factors (or strength reduction factors) for the design of members, and hence the actually provided strength in different codes may not follow the same pattern as the design base shear. A realistic estimation of the over strength (difference between actually provided strength to the design base shear) is a complex task, as it is difficult to objectively account for the interactive effect of all design parameters, and the effect of designers' subjective decisions and local construction practices. In the present study, the design base shear has been normalized for the effect of varying load and material factors in different codes. The normalized design base shear provides a more objective basis for the comparison of design capacity. The scope of the present study is limited to RC frame buildings. The codes considered in the present study include the American code (ASCE7-052006), Eurocode8(EN1998-12004) and New Zealand Standard (NZS 1170.5 2004) along with their complimentary RC design codes, as these are currently the most advanced and widely applied codes. As most South Asian countries refer to the Indian codes, IS 1893 - Part 1 (2002) has also been included in the study.

Table 1: Site classes of different codes equivalent to ASCE 7 site classes

ASCE 7 Site Class	Equivalent site class in other codes		
	Eurocode 8	NZS 1170.5	IS 1893
A	–	A	I
B	A	B	I
C	B	B	I
D	C	C, D	I, II
E	D	E	III

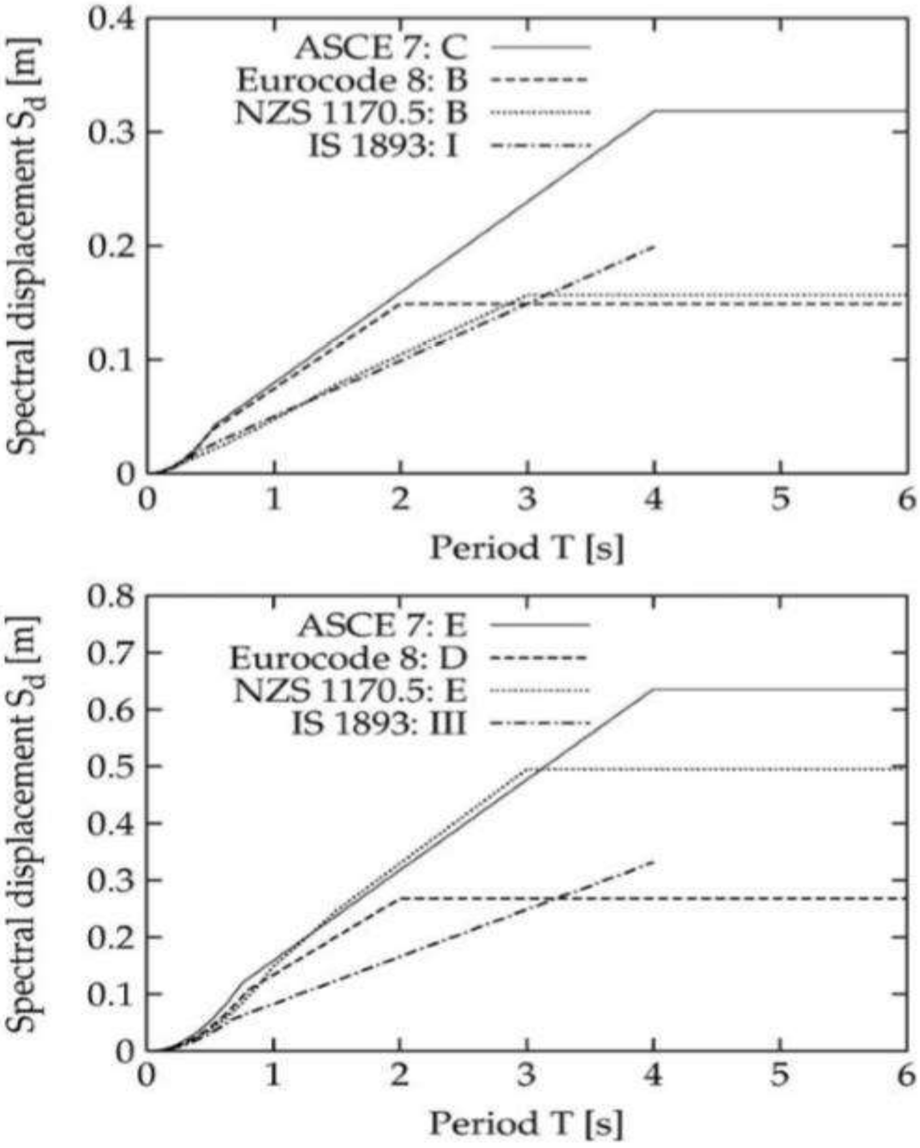

Figure 6: Comparison of displacement spectra of various seismic design codes for ASCE 7 site classes C (top) and E (bottom) for a PGA value of 0.2 g.

D) COMPARATIVE STUDY OF HIGH RISE BUILDING USING INDIAN AND EURO STANDARDS UNDER SEISMIC FORCES.

P.P. Tapkire, Saeed J. Birajdar: The seismic storey forces are determined on the basis of a base shear. It is the total design lateral force acting at the bottom of a structure. The base shear is assumed to be depending on all or several of the following factors:

According to IS1893 (part-1):2002
Fundamental natural period:
1. with infill: Ta = 0.09*h / sqrt (d)
2. without infill: Ta = 0.075*h0.075for RC frame building.

According to BS EN 1998-1: 2004
Fundamental natural period:
T1= 0.075 h 0.75 - for RC frame
T1= 0.085 h 0.75 - for steel frame
T1= 0.050 h 0.75 - for all other structure

Zone Factor: Zone factors are precise on the basis of expected intensity of the earthquake in different zones. In IS Code, it is given based on the Maximum Considered Earthquake (MCE) and service life of the structure in a zone. IS

Code considering 4 zones ranging from low to very severe seismic intensity, where the factor varying from 0.10 to 0.36 respectively Similarly BS EN 1998-1-2004 considers peak ground acceleration from 0.02 to 0.18

Table 2: Seismic zone factor

IS 1893 (Part 1):2002		**BS EN 1998-1-2004**
SEISMIC ZONE	Z	Design Ground Acceleration (ag)
III	0.16	BS EN 1998-1-2004 considers peak ground acceleration from 0.02 to 0.18
IV	0.24	
V	0.36	

Importance Factor: Importance factor are introduced to account for the varying degrees of importance for various Structures. It is a factor used to obtain the design seismic force depending on the functional use of the structure, characterized by hazardous consequences of its failure, its post-earthquake functional need, historic value or economic importance. For residential apartments, importance factor of 1 is considered in IS, and Euro code considers the return period factor (R=1) which describes the importance level 2 for the residential building. It is found that, all codes of practices consider the same factor for residential building.

Horizontal elastic response spectra

Elastic design spectra for dissimilar seismicity conditions and subsoil classes can be created (Figure1). Parameter ag describes the design ground acceleration, S is the soil factor, and η represents the damping correction factor. The choice between corner periods T_B and T_C constitutes the branch of constant spectral acceleration, whereas periods T_C and T_D are the limits of the constant spectral velocity branch. In addition, constant spectral displacement starts at control period T_D.

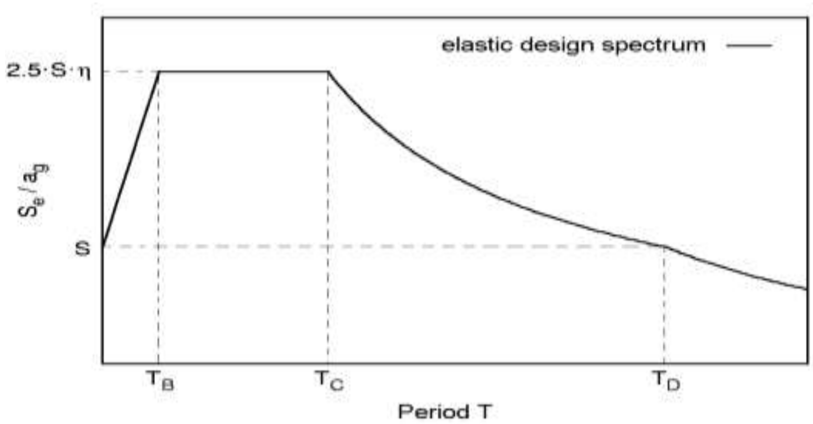

Figure 7: Description of elastic design spectrum as Proposed by EC8.

Table 3: Constraint of elastic design spectra for different subsoil classes for EC8

Subsoil	Vs,30 [m/s]	Soil factor S		Period TB		Period TC		Period TD	
		Type1	Type 2	Type 1	Type 2	Type 1	Type 2	Type 1	Type 2
A	> 800	1.0	1.0	0.15	0.05	0.4	0.25	2.0	1.2
B	360-800	1.2	1.35	0.15	0.05	0.5	0.25	2.0	1.2
C	180-360	1.15	1.5	0.20	0.10	0.6	0.25	2.0	1.2
D	< 180	1.35	1.8	0.20	0.10	0.8	0.30	2.0	1.2
E	-	1.4	1.6	0.15	0.05	0.5	0.25	2.0	1.2

Table 4: Ductility

Class	Class IS 1893	Ductility category EC8
Low dissipative structures	OMRF	DCL
Medium dissipative structures	SMRF	DCM
High dissipative structures		DCH

III. CONCLUSION

1. Design base shear calculated according to EC 8 is higher than IS 1893 by up to 60% on account of high values of response reduction factors specified by IS code
2. Storey displacement is decreased by 22.5% for static loads
3. Bending moment, Shear force, Axial forces and Base design are reduced in Euro code-based design values by 8-13%
4. Due to higher design base shear, the storey displacement at top and storey drifts are high for Euro code- based design, but these parameters are within the safe confinements specified by the codes.
5. Percentage of steel for column as per Euro standards is relatively lower. It's because of higher values of modulus of elasticity of concrete specified by Euro code2 due to this the ductility of columns are enhanced by the concrete and axial force is less comparing to IS values because of low partial factor of safety for the dead loads.
6. The minimum and maximum percentage of reinforcement for columns as per IS is 0.8% and 6% respectively, whereas per EC 2 is 0.2 % and 4%. So, this also makes impact while giving minimum reinforcement.
7. A comparative study of different provisions of ASCE 7, Eurocode 8, NZS 1170.5 and IS 1893 controlling the design base shear in RC buildings has been performed. All the codes follow a common force-based design methodology using an elastic analysis and a response reduction factor to account for inelastic energy dissipation. However, there are a number of differences in the codes regarding: (i) the definition of reference hazard, (ii) the anchorage of spectral shapes using single intensity measure (PGA) or multiple spectral ordinates, (iii) site classification, (iv) site amplification coefficients, (v) response reduction factors, (vi) minimum design base shear, and (vii) over strength.

IV. REFERENCES

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