Comparative Study of High Rise Building using INDIAN Standards and EURO Standards under Seismic Forces

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Abstract: ***This research article is intended to compare the design of High rise structure with different International codes. Two different famous structural building codes have been adopted. Those are the Indian Standards and European Standards. In R.C. buildings, frames are considered as main structural elements, which resist shear, moment and torsion effectively. These frames be subjected to variety of loads, where lateral loads are always predominant. Infrastructures of Gulf countries are always notable as they mainly follow EURO standards for construction development. In view of the demand of such code of practice across the developing countries like India, an attempt is made to compare EURO standards with Indian standards under Seismic Forces.***

Keywords: Seismic analysis, INDIAN standards, EURO standards, Ductility class**,** Response reduction factor

1. Introduction

During the last two decades, metropolitan cities have attempted to develop vertically to meet the building requirements of large influxes of population into urban areas. Having faced the problems of urban population explosion, lack of land, high land prices and unwieldy slump of cities and towns, attempts have been made in our major cities to provide more built-up space vertically for both working and living.

In R.C. buildings, frames are considered as main structural elements, which resist shear, moment and torsion efficiently. These frames are subjected to variety of loads, where lateral loads are always predominant. Earthquake all over the world have affected the seismic resistant design in different countries. In this present study the main factors constitute the seismic load have been studied for various structural system are compared using IS1893 (part1):2002 and BS 1998-1-2004.

2. Literature Review

Following are some highlights about the research work carried in this reports.

Khan, F. R et al. [1] Researcher proposed that the performance of any structure depends upon following criteria lateral sway criteria, Thermal movements and Structural and architectural interaction. The main and primary concern is the stability and reliability of the entire structure and structural components, as well as their ability to carry applied loads and forces. Tall and lean buildings are more susceptible to lateral sway and deflections. The minimum limit to structural sizes suggested by various codes and standards are usually enough to support the weight of the building as well as the imposed dead loads and live loads. However, the real challenge for the structural engineer is to find out the structural behaviour of a building under wind and seismic actions. The effects of these external horizontal forces are highly unpredictable, and these mainly depend on building shape, size, mass, floor plan layout, and climatic conditions.

M.Anitha & B.Q.Rahman et al.[2] Researchers done the comparison of design of slab using different IS code with other country code and researchers conclude that ACI 318, NZS 3101& Euro codes are most effective in designing of flat slabs. **Mendis ,P & Ngo,T et al.[3]** Researchers proposed that this demand is always auxiliary to a multitude of variables, such as strength, durability, forming techniques, material characteristics, nature, aesthetics and much more. However, the design intent has always been to accomplish structures deemed to be affordable and safe during their life span. Any structure, to be reliable and durable, must be designed to withstand gravity, wind, earthquakes, equipment and snow loads, to be able to resist high or low temperatures.

Dr.K. Subramanian&M.Velayuthamet et al.[4] This paper presents a study on influence of zone factors and the various international codal provisions for various lateral load resisting systems. Special moment resisting frames, shear wall systems and dual systems are taken in the present study. Ductile systems are taken in the study, where inelastic analysis procedures effectively account for several sources of force reduction. In the present study, the main factors which contribute for the seismic load have been studied and dynamic analysis results for various structural systems with various zone factors are compared using various international standards. To illustrate the various seismic parameters governing the seismic forces on the building, analytical study is carried out using ETABS for the various structural systems and the similarities and differences are presented for various international standards. The dynamic analysis results such as modal participating mass ratios, response spectrum base reaction, storey shears, storey displacements and storey drifts are discussed in detail. The influence of zone factor and the codal provisions are discussed when the same building is to be located in different regions and remedial measures if any for their strengthening.

Pravin Ashok Shirule, Bharti V. Mahajan et al.[5] In this project a parametric study on Reinforced Concrete structural walls and moment resisting frames building representative of structural types using response spectrum method is carried out. Here, the design spectra recommended by Indian Standard Code IS 1893-2002 (part I) and two other codes (Uniform Building Code, Euro Code 8) are considered for comparison. The objective of this study is to investigate the differences caused by the use of different codes in the dynamic analysis of multi-storeyed RC building. To evaluate the seismic response of the buildings, elastic analysis was performed by using response spectrum method using the computer program SAP2000. It is observed from the comparative study that the base shear using IS code is higher in all the three buildings, when compared to that of with other codes which leads to overestimate of overturning moments in the building and hence heavier structural members. To experimentally verify the applicability of the proposed semi active control system to torsionally coupled responses of an asymmetric building, use of computer software was conducted using in a G+13 storey building model with asymmetric column distribution.

3. Methodology

Buildings with regular or nominally irregular plan configuration may be modeled as a system of masses lumped on floor levels with each mass having one degree of freedom that of lateral displacement in the direction under concern. Undamped free vibration analysis of entire building modeled as spring - mass model shall be performed using suitable masses and elastic stiffness of the structural system to obtain natural periods (T) and mode shapes {φ} of those of its modes of vibration that desires to be considered.. Different codes of practices include the effect of seismic risk, spectral content, structural behavior and soil foundation for seismic load. 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:

a) Time period
b) Seismic activity of the region
c) Importance of the structure
d) Soil profile
e) Weight of the structure
f) Response reduction factor
g) Ductility class

Time Period

The majority seismic codes require that structures be designed to resist specified static lateral forces correlated to the structure and the seismicity of the region. Based on an estimate of the Fundamental natural period of the structure, formulas are specified for the base shear. Empirical formulae used to calculate the time period of the structure recommended by all codes of practices.

According to IS1893 (part-1):2002

Fundamental natural period:
1. with infill: $T_a = 0.09*h / \text{sqrt}(d)$
2. without infill: $T_a = 0.075*h^{0.075}$ for 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 considers 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 1: 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.

Spectral Content

Design acceleration spectrum refers to a graph of maximum acceleration as a function of natural frequency or natural period of vibration in single degree of freedom system for a specified damping ratio, to be used in design of structure. Also it is depends upon the soil profile. The value of damping for the structure is taken as 2% and 5% of the critical for the dynamic analysis of steel and reinforced concrete buildings respectively. The standard spectrum is developed for 5% damping in all code of practices. BS EN 1998-1-2004 provides type 1 and type 2 spectra in which type 1 is used for the surface wave magnitude greater than 5.5 and latter is used for magnitude less than 5.5. All the analyzed standards classify the ground conditions according to the shear wave propagation velocities (vs.) and/or to the number of blows in the Standard Penetration Test (NSPT). For non-homogeneous sites, the criteria for averaging these parameters in the more Superficial subsoil layers (typically in the first 30m) are proposed in the standards. The soil classes, varying from very stiff to soft deposits, are in Euro code 8 classes A to E,

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 TB and TC constitutes the branch of constant spectral acceleration, whereas periods TC and TD are the limits of the constant spectral velocity branch. In addition, constant spectral displacement starts at control period TD.

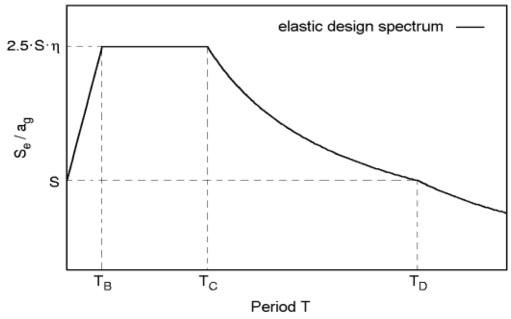

Figure 1: Description of elastic design spectrum as Proposed by EC8.

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

Subsoil	Vs,30 [m/s]	Soil factor S		Period TB [s]		Period TC [s]		Period TD [s]	
		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

Ductility class:

EUROCODE 8 (EN 1998-1) classifies the building ductility as Low (DCL), Medium (DCM) and High (DCH).

IS 1893 (Part 1): 2002 classifies RC frame buildings as Ordinary Moment Resisting Frames (OMRF) and Special Moment Resisting Frames (SMRF).

Table 2: Ductility Class

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

Seismic Weight

The Seismic weight of each floor is its full dead load plus proper portion of live load is considered during the seismic mass participation in IS code, while Euro code considers full dead load plus 25% of imposed load during seismic mass participation.

Response Reduction Factor

The response reduction factor assign to different types of structural system imitate design and construction experience as well as the evaluation of performance of structure in main and moderate earthquakes. It endeavours to explanation for the energy absorption capacity of the structural system be damping and inelastic action through some load reversals. All current national seismic design codes link on the issue of design methodology. The response reduction factor, as considered in the design codes, depends on the ductility and over strength of the structure. Building codes define different ductility classes and specify corresponding response reduction factors based on the structural material, configuration and detailing. According to Indian code, Response reduction factor for OMRF and SMRF is 3 and 5 respectively and According to EC 8 it is 1.5, 3.9 and 5.85 for DCL, DCM and DCH respectively.

Base Shear Calculation

Method of calculation of base shear of the structure is explained below for IS 1893 (Part 1): 2002, and BS EN 1998 -1: 2004.

IS 1893 (part 1): 2002

a) VB = αh *W

As per Clause 7.5.3 of IS 1893 (Part 1):2002

b) αh = (Z/2* I/R* Sa/g)

As per Clause 6.4.2 of IS 1893 (Part 1):2002

c) For different type of soil, Sa/g value is calculate As per Clause 6.4.5 of IS 1893 (Part 1):2002

d) Fundamental natural period:

1. with infill:

Ta = 0.09*h / sqrt (d)

As per Clause 7.6.2 of IS 1893 (Part 1):2002

2. without infill:

Ta = $0.075*h^{0.075}$ for RC frame building

As per Clause 7.6.1 of IS 1893 (Part 1):2002

e) The design base shear VB from the dynamic analysis shall be compared with base shear.

VB calculated using a fundamental period Ta, as given by empirical formula of clause 7.6 of IS 1893 (Part 1):2002. Where VB is less than VB, all the response quantities shall be multiplied by VB / VB.

BS EN 1998-1: 2004

Fb=Sd(T1)mλ

As per Clause 4.3.3.2.2 (1) of BS EN 1998

Where Design Spectrum Sd(T1)shall be defined from the following expression

$0 \leq T \leq TB$ Sd(T1) = ag. S $[\frac{2}{3} + \frac{T}{TB}(\frac{2.5}{q} - \frac{2}{3})]$

As per Clause 3.2.2.5 of BS EN 1998

$TB \leq T \leq TC$: Sd(T1) = ag .S.$[\frac{2.5}{q}]$ As per Clause 3.2.2.5 of BS EN 1998

$TC \leq T \leq TD$: Sd(T1) = ag. S. $\frac{2.5}{q}$ $[\frac{Tc}{T}]$βag As per Clause 3.2.2.5 of BS EN 1998

$TD \leq T$: Sd(T1) = ag. S. $\frac{2.5}{q}$. $[\frac{Tc \cdot TD}{T}]$βag As per Clause 3.2.2.5 of BS EN 1998

Fundamental natural period:

T1 = 0.075 $h^{0.75}$ - for RC frame

As per Clause 4.3.3.2.2 (3) of BS EN 1998

T1 = 0.085 $h^{0.75}$ - for steel frame

T1 = 0.050 $h^{0.75}$ - for all other structure

4. Conclusion

Considering facts mentioned in literature review RCC buildings are compared by using both Standards under gravity loading as well as seismic loading. It can be practical from the results and graphs that variation in values of different parameters is dependent on the load combinations of both the code. This paper conclude that the design base shear as per IS 1893 is lower as compared to EUROCODE 8 because of higher value of RESPONSE REDUCTION FACTOR.

The comparison of several analyzed seismic standards indicates a general agreement regarding the desired main characteristics of seismic resistant structure such as simplicity symmetry, uniformity, and redundancy**.**

References

1) Dr. V.L.Shah & Late Dr. S.R.Karve, “Illustrated design of Reinforced concrete Buildings”
2) Dr. V.L.Shah & Late Dr. S.R.Karve, “Limit State Theory And Design Of Reinforced Concrete”, Structures Publication
3) EURO CODE 2: Design Of Concrete Structures
4) EURO CODE 8: Design Of Structures For Earthquake Resistance
5) IS 456:2000: Code Of Practice For Plain And Reinforced Concrete
6) IS 1893 (Part-1):2002: Criteria For Earthquake Resistant Design Of Structures
7) P.Bisch,E.Carvalho, “Eurocode8:Seismic Design Of Building Worked Examples”,Lisbon,10-11 Feb.2011
8) Richard Fenwick,David Lau,Barry Davidson, “A Comparison Of The Seismic Design Requirement In The New Zealand Loadings Standards With Other Major Design Codes”

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