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Comparative study of typical R.C. building using INDIAN STANDARDS and EURO STANDARDS under seismic forces

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Abstract- In R.C. buildings, frames are considered as main structural elements, which resist shear, moment and torsion effectively. These frames are subjected to variety of loads, where lateral loads are always predominant. Infrastructures of Gulf countries are always remarkable as they mostly follow EURO standards for construction development. In view of the demand of such codes across the developing countries like India, an attempt is made to compare EURO standards with Indian standards using structural software.

Index Terms- R.C. buildings, INDIAN standards, EURO standards, lateral forces, structural software.

I. Introduction

Reinforced concrete, as a composite material, has occupied a special place in the modern construction of different types of structures due to its several advantages. Due to its flexibility in form and superiority in performance, it has replaced, to a large extent, the earlier materials like stone, timber etc. Moreover, its role in structural forms like multistoried frames, bridges, foundations etc. is enormous. With the rapid growth of urban population in both the developing as well as the developed countries, reinforced concrete has become a material of choice for residential construction.

There are mainly two types of structures;

1) Post and beam structure: Here, beam simply rests on top of column.

2) Rigid frame structure: In this type of structure beam and column are rigidly joined. A rigid frame structure is a structure made up of linear elements, typically beams and columns that are connected to one another at their ends with joints that do not allow any relative rotations to occur between the ends of the attached members, although the joints themselves may rotate as a unit. In India, for reinforced concrete structures, Indian standard was introduced in the year 1953, which was further revised and implemented with the course of time. For lateral load, Indian Bureau Standard has introduced criteria for earthquake resistant design of structures in 1993, which is under the stage of revision.

This paper adopts the Recent Indian Standards which are as follows:

1) **IS 456:2000: Code of Practice for Plain and Reinforced Concrete**
2) **IS 1893 (Part-1):2002: Criteria for Earthquake Resistant Design of Structures**

Although Indian Standards are sufficient for construction of buildings in India, there are some International standards which contains some parameters that are not included in IS codes. Infrastructures of Gulf countries are always remarkable. And it is observed that they mostly follow EURO standards for variety of structures. So such codes are very much important in developing Countries like India. This paper adopts the Recent European Standards which are as follows:

1) **EURO CODE 2 (EC 2): Design Of Concrete Structures**
2) **EURO CODE 8 (EC 8)**: **Design Of Structures For Earthquake Resistance**

This paper extends the comparison further and presents a comparative study of the expected performance of a multistoried building under lateral loading using INDIAN AND EURO STANDARDS by means of computer tools. Following discussions are made on some of the parameters which have a due importance in seismic force.

II. RESPONSE REDUCTION FACTOR

All modern national seismic design codes converge on the issue of design methodology. These are based on a prescriptive Force-Based Design approach, where the design is performed using a linear elastic analysis, and inelastic energy dissipation is considered indirectly, through a response reduction factor (or behavior factor). Behavior factor, along with other interrelated provisions, governs the seismic design forces and hence the seismic performance of code-designed buildings. 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. Response reduction factor for OMRF and SMRF is 3 and 5 respectively according to IS 1893.According to EC 8 it is 1.5, 3.9 and 5.85 for DCL, DCM and DCH respectively. So if it is compared SMRF with DCM according to Table 1 response reduction factor for EUROCODE is higher than that provided in IS CODE.

III. DUCTILITY CLASSES

EUROCODE 8 (EN 1998-1) classifies the building ductility as Low (DCL), Medium (DCM) and High (DCH).IS 1893 classifies RC frame buildings as Ordinary Moment Resisting Frames (OMRF) and Special Moment Resisting Frames (SMRF).

Table 1. Ductility classes according to various categories of building

Category	Ductility class	
	IS 1893	EC 8
Low dissipative structures	OMRF	DCL
Medium dissipative structures	SMRF	DCM
High dissipative structures	-	DCH

IV. DRIFT

Drift governs the design and expected seismic performance of a building. In various codes procedure to estimate drift is varying considerably. Drift differ according to effective stiffness of R.C members. Further, as discussed earlier, the drift may govern the design in many cases, resulting in further discrepancies in the actually provided strength. Therefore, in this study, the seismic performance of a building designed for both (i.e. EC 8 and IS 1893) seismic design codes have been compared.

V. MODELLING

For comparison, a residential building of G+7 story is taken under reference. Importance factor is taken as 1 which is same specified in both codes. To have a similar hazardous level, soil condition is taken as medium soil according to IS CODE provisions which is equivalent to soil type B(PGA=0.35g) according to ASCE. (In EUROCODE soil classification is describe based on ASCE code.)So, type B soil in ASCE is equivalent to medium soil condition in India. Here, building type is medium dissipative structure. According to Table 1 ductility class is SMRF for IS 1893 and DCM for EC 8.The story height is 3 m for all floors. Modeling of structure, analysis and design is done on ETABS software.

VI. ANALYSIS OF RESULT

The seismic load according to the relevant codes has been estimated and the building is designed for combined effect of gravity and seismic forces, considering all the design load combinations specified in each code. Poisson's ratio may be taken equal to 0 for cracked concrete as per EC 2(3.1.3.4).

VII. DRIFT:

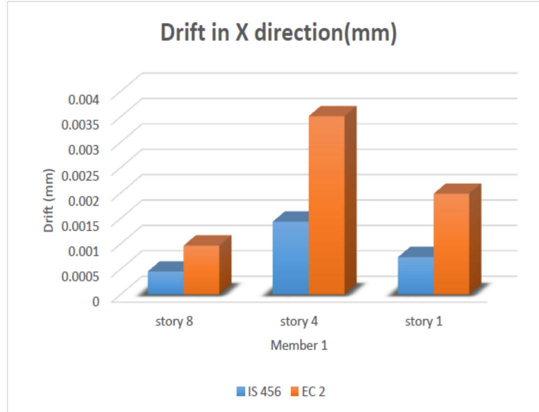

Fig.1 Graphical comparison of drift in X direction

As mentioned earlier, all the codes considered for the study specify drift limits on the total (inelastic) displacement, except for the Indian code, which specifies drift limit on the elastic displacement. Fig.1 depicts drift in x direction by adopting both codes for worst load combination.

VIII. REACTION:

Estimation of reaction generated due to dead load and worst load combination at the base of the building is shown below by means of graphical representation.

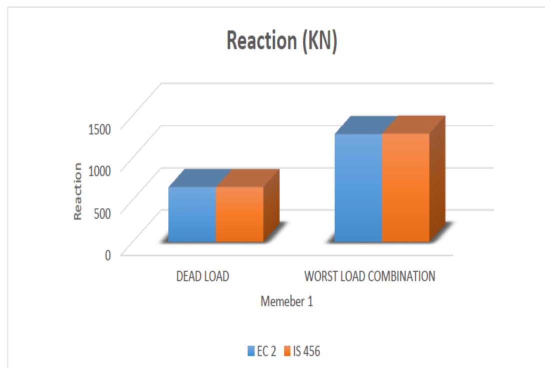

Fig.2 Graphical comparison of reaction value using dl and worst load combination

VII. AXIAL LOAD

Axial load is increasing if we move from 7th story to base level. Axial load is estimated by adopting both codes at various story levels.

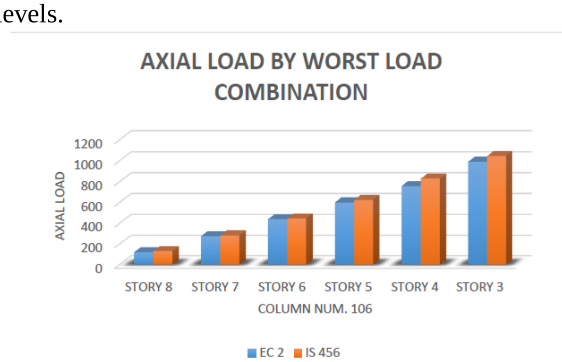

Fig. 3 Graphical comparison of axial load at various story levels

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VIII. MAXIMUM STORY DISPLACEMENT

There are differences among both codes in case of inter story drift also, but the differences are not as drastic.

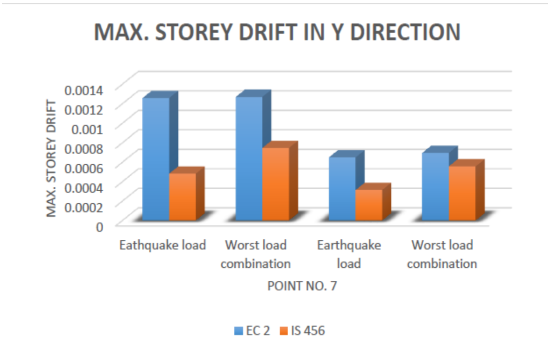

Fig.4 Graphical comparison of maximum story displacement in Y direction

IX. IME PERIOD

By the comparison of results, time period is comparable resulted by both codes. There are 12 modes among full height of building.

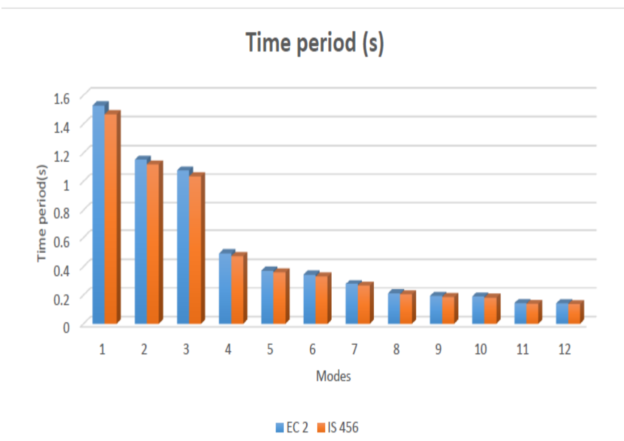

Fig.5 Graphical comparison of time period(s) at various modes

X. . REINFORCEMENT DETAIL OF PARTICULAR COLUMN

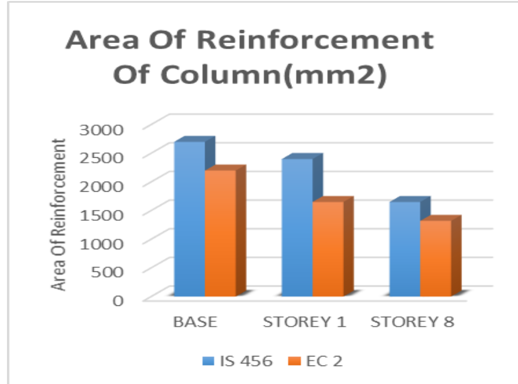

Fig.6 Graphical comparison of area of reinforcement at various story levels

XI. BASE SHEAR

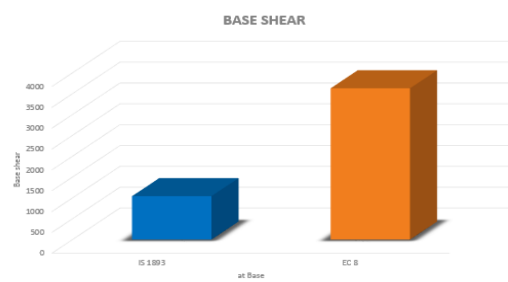

Fig.7 Graphical comparison of base shear

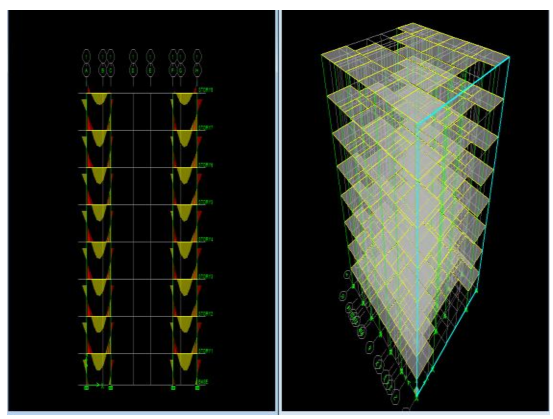

Fig.8 Graphical representation of bending moment diagram of 3rd floor

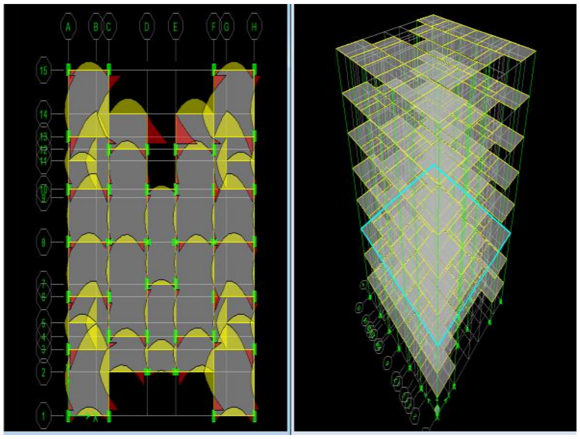

Fig.9 Graphical representation of bending moment diagram of particular column

XII. CONCLUDING REMARKS:

All the above parameters are compared by using both Standards under gravity loading as well as seismic loading. It can be observed 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 allowable story drift as per EURO CODE 8 is 1.5%.while as per IS 1893 is 0.4%.Due to this maximum story drift as per EURO CODE 8 is higher than IS 1893.The area of reinforcement required in column is lower in EC 2 than IS 456. This is because the modulus of elasticity is higher in EC 2. Also the maximum percentage of steel required, suggested by IS 456 in the column is 6% while that suggested by EC 2 is 4%.Therefore, the ductility of column in EC 2 is controlled by modulus of elasticity while that in IS 456 is controlled by area of reinforcement. Variation of the modulus of elasticity with time can be estimated by:

$$E_{cm}(t) = (f_{cm}(t) / f_{cm})^{0.3} E_{cm}$$

where $E_{cm}(t)$ and $f_{cm}(t)$ are the values at an age of t days and E_{cm} and f_{cm} are the values determined at an age of 28 days. Where E_{cm} denotes secant modulus of elasticity of concrete and f_{cm} denotes mean value of concrete cylinder compressive strength.

REFERENCES

[1] Danial l. Schodek & Martin Bechthold, "Structures", Phi publication

[2] Dr. V.L.Shah & Late Dr. S.R.Karve, "Illustrated design of Reinforced concrete Buildings"

[3] Dr. V.L.Shah & Late Dr. S.R.Karve, "Limit State Theory And Design Of Reinforced Concrete", Structures Publication

[4] Duggal S.K., "Earthquake Resistant Design Of Structures", Oxford University

[5] EURO CODE 2: Design Of Concrete Structures

[6] EURO CODE 8: Design Of Structures For Earthquake Resistance

[7] Falak Parikh And Vimlesh Agarawal, "Shear Strength And Column Depth For RC Beam Column Joint Comparison Of Draft Code With Euro Code", International Journal Of Civil And Structural Engineering Research,Vol.2,No.3,August-2013

[8] IS 456:2000: Code Of Practice For Plain And Reinforced Concrete

[9] IS 1893 (Part-1):2002: Criteria For Earthquake Resistant Design Of Structures

[10] Maria A. Parisi, M.ASCE, "The Eurocode For Earthquake-Resistant Design: An Outline"

[11] P.Bisch,E.Carvalho, "Eurocode 8:Seismic Design Of Building Worked Examples",Lisbon,10-11 Feb.2011

[12] Richard Fenwick,David Lau,Barry Davidson, "A Comparison Of The Seismic Design Requirement In The New Zealand Loadings Standards With Other Major Design Codes"

[13] Yogendra Singh & Vijay Namdev Khose; Dominik H. Lang, "A Comparative Study Of Code Provisions For Ductile RC Frame Buildings", 15 WCEE, 2012

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