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

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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 multistorey 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: IS 456:2000: Code of Practice for Plain and Reinforced Concrete and IS 1893 (Part-1):2002: Criteria for Earthquake Resistant Design of Structures. In the era of globalization, there is a need for convergence of design methodologies to result in buildings with uniform risk of suffering a certain level of damage or collapse. A first step in this direction is to compare the expected seismic performance of buildings designed using the provisions of different codes. Indian Standards are sufficient for construction of buildings in India, but there are some International standards which contains parameters that are not included in IS codes. In modern construction, 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: EURO CODE 2 (EC 2): Design of Concrete Structures and EURO CODE 8 (EC 8): Design of Structures for Earthquake Resistance. This paper presents a comparative study of the expected performance of a multi-storeyed 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. CONSIDERED DESIGN PARAMETERS

A. 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.

B. 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).

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

Table I: Ductility classes according to various categories of building.

C. 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.

III. 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 most reliable designing software ETABS for Earthquake loading and Gravity loading.

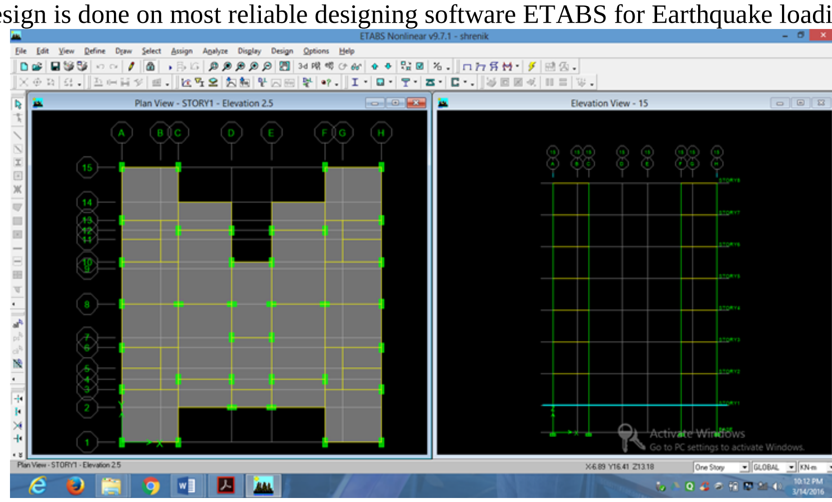

Fig. 1: Floor plan of under consideration residential building created in ETABS Software

IV. RESULT ANALYSIS

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).In this paper, results obtained under gravity loading and lateral loading in ETABS 2013 software.

A. Result Obtained Under Gravity Loading

1) Axial Load

Value of axial load is increasing from top story to the base level. Axial load is estimated by adopting both codes at various story levels.

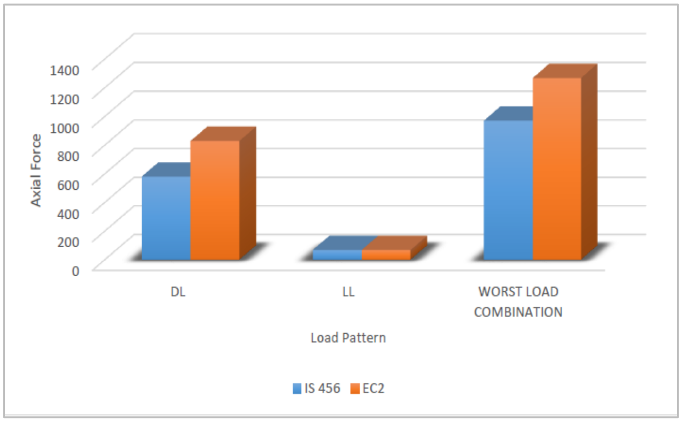

Fig. 2: Graphical comparison of axial load

2) Reaction

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

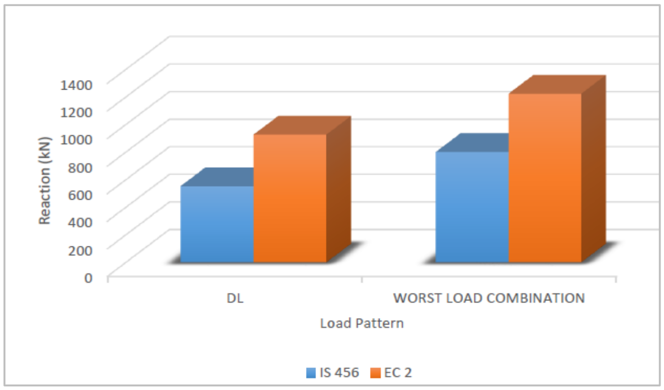

Fig. 3: Graphical comparison of reaction value using dl and worst load combination

3) Area of Reinforcement

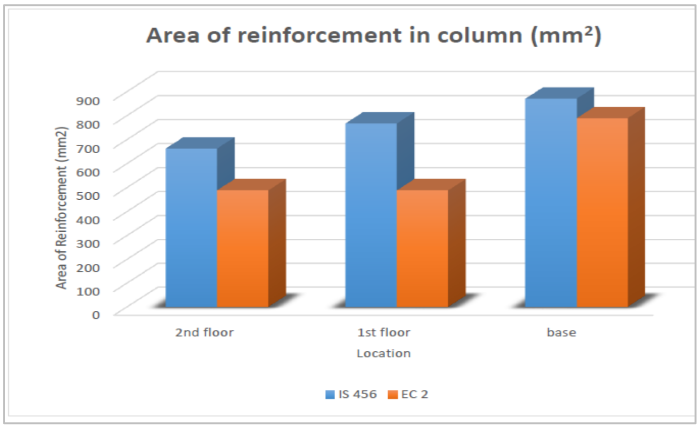

Fig. 4: Graphical comparison of area of reinforcement required at various levels of building

B. Result Obtained Under Lateral Loading

1) Axial Load

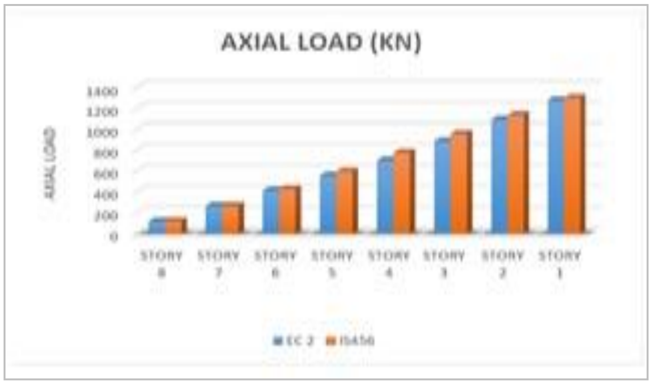

Fig. 5: Graphical comparison of axial load calculation of under consideration column

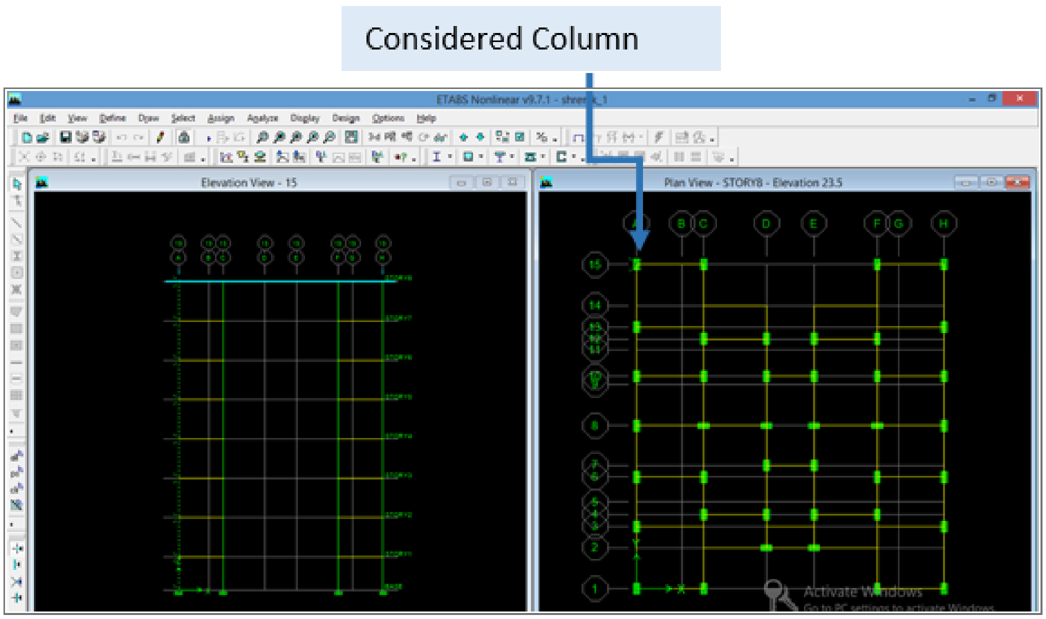

Fig. 6: location of considered column

SHEAR FORCE: Comparison of shear force value at differ story level as shown in figure number 7.

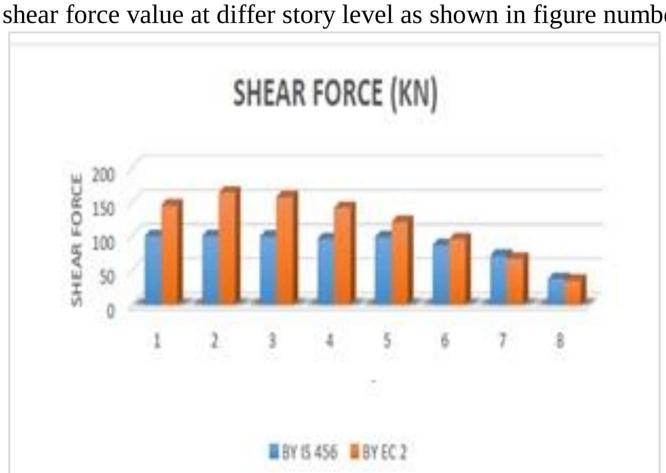

Fig. 7: Graphical comparison of shear force calculation of considered beam

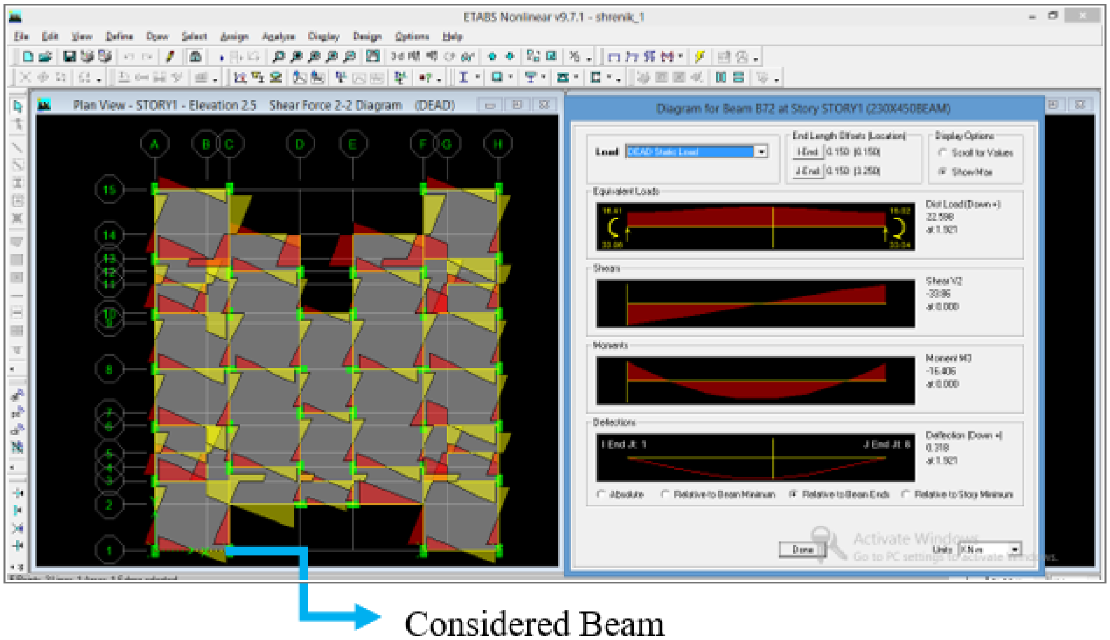

Fig. 8: Shear force diagram of Considered Beam

2) *Bending Moment Diagram*

Comparison of shear force value at differ story level as shown in figure number 9.

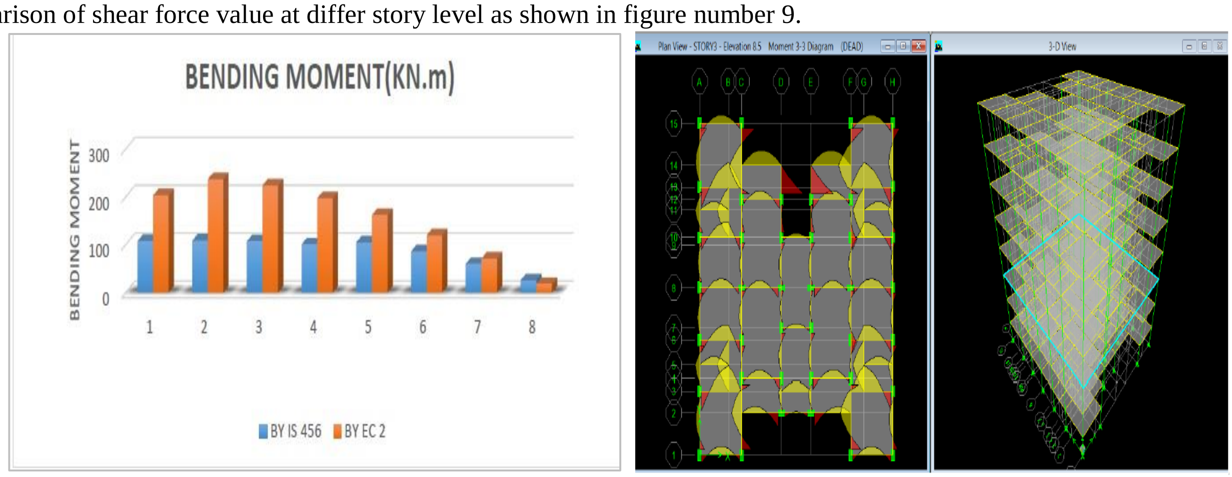

Fig. 9: Bending Moment diagram of considered beam

3) *Reaction*

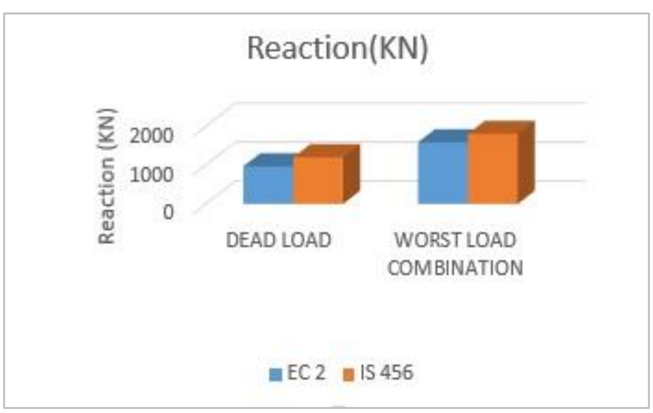

Fig. 10: Graphical comparison of Reaction calculation of considered member at base level

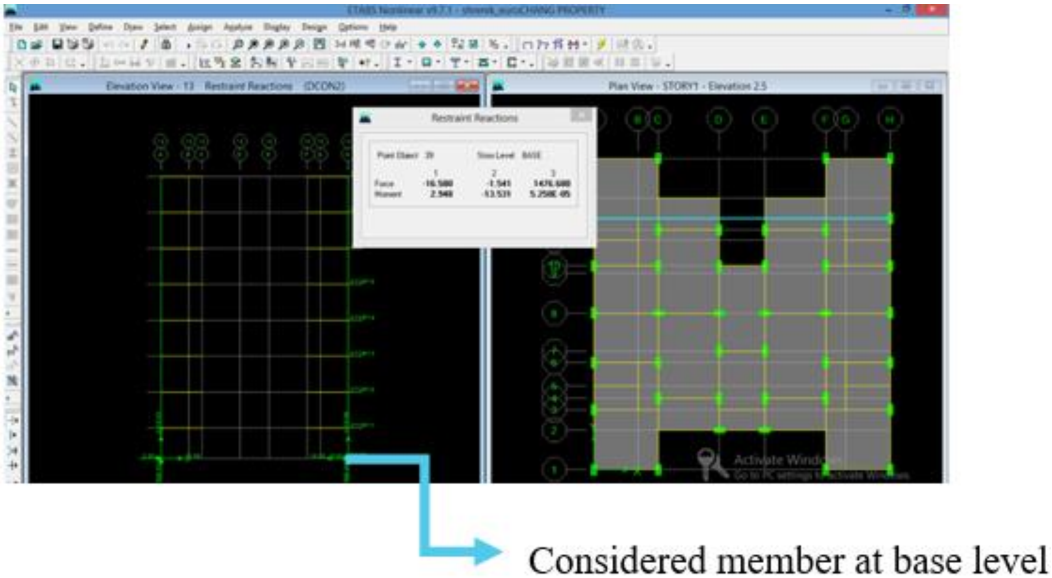

Fig. 11: Representing the location of considered member at base level

C. Area of Reinforcement in Beam

Fig. 12: Graphical comparison of area of reinforcement required for considered beam

D. Area of Reinforcement in Column

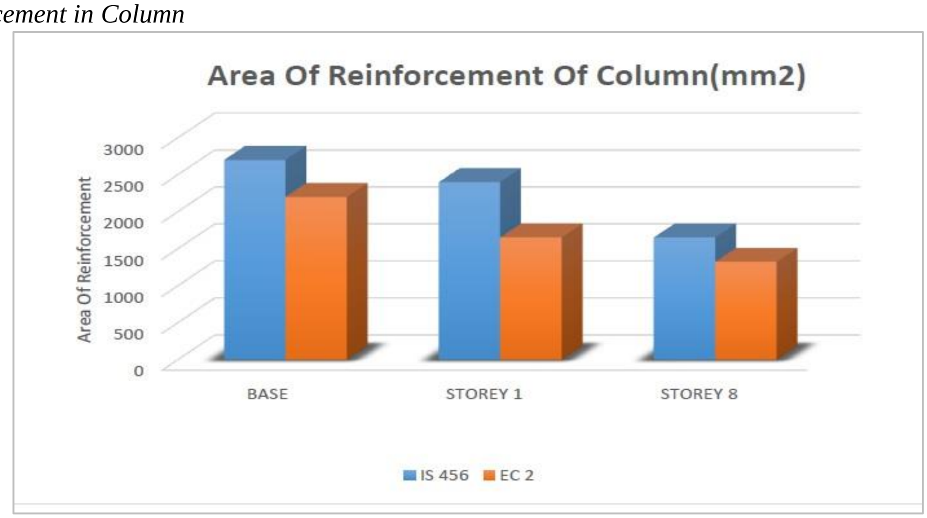

Fig. 13: Graphical comparison of area of reinforcement required for considered Column

E. Time Period

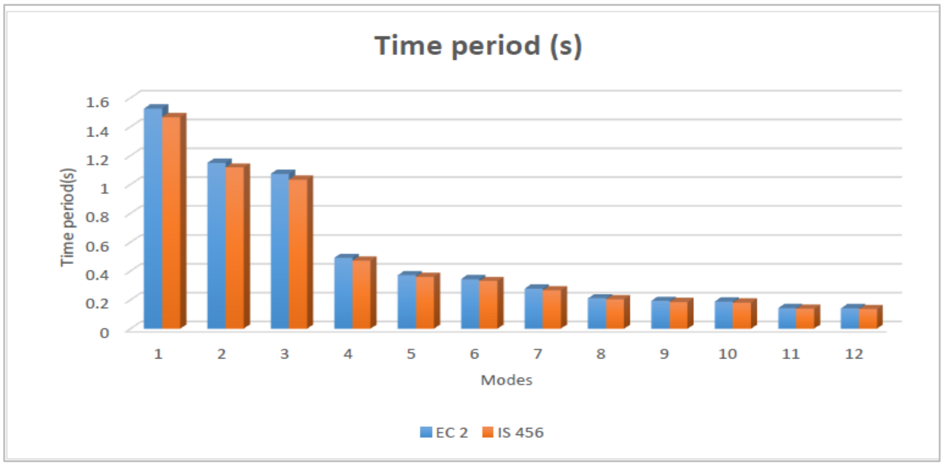

Fig. 14: Graphical comparison of Time period calculation of different mode

V. CONCLUSION

All the above parameters are compared by using both Indian Standards and Euro Standards under gravity loading as well as earthquake loading. It can be observed from the results and graphs that variation in values of different Parameters are dependent on the load combinations of both the codes. The following can be noted from the results and graphs of G+7 building under gravity loading (Dead Load, Live load and Worst Load Combination):

- The value of displacement of a particular node is higher in EC 2 than IS 456 in
- Vertical direction.
- The value of axial force in a particular column is higher in EC 2 than IS 456.
- Therefore, the value of reaction is also higher in EC 2.

The following can be noted from the results and graphs of G+7 building subjected to

A. Earthquake Loading

- The value of axial load obtained is a bit higher in IS 456.Therefore, the value of reaction obtained is almost the same by both the codes.
- After comparing the time period of 12 modes, it is observed that the time period obtained in EC 2 is higher than that obtained in IS 456.
- The area of reinforcement required in column is higher 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 is 6% while that suggested by EC 2 is 4%. So, the ductility of column in EC 2 is controlled by modulus of elasticity while that in IS 456 is controlled by area of reinforcement. So, the ductility is also increased in EC 2.

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