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RESEARCH ARTICLE OPEN ACCESS

Seismic Analysis and Comparison of a Multistorey Building Using Indian Codes and European Codes with ETABS Software

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ABSTRACT
Reinforced structures are usually designed and constructed as framed structures in order to stand the loads such as shear force, bending moment, torsion, etc. among various loads acting on the framed structures seismic loads are dominating since it occurs occasionally very severe or destructive. For countries like India where earthquakes are frequent seismic designing of reinforced structures is unavoidable and some standards are to be followed. This paper deals with analysis and design of multistoried (G+9) building with IS code and EURO code by using ETABS 2019 software considering zone II and medium soil condition. 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 resistant structures respectively.

Keywords – Bending moment, Reinforced structures, Seismic force, Shear force and Torsion.

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I. INTRODUCTION

The seismic waves that reach the earth's surface cause an earthquake. Earthquake causes different shaking intensities at different locations and the damage included in buildings at these locations is also different. It is essential to estimate and specify these lateral forces on the structure in order to design the structure to resist an earthquake. Structures are designed to resist these sudden forces and should have enough stiffness and strength to control displacement at supports. Structural designed are prepared considering the standards published by the regions or country. For India, BIS recommended IS 456:2000 and IS 1893(Part-1)2002 likewise for European Countries European standard recommended EC2 and EC8 for Design of concrete structures and Design of earthquake resistant structures are considered. Accordingly, ETABS software is used to analyze the structures where its features contain powerful graphical interface coupled with unmatched modelling, analytical, and design procedures, all integrated using a common database.

II. OBJECTIVE AND SCOPE OF THE PROJECT

The main purpose of this study is to bring out a detailed seismic analysis and structural design on simulation tool of ETABS 2019 using a rectangular plan of multistorey building. This study is focused to carry out the advantages of seismic design of multistorey building using Indian standard (IS) code and Euro code with ETABS software.

1.1. Importance of the Study

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.

1.2. Objectives of the Study

(i) To do the static and dynamic analysis on a 30 story building, using Indian and Euro code of standards.
(ii) To compare the design standards in view of strength of building.
(iii) To study the performance of building in view of two codes of standards and to measures which building performs better.

(iv) To give comparison with the parameters like: Displacement, Base shear, Story displacement, Story drift, Time period, Shear force, bending moments and Area of steel required.

III. METHODOLOGY

In this paper we consider two types of models for seismic analysis and designing using Indian standards and European standards for storey 1 to 10 in G+9 building as shown in figure.

This paper deals with analysis and design of multistorey (G+9) building with IS code and EURO code by using ETABS 2019 software considering zone II and medium soil condition. 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 resistant structures are considered for the analysis respectively.

1.3. Structural details of the model

Table 1: Structural Detailing

Plan dimension	25m x 25m
Seismic zone	II
Zone factor	0.10
Number of Storey	G+9
Floor height	3.5m
Materials	M30, HYSD500
Type of soil	Medium
Thickness of wall	230mm
Wall material	Masonry
Modeling type of wall	Shell thin
Codes	IS 456:2000 for Plain and reinforced concrete IS 1893 (Part 1):2002 for earthquake design EC2 for Design of concrete structures EC8 for Design of earthquake resistant structures

1.4. Factors Affecting the Lateral Seismic Forces

The total design lateral force acting at the base of the structure is depends on:

1.Time Period: The structure should be intended to oppose seismic forces acting up on structure. The fundamental natural period of structure is dependent on height, type of structural member, material property. The empirical formula as per codes are given below: Fundamental natural period:

i) According to IS 1893 (Part-I) 2002

- With Infill: $Ta = 0.09 * h/\sqrt{d}$
- Without Infill: Ta = 0.075*h ^0.75 for RC frame Buildings.

ii) According to BS EN 1998-1:2004

- Ta = 0.075*h ^0.75 for RC outline.
- Ta = 0.085*h ^0.75 for RC outline Buildings.
- Ta = 0.050*h ^0.75 for every single other structure.

2. Zone Factor: Zone factors are derived on the basis of intensity of earthquakes in various zones. IS code characterized in view service life of structure. IS code has 4 zones from low to very severe seismic intensity with factors 0.10, 0.16, 0.24 and 0.36 for zones II, III, IV and V respectively. Where as in case of Euro code factors are based on peak ground acceleration (ag) from 0.02 to 0.18.

3.Importance factor: Importance factor are introduced to represent level of significance for different structure. It relies upon the functional use and utilization of the structure in view of seismic constraints adopted. Also, it depends upon the utilization of structure, risk factor, notable historic significance, number of occupants resides etc. In this case as per codes the importance factor is taken as 1.2 for both Indian and Euro codes, since it's occupancy capacity of structure is high. i.e., 30 storey building.

4.Seismic Weight: In case of seismic design dead loads and partial proportions of live loads are considered along with the seismic forces are taken in to account for seismic design of structure.

The static design load combination for gravity loadings is given by IS 456:2000 and Eurocode2 are

$w = 1.5gk + 1.5qk$

$w = 1.35gk + 1.5qk$

Where: gk and qk are dead loads and imposed loads respectively. 1.5 and 1.35 are partial safety factors for loads for IS 456:2000 and Eurocode2 respectively.

5.Ductility Class: IS 1893:2002 (Part 1) specified the RC frame ductility as Ordinary Moment Resisting Frames (OMRF) and Special Moment Resisting Frames (SMRF) with factors 3 and 5 respectively. In case of Euro code 8 (EN 1998-1) specified the building ductility as Ductile Class Low (DCL), Ductile Class Medium (DCM) and Ductile Class High (DCH) with ductility factors 1.5, 3.9 and 5.85 respectively.

6. Response Reduction Factor: Response reduction factor is the factor which reduces the actual base shear that would be generated, if the building were remain elastic and responded to a design basis earthquake, to get a design lateral force. According to IS codes the response reduction factors are 3 and 5 for OMRF and SMRF respectively. According to EN 1998 response reduction factors are1.5, 3.9, and 5.85 for DCL, DCM and DCH classes respectively.

7. Base Shear Calculation: The procedure to compute the base shear of the structure according to IS 1893 (Part 1): 2002, and BS EN 1998-1: 2004 are as follows

IS 1893 (Part-1): 2002

a) VB = Ah *W According to Clause 7.5.3 of IS 1893 (Part 1):2002

b) Ah = (Z/2* I/R* Sa/g) According to Clause 6.4.2 of IS 1893 (Part 1):2002

c) For various kind of soil, Sa/g value is calculated according to Clause 6.4.5 of IS 1893 (Part1):2002

BS EN 1998-1: 2004

The seismic base shear force Fb, is given by:

Fb = Sd (T1) . m. λ

Where, T1 is time period, Sd is ordinate at T1, m is mass of building and λ is correction factor. According to Clause 4.3.3.2.2 (1) of BS EN 1998 where Design Spectrum Sd(T1) shall be characterized from the following cases:

$0 \leq T \leq TB$ Sd(T1) = ag. S [2/3+ T/TB (2.5/q - 2/3)] according to Clause 3.2.2.5 of BS EN 1998

$TB \leq T \leq TC$: Sd(T1) = ag .S(2.5/q) according to Clause 3.2.2.5 of BS EN 1998

$TC \leq T \leq TD$: Sd(T1) = ag. S (2.5/q) . (TC/T) >/b ag. According to Clause 3.2.2.5 of BS EN 1998

$TD \leq T$: Sd (T1) = ag. S.(2.5/q) (TC.TD)/(T^2)) . >/b ag. According to Clause 3.2.2.5 of BS EN 1998.

1.5. Modelling in ETABS

ETABS is a highly effective and reliable software developed by Computers and Structures Incorporation, USA, which is used for professional use in analyzing and developing the models and components. It is easy, simple to use and compare and time saving software tool.

1.5.1. Materials Used:

Concrete: M 25 Grade of concrete for Slabs, M 30 Grade of concrete for Beams, M 40 Grade of concrete for Columns and Shear walls

- Concrete density is taken as 25 KN/m3 as per IS 456:2000 clause 19.2.1 and 24 KN/m3 as per EN 1991-1-1:2002: Annex A: Table A-1.
- Poisson's ratio is taken as 0.2 as per both respective codes.
- Modulus of elasticity for IS model is computed as per IS 456:2000 clause 6.2.3.1 is: E = 5000√fck
- Modulus of elasticity for EC model is taken from EN 1992-1: 2004

Steel: Fe 500 HYSD bars for bending reinforcement, Fe 415 HYSD bars for shear reinforcement.

1.5.2. Plan view of the Structure

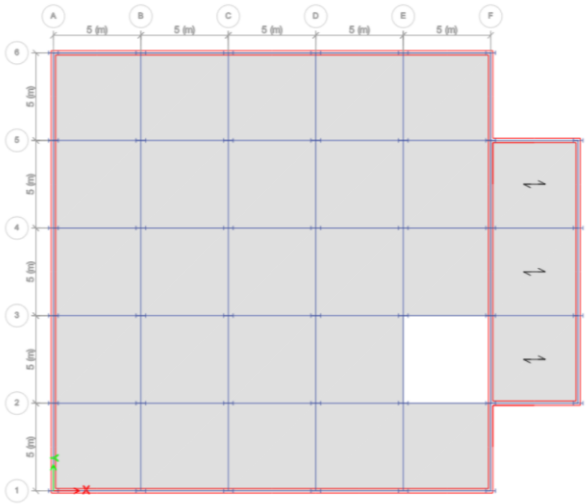

Figure 1 Plan view

1.5.3. 3D view of the Structure

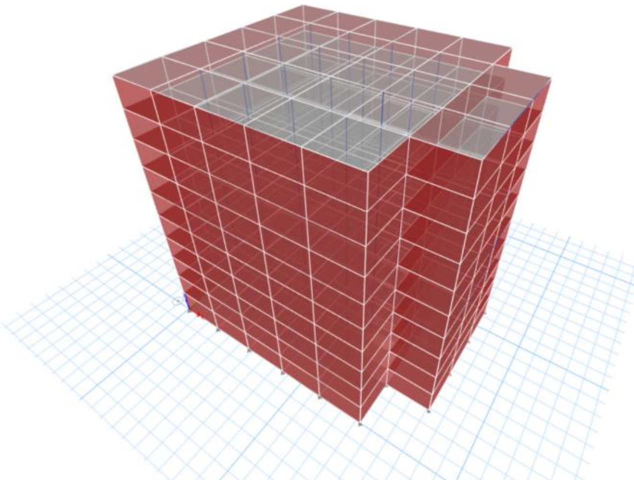

Figure 2 3D view

1.5.4. Defining Load Patterns and Cases

Dead load, Floor finish, Wall loads

- All these are defined under super dead and dead load cases.

Live Loads

- All imposed loads like uniformly or non-uniformly varying loads are defined under live load cases.

Earthquake Loads

- Earthquake loads are defined in both two horizontal directions X and Y from basement to top storey.

IV. RESULTS AND ANALYSIS

4.1 Static Analysis result:

Table 2: Bending Moment for selected beams

Bending Moment (KNm)	**2nd Floor**		**8th Floor**		**Terrace**	
Beam ID	**IS**	**EC**	**IS**	**EC**	**IS**	**EC**
B142(200X 850)M30	113.4	98.33	108.9	95.76	100.1	88.24
B347(200X 850)M30	219.5	196.9	220	199.9	158.3	144.8
B438(200X 650)M30	231.9	211	317	291.3	243.6	221.4

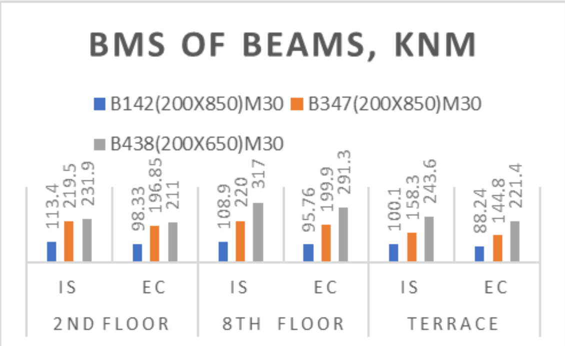

Figure 3 Bending Moment for selected beams

Table 3: Shear Force for selected beams

Shear Force(KN)	**2nd Floor**		**8th Floor**		**Terrace**	
Beam ID	**IS**	**EC**	**IS**	**EC**	**IS**	**EC**
B142(200X 850)M30	92.14	83.95	82.23	72.5	73	64.5
B347(200X 850)M30	106.91	95.83	107.4	96.76	82.36	74.5
B438(200X 650)M30	173.25	159.16	205.23	191.42	151.53	141

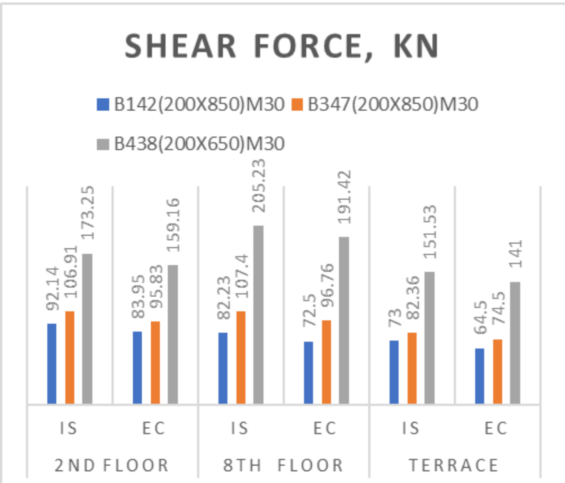

Figure 4 Shear Force for selected beams

Table 4: Axial Force for selected columns

Axial Force, KN	**Basement**		**Terrace**	
Column ID	**IS**	**EC**	**IS**	**EC**
C6-200X750M40	4678.22	4223.57	385.68	345.8
C36-300X900M40	8205.25	7278.88	197.36	172.13
PT1-200X2000M40	10854.56	9699.92	305.26	271.22
PT19-200X2000M40	12603.43	11256.43	377.85	336.35

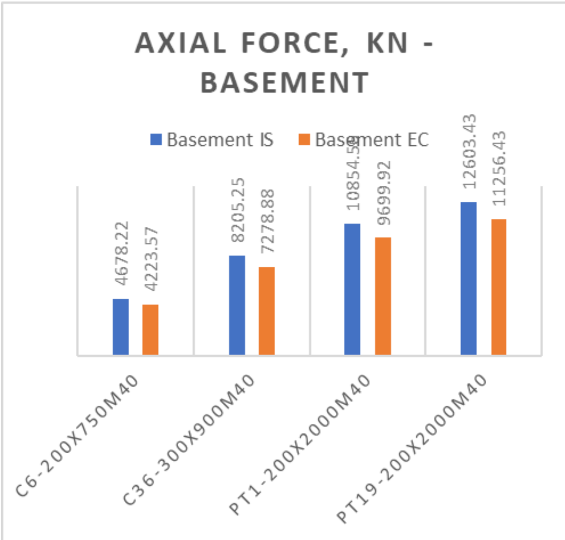

Figure 5 Axial Force for selected columns at Basement

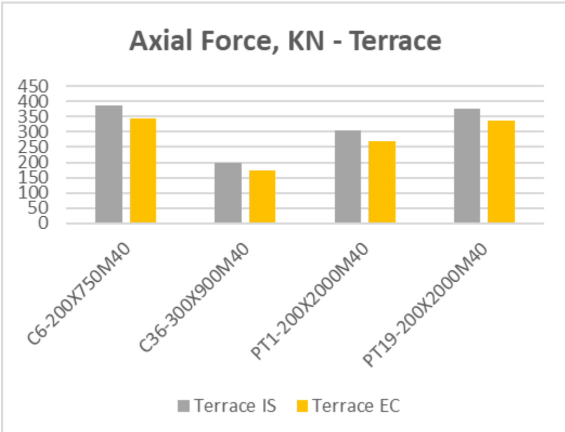

Figure 6 Axial Force for selected columns at Terrace

Table 5: Design reaction at basement for selected columns

Base Reactions, KN		
Column ID	IS	EC
C6	4678.22	4223.57
C36	8205.25	7278.88
PT1	10854.56	9699.92
PT19	12603.43	11256.43

1.6. Dynamic Analysis result:

Table 6: Base shear due to earthquake force

Static Base Shear, KN	Direction, X		Direction, Y	
	IS	EC	IS	EC
EQ X	2011.7	5013.4	0	0
EQ Y	0	0	2011.7	5013.4

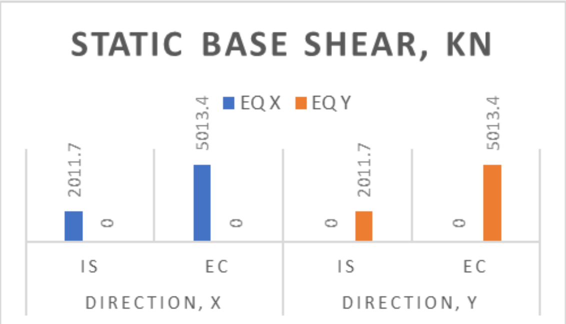

Figure 7 Base shear due to earthquake force

Table 7: Longitudinal reinforcement for selected columns due to Dynamic loading

Longitudinal Reinforcement, (%)	**Basement**		**Terrace**	
Column ID	**IS**	**EC**	**IS**	**EC**
C6	3.13%	2.32%	2.10%	2.42%
C36	4.97%	3.25%	0.80%	0.81%
PT1	2.10%	1.85%	0.80%	0.80%
PT19	2.35%	1.14%	1.30%	1.45%

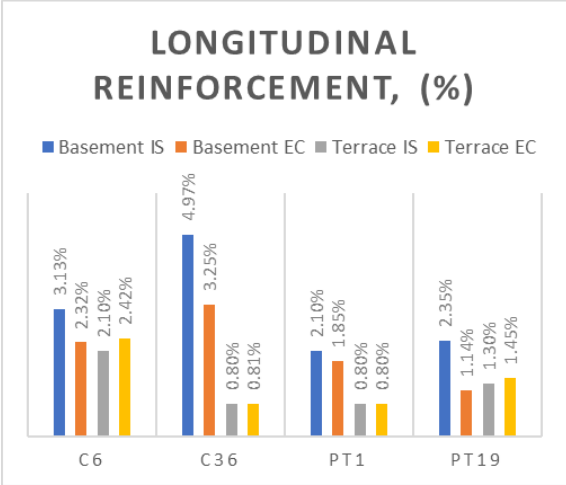

Figure 8 Longitudinal reinforcement for selected columns due to Dynamic loading

V. CONCLUSION

V.1. Static Analysis:

- Due to varied partial safety factors for dead and live loads and unit weight of concrete as indicated in both IS and EC codes, there are numerous variations in design parameters like Bending moment, Shear force, Axial force and Base design reactions.
- Bending moment, Shear force, Axial forces and Base design are reduced in Euro code-based design values by 8-13%
- Storey displacement is decreased by 22.5% for static loads.

V.2. Dynamic Analysis:

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.

- 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.
- 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.
- 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.

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