COMPARATIVE SESMIC ANALYSIS & DESIGN OF MULTISTOREYED BUILDING USING RCC, STEEL & COMPOSITE STRUCTURES BY ETABS

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ABSTRACT

Reinforced concrete and pure steel construction is extensively preferred over the whole world. Steel is generally used as reinforcing material in concrete and also as structural steel. Use of composite construction is of particular interest, due to its significant potential in improving the seismic performance of structure without much more changes in manufacturing and construction techniques. Composite construction has already been taken place all over the world for minor engineering construction. In this study an attempt is made to analyze, design and compare seismic performance of seven storey (G+5) RCC, Steel and Composite commercial building situated in seismic zone-V. Equivalent static method is preferred for seismic analysis and ETABS is used for modeling, analyzing and designing the structures. It is found that the depth of beams in composite structure is lesser than of RCC structure, which results in reduction of the sizes of columns in composite structure. It is also seen that the concrete and steel consumption in composite structure is less but as we are using hot rolled sections the structural steel consumption is increased.

. **KEYWORDS:** ETABS, Composite structure, Composite beam, Composite column, Composite slab, Shear connectors.

1. INTRODUCTION

1.1 General

The use of Steel in construction industry is very low in India compared to many developing countries. Experiences of other countries indicate that this is not due to the lack of economy of Steel as a construction material. There is a great potential for increasing the volume of Steel in construction, especially the current development needs in India exploring Steel as an alternative construction material and not using it where it is economical is a heavy loss for the country. Also, it is evident that now-a-days, the composite sections using Steel encased with Concrete are economic, cost and time effective solution in major civil structures such as bridges and high rise buildings. In the past, for the design of a building, the choice was normally between a concrete structure and a masonry structure. But the failure of many multi-storied and low-rise R.C.C. and masonry buildings due to earthquake have forced the structural engineers to look for the alternative method of construction.

The popularity of steel-concrete composite construction in cities can be owed to its advantage over the conventional reinforced concrete construction. Reinforced concretes frames are used in low rise buildings because loading is nominal. But in medium and high rise buildings, the conventional reinforced concrete construction cannot be adopted as there is increased dead load along with span restrictions, less stiffness and framework which is quite vulnerable to hazards. In construction industry in India use of steel is very less as compared to other developing nations like China, Brazil etc.

1.2 Composite Structures

When a steel component, like an I-section beam, is attached to a concrete component such that there is a transfer of forces and moments between them, such as a bridge or a floor slab, then a composite member is formed. In such a composite T-beam, as shown in Figure 1.1, the comparatively high strength of the concrete in compression complements the high strength of the steel in tension.

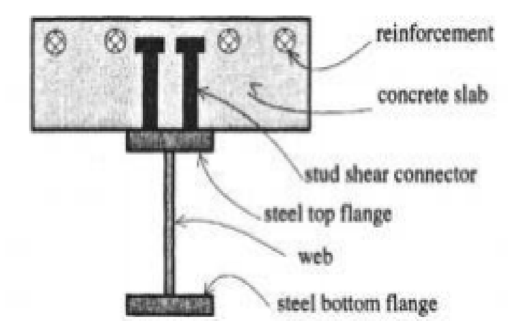


Fig.1.1 Cross Section of a typical composite member

1.3 Composite Steel-Concrete beam:-

A concrete beam is formed when a concrete slab which is casted in-situ conditions is placed over an I-section or steel beam. Under the influence of loading both these elements tend to behave in an independent way and there is a relative slippage between them.

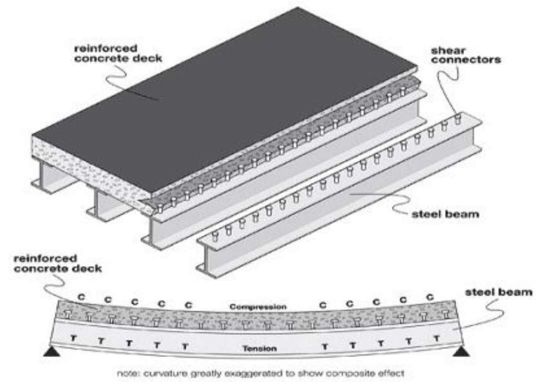


Fig.1.2 Composite beam

1.4 Steel-Concrete Composite Columns:-

A steel-concrete composite column is a compression member comprising of a concrete filled tubular section of hot-rolled steel or a concrete encased hot-rolled steel section. In a composite column, both the concrete and the steel interact together by friction and bond.

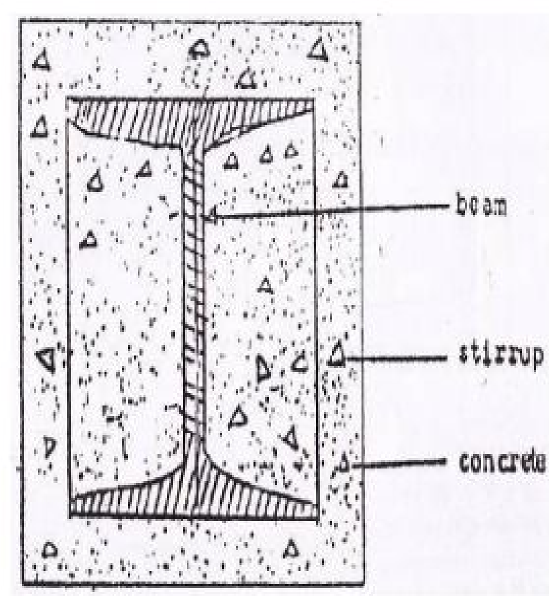


Fig.1.3 Concrete encased steel column

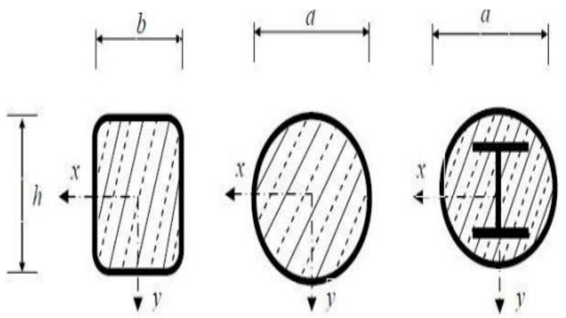


Fig.1.4 Steel encased concrete column sections

1.5 About the Software ETABS

ETABS is a program based on The Finite Element Method (FEM).Its full form is Extended three dimensional analysis of Building system are capable to perform the following methods of seismic analysis and design:

• Equivalent Lateral Force Method (Static, Linear)

• Response Spectrum Analysis (Dynamic, Linear)

• Time-History Analysis (Dynamic, Linear or Nonlinear)

• PBD -Performance Based Design (Static or Dynamic, Nonlinear)

2. LITERATURE REVIEW

D.R. Panchal & Dr. S.C. Pagoda evaluated the seismic performance of multistoried building for which they have considered Steel-Concrete Composite and R.C.C. For their analysis the methods that they used were Equivalent static method and Linear Dynamic Response Spectrum Analysis. The results thus obtained were analyzed and compared with each other .

Jingo Liu, Yangbing Liu, Heng Liu proposed a performance based fragility analysis based method in which the uncertainty due to variability in ground motion and structures are considered. By the proposed method of fragility analysis they performed analysis of a 15 storied building having composite beam and concrete filled square steel tube column.

G.E. Thermou, A.S. Elnashai, A. Plumier, C. Doneux have discussed clauses and deficiencies of the Euro code which earlier used to cause problem for the designers. For obtaining the response of the frames, methods of pushover analysis were also employed. Their main purpose was to study and investigate if the designed structure could behave in an elastically dissipative way.

3. METHODOLOGY

3.1 Step1: Design of beam and column sections

The frame is analyzed with dead and live loads for RCC sections for beams and columns in ETABS.

The codes IS 456-2000, IS 800-2007 and AISC LRFD 1999 are used for RCC, Steel and Composite column section design. The RCC beam section provided is 0.3m x 0.4 m.

Step 2: Analysis

Each type of frame is analyzed separately by using Equivalent Static Load Method and Response Spectrum Method by using ETABS.

The analysis is conducted by using IS 1893(Part 1), 2002 specified combinations of loadings.

Step 3: Comparison of results

The results obtained are compared in terms of base shear, story deflections, story drifts, modal participation factor etc.

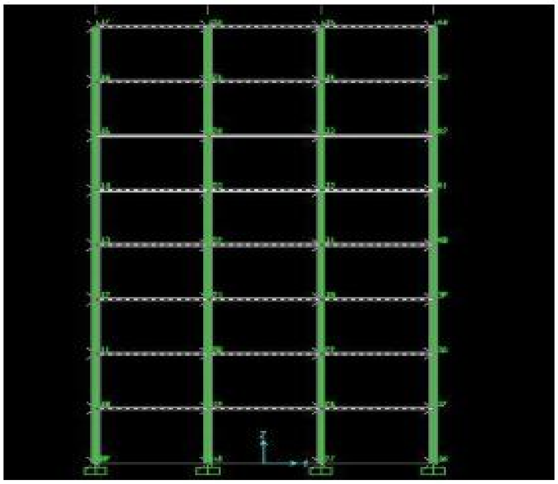


Fig.3.1 Model of the frame structure

3.2 Design and analysis

The sections are designed for maximum moment. The sections adopted for analysis are

SECTIONS USED IN THE STRUCTURES

Section	RCC	Steel	Composite
Column	0.45m X 0.75m Cross Section	ISHB 300 H	0.35m X 0.35m with ISHB 250 steel section
Beam Main and secondary	0.3m X 0.4m	ISMB 200 with 125 mm thick concrete slab on top without shear connectors.	ISMB 250 with 125 mm thick concrete slab on top without shear connectors.

Table.3.1 Sections used in the structures

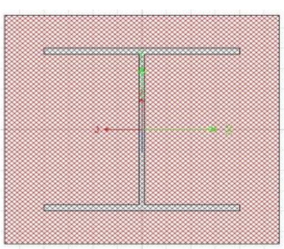


Fig.3.2 Column Section for Composite frame

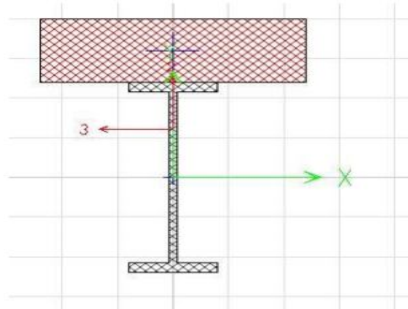


Fig.3.3 Beam section for Composite frame and steel frame

3.3 Analysis

In the present work the two methods of analysis which have been performed are as follows.

Load combinations as per IS1893- 2002:

- 1.7(DL+LL)
- 1.7(DL+EQ)
- 1.7(DL-EQ)
- 1.3(DL+LL+EQ)
- 1.3(DL+LL-EQ)

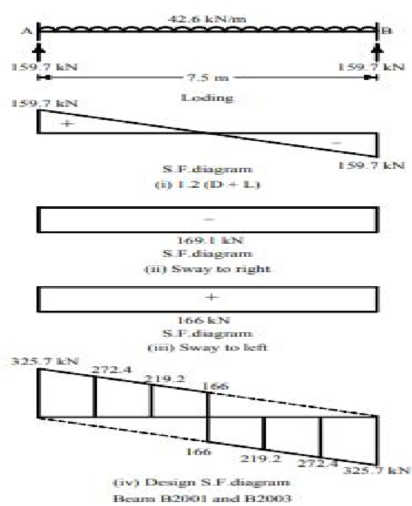


Fig.3.4 Shear Force Diagram

3.4 Design of Selected Columns

The design moment should include:

(a) The additional moment if any, due to long column effect as per clause 39.7 of IS 456:2000.

(b) The moments due to minimum eccentricity as per clause 25.4 of IS 456:2000.

4. Results and Discussion

1. Equivalent Static method

Storey Drift due to Equivalent Static Analysis in X-direction

Storey number	Drift of steel in X-direction	Drift of Composite in X-direction	Drift of RCC in X-direction
0	0	0	0
1	0.228706	0.0634	0.0085
2	0.25166	0.16	0.0185
3	0.2623	0.21	0.026
4	0.2397	0.223	0.028
5	0.2016	0.219	0.032
6	0.19956	0.198	0.027
7	0.170416	0.167	0.02
8	0.132716	0.132	0.0105

Table.4.1 Storey Drift due to Equivalent Static Analysis in X-direction

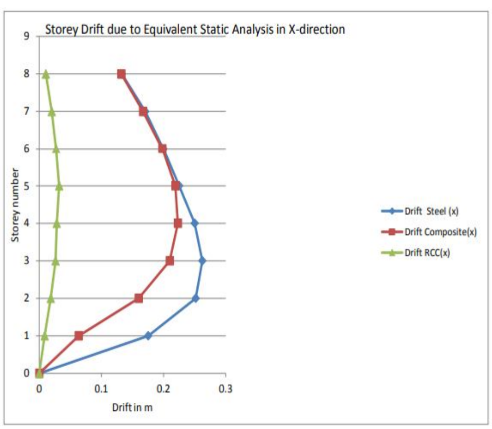


Fig.4.1 Storey Drift due to Equivalent Static Analysis in X-direction

Storey Drift in Equivalent Static method in Y-direction

Storey number	Drift of Steel in Y-direction	Drift of Composite in Y-direction	Drift of RCC in Y-direction
0	0	0	0
1	0.173725	0.0634	0 .0085
2	0.325014	0.16	0.0185
3	0.35656	0.21	0.026
4	0.344811	0.223	0.028
5	0.308372	0.219	0.032
6	0.250333	0.198	0.027
7	0.173608	0.167	0.02
8	0.094878	0.132	0.0105

Table.4.2 Storey Drift due to Equivalent Static Analysis in X-direction

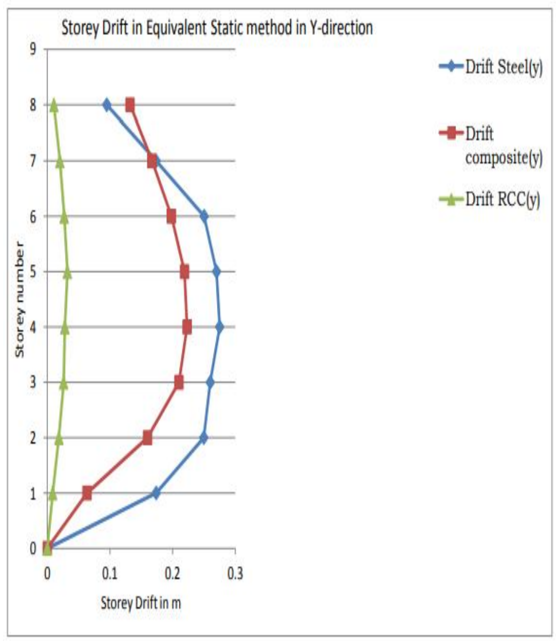


Fig.4.2 Storey Drift due to Equivalent Static Analysis in Y-direction

Storey Drift due to Response spectrum(X-direction)

Storey number	Drift of steel X-direction (m)	Drift of Composite in X-direction (m)	Drift of RCC in X-direction
0	0	0	0
1	0.194584	0.06183	0.00999
2	0.212933	0.14469	0.02082
3	0.24291	0.18271	0.026793
4	0.250454	0.19162	0.029301
5	0.219621	0.1818	0.024973
6	0.176447	0.16061	0.022574
7	0.128406	0.13484	0.015001
8	0.087103	0.112562	0.00792

Table.4.3 Storey Drift due to Response Spectrum in X-direction

Storey Drift due to Response Spectrum (Y-direction)

Storey number	Drift of Steel in Y-direction (m)	Drift of Composite in Y-direction (m)	Drift of RCC in Y-direction(m)
0	0	0	0
1	0.173695	0.070635	0.016823
2	0.2251	0.1625	0.030067
3	0.25015	0.20172	0.033999
4	0.270017	0.207945	0.020062
5	0.253265	0.19353	0.022671
6	0.191607	0.16681	0.020568
7	0.124383	0.1354	0.013956
8	0.064534	0.108515	0.00736

Table.4.4 Storey Drift due to Response Spectrum in X-direction

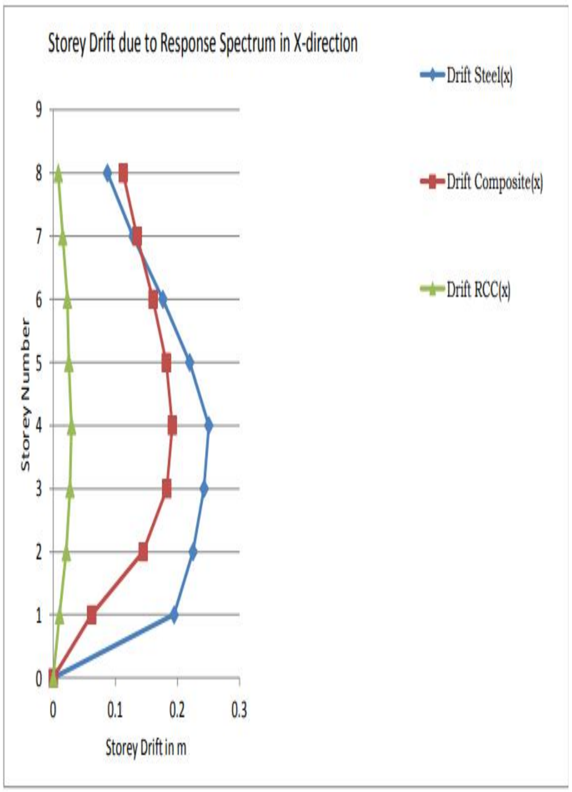


Fig. 4.3 Storey Drift due to Response Spectrum in X-direction

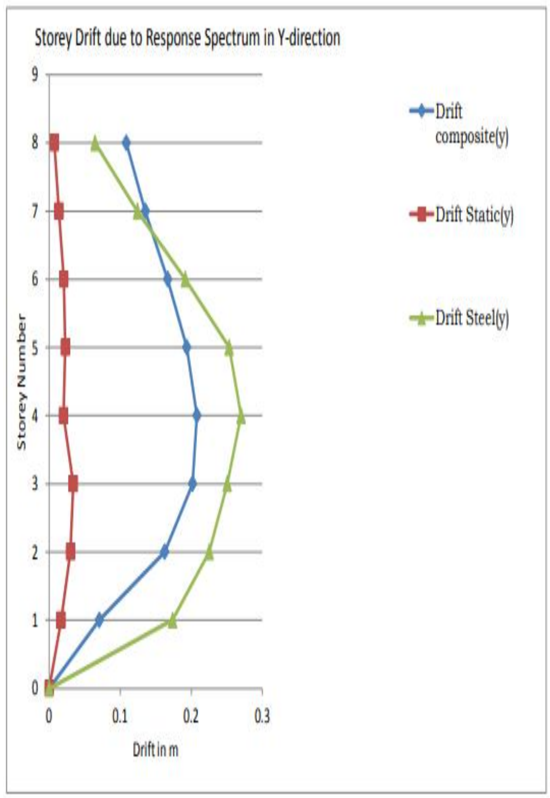


Fig. 4.3 Storey Drift due to Response Spectrum in X-direction

Table.4.5 Base Shear for Different Cases

	Composite	RCC	STEEL
EQx	1305.798KN	2172.7KN	1236.916KN
EQy	1305.798KN	2164.19KN	1236.92KN
RSx	1305.798KN	2179.42KN	1236.969KN
RSy	1305.798KN	2179.42KN	1236.94KN

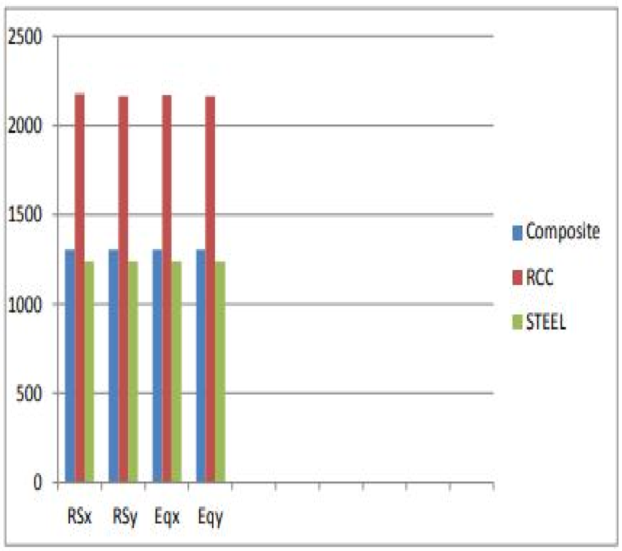
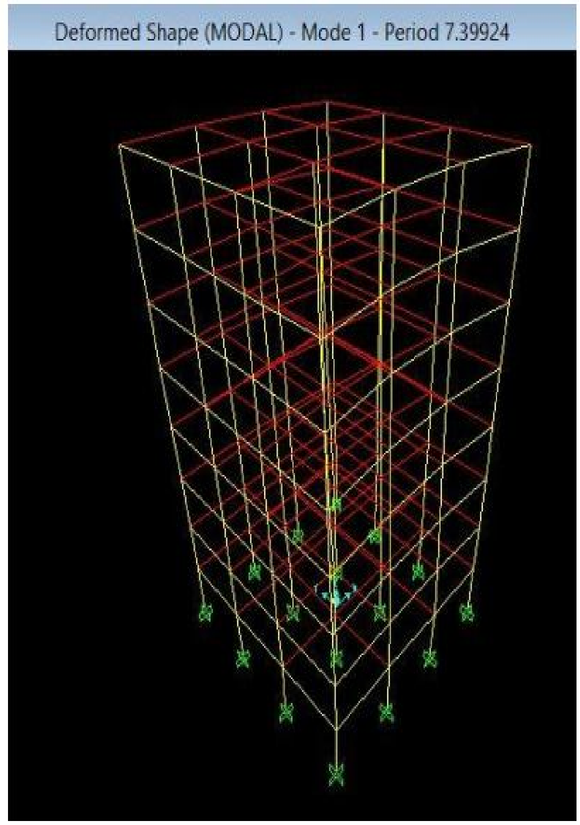
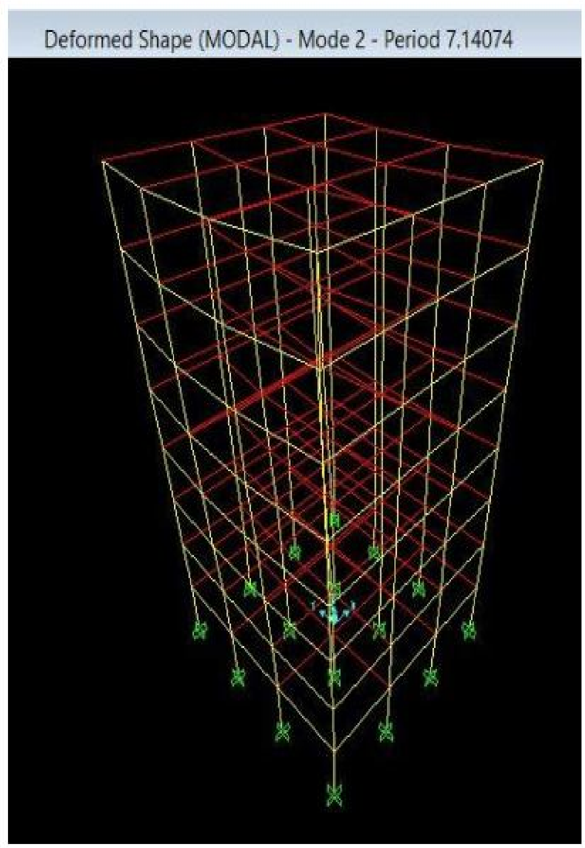


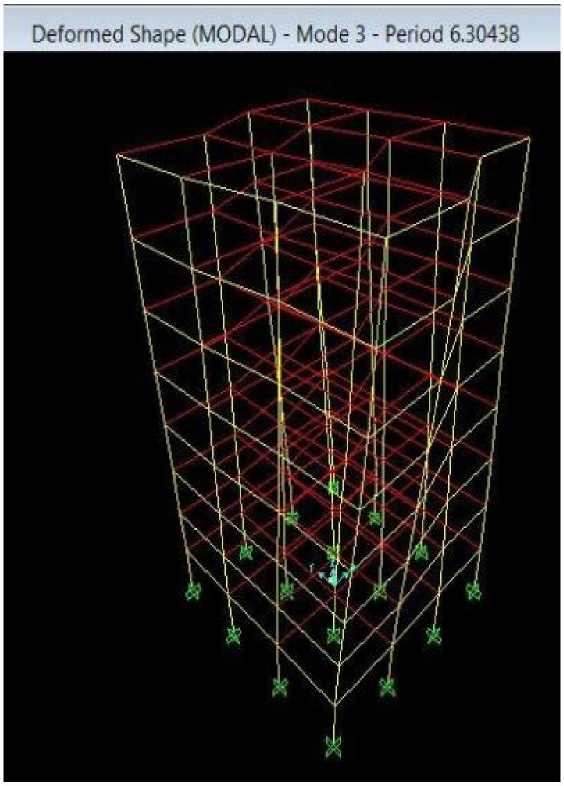
Fig.4.5 Base Shear for Different Cases

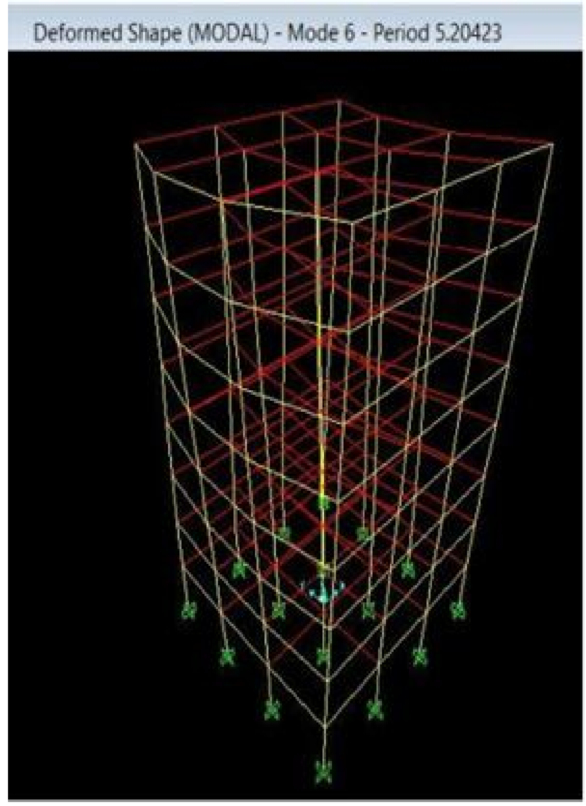
Mode Shapes:-

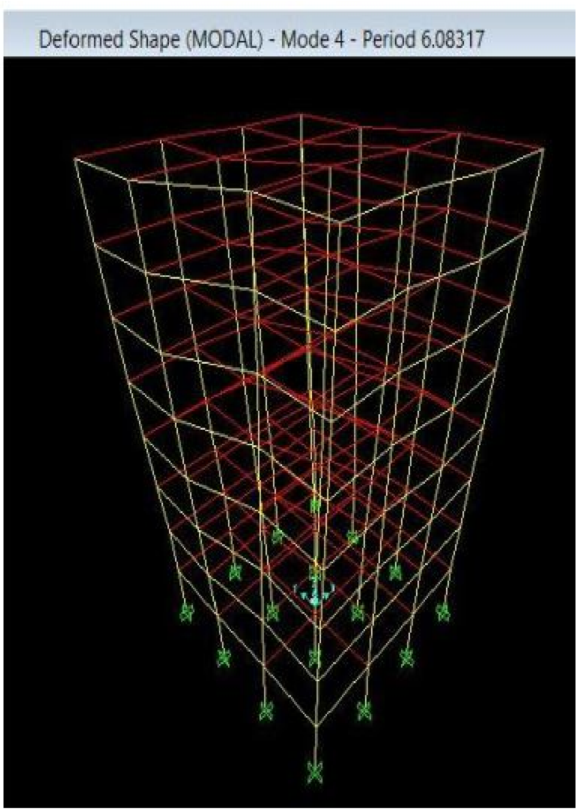
The mode shapes for the first 6 modes for the composite building are:






Deformed Shape (MODAL) - Mode 3 - Period 6.30438


Deformed Shape (MODAL) - Mode 6 - Period 5.20423


Deformed Shape (MODAL) - Mode 4 - Period 6.08317

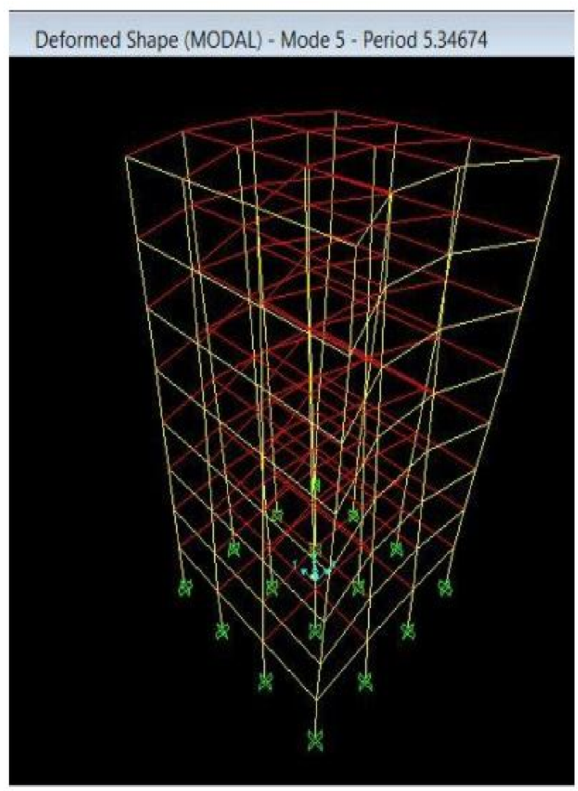

Deformed Shape (MODAL) - Mode 5 - Period 5.34674

Table.4.6 Composite Frame Structure

Material	Quantity Used	Rate of material	Amount
Structural Steel (kg)	320	Rs 42000/MT	Rs 13,440
Concrete used (m 3)	120	Rs 3000/m3	Rs 3,60,000
Total Sum			Rs 3,73,440

Table.4.6 RCC Frame Structure

Material	Quantity Used	Rate of material	Amount
Reinforcing bar (kg)	500	Rs 41500/MT	Rs 20,750
Concrete used (m 3)	180	Rs 3000/m3	Rs 5,40,000
Total Sum			Rs 5,60,750

Table 4.7 Steel Frame Structure

Material	Quantity Used	Rate of material	Amount
Structural Steel (kg)	2328	Rs 42000/ MT	Rs 97,860
Concrete Used (m3)	100	Rs 3000/ m3	Rs. 3,00,000
Total Sum			Rs. 3,97,000

5. Conclusions

- Storey drift in Equivalent Static Analysis in X-direction is more for Steel frame as compared to Composite and RCC frames.
- RCC frame has the lowest values of storey drift because of its high stiffness.
- The differences in storey drift for different stories along X and Y direction are owing to orientation of column sections. Moment of inertia of column sections is different in both directions.
- Same store drift patterns are obtained by using Response Spectrum method validating the results obtained by the Equivalent Static method.
- Base Shear for RCC frame is maximum because the weight of the RCC frame is more than the steel and the composite frame. Base shear gets reduced by 40% for Composite frame and 45% for Steel frame in comparison to the RCC frame.
- Reduction in cost of Composite frame is 33% and Steel frame is 27% compared with cost of RCC frame. This involves material cost only and doesn't include fabrication cost, transportation cost, labor cost etc.

References:-

1. D.R. Panchal, P.M. Marathe (2011), "Comparative Study of RCC, steel and composite (G+30 storey) building", Nirma University, Ahmadabad, India.

2. D.R. Panchal, Dr. S.C. Parody, "steel-concrete composite building under seismic forces", Vadodara, India.

3. LIU Jingo, LIU Yangbing (2008), "Seismic behavior analysis of steel-concrete Composite frame structure systems", Tsinghua University, Beijing, China,.

4. IS 456: 2000, "Code for practice of plain and reinforced concrete code of practice, Bureau of Indian Standards", New Delhi.

5. IS 1893: 2002, "Code for earthquake resistant design of structures- general provisions for buildings, Part I, Bureau of Indian Standards", New Delhi.

6. IS 800: 2007, "Indian Standard Code of practice for General Construction of Steel in India, Bureau of Indian Standards", New Delhi.

7. IS 11384:1985, “Code of Practice for Design of Composite Structure, Bureau of Indian Standards”, New Delhi.

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