Analysis & Deign Of Multistoried Building Having RCC,Steel & Composite Structures Subjected To Seismic Loading

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Abstract - **Composite structure is a structure made with steel and concrete where hot rolled steel sections are used as structural members. Now-a-days construction has gained wide acceptance worldwide as an alternative to pure steel and pure concrete construction. The use of steel in construction industry is very low in India compared to many developing countries. There is a great potential for increasing the volume of steel in construction, especially in the current development needs India and not using steel as an alternative construction material and not using it where it is economical is a heavy loss for the country. Two residential G+15 storied Composite and RCC structure. It is found that the depth of beams in composite structure is lesser than of RCC structure, which results to also reduce 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.**

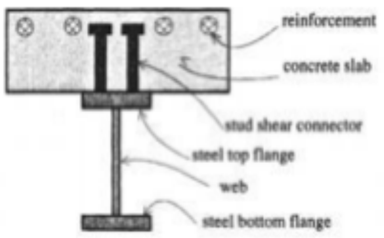
keywords - **Composite structure, Composite beam, Composite column, Composite slab, Shear connectors.**

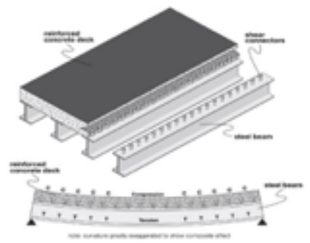
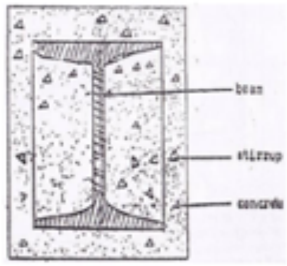
I. INTRODUCTION

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. Use of composite or hybrid material is of particular interest, due to its significant potential in improving the overall performance through rather modest changes in manufacturing and constructional technologies. In India, many consulting engineers are reluctant to accept the use of composite steel-concrete structure because of its unfamiliarity and complexity in its analysis and design. But literature says that if properly configured, then composite steel-concrete system can provide extremely economical structural systems with high durability, rapid erection and superior seismic performance characteristics. Paper is organized as follows. Section II describes automatic text detection using morphological operations, connected component analysis and set of selection or rejection criteria.

In India most of the building structures fall under the category of low rise buildings. So, for these structures reinforced concrete members are used widely because the construction becomes quite convenient and economical in nature. But since the population in cities is growing exponentially and the land is limited, there is a need of vertical growth of buildings in these cities. So, for the fulfillment of this purpose a large number of medium to high rise buildings are coming up these days. For these high rise buildings it has been found out that use of composite members in construction is more effective and economic than using reinforced concrete members. 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. Seeing the development in India, there is a dire need to explore more in the field of construction and devise new improved techniques to use Steel as a construction material wherever it is economical to use it. Steel concrete composite frames use more steel and prove to be an economic approach to solving the problems faced in medium to high rise building structures.

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. Here it is very important to note that both the materials are used to fullest of their capabilities and give an efficient and economical construction which is an added advantage.



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. If there is a proper connection such that there is no relative slip between them, then an I-section steel beam with a concrete slab will behave like a monolithic beam. The figure is shown in the figure 1.2. In our present study, the beam is composite of concrete and steel and behaves like a monolithic beam. Concrete is very weak in tension and relatively stronger in tension whereas steel is prone to buckling under the influence of compression. Hence, both of them are provided in a composite such they use their attributes to their maximum advantage. A composite beam can also be made by making connections between a steel I-section with a precast reinforced concrete slab. Keeping the load and the span of the beam constant, we get a more economic cross section for the composite beam than for the non-composite tradition beam. Composite beams have lesser values of deflection than the steel beams owing to its larger value of stiffness. Moreover, steel beam sections are also used in buildings prone to fire as they increase resistance to fire and corrosion.

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. Therefore, they resist external loading. Generally, in the composite construction, the initial construction loads are bared and supported by bare steel columns. Concrete is filled on later inside the tubular steel sections or is later casted around the I section. The combination of both steel and concrete is in such a way that both of the materials use their attributes in the most effective way. Due to the lighter weight and higher strength of steel, smaller and lighter foundations can be used. The concrete which is casted around the steel sections at later stages in construction helps 4 | P a g e in limiting away the lateral deflections, sway and bucking of the column. It is very convenient and efficient to erect very highrise buildings if we use steel-concrete composite frames along with composite decks and beams. The time taken for erection is also less due to which speedy construction is achieved along better results.

1.5 Objective: 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. This project has been envisaged which consists of analysis and design of a high rise building using Steel Concrete composites. The project also involves analysis and design of an equivalent RCC structure so that a cost comparison can be made between a Steel-Concrete composite structure and an equivalent RCC structure.

II. LITERATURE REVIEW

- **D.R. Panchal & Dr. S.C. Patodi** 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.
- **Jingbo 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 storeyed 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 Eurocode 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.
- **Shashikala. Koppad, Dr. S.V.Itti** considered steel-concrete composite with RCC options for analyzing a B+G+15 building which is situated in earthquake zone III and earthquake loading is as per the guidelines of IS1893(part-I): 2002. The parameters like bending moment and maximum shear force were coming more for RCC structure than the composite structure. Their work suggested that composite framed structures have many benefits over the traditional RC structures for high rise buildings.
- **A.S. Elnashai and A.Y. Elghazouli** developed a model for analysis of structures subjected to cyclic and dynamic loads. These structures were primarily Steel-Concrete Composites and the model they developed was a non-linear model. The efficiency and accuracy of the developed model is shown through correlation between the experimental results and analytical simulations. The model was used for parametric studies resulting in providing important conclusion for ductility based earthquake-resistant design.

Aim of the present study: The aim of the present study is to compare performance of a 3D (G+7) story RCC, Steel and composite building frame situated in earthquake zone V. All frames are designed for same gravity loadings. The RCC slab is used in all three cases. Beam and column sections are made of RCC, Steel or Steel-concrete composite sections. Equivalent static method and Response Spectrum method are used for seismic analysis. Etabs software is used and results are compared. Cost effectiveness based on quantity of materials of all types are determined.

Problem Statement: Multistoried building frame with three bays in horizontal and three bays in lateral direction is analyzed by Equivalent Static Method and Response Spectrum Method. The geometrical parameters of the building are as follows:

- Height of each storey = 3.5 m
- Center-to-center span between each column along X and Y direction = 5 m
- Fixed type support at the bottom.
- The loads on the building are as follows:
- Dead Load:-
- 1. Self weight of the frame
- 2. Dead load of floors
- a. Dead floor load of all the intermediate floors = 6.8 KN/m2
- b. Dead load of the roof floor = 5.5 KN/m2
- 3. Dead load of walls
- a. On outer beams = 12 KN/m2
- b. On inner beams = 6KN/m2
- Live load
- a. Live load on all the intermediate floors = 4 KN/m2
- b. Live load on roof floor = 1.5 KN/m2
- Earthquake load in X-direction & Y-direction as specified in IS 1893: 2002.
- The seismic parameters of the building site are as follows:
- Zone factor 'Z' : 0.36
- Soil type= Type II (Medium Soil)
- Building Frame System: Moment resisting RC frame.
- Response Reduction Factor = 5
- Importance factor = 1
- Fundamental natural time period, T= 0.075 H0.75 (moment-resisting frame building without brick in the panels).
- Since H= 28 m , hence T= 0.9169 sec along both directions.

III. 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 maximum forces in columns and beams are determined from output file. The sections are designed manually for these maximum forces as RCC, Steel and Composite sections for the three types of frame separately. The codes IS 456-2000, IS 800-2007 and AISC LRFD 1999 are used for RCC, Steel and Composite column section design. The steel beam designed for steel frame is provided in composite frame too. 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 SAP 2000. The analysis is conducted for 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. and cost effectiveness with respect to material quantities are determined.

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.

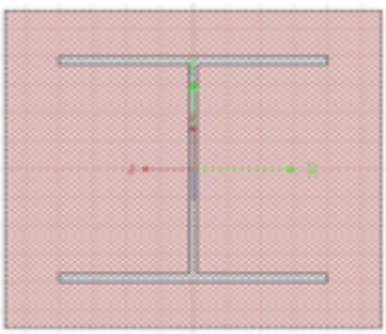


Fig. Column Section for Composite frame

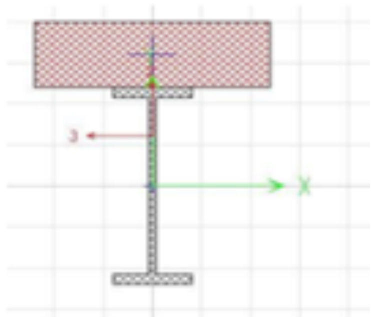


Fig. Beam section for Composite frame and steel frame

3.3 Analysis : In the present work the two methods of analysis which have been performed are:

• Equivalent Static Analysis**:** This method is based on the assumption that whole of the seismic mass of the structure vibrates with a single time period. The structure is assumed to be in its fundamental mode of vibration. But this method provides satisfactory results only when the structure is low rise and there is no significant twisting on ground movement. As per the IS 1893: 2002, total design seismic base shear is found by the multiplication of seismic weight of the building and the design horizontal acceleration spectrum value. This force is distributed horizontally in the proportion of mass and it should act at the vertical center of mass of the structure.

• Response Spectrum Analysis: Multiple modes of responses can be taken into account using this method of analysis. Except for very complex or simple structure, this approach is required in many building codes. The structure responds in a way that can be defined as a combination of many special modes. These modes are determined by dynamic analysis. For every mode, a response is perused from the design spectrum, in view of the modal frequency and the modal mass, and they are then combined to give an evaluation of the aggregate response of the structure. In this we need to ascertain the force magnitudes in all directions i.e. X, Y & Z and afterwards see the consequences for the building. Different methods of combination are as follows:

- Absolute-peak values are added together.
- Square root of the sum of squares(SRSS).
- Complete quadratic combination(CQC).

In our present study we have used the SRSS method to combine the modes. The consequence of a response spectrum analysis utilizing the response spectrum from a ground motion is commonly not quite the same as which might be computed from a linear dynamic analysis utilizing the actual earthquake data. 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)

Check for reinforcement
(IS 13920; Clause 6.2.1)

(a) Minimum two bars should be continuous at top and bottom.
Here, 2–25 mm # (982 mm2) are continuous throughout at top; and 5–20 mm # (1 570 mm2) are continuous throughout at bottom. Hence, ok.

(b) $P_{t,min} = \frac{0.24\sqrt{f_{ck}}}{f_y} = \frac{0.24\sqrt{25}}{415}$
=0.00289, i.e., 0.289%.

$$A_{st,min} = \frac{0.289}{100} \times 300 \times 560 = 486mm^2$$

Provided reinforcement is less. Hence ok.

Web reinforcements

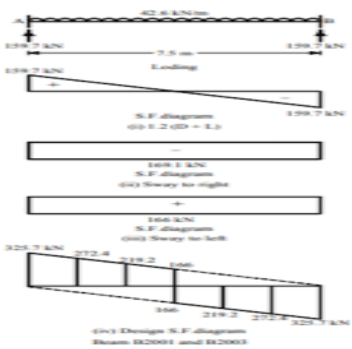
Vertical hoops (IS: 13920:1993, Clause 3.4 and Clause 6.3.1) shall be used as shear reinforcement.
Hoop diameter ≥ 6 mm
≥ 8 mm if clear span exceeds 5 m.
(IS 13920:1993; Clause 6.3.2)

Sway to right

$$V_{u,a} = V_a^{D+L} - 1.4\left[\frac{M_{u,lim}^{As} + M_{u,lim}^{Bh}}{L_{AB}}\right]$$

Sway to left

$$V_{u,a} = V_a^{D+L} - 1.4\left[\frac{M_{u,lim}^{Ah} + M_{u,lim}^{Bs}}{L_{AB}}\right]$$



Maximum shear forces for various cases from analysis. The shear force to be resisted by vertical hoops shall be greater of:
i) Calculated factored shear force as per analysis.
ii) Shear force due to formation of plastic hinges at both ends of the beam plus the factored gravity load on the span.

The design shears for the beams B2001 and B2002
As per Clause 6.3.5 of IS 13920:1993,the first stirrup shall be within 50 mm from the joint face. Spacing, s, of hoops within 2 d (2 x 532 = 1064 mm) from the support shall not exceed:
(a) d/4 = 133 mm
(b) 8 times diameter of the smallest longitudinal bar = 8 x 20 = 160 mm
Hence, spacing of 133 mm c/c governs.
Elsewhere in the span, spacing,

$$s \leq \frac{d}{2} = \frac{532}{2} = 266mm.$$

3.4 Design of Selected Columns: Here, design of column C2 of external frame AA is illustrated. Before proceeding to the actual design calculations, it will be appropriate to briefly discuss the salient points of column design and detailing.
Design: The column section shall be designed just above and just below the beam column joint, and larger of the two reinforcements shall be adopted. This is similar to what is done for design of continuous beam reinforcements at the support. The end moments and end shears are available from computer analysis. 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.
All columns are subjected to biaxial moments and biaxial shears.

The longitudinal reinforcements are designed for axial force and biaxial moment as per IS: 456. Since the analysis is carried out considering centre-line dimensions, it is necessary to calculate the moments at the top or at the bottom faces of the beam intersecting the column for economy. Noting that the B.M. diagram of any column is linear, assume that the points of contra flexure lie at 0.6 h from the top or bottom as the case may be; where h is the height of the column. Then obtain the column moment at the face of the beam by similar triangles. This will not be applicable to columns of storey 1 since they do not have points of contra flexure.
If M is the centre-line moment in the column obtained by analysis, its moment at the beam face will be:
0.9 M for columns of 3 to 7th storey's, and
0.878 M for columns of storey 2.
Critical load combination may be obtained by inspection of analysis results. In the present example, the building is symmetrical and all columns are of square section. To obtain a trial section, the following procedure may be used:
Let a rectangular column of size b x D be subjected to Pu, Mux (moment about major axis) and Muz (moment about minor axis). The trial section with uniaxial moment is obtained for axial load and a combination of moments about the minor and major axis. For the trial section

$$P_u = P_u and M_{uz} = M_{uz} + \frac{b}{D} M_{ux.}$$

Determine trial reinforcement for all or a few predominant (may be 5 to 8) combinations and arrive at a trial section.
It may be emphasized that it is necessary to check the trial section for all combinations of loads since it is rather difficult to judge the governing combination by visual inspection.

3.5 Detailing: Detailing of reinforcement as obtained above is discussed in context with the reinforcement area as obtained above at various column-floor joints for lower and upper column length. The areas shown in this figure are fictitious and used for explanation purpose only. The area required at the beam-column joint shall have the larger of the two values, viz., for upper length and lower length. Accordingly the areas required at the joint. Since laps can be provided only in the central half of the column, the column length for the purpose of detailing will be from the centre of the lower column to the centre of the upper column. This length will be known by the designation of the lower column as indicated.
It may be noted that analysis results may be such that the column may require larger amounts of reinforcement in an upper storey as compared to the lower storey. This may appear odd but should be acceptable.

3.6 Effective length calculations: Effective length calculations are performed in accordance with Clause 25.2 and Annex E of IS 456:2000.
Stiffness factor
Stiffness factors (I / l) are calculated. Since lengths of the members about both the bending axes are the same, the suffix specifying the directions is dropped.
Effective lengths of the selected columns are calculated.

Stiffness factors for Selected Members

Member	Size	I (mm^4)	I (mm)	Stiffness Factor (I/l)x10^{-3}
All Beams	300 X 600	5.4 X 10^9	7500	720
Columns				
C101, C102	600 x 600	1.08 x 10^{10}	1100	9818
C201, C202	500 x 500	5.2 x 10^9	4100	1268

C301, c302	500 X 500	5.2 x 10^9	5000	1040
C401, C402	500 X 500	5.2 x 10^9	5000	1040

3.7 Design of Transverse reinforcement: Three types of transverse reinforcement (hoops or ties) will be used. These are:
i) General hoops: These are designed for shear as per recommendations of IS 456:2000 and ARE 13920:1993.
ii) Special confining hoops, as per IS 13920:1993 with spacing smaller than that of the general hoops
iii) Hoops at lap: Column bars shall be lapped only in central half portion of the column. Hoops with reduced spacing as per IS 13920:1993 shall be used at regions of lap splicing.

Design of general hoops

(A) Diameter and no. of legs: Rectangular hoops may be used in rectangular column. Here, rectangular hoops of 8 mm diameter are used.
Here h = 500 – 2 x 40 + 8 (using 8# ties)
= 428 mm > 300 mm (Clause 7.3.1, IS 13920:1993)
The spacing of bars is (395/4) = 98.75 mm, which is more than 75 mm. Thus crossties on all bars are required
(IS 456:2000, Clause 26.5.3.2.b-1)
Provide 3 no open crossties along X and 3 no open crossties along Z direction. Then total legs of stirrups (hoops) in any direction = 2 +3 = 5.

(B) Spacing of hoops: As per IS 456:2000, Clause 26.5.3.2.(c), the pitch of ties shall not exceed:
(i) b of the column = 500 mm
(ii) 16 φ min (smallest diameter) = 16 x 20
= 320 mm
(iii) 300 mm ….. (1)
The spacing of hoops is also checked in terms of maximum permissible spacing of shear reinforcement given in IS 456:2000, Clause 26.5.1.5
b x d = 500 x 450 mm. Using 8# hoops,
A_{sv} = 5 x 50 = 250 mm^2 .
The spacing should not exceed
$(i)\ \frac{0.87 f_y A_{SV}}{0.4b}$
(Requirement for minimum shear reinforcement)
(ii) 0.75 d = 0.75 X 450 = 337.5 mm
(iii) 300 mm; i.e., 300 mm … (2)
As per IS 13920:1993, Clause 7.3.3,
Spacing of hoops ≤ b/2 of column
= 500 / 2 = 250 mm … (3)
From (1), (2) and (3), maximum spacing of stirrups is 250 mm c/c.

Design Shear: As per IS 13920:1993, Clause 7.3.4, design shear for columns shall be greater of the followings: (a) Design shear as obtained from analysis
For C202, lower height, Vu = 161.2 KN, for load combination 12.
For C202, upper height, Vu = 170.0 KN, for load combination 12.

$$(b) V_u = 1.4\left[\frac{M_{u,lim}^{bL} + M_{u,lim}^{bR}}{h_{st}}\right].$$

For C202, lower height, using sections of B2001 and B2002
$M_{u,lim}^{bL} = 568 \quad kNm \qquad (Table\ \ 18)$
$M_{u,lim}^{bR} = 568 \quad kNm, \qquad (Table\ \ 19)$

For C202, upper height, assuming same design as sections of B2001 and B2002
Design of hoops at lap: As per Clause 7.2.1 of IS 13920:1993, hoops shall be provided over the entire splice length at a spacing not exceeding 150 mm centres
Moreover, not more than 50 percent of the bars shall be spliced at any one section.
Splice length = Ld in tension = 40.3 db.
Consider splicing the bars at the centre (central half) of column 302.
Splice length = 40.3 x 25 = 1008 mm, say 1100 mm. For splice length of 40.3 db, the spacing of hoops is reduced to 150 mm.
Column Details: The designed column lengths are detailed. Columns below plinth require smaller areas of reinforcement; however, the bars that are designed in ground floor (storey 1) are extended below plinth and into the footings. While detailing the shear reinforcements, the lengths of the columns for which these hoops are provided, are slightly altered to provide the exact number of hoops. Footings also may be cast in M25 grade concrete.

Design of footing: (M20 Concrete): It can be observed that load combinations 1 and 12 are governing for the design of column. These are now tried for the design of footings also. The footings are subjected to biaxial moments due to dead and live loads

and uniaxial moment due to earthquake loads. While the combinations are considered, the footing is subjected to biaxial moments. Since this building is very symmetrical, moment about minor axis is just negligible. However, the design calculations are performed for biaxial moment case. An isolated pad footing is designed for column C2.
Since there is no limit state method for soil design, the characteristic loads will be considered for soil design. These loads are taken from the computer output of the example building. Assume thickness of the footing pad D = 900 mm.

IV. RESULTS AND ANALYSIS

4.1 RESULTS

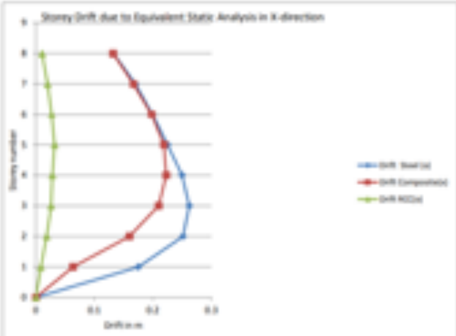
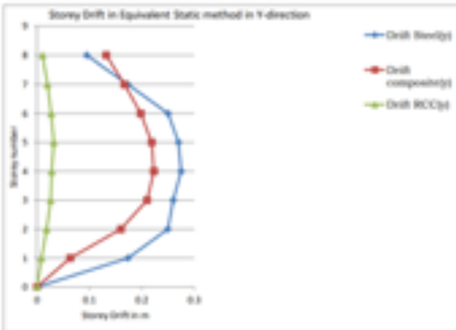
Results obtained from the analysis are:

1. Equivalent Static method

Storey Drift due to Equivalent Static Analysis in X-direction & Y-direction

Storey number	Drift of steel in X-direction	Drift of Composite in X-direction	Drift of RCC in X-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	0	0	0	0
1	0.228706	0.0634	0.0085	1	0.173725	0.0634	0 .0085
2	0.25166	0.16	0.0185	2	0.325014	0.16	0.0185
3	0.2623	0.21	0.026	3	0.35656	0.21	0.026
4	0.2397	0.223	0.028	4	0.344811	0.223	0.028
5	0.2016	0.219	0.032	5	0.308372	0.219	0.032
6	0.19956	0.198	0.027	6	0.250333	0.198	0.027
7	0.170416	0.167	0.02	7	0.173608	0.167	0.02
8	0.132716	0.132	0.0105	8	0.094878	0.132	0.0105

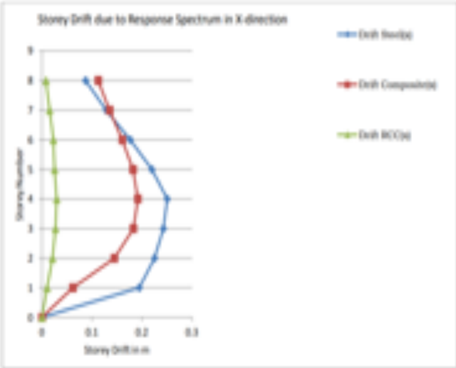
It is observed that storey drift in Equivalent Static Analysis in X-direction is more for Steel frame as compared to Composite and RCC frames. RCC frame has the lowest values of storey drift because of its high stiffness.

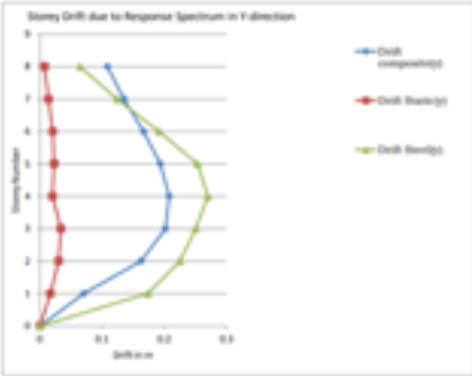



The differences in storey drift for different stories along X and Y direction are owing to orientation of column sections. Moment of inertia of column sections is different in both directions.

Storey Drift due to Response spectrum X & Y directions

Storey number	Drift of steel X-direction (m)	Drift of Composite in X-direction (m)	Drift of RCC in X-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	0	0	0	0
1	0.194584	0.06183	0.00999	1	0.173695	0.070635	0.016823
2	0.212933	0.14469	0.02082	2	0.2251	0.1625	0.030067
3	0.24291	0.18271	0.026793	3	0.25015	0.20172	0.033999
4	0.250454	0.19162	0.029301	4	0.270017	0.207945	0.020062
5	0.219621	0.1818	0.024973	5	0.253265	0.19353	0.022671
6	0.176447	0.16061	0.022574	6	0.191607	0.16681	0.020568
7	0.128406	0.13484	0.015001	7	0.124383	0.1354	0.013956
8	0.087103	0.112562	0.00792	8	0.064534	0.108515	0.00736



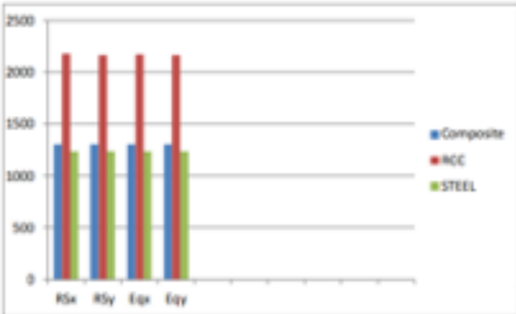


Same storey drift patterns are obtained by using Response Spectrum method analysis validating the results obtained by the Equivalent Static method.

Base Shear Calculation

Table 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

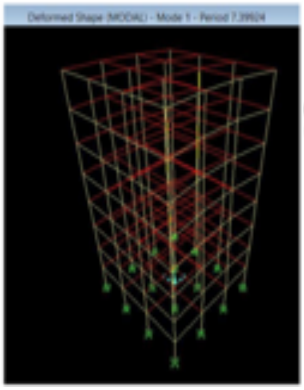


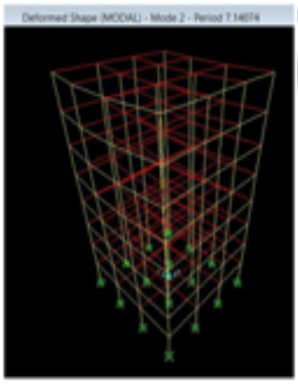
Base Shear for RCC frame is maximum because the weight of the RCC frame is more than the steel and the composite frame.

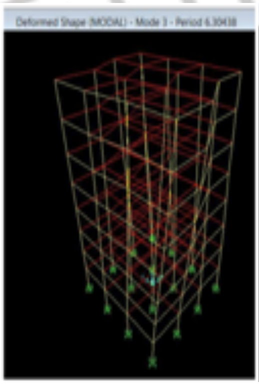
Mode Shapes:-

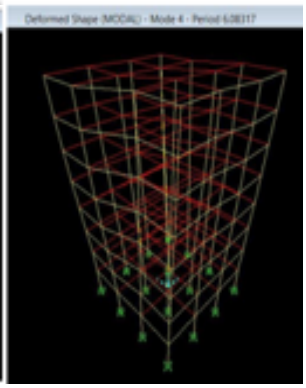
Response Spectrum (Composite)

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









Cost Comparison Analysis

Table 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 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 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

Reduction Factor for Composite = Cost of Composite/Cost of RCC = 373440/560750 = 0.67
Reduction Factor for Steel = Cost of Steel/Cost of RCC = 3, 97,000/560,750 = 0.72
Hence, 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, labour cost etc.

V. CONCLUSION

- 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 are different in both directions.
- Same storey 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, labour cost etc.

FUTURE SCOPES

1. The research needs in regards to composite structures using precast concrete and even pre-stressed concrete in certain applications and steel, should also have good market.
2. The research needs in regard to composite structures for different soil conditions, different zones, effect of fire, different column orientations and different utility of buildings.
3. Idealizing the condition of joints here as rigid joints one can do research on non-linear joint response considering rotational stiffness, moment of resistance and rotational capacity.
4. Different shapes of high-rise buildings can be compared for R.C.C., Steel and Composite options for better guidelines of selection of system.
5. Indian standard is very silent about design of composite column; one can conclude such guidelines and format a proper design method for different types of composite columns.

VI. REFERENCES

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