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Design and Analysis of Composite Structure, Steel Structure, RCC Structure & Comparison

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Abstract: *Low-growth buildings have generally been selected in India as a general option, but now the day in India is growing rapidly and therefore the requirement to build medium and high-rise buildings is also increasing. Reinforced concrete elements are mainly used in the frame system, as this system is the most convenient and economical for low-rise buildings, but for medium and high-rise buildings of this type of construction there is no longer economical due to the operation of a dangerous shape, less rigidity, flight restrictions and increased dead load. The composite structure may be suitable in this case.*

Keywords: Composite Structure, Steel Structure, RCC Structure and buildings

I. INTRODUCTION

The composite design has a wide range of applications. It is very necessary to choose the appropriate type of building in accordance with the requirements of the owner, as well as the construction site. Compared to other developing countries, the use of steel for construction purposes in India is very less. Steel structural elements are prone to local and side buckles. Concrete structural elements are usually thicker and less often fastened, but they are eventually subjected to slidering and shrinkage. Steel is a more plastic material, so it can absorb more shocks and shock loads. Thus, the composite structure is designed to use both materials.

However, in Japan, the higher properties of composite beam earthquakes have long been recognized and have become a widely used form of construction in the region. Due to the growing popularity and use of composite systems, it is necessary to analyze the frame. And nonlinear analysis is a suitable tool for better understanding the behavior of systems, especially when they are exposed to dynamic arousal, unfortunately, many of the available analysis programs are only suitable for modeling traditional steel or reinforced concrete systems and are not applied directly to composite frames.

Construction performance during an earthquake has been shown to depend on several factors, such as rigidity, plasticity, lateral strength, and simple and regular configuration. Therefore, for the final decision of the comparison, all three types of buildings should be compared by drift of history, movement of history, basic shift, shift of forces in beams, bending moments in the beam, Axial forces in the column and bending moments in the column.

II. LITERATURE REVIEW

J. M. Castro, A.J. Elgazuli and B.A. Izzuddin [1] In this article, they study the seismic performance of the folded steel-concrete frames that oppose the moment. Several sensitivity studies and parametric studies are conducted using an advanced analysis program that takes into account material and geometric nonlinearities. Particular attention is paid to the compiled frames, developed in accordance with the provisions of the European Seismic Code, Eurocode 8. The validity of the use of simplified nonlinear approaches to static load is assessed by comparison with the results of a gradual dynamic analysis of time history. To do this, natural earthquake acceleration records are used, which are specially selected and adjusted for compatibility with the accepted design spectrum. With regard to the frame configuration, it has been shown that the span of the folded beam and the number of stories can have a significant impact on the actual characteristics of the inelastic response of the structure. The research presented in this paper highlights important behavioral observations and trends, some of which point to the need to further consider and improve ongoing design procedures.

LIU Jingbo and LIU Yangbing [2] Investigate the seismic behavior of composite frame structures made of steel, based on studies of composite beams and joints between beams and columns, for inelastic analysis of composite frames offers 4 polylinear plastic hinge. And CL-CFST (composite beam-concrete is filled with a square tubular column), SL-CFST

(steel beam-concrete filled square tubular column), CL-ETRC (composite beam-equivalent rigidity RC column), SL-ETRC (equivalent stiffness of steel bundles RC column) and frame structure RC are created separately. Then the analysis of the mode, the spectrum of the reaction and inelastic analysis during rare earthquakes is carried out. The results of the analysis illustrate that the integrated rigidity of the CL-CFST frame is improved compared to the SL-CFST frame; natural periods are reduced; the upper deflection and angular chest of drawers are reduced after taking into account the compound effect of the RC floor slabs. But due to the increase in the rigidity of the composite rays, the integral rigidity of the structure and the linear ratio of the stiffness of the beam and column also change, which probably makes not only the column severely damaged but also weakly moved section. And compared to the CL-RC framework, during rare earthquakes, RC columns cannot meet demand " does not collapse during a strong earthquake ". And after increasing the size and reinforcement coefficients of the columns, the plastic hinge is also at the end of the columns. According to the above comparisons, in general, the structure of the CFST frame has qualified aseismic indicators. But the impact that frame composite beams have on structural seismic behavior should be considered comprehensively.

Anish N. Shah, Dr. P.S. Pajgade [3] Composite concrete steel construction means a steel section enclosed in concrete for columns and & a concrete slab or a profiled floor plate is connected to a steel beam by means of mechanical sliding connectors, that they act as one unit. In this article, a steel concrete composite with R.C.C. options for comparative study of the office building G + 15 floors, which is located in the earthquake zone IV and wind speed 39m / s. An equivalent static method of analysis is used. To model Composite & R.C.C. structures, stad-pro software are used and results are compared; and it is established that the composite structure of the frame is more economical.

III. METHODOLOGY

Here is a building G + 7 floor office buildings located in seismic zone V. The construction plan is shown in Figure 3.2.a. The basic planning and loading conditions are considered to be the same for all framed RCC structures, steel and composite steel concrete structure. In the case of RCC structure, the plate, beam and column of structural elements are designed in accordance with IS456: 2000, and in the case of a composite steel concrete structure, the elements developed in accordance with IS 11384:1985. Composite beams are designed with a structural steel section attached to the steel flooring with sliding studs, and the columns are considered to be made of RCC, with a structural steel section in the core and reinforcement in concrete on the outside. In the case of steel structures, the concrete plate of the deck rests on a structural steel beam, and the I steel section is used as a column. Side loads are considered to be the executed frame of the beam column as the moment that resists the frame. Here is a building - a commercial building.

The size of the plan is 15m15m. The study is conducted according to the same construction plan for the R.C.C building, steel concrete. The main load on all types of structures is kept the same. factual data on problems are considered for analysis and design.

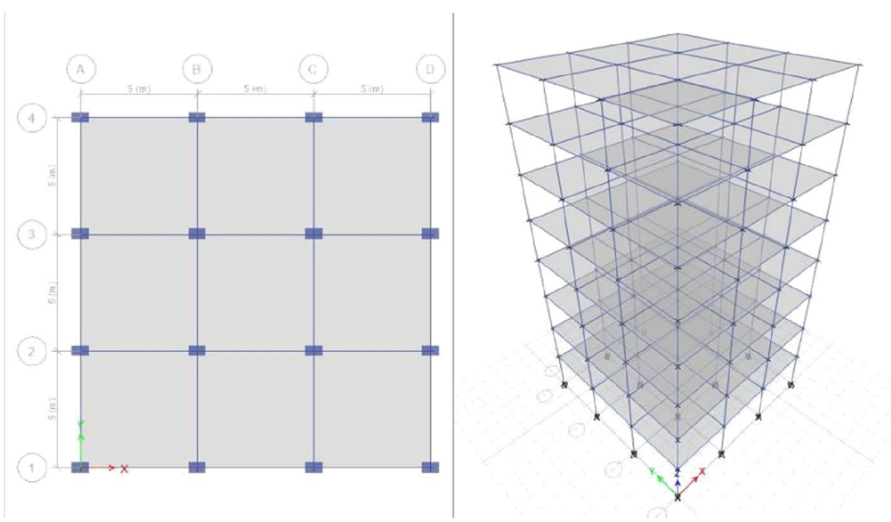

Fig. 1: Plan and 3D elevation of building

- Eight storey (G+7) building frame with three bays in horizontal and three bays in lateral direction is analyzed by ETABS2015.
- 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

- Self weight of the frame
- Dead floor load of the floors = 5.6 KN/m2
- Dead load of walls On beams = 8 KN/m2

Live load

- Live load on the floors = 4 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:
- Seismic Zone: V
- Zone factor 'Z' = 0.36
- Soil type= Type II (Medium Soil)

Building Frame System

- Special Moment resisting RC frame.
- Response Reduction Factor = 5
- Importance factor = 1

3.1 RCC Frame

The table 1 below shows the structural data for RCC frame which obtained from software ETABS2015 and fig.2 shows the modeling of RCC frame structure.

Table 1: Structural data for RCC frame

Plan dimension	15m x 15m
Total height of building	28.0 m
Height of each storey	3.5m
Type of Beam B	Size of Beams 0.3m X 0.4m
Type of columns C	Size of columns 0.45m X 0.75m
Thickness of slab	125 mm
Seismic zone	V
Soil condition	Medium soil

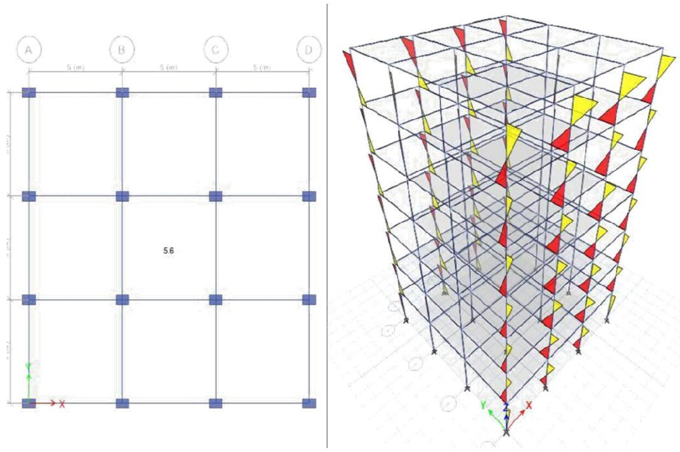

Fig. 2: Modelling for RCC Frame

3.2 Steel Frame

The table 2 shows the structural data for Steel frame which obtained from software ETABS2015 and fig.3 shows the modeling of Steel frame structure.

Table. 2: Structural data for RCC frame

Plan dimension	15m x 15m
Total height of building	28.0 m
Height of each storey	3.5m
Type of Beam B	Size of Beams ISMB350
Type of columns C	Size of columns ISHB350
Thickness of slab	125 mm
Seismic zone	V
Soil condition	Medium soil

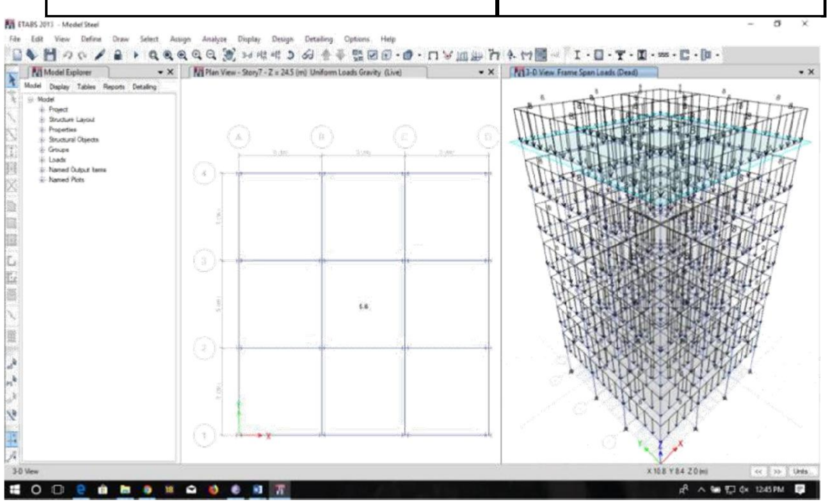

Fig. 3: Modelling for Steel Frame

3.3 Composite Frame

The table 3 below shows the structural data for Composite frame which obtained from software ETABS2015 and fig.4 shows the modeling of Composite frame structure.

Table 3 Modelling for Composite Frame

Plan dimension	15m x 15m
Total height of building	28.0 m
Height of each storey	3.5m
Type of Beam B	Size of Beams ISWB350
Type of columns C	Size of columns 0.40m X0.35m with ISHB300
Thickness of slab	125 mm
Seismic zone	V
Soil condition	Medium soil

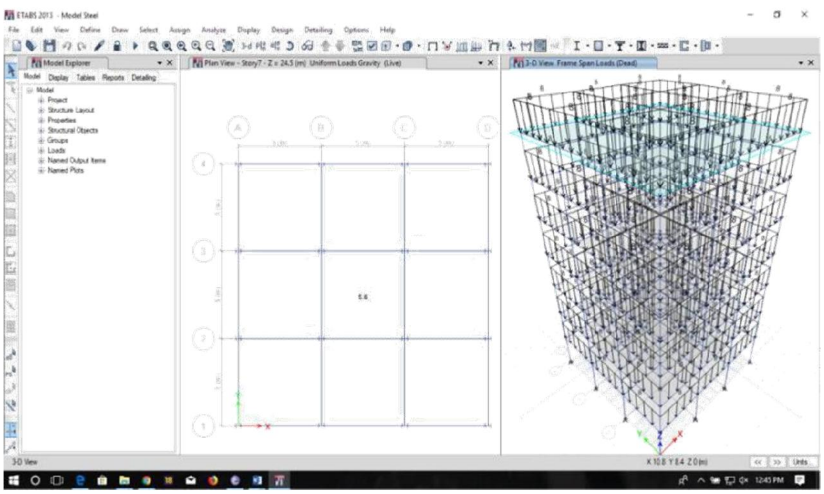

Fig. 3: Modelling for Composite Frame

IV. RESULTS AND DISCUSSIONS

In this study results are obtained from Equivalent dynamic method of analysis in order to compare R.C.C, Steel and Composite structures. Deflection, Story drift, base shear, Bending moments and shear forces in beam, Axial forces and bending moments in columns, Cost, weight and fire performance are taken up to discuss on R.C.C Steel, and Composite structures.

Table 4 Storey deflection in X direction

No of Storey	X Direction Deflection in mm		
	Composite	Steel	RCC
8	42.267	49.659	36.545
7	39.798	46.045	33.731
6	35.8	40.946	29.868
5	30.507	34.576	2.50E+01
4	24.283	27.323	1.93E+01
3	17.48	19.575	1.33E+01

2	10.455	11.717	7.349
1	3.859	4.409	2.37E+00
Base	0	0	0

Table 5 Storey deflection in Y direction

Storey	Y Direction Deflection in mm		
	Composite	Steel	RCC
8	45.529	39.523	39.521
7	43.036	37.027	37.126
6	38.826	33.178	3.33E+01
5	33.224	28.254	2.83E+01
4	26.638	22.595	2.24E+01
3	19.431	16.497	1.60E+01
2	1.19E+01	1.02E+01	9.37E+00
1	4.661	4.142	3.33E+00
Base	0	0	0

Table 6 Storey Drift in X direction

Storey	X Direction Drift in m		
	Composite	Steel	RCC
8	7.09E-04	1.05E-03	8.13E-04
7	1.14E-03	1.46E-03	1.11E-03
6	1.51E-03	1.82E-03	1.40E-03
5	1.78E-03	0.002072	1.62E-03
4	1.94E-03	0.002214	1.73E-03
3	2.01E-03	0.002245	1.70E-03
2	1.89E-03	0.002095	0.001697
1	1.10E-03	0.00126	1.43E-03
Base	0	0	0

Table 7 Storey Drift in Y direction

Storey	Y Direction Drift in m		
	COMPOSITE	STEEL	RCC
8	7.15E-04	7.19E-04	6.92E-04
7	1.20E-03	1.10E-03	1.08E-03
6	1.60E-03	1.41E-03	1.43E-03
5	1.88E-03	1.62E-03	1.69E-03
4	2.06E-03	1.74E-03	1.85E-03
3	2.14E-03	1.79E-03	1.89E-03
2	2.08E-03	1.74E-03	1.73E-03
1	1.33E-03	1.18E-03	9.50E-04
Base	0	0	0

Table 8: Base shear for RCC frame

RCC Model	
Storey No	Base shaer in kN
8	230.77
7	440.69
6	594.91
5	702.01
4	770.56
3	809.11
2	826.25
1	830.53
Base	830.53

Table 9 Base shear for Steel frame

Steel Model	
Storey No	Base shear in kN
8	119.44
7	213.44
6	282.5
5	330.46
4	361.15

Table 10 Base shear for Composite frame

Composite Model	
Storey No	Base shear in kN
8	130.18
7	242.27
6	324.62
5	381.81
4	418.41
3	438.99
2	448.14
1	450.43
Base	450.43

Table 11 Shear force in frames

Maximum shear force in storey beams in kN			
Number of Storey	RCC Frame	Steel frame	Composite frame
Storey 1	429.0247	1118.9464	575.5123
Storey 2	439.033	1197.0979	598.8864
Storey 3	446.33	1249.6885	611.8866
Storey 4	452.51	1293.7607	623.8185
Storey 5	457.44	1328.505	633.501
Storey 6	460.85	1351.646	638.5872
Storey 7	465.5	1388.3839	653.8197
Storey 8	453.69	1250.5305	601.1333

V. CONCLUSION

Following are few conclusions from Model Analysis with Results using ETABS2015.

Following factors be considered to decide structural suitability. Seismic performance of the structure, Deflections, Storey drift, Base shear, Resultant Forces, Moments, Weight and Cost effectiveness of framed structures.

- Overall response of composite structure is better than RCC and Steel structure. i.e. composite structure produces less displacement and resists more design actions.
- Composite structures are best suitable for high rise buildings and they are resulted in speedy construction.
- Steel frame option is better than RCC but the composite frames option for high rise building is best.
- Lateral displacement of top story of Composite frame is 17% lesser than steel frame and 15 % more than RCC frame in X direction
- Lateral displacement of top story of Composite frame is more than steel frame and RCC frame which is equal to 15% in Y direction
- Maximum story drift of third story of Composite frame is 11.17% lesser than steel frame and 55 % more than RCC frame in X direction
- Maximum story drift of third story of Composite frame is more than both Steel and RCC frame which is equal to 13% and 19.50% respectively in Y direction
- Base shear for Composite frame is 84% less than RCC frame and 16% more than steel frame.

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