Comparative Static Analysis of R.C.C and Composite Frame

Dr. S. H Mahure
Head of Dept.
Department of Civil Engineering
Babasaheb College of Engineering, Pusad, India

Abstract— Composite construction posses lesser cost, speedy construction, fire resistance, high durability and superior seismic performance characteristics than RC structures. In this study an attempt has been made to analyze, compare seismic performance of six storey (G+5) RCC and Composite Institutional building situated in seismic zone IV. Equivalent static method is preferred for seismic analysis and ETABS is used for modeling, analyzing the structures. Analytical results are compared to achieve the most suitable resisting system and economic structure against the seismic forces. On the basis of analysis and comparison it is proved that steel concrete composite building is better option.

Key words: RCC, Composite Structures, Static Analysis

I. Introduction

The performance of building during an earthquake depends upon several factors, such as stiffness, ductility, lateral strength and Simple and regular configuration. Concrete structures are bulky and impart more seismic weight and less deflection whereas Steel structures instruct more deflections and ductility to the structure, which is beneficial in resisting seismic forces. In such circumstances, 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.

A. *Objectives of the research*

The objectives of the research are:

- To analyze and compare seismic performance of (G+5) storey RCC and Composite institutional building situated in seismic zone IV.
- To provide a brief description to various components of steel-concrete composite framing system for buildings.
- To compare the analytical results of RCC and composite building models such as maximum displacement, story drift, storey shear.
- To compare the cost effectiveness of steel-concrete composite frame over traditional R.C.C frame**.**
- Equivalent static method is preferred for seismic analysis and ETABS is used for modeling and analyzing the structures.

II. Composite construction

Composite structures can be defined as the structures in which composite sections made up of two different types of materials such as steel and concrete are used for beams, and columns. Numbers of the studies are carried out on composite construction techniques by different researchers in different parts of the world and found it to be better earthquake resistant and more economical as compared to RCC construction.

A. *Elements of Composite Construction*

The primary structural component used in composite construction consists of the following elements.

- Composite slab
- Composite beam
- Composite column
- Shear connector

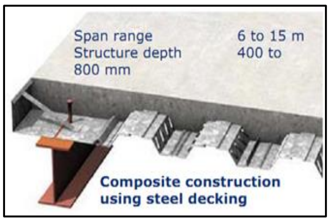

Fig. 1: Composite Construction Using Steel Decking

1) *Composite Slab*

Traditional steel-concrete floors consist of rolled or built-up structural steel beams and cast in-situ concrete floors connected together using shear connectors in such a manner that they would act monolithically .The principal merit of steel-concrete composite construction lies in the utilization of the compressive strength of concrete slabs in conjunction with steel beams, in order to enhance the strength and stiffness of the steel girder.

More recently, composite floors using profiled sheet decking have become very popular in the West for high rise office buildings. Composite deck slabs are particularly competitive where the concrete floor has to be completed quickly and where medium level of fire protection to steel work is sufficient. However, composite slabs with profiled decking are unsuitable when there is heavy concentrated loading or dynamic loading in structures such as bridges. The alternative composite floor in such cases consists of reinforced or pre-stressed slab over steel beams connected together to act monolithically.

2) *Composite Beam*

A steel concrete composite beam consists of a steel beam, over which a reinforced concrete slab is cast with shear connectors. In conventional composite construction, concrete slabs rest over steel beams and are supported by them. Under load these two components act independently and a relative slip occurs at the interface if there is no connection between them. With the help of a deliberate and appropriate connection provided between them can be eliminated.

3) *Composite column*

A steel concrete composite column is a compression member, comprising either of a concrete encased hot rolled steel section or a concrete filled hollow section of hot rolled steel. It is generally used as a load bearing member in a composite framed structure. Composite columns with fully and partially concrete encased steel sections concrete filled tubular section are generally used in composite construction.

Fig. 2: Typical encased composite column section

4) *Shear Connectors*

The total shear force at the interface between concrete slab and steel beam is approximately eight times the total load carried by the beam. Therefore, mechanical shear connectors are required at the steel-concrete interface. These connectors are designed to (a) transmit longitudinal shear along the interface, and (b) Prevent separation of steel beam and concrete slab at the interface.

Following are the commonly used types of shear connectors as per IS: 11384-1985

– Rigid shear connectors,
– Flexible shear connectors
– Anchorage shear connectors

Fig. 3: Types of Shear Connectors

III. Building Description

The building selected for the study is an Institutional building having G+5 storied which is located in seismic zone IV. The plan and elevation of building is shown in Fig.4 and 5.The dimension of the building is 24m x 15m, and total height of the building is 20.5 m. The study is carried out for R.C.C and Composite building. Other relevant data is tabulated in Table 1 and 2.

Plan dimension	24m x 15m
Total height of building.	20.5m.
Height of story	3.5m
Height of parapet	1.0m
Depth of foundation	3.0m
Size of beams 6.0 m span	230mm x 600mm
Size of beams 5.0 m span	230mm x 520mm
Size of beams 4.0 m span	230mm x 450mm
Size of beams 3.0 m span	230mm x 380mm
Size of outer columns	450mm x 650mm
Size of internal columns	450mm x 680mm
Thickness of slab	150mm
Thickness of internal & external walls	230mm
Seismic zone	IV
Soil condition	medium soil
Importance factor	1
Zone factor	0.24
Live load at roof	2.0 KN/m^2
Floor finishes	1.0 KN/m^2
Live load at all floors	4.0 KN/m^2
Grade of concrete	M30
Grade of reinforcing steel	Fe415
Density of concrete	25 KN/m^3
Density of brick	20 KN/m^3
Damping ratio	5%

Table 1: Data for Analysis of R.C Structure

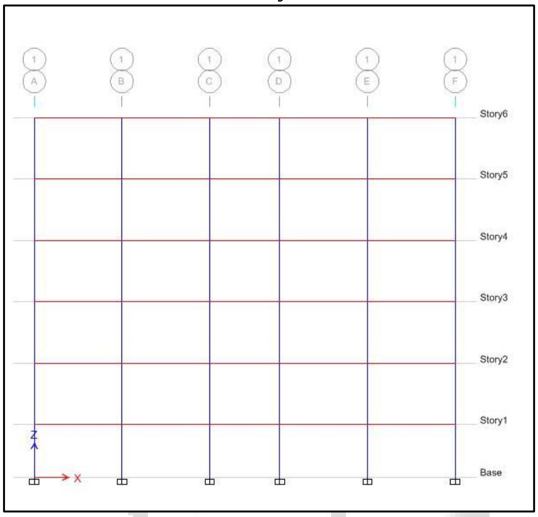

Fig. 4: Elevation

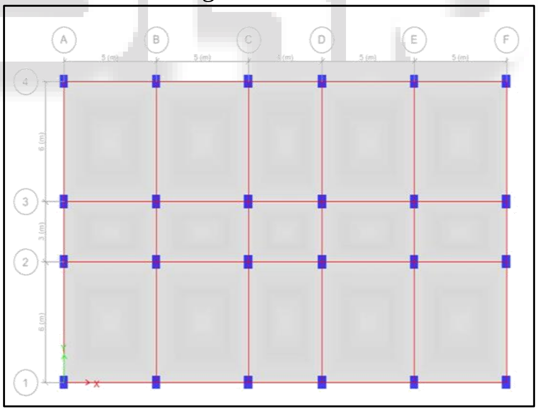
Fig. 5: Plan

Plan dimension	24m x 15m
Size of Main beams	ISMB 200
Size of secondary beams	ISLB 200
Size of outer columns	300mm X 350mm (ISMB 200)
Size of internal columns	300mm X 350mm (ISMB 200)
Thickness of slab	150mm
Thickness of internal & external walls	230mm
Seismic zone	IV
Soil condition	Medium soil
Importance factor	1.0
Zone factor	0.24
Live load at roof	2.0 KN/m^2

Floors finish	1.0 KN/m^2
Live load at all floors	4.0 KN/m^2
Grade of concrete	M30
Grade of reinforcing steel	Fe415
Density of concrete	25 KN/m^3
Density of brick	20 KN/m^3
Damping ratio	5%

Table 2: Data for Analysis of Composite Structure.

IV. ANALYSIS

The Three Dimensional (3D) building model is analysed using Equivalent Static Method, with the software E TABS. Different parameters such as Story drift, displacement, story shear are found for both the models of RCC and composite structures. IS 1893 (PART-1): 2002 is used for calculating seismic design forces.

V. RESULTS AND DISCUSSION

In the present study, analysis of RCC and composite building using ETABS has been carried out. And the maximum displacement, story drift, story shear and period of vibration of both RCC and composite building is obtained.

A. Maximum Displacement

Fig.10 and 11 shows the maximum displacement results along X and Y direction of RCC building and composite building. From the graphs it was observed that maximum displacement along X direction is more than Y direction.

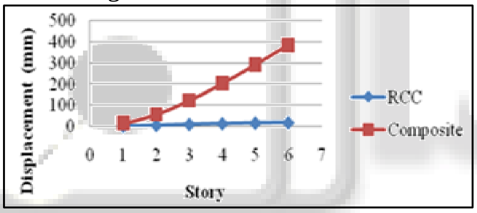

Fig. 10: Story vs. Displacement in X Direction.

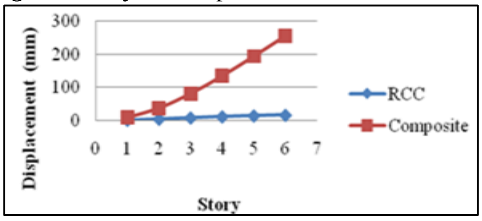

Fig. 11: Story vs. Displacement in Y Direction.

B. Story Drift

Fig.12 and 13. Presents the story vs. Story drift graph of RCC and composite building. From the graphs it was observed that, the maximum story drift along X and Y-direction for RCC building is more for composite building. RCC building has the lowest values of story drift because of its high stiffness.

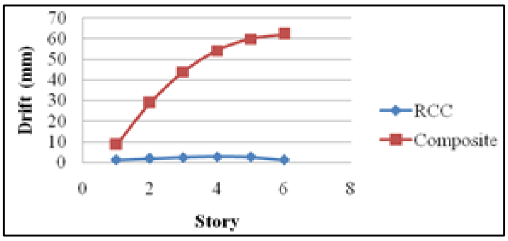

Fig. 12: Story vs. Story Drift in X Direction

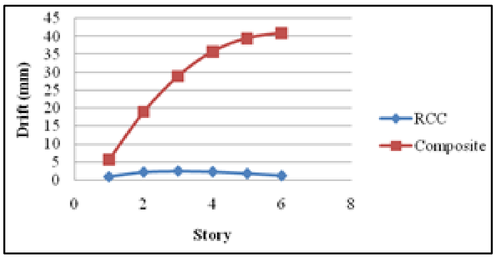

Fig. 13: Story vs. Story Drift in Y Direction.

C. Maximum Story shear

Fig.14 and 15 shows the story shear results along X and Y direction of RCC building and composite building. It was observed that Story shear for RCC building is maximum because the weight of the RCC building is more than the composite building.

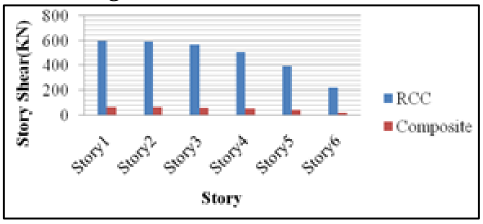

Fig. 14: Story vs. Story shear Along X Direction.

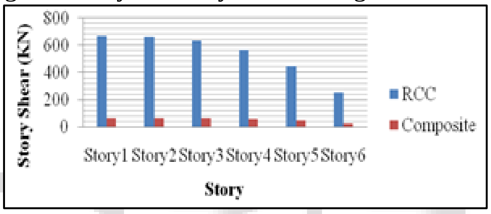

Fig. 15: Story vs. Story shear along Y Direction

D. Cost Comparison Analysis

Table 3 and 4 shows the cost of composite and RCC building. It is observed that cost of composite building is less than RC building because composite building required lesser sizes of members as compare to RCC building. And the difference between the cost of RCC and composite building is found as Rs.1, 80,252/-

Material	Quantity Used	Rate of material	Amount
Structural Steel (kg)	29125.4	Rs-50/kg	Rs-14,56,270
Reinforcing bar (kg)	3463.7	Rs-40/kg	Rs-1,38,548
Concrete used (m3)	51	Rs-5000/m3	Rs-2,25,000
Total Sum			Rs-18,19,818/-

Table 3: Composite Frame Structure

Material	Quantity Used	Rate of material	Amount
Reinforcing bar (kg)	10207.74	Rs-40/kg	Rs-4,70,889.6
Concrete used (m3)	305.84	Rs-5000/m3	Rs-15,29,180
Total Sum			Rs-20,00,070/-

Table 4: RCC Frame Structure

Reduction Factor for Composite = Cost of Composite/Cost of RCC

= 18, 19,818/20, 00,070 = 0.91

Hence, reduction in cost of composite frame is 9% compared with cost of RCC frame. This involves material cost only and doesn't include fabrication cost, transportation cost, labour cost etc.

VI. Conclusions

From the analysis and design of RCC and composite building, it is concluded that,

- The floor displacement is maximum for composite building as compared to RCC building. RCC building has the lowest values of displacement because of its high stiffness.
- Story drift in Equivalent Static Analysis along X and Y direction is more for Composite building as compare to RCC building.
- RCC frame has the lowest values of story drift because of its high stiffness.
- The differences in story drift for different stories along X and Y direction are owing to orientation of column sections. Moment of inertia of column section is different in both directions.
- Story shear for RCC building is maximum because the weight of the RCC building is more than the composite building. Story shear gets reduced by 89.15 % in X-direction and 90.3 % in Y-direction for Composite building in comparison with the RCC building.
- Composite building takes more period of vibration in comparison with RCC building, as composite building is more ductile than RCC building.
- Reduction in cost of Composite frame is 9% compared with cost of RCC frame. This involves material cost only and doesn't include fabrication cost, transportation cost, labour cost etc.

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