Study of Seismic and Wind Effects on Multistorey R.C.C, Steel and Composite Materials Buildings using ETABS

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***Abstract:* - ETABS software is used for analysis, its main objective is comparison of seismic behaviour of 3 types of multi-storey framed structures consisting of R.C.C framed structure, Steel frame with deck, Steel beam deck and concrete filled steel tube (CFST) composite columns. Base shear, displacement, storey drift, column forces and beam forces will be compared and studied. To study the performance point and performance level of the considered building equivalent static and response spectrum analysing will be considered .The results are compared and conclusions are made for all types of structures and to identify the most suitable type of structure for seismic action. The methodology is the type of structure G+ 18 storied framed Multi-storey structure for assumed grids of R.C.C, Steel and Composite. Concrete framed structure is taken as reference and compared with composite and steel structure. The building frame is assumed to be ordinary moment resisting frame (OMRF).The connections at the joints are assured to be simple moment resisting. Seismic analysis by equivalent lateral force method and response spectrum is to be classified as per IS1893: 2002 code provisions .Analysis is to be carried out for the one possible location of structure in Zone 4 for the design of composite column the design provision of euro code (EC4) are adopted. Steel columns are designed as per IS800 2007 codal provisions 2 alternative structures are compared with the, base shear, storey drifts, storey overturning moments and roof displacements.**

***Keywords:* ETABS, Steel frame with deck, Steel beam deck and concrete filled steel tube (CFST) composite columns. Response spectrum, Seismic analysis IS1893: 2002**

1. INTRODUCTION

The reinforced concrete structures are mostly used from many decades because of its stiffness, most convenience, high durability and ease to construct. The RCC structures are more suitable for low rise structure but for medium to high rise structures it is no longer economical because of large dead load, less susceptible, span restriction and complex formwork. , for that multi story structures are best option for construction in metropolis cities where less land is available. Because multi story structure provides large floor area in small land area. Therefore, it is essential to construct high rise buildings. If high rise buildings are constructed than many structural problems arise, such as lateral load effect, lateral displacement and stiffness etc. Generally for high rise structure wind and earth quake load effects are dominant. Therefore for high rise buildings it is essential to have knowledge of various loads and its effect on buildings. The effect of lateral load is very important to consider such as earthquake and wind loads.In some cases the wind load is dominant than earthquake load which depends on area and zone factor defined by codes. But nowadays steel-concrete composite systems have become quite popular in recent times because of their advantages against conventional construction. Composite construction combines the better properties of the both i.e. concrete in compression and steel in tension, they have almost the same thermal expansion and results in speedy construction.

The objectives of the study are

- To provide a brief description to various components of steel-concrete composite framing system for buildings.
- To compare the analytical results of all three buildings models such as storey displacement, nodal displacement, maximum axial force, and maximum shear force and bending moments etc.

1.1. Background

Steel-concrete composite construction means steel section encased in concrete for columns & the concrete slab or profiled deck slab is connected to the steel beam with the help of mechanical shear connectors so that they act as a single unit. It can also 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

2. Elements of composite construction

The primary structural components use in composite construction consists of the following elements.
1 Composite slab
2 Composite beams
3 Composite columns
4 Shear connector

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 high rise buildings.

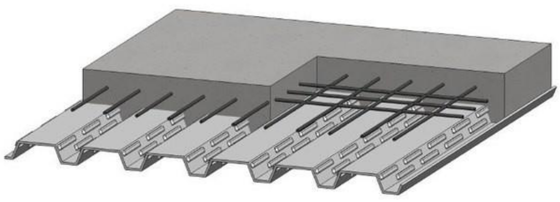

Fig 1: Typical Composite Beam Slab Details

. Advantages of using composite floors with profiled steel decking are
 Savings in steel weight are typically 30% to 50% over non-composite construction.
 Greater Stiffness of composite beams results in shallower depths for the same span. Hence lower storeys heights are adequate resulting in savings in cladding costs, reduction in wind loading and savings in foundation costs.
 Faster rate of construction

2 Composite Beams 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 columns 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.

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.

3. Methodology

The structure is analyzed by using E-tabs software for steel, RCC as well as composite structures.

Design of beam and column section:

1. The frame is analyzed with dead load and live loads for RCC sections.
2. The maximum forces in the sections are determined from the output file.
3. The sections are designed manually for these forces in steel rcc and composite structures.
4. IS-codes IS-456-2000, IS-800-2007 and AISC LRFD 1999 are used

Analysis of sections:

1. Each type of frame is analyzed separately by using equivalent static method.
2. The analysis is conducted for IS-1893(Part-1) 2002 specified combinations of loadings.

4. Comparison of results. The results obtained are compared in terms of base shear, storey drifts, storey deflections, modal participation factors etc.

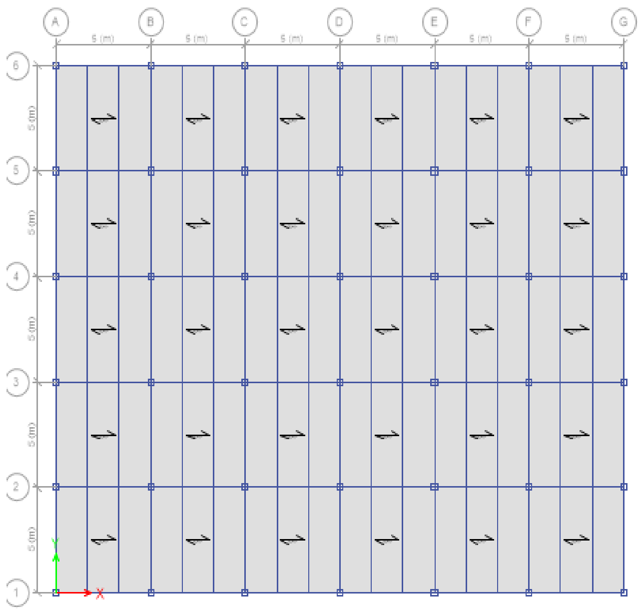

Fig 2: plan of a building (G+18)

Table 1: Material Properties

Grade of Concrete	M25
Grade of Reinforcing steel	Fe 500
Grade of Structural steel	Fe 345
Density of Concrete	25 KN/m³
Density of Brick masonry	20 KN/m³
Damping ratio	5%

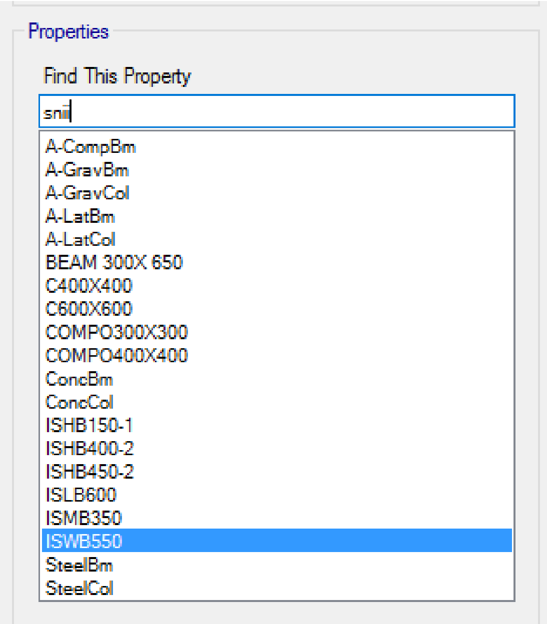

Fig 3: sectional properties

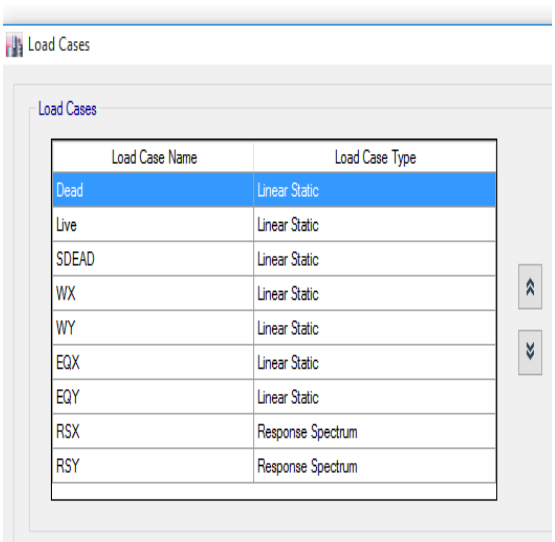

Fig 4: load cases considered

2. ANALYSIS

The explained 3D building model is analyzed using Equivalent Static Method. Different parameters such as deflection, shear force & bending moment are studied for the models. Seismic codes are unique to a particular region of country. In India, Indian standard criteria for earthquake resistant design of structures IS 1893 (PART-1): 2002 is the main code that provides outline for calculating seismic design force. Wind forces are calculated using code IS-875 (PART-3) & SP64.

Floor load	1 KN/m²
Live load	4 KN/m²
Wall load	12 KN/m²
Basic wind speed	50 m/s
Risk coefficient (K1)	1
Topography factor (K3)	1
Wind design code	IS 875:1987 (Part 3)
RCC design code	IS 456:2000
Steel design code	IS 800:2007
Composite design code	AISC-360-10

Fig 5: specification of loading

Table No. 1 : Wind Load Combination		
Sr. No.	Name	Load Combination
1	1.5DL+1.5LL	1.5 x (Dead load + Live load)
2	1.5DL+1.5WL	1.5 x (Dead load + Wind load in Y direction)
3	1.5DL-1.5WL	1.5 x (Dead load - Wind load in Y direction)
4	1.2DL+1.2LL+1.2WL	1.2 x (Dead load + Live load + Wind load in Y direction)
5	1.2DL+1.2LL-1.2WL	1.2 x (Dead load + Live load - Wind load in Y direction)
6	0.9DL+1.5WL	0.9 x Dead load + 1.5 x Wind load in Y direction
7	0.9DL-1.5WL	0.9 x Dead load - 1.5 x Wind load in Y direction

Table No. 2 : Seismic Load Combination		
Sr. No.	Name	Load Combination
1	1.5DL+1.5LL	1.5 x (Dead load + Live load)
2	1.5DL+1.5EQX	1.5 x (Dead load + Earthquake in X direction)
3	1.5DL-1.5EQX	1.5 x (Dead load - Earthquake in X direction)
4	1.5DL+1.5EQY	1.5 x (Dead load + Earthquake in Y direction)
5	1.5DL-1.5EQY	1.5 x (Dead load - Earthquake in Y direction)
6	1.2DL+1.2LL+1.2EQX	1.2 x (Dead load + Live load + Earthquake in X direction)
7	1.2DL+1.2LL-1.2EQX	1.2 x (Dead load + Live load - Earthquake in X direction)
8	1.2DL+1.2LL+1.2EQY	1.2 x (Dead load + Live load + Earthquake in Y direction)
9	1.2DL+1.2LL-1.2EQY	1.2 x (Dead load + Live load - Earthquake in Y direction)
10	0.9DL+1.5EQX	0.9 x Dead load + 1.5 x Earthquake in X direction
11	0.9DL-1.5EQX	0.9 x Dead load - 1.5 x Earthquake in X direction
12	0.9DL+1.5EQY	0.9 x Dead load + 1.5 x Earthquake in Y direction
13	0.9DL-1.5EQY	0.9 x Dead load - 1.5 x Earthquake in Y direction

Fig 6: load combinations

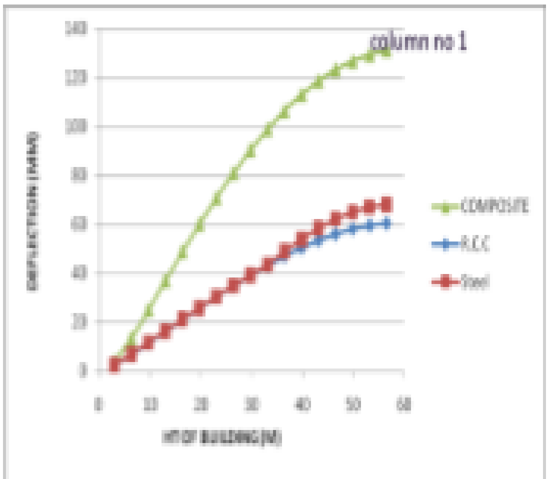

Fig 7: comparison of deflection

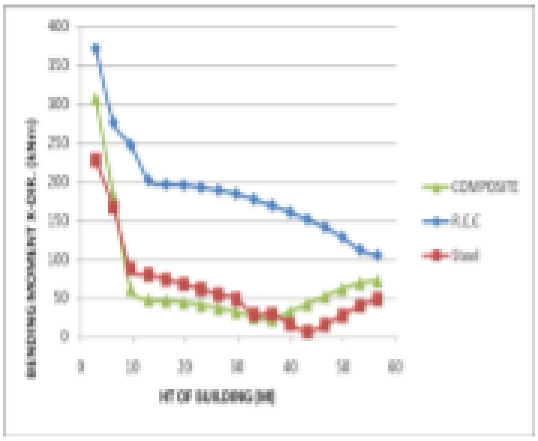

Fig 8: Bending moment in x direction

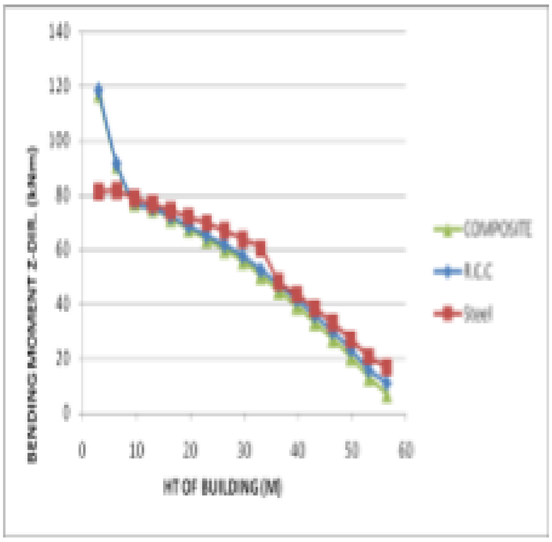

Fig 9: Bending moment in z direction

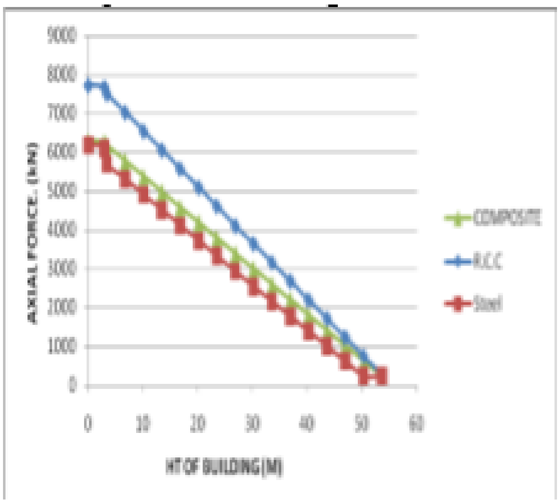

Fig 10: comparison of axial force

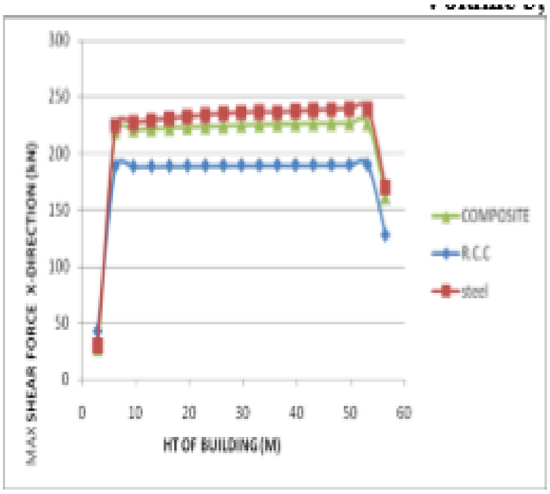

Fig 11: comparison of shear force in x direction

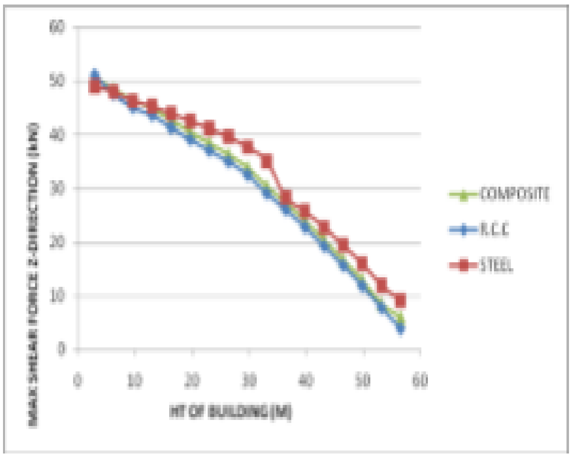

Fig 12: comparison of shear force in z direction

3. CONCLUSION

1. We can conclude the beam S.F. & B.M. is more in the RCC, STEEL & Composite building. But, when we use the composite beam the forces are reduced due to the reduced the section.S.F. & B.M. is increase due to the member size increase and self-weight because forces are increase in the member.

2. Displacement is within the limits for all building RCC, STEEL and COMPOSITE. Critical displacement for WIND is 129, EQ. ZONE-III is 58 & EQ. ZONE-IV is 87 is which is less than the permission limits.

3. Support reaction is maximum in the RCC building in the WIND, EQ. ZONE-III and EQ. ZONE-IV type building.

4. Base shear forces more in the RCC building. Means wind forces more compare to the Earthquake.

5. Composite steel-concrete is relatively a new design concept in the Indian context and no appropriate updated codes are available for the design of same. The present work not only eliminates the costly experimentation required but also facilitates design with multiple options for the steel sections and shear connectors with adequacy checks.

6. Keeping span and loading unaltered, smaller structural steel sections are required in composite construction compared to non-composite construction. This reduction in overall weight of the composite structure compared to other structure results in less cost of structure and foundation.

7. Comparison of beam & column cost for all buildings shows that under the effect of wind force there is percentage average reduction in cost at about 48.83 % w.r.t. R.C.C building structure, similarly, for EQ. ZONE - III there is percentage average reduction in cost at about 53.00 % w.r.t. R.C.C building structure and similarly, for EQ. ZONE - IV there is percentage average reduction in cost at about 46.67 % w.r.t. R.C.C building structure.

8. Comparison of all models buildings shows that composite buildings are more economic for all other buildings structure.

9. We conclude from models of various building in which R.C.C. building subjected to the wind is most critical case.

4. 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.

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