Comparative Study of Seismic Responses of RCC, Steel and Mix Construction

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Abstract— Structural engineers are facing the challenge of striving for the most efficient and economical design solution while ensuring that the final design of a building must be serviceable for its intended function, habitable for its occupants and safe over its design life-time. A Building of mixed Construction , in which the Structure is partly concrete and partly Structural Steel have been built for many years in many parts of the world. In general, this type of construction consists of either steel frames with concrete encasement or structure in which shear wall, tube frame, or other major components are concrete while the remainder of the framing is steel. A New form of mix construction in which five stories steel structure is stacked on top of a five story concrete structure. A RCC medium rise building of 10 stories with floor height 3.5m subjected to earthquake loading in V Zone has been considered. The variation of seismic response of mix construction building depending on various analysis methods namely Equivalent static method, Response spectra method and Time history method are evaluated and compared. This study examines G+10 stories buildings of R.C.C., Steel, & Mix Construction are analyzed and design under effect of wind and earthquake using ETABS. All three models are analyzed & designed by response spectra analysis & it proves that Mix Construction Frame building is satisfied the all result. Analytical results are compared to achieve the most suitable resisting system & economic structure against the lateral forces.

Key words: Mix construction, RCC, Steel structure, Horizontal displacement, Earthquake Force, E-tabs

I. Introduction

India mostly RCC structural member are used and for low rise building they seems to be the most convenient and economic construction. But use of reinforced concrete in case of high rise building is not suitable because of the increased dead load; span restrictions, cost of construction and even the time required is more. To overcome this, structural engineers nowadays are using different materials for construction of high rise building. Steel is being used as an alternative construction material especially when we are dealing with the earthquake and wind forces.

In the past for the design of a building the choice was normally between a concrete structure and a steel structure. Looking at recent practice there is an evident tendency that designers also consider the combined use of concrete and steel in the form of composite or mixed structures as a serious alternative. Use of composite elements in the form of composite beams, composite columns and composite slabs is already common practice in many countries. However, this supporting material is not available for mixed constructions where (reinforced or prestressed) concrete elements and structural steel elements are used in combination. So the designer has to develop design models based on a creative interpretation of methods and rules in use for concrete and steel

In recent years, mixed Construction or hybrid structure system has been increased developed and utilized to build super high-rise buildings in China. So, mixed Construction has notable advantage in decreasing self-weight, reducing section size of structural members, and accelerating construction progress. Many domestic researchers (David O'Connell et al., 2015; R. Shankar Nair et al., 1996) have done research on it. From their work, conclusions can be drawn that by proper design the mixed Construction has well seismic performance. This paper introduces seismic design of a mixed Construction on a background of project. As we all known, high-rise building is complex system engineering, which involving beauty, safety, and economy. According to the site condition of the region building located, and considering both performance and engineering cost, we choose the mixed Construction system. In detail, five stories steel structure is stacked on top of a five story concrete structure has been considered.

II. Brief Literatura Review

The study the Steel-concrete composite, steel and R.C.C. options are considered for comparative study of G+30 storey commercial building which is situated in earthquake zone IV[1]. Equivalent Static Method of Analysis is used. For modeling of Composite, Steel and R.C.C. structures, ETABS software is used and the results are compared; and it is found that composite structure is found to be more economical. Steel and composite structure gives more ductility to the structure as compared to the R.C.C. which is best suited under the effect of lateral forces. Total saving in the composite option as compared to the R.C.C. results in 10 % so as with Steel it will be 6-7%.

The paper discusses the analysis & design procedure adopted for the evaluation of symmetrical high rise multi-storied buildings G+10, G+15 and G+20 under effect of Wind and Earthquake forces [2]. In these buildings, R.C.C. and Steel are considered to resist lateral forces resisting system. New types of construction techniques are introduced which include steel structures, in which beams and columns are made of pre-fabricated steel sections. The changes in the method adopted for construction influences various parameters of the building. These changing aspects can be studied by modeling the multi-storied building under the effect of seismic and wind forces respectively and comparing various parameters like the displacements in the building, column forces and moments generated in the building. This study examines G+10, G+15 and G+20 storied buildings using STAAD.ProV8i. Total 12 numbers of various models are analyzed & designed & it proves that steel building is better option. Analytical results are compared to achieve the most suitable resisting system.

A new form of mixed construction is represented by a 70-story building in Chicago in which a 40-story concrete structure will be stacked on top of a 30-store steel structure [3]. Tall buildings of mixed or Hybrid construction, in which the structure is partly concrete and partly structural steel, have been built for many years in many parts of the world. in general, this type of construction consists of either steel frame with concrete encasement or structures in which shear walls, tube frames, or other major components are concrete while the remainder of the framing is steel. The multiple-use development under construction at 900 North Michigan Avenue in Chicago will have a total of 186 thousand m2of retail, office, hotel apartment (condominium), and service space. The residential uses will be housed in a concrete structure, which will be seated on top of a steel structure that will house the other uses. This unusual configuration results in an efficient structure and provides optimum floor sizes and locations for each use.

III. METHODOLOGY

A. *Structural Modelling*

A RCC medium rise building of G+10 stories subjected to earthquake loading in Zone V has been considered. In this regard, ETABS software have been considered as tool to perform. Displacements and Story drift have been calculated for three different models. The Lateral Force at every Floor Level is Calculated Using Response Spectrum method, IS 1893(Part 1):2002.

Three different models have been taken for analysis

1) Model M1- RCC Frame
2) Model M2- Steel Frame
3) Model M3- Mix Construction

B. *Structure Definition*

A medium rise building G+10 story building with a 3.5-meters height for each story, regular in plan. A New form of mix construction in which five stories steel structure is stacked on top of a five story concrete structure is investigated. This building consists of five spans of 5-meter in X direction and four spans of 5-meter spans in Y direction. Gravity loads on the floors of the building are considered, consisting in 4 kPa live load and 1.5 kPa floor finish load. Concrete compressive strength is 25 MPa, and yielding strength of steel is 500 MPa.

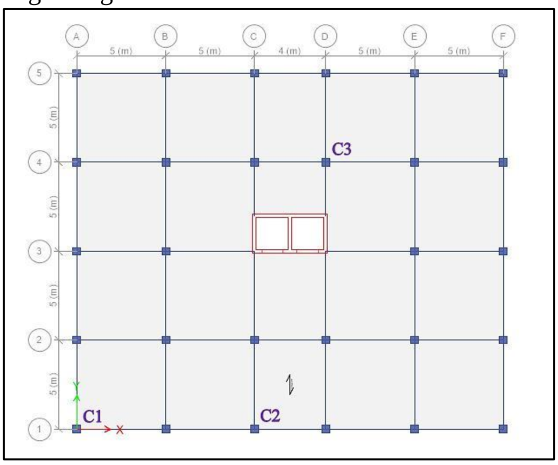

Fig. 1: Typical Structural Plan

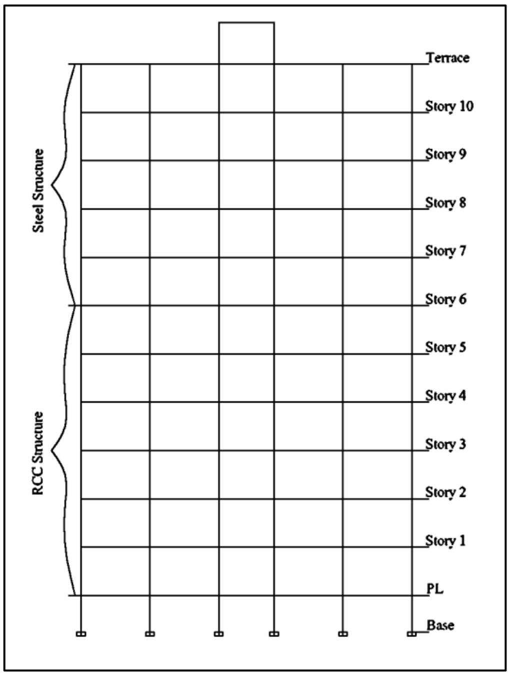

Fig. 2: Typical Structural Elevation

IV. RESULTS AND DISCUSSION

The structures having G+10 storeys are analysed for gravity and lateral loads. The effect of Displacement and storey drift are observed for different stories. The analysis is carried out using ETABS and data base is prepared for different storey levels as follows.

A. *Lateral Displacement*

Lateral displacement for all model in both direction are as shown in Fig. 3and Fig. 4

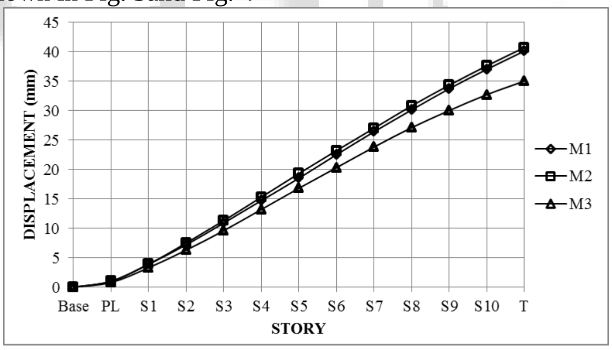

Fig. 3: Displacement in X direction

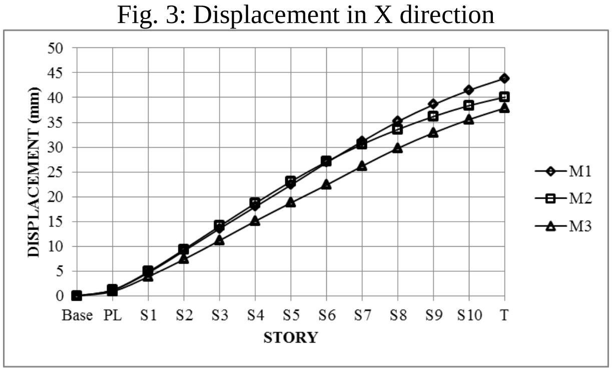

Fig. 4: Displacement in Y direction

The graphical representation of storey displacements results obtained from the analysis of building under consideration are shown in the figure 3and figure 4. The graph shows that the values of storey displacements, in both the directions are varying in similar pattern which is maximum at the top.

Also from the graphs it is observed that the values of storey displacements in X direction for model of M3 are less by 15% and 16% and also in Y direction for model of M3 are less by 16% and 6% as compared to model M1and M2 respectively.

B. Story Drift

Drift is the maximum lateral displacement of the structure with respect to total height or relative inters storey displacement. Drift have three primary effects on a structure; the movement can affect the structural elements (such as beams and columns); non-structural elements (such as the windows and cladding); and adjacent structures. Without proper consideration during the design process, large deflections and drifts can have adverse effects on structural elements, nonstructural elements, and adjacent structures.

$$\text{Story Drift ratio} = \frac{\text{Difference between displacement of two stories}}{\text{height of one story}}$$

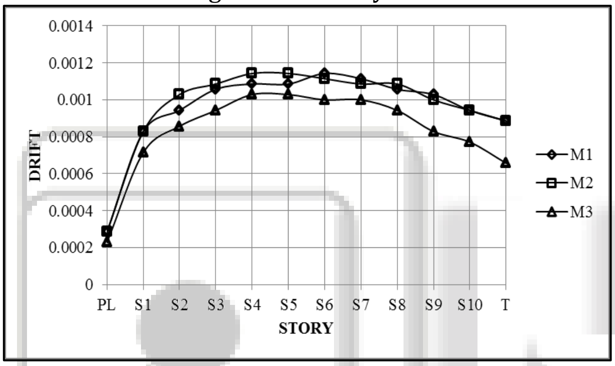

Fig. 5: Drift in X direction

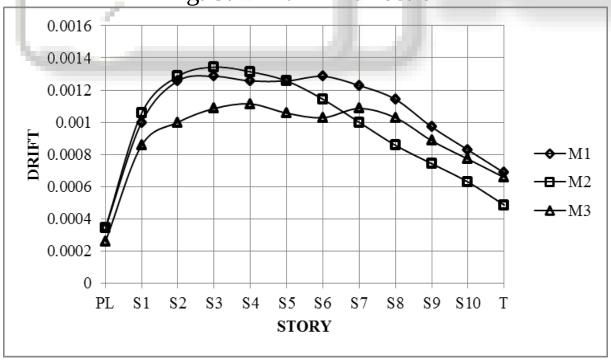

Fig. 6: Drift in Y direction

AS per IS: 1893-2002 maximum storey drifts should not be more than 0.004 times to storey height of the structure. From the figure it is observed that the values of the Storey drifts for all the stories are found to be within the limits.

From the Figure 5 and figure 6 observed that the story drift is maximum at story 4 in x-direction and at story 3 in y-direction .It is observed that the drift is less in model M3 as compared with model M1 and M2.

C. Story Shear

Storey shear is minimum in M3. It should be noted that the Storey shear in model M3 is about 14 to 29% less than other models.

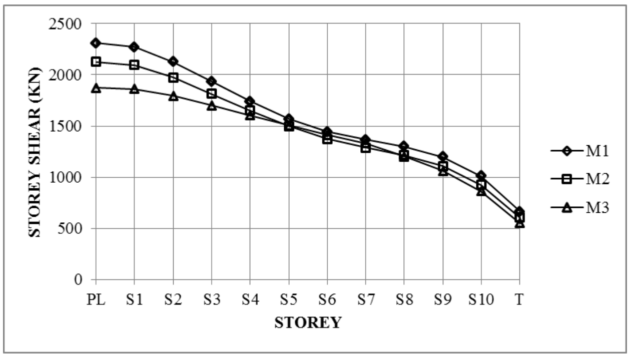

Figure 7: Storey Shear in X direction

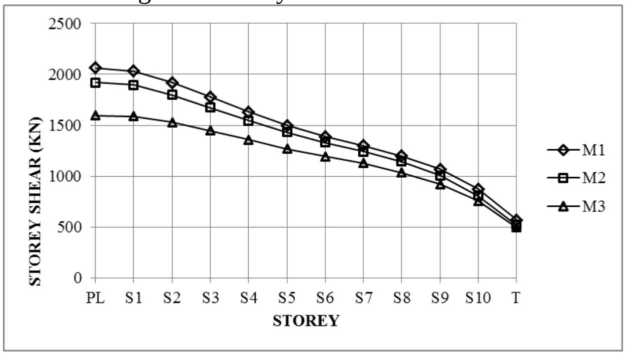

Fig. 8: Storey Shear in Y direction

D. Maximum Forces

The maximum forces in columns C1, C2 and C3 are presented. Column C1 and C2 is outer column whereas C3 is located inside the building. It is observed from the results that the bending moments are dependent on the distance of mass concentration. The bending moment in C1, C2 and C3 is found to be more in model 1(M1) along longitudinal direction and bending moment in column C1, C2 and C3 is found to be more in model M3 in transverse direction. The Shear force in C1 and C3 is found to be more in model 2(M2) and Shear force in column C2 is found to be more in model M1 along longitudinal direction and Shear force in column C1and C3 is found to be more in model M1 and Shear force in column C2 is found to be more in model M2 in transverse direction. It is seen that the model M3 is having less shear force and bending moment than other two models.

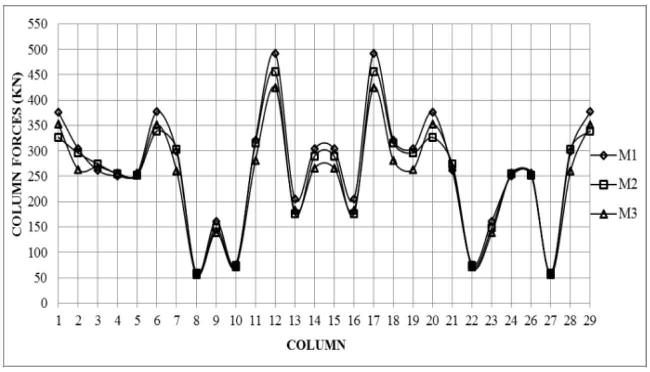

Fig. 9: Column forces

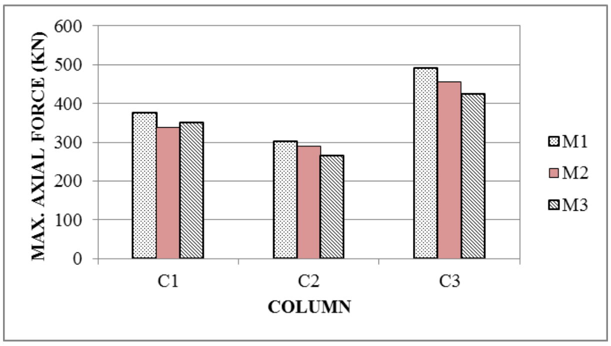

Fig. 10: Max. Axial Force

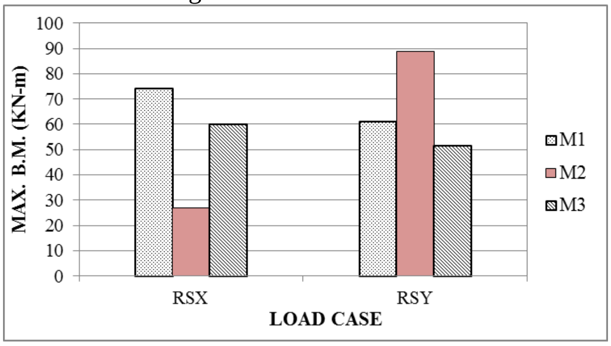

Fig. 11: Max. Bending Moment in Column C1

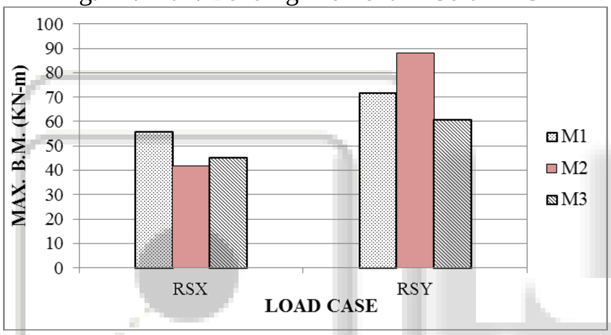

Fig. 12: Max. Bending Moment in Column C2

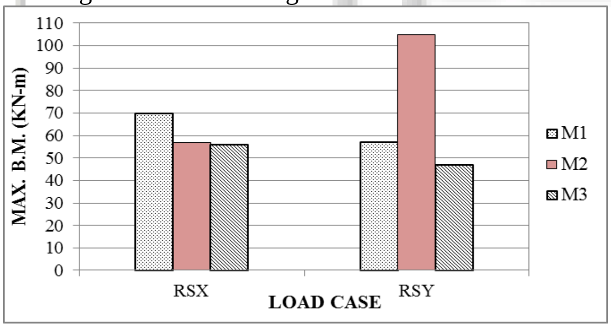

Fig. 13: Max. Bending Moment in Column C3

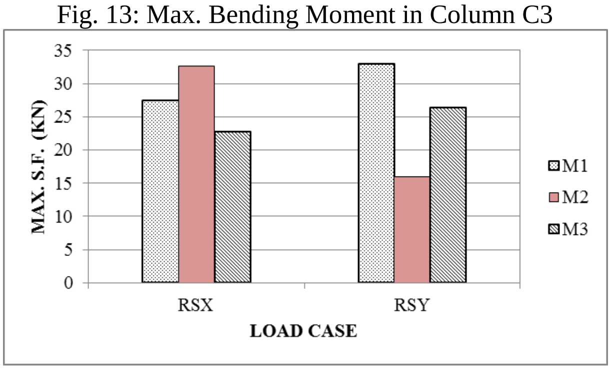

Fig. 14: Max. Shear Force in Column C1

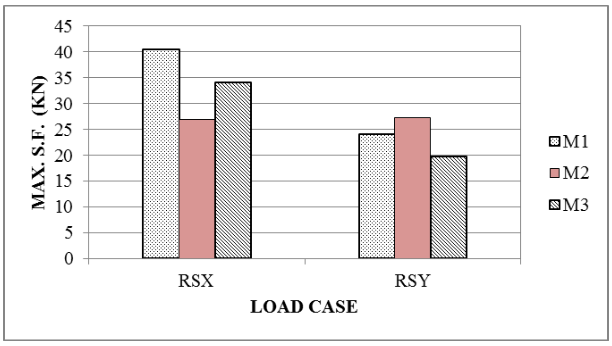

Fig. 15: Max. Shear Force in Column C2

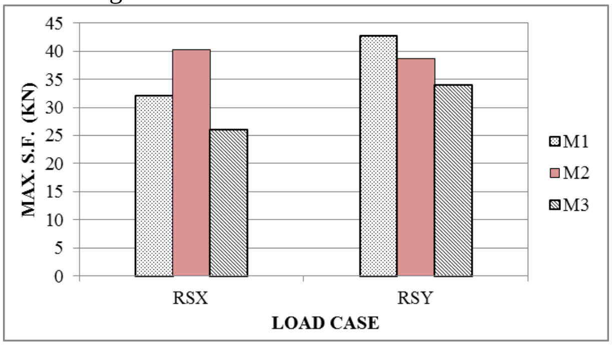

Fig. 16: Max. Shear Force in Column C3

V. Conclusion

From the above results and discussions, following conclusion are drawn from present work:

1) For medium to high rise frames, RCC Structure can provide sufficient lateral strength and deformation capacity under strong shaking as Compare to Steel Structure.
2) Mix construction can reduce residual lateral displacements as compare to RCC and Steel.
3) Variation of storey drift with storey is non-linear.
4) A very good control over displacement, drift, can be achieved by using mix construction in which five stories steel structure is stacked on top of a five story concrete structure.
5) The large effect of earthquakes occurs in the lower stories as compare to above stories. Hence, a sudden decrease in lower story strengths should be carefully controlled by providing Mix construction.
6) Mix Construction Frame building is satisfied the all result.

References

[1] Avani Mandlik and S K Sharma, "Behaviour of Symmetrical RCC and Steel Framed Structures Under Seismic and Wind Loading" IJRSI, Volume 03, Issue 08, August 2016, Indore.

[2] Tabassum G Shirhatti and Dr. S. B. Vanakudre, "The effects of p-delta and construction sequential analysis of rcc and steel building with respect to linear static analysis" IRJET, Dharwad, Karnataka.

[3] R. Shankar Nair in his, "Second Century of the Skyscraper" Chapter: A Tall Building of Stacked Steel and Concrete Structure, pg 353-360

[4] D. R. Panchal and P. M. Marathe, "Comparative Study of R.C.C, Steel and Composite (G+30 Storey)

Building" NUiCONE, 08-10 December, 2011, Ahmedabad.
[5] Nair R. S., 1975a "Linear Structural Analysis of Multi-storey Building" Journal of structural division, ASCE, March.
[6] Bureau of Indian Standards: IS-1893, part 1 (2002),"Criteria for Earthquake Resistant Design of Structures: Part 1 General provisions and Buildings", New Delhi, India.
[7] Bureau of Indian Standards: IS13920:1993,Ductile Detailing of Reinforced Concrete structures subjected To seismic forces — code of practice, New Delhi, India.
[8] IS: 875 (Part 2) – 1987 (Reaffirmed 2008), ―Code of practice for design loads for buildings and structures. Part 2- Imposed load.
[9] Computers and Structures, Inc. ―ETABS, Version 13, India.
[10] Indian standard ―Plain & Reinforced Concrete Code of Practice‖ Fourth Revision IS: 456:2000.
[11] IS 875: 1987 — (Part 1 to 3 and 5), Indian standard Code of Practice for Design loads (Other than Earthquake) for Building and Structures (Second Revision), Indian Standard Institute, New Delhi