

Structural behavior of Composite structure

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Abstract : Construction materials for structures are generally made of either reinforced cement concrete(RCC) or steel, they both have their own benefits and drawbacks when subjected to different types of loading but if both these materials are combined to form composite structure then surely the drawbacks of both the materials can be overcome and best properties of both the materials can be utilized. The present paper work is made for studying research work on response of structures made of RCC, Steel and Composite when subjected to various static and dynamic loads which is mainly due to earthquake.

Key words : Composite beam, Composite column, deck slab, base shear, Time period

INTRODUCTION

High tensile strength and ductility are the key properties of steel structure member, while high compressive strength and stiffness is the best property of a concrete members. Composite members combine steel and concrete, resulting in a member that has the beneficial properties of both materials. Hence by Composite construction method it is found that a greater structure efficiency is achieved with structure elements such as beams as a Composite beam-ISMB steel section made composite with the RCC slab with the help of shear studs, slab as a Profiled Deck-Composite floors using profiled sheet decking in which the structural behavior is similar to a reinforced concrete slab, with the steel sheeting acting as the tension reinforcement and column as a steel-concrete composite column either in the form of encased concrete columns or concrete filled tube column which act as a compression member in which the steel element is a structural steel section, all these three structure members are compared with conventional method of construction ie . using RCC & steel.

LITERATURE REVIEW

Lin-Hai Han (2000) presented theoretical model of concrete filled steel tubes and compared with test results, he calculated deformations and strength of beam-column when subjected to fire and fire resistance of composite member is found out. To find temperature field of concrete filled steel tubes, finite element method is applied by considering concrete filled steel tubes under fire. Fire tests are also carried out on the same model and results are compared with

the test result, which has shown a good agreement. Based on the theoretical model, by changing material's strength, sectional

dimensions, steel ratio, load eccentricity and slenderness ratio impact of these parameters on the fire resistance are discussed. The theoretical model in this paper consist of necessary fire protection measures for the concrete filled steel tubular columns used in a high-rise building, SEG Plaza in Shen-Zhen City, southern China.

Roeder et al.,(2002)^[3] described demands of stress transfer for different systems. A dual system ie moment resisting frame with shear wall is considered. The stress values and force transfer capacities are calculated and presented design strategies for concrete filled tube (CFT) and encased steel section (SRC).

Generally theoretically calculated deflection values do not match with deflection measured on site which affects the serviceability of a structure and leads to increase in cost. Grages et al.,(2006)^[4] focused on the difference between calculated values and on site deflection values by analyzing the measured deflections of steel beams in a structures under construction and concluded that the standards for calculating most of deflection values are not wrong but they are incomplete and need to improve hence deformation due to preparation of steel beam or due to assembly of the structure also has to be consider.

Hicks et al., (2006)^[5] have studied the response of composite floor due to occupant induced vibrations in terms of serviceability. In this paper they have presented results of the vibration test and these values are compared with the SCI publication and AISC design guidance. The comparison is carried out between measured floor response and predicted floor response. And proposed finite element method of analysis instead of hand methods of analysis.

Elghazouli et al.,(2007)^[6] examined the seismic performance of composite steel-concrete moment-resisting frames by non linear static approach. The validity of using nonlinear-static approaches for this type of frame is evaluated by comparing with dynamic time-history analysis, using earthquake records which are carefully selected and adjusted for compatibility with the design spectrum. Numerical studies are carried out in order to check the effect of key loading, geometric and design parameters on

composite frames response. It is observed that several design parameters and assumptions have direct effect on the inelastic behavior of composite frames, as assessed through the overall lateral response, inter-storey drift distribution and plastic hinge patterns. Particularly the choice of performance factor in relation to the intensity of earthquake, the incorporation of moment redistribution under gravity conditions, and the effects of panel zones are all issues which is advantageous as a careful consideration in design. It is also shown that many of geometric parameters, related to the structural configuration, including frame spacing and beam span, have a significant influence on the performance.

Panchal et al., (December, 2011)^[7] considered steel concrete composite, steel and R.C.C. options for comparative study of G+30 storey commercial building which is situated in earthquake zone IV. Equivalent Static Method of Analysis is used. For modeling of Composite, Steel and R.C.C. structures, ETABS software is used and the results in terms of deflection, size and material consumption, seismic forces, total dead weight of structure and shear force and bending moment in beams are compared and concluded that

- The reduction in the dead weight of the Steel framed structure is 32 % with respect to R.C.C. frame Structure and Composite framed structure is 30 % with respect to R.C.C. framed structure.
- Sizes of the steel members from steel option to the composite option reduces about 25 % in main beams and about 60 % in secondary beams.
- Axial forces in column have been reduced by average 46% in steel structure and reduced by average 7% in Composite framed structure as compared to R.C.C. framed structure.
- In all the options the values of story displacements are within the permissible limits as per code limits.
- 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%.

Ozhendekci et al.,(2012)^[8] carried out study on three 10-story steel special moment resisting frames with different span arrangements and designed according to the procedures of Turkish seismic design codes. With the chosen geometric properties, design earthquake load and seismic effective mass is kept constant for model frames. The entire model frames are found to satisfy the acceptance criteria for collapse prevention performance level. Based on the results of the structural systems used in this study, model frame with span length to story height ratio of approximately 2 seems to maintain both performance and economy, while the ratio higher than 2.5 can result in relatively high deflections and high element plastic rotations in lower stories under infrequent earthquake loads which render the frame seismically vulnerable.

Idris et al., (2013)^[9] studied Seismic Behavior of High-Strength Concrete-Filled FRP Tube Columns in which they have consider Five square and one circular concrete-filled FRP tube (CFFT) columns and tested under

constant axial compression and reversed-cyclic lateral loading. The main parameters of the experimental study were the axial load level, column cross-sectional shape, concrete strength, amount and type of FRP confinement, and FRP tube corner radius, the results indicate that square HSCFFT columns are capable of developing very high inelastic deformation capacities under simulated seismic loading. The results also indicate that increasing the FRP tube corner radius up to a certain threshold leads to a significant increase in column lateral drift capacities. By contrast, increasing the corner radius beyond that threshold value provides no additional improvement in the hysteretic behavior of square CFFT columns. The influence of the cross-sectional shape is found to be significant, with the circular CFFT exhibiting a larger lateral drift capacity compared with the companion square CFFT.

Ambadkar et al., (2013) have discussed comparison between three types of column sections ,following cases are considered,

- 1.(G+2) Industrial building with Columns as I-section with alternate bay bracing.
- 2.(G+2) Industrial building with Columns as Rectangular Concrete Filled Tubular (RCFT) Sections with alternate bay bracing.
- 3.(G+2) Industrial building with Columns as I-Section Encased in Concrete with alternate bay bracing.

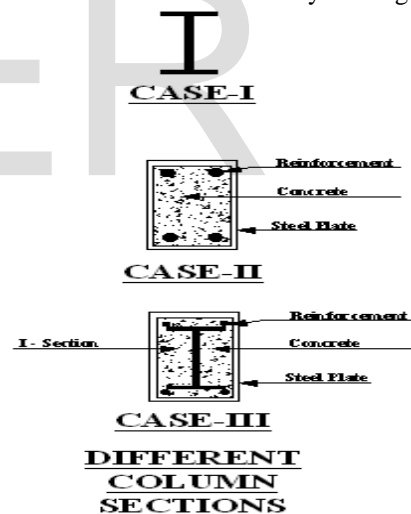


Figure 1.4: Different column sections(Ambadkar et al.,2013)

which are analyzed on STAAD-PRO and design is done by using Eurocode and observed that, the cost of Case I is maximum whereas, the cost of Case III is minimum. While calculating the final cost in Case II the cost of formwork is eliminated.

Patel et al.,(2013) carried out comparative study of 10, 20 and 30 storey Concrete Filled Steel Tube (CFT), R.C.C. and Steel building. Comparison of parameters like time period, displacement, base shear and load carrying capacity is done with steel and R.C.C structures and concluded that filled steel tube columns has been consistently applied in the design of tall buildings as they provide considerable economy in comparison with conventional steel building. Also

performance wise result good compared to RCC and Steel building.

Tedia et al., (Jan. 2014)^[10], considered Steel-concrete composite with R.C.C. options for comparative study of G+5 storey office building with 3.658 m height, which is situated in earthquake zone III. Equivalent Static Method of Analysis is used. For modeling of Composite & R.C.C. structures, staad-pro software is used and the results are compared; design of slab, beam, column and foundation for both composite and RCC have carried out and cost comparison is done and concluded that Steel-Concrete composite design structure is more costly, reduction in direct costs of steel-composite structure resulting from speedy erection will make Steel-concrete Composite structure economically viable. Further, under earthquake considerations because of the inherent ductility characteristics, Steel-Concrete structure will perform better than a conventional R.C.C. structure.

Wagh et al., (April 2014)^[11] have carried out study of Four various multistoried commercial buildings i.e. G+12, G+16, G+20, G+24 and analysed by using STAAD-Pro software. Where design and cost estimation is carried out using MS-Excel programming and from obtained result comparison made between R.C.C and composite structure. They have used equivalent static method for analysis. Comparative study includes deflection, axial force and shear force, bending moment in column and beam, cost of structure component. And it is found that downward reaction (F_y) and bending moment in other two direction for composite structural system is less. Thus smaller size foundation in case of composite construction can be used compared to an R.C.C construction. The cost comparison reveals that steel-concrete composite design structure is more economical in case of high rise buildings and construction is speedy.

Kumawat et al., (May 2014)^[12] considered steel concrete composite with RCC options for comparative study of G+9 story commercial building which is situated in earthquake zone-III and for earthquake loading, the provisions of IS: 1893 (Part1)-2002 is considered. A three dimensional modeling and analysis of the structure are carried out with the help of SAP 2000 software. Equivalent Static Method of Analysis and Response spectrum analysis method are used for the analysis of both Composite and RCC structures. The results are obtained and compared with following parameters:

Equivalent static analysis

- Storey stiffness: It can be observed that the transverse and longitudinal storey stiffness for composite structure is large as compared to RCC structure.
- Lateral displacement: Displacement in composite structure is reduced by 41% to 58% in transverse direction and about 37% to 57% in longitudinal direction than that in RCC structure.

- Storey drift: The result shows that the inter storey drift for composite structure is comparatively less than RCC structure

Response spectrums Analysis:

- Time period and frequency: The increased stiffness of the composite structure results in increased frequency and reduction in time period than the RCC structure.
- Lateral displacement: The lateral displacement in composite structure is reduced up to 46% to 58% and 45% to 56% in transverse and longitudinal directions respectively.

Prof. S. S. Charantimath et al., (2014)^[13] carried out an analytical study on the structural behavior of RCC and composite high rise buildings. The 3D analysis has been carried out on three models of 10, 20, 30 storey building using structural analysis software ETABS 2013, equivalent static analysis and dynamic analysis is carried out and the results such as maximum values of displacements, axial forces, base shear and natural periods are found out and concluded that weight of composite structure is quite low as compared to RCC structure which helps in reducing the foundation cost. As the dead weight of a composite structure is less compared to an R.C.C. structure, it is subjected to less amount of forces induced due to the earthquake. Sizes of the column members from R.C.C option to the composite option reduces about 43.75%, 55.55% and 43.75% for 10 storey, 20 storey and 30 storey.

P.Sairaj et al., (2014)^[14] presented a study on economic aspects of G+4 multi storied building designed by using braced frame composite construction. Since ductility, stiffness, inter storied drift and lateral displacements are the critical issues in seismic design of buildings, different types of braced frame models are developed in this study and evaluated its structural performance. Equivalent static method of seismic analysis used in the analysis of geometric models and the results are compared with STRAP software. five different types of braced frame models (a, b, c, d, and e) considered in the analysis.

- Model (a) is a bare frame five storied structure without bracings.
- Model (b) is a knee type concentric bracing arranged in the mid span of external frame in both X & Z directions.
- Model (c) is a haunch type eccentric bracing pattern arranged in the mid span of external frame in both X & Z directions.
- Model (d) is a K & X type concentric bracing pattern respectively, arranged in the end span of external frame in both X & Z directions.
- Model (e) is a chevron & X type eccentric and concentric bracing pattern arranged in the end span of external frame in both X & Z directions respectively.

Considering overall deflection of the structure, (X & Z directions), bending moments, shear forces in beams and column, model IV is selected from the five trial models.

Braced frame models are efficient means to show ductile performance of the structure, and they provide effective means of lateral load resistance system. also Soft storey effect can effectively controlled by braced frame action .This concept is very useful for retrofitting of, and seismic up gradation of the existing multi storied buildings.

CONCLUSION

- From the above literature, it is seen that the research are in interest of usage of composite structure in construction of all types of building structures.
- Research was carried mainly on dynamic behavior of structure element. Researchers studied various parameters like fire protection measures , stress and force transfer capacities , floor response, Storey stiffness, Lateral displacement, Storey drift, Time period and frequency, axial force and shear force, bending moment in column and beam, cost of structure component in buildings and observed that composite structure provide considerable economy in comparison with conventional RCC and steel building.
- As the dead weight of a composite structure is less compared to an R.C.C. structure, it is subjected to less amount of forces induced due to the earthquake. Sizes of the column members from R.C.C option to the composite option reduces Thus smaller size foundation in case of composite construction can be used.

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