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COMPARISON OF SEISMIC BEHAVIOUR OF COMPOSITE AND RCC COLUMNS IN MULTISTORIED COMMERCIAL BUILDING – A REVIEW

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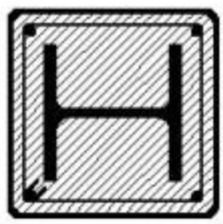
Abstract - *Composite structures render the eccentric possibility of ergonomic design of members and material in the case of vertical structures. Reinforced concrete structures are the traditionally preferred construction practice in most of the developing countries. A coalesced structural property of concrete and steel is achieved while using composite structures. Degrees of freedom plays a crucial role in enabling concurrent optimization in all aspects resulting in various ascendancies such as reduced structural weight, paramount dynamic stability, fire resistance, profitability, and, so on. This paper covers the review on the comparison of seismic behavior of composite columns with RCC columns under various physical conditions.*

***Key Words*: Composite columns, RCC columns, Degrees of freedom, Seismic behaviour.**

1. INTRODUCTION

Composite structures render the eccentric possibility of ergonomic design of members and material. The rampant population growth has led to the need for vertical structures, owing to the privation of land. Degrees of freedom plays a crucial role in enabling concurrent optimization in all aspects resulting in various ascendancies such as reduced structural weight, paramount dynamic stability, fire resistance, profitability, and, so on. Geometric parameters are considered with limitations when conventional materials are pondered for construction since the degrees of freedom available will less in number. **Datta., [1]** proposed about the cost-effectiveness in steel composite concrete construction, for elevated buildings in particular. An insight about cost variation was also observed. The author further emphasizes the fact that steel-concrete composite construction will explicitly provide more carpet area and will turn out to be a sustainable up-gradation, in terms of environmental performance. The Net Construction Cost, quality of construction, tectonic stability were some of the major advantages discussed in brief. The optimum utilization of steel by the Engineers is insisted, to make the growth of Indian society more user- friendly matching with the National Housing and Habitat Policy and Housing needs of citizens.

The components of the composite structure include composite beams, composite slab, composite columns, composite connections, and foundation systems. The composite column is attractive amongst all the elements as they conform to the relative strengths of both steel and concrete. The types of composite columns are concrete infilled, concrete encased, and double skin sections.



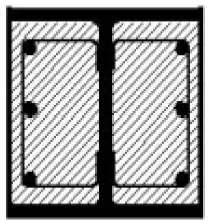


Fig.1 Fully concrete Fig.2 Partially concrete encased steel (CES) encased steel (CES)column column

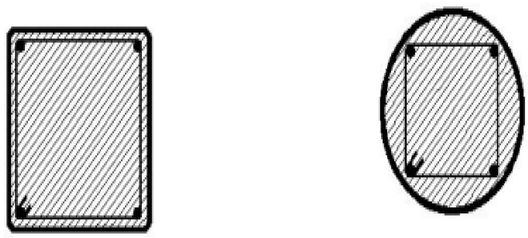


Fig.3 Concrete filled steel tubes (CFST)(rectangular and circular sections)

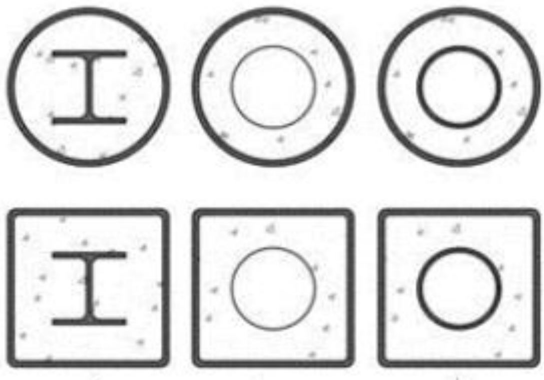


Fig. 4 Combination of CES and CFST, hollow CFST section and double skin sections Preetha et al., [2]

2. LITERATURE REVIEW

The following survey manifests the methods adopted for analyzing the seismic behavior of RCC and composite columns under various conditions. The brief review is as under:

Preetha et al., [2] proposed the linear static and response spectrum analysis methods for analyzing the seismic performance of (G+10) multistoried commercial building with RCC and two different composite columns viz. concrete-encased column (CES) and rectangular concrete-filled tubes (CFST) under earthquake zone III. The design and analysis were carried out using ETABS 2017 software. The story drift for both RCC and composite structures is within the permissible limit, i.e., 0.004 times the height of the story. Story shear value is observed to be minimal in the composite structure. The better lateral load resistance and low story displacement were observed in the RCC structure.

Ganwani., [3] proposed a comparative study of seismic performance of a 3D (G+8) Storey RCC and steel-concrete composite building frame under earthquake zone IV. Equivalent static method and response spectrum method are adopted for seismic analysis. ETABS 2015 software is used and results are compared. In composite structures, overall cost reduction in construction, implicit ductility characteristics of steel for better seismic stability, speedy construction, reduced moments, and axial forces are the advantages observed compared to conventional RCC structure.

Gopinath., [4] has dealt with the relative study of the composite encased column (CEC) and composite infilled column (CIC) for (G+14) composite building located in earthquake zone III, using ETABS software. The dynamic response and material quantity for column fill are the grail of study. The wind analysis has also been carried out. The provision of lateral steel bracings for dynamic stability has been observed. Separate composite building models have been created with the columns and analyzed. The composite infilled columns were provided with increased dimensions than that of the encased columns to meet the strength parameters. The manual verification for design has also been carried out. In terms of lateral displacement, base shear, stiffness, rigidity, and construction time, the composite building with composite infilled columns showed better performance.

Gummireddy et al., [5] proposed the analytical study of a multistoried building of (G+10) stories using ETABS software. In this study, a comparison has been made to differentiate the drift, shear force, bending moment values, for building with and with steel column, and composite column. The values of story drift, shear force, bending moment, building twist were found increasing from story 11 to the bottom story in both buildings (Steel Building and Composite column Building). The maximum values of BM, shear force and story drift were obtained from steel building than general building and composite column buildings. RCC frame has the least values of story drift because of its increased stiffness.

Athira et al., [6] This study has been proposed to compare the seismic evaluation of G+15 story building composed of RCC column and composite column with and without GFRG infill located in seismic zone V. Fully and partially encased type composite columns have been used for analysis. Three models are created including one model with GFRG infill. The seismic behavior of the frames is analyzed by response spectrum analysis using ETABS software. The following results were drawn based on the comparison in the design of conventional and composite buildings. The conventional building is considered in terms of base shear. Story drifts are higher that is 40% in the case of composite building. Structure with a fully composed concrete-encased steel section column has better performance.

Sulke et al., [7] this study has been performed to evaluate the seismic performance of concrete-filled steel tubular column building by combining along with RC columns. A G+30 story residential building is analyzed by the response spectrum method using software package ETABS 2015. Individual building models with conventional RC columns, circular CFST columns, and peripheral CFST columns are created and compared. The building with peripheral CFST columns and interior RC columns are considered to be the most suitable building model as it provides high resistance against seismic loading as well as economy due to the combined use of RC columns with smaller section sizes.

Alghuff et al., [8] aimed to study the static and dynamic analysis methods and compare their results to determine the conditions under which the methods can be adopted. In this research, two structural models are created using the ETABS (V16.1.2) program for regular R.C buildings with typical plans, but with varying building heights of 75 m and 24 m. The buildings are designed under ASCE7-10 and IBC 2015 provisions. The high-rise building shear forces, bending moments, and displacements in the X and Y directions obtained using the response spectrum analysis are 15% less than the corresponding values obtained in equivalent static analysis.

Neeladharan et al., [9] this work proposes a simplified method of design of composite slab, beam, and composite column is used and software is developed with pre and post-processing facilities in Sap2000. The details conforming to the method employed for designing composite slab, beam, and column are furnished. The main objective of modeling the structure is to study the performance of the structure which is implemented with steel-concrete composite construction. SAP2000 is a lone FE based structural software available for the analysis and design of structures. It offers a user-friendly workspace for quick and accurate construction of models, along with the advanced analytical techniques to work even in the most complex projects.

Abhishek et al., [10] deals with the consequence of fully encased composite columns on a G+ 20 storey special moment frame. In this paper, two different structures are considered for the comparison under seismic analysis. The linear static analysis and Pushover analysis are used for analysis, done using ETABS software. Two different models are considered for analysis. The values of base shear, time period, story displacement, and story drift are found to be advantageous for the composite building. The performance point for the FEC model is more than the RCC model, with a remarkable variety of 21%.

Naveen et al., [11] bring forward the comparison for the vibrational performance of RC and composite building frame with plan irregularities, situated in earthquake zone IV. 12 models (6 RC and 6 composites) on whole have been modeled as G+10 story building. Beam and column sections are made of either RCC or structural steel-concrete composite sections and models have been designed for gravity loading. Response spectrum analysis method has been used and ETABS 2015 software has been used for manipulation. Effects of the time period, base shear, story shear, displacements, drift, and axial force are studied for each frame and compared. Slight variations in the time period are observed and the frequency of RC building is high. The values of base shear and story shear are elevated for composite frames. The story drift for RC buildings is minimal. Drift variations are observed due to the differential size of columns in models considered.

Freeman., [12] reviewed the concept of response spectra for design engineers not familiar with their significance and to summarize various uses that can be applied for purposes such as rapid evaluation for a large inventory of buildings, performance verification of new construction, evaluation of existing structures for seismic vulnerability, and post-earthquake estimates of the potential damage of buildings. Methods of constructing smooth response spectra for design purposes have been developed to compensate for the peaks, valleys, and shape variations in actual response spectra. The availability of earthquake ground motion data is essential for response spectra to understand the building performance and for damage detection. The complexity of analysis ascends as it extends to the inelastic nonlinearity of structural response. Visual imagination of building performance during earthquakes during severe earthquakes is possible upon employing the response spectrum analysis technique.

Bedi et al., [13] shown the comparison of various aspects of building construction for steel, RCC as well as composite buildings considering various researches carried out. This paper includes a comparative study between RCC and steel-concrete composite (G+2) story building located in Indore under the earthquake zone II and wind speed of 44m/s. 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. The comparative study includes deflection, axial force, shear force, and bending moment in column and beam, and construction cost. It is found that composite structure is more economical and speedier than the RCC structure.

Sourabh., [14] proposed to study the static analysis under the provision of IS1893:2002 is carried out for three-dimensional models RCC frame structure and RC-steel composite frame structure with the help of ETAB software. A comparative study between the RCC frame structure and the RC-steel composite frame structure is done. Models of regular G+9 R.C.C building, G+9 building with composite steel beam and RCC column, G+9 building with composite column(encased I section) and RCC beam, G+9 building with composite steel beam and composite column were analyzed. Steel beam with composite column frame structure has less base shear which gives economic foundation design, construction period for steel beam with a composite column frame structure is less. Also, the requirement for construction workers is reduced. Also due to the inherent ductility of steel-RC composite structure, it performs better in the earthquake-prone region. Frame with steel-beam with the composite column is superior among the structures taken for analysis.

Uddin et al., [15] investigated a comparison of a composite structure with concrete-filled steel tubular columns, a composite structure with concrete-encased I section columns, and an RCC structure. All the models considered are G+15 story and are irregular in plan and the irregularity condition as per IS 1893-2002 is satisfied resulting in T shape and a plus shape models. It was observed after performing response spectrum analysis on the models that the stiffness is less in composite structures when compared to RCC structures. The displacements and drifts are less in RCC structures owing to a larger value of stiffness but are within the permissible limits. The base shear and base moments are less in composite structures compared to RCC structures. There is no noticeable difference in the response parameters of the two composite structures.

Shaikh., [16] brings out a detailed analysis of multi-story G+20 high rise building having various irregularities with concrete-encased columns is being carried out using ETABS 2015. The effective use of concrete-encased columns against RC columns to overcome the structural irregularity of building mostly the mass irregularity and stiffness irregularity is the aim of the study. It is observed that base shear is reduced by 10-14% by using concrete encased columns conforming to 43% area reduction in mass irregularity & 51% area reduction in stiffness irregularity. Some of the responses of story displacement and time period, obtained due to this type of column are slightly more than that of the conventional RC column, still, these are within permissible limits. Therefore, concrete encased columns are more suitable for stiffness irregularity building due to its high stiffness property which enables the structure to resist it in a better manner.

Cholekar et al., [17] have considered irregularity in the form of mass in G+9 multistoried R.C.C. and composite building and compared both R.C.C. and composite structures. Equivalent static and Response spectrum methods are used to analyze the building as per IS 1893(Part 1):2002 using SAP 2000 software. Mass irregularity on the upper or middle floor should be considered and a comparative study is done on the basis, for both structures. Joint displacement, base shear, story drift, shears force, self-weight, and time period values will help to decide upon the efficient structure. The results obtained for the equivalent static method for R.C.C and composite structures are quite high than the response spectrum method. Hence response spectrum gives better results than the equivalent static method. The study shows that composite structures having mass irregularity will better perform than R.C.C. structures.

Asha et al., [18] proposed an investigation for the seismic behavior of a typical ordinary moment-resisting framed structure with composite columns and conventional Steel columns. The study deals with seismic behavior of a (G+12) storied framed structure analysed through the equivalent static method of analysis as per IS code for seismic zone III using ETABS software. The analyses are performed on 2 types of ordinary moment-resisting framed 3D space models with different column types – Steel, and CFST and the results are compared. Base shear and story overturning moment induced by the seismic forces is reduced by 22 to 28% for composite columns. The composite columns undergo about 25 to 28.5% reduction of lower story drifts when compared with the steel columns. Roof displacement has been reduced by 26.6% in the case of the CFST column when compared with the steel. Thus, all the parameters demonstrate higher order of both global and local stability indicating that the composite columns are stiffer than conventional steel columns.

Sruthi et al., [19] deals with seismic behavior analysis of G+12 to G+44 story buildings situated at Delhi through response spectrum analysis using ETABS software. The analysis was performed on Reinforced Cement Concrete (RCC) building with the ordinary column, RCC building with CFST columns, CFRP wrapped CFST columns, and I section encased CFST columns. The analysis is done by just varying the column design and keeping all other structural members the same for all the structures. Results were compared in terms of critical earthquake response parameters such as base shear, story drifts, and story displacements. Base shear values are 28% and 27% more for CFST columns encased with steel I section compared to RCC columns in transverse and longitudinal directions respectively. Story displacement is reduced up to 17% and drift is reduced up to 18% in composite columns compared to RC columns. CFRP Wrapping minimized the story displacement, and story drift up to 8% and 5% respectively when compared to unwrapped CFST columns. The results indicate that the building with CFRP wrapped CFST columns, and I section encased CFST columns perform better against vibrational forces.

Karthiga et al., [20] studied an RC framed structure of M25 grade of concrete with G+7 storey and also a Composite structure of G+6 storey is modeled in ETABS as per Indian Standard Code 1893: 2002 Part(I). The building is situated in Himachal Pradesh with a seismic intensity of zone factor V. The strong column weak beam concept is adopted for the design. The response spectrum analysis technique was used in the ETABS for both the composite and reinforced concrete structure. The deflection of the composite structure is high when compared with the RC structure. The storey drift of the composite structure is found maximum when it is compared with the RC building. RC building has the maximum base shear.

3. DISCUSSIONS

Therefore the discussion has been made on the incorporation of various types of columns in both RCC and composite structures and their vibration responses. The increase in the verticality of structures is a major instigation for the performance of the seismic analysis. The equivalent static method, response spectrum method, and pushover analysis seem to be the consistently used methods for seismic analysis of structures. The response spectrum analysis is found to give more accurate results amongst all for the comparison between the RCC column and different types of composite columns. The dynamic stability of structures is found to be highly achieved while using composite columns with each type showing variations in performance and also based on the material used for column fill. However future studies are to be carried out to enhance the stability and performance of composite columns along with optimal material selection and usage.

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