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A Review on Multi-Storey RCC& Composite Building Under Seismic Effect using E-Tabs Software

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Review Article

Abstract

The Steel-concrete composite constructions are commonly used in modern construction. Due to its several advantages over RCC and steel structures, composite structures consisting of steel and concrete are particularly popular. The structural members of RCC buildings are heavier and have larger cross-sections. Steel constructions have higher deflections and flexibility than concrete structures, helping resistance to earthquake loads. In composite structures, the appropriate qualities of RCC and steel structures are blended. The composite structures facilitate lower costs, quick construction, and fire protection, among other attributes. Present study covers comparison of high-rise (G+8) RCC and composite structures in seismic zone IV considering the provisions of IS: 1893 (Part1) -2002. The seismic behaviour of frames created using the suggested methodology is assessed using ETABS software's nonlinear time-history analysis and the results are compared using various parametric data, for structures in all sorts of building frames, maximum storey displacement, storey stiffness, storey drift, fundamental time periods, base shear, and weight are determined. The steel-concrete composite frames, along with RCC and steel constructions, are best suited for medium to high rise buildings, according to comparative research.

Keywords: G+8 buildings ETABS, RCC, Steel and Steel concrete Composite frame building, Seismic analysis.

1. Introduction

The majority of the constructions in India are classified as low-rise buildings. As a result, reinforced concrete members are extensively employed in these structures since the construction is very simple and cost-effective [1]. However, because the population of cities is rising exponentially and land is limited, vertical construction of structures is required in many places. As a result, great number of medium- and high-rise buildings are being built to accommodate this need. Steel-concrete composite construction has achieved widespread recognition as a viable alternative to pure steel and concrete building around the world. This technique is still considered as a relatively new concept in construction business. Higher deflections and flexible nature attract its applications compared to concrete structures [2,3]. It has been observed that using composite members in the construction of high-rise buildings is more effective and cost-efficient than using reinforced concrete members [4,5,6]. In medium to high-rise buildings, a steel-concrete composite frame system can provide an effective and cost-effective solution to most of these issues [7].

The revolutionary new ETABS software programme is the ultimate comprehensive software solution for structural analysis and building design. This version of ETABS includes unrivalled 3D modelling and visualization tools, quick linear and nonlinear analytical power, complex and comprehensive design capabilities for a wide range of materials, and incisive graphic presentations, reports, and schematic drawings [2-3]. ETABS models can be created directly from CAD drawings. Steel and concrete frames, composite beams, composite columns, steel joists, concrete and masonry shear walls, and steel connections and base plates are all designed, as is the capacity check for steel connections and base plates. For all analysis and design output, comprehensive and configurable reports are accessible, and construction drawings of frame plans, details, and cross sections are generated for concrete and steel structures.

The present review aims to acquire information and knowledge keeping the following objectives

• For large civil projects such as high-rise buildings and bridges, composite sections made of steel encased in concrete are an economical, cost-effective, and time-effective alternative.

• To compare the analytical results of all three building models, such as storey Drift, Storey displacement, nodal displacement, maximum axial force, maximum shear force, and bending moments.

This paper provides distinct comparison of RCC and Steel with Composite Story Buildings. Storey Drift, Displacement, Storey Stiffness, Axial Force in Column, Shear Force in Column, Bending Moment, Twisting Moments in Composite are compared to RCC and Steel Sections.

2. Literature Review

The Multi-storey RCC and Composite Buildings Under Seismic Effect is the theme subject of this literature review. A few specific studies conducted are analysed here

Kumar and Rao (2016) [2] worked on a high-rise 5,10, and 15-story skyscraper in India's Zone V earthquake zone analyzing Seismicity of Steel Concrete Composite System followed by comparison to RCC Structures. The researchers performed Response Spectrum Method and nonlinear Time History Analysis using E-tabs software for matching different parameters, and concluded that composite structures are suitable for high-rise structures.

Sharma, et al (2016) [3] performed Seismic Analysis of Multi-Storey Steel Concrete Composite System considering G+20 storey building utilising RCC and Composite systems and compared to RCC Structures located in India's Earthquake Zone IV. They used the Equivalent Static Technique in E-Tabs and matched different criteria such as Deflection, Stiffness, Story Drift, and Less Dead Weight before concluding that steel-concrete composite structures are the optimal method of construction for high structures.

Panchal and Prajapati (2013) [4] explored a model G+30 storey structure made of Steel and Composite. They conducted seismic analysis of the Steel Concrete Composite System and RCC structure. The researchers performed Equivalent Static Method using E-Tabs software. The analysis and design approach used for the valuation of symmetric high rises is discussed in this study. Wind and Seismic forces on a multi-story building, Shear walls were used in these types of structures to counteract lateral forces. When the analytical results are compared, it was found that steel concrete composite construction is the superior alternative.

Charantimath, et al. (2014) [5] worked on 10-story, 20-story, and 30-story high-rise building constructions and examined using the composite system and the RCC system. The researcher used the Equivalent Static approach and Response Spectrum analysis, and computed all of the structural parameters of Composite and RCC building elements using E-Tabs software. According to the findings of this study, the composite option for high-rise buildings is the best alternate.

Mahajan,and Kalurkar (2016) [6] explored the effect of Fully Encased Composite (FEC) on the construction of a (G+20) storey building. In the event of a seismic occurrence, the ETAB software was utilized to analyze the structure. In seismic analysis, non-linear static analysis, such as Pushover Analysis, and linear static analysis are utilized. The findings are compared for Base Shear, Modal Time Period, Storey Displacement, and Storey Drift.

Kumawat (2014) [7] performed Seismic Analysis of Steel Concrete Composite System and RCC structure, for a comparative examination of a (G+9) storey commercial structure located in earthquake zone III and for earthquake loading, the provisions of IS: 1893 (Part1)-2002 are used. The structure is three-dimensionally modelled and analysed using SAP 2000 software. The Equivalent Static Approach of Analysis and the Response Spectrum Analysis approach are used to analyse both composite and RCC structures. When the data was compared, the composite structure shown to be more cost effective.

Suthar and Butala (2020) [8] considered a three-dimensional G+15-story high-rise skyscraper with RCC, steel, and composite structure in India's earthquake zone IV. They favoured the analogous static method and the response spectrum method in E-tabs software 2017. They compared several parameters and found that composite frames are the best choice for medium to high-rise structures in terms of increased stiffness and base shear among RCC and steel construction.

Kumar, Ganwani, and Jamkar (2016) [9], for Seismic analysis with RCC and composite system, the researchers worked on a high-rise 3D (G+5) storey building in India's Zone IV earthquake zone. They used E-tabs 2015 software to run the Equivalent Static technique and reported that composite frames are the best choice for medium to high-rise structures in terms of material and weight, as well as improved seismic performance, when compared to RCC and steel construction.

Vedha M (2019) [10] explored a framed multi-story construction made of RCC, Steel, and Composite and contrasted taking into account a G+18 storey building located in India's Earthquake Zone IV. They performed Equivalent lateral force method and Response spectrum approaches using E-tabs Software and compared composite and steel structures with Storey Drift, Storey Over Turning Moments, Base Shear, and Roof Displacements. In this research, a comparison of various construction models reveals that composite structures are more cost-effective than all other structure.

Panchal and Daman (2016) [11] analyzed seismicity of RCC and composite system for a G+15 multistory building in earthquake zone four and compared the steel concrete composite structure with the RCC construction, according to IS:1893-2002, and for different earthquake loads. Despite the fact that the composite structure had more narrative deflection than the RCC structure, the deflection was still within acceptable limits. In comparison to composite structures, RCC structures have higher axial and shear forces. According to studies, the maximum bending moment in composite structures is slightly higher than in RCC structures in some stories.

Aniket and Suryawanshi (2016) [12] modelled G+9, G+12, G+15, and G+18 as four multistorey constructions with a 3.0 m floor height and a plan dimension of 15m*9m for seismic analysis. STAAD Pro software is used to analysis various load combinations according to IS-code. The study confirms that a steel composite structure's total dead weight is lower than that of an RCC structure, meaning that seismic pressures are less damaging to steel composite structures. Because the section of the steel element is less than in RCC structures, the cost is effective.

Sangave, and Madur (2015) [13]. In Indian seismic zone 5, the author looked at the bare and infill frames of four G+6 and G+10 RCC and steel concrete composite structures. Due to the lower seismic weight of steel composite structures, they discovered that the base shear is smaller than in RCC structures. In a steel concrete composite structure with an RCC framework, storey drift and displacement are considerable. According to the conclusions of this study, the shear force in RCC structures is more than in steel composite structures, and the bending moment in RCC beams and columns is greater than in composite structures.

Mujawar, and Sangave (2015) [14]. On reinforced concrete, steel, and composite structures, static and dynamic loads were compared. ETABS software was used to compare three constructions using the response spectrum technique. Composite constructions, rather than reinforced concrete structures, are better ideal for high-rise buildings, according to this study. The displacement of the composite structure is 48 percent larger than that of the RCC construction. Because no formwork is necessary, composite structures take less time to build than R.C structures.

Joshi, and Deulkar (2015) [15] studied how steel concrete composite constructions are formed by using shear connectors to connect steel beams to concrete slabs or profiled deck slabs, allowing the structure to function as a single unit. When modeling and appraising a B+G+11-story commercial building in Kolhapur, they evaluated the results of both steel concrete composite and RCC buildings. The study is conducted using the ETABS software, which applies the Equivalent Linear Static Method. Roof deflections, foundation shear, and storey drifts for the building, as well as axial forces and bending moments for columns and beams at various levels, must all be considered. Steel-concrete composite buildings have been demonstrated to be both safer and more cost-effective, demonstrating their superiority.

Ali and Bhalchandra (2015) [16] analyzed seismicity of Steel Concrete Composite System. RCC and composite buildings were modeled and analysis using the finite element-based program ETABS 2015, and the buildings were also classed by the number of floors. They also compared the costs of RCC and composite constructions under varied support situations. Composite structures, they feel, are more cost-effective than RCC structures, and that composite structures are a better solution for multi-story buildings that must handle seismic stresses.

Koppad, and Itti (2013) [17]. In India, RCC and composite systems were utilized on a 15-story skyscraper in earthquake zone III. They analysis the composite and RCC systems' material costs and discovered that the composite system has lower material costs than the RCC system.

Wagh and Waghe (2014) [18]. In Nagpur, India, a 25-story building using composite and RCC systems is being considered. Nagpur is located in earthquake zone II. The analysis included STAAD PRO to perform a similar static analysis and calculate the material prices of both systems, ultimately finding that employing a composite system for high-rise buildings would save money.

Patil, and Suryanarayan (2015) [19]. The author examined the seismic performance of a G+15 storey building made up of RCC and composite structures Using ETAB 2013 software, as well as a structure located in earthquake zone three on medium soil. For the building's analysis, the response spectrum and static approach are utilized. The proposed work When compared to RCC structures, composite structures have less storey drift. This work's outcome demonstrates Because composite structures have less dead weight than RCC structures, the total cost of construction is lower. the framework This study also shows that composite structures are more ductile and resistant to damage. In comparison to RCC structures, the lateral load is lower.

Sharma, and Mohammad (2016) [20], in their study, compared other characteristics such as building displacements, column forces, and moments created in the structure, as well as simulating a multi-story building under seismic and wind forces. The effects of seismic and wind stresses on the various structural parameters of these different types of construction approaches on symmetrical G+10, G+15, and G+20 multi-story buildings. It includes the analysis and design procedure for symmetrical high-rise multi-story buildings subjected to wind and seismic forces, such as G+10, G+15, and G+20. When seismic loading is applied to steel composite structures, they find that node displacement is lower than in RCC structures.

Kapgate, and Budhlani (2018) [21]. For seismic analysis, the author worked on a high rice G+15 Frame with and without Shear wall using E-Tabs 2016 Software. They used a Non-Linear El-centro Time History Analysis for a unique Moment Resisting Frame that was subjected to earthquake loading.

Rathod, and Gupta (2020) [22] considered G+10 Storey RCC Building for n seismic analysis. They used E-Tabs Software to undertake a Non-Linear Time History Analysis of the El-centro Earthquake of 1940. The load carrying capacity, ductility, stiffness, damping, and mass of structures are the main parameters of seismic analysis. Base shear, storey drift, storey displacements, and other response characteristics are determined. The computed storey drift is compared to the IS 1893:2002 minimum storey drift standard.

Patil and Kumbhar (2013) [23]. The author worked on the RCC for the High Rice G+10 storey. Different Seismic Intensities were taken into account when designing the structure. SAP2000-15 software is used to model the building under evaluation. For the purpose of establishing a relationship between seismic intensities and seismic reactions, five distinct time histories were employed, with seismic intensities V, VI, VII, VIII, IX, and X on the Modified Mercalli's Intensity scale (MMI). The study's findings reveal a similar pattern of variance in seismic reactions such as base shear and storey displacements with intensities ranging from V to X.

Yadav, and Reddy (2017) [24]. In this study, the wind and earthquake forces on a G+20 multi-story building in the most severe zone are investigated. A 3D model for a G+20 multi-story structure was developed in ETABS. On structural systems, the effects of lateral loads on moments, axial forces, shear force, base shear, maximum storey drift, and tensile forces are explored, and the results from zones 2 and 3 are compared.

i. The table clearly indicates that in zone 2 soils, storey drift x and y are higher in earthquake than spectrum.
ii. When comparing zone2 and zone5, storey drift in zone5 is larger than in zone2.
iii. E-Tabs will be in charge of designing each and every member.
iv. Using software improves accuracy.

Panchal, and Dwivedi (2017) [25]. Analyzing Seismicity and design a G+6 existing RCC framed structure in this project using STAAD. Pro V8i software. The structure is built to withstand earthquake stresses in a variety of seismic zones, according to IS 1893(Part 1):2002. The paper's major goals are to compare seismic zone differences in steel %, maximum shear force, maximum bending moment, and maximum deflection. From zone II to zone V, the variances are significantly bigger. From zone II to zone V, steel percent, maximum shear force, maximum bending moment, and maximum deflection all rise.

Inchara, and Ashwini (2016) [26]. The author analyzed seismic analysis in multi-stories RCC and composite structure Five (G+4) models were investigated in this study. For gravity loads and earthquake forces in diverse seismic zones, all four models were created and analyzed. The models were analyzed using the ETABS software. The study's major goals were to look at how R.C. framed irregular buildings performed under gravity loads and in different seismic zones, as well as changes in steel % and concrete volumes. In addition, to understand the differences in steel reinforcing percentages and concrete volumes between structures built to IS 456:2000 for gravity loads and buildings planned to IS 1893(Part 1):2002 for gravity loads. Support reactions tended to develop when the zone migrated from II to V, resulting in bigger concrete volume and steel reinforcement weight in footings and a higher fraction of steel reinforcement in beams, according to their findings.

Mahesh, and Rao (2014) [27]. The author evaluated a residential G+11 multi-story structure for earth quake and wind load using ETABS and STAAD PRO V8i software. The linearity of the material's properties is assumed in both static and dynamic analyses. Many seismic zones are considered in these analyses, and the behaviour of each zone is evaluated using three different types of soils: hard, medium, and soft. For various zones and soil types, various responses such as tale drift, displacements, and base shear are plotted.

Reddy, and Kumar (2017) [28]. In this work, the behaviour of high-rise structures is investigated for both schemes. The results of a mathematical model for models were presented in this work. The graph depicts the story's drift, shear, and support reactions. It's also worth noting that the conclusions of static analysis are more conservative than those of dynamic analysis, resulting in uneconomical structures in both zones 4 and 5.

i. In both zone 4 and zone 5, the storey drift increases from top to bottom storey, with the maximum drift at storey 31 when compared to other stories.
ii. When comparing the drift values in zones 4 and 5, zone 5 shows a larger value of drift.
iii. When we compare the forces in all tales for zone 4 and zone 5, the storey shear is maximal for the moments. When compared to zone 4, zone 5 has a higher shear value.
iv. For forces and moments in support reactions, the greatest value occurs in zone5 rather than zone4.
v. When creating with software like ETABS saves you a lot of time when it comes to design work.

vi. ETABS will acquire information on each and every member.

Kumar, and Rajasekhar (2014) [29]. For the seismic investigation, the author chose a residential structure in zone II with a G+ 15-story structure. STAAD.PRO software was used to evaluate the entire structure on the computer. The methodologies utilized in structural seismic analysis are equivalent static analysis and response spectrum analysis. The major goal of this research is to look at structural seismic analysis for static and dynamic analysis in both ordinary and special moment resistant frames. Using deflection diagrams in static and dynamic analysis, we observed the response decrease of cases conventional moment resisting frame and special moment resisting frame values. The resistant frame structure's unique moment is beneficial in resisting earthquake loads.

Gupta et al. (2017) [30] analyzed the Nonlinear dynamic Time History analysis of a 23-story RCC residential building is undertaken in this study, with various seismic/earthquake intensities taken into account, and the response of such a building to earthquake is explored. To model the building under investigation, SAP2000V.14.00 software is employed. Five different time histories were utilized to develop the link between seismic intensities and seismic reactions, with seismic intensities V, VI, VII, VIII, IX, and X on the Modified Mercalli's Intensity scale (MMI). The data show that seismic reactions, such as base shear and storey displacements, have a similar pattern of variance with intensities ranging from V to X. According to the findings, utilizing the Time History technique to analysis multistorey RCC buildings is now essential to ensure seismic safety.

3. Research Perspective

The literature review presented above shows that there are a number of published works on RCC, Steel and composite structure. Theoretical studies are presented on the behaviour of seismic forces acting on multi stories building structure. Seismic behaviour is different for different Zones. An analytical examination of the structural behaviour of RCC and composite high-rise buildings is being explored. Displacements, axial forces, base shear, and natural period are all taken parameters are considered. The 3D analysis performed using the structural analysis software ETABS, and the results, including maximum displacements, axial forces, twisting moment, base shear, and natural periods, are discovered through analysis. Present study provides state of the art in terms of analysing RCC and composite constructions' seismic performance for high-rise buildings. It is taken into account the natural period, displacements, axial forces, and base shear. The structural analysis software ETABS 2013 was used to compute maximum displacements, axial forces, base shear, and natural periods in 3D. Maximum displacements, axial forces, base shear, and natural periods were all included in the analysis that revealed the results.

i. There should be a healthy market for composite constructions that use precast concrete and, in some cases, pre-stressed concrete, as well as steel.

ii. Different soil conditions, different zones, the impact of fire, different column orientations, and various building functions all need composite structure study.

iii. Non-linear joint response research can be undertaken by treating the joints as rigid joints and accounting for rotational stiffness, moment of resistance, and rotational capacity.

iv. For better system selection suggestions, different geometries of high-rise constructions can be compared for R.C.C., Steel, and Composite alternatives.

v. Although there are no suggestions for the design of composite columns in the Indian standard, such recommendations can be inferred and used to establish a good design process for various types of composite column

Conclusion

Composite constructions have been discovered to be the optimal technique of construction for high-rise structures. Composite structures are less expensive to build than RCC ones. Quicker construction allows for a faster return on investment as well as rent benefits. When compared to RCC constructions, composite structures are the greatest option for high-rise structures.

Conflict of interest

The author declares no conflict of interest.

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