International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 03 | Mar 2024 www.irjet.net p-ISSN: 2395-0072

A Review on Evaluation of Dynamic Response of the Beam Column Connection with RCC and Composite Structure with FEM Tools

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Abstract - A good technique for steel construction or concrete blocks in high-rise structures is the composite system, which combines steel floors, steel beams, and concrete. The finite element method (FEM) is the most widely used simulation technique for predicting the behaviour of objects and structures. In order to produce composite and hybrid designs that are more efficient than these materials alone, engineers have combined reinforced concrete and steel structures to create buildings. More knowledge on the relationship between reinforced concrete and steel structures in construction is crucial, as recent research have shown. A system like that. Exposure of the steel structure to pressures like collision or fracture will result in the gradual collapse of the entire structure. Particularly significant is the beam-column nodes' contribution to the structure's overall strength. This research will use the structure's dynamic response to examine how the beam-column connection behaves.

Key Word: *RCC, ANSYS, Composite, Steel. Dynamic, FEM*

1. INTRODUCTION

The need for building materials including brick, wood, concrete, and steel is rising as a result of the growth of construction and other structures. The weight of the concrete itself makes up a sizable portion of the overall load of constructions made of concrete. It also consumes all available resources, a natural resource in the earth. Finding an alternate approach that satisfies the needs of sustainable development, economy, and environmental friendliness is vital for these two reasons. Precast concrete provides various benefits, including summertime building, excellent quality, dependability, and speed of construction. A comparative study between prefabricated buildings and on-site monolithic construction revealed that prefab buildings require only 954 tonnes of materials, whereas monolithic construction requires 2468 tonnes. This implies that prefab units can save up to 70% of the materials used in monolithic construction. from leftover materials.

Prefabricated concrete technology offers several benefits, including quicker construction, more efficient factories, and cost-effective manufacture. Precast concrete is not commonly employed despite its benefits, particularly in seismically active areas. The reason for this is that the fundamental framework of building laws should take into account the absence of noisy seismic design as well as the lack of confidence and knowledge base in seismic regional output.

1.1 Beam-Column Connections

One of numerous elements that affects a frame's or a portion of a structure's seismic efficiency is the column-to-column connection. Creating an appropriate test model that can forecast the connection's final bearing capacity prior to different embedded steel components is essential. The construction of this test model is based on the findings of several experiments that looked at a variety of topics, including the impact of extra welded reinforcement, the geometry of the embedded element, and the effect of axial stress on each column. The difference between the no-design curves for the connection with and without welded extensions was calculated using these test patterns. The beam-column connection needs to be robust enough to withstand one of the failure modes—the vertical line—where the beam shouldn't fail at all. The nodes will be the most crucial locations to withstand lateral seismic reaction forces under seismic loads. Particularly when exposed to seismic stresses, its characteristics have an impact on how all structures behave overall. As a result, the partnership's power needs to be greater than the combined strength of its members. This makes it difficult and maybe impossible to develop the land properly. Shear damages the intended connection, and the beam only slips after the initial inelastic loading cycle.

2. STATE OF DEVELOPMENT

There is now only horizontal expansion occurring in India, particularly in metropolitan areas, which leads to a rise in the building of new homes. Rapid building is a growing sector these days. One of the largest modifications is the use of cold steel beams as a construction material in high-rise structures. Over the course of the project, steel frame structures with composite flooring will save expenses. The advantages of

laminate flooring over the last 20 years have fueled the expansion of steel-framed houses.

Kang Chen, et. al. (2022)[1] First, damage from the outside of the well (gas, explosives, etc.) will cause damage to the remainder of the building if the construction is not strong enough to survive the impact. Eventually, this will result in total dehydration. Gravity-based constructions are the intended use for slab (also known as shear tongue) connections, which are often less robust than seismic connections. For dynamic loading integrity to effectively limit growth, this is why it is crucial. We performed an impact loading experiment on connections connected by ribbed plate connections in order to study the failure behaviour under unfavourable conditions brought on by falling debris. Interference close to the column-to-column junction. Three middle joints and one side joint are the subjects of these investigations, which involve their design and testing. Test patterns include impact load, joint position, and panel thickness. We look at processes of tension building, failure, and response. To estimate ultimate power, compare test results. Furthermore included in the comparison are composite connections that are quasi-statically stressed. At a strain rate of 1 s1 on average, the test revealed a maximum increase of 28% in concrete and 16% in steel reinforcement. When compared to quasi-static testing, the impact of strain rate in the test can enhance the composite FP joints' compressive dome, catenary, and flexural strength. Furthermore, the composite plate has a positive influence on bending strength, but it also has an effect on contraction since the bending strength at tiny moments is increased by the connecting points' capacity for deformation. [1]

Gustavo J. Parra-Montesinos, et. al. (2000) [2] The purpose of this study is to examine how well continuous concrete-steel girder (RCS) connections withstand seismic activity. We present the findings from experiments conducted on nine external RCS connections under heavy loads. Additionally, there exists a basic formula for determining the shear strength of RCS connections. There is discussion of how different joint parameters affect a joint's seismic reaction. These fasteners include steel joist-drilled two-piece U-shaped stirrups, steel headers or strips around the connection region, dowels fastened to steel joist flanges, and composite materials made of steel fibre concrete or engineering cement composite (ECC). The RCS framework is appropriate for use in seismically active regions, according to experimental findings. Furthermore, the experimental results and the shear strength predicted by the suggested model correspond rather well. [2]

Hiroshi Noguchi, et. al. (2004) [3] Nonlinear three-dimensional finite element methods (FEM) were used to analyse two columns with R/C columns and steel columns (with varied beam-column connections). Beam yielding is the mode of damage for the beam-column linked end bearing plate (FBP) construction. The failure mode of the second model is joint failure, and it is characterised by sealing of column-column junctions. Predicting the model's behaviour involves analysing the latter before testing it. An in-depth examination of the interactions between metal and concrete as well as between concrete and metal to improve the model's structure. The study of the concrete elements' stress-strain relationship findings allowed for the determination of the shear strength of the beam-column nodes, the contribution of different forms of column-column nodes (inner, layer, inner top, and corner), as well as the collapse and shear mechanisms. Failure to infer shear elements and strain components from experimentation. [3]

Bahman Farahmand Azar, et. al. (2013) [4] The benefits of pure reinforced concrete and steel framing have been combined with the introduction of composite reinforced concrete steel (RCS) frames, which are made up of pure reinforced concrete (RC) columns and steel (S) beams. With this technique, the primary beam may go through reinforced concrete without stopping. According to FEMA-356, this article evaluates the seismic performance of RCS frames using plastic rotation, which is a recognised methodology. In the OpenSees programme, nonlinear static analysis (Pushover) was used to examine how the integration affected the RCS framework's overall behaviour. The ability of RCS connections to perform raises the frame's lateral load bearing capability. We also compared the line of the RCS picture with the RC image by comparing our RC image with the RCS image. The outcomes demonstrated that using non-metal RC beams significantly improved overall performance. [4]

O. Mirza et. al. (2010) [5] Current studies look on how well wire and cable connections—including connections between columns—perform under earthquake stress. The behaviour here differs greatly from that of a static load, thus it is important to find the true issue. Australia's contemporary steel and concrete building designs are well-suited to a 1 in 500 year earthquake. On the other hand, there has been substantial discussion over whether the model needs to be ready for an uncommon and significant event like a 2500-year earthquake. This paper summarises the key findings from an investigation of the beam-column connection system that produced a high load factor and a negative value. Experimental data was cross-checked against the finite element analysis results. According to experimental and finite element analysis data, the loading condition affects the strength and deformation behaviour of steel-concrete composite beams. [5]

Omid Rezaifar, Adel Younesi (2016) [6] The rigidity of the orthogonal system has occasionally led to an increase in the employment of box systems. However, it takes a lot of time and money to assemble and weld the horizontal plates needed to complete each row. In order to facilitate seismic testing, this research introduces a unique beam-box-column connection including horizontal bars and exterior trapezoidal stiffeners. Five horizontal bar pads at the concrete fill tube (CFT) column and eight external stiffeners at the beam flange level make up the planned connection. By using horizontal external stiffeners, this novel connection efficiently reduces stress and pulls the plastic hinge away from the cylinder. Furthermore, compared to the combination of the inner joint plate, the results demonstrated that the joint offered the necessary joint stiffness and strength, improving the stiffness by 3.01% and strength by 8.08%. These findings demonstrate that the connection can supply the necessary qualities and power. ability to dissipate energy, which permits the use of time-resistant frames in seismic zones. Thus, sending out a contact request may be an effective means of making contact as well. [6]

Shweta A. Wagh, et. al. (2014) [7] Composite structures are characterised by the use of composite materials—such as steel and concrete—in the columns and beams of the structure. As an alternative to pure metal and pure stone, concrete buildings are becoming more and more popular worldwide. Compared to many wealthy nations, India employs a very little amount of steel in its building. It is feasible to increase the usage of steel in building, particularly in light of India's present growth requirements. It would be a huge loss for the nation to stop utilising steel as a substitute material and to stop using it when it was on sale. This study used STAAD-Pro software to analyse four distinct sectors: G+12, G+16, G+20, and G+24. Using the created MS-Excel programme, design and cost estimations were created, and comparisons were performed based on the outcomes. choose between composite and R.C.C. models. [7]

S. B. More, et. al. (2022) [8] There is a global recognition for stone building as a substitute for pure metal and pure stone. Since reinforced concrete is the most practical and efficient building material for low-rise structures, it is used in the framing process of the majority of projects. The individual dimensions of this construction approach are risky, restricted, and weak, making it unsuitable for medium- and high-rise structures. For many of these issues, steel-reinforced concrete composite frame systems in mid- and high-rise structures will offer a practical and affordable answer. The purpose of this research is to find out how cost-effective the composite model is. In the long run, the designers are able to satisfy short-term demands thanks to the cost-effective, time- and money-saving hollow steel beam concrete building techniques. Compared to other sorts of models, these machines produce bigger carpets. Additionally, composite construction can increase a structure's lifespan. [8]

Il-Seung Yang, et. al. (2022) [9] A novel prefabricated steel mould set was created to provide rapid manufacturing and economical models. The midsection of the horizontal members are supported by minor forces using standard steel broad flange beams. For the column-column connection of the frame, which calls for greater strength and ductility than the site environment, a mix of concrete and steel was used. To do this at row-column connections, fixed panels are pre-cast and subsequently mixed with concrete. The beam-column connection can improve earthquake resistance since the steel beam is attached before the steel beam, so scaffolding need not be installed during construction, and it is generally accepted that the structure should be made solid. In order to assess the seismic performance of the conventional combination of layers, this study conducts comprehensive testing of cyclic loading experiments with different joint area attributes as the primary variable test. The outcomes of the experiments demonstrate that the suggested technology is realised in accordance with the necessary features in accordance with the particular time combination mentioned in the particular design. [9]

Prof. Vijay S Sawant, et. al. (2015) [10] Because composite buildings offer benefits over metal and concrete structures, they have gained popularity. While steel structures have better ductility and flexibility, which helps them survive earthquakes, concrete buildings are larger, have seismic weight, and have little deflection. In addition to being more affordable, quicker to construct, and fireproof, composite structures combine the advantages of steel and concrete. Researchers compared the seismic performance of composite steel and concrete structures in this study. Each of the four instances took the link into account: Each steel beam in an RCC structure, each steel beam in an RCC structure, and each steel beam in an RCC structure. The study makes use of the response spectrum and static equation approach. The modules of SAP 2000 software are comparable to these modules. To estimate the labour cost, the cost of materials for each component of the frame building will be considered. In terms of material cost and seismic performance, the comparison research indicates that the composite frame will be the most appropriate of the four types of constructions. [10]

Minakshi Vaghani, et. al. (2015) [11] For structural engineers, the beam-column connection is a tough and complex work. The safety of the structure depends greatly on the proper design of the concrete panel connection. Even if the length of the frame components dictates the size of the connection, the connection still needs to be able to resist the various characteristics of the materials used for the beam and column. Joint issues are frequently the consequence of

incorrect horizontal and vertical collision prevention design, insufficient external and vertical shear reinforcement, and, of course, insufficient joint anchoring capability. An earthquake frequently causes damage or destruction to load-bearing structures and lines. Recent seismic investigations have demonstrated that the lack of coexistence of seismic sites in the area causes bad behaviour of column-to-column connections, which leads to the failure of many concrete buildings. There's currently a significant risk of collapse for many of the existing concrete structures subjected to extreme seismic stress. This investigation involved casting the reinforced concrete beam-column construction and testing it with cyclic loads. By examining cycle recovery hysteresis, maximum compressive and tensile loads, and starting fracture development loads, we tried to evaluate the test specimens' performance. [11]

Mr. Roshan Onkar Gathekar, et. al. (2022) [12] There are several uses for composite designs. Selecting the appropriate form that satisfies the requirements of both the home and the owner is crucial. India employs a very little amount of steel in its building as compared to other emerging nations. Steel materials are susceptible to lateral and local buckling. Although building materials may eventually decay and shrink, they are often thicker and less stable. Steel can tolerate greater strain and stress since it is a more resilient material. For this reason, the composite model combines two materials in its design. In India, low-rise structures have historically been an option, but as the population of the nation rises, so does the need for mid- and high-rise structures. Although the frame system is the most cost-effective and appropriate for low-rise buildings, work in medium- and high-rise buildings is no longer possible due to the appearance of this structure being less strong and dangerous, flight restrictions, and an increase in personal lifts. A hybrid model would be suitable in this situation. [12]

Mohd Umeir Qureshi, et. al. (2019) [13] Despite being a developing nation, India uses less steel than other industrialised nations worldwide. Because of the huge population, the concentration of development in major cities, and the scarcity of land, cities are getting denser. The need for high-rise structures among the populace is growing quickly. Because of the buildup of loads on all levels, high-rise buildings have heavily loaded columns that dominate the building's architecture. Composite structures are employed as an alternative to steel buildings because of the benefits of RCC construction and the high cost of steel structures. [13]

Xi Chen (2015) [14] The past ten years have witnessed a notable increase in the use of environmentally friendly building practices. Growing public awareness of the advantages of green building practices has resulted in modifications to building owners', designers', contractors', and builders' designs and constructions. A novel frame made of steel bars and reinforced concrete (RCS) built with flawless walls is provided by Composite Frame. The composite frame is practical and cost-effective in both design and viewpoint, fully using the benefits of both steel and concrete. The primary objective of the ongoing project is to create an RCS node design procedure based on current Chinese requirements. This study used the three-dimensional ANSYS finite element approach to gather valuable experimental data. Results of research investigations have demonstrated the adoption of a modified design model in the axial compressive stress to strength ratio. Designers can employ some of these excellent design concepts. [14]

Feng Zhou, et. al. (2007) [15] The practical design and analysis of steel-reinforced concrete composite frames under heavy loads are presented in this article. We created a three-dimensional finite element model to carry out nonlinear analysis. Provided are specific examples of how steel frames, reinforced concrete slabs, and frame beams interact, as well as component relationships for cyclic loads. The authors used suitable design criteria to analyse a combination that they had previously tested. The experiment and the display hysteresis curve showed correlation for rotation amplitudes up to 0.04 rad. The steel beam ends shattering under heavy rotating pressure is one of the key observations. To replicate this behaviour, a simple model of a cracked steel connection is shown. Empirical evidence suggests that the nonlinear model well represents the fracture behaviour of beam ends. [15]

Xuemei Liang, et. al. (2004) [16] This article demonstrates the advantages of our exceptionally durable stones ~RC! Column Metal Beam ~RCS! dynamic investigation of RCS and mass displacement systems in different ground motion scenarios. Strong columns with no distortion serve as the foundation for the design. A 6-layer RCS frame with different structural and structural connections was subjected to inelastic dynamic analysis in order to study the behaviour of the RCS frame system. The study's findings demonstrate the effectiveness of the RCS system as a stress reducer. A variation of around 5.0%. Connection Deformation: Most of the deformation happens in the beam because the design procedure can efficiently control damage in the connection area. According to experimental research, nodal deformation has a 5%, albeit not statistically significant, impact on the maximum inter-story displacement of RCS frame parts under maximum seismic shaking. The analysis takes into consideration simple connections. [16]

Liquan Xiong, et. al. (2022) [17] Reinforced concrete (RC) beams and steel (S) beams make up concrete and steel (RCS) composite systems. This system, which combines many of the benefits of both components, is more rigid, less expensive,

and faster to construct than steel or concrete frame systems, which are typically employed in earthquake-prone locations. A crucial stage in earthquake design is determining the joint shear bearing capability. In order to facilitate applications, this study reviews current research on bearing shear capacity from failure models, shear distribution mechanism, and calculation techniques. It also introduces the features of RCS connections and offers comments on experimental and theoretical investigations. Providing the foundation for more study. The presentation concludes with recommendations for enhancement and more study on the seismic performance of RCS composite frames. [17]

Seyed Rasoul Mirghaderi, et. al. (2013) [18] The reinforced concrete and steel (RCS) beam composite construction enhances the lateral stiffness and damping process of the reinforced concrete column, increases the energy dissipation capacity of the steel beams, and saves a substantial amount of material. Because reinforced concrete and steel columns have distinct qualities, converting one type of column to another may be rather challenging. This study suggests a novel inter-column connection that creates dependable load routes by employing an alternative method. Vertical plates known as plates link the beams, and cover plates and vertical plates that pass through each column reinforce the nodes. This research examines the performance model and the process of altering stress using the content analysis that is referenced above. In comparison to the prior expansion, the new expansion was shown to enhance stiffness and energy dissipation and decrease energy deterioration during cyclic loading. Additionally, the study demonstrates that employing paper might enhance joint function. [18]

Yu-Chen Ou, et. al. (2023) [19] The terms "new RCS systems" refer to steel beam composite frames (S) and very durable reinforced concrete columns (new RC). The creation of row-column joints is the primary advancement of the new RCS system. Determining the seismic performance of new RCS connections thus required the creation and testing of four large-scale beam-column assembly models in this study: three connection models and one external connection model. Whereas the other structures feature concentrically framed beams, two of the integrated structures have beams eccentrically joined to new reinforced concrete beams. Every sample shows persistent and steady hysteretic reactions. According to clinical trials, tie ends can minimise damage to up to 6% of the drift level and produce the best beam bending. Nevertheless, the joint structure suffers significant harm when the disparity between structural steel beams reaches an extremely high level (±6%). The suggested redesigned RCS joint can support eccentric beams without changing the seismic response, according to experimental research. [19]

Ahmadreza Khodabandehlo, et. al. (2019) [20] In the building sector, the need for innovative materials is growing due to factors including population growth, educational progress, and scarce resources and commodities. Composite moment frame (RCS) constructions employ steel beams and reinforced concrete columns. It is easy to assess the strength of the beam since it is lighter than the concrete structure thanks to the application of the steel beam's bending strength and compressive strength proportionate to the concrete. However, the electrical strength of the beam is poor at this length. The electrical cables' attachment to the concrete is the most crucial component of this construction. The connections made to support lines and the connections made to support lines through joints make up the two categories of these connections. This study is to investigate the seismic performance and susceptibility of RCS frames fastened to concrete and steel beams. Excel was utilised for data processing and ABAQUS software for statistical analysis. [20]

Deepak M Jirage, et. al. (2015) [21] Connecting steel bars to concrete or profile concrete is the process of building the steel-concrete composite system. machine-spliced and cut. Cut the connections mechanically so that they function as one. This research compared G+20 structures in seismic zone IV using both the steel-concrete and RCC strategies, while also taking into consideration the seismic loading standards outlined in IS: 1893 (Part 1)-2002. To build and evaluate three-dimensional models, utilise ETAB software. Based on the comparison, the combined model is more cost-effective. [21]

Meissam Nazeryan, et. al. (2022) [22] For a long time, composite concrete and steel (RCS) columns have been recognised as the industry standard. By combining steel and concrete, the system gains from their respective advantages. There are two kinds of connections that these are: line connections and cable connections. This study examines the seismic performance of RCS nodes under uniform and cyclic loads by simulating the laboratory model of prior studies using ABAQUS finite element software. Perform parametric study (verify the thickness of the cover plate, the steel plate in the region, etc.) after using the finite model. Ultimately, after a comparison of this connection type's outcomes, updated models with more capacity and reliable, desired features are suggested. [22]

Prof. Y. P. Pawar, et. al. (2016) [23] An analysis of the exposed steel frames to fire is part of the fire performance of steel buildings at high temperatures. It is important to observe how temperature, strain, and pressure affect a metal structure's ability to withstand fire. Various elements, such as the steel's characteristics and the coating material applied to it, influence how steel frame performs during a fire. This paper summarises studies conducted by different

researchers on the impact of the stress-strain relationship on the fire performance of steel frames subjected to different temperatures when the metal is both unprotected and covered in concrete. [23]

Prof. S. S. Charantimath, et. al. (2014) [24] As an alternative to pure steel and pure concrete, steel-concrete composite constructions are starting to achieve international recognition. This strategy is novel for the construction sector, though. Modern building makes extensive use of steel-concrete composite materials. Composite beams, as well as deck bridges clad with steel profile concrete, have been the subject of much investigation. However, because of their increasing weight, decreased stiffness, span constraints, and design dangers, RCC structures for mid- to high-rise buildings are no longer suitable for commercial use. The study's findings indicate that, when it comes to high-rise buildings, composite constructions work better than RCC ones. [24]

Dr. V. R. Rathi. et. al. (2022) [25] In India, composite constructions are becoming more and more popular for non-residential buildings. Concrete has the highest compressive strength, whereas steel has the strongest tensile strength, which is the straightforward rationale for considering composite construction. Combining these two materials can improve their qualities and make more wearable and effective designs. Shear fasteners are used to join profiled floor panels to steel beams so that the building systems function as a single unit. Concrete is then applied to the steel profiles on each line. In this investigation IV. Using the static equation, a comparison between G+15 D.C.C.C and composite structures in the seismic zone was conducted. Both were modelled with ETABS 2018 programme. Considerations include floor displacement, floor drift, floor sliding, self-weight, axial force, bending moment, and shear force. Comparing the outcomes reveals that the combined model performs the best. [25]

G. D. Lakade, Y. P. Pawar, et. al. (2015) [26] We have seen several earthquake-related calamities in recent years that have claimed lives. As a result, determining whether the RC frame construction is robust enough to tolerate vibrations is crucial. In this project, a four-story reinforced concrete building that is fifteen years old and situated in Zone III of India's IS 1893:2002 Seismic Zone Classification has been taken into consideration. The best technique for strengthening G+3 layer reinforced concrete building failure sites is FRP coating. attributes mentioned in ACI 440-2R. Compute in accordance with 08, and provide techniques and solutions for applying FRP to the materials, processes, and layers that will be leveraged. The restricted case design serves as the basis for all design, analysis, and modelling. [26]

3. CONCLUSION

This study's sole goal is to evaluate the data from earlier investigations. The vertical self-weight of each column dominates the building's structure in tall structures because of the volume of each structure. Because steel constructions are more expensive and have inferior RCC construction, composite structures have taken the place of steel structures. The connection's strength ought to be greater than the sum of the strengths of the elements it joins. As a result, creating and establishing sufficient support for this field is challenging. The steel beam will collapse immediately during the first stress cycle as a result of the intended connection failing owing to shear. For a long time, composite concrete and steel (RCS) frames have been considered an effective option. By successfully combining concrete and metal, this technique benefits from the best features of both systems. Beam-to-beam and column-to-column connections are the two varieties of these connections. New RCS connectors can support eccentric beams without compromising seismic response, according to research. This kind of connection is appropriate for usage in time-resistant frames in seismic zones because of its ductility and energy absorption capabilities.

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vi. **IS 875 Part II-** Live load
vii. **IS 875 Part III-** wind load
viii. **IS 875 Part V-** load combination