A Review on Effect of Stirrups in Beam under Seismic Loading

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Abstract - In many seismically active regions worldwide, massive Reinforced Concrete (RC) structures built before the 1970s existed. These older RC buildings, in countries having seismic history, were designed for gravity loads only. Anyway, the beam-column connections influence the structures where the functions of connection shortage by transport the forces like shear, moment, and torsion through the beam to the column. Also, it could behave in a ductile manner to help the structure resist the seismic, as simulate the seismic loading. Due to the failure of external joints more than the internal beam-column joints, this review focuses on the behavior of vulnerable beam under seismic loading, consequently simulated the behavior under an earthquake and the reinforcement detailed.

Key Words: RC beam, Earthquake, Collapse, Stirrups, Buckling, Shear Failure.

1.INTRODUCTION

The high sensitivity of earthquake for beam-column connections in constructions established before 1980 results according to the fact that since the first provisions of seismic design for beam column connections were provided in the 1960s, these provisions were not formally used within the limits of the significant design specifications for ductile frames in the late 1970s. The edition of the Uniform Building Code (UBC) in1976 was the first code that involved the demands of seismic design like the demands of transverse reinforcement in the joint region. Thereby, most buildings, if not all, constructed prior 1980s have suffered some kind of insufficient seismic design. Then, they are highly exposed to the danger of seismic failure through severe seismic. This matter is dangerous in the developing countries located in seismicity areas. Particularly when their ductile design code did not involve design requirements into the significant design until the late 1980s and sometimes 1990s. Mosier surveyed a comprehensive area of pre-1979 constructions in the US.

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in the design of new products, and refinement of the existing product. A company is able to verify a proposed design and will be able to perform the specification of the client before fabrication or construction. Modifying an existing product or structure is used to qualify the product or structure of a new condition of service. In the case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

2. REVIEW OF LITERATURE

W. Merati and P. Widagdo (1996) studied the Effects of column stirrup and longitudinal beam reinforcement on exterior beam-column joint under cyclic loading. The purpose of this study is to examine how the ratio of longitudinal beam reinforcement in the joints affects performance under cyclic loads. The hysteretic diagram for joint reaction subjected to a specific cyclic loading pattern has been employed as the evaluation's yardstick. Three outside beam-column joints in 1:1 scale were used to demonstrate three different longitudinal beam reinforcement ratios that have an impact on the quantity of joint stirrup needed. The test findings were displayed using graphs of the hysteretic loop, the crack pattern, and the energy dissipation and accumulation for various loading cycles. As long as there are enough joint stirrups placed, the ratio of longitudinal reinforcement has no effect on the ductility of the beam-column connection. Additionally, it is established that in order to achieve a consistent cumulative energy dissipation capacity, a higher ratio of longitudinal beam reinforcement necessitates a higher number of stirrups.

Durgesh C. Rai et al (2006) studied the Behaviour of Seismic and Non seismic RC Frames under Seismic Loading. To investigate how seismic detailing affects the hysteretic behaviour of RC frames, cyclic lateral loads was applied to one-bay, single-storey scale models. No discernible changes in the hysteretic behaviour of models with seismic (IS 3920: 1993) and non-seismic (IS 456: 2000) features were found because beams and columns' premature joint failure prevented them from reaching their full flexural capacities. As a result of extensive cracking at the intersections of the column and footing and the beam-column joints, the test frames eventually evolved a side sway collapse mechanism. Lateral ties in seismic frame joints postponed cracking and strength deterioration but were unable to stop joint shear failure. For such knee joints, concrete spalling on column faces must be avoided, and the anchorage effectiveness of beam bars must be improved. Deep columns and beam stubs are two ways to get the yield mechanisms you want. Despite the unfavourable yield mechanism, both models exhibited steady hysteretic behaviour up until displacements reached a 5 percent drift ratio. Due to the slip of the beam reinforcing bars that were bent down into the column, severe pinching of the hysteretic loops was observed during large displacement cycles. The test constructions' experimental lateral stiffness was significantly less than their computed stiffness, which included bending.

K.R. Bindhu and K.P. Jayab (2010) studied the Strength and Behaviour of Exterior Beam Column Joints with Diagonal Cross Bracing Bars. The test specimens with diagonal confining bars have shown better performance, exhibiting higher strength with minimum cracks in the joint. All the specimens failed by developing tensile cracks at interface between beam and column. The joint region of specimens of group B is free from cracks except some hair line cracks which show the joints had adequate shear resisting capacity. The specimens detailed as per IS: 456 with diagonal confining bars had improved ductility and energy absorption capacity than specimens detailed as per IS 456:2000.The displacement ductility is increased considerably for the non-conventionally detailed specimens. From the analytical study it is observed that the provision of cross diagonal reinforcement increased the ultimate load carrying capacity and ductility of joints in the both upward and downward loading conditions.

G. Sagbasa (2011) studied the Computational Modeling of the Seismic Performance of Beam-Column Subassemblies. Nonlinear finite element analysis procedures can be an accurate and reliable tool in assessing the seismic performance of seismically designed and non-seismically designed beam-column subassemblies. Both interior and exterior units can be modeled effectively. Aspects of behavior such as hysteretic load-deformation response, strength capacity, ultimate ductility, total energy dissipation, cracking and damage progression, and failure mode can be accurately calculated. For the specimens examined, strengths and ductilities were calculated to within means of 5%, and energy dissipation to within a mean of 10%, with reasonably low scatter. For accurate simulations to be achievable, the finite element package employed must contain formulations for comprehensive and realistic constitutive modeling of various importance second-order mechanisms prevalent in the behavior of cracked reinforced concrete. Of particular importance is the rigorous modeling of concrete compression softening (for capturing joint shear damage and strength capacity), concrete tension stiffening (for energy dissipation and ductility calculations), bond slip (for anchorage loss mechanisms), confinement effects (for strength and ductility calculations), and hysteretic response of concrete and reinforcement (for energy dissipation). Most of the large multi-purpose finite element packages currently available will not have this capability, but a number of specially developed programs. The smeared rotating crack model employed in VecTor2, incorporated into a total-load secant-stiffness algorithm, represents a simple and accurate alternative procedure for the finite element modeling of cyclically loaded beam-column subassemblies. Most other programs are based on a fixed crack or micro plane model for concrete, and employ an incremental-load tangent-stiffness based computation procedure. An improved cyclic bond-slip model for smooth reinforcement is required in order to obtain improved simulations for non-seismically designed subassemblies containing such reinforcement. Finite element analysis procedures can provide accurate simulations of seismically retrofitted subassemblies, and can thus be an effective tool in investigating alternative retrofit schemes.

Hasan Kaplan (2011) studied the Seismic strengthening of RC structures with exterior shear walls. It was observed and measured that the newly added external shear wall and the connected end columns and beams behave like a monolithic member. Minor cracks between new and existing elements have been formed after 1% drift. Even after these minor cracks, the shear walls did not lose their load bearing capacity. The first cracking occurred at the bottom of the exterior shear walls due to bending in initial stages of the experiment. During the subsequent cycles, sliding shear capacity of the shear walls drooped due to the rupturing of the longitudinal bars and in addition, shear sliding behaviour was observed at the bottom of the walls. This had an adverse effect on ductility and energy absorption capacity of the system. To prevent such damage, additional shear reinforcement is required at the web of the wall. In order to test the behaviour without any over strength of dowel capacity, no material factor was considered in the design process and experimental yield strength values were used instead of characteristic yield strength. For designing the dowels, ACI318 (ACI 2005) shear friction formulae were used. Although the dowels possessed no over strength, they adequately transferred the loads between existing and new elements safely. Therefore, the shear friction formula can be used for designing the connection of exterior shear wall with existing structural elements.

Momin. S. Zishan (2016) studied the Investigating the Performance of Reinforced Beam-Column Joint under Different Loads. In Indian design practice, beam-column joint has been given less attention than it actually deserves. This paper contributes to the necessity for the design engineers to be aware of the fundamental theory of joints behaviour. In this context, the behaviour of different types of joints under different loading condition is discussed. An analytical study is still required for eccentric joints with and without slab consideration. The mechanisms involved in joint performance with respect to bond and shear transfer are critically reviewed and discussed in detail. A significant amount of ductility can be developed in structure with well-designed beam-column joints wherein the structural members could perform satisfactorily as per the capacity design principles. Further amount of reinforcement, detailing of reinforcement, strength of concrete and type of loading have distinct effects on the performance of beam-column joints. All these parameters should be considered while designing the joint for better effectiveness.

Pathan Irfan Khan and N.R.Dhamge (2016) studied the Seismic Analysis of Multistoried RCC Building due to Mass Irregularities. It shows the seismic analysis of the RCC structures with different irregularities such as mass irregularity, stiffness and vertical geometry irregularity. Whenever a structure having different irregularity, it is necessary to analyze the building in various earthquake zones. From many past studies it is clear that effect of earthquake on structure can be minimize by providing shear wall, base isolation etc. The lateral displacement of the building is reduced as the percentage of irregularity increase. As the percentage of vertical irregularity increases, the story drift reduces and go on within permissible limit as clause no. 7.11.1 of IS 1893-2002 (Part I).

It was found that mass irregular building frames experience larger base shear than similar regular building frames.

Albert Philip and Dr.S. Elavenil (2017) studied the Seismic Analysis of High Rise Buildings with Plan Irregularity. The floor layout of the building significantly affects the displacement, storey drift, and storey shear seismic behaviour of the building. For both designs, the storey displacement increases linearly (by around 2%) from bottom to top, although it is more for irregular structures. Both buildings' displacement values (163.6 mm for a regular building at roof level and 181.6 mm for an irregular building) are within permitted ranges. The second level of an irregular construction has the highest storey drift (0.005862), while the fourth floor of a conventional structure has the lowest (0.005019). According to the seismic analysis, the ground floor of both structures had the highest storey shear force (177.21kN for regular and 206.65kN for irregular), and the value decreased by 2% as height increased. For both constructions, storey stiffness varies nonlinearly, peaking at the first and second floors (94.27 kN/m for regular and 78.75 kN/m for irregular). The structure is safe since the overturning moments for all the stories of both structures are roughly equal to zero (-0.0184kN/m for the regular building and -0.0279kN/m for the irregular building). More displacements, storey drifts and storey shears were seen in the irregular building compared to the regular building, which suggests that buildings with extreme plan irregularity exhibit the most displacement and storey drift.

Hariharan.S (2017) studied the Seismic Performance of Single Pier Building. According to results, the single pier shear force and torsion was found to be maximum for the single pier and it decreased to a minimum in the top storey in all cases. According to results, it was found that mass irregular building frames experience larger base shear than similar regular building frames. According to results the stiffness irregular building experienced lesser base shear and has larger inter storey drifts. The absolute displacements obtained from finite element analysis of geometry irregular building at respective nodes were found to be greater than that in case of regular building for upper stories but gradually as we move to lower stories displacements in both structures tended to converge. This is because in a geometry irregular structure upper stories have lower stiffness (due to L-shape) than the lower stories. Lower stiffness results in higher displacements of upper stories. When finite element analysis was done for regular as well as stiffness irregular building (soft storey),it was found that displacements of upper stories did not vary much from each other but as we moved down to lower stories the absolute displacement in case of soft storey were higher compared to respective stories in regular building. Those in set-back and soft and/or weak first story structures. Conflicting conclusions have been found for the set-back structures; most of the studies, however, agree on the increase in drift demand for the tower portion of the set-back structures. For the soft and weak first story structures, increase in seismic demand has been observed as compared to the regular structures. Finally, buildings with a wide range of vertical irregularities that were designed specifically for code based limits on drift, strength and ductility, have exhibited reasonable performances, even though the design forces were obtained from the (seismic coefficient) procedures. The behavior of multistory building with and without floating column is studied under different earthquake excitation. The static and free vibration results obtained using present finite element code is validated. The dynamic analysis of frame is studied by varying the column dimension. It is concluded that with increase in ground floor column the maximum displacement, torsion, inter storey drift values are reducing. The base shear and overturning moment vary with the change in column dimension.

Pankaj M. Patel (2017) studied the A Review on Flexure Strength of Reinforced Concrete Beam Using FRP Sheet. The flexural strength and stiffness of the strengthened beams increased compared to the reference beam or control beam. The improved on the overall flexural capacity of the CFRP strengthened beams varies between 41% and 125% over the reference beam or control specimens. The CFRP strengthened beams presented greater capacities than the GFRP strengthened beams. CFRP external reinforcement increased the load carrying capacities of damaged/repaired RC beam by 22. 5% to 41.2%. Overall, there is lack of comparison of different arrangement other than full side wrapping and U-wrapping for beams strengthened in shear and flexure. FRP application primes to a variation of some of the important structural aspects like the cracking pattern and deformation levels in shear reinforcing systems. There is no any effect of different environmental conditions on the strength of strengthened beam. Strengthened beam showed better load vs deflection characteristics than the control specimen beam. CFRP or GFRP failure may be due to debonding of CFRP or GFRP or Severe concrete. When increase of number of layers of CFRP sheet or plate the strength of beam increase but at decreasing at rate. Hence, we can say that CFRP sheet or plate plays an important role providing strength and strengthening to structure.

M. Labibzadeh et al (2018) studied the Effect of rectangular spiral stirrup on bearing capacity of RC beams under cyclic loading. Main results obtained from the current study lead to the following conclusions: - Based on a comparison made between the results obtained from experimental and numerical studies, it can be deduced that the ACI-318 is conservative at predicting the ultimate shear strength. The nominal shear strength of the beam predicted by ACI-318 was 40 percent lower than those of the experimental and numerical works. - According to the force-displacement curves obtained from the parametric study, when the concrete strength is considered as 30 MPa, the behavior of the beam with spiral and traditional stirrups under cyclic loading was the same. In other words, when the strength of the concrete is high, the spiral stirrup has no significant effect on the strength of the beam. As the concrete strength is decreased from 30 to 20 MPa, the behavior of the beam is affected by the transverse reinforcement. Hence, the strength of the beam with spiral stirrup is different than that of the traditional stirrup. - The link of the advanced spiral stirrup was perpendicular to the crack line in the straight direction of the cyclic loading. But, in the reverse direction of cyclic loading, the link was parallel with the crack line. So the strength of the beam with advanced spiral stirrup was low. - As the diameter of stirrup increased, the strength of the beam increased and the beam was fractured by shear mode. Moreover, as the spacing of the spiral was increased, the strength of the beam with spiral stirrup was decreased compared to the beam with the traditional stirrup.

Yongping Xie (2018) studied the A Review of the Seismic Performance Size Effect of Reinforced Concrete Beams. The size effect is an increasing concern of scholars all over the world. A large number of studies have shown that the influence of section size on shear bearing capacity of beams is obvious, especially if the stirrup ratio is small or without the stirrup, the size effect is more obvious, and the bending strength decreases with the height of the beam, and the compressive strain of the compression zone decreases with the size of the specimen. Therefore, in the structure design, if the conclusions based on the small size specimen are applied in the large size specimen, the security of the structure or component is necessarily reduced.

Zheng Zhou et al (2018) studied the Square reinforced CFST column to RC beam joint subjected to lateral loading: An investigation using finite element analysis novel composite joint system with internal diaphragms is proposed to connect square reinforced concrete-filled thin-walled steel tube (RCFTWST) column and RC beam FEM was developed based on finite element software ABAQUS, and further parametric studies were conducted. The specimen showed joint shear failure when there was no internal diaphragm between the two holes where the longitudinal beam bars passed through. Increasing the quantity or thickness of internal diaphragms, or decreasing the interval of internal diaphragms can enhance the ultimate strength of the joint specimen, and thus the failure mode would change from joint shear failure to beam flexural failure. While the initial stiffness of joint specimens was hardly changed by these parameters, once the beam flexural failure mode is dominated, the ultimate strength was hardly influenced. Two composite joints designed based on the parametric studies, were tested. Two failure modes, namely, beam flexural failure, and beam flexural failure with bond failure were observed in the current test. The joint specimens tested in this paper showed excellent seismic performance, and all failures occurred at large drift, and can be expected to be adopted in structures. The experimental results can be well predicted by the model before 5% drift. In order to obtain an improved behaviour, at least one internal diaphragm placed at the middle-height of joint region was needed. It seemed that if two internal diaphragm were adopted, they should be place at or close to the trisecting points between the top and the bottom layers of rebars. The diameter of concreting hole should be large enough for concreting if the integrity of joint zone was guaranted.

R.Murugan and G.Kumaran (2019) studied the Experiment on RC Beams Reinforced with Glass Fibre Reinforced Polymer Reinforcements. The ultimate load carrying capacity of GFRP reinforced beams increases when increase in percentage of reinforcement when compared with steel reinforced beam. The ultimate deflection observed in sand coated GFRP reinforced beams show increase in deflection, when increase in percentage of reinforcement. But at the same time, it is reversed in grooved GFRP reinforced beams compared with steel reinforced beams. The performance of sand coated GFRP reinforcements is low when compared to grooved GFRP beams with respect to ultimate load carrying capacity and ultimate deflections. The ultimate load carrying capacity of sand coated GFRP reinforced beam is 34 kN and 50 kN in 0.73% and 1.04% reinforcement ratio and the same in steel reinforced beams is 40 kN in 0.73% reinforcement ratio. It shows 15% reduction and 25% increase in sand coated GFRP reinforced beams compared to conventional steel reinforced beams. The ultimate deflection observed in sand coated GFRP reinforced beams is 34.8 mm and 39.62 mm in 0.73% and 1.04 % reinforcement ratio respectively, which is higher than that observed in steel reinforced beams of 28.4 mm. It shows 12% and 14% increase in deflection in sand coated GFRP reinforced beams when compared to steel reinforced beams. The ultimate load carrying capacity of grooved GFRP reinforced beam is 38 kN and 56 kN in 0.73% and 1.04% reinforcement ratio and the same in steel reinforced beams is 40 kN in 0.73% reinforcement ratio. It shows 5% reduction and 25% increase in grooved GFRP reinforced beams compared to conventional steel reinforced beams. The ultimate deflection observed in grooved GFRP reinforced beams is 41.68 mm and 36.85 mm in 0.73% and 1.04 % reinforcement ratio respectively, which is higher than that observed in steel reinforced beams of 28.4 mm. It shows 14.5% and 13% increase in deflection in grooved GFRP reinforced beams when compared to steel reinforced beams. The number of cracks at ultimate load level is higher in sand coated GFRP beams when compared with grooved GFRP and steel reinforced beams. The grooved GFRP reinforced beams are found superior when compared to sand coated GFRP and conventional steel reinforced beams.

Dan-Yang Ma et al (2019) studied the Seismic performance of the concrete-encased CFST column to RC beam joint. Four types of joint failure modes, i.e. beam bending failure, beam bending-shear failure, column compression-bending failure, and joint shear failure were observed in the current test. The failure mode was predicted based on the relative strength of the beam, the column, and the joint core. The joint shear strength needs to be further studied for this composite joint. Different types of connections had little influence on the strength, the ductility, and the energy dissipation capacity of joints. Each type of connection remained intact after the test. Nevertheless, attention should be paid to the fracture of the longitudinal rebars in the sleeve connection. The bending failure joint had a higher ductility, a higher energy dissipation capacity, and a lower strength degradation than the shear failure joint. The joint J4–1, exhibiting a column compression-bending failure mode, had the largest ductility coefficient of 4.09 and equivalent damping coefficient of 0.163 among all joints with an axial load level of 0.2. It could be concluded that the seismic performance of the column compression-bending failure joint could be improved by the moderate axial load level. Due to the combination of the CFST component and the RC component, the energy dissipation capacity of this composite joint is moderately higher than the joint composed of the CFST column or the RC column.

Ali Fallah et al (2020) studied the A Review of Seismic Response of Precast Structures. In this paper, the seismic performance of precast structures under actual earthquakes was reviewed. Additionally, research using experimental work and computational analyses to examine the seismic response of existing precast buildings were evaluated. Additionally, the most recent developments in the creation of dry and wet precast connectors were demonstrated. The majority of current precast constructions have been found to be sensitive to seismic activities, according to a literature assessment. According to numerous academics, the primary cause of the structural collapse of many precast constructions has been connection failure. Numerous experimental studies and numerical simulations have also shown the fragility of existing precast buildings that were built and designed without taking seismic events into account. However, the earlier works did not adequately address the necessity for strengthening of subpar precast connections, and more research is required. The seismic response of single-story precast buildings has been effectively investigated using the diffused and lumped plasticity models. However, it is necessary to look at how accurate such models are for nonlinear dynamic analysis of multi-story precast structures and bridges. It is also interesting that studies on the seismic susceptibility of precast structures have only been conducted in a small number of nations, including Turkey, Italy, and the USA. Investigating how seismically vulnerable precast buildings are in other nations with various sorts of connections is very interesting and important. These studies can improve our comprehension of the seismic reaction of various precast connections, which will help us improve the upgrade. Such analyses can deepen our comprehension of the seismic reaction of various precast connections and, as a result, aid us in improving or strengthening weak joints. It should be noted that few research have examined the seismic response of substantial precast buildings like hospitals, with the majority of available studies concentrating on single-story precast industrial buildings. More ductile precast connections need to be developed, and the performed literature research emphasizes the crucial function of precast joints during seismic occurrences.

Mustafa Hussini et al (2020) studied the A Review Paper on Seismic Pareformance of High-Rise Building using Bracing, Diagrid and Outrigger System. For structures that are being built to a specific level and height, the use of bracing as a lateral load resisting technique works well. Up to 30 to 35 stories, that is suitable. The diagrid system performs better than the bracing method by increasing the lateral strength and stiffness of the structure. For high-rise and very high-rise buildings, the outrigger system is very effective.

Md. Rifat Bin Ahmed Majumdar (2021) studied the Influence of Beam-Column Joint on the Seismic Response of RC Frames. Further experimental research is needed to fill in the gaps in the literature review that is reported in this work about the influence of different factors on the behavior of the RC beam-column joint. Further research is necessary to quantify the reinforcement's contribution to joint shear strength. The impact of column axial stress on joint behavior has not been the subject of general agreement among academics. Joint behavior is influenced by the amount of transverse reinforcement, although no conclusive findings regarding limiting the percentage have been made. Bond strength is a crucial factor that has a big impact on joint behavior, but more research is needed to understand how reinforcement is distributed. Vertical and horizontal shear reinforcement is largely required to resist the tremendous shear stresses operating on joint cores. To provide proper anchorage and prevent early bond failure, longitudinal column and beam reinforcing bars passing through joint cores shouldn't be too thick. Due to architectural and other factors, joint eccentricity is practically inescapable, yet different building regulations offer varying guidelines. In conclusion, seismic design specifications for RC joints call for both the joints and the frames to perform as needed during a significant earthquake. The purpose of the beam-column joint is to assist the structure in dissipating seismic forces so it can behave ductility when an RC frame is subjected to seismic excitation. Good detailing of the beam-column joint core regions is crucial if reinforced concrete frames subjected to severe seismic events are to respond properly, as beam-column joint cores can be important regions in the ductile RC moment-resisting frames. A crucial problem in the seismic resistance of RC moment-resisting frames (RC MRF) was found to be the performance of the beam-column joints.

Kartik Kumbar and R Shanthi Vengadeshwari (2022) studied the Analysis Of Interior Beam Column Joint with Enhanced Reinforcement . The investigation of the FE models led to the following conclusions regarding interior joints. Interior beam column joints are designed and detailed in accordance with IS regulations. The increased X-shaped bracing in the joint area allows the ANSYS Workbench 2022 FEA model to evaluate inner beam column joints. The FEA results are quite similar to the outcomes seen in the experiments. In terms of predicting final displacement, the variance between FEA model findings and experimental data is accurate to within 12%.

Muhammad Ilyas et al (2022) studied the Review of Modelling Techniques for Analysis and Assessment of RC Beam–Column Joints Subjected to Seismic Loads and the behaviour is presented through non-linear translational or rotational springs. When compared to lumped plasticity or rotating spring techniques, these models produce simulation results that are more precise and lifelike while requiring only a minor increase in computational effort and memory usage. Comparing the FE model, the computing effort and memory requirement is still noticeably lower. - Each zero-length spring or hinge must, however, be given a unique material and constitutive model in order to control its non-linear response. - A number of multi-spring models cannot be used with RC frames if the joint core does not have shear reinforcement, which is a more serious flaw in gravity-designed frames. The Grande et al. model for multi-spring models can be regarded as the most effective in terms of accuracy and computational effort. Two springs have effectively masked the interface and joint panel reaction.

Ms. Shubhangi Balaji Dalave and Prof. A. N. Shaikh (2022) studied the Analysis of Beam Column Joint Subjected to Seismic Lateral Loading. The structural behaviour will differ from what was anticipated during analysis and design if the joints are not able to withstand the forces and deformations brought on by the transfer of forces between the elements coming together at the joint. Particularly, joint opening needs to be carefully examined because it can cause diagonal joint cracking. This type of joint opening may form in multistory buildings as a result of lateral strains. Although the provided information refers to seismic forces, it is generic in nature and can be used to structures vulnerable to lateral forces. The analysis of the issue led to the following conclusions: The column at the second joint is larger than the section size required by ACI 318's specification for IS 13920. The sizes of the columns and beams at the two joints are practically equal, according to two codes. The shear strength at the joint is found to be stronger by the ACI 318 code than by the other code.

Dheeraj Bothra et al (2022) studied the A Review Paper on Analysis of Highrise Building (G+15) with Vertical irregularities Using ETABS. Additionally, it was noted that the building's vertical irregularity rose, its base shear dropped in response to a reduction in the structure's mass, and its capacity to withstand seismic forces fell in response to this. It has been noted that a structure's behaviour changes quickly when an irregularity's location changes. The performance of composite structures is generally improved by the introduction of imperfections. When compared to structures resting on flat ground, it is discovered that buildings resting on sloped ground tend to have more plastic hinges, which tend to form more in the direction of the asymmetry in the building. The behaviour of the structure as a whole is affected by the presence of shear walls. It should also be noted that irregularities are important for construction from an architectural and elevational perspective, thus its impact on structural behaviour needs to be examined in order to make adequate design considerations.

3. LITERATURE SUMMARY

- The ratio of longitudinal reinforcement does not affect the ductility of the beam-column joint, provided that the number of joint stirrup is sufficiently installed.
- Higher ratio of longitudinal beam reinforcement requires higher number of stirrups to reach a constant cumulative energy dissipation capacity.
- Lateral ties in joints of the seismic frame delayed the cracking and strength degradation but could not prevent the shear failure of joints.
- The provision of cross diagonal reinforcement increased the ultimate load carrying capacity and ductility of joints in the both upward and downward loading conditions.
- Amount of reinforcement, detailing of reinforcement, strength of concrete and type of loading have distinct effects on the performance of beam-column joints.
- When the strength of the concrete is high, the spiral stirrup has no significant effect on the strength of the beam.
- As the concrete strength is decreased from 30 to 20 MPa, the behavior of the beam is affected by the transverse reinforcement. Hence, the strength of the beam with spiral stirrup is different than that of the traditional stirrup.
- If the stirrup ratio is small or without the stirrup, the size effect is more obvious, and the bending strength decreases with the height of the beam, and the compressive strain of the compression zone decreases with the size of the specimen.

REFERENCES

1. SP: 34 (S&T):1987 'Handbook on concrete reinforcement and detailing' Bureau of Indian Standards, New Delhi.
2. IS 875: 1987 Code of practice for design loads (other than earthquake) for building and structures - Part 2: Imposed loads; Bureau of Indian Standards, New Delhi.
3. IS 13920 :1993 Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces; Bureau of Indian Standards, New Delhi.
4. Ali F., Mohammadreza V. and Sophia C.A. (2020), 'A Review of Seismic Response of Precast Structures'. International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 13, pp.10 (2020).
5. Albert Philip and Dr.S. Elavenil (2017) 'Seismic Analysis of High Rise Buildings w.ith Plan Irregularity'. International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 4, April 2017, pp. 1365–1375, Article ID: IJCIET_08_04_154 Available online at http://iaeme.com/Home/issue/IJCIET?Volume=8&Issue=4 ISSN Print: 0976-6308 and ISSN Online: 0976-6316.
6. Bindhu K.R and Jayab K.B (2010), 'Strength and Behaviour of Exterior Beam Column Joints With Diagonal Cross Bracing Bars', Asian Journal Of Civil Engineering (Building And Housing) Vol. 11, No. 3 (2010) Pages 397-410.
7. DanYang M. and Lin-Hai H.X. (2019) 'Seismic performance of the concrete-encased CFST column to RC beam joint: Experiment', Journal of Constructional SteelResearch,Vol:154,pp:134–148.DOI: https://doi.org/10.1016/j.jcsr.2018.11.030 pp. 295-319.
8. Dheeraj Bothra , Aakash Suthar and Abbas Jamani (2022) 'A Review Paper on Analysis of Highrise Building (G+15) with Vertical irregularities Using ETABS'. International Journal of Advances in Engineering and Management (IJAEM) Volume 4, Issue 2 Feb 2022, pp: 143-145 www.ijaem.net ISSN: 2395-5252.
9. Durgesh C. R.,S.,TqakkaI S K. and Ramesh U. (2006) 'Behaviour of Seismic and Non-Seismic RC Frames under Cyclic Loading', The Indian Concrete Journal,Vol: 82, pp. 266-283.
10. Hasan K, Salih Y, Nihat C and Ergin A. (2011), 'Seismic strengthening of RC structures with exterior shear walls', Sadhana Vol. 36, Part 1, February 2011, pp.17–34. © Indian Academy of Sciences.
11. Heng Z , Dan G, Xuhong Z. and Kang H T.(2018) 'Square reinforced CFST column to RC beam joint subjected to lateral loading: An investigation using finite element analysis', 12th International Conference on Advances in Steel-Concrete Composite Structures,Valentina, Spain, pp:27-29.DOI: http://dx.doi.org/10.4995/ASCCS2018.2018.7136.
12. Hariharan.S, Tamilvanan.K, Jose Ravindra Raj.B (2017),'Seismic Performance of Single Pier Building, ISSN: 2277-9655 [Hariharan* et al., 6(4): April, 2017] Impact Factor: 4.116 IC™ Value: 3.00 CODEN: IJESS7.
13. Laseimaa S.Y., Mutaliba A.A., Osmana S.A. and Hamidb l .S.H. (2018), 'Effect of rectangular spiral stirrup on bearing capacity of RC beams under cyclic loading'. American journal of solids and structure.
14. Murugan R. and Kumaran G. (2019) 'Experiment on RC Beams Reinforced with Glass Fibre Reinforced Polymer Reinforcements'. International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8, Issue-6S4, April 2019.
15. Md. Rifat Bin Ahmed Majumdar (2022), 'Influence of Beam-Column Joint on the Seismic Response of RC

Frames', © 2022 IJRTI | Volume 7, Issue 10 | ISSN:2456-3315. http://doi.one/10.1729/Journal.31744.

16. Merati.W. and Widagd P. (1996), 'The effects of column stirrup and longitudinal beam reinforcement on exterior beam-column joint under cyclic loading '. Transactions on the Built Environment vol 17.
17. Momin. S. Z. and Sanghai.S. (2016), 'Investigating the Performance of Reinforced Beam-Column Joint under Different Loads: A Review '. IJSTE - International Journal of Science Technology & Engineering Volume 2 , Issue 08 , February 2016 ISSN (online): 2349-784X
18. Muhammad I, Awais A, Abdullah R, Fayaz A K. and Sadaf S.(2022) ,'Review of Modelling Techniques for Analysis and Assessment of RC Beam–Column Joints Subjected to Seismic Loads', Materials,pp:653-703.DOI : https://doi.org/10.3390/ma15217448.
19. Pathan I. K and Dhamge N.R. (2016) ' Seismic Analysis of Multistoried RCC Building Due to Mass Irregularity', ISET Journal of Earthquake Technology, Technical Note, Vol. 1, No. 4, pp. 121-132.
20. Pankaj M. P., Parikh K.B. and A. R. Darji (2017), 'A review on flexure strength of reinforced concrete beam using FRP sheet'. February 2017, JETIR (ISSN-2349-5162) Volume 4, Issue 02.
21. Ravikumar S. and Kothandaraman S. (2022) ' Influencing Parameters of Exterior Reinforced Concrete Beam-Column Joint Shear Strength: A Depth Review of Recent Advances'. International ,Journal of Engineering Applications Vol. 35, No. 05, (May 2022) 931-942.
22. Shubhangi B D. and Shaikh A.N. (2022), 'Analysis of Beam Column Joint Subjected to Seismic Lateral Loading '. Vol-8 Issue-4 2022, IJARIIE-ISSN(O)-2395-4396.
23. Sagbas G and Vecchio F.G (2011), 'Computational Modeling of the Seismic Performance of Beam-Column Subassemblies', Journal of Earthquake Engineering, 15:640–663, 2011 Copyright © A. S. Elnashai & N. N. Ambraseys ISSN: 1363-2469 print / 1559-808X online DOI: 10.1080/13632469.2010.508963.
24. Yongping Xie , Jianming Guo , Lei Jia and Huan Qi (2018), 'A Review of the Seismic Performance Size Effect of Reinforced Concrete Beams'. Advances in Engineering Research, volume 163,7th International Conference on Energy, Environment and Sustainable Development (ICEESD 2018).