# Comparison of Rcc Exterior and Interior Beam Column Joint for Earthquake Resisting Structure As per IS 13920:1993 and IS 13920:2016

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**Abstract -**Beam-column joint is the gap in the modern ductile design of building. Especially under the earthquake loading this is more susceptible to damage. Due to brittle nature of failure this type of failure cannot be afford. Since 1970's this areas is under the light of research, but with the paper of Park and Paul, It got momentum. But still due to versatile nature of the The present work is divided into two phase. In first phase few sample of normal low and medium high building has been chosen and designed according to the IS 456:2000(LSD) and shear force are calculated as per IS 13920:1993 & IS 13920:2016. From this phase we come to conclusion that design size of column by IS 13920:2016 are 10% to 30% more than of IS 13920:1993.

***Key Words*:**IS 13920:2016; shear force, column, beam column

## 1.INTRODUCTION

After the Bhuj earthquake on January 26, 2001, the attitude of the structural engineers of looking towards the earthquakes has totally changed. Earthquake resistant design primarily focuses on improving the ductility of the structural members. In the case of reinforced concrete members subjected to inelastic deformation, not only strength but also ductility plays vital role in the design. The analysis of earthquake forces and design of earthquake resistant structure is very much complex in nature. It is only in the last decade that new strategies have been successfully developed to handle this problem economically. Earthquakes is caused by sudden movement of tectonic plates in the earth's crust. The movement takes place at fault lines. The energy released is transmitted through the earth in the form of waves. It causes ground motion many miles from the epicentre. Adjacent regions to active fault lines experience earthquake mostly. As the ground moves, inertia tends to keep the structure in place. This results in the imposition of displacements and forces of catastrophic nature. The seismic design aims to proportion structures to withstand the displacements and the forces induced by the ground motion. Seismic design has emphasized the effects of horizontal ground motion. The horizontal components of an earthquake usually exceed the vertical component.

Structures are usually much stiffer and stronger in response to vertical loads than to horizontal loads.

Analysing post-earthquake pictures does vividly teach about what designs were faulty and why. Unfortunately, that cannot be said from the structures that were not damaged because from the outside little can be seen. Only the study of the drawings and calculations can determine why, a certain structure did not fail, and while neighboring structure were damaged or totally collapsed. In particular those constructions that are at the point of total failure are interesting because they present themselves as a freeze frame during the process of collapsing.

Performance-based seismic analysis are emphasized in recent years by earthquake engineers as a need. Determination of ultimate inelastic response of the structure is an essential element in many seismic evaluations. Inelastic deformation or damage in structures require reasonable estimates using performance-based methods which are better quantities to assess damage than stress or forces. The performance based analysis is under the lateral forces of an earthquake of a certain level of seismic hazard based on quantifying the deformation of the members. Present codes are based on elastic analysis which has no measure of the deformation capability of members. Based on limit state method of design the performance based analysis gives the analyst more choice of 'performance' as compared to the limit states of collapse and serviceability..

## 2.LITERATURE REVIEW

Paper[1] shows objective of the present study is to compare the behaviour of exterior and interior beam-column joint under different loading conditions. G+4, G+9, G+14 etc. structures in the zone III is analyzed. The earthquake analysis and design are carried out by IS 1893 and IS 13920. IS 456 and SP 34 are used for detailing and designing. Each load is applied to the three models viz. G+4, G+9, G+14 respective to exterior and interior joints.Present work involves a study of different types of beam column junction under different loading conditions using the software STAAD PRO.The test results indicate that the properties of exterior and interior joints show similar results in each loading condition. A comparative study with exterior and interior joint will be studied with different parameters like displacement, stiffness, storey drift and shear stress This paper presents a review of the From the analysis we can notice that, the results obtained from interior and exterior joints are similar. That is when fracture occurs, it affects both interior and exterior. In the present study of beam column joint was analysed and designed using STAAD Pro software. The future work is experimentally carried out to provide sufficient shear transfer capacity to beam column joints to increase the strength and ductility during earthquake. It will leads to reduce the larger cracks appear on a structure and helps to improving the seismic performance. Paper[2] shows Progressive collapse is a nonlinear dynamic event which occurs when load carrying members are removed. In the present study, a progressive collapse assessment according to GSA and DoD guidelines are carried out for a G+7 RCC building. Using nonlinear dynamic analysis with joshua earthquake data. This dynamic phenomena created due to various human activities and natural phenomena adversely affect buildings, its occupants and human life. Aim of this study is to understand performance of RC building under the column removal scenario during an earthquake data. Nonlinear direct integration analysis is performed using ETABS 17.0.1 to understand response of a structure during seismic action. For this study column removal locations considered are corner, intermediate and perimeter of the plans. Beams are considered for this study optimum. L/D ratio of Beam is obtained as per IS 456 2000, for 3m and 4m span L/D ratio 12 is considered and L/D ratio 10 is considered for 6m span beam. DCR value is less than 2. In Paper[3] Analytical models for the design of column-beam joints in earthquake resisting multistorey frames, largely developed in New Zealand, are reviewed. These models were based on evidence obtained from the study of interior joints. To verify the applicability of such models also to exterior beam-column joints, where a better anchorage for the beam reinforcement is possible, three units were tested under reversed cyclic simulated seismic loading. Excellent response was exhibited in spite of the use in two units of only about one half of the currently recommended amount of horizontal joint shear reinforcement. After a detailed description of the observed performance of each test unit, an explanation is offered for the surprisingly good response. Paper[4] presents a review The experimental study reported here indicates that the horizontal joint shear reinforcement in commonly used exterior beam-column units of multistorey ductile frames may well be reduced considerably. Further tests are desirable to verify the detailing requirements for the columns, in terms of transverse stirrup ties outside the joint and the use of intermediate column bars, that are necessary to permit this reduction of horizontal joint shear reinforcement to be formulated. It may well be that the necessary stirrup-tie reinforcement within exterior beam-column joints will be governed by other requirements, such as the confinement of the column. Paper[5] Analytical models for the design of column-beam joints in earthquake resisting multistorey frames, largely developed in New Zealand, are reviewed. These models were based on evidence obtained from the study of interior joints. To verify the applicability of such models also to exterior beam-column joints, where a better anchorage for the beam reinforcement is possible, three units were tested under reversed cyclic simulated seismic loading. Excellent response was exhibited in spite of the use in two units of only about one half of the currently recommended amount of horizontal joint shear reinforcement. After a detailed description of the observed performance of each test unit, an explanation is offered for the surprisingly good response.

In Paper[6] project named as "DESIGN OF EARTH-QUAKE RESISTANT MULTI-STORIED RCC BUILDING ON A SLOPING GROUND" involves the analysis of simple 2-D frames of varying floor heights and varying no of bays using a very popular software tool STAAD Pro. Using the analysis results various graphs were drawn between the maximum axial force, maximum shear force, maximum bending moment, maximum tensile force and maximum compressive stress being developed for the frames on plane ground and sloping ground. The graphs used to drawn comparison between the two cases and the detailed study of "SHORT COLOUMN EFFECT" failure was carried up. In addition to that the detailed study of seismology was undertaken and the feasibility of the software tool to be used was also checked. Till date many such projects have been undertaken on this very topic but the analysis were generally done for the static loads i.e. dead load, live load etc, but to this the earthquake analysis or seismic analysis is to be incorporated. To create a technical knowhow, two similar categories of structures were analyzed, first on plane ground and another on a sloping ground. Then the results were compared. At last the a structure would be analyzed and designed on sloping ground for all possible load combinations pertaining to IS 456, IS 1893 and IS 13920 manually. Paper[7] High performance cementitious composites have been increasingly used for a range of structural applications in many countries. More recently, a notable interest has been focused on structural performance under seismic loading. However, a critical lack of coherent information and experimental/numerical data available in the literature has to be recognized along with the absence of specific and well-accepted code-guidelines for use of FRC in seismic applications. More specifically, when dealing with seismic resistant frame systems, few researchers have investigated in the past the seismic response of beam-column joints reinforced with steel fibres. These preliminary experimental tests have shown that adding steel fibres in joints is an effective method for improving joint behaviour and energy absorption capacity as well as enhancing the damage tolerance of joints and reducing the number of stirrups in seismic joints. However, due to the limited number of experimental tests as well as of the wide dispersion in the type and mechanical properties of the fibres adopted in these independent researches, the actual contributions of concrete, steel fibres and stirrups to the overall joint shear capacity has not yet been clearly identified and understood.This research aims to investigate the seismic behaviour and failure modes of beam-column joint subassemblies reinforced with steel fibres with the intent to provide preliminary suggestions for a simple but rational analytical procedure to evaluate the joint shear strength when either fibres and/or stirrups are adopted. Paper[8] Reinforced concrete moment resisting frames (RCMRF) are structural systems that should be designed to ensure proper energy dissipation capacity when subjected to seismic loading. In this design philosophy the capacity design approach that is currently used in practice demands "strong-column / weak-beam" design to have good ductility and a preferable collapse mechanism in the structure. When only the flexural strength of longitudinal beams controls the overall response of a structure, RC beam-column connections display ductile behaviour (with the joint panel region essentially remaining elastic). The failure mode where in the beams form hinges is usually considered to be the most favourable mode for ensuring good global energy-dissipation without much degradation of capacity at the connections. Though many international codes recommend the moment capacity ratio at beam column joint to be more than one, still there are lots of discrepancies among these codes and Indian standard is silent on this aspect. So in the present work pushover analysis is being done using SAP 2000 for increasing moment capacity ratio at beam column joints and its effect on the global ductility and lateral strength of the structure is studied. To incorporate the uncertainties in material properties, a probabilistic approach is followed to observe the effect of ground motion intensity on probability of exceedance of any specific damage state for structures designed considering different moment capacity ratios (MCR) at the connections. For this objective fragility curves are developed considering the pushover curves obtained from the nonlinear static analysis. Ductility of the structure increases with increase of MCR. Also the buildings designed with lesser MCR values are found to be more fragile compared to the building with higher paper[9] India In reinforced concrete structures, portions of columns that are common to beams at their intersections are called Beam-Column Joint. Beam-column joint is an important part of reinforced concrete frames in terms of seismic lateral loading. The two major failure at joints are, joint shear failure and end anchorage failure. As we know that nature of shear failure is brittle so the structural performance cannot be accepted especially in seismic conditions. In past decades, shear walls are one of the most appropriate and important structural components in multi-storied building. Therefore, it would be very interesting to study the structural response and their systems in multi-storied structure. Shear walls contribute the stiffness and strength during earthquakes which are often neglected during design of structure and construction. The scope of present work is to study the effect of seismic loading on placement of shear wall in building at different alternative location. Paper[10] This study presents analysis of beam-column joint of the structure as well as the effect of shear walls which significantly affect the vulnerability of structures. In order to test this hypothesis, G+10 story building is considered with and without shear walls. Equivalent Static Coefficient Method is used for dynamic analysis and structure was assumed to be situated in zone IV. As the building with shear wall and without shear wall is analyzed for seismic forces in X and Z direction the following results were found for the load combination of 1.2 (DL + LL + EQ X) for earthquake forces in X direction and 1.2 (DL + LL + EQ Z) for earthquake forces in Z direction. Some parameter like node displacements, axial forces, bending moment, shear force and deflection of a structure are determined by using STAAD Pro software and comparison is made for models with shear wall and without shear wall structures. From the comparison of results, it has been observed that the bending moment, shear force and deflection in corner column, middle column and central column are minimum in structure having shear wall as compared to simple frame building. The bending moment, shear force and deflection in beams at all levels is minimum having shear wall in periphery in comparison to simple frame building. The max. Bending moment, shear force and deflection of structure having shear wall is less as compared to simple frame building. paper[11] Earthquake resistant buildings are necessary to reduce the damage caused to structures during devastating earthquakes. One of the characteristics of earthquake resistant buildings is having an adequate design on the beam-column joint. Generally, when large forces occur during earthquakes, joints are severely damaged which endangers the entire structure. Seismic design focuses on the ductility of a frame as the main structure to resist the lateral force. The beam–column joints with inadequate or no transverse shear reinforcement have proved deficient and are likely to experience brittle shear failure during earthquake motions. So ductile detailing of a beam column joint is very important for its better performance under the seismic loads. But it is noted that the anchorage requirements for the beam longitudinal reinforcement bar and the joint confinement are having main issues related to problems of congestion of reinforcement in the beam–column connections. There are lots of practical difficulties in the execution of such conventional designs. With the development of new technologies and materials alternatives for these conventional types of joint reinforcement is possible. The project focuses in the design and analysis using the software ANSYS 15, for an alternative joint reinforcement with better or equivalent performance. An attempt has been made to evaluate the performance of the exterior beam– Column joint by replacing the 90° standard bent bar anchorages By T-type mechanical anchorage. Paper[12] Beam column joint is an important component of a reinforced concrete moment resisting frame and should be designed and detailed properly, especially when the frame is subjected to earthquake loading. Failure of beam column joints during earthquake is governed by bond and shear failure mechanism which are brittle in nature. Therefore, a current international code gives high importance to provide adequateanchorage to longitudinal bars and confinement of core concrete in resisting shear. Modern codes provide for reduction of seismic forces through provision of special ductility requirements. Details for achieving ductility in reinforced concrete structures are given in IS 13920. A two bay five storey reinforcement cement concrete moment resisting frame for a general building has been analyses and designed in STAAD Pro as per IS 1893-2002 code procedures and detailed as IS 13920-1993 recommendations. A beam column joint has been modeled to a scale of 1/5 th from the prototype and the model has been subjected to cyclic loading to find its behavior during earthquake. Non linear analysis is carried out in ANSYS software:2016. Paper[13]The structural behavior of RCC beam column joint interior type has been studied at analytically by using standard software packages STAAD Pro and ANSYS. Experimental investigation has been carried out and test results show that the structural behavior of interior beam column joint model has been similar to that of the analytically predicted one. From test results, important parameter has been worked out such as ductility, energy absorption, stiffness degradation etc., in order to access the seismic behavior of the beam column joint when earthquake comes

paper[14] The behaviour of reinforced concrete moment resisting frame structures in recent earthquakes all over the world has highlighted the consequences of poor performance of beam column joints. Large amount of research carried out to understand the complex mechanisms and safe behaviour of beam column joints has gone into code recommendations. Paper[15] presents critical review of recommendations of well established codes regarding design and detailing aspects of beam column joints. The codes of practice considered are ACI 318M-02, NZS 3101: Part 1:1995 and the Eurocode 8 of EN 1998-1:2003. All three codes aim to satisfy the bond and shear requirements within the joint. It is observed that ACI 318M-02 requires smaller column depth as compared to the other two codes based on the anchorage conditions. NZS 3101:1995 and EN 1998-1:2003 consider the shear stress level to obtain the required stirrup reinforcement whereas ACI 318M-02 provides stirrup reinforcement to retain the axial load capacity of column by confinement. Significant factors influencing the design of beam-column joints are identified and the effect of their variations on design parameters is compared. In paper[16] work, a detailed three-dimensional (3D) nonlinear finite element model is developed to study the response and predict the behavior of beam–column connection subjected to cyclic loads that was tested at the karunya Institute of technology and sciences (KITS) laboratory. The beam column joint is modeled using 3D solid elements and surface-to-surface contact elements between the beam/column faces and interface grout in the vicinity of the connection. The model takes into account the pre-tension effect in the post-tensioning strand and the nonlinear material behavior of concrete. Fracture of the mild-steel bars resulted in the failure of the connection. In order to predict this failure mode, stress and strain fields in the mildsteel bars at the beam–column interface were generated from the analyzed model.. In addition, the magnitude of the force developed in the post-tensioning steel tendon was also monitored and it was observed that it did not yield during the entire loading. Steel mesh was developed in the beam to increase the shear capacity. Finite element modeling will provide a practical and economical tool to investigate the behavior of such connections IS 456:2000 with steel mesh is more stiffer than IS 456:2000 without steel mesh. 2. IS 456:2000 with steel mesh is increasing shear capacity compared to IS 456:2000 and IS 13920:2016. 3. The portion of the joint with steel mesh is more rigid and stiffness is more. It will reduce the rotation in beam column joint and it will reduce the failure. Paper[17] Beam and column where intersects is called as joint or junction. The different types of joints are classified as corner joint, exterior joint, interior joint etc. on beam column joint applying quasi-static loading on cantilever end of the beam. and study of various parameters as to be find out on corner and exterior beam column joint i.e. maximum stress, minimum stress, displacement and variation in stiffness of beam column joint can be analyzed in Ansys software ( Non-Linear FEM Software) Significant experimental research has been conducted over the past three decades on hysteretic behavior of beam-column joints of RC frames under cyclic displacement loading. The various research studies focused on corner and exterior beam column joints and their behavior, support conditions of beam-column joints. Some recent experimental studies, however, addressed beam-column joints of substandard RC frames with weak columns, poor anchorage of longitudinal beam bars and insufficient transverse reinforcement. the behavior of exterior beam column joint is different than the corner beam column joint. Paper[18] Lot of researches have been done on concrete framed structures to retrofit/ strengthen with different kinds of materials with different techniques. The outcome of the research studies were the incremental strength obtained with particular materials with particular technique which were chosen by the researchers arbitrarily. Paper[19] Represent that moment capacity ratio of beam column joint is an important consideration for framed structures. This paper describes that ductility of structures increases with increase of moment capacity ratio and how moment capacity ratio affects the building fragility. The need of this paper is to study the effects of moment capacity ratio on the ductility and strength of structure, and also on the probability of failure of multistoried building.From the various studies mentioned above, it is clear that Moment capacity ratio of column beam joint is certainly an important variable for consideration in overall frame performance. 2. It is observed that MCR effects the ductility and strength of structures. 3. It is evident that ductility of the structures increases with increases of moment capacity ratio. Also the building designed with lesser MCR values are more fragile compared to the building with higher MCR. 4. It is essential to find out the moment capacity ratio suitable for Indian Standard. 5. MCR also effects the probability of failure of multistoryed building. 6. It is observed that value of MCR is normally varied between 1 to 2. Paper[20]The Aim of present study "Earth quake resistant design of multistory building'' by ETABS " is to define technique for stability of structure by taken regular Geometry ,proper cross sections for column and beam etc, developing specification and supports conditions, types of Loads and load combinations. In this study a G+25 storey high rise structure is analyzed for seismic load combination using ETABS and comparison is drawn by replacing of column into shear wall. The frame was found to be adequately designed for seismic loads in Zone IV. The building is designed as per IS 1893(Part 1):2016. The main objectives of the paper are to compare the variation of steel percentage, maximum shear force, maximum bending moment, and maximum deflection in seismic zone IV.

## 3. PROBLEM STATMENT

The structure selected for this project is a simple unmimetrical residential building with the following description as stated below.

IS Code for Dead Load: - IS 875 Part 1
IS Code for Dead Load:- IS 875 Part 2
IS Code for Seismic Load: - IS 1893-2016 Part (1)
IS Code for Ductile Detailing: IS 13920:1993 and IS 13920:2016
Number of bays in X direction and its width= 5 bays of 4 m each
Number of bays in Z direction and its width = 5 bays of 3m each
Story height = 3 m each
Number of storey = G + 7 (Excluding the plinth and substructure and including the Ground floor)
Depth of foundation from ground level = 2.4 m
Plinth height = 600 mm
Thickness of Slab =150 mm
Density of concrete = 25 kN/m3
Live load on roof = 1.5 kN/m2
Live load on floors = 3 kN/m2
Floor finish = 1.5 kN/m2
Brick wall on peripheral beams = 230 mm
Density of brick wall 20 kN/m3

3.2 Seismic design Parameters:-

For the present study following values for seismic analysis are assumed. The values are assumed on the basis of reference steps given in IS 1893-2016, IS 13920-1993, IS 13920:2016 and IS 456:2000.

Zone factor for zone II – 0.12 (Table 3, P.10 C.N.6.4.2)
Zone factor for zone III – 0.16
Zone factor for zone IV – 0.24
Zone factor for zone V – 0.36
Importance factor for office building = 1.2 (Table 8, P.19 C.N.7.2.3)
Special Reinforced Concrete Moment resisting Frame (SMRF)

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SMRF is a moment resisting frame detailed to provide ductile behavior and comply with the requirements of 13920-1993, IS 13920:2016.
Response reduction factor for ductile shear wall with SMRF 5.
Type of soil = Medium (Type II).
Damping percent = 5 % (0.05).
Brick infill panel building type.

## 4.METHODOLOGY

My present work is divided into two phases. In the first one I have design the low to midstory building to find the location of maximum shear force in the beam to column joints. Once we got the joint with maximum shear force we can implement the prestressing in the beam to column joints to prevent the damage and avoiding the congestion at the same time.
Modeling of G+7 story RCC frame structure using commercial software staad pro. Analysis of structure for various seismic zones i.e II,III,IV, V Compare moment capacity ratio for different zone .Compare Strength of beam column joints for different zone. Detailing of beam and column joint for Required shear strength as per IS 13920-1993 and IS 13920-2016:

## 5. RESULT AND ANALYSIS

Table. 5.1 Comparison of column design depth at interior Joint (mm) by IS13920:1993 and IS 13920:2016

| Comparison of column design depth at interior Joint (mm) by IS13920:1993 and IS 13920:2016 | | | | |
|---|---|---|---|---|
| | ZONE-2 | ZONE-3 | ZONE-4 | ZONE-5 |
| X-direction IS 13920-1993 | 350 | 450 | 500 | 650 |
| X-direction IS 13920-2016 | 400 | 500 | 600 | 750 |
| percentage increases in size | 14.2857 | 11.111 | 20 | 15.384 |
| Z-direction IS 13920-1993 | 500 | 700 | 700 | 900 |
| Z-direction IS 13920-2016 | 500 | 700 | 700 | 900 |

Graph 5.1 Comparison of column design depth at interior Joint in X derection (mm) by IS13920:1993 and IS 13920:2016

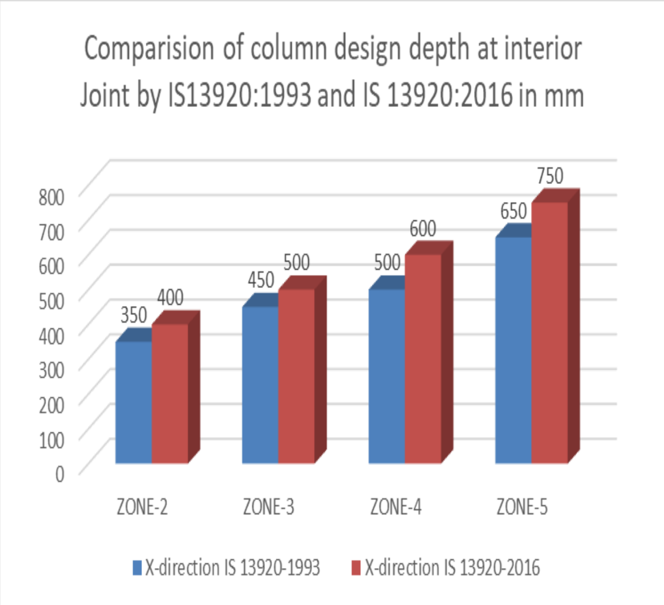
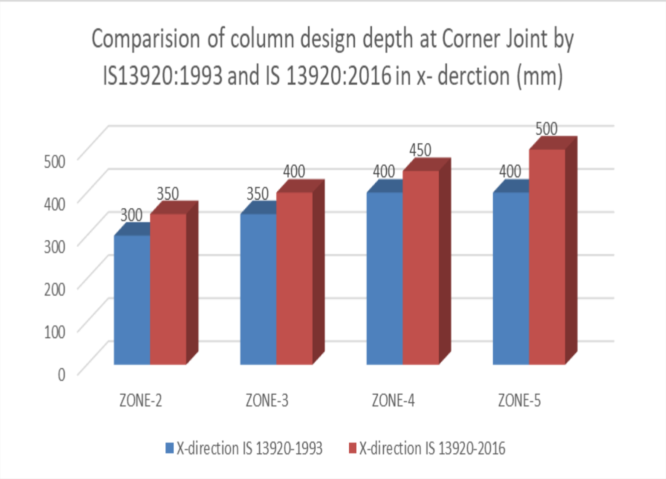


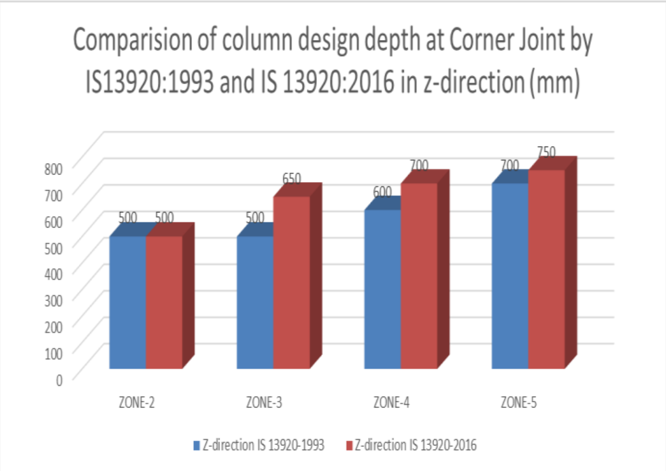

Table 5.2 Comparision of column design depth at Corner Joint by IS13920:1993 and IS 13920:2016 in mm

| Comparision of column design depth at Corner Joint by IS13920:1993 and IS 13920:2016 in mm | | | | |
|---|---|---|---|---|
| | ZONE-2 | ZONE-3 | ZONE-4 | ZONE-5 |
| X-direction IS 13920-1993 | 300 | 350 | 400 | 400 |
| X-direction IS 13920-2016 | 350 | 400 | 450 | 500 |
| percentage increases in size | 16.66667 | 14.28571 | 12.5 | 25 |
| Z-direction IS 13920-1993 | 500 | 500 | 600 | 700 |
| Z-direction IS 13920-2016 | 500 | 650 | 700 | 750 |
| percentage increases in size | 0 | 30 | 16.66667 | 7.142857 |

Graph 5.2 Comparision of column design depth at Corner Joint by IS13920:1993 and IS 13920:2016 in X- derction (mm)




Graph 5.3 Comparision of column design depth at Corner Joint by IS13920:1993 and IS 13920:2016 in Z- derction (mm)




## 6. CONCLUSION

The following are point-wise conclusions which are being drawn from the proposed Beam-Column Joints

above graph and table shows a design depth required for a joint by IS 13920:2016 are more than IS 13920:1993 for all zones and it varies 10% to 30% required more depth by zone to zone

Maximum joint shear demand is located at lower portion of building, starting from second story joint for both interior and exterior joints for the fixed support.

Maximum joint shear demand is located at first story joints for the hinge support condition for the both interior and exterior joints.

The ratio of height of maximum shear to building height is coming out as 0.4 for the fixed support

**Future Scope**

Due to cross prestressing there is increase in the shear strength of the concrete in the joint core. A model can be formulated to calculate the increase in shear strength of the joint core.

Further a formulation can be generated to calculate that how much reinforcement can be reduced due to this cross-prestressing

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