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Structural Analysis of RCC Beam-Column Joints and Shear Walls Strengthened with FRP using ANSYS

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Abstract:** After occurrence of recent earthquakes in the most of world parts, scientific committees for reducing natural disasters and research centers declared based performance design, investigation faults, retrofitting, rehabilitation, new researches are related to strengthening of structures, notice performance, importance of structure, surface of earthquake levels, considering economic and feasibility. One of streningthening method of RC frame is using FRP laminates. 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 (FEM Software) RC shear walls are considered one of the main lateral resisting members in buildings. In recent years, FRP has been widely utilized in order to strengthen and retrofit concrete structures. 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.
***Keywords:** Beam, column, corner, exterior , joint, quasi-static etc.*

I. INTRODUCTION

Concrete structural components exist in buildings and bridges in different forms. Understanding the response of these components during loading is crucial to the development of an overall efficient and safe structure. Different methods have been utilized to study the response of structural components. Experimental based testing has been widely used as a means to analyze individual elements and the effects of concrete strength under loading. While this is a method that produces real life response, it is extremely time consuming, and the use of materials can be quite costly. The use of finite element analysis to study these components has also been used.

Reinforced concrete (RC) shear walls are conventional structural elements incorporated in seismic regions to improve the strength and rigidity of structures against lateral loading (earthquake and wind forces). Limitation of lateral deformations along with minimizing damage to structural/non-structural components are the main advantages of RC shear walls owing to the significant inplane stiffness.

Unfortunately, early attempts to accomplish this were also very time consuming and infeasible using existing software and hardware. In recent years, however, the use of finite element analysis has increased due to progressing knowledge and capabilities of computer software and hardware. It has now become the choice method to analyze concrete structural components. The use of computer software to model these elements is much faster, and extremely cost-effective. To fully understand the capabilities of finite element computer software, one must look back to experimental data and simple analysis.

Data obtained from a finite element analysis package is not useful unless the necessary steps are taken to understand what is happening within the model that is created using the software. Also, executing the necessary checks along the way is key to make sure that what is being output by the computer software is valid. By understanding the use of finite element packages, more efficient and better analyses can be made to fully understand the response of individual structural components and their contribution to a structure as a whole.

Design and detailing of beam-column joints in reinforced concrete frames are critical in assuring the safety of these structures in earthquakes. Such joints should be designed and detailed to Preserve the integrity of the joints sufficiently to develop the ultimate strength and deformation capacities of the connecting beams and columns; Prevent excessive degradation of joint stiffness under seismic loading by minimizing cracking of the joint concrete and by preventing the loss of bond between the concrete and longitudinal beam and column reinforcement; and Prevent brittle shear failure of the joint It has recently been reported that the beam column joints. failures observed in 1980 Assam earthquake, 1985 Mexico, 1986 Salvador, 1989 Loma Prieta and 2000 in India. It is recognizing that Beam-Column Joints can be critical reason in RC frames design for in elastic response to severe seismic attack. As a consequence, seismic moments of opposite signs are develop in columns above and below the joints and at the same time beam moment reversal across the joints. A horizontal and vertical shear force whose magnitude is many times higher than in the adjacent beams and columns developed at the joint region. If not design for, joint failure can result.

This project is a study of reinforced concrete beam-column joint using finite element analysis to understand the response of reinforced concrete beams due to transverse loading. The objective of this Study is to investigate and evaluate the use of the finite element method for the analysis of reinforced concrete beam. A mild-steel reinforced concrete beam with flexural and shear reinforcement was analyzed to failure and compared to experimental results. A calibration model using a commercial finite element analysis package (ANSYS) was set up and evaluated using experimental data. A mild-steel reinforced concrete beam with flexural and shear reinforcement was analyzed to failure and compared to experimental results to calibrate the parameters in ANSYS for later analyses.

II. RESEARCH METHODOLOGY

Earthquakes are one of the most feared natural phenomena that are relatively unexpected and whose impact is sudden due to the almost instantaneous destruction that a major earthquake can produce. Severity of ground shaking at a given location during an earthquake can be minor, moderate and strong which relatively speaking occur frequently, occasionally an rarely respectively. Design and construction of a building to resist the rare earthquake shaking that may come only once in 500 years or even once in 2000 years at a chosen project site even though life of the building itself may be only 50 to 100 years is too robust and also too expensive. Hence, the main intention is to make building earthquake-resistant that resist the effect of ground shaking although it may get damaged severely but would not collapse during even the strong earthquake. Thus, the safety of people and contents is assured in earthquake-resistant buildings. This is a major objective of seismic design codes throughout the world.

The performance of structures in earthquakes indicates that most structures, system and components, if properly designed and detailed, have a significant capacity to absorb energy when deformed beyond their elastic limits. Experience with the behavior of reinforced concrete beam-column joints in actual earthquakes is limited. To fully realize the benefits of ductile behavior of reinforced concrete frame structures, instabilities due to large deflections and brittle failure of structural elements must be prevented under the most severe expected earthquake ground motions..

Investigation of the behaviour of FRP retrofitted reinforced concrete structures has in the last decade become a very important research field. In terms of experimental application several studies were performed to study the behaviour of retrofitted beams and how various parameters influence the behaviour. The effect of number of layers of CFRP on the behaviour of a strengthened RC beam was investigated. They tested simply supported beams with different numbers of CFRP layers. The specimens were subjected to dead load and horizontal forces. The results showed that the load carrying capacity increases with an increased number of layers of carbon fibre sheets. The model of RC building shown in plan was developed in ANSYS software.

The proposed work is planned to be carried out in the following manner,

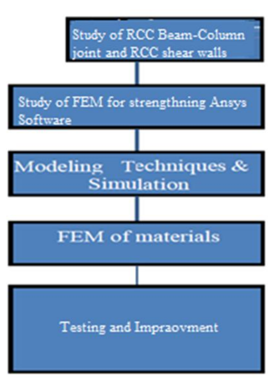

Fig.1. Planning of work

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A. Criteria For The Desirable Performance Of Joints In Ductile Structures Designed For Earthquake Resistance

1. The strength of the joint should not be less than the maximum demand corresponding to development of the structural plastic hinge mechanism for the frame. This will eliminate the need for repair in a relatively inaccessible region and for energy dissipation by joint mechanisms, which as will be seen subsequently, undergo serious stiffness and strength degradation when subjected to cyclic actions in the inelastic range.
2. The Capacity of the column should not be jeopardized by possible strength degradation within the joint. The joint should also be considered as an integral part of the column.
3. During moderate seismic disturbances, joints should preferably respond within the range.
4. Joint deformations should not significantly increase story drift.
5. The joint reinforcement necessary to ensure satisfactory performance should not cause undue construction difficulties.

B. Performance Criteria

Because the response of joints is controlled by shear and bond mechanisms, both of which exhibit poor hysteric properties, joints should be regarded as being unsuitable as major sources of energy dissipation. Hence the response of joints should be restricted essentially to the elastic domain. It is of particular importance to ensure that joint deformations, associated with shear and particularly bond mechanisms, do not contribute excessively to overall story drifts. When large diameter beam bars are used, the early break down of the bond within the joint may lead to story drifts in excess of 1%, even before the yield strength of such bars is attained in adjacent beams. Excessive drifts may cause significant damage to non structural components of the building, while frames respond within the elastic domain. By appropriate detailing, to be examined subsequently, joint deformations can be controlled.

C. Shear Strength

Internal forces transmitted from adjacent members to the joint as shown in fig. result in joint shear forces in both the horizontal and vertical directions. These shear forces lead to diagonal compression and tension stresses in the joint core. The latter will usually result in diagonal cracking of the concrete core. The mechanism of shear resistance at this stage changes drastically.

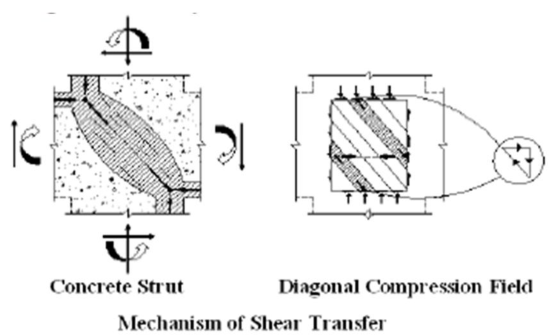

Fig.2 Shear Mechanism

Some of the internal forces, particularly those generated in the concrete, will combine to develop a diagonal strut. Other forces, transmitted to the joint core form beam and column by means of bond, necessitate a truss mechanism.

When the joint shear reinforcement is sufficient, yielding of the hoops will occur. Irrespective of the direction of diagonal cracking, horizontal shear reinforcement transmits tension forces only. The inelastic steel strains that may result are irreversible. Consequently, during subsequent loading, stirrup ties can make a significant contribution to shear resistance only if the tensile strains imposed are larger then those developed previously. This then leads to drastic loss of stiffness art low shear force levels, particularly immediately after a force or displacement reversal.

D. Bond Strength

At exterior column the difficulty in anchoring a beam bear of full strength can be overcome readily by providing a standard hook. At interior columns, however, this is impractical. Some codes require that beam bars at interior beam-column joints must pass continuously that bars may be anchored with equal if not greater efficiency using standard hooks within or immediately behind an interior joint.

The fact that bars passing through interior joints are being "pulled" as well "pushed" by the adjacent beams, to transmit forces corresponding to steel stresses up to the strain hardening range in tension, has not as a rule, been take into account code specifications until recently. In most practical situations bond stresses required to transmit bar forces to the concrete of the joint core consistent with plastic hinge development at both sides of the joint, would be very large and well beyond limits considered by codes for bar strength development. Even at moderate ductility demands, a slip of beam bars through the joint can occur. A breakdown of bond within interior joints does not necessarily result in sudden loss of strength.

E. Design Of Joints

Joint types

According to geometrical configuration

I) Interior

II) Exterior

II) Corner

According to loading conditions and structural behavior

I) Type-I

II) Type-II

Type1- Static loading

I) Strength important

II) Ductility secondary

A type-1 joint connects members in an ordinary structure designed on the basis of strength, to resist the gravity and wind load.

Type2-earthquake and blast loading

I) Ductility +strength

II) Inelastic range of deformation

III) Stress reversal

A type-2 joint connects members designed to have sustained strength under deformation reversals into the inelastic range, such as members designed for earthquake motions, very high wind loads, or blast effects.

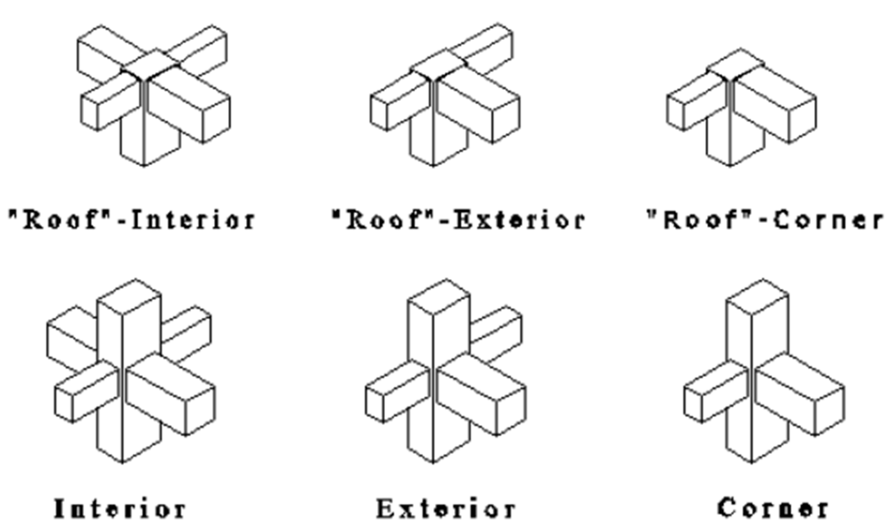

Fig. 2 Typical Beam Column Connections

The design procedure of beam-column joints consists of the following steps:

1) Arrive at the preliminary size for members based on anchorage requirements for the chosen longitudinal bars.
2) Ensure adequate flexural strength of columns to get the desired beam yielding mechanism.
3) Arrive at the design shear force for the joint by evaluating the flexural over strength of the adjacent beams and corresponding internal forces. The simultaneous forces in the column that maintain joint equilibrium must also be determined. From these, the joint shear force demand can be calculated.
4) Obtain effective joint shear area from the adjoining member dimensions.
5) Ensure that the induced shear stress is less than the allowable stress limit. The allowable shear stress limit is expressed as a function of the compressive strength or diagonal tensile strength of concrete. If not satisfied, alter the associated member dimensions, viz., width of the beam or depth of the column.
6) Provide transverse reinforcements both as confining reinforcement and as shear reinforcement.
7) Provide sufficient anchorage for the reinforcement passing through or terminating in the joint.

III. LOADING SYSTEMS

The structures are being imposed by many loads e.g. dead load, live load, imposed(wind) load, snow load, earthquake load etc. The structures have to be designed in such a way that they can bear these loads to overcome the collapse or failure of the structures.

A. *Types of Loading Systems:*

The behavior of building is studied with different types of loads.
Static loading :- Static means slow loading in structural testing. Test of components:-Beams(bending),column (axial),beams and columns
Purpose of testing:- Determine strength limits
Determine the flexibility/rigidity of structures
Quasi-static loading:- Very slowly applied loading in one direction (monotonic)
Quasi-static reversed cyclic loading:-Very slowly applied loading in both direction (cyclic)
Dynamic (random) loading:- Shake at the base or any other elevation of the structure shaking similar to that during earthquakes.

As a rule cyclic loading is applied under displacement-control, with cycles of gradually increasing amplitude. For large-scale specimen‟s actuator stroke length limitations do not allow the ultimate deformation of the specimen to be reached under monotonic loading. The monotonic shear resistance should be significantly higher than the flexure one, because under cyclic conditions shear strength and stiffness deteriorate much faster than the flexural, so shear deformations may become dominant with cycling and failure may takes place at interesting inclined cracks.
Cycling causes a degradation of strength with respect to the envelope provided by the virgin loading curves. This strength degradation is more evident between one cycle of deformation and the next, at the same level of peak deformation

IV. FINITE ELEMENT METHOD

The basic concept in this method is that a body or a structure may be divided into smaller elements of finite dimensions called „Finite Elements‟. The original body or the structure is then considered as an assemblage of these elements connected at a finite number of joints called „ζodes‟ or „ζodal Points‟. The properties of the elements are formulated and combined to obtain the solution for the entire body or structure.
The finite element procedure reduced the unknown infinite numbers by dividing into small elements and by expressing the unknown field variables in terms of assumed approximating functions such as shape functions.

1) Selection of field variables and the elements.
2) Discretization of structure.
3) Finding the element properties
4) Assembling element stiffness matrix
5) Solution of nodal unknown.

A. Discretization Of Structure

The process of modeling a structure using suitable number, shape and size of the elements is called Discretization. Modeling should be good enough to get results as close to actual behavior of the structure as possible.

B. Nodal Loads

While subdividing a structure, nodal locations are selected so as to coincide with external loads applied. This can be easily done in case of concentrated load. But in case of distributed loads like self weight, uniformly distributed load, uniformly varying load, a technique of transferring the loads as nodal loads is adopted. In transferring the load, a portion is assigned to each node and load on that region is considered as nodal load.

C. Assembly And Solution Of Equations

In assembling the element stiffness equation, [K] {□} = {F}, the first step is to derive the expression for element stiffness property and nodal force vector. The overall stiffness matrix and nodal load vectors are assembled from elements and then the set of simultaneous equations are solved to obtain the nodal displacements. Then the nodal stresses are obtained from the stress displacement relations.

D. Finite Element Modeling & Analysis

Ansys software has been used for conducting the finite element analysis of the Concrete Beam Column Joint. Ansys has many features which help to carry out detailed study for such kind of complex problems.

V. PROBLEM STATEMENT

A. Problem Definition

- A G+5 RCC Commercial building is considered.
- Plan dimensions :12 m x 12 m
- Location considered: Zone-IV
- Soil Type considered: Hard Strata.

B. General Data of Building

- Grade of concrete : M 25
- Grade of steel considered : Fe 250, Fe 500
- Live load on roof: 2 KN/m2 (Nil for earthquake)
- Live load on floors : 4 KN/m2
- Roof finish : 1.0 KN/m2
- Floor finish : 1.0 KN/m2
- Brick wall in longitudinal direction : 240 mm thick
- Brick wall in transverse direction : 140 mm thick
- Beam in longitudinal direction : 230X350 mm
- Beam in transverse direction : 230X350 mm
- Column size : 300X750 mm
- Density of concrete : 25 KN/m3
- Density of brick wall including plaster : 20 KN/m3
- Plinth beam(PB1) : 350X270 mm
- Plinth beam(PB2) : 270X300 mm

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VI. ANALYSIS

A. Ansys Software

(Non-Linear finite element analysis) :The exterior and corner beam-column joint to be analyzed in the Ansys FEM Software.

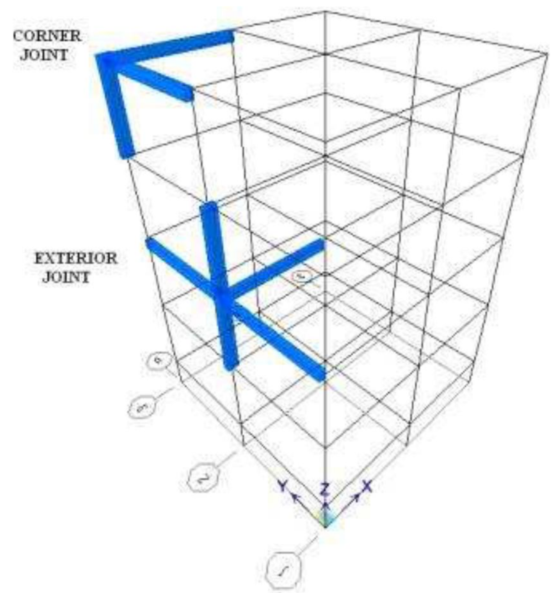


Fig.3 Dimensional view showing exterior and corner beam-column joint

B. Ansys Analysis

Once the reinforcement detailing of the beam and column is known the exterior beam-column joint is modeled in Ansys FEM Software. Non-linear analysis of exterior and corner joint is carried out with 6 load step and 30 iterations in each load step. The mesh size of 80 mm is taken for macro-elements in concrete part of the beam and column. The exterior beam-column joint is modeled and a monotonic loading of 5 KN is applied at the tip of the beam till the failure of the beam takes place.

VII. FINITE ELEMENT MODELING AND ANALYSIS OF BEAM-COLUMN JOINTS

The exterior and corner beam-column joint is considered to study joint behavior subjected to monotonic loading. Preparation of FE model is carried out based on results obtained from space frame analysis of a building located in zone-IV. Model construction is done by defining geometrical joints and lines. Material definition is carried out prior to assigning of macro elements. The joint is fully restrained at the column ends. The load is applied at the tip of the beam in one direction. Mesh arrangement:- A single mesh arrangement was developed for use with the bent down bar anchorage.

A. Material Properties in Ansys

1) Reinforced Concrete :An eight-node solid element, Solid65, was used to model the concrete. The solid element has eight nodes with three degrees of freedom at each node – translations in the nodal x, y, and z directions. The element is capable of plastic deformation, cracking in three orthogonal directions, and crushing. A Link8 element is used to model the steel reinforcement. Two nodes are required for this element. Each node has three degrees of freedom, – translations in the nodal x, y, and z directions. The element is also capable of plastic deformation.
2) Concrete :Development of a model for the behavior of concrete is a challenging task. Concrete is a quasibrittle material and has different behavior in compression and tension. The tensile strength of concrete is typically 8-15% of the compressive strength (Shah, et al. 1995). Figure below shows a typical stress-strain curve for normal weight concrete (Bangash 1989).In compression, the stress-strain curve for concrete is linearly elastic up to about 30 percent of the maximum compressive strength. Above this point, the stress increases gradually up to the maximum compressive strength. After it reaches the maximum compressive strength σ_{cu} , the curve descends into a softening region, and eventually crushing failure occurs at an ultimate strain ε_{cu} . In tension, the stress-strain curve for concrete is approximately linearly elastic up to the maximum tensile strength.

3) Steel Reinforced Concrete [Smeared Model] Material Properties: In this project the structure has been modeled using Steel Reinforced Concrete. The material properties mentioned below act equivalent for a Smeared Reinforcement concrete model using solid 65 element in Ansys. Many research papers have been published using similar kind of model. Broujerdian et. al (2010) have worked using a similar approach. The used of this features enables obtaining good results with less solver and modeling time.
4) Loading The beam load was applied to the model. The load of 5 KN was applied at the tip of the beam end with 6 load steps.
5) Load cases Different type of load cases are already inbuilt in Ansys Software they are supports, prescribed deformation, forces, temperature, shrinkage and prestressing.
6) Maximum Iteration limit A maximum iteration limit of 30 was used with all of the models. This generally proved sufficient to exceed the failure criterion.

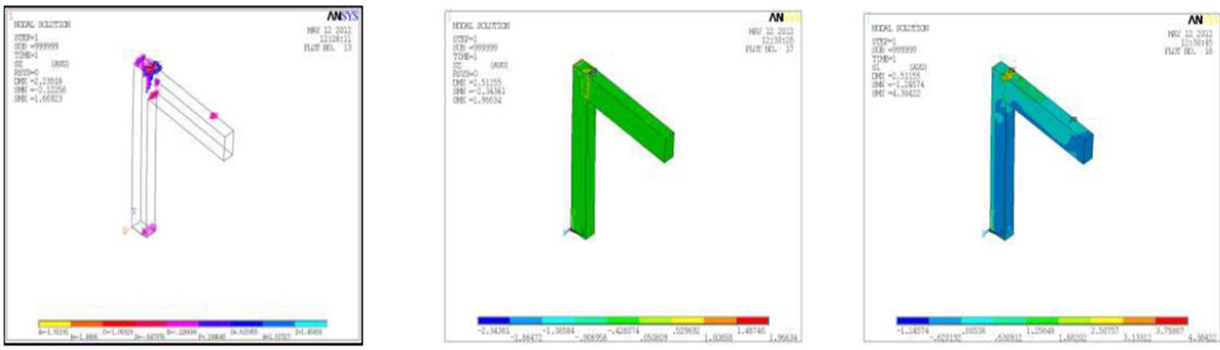


Fig.4 Modeling of corner beam column joints in the Ansys.

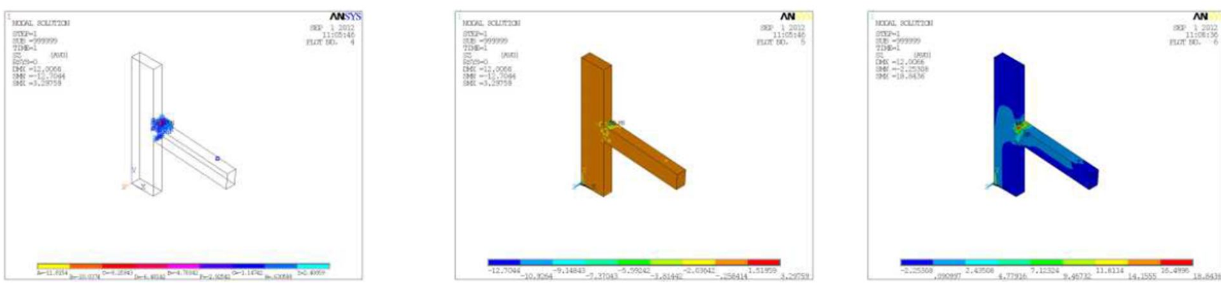
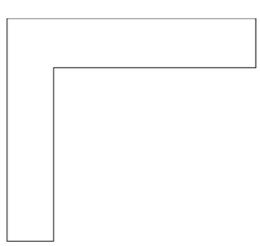


Fig.5 Modeling of Exterior beam column joints in the Ansys.

VIII. RESULTS AND DISCUSSIONS

A. Parametric Study

The exterior and corner beam-column joints are studied with different parameters like i.e. Maximum principle stress, Minimum principle stress, Displacement, Deformation, Stiffness variation of beam column joint i.e. Corner and Exterior joint subjected to monotonic loading.



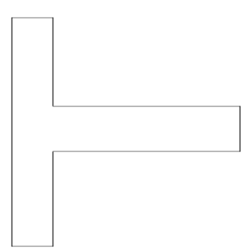


Fig.6 Case No.(1) Corner Beam-column Joint. Fig.7 Case No.(2) Exterior Beam-column Joint

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1) Corner beam column joint
Beam size 230 mm X 350 mm
Column size 230 mm X 700 mm

Load in KN	Displacement in mm	Mini. Stress in N/mm^2	Maxi. Stress in N/mm^2
5	0.8139	-0.6090	0.8418
10	1.6000	-8.099	8.800
15	1.8000	-8.809	8.900
20	2.2000	-10.158	8.500
25	3.0000	-12.500	9.500
30	4.05	-15.908	10.975

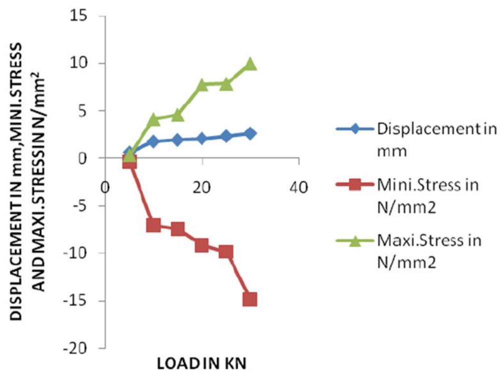


Fig.8 Load Vs Maximum Deformation, Minimum Stress, Maximum Stress Graph For Corner Beam Column Joint

2) Exterior beam column joint
Beam 230mmx 350mm
Column 230mmx 700mm

Table II

Load in KN	Displacement in mm	Mini. Stress in N/mm^2	Maxi. Stress in N/mm^2
5	0.9923	-0.8959	0.83653
10	1.9530	-4.8873	6.60322
15	2.3000	-6.9834	7.82132
20	2.2200	-11.936	11.6000
25	2.4835	-14.996	15.4050
30	2.6580	-17.986	19.6000

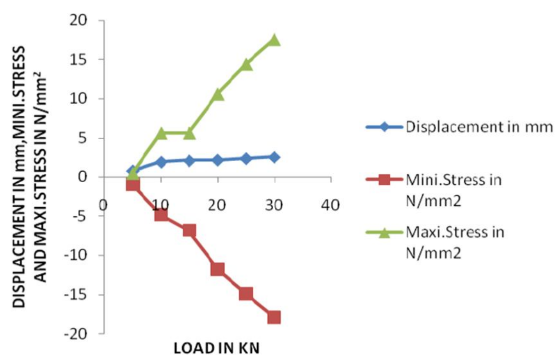


Fig.9 Load Vs Maximum deformation, Minimum Stress, Maximum Stress Graph For Exterior Beam Column Joint

3) Corner beam column joint with varying stiffness

Table III

Load in KN	Displacement in mm	Mini. Stress In N/mm^2	Maxi. Stress in N/mm^2
5	0.80605		1.6168
10	1.50809	-1.92825	2.3332
15	2.8850	-2.66995	4.8430
20	2.9060	-3.60960	6.6852
25	3.8050	-3.98935	8.5089
30	4.5080	-5.60905	10.856

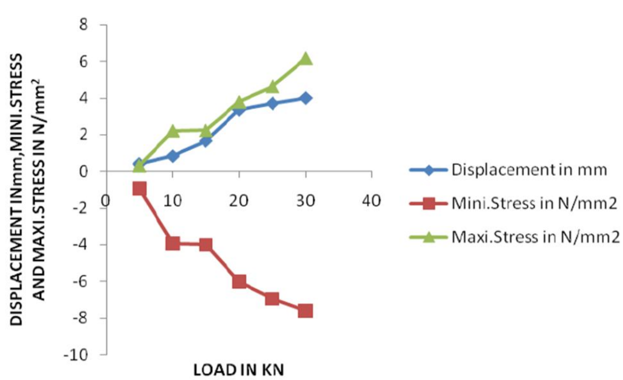


Fig.10 Load Vs Maximum Deformation, Minimum Stress, Maximum Stress Graph

- For Corner Beam Column Joint With Varying Stiffness

Case NO 1
Beam 230 mm X 450 mm
Column 230 mm X 900 mm
Stiffness of beam : KB = 282685.54 mm3
Stiffness of Column : Kc =2380000 mm3
Stiffness of Joint: Kj = KB/ Kc
= 282685.54 / 2380000
= 0.11

Table IV

Load in KN	Displacement in mm	Mini. Stress in N/mm^2	Maxi. Stress in N/mm^2
5	0.6172	-0.8314	0.6034
10	0.9344	-4.9641	2.5058
15	2.3689	-5.6780	3.3358
20	4.4478	-6.7839	4.8844
25	5.6989	-7.9569	5.7425
30	7.9736	-8.5050	6.8811

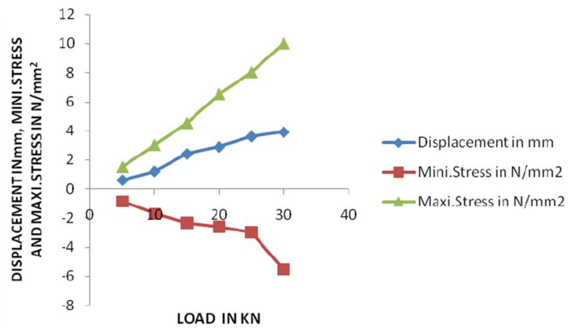


Fig.11 Load Vs Maximum Deformation, Minimum Stress, Maximum Stress Graph For Corner Beam Column Joint

Case NO 2
Beam 230mm X 600 mm
Column 230mm X 600 mm
Stiffness of beam : KB = 436640.62 mm3
Stiffness of Column : Kc = 436640.62mm3
Stiffness of Joint: Kj = KB/ Kc
= 436640.62/436640.62
= 1.00

4) Exterior beam column joint with varying stiffness

Case NO 1
Beam 230 mm X 450 mm
Column 230 mm X 900 mm
Stiffness of beam : KB = 282685.54 mm3
Stiffness of Column : Kc =2380000 mm3
Stiffness of Joint: Kj = KB/ Kc
= 282685.54 / 2380000
= 0.11

Table IV

Load in KN	Displacement in mm	Mini. Stress In N/mm^2	Maxi. Stress in N/mm^2
5	0.80465	-0.88952	1.7288
10	1.60958	-1.92850	3.5080
15	3.48646	-2.66885	5.5690
20	3.90996	-2.80958	7.6085
25	4.65950	-2.99665	9.0580
30	5.80859	-5.95655	10.5090

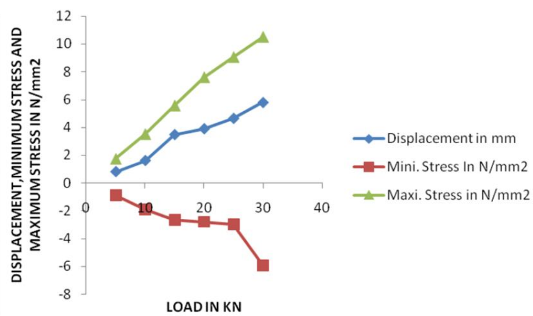


Fig.12 Load Vs Maximum Deformation, Minimum Stress, Maximum Stress Graph For Exterior Beam Column Joint

Case NO 2
Beam 230mm X 600 mm
Column 230mm X 600 mm
Stiffness of beam : KB = 436640.62 mm3
Stiffness of Column : Kc = 436640.62mm3
Stiffness of Joint: Kj = KB/ Kc
= 436640.62/436640.62
= 1.00

Table V

Load in KN	Displacement in mm	Mini. Stress In N/mm^2	Maxi. Stress in N/mm^2
5	0.204060	-0.628264	1.885095
10	0.405070	-0.965852	2.807054
15	0.697950	-1.489700	3.889520
20	1.905080	-1.870850	7.908050
25	2.204088	-2.225578	8.608055
30	2.805689	-2.956850	10.55660

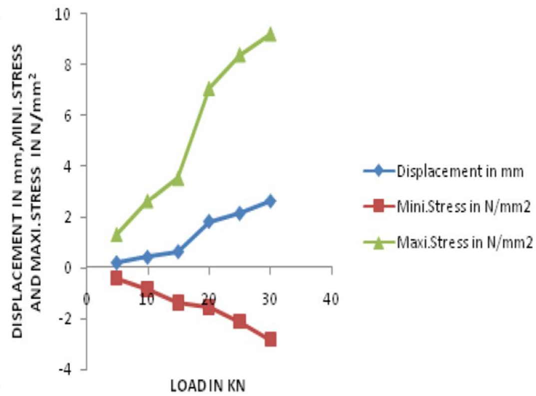


Fig.12 Load Vs Maximum Deformation, Minimum Stress, Maximum Stress Graph For Exterior Beam Column Joint

5) *Variation in stiffness of corner beam column joint*

Table VI

Load in KN	Displacement in mm	Displacement in mm
	Sj=0.11	Sj=1.00
5	0.6172	0.80605
10	0.9344	1.50809
15	2.3689	2.8850
20	4.4478	2.9060
25	5.6989	3.8050
30	7.9736	4.5080

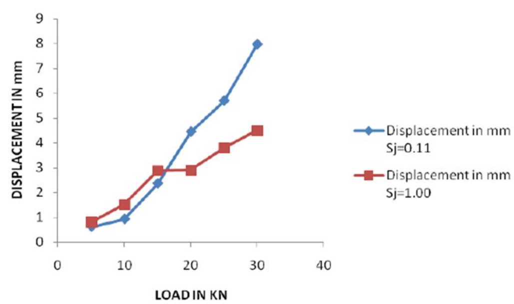


Fig.13 Load Vs Displacement Graph For Corner Beam Column Joint (Variation In Stiffness)

6) *Variation in stiffness of corner beam column joint*

Table. VII

Load in KN	Mini. Stress in N/mm^2	Mini. Stress in N/mm^2
	Sj=0.11	Sj=1.00
5	-0.8314	-0.86965
10	-4.9641	-1.92825
15	-5.6780	-2.66995
20	-6.7839	-3.60960
25	-7.9569	-3.98935
30	-8.5050	-5.60905

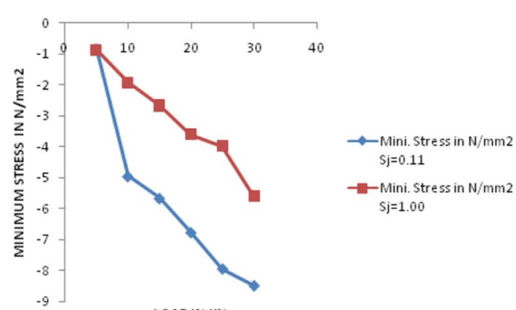


Fig. 14 Load Vs Minimum Stress Graph For Corner Beam Column Joint(Variation In Stiffness)

7) Variation in stiffness of corner beam column joint

Table VIII

Load in KN	Maxi. Stress in N/mm²	Maxi. Stress in N/mm²
	Sj=0.11	Sj=1.00
5	0.6034	1.6168
10	2.5058	2.3332
15	3.3358	4.8430
20	4.8844	6.6852
25	5.7425	8.5089
30	6.8811	10.856

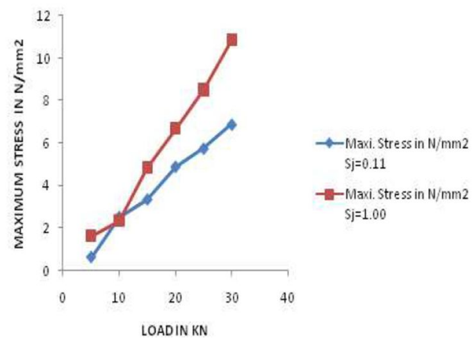


Fig. 15 Load Vs Maximum Stress Graph For Corner Beam Column Joint (Variation In Stiffness)

8) Variation in stiffness of Exterior beam column joint

Table IX

Load in KN	Displacement in mm	Displacement in mm
	Sj=0.11	Sj=1.00
5	0.80465	0.204060
10	1.60958	0.405070
15	3.48646	0.697950
20	3.90996	1.905080
25	4.65950	2.204088
30	5.80859	2.805689

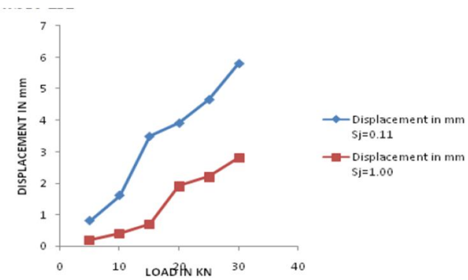


Fig.16 Load Vs Displacement Graph For Exterior Beam Column Joint (Variation In Stiffness)

9) Variation in stiffness of Exterior beam column joint

TABLE X

Load in KN	Mini. Stress in N/mm²	Mini. Stress in N/mm²
	Sj=0.11	Sj=1.00
5	-0.88952	-0.628264
10	-1.92850	-0.965852
15	-2.66885	-1.489700
20	-2.80958	-1.870850
25	-2.99665	-2.225578
30	-5.95655	-2.956850

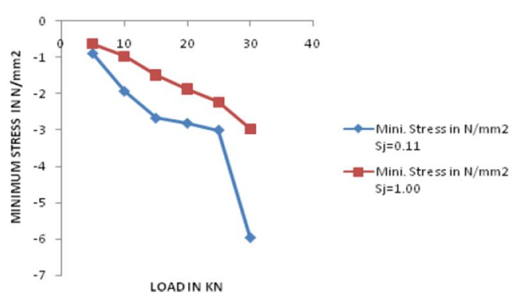


Fig.17 Load Vs Minimum Stress Graph For Exterior Beam Column Joint (Variation In Stiffness)

10) Variation in stiffness of Exterior beam column joint

Table XI

Load in KN	Maxi. Stress in N/mm²	Maxi. Stress in N/mm²
	Sj=0.11	Sj=1.00
5	1.7288	1.885095
10	3.5080	2.807054
15	5.5690	3.889520
20	7.6085	7.908050
25	9.0580	8.608055
30	10.5090	10.55660

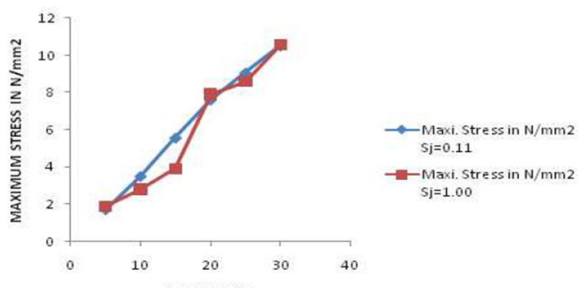


Fig. 18 Load Vs Maximum Stress Graph

For Exterior Beam Column Joint (Variation In Stiffness)

1) As load increases displacement, minimum stress and maximum stress also increases.
2) For stiffness variation of corner joint for Kj=0.11 the displacement is minimum as compare to Kj=1.
3) For stiffness variation of corner joint for Kj=0.11 the minimum stress is more as compare to Kj=1.
4) For stiffness variation of corner joint for Kj=0.11 the maximum stress is more as compare to Kj=1.
5) For stiffness variation of Exterior joint for Kj=0.11 the displacement is minimum as compare to Kj=1.
6) For stiffness variation of Exterior joint for Kj=0.11 the minimum stress is more as compare to Kj=1.
7) For stiffness variation of Exterior joint for Kj=0.11 the maximum stress is less as compare to Kj=1.
8) The behavior of corner beam column joint is different than that of the exterior beam column joint.
9) As stiffness of the structure changes the displacement, minimum stress and maximum stress changes w. r t .loading.
10) Here the behavior of exterior and corner beam-column joint is studied one can also go for interior joint with Ansys.
11) One can also try beam-column joint retrofitted with carbon fiber reinforced polymer sheets (CFRP) to study the Behavior of beam-column joint subjected to monotonic loading.
12) One can also go for experimental model of beam-column joint i.e. corner and exterior beam-column joint in laboratory and apply monotonic loading to the models at the free end of beam.
13) One can also study different loading conditions on beam-column joint. i. e. cyclic loading, random loading etc.
14) The behavior of joint can also be studied by applying column axial load to the Joint in Ansys. Where Kj= beam column joint stiffness ratio/ Factor.

IX. CONCLUSION

In this research work a study of reinforced concrete beams using finite element analysis in order to understand the response of reinforced concrete beams due to transverse loading. The reinforced concrete beam with flexural and shear reinforcement was analyzed to failure and compared to experimental results. 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.

REFERENCES

[1] Barr, P.J. (2008). “Comparison of prestress losses for a prestress concrete bridge made with high performance concrete”, *J. Bridge Eng*., ASCE, 13 (5), 468-475.
[2] Byung Hwan Oh, In Hwan Yang (2001). “Realistic long term prediction of prestress forces in psc box girder bridges”, *J. Structural Eng*., ASCE, 127 (9), 1109-1116.
[3] Chang-Su Shim, Pil-Goo Lee, Sung-Pil Chang (2001). “Design of shear connection in composite steel and concrete bridges with precast decks”, *J. Bridge Eng*., ASCE, 15 (3), 725-733.
[4] Dereck J. Hodson, Paul J. Barr, and Marvin W. Halling (2012). “Live-Load Analysis of Post-tensioned Box-Girder Bridges”, *J. Bridge Eng*., ASCE, 17(4), 644-651.
[5] Gonzalo R., Angel, C. A., Gonzalo R. and Juan R.C. (2000). “Externally prestressed high strength concrete viaduct”, *J. Bridge Eng*., ASCE, 26 (4), 337-345.
[6] IRC: 18.(2000). Design criteria for prestressed concrete road bridges (post tensioned concrete), IRC, New Delhi, India.
[7] IRC: 6. (2010). Loads and stresses, IRC, New Delhi, India.
[8] IRC:112. (2011). Code of practice for concrete bridges, IRC, New Delhi, India.
[9] IS1343.(1980). Indian Standard code of practice for prestressed concrete (First Revision), BIS, New Delhi,India.
[10] Jarret Kasan, s. m., Kent, A. H. (2011). “Redevelopment of prestressing force in severed prestressed strands”, *J. Bridge Eng*., ASCE,16 (3), 431-437.
[11] John B. Kennedy and Mohamed H. Soliman (1987). “Temperature distribution in composite bridges” *J. Structural Eng*., ASCE, 113 (3), 475-482.
[12] Krishna Raju, N. (1995). *Prestressed Concrete*, Tata McGraw- Hill Publishing company Limited, New Delhi.
[13] Leo E. Rodriguez, Paul J. Barr, Marv W. Halling (2013). “Temperature effects on a box girder, integral abutment bridge”, journal of performance of constructed facilities, ASCE, 16(7), 548-553.
[14] Raina, V.K. (1994). *Concrete Bridge Practice-Analysis*, Design and Economics, McGraw- Hill Publishing Company Limited, New Delhi.
[15] S. Maleki (2002). “Effect of deck and support stiffness on seismic response of slab girder bridges”, Engineering Structures, 24, 219-226.
[16] Vikash Khatri, Pramod Kumar Singh and P.R.Maiti (2012). “Comparative study of prestressed steel concrete composite bridge of different span length and girder spacing”, International Journal of Modern Engineering Research, 2(5), 3917-3922.
[17] Hwang Shyh-Jiann and Lee Hung-Jen Analytical Model for Predicting Shear Strengths of Exterior Reinforced Concrete Beam-Column Joints for Seismic Resistance ACI Structural Journal, September-October 2005 , Vol. 96, No.5.
[18] H. F. Wong and J. S. Kuang Effect of Beam-Column depth ratio on design on joint seismic Proceedings of Institution of Civil Engineers Structures and Buildings,2008 , 91-101.

[19] Jaehong kim and James .M. Lafave Key influence parameters for the Joint shear behavior of RC beam-column Connections Engineering Structures, 2007, 2523-2539

[20] Bing Li, Yiming Wu, and Tso-Chien Pan. Seismic Behavior of Non seismically Detailed Interior Beam-Wide Column Joints-Part II: Theoretical Comparisons and Analytical Studies. ACI Structural Journal, January-February 2003, V.100, No.1

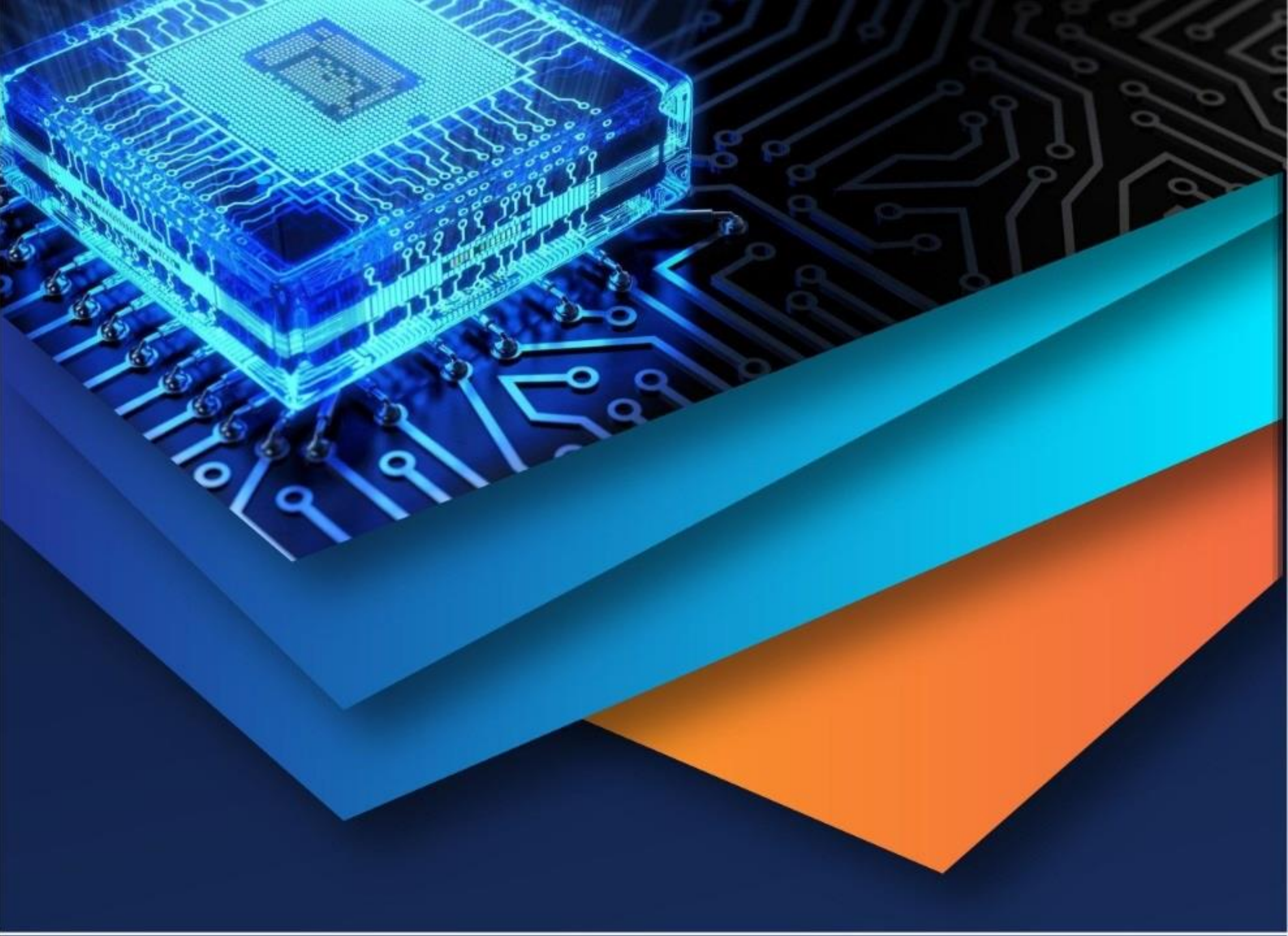
[21] Lowes.N.Laira, Mitra Nilanjan and Altoontash Arash A beam-column Joint model for simulating the earthquake response of Reinforced Concrete Frames. Pacific Earthquake Engineering Research Center (PEER) , 2004,1-66

[22] Murty.C.V.R, Rai.C.Durgesh, Bajpai.K.K and Jain.S.K Anchorage detail and joint design in seismic RC Frames. The Indian Concrete Journal, April 2001 , 274-280

[23] Pampanin.S., Calvi.G.M. and Morati.M. Seismic Behavior of Reinforced Concrete Beam-Column Joints designed for GrLoads 12th European Conference on Earthquake Engineering, 1998 ,1-10

[24] Hegger Josef, Sherif Alaa and Roeser Wolfgang Nonlinear Finite Element Analysis of Reinforced Concrete Beam-ColConnections ACI Structural Journal, Sept-Oct 2004, 604-614

[25] R. Vollum and D. Parker External beam-column joints design to Eurocode2 Magazine of Concrete Research,2008, 511-521.



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