Behavior of Mechanical Reinforcement in R.C.C. Exterior Beam-Column Joint

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Abstract— ***This work concerned with behavior of mechanical reinforcement in Exterior beam-column joint. Beam column joints are critical regions in multi-story moment resisting reinforced concrete frames subject to inelastic response under severe seismic loading. Recent code changes have significantly increased the amount of rebar required while, at the same time, designers are striving for more compact structural elements. This results in rebar congestion and placement problem. Headed bar terminator answer these challenges by eliminating the majority of rebar embedment lengths required, while reducing job side related man hours. Use headed bars in the beam-column joint to overcome the congestion problem.***

Keywords— **Exterior beam-column joint, Mechanical Reinforcement (headed bar), deflection, maximum principle stress, minimum principle stress, ANSYS software**

I. INTRODUCTION

Beam column joints are critical regions in multi-story moment resisting reinforced concrete frames subject to inelastic response under severe seismic loading. Because seismic moments in columns and beams act in opposite directions across the joint, the beam–column joint is subjected to horizontal and vertical shear forces whose magnitude is often many times higher than those found in adjacent beams and columns. The joints should have adequate strength and stiffness to resist the internal forces induced by the framing members.

For many years, the traditional method for terminating reinforcing steel has been hooked rebar anchorage. Recent code changes have significantly increased the amount of rebar required while, at the same time, designers are striving for more compact structural elements. This results in rebar congestion and placement problem. Headed bar terminator answer these challenges by eliminating the majority of rebar embedment lengths required, while reducing job side related man hours. Analysis of R.C.C. beam-column joint using headed bar to overcome congestion problem in joint is using ANSYS software, developed by ANSYS Inc., USA. Using this software package we obtain maximum stress, minimum stress, deformation in joint region.

II. BEAM-COLUMN JOINT

The RC beam column joints are the most vulnerable part and subjected to damage firstly. The commonly seen deficiencies of damaged beam-column joints may be characterized as

- Insufficient shear strength
- Inadequate anchorage or bonding and
- Insufficient flexural strength or ductility

A. Type of Joint

In a moment resisting frame, three types of joints can be identified as interior joint, exterior joint and corner joint,

- When four beams frame into the vertical faces of column the joint is called as interior beam-column joint.
- When one beam frame into vertical face of column and two other beam frame from perpendicular direction into the joint, then the joint is called as exterior beam-column joint.
- When a beam frames into two adjacent vertical faces of column, then the joint is called corner beam-column joint.

III. MECHANICAL REINFORCEMENT

A headed bar is an oversized coupler, plate or ‘head’ that is attached to one or both ends of a piece of reinforcing steel. Headed bars are used to terminate reinforcing bars and provide mechanical anchorage. These end anchorages are the heads.

The capacity of a headed bar can be achieved by a combination of bearing on the concrete and bond development length in front of the head, or simply by bearing alone. Though they can be used for confinement applications, the most common application for headed bars are as an anchor or 90- and 180- degree hooked bar anchorage replacements. The heads are very effective in anchoring the bar.

A. Advantages of Mechanical Reinforcement

- Space saving anchorage (no development, no hooks or bends)
- Safe anchorage, regardless of the bar diameter
- Safe anchorage even under loss of concrete cover
- Independent of bond between rebar and surrounding concrete, thus possible to use plain high-strength steel and beneficial in concrete with low bond properties (as lightweight aggregate concrete)
- Increased shear capacity
- Increased ductility of the construction

IV.ANSYS-FINITE ELEMENT ANALYSIS SOFTWARE

A complete finite element analysis involves three stages:

- Pre-Processing
- Finite Element Solver
- Post-Processing

And for the ANSYS Finite Element system, it consists of two parts to perform a full analysis:

1. ANSYS Modeler is a fully interactive pre- and post-processing graphical user interface.
2. ANSYS Solver performs the finite Element Analysis.

The pre-processing stage involves creating a model of the structure. A model is a graphical representation, consisting of two major parts which are geometry and assigned attributes. In ANSYS attributes types included mesh, geometry, materials, supports and loading. Stiffness method will be solved and produces a result file with the required data.

V.MODELING OF BEAM-COLUMN JOINT

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 type of complex problems.

Prototype model of exterior beam column joint using standard 90^0 Hooke, with rectangular headed bar, with circular headed bar and deformation, maximum principle stress, minimum principle stresses are obtained and compared with each other by using ANSYS Software.

Property of specimen**:-**

- Beam size :- 230 X 420
- Column size :- 230 X 450
- Concrete Grade :- M 25
- Steel Grade :- Fe 415

Geometry of specimen:-

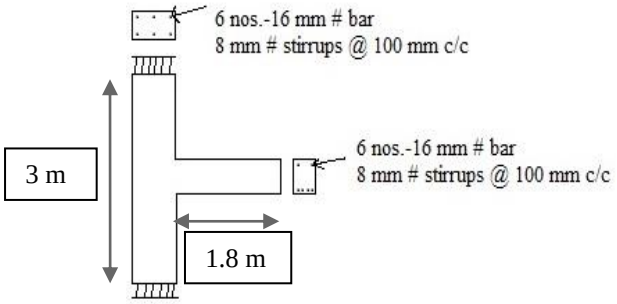

Fig. 1 Geometry

Once the reinforcement detail of the beam-column is known the exterior beam-column joint is modelled in Ansys FEM Software. Non-linear analysis of exterior beam-column joint is carried out with 6 step monotonic loading and 30 iterations in each load step. The mesh size of 80 mm is taken for whole structure. R.C.C. exterior beam-column joint with standard 90^0 hook, with rectangular headed bar, and with circular headed bar were analysed.

VI. RESULT AND DISCUSSION

As discussed above, Exterior beam-column joint with mechanical reinforcement is considered to study the joint behavior subjected to monotonic loading. The exterior beam-column joint is analysed with different parameter like i.e. Maximum Principle Stress, Minimum Principle Stress, and Displacement with different type of Headed bar.

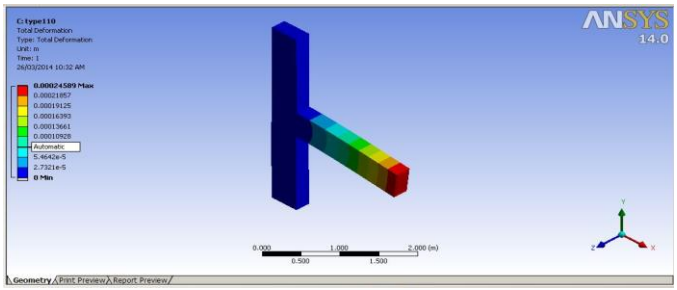

Fig. 2 Displacement in Beam-Column Joint

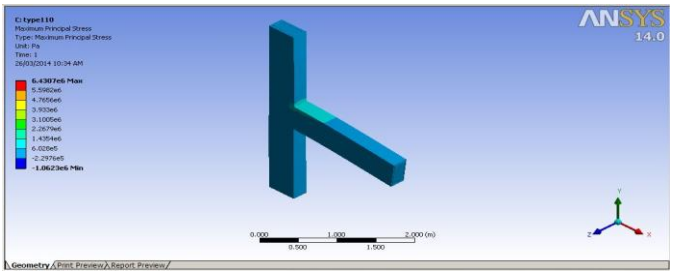

Fig. 3 Maximum Principle Stress in Beam-Column Joint

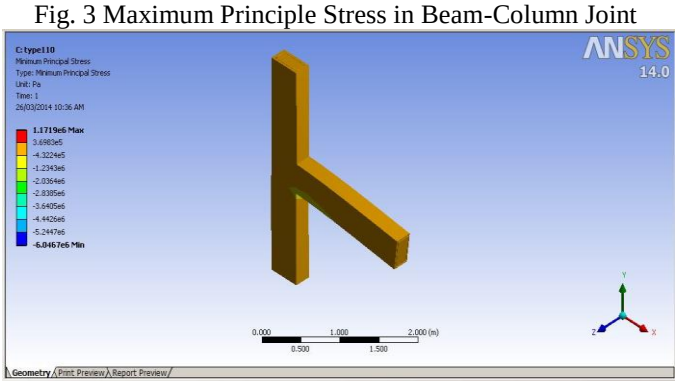

Fig. 4 Minimum Principle Stress in Beam-Column Joint

1. Displacement Comparison for R.C.C. Exterior Beam-Column Joint with Standard 90^0 hook, Rectangular Headed Bar, and Circular Headed Bar

TABLE 1
DISPLACEMENT COMPARISON

Load KN	Standard 90^0 Hooke mm	Rectangular Headed Bar mm	Circular Headed Bar mm
5	0.2459	0.2409	0.24085
10	0.934	0.9153	0.915
15	1.2786	1.2525	1.2524
20	1.5737	1.5416	1.5414
25	1.918	1.879	1.879
30	2.0655	2.0233	2.023

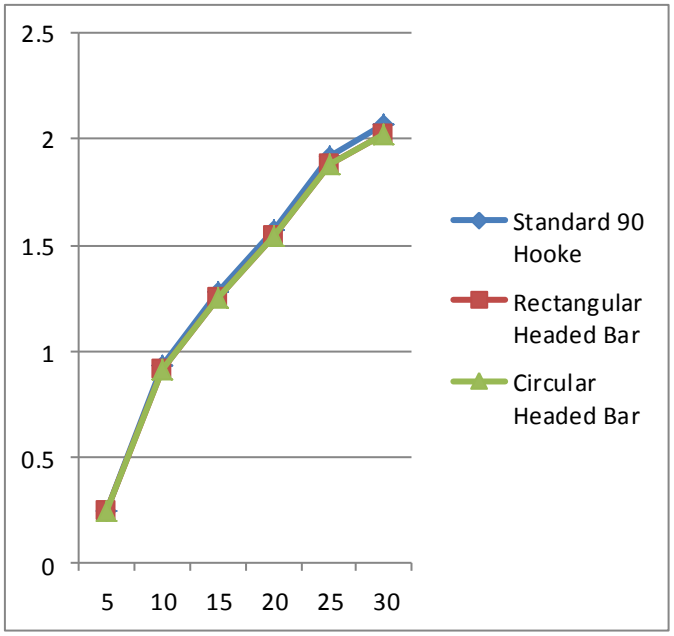

Fig. 5 Load v/s Displacement

2. Comparison of Maximum Principle Stresses for R.C.C. Exterior Beam-Column Joint with Standard 90^0 hook, Rectangular Headed Bar, and Circular Headed Bar

TABLE 2
COMPARISON OF MAXIMUM PRINCIPLE STRESSES

Load KN	Standard 90^0 Hooke N/mm^2	Rectangular headed bar N/mm^2	Circular headed bar N/mm^2
5	6.4307	6.3314	6.27
10	12.861	12.663	12.54
15	14.08	13.929	13.794
20	25.723	25.325	25.08
25	29.441	29.124	28.842
30	38.584	37.988	37.62

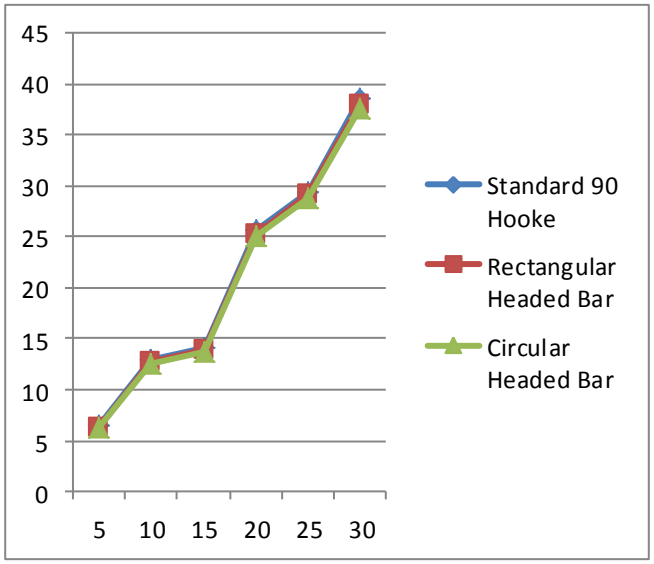

Fig. 6 Load v/s Maximum Principle Stress

3. Comparison of Minimum Principle Stresses for R.C.C. Exterior Beam-Column Joint with Standard 90^0 hook, Rectangular Headed Bar, and Circular Headed Bar

TABLE 3
COMPARISON OF MINIMUM PRINCIPLE STRESSES

Load KN	Standard 90^0 Hooke N/mm^2	Rectangular headed bar N/mm^2	Circular headed bar N/mm^2
5	-6.0467	-6.0602	-6.1287
10	-12.093	-12.12	-12.2574
15	-13.236	-13.332	-13.483
20	-24.187	-24.241	-24.5148
25	-27.675	-27.877	-28.192
30	-36.28	-36.361	-36.772

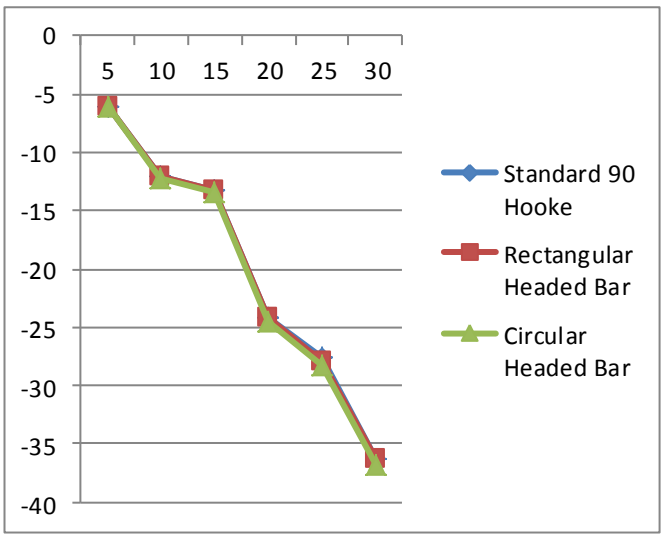

Fig. 7 Load v/s Minimum Principle Stress

VII. CONCLUSION

Normally Standard 90^0 hook is used to anchor the longitudinal re-bar in exterior beam-column joint. However this may results in steel congestion, and it results difficulty in fabrication and construction. The mechanical anchor can be an alternative to the 90^0 standard hooks. In this research, the performance of mechanical anchor in exterior R.C.C. beam-column Joint by Finite Element Analysis in ANSYS. Based on this study it was observed that in Exterior beam-column joint, mechanical anchor get very similar results to the standard 90^0 hook. So it was concluded that mechanical anchor can replace standard 90^0 hook as it has enough anchorage capacity within the exterior beam-column joint.

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