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Analysis of Beam Column Joint using Finite Element Method – Comparative Study

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Abstract - *The design of reinforced concrete structures solely depends on various parameters like bending moment; shear force and stress induced in a particular member of a structure. Variation in the magnitude of these parameters may alter the entire design of a particular element. Hence the analysis of a member quantifying above parameters is very important. Various methods are available for quantification of above referred parameters such as stiffness method, flexibility method, finite element method and strain energy method. It is prerogative of structural designer to use any of these methods. However the realistic design can be achieved if a proper analysis method is used. This paper presents the analysis results of beam column joint located at the intermediate position and at the end position of a two span beam column system. The analysis concludes that there is some variation in magnitude of various parameters quantified using stiffness method, flexibility method, finite element method and strain energy method. The lowest results were obtained by using finite element analysis (ANSYS).*

***Key Words*: Stiffness method, Flexibility method, Finite element method and Strain energy method for beam column joint.**

1. INTRODUCTION

In RC buildings, portions of columns through the beams at their intersections are called beam-column joints. Beam column joint is the crucial zone in a reinforced concrete frame. It is subjected to large forces during its service life and its behavior has a significant influence on the stability of the structure. In the design of reinforced concrete structures, much of the attention is embarked towards calculation of strength of the basic structural elements like beam, columns and slabs. Comparatively lesser emphasis has been laid on intermediate and end column beam joints. Keeping this in view, paper presents the results of numerical study of reinforced concrete end and intermediate joint by force method and displacement method. The second phase of the study includes the comparison of numerical results to the results obtained by general-purpose finite element analysis software ANSYS R16.2. Finite Element analysis method introduced by Zeinkiewicz (1) analyses the structure fairly well and near accurate. The state of stress, bending moment and shear force has been evaluated at centre of the beam column joint (end and intermediate joint).

2. Methodology

The analysis of end and intermediate beam-column joint is carried out using stiffness coefficient method, flexibility coefficient method, strain energy method and finite element method (ANSYS).The beam column joints has identical beam and column sizes. Beam-column joint of size 500 x 700 x 3500 mm long for column and 150 x 625 x 8000 mm long for beam, made of M40 grade concrete are used for study as shown in Table I. The reinforcement design of beam column joints is shown in Table II. Dead load of 16.5 kN/m and live load of 3kN/m are considered for analysis. The end and intermediate joints of the specified beam column structure are idealized for finite element method. ANSYS is widely used finite element software for analysis of reinforced concrete structures.

Table -1: Details of beam column

Specimen	Size (mm)	FCK (N/mm2)	Cover (mm)
Beam	150x 625	40	25
Column	500x 700	40	40

Table -2: Design Details of Reinforcement

Joint Specimen	Beam Upper Section (mm)	Beam Lower Section (mm)	Stirrups (mm)	Column Section (mm)	F_Y (N/mm2)
Joint 1(end)	4□12	2□12	□8@ 300	12□12	500
Joint 2 (intermediate)	4□12	2□12	□8@ 300	12□12	500

The stress, bending moment and shear force is evaluated by hand calculation while using:-

1. Stiffness method
2. Flexibility method
3. Strain energy method

ANSYS program is used to evaluate stress, bending moment and shear force by using finite element method. The key diagram of the analysis by stiffness and flexibility matrix method is shown below:-

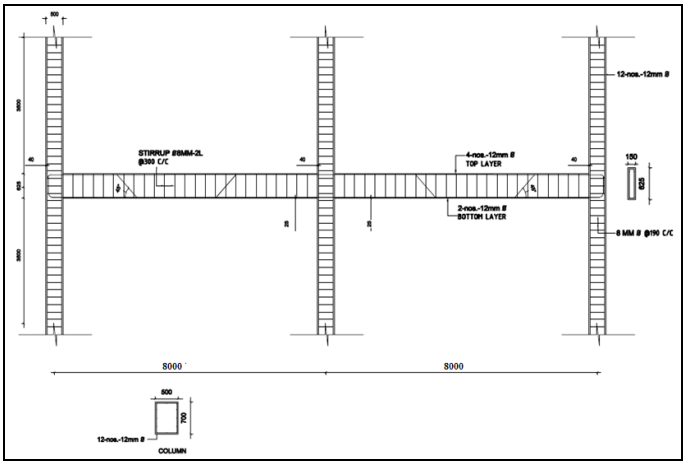

Fig -1: Key diagram of analysis

3. Modeling of Beam-Column Joint

The beam-column joint is modeled in ANSYS software using the above element types and the material properties. Some of the modeling details are shown in the following figures.

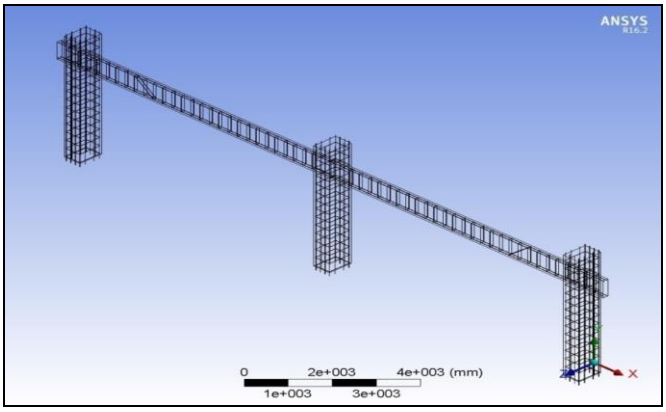

Fig -2: Reinforcement modeling of joints

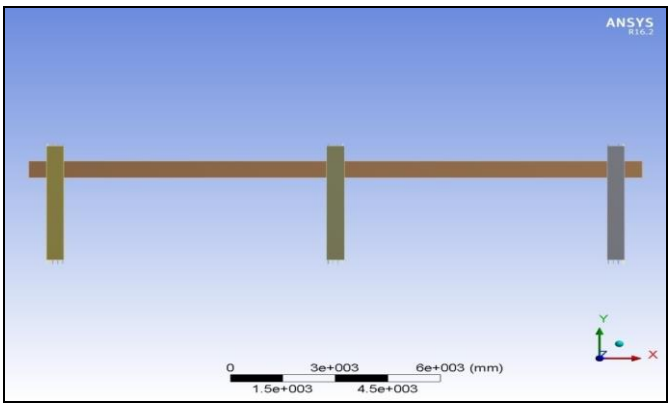

Fig -3: Beam column structure model

4. Result and Discussion

Geometric drawings of the joints are prepared by using finite element analysis tool ANSYS R16.2. ANSYS is a finite element software package for analysis of reinforced concrete structure. ANSYS is adopted for the analysis because of ease provided by it for the results at the centre of the joints. Grade of concrete used for beam column structure is considered as M 40 and HYSD (Fe 500) bars are used as reinforcement. As per IS 875(Part 1 and 2), 1987dead load and live load combination are considered. A uniformly distributed load of 19.5 kN/m is considered.

4.1 Magnitudes of bending stresses at end and intermediate joints are as follows-

Sl. No.	Joint Specimen	Bending Moment (KN-m)			
		Stiffness Method	Flexibility Method	Finite Element Method	Strain Energy Method
1	End Joint	72.16	72.32	83.67	101.18
2	Intermediate Joint	119.78	119.84	98.13	85.00

4.2 Magnitudes of shear force at end and intermediate joints are as follows-

Sl. No.	Joint Specimen	Shear force (KN)			
		Stiffness Method	Flexibility Method	Finite Element Method	Strain Energy Method
1	End Joint	72.10	72.06	67.91	80.06
2	Intermediate Joint	83.90	83.94	70.64	75.94

4.3 Magnitudes of bending stresses at end and intermediate joints are as follows-

Sl. No.	Joint Specimen	Stresses (N/mm2)			
		Stiffness Method	Flexibility Method	Finite Element Method	Strain Energy Method
1	End Joint	0.77	0.77	0.72	0.85
2	Intermediate Joint	0.89	0.90	0.75	0.81

5. Conclusions

The main conclusions drawn from the analysis of beam column joints are summarized below-

1. There is some variation in the magnitude of various parameters quantified using stiffness method, flexibility method, finite element method and strain energy method.
2. The lowest results were obtained by using finite element analysis.

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