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EXPERIMENTAL INVESTIGATION OF REINFORCED CONCRETE BEAM-COLUMN JOINT

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ABSTRACT: Beam-Column joint is one of the major critical part in a building. In case of earthquake the beam-column joint will be more vulnerable to failure when comparing to other structural members, so the beam-column joint must be more concentrated while designing. In this paper replacement of basalt fiber is adopted in case of fine aggregates in concrete mix, so that the basalt fiber will modify the behaviour of beam-column joint, it will make the joint more ductile during earthquakes. Here, Basalt fiber is used as a replacement of fine aggregate in increasing order of 10%, 20% and 30% from this optimum range is determined and used in beam-column joint and a comparative study is made with conventional beam-column joint.

1 INTRODUCTION

A beam column joint is the combination of concrete and steel to provide strength and stiffness to the member. This project deals with the experimental investigation at beam column joint. In order to increase the strength and ductile strength of concrete and to reduce the damage of structures, basalt fibre is added to the concrete. In this project comparisons will take place between the conventional beam column joint and beam column joint with basalt fibre which results in high strength and to resist the joint failure when cyclic load is applied to the specimens.

2 EXPERIMENTAL INVESTIGATION OF BEAMS AND COLUMNS

2.1 EXPERIMENTAL INVESTIGATION

To gain a better understanding about the flexural, compression behavior of strengthened reinforced concrete beams and column member using basalt fiber which used a replacement of fine aggregate were tested with different variables like (BS-1)10%, (BS-2) 20% and (BS-3) 30% under monotonically increasing flexural and compression load at the structural engineering laboratory this chapter also describes the details of the beam specimens material properties, instrumentation and test procedures that were used during the experimental investigation, test results are also discussed at the end of this chapter. In this chapter which clearly explains about the test results and comparison of conventional beam-column joint and optimum range of strengthened basalt fiber beam-column joint.

2.2 R.C.C. BEAM DESIGN

A reinforced concrete beam with simply supported span length of 1.5 m ,and cross section 230 mmx300mm were cast under two point loading details of the beam geometry and flexural reinforcement locations are illustrated these dimensions were selected by considering the following facilities available in structural engineering construction ,testing and handling facilities. Beams were designed using IS: 456:2000 provisions. In which Conventional beam (CB) is compared with basalt fiber beam with different variables like (BS-1-B)10%, (BS-2- B) 20% and (BS-3- B) 30% under flexure.

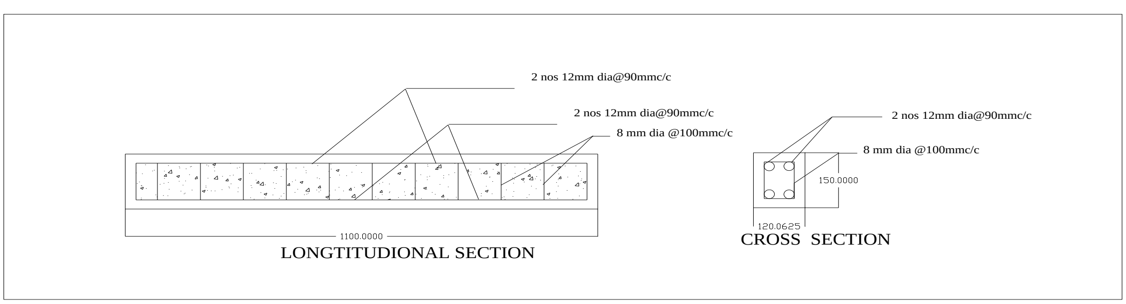

Fig. 1 Reinforcement Details

Table 1 Comparison of Compression strength

Name of the Specimen	Compression strength (N/mm^2)
CC-B	60
BS-1-B	70
BS-2-B	97
BS-3-B	86

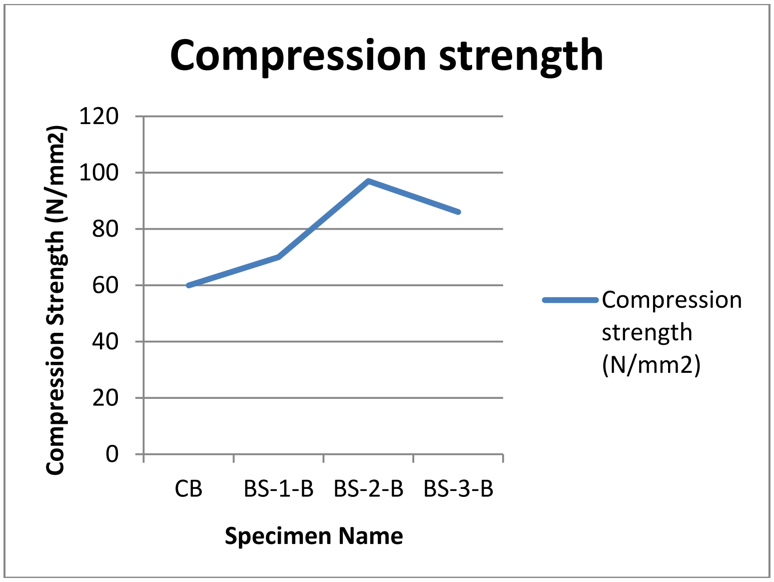

Fig.2Comparison chart for Compression strength

Table 2 Comparison of Split Tensile strength

Name of the Specimen	Split Tensile strength (N/mm^2)
C-B	13.8
BS-1-B	14.5
BS-2-B	18
BS-3-B	15.2

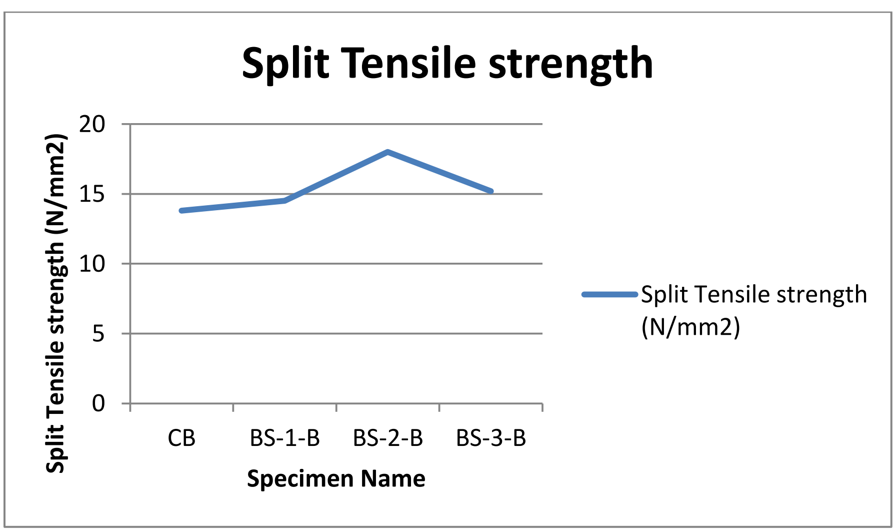

Fig.3 Comparison chart for Split Tensile strength

Table 3 Experimental results for RC Beam

Beam designation	First crack		Ultimate moment (KN)	Maximum deflection (mm)	Energy absorption (kN-mm)	Ductility factor
	Load (kN)	Deflection (mm)				
CC	16	1.11	48	9	248.6	2.4
BS-1	18	1.74	64	8.8	288	1.87
BS-2	32	1.42	82	8.4	372.4	1.28
BS-3	22	1.23	72	8.6	359	1.675

2.3 R.C.C COLUMN DESIGN

Steel of grade 500MPa is used for casting column. Columns of size 250mmx 600 mm with height of 3 m wa designed using IS: 456:2000 provisions. In which Conventional column (CC) is compared with basalt fiber column with different variables like (BS-1-C)10%, (BS-2-C) 20% and (BS-3-C) 30% under compression.

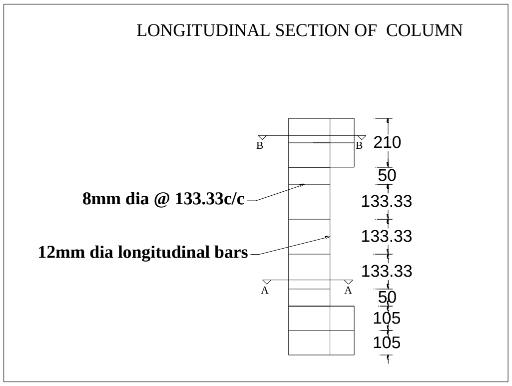

Fig. 4 Longitudinal Section of Column

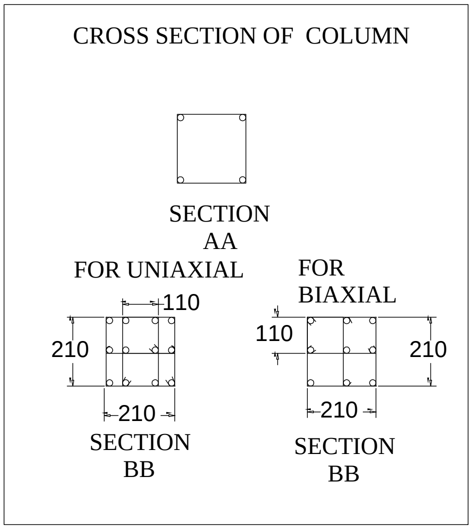

Fig. 5Cross Section of Column

Fig.6 Reinforcement Cage for Column

Table 4 Comparison of first crack load and ultimate load on Columns

Name of the Specimen	First Crack Load (kN)	Ultimate Crack Load (kN)
CC	118	297
BS-1-C	126	315
BS-2-C	154	385
BS-3-C	114	285

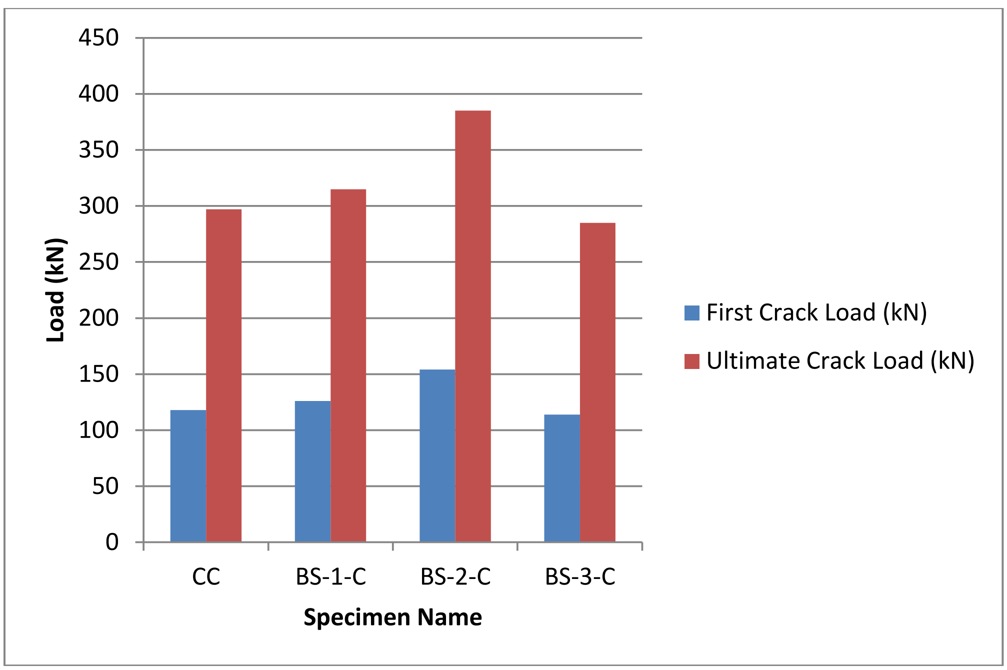

Fig.7 Comparison Chart for first crack load and ultimate load on Columns

3 EXPERIMENTAL INVESTIGATION OF BEAM-COLUMN JOINT

3.1EXTERIOR BEAM-COLUMN JOINT

In RC buildings, portions of columns that are common to beams at their intersections are called beam-column joints. Since their constituent materials have limited strengths, the joints have limited force carrying capacity. When forces larger than these are applied during earthquakes, joints are severely damaged. Repairing damaged joints is difficult, and so damage must be avoided. Thus, beam-column joints must be designed to resist earthquake effects.

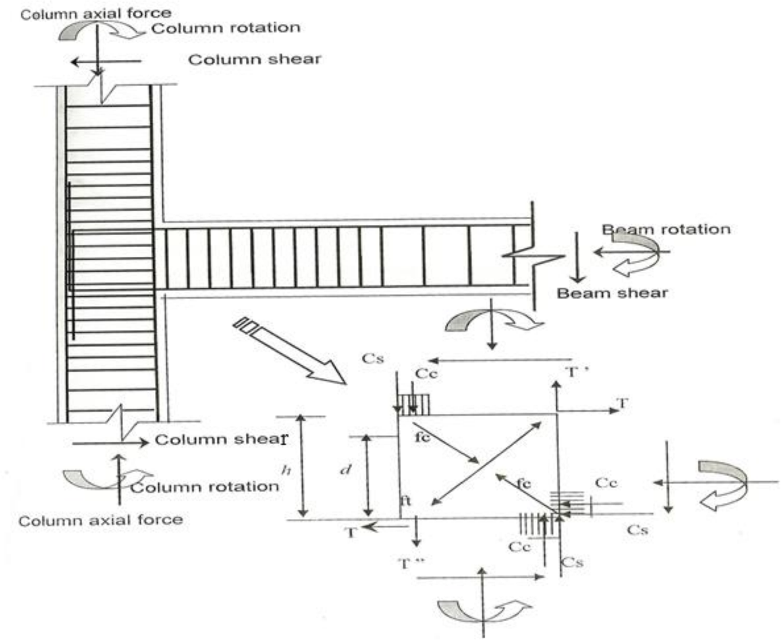

Fig.8 Behaviour of Exterior Beam-Column joint

Here,

C_C- Compression in concrete in beam bottom.
C_S – Compression in reinforcement in beam bars.
T – Tension stress Resultant from beam top reinforcement
T^I – Tension Stress Resultant from column reinforcement above joint region
T^{II} – Tension Stress Resultant from column reinforcement below joint region

From the position of the stress resultant, it’s apparent that diagonal tension and compressive stress are induced in the panel zone of the joint. The diagonal tension may be high when the ultimate capacity of the adjoining member is developed and this can lead to extensive diagonal cracking. The severity of diagonal tension is influenced by flexural steel content and the magnitude of the axial compression load on the column.

Fig.9 Exterior Beam-Column joint cage

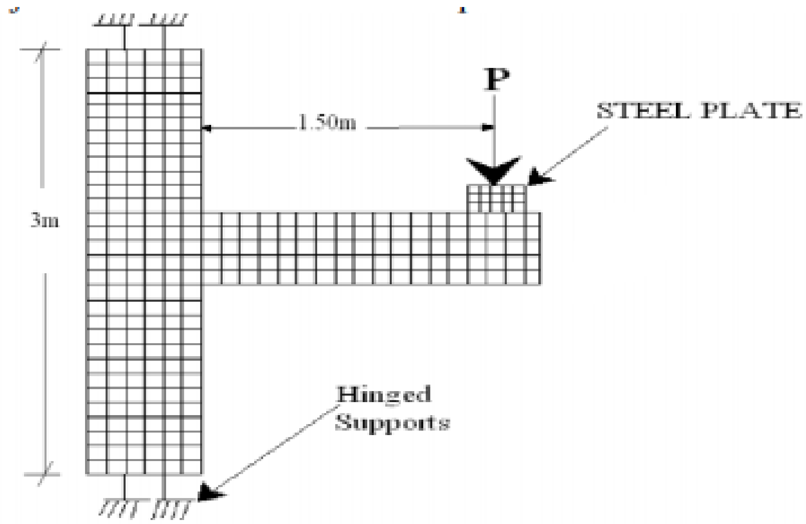

Fig.10 General model layout of exterior beam-column joint

Exterior beam-column joint (Hinge conditions), the dimensions for Beam is 230 mm x 300 mm with 1.5 m span Column 230 mm x 600 mm with 3 m height as shown in Fig.10.

Table 5 Failure load of Conventional beam-column joint

Load (kN)	Displacement (mm)	Minimum Stress (N/mm^2)	Maximum Stress (N/mm^2)
5	0.764	-0.898	0.643
10	1.846	-4.325	4.65
15	2.015	-6.824	5.836
20	2.245	-12.845	11.632
25	2.648	-15.456	15.405
30	2.842	-18.234	19.623
35	2.963	-19.426	19.82
40	3.750	-24.645	24.128

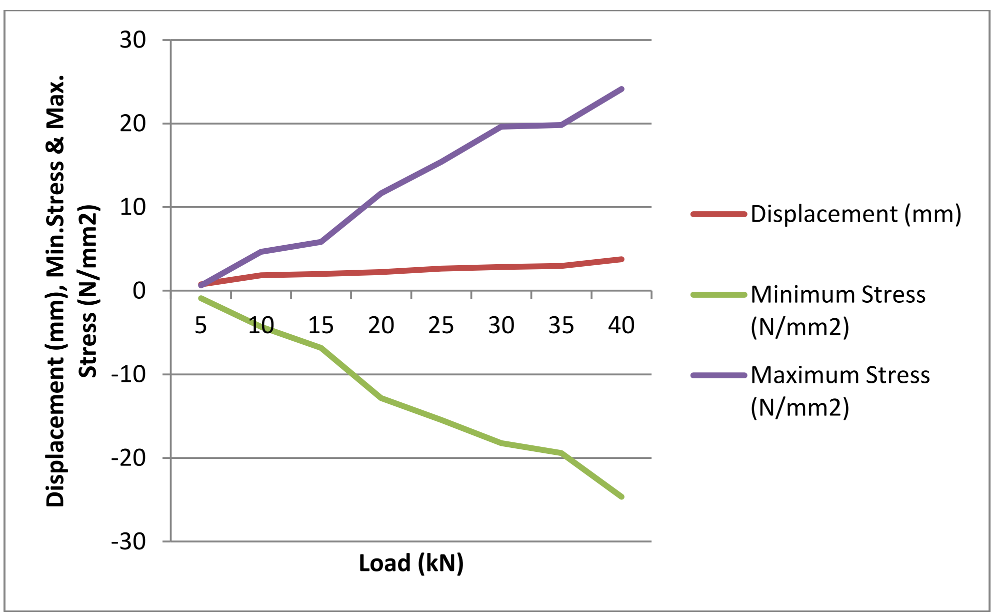

Fig.11 Load Vs Maximum Deformation, Minimum Stress, Maximum Stress Graph for conventional beam-column joint

Table 6 Failure load of 20% replaced basalt fiber beam-column joint

Load (kN)	Displacement (mm)	Minimum Stress (N/mm^2)	Maximum Stress (N/mm^2)
5	0.4172	-0.921	0.3042
10	0.489	-1.731	2.48
15	0.845	-1.882	2.20
20	1.205	-3.452	2.47
25	1.680	-4.154	2.56
30	1.912	-4.804	4.844
35	2.168	-5.425	5.629
40	2.318	-5.987	6.000
45	3.238	-6.145	6.787
50	3.698	-6.845	6.921
55	3.984	-7.608	7.214

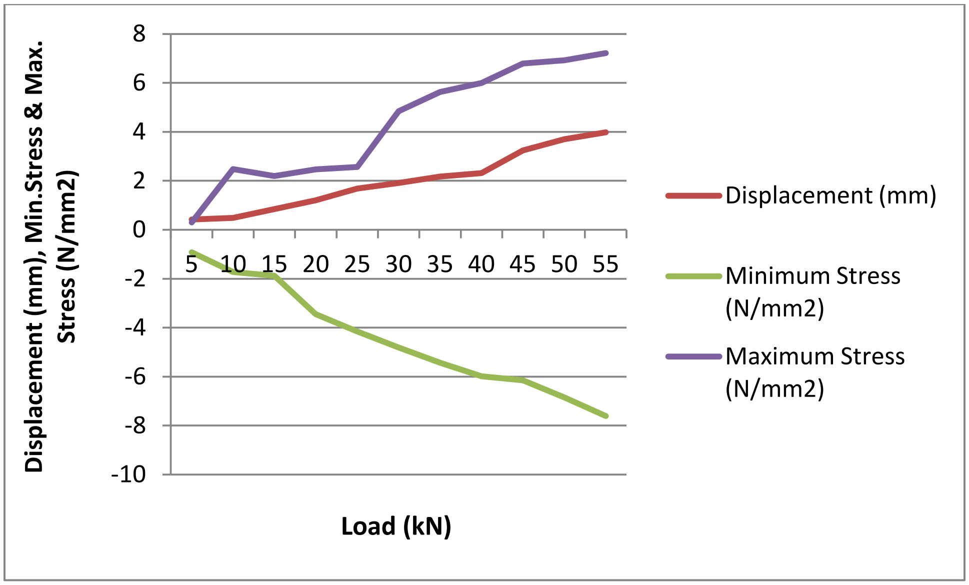

Fig.12 Load Vs Maximum Deformation, Minimum Stress, Maximum Stress Graph for 20% replaced basalt fiber beam-column joint

4 RESULTS AND DISCUSSIONS

The exterior beam-column joints are studied with different parameters like i.e. Maximum principle stress, Minimum principle stress, Displacement also studied end conditions of beam column joint is Hinged end conditions which is subjected to monotonic loading. In which conventional beam-column joint (CC) failed under ultimate load of 40 kN with displacement of 3.75 mm, Minimum stress of -24.645 N/mm^2 and maximum stress of 24.128 N/mm^2. Whereas basalt fiber which is replaced by 20% in terms of fine aggregate used in beam-column joint, which is know as basalt fiber beam-column joint failed under ultimate load of 55 kN with displacement of 3.984 mm, minimum stress of -7.608 N/mm^2 and maximum stress of 7.214 N/mm^2.The parameters are compared and shown in the Fig.7.1.

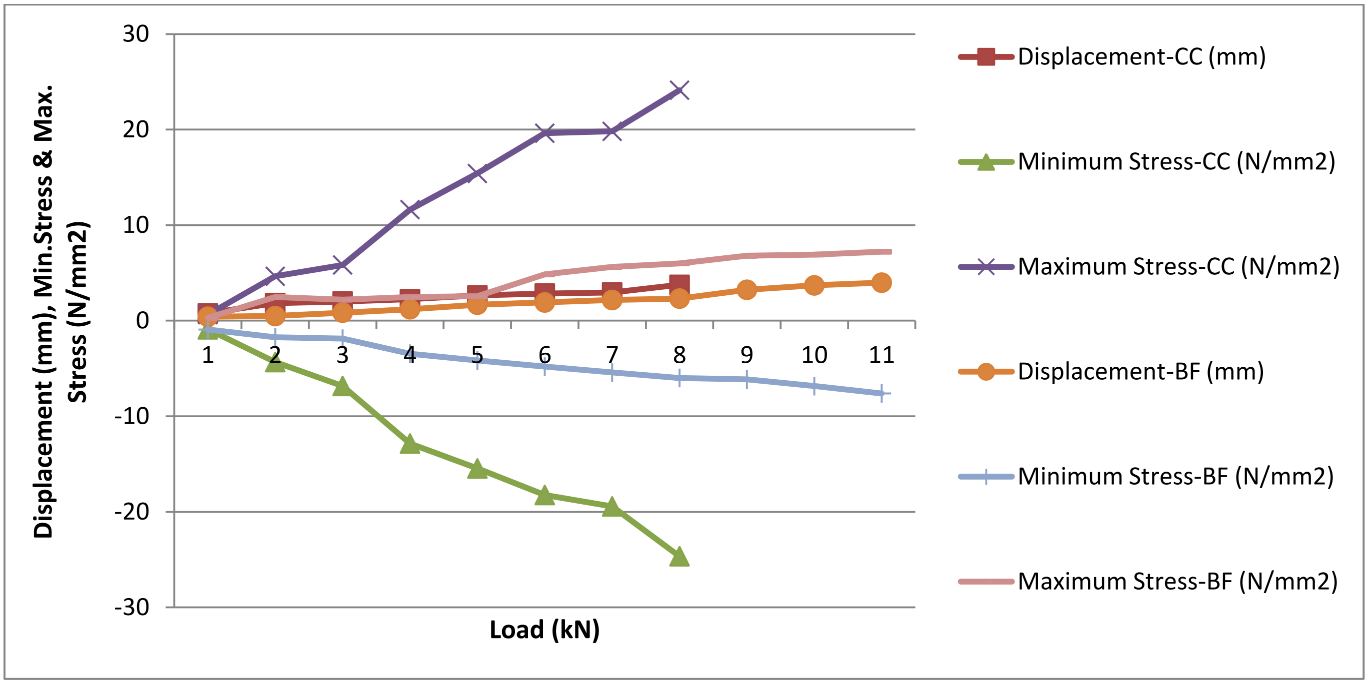

Fig.13 Comparison of conventional beam-column joint and basalt fibre beam-column joint

5 CONCLUSIONS

This experiment suggest a external beam-column joint which adequately have structural, architectural and lifecycle benefits like enhanced strength, ductile behavior, high corrosion resistance, aesthetic appearance, low construction and maintenance cost. This project involves in exterior beam-column joint in which conventional concrete and basalt fibers are used with varying damaged condition and comparing the results. From this the following conclusions are drawn.

- The fine aggregate in the concrete is replaced with basalt fiber for 10%, 20% and 30% and are tested under flexure and compression.
- The optimum performance was observed with the replacement of 20% of basalt fiber for fine aggregate by providing thorough mixing and to obtain the desired strength.
- The maximum compressive strength attained for M60 grade concrete is 86 N/mm^2 for the replacement of 20% basalt fiber.
- The maximum split tensile strength achieved is 18 N/mm^2 for the replacement of 20% basalt fiber.
- For exterior basalt fiber (20% replaced) beam-column joint the displacement, minimum stress and maximum stress values are minimum as compare to exterior conventional beam-column joint.
- The rigidity and ultimate load carrying capacity of the exterior basalt fiber beam-column joint is higher than the exterior conventional beam-column joint which is improved with decrease in deflections.
- Thus, exterior basalt fiber beam-column joint is stiffer than the exterior conventional beam-column and the crack widths exterior basalt fiber beam-column joint are relatively less.

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