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RESEARCH ARTICLE

Analytical and Experimental Study on Flexural Behavior of Beam-column Joint with Addition of Polypropylene Fibers

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ABSTRACT

Key scope of this research is evaluation of actions of beam to column joints under the impact load acting on it. The beam-column joints, a common area between frame beams and columns. It is the most critical zone to ensure the global response of such momentary resistance structures. Several approaches have been attempted over the years by many civil engineers and practitioners to improve the deficiently thorough joint in between beam and column. The highest bending moment and shear forces in the framed structures are at the junction area. As a result, that joint between beam and column is one of a collapse zone. Joint in outer is more important among the beam-column joints. The effect may be caused by a weight falling on the design object or possibly falling off the design object and hitting the hard surface. In this work, an emphasis has been made to understand the joint vulnerability against impact loads and its behavior is analyzed using the ANSYS software. From this experimental program observed that, impact resistance in RCC beam to column joints can be improved by improving stiffness by added polypropylene fibers and energy absorption can also be improved.

Keywords: Beam Column Joint, Impact load, Stiffness, addition of fibers, ANSYS

1 Introduction

We all know, A joint in beam to column was extremely important zone. Structure of concrete with reinforcement framed where the components converge into x, y, z direction and also it maintains the integrity of the system and the transition forces present at the ends of the members [1-4]. Carbon fibre ropes have been demonstrated to be an effective external strengthening reinforcement technique. [5]. The stiffness increased by 236.7 percent when compared to the control beam-column joint when using an X-shaped rope with two ropes on each side of the beam and two on each side of the column. [6]. The usage of additives substantially aids in the improvement of expandability. [7-8]. Under substantial displacement reversals, the joint in the ECC specimens remained intact, whereas the joint in the concrete specimens showed serious cracking [9]. The neural network model accurately predicts the shear strength of the Exterior Beam-Column joint [10]. RBSJ specimens respond similarly to the origin specimen, showing that the proposed joint was practical in precast RC framed structures [11]. Steel rebar inside the joint core performed admirably, and forces were properly transferred to the column [12-13]. FRP composites in beams improve stiffness and strength while reducing environmental concerns [14]. The UHPFRC strengthening scheme outperformed the UHPFRC laminates in terms of enhancing the shear strength of tested beams [15-16]. The Poisson's ratio and rebar slippage generated severe bond deterioration in joints with a low volume-stirrup ratio [17]. Vertical bars prevented the column-joint contact from bending, but failure occurred at the junction in this research. Diagonal bars can also help to avoid joint failure [18-20]. The addition of cementitious materials and fibre can aid to improve the tensile strength of a concrete part [21]. BFRP improves joint energy dissipation capability [22]. The beam-column connection shifts the failure mechanism from joint shear failure to flexural failure [23]. HPFRCC in conjunction can be an effective technique for boosting shear capacity while lowering the quantity of beam and column transverse reinforcements required [24]. Column axial loads of less than 25% increased just the final axial load capacity and associated deflection [25-26]. From the previous studies we known that there will be a performance optimization using different cementitious and fibre materials under cyclic and seismic loading. So, we are worked with new material polypropylene-based fibre in beam column joint under impact load. Objective of this study is analysing the behaviour of beam to column junction when the beam is subjected to impact loading and also to improve bond strength at the joints by adding 1 per cent of polypropylene fibres.

2 Research Methodology

In this research work we selected the materials through literature review. Then after that testing material property was done. 53 grade Ordinary Portland cement with specific gravity 3.17 confirms to IS: 12269 -2013 [27] was used for this experiment work. We tested and found the specific gravity and water absorption of fine aggregate was 2.7 and 1% respectively.it also confirms with IS 2386 -1963 [28]. We have also tested and found the specific gravity and water absorption of coarse aggregate was 2.65 and 0.5% respectively.it also confirms with IS 383-1970[29]. Ordinary water with pH 7.5 was used for experimental work. After that Mix Design was prepared by referring IS: 10262 -2009[29]. M20 Garde concrete Mix design used for experimental work was tabulated in Table 1.

Table 1: *M20 Grade concrete Mix Design*

Water	Cement	Fine Aggregate	Coarse Aggregate
191.6 litres/m3	383 Kg/ m3	574 Kg/ m3	1216 Kg/ m3
0.5	1	1.49	3.17

4 specimens of beam to column joint have been casted. They are,Two Beam-Columns with reinforcement (B-C-1 & B-C- 2).Two Beam-Columns with reinforcement and fibers (B-C- 3 & B-C- 4).In this 1% of polypropylene and 1% of steel fibers are added to the intersection portion of beam column joint. Fibers – 1% - 0.2348 gms and Polypropylene – 1% -0.2348 gms. The details of specimen's reinforcement:

6 nos of 12 mm ϕ be used for main reinforcement of column. 3 numbers of 8 mm ϕ were used for top reinforcement of beam. 2 numbers of 6 mm ϕ were used for bottom reinforcement of column Shear reinforcement consists of 6 mm ϕ at 230 mm c/c. The reinforcement detail for beam column joint was shown in figure 1.

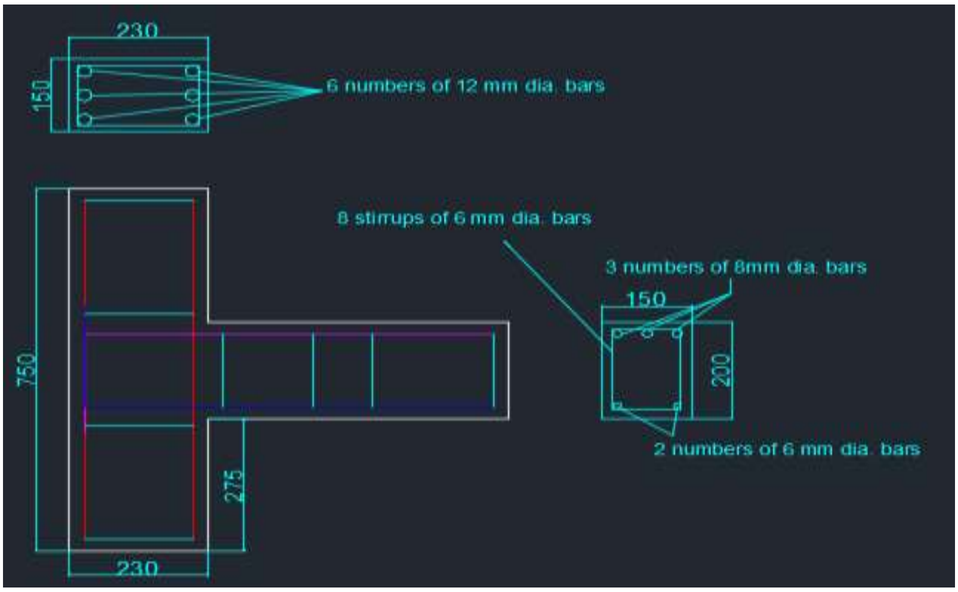

Figure 1: *Reinforcement details of beam-column joint*

3 Experimental Investigation

Two Beam-Columns with reinforcement (B-C-1 & B-C- 2) and Two Beam-Columns with reinforcement and fiber's (B-C- 3 & B-C- 4) were casted for experimental investigation of beam column joint under impact load. Junction assemblages were subject to transverse load and reverse cyclic loading. A consistent load is applied as of a 201.88 N iron ball falling freely from a vertical height 1 meter on the beam at the end. To record the strains precisely, strain gauges of 20 mm gauge length and 350ohms resistance are used. 20.6 kg Weight (including tip striking) be drop from 1 m high. At time of investigation, above specimen hammer is lift to convinced height with pulley and rope. Then now, tight the rope up to the required height. On releasing the rope from hand, the iron ball falls and strikes the specimen. Through preliminary investigation be found, if specimen not prohibited from straight down movements at supports, within short time after contact the iron ball with specimen, contact in supports lost after strains in specimens will fail easily. To prevail over problem, RC beams vertical movement at supports restrained tightly. The beam column joint experimental setup was shown in figure 2.

Figure 2: *Experimental setup*

From the experimental results, the maximum strain of beam and column for specimen BC1 was 0.001221 and 0.000627 respectively. The maximum strain of beam and column for specimen BC2 was 0.001371 and 0.000651 respectively. The maximum strain of beam and column for specimen BC3 was 0.001125 and 0.000357 respectively. The maximum strain of beam and column for specimen BC4 was 0.001194 and 0.000361 respectively. Also due to impact load, Shear crack at the joint in BC 1, BC 2, BC 3 and BC 4 was shown in figure 3, figure 4, figure 5 and figure 6 respectively.

Dhanabal *et al.*, *J. Mod. Mater.;* Vol. 9, Issue 1, pp: 26-35, 2022

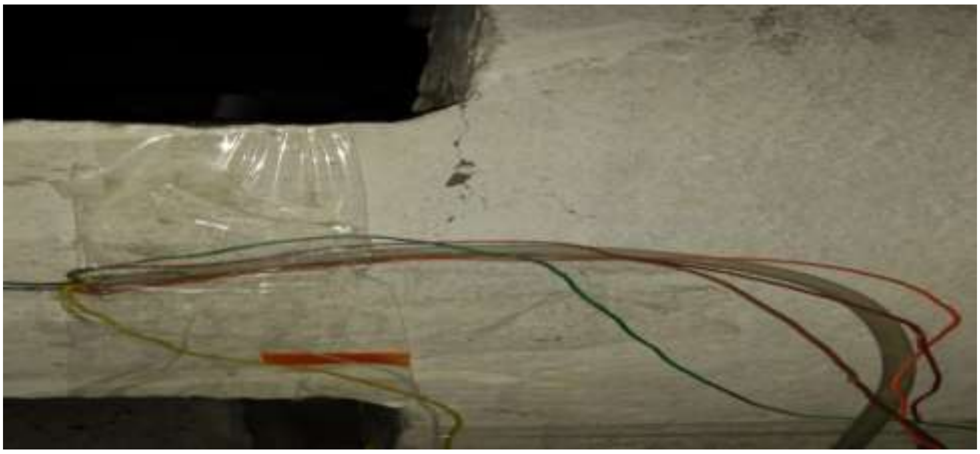

Figure 3: *Shear crack at the joint in BC 1*

Figure 4 *Shear crack at the joint in BC 2*

Figure 5: *Shear crack at the joint in BC 3*

Figure 6: *Shear crack at the joint in BC 4*

Strains in the Beam versus number of blows graphical representation was shown in figure 7 and also Strains in the column versus number of blows graphical representation was shown in figure 8.

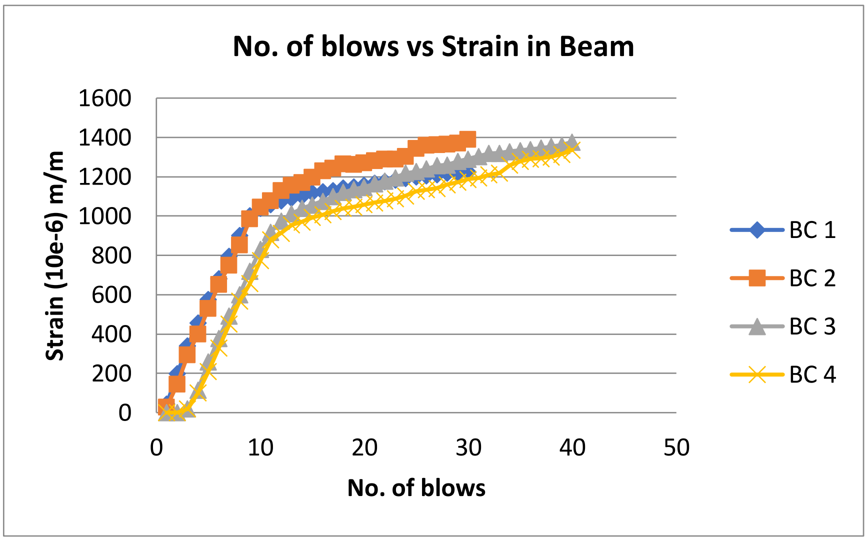

Figure 7: *No. of Blows vs. Strain in Beam*

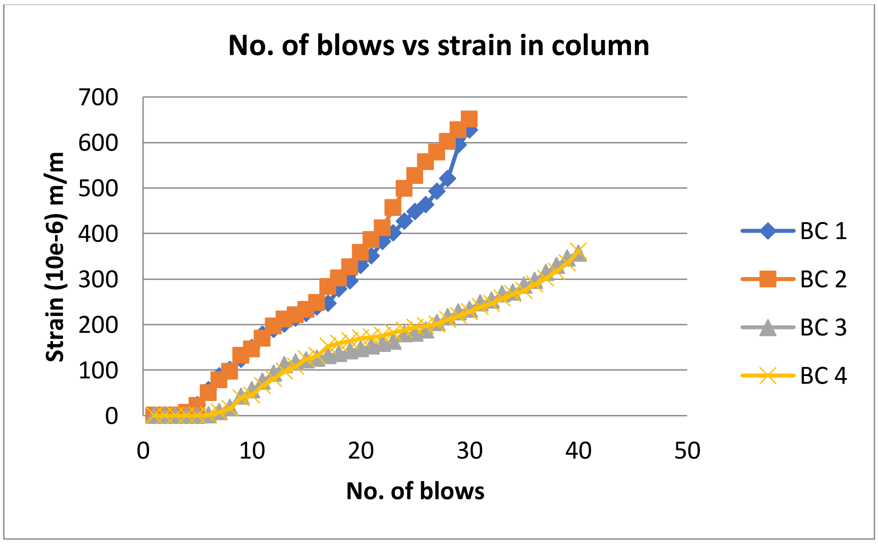

Figure 8: *No. of Blows vs. Strain in Column*

4 Analytical Modelling and Results

For the modeling and analyzing of beam-column joints under impact loads. In this WORKBENCH module in ANSYS is preferred for impact loading. Beam column joint ANSYS model was shown in figure 9 and and also figure 10 shows the model of beam column joint with reinforcement. The total deformation of beam column joint made with addition of polypropylene fiber was given in figure 11.

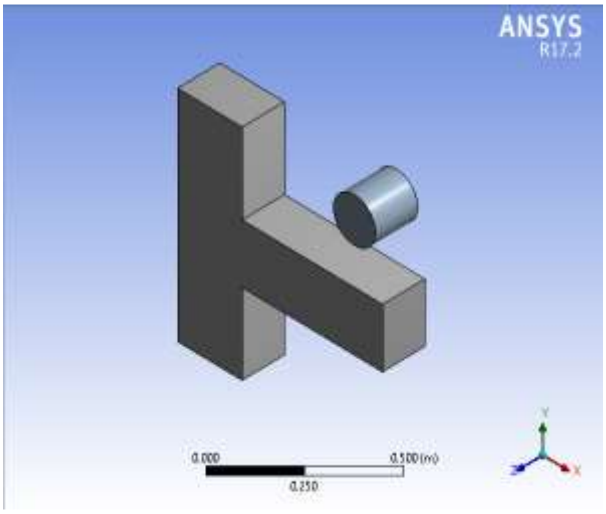

Figure 09: *Beam-Column joint ANSYS Model*

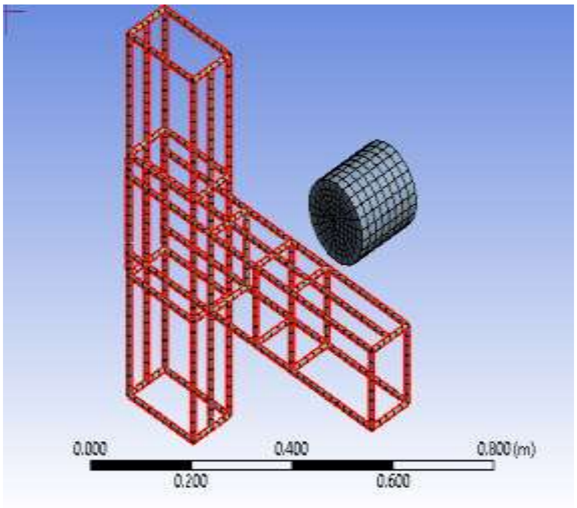

Figure 10: *Beam-column joint with reinforcement*

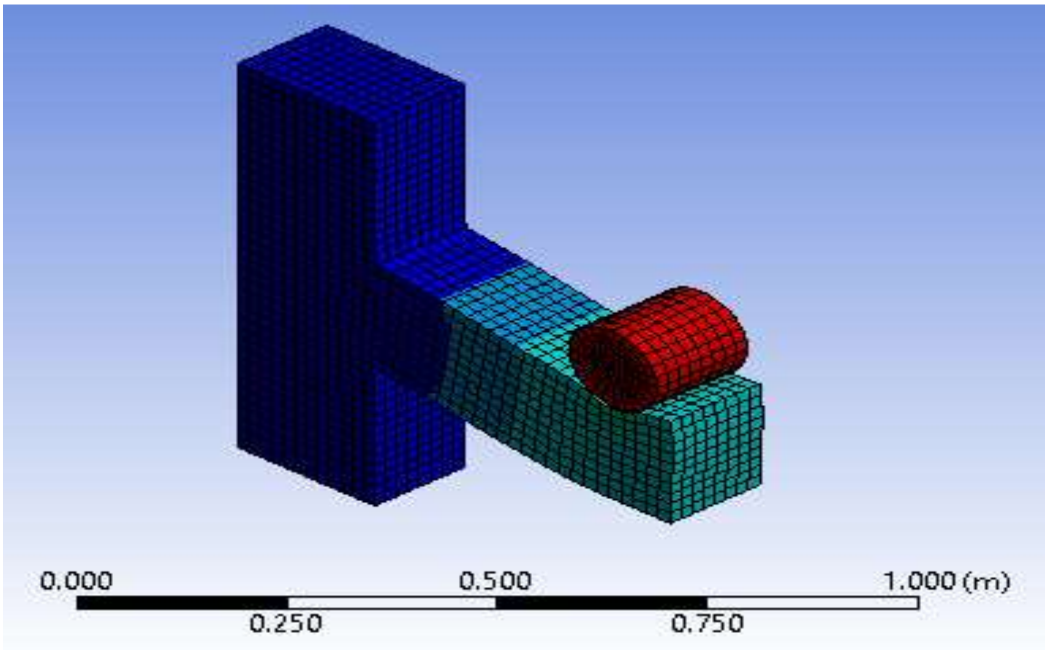

Figure 11: *Total deformation*

After application of impact load on beam column joint. There will be an equivalent elastic strain and equivalent stress. Figure 12 and figure 13 shows the mode of equivalent elastic strain and equivalent stress of ANSYS analytical model respectively.

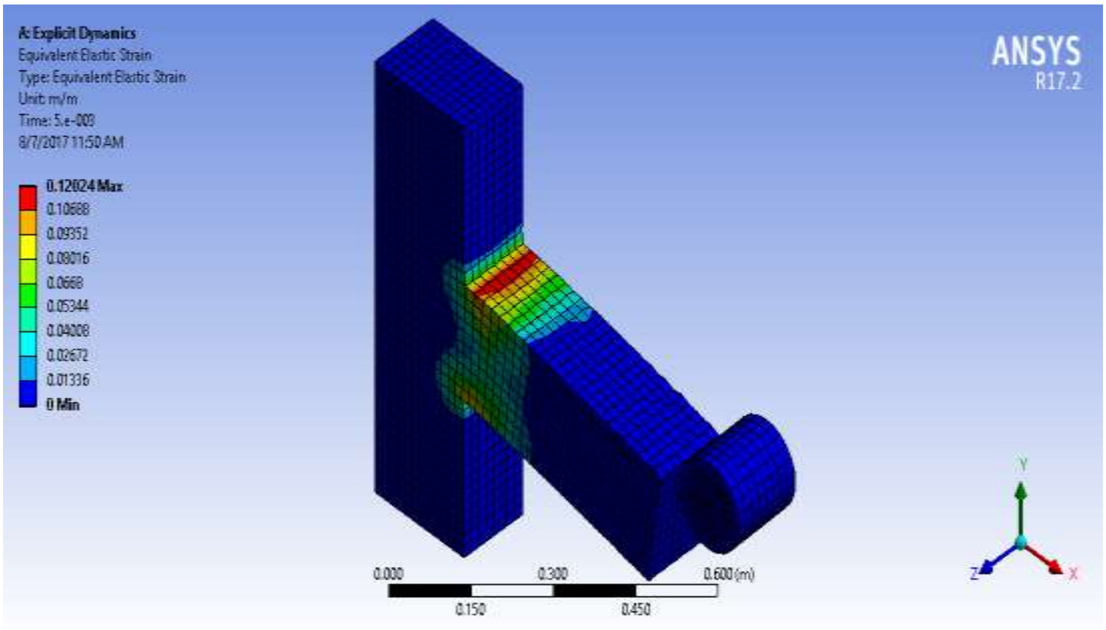

Figure 12: *Equivalent elastic strain*

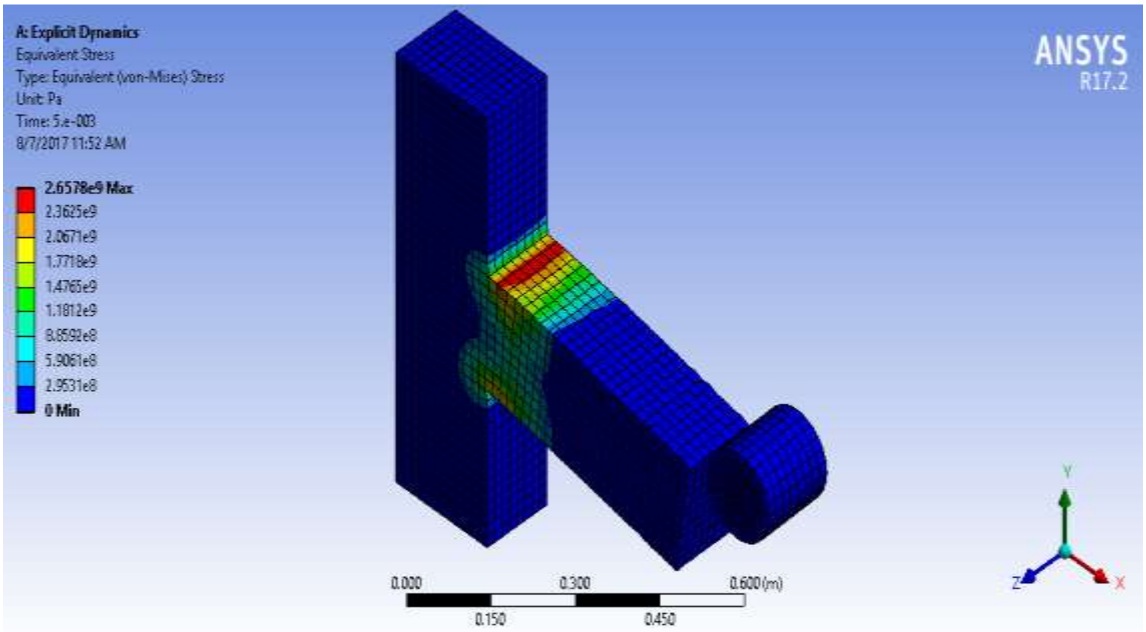

Figure 13: *Equivalent stress*

The beam column joint specimen under impact load produces maximum deformation of about 10.8mm. Also through analytical results it is noted that the maximum strain and maximum stress of beam column joint was 0.002469 and 7.0671e9 respectively. The attained stress strain curve and stress – deflection curve through ANSYS analysis on beam column joint with polypropylene fiver was shown in figure 14 and figure 15 respectively.

Dhanabal *et al., J. Mod. Mater.;* Vol. 9, Issue 1, pp: 26-35, 2022

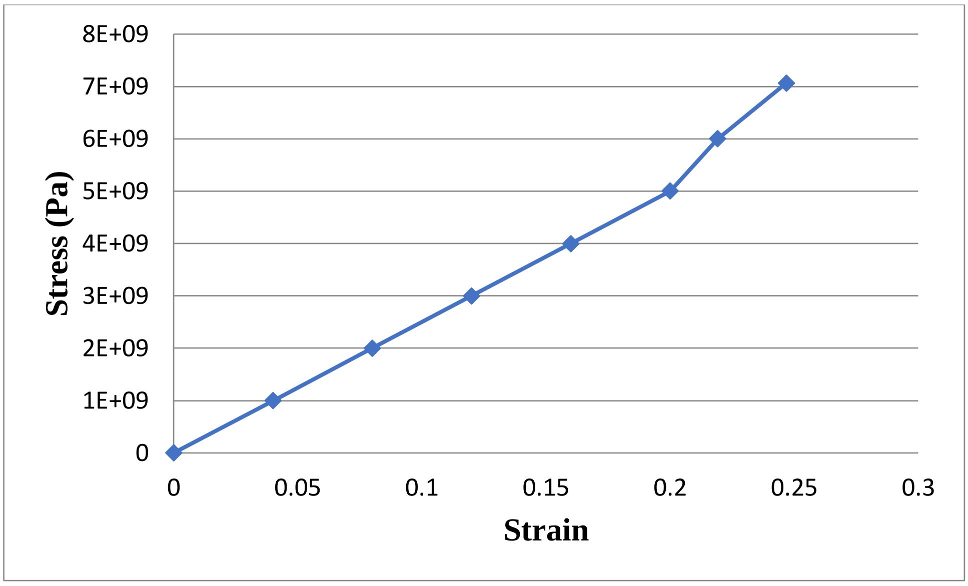

Figure 14: *Stress-Strain Curve*

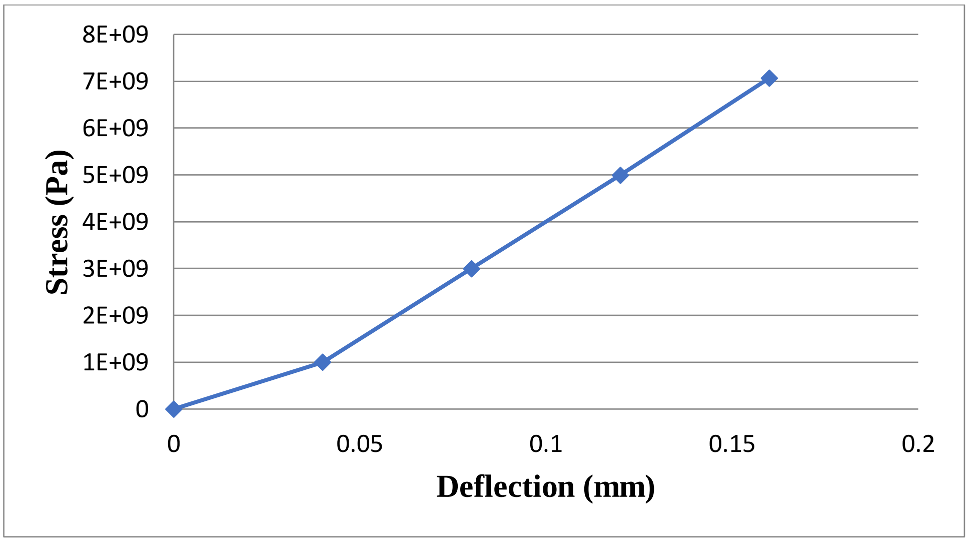

Figure 15: *Stress vs. Deflection*

5 Discussion

In this present study was deals with beam column joint made with addition of polypropylene fibre was subjected to impact load. We did both experimental study as well as Analytical study to obtain the exact result of performance evaluation of beam column joint with fibre. By comparing experiment results with ANSYS analytical report it shows that the total deflection of beam column joint under impact load was 20mm in experimental testing and 10.8 mm during ANSYS analysis. The maximum strain of beam column joint in experimental work was noted as 0.001296mm and during ANSYS analysis 0.002469mm. These results shows that there will be an increase in ductility of beam column joint with addition of polypropylene fibres under impact load comparing basalt fibres and natural fibres. The shear failure of beam column joint with polypropylene fibres (BC3 and BC4) was considerably less comparing conventional beam column joint specimens (BC1 and BC2). On comparing the previous studies which was carried out with basalt fiber in beam column joint, there will be a significant increase in ductility and flexural property while using polypropylene based fiber content of 1% in beam column joint. As per the results obtained from experimental and analytical work, it was found beam column joint with polypropylene fiber reduced the deformation up to 60 percentage by comparing conventional beam column joint without any additives.

Also, maximum strain of beam and column joint with polypropylene fiber was 56 percentage less (0.000357mm) comparing conventional beam and column without fiber (0.000627mm). Through this investigation and discussion, we achieve that there will be an increase in ductility, decrease in deformation and strain and also increase in energy absorption was produced by polypropylene fiber when using in beam-column joint.

6 Conclusion

From analytical and experimental results, we concluded that the performance of exterior type beam column joint analysed with ANSYS shows that the maximum strain 0.002469 and the maximum stress value is 7.0671e9 Pascal. From experimental study we arrived that the maximum strain in beam and column for BC 1, BC 2, BC 3 AND BC4 respectively (0.001221, 0.000627), (0.001371, 0.000651), (0.001125, 0.000357) and (0.001194, 0.000361). this data gives that there will be a decrease in maximum strain when adding polypropylene fiber in beam column joint. Also, by comparing study it is observed that the maximum strain in experimental programme is 0.001296 and 0.002469 in analytical programme. Comparison results shows that both the analytical and experimental results are similar. The beam- column joints BC 3 and BC 4 specimens which are mixed with the additives of steel fibres and polypropylene gives more resistance against failure at the joint than the BC 1 and BC 2. When adding polypropylene fiber in beam column joint there will be a reduction of element deformation of about 60 percentage comparing convention beam column. So we conclude that beam column joint with polypropylene fibers are greatly increasing ductility and energy absorption, reducing deformation and maximums strain

7 Declarations

7.1 Competing Interests

The authors involved in this work have no conflict of interest.

7.2 Publisher's Note

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