# STRENGTHENING OF BEAM COLUMN JOINTS USING MIXED FIBERS

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***Abstract:*** In order to make a structure earthquake resistant, it must be able to bend elastically and disperse energy without collapsing. This is known as ductility. In a frame construction, the junction area has the maximum bending moment and shear force. Beam-column junction is one of the failure zones, thus. When an earthquake occurs, the external joint of the beam-column junction responds more negatively than the interior joint. To increase the joints' ability to resist forces, several researchers have studied joints utilizing various methodologies, materials, and healing approaches. To ensure high tensile strength and precise tolerances, steel fibers used to make polypropylene are manufactured from premium hard-drawn steel wire. Therefore, in the current study, these mixed fiber materials were applied to the joints between beams and columns to see how the joints' strength, stiffness, ductility, and energy dissipation capacity changed or improved. Three (1/3) scaled beam column joints have been cast in the current work using ordinary RC and RC fibers. All of the specimens have been described in accordance with IS: 13920's rules, which include similitude requirements. Cyclical loads were applied to the specimens during testing. The experiments were carried out utilizing a 100kN servo hydraulic actuator produced by MTS. Plotting the recorded data produced a hysteresis loop.

***Keywords:*** **Polypropylene fiber, cement concrete, cyclic loads, fibers, Beam-Column Joints, forces.**

## 1. INTRODUCTION

The most popular building material is concrete. Paste and aggregates are combined to make concrete (rocks). The surface of the fine (small) and coarse (bigger) aggregates is coated with the paste, which is mostly made of Portland cement and water. The paste solidifies and increases strength through a process of chemical reactions known as hydration to create the rock-like mass known as concrete. Concrete has a strong compressive strength and little corrosive or weathering damage. Concrete that has just been mixed or it is still green may be readily manipulated or shaped into almost any shape or size in accordance with requirements.

### 1.1 SIGNIFICANCE OF CONCRETE

One of the strongest construction materials is concrete. Compared to timber construction, it offers higher fire resistance and gets stronger with time. Concrete constructions have a lengthy service life. More than any other man-made substance, concrete is utilized all over the world. Although concrete has a great compressive strength, it has a fairly low tensile strength. When tensile stresses are present, reinforced cement concrete (RCC) or fiber reinforced concrete, a composite structure, is created by adding steel bars or short, randomly placed fibers to the concrete. Concrete has strong flexural and splitting tensile

Strength in addition to its excellent compressive strength. Concrete is a non-combustible substance that is resistant to fire and can tolerate high temperatures.
Concrete in general has a fairly low

### 1.2 FIBER REINFORCED CONCRETE

As a construction material, concrete is among the most resilient. Compared to timber construction, it offers higher fire resistance and gets stronger with time. Concrete constructions have a lengthy service life. More than any other man-made substance, concrete is utilized all over the world. Although concrete has a great compressive strength, it has a fairly low tensile strength. When tensile stresses are present, reinforced cement concrete (RCC) or fiber reinforced concrete, a composite structure, is created by adding steel bars or short, randomly placed fibers to the concrete. Concrete has strong flexural and splitting tensile strengths in addition to its excellent compressive strength. Concrete is a non-combustible substance that is resistant to fire and can tolerate high temperatures. Concrete in general has a fairly low. The stiffness, stiffness, torsional strength, ductility, rotational capacity, and the number of cracks with smaller fracture width are all increased by the inclusion of fibers in reinforced concrete flexure members Adding fibers can boost reinforced concrete beams' shear capability by up to 100%.
Shear-friction strength, initial crack strength, and ultimate strength are all increased by the addition of randomly positioned fibers. Fibers are used to lessen the explosive kind of failure for columns.

### 1.3 POLYPROPELENE FIBERS

It is used as short discontinuous fibrillated material for production of fiber reinforced concrete or a continuous mat for production of thin sheet components. Since then the use of these fibers has increased tremendously in construction of structures because addition of fibers in concrete improves the toughness, flexural strength, tensile strength and impact strength as well as failure mode of concrete.

### 1.4 HYBRID (STEEL AND POLYPROPELENE) FIBER REINFORCED CONCRETE

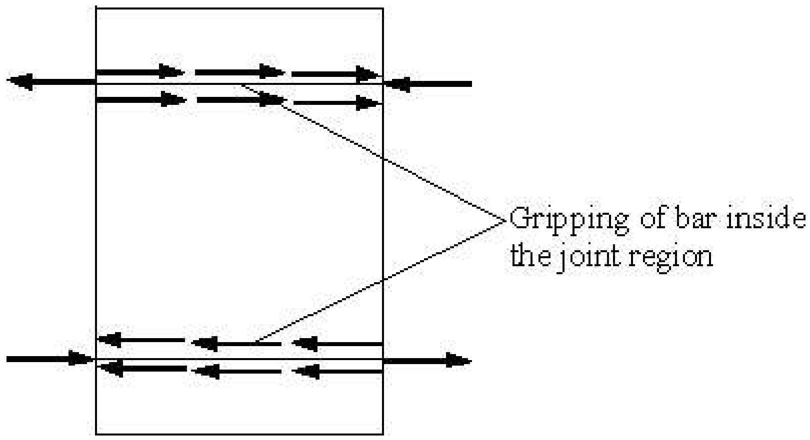
Fibers have been widely employed to enhance the durability, ductility, and strength of concrete. It is advisable to combine cement with fibers that have strong tensile strength in order to enhance the mechanical qualities of concrete. Concrete's toughness is significantly increased by the addition of fibers. The addition of fibers also changes how the fiber matrix composite behaves after cracking, increasing its toughness. In plain concrete, hybrid fibers have been shown to improve the microstructure, leading to greater durability. In hybrid fiber technology, two or more distinct types of fiber are logically mixed to create a composite that benefits from each type of fiber individually, displays a synergistic response, and works well to withstand thermal shocks. In the current work, we employ hybrid fibers made of steel and polypropylene to enhance the different characteristics of the beam-column junction. Concrete's bleeding, plastic settling, heat and shrinkage stresses, and stress concentrations brought on by external restrictions are all greatly reduced when steel and polypropylene are added to the mix. In this method, steel fiber strengthens the first fracture and increases stiffness, while polypropylene fiber, which is more malleable and ductile, increases toughness and strain capacity in the area after the crack has formed

# 2. BEAM COLUMN JOINT

The zone where beams and columns meet at a junction is functionally required to allow the adjacent members to reach and maintain their maximum capacity. These components are usually severely loaded, particularly during earthquakes. The joints must be strong and rigid enough to withstand the internal forces generated by the frame members. Resilience to strain and hardness in the post-cracking zone. The beams adjacent to a joint experience moments in the same direction during an earthquake (clockwise or counter-clockwise). The beam-column joint's top bars are pushed in one direction, while the bottom ones are dragged in the other way.

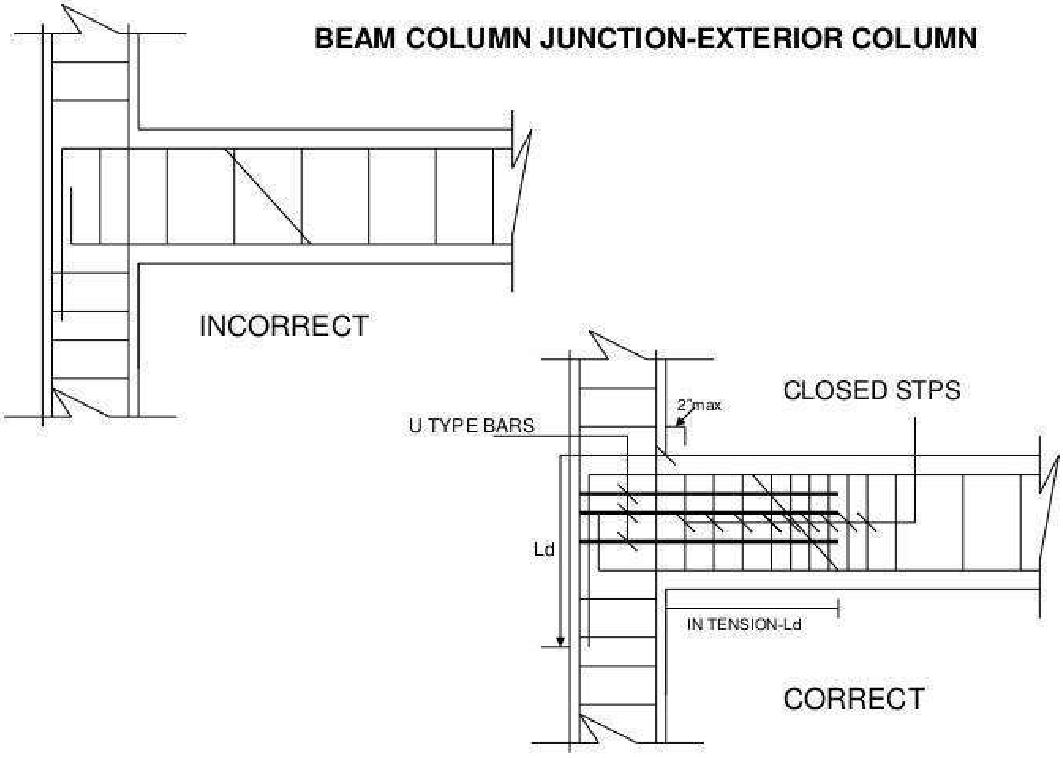
### 2.1 BEHAVIOUR OF JOINTS UNDER EARTHQUAKE FORCES

Bond stress that forms between concrete and steel in the joint region balances these pressures. The bar slides inside the joint zone if the column is not broad enough or if the junction's concrete strength is insufficient, which reduces the beams' ability to support loads. If the column's cross-sectional area is too small, diagonal fractures will form in the concrete at the connection. By supplying massive columns of sand and placing closely spaced closed-loop steel ties around column bars in the joint zone, problems of diagonal cracking and crushing of concrete may be minimized.




## 2.2 FORCES ACTING ON BEAM COLUMN JOINT

A joint's configuration and the kinds of loads it is subject to determine the pattern of forces operating on it. With reference to strains and the ensuing fracture patterns that emerged in the joints, the impacts of loads on the three types of joints are explored. It is possible to represent the forces acting on an internal joint that is being loaded by gravity. Direct transmission via the joint is possible for the axial loads from the columns as well as the tension and compression from the beam ends. The balancing forces from beams and columns in the situation of lateral (or seismic) loading. Create diagonal compressive and tensile strains inside the joint. Cracks form at the faces of the joint where the beams are framed and perpendicular to the stress diagonal at the junction. Strengthening the joint is necessary because diagonal fractures are caused by shear stresses in the joint. Joint efficiency is substantially impacted by longitudinal reinforcement detailed patterns. The patterns for several of the external joints' details are displayed. Efficiency varies between 25 and 40 percent for bars that are bent away from the joint core and 85 to 100 percent for those that pass through and are anchored in the joint core. To keep the concrete core inside the joint, stirrups must be installed.




The reversal of stresses during seismic activities makes conservatively designing corner joints as opening joints with the required details necessary.
The outer portion of the corner concrete detaching from the rest of the specimen causes a diagonal stress fracture to form across the joint, which is the main cause of failure of opening corners or knee joints. To prevent failure of such joints and increase the strength of surrounding components, special and precise detailing is needed. Bond forces along the longitudinal reinforcing bars that pass through the joint and flexural compression forces acting on the joint face transmit the stress resulting from the frame members into the joint. The joints should be robust enough to withstand

## 2.3 JOINT MECHANISM

It is envisaged that beams in the strong column-weak beam configuration will acquire plastic hinges at their ends and flexural over strength above the design strength. The critical bond conditions in the longitudinal reinforcing bars going through the joint are brought on by the high internal pressures created at plastic hinges, and the joint core is also subject to increased shear demands. Bond and shear interact in a complicated way in the joint.

## 2.4 DESIGN OF JOINTS FOR STRENGTH

In addition to the column's required strength, the following three considerations are also taken into account while designing joints:

- Beams primary reinforcing anchors.
- The joint's core is contained.
- The joint's shear strength.

## 2.5 ANCHORAGE OF MAIN REINFORCEMENT OF BEAMS

The anchoring reinforcement has been consistent with IS 13920 since reinforced concrete's inception. The length needed is determined by how well concrete and steel adhere to one another. The increase in the development length from the tangent point is estimated to be 4 diameters for every 45 of hook bend. No tension is thought to be passed to the bend's end with this type of bending. The rod may also be bent in a simple curve, with the development length specified in accordance with code.

## 2.6 ANCHORAGE REQUIREMENT OF JOINTS

The tension bars offered anchoring at exterior joints have to meet code standards. If the beam bars are made continuous through the column and properly spliced outside the column core as is typically done, the anchoring of bars in the internal joints is not an issue. The bond stress that forms in the bar just has to make up for the bar's own stress, which may be compression on one side and tension on the other, adding up the forces. To meet the bond requirements in column bars, it is also typically advised to use the following empirical rule.

- Total depth of column / diameter of the beam bar ≥ 20 and
- Total depth of beam / diameter of column bar ≥ 20.

## 2.7 DESIGN OF SHEAR REINFORCEMENT

A truss mechanism that resists shear can arise if there is horizontal and vertical shear reinforcement within the joint. The minimal reinforcement area required to sustain the truss mechanism and the maximum permitted area based on the limit stress related to diagonal compression failure determine how shear reinforcement should be designed. The horizontal hoop reinforcement must be built to withstand at least 40% of the total horizontal shear force.

## 3 METHODLOGY

- Literature Review
- Material collection for experimental investigation
- Mix design

- Casting of Specimen
- Curing of specimen
- Test setup for hybrid fibre reinforced concrete
- Testing of specimen
- Test results
- Interpretation of results
- Conclusion

## 4 MATERIALS TESTING

### 4.1 CEMENT

The Portland Pozzolanic cement is a kind of blended cement. Pozzolanic is natural or artificial material containing silica in a reactive form. It may be further discussed as siliceous and aluminous material which is it possesses little or no cementitious properties, but is chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. Portland Pozzolanic cement produces less heat of hydration and offers greater resistance to attack of aggressive waters.

| Properties of cement Property | Value |
|---|---|
| Initial setting time | 35minutes |
| Final setting time | 8 hours |
| Specific gravity | 3.15 |
| Consistency | 30% |

### 4.2 FINE AGGREGATE

Due to natural wear, river sand often has a smoother surface texture and better form. In between the particles, moisture is also carried by it. These individuals improve the practicality of concrete**.**

| Properties of fine aggregate Property | Value |
|---|---|
| Specific gravity | 2.68 |
| Water absorption | 1.0% |
| Free moisture content | 0.2% |
| Fine modulus | 2.89 |

### 4.3 COURSE AGGREGATE

The local supply of graded crushed hard blue granite jelly was utilised. Aggregate must adhere to IS 383 specifications. Natural aggregates will be preferred whenever feasible. Within the parameters given, the nominal size of the coarse aggregate should be as large as feasible, but in no circumstance should it be more than one-fourth of the member's minimum thickness. However, because this specific combination had the fewest voids, 20 mm and 12 mm sizes in the proportion of 70% to 30%, respectively, were chosen as coarse aggregate for the majority of the job.

| **Property** | **Value** |
|---|---|
| Specific gravity | 2.68 |
| Water absorption | 1.0% |
| Free moisture content | 0.2% |
| Fine modulus | 6.89 |

## 4.4 STEEL FIBER

| | |
|---|---|
| Fiber length | 50mm |
| Fiber diameter | 0.75mm |
| Aspect ratio | 67 |

### 4.5 POLYPROPYLENE FIBER

| | |
|---|---|
| Geometry of fiber | Fibrillated |
| Fiber length | 12mm |
| Melting point | 1620 C |
| Specific gravity | 0.91 |
| Diameter | 14 microns |
| Aspect Ratio | 12mm |

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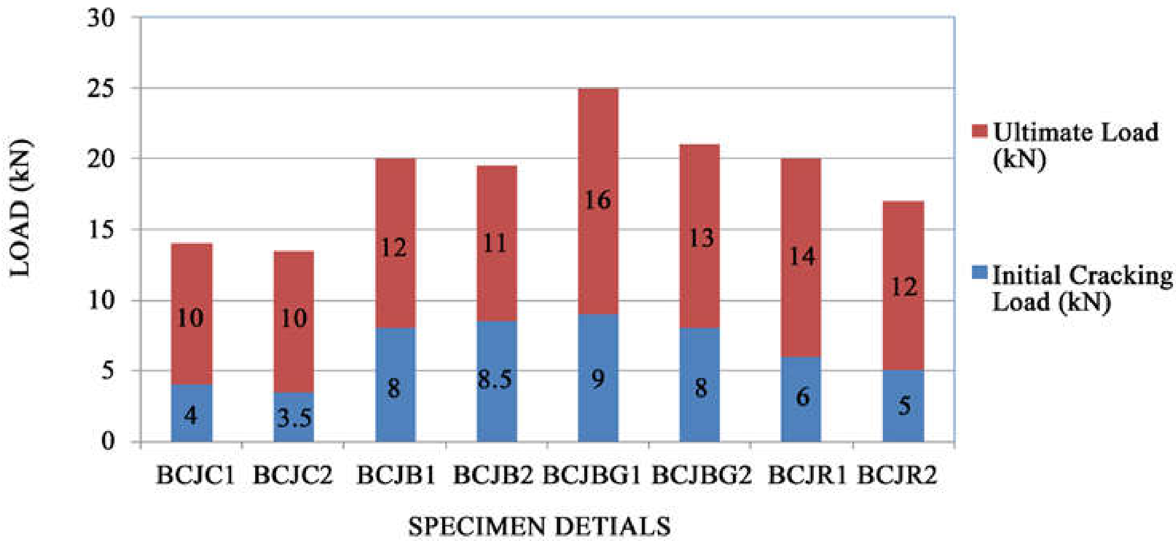
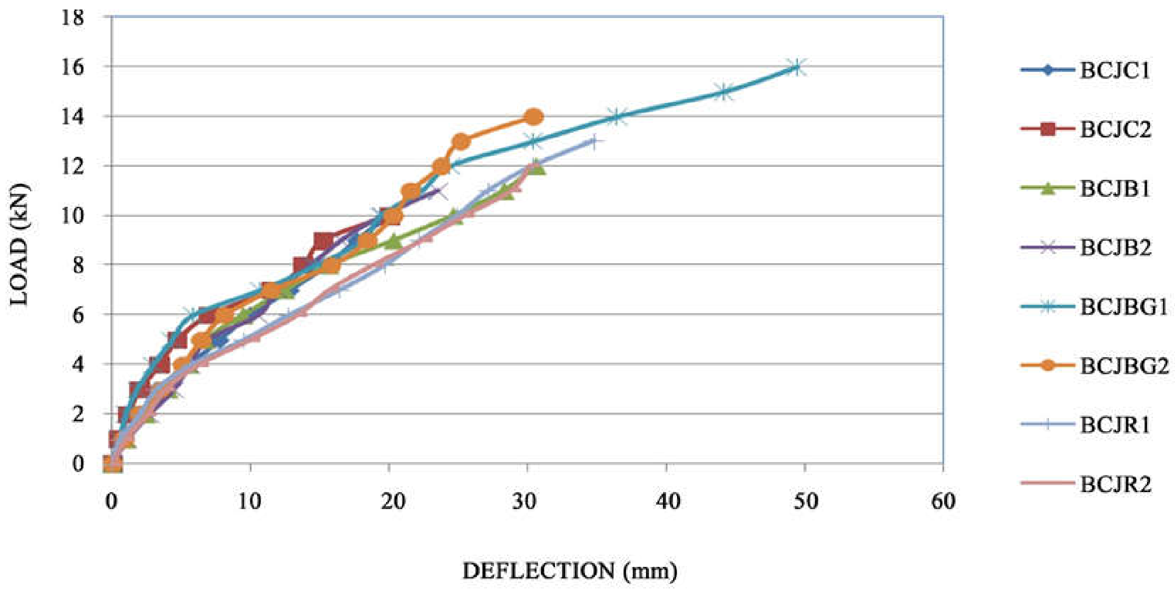
## 5 TEST PROCEDURES

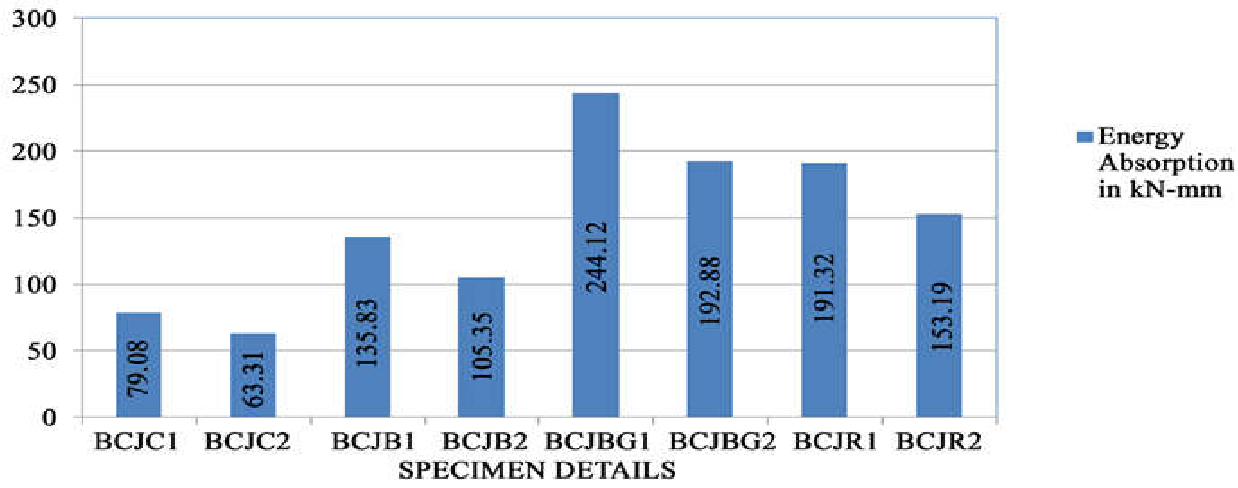
### 5.1 COMPRESSIVE STRENGTH TEST

- The necessary amount of components are measured, formed into cubes and cylinders using moulds, and dried for 28 days.
- The specimens were inserted between the compression plates of the universal testing machine after the conclusion of the curing time and gradually subjected to load. Both at the moment of the first fracture and the collapse, the reading was recorded.
- The ratio of compressive load to specimen area may be used to calculate compressive strength.

| S.no | Specimen | Loaded Area (mm$^2$) | Specimen name | Failure load | Comp. stress (N/mm$^2$) | Avg. comp. stress (N/mm$^2$) |
|---|---|---|---|---|---|---|
| 1 | Conventional (cube) | 150x150 | C1 | 700 | 31.1 | 30.88 |
| | | | C2 | 690 | 30.67 | |
| 2 | Hybrid (cube) | πx150x300 | HC1 | 800 | 35.5 | 36.2 |
| | | | HC2 | 830 | 36.9 | |






| Details of Specimen | Energy Absorption in( KN/mm) |
|---|---|
| BCJC1 (control) | 79.08 |
| BCJC2 (control) | 63.31 |
| BCJB1 (Basalt) | 135.83 |
| BCJB2 (Basalt) | 105.35 |
| BCJBG1 (Hybrid) | 244.12 |
| BCJBG2 (Hybrid) | 192.88 |
| BCJR1 (Rehabilitated) | 191.32 |
| BCJR2 (Rehabilitated) | 153.19 |

## 6 CONCLUSIONS

- For the junction of an RCC beam and column, it was discovered that the first cracking load had increased by 125%.
- The ultimate load for the RCC beam column junction was found to have increased by 60%.
- The RCC beam column junction was found to have a higher energy absorption value of 208.70 %.
- For RCC beam column joints, it was discovered that hybrid reinforced concrete produced an improvement in deflection ductility of 131.6 %
- The stiffness of the hybrid fibers was found to be reduced by 24.48 % compared to control specimens. It was discovered that the control specimens produced an increase in stiffness when compared to the restored specimens.
- The failure in the control specimen is in the column, whereas the failure in the retrofitted specimen is in the beam. This results in the strong column, weak beam theory, which helps to prevent the collapse of the entire structure.

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