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Steel Fibre Reinforced Concrete Beam-Column Joint – A Review

M. Kalaivani
Assistant professor
Department of Civil Engineering
K.S.Rangasamy College of Technology,
Namakkal, India

S. Karthik
PG Student
Department of Civil Engineering
K.S.Rangasamy College of Technology,
Namakkal, India

***Abstract*—Now a day's technology is improving fast in engineering sector. In civil engineering fields several modern new technologies are being adopted. There are many construction materials available in the construction field and fibre reinforced concrete materials are the most commonly used composite materials. In the past few years steel fibres were used over throughout the world. The steel fibre reinforced concrete can be an alternative solution for minimizing the congestion of transverse reinforcement in beam-column joint. The beam-column joints in a structure needs special attention due to high complex behaviour under seismic loads hence to overcome it, the steel fibres are used in beam-column joints.**

Keywords—Beam-Column Joint, steel fibres, fibre reinforced concrete, cyclic loading

I. INTRODUCTION

The beam-column joints are the crucial zones for the transfer between the connecting elements (i.e. beams and columns) in a structure. In RC buildings, portions of columns that are common to beams at their intersections are called beam-column joints.

For moment resisting frame the beam-column joints are important component and should be designed and detailed properly, when the frame is subjected to earthquake loading.

The exterior joint is one beam frames into a vertical face of the column and two other beams frame from perpendicular directions into the joint. Thus, beam-column joints must be designed to resist earthquake effects.

In addition of steel fibres in concrete increases the strength, ductility and energy absorption capacity of flexural members. In case of SFRHPC the tensile strain would be higher than that of the conventional FRC even in the microstructure level.

In past recent decades, to develop the more efficient structural systems with better resistance against the earthquake loading the beam-column joint must be designed based on the strong column week beam theory.

Steel fibres

Steel fibres are often used in concrete to increase the ductility of conventional concrete. Fibres are utilized in concrete to manage the cracking characteristics and reduce permeability. The fibres are generally utilized in concrete to manage the plastic shrink cracking and drying shrink cracking. The steel fibres increase the crack resistance and decrease crack width in concrete.

Uses of steel fibres

The steel fibres provides superior resistance to cracking and crack propagation due to increased tensile strength in a concrete structure. It reduces the amount of cracking under serviceability conditions and improves resistance to material deterioration of fatigue, impact, shrinkage and thermal stresses. By preventing or delaying crack propagation from micro cracks to macro cracks. Steel fibres has the ability to withstand repeatedly applied, shock or impact loading. The steel fibres are mostly used in pavements, tunnel linings, airport pavements and bridge deck slab repairs.

Advantages of steel fibres

Steel fibres control the shrinkage and cracking of concrete also increases the flexural strength, tensile strength and toughness of concrete. Different length of fibres would control different scales of cracking. The compressive strength slightly increases with the increase in fibre volume fraction. Steel fibre reinforced concrete increases the flexural strength, fatigue resistance and impact resistance of concrete than the conventional RC specimen.

II. PREVIOUS RESEARCH WORK

In this chapter, various literatures are presented under the topic of steel fibre reinforced concrete beam-column joints.

Sharma et al. (2015) examined the flexural behaviour of beam-column junction using steel fibres. The corner beam-column joint was analyzed by $(1/4)^{th}$ scale modeled it has been studied. Totally 10 beam-column joints were casted by using high performance fibre Reinforced concrete (HPFRC). The control specimen was casted simultaneously to investigate the structural characteristics of concrete under compression, tension and flexure conditions. The volume fractions of fibre contents can be varied from 0, 6, 8 & 12%. Monotonic loading was applied to all the specimens and crack patterns were observed. The load- deformation behaviour, failure pattern and other ductility associated parameters were studied. Finally, they concluded that the compressive, split tensile, flexural strength of HPFRC specimen values were increased by 78, 144 and 646% when compared with their HPC specimens.

Chidambaram et al. (2015) investigated the behaviour of exterior beam-column joint with different fibre composites. Totally six exterior beam-column joints were casted in this study by using different steel fibres named as brass coated steel fibre, hooked end steel fibre, and polypropylene fibre. All the specimens were tested under cyclic loading. The ductility response, hysteresis behaviour and energy dissipation with damping characteristics, damage index and crack patterns of all the specimens were calculated and compared. From the test results it was found that the Hybrid Cementitious Composite (HCC) specimen increases load carrying capacity and enhances energy dissipation with increased stiffness retention than the conventional specimen. Finally, the authors had concluded that the HPFRCC specimen has high tensile strain over the conventional concrete.

Realfonzo et al. (2014) conducted the seismic performance of RC beam-column joints strengthened with FRP systems. Totally eight full scale RC beam-column joint specimens were designed, and constant reversed axial cyclic load applied to the all beam-column joint. Out of these eight specimens, one is control specimen and remaining specimens were strengthened using different FRP systems after being damaged, specimens were repaired, and retrofitted with FRP systems and re-tested. Once again all the specimens were subjected to cyclic loading. The axial load of column was kept constant and equal up to 300KN. The test results showed that the exterior FRP retrofitted members allowed restoring the strength and significantly increasing the ductility of original members.

Muthuswamy et al. (2014) performed the behaviour of beam-column joints using hybrid fibre reinforced concrete. The HFRC beam-column joint was used to resist the earthquake in any seismic prone area. The conventional concrete and fibre reinforced concrete of exterior beam-column joint was analyzed $(1/5)^{th}$ scale model and it has been studied. Three different types of specimens like conventional, steel fibre & hybrid fibre (steel+glass) were investigated. Cyclic loading was applying to all the specimens and the load carrying capacity, load-deflection behaviour, and flexure parameter like stiffness, ductility, energy absorption and failure pattern had been studied. From this study the author concluded that the experimental results of FRC beam-column joint are 50% increase in ductility and 80% increase in energy absorption capacity compared with conventional concrete.

Mahmoud et al. (2014) studied the experimental performance of reinforced concrete (RC) exterior beam-column joints rehabilitated with CFRP. In this study totally 11 half-scale beam-column joint specimens were casted. 10 half-scale specimens divided in to three groups covering three possible defects in addition to an adequately detailed control specimen were used. Insufficient bond length was considered in main reinforcement for the base control specimen of beam. To rehabilitate the defected beam-column joints, three different strengthening schemes including externally bonded CFRP strips and sheets were used. It was found that ultimate capacity, initial stiffness, ductility and ultimate strain were developed. The failure criteria were studied by strengthening of first two defects using CFRP.

Keerthana et al. (2014) conducted an experimental investigation of reinforced concrete beam-column joints under cyclic loading using hybrid steel fibre. In joint regions the hooked end steel fibres have been applied by different volume fraction and aspect ratios. The axial force was applied on the column while the cyclic load was applied on beams by controlled displacement. For every 0.2 ton load the deflection was measured by both sides using dial gauges. The hysteretic curve was plotted and the energy dissipation capacity of retrofitted beam-column joints with various hybrid steel fibre configurations was compared. The hybrid steel fibre gives optimum value for exterior joints. The hybrid steel fibre reinforced concrete increases the strength, stiffness and energy dissipation when compared with conventional specimen and also efficiently used for seismic areas.

Geethajali et al. (2014) investigated the behaviour of hybrid fibre reinforced concrete in exterior beam-column joints under cyclic loading. In this study totally six exterior beam-column joints were casted & tested. All specimens were designed as per IS 10262-2009. M40 grade of concrete with steel fibre and polypropylene fibre at a volume fraction of 0.5% was used. Incremental forward cyclic load was applied on every 5KN. The deflection was measured by using LVDT and the behaviour of exterior beam-column joints was also measured. The first crack load and ultimate load were observed in all exterior beam-column joints. The test results showed that the HFRC beam-column joint specimens were finer cracks were appeared and also crack width was smaller compared with conventional specimen.

Ganesan et al. (2014) studied the behaviour of high performance hybrid fibre reinforced concrete beam-column joints subjected to reverse cyclic loading. In this study totally 12 no's of beam-column joints were casted and tested. M60 grade of concrete had been used. In this study two types of fibres were used crimped steel fibres and polypropylene fibres. The volume fraction of crimped steel fibres was 0.5%, 1% and a polypropylene fibre was 0.3%, 0.15% and 0.2%. In addition of steel fibres first crack load, ultimate load and ductility factor increased. To gave better performance of the 1% volume fraction of steel fibres and 0.15% volume fraction of polypropylene fibres in exterior beam-column joints when compared with conventional specimen.

Patil et al. (2013) examined the corner and exterior beam-column joints and their behaviour. These beam-column joint were analyzed to find maximum stress, minimum stress, displacement and stiffness variation by ANSYS software. One corner and one exterior beam-column joints were casted and tested in this study. Cyclic loading was applied on both the specimens. The behaviour of exterior beam-column joint was different than the corner beam column joint. Finally the author concluded that the load increased with displacement, minimum stress and maximum stress was also increased.

Oinam et al. (2013**)** studied the behaviour of beam-column joint with different fibres. The steel fibres and polypropylene fibres were used in this study. Steel fibres were made from prime quality hard drawn steel wire to ensure high tensile strength and close tolerances and also polypropylene fibres were combination of plastic polymer.

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The beam-column joints analyzed as (1/3) rd scale model. All specimens had been detailed as per IS 13920 codal provisions. Above these fibres were used in this study the beam-column joint under cyclic loading. The strength, stiffness, ductility and energy dissipation capacity of the joints were found. From this study using the steel fibres were controlling the cracking and reducing the potential sources and brittle failure was observed.

Hooda et al. (2013) performed the structural behaviour of exterior beam-column joint with different detailing of reinforcement, different spacing of connecting ties and different percentage of steel fibres were used. (sp1, sp2 and sp3) specimens were initially tested under monotonic increasing loads. Based on its structural performance the sp2 specimen was selected and detailed. The steel fibres added with volume fraction of 0.5% 1% and 1.5% was casted and tested for the specimens (sp6, sp7 and sp8). Additions of steel fibres were investigated to study the effect of behaviour of joint regions. Stirrups were closely spaced in Sp4 specimen and also reduced to maximum crack width compared to sp2 and sp5 specimens. The results indicated that the addition of steel fibres concrete mix structural performance of beam-column joint measured ultimate load carrying capacity, stiffness, crack width, deflection and curvature ductility factor.

Balaji et al. (2013) summarized the behaviour of exterior beam-column joints using SIFCON laminates. Totally six specimens were casted and tested in this study. All Specimens were designed as per IS 13920-1993 codal detailing. M30 mix proportion was used to cast the beam-column joint. Round crimped steel fibres of aspect ratio 60 were used to cast the specimen. The volume fraction of steel fibre used will be 9%. Forward and reverse cyclic load was applied to all specimens and ultimate load carrying capacity, failure characteristics, deformation behaviour, ductility associated parameters were studied. The SIFCON beam-column joint shows greater extend for ultimate load carrying capacity, stiffness, ductility and energy absorption when compared with conventional beam-column joint.

Chidambaram et al. (2012) investigated the behaviour of exterior beam-column joints with an external anchorage system. The control specimen (CS) and externally anchoraged specimen (EAS) was detailed and constructed as per IS 13920:1993 codal provisions. Small projection was casted beyond the column face. An external anchorage system, providing the reinforcement detailing, and concrete placement eased in the joint region and better behaviour than the conventional method of construction. During the test from column portion small axial load was applied. Finally, the author concluded first crack load was 45% increased externally anchorage specimen compared with conventional joint specimen.

Perumal et al. (2011) conducted the behaviour of high performance concrete and cocktail fibre high performance exterior beam-Column joint using M60 grade of concrete under reversed cyclic loading. This experimental program had been carried out to compare the behaviour of high performance concrete and cocktail fibre reinforced high performance concrete (combination of steel fibres and polypropylene fibres. Totally five exterior beam–column joints were modeled to one fourth of proto type of a building, as per design, based on Bureau of Indian Standards (BIS). All specimens were casted and tested under reverse cyclic loading. The first specimen was designed as per IS 456:2000 and reinforced accordingly without considering the seismic requirement made with high strength concrete. The second specimen was designed as per 1893 (part-1) 2002 where the reinforcement of beam-column joint portion was detailed as per 13920:1993 seismic requirements made with high strength concrete. The remaining three specimens were casted with various combinations of cocktail fibre in the joint region (1.5% of steel fibres and 0 to 0.4 % polypropylene fibres). It had been concluded that fibre reinforced concrete beam-column joint (FRC) increased first crack load and ultimate load comparing with the high performance concrete (HPC). The combination of 1.5% of steel fibre and 0.2% of polypropylene fibre gave best performance considering strength, energy dissipation capacity and ductility factor.

Rajaram et al. (2010) examined the behaviour of RC interior beam-column Joints subjected to cyclic loading. STADD.pro analyzing has been conducted in Salem zone falling under the seismic zone-III. According to seismic load all specimens were designed as per IS 1893 (Part-l) 2002 & IS 13920:1993. 1/5th prototype model had been analyzed subjected to cyclic loading. M30 (1:1:2.5) mix was used with 0.45 water cement ratio. All the specimens were tested in reaction frame. In column portion 0.1 fck axial load was applied using hydraulic jack. The cyclic loading was applied forward and reversed at the beam end. Every 3KN measuring the deflection from the beam at free end tip using LVDT. The author found the structural behaviour of interior beam-column joint model had been worked out similar to that analytically predicted one and also ductility, energy absorption capacity, stiffness degradation.

Kumar et al. (2010) analyzed the behaviour of exterior beam-column joints retrofitted FRP wrapped with detailing as per IS 13920:1993 under seismic condition. In this investigation multi-storey reinforced concrete (RC) building (G+4) had been analyzed using STADD PRO in Salem zone failing under seismic zone-3. According to seismic code all the exterior beam-column joint specimens were designed as per IS 1893(part-1):2002 & IS 13920:1993. In this investigation totally three specimens were casted & tested, first one was control specimen tested up to post ultimate load, and another two was retrofitted specimens in which 70% of ultimate load was carried. To carry out the load ratio, cracking pattern, load-displacement relation, ductility and stiffness. Load carrying capacity of retrofitted specimens 60% more than the control specimen and also load deformation characteristics also improved the retrofitted specimens. Finally, analytical modeling was compared for the exterior beam-column joints using ANSYS software.

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Shannag et al. (2007) studied the interior beam-column joints behaviour under cyclic loading. For this study 1:3 scale model analyzing was adopted. These joint regions were lacked in transverse reinforcement and they were strengthened using HPFRC from 200 & 300mm face of the column. In place of ordinary concrete two types of joint regions were adopted, one of them without critical reinforcement details and another one prepared with critical reinforcement details that include the column main reinforcement lap spliced just above the joint regions. Other eight specimens were volume fraction of brass-coated (BCSF) or hooked steel fibres in joint regions containing 2% (or) 4% were strengthened using high strength concrete. Reversed cyclic loading was applied on all the specimens. The experimental results show that the HPFRC joint region improved the seismic behaviour and higher load levels, moments, curvatures, and larger displacements were attained in the non-seismically designed beam-column joints.

Ganesan et al. (2007) performed the behaviour of steel fibre reinforced high performance concrete (SFRHPC) using beam-column joints. Adopting modified ACI method M60 grade of concrete. The volume fraction of steel fibres used will be 0 to 1% with an increment of 0.25%. Positive cyclic load was used in this beam-column joint. The fibres were used four different volume fractions of (0.25, 0.50, 0.75 and 1.0) in SFRHPC mix. The results were found to be with respect to strength, ductility & stiffness degradation. Finally, the author concluded that the SFRHPC joints without developing wider cracks underwent large displacements when compared to HPC joints and also increasing the load carrying capacity of the SFRHPC joints.

Mukherjee et al. (2005) summarized the performance of reinforced concrete (RC) beam-column joints using FRPC. In this experimental programme two different types of RCC joints had been casted & tested. The first one set of joints were the critical sections with adequate steel reinforcements with proper detailing of reinforcements were adopted. The other set of beam reinforcements had deficient bond lengths at the junctions with the column. M30 grade of concrete had been used in this study and also material properties were to be studied. In different configurations FRP sheets and strips had been applied on the joints. Axial force applied to the column portion while the beams were subjected to a cyclic load. The hysteretic curves had been plotted and the energy dissipation capacities were compared with various configurations of FRP sheets. Most efficiently seismic retrofitting material is glass and carbon composite material as well as it is used for rehabilitation of RC joints. The author says that the use of small amount of composites increased the yield load and energy dissipation capacity from the beam-column joints.

Antonopoulos et al. (2003) evaluated the experimental study on behaviour of exterior reinforced concrete (RC) joints strengthened with fibre reinforced polymers (FRP) under simulated seismic load. Totally 18 exterior RC joints were analyzed 2/3rd scale model. Important role of mechanical anchorages in limiting premature debonding and their important information on the role of various parameters, including: area fraction of FRP; beam and the column FRP distribution; axial load on the column; steel reinforcement internal joint; initial damage; carbon versus glass fibres; sheets versus strips; and effect of transverse beams. Conclusions were drawn upon the response characteristics of certain load versus imposed displacement. The strength, stiffness, maximum lateral load, and the cumulative energy dissipation capacity were comprised.

Li et al. (2002) investigated the behaviour of reinforced concrete beam-column connection with hybrid fibre reinforced plastic (HFRP). Totally three specimens were casted and tested. Two specimens without FRP reinforcement and another one specimen reinforced with hybrid FRP around the beam-column joints. M40 grade of concrete was used for all the specimens. Compression test was conducted on the samples. Finally, the author found to be a hybrid FRP joint improved the load carrying capacity, stiffness degradation and it also crack initiation was delayed at the joint region.

Gencoglu et al. (2002) conducted the effect of exterior beam-column joints using steel fibres. Four full scale specimens were casted and tested under reversed cyclic load. 150KN compressive load was applied to the column portion. Reversed cyclic load was applied on these specimens displacements were measured at 15 different points by using LVDT. In the first three specimens cyclic load was applied once at the tip of beam until the occurrence of crust displacement. For every loading the displacement was recorded on the personal computer until the target displacement level was reached. From this study the author concluded that there is an increase in the ductility and the strength capacity using SFRC and decrease in the stirrups in the joint and confinement regions of the beam and column.

Ghobarah et al. (2002) examined the beam-column joint shear failure by identifying the moment-resisting frame buildings during recent earthquakes. All the joints were designed to simulate non-ductile detailing characteristics of pre-1970 seismic code construction. Specimens were tested subjected to cyclic loading at the beam tip joint shear failure occurred at joint region. To improve the shear strength of joint region different fibre wrap rehabilitation techniques were applied on the joint panel. The GFRP jacket was capable in increasing the shear resistance of the joint and enhancing the performance of the connection from a ductility point of view and the rehabilitated specimens (T1R, T2R and T9). The performance of original specimens and rehabilitated specimens showed that exhibited energy dissipation characteristics were superior to those of the original specimens T1 and T2.

Olariu et al. (1992) summarized the seismic behaviour of steel fibre reinforced concrete frames subjected to earthquake motions. It is suitable for only for precast frames, four full scale central joints were tested during the programme. The dimensioning of reinforcement

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was carried out according to Romanian design codes. From use of steel fibre reinforced concrete to avoid the steel congestion in beam-column joints and to improve the seismic behaviour of structure. The three precast joint behaviour was presented and compared with monolithical one. Finally, the experimental results showed that the effect of SFRC confined from the joint region controlled the cracks and reduced the potential sources of brittle failure.

Table 1 Behaviour of different steel fibre reinforced concrete beam column joint

SL. NO	NAME OF THE AUTHOR	TYPE & SIZE OF SPECIMEN	TYPE OF FIBRE	VOLUME FRACTION OF FIBRE	TYPE OF LOADING	CONCLUSION
1	Sharma et al. (2015)	Corner beam-column joint SIFCON specimen Column size -1000x200x150mm Beam size - 800x200x150mm	Crimped cylindrical steel fibre of length 30mm & aspect ratio 60	0,6,8,10 & 12%	Monotonic loading.	SIFCON joints undergoes small displacement without developing wider cracks.
2	Chidambaram et al. (2015)	Exterior beam-column joints Column size - 1200x150x150mm Beam size - 650x130x150mm	1.Hooked end steel fibre 2.brass coated steel fibre 3.polypropylene fibre	Hybrid combination with a maximum of 3.5%	Cyclic loading	Damage index for HPFRCC joint specimens is lower than conventional joint specimen.
3	Realfonzo et al. (2014)	Exterior beam-column joint Column size - 2000x300x300mm Beam size - 1500x300x400mm	CFRP sheets	Nil	Forward & reverse cyclic loading	FRP retrofitted members have allowed to restore the strength and significantly increase the ductility of the original member.
4	Muthuswamy et al. (2014)	Exterior beam-column joint Column size - 600x230x120mm Beam size - 450x170x120mm	Round Crimped steel fibre of aspect ratio 60 & hybrid fibre (steel+glass)	1%	Forward & Reverse cyclic loading	The presents of hybrid fibre helps in reducing the crack width and causes lesser damage.
5	Mahmoud et al. (2014)	Exterior beam-column joint column size - 2230x300x200mm Beam size - 900x300x200mm	CFRP Sheets	Nil	Reverse cyclic loading	CFRP specimen increases the ultimate capacity and decreases the ductility compared with un strengthened joints.
6	Keerthana et al. (2014)	Exterior beam-column joints Column size - 1000x200x150mm Beam size - 800x200x150mm	Hooked and crimped fibre in hybrid form	1%	Cyclic loading	Hybrid steel fibre can efficiently used for seismic reinforced beam-column joints.
7	Geethajali et al. (2014)	Exterior beam-column joint Column size -1100x100x100mm Beam size - 600x120x100mm	Crimped steel fibres & polypropylene fibres in hybrid form.	0.5%	Cyclic loading	The addition of fibres bridging the cracking effects and delayed the formation of first crack.

8	Ganesan et al. (2014)	Exterior SIFCON beam - column joint Column size - 600x230x120mm Beam size - 450x170x120mm	Crimped steel fibre of length 30mm & dia 0.45mm and Polypropylene fibre of length 12mm & dia 0.038mm in hybrid form.	Steel fibre maximum 1% and polypropylene fibre maximum 0.2%	Reverse cyclic loading	The HFRC specimen increases energy dissipation capacity and stiffness degradation than the RC specimen.
9	Oinam et al. (2013)	Exterior beam-column joints Column size - 800x90x90mm Beam size - 500x110x90mm	Steel fibre & polypropylene fibre in hybrid form	Maximum 1%	Cyclic loading	The addition of fibres plays an important role for arresting, delaying and propagation of cracks.
10	Balaji et al. (2013)	Exterior beam-column joint Column size - 600x230x120mm beam size - 450x170x120mm	Rounded crimped steel fibre of dia 0.5mm & aspect ratio 60	9 %	Cyclic loading	SIFCON specimen increases the ductility & energy absorption capacity than RC specimen.
11	Perumal et al. (2011)	Interior beam-column joints Column size - 745x150x125mm Beam size - 1600x200x125mm	Steel fibre of length 30mm, dia 0.5mm and polypropylene fibre length 20mm, dia 0.008mm	Steel fibre maximum 1.5% and polypropene fibre maximum 4%	Reverse cyclic loading	The cocktail fibre combination increases the ductility, ultimate strength, joint shear stress, and curvature ductility factor and energy dissipation capacity than RC specimen.
12	Kumar et al. (2010)	Exterior beam-column joints Column size - 1000x200x150mm Beam size - 800x200x150mm	FRP sheets	Nil	Forward & reverse cyclic loading	In case of retrofitted specimen the failure was in the beam portion only.
13	Shannag et al. (2007)	Interior beam-column joint Column size - 900x100x100mm Beam size - 900x100x100mm	Brass coated & hooked steel fibre in hybrid form	Maximum 4%	Cyclic loading	The HPFRC specimen increases the load levels, moment curvature & larger displacements than the RC specimen.
14	Ganesan et al. (2007)	Exterior beam-column joint Column size - 1300x300x200mm Beam size - 1000x200x200mm	Crimped steel fibres with an aspect ratio of 66	Maximum 1% was used SFRHPC mix.	Forward cyclic loading	The SFRHPC joints undergo large displacements without developing wider cracks compared with HPC joints.

15	Mukherjee et al. (2005)	Exterior beam-column joint column size - 3000x250x400mm Beam size - 750x250x400mm	CFRP - Ductile joint & GFRP - Non - ductile joint	Eff thickness of CFRP 0.36mm & Eff thickness of GFRP is 0.11mm	Cyclic loading	Both glass & carbon composite materials can be efficiently used for seismic retrofitted as well as rehabilitation of reinforced concrete joints.
16	Antonopoulos et al. (2003)	Interior beam-column joint Column size - 2700x400x600mm Beam size - 5300x400x600mm	CFRP & GFRP sheets with different layers	Nil	Static & cyclic loading	The externally bonded FRP reinforcement is a viable solution towards enhancing the strength, energy dissipation, and stiffness characteristics of Poorly detailed in shear RC joints
17	Ghobarah et al. (2002)	Exterior beam - column joint column size - 3000x250x400mm Beam size - 750x250x400mm	FRP & GFRP wrapping	Nil	Reverse cyclic loading	The GFRP specimen increasing the shear resistance of the joint & energy dissipation capacity compared with RC specimen.
18	Olariu et al. (1992)	Interior beam -column joint Column size - 2700x400x600mm Beam size - 5300x400x600mm	Steel fibres of length 45mm &dia 0.38mm)	1.5%	Reverse loading	The SFRC joints controlling the cracking & reduce the potential sources of brittle failure.

III. SUMMERY OF LITERATURE

Based on literature studies the interior, exterior and corner beam-column joints were studied. The beam-column joint are weak in seismic loads and have limited ductility and little resistance to cracking. To overcome the effects steel fibers have been added in beam-column joints to reduce the crack patterns and also structural strength, ductility was increased and ultimate load carrying capacity, deflection, stiffness degradation, energy absorption capacity was increased.

IV. CONCLUSION

The steel fibres are good composite material in reinforcing concrete structures. The presence of steel fibre in concrete helps to reduce the crack width and causes lesser damages to the fibrous specimen. The steel fibre reinforced concrete (SFRC) beam column joints increases the ultimate load carrying capacity, stiffness, ductility and energy absorption capacity than that of conventional RC specimen. In general, the Cocktail fibre reinforced concrete for beam column joints is recommended for cyclic loading when compared to beam column joints with single fibre and without fibre.

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