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# Review of Using Cementitious Laminates for Calculating Seismic Strengthening of Beam–Column Joint

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**ABSTRACT**

Evidences from previous earthquakes have shown that failure in beam column joints may cause disastrous collapse of structures, especially for the buildings without seismic provisions. To extend the life span of beam column joints, strengthening is required and this can be effectively achieved on using Ferrocement laminates. An investigation on the performance of reinforced concrete beam column joints under cyclic loading is reported. In this study, the beam column joint consisted of both column and beam of size 230×230 mm. Twelve specimens were cast out of which six are based on non ductile and remaining six are based on ductile detailing. In each case one specimen were considered as control specimen.

All the non ductile specimens had identical dimensions and were reinforced so that they would represent non-ductile detailed exterior joint of RC frame as per IS 456-2000 code recommendations. Reinforcement consists of four 12 mm diameter rebars in the column, two 12 mm diameter rebars in each side of the beam 8 mm stirrups at a spacing of 150 mm in the columnand beam uniformly.

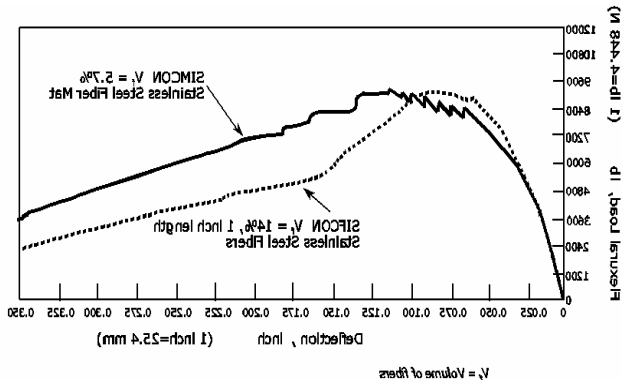
## INTRODUCTION

All the ductile specimens had identical dimensions and were reinforced so that they would represent ductile detailed exterior joint of RC frame as per IS 13920-1993 code recommendations. Reinforcement consists of four 12 mm diameter rebars in the column, two 12 mm diameter rebars in each side of the beam and 8 mm stirrups at a spacing of 100 mm in thecolumn and beam at the non- anchorage zone and 8 mm stirrups at a spacing of 75 mm at the anchorage zone.

The column is subjected to an axial force while the beams are subjected to cyclic load with controlled displacement. The displacement is increased monotonically using a hydraulic push and pull jack. This paper presents a method for the prediction of strength, displacement and energy dissipation capacity for ferrocement strengthened beam column joint under cyclic loading with respect to control specimens. The method proposed is based on cyclic behavior of beam column joint. A Large number of investigations are available in literature, displacement and energy dissipation capacity. But only very few attempts have been made to predict the flexural properties.

## LITERATURE REVIEW

The important point of any framed system is its beam column joint and particularly in RC framed structures it is still complicated. Further complication will arise when a joint experiences unexpected seismic loading. So it becomes necessary to strengthen an existing structural joint system to have enhanced seismic resistance. Many works related to the strengthening of RC joints have been collected and the relevant important reports have been reviewed.




## FIBER REINFORCED CONCRETE COMPOSITES

Lloyd Hackmen et al. (1992), have researched the optimising new developmental uses of

for achieving similar flexural strength and energy absorbing toughness. The author‟s research on thebehavior of approach.SIFCON is usually used in to

specialized applications, because of the high volume of discrete fibers required. However, SIMCON broadens these market applications by reducing the fiber quantity in half and thereby reducing the product cost.

Senthilkumar et al. (2010) have state that sheet, are being used to strengthen a variety of RC elements.

Ravichandran & Antonyjeyasehar (2012) stated that strengthening of beam column joints Shannag et al. (2002) studied a good number of old buildingswhich have been found to be vulnerable to. In the specimens thus repaired, higher load level was attained, more, energy dissipation wa observed, ductilebehavior was achieved Thandavmoorthy (2006) published the results of joint tested under monotonic loading. The core sampling was collected from the test specimens. The monotonic loading exhibited a ductility factor of about 6.65. There was existing cracking in the joint core. Under displacement control, cyclic loadtest was done Reversed cyclic load was applied on the joint. Displacement sequences of 25 mm, 50 mm, 75 mm and 100 mm were applied. Every sequence was applied in three cycles. A pinched hysteric loop was formed. Energy absorption was found to be the maximum in the first cycle of every load sequence. The energy absorption increased with every load sequence Griezic et al. (2001) worked on em. The provision of high performance fiber-reinforced concrete in the beam was extremely useful in controlling the cracks and hence it improved durability.

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to enhance the shear,with analytical modeling of beam column joint that was done through ANSYS Software.

Robert & Arulraj (2010) concludes etc..Ramakrishna & Ravindra (2012) sheet wrapped externally.

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mathematical formulation and numerical demonstration of the theory aredescribed.

It is demonstrated that common concept of quadruple flexural resistance is relevant for interior, exterior and knee joint despite their difference in number of framing member in a rational way. The computated value of joint shear strength agrees well with the average observed joint strength derived from Japanese tests database of beam-column joint.

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(GFRP) and SIMCON for retrofitting purpose. Only limited studies have beenmade with the prediction of ultimate load carrying capacity of HPFRCC. Similarly limited studies have been carried out in CFRP fabrics in morenumber of layers. Most of the studies have been further carried out in single and double layer only. Also only very few studies in cost analysis have only carried out in HPFRCC and FRP. Only a few attempts have been done for the use of retrofitting studies. The number of experimental investigations that have been worked out in cement based ferrocement laminates. This study attempts to investigate the efficiency of ferrocement laminates, with twodifferent volume fractions, in strengthening joint. In developing countries ferrocement laminate is used to repair and strengthen of RC beam-column joint and its raw material are cheap and easily available. A part from this ferrocement laminates are preferred for following reasons too :

i) It has optimistic individuality of easier implementation in joining.

ii) It resist corrosion

iii) It has high strength and stiffness

iv) It is fire retardant and

v) It can be customized in accordance with size requirements forbeams and columns.

Considering the cost of laminate preparation and also the performance factor hence it is chosen for this investigation. The investigation is done on beam-column jointspecimens retrofitted with ferrocement laminate. In the presentstudy, Code IS456-2000 and IS13920-1993 is used in the design ofbeam-column joint. Further they are retrofitted using ferrocement laminates and tested under reverse cyclic load.Read (1996) studied crack propagation analysis for the polymer modified bituminous mixtures by considering stiffness and fatigue as two levels of performance. The study reported that the crack propagation rate is highly influenced by initial stiffness of the mixture. SBS (Styrene Butadiene Styrene) modified bitumen in the mixes resulted in the good performance. The study revealed that increasing the coarse aggregates in the mix will not increase the initial stiffness and improve the resistance against crack propagation.

Shivangi Gupta &Veeraragavan (2009) investigated the benefits of SBS polymer was used to modify conventional binder and its physical and mechanical properties were studied for both Marshall and superpave gyratory compacted specimens. The study concluded that higher density values could be achieved for the superpave mixes possibly because of higher compaction factor. The tensile strength and marshall stability values werereported as higher by 21% and 25% for the SBS modified mixes than conventional mixes. The resilient modulus increased between 2 to 2.5 times for the polymer modified mixes. It was stated that SBS polymer modified bituminous mixes could be recommended for national highways for its increased fatigue life performance under constant temperature.

Davidovits (1994)attempted with an expectation of possible way to reduce carbon dioxide emissions by 5 t0 10% by reducing the use of fossil fuel and new energy technology. The naturally occurring amino-silicates such as kaolinite were transformed in low temperature for a short period into three dimensional tecto-aluminosilicates. The thermo setting method was employed for polycondensation of organic resins. The geosynthesis was termed as ability of the aluminium particle to induce crystallographical and chemical changes in silica structure. The study demonstrated that at low temperature transformation, kaolinite into hydrosodalite tremendous latent energy in the new mineral reaction was observed. The research clearly established the process of formation

of geopolymers which reported to be inorganic, hard, stable at temperature upto 1250°C and non flammable Study reported that lowering sodium silicate concentration was favourable for geopolymer activated with sodium hydroxide whereas higher concentration was favourable for potassium hydroxide. It was observed that significant increment of compressive strength with time was for sample prepared with sodium hydroxide. Study concluded that this might be due to the precipitation of sodium based compound within the pores. The increment of pore pressure allowed development of cracks after few days in most of the cases. This phenomenon was not supported by the sample prepared with potassium hydroxide.

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