International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.14, pp 58-66, 2017

Comparative Study on ECC and RCC Beam Column Connections for Enhancing Seismic Resistance

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Abstract : Earthquake induced damages in beam column joints resulting in building collapse. The beam column connection failure is due to multiple load cycles may lead to collapse of the whole structure. This can be resisted by using Engineered Cementitious composites (ECC) also known as bendable concrete. This study is to evaluate the feasibility of using ultra ductile ECC as means to enhance the performance of beam column connections.
The existing commercial building of G+4 at a zone of high seismicity were taken. From that building, critical beam column connection are chosen. This specimen will be analysed by changing as ECC. Additionally, changes are arrangement of transverse reinforcements, their amount and the materials within the plastic zone of the connection where analysed using ANSYS software. The performances of a series of ECC beam column connections will be compared to that of a control concrete. The ultimate load and ultimate displacement and strain energy capacity were used as criteria in the comparison.
Keywords : Finite element modelling, behaviour, ECC, beam column joint, ANSY.

Introduction

A General

Nowadays Earthquake are rapidly occur on different parts of world especially it increased in India . There are different types of materials used to control the seismic attack in the structure. But no one can completely resist the seismic action. Seismic performance is an execution of a building structures ability to sustain its function such as safety and serviceability. The behaviour of the building earthquake depends not only on the size of the member and reinforcement, but to great on the placing and detailing of the reinforcement.

Mainly ,Earthquake induced damage in beam column joints resulting in building collapse has been observed worldwide in several earthquakes in the past where the cause of failure has been linked to inadequate confinement in the joint. While a significant amount of research has been done on improving the seismic performance of RC building beam–column joints through new design concepts and improved details such as joint hoops and improved anchorage , a limited amount of research has focused on utilizing special materials like High Performance Fibre Reinforced Cementitious Composites (HPFRCC) and Engineered Cementitious Composites (ECC) etc., to improve the seismic behaviours of the beam column joints.

B Development of Engineered Cementitious Composites

ECC concrete is expand as Engineered cementitious composites concrete also called as bendable concrete. Its unlike fibre reinforced concrete, is a family of micromechanical designed material and do not contain large volume of fibre. It is developed based on micromechanics and fracture theory.

ECC not a fixed material design but a broad range of different stages of research and implementation. The fibre used in ECC has different size such as macro, micro, nano and composite scales. The mixing procedure of ECC is similar to the normal concrete. The engineered cementitious composites are economical by reduction in the usage of fibre while maintaining the desired characteristics of strength and ductility.

C Types of ECC

- Light weight Concrete
- Self compacting Concrete
- Sprayable ECC

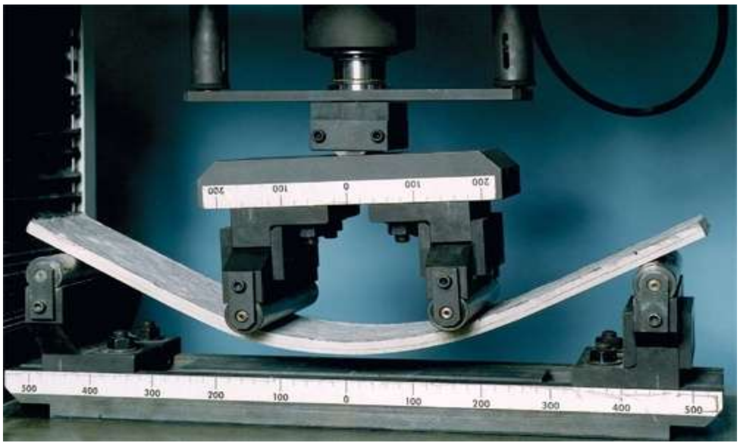


Fig 1 Bendable Concrete

Research objectives

The Failure of beam column joints due to lateral load may lead to collapse of the whole structure. This can be reduced by using ECC in beam column connection subjected to cyclic loading.

The main objective of this research is to investigate the behaviour of beam column joints incorporating a ductile ECC replacement of concrete in the plastic zone of both column and beam as well as joint core of the beam column joints.

Aim of this study is to demonstrate that ECC can be replaced of RC to improve shear strength and ductility, thus reducing complexity. This research would be helpful to demonstrate the effectiveness of alternative design for seismic resistant beam column connection.

Methodology

A Specimen Summary

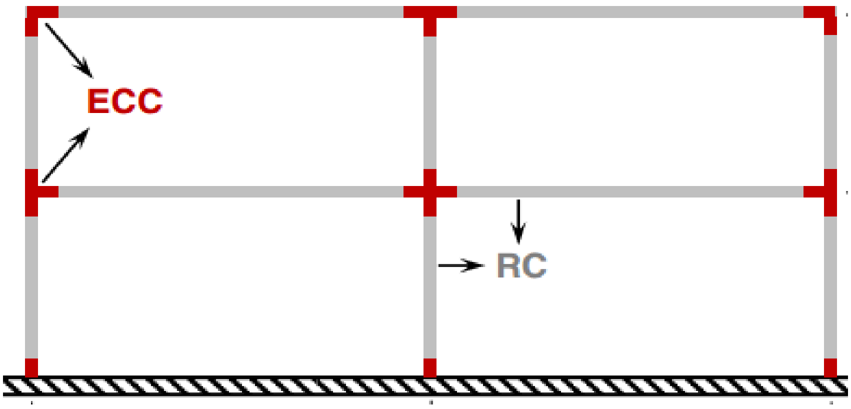


Fig 2 : ECC beam column joints

The details of the main reinforcement of beam and column as well as the transverse reinforcement are taken from the G+4 existing building. Fig 3 shows overall dimensions for the specimen. Columns have a cross section of 450x300 mm with height of about 3000mm and transverse beam have a cross section of 230x300mm with a total length of about 3350mm. The longitudinal reinforcements of the column consisted of 12 bars of 12mm dia, while for the beams consisted 3 bars of 12mm dia at top and 2 bars of 10mm at bottom bars and hoops reinforcement consisted of 8 mm dia. Specimen is incorporated an ultra ductile ECC material within the plastic zone of the beam, column, and joint region (Fig 3)

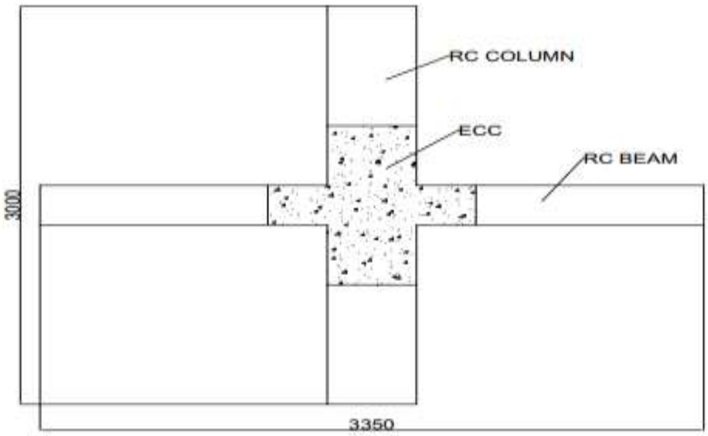


Fig 3: Geometry details for ECC enhanced Specimen

Table 1 Specimen Details

Specimen	Material	Performance Evaluation to be Conducted
S1	RC	Control Specimen
S2	ECC	Effects of replacing concrete by ECC material within plastic zone in beams and columns
S3		Effect of reducing 50% of hoops quantity within joint core
S4		Effect of reducing 50% of beam and column hoops quantity
S5		Effects of reducing 50% of beam hoops quantity and eliminating joint hoops

B Material Properties:

The grade of concrete used in the research is M20. The ECC material used 2% (by Volume) high strength , high modulus and light weight polyethylene fibre with physical properties as shown in table 2.

Table 2 Physical properties of polyethylene fibre

Property	Value
Fibre Length	12mm
Diameter	39µm
Specific gravity	0.96
Tensile strength	2570Mpa

Table 3 Properties of specimen

Property	RCC	ECC
Mass/Volume	2548kg/m^3	2475kg/m^3
Modulus of Elasticity	22360Mpa	32000Mpa
Poisson's ratio	0.2	0.27
Co-efficient of thermal expansion	0.0000055/C	0.00011/C
Shear Modulus	9316.95Mpa	12598Mpa

C ANSYS Software

The beam column joint with and without ECC are modelled using ANSYS. The linear static analysis is performed for the following research.

C.1 Pre processor

Pre-processor contains following steps such as element , Real cross section, Material, Modelling , Meshing, Loads. In element we have to define the element type like concrete as solid 65, Steel reinforcement as link 8.

The cross section of the model is beam as 230x300mm with length as 3350mm and column as 450x300 with height as 3000mm. After material properties are defined by manually as in table 3.

In meshing there are different types of meshing are available like coarse mesh, fine mesh, line mesh. The beam column joint models are meshed as coarse. Beam has simply supported and column is fixed and free at top. Applying the load as 10kN and lateral load as 3.96 kN.

C.2 Solution

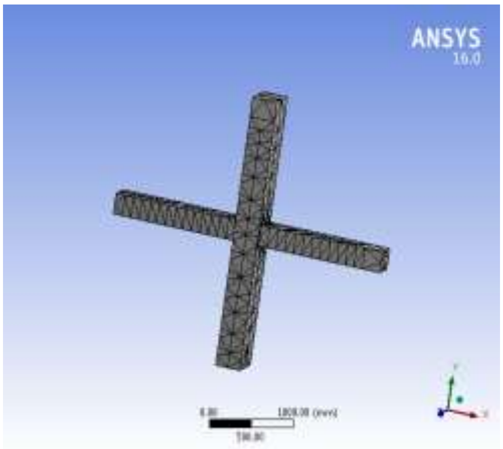
Solving the model and the following results are obtained.

1. Deformation
2. Equivalent stress
3. Strain energy
4. Maximum and minimum principal stress

Post processing is the process that gives the modelled report. Post processing shows the tables, graphs such as contour display, deformed shapes, vector displays, path plot, reaction force displays.

Results and discussion

A Specimen Models:



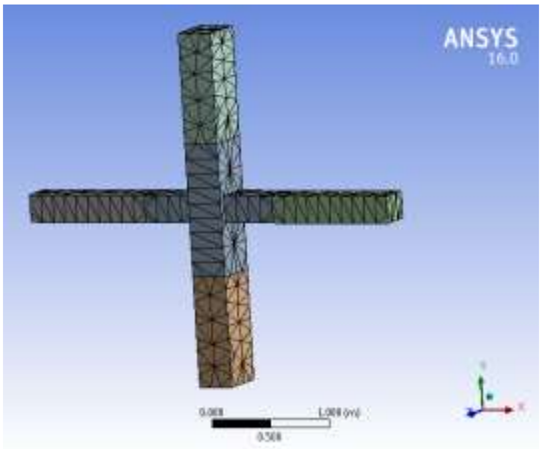


Fig 4 Specimen S1 **Fig 5 Specimen S2**

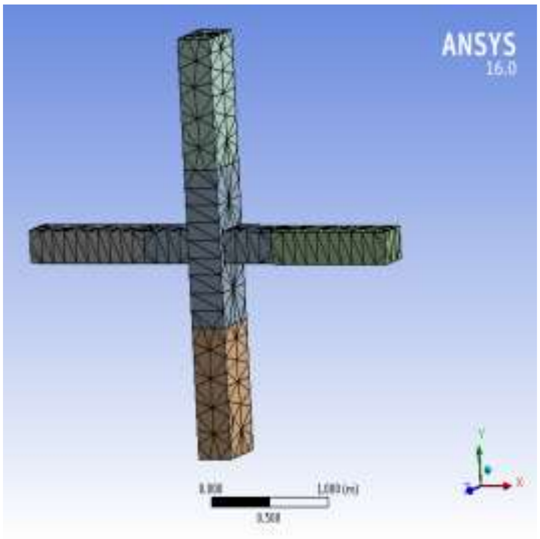


Fig 6 Specimen S3

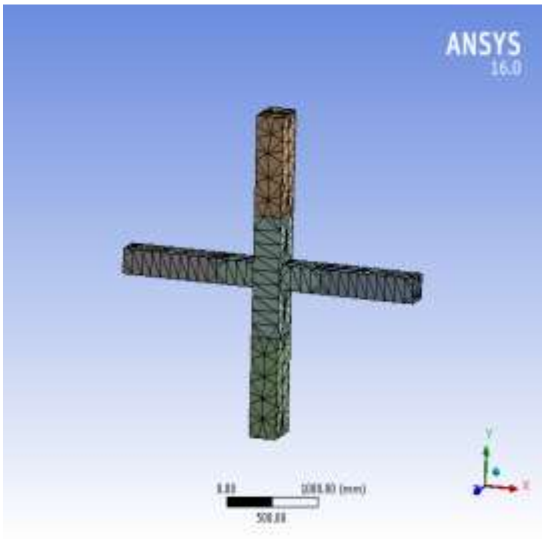


Fig 7 specimen S4

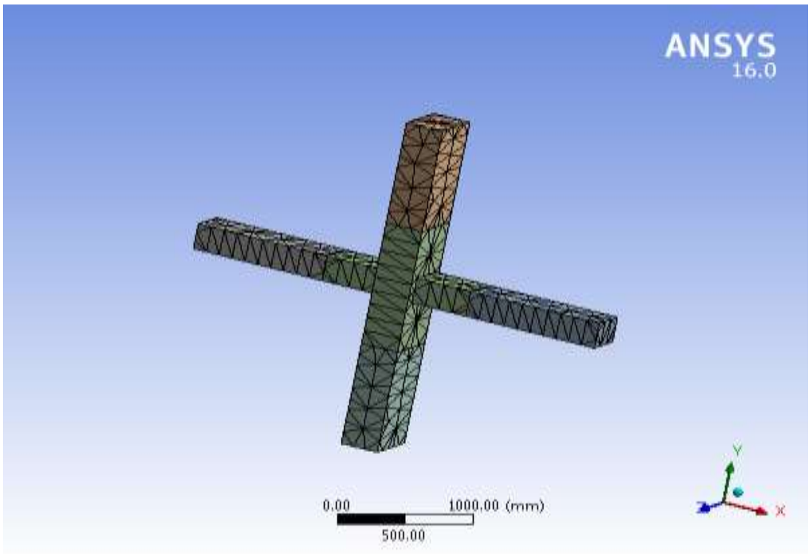


Fig 8 Specimen S5

B. Total Deformation :

Table 4 Comparison of Deformation

Specimen	**S1**	**S2**	**S3**	**S4**	**S5**
Total Deformation (mm)	1.5487	0.928	0.93059	0.93096	0.9298
% Reduction	-	40	39.91	39.88	39.96

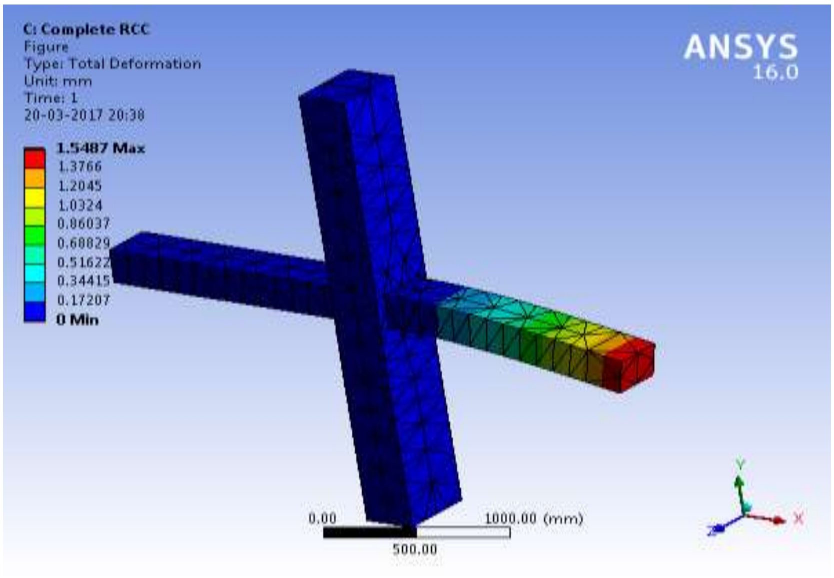


Fig 9 Typical View of Total deformation of S1

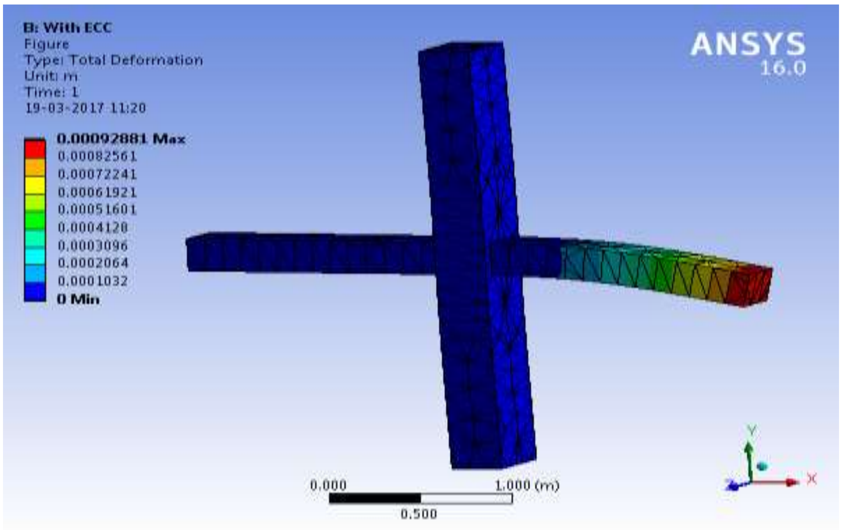


Fig 10Typical View of Total deformation of S2

C Equivalent Stress

Table 5 Comparison of Equivalent Stress

Specimen	**S1**	**S2**	**S3**	**S4**	**S5**
Equivalent Stress (Mpa)	49	54	55	75	79
% Increase	-	10	12	53	61

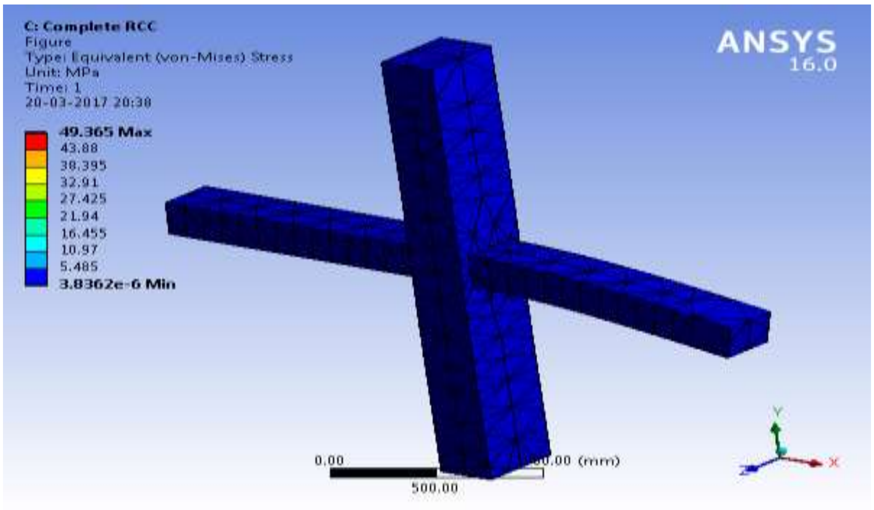


Fig 11Typical View of Equivalent stress of S1

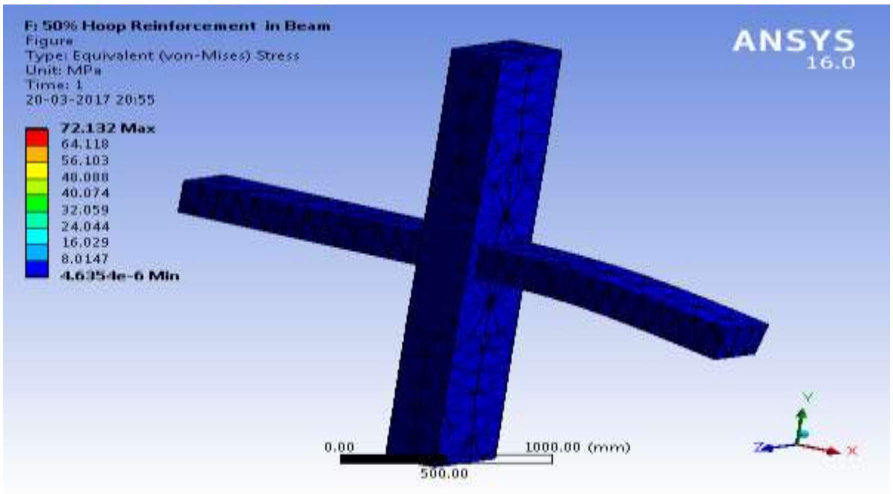


Fig 12 Typical View of Equivalent stress of S5

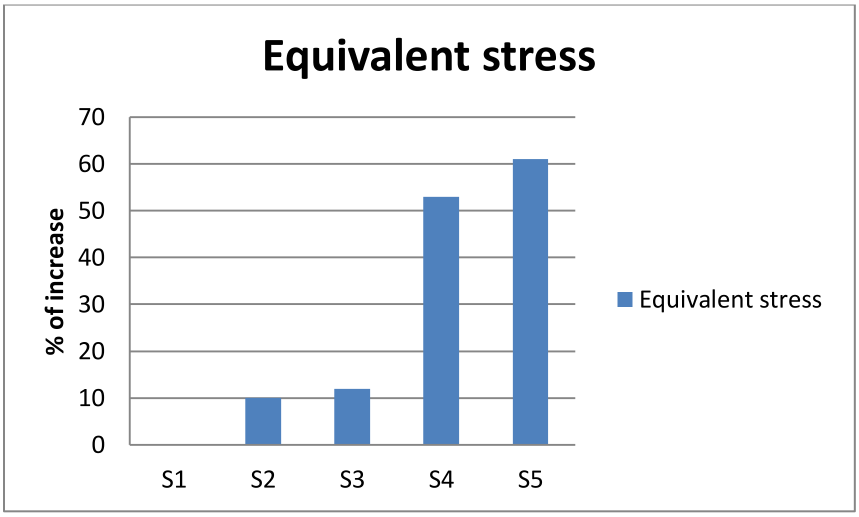


Fig 13Percentage Increase in stress of ECC

D Strain Energy

Table 6 Comparison of Strain energy

Specimen	**S1**	**S2**	**S3**	**S4**	**S5**
Strain Energy (mJ)	29	24.25	30.657	25.108	24.913

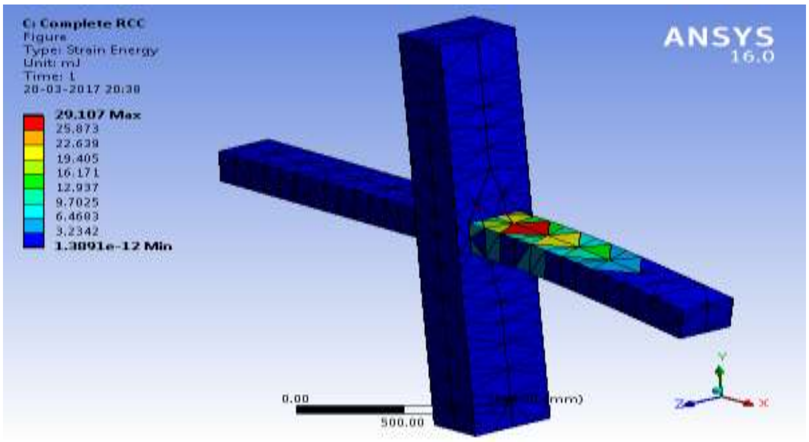


Fig 14 Typical View of Strain Energy S1

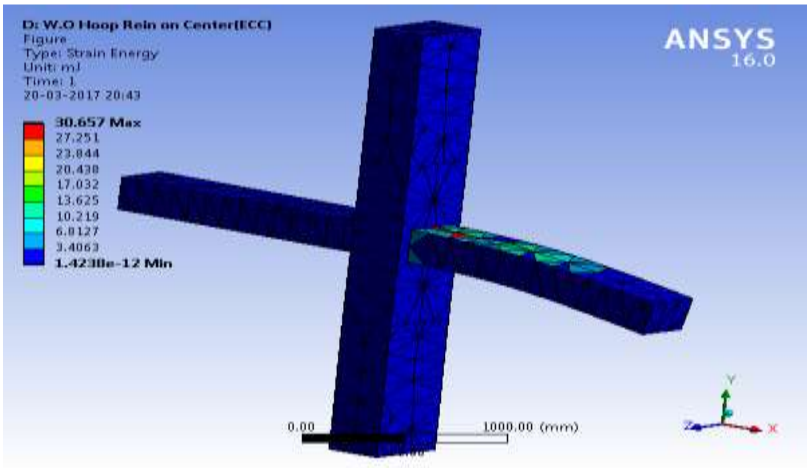


Fig 15 Typical View of Strain Energy S3

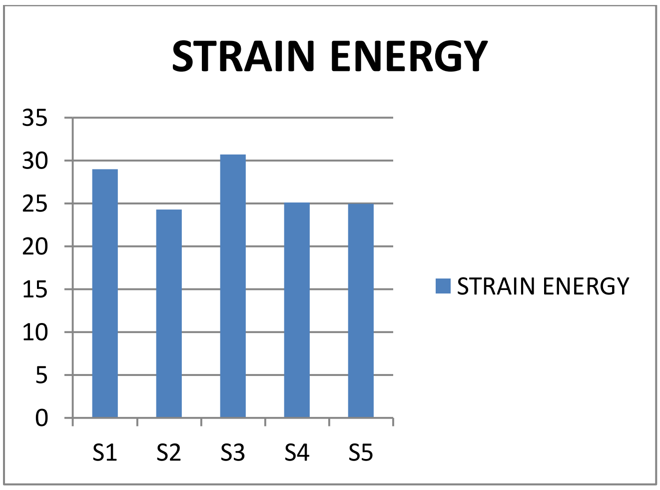


Fig 16 Typical View of Strain energy Capacity in RCC and ECC

Conclusion

From the research it is concluded that many existing building that were built according to past design code and found vulnerable to earthquake damage due to low strength in plastic zone. When we constructed with ECC at plastic zone of beam column joints will results the prevention of damages due to earthquake load.Based on that the ANSYS modelling and analysis carried out on the beam column joint and following results are drawn.

The Equivalent stress for lateral load and 10 kN loads for model S2,S3,S4,S5 were found to be increased by 10%,12%,53%,61% when compared to control concrete S1

The strain energy capacity for model S3 were found to be increased by 6% when compared to control concrete S1.

The result in this study revealed that the use of ECC Engineered cementitious composites concrete has imparted to the specimens a greater ability to resist and survive the cyclic loading.

By comparing the overall performance of all ECC specimen in terms of ultimate load, ultimate displacement, strain energy capacity it appears that specimen S3 and S5 had the most effective design among all other ECC specimen. In both of these specimens, the hoop reinforcement were eliminated in the joint core.In the specimen S5 he hoop reinforcement were reduced to 50% of beam plastic zone and the ECC material was used in the joint core as a well as the plastic zones of beam , while specimen S3 the hoop reinforcement were reduced 50% in the joint core only and the ECC material was limited to the joint core and plastic zone only. Due to influence of micro fibre of polyethylene in concrete will gives good strength and ductility to concrete ad has property of self healing andcontrol of cracks. This will make the concrete bendable in seismic excitation. Thus the proposed Engineered cementitious composites concrete material can be used in beam column joint.

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