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Finite Element Investigation of ECC Encased CFST Columns Under Eccentric Loading

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Abstract- **It is well known that concrete-filled steel tubular (CFST) columns are currently being increasingly used in the construction of buildings, due to their excellent static and earthquake-resistant properties. Recently, the behaviour of the CFST columns has become of great interest to design engineers, infrastructure owners and researchers, therefore to understand the load deformation characteristics of composite columns critically. It has been demonstrated in the past few decades that the cement based composite material can be reinforced with short random fibers of volume fraction less than 2.0 %. This material is designed to confirm the tensile strain hardening, cracking behavior after initial crack, fiber bridging and multiple cracks. Such material is referred to as Engineered cementitious composite (ECC) and it also belongs to the family of ultra high toughness cementitious composite (UHTCC). To increase the durability and fire resistance of concrete filled steel tube (CFST) columns, engineered cementitious composite (ECC)-encased CFST columns were proposed. This thesis investigates the mechanical behaviour of ECC encased CFST columns for different eccentric loading and different encasement. For this different models of columns were modelled in finite element software ANSYS WORKBENCH 16.1. This project includes the determination of ultimate load carrying capacity.**

I. INTRODUCTION

Concrete filled steel columns have seen an increased usage in building structures throughout the world. A well-designed and properly detailed composite column is a structural element that will highlight the synergistic behaviour of its constituent materials, including the high cross-sectional stiffness, high compressive strength, and fire resistance of the concrete and the large ductility, high tensile resistance, high strength to stiffness ratio, and lightweight construction associated with steel. It has been found that CFST columns have better structural performance than steel reinforced concrete (RC) columns in terms of ductility and load carrying capacity. In order to increase the durability and fire resistance of CFST column, the CFST composite columns have been proposed and investigated, such like fiber reinforced polymer (FRP) encased-CFST column and concrete-encased CFST column. The FRP encased-CFST column consists of inner CFSTand externally wrapped FRP sheet,which has various structural benefits compared with normal CFST column, such as higher corrosion and impact resistance . However, the fire resistance of FRP encased-CFST column is questionable, since FRP materials may suffer melting,delamination, deformation and debonding when exposed to fire. The concrete-encased CFST column is a conjunction of inner CFST component and outer RC component. The addition of the outer RC layer is believed to improve the corrosion resistance, fire resistance, and buckling resistance of inner CFST column . However, it was also noticed that the outer concrete was easily crushed while the inner CFST was still in the elastic plastic stage. To improve the durability and fire resistance of CFST composite column, the Engineered Cementitious Composite (ECC) encased-CFST column was proposed .

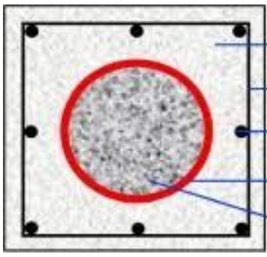

Fig.1. Cross section of ECC encased CFST column

II. METHODOLOGY

- Conduct Literature review on CFST columns and ECC.
- Modelling of ECC encased CFST column by altering geometry.
- Analysing using ANSYS WORKBENCH 16.1
- Deformation and ultimate load carrying capacity is determined using software
- Comparison of results
- Conclusion

III. MODELLING OF COLUMNS

Test specimen 300 x 300 x 1400mm RCC encased CFST columns are chosen for finite element modelling. The main reinforcement having size 12mm dia and stirrups of 8mm dia are used. Concrete of grade 30 MPa is provided.

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Table 1. Material properties of concrete

Characteristic compressive strength	40MPa
Density(kg/m^3)	2400
Modulus of elasticity	31622.77MPa
Poisson's ratio	0.15

Table 2. Material properties of steel

Yield strength	415MPa
Density(kg/m^3)	7850
Modulus of elasticity	2 x 10^5 MPa

Table 3. Material properties of ECC

Compressive strength	53.2MPa
Density(kg/m^3)	2300
Modulus of elasticity	25800 MPa
Poisson's ratio	0.15

Table 4. Description of the models

Sl.no	Models	Encasement	Eccentricity (mm)
1	RCC-I/O-E50	RCC	50
2	RCC-I/O-E100	RCC	100
3	RCC-I/O-E150	RCC	150
4	ECC/O_RCC/I_E50	ECC	50
5	ECC/O_RCC/I_E100	ECC	100
6	ECC/O_RCC/I_E100	ECC	150

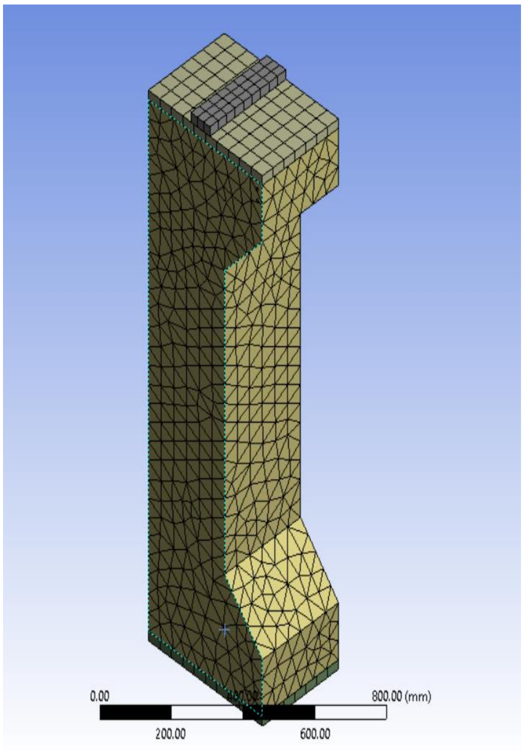

Fig 2. RCC-I/O-E50

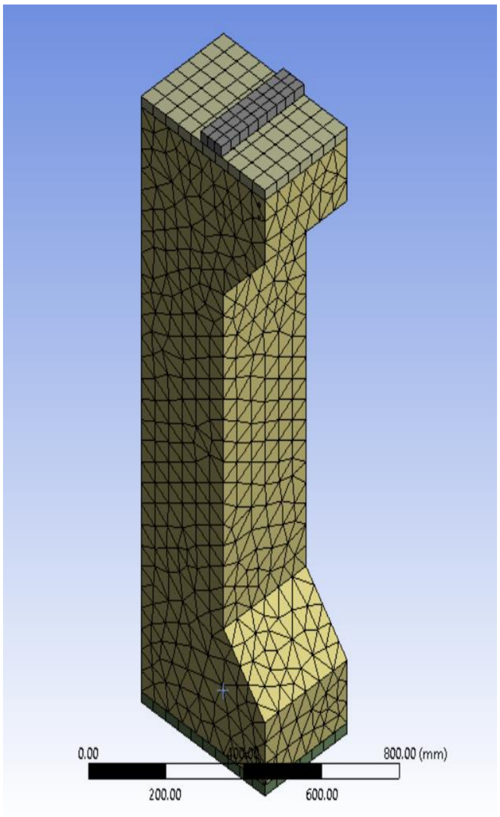

Fig 3. RCC-I/O-E100

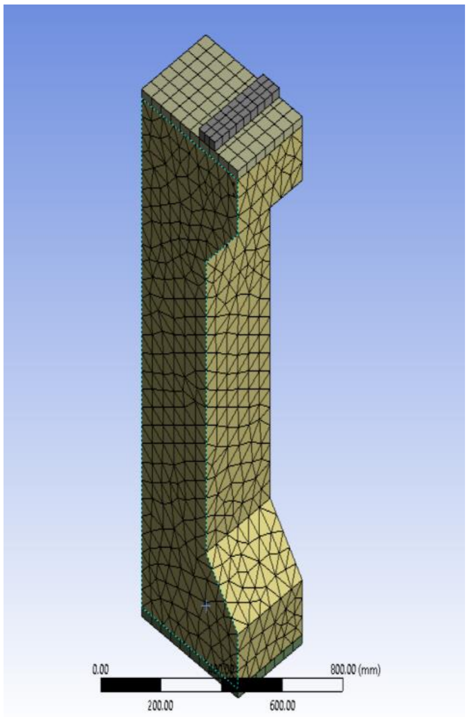

Fig 4. RCC-I/O-E150

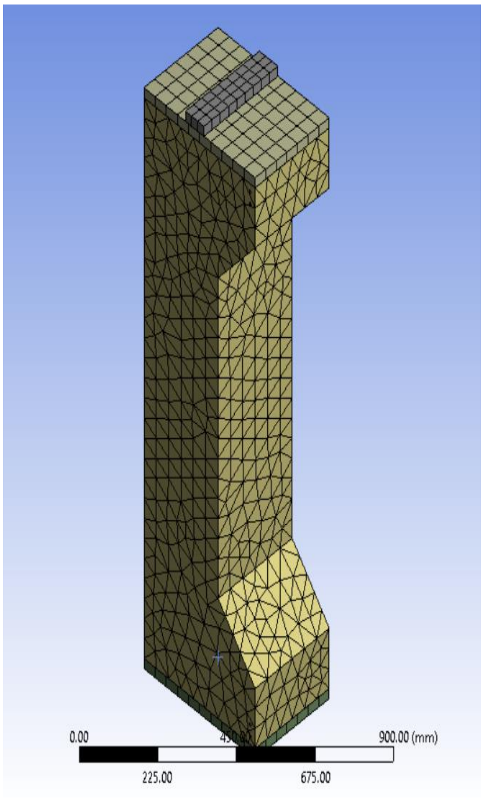

Fig 5. ECC/O_RCC/I_E50

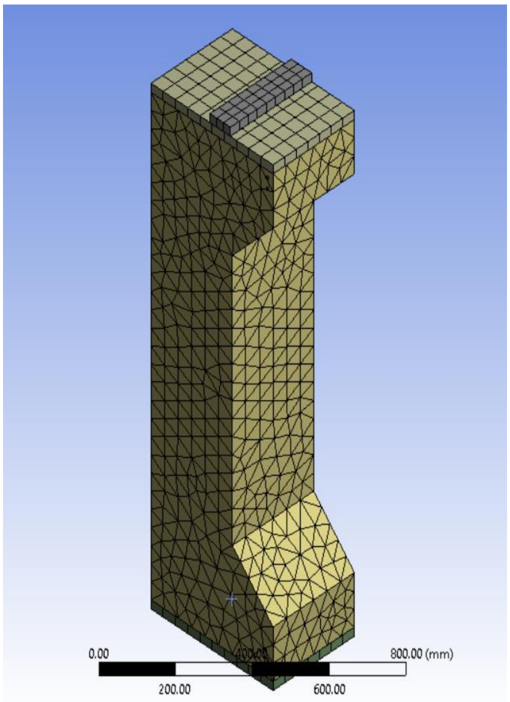

Fig 6. ECC/O_RCC/I_E100

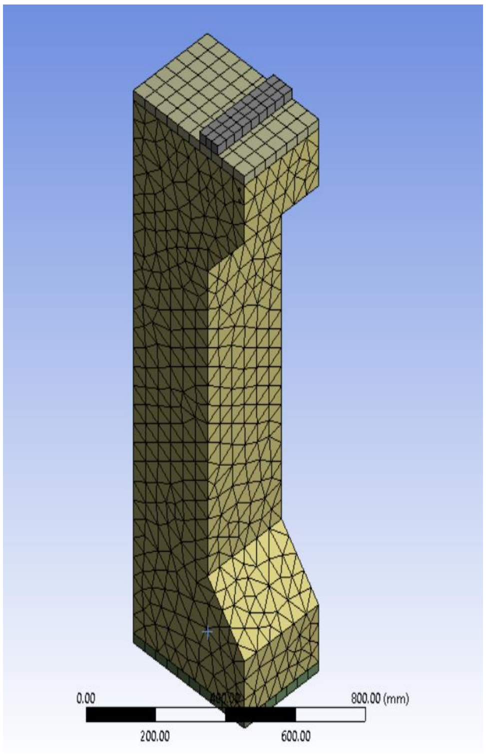

Fig 7. ECC/O_RCC/I_E150

IV. ANALYSIS

The RCC encased CFST columns and ECC encased CFST columns of 6mm thickness for different eccentricities (50,100,150mm) were analysed using finite element analysis in ANSYS workbench.

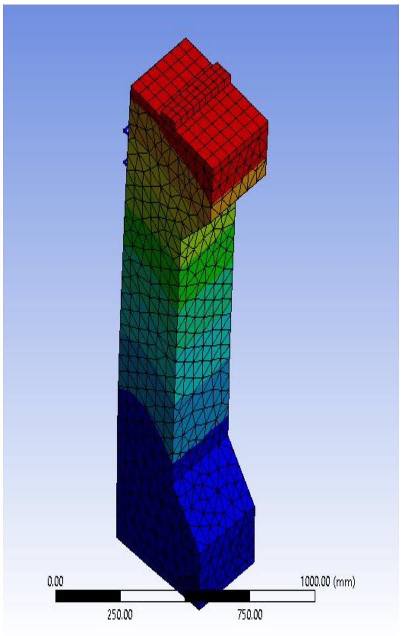

Fig 8. Deformed shape of RCC-I/O-E50

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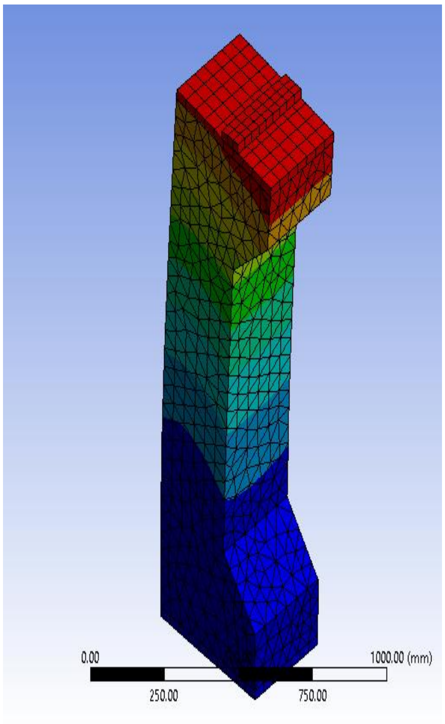

Fig 9. Deformed shape of RCC-I/O-E100

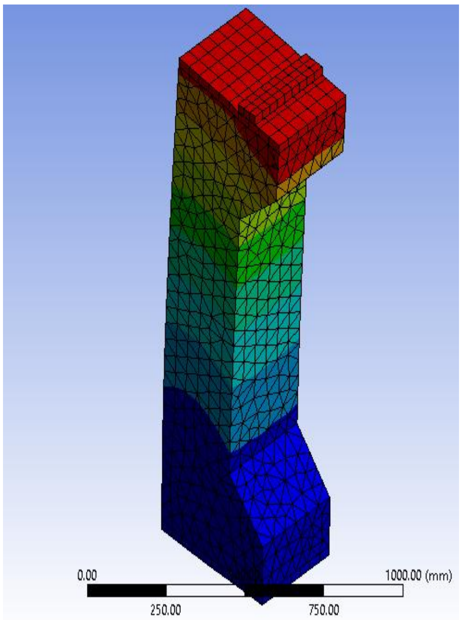

Fig 10. Deformed shape of RCC-I/O-E150

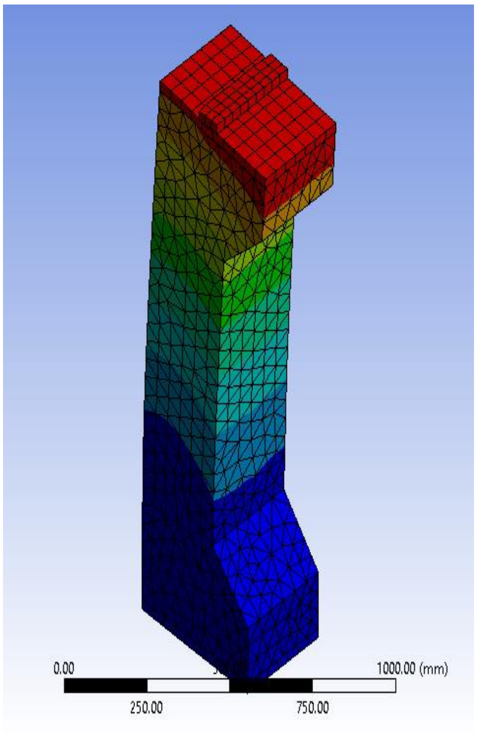

Fig 11. Deformed shape of ECC/O_RCC/I_E50

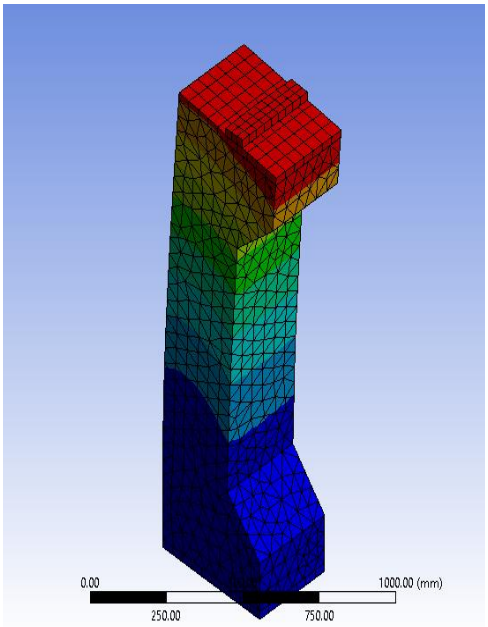

Fig 12. Deformed shape of ECC/O_RCC/I_E100

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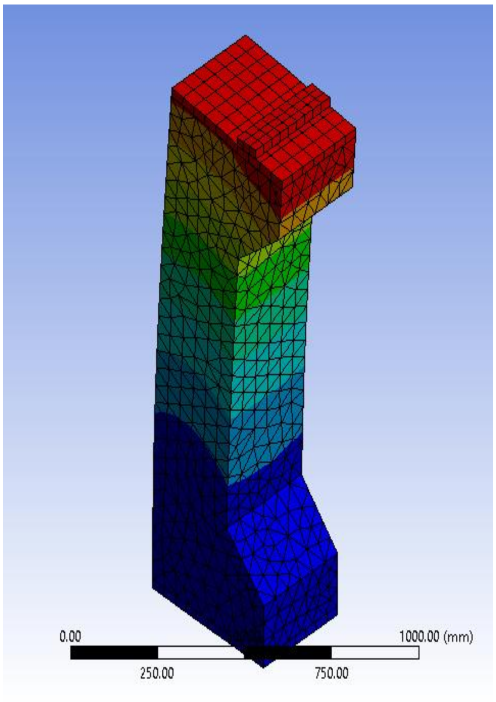

Fig 13. Deformed shape of ECC/O_RCC/I_E150

V. RESULTS AND DISCUSSION

The load-deformation curve corresponding to models with RCC encasement CFST columns and ECC encased CFST columns for different eccentric loading (50,100,150mm).

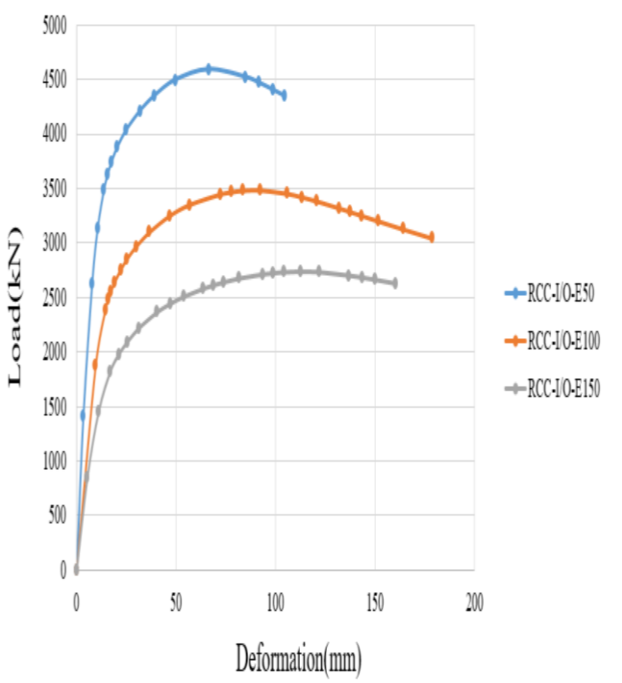

Fig 14. Load-deformation curve corresponding to RCC encased CFST square column with an eccentricity of 50mm, 100mm, 150mm

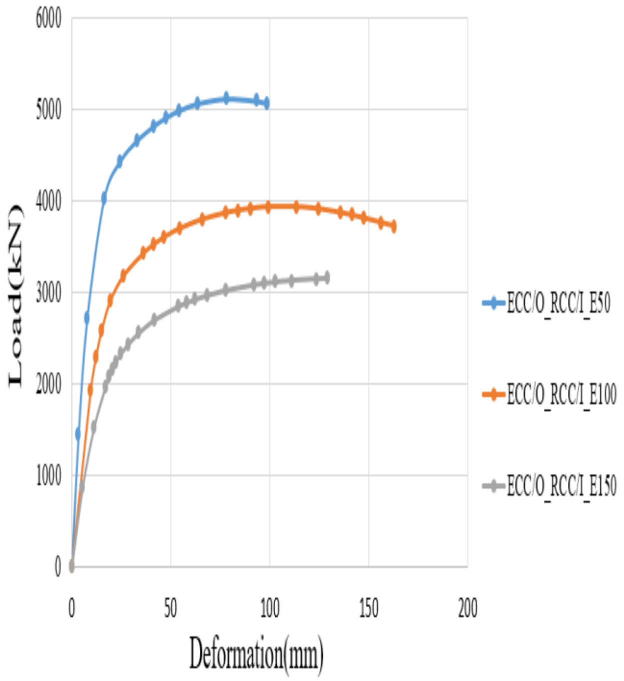

Fig 15. Load-deformation curve corresponding to ECC encased CFST square column with an eccentricity of 50mm, 100mm, 150mm

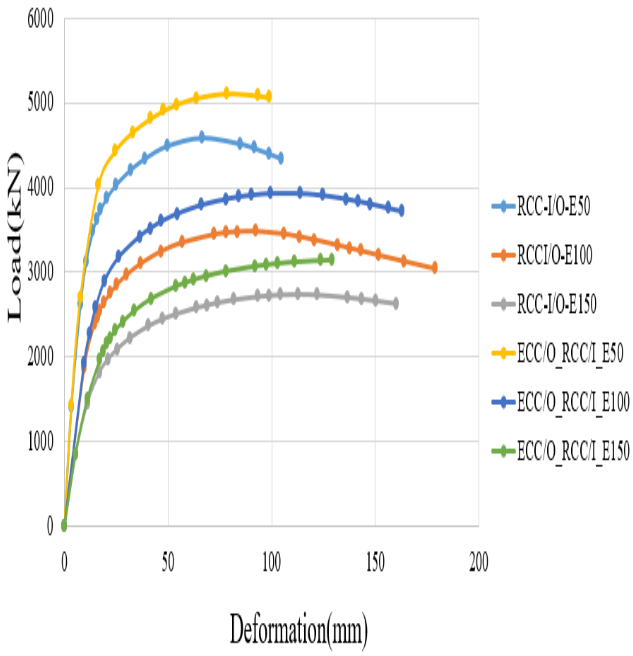

Fig 16. Load-deformation curve corresponding to RCC & ECC encased CFST square column with an eccentricity of 50mm, 100mm, 150mm

Table 5. Ultimate loads and corresponding deformations of models

Column specimen	Deformation(mm)	Load(kN)
RCC-I/O- E50	66.383	4590
RCC-I/O-E100	95.152	3482
RCC-I/O-E150	112.72	2737
ECC/0_RCC/I_E50	78.351	5113
ECC/0_RCC/I_E100	113.72	3927
ECC/0_RCC/I_E150	129.09	3143

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VI. CONCLUSION

The main conclusions obtained from the analysis are summarized below:

- ❖ The study of concrete filled steel tubes and ECC were done.
- ❖ The load carrying performance of CFST column with inner concrete and encasement as ECC performed better than columns with RCC as inner concrete and encasement by 11.39%,12.7% & 14.8% for an eccentricity of 50mm,100mm & 150mm.
- ❖ There was a decreament in the load carrying capacity as there was an increament in eccentricity. Ultimate load of column specimen with an eccentricity of 100mm and 150mm was lower than that of column specimen with eccentricity 50mm by 24.1% &40.3%.
- ❖ From the study it was clear that ECC performed better than that of RCC.

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