iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** X **Month of publication:** October 2021

DOI: https://doi.org/10.22214/ijraset.2021.38525

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

Ferrocement as a Retrofitting Material for Beam Column Joint

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Abstract: ***Structure safety is of utmost importance in modern days. Now- a- days ferrocement is gaining popularity as a retrofitting material due to ease of its application and availability. The most critical location of failure in any structure is beam column joint. The aim of this paper is to analyse the effect of retrofitting on beam column joint using ferrocement as a retrofitting material. Square wire mesh and triangular wire mesh was used for retrofitting beam column joint. Beam column joint is designed using ductile detailing code IS 13930:2016. Axial and reverse cyclic displacement load is applied on the specimen. Further unstrengthen and strengthened specimen were analysed using ANSYS software. A comparative study was done and it was concluded that after retrofitting, the specimen shows considerable decrease in total deformation. It shows that retrofitted beam column joint was more stable than the unstrengthened beam column joint. So, to increase the serviceability of any structure it is recommended to retrofit the structure.***
Keywords: BCJ, ferrocement, wire mesh, retrofitting

I. INTRODUCTION

Reinforced concrete structure and masonry structures often becomes unserviceable before completion of their service life due to various reasons, like change in loading patterns, fatigue, creep and amendments in seismic code. Due to loss in serviceability of the structure, it requires immediate attention.

Demolition of existing unserviceable structure and making new structures is not advisable. In every case retrofitting of such a structure is one of the best ways to increase serviceability of the structure. As per the requirement, a structure can be retrofitted as a whole or only some of its element such as joints can be retrofitted. Various materials like glass fibre, steel plate, concrete jacketing, ferrocement etc are used as a retrofitting material. Ferrocement is an alternative to RCC construction. Ferrocement has important advantage of reduction in CO2 emission so it can be used to replace all conventional materials like RCC, timber, steel etc to make construction eco-friendly

N. Naveena and M. Ranjitham, performed numerical study on retrofitting of beam column joint strengthened using carbon fibre reinforced polymer. The results show that the beam column joint strengthened with CFRP can increase their structural stiffness, strength and energy dissipation capacity [1]. From experimental investigation of small scale ferrocement jacketed RC column under concentric load it was concluded that both approach [(a) strengthen all the corners, and (b) reducing stress concentration at corners] are effective to overcome the stress concentration problem of square jacketing [2].

The objective of this research paper is to determine the effect of ferrocement as a retrofitting material used to strengthen the BCJ. The main aim of the research is to show retrofitting of BCJ as efficient way to upgrade any structure.

II. FERROCEMENT

A French engineer Joseph Monier, published the term ferrocement in 1875. It is cement based composite which is of about 2-3 cm thickness constructed by cement-mortar and closely spaced metal wire used as reinforcement. The ferrocement is of the cement-based composites.

Use of ferrocement is very common in foreign countries but in India it is used rarely. First time it was used for the construction of boat. Now-a-days, it used for construction of swimming pools, domes, water tank etc. It is gaining popularity due to its various advantages like light weight, can be cast in any shape, no requirement of form work, semi-skilled labours are required and ease of availability.

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Table -1: Property of ferrocement

Property	Value
E_s (modulus of elasticity)	148 Gpa
f_y (yield strength)	385 Mpa
f_c (strength of mortar)	17Mpa
υ (Poisson's ratio)	0.3
Diameter of wire mesh	1mm
Spacing between the wire mesh	15mm

Table-2: Description of models to be studied

Models	Type of wire mesh	Number of ferrocement layer
BCJ1	Without wire mesh	Zero
BCJ2	Square	One
BCJ3	Triangular	One

III. DUCTILE DETAILING OF BEAM COLUMN JOINT

A G+2 storey building in zone 3 was considered and corner beam column joint was designed using codes IS456:2000 [3], IS13920:2016 [4], IS1893:2016 [5] and SP16 [6]. Fe415 grade of steel and M20 grade of concrete is used to design the BCJ.

Table-2: Detailing of BCJ

	Dimensions (mm)
Column	325*400
Longitudinal reinforcement diameter	8-20ϕ
Beam	300*300
Reinforcement at top	2-25ϕ and 2-20ϕ
Reinforcement at bottom	2-25ϕ and 2-20ϕ

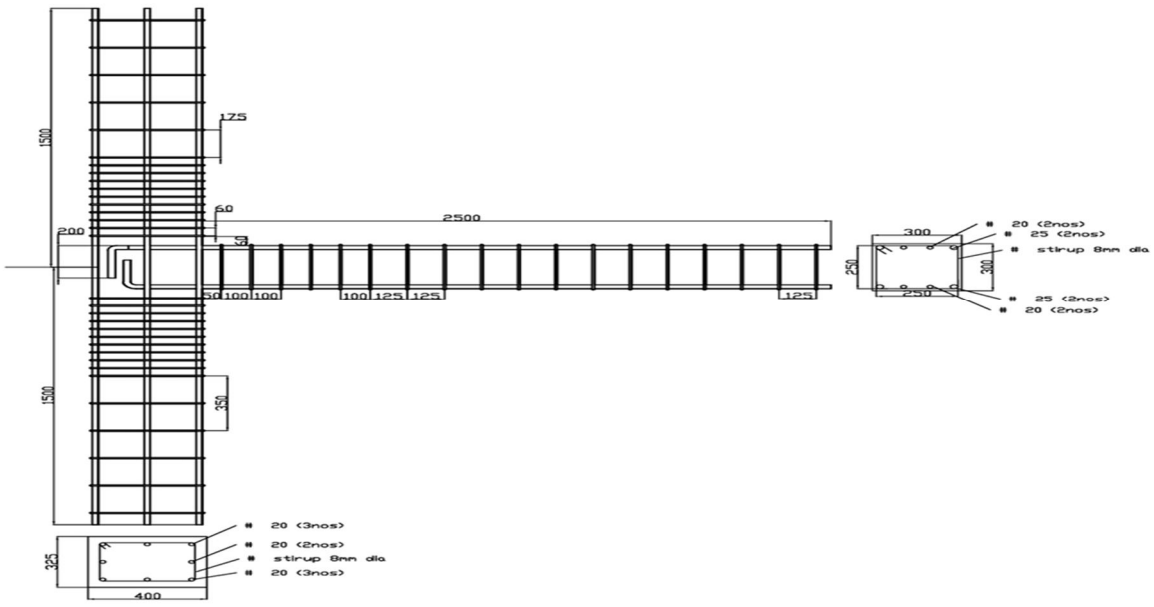

Fig. 1: Original beam column joint

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IV. RESULT

Using IS codes IS 1893:2016 and IS 133920:2016, a beam column joint was designed which was named as BCJ1 and further it was retrofitted using one layer of square wire mesh and one layer of triangular wire mesh ferrocement which was named BCJ2 and BCJ3 respectively. The specimens were analysed using ANSYS software, applying 80% of ultimate load as axial load on column and reverse cyclic displacement on the free end of beam which simulates earthquake type loading.

A. Effect on Total Deformation

On analysing the models, it was found that total deformation of BCJ1 was 1.429 mm which decreases on retrofitting to 0.078057 mm and 0.069834 mm in BCJ2 and BCJ3 respectively. Using triangular wire mesh shows better result in comparison to the use of square wire mesh.

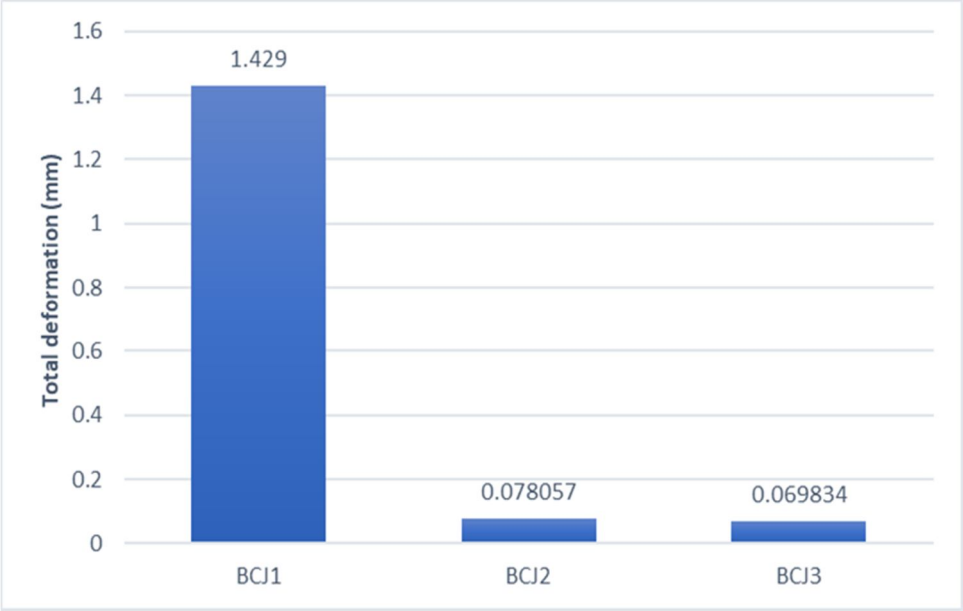

Chart 1: Total deformation

B. Effect on Equivalent Elastic Strain

Equivalent elastic strain was 0.0012622 for BCJ1, 0.000048745 for BCJ2 and 0.000040146 for BCJ3. It is noted that on using triangular wire mesh strain decreases 17.64% in comparison to the use of square wire mesh.

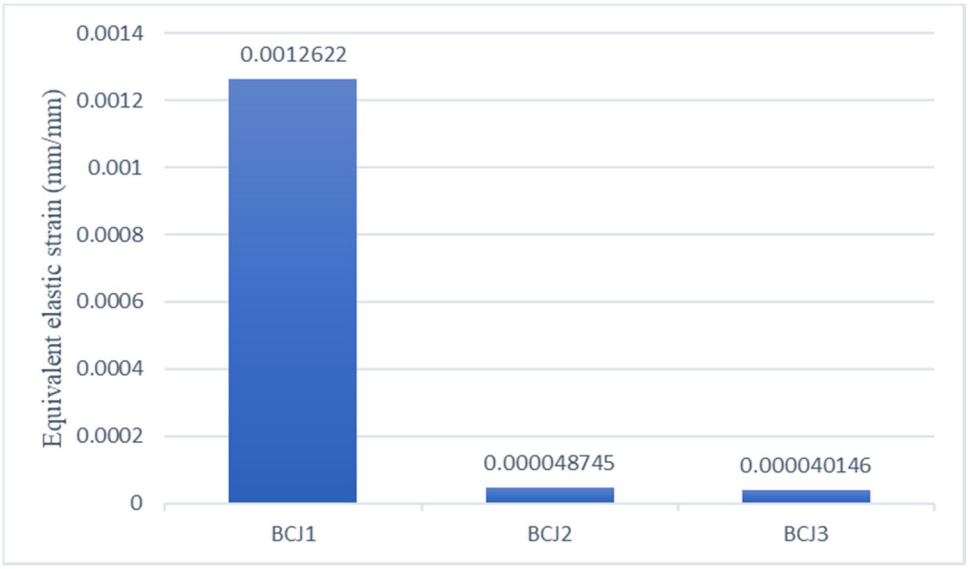

Chart 2: Equivalent elastic strain

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C. Effect On Maximum Shear Stress

Maximum shear stress of BCJ1, BCJ2 and BCJ3 are 20.394MPa, 4.1436MPa and 4.1882MPa respectively. On retrofitting the test model there is considerable decrease in shear stress but due to change in shape of wire mesh from square to triangular wire mesh there was decrease of only 1% in maximum shear stress value.

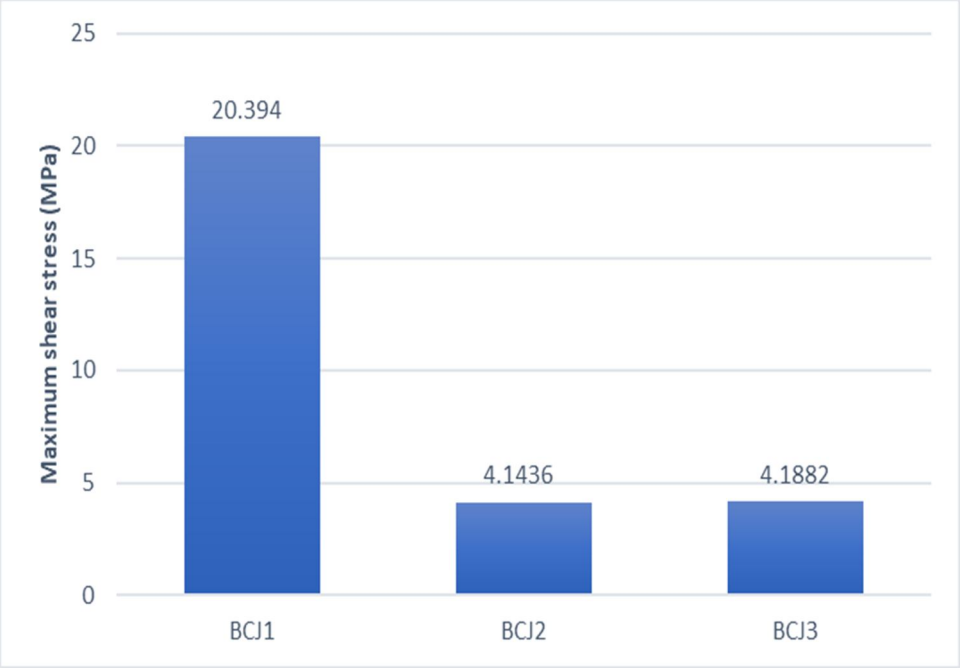

Chart 3: Maximum shear stress

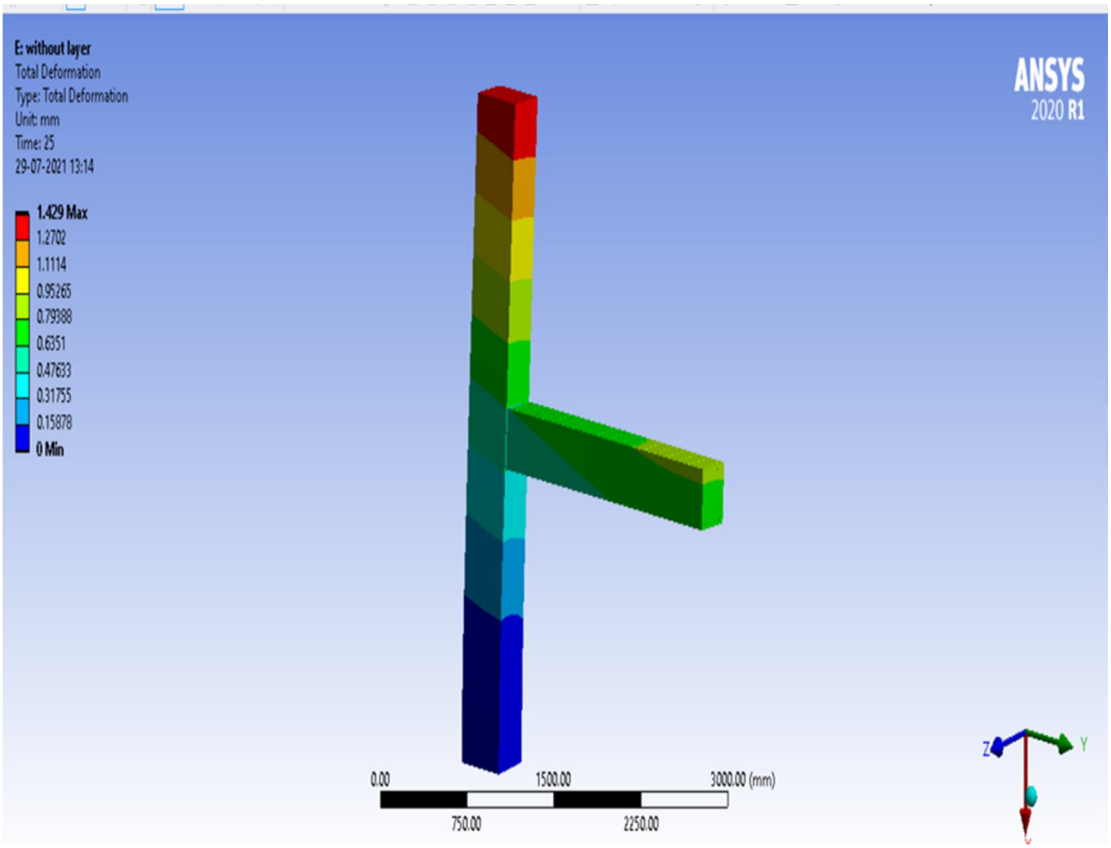

Fig 2: Total deformation of BCJ1

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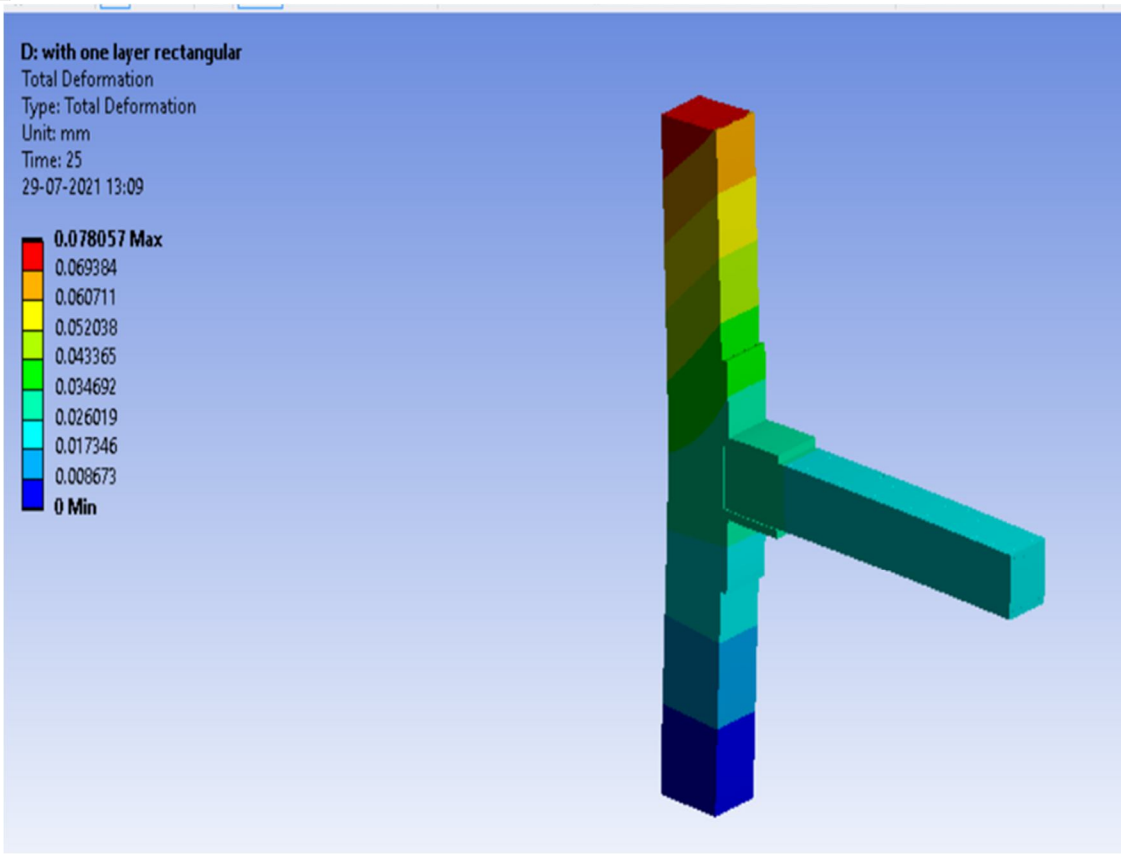

Fig 3: Total deformation of BCJ2

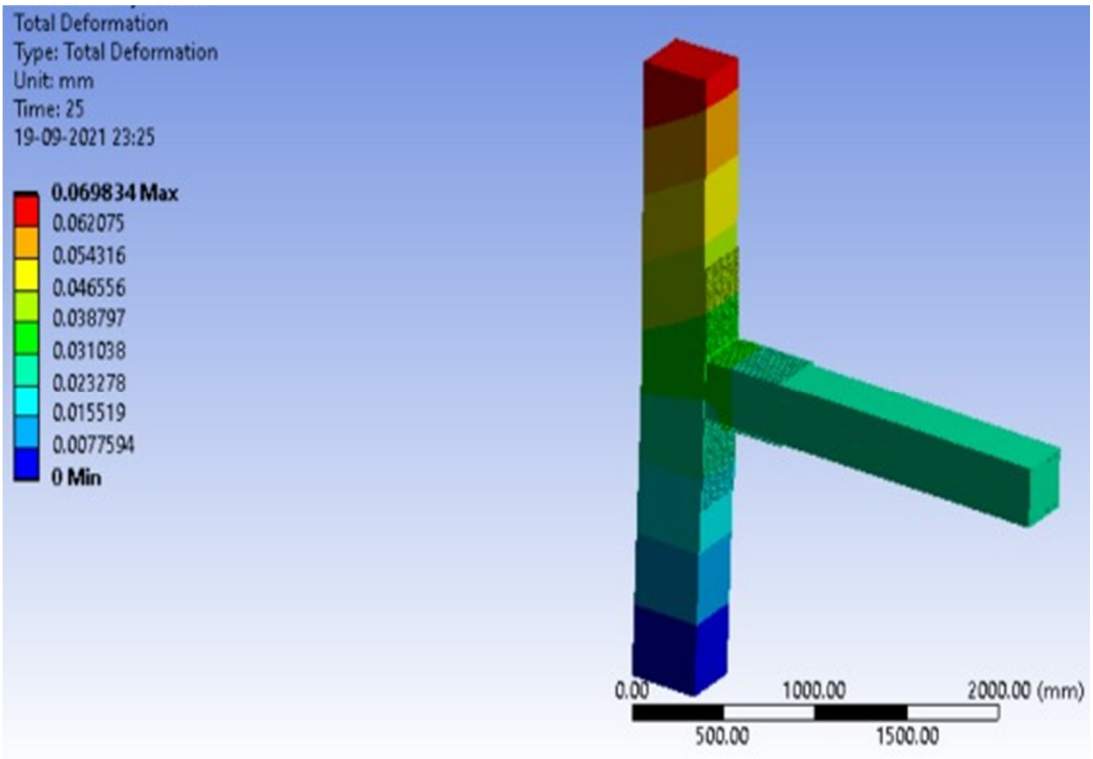

Fig 4: Total deformation of BCJ3

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V. CONCLUSION

A beam column joint was modelled and further it was retrofitted using single layer of square wire mesh and single layer of triangular wire mesh. Test models were analysed using finite element-based software ANSYS and following conclusion was noted:

A. On retrofitting the model there was appreciable decrease in total deformation, equivalent elastic strain and maximum shear stress.
B. On changing the shape of wire mesh from square to triangular wire mesh decrease of 10.5% was observed in total deformation and decrease of 17.64% was observed in equivalent elastic strain.
C. Due to retrofitting, maximum shear stress decreases 79% but due to change in shape of wire mesh used for retrofitting there was a decrease of only 1% on using triangular wire mesh which can be neglected.
D. The results of this research indicate, retrofitting increases the strength, stability and serviceability of the member.
E. Triangular wire mesh is not in use but as it shows better result as compared to square wire mesh so it can be taken in use for retrofitting work.
F. So, it is recommendable to engineers to retrofit a members or whole structure depending upon the need to increase the serviceability of the structure using ferrocement due to its various advantages.

VI. FUTURE SCOPE

Ferrocement is one of the best retrofitting materials. Generally square and hexagonal wire mesh is used but further study could be performed using combination of two or more different types of wire mesh to enhance the strength and property of ferrocement.

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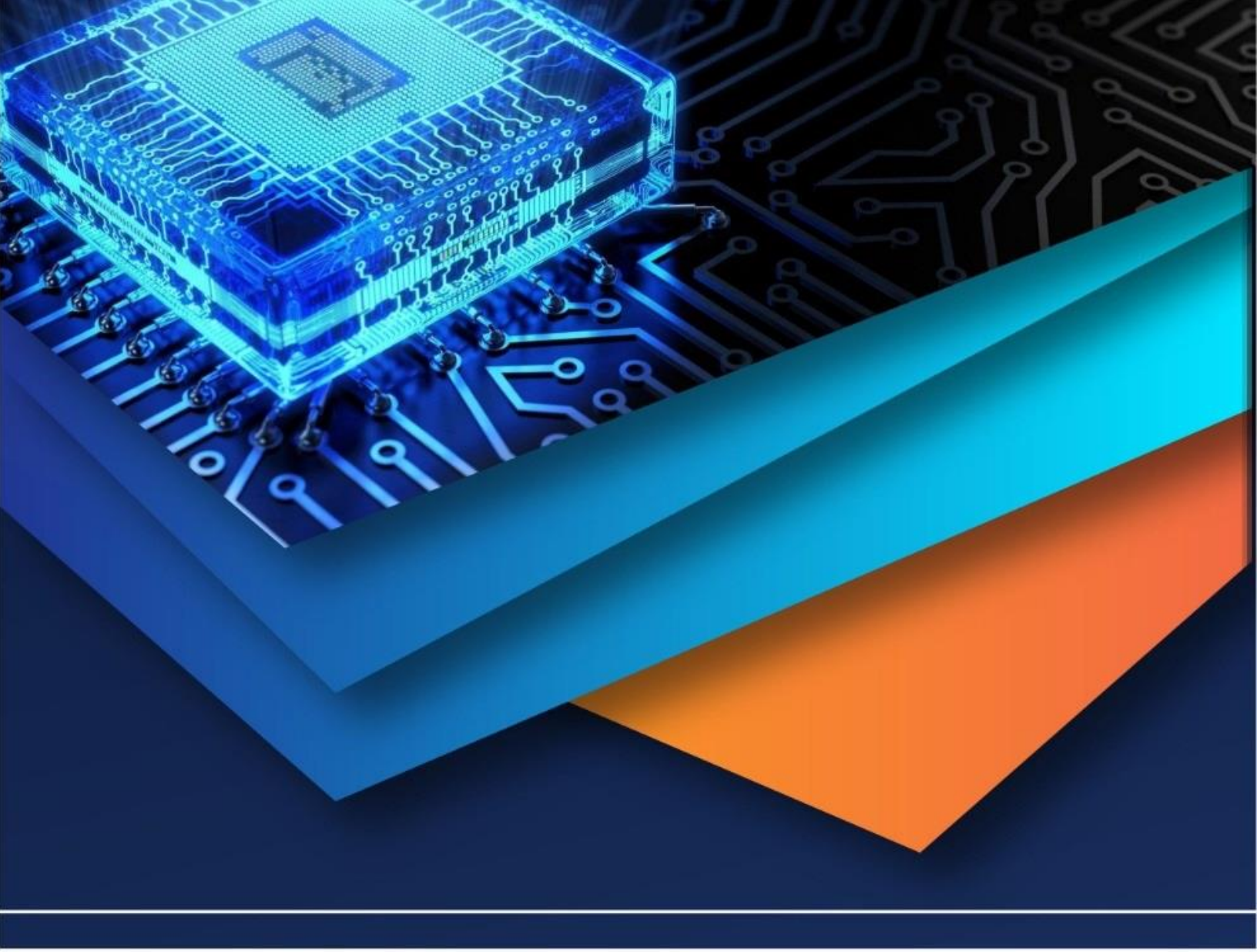

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