iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** II **Month of publication:** February 2023

DOI: https://doi.org/10.22214/ijraset.2023.49087

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue II Feb 2023- Available at www.ijraset.com

Review of Bamboo as a Reinforcement Material

Shantanu Wadkar
JSPM Institutes Tatavde

Abstract: ***Concrete is a basic material for construction used all over the creation. Concrete is more strong in compression force and extremely weak in tension. To counter this steel is used as a reinforcement material to bond. The steel is costly and corrodes easily which leads to decline in strength of the structure. This can be improved by bamboo due to its properties like light weight, cheap, durable and easily renewable. So, the old-style method of using steel strengthening is replaced by using bamboo as a reinforcement material in building industries. Bamboo is a natural, economical and abundantly available material. The deflection in mid span can be reduced by providing bamboo buttressing. We are going to compare the concert of steel and bamboo to find the optimal result. Problems faced in using bamboo as manufacture material are waterengagement and moisture content. This paper shows the exploration of use of bamboo reinforcement in beam and cylinder for M25 grade of concrete. To study the effect of replacement of steel reinforcement by cane, tests have been conducted Flexural strength and split tensile strength. While using the bamboo around twenty five percentage of construction cost less strength material are not in used for the construction and its give less result for the construction project.***

Keywords: Steel Reinforced Concrete, Bamboo Reinforced Concrete, Flexural Behavior, Tensile Behavior, Cost Reduction.

I. INTRODUCTION

Bamboo is a normal easy source of fibre and one of the fastest growing titan's plants with great economic and strengthening. This material are gets fully mature within four year and continuing for material. This material are used for bridges construction and houses and for scaffolding bamboo has been used for thousands of years in Asia. Bamboo used for ethic purpose and maintain the esp. system of the In India, frequent studies have been carried out relating to the protection of bamboo with a goalmouth of enhancing its service life and understanding the other property are found in bamboo in order catching engineers in selecting and designing. In this material highly tensile stench and less compression strength. In the current context when forest cover is fast depleting and availability of wood is increasingly becoming rare, the research and development assumed inpast few decades have established and amply demonstrated that bamboo could be a viable auxiliary of timber and several other outdated materials for housing and building construction sector and some infrastructure works. Its use through industrial processing have shown a high potential for manufacture of composite materials and components which are cost-effective and can be successfully utilized for structural and non- structural applications in construction of housing and buildings.

Structure of cane reinforced concrete structural members. For the mega structure just like water tank, dam, etc. Yet assumptuous standards on cane as a structural material have not been developed in many countries. ISO- 22156 for Cane Structural Design and ISO- 22157 for Resolve of physical and mechanical properties of bamboo have been published by Global Standards. Indian Values have published several codes on bamboo, however, there are only few for bamboo as a structural physical. Bamboo as a strengthening in real slab has been examined by the writers in the laboratory and the results are obtainable.

II. BAMBOO-COMPOSITE REINFORCEMENT SYSTEMS

Bamboo-composite reinforcement systems for reinforcing concrete beams of up to 1,300 mm in length were fabricated following the details that the length of the concrete beams was chosen according to the availability oftesting facilities and Universal Testing Machine's (UTM) loading capacity of 100 kN. There were two types of reinforcement used in this study for reinforcing the concrete beams: longitudinal and transverse (shear) reinforcement. The longitudinal reinforcements were placed parallel to the long axis of the beam to provide the required tensile and flexural capacity, while transverse reinforcements were employed to provide sufficient shear strength perpendicular. This handsome species is distributed in North-eastern India. The diameter is twenty seven to twenty five of clean came and chimneys are used, bamboo is the main constructive material. It is found the best constructive martial like sisum and etc. There are various factors that are involved in the design and proportioning of concrete beams reinforced with the newly developed bamboo composite reinforcement. The bond between bamboo composite reinforcement and the concrete matrix and the effect of water penetration as well as alkaline environment of concrete on the mechanical properties of bamboo composite reinforcement are investigated in this study.

1) *Ambusa Striata:* It is a new sized bamboo 8 m to 10 m in height with around eight cms in diameter, yellow colour are advised in the plan frame. Usually cultivated all over India up to Mean sea level of 250 m. It is generally used for small kids toy and internally material.
2) *Bambusa Tulda:* This bamboo is a native of eastern India and grows gregariously between 400 and 600 m above m.s.l. It is also cultivated in the plains and foothills of north India. It is one of the most useful bamboos. Due to its strong culms; it is used for building purposes, scaffolding and roofing; also used for general purposes, especially for mats and baskets, often for paper pulp.
3) *Dendrocalamus Giganteus:* This is the largest of the bamboos, cultivated often in northeaster parts and occasionally in other parts of our country. Indigenous to Myanmar (Burma). It is 24-35 m high and 20-30 cm in diameter. It is used for building purposes, water buckets, boxes, masts of boats, flower vases, etc. Tender shoot is of good quality for edible purposes. It is better than D. strictus for paper making.

III. LITERATURE REVIEW

Sanjeev Gill, Dr. Rajiv Kumar, bamboo can use as reinforcement. Bamboo is cheap substitute for steel because bamboo grows much faster and is renewable source after 5-6 years. Water absorption in bamboo is directly affect the strength of bamboo. Tensile strength of bamboo is good so it can be use as a reinforcement. The behavior of bamboo as a reinforcement is same as plain steel bar [1].

Pritesh Kumar Singh, Aashish Jodhani, Abhay Pratap Singh, it is been found that bamboo in the vertical position is more durable than in horizontal. Bending of bamboo can be permanently bent if heat, either dry or applied the pressure. The type of coating will depend on the seasoning material is used. A brush coat or dip coat of emulsion is useful for treatment of bamboo. Bamboo reinforced concrete beam design is similar to steel reinforcing design[6].

Anurag Nayak, Arehant S Bajaj, Abhishek Jain, Apoorv Khandelwal, Hirdesh Tiwari, bamboo can replace the timber and other material in construction work. When seasoned bamboo is used as reinforcing material it should receive a waterproofing coating to reduce swelling when in contact with concrete. Without some type of coating bamboo will swell before the concrete has developed sufficient strength. Bamboo reinforcement technique is cheaper than steel reinforcement [4].

Dr. Ashok Kumar Gupta, Dr. Rajiv Ganguly, Ankit Singh Mehra, the density of bamboo is very low which makes it very light material. Water absorption capacity is increase as increase in node. Tensile stress increase as increases in number node [7].

Chandra Sabnani, Madhuwanti. Latkar, Utpal Sharma, use only bamboo showing a pronounced brown colour. This will ensure that plant is at least three-year-old to get good strength. In any case, only a thin coating should be applied. A thick coating will lubricant the surface and weaken the bond with the concrete [5].

Ajinkya Kaware, Prof. U. R. Awari, Prof. M. R. Wakchaure, bamboo weak at node, maximum failure occur at node of the bamboo. Bamboo is weak in bond stress hence it should be treat with epoxy coating to get bond stress. Bamboo is weak in shear so it cannot used as a shear reinforcement. Tensile strength of bamboo is good so it can be used as a reinforcement in R.C.C structure for low cost housing. The behaviour of bamboo is same as the steel bar. Moisture of content of bamboo is varies according to topography [3].

I. K. Khan (2014) has conducted the experimental investigation of bamboo reinforced concrete beams. In this study we are going to compare the beams reinforced with steel and bamboo sticks of square, triangular and circular cross section. Based on the experimental results obtained load carrying capacity, deflection, flexural and shear strength of bamboo reinforced beam with square cross section is higher when compared to bamboo reinforced beam with triangular and rectangular cross section. Hence, the tensile strength and modulus of elasticity of bamboo is one half and one third of steel respectively. [2]

During the past few years, several researchers have found new materials for structural purposes in civil engineering. This section mostly defines about the natural fibre utilization as reinforcement and a convenient option for HYSD bars.

The investigation reported in International Network for Bamboo and Rattan (INBAR) (2002) suggested bamboo's advantages and disadvantages as a constructive material. The advantages of bamboo are ecological value, good mechanical properties, social and economic value, and energy consumption. The other sides, the disadvantages of bamboo are preservation, fire risk, and natural growth. [8] Amada and Untao (2001) mention that bamboo is the most effective material in construction by the superior character of bamboo such as being physically powerful, tough, and a low-cost material. Normally, the CulSm of bamboo with outer surface layer withstand strongl y to any loading with stronger fracture resistance than the node. It suggests that the fibres in the node do not contribute any fracture resistance. The tensile strength of bamboo fibres almost corresponds to that of steel. The main discovery is that the fracture properties of bamboo depend upon the origin of fracture. In the nodes, it is found that the average fracture toughness is lower than the minimum value of the entire Culm, suggesting that the fibres in the node do not contribute any fracture resistance [9].

Ghavami (1995) studied bonding and bending with bamboo in lightweight concrete. Most developing countries have several problems, and one of the main problems is housing. The housing problem has been related to lack of research in field of low-cost housing projects. Scientists, engineers, and designers need training and education for finding low cost construction and efficient plans. In additional, specialist systems for education, various information, and vitality of economy are needed.

The values of the test of compression and shear are dependent on the type of bamboo. The tensile strength is higher than the compression strength with the compressive range 12 to 53MPa. In several tests, Bambusa vulgaris schard and Dendrocalamus were researched the highest value, 141 and 124 MPa. The compression strength was observed as 40~62 MPa for specimens 120 mm length and 10 mm width. The bond test considered two types of bamboo, treatment and untreated. The treated specimens were wrapped with 1.5mm steel wire on embedded 40mm spacing and cared Negrolin-sand. In this test, treated bamboo, 0.97 N/mm2, was more effective than untreated bamboo, 0.52 N/mm2, with up to 90% improved bond stress. [10]

Ghavami (2005) coordinated reinforcement properties of bamboo in concrete. Due to growing problems in the environment, many countries recognize the importance of environmental specifications. A lot of materials used in industry are turned to nonpolluting materials such as natural sources, bamboo, water, recycled materials, and agriculture for engineering applications. To improve the bond strength between bamboo and concrete, three factor of impermeability treatments were used to the bamboo. First was the adhesion properties of the substance applied to bamboo and concrete, second was the water repellent property of the chosen substance, and last one was the topography of bamboo and concrete interface. The effective treatment of the three types was water repellent treatment with a thin layer of epoxy. [11]

Atul agarwal and Damodar maity (2009) they studied axial compression and bending test was performed on Plain, Steel & Bamboo reinforced members. As explained in there experimental program, For example, a total of 12 columns (150x150x1000mm) were casted using design mix (M20) as per IS code. These columns included 3 columns of steel reinforcement, 3 columns of plain concrete, 3 columns of untreated bamboo reinforcement & 3 columns of treated bamboo reinforcements (with varying percentage of reinforcement; i.e. 3, 5, & 8%). The load deformation curves displayed significant nonlinearity, indicating that the bamboo has the capacity to absorb energy. Failure of Columns predominately occurred in shear under compressive loading. Plain concrete and untreated bamboo columns showed brittle behaviour in which, tiny cracks occurred at the surface of the column at about 80% of maximum axial force. After reaching the maximum load, the load capacity decreased

abruptly and it finally failed in few seconds. There were no visible signs of spoiled concrete covering to warn of impending failure. Whereas in steel and bamboo reinforced columns more ductile behaviour was observed, wherein tiny cracks became visible at surface of columns firstly at 80-90% of maximum axial force. Final failure was accompanied by growing signs of cracks and spalling of concrete. Furthermore, the results, exhibited that the maximum load carrying capacity of steel reinforced (min reinforcement, 0.8%) column is nearly equivalent to that of treated bamboo (8% reinforcement) reinforced column (owing to the strength of bamboo samples). Transverse load test performed on above set of columns revealed the lateral deflection, strain characteristics and failure mode pattern of the steel, plain and bamboo reinforced columns. Hence, further analysis of results obtained, would assist in evolving comprehensive design methodology in case of reinforced columns. Bamboo concrete composite structural members can provide tailored solutions to the eco-housing initiatives at cheaper costs. The results obtained accrue the advantage obtained by the composite members when compared to standard reinforced concrete and plain concrete. However, further studies to achieve higher mechanical properties and understanding their behaviors in details would make this a reality. [12]

Efe Ewaen Ikponmwosa (Jan 2011) The tensile stress of seasoned bamboo is about 70N/mm2, about one-third of that of steel, with low ductility and a total strain of 5% compared with an average strain in steel of 12%. The use of bamboo-strip as reinforcement in concrete column increased the load carrying capacity of the column compared to unreinforced concrete. It also improves the post cracking ability of the concrete but not as pronounced as in steel reinforced column. Increase in volume content of bamboo strip reinforcement in the concrete section does not correspond to increase in the ultimate strength but only enhanced the ductility of the section. Failure mode is independent of the materials used for reinforcement but rather on the strength of the reinforcement/concrete matrix. Hence, attention should be on enhancement of the reinforcement/concrete matrix bond. The bamboo-strip reinforced column shows excessive cracking and deflection especially 12No.-strips. [13]

Harish Sakaray, N. V. Vamsi Krishna and I. V. Ramana (Jan-Feb 2012) The constitutive relationship of the nodes differs from those of inter-nodal regions. Further the nodes possess brittle behaviour and the inter-nodal regions possess ductile behaviour. The average tensile strength of moso bamboo from present study is 125N/mm2, which is half the strength of mild steel. There is no failure pattern followed by samples in tensile test. However, the samples with nodes generally failed at higher loads than those samples without nodes. The compressive strength of bamboo is nearly same as the tensile strength of bamboo and this behaviour is similar to steel.

Bond stress of bamboo with concrete is very low compared HYSD steel bars, due to surface smoothness of bamboo. Water absorption of bamboo is very high and waterproofing agent is recommended. From the test conditions, bamboo can potentially be used as substitute for steel reinforcement. As bamboo is eco-friendly material, limiting the use of steel can reduce carbon dioxide emissions. In the green building concept use of bamboo reinforced concrete may be recommendable. [14]

M.R. Wakchaure and S.Y. Kute (Feb 2011) Moisture content of bamboo varies along its topography and with seasoning period, which affects all physical and mechanical properties. It is one of the important factors in deciding the life of bamboo. The author made experimental investigations to evaluate the physical and mechanical properties of the bamboo species Dendrocalamus strictum and its utilization potential as building material may be as whole or in the split form. In the present study moisture content, specific gravity, water absorption, dimensional changes, tensile and compressive strength at different height location are worked out. The moisture content varies along the

height for green bamboo or at any time after harvesting. The top portions had consistently lower moisture content than the middle or basal at all stages of seasoning. Specific gravity on oven dry mass basis decreases from top to bottom and is independent of moisture content. Water absorption is inversely proportional while dimensional changes, tensile and compressive strength are directly proportionate to moisture content. [15]

Ali Awaludina, Viki Andriania, "Bolted Bamboo Joints Reinforced with Fibres, 2nd International Conference on Sustainable Civil Engineering Structures and Construction Materials 2014 (scescm 2014), Procedia Engineering 95 (2014) 15 – 21. In this study, connections in bamboo constructions are regarded as the weakest parts and have hindered the optimal utilization of excellent bamboo engineering properties were studied in this work. This paper discussed development of various methods of bamboo jointing, including the authors' proposal where Fibre Reinforced Plastic (FRP) in the form of sheets is used to improve the structural performance of bolted bamboo joints. The test results showed a significant increase of join slip modulus and lateral load capacity of the bolted bamboo connections due to wrapping effects when they are reinforced with FRP sheets, especially the overlap joints.[16]

Bhavna Sharma, Ana Gatóo, Maximilian Bock, Michael Ramage, "Engineered Bamboo for Structural Applications", Construction and Building materials 81 (2015) 66–73, 23rd February 2015**.** The experimental work characterizes the mechanical properties of two types of commercial products: bamboo scrimber and laminated bamboo. The study utilised timber standards for characterization, which allows for comparison to timber and engineered timber products. The results of the study indicate that both products have properties that compare with or surpass that of timber. Bamboo scrimber and laminated bamboo are heavily processed before testing. Future work includes investigating the influence of processing on the material properties. In particular, the impact of heat treatment performed on the material to achieve a caramel colour. A comparison study on natural coloured bamboo will provide better understanding of the effects of heat treatment on the strength of the material. The beam section can be optimized to take advantage of the high flexural strength to density ratio. Research on the influence of the orientation of the original board on the stiffness will also allow for further optimization. Further investigation of the influence of moisture and the density on the mechanical properties is needed to provide a foundation from which to develop design characterization factors for engineered bamboo. Additional testing of full-scale specimens would also elucidate any effects in comparison to small clear specimens, as well as allow further comparison to timber and provide an additional step forward towards construction.[17]

Humberto C. Lima. Jr, Fabio L. Willrich, Normando P. Barbosa, Maxer A. Rosa, Bruna S. Cunha, "Durability Analysis of Bamboo as Concrete Reinforcement", Materials and Structures (2008), published online on 12th September 2007. The experimental work on the bamboo species Dendrocalamus giganteus showed that the bamboo tensile strength is comparable with the best woods used in constructions and even with steel. The tensile stress Vs strain curve of the bamboo is linear up to failure. Bamboo average tensile strength is approximately 280 MPa in the specimens with node. Finally, 60 cycles of wetting and drying in solution of calcium hydroxide and tap water did not decrease the bamboo tensile strength neither the Young's Modulus.[18]

Leena Khare, "Performance Evaluation of Bamboo Reinforced Concrete Beams", the University of Texas at Arlington December 2005. This study evaluated the feasibility of the use of bamboo as a potential reinforcement in concrete structural members. To achieve this objective a series of tensile tests were conducted on three types of bamboo followed by four point bending tests of concrete beams reinforced with bamboo. The test results were compared with plain and steel reinforced concrete beams behaviour. Three types of bamboo used were: Moso (China); Solid (South America; and Tonkin (China).

Based upon the tests conducted, the following conclusions are at the forefronts:

1) The failure loads varied with the compression strength of the concrete, providing a lower failure load for lower compression strengths.
2) The beam with 4% Bamboo reinforcement produced an over reinforced failure mode.

3) The load carrying capacity of the Moso Bamboo was higher than that of Solid Bamboo. Also Solid bamboo deflected less than Moso indicating that Moso behaved in more ductile manner.
4) Tensile tests indicated that presence of nodes in Solid Bamboo samples did not affect the behaviour.
5) The constitutive relationship of the nodes differs from those of inter-nodal regions with nodes having a brittle behaviour while inter-nodal regions exhibit a more ductile behaviour
6) The waterproofing agent chosen provided poor bonding. Bond-enhancing applications should be required to strengthen the bonding between the concrete and the Bamboo.
7) The stirrups were developed using flexible Tonkein Bamboo. The size selected for stirrups was ½ in(13 mm) to obtain flexibility. This stirrups design provided small resistance to shear forces.
8) Based on the limited number of testing conducted, it was concluded that Bamboo can potentially be used as substitute steel reinforcement. However, for regions of the world that availability of steel is limited and plain concrete members are commonly being used, the use of reinforced bamboo concrete is highly recommended.
9) The breaking patterns of the tensile tests were overall inconclusive. However, there was an indication that the fracture points of the tensile samples containing nodes occurred at the nodes, which was also verified in the beam tests.
10) In general, samples failed by: (1) node failure; (2) end tap failure; and (3) failure at the vicinity of the end tap.
11) The failure load patterns of the tensile samples were overall inconclusive. However, the samples with nodes generally failed at higher loads than those samples without nodes.[19]

Pankaj R Mali, D datta et al. (2018) stated that conventional steel reinforcement is used to provide additional tensile strength and energy absorption capacity to concrete members. But conventional M.S. (Mild steel) or HYSD (High Yielding Strength Deformed) bars are heavy in weight, costly, non-renewable and un-eco-friendly material. Aiming to mitigate this concern sustainable, renewable, eco-friendly material like bamboo has been used as substitute to steel in the present work. Bamboo-concrete Bond behaviour was first studied through a series of pull-out tests.

Bond strength investigation has resulted in a unique bamboo strip profile along with a surface treatment the combination of which exhibited maximum bond strength under uniaxial loading. This new bamboo strip is further used as main reinforcement in concrete slab panels.

A total 15 concrete slab panels were fabricated and tested as per Euro code EN-1448-5 (2006).The effect of total replacement of main steel reinforcement by bamboo on the flexural behaviour of slabs in terms of load-deformation characteristics, energy absorption capacity, crack patterns and failure modes have been studied. The contribution of bamboo strips with respect to PCC in each of the BRC slab was around 1.5–2 times higher in increasing flexural strength at limited deflections and it was similar to those of conventional RCC slabs.

The overall research showed that instead of using treated plain bamboo strip, the proposed grooved bamboo strip (2%) used in concrete slab panels, improved flexural strength, energy absorption capacity, ductility and mode of failure (ductile) compared to that of PTBRC and RCC (0.3%) slab panels.[20]

Dinesh Bhonde, D.K. Parbat, U.P. Waghe et al. (2014) studied that the depletion of natural resources has expose a heavy downside of existence before following generations. Researchers are acting on replacement of typical materials of building construction with eco-friendly material for property development. Bamboo has been in use of man for numerous functions since an extended time. There are quite one thousand species of bamboos and are used for quite 1500 uses everywhere the planet. Bamboo regenerates and might be used at intervals four years, Bamboo has, therefore, no inheritable an area within the list of fabric of inexperienced technology and renewable supply. Bamboo has been used for building construction in numerous components of world. numerous techniques are developed for housing. Walls, Roofs, Trusses, Doors, Composite laminates created of bamboo are used. Bamboo may be a perennial, renewable, eco-friendly, green, quick growing natural material found in most a part of the planet. Bamboo may be a light-weight material with smart durability.

IV. DISCUSSION

Bamboo has excellent engineering properties and can be utilized for low cost housing project. It can mainly be used as reinforcement to the structure. Drawback of bamboo as construction material is its water absorption and moisture content properties. This mainly affects its strength. To reduce this effect seasoning and proper coating to bamboo should be done before using it for reinforcement. Use of bamboo as reinforcement material on damped or water submerged condition is challenging.

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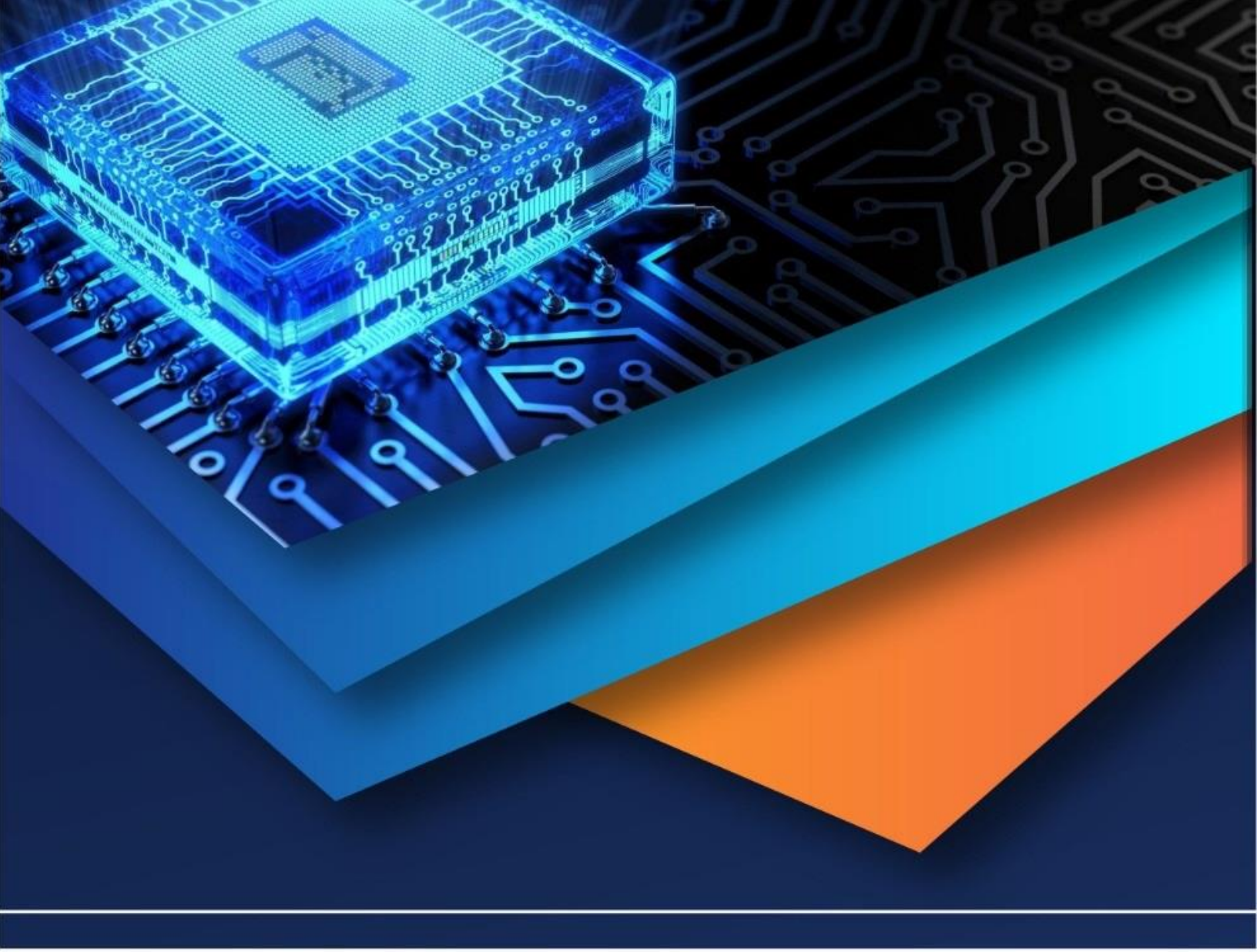

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