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Hollow Tubular Rectangular Steel Section Wrapped GFRP – A Review

J.Balavinayagam[1], N.Sakthieswaran[2], G.Shiny Brintha[3], O.Ganesh Babu[4]
[1,2,3,4]*Department of Civil Engineering*
[1,2,3,4]*Anna University Regional Campus, Tirunelveli, TN, India.*

Abstract—The feasibility study on Glass fiber reinforced plastic (GFRP) in axial strengthening of hollow square sections (HSS) is investigated in this paper, two hollow sections will be welded GFRP is used as strips form with other parameters such as the number of layers and spacing of strips. the external bonding of normal modulus GFRP strips significantly enhanced the load carrying capacity and stiffness of the hollow sections and also reduced by providing external confinement against the elastic deformation.
Keywords—GFRP, Hollow Sections, Elastic deformations, Load carrying capacity, Stiffness

I. INTRODUCTION

The structural applications of hollow square sections (HSS) in offshore structures become widespread due to its numerous advantages such as light weight, high strength, large energy absorption capacity, high Torsional rigidity, and adequate ductility to certain extents. And very recently, designers discovered its economical advantages as well, at the same time, aging and deterioration caused by exposure to the marine environment of tubular and metallic structures were often reported.

In addition to that infrastructure concerned with metallic structures were found to be structurally unsatisfactory due to overloading and deficiency in the design phase. Hence, the engineers are constrained to implement new materials and effective strengthening technique to efficiently combat this problem. From the past, the research initiatives observed that external strengthening provides a practical and cost effective solution.

The earliest investigators utilized steel plates for external strengthening. Though the technique was successful in practice, it posed some harms such as addition of self-weight, required heavy lifting equipment, difficulty in shaping and fitting in complex profiles, and complication in welding and further added plates are susceptible to corrosion which leads to an increase in future maintenance costs. In contrast, rehabilitation using Glass fiber reinforced plastic (GFRP) composites does exhibit any of these.

The GFRP composite material But the composite industry began the glass fiber reinforced plastic (GFRP) were used developed with glass fibers as the major reinforcement. And also, glass fiber was used as an insulator to prevent galvanic corrosion of metals since it is a nonconductive material Establishment had developed the Glass fiber reinforced plastic (GFRP) for special applications Unlike carbon has very high stiffness of the same order as that of the steel and behaves very well against creep deformation and relaxation. After introduction of materials in construction industry, a second generation utilized those materials in external strengthening of structures.

The GFRP has proved to be an excellent candidate for strengthening of reinforced concrete structures because of its superior mechanical, fatigue, and in-service properties. However, research related to GFRP applications to steel structures has started quite recently and there are still few applications in practice due to uncertainties concerning the long term behaviour of these applications and the bonding between the composite materials and steel.

One of the first known studies on this topic that involved the use of GFRP laminates to repair steel structures was conducted. An epoxy adhesive was used to wrap the GFRP laminates in the tension flange of the steel beam in different configurations. High strength steel bolts were also used in an attempt to increase the load transfer to the GFRP laminates Test results indicated that more modest improvement in the elastic response was required, even though significant ultimate strength was gained.

In another investigation, studied the performance of butt-welded very high strength (VHS) steel tubes strengthened with GFRP fabrics under axial tension. Three types of epoxy resins with different lap shear strengths were used. Three kinds of failure modes such as adhesive failure, fiber tear, and mixed failure were observed. The above investigation concluded that a significant strength can be achieved using GFRP-epoxy-strengthening technique and they also recommended a suitable epoxy adhesive for strengthening of VHS steel tubes.

Investigated the effectiveness of an ultrahigh modulus and high modulus GFRP prepreg in strengthening the artificially degraded steel beam of rectangular cross-section under four-point loading by using two different wrapping configurations. The beam containing the ultrahigh modulus GFRP failed when the ultimate strain of the Glass fiber reached the pure moment region. In addition, the failure load exceeded the plastic collapse load of the undamaged beam.

The beams strengthened by using the high modulus GFRP exhibited ductile response leading to very high deflections even after higher ultimate load was reached.

Investigated the materials for the rehabilitation of tubular steel structures for underwater applications. seven tubes were wrapped with GFRP,Two specimens steel tubular were welded.

Presented the results of axial compression and bending tests of fire-damaged steel tubes wrapped Glass fiber reinforcement plastic(GFRP) repaired using,square specimens will be tested to investigate the repair effects of GFRP on them. The test results showed that the load-carrying capacity and the longitudinal stiffness of GFRP-repaired GFST stub columns increased while their ductility decreased with the increasing number of GFRP layers. And also it was recommended that appropriate repair measures should be taken in repairing severely damaged GFST beams or those members subjected to comparatively large bending moments.

In another study, exposed GFST beam columns The test results revealed that the fiber jackets enhanced the load-bearing capacity to some extent, while the influence of GFRP repair on stiffness was not apparent studied the plastic mechanism analysis of un stiffened steel I-section beams strengthened with GFRP composites. The GFRP were added with the specimens on the tension flange and with some specimens on both compression and tension flanges and some were bonded onto the whole section including the web. The results showed that the strength enhanced was for the specimens strengthened on both compression and tension flanges whereas it was in the case of specimens on tension flange only.

Recently experimental and numerical investigations on the structural behaviour of steel I-beams flexural strengthened by GFRP strips numerically investigated the behavior of steel tube strengthened with GFRP plate and the effect of strengthening length. The load-deflection series of experiments to evaluate the bond characteristics between ultrahigh modulus (UHM) GFRP wrapped of steel by double strap joints.

Different adhesives were used in order to compare their effectiveness when used for bonding UHM GFRP with steel, theoretical models were employed for the prediction of bond strength and effective bond length. The simulation results agreed well with experimentation under ultimate load, load extension curves, and bond-slip relationship examined the bond characteristics between GFRP fabrics and steel plate joints under impact tensile loads.

Different numbers of GFRP layers with different bond lengths were investigated. Experimental findings revealed that the effective bond length is insensitive to loading rate for both joints and in addition the maximum improvement in joint capacity investigated the fatigue performance of tensile steel/GFRP double shear lap joints. Fatigue tests were performed on specimens under constant stress range loading cycles. The debonding of fiber was observed at stress concentration zones and propagated along the GFRP/adhesive interfaces,from the past research, it can be observed that there have been investigations done with the use of GFRP fabrics as a strengthening material for metallic members and also the presence of GFRP significantly enhanced the structural behaviour of steel tubular members.

However, research related to strengthening of hollow sections using GFRP strips composites is not widespread and also more experiments are required to derive an optimal combination of fiber orientation, number of layers, and sequence in applying GFRP layers, The main objective of the investigation is to experimentally investigate the suitability of Glass fiber reinforced plastic strips in strengthening the steel tubular members under compression and also compare the effectiveness of geometric shapes (i.e., wrapping scheme) of the upgrading material. To eliminate the galvanic corrosion between steel tube and GFRP fabrics, a thin layer of glass fiber mat was introduced between them.

II. REVIEW OF LITERATURE

M.C Sundarraja (2013), The feasibility study on carbon fiber reinforced polymer (CFRP) fabrics in axial strengthening of hollow square sections (HSS) was investigated in this paper. CFRP was used as strips form with other parameters such as the number of layers and spacing of strips. Experimental results revealed that the external bonding of normal modulus CFRP strips significantly enhanced the load carrying capacity and stiffness of the hollow sections and also reduced the axial shortening of columns by providing external confinement against the elastic deformation. The increase in the CFRP strips thickness effectively delayed the local buckling of the above members and led to the inward buckling rather than outward one. Finally, three-dimensional nonlinear finite element modeling of CFRP strengthened hollow square sections was created by using ANSYS 12.0 to validate the results and the numerical results such as failure modes and load deformation behaviour fairly agreed with the experimental resul.

B. Nur Hafizah & M.Jamaludin (2010), In this paper they studied the behavior of treated and untreated kenaf fibers. The Fibers were treated using 5% solution of sodium hydroxide. A number of 45 samples of fibers were prepared to determine the diameter and physical feature of fiber under SEM (Scanning Electron Microscope) with 30 times magnification. The average fiber tensile strength and Young's modulus for untreated fibers was 129 MPa and 12152 MPa, respectively while the average fiber tensile strength and Young's modulus for treated fibers was 108 MPa and 13281.36 MPa, respectively.

M.A.A Saafan (2006), Investigated the efficiency of GFRP composites in strengthening simply supported reinforced concrete beams designed with insufficient shear capacity. A total number of 20 singly reinforced concrete beams (100×150×1050 mm) were cast. six control beams without strengthening. six control beams with flexural strengthening. eight beams with different schemes of shear strengthening. successive layers of a woven fiberglass fabric were bonded along the shear span to increase the shear capacity and to avoid catastrophic premature failure modes. The results indicated that significant increases in the shear strength and improvements in the overall structural behavior of beams with insufficient shear capacity could be achieved by proper application of GFRP wraps.

A. Khalifa. et.al (2000), studied the shear performance and the modes of failure of reinforced concrete (RC) beams strengthened with externally bonded carbon fiber reinforced polymer (CFRP) wraps. The experimental program consisted of testing twenty-seven, full-scale, RC beams. The variables investigated in this research study included steel stirrups (i.e., beams with and without steel stirrups), shear span-to depth ratio (i.e., a/d ratio 3 versus 4), CFRP amount and distribution (i.e., continuous wrap versus strips), bonded surface (i.e., lateral sides versus U-wrap), fiber orientation (i.e., 900/00 fiber combination versus 900 direction), and end anchor (i.e., U-wrap with and without end anchor). The tests results described in this study indicated that the strengthening technique based on externally bonded CFRP composites can be used to increase significantly shear capacity of RC beams, with efficiency that varies depending on the test variables. For all beams included in this experimental program, results show that an increase in shear strength of 22 to 145% was achieved.

S.Tara & H.N.Jagannatha Reddy (2013), In this study, the woven sisal FRP sheets were bonded on the surface of the RCC (reinforced cement concrete) beam specimens and the strengthened specimens were tested under a two-point bending configuration for their ultimate shear strength. The beams in group A were designed as controlled specimen (ConS1,ConS2), where no FRP application was carried out, the beams in group B were designed to investigate the effect of full wrapping technique 900(3 sided U wrap), for shear strengthening provided by using sisal FRP(SS1,SS2), and the beams in group C were designed to investigate the effect of strip wrapping technique 900 (3 sided U wrap) where 50% of the total area was used for strengthening, i.e. 62mm strips placed at 124mm C/C at a clear gap of 49mm at the ends, for shear strengthening provided by using sisal FRP(SS3,SS4). The tensile test showed that thermally conditioned woven sisal FRP composite had higher tensile strength value of 223 N/mm2 as compared untreated or raw woven sisal fibre reinforced composites, which had a tensile strength value of 205 N/mm2.The flexural test also, showed that thermally conditioned woven sisal FRP composite had higher flexural strength value of 350 N/mm2 as compared to untreated or raw woven sisal fibre reinforced composites, which had a flexural strength value of 311 N/mm2. The use of natural woven sisal FRP was very effective in the case of shear strengthening of reinforced concrete beams. The ultimate shear strength of all the strengthened beams increased with the increasing width of the FRP, as strip wrapping showed lesser load carrying capacity than full wrapping.

A. Khalifa et.al (1999), carried out the test of three simply supports RC T-beams to study the effectiveness of anchorage of surface mounted FRP reinforcement. The first beam was a reference beam, the second beam strengthened with CFRP without end of anchor and the last beam strengthened with CFRP with end of anchor. The anchor system, called U-anchor used GFRP bar inserted in the groove in the beam flange used as end anchor. They found that the shear capacity increased when strengthened with CFRP but, failure was governed by debonding of CFRP when CFRP was used without end anchor. However, the specimen where the anchor was used, shear capacity of the member rather increased and, ultimately no FRP debonding was observed

B.B.Adhikary et.al (2004), carried out the tests of eight simply supported RC beams strengthened for shear with CFRP sheet using two different wrapping schemas; U-wrap and two sides of the beam. He investigated the effectiveness of cross plies one over another, vertical and horizontal; the main parameter, direction of fiber alignment (90°,0°and 90°+0°) and number of layers (1 and 2). They observed that the maximum shear strength was obtained for the beam with full U-wrapped sheets having vertically aligned fibers. Horizontally aligned fibers also showed enhanced shear strengths as compared to beam with no CFRP. On the other part, they found that the lowest concrete strain was the same load range among all beams. The beam with full U-wrapping of a single layer of CFRP with vertically aligned fibers, was observed at a maximum of 119% increase in shear strength. Also, they compared with the experimental value, using models for the prediction of shear contribution of sheet to shear capacity of CFRP bonded beams.

R.Al-Amery & R.AL-Mahaidi (2006), tested six RC beams; having various combinations of CFRP sheet and straps in addition to an un-strengthened beam, as control test. CFRP provided (CFRP sheet for flexural strengthening and CFRP straps for shear strengthening or with a couple of CFRP sheets and straps, for overall strengthening. From the experiment, two beams were tested in four-point bending over a total span of 2300 mm and a shear span of 700 mm, while the rest RR3-RR6 were tested in three points bending over a total span of 2400mm and shear span of 1200 mm. The CFRP sheets consisted of three layers, while CFRP straps consisted of one layer and extra anchorage mechanism for the CFRP sheets. They observed that the used of CFRP straps significantly reduced the interface slip between the CFRP sheets and the concrete section. CFRP straps used to anchor the CFRP sheets, increased in flexural strength of up to 95%. However, with the use of CFRP sheets alone, only an increase of 15% was achieved. Test results and observations showed that was a significant improvement in the beam strength was gained due to the coupling of CFRP straps and sheets. Furthermore, a more ductile behaviour was obtained as the debonding failure was prevented.

O.Anil (2006), Improved the shear capacity of RC T-beams using unidirectional CFRP composites and compared between the experimental and analytical used ACI Committee report. He tested six beams of sizes; 120mm width 360mm depth 1750mm length and 75mm flange thickness. Of these, two beams were control specimen and four beams were strengthened with different configurations of CFRP strips, all these beams were tested under cyclic loading. These beams had longitudinal reinforcement and no stirrups for beams except one of the control beam. The parameters of this case were; 1) CFRP orientation of CFRP and , 2) spacing of CFRP was 285 and 143mm, 3) CFRP strengthened scheme was both sides and U-wrap, 4) different compressing strengths were used and 5) anchorage was used as steel plates on both sides and (L-shaped). From the results, he observed that the stiffness of the beams were very close. He also observed that the strength and stiffness of the specimens improved by using CFRP unidirectional. On the other side, the analytical shear load capacity showed 20% less than the experimental shear load capacity, due to using the successful performance of anchorage.

F.Bencardino et.al (2007), presented an experimental and analytical investigation on the shear strengthening of reinforced concrete rectangular beams wrapped with carbon fiber reinforced polymers (CFRP) laminates. A total of four beams were specifically designed, with and without an external anchorage system. The cross sections of 140mm x 300mm with total length of 5000mm were used. The specimens were two control beams with different av/d, one beam with only CFRP and one beam with CFRP + external links. All beams had identical internal reinforcement and were tested under four point bending over an effective span of 4800 mm and no in the shear span but had stirrups in the near of support. The principle variables included external anchorages, with different lengths in the mode of U-shaped steel stirrup. The results showed the anchorage system enhances the strength and deformability properties of the CFRP plated beam. Also, the anchorage system modifies the failure mode of the strengthened RC beam under predominant shear force, without increasing the load capacity, to a more ductile failure with a substantial increase of load carrying capacity to almost a flexural failure.

J.Jayaprakash et.al (2008), did an experimental investigation on shear strengthening capacity and modes of failure of pre-cracked and non-pre-cracked RC beams bonded externally with bi-directional Carbon Fibre Reinforced Polymer (CFRP) fabric strips. Twelve RC T- beams were fabricated with different internal longitudinal and shear reinforcements. These beams were subjected to two types of loading; namely three-point and four-point bending systems. The beams were classified into three categories namely; control, precracked-repaired and initially strengthened (i.e. non-precracked) beams. The overall increase in shear enhancement of the precracked-repaired and initially strengthened beams ranged between 13% and 61% greater over their control beams. It was found that the application of CFRP strips in the pre-cracked-repaired beams attained better performance as compared to the initially strengthened beams. It was also observed that all strengthened beams failed in premature flexural failure due to the presence of excessive amount of shear reinforcement.

J.Jayaprakash et.al (2008), conducted tests to study shear capacity of pre-cracked and non- pre-cracked reinforced concrete shear beams with externally bonded bi-directional CFRP strips. The experimental program consisted of six specimens that were classified into two categories; namely BT and BS, each category had eight beams, four control beams, six pre-cracked/repaired beams and six initially strengthened specimens. The rectangular beam had a dimension of 2980mm length, 120mm wide and 310mm depth. The variables investigated within this program included longitudinal tensile reinforcement ratio (= 1.69) for 20mm and (= 1.08) for 16mm, no steel stirrups, shear span to effective depth ratio (av/d=2.5 and av/d =4), spacing of CFRP strips (80 mm @ 150 mm c/c and 80 mm @ 200 mm c/c) and orientation of CFRP strips (0/90 deg and 45/135 deg) in 3 sides U- wrap schemes. From the results, they observed that the external CFRP strips act as shear reinforcement similar to the steel stirrups. They also showed that by increasing the amount of longitudinal tensile reinforcement ratio and spacing of CFRP strips, affect the shear capacity. This study found that the orientation of CFRP strips not only affects the cracking pattern but also affects the shear capacity.

A.Godat et.al (2010), studied to obtain a clear understanding of size effects for Carbon Fiber-Reinforced Polymer (CFRP) shear-strengthened beams. Their experimental research presented here, investigated the shear performance of rectangular reinforced concrete beams strengthened with CFRP U-strips as well as one completely wrapped with CFRP sheet. Seven rectangular RC beams were grouped into three test series, three control beams, three beams with U-Shaped CFRP jacket and beam with completely wrapped external CFRP sheets. The cross sections were; first series 100mmx200mm with length 900mm, second series 200x400mm of length 1800mm and third series 300mmx600mm with beam length 2700mm. All beams were heavily reinforced in bending, no steel stirrups were installed in the right shear span of interest but in the left shear span,it was placed to ensure that the failure would occur in the shear span of interest. From these results, they observed that the larger beam size, CFRP sheet provided less improvement in the shear capacity. They investigated the cracking behaviour of these specimens. Their research presented a Comparison between Test Results and Predictions from Design Guidelines.

A.I.Bukhaari et.al (2010), studied the shear strengthening of reinforced concrete beams with Carbone Fiber Reinforced Polymer (CFRP) sheet. Seven, two span continuous reinforced concrete (RC) rectangular beams. The cross section of rectangular was 152mmx305mm and beam length 3400mm. One beam was un-strengthened (control beam)and, the remaining six were strengthened with different arrangements of CFRP sheet. They studied orientation of fiber (0/90 and 45/135) as main variables. The tests showed that it is beneficial to orientate the fibres in the CFRP sheet at 45 so that they are approximately perpendicular to the shear cracks.

H.K.Lee et.al, (2011), investigated the behaviour and performance of reinforced concrete (RC) T-section deep beams strengthened in shear with CFRP sheets. A total of fourteen reinforced concrete T-section deep beams were designed to be deficient in shear. The cross section of 180mmx460mm with flange thickness of 100 mm and the beam’s length of 1800mm, were used. The specimens were reinforced with longitudinal steel and stirrups near the mid-span. They also studied variables such as strengthening length, fiber direction combination of CFRP sheets, and an anchorage using U-wrapped CFRP sheets, these variables have significant influence on the shear performance of strengthened deep beams. Their tested Experimental results T-section beams were regarded as deep beams, since the shear span-to-effective depth ratio (a/d) was 1.22. On the other hand, Crack patterns and behaviour of the tested deep beams were observed during four-point loading tests.

M.Andressa Cecília et.al (2011), In this paper they studied the tensile behavior at four composites: dry sisal/polyurethane, humid sisal/polyurethane, dry sisal/phenolic and humid sisal/phenolic resin. The moisture content influences of sisal fibers on the mechanical behaviors were analyzed. Experimental results showed a higher tensile strength for the sisal/phenolic composites followed by sisal/polyurethane, respectively. In this research, sisal composites were also characterized by scanning electron microscopy. Tensile strength at yield of polyurethane based on castor oil is 2.5 MPa with a correspondent elongation at 29%, which characterize a ductile behavior.

Phenolic resin behaves as a fragile material. This material presents a tensile strength at yield of 4.9 MPa and an elongation of 0.13%. After polymerization, it was observed a great volumetric retraction on the specimens. It was possible to verify the existence of heterogeneity into the sample by scanning electron microscopy. Thermal treatment on the PU/sisal laminates it was not suitable to application of this material as structural reinforce when is considering its tensile behavior, but thermal treatment of sisal is indicated to phenolic/sisal laminates because the treatment causes a decrease to standard deviation on the tensile strength and increases this elongation. Phenolic/sisal fiber laminate presents the biggest tensile strength (25MPa) followed by PU/sisal laminates (17MPa).

III. CONCLUSION

Hollow square tubular rectangular steel strength is increase. two hollow square tubular section welded ,GFRP is used wrapped on hollow square tubular section .GFRP strip significantly enhanced the load carrying capacity and stiffness of hollow section and also reduced by providing external confinement against the elastic deformation

REFERENCES

[1] M.C.Sundarrajan P.Sriram & G.Ganesh Prabhu, (2014), “Strengthening of Hollow Square Section Under Compression Using FRP Composite.”

[2] B. Nur Hafizah and M.Jamaludin, (2010), “ Tensile behavior of the treated and untreated kenaf fibers.”

[3] M. A. A. Saafan,(2006), “Shear Strengthening of Reinforced Concrete Beams Using GFRP Wraps”, Acta Polytechnica Vol. 46

[4] A.Khalifa, W.J.Gold,& A.Nanni,(2000), "Contribution of Externally Bonded FRP to Shear Capacity of Flexural Members" ASCE-Journal of Composites for Construction, Vol. 2, No.4, pp. 195- 203.

[5] S.Tara and H.N.Jagannatha Reddy,(2013), “Efficiency of thermally conditioned sisal FRP composite on the shear characteristics of reinforced concrete beams”, International journal of Innovation, Management and Technology, Vol.3.

[6] A.Khalifa, T.Alkhrdaji, & A.Nanni, (1999), Anchorage of Surface Mounted FRP Reinforcemen.Concrete International: Design and Construction, Vol. 21,

No.10, pp. 49-5.

[7] B.B.Adhikary, M.ASCE, & H.Musuyoshi,(2004), "Behavior of Concrete Beams Strengthened in Shear with Carbon-Fiber Sheets". Journal of Composites for Construction Vol. 8, No.3, pp. 258-264.

[8] R.Al-Amery,&R.Al-Mahaidi,(2006), "Coupled Flexural-Shear Retrofitting of RC Beams using CFRP straps".13th Intenational Conference of Composite Structures, Melbourne, Australia. . Composite Structures 75, pp. 457-464.

[9] , O.Anil,(2006), "Improving shear capacity of RC T-beams using CFRP composites subjected to cyclic load". Cement & Concrete Composites 28, pp. 638–649

[10] F.Bencardino, G.Spadea,& R.N.Swamy,R.N,(2007), "The Problem of Shear in RC Beams Strengthened with CFRP laminates". Composite Structures 21, pp. 1997-2006.

[11] J. Jayaprakash, A.A.AbdulSamad, & A.A.Ashrabov,(2008), "Experimental Investigation on Shear Resistance Behaviour of RC Precracked and Non-Precracked T-Beams using Discrete CFRP Strips". International Journal of Integrated Engineering" (Issue on Civil and Environmental Engineering) pp.1-15

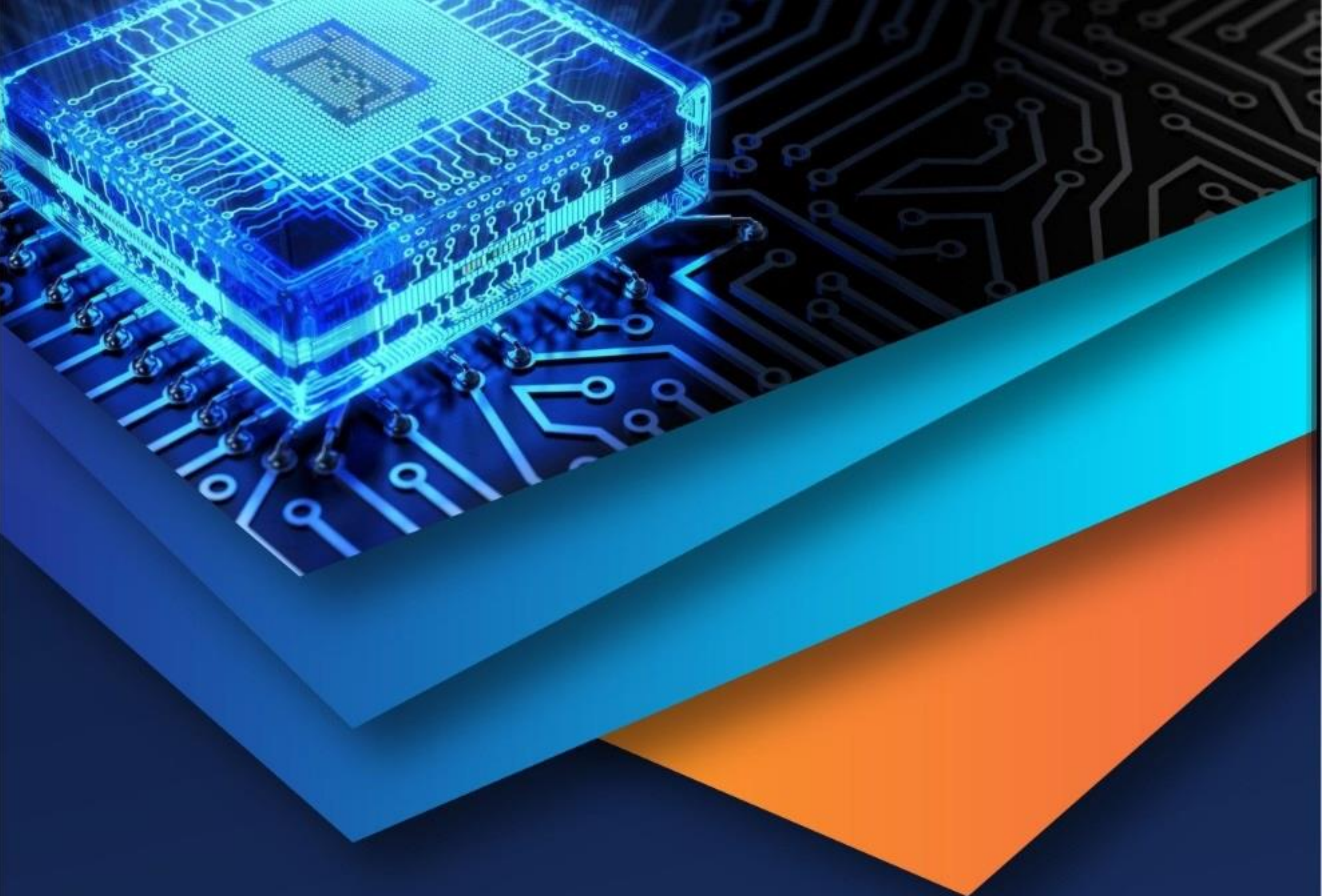
[12] J. Jayaprakash, A.A. Abdul Samad,& A.A. Ashrabov Abbasovich, (2008). "Shear Capacity of Percracked and Non- Percracked Reinforced Concrete Shear Beams with Externally bonded Bi-directional CFRP strips. & Concrete Composites "22, pp. 1148–1165.

[13] A.Godat, Z.X.,Labossiere, &M.ASCE,(2010), "Size Effects for Reinforced Concrete Beams Strengthened in Shear with CFRP Strips". Journal of composites for construction, pp. 260-271.

[14] A.I.Bukhari,L.R.Vollum,&S.Ahmad,(2010), "Shear Strengthening of Reinforced Concrete beams with CFRP. Magazine of Concrete Research", 62, No. 1, pp.65-77.

[15] H.K. Lee, S.H. Cheong,& S.K. Ha (2011), "Behavior and performance of RC T-section deep beams externally strengthened in shear with CFRP sheets". Composite Structures pp. 911–922

[16] M.AndressaCecilia, O.Maria & C.Herman Jacobus,(2011), "Mechanical behavior of natural fiber composites", Procedia Engineering, vol. 10, pp. 2022–2027.



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