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# A Review on Bond Strength of Concrete with Crushed Sand & Fly Ash

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***Abstract:*** ***This article aims to discuss the literature review on Bond Strength of Concrete with crushed sand and fly ash. We know that the Concrete is the very popular material used in the construction works. In concrete cement, sand, aggregate etc. are the main constituents. Also the Concrete is most widely used construction material in civil engineering industry because of its good structural strength, stability, and malleability. Recent technological developments have shown that all these constituents can be used as valuable organic and inorganic resources to produce various useful valuable products. We know, in India the conventional concrete is produced using natural sand which is excavate from river beds as fine aggregate. But Decreasing the natural resources poses the environmental hazards and hence government restriction on this sand. Quarrying result shows the scarcity problems and increase the material cost significantly. Excavating sand, from bed of river in excess quantity causing environmental issue. The deep pits dug in the bed of river, affects the ground water level of land. In order to solve all this issue and to fulfil the requirement of fine aggregate, some alternative material must be found. The easiest and cheapest way of getting alternative for natural sand is obtained from natural stone Quarry. Crushing this natural stone and obtained sand is known as crushed sand.***

***Keywords: Bond Strength, Compressive strength, Natural sand, crushed sand, fly ash, etc.***

## I. INTRODUCTION

### *A. General*

We know that the Concrete is the most widely used material in all construction works. The binding material used for concrete works is Portland Cement. The consumption of concrete is more due to this increase of construction and infrastructure cost. The infrastructure works in countries such as India and japan increase the demand of concrete, and hence all countries and concrete industry is continuously looking for alternative material with the objective of reducing the environmental hazards. Excavating sand from bed of river in more quantity is hazardous to environment. The deep pits dug in the bed of river, affects the level of ground water. In order to solve the environmental issue and to fulfil the requirement of fine aggregate, some alternative material must be found. The easiest and cheapest way of getting alternative for river sand is obtained from stone quarries. Crushing this natural stone and obtained sand is known as crushed sand. In India High quality sand is in short supply thus this increased the cement and concrete demand. This demand can be met by partially or fully replacing river sand with crushed sand and for increase the workability of mix adding fly ash(FA)in concrete mix.

We know the bond behaviour between steel reinforcement and concrete. Also It is very critical to design the reinforced concrete structures. The Bond between the steel and concrete is the interaction of the steel bar and concrete. This attraction can be explained as the force transfer from the steel bar towards the surrounding concrete. The adhesion between steel bar and concrete is depend on surface and dimeter of steel bar. Also this adhesion depends on the condition of surface, interface frictional force and the type of concrete mix we have to used. Bond resistance between steel bar and concrete is governed by many factors such as compressive, tensile and bond strengths of concrete, the concrete cover provided to the steel bar, transverse reinforcement confinement, surface condition of the steel bar and bar geometry. The provisions of designs for reinforced concrete as a composite material used for the bond strength between the steel bar and concrete. We know the concrete member's Structural performance is depending on the bond between concrete and steel bar. Recently steel bars have been developed for use with crushed sand and fly ash based concrete. This paper studied the bond strength of concrete with crushed sand & fly as by using pull-out tests.

The literature survey related to the project bond strength of concrete with crushed sand & Fly ash was undertaken to get acquainted process adopted with the same. Technical articles published in the proceedings and other journals have been referred to determine the further scope of the work and to understand the status of each work undertaken. It has been also noted that many researches and work on Crushed sand & Fly Ash based concrete development process.

*B. Need for the Study*

It is evident from current scenario that concrete made from natural sand causing considerably environmental hazards. Natural river sand is expensive due to excessive cost of transportation from river. The deep pits dugs in the bed of river, affects the level of ground water. Need for this study is to find an substitute for river sand to solve this all this issue.

To find an alternative of natural sand

*1)* To reduce environmental problems.
*2)* To produce a price efficient product.
*3)* The Concrete with crushed sand is Workable, Stronger, Durable, Economical and Eco-Friendly.
*4)* The bond strength of concrete with the use of crushed sand & Fly ash is higher than the corresponding concrete.
*5)* To manage the waste material with cost effectiveness.

*C. Bond Strength of Concrete*

We know the bond stress is the shear stress acts at the bar interface and concrete. This stress helps in transfer of load from concrete to steel bar due to adhesion, frictional resistance and mechanical resistance between steel bar and concrete. The bond strength is depending on factors like surface condition of steel bar, bearing of ribs of steel bar, geometry of steel bar, strength of concrete and development length provided. There are two types of bonds i.e. Flexural bond and anchorage bond. The Steel bar and concrete act together by flexural bond which acts along length of steel bar. Also the bond at bar cut off point causes the slippage between steel bar and concrete is known as anchorage bond. The development length (LD) is the extended length provided to steel bar to transmit the force effectively from steel bar to concrete.

## II. LITERATURE REVIEW

An attempt has been made in this chapter to make a review of the available relevant to the topic of study. Considerable amount of literature is available on the response characteristics of Crushed sand &Fly ash based concrete. Among the study done in the field of Concrete with Crushed Sand & Fly ash, some of them are as follows:

*A.* Shyam Prakash et al. [1] studied on manufactured sand fulfill the requirement fine aggregates such as strength, workability, gradation, shape angularity. Also It is possible to produce manufactured sand in the desired grade. From literature he says that the mechanical properties of manufactured sand depend upon the source of its raw material, i.e., parent rock. Hence the selection of the quarry is very important to quality fine aggregate. He also says that the concrete mix becomes harsh with increase of manufactured sand proportion.

*B.* Priyanka et al. [2] focused on strength properties of concrete by varying water cement ratio along with varying the percentage replacement of crushed sand with river sand. To overcome this author replaced fully river sand with M-Sand. In this paper determine the concrete's strength and durability by using M-Sand as a fine aggregate and comparing with the conventional mix. Wide range of 28 days of healing are considered the design mix in the present study of M40 grade concrete with fully replacement of M-Sand have been considering for investigation. The compressive strength (cube), split tensile strength (cylinder) and flexure strength (beam) testing of concrete is done. Finally, the study concluded that the Manufactured sand concrete worked better than conventional concrete.

*C.* Saeed Ahmad et al. [3] studied on compressive strength of various mix ratios increased from 7% to 33% whereas workability decreased from 11% to 67% with increasing proportion of manufactured sand. This paper presents the results of experimental investigation of partial and fully replacement of natural sand by manufactured sand. The aim of the paper is to compare the compressive strength and workability of concrete with the used of manufactured sand and natural sand in varying proportions. The results show that concrete made with manufactured sand shows higher compressive strength whereas workability decreased with increasing proportion of manufactured sand.

*D.* Mahendra R Chitlange et al. [4] studied on addition of steel fiber to river sand and manufactured sand concrete there is a relatively increase in flexural and split tensile strength whereas there is only a marginal rise in compressive strength. All the mixes of concrete formed by replacement of river sand by manufactured sand when compared to reference mix i.e., 0% replacement, reveal higher compressive strengths.

*E.* Shwetha P C et al. [5] focused on "Experimental Study on Partial Replacement of Cement by Fly Ash with adding Glass fibre Reinforcement". Glass fibres are used as additional reinforcement of constant 0.17% by weight of cement. Here fly ash has been partially replaced with cement at 5% to 30% in the interval of 5% for determining the mechanical properties at the age of 7, 28 and 56 days. The result showed that the workability increases for fly ash concrete mix and decreases for the fly ash and

glass fibre combinational mix in the concrete. 15% FA and 0.17% GF combination seemed to give good tensile strength compared to the control mix and fly ash concrete mixes. The compressive strength of fly ash based concrete specimens is observed to be higher than the corresponding conventional concrete at 28 and 56 days. 10% FA and 0.17% GF seemed to give good flexural strength compared to the control mix and fly ash concrete mixes.

*F.* Sahu et al. [6] studied on crusher dust has a good alternative as fine aggregate in concrete construction. The crusher dust not only reduces the construction cost but also helps to reduce the impact on environment. The crusher dust from quarries, being a waste product will also reduce environmental hazards if they consumed by construction industry in large quantity. In this experiment the crusher dust confirming to grading zone II was used. There is an increase the use of manufactured sand in the field of civil engineering construction due to lack of scarcity of river sand. The study on the strength characteristics of concrete made with fine material a comparison between river sand and crushed sand is studied by B.P Hudson.

*G.* Aman Jatale et al. [7] studied on "Effects on Compressive Strength When Cement Is Partially Replaced by Fly Ash". Here they have partially replaced with 20%, 40% and 60% by weight of cement. The fly ash effect on workability, compressive strength, modulus of elasticity was studied and the concrete mix of grades M-15, M-20, M-25 with different fly ash proportions were studied, the result showed that the use of fly ash improves workability of concrete which reduces the use of admixture dosage in concrete mix. Also the modulus of elasticity of concrete using fly ash also decreases with the increase the percentage of fly ash for a taken diff. W/C ratio. The Rate of strength development of concrete at various stages is related to the diff. W/C ratio and fly ash percentages in the concrete mix. Also the compressive strength of the concrete decreases with increase in fly ash content

*H.* A.Sivakumar et al. [8] focused on usage of pelletized fly ash light weight aggregate in concrete.We know the fly ash is mostly used as a cementitious material in civil engineering industry. Fly ash aggregate is manufactured by palletization. It is an effective aggregate in concrete mix. We know that the palletization efficiency is depending on pelletizer speed, pelletizer angle and the binder type added in fly ash. In recent times, usage of artificial aggregates reduces construction costs compared natural aggregates. In future the fly ash aggregate is best alternative for the natural aggregate.

*I.* Rahall Bansal et al. [9] studied on the "Effect on Compressive Strength with Partial replacement of Fly As. In this paper the fly ash is partially replaced with cement at 10%, 20% and 30. For all the above proportions three cubes of M-20 grade of size 150 X 150 X150 mm were tested on compression testing machine. The compressive strength of these cubes were noted at the age of 7 and 28 days. Result showed that the 10% replacement of fly ash gives 20% and 50% increase in the compressive strength at the age of 7 and 28 days respectively. Also it was observed with replacement of 20% fly ash concrete compressive strength were increased by 7% and 11% as compared to general concrete cubes. In this paper seen that fly ash 23% and 25% increase the compressive strength at 7 and 28 days' period of curing.

*J.* Xin Xin Ding et al. [10] focused on long-term compressive strength of concrete with manufactured sand'. The author proposed the test on compressive strength improvement of cement through manufactured sand. The impacts of stone dust substance on compressive strength of concrete among various W/C ratios be investigated. This experiments demonstrated that substance of stone dust was under 13%, it is fundamentally affirmative connection with the long-standing compressive strength of concrete made with stone dust.

*K.* Suresh et al. [11] studied on high strength concrete by replacing the river sand by crushed sand and concluded that concrete offered good strength. Crushed sand usage significantly reduces the construction cost. Also this concrete does not include any impurities and wastages because its prepared with modern machinery's and technology. This usage overcome towards the concrete defects such as segregation, honey combing, voids, etc. The crushed sand selected on the basis of test related physical properties such as specific gravity, and bulk density.

*L.* Rajendra P. Mogre et al. [12] studied on artificial sand used as a fine aggregate. From this literature we observed that the feasible replacement of natural sand is 60 % to 80% by artificial sand. For M20 grade of concrete the percentage of crushed sand replacing natural sand increase the compressive and tensile strength by 29.44% and 5.39 % respectively. Hence artificial sand is the best alternative substitute for natural sand. The mixes with artificial sand gives better strengths than mixes of river sand due to sharp edge of the artificial sand particle. This sharp edge particle provides good bond with cement than rounded particle of natural river sand. Also the purchase cost of artificial sand is low about to 60% to 70 % that of natural river sand.

*M.* Harshlata R. Raut et al. [13] investigated on "All mixes of concrete formed by replacement of river sand by artificial sand. When this compared to reference mix i.e., 0% replacement gives higher compressive strengths. The 50% replacement offered compressive strength up to 12.18 %. In 100% replacement of natural river sand by artificial sand, the compressive strength increases up to 18.26 %, which is greater. The concrete mix becomes harsh with proportion of manufactured sand increase. This shows that the natural river sand can be fully replace by manufactured sand.

*N.* Akshay A. Waghmare et al. [14] "This experiment shows that the concrete can be done economically and eco-friendly. This experiments shows the results that the compressive strength of 100% replacement natural river sand is higher than 0% replacement. Also the compressive strength is maximum up to 60% replacement variation and then it is decreases when percentage of crushed sand is increased. But in this experimental study at 100% strength is more than 0% replacement of natural river sand. Crushed sand is popular sand as also known as machine-made sand. From this study we can say that the artificial sand has been use in engineering application of concrete with partially or fully replacing the natural river sand in concrete.

*O.* Jadhav et al. [15] studied on light weight aggregate concrete. Crushed sand is obtaining from crushing natural stone mechanically. The features of crushed sand are different than natural river sand. The crushed sand particle has uneven surface, irregular particle shape, angular edges, higher roundness. In recent Several research studies on the crushed sand is to be used as constructional constituents in civil engineering.

*P.* Goncalves et al. [16] Stated that the Manufactured Sand has been recorded by High fines content and they observed impact of high fine content on the workability of concrete. The excess amount of water is required for concrete made with manufactured sand to achieve the similar workability for the same concrete mix proportion. The compressive strength, fracture energy and higher bonding strength to reinforced bar were recorded.

*Q.* Kim et al. [17] focused on the engineering properties of Manufactured Sand. The manufactured sand are governed by raw material sources. Thus properties of manufactured sand can be changed region to region. Therefore, this study intended to identify the potential of using Manufactured Sand as fine aggregates in concrete manufacturing in concrete. In this experiment he was chosen m20 grade of concrete for the study. They represent the intermediate strength of concrete. Manufactured Sand were replaced by the natural river sand with varying proportions in concrete mixtures. The experimental investigation was undertaken to examine the physical properties of Manufactured Sand and strength of concrete.

*R.* P. Daisy Angelin et al. [19] focused on 'Durability Studies on Concrete with Manufacturing Sand as a partial replacement of fine aggregate. The current analysis about the properties of concrete i.e. workability and compressive strength of concrete. In this experiment the artificial sand at various substitution levels (0%, 20%, 40%, 60%, 80% and 100%) are used. The result had outcomes that supplanting of natural sand with manufactured sand in order of 60% deliver acceptable workability and compressive strength. The durability of the concrete was additionally found by an immersing the cubes in 5% hydrochloric acid solution.

*S.* M. Adams Joe et al. [20] focused on 'Experimental Investigation on Effect of M-Sand in High Performance Concrete'. The author had proposed the river sand was the least expensive resource of sand. The silt and clay presents in sand decrease the strength of the concrete and holds dampness property. The utilization of crushed sand reduced the cost. Since river sand does not include contaminations and wastages. The reason for this examination was explore the impact of crushed sand in structural industry. The examination is done by utilizes few tests, which is workability test, compressive test, tensile test, flexural test and bond test.

*T.* Nagabhushana et al. [21] studied on properties of concrete in which crushed rock powder (CRP) is used as a partial and full replacement for natural river sand. The auther research was conducted to study the effect of crushed rock powder (CRP) as fine aggregate in concrete mix.

*U.* Raman et al. [22] Investigate the impact of partial replacement of natural river sand with quarry dust, and cement with fly ash. Saeed Ahmad investigated the effects of crushed sand and natural river sand on the properties of fresh and hardened concrete. The durable and hardened properties of concrete using quarry dust were investigated by Siva Kumar and Prakash.

*V.* N.P. Rajmani et al. [23] studied on the usage of light weight concrete. In this experiment he made fly ash based aggregate. This aggregate was examined and found that the aggregate of fly ash is technically viable. Also the fly ash aggregates can be used for manufacturing of concrete blocks which is used in masonry structures.

*W.* T. Subramanian et al. [24] "Experimental Investigation on partial replacement of fly ash and fully replacement of natural river sand with M-Sand". The fly ash is partially replaced with 25%, 30% and 35% by weight of cement in concrete mix, after that the cubes, cylinders and beams were casted, cured and tested after 7, 14 and 28 days of curing. The result showed that the compressive, flexural and split tensile strength increases with increase in fly ash percentage for 7, and 14 days compared to normal concrete. The 28 days compressive strength, flexure strength and split tensile strength of mix were increases and reaches maximum at 30% fly ash compared normal concrete.

*X.* Shanmugapriya et al. [25] studied on the compressive and flexural strength of concrete. Thus can be improved by partial replacement of cement by silica fume and natural sand by crushed sand. The author suggested that optimum replacement of natural river sand by manufactured sand is 50%.

*Y.* Praveen Kumar et al. [26) studied on Properties of concrete made with Portland cement. The property of concrete can be improved and greenhouse gas (GHG) emissions can be reduced by replacing Portland cement with fly ash. The fly ash is a waste product obtained from thermal power stations. Also the fly Ash is used as a pozzolana in concrete and can easily use up to 15–35 percent in concrete mixes without reduction of concrete strength. Also fine particles present in M-sand and fly ash behaves like ball bearing which improves the packing of the concrete. Due to packing of mix this results in reduction of voids.

*Z.* Ayushi R. Sharma et al. [27] focused on the different property of natural river sand and crushed sand. The specific gravity of manufactured sand is 2.61 is comparable to the natural river sand. The bulk density of manufactured sand is superior to the natural river sand. Further respect to the sieve analysis, natural river sand is finer than the manufactured sand but both the materials of sands falls under the same category of zone II. The main objective of this paper is to investigate the usage of manufactured sand instead of natural river sand.

*AA.* S. Shanmugasundaram et al. [29] focused on utilization of fly ash aggregates in concrete. In this experiment the \ coarse aggregate and fine aggregates were fully replaced by aggregates made of fly ash and sand made with crushing natural stone. In this experiment the M20 grade of concrete was used. The fly ash aggregate was manufactured by mixing the fly ash with water and cement. The proportions used of fly ash and cement were 90:10, 87.5:12.5, 85:15, 82.5:17.5, 80:20 and 77.5:22.5 were tried with W/C ratio kept as 0.3. Further the concrete cubes, beams and cylinders casted and tested with the above proportions of fly ash. From study it was found that the flexural, compressive, and split tensile strength were increased for the ratio 85:15 for 7 and 28 days compared with normal concrete.

*BB.* Rafat Siddique et al. [30] Studied on “Effect of fine aggregate replacement with Class F fly ash on the mechanical properties of concrete”. In this works the fine aggregates were replaced with 10%, 20%, 30%, 40% and 50% of class F fly ash by the weight of cement. After that the compressive strength, tensile strength, flexure strength and modulus of elasticity were found out at 7, 14, 28, 56, 91, and 365 days of water curing. The result shows that the compressive, split tensile, flexural strength and Elastic Modulus of concrete specimens were found to be higher than the normal concrete specimens.

*CC.* Jayesh kumar pitroda et al. [31] studied on Experimental Investigation on Partial Replacement of Cement with Fly Ash in Design Mix Concrete. In this study the cement is replaced by fly ash in different proportions of 0%, 10%, 20%, 30%& 40% by weight of cement. In this works M-25 and M-40 grade of concrete are used. The concrete specimens were casted, tested and compared in all terms. The tests were carried out to find the physical properties of concrete for the test results. From the result we can say that the compressive strength and split tensile strength decreases with increase in fly ash content in concrete mix.

*DD.* Naik et al. [32] focused on bond strength of fly ash based concrete. The bond test was run on typical pull-out specimens as suggested by RILEM and ACI. In which for each specimen a single piece of steel reinforcing bar was set vertically into a concrete specimen. The steel bar was then pulled out of the cylinder at a rate of 0.081 in. (2 mm) per minute. The bond strength increased with the increase in fly ash up until a point. At this point about 20 percent fly ash the bond strengths are decrease. This result understanding of how bond behaves in high-volume fly ash concrete.

## III. CONCLUSION

From this experimental study we will say that utilization of crushed sand instead of natural river sand affects the compressive strength, workability and bond strength of concrete. Adding fly ash content up to 10% in concrete may be slightly increase the compressive strength and workability of the concrete. Beyond that the increase the volume of fly ash in concrete will gradually reduce the compressive strength. The concrete made with crushed sand performed better property than concrete with natural river sand. The property of crushed sand is better than that of natural river sand. We will also say that the workability is reduced with the excessive use of crushed sand and this can be maintained by adding fly ash. Thus from above results we will say that the crushed sand is the best substitute material for natural river sand.

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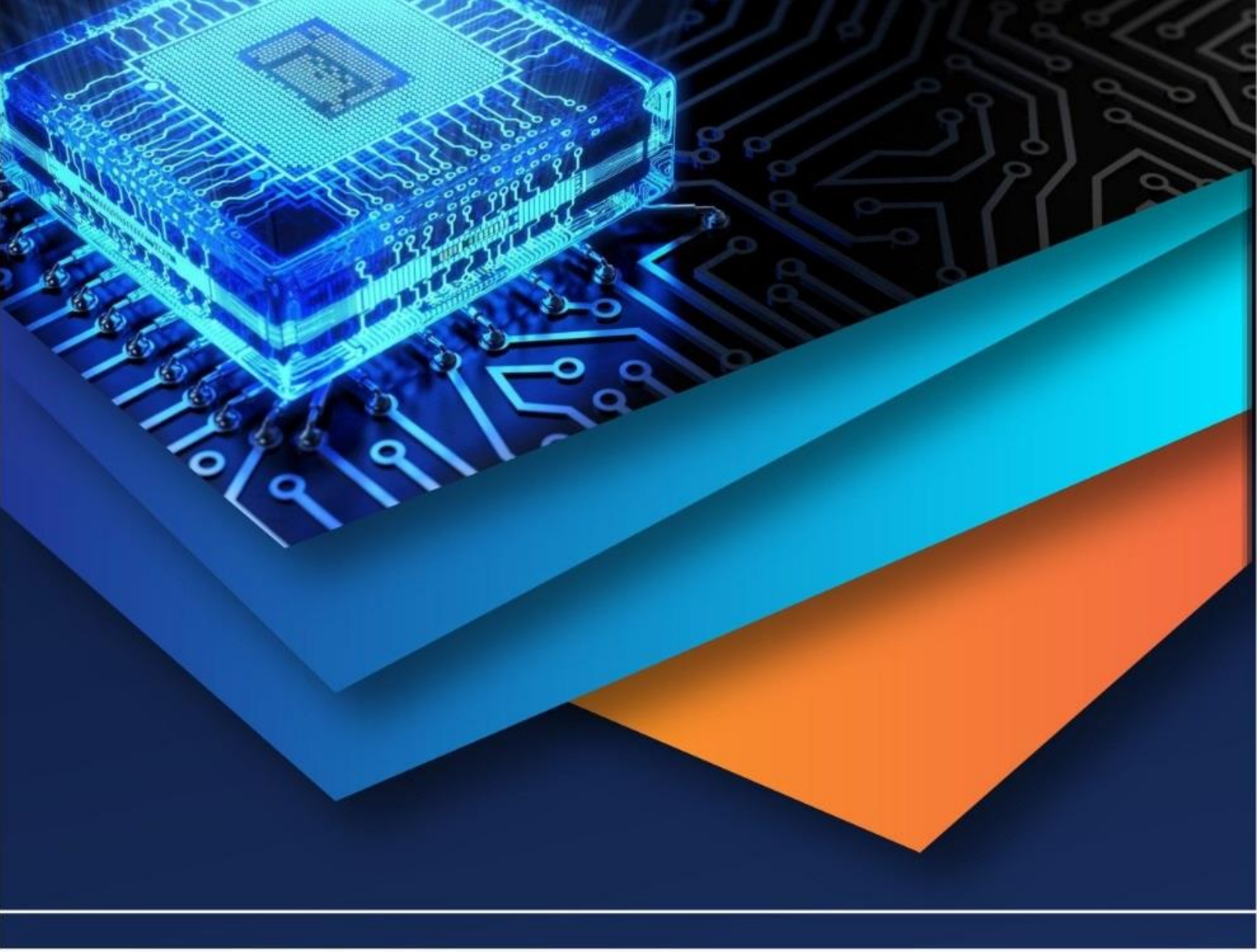

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