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Influence of Sisal Fibre on the Properties of Foam Concrete

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Abstract: Foam concrete has become most trending material in construction industry. People from construction field were come out with the mix design of foam concrete to meet the specifications and the requirement needs. This is because foam concrete has the possibility as alternative of lightweight concrete for producing intermediate strength capabilities with excellent thermal insulation, freeze-thaw resistance, high impact resistance and good shock absorption. Fibres are generally used in concrete to reduce the crackings due to plastic and drying shrinkages. They also reduce the permeability of concrete and thus reduce bleeding of water. The inclusion of fibre reinforcement in concrete can enhance many more engineering properties of the basic materials, Such as fracture toughness, flexural toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling. From the practical observations on addition of 2% of fibre gives the effective distribution of fibre in the concrete. The strain value of the concrete is decreases with increase in fibre content.
Keywords: Foam Concrete, Sisal Fibres, Properties

I. INTRODUCTION

Foamed concrete is cement-based slurry into which stable and homogeneous foam is mechanically blended, either by mixing or by injecting. When compared with normal concrete, coarse aggregate is replaced with foam in producing foamed concrete. In the late 1980's significant research and development was conducted in the Netherlands. This helped establish foamed concrete as an accepted building material. In the UK, British Cement Association (BCA) initiated research on foamed concrete in 1990. In addition to the BCA research, the recommendations for use of foamed concrete in highway reinstatement works in the Horne report and the Highways Authorities and Utilities Committee (HAUC) Specification for the Reinstatement of Openings in Highways helped increase production and broaden the scope of applications of foamed concrete in the UK in the last 20 years. Foamed concrete is now being used in a wide range of construction applications. However, in India no major project applications were found may be due to lack of awareness and confidence on the material and availability of technology.

Foamed concrete is making important contributions to sustainable construction. With the use of foamed concrete, primary aggregate consumption can be minimised, as it does not require coarse aggregate and natural sand can be replaced either partially or fully with recycled and secondary aggregates, such as construction and demolition waste, conditioned fly ash, glass fines, incinerated bottom ash and even crumb rubber that would be either difficult or uneconomic to use in conventional normal weight concrete. Furthermore, foamed concrete offers benefits such as reducing the dead weight of a structure which economises the design of supporting structures including the foundation and walls of lower floors. Foamed concrete has higher consistency due to absence of coarse aggregate and a ball bearing effect. Therefore, requires no compaction and has excellent load spreading. Foamed concrete can be used for casting into the necessary shapes and can be pumped straight to where it is required. Densities of foamed concrete can range from 300 to 1800 kg/m^3.

Foamed concrete is a material suitable for a wide range of purposes and applications such as roofing insulation, trench reinstatement, void filling, road sub-base, floor construction, sewer infilling, storm drain infilling, culvert abandonment's filling, culvert's or bridge approach, subway abandonment's filling, bridge strengthening, bridge decks, large diameter shaft and tunnel abandonment's bridge abutments, slope protection, basement infill, vault infill, pipeline infill, tank infill, fuel tank infill, swimming pool infill, raising the levels of flooring, under floor infilling, train platform infilling/re-profiling, floor and roof screeds, panels and blocks production, wall casting, complete house casting, sound barrier walls, subsurface for sport arenas, aircraft arresting beds, road crash barriers, floating barge, jetties platform, floating homes, soil stabilisation and as a semi structural material . Figure 1 illustrates few construction applications of foamed concrete.

Figure 1: Applications of foam concrete in construction industry.

II. LITERATURE REVIEW

G Indu Siva Rajini, K Ramamurthy [1] reports the performance evaluation of a sodium lauryl sulfate to qualify as a foaming agent. When new surfactants are used in an systematic study of production parameters on the foam characteristics needs to be undertaken unlike proprietary foaming agents and foam generator for which manufacturer has predefined the parameters. The relative influence of the foam parameters and optimization of factors were carried out through a systematic experiment design. The foam production parameters namely foam generation pressure and dilution ratio of foaming agents are observed to have significant effect on all foam characteristics with the exception of foam output rate on which only foam generation pressure has influence. The foam with good initial foam density need not necessarily be stable foam. The optimum levels of foam production parameters are determined for the surfactant Sodium lauryl sulfate which can be used to produce stable foam for foam concrete production.

C G Puttappa, H S Raghavendra, K U Muthu [2] presents the foamed concrete can be considered relatively homogeneous when compared to normal concrete, as it does not contain coarse aggregate phase. However, the properties of foamed concrete depend on the microstructure and composition, which are influenced by the type of binder used, methods of pre-formation and curing. Though, it has been widely recognized as an insulation material, a renewed interest is shown by researchers in its structural character exhibits. As the production involves the materials of low density: a few fillers viz fly ash, quarry dust, GGBS and sludge from paper mills are used. An attempt has been made in the present investigations to produce foamed concrete of desired density 600 kg/m^3 to 800 kg/m^3. Then their strength properties viz compressive strength, flexural strength and the resistance against sulphate attack were investigated and the results are reported.

Md Azree Othuman Mydin and Sara Soleimanzadeh [3] The impacts of volume fraction of polypropylene fibre (PF) on the bending behavior of lightweight foamed concrete (LFC) before and during exposing it to high temperature is experimentally studied. Five mixes of LFC with 600, 800, 1000, 1200 and 1400 kg/m^3 densities were made in current investigation. Then, the effect of adding PF with volume fraction of 0.1, 0.2, 0.3, 0.4, 0.45 and 0.5% on the flexural strength and pore structure of each considered density at ambient and elevated temperatures up to 600℃ was examined. The outcomes demonstrated that an increasing temperature had a detrimental influence on LFC property especially in a temperature range of 200 to 600℃ degrees in which flexural resistance was reduced by about 15 to 60% due to the micro diffusion of bound water molecules, detachment of the C-S-H gel and CH, weakness in chemical bond structure of cement paste and suppresses of the cohesive forces in the micropores. Adding PF by 0.1 0.4% of mix volume enabled LFC to resist high temperatures better than control plain concrete and the improvement percentage was directly correlated with PF content and LFC density. However, adding PF with volume fraction more than 0.4% reduced the flexural strength considerably.

Lee Yee Loon, Ahmad Mujahid Ahmad [4] the objective is to develop an environmental friendly and economical material for sustainable construction on peat. He described a four-year study showed on the rate of carbonation is related to the permeability, time and density. It features a dual-test method for the measurement of water permeability. The proposed water permeability test system and the draft standard enable the values of water permeability of a concrete as the durability performance indicator. It is to be assessed at the early stage on the standard 150 mm concrete test cube for the determination of water permeability prior to the standard test for compressive strength will provide useful information on concrete durability.

G. Ramakrishna, T. Sundararajan and S. Kothandaraman [5] in this paper natural fibre namely sisal fibres are used as reinforcement in cement matrices for producing corrugated roofing sheets has been investigated and reported. Flyash- based sisal fibre roofing sheets were cast manually and the strength of the corrugations of the above composite sheets in terms of splitting, due to direct and impact loads, were experimentally evaluated. It is found that the strength towards splitting of corrugations of the flyash based sisal fibre corrugated roofing sheets due to direct and impact loads was improved as compared to the corrugated sheets without sisal fibres. Also it is observed that flyash based sisal fibre reinforced sheets are comparable to the splitting of corrugations due to direct and impact loads of a commercial roofing sheet, available in India.

Abdul Rahuman, Saikumar Yeshika [6] The present research was designed to check the workability and strength properties of sisal fibre reinforced concrete with different mix proportions and different percentage of fibre addition. The materials were chosen to improve the various strength properties of the structure to obtain sustainability and better quality structure. Short discrete vegetable fibre (sisal) was examined for its suitability for incorporation in cement concrete. The physical property of this fibre has shown no deterioration in a concrete medium. Fibres were brushed, lined up and cut to obtain 4cm length. Degree of workability of concrete mix with 0.2% super plasticizer and water cement ratio 0.45 had good workability with slump value 53mm and compaction factor 0.88, which is effective, was obtained. Materials were hand mixed with 0.5%, 1% and 1.5% addition of fibre in M20 and M25 mix design and casted in cubes and cylinders. The obtained specimens were subjected to tests aimed to check the compressive, tensile and flexural strength. An increase in compressive strength by 50.53% and tensile strength by 3.416% was observed for 1.5% addition of fibre in M20 mix design respectively. An increase in compressive strength by 52.51% and tensile strength by 3.904% was observed for 1.5% addition of fibre in M25 mix design respectively.

III. METHODOLOGY

A. Mix proportions

There is no particular method for proportioning foamed concrete (i.e. mix design), but it is a specified target plastic density that becomes a prime design criterion. On the basis of target plastic density a theoretical mix design is to be formulated and site trials are undertaken and the results from the site trials are used as mix design for the foamed concrete. A tolerance on plastic density was considered about 100 kg/m^3 of the target plastic density. Assuming a target plastic density of 1200 kg/m^3. Since the foam concrete is in slurry form higher water-cement ratio is required so assuming W/C is 0.50 The mix proportions of the materials are as shown in the table 1 below:

Table 1 : Mix Proportions

Cement(kg/m^3)	Water(kg/m^3)	Sand(kg/m^3)	Foam(kg/m^3)
250	125	825	24

B. Generation of Foam

The generation of foam is main objective in foam concrete. The procedure may be categorized as including the steps:

1) Supplying a synthetic resinous foaming agent, in liquid form
2) Combining the foaming agent with water, to form a liquid mix, and pressurizing the mix,
3) Sub-dividing the mix into droplets, in a confined flowing stream
4) And reducing the stream confinement,
5) Whereby the droplets expand as foam.

As will be seen, the combining of foaming agent chemical with water, or aqueous fluid, typically includes pumping the mix to form the flowing stream which is pressurized, through use of a double diaphragm, positive displacement, gas or air operated pump. Such a pump incorporates certain sub-chambers for reception of air pressure to drive the pump, and other sub-chambers to receive water to be pumped, and in accordance with the invention fluid chemical metering means is provided to operate in synchronism with the pump to feed chemical to water being pumped. As will appear, the metering means may also comprise a positive displacement pump, reciprocated in response to water flow to and from the diaphragm pump, thereby to feed metered quantities of chemical in correct proportion to the water being pumped. Foam is not produced at the pump or pumps, but is produced later as air under pressure is mixed with the pre-mixed chemical foaming agent and water.

Further, the chemical and water that has been pumped at established ratios, can be kept separated and diverted to a transparent, calibrated container for visual check of exact amounts of each material, prior to discharging into the blending unit. The blending or discharging cycle is the same as the charging cycle, except the chemical, water and air are, by valve selection, pumped from the

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sight container and combined through static mixing chambers to produce the required density and volume of micro-spheres. The blending chambers contain filter elements in the range of 5 to 25 microns in fineness, i.e. size.

Further, the pressurized gas or air used for driving the pump, and exhausted from the pump, is typically recovered and used as a source of gas or air blended with the water-chemical mix, thereby to control the air to water, and chemical mix ratios for accurate and reliable production of foam productive of micro-sphere aggregates when added to concrete at the batching plant, such foam improves concrete pumpability and extrusion; it improves concrete finishing, insulation and stucco; and it enhances concrete fire proofing capability.

The foam is generated by allowing a high air pressure through the liquid mix of surfactant and water.

Figure2: Generation of Foam

C. Production of Base Mix

Separately weight the required quantity of mixing materials (sand, cement and water) separately and keep them aside. First the inner walls of the mixer should be made wet to reduce the water absorption by inner walls of mixer. Add half quantity of cement and sand to the mixer and start the mixer. Slowly add the water along the inner walls of the mixer. After some time add remaining amount of sand and cement to the mixer. Allow the mixer for few minutes to get a equivalent mix. This mix is called base mix.

*Production of Foam Mixes***:** After formation of base mix, the readily generated foam is added to the base mix within very short time and switch on the mixer and allow it to run for few minutes for efficient mix. Check the density of the mix it should be very near to 1200 kg/m^3.

D. Mixing of Fibre

The sisal fibre is mixed by cutting it into small parts of length 2-3 cms. The sisal fibre is added to the foam mix according to the desired percentages of cement weight. Here the fibre is added in the percentages as shown in below table2.

Table2: Fibre is added in the percentages

MIX	Fibre added (% of cement weight)
MIX1	0
MIX 2	0.67
MIX 3	1.33
MIX 4	1.67
MIX 5	2.00

The fibre is made separated one from the other to avoid clumsiness. That fibre is weighted and taken out the required quantity and added to the foam mix present in the mixer as shown below. The mixer is started and allowed to run for few minutes.

Figure 3(a). Production of Foam Concrete

Figure 3(b). Mixing of Fibres

E. Filling of Mix Paste Into Moulds

After collecting of desired mix, the cement paste is filled in the moulds. The lubricant should be applied to the inner walls of the moulds to free removal of specimen from the mould after hardening.

Curing of Specimens: Curing Means Taking Steps To Keep The Concrete Under The Right Temperature And Moisture Conditions During The First Few Days Of Hardening After Placement. Proper Curing Is Vital Because The Concrete Will Eventually Be Much Harder And Stronger If It Is Cured Correctly.

The hardening of concrete is not a drying process, but Rather the result of a chemical reaction between the finely ground portland cement particles and the water in the mix. This reaction is known as hydration. Like most chemical reactions, hydration is greatly influenced by temperature. The basic idea behind proper curing is to Allow This Reaction to Continue As Long As Practical by Maintaining a Suitable Curing Temperature, Usually 50°F to 90°F, And by Keeping the Concrete Wet. If The Temperature Of The Concrete Drops Below 50°F, Hydration Begins To Slow, And If The Water In The Mix Freezes, The Concrete Will Be Ruined. Also, If Too Much Water Escapes From The Concrete, Hydration Will Stop Altogether. The Longer Favourable Conditions Are Maintained, The Longer The Concrete Will Cure, Resulting In A Better Product.

Figure 4(a). Filling of paste into moulds

Figure 4(b). Curing of Specimens

IV. EXPERIMENTAL RESULTS

A. Fresh Properties

Fresh concrete is that stage of concrete in which concrete can be moulded and it is in plastic state. This is also called "Green Concrete". Another term used to describe the state of fresh concrete is **consistence**, which is the ease with which concrete will flow.

Visual observations during mixing and compaction of all the concretes suggested that the concretes were homogeneous; there was no segregation and bleeding, the mixes were self compactable. The fresh state performance of the foamed concretes was comparable with control concrete. As the formed concrete is flow able, it is difficult measure normal slump value. Therefore, the diameter of the

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slump spread was measured to assess consistency of the concrete. The slump spreads of the concretes were between 550-650mm. The slump decreased with decrease in foam percentage.
Slump Test can be used to find out the workability of concrete.

Figure 5: Slump Flow

The following table 3 shows the values of slump test, which is conducted for both base mix and foam mix

Table 3: Slump Flow values

Mix	Slump values		
	Base mix(mm)	Foam mix(mm)	Fibre mix(mm)
M1	530	550	550
M2	530	540	560
M3	500	550	560
M4	500	610	610
M5	500	580	570

A. Permeable Voids & Water Absorption: Permeable voids of the concretes are shown in Table 4. As we can be seen the permeable voids increased with increase in water absorption. Take a container and place samples in it and fill the water up to the top of container that the samples are to be completely dipped in water and weight the samples at certain intervals of time.

Figure 6: Water Absorption

Table 4: Water Absorption Values

WATER ABSORPTION TEST										
MIX		TIME								
	0 min	15 min	30 min	1 hr	2 hrs	4 hrs	20 hrs	24 hrs	48 hrs	72 hrs
	WEIGHTS (kgs)									
MIX1	1.875	1.68	1.85	2.07	2.08	2.05	2.035	2.045	2.065	2.09
MIX2	1.885	2.025	2.03	2.055	2.065	2.045	2.037	2.037	2.055	2.075
MIX3	1.43	1.655	1.685	1.71	1.705	1.655	1.625	1.645	1.69	1.73
MIX4	1.915	2.03	2.06	2.075	2.085	2.02	2.05	2.07	2.09	2.115
MIX5	2.885	2.08	2.105	1.95	2.13	2.09	2.09	2.11	2.13	2.15

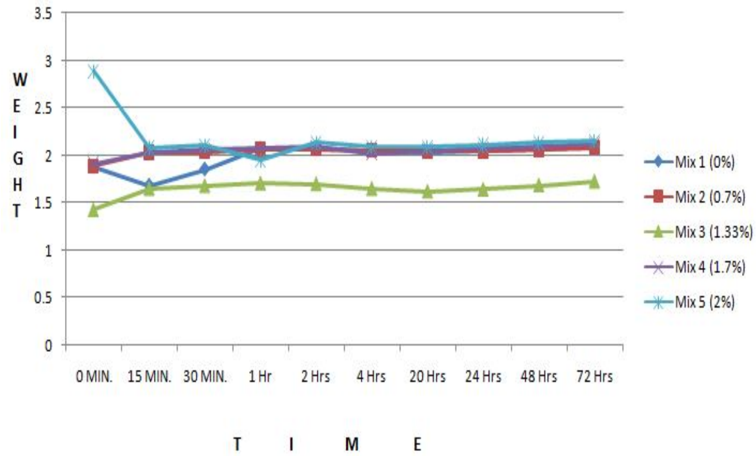

Figure 7: Time vs Weight

B. Evaporation

Take the required samples and place them in the oven maintaining 60^{o}C and take the weights of the samples at certain intervals. The fihure and tables are shown below in Table5:

Figure8 : Evaporation

Table5 : Weight of the sample after evaporation of certain time

MIX	WEIGHT ACCORDING TO TIME (Kgs)										
	0 min.	15 min	30 min.	1 hr	2 hrs	4 hrs	6 hrs	24 hrs	48 hrs	52 hrs	72 hrs
MIX1	2.025	2.01	2.007	2	2.1	1.9975	1.985	1.9475	1.935	1.94	1.867
MIX2	2.1	2.0475	2.05	2.045	2.037	2.032	2.025	1.992	1.942	1.95	1.882
MIX3	1.9	2.267	1.832	2.217	2.39	2.464	2	1.752	1.692	1.702	1.627
MIX4	2.175	2.102	2.1	2.095	2.09	2.09	2.0775	2.062	1.995	2.012	1.95
MIX5	2.175	2.117	2.1225	2.117	2.1175	2.1	2.09	2.055	1.982	1.99	1.912

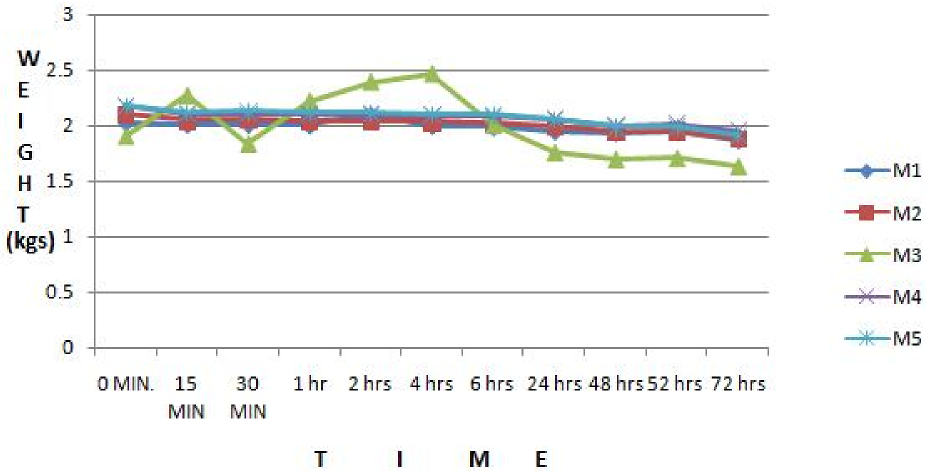

Figure 9 : Weight of the Sample Vs Time

V. CONCLUSIONS

From the brief work carried out in this investigation following tentative conclusions can be drawn.

1) From practical observations the density of foam concrete is found to be nearly same with addition of fibre.
2) Addition of 2% of fibre gives the effective distribution of fibre in the concrete.
3) From the slump values, the workability is nearly same in all the different type of mixes.
4) From M5 mix the water absorption is less compare to other mixes.
5) The fibre should be added in a limit quantity for effective mix.

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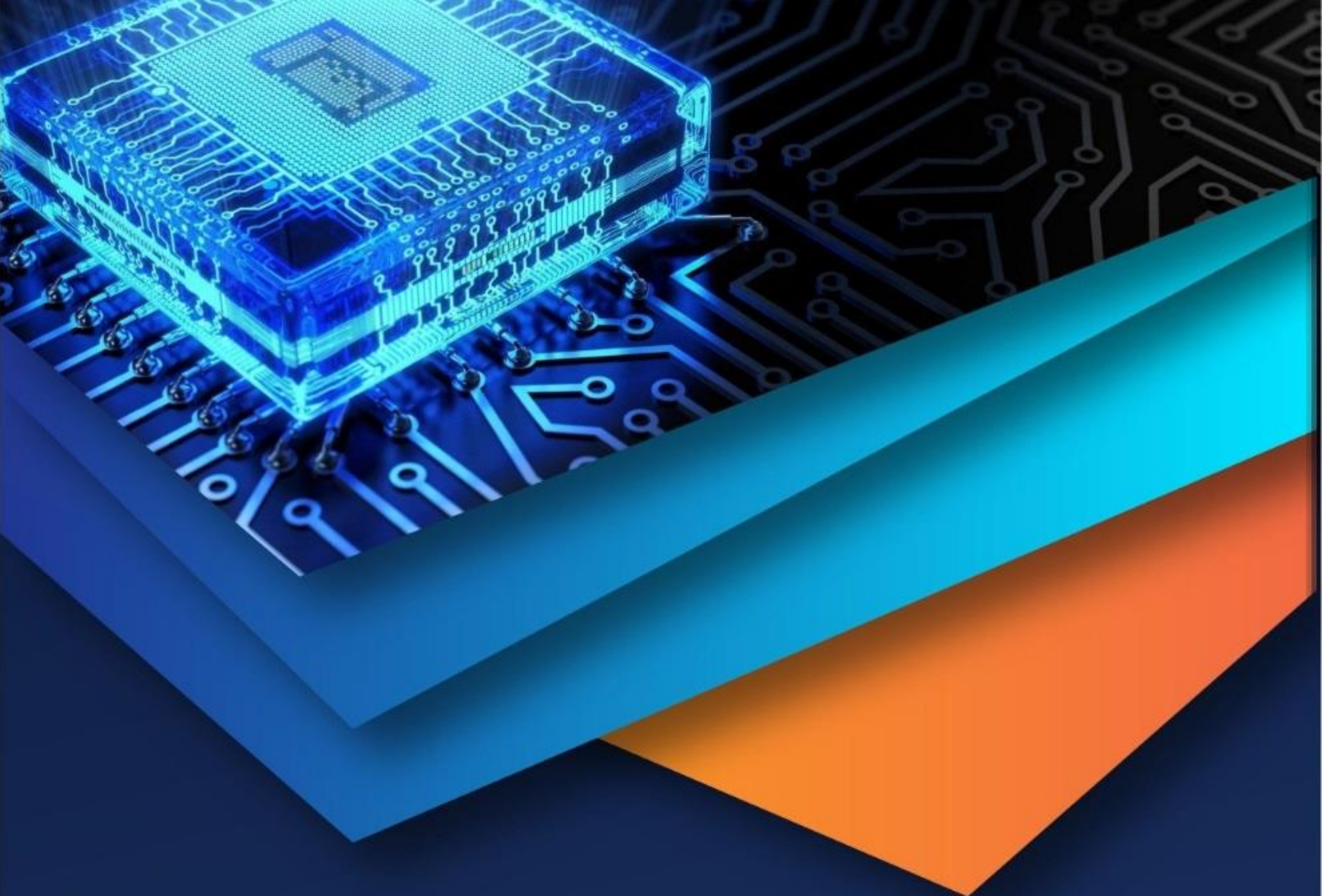

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