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Study of Combined Effect of Polypropylene Fibres and Raw Rice Husk to Enhance Insulation Property of Concrete at Elevated Temperature

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Abstract: ***Sudden high temperature exposure to concrete is one of the major concerns in building industries. When concrete is subject to high temperature excess vapour pressure developed inside, and sudden spalling may happen. In this study thermal insulation characteristic of concrete tried to improve by using raw rice husk. But it is found that rice husk affects the mechanical properties of concrete, it reduces strength, increase water absorption, increase porosity etc. So, to maintain strength of concrete additionally polypropylene fibre 2% by weight of cement (adopted from previous studies) is added in concrete. Four different samples are made and tested for workability, water absorption, compressive strength and thermal gradient test. Up to 300^{o}C samples gives desirable result and also don't lose their strength drastically. Thermal gradient has increased as percentage of raw rice husk.***

Keywords: Raw Rice Husk, Thermal insulation, mechanical properties, polypropylene fibre, elevated temperature.

I. INTRODUCTION

A. Introduction of Rice Husk

Rice husk Initiative in item advancement: Rice husk (RH) is a rural waste material abundantly accessible in paddy creating nations. They are the common scabbards that form around rice grains during their development, it gets Eliminated during the processing of rice, this husk has don't have any commercial use. Around the world, roughly 60 Crore tons of paddy is produced every year. On normal 20% of the paddy is husk by weight, giving a yearly all out creation of 12 Crore tones. An enormous amount of husk, which is a stringy material with high percentage of silica, is accessible as a solid waste from rice processing ventures. The dealing of rice husk as a "resource" for energy creation is a take-off from the discernment that husks present removal issues. Rice husk is strangely high in debris contrasted with another biomass energizes – near 20%. The debris is 92-95% silica, exceptionally permeable and lightweight, with an extremely high outside surface zone. Its retentive and protecting properties are helpful to many examinations considers.

The substance piece of the rice husk debris fluctuates from test to test which might be because of the diverse geological situation, sort of paddy, climatic circumstances and kind of manure utilized.

Anyway, it is intriguing to take note of that rice husk by and large contains 21% debris, 20% lignin, 37% cellulose, 17% pentosans and 3% dampness. Raw Rice Husk (RRH) is an overall term portraying a wide range of debris delivered from copying rice husks. By and by, the kind of debris changes impressively as indicated by the consuming strategy.

Rice husk contain primarily 15-20% silica by weight and various natural organic matters that will liberate carbon when thermally deteriorated. Thusly RRH contains two fundamental crude materials known as: SiO_2 and C, which acts as reagent for the planning of silicon carbide.

With the extremely high surface territory and personal substance accessible for the carbon and silica in RRHs, it is conceivable to shape SiC(silicon caride) at moderately much lower temperature than showed by thermodynamic and dynamic computations, furthermore , the silica in the RRH can keep up the underlying molecular formation of the RRH. Both the low thickness and the small space in the crude materials encourage the creation of silicon carbide hence RRH is one of the most efficient and hopeful crude materials for the delivering silicon carbide.

Rice husk is the shell that is produced during the refining of paddy and speaks to about 20% of the general creation. Inferable from its high energy limit, RRH has been utilized in numerous innovations, for instance, (e.g., biofuel for boiler feed, lightweight material for lightweight concrete, a protection material attributable to its low heat conductivity coefficient, and its debris as a pozzolanic ingredient of cement. What's more, RRH consists of dynamic carbon and is additionally utilized as a shading and smell remover because of its high adsorbent capacity.

B. Introduction of polypropylene fibre:

Polypropylene fibre also called polypropene is synthetic fibrous substance transformed from 85% propylene. Its is used in various industries but popularly in manufacturing industries. Researchers says that each kind of fibre has been given a shot in concrete constantly, not every one of them can be adequately and financially utilized. Each kind of fibre has its trademark properties and constraints. A portion of the filaments that could be utilized are steel strands, polypropylene, nylons, asbestos, coir, glass and carbon. Fibre is a little bit of fortifying material having certain trademark properties. They can be roundabout or level. The fibre is regularly depicted by a helpful boundary called "viewpoint proportion". The angle proportion of the fibre is the proportion of its length to its measurement. Regular viewpoint proportion goes from 30 to 150.

Polypropylene and nylon filaments are discovered to be appropriate to expand the effect strength. They have high rigidity, yet their low modulus of flexibility and higher stretching don't add to the flexural strength.

Numerous examinations have indicated that utilizing polymer strands, for example, polypropylene (PP) as an added substance in cement is an effective strategy to forestall disintegration in cement. Polypropylene strands dissolve at about a temperature 160°C and produces micro voids that permit emptying the fume, easing the inside weight inside cement and forestall hazardous spalling and loss of cross. Numerous examinations have indicated that utilizing polymer filaments, for example, polypropylene (PP) as an added substance in cement is an effective strategy to forestall spalling in cement. Polypropylene strands liquefy at about 160°C and give micropores that permit emptying the fume, easing the inward weight inside cement and forestall unstable spalling and loss of cross area.

The utilization of polypropylene (PP) fibre has been prescribed by the entirety of the analysts to lessen and dispose of the danger of the unstable spalling in HSC at raised temperatures. From the modern perspective, a measurement of 2kg/m3, a fibre length somewhere in the range of 1cm and 2cm, and a fibre width of 5cm–20cm are commonly received for forestalling current HSCs from spalling. Polypropylene fibres are created from homopolymer polypropylene sap. PP fibres effectively decline the plastic shrinkage breaking just as drying shrinkage breaking. Moreover, PP fibres improve the flexibility, sturdiness, and effect obstruction of cements. As to these preferences of the presence of PP fibres, they are effectively utilized for overlays and asphalts, sections, floor frameworks, break hindrance, precast heap shells, and shotcrete for burrow linings, waterways, and supplies. Another territory of utilizing PP fibres is concrete filled steel empty areas. As referenced before, a few scientists have announced the protection impact of PP fibres against spalling under raised temperatures. Indicated the great efficiency of PP fibres seeing spalling even at doses as low as 0.9kg/m^3. Notwithstanding, various scientists have conflictingly detailed the overall leftover strength of HSC containing PP fibres after introduction to high temperatures.

II. MATERIALS AND ITS PROPERTIES

To enhance insulation properties of concrete raw rice husk was used and polypropylene fibre compensates the loss of strength due to RRH. For this research one of the most abundant material raw rice husk is arranged from locally established rice mill and polypropylene fibre was purchased from material supplier. Portland pozzolana cement of 53 grade is used during whole experiment. A plasticizer admixture (lignosulphonate) is also used in mix design of concrete. Physical properties of composite materials given in table below: -

Table I
Physical Properties of RRH And Pp Fibre

material.	Densiy (g/cm^3)	Length (mm)	Aspect ratio	Melting piont (°C)	Water Absorption (%)
Raw rice husk	.95	8-10	25	450	120
Polypropylene	.125	18	24-30	150	–

IV. EXPERIMENTATION AND TEST RESULTS

In this paper main objective is to enhance thermal insulation of concrete by reducing thermal conductivity of concrete. To do so raw rice husk (RRH) is added to concrete mix which act as a hydrocellulose aggregate. The raw rice husk was used at three different dosages, i.e., 1.5, 3, and 5%. Although addition of RRH slightly decreased the mechanical properties of the concrete. Therefore, polypropylene (PP) fibre has also been added to maintain the strength PP fibre also helps to avoid sudden spalling of concrete at high temperature.

When concrete is subjected to elevated temperature internal stresses increased in the form of excess vapour pressure (when temperature rises structural water evaporated and try to expel out from the pores) due to this excess vapour pressure concrete may suddenly spall. PP fibre melted at range of 160-180^{o}C. This phenomenon provides a porous interconnected passage to escape excess vapour pressure. The amount of PP fibre added to concrete mix is decided from the test results of previous studies, it can be concluded that the addition of 2kg/m^{3} PP fibre can significantly promote the residual mechanical properties of during heating. The lower and higher dosages of fibre generally showed worse performance due to more deteriorations and higher volumes of voids, respectively [19].

In this study slump test, water absorption test and compressive strength test were performed, and thermal insulation property is checked by direct heat method. Since workability is high so slump test is used (as per IS 1199-1959). compressive strength test performed on 150 mm cube as per IS 516-1959 standards. Three specimens are tested in each combination of materials.

A. Test Results are given Below

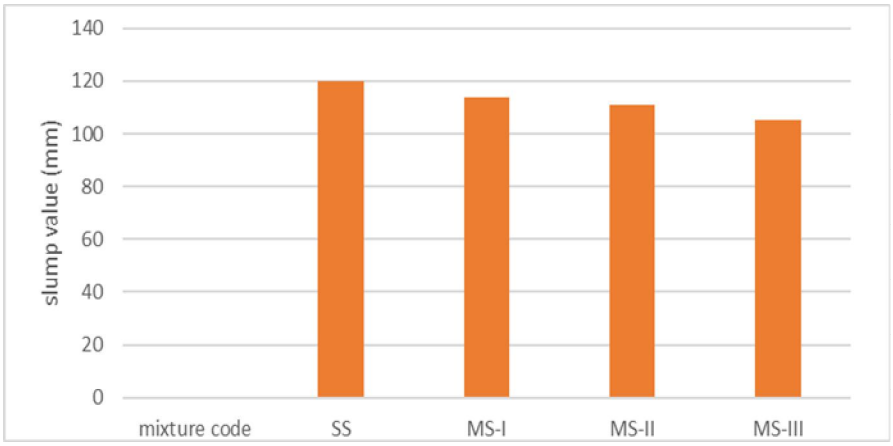

Fig. 1 Bar chart of Slump test values

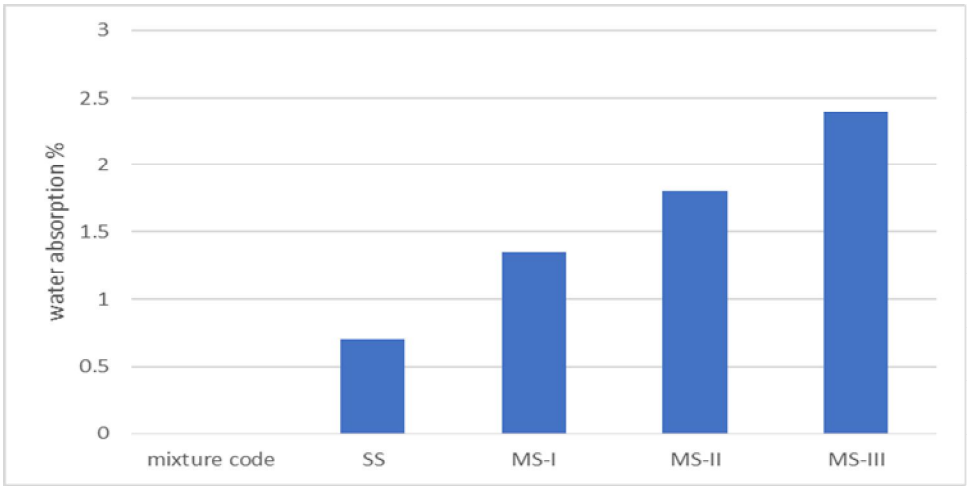

Fig. 2 Bar chart of water absorption values.

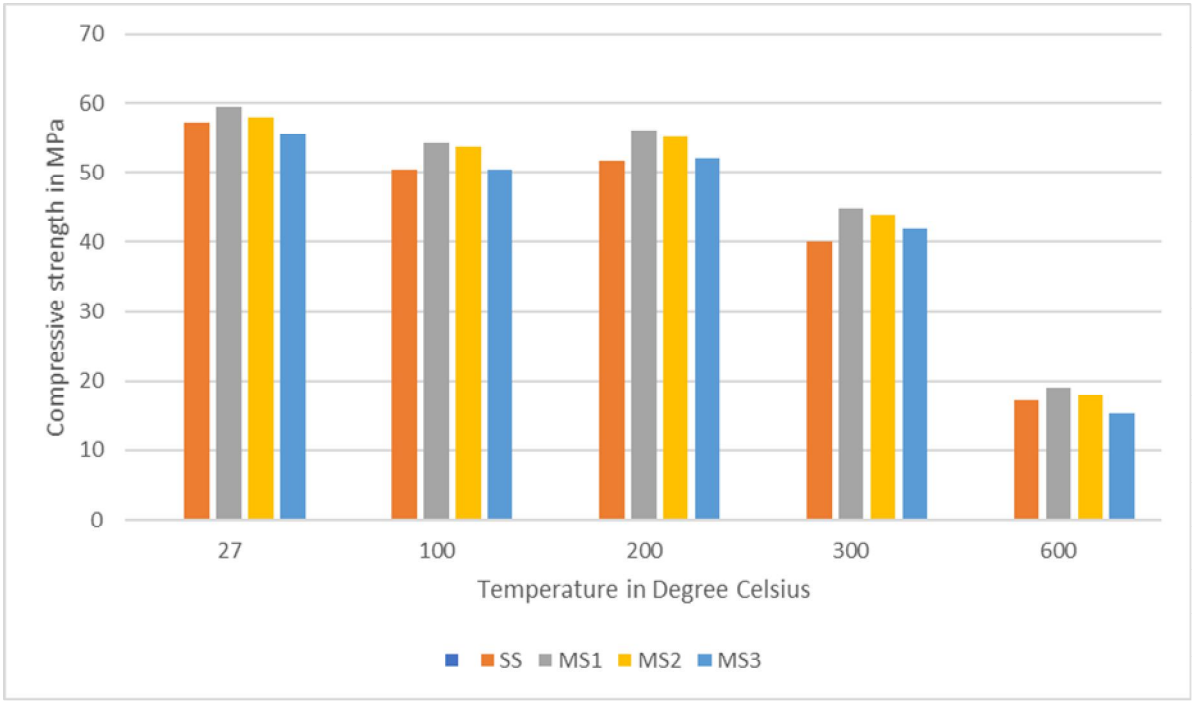

Fig .3 Bar Chart of Water Compressive Strength Values at Different Temperature

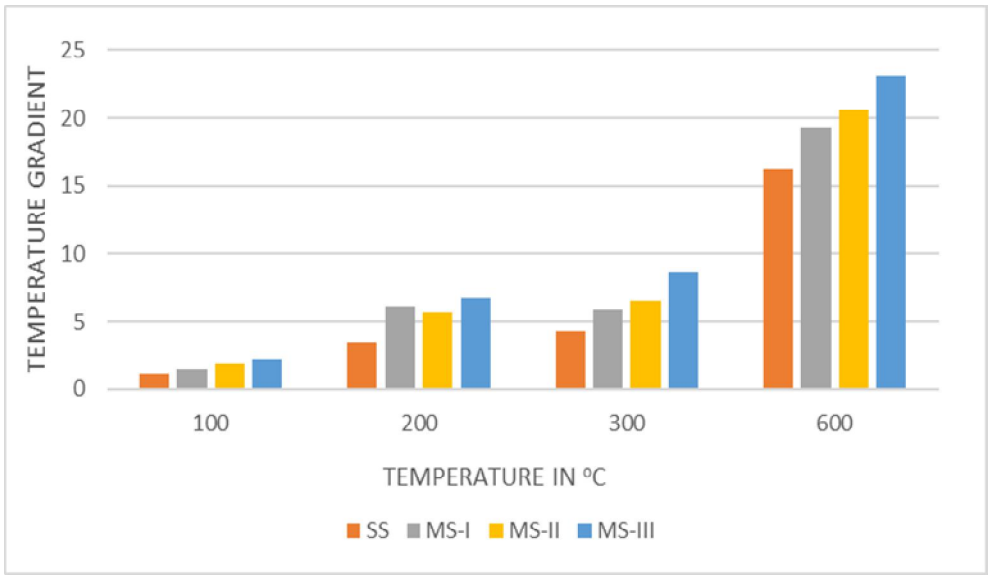

Fig. 4 Bar Chart of Temperature gradient of concrete specimens at different temperature

B. Correlation & Regression Analysis

1) Correlation Between Temperature and Compressive Strength: - Using MS Excel software, there was a correlation analysis established between temperature and compressive strength such that temperature values were the independent variable "x" and compressive strength were dependent variable "y".

Negative correlation shows that compressive strength is inversely proportional to temperature. All specimens show decrease in compressive strength with increase in temperature.

R^2 Value: - It is the square of the correlation. It measures the proportion of variation in the dependent variable that can be attributed to the independent variable. The R-squared value R^2 is always between 0 and 1 inclusive.

a) For standard specimen not containing RRH, required relation is:

$$y = 60.405 - 0.0696x$$
$$R^2 = 0.9604$$

b) For specimen containing 1.5% RRH (MS-I), required relation is:

$$y = 64.241 - 0.0713x$$
$$R^2 = 0.9402$$

c) For specimen containing 3% RRH (MS-II), required relation is:

$$y = 63.392 - 0.0695x$$
$$R^2 = 0.9239$$

d) For specimen containing 5% RRH (MS-III), required relation is:

$$y = 60.472 - 0.0707x$$
$$R^2 = 0.9377$$

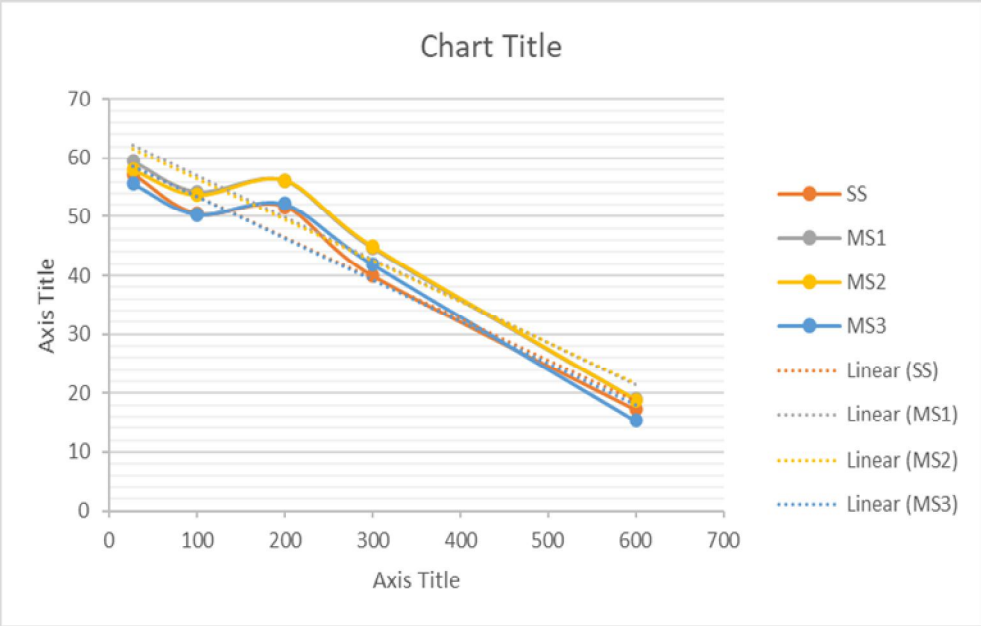

Fig. 5 Correlation between temperature and compressive strength

2) Correlation Between Temperature and Thermal Gradient: - Correlation between temperature and thermal gradient shows positive correlation.

As temperature rises thermal gradient also increases and it shows almost linear correlation.

Correlation equations for different concrete samples shown below.

a) For standard specimen not containing RRH (SS), required relation is:

$$y = 0.0307x - 2.9093$$
$$R^2 = 0.9576$$

b) For specimen containing 1.5% RRH (MS-I), required relation is:

$$y = 0.0347x - 2.2004$$
$$R^2 = 0.9585$$

c) For specimen containing 3% RRH (MS-II), required relation is:

$$y = 0.037x - 2.4614$$
$$R^2 = 0.9693$$

d) For specimen containing 5% RRH (MS-III), required relation is:

$$y = 0.0414x - 2.2454$$
$$R^2 = 0.9852$$

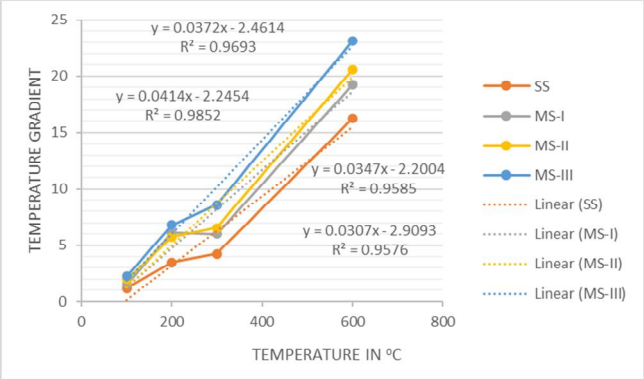

Fig. 6 Correlation between temperature and thermal gradient

V. CONCLUSIONS

1) Four concrete specimens with different RRH content were tested with constant water cement ratio. But the addition of raw rice husk altered the slump value because RRH absorbed significant amount of water.

2) These specimens casted at 27°C (laboratory temperature) and exposed to high temperature such as 100, 200, 300 & 600°C and then cooled down to room temperature before testing. It has been determined that the addition of raw rice husk decreases the density but increases the porosity of concrete specimen.

3) RRH addition in small amount leads to slight reduction in compressive strength but is has been compensated by adding PP fibres. Which act as a fibrous reinforcement however this admixture modifies the physical and thermophysical properties of concrete.

4) On the basis of the result obtained from test following conclusion can be made:

a) Workability of concrete mixture decreases due to the increase in RRH content because RRH absorbs water significantly thus reducing the effective water cement ratio. Hardened raw rice husk containing concrete specimen also absorb more water than standard sample reason behind this is increase in porosity.

b) As RRH content increases in concrete mixture compressive strength decreased when RRH content increases from 1.5% to 3% and 3% to 5% respectively.

c) From the experimental results it has been clearly shown that addition of raw rice husk significantly improves the thermal insulation property of concrete. Results shows that as Raw rice Husk content increases Thermal gradient on each sample increases significantly.

d) At 300°C, 3% RRH mix (i.e.MS-II) shows better result than 1.5% and 5% RRH mix. But at 600°C all concrete sample shows almost same result because at 600 °C RRH burned and PP fibre melted completely and in concrete heating by radiation also started along with conduction.

5) The effect of RRH is more dominant than PP fibre in concrete mix. Because in general PP fibres melts above 170°C, however it helps to improve compressive strength but at lower temperature. At temperature more than 300°C presence of PP fibre becomes quite insignificant.

6) Again, it can't be ignored that when temperature rises and PP fibre melts it gives a path to excess vapour pressure to expel out from the specimen which prevent sudden spalling of concrete. So, indirectly PP fibre also plays an important role when concrete is exposed to a temperature of more than 300°C.

VI. SCOPE OF FUTURE WORK

The research work on raw rice husk and poly propylene fibre is still limited. But it promises a great scope for further studies. Following aspects are considered for future study and investigation: -

A. Percentage of raw rice husk and polypropylene can alter and it may improve result.

B. Greater length of PP fibres can upgrade the compressive strength because greater length imparts better reinforcing property.

C. Heating process used in this experiment is not very efficient. In direct heating method heat loss may occurs in many ways. Different method of finding thermal gradient or conductivity may modify the result.

VII. ACKNOWLEDGMENT

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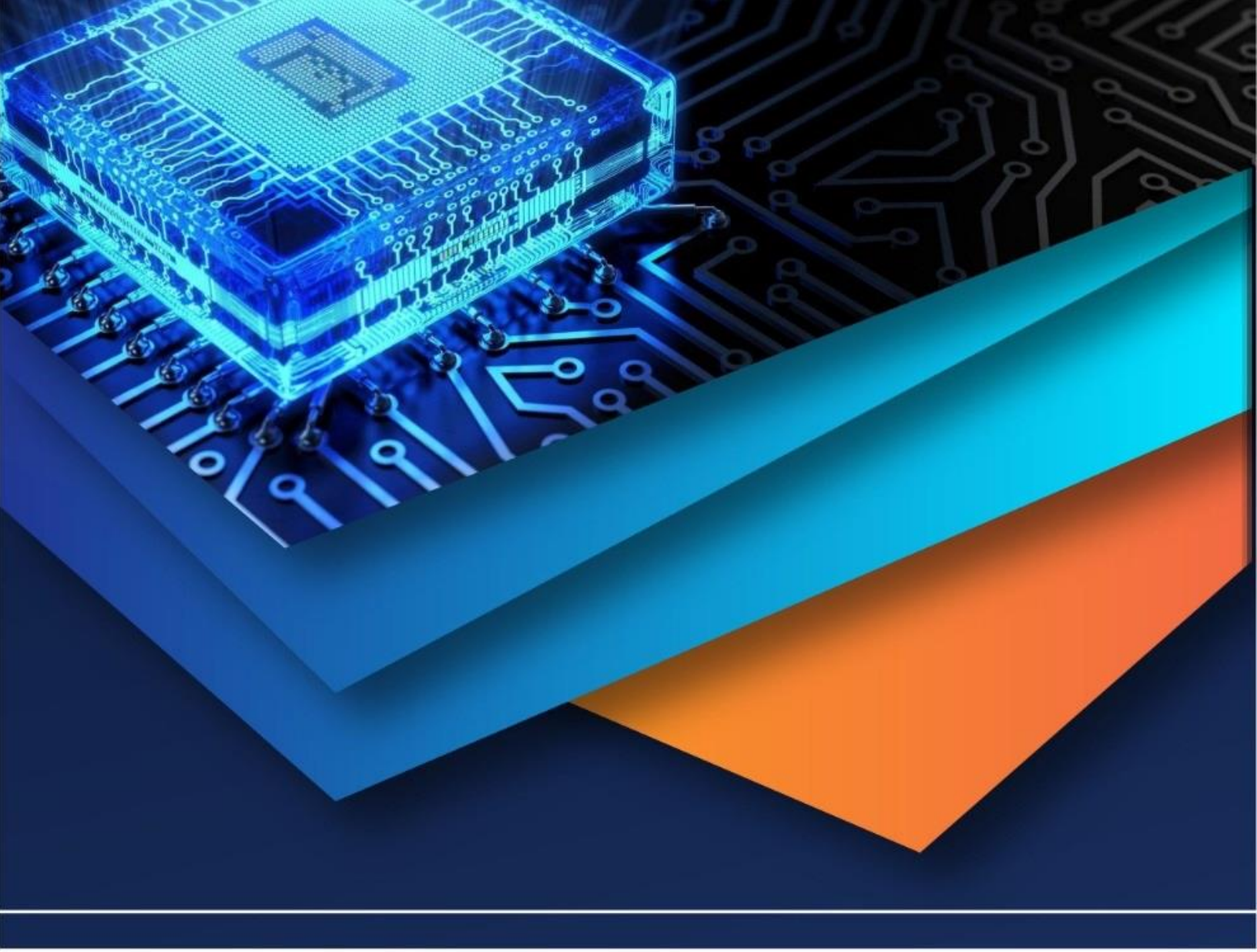

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