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To Study the Behaviour of M30 Grade Concrete by Using Rice Husk Ash, Crushed Stone Dust, Recycled Plastic and Demolition and Debris

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Abstract: This study investigates the strength characteristics of M30 GRADE concrete composites incorporating sustainable alternatives to traditional cementitious and aggregate materials. Specifically, the research aims to quantify and compare the strength performance of conventional concrete specimens with other concrete where cement, fine aggregate, and coarse aggregate are partially replaced with rice husk ash (20%), crushed stone dust (20%), recycled-plastic (10%), & demolition and construction debris (20%), respectively. Preliminary findings suggest that formulations incorporating rice husk ash and recycled plastic achieve approximately 70% of the strength observed in conventional concrete specimens. On the other hand, the inclusion of crushed stone dust and demolition and construction debris demonstrates the potential for exceeding the strength attained by traditional concrete mixtures. Concrete specimens, in the form of cubes and cylinders, were fabricated incorporating varying replacement materials along with the traditional ones. These specimens, alongside conventional concrete, were subjected to standard curing for 7 and 28 days. Compressive and tensile strength were performed at both curing ages. Comparative analyses were then conducted between the modified concrete mixes and conventional concrete, allowing for a determination of the impact of each replacement material on the performance of the concrete. Some standardized laboratory tests were to be conducted. This includes assessment of compressive strength (indicate load-bearing capacity), and slump cone test (to determine fresh concrete's consistency and flow characteristics). Additionally, the split tensile strength (crucial for evaluating resistance to cracking). Beyond structural integrity, this research emphasizes the environmental benefits associated with utilizing these wastes, and readily available materials & helps reduce the demand for primary materials. The utilization of these low-cost products offers significant potential for reducing construction costs, and pollution and contributes to the development of solid–waste management and, promoting sustainable construction practices.

Keywords: Rice Husk Ash, Crushed Stone Dust, Recycled Plastic and Demolition & debris, split tensile strength.

I. INTRODUCTION

The construction sector's substantial reliance on natural resources necessitates a shift towards sustainable building materials. Concurrently, the disposal of construction and demolition waste, rice husk ash, recycled plastics, and crushed stone dust presents considerable ecological challenges. Incorporating these materials into concrete formulations offers a viable strategy for resource conservation and environmental mitigation. Driven by rising conventional material costs and the imperative for effective waste management, the exploration and adoption of alternative resources in concrete production have gained significant momentum.

II. METHODOLOGY

1) *Collection Of Materials*: The process of creating both conventional concrete and incorporating sustainable alternatives to traditional concrete relies on collecting precise ingredients. This section details the materials used in this study. The initial stage involves acquiring the necessary components, which for the M30 grade, are crucial for achieving the desired strength and durability. The list of materials required involves:
2) *Cement*: Cement is the fundamental binding agent in concrete, when mixed with water, it undergoes a chemical reaction called hydration, forming a hardened paste that binds aggregates (sand, gravel or stone) together. The selection of cement type significantly influences the concrete's strength, resistance, and overall performance. The proportion of cement in a concrete mix along with the water-cement ratio is crucial for achieving the desired strength and performance.

3) *Aggregates*: Sand and gravel are examples of fine and coarse aggregates that will give structural integrity. The workability and strength of concrete are largely dependent on the size and gradation of the aggregates.
4) *Water*: Water used in concrete mixing should be clean and free from impurities like excessive salts, oils, or organic matter, as these can negatively impact the concrete's setting time and strength. Potable water is generally acceptable, ensuring a sound and durable concrete product.
5) *Concrete mix*: Concrete mix design is the process of selecting the proportions of various ingredients like cement, aggregates, and water to produce concrete with desired properties. It is an important step for ensuring the strength, durability, and workability of the concrete. For the M30 grade, the mix ratio is 1: 1.466:2.56.
6) *Curing of cubes*: Concrete cubes are cured to control temperature and moisture. Curing starts immediately after casting and continues for 28 days. Curing ensures the hydration of cement, leading to strong and durable concrete. Essentially, it involves maintaining adequate moisture and temperature conditions within the concrete after placement and finishing. Proper curing leads to optimal strength development.

III. REPLACEMENT MATERIALS USED

1) *Rice husk ash (RHA):* Rice husk ash (RHA), a by-product of rice milling, can be used as a partial replacement for cement in concrete, offering benefits like cost-effectiveness and providing strength and durability, while also addressing environmental concerns related to waste disposal. RHA's high silica content contributes to the pozzolanic properties, enhancing the durability and resistance of concrete to harsh environmental conditions. Using RHA as a cement replacement leads to a reduction in the overall cost of concrete production, as RHA is a readily available and inexpensive agricultural waste product.
2) *Crushed stone dust (CSD):* Crushed stone dust, a by-product of stone crushing, can be used as a partial or full replacement for fine aggregate (sand) in concrete, offering cost savings and potentially improved concrete quality. As crusher dust often contains recycled concrete, it is especially useful for creating strong smooth surfaces beneath slabs, pads, and pavers. It is a non-porous material that stops water from seeping in below surface structures, reducing subsidence and waterlogging. An alternative for fine aggregate in concrete mixes is using recycled materials like crushed concrete can help reduce the demand for natural fine aggregate while also promoting sustainable construction practices.
3) *Recycled plastic:* Using recycled plastic as a partial replacement for coarse aggregate in concrete offers a sustainable solution for waste management and resource conservation. Recycling plastic waste into concrete aggregates helps divert plastic from landfills and reduces reliance on natural aggregates, which are becoming increasingly scarce. Concrete manufacturing can act as a safe outlet for plastic waste, contributing to a circular economy. Various types of plastic waste, such as PET (Polyethylene Terephthalate) PP (Polypropylene), and HDPE (High-density polyethylene) have been explored as aggregate replacements. Plastic waste needs to be cleaned, shredded, and sometimes melted and formed into aggregate shapes to ensure proper bonding with cement.
4) *Demolition and debris:* The utilization of demolition debris as a replacement for coarse aggregate in concrete is gaining traction as a sustainable construction practice. This process involves crushing and processing concrete and other suitable materials from demolished structures to produce recycled coarse aggregate. Replacing natural aggregates with demolition & debris offers several environmental benefits, including reducing landfill waste, conserving natural resources, and lowering the energy consumption associated with quarrying and transporting virgin materials.

However, the properties of D&D, such as higher water absorption and potentially lower density, can influence the performance of the resulting concrete. Therefore, careful quality control, mix design adjustments, and thorough testing are essential to ensure that concrete containing D&D meets the required structural and durability standards.

IV. SLUMP TEST

The concrete slump test is a simple, widely used method to assess the workability and consistency of fresh concrete by measuring how much it settles when a cone-shaped mould is removed. The slump value, measured in milli meters, indicates the ease with which the concrete flows and is compacted. It also helps ensure that the concrete mix has the appropriate amount of water for the intended application, as too much water can lead to excessive slump and weak concrete.

V. COMPRESSIVE STRENGTH

Compressive strength refers to the maximum load per unit area that a material can withstand under fractures. In the context of concrete, compressive strength is a critical parameter as it indicates the ability of the concrete to withstand applied loads or pressure without undergoing significant deformation or failure.

It is typically measured in megapascals (MPa) or pounds per square inch (psi) and is determined by conducting standardized compression tests on concrete specimens. The compressive strength of concrete is influenced by various factors including the mix proportions, curing conditions, age of the concrete, and type of replacements used.

VI. SPLIT TENSILE STRENGTH

The split tensile strength test evaluates concrete's ability to resist tensile forces, a critical property for structural integrity. Applying compressive loads to a cylindrical specimen, induces tensile stresses along the loaded diameter, leading to failure. The maximum load at failure is used to calculate the split tensile strength, providing a measure of concrete's resistance to cracking. Though an indirect test, it's a valuable indicator of tensile behaviour, especially in applications where direct tension is difficult to measure.

VII. RESULTS AND DISCUSSIONS

Table 1,2 and 3 showing 28 days strength of Rice Husk Ash, Crushed Stone Dust, Recycled Plastic and Demolition & Debris compared with conventional concrete.

CUBES

S.no	Material	Strength(N/mm^2)
1.	Rice husk ash	27
2.	Crushed stone dust	39.2
3.	Recycled plastic	23.73
4.	Demolition & Debris	38.07

[Table.1]

CYLINDERS2

S.no	Material	Strength(N/mm^2)
1.	Rice husk ash	2.19
2.	Crushed stone dust	3.07
3.	Recycled plastic	1.91
4.	Demolition & Debris	3.04

[Table.2]

CONVENTIONAL

Conventional cubes	Conventional cylinders
32.07 N/mm^2	3.17N/mm^2

[Table.3]

Table showing 7 days strength of Rice Husk Ash, Crushed Stone Dust, Recycled Plastic and Demolition & Debris compared with conventional concrete.

CUBES

S.no	Material	Strength(N/mm^2)
1.	Rice husk ash	19.03
2.	Crushed stone dust	25.62
3.	Recycled plastic	17.03
4.	Demolition and debris	27.25

[Table.4]

CYLINDERS

S.no	Material	Strength(N/mm^2)
1.	Rice husk ash	1.70
2.	Crushed stone dust	2.40
3.	Recycled plastic	1.556
4.	Demolition and debris	2.546

[Table.5]

CONVENTIONAL

Conventional cubes	Conventional cylinders
23.99 N/mm^2	2.12N/mm^2

[Table.6]

A. *Slump Test*

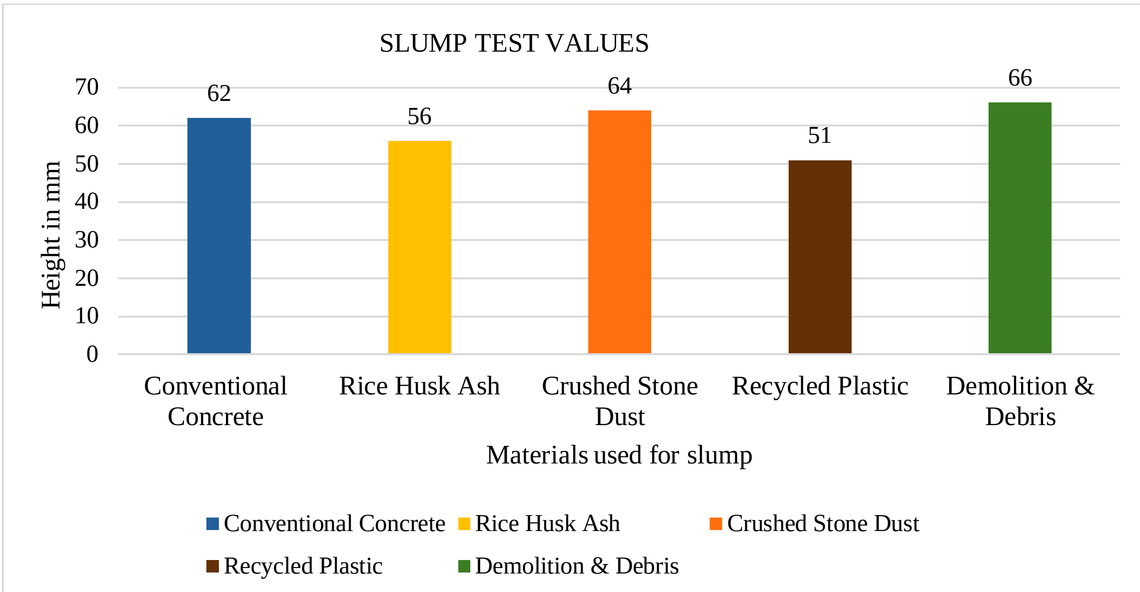

Fig.1

From the Fig,1 graph shows,

- In Crushed Stone Dust it is observed that the slump result is good.
- In Demolition & Debris it is observed that the slump result is good.
- In Rice Husk Ash and Recycled Plastic it is observed that the slump result is satisfactory.

B. *Cube Compressive Strength-7 Days*

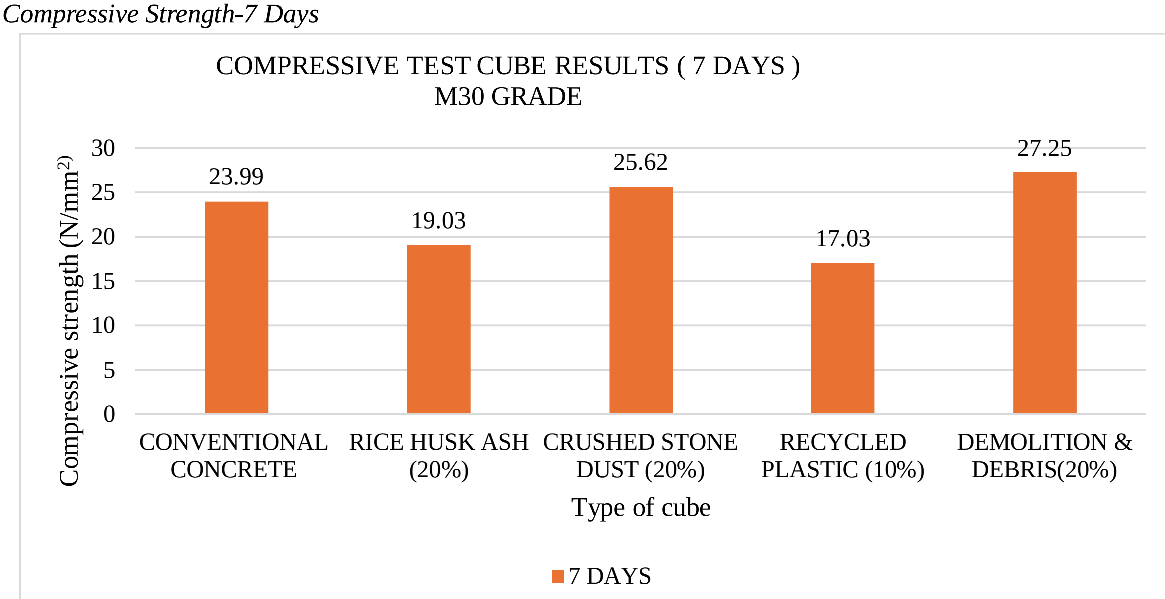

Fig.2

From Fig.2 graph shows,
- The compressive strength of the concrete of mix proportion 1:46:2.56 with the water-cement ratio of 0.45
- It is observed that Crushed Stone Dust (F.A replacement) give better compressive strength compared to conventional concrete.
- It is also observed that Demolition & Debris (C.A replacement) give better compressive strength compared to conventional concrete.
- In Rice Husk Ash (Cement replacement) and Recycled Plastic (C.A replacement), it is observed that compressive strength has eventually decreased compared with conventional concrete.

C. *Cube Compressive Strength-28 Days*

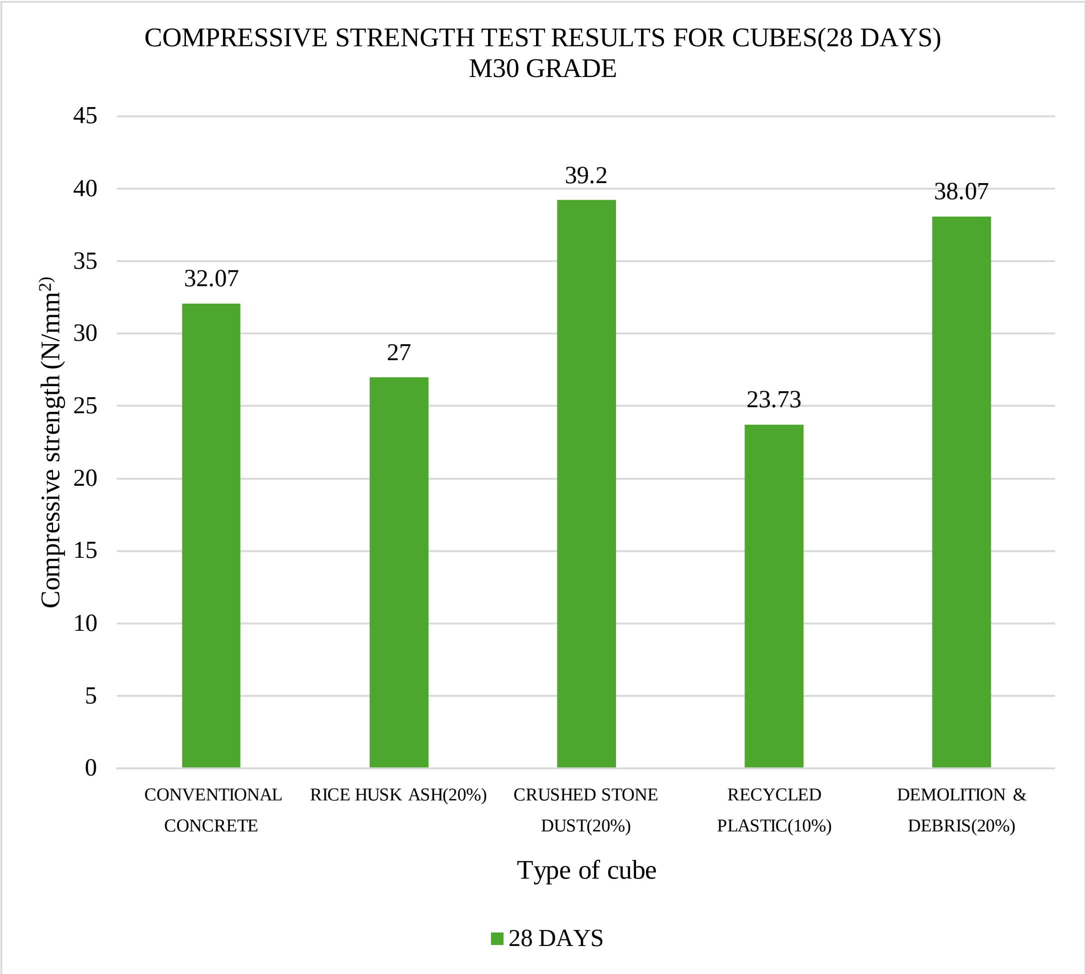

Fig.3

From Fig.3 graph shows,
- It is observed that Crushed Stone Dust (F.A replacement) give better compressive strength compared to conventional concrete at 28 days with a test value of 39.2 N/mm^2.
- It is also observed that Demolition & Debris (C.A replacement) give better compressive strength compared to conventional concrete at 28 days with a test value of 38.07 N/mm^2.
- In Rice Husk Ash (Cement replacement) and Recycled Plastic (C.A replacement), it is observed that compressive strength has eventually decreased compared with conventional concrete.

D. Split Tensile Test-7 Days

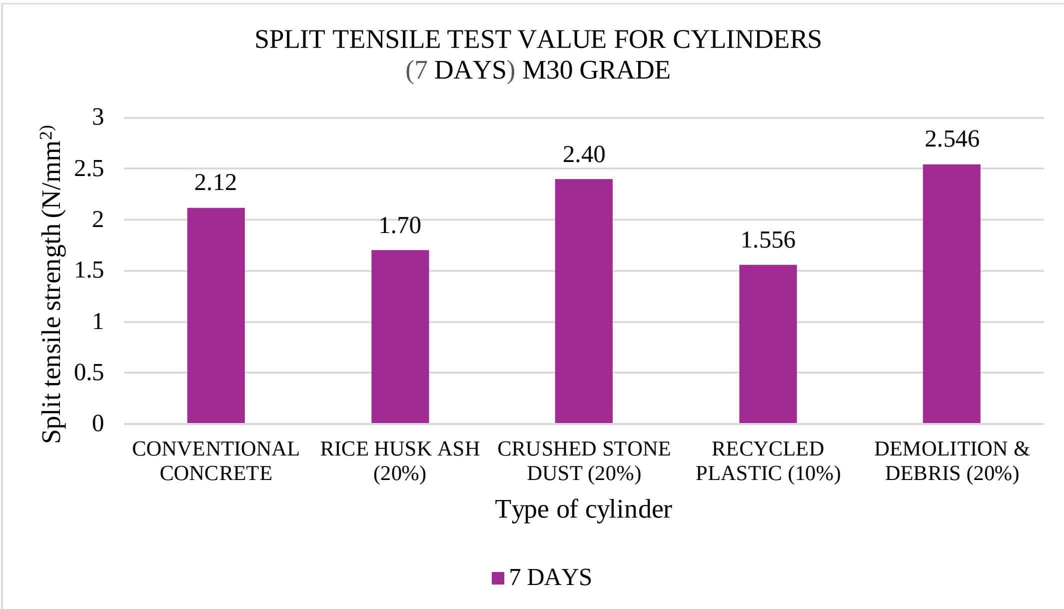

Fig.4

From Fig.4 graph shows,

- The Split Tensile strength of the concrete of mix proportion 1:46:2.56 with the water-cement ratio of 0.45
- It is observed that Crushed Stone Dust (F.A replacement) give better Split Tensile strength compared to conventional concrete.
- It is also observed that Demolition & Debris (C.A replacement) give better Split Tensile strength compared to conventional concrete.
- In Rice Husk Ash (Cement replacement) and Recycled Plastic (C.A replacement), it is observed that Split Tensile strength has eventually decreased compared with conventional concrete.

E. Split Tensile Test-28 Days

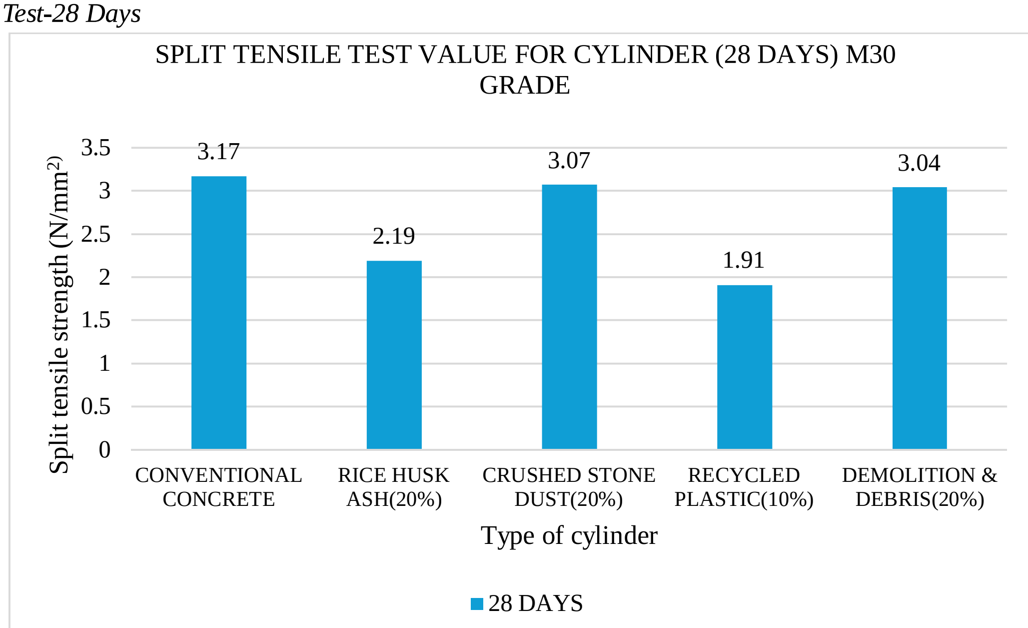

Fig.5

From Fig.5 graph shows,

- It is observed that Crushed Stone Dust (F.A replacement) give better Split Tensile strength of 3.07
- It is observed that Demolition & Debris (C.A replacement) give better Split Tensile strength of 3.04
- In Rice Husk Ash (Cement replacement) and Recycled Plastic (C.A replacement), it is observed that Split Tensile strength has eventually decreased compared with conventional concrete, crushed stone dust and demolition & debris.

VIII. CONCLUSION

From the results and discussions, we can conclude that;

This study demonstrates the feasibility of partially replacing traditional concrete aggregates i.e 20% of cement with rice husk ash (RHA), 20% of fine aggregate with crushed stone dust (CSD), 10% of coarse aggregate with recycled plastic (RP), and 20% of coarse aggregate with demolition & debris (DD) in M30 grade concrete. Notably, the concrete mixes incorporating CSD and DD exhibited superior compressive strength and split tensile strength compared to conventional concrete, suggesting their potential as viable alternatives. Conversely, the inclusion of RHA and RP resulted in a reduction in strength, achieving approximately 70-75% of the conventional concrete mix's strength. While this reduction needs to be considered for structural applications, it still indicates the possibility of using these materials in non-load-bearing elements or in applications where lower strengths are acceptable. The environmental benefits of utilizing these waste and readily available materials are significant. Employing RHA, a by-product of rice milling, reduces landfill waste and the associated environmental pollution. RHA reduces the demand for Portland cement, which is a major contributor to carbon dioxide emissions. Similarly, utilizing CSD by-product of quarrying operations, helps to decrease the demand for natural river sand, which is a valuable natural resource. Excessive extraction of river sand can have detrimental environmental consequences, such as riverbed erosion and ecological damage. Using CSD can lead to a denser concrete matrix. This increased density contributes to higher compressive strength. Moreover it presents a sustainable and economically viable approach, while also reducing the demand for traditional aggregates. Whereas using recycled plastic, diverts significant amounts of plastic waste from landfills, reducing the environmental burden associated with plastic disposal. This helps mitigate plastic pollution, which is a major global concern. Incorporating demolition debris into concrete can lead to significant cost savings. Demolition debris is often available at a lower cost than traditional coarse aggregates, reducing material expenses for construction projects. Furthermore, the incorporation of these materials contributes to a more sustainable construction industry, also offers a pathway for developing cost-effective and durable concrete solutions. & helps preserve natural ecosystems and minimizes the environmental footprint.

IX. ACKNOWLEDGEMENT

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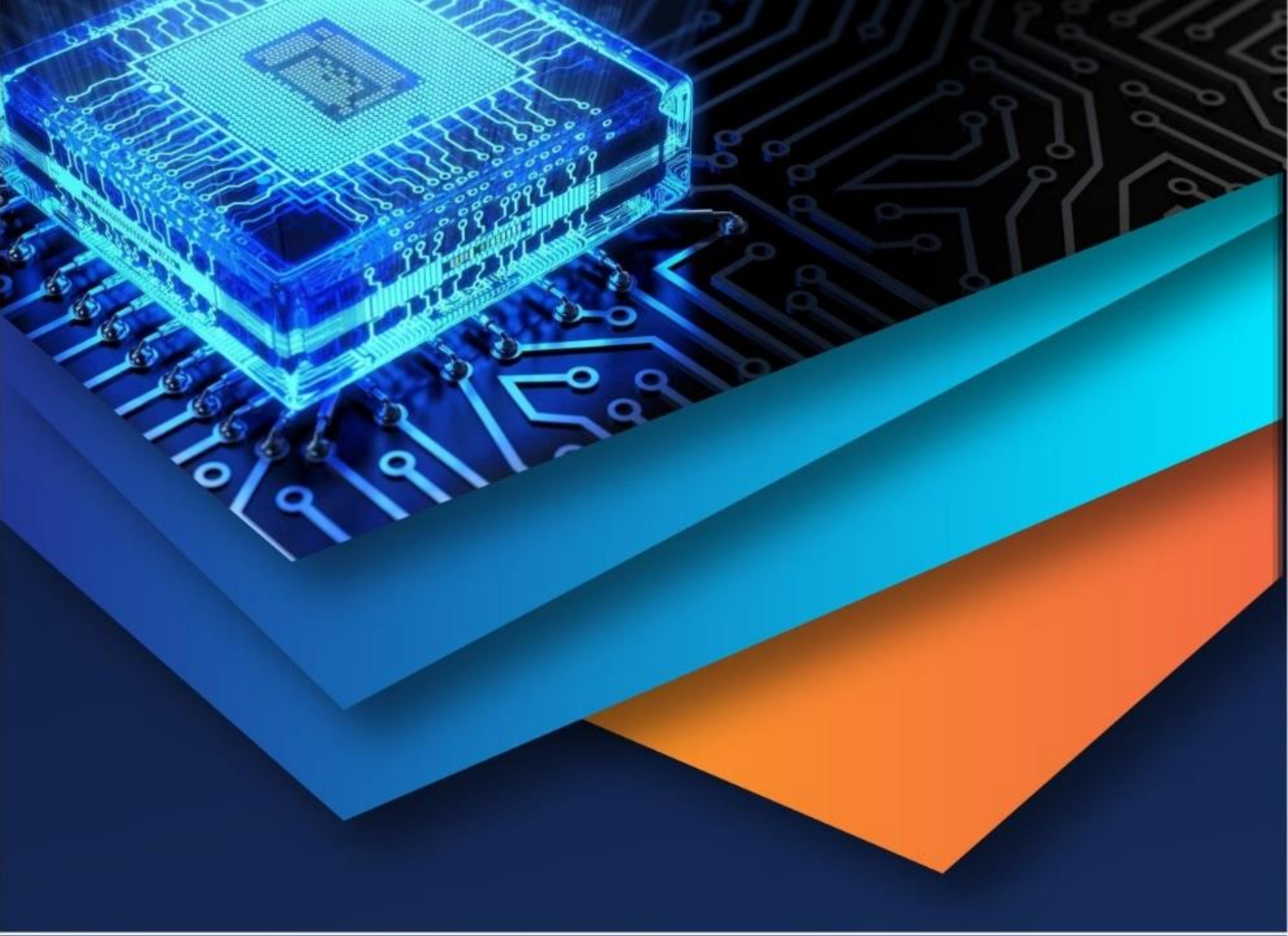

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