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Utilizing Rice Husk Ash and Crumb Rubber to Evaluate the Characteristics of Concrete

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ABSTRACT- Concrete has been widely employed by the building industry for a no. of decades. Every construction, whether large or small, includes concrete, which is produced worldwide every year using over 2 millions tonnes of cement and over 9 million tonnes of aggregate. Natural resources are under a lot of stress as a result, and the ecosystem is also suffering. Cement, which makes up the majority of concrete, possessing unique social and environmental effects, as well as considerably having an impact on concrete users. More than 5% of the worlds Co_2 emissions came from the manufacture of Portland cement. Therefore, many researchers are looking for ways to make concrete environmentally friendly as well as substitute materials for the aggregates used in concrete mixtures in order to satisfy the growing need for cement and also reduce its effects on the environment. Many of the wastes evaluated for use in concrete for various industries have been shown to be efficient. Among these wastes, Rice Husk Ash and Crumb Rubber from recycled tyres have been used to concrete to create unique concrete with qualities including acoustic (sound absorption) and Thermal defence, resisting impacts, increased workability and strength. Additionally, the practise of employing garbage in concrete addresses theproblem of safely disposing of the enormous amounts of waste that are produced each.

KEYWORDS- Acoustic, Crumb Rubber, Impact Resistance, Rice Husk Ash, Waste disposal.

I. INTRODUCTION

Concrete is thought to be the primary component of a country's infrastructure due of its high calibe, long service life and economic development. Forcarrying out variousbuilding activities, the construction sector uses enormous amounts of natural resources, including materials made of calcium and argillaceous (for the manufacturing of cement), sand, coarse aggregate, etc. Due to concretes large carbon footprints when compared to other materials, this practise having a significant negative impact on the environment. Continuous attempts are done to reduce these negative effects and transform concrete into a more environmentally friendly material.

In addition to having a significant impact on concrete's environmental and social impacts, cement, a crucial component of concrete, has its own affects. The manufacturing the use of portable cement is to blame more than a fifth of the world's CO2 emissions. One tonne of structural concrete is thought to produce about 410 Kg/m^3 carbon dioxide when it is manufactured. One of the major sources of CO_2, a significant Greenhouse gas, is the cement industry. As a result, there has been growing interest in lowering concrete related carbon emissions.

A unique substance been developed from the agricultural waste known as rice husk ash with excellent pozzolanic qualities and it has a cement-like fineness, similar to rubber tyre waste. The majority of the worlds rice out-put comes from India. A further 120 million metric tonnes of Rice Husk are created each year from the roughly 600 million metric tonnes of rice paddy that are produced. This husk is typically burned or discarded as waste. India produces 132 million metric tonnes of rice every year and is the second-largest producer. Reactive silica makes up 90%-95% of RHA. The practise of substituting RHA for cement not only reduces the carbon emissions caused by concrete however, there are also aids in the production concrete made of lightweight.

A. Crumb Rubber Concrete

Three different kinds of tires- those on trucks, passenger cars and off-road vehicles can be used to make Crumb Rubber. A normal trash tyre can have about 70% of its rubber recovered. An average passenger can tyre yields between 10 and 12 pounds of crumb rubber. Concrete can be made more affordably than usual mixtures by substituting some of the fine aggregate with granulated rubber fragments. To produce granulated rubber crumbs that can replace an aggregate as fine as sand, rubber tyres are constantly shredded till the desired fineness.

And the following techniques are employed to transform this rubber into crumb rubber.

A.1Cracker Mill Method

A.2 Granular Method

A.3 The Micro-Mill Technique

B. Rice Husk Ash

India is a significant generating rice nation. The majority of the time, the boilers are fuelled by the husk produced after milling to process paddy and generate electricity by gasification or direct burning. The husk is approximately 75% made up of vaporised organic compounds, while theremaining 25% is known as Rice Husk Ash since it burns to ash during the burning process.

C. Applications of Rice Husk Ash

RHA enhances the efficiency and stability of the concrete mixture because it is a fine substance. Because it has a high silica concentration, it generates less heat, which reduces thermal cracking and plastic shrinkage to some amount. Through pozzolanic reaction, RHA alters the hydrated cement paste's porous composition, closes the big pores, and increases impermeability and durability.

D. Rice Husk Ash Concrete

By adding RHA to concrete, cement is transformed into additional cement-based materials that are environmentally benign. The durability of the concrete mix is improved by RHA concretes resistance to drying shrinkage. Bleeding and segregation issues are minimal for concrete that incorporates RHA. In an effort to avoid the disintegration within the concrete structure, the concrete buildings increased permeability also aids in decreasing the infiltration ions of chloride. Higher resistance to assault from chloride and sulphate is a feature of RHA concrete. More hydration products are resulted from the interaction between the calcium oxide and Rice Husk Ashes in the concrete. The calcium hydroxide and rice husk ashes within the concrete react to create additional hydration products. Calcium hydroxide usage will reduce the reactivity of chemicals from the environment. The mass per unit volume is decreased resulting from RHA's low particular gravity. The use of finer RHA makes the concrete mix denser and gives it greater strength than concrete that contains coarser RHA. RHA concrete is intended to be more tightly packed than controlled mix concrete. It is possible to classify RHA concrete as "Green" as well as High-Performance Concrete.

II. LITERATURE REVIEW

A. S. Selvakumaret al., "Rubberized Concrete Made With Crumb Rubber"

International Journal of Science Research, 2015(1), investigated using broken Rubber from tyre treads replacing the fine aggregate in concrete and rubber. For concrete mixes with different percentages of replacement (5%,10%,15% and 20%), concrete specimens were made and examined. As a control mix, M30 grade concrete was used. We performed flexural tests, compression tests and breaking tensile tests. The test outcomes had let to the following deductions

A.1 Crumb rubber concrete's flexural and breaking tensile strengths were found to be low when compared to standard concrete.

A.2 Increased Broken Rubber component the mixture of concrete had a negative impact on compressive strength.

A.3 Concrete's strength is ultimately impacted by the binding strength of Crumbled Rubber, which has a lesser density than sand.

Rafat Siddiqueetal, "Properties of Concrete Containing Scrap -tire Rubber- an Overview"

Waste Management 24 (2004) [9]. According to research, it is possible to create usable rubberized concrete mixtures using used tyre rubber. A description of some of the published studies on making advantage of used tyres concrete made with Portland cement is provided in this publication. In this paper, the results and suggestions below were made:

B.1 Rubberized concrete offers some advantageous qualities, including a decreased density, increased toughness and impact resistance, improved ductility, and improved sound insulation.

B.2 Additionally, magnesium oxychloride cement can be used to create high- strength rubber concrete, which has higher rubber bonding properties and greatly enhances the performance of rubberized concrete.

B. E.Abalaka, " Strength and Some Durability Properties of Concrete Containing Rice HuskAsh Produced in a charcoal Incinerator at Low Specific Surface"

International Journal of Concrete Structures and Materials, 2013 [18]. In this study, it was found that concrete made using RHA, of which is mainly formed of amorphous silica and manufactured using a charcoal incinerator, has good strength and some durability attributes at a particular surface of 235 m^2/kg. The charcoal-burning oven was employed to create the RHA for this investigation. After manufacture, a commercial hammer mill was used to mill the RHA. The coarse aggregate was crushed granite its specific gravity being 2.63 and a max. particle size of 20 mm, while the fine aggregate was river sand [particular gravity (SG)=2.73, Cc =1.82, Cu=6]. OPC was used as cement. For three minutes, a drum mixer was used to mix the concrete. After 24 hours, all samples were demolded, and they were all water-cured after 21. 100mm steel moulds were used to cast the cubes. Cubes were manually compressed. Cylinders made of concrete produced in 150×9 ×300 mm steel moulds to prevent mining tensile strength of the split in the concrete mixtures. As a percentage cement substitute in the concrete mixes, milled RHA was used.

C. Md. Akhtar Hossain et al. [2011]

An overview of the research on the use of RHA as a partial replacement for cement in concrete is covered in this publication. The Rice Husk utilised to make the Rice Husk Ash for this investigation was simply burned in a lab over a steel box that was 1.5m*1.5m in size without regulating the burning temperature or duration. In this project, regular Portland cement was employed. The mixes were created to reach the desired mean strength of 40MPa for the OPC control mixture.

D. Nadim A. Emira and Nasser S. Bajaba, "Utilization of Waste Crumbed Rubber Tyre as Fine Concrete Aggregate"

Yanbu Journal of Engineering and Science,2012[7], investigated the feasibility of using recycled tyre rubber as an aggregate in place of concrete with natural particles as well as the impact the engineering's period of curing qualities using concrete. Rubber scraps were utilised as a replacement for fine particles in different concrete groups formed with plain Portland concrete (0,10,20, and30% based on volume).

The Broken rubber sizes, which ranged from 0.01 to 1.5 millimetres, from 0.5 to 2 millimetres, and from 2 to 3 millimetres, were used. The specimens from each group were examined at various curingtimes, including 7,14,21 and 28 days. The study's standard concrete was graded M25.

E. Khalid BattalNajim, "Workability and Mechanical Properties of Crumb Rubber Concrete"

Construction Materials, 2013[15], conducted an experiment to ascertainthe impact of changing the ratio(w/c) while maintaining surface area of aggregate and cement composition on the qualities of rubberized both freshly-poured and fully-hardened concrete. The ability to create rubber-modified concrete with a workable level was evaluated. Rubber Tyre particles were substituted for fine, coarse and (coarse + fine) a mixture of various percentages of 10, 20, 30 and 50% (via weight) in high strength Portland cement.

III. RESEARCH METHODOLOGY AND MATERIAL USED

This section describes in more detail the process that will be followed to accomplish the aforementioned goals. The specific materials employed, the techniques used to create the test specimens, and other test protocols are also covered in detail. We'll use a methodical approach to fill in the gaps found in the literature review. We'll investigate the specific characteristics of rubber-modified concrete piece by piece as follows:

- Using readily accessible natural aggregates, the M30 grade concrete mix design recommended for controlled concrete based on "Indian Standard Concrete mix proportioning (IS 10262: 2009)" shall be created.
- All concrete mixtures are suggested to contain OPC as a binder. Rice Husk Ash will be used in place of cement to varied degrees (2%,4% and6%).
- To create a rubber-modified concrete mix, Crumb Rubber tyre aggregates will substitute fine aggregates (sand) at a predetermined percentage of 4% and 8% by weight.
- The qualities of newly produced concrete, both fresh and hardened, would be worked out, and their impact would be investigated. Three 150 × 150 × 150 mm cubes will be cast for each mix group to test compressive strength, three 100 × 200 mm cylinders will be cast to test tensile strength, and a 100× 100 × 400 mm beam will be cast to test flexural strength. According to IS specifications, the sample would be cured and evaluated after 7 and 28 days.
- MATERIALS USED
- The following are the materials used:
- OPC cement 43 Grade.
- Natural River Sand.
- Crushed aggregates with angular shapes.
- Crumb Rubber.
- Rice Husk Ash.

IV. MIX DESIGN

The concrete mix model adopted for M30 concrete in this study follows IS:10262-2009. It state that concrete mix design requires following step by step process:

- Stipulations for proportioning.
- Test data for materials.
- Target strength for mix proportioning.
- Selection of Water-Cement ratio**.**
- Selection of water content.
- Calculation of cement content.
- Proportion of volume of coarse aggregate and fine aggregate content.
- Design mix calculation.
- Mix proportion for trial.

- **Calculating the mix ratio for rubber- modified concrete**

In the current investigation, 4% and 8% (when weighed against fine aggregate) of Rubber bits were employed in place of sand to create a rubber-modified concrete mix. However, sand and Crumb Rubber are both subjected to sieve analysis at the same proportion of separated sign before the mixture of rubberized concrete is prepared.

- **Assuming a 4% and 8% replacement level, the following calculations were made for the proportioning of the rubber-modified concrete mix:**

- Kilogram's of Cement = 415 kg/m3
- Liters of Water = 174.33 liters
- The Coarse Aggregate= 1255.64 kg/m3
- There were 625.16Kg/m3 of fine aggregate with 0% replacement. In order to replace the sand (by wright sand) with 4% and 8% crumb rubber. For fine aggregate, we receive the new amount below.
- Broken Rubber = (0.04 × 625.16) = (25.006 Kg/m3)
- Sand = (625.16 – 25.006) = (600.154 Kg/m3)
- Broken Rubber= (0.08×625.16)= (50.012Kg/m3)
- Sand= (625.16–50.012) = (575.148Kg/m3)

- **RICE HUSK ASH based mix proportioning concrete mixture with rubber bits**

Within the current investigation, several altered-rubber concrete mixtures (crumb rubber at a constant rate of 4% and 8%) were created, & cement was substituted with RICE HUSK ASH at varying percentages of 2 ,4, & 6%.

- **The following calculations were made for the proportioning of a 4% and 8% replacement level rubber modified concrete mix based on RICE HUSK ASH:**

- Rice Husk Ash replacement level at 2%
    - Content of cement=423.50 Kg/m^3
    - Moisturecontent=174.330liters
    - The CoarseAggregate=1251.990 Kg/m^3
    - The Fine aggregate=618.820 Kg/m^3
    - RHA=2% of the cement content
    - Broken Rubber = [0.04 × 625.16 = 25.006 Kg/m^3]
    - Broken Rubber= [0.08×625.16=50.012Kg/m^3]
    - RICE HUSK ASH = [0.02 ×423.5=8.47kg/m^3]

  - Kg's of Cement = 415 kg/m^3
  - Sand at 4% = 600.15 kg/m^3
  - Sand at 8% = 575.14 kg/m^3
- RICE HUSK ASH REPLACEMENT LEVEL AT 4%
  - Content of cement=433.0 Kg/m3
  - Moisture content =174.330 litters
  - The Coarse Aggregate=1248.36 Kg/m^3
  - The Fine aggregate=621.540 Kg/m3
  - Rice Husk Ash=4% of theCement
  - Broken Rubber = [0.04 × 625.16 = 25.006 Kg/m^3]
  - Broken Rubber= [0.08×625.16] =50.0128Kg/m^3
  - Rice Husk Ash= [0.04×433] =17.322 kg/m^3
  - Kg's of Cement = 415 kg/m^3
  - Sand at 4% = 600.15 kg/m^3
  - Sand at 8% = 575.14 kg/m^3
- RICE HUSK ASH replacement level at 6%
  - Content of cement=442 Kg/m^3
  - Moisture =174.33 liters
  - The coarse aggregate =1282.911 kg/m3
  - The fine aggregate =618.822 kg/m3
  - Rice husk ash = 6 % of the cement
  - Broken Rubber= [0.04 × 625.16 = 25.006 Kg/m^3]
  - Broken Rubber= [0.08×625.16] =50.0128Kg/m^3
  - Rice Husk Ash= [0.066×442= 26.522 Kg/m^3]
  - Kg's of cement= 415 kg/m^3
  - Sand at 4% = 600.15 kg/m^3
  - Sand at 8% = 575.14 kg/m^3

VI.TESTS

The recommended work shall be based on the discussion that was just had **"To Study The Properties of M30 Grade of Concrete Using Rice Husk Ash and Crumb Rubber".**
It is suggested that the study be carried out in light of the following factors:

A. Workability

By performing a, according to IS: 1199-1959, the slump test. The consistency of a mixture of rubberized concrete with a 4% and 8 percent replacement rate was assessed. The tools employed in the Bulk test are a mould with a frustum shape (30 cm in tall, 20cm in diameter at the bottom, and 10cm at the top), a measuring scale, and a tamping rod (16cm in diameter,60cm long), and a foundation plate without pores. First, the mould's interior surface was cleaned and lubricated. It was a mould then place on the impermeable base plate, and the ready-mixed concrete was then filled the mould with liquid in a round 4 layers, filling it fully. With 25 strokes, each layer was tamped down, the surface was levelled, and extra concrete was removed by using a trowel. The mould was then quickly eliminated by carefully bringing it up vertically. The distance in height between the mould and the specimen's highest point mix under test was then used to calculate slump.

B. Compressive strength

Concrete, and rubberized concrete based onrice husk ash mixtures were conducted. A set of three cubes measuring 150 mm each they created testing for each mix group of control mix, rubber-modified concrete, and Crumb rubber + rice husk ash-based concrete was conducted at 7 and 28 days after curing, respectively; hence, a total of 30 cubes were cast. An apparatus for testing compression (CTM) with the test was conducted on the specimens with a 3000 KN capacity. The strength of concrete samples modified with rubber from various mix groups was used to determine the typical strength of three specimens. A rate of about 140 kg/cm^2/min. was continually applied to the load as it was steadily increased. The specimens maximum load before failure and any peculiar characteristics of the failure observed types. According to IS:516-1959, Compressive strength tests on concrete that has not been rubberized, rubberized concrete, and rubberized concrete based on RHA mixtures were conducted.

C. Flexural Strength

When determining the load at which cracking will occur, understanding the tensile strength of concrete is useful. The elasticity of rupture, sometimes known as the flexural strength, is the highest tensile stress that may be applied to the test beams bottom fibre. The specimen was positioned in the machine so that the load was given to the top surface, casting the mould along a 133mm spaced line. The specimens axis and the loading devices axis were precisely lined up. Between the specimens bearing surfaces and the rollers, there was no packing, without applying any shock, the load was gradually increased at a pace where the severe fibre stress grew at a rate of around 7kg/cm2/min., or 180 kg /min. of loading, the specimen measuring 100mm. During the test, the specimen received the most force, which was noted. Up till the specimen broke, the load was increased. It was noticed how the concrete's broken forces were visible

D. Tensile strength

Concrete's tensile strength is evaluated using split tensile test. The difference in the split tensile strengths between crumb rubber concrete and crumb rubber concrete mixtures based on RHA were measured using cylinders that were 20cm long and 10cm in diameter. For testing at 7 and 28 days of cure, a total of 30 cylinders were cast. Each mix group had a minimum of 3 cylindrical specimens each stage of curing requires a cast to be tested. Test sample is subjected to a Identical pace of loading until it fails. The average strength of three specimens was determined by testing concrete samples made from various mix groups. As required by IS:5816-1999, the test was conducted.

VII. RESULT AND DISCUSSION

A. *Effect on Workability*

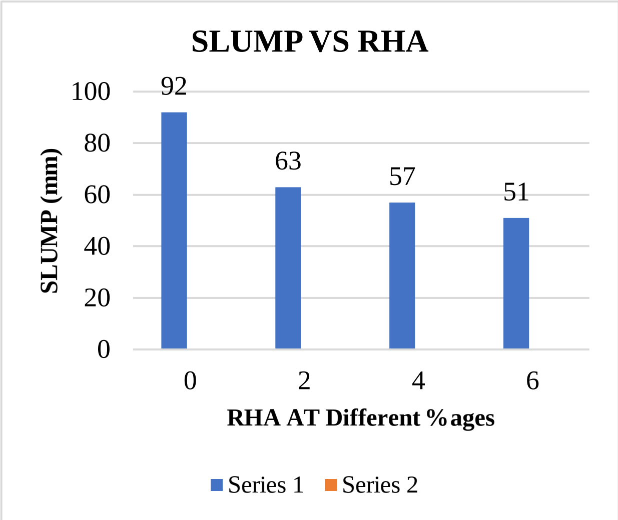

Figure 1: Concrete slump values are affected by the Rice Husk Ash content

- ***Rice Husk Ash[Rha]***

In RHA mixes for concrete, bleeding and segregation were found to be extremely low or nonexistent. The only factor at play was the low specific gravity. There was a decrease in terms of volume per mass due lowered degree particular gravity. Fig.1 shows the concrete slump values are affected by the Rice Husk Ash content. However, RHA has a large specific surface area, which can increase the need for water, The SP content needs to be increased in tandem with rise in amount and RHA fineness in order to preserve workability. As the percentages of RHA in the mixes grew, concrete's ability to be worked declined.

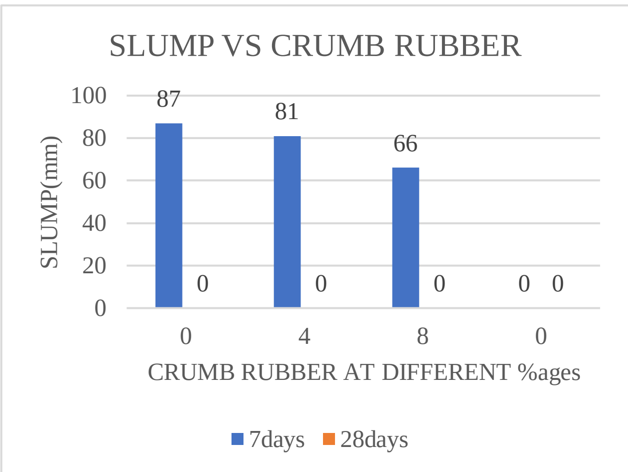

Figure2:Concrete slump values are affected by the crumb rubber content

- ***Crumb Rubberized Concrete***

Poor workability The outcome demonstrates how workability as the amount of Crumb Rubber rises decreases. The surface characteristics of the Broken Rubber particles may be to blame for this decrease in workability. Fig.2 clearly shows the concrete slump values are affected by the crumb rubber content.

B. *Compressive Strength Test*

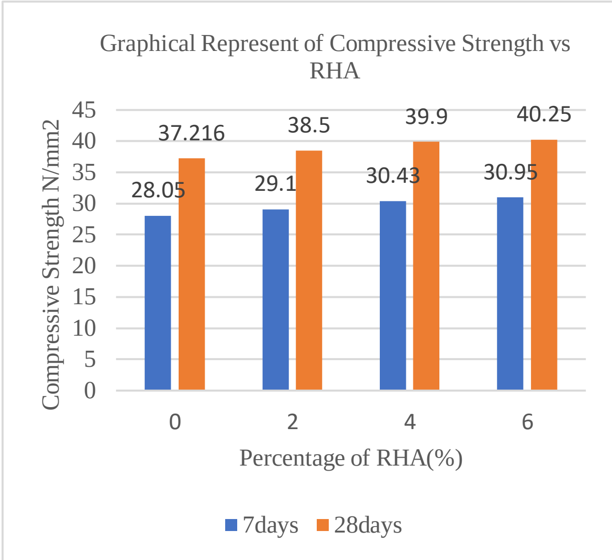

Figure 3: At ages 7&28, there is correlation between compressive strength and various percentages of RHA.

- ***Rice Husk Ash***

Concrete's ability to withstand compression 2,4 and 6% RHA increased significantly, moreover, cement might substituted with RHA absent sacrificing defining qualities of strength. The strength of concrete likewise rises as RHA's fineness is increased. Fig.3 shows at ages 7 and 28, there is correlation between compressive strength and various percentages of Rice Husk Ash.

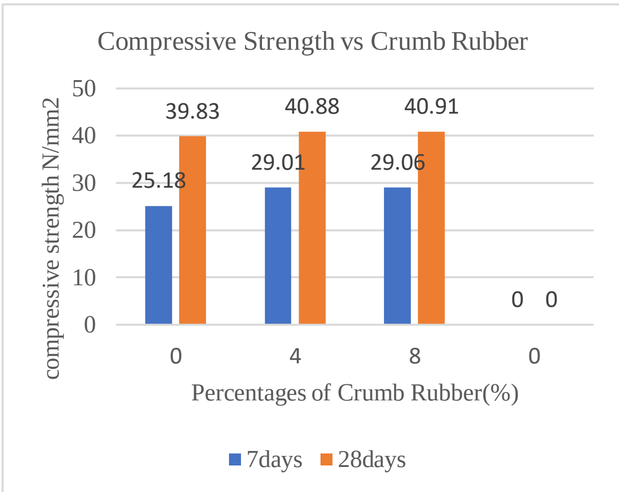

Figure4: Relationship between crumb rubber at 4 and 8%, at a 7 and 28-day age, and compressive strength.

- ***Crumb Rubber***

Fig.4 shows the relationship between crumb rubber at 4 and 8%, at a 7 and 28-day age, and compressive strength. The compressive durability of concrete decreased when the usual concrete mix was supplemented with rubber aggregates. This decrease with power kept growing as to rubber percentage increased, and it was discovered to be more pronounced when coarse particles were replaced.

C. Impact On The Split Tensile Strength

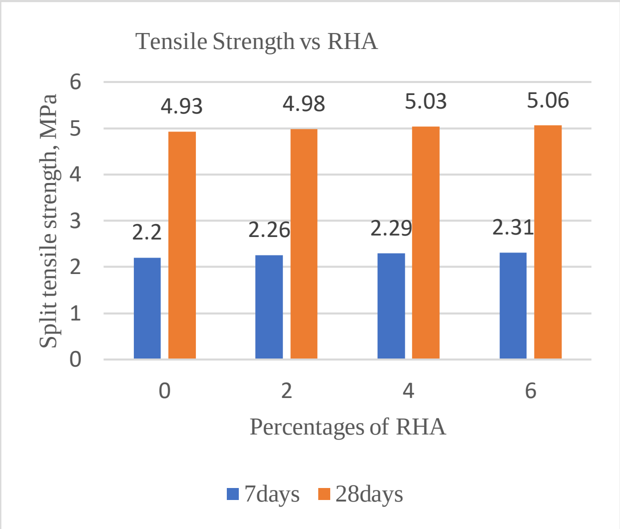

Figure5: Strength of cylinders split tensile fibres(7 and 28 days)

- ***Rice Husk Ash***

According to some findings, the specific surface RHA is low. However, at seven and twenty-eight days, the concrete specimens using Rice Husk Ash substitution displayed a higher split tensile strength. Fig.5 shows the strength of cylinders split tensile fibres (7 and 28 days).

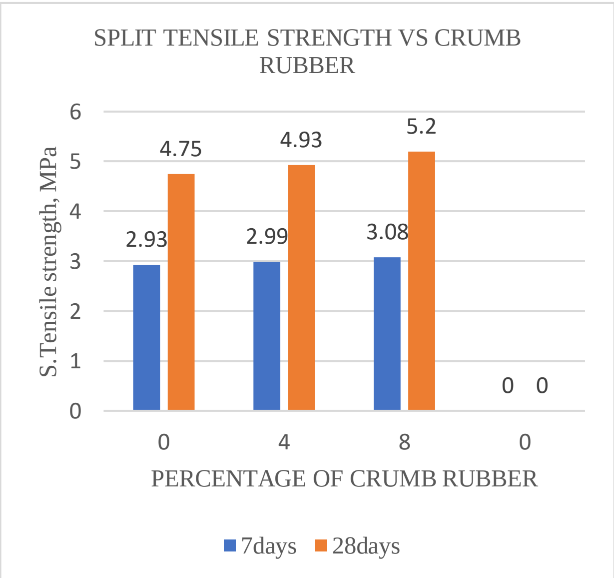

Figure 6: Split tensile strength (crumb rubber at 0,4&8%) of cylinders at 7 and 28 days.

- ***Rubberized Concrete***

Fig.6 shows the split tensile strength (crumb rubber at 0,4&8%) of cylinders at 7 and 28 days. Aggregates have a detrimental effect on the split tensile the power of rubber materials. However, the specimens collapse was not brittle.

D. Effect On Flexural Strength

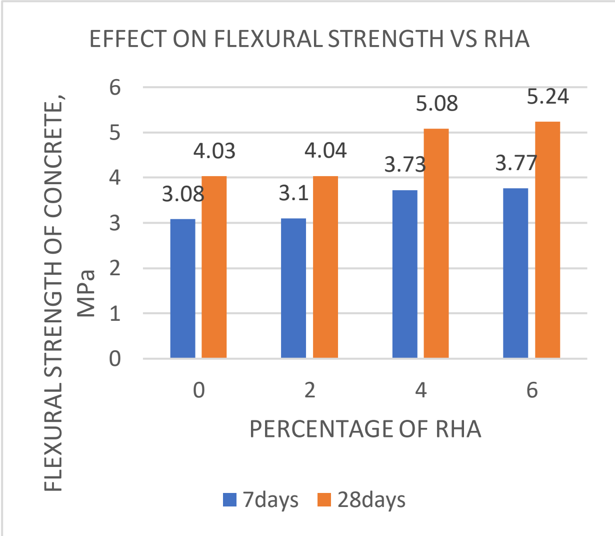

Figure7: Between 7 and 28 days, RHA's Flexural Strength

- ***Rha***

The rate at which flexural strength develops is rapid between days 7 and 28.Fig.7 shows the RHA's Flexural strength between 7 and 28 days. At longer curing times, RHA concretes flexural strengths showed a comparable rise. Results indicate that adding RHA to concrete can boost its flexural capacity. As a result of the RHA fine particles enhanced pozzolanic reaction and packing capacity, RHA concrete mixes with superior Rice Husk Ash were detected to have better flexural toughness.

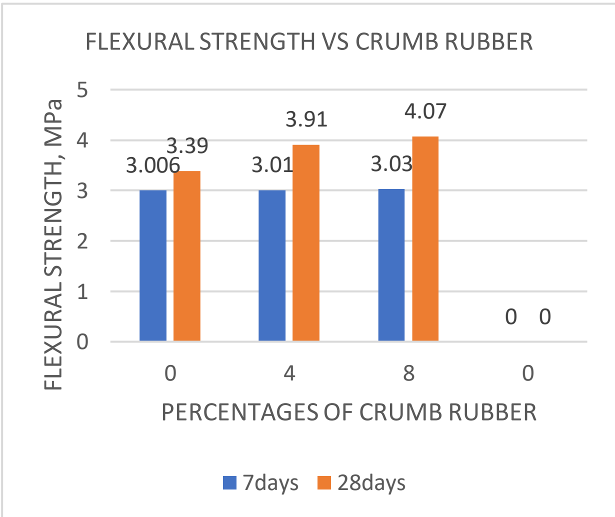

Figure 8: Flexural Strength Of Crumb Rubber At seven & twenty-eight days.

- ***Crumb Rubber***

Fig.8 shows flexural strength of crumb rubber at seven and twenty-eight days. As the amount of rubber aggregate grows, it increases up to 8%.

V. CONCLUSIONS AND FUTURE CONCLUSION

- When Rubber aggregates are added to concrete, it becomes ductile and specimen failure is slow. Above that, rubberized concrete has the capacity to sustain loads even after cracks have spread at peak loads.
- RUBBER modified concrete has improved impact resistance and hardness, and it is more resilient than standard concrete mix.
- The Rice Husk Ash works well as a pozzolanic substance. 85%-90% of it is made up of silica amorphous. Rice Husk Ash's responsiveness rises as fineness is increased. Lime is released during cement hydration, amorphous silica in which the Rice Husk Ash reacts with to create more CSH gels, enhancing the strength and longevity within the concrete.
- Concrete's capacity to withstand compression mixes including up to 10% RICE HUSK ASH has enhanced dramatically, and concrete mixescontaining more than 10% RICE HUSK ASH might substitute cement without reducing RICE HUSK ASH fineness.
- RICE HUSK ASH has been added, the flexural and tensile strengths of the mechanical characteristics have greatly enhanced, using the rough RICE HUSK ASH showing the least improvement.
- The prospect of obtaining additional carbon credits automatically rises with RHA's application in concrete as an alternative to cement, which can significantly reduce greenhouse gas emissions.
- Rubber particles naturally repel water and hold onto air, increasing the content of air and weakening the concrete. In this situation, RICE HUSK ASH may be employed in rubberized concrete mixtures to see if it affects whether or whether the concrete mix is permeable because it is a finer substance. RICE HUSK ASH can also be used to make lightweight concrete mix for the appropriate strength without impacting the mix's strength characteristics.
- The rice husk ash-infused concrete's compressive strength contents of 2,4 and 6% for grade M30 at different ages, that is 7 and 28 days, significantly increased.
- To enhance the technical qualities within the concrete, RHA and BROKEN RUBBER were added. It was discovered that adding RHA and BROKEN RUBBER tends to make the concrete less porous.
- The use of RHA revealed a substantial an increase in volume of water needed for specimen preparation.
- Compared to concrete that has been replaced with RICE HUSK ASH, standard concrete mixtures require less water.
- The study's test results show that adding used Tyres to concrete mixtures in various amounts, from 0 to 8%, has a lot of promise.

VI. FUTURE STUDY

To be able to take into account more variables and various combinations of variables determining the impact on the behaviour and engineering qualities of fresh and cured concrete containing various percentages of RHA and Crumb rubber, it is advised that the future studies expand this research to a wider perspective. The new research Endeavour aims to investigate the study's findings while taking this stage into account as a threshold for a more thorough and accurate investigation of the facts. If the qualities of concrete made with RHA comparable to the conventional concrete in the future, it may be possible to employ RHA for use in place of fine aggregate in various percentages.

As the amount of water required rises, RICE HUSK ASH lessens the concrete's ability to be worked. However, using RHA, Fly Ash and some steel fibre will make concrete stronger. Therefore, it may be utilized in the future like regular concrete.

There is a need to put scrap rubber tyres to use because they are harming the environment. The crumb rubber can be as a replacement some among the aggregates.

Concrete that incorporates rubber has several benefits, such as reduced maintenance costs, the provision of ecologically friendly solutions in structures with high dynamic qualities, an increase in the sustainability of the structure, and the conservation of energy and natural resources.

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