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Partial Replacement of Cement by Fly Ash & RHA and Natural Sand by Quarry Sand in Concrete

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ABSTRACT : The study explores the potential of incorporating fly ash, rice husk ash (RHA), and quarry sand as partial replacements for cement in concrete production. The study evaluates the impact of these materials on concrete properties like compressive strength, durability, and workability. Results suggest that these materials can reduce environmental impact while improving performance. This research contributes to the advancement of eco-friendly practices in the construction industry, offering valuable insights for engineers and stakeholders seeking to adopt more sustainable materials and methods. The study also investigates the mix proportions of cement and natural sand, assessing their impact on concrete properties. The findings suggest that these partial replacements can reduce environmental impact while maintaining or improving performance. This research is a significant step towards promoting eco-friendly practices in the construction industry.

KEYWORDS: Concrete, Fly ash, Rice husk ash (RHA), Quarry sand, Partial replacement, Sustainability, Environmental impact, Compressive strength, Durability

I. INTRODUCTION

In recent years, significant efforts have been made in the field of concrete engineering and technology to research and explore the use of byproducts and waste materials in the manufacturing of concrete. The successful application of these materials will reduce global warming and environmental loading, waste management costs, and concrete manufacturing costs, while also improving the characteristics of concrete in both fresh and hardened states. Efforts in this approach have been focused on discovering and optimizing the benefits of various types of cement replacement materials, as well as identifying alternative materials as aggregates in concrete and developing a better understanding of the constituent chemistry of the concrete mixture. Among the several current leftovers and by-products, the ability to use rice husk ash in the manufacturing of structural concrete is critical for India. The goal of this study is to determine the effects of Fly Ash, RHA, and Quarry Sand on the workability, compressive strength, flexural tensile strength, splitting tensile strength and modulus of elasticity of rice husk ash concrete. Fly ash, condensed silica fume, blast furnace slag, and rice husk ash are examples of pozzolanic materials that have been used to make high-performance concrete. In this with a pro with an ect, with a part 1 with a tarted proportion from 30% FA and 0% RHA mix together in concrete by replacement of cement with the gradual increase of RHA by 2.5% wi with th and simulate with generously gr with a dual decrease of FA by 2.5%, the last proportion taken 22.5%FA and 7.5% RHA. In Part 2, keeping the proportions constant at 70% cement, 22.5% fly ash, and 7.5% RHA, replace natural sand with quarry sand at a rate of 0% - 45%, increasing gradually by 15%.

FLY ASH

Fly ash can be used in concrete as a partial replacement for ordinary Portland cement (OPC). Fly ash can be added directly to concrete as a separate ingredient at the batch plant, or it can be combined with OPC to generate blended cement, also known as Portland-pozzolana cement (PPC in India). Currently, the ratio of fly ash in total cementing elements in concrete typically varies from 15 to 25%, while it can reach 30 to 35% in some applications. The use of fly ash in concrete will improve several aspects of its performance, as long as it is appropriately constructed. The major

characteristics of concrete performance that will be improved by the use of fly ash are higher long-term strength and reduced permeability, which could lead to better durability. The use of fly ash in concrete can also help with specific durability difficulties like sulphate attack and alkali-silica response. However, a little more care must be taken to ensure that the fly ash concrete meets all performance requirements. Fly ash is an industrial byproduct produced by the burning of pulverized coal. Fly ash increases the fresh and hardened characteristics of hydraulic cement concrete. Superplasticizers are used to compensate for the shortcomings generated by replacing cement with high quantities of fly ash in hydraulic cement concrete.

RICE HUSK ASH

RHA is a good super pozzolana. It can be used extensively to create specialized concrete mixes. Fine amorphous silica is in high demand for use in the manufacturing of specific cement and concrete mixtures, high-performance concrete, high strength, low permeability concrete, and other applications such as bridges, maritime environments, and nuclear power plants.



Fig 1.3: Rice Husk Ash:

QUARRY SAND

The cheapest and simplest way to obtain a substitute for natural sand is to crush natural stone to produce artificial sand of the specified size and grade that is free of any contaminants, known as Quarry Sand. It is high-quality sand created by the specifications of IS12116- 1980-2.0, IS 456:2000, and IS 383: 1970. The use of crushed sand produces dense and cohesive concrete, which increases its strength and durability. Because of its fineness, QS can only be added to standard concrete mixes in small amounts. The addition of QS to fresh concrete raises the water consumption, and thus the cement content, for certain workability and strength criteria. However, one possible benefit of employing QS is cost savings, as material costs vary based on source.

II. OBJECTIVES OF THE STUDY

1. To create an alternative to cement and sand that makes the mix workable, inexpensive, and reduces CO₂ emissions, thereby reducing the negative impact on the environment and benefiting society.
2. To employ Fly Ash and Rise Husk Ash in concrete as a partial replacement for cement.
3. To utilize Quarry Sand in concrete as a partial replacement for Natural Sand.
4. Determine the concrete with the maximum compressive, flexural, and tensile strength and durability.
5. Compare various parameters of conventional and modified concrete.

III. LITERATURE REVIEW

D. S. Rajendra Prasad (2021) During the twentieth century, the cement and concrete industries increased their consumption of mineral admixtures. This rate is predicted to rise, and the growing demand for cement and concrete is satisfied through partial cement substitution. When industrial by-products are used to partially replace the energy-intensive Portland cement, significant energy and cost savings can be realized. Mineral admixtures in concrete have been shown to significantly improve workability and durability. The utilization of byproducts is an environmentally friendly way to dispose of vast amounts of material that would otherwise harm land, water, or air.

Satish D. Kene (2017) Rice husk ash is a highly reactive pozzolanic substance created from the controlled combustion of rice husk. FA is finely split and produced by coal-fired power plants. Fly ash has pozzolanic characteristics comparable to naturally occurring pozzolanic material. A thorough experimental examination was conducted to determine the impact of partial cement replacement with RHA and FA on concrete. In this paper, I began with a proportion of 30% FA and 0% RHA mixed in concrete by replacing cement, and ended with 0% FA and 30% RHA,

with a steady increase of RHA by 1% and a concomitant gradual decrease of FA by 1%. It has been discovered that, while the strength of RHA concrete diminishes after the 15% addition of RHA, the composition of 10% RHA + 20% FA produces the highest strength results and has the potential to be used as a beneficial material for various building materials.

Godwin A. Akeke (2015) This study was conducted experimentally to evaluate the effects of using Rice Husk Ash (RHA) as a partial replacement for ordinary Portland Cement (OPC) on the structural properties of concrete. Rice Husk Ash, an agricultural waste known as a Super Pozzolana, was employed in mass concrete and found to have compressive strength ranging from 33-38.4N/mm² at replacement percentages of 10-25% in a 1:1.5:3 mix. A second study was conducted on its flexural properties to determine their moduli of rupture, as well as its tensile strength characteristics for cracking determination. The values obtained at 28 days are 3, 2.5, and 2.4N/mm², while the tensile strength values are 1.94, 1.17, and 0.91N/mm² at replacement percentages of 10%, 20%, and 25%.

Joseph O. Ukpata (2016) This work is part of a larger investigation on the structural properties of concrete utilizing various mixes of lateritic sand and quarry dust as a complete replacement for ordinary river sand fine aggregate. Concrete samples (e.g., cubes) were constructed using different amounts of laterite and quarry dust as fine aggregate. The amount of laterite was adjusted from 0 to 100% against quarry dust at 25% intervals. The samples were cured for specific periods before being examined in the laboratory for compressive strength. Workability studies were previously conducted to identify the optimal water/cement ratios for three different mixes: 1:1:2, 1:1.5:3, and 1:2:4. It was discovered that a 0.5 water/cement ratio gave higher compressive strengths for a 1:1:2 mix, whilst a 0.6 water/cement ratio demonstrated superior workability for a 1:1.5:3 mix proportion. The compressive strength of the mixes under consideration ranged from 17 to 34.2 N/mm². These results compare favourably to those of regular concrete. The concrete was determined to be appropriate for usage as structural members in buildings and related constructions with a laterite content of less than 50%.

IV. MATERIALS PROPERTIES AND TEST RESULTS

Civil engineers in the building industry are always interested in the long-term performance of construction materials, such as Ordinary Portland Cement and waste rice husk ash mixed with steel fibres to make concrete.

The following materials are used for concrete:

Ordinary Portland Cement (43 Grade), Fly Ash, Rice Husk Ash, Natural Sand, Quarry Sand, Aggregates, Water, and Admixture

MATERIALS

1. CEMENT

The concrete was made with Ordinary Portland Cement (OPC) Ultra Tech 43 grade. Cement may be defined as a substance with adhesive and cohesive qualities that enable it to unite mineral pieces into a compact whole.

2. FLY ASH

Fly ash is a fine powder produced after the combustion of pulverized coal in coal-fired power plants. It is extracted from flue gases using electrostatic precipitators or other particle filtration systems. Fly ash is predominantly made up of silicon dioxide (SiO₂), aluminium oxide (Al₂O₃), and iron oxide (Fe₂O₃), with minor amounts of calcium oxide (CaO), magnesium oxide (MgO), and other metals. Fly ash is widely used as a supplemental cementitious ingredient in concrete manufacturing. When used as a partial replacement for cement, it can increase concrete's workability, durability, and strength. Furthermore, adding fly ash into concrete has an environmental benefit since it reduces the demand for Portland cement, which contributes significantly to carbon dioxide emissions during production. As a result, the use of fly ash encourages sustainability in the construction industry.

3. RICE HUSK ASH

Rice husk ash (RHA) is produced by burning rice husks, the outer layer of rice grains, under regulated conditions. It is a valuable byproduct in construction, especially in concrete manufacture. Like fly ash, RHA can be employed as a supplemental cementitious or pozzolanic material. When RHA is mixed into concrete, it interacts with calcium hydroxide to generate extra cementitious compounds that increase the strength and longevity of the concrete. It also increases the workability of concrete mixtures and lowers the permeability of hardened concrete, increasing resistance to chemical assaults and corrosion. RHA not only decreases the environmental impact of rice husk disposal, but it also promotes sustainable construction practices by minimizing the use of traditional cementitious materials.

4. AGGREGATE

Aggregates are inert, granular, inorganic materials that are typically composed of stone or stone-like substances. Aggregates can be used alone (in road bases and various forms of fill) or combined with cementing materials (such as Portland cement) to create composite materials or concrete. The most common use of aggregates is to make Portland cement concrete. Aggregate accounts for approximately three-fourths of the volume of Portland cement concrete. An element accounting for such a big percentage of the mass should have a significant impact on the characteristics of both fresh and hardened goods. Because of their high volume fraction, aggregates have a significant influence on composite characteristics. Aggregate is less expensive than cement, hence it is more cost effective to use as much of the former and as little of the latter as feasible. However, aggregate is used for more than just economic reasons; it also provides significant technical advantages to concrete, giving it more volume stability and durability than hydrated cement paste alone.

5. NATURAL SAND

Natural sand, often known as river sand or pit sand, is a granular substance composed of finely separated rock and mineral particles. It is an essential component in concrete production, mortar, plastering, and construction applications. It fills the gaps between larger aggregates, increasing the workability and cohesiveness of concrete mixes. The particle size distribution and shape of natural sand have an impact on concrete's strength, durability, and finishing properties. However, removing natural sand from riverbeds can have significant environmental consequences, such as habitat destruction and erosion. The decline of natural sand reserves has sparked concerns about sustainability and the need for alternate construction materials. Researchers and engineers are looking into alternatives to natural sand, such as artificial sand, quarry sand, and recycled aggregates, to reduce reliance on natural sand while preserving or increasing concrete mix performance.

6. QUARRY SAND

Quarry sand, also known as quarry dust or produced sand, is a byproduct of quarrying operations that involve crushing rock into various sizes for construction purposes. It is created through the mechanical crushing of hard rock formations such as granite, basalt, and limestone. Quarry sand is used as a substitute for natural sand in concrete, mortar, and other construction products. It has various advantages, such as consistency, availability, gradation control, and sustainability. It is manufactured under regulated conditions, ensuring uniform particle size distribution and quality. Quarry sand is easily accessible near quarrying sites, lowering transportation costs and environmental implications. It can be made in various gradations to accommodate various concrete mix patterns. Using quarry sand decreases reliance on natural sand, which helps to conserve natural resources and reduce environmental deterioration. However, changes to mix proportions and admixtures may be required to achieve the appropriate workability, strength, and durability qualities. Effective quality control procedures are required to ensure consistent performance.

7. COARSE AGGREGATE

Coarse aggregate, also known as stone aggregate or crushed stone, is a granular substance composed of natural rock fragments that are mechanically crushed and graded to a specific size range. Common varieties include crushed stone, gravel, and recycled concrete aggregate. Coarse aggregate is essential for concrete production and construction due to its mechanical strength, volume stability, workability, durability, and drainage. It increases load-bearing capacity, lowers shrinkage and cracking, and improves workability in concrete mixes. It also improves the longevity of concrete by resisting abrasion, weathering, and chemical attacks. Coarse aggregate must be properly selected and graded to achieve the appropriate characteristics and performance in a variety of building applications.

8. WATER

The water used for mixing and curing is pure and free of harmful chemicals such as oils, acids, alkalis, salts, sugar, organic material, and others that could harm concrete or steel. The pH of water is higher than 6.

V. COMBINED GRADING

Aggregate makes up around 55% of the volume of mortar and 85% of the volume of mass concrete. Mortar has 4.75 mm aggregates, whereas concrete contains aggregates up to 150 mm. Thus, it is not surprising that how aggregate particles fit together in the mix, as determined by gradation, form, and surface texture, has a significant impact on the workability and finishing properties of fresh concrete. A proper aggregate gradation is one of the most significant aspects of generating workable concrete. Good grading implies that a sample of aggregate has all standard fractions of aggregate in the proper proportion, resulting in a sample with few voids. A sample of well-graded aggregate with little voids will require minimal paste to fill the spaces. A minimum paste will require less cement and less water, resulting



in enhanced economy, higher strength, lower shrinkage, and greater durability. Sometimes the aggregate available on-site may not meet the stipulated or desired grading standards. In such circumstances, two or more aggregates from various sources can be blended to achieve the necessary grading. Often, blending available fine aggregate with available coarse aggregate in approximate percentages might result in desirable gradings. However, in other cases, two or more fractions of coarse aggregate are mixed first, followed by fine aggregate to achieve the necessary grade. Knowing the grading of available aggregates allows you to compute the proportions of mixing different sizes, either graphically or arithmetically.

VI. RESULTS

TESTING METHODS

A slump cone was used to undertake an experimental evaluation of the fresh mix qualities of Fly Ash, Rice Husk Ash, and Quarry Sand concrete by IS: 516 - 1959. Each specimen's compressive and flexural strength was tested using IS: 516 - 1959, while its splitting tensile strength was calculated using IS: 5816 - 1959. The length change was measured by IS 516 - 1959. Compressive strength was tested at 7, 14, 28, and 56 days, whereas flexural tensile strength was measured at 28 days. Tensile strengths were tested at 28 days. The specimens included a cube with a 150 mm side for compressive strength, a beam with dimensions of 150 * 150 * 500 mm for flexural tensile strength, and a cylinder with a 150 mm diameter and 300 mm height for splitting tensile strength. Sulphuric and hydrochloric acids were used to assess the durability of concrete cubes.

DENSITY

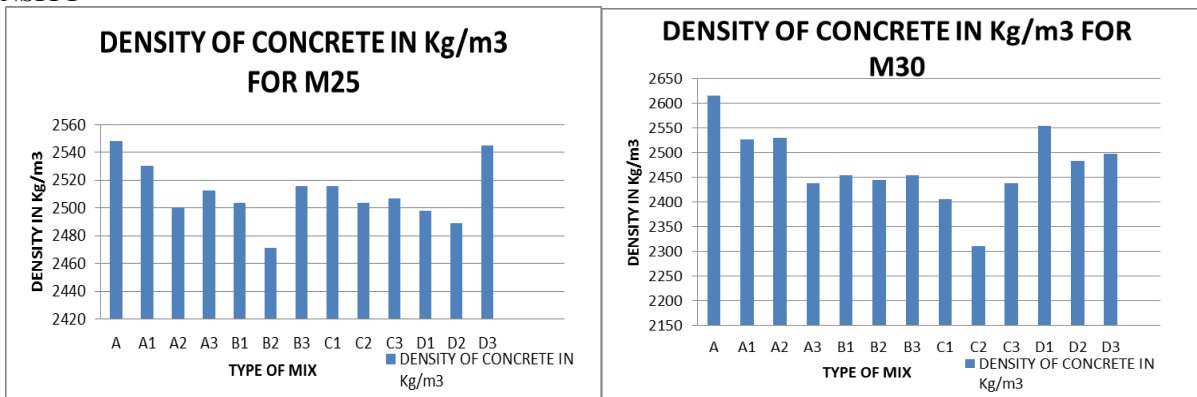


Chart 1: Various percentage and their Densities for M25 & M30 grades of concrete.

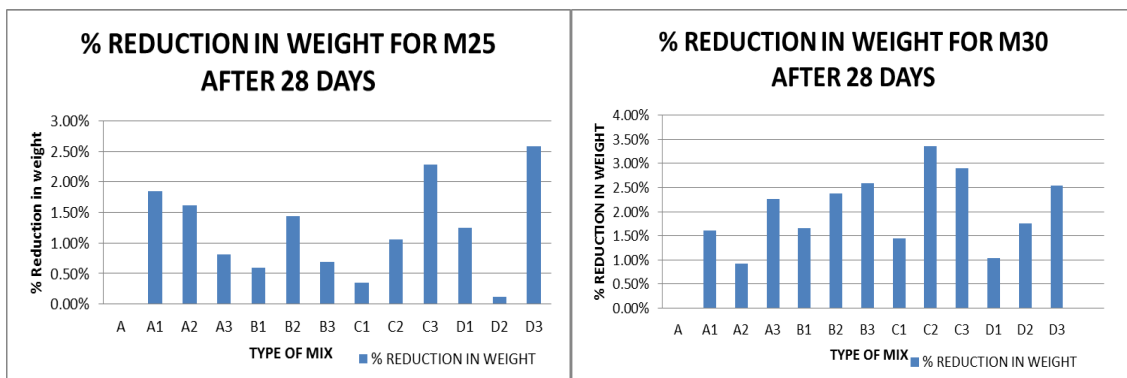


Chart 2: Percentage reduction in weight after 28 Days for M25 & Mat 30

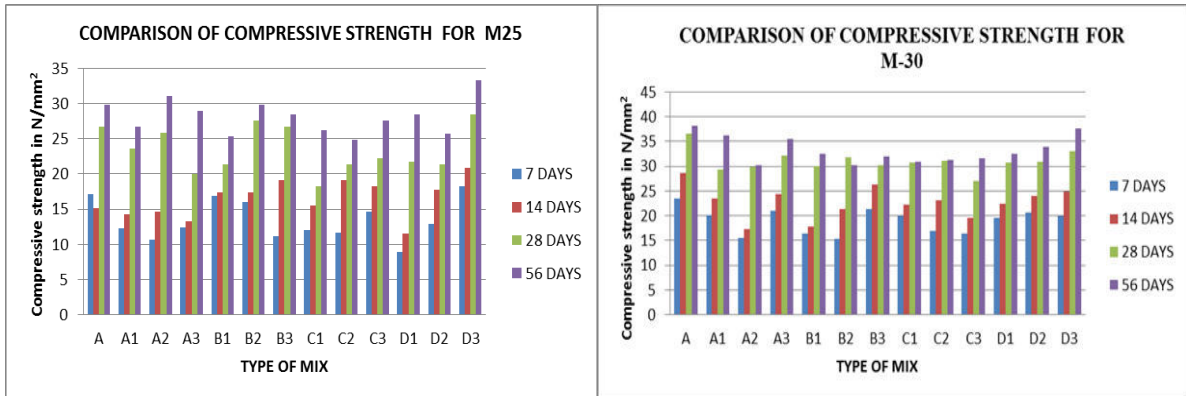


Chart 3: Effect on compressive strength of cube specimens (M25 & M30)

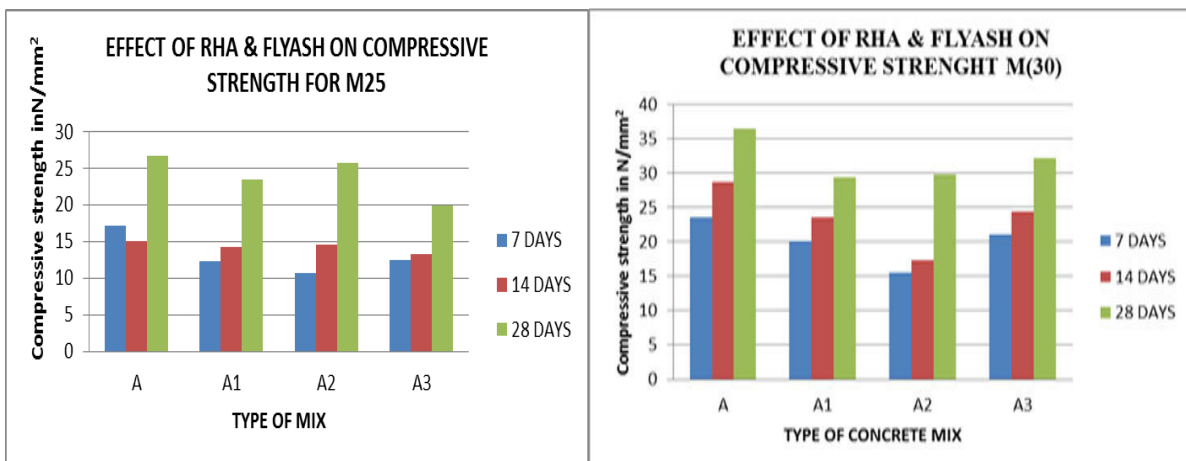


Chart 4: Effect of Rice husk ash & FA on compressive strength of cube specimens (M25 & M30)

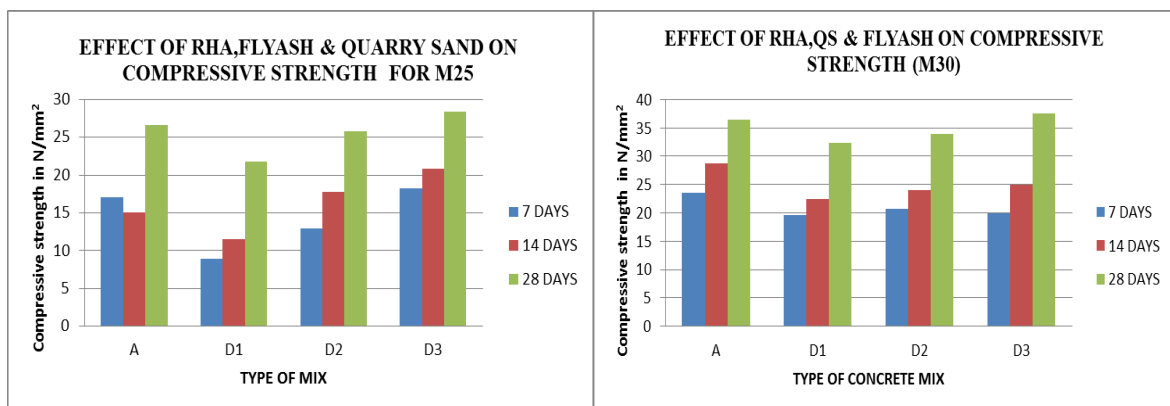


Chart 5: Effect of RHA, FA & QS on Compressive Strength of cube specimens for 7,14,28 days curing (M25 & M30)

VII. CONCLUSION

Because RHA is a highly porous material, the percentage of the water-cement ratio is determined by the amount of RHA and QS utilized in the concrete. The workability of concrete improves with increased fly ash and decreases with increased RHA and QS in concrete. Compressive strength improves with the ratio of Quarry Sand (up to 45% replacement of Sand) and Rice Husk Ash (up to 7.5% replacement of Cement) in concrete for various mix proportions. The maximum flexural strength is provided by a concrete mix that includes 22.5% fly ash, 7.5% RHA, and 45% quarry sand in Natural Sand. A concrete mix with 22.5% fly ash, 7.5% RHA, and 45% quarry sand in natural sand has the highest splitting tensile strength. The rice husk is burned at 600° to 800°C. It has been noticed that 80% silica was

created, which provides good thermal insulation. Rice husk ash and F.A. are toxic to humans. RHA causes respiratory issues. Rice Husk Ash and Fly Ash have no cost, thus we can partially substitute cement in concrete with RHA and Fly Ash rather than silica fumes, which are equally expensive. Admixtures, plasticizers, and superplasticizers can be used in conjunction with Rice Husk Ash and QS to improve the workability and strength of concrete when cement is partially replaced. The combination of RHA and QS enhanced the mechanical qualities in terms of flexural strength but not considerably so. The unit weight of concrete grows consistently with quarry sand content and decreases with rice husk and fly ash content. It has been observed that Rice Husk Ash and QS concrete are more durable than control concrete. The cost of concrete in partial substitution of cement with a 30% combination of fly ash, rice husk, and 45% QS is 17% lower than the Control Concrete Mix. permeable spaces decrease with the age of curing.

VIII. FUTURE SCOPE

Cement and sand are expensive and limited, thus they can be partially replaced by rice husk ash, fly ash, and quarry sand. Pollution can be reduced by using industrial and agricultural waste, such as fly ash and RHA. Poorly graded, unfine, impure natural sand can be replaced with well-graded, consistent, and pure Quarry or Crushed Sand. Fly ash and rice husk ash be superior to other supplementary materials such as slag and silica fume. Rise husk and fly ash diminish the density of concrete, which reduces the dead load. Rise Husk and Fly Ash can be utilized as plasticizers, admixtures, or superplasticizers. Steel fibres improve split tensile strength and deflection.

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