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# The Incorporation of Agricultural Waste Materials and Industrial Byproducts into the Construction Process as an Alternative to Tradition Materials

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**ABSTRACT**

High performance concrete has been produced using a variety of pozzolanic ingredients, including fly ash, condensed Rice Husk Ash, blast furnace slag, and rice husk ash. Mineral additive consumption by the cement and concrete industries has increased in the latter half of the 20th century. Cement is partially replaced by supplemental elements in concrete to satisfy the growing demand for cement and concrete. Many pozzolanic substances have proven to be beneficial in creating high performance concrete.

This experimental research deals with the utilization of the agricultural and commercial waste material into concrete, which may enhance the characteristics of concrete and makes environment eco-friendly. In the present work Rice Husk Ash (RHA) has been used as partial replacement of cement in 12.5%, 15%, 17.5%, 20%, 22.5%, and sand is also replaced by Shredded Steel Waste (SSW) in different proportions such as 10%, 15%, 20%, 25% and 30% in M1, M2, M3, M4 and M5 mix both the ingredients have been replaced simultaneously. Properties tested are compressive strength after 3, 21 and 28 days and workability by measuring slump cone in 1:1:2 proportions.

It has been observed that with the increase in percentage of RHA compressive strength increases upto 20% and then decreases. However, with the increase in percentage of Shredded Steel Waste compressive strength keeps on increasing till 25%.

## 1. INTRODUCTION

Concrete is a composite material made up of a mixture of cement, water, and various aggregates such as sand, gravel, or crushed stone. When mixed together, these materials form a hard, durable substance that is commonly used in construction for buildings, bridges, roads, and other infrastructure. Concrete is valued for its strength and durability, as well as its ability to be molded into a variety of shapes and sizes. It is also relatively inexpensive and easy to produce, making it a popular choice for many construction projects. However, concrete does have some drawbacks. It can crack over time due to temperature changes and other factors, and it is not always the most environmentally friendly choice as the production of cement, a key ingredient in concrete, is a major source of greenhouse gas emissions.

Concrete is the most widely used man- made construction material in the world, and after water it is the most utilized substance on the planet. It can be obtained by mixing cementing materials, water and aggregates and sometimes admixtures, in required proportions. The mixture when placed in forms and allowed to cure hardens into a rock- like mass known as concrete. The hardening is caused by chemical reaction between water and cement and it continues for a long time, and consequently the concrete grows stronger with age. The hardened concrete may also be considered as an artificial stone in which the voids of larger particles are filled by the smaller particles and the voids of fine aggregate are filled with cement like binding materials. Cement is utilized mutually in mortar and concrete, so it is the most vital element of the infrastructure and has been identified as a resilient construction material. Though, the environmental characteristics of cement are now growing anxiety of researchers, as cement manufacturing is to be blame for approximately 2.5% of whole universal waste releases from commercial resources.

The use of agricultural and industrial waste in the production of cement concrete can help reduce environmental pollution and promote sustainable development. Here are some examples of how these wastes can be used in making cement concrete:

Fly ash: Fly ash is a byproduct of coal combustion and can be used as a partial replacement for cement in the production of concrete. It improves the workability and durability of concrete and reduces the amount of cement required, thereby reducing the carbon footprint of concrete.

Rice husk ash: Rice husk is a byproduct of rice milling, and its ash can be used as a partial replacement for cement in concrete. Rice husk ash improves the strength, workability, and durability of concrete.

Ground granulated blast furnace slag (GGBFS): GGBFS is a byproduct of the iron and steel industry and can be used as a partial replacement for cement in concrete. GGBFS improves the workability, durability, and chemical resistance of concrete.

Sawdust: Sawdust can be used as a partial replacement for sand in concrete. It reduces the weight of concrete, improves insulation, and reduces the amount of sand required.

Waste glass: Waste glass can be used as a partial replacement for fine aggregates in concrete. It reduces the amount of natural resources required, improves the durability of concrete, and reduces the amount of waste sent to landfills.

Overall, the use of agricultural and industrial waste in making cement concrete can help reduce environmental pollution and promote sustainable development.

Use of recycled or waste materials for the construction of civil structures is a matter of great significance in this century. Use of waste materials in construction industry reduces the utilization of Portland cement per unit volume of concrete. OPC has large energy emanation related with its production, which may be declined by substituting cement partly with waste products. Mixing of mineral admixtures in concrete and mortar enhances compressive strength, pore structure and permeability. Some materials known as Pozzolana, which have no cementitious properties, but when added with OPC reacts to form cementitious materials. Fractional substitution of Pozzolana in concrete decreases the amount of Portland cement. This reduction in cement quantity further decreases the construction cost, energy loss and waste emissions such as carbon dioxide (CO2) emission. This also, decreases the energy consumption and thus, reduces the rate of global warming.

## 2. LITERATURE REVIEW

The contamination of the natural environment and the falling capability of the dumping facilities is a major problem worldwide. Now a day, the increasing industrialization is accountable for a considerable amount of deposited industrial wastes, which is a call for recycling of wastes to protect the surrounding environment.

Several researchers investigated the suitability of these waste materials as construction materials by partially replacing cement, sand or aggregate in concrete and mortar with these materials.

**Arunabh Pandey & Brind Kumar, 2022** concluded in their paper that over the years, supplementary cementitious materials (SCM) have been successfully utilized in concrete buildings, but they have been rarely exploited in concrete pavements. In recent years, due to the growing importance of concrete pavements, researchers have begun studying the performance of various types of SCMs from pavement perspective. The overview herein assesses the existing research associated with utilizing different kinds of silica-rich waste as SCM. For this purpose, five agricultural waste (AW) comprising rice husk ash (RHA), rice straw ash (RSA), corn cob ash (CCA), palm oil fuel ash (POFA), sugarcane bagasse ash (SBA) and three industrial by-products (IB), i.e., fly ash (FA), ground granulated blast furnace slag (GGBFS) and microsilica (MS), were selected. Their effects on various properties of concrete were exhaustively reviewed. This study also furnishes reasons for limited literature on SCMs utilization in concrete pavements. Moreover, this review accentuates the previous studies' gaps, which require further research, such as the need for dedicated standard codes for AW utilization in concrete pavements. The guidance for future research to further enhance the properties of pavement quality concrete is also given **(1)**.

**Wei Wang et al. 2021** reviewed in their paper The application of agricultural and aquaculture waste in concrete greatly reduces the pressure on the ecological environment brought by traditional concrete production. The use of agricultural and aquaculture wastes as cement replacement, aggregate replacement and fiber reinforcement has showed great potential. Making full use of these wastes can help the development of sustainable concrete. This paper provides an objective evaluation and summary of agricultural waste and aquaculture waste in green concrete. Agricultural waste is divided into natural plant fiber, agricultural waste ash and multi-application waste according to useful function and alternative methods, such as sisal fiber, olive waste ash, and bamboo. Aquaculture waste mainly refers to some shells such as oyster shell. This paper analyzes the advantages and disadvantages of agricultural and aquaculture waste concrete applications that have been reported and shows how different agricultural and aquaculture wastes are made in concrete. The selection of appropriate treatment methods and usage scenarios is extremely important for agricultural and aquaculture waste concrete, which can determine whether the concrete has reliable performance. This paper will lay a foundation for the progress of waste concrete and provide reliable help for the development of environmental protection concrete **(2)**.

**Tanu H.M. a, Sujatha Unnikrishnan, 2022** explained in their paper that the concrete is a highly consumed construction material. Cement is the first and foremost ingredient in the manufacture of concrete. Manufacturing of cement results in emission of an equal amount of carbon dioxide. These greenhouse gases cause global warming. The utilization of environment-friendly construction materials has been identified to be most essential to overcome environmental issues. An ecofriendly concrete such as geopolymer concrete founds to be an alternative for cement concrete. Geopolymer concrete (GPC) is a sustainable construction material as it can reduce carbon dioxide emission by utilizing industrial and agricultural waste by-products. Hence in this context, to reduce global warming, usage of cement can be minimized by replacing it with other materials such as Fly ash, Silica fume, Red mud, Ground granulated blast furnace slag, Metakaolin, Rice husk ash, Corncob ash, Sugarcane bagasse ash etc. These materials have been utilized to prepare geopolymer concrete with good mechanical strength, durability and thermal resistivity. A lot of research has gone into the development of sustainable geopolymer concrete utilizing various industrial and agricultural waste. This review paper is on the research on the utilization of industrial and agricultural waste materials to produce sustainable geopolymer concrete **(3).**

Many works have been done to explore the benefits of using pozzolanic materials in making and enhancing the properties of concrete. Thomas and Shehata [1] have studied the ternary cementitious blends of Portland cement, Rice Husk Ash, and fly ash offer significant advantages over binary blends and even greater enhancements over plain Portland cement. Sandor [2] have studied the Portland cement-fly ash – Rice Husk Ash systems in concrete and concluded several beneficial effects of addition of Rice Husk Ash to the fly ash cement mortar in terms of strength, workability and ultra sonic velocity test results.

The enhancement of concrete technology can minimize the consumption of normal assets and energy sources which diminish or destroy the burden of pollutants on the surroundings. At the moment, huge extent of marble powder have been generated in ordinary stone processing plants with an critical collide on the ambiance and life (Aalok and Sakalkale) [3]**.**

Lam, Wong, and Poon [4] in their studied entitled Effect of fly ash and Rice Husk Ash on compressive and fracture behaviors of concrete had concluded enhancement in strength properties of concrete by adding different percentage of fly ash and Rice Husk Ash.

Replacement of sand with waste powder as a fine aggregate in concrete draws severe awareness of researchers and investigators. The utmost compressive and flexural strengths were experimented for specimens containing a 6% dissipate mud when compared with ordinary mix and it has been also instigate that mixing of waste powders up to 9% could efficiently be used as a preservative material in civil materials (Singh and Nanda )[5].

With the addition of obtained waste marble powder the characteristics of concrete steadily increases up to certain bound. With the addition of Marble powder early strength increase in concrete is elevated. It has been revealed that the best percentage for substitution of marble powder with cement and it is approximately 10% binder for both casted cubes and cylinders (Valeria et al.) [6].

According to Hendriks and Janssen (2003) [7] there are numerous alternatives for the reuse of recycled materials in structures. For each alternative a number of scientific and environmental aspects are applicable. Also, explains numerous models which can be utilized to take the optimal assessment. In common the world-wide used Life Cycle Assessment can be applied as a multi-parameter model for the ecological effects.

Khari et al. (1995) [8] explained that minimum essential mixing time has been determined from the development of the power applied to the tool during mixing. It has been concluded that high w/c values resulted in short stabilization times. In addition, the contents of Rice Husk Ash and quartz flour as well as the type of cement and super plasticizer affected the stabilization time considerably.

Concrete prepared using recycled aggregates have been used for many years in several countries which go ahead the way in this concept (Kwan et al., 2012) [9]. Many major projects have been completed in these countries with cheering results. Its utilization is so widely spread worldwide, so, that several countries have adopted it and are preparing regulatory documents about its use.

Application of fine recycled aggregates in concrete improves the properties of cement concrete. Several researchers determined effect over most vital properties of concrete compressive and tensile strength; modulus of elasticity; water absorption; shrinkage; carbonation and chloride penetration. For the long-term durability of reinforced or pre-stressed concrete carbonation and chloride penetration are significant properties. Experiments have been performed by preparing concrete mixes with different rates of substitution of fine aggregates with fine recycled aggregates obtained from crushed concrete. Testing results had been compared with concrete of same mix proportions without any recycled aggregates.

Reuse of waste materials from construction industry is a creative step towards sustainable and green construction (Uygunoğlu, 2011)[10].

Usage of waste materials in construction has been considered as good thought; however, this thought has been not accepted widely between the researchers. But, through proper concrete mix design the concrete having recycled aggregate can achieve target strength and is appropriate for broad variety of applications in construction. Good knowledge regarding durability and properties influencing durability is required for applying recycled aggregate in construction.

Pacheco-Torgal and Jalali S, 2011[11] presented important information over the robustness and design methodology for recycled aggregates. Parameters investigated in this study are compressive strength, ultrasonic pulse velocity, shrinkage, water absorption and intrinsic permeability. It has been observed from results that the in recycled aggregates concrete ultrasonic pulse velocity is higher, and it contains low water absorption intrinsic permeability. By replacing 80% of the total coarse aggregate with recycled aggregates and by following mix design method proposed by the Department of Environment, target crushing strength can be achieved.

Radlinski, Olek and Nantung [12] in their experimental work entitled effect of mixture composition and Initial curing conditions on the scaling resistance of ternary concrete have find out effect of different proportions of ingredients of ternary blend of binder mix on scaling resistance of concrete in low temperatures.

Barbhuiya, Gbagbo, Russeli and Basheer [13] studied the properties of fly ash concrete modified with hydrated lime and Rice Husk Ash concluded that addition of lime and Rice Husk Ash improve the early days compressive strength and long term strength development and durability of concrete.

Accumulation of waste marble dust in cement has been presented by Aliabdo [14], in this work cement mortar and concrete composed by applying marble dust have been found to be improved, with the addition of marble dust. Concrete composed adding of marble dust as replacement of sand reveals improved act compared to replacement of cement. The chief idea of this investigation has been found to be examine the opportunity of utilizing waste marble dust in cement and concrete making.

The usefulness of waste marble dust as preservative material combine together with cement is examined by Aruntaş et al. [15]**.** For this plan, waste marble dirt added cements were attained by inter blending with marble dust with Portland cement ashes at dissimilar combine ratios at different percentages by weight. Standard cube size of mortar prisms has been artificial with the obtained cements. On these mortar prisms, strength tests have been accepted sample on different days of curing.

Emre and Şükrü in 2015 [16] examined the blended cements produced by using the building stone powder were out to sulfate concentration for unusual properties. Prepared mortar specimens had been cured under water for 28 days and then exposed to several different extents of sodium sulfate solution for large number of days. Performances of cements had been determined by testing properties like compressive and tests. In mixed binders exclusively cements produced by substituting waste provides like strength data when compared with ordinary Portland cement at the ages of different curing days.

Shayan and Xu (2006) [17] studied the presentation of glass powder in concrete in the real situations, a field examination has been performed by means of a 40 MPa concrete combination, including and considering a range of proportions of glass powder in and as cement replacement. Several blends were formed and most of the mixtures also involves sand-size meshed glass collective substance, were used to cast several concrete slabs. Concrete casted has been tested for the compressive and separating tensile strength, shrink and rise, ultrasonic pulse velocity, and permeability of chloride. Basic models had been cut from the slabs of various life spans for the same as well as for micros assessment. Mixtures with glass powder blend showed acceptably when compared in drying shrinkage and alkali reactivity. The outcomes revealed that GLP can be incorporated into high strength concrete at considerable proportions such as 20 – 30% to substitute of cement. Application of glass powder provides for substantial well utilization of waste glass in prepared mixes and noteworthy changes in the production of harmful gases to environment. .

Mehmet (2014) [18] discussed the result of chemical over few good strength gains of mixed cement mortars in order to expand a enhanced consideration for enhancement of hydration and strength of newly mixed cements. Pastes and mortars, containing the mixed blends and the ordinary cement had been also formed and they had been cured within water to pending tests. Experimentations including test of chemical compositions of mixtures and strengths after different curing periods have been performed according to standard codes.

## 3. MATERIALS AND METHODOLOGY

### *3.1 BACKGROUND*

This chapter presents the description materials used in the present work.

Following materials have been discussed here –

i. Cement

ii. Coarse and Fine aggregates

iii. water

iv. Shredded steel waste

v. Fly Ash

vi. Rice husk ask

vii. Concrete

### *3.2 CEMENT*

Generally ordinary Portland cement is used for normal construction. The materials used for making cement are lime, silica, alumina and iron oxide. These oxides are combined at high temperature in the kiln and complex compounds are formed and finally grinded**.**

At high temperature in the kiln the complex compounds are formed. These compounds are called bogus compounds. Compounds formed are:

1. Tricalcium Silicate C3S (3CaO.SiO2)
2. Dicalcium Silicate C2S (2CaO.SiO2)
3. Tricalcium Aluminate C3A (3CaO.Al2O3)
4. Tricalcium Allumino Ferrite C4AF (4CaO.Al2O3.Fe2O3).

**Table-1 Composition of Oxides in Cement**

| **Component** | **Content in percentage** |
|---|---|
| CaO | 60-70 |

| | |
|---|---|
| $SiO_2$ | 17-25 |
| $Al_2O_3$ | 3-8 |
| $Fe_2O_3$ | 5-6 |
| MgO | 1-4 |
| Alkalies ($K_2O$, $N_2O$) | 0.4-1.3 |
| $SO_3$ | 1.3-3 |

### *3.2.1 Types of Cement*

- Ordinary Portland cement, OPC
- OPC 33 grade (as per is 269:1989)
- OPC 43 grade (as per is 8112:1989)
- OPC 53 grade (as per is 12269:1987)
- Rapid hardening cement (as per is 8041:1990)
- Hydrophobic cement (as per is 8043:1991)
- Oil well cement (as per is 8229:1986)
- High alumina cement (as per is 6452:1989)
- Sulphate resisting cement (as per is12230:1988)
- Portland slag cement (as per is 455:1989)
- Super sulphated cement (as per is 6909:1990)
- Low heat cement (as per is 12600:1989)
- Portland pozzolana cement
- Fly ash based (as per is 1489:1991 part 1)
- Calcined clay based (as per is 1489:1991 part 2)
- Coloured cement (as per is 8042:1989)

### *3.2.2 FUNCTIONS OF CEMENT INGREDIENTS:*

The ingredients of ordinary cement perform the following functions:

1. **LIME (CAO):**

This is the important component of cement. The lime in excess makes there cement unsound and causes the cement to expand and deteriorate. On the other hand, if lime is in deficiency, the strength of cement is decreased and it causes cement to set quickly.

2. **SILICA (SIO2)**

This is an also important component of cement and it gives or imparts strength to the cement due to the formation of dicalcium and tricalcium silicates. If silica id present in excess quantity the strength of cement increases but at the same time its setting time is prolonged

3. **ALUMINA (AL2O3):**

This ingredient imparts quick setting property to the cement it acts as a flux and it lowers the clinkering temperature however the high temperature is essential for the formation of a suitable type of cement and hence the alumina should not be present in excess amount as it weakens the cement.

4. **CALCIUM SULPHATE (CASO4):**

This ingredient is in the form of gypsum and its functions to increase the initial setting time of cement.

5. **IRON OXIDE (FE2O3**):

This ingredient imparts colour, hardness and strength to the cement.

6. **MAGNESIA (MGO)**:

This ingredient, if present in small amount imparts. Hardness and colour to the cement .a high content of magnesia makes the cement unsound.

7. **SULPHUR (S):**

A very small amount of sulphur is useful in making sound cement unsound.

8. **ALKALIES;**

The most of the alkalies present in raw materials are carried away by the flue gases during heating and the cement and the cement contains only a small amount of alkalies if they are in excess in cement they cause a number of troubles such as alkali aggregate reaction efflorescence and staining when used in concrete brickwork or masonry mortar.

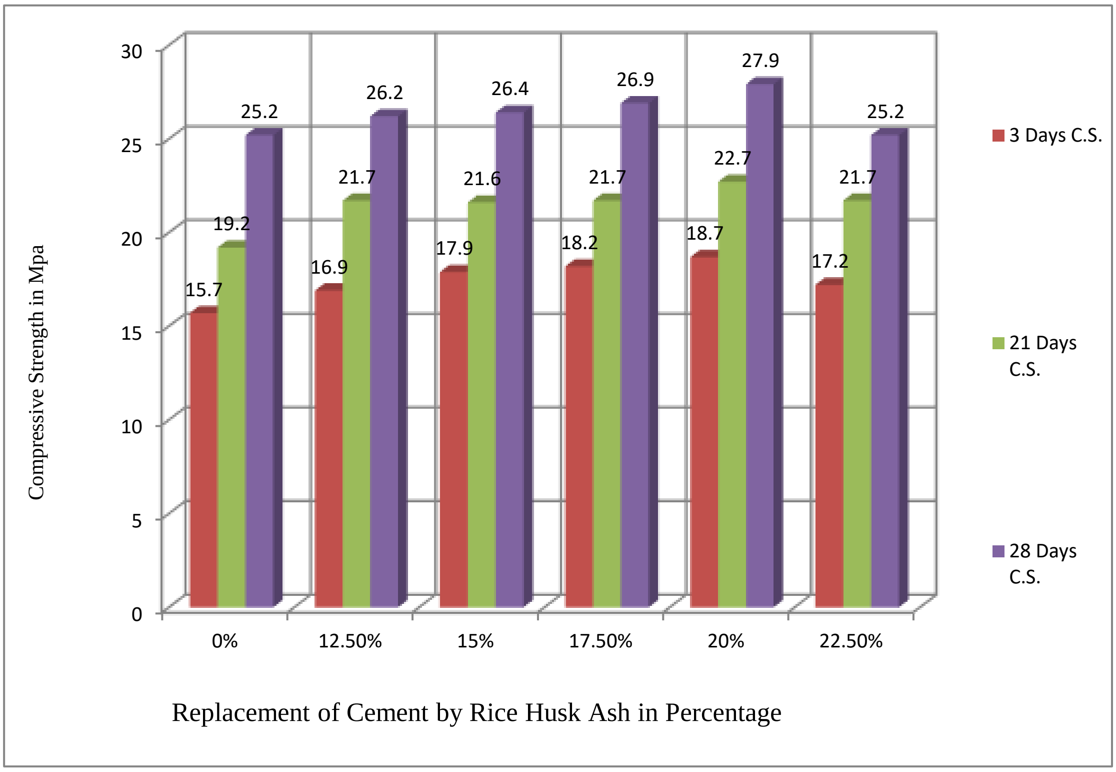
## 4. EXPERIMENTAL RESULTS

Cement and Sand in cement concrete has been replaced in 12.5, 15, 17.5, 20, 22.5% with Rice Husk Ash and 10, 15, 20, 25 and 30% with Shredded Steel Waste respectively naming M1, M2, M3, M4 and M5 mix with both the ingredients have been replaced simultaneously. Their compressive strength has been tested after different curing periods such as 3 days, 21 days and 28 days standard curing conditions. Results of Compressive Strength Testare shown in table below. 0% replacement represents the original OPC concrete mix. Hence, following tables compares concrete prepared by OPC with the modified concrete formed by replacing cement and sand with Rice Husk Ash and Shredded Steel Waste respectively.

Table-2 Results of Compressive Strength Test for Mix M1 in MPa

| **S. No.** | **Days** | **% of Replacement** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **0%** | **12.5%** | **15%** | **17.5%** | **20%** | **22.5%** |
| **1** | **3** | 15.7 | 16.9 | 17.9 | 18.2 | 18.7 | 17.2 |
| **2** | **21** | 19.2 | 21.7 | 21.6 | 21.7 | 22.7 | 21.7 |
| **3** | **28** | 25.2 | 26.2 | 26.4 | 26.9 | 27.9 | 25.2 |

Graph-1 Compressive Strength Test results of Mix M1



## 5. DISCUSSION, CONCLUSIONS RECOMMENDATION

**FOR FUTURE WORK**

### *5.1 DISCUSSION*

Utility of waste materials such as Rice Husk Ash (RHA) and Shredded Steel Waste (SSW) in construction industry reduces the use of Ordinary Portland Cement (OPC) and thus reduces the construction cost as well as reduces the air pollution.

In our experimental research we present different concrete mixes prepared by adding these materials in different percentage. Concrete mixes formed are tested for Compressive Strength Test and Slump Values and compared with concrete prepared by Ordinary Portland Cement concrete values.

### *5.2 CONCLUSIONS*

Following are the conclusions of the present work –

1. By replacing cement with RHA in M1 mix Compressive Strength increases up to 10.7 % and then decreases with increase in percentage replacement of cement.
2. Compressive Strength has been found to be highest at 20% replacement of Cement by RHA in M1 mixes.
3. Slump value is found to be decreasing by increasing the percentage of RHA.
4. Compressive Strength increases and Slump value decreases by increasing the percentage of replacement of Sand by SSW in M2 mixes.
5. Hence, from above results it has been recommended to replace Cement about 20% with RHA for higher compressive strength and optimum workability.
6. Results indicate that compressive strength increases with the combined use of SSW and RHA in concrete mixture.
7. Slump value is higher in case of M4 concrete mix when compared with M1, M2, M3 and M5 mixes. However, with the increase in percentage of replacement value of slump cone decreases in all the five concrete mixes M1, M2, M3, M4 and M5.

### *5.3 RECOMMENDATION FOR FUTURE WORK*

There are several potential research directions that you could consider in the field of concrete using:

#### *5.3.1 Rice Husk Ash (RHA)*

Rice Husk Ash as a partial replacement of cement. Here are a few suggestions:

1- Optimal proportion of RHA

Investigate the optimal proportion of RHA that can be used as a replacement for cement. Researchers have used RHA as a partial replacement for cement in varying percentages, but determining the optimal percentage can have significant impacts on the mechanical properties, durability, and cost-effectiveness of the resulting concrete.

2- Durability and strength of RHA concrete

Assess the durability and strength of RHA concrete compared to traditional concrete. Factors such as the curing time, temperature, and exposure to environmental elements can affect the performance of RHA concrete. Investigate the effects of these factors on the durability and strength of the resulting concrete.

3- Chemical composition of RHA

Characterize the chemical composition of RHA and its effects on the properties of concrete. The chemical composition of RHA can vary based on factors such as the type of rice, the burning temperature, and the combustion time. Investigate how these factors affect the chemical composition of RHA and how it, in turn, affects the properties of concrete.

4- Environmental impact of RHA concrete

Evaluate the environmental impact of RHA concrete compared to traditional concrete. Concrete production is known to be a significant contributor to carbon emissions. Investigate how using RHA as a partial replacement for cement can reduce carbon emissions and other environmental impacts.

5- Rheology and workability of RHA concrete

Study the rheological and workability properties of RHA concrete. The incorporation of RHA in concrete can affect the workability and flow of the concrete mix. Investigate the effects of RHA on the rheological and workability properties of concrete.

### *5.3.2 SHREDDED STEEL WASTE (SSW)*

Shredded Steel Waste as a partial replacement of sand. Here are a few suggestions. Here are some of the benefits of using shredded steel waste in concrete:

1- Sustainability

Using shredded steel waste in concrete reduces the amount of waste that would otherwise end up in landfills.

2- Cost-effective

Shredded steel waste is often cheaper than traditional coarse aggregates, making it an attractive option for concrete manufacturers.

3- Improved strength and durability

The use of shredded steel waste can improve the strength and durability of concrete due to the high strength of steel.

4- Reduced weight

Since shredded steel waste is lighter than traditional coarse aggregates, it can be used to create lightweight concrete.

5- Fire resistance

Steel is a non-combustible material, and using shredded steel waste in concrete can improve the fire resistance of the material.

6- Sound insulation

Steel waste can be used in concrete to create a sound barrier, making it an ideal material for constructing buildings in noisy areas

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