# A STUDY ON THE EFFECTIVENESS OF RICE HUSK ASH AS A PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering

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Section: 15D
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# DECLARATION

It is hereby declared that this thesis/project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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***Dedicated***

*to*

*"Our beloved Parents"*

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# ABSTRACT

Increasing in the demand of conventional construction materials and the need for providing a sustainable growth in the construction field has prompted the designers and developers to opt for 'alternative materials' feasible for use in construction. Bangladesh, being an agro-based nation, has plenty of RHA production as an agricultural byproduct. Previous studies reported that almost 400 pounds of rice husk can be gotten after processing around 2000 pounds of paddy. In this study, summarizes the work on the properties of Rice Husk Ash (RHA) when used as partial replacement for cement. Compressive quality of 100x200 mm concrete cylinder has been decided to see the variety in quality of concrete with the partial replacement of cement by RHA. After a thorough review on related available research articles, Cement to RHA substitution are chosen as 0%, 5%, 10%, and 15% by the weight of cement and after that compared with the controlled concrete test. 0% replacement of cement served as the control concrete. Curing periods of 7, 28 days are considered for all the combinations and a consistent blending proportion of 1:1.5:3 for cement, fine aggregate & coarse aggregate, respectively, and a w/c ratio of 0.45, is chosen. RHA is collected from a rice process in the Dhaka area. Results depict that with the consideration of RHA as partial binders, the quality of concrete expectedly decreases. It has been spotted that the compressive strength and the tensile strength of hardened concrete is decreased with the increase of cement replacement with RHA. It is observed that expansion of  up to 10%  RHA to cement by weight (curing period 28 days) yields about the required compressive quality and the tensile quality. The tendency of compressive strength and tensile strength of concrete (replacement with RHA) is increasing with the curing time increase. It is recommended that further studies be carried out to gather more facts about the suitability of partial replacement of cement with RHA in concrete.

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# CHAPTER 1
# INTRODUCTION

## 1.1 IMPORTANCE OF THE STUDY

Concrete is the most commonly used of all building materials in the world due to its unique advantages compared to other materials. The vital role of cement as a sole binder in concrete that results in formation of solid material with ability to sustain load is undeniable. It is important to highlight that Ordinary Portland cement has been used as an important ingredient of concrete material in construction for even more than 200 years [1]. The total volume of cement production worldwide amounted to an estimated 4.4 billion tons in 2021. According to Bangladesh Cement Manufacturers Association (BCMA) the cement production capacity (Effective) in 2019- Approximate 61.02 million tons. As the demand for cement continues to rise. To meet this growing demand for cement, the cement industry is producing large quantities of cement that are adversely affecting the environment.

Cement manufacture contributes greenhouse gases directly through the production of carbon dioxide when calcium carbonate is heated (producing lime and carbon dioxide) and indirectly using energy, particularly if the energy is sourced from fossil fuels. The continuous harvesting of natural resources is exposed to permanent economic deterioration such as biodiversity loss, global warming, climate change, vegetation degradation, ecosystem destruction, river damage and dust contamination.

Realization of the harmful effect of the cement industry on the environment and mankind, endeavors have been persistently taken to diminish the contamination caused by industrial activity. In search of alternate materials, Rice Husk Ash (RHA) is luxuriously accessible in Bangladesh becoming the choice of cement replacement, partially though. Rice husk is considered as an agricultural waste that is generally used as fuel in rural areas and a small quantity is used as animal feed. Utilization of RHA in concrete as a partial replacement of cement minimizes the cost of concrete construction and makes a difference to simple reusing of squander created from incinerations or combustions of rice husk utilized in rural and industrial projects conjointly makes a difference to decrease the $CO_2$ contamination from cement production process.

Therefore, RHA is becoming one of the best replacement materials to reduce the dependency on cement in many countries of the world where paddy production is substantial. Researchers are examining the mechanical and basic properties of RHA to utilize in concrete with and without extra materials. Some studies have been recently published that on the production of concrete by using RHA as partial replacement of cement. These studies said that the performance of concrete contains RHA can be used if RHA added to concrete as partial replacement of cement, under proper justification. Mehta and Pirtz found that RHA is exceptionally valuable to decrease the temperature of mass concrete more than ordinary Portland cement (OPC) concrete [2]. A study summarized that the general decreasing trend of compressive strength with the addition of RHA for a particular curing period is precisely understood. The typical strength gaining with curing periods 7 days, 14 days, 28 days, 60 days and 90 days is also obvious. Based upon the results of their study, it is clearly understood that for the regular civil engineering construction practice, partial replacement of RHA up to 15% can be undoubtedly considered, provided that RHA is properly burnt and suitably mixed in concrete [3].

In spite of the fact that RHA has been reported as good materials to be utilized in concrete construction, however, it is not in worldwide best practice. In Bangladesh, huge amount of paddy is available, and we need to reduce of $CO_2$ emissions causes by cement production also need to reduce the construction cost.

## 1.2 OBJECTIVES OF THIS STUDY

- To evaluate the mechanical properties of concrete containing Rice Husk Ash (RHA)
- To compare the compressive strength and the tensile strength of the concrete at different level of replacement of cement by RHA.
- To determine the optimum percentage of rice husk ash that can be used in concrete as a partial replacement of cement.

## 1.3 ORGANIZATION OF THE THESIS

This thesis contains five chapters organized as following:

**Chapter 1: Introduction**

This chapter gives a general background about the impotence of the study, contains research problem and objectives of this studies.

**Chapter 2: Literature Review**

This chapter gives general review of previous research related to partial replacement of cement and the main materials used for study.

**Chapter 3: Research Method**

This chapter deals with the materials properties, their mixing proportion, testing procedure and equipment were used in the testing program.

**Chapter 4: Results and Discussion**

This chapter explain and discusses the result of the tests that were performed on the concrete at different stage of replacement of cement by RHA and also contains discussion based on result

**Chapter 5: Conclusions and Further Study**

This chapter includes the concluded remarks, main conclusions and recommendations from this study.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 INTRODUCTION

Concrete is used to provide strength, durability, and versatility during the construction of a structure. These excellent properties have made concrete a reliable and long-lasting choice of construction companies for both commercial and domestic types of constructions. The main reasons for its fame are because concrete has excellent mechanical feature and affordable [3-6]. It also has the tendency to be designed into a variety of sizes and forms [7]. Concrete is composite constructional materials as it is a mixture of several other materials like cement, crushed stones or brick chips, fine aggregate, and water. It solidifies and hardens after mixing with water and placement due to a chemical process which is known as hydration. It binds other building materials together. It is a material extensively used in the construction process. Concrete is used to make pavements, architectural structures, foundations, motorways, roads, and bridges, overpasses, parking structures, walls and footings for gates, fences and poles. Moreover, the conventional concrete is estimated to be produced about 6 billion tones every year worldwide [8]. So, the use of concrete in worldwide is increasing day by day and the corresponding materials production also increasing to meet up the demand.

Ordinary Portland Cement is the most important blinding materials of concrete. The largest concrete producer is China also their cement production while the second highest producer, which is India is 8.6% from China, and the United States as the third highest producer marked 29% of it [9]. It grew by 24.96 percent compared to total output in 2010 [10]. As the demand for cement supply is persistently developing, this causes an increment within the utilization of aggregate, particularly limestone since it is imperative for the production of Portland cement. Fatigue of the earth's non-renewable assets is a growing predicament when the reason is that the vitality utilization has quickly expanded amid the 21st century. As the quarrying and mining sector is broadly dynamic, at a few times in the future, the saves of non-renewable assets would unyieldingly be decreased as they are extricated from the environment and utilized for economy reason.

## 2.2 BACKGROUND

Researchers are examining the mechanical and basic properties of RHA to utilize in concrete with and without extra materials. Mehta and Pirz explored that the utilization of the rice husk ash as a replacement material decrease the temperature within the high-quality mass concrete [2]. Malhotra and Mehta afterwards reported that ground RHA with better particle size than OPC progresses concrete properties, counting that higher substitution amounts results in lower water retention values and the expansion of RHA causes an increase within the compressive strength [11]. Mahmud et. al. found that RHA-used concrete has superior quality, low shrinkage and higher strength than OPC concrete [12]. Chindaprasirt and Mahachai encourage considered the impact of pounding on the chemical and physical properties of rice husk ash and the impact of RHA fineness on properties of mortar and found that pozzolans with better particles had a more prominent pozzolanic response [13]. Zerbino et. al. concluded that concretes arranged with ground RHA appeared recognizable enhancement within the mechanical properties as fractional replacement of cement in concrete up to 25% [14]. Hence, RHA is getting to be one of the finest replacement materials to decrease the reliance on cement in numerous nations of the world where paddy generation is significant. RHA has satisfactory holding quality and gives extra quality if included to concrete as partial replacement of cement, under appropriate avocation [15-22].

So, much more strong evidence is required to create individuals mindful of the utilization of RHA in all sorts of civil engineering developments.

## 2.3 CONSTITUENT MATERIALS IN CONRETE

Concrete is a composite material composed of fine and coarse aggregate banded together with a fluid cement that hardens over time. The ordinary Portland cement is used as a blind material in conventional concrete. when aggregate is mixed together with dry Portland cement and water, the mixture forms a fluid slurry that is easily pulled and molded into shape. The cement reacts chemically with the water and other ingredients to form a hard mix Metrix that binds the materials together into a durable stone-like material that has many uses. Often, additives (such as pozzolanas or superplasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished materials. Most concrete is poured yielding reinforced concrete. Over the few decades, the use of various alternative fine and coarse aggregate in the production of concrete have been investigated.

### 2.3.1 CEMENT

Cement is a binder as well as a substance used in construction that sets, hardens and adheres to other materials and binding them together. Cement is seldom used solely but is used to bind sand and gravel (aggregate) together. Cement is used with fine aggregate to produce mortar for masonry or with sand and gravel aggregates to produce concrete. There are various types of cement used in construction works for various purposes such as rapid hardening Cement, quick setting cement, low heat Cement, white cement etc.

Ordinary Portland Cement (OPC) is the most common cement used in general concrete construction when there is no exposure to sulphates in the soil or groundwater. The most commonly used Ordinary Portland cement (OPC) is greys in colour but white Portland cement is also available. Ordinary Portland cement is a controlled blend of calcium silicates, aluminates and ferrate, which is ground to a fine powder with gypsum and other materials. OPC is divided into 3 types based on the strength obtained at 28 days.

OPC 33 grade:- strength not less than 33N/mm$^2$ at 28days

OPC 43 grade:- strength not less than 43N/mm$^2$ at 28 days

OPC 53 grade:- strength not less than 53N/mm$^2$ at 28days

Portland cement gets its strength form chemical reactions between the cement and water. The process is known as hydration. This is complex process that is best understood by first understanding.

The main chemical components of cement are following Table 2.1 [17]

| Constituent | Percentage Composition |
|---|---|
| Lime (CaO) | 60-67% |
| Silica ($SiO_2$) | 17-25% |
| Alumina ($A1_2O_3$,) | 3-8% |
| Magnesia (MgO) | 0.1-44% |
| Sulphur trioxide ($SO_3$) | 1-3% |
| Iron Oxide ($Fe_2O_3$) | 0.5-6% |
| Soda and Potash alkalis | 0.2-1% |

### 2.3.2 RICE HUSK ASH

Rice husk is considered as an agricultural waste that is generally used as fuel in rural areas and a small quantity is used as animal feed. According to Bangladesh Rice Research Institute, rice, paddy production for Bangladesh was 54.9 million tons in 2020, which generate about 9.83 million tons of RH after milling of the paddy. Which means a huge amount of RHA is accessible, which was already considered fair a squander material. Other than that, RHA has some great quality ingredients to be considered as a binder material in concrete development. Typical chemical composition of RHA found in Bangladesh is given in Table 2.2.

Table 2.2: Chemical composition of RHA found in Bangladesh [17]

| **Constituent** | **Percentage Composition** |
|---|---|
| Fe2O3 | 1.38 |
| SiO2 | 90.20 |
| Al2O3 | 0.85 |
| CaO | 1.18 |
| MgO | 1.21 |
| Loss on Ignition | 3.95 |

It can be seen that the silica is predominant in RHA. Materials that are rich in siliceous or siliceous and aluminous contents are known as pozzolans. Pozzolans, itself possess little or no cementitious value, however, if divided into a very fine powder and in the presence of water, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

RHA is found to be a great fabric that satisfies the physical characteristics and chemical composition of mineral admixtures. A little sum expansion of RHA (lesser than two to three by weight of the cement), to a given water-cement proportion, is adequate and accommodating to make strides in the soundness, solidness, as well as workability, tends to extend the compressive quality and solidness of the concrete. Utilization of the fine rice husk inquiries diminishes the temperature as compared to the typical OPC temperature. As per the analyst, perception is was found that appropriate proportionate apportion of RHA can diminish the initial setting time additionally it gets its greatest quality inside some days. RHA depends primarily on silica substance, silica crystallization stage, and estimate and surface range of ash particles [23]

#### 2.3.2.1 USES OF RHA IN CONCRETE

Workability of concrete decreases with the increasing percentage of replacement of cement by RHA unless any suitable admixtures are used. Researchers suggests low water–cement ratio with admixtures for use of RHA concrete. Researches showed that RHA contains high silica, which is helpful for increasing durability of concrete if used in proper proportion with cement. RHA concrete possesses lower expansion than normal OPC concrete (control concrete) when exposed to magnesium sulphate solution [24]. They found 2% lower strength reduction in RHA concrete than OPC concrete when exposed to magnesium sulphate solution. Moreover, RHA used in concrete increased the resistance to chemical attack [25]. This study RHA would be used 5%-15% as partial replacement of cement. Consequently, the present study is a preliminary attempt to investigate the workability, compressive strength, and split tensile strength of RHA used concrete as partial replacement of cement.

### 2.3.3 FINE AGGREGATE

Aggregates consist of natural sand or crushed stone with most particles passing through No. 4 sieve (4.75mm) and retaining on No. 100 sieve. It covers almost one-third of total concrete volume. Fine aggregate fills the open spaces in between the coarse particle which reduces porosity and increases the strength. Sand is generally considered to have a lower size limit of about 0.07mm. Material between 0.06mm and0.002mm is classified as silt, and still smaller particles are called clay [26].

According to size, the fine aggregate may be described as coarse, medium and fine sands provided in Table 2.3

Table 2.3: Classification of Fine Aggregate

| Fine aggregate | Size variation (mm) |
|---|---|
| Coarse Sand | 2.0 – 0.5 |
| Medium sand | 0.5 – 0.25 |
| Fine sand | 0.25 – 0.06 |
| Silt | 0.06 – 0.002 |
| Clay | <0.002 |

### 2.3.4 COARSE AGGREGATE

When the aggregate is sieved through 4.75mm sieve, the aggregate retained is called coarse aggregate. Gravel, cobble and boulders come under this category. The maximum size aggregate used may be dependent upon some conditions. In general, 40mm size aggregate used for normal strengths and 20mm size is used for high strength concrete. The size range of various coarse aggregates is given below. Sources for these basic materials can be grouped into three main areas: Mining of mineral aggregate deposits, including sand, gravel, and stone; use of waste slag from the manufacture of iron and steel and recycling of concrete [27]. Classification of coarse aggregate according to size is shown in Table 2.4.

Table 2.4: Classification of Coarse Aggregate

| Coarse aggregate | Size (mm) |
|---|---|
| Fine gravel | 4 – 8 |
| Medium gravel | 8 – 16 |
| Coarse gravel | 16 – 64 |
| Cobbles | 64 – 256 |
| Boulders | >256 |

### 2.3.5 SHAPE OF AGGREGATE

According to Galloway, the Shape of aggregate is related to three different characteristics sphericity, form and roundness [28]. Sphericity is a measure of how nearly equal are the three principal axes or dimensions of a particle. Form is the measure of the relation between the three dimensions of a particle based on ratios between the proportions of the long, medium and short axes of the particle. According to Hudson B, form also called “shape factor” is used to distinguish between particles that have the same nominal sphericity [29] However, different definitions exist that do not necessarily correlate. Besides sphericity and shape factor, two more parameters have been defined in order describe the shape of aggregate better the elongation factor and the flatness factor. If the principal dimensions of a particle are L.I.S (long, intermediate, short) Regarding spericity and form, particles can be classified qualitatively as cubical. Spherical or flat and elongated According to Kwan there are two other characteristics which he terms roundness and angularity [30]. Angularity is related to the sharpness of the edges and corners of a particle, while roundness attempts to describe the outline of the particle, which may be measured in terms of “convexity’’ Angularity can be defined numerically as the ratio of the average radius of curvature of the corners and edges of the particle to the radius of the maximum inscribed circle, but descriptive terms are commonly used as the following

| | |
|---|---|
| Angular | : little evidence of wear on the particle surface |
| Sub angular | : evidence of some wear, but faces untouched |
| Surrounded | : considerable wear, faces reduced in area |
| Rounded | : faces almost gone |
| Well rounded | : no original faces left |

### 2.3.6 EFFECT OF AGGREGATE CHARACTERISTICS

Aggregate characteristics have a significant effect on the behavior of fresh and hardened concrete. Although these effects of aggregate characteristics change continuously as a function of particle size, the following classification will be made according to common practice material retained in the N 4 sieve will be considered coarse aggregate, material passing No 4 sieve will be considered fine aggregates.

The main characteristics of aggregate that affect the performance of fresh and Hardened concrete are:

-  Shape and texture
-  Grading
-  Absorption
-  Mineralogy and coatings
-  Strength and stiffness
-  Maximum size
-  Specific gravity or relative density
-  Soundness
-  Toughness

### 2.3.7 GRADING OF AGGREGATE

Grading of aggregate means particle size distribution of the aggregate. If all the particle of an aggregate were of one size more voids will be in the aggregate mass. On the other hand an aggregate having particles fill up the void left in larger size particles. By adopting proper percentage various size aggregate composite aggregate mixes can be developed which will be thoroughly graded. Properly graded aggregate and cement. The grading of aggregate is expressed in term of percentages by weight retained on a series of sieves. 75mm, 20mm, 4.75mm coarse are used for Grading of coarse aggregate. Whereas 10mm, 4.75mm, 2.36mm, 18mm fine are used for grading of fine aggregate.

Grading determines the work ability of the mix, which control segregation, bleeding water-cement ratio handling placing and other characteristics of the mix. These factors also affect economy, strength, volume change and durability of hardened concrete. There is no universal ideal grading for the aggregate. However, I.S.I has specified certain limits within which a grading must lie to produce a satisfactory concrete. But these limits depend upon the shape, surface texture type of aggregate and amount of flaky or elongated material variations in grading of sand, causes a large variation in workability, strength and other properties, But the variation in the grading of coarse aggregate does not affect these properties to the extent of fine aggregate.

### 2.3.7.1 FINE AGGREGATE GRADING

Over the years, there have been several approaches to specifying the grading requirements for the aggregate. First type grading curves were given as representing good grading in the 1973 edition of BS 882, four grading zones were introduced, the division into zones was based primarily on the percentage passing the 600pm sieve. The main reason for this was that a large number of natural sands divide themselves at just that size the grading above and below being approximately uniform. Furthermore, the content of particles timer than the sieve has a considerable influence on the workability of the mix and provides a fairly reliable index of the overall specific surface of the sand. Thus, the grading zones largely reflected the grading of natural sands available in the united kingdom, Little of these sands are now available for concrete making and a much less restrictive approach to grading is reflected in the requirement of BS 882, 1992, This does not mean that any grading will do rather, given that grading is one feature of aggregate, a wide range of grading may be acceptable but a trial error approach is required. Specifically, BS 882, 1992 requires any fine aggregate to satisfy the overall grading limits of Table 2.3 and also one of the three additional grading limits of the same table, but one in ten consecutive samples is allowed to fall outside the additional limits. The additional limits are in effect a course a medium and a fine grading

### 2.3.7.2 COARSE AGGREGATE GRADING

Course in general terms, the ratio of course to fine aggregate. When crushed rock coarse aggregate is used, a slightly higher proportion of fine aggregate is required than with gravel aggregate in order to compensate for the lowering of work ability by the sharp, angular shape of the crushed particles.

The requirements of ASTM C 33-02 for the grading of coarse aggregate are reproduced in Table. The actual grading requirement depends to some extent, on the shape and surface characteristics of the particles. For instance, sharp, angular, particles with rough surface should have a slightly finer grading in order to reduce the possibility of interlocking and to compensate for the high friction between the particles. The actual grading of crushed aggregate is affected primarily by the type of crushing plant employed. A roll granulator usually produces fewer fines than other types of crushers, but the grading depends also on the amount of material fed into the crusher.

**Other Consideration for Coarse Aggregate**

The larger the maximum size of the coarse aggregate, the lower the water demand of the mix. For example, a mix containing 1-inch –maximum size aggregate will require about 5 gallons less water per cubic yard than a mix using -inch –maximum size aggregate when both mixes are adjusted to the same slump. ASTM C33-02 generally limits the amount of material passing the #200 sieve to 1 percent for natural coarse aggregate containing clay. As stated above, clay is a very fine particle that greatly increases the water demand of a mix, reduces strength significantly, and promotes bleeding.

### 2.3.7.3 EFFECT OF GRADING

Grading or particle size distribution affects significantly some characteristics of concrete like packing density, voids content and consequently, workability, segregation, durability and some other characteristics of concrete. Particle size distribution of fine aggregate plays a very important role on workability, segregation and permeability of fresh concrete.

A concrete mix basically consists of sand and rock of various sizes glued together with a mixture of cement and water. Concrete aggregates displace a significantly large portion of the volume of a cubic yard of concrete. For example, in a typical 600 pound cement mix with entrained air the fine and coarse aggregate will make up approximately 67 percent of the total volume. With leaner mixes the aggregate takes up even more volume. The gradation and overall fineness of the aggregate used will affect the physical properties and cost of the mix.

### 2.3.7.4 EFFECT OF AGGREGATE GRADATION AND FINENESS ON CONCRETE PROPERTIES

A concrete mix basically consists of sand and rock of various sizes glued together with a mixture of cement and water. Concrete aggregate displaces a significantly large portion of the volume of a cubic yard of concrete. For example, in a typical 600 pound cement mix with entrained air, the fine and coarse aggregate will make up approximately 67 percent of the total volume. With leaner mixes, the aggregate takes up even more volume. The gradation and overall fineness of the aggregate used will affect the physical properties and cost of the mix.

The gradation of the aggregate, or distribution of particle size, should meet the specifications outlined in ASTM C33-02, Standard Specification for Concrete Aggregates ASTM C33-02 suggests that the gradation curve be smooth with neither a deficiency nor excess of material of any one size. A smooth gradation curve decreases the voids between the aggregate particles in a homogeneous concrete mix, and because the voids must be filled with a mixture of cement and water, it therefore decreases the amount of cement required (The pasts portion of the concrete can also be increased by adding water, but this increases the water cement ratio and decreases strength). Cement is usually the most expensive component in concrete, so minimizing the amount needed makes the mix more economical.

### 2.3.8 WATER

Water is an important constituent in concrete. It chemically reacts with cement (hydration) to produce the desired properties of concrete. Mixing water is the quantity of water that comes in contact with cement, impacts slump of concrete and is used to determine the water to cementations materials ratio (w/c) of the concrete mixture. Strength and durability of concrete is controlled to a large extent by its w/c ratio. Mixing water in concrete includes batch water measured and added to the mixer at the batch plant, ice, and free moisture on aggregates, water included in any significant quantity with chemical admixtures and water added after batching during delivery or at the jobsite. Water absorbed by aggregates is excluded from mixing water. Besides its quantity the quality of mixing water used in concrete has important effects on fresh concrete properties such as setting time and workability; it also has important effects on the strength and durability of hardened concrete. In general, water that is fit for human consumption (potable) is acceptable for use as mixing water. However, non-potable sources of water can also be used provided the source does not negatively impact the properties of concrete. Most concrete plants have a source of municipal water that supplies potable water and this can be used as mixing water without any testing. In rural areas or for portable plants set up on project sites, the concrete producer may have to rely on non-potable sources such as wells, streams or other bodies of water. All concrete producers will also generate process water by cleaning mixers and plant components also referred to as wash water. Additionally, precipitation on the site of the concrete plant generates storm water that may be collected at the plant. Environmental regulations typically require concrete plants to treat process and storm water to achieve certain characteristics like pH or solids content before it is discharged from the property. Process and storm water at concrete plants is referred to as water from concrete production operations in ASTM C1602. Process water is also generated when returned concrete is washed out in concrete reclaimed systems. These systems collect process water with the cement and aggregate fines in the form of slurry that can be re-used as mixing water in concrete. Water is critical in the making of concrete. Adding water to the mix sets off a chemical reaction when it comes into contact with the cement. The water used in the mixing of concrete is usually of a potable standard. Using non-drinking water or water of unknown purity risks the quality and Workability of the concrete.

Water serves the following three purposes:

1. To wet the surface of aggregates to develop adhesion because the cement paste adheres quickly and satisfactory to the wet surface of the aggregates than to dry surface.
2. To prepare a plastic mixture of the various ingredients and to impart workability to concrete to facilitate placing in the desired position and
3. Water to also needed for the hydration of the cementing materials to set and hard enduring the period of curing.

### 2.3.9 INFLUENCE OF AGGREGATE WATER/CEMENT RATION ON STRENGTH OF CONCRETE

The richness of the mix affects the strength of all medium and high strength concrete, i .e those with strength of about 35 MPa (5000 psi) or more. There is no doubt that aggregate/cement ratio, is only a secondary factor in the strength of concrete but it has been found that for a constant water/cement ratio a leaner mix leads to higher strength.

The reasons for this behavior are not clear. In certain cases, some water may be absorbed by the aggregate. A larger amount of aggregate absorbs quantity of water. The effective water/cement ratio being thus reduced. In other cases a higher aggregate content ratio would lead to lower shrinkage and lower bleeding and therefore to less damage to the bond between the aggregate and the cement paste, the thermal change caused by the heat of hydration of cement would be smaller 6.80. The most likely explanation however, lies in the fact that the total water content per cube meter of concrete is lower in a leaner mix than in a rich one. As a result, in a leaner mix, the voids form a smaller fraction of total volume of concrete and it is these voids that have an adverse effect on strength.

Studies on the influence of aggregate content on the strength of concrete with a given quality of cement paste indicate that when the volume of aggregate (as a percentage of the total volume) is increased from zero to 20, there is a gradual decrease in compressive strength but between 40 and 80 percent there is an increase 6.40. The reasons for this effect are not clear, but it is the same at various water cement ratio 6.41.The influence of the volume of aggregate on tensile strength is broadly similar 6.40.

### 2.3.10 INFLUENCE OF WATER CEMENT RATIO ON STRENGTH

It is the ratio of water to cement in a concrete mixture. Water and cement both are taken by volume. Strength and workability of the concrete greatly depend upon the amount of water. For a particular proportion of materials, there is a specific amount of water which gives the optimum strength to the concrete. W/C ratio is less than 0.4 to 0.5 complete hydration of the cement can be secured.

W/C ratio also depends upon the method adopted to secure compaction of concrete. It compaction is to vibrations, less W/C ratio is required. Addition of plasticizing agents in the concrete mix, also increase the workability and reduce the W/C ratio.

### 2.3.11 COMPRESSIVE STRENGTH

Compressive strength is the most important property of concrete. The compressive strength of concrete is determined in the laboratory in controlled conditions. On the basis of this test result we judge the quality of concrete. But sometimes the strength test results vary so widely that it becomes difficult to reach at any conclusion. This variation in test results can be avoided by taking necessary steps. The typical stress strain curve for normal weight concrete is shown in Fig. 2.1.

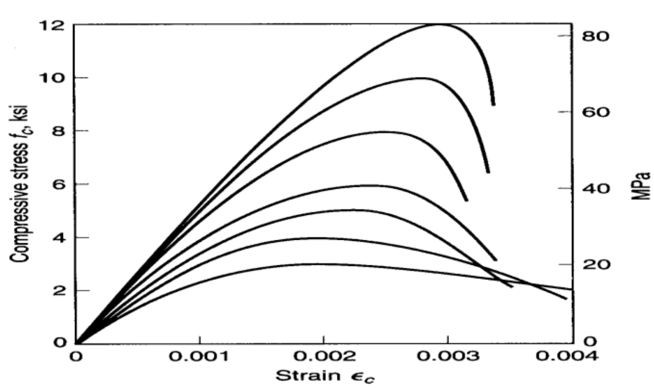


Figure 2.1: Stress strain curve for normal weight concrete [26]

Compressive strength of concrete cylinders has been shown to vary with the height and diameter of concrete cylinders. In this regard, the height/diameter ratios can be considered as the determining factor of the concrete compressive strengths. Fig. 2.2 illustrates the effect of height/diameter ratio on relative concrete compressive strengths. It can be observed that lower height/diameter ratio of concrete cylinders results in higher relative strengths [26].

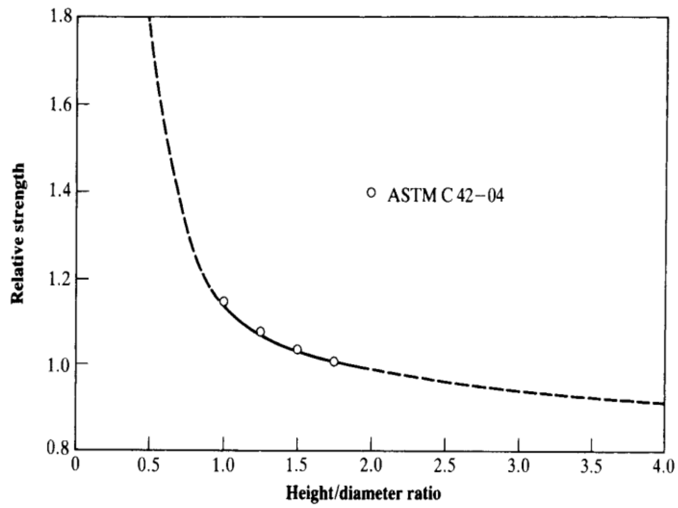


Figure 2.2: Influence of height/diameter ratio on the apparent strength of cylinder [26]

The effect of specimen diameter on the magnitude and precision of the compressive strength of concrete cores are analyzed in different conditions. Based on the analyses, the predicted average strength of a 2-inch diameter core is 94 percent of the predicted average strength of a 4-inch diameter core and 92 percent of that of a 6-inch diameter core.

These overall average values do not reflect the considerable scatter of the data and, therefore, should be used with caution. The large variability commonly attributed to small-diameter specimens is often caused by the large variability of the in situ concrete strength within the element being cored. The data also indicate that the effect of the core height/diameter ratio on the compressive strength is more significant for 2-inch diameter cores than for 4-inch diameter cores.

### 2.3.12 WORKABILITY

A concrete is said to be workable if it is easily transported, placed, compacted and finished without any segregation. Workability is a property of freshly mixed concrete, and a concrete is a mixture of cement, aggregate, water & admixture. Due to this all the properties of concrete, whether in fresh state or hardened state, is affected by these ingredients and their proportions [26].

The single most important nature of workable concrete is its lubricating nature. If a concrete shows more lubricating nature, then it will have the following advantages, such as-

- It will exhibit little internal friction between particle and particle.
- It will overcome the frictional resistance offered by the surface of the formwork and reinforcement contained in the concrete.
- It can be consolidated with minimum compacting effort.

### 2.3.13 CURING

Curing of concrete is defined as providing adequate moisture, temperature, and time to allow the concrete to achieve the desired properties for its intended use. This would mean maintaining a relative humidity in the concrete of greater than 80 percent, a temperature greater than 50 degrees fahrenheit, and for a time typically ranging from three to 14 days depending on the specific application.

According to British standard for structural use of concrete, BS 8110 (1997), the intension of curing the concrete is-

- To ensure the adequate amount of water required for the hydration reaction of cement.
- Premature drying out, particularly by solar radiation and wind (plastic shrinkage)
- Leaching out by rain and flowing water
- Rapid cooling during the first few days after placing
- High internal thermal gradients
- Low temperature or frost
- Vibration and impact which may disrupt the concrete and interfere with bond to reinforcement

There are various methods of curing. The adoption of a particular method will depend upon the nature of work and the climatic conditions.

# CHAPTER 3

# METHODOLOGY

## 3.1 GENERAL

For a good design, a good concrete is a must. It is not very difficult to make a good concrete. The only necessary thing is to have through idea about the physical properties of concrete. More than sixty factors can affect the quality of concrete and for that reason vigorous investigation are needed. The design of concrete mix by traditional method requires the properties of concrete materials i.e. coarse and fine aggregate, such as specific gravity, unit weight, fineness, modulus etc. Hence information should be available about the properties of different elements of concrete.

## 3.2 SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE

The term sieve analysis, given to the sample operation of dividing a sample of aggregates in to fraction each consisting of pa articles between specific limits. The analysis is conducted to determine the grading of material proposed for use as aggregates. The term fineness modulus (F.M) is a ready index of coarseness or fineness of material. It is an empirical factor obtained by adding the cumulative percentages of aggregates. Retained of each of the standard sieves and dividing this sum arbitrarily by 100.

No. 100, No. 50, No.30, No.16, No.8, No.4, No.3/8in..., No.3/4 in…, No.1.5 in... , is the ASTM standards sieves .This test method conforms to the ASTM standard requirements of specification ASTM C 136.

**Apparatus:**

- Balance (sensitive to within 0.1% of the weight of the sample),
- Sieves (ASTM standard).
- Oven and
- Containers.

**Test Procedure**

a) The samples were dried to a constant mass at a temperature of around 110°C and after drying samples were weighted.

b) A set of IS sieves with suitable openings were used to sieve the samples. Quantity of materials were limited so that all the materials could reach the sieve opening a number of times during sieve analysis.

c) Sieving process was continued for a sufficient period until the particles were not pass through the sieve.

d) On completion of sieving, the materials retained on each sieve was weighted on balance.

e) Cumulative weight retained into each sieve and percentage of cumulative weight retained was calculated.

f) Fineness modulus was obtained by taking the sum of the cumulative percentage of samples retained on each sieve and dividing the sum by 100.

Figure 3.1: Sieve Analysis of Natural Aggregate

## 3.3 SPECIFIC GRAVITY AND ABSORPTION CAPACITY OF FINE AGGREGATE

Aggregate generally contains pores, both permeable and impermeable, for which specific gravity must be carefully defined. With this specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate us also required in calculating the compacting factor in connection with workability measurements. This test method covers the determination of bulk and apparent specific gravity, 23/23˚C (73.4/72.4˚F) and absorption capacity of fine aggregate. This is used for calculation of the volume occupied by the aggregate and the determination of moisture in aggregate.

The specific gravity of a porous solid, when the volume of the solid as used in the calculation includes both the permeable and impermeable voids. Bulk specific Gravity (also known as Bulk Dry Specific Gravity) is the ratio of the weight in air of a unit volume of aggregate at a stated temperature to the weight in air of a volume of gas free distilled water at the stated temperature.

Apparent specific gravity is the ratio of the weight in air of a unit volume of the impermeable portion of aggregate (does not include the permeable pores in aggregate) to the weight in air of an equal volume of gas free distilled water at the stated temperature.

**Apparatus**

a. Balance sensitive to 0.1 gm or less.

b. Pycnometer a flask of other suitable container of 1000ml capacity. The volume of the container filled to mark shall be at least 50%greater than the space required to accommodate the sample of fine aggregate.

c. Mold – A Metal mold in the form of a frustum of a cone with dimensions as follows: 40±3mm inside diameter at the top 90±3 mm inside diameter at the bottom 75± 3mm in height 0.8mm minimum thickness of metal.

d. Tamper – A metal tampers weighing 350±15gm and having a flat circular tamping face 25±30 mm in diameter.

Aggregate into the mold with 25 light drops of the tamper. Each drop should start about 5mm (0.2in) above the top surface of the fine aggregate. Permit the tamper to fall freely under gravitation attraction on each drop. Adjusted the string height to the starting height to the new surface elevation on each drop and distribute the drops over the surface. Removed loose sand from the base and lift the measured vertically. If surface moisture is still present, the fine aggregate will retain the molded sharp. Continue drying with constant stirring and test at frequent intervals until the cone to the slums upon the removal of mold. When the fine aggregate slumps slightly it indicates that it reached a surface dry condition.

Table 3.1: Specific gravity and absorption capacity of fine aggregate.

| Tests | Results |
|---|---|
| Bulk Specific Gravity (S.S.D Basis),Ss | 2.575 |
| Bulk Specific Gravity (Oven-Dry Basis), $S_d$ | 2.548 |
| Apparent Specific Gravity, $S_s$ | 2.619 |
| Absorption Capacity, A (%) | 1.33 |

## 3.4 SPECIFIC GRAVITY AND ABSORPTION CAPACITY OF COARSE AGGREGATE.

This test covers the determination of specific gravity and absorption of coarse aggregate. Aggregate generally contains pores, both permeable and impermeable, for which specific gravity has to be carefully defined. With this specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can calculated. Specific Gravity of aggregate is also required in calculating the compacting factor in connection with workability measurements. This test method covers the determination of bulk and apparent specific gravity, 23/23˚C (73.4/72.4˚F) and absorption capacity of fine aggregate. This is used for calculation of the volume occupied by the aggregate of varying mixtures on an absolute volume basis, the computation of voids in aggregate and the determination of moisture in aggregate.

The specific gravity of a porous solid, when the volume of the solid as used in the calculation includes both the permeable and impermeable voids. Bulk Specific Gravity (also known as Bulk Dry Specific Gravity) is the ratio of the weight in air of a unit volume of aggregate at a stated temperature.

Apparent specific gravity is the ratio of the weight in air of a unit volume of the impermeable portion of aggregate (does not include the permeable pores in aggregate) to the weight in air of an equal volume of gas-free distilled water at the stated temperature.

**Apparatus:**

1. Balance- Sensitive to 0.05% of the sample weight at any point within the range used for the test, or 0.5g; whichever is greater.

2. Sample container- A wire basket of 3.35mm (no 6) or finer mesh, or a bucket of approximately equal breath and height, with a capacity of 4 to 7 liter for 37.5mm(1.5 in) nominal maximum size aggregate. The container shall be constructed to prevent trapping air when the container is submerged.

3. Water tank- A watertight tank into which the sample container may be placed while suspended below the balance.

4. Sieves-A 4.75mm (No.4) sieve or other sizes as needed.

**Procedure:**

a) Dry the test sample to constant weight at a temperature of 110±5˚C (230±9˚F), cool in air at room temperature for 1 to 3 hour for test samples of 37.5mm (1.5 in) nominal maximum size, or longer for larger sizes unit the aggregate has cooled to a temperature that is comfortable to handle (approximately 50˚C). Subsequently immerse the aggregate in water at room temperature for a period of 24±4 hr.

b) Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the roll it in a large particle individually. A moving stream of air used to assist in the drying operation. Take care to avoid evaporation of water form aggregate pores during the operation surface drying. Weigh the test sample in the saturated surface –dry condition. Record this and all subsequent weights to the nearest 0.5% of the sample weight, whichever is greater.

c) After weighing, immediately placed the saturated surface dry test sample container and determined its weight in water at 23±1.7˚C(73.4±5˚F), having a density of 997±2 kg/m3. Take care to remove all entrapped air before weighing by shaking the container while immersed.

d) Dry the test sample to constant weight at a temperature of 110±5˚C (230±9˚), cool in air at room temperature for 1 to 3 hr or until the aggregate is cooled to a temperature that is comfortable to handle (approximately 50˚C), and weight.

**Result:**

Table 3.2: Specific gravity and absorption capacity of course aggregate.

| Table | Result |
|---|---|
| Bulk Specific Gravity (S.S.D. Basis), $S_s$ | 2.701 |
| Bulk Specific Gravity (Oven-Dry Basis),$S_d$ | 2.677 |
| Apparent Specific Gravity, $S_a$ | 2.745 |
| Absorption Capacity, A (%) | 0.89 |

## 3.5 MIX PROPORTIONS OF CONCRETE

For this research mixture proportion of different groups of concrete were determined in accordance with following conditions-

a) Same water/cement ratio,

b) Same maximum grain size (19.5mm)

c) Same type and quantity of fine aggregate

d) Same type and quantity of coarse aggregate.

e) Variable quantity of cement and the rest quantity replaced by RHA

**Mix Proportions for Concrete cylinder**

To perform compressive and tensile strength test, 100mm x 200 mm cylinder concrete was made. Two groups of concrete samples were carried out for this research. In one group, only cement natural coarse and fine aggregates were used to made concrete. In second group, concrete was made with partial replacement of Ordinary Portland Cement with Rice Husk Ash. The replacements were done by 5%, 10% and 15% by wight.

The mix proportions were 1 :1.5 :3 for cement: sand: coarse aggregate. Amount of concrete for a cylinder of each batch are shown in the following table 3.3:

Table 3.3: Estimation of materials for concrete cylinder

| Batch No | % Replacement | Cement (g) | RHA (g) | Sand (g) | Coarse Aggregate (g) | Water (g) |
|---|---|---|---|---|---|---|
| 1 | 0% | 550 | 0 | 975 | 1650 | 247.5 |
| 2 | 5% | 522.5 | 27.5 | 975 | 1650 | 247.5 |
| 3 | 10% | 495 | 55 | 975 | 1650 | 247.5 |
| 4 | 15% | 467.5 | 82.5 | 975 | 1650 | 247.5 |

## 3.6 MIXING OF CONCRETE

- In case of mixing of concrete is done by hand with the help the using bucket. Each ingredient of the concrete mix needs to be measured. Be measured, by volume, to get the proportions right, we did this by shovel load. We used the medium size of the bucket as after we have measured the entire ingredient, we could end up with larger pile to mix in one go. It is a lot easier to mix two smaller piles than just one larger one.
- Clean off the working surface to remove any odd debris and wet the area.
- Carefully measure out about half the coarse aggregate and dump it in mixing area to form acne shape.
- Use a shovel to from a crater in the middle of the heap, then measure out all the cement required and adds this to the crater.
- Measure out the remainder of the coarse aggregate.
- Without adding any water, use shovel to mix all the ingredients together, work around the heap taming over each part three- or four-times unit the mixture is evenly colored (grey).
- Uses a shovel to reform a cone shape and mark a crater in the top of the heap add some water to the crater.
- Use a shovel to move the move the mixture into the central crater from around the edges and turn it over to distribute the water throughout the mixture. Watch for any water escaping, use the shovel to trap any with the mixture.

Figure 3.2: Preparation of Mixing of Cement and Aggregate

## 3.7 PREPARATION OF MOLD AND DEMOLDING

### 3.7.1 PROCESS OF MOLDING

1. For compressive and tensile strength test, cylindrical mold was used. height and diameter of the mold was 200 mm and 100 mm respectively.

2. Molds were cleaned, and grease was applied on the inner surface of the mold.

3. Concrete was filled in the mold in 3 layers.

4. Each layer was rodded 25 times in an even pattern using a tamping rod.

5. After tamping, the top surface was levelled.

6. The molded specimens were kept at normal temperature to dry.

Molding of cylinder and beam concrete specimens are shown in figure 3.4.

Figure 3.3: Molding of concrete specimens

### 3.7.2 PROCESS OF DEMOLDING

After 24 hours of casting, the concrete specimens were removed from the mold and allowed for curing.

### 3.7.3 CURING

After demolding, the specimens were placed under water up to 7 days, 14 days and 28 days. The specimens were fully immersed under water.

Table 3.4: Details of property, test method age at test, Number and size of specimens

| Name of Property | Test Method | Age at Test (days) | Size of Specimens | No. of specimens |
|---|---|---|---|---|
| Compressive Strength | ASTM C39 | 7 | 100 mm dia × 200 mm height Cylinders | 8 |
| | | 14 | 100 mm dia × 200 mm height Cylinders | 8 |
| | | 28 | 100 mm dia × 200 mm height Cylinders | 8 |
| Splitting Tensile Strength | ASTM C496 | 7 | 100 mm dia × 200 mm height Cylinders | 8 |
| | | 14 | 100 mm dia × 200 mm height Cylinders | 8 |
| | | 28 | 100 mm dia × 200 mm height Cylinders | 8 |

## 3.8 COMPRESSIVE STRENGTH TEST

Cylinder concrete specimens of 4-inch diameter and 8 inch height were made. The specimens were demoded and one day before testing of the specimens, the specimens were kept under wet condition. The specimens were tested under a universal testing machine (UTM). The specimens were tested at 7, and 28 days the compressive strength was determined as par ASTMC 39.

### 3.8.1 APPARATUS

1. Compression testing machine and
2. Balance.

### 3.8.2 PROCEDURE

1. The weight of specimen was measured and then it was placed on the lower bearing block so the axis of the specimen is aligned with the center of thrust of the spherically seated bearing block.

2. Age, weight, type and peak load was provided in the screen of testing machine and a compressive load of .25 MPa/s was applied continuously and without shock until failure.

3. Maximum load carried by the specimen during the test was recorded and the type of fracture pattern was noted.

Figure 3.4: Compressive strength test of Cylinder

## 3.9 SPLITTING TENSILE STRENGTH

The tensile strength of concrete is one of the important properties, which greatly affect the extent, and size of cracking in structures. Splitting test is generally an indirect way to determine tensile strength of concrete which is greater than direct tensile strength and lower than flexural strength. It is expressed as the minimum tensile stress needed to split the material apart. Splitting tensile strength is used to design the lightweight concrete members to evaluate the shear resistance provided by concrete and to determine the development length of reinforcement.

In this study, the splitting tensile strength of specimens was measured according to ASTM C496. ASTM C496 determines the splitting tensile strength of cylindrical concrete specimens such as molded concrete cylinders and drilled cores.

### 3.9.1 APPARATUS

1. Testing machine- Compression testing machine according to ASTM C39 was used. The machine was able to apply the load continuously and without shock.

2. Supplementary bearing bar – As the diameter of the upper bearing face and the lower bearing block was less than the length of the cylinder to be tested, a supplementary bearing bar or plate of machined steel was used.

3. Bearing strips- The bearing strips was placed between the bearing bar and both the upper and lower bearing blocks of the testing machine.

4. Balance.

### 3.9.2 PROCEDURE

1. The bearing blocks and other test fixtures were installed as necessary to complete the splitting tensile strength. The bearing faces of bearing blocks were cleaned as well as possible. The bearing bar was placed between bearing blocks and bearing strips were placed between bearing bar and bearing blocks.

2. Weight of the sample was measured.

3. Specimen was placed ensuring that it was centered along the length of the upper block and lower blocks.

4. After placing the specimen in the machine and age, weight, type and peak load was provided in the screen of testing machine.

5. A compressive load of 1.5 MPa per minute was applied continuously and without shock until failure.

4. Maximum load carried by the specimen during the test was recorded and the type of fracture pattern was noted.

Figure 3.5: Splitting tensile strength test of cylinder

# CHAPTER 4
# RESULTS AND DISCUSSION

## 4.1 GENERAL

This chapter consists of the result obtained from this experimental study. This chapter also includes the comparison among the test results.

## 4.2 COMPRESSIVE STRENGTH OF CYLINDER SPECIMENS

Compressive strengths of concrete for all the blending combinations are reported in this section. table 4.1, table 4.2 depict the outcomes from this study for the curing periods of 7 days, 28 days, correspondingly. From the results presented, it is evident that for any of the curing periods employed in this study, compressive strength of concrete in general decreased with the increase in percentages of RHA replacement.

Table 4.1: Test results of Compressive Strength for 7days.

| Mix Ratio | Age of concrete (Days) | Cement replaced by RHA | Average Compressive Strength (PSI) |
|---|---|---|---|
| 1:1.5:3 | 07 | 0% | 2037.57 |
| | | 5% | 1677.09 |
| | | 10% | 1503.72 |
| | | 15% | 857.84 |

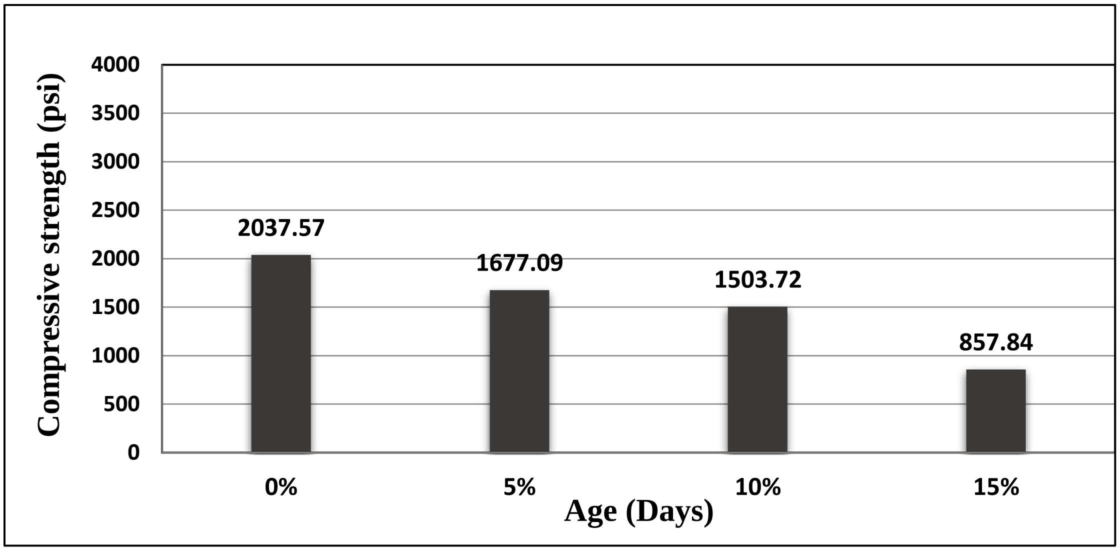


Fig. 4.1: Compressive Strength for 7days.

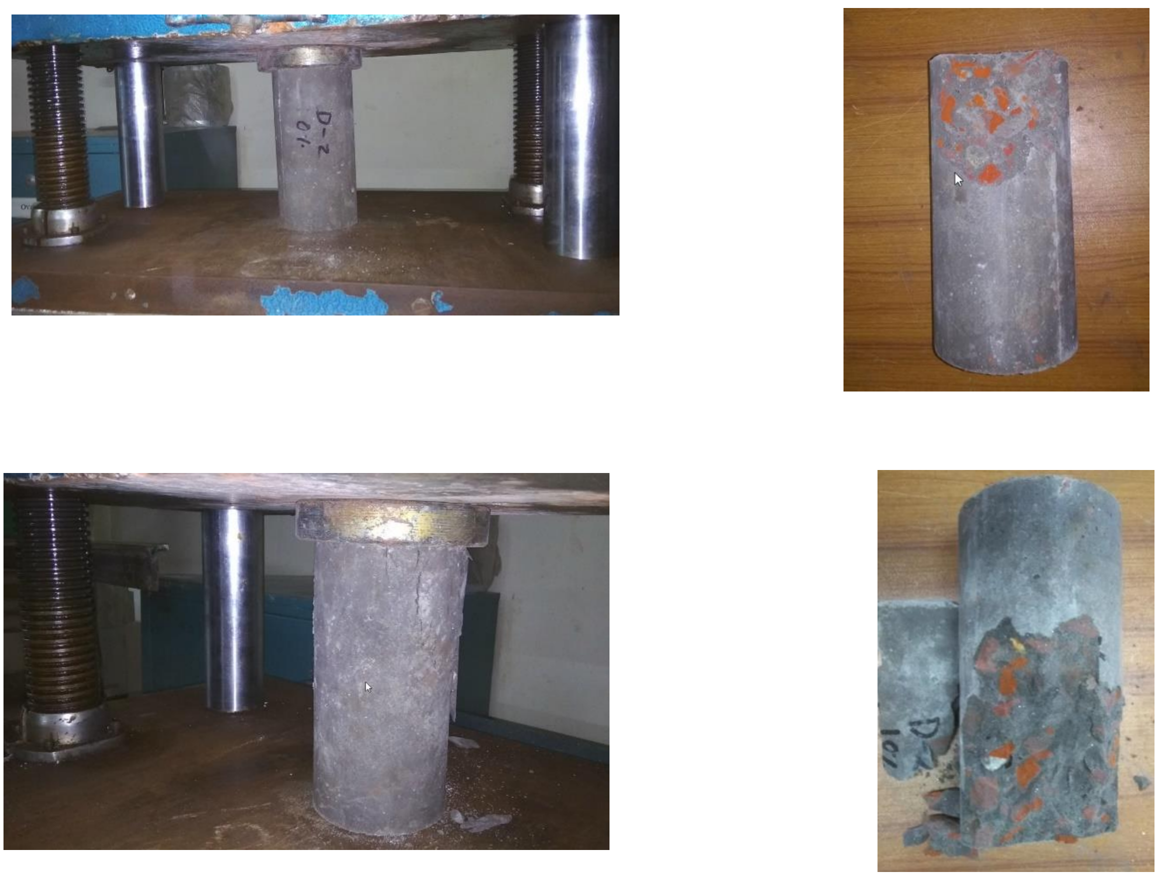

Fig. 4.2: Compressive crushing for 7days.

Table 4.2: Test results of Compressive Strength for 28days.

| **Mix Ratio** | **Age of concrete (Days)** | **Cement replaced by RHA** | **Average Compressive Strength (PSI)** |
|---|---|---|---|
| 1:1.5:3 | 28 | 0% | 3416.33 |
| | | 5% | 3102.78 |
| | | 10% | 2937.07 |
| | | 15% | 1836.48 |

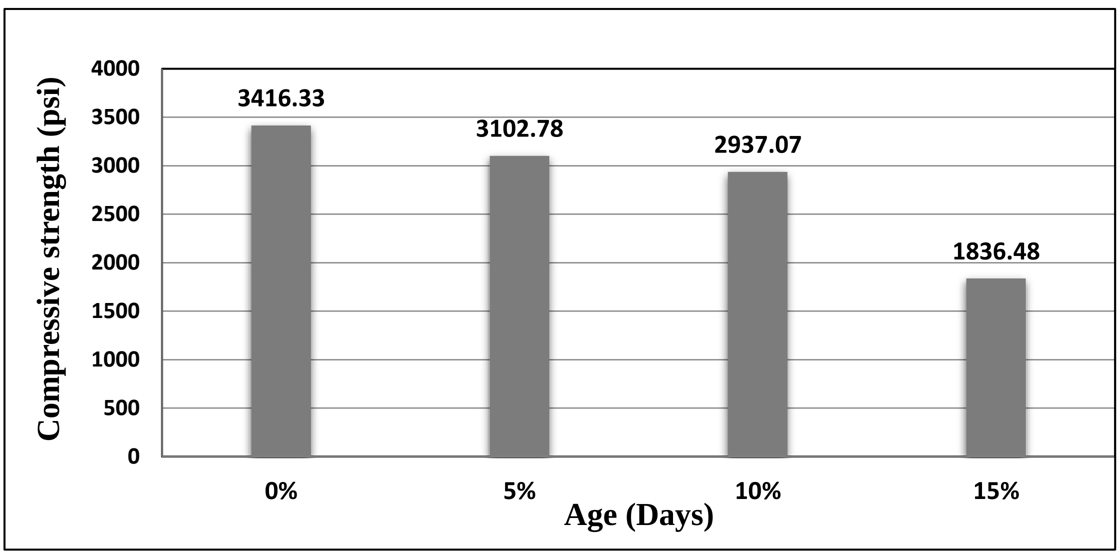


Fig. 4.3: Compressive Strength for 28days.

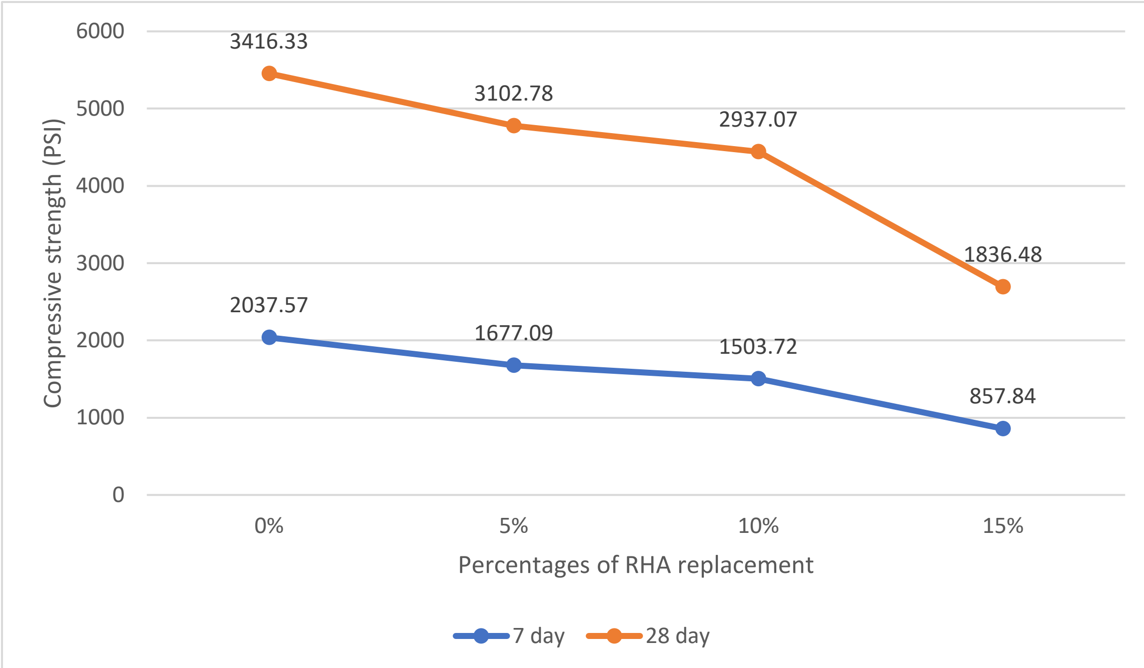


Fig. 4.4: Compressive strength of concrete for varying percentages of RHA replacement to cement and different curing periods.

Concrete is very important construction materials of a building for durability, absorbs and retains heat and others. So, concrete must have the permeable strength. As we are working on M20 grade concrete, the compressive strength of concrete should be 2900 psi (20MPa) at 28 days curing time. On the other hand, concrete should gain 65% strength in 7 days curing time. In figure 4.7 shows that the compressive strength of concrete for varying percentages of RHA replacement. For 5% replacement of cement concrete gained 57.80% strength, 10% replacement of cement concrete gained 51.85% strength and 29.55% strength gained at 15% replacement of cement concrete in 7 days curing time. But up to 10 % replacement of cement satisfied the M20 grade strength in 28 days curing time. It's observed that the compressive strength of concrete is decreasing when RHA replacement is increasing in concrete. We also see that the tendency of compressive strength in varying percentages of RHA replacement of concrete is increased with increasing curing time.

## 4.3 TENSILE STRENGTH OF CYLINDER SPECIMENS

Tensile strengths of concrete for all the blending combinations are reported in this section. Table 4.3, table 4.4 depict the outcomes from this study for the curing periods of 7 days, 28 days, correspondingly. From the results presented, it is evident that for any of the curing periods employed in this study, split tensile strength of concrete in general decreased with the increase in percentages of RHA replacement.

Table 4.3: Test results of tensile Strength for 7 days.

| Mix Ratio | Age of concrete (Days) | Cement replaced by RHA | Average split Tensile Strength (PSI) |
|---|---|---|---|
| 1:1.5:3 | 7 | 0% | 492.197 |
| | | 5% | 447.452 |
| | | 10% | 366.911 |
| | | 15% | 259.522 |

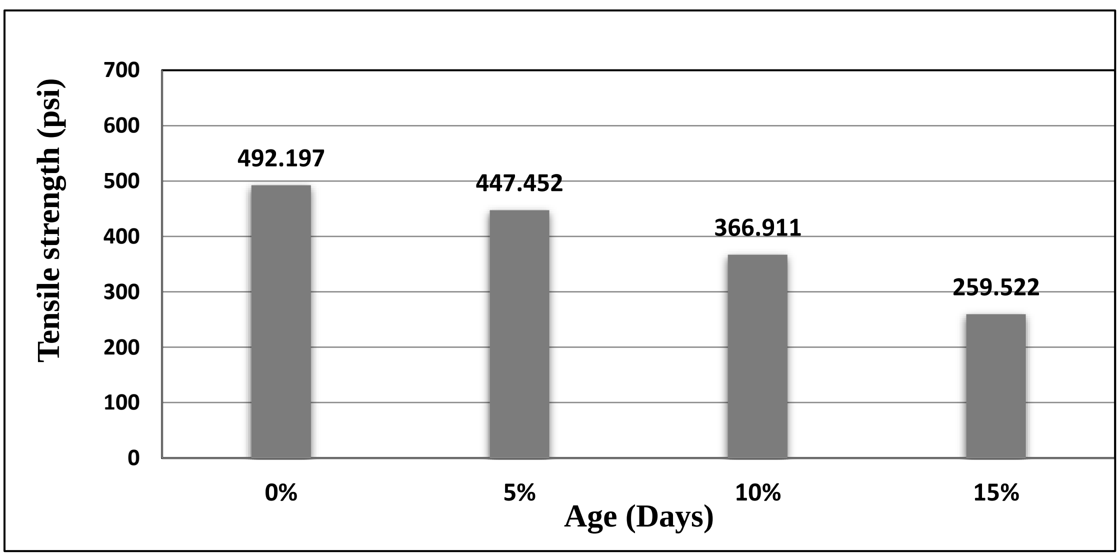


Fig. 4.5: Tensile Strength for 7 days.

Table 4.4: Test results of tensile Strength for 28 days.

| Mix Ratio | Age of concrete (Days) | Cement replaced by RHA | Average Compressive Strength (PSI) |
|---|---|---|---|
| 1:1.5:3 | 28 | 0% | 894.904 |
| | | 5% | 787.516 |
| | | 10% | 706.975 |
| | | 15% | 492.197 |

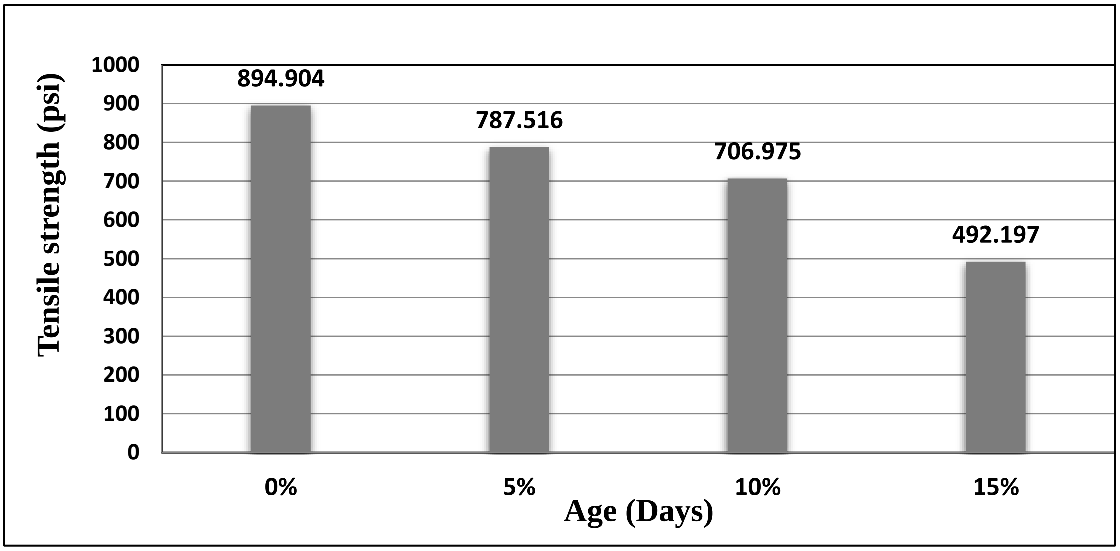


Fig. 4.6: Tensile Strength for 28 days.

Fig. 4.7: Tensile crushing for 7 days.

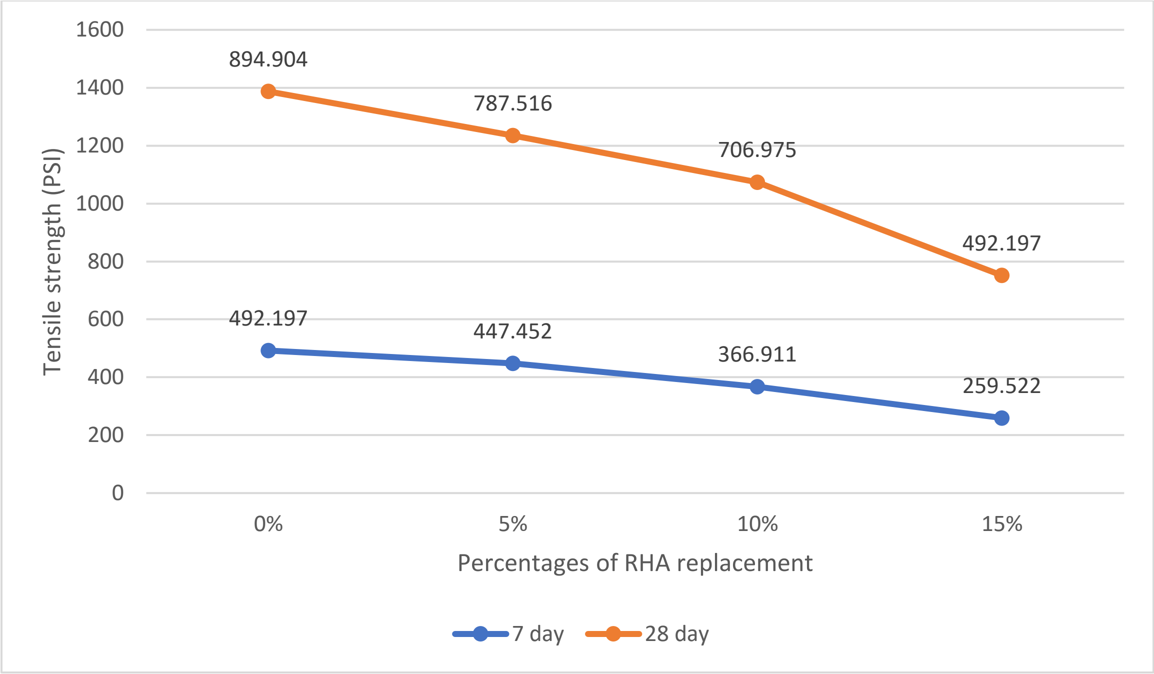


Fig. 4.8: Tensile strength of concrete for varying percentages of RHA replacement to cement and different curing periods.

As it can be seen from the results presented in figure 4.8, the split tensile strength of concrete is decreasing when RHA replacement is increased. After 28 days of curing time, the concrete achieves almost 25% tensile strength of compressive strength (up to 10% replacement). We also see that the tendency of tensile strength in varying percentages of RHA replacement of concrete is increased with increasing curing time.

Whereas, 15% RHA replacement, compressive strengths and tensile strengths of concrete for 28 days are 1836.48 psi and 492.197 psi, respectively, which necessarily state that a great amount of RHA can be consumed in concrete for casting lean concrete. Such lean concrete can be used for less important civil engineering works which in turn will substantially reduce the problem associated with rice husk ash because typically it is a waste material that needed to be disappeared from the environment.

# CHAPTER 5

# CONCLUSIONS AND RECOMMENDATIONS

## 5.1 OUTCOMES OF THE STUDY

This study gives an understanding of the effect of RHA on strength of concrete. From the limited scope of present study, the following conclusions can be drawn:

- The compressive strength of the concrete with partial replacement of rice husk ash decreases with increase the percentage of rice husk ash at some extent.
- The splitting tensile strength of the concrete with partial replacement of rice husk ash is decreasing with the increasing the percentage of rice husk ash in concrete.
- Reasonable compressive strength of RHA blended concrete is attained. For few particular cases, compressive strength very near to the controlled concrete sample is available.
- Rice husk ash can be added to cement concrete as partial replacement of cement up to 10% without any significant reduction in any of the property of concrete.
- Overall, based upon the results it can be said that optimum RHA replacement of cement falls within a range of 0 to 10%, where, above 85% of controlled sample's compressive strength is available in RHA blended concrete, almost for all the curing periods, which can still be considered for good quality construction works.
- The compressive strength, and tensile strength of concrete specimens with 10% cement replacement with RHA are comparable to the control specimens.
- Uses of RHA in concrete lower the reduction in strength due to some chemical attack.

## 5.2 RECOMMENDATIONS

- ✓ Reduction of environmental pollutants and economy in concrete construction was possible using RHA as partial replacement of cement.
- ✓ In this experiment, mix ratio of 1:1.5:3 was used. Water cement ratio was kept 0.45. Different mix ratios and water cement ratios can be used to validate this test result.
- ✓ Partial replacement of demolished aggregate can be done for future study.
- ✓ Other properties such as modulus of elasticity, creep behavior, corrosion characteristics can be investigated.
- ✓ Different types of admixtures can be used to investigate the deviation of test results.
- ✓ In this experiment, we used local rice husk. Rice husk can be collected from rice mill and also investigate the physical and chemical properties.

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