PRODUCTION OF ARTIFICIAL LIGHTWEIGHT AGGREGATE USING RICE HUSK ASH

By

Md. Saddam Ali Khan

Biprodas Halder

Md. Mahfuzur Rahman Nipun

Md. Rubel Ahmed

Md. Baratunnbi

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

Department of Civil Engineering

Sonargaon University

147/I, Green Road, Dhaka-1215, Bangladesh

Section: (19C+19E)

Semester- Fall 2023

PRODUCTION OF ARTIFICIAL LIGHTWEIGHT AGGREGATE USING RICE HUSK ASH

By

MD. SADDAM ALI KHAN	BCE2001019107
BIPRODAS HALDER	BCE2001019174
MD. MAHFUZUR RAHMAN NIPUN	BCE2001019230
MD. RUBEL AHMED	BCE2001019250
MD. BARATUNNBI	BCE2001019254

Supervisor
Md. Ensan Kabir
Lecturer,
Department of Civil Engineering
Sonargaon University (SU)
147/I, Green Road, Panthapath, Dhaka-1215, Bangladesh

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

Department of Civil Engineering

Sonargaon University

147/I, Green Road, Dhaka-1215, Bangladesh

Section: (19C+19E)

Semester Year

BOARD OF EXAMINERS

The thesis titled “Production of artificial lightweight aggregate using rice husk ash” submitted by Md. Saddam Ali Khan (BCE2001019107), Biprodas Halder (BCE2001019174), Md. Mahfuzar Rahman Nipun (BCE2001019230), Md. Rubel Ahmed (BCE2001019250), Md. Baratunnbi (BCE2001019254) has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering on Date-of-Defense.

………………………………………
1. Md. Ensan Kabir Chairman
   Lecture,
   Department of Civil Engineering
   Sonargaon University (SU)
   147/I, Green Road, Panthapath,
   Dhaka

………………………………………
2. Name of the External Member Member
   Designation
   Address

………………………………………
3. Name of the External Member Member
   Designation
   Address

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.

STUDENT NAME	STUDENT ID.	SIGNATURE
Md. Saddam Ali Khan	BCE2001019107	………………..
Md. Biprodas Halder	BCE2001019174	………………..
Md. Mafuzar Rahman Nipun	BCE2001019230	………………..
Md. Rubel Ahmad	BCE2001019250	………………..
Md. Baratunnbi	BCE2001019254	..………………

Dedicated

to

“Our Honorable Teachers”

ACKNOWLEDGEMENTS

All praise be to Allah, Load of the Worlds, and may the peace and blessing be on the most noble of, Prophets and Messengers, our Prophet Muhammad, and his family and all of his Companions. We offer to Him all praise and gratitude and seek His assistance and forgiveness. We seek refuge in Allah from the evils of our souls and the wickedness of our deeds. Whomsoever Allah guides, none can misguide and whomsoever Allah misguided, none can guide. We thank Allah, the Exalted, for the completion of this thesis. Alhamdulillah, Allah gave me enough strength and patience to tackle every problem with calm and ease. This thesis has been kept on track and been seen through to completion with the support and encouragement of numerous people including our supervisor, our teachers, and classmates. We would like to express gratitude to all those people who made this thesis possible and an unforgettable experience for us. We ask Allah to bountifully reward all these people. Allah!! Mercy, Love, and Guidance are what we seek from Him. May He the Elevated bless us with them, like He blessed those before us; those who loved Him and He Loved them in turn. Amin

We would like to express our deepest gratitude to our supervisor **MD. ENSAN KABIR** for his guidance and invaluable advice. His constructive comments and suggestions throughout the experimental and thesis work have contributed to the success of this research. His timely and efficient contribution helped us shape this thesis into its final form and we express our sincerest appreciation for his assistance in any way that we may have asked. We consider it our privilege to have accomplished this thesis under his right guidance. We are extremely indebted to Assistant Professor **MD. LUTFOR RAHMAN**, Head, Department of Civil Engineering, Sonargaon University (SU) for providing the necessary infrastructure and resources to accomplish our research work. Finally, the authors would like to convey their thanks to all faculty members of the Department of Civil Engineering (SU), for providing continuous inspiration in every step of the research.

ABSTRACT

The demand for construction materials is increasing rapidly due to the growth of the construction industry worldwide. However, the aggregates used in concrete are typically collected from natural resources, which are limited. The continuous collection of these natural resources indicates their depletion, which could be a threat to all life on Earth. On the other hand, waste disposal from industries is a major issue in terms of sustainable development. Recycling is introduced in many countries worldwide to reduce pollution from industrial waste. A better sustainable system largely depends on recycling and reducing waste materials generated by different types of industries. These waste materials can be utilized by producing new materials like lightweight aggregates. The non-accessibility of natural lightweight aggregates and their increasing demand worldwide necessitates the development of new alternatives for producing artificial aggregates. The world is tremendously inspired by the innovative creation of alternative materials in the development industry as of late utilizing industrial by-products, the huge-scale use of these modern side-effects lessens ecological contamination and decreases the scarcity of aggregates. Subsequently, there is a requirement for, the generation of artificial aggregates, which meets the present necessity of the industrial business. In this research work, lightweight aggregates were manufactured from industrial waste such as rice husk ash and a binding material like cement. Cement and rice husk ash were mixed concerning volume (0%, 5%, 10%, 15%, 20%, 25%) with water. The determination of unit weight, specific gravity & water absorption of artificial aggregate was carried out. Also, the aggregate crushing value (ACV) test and aggregate abrasion value test were performed. Different types of mixing ratios showed different values of unit weight, specific gravity, aggregate crushing value, and aggregate abrasion value. The unit weight of artificial aggregates was calculated, which ranged from 740 kg/m3 to 1050 kg/m3, and the value of specific gravity was laid between 1.80 and 2.10. According to the mixing ratio of cement and rice husk ash (15%), the best result was obtained.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Rice milling operations lead to generation of huge quantities of rice husk as waste. Rice husk is the outer shell of the rice grain which breaks to expose the rice, and makes up 20% to 22% of the weight of rice [1]. When it is separated from the grain, it becomes a waste material that is no longer required in further processing of rice. The chemical composition of rice husk varies depending on climate, geographical location, type of paddy, among other factors. On the average, it is composed of about 40% - 50% cellulose, 25% - 30% lignin, 15% - 20% silica, and 10% - 15% moisture content. Bulk density of rice husk falls within the range of 90 to 150kg [2,3]. In Nigeria, particularly South-eastern Nigeria which has rice producing communities like Abakiliki and Akaeze both in Ebonyi state, rice husk is often disposed of in open air heaps, and left for very long periods of time after which sometimes they are burned, also in open air. It is estimated that rice husk dumped as waste in Nigeria every year is appropriately 1.1 million metric tons [4], and generates millions of tons of carbon dioxide into the atmosphere from burning [5]. The rice husk disposed of in this way, causes air pollution, thus adding to the waste management problems of an already overwhelmed and inefficient system [6]. As a result, rice husk has become a threat to the environment [5,4], thereby calling for viable measures of turning such wastes to productive uses. As part of waste recovery strategies, rice husk has been used in different productive applications. As an organic waste material, rice husk has found a variety of uses over time in different parts of the world. They have been used as an energy source, and pellets made from a mixture of rice husks and olive residues have been marketed [7]. Rice husk has also been used for electricity generation in off-grid rural locations, and for commercial and industrial uses [5]. As an insulating material, rice husk has been used as filling in walls and roofs for many years in China [8]. In building construction, studies have shown promise on the use of rice husk in development of composite materials. Rice husk ash has been used as part replacement for cement in concrete [9,10,11]. It has also been proposed as filler in the construction of bricks [12]. The possibilities for the use of rice husk in other aspects of building construction can be further explored, following from already existing results. As a component in building materials, rice husk has been used mostly as Rice Husk Ash

(RHA). This involves burning the rice husk under controlled conditions to remove cellulose and lignin which are volatile organic matters in rice husk. The resulting residual ash is predominantly amorphous silica with a micro porous cellular structure [3]. The ash of rice husk contains about 90% silica, is highly porous, and has good insulating properties [3]. Good results have been recorded with this material, especially as part replacement for cement in concrete [13,9]. However, the use of rice husk in its raw state in manufacturing of material for building construction needs to be further explored, especially in low income communities where rice husk is dumped in large quantities as waste. Success in this area will eliminate the need for burning, which if uncontrolled, can greatly amplify air pollution in the affected communities. Controlled burning, which is the more commonly explored strategy has the likelihood of taking the resulting product out of the reach of the low-income earners, as it would likely be done in properly set up industrial facilities. This approach will to some extent address the issue of indiscriminate dumping of rice husk as waste, but may put the resulting product out of the reach of intended beneficiaries. This research is focused on two aspects of importance in Nigeria. First is waste management, and the second is housing affordability. The focus on waste management is to address the challenge of creating a clean and healthy environment, and reducing attendant hazards and degradation due to open air dumping and burning of wastes. The quest for housing affordability on the other hand is centered on exploring options in the use of alternative materials that can meet the functional requirements of conventional materials up to an acceptable standard, but at cheaper costs. Housing is a fundamental need in human societies, but its availability to the entire population has been limited due to a variety of factors, chief of which are socio-economic considerations. Affordability of housing especially where land is available, is largely dependent on cost of the materials and components required to erect the house. In Nigeria, where sand concrete blocks are used extensively in building construction, any variation in cost of blocks will reflect on the overall cost of the building.

1.2 Background of the study

The evolution of the construction industry towards sustainability and efficiency has fueled the quest for innovative materials that can alleviate the ecological footprint while maintaining structural integrity. Within this context, the utilization of lightweight aggregates has emerged as a pivotal strategy to revolutionize traditional construction practices. Conventional aggregates, typically derived from natural resources like quarried stone, exhibit inherent limitations due to their high density, leading to increased dead loads in structures and heightened energy consumption during transportation and construction. These challenges have spurred the exploration of lightweight alternatives, essential for enhancing energy efficiency and reducing environmental impacts. Artificial Lightweight Aggregates (ALWAs) have garnered attention for their capacity to address these limitations. These aggregates, characterized by their low density and adequate mechanical properties, present a compelling solution across various construction applications, ranging from insulating materials to structural components. Rice husk, a byproduct of the rice milling industry, accumulates as a significant agricultural waste globally. Despite its abundance, it often poses disposal challenges and environmental concerns. However, owing to its composition—primarily composed of silica along with other minerals—rice husk ash (RHA) emerges as a potential candidate for resource optimization and sustainable materials development. The utilization of RHA in cementitious applications has been explored extensively due to its pozzolanic reactivity. However, the utilization of RHA as a precursor for the production of lightweight aggregates represents a novel and underexplored domain. Leveraging RHA’s unique properties in the synthesis of ALWAs holds promise not only in repurposing agricultural waste but also in addressing the construction industry's need for lighter, yet robust, materials. The chemical composition of RHA, predominantly high in silica and possessing pozzolanic properties, forms the foundation for its suitability in aggregate production. Its amorphous nature and reactivity when exposed to calcium hydroxide present an opportunity for binding and structural enhancement in ALWAs. Previous studies have primarily focused on RHA's utilization of cement-based materials and its pozzolanic behavior in concrete. However, the application of RHA as a precursor for ALWA production remains relatively unexplored, opening avenues for innovative research and practical applications. This research aims to bridge this gap by investigating the transformation of RHA into ALWAs, encompassing a comprehensive study of the material's chemical, physical, and mechanical properties. The exploration extends to the synthesis process, optimization techniques, and performance evaluation of resulting ALWAs, intending to contribute substantively to sustainable construction practices. By delving into this uncharted territory of RHA-based ALWA production, this study endeavors to not only offer a novel approach to repurposing agricultural waste but also to present a sustainable solution that aligns with the industry's evolving demands for lightweight, eco-friendly construction materials.

1.3 Objectives of the Study

1. To produce artificial light weight aggregate using rice husk ash (RHA)
2. To investigation the properties of aggregate made of rice husk ash.
3. To comperes the properties of artificial light weight aggregate with traditional aggregate.
4. To find the optimum % rice husk ash (RHA) to produce good quality concrete.

1.4 Methodology

Processing of raw materials included selecting the suitable types of raw materials to be used for the preparation of the specimens, primary processing of these materials to make them suitable for the next operation, and determining their chemical compositions. The raw materials used in this experiment were: normal clay, RHA, and water. The complete process was divided into three parts.

1. Characterization of RHA and clay to understand their inherent properties.
2. Preparation of blocks with different proportions of RHA and clay.
3. Using crushed block aggregates as coarse material in concrete.

1.5 Scope

- It can be used for waterproofing and as an admixture to make the concrete resistant to chemical penetration Research shows that the usage of finely segregated siliceous materials in concrete will improve the durability of concrete.
- Rice husk is an agricultural waste product that is available in millions of tons posing disposal problems. Studies showed that after burning Rice husks, RHA will be produced which has greater pozzolanic as well as reactivity properties RHA can be used as a partial replacement for Ordinary Portland Cement (OPC) which is the major component in concrete and levies huge cost.
- The quality of the concrete depends solely on its durability and strength. Further research should be carried out in the future to study the optimization in the usage of a percentage of Rice Husk Ash in concrete and also its microstructure properties 2. RHA is a sustainable, cost-effective, and energy-efficient solution for sustainable construction.

CHAPTER 2

Literature Review

2.1 Introduction

Compressive strength analysis is most important in selecting the coarse aggregate. Most importantly cement, sand, and aggregate properties with mixing procedure in this chapter. Water, admixture details, curing, and compressive strength calculations were also performed.

2.2 Cement

Cement is a cementing of bonding materials and water-resistant products used in engineering construction. Portland cement was developed from natural cement made in Britain in the early part of the nineteenth century, and its name is derived from its similarity to Portland stone, a type of building stone that was quarried on the Isle of Portland in Dorset, England.

The Portland cement is considered to originate from Joseph Aspdin, a British bricklayer from Leeds. It was one of his employees [16], however, who developed the production technique, which resulted in a more fast-hardening cement with a higher compressive strength [17]. Portland cement (often referred to as OPC, from Ordinary Portland Cement) is the most common type of cement in general use around the world because it is a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It is a fine powder produced by grinding Portland cement clinker (more than 90%), a limited amount of calcium sulfate (which controls the set time), and up to 5% minor constituents as allowed by various standards such as the European Standard EN17.1.Portland cement clinker is a hydraulic material that shall consist of at least two-thirds by mass of calcium silicates (3CaO.Si02 and 2CaO.Si02), the remainder consisting of aluminum-and iron-containing clinker phases and other compounds. The ratio of Ca0 to Si02 shall not be less than 2.0. The magnesium oxide content (MgO) shall not exceed 5.0% by mass. ASTM C 150 defines Portland cement as “hydraulic cement (cement that not only hardens by reacting with water but also forms a water-resistant product) produced by pulverizing clinkers consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulfate as an inter ground addition.’’ (ASTM n.d.) Clinkers are nodules (diameters, 0.2-2.0 inch [5-25 mm]) of a sintered material that is produced when a raw mixture of predetermined composition is heated to high temperature. The low cost and widespread availability of the limestone, and other naturally occurring materials make Portland cement one of the lowest-cost materials widely used over the last century throughout the world. Concrete has become one of the most versatile construction materials available in the world.

Figure 2.1: Cement

Portland cement clinker is made by heating, in a kiln, a homogeneous mixture of raw materials to a sintering temperature, which is about 1450 °C for modern cement. The aluminum oxide and iron oxide are present as a flux and contribute little to the strength. For special types of cement, such as Low (LH) and Sulfate Resistant (SR) types, it is necessary to limit the amount of tricalcium aluminates ($3CaO.Al203$) formed. The major raw material for clinker making is usually limestone ($CaCO3$) mixed with a second material containing clay as a source of alumina-silicate. Normally, an impure limestone, which contains clay or $Si02$, is used. The $CaCO3$ content of these limestones can be as low as 80%. Second raw materials (materials in the raw mix other than limestone) depend on the purity of the limestone. Some of the second raw materials used are clay, shale, sand, iron ore, bauxite, fly ash, and slag. When a cement kiln is fired by cola, the ash of the cola acts as a secondary raw material.

2.3 Aggregate

Construction aggregate, or simply "aggregate," is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, and recycled concrete. Aggregates are components of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. The American Society for Testing and Materials publishes an exhaustive listing of specifications for various construction aggregate products, which, by their design, are suitable for specific construction purposes. These products include specific types of coarse and fine aggregate designed for such as additives to asphalt and concrete mixes, as well as other construction uses. State transportation departments further refine aggregate material specifications to tailor aggregate use to the needs and available supply in their particular locations.

2.3.1 Physical properties of aggregate

1. Unit weight and voids
2. Specific gravity
3. Particle shape and surface texture
4. Absorption capacity and surface moisture

2.3.2 Coarse aggregate

Coarse aggregates are larger-size filler materials in construction. Coarse aggregates are the particles that retain on a 4.75 mm sieve. Brick chips (broken bricks), stone chips (broken stones), gravels, pebbles, clinkers, cinders, etc. are used as coarse aggregate in concrete. Coarse aggregate acts as intent filler material for concrete. Coarse aggregates are mainly used in concrete, railway track ballast, etc.

Figure 2.2: Stone Chips

2.3.3 Fine aggregate

Fine aggregates are small-size filler materials in construction. Fine aggregates are the particles that pass through a 4.75 mm sieve and retain on a 0.075 mm sieve. Sand, Sorkin, stone screenings, burnt clays, cinders, fly ash, etc. are used as fine aggregate in concrete. The voids between the coarse aggregate are filled up by fine aggregate. Fine aggregates are used in mortar, plaster, concrete, filling of road pavement layers, etc. Sand is an engineering material in concrete work. It is usually termed a fine aggregate. Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO2), usually in the form of quartz.

Figure 2.3: Sylhet Sand

General conditions of aggregate:

- More or less 75% volume of concrete is aggregate. So good quality of aggregate should be used.
- Aggregate act as filler materials on concrete.
- Good quality of aggregate needed to make good quality of concrete.
- Sand Should be free from dust (Clay & silt)
- Sand should be free from related silica or carbonate and organic matter.
- Sand should be well graded.
- Washing of sand is necessary to remove dust.
- Dust: This passes through the #100 sieve. (Dust=clay & silt)

2.3.4 Classification of sand

According to the source:

- Pit sand
- River sand
- Sea sand

According to the shape:

- Angular
- Round
- Flaky

According to the size:

- Coarse sand (3/8”), F.M-2.6
- Medium sand (1/8”), F.M-2.2

- Fine sand (1/16”), F.M- 1.8-2.0

2.3.5 Bulking of sand

In the increase in the volume of a given weight of sand due to the presence of moisture, for up to about 5-6% of the moisture of sand, there is a steady increase in volume to about 20-30%. The bulking of sand with a small moisture content is due to the formation of the film of water around the sand grains and the interlocking of the air in between the sand grains and the film of water.

2.3.6 Rich hush ash

Rice husk ash is a by-product of agriculture and is generated in rice mills. Rice husk (rice hull) is the coating of seeds or grains of rice. This coating protects the seed or grain during the growing season. The husk converts to hard materials, including opaline silica and lignin. When properly burnt, rice husk contains high amounts of silica (SiO2). Hence it can be used as supplementary cementitious material in combination with cement to make concrete products. When paddy is milled, 80% of the weight is rice and 20% of the weight obtained is husk. This husk can also be used as a fuel for steam or power generation and other purposes. According to ‘Habeeb et al’ (Published in Materials Research), the world produces about 649.7 million tons of rice every year. For every 1000kg (1 ton) of paddy milled, about 200kg (20%) of husk is produced, and when this husk is burnt in the boilers, about 40kg (20%) of rice husk ash is generated. RHA makes a great pozzolanic material since it has almost the same properties as that of silica fume or micro silica. Thus, there is great potential in using RHA as an admixture of concrete.

Figure 2.4: Rice Husk Ash for Concrete

2.3.7 Manufacturing procedure of rich husk ash

Rice husk contains around 75% of organic fickle matter. The other 25% of the weight of this husk is converted into ash during the firing process. This ash is known as rice husk ash (RHA). It is also known as a rice hull ash. According to 'Fapohunda et al' (Published in the International Journal of Sustainable Built Environment), the highest amorphous silica could be obtained by burning the rice husk at the temperature of 500–700°C.

Figure 2.5: Rice Husk Ash

Rice husk ash is an active pozzolana and has several applications in the cement and concrete industry. The use of RHA is less expensive because it reduces the cement requirement, thereby decreasing the overall production cost of concrete. Reduction in cement requirement leads to less environmental pollution by cement factories and provides economic and environmental benefits, along with providing a utilitarian way of disposing of this agricultural waste product which has little alternative use.

2.3.8 Properties of rich husk ash

Chemical properties:

- **SiO_2:** 78–86
- **Al_2O_3:** 1–2.0
- **Fe_2O_3:** 16–1.85
- **CaO:** 55–4.81
- **MgO:** 35–4.5
- **SO_3:** 24–1.18
- **Na_2O:** 1–1.14

- **K_2O:** 54–3.68
- **Loss in ignition:** 4–8.55

Physical Properties:

- **Color:** Grey
- **Specific Gravity:** 05-2.53
- **Specific Surface Area:** 40-100 m^2/g

Bulk Density: 200-300 kg/m^3

2.3.9 Advantages of rich husk ash

- Rice husk ash provides good compressive strength to the concrete.
- It is a by-product; hence, it helps in cutting down the environmental pollution.
- The high silica content makes it a good supplementary cementitious material or pozzolanic admixture.
- The density of concrete containing rice husk ash is similar to the normal weight concrete; hence, it can also be used for the general-purpose application too.
- The impervious microstructure of rice husk ash concrete provides better resistance to the sulphate attack, chloride ingress, carbonation etc.
- Rice hull concrete has good shrinkage property and increases the durability of concrete.

2.4 Water

Potable water (that which is fit for human consumption) can be used without testing. This information summarized requirements for mixing water for use in ready mixed concrete. In October 2004 ASTM approved two new standards that address mixing water for use in concrete. While the requirements for water were addressed in ASTM C94, increased on concrete producers to use process water from concrete production operations and other recycled sources created a need for a more comprehensive coverage on the standard of water.

2.5 Admixture

The paper assesses the use of rice husk ash (RHA) as an admixture in concrete in normal environment by determining the effect of addition of RHA of 0%, 5%, 10%

and 15%, 20% and 25% respectively to concrete grades 20 and 30 concrete respectively.

The use of durability enhancing mineral admixtures or supplementary cementing materials has gained considerable importance the last decade or so as a key to long service life of concrete structures. This paper attempts to bring out the effectiveness of rice husk ash as a versatile concrete admixture and discusses some versatile application of rice husk ash concrete. The annual generation of rice husk in India is 18-22 million tons and this corresponds to a power generation potential of 1200 MW. A few rice husk-based power plants with capacities between I and 10 MW are already in operation and these are based either on direct combustion or through fluidized bed combustion. Rice husk is characterized by low bulk density and high ash content (18-22% by weight). The large amount of Ash generated during combustion has to be continuously removed for a smooth operation of the system. Silicon oxide forms the main component (90-97%) of the. Since they are bulky disposal of husk present an enormous problem. Each ton of paddy produces about 200kg of husk and this rice husk can be effectively converted through controlled burning. At around 500ºC a valuable siliceous product that can enhance the durability of concrete in the chemical composition of rice husk ash is obtained. Variations in the burning temperature much above or below will drastically alter the silica content of the ash. It is estimated that one fifth of the five hundred million tons of world annual paddy production is available.

Figure 2.6: Concrete Admixture

2.5.1 Use of Admixture

- Placing and finishing qualities
- Workability increasing
- Appearance improving
- Protect Against Freeze Thaw Cycles Improve Durability
- Water Reduction in the Mix
- Mid-Range water reducers
- High-Range water reducers
- High Strength Concrete
- Corrosion Protection
- Set Acceleration
- Strength Enhancement
- Set Retardation
- Crack Control (shrinkage reduction)
- Flow ability

2.5.2 Category of Admixture

Water reducing Admixture

1. Retarding Admixture
2. Air-entrained Admixture
3. Accelerating Admixture
4. Pozzolanic Admixture
5. Damp proofing Admixture
6. Grouting Admixture
7. Bonding Admixture
8. Coloring Admixture
9. Gas forming Admixture
10. Anti-washout Admixture

5.6 Cylinder

The compressive strength of the concrete cylinder is one of the most common performance measures performed by engineers in structural design. Here, the compressive strength of concrete cylinders is determined by applying continuous load over the cylinder until failure occurs. The test is conducted on a compression-testing machine.

5.6.1 Test procedure

1. The concrete cylinder is cast for standard size and allowed to cure for 28 days. Three specimens of the same dimension are cast for testing.
2. Takeout the specimen from the curing tank.
3. Wipe out the excess water from the surface of the specimen.

4. Place the specimen vertically on the platform of compression testing machine. Uniform load application and distribution is facilitated by having pad caps at the ends of the cylinders.
5. Before starting to apply the load, make it sure that the loading platforms touch the top of the cylinder.
6. Apply the load continuously and uniformly without shock at the rate of 315 KN/min. And continue the loading until the specimen fails.
7. Record the maximum load taken.
8. The test is repeated for the remaining two specimens.

Figure 2.7: Concrete cylinder for compression test

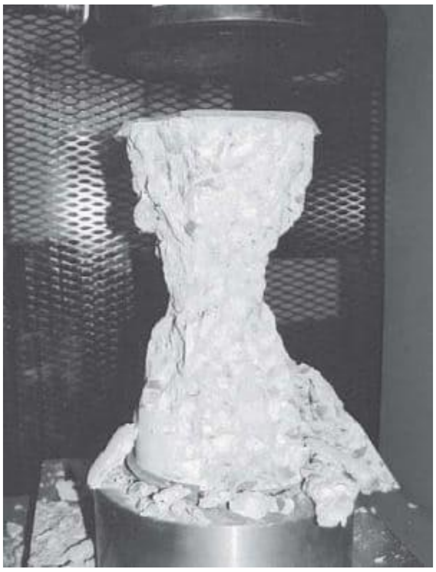

Figure 2.8: Fractured concrete cylinder specimen at failure

2.7 Curing of concrete

Adding water to Portland cement to form the water-cement paste that holds concrete together starts. A chemical reaction that makes the paste into a bonding agent. This reaction, called hydration, produces a stone-like substance the hardened cement paste. Both the rate and degree of hydration and the resulting strength of the final concrete, depending on the curing process that follows placing and consolidating the plastic concrete. Hydration continues indefinitely at a decreasing rate as long as the mixture contains water and the temperature conditions are favorable. One the water is removed, hydration ceases and cannot be restarted. Curing is the period of time from consolidation to the point where the concrete reaches its design strength. During this period, you must take certain steps to keep the concrete moist and as near

73°F as practical. The properties of concrete, such as freeze and thaw resistance, strength, water tightness, wear resistance, and volume stability, cure or improve with age as long as you maintain the moisture and temperature conditions favorable to continued hydration. The length of time that you must protect concrete against loss depends on the type of cement used, mix proportions, required strength, size and shape of the concrete mass, weather, and future exposure conditions. The period can very from a few days to a month or longer. For most structural use, the curing period for cast-in-place concrete is usually 3 days to 2 weeks. This period depends on such conditions as temperature, cement type, mix proportions, and so forth.

Figure 2.9: Curing

2.8 Curing methods

Method that supply additional moisture include sprinkling and wet covers. All of these methods add moisture to the concrete surface during the early hardening or curing period. They also provide some cooling through evaporation.

Table 2.1: Curing Methods and their advantages and disadvantages

Methods	Advantages	Disadvantages
Sprinkling with water or covering with Burlap	Excellent results if kept constantly wet	Likelihood of drying between sprinklings; difficult on vertical walls
Straw	Insulator in water	Can dry out, blow away, or burn
Moist earth	Cheap but messy	Stains concrete; can dry out; removal problem
Pending on flat surfaces	Excellent results; maintains uniform temperature	Requires considerable labor
Curing compounds	Easy to apply and inexpensive	Sprayer needed; inadequate coverage allows drying out; unless pigmented, can allow concrete to get too hot.
Waterproof paper	Excellent protection, prevents drying	Heavy cost can be excessive; must be kept in rolls; storage and handling problems.

2.9 Sieve Analysis

A sieve analysis (or gradation test) is a practice or procedure used (commonly used in civil engineering) to assess the particle size distribution (also called gradation) of agranular material by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the material that is stopped by each sieve as a fraction of the whole mass. The size distribution is often of critical importance to the way the material performs in use. A sieve analysis can be performed on any type of non-organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, soil, a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the exact method. Being such a simple technique of particle sizing, it is probably the most common.

Figure 2.10: Sieve analysis

The results are presented in a graph of percent passing versus the sieve size. On the graph the sieve size scale is logarithmic. To find the percent of aggregate passing through each sieve, first, find the percent retained in each sieve. To do so, the following equation is used,

% Retained = (Wsieve / Wtotal) * 100%

Where Wsieve is the mass of aggregate in the sieve and Wtotal is the total mass of the aggregate. The next step is to find the cumulative percent of aggregate retainer in each sieve. To do so, add up the amount of aggregate that is retained in each sieve and the amount in the previous sieves. The cumulative percent passing of the aggregate is found by subtracting the percent retained from 100%.

% Cumulative Passing=100% - % Cumulative Retained.

The values are then plotted on a graph with cumulative percent passing on the y-axis and logarithmic sieve size on the x-axis.

2.10 Compressive strength test

Compressive strength of concrete is the strength of hardened concrete measured by the compression test. The compression strength of concrete is a measure of the concretes ability to resist loads which tend to compress it. It is measured by crushing cylindrical concrete specimens in the compression testing machine. The compressive strength of concrete can be calculated by the failure load divided with the cross-sectional area resisting the load and reported in pounds per square inch in US customary units and mega (MPa) in SI units. Concretes compressive strength requirements can vary from 2500 psi (17 MPa) for residential concrete to 4000 psi (28 MPa) and higher in commercial structures. Higher strengths up to and exceeding 10,000 psi (70 MPa) are specified for certain application.

Figure 2.11: Universal Testing Machine

2.10.1 Importance of determining the compressive strength

Compressive strength results are primarily used to determine that the concrete mixture as delivered on- site meets the requirements of the specified strength, fc’, in the job specification. Cylinders tested for acceptance and quality control are made and cured in accordance with Compressive strength results are primarily used to determine that the concrete mixture procedures described for standard-cured specimens in ASTM C-31 (which is the Standard Practice for Making and Curing Concrete Test Specimens in the Field). For estimating the in-place concrete strength, ASTM C-31 provides procedures for field-cured specimens. Cylindrical specimens are tested in accordance with ASTM C-39 (which is the Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens).

A test result is the average of at least two standard-cured strength specimens made from the same concrete batch and tested at the same age. In most cases, strength requirements for concrete are at 28 days.

CHAPTER 3

Methodology

3.1 Introduction

The compressive strength analysis will give the clear concept about the selection of aggregate before construction. Before the compressive strength test the below mentioned physical test have to perform.

3.1.1 Physical properties of aggregate

Unit weight of coarse aggregate was performed according to ASTM C29 test method in laboratory. Specific gravity and Absorption of coarse aggregate was conducted in the laboratory according to ASTM C127 test method.

3.1.2 Mechanical properties of aggregate

The los Angele test was performed according to ASTM C535 to observe the resistance to degradation against abrasion and impact.

BS 812 test method was followed in the laboratory to conduct the Aggregate Crushing Value (ACV) test.

3.2 Physical test

3.2.1 Physical test for coarse aggregate

- Sieve analysis and void calculation
- Abrasion test
- Specific gravity and absorption capacity
- Unit weight

3.2.2 Physical test for fine aggregate

- Sieve analysis
- Specific gravity, and Crushing value

Table 3.1: Physical properties of artificial aggregate

Properties	1:3	1:4	1:5	Brick Chips (1st class)	Stone Chips
Specific Gravity	1.81	1.94	1.96	1.95	2.68
Unit Weight (kg/m^3)	918	748	752	882	1393
Water Absorption (%)	9.47	15.69	28.50	13.89	2.22

Table 3.2: Mechanical properties of artificial aggregate

Properties	1:3	1:4	1:5	Brick Chips (1st class)	Stone Chips
Crushing Value (%)	14.33	18.67	16.01	14.64	5.47
Abrasion Value (%)	9.47	15.59	28.50	13.89	2.22

3.3 Sieve analysis of fine aggregate and coarse aggregate

The term sieve analysis, given to the sample operation of dividing a sample of aggregates in to fraction each consisting of articles between limits. The analysis is conducted to determine the grading of material proposed for use as aggregate. The term fineness modulus (F.M) is a ready index of coarseness of fineness of material. It is 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. 3/8 in, 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) After drying samples were weighted.
b) A set of is sieve 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 sieves analysis.
c) Sieving processes was continued for a sufficient period until the particles were not pass thought the sieve.
d) On completion of sieving materials retained on each sieve was weighted on balance. Fineness modulus the samples were dried to a constant mass at a temperature of around 110° C and was obtained by taking the sum of the cumulative percentage of samples retained on each sieve and dividing the sum by 100.

3.4 Specific Gravity and Absorption Capacity of Fine Aggregate

3.4.1 Introduction

Aggregates generally contain 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 be 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 i) calculation of the volume occupied by the aggregate of varying mixtures on an absolute volume basis, ii) the computation of voids in aggregate and iii) 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 an equal 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 0.1gm or less. b.
b) Pycnometer: A flask or 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 ± 3 mm inside diameter at the top 90 ± 3 mm inside diameter at the bottom 75 ± 3 mm in height 0.8 mm minimum thickness of metal d.
d) Tamper- A metal tamper weighing 350 ± 15gm and having a flat circular tamping face 25 ± 30 mm diameter.

Experimental Procedure:

a) Obtain approximately 1kg sample of fine aggregate.
b) Dry it in a suitable pan or vessel to constant weight at a temperature of (110 ± 5° C) or, (230 ± 9°F). Allow it to be cooled to a comfortable handling temperature. c.
c) Cover the sample with water either by immersion or by the addition of at least 6% moisture to the fine aggregate, and permit to stand for 24 ± 4 hr. d.
d) Decant excess water with care to avoid loss of fines, spread the sample on a flat non-absorbent surface exposed to a gently moving current of warm air, and stir frequently to successful homogeneous drying. Continue this operation until the test specimen approaches a free-flow condition. e.
e) Cone test for surface moisture: Place a portion of the partially dried fine aggregate loosely in the mold to overflowing, and heaping additional material

above the top of the mold with the help of cupped fingers of the hand holding the mold. Lightly tamp the fine 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. Adjust the starting height to the new surface elevation after each drop and distribute the drops over the surface. Remove loose sand from the base and lift the measure 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. These various stages are shown diagrammatically in Figure-1. If the first trial of the surface moisture test indicate that moisture is not present on the surface, it has been dried past he saturated surface-dry condition. In this case thoroughly mix a few milliliters water with the fine aggregate and permit the specimen to stand in a covered container for minutes. Then resume the process of drying and testing at frequent interval for the onset of the surface-dry condition.

Test of Sample:

a) Partially fill the Pycnometer with water. Immediately introduce into the Pycnometer 500

b) ± 10 ml of saturated surface dry fine aggregate prepared and fill with additional water to approximate 90% of capacity. Roll, never, and agitate the Pycnometer to eliminate all air bubbles. Adjust the temperature to 23 ± 1.7°C (73.4 ± 3° F). If necessaries by immersion in circulating water bring the eater level in the Pycnometer to its calibrated capacity. Determine the total weight of the Pycnometer, specimen, and water. b)

c) Remove the fine aggregate from the Pycnometer, dry to constant weight at a temperature of 110 ± 5°C (230 ± 9° F), cool in air at room temperature for 1 ± ½ hr. and weigh.

d) Determine the weight of the Pycnometer filled to its calibration capacity with water at 23 ± 1.7°C (73.4 ± 3° F).

Table 3.3: Specifics gravity and absorption capacity of fine aggregate

Size: 1/2", (1:5)

Test	Formula	Calculation	Result
Apparent specific gravity	A/A-C	2.68	2.68
Bulk specific gravity S.S.D - Basis	B/B-C	1.96	1.96
Bulk specific gravity (oven dry Basis)	A/B-C	1.52	1.52
Absorption capacity	B-A/A*100%	28.50	28.50%

3.5 Specific gravity and absorption capacity of coarse aggregate

3.5.1 Introduction

This test method covers the determination of specific gravity and absorption of coarse aggregate. All the terminologies and their uses are same as the specific gravity and absorption of fine aggregate (see Expt-5). This test method conforms to the ASTM standard requirements of specification C127.

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

Experimental 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 (1.5in) nominal maximum size, or longer for larger sizes until 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 ± 4hr.

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 large particles individually. A moving stream of air may be used to assist in the drying operation. Take care to avoid evaporation of water from 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 0.5gm, or 0.05% of the sample weight, whichever is greater.

c. After weighing, immediately place the saturated-surface-dry test sample container and determine its weight in water at 23 ± 1.7°C (73.4 ± 3° F), having a density of 997 ± 2 kg/m^3. Take care to remove all entrapped air before weighing by shaking the container while immersed. 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 or until the aggregate is cooled to a temperature that is comfortable to handle (approximately 50°C), and weigh.

Table 3.4: Specific gravity and absorption capacity of course aggregate

Size: 3/4", (1:5)

Test	Formula	Calculation	Result
Apparent specific gravity	A/A-C	2.04	2.04
Bulk specific gravity S.S.D - Basis	B/B-C	1.93	1.93
Bulk specific gravity (oven dry Basis)	A/B-C	1.83	1.83
Absorption capacity	B-A/A*100%	5.83	5.83%

3.6 Unit weight and void calculation

3.6.1 Introduction

The specific weight, also known as the unit weight, is a volume-specific quantity defined as the weight per unit volume of a material. A commonly used value is the specific weight of water on Earth at 4 °C, which is 9.807 kilonewtons per cubic meter or 62.43 pounds-force per cubic foot.

3.6.2 Unit weight calculation

The experiment was done to find the unit weight and void calculation of coarse aggregate, value is given in the below table:

Volume of the mold, $V=(3.1416*D^2/4)*h$

Here, Diya, d=6”, Height, h=6”

So, Volume, $V= (3.1416*6^2/4)*6=169.65$ in^3

Table 3.5: Unit weight of coarse aggregate

Sample	Wt. of the mold (gm)	Wt. of the specimen with mold (gm)	Wt. of the specimen (gm), W	Volume of the mold(m^3), V	Unit weight (W/V), (gm/m^3)	Unit weight kg/m^3
Stone chips	4000	870	3780	0.002772	1363636.36	1363.63
Made RHA (1/2”) stone	2630	5320	2690	0.002772	987630	987.63

3.7 Mix Design

3.7.1 Introduction

Mix design refers mainly to *w/c* ratio and cement concrete. The *w/c* ratio influences the permeability of concrete and should be decreased with increasing harsh environmental conditions. The *w/c* ratio for a hydropower structure is generally in the range of 0.4–0.55, depending on the harshness of the environment. The cement content of concrete is of less significance than the *w/c* ratio for structural durability, provided the mix is of adequate workability. The cement content for a hydropower structure is normally between 220 and 375 kg m^{-3}.

Concrete mix design is decided by two factors: strength and durability. Mix design based on strength is the more advanced at present, and plenty of codes and theories are available.

3.7.2 Mix proportion

For this research mixture proportion of different materials and make a Rich Husk Ash (RHA) concrete were determined in accordance with flowing condition-

i. Some water
ii. Cement ratio
iii. Rich Husk Ash

3.7.3 Mix proportion

Design compressive strength of concrete (fc′) at 28 days was 20Mpa. Ordinary Portland cement was used as binder. River sand having fineness modulus of 2.60 was used as the fine aggregate. Mixing ratio of 1/2″ and 3/4″ artificial aggregate was 1:1 in the concrete mix. Water-cement ratio was 0.69. Target slump value of concrete was taken 75-100 mm and concrete mix ratio (by weight) was 1: 1.1: 1.87. All of the aggregates were presoaked in water and made saturated surface dry (SSD) condition before incorporating in the concrete mix.

3.7.4 Mix Propositions for Concrete Cylinder

To perform compressive and tensile strength test, 100mm*200mm cylinder concrete was made. To 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 Rich Husk Ash. The replacement Were done by 5%, 10%, 15%, 20%, 25%,.by weight. The mix proportion were 1:3, 1:4, 1:5. For cement, sand, and coarse aggregate. Amount of concrete for a cylinder of each batch rare shown in the following table 3.3.

Table 3.6: Estimation of material concrete cylinder

Bach No	% Replacement	Cement (g)	Sand (g)	Coarse aggregate (g)	Water (g)
1	5%	520	1106	1780	325
2	20%	520	1106	1100	280
3	25%	520	1106	1110	285

3.8 Compressive Strength Test

Cylinder concrete specimens of 4” diameter and 8” height were made. The specimen was demoted and one day before testing of the specimens, the specimens were kept under wet condition. The specimens were tested at 7, and 28 days the compressive strength was determined as per ASTM39

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 cement 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 .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.

Table 3.7: Determination compressive strength of concrete cylinder

Type of Cylinder	Simple Id	Compressive Strength	Average Compressive Strength (psi)
Cylinder with 5% (RHA) Aggregate	1	980	1000
	2	1000	
	3	1020	
Cylinder with 20% (RHA) Aggregate	1	1290	1340
	2	1350	
	3	1380	

Cylinder with 25% (RHA) Aggregate	1	1540	1520
	2	1500	
	3	1520	

3.9 Preparation of molding and demolding

3.9.1 Mold and tools

Two wooden frame type molds were used for article aggregate production. The molds were 1ft x 1 ft in size with top and bottom surface open having a depth of ½” and ¾”, respectively. Two different sizes of were meshes having ½” squire and ¾” squire opening wire used for slicing the past. Wire -mesh generally dividing into number of small squire block.

Figure 3.1: Wire Mesh and Mold

Figure 5: present the picture of Wire mesh (Each square block of ½” and3/4”) and wood mold (1*1 fit*1/2”) and (1*1 fit *3/4”).

3.9.2 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.

3.9.3 Process of Demolding

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

3.10 Casting

Concrete mixture was prepared by hand trial mix was done for every case before the final mix at construction sites all the element, such as cement, sand, Stone and water put together in the mixture machine to produce concrete mix, but in fact, it is not a good way to gain in the good strength of concrete. To ensure the quality strength in the matrix; the following procedure was followed for mixing concrete.

At first, all the coarse aggregate sand and cement putted together and mixed properly with the help of kurni. After that one third of the water the mixed aggregate. Then after mixing that properly; the rest of the water was putted into the mixture and mixed and mixed properly. After that casting was done of the specimens. For water-cement ratio we have used 0.55, this is found from the mix design calculation.

3.11 Curing of Concreate

After all the casting was done, curing was ensured properly. Normal tape water was used for curing. We have used a water drum for curing procedure. All the specimen are putted into the water in the drum. Before crashing these Cylinder, all of them were putted under water in the drum for 28 days.

3.12 Concrete Mix Proportion

Design compressive strength of concrete (fc′) at 28 days was 20 Mpa. Ordinary Portland cement was used as binder. River sand having fineness modulus of 2.60 was used as the fine aggregate. Mixing ratio of 1/2″ and 3/4″ artificial aggregate was 1:1 in the concrete mix. Water-cement ratio was 0.69. Target slump value of concrete was taken 75-100 mm and concrete mix ratio (by weight) was 1: 1.1: 1.87. All of the aggregates were presoaked in water and made saturated surface dry (SSD) condition before incorporating in the concrete mix.

3.13 Compressive Strength of Concrete

Cylindrical specimens (Diameter 4” & Height 8”) were made to determine the compressive strength of concrete. Concrete was made incorporated with both Artificial aggregate and Natural aggregate (stone chips). For both types of specimen, curing period was 7 days and 28 days. After curing, compressive strength of both type of cylindrical specimen was determined and then comparison of compressive strength of concrete was done. Compressive strength of cylindrical concrete specimens was conducted according to ASTM C39. Figure 2: Artificial Aggregate and Concrete Incorporated with Artificial Aggregate Figure 2 shows the artificial aggregates after curing for 7 days in water and cylindrical specimens incorporated with artificial aggregate. Cylindrical specimens were cured for 7 days and 28 days in water to determine the compressive strength of concrete.

CHAPTER 4

Results and Discussion

4.1 Introduction

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

4.2 Result and discussion

Specific gravity is increasing significantly with mix proportion of increasing of binder and decreasing of rice husk ash. But, finally specific gravity of artificial aggregate (1.81) shows the lower value than the natural aggregate like.

stone chips (2.68) and brick chips (1.95). According to other research, lower value of specific gravity compared to natural aggregate can be considered as a lightweight aggregate. Table 1 illustrates the change in unit weight of artificial aggregates which ranges from 882 to 918 Kg/m^3. The 1:3 mixing ratio shows the highest (918 Kg/m^3) value of unit weight. Overall, the unit weight of artificial aggregate is comparatively lower rather than Brick chips (882 Kg/m^3) and natural aggregate of stone chips (1393 Kg/m^3). According to ACI code, there are three (3) types of lightweight aggregate based on unit weight. Among them, lightweight aggregate for insulation purposes should have unit weight less than 1000 Kg/m^3. This experiment values were satisfied this criterion.

Unit weight value of Aggregate

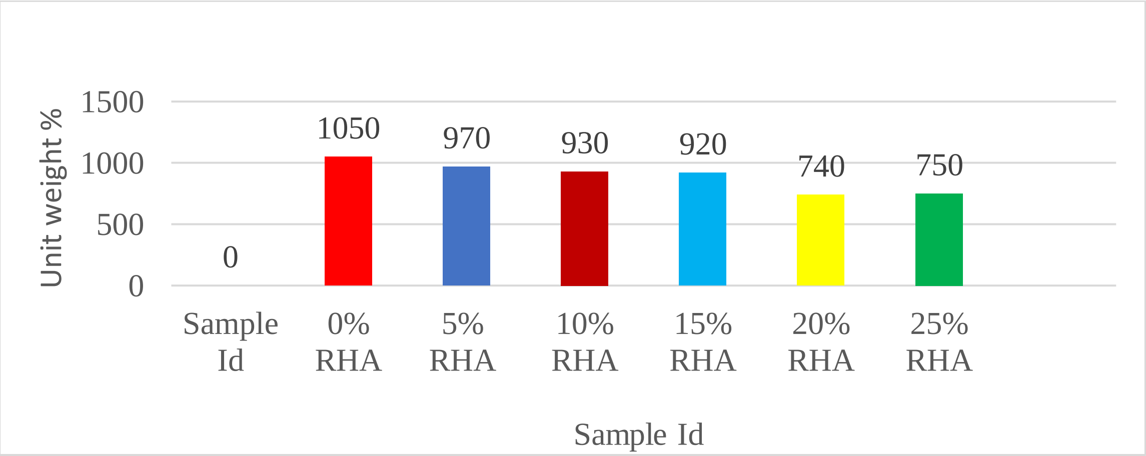

Figure 4.1: Unit weight vs sample Id

The bar chart demonstrates the variation of percentage (%) of Unit weight of artificial aggregate with change in mix ratio. Unit weight of coarse aggregate contributed mostly by open and closed pore space of aggregate. Artificial aggregates' cellulose structure Leads to consuming more water than normal coarse aggregates. According to ASTM C127 and ASTM C128 procedures, the water absorption of structural lightweight aggregate varies from 0% to more than 20% by mass of dry aggregate. The mix ratio of 0% shows the 1050kg/m3 of unit weight which is relatively larger than 20% of unit weight. The deviation of unit weight percentage from the standard value occurred due to a high proportion of rice husk ash which was turned into a large value in the aggregate.

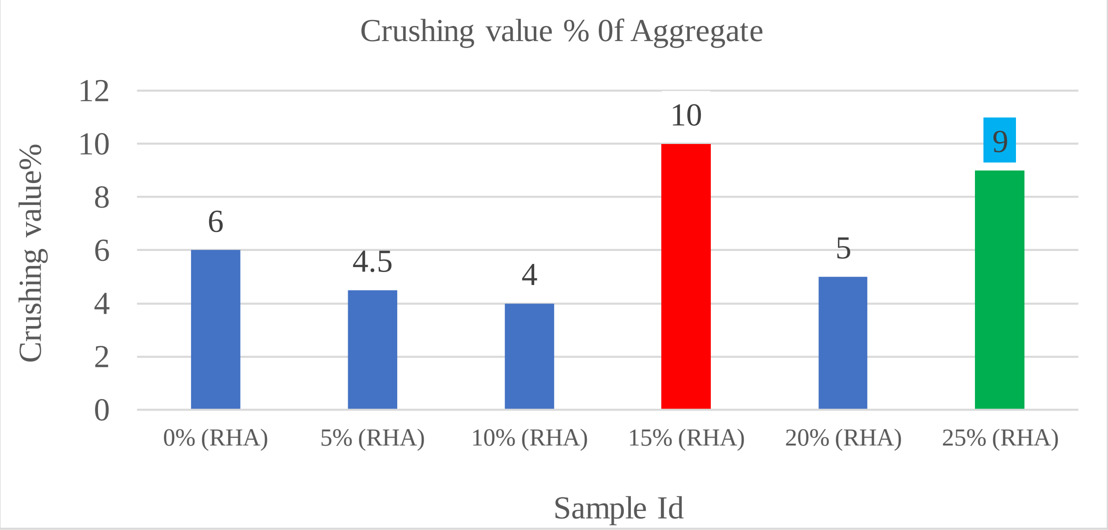

Figure 4.2: Crushing value vs sample Id

The bar chart shows the variation in the crushing value of artificial aggregate. For structural purposes, the recommended Aggregate crushing value is 15% is a maximum value and 10% is a small value.

So, 10% aggregate is a good aggregate. Because 10% aggregate is a low crushing aggregate.

Compressive strength of cylinder

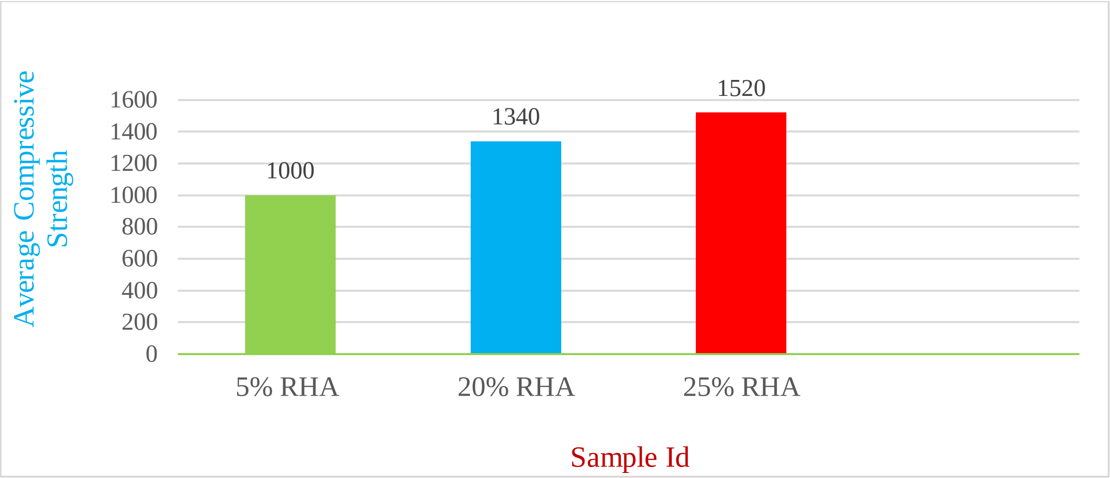

Figure 4.3: Determination of compressive strength of concrete cylinder

The bar chart shows the variation in compressive strength of concrete cylinders. The figure shows that the age of the test is 28 days.

The 28-day curing cylinder test of compressive strength was 5%, 20%, and 25%. The concrete cylinder test value of compressive strength and got the failure load 1000 psi, 1340 psi, and 1520 psi. 25% is the maximum value.

So, 25% is a standard cylinder.

CHAPTER 5

Conclusions and Recommendation

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 conclusion can be drawn:

- The compressive strength of the concrete with partial replacement of rich husk ash decreases with increase the percentage of rich 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 very near 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%; with 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 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 attacks.

5.2 Recommendations

- Different type of admixtures can be used to investigate the changes of test result.
- Types of sample and number of samples for each test should be increased for each test.
- Before using these aggregates in construction more extensive research needs to be done.

In this experiment, we used local rice husk. Rice husk can be collected from rice mill and also investigate the physical and chemical properties.

REFERENCES

[1] International Rice Research Institute (IRRI) (n.d.). Commercial rice milling systems. Available:https://www.knowledgebank.irri.o rg/step-by-step-production 30th September 2021

[2] Singh B. Rice husk ash. In R. Siddique, & P. Cachim, (Eds.), Waste and Supplementary Cementitious Materials in Concrete: Characterization, Properties and Applications. Woodhead publishing. 2018; 417-460. Available:https://doi.org/10.1016/C2016-004037-8

[3] Phonphuak N, Chindaprasirt P. Types of waste properties and durability of poreforming waste based fired masonry bricks. In F. Pacheco-Torgal, P. B. Lourenço, J. A. Labrincha, S. Kumar, & P. Chindaprasirt, (Eds.), Eco-efficient Masonry Bricks and Blocks, Design Properties and Durability Elsevier: Woodhead Publishing. 2015; 103-122.

[4] Altine J, Ezekiel AM, Tanko B. Rice husk conversion for economic empowerment in Taraba state, Nigeria: A review. International Journal of Trend in Research and Development. 2017;4(5):515-519.

[5] Ejiofor OS, Okoro PA, Ogbuefi UC, Nnabuike CV, Okedu KE. Off-grid electricity generation in Nigeria based on rice husk gasification technology. Cleaner Engineering and Technology. 2020;1:1-13. Available:https://doi.org/10.1016/j.clet.2020 .100009

[6] Chinedu I, Ezeibe C, Anijiofor SC. Solid waste management in Nigeria: Problems, prospects and policies. Journal of Solid Waste Technology and Management, 2018;44(2):163-172.

[7] Nuamah A, Malmgren A, Riley G, Lester E. Biomass co-firing. Comprehensive Renewal Energy. 2012;5:55-73. Available:https://doi.org/10.1016/B978-008-087872-0.00506-0

[8] Lin Ze-Zu. Reduction of energy consumption by enhancing thermal resistance of cold storage building. In S. W. Yuan (Ed.) Energy, Resources and Environment Papers presented at the first US – China conference on energy Resources and environment. November 1982, Beijing, China. 1982;7-12. Available:https://doi.org/10.1016/C2013-003669-9

[9] Ettu LO, Njoku FC, Awodiji CTG, Amanze APC, Arimanwa MC. Variation of OPC-rice husk ash-saw dust ash composites strength with mix proportion. International Journal of Engineering Sciences and Research Technology. 2013;2(8):1964– 1969.

[10] Zerbino R, Giaccio G, Isaia GC. Concrete incorporating rice husk ash without processing. Construction and Building Materials. 2011;25 (1):371-378.

[11] Srinivasreddy AB, Mc Carthy TJ, Luke E. Effect of rice husk ash on workability and strength of concrete. Faculty of Engineering and Information Sciences – Papers: PART A; 2004 . Available:https://ro.how.edu.au/eispapers/2 004

[12] Akinyele JO, Olateju OT, Oikelome OK. Rice husk as filler in the Production of bricks using Gboko clay. Nigerian Journal of Technology (NIJOTECH). 2015;34(4): 672-678.

[13] Zareei SA, Ameri F, Dorostkar F, Ahmadi M. Rice husk ash as a partial replacement of cement in high strength concrete containing micro silica: Evaluating durability and mechanical properties. Case Studies in Construction Materials. 2017; 7:73-81. Available:https://doi.org/10.1016/j.cscm.20 17.05.001

[14] Nigerian Industrial Standard. NIS 87:2007 Standard for sandcrete blocks. Standards Organisation of Nigeria, Lagos; 20087;

[15] Mahmoud H, Hama HA, Abba HA. Compressive strength of marketed sandcrete blocks produced in Yola Nigeria
Journal of Engineering and Applied Sciences. 2010; 2:74-81.

[16] Nassar, Roz Ud Dinand Parviz Soroushian. "Strength and Durability of Recycled Aggregate Concrete Containing Milled Jute Fiber as Partial Replacement for Cement." Construction and Building Materials.

[17] Courland, Robert.2011.Concrete planet: The Strange and Fascinating Story of the World's Most common Man-Made Material. Prometheus Books.

[18] International Journal of Environment and Climate Change
11(9): 24-30, 2021; Article no.IJECC.75202 ISSN: 2581-8627 (Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

[19] Mishra, G. (2014, April 20). *Compressive Strength of Concrete Cylinders*. The Constructor. https://theconstructor.org/concrete/concrete-cylinders-compressive-strength/2234/

[20] Patel, H. (2019, October 23). *Rice Husk Ash in Concrete: Uses, Pros & Cons & Effect on Properties of Concrete*. GharPedia. https://gharpedia.com/blog/rice-husk-ash-in-concrete-pros-cons/

[21] The Constructor. (2017, February 15). *Rice Husk Ash in Concrete -Properties, Advantages and Uses*. The Constructor. https://theconstructor.org/concrete/rice-husk-ash-concrete-construction/15725/

[22] Ketov, A., Rudakova, L., Vaisman, I., Ketov, I., Haritonovs, V., & Sahmenko, G. (2021). Recycling of rice husks ash for the preparation of resistant, lightweight and

environment-friendly fired bricks. *Construction and Building Materials*, *302*, 124385. https://doi.org/10.1016/j.conbuildmat.2021.124385