HARDENED PROPERTIES OF BRICK AGGREGATE CONCRETE USING COCONUT SHELL AS A PARTIAL REPLACEMENT OF COARSE AGGREGATE

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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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BOARD OF EXAMINERS

The thesis titled " Fresh And Hardened Properties Of Brick Aggregate Concrete Including Cocount Shell As A Partial Replacement Of Coarse Aggregate" submitted by Md. Abu Naser (BCE 1902017037), Md. Shahin Ali (BCE 1902017040), Sorowar Hossain (BCE 1902017047), Mizanur Rahman (BCE 1902017074), Md. Nasir Uddin (BCE 1902017104) , 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.

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DECLARATION

This is to declare that, except where specific references are made to other investigators, the work embodied in this thesis paper is the result of investigation carried out only by the author under the supervision of Md. Lutfor Rahman, Associate Professor, Department of Civil Engineering, Sonargaon University (SU).

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Dedicated

to

"Our Parents
&
Respectable Supervisor"

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ABSTRACT

The study was conducted to develop brick aggregate concrete including coconut shell as a partial replacement of coarse aggregate. Different coconut shell brick aggregate concretes (CSBACs) were prepared using 0–15% coconut shell aggregate (CSA) as a partial replacement of brick coarse aggregate and considering the water to cement (w/c) ratios of 0.45, 0.50 and 0.55 at the constant mix ratio of 1:1.5:3 (cement: fine aggregate: coarse aggregate) by bulk volume. CSBACs were tested to determine the major fresh and hardened properties. The fresh properties of CSBACs examined were workability and wet density. Among the hardened properties of CSBACs investigated, compressive strength was determined at the ages of 28,56 and 90 days whereas splitting tensile strength, flexural strength, modulus of elasticity, Poisson’s ratio, and dry density were examined at the age of 28 days only. Test results revealed that the workability of CSBAC was lesser than that of the control concrete, but the decrease was lower with higher CSA content whereas the wet density of CSBAC decreased progressively with the increased amount of CSA. The compressive strength, splitting tensile strength, and flexural strength of CSBAC at 28 days decreased significantly for 10% and 15% CSA contents. However, at the ages of 56 and 90 days, the rate of gain in the compressive strength of CSBAC was higher for the w/c ratio of 0.50. The dry density and modulus of elasticity of CSBAC decreased with the increased amount of CSA for all replacement levels of brick aggregate whereas its Poisson’s ratio was higher than that of the control concrete at 28 days. Based on the data obtained, the correlations for the mechanical properties of CSBAC were sought. Strong correlations between most of the mechanical properties of CSBAC were observed in this thesis..

CHAPTER 1

INTRODUCTIOIN

1.1 Background of the Study

Aggregate is a major ingredient of concrete. It occupies almost 70–80% of the volume of concrete [1]. Coarse aggregates should be selected carefully because they significantly influence the fresh and hardened properties of concrete [2]. Generally, natural coarse aggregates (e.g., crushed stone, gravel) are used in making concrete. For sustainable development, harvesting of coarse aggregate from natural sources should be reduced and alternative materials need to be searched to replace natural aggregate. Concrete is a broadly utilized composite material in the field of developments because of its strength and durability, the accessibility and affordability of the raw materials, and the capacity to be framed in the ideal structural shape. Therefore, these days, there are an enormous number of existing concrete structures and step by step this number is in advancement. So, during construction , its quality should be maintained properly .

In case of, suspicion that concrete in an existing structure has adequate strength, a quality inspection of the concrete's structural integrity and compressive strength must be carried out. So existing concrete need to be tested. Molded cylinders are most often used as a measure of quality assurance and have long been the industry standard for determining the quality of the concrete provided to the job site. If the compressive strength of the cylinders do not satisfy the project specified design strength requirements, then it is common practice to do in-place testing on the concrete in question. This can be done by two methods, one is non - destructive and other is destructive method. Nondestructive tests of the concrete in place, such as by probe penetration, impact hammer, ultrasonic pulse velocity or pull out may be useful in determining whether or not a portion of the structure actually contains low-strength. Many factors can significantly influence the compressive strength of the concrete cylinder with coconut shell. These comprise cement type, water - cement ratio, aggregate content, water curing period, and exposure conditions.

1.2 Motivation of the Study

Testing of both standard and in-situ compressive strengths are significant to verify conformity with specifications set out by the engineer. Furthermore, in-situ compressive strength tests (cylinder with coconut shell testing) allows practitioners to assess whether an existing concrete structure has adequate strength for its future performance. There are many number of factors that affect concrete core strength. These factors include: aspect ratio, diameter of the sample, aggregate type, maximum aggregate size, curing history and degree of compaction.

Many studies were conducted considering these factors to develop a correlation between the strength of concrete core with the concrete strength. But very few studies were conducted considering presence of reinforcement in the concrete core. Since all the study were used the stone chips but in our subcontinent, brick chips are commonly used. So in this study brick chips are used. This study will aid in making the analysis and interpretation of concrete core test results more clear with and without presence of reinforcement.

1.3 Objective of the Study

The main objective of this study is to evaluate the strength of concrete cylinder with coconut shell.

The specific objectives of this study is :

- To evaluate the effect on the strength of concrete cylinder with coconut shell.

1.4 Scope of the Study

Significant number of researches have already been done to evaluate the effect of some factors on the concrete cylinder with coconut shell. Strength like as aspect ratio, diameter of the sample, aggregate type, maximum aggregate size, curing history and degree of compaction etc. In this study six several slab with different diameter of reinforcement and mix ratio were used to see the effect on concrete cylinder with coconut shell.

It is expected that this research will help Civil Engineers and investigators to evaluate in place concrete quality accurately and also for safety evaluation of existing structures that need rehabilitation and retrofitting.

1.5 Organization of the Thesis

Chapter 1 Apart from this introductory chapter, the remainder of the thesis is structured into five more chapters.

Chapter 2 outlines the theoretical literature reviews relevant to this research and also describes about concrete compressive strength and the different methods in which it may be tested. It reviews the mechanisms in which concrete fails and the factors that may affect concrete compressive strength.

Chapter 3 elaborately describes the method in which the extensive laboratory investigation was completed. It discusses the test of materials and methodology of the work.

Chapter 4 gives a brief description of tested data and analysis of the study.

Chapter 5 sets out the conclusion of the thesis and is organized with the summary of the study as concluding remarks, research contributions, recommendations of the study, limitations of the study, and finally the scope of future studies.

1.6 Overview

This chapter clearly describes the background of this study, why author is motivated to conduct this study, the main and specific objectives of this study, specified scope of this study and finally ends with organization of this thesis work that will be maintained throughout the study. The next chapter systematically elaborates on the literature review related to the factors that is affected on concrete cylinder with coconut shell strengt.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter aims to outline the theoretical reviews of this research. The following review provides a conceptual overview of development of concrete from the beginning of concrete history. It also describes about concrete compressive strength and the different methods in which it may be tested. It reviews the mechanisms in which concrete fails and the factors that may affect concrete compressive strength. Coconut shells can be used as aggregates in concrete. The characteristic properties of coconut shell concrete such as workability, bulk density, compressive strength, flexural tensile, water absorption and thermal performance were reviewed in this paper.

2.2 Introduction to Concrete

Concrete was a name applied to any of various creations comprising of Sand, rock, squashed stone, or other coarse material, bound together with different sorts of cementations materials, for example, lime or bonds. Here, brick aggregate (BA) is commonly used as coarse aggregate in concrete for construction of light- to medium-duty rigid pavements, small- to medium-span bridges, culverts, and buildings up to six-story high [3] At the point when water was included, the blend experiences a concoction response and solidifies. The word cement emerges from the Latin word "concertos", which signifies "hardened" or "hard". On the planet, concrete has been utilized hugely in development for more than 2000 years, maybe first by the Romans in their water channels and roadways.

2.3 Historical Development of Concretes

The first concrete-like structures were constructed by the Nabataea dealers or Bedouins who utilized and controlled a progression of desert gardens and built up a little region in the locales of southern Syria and northern Jordan in around 6500 BC. They later uncovered the upsides of pressure driven lime - that is, bond that hardens submerged and by 700 BC, they were building ovens to accumulate mortar for the development of rubble-divider houses, solid floors, and underground waterproof repositories. The stores were kept underground and were one reason the Nabataea had the option to frivolity in the desert.

Like the Romans had 500 years after the fact, the Nabataea had a locally accessible material that could be utilized to make their bond waterproof. Inside their domain were significant surface stores of fine silica sand. Groundwater leaking through silica can change it into a pozzolana material, which is a sandy volcanic debris. To make bond, the Nabataea found the stores and gathered up this material and joined it with lime, at that point warmed it in similar ovens they used to make their ceramics, since the objective temperatures lay inside the equivalent range. By around 5600 BC along the Danube River in the region of the previous nation of Yugoslavia, homes were fabricated utilizing a kind of concrete for floors. Among the agricultural wastes, large quantities of coconut shell (CS) solid waste from de-husked coconuts are generated in the tropical countries of the world. Each year, about 62 million tons of coconuts are produced that create a large amount of CS (around 9.7 million tons) in the world [4].

2.4 Compressive Strength of Concrete

Quality of hardened concrete evaluated by the compression test. The compression strength of concrete is a measure of the concrete's ability to repel loads which tend to compress it. The compressive strength of concrete is determined by crushing cylindrical concrete specimens in compression testing machine. The compressive strength of concrete can be determined by the failure load divided with the cross sectional area resisting the load and stated in pounds per square inch in US standard units and mega Pascal (MPa) in SI units. Concrete's compressive strength necessities can differ from 2500 psi (17 MPa) for residential concrete to 4000psi (28 MPa) and higher in commercial structures.

2.5 Concrete Cylinder with Coconut Shell Strength

The test results shows that concrete using coconut shell aggregate has resulted in acceptable strength required for structural lightweight concrete. By using a drill with a hollow barrel tipped with industrial diamonds cores are cut. The entire apparatus must be immovably fixed in position by loads, grapple jolts, vacuum cushions or supporting against different pieces of the structure. To get authentic result the diameter of the core should be at least 3.5 x the maximum aggregate size. Sometimes even smaller diameter cores ought to be used for strength testing. During this case the strength results are often a lot of variable and a larger range of cores ought to be extracted. For strength testing, the length to diameter magnitude relation ought to be between 1 and 2and ideally between one and 1.2. Once cores area unit received within the laboratory they will be examined for degree of compaction, cracks, voids, honeycombing and also the presence of reinforcement. Prior for testing cores for quality, they must be cut to length and the finishes arranged with the goal that they are level and opposite to the longitudinal hub. This is accomplished by granulating or, all the more normally, topping with high alumina bond (calcium aluminate concrete) mortar or a sulfur/sand blend. Centers ought to be tried in a dry state. This is air dry, not stove dry.

Figure 2.1: Strength of concrete.

2.6 Factor Affecting on Concrete Cylinder with Coconut Shell Strength

The factors that are significant which influence the core compressive strength of concrete are:

- ✓ Moisture and Voids
- ✓ Length/Diameter Ratio of Core
- ✓ Diameter of Core

Moisture and Voids:

The moisture condition of the core influences the measured strength. It has been observed that a saturated specimen has a value of 10 to 15% lower than comparable dry specimen. Thus while estimating the actual in-situ concrete strength the relative moisture conditions of the core and the in-situ concrete should be taken into consideration. Voids in the core concrete will reduce the measured strength. Peterson found that the ratio of core strength to standard cylinder strength at the same age is always less than 1.0, and decreases with the increase in the strength of cylinder. Up to cylinder strength of 20 MPa it is just less than 1 and 0.7 for 60 MPa strength.

Length/Diameter Ratio of Core:

It has been observed that as the l/d ratio increases, the measured strength decreases due to the effect of specimen shape and stress distribution during the test. For establishing a relation between core strength and standard cube strength, ratio of l/d = 2.0 is taken as the basis of computation.

Diameter of Cylinder:

The diameter of the core may influence the measured strength and variability. Measured concrete strength decreases with the increase in the size of specimen. This effect is significant. However this effect will be small for sizes above 100 mm, but for smaller sizes this effect is significant.

2.7 Guidelines for Cylinder with Coconut Shell Sampling

The following rules should be maintained for specific significance in core sampling:

- ✓ The number, size, and location of core samples should be carefully selected to permit all necessary laboratory tests. If possible, use virgin samples for all tests so that there will be no influence from prior tests.
- ✓ For determination of strength the core must have a minimum diameter of greater of three times the maximum nominal size of the coarse aggregate, or 50 mm.
- ✓ For strength tests, the cores length must have at least twice of their diameter.
- ✓ Reinforcing steel should not be included in a core to be tested for strength.
- ✓ At least three cores must be evacuated at every area in the structure for strength evaluation.

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Figure 2.2: Materials Sampling.

2.8 Concrete Cylinder Strength Related Study

The study was conducted to develop brick aggregate concrete including coconut shell as a partial replacement of coarse aggregate. Different coconut shell brick aggregate concretes (CSBACs) were prepared using 0–15% coconut shell aggregate (CSA) as a partial replacement of brick coarse aggregate and considering the water to cement (w/c) ratios of 0.45, 0.50 and 0.55 at the constant mix ratio of 1:1.5:3 (cement: fine aggregate: coarse aggregate) by bulk volume. CSBACs were tested to determine the major fresh and hardened properties. The fresh properties of CSBACs examined were workability and wet density. Among the hardened properties of CSBACs investigated, compressive strength was determined at the ages of 14, and 28 days whereas splitting tensile strength, flexural strength, modulus of elasticity, Poisson's ratio, and dry density were examined at the age of 28 days only. The compressive strength, splitting tensile strength, and flexural strength of CSBAC at 28 days decreased significantly for 10% and 15% CSA contents. However, at the ages of 14 and 28 days, the rate of gain in the compressive strength of CSBAC was higher for the w/c ratio of 0.50. The dry density and modulus of elasticity of CSBAC decreased with the increased amount of CSA for all replacement levels of brick aggregate whereas its Poisson's ratio was higher than that of the control concrete at 28 days. Based on the data obtained, the correlations for the mechanical properties of CSBAC were sought. Strong correlations between most of the mechanical properties of CSBAC were observed in this study.

2.9 Overview

This chapter has been methodologically delineated the literatures relevant to this study. First, Author has tried to establish a conceptual framework to develop the concept of concrete. Then, Author has put an effort to clear the term "concrete compressive strength" and showed a historical development of concrete throughout world since the beginning to today. In from the beginning of the history. In the next section, Author has shown the testing method and compared them clearly. This section also covers how different types of factors change the concrete cylinder strength. Finally, it has been concluded with relevant studies those have already been done incorporating the compressive strength of concrete core and their findings of those studies have also been described to make differentiate those from the present study.

CHAPTER 3

METHODOLOGY OF THE STUDY

3.1 Introduction

This chapter describes the methodology adopted to conduct this research. It covenants with the different experimental data required to determine the properties of various ingredients of concrete. This chapter also comprises the processes of manufacturing of concrete. Fresh And Hardened Properties Of Brick Aggregate Concrete Including Coconut shell As A Partial Replacement Of Coarse Aggregate.

3.2 Overview of Experimental Plan

The experimental work performed for this research took place within the Sonargaon University (SU). Mechanics of Solid and Materials Laboratory. Three different Water-Cement ratio and 72 Nos. of (without Coconut Shell Concrete Cylinder & Cylinder with Coconut Shell) Strength were taken from the cylinder . Details are mentioned in the following table:

Table 3.1: Different types of concrete Cylinder with Coconut Shell quantity.

Mix Ratio	Diameter of Cylinder	W/C	Coconut Shell	Coconut Shell	Coconut Shell	Coconut Shell
1:1.5:3	4 inch	0.45	0%	5%	10%	15%
1:1.5:3	4 inch	0.50	0%	5%	10%	15%
1:1.5:3	4 inch	0.55	0%	5%	10%	15%

Total Quantity of Cylinder = 72 Nos.

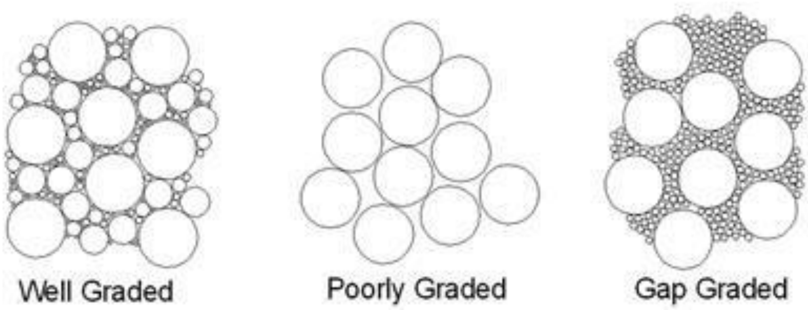
3.2.1 Gradation of Coarse Aggregate

Well-graded mixture contains a gradation of particle sizes that fairly equally spans the dimensions from the best to the coarsest. A slice of a core of well-graded mixture concrete shows a packed field of many totally different particle sizes.

Poorly graded aggregate is characterized by little variations in size. This implies that the particles wedge, departure comparatively massive voids within the concrete.

Gap-graded aggregate consists of coarse aggregate particles that are similar in size, however considerably totally different from the fine aggregate. A core slice of gap-graded concrete shows a field of fine aggregate interspersed with slightly isolated, massive aggregate items embedded within the fine aggregate.

Typical aggregate gradations are shown in the drawing below:



Figue 3.1: Typical aggregate gradations.

Poorly graded concretes generally require extreme amounts of cement paste to fill the voids, making them uneconomical. Gap-graded concretes fall in between well-graded and poorly graded in terms of performance and economy. Gap-graded concrete is a viable gradation, but not optimal.

Well-graded aggregates are tricky to proportion. The goal of aggregate proportioning and sizing is to maximize the volume of aggregate in the concrete (and thus minimize the volume of cement paste) while preserving strength, workability, and aesthetics. This balances the proportions of each so there are just enough of each size to fill all the voids, while preserving workability and cast-surface quality.

The sieve analysis is conducted to determine the particle size distribution and fineness modulus of fine aggregate called gradation. The fineness modulus is a numerical index of fineness, giving some idea of the mean size of the particle present in the entire body of the aggregate. The determination of the fineness modulus consists in dividing a sample of aggregate into fractions of different sizes by sieving through a set of standard sieves taken in order of size, with larger sieve on the top. Each fraction contains particle between definite limits. The limits are being the opening size of standard sieves. The materials retained on each sieve after sieving represent the fraction of aggregate coarser than the sieve in question than finer than the sieve above. The sum of cumulative percentages retained on the sieves divided by 100 give the fineness modulus.

Grading refers to the distribution of particle sizes present in an aggregate. A sample of the aggregate is shaken through a series of sieves nested one above the other in order of size, with the sieve having the largest openings on top and the one having the smallest openings at the bottom. Coarse aggregate may be available in several different size groups, such as 19 to 4.75 mm (3/4 in to No. 4), or37.5 to 19 mm (1-1/2 to 3/4 in.).

Figure 3.1(a) : Gradation of Coarse Aggregate.

Table 3.2: Gradation of 20 mm downgrade Brick Chips.

Sieve size (mm)	Weight of Retained (kg)	% Retain	Cumulative % Retain	% Finer	F. M
37.5	0	0.00	0.0	100	6.76
19	0.53	10.60	10.6	89	
9.5	3	60.00	70.6	29	
4.75	1.29	25.80	96.4	4	
2.36	0.09	1.80	98.2	2	
1.18	0.09	1.80	100.0	0	
0.6	0	0.00	100.0	0	
0.3	0	0.00	100.0	0	
0.15	0	0.00	100.0	0	
Pan	0				
Total	5 kg		675.8		

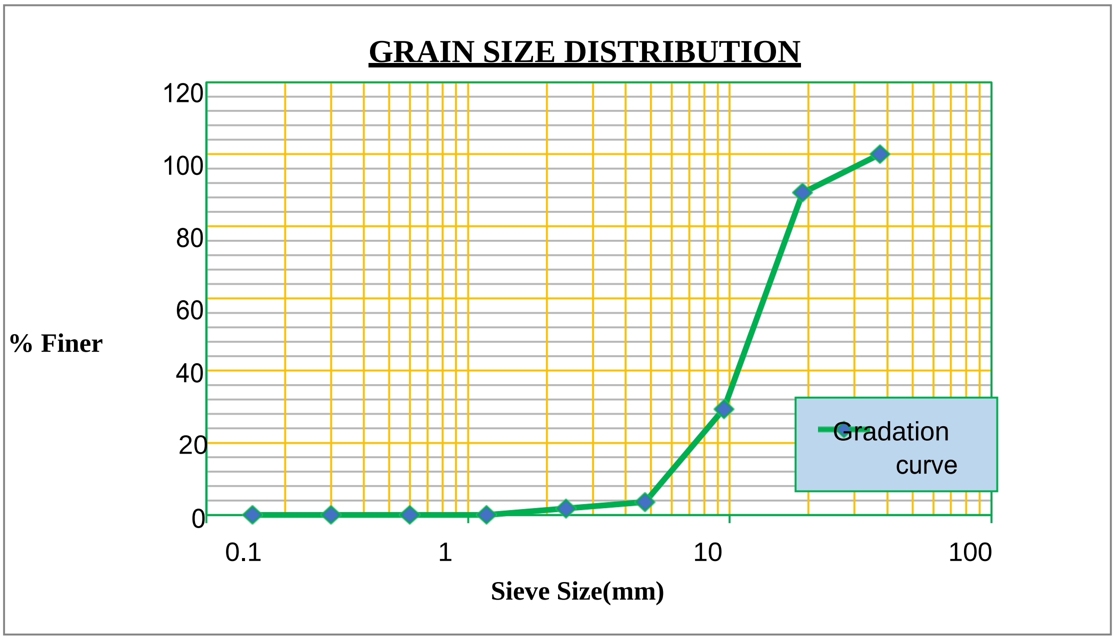


Figure 3.1(b) : Grain size distribution curve of Coarse aggregate.

3.2.2 Test for Specific Gravity and Absorption Capacity of Brick Aggregate

Specific gravity test of aggregates is done to measure the strength or quality of the material while water absorption test determines the water holding capacity of the coarse and fine aggregates.

Aggregate generally contain pore, 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 this is also required in calculating the compacting factor in connection with the workability measurements .This test method covers the determination of bulk specific gravity, apparent specific gravity and water absorption of coarse aggregate.

The volume of the aggregate particle is usually assumed to be the volume of solid matter and internal pores. Two different values of specific gravity may be calculated depending upon whether the mass used is an oven-dry or a saturated surface dry mass. Bulk specific gravity is the oven-dry mass divided by the mass of a volume of water equal to the SSD aggregate volume, while bulk specific gravity SSD is the saturated surface-dry mass divided by the mass of a volume of water equal to the aggregate volume.

It is then removed from the water and dried to a saturated surface-dry state with a large absorbent cloth. Care is taken to avoid evaporation of water from the aggregate pores during this operation. The mass of the sample in air is determined and then it is placed in a sample container for determination of its mass in water. The mass of the sample in water will be less than that in air and the loss in mass is equal to the mass of the water displaced. Therefore, the loss in mass is the mass of a volume of water equal to the aggregate volume. After the mass in water is determined, the sample is oven-dried and it's mass determined again. The bulk specific gravity and the bulk specific gravity in SSD, are calculated as follows.

where,

A = mass of oven-dry sample in air

B = mass of saturated surface-dry mass in air; and

C = mass of saturated sample.

3.2.3 Unit Weight of Coarse Aggregate

Determination of the unit weight of coarse aggregates in a compacted or loose condition. This test method is applicable to aggregates not exceeding 15 cm in nominal size. The unit weight so determined is necessary for the design of a concrete mixture by the absolute value method. The procedure yields values based on aggregates in a dry condition. Unit weight values of aggregates are necessary for use for many methods of selecting proportions for concrete mixtures.. Bulk Density also indicates the %age of voids present in the aggregate material. This %age of voids effects the grading of the aggregate which is important in higher strength concrete. When measured on any aggregate of a known grading, uncompact void content provides an indication of the aggregate's angularity, spherical shape, and surface texture. ASTM standard test methods were used to obtain the particle size distribution (gradation) and fineness modulus [5], bulk density [6], moisture content [7], and specific gravity (saturated surface-dry, SSD) and water absorption [8] of fine, coarse and combined sands.

Calculation of Unit weight:

Calculate the unit weight for the rodding procedure as follows M= G-T V or, M= (G-T) x F

Where, M= Unit weight of the aggregate, lb/ft^3 (kg/m^3),

G=Mass of the aggregate plus the measure, lb. (kg),

T= Mass of the measure, lb. (kg),

V=Volume of the measure,ft^3 (m^3) and

F=Factor for measure,ft-^{3} (m-^{3}).

The unit weight determined by this test method is for aggregate in an oven-dry condition. If the unit weight in terms of saturated-surface (S.S.D) condition is desired, use the exact procedure in this test method, and then calculate the SSD unit weight using the following formula MSSD= M [1+ A 100]

Where

MSSD=Unit weight in SSD condition, lb/ft^3 (kg/m^3) and A=% absorption

Table 3.3: Properties of Coarse Aggregate.

Aggregate size(mm)	F.M	Specific Gravity	Dry loose unit weight (kg/m³)	Dry Unit weight (kg/m³)	Absorption capacity (%)
19	6.66	2.4	817	957	16

3.3 Tests for Fine Aggregate

The portion of an aggregate passing the 4.75 mm (No. 4) sieve and predominantly retained on the 75 mm (No. 200) sieve is called fine aggregate or sand. In other word, Fine aggregate is the aggregate most of which passes through No. 4 sieve (4.75 mm opening) and contain only that much coarser material as is permitted by the specification. It should be clean and free from organic substances and size should be uniformly distributed. The fine aggregate that had been used in this study was locally available and coarse sand mixed with it. The following tests were employed to determine the properties of fine aggregate.

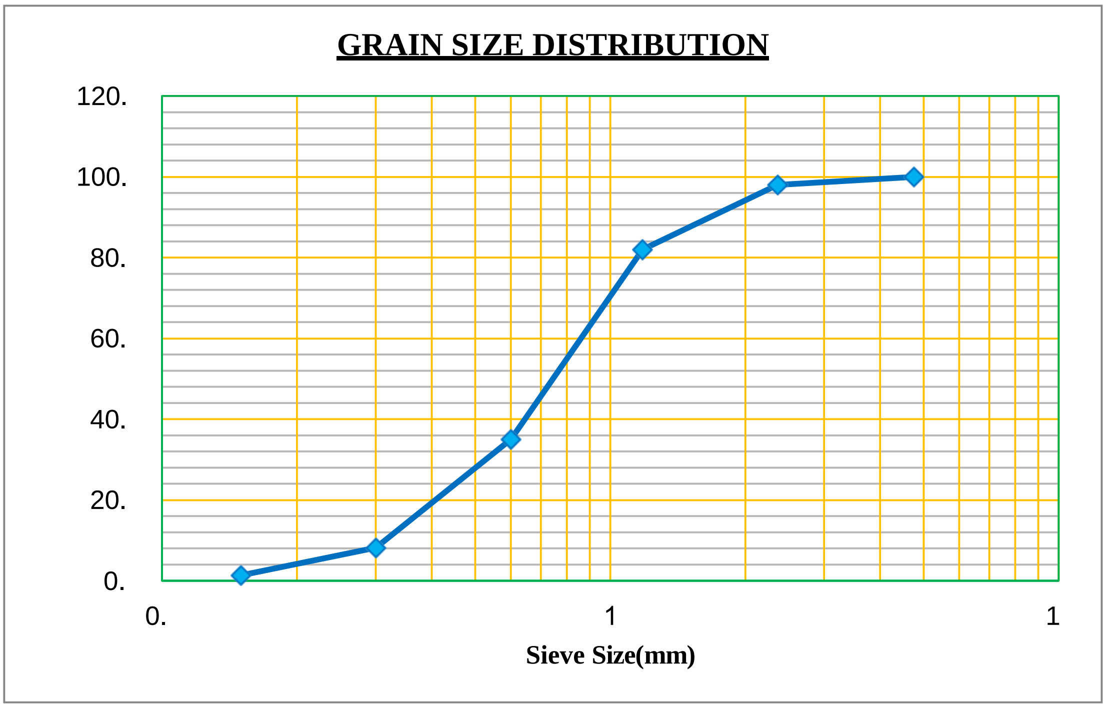
3.3.1 Gradation of Fine Aggregate

Gradation of fine aggregate is performed following the same procedure of coarse aggregate. The test method conforms to the ASTM standard requirements of specification C136. ASTM standard test methods were used to obtain the particle size distribution (gradation) and fineness modulus [5], bulk density [6], moisture content [7], and specific gravity (saturated surface-dry, SSD) and water absorption [8] of fine, coarse and combined sands.

Figure 3.2: Gradation of fine Aggregat.

Table 3.4: Gradation of Fine aggregate (Sylhet sand)

Sieve size (mm)	Weight of Retained (gm)	% Retain	Cumulative % Retain	% Finer	F. M
4.75	0	0	0.0	100.0	2.8
2.36	10	2	2.0	98.0	
1.18	80	16	18.0	82.0	
0.6	235	47	65.0	35.0	
0.3	134	26.8	91.8	8.2	
0.15	34	6.8	98.6	1.4	
Pan	7				
Total	500		280.0		



Figue 3.3: Grain size distribution curve of fine aggregate (Sylhet Sand).

3.3.2 Unit Weight of Fine Aggregate

This test covers the determination of unit weight in a compacted or loose condition of coarse aggregates. Unit weight values of aggregate are necessary for selecting proportions for concrete mixture. They may also be used for determining mass/ volume relationship of aggregate.

Table 3. 5 : Properties of Fine Aggregate.

Type of sand	Unit Weight (lb/ft3)	Fineness modulus (F.M)	Bulk specific gravity		Absorption capacity (%)	Combined F.M.
			Dry	SSD		
Coarse Sand	99	2.8	3.81	3.85	1.01	2.8

3.3.3 Normal Consistency Test of Cement

The water content of a paste has a marked effect upon the time of set as well as other properties. Bringing the cement paste to a standard condition of wetness, called 'normal consistency' regulates the water content. For finding out initial setting time, final setting time and soundness of cement, normal consistency has to be used. The normal consistency of a cement paste is defined as that consistency which will permit a VicatS plunger having 10 mm diameter and 50 mm length to penetrate to a depth of 10 mm from the top of the mold.

Figure 3.4: Consistency of Cement.

3.3.4 Coconut Shell

Coconut shell is the toughest component covered in coconut fruit. The coconut shell is situated between the coconut flesh and the coconut husk. This shell is usually designed to cover the inner portion of the coconut. Shell is used for the development of various handicrafts and other applications. It gives your hair a smooth and lustrous texture. And also repairs the damaged hair, leveling down all the frizz and dryness. The coco coir rubs through the skin of the scalp and this, in turn, increases the blood circulation at the scalp area. Available in natural-looking shades like dark chestnut, honey blonde, and copper, the dye is ammonia-free and gentle. Keep in mind, however, that an herbal formula may fade a bit faster than other picks, and according to reviewers, you may need to reapply about every five weeks.

Figure 3.5: Gradation of Coconut Shell.

3.4 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. In this study potable water from tap was used in the mixture of concrete.

Figure 3.6: Measure of Water.

3.5 Process of Casting and Testing of Concrete Specimen (Slump Test)

Production of quality concrete requires meticulous care exercised at every stage of manufacture of concrete. The various stages of casting of test specimens are discussed in the below step by step.

3.5.1 Slump Test

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch. Slump height 30cm, Top width 10cm, Bottom width 20cm.

Figure 3.7: concrete slump test .

3.5.2 Formwork preparation

Formwork molds the concrete to the desired size and shape, and controls its position and alignment. It is a temporary structure that supports its own weight and the freshly placed concrete, as well as construction live loads including materials, equipment, and workers.

Figure 3.8: Formwork preparation for Cylinder.

3.5.3 Working Process

A proper and accurate measurement of all the materials used in the production of concrete is essential to ensure uniformity of proportions and aggregate grading in successive batches. In this study gravimetric batching had been used for measuring the materials. The objective of mixing is to coat the surface of all aggregate particles with cement paste, and to blend all the ingredients of concrete into a uniform mass.

Figure 3.9: Mixing of aggregate.

Table 3.6 : Slump.

Mix Ratio	W/C	Slump
1:1.5:3	0.45%	2 cm
	0.50%	4 cm
	0.55%	7 cm

3.6 Process of Concrete Cylinder with Coconut Shell

Production of quality concrete requires meticulous care exercised at every stage of manufacture of concrete. The various stages of casting of test specimens are discussed in the below step by step.

3.6.1 Formwork Preparation

Cylinder with Coconut Shell Strength are usually cut by means of a rotary cutting tool with diamond bits. Before making the cylinder it is need to prepare cylinder formwork. Use lubricants Oil in the inner side form work. Make easy the Nut-Bolts before work starting.

Figure 3.10: Formwork Preparation.

3.6.2 Working Process

Twelve CSBACs were prepared in the present study considering the w/c ratios of 0.45, 0.50, and 0.55. These w/c ratios were selected following the guidelines given in IS 10262: 2019 [9] and IS 456: 2000 [10] to produce normal concrete mixes possess. The coconut shell concrete made with 15% CSA provides the optimum compressive strength. The concretes with 5–15% CSA give the targeted strength of M20 Grade

concrete (20 MPa cube compressive strength). In the present study, the constant mix ratio of 1:1.5:3 by bulk volume of cement, fine aggregate, and coarse aggregate, respectively, was used to produce CSBAC mixes, targeting the strength of M20 Grade concrete (20 MPa cube compressive strength) as the minimum requirement of compressive strength. The mix proportions of the concrete mixes were determined based on the instructions given in IS 456: 2000 for M20 Grade concrete . Rajeevan and Shamjith [11] stated that the coconut shell concrete made with 15% CSA provides the optimum compressive strength. Mohapatra and Parhi [12] demonstrated that the concretes with 5–15% CSA give the targeted strength of M25 Grade concrete (25 MPa cube compressive strength). In the present study, the constant mix ratio of 1:1.5:3 by bulk volume of cement, fine aggregate, and coarse aggregate, respectively, was used to produce CSBAC mixes, targeting the strength of M20 Grade concrete (20 MPa cube compressive strength) as the minimum requirement of compressive strength. The volumes of CA, FA, and cement were computed for 1 m3 wet volume of concrete (about 1.5 m3 dry volume of concrete) based on the selected volumetric mix ratio. These volumes were then multiplied by the respective bulk density of CA, FA, and cement to obtain their weights. The amount of CSA was determined based on the replacement level of BA by weight. The quantity of water was calculated from the weight of cement and the selected w/c ratios of 0.45, 0.50, and 0.55. In all concrete mixes, the volumetric mix ratio of 1:1.5:3.0 for cement, fine aggregate, and coarse aggregate was kept unchanged, but the water content was varied based on the w/c ratios of 0.45, 0.50, and 0.55. However, all water contents were well below the maximum allowable limit (30 kg per 50 kg of cement). Also, the cement contents used were above the minimum limit (250– 300 kg/m3) for the M20 Grade plain and reinforced concretes under all applicable environmental exposure conditions, but they remained below the maximum limit (450 kg/m3). After obtaining the weights of all concrete constituents, the total absolute volume was calculated for each mix, and then the weight-based mix proportions were adjusted for 1 m3 of wet concrete. It should be mentioned that CSBAC mixes were designated based on their w/c ratio and CSA content. For example, WC45CS5 designates a CSBAC mix whose w/c ratio and CS content is 0.50 and 5%, respectively.

Figure 3.11: Materials selection.

Table 3.7: The quantity of cylinder is 12 Nos.(Curing time 28 days)

Trial-01

Mix Ratio	**W/C**	**Cylinder Dia**	**Brick Chips**	**Sand**	**Cement**	**Coconut Shell**	**Water**
1:1.5:3	0.45	4 inch	1500gm	750gm	500gm	0gm	225gm
		4 inch	1425gm	750gm	500gm	75gm	225gm
		4 inch	1350gm	750gm	500gm	150gm	225gm
		4 inch	1275gm	750gm	500gm	225gm	225gm

Table 3.8: The quantity of cylinder is 12 Nos.(Curing time 28 days)

Trial-02

Mix Ratio	**W/C**	**Cylinder Dia**	**Brick Chips**	**Sand**	**Cement**	**Coconut Shell**	**Water**
1:1.5:3	0.50	4 inch	1500gm	750gm	500gm	0gm	250gm
		4 inch	1425gm	750gm	500gm	75gm	250gm
		4 inch	1350gm	750gm	500gm	150gm	250gm
		4 inch	1275gm	750gm	500gm	225gm	250gm

Table 3.9: The quantity of cylinder is 12 Nos.(Curing time 28 days)

Trial-03

Mix Ratio	**W/C**	**Cylinder Dia**	**Brick Chips**	**Sand**	**Cement**	**Coconut Shell**	**Water**
1:1.5:3	0.55	4 inch	1500gm	750gm	500gm	0gm	275gm
		4 inch	1425gm	750gm	500gm	75gm	275gm
		4 inch	1350gm	750gm	500gm	150gm	275gm
		4 inch	1275gm	750gm	500gm	225gm	275gm

Table 3.10: The quantity of cylinder is 12 Nos.(Curing time 14 days)

Trial-04

Mix Ratio	W/C	Cylinder Dia	Brick Chips	Sand	Cement	Coconut Shell	Water
1:1.5:3	0.45	4 inch	1500gm	750gm	500gm	0gm	225gm
		4 inch	1425gm	750gm	500gm	75gm	225gm
		4 inch	1350gm	750gm	500gm	150gm	225gm
		4 inch	1275gm	750gm	500gm	225gm	225gm

Table 3.11: The quantity of cylinder is 12 Nos.(Curing time 14 days)

Trial-05

Mix Ratio	W/C	Cylinder Dia	Brick Chips	Sand	Cement	Coconut Shell	Water
1:1.5:3	0.50	4 inch	1500gm	750gm	500gm	0gm	250gm
		4 inch	1425gm	750gm	500gm	75gm	250gm
		4 inch	1350gm	750gm	500gm	150gm	250gm
		4 inch	1275gm	750gm	500gm	225gm	250gm

Table 3.12: The quantity of cylinder is 12 Nos.(Curing time 14 days)

Trial-06

Mix Ratio	W/C	Cylinder Dia	Brick Chips	Sand	Cement	Coconut Shell	Water
1:1.5:3	0.55	4 inch	1500gm	750gm	500gm	0gm	275gm
		4 inch	1425gm	750gm	500gm	75gm	275gm
		4 inch	1350gm	750gm	500gm	150gm	275gm
		4 inch	1275gm	750gm	500gm	225gm	275gm

3.6.3 Materials Mixing

Concrete mixing is the process of properly mixing the materials needed to form concrete, such as cement, sand, aggregate, water, and admixtures (if any). The primary goal of concrete mixing is to make the concrete mass homogeneous and uniform in color while maintaining the required consistency.

Figure 3.12: Materials Mixing.

3.6.4 Concrete placing & Compaction

Compaction significantly increases the ultimate strength of concrete and enhances the bond with reinforcement. It also increases the abrasion resistance and general durability of the concrete, decreases the permeability and helps to minimize its shrinkage and creep characteristics.

Figure 3.13: Concrete placing & Compaction.

3.6.5 Remarks The Cylinder

After Complete the work here is necessary to identify the cylinder for the result by each to another cylinder. Percentage of coconut shell is remarks on the cylinder . & The water-cement ratio also remarks on cylinder .

Figure 3.14: Remarks the Cylinder.

3.6.6 Curing the Cylinder

Concrete cylinder curing is defined as the process of maintaining satisfactory temperature and moisture conditions in concrete long enough for hydration to develop desired concrete properties. Keeping the concrete moist during the process will ensure that optimal strength and durability are achieved. The curing time measured 28 days for 36 nos cylinder & other 36 nos cylinder curing time measured 14 days .

Figure 3.15: Curing The Cylinder.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter includes the cylinder test results to find compressive strength of brick aggregate concrete & with coconut shell. There are three water-cement ratio in used(0.45, 0.50, 0.55) And the casting ratio is (1:1.5:3). Dia of Cylinder is 4 inch. Number of 36 Nos cylinder test after 28 days curing time & number of 36 Nos cylinder test after 14 days curing time. In this chapter the test result are presented in graphical and tabular form and discuss under different category.

4.2 Test Results

Which is stand for different water ratio & different proportion of coconut sell & other materials all cylinder strength. The comparison is conducted by the variation of compressive strength, which is stand for different water ratio and different mix proportion . All core and cylinder strength collected data are presented in **Appendix**.

4.3 Failure Mode of Cylinder

During testing of the concrete cylinder with coconut shell by Universal Testing Machine (UTM) , cores were crushed under applying load. Due to presence of coconut shell in core was failed in different types mode. It seems that existing of coconut shell in core is influenced it to failed at a little pressure. Some failure modes of the core are given in the bellow:

Figure 4.1: Different types of failure mode of the concrete cylinder.

4.4 Compressive Strength of Cylinder

The compressive strength of the concrete cylinder is one of the most common performance measures performed by the engineers in the 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.

4.4.1 Compressive Strength of Cylinder (Type-1)

Compressive strength of cylinders were collected for this study. This type cylinder mix ratio 1:1.5:3 & water-cement ratio is 0.45.

And the curing time is 28days . Cylinder were differentiate by uses of coconut shell in proportion of (0%,5%,10% & 15%).

4.4.2 Compressive Strength of Cylinder (Type-2)

Compressive strength of cylinders were collected for this study. This type cylinder mix ratio 1:1.5:3 & water-cement ratio is 0.45.

And the curing time is 14days . Cylinder were differentiate by uses of coconut shell in proportion of (0%,5%,10% & 15%).

4.4.3 Compressive Strength of Cylinder (Type-3)

Compressive strength of cylinders were collected for this study. This type cylinder mix ratio 1:1.5:3 & water-cement ratio is 0.50%.

And the curing time is 14days . Cylinder were differentiate by uses of coconut shell in proportion of (0%,5%,10% & 15%).

4.4.4 Compressive Strength of Cylinder (Type-4)

Compressive strength of cylinders were collected for this study. This type cylinder mix ratio 1:1.5:3 & water-cement ratio is 0.55%.

And the curing time is 14days . Cylinder were differentiate by uses of coconut shell in proportion of (0%,5%,10% & 15%)

4.5 Summary

In this chapter concrete core strength test results are presented and illustrated by graphical method. Also all the bar chart is discussed to find out reasons of the behavior of the concrete core under loading with presence of different % of coconut shell uses with concrete. .

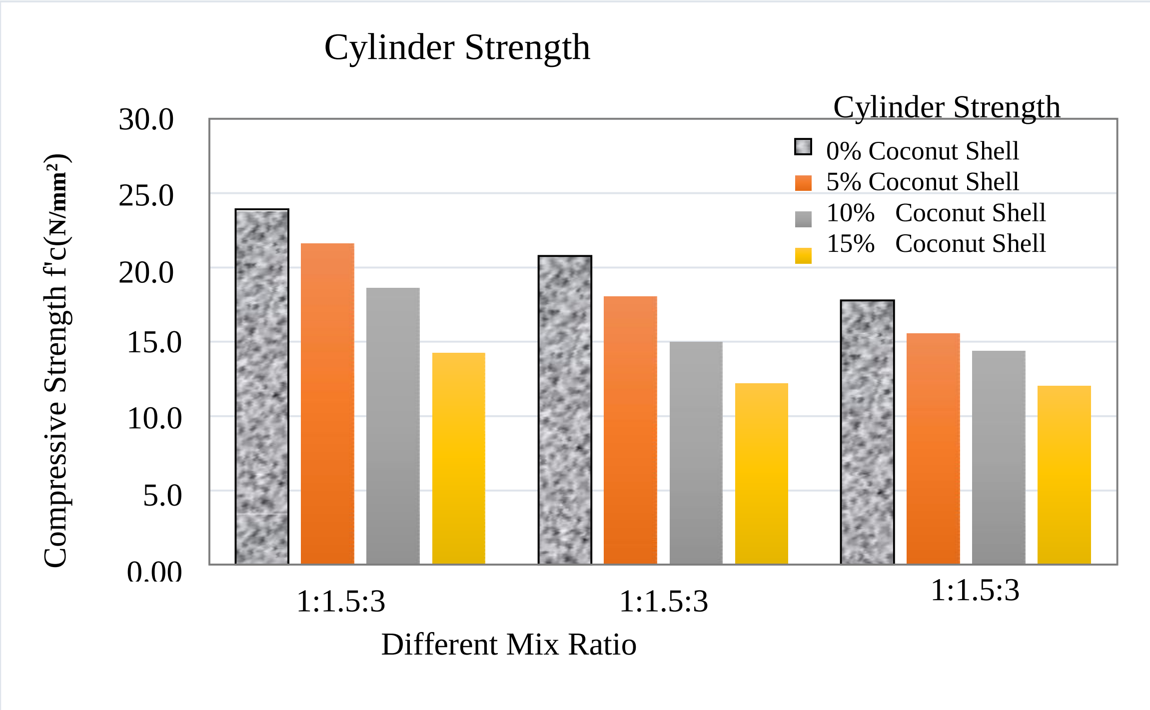


Figure 4. 2 : Comparison of compressive strength between cylinders.

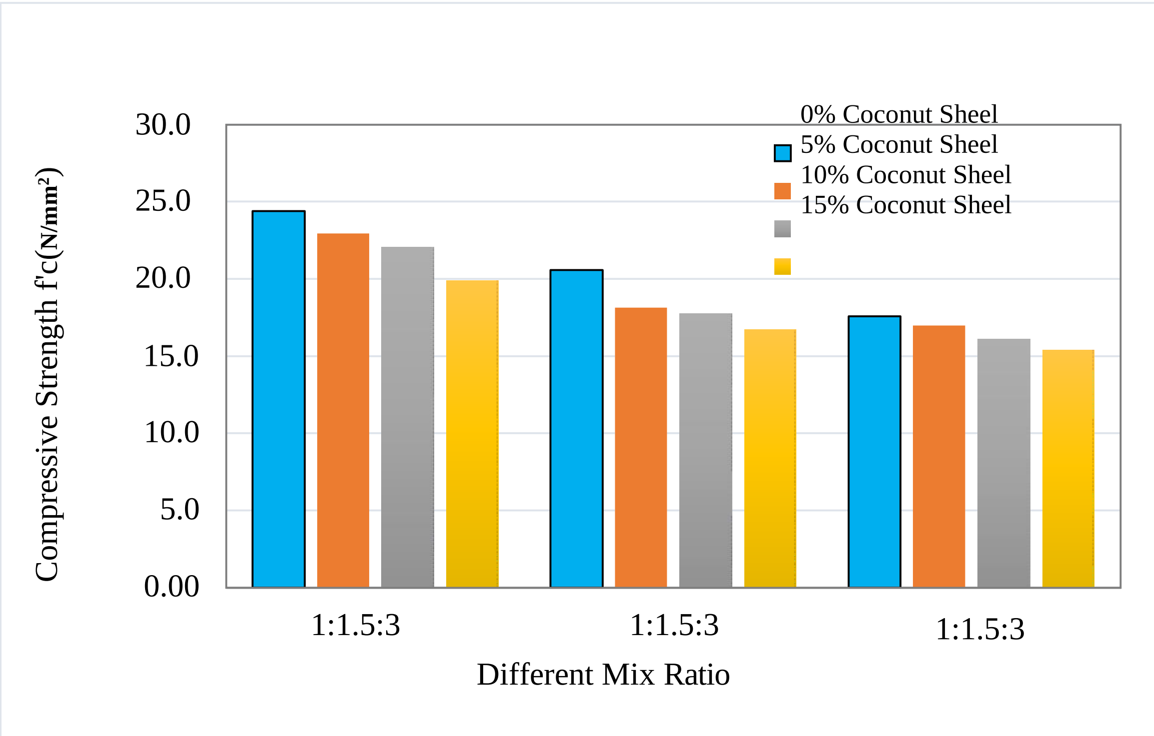


Figure 4. 3 : Comparison of compressive strengt

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Research Conclusions

The research described in this thesis was conducted to evaluate the in-place concrete strength by core testing. This phase of the thesis was primarily undertaken to assess the effects of various proportion of coconut shell with concrete core specimens. Data were collected from 72 Nos. core specimens from three different water ratio. In this study, 72 Nos. cylinder (4" x 8") were casting in the concrete mixes ratio 1:1.5:3 . The concrete were made by using bricks chips as coarse aggregate. The 4 in. diameter cylindrical cores were taken. According to obtained results and their analysis, following conclusions can be deduced:

- ✓ It seems that core strength decreases significantly with compare to cylinder strength. Strength of 4 inch core with coconut shell is decreased about 12% and 6% respectively with compare to cylinder strength.
- ✓ It also appears that compressive strength of concrete increasing up to 5% but decreases significantly with the increase of coconut shell.

5.2 Research Recommendations for Further Study

On the basis of the present study following recommendation are suggested for further study.

a) To evaluate the cylinder strength for different diameter using as a partial replacement of coarse aggregate.

b) Furthermore parameters may be considered for evaluating like slump, setting time, fresh and hardened properties of concrete .

c) Effect of w/c on concrete using different source (drinking water, river water) of water.

d) More detailed study needed for proportion 0-5% partial replacement coarse aggregate as coconut shell

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APPENDIX
LIST OF ABREVIATIONS OF TECHNICAL

SYMBOLS AND TERMS

ASTM	American Society for Testing and Materials
CC	Cement Concrete
NDT	Non-destructive test
DT	Destructive test
F.M	Fineness Modulus
kN	Kilo Newton
MPa	Mega Pascal (N/mm^2)
f'_c	Compressive strength concrete
W/C	Water/Cement Ratio
mm	Millimeter
AASHTO	American Association of State Highway Transportation Officials
ACI	American Concrete Institute
SSD	saturated surface dry
H/D	Height/Diameter
BC	Before Christ
RHT	Rebound Hammer Test
UPV	Ultrasonic Pulse Velocity
L/D	Length/Diameter
CMT	Construction Materials Testing

SOME ESSENTIAL DATA TABLE AND DETAILS TEST RESULTS

Table A-1 : Water absorption capacity of bricks sample.

Sample No	Absorptions Capacity (%)	Average (%)
1	17	16
2	16.5	
3	16	
4	15	
5	15.5	

Table A-2 : Calculation of the compressive strength of Bricks.

Sample No	Stress (psi)	Average (psi)	
1	1941	2088	2252
	2235		
2	2618	2615	
	2611		
3	2040	1991	
	1941		
4	1883	1962	
	2041		
5	2712	2605	
	2499		

Table A-3: Data for compresive strength of the without coconut shell concrete (cylinder) after the curing time of 28 days.

SL. No.	Mix Ratio	W/C	Sample Dia (mm)	Length (mm)	Load (KN)	Area (mm^2)	Stress (N/mm^2)	Average (N/mm^2)
1	1:1.5:3	0.45%	92.5	206.5	150.0	6720.07	22.32	22.43
2			91.0	207.3	148.5	6503.89	22.83	
3			92.7	212.0	149.6	6749.16	22.16	
4	1:1.5:3	0.50%	93.35	213.01	167.8	6844.13	24.51	23.08
5			92.83	210.0	156.5	6768.09	23.12	
6			92.70	208.8	155.8	6749.15	23.08	
7	1:1.5:3	0.55%	91.78	215.5	144.6	6615.85	21.85	21.86
8			93.53	207.2	155.0	6870.55	22.56	
9			93.03	206.5	143.9	6797.29	21.17	

Table A-4: Data for compresive strength of the 5% coconut shell with concrete (cylinder) after the curing time of 28 days.

SL. No.	Mix Ratio	W/C	Sample Dia (mm)	Length (mm)	Load (KN)	Area (mm^2)	Stress (N/mm^2)	Average (N/mm^2)
1	1:1.5:3	0.45%	90.40	202.10	140.2	6418.39	21.84	21.58
2			90.46	206.30	138.5	6426.92	21.54	
3			92.15	210.00	142.5	6669.30	21.36	
4	1:1.5:3	0.50%	92.15	212.18	145.6	6669.31	21.83	21.37
5			93.20	210.44	140.3	6822.15	20.56	
6			92.70	209.11	139.9	6749.15	20.72	
7	1:1.5:3	0.55%	92.78	218.50	138.5	6760.80	20.48	20.21
8			93.55	209.30	135.6	6873.49	19.72	
9			93.56	209.33	140.6	6874.96	20.45	

Table A-5: Data for compresive strength of the 10% coconut shell with concrete (cylinder) after the curing time of 28 days.

SL. No.	Mix Ratio	W/C	Sample Dia (mm)	Length (mm)	Load (KN)	Area (mm^2)	Stress (N/mm^2)	Average (N/mm^2)
1	1:1.5:3	0.45%	88.70	201.85	142.1	6179.26	22.93	22.13
2			89.22	201.90	135.6	6251.93	21.68	
3			90.10	205.20	138.5	6375.87	21.72	
4	1:1.5:3	0.50%	90.18	207.88	145.6	6387.19	22.79	21.22
5			87.90	213.20	130.2	6068.30	21.75	
6			95.00	210.25	135.6	7088.21	19.13	
7	1:1.5:3	0.55%	89.70	215.35	138.5	6319.38	21.91	21.39
8			92.15	218.20	140.6	6669.30	21.08	
9			90.27	219.08	135.6	6399.95	21.58	

Table A-6: Data for compresive strength of the 15% coconut shell with concrete (cylinder) after the curing time of 28 days.

SL. No.	Mix Ratio	W/C	Sample Dia (mm)	Length (mm)	Load (KN)	Area (mm^2)	Stress (N/mm^2)	Average (N/mm^2)
1	1:1.5:3	0.45%	90.10	200.20	130.8	6375.87	20.51	20.51
2			95.00	204.35	128.6	7088.21	18.14	
3			84.30	207.10	127.6	5581.42	22.86	
4	1:1.5:3	0.50%	90.05	215.40	135.5	6368.79	21.27	19.83
5			91.89	219.20	129.5	6631.72	19.52	
6			93.15	222.25	127.5	6814.83	18.70	
7	1:1.5:3	0.55%	82.50	219.35	127.5	5345.61	23.85	20.45
8			94.11	205.50	126.8	6956.02	18.22	
9			92.88	210.88	130.8	6775.38	19.30	

Table A-7: Data for compresive strength of the without coconut shell concrete (cylinder) after the curing time of 14 days.

SL. No.	Mix Ratio	W/C	Sample Dia (mm)	Length (mm)	Load (KN)	Area (mm^2)	Stress (N/mm^2)	Average (N/mm^2)
1	1:1.5:3	0.45%	93.35	202.15	130.5	6844.13	19.06	19.94
2			92.83	213.22	135.7	6768.09	20.04	
3			92.70	204.55	140.0	6749.15	20.74	
4	1:1.5:3	0.50%	90.40	200.01	137.5	6418.39	21.42	21.24
5			90.46	200.40	135.0	6426.92	21.00	
6			92.15	205.78	142.2	6669.30	21.32	
7	1:1.5:3	0.55%	92.50	206.14	138.5	6720.07	20.60	20.08
8			91.00	207.10	132.5	6503.89	20.37	
9			92.70	204.12	130.2	6749.16	19.29	

Table A-8: Data for compresive strength of the 5% coconut shell with concrete (cylinder) after the curing time of 14 days.

SL. No.	Mix Ratio	W/C	Sample Dia (mm)	Length (mm)	Load (KN)	Area (mm^2)	Stress (N/mm^2)	Average (N/mm^2)
1	1:1.5:3	0.45%	92.15	198.20	135.6	6669.31	20.33	20.22
2			93.20	195.22	133.5	6822.15	19.56	
3			92.70	195.20	140.2	6749.15	20.77	
4	1:1.5:3	0.50%	90.40	196.00	138.5	6418.39	21.57	21.58
5			90.46	197.20	140.2	6426.92	21.81	
6			92.15	200.11	142.5	6669.30	21.36	
7	1:1.5:3	0.55%	88.70	199.11	133.5	6179.26	21.60	21.05
8			89.22	195.05	130.2	6251.93	20.82	
9			90.10	194.98	132.2	6375.87	20.73	

Table A-9: Data for compresive strength of the 10% coconut shell with concrete (cylinder) after the curing time of 14 days.

SL. No.	Mix Ratio	W/C	Sample Dia (mm)	Length (mm)	Load (KN)	Area (mm^2)	Stress (N/mm^2)	Average (N/mm^2)
1	1:1.5:3	0.45%	92.78	198.50	128.9	6760.80	19.06	18.83
2			93.55	195.00	130.2	6873.49	18.94	
3			93.56	195.40	127.2	6874.96	18.50	
4	1:1.5:3	0.50%	88.70	196.30	130.2	6179.26	21.07	21.04
5			89.22	197.28	135.4	6251.93	21.65	
6			90.10	200.00	130.2	6375.87	20.42	
7	1:1.5:3	0.55%	90.18	199.18	128.9	6387.19	20.18	19.64
8			87.90	195.10	127.0	6068.30	20.92	
9			95.00	194.60	126.5	7088.21	17.84	

Table A-10: Data for compresive strength of the 15% coconut shell with concrete (cylinder) after the curing time of 14 days.

SL. No.	Mix Ratio	W/C	Sample Dia (mm)	Length (mm)	Load (KN)	Area (mm^2)	Stress (N/mm^2)	Average (N/mm^2)
1	1:1.5:3	0.45%	89.70	194.40	125.6	6319.38	19.87	19.43
2			92.15	190.20	126.5	6669.30	18.96	
3			90.27	191.40	124.6	6399.95	19.46	
4	1:1.5:3	0.50%	90.10	194.30	130.2	6375.87	20.42	20.42
5			95.00	190.28	128.9	7088.21	18.18	
6			84.30	190.00	126.5	5581.42	22.66	
7	1:1.5:3	0.55%	90.05	194.10	124.6	6368.79	19.56	18.63
8			91.89	193.12	120.7	6631.72	18.20	
9			93.15	192.50	123.6	6814.83	18.13	

CONCRETE MIX DESIGN

Required Data M20 Grade Concrete

- Grade of concrete -M20
- Characteristic compressive strength of concrete at 28days-20N/mm²
- Nominal maximum size of aggregate=20mm
- Specific Gravity of cement= 3.15
- Specific gravity of fine aggregate = 2.5
- Specific gravity of Coarse aggregate = 2.8

Step 1: Calculation of Target strength

Target Mean strength of concrete is derived from the below formula

$$F_t=f_{ck}+1.65s$$

Where S= standard deviation which is taken as per below table= 4

Table A-11 : Grade of concrete with Standard deviation.

Grade of concrete	**Standard deviation (N/mm²)**
M10	3.5
M15	3.5
M20	4.0
M25	4.0
M30	5.0
M35	5.0
M40	5.0
M45	5.0
M50	5.0

Characteristic compressive strength after 28 days f_{ck}= 20N/mm²

F_t=20+1.65X4

Therefore, target mean strength f_t=26.6N/mm

Step 2: Selection of Water-Cement Ratio

From Table 5 of IS 456, (page no 20)

Maximum water-cement ratio for Mild exposure condition=0.55

Based on experience, adopt water-cement ratio as 0.5.

Let, W/C ratio= 0.50

Step 3: Air Content Calculation

Nominal maximum size of aggregate taken is=20mm

Table A-12 : Air content (%) of aggregate.

Nominal maximum size of aggregate	Air content (% of the volume of concrete)
10mm	5%
20mm	2%
40mm	1%

So, from the table entrapped air content in % of the volume of concrete = 2%

Step 4: Water Content Calculation

For nominal maximum size of aggregate of 20mm, the required water content is selected form the table-

Table A-13: Maximum water Content of aggregate.

Nominal maximum size of aggregate	Maximum water content
10mm	208
20mm	186
40mm	165

Therefore, water content = 186+(186 x 3/100)=191.6 lit/m^3 of concrete.

Step 5: Cement Content Calculation

From step 2, Water cement ratio = W/C=0.50

From step 4, Water content W = 191.6 liters = 191.6kg

191.6/C=0.50

Finally, C=348.36Kg/m³ of concrete.

Step 6: Aggregate Ratio for Concrete

Table A-14: Aggregate (Coarse Aggregate & Fine Aggregate)Ratio for Concrete for Different Zones.

Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate
(Clauses 4.4, A-7 and B-7)

Sl No	Nominal Maximum Size of Aggregate	Volume of Coarse Aggregate" per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
	mm	Zone I	Zone IV	ZoneIII	ZoneII
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.50	0.48	0.46	0.44
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.75	0.73	0.71	0.69

1) Volumes are based on aggregates in saturated surface dry condition.

From the table, ratio of volume of coarse aggregate to volume of total aggregate, for 20mm nominal maximum size aggregate and zone-2 fine aggregate is

Therefore, **P=0.62**

Step 7: Aggregate Content Calculation

Volume of concrete (with entrapped air) = 1 m3

From step 3, Entrapped air %-2%-0.02

Therefore, volume of concrete (without air content)=1-0.02-0.98m

Fine aggregate content F.A is determined from below formula,

V=IW+C/Ge+(1/(1-P) X (F.A)/GD)] x 1/1000

0.98= [191.6+348.36/3.15+(1/(1-0.62) X (F.A)/2.5)] x 1/1000

Therefore, amount of fine aggregate **F.A= 643.92 kg**

V-IW+C/Ge+(1/P) X (FA)/GO) x 1/1000

0.98=[191.6+348.36/3.15+(1/0.62) X (FA)/2.5)] x 1/1000

Therefore, amount of coarse aggregate C.A=1050.59 kg

Step 8: Final Mix Proportions of Ingredients

W/C ratio=0.50

Cement quantity=348.36Kg=345kg

Fine aggregate quantity = 673.52kg=669.67 kg

Coarse aggregate Quantity = 1050.59 kg

Mix proportion for M20 Concrete = Cement: F.A: CA=1:1.5:3