EVALUATION THE EFFECT OF REINFORCING BAR ON THE COMPRESSIVE STRENGTH OF CONCRETE

By

MD. ANOWAR HOSSAIN
ASHRAFUL SIDDIK
MAHIM ISLAM
MD. EMON HASAN
TANIN AHMED
MOST.ZURAIN AKTER

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 (SU)
147/I, Green Road, Dhaka-1215, Bangladesh
Section: 16B
Summer-2022

EVALUATION THE EFFECT OF REINFORCING BAR ON THE COMPRESSIVE STRENGTH OF CONCRETE

By

MD. ANOWAR HOSSAIN (BCE-1702011145)
ASHRAFUL SIDDIK (BCE-1901016007)
MAHIM ISLAM (BCE-1901016005)
MD.EMON HASAN (BCE-1901016135)
TANIN AHMED (BCE-1901016079)
MOST.ZURAIN AKTER (BCE-1901016275)

Supervisor

Md. Rakibul Islam
Lecturer
Department of Civil Engineering,
Sonargaon University (SU)

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 (SU)
147/I, Green Road, Dhaka-1215, Bangladesh
Section: 16B
Summer-2022

BOARD OF EXAMINERS

The thesis titled "**Evaluation The Effect of Reinforcing Bar on The Compressive Strength of Concrete.**" submitted by Md. Anowar Hossain (BCE-1702011145), Ashraful Siddik (BCE-1901016007), Mahim Islam (BCE-1901016005), Md. Emon Hasan (BCE-1901016135), Tanin Ahmed (BCE-1901016079), Most.Zurain Akter (BCE-1901016275), has been accepted as satisfactory in partial fulfillment of the requirement for the degree of "Bachelor of Science in Civil Engineering".

……………………………......
Supervisor Chairman
Md. Rakibul Islam
Lecturer
Department of Civil Engineering
Sonargaon University (SU)

………………………………
1. Internal/External Member Member

………………………………
2. Internal/External Member Member

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**
1.	Md. Anowar Hossain	(BCE-1702011145)	…………………….
2.	Ashraful Siddik	(BCE-1901016007)	………………………
3.	Mahim Islam	(BCE-1901016005)	……………………….
4.	Md. Emon Hasan	(BCE-1901016135)	……………………….
5.	Tanin Ahmed	(BCE-1901016079)	………………………..
6.	Most. Zurain Akter	(BCE-1901016275)	………………………….

Dedicated

to

“Our Parents

&

Respectable Teachers”

ACKNOWLEDGEMENTS

First of all, we would like to thank Almighty Allah who gave us the capability to complete the research in time without any interruption. We are indebted to our parents and siblings who motivated us, helped us and provided financial support without which it would be almost impossible to accomplish this research. We are really grateful and indebted to our thesis supervisor Md. Rakibul Islam, lecturer, Department of Civil Engineering, Sonargaon University (SU), Dhaka, Bangladesh. For his flawless guidance, monitoring, motivation throughout the research and during the writing of this thesis. We are also grateful to all the faculty and staff who helped us, motivated us, inspired us and provided us such a friendly environment throughout our undergraduate academic life. We would like to express our gratitude to all those who have directly and indirectly guided and helped us in completing this research.

Finally, we would like to thank our family and friends who made our journey of undergraduate life at SU smooth, easy, friendly and comfortable by helping and motivating us.

ABSTRACT

In this study focus on the evaluation of concrete strength made of brick and stone aggregate by using cylinder. one sizes cylinder diameter (4 inch) are used to find out the effect of core diameter on the core strength. Three different sizes of rebar diameter (10mm, 12mm, 16mm) without rebar are used to evaluation the effect rebar presence in core on the core strength.

concrete was prepared with two mixing ratios (1:1.5:3 and 1:2:4) & different materials (Bricks & stone chips) Each mix ratio of fresh concrete, three Ø4"x8"cylinder samples were taken and tested at 28 days. From the cylinder, 48 numbers cylinder of 4inch diameter core samples were taken. Each diameter of core, three samples were taken without presence of rebar and other core samples were taken with presence of 10mm, 12mm, 16mm rebar in each set of core samples. The cylinders and concrete core samples were tested. The test results are analyzed.

From the test results, it is found that cylinder strength (with rebar) decreases significantly with compare to cylinder strength (without rebar). Strength of with rebar(10mm,12mm,16m) is decreased about 13.60% and 17.64%,21.93% respectively with compare to cylinder strength (without rebar) for stone & ratio 1:1.5:3. Strength of with rebar(10mm,12mm,16m) is decreased about 12.11% and 22.05%,30.76% respectively with compare to cylinder strength (without rebar) for bricks & 1:1.5:3. respectively with compare to cylinder strength of between mixing ratios (1:1.5:3 and 1:2:4) & different materials (Bricks & stone chips), without rebar & different rebar.

It is found that cylinder strength (with rebar) decreases significantly with compare to cylinder strength (without rebar). Strength of with rebar(10mm,12mm,16m) is decreased about 10.62% and 21.76%,23.42% respectively with compare to cylinder strength (without rebar) for stone & ratio 1:2:4. Strength of with rebar(10mm,12mm,16m) is decreased about 16.10% and 28.14%,35.11%, respectively with compare to cylinder strength (without

rebar) for bricks & 1:1.5:3, respectively with compare to cylinder strength of between mixing ratios (1:1.5:3 and 1:2:4) & different materials (Bricks & stone chips), without rebar & different rebar.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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.
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

CHAPTER I
INTRODUCTIOIN

1.1 Background of the Study

Concrete is one of the most essential building materials in all divisions of modern construction. Its utilization around the world, ton for ton, is twice that of steel, wood, plastics, and aluminum consolidated (Cement Trust Coalition, 2013).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. Among the concrete mechanical and physical properties, the solid compressive strength is the most significant property since it is fundamental for planning a basic part or computing its heap bearing limit (Alwash, 2017) . So, during construction , its quality should be maintained properly .To comprehend concrete placing quality and safety evaluation of existing structures that need rehabilitation and retrofitting, it's required to have some information about existing concrete (Tadayon, Moghadam and Tadayon, 2009).

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 does 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 concrete (Tadayon, Moghadam and Tadayon, 2009). Such tests are of value principally for assessments within the same job rather than as quantitative measures of strength. But non-destructive test does not give genuine result. Because of this, concrete coring is used for determining compressive strength of hardened concrete.

Many factors can significantly influence the compressive strength of the concrete core. These comprise cement type, water-cement ratio, aggregate content, water curing period, and exposure conditions. Some particular consideration such as preparing suitable diameter and height, not contacting with reinforcements if possible, positioning perilous areas, and some non- destructive tests such as rebar locating test, impact hammer and ultrasonic pulse velocity are needed for coring. In any case, if rebar is closely spaced or rebar positions cannot be determined, rebar will be cut and core will contain them. Rebar always make trouble in coring of reinforced concrete structures. Some consider that rebar increases sample strength, others believe that strength will be reduced when rebar exist; the others believe in very low effect of rebar presentation. So, presence of rebar in the concrete core dominate to change the compressive strength of concrete core.

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 (core testing) allow practitioners to assess whether an existing concrete structure has adequate strength for its future performance. There are many numbers 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 (Peter and Beushausen, 2013) .

In the literature, 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 clearer with and without presence of reinforcement.

1.3 Objective of the Study

The main objective of this study is to evaluate the rebar effect on the concrete core.

The specific objectives of this study are:

- To evaluate the effect of rebar diameter on the strength of concrete core.
- To determine the effects of mixing ratio (1:1.5:3 & 1:2:4) on the strength of concrete core.
- To determine the effects of different aggregate (Stone & Bricks chips) on the strength of concrete core.

1.4 Scope of the Study

Significant number of researches have already been done to evaluate the effect of some factors on the concrete core strength like as aspect ratio, diameter of the sample, aggregate type, maximum aggregate size, curing history and degree of compaction etc. In this study forty-eight cylinder with different mix ratio and different aggregate and different reinforcement were used to see the effect of rebar on concrete core.

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

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 core strength.

CHAPTER II
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.

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. 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. As per Nan Su and Buquan Miao (2003), concrete was the predominant development material these days with a yearly overall creation of spread 4.5 billion metric tons.

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.

Underway concrete, the Nabataea expected the need to keep the blend as dry or low-droop as could reasonably be expected, as overabundance water brings voids and shortcomings into the solid. Their structure practices included packing the recently set cement with unique instruments. The packing procedure created more gel, which is the holding material delivered by the synthetic responses that happen during hydration which bond the particulates and total together.

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(Wikipedia, 2019).

Anonymous said that the Romans found that the mixture of lime putty with pozzolana, a fine volcanic ash, would harden under water. The result was possibly the first hydraulic cement. It became a major feature of Roman building practice, and was used in many buildings and engineering projects such as bridges and aqueducts. Concrete technology was kept alive during the Middle Ages in Spain and Africa, with the Spanish acquainting a type of concrete with the New World in the primary many years of the sixteenth century. It was utilized by both the Spanish and English in waterfront territories extending from Florida to South Carolina. Called tapia or dark-striped cat, the substance was a velvety white, solid brick work material made out of lime, sand, and a total of shells, rock, or stone blended in with water. Concrete was generally utilized in residential, business, recreational, country and instructive development.

Un-reinforced concrete was a composite material containing aggregates (sand, gravel, crushed shell, or rock) held together by a cement combined with water to form a paste. It gets its name from the fact that it does not have any iron or steel reinforcing bars. It was the earliest form of concrete. The ingredients become a plastic mass that solidifies as the solid hydrates, or. cures. While for the fortified concrete was concrete reinforced by the consideration of metal bars, which increment the elasticity of cement. Both un-reinforced and reinforced concrete can be either cast in place or pre-cast (CHUAN, 2009).

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. Higher strengths up to and exceeding 10,000 psi (70 MPa) are specified for particular applications (Ajagbe and Tijani, 2018).

2.5 Test Methods for Compressive Strength

Different test methods and techniques are used in different countries and sometimes even in the same country. Since a significant number of these tests are utilized in laboratory work, and particularly in research, a knowledge of the impact of the test methods on the measured property is of importance. Tests can be extensively ordered into mechanical tests to destruction and non-destructive tests which allow frequent testing of the same specimen and thus make possible a study of the change in properties with time. Non-destructive tests also allow testing concrete in an actual structures (A. M. Neville, 2011).

2.6 Concrete Core Strength

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 variables and a larger range of cores ought to be extracted. For strength testing, 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. Whenever tried wet a little positive amendment to the quality is made(Concrete @ your Fingertips, 2019).

2.7 Factor Affecting on Concrete Core Strength

The factors that are significant which influence the core compressive strength of concrete are(S Saradu, 2019):

- ✓ Moisture and Voids.
- ✓ Length/Diameter Ratio of Core.
- ✓ Diameter of Core.
- ✓ Position of Cut out Concrete in Structure.
- ✓ Direction of Drilling.
- ✓ Effect of Age.

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 Core:

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.

Position of Cut out Concrete in Structure:

Cores taken from near the top surface have usually lowest strength may it be a column, beam, or wall or slab. With the increase in depth below the top surface the strength increases, but at depths more than 300 mm, there is no further increase in strength. The difference may be 10 to 20%. In case of slabs, poor curing increases this difference.

Direction of Drilling:

Due to the layering effect, the measured strength of specimen drilled vertically relative to the direction of casting is likely to be greater than that for a horizontally drilled specimen from the same concrete. The average value of 8% of this difference has been reported in literature.

Effect of Age:

It has been seen that in-situ, concrete increases little quality following 28 days. Tests on high strength concrete have demonstrated that, however the core quality increments with age up to 1 year. On the other hand, Petersons has suggested the increase in core strength over that of 28 days cylinder strength as 10% after 3 months and 15% after 6 months. Therefore, the impact of age isn't anything but difficult to examine, yet without distinct damp restoring, no expansion in quality ought to be expected.

2.8 Concrete Core Strength Related Study

Suresh, Patil and Shivakumar (2017) conducted research on correlation between actual compressive strength of concrete and strength estimated from core. They found that the cores free from reinforcement with H/D ratio 1.50, 1.75 and 2.0 indicate the lower core compressive strength as compared to cores with reinforcement for the same H/D ratios. The core compressive strength increases with increase in the H/D ratio. The corrected core compressive strength is 1.056 times the measured core compressive strength for all the three H/D ratio (1.5, 1.75 and 2.0) (Patil, 2017).

Alizadeh (2017) studied on a review of the effect of the behavior of core diameter varying H/D ratio on concrete core strength. He found that the compressive strength of cylindrical concrete specimen grows up as the height to diameter ratio decreases. In fact, the strength correction factors are responsible for evaluating this feature shown in ASTM C42 and BS1881 although we cannot apply it to high-strength concrete over 40 MPa. For this purpose, concrete core specimens of 100 mm diameter were cut into different lengths with respect to the following height-to-diameter ratios 1.0,1.25, 1.5, 1.75 and 2.0. The results presented that strength decreases when L/D ratio increases. Also, for different strength classes, the correction coefficients of L/D are not the same (Mohammad, 2017).

Hamad (2015) was carried out on the size and shape effect of specimen on the compressive strength of HPLWFC reinforced with glass fiber. He found that the compressive strength of high performance lightweight foamed concrete increased with rising glass fibers content. The small size of specimen for cubes or cylinder gives higher compressive strength of high-performance light- weight foamed concrete compared with other sizes. The compressive strength of 50 mm cube for mix S3 increased by 38% and 15% compared with the 150 mm and 100 mm cube (S1 and S2), respectively (Hamad, 2015)

Grubbs, Carroll, Schindler et al. (2014) conducted research on the strength of the cast-in-place cylinders were not affected by their location, as their cylinder molds provide room for them to expand and contract within the support system which holds them in place. The average core strength from the concrete with the highest restraint and thus most micro cracking, was approximately 87 % of the average molded cylinder strength (Grubbs *et al.*, 2014).

Carroll and Adam (2014) obtained that the 3 in. diameter cores do not behave the same as 4 in. diameter cores when evaluated for core l/d effects on compressive strength. For 3 in. diameter cores, the calculated core l/d strength correction factor increases as the coarse aggregate size increases and as the l/d decreases. In addition, for 3 in. diameter cores, the calculated core l/d strength correction factor increases as the concrete strength increases and as the l/d decreases (Carroll, 2014).

Aggarwal, Sharma et al. (2013) conducted an experimental study of core diameter varying h/d ratio on concrete core strength. They were casted cubes of 150mm x 150mm x 150mm and cured for 28 days, desired core samples having diameter 50mm and 75 mm have been prepared from these cubes having different h/d ratios of 1, 1.25, 1.5, 1.75 and 2 respectively. the core samples were tested on compression testing machine. It was found that with the increase in the h/d ratio and decrease in the diameter of the core, compressive strength of the core increase. It has also been observed that the strength of core samples was less than those of the standard cubes(Aggarwal, Sharma and Naval, 2013)**.**

Masi, Digrisolo et al. (2013) studied on the experimental evaluation of drilling damage on the strength of cores extracted from R.C buildings. They concluded that the magnitude of the strength reduction due to drilling damage is strongly affected by the concrete strength itself. Therefore, the application of a single value of the correction coefficient, as generally suggested in the technical literature and in structural codes, appear inappropriate. On the contrary, the adoption of a correction coefficient inversely proportional to the original core strength appears more correct (A, Digrisolo and Santarsiero, 2013).

Uzunoglu, Ozgan et al. (2012) were taken core samples from structure elements such as column, reinforced wall in order to make reinforcement or restoration. The consequence of the element height and volume of voids of these samples to the compressive strength were inspected. The typical compressive strength of the referenced samples was 36.95 MPa and the compressive strength of different samples was ranging between 37.3 and 43.0 MPa. However the height increases, compressive strength of concrete increases as well (Uzunoğlu, 2012).

Tadayon, Moghadam et al. (2009) carried out an experiment that the strength reduction of cast cylindrical samples with rebar is usually less than that of concrete cores. They investigated that strength reduction due to existence of rebar in cores is between 25 to 60 percent. This reduction in cast cylindrical samples is about 16 to 24 percent (Tadayon, Moghadam and Tadayon, 2009).

Tuncan, Arioz et al. (2008) conducted a reaserch and found that the compressive strength of cores increased with the decrease in l/d ratio of the core. The effect was more pro- nounced for 46 mm diameter cores. The difference between the strengths of cores with l/d ratios of 1 and 0.75 were not found to be excessive although the cores with l/d ratio of 0.75 gave higher strengths. Therefore, these cores can be used in the evaluation of core strengths by applying appropriate corrections. In addition, the strength of cores gradually decreased as the maxi- mum size of the aggregate increased. The effect was more apparent for 46 mm diameter cores especially tested at 7-day age. The effect of age on core strength was found to be more significant for 46 mm diameter cores drilled from natural aggregate-bearing concretes. Lower relative strength values were obtained from 7-day age tests than 28 and 90-day age tests (Tuncan *et al.*, 2008).

Arioz,Ramyar et al. (2008) were drilled the core samples with diameters of 94, 69, 46 mm and length to diameter (l/d) ratio ranging from 2 to 0.75 from beams and the cores were taken from cold cubes with diameter of 69 mm. Then they were considered that the strength of cores increased with decreased in l/d ratio. The effect was more prominent for smaller diameter cores. The cores having l/d ratio of 0.75 showed somewhat higher strengths than the cores with l/d ratio of 1. However, they may be used in the calculation of core strength results. Strength of cores reduced with the reduction in core diameter. The effect was more substantial for natural aggregate concrete (O. Arioz, M. Tuncan, K. Ramyar, B. Karasu, 2008).

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 core 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. To this end, the basic purpose of this extensive literature review is to form a basis on which the significance of the present study can easily be apprehended. However, the next chapter focuses on the methodology of the study and provides elaborative description of the testing process and data collection technique of this study.

CHAPTER III

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. Concrete core cutting and tests to determine the properties of fresh and hardened concrete.

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. Two different mix ratio & two different materials (Bricks & stone chips) 48 Nos. of cylinders. Details are mentioned in the following table:

Table 3. 1 : Different types of mix ratio & different aggregate Cylinder quantity.

Mix Ratio	Aggregate Type	Diameter of cylinder	Without rebar (Nos.)	Core with 12mm bar (Nos.)	Core with 12mm bar (Nos.)	Core with 16 mm bar (Nos.)
1:1.5:3	Stone	4"	3	3	3	3
	Bricks	4"	3	3	3	3
1:2:4	Stone	4"	3	3	3	3
	Bricks	4"	3	3	3	3
	Total (Nos.)		12	12	12	12

3.3 Test of the Materials

Construction materials testing (CMT) is a vigorous process that helps builders and site owners ascertain potential problems before committing resources to the project. Testing is also obligatory for keeping the structure in line with relevant legal requirements, including occupational safety and environmental guidelines.

3.4 Tests for Coarse Aggregates

When the ration of the aggregate used in concrete that is greater than about 4.75 mm is known as coarse aggregate. In general, coarse aggregates tend to be about 10 times larger than the fine aggregates in concrete, but the range of sizes could be greater than that in certain circumstances.

3.4.1 Gradation of Coarse Aggregate

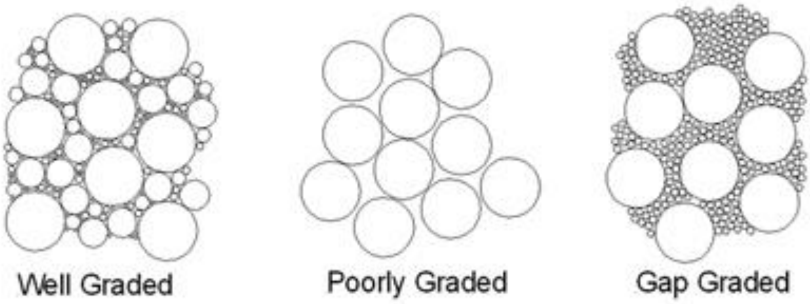
This particle size distribution of the coarse aggregates is termed as “Gradation”. As shown in the Figure 3. there are three typical range categories:

Well-graded mixture contains a gradation of particle sizes that fairly equally spans the dimensions from the best to the course. 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. These 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. The grading is determined in accordance with ASTM C 136, Sieve or Screen Analysis of Coarse Aggregates. 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. A pan is used to catch material passing the smallest sieve. Sieve sizes commonly used for coarse aggregates are No. 100, No. 50, No. 30, No. 16, No. 8, No. 4, 3/8, 3/4, 1.50 in. Coarse aggregate may be available in several different size groups, such as 19 to 4.75 mm (3/4 in to No. 4), or 37.5 to 19 mm (1-1/2 to 3/4 in.). The number and size of sieves selected for a sieve analysis is dependent upon the particle sizes present in the sample and the grading requirements specified (ASTM C136/C136M, 2014).

After sieving, the mass of material retained on each sieve and on the pan is obtained using a balance accurate to 0.1% of the test-sample mass. Results are recorded in tabular form with some or all of the following quantities retained on each sieve, total percent retained on each sieve, and total percent passing each sieve. For an accurate determination of the amount of material finer than the 0.75 mm (No. 200) sieve, the ASTM C 117 test method should be used(ASTM C117, 2017). Grading charts are drawn to show the results of a sieve analysis graphically. The percent passing is usually plotted on the vertical axis, while the sieve sizes are plotted on the horizontal axis. Upper and lower limits specified for the allowable percentage of material passing each sieve may also be included on the grading chart.

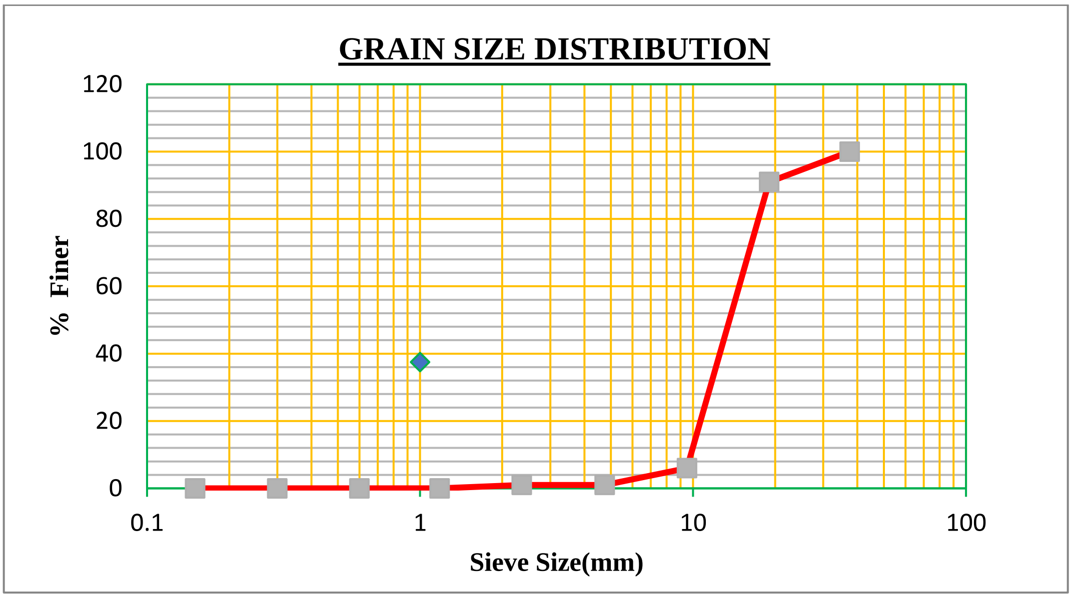
In sieve analysis of coarse aggregate a stack of sieve of size 150 µm (No. 100), 300 µm (No. 50), 600 µm (No. 30), 1.18 mm (No. 16), 2.36 mm (No. 8), 4.75 mm (No. 4), 9.5 mm (3/8 in.), 19.0 mm (3/4 in.), 37.5 mm (1.50 in.) (ASTM C117, 2017).

The test method for sieve analysis of coarse aggregate conforms to the ASTM standard requirements of the specifications C 136.

The values of fineness modulus for various size of coarse aggregate have given in the following **Table 3. 2** and the gradation curve for each of coarse aggregate has shown in **Figure 3.2**

Table 3.2: Gradation of 20 mm downgrade (Stone Chips)

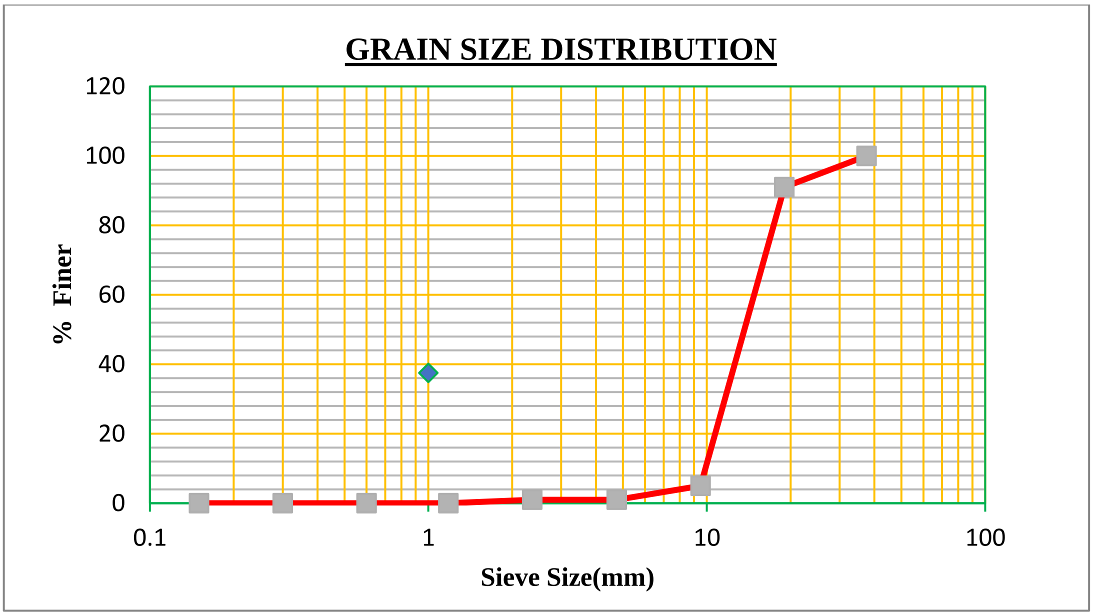
Sieve size (mm)	Weight of Retained (kg)	% Retain	Cumulative % Retain	% Finer	F. M
37.5	0	0.00	0.0	100	3.99
19	0.174	8.7	8.7	91	
9.5	1.688	84.40	93.1	6	
4.75	0.108	5.4	98.50	1	
2.36	0.02	1.0	99.5	1	
1.18	0.01	.5	100.0	0	
0.6	0	0.00	0.00	0	
0.3	0	0.00	0.00	0	
0.15	0	0.00	0.00	0	
Pan	0				
Total	2 kg		399.8		



Figue 3.2: Grain size distribution curve of Coarse aggregate (Brick Chips) 20mm downgrade

Table 3.3 : 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	4.02
19	0.177	8.85	8.86	91	
9.5	1.72	86	94.86	5	
4.75	0.083	4.15	99.01	1	
2.36	0.014	0.7	99.71	1	
1.18	.006	0.3	100.0	0	
0.6	0	0.00	0.00	0	
0.3	0	0.00	0.00	0	
0.15	0	0.00	0.00	0	
Pan	0				
Total	2kg		402.44		



Figue 3.3: Grain size distribution curve of Coarse aggregate (Brick Chips) 20 mm downgrade.

3.5 Tests for Fine Aggregate

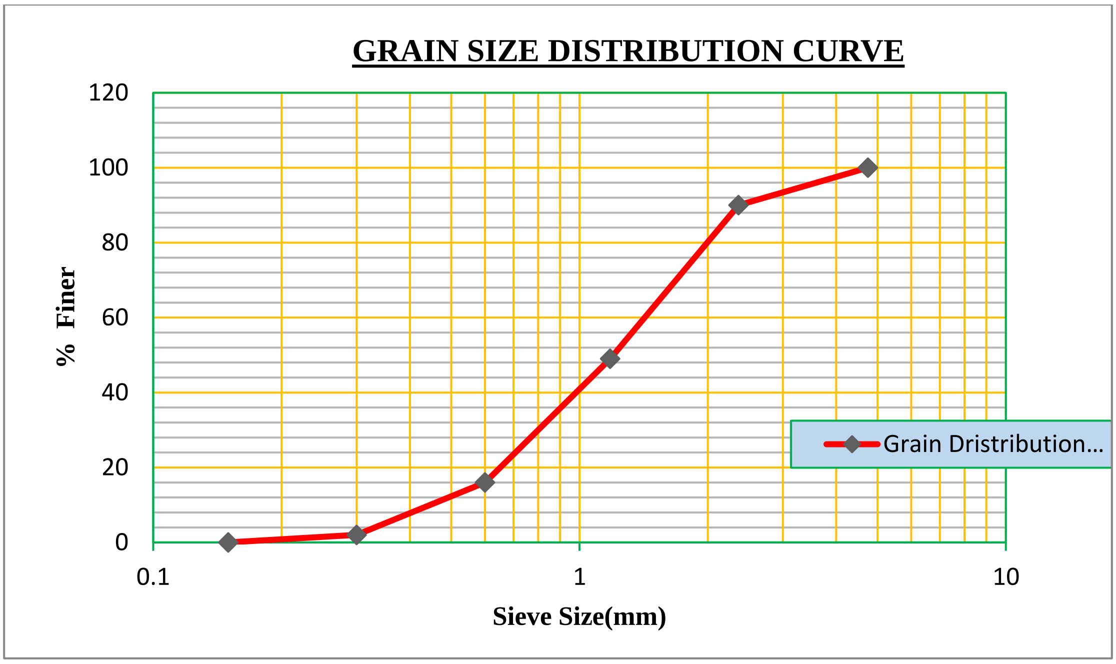
The portion of an aggregate passing the 4.75 mm (No. 4) sieve and predominantly retained on the 75 mm (No. 200) sieve is called fine aggregate or sand. In other word, Fine aggregate is the aggregate most of which passes through No. 4 sieve (4.75 mm opening) and contain only that much coarser material 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.

3.5.1 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.

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	100	3.42
2.36	94	9.4	9.4	90	
1.18	414	41.4	50.8	49	
0.6	328	32.8	83.6	16	
0.3	150	15	98.6	2	
0.15	14	1.4	100	0	
Pan	0	0	0	0	
Total	1000gm		342.4		



Figue 3. 4: Grain size distribution curve of fine aggregate (Sylhet Sand).

3.5.2 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. This test method conforms to the ASTM standards requirement of specification C29 (ASTM C 29, 2017).

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	3.42	3.81	3.85	1.01	3.42

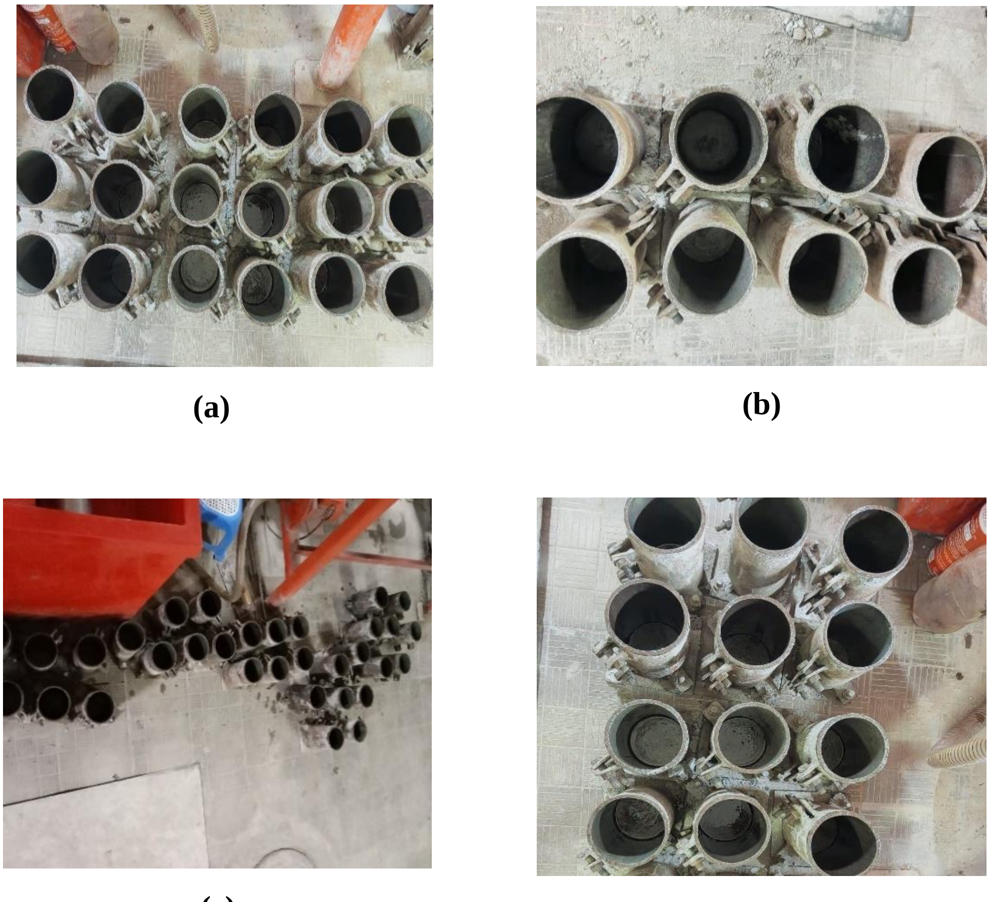
3.6 Water

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.

3.7 Process of Casting and Testing of Concrete Specimen

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.

3.7.1 Cylinder preparation



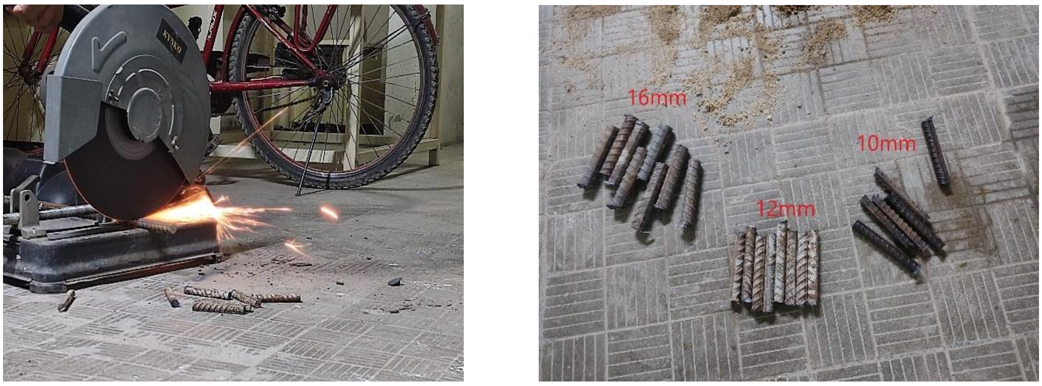
(a) (b)

(c) (d)

Figure 3.5: Cylinder preparation

3.7.2 Reinforcement Cutting.

In this study 10 mm, 12 mm and 16 mm Diameter bar were used.



(a) **(b)**

Figure 3. 6: a) reinforcement cutting b) cutting bar.

3.7.3 Batching and Mixing

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.

(a) **(b)**

(c) (d)

Figure 3. 7: a) sand, stone, bricks aggregate b) sand, cement, bricks mixing c) water measurement for mixing d) Hand mixing of all aggregate .

3.7.4 Compaction.

.

(a) (b)

Figure 3.8: a) first layer compaction and bar using. b) Tamping.

3.7.5 Assessment of Fresh Concrete Properties by Making Cylinder

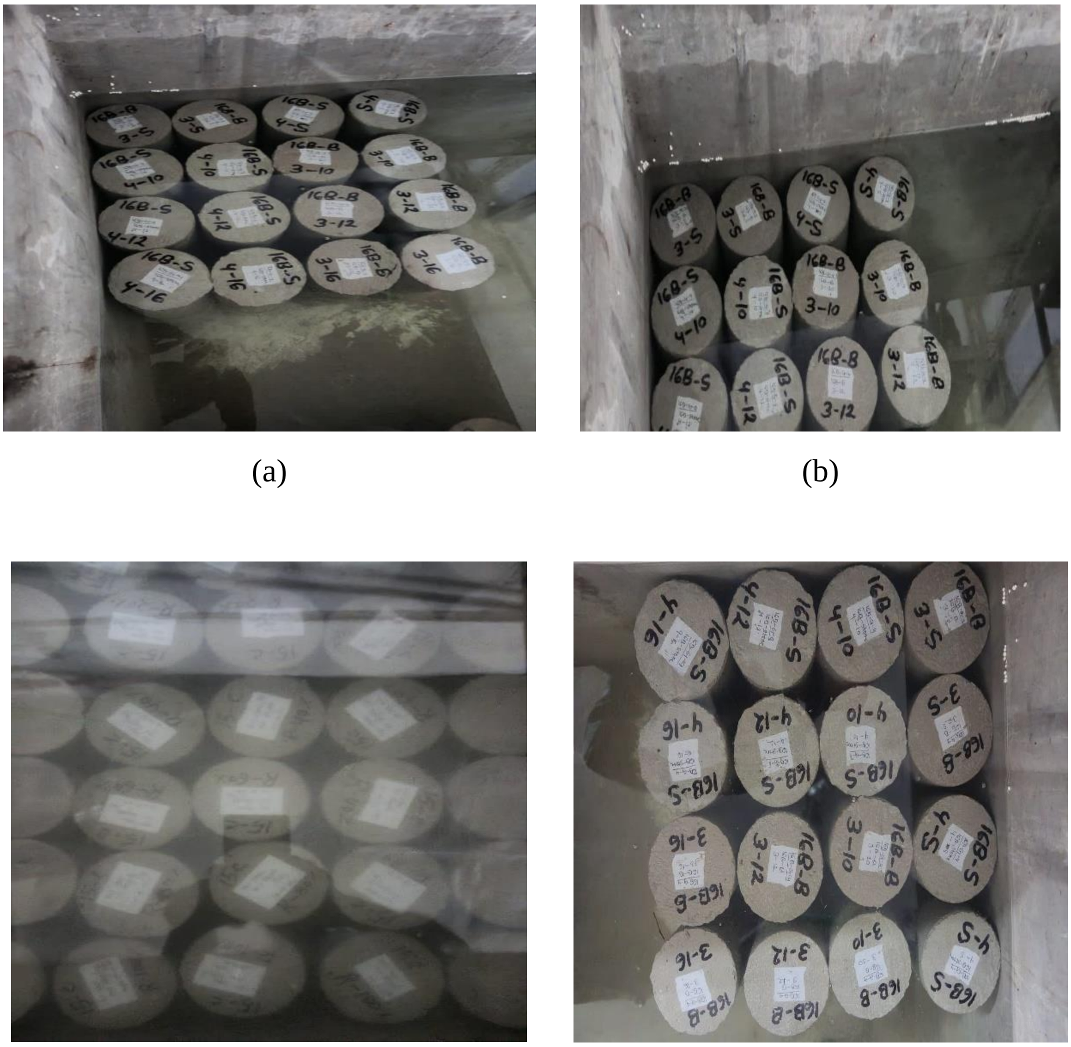
All test specimens were made in accordance with (ASTM C192, 2007). A total of three 4 x 8-inch cylinders were made for each mixture. These cylinders were tested at 28 days. Each cylinder comprised three equal lifts of concrete, and each lift was tamped 25 times with a 5/8 in. tamping rod. By using 25 mm temping rod concrete layer of the slab were compacted properly. After the completion of proper compaction, the surface is roughly smoothened by trowel and stored on a horizontal plane up to removal of mold so that both the top and bottom surface remain horizontal and parallel to each other. Details test data are given in the **Table A-6** of Appendix.

(a) **(b)**

Figure 3.9: a,b) Cylinder making

3.7.6 Curing of Cylinder

Curing is the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired properties may develop. Curing has a strong influence on the properties of hardened concrete; proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability, and resistance to freezing and thawing and deicers. Exposed slab surfaces are especially sensitive to curing as strength development and freeze-thaw resistance of the top surface of a slab can be reduced significantly when curing is defective.



(a) (b)

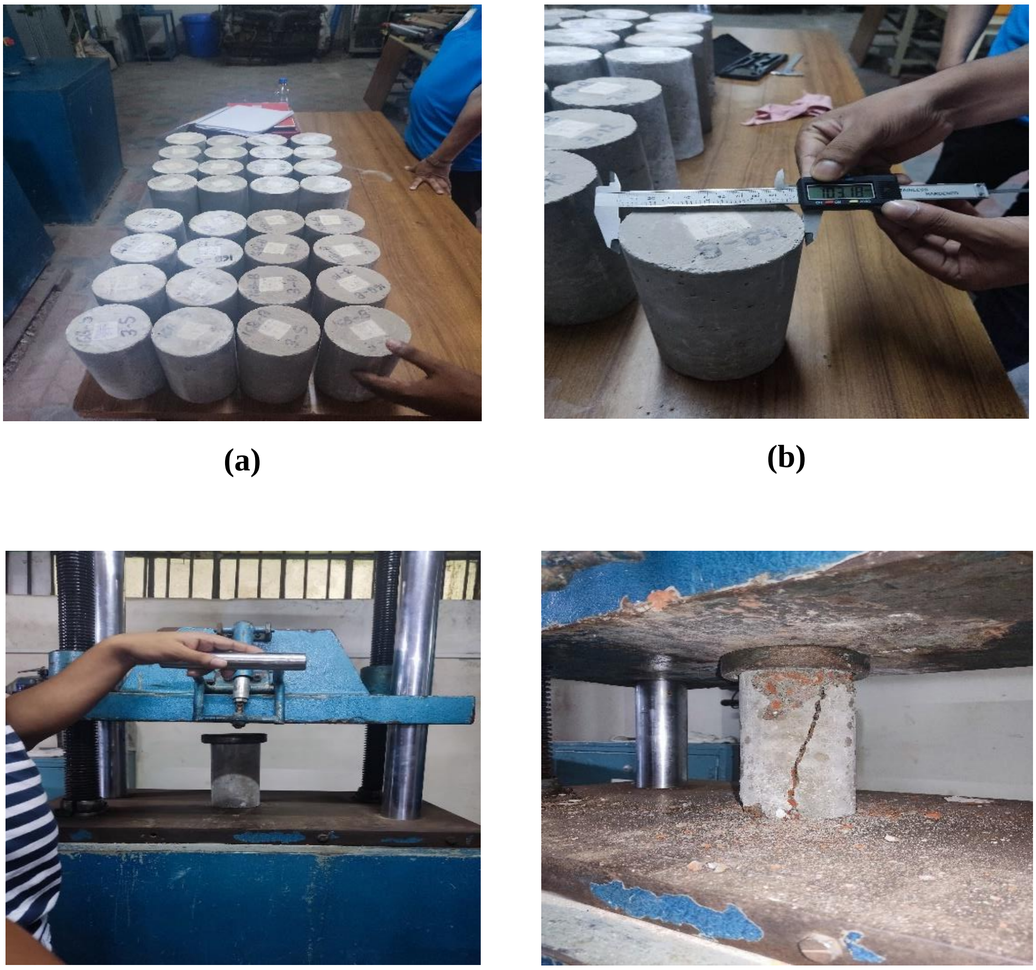
(c) (d)

Figure 3.10: (a,b,c,d) all cylinder curing

The water was filled between the ponds. The filling of water in these ponds was done twice or thrice a day. Curing was continuously done up to 28 days.

3.8 Compressive strength test of Cylinder.

To conduct compression test on a specimen using a universal testing machine (UTM) to determine ultimate compressive strength of the material. When a material is subjected to compressive loading, the relationship between stress and strain is similar to that obtained for a tensile loading Compressive strength test, mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. The test piece, usually in the form of a cube, prism, or cylinder, is compressed between the platens of a compression-testing machine by a gradually applied load.



(a) **(b)**

(c) **(d)**

Figure 3.11: a) Curing After. b) Diameter checking. c) Mold plate using . d) cylinder crushing after.

CHAPTER IV
RESULTS AND DISCUSSION

4.1 Introduction

This chapter includes the cylindrical core test results to find compressive strength of brick & stone aggregate concrete. Three different sizes (10 mm, 12 mm and 16 mm) of rebar and without rebar were used. Water cement ratio was taken as 0.45 and three mixing ratios (1:1.5:3 and 1:2:4) . cylinder 4" diameter (48 nos. for 4"). Also, cylindrical Specimen (Ø4"x8") were filled by fresh concrete and tested at 28 days. In this chapter, the test results are presented in graphical and tabular form and discuss under different category.

4.2 Test Results

The comparison is conducted by the variation of compressive strength, which is stand for different mix proportion, core size, presence of different size of rebar. All core strength data were collected with the intentions of being statistically analyzed for the objectives listed in Section 1.3. Data was inputted into Microsoft Excel and all data analysis was performed using Excel. All core and cylinder strength collected data are presented in **Appendix**.

4.3 Failure Mode of Core

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

(a) Without Rebar **(b) 10mm bar**

(c) 12mm bar **(d) 16mm bar**

Figure 4.1: Different types of failure mode of the Cylinder.

In the above **figure 4.1**, it appears that crack is occurred along the rebar position. So existing of rebar results in weakening of cores. After core breaking-up, it observed that usually rebar was separated from adjacent concrete matrix. Rebar with more size is more affected.

4.3.1 Compressive Strength of Cylinder

Compressive strength data on different mix ratio without rebar between stone & bricks. were collected for this study. As discussed in **Section 3.17**, 28-day cylinder strengths were collected as a reference for checking the strength for each mixture. The range for these averaged values is presented in **Figure 4.2**.

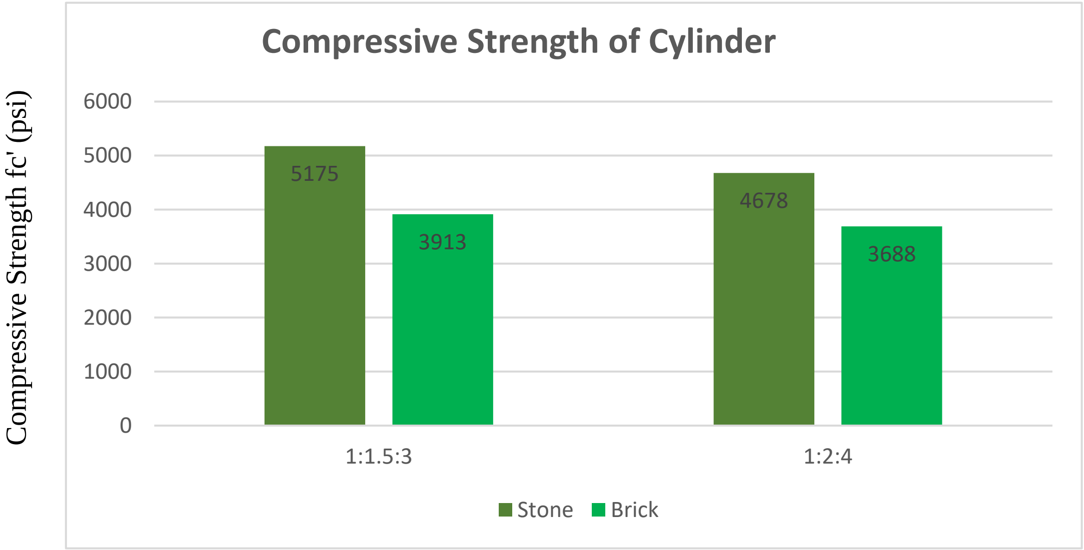


Figure 4.2: Compressive strength of cylinder for different mix ratio different aggregate (stone & bricks) without Rebar.

From the Figure 4.2, it appears that the compressive strength of cylinder decreases with the increase of mix ratio. The ratio of 1:1.5:3 has provided maximum strength and 1:2:4 has provided minimum strength. Since the brick & Stone aggregate was used, so the desired strength has found.

4.3.2 Compressive Strength of Bricks Vs Stone and Mix ratio 1:1.5:3 Vs 1:2:4

4 Inch Diameter:

When rebar is present in the 4inch diameter concrete core, then the compressive strength decreases significantly. In the following **Figure 4.3,** variation of cylinder strength(solid) to cylinder strength with rebar is illustrated:

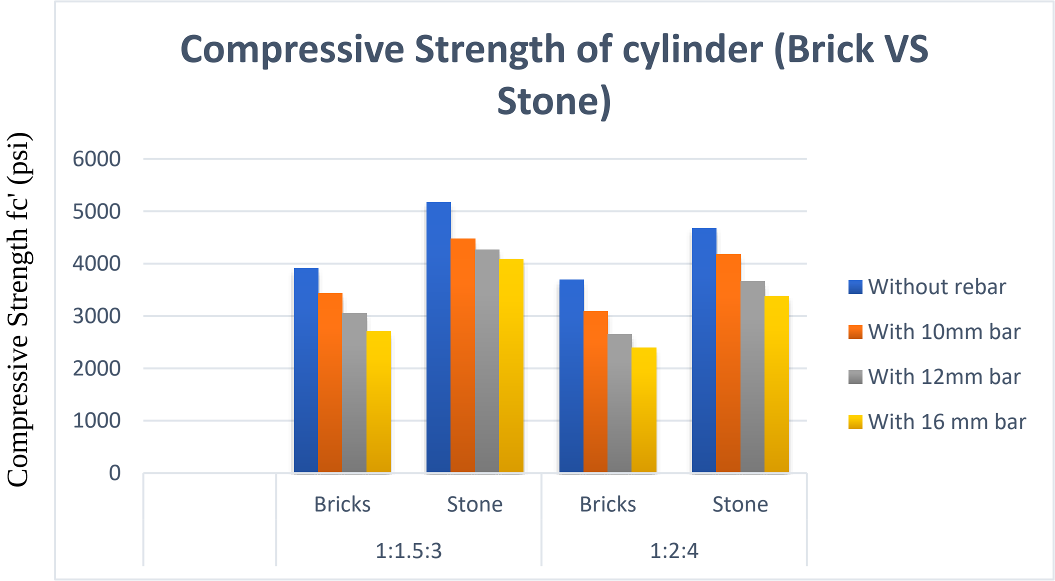


Figure 4. 3: Comparison of compressive strength cylinders(Without rebar vs rebar).

From the above Figure 4.3, it appears that in mix ratio of 1:1.5:3(for stone) , strength reduction amount for cylinder with 10 mm, 12 mm and 16 mm rebar from cylinder(solid) are 13.60% ,17.64% and 21.04% .then, that in mix ratio of 1:1.5:3(for Bricks) , strength reduction amount for cylinder with 10 mm , 12 mm and 16 mm rebar from cylinder(solid) are 12.11% ,20.05% and 30.67% respectively. At last, in mix ratio of 1:2:4(for stone) , strength reduction amount for cylinder(solid) with 10 mm , 12 mm and 16 mm rebar from cylinder are 10.62% ,21.67% and 23.42%.Agin, in mix ratio of 1:2:4(for stone) , strength reduction amount for cylinder(solid) with 10 mm , 12 mm and 16 mm rebar from cylinder are 16.10% ,28.14% and 25.11% respectively.

Mix Ratio 1:1.5:3

In the mix ratio of 1:1.5:3, it seems that the cylinder strength of without rebar is less than without rebar. The strength variation is very slight for cylinder with 10 mm bar. On the other hand, cylinder with 12 mm bar is a little more than 10 mm bar. In the following **Figure 4.4,** variation of cylinder strength(solid) to cylinder strength with rebar is illustrated:

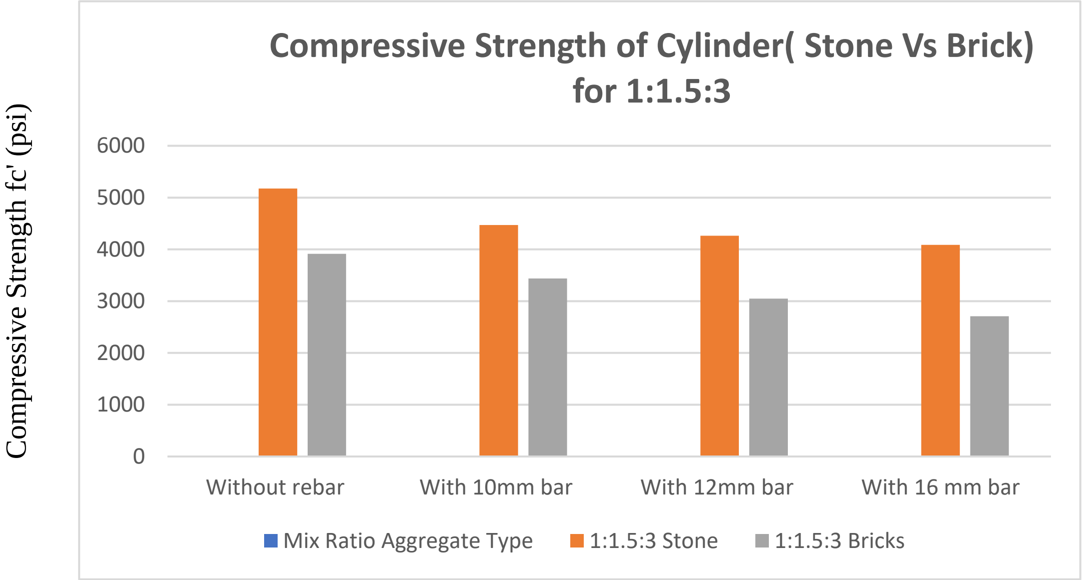


Figure 4. 4: Comparison of Compressive Strength Between without rebar & rebar(1:1.5:3)

From the above **Figure 4.4,** it can be seen that in mix ratio of 1:1.5:3, strength reduction amount for cylinder with 10 mm, 12 mm and 16 mm rebar from cylinder(solid) are 13.60% ,17.64% and 21.04%. then, that in mix ratio of 1:1.5:3(for Bricks), strength reduction amount for cylinder with 10 mm, 12 mm and 16 mm rebar from cylinder(solid) are 12.11% ,20.05% and 30.67% respectively.

Mix Ratio 1:2:4

In the mix ratio of 1:2:4, it seems that the cylinder strength of without rebar is less than without rebar. The strength variation is very slight for cylinder with 10 mm bar. On the other hand, cylinder with 12 mm bar is a little more than 10 mm bar. In the following **Figure 4.5,** variation of cylinder strength(solid) to cylinder strength with rebar is illustrated:

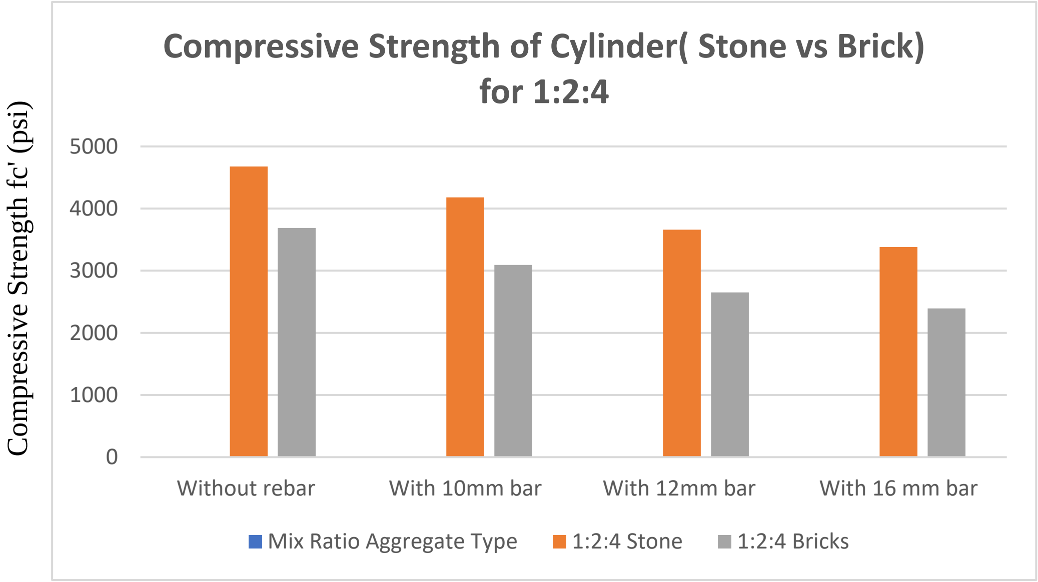


Figure 4.5: Comparison of Compressive Strength Between without rebar & rebar(1:2:4)

From the above **Figure 4.5,** it can be seen that in mix ratio of 1:2:4(for stone) , strength reduction amount for cylinder(solid) with 10 mm , 12 mm and 16 mm rebar from cylinder are 10.62% ,21.67% and 23.42%.Agin, in mix ratio of 1:2:4(for stone) , strength reduction amount for cylinder(solid) with 10 mm , 12 mm and 16 mm rebar from cylinder are 16.10% ,28.14% and 25.11% respectively.

4.3.3 Comparison of Compressive Strength cylinder of without rebar Vs with rebar (Bricks and Stone).

With 10 mm Bar (for Stone & Bricks).

In the **Figure 4.6**, it can be seen that strength of the cylinder with presence of 10 mm rebar(stone) in 1:1.5:3 and 1:2:4 mix ratio are 13.60% ,10.62% so, 2.44% consequently less than with rebar from without rebar .again, 10 mm rebar(Bricks) in 1:1.5:3 and 1:2:4 mix ratio are 12.11% ,16.10% so, 4.01% consequently less than with rebar from without rebar . Here average reduction quantity is very few, because interloacking of 10 mm bar with the concrete is satisfactory.

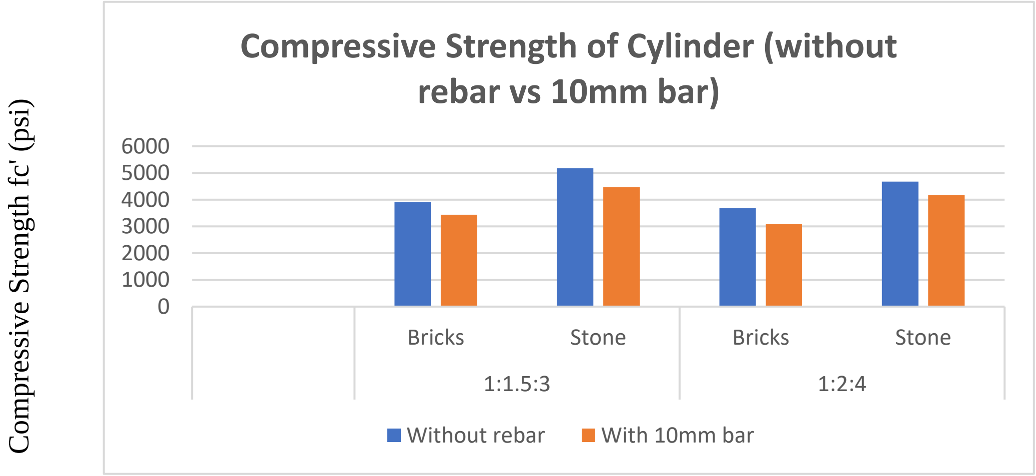


Figure 4. 6: Comparison of Compressive Strength Between without rebar vs (10mm).

With 12 mm Bar (for Stone & Bricks).

In the **Figure 4.7**, it can be seen that strength of the cylinder with presence of 12mm rebar(stone) in 1:1.5:3 and 1:2:4 mix ratio are 17.64% ,21.76% so, 4.12% consequently less than with rebar from without rebar .again, 12 mm rebar(Bricks) in 1:1.5:3 and 1:2:4 mix ratio are 22.05% ,28.14% so, 6.09% consequently less than with rebar from without rebar . Here average reduction quantity is very few, because interloacking of 10 mm bar with the concrete is satisfactory, because 12 mm bar with the concrete is less than 1o mm bar.

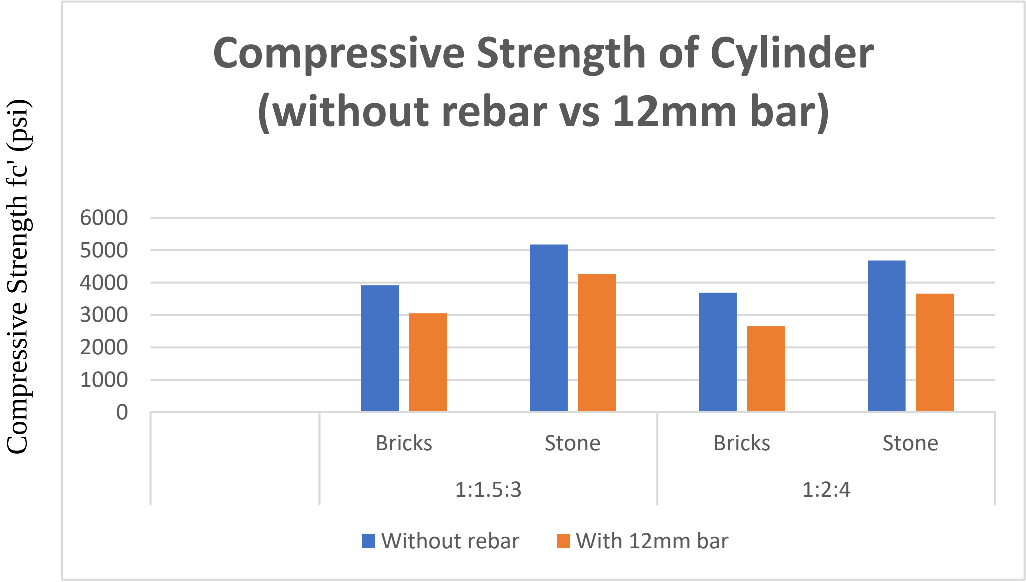


Figure 4.7: Comparison of Compressive Strength Between with and without rebar (12mm).

With 16 mm Bar

In the **Figure 4.8**, it can be seen that strength of the cylinder with presence of 16mm rebar(stone) in 1:1.5:3 and 1:2:4 mix ratio are 21.04% ,23.42% so, 2.38% consequently less than with rebar from without rebar .again, 16 mm rebar(Bricks) in 1:1.5:3 and 1:2:4 mix ratio are 30.76% ,35.11% so, 4.35% consequently less than with rebar from without rebar . Here average reduction quantity is very few, because interloacking of 10 mm bar with the concrete is satisfactory, because 16 mm bar with the concrete is less than 12 mm bar.Here 1:1.5:3 & 1:2:4 mix ratio shows maximum reduction of compressive strength than without rebar core. Because interloacking of concrete with 16 mm bar is more weaker than other size of bars.

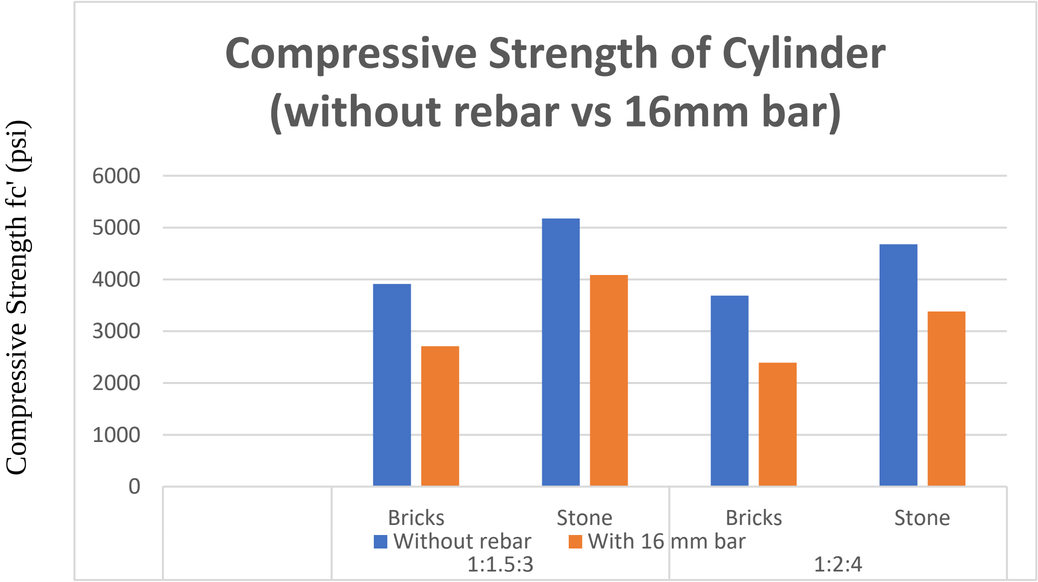


Figure 4. 8: Comparison of Compressive Strength Between with and without rebar (16mm).

4.4 Summary

In this chapter concrete cylinder 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 cylinder under loading with presence of different size of rebar and cylinder dia.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Research Conclusions

The research described in this thesis was conducted to evaluate the in-place concrete strength by cylinder testing. This phase of the thesis was primarily undertaken to assess the effects of various rebar diameter on concrete & various aggregate (stone & Bricks), various mix ratio. Data were collected from 48 Nos. In this study the two different concrete mixes ratio (1:1.5:3 and 1:2:4) & two different materials (Bricks & Stone chips) the concrete was made by using bricks chips & stone chips coarse aggregate. The 4 in. diameter cylinder use. According to obtained results and their analysis, following conclusions can be deduced:

From the test results, it is found that cylinder strength (with rebar) decreases significantly with compare to cylinder strength (without rebar). Strength of with rebar(10mm,12mm,16mm) is decreased about 13.60% and 17.64%,21.93% respectively with compare to cylinder strength (without rebar) for **stone & ratio 1:1.5:3**. Strength of with rebar(10mm,12mm,16mm) is decreased about 12.11% and 22.05%,30.76% respectively with compare to cylinder strength (without rebar) for **bricks & 1:1.5:3**. respectively with compare to cylinder strength of between mixing ratios (1:1.5:3 and 1:2:4) & different materials (Bricks & stone chips), without rebar & different rebar.

From the test results, it is found that cylinder strength (with rebar) decreases significantly with compare to cylinder strength (without rebar). Strength of with rebar(10mm,12mm,16mm) is decreased about 10.62% and 21.76%,23.42% respectively with compare to cylinder strength (without rebar) for **stone & ratio 1:2:4**. Strength of with rebar(10mm,12mm,16mm) is decreased about 16.10% and 28.14%,35.11%, respectively with compare to cylinder strength (without rebar) for **bricks & 1:2:4**, respectively with compare to cylinder strength of between mixing ratios (1:1.5:3 and 1:2:4) & different materials (Bricks & stone chips), without rebar & different rebar.

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 rebar effect at different position of core, rebar location in the concrete core may change.

b) Further more parameter may consider to establish an equation.

REFERENCES

A. M. Neville (2011) *Properties of Concrete*. 5th edn. Pearson Education Limited. Essex.

A, M., Digrisolo, A. and Santarsiero, G. (2013) 'Experimental Evaluation of Drilling Damage on the Strength of Cores Extracted from RC Buildings', *International Journal of Structural and Construction Engineering*, 7(7), pp. 525–531

Aggarwal, P. K., Sharma, S. and Naval, S. (2013) 'Experimental Study Of Core Diameter Varing H/D Ratio On Concrete Core Strength', *International Journal of Engineering Research & Technology (IJERT),* Vol. 2(Issue 3), p. 5.

Ajagbe, W. and Tijani, M. A. (2018) 'Compressive Strength of Concrete Made from Aggregates of Different Sources Compressive Strength of Concrete Made from Aggregates of Different Sources', *USEP Journal of Research Information in Civil Engineering*, 15(1), pp. 1963–1974.

Alwash, M. (2017) 'Assessment of concrete strength in existing structures using non-destructive tests and cores'.

ASTM C 127 (2015) 'Specific Gravity and Absorption of Coarse Aggregate', *ASTM International, West Conshohocken, PA*. doi: 10.1520/C0127-15.

ASTM C 187 (2016) 'Standard Test Method for Amount of Water Required for Normal Consistency of Hydraulic Cement Paste', *ASTM International, West Conshohocken, PA*. doi: 10.1520/C0187-16.

ASTM C 191 (2019) 'Standard Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle', *ASTM International, West Conshohocken, PA*. doi: 10.1520/C0191-19.

ASTM C 29 (2017) 'Test Method for Bulk Density (Unit Weight) and Voids in Aggregate', *ASTM International, West Conshohocken, PA*. doi: 10.1520/C0029_C0029M-17A.

ASTM C109/109M-16a (2016) ‘Standard Test Method for Compressive Strength of Hydraulic Cement Mortars’, *ASTM International, West Conshohocken, PA*. doi: 10.1520/C0109_C0109M-16A.

ASTM C117 (2017) ‘Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate’, *ASTM International, West Conshohocken, PA, 2017*. doi: 10.1520/C0117-17.

ASTM C136/C136M (2014) ‘Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates’, *ASTM International, West Conshohocken, PA*. doi: 10.1520/C0136_C0136M-14.

ASTM C192 (2007) ‘Standard Practice for Sampling Freshly Mixed Concrete’, *ASTM International, West Conshohocken, PA*. doi: 10.1520/C0192_C0192M-18.

Carroll, A. C. (2014) ‘Effect of Core Geometry and Size on Concrete Compressive Strength’, p. 122.

Cement Trust Coalition (2013) *What is the development impact of concrete?* Available at: https://cementtrust.wordpress.com/a-concrete-plan (Accessed: 31 October 2019).

CHUAN, V. V. B. (2009) ‘Effect of concrete compressive strength with various natural additives fiber for green environment’.

Civil Engineering (2013) *Compressive Strength of Bricks*. Available at: https://civiltoday.com/civil-engineering-materials/brick/137-compressive-strength-of-brick (Accessed: 1 November 2019).

Concrete @ your Fingertips (2019) *Core testing for strength*. Available at: http://www.concrete.org.uk/fingertips-document.asp?id=576 (Accessed: 31 October 2019).

Gharpedia (2007) *Water Absorption Test of Bricks*. Available at: https://gharpedia.com/blog/water-absorption-test-of-bricks (Accessed: 1 November 2019).

Grubbs, A. R. *et al.* (2014) ‘Evaluation of In-Place Concrete Strength by Core Testing’, (2).

Guidebook on non-destructive testing of concrete structures, IAEA, vienna, 2002 (2002) ‘<IAEA2002 NDT of concrete structures.pdf>’, (17).

Hamad, A. J. (2015) ‘Size and shape effect of specimen on the compressive strength of HPLWFC reinforced with glass fibres’, *Journal of King Saud University - Engineering Sciences*. King Saud University, 29(4), pp. 373–380. doi: 10.1016/j.jksues.2015.09.003.

MISHRA, G. (2017) Testing of Concrete Cores for Strength – Sampling and Procedure, The Constructore Civil Engineering Home.

Mohammad, A. (2017) ‘A review of the effect of the behavior of core diameter varing H / D ratio on concrete core strength’, pp. 42–45.

O. Arioz, M. Tuncan, K. Ramyar, B. Karasu, A. T. and K. K. (2008) ‘Determination of Concrete Strength by Core Test ; Effects Determination of Concrete Strength by Core Test ; Effects of Sodium Sulphate and Frost Action’, (January).

Patil, D. S. G. (2017) ‘Correlation between Actual Compressive Strength of Concrete and Strength Estimated From Core’, *IOSR Journal of Mechanical and Civil Engineering*, 14(02), pp. 27–44. doi: 10.9790/1684-1402032744.

Peter, W. and Beushausen, H. (2013) ‘Relating concrete cube, core and cylinder compressive strengths that are cast, cured, prepared and tested in laboratory conditions’.

RHD(Bangladesh) (2001) ‘Tests For Aggregates And Bricks’, in *Standard Test Procedures*, pp. 39–45.

S.Saradu (2019) Core Compressive Strength of Concrete: 6 Factors, Concrete Technology. Available at: http://www.engineeringenotes.com/concrete-technology/concrete/core-compressive-strength-of-concrete-6-factors-concrete-technology/31682 (Accessed: 5 November 2019).

Singh, R. (2017) Popular Non Destructive Testing of Concrete Structure-review of Std. Methods.

Tadayon, M., Moghadam, H. T. . and Tadayon, M. H. (2009) ‘Effect of Rebar on Compressive strength of Concrete cores’, *3rd International Conference on Concrete & Development*, pp. 965–971.

Tuncan, M. *et al.* (2008) ‘Assessing concrete strength by means of small diameter cores’, *Construction and Building Materials*, 22(5), pp. 981–988. doi: 10.1016/j.conbuildmat.2006.11.020.

Uzunoğlu, M. (2012) ‘Prediction of concrete compressive strength in buildings that would be reinforced by fuzzy logic’, *International Journal of the Physical Sciences*, 7(31). doi: 10.5897/ijps12.155.

Wikipedia (2019) *History of the concrete*. Available at: https://en.wikipedia.org/wiki/Concrete#History (Accessed: 31 October 2019).

APPENDIX

SOME ESSENTIAL DATA TABLE AND DETAILS TEST

Table A-1: Data for compressive strength (cylinder) of the fresh concrete (Bricks)

mix ratio	Aggregate Type	Dia (in)	Area (in^2)	Load (KN)	f'c (psi)	Average f'c (psi)
1:1.5:3	Bricks	4.05	12.9	223	3893	3913
		4.04	12.8	228	4000	
		4.03	12.7	218	3844	
1:2:4	Bricks	4.04	12.8	217	3807	3685
		4.03	12.7	208	3668	
		4.05	12.9	205	3579	

Table A-2: Data for compressive strength(cylinder) of the fresh concrete (Stone**)**

mix ratio	Aggregate Type	Día (in)	Area (in^2)	Load (KN)	f'c (psi)	Average f'c (psi)
1:1.5:3	Stone	3.996	12.535	295	5291	5176
		3.992	12.510	282	5059	
		3.998	12.547	289	5178	
1:2:4	Stone	4.060	12.940	273	4743	4678
		4.010	12.623	266	4728	
		4.040	12.812	260	4562	

Table A- 3 : Data for compressive strength(cylinder) of the 10mm rebar (Bricks)

mix ratio	Aggregate Type	Día (in)	Area (in^2)	Load (KN)	f’c (psi)	Average f’c (psi)
1:1.5:3	Bricks	4.053	12.895	195	3399	3439
		4.048	12.863	205	3583	
		4.039	12.806	190	3335	
1:2:4	Bricks	4.045	12.844	181	3168	3094
		4.048	12.863	190	3320	
		4.050	12.876	160	2793	

Table A- 4 : Data for compressive strength(cylinder) of the 10mm rebar (Stone)

mix ratio	Aggregate Type	Día (in)	Area (in^2)	Load (KN)	f’c (psi)	Average f’c (psi)
1:1.5:3	Stone	4.030	12.749	252	4443	4471
		4.028	12.736	260	4589	
		4.035	12.781	249	4380	
1:2:4	Stone	4.035	12.781	225	3958	4181
		4.023	12.702	262	4637	
		4.030	12.749	224	3950	

Table A-5: Data for compressive strength(cylinder) of the 12mm rebar (Bricks)

mix ratio	Aggregate Type	Día (in)	Area (in^2)	Load (KN)	f’c (psi)	Average f’c (psi)
1:1.5:3	Bricks	4.028	12.736	187	3301	3050
		4.020	12.686	160	2835	
		4.030	12.749	171	3015	
1:2:4	Bricks	4.048	12.863	155	2709	2650
		4.021	12.692	148	2621	
		4.035	12.781	149	2621	

Table A- 6: Data for compressive strength(cylinder) of the 12mm rebar (Stone)

mix ratio	Aggregate Type	Día (in)	Area (in^2)	Load (KN)	f'c (psi)	Average f'c (psi)
1:1.5:3	Stone	4.020	12.686	240	4253	4262
		4.015	12.654	230	4086	
		4.028	12.736	252	4448	
1:2:4	Stone	4.035	12.781	209	3676	3660
		4.028	12.736	214	3777	
		4.040	12.812	201	3527	

Table A-7: Data for compressive strength(cylinder) of the 16mm rebar (Bricks)

mix ratio	Aggregate Type	Día (in)	Area (in^2)	Load (KN)	f'c (psi)	Average f'c (psi)
1:1.5:3	Bricks	4.030	12.749	159	2804	2709
		4.021	12.692	161	2852	
		4.027	12.730	140	2472	
1:2:4	Bricks	4.025	12.717	135	2386	2393
		4.038	12.800	142	2494	
		4.024	12.711	130	2299	

Table A- 8 : Data for compressive strength(cylinder) of the 16mm rebar (Stone)

mix ratio	Aggregate Type	Dia (in)	Area (in^2)	Load (KN)	f'c (psi)	Average f'c (psi)
1:1.5:3	Stone	4.023	12.705	223	3946	4086
		4.032	12.762	234	4122	
		4.041	12.819	239	4191	
1:2:4	Stone	4.031	12.755	190	3349	3382
		4.028	12.736	197	3477	
		4.026	12.724	188	3322	

Table A- 9 : Compressive strength of concrete of Bricks & Stone (4 inch).

Mix Ratio	Concrete Type	Diameter (in)	Without rebar (psi)	With 10mm bar (psi)	With 12mm bar (psi)	With 16 mm bar(psi)
1:1.5:3	Bricks	4.000	3913	3439	3050	2709
	Stone	4.000	5175	4471	4262	4086
1:2:4	Bricks	4.000	3688	3094	2650	2393
	Stone	4.000	4678	4181	3660	3382

Table A- 10: Compressive strength test data for (4 inch dia) without rebar (Bricks).

Sl. No	Mix Ratio	Sample Día (in)	Length (in)	Load (KN)	Area (in^2)	Stress (psi)	Average (psi)	L/D
1	1:1.5:3	4.050	8.060	223	12.876	3893	3913	1.990
2		4.040	8.020	228	12.812	4000		1.985
3		4.030	7.900	218	12.749	3844		1.960
4	1:2:4	4.040	8.010	217	12.812	3807	3685	1.983
5		4.030	8.000	208	12.749	3668		1.985
6		4.050	8.030	205	12.876	3579		1.983

Table A- 11 : Compressive strength test data for (4 inch dia) without rebar (Stone).

Sl. No	Mix Ratio	Sample Día (in)	Length (in)	Load (KN)	Area (in^2)	Stress (psi)	Average (psi)	L/D
1	1:1.5:3	3.996	8.060	295	12.535	5291	5176	2.017
2		3.992	8.020	282	12.510	5059		2.009
3		3.998	7.900	289	12.547	5178		1.976
4	1:2:4	4.060	8.010	273	12.940	4743	4678	1.973
5		4.010	8.000	266	12.623	4728		1.995
6		4.040	8.030	260	12.812	4562		1.988

Table A- 12 : Compressive strength test data for 4" with rebar (Bricks)

Sl. No	Mix Ratio	Rebar Día (mm)	Sample Dia (in)	Length (in)	Load (KN)	Area in^2	Stress (Psi)	Average (psi)	L/D
1	1:1.5:3	10 mm	4.053	8.080	195	12.895	3399	3439	1.994
2		10 mm	4.048	8.030	205	12.863	3583		1.984
3		10 mm	4.039	7.980	190	12.806	3335		1.976
4		12 mm	4.028	8.010	187	12.736	3301	3050	1.989
5		12 mm	4.020	8.000	160	12.686	2835		1.990
6		12 mm	4.030	8.030	171	12.749	3015		1.993
7		16 mm	4.030	7.980	159	12.749	2804	2709	1.980
8		16 mm	4.021	8.010	161	12.692	2852		1.992
9		16 mm	4.027	8.000	140	12.730	2472		1.987

Table A- 13 : Compressive strength test data for 4" with rebar (Stone)

Sl No	Mix Ratio	Rebar Dia (mm)	Sample Dia (in)	Length (in)	Load (KN)	Area in^2	Stress (Psi)	Average (psi)	L/D
1	1:1.5:3	10 mm	4.030	8.080	252	12.749	4443	4471	2.005
2		10 mm	4.028	8.030	260	12.736	4589		1.994
3		10 mm	4.035	7.980	249	12.781	4380		1.978
4		12 mm	4.020	8.010	240	12.686	4253	4262	1.993
5		12 mm	4.015	8.000	230	12.654	4086		1.993
6		12 mm	4.028	8.030	252	12.736	4448		1.994
7		16 mm	4.023	7.980	223	12.705	3946	4086	1.984
8		16 mm	4.032	8.010	234	12.762	4122		1.987
9		16 mm	4.041	8.000	239	12.819	4191		1.980

Table A- 14 : Compressive strength test data for 4" core dia with rebar (Bricks)

Sl. No	Mix Ratio	Rebar Dia (mm)	Sample Dia (in)	Length (in)	Load (KN)	Area in^2	Stress (Psi)	Average (psi)	L/D
1	1:2.:4	10 mm	4.045	8.070	181	12.844	3168	3094	1.995
2		10 mm	4.048	8.035	190	12.863	3320		1.985
3		10 mm	4.050	7.900	160	12.876	2793		1.951
4		12 mm	4.048	8.015	155	12.863	2709	2650	1.980
5		12 mm	4.021	8.022	148	12.692	2621		1.995
6		12 mm	4.035	8.030	149	12.781	2621		1.990
7		16 mm	4.025	7.940	135	12.717	2386	2393	1.973
8		16 mm	4.038	8.010	142	12.800	2494		1.984
9		16 mm	4.024	8.000	130	12.711	2299		1.988

Table A- 15 : Compressive strength test data for 4" core dia with rebar (Stone)

Sl No	Mix Ratio	Rebar Dia(mm)	Sample Dia (in)	Length (in)	Load (KN)	Area in^2	Stress (Psi)	Average (psi)	L/D
1	1:2.:4	10 mm	4.035	8.040	225	12.781	3958	4181	1.993
2		10 mm	4.023	8.039	262	12.702	4637		1.999
3		10 mm	4.030	7.970	224	12.749	3950		1.978
4		12 mm	4.035	8.012	209	12.781	3676	3660	1.986
5		12 mm	4.028	8.040	214	12.736	3777		1.996
6		12 mm	4.040	8.030	201	12.812	3527		1.988
7		16 mm	4.031	8.022	190	12.755	3349	3382	1.990
8		16 mm	4.028	8.010	197	12.736	3477		1.989
9		16 mm	4.026	7.980	188	12.724	3322		1.982

Concrete Mix Design for M25 & M20

(A). Required Data M25 Grade Concrete:

- Grade of concrete =M25
- Characteristic compressive strength of concrete at 28days = 25N/mm^2
- Nominal maximum size of aggregate = 20mm
- Specific Gravity of cement = 3.15
- Specific gravity of fine aggregate = 2.6
- Specific gravity of Coarse aggregate = 2.65

Step 1: Calculation of Target Strength

Target mean strength of concrete is derived from the below formula

$$f_t = f_{ck} + 1.65\ s$$

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

Grade of concrete	**Standard deviation (N/mm^2)**
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} = 25N/mm^2

f_t = 25 + 1.65 x 4

Therefore, target mean strength f_t = 31.6N/mm^2

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.

0.5<0.55, hence OK.

Let, W/C ratio = 0.55

Step 3: Air Content Calculation

Nominal maximum size of aggregate taken is = 20mm

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-

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

The aggregate nominal maximum size is 20mm and they belong to zone 2 (From Table 3 of IS 10262- 2009). So, Adjustment for compacting factor is to be applied.

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 = 0.55
From step 4, Water content W = 191.6 liters = 191.6kg
191.6 / C = 0.55
Finally, C = 348.36Kg / m^3 of concrete

Step 6: Aggregate Ratio for Concrete

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 m^3

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

Therefore, volume of concrete (without air content) = 1-0.02 = 0.98m^3

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

$$V = [W + C/Gc + (1/ (1-P) \times (F.A)/Gf)] \times 1/1000$$

0.98 = [191.6 + 348.36/3.15 + (1/ (1-0.62) X (F.A)/2.6)] x 1/1000

Therefore, amount of fine aggregate F.A = 639.67 kg

$$V = [W + C/Gc + (1/ P) \times (F.A)/Gf)] \times 1/1000$$

0.98 = [191.6 + 348.36/3.15 + (1/ 0.62) X (F.A)/2.6)] x 1/1000

Therefore, amount of coarse aggregate C.A = 1092.63 kg

Step 8: Final Mix Proportions of Ingredients

W/C ratio = 0.55
Cement quantity = 336.14Kg = 337kg
Fine aggregate quantity = 639.67kg = 640 kg
Coarse aggregate Quantity = 1092.63 kg=1093kg

Mix proportion for M25 Concrete = Cement: F.A: C.A

$$= \frac{337}{337} : \frac{640}{337} : \frac{1093}{315}$$

=1:1.89:3.46

= 1: 1.5: 3

B. Required Data 20 Grade Concrete:

- Grade of concrete =M20
- Characteristic compressive strength of concrete at 28days = 25N/mm^2
- Nominal maximum size of aggregate = 20mm
- Specific Gravity of cement = 3.16
- Specific gravity of fine aggregate = 2.46
- Specific gravity of Coarse aggregate = 2.73

Step 1: Calculation of Target Strength

Target mean strength of concrete is derived from the below formula

$$\mathbf{f_t = f_{ck} + 1.65\ s}$$

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

Grade of concrete	**Standard deviation (N/mm^2)**
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} = 25N/mm^2

f_t = 20 + 1.65 x 4

Therefore, target mean strength f_t = 26.6N/mm^2

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.

0.5<0.55, hence OK.

Let, W/C ratio = 0.55

Step 3: Air Content Calculation

Nominal maximum size of aggregate taken is = 20mm

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-

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

The aggregate nominal maximum size is 20mm and they belong to zone 2 (From Table 3 of IS 10262- 2009). So, Adjustment for compacting factor is to be applied.

Therefore, water content = 186 + (186 x 6/100) = **197 lit / m^3 of concrete.**

Step 5: Cement Content Calculation

From step 2, Water cement ratio = W/C = 0.55
From step 4, Water content W = 197 liters
197 / C = 0.55
Finally, C = 315Kg / m^3 of concrete

Step 6: Aggregate Ratio for Concrete

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 m^3

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

Therefore, volume of concrete (without air content) = 1-0.02 = 0.98m^3

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

V = [W + C/Gc + (1/ (1-P) X (F.A)/Gf)] x 1/1000

0.98 = [191.6 + 348.36/3.15 + (1/ (1-0.62) X (F.A)/2.6)] x 1/1000

Therefore, amount of fine aggregate F.A = 821.06 kg/m^3

V = [W + C/Gc + (1/ P) X (F.A)/Gf)] x 1/1000

0.98 = [191.6 + 348.36/3.15 + (1/ 0.62) X (F.A)/2.6)] x 1/1000

Therefore, amount of coarse aggregate C.A = 1110.01 kg/m^3

Step 8: Final Mix Proportions of Ingredients

W/C ratio = 0.55
Cement quantity = 314.5Kg = 315kg
Fine aggregate quantity = 821.06kg = 821 kg
Coarse aggregate Quantity = 1410.01 kg =1410kg

Mix proportion for M20 Concrete = Cement: F.A: C.A

$$=\frac{315}{315}:\frac{821}{315}:\frac{1410}{315}$$

=1:2.63:4.47

= 1: 2: 4

Estimation of concrete for cylinder (Ratio 1:1.5:3 & 1:2:4)

- **For Ratio: 1:1.5:3**

Data:

- D=4 in= .33 ft * H=8 in = .67ft

Note:

* Cement= 40.80 kg/cft * Sand = 45.32 kg/cft

* 1 bag= 1.25cft * 1cft=.80 bag/ft

* Volume of Cylinder, V=$\frac{\pi}{4} \times (D)^\wedge 2 \times H$

$=\frac{\pi}{4} \times (.33)^2.67$

= .057 cft

- Wet Volume = .057 cft For Ratio: 1:1.5:3
- Dry volume = .057×1.50 = .0855cft
- Additional Ratio = 1: 1.5 :3 =5.5

1) Cement = $\frac{.0855\times1}{5.5}$ = .0156 cft × .8 =.0125 bag =.0622kg/Cylinder.
2) Sand =$\frac{.0855\times2}{5.5}$ = .0310 cft × 45.32 = 1.405 kg/Cylinder
3) Bricks Khoa = $\frac{.0855\times3}{5.5}$ = .0467 cft × 33.98 = 1.587 kg/Cylinder
4) Stone Khoa = $\frac{.0855\times3}{5.5}$ = .0467 cft × 45.31 = 2.116 kg/Cylinder

For Ratio: 1:1.5:3 of Total cylinder = 24 Nos

A) Total Cement = 24×.622kg = 14.928 kg

B) Total Sand = 24×1.405 kg =

C) Total Bricks Chips = 12×1.587kg =33.72kg

D) Total Stone Chips = 12 ×2.116 =25.392 kg

- **For Ratio: 1:2:4**

Data:

- D=4 in= .33 ft *H=8 in = .67ft

Note:

- Cement= 40.80 kg/cft Sand = 45.32 kg/cft
- 1 bag= 1.25cft 1cft=.80 bag/ft^3
- Volume of Cylinder, V=$\frac{\pi}{4} \times (D)^2 \times H$

$$=\frac{\pi}{4} \times (.33)^2 .67 = .057 \text{ cft}$$

- Wet Volume = .057 cft
- Dry volume = .057×1.50 = .0855cft
- Additional Ratio = 1: 2 :4 = 7 .0

5) Cement = $\frac{.0855\times1}{7}$ = .0122 cft × .8 =.00978 bag =.488 kg/Cylinder.

6) Sand =$\frac{.0855\times2}{7}$ = .0244 cft × 45.32 = 1.105 kg/Cylinder

7) Bricks Khoa = $\frac{.0855\times4}{7}$ = .0489 cft × 33.98 = 1.661 kg/Cylinder

8) Stone Khoa = $\frac{.0855\times4}{7}$ = .0467 cft × 45.31 = 2.21 kg/Cylinder

For Ratio: 1:2:4 of Total cylinder = 24 Nos

E) Total Cement = 24×.488kg = 11.712 kg

F) Total Sand = 24×1.105 kg =26.52 kg

G) Total Bricks Chips = 12×1.661kg =19.932kg

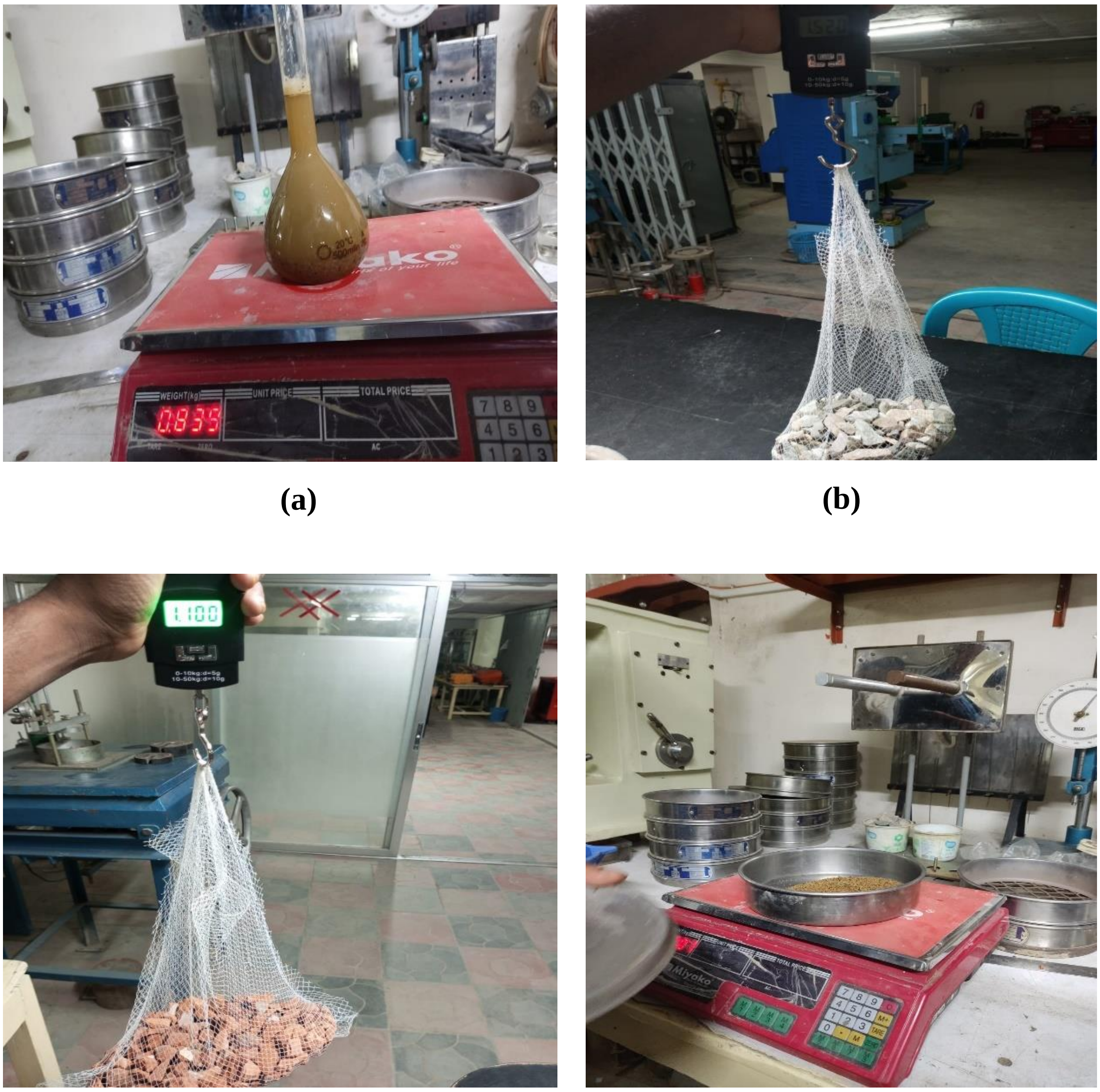
H) Total Stone Chips = 12 ×2.21 = 26.52 kg

SOME PICTURE OF THIS STUDY

(a) (b)

(c) **(d)**

Figure A- 1: a) Stone Broken & Sieved. b) Stone, Bricks, Sand curing after.
c) Cement weight measurment for concrete . d) SSD Stone weight measurment for concrete.



(a) **(b)**

(c) **(d)**

Figure A-2: a) Determination of specific gravity.b) Cement weight measurment.
c) Stone weight measurment d) Sand weight measurment

(a) (b)

(c) (d)

Figure A-3: b) Date record c) oven dry d) oven dry after.

(a) (b)

(c) (d)

Figure A- 4 : a)Aggregate mixing b) water measurment c)slump test d) compacting.

(a) (b)

(c) (d)

Figure A- 5: a) Curing after.b) Diameter checking.

(a)

(b)

(c)

(d)

Figure A- 6 : (a, b, c,d) Different types of failure mode of the Cylinder.

(a)

(b)

(c)

Figure A- 7 : (a,b) Different types of failure mode of the Cylinder.

(c) All the group members.

THE END