A STUDY ON THE COMPRESSIVE STRENGTH OF CONCRETE USING BRICK AGGREGATE AND TWO DIFFERENT TYPES OF CEMENT

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A thesis submitted to the Department of Civil Engineering
of Sonargaon University (S.U) in partial fulfillment for the degree of Bachelor of Science in Civil Engineering

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DECLARATION

It is hereby dedicated that except for the content where specific reference have been made to work of others, the studies contained on this research is the result of the investigation carried out by the author's. No part of this research has been submitted to any other university or educational institutions for any award or degree.

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Dedicated

to

“Our Beloved Parents”

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ABSTRACT

Concrete construction is becoming increasingly complex and the importance of producing structures that are both cost effective and durable has never been higher. Many experimental works have been performed to determine the compressive strength of different types of cement. The objectives of the study are to determine the compressive strength of concrete by using two different types of cement for grades M15 and M20. The materials used for the experiment are OPC & PCC Cement, Brick Chips, Sylhet sand and water. The mass of the specimens was recorded carefully. For 7 days, the values of compressive strength of concrete for OPC and PCC are 7.26 MPa and 7.30 MPa respectively of grade M15. For 28 days, the values are 11.39 MPa and 11.72 MPa respectively for the same types of cements for OPC and PCC of grade M15. For 7 days, the highest compressive strength of the concrete found 12.27 MPa for PCC of grade M20 and the lowest compressive strength is 7.26 MPa for OPC of grade M15. For 28 days, the highest compressive strength of the concrete found 14.27 MPa for PCC of grade M20 and the lowest compressive strength is 11.39 MPa for OPC of grade M15. The compressive strength of PCC cement was better than the OPC cement for the both grade M15 and M20.

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CHAPTER 1

INTRODUCTION

1.1 General

The self-weight of normal cement concrete varies from 2200 to 2600 kg/m3. This is one of the main disadvantages of conventional cement concrete as this heavy weight of concrete makes it uneconomical structural material. To increase the efficiency of cement as a structural material attempts have been made to reduce the weight of normal cement concrete.

A cement concrete having self-weight ranging from 300 to 1850 kg/m3 is called lightweight concrete. In recent years lightweight concrete has become more popular due to manifold advantages it offers over the conventional concrete. A better understanding and development of modern technologies have also helped in the promotion and use of light weight concrete.

The dominant coarse aggregate of concrete is asphalt, stone & brick. Since bricks are a dominant material in residential construction, they account for a large proportion of construction and demolition waste. In a recent study, it is estimated that the brick will remain the second most significant building material after concrete over the next 50 years. Bricks are considered as waste when broken or damaged from the brick production line or from construction and demolition sites.

1.2 Background and Motivation

Using crushed bricks as aggregates in concrete is of particular interest to preserve natural aggregate sources as well as to reduce waste and waste storage. The first use of crushed brick with Portland cement was recorded in Germany in 1860 for the manufacturing of concrete products. However, the first significant use of crushed brick as aggregates in new concrete has been recorded for reconstruction after the Second World War. Brick masonry has long been used as a reliable building material in many country. Considering the world annual production of clay bricks which is approximately 6.25×108 ton, about 7 ×106 ton bricks go to the landfills each year. One solution to this problem could be recycling the waste bricks, either excess new bricks, or waste from demolished structures, and using them as aggregates in concrete. With increased environmental awareness during the past decades and economic motivations to reuse waste, use of masonry rubble is once again receiving attention.

Nevertheless, generally, the lack of knowledge of performance of concrete made with brick as its aggregates is an obstacle for reuse of brick waste in concrete. Most of the studies on the use of crushed bricks as aggregates in concrete were focused on mechanical performance of such concrete structures. Some studies showed that the use of brick aggregate as a substitute for granite aggregates results in a loss of compressive strength. This loss of strength is to the order of 10 – 35% for coarse aggregates, and 30 – 40% for fine aggregates, depending on the rate at which the brick was substituted for natural aggregates. However, with this decrease in compressive strength, a gain of about 11% is made for tensile strength, compared to concrete made with natural aggregates. On the other hand, another study showed that the 28-day compressive strength of concrete made with crushed brick exceeded that of concrete made with natural granite aggregate and their values were virtually identical. While the high porosity of brick particles contributes to higher permeability, it is expected that the porosity of the particles potentially improves the performance in freeze-thaw testing. Most studies in this area have been performed on brick particles used as a partial replacement for fine aggregate. It is foundthat incorporation of brick as fine aggregates with high porosity to mortar and concrete mixtures can improve the freeze-thaw resistance of the mixtures due to providing a similar air entraining action.

Corrosion is the other important durability issue in steel reinforced concrete structure which is mainly the result of DE passivation of the steel due to the ingress of chloride ions. Consequently, it is important to consider a concrete's ability to resist chloride penetration. However, number of studies on the chloride diffusion into concrete made with brick aggregates is very limited. A studied says that the chloride ion diffusion in concrete made with brick and natural aggregates and found that the chloride diffusivity of the concrete with brick aggregates was greater than that in the control specimens with natural aggregates. On the contrary, the result of the tests conducted by Cavalline showed that the brick concrete mixtures exhibit fairly good results in chloride ion permeability testing. The objective of this work was to study the durability of the concrete made with crushed brick as partial replacement for natural aggregates. Mechanical properties, freeze-thaw durability, chloride permeability, electrical properties as well as corrosion of reinforcing bars in the samples were studied and evaluated.

1.3 Research Objectives and Overview

The objectives of the study are following-

1. To determine the compressive strength of concrete by using brick aggregate for two different types of cement.

2. To know different types of compressive strength test.

3. To compare compressive strength of concrete using brick aggregate for two different types of cement for grade M15 and M20.

1.4 Outline of the Study

The study consists use of brick chips as coarse aggregate in concrete. The properties of harden concrete such as fc', Ec, fr, water absorption and unit weight of brick aggregate concrete have been determine.

1.5 Organization of thesis

Chapter 1: Introduction: This chapter provides the background of study and motivation of the research the overall objective and expected outcomes are also described in this chapter.

Chapter 2: Literature Review: This part discuss about the previous history about concrete compressive strength test with brick aggregate.

Chapter 3: Methodology: This part discuss about the process of concrete compressive strength test procedure in detail step by step.

Chapter 4: Result and Discussion: This chapter describes the result of the compressive strength test of different type of cylinder.

Chapter 5: Conclusion: This chapter summarization the conclusion and major condition of this study and provides recommendation for studies.

CHAPTER 2

LITERATURE REVIEW

2.1 History

Crushed bricks are widely used in parts of India and Bangladesh as a substitute source of coarse aggregate and the performance of this concrete is found to be quite satisfactory Schulz et. al. (1988). Brick aggregates are effortlessly presented in Bangladesh and with low cost compared to other sources of aggregates. In addition, strength of 20 MPa can be reached easily using this type of aggregate and according to the usual practice of making concrete Rashid et. al.(2008). And the use of brick aggregate concrete effectively reduced the dead load on columns in addition to foundations. Therefore, the process of replacing the aggregates effectively reduced the cost in making concrete.

The research done by Akhtoruzzaman et. al. (1983) mainly focused on determining the mechanical properties of brick aggregate concrete. They used burned brick in concrete as an alternative to coarse aggregate. The study showed that high strength concrete can't be achieved through using crushed brick when used as coarse aggregate. Khaloo (1994) Stated that when using crushed clinker bricks in concrete as coarse aggregate, a reduction in concrete strength of 7% have marinated when compared with concrete manufactured with natural aggregate. Furthermore to this reduction in strength, there is a reduction in the unit-weight of crushed brick concrete of 9.5%.

In a study carried out by Husain et. al. (1995 treated or untreated crushed brick as an alternative to coarse aggregate. Cement syrups of different consistencies have be used to treat the aggregates. They found a reduction in compressive strength up to 75-85 % when compared to normal concrete at 28 days, and a lower modulus of elasticity, even though the results of splitting tensile strength using crushed brick were more than the normal concrete. Also Bolouri (2006) used crushed brick in their study, they found that the compressive strength of concrete prepared with crushed bricks is comparatively low in comparison with ordinary concrete. Nevertheless, concrete bricks made with crushed bricks have higher strength than ordinary bricks, they could be used as new constructions.

Abdur et. al. (2012) indicated that the weight of brick aggregate concrete reduced about 14.5% compared to that of normal aggregate concrete. Also, they showed a decrease of 33% in compressive strength of concrete when using brick aggregate instead of stone aggregate moreover a 28% decrease in elastic modulus of concrete. Widespread work on recycled aggregate concrete has proven that using of numerous types of recycled aggregate in concrete yields to a concrete with light weight and less expenses Ibrahim et. al. (1996), Crwaford et. al. (2001), Fouad et. al. (2005).In present study, an endeavor has been made to study the possibility of using crushed clay bricks of locally existing construction waste for production of recycled brick aggregate concrete.

2.2 Concrete

Concrete, an artificial stone-like mass, is the composite material that is created by mixing binding material (cement or lime) along with the aggregate (sand, gravel, stone, brick chips, etc.), water, admixtures, etc in specific proportions. The strength and quality are dependent on the mixing proportions.

The formula for producing concrete from its ingredients can be presented in the following equation:

Concrete = Binding Material + Fine& Coarse Aggregate + Water + Admixture (optional)

Concrete is a very necessary and useful material for construction work. Once all the ingredients -cement, aggregate, and water unit of measurement mixed inside the required proportions, the cement and water begin a reaction with one another to bind themselves into a hardened mass. This hardens the rock-like mass in the concrete.

Figure 2-1. Concrete.

Concrete is powerful, easy to create, and can be formed into varied shapes and sizes. Besides that, it is reasonable, low cost, and instantly mixed. It is designed to allow reliable and high-quality fast-track construction. Structures designed with the concrete unit of measurement are plenty durable and should be designed to face up to earthquakes, hurricanes, typhoons, and tornadoes. This is an incredible advancement. With all the scientific advances there are in this world, there still has not been a way of preventing nature's injury.

- **Composition of Basic Concrete Mix**

  If we evaluate the concrete composition to see what concrete is made of, we can see there are four basic ingredients within the concrete material mix:

- Binding materials like cement or lime
- Aggregates or Inert Materials
- Fine aggregate (sand)

- Coarse aggregate (stone chips, brick chips)
- Water
- Admixture (e.g. Pozzolana)

A brief description of the concrete ingredients is given below:

- **Binding Materials**

  Binding material is the main element of a concrete material mix. Cement is the most commonly used binding material. Lime could also be used. When water is mixed with the cement, a paste is created that coats the aggregates within the mix. The paste hardens, binds the aggregates, and forms a stone-like substance.

- **Aggregates**

  Sand is a fine mixture. Gravel or crushed stone is the coarse mixture in most mixes.

- **Water**

  Water is required to with chemicals react with the cement (hydration) and to supply workability with the concrete. The number of water combined in pounds compared with the number of cement is named the water/cement quantitative relation. The lower the w/c quantitative relation, the stronger the concrete. (Higher strength, less permeability)

➢ **Types of Concrete Mix**

Based on the variations in concrete materials and purposes, concrete can be classified into three basic categories-

I. Lime Concrete
II. Cement Concrete
III. Reinforced Cement Concretes

I. Lime concrete

Uses Lime as the binding material. Lime is usually mixed with surki and khoa or stones in the proportion 1:2:5 unless otherwise specified. The khoa or stones are soaked in water before mixing. Lime concrete is used mainly in foundation and terrace roofing.

II. Cement Concrete

Most engineering construction uses cement concrete composites as the main building material. It consists of cement, sand, brick chips, or stone chips of the required size. The usual proportion is 1:2:4 or 1:3:6. After mixing the required amounts of concrete materials, the mix is cured with water for 28 days for proper strength building.

Cement concrete is a versatile construction material with a wide range of applications. It can be used in structural applications such as beams, columns, slabs, and foundations. It can also be used in non-structural applications such as paving, curbing, and landscaping. Cement concrete is also a popular choice for precast applications such as pipes, paving stones, and sewer systems. The main advantages of cement concrete are its strength, durability, and fire resistance. It is also relatively low maintenance and can be easily repaired if damaged. However, cement concrete is a relatively heavy material and can be difficult to work with. It is also susceptible to cracking and can be damaged by extreme weather conditions.

III. Reinforced Cement Concretes

For enhancing the tensile strength of concrete, steel reinforcements are added. Sometimes, RCC is pre-stressed under compression to eliminate or reduce tensile stresses. The resulting concrete is known as Pre-stressed Concrete.

The word 'Reinforced' means 'strengthened' or 'supported'. Reinforced Cement Concrete, therefore, is a composite material consisting of concrete and steel reinforcements.

The steel reinforcements used in RCC can be in the form of rods, bars, wires, meshes, etc. The concrete is cast around these steel reinforcement bars or rods to form the desired shape. The steel reinforcement bars are placed in such a way that they provide enough support to the concrete against the expected loads.

The steel reinforcement bars are placed in such a way that they provide enough support to the concrete against the expected loads.

2.3 Cement

Cement, one of the most important building materials, is a binding agent that sets and hardens to adhere to building units such as stones, bricks, tiles, etc. Cement generally refers to a very fine powdery substance chiefly made up of limestone (calcium), sand or clay (silicon), bauxite (aluminum), and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate. The raw ingredients are processed in cement manufacturing plants and heated to form a rock-hard substance, which is then ground into a fine powder to be sold. Cement mixed with water causes a chemical reaction and forms a paste that sets and hardens to bind individual structures of building materials.

Cement is an integral part of the urban infrastructure. It is used to make concrete as well as mortar, and to secure the infrastructure by binding the building blocks. Concrete is made of cement, water, sand, and gravel mixed in definite proportions, whereas mortar consists of cement, water, and lime aggregate. These are both used to bind rocks, stones, bricks, and other building units, fill or seal any gaps, and make decorative patterns. Cement mixed with water silicates and aluminates makes a water-repellant hardened mass that is used for water-proofing.

Figure 2-2. Cement.

- **Cement Chemistry**

Cement is chiefly of two kinds based on the way it is set and hardened: hydraulic cement, which hardens due to the addition of water, and non-hydraulic cement, which is hardened by carbonation with the carbon present in the air, so it cannot be used underwater.

Non-hydraulic cement is produced through the following steps (lime cycle):

1. Calcination: Lime is produced from limestone at over 825°C for about 10 hours. ($CaCO_3 \rightarrow CaO + CO_2$)
2. Slaking: Calcium oxide is mixed with water to make slaked lime. ($CaO + H_2O \rightarrow Ca(OH)_2$)
3. Setting: Water is completely evaporated.
4. The cement is exposed to dry air and it hardens after time-consuming reactions. ($Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$)

On the other hand, hydraulic cement is mainly made up of silicates and oxides:

1. Belite ($2CaO \cdot SiO_2$);
2. Alite ($3CaO \cdot SiO_2$);
3. Tricalcium aluminate/ Celite ($3CaO \cdot Al_2O_3$)
4. Brownmillerite ($4CaO \cdot Al_2O3 \cdot Fe_2O_3$

The ingredients are processed in the kiln in cement plants. The complete chemistry of the reactions is still a subject of research.

- **Type of cement**

  There are two type of cement are available in our market based on material composition of cement

  I. Portland Composite Cement (PCC)
  II. Ordinary Portland Cement (OPC)

I. Portland Composite Cement (PPC)

The most commonly used cement nowadays is hydraulic cement (i.e. hardens when water is added) known as Portland cement or Portland cement blends. These are usually the basic ingredient in making concrete, which is a construction material used as a load-bearing element. Portland cement is suitable for wet climates and can be used underwater. Different types or blends of Portland cement include Portland blast furnace slag cement, Portland fly-ash cement, Portland pozzolan cement, Portland-silica fume cement, masonry cement, and expansive cement, white blended cement, colored cement, and very finely ground cement.

85% Portland cement clinker (37-72% of $3CaO.SiO_2$; 6-47% $2CaO.SiO_2$; 2-20% $2CaO.Al_2O_3$; 2-19% $4CaO. Al_2O_3.Fe_2O_3$), 1.5-3.5% gypsum by SO_3 content, up to 15% admixtures

II. Ordinary Portland Cement (OPC)

Ordinary Portland Cement (OPC) is mostly used for common structures and also for important civil works. In India, about 70% of cement is of this category. It has mainly three grades. Grade means mortar cube strength in N/mm^2 after 21 days. Let's know more about the Ordinary Portland Cement.

Ordinary Portland Cement (OPC) is the most common cement used in the world mostly because of the abundance and low cost to produce it. OPC is produced simply by grinding limestone and secondary materials to a powder. It got its name as it was first produced in Portland.

The grades of Ordinary Portland Cement (OPC) are:-

(a) Grade 33
(b) Grade 43
(c) Grade 53

Grade 33 means after 21 days, the strength of this type of cement with standard must be 33 N/mm^2. The ratio of cement mortar must be 1:3 (standard cement and sand).The initial setting time of this cement is not less than 30 minutes and final setting time should not exceed 10 hours. Properties and uses of Ordinary Portland Cement. It is commonly used for various engineering works. The OPC cement has moderate strength and less heat of hydration, of be does not cause any defect. It is mainly used in pavements. This cement does not attain the strength so quickly and its setting time is normal so it may also be called as normal setting cement. The cost of producing Ordinary Portland Cement (OPC) is very low and available at the best quality because of the readily available raw material in the area where it is produced. Being low-cost cement it is widely used in the production of concrete, which is the most popular material used for construction in the world for roads, houses, buildings, dams and in other construction work etc. Ordinary Portland cement is also used for mortars and in making grouts. To produce Ordinary Portland Cement (OPC) need mixing raw materials and use of a rotary kiln with maintained 1400–1450°C temperature by rising chemical reactions. Ordinary Portland cement (OPC)-53 grade is produced using a highly specialized process that allows optimum distribution of each particle, thereby allowing superior crystalline structure and balanced composition. The result is better strength and durability. Ordinary Portland cement (OPC)-43-grade cement is produced by inter- grinding of clinker and gypsum, to an optimum fineness to ensure both strength & durability of concrete at all ages, which is suitable for all construction works.

2.4 Aggregate

Construction aggregate, or simply aggregate, is a broad category of coarse to medium grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geo-scientific aggregates. Aggregates are the most mined materials in the world. The products characteristics are standard in order to ensure the necessary levels of reliability and process.

Aggregate information in building and construction, materials are used for mixing with cement, bitumen, lime, gypsum, or other adhesive to concrete or mortar. Aggregate can either be natural or manufactured. Natural aggregate are generally extracted from larger rock formation through an open excavation. Extracted rock is typically reduced to usable sizes by mechanical cruising.

2.4.1 Fine Aggregate

Aggregate is the granular material used to produce concrete or mortar and when the particles of the granular material are so fine that they pass through a 4.75mm sieve, it is called fine aggregate. It is widely used in the construction industry to increase the volume of concrete, thus it is a cost saving material and you should know everything about the fine aggregate size, its density and grading zone to find the best material.

Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and fine aggregate density strongly influence the hardened properties of the concrete. The concrete or mortar mixture can be made more durable, stronger and cheaper if you made the selection of fine aggregate on basis of grading zone, particle shape and surface texture, abrasion and skid resistance and absorption and surface moisture.

Fine aggregates are the structural filler that occupies most of the volume of the concrete mix formulas. Depending on composition, shape, size and other properties of fine aggregate you can have a significant impact on the output. The role of fine aggregate can be described in few points:

Fine aggregates provide dimensional stability to the mixture

- The elastic modulus and abrasion resistance of the concrete can be influenced with fine aggregate
- Fine aggregates quality also influence the mixture proportions and hardening properties
- The properties of fine aggregates also have a significant impact on the shrinkage of the concrete.

Figure 2-3. Fine Aggregate

While making the selection for appropriate aggregate to be used in particular concrete mix, few properties needs to be considered, such as:

- Void content: How much amount of cement paste will be required for the mix eventually depends on the empty spaces between the aggregate particles. Always keep in mind that angular aggregates increase the void content, whereas well-graded aggregate and improved grading decreases the void content.
- Shape and texture: Size and shape greatly influence the quality of the concrete mix. For the preparation of economical concrete mix, you should know that rough- textured, angular, and elongated particles require more water for the formula. However, you will need less water to produce workable concrete when the aggregates are smooth, rounded compact aggregate.
- Absorption and surface moisture: The fine aggregate density depends on the inside solid material and void content, thus you need to measure the absorption rate prior to ensure how

much water will be required in the concrete mixture.

- Abrasion and skid resistance: In order to minimize the wear in high traffic areas, such as heavy duty floors and pavements you can consider the relative measure when the fine aggregate is rotated in a cylinder along with some abrasive charge.

According to F.M. sand can be classified as under:

Types of Sand	Range of Fineness Modulus
Fine Sand	2.2- 2.6
Medium Sand	2.6- 2.9
Coarse Sand	2.9- 3.2

Sand having a fineness modulus more than 3.2 will not be suitable for making satisfactory concrete.

Properties of Fine Aggregate:

1) Size of Fine Aggregates.
2) Strength.
3) Shape of Fine Aggregates.
4) Specific Gravity.
5) Surface Texture of Fine Aggregates.
6) Water Absorption.
7) Surface Index of Fine Aggregates.
8) Soundness.
9) Surface Moisture.
10) Specific Surface of Fine Aggregates.

2.4.2 Coarse Aggregate

Coarse aggregate is stone which are broken into small sizes and irregular in shape. In construction work the aggregate are used such as limestone and granite or river aggregate. Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder. Coarse aggregates are generally categorized as rock larger than a standard no. course aggregates are used in every construction projects. Which includes the construction of roads, buildings, railway tracks etc. Aggregate makes concrete strong and durable when mixed with cement, sand, and water. The size of coarse aggregates affects several aspects of the concrete, mainly strength and workability, and the amount of water needed for the concrete mix. It also helps to determine how much fine aggregate is needed to produce a concrete batch.

Figure 2-4. Coarse Aggregate.

Concrete is more workable when smooth and rounded aggregate is used instead of rough angular or elongated aggregate. Most natural sands and gravel from riverbeds or seashores are smooth and rounded and are excellent aggregates. Coarse aggregate size is directly proportional to the slump (workability) of a fresh concrete with constant water cement ratio. Compressive strength of a concrete increases with increase in coarse aggregate size. The size of the coarse aggregate determines the maximum water-cement ratio for grade M15 is 0.45 and grade M20 is 0.45.

2.5 Sieve Analysis of Fine and Coarse Aggregate

Sieve analysis forms the basic essential test for determining the gradation of aggregates. The main property investigated in this test is the particle size. Sieve analysis is the method of dividing a sample of aggregates into various fractions each consisting of particles of same size. The sieve analysis is carried out to determine the particle size distribution in a sample of aggregate, which we call gradation. The aggregate fraction from 4.75 to 75 micron is referred to as fine aggregates.

Figure 2-5. Sieve Analysis of Fine and Coarse Aggregate

In practice, each fraction contains particles between definite limits, these being the openings of standard test sieves. Before sieving, the soil should be air dried in order to avoid lumps of fine particles and also to prevent clogging of the finer sieves. Sieves should also be cleaned before use.

The term sieve analysis is given to the operation of dividing a sample of aggregates into fraction each consisting of particles between specific limits. The analysis is conducted to determine the grading of material proposed for using as aggregates. The term fineness modulus (F.M) is a ready index of coarseness or fineness of material. It is an empirical factor obtained by adding the cumulative percentages of aggregates retained on each of the standard sieves and dividing this sum arbitrarily by .No.100, No.50, No.30, No.16, No.8, No.4, 3/8 in, ¾ in, 1.5 in, 3 in. are the ASTM standard sieves. This test method confirms to the ASTM standard requirements of specification C136.

CHAPTER 3

METHODOLOGY

3.1 Preparation of Cylinder

Most commonly, the compressive strength of concrete is measured to ensure that concrete delivered to a project meets the requirements of the job specification and for quality control. For testing the compressive strength of concrete, cylindrical test specimens of size 4” x 8”-inch (100 x 200-mm) are cast and stored in the field. The mold must hold the concrete without any leakage. Before placing the concrete mix within the mold, the interior of the mold must be properly greased to facilitate easy removal of the hardened cylinder. The mixed concrete is placed into the molds in layers not less than 5 cm deep. The strokes per layer during the compaction must not be less than 30 in number. Compaction must reach the underlying layers allowing the majority of the air voids to escape. The specimens are stored undisturbed in a place with at least 90% relative humidity at normal room temperature for 24 hours. After this period, the samples are taken and submerged in clean and fresh water until the testing age is reached.

Figure 3-1 (a). Preparation of Cylinder.

Figure 3-1 (b). Mold Ready for Casting.

3.2 Concrete Mixing

Concrete is a composite material made up of cement, sand, coarse aggregates, water and chemical admixtures (if required). It is the primary construction material. It plays a significant role in the structure's serviceability and durability. Not only the concrete but the process of concreting such as batching, mixing, transporting, compacting and finishing etc. also plays a significant role. Proper mixing of concrete ingredients is of utmost importance in order to produce good quality of fresh concrete. During the process of mixing the surface of all the aggregate particles is coated with cement paste. Well mixed concrete is required for the desired workability and performance of concrete in both the fresh as well as the hardened state. If the concrete is not well mixed, then it tends to segregation and bleeding.

Mixing of concrete should be done on a masonry platform or sheet iron tray. For concrete of 1:2:4 mix proportion, first two boxes of sand and one bag of cement should be dry-mixed thoroughly. Then, a dry mix of cement and sand is placed over a stack of 4 boxes of coarse aggregates and the whole mixture is dry-mixed, turning at least three times to have a uniform mix.

Water is then added slowly and gradually with a water-can while the contents are being mixed. Generally, 25 to 30 liters (5 to 6 gallons) of water is added for every bag of cement. The contents should be mixed to give a plastic mix of required workability and water-cement ratio. The contents should be mixed thoroughly turning at least three times to give a uniform concrete.

Figure 3-2. Mixing of Sand, Cement & Brick Chips

3.3 Casting of Cylinder

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting. When we casting the cylinder, moulds should be filled in 3 equal layers and each layer rodded uniformly 20 times with a 10 mm diameter x 450 to 600 mm long hemispherically tripped still road. The strokes shall be distributed uniformly over the cross section of the mold. The bottom layer shall be rodded throughout its depth. For each upper layer, the road shall be penetrate about 25 mm into the underline layer. If void are left by the rod the side of the mold should be tapped to close void before adding the next layer of material. After filing the mold strike off the surface with the tamping rod, handheld float or trowel to produce a flat, even surface. Install the mold cap and move the cylinders to an initial curing place for storage.

Figure 3-3. Casting of Cylinder

3.4 Curing

After finishing & marking, specimens were stored for 24 to 48 hours in normal room temperature for specified concrete strength of 40MPa or higher, Specimens should be protected from direct sun light, radiant heating devices to prevent the loss of moisture. Heating and cooling machineries may be used for this purpose.

After all test specimens are stored, a large amount of water needs to be disposed of on the curing side. But water cooler than 50°C is not suitable for curing concrete. As the hydration reaction in concrete expels heat and keeps concrete warm, using cold water less than 50°C on concrete may lead to cracking and failing. Alternate drying and wetting on the concrete surface causes volumetric changes in concrete and ultimately leads to cracking.

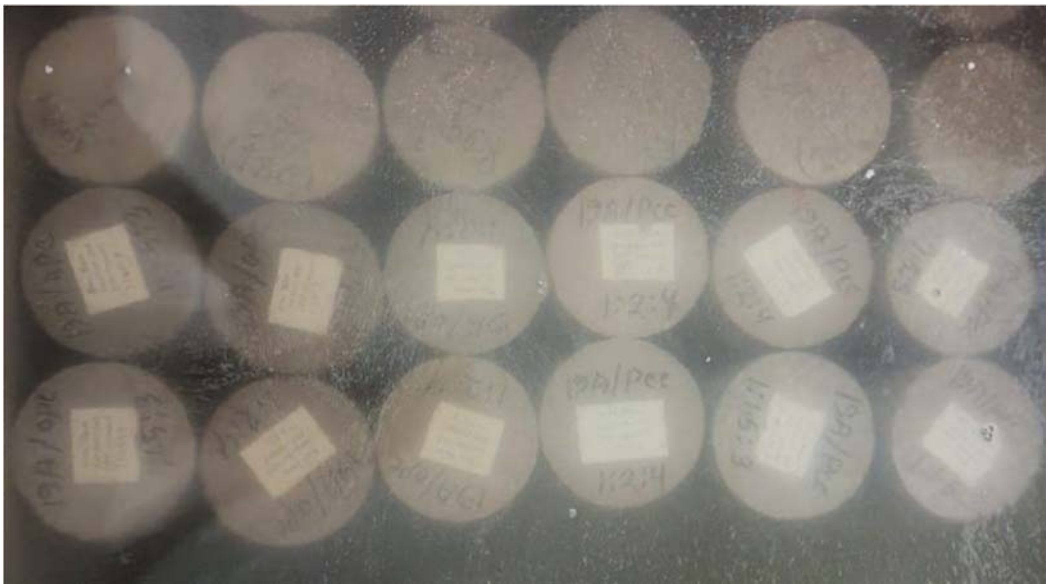

Figure 3-4. Curing of Cylinder

3.5 Preparation to Crush the Concrete Cylinders

The cylinders were kept submerged as long as for 7 days. After that were withdraw 12 pcs cylinder of M15 grade are made by cylinders (PCC) cement 3 pcs and (OPC) cement 3 pcs and M20 grade are made by cylinders (PCC) cement 3 pcs and (OPC) cement 3 pcs from the dram. In Sonargaon University (SU) Lab, after that the cylinders had been placed in the center of Universal Testing Machine (UTM) one by one (take help from the manual) to find out the crushing of each cylinder. Then were kept submerged as long as for 28 days. Then we kept another test for 28 days. After that we are withdrew from the dram and crushing the cylinders and noted down the value.

Figure 3-5. Preparation Cylinder M15 and M20 Grade.

3.6 UTM Machine

UTM machine is also known as UTM tester, materials testing machine or material testing frame and that’s why manufactures gave a common name `Universal testing machine’ and this machine used to test the compressive strength of materials. UTM machines have different roles stripped of capabilities or marketed for specific industries & sectors which play unique roles in the development of infrastructure, roads, and highways. UTM is one of the best multi- purpose equipment for R&D labs or the QC department.

• **Compression Test:** This is compressive strength of materials means this is completely opposite of Tensile strength testing as mentioned above, basically a maximum pressure has to apply on any object up to its break points. This is called compressive strength of any object. This test also useful to find how much load can bear on bridges pillars, building beams or etc.

3.7 Compressive Strength Test

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 cylinder is compressed between the platens of a compression testing machine by a gradually applied load. Brittle materials such as rock, brick, cast iron, and concrete may exhibit great compressive strengths but ultimately, they fracture. The crushing strength of concrete, determined by breaking a cylinder, and often called the cylinder strength. Some ductile metals, such as mild steel, have very great compressive strengths, but the actual values are difficult to measure. When a load is applied to a ductile metal, it deforms elastically up to a certain point and then plastic deformation occurs. Increasing loads may even completely flatten a test piece without any definite fracture occurring, so that value can be obtained for the compressive strength for two different grade M15 and grade M20 respectively.

Figure 3-6. Placing the cylinder in UTM machine.

3.8 Compressive Fracture of Cylinder

For 7 days and 28 days test, the specimen was kept at the center of UTM machine and crushed one by one and noted the value. Total crushed 24 specimen in Sonargaon University lab.

Figure 3-7. Compressive fracture of Cylinder Grade M15 and M20

3.9 Compressive Strength Importance

a) Effect of cement:

The Inhaling high levels of dust may occur when workers empty bags of cement. In the short term, such exposure irritates the nose and throat and causes choking and difficult breathing. Cement industry is one of the main producers of carbon dioxide, a potent greenhouse gas. Concrete causes damage to the most fertile layer of the earth topsoil. Compressive strength increases with the increasing of cement content. Cement dust may enter into the systemic circulation and thereby reach the essentially all the organs of body and affects the different tissues including heart, liver, spleen, bone, muscles and hairs and ultimately affecting their micro-structure and physiological performance.

b) Effect of aggregate / cement ratio:

Well graded aggregates result in the least amount of voids in a given volume. Less voids result in excessive paste availability in a unit volume and more lubrication decreasing the aggregate/cement ratio increases the compacting factor due to the increase in the amount of fines (cement) in the mix and decreasing aggregate content, which acts as lubricant and leads to a decrease in the internal friction between the aggregates particles, and as a result, compacting factor increases.

c) Effect of aggregate properties:

Aggregates influence the properties of concrete/mortar such as water requirement, cohesiveness and workability of the concrete in plastic stage, while they influence strength, density, durability, and permeability, surface finish and color in hardened stage. Aggregate is commonly considered inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Although aggregate is considered inert filler, it is a necessary component that defines the concrete's thermal and elastic properties and dimensional stability.

d) Effect of admixture:

Admixtures have increased both compressive strength and durability of concrete.

e) Effect of the specimen size:

Concrete strength decreased as the specimen size increased and the decrement was more obvious in the specimens with low aspect ratio.

f) Effect of the rate of loading:

As rate of loading increases, compressive strength, modulus of elasticity, and the slope of the descending portion of the stress-strain curve of concrete increase.

g) Effect of the moisture content:

The results indicate that, with increasing moisture content, the compressive strength Decreases initially and then increases. The effect of moisture content on compressive strength increases with the increasing porosity.

h) Effect of the temperature of the testing:

The compressive strength can be classified into four distinct patterns of strength loss: 23–200°C, 200–400°C, 400–600°C, and 600–800°C. From 23 to 200°C, the compressive strength of specimens increases with temperature.

3.10 Compressive Strength Formula

Compressive strength is the maximum compressive stress that, under a gradually applied given solid material can sustain without fracture. Compressive strength is calculated by dividing the maximum load by the original cross-sectional area of a specimen in a compressive test. The compressive strength is one of the most important and useful properties of concrete. The design strength of the concrete normally represents its 28th day. Compressive strength can be defined as the capacity of concrete to withstand loads before failure of the many tests applied to the concrete, the compressive strength test is the most important, as it gives an idea about the characteristics of the concrete.

The compressive strength was calculated by using the equation:

$$F = \frac{P}{A}$$

Where, F is compressive strength of specimen in pound per square inch (psi). P is the maximum applied load by pound. A is the cross-sectional area (inch square). 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 compressive-testing machine by a gradually applied load.

CHAPTER 4
RESULT AND DISCUSSION

4.1 Result of Fine Aggregate

The test sample of the aggregate (F.M) shall weight after drying & approximately the following requirement:

- Aggregate with at least 85% passing by No. 4 Sieve.
- More than 5% retained on a No. 8 Sieve.
- Aggregates with at least 95% passing by No. 8 Sieve

Table 4-1. Result of Fine aggregate sieve analysis

Sieve No.	Retain	% Retain	Cumulative % Retain	Finer	FM
#4	0	0	0	100	$\frac{235.8}{100} = 2.358$
#8	14	2.8	2.8	97.2	
#16	26	5.2	8	92	
#30	135	27	35	65	
#50	280	56	91	9	
#100	40	8	99	1	
Pan	5	1	100	0	

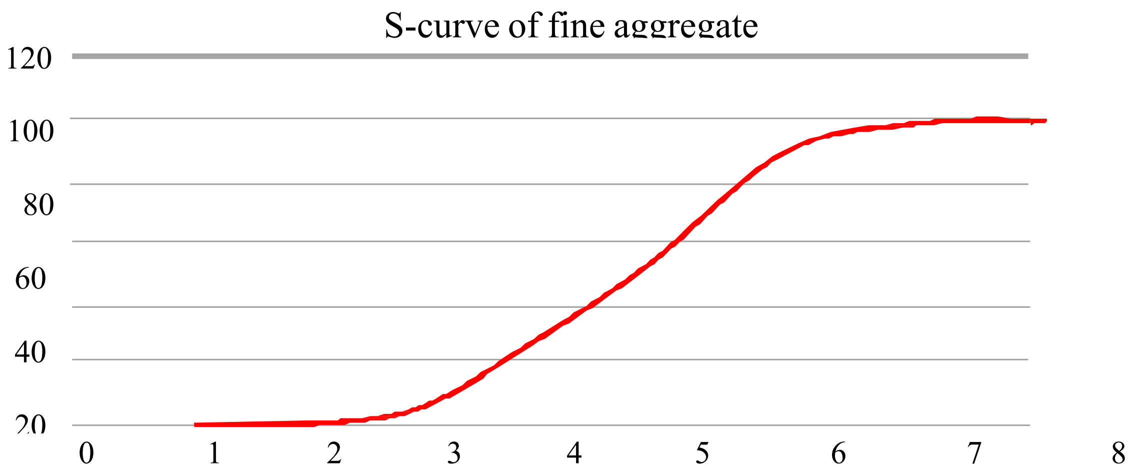

Figure 4-1. S-curve from sieve analysis of fine aggregate

4.2 Result of Coarse Aggregate

The weight of the test sample of coarse aggregate (C.A) shall conform to the following Requirements:

- Aggregates with nominal maximum size of ¾ in. 10 lbs

Table 4-2. Result of Coarse Aggregate:

Sieve No.	Retain	% Retain	Cumulative % Retain	Finer	FM
#3/4	302	16.56	16.57	83.44	
#3/8	1428	78.33	94.90	5.10	$\frac{711.45}{100} = 7.114$
#4	93	5.10	100	0	

4.3 Specific Gravity of Coarse Aggregate

Table 4-3. Data sheet for specific gravity of coarse aggregate:

Weight of S.S.D sample in air, B (gm)	Weight of S.S.D sample in water, C (gm)	Oven dry weight in air, A gm
1008 gm	580 gm	1000 gm

Table 4-4. Specific gravity of coarse aggregate:

Test	Formula	Calculation	Result
Apparent specific Gravity	$\frac{A}{A - C}$	$\frac{1000}{1000-580}$	2.38
Bulk Specific Gravity (Oven Dry Basic)	$\frac{A}{B - C}$	$\frac{1000}{1008-580}$	2.33
Bulk Specific Gravity (S.S.D. Basic), G	$\frac{B}{B - C}$	$\frac{1008}{1008-580}$	2.36
Absorption Capacity, D%	$\frac{(B - A) \times 100}{A}$	$\frac{(1008-1000)\times100}{1000}$	0.8%

4.4 Specific Gravity of Fine Aggregate

Table 4-5. Data sheet for Specific gravity of fine aggregate:

Weight of pycnometer filled with water to calibration, B gm	Oven dry weight. in air, A gm	Weight of pycnometer with specimen and water to calibration Mark, C gm	Weight of S.S.D sample In Air, S gm
652 gm	288 gm	823 gm	294 gm

Table 4-6. Specific gravity of fine aggregate:

Test	Formula	Calculation	Result
Apparent Specific Gravity	$\frac{A}{B + A - C}$	$\frac{288}{652+288-823}$	2.462
Bulk Specific Gravity (Oven Dry Basic)	$\frac{A}{B + S - C}$	$\frac{288}{652+294-823}$	2.341
Absorption Capacity, D%	$\frac{S - A}{A} \times 100$	$\frac{294-288}{288} \times 100$	2.08%
Bulk Specific Gravity (S.S.D. Basic), G	$\frac{S}{B + S - C}$	$\frac{294}{652+294-823}$	2.390

4.5 Results of 7 Days Compressive Strength Test of Grade M15

Table 4-7. Seven Days Compressive Strength Test of Grade M15

Sl. No.	Types of Cement	Mix Properties	Water Cement (Ratio)	Compressive Strength(psi)	Average Strength (psi)	Average Strength (MPa)
1	OPC	1:2:4	0.45	1068	1053	7.26
				1007		
				1085		
2	PCC	1:2:4	0.45	980	1059	7.30
				1053		
				1145		

4.6 Results of 28 Days Compressive Strength Test of Grade M15

Table 4-8. Twenty Eight Days Compressive Strength Test of Grade M15

Sl. No.	Types of Cement	Mix Properties	Water Cement (Ratio)	Compressive Strength(psi)	Average Strength (psi)	Average Strength (MPa)
1	OPC	1:2:4	0.45	1700	1652	11.39
				1611		
				1646		
2	PCC	1:2:4	0.45	1825	1700	11.72
				1575		
				1700		

4.7 Results of 7 Days Compressive Strength Test of Grade M20

Table 4-9. Seven Days Compressive Strength Test of Grade M20

Sl. No.	Types of Cement	Mix Properties	Water Cement (Ratio)	Compressive Strength (psi)	Average Strength (psi)	Average Strength (MPa)
1	OPC	1:1.5:3	0.45	1270	1258	8.68
				1151		
				1353		
2	PCC	1:1.5:3	0.45	1739	1779	12.27
				1151		
				1679		

4.8 Results of 28 Days Compressive Strength Test of Grade M20 Ratio

Table 4-10. Twenty Eight Days Compressive Strength Test of Grade M20

Sl. No.	Types of Cement	Mix Properties	Water Cement (Ratio)	Compressive Strength(psi)	Average Strength (psi)	Average Strength (MPa)
1	OPC	1:1.5:3	0.45	2237	1849	12.74
				1700		
				1611		
2	PCC	1:1.5:3	0.45	2362	2070	14.27
				1879		
				1969		

After the experiment it shows the result below:-

- For grade M15 compressive strength of the concrete is to reach 7.26 MPa in 7 day & 11.39 MPa in 28 days of OPC.
- For grade M15 compressive strength of the concrete is to reach 7.30 MPa in 7 day & 11.72 MPa in 28 days of PCC.
- For grade M20 compressive strength of the concrete is to reach 8.68 MPa in 7 day & 12.74 MPa in 28 days of OPC.
- For grade M20 compressive strength of the concrete is to reach 12.27 MPa in 7 day & 14.27 MPa in 28 days of PCC.

The compressive strength of most cylinders reaches this benchmark in less than seven days. For 7 days, by using crushed brick aggregate the highest compressive strength of the concrete found 12.27 MPa for PCC cement of grade M20 and the lowest compressive strength is 7.26 MPa for OPC cement of grade M15. For 28 days, by using crushed brick aggregate the highest compressive strength of the concrete is found 14.27 MPa for PCC cement of grade M20 and the lowest compressive strength is 11.39 MPa for OPC cement of grade M15. The compressive strength of PPC cement was better than OPC cement.

4.9 Comparison Chart between Grade M15 and M20

The comparison between two different types of cement for grade M15 and M20 are given below:

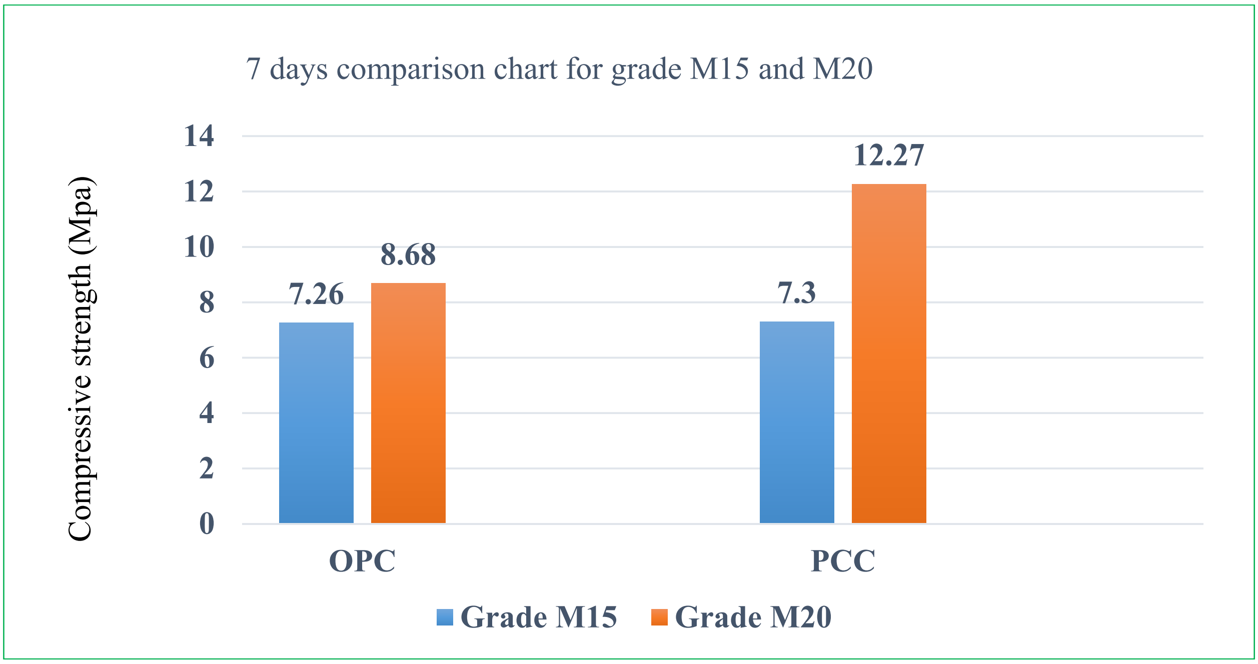

Figure 4-2. 7-days comparison chart of grade M15 and M20 for two different types of cement.

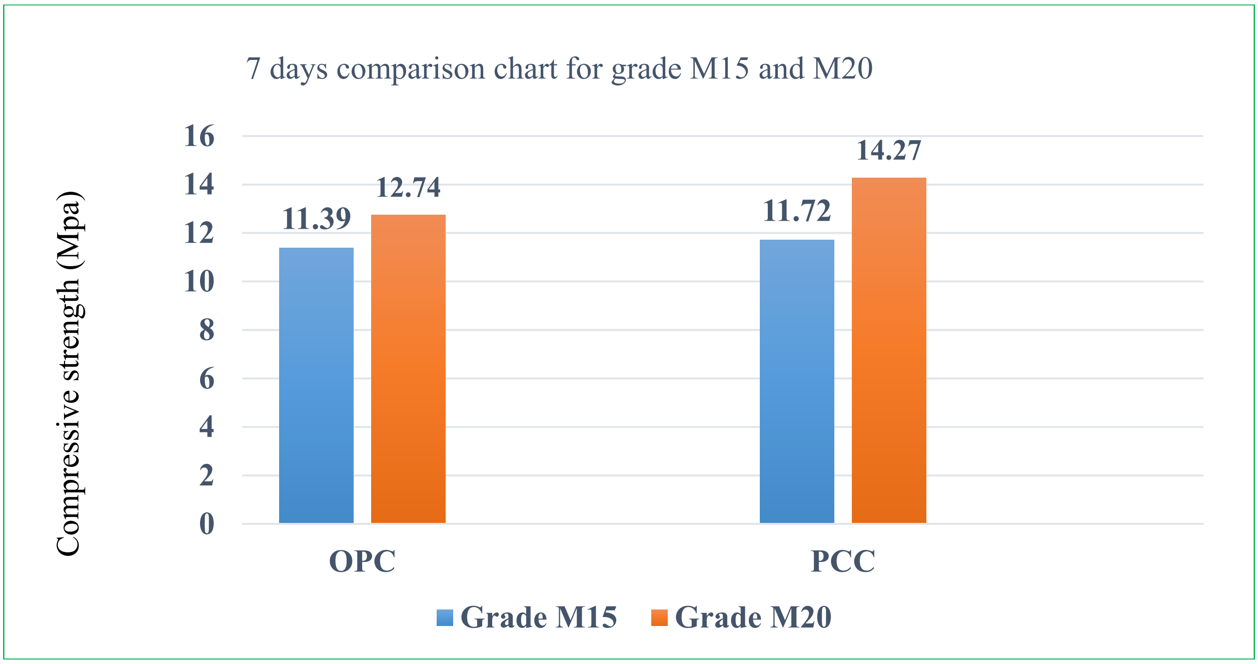

Figure 4-3. 28-days comparison chart of grade M15 and M20 for two different types of cement.

CHAPTER 5
CONCLUSIONS AND FUTURE WORKS

5.1 Conclusion

By conducting detailed experimental investigation and data analysis, the key findings of the study have been presented below:-

1. The comparison of compressive strength of concrete using brick aggregate for two different types of cement for grade M15 and M20 has been done.
2. For 7 days, the compressive strength test result of OPC cement is 7.26 Mpa and for PCC cement is 7.30 Mpa which is 48.40% and 48.67% respectively for grade M15.
3. For 28 days, the compressive strength test result of OPC cement is 11.39 Mpa and for PCC cement is 11.72 Mpa which is 75.93% and 78.13% respectively for grade M15.
4. For 7 days, the compressive strength test result of OPC cement is 8.68 Mpa and for PCC cement is 12.27 Mpa which is 43.40% and 61.35% respectively for grade M20.
5. For 28 days, the compressive strength test result of OPC cement is 12.74 Mpa and for PCC cement is 14.27 Mpa which is 63.70% and 71.35% respectively for grade M20.

5.2 Recommendation for Future work

The following are some recommendations provided considering the previous discussion:

1. More work or study can be done in further with others local cement types.
2. The other grade like M7, M10, M25, M30, M35, M40, M45 and M50 may be worked in further.
3. Different water cement ratio can also be worked in further.

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Casting of Cylinder:
(Website:https://www.ask-chemicals.com/technology/applications/cylinder-head- casting#:~: text=the%20cylinder%20head%20of%20an, component%20assembly%20of %20the%20 engine).