A COMPARATIVE STUDY ON COMPRESSIVE STRENGTH OF CONCRETE WITH THE VARIATION OF COARSE AGGREGATE AND CURING CONDITIONS

By

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

Department of Civil Engineering

Sonargaon University

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

Section: 17 C (Abelia)

Semester: 12th (Spring-2023)

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Dedicated

to

“Our Beloved Parents”

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ABSTRACT

Concrete is a mixture of cement, sand and Brick chips, stone chips and water in some specified proportion which is generally used for R.C.C and C.C. We have worked on a comparative study on the effect of membrane curing of concrete work. Firstly, 24 concrete cylinders of 4 x 8 inch were made and eight of them were cured continuously in the bathtub for 28 days. The rest of the cylinders were covered with jute membrane like the local construction side. Eight of them cured after 2 hours and others 3-hour intervals. In this process it was tried to find out reduction factors that should be multiplied with the claimed cylinder strength for a structure that was cured under membrane curing.

Curing is essential if concrete is to perform the intended function over the design life of the structure while excessive curing time may lead to the escalation of the construction cost of the project unnecessary delays. The new tread of using high strength concrete in construction has caused a need for the use of 4 x 8 in. Cylinders for assurance testing. A controlling factor that affects the curing of specimen that can be tested in compression machine is the strength of the concrete on evaluation

The curing method for wet covering immersion under water is the type of cement ordinary Portland cement (OPC). The study demonstrates that the method and duration of curing greatly affects the strength characteristics of concrete. Hence, quality control for proper field curing is of the utmost importance. Form our study, it can concluded that the Bhurungamari Stone and the immersion curing method gives higher compressive strength than Indian Black Stone and wet covering curing method respectively.

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CHAPTER 1
INTRODUCTION

Concrete is one of the most widely used construction materials in the world. Its compressive strength is an essential property that determines its ability to withstand loads and stresses without failure. The compressive strength of concrete is affected by various factors such as the type of cement, water-cement ratio, curing conditions, and the type of coarse aggregate used.

In recent years, there has been a growing interest in studying the effect of coarse aggregate on the compressive strength of concrete. The use of different types of coarse aggregate in concrete can significantly affect its strength and durability. The properties of the coarse aggregate, such as size, shape, texture, and strength, influence the interfacial bonding between the aggregate and cement paste, which ultimately affects the strength of the concrete.

Moreover, curing conditions also play a vital role in determining the compressive strength of concrete. The strength of concrete can be significantly affected by the moisture content, temperature, and duration of the curing period. Therefore, it is essential to study the effect of different curing conditions on the compressive strength of concrete with different types of coarse aggregate.

This study aims to investigate the compressive strength of concrete with different types of coarse aggregate in different curing conditions. The study will compare the strength of concrete made with different types of coarse aggregate, such as crushed stone, gravel, and recycled concrete aggregate (RCA), and subjected to different curing conditions, such as standard curing, water curing, and air curing.

The findings of this study will provide valuable insights into the effect of coarse aggregate and curing conditions on the compressive strength of concrete. This information can be used by engineers and construction professionals to design and construct durable and sustainable concrete structures.

1.1 DEFINITION OF CURING

Curing refers to the process of preserving or preparing a material, substance, or product by allowing it to undergo a particular set of chemicals, physical, or biological treatments. The goal of curing is to improve the quality, safety, or durability of the material or product.

The curing process is commonly used in several industries, including food processing, medicine, construction, and manufacturing. For instance, curing can refer to the process of preserving meat or fish by adding salt, smoke, or other chemicals. In medicine, curing refers to the process of treating a disease or illness, while in manufacturing, curing can refer to the process of hardening or strengthening a material, such as plastic or concrete, by exposing it to heat or radiation.

Curing is a process that can involve different methods and techniques, depending on the specific material or product being treated. Some common methods of curing include:

Heat curing: This involves exposing the material or product to a high temperature for a specific duration. Heat curing can be used to cure adhesives, coatings, and polymers.

Chemical curing: This involves adding a curing agent or catalyst to the material, which initiates a chemical reaction that leads to curing. This method is commonly used in the manufacturing of composites, coatings, and adhesives.

Radiation curing: This involves exposing the material or product to a high-energy source of radiation, such as ultraviolet light or electron beams. Radiation curing is commonly used in the manufacturing of inks, coatings, and adhesives.

Biological curing: This involves the use of bacteria, fungi, or enzymes to cure materials or products. For example, in the production of cheese or yogurt, specific bacteria are used to curdle the milk.

The benefits of curing can include increased durability, improved strength, enhanced chemical resistance, and extended shelf life. Curing can also improve the physical and mechanical properties of materials, such as hardness, stiffness, and flexibility.

However, the curing process can also have some drawbacks. For example, some curing methods can produce harmful byproducts or emissions, which can be hazardous to human health or the environment. Additionally, the curing process can be time-consuming and expensive, depending on the method used.

Overall, curing is a crucial process in several industries, and it plays a vital role in improving the quality and safety of many products that we use in our daily lives.

In general there are three basic and common points mentioned about curing.

* Curing maintains satisfactory moisture moisture and temperature in concrete so that hydration of hydraulic cement can continue
* Curing prevents moisture loss from concrete
* Curing allows hydration reaction so that desired properties, such as strength and durability, can develop

1.2 OBJECTIVE OF THE STUDY

The objective of this research is given below

i. To compare the compressive strength of concrete with different types of coarse aggregate.

ii. To compare the compressive strength of concrete under different curing conditions.

iii. To find the type of coarse aggregate and curing condition that provide higher compressive strength to concrete.

1.3 SCOPE AND LIMITATION

The research on the effectiveness of current curing practices was studied by preparing mortar cubes and by exposing the samples to actual environmental conditions on selected construction sites. Due to time to budget conditions the research cannot be done throughout the season/year. Therefore, the effectiveness of curing practices was assessed for a specific season, which is from March – May. 0n this season the humidity is relatively low and the temperature is also relatively high. In Bangladesh there are two different types of cement produced, OPC and PPC. But due to budget constraints the study was only conducted by using Portland pozzolana cement (PPC) which is produced and consumed in high amounts in the construction industry. (Sri Ravindrarajah, R., and Tam, C. T., March 1985)

CHAPTER 2
LITERATURE RIVIEW

2.1 THE SIGNIFICANCE AND IMPORTANCE OF CURING

Curing is an essential process in concrete construction that involves maintaining the moisture content and temperature of the concrete for a specific period after it has been poured. Curing helps to ensure that the concrete develops its maximum strength, durability, and other desirable properties.

2.1.1 The following are some of the significant and essential reasons why curing is essential in concrete construction:

i. Enhances Strength Development: Proper curing promotes the hydration process of cement and allows the concrete to develop its maximum strength. If concrete is not adequately cured, it can develop cracks, which can weaken the structure and reduce its strength.
ii. Improves Durability: Curing helps to improve the durability of concrete by reducing the rate of moisture loss from the concrete. This helps to prevent shrinkage cracks and ensures that the concrete remains strong and durable over time.
iii. Reduces Surface Cracking: If concrete is not correctly cured, it can develop surface cracks due to rapid moisture loss. Proper curing helps to reduce the rate of moisture loss, preventing surface cracks and improving the aesthetic appeal of the concrete.
iv. Increases Resistance to Chemical Attack: Curing helps to increase the resistance of concrete to chemical attack by enhancing the density and strength of the concrete. This is particularly important in environments where concrete is exposed to harsh chemicals.
v. Improves Bonding: Proper curing ensures that the concrete develops good bonding properties, which are essential for proper adhesion to reinforcing steel, masonry, or other materials.

In summary, curing is an essential process in concrete construction that should not be overlooked. Proper curing ensures that the concrete develops its maximum strength, durability, and other desirable properties, which are crucial for the longevity and safety of the structure.

2.1.2 Here are some additional details on the importance of curing in concrete:

vi. Minimizes Cracking: Curing minimizes the risk of cracking by preventing rapid moisture loss, which can lead to shrinkage and cracking. Concrete that is properly cured has fewer cracks and is more resistant to cracking from external factors, such as temperature changes, load stresses, and settling of the foundation.

vii. Enhances Surface Hardness: Proper curing enhances the surface hardness of concrete, making it more resistant to abrasion and wear. This is particularly important in high traffic areas or areas that are subject to heavy use, such as industrial floors, parking lots, and sidewalks.

viii. Enhances Surface Hardness: Proper curing enhances the surface hardness of concrete, making it more resistant to abrasion and wear. This is particularly important in high traffic areas or areas that are subject to heavy use, such as industrial floors, parking lots, and sidewalks.

ix. Reduces Permeability: Curing helps to reduce the permeability of concrete, which is essential for preventing water penetration and protecting the reinforcing steel from corrosion. Concrete that is properly cured is more resistant to water damage and has a longer lifespan.

x. Improves Aesthetics: Curing helps to improve the appearance of concrete by reducing the number of surface blemishes, such as cracks and discoloration. Proper curing enhances the texture and finish of the concrete, making it more visually appealing and improving the overall aesthetics of the structure.

xi. Saves Time and Money: Proper curing saves time and money by reducing the need for repairs and maintenance. Concrete that is properly cured has fewer defects and lasts longer, reducing the need for costly repairs or replacement. Additionally, curing helps to ensure that the project stays on schedule, as delays due to repairs or replacement can be costly.

In conclusion, curing is a critical process in concrete construction that has many benefits. Proper curing enhances the strength, durability, and other desirable properties of concrete, reduces the risk of cracking, improves surface hardness, and reduces permeability. Additionally, curing improves the aesthetics of the concrete and saves time and money by reducing the need for repairs and maintenance. (Mehta, P.K.,1983)

2.2 SIGNIFICANCE OF MAINTAINING MOISTURE

Maintaining moisture in concrete is crucial during the curing process to ensure that the concrete develops its maximum strength and durability. The following are some of the significant reasons why maintaining moisture in concrete is essential:

i. Promotes Cement Hydration: The curing process involves keeping the concrete moist, which promotes the hydration process of cement. Cement hydration is a chemical

ii. reaction between water and cement, which is essential for concrete to develop its maximum strength and durability. Without sufficient moisture, the hydration process slows down, which can weaken the concrete and reduce its durability.

iii. Reduces Shrinkage: Maintaining moisture in concrete during the curing process reduces the risk of shrinkage cracks. Concrete shrinks as it dries, and if the concrete dries too quickly, it can develop shrinkage cracks. Proper moisture control during curing ensures that the concrete dries at a controlled rate, reducing the risk of shrinkage cracks.

iv. Prevents Surface Cracking: Maintaining moisture in concrete during the curing process also helps to prevent surface cracking. Surface cracking can occur due to rapid moisture loss, which can weaken the surface of the concrete. Proper moisture control ensures that the surface of the concrete remains moist, reducing the risk of surface cracking.

v. Enhances Concrete Strength: Maintaining moisture in concrete during the curing process enhances its strength by promoting the cement hydration process. The hydration process results in the formation of strong chemical bonds between cement particles, which contribute to the overall strength of the concrete.

vi. Improves Durability: Proper moisture control during the curing process also improves the durability of the concrete. Moisture helps to prevent shrinkage and surface cracking, which can weaken the concrete and reduce its durability. Concrete that is cured with proper moisture control is more resistant to damage from external factors, such as temperature changes, weather, and heavy use.

In summary, maintaining moisture in concrete during the curing process is critical to ensuring that the concrete develops its maximum strength, durability, and other desirable properties. Proper moisture control reduces the risk of shrinkage and surface cracking, enhances concrete strength, and improves its overall durability

2.3 SIGNIFICANCE OF MAINTAINING TEMPERATURE

Maintaining a consistent temperature during the curing process is critical for ensuring the quality and durability of concrete structures. High temperatures can compromise the strength development of the concrete and accelerate carbonation, leading to micro cracks and reduced durability over time. Rapid changes in temperature can cause thermal stresses and

cracking, while temperature that's too low or too high can affect the workability of the concrete. Therefore, controlling the temperature is essential for optimizing strength, preventing cracking, ensuring durability, and optimizing workability.

It's worth noting that temperature control in concrete is particularly important in extreme weather conditions. For example, in hot and dry climates, the evaporation of water from the surface of the concrete can cause it to dry out too quickly, leading to cracking and reduced strength. In contrast, in cold weather conditions, freezing and thawing can cause the concrete to expand and contract, also leading to cracking.

Another reason why temperature control is significant in concrete is that it can affect the time it takes for the concrete to reach its final strength. Generally, concrete achieves 70% of its final strength within 28 days of casting, but this can vary depending on the temperature. If the temperature is too low, the concrete may take longer to reach its final strength, while high temperatures can cause the concrete to reach its final strength too quickly, leading to reduced durability.

In conclusion, maintaining temperature in concrete is crucial for ensuring the long-term quality and durability of concrete structures. Temperature control can help optimize strength development, prevent cracking, ensure durability, and improve workability. It's important to take into account the local climate and temperature conditions to ensure proper temperature control during the curing process.

2.4 EVAPORATION FROM FRESHLY PLACED CONCRETE ON SITE

When freshly placed concrete is exposed to air, water from the concrete surface begins to evaporate. This process of water loss from the surface is called evaporation. Evaporation is a natural process that occurs whenever water is exposed to air.

2.4.1 Evaporation of water from freshly placed concrete can cause several issues if not properly managed. These issues include:

i. Cracking: Evaporation of water can cause the surface of the concrete to dry too quickly, leading to cracking.

ii. Reduced Strength: If too much water evaporates from the surface of the concrete, the remaining water may not be enough to properly cure the concrete. This can lead to reduced strength and durability.
iii. Discoloration: Evaporation can cause discoloration and mottling of the surface of the concrete, which can be difficult to correct.

2.4.2 To prevent these issues, it is important to properly manage evaporation from freshly placed concrete. Some ways to manage evaporation include:

i. Covering the concrete with plastic sheeting or other moisture-retaining materials to slow down the rate of evaporation.
ii. Using evaporation retarders, which are chemical additives that slow down the rate of evaporation.
iii. Applying a curing compound to the surface of the concrete to help retain moisture and promote proper curing.
iv. Keeping the surface of the concrete wet by spraying it with water or by using a fog misting system.

Overall, proper management of evaporation from freshly placed concrete is essential to ensure that the concrete cures properly and has the desired strength and durability.

2.5 CURING REQUIREMENTS

Curing is the process of maintaining adequate moisture and temperature in newly placed concrete to promote hydration of the cement, which results in the development of strength and durability of the concrete. Curing is a critical step in the concrete construction process, and proper curing is essential for achieving the desired strength and durability of the concrete.

The curing requirements for concrete depend on various factors, such as the type of concrete, the mix design, the weather conditions, and the intended use of the concrete. However, some general requirements for curing include:

i. Moisture: Concrete must be kept moist during the curing process to ensure proper hydration of the cement. The surface of the concrete should be kept damp by spraying it with water, using a curing compound, or covering it with wet burlap or other moisture-retaining materials.
ii. Temperature: Concrete should be kept at a temperature that promotes proper hydration of the cement. The temperature of the concrete should be maintained between 50°F to 85°F (10°C to 30°C) during the curing process.
iii. Time: Concrete should be cured for a sufficient amount of time to ensure that it reaches the desired strength and durability. The curing time can vary depending on the type of concrete, the mix design, and the weather conditions.

iv. Protection: Concrete should be protected from excessive wind, rain, and other weather conditions that can affect the curing process. Concrete should also be protected from traffic, equipment, and other activities that can damage the surface of the concrete during the curing process.

In summary, proper curing is essential for achieving the desired strength and durability of the concrete. Curing requirements depend on various factors, and it is important to follow the manufacturer's recommendations and industry standards to ensure that the concrete cures properly. (Tam, C. T., August 1977)

2.6 CURING AFFECTED ZONE IN CONCRETE

The term "curing affected zone in concrete" refers to the process of repairing or treating the damaged or weakened portion of a concrete structure by applying a curing compound or other appropriate materials. This is done to ensure that the concrete maintains its strength and durability over time, and to prevent further damage or deterioration. The process typically involves cleaning and preparing the affected area, applying the curing compound or treatment material, and allowing it to dry and cure properly. Proper curing of concrete is essential to ensure its long-term structural integrity and performance.

Concrete is a popular building material due to its strength and durability, but it is not immune to damage and deterioration over time. The curing process is an essential step in maintaining the integrity of concrete structures, especially in areas where the concrete has been affected by damage or wear.

When concrete is poured and allowed to dry, a curing process occurs naturally as the water in the mixture evaporates and the cement and other materials harden. However, in areas where the concrete has been damaged, such as cracks or areas of surface wear, the curing process can be disrupted. This can result in weaker areas of the structure that are more susceptible to further damage.

To address this issue, a curing compound or other appropriate materials can be applied to the affected area to promote proper curing and help restore the strength and durability of the concrete. The curing compound or treatment material is typically applied to the surface of the concrete and allowed to penetrate into.

He damaged the area. The material will then cure and harden, forming a strong bond with the surrounding concrete.

Proper curing is essential for maintaining the long-term performance and structural integrity of concrete structures. If not properly cured, concrete can become brittle and prone to cracking, which can lead to further damage and eventual failure of the structure. By properly curing the affected zone in concrete, the structure can be strengthened and protected against further damage, ensuring its longevity and safety.

2.7 METHODS OF CURING

There are several methods of curing concrete, and the most appropriate method depends on the type of concrete, the environmental conditions, and the intended use of the structure. Some of the common methods of curing concrete include:

i. Water curing: This is one of the most common and effective methods of curing concrete, and it involves keeping the concrete surface moist by spraying or flooding with water. The concrete is covered with a layer of wet burlap or plastic sheeting to retain moisture and prevent drying out.

ii. Membrane curing: This method involves covering the concrete surface with a thin layer of plastic sheeting or membrane, which prevents the evaporation of moisture from the concrete. The membrane is left in place until the concrete is fully cured.

iii. Chemical curing: Chemical curing involves applying a curing compound to the concrete surface. The compound reacts with the moisture in the concrete to form a protective layer, which prevents the evaporation of moisture and promotes proper curing.

iv. Steam curing: This method involves applying heat to the concrete surface using steam. The heat helps to accelerate the curing process by promoting the chemical reactions that occur when concrete is curing.

v. Insulation curing: This method involves insulating the concrete surface with materials such as blankets or foam to retain heat and moisture, which helps to promote proper curing.

The choice of curing method depends on various factors, such as the type of concrete, environmental conditions, and the intended use of the structure. The curing process should be closely monitored to ensure that the concrete cures properly, and any signs of damage or weakness should be addressed promptly to prevent further damage.

2.7 (I) WET COVERINGS

Wet coverings are materials used to protect surfaces from water or moisture. Common types include tarpaulin, plastic sheeting, waterproof membranes, and drop cloths. Choosing the right type of wet covering is important to prevent water damage and other issues.

Wet coverings are essential to prevent water damage to surfaces and protect them from moisture. Different types of wet coverings are used based on their purpose and the specific requirements of the surface being covered. Tarpaulin is a popular heavy-duty waterproof fabric made from canvas or polyethylene, which is widely used to cover roofs, outdoor furniture, and vehicles. Plastic sheeting is another type of wet covering, commonly used to cover floors, walls, and furniture during painting or construction. It is lightweight and easy to use, and available in different thicknesses depending on the required level of protection. Waterproof membranes are thin layers of material applied to surfaces to create a waterproof barrier. They are commonly used in construction, particularly in basements and bathrooms, and can be made of various materials like rubber, PVC, or asphalt. Drop cloths are large, absorbent sheets of fabric used to protect floors, furniture, and other surfaces from spills and splatters. They are commonly used during painting or other messy tasks and can be made of different materials like canvas, paper, or plastic.

Choosing the right type of wet covering is essential to prevent water damage and other issues. Tarpaulin, plastic sheeting, waterproof membranes, and drop cloths are some of the most common types of wet coverings available, and their use depends on the specific requirements of the surface being covered.

2.7 (II) PONDING OR IMMERSION

Immersion curing is a process used to cure or harden materials, such as concrete or polymers, by immersing them in a liquid. The liquid used for immersion curing is typically water, but can also be a chemical solution.

In the case of concrete, immersion curing is commonly used to prevent the loss of moisture, which is necessary for proper hydration of the cement. After concrete is poured, it is covered with a material to prevent moisture loss, and then submerged in water for a period of time. This allows the concrete to cure more evenly and with less cracking.

In the case of polymers, immersion curing can be used to improve the strength and durability of the material. The polymer is typically immersed in a chemical solution that reacts with the material to harden it. This process is often used in the production of coatings, adhesives, and composites.

Immersion curing can be an effective way to improve the properties of materials, but the specific process and liquid used can vary depending on the material and desired outcome.

CHAPTER 3
METHODOLOGY

3.1 TEST PROCEDURE

The term sieve analysis is the sample operation of diving a sample of into factions each consisting of particles between specific limits **#100, #50, #30,#16,#8,#4,3/8'', ¾'' and 1-½''** in are the ASTM standard sieves. This test method conforms to the ASTM standard requirement of specification C136.

3.2 SIEVE ANALYSIS OF AGGREGATES

The sieve analysis determines the gradation (the distribution of aggregate particles by size, within a given sample) in order to determine compliance with design, production control requirements, and verification specification.

*The sample was dried to constant weight at a temperature of 110+5°C.

*Next, the sieve was placed to decrease the size of the opening from top to bottom,

and the sample was placed on the top of the sieve.

*The sieves were agitated by hand or by mechanical apparatus for a sufficient period, say 1.5 minutes.

The quantity of material on a given sieve was limited so that all particles could reach the sieve opening a number of times during the sieving operation. The weight retained on an ant sieve at the completion of the sieving operation did not exceed the surface for sieves with openings smaller than 4.75 mm. For sieves with openings 4.75 mm and larger, they exceeded the product of 2.5 sieve openings in mm, in order to cause permanent deformation of the sieve cloth. Sieving was continued for a sufficient period and in such a manner that after completion, no more than 1% weight of the residue on any individual sieve would pass that sieve during 1 minute of continuous hand sieving.

The weight of each size increment was determined by weighing to the nearest 0.1 of the total original dry sample weight. The total weight of the material after sieving was checked closely with the original weight of the sample placed on sieves (Methods of testing concrete)

CALCULATION:

- Calculate percentage passing and total percentage retained to the nearest 0.1% of the initial dry weight of the sample
- Calculate the fineness modulus as follows fine aggregate
- F.M fine aggregate = {(cumulative % retained on #4,8,16,30,50, and 100 sieves)/100.
- F.M for coarse aggregate - {(cumulative % retained on 1-½'',¾'',3/8'', on #4,8,16,30,50 and 100 sieves)/100

3.3 PROPERTIES OF CONSTITUENT MATERIALS

The concrete mix consisted of ordinary portland cement, fine aggregate and coarse aggregate. Sand was used as fine aggregate and stone chips were used as coarse aggregate and potable water was used in the investigations for both mixing and curing.

3.3.1 CEMENT

In the most general sense of the world, cement is a binder, a substance which sets and can bind other materials together. The word 'cement' can be traced to the roman term 'opus cementitious' to describe masonry which resembles modem concrete that was made from crushed rock with burnt lime as binder. Portland cement is the most common type of cement in general usage in many parts of the world, as it is a basic ingredient of concrete. Ordinary Portland Cement shown in the below figure was used as binding material for the preparation of fresh concrete locally produced shah cement. It was free from lumps adulteration.

3.3.2 SPECIFICATIONS OF CEMENT:

- Name : **Crown Cement** (Portland Composite Cement)
- Specific gravity of cement – 3.15
- Setting times of cement : i) initial setting time – 30 minutes,
- ii) Final setting time : 10 Hours
- Weight : 50 Kg.
- BDS EN 197-1 : 2003 CEM II / B – M (S-V-L) 42.5N
- Clinker : 70-79%
- Limestone : 21-30%

- Gypsum : 0-5%

Application: Crown Cement is a multi-purpose cement applicable for a wide range of construction works:

- Especially suitable for building foundations, slab & any RCC members.
- Also suitable for bridges and flyovers etc.

Figure: -1: Cement as Binding Material

(Crown Cement)

3.3.3 FINE AGGREGATE

It is the aggregate most of which passes through No.4 (4.75mm) sieve and contains only that much coarser material as it is permitted by the specifications. Same type of sand was used as the fine aggregate for both with admixture and without admixture in this study as shown in below figure. The sand was washed with water and air dried before being used to obtain Saturated Surface (SSD) condition.

Figure-2: Sand as Fine Aggregate

3.3.4 COARSE AGGREGATE

Generally stone chips, crushed brick chips are used as coarse aggregate. In this study **Stone Chips** (Local Sylhet) had been used as a coarse aggregate as shown in the Figure. For the preparation of concrete, 20 mm downgraded crushed stone chips were used as coarse aggregate. The aggregate most are retained on the 4.75 mm sieve. The coarse aggregate was properly washed to remove dust and dried up before using in the preparation of concrete.

Figure-3: Stone Chips as Coarse Aggregate

Safety Instructions & Safety Precautions

- Accidental splashes on skin must be washed off with water and soap.
- In contact with eyes or mucous membrane, rinse with clean warm water and seek medical attention without delay.
- Do not dispose of water or soil but according to local regulations.
- Non-toxic under the relevant Swiss Health and Safety Codes.
- Non-hazardous.

3.4 PREPARATION OF CONCRETE CYLINDERS

We have twelve steel cylinders; the cylinders were the same sizes (4”X8”). And we will make 24 concrete cylinders. By using oil to wipe the inside of the molds for its easy removal after hardening of the concrete as shown in the below figure. Fresh concrete was prepared as per ratio (1:1.5:3). The fresh concrete was placed in the mold in four layers and compacted by using 16mm (5/8”) diameter and 600mm (24”) in length tampering rod with hemispherical tip. In all cases the number of tamping was randomly 25 times per layer. Proper compaction was ensured over the cross-section of the mold through uniform distribution of the temping strokes. Then the specimen was stored undisturbed for 24 hours in such a way that prevents moisture loss and maintains the specimen within room temperature. Weight batching is the correct method of measuring the materials. For important concrete, invariably, a weight batching system should be adopted. In this study weight batching has been used for measuring the materials.

Figure-4: Preparing of Molds- Cleaning works

Figure-5: Constructed Concrete Cylinders

3.5 CURING PROCESS OF CYLINDERS

After completion of cylinder casting, we can go to curing. Here, we can use two type curing method:

a) Immersion Curing Method

b) Wet Covering Curing Method

Figure-6: Immersion and Wet Covering Curing Method of Concrete Cylinders

3.6 CURING PROCESS OF CYLINDERS

We can use the Universal Testing Machine (UTM) for compressive strength tests of RCC cylinders. There are some images of compressive strength test-

Figure-7: Concrete Cylinder after Crushing

CHAPTER 4

TEST RESULT AND ANALYSIS

4.1 TEST RESULTS

Test results of fine aggregates, coarse aggregate (Bhurungamari Stone, Indian Black Stone), binding materials and RCC.

4.1.1 TEST FOR FINE AGGREGATE (SYLHET SAND

- Sieve analysis of fine aggregate (Sylhet Sand F.M.-2.74)
- Dust free sand
- Sand is washed by fresh water before using etc.

Sieve No.	Materials Retained (gm.)	% Materials Retained	Cumulative % Retained	% Finer
# 4	0	0.00%	0.00%	100.00%
# 8	24	4.8%	4.8%	95.2%
# 16	159	31.8%	36.6%	63.4%
# 30	186	37.2%	73.2%	26.8%
# 50	109	21.8%	95%	5%
# 100	18	3.6%	98.6%	1.4%
Pan	4	0.8%	99.4%	0.6%
Total	500		F.M. =	2.92

Table-4.1 : FM of sand

4.2 THE RESULT OF MIX DESIGN (GIVEN)

- **1:1.5:3**

4.3 PREPARATION OF CYLINDERS (CONCRETE SPECIMEN)

- In all sets of cylinders cement content, water content, fine aggregate (Sylhet Sand) content and coarse aggregate content were same.

4.4 RESULTS & DISCUSSIONS

This result can be used to determine the correlation of compressive strength of concrete cylinder and the recommended curing period respectively. The result as the strength increases with the decreases of curing time interval.

4.4.1 COMPRESSIVE STRENGTH RESULTS (7 DAYS CYLINDER TEST RESULTS)

It is observed from the test results that the wet covering method of curing gave better strength (12.23 MPa) of cylinder for Indian Black Stone at 7 days. On the other hand, in immersion curing method Bhurungamari Stone gave better strength (17.37 MPa) of cylinder.

Method of Curing		Dia of Cylinder (mm)	Height of Cylinder (mm)	Weight of Cylinder (kg)	Crushing Value (KN)	Compressive Strength (MPa or N/mm^2)	Average Compressive Strength (MPa)
Wet Covering	Indian Black Stone	102	201	4.92	100	12.24	12.23
		100	205	4.46	96	12.22	
	Bhurungamari Stone	100	204	4.13	93	11.84	12.04
		102	204	3.79	100	12.24	
Immersion	Indian Black Stone	100	205	4.21	110	14	14.63
		98	203	4.12	115	15.25	
	Bhurungamari Stone	99	204	4.0	135	17.54	17.37
		100	203	3.94	135	17.19	

Table 4.2 : 7 Days Cylinder Test Results

4.4.2 COMPRESSIVE STRENGTH RESULTS (14 DAYS CYLINDER TEST RESULTS)

It's observed from the test results that the wet covering method of curing gave better strength (16.06 MPa) of cylinder for Bhurungamari Stone at 14 days. Similarly, in immersion curing method Bhurungamari Stone gave better strength (18.09 MPa) of cylinder.

Method of Curing	Dia of Cylinder (mm)	Height of Cylinder (mm)	Weight of Cylinder (kg)	Crushing Value (KN)	Compressive Strength (MPa or N/mm^2)	Average Compressive Strength (MPa)

Wet Covering	Indian Black Stone	101	205	4.07	107	13.36	14.17
		101	201	4.2	120	14.98	
	Bhurungamari Stone	101	201	3.97	120	14.98	16.06
		102	203	4	140	17.13	
Immersion	Indian Black Stone	102	201	4.07	127	15.54	16.22
		99	205	4.13	130	16.89	
	Bhurungamari Stone	101	201	4.10	142	17.72	18.09
		101	203	4.13	148	18.47	

Table 4.3 : 14 Days Cylinder Test Results

4.4.3 COMPRESSIVE STRENGTH RESULTS (28 DAYS CYLINDER TEST RESULTS)

It’s observed from the test results that the wet covering method of curing gave better strength (20.71 MPa) of cylinder for Bhurungamari Stone at 28 days. On the contrary, in immersion curing method Indian Black Stone gave better strength (23.38 MPa) of cylinder.

Table 4.4 : **28 Days Cylinder Test Results**

Method of Curing		Dia of Cylinder (mm)	Height of Cylinder (mm)	Weight of Cylinder (kg)	Crushing Value (KN)	Compressive Strength (MPa or N/mm^2)	Average Compressive Strength (MPa)
Wet Covering	Indian Black Stone	101	201	4.21	150	18.72	19.04
		101	205	3.99	155	19.35	
	Bhurungamari Stone	101	201	3.97	170	21.22	20.71
		102	203	3.96	165	20.19	
Immersion	Indian Black Stone	102	201	4.17	190	23.25	23.38
		99	205	4.23	181	23.51	
	Bhurungamari Stone	101	201	3.97	145	18.09	18.22
		101	204	4.13	147	18.35	

Table 4.5 : Average of the Cylinder Test Results

Method of Curing		7 Days Test Results (MPa)	14 Days Test Results (MPa)	28 Days Test Results (MPa)
Wet Covering	Indian Black Stone	12.23	14.17	19.04
	Bhurungamari Stone	12.04	16.06	20.71
Immersion	Indian Black Stone	14.63	16.22	23.38
	Bhurungamari Stone	17.37	18.09	18.09

4.4.4 UNIT WEIGHT RESULTS (7 DAYS CYLINDER TEST RESULTS)

It's observed from the test results that both the wet covering and immersion method of curing gave better unit weight for Indian Black Stone at 7 days.

Table 4.6 : 7 Days Cylinder Test Results

Method of Curing		Dia of Cylinder (mm)	Height of Cylinder (mm)	Weight of Cylinder (kg)	Unit weight (kN/m^3)	Average Unit weight (kN/m^3)
Wet Covering	Indian Black Stone	102	201	4.92	29.39	27.94
		99	205	4.26	26.48	
	Bhurungamari Stone	100	204	4.13	25.29	24.8
		100	204	3.97	24.31	
Immersion	Indian Black Stone	100	205	4.21	25.65	26.02
		98	203	4.12	26.39	
	Bhurungamari Stone	99	204	4.00	24.99	24.62
		100	203	3.94	24.24	

4.4.5 UNIT WEIGHT RESULTS (14 DAYS CYLINDER TEST RESULTS)

It's observed from the test results that both the wet covering and immersion method of curing gave better unit weight for Indian Black Stone at 14 days.

Table 4.7 : 14 Days Cylinder Test Results

Method of Curing		Dia of Cylinder (mm)	Height of Cylinder (mm)	Weight of Cylinder (kg)	Unit weight (kN/m^3)	Average Unit weight (kN/m^3)
Wet Covering	Indian Black Stone	101	205	4.07	24.31	24.95
		101	201	4.2	25.59	
	Bhurungamari Stone	101	201	3.97	24.18	23.86
		102	204	4	23.54	
Immersion	Indian Black Stone	102	201	4.07	24.31	24.96
		99	205	4.12	25.61	
	Bhurungamari Stone	101	201	4.10	24.98	24.95
		101	203	4.13	24.91	

4.4.6 UNIT WEIGHT RESULTS (28 DAYS CYLINDER TEST RESULTS)

It's observed from the test results that both the wet covering and immersion method of curing gave better unit weight for Indian Black Stone at 28 days

Table 4.8 : 28 Days Cylinder Test Results

Method of Curing		Dia of Cylinder (mm)	Height of Cylinder (mm)	Weight of Cylinder (kg)	Unit weight (kN/m^3)	Average Unit weight (kN/m^3)
Wet Covering	Indian Black Stone	101	201	4.21	25.65	24.74
		101	205	3.99	23.83	
	Bhurungam	101	201	3.97	24.18	22.69

	ari Stone	102	204	3.6	21.19	
Immersion	Indian Black Stone	102	201	4.17	24.91	25.6
		99	205	4.23	26.29	
	Bhurungamari Stone	101	201	3.97	24.18	24.49
		101	204	4.13	24.79	

Table 4.9 : Average of the Cylinder Test Results

Method of Curing		7 Days Test Results (kN/m^3)	14 Days Test Results (kN/m^3)	28 Days Test Results (kN/m^3)
Wet Covering	Indian Black Stone	27.94	24.95	24.74
	Bhurungamari Stone	24.8	23.86	22.69
Immersion	Indian Black Stone	26.02	24.96	25.6
	Bhurungamari Stone	24.62	24.95	24.49

Chapter 5

CONCLUSION

5.1 CONCLUSION

The compressive strength of concrete cylinder for immersion curing was greater than that of wet covering curing method in most of the cases. At 7 days of curing, compressive strength for wet covering curing showed 12.23 MPa and 12.04 MPa for Indian Black Stone and Bhurungamari Stone respectively. On the other hand, in immersion, compressive strengths were 14.63 MPa for Indian Black Stone and 17.37 MPa for Bhurungamari stone. In 14 days of curing, compressive strength for wet covering curing showed 14.17 MPa for Indian Black Stone and 16.06 MPa for Bhurungamari Stone. Then, we found that 28 days of curing compressive strength for Indian Black Stone in wet covering curing showed 19.04 MPa and for Bhurungamari Stone the strength was 20.71 MPa. Finally, we found that 28 days of curing compressive strength for Indian Black Stone in immersion curing was 23.38 MPa and for Bhurungamari Stone the strength was 18.09 MPa. So, it can be concluded that the Bhurungamari Stone and the immersion curing method gives higher compressive strength than Indian Black Stone and wet covering curing method respectively.

5.2 RECOMMENDATION

Due to constraints of tie and scope, there were some limitations in the findings of this experiment. So, some recommendations are made for further investigation.

- Most of Construction project, they use hessian cloth for membrane curing. Here just done an experiment, where how can we get maximum compressive strength by membrane curing & also find the average curing time interval in a day.
- Various w/c may be considered within a reasonable range to know the change of strength for variation of w/c ratio.
- Concrete with different proportions may be used (suppose 1:2:4 and 1:3:6).

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