A COMPARATIVE STUDY ON THE COMPRESSIVE STRENGTH OF CONCRETE FOR DIFFERENT COARSE AGGREGATE UNDER VARIOUS CURING CONDITIONS

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



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147/1, Green Road, Dhaka-1215, Bangladesh

Section: 23A+23E

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Dedicated

To

"Our Beloved Parents"

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ABSTRACT

Concrete is a mixture of cement, sand and stone chips in some specified proportion which is generally used for R.C.C and C.C. We have worked on a comparative study about the effect of membrane curing of concrete. Firstly, 36 concrete cylinders of 4 x 8 inch were made and twelve of them were cured continuously in the bathtub for immersion method. Another twelve of the cylinder was covered with jute membrane like the local construction side and cured 2 hours to 3-hours intervals. Rest of them without any covering cured 2 hours to 3-hours intervals. Curing were done for 7 days and 28 days. Mixing and curing water is one of the components required, and it should be suitable for producing concrete. In this study two different stone type used to observe the difference effected concrete with various curing method.

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.

In this study, it is observed that The Indian pakur stone gave better compressive strength value in both spraying curing method (14.809 MPa) and wet covering (14.470 MPa) method for 7 days' test. The wet covering method of curing gave high compressive strength (27.770 MPa) for 28 days curing test. 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 the utmost importance.

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CHAPTER-1
INTRODUCTION

1.1 GENERAL

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 and subjected to different curing conditions, such as wet covering curing, immersed water curing and spraying water 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.

1.2 SIGNIFICANCE OF THE STUDY

Curing may be described as the process of controlling the relative humidity and temperature of newly poured concrete for a certain amount of time after it has been cast or finished to ensure that the cement has been properly hydrated and the concrete has hardened. Once curing is

finished, the concrete can no longer grow strength since the cement can no longer be able to hydrate. The process requires adequate moisture, temperature and time. If any of these parameters is missing in the early period of hydration of concrete, the desired strength of concrete cannot be obtained. Hydration is the most significant part in the process of curing. Without enough water, hydration cannot occur, and the final concrete could not be as strong and impermeable as desired. Additionally, due to premature concrete drying, micro-cracks or shrinkage cracks would appear on the concrete's surface. When concrete is exposed to the environment, water evaporates and the original water-to-cement ratio is reduced. This causes the cement to only partially hydrate, degrading the quality of the concrete. Curing has to play a very vital role in the development of compressive strength of concrete. It is required for completing the hydration reaction in cement and concrete. It is further required for prevention of loss of water from concrete through evaporation and hence the self-desiccation (dryness due to internal water-loss and hence the weakening) of concrete, for capillary segmentation and maintaining a conductive temperature within concrete. It is also very important to produce strong, durable, water-tight and impermeable concrete member. Contrary to this, if curing is not properly carried out, it can result in inadequate strength, drying and shrinkage of concrete, formation of cracks and poorly segmented capillaries.

1.3 OBJECTIVE OF THE STUDY

The objectives of this research are given below:

- To determine the compressive strength of concrete by using two different types of coarse aggregate.
- To identify suitable curing method by comparing compression strength test.
- To access the current curing practices and to explore the adequacy or effectiveness of curing practices in Bangladesh.

1.4 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 to 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.

CHAPTER-2
LITERATURE REVIEW

2.1 PREVIOUS BACKGROUND OF THE STUDY

This section presents literature relevant to Compressive Strength of Concrete in different types of curing conditions. Curing of concrete products may start after 24 hours of costing the concrete and can be done in various ways and methods.

Many studies have been conducted to investigate the effect of curing water quality on the mechanical strength of concrete. Carlos Thomas et al. (2019) accomplished an article on "Influence of Curing Condition on Recycled Aggregate Concrete" in the Magazine of Concrete Research. In his research he found the result of the concretes cured in a marine environment are compared with the result of the concrete cured in a humidity chamber.

S. Islam et al. (2018) investigated the effect of various curing methods on the mechanical strength of concrete. The researchers found that immersion curing in fresh water for 28 days resulted in the highest compressive strength of the concrete, followed by steam curing and air curing. The researchers noted that immersion curing allowed for the most effective hydration of the cement, resulting in a higher strength.

Ahmed, S. and Hay, A. (2015) investigated the properties of recycled concrete aggregate under different curing conditions. The researchers found that Curing with Paint material is beneficial in all cases and ages than water or air curing except in the case of full replacement where the maximum value of the compressive and tensile strengths in this case, was obtained at curing using water.

Aitcin, P. C. et al. (1994) studied "The Effects of Size and Curing on Cylinder Compressive Strength of Normal and High-Strength Concrete". In their study, they found the highest compressive strength for wet covering method than immersion method.

2.2 THE IMPORTANCE OF CURING

Proper curing is essential process in concrete construction for ensuring the moisture content, longevity, strength, temperature and overall quality 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.

The following are some of the significant and essential reason why curing is essential in concrete construction.

Enhanced Structural Performance

- Load-Bearing Capacity: Properly cured concrete can better withstand loads and stresses, ensuring the safety and performance of the structure.
- Longevity of Structures: Curing contributes to the longevity of concrete structures, making them more reliable and less prone to long-term deterioration.

Durability and Longevity

- Resistance to Environmental Damage: Proper curing enhances concrete's resistance to weathering, chemical attacks, and freeze-thaw cycles, thus improving its durability.
- Reduced Permeability: Well-cured concrete is less permeable, making it more resistant to water infiltration and related damage.

Strength Development

- Hydration of Cement: Curing provides the necessary moisture for cement to fully hydrate, which is crucial for the development of concrete's strength.
- Achieving Full Strength: Without adequate curing, concrete may not achieve its designed compressive strength, compromising the structural integrity.

Volume Stability

- Controlling Shrinkage: Curing helps maintain volume stability by preventing premature drying and ensuring uniformity in the concrete's internal structure.
- Reducing Thermal Cracking: Proper curing conditions help manage the concrete's temperature, reducing the risk of thermal cracking.

Minimizing Defects

- Prevention of Cracking: Curing helps control the rate of water evaporation, reducing the likelihood of shrinkage cracks and other defects.
- Improved Surface Quality: Adequately cured concrete has a better surface finish, reducing problems like scaling, crazing, and dusting.

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.

Improves Bonding

Proper curing ensures that the concrete develops good bonding properties, which are essential for proper adhesion to reinforcing steel, masonry, or other material.

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.

Improves Aesthetics

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

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 and aesthetics of the concrete and saves time and money by reducing the need for repairs and maintenance.

2.3 IMPORTANCE 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.

Cement Hydration: The curing process involves keeping the concrete moist, which promotes

the hydration process of cement. Cement hydration is a chemical process where cement working as a bonding materials. 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.

Strength Development: Proper moisture levels during the curing process are essential for concrete to achieve its optimal strength and durability. Without adequate moisture, concrete can cure too quickly, leading to weaker structures.

Sustainability: Efficient moisture management in construction processes contributes to the sustainability of the project by reducing the need for repairs and maintenance.

Energy Efficiency: Moisture control in building envelopes improves the energy efficiency of buildings by preventing issues like mold and dampness, which can compromise insulation.

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.

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.

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.

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.

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.

2.4 IMPORTANCE 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.

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

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

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.

Discoloration: Evaporation can cause discoloration and mottling of the surface of the concrete, which can be difficult to correct.

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

1. Covering the concrete with plastic sheeting or other moisture-retaining materials to slow down the rate of evaporation.
2. Using evaporation retarders, which are chemical additives that slow down the rate of evaporation.
3. Applying a curing compound to the surface of the concrete to help retain moisture and promote proper curing.
4. 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.

2.6 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-

1. **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.

2. **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.

3. **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.

4. **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.

2.7 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. 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.

2.8 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:

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.

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.

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.

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.

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.

Wet Covering: 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.

Ponding and 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.

Spraying Water: By spraying a fine mist of water regularly over concrete (a process known as ‘fogging’), the humidity is raised to help maintain moisture. It can also aid in reducing the temperature of the concrete during hot weather conditions. As with all methods of curing, it is important to keep the concrete permanently moist.

Spraying of water may be done manually. These concrete curing methods can be adopted for both horizontal and vertical concrete surfaces. However, huge availability of water is necessary throughout the curing period and round the clock. There is more wastage of water and it needs a drainage system to handle run-off. By using nozzles or sprayers; we can sprinkle the water frequently to raise the relative humidity of the air.

CHAPTER-3
METHODOLOGY

3.1 MATERIALS

In this study, cement, fine aggregate, coarse aggregate and fresh water are used to reduce desire concrete mix. 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.

Cement

Cement, in general, adhesive substances of all kinds, but, in a narrower sense, the binding materials used in building and civil engineering construction. Cements of this kind are finely ground powders that, when mixed with water, set to a hard mass. Setting and hardening result from hydration, which is a chemical combination of the cement compounds with water that yields submicroscopic crystals or a gel-like material with a high surface area. Because of their hydrating properties, constructional cements, which will even set and harden under water, are often called hydraulic cements. The most important of these is Portland-cement.

Specifications of Cement

Name	: Fresh 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%

Fine aggregate

Aggregate significantly influences rheological and mechanical properties on both mortars and concrete. Fine aggregate being a main component in concrete production has a significant part to play in influencing concrete strength. Sand is commonly used as the standard material for a fine aggregate. In this 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 3-1. Sand as Fine Aggregate

Coarse aggregate

Aggregate materials help to make concrete mixes more compact. They also decrease the consumption of cement and water and contribute to the mechanical strength of the concrete, making them an indispensable ingredient in the construction and maintenance of rigid structures aggregate materials help to make concrete mixes more compact. They also decrease the consumption of cement and water and contribute to the mechanical strength of the concrete, making them an indispensable ingredient in the construction and maintenance of rigid structures. Coarse aggregates are particulates that are greater than 4.75mm. The usual range employed is between 9.5mm and 37.5mm in diameter.

In this study two different type of stone chips (Dubai LC stone and Indian Pakur stone) had been used as a coarse aggregate as shown in the Figure.



Figure 3-2. Indian Pakur stone



Figure 3-3. Dubai LC stone

Water

Water is critical in the making of concrete. Adding water to the mix sets of a chemical reaction when it comes into contact with the cement. The water used in the mixing of concrete is usually of a potable standard. Using non-drinking water or water of unknown purity risks the quality and workability of the concrete.

3.2 SEIVE ANALYSIS

For particle size distribution for both coarse and fine aggregate sieve analysis method ware uses according ASTM Cl36.

For sieve analysis, following apparatuses ware used-

a) Balance;

b) Sieves;

c) Oven and

d) Containers.

e) Brash.

3.3 TEST PROCEDURE

- Clean the sieves of sieve shaker using cleaning brush if any particles are struck in the openings.

- Record the weight of each sieve and receiving pan.
- Dry the specimen in oven for 3-4 minutes to get the dried specimen (ignore, if the specimen is already dried).
- Weigh the specimen and record its weight.
- Arrange the sieves in order as the smaller openings sieve to the last and larger openings sieve to the top. (Simply, arrange them to the ascending order of sieve numbers – No.4 sieve on top and no.200 sieve at bottom)- Sieve numbers and the particle sizes are provided below in a chart for further understanding.
- Keep the weight recorded specimen on the top sieve and then keep the complete sieve stack on the sieve shaker (Don't forget to keep the lid and receiving pan).
- Allow the shaker to work 10-5 minutes – use the clock here.
- Remove the sieve stack from the shaker and record the weight of each sieve and receiving pan separately.



Figure 3-4. Sieve Analysis

3.4 CONCRETE MIX PROPERTIES

For this Research mixture proportion of concrete were determine in accordance with following condition: -

- Water/Cement Ratio 0.46
- Mixing Ratio 1:1.5:3.

3.5 CONCRETE MOULDING PROCEDURE

- For compressive and tensile strength test, steel cylindrical mold was used. Height and diameter of the mold were 200mm and 100mm respectively.
- Molds were cleaned and grease was applied on the inner surface of the mold.
- Concrete was filled in the mold in 3 layers.
- Each layer was rodded 25 time in an even pattern using a tamping rod.
- After tamping, the top surface is leveled.
- The molded specimens were kept at normal temperature to dry.



Figure 3-5. Concrete Mixing and Molding



Figure 3-6. Mold of Cylinder

3.6 CURING PROCESS OF CYLINDERS

After 24 hours of casting, the concrete specimens were removed from the mold and allowed for curing. Here, we used three type curing method:

i. Immersion Curing Method
ii. Wet Covering Curing Method
iii. Spraying Water Curing Method



Figure 3-7. Immersion Curing Method



Figure 3-8 Wet Covering Curing Method



Figure 3-9. Spraying Water Curing Method

3.7 COMPRESSIVE STRENGTH TEST 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 3-10. Universal Testing Machine (UTM)

CHAPTER - 4
RESULT AND DISCUSSION

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.

4.1 SIEVE ANALYSIS OF SAND

The test sample of the aggregate (F.M) shall weigh, after drying.

Table 4-1. Sieve Analysis of Sand

Sieve No.	Materials Retained (gm.)	Cumulative Materials Retained (gm.)	Cumulative % Retained	% of passing	FM
# 4	4	4	0.4%	99.6%	2.542
# 8	42	46	4.6%	95.4%	
# 16	204	250	25%	75%	
# 30	196	446	44.6%	55.4%	
# 50	373	819	81.9%	18.1%	
#100	158	977	97.7%	2.3%	
Pan	23	-	-		
Total	1000	Total	254.2		

4.2 SIEVE ANALYSIS OF DUBAI LC

Table 4-2. Sieve Analysis of Dubai LC

Sieve No.	Materials Retained (gm.)	Cumulative Materials Retained (gm.)	Cumulative % Retained	% of passing
1''	0	0	0%	100%
¾''	35	35	2.33%	97.67%
3/8''	1324	1359	90.6%	9.4%
#4	41	1500	100%	0%

4.3 SIEVE ANALYSIS OF INDIAN PAKUR

Table 4-3. Sieve Analysis of Indian Pakur

Sieve No.	Materials Retained (gm.)	Cumulative Materials Retained (gm.)	Cumulative % Retained	% of passing
1''	0	0	0%	100%
¾''	458	458	30.5%	69.5%
3/8''	988	1446	96.4%	3.6%
#4	54	1500	100%	0%

4.4 SPECIFIC GRAVITY OF FINE AGGREGATE

Table 4-4. Data sheet for specific gravity of fine aggregate

Wt. of pycnometer Filled with water to Calibration, B gm	Oven Dry Wt. in air, A gm	Wt. of pycnometer with Specimen and water to Calibration mark, C gm	Wt. of S.S.D. sample in Air, S gm
654 gm	290 gm	836 gm	300 gm

Table 4-5. Specific gravity of fine aggregate

Test	Formula	Calculation	Result
Apparent Specific Gravity	$\frac{A}{B + A - C}$	$\frac{290}{654 + 290 - 836}$	2.685
Bulk SG (Oven Dry Basic)	$\frac{A}{B + S - C}$	$\frac{290}{654 + 300 - 836}$	2.457
Absorption Capacity, D%	$\frac{S - A}{B} * 100$	$\frac{300 - 290}{290} * 100$	3.450
Bulk SG (S.S.D. Basic), G	$\frac{S}{B + S - C}$	$\frac{300}{654 + 300 - 836}$	2.542

The apparent specific gravity of the local sand as fine aggregate after oven drying was found 2.685. We found the bulk specific gravity for oven dry basic was 2.457. Absorption capacity redaction received 3.450. And bulk SSD received 2.542.

4.5 SPECIFIC GRAVITY OF COARSE AGGREGATE

Table 4-6. Data sheet for specific gravity of coarse aggregate (Dubai LC)

Wt. of S.S.D sample in air, B (gm)	Wt. of S.S.D. sample in water, C (gm)	Oven dry Wt. of sample in air, A (gm)
1700 gm	1115 gm	1645 gm

Table 4-7. Specific gravity of coarse aggregate (Dubai LC)

Test	Formula	Calculation	Result
Apparent Specific Gravity	$\frac{A}{A - C}$	$\frac{1645}{1645 - 1115}$	3.10
Bulk Specific Gravity (Oven Dry Basic)	$\frac{B}{B - C}$	$\frac{1700}{1700 - 1115}$	2.91
Bulk Specific Gravity (S.S.D. Basic), G	$\frac{A}{B - C}$	$\frac{1645}{1700 - 1115}$	2.81
Absorption Capacity, D %	$\frac{(B - A) * 100}{A}$	$\frac{(1700 - 1645) * 100}{1645}$	3.34

The apparent specific gravity of the Dubai L.C after oven drying was found 3.10. We found the bulk specific gravity for oven dry basic was 2.91. Absorption capacity redaction received 3.34. And bulk SSD received 2.81.

Table 4-8. Data sheet for specific gravity of coarse aggregate (Indian pakur)

Wt. of S.S.D sample in air, B (gm	Wt. of S.S.D. sample in water, C (gm)	Oven dry Wt. of sample in air, A (gm)
2105 gm	1350 gm	2020 gm

Table 4-9. Specific gravity of coarse aggregate (Indian pakur)

Test	Formula	Calculation	Result
Apparent Specific Gravity	$\frac{A}{A-C}$	$\frac{2020}{2020-1350}$	3.01
Bulk Specific Gravity (Oven Dry Basic)	$\frac{A}{B-C}$	$\frac{2020}{2105-1350}$	2.67
Bulk Specific Gravity (S.S.D. Basic), G	$\frac{B}{B-C}$	$\frac{2105}{2105-1350}$	2.79
Absorption Capacity, D %	$\frac{(B-A)*100}{A}$	$\frac{(2105-2020)*100}{2020}$	4.21

The apparent specific gravity of the Indian Pakur after oven drying was found 3.01. We found the bulk specific gravity for oven dry basic was 2.67. Absorption capacity redaction received 4.21. And bulk SSD received 2.79.

4.6 CYLINDER TEST RESULTS

Table 4-10. 7 Days Cylinder Test Results

Types of stone	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)
Method of Curing (Wet Covering)						
Dubai LC Stone	102.3	204	4.108	112	13.626	12.491
	102.25	204	4.055	75	9.134	
	101.9	205.5	4.094	120	14.714	
Indian Pakur Stone	102.4	206	4.199	125	15.178	14.470
	102.6	205.5	4.156	120	14.514	
	101.5	205	4.001	111	13.718	
Method of Curing (Immersion)						
Dubai LC Stone	101.4	204.4	4.020	109	13.498	13.837
	101.9	205	4.057	110	13.488	
	101.7	205	4.082	118	14.526	
Indian Pakur Stone	102.5	205.5	4.104	97	11.755	12.618
	102.6	205.5	4.044	100	12.095	
	102.7	206	4.121	116	14.003	
Method of Curing (Spraying water)						
Dubai LC Stone	101.4	199	3.934	120	14.86	13.985
	102.65	205	4.031	116	14.017	
	101.1	206	4.057	105	13.08	
Indian Pakur Stone	102.2	205	4.093	122	14.872	14.809
	102.2	205	4.112	127	15.481	
	102	205	3.981	115	14.074	

It is observed from the test results that both the wet covering method & spraying water method of curing gave better strength of cylinder for Indian Black Stone at 7 days.

Table 4-11. 28 Days Cylinder Test Results

Types of stone	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)
Method of Curing (Wet Covering)						
Dubai LC Stone	103.30	205	4183	233	27.801	27.770
	101.33	205.5	4040	227	28.149	
	103.23	206	4050	229	27.361	
Indian Pakur Stone	103	206.5	4178	220	26.403	26.744
	102.32	206	4037	217	26.391	
	102.18	206	4038	225	27.439	
Method of Curing (Immersion)						
Dubai LC Stone	102.58	206	4161	215	26.015	24.808
	102.68	205	4175	205	24.757	
	103.76	205.5	4210	200	23.653	
Indian Pakur Stone	102.48	205.5	4056	185	22.429	23.175
	102	205	4116	195	23.864	
	102.58	205	4159	192	23.232	
Method of Curing(Spraying water)						
Dubai LC Stone	102.46	205.5	4128	212	25.712	25.735
	101.77	206	4131	225	27.660	
	102.85	205	3982	198	23.832	
Indian Pakur Stone	102.7	206	4034	193	23.298	23.827
	101.92	205.5	3923	187	22.921	
	102.14	206	4128	207	25.263	

It is observed from the test results that the wet covering method of curing gave better compressive strength value for both Dubai LC Stone & Indian Black Stone at 28 days. On the contrary immersion curing method showing lowest strength at 28 days compressive strength test.

Table 4-12. Summary of the Cylinder Test Results

Types of stone	7 Days Test Results (MPa)	28 Days Test Results (MPa)
Method of Curing (Wet Covering)		
Dubai LC Stone	12.491	27.770
Indian Pakur Stone	14.470	26.744
Method of Curing (Immersion)		
Dubai LC Stone	13.837	24.808
Indian Pakur Stone	12.618	23.175
Method of Curing (Spraying water)		
Dubai LC Stone	13.985	25.735
Indian Pakur Stone	14.809	23.827

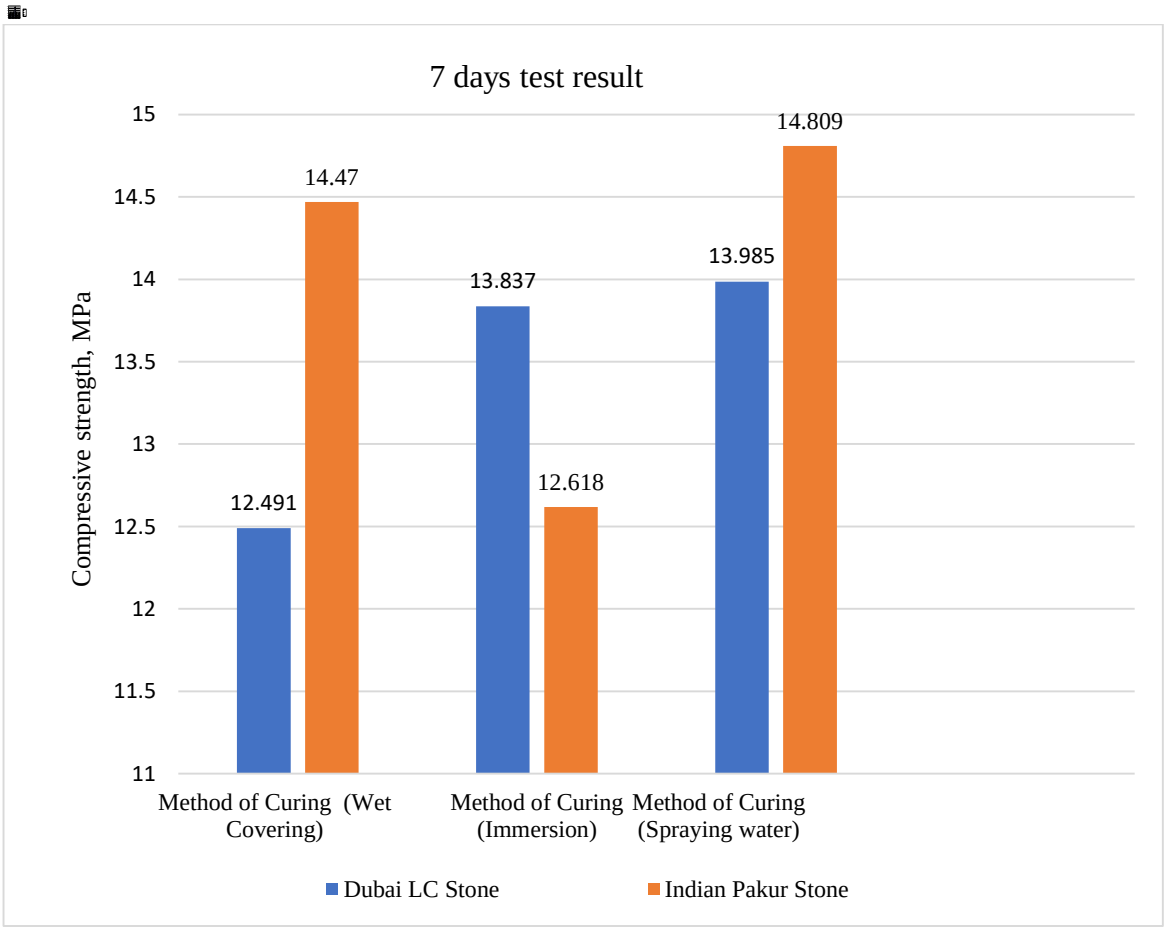


Figure 4-1. 7 Days Test Result

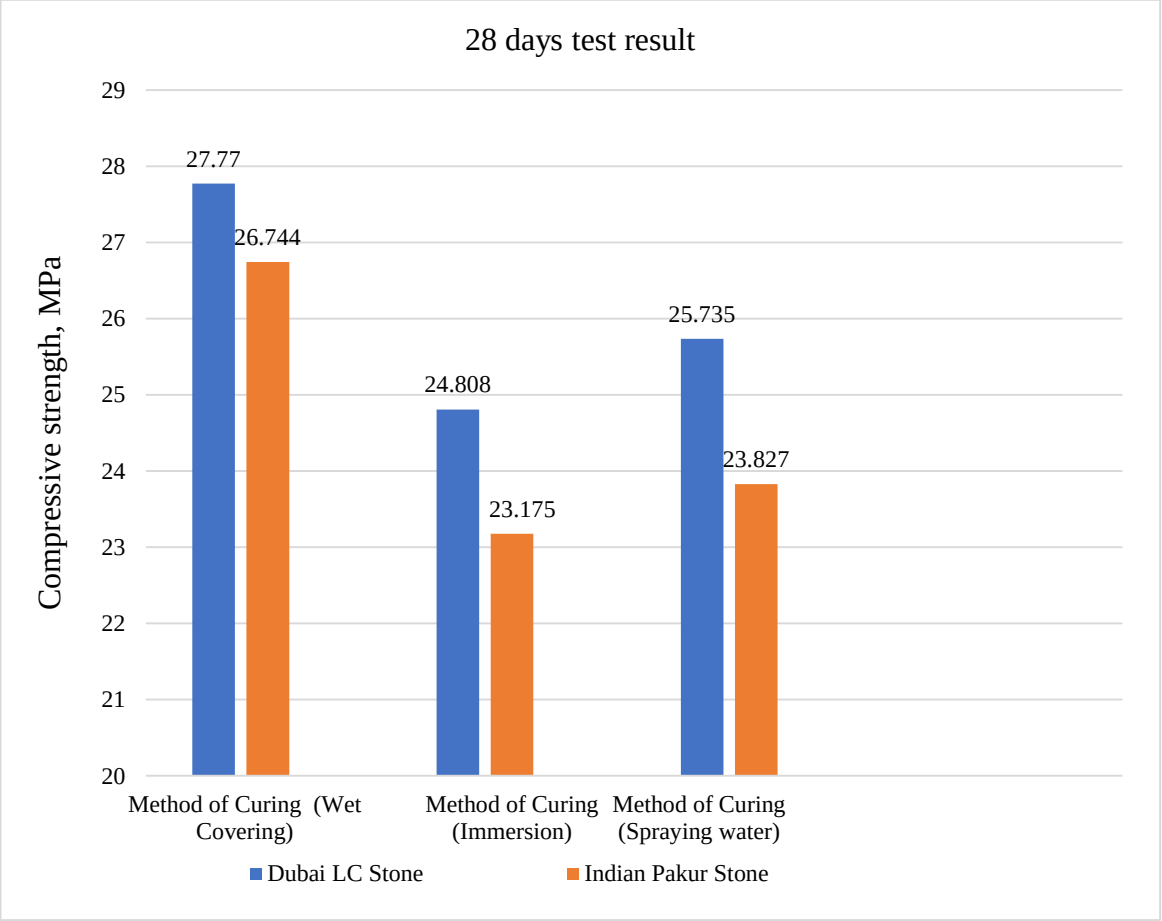


Figure 4-2. 28 Days Test Result

- The development of good compressive strength in wrapped and water curing is credited to sufficient moisture and suitable vapor pressure, which were maintained to continue the hydration of cement.

- The strength results of wrapped curing also indicate that a good gain in compressive strength can be achieved if the moisture content maintained in the concrete properly.

CHAPTER – 5
CONCLUSION AND FUTURE WORKS

5.1 CONCLUSION

The main findings of the study are mentioned below –

- In all the experiment of curing (wet covering, immersion and spraying water) shows that with the increasing of the concrete age, led to an increase in its compressive strength.

- It is observed from the test results that the wet covering method of curing gave high compressive strength (27.770 MPa for 28 days curing test).

- At the early stage, Dubai LC stone gave 13.985 Mpa for spraying water curing method and 13.873 Mpa for immersion curing method. The values are very close.

- The Indian pakur stone gave better compressive strength value in both spraying curing method (14.809 MPa) and wet covering (14.470 MPa) method for 7 days' test.

- Immersion curing method showed less compressive strength (12 MPa for 7 days and 23.175 MPa for 28 days) than wet covering curing method. On the other hand, Dubai Stone gave higher compressive strength value in all three (air, wet covering, immersion) curing method for 28 days compressive strength test.

5.2 RECOMMENDATION

Because of time and resource limitations, the results of this experiment were somewhat restricted. Therefore, certain suggestions are put forward for additional research.

- Similar study can be conducted by using different w/c ratio.
- Concrete with different mixture proportions can be studied.
- Different types of fine aggregate can be used.

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