A COMPARATIVE STUDY ON COMPRESSIVE STRENGTH TEST NATURAL AGGREGATE CONCRETE (NAC) AND RECYCLE AGGREGATE CONCRETE (RAC)

PROVIDED 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: (25B) Dhanu
Semester -11th (FALL-2025)

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Dedicated

to

“Our Beloved Parents

and

Our Honorable Teachers”

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ABSTRACT

Concrete is a mixture of cement, sand, natural aggregate and recycled concrete in some specified proportion which is generally used for R.C.C and C.C. We have worked on a comparative study about on compressive strength test natural and recycled concrete. Firstly, mixing (mix proportion 1:2:4) 100% recycle concrete, 100% natural aggregate, 50% natural aggregate and recycle, 25% natural aggregate 75% recycle and 75% natural aggregate 25% recycle concrete mixing 60th concrete cylinders of 4 x 8 inch were made. Total cylinder cured with laboratory water tank and sign every molding top mix proportion and date. In this study two different type coarse aggregate used to observe the difference affected concrete with various curing method.

As the global construction industry seeks sustainable alternatives to mitigate the depletion of natural resources and manage demolition waste, Recycled Aggregate Concrete (RAC) has emerged as a viable solution. This research presents a comparative laboratory investigation into the compressive strength properties of conventional Natural Aggregate Concrete (NAC) and Recycled Aggregate Concrete (RAC) on evaluation.

The experimental program involved replacing natural coarse aggregates with recycled concrete aggregates (RCA) at varying percentages: 25%, 50%, 75%, and 100%. Concrete cylinders of 4 x 8 inch cast for each mix ratio (1:2:4) and tested for axial compressive strength at curing ages of 7, 14, 21 and 28 days.

The research concludes that while Natural Aggregate Concrete remains superior in high-load structural applications, Recycled Aggregate Concrete at partial replacement levels is an environmentally and technically feasible alternative for non-structural elements, pavements, and low-rise residential structures. Recommendations are provided for the use of mineral admixtures and adjusted water-cement ratios to optimize the performance of RAC in structural applications.

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CHAPTER-1

INTRODUCTION

Check Specing

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.

The construction industry is the backbone of global infrastructure development, yet it remains one of the most resource-intensive sectors in the world. As of 2026, the global demand for concrete—the most widely used man-made material—continues to surge due to rapid urbanization in developing economies and the modernization of aging infrastructure in developed nations. Concrete production relies heavily on Natural Aggregates (NA), which typically constitute 60% to 75% of the total volume of a concrete mix.

Traditionally, these aggregates are sourced from natural quarries, riverbeds, and mountains. However, the relentless extraction of virgin stone has led to severe ecological imbalances, including the depletion of natural reserves, destruction of habitats, and significant carbon emissions during mining and transportation. Simultaneously, the industry faces a second crisis: the management of Construction and Demolition (C&D) waste. As old structures are demolished to make way for new ones, millions of tons of concrete debris are generated, most of which are traditionally relegated to landfills, occupying valuable land and causing environmental pollution.

This study aims to investigate the compressive strength of concrete with different types of coarse aggregate Natural Aggregate Concrete (NAC) and Recycled Aggregate Concrete (RAC). The study will compare the strength of concrete made with different types of coarse aggregate, such as crushed stone and subjected to different usable conditions.

The findings of this study will provide valuable insights into the effect concrete of Natural Aggregate Concrete (NAC) and Recycled Aggregate Concrete (RAC)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 STATEMENT

The primary barrier to the widespread adoption of Recycled Aggregate Concrete (RAC) is the inherent physical difference between Natural Aggregates (NA) and Recycled Concrete Aggregates (RCA). RCA particles are typically covered with a layer of adhered old mortar, which makes them more porous, less dense, and highly absorbent compared to virgin stone.

These weak links often result in a reduction in compressive strength, typically ranging from 10% to 25% depending on the replacement level. Without a comprehensive comparative study that quantifies these strength losses across different curing ages (7, 14, 21 and 28 days), engineers and contractors remain hesitant to utilize RAC for structural applications, fearing premature failure or lack of durability.

"Concrete is a composite material consisting of cement, sand, and coarse aggregates mixed in specific proportions for Reinforced Cement Concrete (RCC) and Cement Concrete (CC) structures. This research presents a comparative laboratory investigation into the compressive strength of conventional Natural Aggregate Concrete (NAC) and Recycled Aggregate Concrete (RAC).

However, the main problem our environment faces today is the management of Construction and Demolition (C&D) waste. When old buildings, bridges, or roads are demolished, they create a huge amount of concrete waste. Most of this waste is thrown into landfills, which causes soil pollution and occupies valuable land.

On the other hand, collecting new natural stones is becoming expensive and environmentally unsustainable. Therefore, we need an alternative. Using "Recycled Aggregate" (broken pieces of old concrete) instead of "Natural Aggregate" can be a great solution. But before using it in important structures, we must compare its strength and performance with new materials..

1.2 OBJECTIVE OF THE STUDY

The objectives of this research are given below:
The main goals of this study are:

- To evaluate the compressive strength of concrete made with Recycled Aggregates.
- To compare the results of RAC with traditional Natural Aggregate Concrete (NAC).
- To observe the effect of different curing periods (7, 14, 21, and 28 days) on the strength of both types of concrete.
- To determine if RAC can be a reliable alternative for the local construction industry.

1.3 SCOPE AND LIMITATION

This study focuses specifically on the "Compressive Strength" using a 1:2:4 mix ratio. We have used cylinder samples (4"x8") for testing. The comparison is based on laboratory results after proper curing in water tanks. Other properties like tensile strength or durability are not the primary focus of this specific report but can be considered for future research.

CHAPTER-2
LITERATURE REVIEW

This section presents literature relevant to A Comparative Study on compressive strength test Natural Aggregate Concrete (NAC) and Recycled Aggregate Concrete (RAC). Comparative Study on compressive strength may start after 24 hours of the concrete and can be done in various ways and methods.

Research on Recycled Aggregate Concrete (RAC) began several decades ago. Scientists like **Buck (1977)** found that crushed concrete from old structures could be reused to make new concrete. In many developed countries, using recycled materials is now a common practice to reduce landfill waste. However, in developing countries like Bangladesh, the use of RAC is still in the testing phase.

Because of the old mortar, recycled aggregates absorb much more water (usually 3% to 10% more) than natural stone. This is a major finding by researchers like **Sri Ravindrarajah and Tam (1985)**

According to **Khatib (2005),** the amount of recycled aggregate used in the mix is very important. His research titled *"Properties of concrete incorporating fine recycled aggregate"* shows that as we increase the percentage of recycled material, the strength of the concrete slowly decreases. However, he found that a replacement level of 25% to 50% is often safe for many types of construction.

2.1 Research Plan:

To compare the materials, we followed these steps:

1. **Material Collection:** We collected new stone chips (Natural) and old concrete waste (Recycled).
2. **Sieving:** We cleaned and sized the materials to make them equal.
3. **Mixing:** We used a standard mix ratio of **1:2:4**.
4. **Cylinder Casting:** We made 60 concrete cylinders (size 4" x 8").
5. **Curing:** The samples were kept in water for 7, 14, 21, and 28 days to gain strength.

Enhanced Structural Performance

- Load-Bearing Capacity: Properly (NAC) concrete is only one ITZ (Natural aggregate +Cement). This bond is very strong. concrete can better withstand loads and stresses, ensuring the safety and performance of the structure. **In RAC** "Double ITZ" because of the old mortar (dry cement) sticking to the recycled stones. To enhance performance, we must ensure the new cement fills all the pores in the old mortar.

- Longevity of Structures: **NAC** is the best choice for high-rise buildings and heavy bridges where maximum strength is required. However, **RAC** is an excellent, eco-friendly alternative for residential homes, pavements, and rural roads, helping to reduce construction waste and protect the environment.

Durability and Longevity

Porosity and Permeability:

- Natural stones are dense and have very low permeability. This prevents water and harmful chemicals (like chlorides or sulfates) from entering the concrete and rusting the steel reinforcement inside.

- Recycled aggregates are more porous because of the **old mortar** attached to them. This higher porosity can allow water to seep in more easily, which may reduce the lifespan of the structure if not managed properly.

Strength Development

- Concrete does not dry; it hardens through a chemical reaction called **Hydration**. When water is mixed with cement, it forms a paste that binds the aggregates together. This process continues for a long time, but the most significant strength is gained within the first 28 days.

- **Natural Aggregate Concrete (NAC)**, this process is very stable because the stone is dense. In **Recycled Aggregate Concrete (RAC)**, the "old mortar" on the recycled stones can affect the hydration process by absorbing water, which is why proper curing is essential to ensure consistent strength development.

Volume Stability

- Controlling Shrinkage: a critical factor in determining the long-term performance and structural integrity of both Natural Aggregate Concrete (NAC) and Recycled Aggregate Concrete (RAC). In NAC, volume stability is generally high because natural aggregates are dense and chemically stable, leading to predictable thermal expansion and minimal drying shrinkage. However, in RAC, achieving volume stability is more challenging due to the presence of adhered mortar on the recycled aggregates. This old mortar is highly porous and tends to undergo higher moisture movements, which can lead to increased drying shrinkage and potential cracking if not managed through proper mix design and curing.

- Reducing Thermal Cracking: to enhance the volume stability of RAC to a level comparable with NAC, engineers focus on controlling the internal moisture and temperature of the concrete. Proper curing prevents premature drying, which ensures that the internal structure remains uniform and minimizes the risk of thermal cracking. While NAC naturally maintains its dimensions better under varying environmental conditions, RAC's stability can be significantly improved by using mineral admixtures or by partially replacing natural aggregates rather than using 100% recycled content. By maintaining a stable volume, both types of concrete can effectively protect reinforcing steel from corrosion and ensure a longer service life for the structure.

Minimizing Defects

- Prevention of Cracking: Curing plays a vital role in minimizing defects in both NAC and RAC by controlling the rate of water evaporation. In NAC, consistent moisture prevents common shrinkage cracks, while in RAC, it addresses the high water absorption of recycled aggregates to stop premature drying. By managing this moisture loss, the likelihood of internal micro-cracks and structural flaws is significantly reduced across both concrete types.

- Improved Surface Quality: Properly cured concrete results in a superior surface finish, effectively reducing problems like scaling, crazing, and dusting on the exterior. While NAC naturally achieves a dense surface, RAC requires more intensive curing to ensure the porous recycled stones do not create surface blemishes or discoloration. This process enhances the overall texture and durability, making the structure more visually appealing and resistant to external wear..

Reduces Surface Cracking:

- Moisture Loss Prevention: Proper curing reduces the rate of moisture loss in both NAC and RAC, preventing the formation of unsightly surface cracks. By maintaining a wet surface, the concrete gains better aesthetic appeal and structural density compared to uncured samples.

- Evaporation Control: In RAC, recycled aggregates absorb more water, making evaporation control even more vital than in standard NAC to avoid rapid drying. Correct curing ensures a smooth, crack-free finish that enhances the overall durability and visual quality of the structure.

Improves Bonding:

- **Structural Adhesion**: Proper curing ensures that NAC develops strong bonding properties between the new cement paste and dense natural stones for high structural integrity
- **Reinforcement Interfacing:** In RAC, consistent moisture is essential to strengthen the bond between the new cement, the old mortar layer, and the reinforcing steel.

Reduces Permeability:

- **Hydraulic Resistance** Proper curing reduces the permeability of NAC by creating a dense cement matrix that prevents water penetration and protects reinforcing steel from corrosion.

- **Porosity Mitigation** In RAC, extended curing is crucial to fill the internal pores of recycled aggregates, significantly lowering permeability to increase the structure's overall lifespan. Concrete that is properly cured is more resistant to water damage and has a longer lifespan.

Improves Aesthetics

- **Surface Uniformity** Proper curing improves the appearance of NAC by reducing surface blemishes like cracks and discoloration, ensuring a smooth and professional finish.

- **Texture Enhancement** In RAC, consistent moisture management enhances the texture and finish of the concrete, making recycled structures more visually appealing and uniform.

Saves Time and Money

- **Maintenance Reduction** Properly cured NAC saves money by reducing the need for costly future repairs and ensuring the project stays on schedule with fewer defects.

- **Long-term Cost-Efficiency** Using RAC saves money on material costs while proper curing prevents expensive replacements, making sustainable construction more economically viable for long-term use.

2.2 IMPORTANCE OF MAINTAINING MOISTURE IN NAC AND RAC

Maintaining moisture during the curing process is critical for both Natural Aggregate Concrete (NAC) and Recycled Aggregate Concrete (RAC) to reach their maximum potential strength. In NAC, moisture is needed for the hydration of cement, where cement acts as a binding material to hold natural stones together. However, for RAC, maintaining moisture is even more vital. Recycled aggregates are more porous and tend to absorb water from the fresh mix. Without sufficient moisture control, the hydration process in RAC slows down significantly, leading to a weaker structure and reduced durability compared to NAC. Proper moisture management also contributes to sustainability by reducing the need for future repairs in both types of concrete.

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 works as a bonding material.
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.

2.3 IMPORTANCE OF TEMPERATURE CONTROL

Consistent temperature control is essential to ensure the long-term quality of concrete structures. For both NAC and RAC, high temperatures can accelerate the hydration process but may lead to micro-cracks and reduced durability over time due to faster carbonation. In extreme weather conditions, such as the hot and dry climate of Bangladesh, water evaporates quickly from the surface, causing thermal stresses and cracking. While NAC is more stable, RAC is particularly sensitive to temperature changes because of the "old mortar" attached to recycled stones. Controlling the curing temperature between 10°C to 30°C helps optimize strength development and improves the workability of both NAC and RAC.

2.4 EVAPORATION MANAGEMENT FROM FRESH CONCRETE

When freshly placed NAC or RAC is exposed to air, surface water begins to evaporate. If not properly managed, rapid evaporation leads to plastic shrinkage cracks, reduced surface strength, and discoloration. In RAC, the risk is higher because the recycled aggregates themselves compete for the available water. To prevent these issues on-site, it is important to slow down evaporation by covering the concrete with plastic sheeting, using chemical evaporation retarders, or applying curing compounds. Keeping the surface wet through fog misting or water spraying ensures that both NAC and RAC gain the desired structural integrity and aesthetic appeal. 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:

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 FOR NAC AND RAC

The curing requirements for concrete depend on factors like mix design and weather conditions. For both NAC and RAC, there are four general pillars of curing: moisture, temperature, time, and protection. The surface must remain damp to promote full hydration, and the internal temperature should ideally be maintained between 50°F and 85°F. While NAC follows standard curing times, RAC may require a more extended or intensive curing period to compensate for its higher porosity. Additionally, both types must be protected from excessive wind, rain, and early construction traffic to prevent surface damage during the initial hardening stage.

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.

2.6 CURING AFFECTED ZONE IN CONCRETE

The "Curing Affected Zone" refers to the outer layer of the concrete that is most impacted by curing practices. This zone is crucial because it protects the reinforcing steel from corrosion. In NAC, a well-cured zone creates a dense barrier against water penetration. In RAC, this zone is often more vulnerable because the recycled aggregates can create a more permeable structure. Applying curing compounds or treatments to this affected zone helps restore strength and prevents the concrete from becoming brittle. Proper treatment of the CAZ is essential to ensure the longevity and safety of structures built with either natural or recycled materials.

2.7 COMPARATIVE 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.

CHAPTER-3
METHODOLOGY

3.1 MATERIALS

In this study, cement, fine aggregate, new coarse aggregate, recycle concrete 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 comparing strength (NCA) and (RCA).

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 :	Shah 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 :	2010 CEM II / A – M (S-V-L) 42.5N
Clinker :	80-94%
Limestone :	6-20%
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 without admixture in this study, as shown in below figure. The sand was washed with water and air-dried before being used to obtain the Saturated Surface (SSD) condition.

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 (Indian Pakur stone) had been used as a coarse aggregate as shown in the Figure.

Recycle Materials: 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.

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.

Apparatus

For sieve analysis, following apparatuses ware used

a) Balance;

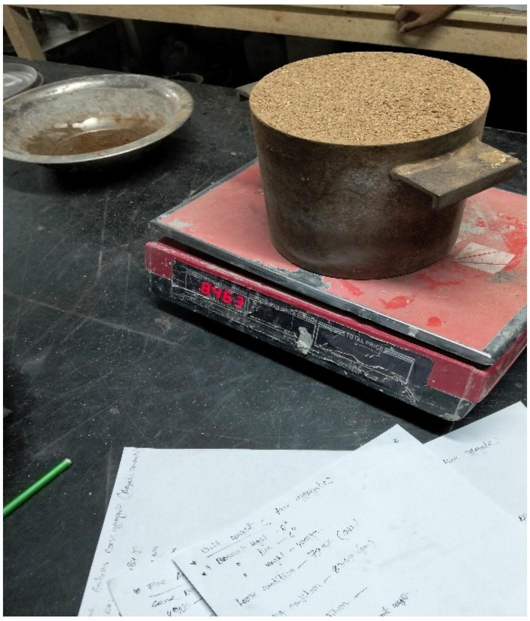
b) Sieves;

c) Oven and

d) Containers.

e) Brash.

- 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.



3.4 CONCRETE MIX PROPERTIES

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

Water/Cement Ratio 0.42

Mixing new stone chips (usable percentage) (max 20mm)

Mixing recycle concrete (usable percentage)

Same type and quantity of fine aggregate

Variable type and same quantity of coarse aggregate

Mixing Ratio 1:2:4

Mixing Recycle Concrete (usable percentage)

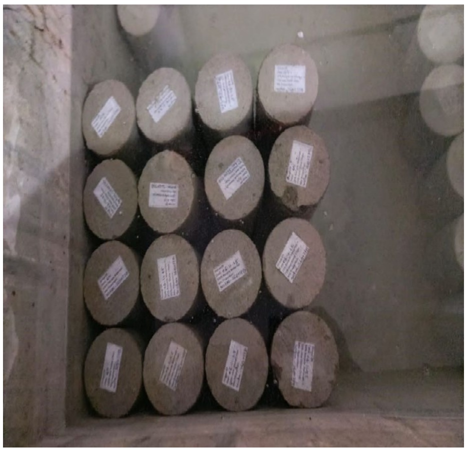
3.5 CONCRETE MOULDING PROCEDURE

For the compressive and tensile strength test, a steel cylindrical mold was used. Height and
diameter of the molds were 200mm and 100mm, respectively.
Molds were cleaned, and grease was applied to the inner surface of the mold.
Concrete was filled into the mold in 3 layers.
Each layer was rodded 25 times 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.

Molding of cylinder concrete specimens are shown in figure.

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 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

CHAPTER - 4
RESULT AND ANALYSIS OF LAB TEST

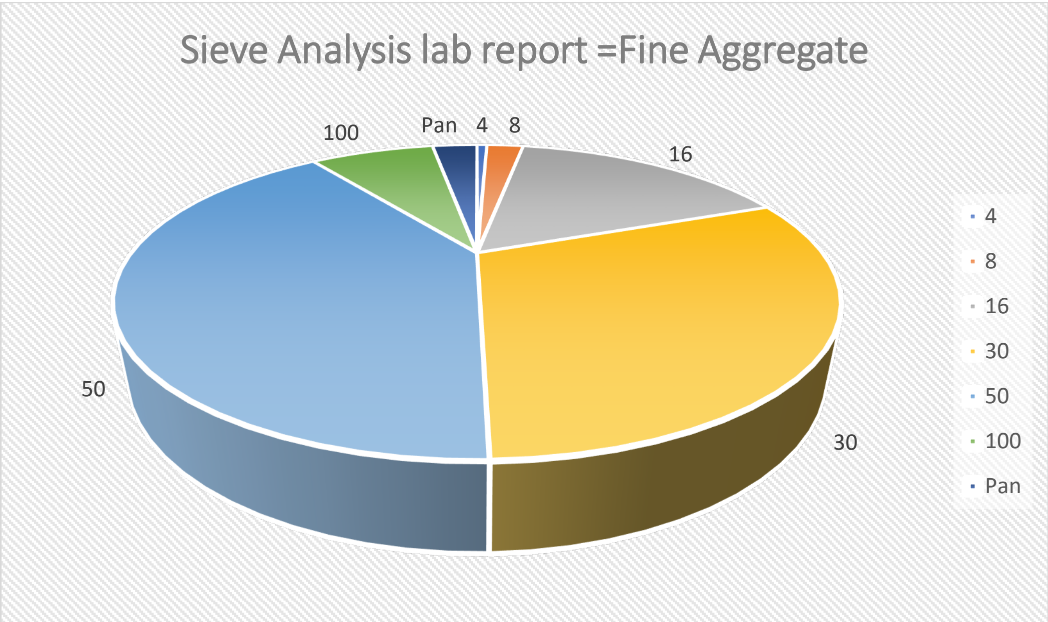
This result can be used to determine the correlation of compressive strength of concrete cylinder and the recommended curing period respectively. The result as the strength increases with the decreases of curing time interval.

4.1 SIEVE ANALYSIS OF FINE AGGREGATE

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

Table 4.1.1: Sieve Analysis of Fine Aggregate

Sieve Analysis lab report = Fine Aggregate						
Sl	Sieve No.	Material Retained (gm)	% Material Retained (gm)	% Cumulative Retained (gm)	% Finner	Remarks
1	4	6	0.6	0.6	99.4	FM=% Cumulative Retained/100 F.M=2.594 mm
2	8	22	2.2	2.8	97.2	
3	16	164	16.4	19.2	80.8	
4	30	304	30.4	49.6	50.4	
5	50	403	40.3	89.9	10.1	
6	100	74	7.4	97.3	2.7	
7	Pan	27				
	Total	1000		259.4	340.6	



4.2 SIEVE ANALYSIS OF NATURAL AGGREGATE

Table 4.2.1: Sieve Analysis of course aggregate ((Indian Pakur Black Stone)

Sieve Analysis lab report =coarse aggregate (Natural aggregate)						
Sl	Sieve No.	Material Retained (gm)	% Material Retained (gm)	% Cumulative Retained (gm)	% Finner	Remarks
1	3/4"	235	23.5	23.5	76.5	FM=%Cumulative Retained/ 100F.M=7.22
2	3/8"	753	75.3	98.8	1.2	
3	4	12	1.2	100	0	
4	8	0	0	100	0	
5	16	0	0	100	0	
6	30	0	0	100	0	
7	50	0	0	100	0	
8	100	0	0	100	0	
	Total	1000		722.3	77.7	

4.2 SIEVE ANALYSIS OF RECYCLE CONCRETE

Table 4.2.2: Sieve Analysis of Recycled Concrete

Sieve Analysis lab reports coarse aggregate (Recycle Concrete)						
Sl	Sieve No.	Material Retained (gm)	% Material Retained (gm)	% Cumulative Retained (gm)	% Finner	Remarks
1	3/4"	484	48.4	48.4	51.6	FM=% Cumulative Retained/100 =7.469mm
2	3/8"	501	50.1	98.5	1.5	
3	4	15	1.5	100	0	
4	8	0	0	100	0	
5	16	0	0	100	0	
6	30	0	0	100	0	
7	50	0	0	100	0	
8	100	0	0	100	0	
	Total	1000		746.9	53.1	

4.3 UNIT WEIGHT TEST:

Table 4.3.1: Unit Weight Test

Unit Weight =Recycle Concrete							
Sl	Condition	WT of the Bracket (gm)	WT of the Bracket + Materials (gm)	WT of the Materials (gm)	Volume of the Bracket (gm)	Unit Weight W= (gm)	Remarks
1	Shoveling	4000	7162	3162	0.00278	1137.41	W=WT of the Materials /Volumn of the Bracket/1000
2	Roddiling	4000	7690	3690	0.00278	1327.34	Average =1265.59 (gm)
3	Jiggling	4000	7703	3703	0.00278	1332.01	

Unit Weight = Coarse Aggregate (Natural aggregate)							
Sl	Condition	WT of the Bracket (gm)	WT of the Bracket + Materials (gm)	WT of the Materials (gm)	Volume of the Bracket (gm)	Unit Weight W= (gm)	Remarks
1	Shoveling	4000	7889	3889	0.00278	1398.92	W=WT of the Materials /Volumn of the Bracket/1000
2	Roddiling	4000	8450	4450	0.00278	1600.72	Average =1544.60 gm
3	Jiggling	4000	8543	4543	0.00278	1634.17	

Unit Weight = Fine Aggregate							
Sl	Condition	WT of the Bracket (gm)	WT of the Bracket + Materials (gm)	WT of the Materials (gm)	Volumn of the Bracket (gm)	Unit Weight W= (gm)	Remarks
1	Shoveling	4000	7947	3947	0.00278	1419.78	W=WT of the Materials /Volumn of the Bracket/1000
2	Roddiling	4000	8349	4349	0.00278	1564.39	Average =1529.38
3	Jiggling	4000	8459	4459	0.00278	1603.96	

4.4 SPECIFIC GRAVITY TEST:

Specific Gravity Test =Recycle Concrete

A=1405 gm, B=1540 gm and C=815

Sl	Description	Formula	Calculation/Result
1	Apparent Specific Gravity	A/A-C	2.38
2	Bulk Specific Gravity (S.S.D Basic)	B/B-C	2.12
3	Bulk Specific Gravity (Oven Dry Basic)	B-A/B*100	1.94
4	Absorption Capacity D %	(B-A)*100/A	8.77

Specific Gravity Test= Stone

A=1385 gm, B=1405 gm and C=880

Sl	Description	Formula	Calculation/Result
1	Apparent Specific Gravity	A/A-C	2.74
2	Bulk Specific Gravity (S.S.D Basic)	B/B-C	2.68
3	Bulk Specific Gravity (Oven Dry Basic)	B-A/B*100	2.64
4	Absorption Capacity D %	(B-A)*100/A	1.44

Specific Gravity Test= Sand

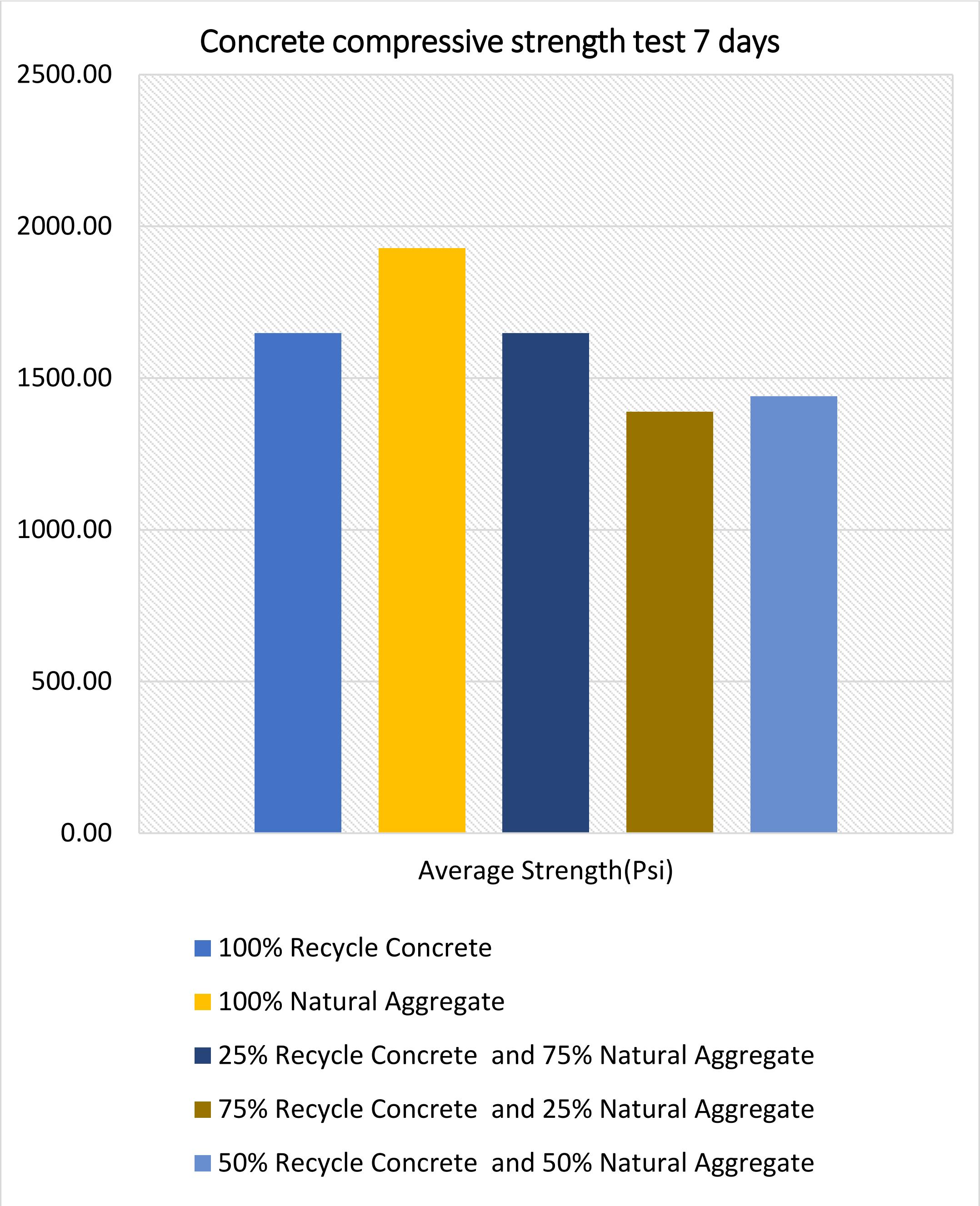
A=304 gm, B=656 gm, C=840 gm and S=320 gm

Sl	Description	Formula	Calculation/Result
1	Apparent Specific Gravity	A/B+A-C	2.53
2	Bulk Specific Gravity (Oven Dry Basic)	A/B+S-C	2.24
3	Absorption Capacity D %	(S-A)/A*100	5.26
4	Bulk Specific Gravity (S.S.D Basic)	(S)/(B+S-C)	2.35

4.5 CYLINDER TEST RESULTS:

Table 4.5.1: 7 Days Cylinder Test Results

Sl	Date	Description	Cylinder Hight (mm)	Cylinder Diameter (mm)	Weight (gm)	Load (Kn)	Cylinder Area (mm^2)	Strength (Psi)	Average Strength (Psi)
1	14/11 /2025	100% Recycle Concrete	204	101.9	3565	95	8155.29	1689.43	1647.32
2			204	101.6	3595	90	8107.34	1609.98	
3			205	101.7	3592	92	8123.31	1642.52	
1		100% Natural Aggregate	207	101.5	4028	105	8091.39	1882.01	1927.41
2			207	101.2	4003	110	8043.63	1983.34	
3			206	102	4020	108	8171.30	1916.85	
1		25% Recycle Concrete and 75% Natural Aggregate	207	103.3	3906	100	8380.92	1730.47	1647.82
2			208	102.1	4050	90	8187.33	1594.25	
3			206	103	4040	93	8332.31	1618.73	
1		75% Recycle Concrete and 25% New Stone Materials	203	102.5	3785	80	8251.61	1406.07	1388.52
2			204	102.6	3807	78	8267.72	1368.25	
3			205	102.4	3803	79	8235.52	1391.21 4604	
1		50% Recycle Concrete and 50% Natural Aggregate	207	103.2	3849	85	8364.70	1473.75 9037	1440.57
2			207	102.5	3903	80	8251.61	1406.07 733	
3			206	103.1	3850	83	8348.50	1441.87 5332	



Concrete compressive strength test 7 days
2500.00
2000.00
1500.00
1000.00
500.00
0.00
Average Strength(Psi)
100% Recycle Concrete
100% Natural Aggregate
25% Recycle Concrete and 75% Natural Aggregate
75% Recycle Concrete and 25% Natural Aggregate
50% Recycle Concrete and 50% Natural Aggregate

Table 4.5.2: 14 Days Cylinder Test Results

Concrete compressive strength test 14 days									
Sl	Date	Description	Cylinder Hight (mm)	Cylinder Diameter (mm)	Weight (gm)	Load (Kn)	Cylinder Area (mm^2)	Strength (Psi)	Average Strength (Psi)
1	21/11 /2025	100% Recycle Concrete	205	102.66	3668	110	8277.39	1927.33	1959.18
2			206	102.1	3670	112	8187.33	1983.96	
3			206	102.1	3669	111	8187.33	1966.25	
1		100% Natural Aggregate	205	101.9	4011	137	8155.29	2436.35	2342.73
2			204	103.9	4033	130	8478.56	2223.72	
3			205	102.6	4035	135	8267.72	2368.13	
1		25% Recycle Concrete and 75% Natural Aggregate	206	103	3932	102	8332.31	1775.39	1815.06
2			206	102.6	3895	105	8267.72	1841.88	
3			205	102.5	3934	104	8251.61	1827.90	
1		75% Recycle Concrete and 25% Natural Aggregate	206	101.7	3766	107	8123.31	1910.33	1900.26
2			206	102.9	3765	107	8316.14	1866.04	
3			205	101.8	3770	108	8139.29	1924.40	
1		50% Recycle Concrete and 50% Natural Aggregate	206	102.7	3928	105	8283.84	1838.30	1823.10
2			207	103.3	3950	103	8380.92	1782.39	
3			205	102.9	3925	106	8316.14	1848.60	

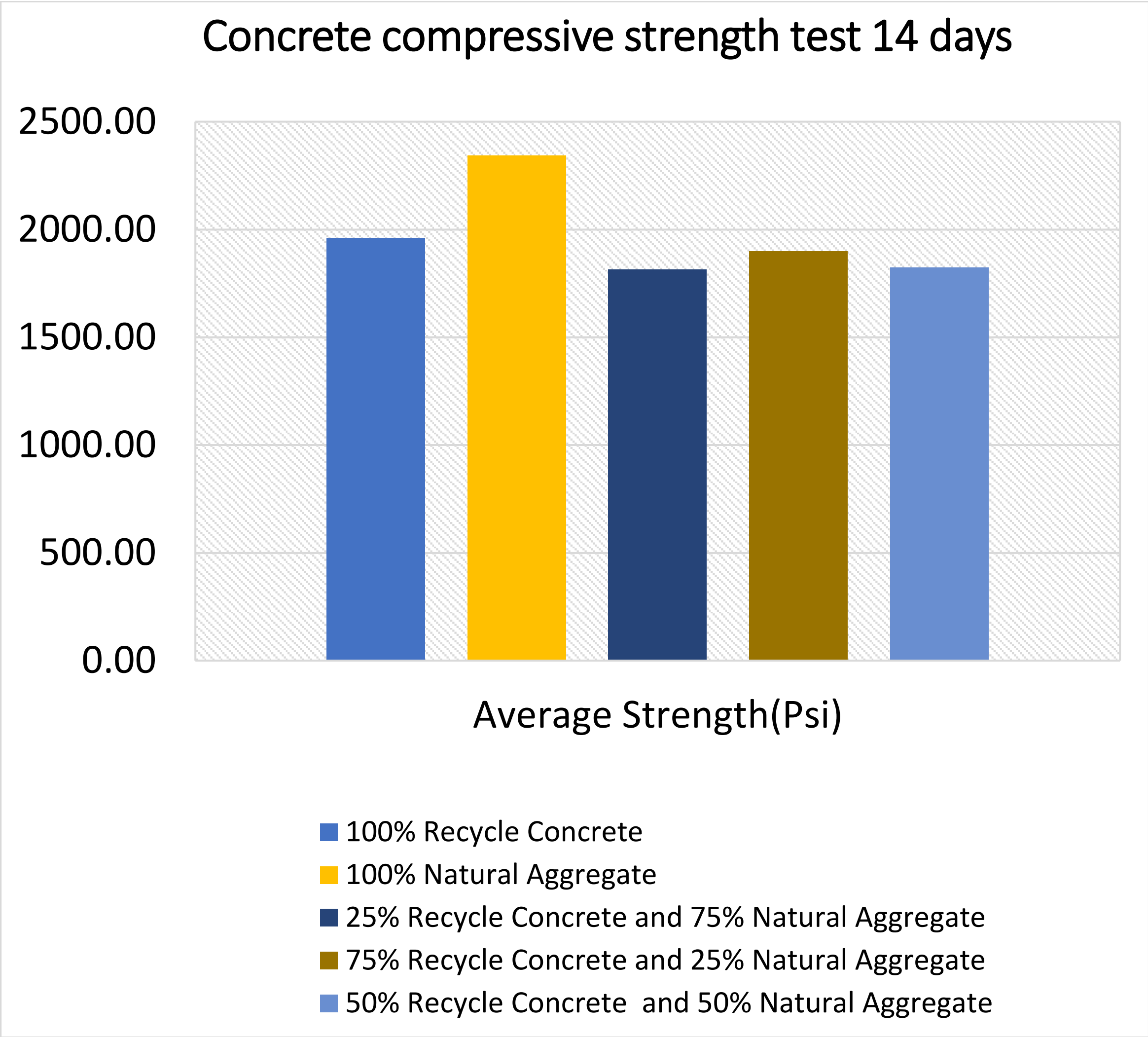
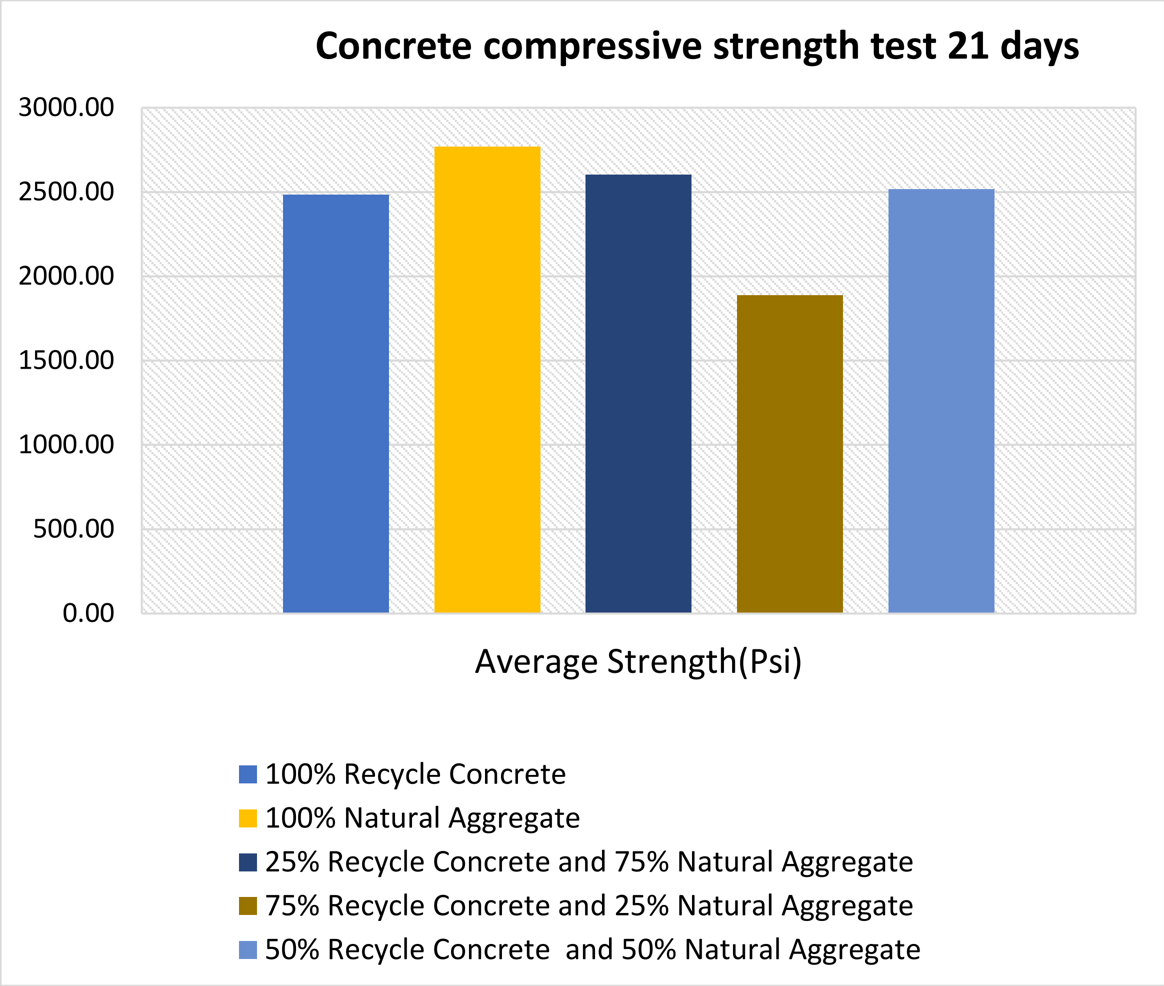

Concrete compressive strength test 14 days
2500.00
2000.00
1500.00
1000.00
500.00
0.00
Average Strength(Psi)
100% Recycle Concrete
100% Natural Aggregate
25% Recycle Concrete and 75% Natural Aggregate
75% Recycle Concrete and 25% Natural Aggregate
50% Recycle Concrete and 50% Natural Aggregate

Table 4.5.3: 21 Days Cylinder Test Results

Concrete compressive strength test 21 days									
Sl	Date	Description	Cylinder Hight (mm)	Cylinder Diameter (mm)	Weight (gm)	Load (Kn)	Cylinder Area (mm^2)	Strength(Psi)	Average Strength(Psi)
1	28/11 /2025	100% Recycle Concrete	206	102.8	4106	135	8299.98	2358.93	2486.77
2			206	100	3907	140	7854.00	2585.20	
3			204	101	4006	139	8011.87	2516.16	
4		100% Natural Aggregate	207	103.8	3767	155	8462.25	2656.46	2768.71
5			207	101.9	3756	160	8155.29	2845.37	
6			206	102	3740	158	8171.30	2804.29	
1		25% Recycle Concrete and 75% Natural Aggregate	206	103	3901	145	8332.31	2523.83	2603.99
2			205	102	3803	147	8171.30	2609.06	
3			204	101	3833	148	8011.87	2679.08	
4		75% Recycle Concrete and 25% Natural Aggregate	206	102.2	3986	107	8203.38	1891.69	1890.17
5			204	102.5	3954	107	8251.61	1880.63	
6			205	102.5	3951	108	8251.61	1898.20	
4		50% Recycle Concrete and 50% Natural Aggregate	206	102.4	3784	140	8235.52	2465.44	2516.59
5			205	102.5	3658	147	8251.61	2583.67	
6			204	102.4	3660	142	8235.52	2500.66	



Concrete compressive strength test 21 days
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
Average Strength(Psi)
100% Recycle Concrete
100% Natural Aggregate
25% Recycle Concrete and 75% Natural Aggregate
75% Recycle Concrete and 25% Natural Aggregate
50% Recycle Concrete and 50% Natural Aggregate

Table 4.5.4: 28 Days Cylinder Test Results

Concrete compressive strength test 28 days									
S l	Date	Description	Cylinder Hight (mm)	Cylinder Diameter (mm)	Weight (gm)	Load (Kn)	Cylinder Area (mm^2)	Strength (Psi)	Average Strength (Psi)
1	5/12/ 2025	100% Recycle Concrete	206	101	3685	140	8011.87	2534.27	2555.72
2			205	103	3797	145	8332.31	2523.83	
3			204	102	3798	147	8171.30	2609.06	
1		100% Natural Aggregate	205	103.2	4100	185	8364.70	3207.59	3154.97
2			205	103	4118	180	8332.31	3133.03	
3			206	104	4117	183	8494.89	3124.29	
1		25% Recycle Concrete and 75% Natural Aggregate	205	101.9	3860	147	8155.29	2614.18	2513.61
2			206	103	3980	150	8332.31	2610.86	
3			205	109	3979	149	9331.34	2315.80	
1		75% Recycle Concrete and 25% Natural Aggregate	206	102	3790	140	8171.30	2484.82	2524.86
2			206	102.5	3888	145	8251.61	2548.52	
3			205	103	3887	146	8332.31	2541.24	
1		50% Recycle Concrete and 50% Natural Aggregate	205	101	3823	150	8011.87	2715.29	2706.68
2			205	102.5	3862	155	8251.61	2724.27	
3			206	103	3860	154	8332.31	2680.48	

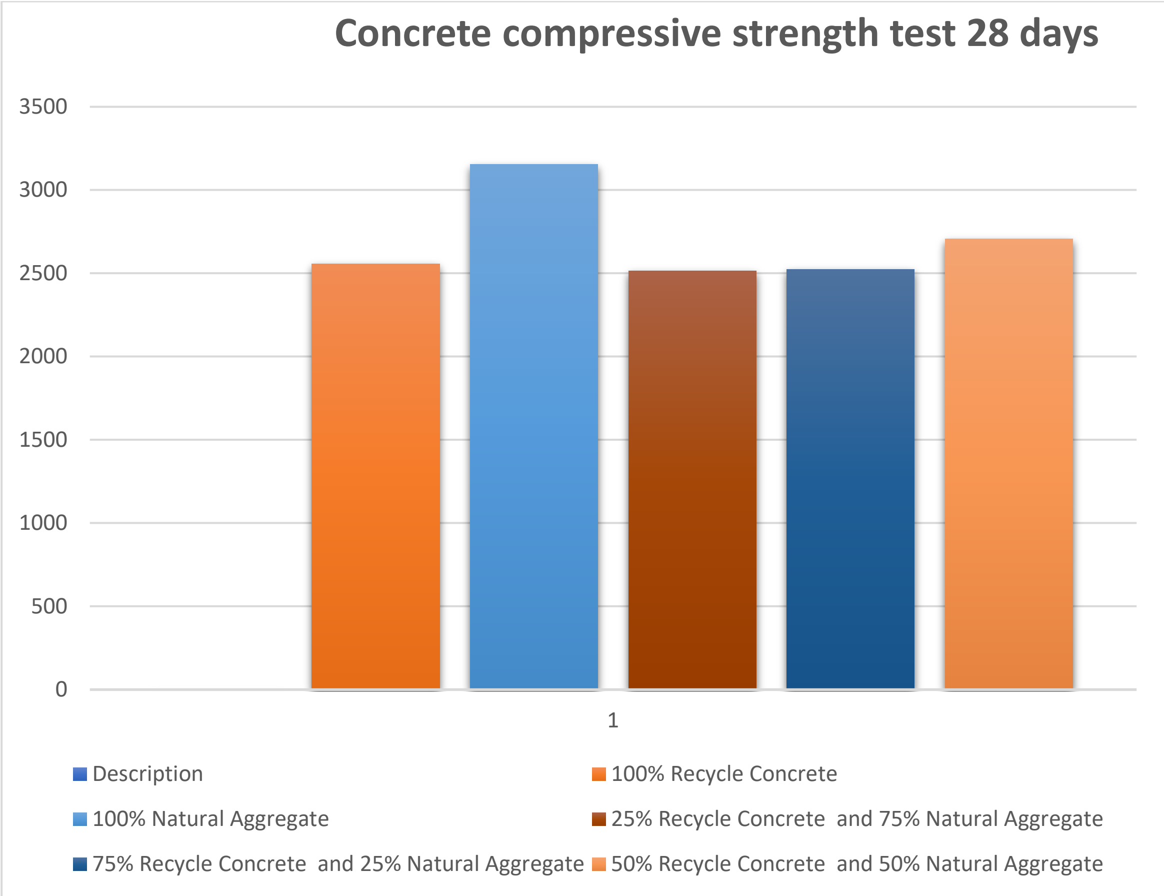
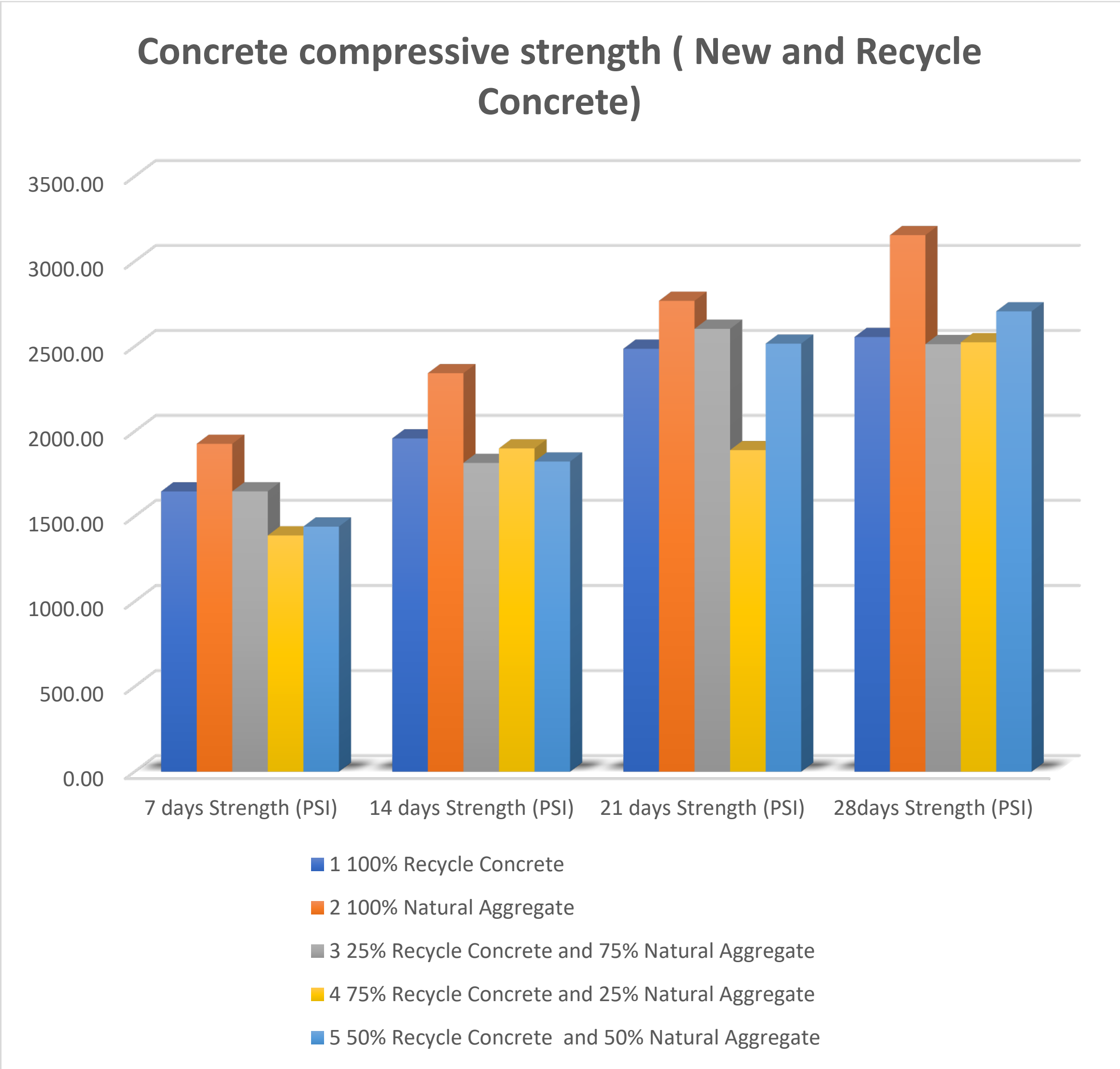

Concrete compressive strength test 28 days
3500
3000
2500
2000
1500
1000
500
0
1
Description
100% Recycle Concrete
100% Natural Aggregate
25% Recycle Concrete and 75% Natural Aggregate
75% Recycle Concrete and 25% Natural Aggregate
50% Recycle Concrete and 50% Natural Aggregate

Table 4.5.5: 7,14,21 & 28 Days Cylinder Test Results

Concrete compressive strength (Natural Aggregate and Recycle Concrete)					
Sl	Description	7 days Strength (PSI)	14 days Strength (PSI)	21 days Strength (PSI)	28 days Strength (PSI)
1	100% Recycle Concrete	1647.32	1959.18	2486.77	2555.72
2	100% Natural Aggregate	1927.41	2342.73	2768.71	3154.97
3	25% Recycle Concrete and 75% Natural Aggregate	1647.82	1815.06	2603.99	2513.61
4	75% Recycle Concrete and 25% Natural Aggregate	1388.52	1900.26	1890.17	2524.86
5	50% Recycle Concrete and 50% Natural Aggregate	1440.57	1823.10	2516.59	2706.68


Concrete compressive strength (New and Recycle Concrete)
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
7 days Strength (PSI)
14 days Strength (PSI)
21 days Strength (PSI)
28days Strength (PSI)
1 100% Recycle Concrete
2 100% Natural Aggregate
3 25% Recycle Concrete and 75% Natural Aggregate
4 75% Recycle Concrete and 25% Natural Aggregate
5 50% Recycle Concrete and 50% Natural Aggregate

Chapter - 5
CONCLUSION

This study investigated the strength and durability performance of A Comparative Study on compressive strength test, Natural Aggregate Concrete (NAC), and Recycled Aggregate Concrete (RAC). The experimental results showed that the compressive, split tensile, and flexural strengths decreased with Recycled Aggregate Concrete (RAC) compared to Natural Aggregate Concrete (NAC).

However, at lower replacement levels, the reduction in strength remained within acceptable limits for practical use. Natural Aggregate Concrete (NAC) containing Recycled Aggregate Concrete (RAC) exhibited relatively higher strength compared to concrete incorporating recycled concrete. In contrast, Recycled concrete based concrete demonstrated improved ductility and energy absorption capacity. Durability assessments indicated that recycled concrete showed satisfactory resistance to water absorption and degradation. The recycled concrete contributed to improved crack resistance and enhanced toughness of the concrete. Recycled concrete replacement levels led to a significant decline in both strength and durability properties. Based on the overall performance, a Recycle concrete level of 30%–50% was identified as optimal for practical applications. Overall, the use of recycled concrete in construction offers a sustainable solution for recycling concrete waste management while producing environmentally friendly construction materials.

The main findings of the study are mentioned below -

- **Comparative Strength and Performance** The research confirms that Natural Aggregate Concrete (NAC) remains the superior material in terms of maximum compressive strength, achieving an average of **3155Psi**. In comparison, Recycled Aggregate Concrete (RAC) achieved a peak strength of **2556Psi**. While RAC is approximately **19% weaker** than NAC, it still provides sufficient strength for various structural applications, particularly in residential buildings and non-load-bearing elements.
- **Environmental and Economic Impact** Using Recycled Aggregate Concrete offers significant environmental benefits by reducing construction waste and preserving natural stone resources. Although NAC is the "Gold Standard" for heavy infrastructure, RAC provides a cost-effective and sustainable solution for the future of the construction industry. By optimizing the water-cement ratio and replacement levels, we can build structures that are both strong and eco-friendly

Limitations:

- Conducted under laboratory conditions, which may not fully represent field behavior.

- Only selected replacement levels of Recycled Aggregate Concrete were tested.

- Long-term performance beyond the tested curing periods was not evaluated.

- Certain durability aspects, such as fire and chemical resistance, were not assessed.

- Economic feasibility and large-scale applicability were not analyzed.

RECOMMENDATION

Due to limitations in time and resources, the findings of this study are somewhat restricted. To build upon this research, the following recommendations are proposed for future studies:

- Investigation of higher replacement ratios: Further experiments should be conducted using higher and more diverse replacement ratios of Recycled Aggregate (RA) to Natural Aggregate (NA).

- Long-term durability assessment: Future research should focus on the long-term performance of RAC, specifically analyzing its creep, shrinkage, and fatigue behavior.

- Environmental and chemical resistance: Additional durability tests, including fire resistance, chemical attack resistance (sulfate and chloride), and freeze–thaw cycles, are recommended.

- Economic and Environmental Analysis: A detailed life-cycle assessment (LCA) and cost-benefit analysis should be performed to evaluate the practical feasibility of RAC in large-scale construction.

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