EFFECT OF WATER CEMENT RATIO ON THE COMPRESSIVE STREGTH OF CONCRETE BY USING DIFFERENT TYPES OF COARSE AGGREGATE

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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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Section: 24A+24E

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DECLARATION

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

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To

"Our Beloved Parents"

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ABSTRACT

Concrete is a composite material consisting of cement, sand, and coarse aggregates, commonly used in reinforced cement concrete (R.C.C) and plain cement concrete (P.C.C) works. This study presents an experimental analysis of the effects of different water-cement (W/C) ratios on the compressive strength of concrete using various types of coarse aggregates. A total of 36 concrete cylinders (4 in. × 8 in.) were prepared using two types of coarse aggregates—crushed local stone chips and pea gravel—and three different water-cement ratios: 0.40, 0.45, and 0.50. Ordinary Portland Cement (OPC) and Sylhet sand were used in all mixes to maintain consistency. The specimens were cast, cured, and tested at 7-day and 28-day intervals to assess the influence of water-cement ratio on strength development. Mixing and curing were done using potable water under controlled conditions. The key parameters of this study include variation in W/C ratio and type of coarse aggregate used. Results showed that a lower water-cement ratio (0.40) generally produced higher compressive strength, especially when combined with crushed stone chips, while pea gravel yielded comparatively lower strengths at all W/C ratios. The study highlights that both the type of aggregate and the water-cement ratio significantly affect the strength characteristics of concrete. Hence, determining the effective W/C ratio is crucial for optimizing concrete performance, ensuring durability, and maintaining quality control in construction practices.

TABLE OF CONTENT

ABSTRACT vii
LIST OF FIGURES ix
LIST OF TABLES ix
CHAPTER 1: INTRODUCTION 1
1.1 Background and Motivations 1
1.2 Research Objectives and Overview 1
1.3 Organization of the Thesis 2
1.4 Research Objectives and Overview 2
1.5 Outline of the Study 2
CHAPTER 2: LITERATURE REVIEW 3
2.1 Introduction 3
2.2 Cement as a Binding Material 3
2.3 Water-Cement Ratio 4
2.4 Fine Aggregate 5
2.5 Coarse Aggregates 6
2.6 Sieve Analysis 6
2.7 Summary 7
CHAPTER 3: METHODOLOGY 8
3.1 Introduction 8
3.2 Materials 8
3.3 Concrete Mixing 10
3.4 Water-Cement Ratio 11
3.5 Casting Cylinder 11
3.6 Curing 12
3.7 Preparation to Crush the Concrete Cylinders 12
3.8 UTM Machine 13
3.9 Compression Test 13
3.10 Finishing 14
CHAPTER 4: RESULTS AND DISCUSSION 15
4.1 Result of Fine Aggregate 15
4.2 Result of Coarse Aggregate 16
4.3 Specific Gravity of Coarse Aggregate 16

4.4 Specific Gravity of Fine Aggregate 18
4.5 Results of 7 Days Compressive Strength Test of Grade M20 Ratio.....19
4.6 Results of 28 Days Compressive Strength Test of Grade M20 Ratio.....21
CHAPTER 5: CONCLUSION AND FUTURE WORKS.....24
5.1 Conclusions.....24
5.2 Limitations and Recommendations for Future Works.....24
REFERENCES 25

LIST OF FIGURES

Figure 3.1 Preparation of Cylinder…….....8
Figure 3.2 Fine Aggregate……...……...9
Figure 3.3 Coarse Aggregate ……....10
Figure 3.4 Concrete mixing……...10
Figure 3.5 Casting Cylinder….…….……11
Figure 3.6 Curing of Cylinder……12
Figure 3.7 Compression Test…….....13
Figure 4.1 Chart of 7 days test result ……20
Figure 4.2 Chart of 28 days test result ……...22
Figure 4.3 Compressive strength after 7 & 28 days……...23

LIST OF TABLES

Table. 4.1: Result of aggregate sieve analysis …….....15
Table 4.2: Result of Coarse Aggregate…….16
Table 4.3: Data sheet for specific gravity of coarse aggregate…….16
Table 4.4: Specific gravity of Local Deshi Stone ……...…….…….....17
Table 4.5: Specific gravity of Pea Gravel.…….…….…….17
Table 4.6: Data sheet for Specific gravity of fine aggregate…….…….…….18
Table 4.7: Specific gravity of fine aggregate…….……...……18
Table 4.8: Seven Days Compressive Strength Test …….…….…….....19
Table 4.9: Twenty-Eight Days Compressive Strength Test ……....….……21

CHAPTER 1
INTRODUCTION

1.1 General

Concrete is one of the most important and widely used construction materials in the modern civil engineering world. Its performance and durability depend on several factors, among which the water-cement (W/C) ratio plays a key role. Concrete's compressive strength varies depending on the materials used and the mix proportion. The W/C ratio directly influences the strength and workability of concrete. An effective W/C ratio ensures a balance between adequate strength and proper workability.

In this study, Ordinary Portland Cement (OPC) was used as the binding material. It is one of the most commonly used types of cement due to its high early strength and availability. Different water-cement ratios were used to prepare concrete mixes. Two types of coarse aggregates were considered: Crushing Stone Chips and Pea Gravel. Sylhet Sand was used as the fine aggregate. The goal was to determine which combination provides the highest compressive strength, thus identifying the most effective water-cement ratio for practical use.

1.2 Compressive Strength

Compressive strength is the most significant mechanical property of concrete, as it defines the ability of a structure to resist external compressive loads. It is usually measured in N/mm^2 (or MPa), and the strength is determined by testing concrete cubes or cylinders. The compressive strength of concrete depends largely on the mix design, materials quality, curing method, and most importantly, the water-cement ratio.

The lower the W/C ratio, the higher the expected strength, provided the concrete remains workable and compactable. However, if the ratio is too low, it may result in poor workability and improper compaction, leading to strength reduction. This study focuses on finding the optimal W/C ratio where strength is maximized using the selected materials**.**

1.3 Background and Motivation

In real-life construction, especially in regions like Bangladesh, materials vary by region. Coarse aggregates like stone chips and pea gravel are commonly available, and Sylhet sand is widely used for its purity and fineness. However, the choice of water-cement ratio is often based on assumption rather than testing.

The motivation for this research arose from the need to study how different combinations of these materials and varying W/C ratios affect the compressive strength of concrete. Determining the most effective W/C ratio can contribute significantly to improving construction quality, reducing material waste, and ensuring structural safety.

1.4 Research Objectives and Overview

The main objectives of this experimental study are as follows:

1. To determine the compressive strength of concrete using different water-cement ratios
2. To observe and compare the effect of two types of coarse aggregates (Crushing Stone Chips and Pea Gravel) on concrete strength.
3. To evaluate the effectiveness of Sylhet sand as fine aggregate in all mixes.
4. To identify the most effective water-cement ratio that yields the highest compressive strength for the selected materials.

1.5 Outline of the Study

This research includes casting of concrete cubes using three different water-cement ratios and two types of coarse aggregates while keeping fine aggregate constant (Sylhet sand). The concrete cubes were cured and tested for compressive strength at 7 and 28 days. The results were analyzed to determine the variation in strength and the optimum mix for practical application. This study highlights the importance of selecting the right water-cement ratio and aggregate type to achieve desired compressive strength in concrete construction.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Concrete is the most widely used construction material globally, primarily due to its durability, high compressive strength, and cost-effectiveness. Among the many factors that influence the performance of concrete, the water-cement (W/C) ratio plays a critical role in determining its compressive strength and durability (Neville, 2011). A lower W/C ratio typically results in higher strength and lower permeability, whereas a higher W/C ratio improves workability but reduces mechanical strength (Mindess et al., 2003).

Shetty, M.S. (2002) developed the fundamental relationship between water-cement (w/c) ratio and compressive strength. The study emphasizes that lower w/c ratios generally result in higher strength due to reduced capillary porosity. The influence of coarse aggregate is noted as significant, especially with angular aggregates providing better mechanical interlock and strength compared to rounded ones.

Apebo, N. S. (2013) conducted a comparative analysis of the compressive strength of concrete using gravel and over-burnt bricks as coarse aggregates. The study found that concrete with gravel as the coarse aggregate exhibited higher compressive strength than concrete made with over-burnt bricks, under the same water-cement ratio, emphasizing the impact of the type of coarse aggregate on concrete strength.

Ahmad, S. and Shabir, Z. (2005) focused on his study the crucial role of water-cement ratio in concrete durability and strength. Lower w/c ratios enhanced not only durability but also compressive strength. The research also briefly mentions that aggregate type can influence concrete's resistance under chemical exposure conditions.

This chapter discusses in detail the materials used in this study, including Ordinary Portland Cement (OPC), Sylhet sand as fine aggregate, and two types of coarse aggregates—Crushing Local Stone Chips and Pea Gravel. It also reviews the importance of water-cement ratio in the context of compressive strength and overall concrete quality. The literature and practical standards such as ASTM and BSTI are referred to where applicable.

2.2 Cement as a Binding Material

Cement is the primary binding material used in concrete and mortar. In this study, Ordinary Portland Cement (OPC) was used as the binder. OPC is known for its reliability, strength, and wide application in general and structural concrete. It is made by grinding clinker with gypsum under controlled conditions. The chemical constituents like calcium oxide, silicon dioxide, aluminum oxide, and iron oxide give cement its strength and setting properties.

Cement reacts with water to form a paste that binds the aggregates, resulting in a hardened mass over time. The cement used in this study conforms to the specifications of ASTM and BSTI standards.

Additionally, according to ASTM C150, OPC is classified into different types (Type I to V) based on its properties such as early strength gain, sulfate resistance, and heat of hydration. Type I OPC, commonly used in general construction, offers balanced performance in terms of strength and setting time. The hydration process primarily produces calcium silicate hydrate (C-S-H) gel, which is responsible for strength development, and calcium hydroxide (CH), which affects durability (Taylor, 1997).

The fineness of cement also plays a crucial role, as finer particles increase the rate of hydration and early strength gain (Neville, 2011). Cement used in this study had standard consistency and initial setting time within the limits prescribed by BSTI (BDS EN 197-1) and ASTM standards, ensuring its suitability for structural-grade concrete.

2.3 Water-Cement Ratio

The water–cement ratio is the ratio of the weight of water to the weight of cement used in a concrete mix. A lower ratio leads to higher strength and durability, but may make the mix difficult to work with and form. Workability can be resolved with the use of plasticizers or super-plasticizers.

Often, the ratio refers to the ratio of water to cement plus pozzolan ratio, w/c. The pozzolan is typically a fly ash, or blast furnaces lag. It can include a number of other materials, such as silica fume, rice husk ash or natural pozzolans. Pozzolans can be added to strengthen concrete.

Concrete hardens as a result of the chemical reaction between cement and water (known as hydration, this produces heat and is called the heat of hydration). For every pound (or kilogram

or any unit of weight) of cement, about 0.35 pounds (or 0.35 kg or corresponding unit) of water is needed to fully complete hydration reactions.

However, a mix with a ratio of 0.35 may not mix thoroughly, and may not flow well enough to be placed. More water is therefore used than is technically necessary to react with cement. Water–cement ratios of 0.40 to 0.60 are more typically used. For higher-strength concrete, lower ratios are used, along with a plasticizer to increase flow ability.

Too much water will result in segregation of the sand and aggregate components from the cement paste. Also, water that is not consumed by the hydration reaction may leave concrete as it hardens, resulting in microscopic pores (bleeding) that will reduce final strength of concrete. A mix with too much water will experience more shrinkage as excess water leaves, resulting in internal cracks and visible fractures (particularly around inside corners), which again will reduce the final strength.

The 1997 Uniform Building Code specifies a maximum of 0.5 ratio when concrete is exposed to freezing and thawing in a moist condition or to de-icing chemicals, and a maximum of 0.45 ratio for concrete in a severe or very severe sulfate condition.

2.4 Fine Aggregate

Sylhet sand was used as the fine aggregate in all concrete mixes. It is well-graded, clean, and free from impurities. Fine aggregates fill the voids between coarse aggregates and help in achieving a dense and strong concrete matrix. The grading of fine aggregate influences the workability and strength of concrete. According to the fineness modulus (F.M), Sylhet sand falls within the range of 2.6–2.9, which categorizes it as medium sand, suitable for general concrete work.

Additionally, the quality and gradation of fine aggregates significantly affect the water demand, workability, and ultimate strength of concrete. Well-graded fine aggregates allow for better packing and reduce voids in the concrete mix, resulting in higher density and lower permeability (Shetty, 2005). In contrast, poorly graded sand may increase the water-cement ratio and affect the overall strength and durability of the concrete.

Research has shown that the angularity and texture of fine aggregates can also influence the bond strength between cement paste and aggregate particles (Mehta & Monteiro, 2006). Sylhet

sand, being of medium fineness, provides a good balance between workability and strength in concrete, making it suitable for a wide range of concrete applications. Furthermore, the chemical composition and cleanliness of fine aggregates, as specified in ASTM C33, are essential to prevent any deleterious effects on concrete hydration and long-term durability (ASTM C33/C33M-18).

2.5 Coarse Aggregates

Two different types of coarse aggregates were used in this study:

- Local Deshi Stone (Burugghamari): These are angular in shape and provide better bonding in concrete. They offer high strength due to their rough texture and interlocking capability.
- Pea Gravel: Rounded and smooth aggregates that offer better workability but may reduce the interlocking effect compared to crushed stone. Pea gravel is typically used where concrete needs better flowability.

Crushing Stone Chips are known for their angularity, which enhances the mechanical interlock between particles, improving the overall strength of the concrete (Mindess et al., 2003). The rough texture of these aggregates leads to better adhesion with the cement paste, resulting in increased compressive strength and reduced permeability. According to ACI 211.1-91, angular aggregates like stone chips generally result in stronger concrete mixes.

On the other hand, Pea Gravel—with its smooth, rounded texture—improves the workability of concrete, making it easier to mix and place. However, its interlocking ability is lower than that of crushed stone, which may lead to slightly lower strength in comparison (Mehta & Monteiro, 2006). Pea gravel is generally used when high workability and flowability are required, such as in self-compacting concrete or where placement is challenging.

Both aggregates were tested for specific gravity, water absorption, and size conformity. The maximum size of coarse aggregate used was 18 mm, which is considered optimal for most structural works (ASTM C33/C33M-18). The grading of these aggregates was verified to ensure they meet the necessary specifications for strength and durability, as outlined in the standards.

2.6 Sieve Analysis

Sieve analysis was conducted for both fine and coarse aggregates to determine their particle size distribution. The test helps to evaluate whether the aggregates meet the grading

requirements for concrete production. The results ensured that both fine and coarse aggregates used in this study conform to ASTM C136 standards.

Sieve analysis is essential for determining the fineness modulus (F.M.) of aggregates, which directly impacts the mix design and workability of the concrete. The fineness modulus indicates the average size of the particles in the aggregate and is used as an indicator of the aggregate's grading. For fine aggregates, an F.M. of 2.6–2.9 is considered ideal for normal concrete applications (Shetty, 2005), which aligns with the characteristics of Sylhet sand used in this study.

Additionally, sieve analysis allows for the identification of the gradation curve—a key factor influencing concrete's workability, strength, and durability. Well-graded aggregates, like those used in this study, result in denser and more durable concrete due to the optimal packing of particles (Mindess et al., 2003). Conversely, poorly graded aggregates lead to a greater void content and require higher amounts of cement paste, potentially compromising both strength and economy.

The sieve analysis conducted on coarse aggregates (Crushing Stone Chips and Pea Gravel) ensured that they adhered to the size distribution limits prescribed by ASTM C33/C33M-18. These standards define the acceptable ranges for different types of aggregates based on their maximum size, shape, and gradation.

2.7 Summary

In this chapter, an in-depth review of the primary materials used in concrete has been presented with special focus on their roles in determining the compressive strength of concrete. Ordinary Portland Cement (OPC) was selected as the binding material due to its wide availability and reliability. The water-cement ratio—one of the most crucial variables—was tested at three different levels (0.40, 0.45, and 0.50) to observe its effect on strength development.

Fine aggregate used in this study was high-quality Sylhet sand, conforming to standard gradation. For coarse aggregates, two types—Crushing Stone Chips and Pea Gravel—were used to assess the impact of aggregate type on the effective W/C ratio. Sieve analysis confirmed that both fine and coarse aggregates met the requirements of ASTM C136 standards.

The findings from previous studies have been included to justify the selection of materials and parameters, forming the basis for the experimental investigation in the subsequent chapter.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Concrete test cylinders play an extremely important role in the placement of concrete for construction and engineering purposes. Every type of concrete has a design strength, and making concrete cylinders allows the strength of a particular batch of concrete to be tested. This is necessary for quality control and acceptance, ensuring that the structure will be able to support any loads encountered, and ensure that the concrete cures properly. For all of these applications, though the concrete test cylinders need to be made, cured, and transported properly. This article follows ASTM C31/C31M: Standard Practice for Making and Curing Concrete Test Specimens in the Field.



Figure 3.1: Preparation of Cylinder

3.2 Materials:

1. Cement
2. Fine Aggregate
3. Coarse Aggregate
4. Water

Specifications of Cement:

Name: Portland Composite Cement (Fresh cement)

- Specific gravity of cement :3.15
- Setting times of cement: i) Initial setting time 30 minutes
- Final setting time 10 Hours
- Clinker :70-79%
- Limestone :21-30%
- Gypsum :0-5%

Fine Aggregate: Fine aggregate is a construction material consisting of small particles, such as sand, that pass through a 4.75 mm sieve, used to fill voids and improve the workability and cohesion of concrete or mortar.

In this study, Sylhet Sand used as fine aggregate.



Figure 3.2: Fine Aggregate

Coarse aggregate: Coarse aggregate is a construction material consisting of large particles, typically gravel or crushed stone, retained on a 4.75 mm sieve, used to provide strength and stability in concrete and asphalt.

In this study, we used two types of coarse aggregate. These are –

1. Local Deshi Stone (Burugghamari)
2. Pea Gravel.



Figure 3.3: Coarse Aggregate

3.3 Concrete mixing

A concrete mixer is a device that homogeneously combines cement, aggregate such as sand or stone, and water to from concrete. A typical concrete mixer uses a revolving drum to mix the components. This process is so crucial that if the concrete making ingredients aren't mixed properly, it can lead to concrete failure under compression load. A concrete mixture ratio of 1-part cement, 1.5 parts sands, and 3 parts aggregate will produce a concrete mix of approximately 3000 psi. Mixing water with the cement, sand and stone will from a paste that will bind the materials together until the mix hardens.

The primary goal of concrete mixing is to make the concrete mass homogeneous and uniform in color while maintaining the required consistency. Production of good quality and bad quality of concrete includes the same material, but the proportion and mixing methods can be differentiating. As a result, sufficient precautions should be followed while mixing concrete.



Figure 3.4: Concrete Mixing

3.4 Water-Cement Ratio

The water-cement ratio is defined as the ratio of the weight of water to the weight of cement used in a concrete mix. A lower water-cement ratio typically results in higher strength and durability, while a higher ratio may improve workability but reduces strength. In this study, three different water-cement ratios were selected:

- 0.40
- 0.45
- 0.50

3.5 Casting Cylinder

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods. In addition to the exact geometry of the component, the possible casting and molding methods must also be considered in advance in order to obtain an optimum cast part under series production conditions too.

Besides various changes to the construction, initial experiences with regard to future component properties, rejections and rework are also gained during pilot production. It is extremely important to have been rejection and ultimately all factor that restrict the output under control by the start of series production at the latest. This is the only way to achieve high productivity and low costs at the same time in order to be able to maintain the specified price for the component.



Figure 3.5: Casting Cylinder

3.6 Curing

- Curing concrete involves maintaining moisture and temperature conditions to allow the cement to hydrate.
- Curing time begins when the concrete is placed and continues until it has the desired properties.
- Curing affects the concrete's strength, permeability, and resistance to cracking.
- To cure concrete, you can use temperature recorders and data loggers to monitor the temperature and humidity.



Figure 3.6: Curing of Cylinder

3.7 Preparation to Crush the Concrete Cylinders

The water-cement ratio (W/C ratio) is the ratio of water to cement in concrete. It's a crucial factor in concrete's strength and durability.

Water-cement ratio for different types of concrete

- Normal concrete: Typically uses a W/C ratio of 0.40–0.50
- Higher-strength concrete: Uses a lower W/C ratio, plus a plasticizer to improve flowability
- Brick aggregate concrete: Strength and stiffness improve with a W/C ratio up to 0.40–0.55
- How water-cement ratio affects concrete

- A lower W/C ratio results in:
    - ✓ Fewer air pores
    - ✓ A more compact concrete structure
    - ✓ Higher strength
    - ✓ Reduced drying shrinkage and cracking
    - ✓ Lower permeability
    - ✓ A better bond between concrete and reinforcement
- Other factors affecting concrete performance
- Other factors that affect concrete performance include: The amount of cement, The amount of sand and aggregate, The amount of slag, and the amount of fly ash.
- Science Direct notes that the W/C ratio has a vital impact on the fresh and hardened properties of concrete.

3.8 UTM Machine

A Universal Testing Machine (UTM) is a mechanical testing machine that measures the strength and durability of materials. It's also known as a universal tensile testing machine, tensile tester, or tensile strength testing machine.

3.9 Compression Test

During the process of mixing the mortar, an external vibrator was also attached to the bottom of the machine and operated. The pressure of the press machine Figure 3.8. was applied from the top of the mold so that the concrete compacted perfectly. The pressing process was continued until the concrete was completely compact and dense. It was marked by the inability of the pressure machine to press down the concrete anymore.



Figure 3.7: Compression Test

3.10 Finishing

The final cast process was the process of mold removal where the concrete was released from the mold. This process was carried out by conducting the observation and measurement of the concrete that has been compacted to check if it is already in accordance with the designed size, or perhaps there are still minor damages due to the lack of compaction process. When there is a damage on the concrete specimen, then the process will be repeated all over again starting from the vibration and compaction processes until the specimen is cast perfectly as expected. The whole casting process is very quick and it only takes up about 4 to 7 minutes.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Result of Fine Aggregate

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

Table 4.1: Result of fine aggregate sieve analysis

Sieve No.	Retain	% Retain	Cumulative % Retain	FM
#4	4	0.4	0.4	275.8/100 =2.75
#8	30	3	3.4	
#16	215	21.5	24.9	
#30	335	33.5	58.4	
#50	320	32	90.4	
#100	79	7.9	98.3	
Pan	17	1.7	100	
Total	1000			

4.2 Result of Coarse Aggregate

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

Table 4.2: Result of Coarse Aggregate

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

Sieve No.	Retain	% Retain	Cumulative % Retain	FM	Finer
#3/4	1064	70.9	70.9	770.7/100 =7.70	29.1
#3/8	434	99.8	99.8		0 .2
#4	02	0.1	100		0
#8	0	0	100		0
#16	0	0	100		0
#30	0	0	100		0
#50	0	0	100		0
#100	0	0	100		0
total	1500				

4.3 Specific Gravity of Coarse Aggregate

Table 4.3: Data sheet for specific gravity of coarse 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
2000 gm	1948 gm	1225gm

Table 4.4: Specific gravity of Local Deshi Stone

Test	Formula	Calculation	Result
Apparent specific Gravity	A	1948	2.6
	A - C	1948-1225	
Bulk Specific Gravity (Oven Dry Basic)	B	2000	2.5
	B - C	2000-1225	
Bulk Specific Gravity (S.S.D. Basic), G	A	1948	2.5
	B - C	2000-1225	
Absorption Capacity, D%	(B - A) x 100	(2000-1948) x100	2.6
	A	1948	

Table 4.5: Specific gravity of Pea Gravel

Test	Formula	Calculation	Result
Apparent specific Gravity	A	2175	3.11
	A - C	2175-1475	
Bulk Specific Gravity (Oven Dry Basic)	B	2265	2.87
	B - C	2265-1475	
Bulk Specific Gravity (S.S.D. Basic), G	A	2175	2.75
	B - C	2265-1475	
Absorption Capacity, D%	(B - A) x 100	(2265-2175) x100	4.10
	A	2175	

The specific gravity of the normal stone course aggregate after oven drying was found 2.543 for coarse aggregate. We found the specific gravity of the apparatus to be 2.6 and bulk specific gravity oven dry ac obtained from 2.5. Apparent capacity reduction received 2.6 and bulk SSD received 2.77.

4.4 Specific Gravity of Fine Aggregate

Table 4.6: 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
653 gm	289 gm	836 gm	300 gm

Table 4.7: Specific gravity of fine aggregate

Test	Formula	Calculation	Result
Apparent Specific Gravity	A	289	2.72
	B + A - C	653+289-836	
Bulk SG (Oven Dry Basic)	A	289	2.47
	B + S - C	653+300-836	
Absorption Capacity, D%	S – A /A x 100	300-289 x 100 289	3.80
Bulk SG (S.S.D. Basic), G	S	300	2.56
	B + S - C	653+300-836	

The specific gravity of the Sylhet sand as fine aggregate after open drying was found 2.47. We found the specific gravity of the apparatus to be 2.72 and bulk specific gravity oven dry ac obtained from 2.47. Apparent capacity reduction received 3.80 and bulk SSD received

4.5 Results of 7 Days Compressive Strength Test

Table 4.8: 7 Days Compressive Strength Test

SL No	Types of Aggregate	Types of Sand	Mix Proportion	Water-cement Ratio	Compressive Strength (Psi)	Average Strength (Psi)	Average Compressive Strength (Mpa)
1	Pea Gravel	Sylhet Sand	1:1.5:3	0.40	3525.92	3062.79	21.05
					1822.702		
					3830.75		
2				0.45	2833.91	3044.07	20.92
					3436.88		
					2861.42		
3				0.50	2951.04	2738.64	18.82
					2657.21		
					2607.68		
4	Local Deshi Stone	Sylhet Sand	1:1.5:3	0.40	4427.33	4071.81	27.98
					3471.81		
					4316.30		
5				0.45	2740.18	2980.81	20.49
					2735.48		
					3466.88		
6				0.50	2893.29	2837.95	19.50
					2857.05		
					2763.50		

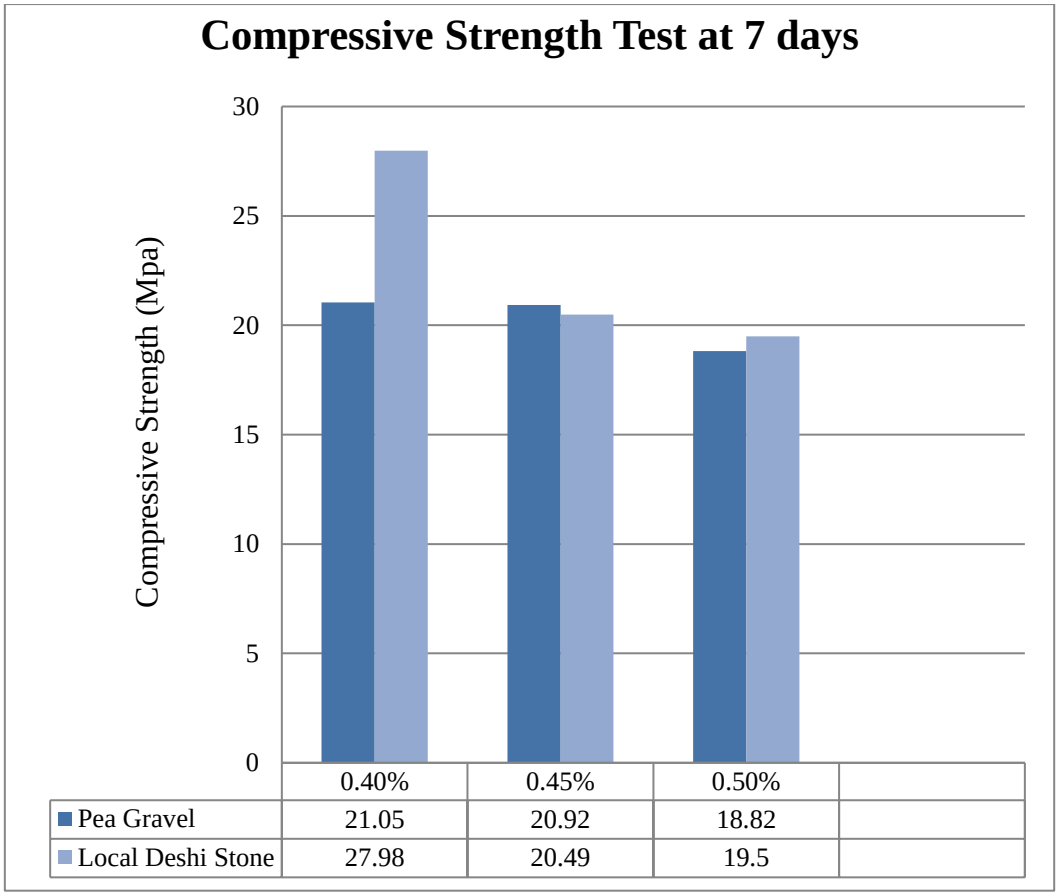


Figure 4.1 Chart of 7 days test result

It is observed from the 7 days test results that; the highest compressive strength is 27.98 Mpa for 0.40 water-cement ratio. On the other hand, the lowest compressive strength is 18.82 Mpa for 0.50 water-cement ratio at 7 days. For the lowest water-cement ratio, the compressive strength was the highest, and for the highest water-cement ratio, the lowest. It is observed that the local stone has the maximum compressive strength at 7 days for the lowest water-cement ratio.

4.6 Results of 28 Days Compressive Strength Test

Table 4.9: 28 Days Compressive Strength Test

SL No	Types of Aggregate	Types of Sand	Mix Proportion	Water-cement Ratio	Compressive Strength (Psi)	Average Strength (Psi)	Average Compressive Strength (Mpa)
1	Pea Gravel	Sylhet Sand	1:1.5:3	0.40	4604.33	4456.78	30.63
					4751.72		
					4014.29		
2				0.45	3815.33	3839.77	26.39
					3648.77		
					4055.21		
3				0.50	2976.07	3217.83	22.12
					3327.04		
					3350.39		
4	Local Deshi Stone	Sylhet Sand	1:1.5:3	0.40	4649.80	4515.53	31.03
					4136.32		
					4760.47		
5				0.45	4559.12	4121.21	28.32
					4496.00		
					3303.51		
6				0.50	3695.11	3640.54	25.02
					3631.81		
					3594.70		

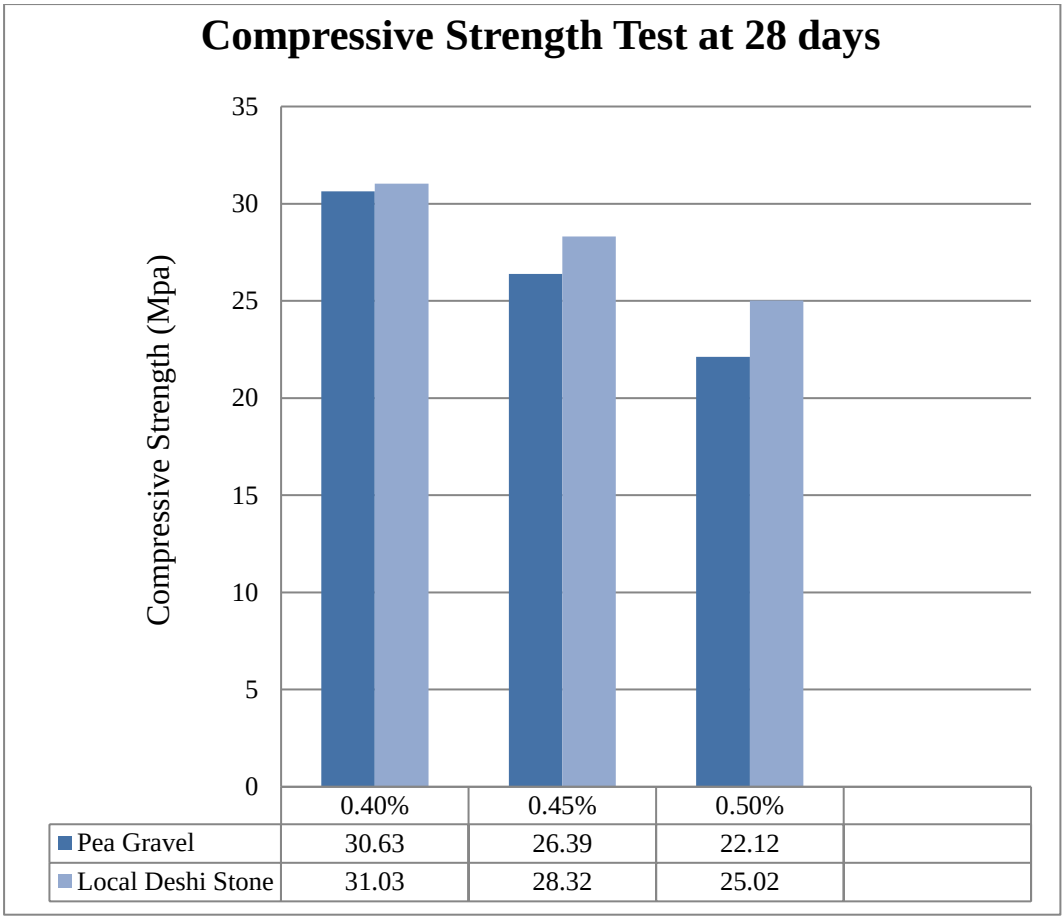


Figure 4.2 Chart of 28 days test result

It is observed from the 28 days test results that; the highest compressive strength is 31.03 Mpa for 0.40 water-cement ratio. On the other hand, the lowest compressive strength is 22.12 Mpa for 0.50 water-cement ratio at 28 days. For the lowest water-cement ratio, the compressive strength was the highest, and for the highest water-cement ratio, the lowest. It is observed that the local stone has the maximum compressive strength at 28 days for the lowest water-cement ratio.

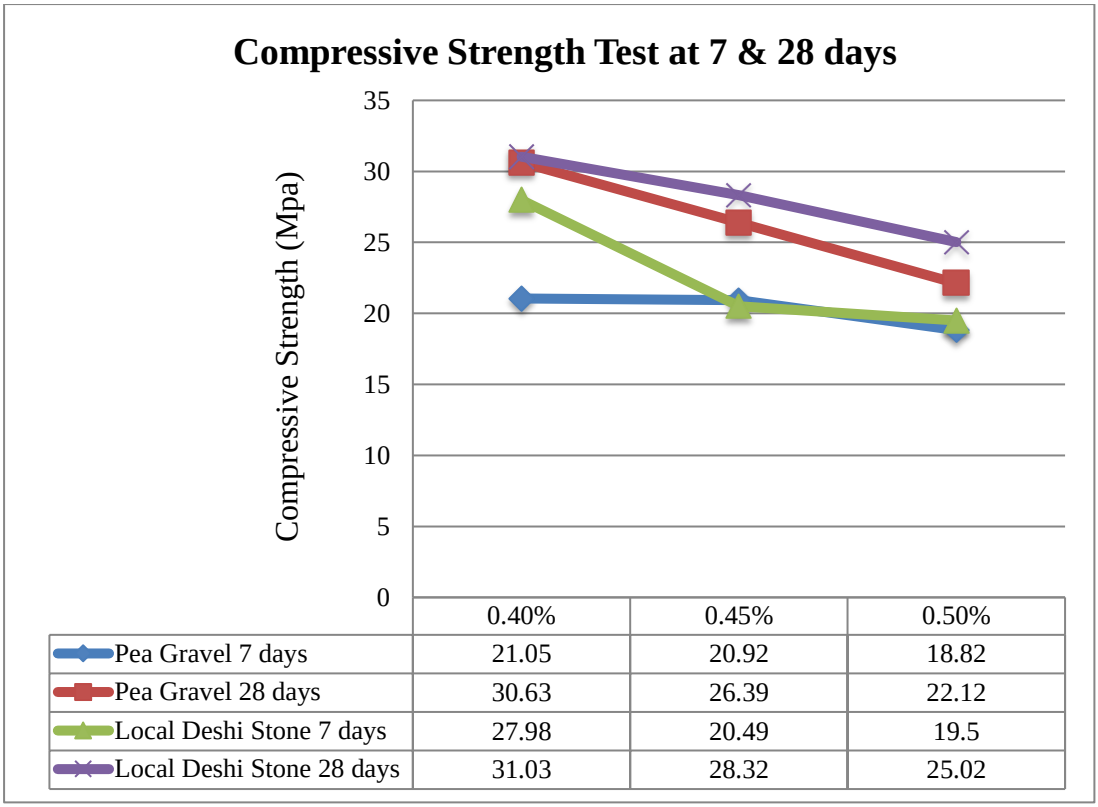


Figure 4.3: Compressive strength after 7 & 28 days

- Figure shows that the compressive strength of concrete decreases as the water/cement ratio increases. The strength of concrete depends mainly on the strength of the cement paste, and the strength of the cement paste rises with the cement content and falls with the air content.
- A lower water-cement ratio leads to a denser concrete mix, with fewer capillary pores. This results in higher compressive strength and better durability. Lower w/c ratio leads to a more compact and dense concrete structure with fewer air pores, which in turn improves strength. The reduced water content allows for a stronger bond between the cement paste and aggregates, enhancing the structural integrity of the concrete.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

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

1. In all the experiments for different water cement ratios, it shows that as the water cement ratio increases, the compressive strength decreases.
2. It is observed from the test results that the lowest water-cement ratio gave the high compressive strength (31.03 MPa for 28 days).
3. The Local stone gave better compressive strength value in both 7 days and 28 days at 0.40 water-cement ratio. On the other hand, Pea gravel gave very close compressive strength (30.63 Mpa) for the same water-cement ratio at 28 days.
4. In comparison to the other water cement ratios, the highest water cement ratio produced the lowest compressive strength.
5. It is observed that the 0.45 water cement ratio shows the average compressive strength at both 7 days and 28 days.

5.2 Recommendations

Based on the findings, the following recommendations are provided:

1. Further study can be conducted using other types of local cement available in the market to compare performance.
2. The research can be extended by working with other concrete grades such as M7.5, M10, M25, M30, M35, M40, M45, and M50 to observe the behavior at different strength levels.
3. More variations of water-cement ratios can be tested beyond 0.40, 0.45, and 0.50 to understand their impact on strength and workability more comprehensively.
4. The effect of chemical admixtures (like superplasticizers or retarders) can be studied in combination with different W/C ratios.

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