EXPERIMENTAL STUDY ON THE INFLUENCE OF ADMIXTURES ON CONCRETE WORKABILITY AND COMPRESSIVE STRENGTH

By

Ripon Hossain

Md. Rezaul Karim

Md. Monsur Ali

Mohidul Alam

Md. Mofazzal Hossain

Kazi Md. Rejaul Islam

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

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

Section: 25A

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By

Ripon Hossain	ID: CE 2201025086
Md. Rezaul Karim	ID: CE 2201025105
Md. Monsur Ali	ID: CE 2201025001
Mohidul Alam	ID: CE 2201025042
Md. Mofazzal Hossain	ID: CE 2201025007
Kazi Md. Rejaul Islam	ID: CE 2201025005

Supervisor
Tamanna Haque Himi
Lecturer
Department of Civil Engineering
Sonargaon University

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

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BOARD OF EXAMINERS

The thesis titled **"Experimental Study On The Influence Of Admixtures On Concrete Workability And Compressive Strength"** submitted by Ripon Hossain, ID: CE2201025086, Md. Rezaul Karim, ID: CE2201025105,Md. Monsur Ali, ID: CE2201025001, Mohidul Alam, ID: CE2201025042, Md. Mofazzal Hossain, ID: CE2201025007, Kazi Md. Rejaul Islam, ID: CE2201025005 have been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering on 20th September, 2025.

…….....

Tamanna Haque Himi — Chairman

Lecturer

Dept. of Civil Engineering

Sonargaon University

.....

1. Internal/External Member — Member

.....

2. Internal/External Member — Member

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STUDENT NAME	STUDENT ID	SIGNATURE
Ripon Hossain	ID: CE2201025086	
Md. Rezaul Karim	ID: CE2201025105	
Md. Monsur Ali	ID: CE2201025001	
Mohidul Alam	ID: CE2201025042	
Md. Mofazzal Hossain	ID: CE2201025007	
Kazi Md. Rejaul Islam	ID: CE2201025005	

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. Half of them 7days and rest of them for 28 days. Another twelve of the cylinders was covered with jute membrane like the local construction side and cured 2 hours to 3-hour intervals. Rest of them without any covering cured 2 hours to 3-hour intervals. Mixing and curing water is one of the components required, and it should be suitable for producing concrete. 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 1.5% percentage admixture with 0.325 water cement ratio gave better compressive strength value (20.17 MPa) for 7 days test. and (25.98 MPa) for 28 days test. The study we can see that using admixture to increase the workability of concrete and reducing the water to cement ratio increases the compressive strength of concrete.

TABLE OF CONTENTS

ABSTRACT ..... (vi)
LIST OF FIGURES ..... (ix)
LIST OF TABLES ..... (x)
CHAPTER 1 1
INTRODUCTION 1
1.1 General 1
1.2 Concrete 1
1.3 Background and motivations 2
1.4 Research objectives of the study 4
CHAPTER 2 5
LITERATURE REVIEW 5
2.1 The main literature relevant of the study 5
2.2 Concrete 6
2.3 Composition of basic concrete mix 6
2.4 Properties of concrete 7
2.5 Water 7
2.6 Water to cement ratio 8
2.7 Testing the water-cement ratio: the slump test 8
2.8 Cement: binding materials 9
2.9 Portland composite cement (PCC) 9
2.10 Aggregates 10
2.11 Coarse aggregate (CA) 11
2.12 Fine aggregates (FA) 12
2.13 Sieve analysis of fine and coarse aggregates 13
2.14 Admixture & additives 13
2.15 Chemical composition of admixtures 13
2.16 Types of admixtures 14
2.17 Mechanism of action chemical admixtures 15

2.18 Production of admixture 15
2.19 Compressive strength 15
2.20 Compressive strength formula 17
CHAPTER 3 18
METHODOLOGY 18
3.1 Preparation of cylinder 18
3.2 Concrete mixing 19
3.3 Admixture adding 20
3.4 Slump test and result 20
3.5 Casting of cylinder 21
3.6 Cylinder curing 22
3.7 Preparation to crush the concrete cylinders 22
3.8 UTM machine 23
3.9 Compressive strength test 24
CHAPTER 4 25
RESULT AND DISCUSSION 25
4.1 Result of fine aggregate 25
4.2 Result of Coarse Aggregate 28
4.3 Details of the Concrete properties 31
4.4 Cylinder compressive strength of 7 days test report 32
4.5 Cylinder compressive strength of 28 days test report 33
4.6 Concrete workability result by initial slump test 34
CHAPTER 5 36
CONCLUSION AND FUTURE WORKS 36
5.1 CONCLUSIONS 36
5.2 RECOMMENDATIONS 36
5.3 LIMITATIONS 36
REFERENCES 37

LIST OF FIGURES

Figure 2.1 Concrete Mixture. 6

Figure 2-2 Sand Fineness Modulus Test. 11

Figure 3-1 Mold Preparation for casting. 18

Figure 3-2 Weight of cement and coarse aggregate. 19

Figure 3-3 Mixing of cement fine aggregate and coarse aggregate. 19

Figure 3-4 Admixture adding in concrete. 20

Figure 3-5 Concrete slump test. 21

Figure 3-6 Concrete cylinder making. 21

Figure 3-7 Cylinder curing. 22

Figure 3-8 Measurement of cylinder diameter & height. 23

Figure 3-9 Place the cylinder in UTM machine. 23

Figure 4-1 Fine aggregate unit weight. 26

Figure 4-2 Fine aggregate drying. 27

Figure 4-3 Weight of coarse aggregate. 29

Figure 4-4: Compressive strength test result of 7 days. 32

Figure 4-5: Compressive strength test result of 28 days. 33

Figure 4-6: Compressive strength (MPa) of 7 days vs 28 days. 34

Figure 4-7: Concrete initial slump test result. 34

LIST OF TABLES

Table 4-1 Result of Fine Aggregate Sieve Analysis 25

Table 4-2 Result of fine aggregate unit weight 26

Table 4-3 Result of Fine Aggregate Specific Gravity 27

Table 4-4 Result of Coarse Aggregate Gradation 28

Table 4-5 Result of Coarse Aggregate Unit Weight 29

Table 4-6 Result of Coarse Aggregate Specific Gravity 30

Table 4-7 Concrete Mix Design 31

Table 4-8 Cylinder area & weight after curing 31

Table 4-9 Cylinder Test Results of 7 days 32

Table 4-10 Cylinder Test Results of 28 days 33

CHAPTER 1
INTRODUCTION

1.1 General

Concrete is one of the oldest and most commonly utilized construction materials around the world, mainly due to its cost-effectiveness, availability, durability, and ability to withstand harsh weather conditions. The amount of concrete produced globally is ten times that of steel in terms of weight. In contrast, other construction materials, such as steel and polymers, are generally more expensive and not as extensively used as concrete. Although concrete has high compressive strength, it is a brittle material with low tensile strength. As a result, it is important to reinforce concrete to help it withstand tensile stresses, which is usually done with the use of steel.

1.2 Concrete

Concrete, a vital construction material is traditionally composed of cement, water, fine aggregates (such as sand), and coarse aggregates (such as gravel or crushed stone). Aggregates form the largest portion of concrete, typically making up about 70-80% of its volume. Cement functions as a binding material in concrete.

Concrete compressive strength:

Concrete compressive strength measures its resistance to crushing forces and is the most common indicator of concrete performance. This test is vital for ensuring a concrete mix's quality, strength, and suitability for construction projects, with common test specimens being cylindrical or cubic.

Admixture:

Admixtures are added to the concrete mix to provide several benefits like waterproofing, water reduction or accelerated hydration rate and hardened properties, enhancing workability, increasing strength, reducing permeability, and improving durability. addition to the fundamental components such as cement, water, and aggregates, can improve workability, change setting times, increase strength, and boost durability.

Water:

The greater the amount of water in concrete, the more workable the concrete becomes, as water reduces its thickness. Adding water to concrete initiates a hydration reaction, leading to the hardening process. The pH level of the water should be between 6 and 8. If water is to be used for reinforced concrete, it should be free of salt, as salt can lead to the corrosion of the reinforcing steel.

Chemical composition of admixture:

Concrete admixtures are substances incorporated into concrete mixtures in addition to water, aggregates, and cement, in order to change its characteristics in both fresh and cured forms. They can be generally divided into two categories: chemical and mineral admixtures. Chemical admixtures, usually in liquid or powder form, are employed to modify workability, setting times, strength gain, and durability. Mineral admixtures, such as fly ash and slag, are utilized to improve the long-term properties and durability of concrete.

History of admixture:

Concrete admixtures are substances incorporated into concrete to enhance its characteristics and have been used since ancient times, notably by the Romans who employed different materials to strengthen their concrete. Nevertheless, the development of modern chemical admixtures started in the 20th century, with major progress occurring in the 1930s and later, resulting in their extensive application in the construction industry.

Production of admixture:

Concrete admixtures, which are substances incorporated into concrete to improve its characteristics, are created by mixing different chemicals and additives. These admixtures are usually supplied as liquids and are introduced to the concrete either at the manufacturing facility or at the construction site during the mixing process.

1.3 Background and motivations

Admixtures in concrete are substances introduced into the mix, in addition to cement, water, and aggregates, to improve particular characteristics. The origins and purpose of these materials derive from the intent to enhance concrete's performance during both the mixing and curing stages, as well as in its finished form. This encompasses enhancing workability, strength, durability, and

managing setting time, which ultimately results in more efficient and cost-effective construction practices.

Early use:

While the formal study and use of admixtures is relatively recent, the concept of modifying concrete properties dates back to ancient times, with the Romans using materials like volcanic ash to enhance concrete.

Modern development:

The systematic development and use of chemical admixtures began in the 20th century, driven by the need for more advanced concrete materials to meet the demands of modern construction.

Evolution of admixtures:

From simple water-reducing agents to complex superplasticizers and other specialized additives, the range of admixtures has expanded significantly, allowing for precise control over concrete properties.

Motivation:

Improved workability: Admixtures can improve the consistency and flow of concrete, making it easier to place and compact, especially in complex or congested areas.

Enhanced strength and durability: Certain admixtures can increase the compressive and tensile strength of concrete, as well as its resistance to weathering, chemical attack, and other forms of deterioration.

Controlled setting time:

Admixtures can accelerate or retard the setting and hardening process, allowing for greater flexibility in construction schedules and enabling the use of concrete in extreme temperatures.

Reduced water content:

Water-reducing admixtures can lower the water-cement ratio, leading to stronger and more durable concrete while potentially reducing the amount of cement needed.

Cost-effectiveness:

By optimizing concrete mixes and reducing the need for excessive cement or other materials, admixtures can contribute to cost savings in construction projects.

Sustainability:

Admixtures can play a role in sustainable construction by enabling the use of supplementary cementitious materials (like fly ash or slag) and reducing the overall environmental footprint of concrete.

1.4 Research objectives of the study

1. To determine the compressive strength of concrete by using different percentage of admixture.
2. To reduce the value of the water-cement ratio.
3. To evaluate the workability of concrete with the use of admixture.

CHAPTER 2

LITERATURE REVIEW

2.1 The main literature relevant of the study:

Muhsen Salem et al. (2016) found that lowering the water-to-cement ratio improves the workability of concrete as the amount of admixture increases, leading to enhanced properties of concrete that contribute to better workability. In terms of hardened concrete, the incorporation of admixtures boosts compressive strength by improving compaction effectiveness, resulting in denser concrete. Their study involved experimental optimization of admixtures in cement mortar and concrete, which significantly increased the diameter at early ages.

Nagaraju et al. (2018) conducted a comparative analysis to determine the optimum dosage of various admixtures using the slump test. This paper aims to explore how different dosages of admixtures affect the fresh properties of concrete. They investigated an M40 mix grade by creating seven different mixes to establish the required dosage of admixture. Although the dosage of admixture increased, the variation in compressive strength was only minimal.

Ali M Mansor et al. (2018) examined how the water-cement ratio and chemical admixtures influence the workability of concrete through the incorporation of various optimized percentages of chemical admixtures. Their inclusion allows for a reduction in the w/c ratio without compromising the mixture's workability, resulting in higher density for the cement paste. Among all mixes, the optimal slump results were achieved, with maximum compressive strengths obtained at different points of admixture inclusion. Their findings support the use of chemical admixtures in concrete mixtures.

R. Karolina et al. (2023) focused on "The compressive strength of concrete by incorporating an admixture of graphene oxide dispersion." The study explored the compressive strength of concrete with the addition of admixture at a concentration of 1 mg/ml, varying between 20 mL, 30 mL, and 50 mL. Generally, adding admixtures to concrete enhances its compressive strength compared to conventional concrete. The highest compressive strength was achieved with the addition of 50 mL of admixture, indicating that increased amounts of admixture lead to enhanced compressive strength in concrete.

2.2 Concrete

Concrete is a composite building material composed of a blend of cement, water, aggregates (like sand, gravel, or crushed stone), and sometimes additives (such as silica fume). When these components are combined, they create a paste that solidifies over time due to chemical reactions, mainly the hydration process of the cement particles with water, resulting in a robust and long-lasting material utilized in construction. Concrete is strong, simple to produce, and can be molded into various shapes and sizes.



Figure 2-1: Concrete Mixture

This system is intended to enable dependable and efficient fast-track building processes. Structures built using concrete as a measurement unit are highly resilient and should be engineered to withstand earthquakes, hurricanes, typhoons, and tornadoes. This represents a significant progression. Concrete that achieves a compressive strength of at least 21 MPA (3000 PSI) after 28 days is generally regarded as high strength.

2.3 Composition of basic concrete mix

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

- Binding materials like cement or lime
- Aggregates or Inert Materials:
  - Fine aggregate (sand) and Coarse aggregate (stone chips, brick chips)
- Water
- Admixture

2.4 Properties of concrete

Concrete has several properties that make it an ideal building material for various applications. Here are some of the most important properties of concrete:

1. **Poisson's ratio**- measures the ratio of lateral strain to axial strain when a material is stretched or compressed. Poisson's ratio can affect the overall strength and stability of concrete structures.

2. **Workability** - This refers to the ease with which the concrete can be mixed, transported, and placed into its final position. A high degree of workability is essential for achieving the desired shape and finish of the concrete.3. Strength - Concrete is known for its strength and can withstand heavy loads and stresses. The compressive strength of concrete can vary widely depending on its composition and curing time.

3. **Durability** - Concrete is highly durable and can withstand environmental exposure, including water, wind, and extreme temperatures. Proper curing and maintenance can extend the lifespan of concrete structures.

4. **Creep** refers to the gradual deformation of concrete under sustained loads over time. If not accounted for during the design and construction process, creep can result in structural damage.

5. **Shrinkage** - Concrete can shrink as it dries, which can result in cracking and other damage. Proper reinforcement and curing can help minimise the effects of shrinkage.

6. **Unit weight** - The unit weight of concrete refers to its density and can vary depending on its composition and strength. A higher unit weight can result in stronger, more durable concrete.

2.5 Water

Water plays an essential role in concrete, serving not only for mixing but also for the hydration reaction that solidifies and strengthens the mixture. The appropriate amount of water is vital; excess can compromise the concrete's strength, while insufficient water can render it difficult to work with. A general guideline is that water constitutes about 15-18% of the total volume of concrete. Typically, it is recommended to use around 0.2 to 0.25 m3 of water for every m3 of

concrete for curing purposes. This ratio ensures that the concrete remains sufficiently moist during the curing phase, facilitating proper hydration and the development of strength. The pH level of water deemed suitable for concrete work should generally fall between 6 and 8. Water that is safe for drinking will also be appropriate for use in concrete construction. The procedure for determining the solid content should adhere to IS: 3025 standards.

2.6 Water to cement ratio

The water-cement ratio refers to the weight of water in relation to the weight of cement in a concrete mix. The American Concrete Institute (ACI) usually suggests a W/C ratio between 0.45 and 0.60 for standard concrete. This ratio, calculated by dividing the mass of water by the mass of cement, plays a crucial role in determining the strength and durability of concrete. A lower ratio (around 0.40) typically results in greater strength and less shrinkage, whereas a higher ratio (approximately 0.60) enhances workability but may decrease strength and increase permeability. The issue of workability can be addressed by using plasticizers or superplasticizers. Conventional mixing techniques generally achieve a water-cement ratio of about 0.45 for M20 grade concrete, yielding a compressive strength of roughly 60 to 70 MPa after 28 days when normal density aggregates are utilized (FIP/CEB, 1990). In general, the water used for concrete should be of potable quality.

Minimum water cement ratios for PCC (Plain Cement Concrete) as per IS 456 (2000):

M15 grade concrete: 0.60 M20 grade concrete: 0.45-0.50 M25 grade concrete: 0.40

Minimum water cement ratios for RCC (Reinforced Cement Concrete) as per IS 456 (2000):

M20 grade concrete: 0.55 M25 grade concrete: 0.50 M30 grade concrete: 0.45

M35 grade concrete: 0.45 M40 grade concrete: 0.40

2.7 Testing the water-cement ratio: the slump test

Conducting a slump test is vital for verifying the correctness of your cement mixture. This straightforward but crucial assessment helps assure that the cement you selected has the potential to provide the strength your home requires. Standard Slump Values: (i) Mass Concrete and Road Work: 2.5 to 5 cm, (ii) Beams and Slabs: 5 to 10 cm, (iii) Columns and Retaining Walls: 7.5 to 12.5 cm.

2.8 Cement: binding materials

Cement serves as a glue that functions as a hydraulic binder, meaning it solidifies when water is added. Its main purpose is to bind fine sand and coarse aggregates together to form concrete. As a fine powder composed of a blend of mineral materials, it creates a paste when mixed with water, which hardens over time. Cement is a vital component of concrete, alongside aggregates (sand, gravel, or crushed stone) and water. Acting as a bonding agent, cement unites the other materials in concrete and imparts strength once it has set and cured. Only hydraulic cements are utilized for structural concrete. The hydration process requires water, during which the cement powder solidifies into a firm mass. Numerous hydraulic cements have been created, with Portland cement—first patented in England in 1824—being the most widely used. Hydraulic cements harden by reacting with water and develop compounds that resist water once fully set. They exhibit remarkable durability and compressive strength in both mortar and concrete. Their specific gravity varies from 3.12 to 3.16, with a density of 1208 kg/m3.

2.9 Portland composite cement (PCC)

Portland Composite Cement (PCC) is a form of cement that integrates Portland cement with various additional substances, also referred to as blended materials or supplementary cementitious materials. Portland cement primarily comprises compounds of lime (calcium oxide, CaO) mixed with silica (silicon dioxide, SiO2) and alumina (aluminum oxide, Al2O3). The lime is extracted from a calcareous (lime-rich) raw material, while the other oxides come from an argillaceous (clayey) source. Other raw materials, including silica sand, iron oxide (Fe2O3), and bauxite—containing hydrated aluminum, Al(OH)3—may be incorporated in smaller amounts to achieve the desired mix. The most common calcareous raw materials include limestone and chalk, though alternative sources such as coral or shell deposits can also be utilized. Common argillaceous raw materials include clays, shales, slates, and estuarine muds. Marl, a cohesive calcareous clay, and cement rock provide both calcareous and argillaceous components in proportions that can sometimes resemble cement compositions. Another relevant raw material is blast-furnace slag, which is mainly composed of lime, silica, and alumina and is combined with a calcareous material that has a high lime content. Kaolin, a white clay with minimal iron oxide, serves as the argillaceous component in white Portland cement. Industrial byproducts, such as fly ash and calcium carbonate from chemical production, can also serve as raw materials, albeit to a lesser

extent compared to natural materials. The content of Magnesia (magnesium oxide, MgO) in raw materials must remain low, as the allowable limit in Portland cement is between 4 and 5 percent. Gypsum is another crucial raw material, with approximately 5 percent being added to the ground cement clinker during the grinding process to regulate the setting time of the cement**.**

European cement standard EN 197-1 Cement – Part 1: "Composition, specifications and conformity criteria for common cements" which defines 27 distinct common cement products and their constituents. These 27 products are grouped into the following categories:

- CEM I Portland cement (>95% clinker)
- CEM II Portland-composite cement (65-94% clinker)
- CEM III Blast furnace cement (5-64% clinker)
- CEM IV Pozzolanic cement (45-89% clinker)
- CEM V Composite cement (20-64% clinker)

2.10 Aggregates

In the construction industry, aggregates are granular substances such as sand, gravel, and crushed stone that are mixed with a binding agent (such as cement or asphalt) to produce concrete, mortar, or asphalt. They are essential components of various building and infrastructure projects, offering bulk, strength, and stability to these materials. Aggregates can make up as much as 60% to 80% of a typical concrete mixture, so it is vital to choose them properly to ensure durability, to blend them for maximum efficiency, and to control them to achieve consistent concrete strength, workability, finish quality, and longevity. Aggregate base usually consists of crushed rock that can pass through a 20-millimeter (3⁄4 in) rock screen. The particle sizes will range from 20 mm down to dust. This material may be derived from either newly mined rock or recycled asphalt and concrete. The base is utilized as a foundational layer in roadways, as a supporting layer for cement pads and foundations, and as backfill for underground pipelines and various underground utilities. The base course serves as the sub-base layer of an asphalt roadway. The attributes of aggregate in construction include (i): size and shape, (ii): density and packing, and (iii): strength and durability.

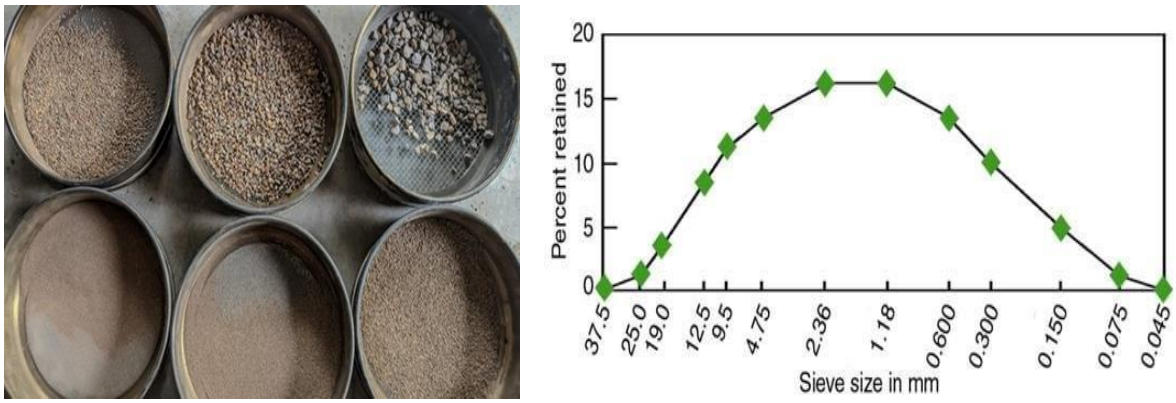


Figure 2-2: Sand Fineness Modulus Test

(iv) Moisture content. The fineness modulus (FM) serves as an indicator of the particle size of an aggregate. For fine aggregate, the FM should be within the range of 2.3 to 3.1. Any variation in the FM should not exceed 0.2. The largest size of coarse aggregate that can be incorporated into a mix is determined by the dimensions, shape, and reinforcement of a member, according to these "not-to-exceed" criteria: (i) three-quarters of the clear spacing between rebars or between rebars and forms (cover distance), (ii) one-third the depth of the slab, and one-fifth the narrowest dimension of a member.

2.11 Coarse aggregate (CA)

Coarse aggregates are materials that are granular in nature. They are commonly utilized in construction for producing concrete. Their primary makeup consists of crushed stone, gravel, or recycled concrete materials. Coarse aggregates usually make up over 60-80% of concrete's total volume. The durability of these aggregates is contingent upon their quality, which significantly influences the strength and workability of the concrete mix. According to sieve analysis, coarse aggregates are categorized as those with sizes greater than 4.75 mm, typically falling between 3/8 inch (about 9.5 mm) and 1.5 inch (around 38 mm) in diameter.

They provide essential strength to concrete for structures that bear heavy loads. They enhance the structural integrity and improve water resistance while ensuring dimensional stability within the concrete. They help manage shrinkage and maintain thermal balance during the curing phase, which is vital for the hydration of cement. The quantity of coarse aggregates influences the concrete mix's size and shape and affects the adhesion of the cement paste course aggregates are sourced naturally from deposits of crushed stone, quarries, river gravel, and similar locations. The

process of producing these aggregates entails several steps, including blasting, crushing, and screening, mainly influenced by the rock type utilized. This rock type may fall into metamorphic, igneous, or sedimentary categories. Choosing the right type and size of coarse aggregate can enhance the durability and stability of the structure. The aggregate size also plays a role in determining the cement-to-water ratio, which is 0.45 for M20. A lower water content results in a stronger mix; however, it can also reduce workability. An essential consideration is the spacing between TMT bars, as the aggregate must be smaller than the openings between internal reinforcements.

2.12 Fine aggregates (FA)

Fine aggregates are categorized as inert granular materials. They possess various characteristics that influence the performance of concrete. Typically, they have a high surface area. The gaps between the coarse aggregates are referred to as voids. Fine aggregates serve to occupy the voids present in the coarse aggregates. These materials are primarily natural substances made up of crushed stone or sand. Common sources include gravel, crushed stone, and river sand. They are economical and play a crucial role in the strength, durability, and stability of concrete. The particle size must have a diameter smaller than 4.75 mm. Fine aggregates constitute 35% to 45% by mass or volume of concrete mixtures. The extraction of these fine aggregate materials occurs through mining. The fineness modulus for fine aggregates in the grading zone ranges from 2.30 to 3.10.

The main impact of fine aggregate is to achieve the necessary density and a cohesive mix. Their quality is vital for determining the integrity of the structure. The role of fine aggregate is to improve the workability and finish of concrete. It fills the voids and decreases the needed amount of cement. This, in turn, enhances the overall strength of the cement mixture. Absorption denotes the capability of fine aggregates to take in water. This characteristic greatly influences the water-cement ratio in the concrete mix and helps preserve the integrity of the mix by limiting excessive water absorption. It reduces cracking, which leads to less concrete shrinkage and has a significant effect on the strength and durability of the final product. Additionally, fine aggregates may act as soil amendments, aiding in the formation of high, compact surfaces while offering substantial mechanical strength.

2.13 Sieve analysis of fine and coarse aggregates

Sieve analysis is a standard laboratory method used to determine the particle size distribution of both fine and coarse aggregates. This test, following IS specifications and MORTH guidelines, categorizes sand into different grading zones to evaluate its suitability for concrete construction. The phrase "sieve analysis" refers to the process of separating a sample of aggregates into fractions, each containing particles within defined limits. The term Fineness Modulus (F.M) serves as an index indicating the coarseness or fineness of the material. It is an empirical measure derived by adding the cumulative percentages of aggregates trapped on each of the standard sieves and dividing the total by 1000. The ASTM standard sieves include No. 100, No. 50, No. 30, No. 16, No. 8, No. 4, and 3/8 in. This testing method meets the ASTM standard specifications outlined in C136.

2.14 Admixture & additives

An admixture refers to any substance apart from water, aggregates, cementitious materials, and fiber reinforcement, that is added to a cementitious mixture to alter its properties when fresh, during setting, or once hardened. These materials can improve the workability, strength, durability, and various other attributes of concrete in both its fresh and hardened forms. Natural admixtures in concrete mainly consist of pozzolanic substances such as volcanic ash, rice husk ash, and different types of clays. The inclusion of pozzolana in cement enhances workability and offers resistance to attacks from salt and sulfate. Admixtures are classified according to their roles, including those that reduce water content, entrain air, accelerate, or slow down the setting process.

2.15 Chemical composition of admixtures

Concrete admixtures are substances incorporated into concrete mixtures in addition to water, aggregates, and cement, to change its characteristics in both its fresh and hardened forms. These admixtures are generally divided into two categories: chemical and mineral. Chemical admixtures, which are usually in liquid or powder form, serve to modify workability, setting time, strength development, and durability. Mineral admixtures, such as fly ash and slag, are utilized to improve the long-term properties and durability of concrete.

2.16 Types of admixtures

To obtain the desired characteristics in concrete and to meet the requirements of the structures built today, several different types of admixtures are used:

i) Chemical Admixtures	**ii) Mineral Admixtures**
a) Plasticizers	a) Cementitious
b) Super Plasticizers	b) Pozzolanic
c) Accelerators	c) Ground Granulated Blast Furnace Slag
d) Set Retarders	d) Fly Ash

ASTM C494 specifies the requirements for seven chemical admixture types. They are:

Type A: Admixtures that reduce water content

Type B: Admixtures that delay setting time

Type C: Admixtures that speed up setting time

Type D: Admixtures that reduce water and delay setting

Type E: Admixtures that reduce water and speed up setting

Type F: High-range water-reducing admixtures

Type G: High-range water-reducing and retarding admixtures

2.17 Mechanism of action chemical admixtures

Chemical admixtures incorporated into concrete mixtures impact the characteristics of concrete via chemical interactions. The specific type of chemical interaction that occurs within the concrete mix is determined by the category of admixture used and the chemical makeup of the concrete admixtures. The reactions of the admixtures in concrete blends may include any of the following:

1. Chemical interactions that affect the cement hydration process by speeding up or slowing down the hydration rate.

2. Adsorption onto cement particles, which leads to particle dispersion (electrostatic repulsion resulting from sulfonate-based admixtures).

3. Modifying the surface tension of water (air entrainment due to surface-active agents).

4. Influencing the water's rheology, resulting in increased plastic viscosity or enhanced mix cohesion (steric hindrance caused by poly-carboxylate ether-based admixtures).

5. Penetrating hardened concrete with specific chemicals to safeguard concrete and enhance durability (such as corrosion resistance and water repellency).

2.18 Production of admixture

Concrete admixtures are substances incorporated into concrete to improve its characteristics, created by blending different chemicals and additives. Usually available in liquid form, these admixtures are introduced to the concrete either at the batching plant or at the construction site during the mixing phase. The manufacturing process consists of choosing suitable raw materials, formulating them according to the intended properties, and then combining them in a regulated setting.

2.19 Compressive strength

a) Effect of cement

Workers may inhale elevated levels of dust while emptying cement bags. In the short term, this exposure can lead to irritation of the nose and throat, resulting in choking and breathing difficulties. The cement industry is a significant contributor to carbon dioxide emissions, which is a powerful greenhouse gas. The production of concrete negatively impacts the most fertile layer of topsoil.

The compressive strength of concrete increases as the cement content rises. Cement dust can enter the bloodstream, reaching nearly all body organs and affecting various tissues, including the heart, liver, spleen, bones, muscles, and hair, ultimately influencing their microstructure and physiological functioning.

b) Effect of aggregate/cement ratio

Well-graded aggregates minimize the number of voids within a specific volume. Fewer voids lead to increased paste availability in a unit volume, enhancing lubrication. A higher aggregate/cement ratio results in a greater compacting factor due to the increased proportion of fines (cement) in the mix and reduced aggregate content, which serves as a lubricant and lowers the internal friction among aggregate particles, ultimately causing an increase in the compacting factor.

c) Effect of aggregate properties

Aggregates affect the characteristics of concrete and mortar, such as the amount of water needed, as well as the cohesiveness and workability of the mixture in its plastic state. In the hardened state, they impact strength, density, durability, permeability, surface finish, and color. Typically viewed as an inert filler, aggregates make up 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Although aggregates are deemed as inactive fillers, they play a crucial role in determining the thermal and elastic properties, as well as the dimensional stability of concrete.

d) Effect of admixture

Admixtures have increased both compressive strength and durability of concrete.

e) Effect of the specimen size

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

f) Effect of the rate of loading

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

g) Effect of the moisture content

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

h) Effect of the temperature of the testing

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

2.20 Compressive strength formula

Compressive strength refers to the highest compressive stress that a solid material can endure without breaking when a load is applied gradually. It is determined by dividing the peak load by the original cross-sectional area of a specimen during a compressive test. This property is one of the key and valuable characteristics of concrete. Typically, the design strength of concrete represents its compressive strength after 28 days. Compressive strength can be understood as the ability of concrete to support loads prior to failure, and among the various tests performed on concrete, the compressive strength test is the most critical as it provides insight into the material's characteristics.

The compressive strength is computed using the formula $F=P/A$, where F represents the compressive strength of the specimen in pounds per square inch (psi), P indicates the maximum load applied in pounds, and A denotes the cross-sectional area in square inches. The compressive strength test is a mechanical assessment that gauges the greatest amount of compressive force a material can withstand before it fails.

CHAPTER 3

METHODOLOGY

3.1 Preparation of cylinder

The compressive strength of concrete cylinders is a widely used performance metric in structural design by engineers. This strength is assessed by applying a continuous load to the cylinder until it fails. A compressive testing machine is employed for conducting this test. The cylinder specimens can be formed using steel, cast iron, or any non-absorbent material molds. Even under challenging conditions, the molds must maintain their original shape and dimensions. For testing purposes, cylindrical specimens should measure 4 inches by 8 inches. The prepared concrete is poured into the molds in layers that are no deeper than 5 cm. Each layer must undergo at least 25 strokes during compaction to ensure the underlying layers are reached and most of the air voids are eliminated. The samples are then placed in clean, fresh water until they reach the designated age for testing.



Figure 3-1: Mold preparation for casting

3.2 Concrete mixing

A concrete mixer is a machine that thoroughly blends cement, aggregates like sand or larger particles, and water to create concrete. Typically, a concrete mixer employs a rotating drum to combine the ingredients. This mixing process is essential since improper blending of concrete components can result in failure when the concrete is subjected to compression loads. A concrete mix proportion of 1 part cement, 1.5 parts sand, and 3 parts aggregate yields a concrete mix with an estimated strength of about 3000 psi. Adding water to the cement, sand, and coarse aggregates creates a paste that binds the components together until the mixture sets. The main objective of mixing concrete is to achieve a homogeneous and uniformly colored material while ensuring the desired consistency is maintained. The production of both high-quality and low-quality concrete utilizes the same materials; however, the proportions and mixing techniques can vary. Therefore, it is important to take appropriate precautions when mixing concrete.



Figure 3-2: Weight of cement and coarse aggregate



Figure 3-3: Mixing of cement, fine aggregate and coarse aggregate

3.3 Admixture adding

Admixtures are ingredients added to concrete mixes, besides cement, water, and aggregates, to modify its properties. They are used to enhance workability, strength, durability, and other characteristics of fresh or hardened concrete.

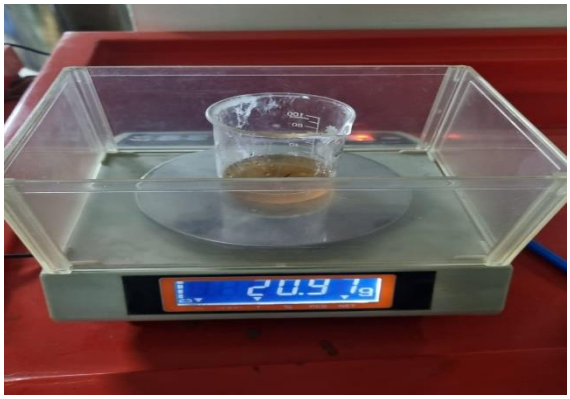




Figure 3-4: Admixture adding in concrete

3.4 Slump test and result

The term "slump test" can denote two distinct procedures: one being a concrete slump test that evaluates the consistency of newly mixed concrete, and the other being a slump test in physical therapy aimed at assessing nerve impingement. The concrete slump test aids in determining the workability of the mixture, whereas the physical therapy version assists in pinpointing irritation of the sciatic nerve.

The slump test report of our experimental study is given below-

Table 3-1: Slump test report

Case	Admixture percentage (%)	Water/Cement Ratio	Slump (mm)
1	0.00	0.450	100
2	0.50	0.425	130
3	0.75	0.400	140
4	1.00	0.375	155
5	1.25	0.350	170
6	1.50	0.325	190

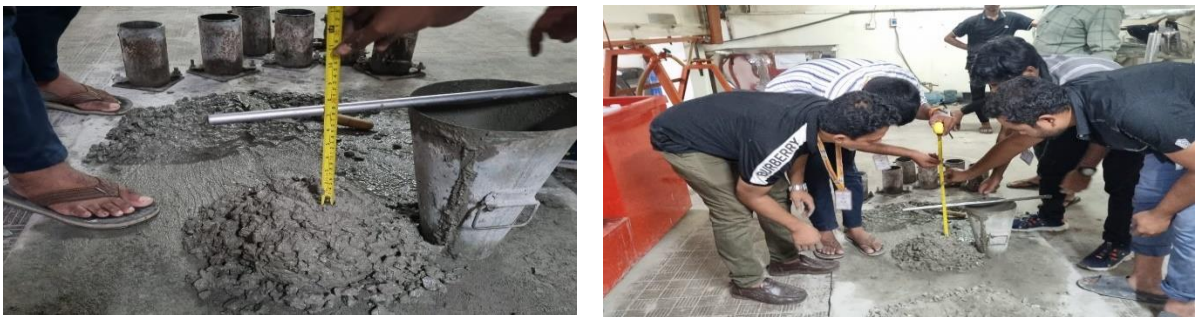


Figure 3.5: Concrete slump test

3.5 Casting of cylinder

Casting is a manufacturing technique where a liquid material is typically poured into a mold that has a hollow space shaped as desired, and then permitted to solidify. The resulting solid piece is referred to as a casting, which is either ejected or removed from the mold to finish the procedure. This method is primarily utilized for producing intricate shapes that would otherwise be challenging or costly to create using other techniques. Besides the precise design of the part, it is crucial to consider the different casting and molding techniques beforehand to achieve an optimal cast component in series production settings as well. Along with various modifications to the design, initial insights regarding future component characteristics, as well as potential rejections and rework, are obtained during initial production runs. It is essential to manage rejections and every factor that limits output by the onset of series production at the latest. This approach is the only means to ensure high productivity and minimized costs simultaneously, allowing the specified pricing for the component to be sustained.



Figure 3-6: Concrete cylinder making

3.6 Cylinder curing

The curing process for concrete involves maintaining a moist or damp environment and a warm temperature following its initial setting or the removal of forms. Adequate curing ensures that the concrete retains sufficient moisture and an optimal temperature, allowing the hydration of cement to proceed until the concrete achieves the desired characteristics. Curing must be sustained for an appropriate timeframe to reach the intended strength and durability. During the first 24 to 48 hours after casting, all test samples are stored for initial curing. Once curing is complete, a significant amount of water needs to be managed on the curing side. However, water cooler than 50°C is unsuitable for curing concrete. Since the hydration process produces heat and keeps the concrete warm, using water that is colder than 50°C can result in cracking and failure. Alternating between drying and wetting on the concrete surface creates volumetric changes, which eventually cause cracking.



Figure 3-7: Cylinder curing

3.7 Preparation to crush the concrete cylinders

The cylinders were kept submerged as long as for 7 days. After that were withdraw 18 pieces cylinder of M20 grade are made by cylinders with different percentage of Admixture (0%, 0.5%, 0.75%, 1.00%, 1.25% & 1.50%), In Sonargaon University (SU) Lab, after that the cylinders had been placed in the center of Universal Testing Machine (UTM) one by one (take help from the manual) to find out the crushing of each cylinder. Then we kept another test for 28 days. After that we are withdrew from the dram and crushing the cylinders and noted down the value.



Figure 3-8: Measurement of cylinder diameter & height

3.8 UTM machine

UTM machine is also known as UTM tester, materials testing machine or material testing frame and that's why manufactures gave a common name "Universal testing machine" and this machine is used to test the compressive strength of materials. UTM machines have different roles stripped of capabilities or marketed for specific industries & sectors which play unique roles in the development of infrastructure, roads, and highways.



Figure 3-9: Place the cylinder in UTM machine

3.9 Compressive strength test

A compressive strength test is a mechanical assessment that determines the highest compressive load a material can withstand before breaking. The sample, typically shaped like a cylinder, is compressed between the platens of a compression testing machine with a load that is applied gradually. Brittle materials such as rock, brick, cast iron, and concrete can demonstrate significant compressive strengths but will eventually fracture. The crushing strength of concrete is calculated by breaking a cylinder and is often referred to as cylinder strength. Some ductile metals, including mild steel, can achieve very high compressive strengths, yet obtaining accurate values can be challenging. When a load is applied to a ductile metal, it initially deforms elastically until it reaches a certain limit, after which plastic deformation begins. Increased loads can even make a test piece completely flat without a clear fracture occurring, allowing for the determination of the compressive strength for grade M20 respectively.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Result of fine aggregate

Fineness Modulus:

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

Requirement:

Aggregate with at least 85% passing No. 4 Sieve 1000gm.

And more than 3.4% retained on a No. 8 Sieve.

Aggregates with at least 96.6% passing No. 8 Sieve 34gm.

Table 4-1: Result of Fine Aggregate Sieve Analysis

Sieve No.	Retain	% Retain	Cumulative % Retain	FM	Finer
#4 (4.75mm)	12	1.2	1.2	301.1/100 =3.01	98.8
#8 (2.36mm)	54	5.4	6.6		93.4
#16 (1.19mm)	301	30.1	36.7		63.3
#30 (0.59mm)	302	30.2	66.9		33.1
#50 (0.30mm)	248	24.8	91.7		8.3
#100 (0.15mm)	63	6.3	98		2
Pan	20				
Total	1000		301.1		

Unit weight:

The test sample of the aggregate (Unit Weight) shall wet after drying, approximately the following.

Requirement:

Dry Sand: A common value for dry sand is around 1602 kg/m³.

Wet Sand: Wet sand will be heavier, with a unit weight ranging from 1760 to 2000 kg/m³.

Packed Sand: Compacted or packed sand will have a higher unit weight than loose sand. For example, packed sand might be around 1682 kg/m³.

Loose Sand: Loose sand, not compacted, will have a lower unit weight, potentially around 1500-1800 kg/m³.

Fine Sand: Fine sand may have a density around 1.55 g/cm³.



Figure 4-1: Fine aggregate unit weight

Table 4-2: Result of Fine Aggregate Unit Weight

Condition	Weight Of Bucket	Weight Of Bucket + Materials	Weight Of Materials	Volume Of Bucket	Unit Weight	Avg. Unit Weight
Shoveling	4000	8111	4111	0.00278	1478	1568
Rodding	4000	8443	4443	0.00278	1598	
Jiggling	4000	8526	4526	0.00278	1628	

Specific Gravity:

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
657 gm	293 gm	837 gm	300 gm

Table 4-3: Result of Fine Aggregate Specific Gravity

Test	Formula	Calculation	Result
Apparent Specific Gravity	$\frac{A}{B + A - C}$	$\frac{293}{657 + 293 - 837}$	2.60
Bulk SG (Oven Dry Basic)	$\frac{A}{B + S - C}$	$\frac{293}{657 + 300 - 837}$	2.44
Absorption Capacity, D%	$\frac{S - A}{A} * 100$	$\frac{300 - 293}{293} * 100$	2.40
Bulk SG (S.S.D. Basic), G	$\frac{S}{B + S - C}$	$\frac{300}{657 + 300 - 837}$	2.50



Figure 4-2: Fine aggregate drying

4.2 Result of Coarse Aggregate

Gradation

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

Table 4-4: Result of Coarse Aggregate (indian pakur stone) Gradation

Sieve No.	Retain	% Retain	Cumulative % Retain	FM	Finer
#3/4	58	5.8	5.8	692.8/100 = 6.93	94.2
#3/8	812	81.2	87		13
#4	130	13	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

Calculation:

1. Determine the passing percentages, overall percentage retained, or percentages in different size fractions, rounding to the nearest 0.1g based on the total weight of the original dry sample.

2. When needed, compute the fineness modulus by adding the total percentage of material in the sample that is coarser than each of the specified sieves (Cumulative percentage retained) and dividing the total by 100. The sieves include 150μm (No. 100), 300μm (No. 50), 600μm (No. 30), 1.18mm (No. 16), 2.23mm (No. 8), 4.75mm (3/8 in), 37.5mm (1.5 in), and sizes larger, increasing in a 2 to 1 ratio.

Unit Weight:

The test sample of the aggregate (Unit Weight) shall wet after drying, approximately the following.

Requirement:

General Range:

Coarse aggregates generally have a unit weight between 1,500 kg/m³ and 1,800 kg/m³.



Figure 4-3: Weight of coarse aggregate

Table 4-5: Result of Coarse Aggregate Unit Weight

Condition	Weight Of Bucket	Weight Of Bucket + Materials	Weight Of Materials	Volume Of Bucket	Unit Weight	Avg. Unit Weight
Shoveling	4000	8019	4019	0.00278	1445	1539
Rodding	4000	8343	4343	0.00278	1562	
Jiggling	4000	8481	4481	0.00278	1611	

Specific Gravity:

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)
1595 gm	1017 gm	1570 gm

Table 4-6: Result of Coarse Aggregate Specific Gravity

Test	Formula	Calculation	Result
Apparent Specific Gravity	$\frac{A}{A - C}$	$\frac{1570}{1570 - 1017}$	2.80
Bulk Specific Gravity (Oven Dry Basic)	$\frac{B}{B - C}$	$\frac{1595}{1595 - 1017}$	2.75
Bulk Specific Gravity (S.S.D. Basic), G	$\frac{A}{B - C}$	$\frac{1570}{1595 - 1017}$	2.70
Absorption Capacity, D %	$\frac{(B - A) * 100}{A}$	$\frac{(1595 - 1570) * 100}{1570}$	1.60

4.3 Details of the Concrete properties

Table 4-7: Concrete properties

Case No.	Admixture Percentage	Water/Cement Ratio	concrete mix ratio	Cement	Course Aggregate	Fine Aggregate
1	0.00%	0.450	1:1.5:3	Seven Rings Cement (PCC)	Indian pakur Stone	Sylhet Sand
2	0.50%	0.425				
3	0.75%	0.400				
4	1.00%	0.375				
5	1.25%	0.350				
6	1.50%	0.325				

Table 4-8: Cylinder area & weight after curing

Case	Diameter (mm)	Height(mm)	Weight(gm)
1	102.57	206	4189
	101.79	206	4093
	103.66	206	4107
2	103.34	205	4210
	102.37	205	4043
	103.30	206	4229
3	102.60	205	4206
	103.73	207	4282
	102.50	206	4173
4	103.75	206	4175
	103.95	206	4248
	102.08	205	4170
5	102.74	204	4141
	103.26	205	4241
	103.02	204	4210
6	103.90	204	4209
	102.85	204	4145
	102.46	204	4195

4.4 Cylinder compressive strength of 7 days test report:

Table 4-9: 7 Days Cylinder Test Results

Case	Admixture Percentage (%)	Water/Cement Ratio	Initial Slump(mm)	Crushing Value (KN)	Average Crushing Value (KN))	Average Compressive Strength (PSI)	Average Compressive Strength (MPa)
1	0.00%	0.450	100	137 142 132	137.00	2534.50	17.47
2	0.50%	0.425	130	148 137 142	142.33	2633.17	18.15
3	0.75%	0.400	140	145 145 150	146.66	2713.33	18.71
4	1.00%	0.375	155	151 147 149	149	2756.5	19.01
5	1.25%	0.350	170	151 155 152	152.67	2824.33	19.47
6	1.50%	0.325	190	154 162 157	157.67	2916.83	20.17

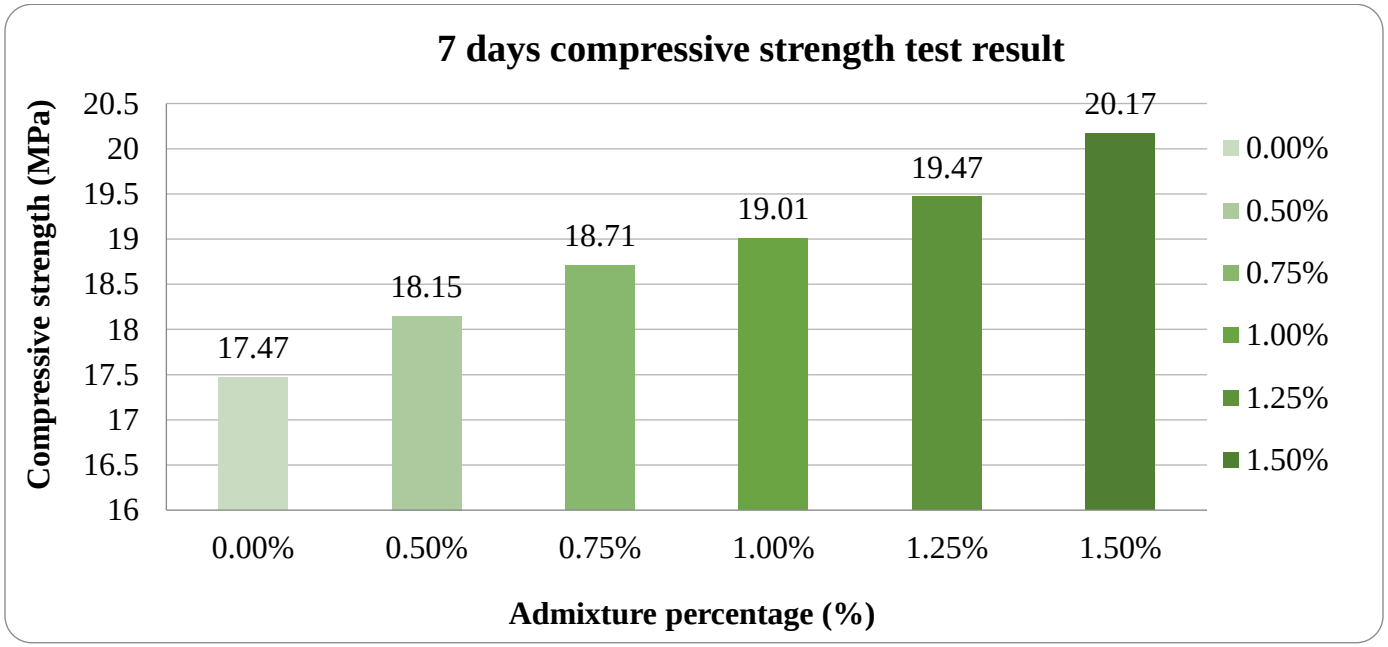


Figure 4-4: Compressive strength test result of 7 days

4.5 Cylinder compressive strength of 28 days test report:

Table 4-10: 28 Days Cylinder Test Results

Case	Admixture Percentage (%)	Water/Cement Ratio	Initial Slump(mm)	Crushing Value (KN)	Average Crushing Value (KN))	Average Compressive Strength (PSI)	Average Compressive Strength (MPa)
1	0.00%	0.450	100	180 175 170	175.00	3237.50	22.32
2	0.50%	0.425	130	178 180 172	176..67	3268.33	22.54
3	0.75%	0.400	140	184 182 184	183.33	3391.67	23.38
4	1.00%	0.375	155	189 185 187	187	3469.5	23.86
5	1.25%	0.350	170	193 191 195	193	3570.5	24.62
6	1.50%	0.325	190	205 206 200	203.67	3767.83	25.98

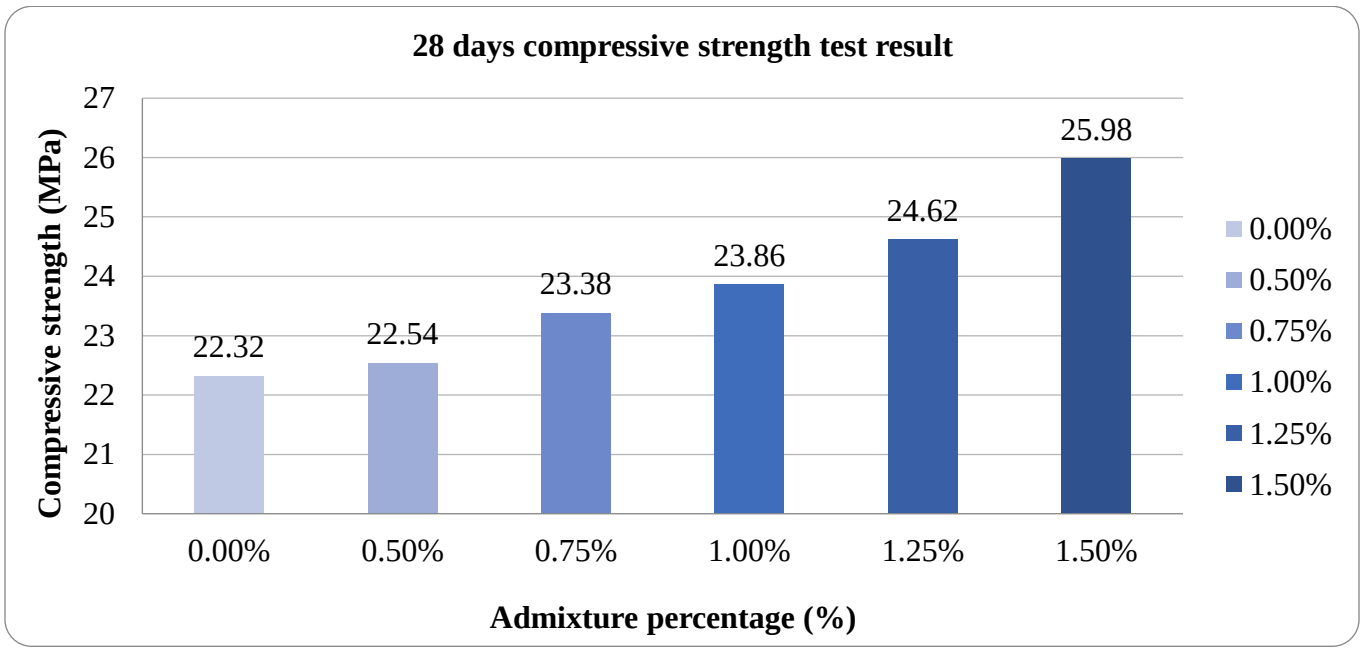


Figure 4-5: Compressive strength test result of 28 days

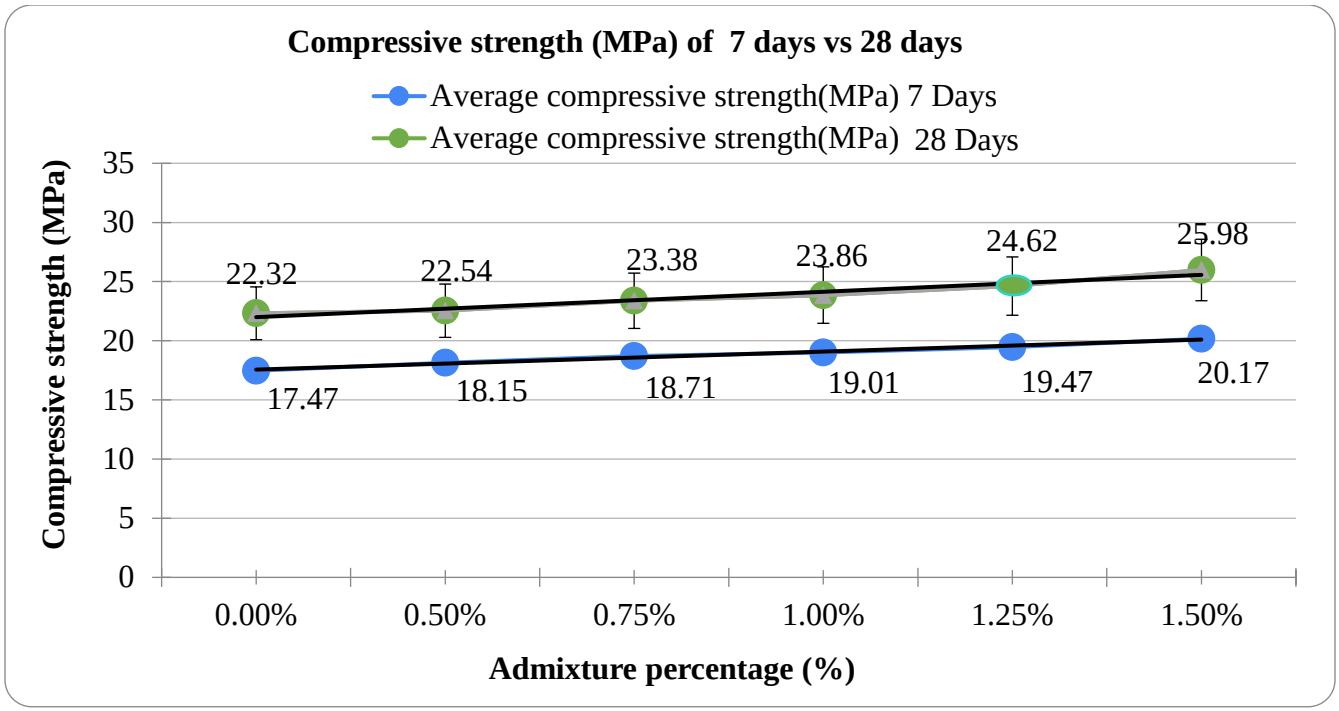


Figure 4-6: Compressive strength (MPa) of 7 days vs 28 days

4.6 Concrete workability result by initial slump test

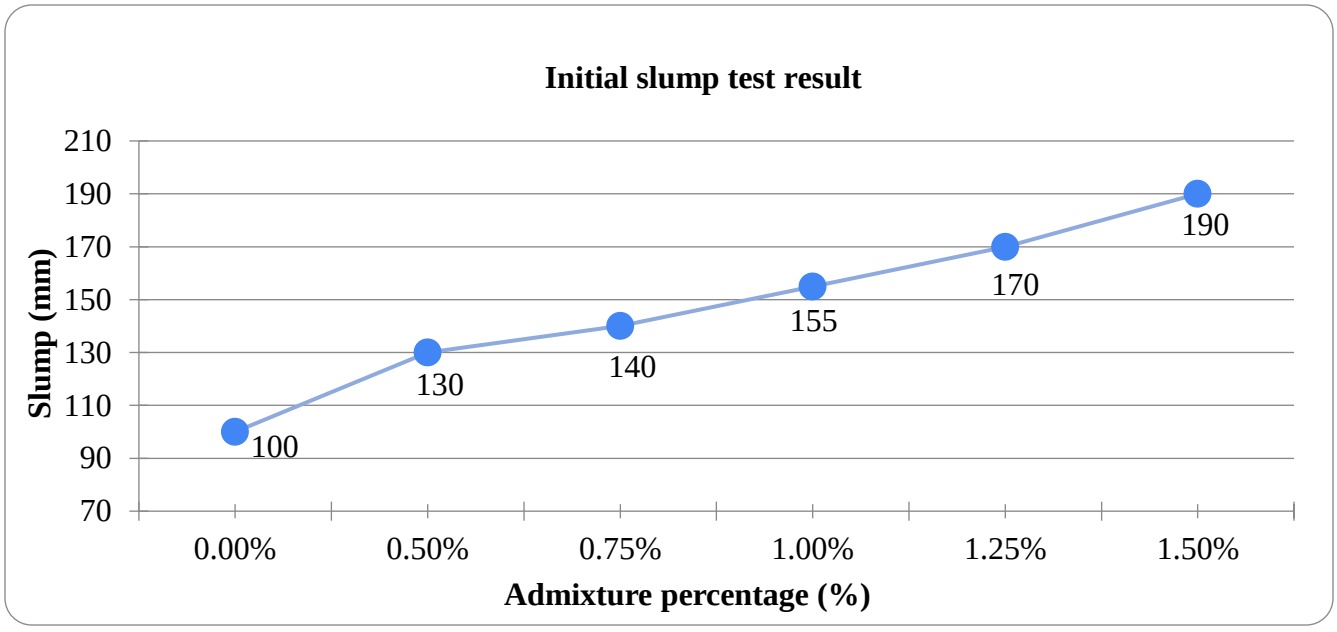


Figure 4-7: Concrete initial slump test result

After the experiment shows below the result of the compressive strength:

- For without Admixture, Compressive strength of the concrete is to reach 17.47 MPa in 7 day & 22.32 MPa in 28 days.
- For 0.50% Admixture, Compressive strength of the concrete is to reach 18.15 KN in 7 days & 22.54 MPa in 28 days
- For 0.75% Admixture, Compressive strength of the concrete is to reach 18.71 MPa in 7 days & 23.38 MPa in 28 days.
- For 1.00% Admixture, Compressive strength of the concrete is to reach 19.01 MPa in 7 days & 23.86 MPa in 28 days.
- For 1.25% Admixture, Compressive strength of the concrete is to reach 19.47 MPa in 7 days & 24.62 MPa in 28 days.
- For 1.50% Admixture, Compressive strength of the concrete is to reach 20.17 MPa in 7 days & 25.98 MPa in 28 days.

The main findings of the study are mentioned below –

• After 7 days, the concrete with the highest compressive strength measured 18.94 MPa, achieved with a 1.50% admixture and a water-cement ratio of 0.325, while the lowest compressive strength recorded was 17.47 MPa for a mix without admixture and a water-cement ratio of 0.450.

• At 28 days, the concrete's highest compressive strength was recorded at 25.98 MPa for a mix with 1.50% admixture and a water-cement ratio of 0.325, whereas the lowest compressive strength was 22.32 MPa for the mixture that did not contain admixture and had a water-cement ratio of 0.450.

• This research indicates that the inclusion of admixture enhances the workability of concrete and lowers the water-cement ratio, resulting in improved compressive strength.

• It was noted that incorporating an admixture into the concrete mix yielded the highest compressive strength, with an optimal admixture percentage of 1.50% combined with a water-cement ratio of 0.325.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 CONCLUSIONS

The main findings of the study are mentioned below –

- For 7 days, the highest compressive strength of the concrete found 18.94 MPa for 1.50% admixture and water cement ratio is 0.325 and the lowest compressive strength is 17.47 MPa for without admixture and water cement ratio is 0.450.
- For 28 days, the highest compressive strength of the concrete found 25.98 MPa for 1.50% admixture and water cement ratio is 0.325 and the lowest compressive strength is 22.32 MPa for without admixture and water cement ratio is 0.450.
- This study shows that using admixture increase the workability of concrete and reduce the water cement ratio. Thus increase the compressive strength of concrete.
- It was observed that by using admixture with concrete gave maximum compressive strength and the effective admixture percentage is 1.50% with 0.325 water/cement ratio.

5.2 RECOMMENDATIONS

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 admixture.
- Concrete with different mixture proportions can be studied.
- Different types of fine aggregate and coarse can be used.
- Different types of cement can be used.

5.3 LIMITATIONS

1. Mechanical mixer machine is not available.
2. Variable lab temperature.
3. Tensile test machine is not available.

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