A STUDY ON THE COMPRESSIVE STRENGTH OF CONCRETE USING CONSTRUCTION DEMOLITION WASTE (CDW) AS PARTIAL REPLACEMENT FOR 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: (21C)
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ABSTRACT

Nowadays, concrete construction is becoming very much complex. Everyone try to build cost effective and durable structures. So many experimental works have been performed to gather both of these quality by determining the compressive strength of concrete. The objectives of our study is to find the difference between the values of compressive strength of concrete by using two different types of coarse aggregate. The materials used for the experiment are new normal black stone, construction and demolition waste, sylhet sand and water. Concrete prepared with the ratio of 1:2:4 and water cement ratio was 46%. From fluid construction we know that, M15 grade concrete with mixing properties ratio of 1:2:4 and w/c ratio of 45%, the value of compressive strength is 15 MPa or N/mm^2. [1] From the experiment, For N-100%, compressive strength is almost accurate For N-70% and W-30%, compressive strength is almost 8% less than normal concrete. For N-50% and W-50%, compressive strength is almost 20% less than normal concrete. For N-30% and W-70%, compressive strength is almost 27% less than normal concrete. For W-100%, compressive strength is almost 25% less than normal concrete.

So, for cost saving, environmental health and for reuse of Construction and Demolition waste, this experiment will help us for construction management.

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CHAPTER 1

INTRODUCTION

1.1 General

Concrete is primarily known for its massive compressive strength. Portland cement concrete is a simple material in appearance but has a very complex internal nature. Despite its internal complexity, the versatility, durability, and economy of concrete have made it the world's most used construction material. Concrete is a mixture of Portland cement, water and aggregates with or without admixtures. Portland cement and water form a paste that hardens due to chemical reactions between the cement and water. The paste acts as a glue, binding the aggregates, composed of sand and gravel or crushed stone, into a solid rock-like mass. The quality of the paste and aggregates dictates the engineering properties of concrete construction. Paste qualities are directly related to the amount of water used in relation to the amount of cement. The less water used, the better the quality of the concrete. Reduced water content results in improved strength and durability and reduced permeability and shrinkage. [2]

1.2 Research Background and Motivations

Concrete is the most widely used construction material in the world after water and for good reason. It is strong, durable, and versatile with a wide range of applications from buildings to bridges, roads to dams [3]. Due to the increasingly better calculation possibilities, evolving formwork technologies and new formulas, it has been possible to make concrete increasingly material-saving over time. Thanks to modern methods of surface treatment, exposed concrete has long been used as more

than just a construction material. That's why we motivated to make some different types of concrete. From which we get some benefits also [4].

1.3 Research Objectives and Overview

1.3.1 Objectives

The main objectives of our study is to find the difference among the values of compressive strength of concrete. Where we use new stone chips and CDW as coarse aggregate. Compressive strength is one of the most important properties of concrete. By this research we want to know -

- To make a reuse of construction and demolition waste. Reuse will reduce wastages. Utilization of construction and demolition waste aggregates replacing coarse aggregate yields improved compressive strength.
- To reduce construction cost. Concrete which is economically balanced then it will get some priority to use in construction project. An Engineer always keeps an eye on the construction cost.

1.3.2 Overview

In this study, we prepare normal concrete mix and also a series of concrete mixtures with different proportions of new and construction and demolition waste materials as coarse aggregate. The concrete has casted in cylinder cured for 7, 14, 21 and 28 days respectively with 46% water cement ratio. Cylinder constructed by 100% new -0% waste, 70% new -30% waste, 50% new – 50% waste, 30% new – 70% waste, 0% new – 100% waste as coarse aggregate.

There are also some scopes and limitations in the study that can be examined in the future works:

- Durability test of the concrete were not performed.
- The tensile strength of the concrete was not considered.
- We have limited number of mold in the laboratory. That's why we have to work several times.

1.4 Organization of the Thesis

Chapter 1: Introduction and Objective.

This chapter provides the background and motivations of the research. The overall objectives and expected outcomes are also described in this chapter.

Chapter 2: Literature Review.

This chapter reviews the related works in the study of Compressive strength of concrete with a special focus on construction and demolition waste as coarse aggregate replacement.

Chapter 3: Methodology.

This chapter describes the methodology adopted to carry out the research.

Chapter 4: Results and Discussion.

This chapter describes the results of the test on a study on the compressive strength of concrete using construction and demolition waste as a partial replacement for coarse aggregate.

Chapter 5: Conclusions and Future Work.

This chapter summarizes the conclusions and major contributions of this study and provides recommendations for future studies.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The fast pace of infrastructure development worldwide has led to the demolition of a large number of obsolete concrete and masonry structures resulting in the generation of tremendous quantities of construction demolition waste consisting of concrete, broken glass, brick, wood, steel and waste of miscellaneous types, like marble, ceramic tile, stone, electrical and electronic items…. etc. Such large quantity of construction demolition waste, if disposed of haphazardly without proper disposal sites, leads to the destruction of ecology, flora and fauna including micro-organisms. Further, it gives an ugly appearance to natural scenic beauty of the region and causes havoc on the environment. Utilization of construction and demolition (C & D) waste in concrete as fine aggregate and coarse aggregate has been investigated by many investigators.

Frondistou-Yannas (1977) revealed that recycled concrete matches the mechanical behaviour of conventional concrete if it is enriched in gravel at the expense of mortar with an achieved compressive strength of nearly two thirds and a modulus of elasticity equal to or less than that of the control mix. [12]

Hansen and Narud (1983) found that the compressive strength of recycled concrete is strongly correlated with the water– cement ratio of the original concrete if other factors are kept the same and if the water–cement ratio of the original concrete is the same or lower than that of the recycled concrete, new strength will be as good as or better than the original strength.[13]

Tavakoli and Soroushian (1996) If construction demolition concrete waste is processed to obtain coarse and fine aggregates which can replace natural aggregates,

the preservation of precious natural resources and the environment is possible. [14]

Sagoe-Crentsilet and Brown (2001) observed that the processing of recycled concrete aggregates commercially produced smoother spherical particles than those produced in the laboratory, which improved the workability of concrete. The compressive and tensile strengths of hardened concrete showed no significant differences between recycled concrete and concrete made with natural aggregates, but recycled aggregates caused higher drying shrinkage and reduced the abrasion resistance slightly. [15]

Ajdukiewicz and Kliszczewicz (2002) examined the mechanical properties of high performance and high-strength concretes made with recycled aggregates and concluded that water content should be modified in the recycled concrete mix design in order to obtain the same workability. The compressive strength decreased slightly with recycled aggregates depending on the type of fine aggregate used in concrete.[16]

Olorunsogo and Padayachee (2002) investigated the durability of concrete made with different percentages of recycled concrete coarse aggregates and showed that durability quality of recycled concrete is reduced with increases in the quantities of recycled aggregates and the quality improved with the age of curing which occurred due to cracks and fissures created within the recycled aggregate during processing, making aggregate susceptible to ease of fluid permeation, diffusion and absorption.[17]

Khaldoun (2007) reported that 28-day compressive strength of recycled aggregate concrete decreased only by one tenth, whereas modulus of elasticity reduced only very slightly and the trends of development of compressive strength and strain at peak stress in recycled aggregate concrete were similar to those in natural aggregate concrete. [18]

Yang et al. (2008) showed that the properties of fresh and hardened concrete containing recycled aggregates were dependent on the relative water absorption of aggregates, whereas the moduli of rupture and elasticity of recycled aggregate concrete were lower than the design equations specified in standards when the relative water absorption of aggregates is above 2.5%. [19]

Padmini et al. (2009) revealed that recycled aggregate concrete requires relatively lower water–cement ratio as compared to parent concrete to achieve a particular compressive strength and the difference in strength between the two increases with the strength of concrete.[20]

Tsoumani et al. (2015) compared the properties of several recycled aggregates and indicated that fine recycled aggregate should not be used due to its low quality, whereas coarse recycled aggregates can be used in concrete production.[21]

The literature review shows that construction and demolition waste can be used in the production of concrete without any compromise on mechanical strength.

2.2 Concrete

The concrete is the man-made artificial stone and the basic building material in the modern times. The strength and durability properties can be varied widely by changing the relative composition of its constituents. The different grades of concrete vary from M15 to M80. Ordinary concrete (strength ranging from 15-20 N/mm2), standard concrete (25-55 N/mm2) and high strength concrete (60-80 N/mm2). Varying the water cement ratio and using well graded aggregate and certain admixtures, the higher grades of concrete are obtained. Concretes of grades up to M15 are normally used in plain concrete constructions, lean concrete, simple foundations, foundation for masonry walls and temporary constructions.

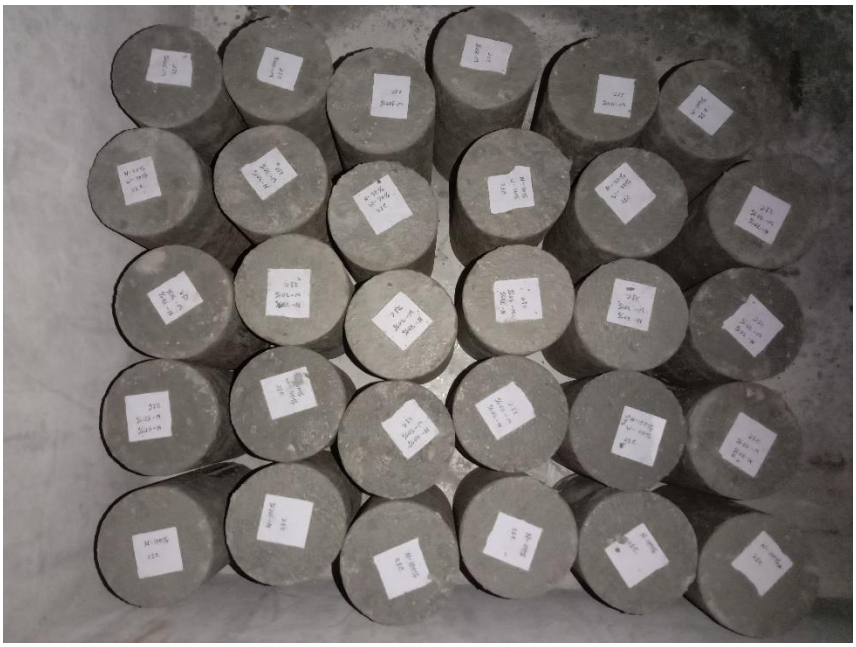


Fig 2.1: Concrete cylinder

2.3 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. UTM is one of the best multi-purpose equipment for R&D labs or the QC department.



Fig 2.2: Universal testing machine (UTM)

2.4 Compressive Strength

Compressive strength test is a mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. The test piece, usually in the form of a cylinder is compressed between the platens of a compression testing machine by a gradually applied load. Brittle materials such as rock, brick, cast iron, and concrete may exhibit great compressive strengths but ultimately, they fracture. The crushing strength of concrete, determined by breaking a cylinder, and often called the cylinder strength. Some ductile metals, such as mild steel, have very great compressive strengths, but the actual values are difficult to measure. When a load is applied to a ductile metal, it deforms elastically up to a certain point and then plastic deformation occurs.



Fig 2.3: Compressive strength test

2.5 Importance of Compressive Strength

a) Effect of cement

The Inhaling high levels of dust may occur when workers empty bags of cement. In the short term, such exposure irritates the nose and throat and causes choking and difficult breathing. Cement industry is one of the main producers of carbon dioxide, a potent greenhouse gas. Concrete causes damage to the most fertile layer of the earth topsoil. Compressive strength increases with the increasing of cement content. Cement dust may enter into the systemic circulation and thereby reach the essentially all the organs of body and affects the different tissues including heart, liver, spleen, bone, muscles and hairs and ultimately affecting their micro-structure and physiological performance.

b) Effect of aggregate/cement ratio

Well graded aggregates result in the least amount of voids in a given volume. Less voids result in excessive paste availability in a unit volume and more lubrication decreasing the aggregate/cement ratio increases the compacting factor due to the increase in the amount of fines (cement) in the mix and decreasing aggregate content, which acts as lubricant and leads to a decrease in the internal friction between the aggregates particles, and as a result, compacting factor increases.

c) Effect of aggregate properties

Aggregates influence the properties of concrete/mortar such as water requirement, cohesiveness and workability of the concrete in plastic stage, while they influence strength, density, durability, and permeability, surface finish and color in hardened stage. Aggregate is commonly considered inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Although aggregate is considered inert filler, it is a necessary component that defines the concrete's thermal and elastic properties and dimensional stability.

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.

2.6 Compressive Strength Formula

Compressive strength is the maximum compressive stress that, under a gradually applied given solid material can sustain without fracture. Compressive strength is calculated by dividing the maximum load by the original cross-sectional area of a specimen in a compressive test. The compressive strength is one of the most important and useful properties of concrete. The design strength of the concrete normally represents its 28th day. Compressive strength can be defined as the capacity of concrete to withstand loads before failure of the many tests applied to the concrete, the compressive strength test is the most important, as it gives an idea about the characteristics of the concrete.

The compressive strength was calculated by using the equation: $F = P / A$

Where, F is compressive strength of specimen in pound per square inch (psi). P is the maximum applied load by pound. A is the cross-sectional area (inch square). Compressive strength test, mechanical test measuring the maximum amount of compressive load a material can bear before fracturing.

2.7 Cement

In 1824 Joseph Aspdin, a British bricklayer, patents a new type of cement that he calls "Portland cement" because its appearance resembles that of Portland stone, a limestone quarried on the Isle of Portland in Dorset, England. By 1850s, Portland cement started to be used in the USA. And by 1870, Portland cement became the most popular cement in the world and many famous infrastructures were built by Portland cement. Cement, as it is commonly known, is a mixture of compounds made by burning limestone and clay together at very high temperatures ranging from 1400 to 1600. Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminum, iron and other ingredients. Common materials used to manufacture cement include limestone, shells, and chalk or marl combined with shale, clay, slate, blast furnace slag, silica sand, and iron ores.



Figure 2.4: Portland Composite Cement

2.8 Chemical composition of Cement

Concrete is prepared through a process of combining cement, water, and aggregate, resulting in a workable paste that can be molded or placed according to specific

requirements. The substance is then consolidated and left to harden, contrary to popular belief that it must dry out in order to achieve the desired effect. Rather, concrete - and more specifically, the cement contained within it - requires moisture to hydrate and cure, ultimately leading to its hardening. The reaction between water and cement is of paramount importance to the properties of concrete, as such reactions may continue for several years.

Portland cement consists of five major compounds and a few minor compounds. The composition of a typical Portland cement is listed by weight percentage in Table 2.1.

Table 2.1: Composition of Portland cement with chemical composition and weight percent.

Cement Compound	Weight Percentage	Chemical Formula
Tri-calcium silicate	50 %	Ca_3SiO_5 or $3CaO.SiO_2$
Di-calcium silicate	25 %	Ca_2SiO_4 or $2CaO.SiO_2$
Tri-calcium aluminate	10 %	$Ca_3Al_2O_6$ or $3CaO.\ Al_2O_3$
Alumina ferrite	10 %	$Ca_4Al_2Fe_2O_{10}$ or $4CaO.Al_2O_3.Fe_2O_3$
Gypsum	5 %	$CaSO_4.2H_2O$

2.9 Aggregates

Aggregates, which are composed of inert materials, are blended with binding substances like cement or lime to manufacture mortar or concrete. They are utilized as fillers in mortar and concrete and are also employed to decrease production costs. These granular materials comprise minerals such as sand, gravel, shale, slag, or crushed stone. Generally, aggregates occupy approximately 70% to 80% of concrete volume. Consequently, the significance of selecting the appropriate type of high-

quality aggregate cannot be disregarded. Recycled concrete is a viable source of aggregate and has been successfully employed in granular sub-bases, soil-cement, and new concrete. In the construction sector, aggregates are generally classified into two categories:

- Fine Aggregates
- Coarse Aggregates.

2.9.1 Fine Aggregate

According to ASTM Standards, fine aggregate is defined as material that passes through a No.4 sieve (4.75mm). This type of aggregate is primarily composed of naturally-occurring sand particles obtained from mining operations. In construction, aggregate refers to sand that is typically considered to have a lower size limit of around 0.07mm. The fine aggregate content is usually 35% to 45% by mass or volume of the total aggregate. Fine aggregates serve to fill all of the open spaces between coarse particles, reducing the porosity of the final mass and significantly increasing its strength. Fineness modulus of fine aggregate varies from 2.0 to 3.5mm. Various values of fineness modulus for different sands are detailed below. [4]

Type of sand	**Fineness modulus range**
Fine sand	2.2 – 2.6
Medium sand	2.6 – 2.9
Coarse sand	2.9 – 3.2



Fig 2.5: Sample of Fine Aggregate (Sylhet Sand)

2.9.2 Coarse Aggregate

Fineness modulus of coarse aggregates represents the average size of the particles in the coarse aggregate by an index number. As per the ASTM standards, any material that is held back by a No.4 sieve (4.75mm) is categorized as coarse aggregate. Nonetheless, in construction practices, the maximum allowable size of coarse aggregate is restricted to 19mm. Crushed stone, gravel, and fragmented burnt bricks are among the most commonly utilized coarse aggregates. Sizes of gravel have an impact on several aspects, particularly workability and strength. Fineness modulus of coarse aggregate varies from 5.5 to 8.0. And for all in aggregates or combined aggregates fineness modulus varies from 3.5 to 6.5. Range of fineness modulus for aggregate of different maximum sized aggregates is given below.

Maximum size of coarse aggregate	**Fineness modulus range**
20mm	6.0 – 6.9
40mm	6.9 – 7.5
75mm	7.5 – 8.0
150mm	8.0 – 8.5



Figure 2.6: Sample of Coarse Aggregate (CDW and Normal)

2.10 Water- Cement ratio

Water constitutes a pivotal ingredient that, upon mixing with cement, generates a paste that binds the aggregate together. Not only does water facilitate the workability of the mixture, but it is also crucial for the cement to hydrate. Water plays a critical role in the entire lifespan of concrete, with most actions on concrete, except loading, involving water, either in its pure form or carrying salts or solids. As a general rule, water with a pH ranging from 6 to 8, and that does not taste saline or brackish, is deemed appropriate for use. The water–cement ratio is the ratio of the mass of water (*w*) to the mass of cement (*c*) used in a concrete mix. The typical values of this ratio $f = {}^{w}\!/_{c}$ are generally comprised in the interval 0.40 and 0.60.



Figure 2.7: Water

CHAPTER 3

METHODOLOGY

3.1 Introduction

The concrete composition in this test satisfy various concrete design codes for high durability and impact load resistance. To study the behavior of concrete at different combinations of replacement of coarse aggregate, 40 specimens were cast and tested for compressive strength. There were also some tests conducted on materials to see if they fulfill the minimum requirement of subjected code to be used in structural concrete. Tests such as fineness modulus, specific gravity, absorption capacity etc. were conducted and the data will be provided in later part in this chapter. We just want to know about the difference of compressive strength value of concrete when we use construction and demolition waste as a partial replacement of coarse aggregate.

3.2 Methodology and Tests

Various tests have been conducted on aggregates to determine if their standards meet the codes to be used in a concrete Mix. They are –

- Fineness modulus test / sieve analysis
- Specific gravity
- Unit weight and
- Absorption capacity.

The procedures and details of the tests will be described below.

3.2.1 Fineness modulus test / sieve analysis

It is an index which gives an idea about fineness or coarseness of aggregate. The Fineness Modulus (FM) of fine aggregates (sand) is an empirical figure obtained by adding the total percentage of the sample of a sand retained on each of a specified series of sieves, and dividing the sum by 100.

- FM is not an indication of grading of aggregates as an infinite number of grading can have same FM.
- FM for good Concrete-

  FM for FA is (2.25-3.25)

  FM for CA is (5.50-7.50)
- The smaller the value of FM, the more is smaller sizes in aggregate. Test sieve conforming ASTM C136 specification (#4, #8, #16, #30, #50, and #100) were used. All test procedure was executed and maintained according to the code. [4]



Fig 3.1: Sieve analysis

3.2.2 Specific Gravity

Specific gravity is a metric that quantifies the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. This parameter serves as a reliable indicator of the strength and quality of a particular material. In essence, it helps determine how robust and resilient the material is. In general, aggregates with lower specific gravity values tend to be weaker compared to those with higher specific gravity values. This makes specific gravity an essential factor to consider when selecting aggregates for construction purposes. It's worth noting that the specific gravity test can be conducted using different methods, depending on the size of the aggregates being tested. [4]



Fig 3.2: Specific Gravity test of aggregate

3.2.3 Unit weight

The unit weight of a material can be defined as the weight of a given volume of graded aggregate. It effectively measures the volume that the graded aggregate will occupy and includes both solid particles and the voids between them. The unit weight of fine and coarse aggregates within the ASTM grading limits are generally in the range of 1450-1750 kg/cu. m. The unit weight values are used in designing concrete mixtures. Void in between aggregate particles that can be filled by the mortar can also be calculated. [5]

Three different procedures are generally followed for the determination of unit weight. They are:

- Shoveling procedure
- Rodding procedure
- Jiggling procedure;

The shoveling procedure for loose unit weight shall be used only when specifically stipulated. Otherwise, the compact unit weight shall be determined by the roding procedure for aggregates having a nominal maximum size of 1.5 in (37.5 mm) or lesser, by the jiggling procedure for aggregates having a nominal maximum size greater than 1.5 in. (37.5 mm) and not exceeding 6 in. (150 mm).



Fig 3.3: Unit weight of aggregate

3.2.4 Absorption Capacity

All normal weight aggregates include pores which can be filled with water. When these pores are full the aggregates can also maintain a thin film of water around the aggregate particles. The water absorption of the aggregates along with the moisture content of the aggregates are important factors to consider when proportioning the concrete mix, particularly the amount of water required. [6]



Fig 3.4: Water absorption of aggregate

3.3 Preparation of Cylinder

The Compressive strength of the concrete cylinder is one of the most common performance measurers performed by the engineers in the structural design. The comprehensive strength of concrete cylinders is determined by applying continuous load over the cylinder until failure occurs. The test is conducted using a compression testing machine. The cylinder specimens are cast in steel, cast iron or any mold made of non-absorbent material. Even under severe conditions, the molds used must retain its original shape and dimensions. Cylindrical specimens for testing should be 4 inch x 8 inch.



Fig 3.5: Mold preparation for casting

3.4 Concrete Mixing

A concrete mixer is a device that homogeneously combines cement, aggregate such as sand or coarse aggregate, 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 M15 concrete mixture ratio of 1:2:4 will produce a strength of 2175 psi. [8] Mixing water with the cement, sand and coarse aggregate 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.



Fig 3.6: Concrete mixing

3.5 Casting of 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. 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. The mixed concrete is placed in to the molds in layers than 5 cm deep. The strokes per layer during the compaction must not be less than 25 in number Compaction must reach the underlying layers allowing the majority of the air void to escape. The samples are taken and submerged in clean and fresh water until the testing age is reached.



Fig 3.7: Casting of Cylinder

3.6 Curing of concrete

Curing is the process of maintaining ambient temperature and desired moisture content in concrete during its initial stages. It is usually performed by either immersing the concrete member in water, covering it with wet membranes, coating it with curing compounds or use of accelerated steam curing. It is initiated 24 hours after casting the structural member and is usually continued for 7 to 28 days. Curing is very important for development of compressive strength in concrete. Loss of moisture from concrete due to evaporation particularly in hot and arid climate can lead to insufficient water available for hydration and occupying gel pores. Therefore, a concrete member which is not cured enough is likely to develop poor strength as compared to a continuously cured concrete member. [7]

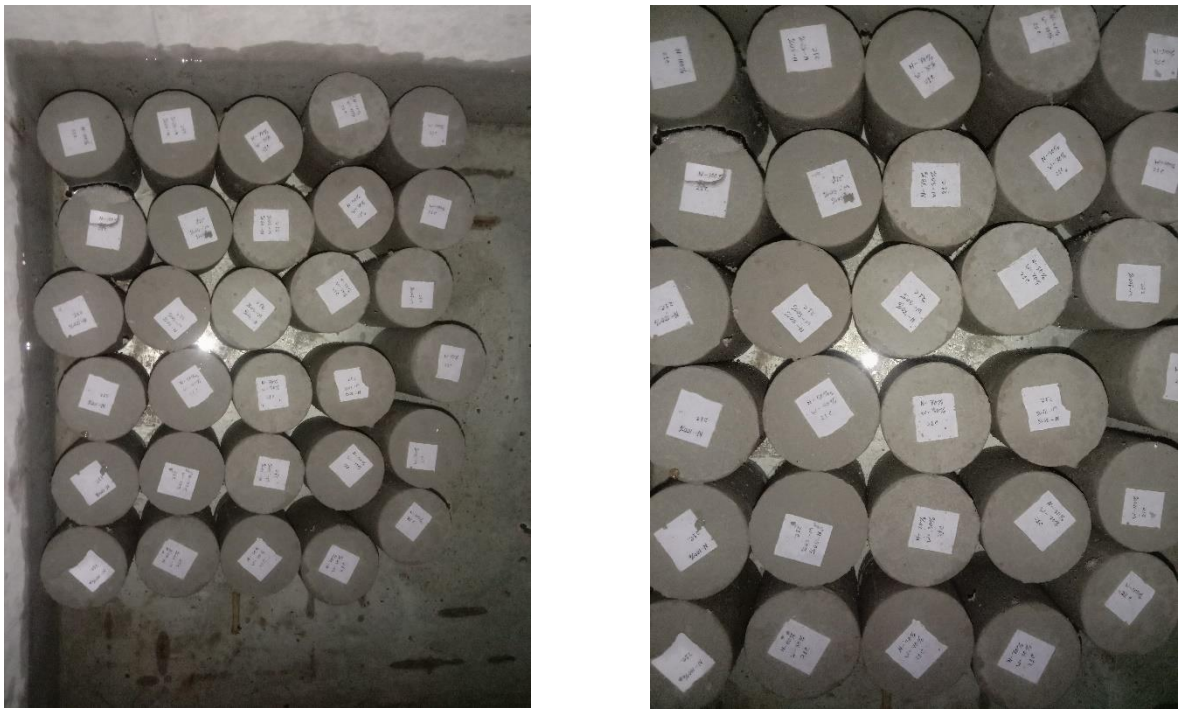


Fig 3.8: Curing of concrete

3.7 Preparation to Crush the Concrete Cylinders

The cylinders were kept submerged as long as for 7 days, 14 days, 21 days and 28 days respectively. After 7, 14, 21 and 28 days we were withdrew 10 piece of cylinder of M15 grade (1:2:4) which are made by cylinders with –

1) 100% new aggregates - 2 nos.
2) 70% new aggregates & 30% CDW aggregates -2 nos.
3) 50% new aggregates & 50% CDW aggregates -2 nos.
4) 30% new aggregates & 70% CDW aggregates -2 nos.
5) 100% CDW aggregates -2 nos.

from the curing pot. In Sonargaon University (SU) Lab, then the cylinders had been placed in the center of Universal Testing Machine (UTM) one by one (take help from the manual and lab assistant) to find out the crushing value of each cylinder and noted down the value.



Fig 3.9: Crush the Concrete Cylinders

Chapter 4
RESULTS AND DISCUSSION

4.1 Result of Fine Aggregate (Sylhet Sand)

4.1.1 Fineness Modulus of Sylhet sand

The sylhet sand was collected from the local market of Gabtoli. After bringing the sand to the laboratory we tested its fineness modulus test, and the data is given below:

Table 4.1: Fineness Modulus of Sand Used

Sieve No.	Wt. Retain (gm)	% Retain	Cumulative % Retain	FM
#4	9	.9	.9	275.6/100 = 2.75
#8	39	3.9	4.8	
#16	228	22.8	27.6	
#30	277	27.7	55.3	
#50	335	33.5	88.8	
#100	94	9.4	98.2	
Pan	18	0	0	
Total	1000		275.6	

FM of sand has found to be 2.75, which is allowable by the ACI code.

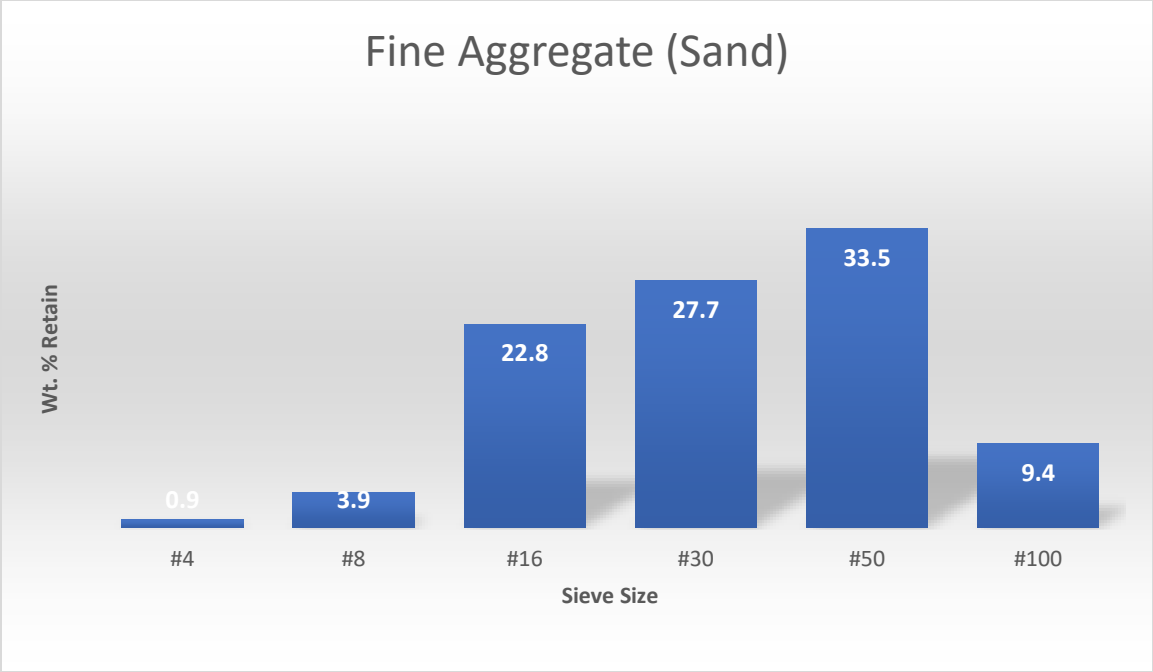


Fig 4.1: Fineness Modulus of Sylhet Sand

4.1.2 Specific Gravity and Absorption Capacity of Fine Aggregates

Table 4.2: Specific Gravity and Absorption Capacity of Fine Aggregates data

DATA SHEET

Wt. of pycnometer filled with water to calibration mark, 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)
656	285	835	300

Table 4.3: Specific Gravity and Absorption Capacity of Fine Aggregates result

Tests	Formula	Calculation	Results
Apparent Specific Gravity	A / (B+A-C)	285 / (656+285-835)`	2.69
Bulk specific Gravity (Oven dry Basis)	A / (B + S –C)	285/(656+300-835)	2.36
Bulk specific Gravity (S.S.D. Basis)	S / (B+S-C)	300 / (656+300-835)	2.48
Absorption capacity, D%	(S-A/A)*100	(300-285/285)*100	5.3%

4.1.3 Unit Weight of Fine Aggregates

Bucket weight = 4000 gm

Bucket dia = 6 in. = 0.5 ft

Bucket height = 6 in. = 0.5ft

Volume of measure Bucket = $(3.1416/4)*0.5^2*0.5$

= $0.098\ ft^3$

= $0.002834\ m^3$

Temping rod dia = 16mm

Temping rod height = 240mm

Temping rod weight = 100gm

(a) Shoveling Procedure:

Bucket weight = 4000 gm or 4 Kg

Bucket + Aggregate weight = 7995 gm or 7.995 Kg

So Aggregate weight = 7995 - 4000 = 3995 gm. Or 3.995 Kg

Unit weight = 3.995/0.002834

= **1409.67 kg/m^3**

(b) Rodding Procedure:

Bucket weight = 4000 gm or 4 Kg

Bucket + Aggregate weight = 8372 gm or 8.37 Kg

So Aggregate weight = 8372 - 4000 = 4372 gm. Or 4.37 Kg

Unit Weight = 4.37/0.002834

= **1542 kg/m^3**

(c) Jiggling Procedure:

Bucket weight = 4000 gm or 4 Kg

Bucket + Aggregate weight = 8476 gm or 8.48 Kg

So Aggregate weight = 8476 - 4000 = 4476 gm. Or 4.48 Kg

Unit Weight = 4.48/0.002834

= **1580.80 kg/m^3**

4.2 Result of the Coarse Aggregate (Normal Stone chips)

4.2.1 FM of coarse aggregate (Normal stone chips)

The Normal Stone chips was collected from the local market of Gabtoli. It is called Nepali Black stone chips in local people. After bringing the stone to the laboratory we tested its fineness modulus test, and the data is given below.

Table 4.4: FM of coarse aggregate (Normal stone chips)

Sieve No.	Wt. Retain (gm)	% Retain	Cumulative % Retain	FM
3/4”	339	22.6	22.6	718.4/100 = 7.18
3/8”	1098	73.2	95.8	
#4	63	4.2	100	
#8	0	0	100	
#16	0	0	100	
#30	0	0	100	
#50	0	0	100	
#100	0	0	100	
Pan	0	0	0	
Total	1500		718.4	

Allowable FM value for coarse aggregate is 6.75 to 8.00. So the value 7.18 is within the allowable limit for FM of coarse aggregate.

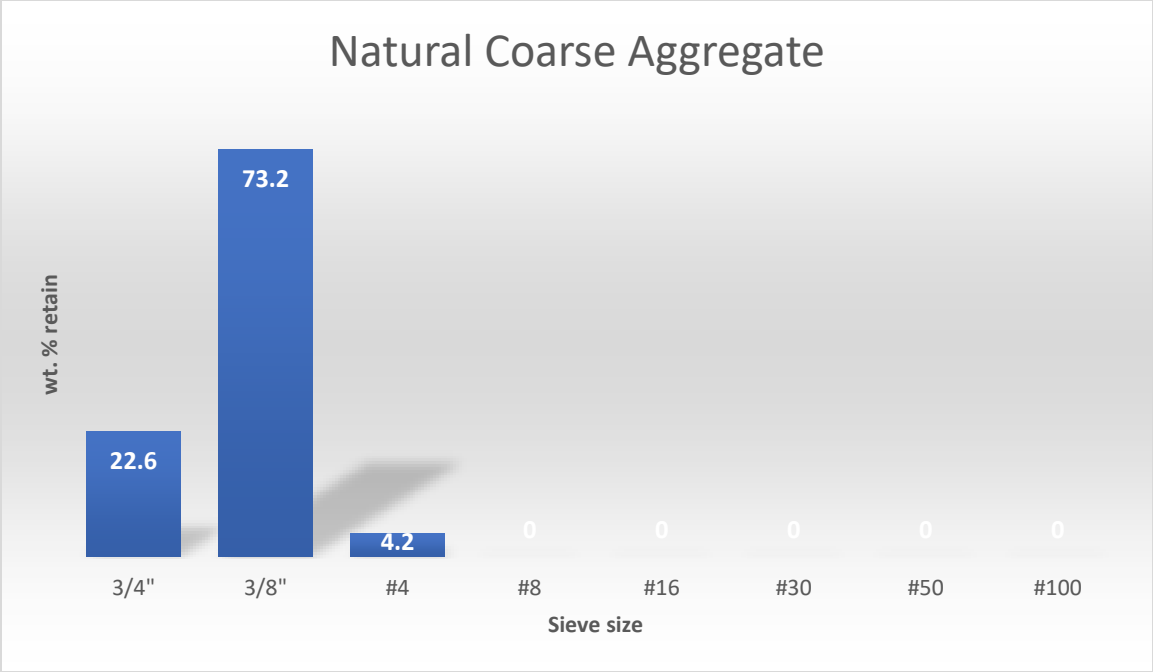


Fig 4.2: Fineness Modulus of Natural Coarse Aggregate

4.2.2 Specific Gravity and Absorption Capacity of Coarse Aggregates (Normal)

Table 4.5: Specific Gravity and Absorption Capacity of Coarse Aggregates (Normal stone chips) data.

DATA SHEET

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)
1465	950	1430

Table 4.6: Specific Gravity and Absorption Capacity of Coarse Aggregates (Normal stone chips) result

Tests	Formula	Calculation	Results
Bulk specific Gravity (Oven dry Basis)	A / (B-C)	1430/(1465-950)	2.78
Apparent Specific Gravity	A / (A-C)	1430/(1430-950)	2.98
Bulk specific Gravity (S.S.D. Basis)	B / (B-C)	1465/(1465-950)	2.84
Absorption capacity, D%	(B-A/A) *100	{(1465-1430)/1430}*100	2.45%

4.2.3 Unit Weight of Coarse Aggregates (Normal)

Table 4.7: Unit Weight of Coarse Aggregate (Normal)

DATA SHEET

Type of Test	Type of Aggregate, (Normal)	Wt. of Bucket (kg)	Wt. of Bucket + Material (kg)	Wt. to Material, w (kg)	Volume Of Bucket, V (m^3)	Unit Weight, M=w/v (kg/m^3)
Shoveling Procedure	Coarse Aggregates	4	7.978	3.978	0.002834	1403.67
Rodding Procedure	Coarse Aggregates	4	8.409	4.409	0.002834	1555.75
Jiggling Procedure	Coarse Aggregates	4	8.488	4.488	0.002834	1583.63

Unit weight of Normal stone chips coarse aggregate found after -

1) Shoveling procedure 1403.67 kg/m^3.
2) Rodding Procedure 1555.75 kg/m^3.
3) Jiggling Procedure 1583.63 kg/m^3.

4.3 Result of the Coarse Aggregate (Construction and demolition waste)

4.3.1 FM of coarse aggregate (Construction and demolition waste)

The construction and demolition waste (CDW) was collected from the local area of Farmgate. After bringing the sand to the laboratory we tested its fineness modulus test, and the data is given below.

Table 4.8: FM of coarse aggregate (Construction and demolition waste)

Sieve No.	Wt. Retain (gm)	% Retain	Cumulative % Retain	FM
3/4”	344	34.4	34.4	706.5/100 = 7.07
3/8”	577	55.7	90.1	
#4	69	6.9	97	
#8	0	0	97	
#16	0	0	97	
#30	0	0	97	
#50	0	0	97	
#100	0	0	97	
Pan	10	0	0	
Total	1000		706.5	

Allowable FM value for coarse aggregate is 6.75 to 8.00. So the value 7.07 is within the allowable limit for FM of coarse aggregate.

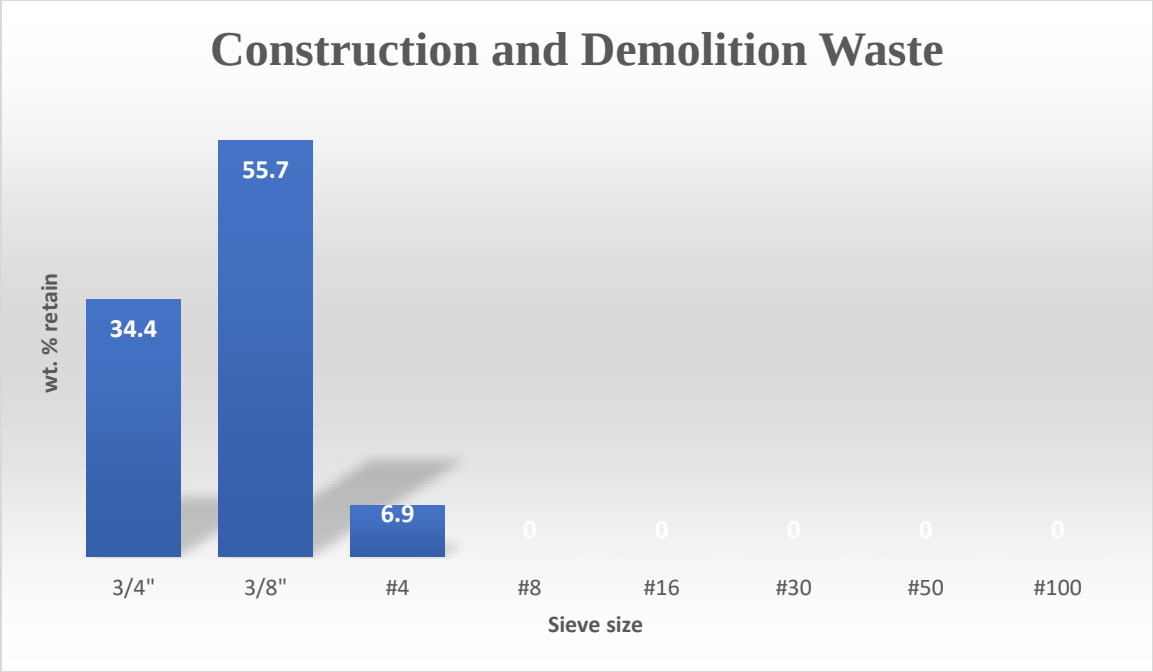


Fig 4.3: Fineness Modulus of C & D waste Aggregate

4.3.2 Specific Gravity and Absorption Capacity of Coarse Aggregates (CDW)

Table 4.9: Specific Gravity and Absorption Capacity of Coarse Aggregates (Construction and demolition waste) data

DATA SHEET

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)
980	500	835

Table 4.10: Specific Gravity and Absorption Capacity of Coarse Aggregates (Construction and demolition waste) result

Tests	Formula	Calculation	Results
Bulk specific Gravity (Oven dry Basis)	A / (B-C)	835/(980-500)	1.74
Apparent Specific Gravity	A / (A-C)	835/(835-500)	2.49
Bulk specific Gravity (S.S.D. Basis)	B / (B-C)	980/(980-500)	2.04
Absorption capacity, D%	(B-A/A)*100	{(980-835)/835}*100	17.37%

The specific gravity of the Construction and demolition waste coarse aggregate after oven drying was found 1.74 for coarse aggregate. We found the specific gravity of the apparatus to be 2.49. Absorption capacity received 17.37% and bulk SSD received 2.04.

4.3.3 Unit Weight of Coarse Aggregates (CDW)

Table 4.11: Unit Weight of Coarse Aggregate (CDW)

DATA SHEET

Type of Test	Type of Aggregate, (CDW)	Wt. of Bucket (kg)	Wt. of Bucket + Material (kg)	Wt. to Material, w (kg)	Volume Of Bucket, V (m^3)	Unit Weight, M=w/v (kg/m^3)
Shoveling Procedure	Coarse Aggregates	4	6.647	2.647	0.002834	934.02
Rodding Procedure	Coarse Aggregates	4	7.032	3.032	0.002834	1069.87
Jiggling Procedure	Coarse Aggregates	4	7.120	3.120	0.002834	1100.92

Unit weight of Construction and Demolition waste coarse aggregate found after -

1) Shoveling procedure 934.02 kg/m^3.
2) Rodding Procedure 1069.87 kg/m^3.
3) Jiggling Procedure 1100.92 kg/m^3.

4.4 Results of 7 days Compressive strength test

Table 4.12: Results of 7 days Compressive strength test

Results of 7 days Compressive strength test where mix properties 1:2:4 and water cement ratio 46%							
Serial No.	Types of aggregates And percentages	Weight, gm	Height, mm	Dia, mm	Load P, N	Compressive strength, P/A N/mm^2	Average compressive strength, N/mm^2
1	N - 100%	4094	204	101.37	83000	10.28	10.45
2	N - 100%	4224	205	102.20	87000	10.61	
3	N – 70% W – 30%	3952	204	103.02	77000	9.24	9.44
4	N – 70% W – 30%	3856	205	101.51	78000	9.64	
5	N – 50% W – 50%	3618	205.5	102.08	60000	7.33	7.53
6	N – 50% W – 50%	3780	204	102.72	64000	7.72	
7	N – 30% W – 70%	3703	205	102.73	52000	6.27	6.62
8	N – 30% W – 70%	3733	204.5	102.07	57000	6.97	
9	W – 100%	3433	205	102.08	58000	7.09	7.39
10	W – 100%	3455	205	102.13	63000	7.69	

For N =100%,

Area, A = (3.1416/4)*101.37^2 = 8070.67 mm^2, Load, P = 83000 N

Compressive strength, F = P/A = 83000/8070.67 = 10.28 N/mm^2 or MPa

Similarly calculated for other specimen.

4.5 Results of 14 days Compressive strength test

Table 4.13: Results of 14 days Compressive strength test

Results of 14 days Compressive strength test where mix properties 1:2:4 and water cement ratio 46%							
Serial No.	Types of aggregates and percentages	Weight, gm	Height, mm	Dia, mm	Load P, N	Compressive strength, P/A N/mm^2	Average compressive strength, N/mm^2
1	N - 100%	4093	204.5	102.51	108000	13.09	13.29
2	N - 100%	4262	205	102.83	112000	13.49	
3	N – 70% W – 30%	3901	205	102.16	101000	12.32	12.09
4	N – 70% W – 30%	3893	205	101.53	96000	11.86	
5	N – 50% W – 50%	3782	205	103.24	85000	10.15	10.35
6	N – 50% W – 50%	3844	205.5	103.04	88000	10.55	
7	N – 30% W – 70%	3603	205.5	101.51	76000	9.39	9.09
8	N – 30% W – 70%	3747	205	103.55	74000	8.79	
9	W – 100%	3503	205	101.45	77000	9.53	10.26
10	W – 100%	3425	205	101.60	89000	10.98	

4.6 Results of 21 days Compressive strength test

Table 4.14: Results of 21 days Compressive strength test

Results of 21 days Compressive strength test where mix properties 1:2:4 and water cement ratio 46%							
Serial No.	Types of aggregates and percentages	Weight, gm	Height, mm	Dia, mm	Load P, N	Compressive strength, P/A N/mm^2	Average compressive strength, N/mm^2
1	N - 100%	4176	204.5	102.48	120000	14.55	14.76
2	N - 100%	4198	205	102.73	124000	14.96	
3	N – 70% W – 30%	3867	205	101.12	114000	14.20	13.46
4	N – 70% W – 30%	3912	205.5	103.03	106000	12.71	
5	N – 50% W – 50%	3743	205	102.67	92000	11.11	11.33
6	N – 50% W – 50%	3780	205	102.89	96000	11.55	
7	N – 30% W – 70%	3648	204	101.94	79000	9.68	9.83
8	N – 30% W – 70%	3701	205.5	102.26	82000	9.98	
9	W – 100%	3426	205.5	102.57	87000	10.53	11.04
10	W – 100%	3513	205	102.33	95000	11.55	

4.7 Results of 28 days Compressive strength test

Table 4.15: Results of 28 days Compressive strength test

Results of 28 days Compressive strength test where mix properties 1:2:4 and water cement ratio 46%							
Serial No.	Types of aggregates and percentages	Weight, gm	Height, mm	Dia, mm	Load P, N	Compressive strength, P/A N/mm^2	Average compressive strength, N/mm^2
1	N - 100%	4280	206	103.56	128000	15.20	15.60
2	N - 100%	4203	205.5	102.53	132000	15.99	
3	N – 70% W – 30%	3893	205	101.85	122000	14.97	14.38
4	N – 70% W – 30%	3968	205	102.15	113000	13.79	
5	N – 50% W – 50%	3764	205	102.99	98000	11.76	12.14
6	N – 50% W – 50%	3796	204.5	102.87	104000	12.51	
7	N – 30% W – 70%	3657	205.5	102.01	84000	10.28	10.44
8	N – 30% W – 70%	3560	205.5	102.29	87000	10.59	
9	W – 100%	3394	206	100.44	95000	11.99	12.24
10	W – 100%	3568	205	100.46	99000	12.49	

4.8 Comparison Chart

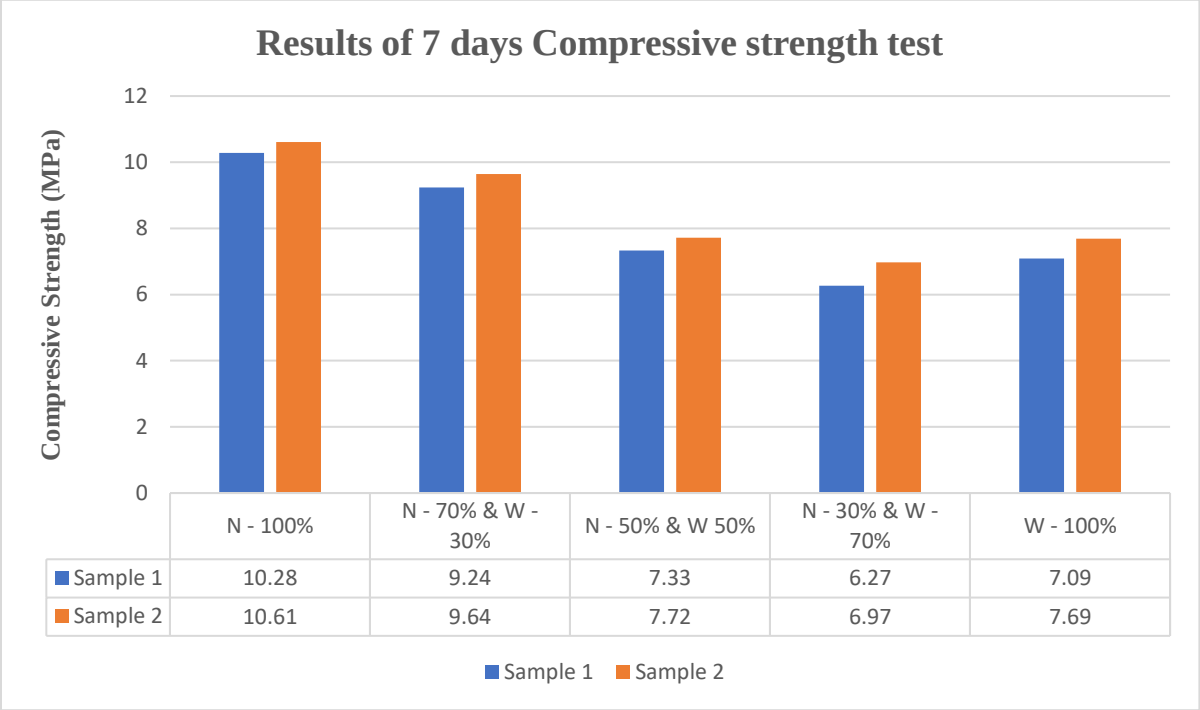


Fig 4.4: Results of 7 days Compressive strength test

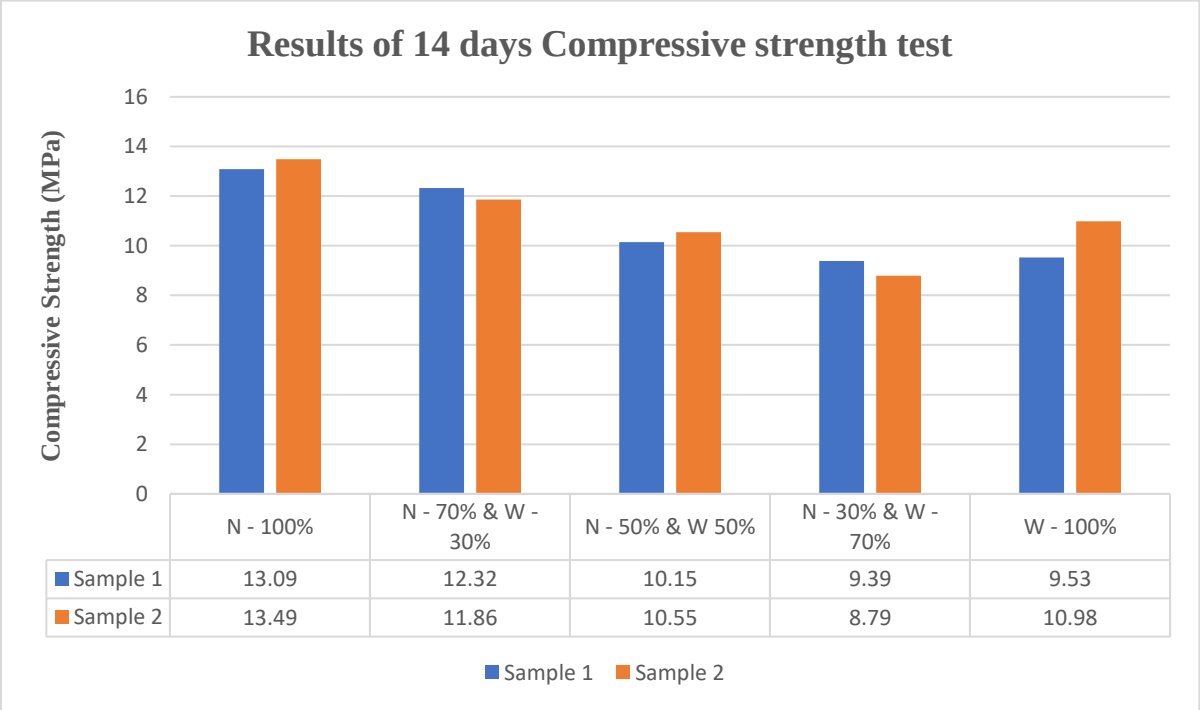


Fig 4.5: Results of 14 days Compressive strength test

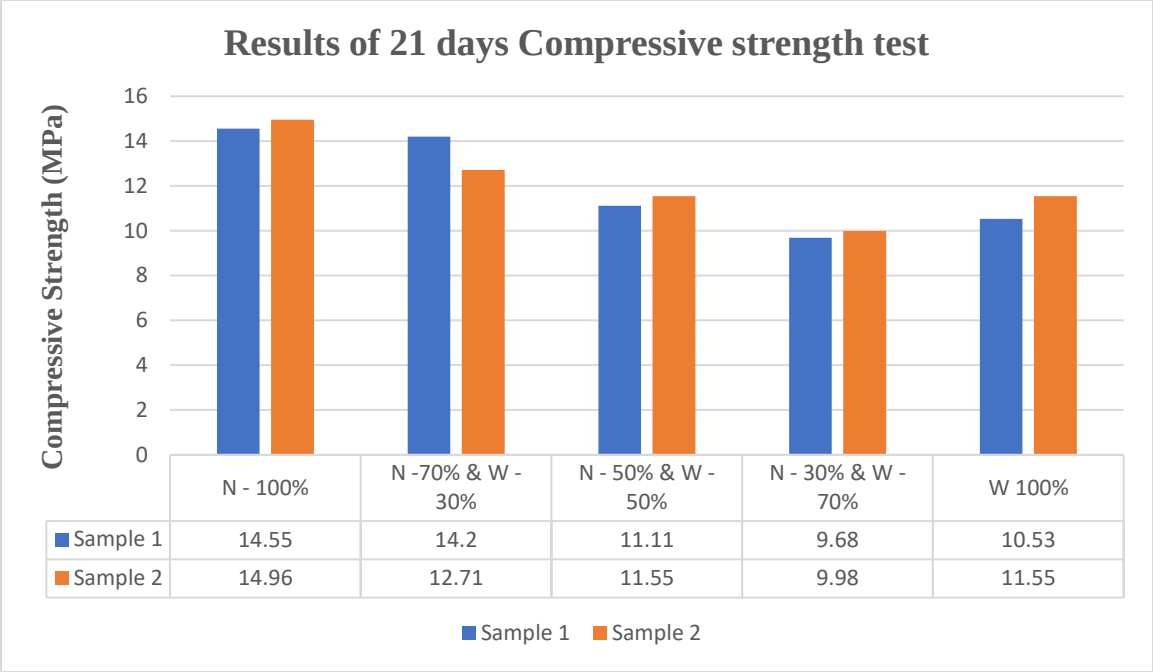


Fig 4.6: Results of 21 days Compressive strength test

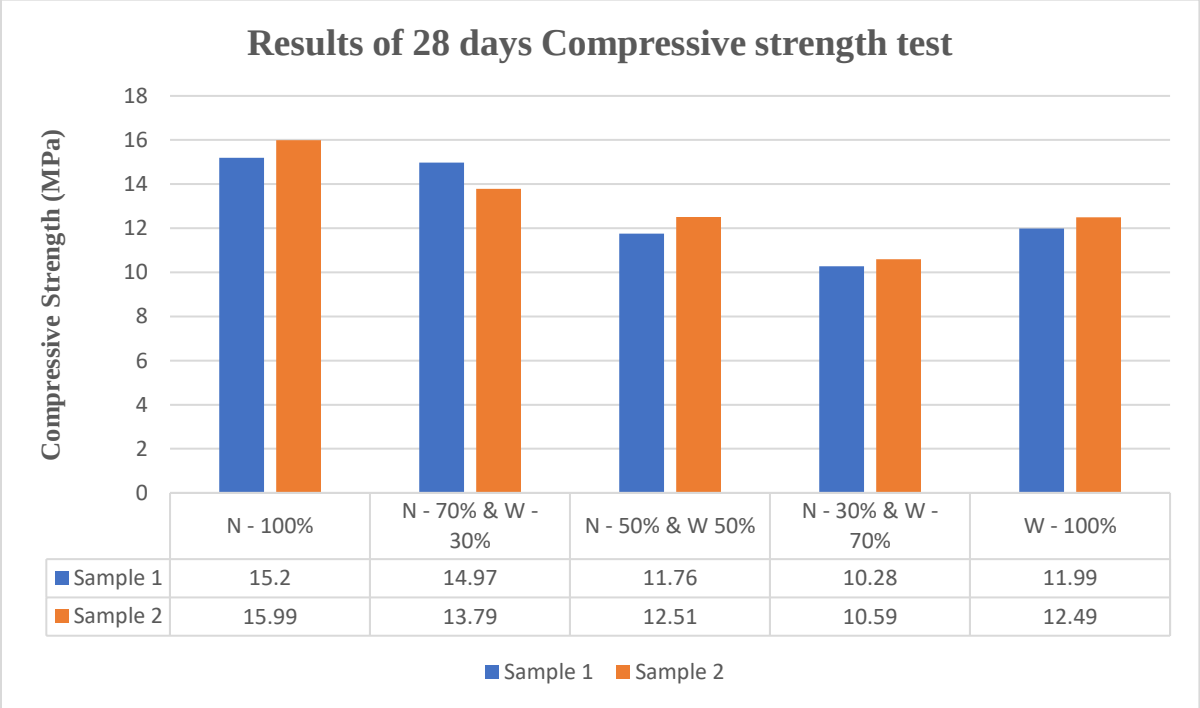


Fig 4.7: Results of 28 days Compressive strength test

4.9 Discussion about average compressive strength

After the experiment we get, concrete casted in cylinder and cured for 7, 14, 21 and 28 days respectively with 46% water cement ratio and mix properties ratio 1:2:4. Cylinder constructed by 100% new - 0% waste, 70% new - 30% waste, 50% new - 50% waste, 30% new – 70% waste, 0% new – 100% waste as coarse aggregate.

7 days cured concrete's average Compressive strength-

1) 100% new - 0% waste =10.45 N/mm^2
2) 70% new - 30% waste =9.44 N/mm^2
3) 50% new – 50% waste=7.53 N/mm^2
4) 30% new – 70% waste=6.62 N/mm^2
5) 0% new – 100% waste= 7.39 N/mm^2

14 days cured concrete's average Compressive strength-

1) 100% new - 0% waste =13.29 N/mm^2
2) 70% new - 30% waste =12.09 N/mm^2
3) 50% new – 50% waste=10.35 N/mm^2
4) 30% new – 70% waste=9.09 N/mm^2
5) 0% new – 100% waste= 10.26 N/mm^2

21 days cured concrete's average Compressive strength-

1) 100% new - 0% waste =14.76 N/mm^2
2) 70% new - 30% waste =13.46 N/mm^2
3) 50% new – 50% waste=11.33 N/mm^2
4) 30% new – 70% waste=9.83 N/mm^2
5) 0% new – 100% waste= 11.04 N/mm^2

28 days cured concrete's average Compressive strength-

1) 100% new - 0% waste =15.60 N/mm^2
2) 70% new - 30% waste =14.38 N/mm^2
3) 50% new – 50% waste=12.14 N/mm^2
4) 30% new – 70% waste=10.44 N/mm^2
5) 0% new – 100% waste= 12.24 N/mm^2

For 7days,

Average compressive strength of 100% new normal black stone chips mix concrete is 10.45 N/mm^2 and 100% CDW mix concrete is 7.39 N/mm^2. Almost 30% less than normal concrete.

For 14days,

Average compressive strength of 100% new normal black stone chips mix concrete is 13.29 N/mm^2 and 100% CDW mix concrete is 10.26 N/mm^2. Almost 23% less than normal concrete.

For 21days,

Average compressive strength of 100% new normal black stone chips mix concrete is 14.76 N/mm^2 and 100% CDW mix concrete is 11.04 N/mm^2. Almost 25% less than normal concrete.

For 28days,

Average compressive strength of 100% new normal black stone chips mix concrete is 15.60 N/mm^2 and 100% CDW mix concrete is 12.24 N/mm^2. Almost 22% less than normal concrete. Average 25%.

Similarly

For N-100%, compressive strength is almost accurate.

For N-70% and W-30%, compressive strength is almost 8% less than normal concrete.

For N-50% and W-50%, compressive strength is almost 20% less than normal concrete.

For N-30% and W-70%, compressive strength is almost 27% less than normal concrete.

For W-100%, compressive strength is almost 25% less than normal concrete.

4.10 COST ANALYSIS

Table 4.16: Cost comparison

Cost Comparison of fresh & CDW aggregate concrete									
Item Name	Unit	Quantity	Unit price	Cost(tk)	Item Name	Unit	Quantity	Unit price	Cost(tk)
Cement	kg	8.56	11	94.16	Cement	kg	8.56	11	94.16
Sand	cft	0.42	75	31.5	Sand	cft	0.42	75	31.5
Fresh stone chips	cft	0.85	220	187	CDW agregate	cft	0.85	65	55.25
Per Cft cost of fresh aggregate concrete				312.66	Per Cft cost of CDW aggregate concrete				180.91

From the cost estimation, we get almost 42% savings when we use CDW waste as coarse aggregate in concrete instead of fresh material concrete.

CHAPTER 5

CONCLUSIONS AND FUTURE WORKS

5.1 Conclusions

The following conclusions are drawn based on the results obtained from the various tests and discussion of findings:

Concrete is effected by many factors. Such as –

1) Quality of raw materials
2) Water/cement ratio
3) Coarse/fine aggregate ratio
4) Age of concrete
5) Compaction of concrete
6) Temperature and
7) Curing of concrete.

5.2 Limitations and Recommendations for Future Works

5.2.1 Limitations

- Only compressive strength of the concrete is determined in this study.
- We have limited number of mold in the laboratory. That's why we have to work several times.

5.2.2 Recommendations for Future Works

World is growing and urbanizing at a very fast rate and so is Bangladesh. This effect of rapid urbanization is also seen in construction industry. However, with urbanization comes the moral responsibility of sustaining the environment. Concrete is the favorite choice as a construction material among civil engineers around the

globe for decades. It is preferred for its better performance, longer life and low maintenance cost. To achieve rapid urbanization every year smaller structures are demolished and newer and bigger ones are constructed. These demolished materials (majority of which is usually concrete) are often dumped on land and is not reused for any purpose. This practice effects the fertility of land. To evaluate the environmental impact of using recycled aggregates in terms of reduced resource costs and waste reduction. With the wave of sustainability also impacting the construction industry, scientist and engineers throughout the world are looking for sustainable and reusable construction materials.

- Durability and tensile strength test can be done to observe how effective this concrete is for structural use.
- Long period compressive test can be done to see the behavior of concrete.

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