Effect of Demolition Concrete Aggregate on the Mechanical Properties of Concrete

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A thesis submitted in partial fulfillment of the requirement for the degree of

Bachelor of Science in Civil Engineering.

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CERTIFICATION

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First and foremost, we give thanks to Allah for giving us excellent health and a sound mind, which enable us to successfully finish our project.

We would especially want to thank our honorable supervisor, **Mr. Md. Masud Rana**, Lecturer in the Department of Civil Engineering, Faculty of Engineering, Daffodil International University, for his assistance and direction during the thesis period. This effort is made possible by his unwavering patience, intellectual guidance, unceasing support, supervision, constructive criticism, useful advice, and reviewing numerous versions and making necessary corrections at every turn.

Finally, we would like to thank our loving parents and friends for their help, confidence, and emotional support during this study period.

DEDICATION

"We dedicate this thesis work to our beloved supervisor and our parents"

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ABSTRACT

Currently, the entire world is working together to achieve the Sustainable Development Goals (SDGs) by 2030, and Demolition Coarse Aggregates (DCA) are a key component of this goal. The removal of coarse aggregates from remaining concrete is a major waste management problem and impacts the environment. Our research focus calls for promoting its reuse using the 5R strategy (Refuse, Reduce, Reuse, Recycle, and Rethink). In this study, 20 flexural beams and 60 cylindrical specimens were tested. The water-cement ratio in the concrete mix design was 0.54, and the proportions were 1:2.24:2.57 (M30 grade). The coarse aggregate was partially replaced with demolition coarse aggregates at percentages of 0%, 25%, and 75%. For the purposes of testing, all samples were cured for 14 and 28 days, ensuring reliable outcomes. For the purposes of this study, the unit weight, flexural tensile strength, split tensile strength, and compressive strength were determined. We additionally inquired into using a water-reducing admixture to improve the concrete's tensile and compressive strength as reformed with demolition coarse particles. As to our study results, adding admixture to normal concrete improved its compressive strength, split tensile strength, and flexural tensile strength. In addition, the addition of appropriate admixtures significantly improved the tested strength properties of concrete, while the use of demolition coarse aggregates decreased all of them for all percentages of aggregate replacement. Therefore, adding demolition coarse aggregates to concrete mixes as an admixture could offer a practical solution to manage waste sustainably and improve material performance.

Keywords: Demolition Concrete Aggregate, Compressive Strength, Tensile Strength, Flexural Strength, Admixture, Water-Cement Ratio, Waste Management.

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CHAPTER 1
INTRODUCTION

1.1 General

One of the most common used building materials in modern construction is concrete. Roads bridges, homes, and other construction projects all make extensive use of it. Statistics from the Global Cement and Concrete Association show that residential buildings utilize around 40% of the world's concrete. (Jia et al., 2023).

Bangladesh is one of the emerging nations. With a population of 21.74 million as of 2021, Dhaka is the capital and largest city of Bangladesh (Bangladesh Bureau of Statistics). With around 29,029 inhabitants per square kilometer as of 2020, it is the sixth most densely populated city in the world. Bangladesh's most significant political, cultural and economic hub is Dhaka. The city's population has been growing pace of about 4.2 percent annually since 2016, according to the Bangladesh Bureau of Statistics. High-height building construction is becoming more common these days in order to keep up with the growing population. The deterioration of concrete structures, the replacement of many low-rise structures with comparatively high-rise structures, and the development of new structures are all contributing to the growing amount of ruined concrete. The amount of construction waste produced by this demolished structure is substantial. Around the world, 145 million tons of construction waste are generated annually necessitating enormous quantities of land for landfilling. (Shuvo et al., 2022).

The demolition of concrete structures in Bangladesh has resulted in an increase in the volume of demolition concrete. For the construction industry, the disposal of this demolished concrete is a major challenge. If the demolition concrete is used for new construction, the disposal problem will be solved, the demand for virgin coarse aggregates will be reduced and finally consumption of natural resources for making aggregate will also be reduced (M. Ashiquzzman, n.d.). Demolition concrete aggregate (DCA) has been acknowledged as an appealing method to save natural resources and lessen the environmental effect of the construction sector when used as aggregate in the construction of new concrete structures. Buildings demolished by humans or by natural calamities like hurricanes or earthquakes generate enormous amounts of garbage. The effectiveness of adding certain waste materials to concrete to enhance its mechanical and physical qualities was investigated. (Elansary et al., 2021).

To make concrete more environmentally friendly, one typical method is to crush it to create coarse aggregate for fresh concrete. This lessens the need for landfills to store leftover concrete and the consumption of natural resources. (K Rahal, n.d.). Many nations, including Bangladesh, rely on imports to provide their coarse aggregate needs, which has led to the uncontrolled exploitation of natural rocks. Concrete waste recycling and reuse have become essential for lowering the use of new natural aggregates and promoting sustainable development (Patowary, 2021).

Admixtures that improve workability in mix designs with low water cement ratios have been employed to restore strength. In order to compare the amount of strength that can be recovered, the same admixture has been used for both recycled stone and brick chips, keeping all the parameters the same. (Hannan Khan, 2018).

Many researchers worldwide have expressed interest in finding a solution to the building waste disposal issue, and the majority of them recommend recycling and waste reuse. (Shuvo et al., 2022).

1.2 Project Objective

Assessing the overall performance of concrete in Bangladesh that incorporating residual demolished concrete is the main goal of this study. The following goals have been set in addition to this main objective:

a) To determine the concrete's compressive strength while using demolition concrete as a coarse aggregate.
b) To determine the concrete's splitting tensile strength when demolition concrete is used as coarse aggregate.
c) To determine the concrete's flexure tensile strength when demolition concrete is used as coarse aggregate.

CHAPTER 2
LITERATURE REVIEW

2.1 General

One of the main components of a structural member is concrete. Sand and cement are employed as binder materials, while brick chips and stones are used as coarse aggregate. The aggregate is recyclable among those components of concrete. Additionally, the strength of the aggregate used will have a significant outcomes on the strength of concrete made with recycled material. Additionally, there are other factors that will affect concrete's strength, such as the Concrete includes a variety of binder materials, fine aggregate types, workability, coarse aggregate sizes and grades, admixtures, water cement ratios, and above all mix design processes. (Hannan Khan, 2018).

2.2 Concrete

Concrete, after water, is the second most consumed material worldwide. Because of its low cost and flexibility in casting, it is the most extensively used building material worldwide. Because of this, ancient concrete structures are being demolished, producing millions of tons of concrete trash. (Patowary, 2021). The most usual material utilized in construction projects is concrete. However, a significant quantity of discarded concrete has led to serious environmental issues as a result of the growing rate of urbanization and the expansion of building projects. (Su et al., 2023).

2.3 Properties of Concrete

Concrete is normally reinforced with materials that are strong in tension, usually steel, because it has a reasonably high compressive strength but a much lower tensile strength. The elasticity of concrete is relatively constant at low stress levels but start decreasing at higher stress levels as matrix cracking develops. Concrete has a very low coefficient of thermal expansion, and as it matures concrete shrinks. Every concrete structure will eventually crack as a result of strain and shrinkage. Concrete is prone to creep when it is subjected to long-term stresses (ALAM, 2019).

2.4 Demolition Concrete Aggregate

Demolition concrete aggregate (DCA) is typically produced in two steps: crushing the demolished concrete and screening to remove impurities including gypsum, paper, wood, plastics, and reinforcement. To the literature review, some mortar and cement paste from the original concrete stay bonded to stone particles in recycled aggregate after crushed concrete that has been demolished. (Nuruzzaman, 2016).

2.5 Compressive Strength

For determining the quality of concrete, compressive strength is the most relevant factor. (Shuvo et al., 2022). The cubes were positioned in the center of the compression testing equipment and secured to stay there. The tested cube was then gradually placed under the stress until it failed (Ali et al., 2020).

Purpose: To measure the maximum compressive load a concrete specimen (usually a cube or cylinder) can bear before failure.

This equation is used to convert the Compressive Strength test results in KN to megapascals (MPa) formation**:**

$$\frac{\pi d^2}{4} = \frac{3.1416 * \text{dia}^2}{4}$$

$$= \frac{\text{p} * 1000}{(\frac{\pi d^2}{4})}$$

Where**,**

d = Dia (mm)

p = Load

2.6 Split Tensile Strength

One of the fundamental and vital features in concrete that significantly influences the degree and amount of cracking in structures is its tensile strength. In order to ascertain the load at which the concrete members may fracture, it is important to ascertain the concrete's tensile strength. Additionally, one way to ascertain the tensile strength of concrete is to conduct a splitting tensile strength test on a concrete cylinder. Similar to other codes such as IS 5816 1999, the method is based on ASTM C496 (Standard Test Method of Cylindrical Concrete Specimen) (Prashanth, 2021).

Purpose: to ascertain concrete's tensile strength, which aids in assessing crack resistance and structural design factors.

Using this formula, the split tensile test results in KN are converted to MPa formation.

$$\frac{2 * \mathrm{p}}{\pi d L}$$

Where,

p = Load

d = Dia (mm)

L = Length (mm)

2.7 Flexural Strength Test

For estimating the load at which concrete members may crack, a flexural strength test is necessary. (Vashisth & Dhull, 2018).

Purpose: To measure the modulus rupture (flexural strength), which reflects concrete tensile strength under bending.

The flexural strength test results in KN are converted to MPa by using this formula:

$$\frac{3PL}{2bd^2}$$

Where,

P = Load

b = Width (mm)

d = Depth (mm)

L = Length (mm)

2.8 Summary

The literature indicates that DCA can be used in concrete with manageable reductions in mechanical strength, particularly when replacement is limited and adequate curing is provided. Key factors influencing performance include RCA quality, percentage of replacement, mix design, and curing period. This study builds on existing work by evaluating the performance of concrete with 0%, 25% and 75% demolished concrete as coarse aggregate replacement, under 14-day and 28-day curing conditions, focusing on compressive, tensile, and flexural strength.

CHAPTER 3
METHODOLOGY

3.1 Introduction

In this study, the combination will be created utilizing admixture and different percentages of destroyed coarse aggregate, such as 0%, 25%, and 75%.

3.2 Collection of Raw Materials

3.2.1 Portland Composite Cement (PCC)

As Portland Composite cement (PCC) we have used Crown Cement brand which is availability there in any local area market of bd. Table 3.1 shows the properties of cement.

Table 3.1: Properties of Cement

Property	Average value of PCC from experiment
Normal Consistency	29%
Initial Setting Time (min)	142
Final Setting Time (min)	362

3.2.2 Normal Consistency Test

Place the mold under Vicat apparatus. Gently lower 10 mm plunger until it touches the surface of paste. Release it and let it penetrate under its weight only. To attain standard consistency, the plunger must be able to penetrate to 5 to 7 mm from the bottom of the mold. If the penetration is out of the range of 5 to 7 mm, then modify the water content and repeat the test until penetration is obtained. The range usually about (by dry cement weight) 25 – 30 percent.

3.2.3 Initial and Final Setting Time

When the paste (cement + water) begins to lose its flexibility, it is said to have reached its initial setting time. Concrete or cement mortar must be laid no later than 45 minutes after water is added if the cement's initial setting period is at least 45 minutes. Delays will cause the concrete or mortar to weaken. However, as cement reaches its final setting time, it loses its fluidity and fully solidifies. The time required for the cement to reach its greatest strength is known as the ultimate setting time. The maximum final setting time for Portland composite cement is 375 minutes.

3.2.4 Properties Aggregates

The Coarse, fine and demolition concrete aggregate sizes vary according to the type of work. The properties of aggregates are given in table 3.2.

Table 3.2: Properties of Aggregates

Property	Fine Aggregate	Coarse Aggregate	Demolition Concrete Aggregate
Fineness Modulus (FM)	2.69	6.40	6.25
Specific Gravity	2.43	2.29	2.32
Moisture Content	1.17	1.40	2.33
Water Absorption %	6.07	1.21	2.53
Unit Weight (kg/m^3)	1690	1416.67	1583.33

3.2.5 Sieve Analysis and Distribution Curve

3.2.5.1 Fine Aggregate

Sample = 500gm

Table 3.3: Sieve Analysis (Fine Aggregate)

Sieve No.	Sieve Size (mm)	Weight Retained (gm)	% Weight Retained	Cumulative Wt. Retained %	Percentage Finer
# 4	4.75	8	1.64	1.64	98.35
# 8	2.36	35.4	7.25	8.89	91.1
# 16	1.18	73.6	15.08	23.97	76.02
# 30	0.6	127.8	26.18	50.15	49.84
# 50	0.3	168.8	34.58	84.73	15.26
# 100	0.15	74.5	15.25	99.99	0.01
Pan		9.7			
Total		497.8			
FM=2.69					

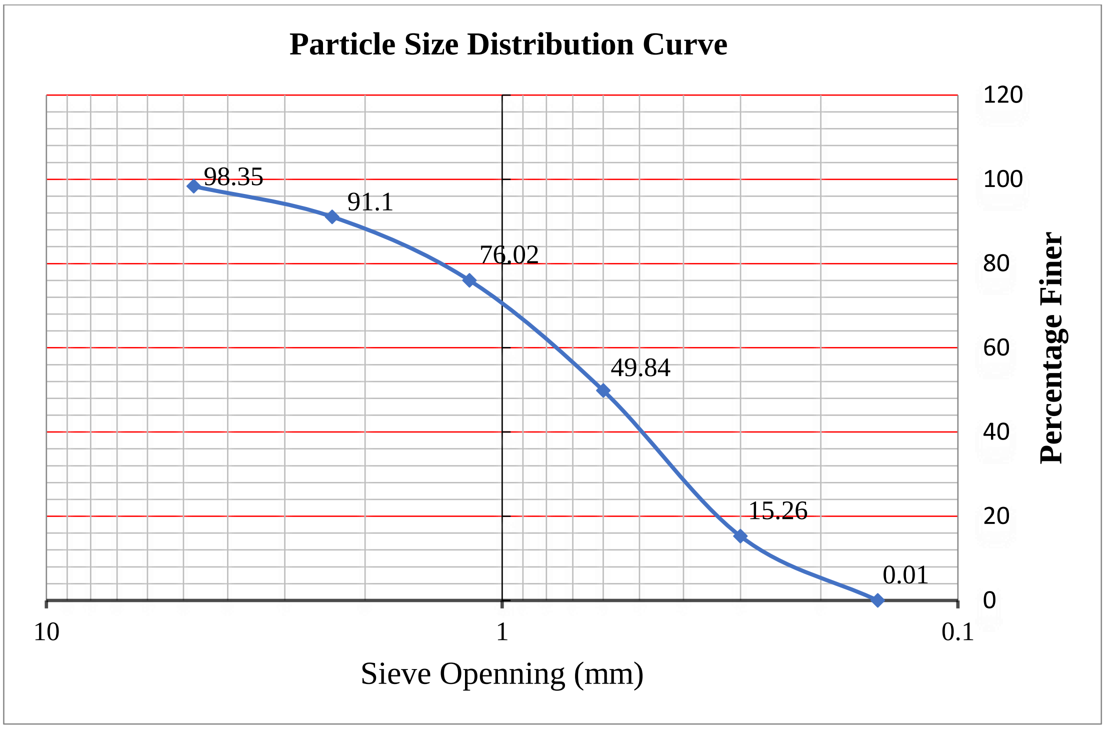

Figure 3.1: Particle Size Distribution Curve (Fine Aggregate)

3.2.5.2 Coarse Aggregate

Sample = 5000gm

Table 3.4: Sieve Analysis (Coarse Aggregate)

Sieve No.	Sieve size (mm)	Weight Retained (gm)	% Weight Retained	Cumulative Wt. Retained %	Percentage Finer
3/2 in	37.5	182.77	3.65	3.65	96.35
1 in	25	268.31	5.37	9.02	90.98
3/4 in	19	374.56	7.63	16.51	83.49
1/3 in	12.5	2534.85	50.71	67.22	32.78
3/8 in	9.5	441.07	8.82	76.22	23.96
# 4	4.75	502.81	10.06	86.1	13.9
# 8	2.36	249.52	4.99	91.09	8.91
# 16	1.18	154.29	3.09	94.18	5.82
# 100	0.15	103.7	2.07	96.25	3.75
Pan		187.12	3.74	99.99	0.01
Total		4998.77			
FM =6.40					

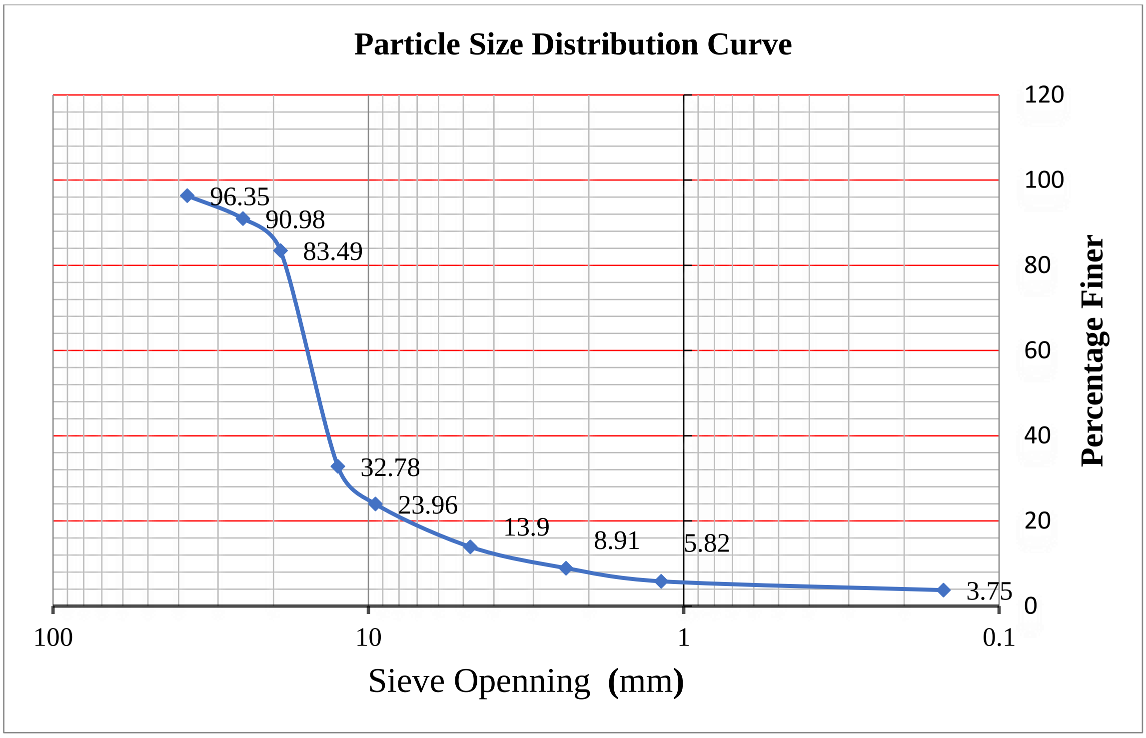

Figure 3.2: Particle Size Distribution Curve (Coarse Aggregate)

3.2.5.3 Demolition Concrete Aggregate

Sample = 5300gm

Table 3.5: Sieve Analysis (Demolition Concrete)

Sieve No.	Sieve size (mm)	Weight Retained (gm)	% Weight Retained	Cumulative Wt. Retained %	Percentage Finer
3/2 in	37.5	0	0	0	0
1 in	25	323.13	6.21	6.21	93.79
3/4 in	19	251.72	4.75	10.96	89.04
1/2 in	12.5	2750.31	51.9	62.86	37.14
3/8 in	9.5	582.47	10.99	73.85	26.15
# 4	4.75	602.61	11.37	85.22	14.75
# 8	2.36	452.11	8.53	93.75	6.25
# 16	1.18	80.56	1.52	95.27	4.73
# 100	0.15	106.29	2.01	97.28	2.72
Pan		143.69	2.71	99.99	0.01
Total		5298.89			
FM =6.25					

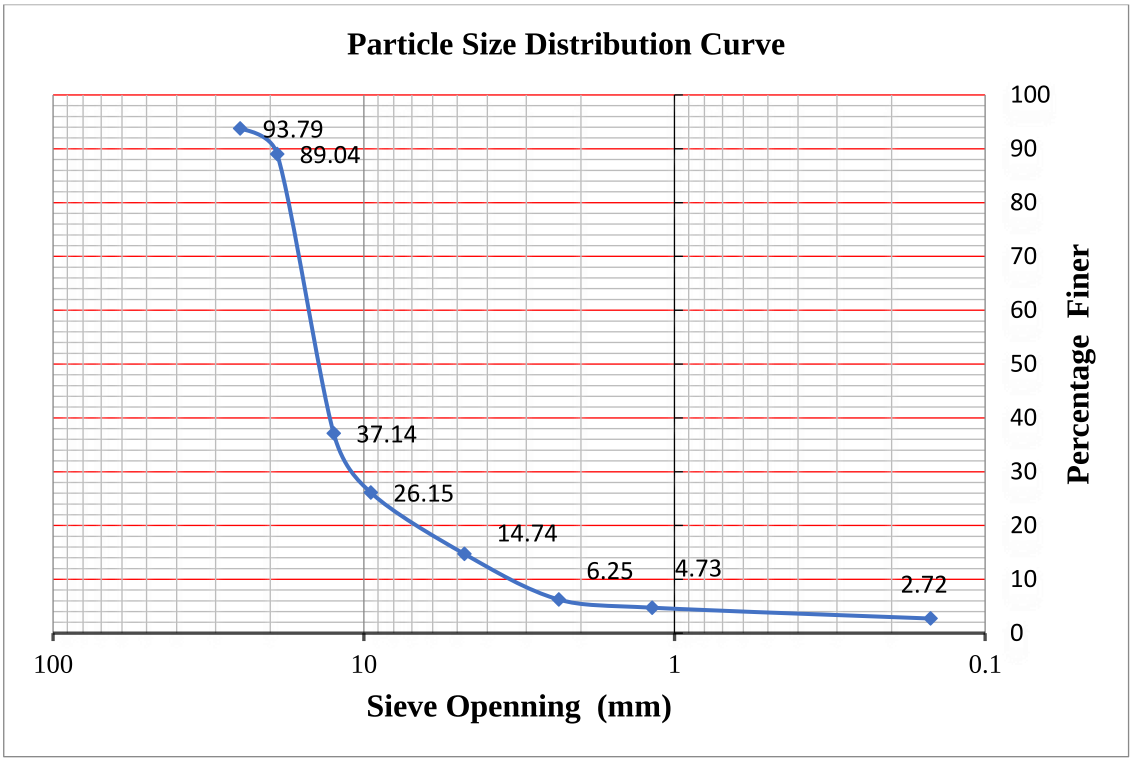

Figure 3.3: Particle Size Distribution Curve (Demolition Concrete)

3.2.6 Water

Water has accumulated from the water supply in the Civil Engineering lab and ensure that there are no iron or particles in our water.

3.2.7 Admixture

The main purposes of additives are to change the characteristics of both fresh and hardened concrete, to maintain the quality of the material while it is being mixed, transported, placed, and cured, and to address specific situations that may arise during concrete operations. (ALAM, 2019).

The use of admixtures helps produce concrete that meets specific requirements while being cost-effective and environmentally friendly.

Figure 3.4: Admixture

3.2.8 Sylhet Sand

Sand is a crucial construction material, used mainly in concrete, mortar, plaster, and backfilling. It’s sourced from various natural and artificial origins. We purchased fine aggregate from the Birulia, Savar.

Characteristics: Clean, coarse, angular particles. Using high-quality construction work, especially RCC (reinforced concrete).

Figure 3.5: Sylhet Sand

3.2.9 Coarse Aggregate

One of the main components of concrete is coarse aggregate, which is composed of particles that are kept on a 4.75 mm screen. It gives concrete strength, volume, and durability. There is no silt, clay, or organic stuff present, and it is pure. It is well-graded (an assortment of sizes), durable, and long-lasting. It is angular (better for cement bonding).

Coarse Aggregate we are collected from Ashulia Bazar.

Figure 3.6: Coarse Aggregate

3.2.10 Demolition Coarse Aggregate

Currently, it is projected that 2 to 3 billion tons of concrete are produced annually worldwide. The amount of destroyed concrete produced worldwide is expected to increase to 7.5–12.5 billion tons during the next ten years. There will be no need to burn clay or destroy mountains in order to produce new aggregates if it is feasible to recycle all of the concrete that has been demolished. In Bangladesh, the amount of concrete being demolished is likewise growing daily as a result of the deteriorating infrastructure and the replacement of low-rise structures with comparatively high-rise structures brought about by the rising real estate market. Consequently, an effort was conducted to determine the potential methods for recycling concrete that had been demolished for use as coarse aggregates in new construction (Uddin, 2013).We collected Demolition coarse aggregate collected from near by Biruliya Bridge. The fineness modulus (FM) of demolition coarse aggregate is 6.25.

Figure 3.7: Demolition Coarse Aggregate

3.2.11 Procedure and Casting the Specimen

Research has been conducted at Daffodil International University's Civil Engineering Laboratory in Dhaka, Bangladesh. Using M30 grades plane cement concrete. The main working principle behind this.

For experiments, its maximum Dia is 101.6 mm and maximum level length is 202.2 mm concrete cylinder were made. We also made beam for flexural strength test and curing period is 14 & 28 days.

Figure 3.8: Molds Making

Mixing the concrete perfectly and carefully. If the mixing is not good, it is very critical to produce solid concrete. It is very crucial to combine all of those materials (cement, water, sand, coarse aggregate, demolished coarse aggregate) to create pure concrete.

Figure 3.9: Materials used in the experimental work for concrete production

To make sure there is no air inside our molds, we take great care when casting our molds and beams. We also make an effort to compact the concrete thoroughly. For casting, we have also ensured that the surface is smooth and using a tamping rod and 21 blows each time for three periods. Casting images are shown in Figs. 3.10 and 3.11.

Figure 3.10: Slum Test

For both natural and DCA fresh concrete mixes, the slump test was utilized only to examine the consistency of the fresh concrete and determine its workability. In accordance with ASTM C143, these tests were performed during this investigation. (Mohammed & Abbas, 2019).

We created molds and beams for our experiment. In total, we produced 60 molds and 24 beams for our tests.

Figure 3.11: Beams

Properly mixing the dry components was the primary focus of the entire experiment, as shown in Figs. 3.11 and 3.12. The purpose of the molds and beams is to ensure that concrete is properly placed in them layer by layer, preventing any gaps between the binding ingredients and aggregate. To stop air bubbles or voids from getting into the concrete molds and beams, the concrete should be properly placed until it is completely filled. For a full day, the molds and beams kept in the laboratory remained untouched. After the molds and beams were taken out, they were then put in the water tank for different curing times of 14 and 28 days. For figuring out the compressive, tensile and flexural strength of the mix, the molds and beams was finally tested on a compression testing, split tensile and flexural strength equipment. In order to compare the strengths of traditional concrete with tiled aggregate concrete, this test was conducted on both types of specimens.

Figure 3.12: Specimen for the compressive & split tensile test

Figure 3.13: Specimen for the flexural strength test

Figure 3.14: Compressive Strength Test.

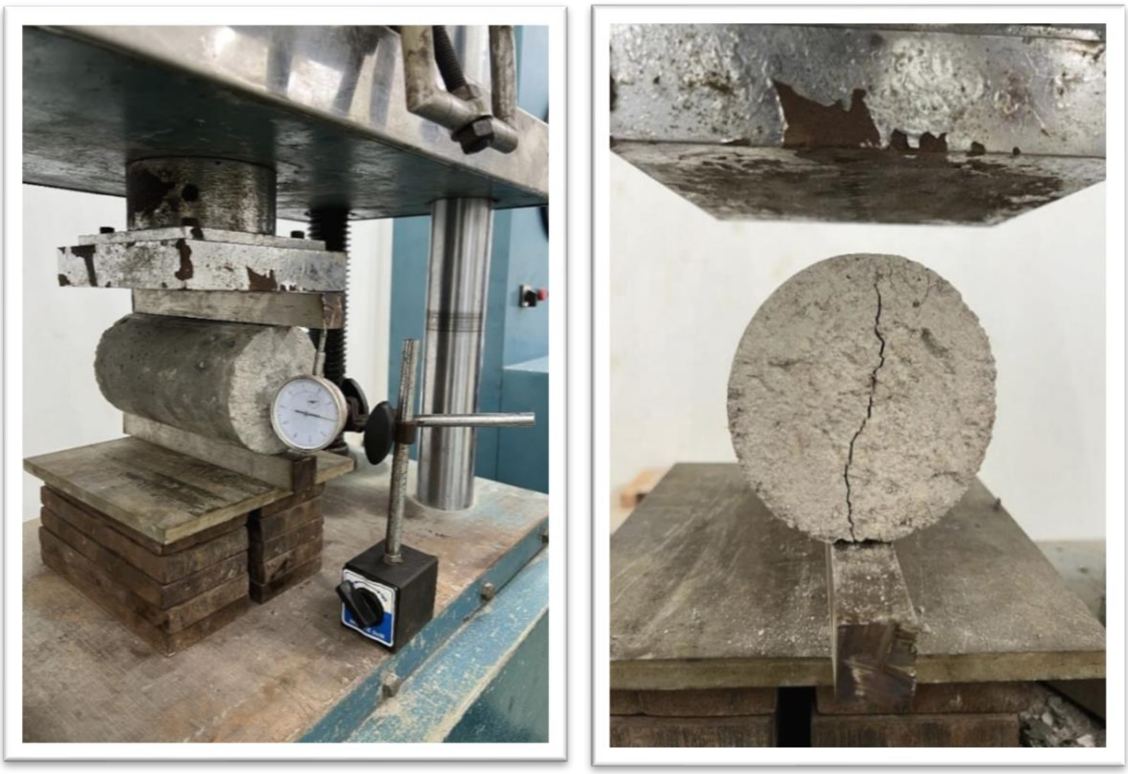

Figure 3.15: Split Tensile Strength Test

Figure 3.16: Flexural Strength Test

3.3 Summary

Mix design is the process of selecting the ideal mix materials and their proportions for a concrete mixture. The amount of cement, fine aggregate, and coarse aggregate as well as the connection between the water/cement ratio and the necessary strength, are all calculated in the mix design.

Chapter 4
RESULT AND DISCUSSION

4.1 Introduction

This chapter presents the results of the experiment and other tests and analyzes the different findings.

4.2 Result

4.2.1 Slump of Concrete:

Concrete slump changes after adding DCA and admixture. The concrete's slump when 0%, 25%, and 75% DCA are added is clearly visible; the proportions of water-cement ratio were 0.54 and 0.30 respectively. The slump values of the concrete increased when the water-cement ratio in the mixture was 0.54.

Note: (CS-Control Specimen), (25DCA- 25% of Demolition Concrete Aggregates), (75DCA- 75% of Demolition Concrete Aggregates), (25DCA(A)- 25% of Demolition Concrete Aggregates with Admixture), (75DCA(A)- 75% of Demolition Concrete Aggregates with Admixture)

Table 4.1 Slump flow examination and ratio with the activity of aggregate

SL.NO	Sample Type (%)	Slump Test (mm)
1.	CS	72
2.	25DCA	58
3.	75DCA	52
4.	25DCA(A)	69
5.	75DCA(A)	63

When we used chemicals while mixing concrete, the water cement ratio was 0.3, resulting in a decrease in the slump value. The super plasticizer was used at the rate of 1% per kg of cement.

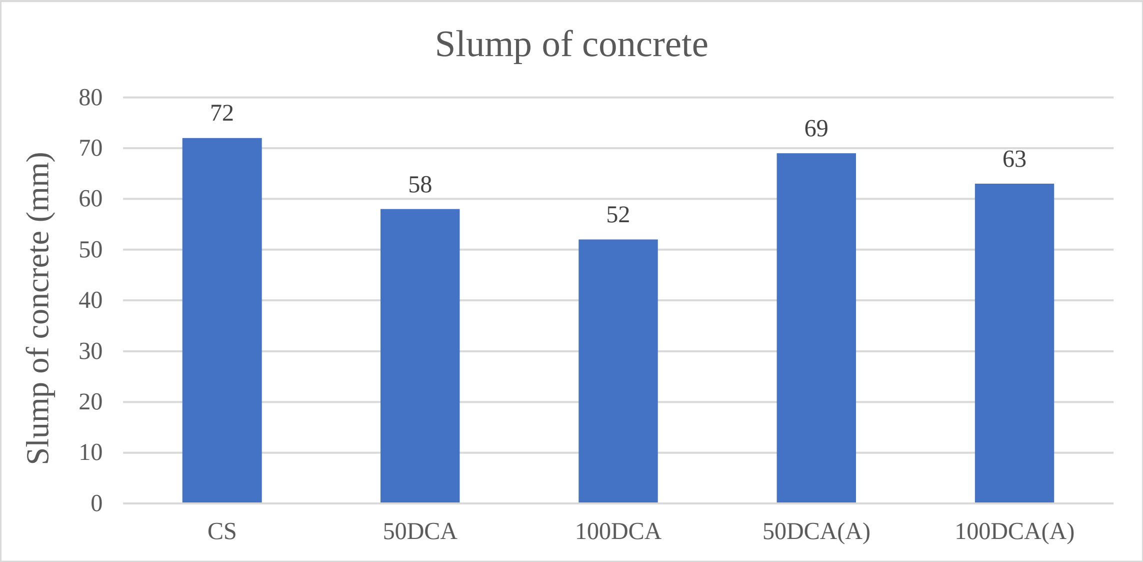

Figure 4.1: Slump flow examination and ratio with the activity of aggregate.

The mix's consistency in concrete, or its flexibility, is measured by slump, which can be utilized to measure the amount of water added to the mixture. It is extremely hard, dry, and challenging to work with low slump concrete. Concrete with a higher slump is more fluid and simpler to work with.

The amount of concrete that "slumps," or sinks, when taken out of an inverted 12-inch-tall cone is known as the slump value. The result may be close to zero, indicating that the concrete is very stiff and almost difficult, or it may be so highly wet and flow able that, when taken out of the cone, the concrete collapses completely. It can also serve as an indication that the mixture was not properly mixed. The purpose of the slump test is to ensure consistency with different concrete loads in the field.

The value of 25DCA(A) is smaller than CS, as stated in Table 4.2 then gradually lower by 25DCA, 75DCA(A) and 75DCA. Testing the mold revealed remarkable strength.

Table 4.2: Result of compressive strength test for 14th day's

SL No.	Sample Type (%)	Compression load (KN)	Dia (mm)	Compressive Strength (MPa)	Average Compressive strength (MPa)
1	CS	183.78	101.1	24.89	24.60
		189.95	100.5	24.06	
		179.52	100.8	23.50	
2	25DCA	186.81	101.5	23.09	22.48
		179.86	100.9	22.49	
		176.15	101.3	21.86	
3	75DCA	172.85	101.4	20.85	19.85
		155.92	101.6	19.23	
		156.18	101.1	19.46	
4	25DCA(A)	193.49	101.3	24.01	23.44
		190.78	101.5	23.58	
		186.11	100.9	23.95	
5	75DCA(A)	171.40	101.3	21.27	21.44
		176.43	101.2	21.93	
		168.92	100.9	21.13	

In Figure 4.2, the compressive strength 25DCA(A) value is close to CS. Then, progressively decreased by 25DCA, 75DCA(A) and 75DCA. It is found that the optimum value of compressive strength was attained for sample type 25DCA(A) with demolition concrete aggregate.

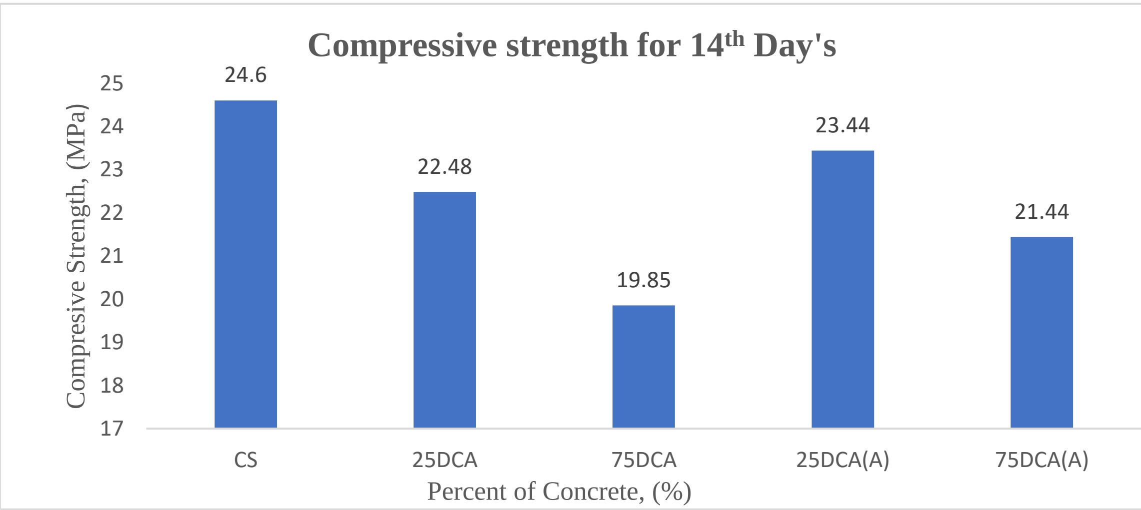

Figure 4.2: Compressive Strength for 14th Day’s

The value of 25DCA(A) is smaller than CS, as stated in Table 4.3, then gradually lower by 25DCA, 75DCA(A), and 75DCA.

Table 4.3: Result of Compressive Strength test for 28th Day's

SL No.	Sample Type (%)	Compression load (KN)	Dia (mm)	Compressive Strength (MPa)	Average Compressive Strength (MPa)
1	CS	238.56	101.4	29.54	28.84
		243.06	101.1	28.28	
		228.43	101.2	28.40	
2	25DCA	206.23	100.9	25.79	26.45
		218.17	101.1	27.18	
		210.54	100.8	26.38	
3	75DCA	196.45	101.5	24.28	24.13
		190.61	100.8	23.87	
		193.52	100.8	24.25	
4	25DCA(A)	227.46	101.2	27.29	27.89
		238.56	101.4	28.29	
		244.87	101.1	27.18	
5	75DCA(A)	242.29	101.6	26.39	26.14
		209.18	100.8	26.22	
		208.36	101.1	25.80	

In Figure 4.3, the compressive strength 25DCA(A) value is close to CS. Then, progressively decreased by 25DCA, 75DCA(A) and 75DCA. It is found that the optimum value of compressive strength was attained for sample type 25DCA(A) with demolition concrete aggregate

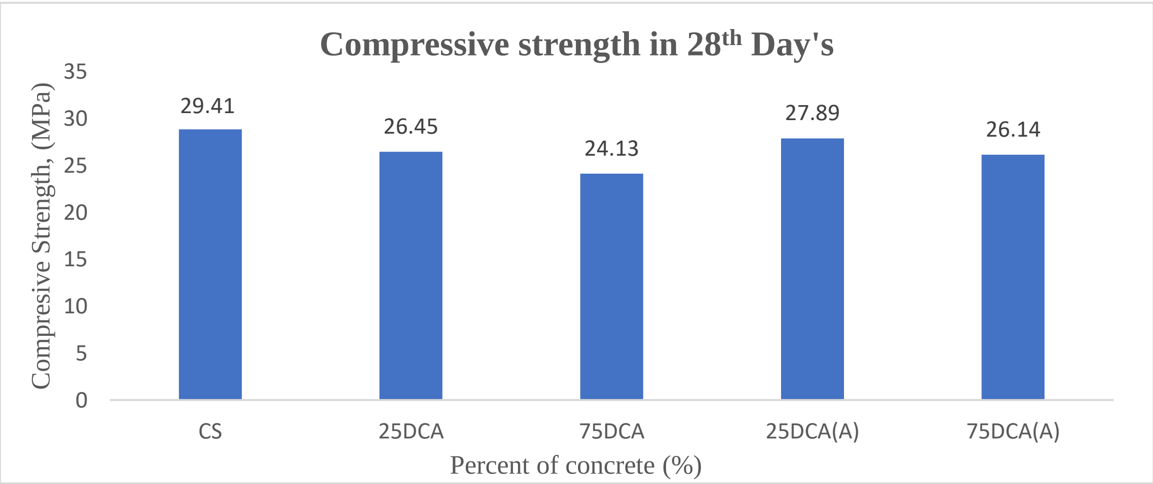

Figure 4.3: Compressive strength for 28th Day’s

Out of many tests applied to the concrete, this is the most important, which gives an idea about all the characteristics of concrete and the compressive strength of it. By this single test, one judges whether concreting has been done properly or not.

The water-cement ratio, cement strength, concrete material quality, quality control during production, and other factors all affect the concrete's compressive strength.

The test for compressive strength is carried out either on a cube or a cylinder. Various standard codes recommend a concrete cylinder or concrete cube as the standard specimen for the test.

In Table 4.4, combine 14 days and 28 days to compare compressive strength.

Table 4.4: Result of Compressive strength combination

SL No.	Sample Type (%)	Compressive Strength (MPa)	
		14th Day's	28th Day's
1	CS	24.60	28.84
2	25DCA	22.48	26.45
3	75DCA	19.85	24.13
4	25DCA(A)	23.44	27.89
5	75DCA(A)	21.44	26.14

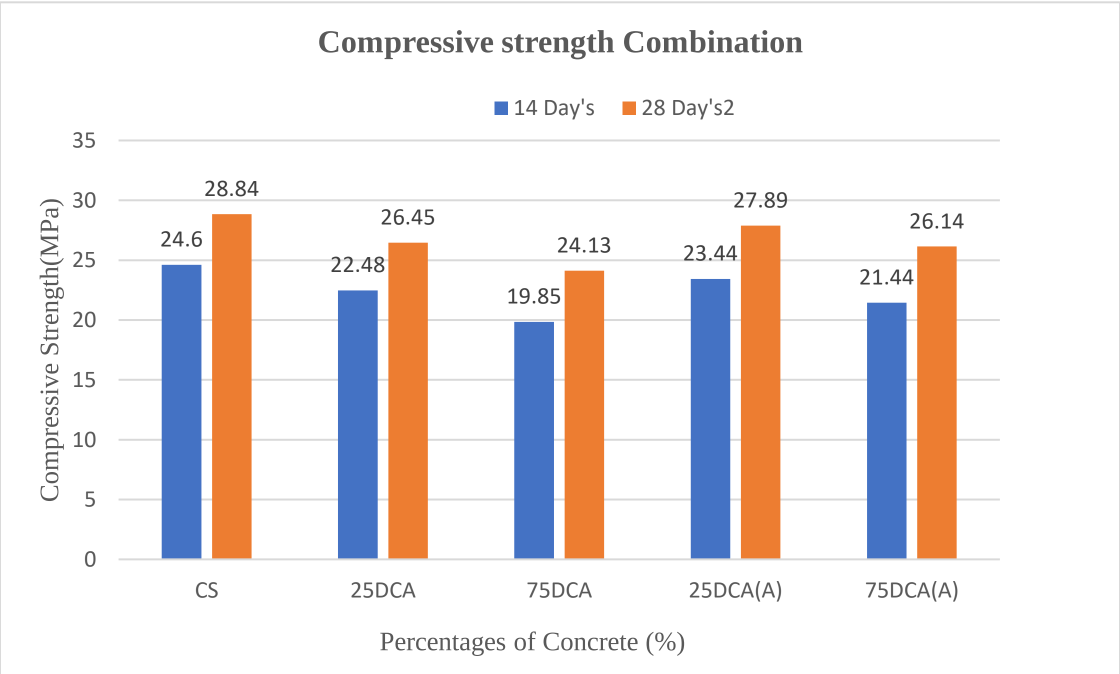

Figure 4.4: Compressive Strength Combination

In this graph, it is indicated that at the end of 28 days, curing 25DCA(A) replacement of demolition concrete aggregate has the maximum compressive strength of 27.89 (MPa).

Table 4.5 shows that the value of CS is greater than 25DCA(A), 25DCA, 75DCA(A), and 75DCA.

Table 4.5: Result of Split Tensile strength for 14th Day's

SL No.	Sample Type (%)	Splitting Load (KN)	Length (mm)	Dia (mm)	Tensile Strength (MPa)	Average Tensile strength (MPa)
1	CS	85	200	101.2	3.20	2.99
		80	200	101.5	2.91	
		65	200	100.9	2.85	
2	25DCA	75	200	100.8	2.35	2.31
		75	200	101.2	2.36	
		70	200	101.5	2.21	
3	75DCA	65	200	100.4	2.04	2.00
		55	200	100.6	1.74	
		70	200	100.2	2.22	
4	25DCA(A)	80	200	101.2	2.50	2.52
		90	200	100.7	2.83	
		75	200	100.3	2.37	
5	75DCA(A)	65	200	100.5	2.03	2.19
		75	200	100.9	2.34	
		70	200	100.5	2.21	

In Figure 4.5, the split tensile strength 25DCA(A) value is close to CS. Then, progressively decreased by 25DCA, 75DCA(A) and 75DCA. It is found that the optimum value of split tensile strength was attained for sample type 25DCA(A) with demolition concrete aggregate

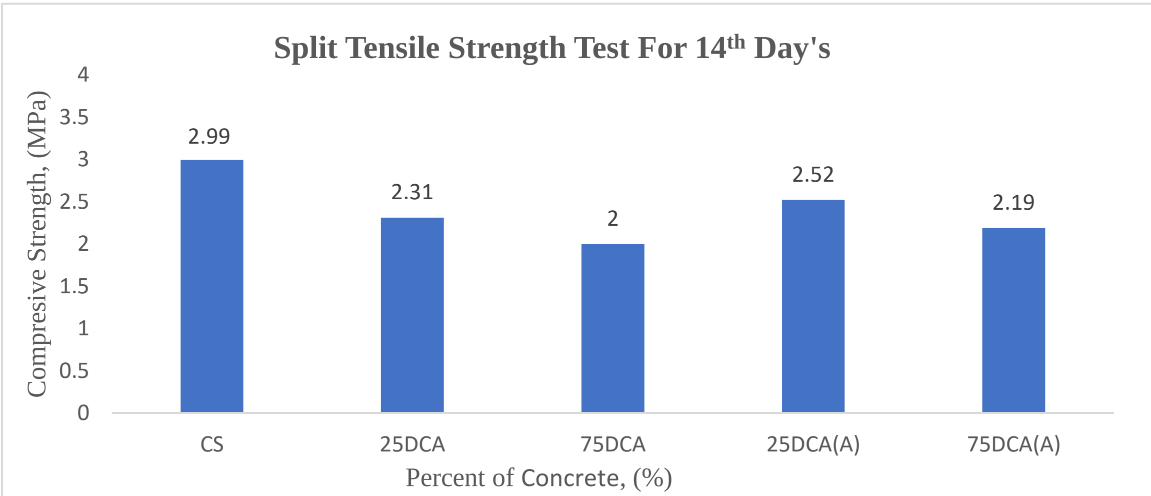

Figure 4.5: Split Tensile Strength for 14th Day's

Table 4.6 shows that the CS value is greater than 25DCA(A), 25DCA, 75DCA(A), and 75DCA.

Table 4.6: Result split Tensile Strength test for 28th Day's

SL. No.	Sample Type (%)	Splitting Load (KN)	Length (mm)	Dia (mm)	Tensile Strength (MPa)	Average Tensile strength (MPa)
1	CS	95	200	100.3	3.81	3.59
		100	200	101.6	3.98	
		90	200	101.0	2.81	
2	25DCA	85	200	100.7	2.66	2.76
		90	200	101.3	2.81	
		90	200	101.5	2.82	
3	75DCA	80	200	100.3	2.54	2.48
		75	200	100.7	2.36	
		80	200	101.2	2.52	
4	25DCA(A)	105	200	100.7	3.32	3.15
		95	200	101.2	2.99	
		100	200	100.7	3.14	
5	75DCA(A)	80	200	101.3	2.51	2.51
		75	200	101.1	2.35	
		85	200	101.5	2.67	

In Figure 4.6, the split tensile strength 25DCA(A) value is close to CS. Then, progressively decreased by 25DCA, 75DCA(A) and 75DCA. It is found that the optimum value of split tensile strength was attained for sample type 25DCA(A) with demolition concrete aggregate

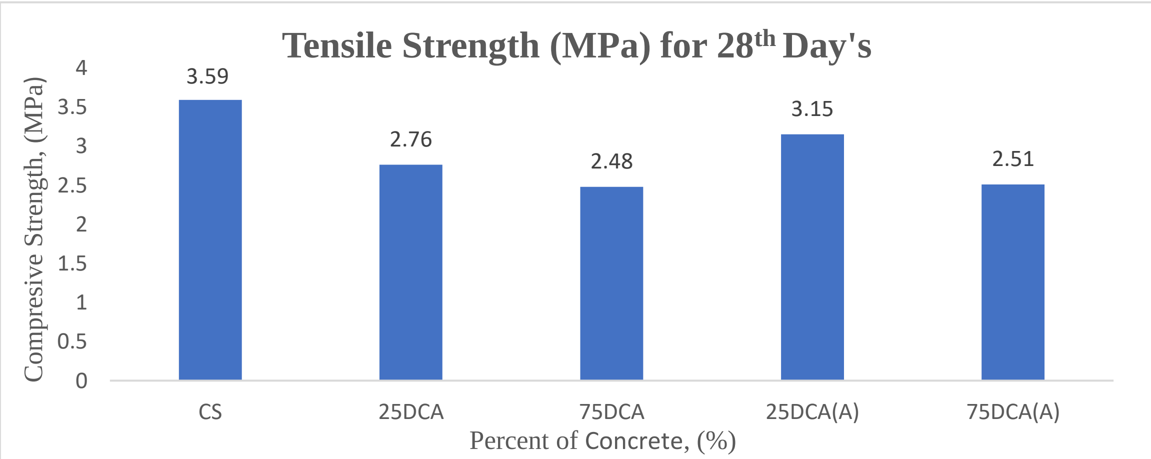

Figure 4.6: Split Tensile Strength for 28th Day's

In Table 4.7, combine 14 days and 28 days to compare spilt tensile strength.

SL No.	Sample Type (%)	Tensile Strength (MPa)	
		14th Day's	28th Day's
1	CS	2.99	3.59
2	25DCA	2.31	2.76
3	75DCA	2.00	2.48
4	25DCA(A)	2.52	3.15
5	75DCA(A)	2.19	2.51

Fig.4.7:Tensile Strength Combination for 14th and 28th Day's

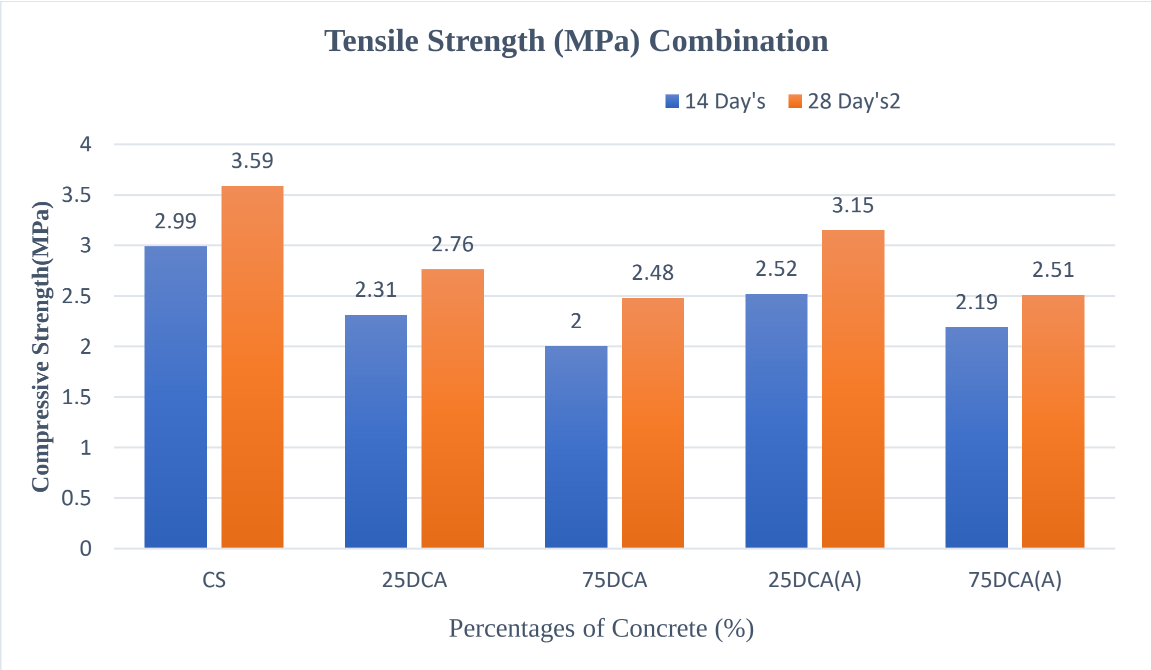

Figure 4.7: Tensile Strength Combination (MPa) for 14th and 28th Day's

In this graph, it is indicated that at the end of 28 days, curing 25DCA(A) replacement of demolition concrete aggregate has the maximum split tensile strength of 3.15 (MPa).

Table 4.8 shows that the CS value is greater than 25DCA(A), 25DCA, 75DCA(A), and 75DCA.

Table 4.8: Result of Flexural Strength Test for 14th Day's

SL No.	Sample Type (%)	Flexure load (KN)	Length (mm)	Width (mm)	Depth (mm)	Flexural strength (MPa)	Average Flexural Strength (MPa)
1	CS	17	406.4	151.5	152.4	4.07	3.94
		20	406.4	152.4	152.4	3.91	
2	25DCA	22	406.4	151.5	152.4	3.97	3.25
		14	406.4	152	152.4	2.53	
3	75DCA	15	406.4	151	152.4	2.71	3.07
		19	406.4	152	152.4	3.43	
4	25DCA(A)	22	406.4	152.4	152.4	3.97	3.61
		18	406.4	151	152.4	3.25	
5	75DCA(A)	14	406.4	151	152.4	2.53	3.16
		21	406.4	151.5	152.4	3.79	

In Figure 4.8, the flexure strength 25DCA(A) value is close to CS. Then, progressively decreased by 25DCA, 75DCA(A) and 75DCA. It is found that the optimum value of flexure strength was attained for sample type 25DCA(A) with demolition concrete.

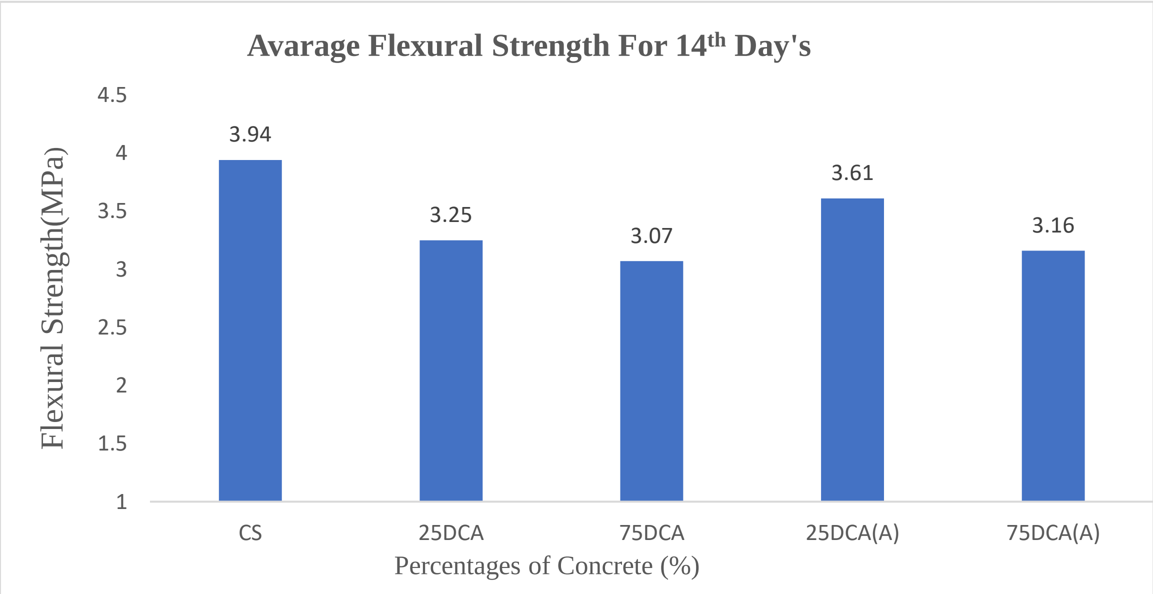

Figure 4.8: Average Flexural Strength for 14th Day’s

Table 4.9 shows that the 25DCA(A) value is greater than CS, 25DCA, 75DCA(A), and 75DCA

Table 4.9: Result of Flexural Strength (MPa) Test (Beam) for 28th Day's

SL No.	Sample Type (%)	Flexure load (KN)	Length (mm)	Width (mm)	Depth (mm)	Flexural strength (MPa)	Average flexural Strength (MPa)
1	CS	19	406.4	152.4	152.4	3.93	4.17
		23	406.4	151	152.4	4.35	
2	25DCA	18	406.4	151	152.4	3.25	3.61
		22	406.4	151.5	152.4	3.97	
3	75DCA	21	406.4	151.5	152.4	3.79	3.43
		17	406.4	152.4	152.4	3.07	
4	25DCA(A)	21	406.4	151.5	152.4	3.79	3.96
		24	406.4	152	152.4	4.33	
5	75DCA(A)	20	406.4	151	152.4	3.61	3.52
		19	406.4	152	152.4	3.43	

In Figure 4.9, the flexure strength 25DCA(A) value is close to CS. Then, progressively decreased by 25DCA, 75DCA(A) and 75DCA. It is found that the optimum value of flexure strength was attained for sample type 25DCA(A) with demolition concrete aggregate.

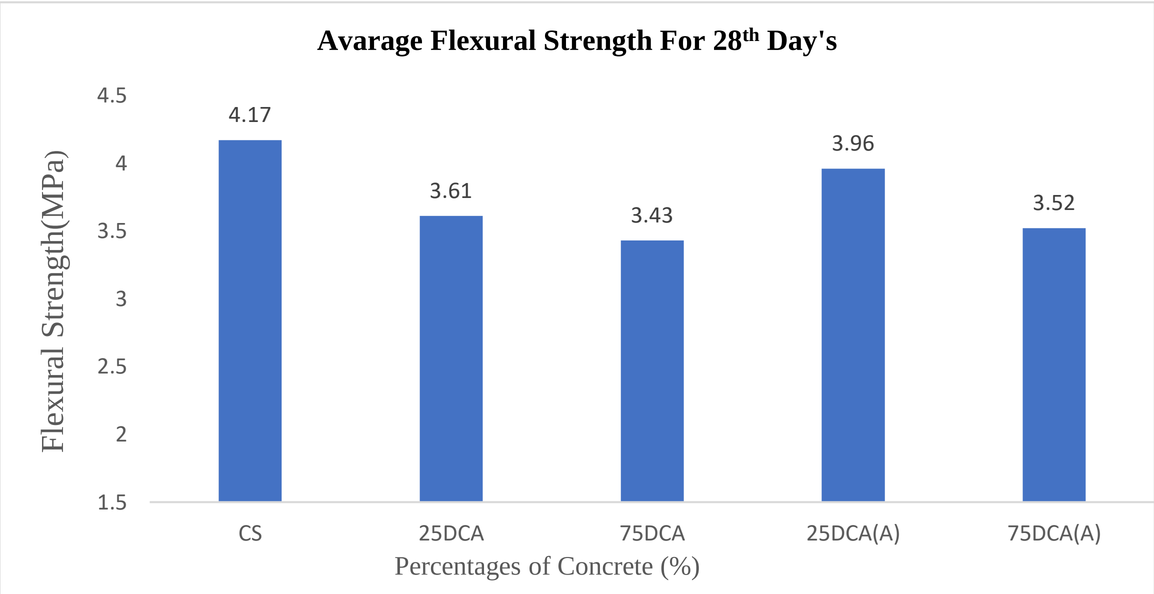

Figure 4.9: Average Flexural Strength for 28th Day's

In Table 4.10, combine 14 days and 28 days to compare flexural strength

Table 4.10: Flexural Strength Combination (MPa) for 14th and 28th Days

SL No.	Sample Type (%)	Flexural Strength (MPa)	
		14^{th} Day's	28^{th} Day's
1	CS	3.94	4.17
2	25DCA	3.25	3.61
3	75DCA	3.07	3.43
4	25DCA(A)	3.61	3.96
5	75DCA(A)	3.16	3.52

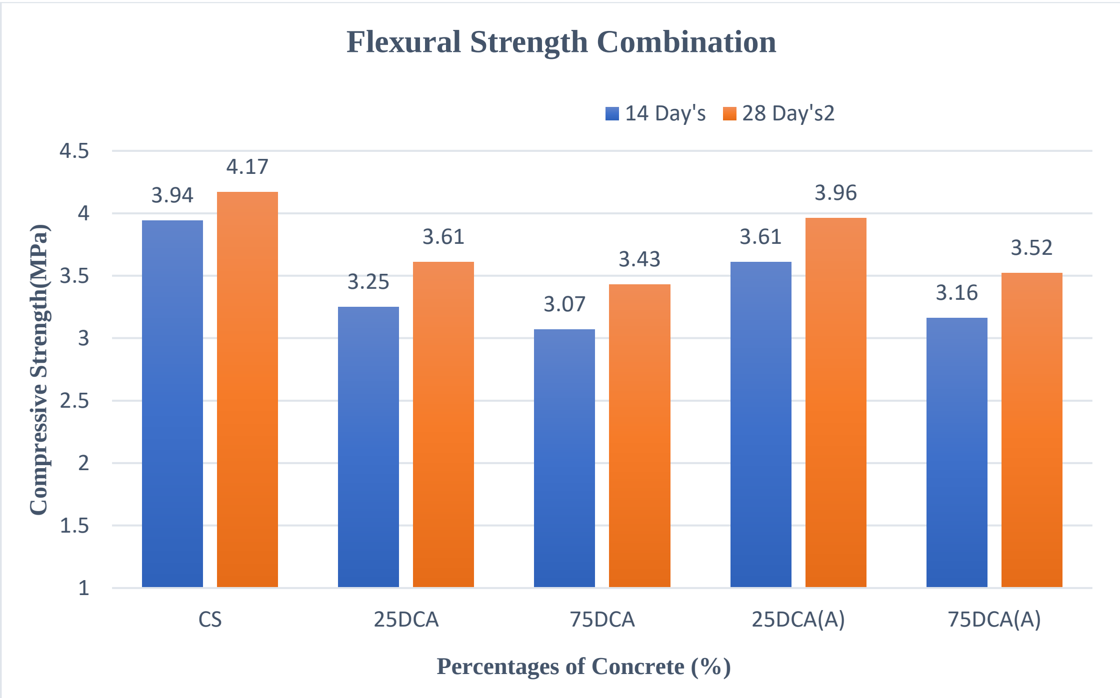

Figure 4.10: Flexural Strength Combination (MPa) for 14th and 28th Days

In this figure, it is indicated that at the end of 28 days, curing 25DCA(A) replacement of demolition concrete aggregate has the maximum flexural strength of 3.96 (MPa).

Chapter 5
CONCLUSION

5.1 General

The study's main goal is to make concrete that is more durable and stable than standard concrete by substituting demolished concrete aggregates. A total of 84 specimens (60 molds & 24 beams) are created and tested in the area of strength calculation and also comparisons.

5.2 Conclusion

The mechanical characteristics of concrete that contains demolition concrete aggregates (DCA) at replacement levels of 0%, 25%, and 75% for natural coarse aggregates were examined in this study. To enhance workability and performance, admixture additive was also added to concrete mixes. At 14 and 28 days of curing, the specimens underwent testing for flexural, split tensile and compressive strength.

Utilizing demolition aggregates reduces landfill waste, fosters a circular economy, and lessens the demand on natural resources. Proper processing, sorting, and quality control are necessary to ensure these materials satisfy the requirements required for their intended applications. The construction sector may reduce costs, increase resource efficiency, and promote environmentally responsible building practices by making effective use of demolition aggregates.

- The result shows that maximum compressive strength was 23.44 MPa and 27.89 MPa for 14 and 28 days curing periods respectively for 25DCA(A) sample type.
- The result shows that maximum tensile strength was 2.52 MPa and 3.15 MPa for 14 and 28 days curing periods respectively for 25DCA(A) sample type.
- The result shows that maximum flexural strength was 3.61 MPa and 3.96 MPa for 14 and 28 days curing periods respectively for 25DCA(A) sample type.
- As a result of the findings, only 25DCA(A) of demolition concrete aggregate can be readily replaced with coarse aggregate in concreting to generate strong and safe concrete.

5.3 Recommendation

Before using demolition concrete aggregates in new construction projects, it's essential to carry out thorough testing to ensure they meet the required standards for strength, durability, and size. The aggregates should be carefully sorted during demolition to separate concrete from other materials. Once sorted, the aggregates should be processed (crushed, cleaned, and graded) to ensure uniformity and suitability for reuse in construction. The use of demolition concrete aggregate material to partially replace coarse aggregate is not going to result in increased costs, as we have shown above. It is therefore economically significant to use demolition coarse aggregate material in place of some of the traditional coarse aggregate. More experiments with a variety of combinations, such as partial replacement of the demolition concrete aggregate and full replacement of the coarse aggregate in concrete, will produce better results.

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APPENDIX

Table. A1 Sieve Analysis (Fine Aggregate)

Sieve No.	Sieve Size (mm)	Weight Retained (gm)	% Weight Retained	Cumulative Wt. Retained %	Percentage Finer
# 4	4.75	8	1.64	1.64	98.35
# 8	2.36	35.4	7.25	8.89	91.1
# 16	1.18	73.6	15.08	23.97	76.02
# 30	0.6	127.8	26.18	50.15	49.84
# 50	0.3	168.8	34.58	84.73	15.26
# 100	0.15	74.5	15.25	99.99	0.01
Pan		9.7			
Total		497.8			
FM=2.69					

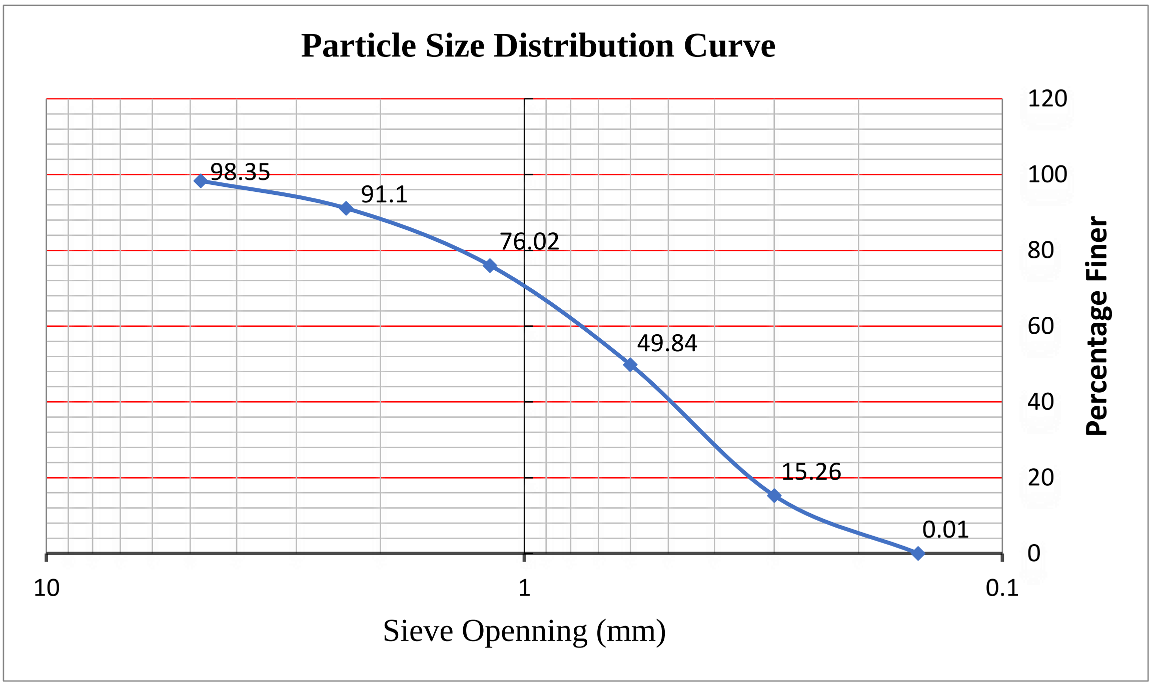

Figure A1: Particle Size Distribution Curve (Fine Aggregate)

Table A2: Sieve Analysis (Coarse Aggregate)

Sieve No.	Sieve size (mm)	Weight Retained (gm)	% Weight Retained	Cumulative Wt. Retained %	Percentage Finer
3/2 in	37.5	182.77	3.65	3.65	96.35
1 in	25	268.31	5.37	9.02	90.98
3/4 in	19	374.56	7.63	16.51	83.49
1/3 in	12.5	2534.85	50.71	67.22	32.78
3/8 in	9.5	441.07	8.82	76.22	23.96
# 4	4.75	502.81	10.06	86.1	13.9
# 8	2.36	249.52	4.99	91.09	8.91
# 16	1.18	154.29	3.09	94.18	5.82
# 100	0.15	103.7	2.07	96.25	3.75
Pan		187.12	3.74	99.99	0.01
Total		4998.77			
FM =6.40					

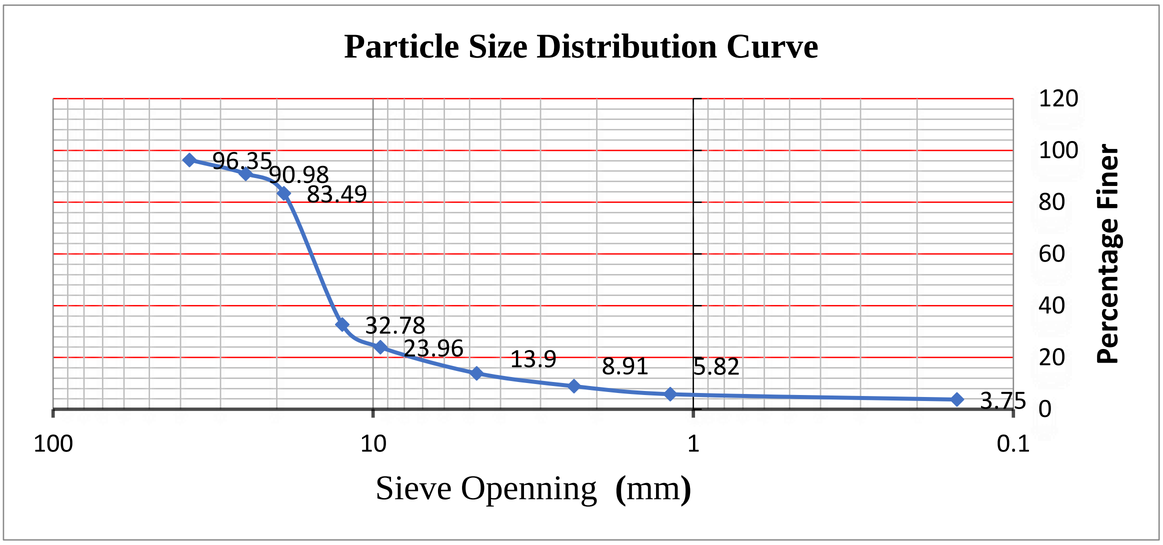

Figure A2: Particle Size Distribution Curve (Coarse Aggregate)

Table A3: Sieve Analysis (Demolition Coarse Aggregate)

Sieve No	Sieve size (mm)	Weight Retained (gm)	% Weight Retained	Cumulative Wt. Retained %	Percentage Finer
3/2 in	37.5	0	0	0	0
1 in	25	323.13	6.21	6.21	93.79
3/4 in	19	251.72	4.75	10.96	89.04
1/2 in	12.5	2750.31	51.9	62.86	37.14
3/8 in	9.5	582.47	10.99	73.85	26.15
# 4	4.75	602.61	11.37	85.22	14.75
# 8	2.36	452.11	8.53	93.75	6.25
# 16	1.18	80.56	1.52	95.27	4.73
# 100	0.15	106.29	2.01	97.28	2.72
Pan		143.69	2.71	99.99	0.01
Total		5298.89			
FM =6.25					

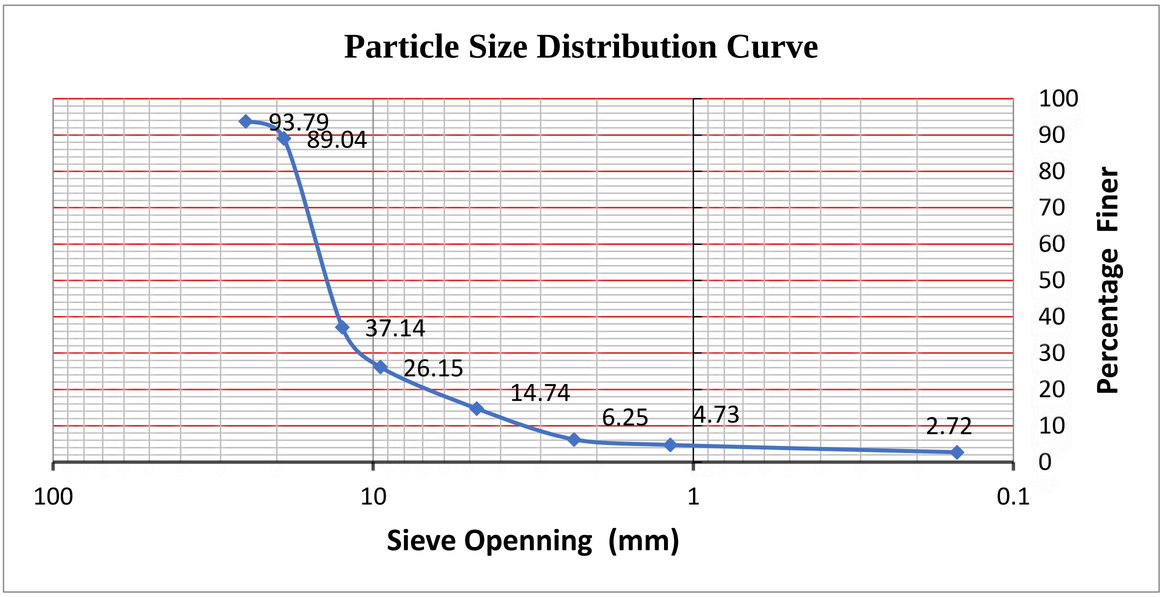

Figure A3: Particle Size Distribution Curve (Demolition Coarse Aggregate)

Table A4: Specific Gravity, Water Absorption and Moisture Content of F.A

Name of the Item	Quantity	Bulk Specific Gravity	Absorption Capacity	Moisture Content
Weight of oven-dry specimen, A	494.2 gm	2.86	6.07	1.17
Weight of pycnometer filed with water, B	1902.3 gm			
Weight of pycnometer with specimen and water, C	2223.5 gm			
Weight of the saturated surface-dry specimen, S	524.2 gm			

Calculation:

Bulk specific gravity (Oven-Dry Basis), S_{od}

$$S_{od} = \frac{A}{(B+A)-C} = \frac{494.2}{(1902.3+494.2)-2223.5} = 2.86$$

<u>Absorption Capacity</u>

$$A\ \% = \frac{S-A}{A*100} = \frac{524.2-494.2}{494.2*100} = 6.07$$

<u>Moisture Content:</u>

$$MC = \frac{500-494.2}{494.2} * 100 = 1.17$$

Table A5: Specific Gravity, Water Absorption and Moisture Content of C.A.

Name of the Item	Quantity	Bulk Specific Gravity	Absorption Capacity	Moisture Content
Weight of oven-dry specimen, A	2958.5 gm	2.36	1.21	1.40
Weight of pycnometer filed with water, B	2994.3 gm			
Weight of pycnometer with specimen and water, C	1705.7 gm			

Calculation:

Bulk specific gravity (Oven-Dry Basis), S_{od}

$$S_{od} = \frac{A}{(B+A)-C} = \frac{2958.5}{(2994.3+2958.5\,)-2120.7} = 2.36$$

Absorption Capacity

$$A\ \% = \frac{B-A}{A*100} = \frac{2994.3\ -2958.5}{2958.5\ *100} = 1.21$$

Moisture Content:

$$MC = \frac{3000-2958.5}{2958.5} * 100 = 1.40$$

Table. A6 Specific Gravity, Water Absorption and Moisture Content of DCA

Name of the Item	Quantity	Bulk Specific Gravity	Absorption Capacity	Moisture Content
Weight of oven-dry specimen, A	2931.7 gm			
Weight of pycnometer filed with water, B	3005.8 gm	2.46	2.53	2.33
Weight of pycnometer with specimen and water, C	1741.2 gm			

Calculation:

Bulk specific gravity (Oven-Dry Basis), S_{od}

$S_{od} = \frac{A}{(B+A)-C} = \frac{2931.7}{(3005.8+2931.7\ )-2113.1} = 2.46$

<u>Absorption Capacity</u>

$A\ \% = \frac{B-A}{A*100} = \frac{3005.8-2931.7}{2931.7\ *100} = 2.53$

<u>Moisture Content:</u>

$MC = \frac{3000-2931.7}{2931.7} * 100 = 2.33$

Table A7: Unit Weight of FA, CA. and DCA

Materials	Weight of Bucket + Materials, Kg (G)	Weight of Bucket + Material, Kg (T)	Volume of Bucket, V (in3)	Unit Weight, Kg/m3 (M)
FA	7.17	2.40	0.002955	1614.21
CA	6.87	2.40	0.002955	1512.69
DCA	6.75	2.40	0.002955	1472.08

Calculation:

Unit weight of FA, $U_{FA.}$

$$U_{FA.} = \frac{G-T}{V} = \frac{7.17-2.40}{0.002955} = 1614.21 Kg/m3$$

Unit weight of CA, $U_{C.A.}$

$$U_{CA.} = \frac{G-T}{V} = \frac{6.87-2.40}{0.002955} = 1512.69 Kg/m3$$

Unit weight of DCA, U_{DCA}

$$U_{DCA} = \frac{G-T}{V} = \frac{6.75-2.40}{0.002955} = 1472.08 Kg/m3$$

Table A8: Mix Design (Normal Weight Concrete)

Required Data	**Unit**
Compressive Strength(28 days)	30Mpa
Water/Cement	0.54
Slump	100 mm
Maximum size of course aggregate	19 mm
Dry rodded unit weight Bulk density of CA	1512.69 kg/m^3
Specific gravity of CA	2.36
Absorption capacity of CA	1.21 %
Surface moisture of CA	1.40 %
F.M of fine aggregate	2.69
Specific gravity of FA	2.86
Absorption capacity of FA	6.07 %
Surface moisture of FA	1.17 %
Specific gravity of cement	3.15
Calculation	
Weight of materials Required per m^3 of concrete	
Required water	200 kg/m^3
Air content	2 %
Water/cement	0.54
Cement content	370.37 kg/m^3
Bulk volume of dry rodded CA	0.624
OD weight of CA	943.9186 kg/m^3
SSD weight of CA	953.0746 kg/m^3
Expected weight of concrete	2355 kg/m^3
SSD weight of FA	831.56 kg/m^3
Volume of Materials	
Volume of water	0.2 m^3
Solid volume of cement	0.118 m^3

Solid volume of CA		0.356 m^3		
Volume of entrapped air		0.020 m^3		
volume of FA		0.307 m^3		
Total volume		1.00 Ok		
Check SSD weight of FA		825.28 kg/m^3		
Final Result: Quantity of materials (kg/m^3)				
	Cement	FA	CA	
	370.37	831.56	953.0746	
Ratio:	1	2.245	2.573	(wrt. Weight)
	1	2.609	3.025	(wrt. volume)

Calculation:

- The compressive strength of the specimen can be calculated as:

$$f_c = \frac{P}{\pi(\frac{D^2}{4})}$$

Where,

f_c: The compressive strength, (Mpa)

P: The maximum load sustained by the specimen, KN

D: The diameter of the specimen,

- The splitting tensile strength of the specimen can be calculated as:

$$T = \frac{2P}{\pi Ld}$$

Where,

T: Splitting tensile strength, (Mpa)

P: Maximum applied load indicated by testing machine, KN

L: Length,

d: Diameter

- The flexural strength of the specimen can be calculated as:

$$f_b = \frac{3PL}{2bd^2}$$

Where,

P: Maximum applied load indicated by testing machine, KN

L: Length,

b: Width of specimen,

d: Depth,

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