STUDY ON COMPRESSIVE STRENGTH OF CONCRETE USING RECYCLED CONCRETE AS PARTIAL REPLACEMENT OF COARSE AGGREGATE

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A thesis
Submitted to the Department of Civil Engineering in partial fulfillment for the degree of
Bachelor of Science in Civil Engineering



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Sonargaon University
147/I, Green Road, Dhaka-1215, Bangladesh
Section: 23A+23E
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It is hereby declared that this thesis/project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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Dedicated

to

"Our Beloved Parents & Honorable Teachers"

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ABSTRACT

Concrete is a major construction material used in the construction. It is a composite material containing cement, fine aggregate, coarse aggregate and water. Coarse aggregate is required in large quantities for manufacturing of concrete. Generally natural stone chips/brick chips is used as a coarse aggregate. Concrete waste is a solid waste and discarding this waste is a serious problem and requires large space for its disposal and a few percent of it is recycled or reused. This waste can be used instead of natural aggregates in fresh concrete, thus reducing the space for landfill deposits and minimizing environmental pollution. In the recent years, utilization of recycled materials in concrete has gained considerable attention as it means to enhance sustainability and reduce the environmental impact of construction practices. This study focuses on investigating the compressive strength behavior and sustainability analysis of recycled aggregates is partially or completely replaced. The utilization recycled coarse aggregates sourced from various waste materials, including pile head broken and demolished concrete. For this study first control specimens were laid for M15 grade concrete. The coarse aggregate proportion from the mix design was replaced partially in percentages of 0%, 25%, 50%, 75% and 100% by coarse aggregates as pile head broken and demolished concrete on the compressive strength and sustainability of concrete.

The compressive strengths of concrete specimens for respective mix proportions were tested at 7, 21 and 28 days of water curing. The behavior of concrete by partial replacement of coarse aggregate as pile head broken and demolished concrete has been studied. The compressive strength of the concrete significantly changed with increasing percentage of replacement in concrete.

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CHAPTER-1
INTRODUCTION

1.1 Background and Motivations

Concrete is one of the most widely used materials in construction works. One of the most significant contributors to a nation's economic and social development is the construction industry. The majority of facilities, including residential homes, large buildings, dams, retaining walls, and bridges, have been built with concrete. For continuing this, raw materials are required from natural resources from far side which is cost is not a little bit. On the others side, developing country like our Bangladesh has little free land compared to a huge population. Some city in Bangladesh i.e., Dhaka is very dense with a huge old building constructed during 1960-1990. These structures are very much old and obviously they required demolition work to start new construction. This may include demolishing concrete foundations, driveways, sidewalks, walls and other building elements. Also for new heavy construction need pile foundation. In pile foundation work, pile heads are broken after construction. The process results in large amounts of heavy construction materials that usually go to waste. Furthermore, a huge land will be required to dispose these pile head broken and demolished materials as well as requiring a huge transportation coast to land fill.

To mitigate the problems reusing this pile head broken and demolished concrete can be better option by recycled of concrete construction costs can be minimized, since it saves the cost of transporting concrete to the land fill. Recycled also eliminates disposal costs, while reducing the environmental impact of the project.

Concrete that is recycled will not end up in landfills and can also replace raw materials. It can be used instead of gravel, for example, which must otherwise be collected and transported to the job site. Hence from above short descriptions definition of concrete recycled “the use of rubble from pile head broken and demolished concrete structures is called Recycled Concrete”.

1.2 Overview of the Study

The primary goal of this research is to determine the compressive strength and environmental impact of recycled aggregates carries significant importance for the construction industry and sustainable development. This study includes a thorough experimental investigation of the mechanical properties of concrete containing recycling disposal concrete. The utilization recycled coarse aggregates sourced from various waste materials, including broken pile head and demolished concrete. This study makes use of M15 grade concrete. The most important benefit is waste management and reduced environmental impact. The sustainability analysis, evaluating environmental impacts using methodology, guides decision-making processes and policy development towards eco-friendly construction materials.

1.3 Research Objectives

1. To determine the mechanical properties of concrete, such as compressive strength of concrete with different percentages of pile head broken and demolished concrete coarse aggregate as partial or completely replacement.
2. To investigate the limit up to which the natural aggregates (NCA) can be replaced by recycled coarse aggregates (RCA).
3. To reduce the environmental impact and minimizing the cost of construction replaced by recycled coarse aggregates.

1.4 Scope of the Study

Using recycled coarse aggregate (RCA) in concrete has gained significant attention due to its potential environmental benefits and contributions to sustainable construction practices. Here's a comprehensive overview of the scope of using RCA in concrete:

1.4.1 Environmental Benefits

- **Waste Reduction**: RCA helps divert construction and demolition waste from landfills, reducing environmental impact.
- **Resource Conservation**: It decreases the demand for natural aggregates, conserving natural resources and reducing the ecological foot print of aggregate extraction.

1.4.2 Material Properties

- **Quality and Performance:** RCA can have varying properties based on its source (e.g., crushed concrete, asphalt) and the processing methods used. Generally, it may exhibit lower density, higher water absorption, and different strength characteristics compared to natural aggregates.
- **Strength and Durability:** With proper processing and quality control, RCA can achieve comparable strength and durability to conventional aggregates. However, it may require adjustments in the mix design to accommodate its properties.

1.4.3 Economic Considerations

- **Cost-Effectiveness:** Using RCA can reduce material costs, especially in regions where natural aggregates are expensive or scarce. However, initial processing and quality control may incur additional costs.
- **Market Demand:** The increasing focus on sustainability can enhance the demand for RCA in construction projects, potentially leading to economic incentives or support from regulatory frameworks.

CHAPTER-2
LITERATURE REVIEW

2.1 Introduction

The purpose of the study is to test the impact of recycled coarse aggregate on concrete by partially or totally substituting of coarse aggregate for concrete and viable solution to reduce the demand for natural aggregates while simultaneously mitigating the detrimental environmental impacts associated with solid waste disposal. This study proposes a new framework to guide the life cycle analysis of concrete structure with reuse and recycling strategies. The impact of recycled coarse aggregate on various properties of concrete at various ages and for M15 grades of concrete has already been the subject of numerous research projects. This document reviews some research studies and presents them.

2.2 Content

A study of recycled aggregate as coarse aggregate in concrete. The waste-demolished concretes were partially replaced in place of coarse aggregates by 10%, 20%, 30%, 40% and 50%. M25 grade of concrete was designed and tested. The mix design for different types of mixes was prepared by replacing the coarse aggregates. Experimental investigations like workability, Compressive strength test, and Split tensile strength test for different concrete mixes with different percentages of waste-demolished after 7, 14, and 28 days of curing period has done. It has been observed that the workability increases with the increase in the percentage of replacement of granite powder and crushed tiles increases. The strength of the concrete also increases with the ceramic coarse tile aggregate up to 30% percentage[1]. A study of recyclability of pile head broken concrete in structural use. This paper presents the recyclability of broken pile head concrete in structural use. Laboratory tests were conducted on both recycled and virgin aggregate. The test results revealed that aggregate gradation, aggregate crushing value, ten percent fine value, abrasion, rodded unit weight, flakiness index, elongation, wash passing, water absorption, clay lumps and friable particles, soundness, and soft fragments were all within acceptable limits. These coarse aggregates were used in the design of C-15 and C-25 class concrete. Eighteen set cylindrical molds from the concrete mix design were taken. At 7, 14, and 28 days, the compressive strengths (MPa) of concrete molds were tested. The C-15 class concrete strength was found to be 19.6, 22.9, and 24.8 with virgin aggregate and 18.1, 21.2, and 22.6 with recycled concrete aggregate,

respectively. Similarly, C-25 concrete strength was found to be 28.2, 33.2, and 35.05 with virgin aggregate, whereas 25.9, 30.9, and 32.2 with recycled concrete aggregate. These findings indicate that broken pile head recycled concrete aggregate could be used as a substitute material for virgin aggregate, reducing the need for virgin aggregates **[2]**. A study on recycled concrete aggregates in this study, for the 28th day cube compressive strength using OPC; the strength for 25%, 50%, 75% and 100% RCA mixes were 23.5%, 33.5%, 32.4% and 10.7%, respectively less than 0% RCA mix whereas for PSC, were 17.8%, 36.7%, 40.6% and 19.1% respectively less than normal concrete. The cylinder compressive strengths at 28 days for 25%, 50%, 75% and 100% RCA mixes, using OPC were 37.7%, 32.0%, 33.7% & 28.4% and using PSC were 20.5%, 27.5%, 25.1% & 30.3% respectively less than that of normal concrete mix. However, in split tensile strength, a continuous decrease in strength was observed with addition of RCA. The values obtained for 25%, 50%, 75% & 100% RCA, for OPC, were 20.6%, 33.0%, 34.9% & 42.5% respectively less than 0% RCA concrete while for PSC, were 1.1%, 16.3%, 26.1% & 27.2% less correspondingly. This study proves that, though the strength of concrete is affected by addition of RCA, the cost saving is up to 16% by 100% substitution of natural aggregates. Moreover, the use of PSC instead of OPC leads up to 29% reduction in cost**[3]**.A study on recycled coarse aggregate as a partial or full replacement of coarse aggregate in concrete production using fine aggregate of FM 1.23.The recycled aggregate prepared from the crushing of old concrete was studied. It was found that the recycled aggregate is covered with loose particles that may prevent good bonding between the new cement matrix and the recycled aggregate. The old cement paste that remained on the natural aggregate was porous and cracked, leading to weak mechanical properties of the recycled aggregate and finally reduction of compressive strength of concrete. The compressive strength of concrete made by recycled coarse aggregate with fine aggregate of fineness modulus value of 1.23 gives the maximum compressive strength for target strength 3000 psi (P.Dayet all,2012). From this perspective, our studies on recycled coarse aggregate as a partial or full replacement of coarse aggregate in concrete production using fine aggregate of FM 1.23. A total of 40 cylinders of diameter 150 mm and 300 mm height with different percentages by weight of fresh coarse aggregate to recycled coarse aggregate as coarse aggregate in the order 100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 30:70 and 0:100 were cast, tested and their compressive strength were determined subjected to water curing for 28 days**[4]**. Study of partial replacement of natural aggregate by recycled aggregate on concrete. A study has been carried out to determine the properties of recycled aggregate which is to be used as a coarse aggregate for M25 grade of concrete. The

percentages of recycled aggregate that partially replaced natural aggregate by weight was 0%, 10%, 20%, 30% and 40%. Concrete cubes were casted and tested in laboratory. Properties of natural aggregates and recycled aggregates were studied, workability tests and compressive strength tests were performed. The results show that upto 30% replacement of recycled aggregate with natural aggregate there is a slight decrease in strength when compared with conventional concrete. The goal of this study is to develop the economical and sustainable concrete by using the concrete waste available in the site**[5]**.The relationship between split tensile strength and compressive strength for RCA concrete as well as controlled concrete. In this paper, the author found the relationship between split tensile strength and compressive strength for RCA concrete as well as controlled concrete. The recycled concrete aggregate used was that passing through IS sieve 40mm and retained on IS sieve 4.75mm. For controlled concrete the natural stone chips of same nominal size was used in making concrete. If required a dose of super plasticizer [Conplast SP 430 (M)] was also added to ordinary tap water to obtain desired degree of workability. In this study, 3 mixes were prepared replacement of natural aggregates by 0%, 50% and 100% RCA. The strength was tested at 28 days maturity of casted concrete. It was observed that recycled concrete aggregate has lower value of specific gravity and moderately high values of water absorption, crushing value, impact value and abrasion value. Furthermore, similar to concrete containing natural aggregate, tensile strength of recycled aggregate concrete containing recycled concrete aggregate, mainly depends on compressive strength **[6]**. Strength properties of concrete using demolished waste as partial replacement coarse aggregate. An experimental investigation was conducted to study the mechanical properties of concrete where natural coarse aggregate is partially replaced with recycled coarse aggregate. It was concluded that RCA increases the mechanical properties of conventional concrete and it was observed that a mix of 75% RCA and 25% natural aggregates has good mechanical properties. RCA with rough surface allows better bonding with cement mix**[7]**.The compressive strength properties of concrete were investigated by completely replacing natural aggregate (NA) with recycled concrete aggregate (RCA).In this study, the compressive strength properties of concrete were investigated by completely replacing natural aggregate (NA) with recycled concrete aggregate (RCA). Densities of both RCA concrete and NA concrete were within the range of normal weight concrete. Both RCA concrete and NA concrete showed the similar trends in the variation of strength and density with time. Reduction in the 28-day compressive strength of concrete due to complete replacement of natural aggregates with recycled concrete aggregate ranges from 11% to 33%. RCA can replace NA in the production of both non-

structural and structural concrete**[8]**. Evaluate physical properties of concrete using recycled coarse aggregate. This study aimed to evaluate physical properties of concrete using recycled coarse aggregate. In this research, concrete waste from demolished structure has been collected and coarse aggregate of different percentages is used for preparing fresh concrete (0%, 25%, 50%, 75% & 100%). The compressive strength of recycled coarse aggregate (RCA) is found to be higher than the compressive strength of normal concrete when used up to a certain percentage. Recycled aggregate concrete is in close proximity to normal concrete in terms of split tensile strength. The slump of recycled aggregate concrete is more than the normal concrete. At the end, it can be said that the RCA up to 50 % can be used for obtaining good quality concrete**[9].**

2.3 Summary

In this study, many times research on the compressive strength properties of concrete were investigated by completely or partially replacing Natural Aggregate (NA) with recycled concrete aggregate (RCA). Some tests were conducted using the recycled aggregates to study and compare the results with the naturally available aggregates. It helps to save and sustain natural resources that are not replenished, it decreases the pollution of the environment, and it also helps to save and recycle energy production processes. We research pile head broken and demolished as coarse aggregate in concrete. We replace coarse aggregate in concrete with pile head broken and demolished in various percentages from 0%, 25%, 50%, 75%, & 100% after various curing days.

CHAPTER-3
METHODOLOGY

3.1 Introduction

This chapter will discuss the methodology of the research work. The research of that project is to pile head broken and demolished as a coarse aggregate in the concrete mixture. Essential to know if the replacement of pile head broken and demolished in concrete is acceptable there are the making of concrete using coarse aggregate, coarse sand, and Portland Composite Cement (PCC) CEM-II/AM used for making concrete, and Recycle Coarse Aggregate used from pile head broken and demolished. Test carried out on these aggregate specific gravity and bulk density, unit weight, water absorption, and sieve analysis. The engineering properties of the pile head broken and demolished were also compared to those of the reference concrete.

3.2 Research Materials

3.2.1 Cement

Portland Composite Cement (PCC) CEM-II/A-M for Test. Portland Composite Cement (PCC) CEM-II/A-M is a type of cement that's commonly used in Bangladesh for construction. It's made from a combination of materials, including:

- Clinker
- Gypsum
- Pulverized Fuel Ash (PFA)
- Blast Furnace Slag
- Limestone

Here are some characteristics of PCC CEM-II/A-M:

- Strength: PCC CEM-II/A-M has a strength of 42.5 N (Newton).
- Composition: PCC CEM-II/A-M is 80–94% clinker, which is higher than CEM-II/B-M, which is 65–79%.
- Durability: PCC CEM-II/A-M is durable, strong, and has high chemical resistance.

- Uses: PCC CEM-II/A-M is used for a variety of construction projects, including basements, foundations, residential buildings, high-rise buildings, dams, and more.

3.2.2 Coarse Aggregate

Aggregate are the important constituent in concrete. Aggregate are granular materials, derived from the most part from the natural rocks, crushed stones, or natural gravels and sand. Aggregate generally occupy about 70% to 80% of the volume of concrete and can therefore be expected to have an important influence on its properties. Aggregate which retained on the No.4 (4.75mm) sieve. The function of the coarse aggregate is to act as the main load-bearing component of the concrete. The shape of aggregate is an important characteristic, since it affects the workability of concrete rounded, party rounded, angular, flaky, stone chips were collected from Sonargaon University (SU)'s concrete lab. Natural stone chips used as coarse aggregate. Used the maximum size of coarse aggregate 19 mm.

3.2.3 Recycled Coarse Aggregate

Recycling of concrete is a relatively simple process. It involves breaking, removing, and crushing existing concrete into a material with a specified size and quality. See ACI 555 (2001) for more information on processing old concrete into recycled concrete aggregates. The quality of concrete with RCA is very dependent on the quality of the recycled material used. Reinforcing steel and other embedded items, if any, must be removed, and care must be taken to prevent contamination by other materials that can be troublesome, such as asphalt, soil and clay balls, chlorides, glass, gypsum board, sealants, paper, plaster, wood, and roofing materials. Pile head broken and demolished collected from the disposal area. Used as per required size.

3.2.4 Fine Aggregate

Fine aggregate is a type of aggregate used in concrete that is smaller than 4.75 mm in size. It is typically made up of sand, crushed stone or recycled concrete, and is used to fill the voids in the concrete mixture, provide a smooth finish, and improve the workability of the concrete. Fine aggregates are typically classified based on their size, shape, and texture.

- **Size:** The size of fine aggregate is typically measured in millimeters, and it can range from 0.075 mm to 4.75 mm in diameter. The most common sizes of fine aggregate used in concrete are 2.36 mm, 1.18 mm, and 0.6 mm.

- **Shape:** The shape of fine aggregate can also have an impact on the properties of the concrete. The most common shapes of fine aggregate are rounded and angular. Rounded aggregates are smooth and provide good workability, while angular aggregates are more jagged and provide better bonding between the aggregate and the cement paste.

- **Texture:** The texture of fine aggregate is related to the surface characteristics of the particles. The most common types of fine aggregate textures are smooth, rough, and porous. Smooth textures provide good workability, while rough and porous textures provide better bonding between the aggregate and the cement paste.

- **Strength:** The strength of fine aggregate is typically measured in terms of its compressive strength, which is the amount of pressure the aggregate can withstand before it fails. The compressive strength of fine aggregate can range from 5 MPa to 60 MPa, depending on the type of sand or crushed stone used.

Sylhet sand (F.M 2.4) was used as fine aggregate was collected from SU's concrete lab too.

3.2.5 Water

Potable water free from impurities and salt used for casting and curing.

3.2.6 Size and Number of Specimen

Size of Cylinder (100mm x 200mm) and total 45 number of cylinders for compression test.

3.2.7 Percentage of Recycled Coarse Aggregate

Percentage of recycle coarse aggregate 0%, 25%, 50%, 75% & 100% replacement.

3.2.8 Curing Period

7-days, 21-days & 28-days curing period.



Portland Composite Cement (PCC) CEM-II/A-M



Sylhet sand (F.M 2.4)



Fresh Coarse Aggregate



Recycle Coarse Aggregate

Figure: 3-1. Raw Materials for Research.

Table 3-01: Percentage (%) of replacement:

Sl. No.	% of Replacement	Number of Cylinders
1	0%	9 Nos
2	25%	9 Nos
3	50%	9 Nos
4	75%	9 Nos
5	100%	9 Nos
Total =		45 Nos

3.3 Methodology Overview

The methodology adopted for this study is given below:

1. Literature study was done on the available data on use of pile head broken and demolished partially replaced in concrete.
2. Pile head broken and demolished waste collected from Construction waste materials dumping area which in Dhaka city, Bangladesh.
3. Pile head broken and demolished was broken into as per required size.
4. Proportion of pile head broken and demolished waste as a coarse aggregate indifferent mix ratio was selected on the basis of available literature.
5. Sieve Analysis, Specific Gravity, and Water Absorption and Unit weight test for mix design.
6. Mix design for different proportions of concrete was decided and tests were performed to obtain the mechanical properties of different mixes.
7. Based on the literature survey and mixed design of pile head broken and demolished waste, the following combinations were adopted.

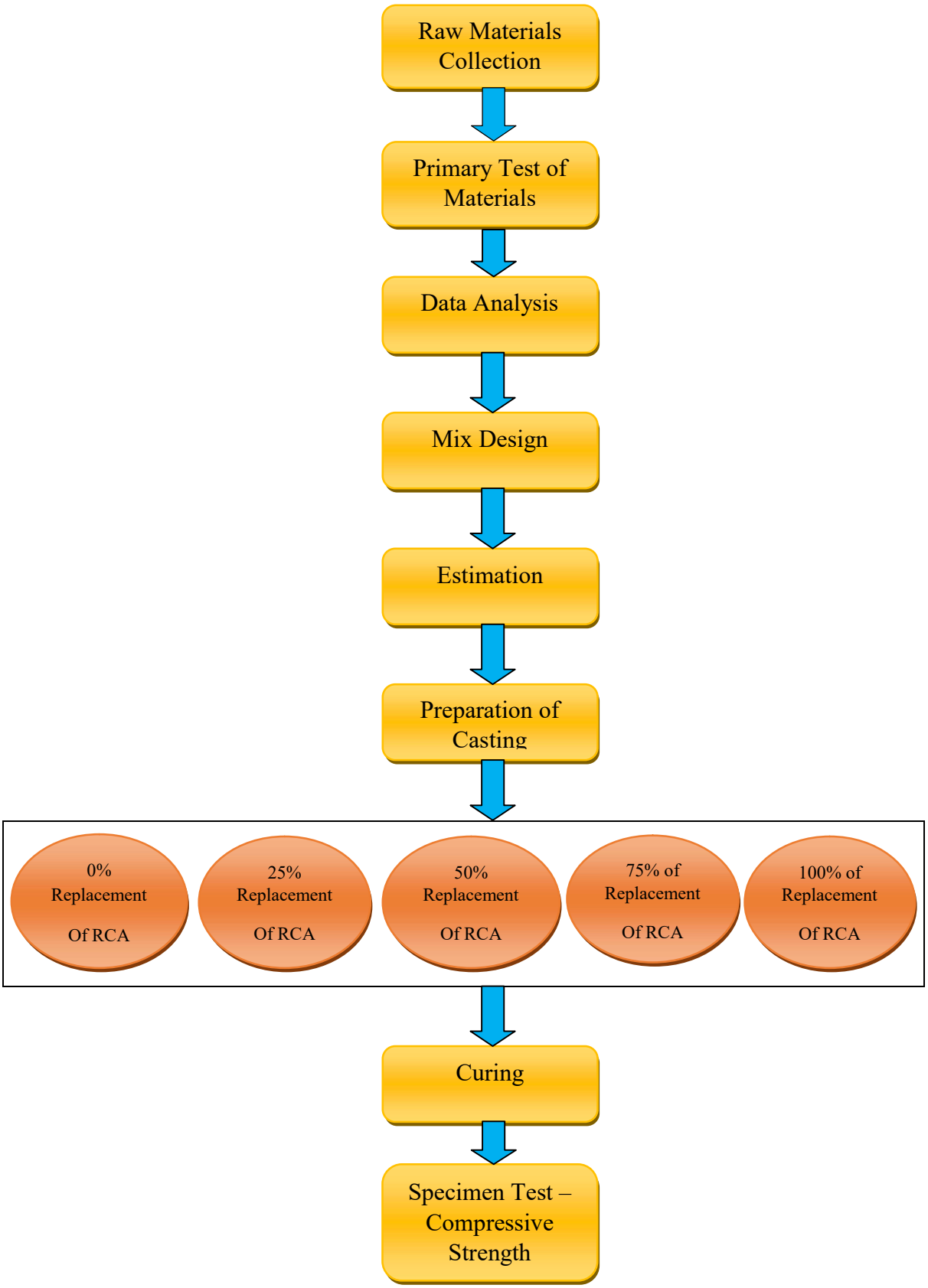


Figure: 3-2. Flowchart of Research.

3.4 Materials Tests for Our Research

1. Sieve Analysis of Fine aggregate and Coarse aggregates.
2. Unit weight of Cement, Fine aggregate and Coarse aggregates.
3. Specific gravity of Cement, Fine aggregate and Coarse aggregates.
4. Water Absorption Capacity of Fine aggregate and Coarse aggregates.



Figure: 3-3. Sample Materials for Test.

Table 3-02: Sieve Analysis of Fine Aggregate

Sieve Analysis of Fine Aggregate -ASTM C 136 – 01					
		Sample taken	1000 gm		
Sieve No	Sieve Size (mm)	Retained weight (gm)	% of retained	% of Cumulative retained weight	F.M
#4	4.75 mm	0	0	0	2.4
#8	2.36 mm	8	0.8	0.8	
#16	1.18 mm	135	13.5	14.3	
#30	0.60 mm	329	32.9	47.2	
#50	0.30 mm	381	38.1	85.3	
#100	0.15 mm	134	13.4	98.7	
Pan	-	13	-	-	
	Total	1000	Total	246.3	



Figure: 3-4. Sieve Analysis of Fine Aggregate.

Table 3-03: Sieve Analysis of Recycle Coarse Aggregate

Sieve Analysis of Recycle Coarse Aggregate					
		Sample taken	1500 gm		
Sieve Size (inch)	Sieve Size (mm)	Retained weight (gm)	% of retained	% of Cumulative retained weight	F.M
4	100 mm	0	0	25.8	5.3
3-1/2	90 mm	0	0	25.8	
3	75 mm	0	0	25.8	
2-1/2	63 mm	0	0	25.8	
2	50 mm	0	0	25.8	
1-1/2	37.5 mm	0	0	25.8	
1	25 mm	0	0	25.8	
3/4	19 mm	387	25.8	51.6	
1/2	12.5 mm	0	0	51.6	
3/8	9.5 mm	1087	72.47	124.07	
No.4	4.75 mm	26	1.73	125.8	
	Total	1500	Total	533.67	



Figure: 3-5. Sieve Analysis of Recycle Coarse Aggregate.

Table 3-04: Specific Gravity of Used Materials

Specific Gravity of Used Materials	
Materials Name	Specific Gravity
Sand	2.12
Cement	3.15
Coarse aggregate	2.68
Recycle Coarse aggregate	2.64

Table 3-05: Unit Weight of Used Material

Unit Weight of Used Materials	
Materials Name	Unit Weight (kg/m^3)
Sand	1568
Cement	1440
Coarse aggregate	1580
Recycle Coarse aggregate	1561

Table 3-06: Water Absorption Capacity of Used Materials:

Water Absorption Capacity of Used Materials:	
Materials Name	Water Absorption (%)
Sand	3
Coarse aggregate	1.64
Recycle Coarse aggregate	3.14



Figure: 3-6. Water Absorption Capacity of Raw Materials.

Table 3-07: Materials Requirement for M15 Grade Concrete

Materials requirement for 1 cum of concrete	
Cement	337.37 kg
Fine aggregate	735.00 kg
Coarse aggregate	1462.88 kg
Water	168.68 Ltr.
W/C ratio	0.50
For dry	54%
For wastage	10%

Table 3-08: Materials Estimation for Cylinder Casting

For 1 set=3 nos cylinder. Cylinder size= 100mmX200mm		Required Materials				
Case No.	% of RCA	Cement (kg)	Fine aggregate (kg)	Natural Coarse aggregate (kg)	Recycle Coarse aggregate (kg)	W/C=0.5 Water (ltr.)
Case-1	0% of RCA	1.589	3.462	6.977	0.000	0.795
Case-2	25% of RCA	1.589	3.462	5.233	1.723	0.795
Case-3	50% of RCA	1.589	3.462	3.489	3.447	0.795
Case-4	75% of RCA	1.589	3.462	1.744	5.170	0.795
Case-5	100% of RCA	1.589	3.462	0.000	6.893	0.795

Table 3-09: Materials requirement for 45 nos Cylinders:

Total materials for 45 nos cylinders of all case	
Cement	7.945 kg
Fine aggregate	17.31 kg
Natural coarse aggregate	17.416 kg
Recycle coarse aggregate	17.233 kg
Water	3.975 Ltr.



Figure: 3-7. Cylinders Cleaning and Oiling before Casting.



Figure: 3-8. Materials Balancing for Casting.



Figure: 3-9. Materials Mixing for Casting.

3.5 Procedure

All the specimens were casted according to the mix proportions. For these mix proportions required quantities were measured and then mixed with hand. Specimen of cylinder size height 200mm & diameter100mm were prepared. The required quantities of materials were weighted according to the mix proportion. Aggregates and cement was firstly thorough mixed. Then water was added to the dry mix.



Figure: 3.10. After Casting Cylinders.

24 hours after casting were removed from the cylinders and placed in the tank for curing.



Figure: 3.11. Casting Cylinders Ready for Curing.



Figure: 3-12. After 7 days curing cylinders ready for Compressive Strength.



Figure: 3-13. Take Measurement for Compressive Strength.



Figure: 3-14. Compressive Strength Test.

Compressive Strength = P/A

Where, P = Load in KN

A = Area of cross section

3.6 Summary

First collected pile head broken and demolished as a Recycle Coarse aggregate. Then all ingredients were prepared for casting. Concrete prepared with replacement 0%, 25%, 50%, and 100% by Recycle Coarse aggregate. Curing was done 7, 21 & 28 days immersion in water. Finally the compressive strength of the concrete was determined by the Universal Testing Machine (UTM).

CHAPTER-4
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the findings of the research. The discussion on the results can be presented in this chapter also. The discussion of results can also be presented in a separate chapter. If the findings are distinct enough, the results can be presented in more than one chapter also. The results should be organized as per the specific aims mentioned in Chapter 1.

4.2 Specific Motives

This research is performed on hardened concrete, to check the compressive strength of concrete. A compressive axial load is applied to molded cylinders until failure occurs. The compressive strength of the specimen is calculated by dividing the maximum load achieved during the test by the cross-sectional area of the specimen. The results of this research method are used as a basis for quality control of concrete. The concrete specimens were put under the load per unit area of cross section in axial compression under fixed rate of loading. The compressive strength of concrete is expressed in N/mm^2. We performed this research on standard cylinder of size100mm X200mm.

4.3 Compressive Strength Test

The water cured concrete specimens were tested at the age of 7, 21 and 28 days. The specimens were tested by Universal Testing Machine (UTM). The following are the results obtained after testing.

Table 4-01: Compressive Strength Test after 7 days

Compressive Strength Test after 7 days									
Case No.	% of RCA	Sample No.	Dia (mm)	Height (mm)	Weight (gm)	Area (mm^2)	Load (KN)	Compres -sive Strength (MPa)	Average Compressive Strength (MPa)
Case 1	0% of RCA	1	102.2	204	4207	8203.36	145	17.67	16.66
		2	101.6	204	4104	8107.32	138	17.02	
		3	102.0	203	4110	8171.28	125	15.30	
Case 2	25% of RCA	1	101.69	204	3972	8121.69	75	9.23	12.30
		2	103.3	205	4056	8380.90	100	11.93	
		3	103.38	205	4120	8393.88	132	15.72	

Case 3	50% of RCA	1	102.07	204	3900	8182.50	92	11.24	11.42
		2	102.06	204	3925	8180.90	85	10.39	
		3	102.9	202	3895	8316.12	105	12.63	
Case 4	75% of RCA	1	103.6	206	3849	8429.64	72	8.54	9.10
		2	102.49	206	3886	8249.98	70	8.48	
		3	102.5	205	3754	8251.59	85	10.30	
Case 5	100 % of RCA	1	102.06	204	3727	8180.90	71	8.67	8.60
		2	101.9	203	3697	8155.27	68	8.33	
		3	102.7	202	3744	8283.82	73	8.81	





Figure: 4-1. Compressive Strength Test after 7 days.

Table 4-02: Compressive Strength Test after 21 days

Compressive Strength Test after 21 days									
Case No.	% of RCA	Sample No.	Dia (mm)	Height (mm)	Weight (gm)	Area (mm^2)	Load (KN)	Compres -sive Strength (Mpa)	Average Compressive Strength (Mpa)
Case 1	0% of RCA	1	101.17	206.0	4035	8038.84	127	15.80	16.8
		2	103.37	206.0	4105	8392.26	145	17.27	
		3	102.19	206.5	4072	8251.59	143	17.33	
Case 2	25% of RCA	1	101.41	205.0	3989	8077.03	115	14.23	14.82
		2	103.77	205.0	4106	8457.33	114	13.48	
		3	102.70	206.0	4031	8283.82	115	13.88	
Case 3	50% of RCA	1	100.04	205.5	3800	7860.27	100	12.72	14.29
		2	102.68	205.0	3890	8280.60	125	15.09	
		3	103.18	206.0	3784	8361.43	126	15.07	
Case 4	75% of RCA	1	103.19	206	3677	8363.06	135	16.14	13.86
		2	103.12	205	3852	8351.71	124	14.85	
		3	101.00	205.5	3751	8011.85	108	13.48	
Case 5	100 % of RCA	1	102.54	205.5	3768	8258.03	109	13.19	13.07
		2	101.50	206	3707	8091.37	106	13.10	
		3	102.63	206	3693	8272.53	107	12.93	



Figure: 4-2. Compressive Strength Test after 21 days.

Table 4-03: Compressive Strength Test after 28days

Compressive Strength Test after 28 days									
Case No.	% of RCA	Sample No.	Dia (mm)	Height (mm)	Weight (gm)	Area (mm^2)	Load (KN)	Compres -sive Strength (Mpa)	Average Compressive Strength (Mpa)
Case 1	0% of RCA	1	103.07	207.0	4258	8343.62	204	24.44	22.50
		2	101.54	206.0	4232	8097.75	182	22.47	
		3	102.29	210.0	4233	8217.81	169	20.56	
Case 2	25% of RCA	1	102.76	206.0	4152	8293.50	162	19.53	18.70
		2	103.10	207.0	4005	8348.48	162	19.40	
		3	103.29	206.0	4132	8379.27	144	17.18	
Case 3	50% of RCA	1	102.68	207.0	3967	8280.60	151	18.23	16.25
		2	101.38	205.0	3924	8072.25	137	16.97	
		3	101.60	204.0	3893	8107.32	110	13.56	
Case 4	75% of RCA	1	103.37	206.0	3901	8392.26	110	13.10	14.60
		2	103.21	205.0	3862	8366.30	118	14.10	
		3	102.95	205.0	3807	8324.20	113	13.57	
Case 5	100 % of RCA	1	102.27	205.5	3766	8214.60	111	13.51	13.51
		2	103.0	206.5	3821	8332.29	115	13.80	
		3	102.91	206.0	3754	8317.73	110	13.22	



Figure: 4-3. Compressive Strength Test after 28 days.

Table 4-04: Compressive Strength Comparison of 7 days, 21 days & 28 days.

Compressive Strength of 7 days, 21 days & 28 days.					
Days	0% RCA	25% RCA	50% RCA	75% RCA	100% RCA
7 days (Mpa)	16.66	12.30	11.42	9.10	8.60
21 days (Mpa)	16.80	14.82	14.29	13.86	13.07
28 days (Mpa)	22.50	18.70	16.25	14.60	13.51

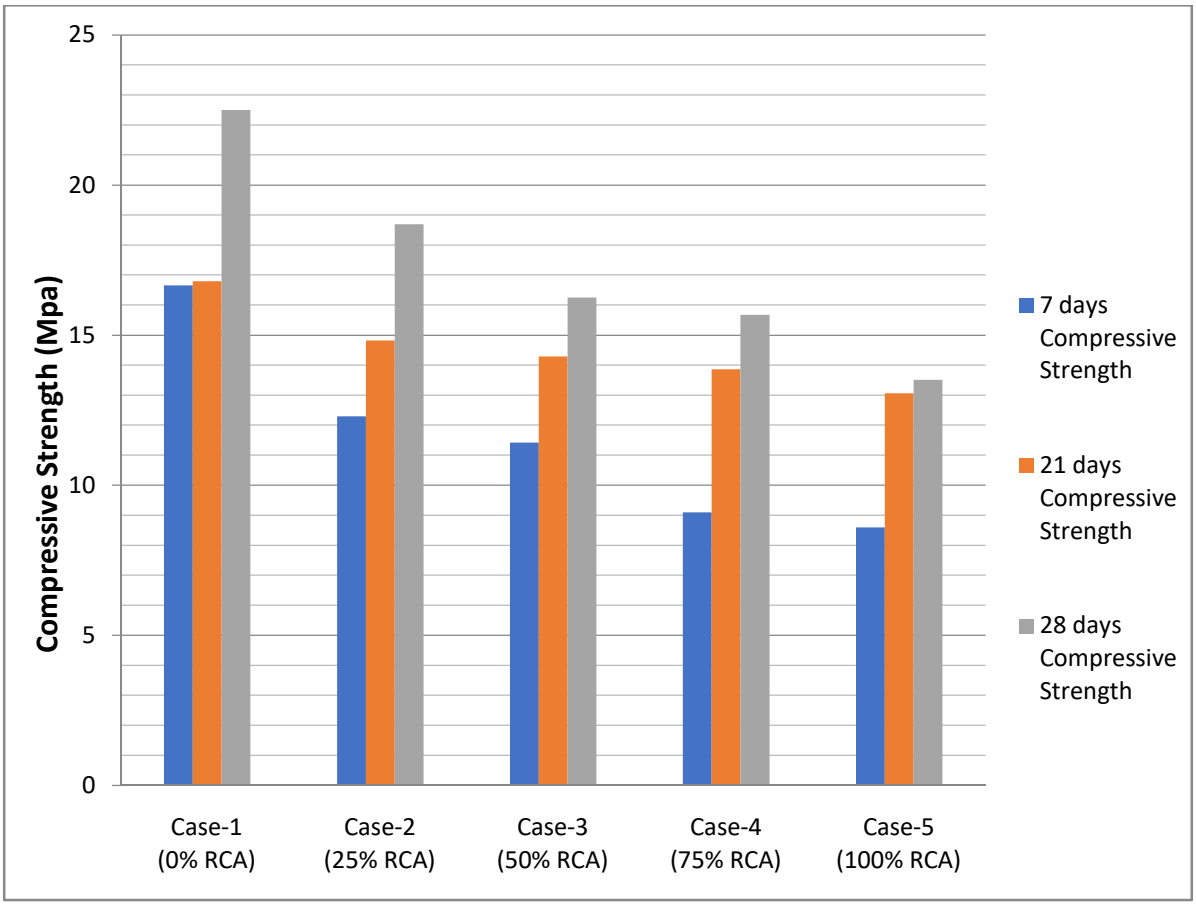


Figure: 4-4. Chart-1: Variation of 7, 21 &28 days Compressive Strength for Different Mixes.

4.4 Summary

The compressive strength test is the most crucial of the several tests conducted on the concrete since it provides information about the properties of the concrete. Compressive strength can be defined as the capacity of concrete to withstand loads before failure. Partially replacing the coarse aggregates with pile head broken and demolished as a recycle coarse aggregate (RCA) gives us a light weight concrete, preventing wastage, financial loss and good for the environment. By comparing the compressive strength between pile head broken and demolished as a recycle coarse aggregate (RCA), when 0% replacement of recycle coarse aggregate (RCA) (by volumetric weight) gives maximum compressive strength. Then compressive strength decrease comparatively 25%, 50%, 75% replacement of recycle coarse aggregate (RCA) and 75% replacement of recycle coarse aggregate (RCA) (by volumetric weight) gives minimum compressive strength.

CHAPTER-5
CONCLUSIONS AND FUTURE WORKS

5.1 Conclusions

During the last decade, a lot of research works have studied the performance of concrete using recycled pile head broken and demolished as partial replacement of coarse aggregate. The main purpose of this paper analyzed in-depth and remarkable results were found and discussed. Here under, conclusions and recommendations for future research works are presented. The main focus of this research was on the compressive strength of concrete containing pile head broken and demolished and very less attention was given to other properties of concrete. Pile head broken and demolished was added to concrete in replacement of coarse aggregates by volumetric weight replacement 0%, 25%, 50% and 100%. On the basis of the results from the present study, following conclusions were drawn.

- By comparing the compressive strength between pile head broken and demolished as a recycle coarse aggregate (RCA), when 0% replacement of recycle coarse aggregate (RCA) (by volumetric weight) gives maximum compressive strength. Then compressive strength decrease comparatively 25%, 50%, 75% replacement of recycle coarse aggregate (RCA) and 75% replacement of recycle coarse aggregate (RCA) (by volumetric weight) gives minimum compressive strength.
- Based on research, we can conclude, the compression strength of the RCA concrete is satisfactory and further we can reduce RCA/NCA ratio to rise the compression strength for concrete utilized recycled coarse aggregate.
- With bringing construction and demolition wastes into production lines, we can reduce the adverse.
- By using pile head broken and demolished at a time, we can reduce environment pollution & on the other hand we can reduce the use of natural stone & brick chips.
- We have so many wastage pile head broken and demolished while we can used in many construction and it would be also helpful for our economic.

- The replacement level of the natural coarse aggregate with the RCA would reduce the compressive strength of the concrete. We can use up to 25% percentage partial replacement by pile head broken and demolished.
- Most probably this concrete we can use in light structure and also we can use it footpath, garage, road side etc.
- By using this concrete, we can reduce the pressure of natural concrete.
- The water content used in all mixes is 0.5. The proportion of Cement: Sand: Gravel is 1:2:4
- Water absorption of RCA is higher than natural aggregate.

5.2 Limitations

- UTM requires periodical calibration to get accurate results.
- As we collected the pile head broken and demolished waste from the construction site and broken it by manually over the hand. So, that the shape of the particles was not angular.
- We could not manufacture enough concrete cylinders to test and get more strength data due to shortage of molds in our lab.

5.3 Recommendations for Future Works

- Comparatively better result was found with 25% replacement of pile head broken and demolished (by volumetric weight). The reason behind this could be particle interlocking, compaction and reduction in voids, which could be further taken into study.
- Study on direct tensile strength or split tensile strength may be taken into consideration.
- In future if one might want to try admixture chemical with the concrete to see if there is any change in compressive strength.
- Better strength results could be found reducing water-cement ratio and utilizing water reducing admixture.
- Further research can be done using different percentage of RCA with Fly Ash.

REFERENCE

[1] Yong, P.C.1and Teo, D.C.L.," Utilization of Recycled Aggregate as Coarse Aggregate in Concrete", UNIMAS Journal of Civil E- Engineering, Vol. 1: issue 1 /August 2009.

[2] H. A. Rashid, B. A. Nur, R. Ahsan," 21-23 December 2022 Department of Civil Engineering, BUET, Bangladesh," performed a study of Recyclability of broken pile head concrete in structural use.

[3] A Study On Recycled Concrete Aggregates, in 2018, Pavan PS, Babitha Rani H,Deepika Girish,Raghavendra K M, Vinod P N ,Dushyanth.V.Babu.R , Shaikh Numan, Assistant Professor, Department of Civil Engineering, SET, Jain University. 2 Student, Department of Civil Engineering, SET, Jain University.

[4] Tafsirojjaman, K. M. Taha and M. H. Haque, "A Study on Recycled Coarse Aggregate as a Partial or Full Replacement of Coarse Aggregate in Concrete Production using Fine Aggregate of FM 1.23," in 4th International Conference on Solid Waste Management in the Developing Countries, Khulna, Bangladesh, 2015.

[5] Anusuri Uma Maheswari, B. Naidu Babu, K. Jagan Assistant Professor & HOD, U.G. Student Department of Civil Engineering, Chaitanya Engineering College, Kommadi, Visakhapatnam, India, in July 2021, Study of partial replacement of natural aggregate by recycled aggregate on concrete.

[6] Shailendrakumar, Dr. A. K. Choudhary, Dr. B. P. Verma. In 2004 International Journal of Pure and Applied Mathematics. The relationship between split tensile strength and compressive strength for RCA concrete as well as controlled concrete.

[7] Dr S.C. Natesan, C Lavana Kumar and Chandra Mohan M P., Strength Properties of Concrete Using Demolished Waste as Partial Replacement Coarse Aggregate, in 2005.

[8] Daniel Yaw Osei., Compressive Strength of Concrete Using Recycled Concrete Aggregate as Complete Replacement of Natural Aggregate, October 2013, Volume 2, No.10.

[9] Sudhir P. Patil, Ganesh S. Ingle, Prashant D. Sathe. in 2013, International Journal of Pure and Applied Mathematics. Evaluate physical properties of concrete using recycled coarse aggregate.

[10] Winston F.K. Fong, Jaime S.K. Yeung, and C.S. Poon,
Civil Engineering Department, Hong Kong SAR Government, Hong Kong; Yue Xiu Concrete Co. Ltd., Hong Kong Department of Civil and Structural Engineering, Hong Kong Polytechnic University, Hong Kong; "Hong Kong Experience of Using Recycled Aggregates From Construction And Demolition Materials In Ready Mix Concrete".