Experimental Study of Recycled Aggregate Concrete by Partial Replacement of Cement with Bamboo Leaf Ash

Author

Ameer Hamza	(19F-UET-CE-049)
Amir Hamid Ali	(19F-UET-CE-033)
M. Usman Shehzad	(19F-UET-CE-024)
Jassim Ali	(19F-UET-CE-035)

Supervisor
Engr. Syed Haroon Ali Shah
Lecturer

DEPARTMENT OF CIVIL ENGINEERING

SWEDISH COLLEGE OF ENGINEERING AND TECHNOLOGY WAH CANTT AFFILIATED WITH UET TAXILA

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Jassim Ali	(19F-UET-CE-035)

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Engr. Syed Haroon Ali Shah

Lecturer Civil Engineering

External Examiner’s Signature: ________________________________

Thesis Supervisor’s Signature: _________________________________

DEPARTMENT OF CIVIL ENGINEERING

SWEDISH COLLEGE OF ENGINEERING AND TECHNOLOGY

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ABSTRACT

In today's world, concrete is an important component in any field of construction and development, this is the reason that the modern world is trying to experiment more about this material. In the same manner,

This project presents an experimental study on the use of recycled aggregate concrete with partial replacement of cement by bamboo leaf ash. The recycled aggregate concrete was produced by soaking the recycled aggregates in a solution of sodium silicate for one hour. The bamboo leaf ash was added in varying percentages of 3%, 6% & 9%with cement.

The aim of the study was to investigate the effect of bamboo leaf ash on the mechanical properties of recycled aggregate concrete. The experimental results showed that the addition of bamboo leaf ash improved the compressive strength, splitting tensile strength, and flexural strength of the recycled aggregate concrete. The study concludes that bamboo leaf ash can be used as a partial replacement of cement in recycled aggregate concrete to improve its strength and sustainability.

Keywords: American Society of Testing and Materials; Bamboo Leaf Ash; Virgin Aggregate Concrete; Compression Testing Machine; Recycled Aggregate Concrete; Recycled Concrete Aggregate; Ordinary Portland Cement; Sodium Silicate; Water Cement Ratio

UNDERTAKING

I certify that research work titled "*enter title of your research proposal here*" is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged / referred.

AMEER HAMZA
UET/SCET-19F-CE-049

AMIR HAMID ALI
UET/SCET-19F-CE-033

M. USMAN SHEHZAD
UET/SCET-19F-CE-024

JASSIM ALI
UET/SCET-19F-CE-035

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CHAPTER 1

INTRODUCTION

The building business is widely recognised as a significant contributor to environmental degradation. Concrete, being the prevailing construction material, necessitates a substantial allocation of natural resources throughout its manufacturing process, hence engendering a considerable volume of waste and emitting copious amounts of greenhouse gases. One potential solution to this problem involves the practise of recycling building and demolition trash. The utilisation of recycled concrete aggregates as a substitute for natural aggregates results in a reduction in the need for new aggregates and the preservation of natural resources, all while facilitating the production of recycled aggregate concrete. The incorporation of recycled elements in concrete has a significant impact on its properties, namely in terms of compressive strength and durability.[1]. Therefore, the purpose of this study is to ascertain how recycled aggregate concrete's qualities are affected when some of the cement is replaced with bamboo leaf ash.

But the problem is that the recycled material is weak in strength so, the treatment of this recycled material must be required to gain or maintain its strength. The method which is used in the treatment of recycled aggregate is Impregnation method. In this method different solutions are used for the treatments which are Sodium Silicate, Polyvinyl Alcohol and Silane Slurry etc. From these solutions we used the solution of Sodium Silicate for this purpose[1].

Bamboo leaf ash is derived as a byproduct from the combustion of bamboo leaves, representing an easily accessible and cost-effective resource. The incorporation of bamboo leaf ash into concrete has been observed to enhance its mechanical and durability characteristics. The utilisation of sodium silicate solution is employed in the surface modification of recycled aggregates with the aim of enhancing their inherent characteristics. [2].

This study investigates the impact of incorporating bamboo leaf ash at different proportions (3%, 6%, and 9%) into cement on the compressive strength, splitting tensile strength, and flexural strength of concrete built using recycled aggregate.

Before being utilised, the recycled aggregates undergo a soaking process in a sodium silicate solution for a duration of one hour. The objective of this study is to investigate the potential of bamboo leaf ash as an environmentally-friendly alternative to cement in the production of recycled aggregate concrete.

1.1 Problem Statement

Construction and transformation activities have produced a sizable amount of garbage recently, which has had negative consequences on the ecosystem as well as the urban and rural landscape. Additionally, there has been a rise in the amount of natural stone and sand used in engineering construction. Recycling construction waste into recycled coarse aggregate (RCA) can help protect natural resources, reduce environmental pollution, and lower the cost of aggregate used in construction projects. Recycling construction waste involves crushing, cleaning, and screening waste materials into RCA. However, in order to use RAC, it must first undergo a process known as impregnation, which helps the recycled material gain qualities comparable to those of virgin material.

Also to make the project or RAC economical and eco-friendly we use BLA (Bamboo Leaf Ash) as binding material and reduce the amount of cement in it.

The main problem that we addresses in our research is the waste of material of construction demolition and the use of cement that becomes the cause of huge amount of CO_2 in the atmosphere.

1.2 Aims and Objectives

The project's goals and objectives serve as the framework, thus they must be solid and long-lasting.

Aims: Usually, one or two are plenty. One is preferred, though.
a) Recycling of the concrete from construction demolition b) To make RAC economic and eco-friendly
Objectives

a) To experimentally determine the use of construction demolition concrete so that it is not wasted and can be recycled to positively impact the environment.
b) To experimentally determine that how the use of BLA in replacement of cement is economically and environmentally beneficial.

1.3 Scope

This study aims to conduct an empirical examination on the application of recycled aggregate concrete incorporating bamboo leaf ash as a partial replacement for cement. The objective of this research is to assess the influence of incorporating bamboo leaf ash into cement at varying proportions of 3%, 6%, and 9% on the mechanical properties of recycled aggregate concrete. Before being used, the aggregates that have been collected will undergo a treatment with a sodium silicate solution for a duration of one hour in order to enhance their properties.

The primary areas of investigation will encompass the compressive strength and splitting tensile strength of recycled aggregate concrete, whereby the quantities of bamboo leaf ash will be varied. This study aims to evaluate the impact of bamboo leaf ash on the characteristics of recycled aggregate concrete. Specifically, a comparison will be made between recycled aggregate concrete samples with varying percentages of bamboo leaf ash and those without any bamboo leaf ash. The objective is to assess the influence of bamboo leaf ash on the aforementioned features.

The investigation will be conducted within a controlled laboratory environment, where the specimens will be analysed in accordance with established testing methodologies. The findings will be analysed and presented using tables, graphs, and charts. The objective of this study is to investigate the potential of bamboo leaf ash as an environmentally-friendly alternative to cement in the production of recycled aggregate concrete. The primary objective of this study is to investigate the impact of bamboo leaf ash on the mechanical properties of recycled aggregate concrete. Other criteria such as durability, utilisation, and cost-effectiveness will not be considered in this research.

1.4 Methodology

In methodology we need to determine the mechanical properties of RAC such as:

compressive strength, modulus of elasticity, tensile strength, density and w\c ratio. Besides these properties we also required to determine the durability of RAC. Also the micro structure properties of i.e. cement paste, pore structure, interfacial transition zone between paste and aggregates.

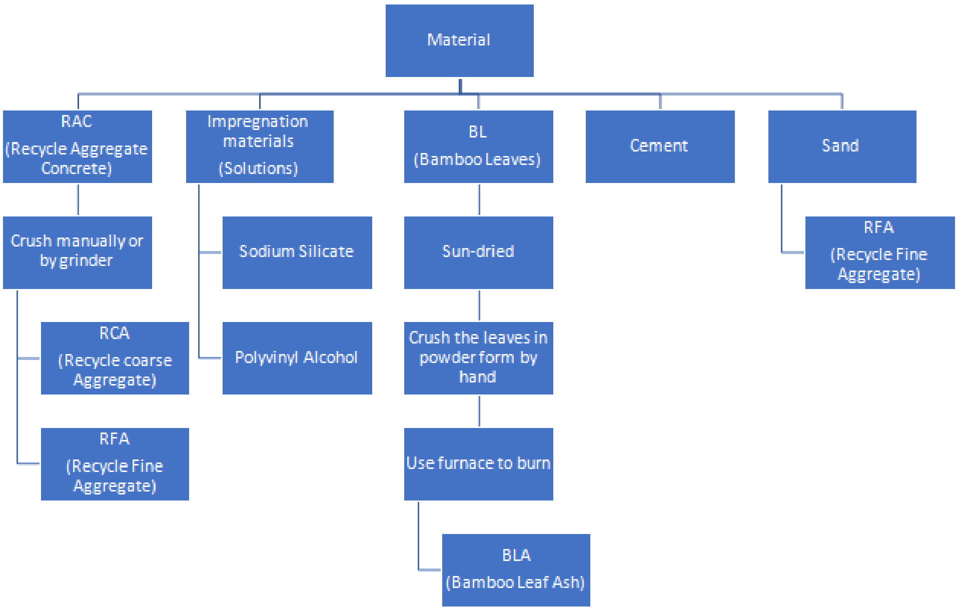


Figure 1: Methodology

1.4.1 Thesis Layout

The following chapters include further information and testing methods performed in thisthesis.

Chapter 1: This chapter includes the introduction, aim & objectives, scope and methodology of thethesis.

Chapter 2: Deals with the literature review and gives an overview of the previous researches on thefollowing experimentations and their findings.

Chapter 3: Deals with the methodology and material properties used in the experimentation.

Chapter 4: Deals with the testing and results on the concrete, comparing them with the standards.

Chapter 5: Deals with the conclusion and the recommendations on the work we have done in thisthesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Object oriented description of proposed research area with references cited as

Due to the rising rate of urbanisation and the increasing importance of infrastructure, the construction industry in China and other emerging nations has seen phenomenal expansion over the past few decades. Additionally, there is a significant need for concrete worldwide. Concrete production requires a sizable amount of resources, such as cement, gravel, and river sand, which makes it problematic for the development of sustainable communities. The absence of river sand has been one of the key issues with regard to all of the resources. Numerous environmental, social, and economic issues have been directly attributed to the overuse of river sand mining, which led to the depletion of river sand resources. In particular, the scarcity of naturally occurring aggregates drove up the cost of basic resources like river sand and gravel, which in turn increased the price of concrete. This was the main reason for the price increase. The concept of recycled concrete was created by researchers as a solution to the issues related to the management of C&D waste and a lack of raw materials. As research into recycled concrete has advanced, waste concrete production with a range of particle sizes can now be used in place of various concrete raw resources, including cementitious materials, cement, and coarse, fine, and minuscule aggregate. This is made possible by the creation of repurposed waste concrete[3].

The findings indicated that the enhancement in mechanical characteristics of recycled aggregate concrete (RAC) exhibited a higher rate of increase over a period of time compared to natural aggregate concrete. [4]. Recycled aggregate concrete (RAC), alternatively referred to as concrete derived from recycled aggregate, is a form of environmentally sustainable construction material that substitutes natural aggregate with recycled aggregate to mitigate the environmental impact associated with construction and demolition waste (CDW) generation. The mechanical characteristics of natural aggregate concrete (NAC) were notably impacted by the presence of ancient mortar-coated recycled aggregate (RA), in contrast to NAC. at contrast, it is estimated that China annually disposes of around 3.6 billion kilogrammes of tyres at landfill sites. The improper utilisation of landfills not only results in the inefficient use of valuable land resources, but also exacerbates the issue of environmental pollution. [5].

In recent years, a substantial amount of trash has been produced as a result of construction and other transformational activity. The natural environment, as well as the urban and rural landscape, have all been harmed by this trash. In the same time frame, there has been an increase in the quantity of natural stone and sand used in engineering construction. Reusing construction debris has become a major concern in the field of concrete research on a global scale, attracting the interest of experts and academics from all over the world. By doing this, it is possible to protect natural resources and find a use for leftover building waste. Crushing, cleaning, and screening construction waste to create recycled coarse aggregate (RCA) can not only reduce environmental pollution and help protect natural resources, but it can also lower the price of aggregate used in construction projects. The working performance, mechanical properties, and durability of concrete are all significantly reduced when recycled aggregate is used in place of natural aggregate [1].

The utilisation of waste materials possessing pozzolanic characteristics is experiencing a notable surge in their incorporation within the concrete manufacturing process. The assessment of the pozzolanic activity of alternative materials for cement is of growing significance in response to the heightened need for environmentally sustainable cementing options. One such approach that could be utilised is the partial substitution of Portland cement clinker with economically viable materials. Wastes refer to inexpensive materials derived from the processes of production and agriculture. Cements that incorporate Portland cement plus the aforementioned by-products are commonly known as "blended cements" or "composite cements." Blended cements are classified as hydraulic binders due to their composition, which involves the substitution of a portion of Portland cement with either other hydraulic or non-hydraulic constituents. Both materials exhibit similar characteristics to Portland cement in terms of their overall behaviour, since they both generate the same hydration products and undergo hardening when mixed with water. In general, Portland cement clinkers are commonly mixed with a latent hydraulic constituent, which is sometimes referred to as a blending component.

Various products, such as pozzo-lana, fly ash, rice husk ash, condensed silica fume, burned clay, lime stone and other waste materials, can be classified as blast furnace slag. Undoubtedly, bamboo stands out as the natural resource and building material capable of yielding the highest quantities and exhibiting the most rapid growth rate. Nevertheless, during the processing of bamboo, many types of waste are generated that are not utilised for fibre production, such as the leaves of the bamboo plant. [6].

2.2 Review of Relevant cutting edge Research Papers

The possibility of using waste bamboo leaf as a pozzolanic material has not received significant research to yet. In order to explain the reaction that occurred between calcium hydroxide and the ash from bamboo leaves over the course of four hours, Dwivedi employed the differential scanning calorimeter (DSC) technique [7].

The scientific presentation delivered by Ernesto Villar primarily centred around the examination and delineation of the pozzolanic properties exhibited by the combination of calcium hydroxide and bamboo leaf ash. The production of bamboo leaf ash involved subjecting bamboo leaves to a calcination process in a laboratory electric furnace, where they were exposed to a temperature of 600 degrees Celsius for a duration of two hours. The pozzolanic behaviour was determined using the conductometric technique. This approach is proposed on the basis of evaluating the electrical conductivity in a solution containing BLAsh/CH, in conjunction with the reaction duration. The kinetic parameters will then be determined by the utilisation of a kinetic-diffusive model. The accuracy level was deemed quite high since it was employed in determining the reaction rate constant and the free energy of activation. Specifically, it utilised process-specific data during the model fitting procedure. The pozzolanic activity is assessed using a quantitative study, utilising the data obtained from measurements of the kinetic parameters. The results indicate that the production of this particular type of ash is attributed to the presence of a totally amorphous silica with a high level of pozzolanic activity. The existing body of literature thoroughly examines theoretical inquiries into rate processes, which offer substantial evidence supporting the correlation between activation free energy values and reaction rate constants. [8].

Singh et al. (year) propose that a variety of cost-effective materials can be employed as partial substitutes for Portland cement in the production of eco-friendly composite cements. This exchange may lead to the intended outcome. The researchers conducted an observation on the hydration process of bamboo leaf ash when mixed with Portland cement. The utilisation of bamboo leaf ash as a pozzolanic material has demonstrated exceptional performance. The compressive strength values of mortars, following a 28-day hydration period, were observed to be nearly identical to those of Portland Pozzolana Cement (PPC) when a 20% weight proportion of bamboo leaf ash was incorporated into the PPC mixture. [9].

Several studies on the pores in Portland cement paste have consistently demonstrated that elevated curing temperatures result in an increase in pore coarseness. The findings of these investigations have demonstrated this phenomenon. It is widely acknowledged that the long-term strength of concrete diminishes as the curing temperatures increase. Despite the little amount of study conducted on this subject matter, it is reasonable to infer that the longevity of the product will correspondingly diminish. The report presents the findings of an initial inquiry into the susceptibility of concrete to corrosion induced by steel reinforcement. Concrete specimens were prepared with water-cement ratios of 0.40, 0.50, and 0.58, without the use of chemical or mineral additions. During the mixing and curing processes, the temperatures were consistently maintained at 5, 20, and 50 degrees Celsius (41, 68, and 122 F). Various curing durations were utilised in order to get a comparable degree of hydration, around 70%. Multiple distinct methodologies were employed to assess the extent of chloride diffusion. The researchers employed an accelerated corrosion test in order to evaluate the concrete's capacity to withstand the corrosion of the reinforcing steel. In this context, a comprehensive description of each testing technique is provided with meticulous attention to detail. The findings of both studies clearly indicate that higher curing temperatures have a detrimental effect on the resistance of Portland cement concretes to chloride diffusion and the subsequent de-passivation of reinforcing, when considering a specific water-to-cement ratio. The aforementioned deduction can be drawn from the outcomes of the examination. The aforementioned phenomenon may exhibit more prominence in instances where the ratio of water to cement is reduced. When considering concerns related to the durability of concrete structures, it is imperative to incorporate these findings into the design process. [10].

Frias et al. conducted an analysis on the ash derived from sugarcane leaves. This work investigates the hydration process of a composite Portland cement with a 10% SCLA content. Various techniques, such as differential scanning calorimetry, powder X-ray diffraction, and FTIR spectroscopy, were employed to analyse the hydration reactions. The results indicate that the pozzolanic response of sugarcane leaf ash becomes increasingly pronounced as time progresses. A novel kinetic-diffusive model was formulated to effectively assess the pozzolanic activity of a composite material comprising sugar cane waste and clay at different stages of the reaction. This model enables the determination of the kinetic coefficients, which represent the reaction rate constants, specifically for the CH/sugar cane-clay ash reaction. The present model was constructed with the purpose of elucidating the mechanisms underlying the reaction between clay and sugar cane waste, which ultimately leads to the generation of pozzolanic activity throughout all stages of the process. The results obtained in this study revealed a robust correlation between the experimental data and the theoretical predictions. Consequently, the enhancement of the cement's bonding characteristics can be achieved through the incorporation of suitable pozzolanic material in the appropriate type, quantity, and ratio into the hydration process of Portland cement. [11].

Nachbaur conducted a comprehensive investigation on the evolutionary process of cement and pure tricalcium silicate pastes, spanning from the initial mixing stage to the setting stage and even beyond. Additionally, the study explored the underlying forces responsible for the mechanical properties exhibited by these pastes. He accomplished this by doing studies utilising dynamic mode rheometry. The utilisation of a dedicated mixer-type instrument was vital for investigating rheology during the initial minutes subsequent to the conclusion of mixing. These minutes pose challenges for traditional methodologies due to their inherent characteristics. Both varieties of paste exhibit identical behaviour. The study revealed that the primary changes in the structures of the pastes predominantly take place within the initial few minutes subsequent to the conclusion of the mixing process. However, the interparticular forces stay unaltered until the setting stage and persist for several hours thereafter. The Vicat needle postulates that the process of setting in a paste is not influenced by any specific alteration in the nature of forces or structural changes occurring inside the paste. [12].

The search for appropriate supplementary materials with hydraulic or pozzolanic properties is underway. In developing countries, where there is a lack of power and great quality raw materials, this is far more crucial. Our work in this area will lead us to the conclusion that the ash that could be produced from bamboo leaf has pozzolanic properties and has an amorphous nature. Around 20 million tonnes of bamboo are produced annually throughout the world, with 10 million tonnes or so coming from India, China, and Japan [13].

2.3 Discussion culminating to identify bottlenecks/challenges

The results of the experiments mentioned above suggest that there is a lot of unrealized potential for the use of pozzolans in concrete. However, they haven't yet been widely utilised in the building industry. The reason why this is the case hasn't received much attention from researchers. Research was done by Botchway and Masoperh to identify the causes of the limited use of pozzolana cement in Ghana's construction industry. Insufficient information, a shortage of commercial pozzolans, a small market, and a lack of active government support are some of the main factors that discourage the use of pozzolanic cement, according to the research's findings [14].

Chandramouli's study highlights the prevalence of environmental factors that contribute to the degradation of concrete structures, with a particular focus on the corrosion of reinforcing steel due to chloride intrusion. The degradation of concrete due to corrosion is a prominent and widespread concern. In recent years, there has been a growing concern among individuals over the topic of durability, primarily due to its frequent occurrence and the significant costs associated with replacement. Chlorides have the ability to permeate crack-free concrete through many mechanisms, such as capillary absorption, hydrostatic pressure, diffusion, and evaporative transfer. One of the most prevalent mechanisms is diffusion. Diffusion occurs when the concentration of chloride on the exterior of the concrete element exceeds that of the inside. Consequently, chloride ions permeate the concrete matrix and ultimately encounter the reinforcing steel. When the aforementioned circumstances occur, coupled with alternating cycles of moisture and desiccation, and in the presence of oxygen, the environmental conditions become conducive to the process of reinforcing corrosion. The rate at which chloride ions permeate concrete is mostly influenced by the internal pore structure of the material. The pore structure of a material is subject to various factors, including the composition of the mixture, the hydration process, the circumstances during curing, the incorporation of additional cementitious materials, and the practises employed during construction. Hence, in the event of potential chloride-induced corrosion, it becomes imperative to conduct an assessment of the chloride permeability of the concrete. This action should be implemented in any location where there exists a likelihood of encountering such a hazard.. [15].

An online survey was conducted to better understand the variables that contribute to their low level of acceptance in the construction industry. The survey's findings showed that while concrete is a very effective building material, its negative effects on the environment make it necessary to substitute a portion of the regular Portland cement with supplemental cementitious materials. This is done to lessen the harmful effects on the environment and, in some situations, to cut costs. The research's findings also indicated that using pozzolans as a part-time replacement for cement in the production of concrete has been highly successful. However, the study found that the following issues, particularly in the construction sector, are the most significant barriers to their widespread adoption: the lack of commercial production of pozzolanic concrete; the absence of pertinent design mix standards for pozzolanic concrete; the lack of professionals with the necessary expertise involved in using pozzolans; a lack of public awareness; the absence of policies endorsing and guiding its use; and fears [16].

Effective pozzolanic material made from bamboo leaf ash results in the development of calcium silicate hydrate when paired with calcium hydroxide. As a pozzolanic substance, bamboo leaf ash becomes more active with rising temperature and passing time. As the amount of BLA content increases, more water must be added to the mixture in order to achieve a paste with a consistent texture that is comparable to cement since BLA is less dense than cement and occupies a higher volume for the same amount of mass as cement [2].Potential avenues of further research:

In the context of Pakistan, bamboo is predominantly acknowledged as a construction material commonly employed in rural areas, while individuals aspiring to possess a contemporary dwelling tend to perceive bamboo as an element associated with historical eras. While some individuals may not acknowledge bamboo as a locally sourced material, others recognise its extensive utilisation in the construction sector. Bamboo finds significant application in the manufacturing of ladders, scaffolding, animal sheds, shading structures, furniture, ornamental landscape features, roofing materials, as well as emergency and temporary shelters. The utilisation of bamboo in construction is currently constrained as a result of the inadequate comprehension of the material's prospective uses. Furthermore, a dearth of proficient abilities in the realms of cutting, treatment, and construction procedures contributes to the production of substandard materials, hence dissuading individuals from using those materials. The utilisation of natural resources in construction necessitates a greater investment of time and effort due to the lack of proficiency among persons in the requisite construction techniques. [17].

2.4 Selected Avenue with Reference

Bamboo is regarded as a feasible alternative to timber in some parts of the world, and its use could slow the rate of deforestation. Due to the growing demand for affordable and environmentally friendly materials, bamboo is seen as a promising option in this industry. Additionally, given that the country frequently experiences flooding, there is a need for quickly regenerable materials that may be made available for the purpose of reconstruction [17].

We're going to recycle and use concrete from old buildings. BLA is also added.

CHAPTER 3

MATERIAL AND METHODS

3.1 Flow chart

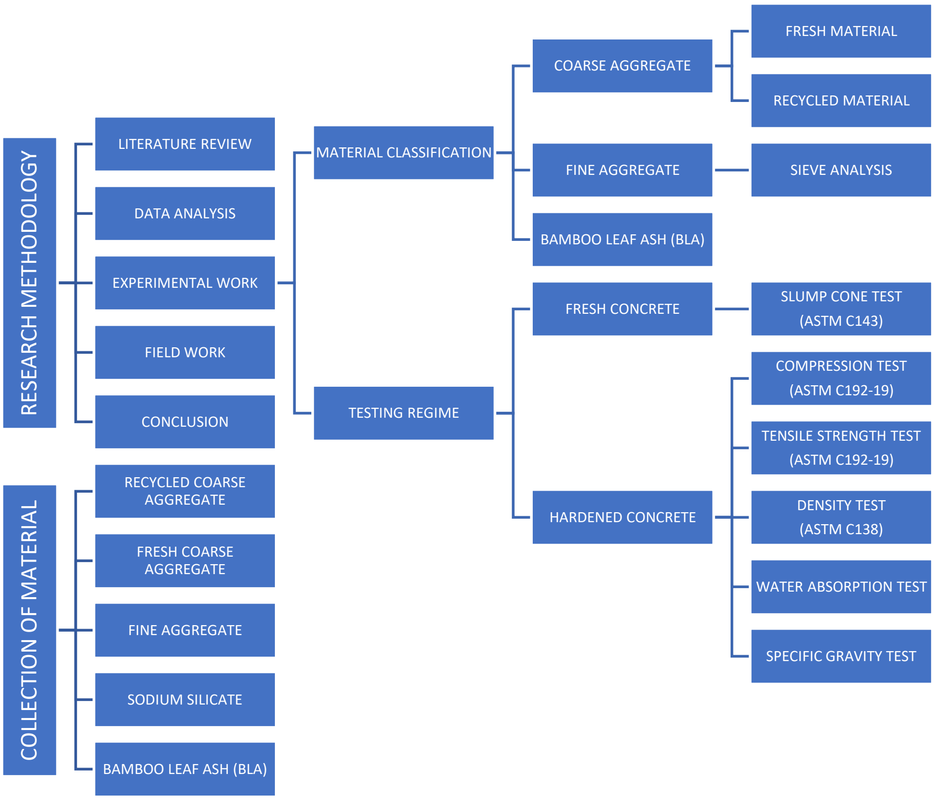


Figure 2: Methodology

3.2 Material Used

3.2.1 Cement

In our project, The Ordinary Portland Cement (OPC) used complying with ASTM C150 Type-I from Lucky Cement Industry was utilized in this investigational study. Cement used was taken from the fresh stock from Main G.T road, opposite of Basti Barrier, Wah Cantt. Fundamental properties of cement are given below:

Table 1: Cement Properties

Sr. #	Characteristics	Standard value	Obtained value
01	Initial setting time	Not less than 30 minutes	40 minutes
02	Final setting time	Not greater than 600 minutes	285 minutes
03	Normal consistency	22-30%	32%
04	Specific gravity	2.78-3.15	2.80
05	Fineness	<10	4.5

3.2.2 Fresh Aggregate

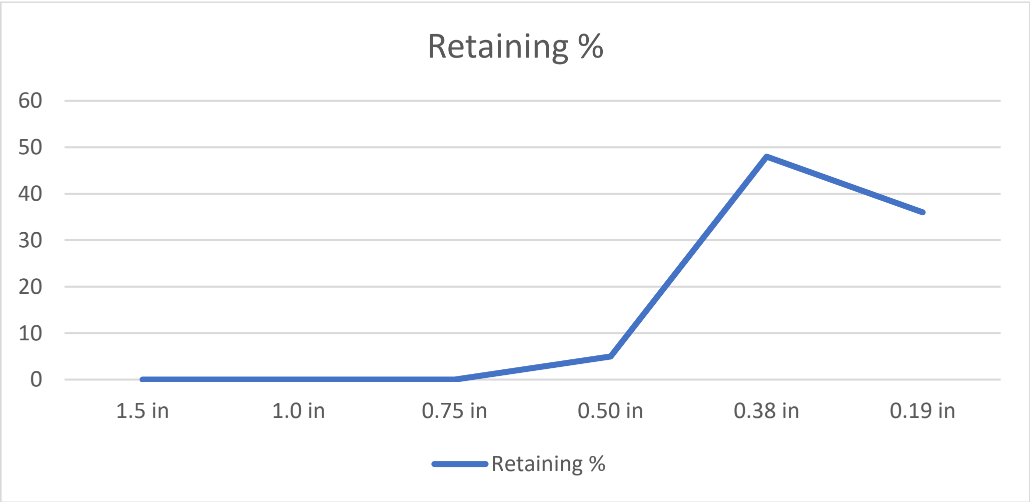
The most typical aggregate size used in construction is 20 mm. In mass concrete, a bigger size, 40mm, is more typical. The amount of cement and water required is less with larger aggregate sizes.

Figure 3: Aggregate Material

Aggregate takes an essential part in the quality and strength of concrete.

Table 2: Aggregate Properties

Sieve sizes (in)	Weight retained (g)	Percent retained	Cumulative percent Retained	Percent passing %
1.50	0	0%	0%	100.00%
1.00	0	0%	0%	100.00%
0.75	0	0%	0%	100.00%
0.50	200	5%	5%	95.24%
0.38	2000	48%	52%	47.62%
0.19	1500	36%	88%	11.90%
Pan	500	12%	100%	0.00%
Total	4200	100%		



3.2.3 Recycled Aggregate

In recycled aggregate the natural strength of material becomes weak as it is already used in construction purposes. But to use it in proper way can reduce the demolished material and helps in making environment friendly. We brake the demolished material and make the aggregate usable according to our need.

Figure 4: RAC preparation

3.2.4 Sand

Sand makes a powerful impact on the strength of concrete like compressive as well as tensile strengths. In concrete, the sand helps in binding of material and make it as a rock. So the sand we use in our project have the properties:

Table 3: Sand Properties

Sr. #	**Sieve sizes**	**Retained wt. (gm)**	**Retained %age**	**Commulative %age**
1	**#4**	**1**	0.1	0.1
2	**#8**	**3**	0.3	0.4
3	**#16**	**80**	8	8.4
4	**#40**	**608**	60.8	69.2
5	**#50**	**297**	29.7	98.9
6	**#100**	**6**	0.6	99.5
7	**#200**	**5**	0.5	100
	TOTAL WEIGHT	**1000**		

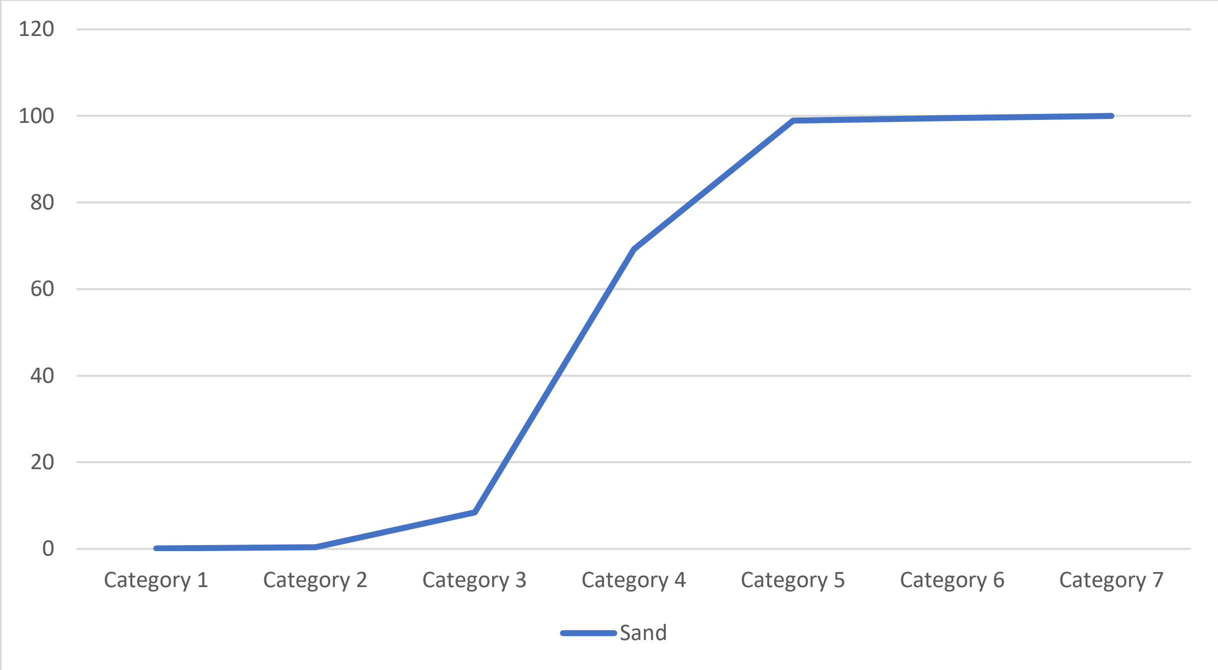


Figure 5: Graph

3.2.5 Sodium Silicate

As we know that when a material is used the strength of that material reduces day by day. Same here in case of recycled aggregate, when the material is used its strength reduces. So when we reuse this material we have to regain its strength to attain good results and strength in concrete. For such treatment of recycled aggregate a lot of methods are used, but from these we use the method of **impregnation** for the treatment of recycled aggregate. In this method we use the Sodium Silicate chemical for the treatment.

3.2.6 Super plasticizer

By employing a superplasticizer (ULTRA SUPERPLAST 675) that raises slump without the slump loss seen with conventional superplasticizers, it reduces water usage. In any concrete where it is desired to keep the water/cement ratio as low as possible while yet achieving the degree of workability required to ensure smooth placement and consolidation, ULTRA SUPERPLAST 675 is the best product to use.

Figure 6: Superplasticizer

Properties:

Symptoms: A brown liquid

At 20 °C, the typical specific gravity is 1.150 2%.

Chloride content is 0 according to BS 5075

air entrainment Less than 3% extra air is usually entrained at normal. dosages.

Less than 72.0 g of Na20 equivalent per litre of admixture is the typical alkali level. There is a fact sheet available on this topic.

Standard dosage:

To get the most out of trail mix, use it.

The standard dosage is 0.5 to 2 litres per 100 kg of cementitious material.

Concrete dosage should range from 0.5 to 2 litres per 100 kg of cementitious material for greater workability.

Use of Superplasticizer range in our project:

We are use ULTRA SUPERPLAST 675 dosage range is 2 litre/100 kg.

3.2.7 Bamboo Leaf Ash (BLA)

As mentioned in title we had to partially replace the cement with bamboo leaf ash (BLA). For this purpose, we collect the bamboo leaves and then sundried it. After it we use a closed controlled furnace to burn the leaves by indirect heating. Fro burning we prepare the furnace and pre heat it upto 200^{o}C and then put the leaves in it for indirect heating. The heating goes until the temperature reaches 400^{o}C and maintain it for about 1 hour and closed the furnace. After 24 hours, remove the leaves ash and grind it in grinder and then pass it by sieve # 200 for proper and good results.

3.3 Testing Regime

In testing regime, there are two methods of testing which we used in our project. First is Fresh Concrete Test and the other one is Hardened Concrete Test. These are discussed below:

3.3.1 Fresh Concrete Test

In fresh concrete test, the workability of the concrete is to be checked before the use of material. So for this purpose we use the slump cone test to check the workability of concrete as:

3.3.1.1 Slump Cone Test

The primary objective of the slump cone test is to assess the consistency or workability of a concrete mixture that has been prepared either in a laboratory setting or at a construction site. In order to maintain uniformity in the quality of concrete during the entirety of the construction procedure, it is necessary to conduct concrete slump tests on a batch-to-batch basis.

Figure 7: Slump Cone Test

3.3.2 Hardened Concrete Test

Hardened concrete tests are those tests which are performed when the concrete is in harden form. These tests are destructives as well as non-destructives. In this project, we perform the destructive tests of hardened concrete which are:

3.3.2.1 Compression Test

For the compressive strength test, standard concrete cubes were cast and then cured. After curing for 7days, cubes were placed vertically in the compression testing machine and the load was applied gradually as per ASTM standards. When cylinders start fracturing and stops automatically then the values were noted down.

Figure 8: Compression testing machine

3.3.2.2 Tensile Test:

For the tensile testing machine, standard concrete cylinders were used to cast and then cured. After curing for 7days, cylinders were placed horizontally in Compression Testing machine and the load was applied gradually as per ASTM standards. When cylinders start fracturing and stops automatically then the values were noted down.

Figure 9: Tensile testing machine

3.4 Castings and Curing of Sample

3.4.1 Casting Samples

Table 4: Samples Casting

Casting	**Cube Samples**	**Cylinder Samples**	**Total**
VAC	6	2	8
RAC 0%	6	2	8
RAC 3%	6	2	8
RAC 6%	6	2	8
RAC 9%	6	2	8
Total	30	10	40

Figure 10: Casting of Samples

3.4.2 Curing

ASTM Designation: ASTM C192-19

Objective: Describe the procedure for curing concrete samples in a water tank for 7 days.

Procedure:

1. Prepare concrete samples according to specifications.
2. Submerge samples in a water tank immediately after demolding.
3. Keep the water's temperature between 68°F and 81°F, or 20°C and 27°C.Keep samples fully submerged and avoid disturbances.
4. Maintain curing for 7 days following ASTM C192-19.
5. Remove samples after 7 days for further testing.

Figure 11: Curing Tank

3.5 Water cement ratio w/c

The ratio of a load of cement to a load of water is known as the water/cement ratio. It is the most important component for strengthening concrete. The lower w/c ratio is what gives concrete its enhanced strength. A water to cement ratio of 0.45 to 0.60 is typically used. But because the trials were conducted using high-strength concrete, the water to cement ratio we used was 0.32.

3.6 Compaction of Concrete

Concrete loses a lot of strength when air spaces are present. An average of 5% of air gaps might cause a 30–40% reduction in strength. It relates inversely to the concrete's strength. In order to achieve the actual performance of concrete with partial replacement of critical concrete materials, ASTM requirements were meticulously adhered to during the casting of various samples and during proper curing. Standard 6-by-12-inch cylinders were cast and given a 7-day cure in the curing tank.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 General

In this chapter, different test and results which were obtained during testing of concrete mixtures have been compiled. Tests results of compressive strength, tensile strength, specific gravity, density and water absorption test are presented in this chapter and compared with properties of normal strength concrete.

4.2 Specific Gravity and Water Absorption Test of Recycled Aggregate

According to ASTM C127, coarse aggregate underwent testing to determine its apparent specific gravity, bulk specific gravity, bulk SSD specific gravity, and water absorption.

The findings are as follows.Weight of oven-dry sample, W1=3552.07 g

Weight of Saturated Surface Dry sample in air, W2= 3569.8g

Weight of saturated sample in water, W3= 2205.13g

Bulk specific gravity (oven dry) = W1 / (W2-W3) = 3551.07 / (3569.8-2205.13) = 2.602

Bulk specific gravity (saturated surface dry) = W2 / (W2-W3) = 3569.8 / (3569.8-2205.13) = 2.62

Apparent specific gravity= W1 / (W1-W3) = 3551.07 / (3551.07-2205.13) = 2.64

Absorption percent= (W2-W1) * 100 / W1 = (3569.8-3552.07) * 100 / 3552.07 = 0.49 %

Figure 12: Specific gravity test apparatus

4.3 Fresh concrete test

4.3.1 Slump value

A slump test was done on various concrete blends as talked about in Chapter 3 to assess the properties of new concrete according to ASTM C143. The test result showed that with partial replacement of cement with BLA, the slump decreased with an increase in BLA percentage. The effect of material replacement showed that the workability of concrete was decreased. This was due to the dryness of BLA because water content and texture affect the workability of concrete. The reason for the reduction in workability was that water content in the mixture was absorbed by the BLA due to its higher absorption capacity, which made less water available for mixing, and hence no proper mixing took place.

Table 5: Slump value

Mix	w/c ratio	Obtained value	Code
VAC	0.32	7.8 in	ASTM C143
RAC, BLA 0%	0.32	7.6 in	ASTM C143
RAC, BLA 3%	0.32	6.8 in	ASTM C143
RAC, BLA 6%	0.32	6.3 in	ASTM C143
RAC, BLA 9%	0.32	6.1 in	ASTM C143

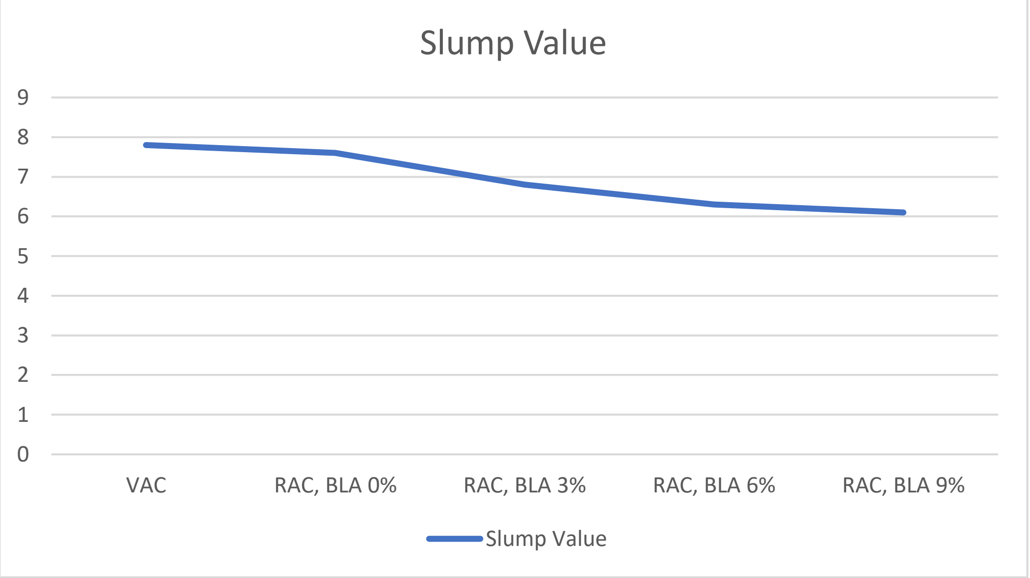


Figure 13 : Slump Value

4.4 Hardened Tests Values

4.4.1 Compression test

Compressive tests were carried out on cubes samples at age of 7days after proper curing as per ASTM C192-19. A total of 20 standard cubes of 0.32 w/c ratios were cast. The specimens were tested in a compression machine as per test specification ASTM: C873-94/C39-96.

Table 6: Compression values

Sample #	VAC (psi)	RAC, BLA 0% (psi)	RAC, BLA 3% (psi)	RAC, BLA 6% (psi)	RAC, BLA 9% (psi)
01	4328.8	4134.76	4007.32	4119.45	3911.22
02	4445.14	4032.20	4090.50	4074.77	3815.40
Average	4386.97	4083.48	4048.91	4097.11	3863.31

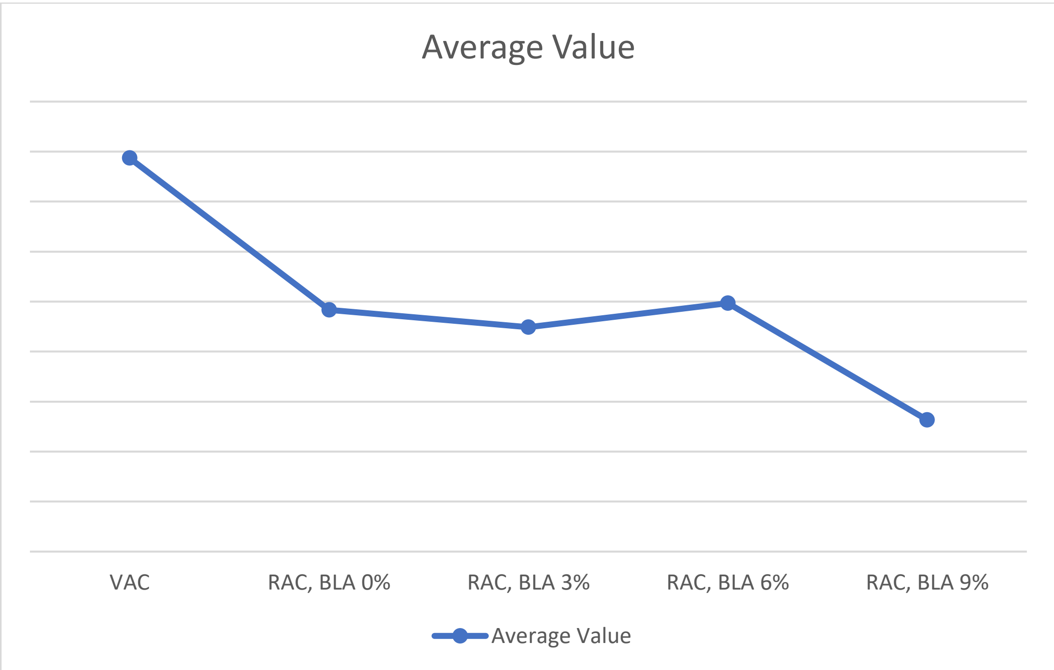


Figure 14: Compression

4.4.2 Tensile strength test

Tensile test were carried out on cylindrical samples at age of 7days after proper curing as per ASTM C192-19. A total of 20 standard cylinders of 0.32 w/c ratios were cast. The specimens were tested in a compression machine as per test specification ASTM: C496/C496-17.

Table 7: Tensile values

Sample #	VAC (psi)	RAC, BLA 0% (psi)	RAC, BLA 3% (psi)	RAC, BLA 6% (psi)	RAC, BLA 9% (psi)
01	1455.06	1367.95	1437.08	1495.39	1345.61
02	1520.92	1389.59	1387.90	1431.04	1302.05
Average	1487.99	1378.77	1412.49	1463.215	1323.83

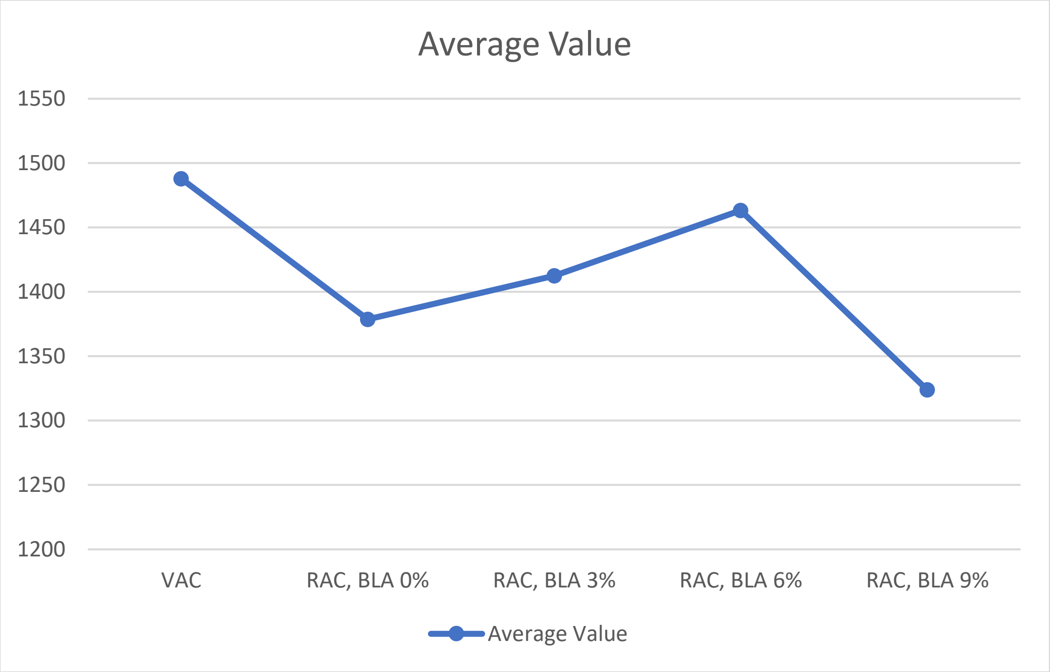


Figure 15: Tensile

4.4.3 Density

Density of concrete mix cubes are calculated by using wire basket apparatus according to ASTM C138 / C138M. As we use high strength concrete ratio with partial replacement of cement with BLA. So, the density of our specimen is calculated by:

Density = Specific gravity x 1000 kg/m3

The results are explained below for different samples:

Table 8: Density values

VAC Kg/m3	RAC, BLA 0% (Kg/m3)	RAC, BLA 3% (Kg/m3)	RAC, BLA 6% (Kg/m3)	RAC, BLA 9% (Kg/m3)
2246	2140	2090	2027	1880

Figure 16: Density test apparatus

The density of concrete with partial replacement of cement decreases because when the %age of ash increases the water to cement ratio requirement also increases.

4.4.4 Specific Gravity

Specific gravity also a factor that effects the concrete strength. So it is essential to calculate the specific gravity of concrete mix cubes specimen. Similar to density the specific gravity of BLA replaced concrete decreases as the %age of ash increases in specimen. The specific gravity of our specimen is calculated by:

Specific Gravity = weight of specimen [in air / (SSD - in water)]

The results are explained below for different samples:

Table 9: Specific gravity values

VAC	RAC, BLA 0%	RAC, BLA 3%	RAC, BLA 6%	RAC, BLA 9%
2.246	2.140	2.090	2.027	1.880

4.4.5 Water absorption Ratio

The ratio of water absorption in concrete also explained about the strength and behavior of concrete. Higher the water absorption ratio decreases the strength as well as the lower than specific point also effect the strength of concrete. When the %age of BLA increases in concrete the water absorption ratio also increases. The water absorption ratio of concrete is calculated by:

Water Absorption Ratio = wt. of specimen [(SSD - in air) / (SSD - in water)]

The results of water absorption ratio of different samples are:

Table 10: Water absorption values

VAC	**RAC, BLA 0%**	**RAC, BLA 3%**	**RAC, BLA 6%**	**RAC, BLA 9%**
2.246	3.36	3.8	5.75	8.31

4.4.6 Cost Analysis

After completing project, it is essential for us to determine the cost comparison between fresh concrete, Recycled concrete with 0% BLA ratio and with 6% BLA ratio because at 6%, it gives the max value. So, the cost analysis is:

Table 11: Cost Analysis

	VAC		RAC with 0% ash		RAC with 6% ash	
	Weight	Cost	Weight	Cost	Weight	Cost
Cement	6.42kg	Rs. 200	6.42kg	Rs. 200	6.03kg	Rs. 180
Aggregate	9.42kg	Rs. 150	9.42kg	Rs. 0	9.42kg	Rs. 0
Total		Rs. 350		Rs. 200		Rs. 180

As the sand is constant in all cases so it is neglected.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

- BLA is a good alternative for OPC at an acceptable ratio because it contains all the major chemical components of cement, albeit in differing amounts than OPC.
- Because OPC has a larger specific gravity than BLA, the slump value that is acquired when the percentage of BLA replacement rises is decreased.
- By using BLA, concrete costs, environmental issues, and landfill space for bamboo leaves will all be reduced.
- It has less amount of lime which makes it to release less heat and reduce the amount of curing water.
- Recycled aggregate can be used after the proper treatment with Sodium Silicate.
- Demolished material which is an environmental problem can be reduced by using this technique.
- As the usage of cement decreases the production of CO2 also reduces which is an environmental beneficial way.

5.2 Recommendation

- The main chemical binding components are present in BLA. So, it can be partially replaced with OPC and used as a binder.

- Care must be made when combining the components of concrete to ensure proper mixing of all the components.

- For the further increase of percentage of BLA we can use admixtures to increase the workability and strength of concrete. Lime can be added to mixture.

- After burning and heating, BLA should be stored sealed and in a dry location to prevent weather attack, which could weaken it.

- Similarly after the demolition of concrete structure, its material properties can be regained by proper treatment with Sodium Silicate and can be reused.

- By using recycled material we can reduce the material pollution from environment.

- The main thing is the by using these materials the natural assets can be saved.

REFERENCES

[1] C. Zhong, P. Tian, Y. Long, J. Zhou, K. Peng, and C. Yuan, “Effect of Composite Impregnation on Properties of Recycled Coarse Aggregate and Recycled Aggregate Concrete,” *Buildings*, vol. 12, no. 7, p. 1035, Jul. 2022, doi: 10.3390/buildings12071035.

[2] S. Babatunde, O. Olanrewaju, J. Abass, and K. O. Olusola, “Effect of Open Air Burnt Bamboo Leaf Ash Blended Cement Concrete,” *IOSR J. Mech. Civ. Eng. (IOSR-JMCE*, vol. 18, no. 5, pp. 49–57, 2021, doi: 10.9790/1684-1805024957.

[3] C. S. Zhang, H., Xiao, J., Tang, Y., Duan, Z., & Poon, “Long-term shrinkage and mechanical properties of fully recycled aggregate concrete: Testing and modelling.,” *Cem. Concr. Compos.*, 2022, [Online]. Available: https://doi.org/10.1016/j.cemconcomp.2022.104527

[4] D. Prasad, A. Pandey, and B. Kumar, “Sustainable production of recycled concrete aggregates by lime treatment and mechanical abrasion for M40 grade concrete,” *Constr. Build. Mater.*, vol. 268, no. xxxx, p. 121119, 2021, doi: 10.1016/j.conbuildmat.2020.121119.

[5] X. Feng, W., Wang, Y., Sun, J., Tang, Y., Wu, D., Jiang, Z., ... & Wang, “Prediction of thermo-mechanical properties of rubber-modified recycled aggregate concrete,” *Constr. Build. Mater.*, 2022, [Online]. Available: https://doi.org/10.1016/j.conbuildmat.2021.125970

[6] P. Asha, A. Salman, and R. A. Kumar, “Experimental Study on Concrete with Bamboo Leaf Ash,” *Int. J. Eng. Adv. Technol.*, no. 6, pp. 2249–8958, 2014.

[7] V. N. Dwivedi, N. B. P. Singh, S. S. Das, and N. B. P. Singh, “A new pozzolanic material for cement industry: Bamboo leaf ash,” *Int. J. Phys. Sci.*, vol. 1, no. 3, pp. 106–111, 2006.

[8] E. Villar-Cociña, E. V. Morales, S. F. Santos, H. Savastano, and M. Frías, “Pozzolanic behavior of bamboo leaf ash: Characterization and determination of the kinetic parameters,” *Cem. Concr. Compos.*, vol. 33, no. 1, pp. 68–73, 2011, doi: 10.1016/j.cemconcomp.2010.09.003.

[9] N. B. Singh, V. D. Singh, and S. Rai, “Hydration of bagasse ash-blended portland cement,” *Cem. Concr. Res.*, vol. 30, no. 9, pp. 1485–1488, 2000,

doi: 10.1016/S0008-8846(00)00324-0.

[10] R. J. Detwiler, K. O. Kjellsen, and O. E. Gjorv, “Resistance to chloride intrusion of concrete cured at different temperatures,” *ACI Mater. J.*, vol. 88, no. 1, pp. 19–24, Jan. 1991, doi: 10.14359/2326.

[11] M. Frías, E. Villar-Cociña, M. I. S. De Rojas, and E. Valencia-Morales, “The effect that different pozzolanic activity methods has on the kinetic constants of the pozzolanic reaction in sugar cane straw-clay ash/lime systems: Application of a kinetic-diffusive model,” *Cem. Concr. Res.*, vol. 35, no. 11, pp. 2137–2142, 2005, doi: 10.1016/j.cemconres.2005.07.005.

[12] L. Nachbaur, J. C. Mutin, A. Nonat, and L. Choplin, “Dynamic mode rheology of cement and tricalcium silicate pastes from mixing to setting,” *Cem. Concr. Res.*, vol. 31, no. 2, pp. 183–192, 2001, doi: 10.1016/S0008-8846(00)00464-6.

[13] B. N. Pandey and N. B. Singh, “Micropropagation of Dendrocalamus strictus nees from mature nodal explants,” *J. Appl. Nat. Sci.*, vol. 4, no. 1, pp. 5–9, Jun. 2012, doi: 10.31018/jans.v4i1.213.

[14] A. Botchway, E. A., & Masoperh, “Investigating the low utilization of pozzolana cement in the Ghanaian construction industry,” *Int J Adv Res Eng Technol*, 2019, doi: http://dx.doi.org/10.34218/IJARET.10.4.2019.007.

[15] K. Chandramouli, S. R. P, S. S. T, N. Pannirselvam, and P. Sravana, “Rapid chloride permeability test for durability studies on glass fibre reinforced concrete,” *J. Eng. Appl. Sci.*, vol. 5, no. 3, pp. 67–71, 2010.

[16] O. O. Omotayo and C. Arum, “Challenges and Prospects of Widespread Adoption of Pozzolans for Building Construction: A Statistical Assessment,” *Int. J. Eng. Trans. A Basics*, vol. 35, no. 10, pp. 1929–1940, 2022, doi: 10.5829/ije.2022.35.10a.12.

[17] E. Wagemann and M. H. Ramage, “Briefing: Bamboo for construction in Pakistan - A scoping review,” *Proc. Inst. Civ. Eng. Constr. Mater.*, vol. 172, no. 1, pp. 3–9, 2019, doi: 10.1680/jcoma.17.00045.

ABBREVIATIONS

ASTM: American Society of Testing and Materials

BLA: Bamboo Leaf Ash

VAC: Virgin Aggregate Concrete

CTM: Compression Testing Machine

RAC: Recycled Aggregate Concrete

RCA: Recycled Concrete Aggregate

OPC: Ordinary Portland Cement

SS: Sodium Silicate

W/C: Water Cement Ratio