EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF COARSE & FINE AGGREGATE IN CONCRETE BY BAMBOO CHIPS & QUARRY DUST RESPECTIVELY

By

MD. ZUAL RANA

RAJESH CHAKMA

MD. MEHEDI HASAN

MD SHOHEL RANA

MD. BELLAL MOLLA

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



Department of Civil Engineering

Sonargaon University

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

Section: 23(A+E)

Semester: Fall-2024

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By

MD. ZUAL RANA	CE2102023156
RAJESH CHAKMA	CE2102023181
MD. MEHEDI HASAN	CE2002020045
MD SHOHEL RANA	CE2102023157
MD. BELLAL MOLLA	CE2102023171

Supervisor

TAHMID MUSTAFA

Assistant Professor, Department of Civil Engineering, SU

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BOARD OF EXAMINERS

The thesis titled "**Experimental study on partial replacement of coarse & fine aggregate in concrete by bamboo and quarry dust respectively**" submitted by Md. Zual Rana Student ID: CE2102023156, Rajesh Chakma Student ID: CE2102023181, Md. Mehedi Hasan Student ID: CE2002020045, Md. Shohel Rana Student ID: CE2102023157, Md. Bellal Molla Student ID: CE 2102023171 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering on 17th January 2025.

- Tahmid Mustafa — Chairman
  Assistant Professor Department of Civil Engineering
  Sonargaon University

- Internal Member — Member

- Internal Member — Member

DECLARATION

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.

STUDENT NAME	STUDENT ID.	SIGNATURE
1. MD. ZUAL RANA	CE2102023156	
2. RAJESH CHAKMA	CE2102023181	
3. MD. MEHEDI HASAN	CE2002020045	
4. MD. SHOHEL RANA	CE2102023157	
5. MD BELLAL MOLLA	CE2102023171	

Dedicated

to

“OUR PARENTS & TEACHERS”

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ABSTRACT

Concrete is the most used construction material across the world and in concrete maximum part is coarse aggregate and fine aggregate. Naturally available brick chips commonly used as a coarse aggregate and river sand is the commonly used as a fine aggregate in many countries and. The more requirement for concrete has made this natural brick chips and river sand resource to get weakens. On one side the depletion of brick chips and river sand in excess has shows very clear environmental impacts, on the other side, production of very huge amount of bamboo and quarry dust is being produced during the process of quarrying and its leading to many environmental problems. It is necessary to carry out the research on identifying the feasibility of using alternative waste materials like bamboo and quarry dust. The percentage of bamboo added by volume basis was 0%, 5%, 10%, 15%, 20%, and 25% as replacement of coarse aggregate used in concrete. Compressive strength decreases due to 7, 14 & 28 days test result replacing coarse aggregate with 5%, 10%, 15%, 20% & 25% Bamboo. But compressive strength increases gradually due to replacing coarse aggregate with 15% bamboo and fine aggregate with 5%, 10% & 15% Quarry dust. Replacing course aggregate with 15% bamboo and fine aggregate with 10% and 15% quarry dust resulted in a 21% increase in the result of 15% quarry dust over the result of 10% quarry dust.

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CHAPTER 1

INTRODUCTION

1.1 Background and Motivations

Concrete is a flexible and frequently used building material. One of its most crucial characteristics is its compressive strength, which governs how much weight concrete structures can support. The type of cement used, the amount of water to cement, the amount of aggregate, and the curing conditions are some of the variables that might impact the compressive strength of concrete.

We will go over the elements that impact the compressive strength of typical concrete in this brief article. The significance of compressive strength in concrete design and construction will also be covered. The results of current studies on the compressive strength of typical concrete will be shown before we conclude.

1.2 Research Objectives and Overview

To study the effect of partial replacement of course aggregate by bamboo with 5%, 10%, 15%, 20% and 25% and fine aggregate by quarry dust with 5%, 10%, 15% respectively. Our main goal was to reduce costs by partially replacing coarse and fine aggregates with bamboo and quarry dust. The effect of replacement of bamboo and quarry dust was studied using basic properties, fresh concrete behavior and hardened concrete behavior based mechanical strength test result.

1.3 Organization of the thesis

The layout of the thesis is written through five chapters in the following sequence. Chapter one deals with the background and the definition of compressive strength and its importance in concrete design and construction. Chapter Two is a literature review which includes the definition of the compressive strength of Baboo and Quarry dust. Chapter Three contains the Methodology and Experimental Program which Material, the Procedure of Making the cylinder, the methodology Overview and a Summary. Chapter Four contains the experimental results along with the data, figures and graphs obtained from the laboratory tests, discussions on the test results, specific aim and summary. Chapter Five describes the conclusion of the research work and recommendations for further research.

Chapter 1: Introduction and Objective:

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

Chapter 2: Literature Review:

This chapter reviews the related works in the Bamboo field with a special focus on Quary dust.

Chapter 3: Methodology:

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

Chapter 4: Results and Discussion:

This chapter describes the results of 7, 14 & 28 days.

Chapter 5: Conclusions and Future Work:

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

CHAPTER 2

Literature Review

2.1 Introduction

There are different types of waste materials being used in the industry [1].to produce fine aggregate, stone quarry blasting is essential and naturally production of quarry dust also associates with it. Quarry dust results in harmful disease like lungs cancer, Asthma, eye disease etc.[2,3]. Several researchers have made an attempt to study the use bamboo as one of the reinforcement to replace the steel in construction works. Based on economic analysis and strength aspect of bamboo was used in design and construction of retrofit structures and construction materials [4].

2.2 Content

2.2.1. **Cement:** Crown Portland Composite Cement is CEM-II/A-M which is a cement consisting of Clinker, Gypsum, Pulverized Fuel Ash (PFA), Blast Furnace Slag and Limestone designated by the recommendation of BDS EN 197-1: 2010; CEM -II/A-M (V-S-L), 42.5 N. PCC is the most suitable cement for constructions in Bangladesh. CEM – II /A-M contains 80-94% Clinker, which is substantially higher than CEM – II/B-M containing 65 – 79% which provides us extra advantage in strength development and better of concrete performance.

Both slag & fly ash (PFA) are used in PCC. Percentage of SiO2 in PFA is higher than slag which is advantageous to gain more long-term strength and ensure production of durable concrete. This type of cement is used for most of constructions all over the world and it has been used during the last few decades. The hydration process of normal cement produces Calcium Silicate Hydrate CHS & Calcium Hydroxide Ca(OH)2. Calcium Hydroxide Ca(OH)2 does not contribute to gain strength and it is the weak part of reaction which is not suitable for concrete. Since PFA contains higher portion of reactive silica and slag contains alumina, it helps to convert Ca(OH)2 into CSH to gain further Compressive strength.



Figure: 2.2.1 Cement

2.2.2. Fine Aggregates: Fine aggregates are an essential component in the construction industry, forming a significant portion of concrete, mortar, and other building materials. They are granular materials, typically smaller than 5mm in diameter,



Figure: 2.2.2 Fine Aggregates

that play a crucial role in enhancing the workability, strength, and durability of construction mixes. Here's an in-depth overview of fine aggregates. Sylhet sand was used for producing lightweight cylinder for performing compressive strength test.

2.2.3. Coarse Aggregates: Coarse aggregates are an integral component in construction, constituting a substantial portion of concrete, asphalt, and other building materials. These granular materials, typically larger than 4.75mm in diameter, play a crucial role in providing structural strength, stability, and durability to construction mixes. Here's an in-depth exploration of coarse aggregates.



Figure: 2.2.3 Coarse Aggregates

We used Brick chips here. Brick chips are a manufactured decorative stone. They are developed from brick that has been crushed, screened and sized for use in landscaping applications.

2.2.4. Water: According to IS 456 : 2000, water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. The pH value of water shall be not less than 6. Water is a fundamental and essential element in the construction industry, playing a critical role in various construction processes and materials. It serves as a mixing and curing agent, a component of construction materials, and a medium for cleaning and hydration. Here's an exploration of the significance and functions of water in construction

.



Figure: 2.2.4 Water

2.2.5. Bamboo: For making bamboo, the bamboos were splitted along the horizontal axis. Then the bamboo specimens were soaked in water for seven days. After that it was dried in sun for 7 days to improve the strength and durability of specimen. The different percentage of bamboo such as 5%, 10%, 15%, 20% and 25% were used in this experiment.



Figure: 2.2.5 Bamboo

2.2.6. Quary dust: Quarry dust, also known as crushed fines, is a byproduct of blasting, crushing, and screening operations. It is a type of sand that is made from granite, gneiss, or limestone. Quarry dust is commonly used as a base material for construction projects, such as roads, highways, and parking lots.



Figure: 2.6 Quary dust

2.3 Summary

The literature has highlighted the potential of bamboo and quarry dust to improve the properties of concrete. Quarry dust reduces the density of concrete, makes it lighter while maintaining adequate strength and will play an effective role in improving thermal insulation. Bamboo is known for its durability and strength, strengthens concrete, and increases compressive and flexural strengths. However, excess bamboo and quarry dust can reduce performance. Overall, the combination of bamboo and quarry dust promises to produce lightweight, strong concrete with the best ratio for strength and performance balance. This study further explores their combined effects on concrete performance.

CHAPTER 3

Methodology

➢ 3.1 Introduction

The methodology employed in this study focuses on analyzing the compressive strength of concrete through the partial replacement of coarse aggregate with Bamboo and fine aggregate with Quary dust. The experimental process is designed to evaluate the potential of these materials to enhance the properties of lightweight concrete, specifically its compressive and flexural strength.

The study involves the preparation of concrete cylinders using different proportions of Bamboo, ranging from 0% to 25% by volume of coarse aggregate and Quary dust, ranging from 0% to 15% by volume of fine aggregate. The concrete mix is prepared with standard materials such as cement, fine and coarse aggregates, and water. After casting the specimens, they are cured for specified periods (7, 14, and 28 days), followed by compressive strength testing using a Universal Testing Machine. This methodology aims to provide a comparative analysis of how these eco-friendly materials affect the structural performance of concrete, offering potential applications in lightweight and sustainable construction practices.

➢ 3.2 Methodology Overview

The methodology employed for investigating the compressive strength of concrete using Bamboo and Quary dust involves a systematic approach that encompasses various experimental and analytical steps. This section provides a concise overview of the key methodologies utilized in the research process

Mix design parameter:

Water to cement ratio: 0.5
Sand to aggregate ratio: 0.44

Unit weight and specific gravity of the materials used

Material	Unit weight	Specific gravity
Cement content	1440 kg/m^3	3.09
Coarse aggregate	999.21 kg/m^3	1.7
Fine aggregate	1582.4 kg/m^3	2.5

Weight base mixing ratio:

Case no:1					
Number of cylinder	6	FA replacement	0%	CA replacement	0%
Description		Weight(kg)			
Cement		2.98387			
Coarse aggregate		7.65511			
Replaced CA		0			
Fine aggregate		5.05984			
Replaced FA		0			
Water		1.4919			

Case no:2					
Number of cylinder	6	FA replacement	0%	CA replacement	5%
Description		Weight(kg)			
Cement		2.98387			
Coarse aggregate		8.058			
Replaced CA		0.4029			
Fine aggregate		5.05984			
Replaced FA		0			
Water		1.4919			

Case no:3					
Number of cylinder	6	FA replacement	0%	CA replacement	10%
Description		Weight(kg)			
Cement		2.98387			
Coarse aggregate		7.252			
Replaced CA		0.805			
Fine aggregate		5.05984			
Replaced FA		0			
Water		1.4919			

Case no:4					
Number of cylinder	6	FA replacement	0%	CA replacement	15%
Description		Weight(kg)			
Cement		2.98387			
Coarse aggregate		6.849			
Replaced CA		1.2087			
Fine aggregate		5.05984			
Replaced FA		0			
Water		1.4919			

Case no:5					
Number of cylinder	6	FA replacement	0%	CA replacement	20%
Description		Weight(kg)			
Cement		2.98387			
Coarse aggregate		6.4464			
Replaced CA		1.611			
Fine aggregate		5.05984			
Replaced FA		0			
Water		1.4919			

Case no:6					
Number of cylinder	6	FA replacement	0%	CA replacement	25%
Description		Weight(kg)			
Cement		2.98387			
Coarse aggregate		6.0643			
Replaced CA		2.0145			
Fine aggregate		5.05984			
Replaced FA		0			
Water		1.4919			

Case no:7					
Number of cylinder	6	FA replacement	5%	CA replacement	15%
Description		Weight(kg)			
Cement		2.98387			
Coarse aggregate		6.849307			
Replaced CA		1.208701			
Fine aggregate		4.806852			
Replaced FA		0.252992			
Water		1.4919			

Case no:8					
Number of cylinder	6	FA replacement	10%	CA replacement	15%
Description		Weight(kg)			
Cement		2.98387			
Coarse aggregate		6.849307			
Replaced CA		1.208701			
Fine aggregate		4.55386			
Replaced FA		0.505984			
Water		1.4919			

Case no:9					
Number of cylinder	6	FA replacement	15%	CA replacement	15%
Description		Weight(kg)			
Cement		2.98387			
Coarse aggregate		6.849307			
Replaced CA		1.208701			
Fine aggregate		4.300868			
Replaced FA		0.758977			
Water		1.4919			

➢ 3.2.1 Materials Selection and Preparation:

The materials for the concrete mixture will include Portland composite cement, fine and coarse aggregates, water, Bamboo, and Quary dust. High-quality materials will be selected to ensure accurate and repeatable results. The Bamboo will be of uniform size, and the Quary dust will be properly processed to remove impurities.

➢ 3.2.2 Mix Proportioning:

A series of concrete mixtures will be designed with varying proportions of Bamboo and Quary dust. The mix design will be based on established guidelines for achieving the desired compressive strength. The control mixtures without any additives will also be prepared for comparison.



Figure 3.1 Mix proportioning

➢ 3.2.3 Concrete Mixing:

The concrete mixtures will be batched using a concrete mixer, following standard mixing procedures. The sequence of adding materials, mixing duration, and water-cement ratio will be consistent for all batches to ensure consistency.



Figure 3.2 Concrete mixing

➢ 3.2.4 Specimen Casting:

The freshly mixed concrete will be cast into standard cylindrical or cubic molds, adhering to relevant testing standards. Special care will be taken to prevent segregation during casting. The molds will be properly vibrated to eliminate air void



Figure 3.3 Specimen casting

➢ 3.2.5 Curing Regime:

The cast specimens will undergo a controlled curing process to simulate real-world conditions. This process will involve both moist curing and air curing, as per established concrete curing practices. The curing duration will be chosen to ensure proper hydration and development of strength

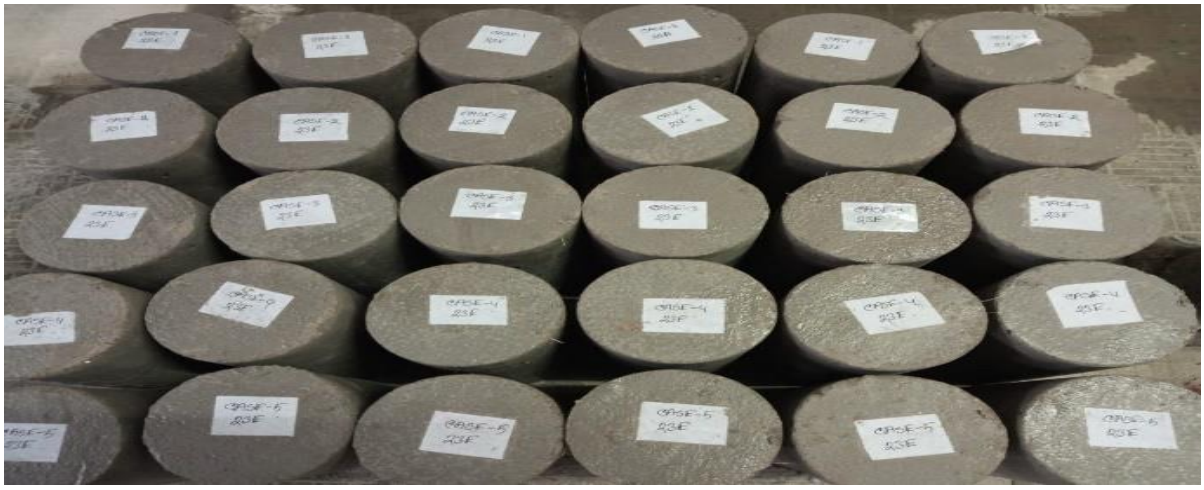


Figure 3.4 Curing regime

➢ 3.2.6 Compressive Strength Testing:

After the curing period, the specimens will be carefully demoded and tested for compressive strength using a universal testing machine.



Figure: 3.5 Compressive Strength Testing

The load will be applied gradually and uniformly until failure occurs. The maximum load at failure and the corresponding stress will be recorded to calculate the compressive strength.

➢ 3.2.7 Data Collection and Analysis:

The obtained compressive strength values from different mixtures will be compiled and analyzed statistically. The effects of varying proportions of Bamboo and Quary dust on the compressive strength will be studied. Comparative analysis will be conducted between the modified concrete mixes and the control mixes.

➢ 3.3 Summary

The methodology of this study focuses on evaluating the compressive strength of concrete with partial replacement of coarse aggregate using Bamboo. Ordinary Portland Cement (OPC), fine aggregates replacement using Quary dust, and natural coarse aggregates were used alongside varying percentages of Bamboo (0%, 5%, 10%, 15%, 20%, 25%) and Fine aggregate were used alongside varying percentages of Quary dust (5%, 10%, 15%).

Concrete cylinders were cast following a standard Volume ratio and water-cement ratio. The specimens were cured in controlled environments for 7, 14, and 28 days. Compressive strength tests were conducted using a Universal Testing Machine to assess the performance of the different concrete mixes. The methodology also included data analysis to compare the performance of modified concrete mixes with normal concrete. This experimental approach aims to provide insights into the viability of Bamboo and Quary dust as sustainable alternatives to traditional coarse aggregates and fine aggregates in concrete.

CHAPTER 4

Results and Discussion

➢ 4.1 Introduction

This pivotal section delves into the empirical outcomes and insightful interpretations derived from the experimental investigation on the utilization of Bamboo and Quary dust as additives in concrete. The primary focus centers on the compressive strength characteristics of the modified concrete mixes.

➢ 4.2 Specific Aim 1:

The quantity and density of lightweight aggregates are two of the most crucial elements in regulating a variety of physical properties in LWC. Due to the low density of Bamboo and Quary dust, the density of LWC falls as Bamboo volume increases. This rise is the result of the cement hydration process becoming more advanced with time. and both provide a comparison of the compressive strengths of several specimens at 7 days, 14 days and 28 days of age.

For 7 days							
Case no	Dia (mm)	Height (mm)	Weight (kg)	Load (kn)	Crushing Strength (mpa)	Average Crushing Strength (mpa)	PSI
Normal concrete							
1	103.14	205.5	3448	120	14.36	14.31	2076.1
1	103.49	205	3505	120	14.27		
5% Bamboo							
2	103.64	206	3385	80	9.48	9.65	1399.58
2	103.11	206	3383	82	9.82		
10% Bamboo							
3	103.43	206.5	3353	73	8.69	8.97	1301.27
3	102.92	205.5	3295	77	9.26		

Case no	Dia (mm)	Height (mm)	Weight (kg)	Load (kn)	Crushing Strength (mpa)	Average Crushing Strength (mpa)	PSI
15% Bamboo							
4	102.66	205.5	3232	48	5.8	6.27	909.606
4	101.90	205.5	3276	55	6.74		
20% Bamboo							
5	102.35	205	3217	40	4.86	5.11	740.594
5	103.48	205	3221	45	5.35		
25% Bamboo							
6	102.78	206	3097	35	4.22	4.15	601.434
6	103.07	206	3107	34	4.07		
15% Bamboo & 5% Quarry dust							
7	103.26	205.5	3208	32	3.82	3.75	543.455
7	101.98	205	3165	30	3.67		
15% Bamboo & 10% Quarry dust							
8	102.77	205	3106	37	4.46	4.63	671.6
8	103	206	3212	40	4.8		
15% Bamboo & 15% Quarry dust							
9	102.56	206	3206	47	5.69	6.58	954.388
9	102.79	206	3279	62	7.47		

For 14 days							
Case no	Dia (mm)	Height (mm)	Weight (kg)	Load (kn)	Crushing Strength (mpa)	Average Crushing Strength (mpa)	PSI
Normal concrete							
1	100.25	200	3324	145	18.37	17.10	2480.49
1	102.24	200	3415	130	15.83		
5% Bamboo							
2	102.44	204	3426	102	12.38	11.75	1704.75
2	102.58	204	3292	92	11.03		
10% Bamboo							
3	101.65	205	3291	85	10.47	10.08	1461.27
3	102.60	206	3395	80	9.68		
15% Bamboo							
4	103.28	208	3372	70	8.36	8.63	1252.16
4	100.72	207	3120	71	8.91		
20% Bamboo							
5	102.48	205	3125	51	6.18	5.82	844.252
5	102.45	205	3215	45	5.46		
25% Bamboo							
6	102.73	206	3150	50	6.03	5.6	812.355
6	102.91	206	3082	43	5.17		
15% Bamboo & 5% Quarry dust							
7	103.12	206.5	3156	39	4.67	4.44	643.435
7	102.97	205.5	3127	35	4.2		

Case no	Dia (mm)	Height (mm)	Weight (kg)	Load (kn)	Crushing Strength (mpa)	Average Crushing Strength (mpa)	PSI
15% Bamboo & 10% Quarry dust							
8	102.37	206	3302	48	5.83	5.84	847.318
8	103.25	205	3282	49	5.85		
15% Bamboo & 15% Quarry dust							
9	102.83	206	3230	55	6.62	6.43	932.841
9	103	206	3250	52	6.24		

For 28 days							
Case no	Dia (mm)	Height (mm)	Weight (kg)	Load (kn)	Crushing Strength (mpa)	Average Crushing Strength (mpa)	PSI
Normal concrete							
1	101.27	206	3408	167	20.72	20.15	2919.33
1	101.51	206	3442	158	19.52		
5% Bamboo							
2	102.09	205.5	3487	140	17.10	16.64	2412.75
2	101.57	205	3372	131	16.17		
10% Bamboo							
3	102.12	205	3195	108	13.19	11.89	1724.27
3	102.27	206	3372	131	16.17		

Case no	Dia (mm)	Height (mm)	Weight (kg)	Load (kn)	Crushing Strength (mpa)	Average Crushing Strength (mpa)	PSI
15% Bamboo							
4	102.55	206	3287	73	8.84	8.71	1263.76
4	101.87	205	3323	70	8.59		
20% Bamboo							
5	101.66	205	3218	57	7.02	6.81	987.938
5	103	206	3173	55	6.6		
25% Bamboo							
6	103.07	205.5	3185	52	6.23	6.48	939.787
6	1102.03	206	3177	55	6.73		
15% Bamboo & 5% Quarry dust							
7	101.83	206	3283	45	5.53	5.32	772.205
7	102.17	205	3123	42	5.12		
15% Bamboo & 10% Quarry dust							
8	102	206	3352	76	9.3	8.94	1297.31
8	101.87	205.5	3253	97	8.59		
15% Bamboo & 15% Quarry dust							
9	101.91	205	3242	90	11.09	11.42	1655.79
9	102.31	205.5	3253	97	11.8		

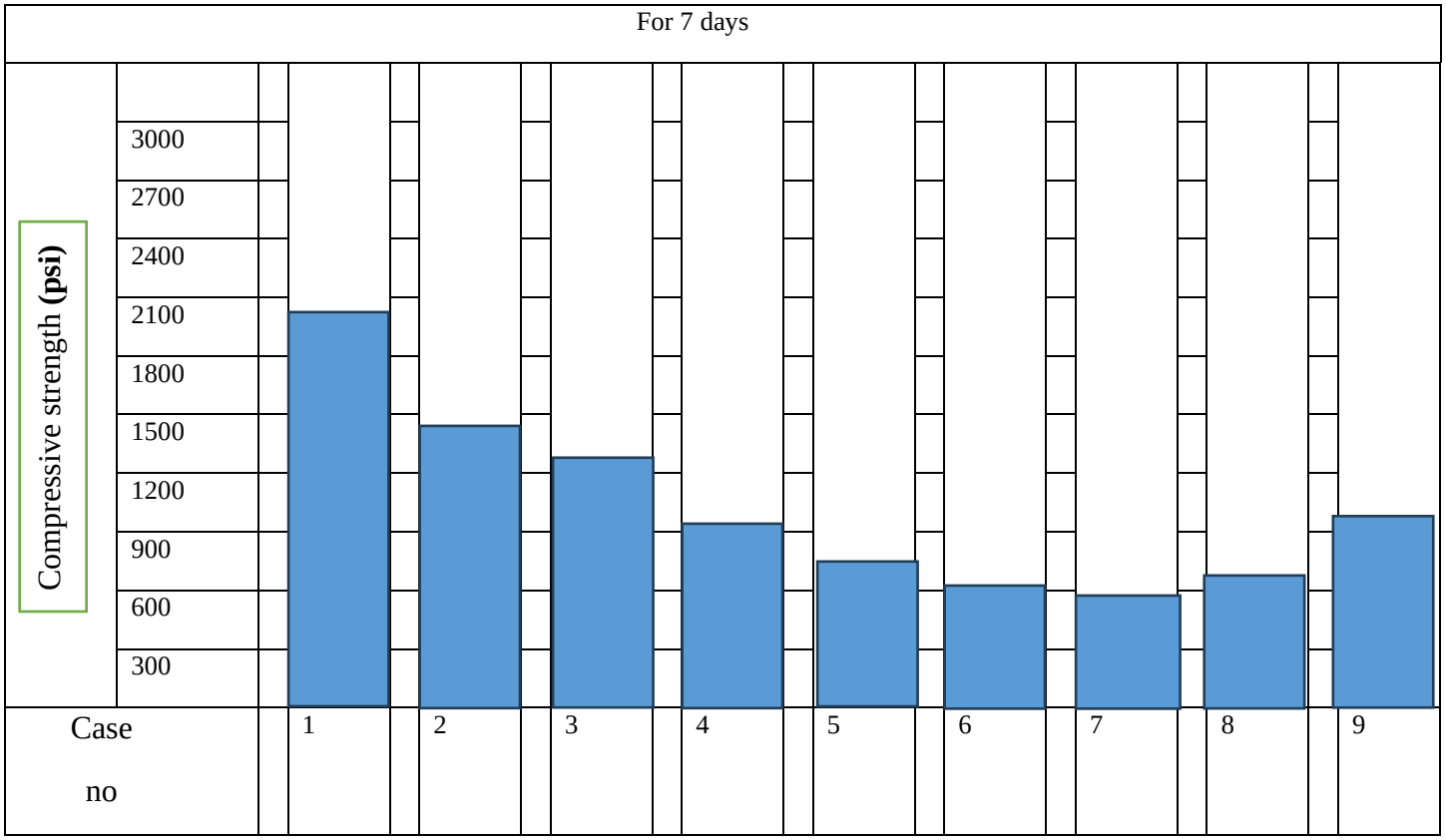


Fig 4-1. Compare with normal concrete graph for 7 days

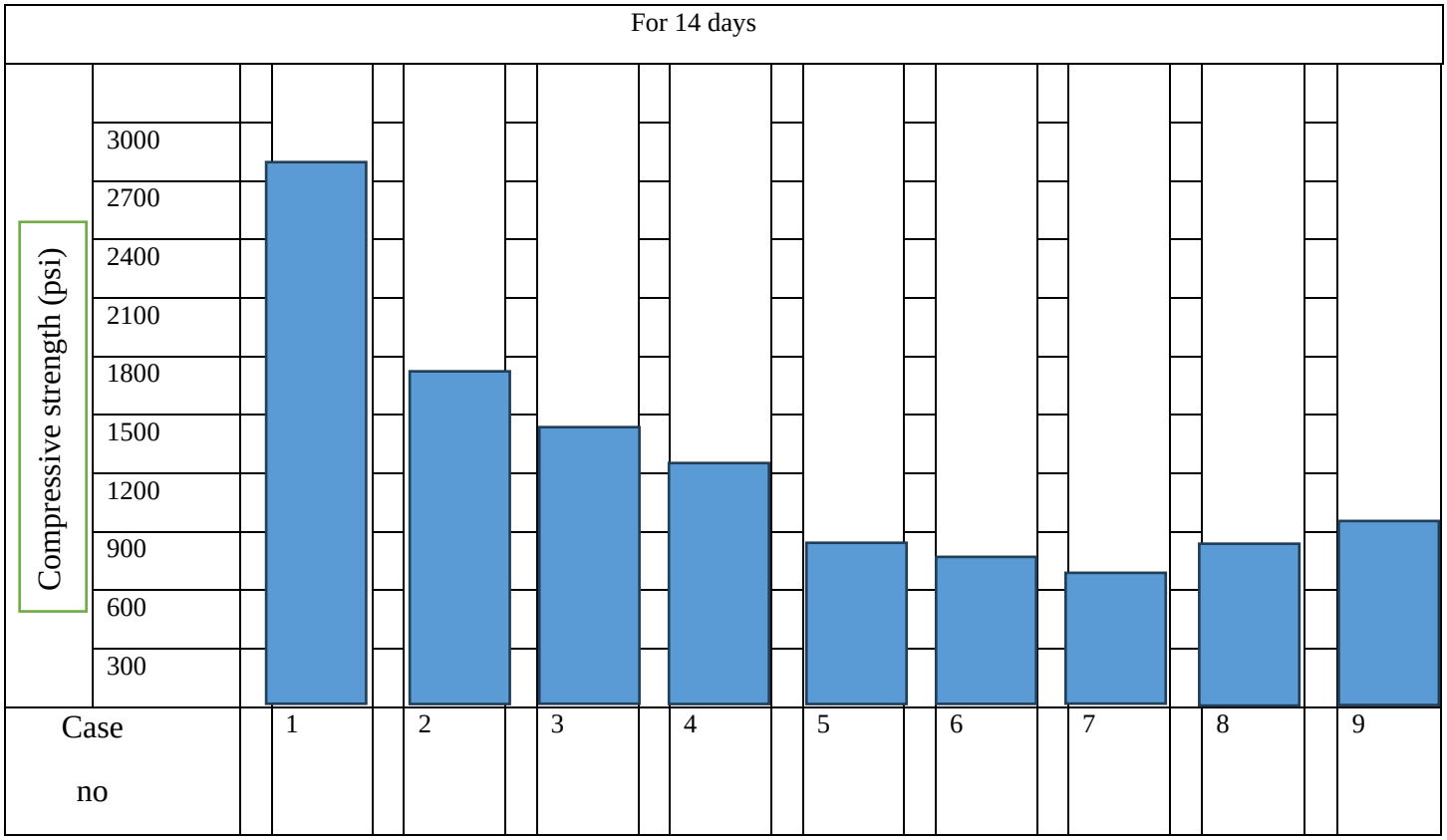


Fig 4-2. Compare with normal concrete graph for 14 days

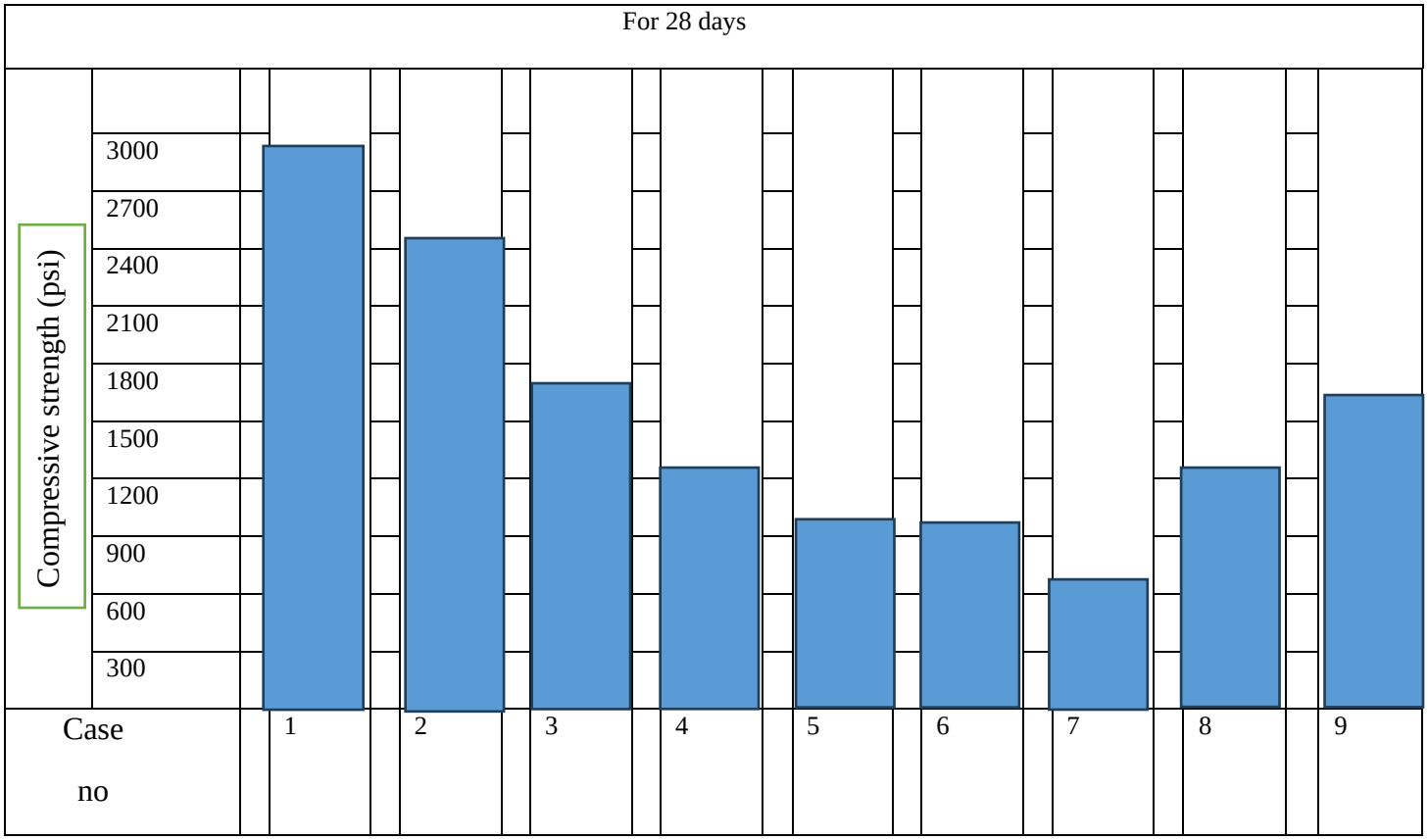


Fig 4-3. Compare with normal concrete graph for 28 days

➢ 4.3 Summary

The "Results and Discussion" section stands as the culmination of empirical data and interpretative insights, driving the narrative towards a more profound understanding of the application of Bamboo and Quarry dust in enhancing concrete's compressive strength and broader performance attributes.

CHAPTER 5

Conclusions and Future Works

➢ 5.1 Conclusions

We have replacing coarse aggregate with 5%, 10%, 15%, 20% and 25% Bamboo to normal concrete, again replacing coarse aggregate with 15% Bamboo and replacing fine aggregate with 5%, 10%, & 15% Quarry dust. To evaluate the compressive strength, tests were conducted at 7, 14, and 28 days. From this experimental results it is observed that replacing coarse aggregate with 5%, 10%, 15%, 20%, 25% of Bamboo compressive strength is gradually decreased. But when we replaced coarse aggregate with 15% of the bamboo and replaced fine aggregate with 5%, 10% and 25% of the quarry dust compressive strength is gradually started to increase. From these findings, we conclude that replacing coarse aggregate with bamboo and fine aggregate with Quarry dust are is effective for increasing compressive strength.

➢ 5.2 Limitations and Recommendations for Future Works

Limitations:

Material Availability: Bamboo and Quarry dust may be easily accessible in all regions, potentially affecting the scalability of this solution. Cost Implications: The cost-effectiveness of using these materials in large-scale construction is not fully explored and may vary based on local markets. Durability Concerns: Long-term durability and performance of concrete with these materials under different environmental conditions require further investigation. Optimal Mix Proportions: Determining the exact proportions of Bamboo and Quarry dust that consistently yield the best strength results can be challenging.

Recommendations:

Further Research: Conduct long-term studies on durability, especially under extreme weather conditions, to validate the use of Bamboo and Quarry dust. Field Trials: Implement pilot projects in real-world construction to evaluate performance and practicality on a larger scale. Cost-Benefit Analysis: Assess the economic viability of using these materials, considering factors like transportation, processing, and availability. Refinement of Mix Ratios: Explore different combinations and curing methods to optimize the balance between compressive strength and material use.

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