Utilization of Eggshell Powder as a Partial Replacement of Fine Aggregate

Submitted By

Mostafizur Rahman

A Thesis Submitted to the Department of Civil Engineering, Daffodil International University is a Partial Fulfillment of the Requirement for the award of the Degree of **Bachelor of Science in Civil Engineering**

Department of Civil Engineering

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CERTIFICATION

I would like to say that the thesis paper on "**Utilization of Eggshell Powder as a Partial Replacement of Fine Aggregate**" was written by Mostafizur Rahman with ID: 201-47-376. His Project Paper is an excellent work. To my knowledge, it is original.

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The project and thesis **Utilization of Eggshell Powder as a Partial Replacement of Fine Aggregate.** Submitted by **Mostafizur Rahman**, ID No: **201-47-376,** Session: Spring 2020, has been accepted as satisfactory. This work fulfils, in part, the requirements for the Bachelor of Science in Civil Engineering degree. The presentation of the work was held on 20th November 2024.

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DEDICATION

I dedicate this thesis to my beloved parents, whose unwavering support and generosity have been the foundation of my academic journey. Your belief in my abilities has been my primary motivation.

I extend my heartfelt gratitude to my dear Father. Your constant support, encouragement, and confidence have been the cornerstone of my progress. The sacrifices and wisdom you have shared have deeply shaped who I am. This achievement is as much yours as it is mine. Thank you for being my guiding light.

I am thankful to my family for their love, compassion, and patience, which have provided me with steadfast support. Your unwavering belief in my dreams has driven me to achieve great success.

I deeply appreciate my educators and mentors, whose guidance and wisdom have greatly influenced my academic pursuits. Your dedication to fostering knowledge and intellectual curiosity has been invaluable.

This work is dedicated to all those who have played a significant role in my life, contributing to my personal growth and accomplishments. Your constant support and motivation have been my enduring source of inspiration

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ABSTRACT

As urban areas continue to expand, pursuing a better quality of life has led to increased environmental pollution. Currently, the world generates approximately 2.01 billion tons of municipal solid waste annually, with Bangladesh contributing around 25 thousand tons, posing significant environmental and health risks. Concurrently, the construction of new buildings, which heavily rely on materials like cement, is rising. However, the high cost and scarcity of quality cement, compounded by the detrimental effects of certain additives like ammonia, calcium nitrate, and silicates, present challenges. Eggshells, a readily available waste product from biscuit and bread factories, primarily contain calcium carbonate. This study explores the potential of using eggshell powder as a partial replacement for fine aggregate. By incorporating eggshell powder in varying proportions (0%, 3%, 9%, 15%), and conducting sieve analysis, Splitting tensile strength, and compressive tests, the research demonstrates that a 9% eggshell powder mixture can effectively replace fine aggregate. This approach not only mitigates waste but also offers a cost-effective solution.

CHAPTER ONE
INTRODUCTION

1.1 General

Cement industry is most involved in urban development. Concrete is used extensively around the world to construct most buildings, bridges, and other structures. As a result, it has been correctly identified as the backbone of a country's economic development. The main ingredients of cement include sand, limestone, clay, and shale. Eggshells are considered bio waste. Calcium carbonate, the major component of eggshells, is also found in several varieties of marble as well, chalk, and limestone. About 94-96% calcium carbonate (Malahayati, 2021) is found in eggshell.

Fig. 1.1 Eggshells

1.2 Background

Manufacturing cement is an essential part of the construction sector, as it is required for global infrastructure development. However, it offers substantial environmental challenges. Cement manufacturing is a highly efficient process that accounts for approximately 8% of worldwide carbon dioxide (CO_2) emissions, mostly due to the processing of limestone ($CaCO_3$) and the burning of fossil fuels. As the need for building materials grows, there is a pressing need to investigate sustainable options that can reduce the environmental impact of the manufacture of cement.

1.3 Using Sustainable Concrete

Considering growing environmental issues, it is critical that environmentally friendly and sustainable materials be explored for a broader range of uses in order to provide viable alternatives to traditional materials. Green concrete is unrelated to its hue. Green concrete is concrete that contains at least one ingredient made from waste, or whose manufacturing process does not harm the environment.

1.4 Statement of the problem

The cement business has substantial environmental issues, such as excessive carbon emissions and loss of natural resources. Traditional cement manufacturing is primarily dependent on the excavation and reduction of limestone, is which can be both environmentally and economically expensive. In addition, disposing of eggshell waste is a different environmental issue. There is a need for new solutions that solve both challenges at the same time, such as using waste materials like eggshells in cement manufacturing.

1.4 Rational

A rash disposal of eggshells has major consequences. It is toxic and bio-waste. This pollution affects people, the soil, and the air. Certain bacteria, such as Salmonella enteritis, may infect eggshells. Eggshells are regularly tossed into the environment, yet they can be used for a variety of purposes if not discarded.

1.5 Objectives

- To assess the effectiveness of eggshell powder as a partial replacement of fine aggregate concrete by compressive and Splitting tensile strength test.
- To determine an appropriate ratio for eggshell additive as a partial fine aggregate substitute.

1.6 Significance of the Study

There are numerous potential advantages of employing eggshells in cement manufacturing. Environmentally, it has the potential to considerably cut CO_2 emissions related with cement production while also reducing the amount of waste transported to landfills. Economically, it might reduce the cost of raw materials for cement manufacturing while also finding a new use for a waste product. This study also promotes the ideas of an economy that is circular by encouraging the recycling and reuse of waste products in industrial processes. This study intends to help establish more sustainable construction techniques by exploring the practical application of eggshells in cement.

CHAPTER TWO
LITERATURE REVIEW

2.1 A Review of Cement Production.

Cement manufacture is a multifaceted process that involves the mining and processing of raw materials, most notably limestone and clay. The raw materials undergo heating in a kiln that rotates at high temperatures (about 1450°C) to create clinker, which is subsequently crushed with gypsum to make cement. The chemical reactions that occur in the kiln convert the raw ingredients into compounds like tricalcium silicate and dicalcium silicate, which contribute to the strength and durability of cement. The cement business is critical to the construction sector since it provides a necessary material for infrastructure development.

2.2 Components of Eggshells

Eggshells are mostly made up of calcium carbonate ($CaCO_3$), but they also contain other elements that contribute to their distinct structure and features. A full description of the composition and properties of eggshells is provided below:

2.2.1 Composition:

Calcium carbonate ($CaCO_3$).

Function: Adds rigidity and strength to the eggshell. The shell's basic structural matrix is made up of calcium carbonate, a crystalline substance.

Structure: Calcite crystals are placed in an extremely ordered method to optimize strength.

Magnesium carbonate ($MgCO_3$) and calcium phosphate ($Ca3\ (PO_4)_2$)

Percentage: Less than 1%

Function: These minerals help to increase the shell's toughness and durability. Magnesium carbonate helps to stabilize the structure, and calcium phosphate has a small strengthening role.

Other Trace Elements:

Components include sodium, potassium, zinc, and manganese. Function: These elements exist in trace levels and serve important functions in biological functions such as shell formation and structural integrity.

2.2.2 Properties

1. Mechanical Strength: Hardness: Eggshells have a high calcium carbonate concentration, which makes them good at protecting the egg's contents.

2. Fracture Toughness: The organic matrix, particularly collagen, gives the shell toughness, preventing cracks and fractures.

Summary: Despite being utilized in different situations, cement and eggshells have comparable basic elements and purposes. The majority of eggshells, or 94%–97%, are made of calcium carbonate ($CaCO_3$), which gives them strength and stiffness due to their crystalline structure. Tricalcium silicate (C_3S) and dicalcium silicate (C_2S) are two types of calcium silicates that comprise up 70–80% of the cement mixture. Hydration processes provide these silicates their major binding strength.

2.3 Eggshells and Cement

The exclusive properties of expansive soils present serious construction-related issues. This study looks into stabilizing expansive soils by adding eggshell powder (ESP) to lime. When coupled with lime, eggshell powder, which is high in calcium oxide, can improve the characteristics of soil. According to experimental results, adding ESP improves compressive strength and decreases linear shrinkage; 5% ESP is the ideal level. By reusing waste materials, this method not only increases soil stability but also tackles environmental issues. (Alqaisi, 2020)

Bogue's equations for determining Portland cement clinker composition often don't apply to oil well cements due to additional oxides and phase reconversion. This study used Taylor's procedure, involving linear equations for the main clinker phases, to determine crystalline phase concentrations in oil well cement. Results showed good correlation with optical micrography, particularly for aluminate and ferrite contents. Incorporating eggshells, which are rich in calcium carbonate, can further enhance cement properties and sustainability. (Ulisses Targino Bezerra, 2011)

When disposed of in landfills, eggshell (ES), a bio-waste from bakers and fast-food restaurants, presents concerns to human health and the environment. Eggshell powder (ESP), which is high in calcium, can be added to low-calcium pozzolanic materials such as fly ash to improve the characteristics of concrete. Research indicates that at low replacement levels, ESP increases the compressive, flexural, and Splitting tensile strength of concrete; but, at larger percentages (over 10%), these strengths as well as the modulus of elasticity, can be diminished. ESP presents a viable solution for lowering cement output and environmental impact since, although having a lower specific gravity than cement, it minimizes water absorption and improves concrete durability. (Hamada, 2020)

Concrete is widely utilized in modern building, and novel materials are being investigated to improve sustainability. This work examines replacing some of the fine aggregate (three percent) with crushed groundnut shell and some of the cement (zero to fifteen percent) with powdered eggshell (0–15%) plus 1% nylon fiber. By lowering the demand for natural sand and cement, eggshell and groundnut shell are both waste products that aid in waste management and lower construction expenses. In order to show potential gains in strength and sustainability, the research focuses on assessing the standard compressive, flexural, and split Splitting tensile strength strengths of concrete using these environmentally beneficial additives (Depaa, 2020).

This study looks into the effects of adding eggshell ash mixed with Plastiment BV-40 to concrete in place of some of the cement. With different eggshell ash contents (0%–25%), tests for slump, compressive strength, Splitting tensile strength, and density were carried out. The findings show that adding eggshell ash to concrete decreases workability but increases compressive strength up to 5% replacement, beyond which strength starts to decrease. Eggshell ash also increases concrete's Splitting tensile strength. According to the research, eggshell ash can partially substitute cement in construction projects, which supports environmentally friendly building methods. (Aliyu, 2020).

This study assesses the use of oven-dried eggshell powder in both water- and air-cured concrete as a partial cement replacement. Eggshell powder was tested at 5%–20% by volume. The compressive and flexural strengths of water-cured concrete were found to have significantly improved, reaching 51.1% and 57.8%, respectively. When eggshell powder was used to fill in the voids, water absorption was lowered by 50%. Nevertheless, upon acid and alkali immersion, compressive strength dropped with increasing eggshell content, with a reduction in strength of up to 31.2%. It was discovered that 15% was the ideal replacement level for oven-dried eggshell powder. (Yeong Yu Tan, 2018).

This study investigated the possibility of using 100% recycled eggshells in place of traditional fine aggregate as a fine aggregate in concrete. Eighteen cubes were cast, cured, and their strength growth was compared with traditional concrete mixed with sand in a laboratory setting. The compressive strength decreased, but it was still within the range for lightweight concrete, according to the results. According to the research, eggshells can be utilized to make lightweight concrete that has advantages for lowering a structure's dead load. Eggshells have the potential to be a sustainable material for some concrete applications, according to this research. (S.A. Raji, 2015)

The topic of global warming and climate change is crucial, as cement plants account for 5-7% of the world's CO_2 emissions. In particular, fly ash (FA) and eggshell powder (ESP) are environmentally beneficial waste materials that can be used to reduce the amount of cement in concrete. Concrete mixtures with ESP of 5% and 10% and FA of 20%, 30%, 40%, and 50% were examined in the study. Slump, compressive strength, flexural strength, and ultrasonic pulse velocity tests were performed on both fresh and cured samples.

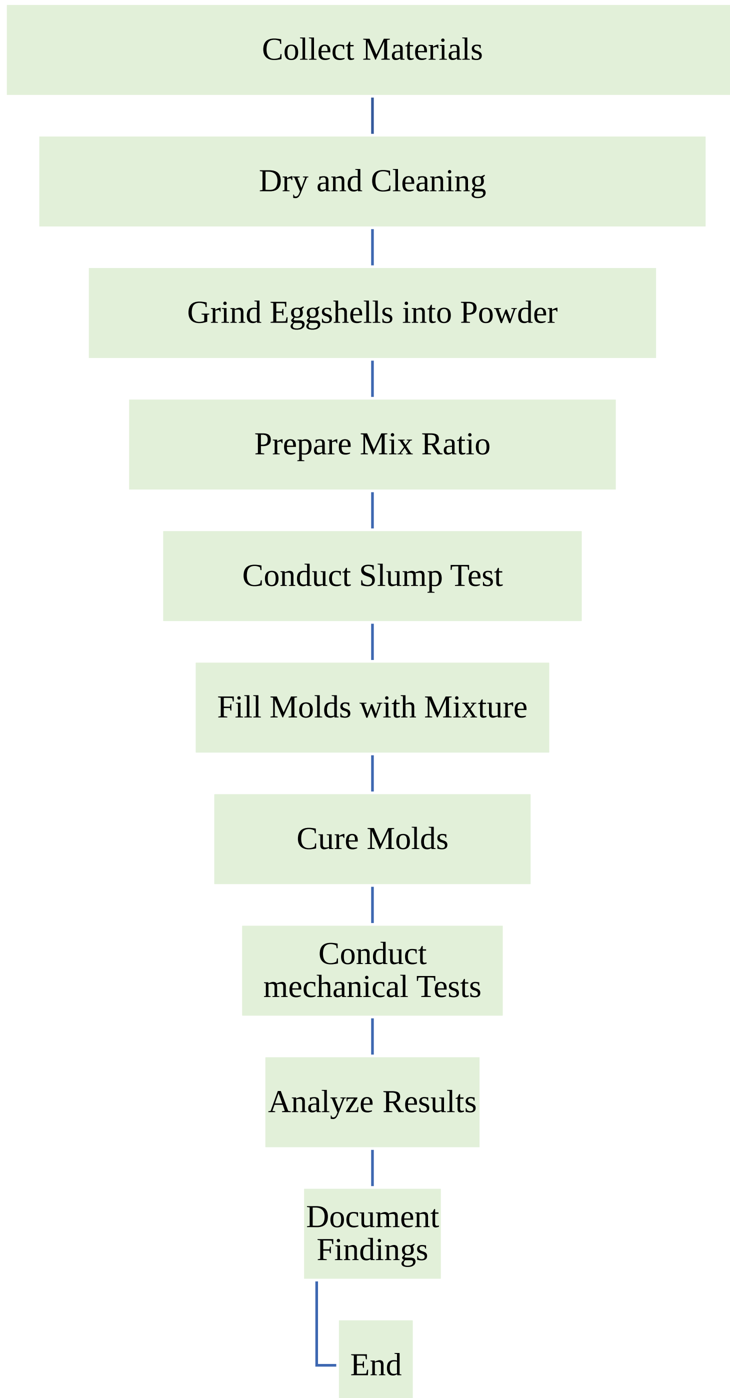
Specifically, compressive strengths of 58.9 MPa and 56 MPa were attained by the best mixes, which were 5% ESP with 30% FA and 5% ESP with 40% FA. These results show that high-strength concrete may be produced utilizing green ingredients in place of cement, resulting in a significant reduction in cement usage. (Teara, 2020).

Since it provides the structural support for buildings, bridges, and other structures, concrete is crucial for the development of infrastructure. The country of India is investing an estimated Rs. 4356 billion on infrastructure improvements by 2009, which will require a significant amount of concrete. But there is a cement manufacturing deficit in India, which drives up building costs. Waste items like eggshells, fly ash, silica fumes, and rice husk ash (RHA) are being investigated by the building industry as partial cement substitutes. Of them, RHA and Eggshells have the most promise for lowering cement use and building expenses, promoting the development of affordable and sustainable infrastructure. (R, 2013)

This study investigates the use of eggshell powder (ESP) in lightweight foamed concrete (LFC) with a density of 1300 kg/m^3 as a partial substitute for cement. The effects of different ESP replacement amounts (0%, 2.5%, 5%, 7.5%, and 10%) on the qualities of concrete, such as water absorption, compressive strength, surface absorption, and ultrasonic pulse velocity (UPV), were investigated over 7, 28, and 90 days. The best results were obtained with 7.5% replacement of ESP, which decreased absorption rates and increased compressive strength and UPV. Furthermore, life cycle assessment (LCA) demonstrated benefits for the environment, lowering impacts by 6.6% to 9.9% in areas including ozone layer depletion and climate change, emphasizing ESP's potential for sustainable concrete production. (Hock Yong Tiong, 2020).

With varying amounts of eggshell powder (0% to 20%) substituting some of the cement, this study assesses the usage of eggshell powder as an additive in Grade 25 concrete. Portland cement, plasticizer, crushed sandstone, river sand, and eggshell powder were all ingredients in the concrete mix. The results indicated that all of the mixes had a 65–75 mm medium workability slump. The highest compressive strength was reached by concrete containing 10% eggshell powder, at 42.82 N/mm^2, which was 57% higher than the control. When eggshell powder was raised from 0% to 20%, flexural strength improved from 2.36 to 3.50 N/mm^2. Furthermore, there were notable decreases in both water absorption and water penetration in eggshell concrete. (DOH Shu Ing, 2014)

CHAPTER THREE
METHODOLOGY



3.1 General

This chapter outlines the exact procedures needed to form a cylinder from a cement, eggshell, stone, and sand mixture. The methodology is summarized as follows:

1. Test the current state of technology.
2. Estimate of materials.
3. Create a mold.
4. Assess the model's resilience.

Fig. 3.1 Materials for molds

3.2 Current State of Technology.

Using online resources including articles and films that have been released, a thorough analysis of the material and current recycling technologies was carried out. A summary of the particular results is provided in the preceding chapter.

3.3 Analysis the Properties

These days, fast food is the most popular foods. You can see all of these in the city's alleyways. In addition, there are large facilities that produce pastries and biscuits. These bakeries and fast food restaurants use a lot of eggs. Typically, eggshells are disposed of in the trash. If we decide to, we can readily gather the eggshells from these locations. It has calcium carbonate in it, which can contribute most to the creation of cement. An average of about 35% more eggshell ash is added to the cement stabilized matrix, increasing its strength. By removing this bio-waste from the environment, we will also reduce the cost of cement used in construction and prevent pollution in our surroundings.

3.4 Collection of the Properties

We need some necessary materials for the test, like eggshells, sand, cement, and stone. Which we may get from local area.

3.4.1 Eggshells

We usually collect eggshells from street hawkers. They will easily sell as per kg at a nominal price only. We initially collected 9 kg of eggshells. Then let it dry in the sun.

3.4.2 Cement Bag

We have used a local brand of cement for the experiment. It is Ordinary Portland Cement (OPC). We can get it easily.

Fig. 3.2 Cement

3.4.3 Stone

We use a 20-25mm stone sieve for this experiment. We collect this stone from Pathorghat, Gabtoli, Dhaka. The stone FM is 6.5.

Fig. 3.3 20-25mm Stone

3.4.4 Water

We use as usual tap water for mixing and curing mold. When producing concrete, the water utilized must be devoid of any hazardous substances such as oil, acid, alkali, salt, sugar, slit, and organic debris.

3.4.5 Sand

We collect selected sand from the local area which FM is 2.7

3.5 Cleaning and Grinding Process

We put these eggshells in the oven for 24 hours for drying. After that, a cleaning procedure was used on the dried eggshells to make sure no organic material was left behind. Equipment was used to crush the dry, clean eggshells into a fine powder. To guarantee consistency in the finished product, the grinding procedure was carried out repeatedly until a uniform particle size was reached.

3.6 Instruments

We need some instruments like

1. Oven
2. Tamping rod, Trowel, Shovel,
3. Water Jar, Steel bowl
4. Weight machine, Measuring tap
5. Slump, Brush
6. Grinder machine
7. Sieves (4mm, 8mm, 16mm, 50mm, 30mm)

3.7 Procedure

1. The cement, sand, and stone mixture used in this experiment had a volume of 1:1.5:3, with eggshells making up 0%, 3%, 9%, and 15% of the cement.

2. Since each of the 18 cylinders has required 5 liters of water.

3. Initially, the eggshells are left to dry in the sun. A 100-degree Celsius oven is also required. Then, it is ground into a powder using a grinder. All we have to do is take the powder and supernatant, sift the analysis, and discard them. Weighting 5.5 grams, calcium carbonate makes up about 95% of dried eggshells. There will be 1.5 grams left over after that. For the test, we're simply going to need fine powder. We'll perform a sieve analysis on this.

4. The concrete slump test shows the batch quality and flow ability of the material. Therefore, we first test the mixing in the slump. All are combined and placed in the mold after passing the test. Prior to inserting the mobile into the mold, it is preferable to affix it inside. In three steps, add the spices to the mold. This is the first experience camping with a side vibration and a third section. I'll finish the molds in this order. Keep in mind that there isn't any form of void or honeycomb inside. It won't receive a proper load otherwise. We will create each cylinder in the same way.

Fig. 3.5 Clean Eggshell

Fig. 3.4 Eggshell for oven dry

Fig. 3.6 Grinder

Fig. 3.7 Powder of Eggshell

Fig. 3.9 Sieve Analysis

Fig. 3.8 Mixing Materials

3.8 Cylinder Test

Compressive strength test and Splitting tensile strength test is compulsory for this experiment. To assess the mechanical properties, suitability, and performance of materials for various structural and engineering applications, compressive and Splitting tensile strength tests are necessary. These tests provide vital data for design, quality control, and ensuring the safety and dependability of components and structures. A UTM (Universal Testing Machine) used for all the test. Generally, structures made of concrete are meant to support weight. The weight of compression is supported by load-bearing masonry structures made of concrete. Consequently, a concrete's compressive strength is the primary determinant of its crucial fitness for construction.

Fig. 3.10 Cylinder

3.9 Compressive Test

To test the specimens filled with mortar for Compressive strength:

1. Specimen Placement: Set place the specimens such that the testing machine's plates are horizontally aligned with their flat sides. Make sure that each specimen's mortar-filled face is pointing upward toward the machine's plate
2. Loading Procedure: At a rate of 14 kn/mm² (143 kg/cm²) per minute, gradually apply a constant load. Apply the load continuously until the specimen fails or a crack appears. Keep track of the final load at the point of failure as well as the peak load during this phase. The sample's compressive strength is indicated by the peak load.

3. Documentation of findings: Keep a table with each sample's compressive strength test findings. To ensure reliable findings, make sure all samples are completely dry before testing.

3.10 Splitting tensile strength Test

To test the specimens filled with mortar for Splitting tensile strength:

1. Placement of the Specimen: Hold the specimens vertically so that their flat surfaces are up against the testing machine's plates and that the face filled with mortar is facing upward.

2. Steps involved in loading: Apply a consistent load gradually at a rate of 14 kn/mm² (143 kg/cm²) per minute. The maximum load at the point of failure should be observed and noted, as it signifies the sample's Splitting tensile strength.

3. Documentation: Keep a table with each sample's Splitting tensile strength test results. To ensure the best accuracy, make sure samples are completely dry.

Fig. 3.11 Compressive Strength Test

Fig. 3.12 Splitting Tensile Strength Test

CHAPTER FOUR
RESULT AND DISCUSSION

4.1 General

This chapter includes an overview of the many discoveries, as well as the experiment's outcomes and other tests carried out during the investigation. the general characteristics of several cylinder designs. We created 72 cylinders in total for 4 ratios for this test. 18 molds were broken as part of the 7, 14, and 28-day test, with 18 molds per ratio. To get its optimum value, the mold was taken out of the curing process and left to dry for a full day before testing. Every cylinder was the same size. We'll average every value.

4.2 Sieve Analysis Test

Table 1: Coarse Aggregate

Sieve size	**weight retained(g)**	**% retained**	**cumulative wt. retained%**	**% Finer**
25	0	0	0	100
19	2580	52.49	52.49	47.507
9.5	290	5.90	58.39	41.60
4.75	1190	24.21	82.60	17.39
2.36	160	3.25	85.85	14.14
1.18	230	4.67	90.53	9.461
0.6	290	5.98	96.43	3.56
0.3	115	2.33	98.77	1.22
0.15	60	1.22	100	0
Total	4915	100	665.10	

Then FM = 665.10/100

=6.65

Standard FM = 6.65-8

Table 2: Fine Aggregate

Sieve size	**weight retained(g)**	**% retained**	**cumulative wt. retained%**	**% Finer**
4	52.9	2.80	0	100
8	87	4.61	4.54	95.45
16	366	19.40	23.55	76.44

30	810	42.95	65.52	34.47
50	495	26.24	92.50	7.49
100	75	3.97	97.19	0
Total	1885.9	100	270.84	

FM = 2.7

Standard FM = 2.3-2.9

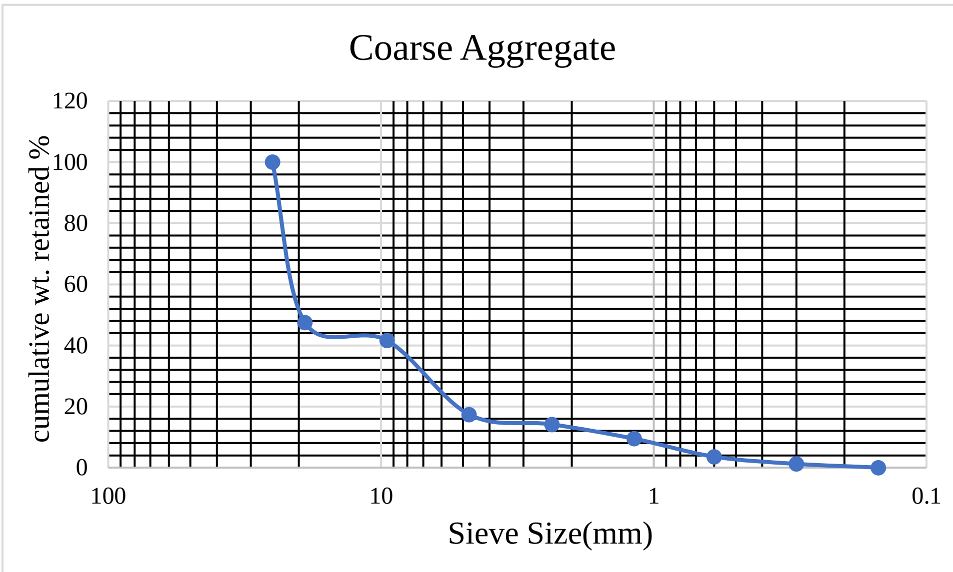


Fig. 4. 1 Sieve Analysis of Coarse Aggregate

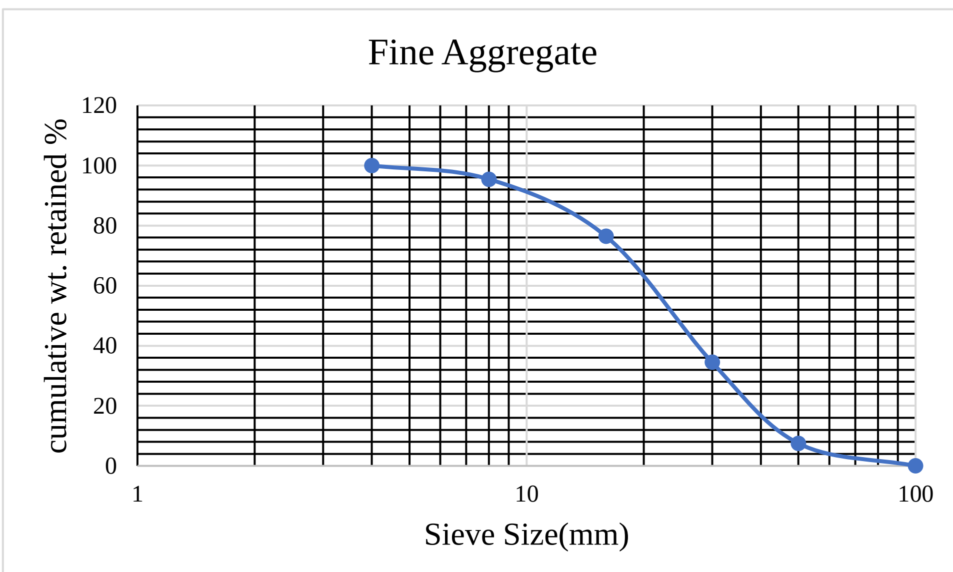


Fig. 4. 2 Sieve Analysis of Fine Aggregate

4.3 Compressive strength

Table 3: Compressive strength of cylinder without eggshell powder

Compressive Strength of cylinder						
Day	**Specimen ID**	**Ratio**	**Specimen area(in^2)**	**Crushing Load (lb.)**	**Compressing Strength (psi)**	**Avg. Compressing Strength**
7	T 1	0%	12.6	23829.86	1891.25	1778.25
	T 2	0%		21581.76	1712.83	
	T 3	0%		21806.57	1730.68	
14	T 4	0%		22930.62	1819.89	1909.10
	T 5	0%		28550.87	2265.94	
	T 6	0%		20682.52	1641.46	
28	T 7	0%		25178.72	1998.31	2152.94
	T 8	0%		27651.63	2194.57	
	T 9	0%		28550.87	2265.94	

Table 4: Compressive strength of cylinder with 3% eggshell powder

Compressive Strength of cylinder						
Day	**Specimen ID**	**Ratio**	**Specimen area(in^2)**	**Crushing Load (lb.)**	**Compressing Strength (psi)**	**Avg. Compressing Strength**
7	T 1	3%	12.6	21806.57	1730.68	1558.20
	T 2	3%		19558.47	1552.25	
	T 3	3%		17535.18	1391.68	
14	T 4	3%		20682.52	1641.46	1831.78
	T 5	3%		26752.39	2123.20	
	T 6	3%		21806.57	1730.68	
28	T 7	3%		25178.72	1998.31	2325.41
	T 8	3%		37543.27	2979.62	
	T 9	3%		25178.72	1998.31	

Table 5: Compressive strength of cylinder with 9% eggshell powder

Compressive Strength of cylinder						
Day	**Specimen ID**	**Ratio**	**Specimen area(in^2)**	**Crushing Load (lb.)**	**Compressing Strength (psi)**	**Avg. Compressing Strength**
7	T 1	9%	12.6	28550.87	2265.94	2093.46
	T 2	9%		24279.48	1926.94	
	T 3	9%		26302.77	2087.52	
14	T 4	9%		31473.4	2497.88	2271.88
	T 5	9%		27426.82	2176.73	
	T 6	9%		26977.2	2141.04	
28	T 7	9%		29899.73	2372.99	2587.09
	T 8	9%		32147.83	2551.41	
	T 9	9%		35744.79	2836.88	

Table 6: Compressive strength of cylinder with 15% eggshell powder

Compressive Strength of cylinder						
Day	**Specimen ID**	**Ratio**	**Specimen area(in^2)**	**Crushing Load (lb.)**	**Compressing Strength (psi)**	**Avg. Compressing Strength**
7	T 1	15%	12.6	20232.9	1605.78	1623.62
	T 2	15%		19108.85	1516.57	
	T 3	15%		22031.38	1748.52	
14	T 4	15%		19783.28	1570.10	1778.25
	T 5	15%		22256.19	1766.36	
	T 6	15%		25178.72	1998.31	
28	T 7	15%		21581.76	1712.83	1891.25
	T 8	15%		24729.1	1962.62	
	T 9	15%		25178.72	1998.31	

4.4 Splitting tensile Strength

Table 7: Splitting tensile strength without eggshell powder

Splitting tensile Strength of cylinder						
Day	**Specimen ID**	**Ratio**	**Specimen area(in^2)**	**Crushing Load (lb.)**	**Splitting tensile Strength (psi)**	**Avg. Splitting tensile Strength**
7	S 1	0%	88	11240.5	127.73	129.43
	S 2	0%		11914.93	135.39	
	S 3	0%		11015.69	125.17	
14	S 4	0%	88	16860.75	191.59	189.04
	S 5	0%		17759.99	201.81	
	S 6	0%		15287.08	173.71	
28	S 7	0%	88	17535.18	199.26	205.22
	S 8	0%		17984.8	204.37	
	S 9	0%		18659.23	212.03	

Table 8: Splitting tensile strength of cylinder with 3% eggshell powder

Splitting tensile Strength of cylinder						
Day	**Specimen ID**	**Ratio**	**Specimen area(in^2)**	**Crushing Load (lb.)**	**Splitting tensile Strength (psi)**	**Avg. Splitting tensile Strength**
7	S 1	3%	88	8992.4	102.18	110.701
	S 2	3%		7868.35	89.41	
	S 3	3%		12364.55	140.50	
14	S 4	3%	88	14612.65	166.05	144.76
	S 5	3%		12364.55	140.50	
	S 6	3%		11240.5	127.73	
28	S 7	3%	88	14612.65	166.05	171.16
	S 8	3%		15736.7	178.82	
	S 9	3%		14837.46	168.60	

Table 9: Splitting tensile strength of cylinder with 9% eggshell powder

Splitting tensile Strength of cylinder						
Day	**Specimen ID**	**Ratio**	**Specimen area(in^2)**	**Crushing Load (lb.)**	**Splitting tensile Strength (psi)**	**Avg. Splitting tensile Strength**
7	S 1	9%	88	10116.45	114.95	123.47
	S 2	9%		11240.5	127.73	
	S 3	9%		11240.5	127.73	
14	S 4	9%	88	14612.65	166.05	166.05
	S 5	9%		15736.7	178.82	
	S 6	9%		13488.6	153.27	
28	S 7	9%	88	21581.76	245.24	241.84
	S 8	9%		20232.9	229.91	
	S 9	9%		22031.38	250.35	

Table 10: Splitting tensile strength of cylinder with 15% eggshell powder

Splitting tensile Strength of cylinder						
Day	**Specimen ID**	**Ratio**	**Specimen area(in^2)**	**Crushing Load (lb.)**	**Splitting tensile Strength (psi)**	**Avg. Splitting tensile-strength**
7	S 1	15%	88	10566.07	120.06	115.81
	S 2	15%		12814.17	145.61	
	S 3	15%		7193.92	81.74	
14	S 4	15%	88	14837.46	168.60	162.64
	S 5	15%		14163.03	160.94	
	S 6	15%		13938.22	158.38	
28	S 7	15%	88	20682.52	235.02	218.84
	S 8	15%		18659.23	212.03	
	S 9	15%		18434.42	209.48	

4.5 Compare with sample for Compressive Strength

According to the display, UTM loads against the ratio's %. Whereas some use powdered eggshells and 0% is just a concrete mixture. Studies indicate that when 3% eggshell powder is used, the compressive strength exceeds 0% and 15%. On the other hand, 3% is less than the crushing load of 9% eggshell powder. The test comparison with crushing loads at 7, 14, and 28 days

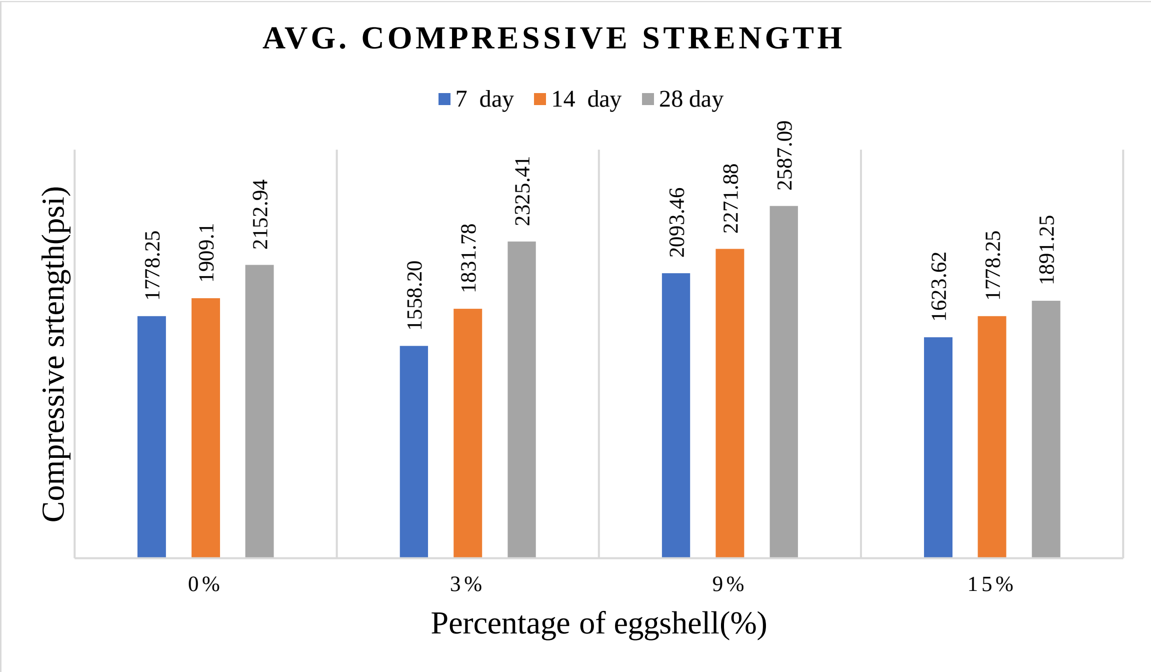


Fig. 4. 3 Avg. compressive strength (psi) (0%, 3%, 9%, 15%)

In this illustrator, we can see an average value of total compressive strength. From the graph, we observe that the line of 9% is the maximum which value is 2587.09 psi and we can say 9% mix ratio is the most suitable value.

4.6 Avg. compressive strength of 28 days

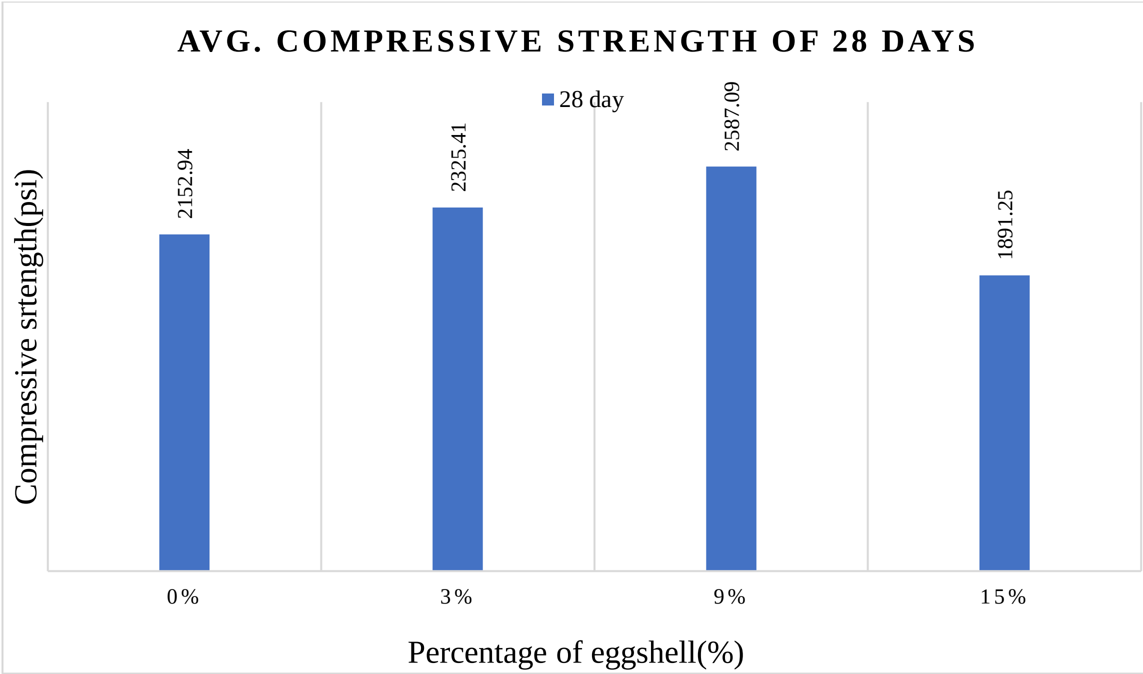


Fig. 4. 4 Avg. compressive strength (psi) of 28 days

In this illustrator, we can see an average value of total compressive strength for 28 days. From the graph, we observe that the line of 9% is the maximum value which is 2587.09 psi and we can say 9% mix ratio is the most suitable value.

4.7 Compare with sample for Splitting tensile Strength

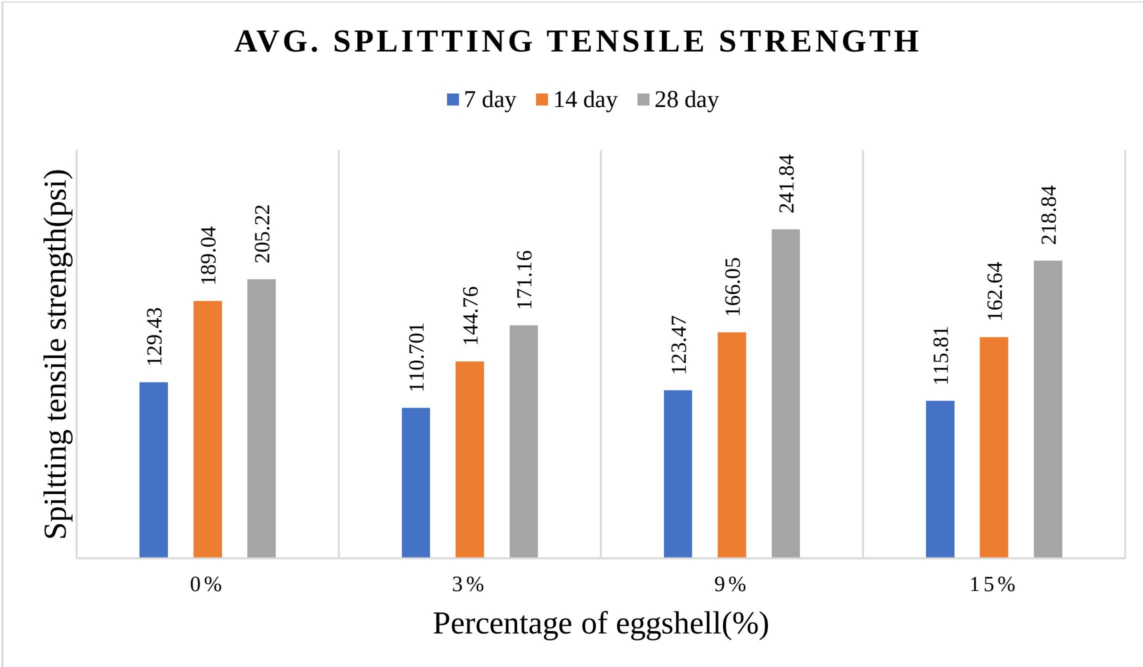


Fig. 4. 5 Avg. Splitting tensile strength (psi) (0%, 3%, 9%, 15%)

In this illustrator, we can see an average value of total Splitting tensile strength. From the graph, we observe that the line of 9% is the maximum which value is 241.84 psi and we can say 9% mix ratio is the most suitable value.

4.8 Avg. Splitting tensile Strength of 28 days

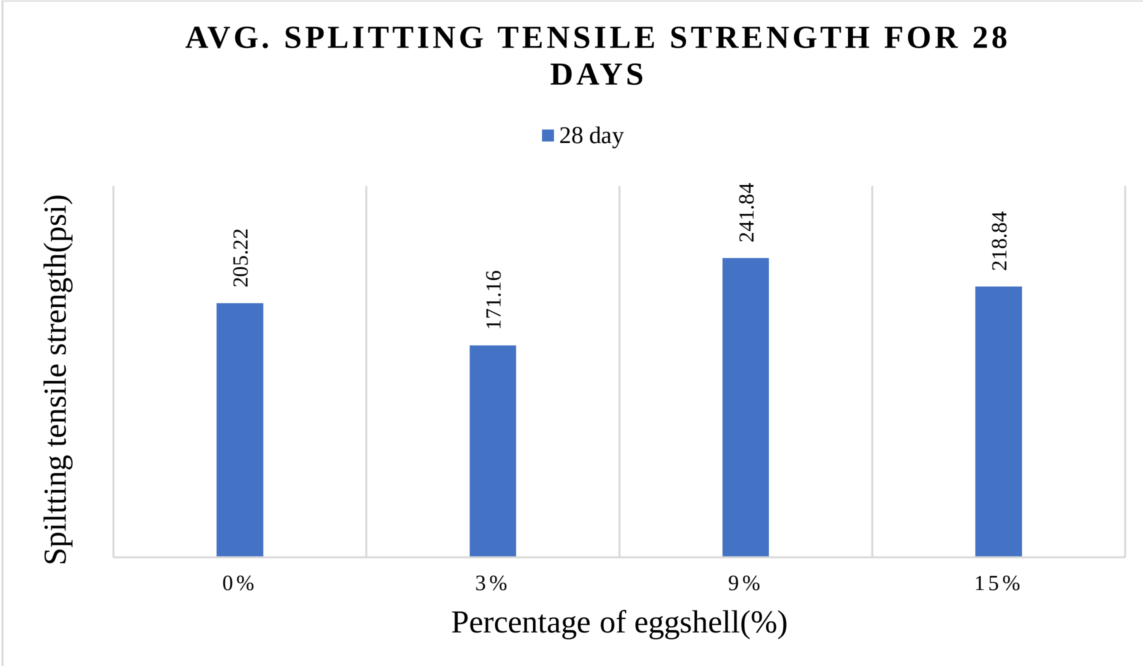


Fig. 4. 6 Avg. Splitting tensile strength (psi) for 28 days

In this illustrator, we can see an average value of total compressive strength for 28 days. From the graph, we observe that the line of 9% is the maximum value which is 241.84 psi and we can say 9% mix ratio is the most suitable value.

4.9 Compare with between normal and mixture concrete (Compressive Strength)

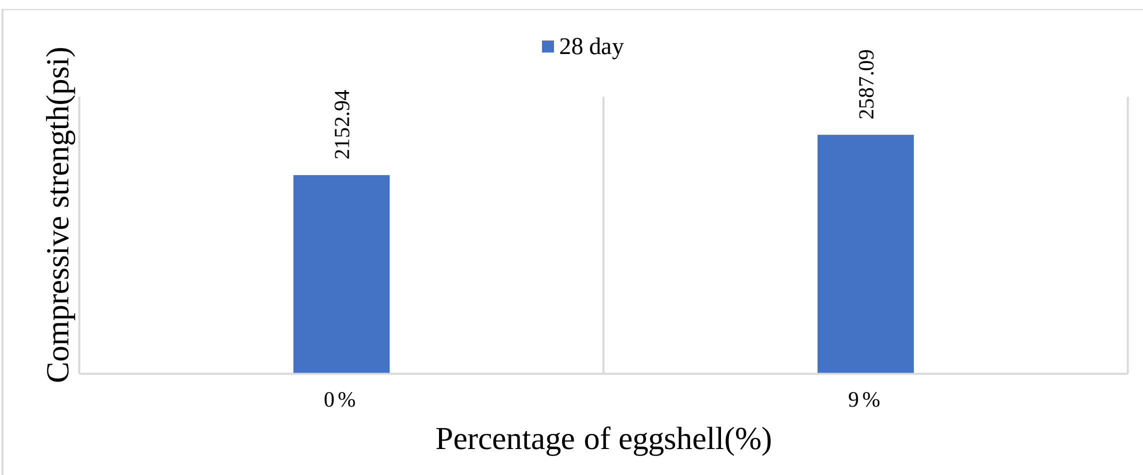


Fig. 4. 7 Compare with between normal and mixture concrete (Compressive Strength)

In this illustrator, we can see an average value of total compressive strength for 28 days. From the graph, we observe that the line of 9% is the maximum value which is 2587.09 and we can say 9% mix ratio is the most suitable value.

4.10 Compare with between normal and mixture concrete (Splitting tensile strength)

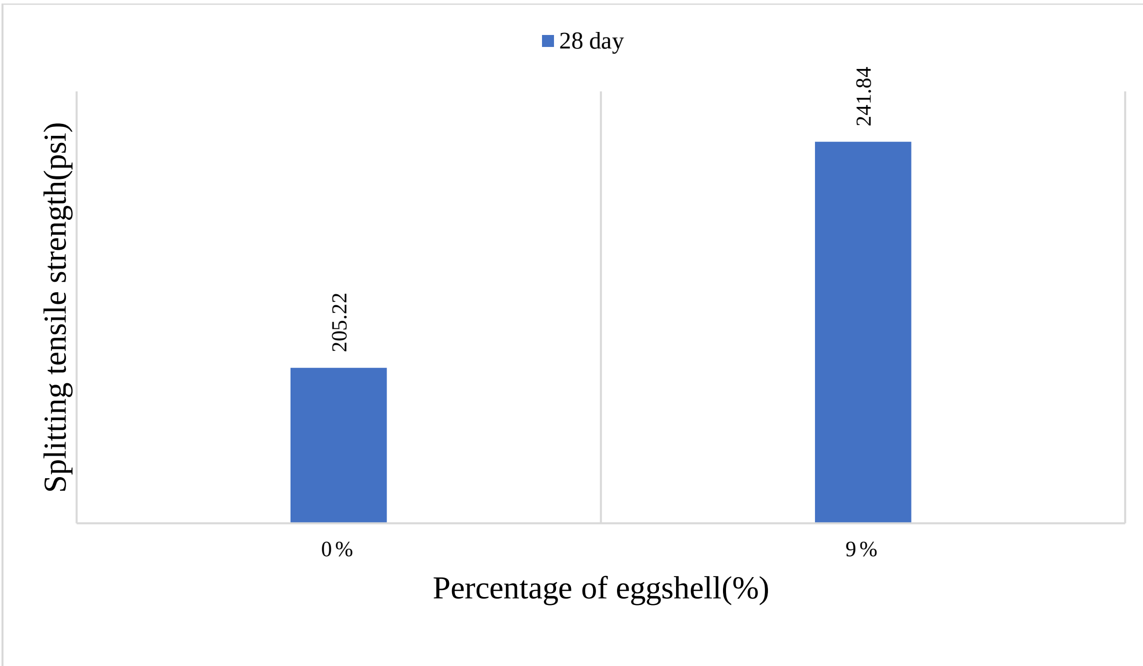


Fig. 4. 8 Compare with between normal and mixture concrete (Splitting tensile strength)

In this illustrator, we can see an average value of total Splitting tensile strength for 28 days. From the graph, we observe that the line between 0% and 9% and the percent of 9% is the maximum value which is 2587.09 and we can say the 9% mix ratio is the most suitable value.

4.11 Price Comparison

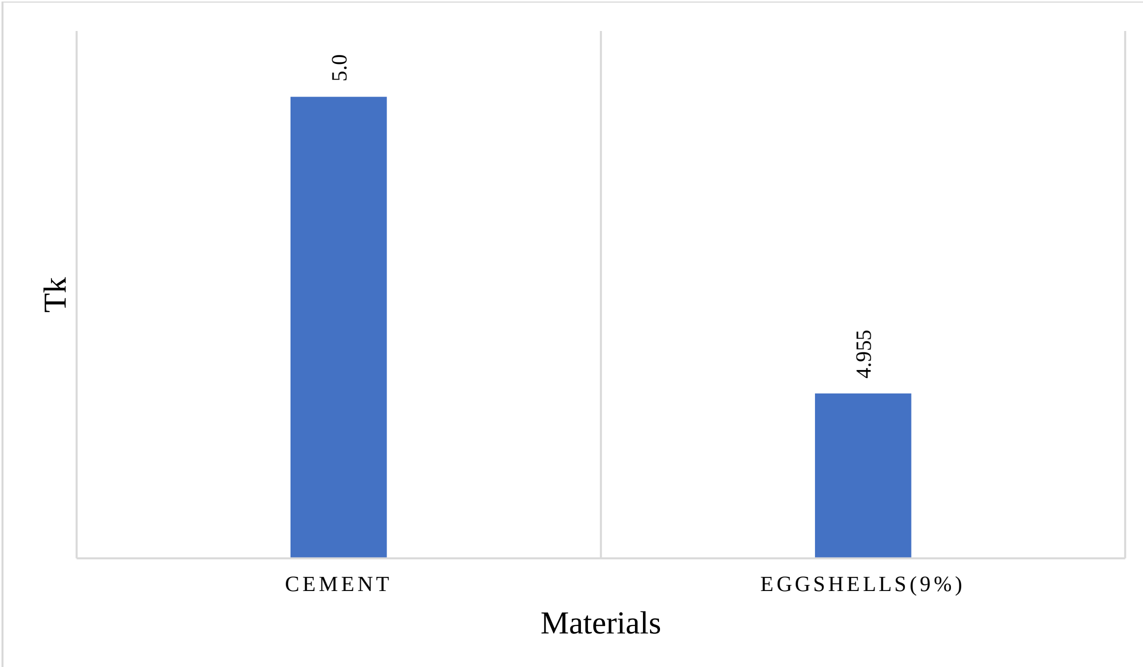


Fig. 4. 9 Price Comparison

Comment: Here we can see the comparable prices of cement and eggshells. Where the cost for 1 mold, cement = 5 tk, and Eggshells = 4.955 tk. Though it's a little low than cement it's very sustainable for our environment.

CHAPTER FIVE
CONCLUSION & RECOMMENDATION

Conclusion

This experiment highlights the financial and environmental benefits of using bio-waste, specifically eggshells, in concrete production. By incorporating 9% eggshell powder into fine aggregate, we achieved a satisfactory ratio that can be used as a partial replacement for fine aggregate. The results indicate that this mixture can provide equal or greater strength than normal concrete.

Key findings include:

1. Finely ground eggshells can be used as a partial replacement for fine aggregate, enhancing concrete's strength, workability, and environmental sustainability when optimized for replacement ratios.
2. A 9% eggshell powder mixture can match or exceed the strength of normal concrete.

Recommendations

Research on using eggshell powder (ESP) in concrete should continue now that its potential has been established. Future studies should aim to address the limitations identified in this experiment as thoroughly as possible. Specific recommendations include:

1. Continue exploring the use of fully cleaned and finely ground eggshell powder (ESP) as a construction material to enhance its reactivity with fine aggregates and reduce environmental pollution..

2. Investigate various replacement levels, typically ranging from 5% to 20% by weight of fine aggregate, to determine the optimal ratio for different concrete properties.

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APPENDIX

1. Calculate the FM of FA

FM = $\frac{\text{wt. retained\%}}{100}$

= $\frac{665}{100}$ = 6.65

2. Calculate the FM of CA

FM = $\frac{\text{wt. retained\%}}{100}$

= $\frac{28}{100}$ = 2.8

3. Volume of Cylinder

V=$\frac{\pi}{4}D^2h$

=$\frac{\pi}{4}4^2 8$

=100.53 in^3

=0.0582 cft (Per cylinder)

V= 18×0.0582 cft = 1.047cft (For 18 cylinder)

Shrinkage factor = 1.047 × 1.5 cft

= 1.75 cft

4. Volume of given ratio per 18 cylinders

Cement: Sand: Aggregate = 1: 1.5: 3

V = 1.75cft

Cement: $1.75 \times \frac{1}{1+1.5+3} = 0.38$ cf $= 9.011 \approx 9$ kg

Sand: $1.75 \times \frac{1.5}{1+1.5+3} = 0.47$ cft $= 13.52$ kg ≈ 13 kg

Aggregate: $1.75 \times \frac{3}{1+1.5+3} = 0.95$ cft $= 27.03$ kg ≈ 27 kg

Replacement ratios are- 0%, 3%, 9%, 15%

Total Cement for 3% = (9-0.270) = 8.73 kg and eggshell= $\frac{3}{100} \times 9 \times 1000$ = 270g

Total Cement for 9% = (9-0.810) = 8.19 kg and eggshell= $\frac{9}{100} \times 9 \times 1000$ = 810g

Total Cement for 15% = (9-0.9) = 7.65 kg and eggshell =$\frac{15}{100} \times 9 \times 1000$ = 1350g

5. Compressive strength

For Sample -1 (S 1)

Area A=$\frac{\pi}{4}d^2$ = $\frac{\pi}{4}4^2$ = 12.6 in^2

Crushing Load P = 23829.86lb.

Compressing Strength F = $\frac{P}{A}$ = $\frac{23829.86}{12.6}$ psi = 1891.25

Follow this for all samples.

6. Splitting tensile strength strength

For Sample -1 (S 1)

Area A=$\frac{\pi}{4}d^2h$ = $\frac{\pi}{4}4^2 7$ = 88 in^2

Splitting tensile strength Strength σ = $\frac{P}{A}$ = $\frac{11240.5}{88}$ psi = 127.73

Follow this for all samples.

7. Comparison of Cost

Cement bag (OPC) 50 kg = 500 tk

So, per kg cement cost = 10 tk

Stone sieves per cft = 180 tk

Sand per cft = 150 tk

For 18 molds, we need

Cement = 9kg

Another way,

For 9% admixture

We need 0.810 kg of eggshells

So, (Cement-Eggshells) = (9-0.81) = 8.19 kg

We take 9 kg eggshell = 90 tk

So, per kg eggshells = 10tk

Total cement needed for 9% = (Cement-Eggshells) = (9kg -0.81kg) = 8.19kg

Cost of cement = $8.19 \times 10 = 81.9$ tk

Cost of eggshell = $0.81 \times 10 = 8.10$ tk

For 18 molds we need 9 kg of cement

Then for 1 mold, we need 0.5 kg of cement which price is 5 tk

For 9% eggshell of cement is 0.045 kg

The actual cement we need (0.5-0.045)=0.455 kg

1 kg cement price is 10 tk

Then 0.455kg cement price is $=0.455 \times 10 = 4.55$ tk

Otherhand 1 kg eggshell price is 9 taka

Then 0.045 eggshell price is $=0.045 \times 9 = 0.405$ tk

Total cost of cement with egshell for 1 mold = (4.55+0.405)= 4.955 tk

The difference between only cement and eggshell replacement of cement is = (5-4.955) = 0.045 tk

The cost seems almost equal. Using eggshells is another way we can reduce some biowaste from our environment.