EGG SHELLS: PARTIAL REPLACEMENT OF CEMENT

Submitted By

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A Thesis Submitted to the Department of Civil Engineering, Daffodil International University is 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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DECLARATION

I'm pleased to declare that this paper is authentic work and is not to be submitted anywhere else. And also, it was not submitted previously. My supervisor Engr. Md. Imran Hasan Bappy guided me throughout the writing of the thesis paper.

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CERTIFICATION

I would like to say that the thesis paper on **“Egg Shells: Partial Replacement of Cement”** written by Md. Jahid Hasan Prince with ID:201-47-391. His Project Paper is an excellent work. To my knowledge, it is original.

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The thesis titled **Egg shells: Partial Replacement of Cement** submitted by Md Jahid Hasan Prince, ID No: 201-47-391, Session: Spring 2020, has been accepted as satisfactory. This work fulfils, in part, the requirements for the Bachelor of Science in Civil Engineering degree. Date of Acceptance: 06 June 2024.

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ABSTRACT

At present, the city is growing day by day. People are constantly moving towards a better life. Along with a better life, peoples are making the environment dirty. As of now, only 2.01 billion tons of municipal solid waste is generated in the world every year. As such, there are about 25 thousand tons of municipal solid waste in Bangladesh, which is a threat to the environment and our lives. On the other hand, new buildings are being built for a better life. Where rod, brick sand along with cement plays the most important role. Cement is very expensive nowadays. Even getting good quality cement is difficult. Certain ingredients are used in cement, notably ammonia or calcium nitrate and silicates, which in excess can damage the quality of cement and its color. Eggshells are waste material. Eggshells are usually easily available in biscuit and bread factories. The main component of eggshells is calcium carbonate. In this paper we can see how we can use eggshells powder as some partial replacement of cement where we have compared normal cement as well as partial mixture to get a better strength. We have used eggshells of 0%, 1%, 6%, 12% of cement. For this we did sieve analysis, a tensile and compressive test. By using eggshells powder, we can save some waste from the environment while being cost-effective. After the test we can say that 6% of eggshells powder can be replaced against cement.

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CHAPTER 01
INTRODUCTION

1.1 General

Waste is the most challenging subject in this world. In growing cities, it threatens the environment. According to the United Nations Environment Program (UNEP, 2024), one-third of foods are wasted by people in the world and it's costing our global economy almost USD 1 trillion annually dollars. Also, it's known that 10% of the greenhouse gas is produced from food waste in the atmosphere. The amount of 30% of the waste is coming from bakery waste. Where eggshell is a bio-waste material. A large amount of this waste is generated by bakers and fast-food restaurants. It is disposed of in landfills which is very harmful for human health. The main component of eggshells is calcium carbonate, which is also present in numerous types of marble, chalk, and limestone. About 95% of the material in an eggshell is calcium carbonate (Askusda, 2024). In addition, eggshells have tiny quantities of proteins and other minerals including calcium phosphate and magnesium carbonate.

1.2 Background

Cement is made in a number of steps, the main ones being the mining of raw materials, grinding them into a fine powder, and mixing them in exact amounts to make clinker in a kiln. Cement is finally created by finely powdering the clinker.

1.2.1 Raw materials of cement: The main ingredients required to make cement are sand, limestone, clay, and shale. Usually, quarries or mines provide these resources.

1.2.2 Crushing, grinding and mixing: Using crushers and ball mills, the raw materials are first reduced in size and then processed into a fine powder. By increasing the raw materials' surface area, this procedure helps to speed up their chemical reaction in the kiln. The term "raw meal" refers to the mixture of precisely measured amounts of finely ground raw components. Typically, this combination contains clay, limestone, and additional additives as needed to achieve particular cement qualities.

1.2.3 Production: The clinker is cooled and then processed into a fine powder with gypsum (calcium sulfate) and further modifications such fly ash or slag, depending on the necessary cement characteristics. This highly powdered substance is the final product, known as cement.

1.2.4 Final result: Depending on the required cement qualities, the clinker is cooled and then ground into a fine powder with gypsum (calcium sulfate) and additional changes like fly ash or slag. The end result is called cement, and it is this finely powdered powder.

1.3 Rational

The effects from indiscriminate disposal of the egg shells are quite serious. It is hazardous and bio-waste. This pollution has an impact on humans and the soil and air. Certain bacteria, including Salmonella enteritidis, can contaminate eggshells. Eggshells are constantly being thrown into the environment, but they can be used for a variety of things if they aren't thrown away.

1.4 Objective

- To know the possibility of effective use of bio-waste material (eggshells).
- To determine an appropriate ratio for eggshell additive as a partial cement substitute.

1.5 Scope of the thesis

The use of eggshells in the manufacture of cement is an innovative and sustainable method of recycling bio waste (eggshell) while meeting infrastructural needs. The scope of testing for such materials often includes a variety of technical and environmental considerations. Here are some factors to consider when assessing these components:

- Determine the most effective bio-waste material ratio for cement.
- Analyze the strength and its durability of the mixture.

1.6 The impact on the environment

- Assess the environmental benefits of utilizing eggshells in construction.
- Compared to the cement stock supply

CHAPTER 02
LITERATURE REVIEW

2.1 Composition of eggshells

Eggshells are principally made of calcium carbonate, making up for around 94% of their structure. This calcium carbonate provides eggshells their distinctive hardness and strength. As previously stated, incorrect eggshell (Fig. 2-1) disposal can have both good and harmful environmental repercussions.

Fig. 2-1Raw Eggshell

2.1.1 Positive Impacts

a. Composting: Eggshells are an advantageous supplement to compost piles. When eggshells are put into compost, they give calcium and other minerals, enriching and fertilizing the soil. This can boost plant development and contribute to stronger ecosystems.

b. Soil Amendment: Crushed eggshells can be mixed directly into the soil of the garden to improve the soil's form, drainage, and levels of nutrients. This benefits organisms by delivering important minerals like calcium while also deterring pests like slugs and snails.

c. Natural Pest Control: The jagged edges of broken eggshells repel pests such as slugs and snails. This natural pest management strategy lowers the need for hazardous pesticides, which benefits the environment.

d. Using as replacement: The study investigates the use of Egg Shell Powder (ESP) and Earthenware Aggregates (EA) as alternatives in concrete manufacturing, with the goal of repurposing waste materials to promote sustainability. By replacing sections of cement and fine aggregates with ESP and EA, respectively, optimal compressive strength at 28 days was attained with a 15% substitution of both materials. This strategy not only effectively uses garbage, but it also minimizes CO_2 emissions during production. (Gaurav Mishra, 2017).

This study looks into using eggshell powder as a sustainable substitute for cement in concrete manufacturing. Despite worries regarding its designation as hazardous, eggshell's high calcium content increases concrete strength and impermeability. The study shows that replacing up to 20% of the cement with eggshell powder enhances concrete characteristics, as evidenced by Artificial Neural Network modeling with an R2 value of 0.96. This shows that eggshell powder has the potential to minimize cement usage while increasing concrete sustainability in construction applications. (Sagar Paruthi, 2023).

The purpose of this study was to determine the best combination of eggshell ash and rice husk ash (RHA) to use as partial replacements for cement in G30 concrete. Various amounts of eggshell ash and RHA were incorporated into the concrete, and mechanical characteristics were measured with cube and prism samples. The testing included slump, compressive, and flexural tests. Previous research revealed that eggshell ash replacement reduced concrete strength. To address this, RHA, which is known for its pozzolanic reactivity, was used to increase concrete strength. (Nurul Shahadahtul Afizah Asman1*, 2017) .

Cement manufacturing adds to environmental degradation and warming the planet through CO_2 emissions from fossil fuel burning. Meanwhile, the abundance of calcium-rich eggshell debris creates issues in landfills, hurting both human health and the environment. This study investigates the viability of using eggshell powder (ESP) as a cement substitute material in ferrocement manufacture. Mechanical qualities such as compression, flexural, and split tensile strength, as well as durability properties such as water absorption and sports performance, are tested and compared to traditional self-compacting ferrocement. (Akshay B. Meshram1, 2022).

This study looks at adding eggshell powder (ESP) into concrete as a partial cement replacement (5-15%). The results reveal that ESP efficiently increases concrete strength, with a 5% replacement producing ideal strength. Up to 10% ESP substitution keeps transport characteristics similar to control concrete. Combining ESP and fly ash enhances total concrete performance. (Amarnath, 2014).

India ranks fifth in worldwide egg production, producing 1.61 million tons of eggshell trash each year. Eggshells, which are primarily composed of calcium carbonate, are chemically comparable to limestone, a fundamental component in cement. Benefits of using eggshell waste instead of natural lime in concrete include reduced cement usage and waste repurposing. Additionally, eggshell waste has advantages in agriculture. (Sathvik S E. A., 2019) .

This study investigates the use of Eggshell Powder (ESP) as a supplemental cementitious material in M40 grade concrete to minimize cement content and CO_2 emissions. ESP, ground to two fineness levels (50 um and 100 um), replaced cement in varied quantities (5%, 10%, and 15%). The results showed that partial cement replacement with ESP increased compressive strength relative to the control sample. Optimal strength was attained with 10% ESP replacement, and finer ESP produced superior outcomes. Overall, 10% ESP replacement at a fineness of 50 um was found to be the most effective method for improving concrete performance. (Ashfaque Ahmed Jhatial 1 *. S.-u.-K., 2019).

This study investigates the use of eggshell powder (ESP), a bio-waste material, in the manufacture of concrete as a filler, cement, and fine aggregate. Several studies have found that ESP has the ability to improve concrete qualities while also reducing environmental pollution by reducing cement output. While some studies demonstrate increased compressive, flexural, and tensile strengths with ESP, high replacement percentages (>10%) may result in decreased strength and modulus of elasticity. Furthermore, while ESP reduces the specific gravity of concrete, it may have a negative impact on durability and water absorption. Overall, ESP shows potential as a sustainable option in concrete manufacturing when replacement ratios are properly considered. (Alyaa Al-Attar, 2020).

This study investigates eggshell powder as a long-term alternative to cement in concrete production, with the goal of reducing environmental effect. Eggshell, which is typically discarded as waste, has the potential to improve toughened characteristics and shorten setting time in eggshell concrete (ESC), especially at a 10% replacement rate. However, ESC is susceptible to chloride and sulfate exposure. More research on ESC's durability qualities is needed to gain a complete understanding. (B.W. Chong, 2020).

This study looks into using Eggshell Powder (ESP) as an additional cementitious ingredient in M40 grade concrete to lower cement content and reduce CO_2 emissions. ESP, ground to two fineness levels (50 um and 100 um), replaced cement in varied quantities (5%, 10%, and 15%). The results reveal that partial cement substitution with 10% ESP increases compressive strength significantly when compared to the control sample. Additionally, finer ESP (<50 um) produces superior strength outcomes. As a result, the ideal ESP content for enhancing compressive strength is 10% for both fineness levels. (Ashfaque Ahmed Jhatial 1 *. S.-u.-K., 2019)

2.1.2 Negative Impacts

a. Landfill Contribution: When eggshells are disposed of in landfills, they add to the overall trash volume. In garbage dumps, organic waste such as eggshells decomposes analogously, releasing methane, a strong greenhouse gas that causes climate change.

b. Resource Depletion: Although eggshells are renewable, their disposal in landfills contributes to biodiversity loss. The calcium along with other elements found in eggshells are essential minerals that might be returned to the soil via composting or other environmentally friendly disposal techniques.

c. Pollution: When eggshells are incorrectly disposed of, such as by dumped in bodies of water or left to rot in sensitive environments, they can contribute to water pollution and habitat destruction. This can affect aquatic ecosystems and interfere with natural processes.

To summarize, how eggshells are disposed of has an impact on the environment. Correct disposal techniques, such as decomposing or recycling, can improve soil quality, promote the development of plants, and reduce reliance on pesticides that contain chemicals. In contrast, incorrect disposal in landfills or ecological systems can cause pollution, depletion of resources, and habitat decline, all of which have negative environmental consequences. As a result, it is essential to promote safe disposal techniques in order to reduce negative consequences and maximize the benefits of eggshell recycling.

2.2 Introduction of cement

Cement is an important building material utilized in many construction projects around the world. It is a fine powder (ferrovial, 2024) composed mostly of limestone, clay, sand, and iron ore. When cement is mixed with water and aggregates (such as sand, gravel, or crushed stone), it forms a paste that hardens and binds the particles together, resulting in concrete.

2.2.1 Types of cement

1. There have six types of cement. These are:
2. Ordinary Portland Cement (OPC)
3. Portland Pozzolana Cement (PPC)
4. Cement with high alumina content (HAC)
5. Blast furnace slag cement
6. Sulphate resistant cement

7. Fast-setting cement

Bangladesh has two significant uses for cement. These are OPC and PPC. However, they are referred to as CEM I and CEM II, with CEM I being OPC and CEM II being PPC.

OPC cement (bdnews24, 2019) has clinker content ranging from 95 percent to 100 percent. And gypsum accounts for little more than 0-5 percent. Clinker concentration in PCC cement ranges from 65 to 79 percent. The percentages of slag, fly ash, and limestone range from 21 to 35 percent, with a maximum of 0-5 percent gypsum content.

2.3 Production of cement

About 75-90 percent of limestone is used in cement. Which we see as cement through a process. In 2023, China, the United States, and India were the world's top three lime producers, with production quantities of 310 million metric tons, 17 million metric tons, and 16 million metric tons, accordingly. Bangladesh have some cement company but they don't have own limestone resource. Due to which these raw materials are imported from abroad to Bangladesh which are expensive and time consuming.

2.4 Cement and its future

Limestone is among the most abundant rocks in the Earth's crust. We would have to mine the majority of the historic seabed's that have existed on Earth since the beginning of multicellular life. That is functionally impossible. Even if we were to eliminate present shallow-surface limestone sources for quicklime, we could simply transition to other sources of base while leaving trillions of tons of limestone intact. Though Bangladesh have to import from other country. The use of cement in Bangladesh has expanded dramatically over the past 10 years, owing to a growth in the number of large-scale developments performed by governments, urbanization, and a thriving real estate industry across the country. According to a study published by the Bangladesh Cement Manufacturers Association (BCMA, 2020), cement sales reached a new high of 33 million tons in 2018, up from 29 million tons in 2017. The growth was a record 12%. Bangladesh's cement sector is also one of the world's fastest-growing cement industries, with a CAGR of about 11.5% over the past decade. In 2011, the average per capita usage of cement was 95 kg. As of 2018, per capita cement usage had reached 187 KG. However, Bangladesh continues to be one of the world's lowest cement consumers. Bangladesh must import (Mircement, 2022) all materials required for cement manufacture from several nations. The price of raw materials has risen dramatically during the last six to seven years. Despite the hurdles, Bangladesh reported a 15.5% increase in 2018. Bangladesh exported cement worth $12.6 million in the fiscal year

2017-2018. The export amount also increased by more than 15% over the previous year. Bangladesh is India's biggest cement exporter.

2.5 Price hike

Bangladesh imports important raw materials for cement manufacture, including clinker, slag, fly ash, gypsum, and limestone, from a variety of nations, principally Vietnam. China's reduction in clinker production in late 2017 resulted in an increase in demand, causing the clinker price to climb by about $10 per ton at the start of 2018. Cement makers in Bangladesh were obliged to boost their prices due to an increase in production expenses. Bangladesh's cement industry relies largely on imported raw materials due to a scarcity of important mineral resources such as limestone, the principal ingredient used in cement manufacture. Gas price increases enforced by the Bangladesh government had a detrimental impact on industries with gas-based captive power plants, reducing overall sector growth, as projected by BCMA.

Overall, Bangladesh's cement industry has a number of difficulties including as raw material dependency, government policies that affect production costs, and transportation issues, all of which have an impact on cement prices and industry growth.

The cost of cement production can be around Tk 500-600 per bag or ton in Bangladesh.

2.6 Emission of carbon in the cement industry

Cement, the primary component of concrete, has become a significant part of our surroundings. But we don’t know how much cement or concrete production contributes to the carbon emissions (sharif_2006_, 2021) that cause climate change. According to a UK study, cement or concrete accounts for 8% of total global carbon dioxide emissions. If concrete were a country, it would be the third-largest carbon emitter behind China and the United States. The cement making process emits a significant amount of CO_2. Carbon dioxide and methane are thought to be the primary greenhouse gases responsible for global warming. Bangladeshis businesses can replicate the mechanism by which the world's largest corporations reduce carbon emissions. Three of these initiatives are widely debated.

1. Green Concrete: 'Green concrete' is being utilized to reduce carbon emissions from cement production around the world. It could be the use of alternate raw materials, slag, or other methods for lowering carbon emissions.
2. Concrete recycling should be enhanced. This can help to minimize clinker or cement output while also lowering carbon emissions.
3. Waste management: Waste management and recycling can be applied in a variety of industries, lowering carbon emissions in cement manufacture.

2.7 Eggshells and cement

Eggshells, which contain calcium carbonate, can be ground into a fine powder and used as a partial replacement for cement in concrete manufacturing, resulting in "bio concrete." This approach increases concrete strength, minimizes environmental effect, and may result in cost savings. However, it is critical to handle issues such as determining the best eggshell powder percentage, ensuring long-term durability, and adopting quality control procedures to get consistent outcomes.

CHAPTER 03
METHODOLOGY

3.1 General

This chapter describes the precise steps required to create a cylinder out of a mixture of stone, sand, cement, and eggshell. Here's a summary of the methodology:
1. Examine the present technology landscape.
2. Material estimate.
3. Make a mold.
4. Determine the durability of the model.

3.2 Examine the current technology.

A detailed examination of the material and existing recycling technology was completed using online resources such as published videos and papers. The previous chapter offers a list of the specific findings.

3.3 Analysis of the component

The most popular food nowadays is fast food. All these can be seen in the alleys of the city. Besides, there are big factories for making biscuits or cakes. A lot of eggs are used in these fast food and bakeries. Eggshells are usually thrown in the dustbin. We can easily collect the eggshells from these places if we want. It contains calcium carbonate, which can make the biggest contribution to making cement. The rise in eggshell ash content increases the strength of the cement stabilized matrix by approximately 35% on average. On the one hand, we can reduce the cost of cement for construction, and on the other hand, we can keep our environment pollution-free by removing this bio-waste from the environment.

Note: Eggshells are also popularly used as chicken feed, pigeon feed, and plant fertilizer.

3.4 Collection of the materials

The test required eggshells, sand, cement, and stone. Which we get very easily.

3.4.1 Eggshells

We collect eggshells (Fig. 3-1) from a traveling hawker. In that case we have to wait a day. Initially we collect 10 kg of egg shells. Hawkers sell eggshells by the kilogram to pigeon or fertilizer traders. Which costs 10 Bangladeshi taka per kg.

Fig. 3-1 Grinding of eggshells

3.4.2 Sand

The sand was collected from the construction site of a 12-story building which FM is 2.83.

3.4.3 Cement

For this test, we have used Local Cement (OPC) (Fig. 3-2), a well-known company in Bangladesh. Which we got locally.

Fig. 3-2 OPC Cement Special

3.4.4 Stone

The stone (Fig. 3-3) used for this test is 3/4 down A-grade stone. Collect this stone from Dipnogor Pathorghat, Gabtoli, Dhaka, which FM is 6.72

Fig. 3-3 Stone

3.4.5 Water

Water is a crucial component for producing excellent concrete. Improper water quality can induce corrosion in steel reinforcement. Water used in concrete production should be free of harmful chemicals including oil, acid, alkali, salt, sugar, slit, and organic waste.

3.5 Instruments

It requires some instruments from our lab to function properly. It is given below:

1. Steel bowl

2. Weight machine

3. Trowel, Shovel, Tamping rod

4. Water Jar

5. Oven

6. Slump, Measuring tap, Brush

7. Grinder machine (for grinding eggshells)

8. Pan, Sieve (4mm, 8mm, 16mm, 50mm, 30mm)

3.6 Procedure

1. In this experiment, the total volume of the mixture used was 1:1.5:3 cement, sand, and stone, with eggshells accounting for 0%, 1%, 6%, 12% of the cement.

2. As 5 liters of water has been used per 18 cylinders

3. The eggshells (Fig. 3-4) are initially allowed to dry in the sun. It is then cleaned and placed in an oven (Fig. 3-5 (a)) at 100 degrees Celsius for 24 hours (Fig. 3-5 (b)). Then the help of a grinder (Fig. 3-6) is taken to make it powder. We only need to take the powder (Fig. 3-7) and the supernatant we will sieve the analysis and throw them away. About 95% of dry eggshells are calcium carbonate, weighing 5.5 grams. Out of that 1.5 grams will be left over. We will take only fine powder for the test. For this we will do a sieve analysis (Fig. 3-8)

4. The slump test for concrete determines the quality of a concrete batch and how easily it will flow. So, 1st we put the mixing in the slump and test it. After passing the test all are mixed and put in the mold. It is better to attach the mobile to the inside of the mold before placing it in the mold. Put the spices in the mold in 3 steps. This first-time camping with 1/3 part and vibrating from the side. I will complete the molds in this way. It should be remembered that there is no honeycomb or any kind of void inside. Otherwise, it won't get a proper load. In this way, we will make each cylinder.

Fig. 3-4 Egg Shells

Fig. 3-5 (a) dry in the oven

Fig. 3-5 (b) dry in the oven

Fig. 3-6 Grinding of shells

Fig. 3-7 Powder of eggshells

Fig. 3-8 Sieve analysis

Fig. 3-9 Weight measuring

Fig. 3-10 Mixing eggshells with sand, cement, stone

Fig. 3-11 Slump test

Fig. 3-12 Sample mold

3.7 Laboratory Test of Cylinder

In the experiment we need to do Compressive strength test and Tensile strength test. Compressive and tensile tests are required to evaluate the mechanical qualities, performance, and appropriateness of materials for a variety of structural and engineering applications. These tests give crucial data for design, quality assurance, and guaranteeing structural and component safety and reliability. We need a Universal Testing Machine (UTM) to do this experiment. Concrete is typically used to build constructions that can hold weight. Concrete-based load-bearing masonry constructions take the weight of compression. Therefore, the most important factor in establishing a concrete's critical appropriateness for building is its compressive strength.

3.8 Compressive strength test

The compressive strength (Fig. 3-13) of a material, such as concrete or brickwork, is its capacity to bear axial loading (compression) without failing.

3.8.1 Procedure:

1. Place the specimens so that their flat sides are horizontally orientated towards the testing machine's plates. As a result, the mortar-filled face now faces the plate upward.

2. As a crack forms or a failure occurs, slowly apply a uniform load of 14 KN/mm^{2-}(143 kg/cm^{2}) per minute, noting the highest and final load at failure. The highest load determines the compression value for that given sample. Table the compressive strength test results for various sample.

Note: Make sure the samples are fully dried for the best result.

3.9 Tensile strength test

A tensile strength (Fig. 3-14) test is a mechanical test used to measure a material's capacity to withstand forces pulling it apart.

3.9.1 Procedure

1. Place the specimens so that their flat sides are vertically orientated towards the testing machine's plates. As a result, the mortar-filled face now faces the plate upward.

2. As a crack forms or a failure occurs, slowly apply a uniform load of 14 KN/mm^{2-}(143 kg/cm^{2}) per minute, noting the highest and final load at failure. The highest load determines the compression value for that given sample. Table the compressive strength test results for various sample.

Note: Make sure the samples are fully dried for the best result.

Fig. 3-13 Compressive strength test

Fig. 3-14 Tensile strength test

CHAPTER 04
RESULT AND DISCUSSION

4.1 General

This chapter contains a look of the numerous findings, as well as the results of the experiment and additional tests conducted during the study. The general properties of several types of cylinders.

For this test, we made a total of 72 cylinders for 4 ratios. 18 molds per ratio and these 18 molds were broken as 7, 14, 28-day test. Before testing, the mold was removed from curing and allowed to dry for 24 hours to obtain its maximum value. Each cylinder had the same dimensions. All values will be averaged.

4.2 Sieve Analysis Test Report

Table 1 Sieve Analysis for Coarse Aggregate

Sieve size	weight retained(g)	% retained	cumulative wt. retained%	% Finer
25	0	0	0	100
19	2610	53.26	53.26	46.73
9.5	280	5.71	58.97	41.02
4.75	1250	25.51	84.48	15.51
2.36	150	3.06	87.55	12.44
1.18	210	4.28	91.83	8.16
0.6	270	5.51	97.346	2.65
0.3	100	2.04	99.38	0.61
0.15	50	0.61	100	0
Total	4920	100	672.85	

FM = 6.72

Standard FM = 6.72-8

Table 2 Sieve Analysis for Fine Aggregate

Sieve size	weight retained(g)	% retained	cumulative wt. retained%	% Finer
4	53.6	2.80	0	100
8	86.7	4.54	4.54	95.45
16	362.7	19.01	23.55	76.44
30	800.7	41.96	65.52	34.47
50	514.8	26.98	92.50	7.49

100	89.4	4.68	97.19	0
Total	1907.9	100	283.31	

FM = 2.83

Standard FM = 2.3-2.9

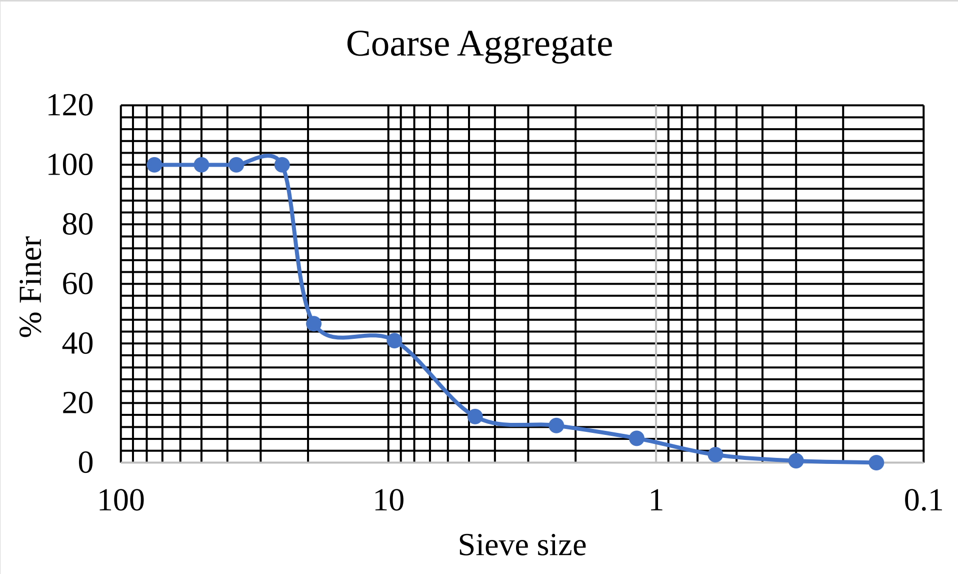

Figure 4-1 Sieve analysis test for Coarse aggregate

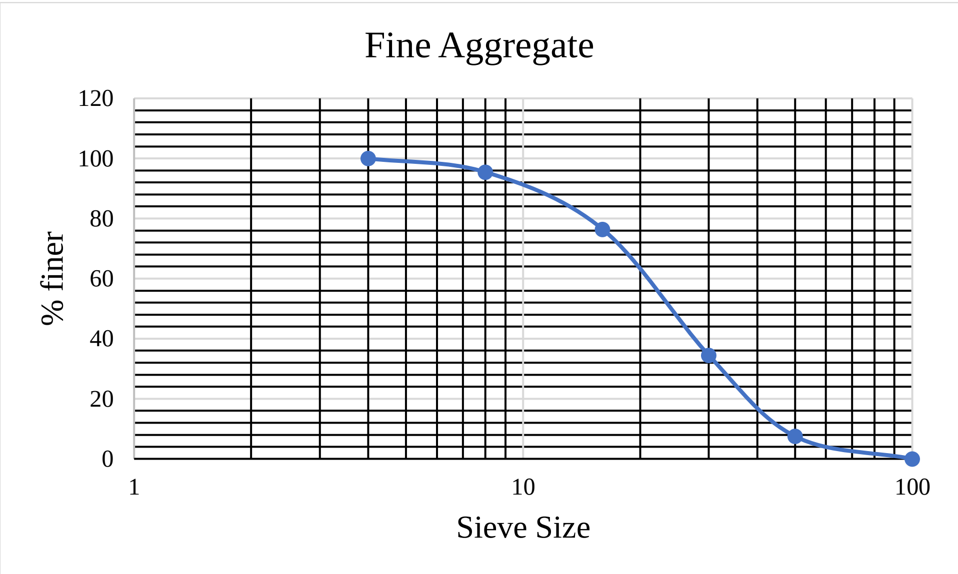

Figure 4-2 Sieve analysis test for Fine aggregate

4.3 Testing result of samples

First, we are doing a compressive strength test of a total of 36 samples. These values are mentioned below:

4.3.1 Compressive strength test result

Table 3 Compressive Strength of cylinder (0%)

Compressive Strength of cylinder (0%)						
Day	Specimen ID	Ratio	Specimen area(in^2)	Crushing Load (lb.)	Compressing Strength (psi)	Avg. Compressing Strength
7	S 1	0%	12.56	22364.56	1801	1834
	S 2	0%		22390.95	1819	
	S 3	0%		22581.76	1882	
14	S 4	0%		24366.4	1940	1954
	S 5	0%		23864	1928	
	S 6	0%		24215.68	1995	
28	S 7	0%		27443.1	2185	2210
	S 8	0%		27707.36	2206	
	S 9	0%		29352.72	2237	

Table 4 Compressive Strength of cylinder (1%)

Compressive Strength of cylinder (1%)						
Day	Specimen ID	Ratio	Specimen area(in^2)	Crushing Load (lb.)	Compressing Strength (psi)	Avg. Compressing Strength
7	S 1	1%	12.56	21753.92	1732	1723
	S 2	1%		21356.25	1700	
	S 3	1%		21829.28	1738	
14	S 4	1%		24994.4	1990	1963
	S 5	1%		24793.44	1974	

	S 6	1%		24203.12	1927	
28	S 7	1%		27117.04	2159	2192
	S 8	1%		27518.96	2191	
	S 9	1%		27983.68	2228	

Table 5 Compressive Strength of cylinder (6%)

Compressive Strength of cylinder (6%)						
Day	Specimen ID	Ratio	Specimen area(in^2)	Crushing Load (lb.)	Compressing Strength (psi)	Avg. Compressing Strength
7	S 1	6%	12.56	22490.16	1811	1883
	S 2	6%		22670.8	1830	
	S 3	6%		22959.2	1890	
14	S 4	6%		25729.1	2169	2200
	S 5	6%		25356.95	2151	
	S 6	6%		28605.05	2245	
28	S 7	6%		28597.45	2319	2347
	S 8	6%		29125.3	2327	
	S 9	6%		29581.76	2396	

Table 6 Compressive Strength of cylinder (12%)

Compressive Strength of cylinder (12%)						
Day	Specimen ID	Ratio	Specimen area(in^2)	Crushing Load (lb.)	Compressing Strength (psi)	Avg. Compressing Strength
7	S 1	12%	12.56	17984.8	1432	1507
	S 2	12%		19108.85	1522	

	S 3	12%		21581.76	1569	
14	S 4	12%		21984.80	1742	1773
	S 5	12%		22856.92	1810	
	S 6	12%		21905.30	1769	
28	S 7	12%		23156.99	1895	1927
	S 8	12%		23605.05	1930	
	S 9	12%		23729.10	1957	

4.3.2 Tensile strength test result

Second, we are doing a tensile strength test of a total of 36 samples. These values are mentioned below:

Table 7 Tensile Strength of cylinder (0%)

Tensile Strength of cylinder (0%)						
Day	Specimen ID	Ratio	Specimen area(in^2)	Crushing Load (lb.)	Tensile Strength (psi)	Avg. Tensile Strength
7	S 1	0%	87.96	10116.45	136	133
	S 2	0%		10790.33	123	
	S 3	0%		11465.31	131	
14	S 4	0%	87.96	14612.65	167	180
	S 5	0%		15736.7	179	
	S 6	0%		16860.75	192	
28	S 7	0%	87.96	18647.52	212	225
	S 8	0%		20230.8	230	
	S 9	0%		20670.6	235	

Table 8 Tensile Strength of cylinder (1%)

Tensile Strength of cylinder (1%)						
Day	Specimen ID	Ratio	Specimen area(in^2)	Crushing Load (lb.)	Tensile Strength (psi)	Avg. Tensile Strength
7	S 1	0%	87.96	11415.69	126	129
	S 2	0%		11088.6	114	
	S 3	0%		13038.98	149	
14	S 4	1%	87.96	14612.65	167	162
	S 5	1%		14612.65	167	
	S 6	1%		13488.6	154	
28	S 7	3%	87.96	15736.7	179	188
	S 8	3%		17984.8	205	
	S 9	3%		15736.7	179	

Table 9 Tensile Strength of cylinder (6%)

Tensile Strength of cylinder (6%)						
Day	Specimen ID	Ratio	Specimen area(in^2)	Crushing Load (lb.)	Tensile Strength (psi)	Avg. Tensile Strength
7	S 1	0%	87.96	9059.88	133	148
	S 2	0%		16860.75	192	
	S 3	0%		10555.2	120	
14	S 4	1%	87.96	17328.12	197	167
	S 5	1%		18031.8	205	
	S 6	1%		20230.8	230	
28	S 7	3%	87.96	20934.48	238	231
	S 8	3%		23485.32	267	
	S 9	3%		18383.64	209	

Table 10 Tensile Strength of cylinder (12%)

Tensile Strength of cylinder (12%)						
Day	Specimen ID	Ratio	Specimen area(in^2)	Crushing Load (lb.)	Tensile Strength (psi)	Avg. Tensile Strength
7	S 1	0%	87.96	6744.3	95	117
	S 2	0%		10116.45	116	
	S 3	0%		12364.55	141	
14	S 4	1%	87.96	13532.72	154	158
	S 5	1%		13488.6	155	
	S 6	1%		14612.65	167	
28	S 7	3%	87.96	17984.8	205	221
	S 8	3%		19108.85	218	
	S 9	3%		21132.14	241	

4.4 Comparison of different Ratio of cylinder

Here the showing the difference ratio of cylinder.

4.4.1 Average compressive strength of cylinder

Display says that UTM loads against the percentage of ratio. Where 0% is only concrete mixture and others are using eggshells powder. Research it shows that using 1% of eggshells powder, compressive strength is greater than 0%, and 12%. Another hand 1% is less than 6% eggshells powder crushing load. The test comparison with after 7,14- and 28-days crushing loads.

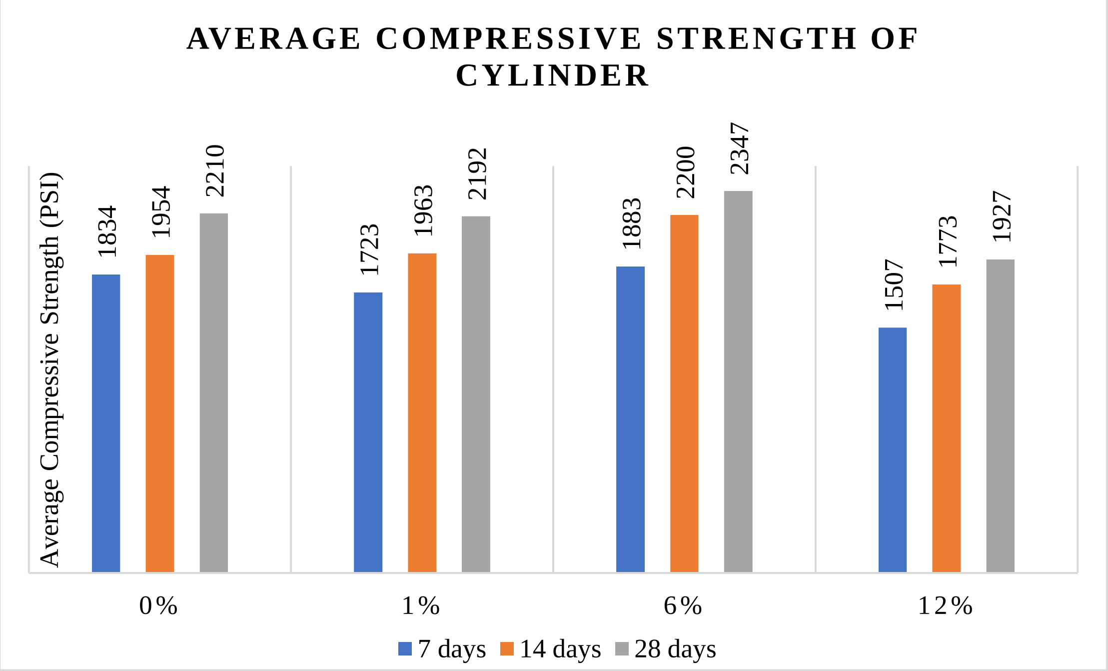

Fig. 4-3 Average compressive strength of cylinder

Comment: This graph shows average compressive strength of cylinder. Total 4 ratio of eggshells powder used for the compressive test and number of molds are 36. Where using 6% of eggshells powder is appreciable for the work.

4.4.2 Average compressive strength of cylinder (28 Days)

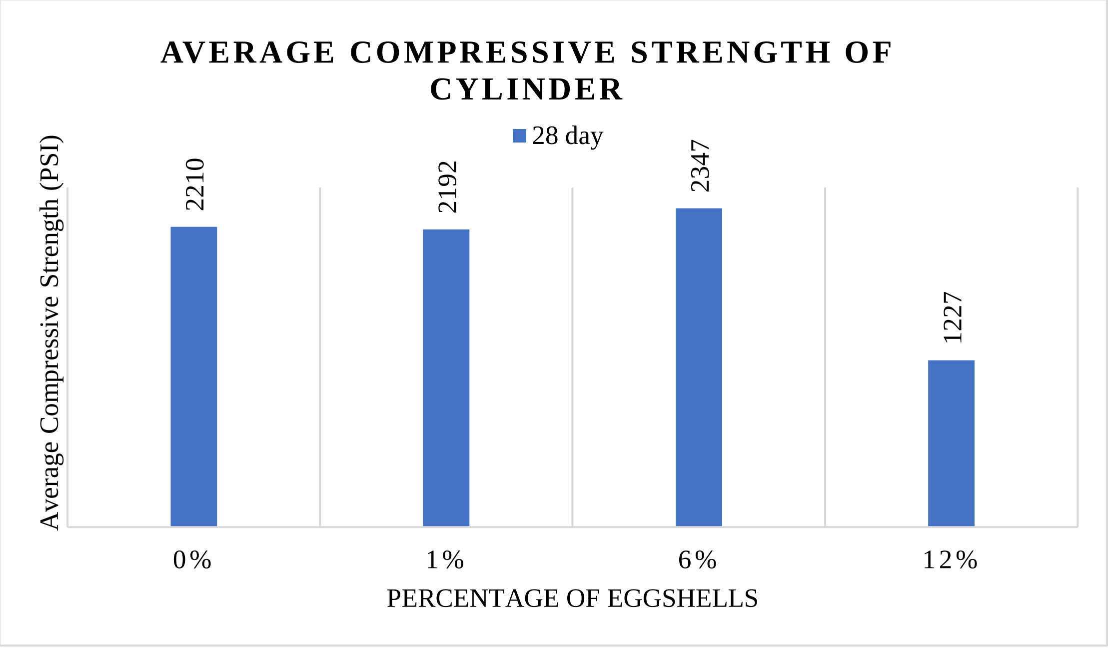

Fig. 4-4 Average compressive strength (28 days)

Comment: It seems that, best compressive strength (Fig. 4-4) can be found in 28 days. Here in 0% it is 2210 psi and it is more than 12% of strength. Another hand using 6%

eggshells powder is more than 1% and 1% is more than 0%. Using eggshells powder 6% of the strength is 2347 PSI and it is appreciable.

4.4.3 Average tensile strength of cylinder

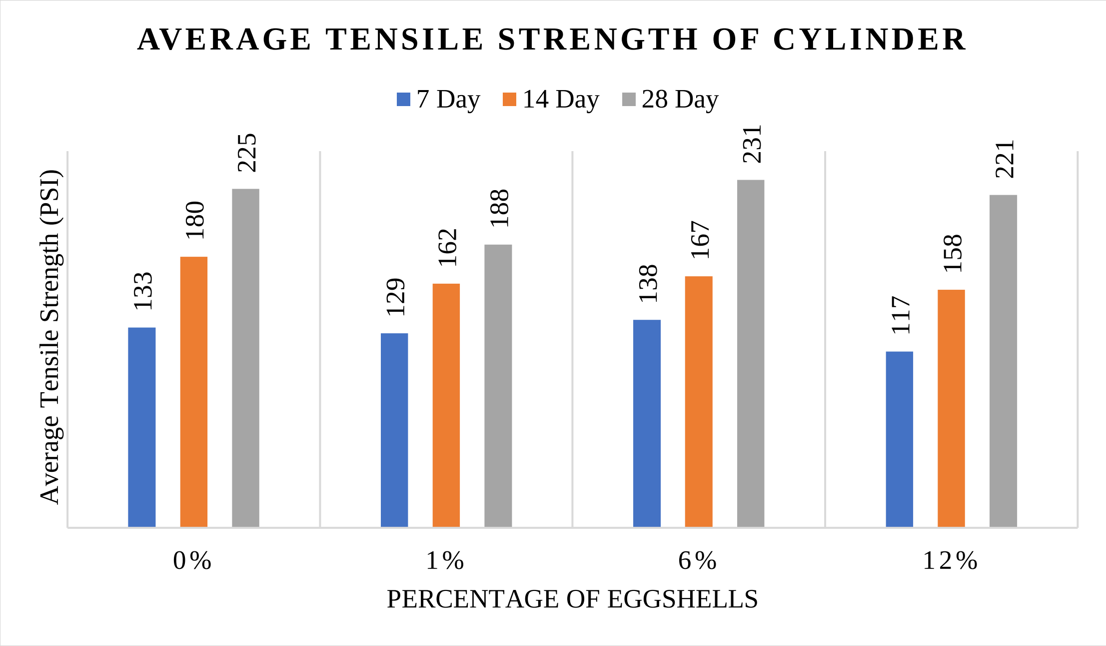

Fig. 4-5 Average tensile strength of cylinder

Comment: This graph shows average tensile strength (Fig. 4-5) of cylinder. Total 3 ratio of eggshells powder used for the tensile test and number of molds are 36. Where using 6% of eggshells powder is appreciable for the work.

4.4.4 Average Tensile strength of cylinder (28 Days)

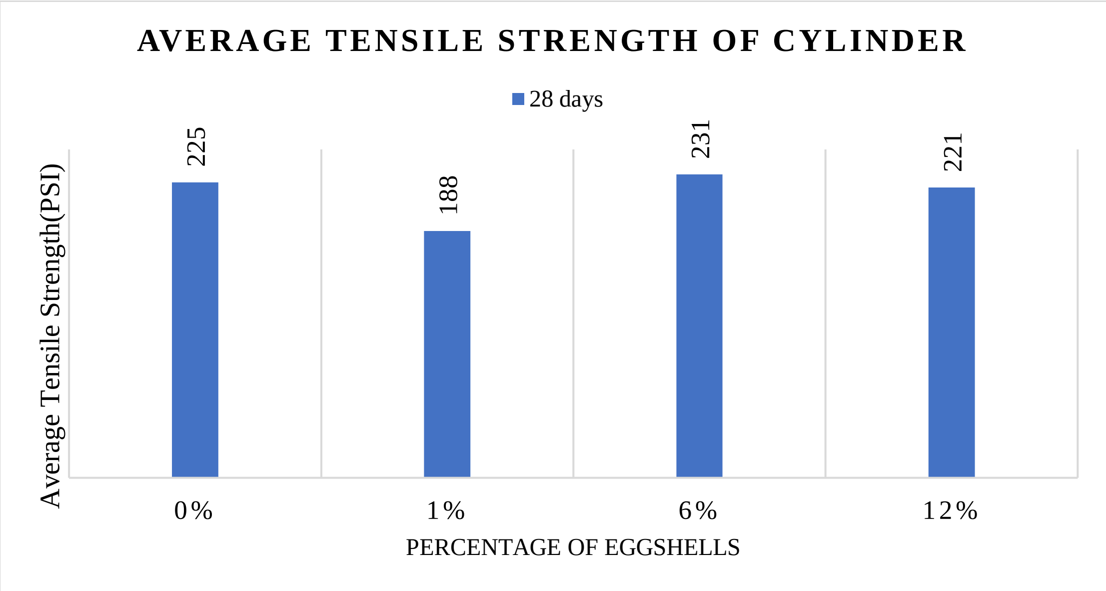

Fig. 4-6 Average Tensile Strength of Cylinder (28days)

Comment: It seems that, best tensile strength (Fig. 4-6) can be found in 28 days. Here in using eggshells powder 12%, tensile strength is 221 psi and it is more than 1% of strength. Another hand using 6% of eggshells powder is more than 1% and 1% is more than 0%. The 6% of eggshells powder strength is 231 PSI and it is appreciable.

4.4.5 Comparison with normal concrete

Comparison Compressive Strength of concrete (eggshells powder and normal concrete)

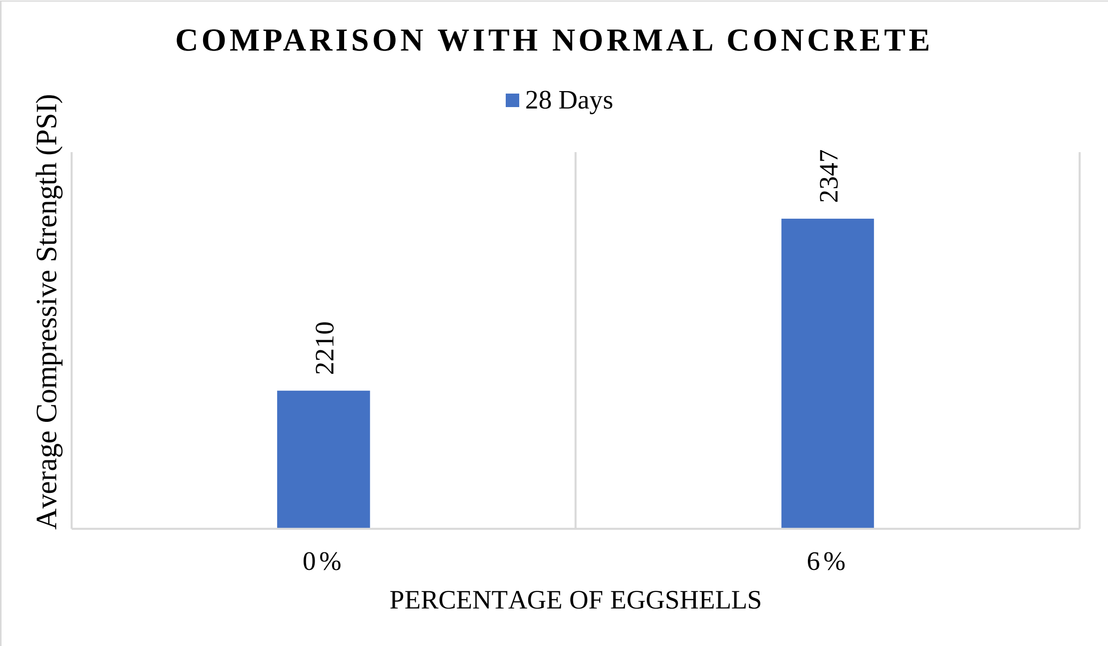

Fig. 4-7 Comparison with normal concrete

Comment: This graph shows average compressive strength (Fig. 4-7) of cylinder. After 28 days later compressive strength of using 0% eggshells powder is 2210 psi and using 6% eggshells powder loads are 2347 psi. Where using 6% of eggshells powder is appreciable for the work.

4.4.6 Comparison with normal concrete (Tensile)

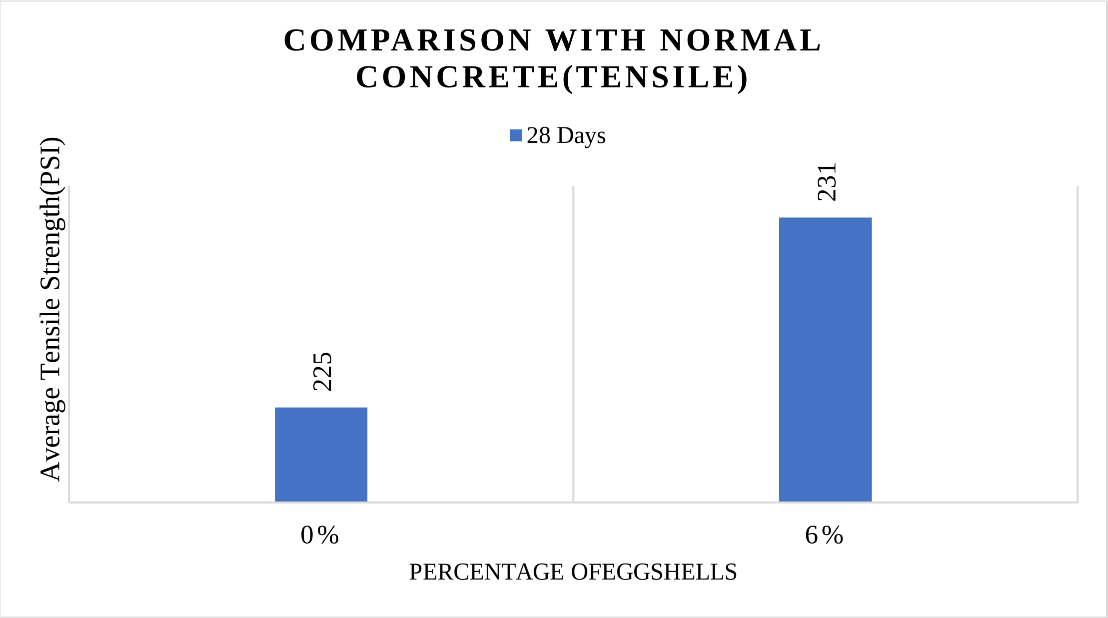

Fig. 4-8 Comparison with normal concrete

Comment: This graph shows average tensile strength (Fig. 4-8) of cylinder. After 7days, 14days, 28days later the load of using 0% eggshells powder is 225 psi and using 6% eggshells powder load is 231 psi. Where 6% of mixture is appreciable for the work.

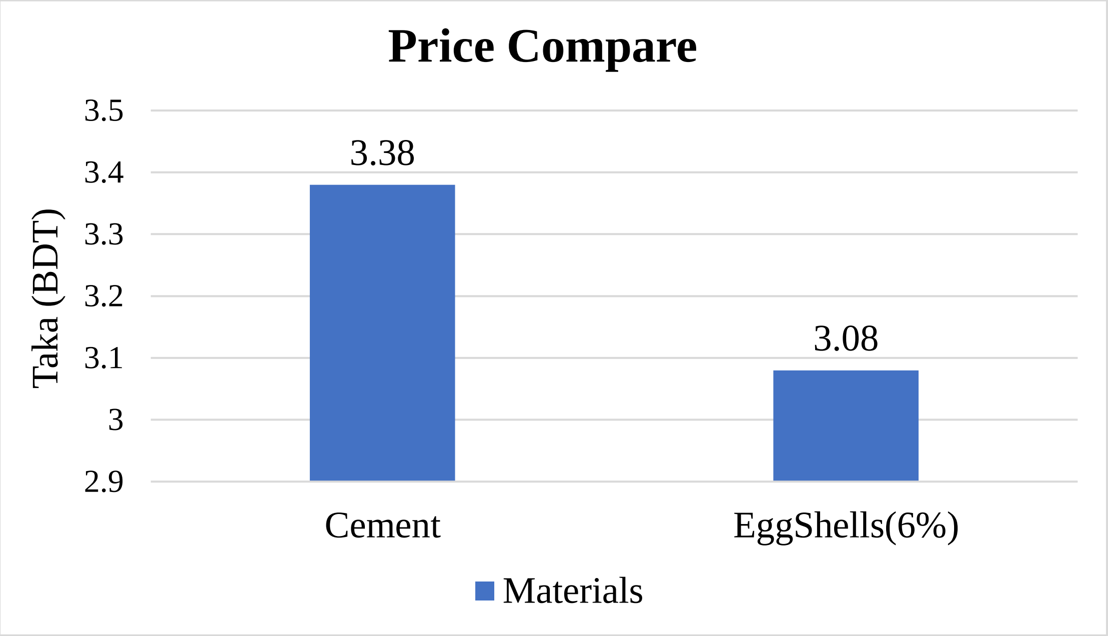

Fig. 4-9 Comparison with normal concrete

according to use 6% eggshells powder data, this graph (Fig. 4-9) say the Cost Comparison between cement and eggshells.

CHAPTER 05
CONCLUSION & RECOMMENDATION

5.1 Conclusion

Through this experiment, we see how we can benefit financially and environmentally by utilizing our bio-waste. For this test, we made a cylinder with cement as usual. The result shows that using 6% of eggshells powder can be used against cement. I tried mixing a certain amount of eggshell powder. Comparing the two results we find a satisfactory ratio. Which we can use if we want.

Overall, this study can be characterized as a flowing decision.

1. This bio waste(eggshells) can be used as partial replacement of cement.

2. Engineers and builders can produce stronger, more workable, and environmentally friendly concrete by finely grinding eggshells and optimizing their replacement ratio. After comparing of mixing ratio with normal concrete, it shows that 6% of eggshells powder can give equal or more strength than normal concrete.

5.2 Recommendation

Research on using ESP (Eggshell Powder) to make concreate should continue now that it has been established. Future study should address the limitations found during this experiment to the greatest extent possible. Among the specific recommendations might be:

1. Using ESP as a construction material is an excellent way to reduce pollution in the environment.

2. To increase the eggshell powder's reactivity with cement, ensure that it is fully clean and it is finely ground.

3. In most research trials, replacement levels ranging from 5% to 20% by weight of cement were used. However, the actual ratio may differ depending on the intended strength, setting period, and workability of the concrete.

4. More than a 10% ratio of eggshells powder can be commended for test

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APPENDIX

Calculation

1. **Calculate the Fine Modulus of Fine Aggregate**

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

$= \frac{672.85}{100} = 6.72$

2. **Calculate the Fine Modulus of Coarse Aggregate**

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

$= \frac{283.31}{100} = 2.83$

1. Calculate the volume of Cylinder:

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

Where V is the volume

D is the Diameter of the cylinder

h is the height (length id the cylinder)

Given that

Cylinder length 8 inch

Diameter of Cylinder 4 inch

For 1-cylinder volume,

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

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

$=100.53 \text{ in}^3$

$=0.0582$ cft

Now we calculate the volume for 18 cylinders,

V= 18×0.0582 cft

Shrinkage factor $= 1.047 \times 1.5$ cft

= 1.75 cft

2. Calculate the volume of each ingredient using the given ratio:

Cement: Sand: Aggregate = 1: 1.5: 3

We got a total volume of 1.75 cft, Now we can break it down according to the ratio:

Cement: $1.75 \times \frac{1}{1+1.5+3} = 0.382$ cf $= 9.0114 \approx 9$ kg

Sand: $1.75 \times \frac{1.5}{1+1.5+3} = 0.478$ cft $= 13.53$ kg ≈ 13 kg

Aggregate: $1.75 \times \frac{3}{1+1.5+3} = 0.954$ cft $= 27.01$ kg ≈ 27 kg

We used 1%,6%, and 12% eggshell powder replacement for cement.

For the 1st 18 cylinders, we need 1% eggshell of total cement of 9kg

For 1% eggshell used replacement for cement $=\frac{1}{100} \times 9 \times 1000 = 90$g = 51.4 g (per cft)

For the 2nd 18 cylinders, we need 6% eggshell of total cement of 9kg

For 6% eggshell used replacement for cement $=\frac{6}{100} \times 9 \times 1000 = 540$g = 308.4 g (per cft)

For the 3rd 18 cylinders, we need 12% eggshell of total cement of 9kg

For 12% eggshell used replacement for cement $=\frac{12}{100} \times 9 \times 1000 = 1080$g = 616.8 g (per cft)

Total Cement for 1% = (9-0.9) = 8.1 kg

Total Cement for 6% = (9-0.540) = 8.46 kg

Total Cement for 12% = (9-0.9) = 7.92 kg

3. Calculation of compressive strength

For Sample -1 (S 1)

Specimen of Area $A=\frac{\pi}{4} d^2 = \frac{\pi}{4} 4^2 = 12.56$ in^2

Crushing Load P = 23605.05 lb.

Compressing Strength $F = \frac{P}{A} = \frac{23605.05}{12.56}$ psi = 1879.382962

We calculate compressive strength all sample with following this method.

4. Calculation of tensile strength

For Sample -1 (S 1)

Specimen of Area $A=\frac{\pi}{4} d^2 h = \frac{\pi}{4} 4^2 7 = 87.96$ in^2

Tensile Strength $\sigma = \frac{P}{A} = \frac{10116.45}{87.96}$ psi = 122.6793997

We calculate tensile strength all sample with following this method.

5. Cost Comparison

We know,

1bag cement (50kg) = 550 tk

1 kg cement price = 11 tk

9 kg cement price = 11*9 = 99 tk

For 18 mold, we need

cement = 9/18 = 0.5 kg

Cement price = 0.5* 11 tk = 5.5 tk

Now,

For 1.75 cft, cement needed = 9kg

So, for 1cft, cement needed = $\frac{9}{1.75} =$ 5.14 kg per cft

1cft for 1% eggshell = $\frac{1}{100} \times 5.14 \times 1000 = 51.4\text{g} = 0.0514$ kg

1cft for 6% eggshell = $\frac{6}{100} \times 5.14 \times 1000 = 308.4\text{g} = 0.308$ kg

1cft for 12% eggshell = $\frac{12}{100} \times 5.14 \times 1000 = 616\text{g} = 0.616$ kg

So,

For 1 cft cement

= 11 tk ×5.14 =56.54 tk

For 1 cft eggshells (6%)

= 10 tk ×0.308 = 3.08 tk

1 kg eggshell = 10 tk

For 18 mold

Total eggshell for 1% = 0.051kg (per cft)

Total eggshell for 6% = 0.308kg kg (per cft)

Total eggshell for 12% = 0.616 kg (per cft)

So,

Total Cost of eggshell for 1% = 0.05*10 = 0.5 tk

Total Cost of eggshell for 6% = 0.308*10 = 3.08 tk

Total Cost of eggshell for 12% = 0.616*10 = 6.16 tk

Using eggshells as a 6% replacement in cement in Bangladesh can result in a cost may not saving, alongside environmental benefits such as reduced CO_2 emissions and waste diversion.

As per replacement 0.308 kg cement = $11 \times 0.308 = 3.38$ tk

As per replacement 0.308 kg eggshells = = $10 \times 0.3080 = 3.08$ tk