Experimental Analysis Using Egg Shell Powder as a partial alternative for Cement

Mr. Shrikant Phulari[1] Miss. Vaishali Vijay Rokade [1] Prof. N.P. Phadtare[2]

Student, M.E, Dept. of Civil Engineering, Padmabhooshan Vasantraodada Patil Institute of Technology Sangli - Tasgaon Rd, Budhgaon.[1]
Professor, Dept. of Civil Engineering, Padmabhooshan Vasantraodada Patil Institute of Technology Sangli - Tasgaon Rd, Budhgaon [2]

Abstract— There is currently a widespread trend to decrease the usage of common resources and recycle garbage. Concrete serves a crucial role and is produced in vast quantities. Eggshell waste is abundant worldwide, and because eggshells are composed of calcium, they can be used as a partial replacement for Portland cement in concrete. The objective of this study is to evaluate the qualities of waste eggshell powder (ESP) as a partial replacement for Portland cement in concrete, in addition to the reuse of waste eggshell powder. Eggshell powder is used in numerous mixes, which can be substituted for 0% to 20% of the weight of cement in concrete in 5% increments. The compressive strength, tensile strength at tear, flexural strength test, and durability test are evaluated after 28 days of curing. These are compared to a standard mix containing 0% ESP to identify the optimal replacement material combination.

Keywords: Eggshell powder, Concrete, Cement, RCC, IS456, ANSYS,

1. INTRODUCTION

Concrete is frequently employed in the construction of the world's largest buildings, bridges, etc. Presently, the construction industry as a whole is searching for a suitable and operational waste that would greatly reduce the consumption of cement and maybe lower production costs. Therefore, a viable alternative is required for waste management. The objective of this research is to employ eggshell powder as a restricted cement additive. Cement replaces eggshell powder by 5%, 10%, 15%, and 20% by weight. Experimentation reveals the tensile strength, compressive strength, and flexural strength of eggshell-based concrete. It has been discovered that adding eggshell powder to concrete boosts its strength.

Energy is crucial to the success of developing nations like India. In light of the limited availability of nonrenewable energy sources and the high energy demands of construction materials such as cement, the significance of utilising industrial waste cannot be overstated. In order to produce one tonne of typical portland cement, approximately 1.1 tonnes of earth resources, such as limestone, are required. In addition, the manufacture of 1 tonne of standard portland cement emits the equivalent quantity of carbon dioxide into the atmosphere. Carbon dioxide emissions are a variety of silent killers in the environment. In light of this, the quest for a cheaper alternative to OPC is crucial.

1.1. Egg Shell Powder

- The eggshell is composed of many mutually developing layers of CaCO3; the innermost layer-maxillary 3 layer grows on the outermost egg membrane and forms the base upon which the palisade layer forms the shell's thickest portion.
- The upper layer is a vertical layer covered by a cuticle made of organic material. Eggshell is primarily composed of calcium, magnesium carbonate (lime), and proteins. In many other nations, it is common practise to dry eggshells and incorporate them into animal feed as a source of calcium.
- The degree of exposure to sunshine, untreated water, and severe weather has a significant impact on the quality of lime in eggshell waste. It is a fine-grained powder that is sieved to the desired particle size prior to use in concrete/mortar.
- Eggshell known as a smooth surface which is desirable compared to rough shells is easier to break. The majority of high-quality eggshells from commercial laying hens contain roughly 2.2 grammes of calcium carbonate. 95% of dry eggshell is composed of calcium.

Fig. 1 Eggshell powder

2. STATE OF DEVELOPMENT

Manzoor Ahmad Allie et al. With 10% eggshell powder replacement, the compressive strength increased by 13.4%. The flexural strength rose by 19.5% for the same 10% eggshell powder replacement. The outcome demonstrated that eggshell powder can be advantageous when substituted with 10% cement.

Pradeep Sharma et al. Various eggshell combinations are utilised to test the viability of employing eggshell as an alternative to cement. By using eggshell trash as an extra ash-forming material, this research aims to avoid environmental contamination caused by the inappropriate disposal of eggshell waste from schools, restaurants, bakeries, households, and fast food establishments. & powder for normal M35 grade concrete, as it is typically employed on building sites.

N. Parthasarathi and others. Experimentation reveals the tensile strength, compressive strength, and flexural strength of eggshell-based concrete. It was discovered that the addition of eggshell powder and silica fume increases the strength of concrete, and a comparison is done between the strength of concrete with added shell and silica fume.

3. EXPERIMENTAL INVESTIGATION

Investigations such as concrete structures, coarse aggregate and fine-grained collection, as well as the process of various inspection processes in accordance with IS codes for the detection of these structures and mixing parameters acquired from mixing, are included.

Table 1 Mix proportions of all Mixes

Grade of Concrete	Cement (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)	Water (Lt)
M20	347	550	1120	180
M25	385	578	1150	212

3.1 Preparation of ESP

The concretes were mixed in a 100-liter capacity planetary mixer. The mixing duration was kept between three and four minutes. The ingredients were combined in the following order: I coarse aggregate was placed in the mixing drum first; (ii) a portion of the water required for concrete mixes was poured into the mixing drum; (iii) cement and ESP were carefully placed in the drum; and (iv) sand was pulverized and mixed. During mixing, the remaining anticipated quantity of water was added to the mixer's drum in order to properly combine the materials. After preparation, the samples were left for 24 hours. After 24 hours, the samples were disassembled and placed in normal water for curing till the test age.

Fig 2 Egg Shell Powder

3.2 Cube Test Analysis In Lab

Table 2 Number of specimens tested for compressive strength of M20 and M25

Percentage replacement of ESP (%)		**0%**	**5%**	**10%**	**15%**	**20%**	**Total Cubes Cast**
No. of cubes cast	M20	2	2	2	2	2	10
	M25	2	2	2	2	2	10
Total Cubes							20

4. RESULT OF EXPERIMENTAL INVESTIGATION

4.1 Density of concrete

Concrete concentration, also known as the weight per cubic metre of concrete, must be determined in advance in order to evaluate the concrete's strength. As the density of the concrete drops, the voids and consequently the strength diminish as well. Immediately after mixing the layers, freshly mixed concrete is poured over the scale.

$$Density = \frac{Weight of the Measure}{Volume of the Measure}$$

Table 3 Results for Density of concrete

Percentage Replacement	0%	5%	10%	15%	20%
M20 (Kg/m²)	2610	2515	2400	2255	2125
M25 (Kg/m²)	2746	2682	2591	2400	2274

According to the conclusions of the analytical study, eggshell powder reduced the density of concrete. It demonstrates that lightweight concrete is produced when eggshell powder is substituted for cement. It will assist minimize the structure's dead weight.

4.2 Compressive strength of concrete

The sample's heaviest load is noted, and the compressive strength of the template is calculated as follows.

$$Fck = P/A$$

Where,

P = Maximum load applied on the specimen

A = area of cross-section of the specimen on which the load is applied.

Fig 3 Laboratory compression testing machine setup

Table 4 Compressive strength of concrete

Percentage Replacement	0%	5%	10%	15%	20%
M20 (N/mm²)	26.77	26.56	18.37	11.55	7.88
M25 (N/mm²)	31.71	31.61	22.04	13.98	10.21

After testing the compressive strength of the cubes, it was determined that substituting the eggshell powder decreased the compressive strength; therefore, to attain the necessary strength, the concrete cubes should be prepared with an admixture.

4.3 Results after Adding Admixture (Results For 7 Days)

The Romans and ancient Egyptians were the first civilizations to utilize concrete as a construction material. Given that concrete is used in construction twice as often as all other building materials, it is necessary for the industry's growth and prosperity to place a premium on quality, performance, and sustainability. Concrete admixtures are one of the most significant components of high-performance, durable, beautiful concrete produced today. Concrete admixtures are natural or synthetic chemicals or additions added during concrete mixing to improve the workability, durability, or early and final strength of fresh or hardened concrete.

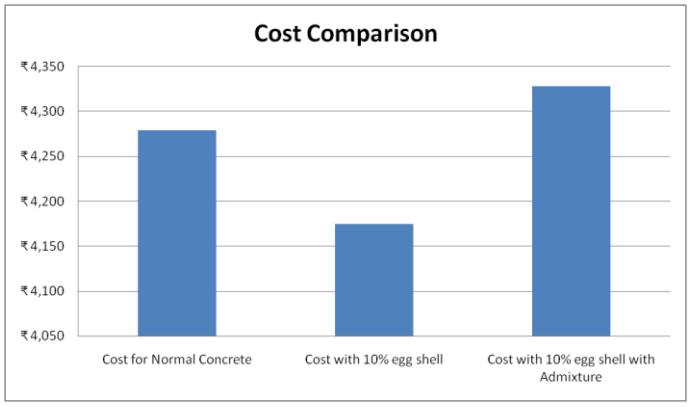
Table 5 Compressive strength of concrete After Adding Admixture

Percentage Replacement	0%	5%	10%	15%	20%
M20 (N/mm2)	26.77	26.56	18.37	11.55	7.88
Results For 7 Days After adding Admixture	17.94	20.06	21.06	21.18	18.80
Results For 28 Days After adding Admixture	27.62	30.86	32.40	32.58	28.92

Add additive to concrete cubes to acquire the desired strength and enhance their strength. They also examined the cubes after 7 days of curing to determine their compressive strength (after 7 days, a cube should have achieved 65% of the requisite strength). According to the test results, adding egg shell and additives to the cubes enhanced their compressive strength.

Table 6 Cost Comparison

Cost for Normal Concrete	Cost with 10% egg shell	Cost with 10% egg shell with Admixture
₹ 4,279	₹ 4,175	₹ 4,328



Graph 1 Cost Comparison

As per the cost with 10% egg shell with admixture is 49 Rs costly but it gives higher compressive strength.

5. CONCLUSION

In order to meet society's continuously expanding infrastructure requirements, concrete is becoming increasingly prevalent. This quick use of concrete in the construction industry has resulted in a significant resource depletion problem including sand, coarse aggregate, etc. In addition, concrete is exposed to fire for a variety of reasons, including natural disasters, insufficient supply, gas leaks, etc., resulting in the degradation of concrete percentage replacement of ESP in order to achieve the required ESP of class M20 and M25 concrete in the form of a density and compressive strength test. By replacing eggshell powder for cement, the density of concrete can be decreased, as determined by the results of the study. It demonstrates that lightweight concrete may be made by substituting cement with eggshell powder. It will assist minimise the structure's dead weight. Testing the compressive strength of the cubes reveals that the compressive strength was also lowered when eggshell powder was substituted; therefore, to attain the necessary strength, make the concrete cubes by adding an admixture. Improve the strength of the concrete blocks by adding an admixture to attain the necessary strength. They also examined the cubes after 7 days of curing to determine their compressive strength (after 7 days, the cubes should have reached 65 percent of the needed strength). According to the test results, adding eggshell and chemicals to cubes increased their compressive strength. It costs the same as 10% eggshell with 49 RS additive, but has greater compressive strength. According to the investigation, results with up to 15% eggshell replacement admixture are superior.

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