

An Experimental Study on Properties of Concrete by Partial Replacement of Cement with Eggshell Powder and Flyash

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ABSTRACT: Currently India has taken a major initiative on developing the infrastructure such as express highways, power projects and industrial structure etc., to meet the requirements of globalization, in the construction of building and other structure. Concrete plays the key role and a large quantum of concrete is being utilized in every construction practices. The egg shell and fly ash are usually which are disposed, is used as an alternate for the cement since the shell is made up of calcium. Fly ash is an ash produced during combustion of coal. There are two types of fly ash, one is class F fly ash and another one is class C. Class F fly ash contains less than 5% lime and class C fly ash contains more than 10% of lime. An egg shell is used in different combinations to find the feasibility of using the egg shells as an alternate to cement. Egg Shell powder replaces 10% and fly ash replaces 10%,20%,30% and 40% of weight of cement. Concrete is cast and compressive test, flexural test, tensile tests and durability test were carried out to find the best combination which results in optimum percentage of strength.

KEYWORDS: Flyash, Eggshell, Compressive strength

I. INTRODUCTION

Concrete is being widely used for the construction of most of the buildings, bridges and it is also known as backbone to the infrastructure development of a nation. At present, for a variety of reasons, the concrete industry is not sustainable. Firstly, it consumes huge amount of natural resource due to which no virgin material will be left for future generation. Secondly, the major component of concrete is cement. Lot amount of greenhouse gas will be emitted in the manufacturing processes of cement. Thirdly, concrete structure suffers from durability problem due to which natural resources are wasted. Therefore, there is a need to find an alternative method so that concrete industry becomes sustainable. The cement produces about 5% of CO₂ emissions of the world. 900kg of CO₂ for every 1000kg of cement produced.

Hence, currently, the entire construction industry is in search of a suitable and effective the waste product that would considerably minimize the use of cements and ultimately reduces the construction cost. And also waste by products from agriculture and industry like fly ash, rice husk ash, egg shells, copper slag, quarry dust etc. are creating environmental and health concern problems. Therefore, in the present study fly ash and egg shell powder are used in concrete as a partial replacement of cement. India stands third in the world electricity generation according to Global Energy Statistical Yearbook. In the past, fly ash obtained from coal combustion was simply and dispersed into atmosphere. This created environmental and health concerns problems. Instead of dispersing it into atmosphere or sending it to land fill it can be effectively used in concrete production as supplementary material to cement. Fly ash is an ash produced during combustion of coal. There are two types of fly ash, one is class F fly ash and another one is class C. Class F fly ash contains less than 5% lime and class C fly ash contains more than 10% of lime. India ranks second in the world with annual egg production. These many egg shells will be a waste annually. Disposal of these egg shells is a big problem because if they are send to landfills attracts vermin and causes problems related to human health and environment. Egg shell are rich in calcium and has nearly same composition that of limestone. Use of eggshell waste instead of natural lime in cement can have benefits like conserving natural lime and utilizing waste material. The

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aim of the current study is to determine the potential use of these wastes as a cementing material for concrete. The materials are proportioned by their weights. The obtained results are compared with that of conventional mix.

II. RELATED WORK

This section reviews the work done by various authors in the field of developing Blended concrete. Literature review was carried out to understand the different approaches in developing Blended concrete.

Bandhavaya G.B, SandeepK, Bindhushree G.B (2017) In this study egg shell powder replaces 0%, 5%, 10% and 15% of weight of cement. Compressive strength was higher than conventional concrete for 5% and 10% ESP replacement at 3, 7 and 28 days of curing ages. ESP replacements greater than 10% had lower strength than conventional concrete. Split tensile strengths of ESP concretes were comparable with conventional concrete up to 15% ESP replacement. However, concrete with 10% and 15% ESP had lower split tensile strength than conventional concrete.

D.Gowsika, S.Sarankokila, K.Sargunan (2014) This paper reports the results of experiments evaluating the use of egg shell powder from egg production industry as partial replacement for ordinary Portland cement in cement mortar. The chemical composition of the egg shell powder and compressive strength of the cement mortar was determined. The cement mortar of mix proportion 1:3 in which cement is partially replaced with egg shell powder as 5%, 10%, 15%, 20%, 25%, 30% by weight of cement. The compressive strength was determined at curing ages 28 days. There was a sharp decrease in compressive strength beyond 5% egg shell powder substitution. The admixtures used are Saw Dust ash, Fly Ash and Micro silica to enhance the strength of the concrete mix with 5% egg shell powder as partial replacement for cement.

Amarnath Yerramala (2014) Studied the Properties of concrete with eggshell powder as cement replacement. This paper describes research into use of poultry waste in concrete through the development of concrete incorporating eggshell powder (ESP). Different ESP concretes were developed by replacing 5-15% of ESP for cement. The results indicated that ESP can successfully be used as partial replacement of cement in concrete production. The data presented cover strength development and transport properties. With respect to the results, at 5% ESP replacement the strengths were higher than control concrete and indicate that 5% ESP is an optimum content for maximum strength. In order to investigate properties of ESP concretes, five mixes were employed in this study. Several laboratory trial mixes were carried out with 300kg/m³ cement. Water to cementitious ratio, coarse and fine aggregate quantities was arrived for concretes to be tested from the trial mixes. In this study, Compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 KN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516.1959 [10]. The test was conducted on 150mm cube specimens at 1, 7 and 28 days. Compressive strength was higher than control concrete for 5% ESP replacement at 7 and 28 days of curing ages. ESP replacements greater than 10% had lower strength than control concrete. Addition of fly ash improved compressive strength of ESP concrete.

Praveen Kumar R (2014) Experimentally investigated the Partial Replacement of Cement with Egg Shell Powder. The aim of this study is to study the chemical composition of the egg shell to find its suitability of replacement in the concrete. To examine the feasibility of utilizing the egg shell and silica fume as cement replacement material. To study the strength parameters of the egg shell powder mixed specimens and to compare it with conventional specimens. The scope of the study is to cast the concrete specimens and conduct the compressive strength test, split tensile strength test and flexural strength test at 7th & 28th day, with the specified combinations of egg shell powder and compare it with the controlled concrete specimens. In this project M30 Concrete is designed for various combinations. A combination of Egg shell with silica fumes are used in different combinations to find the feasibility of using the Egg shells as an alternate to cement. Egg shell powder replaces 10%, 20% and 30% in addition with the silica fume by 5%, 10%, 15% of weight of cement.

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Freire(2014)Carried out the investigation on egg shell waste and found out its use in a ceramic wall tile paste. Based on the presence of CaCO_3 in egg shell it can be used as a alternative raw material in the production of wall tile materials they Also found that egg shell can be used as an excellent alternative for material reuse and waste recycling practices.Jayasankar(2013)Has investigated the experiment by partially replacing cement with flyash and egg shell powder. They had conducted experiment by varying percentage of RHA, ESP, Fly ash in M20, M25 and M30 concrete. Based on theresults obtained from the experiment it can be concluded that, RHA, Fly ash and ESP mixed cubes has equal strength with that of conventional concrete cubes in certain categories.

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III.OBJECTIVES OF STUDY

The objectives of this study are as follows

- To investigate the best mix proportion of the partial replacement of egg shell powder and fly ash for cement in concrete by the value of strength.
- To investigate the feasibility of the partial replacement of above material in concrete by determining its compressive strength, flexural strength and split tensile strength.
- Based on the test results, to suggest most approximate level of adding egg shell powder and fly ash.

IV.METHODOLOGY

The materials used in this investigation are:

Cement: A cementis a binder, a substance that sets and hardens and can bind other materials together. In this project work, we used Ordinary Portland Cement (OPC) of grade 53 which is manufactured by RAMCO company.

Coarse Aggregate : Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. In this project work, aggregate of 20 mm size is used.

M-sand: Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The size of manufactured sand (M-Sand) is less than 4.75mm.

Flyash:Fly ash produced from the burning of younger lignite or sub-bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO).In this project work, class F fly ash is used collected from Hindustan Newsprint Ltd. Velloor, Kerala. Figure 1 shows the picture of flyash.



Figure 1: Fly ash

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Egg shell powder: The egg shell wastelands in the poultry manufacturing have been highlighted because of its recovery potential. Egg shell waste is available in huge amounts from the food processing, egg breaking, and shading industries. The food indulgence industry is in need of investigation to find another method for processing and using egg shells waste in an ecological friendly way. There is a need to find a low cost solution. Removal of egg shell waste are usually not income centers but cost centers. Therefore, the least cost of removal is most necessary. Some of the options left should be watched at very critically and the most cost effective method of recycling are considered. Egg shells procured from local nearby schools regularly and packed in bags. Then the collected egg shells were washed in normal water and then dried in hot sun light for a day to make it dry to make grinding easy and also to avoid the paste formation while grinding. Blackened egg shells were removed separately and the unwanted dust mixed in the sample collections were removed before bringing it to grinding. After collecting, drying and clearing, the samples were placed in a box for manual crushing up to some extent. Then samples were crushed by using some electronic equipment like mixer, grinder, etc. The grinded egg shells were sieved through the 90 micron sieve size and then packed to use it in the cement replacement. Given below in figure 2 shows the eggshell powder.



Figure 2: Egg shell powder

Water: Mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportions. In this project clean potable water is used for mixing and curing of samples.

Table 1: Chemical Test Result Of Egg shell powder

SL No :	Component	Symbol	Percentage (%)
1.	Calcium oxide	CaO	52.15
2.	Silica	SiO ₂	1.22
3.	Ferric oxide	Fe ₂ O ₃	0.16
4.	Alumina	Al ₂ O ₃	0.28
5.	Magnesium oxide	MgO	0.60
6.	Chloride	Cl	.011

Properties of Egg shell Powder and Fly ash

Fineness of Fly ash and Egg shell powder is measured by sieving on standard sieve. The proportion of Fly Ash of which the Fly ash particle sizes are greater than the 90 micron is determined. Also the proportion of Egg shell powder of which the Egg shell powder particle sizes are greater than the 90 micron is determined. The chemical test results of egg shell powder is given in table 1.

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Table 2: Physical properties of Fly ash and Egg shell powder (IS 1727:1967)

Property	Value
Fineness of Fly ash	3%
Fineness of Egg shell powder	5%

V. EXPERIMENTAL STUDY

Eggshell preparation:

Before the preparation of Eggshell, the eggshell was dried in sunlight to remove the moisture content. The eggshell werecrushed into powdered form under normal conditions .The eggshell powder passing from 90 micron was used in this experiment work.

Casting of Samples:

Preparation of the Specimens: For the experimental work concrete cubes of size 150x150x150mm,concrete beams of size 100x100x500mm,concrete cylinders of 300 mm height and 150 mm diameter were prepared. The 53 grade OPC was replaced with 10% Eggshell powder and coarse aggregate was replaced with 0% ,10% ,20%,30% and 40% flyash. M25 Grade of concrete is adopted throughout the study with w/c ratio of 0.5.

Sample M0: 10% Eggshell And 0% Flyash

Sample M1: 10% Eggshell And 10% Flyash

Sample M2: 10% Eggshell And 20 % Flyash

Sample M3: 10% Eggshell And 30 % Flyash

Sample M4: 10% Eggshell And 40% Flyash

Mix Proportion For M25 Concrete:

The mix proportion for M25 concrete is given in Table 3.

Table 3: Mix proportion for M25 concrete

Ingredient	Quantity (kg/m3)
Cement	383.2
Fine Aggregate	783.75
Course Aggregate	1080.77
Water	191.6

Cubes were tested in compression testing machine at 28th day of curing for compressive strength. The figure 3 given below shows the variations in compressive strength. The compressive strength increases by the addition of FA and ESP to an optimum value. The optimum value of compressive strength is obtained for the addition of 10% FA and 10 % ESP. The increase in compressive strength of FA replaced concrete is due to the high pozzolanic property of FA.

Cylinders were tested in compression testing machine at 28th day of curing for split tensile strength. The variations in split tensile strength is given in figure 4.The Split Tensile Strength Of Cylinder increases by the addition of FA and ESP to an optimum value. The optimum value of compressive strength is obtained for the addition of 10% FA and 10 % ESP. The increase in compressive strength of FA replaced concrete is due to the high pozzolanic property of FA.

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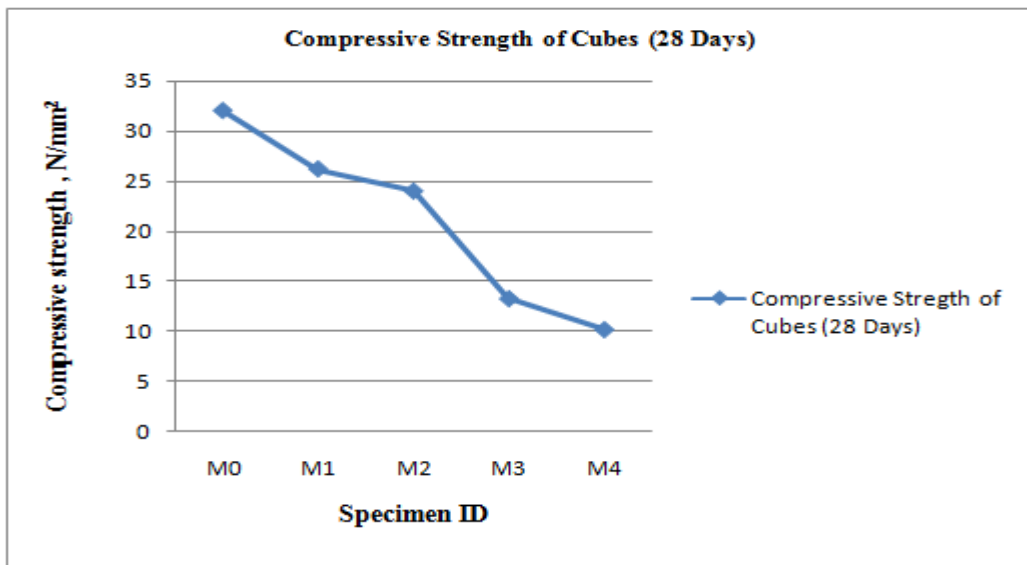


Figure 3: Compressive Strength of Cubes (28 Days)

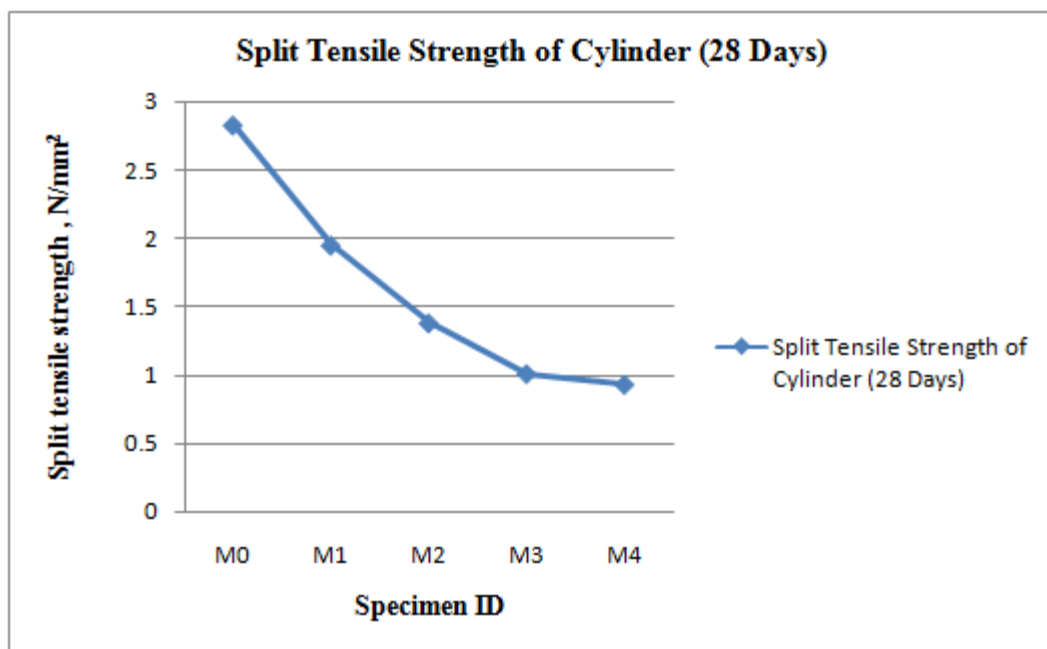


Figure 4: Split Tensile Strength of Cylinder (28 Days)

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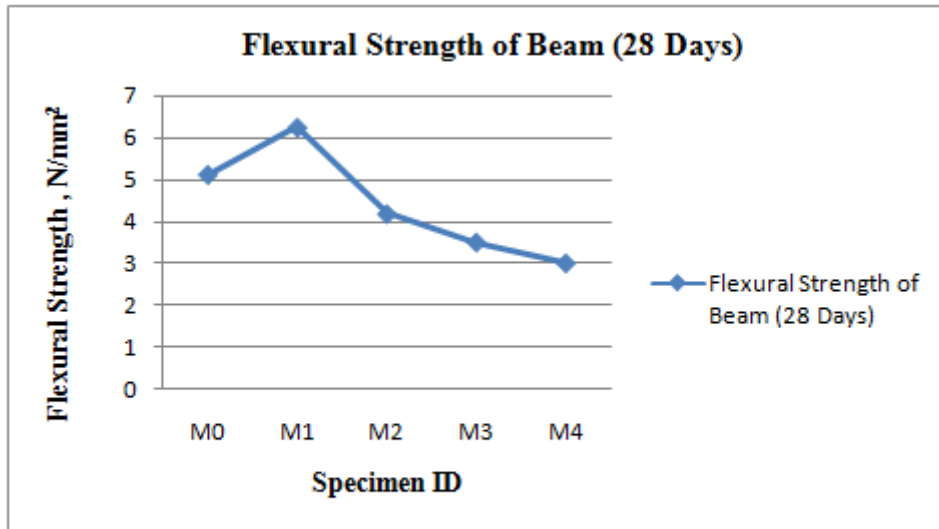


Figure 5: Flexural Strength of Beam (28 Days)

Beams were tested in flexural testing machine at 28th day of curing for flexural strength. The variations in flexural strength is given in figure 5. The flexural strength increases by the addition of FA and ESP up to an optimum value. The optimum value of flexural strength is obtained for the addition of 10% FA and 10% of ESP. Thereafter, the flexural strength seems to be decreasing. The decrease in flexural strength is due to the higher percentage replacement of cement by FA.

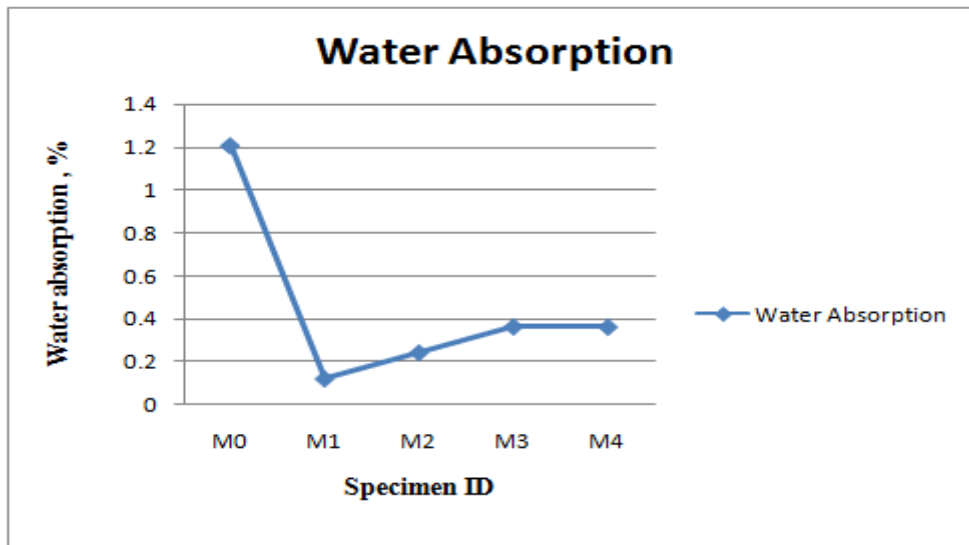


Figure 6: Water absorption test

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The water absorption is least for sample M1 i.e.; sample with 10% FA and 10 % ESP. The FA and ESP added concrete is much durable since water absorption is less and can be adopted for construction works. Figure 6 represents the variation.

VI. CONCLUSION

By the addition of Fly ash and egg shell powder it is proved that overall effectiveness of concrete increases. From the above study, it is concluded that the FA and ESP can be used as a replacement material for cement and for 10 % replacement of FA and 10% replacement of ESP gives an excellent result in strength aspect and it is obtained the value of selected grade. The results showed that the substitution of 10% of the cement content by fly ash (FA) and 10 % of egg shell powder (ESP) induced higher compressive strength, higher splitting tensile strength, high flexural strength and improvement of properties related to durability.

The following conclusions can be made from this project:

- The compressive strength, split tensile strength, flexural strength of FA and ESP added concrete (10% FA and up to 10 % ESP) gives better results and thereafter strength starts decreasing. 10% FA and 10 % ESP added concrete attains maximum strength.
- Concrete with ESP and FA gives greater flexural strength compared to concrete without ESP and FA.
- The workability of egg shell powder and fly ash added concrete was found to be decreasing after the addition of FA . But, thereafter for the remaining addition of FA and ESP, the workability of the FA and ESP added concrete increases.
- The FA and ESP added concrete is much durable since water absorption is less and can be adopted for construction works.
- Overall, for compressive and flexural strength of the concrete with eggshell ash and fly ash replaced gains lower strength compared to normal concrete using fully OPC.
- However, the strength developed from day 7 to day 28 due to pozzolanic effect that refers to high content of amorphous silica that gives positive effect to the strength of concrete.
- Because of using the egg shell powder and fly ash we can reduce the cost of the cement and also the construction cost.
- Hence we can provide eco-friendly concrete with use of egg shell powder and flyash.

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