Experimental Investigation of Egg Shell Powder as Partial Replacement with Cement In Concrete

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Abstract

With increasing industrialization, the industrial by products (wastes) are being accumulated to a large extent, leading to environmental and economic concerns related to their disposal (land filling). Egg shells are the biodegradable waste obtained from chick hatcheries, bakeries, fast food restaurants. Among other biodegradable wastes, this can damage the surroundings and thus leads to ecological issues/contamination which would need appropriate treatment. In the ever-soaring tasks to change waste to wealth, the efficiency of adopting eggshells to advantageous application constitutes a concept worth recognizing. It is systematically acknowledged that the egg shell chiefly consists of calcium compounds. It is estimated that roughly 90 million tons of hen egg are generated throughout the world every year. In India, 77.7 billion eggs are produced in the year 2010-2011.Cement is an energy extensive industrial commodity and leads to the emission of a vast amount of greenhouse gases. By reducing the demand of cement, natural reserves of limestone can be preserved, energy can be saved and pollution due to CO2 can be reduced. In this project, concrete will be casted for M30 grade and the partial replacement of cement with egg shells powder (ESP) in the range of 0%, 2.5%, 5%, 7.5%, 10% and 12.5% by weight of cement. The workability, compressive strength and tensile strength were conducted and results were analysed. Keywords: egg shell powder (ESP), workability, tensile strength and compressive strength.

1. INTRODUCTION

Concrete is a mixture of different materials like binder (cement), fine aggregate, coarse aggregate and water. Use of concrete is very large so availability of natural material is reduced and there is no material which plays the role of this ideal material. So, to fulfill the requirement of industries we have to replace fully or partially all the materials. In presence, concrete is broadly used for the shape of greatest of the buildings, bridges and so forth. Presently, the entire construction industry is in exploration of the precise and operative the wasted product that could significantly minimized the use of cement and in the end decrease the manufacture cost of concrete.

Concrete materials are extensively used in the building and construction industries. Cement is considered as one of the oldest and irreplaceable building material [8]. It is a soft and fine constituent of various mixtures of elements including limestone, shale and clay. Cement when further mixed with water, sand and gravel forms into a hard solid mass called the concrete. Tremendous amount of thermal and electrical energy is consumed during the manufacturing process of the cement which alone accounts for 40% of the operational cost. During manufacturing of 1 tonne of OPC we need approximately

1.1 tonnes of earth sources like limestone, etc. One of the main ingredients, Portland cement (PC) is generally expensive and yields carbon dioxide (CO2) emissions during its production (approximately 1 ton of CO2 greenhouse gases are generated for making 1 ton of PC) and consumes a lot of energy in its manufacturing process [1]. Energy performs an important role in successful of growing nations like

India. In the context of short availability of non-renewable energy sources fixed with the necessities of huge quantities of energy for Building materials like cement, the position of the usage of commercial waste cannot be underneath anticipated. Social and environmental issue of sustainability and energy conservation are assisting in changing the PC industry by lowering and partially replacing its cement production with supplementary cementing materials (SCMs).

2. Literature survey

Manzoor Ahmad Allie (2018) In this paper, it is studied that quality of construction material is an important issue which enhances the stability of the structure, an attempt has been made to study the possibilities of using Eggshell powder in paver block. Cement was partially replaced by Eggshell Powder at 5% intervals from 0% to 25% by the method of replacement by weight. The paver block Curing process is done for 7 days and 28 days, after curing it is checked for its Compressive Strength and flexural strength. It was noted that 13.4% increase of compressive strength at 10% replacement of Eggshell Powder. Flexural strength was also 19.5% increased at the same 10% replacement of Eggshell Powder. The result showed the Eggshell Powder can gives more strength if it was replaced as 10% of cement.

N. Parthasarathi (2017) In this paper, concrete is broadly used for the structures. Cement is main material in concrete but due to high demand of cement is costly. And to minimize the cost of structure, alternate material is required to manage the wastes in eco-friendly way. The intention of this research work is to apply the egg shell powder constrained extra of cement. Eggshell powder is changed by using 5%, 10% and 15% weight of cement. An experimental study proves the strength capabilities consisting of spilt tensile strength take a look at that is decreased with addition of eggshell powder, compressive strength test and flexural strength take a look at which can be increased up to 15%.

Amarnath Yerramala (2014) In this paper, it describes the usage of poultry waste in concrete thru the improvement of concrete and studied the Properties of concrete with eggshell powder (ESP) as cement alternative. Different ESP concretes had been advanced through replacing 5-15% of ESP for cement. Test are taken, compressive energy and split tensile strength take a look at turned into better than normal concrete for 5% of ESP alternative and it had lower strength than normal concrete with greater than 10% of substitute on the age of 7 & 28 days. The results proven that irrespective of ESP percentage substitute there has been proper relationship among compressive strength and split tensile strength.

S. Karthikeyan (2012) Reduce and Reuse of the opportunity substances is a whole lot energetic to preserve our strength assets. In the field of construction, the use of admixtures and re-utilization of available wastage substances is not a new one. But it is deals with a look at of Egg Shell Powder as a partial substitute of cement in concrete, to improve the strength in addition to reuse & reduce the egg shell wastage. The various traits of ESP are examined and it's far allowed to concrete as a partial alternative of cement. The numerous proportions such as 2.5, 5 and 7.5% are tried on this research and the strength performed by way of ESP concrete is much higher than a nominal concrete. Every admixture has its own strength. There became a pointy decrease inside the power while the proportion of ESP is beyond the extent of 5%.

Praveen Kumar (2006) Experimentally investigated the Partial Replacement of Cement with Egg Shell Powder. The goal of this takes a look at the chemical composition of the egg shell to locate its suitability of substitute within the concrete. To look at the probability of using the egg shell and silica fume as cement alternative cloth. To take a look at the strength parameters of the egg shell powder combined specimens and to examine it with traditional specimens. The scope of the look at is to the concrete samples and conduct the compressive strength check, split tensile strength take a look at and flexural power check at 7th & 28thday, with the desired mixtures of egg shell powder andevaluate it with the controlled concrete specimens. In this assignment M30 Concrete is designed for numerous combos. Egg shell with silica fumes is used in special combos to discover the possibility of using the Egg shells as a trade to cement Egg shell powder replaces 10%, 20% and 30% further with the silica fume by using 5%, 10%, 15% of weight of cement. Concrete is cast and Compressive check, split tensile and Flexural assessments were performed to discover the best combination which leads to optimum percent of power.

D. Gowisiet.al, (2011): - "eggshell powder as replacement with cement in concrete" experimentally investigated the egg shell powder as replacement with Cement in Concrete. 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. In this study it is proved that Egg Albumen Foamed Concrete (EAFC) can mix with 5% egg shell powder as partial replacement for cement. In this direction, an experimental investigation of compressive strength, split tensile strength, and Flexural strength was undertaken to use egg shell powder and admixtures aspartial replacement for cement in concrete.

3. Objectives and Methodology

3.1 Objectives

- To develop mix design methodology for mix 30 MPa
- To study the effect of adding different percentages (0% - 12.5%) of ESP by theweight of cement in the preparation of concrete mix.
- To determine the workability of freshly prepared concrete by Slump test.
- To determine the compressive strength of cubes at 7, 14, 28 days.
- To determine the Tensile strength of cylinders at 28 days.

3.2 Methodology

- Collect the egg shells from, by blending process the egg shell powder (ESP) wasobtained.
- The ESP and sieve with 75microns IS sieve, passed ESP used for cementreplacement.
- Find out the fineness modulus and specific gravity tests for ESP.
- Find out the physical properties of Coarse aggregate, Fine aggregate, cement.
- Design mix design of M30 grade concrete. And calculate the mix proportions for individual mix.
- Partial replacement of cement with ESP with varying percentages (0% - 12.5%) in the preparation of concrete.

Perform the workability, compressive strength and tensile strength tests on conventional and ESP-based concrete. Compare the values and find out the optimum percentage of ESP replacing by cement

4. Experimental work

Cement used in the investigation was found to be Ordinary Portland Cement (53 grade)confirming to IS : 12269 – 1987.

Fig. 1: Cement.

4.1 Fine aggregate

The fine aggregate used was obtained from a near by river course. The fine aggregate confirming to zone – II according to Is 383-1970 was used.

Coarse aggregate

The coarse aggregate used is from a local crushing unit having 20mm nominal size. The coarse aggregate confirming to 20mm well-graded according to IS:383-1970 is used in this investigation.

Fig. 2: 3 Coarse aggregates.

Egg shell powder

The ESP (Figure - 4.4) prepared in the month of February 2022 in a blending process. The generated powder from blending involves a wide range of particles size; only the fraction less than 75 microns has been used in this work. The powder has been dried before experiments.

Fig. 3: Egg shell powder.

a). Specific gravity of Cement

- Density bottle is cleaned with distilled water and dried.
- The weight W1 of the clean, dry density bottle with cap is noted.
- About one-third of the density bottle is filled with cement. The weight W2 of the density bottle and cement solids is determined.
- Small quantity of kerosene is poured into the soil and left until all pores are completely filled with water.
- Additional kerosene is poured into the density bottle to fill it completely upto the top of the cap. The density bottle is dried from outside. The weight W3 of density bottle and its contents is determined.
- The contents of the density bottle are removed. It is filled completely with kerosene upto the top of the cap. The density bottle is dried from outside and its weight W4 is noted.
- The specific gravity of the sample is determined by

$$G=\frac{w2-w1}{(w2-w1)-(w3-w4)0.79}$$

- The procedure is repeated twice, from steps 3 to 6 with other specimens from the same material. The specific gravity is reported as the average of three readings.
- Average Specific Gravity of Cement = 3.14

b). Specific gravity of Coarse aggregate

- Pycnometer is cleaned with distilled water and dried.
- The weight W1 of the clean, dry pycnometer with cap is noted.
- About one-third of the pycnometer is filled with coarse aggregates. The weight W2 of the pycnometer and soil solids is determined.
- Small quantity of water is poured into the soil and left until all pores are completely filled with water.

- Additional water is poured into the pycnometer to fill it completely upto the top of the cap. The pycnometer is dried from outside. The weight W3 of pycnometer and its contents is determined.
- The contents of the pycnometer are removed. It is filled completely with distilled water upto the top of the cap. The pycnometer is dried from outside and its weight W4 is noted.
- The specific gravity of the sample is determined by $G = \frac{w2-w1}{(w2-w1)-(w3-w4)}$
- The procedure is repeated twice, from steps 3 to 6 with other specimens from the same material. The specific gravity is reported as the average of three readings.
- Average Specific Gravity of C.A = 2.83

c) Specific gravity of fine aggregate

- Pycnometer is cleaned with distilled water and dried.
- The weight W1 of the clean, dry pycnometer with cap is noted.
- About one-third of the pycnometer is filled with fine aggregates. The weight W2 of the pycnometer and soil solids is determined.
- Small quantity of water is poured into the soil and left until all pores are completely filled with water.
- Additional water is poured into the pycnometer to fill it completely up to the top of the cap. The pycnometer is dried from outside. The weight W3 of pycnometer and its contents is determined.
- The contents of the pycnometer are removed. It is filled completely with distilled water upto the top of the cap. The pycnometer is dried from outside and its weight W4 is noted.
- The procedure is repeated twice, from steps 3 to 6 with other specimens from the same material. The specific gravity is reported as the average of three readings.
- Average Specific Gravity of F.A = 2.61

Coarse aggregate

The coarse aggregate produced from quarry was sieved through all the sieves (i.e., 80mm, 40mm, 20mm, 10mm and 4.75mm). The material retained on each sieve was filled in bags and stacked separately. To obtain 20mm well-graded aggregate, coarse aggregate retained on each sieve is mixed in appropriate proportions which are shown below.

The fineness modulus for coarse aggregate(20mm) 7.07

The fineness modulus for coarse aggregate(12.5mm) 7.75

Sieve sizes (mm)	Weight retained (gm)	% weight retained	Cumulative % weight retained	% passing
80	0	0	0	100
40	0	0	0	100
20	490	9.8	9.8	90.2
10	4411	88.22	98.02	1.98
4.75	99	1.98	100	0

Fig. 4: Proportions of different size fractions to obtain 20mm aggregate.

Fine aggregate

The sand was sieved through a set of sieves (i.e. 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ and 150µ). Sand retained on each sieve was filled in different bags and stacked separately. To obtain zone – II sand correctly, sand retained on each sieve is mixed in appropriate proportion.

The fineness modulus for fine aggregate 2.8

Sieve sizes	Weight retained (gm)	% weight retained	Cumulative % weight retained	% passing
4.75mm	25	2.5	2.5	97.5
2.36mm	52	5.2	7.7	92.3
1.18mm	161	16.1	23.8	76.2
600µ	355	35.5	59.3	40.7
300µ	364	36.4	95.7	4.3
150µ	36	3.6	99.3	0.7
75µ	5	0.5	99.8	0.2

Fig. 5: Proportions of different size fractions to obtain zone-II sand.

Aggregate Impact Value on Coarse Aggregates (IS: 2386)

- The test sample consists of aggregates sized 10.0 mm 12.5 mm. Aggregates may bedried by heating at 100-110° C for a period of 4 hours and cooled.
- Sieve the material through 12.5 mm and 10.0mm IS sieves. The aggregates passingthrough 12.5mm sieve and retained on 10.0mm sieve comprises the test material.
- Pour the aggregates to fill about just 1/3 rd depth of measuring cylinder.
- Compact the material by giving 25 gentle blows with the rounded end of the tampingrod.

- Add two more layers in similar manner, so that cylinder is full.
- Strike off the surplus aggregates
- Determine the net weight of the aggregates to the nearest gram(W).
- Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.
    - Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.
    - Raise the hammer until its lower face is 380 mm above the surface of aggregate sample in the cup and allow it to fall freely on the aggregate sample. Give 15 suchblows at an interval of not less than one second between successive falls.
    - Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm. Also, weigh the fraction retained in the sieve.

Mix design

One of the ultimate aims of studying the various properties of the materials of concrete and hardened concrete is to enable a concrete technologist to design a concrete mix design for a particular strength and durability. The design of concrete mix is not a simple task on account of the widely varying properties of the materials, the conditions that prevail at the site work in particular the exposure condition, and the condition that are demanded for a particular work for which mix is designed. Design of concrete mix designrequires complete knowledge of various properties of these constituent materials, the implications in case of change on these conditions at the site, the impact of the properties of plastic concrete on the hardened concrete and the complicated inter-relationships between the variables. All these make the task of mix design more complex and difficult. Design of concrete mix needs not only the knowledge of material properties and properties of concrete in plastic condition, it also needs wider knowledge and experience of concreting. Even then the proportion of the materials of concrete found out at the laboratory requires modification and readjustments to suit the field conditions.

Mix design can be defined as the process of selecting the suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certainminimum strength and durability as economically as possible. The first objective is to archive the stipulated minimum strength and durability. The second objective is to make the concrete in the most economical manner. Cost wise all concretes primarily depends on two factors namely cost of the material and cost of material. Since the cost of cementis many times more than cost of other ingredients, attentionn is mainly directed to the use of as little cement as possible consistent with strength and durability.

Material	Quantity
Cement (grade 53)	425.73Kg/m^3
Water	191.58 liters
Fine aggregate	649.63 kg/m^3
Coarse aggregate	1199.92 Kg/m^3
Water: cement	0.45

Fig. 6: Quantities of materials in cement concrete.

5. Results and discussions

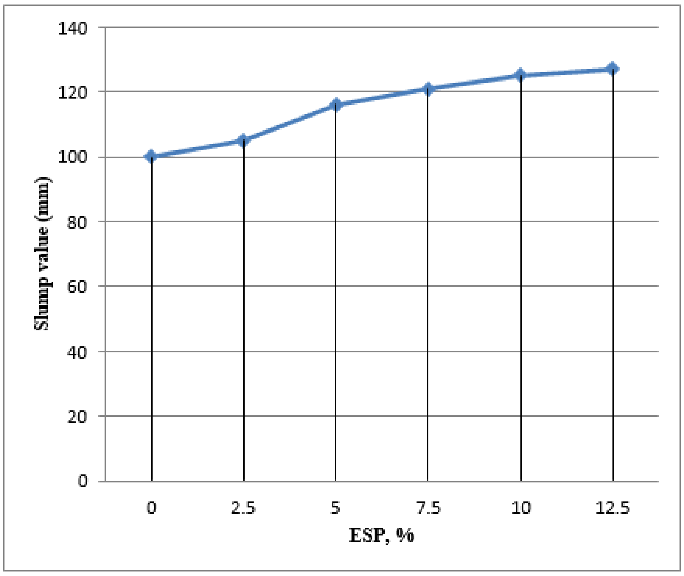

Fig. 7: Slump test results**.**

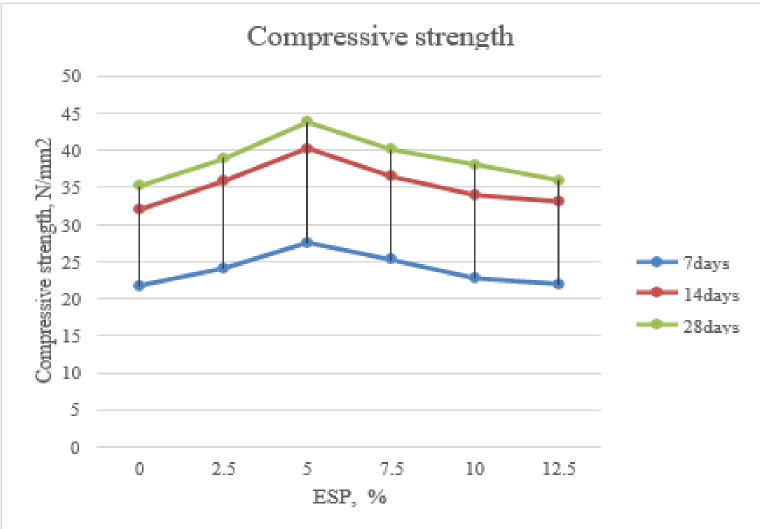

Fig. 8: Effect of ESP on 7, 14 and 28days compressive strength.

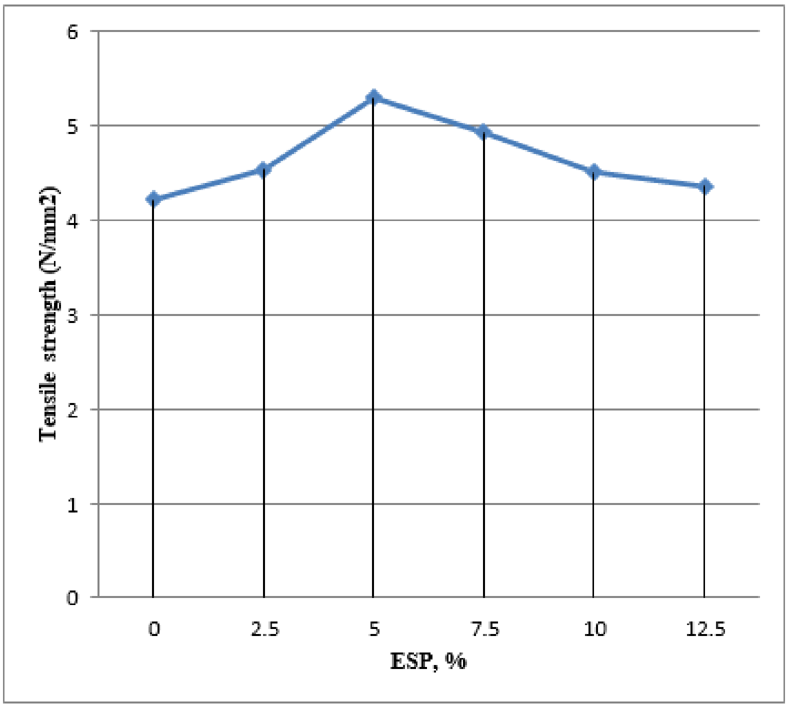

Fig. 9: Effect of ESP on 28 days Tensile strength.

6. Conclusions

From our investigation for M30 grade concrete by replacing 5% also it attains 43.8Mpa. The percentage of increment in compressive and tensile strength as compare to the conventional concrete was 25.6% and 24.43%. So we can make it as a practice by replacing 5% in all conventional buildings. It also makes it as a economical and eco- friendly building. The above-mentioned work of various researcher and our present experimental work, it is clear that egg shell powder can be used as a partial replacement of cement in concrete because of its increased workability, strength parameters like compressive strength and split tensile strength. As disposal, utilization of egg shell powder in concrete will not only provide economic, it will also help in reducing disposal problems.

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