A Comparative Study on Egg Shell Concrete with Partial Replacement of Cement by Fly Ash

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Abstract - **The carbon dioxide produced by cement industries causes environmental pollution and global warming. In 1000Kg of cement manufacturing processes approximately 900Kg of CO2 is emitted. In order to reduce the impact of cement production on atmosphere, wastes by products are used as admixture in this study, so that environmental pollution and natural resources consumption is reduced. 75million tones of fly ash which are rich in silica are disposed to landfill as a waste annually in India. Egg shell powder which is rich in calcium is thrown away as a waste. In the present study, these two wastes are used as a partial replacement of cement and various properties like workability, compressive strength, and density were determined. Egg shell powder are varied upto 12.5% (0%, 2.5%, 5%, 7.5%, 10% and 12.5%) and fly ash is added to optimum egg shell powder content cement concrete from 0% to 30% (0%, 5%, 10%, 15%, 20%, 25% and 30%).**

Key Words: Egg shell powder (ESP), Fly ash (FA), Compressive strength, Slump test, Density.1

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 and lot amount of green house 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 CO_2 emissions of the world. 900kg of CO_2 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 byproducts 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 stand is 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 aim of the current study is to determine the potential use of these wastes as a cementing material for concrete.

2. BACKGROUND AND RELATED WORK

Mtallib and Rabiu (2009) carried out the investigation on properties of ESA as an admixture in concrete. They conducted consistency test on ESP. It was observed that higher the contents of ESA in the cement, the faster the setting of cement. The decreased setting time of OPC was due to addition of ESA portrays ESA as an accelerator.

Moinul and Saiful (2010) an experimental investigation was carried out to study the effects of fly ash on strength development of mortar and the optimum use of fly ash in mortar. The optimum fly ash content was observed to be 40% of cement. 40% fly ash replacement mortar showed 14% higher compressive strength than OPC mortar after 90 days curing. The corresponding increase in tensile strength was reported to be around 8%.

Jayasankar et al (2010) conducted an experimental study on properties of concrete by substituting rice husk ash, fly ash and egg shell powder to cement in concrete. M_{20}, M_{25} and M_{30} mix design was used with 5%, 10%, 15% and 20% variation of egg shell powder, rice husk ash and fly ash to cement and also in the combination of ESP +fly ash, ESP + RHA, fly ash + RHA, fly ash + RHA + ESP. It was observed that M_{20} and M_{25} cubes was taking equal load compared to conventional concrete but M_{30} grade concrete's load carrying capacity was slightly decreased. Therefore they concluded that RHA, ESP and Flyash mixed cubes when added with grades above M_{25} may results in the decreased strength level.

Marthong and Agrawal (2012) carried out a comparative study on effects of concrete properties by partially replacing ordinary Portland cement of varying grades by fly ash. It was also observed that at the age of 90 days the rate of strength gain for 33, 43 and 53 grades concrete was increased and had been maximum up to 20% fly ash replacement. They concluded that influence of fly ash on shrinkage was negligible. Increase in normal consistency with increase in fly ash content was observed. Setting time and soundness was decreased with the increase in grade of cement.

Sathanantham et al (2014) carried out a study on properties of M_{25} concrete by replacing fine aggregate partially by rice husk ash and egg shell powder. The maximum strength was observed at 20% for compressive, split tensile and flexural strength.

3. MATERIALS AND EXPERIMENTAL CONDITIONS

3.1 Cement

Ordinary Portland cement of 43grade conforming to IS 8112-1989 is used. Table 1 shows the test results of basic properties of cement.

Table 1: Basic Properties of Cement

Properties	Results
Specific gravity	3.1
Standard consistency	31%
Initial setting time	38min
Final setting time	480min
Fineness	5.3%

3.2 Fine Aggregate

Natural river sand of size below 4.75mm conforming to zone II of IS 383-1970 was used as fine aggregate. Table 2 shows the test results of basic properties of fine aggregates.

Table 2: Basic Properties of Fine Aggregates

Properties	Results
Specific gravity	2.62
Water absorption	1.45%

3.3 Coarse Aggregate

Natural crushed stone with 20mm down size was used as coarse aggregate. Table 3 shows the test results of basic properties of coarse aggregates.

Table 3: Basic Properties of Coarse Aggregates

Properties	Results
Specific gravity	2.65
Water absorption	0.39%

3.4 Fly Ash

Class F fly ash was used in this study and it was collected from Udupi Power Corporation Limited. Table 4 shows the test results of basic properties of fly ash.

Table 4: Basic Properties of Fly Ash

Properties	Fly Ash
Specific gravity	2.5
Fineness	2.28%

3.5 Egg Shell Powder

Egg shell which was a waste material was collected from KVG Engineering Hostel mess and is sun dried. Stored egg shell was powdered in flour mill. Table 5 shows the test results of basic properties of egg shell powder.

Table 5: Basic Properties of Egg Shell Powder

Properties	Results
Specific gravity	1.95
Fineness	5.9%

3.6 Water

In this investigation, for both mixing and curing ordinary portable water was used.

3.7 Superplasticizer (SP)

Conplast SP430 was used as a superplasticizer. It is a chloride free, super plasticizing admixture. It was supplied as a brown solution which instantly disperses in water.

3.8 Concrete Mix Design

Mix proportion used in this study was 1:1.61:2.65 (M40) conforming to IS 10262-2009 with water-cement ratio of 0.4 and superplasticizer of 0.75%

3.9 Mix Proportion

Cement is replaced by egg shell powder at 0%, 2.5%, 5%, 7.5%, 10% and 12.5% and fly ash is added to cement in optimum egg shell concrete by 5%, 10%, 15%, 20%, 25% and 30%.

Table 6: Mix Proportion of Concrete with Replacement

ESP Replacement		Optimum ESP + FA Replacement		
Mix Name	ESP (%)	Mix Name	ESP (%)	FA (%)
0% E	0	7.5% E + 5% F	7.5	5
2.5% E	2.5	7.5% E + 10% F	7.5	10
5% E	5	7.5% E + 15% F	7.5	15
7.5% E	7.5	7.5% E + 20% F	7.5	20
10% E	10	7.5% E + 25% F	7.5	25
12.5% E	12.5	7.5% E + 30% F	7.5	30

3.10 Casting of Specimens

Weight batching and machine mixing were adopted in this study for concrete production. Cubes of size 100*100*100mm, cylinders of size 100mm diameter and 200mm length and beams of size 100*100*500mm were casted. Mixing was done by adding coarse aggregates followed by water + superplasticizer, sand and cement. For each mix slump test was conducted to measure workability. Afterwards moulds were casted and compacted on table vibrator. Demoulding was done after 24 hours of casting and specimens are cured in water tank. Fig 1 shows the concrete placed in moulds.

Fig 1: Concrete placed in moulds

3.11 Slump Test

Slump test was carried out on each mix with inverted cone. Concrete is filled in three layers and each layer is tamped 25 times by tamping rod. Fig 2 shows the slump test carried out on concrete.

Fig 2: Slump test carried out on concrete

3.12 Testing of Specimen

7, 28 and 56 days compressive strength tests were carried out on compressive testing machine as shown in Fig 3. And also density test was conducted on cubes.

Fig 3: Compressive Strength Test on Cubes

4 RESULTS AND DISCUSSIONS

Chart 1 graphically represents the result of workability on cement concrete with ESP as a partial replacement to cement. From the graph it is observed that as ESP content increases workability decrease. The results obtained were compared to the study carried out by Doh Shu Ing and Chin Siew Choo (2014) on ESP as potential filler in cement. In that study medium workability was observed when ESP was replaced to cement concrete.

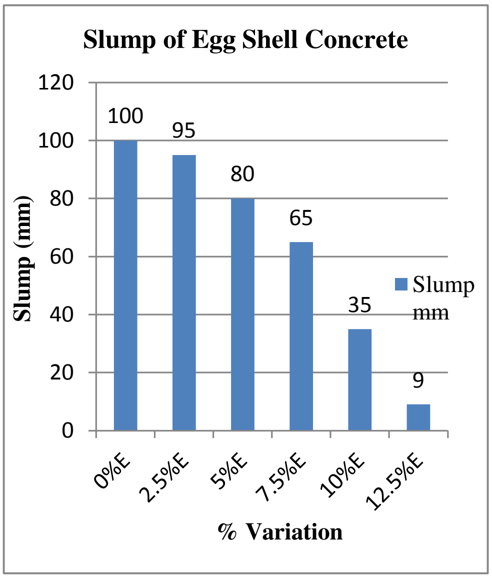

Chart 1: Slump Test Result of Egg Shell Concrete

Chart 2 graphically represents the slump test on optimum ESP + FA variation concrete. It was observed that optimum ESP replacement concrete slump value is lower than control concrete. Addition of fly ash to optimum ESP content concrete has increased the workability compared to egg shell concrete slump results.

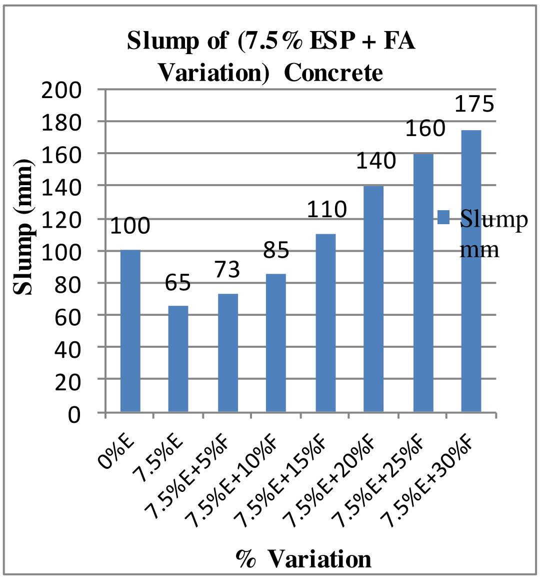

Chart 2: Slump Test Results of Optimum ESP + FA Variation Concrete

Chart 3 graphically represents the density of egg shell concrete cubes. It is observed that increase in ESP content decreases the density of concrete cubes. Amarnath (2014) carried out the similar study on ESP and observed that ESP concrete had lower density compared to control concrete.

Chart 4 graphically represents the density of optimum egg shell concrete with fly ash variation. It is observed that density increases after addition of fly ash to optimum egg shell powder concrete in reverse order compared to egg shell powder concrete.

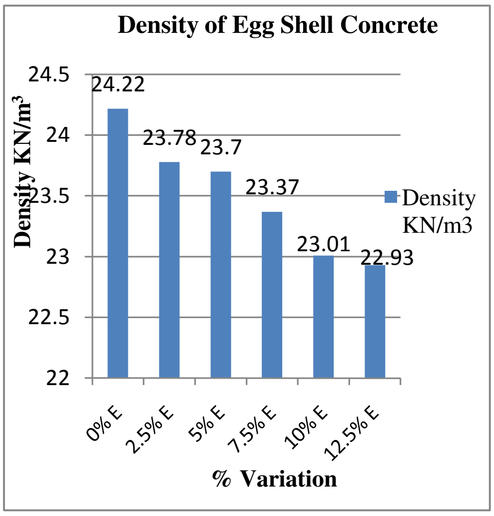

Chart 3: Density Result of Egg Shell Concrete

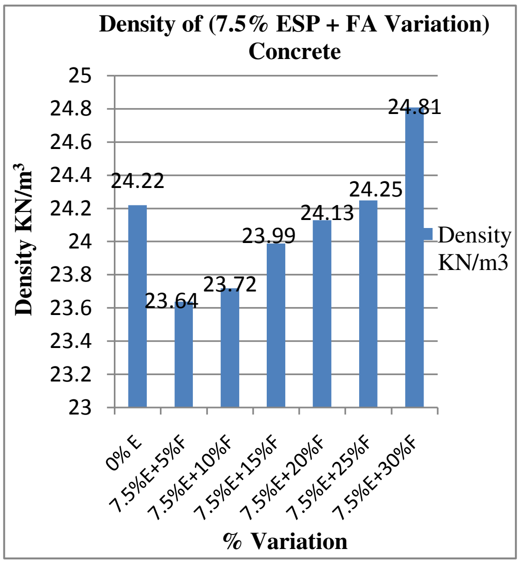

Chart 4: Density Results of Optimum Egg Shell Concrete with Fly Ash Variation

The Chart 5, Chart 6 and Chart 7 graphically represents the compressive strength of concrete with partial replacement of cement by egg shell powder at 7, 28 and 56 days respectively. Compressive strength of egg shell powder concrete is lower to that of control concrete mix. Maximum compressive strength is obtained at 7.5% replacement of ESP for all ages. Amarnath (2014) got similar result and concluded that addition of ESP to cement concrete shows the reduction in compressive strength compared to control concrete. Jayasankar et al (2010) carried out the study on ESP by varying it from 0% to 20% in steps of 5% and obtained maximum compressive strength at 5% replacement to cement. For this maximum compressive strength of egg shell concrete, fly ash is added at different percentage.

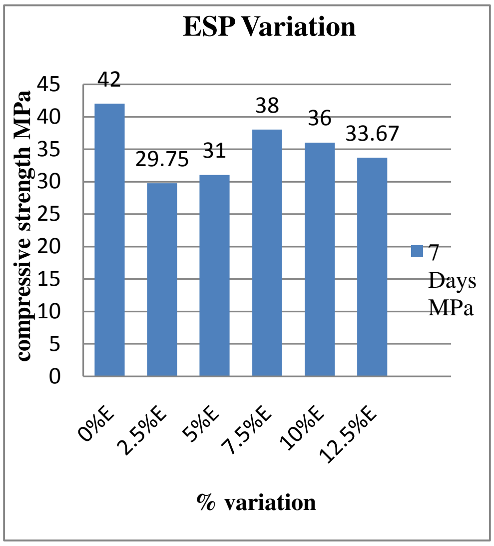

Chart 5: 7 Days Compressive Strength of Egg Shell Concrete

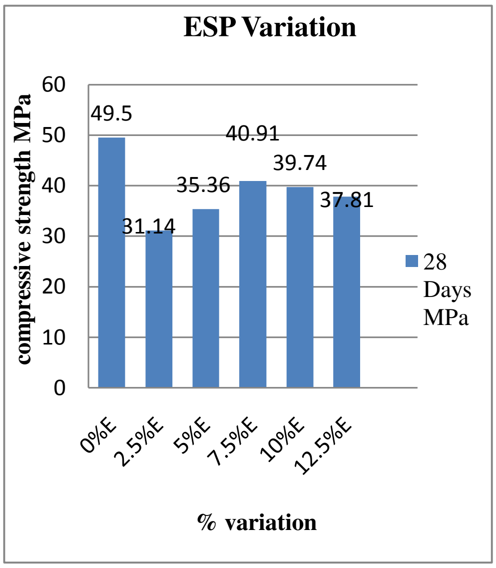

Chart 6: 28 Days Compressive Strength of Egg Shell concrete

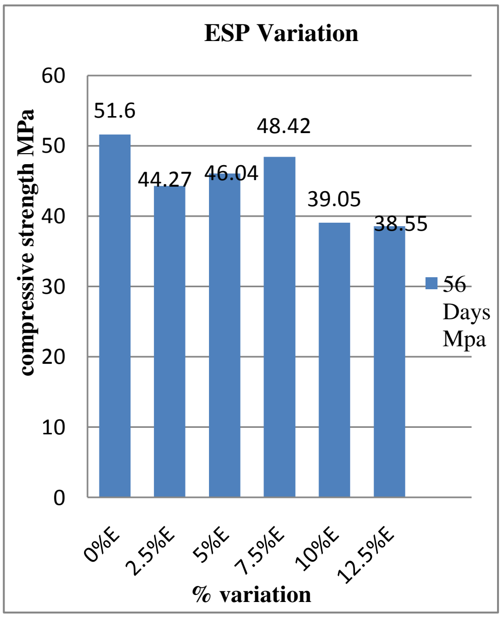

Chart 7: 56 Days Compressive Strength of Egg Shell Concrete

By considering 7.5% ESP as optimum dosage, FA was varied in concrete mix. Chart 8, Chart 9 and Chart 10 represents the compressive strength of optimum ESP content and FA variation concrete at 7, 28 and 56 days respectively. It can be observed that, the maximum compressive strength of optimum ESP + FA concrete is attained at 7.5%ESP +
5%FA. Addition of fly ash at 10%, 15%, 20% and 30% to optimum egg shell concrete has decreased the strength in all ages but addition of fly ash at 5% and 25% to optimum egg shell concrete has increased the strength. Optimum egg shell powder with addition of fly ash concrete result is less compared to optimum ESP concrete strength at 7, 28 and 56 days (Chart8, Chart 9 and Chart10). But all results were low compared to control concrete. Similar result was observed in the study carried out by Jayasankar et al (2010). It was observed that addition of fly ash to egg shell concrete had decreased the strength at 14 days curing compared to egg shell concrete.

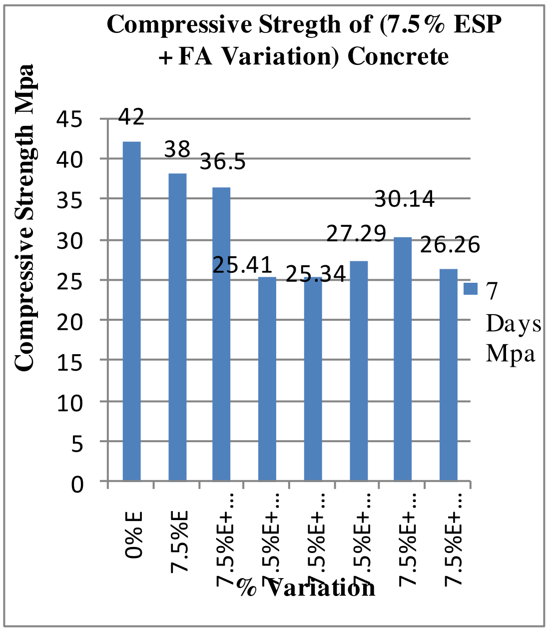

Chart 8: 7 Days Compressive Strength of 7.5% ESP + FA Variation

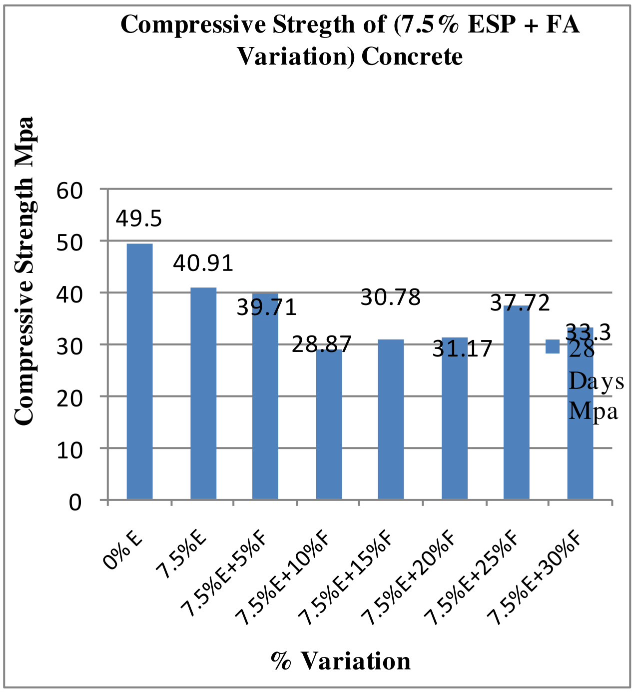

Chart 9: 28 Days compressive Strength of 7.5% ESP + FA Variation

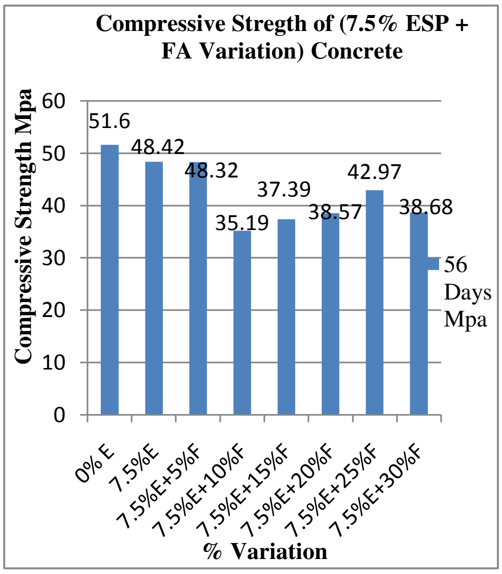

Chart 10: 56 Days Compressive Strength of 7.5% ESP + FA Variation

5 CONCLUSIONS

Based on the experimental investigation the following conclusion are drawn

- Addition of ESP to cement concrete leads to reduction in workability.
- Density decreased with addition of ESP to cement concrete.
- Increase in workability was found with addition of fly ash to optimum egg shell powder concrete.
- Increase in density was observed to addition of fly ash to optimum egg shell concrete.
- Compressive strength of egg shell concrete was lower than control concrete mix (M40).
- The combination of ESP + FA showed the reduction in compressive strength compared control concrete and egg shell powder concrete.

REFERENCES

(1) Mtallib M. O. A., Rabiu A., (2009), "Effect of Eggshells Ash on the Setting Time of Cement", Nigerian Journal of Technology, Volume 28, Issue 2, PP 29-38.

(2) Moinul Islam Md., Saiful Islam Md., (2010), "Strength Behaviour of Mortar Using Fly Ash as Partial Replacement of Cement", Concrete Research Letters, Issue 3, Volume 1, pp 98 - 106.

(3) Jayasankar R., Mahindran N., Hangovan R., (2010), "Studies on Concrete using Fly Ash, Rice Husk Ash and Egg Shell Powder", International Journal of Civil and Structural Engineering, ISSN 0976-4399, Volume 1, Issue 3, PP 362-372.

(4) Marthong C., Agrawal T. P., (2012), "Effect of Fly Ash Additive on Concrete Properties", International Journal of Advanced Engineering Research and Applications, ISSN 2248 - 9622, Issue 4, Volume 2, pp 1986 - 1991.

(5) Sathanantham T., Dinesh N., Ramesh Kumar R., Arunachalam., Chandra Sekar., Gowtham P., (2014), "Partially Replacement of Fine Aggregate by Rice Husk and Eggshell in Concrete", International Journal of Innovative research and studies, ISSN 2319-9725, Volume 3, Issue 1, PP 444-460.
(6) TEXT BOOK - Shetty M. S., (2013), "Concrete Technology - Theory and Practical", S.Chand Publishing.
(7) Doh Shu Ing., Chin Siew Choo., (2014), "Eggshell Powder: Potential Filler in Concrete", Malaysian Technical Universities Conference on Engineering and Technology.
(8) IS 456-2000, Indian Standard, Plain and Reinforced Concrete - code of practice.
(9) IS 383-1970, Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete.
(10) IS 10262-2009, Indian Standard Recommended Guidelines for Concrete Mix Design.