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STUDY ON EFFECT OF EGGSHELL POWDER AND WASTE FOUNDRY SAND ON MECHANICAL PROPERTIES OF CONCRETE

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Abstract- *Concrete is the crucial component used in the construction industry all over the world, where the fine aggregate is usually natural sand. Discarding waste materials to the environment directly, can cause environmental problem. Thus the reuse of waste material has been in present industrial trend. The eggshell usually thrown away as waste is used as a substitute to the cement since the shell is made up of calcium. This research was carried out to determine the strength properties of concrete by using eggshell powder as a partial replacement of cement and waste foundry sand partially replaced with fine aggregates. Cement is partially replaced with eggshell powder in the range of 0%, 5%, and 10% and15% for M25 grade of concrete. The compressive strength was determined at the 7 days and 28 days of curing age. There was a sharp decrease in compressive strength beyond 10% eggshell powder replacement. To enhance the strength of concrete mix WFS was used in different proportions (0%, 10%, 20% and 30%) with optimum value of ESP (i.e.10%) as a partial replacement for sand. In this way, an experimental investigation of compressive strength and split tensile strength and was undertaken to use eggshell powder and foundry sand.*

Keywords- Eggshell powder, foundry sand, compressive strength, split tensile strength.

1. INTRODUCTION

In the modern time, the construction sector is expanding rapidly on a large scale involving newer techniques. The concrete is one of the main components in the construction whose manufacturing process consists of ingredients such as aggregates, cement, water and admixtures. The consumption of natural resources in construction is remarkable and results higher in cost. To overcome the use of natural resources and by making an effort to use waste materials could result in reduction in cost of construction. The waste produced by the factories and agricultural fields can be used as an alternative construction material, in order to the conservation of natural resources and disposal of harmful wastes can be reduced.

The present study is aimed at utilizing waste foundry sand as fine aggregate and eggshell powder as a partially replaced with cement in the concrete. Foundry sand is the waste generated from the industries and eggshell is an agricultural waste. If such materials are found suitable in concrete making both reduction in cost of construction material as well as safe disposal of waste materials can be achieved.

2. LITERATURE REVIEW

2.1 GENERAL

Very few experimental investigation were carried out on concrete wherein cement and fine aggregates are partly replaced by eggshell powder and foundry sand and the strength parameters such as compressive strength, split tensile strength and flexural strength were obtained. An overview of research work carried out by various researchers in the field of eggshell powder and waste foundry sand has been summarized below:

Amu et al 2005 carried out the experimental investigation and reported that eggshell powder can be used as supplement or industrial lime on an expansive clay soil and also stated that the combination can be used where high subgrade performance is not required.

Jayasankar at el 2010 had investigated the experiment by partially replacing cement with ESP and fly ash. They had conducted the experimental study by varying the percentage as 5%, 10%, 15% and 20% of ESP, RHA and fly ash to cement in M20, M25 and M30 grade of concrete mix. Based on the results obtained from this investigation it can be observed that M20 and M25 grade of concrete cubes was taking equal load as compared to controlled concrete and the load carrying capacity of M30 grade of concrete was slightly decreased. Thus, they concluded that ESP, RHA and Fly Ash mixed cubes when added with grades higher than M25 may results in the decreased strength level.

Okonwo et al 2012 has concluded in his research that eggshell can be used as substitute for cement which resulted in higher compressive strength on lateritic soil.

Constant percentage of 6 and 8% added with the eggshell powder of 0-10% at 2% interval shows increase in 35% of compressive strength. Ultimately they observed that soil-cement eggshell mixture can be used for road pavements.

D.Gowsika et al 2014 carried out the experimental investigation on the properties of cement concrete by partially replacing OPC with ESP, fly ash, saw dust and micro silica. Researchers adopted M20grade of concrete mix in the proportion of 1: 1.7: 3.08 in which cement was partially replaced with ESP as 10%, 15%, 20%, 25% and 30% by weight of cement. Water cement ratio was taken 0.5. Compressive strength, flexural strength and split tensile strength were found out to use ESP in cement mortar along with some admixtures. The compressive strength test was conducted after 28 days of curing. The results shows that there was a sharp decrease in compressive strength beyond 5% eggshell powder replacement. The admixtures used were saw dust ash, micro silica and fly ash to enhance the properties of concrete mix with 5% ESP as partial replacement with cement.

J.M.Khatib, S.Baig 2010 investigated the properties of concrete in fresh and hardened state by replacing fine aggregates with WFS 0-100%. Water to cement ratio was kept constant for all mixes. Testing was performed on hardened concrete after 14, 28 and 56 days. The results obtained from the investigation shows that the workability of concrete decreases as the percentage of WFS increases in the concrete. It was also concluded that certain amount of WFS content was giving slightly higher strength as compared with conventional concrete. This paper primarily focused on the utilization of waste foundry sand.

Eknath P. Salokhe, D.B.Desai 2011 performed experimental investigation to evaluate the comparative study on fresh and hardened properties of concrete by using foundry sand for M20 grade of concrete. Natural sand was replaced by WFS (0, 10, 20 and 30%) by weight at different levels. Tests were performed for all the replacement level at 7 and 28 curing days.

30%replacements of fine aggregates were showing the maximum compressive strength after 28days of curing.

Khatib and Herki 2013 carried out an experimental study on the concrete produced by replacing the fine aggregates with 0%, 30%, 60% and 100% WFS. The water content, coarse aggregates, cement and w/c ratio kept constant. The properties studied at 7, 28 and 90 days of curing age were: ultrasonic pulse velocity, compressive strength and water absorption by capillary action. The results indicated that there is a systematic increase in water absorption and a decrease in compressive strength and UPV with the increase in the WFS content in concrete.

3. MATERIAL USED

3.1 EGG SHELL POWDER

For making eggshell powder, white eggs were used and these shells were collected from the nearby bakery. After collection eggshell were washed in the flowing water and then air dried for 3-5 days at a temperature of about 20˚-25˚C. The shells then crushed by hands and grained in a grinding machine for obtaining a very fine powder and then sieved through 90µm IS sieve. The powder which passed through 90µm sieve was used as a cement replacement in the whole research work and material which retained on the sieve was thrown away as a waste. The properties of ESP are given below in table1.

Fig1 (a. crushed eggshell

Fig1 (b. Grinding of eggshell

Fig1 (c. Sieving eggshell powder Through 90µ sieve

Table1. Chemical Composition of Eggshell Powder

S.No.	Constituents	%age by weight
1	Calcium oxide(CaO)	51.57
2	Silica(SiO_2)	0.35
3	Alumina(Al_2O_3)	0.40
4	Iron oxide(Fe_2O_3)	0.03
5	Sodium oxide(Na_2O)	0.15
6	Sulphur Trioxide(SO_3)	2.21
7	Loss on ignition(LOI)	54.1
8	Specific gravity	2.35

3.2 WASTE FOUNDRY SAND

Foundry sand used for making sand molds for metal castings is usually recycled. After reusing for multiple times they lose their characteristics thus becoming unsuitable for further use in the manufacturing process and discarded as a waste.

Waste Foundry Sand is used as earth fill materials in construction industries. It is cheapest and suitable alternative to sand. Properties of WFS depend on the metal casting process. In the present work foundry sand is collected from BOPARAI Metals Pvt. Mohali, Punjab.

Fig2. Waste foundry sand

Table 2. Physical Properties of WFS

S.NO.	Parameters	Observed results
1	Color	Black
2	Specific Gravity	2.16
3	Fineness Modulus	1.8

3.3 WATER

Fresh and clean tap water was used for the specimen casting process. Water was relatively free from organic matters, oil, silt and other type of impurities as per IS 456:2000.

3.4 SUPERPLASTICIZER

It was observed that with the increase in WFS content in concrete, slump value decreases. It could be as a result of; increase in fine particles of WFS concrete mixes which lead to increase in surface area of fine aggregates with constant water cement ratio. To maintain the slump value, Rheoplast SP-450 superplasticizer conformed to the specifications ASTM C494- type F was used.

3.5 FINE AGGREGATES

Those particles passing from 4.75mm sieve and retained on 75µ sieve are called fine aggregates. The aim of fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. The fine aggregate should have rounded shape for increased workability and for economy as reflected by use of less cement.

The sand used for the experimental work was locally obtained and conformed to zone II. Sieve analysis of fine aggregates was performed in the laboratory as per IS 383-1970.

3.6 COARSE AGGREGATE

In this experimental work, crushed stone aggregates were used for concrete mixes which were locally available. Coarse aggregates of size 20mm and 10mm were used for this work. To find the physical properties, various tests were performed on coarse aggregates such as specific gravity, fineness modulus conforming to IS 383:1970

3.7 CEMENT

In the present investigation, Portland Pozzolana (fly ash based) cement was used. Cement used for experimental work was fresh and lumps free. The various tests on cement are performed as per Indian Standard Specifications (BIS-1489 part I: 1991).

3.8 METHODOLOGY

Mix Design was prepared as per IS: 10262-2009. The details on the mix proportion for the conventional concrete are listed in the table3.

Table3. Mix proportion

Grade	Cement (kg/m^2)	FA (kg/m^2)	CA (kg/m^2)	w/c ratio
M25	1	1.92	2.68	0.42

Further the studies were performed by the replacement of cement by eggshell powder in a proportion of 5%, 10%, 15% and fine aggregate is replaced by foundry sand by 10%, 20% and

30%.the samples were kept in water for curing for 7 days and 28 days and test for determination of compressive strength, split tensile strength and flexural strength of concrete were performed.

4. EXPERIMENTAL RESULTS

The strength properties of concrete using eggshell powder and foundry sand was compared with the conventional concrete based on the experimental results.

4.1 COMPRESSIVE STRENGTH

Cube of size 150mm x 150mm x150mm were used and tested at 7 and 28 days of curing in water. The strength of concrete was evaluated as per IS516-1959 for different replacement level.

Table 4. Compressive Strength Test Results

Mix Designation	Avg. compressive strength of specimen in N/mm²	
	7 days	28 days
CC (0%)	18.89	31.33
ESP1 (5%)	19.78	31.56
ESP2 (10%)	20	32
ESP3 (15%)	15.46	27.20
EF 1(ESP 10% + WFS 10%)	20.44	32.22
EF 2(ESP 10% + WFS 20%)	22.04	34.67
EF 3(ESP 10% + WFS 30%)	16.67	27.33

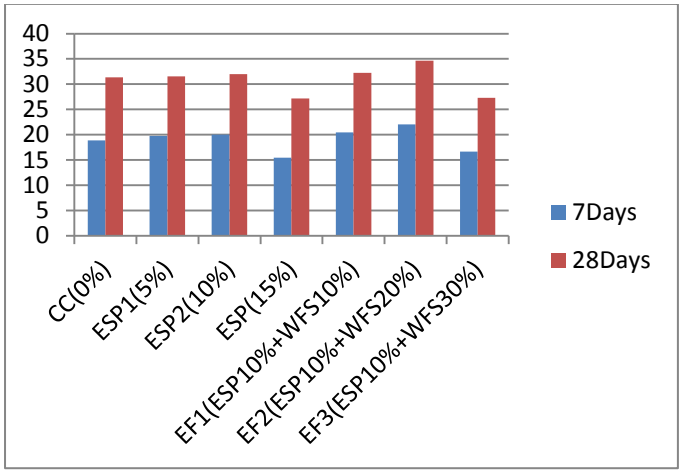

Fig3. Avg. compressive strength of design mix with different proportions

4.2 SPLIT TENSILE STRENGTH

This test was conducted to determine the tensile strength of concrete. Split tensile strength was performed for different replacement level as per IS5816-1999. The strength of different mixes was calculated after 7 and 28 days of curing and results are shown in table5.

Table5. Split Tensile Strength of Concrete

Mix Designation	Avg. split tensile strength in N/mm²	
	7days	28days
CC (0%)	2.26	3.28
EF1 (ESP10%+WFS10%)	2.49	3.44
EF2 (ESP10%+WFS20%)	2.63	3.84
EF3 (ESP10%+WFS30%)	2.17	2.96

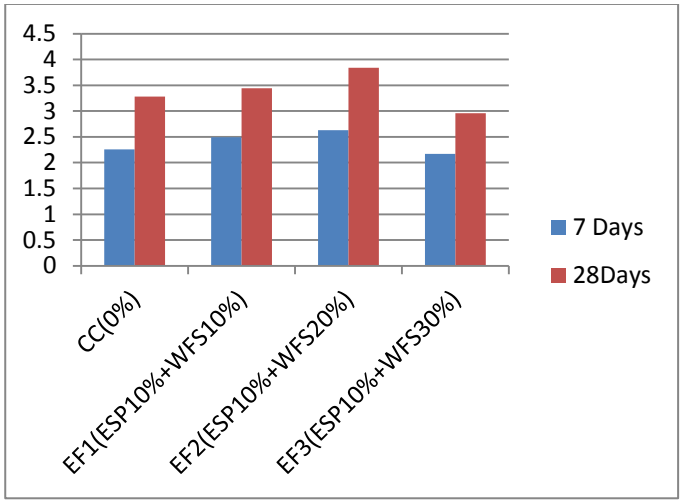

Fig4. Split Tensile Strength of Concrete

5. CONCLUSION

From the above data there are many conclusions to conclude. As the eggshell is rich in calcium and having nearly same composition to limestone. The research has been performed for different proportions of 5, 10 and 15 percentages. From based on these results I have taken 10% of eggshell powder as constant and the foundry sand varies as 10,20 and 30 percent. The following conclusions are made from above study:

- With the increase in the amount of waste foundry sand along with the constant amount of eggshell powder the compressive strength of the concrete increases up to an optimized value and beyond that of further increases the quantity of waste foundry sand then strength start reducing.
- The compressive strength of concrete containing 20% waste foundry sand and 10% egg shell powder gave the better results when compared with the other proportions.
- Foundry sand having about 98% silica content, which increases the compressive strength of concrete.

- Split tensile strength of all concrete mixes for M25 grade of concrete was found to increase with increase in with varying percentage of waste foundry sand.

- Maximum increase in split tensile strength was observed at 20% replacement of fine aggregates with waste foundry sand and 10% replacement of cement with ESP at 7 and days 28 days of curing.

- Concrete having 30% replacement of sand with WFS and 10% replacement of cement with ESP showed that these sample have least splitting tensile strength.

- Use of eggshell powder and waste foundry sand in concrete reduces the production of agricultural and metal industries waste.

From the experimental work results, it can be proved that certain replacement level of WFS and ESP in concrete is showing good results as compared to the conventional concrete.

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