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EXPERIMENTAL STUDY OF EGG SHELL POWDER AND ALUMINIUM FOIL CONCRETE

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ABSTRACT:

Construction industry depends heavily on conventional materials such as cement, granite and sand for the production of concrete. Cement is the most economical constituents used in the production of concrete and also poses the problem of acute shortage in many areas, which poses serious problems on its availability, cost and environmental impact. Approximately 1.1 tonnes of earth resources such as limestone, clay etc., are needed for the production of one tone of Ordinary Portland Cement also the process results in the emission of an equal amount of carbon-di-oxide into the atmosphere which may be serious threat to the environment in various forms. So there is always a need for substituent to OPC. For preventing environment and to produce a low cost concrete an attempt is Being made in this project that the cement is partially replaced by locally available material such as egg shell powder. Generally egg shells were disposed as waste which comprises of 95% of CaCO3 and 5% of Magnesium, Sodium, Potassium, Ironic acid and Silica acid which may be used as an alternate for the cement. Statistics shows that the huge amounts of egg shells were laid as waste and disposed as landfills in India. So it can be replaced for cement due to its chemical properties and its abundant in nature. In this work, experiments were carried out by using egg shells as a partial replacement for cement. The concrete design mix

considered is M40 of ratio 1:1:2. The specimens were prepared by replacing cement by 10%, 15% and 20%. The mechanical properties of Egg shell powdered Concrete like compressive, split tensile and flexural strength were determined for 7, 14 and 28 days of curing period and results were compared with the conventional concrete.

CHAPTER 1

INTRODUCTION:

Utilization of waste products in concrete has advantage on both construction and environmental factors. Cement is the most important constituents used in concrete production. Parallel to the need for the utilization of the natural resources emerges a growing concern for protecting the environment and a need to preserve natural resources by using alternative materials that are either recycled or discarded as a waste. This study was aimed to use ESP in concrete. Although Egg shell is calcium rich and analogous to limestone in chemical composition, it is a waste material. Therefore, to initiate use of Egg shell waste for partial replacement of cement in concrete, there is a need to understand concrete properties made with Egg shell powder. Thus, the objective of this study was to understand the possibilities of use of ESP in concrete. Investigations were systematically conducted on performance of ESP concretes in terms of properties like compressive strength and splitting tensile strength and transport properties like water absorption. ESP was replaced concrete specimens were tested for 1, 7 and 28 days. Based on the test results, the influence of ESP replacement and the curing age on the concrete properties were discussed. The manufacturing process of one

tonne of Ordinary Portland Cement requires about 1.1 tonne of earth resources like limestone, etc. Further during manufacturing of 1 tonne of Ordinary Portland Cement an equal amount of carbon-di-oxide are released into the atmosphere. Among the many threats that affect the environment are the wastes which are generated in the production process or discarded after a specific material ends its life time or the intended use. The wastages are divided as solid waste, liquid waste and gaseous wastes. There are many disposal ways for liquid and gaseous waste materials. Some solid waste materials such as plastic bottles, papers, steel, etc can be recycled without affecting the environment. However, studies on how to dispose some solid wastes such as egg shells in the most beneficial ways are not yet fully exhausted.

1.1 OBJECTIVE:

The objectives of this study are as follows:

a) To investigate the best mix proportion of the partial replacement of egg shell powder for cement in concrete by the value of strength per weight ratio of sample specimen.

b) To investigate the feasibility of the partial replacement of above material in concrete by determining its compressive strength and split tensile strength.

c) Based on the test results, to suggest most approximate level of adding egg shell powder.

Overall, the objective is to evaluate the feasibility and effectiveness of using eggshell powder and aluminum foil as partial replacements for cement and conventional fiber additives, respectively, aiming to improve

the performance, sustainability, and cost-efficiency of concrete construction.

1.2SCOPE:

Consumption of cement can be reduced significantly if eggshell powder used as a partial replacement without compromising performance characteristics of concrete including durability. The scope of study is to establish to achieve the objectives and this study will be mainly concentrated on experimental works. Experiments regarding compression strength and split tensile strength on the partial replacement of egg shell powder in concrete will be carried out in order to study the behavior of concrete. An investigation the effect on the performance of the eggshell powder as in additive in concrete mixed. In eggshell concrete production, Portland composite cement, coarse aggregate, fine aggregate, water, aluminium foil and eggshell. The experiments will use to investigate are sieve analysis test, slump test, curing, compressive strength, flexural test, water absorption test. Thus, the amount of eggshell waste can be used as additive in concrete production. Besides that, it also will decrease the construction cost and landfill. Some test and experiments are proposed to be performing to determine the performance concrete strength and eggshell ash. These eggshells must begrinded into fine powder. This test will be tested at 7 day, 14 day and 28 days to get the strength.

1.3 NEED FOR STUDY:

- Identifying the types, quantity and useful components present in the Waste Egg shells (ESP) materials.
- Replacing cement with ESP to various percentages in concrete, and identifying the strength comparing with conventional concrete.
- Working out relative cost of using the ESP concrete mixes in Construction works.

CHAPTER 2

2.1 LITERATURE REVIEW:

1) AmarnathYerramala 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. 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.

2) D.Gowsikaet al experimentally investigated the Egg Shell Powder as Partial 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 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 as partial replacement for cement in concrete.

3) Praveen Kumar RExperimentally 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 & 28thday, 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. Concrete is cast and Compressive test, Tensile and Flexural tests were carried out to find the best combination which results in optimum percentage of strength.Freire et al carried out the investigation on egg shell waste and found out its use in a ceramic wall tile paste. Based on the presence of CaCO3 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. Lauyihbling conducted the investigation in egg albumen and reported that foamed concrete were prepared by egg albumen which has reduce the cost and time of project. 1 per cent and 5 per cent egg albumen were used. From the investigation it is concluded that 5 per cent of EAFC consists of unstable compressive strength and higher flexural strength with increased density when

compared with control foamed concrete which was 64 per cent and 35 per cent. In this study it is proved that Egg Albumen Foamed Concrete (EAFC) can produce light weight concrete which is more environment friendly and improved properties.Amu et al carried out the experiment and stated that common salt with egg shell on lateritic soil obtaining a good compliment for egg shell as a useful stabilizer for road works. Stabilization obtained by adding 2-10 per cent of common salt with optimum egg shell powder. The result showed that the addition of common salt improved the compaction and CBR characteristics of egg shell stabilized soils.Ngo slew keep investigated on the topic of .Effect of coconut fiber and egg albumen in mortar for greener environment. Andreported the effect of coconut fiber and egg albumen on mortar compressive and flexural strength. 3 types of samples were tested to compare the strength development of each other's that was mortar control, mortar containing 0.1 per cent coconut fiber with 1 per cent egg albumen and mortar containing 0.5 per cent coconut fiber with 5percentegg albumen. The strength of mortar containing 0.1 per cent coconut fiber with 1 per cent egg albumen was higher than the mortar control whereas the mortar containing 0.5 percent coconut fiber ± 5 per cent egg albumen was lower strength than the mortar control. The strength of mortar containing 0.1 per cent coconut fiber with 1 per cent egg albumen was higher than the mortar control whereas the mortar containing 0.5 per cent coconut fiber ± 5 per cent egg albumen was lower strength than the mortar control.

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Egg Shells

Egg shells are agricultural throw away objects produced from chick hatcheries, bakeries, fast food restaurants among others which can damage the surroundings and as a result comprising ecological issues/contamination which would need appropriate treatment. Egg shell consists of several mutually growing layers of CaCO3.

The top layer is a vertical layer covered by the organic cuticle. The Egg shell primarily contains calcium, magnesium carbonate (lime) and protein. The quality of lime in Egg shell waste is influenced greatly by the extent of exposure to sunlight, raw water and harsh weather conditions. It is the fine grained powder with suitable proportion which is sieved to the required size before use with concrete/mortar. The ESP had to be fine grained and it has to be sieved for the suitable size before adding into concrete.

Fig 1. Egg Shell

CAHPTER 3

MATERIALS USED

A step by step process of conducting trail run of the experiments to be conducted as discussed in the previous chapters has been discussed in detailed in the following. The materials used for the study is briefly explained below. The sources of the materials, the tests carried out for their properties and the usage method is also mentioned.

3.1 EGG SHELL POWDER

Broken egg shells collected from the local sources. The shells cleaned in normal water and air dried for five days approximately at a temperature range of 25 – 30 °C. The shells then hand crushed, grinded and sieved through 90 μm. Material passed through 90 μm sieve was used for cement replacement and the retained material was discarded.

Fig 2. Egg shell Powder used in Concrete

3.2 CEMENT

Cement is a well-known building material has occupied an indispensable place in construction works. It is obtained by burning together, in a definite proportion, a mixture of naturally occurring argillaceous and calcareous materials to a partial fusion at high temperature. Generally

Cement is a binding material used in the preparation of concrete. It binds the coarse aggregates and fine aggregates with help of water to a monolithic matter and also it fills the voids in the concrete. The cement used in this study is OPC 53 grade confining to IS 8112 is used throughout the work.

3.3 ALUMINIUM FOIL

Using aluminum foil as a fiber in cement concrete is not a common practice in traditional concrete construction, primarily because aluminum foil lacks the structural integrity and bonding properties required for reinforcing concrete effectively.However, there have been experimental applications where aluminum fibers or particles are added to concrete mixes for specific purposes. For instance, aluminum fibers or particles can be used to enhance the thermal conductivity or resistivity of concrete, depending on the application requirements.

3.4 COARSE AGGREGATE

Coarse aggregate plays a crucial role in cement concrete, contributing to its strength, durability, and overall performance.Coarse aggregates are integral components of cement concrete, providing strength, durability, stability, and other essential properties necessary for various construction applications. The selection and proper proportioning of coarse aggregates are critical factors in ensuring the desired performance and longevity of concrete structures.

3.4 FINE AGGREGATE

Fine aggregates are essential components of cement concrete, contributing to its workability, strength, durability, and overall performance. Proper selection, grading, and proportioning of fine aggregates are critical aspects of concrete mix design, ensuring optimal workability and long-term durability of concrete structures.

TESTS AND MIX DESIGN

The following tests are conducted to find the physical properties of materials.

Tests on fine aggregate

In this project, the river sand, which was available in saturated surface dry Condition was used as fine aggregate and the following tests were carried out on sand as per IS: 2386 - 1968.

- Sieve analysis
- Density

• Specific Gravity

• Water absorption

Tests on coarse aggregate

• Impact value

• Sieve analysis

• Density

• Specific gravity

• Water absorption.

Sieve analysis test

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I)-1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

Sieve analysis test on Fine Aggregate

The experiment is carried out to find and check the gradation of the fine aggregate i.e., sand. The sand is differentiated on the basis of its gradation, such type sand will possess the capability to form a compact structure thus will have more strength.

Is sieve size	Weight Retained(gm)	% of Weight Retained	Cumulative % Retained	% of Passing
4.75mm	94	4.7	4.7	95.3
2.36mm	158	7.6	12.6	87.4
1.18mm	708	35.4	48	52

600	812	40.6	88.6	11.4
300	180	9	97.6	2.4
150	4	0.2	99.6	0.4
75	2	0.1	99.7	0.3
pan	6	0.3	100	0

Sieve Analysis Test on Coarse Aggregate

The sieve analysis of coarse aggregate is to find the average size of the particles in coarse aggregate by an index number. The cumulative percentage retained on each sieve is added and subtracted by 100 gives the value of fine aggregate.

Is sieve size	Weight Retained(gm)	% of Weight Retained	Cumulative % Retained	% of Passing
20mm	290	5.8	5.8	94.2
16mm	2768	55.36	61.16	38.84
12.5mm	1454	29.08	90.24	9.76
10mm	430	8.6	98.84	1.16
6.3mm	58	1.16	100	0
4.75mm	0	0	0	0
pan	0	0	0	0

Density Test on Fine Aggregate

This method is used to determine the bulk density of the fine aggregate. If we know the bulk density of fine aggregate then we can easily calculate the mass required to fill a unit volume container. The bulk density indicates the percentage of voids present in the aggregate material. The percentage of voids effects the grading of the aggregate which is important in higher strength concrete. We will get the percentage of voids by comparing loose state and compacted state. Volume of Cube = 8.1 kg.

Density Test on Coarse Aggregate

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Specific Gravity Test

Following were the test results of specific gravity of materials,

S.no	Material	Specific Gravity
1	Fine Aggregate	2.65
2	Coarse Aggregate	2.80
3	Cement	3.14

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Mix Design

The mix calculation arrived per unit volume of concrete shall be as follows,

S.no	Material	Quantity
1	Cement	1000
2	Water	
3	Fine aggregate	1000
4	Coarse aggregate	1500
5	Water cement ratio	0.45

EXPERIMENTAL INVESTIGATION

The Egg shell powder concrete specimens of various mixes has to be tested for Compressive, Split and Flexural strength at 7, 14 and 28 days of age in the laboratory.

Compressive Strength Test

Compressive test are made at recognized ages of the test specimens. Least three specimens, preferably from different batches shall be made for

testing at each selected age. The cubes are placed in the compression testing machine in such manner that the load is applied to the opposite sides of the cube as cast. The load is applied at the rate of 140 kg/cm2 /min (approximately) until the failure of the specimen. Compression test was carried out on the specimens after 7, 14 and 28 days of curing of concrete.

From each concrete mixture, cubes of size 150mmx150mmx150mm have been casted for the determination of compressive strength and. The concrete specimens were cured under normal conditions as per IS 516-1959 and tested at 7, 14 and 28 days for determining Compressive strength as per IS 516-1959. Experimental results for cube compressive strength for M40 grade of concrete for mix proportions 10%, 15% and 20% for 7,14and 28 days are tabulated in the below table.

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Mix	Compressive strength at 7 days (N/mm^2)			Compressive strength at 14 days (N/mm^2)			Compressive strength at 24 days (N/mm^2)		
	Load (KN)	Stress N/mm^2	Avg	Load (KN)	Stress N/mm^2	Avg	Load (KN)	Stress N/mm^2	Avg
	695	30.9		790	35.1		943	41.9	
10%	718	31.9	31.0	785	34.9	35.6	950	42.2	41.8
	706	30.3		828	36.8		931	41.4	
	725	32.2		834	36.0		950	42.2	
15%	706	31.4	31.2	828	36.8	36.3	960	92.7	42.5
	675	30.0		816	36.3		958	42.6	
	690	30.7		819	36.4		943	41.9	
20%	697	31.0	31.2	810	36.2	36.0	940	41.8	41.1
	703	31.9		820	36.4		958	42.6	

Results on compression strength

The Compressive strength of concrete mixes made with Egg shell powder was determined at 7, 14 and 28 days of curing. The test results are given in table 9 and shown in fig.6 shows the variation of compressive strength (M40) with age for various egg shell powder percentages and the variation of compressive strength with egg shell powder percentages at different ages. The compressive strength of the egg shell powder concrete is compared to the conventional concrete. From fig.5.1it can be seen that there is increase in strength with the increase in egg shell powder percentages up to 15% however, the rate of increase of strength decreases with the increase in egg shell powder content. The maximum strength at all ages occurs with 15% Egg shell replacement.

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WATER ABSORPTION TEST:

The water absorption test was determined as per ASTM C 642-06. Water absorption values of ESP blended concrete specimens after 28, 56 and 90 days of curing. Then the test specimens were dried in an oven at a temperature of 1100 C for 2 days, and allowed to cool at room temperature. At the end of specified days, the weights of the specimens were measured and then the specimens were kept immersed in water continuously for 2days.The specimens were taken out from the water weighed at a regular interval of time. The process was continued till the weights become constant.

The percentage of saturated water absorption was determined the difference between the saturated mass and oven dry mass based on Equations 3.5. The percentage of total voids of the specimens was determined by Equation 3.671

Percentage of Water absorption = W2-W1/W1× 100

Percentage of Voids = W3-W1/ W3-W4× 100

Where,

W1= Weight of specimen after drying at oven temperature of 110 0C

W2 = Weight of surface dry sample in air after immersion in water

W3 = Saturated mass of the specimen in air after immersion and boiling

W4 = Apparent mass of the specimen in water (submerged weight) after immersion and boiling

COEFFICIENT OF WATER ABSORPTION:

The Coefficient of water absorption test was carried out as per ASTM C642-97.This was assessed by the degree of uptake of water by dry concrete in a period of 1 h. The concrete cube specimens were dried in an oven at 1100C for seven days until constant weight was attained and then permitted to cool in a concealed container for one day. The sides of the concrete samples were covered with crystal clear wax sealant resin with a view to facilitate the flow in one direction. Then the samples in a vertical position were set aside partly absorbed to a depth of 5 mm at one end while the remainder of the parts was kept uncovered. The quantity of water absorbed during the first 60 min was estimated. Coefficient of water absorption values of concrete specimens after 28, 90 and 180 days of moisture curing were assessed by means of the Equation 3.7. (AlirezaNajiGivi et al

2010b)

$Ka=(Q/A)^{2} X 1/t$

Where, Ka is the coefficient of water absorption (m2 /s), Q is the quantity of water absorbed (m3) by the oven dry specimen in time (t), t is 3600 s and A is the surface area (m2) of concrete specimen through which water penetrates.

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WATER PERMEABILITY TEST:

High pressure water permeability test for concrete cube specimens were conducted as per IS3085 -1997.The test cube specimen was kept dried for two days after 28, 90 and 180 days moisture curing. The water penetrability experimentation set up. The coefficient of water permeability was determined by measuring the amount of water passing through the specimen and calculated using Darcy‘s law and the equation of continuity (Chindaprasirt et al 2007)76

$K=Q/AT(H/L)$

Where,

K = Coefficient of permeability in cm/sec,

Q = Quantity water of in milliliters percolating over the complete period of test after reaching the consistent phase,

A = Area of the specimens face in cm^2,

T = Time in seconds over which Q is determined,

H/L= Ratio of the pressure head to the thickness of models

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