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EXPERIMENTAL INVESTIGATION OF EGG SHELL POWDER AS PARTIAL REPLACEMENT WITH CEMENT IN THE PREPARATION OF 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 analyzed.

Keywords: egg shell powder(ESP), workability, tensile strength and compressive strength.

I.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).

All the waste products are seriously polluting the environment. There are many types of waste disposal systems are possible. Such as land filling, open burning and river fill definitely indicate the solid waste.[1] Nowadays, waste products are used in construction industry and maximize the profit and reducing the amount of waste. The construction industry is searching for alternative products that can reduce the construction cost.[2] The eggshell has good characteristics when mixed with concrete and it has a good strength durability.[3] Most of the eggshell waste is commonly disposed in landfills without any pre-treatment because it is traditionally useless. Eggshell has a cellulosic structure. Egg Shell Powder (ESP) is the fine-grained powder with suitable proportion which is sieved to the required size before use with concrete/mortar

An eggshell on an average is composed with 2.2 g of calcium in the form of CaCO3. An estimate of around 98.2% of dry shell constitutes CaCO3, and 0.9% of each magnesium and phosphorous are the composition of eggshell [1]. The chemical composition of chicken eggshells has been well researched upon [2]. Elemental and ultra-structural analysis revealed heterogeneous distribution of minerals throughout the thickness of the shell. Concentration of calcium, magnesium, and sodium were higher in inner layer of the shell before hatching [3]. Eggshells offer wide range of applications in varied sectors such as in nutrition, art works, construction, fertilizers, and medicine It is speculated to be the better source of calcium than limestone [4]. Eggshells have been reported has an alternative source for soil stabilizing agent [5]. It is used as fertilizer supply for calcium. The acidity of soil can be reduced with the utilization of calcium from eggshell. The waste eggshells were reported to be a good adsorbent of humidity. CaO was produced when the eggshells were heated at 1300oC for four hours. The difference in hydration rate of CaO produced from heating of duck and chicken eggshells were investigated, where duck eggshells showed higher adsorption of humidity [6]. Eggshell waste produced from poultry is huge in number. Traditional methods of disposal are employed such as landfill, rendering, composting, and incineration [7]. Ground water and soil get equally polluted. The expenditure for disposal is huge setback for the industry

A limited number of studies had been conducted on the re-use of eggshell waste as an alternative material. The powdery form of eggshell powder was partially replaced in cement in this study. Eggshell powder was added to Portland cement in various amount. The effect of replacement of eggshell powder for cement in proportion such as 2.5%, 5%, 7.5% and 10% by weight of cement Was studied in detail [3]. The scope of the study is to determine the optimum percentage of eggshell powder-based concrete by conducting compressive strength test, splitting tensile test at the age of 7 and 28 days with the specified combinations of eggshell powder and comparing with the control normal concrete specimen. The causes of damages in concrete were freezing, water penetration, chemical gradation and erosion [4]. Therefore, it is important that durability of concrete be enhanced. In durability test, the concrete was immersed in 5% sodium sulphate solution. The pH value was tested at every 7 days of

interval. After 84 days the specimen was weighed and loss in weight and hence the percentage loss of weight was calculated [5].

II.LITERATURE REVIEW

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.

Pradeep Sharma (2018) In this study performed to decide the very best excellent percent of eggshell powder as partial cement replacement. The creation industries are looking for 'alternative material that may lessen the Construction cost. Over 5% of world CO2 emissions can be credited to Portland cement manufacturing. Demand for cement maintains to develop different ESP concretes were established through replacing 4 to 16% of ESP for cement. Concrete performs the important thing function and a large quantity of concrete is being implemented in every introduction exercise. The egg shell commonly that are disposed, is used as an exchange for the cement for the reason that shell is manufactured from calcium. An egg shell is utilized in first rate combos to discover the feasibility of the use of the egg shells as an exchange to cement. Intention of this task is to prevent the pollution of environment with the aid of the usage of the wrong disposal of the eggshell waste, a live from eggshells domestic waste which includes schools, restaurant, bakeries, homes and rapid food accommodations, via the use of the usage of it as an additive fabric inform of ash & powder in traditional concrete with grade M35 because it's far usually utilized in manufacturing internet websites.

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%.

III.OBJECTIVE AND METHODOLOGY

3.1 Objective

The objectives of the work are stated below:

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

3.2 Methodology

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1. Collect the egg shells from, by blending process the egg shell powder (ESP) was obtained.
2. The ESP and sieve with 75microns IS sieve, passed ESP used for cement replacement.
3. Find out the fineness modulus and specific gravity tests for ESP.
4. Find out the physical properties of Coarse aggregate, Fine aggregate, cement.
5. Design mix design of M30 grade concrete. And calculate the mix proportions for individual mix.
6. Partial replacement of cement with ESP with varying percentages (0% - 12.5%) in the preparation of concrete.
7. 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.
8. Conclusions.

3.3 Experimental program

To achieve the specified objectives (section 3.1) the following test program was planned and presented in the table 3.1. The number of specimens allotted for each test was included in the same table.

Table 3.1: Experimental Program

Type of test to be conducted	Behavior to be identified	Specimen	Size	No
Slump cone test	Fresh concrete properties	-	-	
Compression test	Compressive strength	Cube	150 X 150 X 150 mm	54
Split tensile strength test	Tensile strength	Cylinder	300 dia X 100 mm height	18

IV.EXPERIMENTAL WORK

4.1 Materials Used

The different materials used in the investigation are:

4.1.1 Cement

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

Figure 1 Cement

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.

Figure 2 Fine aggregates

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.

Figure 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.

4.2 Testing of specimen

Fresh properties of concrete (Workability)

Slump test is the most commonly used method for measuring the consistency of concrete. It can be employed either in the laboratory or at the site. The test is popular owing to its simplicity. The apparatus for conducting slump test consists of a mould in the form of a frustum of a cone having internal dimensions as per IS 1199-1959.

The slump cone is placed on a clean non-absorbent tray. The mix concrete is filled in the slump cone in four layers, compacting each layer by tamping 25 times using the standard tamping rod. Care is taken to distribute the strokes evenly over the cross section. After filling the fourth layer, the top surface is leveled off using a trowel. Immediately, the slump cone mould is removed from the concrete by raising it slowly in a vertical direction. This allows the concrete to subside. The subsidence is referred to as the slump of concrete. The difference in level between the height of the mould and the highest point of the subsided concrete is measured in millimetres. This difference in height in "mm" is referred to as the slump of concrete.

Figure 4: Slump cone test

Harden properties of concrete

The strength related tests were carried out on hardened cement concrete to determine the strength related properties such as cube compressive strength, cylinder split tensile strength.

Compressive strength

For cube compression tests on concrete, cube of size 150mm were employed. All the cubes were tested in saturated condition after wiping out the surface moisture from the specimen. For each trial mix combination, three cubes were tested at the age of 7, 14 and 28 days of curing using 400 Ton capacity compression testing machine (CTM) as per BIS: 516-1959.The tests were carried out at a uniform stress after the specimen has been centred in the testing machine. Loading was continued until the dial gauge needle just reserves its direction of motion. The reversal in the directions of motion of the needle indicates that the specimen has failed. The dial reading at the instant was noted, which is the ultimate load. The ultimate load divided by the cross - section area of the specimen is equal to the ultimate cube compressive strength.

$Compressive\ strength = Load\ /\ Area$ ($N/mm2$)

Figure 5: Failure pattern of cube specimen in CTM

Split tensile test

This is an indirect test to determine the tensile strength of the specimen. Splitting tensile tests were carried out on 150mm x 300mm sized cylinder specimens at an age of 28,56 and 90 days using 400 Ton capacity compression testing machine as per IS: 5816 – 1970. The load was applied until the specimen split and readings were noted. The splitting tensile

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strength has been calculated using the following formula.

Tensile strength = 2P / π L D Here; P = peak load

L = length of cylinder = 300mm D = diameter of cylinder = 150mm

Figure 6: Failure pattern of cylinder specimen in CTM

V. RESULTS AND DISCUSSIONS

5.1 General

The results of the strength and workability tests that were carried out on the five trial mixes of M30 grade concrete to evaluate their workability, strength related properties were presented in this chapter. The effects of egg shell powder on the properties of the concrete mixtures were discussed separately in this chapter.

5.2 Experimental outputs

5.2.1 Workability of concrete (Slump cone test)

Table 5.1: Result of slump test

S. No	% of ESP	Slump (mm)
1	0	100
2	2.5	105
3	5	116
4	7.5	121
5	10	125
6	12.5	127

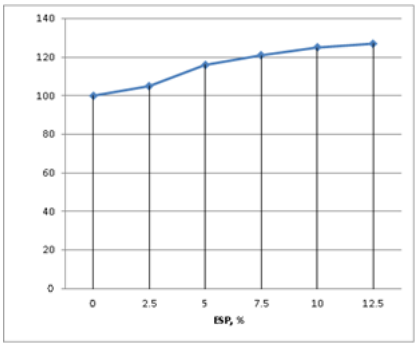

Figure 7: Slump test results

The above figure shows the slump results. It was observed that, the slumps increase as the egg shell powder content was increased in the mix.

Compressive Strength of Concrete (in N/mm2)

The 7, 14, 28 days compressive strength was studied and the values of 3 samples studied are shown in the tabular form. Table 5.2 shows the data of 7, 14, 28 days compressive strength obtained. Below tables gives the 7, 14, 28 days compressive strength of concrete with maximum nominal size of aggregates 20mm. The 7, 14, 28 days compressive strength was also plotted Fig 5.2 by taking the average of these three values overall an increase in the compressive strength was observed with addition of egg shell powder as compare to conventional concrete.

Table: 5.2 Compressive strength of concrete

% of ESP	Avg Compressive strength (N/mm^2)		
	7days	14days	28days
0	21.82	32.032	35.2
2.5	24.12	35.9	38.9
5	27.6	40.3	43.8
7.5	25.3	36.5	40.1
10	22.8	34	38.1
12.5	22	33.1	36

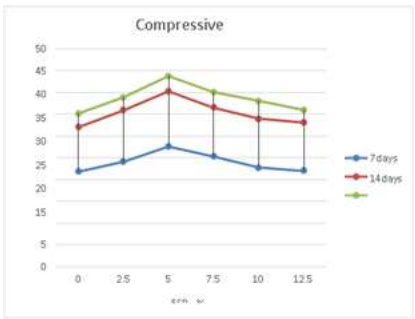

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Figure 8 Effect of ESP on 7, 14 and 28days compressive strength

5.3 Tensile Strength Test

The Tensile test was performed on the beams of size 15dia x 30height cm to check the split tensile strength of the marble dust as fine aggregate replacement in the concrete and the results obtained while performing the tension test on CTM are given in Table 5.3 and Figure 5.3.

Table 5.3: Result of split tensile strength

S.No	% of ESP	Tensile Strength for 28 days (N/mm^2)
1	0	4.22
2	2.5	4.54
3	5	5.3
4	7.5	4.93
5	10	4.51
6	12.5	4.36

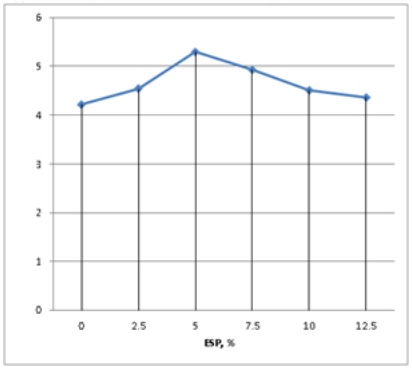

Figure 9 Effect of ESP on 28 days Tensile strength

From the above figure, it was observed that the tensile strength of ESP- based concrete was better than that of conventional concrete (i.e. at 0% replacement). The maximum tensile strength gained for 5% Cement replacement with egg shell powder.

VI.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 researchers 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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