A Review Study of Egg Shell Powder as a Cement Replacing Material in Concrete

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Abstract - *Effective deployment of bio-waste has been given importance in our society for environmental and economic concerns. Reclamation of eggshell from hatcheries, home, bakeries and industries is an efficient and cost productive way to reduce waste disposal and prevent serious environmental pollution. Egg shells waste constitutes essential organic and inorganic materials that can be composted with other materials for enhancing the pre-existing property. The major concern in any civil sector is efficient construction with minimal cost investment. Cement is one of the pivotal components for construction. It is the backbone to the infrastructure development. Rapid infrastructure developments ensued in high demand for raw materials worldwide that resulted in huge imbalance between demand and supply. However, cement plants are the source of few harmful compounds like nitrogen oxide (NOx), Sulphur dioxide (SO2) and Carbon monoxide (CO) which can cause serious health defects and also affects our environment as well. The cement manufacturing sector is the third largest reason for total pollution in our environment. In spite of all these there is a huge demand for the cements for the development of a country. This increase in demand, led to search for alternative raw materials from enormous waste product which is both efficient and cost productive began. In this work, calcinations of chicken eggshells with different ingredients were carried out and the chemical composition of the resultant product was analyzed.*

Key Words: ESP, OPC, EGG SHELL, POWDER, CHEMICALS etc

1. INTRODUCTION

An eggshell on an average is composed with 2.2 g of calcium in the form of $CaCO_3$. An estimate of around 98.2% of dry shell constitutes $CaCO_3$, 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.

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[9].

Energy is an important aspect in the growth and development of a country especially in India. In the current scenario of less availability of nonrenewable energy resources and the huge demand of the construction materials, it is very much necessary to implement and adapt other alternative methods to manufacture cements. To manufacture two tons of cements, about 1.1 tons of various elements of the mixtures of earth resources are used. While in the manufacture equal amount of CO_2 is released to the environment.

In portland cement, around 5 % mass fraction of limestone is mixed [10]. But due to over exploitation of limited resources of natural limestone and rising concerns in carbon dioxide emissions necessitatesa substitute for limestone. Utilization of eggshell as a sustainable analogue for limestone tackles various issues. Conservation of natural resources and recycling of waste materials can occur simultaneously with the use of eggshell. Also, production of lime is an energy intensive and water consuming procedure. Use of eggshell can be cost effective and tremendously decrease the energy consumption.

This work focuses on calcinations of eggshells and anlayse the chemical composition of the resultant product.

2. LITERATURE REVIEW

1.**AmarnathYerramala et.al,(2010**):-"eggshell powder as cement replacement" studied the properties of concrete with eggshell powder as cement replacement. This paper describes research in to 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 result 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 cementations ratio, coarse and fine aggregate quantities was arrived for concretes to be tested from the trail mixes. IN this study, compressive loading tests, a loading rate of 2.5KN/s was applied as per IS:516-1959[10].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 offly ash improved compressive strength of ESP concrete.

2.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 as partial replacement for cement in concrete

3. MATERIALS

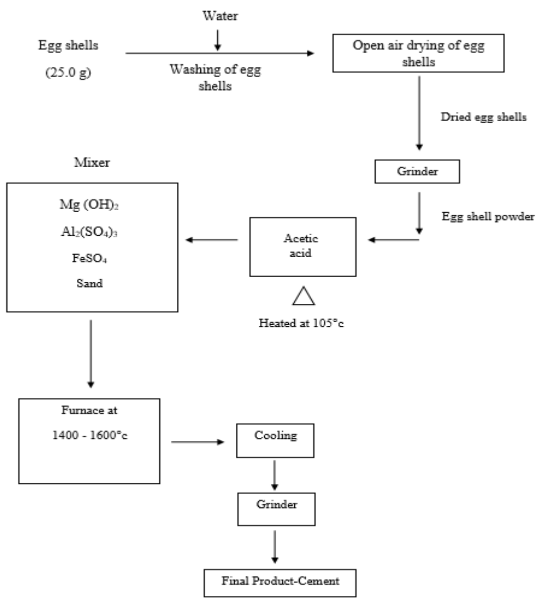
Egg shells (30 g), Calcium carbonate (2 g), Sand (21 g), Aluminium sulphate (10 g), ferrous sulphate (5 g), and Magnesium hydroxide (2.5 g).

3.1 METHODOLOGY

It is described below:

3.1.1 MANUFACTURING OF CEMENTS FROM EGG SHELLS

Waste eggshells were collected and sterilized by boiling in fresh water for 15-20 minutes. Shells were air dried and grinded in acetic acid which was further heated to 110oC for 20 minutes. Acetic acid is used to dissolve polar and hydrophilic components, with its relative static permittivity of 6.2 it dissolves not only the polar compounds such as inorganic salts and sugars but also the non-polar solvents like oils, sulfur and iodine. The whole experimental setup is shown in Fig 1 (Manufacturing of cement from egg shell)



To the egg shell powder, Magnesium hydroxide (Mg (OH)2), Aluminum sulfate (Al2(SO4)3), Ferrous sulphate (FeSO4), and sand were added and mixed thoroughly to form a raw mix. The raw mix thus firmed is heated to about 1400-1600°C for about 4.5 hours. The calcium oxide thus formed reacts with alumina and ferric oxides (formed from the respective sulphates of oxidation at high temperatures) to form calcium silicate, tri calcium silicate, tri calcium silicate and tetra calcium aluminoferrite. The product thus formed is cooled and grinded to better fineness.

4. EXPERIMENTAL ANALYSIS:

4.1 Specific Gravity Of Cement

Specific gravity of given Cement OPC = 2.9

Specific gravity of given Cement ESP = 2.8

4.2 Normal consistency test

Normal consistency for the given sample of cement is

OPC ...32.....................%

Normal consistency for the given sample of cement is ESP......30...............%

4.3 Initial setting time and Final setting time

Sl. No.	Setting Time (min)	Penetration (mm)	Remark
1	30 Min	5mm	Initial setting time
2	10 Hours	-	Final setting time

4.4 Compressive Strength Of Concrete Cubes

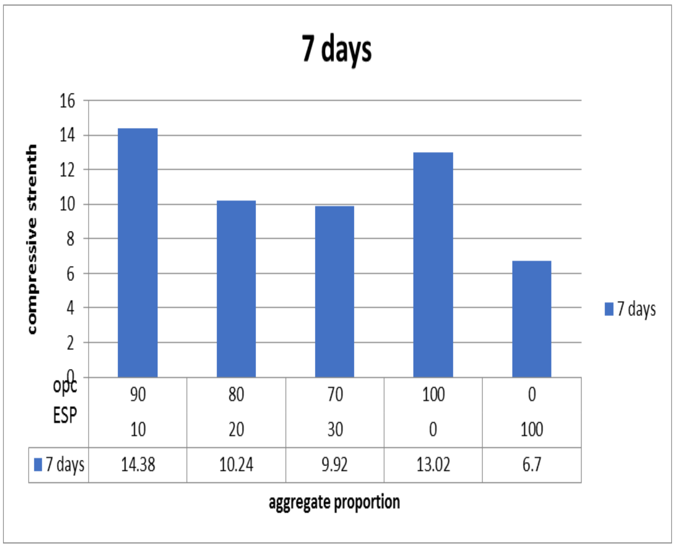
Method Of Cast And Testing Of Specimens

Concrete cubes of 150mm X 150mm x 150mm has been cast according to the specifications mentioned in the IS codes : 516 :1959. The Concrete specimens were cast based on the specifications and tested to determine the feasibility of egg shell powder in concrete.

S.No	MIX COMBINATION	CEMENT (%)	ESP (%)
1	C100 ESP0	100	0
2	C90ESP10	90	10
3	C80 ESP20	**80**	**20**
4	C70 ESP30	70	30
5	C0 ESP100	0	100

4.4.1 Compressive strength of concrete cubes of 7days

MIX PROPORTION	Trail No.	Wt. of specimen kg	Dimensions of the specimen			Cross sectional area mm2	Crushing load KN	Compressive strength N/mm2
			L	B	D			
Chart Area [illegible] and OPC 90%	1	6.5	0.15	0.15	0.15	2.25	30	13.08
	2	6.9	0.15	0.15	0.15	2.25	34	14.82
	3	6.8	0.15	0.15	0.15	2.25	36	15.69
ESP 20 % and OPC 80 %	1	7	0.15	0.15	0.15	2.25	24	10.46
	2	6.5	0.15	0.15	0.15	2.25	24	10.46
	3	6.3	0.15	0.15	0.15	2.25	24.3	10.594
ESP30% and OPC 70 %	1	7.1	0.15	0.15	0.15	2.25	22	9.59
	2	6.2	0.15	0.15	0.15	2.25	23	10.028
	3	6.3	0.15	0.15	0.15	2.25	23.5	10.246
ESP 0% and OPC 100%	1	6.4	0.15	0.15	0.15	2.25	30.2	13.16
	2	7	0.15	0.15	0.15	2.25	35	15.26
	3	7.1	0.15	0.15	0.15	2.25	36	15.69
ESP 100%	1	6.8	0.15	0.15	0.15	2.25	15	6.54
	2	6.82	0.15	0.15	0.15	2.25	15.3	6.67
	3	6.35	0.15	0.15	0.15	2.25	15.4	6.714



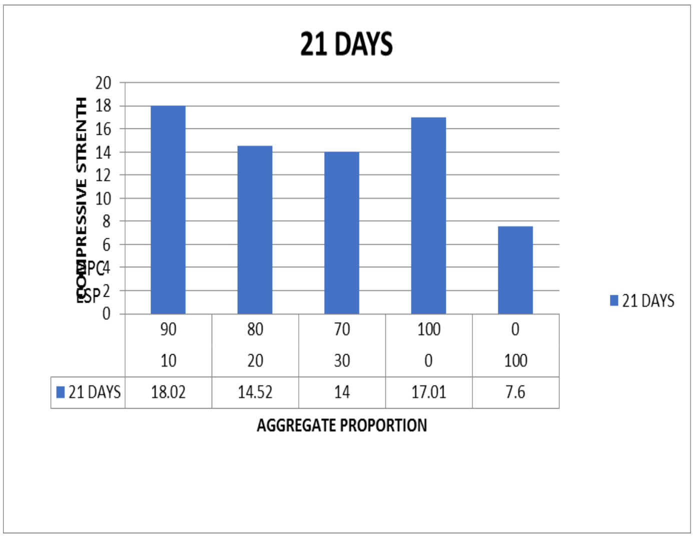
Graph 1: comparison of aggregate proportion (%) verses compressive strength for M20 grade concrete mixes

The compression test results which are obtained are plotted in graph 1, with compressive strength along y axis and the cement proportions along x axis.

With 0% replacement of ESP and 100% replacement of OPC , compressive strength for M20 is 13.02 for 7 days curing period 10% replacement of ESP and 90% replacement of OPC , compressive strength for M20 is 14.38 same extent as the aggregate proportions are varied. From the above compression test values it has been observed that the strength goes on decreasing from the first proportion to the last in a gradual sense.

4.4.2 Compressive strength of concrete cubes of 21days

MIX PROPORTION	Tral No.	Wt. of specimen kg	Dimensions of the specimen			Cross sectional area mm2	Crushing load KN	Compressive strength N/mm2
			L	B	D			
ESP10%	1	8.40	0.15	0.15	0.15	2.25	41.2	17.96
and	2	8.53	0.15	0.15	0.15	2.25	40	17.44
OPC 90%	3	8.52	0.15	0.15	0.15	2.25	44.5	19.40
ESP 20 %	1	8.45	0.15	0.15	0.15	2.25	32.2	14.039
and	2	8.30	0.15	0.15	0.15	2.25	35.6	15.52
OPC 80 %	3	8.53	0.15	0.15	0.15	2.25	35	15.56
ESP30%	1	8.61	0.15	0.15	0.15	2.25	32	13.952
and	2	8.63	0.15	0.15	0.15	2.25	32.5	14.17
OPC 70 %	3	8.68	0.15	0.15	0.15	2.25	32.2	14.039
ESP 0%	1	8.30	0.15	0.15	0.15	2.25	44.5	19.402
and	2	8.34	0.15	0.15	0.15	2.25	41.2	17.963
OPC 100%	3	8.31	0.15	0.15	0.15	2.25	40.3	17.570
	1	7.8	0.15	0.15	0.15	2.25	18	7.848
ESP 100%	2	7.82	0.15	0.15	0.15	2.25	17.9	7.80
	3	7.35	0.15	0.15	0.15	2.25	17.5	7.63



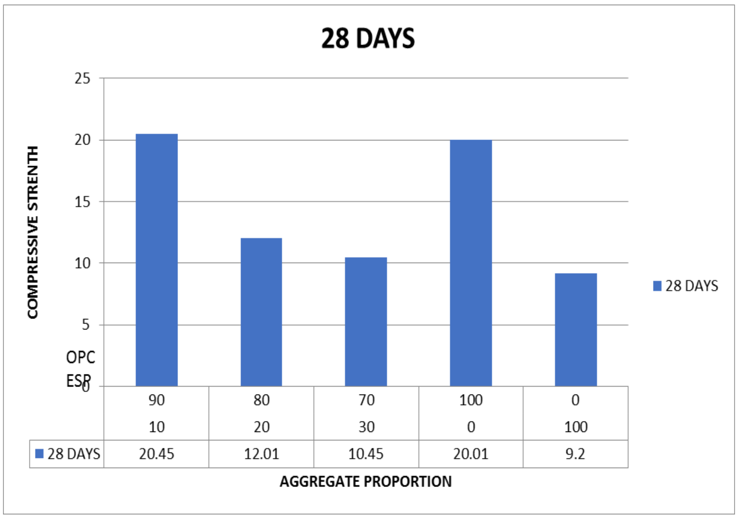
Graph 2: comparison of aggregate proportion (%) verses compressive strength for M20 grade concrete mixes

The compression test results which are obtained are plotted in graph 2, with compressive strength along y axis and the cement proportions along x axis.

With 0% replacement of ESP and 100% replacement of OPC , compressive strength for M20 is 17.01 for 7 days curing period 10% replacement of ESP and 90% replacement of OPC , compressive strength for M20 is 18.02 same extent as the aggregate proportions are varied. From the above compression test values it has been observed that the strength goes on decreasing from the first proportion to the last in a gradual sense.

4.4.3 Compressive strength of concrete cubes of 28days

MIX PROPORTION	Tral No.	Wt. of specimen kg	Dimensions of the specimen			Cross sectional area mm2	Crushing load KN	Compressive strength N/mm2
			L	B	D			
ESP10%	1	10.2	0.15	0.15	0.15	2.25	48	20.92
and	2	10.3	0.15	0.15	0.15	2.25	47	20.49
OPC 90%	3	10.2	0.15	0.15	0.15	2.25	46.5	20.27
ESP 20 %	1	10.4	0.15	0.15	0.15	2.25	30	13.08
and	2	10.5	0.15	0.15	0.15	2.25	28	12.208
OPC 80 %	3	10.4	0.15	0.15	0.15	2.25	27.5	11.99
ESP30%	1	10.6	0.15	0.15	0.15	2.25	25	10.9
and	2	10.63	0.15	0.15	0.15	2.25	24	10.46
OPC 70 %	3	10.61	0.15	0.15	0.15	2.25	24.5	10.68
ESP 0%	1	10.2	0.15	0.15	0.15	2.25	49	21.36
and	2	10.31	0.15	0.15	0.15	2.25	46	20.05
OPC 100%	3	10.42	0.15	0.15	0.15	2.25	48	20.92
	1	9.2	0.15	0.15	0.15	2.25	23	10.28
	2	9.1	0.15	0.15	0.15	2.25	24	10.46
ESP 100%	3	9.4	0.15	0.15	0.15	2.25	23.5	10.24



Graph 3: comparison of aggregate proportion (%) verses compressive strength for M20 grade concrete mixes

The compression test results which are obtained are plotted in graph 3, with compressive strength along y axis and the cement proportions along x axis.

With 0% replacement of ESP and 100% replacement of OPC , compressive strength for M20 is 20.01 for 7 days curing period 10% replacement of ESP and 90% replacement of OPC , compressive strength for M20 is 20.45

same extent as the aggregate proportions are varied. From the above compression test values it has been observed that the strength goes on decreasing from the first proportion to the last in a gradual sense.

5. CONCLUSIONS

1. Compressive strength was higher than control concrete for 10 % ESP replacement at 7 and 28 days of curing ages. ESP replacements greater than 10 % had lower strength than control concrete. Addition of OPC improved compressive strength of ESP concrete.
2. The results which came after carrying out all tests found successful which indicates that eggshell powder can be used as an replacement material for cement. From the results it is proved that replacement of ESP cement if about 10 % to 20 % is effective and when we increasing further the percentage of ESP cement decreases the compressive strength
3. Initial and final setting time of cement is 93 and 210 minutes
4. The egg shells as a useful material instead of a waste material (harm to the environment) that they were hurled in many hundred tons annually had been use in an engineering applications
5. The hardness and specific gravity were increased with increasing ESP
6. Compressive strength increases with increase of percentage of egg shell powder up to certain limit
7. The workability of concrete is decreased by increasing the amount of egg shell powder cement
8. The resulting demonstrated that irrespective of ESP percentage replacement there was good relationship between compressive strength

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