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A REVIEW STUDY ON REPLACEMENT OF CEMENT BY SILICA FUME AND EGG SHELL IN CONCRETE

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ABSTRACT: ***The objective of the study performed here is based on the potential use of waste material associated with the concrete industry. To support this, recent trends are examined by performing an extensive literature survey and the conclusion is drawn to check the utilization of Egg Shell Powder (ESP) and Silica Fumes (SF). The various researchers has suggested limiting the range of ESP and SF from 0% to 20% through trial and error method and positive results are obtained in terms of compressive strength, split tensile strength, flexural strength, workability, corrosion resistance, etc. It is observed that the strength of the concrete rises with the adding of eggshell powder and silica fume and finally, the comparative literature results of concrete produced by using eggshell and silica fume are presented graphically. In this literature study, the focus is drawn by reducing cement content by adding ESP and SF and results obtained after experiments are recorded to support the re-use of waste material and provide a sustainable solution to concrete industry for better future.***

Keywords: Egg Shell Powder, Silica Fume, Compressive Strength, Re-use, Waste

INTRODUCTION

Owing to rapid economic and population growth, the infrastructure development growth in countries like India is recorded at its full pace, and the continuity is expected for the next two decades. Since concrete is the backbone of building material, and the vital ingredient associated with it is cement which approximately produces 900 kg of carbon dioxide greenhouse gases [1]. Due to this, the negative effect on factors such as ecological, social disturbance, and the high volume of natural resource consumption is predominately visible in society. To compensate such effect, the re-use of waste material becomes a critical aspect and in addition, it reduces the burden on the environment and natural resources. Various studies and experiments suggest that use of Eggshell in the concrete industry as a pozzolan shows positive results in terms of character strengths and chemical properties. It also reduces the burden on landfilling of eggshell wastes from poultry and food industry and it is seen India is developing as the world's second major poultry marketplace with a yearly development of additional than 14%, creating 61 million tons or 3.6 percent of global egg manufacture [2]. Therefore ESP is setting a trend as a component in soil stabilization, bricks, and cement industries because of its low binding properties and the percentage of lime available. Another challenge associated with concrete industries such as maximum potential strength, self-compaction, improved workability, etc. To support this, researchers are experimenting with different admixtures and out of one is Silica fumes (SF) powder, and its outstanding properties like incredibly smaller particles makes it a material to support higher compressive strength of approximately 100-150 MPa [3]. In addition, it plays a vital role as a corrosion resisting materials which is a critical issue in reinforced concrete construction.

MATERIALS

a) Egg Shell

Eggshell is a poultry waste which is commonly available throughout the world at very low cost, and it is an eco-friendly material because its recycling doesn't affect the environment. Eggshell consists of a few commonly developing layers of $CaCO_3$, and the quality of lime in eggshell has a high dependence on factors such as: exposure of daylight, water quality, and weather conditions [4]. According to a study eggshell waste generation in India, the United States and the United Kingdom is 190000, 150000 and 11000 tone's per annum respectively [2]. Effective use of such waste provides an opportunity for the researcher to check the valuable recovery from it, and it is observed during the literature studies, the chemical composition of Egg Shell Powder (ESP) which is shown in Table 1 creates a high potential to use it as a cement replacing material. The critical factor which allows the researcher to use ESP (Figure 1), as a suitable alternative composition of cement is, primarily due to Calcium Carbonate oxide content i.e. nearly 50% [5]. Since naturally occurring limestone presents in the Ordinary Portland Cement (OPC) can be replaced with the help of ESP to make the cement industry more sustainable, and studies have suggested that the same or better structural strength, lightweight, etc. can be achieved when ESP is used in concrete. In addition to that, the use of eggshell powder as a building material helps in reducing the burden on landfilling, economic benefits by re-using the waste material, conserving natural resources such as limestone, and minimizing cement consumption [6].

Figure 1 Egg Shell Powder

Table 1 Percentage oxide content of the egg shell powder [5]

Oxide contents	Percentage (%)
CaO	50,7
SiO2	0.09
Al2O3	0.03
MgO	0.01
Fe2O3	0.02
Na2O	0.19
P2O5	0.24
SrO	0.13
NiO	0.001
SO3	0.57
Cl	0.219

b). Silica fume

Silica Fumes (SF) is obtained as a byproduct during the production of silicon metal or ferrosilicon alloys, and due to it extremely smaller individual particle size which is approximate 1/100th the size of an average cement particle makes it highly reactive pozzolan [5]. SF is composed principally of crisp silica in non- crystalline shape and its X-beam diffraction investigation of various silica vapor found that the material is essentially vitreous silica, primarily of Cristobalite shape. It has a high substance of nebulous silicon dioxide and its maximum particles are circular in shape which is shown in Figure 2. Silica mainly contains more than 90% SiO and a small amount of iron, magnesium, and antacid oxides [3]. The SF in the concrete industry has derived outstanding physical and chemical properties like more cohesive, less prone to segregation, reduced bleeding, less permeable, resistance towards corrosion, etc. Due to this worldwide utilization of silica rage has crossed 1 million tons per annum consumption [5].

Figure 2 Silica fumes powder

Table 2 Chemical Composition of Silica fume [5]

Oxide content	Percentage (%)
SiO2	90.21
CaO	0.30
Fe2O3	0.15
Al2O3	0.12
MgO	0.73
SO3	0.01
Na2O	0.46
K2O	1.51

LITERATURE REVIEW

P.Kalpana and M.chandu. [7] (2018) tried to minimize environmental pollution and maximize the strength by replacing Agro waste in the fine aggregate, and eggshell with cement and E-waste in coarse aggregate in concrete with percentage replacement from 0 % to 15% on M25 grade.

Ashish Kumar Singh et al. [3] (2018) conducted the experiment for compressive strength, flexural strength, and tensile strength. Eggshell and silica fume are replaced for cement whereas E-waste for aggregates for the M25 concrete mix.

Tan Yeong Yu et al. [8] (2017) assessed the work of various curing conditions on the compressive strength of eggshell concrete .the replacement for cement with 5%,10%,15% and 20% of the eggshell. The two types of curing techniques used are full water curing technique and Open-air curing technique for 1, 7 and 28 days.

S.A. Raji and A. T. Samuel. [9] (2015) tested the use of eggshell remaining in concrete material. The remaining of used egg shells were used for the replacement of fine aggregate in the concrete. 18 cubes were cast for the compression strength test, the replacement of fine aggregate was up to 100%. The result in the compression test was lower than the nominal mix. This paper recommends the eggshell waste for lightweight concrete.

Anand Prakash, Rajinder Singh. [1] (2017) replaced cement with eggshell powder, here they tested the concrete for workability, compressive strength, split tensile strength and flexural strength was tested for the partial replacement to 24%

Yeong Yu Tan et al. [6] (2017) did the research to verify the strength and performance of oven-dried eggshell powder as a partial replacement for concrete under air-cured and water-cured specimens. The percentage varies from 5% to 20% in proportion was added for the OPC replacement in concrete. Here the water-cured concrete specimen shows the better result for compressive strength and flexural strength by 51.1% and 57.8%, respectively. The optimum result found to be 15% for the oven dry concrete.

Praveen Kumar R et al. [10] (2015) shows the eggshell conservation and reusing it for concrete with silica fume. The percentages of eggshell powder 10%, 20% and 30% in addition to silica fume 5%, 10%, 15% for weight of cement in concrete casting. Compressive, Tensile and Flexural test is done.

Amarnath Yerramala. [2] (2014) have used the eggshell powder mentioned as poultry waste for concrete formation. 5 -15% of eggshell powder replaced for cement in the concrete .the strength is optimum for 5% of eggshell powder, further, the addition of fly ash to the concrete specimen is done for the increment of properties.

N. Parthasarathi et al. [5] (2017) mentioned the effect of minimizing the cement with the replacement of eggshell and silica fume, which reduce the cost as well as increase the strength. The eggshell is replaced by 5%, 10%and 15% whereas silica fume is replaced by 2.5%, 5% and 7.5%of weight of cement. Here the strength increase with the rise in the percentage of the eggshell.

D. Gowsika et al. [4] (2014) have taken results from the compressive strength, split tensile strength and flexural strength for mortar cube and M20 cube where the eggshell powder is replaced for 5% to 30% specimens. The compressive strength for mortar cube fall after 5% replacement of eggshell.

Beck et al. [11] (2014) arranged lime based concrete mortars with fine tuffeau totals containing eggshell lime (ESL) and business lime (CL) for reclamation purposes. The smashed eggshell based limestone was at first warmed to hoisted temperature to make lime or quicklime and further responded with water in a procedure known as slaking to produce slaked lime or then again airborne lime-calcium hydroxide (Ca(OH)2). Including fine totals delivered the lime-based mortars. The creators watched ESL was cleaner and whiter than the CL with calcium hydroxide substance of 97.1% and 92.2%, separately. This was clarified by a higher substance of polluting influences in the limestone-based calcareous stone.

Rabiu. [12] (2009) assessed the setting time of PC glue comprising of various measures of eggshell fiery debris. The bond glue with the most noteworthy eggshell substance of 2.5 wt. % had the ideal quickening impact. The creators' resolved eggshell slag could be utilized to diminish the setting time in bond glue as the fiery remains contained CaO which quickens the hydration rate.

O.O.Amu. [13] (2005) tested experiment and reported that Egg Shell Powder (ESP) can be used as an addendum for industrial lime on spacious clay soil and further state that the combination is suitable if no higher strength is required to attain.

Freire and Holanda. [14] (2006) carried out a few tests on eggshell waste and discovered its use in a ceramic wall tile paste. In the presence of CaCO3 in eggshell, it can be used as an alternative raw material in the production of wall tile materials that is easily accessible. They on further conclusion discovered that eggshell can be used for waste recycled construction.

Figure 3 Test results for Compressive strength at Different Mix Combination at 7^{th} Day [5]

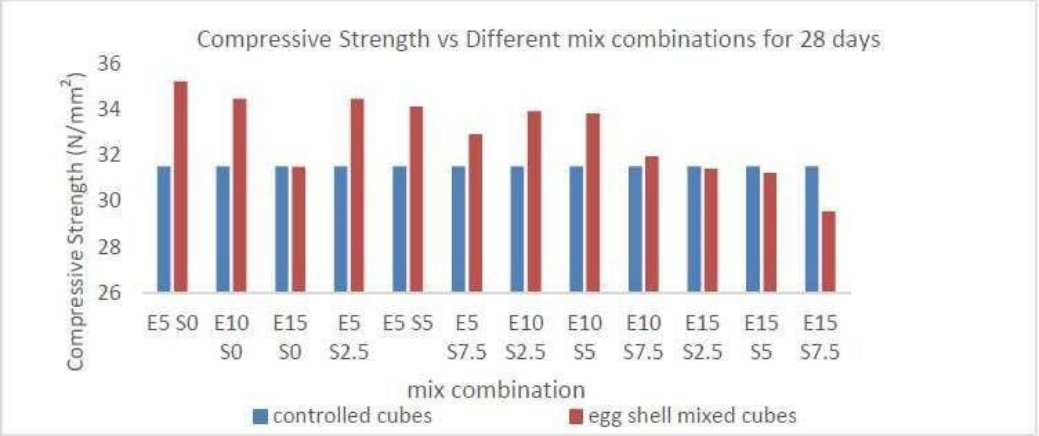

Figure 4 Test results for Compressive strength at Different Mix Combination at 28th Day [5]

CONCLUSION

The studies of different scientists and researchers suggest that ESP and SF can be effectively used as an ingredient in the concrete industry and in addition the results obtained regarding physical and chemical properties are described below, and the literature results are shown in Figure 3 and Figure 4. Here the variation in the compressive strength of controlled cubes (blue) and eggshell mixed cubes (red) is performed by varying percentage of ESP and SF whereas for example in Figure 3 and Figure 4 'E5 and S0' denotes 5% ESP and 0% SF replacement of cement by weight.
From our above analysis of reviewing we can clearly state that, compressive strength can be increased up to 15%, and it depends on the amount of ESP and SF [3] as well as silica fumes decreases the water content, hence specific admixtures to be used [5]. Split tensile strength decreases with the use of eggshell [11] and ESP replacements greater than 10% shows negative results in terms of strength [13].

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