Experimental Investigation of Egg Shell Powder as Partial Replacement with Cement in Concrete

D.Gowsika[#1], S.Sarankokila[#2], K.Sargunan*[3]

[#]PG Student, Dept of Civil Engineering, KSR College of Engineering, Tiruchengode, TamilNadu, India.

*Asst.Professor, Dept of Civil Engineering, KSR College of Engineering, Tiruchengode, TamilNadu, India.

Abstract--- **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.**

Keywords--- **Egg shell powder, cement mortar, Saw dust ash, Fly ash, Micro silica, compressive strength, split tensile strength, Flexural strength.**

I. INTRODUCTION

A. General

Energy plays a crucial role in growth of developing countries like India. In the context of low availability of non-renewable energy resources coupled with the requirements of large quantities of energy for Building materials like cement, the importance of using industrial waste cannot be under estimated. During manufacturing of one tonnes of Ordinary Portland Cement we need about 1.1 tonnes of earth resources like limestone, etc. Further during manufacturing of 1 tonnes of Ordinary Portland Cement an equal amount of carbon-di-oxide are released into the atmosphere. The carbon-di-oxide emissions act as a silent killer in the environment as various forms. In this Backdrop, the search for cheaper substitute to OPC is a needful one.

B. Industrial Wastes

Industrial waste is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process such as that of factories, mills and mines. It has existed since the outset of the industrial revolution. In recent years, special attention has been devoted to industrial sectors that are sources of pollution of the environment. The industry produces large volumes of solid wastes such as Fly Ash, Saw dust Ash, Micro silica, which can end up in rivers, lakes and coastal waters. The disposal of these wastes is a very important problem, which can cause risk to public health, contamination of water resources and polluting the environment. A large number of food plants are constantly accumulating substantial quantities of industrial waste.

C. Egg Shell Powder

Eggshell consists of several mutually growing layers of $CaCO_3$, the innermost layer-maxillary 3 layer grows on the outermost egg membrane and creates the base on which palisade layer constitutes the thickest part of the eggshell. The top layer is a vertical layer covered by the organic cuticle. The eggshell primarily contains calcium, magnesium carbonate (lime) and protein. In many other countries, it is the accepted practice for eggshell to be dried and use as a source of calcium in animal feeds. The quality of lime in eggshell 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.

Fig1. Egg shell powder

D. Saw Dust Ash

Sawdust or wood dust is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool; it is composed of fine particles of wood. Saw dust affect adversely the setting and hardening of Portland cement owing to the content of taming and soluble carbohydrates. Sawdust is the main component of particleboard. Saw dust ash is obtained from the combustion of saw dust. Sawdust is an organic waste resulting from the mechanical milling or processing of timber (wood) into various shapes and sizes. The dust is usually used as domestic fuel. The resulting ash known as saw-dust ash (SDA) is a form of pozzolana. Dry sawdust concrete weighs only 30% as much as normal weight concrete and its insulating properties approximate those of wood. With proper cement to sawdust ratios, it is not flammable.

Fig2. Saw Dust Ash

E. Fly Ash

Fly ash is a fine, glass powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. When mixed with lime and water the fly ash forms a cementitious compound with properties very similar to that of Portland cement. Because of this similarity, fly ash can be used to replace portion of cement in the concrete, providing some distinct quality advantages. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (both amorphous and crystalline) and calcium oxide, both being endemic ingredients in many coal-bearing rock strata.

Fig3. Fly Ash

F. Micro Silica

Micro silica, or silica fume, is an amorphous type of silica dust mostly collected in bag house filters as by-product of the silicon and ferro-silicon production. Micro silica contains trace amounts of heavy metal oxides and organic deposits, which originate from natural raw materials. Since the concentration of these impurities is very low. The effect of silica fume can be explained by two mechanism i.e. pozzolanic reaction and micro filler effect. The first product is calcium silicate-hydrate (C-S-H) gel, that is cementitious and binds the aggregate together in concrete and $Ca(OH)_2$ The C-S-H formed by the reaction between micro-silica and the product $Ca(OH)_2$ which comprises 25% of volume of hydration product.

Fig4. Micro Silica

II. OBJECTIVES

To investigate the utilization of Industrial wastes as a replacement for cement in concrete and influence of this on the Strength of concretes made with different cement replacement levels with admixtures.

III. EXPERIMENTAL PROGRAM

A. Materials Used

Ordinary Portland Cement of 53grade confirming to IS 12269-1987 was used in this study. River sand confirming to grading zone III of Is 383-1970 was used as a fine aggregate. Well graded coarse aggregate passing through 20mm sieve according to IS 383-1970 was used. Well graded coarse aggregate passing through 20mm sieve according to IS 383-1970 was used. Egg shell procured from local industry. It grained and sieved to the required size before used in concrete mix. Saw dust was obtained from sawmill and saw dust ash was obtained by incineration process and sieved before used. Fly ash was collected from Salem steel Plant, Salem, Tamilnadu and sieved before used confirming to IS 3812 (part I). Micro silica was a by product of the silicon and Ferro-silicon production. Portable water was used in the investigations for both mixing and curing purposes.

TABLE I
PHYSICAL PROPERTIES OF CEMENT

S.NO	Description	Test Values
1	Standard Consistency	33%
2	Initial Setting Time	34 min
3	Final Setting Time	350 min
4	Compressive Strength	54.5 N/mm^2
5	Fineness Modulus	3.2%

TABLE II
PHYSICAL PROPERTIES OF FINE AGGREGATE AND COARSE AGGREGATE

S.NO	Description	Fine Aggregate	Coarse Aggregate
1	Fineness Modulus	2.369	6
2	Water Absorption	0.51 %	0.3 %
3	Specific Gravity	2.63	2.68

TABLE III
CHEMICAL PROPERTIES OF CEMENT AND INDUSTRIAL WASTE

Compo-sition	Cement	ESP	Sawdust ash	Fly ash	Micro silica
CaO	63.8%	47.49%	9.39%	5.0%	0.5%
SiO2	21.4%	0.11%	65.79%	52%	96%
Al2O3	5.1%	Nil	4.88%	23%	1.0%
Fe2O3	2.6%	Traces	2.01%	11%	1.5%
MgO	0.36%	Nil	3.92%	Nil	2.0%
SO3	3.38%	0.38%	0.98%	0.8%	0.4%
K2O	1.88%	Nil	2.68%	1.0%	3.0%
Na2O	0.14%	0.14%	0.07%	1.0%	0.5%
Sp. Gravity	3.12	2.14	2.19	2.17	2.2

B. Mix Proportioning

The mix proportioning for M20 grade concrete used in the present work. It is designed as per IS 10262-1982 standards. The mix proportioning adopted was cement: sand: coarse aggregate: water/cement ratio respectively.

TABLE IV
ADOPTED MIX PROPORTION

Cement	Fine Aggregate	Coarse Aggregate	Water
383.16 Kg/m^3	652.35 Kg/m^3	1181.77 Kg/m^3	191.58 lit
1.00	1.70	3.08	0.50

C. Experimental Work

Determination of strength for M20 grade concrete, using Ordinary Portland cement (OPC) with 5% egg shell powder and increasing admixtures content as a part replacement of cement. The different proportion of admixtures (Fly ash, Micro silica, Saw dust ash) will be 0%, 10%, 20%, 30%. The different mixes are conveniently designates as C, F10, F20, F30, M10, M20, M30, S10, S20 and S30 respectively. The cubes of 150 x 150 x 150 mm size and beam of 100 x 100 x 500 mm were tested. The concrete specimens will be tested for following strengths: i) Compressive strength for 28 days curing using standard cube specimen and ii) Flexural strength after 28 days curing using standard beam specimen.

IV. RESULTS AND DISCUSSION

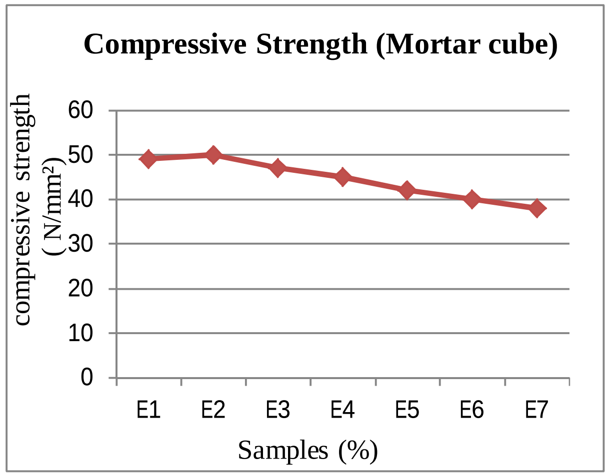

Fig 5. Compressive strength for egg shell powder (28 days)

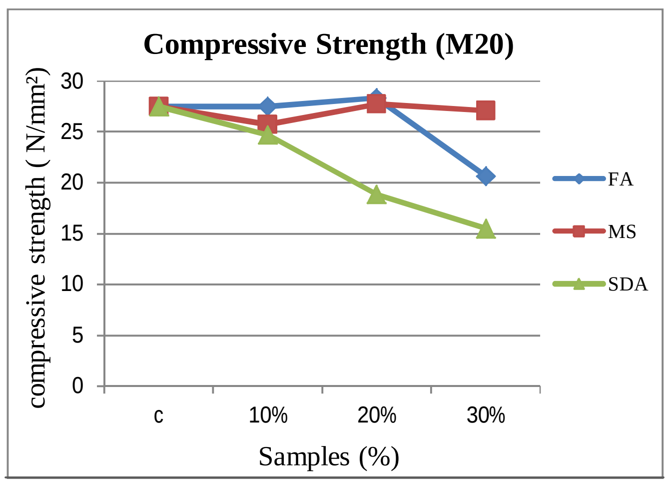

Fig 6. Compressive strength for egg shell powder with admixtures (28 days)

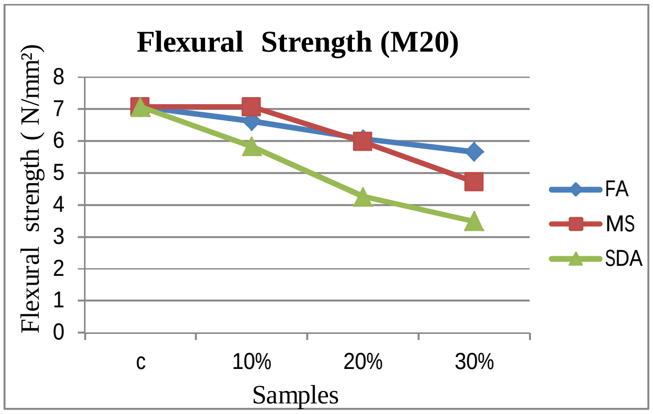

Fig 7. Flexural strength for egg shell powder with admixtures (28 days)

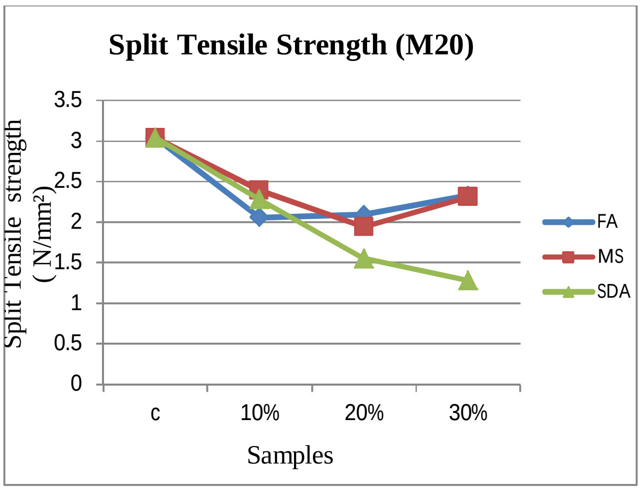

Fig 8.Splittensile strength for egg shell powder with admixtures (28 days)

V. CONCLUSION

Egg shell powder obtained from industrial wastes is added in various ratios for cement replacement and it was found that replacement of 5% Egg shell powder + 20 % Microsilica can be added without any reduction in compressive strength properties of conventional cement. And replacement of 5% Egg shell powder + 10% Microsilica replacement in cement yields similar flexural strength as in conventional concrete. And replacement of 5% Egg shell powder + 10% Microsilica replacement in cement yields higher SplitTensile strength as compared to other compositions.

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