Investigating the Combined Influence of Metakaolin and Egg Shell Powder on Concrete Properties through Partial Cement Replacement

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ABSTRACT

The discussion in this paper is about the combined effect of metakaolin and eggs shell powder on the properties of concrete by replacing slight amount of cement. As metakaolin has tendency to increase durability of concrete by reducing the effect of alkali silica reaction at the same time some percentage of eggs shell may be used as a constituent in form of fine aggregate, which has tendency to reduce the dead load of the structure due to its very low density. In this research work five trials having different percentage of ESP& MK were done with opc (43grade) for concrete mix to analysis the properties of concrete in fresh and hardened stage. The performance of concrete was checked by partially replacing cement with Egg shells powder and metakaolin by various percentages viz 0%,2.5%,5%,7.5%,10%, 12.5% and 15% after different days of curing like compressive strength test (after 7 and 28 days), split tensile strength test (after 7 and 28 days) and flexural strength test (after 28 days), combined effect of Egg shell powder and Metakaolin at 10% gained the maximum compressive strength of 48.25N/mm2.And presence of ESP in concrete mix also enhanced flexural strength value to 7.19N/mm2, which is much better than normal mix concrete.

KEYWORDS: Metakaolin, concrete, flexural strength.

I. INTRODUCTION

Concrete is the integral part of any infrastructure and cement is one of the key constituent of concrete. As one of the key constituent it has large demand all over the world and hence increasing its cost.Our country India is the second largest cement producing nation in the world just after china. After all our per capita consumption of this binding material is very low due to various issues like shortage of coal, unavailability of wagons as per requirement, cement is highly taxed, and the combined effects of all these issues are increasing the overall cost of cement production day by day .One more serious issues regarding environment is huge emission of Co_2 during production of cement, which is a root cause of various problems associated with environment. We may not stop the production of cement until we find a substitute, which may completely replace this binding material by maintaining its strength at the same time but we may control the emission of Co_2 up to a limited extent by cut down the utilization of cement by partial replacement of this binding material by Egg shells powder. As ESP are very calcium rich in nature and may be comparable near about to limestone, due to low density of ESP will leads to light construction of structure by cutting down the overall dead load of the structure. At the same time addition of metakaolin can greatly enhance the various properties of concrete like compressive strength, flexural strength as various researches were conducted on metakaolin and found that it has also tendency to minimize the chances of efflorescence, reduce ASR and gives reduction in shrinkages of concrete.

In future the cost of overall structure is likely to be reduced due to partial replacement of cement by introducing combination of egg shells and metakaolin. Using ESP in industry will result in reduction the overall cost of raw material in construction site. Durability of the structure may be enhanced by reducing alkali silica reactivity, and utilisation of egg shell in concrete will help to reduce in dead load of structure which will give better performance especially in tall buildings.

II. LITERATURE REVIEW

Amarnath Yerran used poultry waste as a construction material in a form of fine aggregate .He performed different test on concrete by replacing 5-15% of cement using ESP and found that 5%replacement of cement using egg shell powder, shows higher strength than control concrete at 7 and 28 days. And the relationship between compressive strength and split tensile strength was good. Further in his research work he found that concrete gives better performance when fly ash is used with ESP in concrete.

S.A. Raji and Samuels investigated that egg shell powder may be potentially used as a fine aggregate in concrete .In this research work total 18 numbers of cubes were prepared for result analysis .And results were compared with conventional concrete .It was a reduction in compressive strength of concrete while ESP used a fine aggregate in concrete but still falls within light weight concrete. And they told that ESP can't be used in concrete at a 100% replacement level and finally recommended that these waste products may be used to produce light weight concrete for some particular work where light weight concrete is needed. Further result should be carried out for replacement of sand using ESP at different level.

Freeda Christy told that ESP can be used as a accelerator for faster rate of setting time. Here he burnt the crushed Egg shells in a furnace then ash was sieved using 90 micron sieve to make a paste with cement. He replaced 0 to 1.5% of cement using ESA by weight of cement and conducted setting time test of prepared paste and found that setting time decreased as compared to normal cement paste. And recommended that Egg shell ash may be used as accelerator in if faster rate of setting is needed in construction work.

In this investigation. Anu paul found the use of egg shell to improve the properties of clayey soil. He told that using egg shell product in clayey soil combination of quarry dust is a economical approach to improve various properties of soil in place of chemical admixture. In his test it was exposed that the utilization of waste poultry product has significant impact on engineering properties of soil like a considerable change in Atterberg's Limits. Atterberg's Limit was decreased and also increase in shearing strength of soil with increasing three percentage of Egg shell product up to 20% and after that seem to be constant. Finally recommended that 20% of egg shell product gives the improvement in engineering properties of soil.

Sanjay N.Patil shown that optimal performance of concrete may be achieved by partially replacing of cement with metakaolin by 7% to 15%by the weight of cement and compressive strength value after 28 days will be higher by 20%.He also stated that emission of carbon dioxide during manufacturing of cement is serious problem associated with environment and need to reduce the consumption of cement in concrete. As metakaolin is having their pozzalonic activity can be used in various construction work like building, dams, water retaining structure, nuclear power station etc.

Aiswarya stated that metakaolin may be used in concrete for partial replacement of cement as it is very effective pozzalonic admixture and may enhance the strength parameter when used in concrete. The result showed better performance of concrete than normal concrete. Using metakaolin in concrete reduces the setting time of paste than normal mix. Metakaolin in concrete may be uneconomical due to its more cost than cement but at the same time it is economic in the aspects of strength and durability.

Nabil found, using metakaolin gives excellent sulphate resisting property when used in concrete by partially replacing of cement. In his experimental work he replaced cement by metakaolin in different level like 5%, 10%& 15% by weight of cement and result showed that it is very effective in improving the sulphate resisting and durability of concrete at a 10% & 15% replacement level concrete showed a excellent results in sulphate resisting property. He also found that if air content is increased 1.5% to 5%, sulphate resisting property of concrete is improved however in plane concrete; there is lower improvement in sulphate fighting property by increasing air content.
R.M Sawant used metakaolin for partial replacement of ordinary Portland cement. He partially replaced cement by metakaolin in 10 to 15% by weight of cement and he found a significant increase in various strength of concrete like in flexural strength, compressive strength, split strength and also stated that emission of $Co_2$is a ill impact of environment during production of cement and time has come to think about reducing the consumption of cement by introducing certain admixture having cementious properties. Using metakaolin result in improvement in durability of concrete by resisting chemical attacks and alkali reaction, reducing in shrinkage. Metakaolin also improve workability of fresh concrete and gives good finishing.

III. METHODOLOGY

To reach the goals of present research work, an experimental programme is done to analyse the compressive strength and the flexural strength of concrete when binding material cement is partially replaced by ESP&MK in varying viz 0%,2.5%,5%,7.5%,10%, 12.5%and 15%.The importance of OPC basically examined from the types of the chemical reactions. Initially, the strength development and the rates of heat liberation is too slow, due to

slow chemical process is. Secondly, the process consumes much lime as compared to production of lime, that leads to increase in the firmness of the hydrated paste to acidic environments. Third, the resultants of reaction are obtained through pozzolanic activity filled large capillary voids, hence increasing the durability and impermeability of the concrete structure. Two physical effects obtained due to the chemical reaction between Ca(OH)2 and pozzolanic particles: (a) grain size refining and (b) pore size refining. Both grain & pore size refining should take place to form certain solid establishment of the concrete so that more durability, strength and higher impermeability are obtained. The chemical reaction of MK consist of combining of silicon with lime for the formation of calcium silicate hydrates, these mixtures in binding material cement are basically liable for strength. Also in a mixture of ESP and OPC, the silica contains with the additional lime of cement and in many cases can be high as 60.

General View on egg shell

In our country India huge amount of waste produced from poultry farm and are treated as a dump material and used in land filling. Although it is natural solid waste and non dangerous after all many lands do not accept these products because it contains a combination of Cao3 and protein membrane, the shell attract the vermin, rats which may be health issue to the public. In other hand these egg shell product are very calcium rich in nature, and can be compared near about to limestone .And it is having very low density which helps in reducing the load of the structure. In concrete, cement is used as a main constituent that can be partially replaced by slight amount of eggs shell and metakaolin to cut down the cost. Further in production of cement Co2 gasses are released into atmosphere, which is a root cause of various problems associated with environment. But we cannot stop the production of cement until we find a substitute, which may completely replace this binding material by maintaining its strength at the same time but we may control the emission of Co2 up to a limited extent by partial replacement of cement by Egg shells. Eggs shells are fine powder which helps concrete to make impermeable in nature by filling small porous.

Benefits of Egg shell as a Fine aggregate in concrete

I. Reducing dead load.
II. Making impermeable
III. Economic
IV. Aesthetic look
V. Durability and washable finishing.

By using such admixture in concrete, dead load of structure will also be reduced due to very low weight density of egg shell powder. And by using light weight density concrete results in saving cost due to smaller member sizes, if the dead load of the structure is less, then it allows to reduce the dimension of supporting member like beam, column foundation. Light weight concrete also eases in constructing large cantilever structure. It reduces the cost of material by replacing partial amount of cement.

Figure. Cement used in study

Metakaolin

Metakaolin is a kind of pozzalonic material which is obtained from a clay mineral named kaolinite. Kaolinite mineral is found in abundance in soil which have been made from the chemical action of rocks in a moist-hot climates. Metakaolin is obtained by calcining kaolin clay varying a temp range of 650°-800°.As metakaolin is very fine in nature as smaller than cement can be used for making concrete. It is found that this pozzalonic material may enhance various properties of concrete like, flexural strength, compressive strength and the durability of concrete by reducing the chance of ASR and efflorescence.

It is seen that during the production of Portland cement, huge emission of Co2 gasses taken place, which is very serious cause of global warming .That should be controlled by reducing the amount of cement used in concrete, introducing metakaolin. In production of Metakaolin less generation of Co2 took place. The addition of metakaolin leads to fill the small porous, which even cannot fill by cement and results in controlling the permeability of concrete and enhance overall durability of concrete by making resistant against various chemical attacks including sulphates. The presence of this admixture causes a mitigation of PH value. The PH value lies within a safe range, needed to offer proper corrosion protection of reinforced steel. Composition of cement and MK in regards of mineral highly seems to each other according to their function.

Figure. Sample of metakaolin powder used in study

IV. FINAL RESULT

The graphical representation of various test results could stipulate the results in efficient manner as different cases results may be compared in one single graph which further may lead to efficient and accurate study of results. The various results at different cases has been shown here.

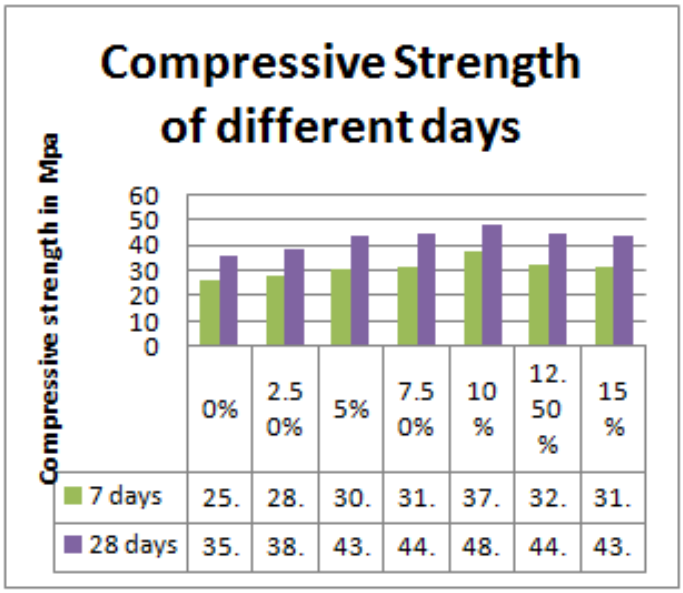

Figure: Compressive Strength of different days of curing

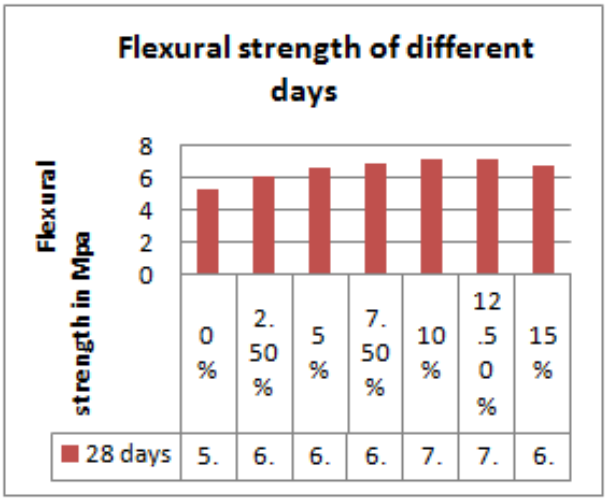

Figure: Flexural strength of different days of curing

Actual quantities required for the mix per m3 of concrete(for 10% combined replacement of ESP & MK)

a) Cement =332.43 kg
b) Volume of Water=0.147 m^3
=147.75 litres
c) Fine aggregate=801.44 kg
d) Coarse aggregate=1228.33 kg
e) Super plasticizer=7.38 kg/m^3
f) Metakaolin=18.5 kg/m^3
g) ESP=18.5 kg/m^3
i) Actual quantity of coarse aggregate required:

Fraction 1 = 614.16 kg(20 mm)
Fraction 2 = = 614.16 kg(10 mm)

V. CONCLUSION

From this experimental research work, following conclusion may be derived-

1. The addition of metakaolin and ESP in concrete mix is gained the desired improvement in the behaviour of concrete.
2. A replacement level of 10% may be adopted for highest compressive strength of concrete (45N/mm2 from obtained result).Beyond this replacement level there is decreasing the strength of concrete.
3. The inclusion of ESP shown a significantly reduction of water penetration, which is
4. 75% as compared to control concrete.
5. The flexural strength of concrete obtained from result was far better than control concrete. Presence of ESP also gives very finishing appearance.

In future the cost of overall structure is likely to be reduced due to partial replacement of cement by introducing combination of egg shells and metakaolin. Using ESP in industry will result in reduction the overall cost of raw material in construction site. Durability of the structure may be enhanced by reducing alkali silica reactivity, and utilisation of egg shell in concrete will help to reduce in dead load of structure which will give better performance especially in tall buildings.

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