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Review on High Volume Replacement of Mineral Admixtures in Concrete

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Abstract: Today the cost of construction is soaring at an exponential rate with the use of materials like cement, fine aggregate, coarse aggregate. Cement production requires high energy input and also it is generating greenhouse gases. Carbon dioxide is released by cement manufacturing both indirectly (emission of energy) and directly (heating of calcium carbonate). Manufacturing of cement causes emission of the most common greenhouse gas i.e. carbon dioxide, from 5% in cement structures to 8% in case of cement roads. The cement factories produce up to 5% of global artificial emission. Also, the prices of cement are increasing day by day. The main objective of the concrete industry today is to meet up with the rising demands to perform at its level best to maintain the ecological balance. The excessive emission of greenhouse gases inhibits the sustainable growth of the environment. It has a greater impact on the climate and society. These are the major reasons that the use of high volume replacement of mineral admixtures in cement has gained popularity. Mineral admixtures may be categorized into two groups, namely, chemically active mineral admixtures (Silica Fume and Metakaolin) and micro filler mineral admixtures (Fly ash, Ground Granulated Blast Furnace Slag and Rice Husk Ash). Replacement of mineral admixtures in concrete leads to substantial environmental benefits. This study emphasizes on the usage of high volume replacement of mineral admixtures in concrete.

Keywords: Cement, Mineral Admixtures, Silica Fume, Metakaolin, Fly Ash, Ground Granulated Blast Furnace Slag, High Volume Replacement.

I. INTRODUCTION

The main objective of the concrete industry today is to meet up with the rising demands to perform at its level best to maintain the ecological balance. The cement production is responsible for 87 percent of all emissions.The excessive emission of green house gases inhibits the sustainable growth of the environment. It has a greater impact on the climate and the society. Though different methods have been proposed the most efficient is the replacement of cement as a binder in concrete with mineral admixtures. Mineral admixtures can be broadly divided into two groups, namely, chemically active mineral admixtures (highly reac- tive pozzolana) and micro filler mineral admixtures (low to moderate reactive pozzolana). Silica Fume and Meta Kaolin are chemically active mineral admixtures, whereas Fly Ash, Ground Granulated Blast Furnace Slag, and Rice Husk Ash are micro filler mineral admixtures. Based on these two groups, the following generalized conclusions can be drawn on the high volume replacement of mineral admixtures in concrete.

II. LITERATURE REVIEW

FLYASH

Chao-Shun Chang et al. [1] used 20 to 80% fly ash as a replacement of cement. Class F fly ash with 4.6% and 7.8% loss of ignition were used. Mechanical properties of concrete were determined. Test results indicated that fly ash increases setting time of concrete and thus development of strength takes place between 91 to 365 days. Finally they found that 80% of class F-fly ash can be used as a replacement in concrete by means of rational mix. From the various trials, it has been observed that replacement of cement by only fly ash can be done up to 65%. Concrete containing fly ash of up to 80% of cementitious material content can be proportioned to have adequate workability when a more suitable SP is used.As we go on adding fly ash in mix design workability gets increased. Replacing cement by fly ash up to 65% gives about 46.77% cost beneficial to that of original mix cost thereby making it economical. The addition of fly ash in concrete leads to an increase of drying shrinkage at various ages. The shrinkage of fly-ash concrete is proportionate to the replacement percentage of fly ash and it has exhibited a higher shrinkage strain after a drying period of 224 days.

Fig 1 Flyash

Snehal Afiniwala et al. [2] found that Self Compacting Concrete of low cost can be developed by using fly ash.M20 and M25 mixtures with 50%, 55% and 60% replacement of cement by class F fly ash were prepared. The rheological properties of concrete were determined by the tests. It was found out that all the properties satiated the standards for 50% and 55% of replacement. Further addition of fly ash lead to the reduction in workability and pumpability of concrete.

P. Vipul Naidu et al. [3] Lime possess the hydration as well as the binding property, so the results of combined mixture of cement and lime gives the desired results. Lime increase the strength of about 5 to 10 percent of the original mix The hydration of cementitious material performs in two types of hydration, primary hydration due to cement content and secondary hydration due to lime content. Replacing ce- ment by fly ash and lime up to 75% gives about 40.78% cost beneficial to that of original mix cost. Hence it is more economical because only 25% of cement is used to get M40 grade cement.

GROUND GRANULATED BLAST FURNACE SLAG

D. Suresh et al. [4]Ground Granulated Blast Furnace Slag (designated as GGBS) has been used as the building material alternative. GGBS is an abundant mineral admixture available for blended PC and concrete but only a little quantity of the total GGBS is used for this purpose. Consequently replacement of cement with high-volume of GGBS has generated considerable interest. He came up with the conclusion that 66 to 80% GGBS is best suited for high sulphate resistance.

GGBS is used in reducing heat of hydration and control early-age cracking. 25 to 40% GGBS is best to avoid extended finishing times. 20 to 40% GGBS is best suited to ensure high early strength. 30 to 45% GGBS may be best to avoid excessive retardation in cold weather.

Fig 2 Ground Granulated Blast Furnace Slag

Alaa M.Rashad et al. [5] At 400 °C, the neat High Volume GGBS paste (HVS) paste residual strength can be increased by 6.47%, 10.17%, 13.29%, 16.39% and 22.72% with the addition of 2%, 4%, 6%, 8% and 10% micro size Meta Kaolin, respectively. The 2%, 4%, 6%, 8% and 10% micro size Meta Kaolin blends showed approximately 1.1, 1.15, 1.2, 1.27 and 1.35 times greater residual strength than that of the neat High Volume GGBS paste (HVS) paste respectively at 600°C. At 800 °C and 1000 °C the micro size Meta Kaolin paste showed enhancement in the residual compressive strength over that of paste by approximately 1.38 and 1.59 times respectively. Thus the low compressive strength of the neat HVS paste can be modified and enhanced with the inclusion of micro size Meta Kaolin particles. The improvement increased upto 10 percent inclusion.

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RICE HUSK ASH

K. Ganesan et al. [6]Rice husk ash (RHA) is the residue of a boiler burnt husk in a particular rice mill. The optimal level of replacement with cement is determined. The properties of concrete such as physical, chemical and mechanical were obtained This Rice Husk Ash consist of 87 percent silica predominantly in amorphous form with the specific surface area of 36.47 m^2/g. Finally they came up with the conclusion that Rice Husk Ash can be blended with cement upto a maximum of 30 percent.


Fig 3 Rice husk


Fig 4 Rice husk ash

SILICA FUME

Dilip Kumar Singha Roy et al. [7] Silica fume is obtained as a by- product from the production of silicon alloys such as ferro-chromium, ferro-manganese, calcium silicon .It can be concluded that use of silica fume is a necessity in production of high strength concrete and low or medium strength concrete as it material facilitate the adoption of lower water - cement material ratio and better hydration of cement particles including strong bonding amongst the particles.


Fig 5 Silica Fume

It has been observed that maximum compressive strength (both cube and cylinder) is noted for 10% replacement of cement with silica fume and the values are higher (by 19.6% and 16.82% respectively) than those of the normal concrete (for cube and cylinder) where as split tensile strength and flexural strength of the Silica Fume concrete (3.61 N/mm2 and 4.93 N/mm2 respectively) are increased by about 38.58% and 21.13% respectively over those (2.6 N/mm2 and 4.07 N/mm2 respectively) of the normal concrete when 10% of cement is replaced by Silica Fume . Silica Fume concrete is more compact and durable.
With 10% of cement replaced by silica fume, the characteristic strength of higher grade of cement concrete namely M25 is achieved only by using the M20 grade designed mix proportion and consequently this Silica Fume concrete can certainly be used as a supplement to M20 grade normal concrete with minimal value 4% of cost reduction.
Lewis et al. [8] has observed that there is a considerable reduction in rebound from (35-15)% by addition of Silica Fume which also increased the pumpability of high workability mix having slump value above 250mm. Incorporation of Silica Fume and other admixtures play a vital role in the production of high pumpable concrete in order to obtain superior mechanical and durability properties.

METAKAOLIN

Wild et al. [9] tested concretes ranging from 1 to 90 days in age, at a water cement ratio of 0.45. He found that the

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optimal replacement of cement with Meta Kaolin is 20 percent which enhanced the long term strength.In a broader view, three elementary factors were found to influence the strength of the concrete when it partially replaces Meta Kaolin . These are the filler effect, the acceleration of hydration, and the pozzolanic reaction. The filler effect is immediate, the acceleration of hydration has maximum impact within the first 24 hours, and the pozzolanic reaction paved way for the greatest contribution to strength between 7 and 14 days of age.

Fig 6 Metakaolin

III.FUTURE SCOPE OF WORK

1. The researches were intended to examine the optimum level of replacement of cement by mineral admixtures such as Fly ash, Ground Granulated Blast Furnace Slag ,Rice Husk Ash, Silica Fume and Metakaolin in concrete..The same work can be extended for higher percentage of replacements.
2. The percentage of replacement of cement by different mineral admixtures can be analyzed for cost benefit analysis.
3. By cost analysis the research work can be extended into low cost housing.
4. Extensive experimental work must be carried out to ensure the proper processing of mineral admixtures thereby maintaining high workability.

IV.CONCLUSIONS

The high volume replacement of flyash content by weight of cement in concrete is 80 percent. However 65 percent replacement aids in the economical mix design. The cement replaced by 15 percent silica fume have exhibited excellent mechanical properties of concrete. The optimum high volume replacement of cement by Rice Husk Ash and Metakaolin is 30 percent and 20 percent respectively. Ground Granulated Blast furnace slag has exhibited excellent sulphate resistance upon replacement of cement from 66 to 80 percent. It also aids in the crack propagation. High volume replacement of mineral admixtures in concrete not only promotes a sustainable eco system by reducing the Carbon di oxide emissions but also helps in improving the mechanical properties of concrete. It paves way for an economic mix design.

REFERENCES

1) Huang, C. H., Lin, S. K., Chang, C. S., & Chen, H. J. (2013). Mix proportions and mechanical properties of concrete containing very high-volume of Class F fly ash. *Construction and Building Materials*, *46*, 71-78.
2) Afiniwala, S., Patel, I., & Patel, N. (2013). Effect of high volume fly ash on rheological properties of self compacting concrete. *International Journal of Emerging Technology and Advanced Engineering*, *3*(7).
3) Naidu, P. V., & Pandey, P. K. (2014). Replacement of cement in concrete. *International journal of environmental research and development*, *4*(1), 91-98.
4) Suresh, D., & Nagaraju, K. (2015). Ground granulated blast slag (GGBS) in concrete–a review. *IOSR journal of mechanical and civil engineering*, *12*(4), 76-82.
5) Rashad, A. M., & Sadek, D. M. (2017). An investigation on Portland cement replaced by high-volume GGBS pastes modified with micro-sized metakaolin subjected to elevated temperatures. *International Journal of Sustainable Built Environment*, *6*(1), 91-101.
6) Ganesan, K., Rajagopal, K., & Thangavel, K. (2008). Rice husk ash blended cement: assessment of optimal level of replacement for strength and permeability properties of concrete. *Construction and building materials*, *22*(8), 1675-1683.
7) Roy, D. K. S., & Sil, A. (2012). Effect of partial replacement of cement by silica fume on hardened concrete. *International journal of emerging technology and advanced engineering*, *2*(8), 472-475.
8) Lewis, R. C., & Hasbi, S. A. (2001). Use of silica fume concrete: Selective case studies. *Indian Concrete Journal*, *75*(10), 645-652.
9) Wild, S., Khatib, J. M., & Jones, A. (1996). Relative strength, pozzolanic activity and cement hydration in superplasticised metakaolin concrete. *Cement and concrete research*, *26*(10), 1537-1544.