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REVIEW PAPER ON PERFORMANCE OF HIGH STRENGTH CONCRETE PAVEMENT USING METAKAOLIN AND HYBRID FIBRES

Priya[1], Pardeep[2]

[1]Student, Sat Priya Group of Institutions, Rohtak, India.

[2]Assistant Professor Sat Priya Group of Institutions, Rohtak, India.

*Corresponding Author

E-mail Id: priyaranice21376@gmail.com

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ABSTRACT

Cement concrete construction in today's developing countries is very common and the use of concrete is increased day by day. In the past few years, many research and modification has been done to produce concrete achieve desired characteristics. There is always a search for concrete with higher durability. However, environmental concerns both in terms of damage caused by the extraction of raw material and carbon dioxide emission during cement manufacturing have brought pressures to reduce cement consumption by the use of supplementary materials. Supplementary materials such as metakaolin, silica fume, quarry dust, fly ash, bottom ash and blast furnace slag can be used as a replacement of cement in mortar and concrete. Another main concern about concrete is its brittleness. Studies have reported that tensile strength and ability to resist cracking are also enhanced with the addition of fibers The effect of using metakaoline and hybrid fiber on the mechanical properties of high strength concrete mixture is present in this thesis.

The use of metakaoline and hybrid fiber decreases the use of concrete mix and also increases the strength of concrete pavement Since the cost cement concrete pavement is governed by the cost of material, plant and labor. The high strength concrete mix decrease the use of both material and labor and the pavement in more also used by heavy load for long duration. The high strength concrete pavement required less maintenance and less labor which decrease the maintenance cost of pavement. The hybrid fibers used in the research is combination of steel fiber and polypropylene fibers. The cement is replaced by 0% to 25% of metakaolin.

The hybrid fibers used at 1% by fractional volume. The results show that compressive strength increased by 10%. The gain in flexural strength is more as compared to compressive strength. The pavement thickness is also design with experiment result data. But form the economic analysis it is conclude that hybrid fibers at 1% increase the cost of pavement.

Keywords- polypropylene fibre, metakaolin, silica fume, kaolinite

1. INTRODUCTION

Concrete is one of the most common materials used in the construction industry and the use of concrete is increasing day by day. Concrete is a versatile construction material, it is plastic and malleable when newly mixed, yet strong and durable when hardened. These qualities explain why concrete can be used to build skyscrapers, bridges, sidewalks, highways, houses and dams.

In the past few years, many research and modification has been done to produce concrete to achieve desired characteristics. There is always a search for concrete with higher durability. Concrete is a composite material, consisting mainly of Portland cement, water and aggregate (gravel, sand or rock). When these materials are mixed together, they form a workable paste which then gradually hardens over time However, environmental concerns both in terms of damage caused by the extraction of raw material and carbon dioxide emission during cement manufacturing have brought pressures to reduce cement consumption by the use of supplementary materials. The consumption of use of cement can be reduces by the use of supplementary materials Supplementary materials such as metakaolin, silica fume, quarry dust, fly ash, bottom ash and blast furnace slag can be used as a replacement of cement in mortar and concrete Another main concern about concrete is its brittleness. The use of fiber in concrete overcomes the problems related to low tensile strength, poor fracture toughness and brittleness The present area in concrete includes introducing metakaolin (clay) and hybrid fibers Clays have been and continue to be one of the most important industrial minerals. Clay and clay minerals are widely utilized in our society. Metakaolin is one of the innovative clay products in recent years. It is produced by the controlled thermal treatment of kaolin Metakaolin can be used as a concrete constituent, replacing part of the cement content since it has pozzolanic properties.

The use of metakaolin as the partial cement replacement material in mortar and concrete has been studied widely in recent years despite of the recent studies, there are still many unknowns with the use of metakaolin.

Metakaolin, generally called "calcined clay" is a reactive alumina-silicate pozzolan produced by heating kaolinite at a specific temperature regime. Metakaolin is a chemical phase that forms upon thermal treatment of kaolinte. Kaolinite's chemical composition is $Al_2Si_2O_5(OH)^2{}_4$ and as a result of thermal treatment in the range 700-850°C, the water is driven away to form an amorphous alumina silicate called metakaolin. The range depends on the kaolin (kaolinite with minor impurities) characteristics such as degree of crystallinity and particle size.

The principal reaction is that between the metakaolinite and calcium hydroxide derived from cement hydration, in the presence of water. This reaction forms additional cementitious aluminum containing C-S-H gel, together with crystalline products, which include calcium aluminates hydrate and alumino-silicate hydrates. The crystalline products formed depend principally on the metaolinite/calcium hydroxide ratio and the reaction temperature. In addition if carbonate is freely available carbon-aluminates may also be produced.

2. LITERATURE REVIEW

Ambroise et al (1985) studied the improvement in the strength of metakaolin cement activated with calcium hydroxide. It was found that the more convenient curing process implied the immersion water after the removal of sample from the moulds at 7 days and drying at 50°c for one day before mechanical testing. The process led to considerable improvement of strength.

Qian and Stroeven (1998) investigated the optimization of fibers size and fiber content and fly asli content with the hybridization of steel fibers and polypropylene fibers. The results show that fine particles such as fly ash is necessary in some amount to evenly disperse the hybrid fibers in the cement concrete mixture. Addition of a small fibers type had a significant influence on the compressive strength but the splitting tensile strength is slightly affected. A large fiber type gave rise to negative mechanical effect which was further fortified by optimization of the aspect ratio.

Chunxiang et al (1999) studied the polypropylene fibers and three sizes of steel fibers in concrete mixture. A four point bending test is done by varying the total fibers content ranges from 0% to 0.98%. The research result shows that large steel fibers and polypropylene fibers have positive synergy on the load bearing capacity and fracture toughness in the small displacement of the beam. The large steel fibers show the most sienificantly effect on the energy absorption capacity in the large displacement range,

Wei et al (2000) studied the effect of expansive agent and hybrid fibers of steei fibers, polyvinyl fibers and polypropylene fibers in high performance concrete. Test results indicate that different type and size of hybrid fibers can reduce the amount and size of crack at different scales. The use of expansive agent with hybrid fibers improves the shrinkage resistance and impermeability of high performance concrete. The shrinkage compensation due to expansive agent could not be neglected.

Poon et al (2001)28 showed that the cement paste containing 5 to 20% metakaolin had higher compressive strength than the control mixture at all ages from 3 to 90 days. The paste containing 10% of metakaolin perform best. The cement paste containing silica fume or fly ash had lower compressive strength the control mixture at 28 and 90 days. The fly ash replacement resulted in high compressive strength than the control mixture only at 90 days. The above results indicated that at early ages the metakaolin contributed better to the compressive strength development of high performance cement paste than silica fume.

Zongjin and Ding (2003) investigated that a 10% blend of metakaolin reduces the fluidity of the concrete mixture. The water demand was increased by roughly 11%, which is attributed to the plate like particle shape and it is tendencies to absorb water. Setting time was also shown to decrease by 26 and 36% for initial and finial setting time respectively.

Justice.J.M et al (2005) made a comparative study by replacing 8% by weight of cement with Metakaolin and Silica fume. Metakaolin addition proved to be beneficial, resulting in concrete with considerably higher strengths and greater durability than the normal mixes. The use of finer Metakaolin was more effective in improving concrete properties than the coarser Metakaolin. Addition of Metakaolin increased the use of super plasticizers. Addition of Metakaolin exhibited improvements in shrinkage, durability and other strength aspects.

Nabil M. Al-Akhras (2005) carmed out an investigation by replacing cement with Metakaolin to find out the durability of concrete against sulphate attack Three replacements of cement with Metakaolin (5, 10 and 15% by weight of cement) were taken with w/c ratio at 0.5 and 0.6. After the specified days, the samples were immersed in 5% sodium sulphate solution for 18 months. The effect of metakaolin addition proved to be beneficial in improving the resistance of concrete to sulphate attack. Metakaolin with a w/c ratio of 0.5 exhibited better results in sulphate resistance than 0.6. Autoclaved cured specimens had better resistance against sulphate than moist cured specimens.

Abid Nadeem et al (2008) made an investigation on the chloride permeability of high strength concrete and mortar specimens containing varying proportions of Metakaolin (MK) and Fly ash at elevated temperatures.

A total of seven concrete and three mortar mixes were tested after exposing each mix to 200, 400, 600 and 800°C. In concrete, the dosage levels of MK were 5, 10 and 20% and for Fly ash the dosage levels were 20, 40 and 60%. In mortar, the dosage level of Metakaolin and Fly ash was 20%. All concrete specimens investigated in this study had a minimum compressive strength of 85 MPa At normal temperatures, concrete and mortar specimens had very low chloride ion Penetrability. At normal temperature, metakaolin mixes had lower chloride permeability than Fly ash and Portland cement mixes.

At normal temperatures, mortar specimens were more chloride permeable than concrete specimens. At 200°C and 400°C, mortar was still more chloride permeable than concrete but the ratio of mortar to concrete chloride permeability was less than that at normal temperature.

Pacheco Torgal.F et al (2011)29 study the effects of Metakaolin and Fly ash on strength and durability on concrete. The durability was found by three methods namely water absorption, oxygen permeability and concrete resistivity. They reported that partial replacement of Portland cement by 30% fly ash leads to serious decrease in early age compressive strength than the reference mix made with 100% Portland cement. The use of hybrid of them at 15% Fly ash and 15% Metakaolin based mixtures resulted in minor strength loss at early stages but showed outstanding improvement in durability.

Muthupriya.P et al (2011)[11] performed an experimental investigation on the behavior of High Performance Reinforced Concrete column (HPRC) to assess the suitability of HPRC columns for the structural applications. High performance concrete was prepared by partial replacement of Ordinary Portland cement with Metakaolin and Fly ash. The test results showed improvements in strength, brittleness and durability. The optimum replacement level for Metakaolin and Fly ash was reported as 7.5%. They reported that the compressive strength of high performance reinforced concrete containing 7.5% of Metakaolin was 12% than the normal concrete.

Yusof et al. (2011) have investigated the mechanical properties of HFRC with different aspect ratios. The results showed that high strength FRC with concrete mixture containing 30% long fibers and 70% short fibers at 1.5% volume fraction gave the highest compressive strength.

In addition, concrete with short steel fiber performed better in compression, compared to the performance of concrete with long steel fiber. Moreover, the results indicated that the HFRC (at volume fraction of 1.5%, consisting of 70% long fiber and 30% short fiber) gave the highest value of split tensile strength and longer fiber performed better in tensile strength.

The mechanical properties and durability of high strength concrete mixtures included MK with a percentage of replacement of 15% was investigated. The study concluded that the addition on MK showed accelerated setting time of cement pastes and reduced the workability.

Paiva.H et al (2012)[31] determined the effect of Metakaolin on strength and workability of concrete. The experimental results showed that the use of Metakaolin decreased the workability and to get the required slump. High range water reducing admixtures (HRWRA) were essential. HRWRA resulted in deflocculating of Metakaolin particles and thus a well dispersion of Metakaolin particles was achieved. The work concluded that use of HRWRA was very essential in concrete containing fine particles like Metakaolin to achieve well dispersion and better results.

3. CONCLUSIONS

The study 'Study of Performance of High Strength Concrete Pavement Using Metakaolin and Hybrid Fibers have been taken up with a view to investigate the effects of addition of metakaolin as partial replacement of cement and hybrid fibers on the strength of concrete. Various investigations were made on M60 grade concrete for pavement with varying proportion of metakaolin from 0 to 25% and at 1% hybrid fibers. The main conclusions drawn from the study are:

1. There is a reduction in workability of the concrete with the addition of metakaolin due to its finer particle size as compared to cement. The hybrid fiber used in concrete mix reduces workability of the concrete.
2. The content of polypropylene fibers, combined with the high stiffness steel fibers and various percentage of metakaolin results in enhanced behavior in term of compressive strength and flexural strength.
3. Compressive strength at 28 days is found to increase with addition of metakaolin and hybrid fibers. The maximum increase in compressive strength occurs at 20% replacement level of cement by metakaolin and at 1% hybrid fibers.

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