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Experimental Investigation on Concrete Incorporating Metakaolin and Polyproplyne Fiber

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***Abstract:*-- Concrete is the most versatile and important building material. The main concern in today's era is that its manufacturing as well as overuse in the construction sector makes our environment polluted. Since we know that when cement reacts with water it exhibits cement hydration reaction which is generally exothermic in nature and has other repercussions also.. The major drawback of using excess cement is its manufacturing as it is very hazardous and evolves the green house gas carbon dioxide which is very toxic in nature. To overcome these problems, the use of Supplementary Cementing Material like metakaolin, rice husk ash, blast furnance slag, Fly ash and silica fume are some pozzolanic materials which itself doesn't contribute anything as these are probably the waste product but when get merged with cement shows excellent bond strength and makes concrete less permeable. It also makes the concrete eco friendly and more economical. Experimental investigation has been carried out at M-25 grade. Fibres also enhances the fresh and hardened properties of concrete. It provides protection against micro cracks and makes the overall matrix strong by reducing cracks. This paper deals with the fresh and hardened properties of concrete with partial substitution of binding material known as cement by metakaolin and incorporation of polypropylene fiber at constant 0.3% by mass of cement. The concrete mixes were prepared by replacing Ordinary Portland Cement 43 with 0%, 5%, 10%, 15% and 20% of metakaolin and by adding polypropylene fiber at 0.3% by mass of cement. The test results will taken for Compressive, Split Tensile Strength and Flexural Strength and it would be observe that metakaolin as a binder will react with cement at early stage because of its fine particle size will make the concrete less permeable and addition of polypropylene fiber also fills the micro cracks then the desired results will achieved. Cubes, Cylinders and Beams will be casted for 7, 14 and 28 days .Superplasticizer will also be used as the both metakaolin and polypropylene fiber will make the concrete unworkable. In order to maintain the workability critera the dosage is fixed at 0.2%. The overall results shows this combination will provide us excellent results.**

Keywords: Metakaolin, Superplasticizer, Carbon dioxide, Polypropylene Fiber, Workability

I. INTRODUCTION

Concrete has been widely used in recent years, not only for its increased compressive Strength, improved durability and economic benefits, but also for its positive impact on the environment the demand for Portland cement is increasing dramatically in developing countries. Portland cement production is one of the major reasons for CO2 emissions into atmosphere. Metakaolin when used as a partial replacement substance for cement in concrete, it reacts with Ca(OH)2 one of the by-products of hydration reaction of cement and results in additional C-S-H gel which results in increased strength. Metakaolin is obtained by thermal activation of kaolin clay. This activation will cause a substantial loss of water in its constitution causing a rearrangement of its structure. To obtain an adequate thermal activation, the temperature range should be established between 600 to 750ºC. The principal reasons for the use of clay-based pozzolans in mortar and concrete have been due to availability of materials and durability enhancement. However, when the high range water reducer or super plasticizer was invented and began to be used to decrease the water/cement (w/c) or water/binder (w/b) ratios rather than being exclusively used as fluid modifiers for normal-strength concretes, it was found that in addition to improvement in strength, concretes with very low w/c or w/b ratios also demonstrated other improved characteristics, such as higher fluidity, higher elastic modulus, higher flexural strength, lower permeability, improved abrasion resistance, and better durability. Concrete is predominantly used in resisting compressing force and it is the most broadly used composite material. Typically pozzolans are used as cement replacements rather than cement additions. Replacing some of the cement with pozzolans improves the performance of concrete. The present research in the high performance concrete is introducing metakaolin the concrete. It enhances the strength and durability of concrete to make concrete even more suitable for construction. The principal reason for the use of pozzolans such as metakaolin in concrete is due to easy availability. The use of metakaolin results inconsiderable enhancement in strength particularly at the early stages of curing along with the strength that later age Calcium hydroxide is one of the by-products of hydration reaction of cement. When cement is partially replaced with metakaolin, it reacts with calcium hydroxide and results in extra gel. C-S-H(Calcium Silicate hydrate) gel which is the sole cause for strength development in cement and cement based concrete. The chemical reaction is given below:

Cement + H2O = C-S-H gel + Ca (OH) 2

Ca (OH) 2 + Metakaolin = C-S-H gel

Investigations were carried out by many researchers which have established the fact that Addition of fibres in concrete enhances its engineering properties. It has been observed that the concrete shrinks when it is subjected to a drying environment. The extent of shrinkage depends on many factors, including the properties of materials, temperature, and humidity of the environment and the size of the structure. When concrete is restrained from shrinkage, tensile stresses develop and concrete may crack. One possible method to reduce these adverse effects of cracking is addition of short and randomly distributed fibres. It has also been observed that the properties of crack resistance, impact resistance, frost resistance and fatigue resistance of concrete are improved by addition of polypropylene fibre. Use of polypropylene fibres may enhance the toughness of concrete, reduce shrinkage cracks and decrease permeability.The plastic shrinkage cracking resistance is also increased with the increase of polypropylene fibre addition. Basically the polypropylene fibers hinders the growth of cracks and therefore limit the development of flaws in the concrete matrix. This combination will definitely makes the concrete to achieve good strength in all aspect whether in case of fresh property or hardened property. But both material metakaolin and polypropylene fiber will block the pore size of cement and then it will become unworkable. So in order to resolve this problem the dosage of superplasticizer is constant 0.2% by mass of cement. Superplasticizer are chemical admixtures which are generally used in order to maintain the workability criteria.

II. LITERATURE REVIEW

2.1 FRESH PROPERTIES

Jagtap et al.(2017) has completed an exploratory investigation on the impacts of metakaolin in the typical cement. Workability criteria has been checked. Experimental investigation was done for M35 review of cement by code IS 10262:2009, coming about to a blend extent of 1:1.69:2.28 with water cement proportion of 0.42. The substitution of cement by metakaolin was 5% to 25% at addition of 5% each.

Table 1: Replacement of cement with metakaolin Jagtap et al.(2017)

Mix Designation	% Replacement	Value of Slump (mm)
A1	0	63
A2	5	61
A3	10	56
A4	15	52
A5	20	45
A6	25	40

Mohamed R.A.S (2006) carried out research at normal concrete. He used white coloured polypropylene fiber (CMB FIBER) which is having a density of 0.91g/cm3, bundle thickness 2mm, fibrils bundle 10, cut length 15mm, tensile strength 370 N/mm2. The slump of the given percentage is observed. The fibres were added at a varying percentage of 0.25, 0.5, 1 and 1.5% by volume. In order to maintain the workability criteria superplasticizer has also been used. Manindra Kumar et al (2015) has done observation at light weight concrete by incorporating polypropylene fiber . Fibers are used in two different length 6mm, 12mm and 19mm and fiber proportions can be taken as 15%, 25% and 35%. The water cement ratio is constant at 0.5%. The use of fibres makes the concrete light weight and low cost material. The slump value is observed .

Fig 1: Slump Value Manindra Kumar et al (2015)

III. HARDENED PROPERTIES

Sabir.B.B et al (2001) carried out a study on the use of Metakaolin which is a binding material for mortar and concrete and mentioned about the wide range application of. They Metakaolin improve the concrete matrix and greatly improve its transportation as there is substantial loss of water Murali.G and Sruthee P (2012) experimentally studied the use of Metakaolin as a partial replacement substance for cement in concrete. The use of metakaolin in concrete effectively enhanced the strength properties. The optimum level of replacement was reported as 7.5%. The result showed that 7.5% of metakaolin increased the compressive strength of concrete by 14.2%, the split tensile strength by 7.9% and flexural strength by 9.3%. Dubey et al.(2015) out at M-25 grade. There was replacement of cement with metakaolin at 0%, 5%, 10%, 15% and 20%. The test

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spicemen were casted and tested as per relevant IS code for compressive strength results. It has been seen from the experiment that with the varying percentage of metakaolin it shows better results as compared to the conventional concrete. It has been observed that 10% replacement it shows better compressive strength 38.81 N/mm2.

TABLE 2 COMPRESSIVE STRENGTH AT 28 DAYS Dubey et al. (2015)

Mix	% of Metakaolin	Compressive Strength (N/mm^2)
Mk 0	0	31.90
Mk 5	5	35.84
Mk 10	10	38.81
Mk 15	15	32.58
Mk 20	20	32.00

Pasha et al., (2015) investigated the research on M25 grade and ordinary Portland bond. This test is accomplished by using this code IS 516 – 1959. The flexural strength of concrete might be communicated as the modulus of crack which parallels the separation between the line of break and the closer help, measured on the middle line of the malleable side of the example, in cm, should be computed to the closest 0.5 kg/sq cm

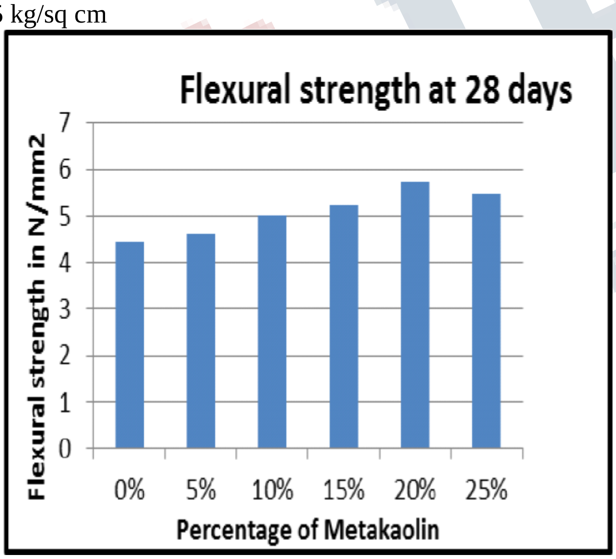

FIG 2 Flexural Strength OF Normal Concrete Pasha et al., (2015)

IV. CONCLUSIONS

The maximum compressive strength is achieved at 10% replacement of cement with metakaolin. The addition of polypropylene fiber makes concrete more dense and reduce the generation of microcracks. The slump value get decreased on the addition of polypropylene fiber because it makes the concrete less permeable. The split tensile strength also increases at 15% replacement but after that it starts declining The flexural strength is maximum at 10% replacement of metakaolin

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