Performance Assessment Of Arecanut Fibre Reinforced Metakaolin Modified Concrete

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Abstract- *In this effort a variety of Waste product additives can be combined with concrete to optimize strength properties. In this effort a variety of Waste product additives can be combined with concrete to optimize strength properties. Concrete production has been posing a major problem environmentally now a days and it involves lot of power consumption for production of cement. The rapid production of cement creates big problems to environment. The first environment problem is emission of CO2 during the production process of the cement. The CO2 emission is very harmful which creates big changes in environment. Hence, a solution to this problem has to be found out. As there is no alternative building material which totally replaces the cement, the search for any such material, which can be used as an alternative or as a supplementary for cement, should lead to global sustainable development and lowest possible environmental impact. Metakaolin, a pozzolanic material derived from the calcination of kaolin clay, is known for its pozzolanic reactivity. When metakaolin reacts with calcium hydroxide produced during cement hydration, forming additional cementitious products. This project focuses on the potential of two such materials, metakaolin and arecanut fiber, in enhancing the strength and properties of concrete. This project work is carried with a set of objectives viz., effect of metakaolin and arecanut fibre on mechanical properties of M30 grade of concrete with different proportions of replacement of cement with metakaolin together with 1%, 2%, 3%, and 4% of arecanut fibers.*

Keywords- Metakaolin, Arecanut fibre, workability, compressive strength, split tensile strength test, water absorption test.

I. INTRODUCTION

In the last decades, environmental sustainability has The impact of carbon dioxide emission due to production of Portland cement can be reduced by partial replacement of cement with supplementary cementitious materials. Metakaolin (MK) or calcined kaolin or other type of pozzolan produced by calcination has the capability to replace silica fume as an alternative material. In India MK can be produced in large quantities, as it is a processed product of kaolin mineral which has wide spread proven reserves available in the country. At present the market price of MK in the country is about 3 - 4 times that of cement. Therefore the use of metakaolin proves economical over that of silica fume. Previously, research findings have shown a lot of interest in MK as it has been found to possess both pozzolanic and micro filler characteristics. It has also been used successfully for the development of high strength concrete using mathematical modeling. However limited test data are available regarding the performance of the commercially available MK and Indian cements in the case of high strength concrete in the country, Hence, carried out this project with metakaolin as a partial replacement of cement.

Thus fibres are another to concrete to beat these disadvantages. The addition of fibres within the matrix has several vital effects. Fiber reinforced concrete has been recognized that addition of small, closely spaced and uniformly dispersed fibres to concrete would act as reinforcement to the concrete thereby improves the properties of concrete.

The Fibre concrete (FRC) could be a material primarily consisting of concrete strengthened by random placement of short discontinuous and distinct fine fibers of specific pure mathematics. It’s currently well established that the addition of short, discontinuous fibers plays a vital role within the improvement of the mechanical properties of concrete. In the FRC, the fibers facilitate to transfer load to the inner small cracks. Within the recent past, several developments are created within the fiber concrete.

Arecanut husk fiber, a natural and abundant agricultural byproduct, into the concrete mix. Areca nut husk fibers possess unique characteristics that make them suitable for enhancing the mechanical properties of concrete. Areca fiber is an attractive reinforcement for concrete. Thus fibres are another to concrete to beat these disadvantages. The addition of fibres within the matrix has several vital effects. Fiber reinforced concrete has been recognized that addition of small, closely spaced and uniformly dispersed fibres to concrete would act as reinforcement to the concrete thereby improves the properties of concrete.

The experimental approach involves designing and testing various concrete mixtures with different proportions of metakaolin and areca nut husk fiber. Compressive strength tests, split tensile strength and flexural strength test will be conducted to evaluate the performance of these mixtures in comparison to conventional concrete.

The present project involves a comprehensive laboratory experimentation study for the application of new waste materials in the preparation of concrete. The main objective of investigation is to study the strength behaviour i.e. compressive strength, split tensile strength and flexural strength of concrete with different percentages replacement of cement with metakaolin and to study the tensile behaviour on adding with Arecanut husk fibers.

The objective of the present study was to investigate experimentally the properties of Concrete with the following test results

- Workability
- Compressive strength
- Flexure strength
- Tensile strength

II. REVIEW OF LITERATURE

This chapter deals with the review of works previously carried out in the area of metakaolin replacement experiments and the role of Areca nut husk fibers in the field of fibre reinforced concrete in the earlier studies are presented. Importance of fibres in toughness and tensile strength point of view and its optimum percentage is also discussed. It is possible to make several classifications among fiber types. Fibers can be divided into two groups, those with elastic moduli lower than the cement matrix, such as cellulose, arecanut, and polypropylene and those with higher elastic moduli such as asbestos, glass, steel, and carbon.

Among all the fibers Areca nut husk fibers have been used in pavements, in shotcrete, and in a variety of other structures. Banana fibers are renewable and obtained from natural resources that present several advantages, including low density, acceptable specific strength properties, good sound abatement capability, low abrasivity, low cost, high biodegradability and existence of vast resources. In addition, at the end of their life cycle these can be incinerated for energy recovery, because they have a good calorific value. New application areas become available as new fiber types and new FRC production techniques are developed.

D. Patil, Patil & Veshmawala Observed the Performance of Copper Slag as Sand Replacement in Concrete.M30 concrete was used and several tests like compressive, flexural, split tensile strength were taken for different portions of copper slag and sand from 0 to 100%. The outcome showed that workability increases with growth in percentage of copper slag. Maximum Compressive strength of concrete increased by 34 % at 20% replacement of fine aggregate with copper slag, and up to 80% replacement of copper slag, concrete gain more force than normal concrete strength. The flexural strength of concrete found to be increased by 14% with 30% substitution of copper slag.

A.N.Dancygier and Z.Savir studied the influence of nylon fiber on flexural performance of high strength concrete beam with low longitudinal reinforcement magnitude relation, that tried that nylon fiber enhance crispiness of beam compared to it of beam with minimum longitudinal reinforcement magnitude relation. Compared to nylon fiber concrete, the hybrid fiber with completely different kind and size will improve effectively strength and toughness of concrete, kind hybrid result throughout completely different fiber, play various useful influence from completely different level. However, few researches on flexural performance of hybrid fiber strengthened RC beam were studied.

Mr. R. Srinivasan et al., has investigated on “Experimental Study on pulp Ash in Concrete” that they had ascertained that Sugar Cane pulp is fibrous waste-Product of sugar industry, and inflicting serious environmental drawback that principally contain metal particle and oxide. Hear pulp ash has been with chemicals and physically characterised, and part replaced within the quantitative relation of 1/3, 5%, 15%, twenty fifth by weight of cement in concrete.

Shaik Fazlur Rahman, Smt. K Chandrakala (2019) conducted Experimental Study on Partial Replacement of Cement with Metakaolin and Coarse Aggregate with Blast Furnace Slag.This paper presents results of an experimental investigation carried out to evaluate effects of replacing coarse aggregate with blast furnace slag and cement with metakaolin. Slag is a by-product generated during manufacturing of pig iron and steel. Primarily the slag consists of calcium, magnesium, manganese and aluminium silicates in various combinations. The cooling process of slag is responsible mainly for generating different types of slags required for various end use consumers. In this investigation we are going to replace 10% of cement with metakaolin and coarse aggregate with blast furnace slag with increasing percentages of 0%, 10%, 20%, 30%, 40% and we cast cubes and cylinders at various percentages of replacements and we can find the compressive and tensile strength of concrete. The strength of concrete increase gradually upto30% replacement of concrete and the decreases this is mainly due to arrangement and the increase of air voids beyond 30% replacement. This replacement leads to the reduction of cost of construction due to the use of industrial waste as ingredient of concrete.

- The compressive strength and split tensile strength are higher for replacement of 30% of GBFS and replacement of cement with 10% Metakaolin.
- The compressive strength and split tensile strength are lower for 0% replacement.
- The results showed that using Meta Kaolin and increasing % of flash with GBFS an improvement in the impermeability of concrete.
- The replacement of cement by MK leads to decrease in pore space.
- The physical and chemical properties of GBFS are suitable for the production of concrete mix.

Ghutke&Bhandari Examine the Influence of silica fume in concrete. Results indicated that the silica fume is a better replacement of cement. The rate of strength gain in silica fume concrete is high. Workability of concrete decreases as increase with % of silica fume. The optimum value of compressive strength can be achieved in 10% replacement of silica fume. As strength of 15% replacement of cement by silica fume is more than normal concrete. The optimum silica fume replacement percentage is varying from 10 % to 15 % replacement level.

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Coarse aggregate
3. Water
4. Metakaolin
5. Arecanut fibre

1. Cement

Ordinary Portland cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirming to IS 8112:1989 was used in the field.

2. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

3. Coarse Aggregate

Coarse aggregate shall be of hard broken stone of granite shall be of hard stone, free from dust, dirt and other foreign matters. The stone ballast shall be of 20mm and down and should me retained in 5mm square mesh and well graded such that the voids do not exceed 42 percent. Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

4. Metakaolin

Metakaolin is a white, amorphous, highly reactive aluminium silicate pozzoloan forming stabile hydrates after mixing with lime stone in water and providing mortar with hydraulic properties. It is a mineral admixture obtained from clay. Metakaolin is a highly pozzolanic material, it is in powder form and fineness of MK up to 700 to 800m²/kg. It is derived from the calcination of a high-purity kaolin clay. The product is then ground to between 1-2 gm. (about 10 times finer than cement). Indeed Metakaolin is not a by-product, one of the prominent use of MK is mixing with concrete because its physical and chemical properties are similar to the cement. As a raw material, it is rarely found in crystallized form and Kaolinite is a clay mineral found fairly commonly throughout the world.

5. Arecanut fibre

Arecanut fiber (ANF) is a natural fiber obtained from the areca palm tree. It acts as a light weight composite material

Fig 3.1 Arecanut fiber

IV. MIX DESIGN

The property of workability, therefore, becomes of vital importance. The mix design is done as per IS 10262-2009. Percentage dosage of super plasticizer (high range water reducers) is an additional parameter to be considered for designing an OPC mix. Percentage dosage of super plasticizer was fixed as per the mix design method described in IS 10262-2009. Mix proportion was arrived through various trial mixes. The grade of concrete prepared for the experimental study was M30.

V. RESULTS AND DISCUSSIONS

5.1 INTRODUCTION

This session provides an outline of the experimental results and endeavors to draw some conclusions. The take a look at result covers the workability, mechanical properties and sturdiness properties of concrete with and while not admixtures. The experimental program was aimed to study the strength of concrete in which Cement was replaced by metakaolin to find the optimum content thereafter arecanut fibers are added. To study the properties of concrete, mix of M0 is considered. Casting of standard cubes, cylinders and beams for regular concrete and Metakaolin with and without addition of Arecanut fibers. The scheme of experimental program as follows. The proportions of the control OPC concrete mixtures were 1:1.53:2.81. Compressive strength, flexural strength for various mixes then studied the durability with addition of arecanut fibres of varied percentages.

5.2 SLUMP TEST

Slump test was carried out to measure the workability of various mixes. The workability of various mixes was assessed as per the IS 1199:1959 specification. The minimum workability for MIX I may be due to the lesser fine particle size of cement which can result in higher water consumption thereby reducing workability.

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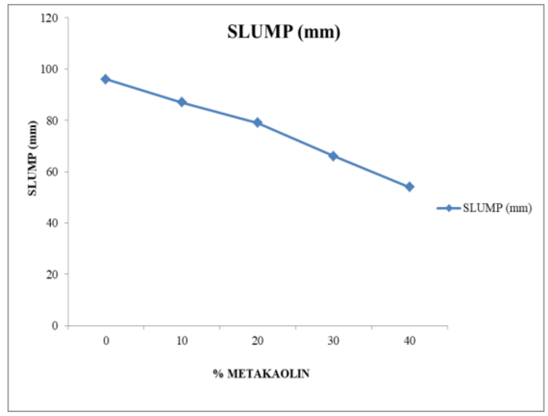

Fig 5.1: Plot shows the Variation of Slump Values for % metakaolin

5.3.1 COMPRESSIVE STRENGTH

The main function of the concrete in structure is mainly to resist the compressive forces. When a plain concrete member is subjected to compression, the failure of the member takes place, in its vertical plane along the diagonal. The vertical cracks occur due to lateral tensile strain. A flow in the concrete, which is in the form of micro crack along the vertical axis of the member will take place on the application of axial compression load and propagate further due to the lateral tensile strain.

Cubes are prepared of size 150 mm x 150 mm x 150 mm are checked for compressive strength. The specimens tested for 7, 14 and 28 days. The specimen were tested for compressive strength parallel to the plane of the board by applying increasing compressive load until failure occur. The arrangement of load is applied to the specimen by placing the specimen length vertical between the surfaces of the testing machine. Prior to that, measurement for the thickness and width was carried out in order to get the values of cross section area for the test specimens.

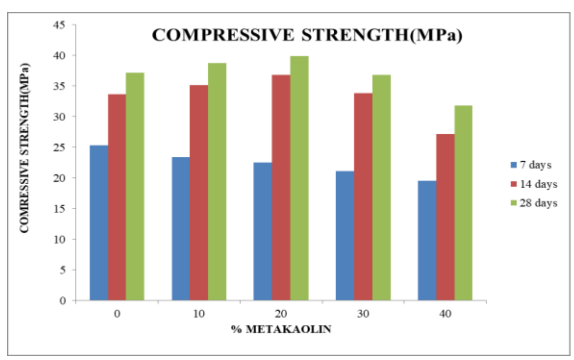

Fig 5.2 Plot shows the Variation in Compressive Strength for % Metakaolin

5.4 VARIATION OF COMPRESSIVE STRENGTH FOR ADDITION OF ARECANUT FIBRES TO OPTIMUM PERCENTAGE OF METAKOLIN

Compressive strength of concrete keeping 20% Metakaolin as constant and with different percentages of arecanut fibres for curing period of 7-days and 28-days respectively and Table shows the summarized Compressive strength Results for different curing periods– M30 grade.

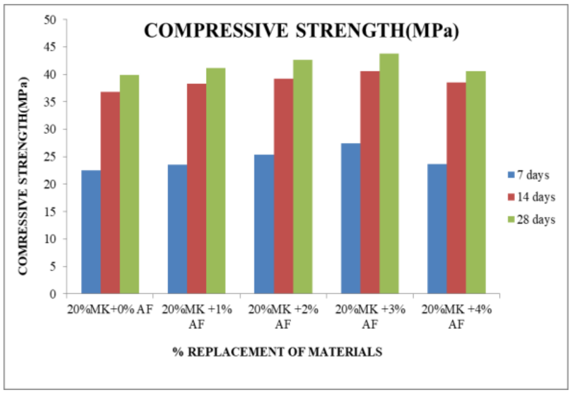

Fig 5.3 Variation in Compressive Strength for % Arecanut Fibers to optimum percentage of Metakaolin

5.5 SPLIT TENSILE STRENGTH

The cylinder specimen is of the size 150 mm diameters and 300mm height was cast to determine the split tensile strength of concrete. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of compression testing machine and the load is applied until failure of cylinder, along its longitudinal direction.

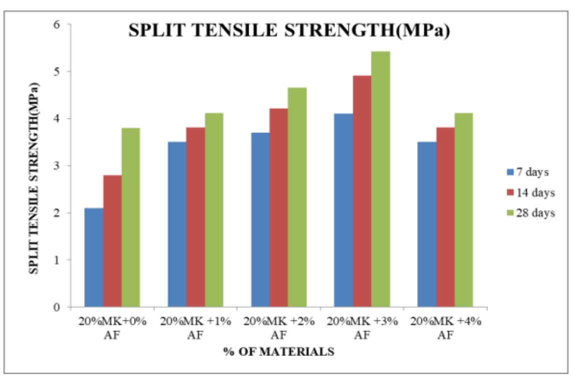

Fig 5.4 Plot shows the Variation in Split Tensile strength for different percentages of Arecanut fibers

5.6 FLEXURAL STRENGTH

The size of specimens 100 mm x 100 mm x 500 mm was used and the specimens were cured in water. Concrete specimen beams are used to determine flexural strength of concrete and were tested as per as per IS 516 (1959).

Flexural strength of concrete keeping 20% Metakaolin as constant and with different percentages of arecanut fibre for curing period of 7-days, 14-days and 28-days respectively and table shows the summarized Split tensile strength Results for different curing periods– M30 grade.

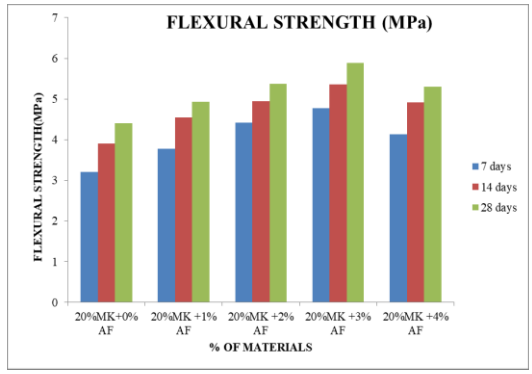

Fig 5.5: Plot shows the Variation in Flexural strength for different percentages of Arecanut fibres

From the results it is evident that with the increase of fibre content the tensile nature of the concrete also increases results in higher values compared to that of Plain concrete.

VI. CONCLUSIONS

- This study has been carried out to investigate the combined influence of Metakolin and Arecanut Fibers replacing cement on fresh and hardened properties of Concrete. Accordingly, experimental program is carried out with M30 grade concrete and tested the specimens. Following conclusions are inferred from the test results.
- It has been observed that workability decreases linearly at rate of 10 % for every 10% metakaolin addition. It has been observed that by the incorporation of
- Compressive strength of concrete increases linearly with increase of % Metakaolin up to 20 % and decreases thenceforth. Hence 30 % is the optimum Metakaolin limit for M30 concrete.
- Only for 20% Metakaolin and 3% Arecanut Fibres replacement concrete, Compressive strength is meeting the target mean strength. This may be due to the fact that the C-S-H gel formed at this percentage is of good quality and have better composition.
- The compressive strengths of M30 concrete for optimum values of metakaolin (20%) and arecanut fibre (3%) are 27.40 MPa for 7 days and 43.82 MPa for 28 days. It is evident from the present investigation that the addition of arecanut fibers to concrete improve compressive strength, split tensile strength, flexural strength of the mix.

- It is evident from the present investigation that the addition of arecanut fibers to concrete improve compressive strength, split tensile strength, flexural strength etc. of the mix.
- There was a 17.7% increase in the compressive strength and 42.9% increase in the tensile strength and 33.86% increase in the flexural strength because of the high elastic modulus of arecanut fiber. Due to the high stiffness of arecanut fibres, resulted in a significant enhancement in split tensile strength and flexural strength.
- The use of metakaolin and arecanut fibre combined is economic when compared to cement in concrete. Likewise saves a great deal of waste disposal problems and reduces the cement price rise and intensities of CO2 release by the cement production. Also these materials make the concrete more sustainable, light weight and low energy emitting which is noble.

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