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RESEARCH ARTICLE

Experimental investigation on strength of concrete using plastics and metakaolin.

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Abstract

This paper presents the result of an experimental investigation carried out to find the suitability of metakaolin and plastic fibre in production of concrete. The conventional concrete M_{30} was made using OPC 53 grade and other mixes were prepared by replacing part of OPC with metakaolin and adding plastic fibre by weight of fine aggregate. The replacement metakaolin level were 5%,10%,15%,20% and from this finding the optimize value and kept constant further adding plastic fibre with 0.5%,1%,1.5% by weight of fine aggregate. All mixes were tested for compressive, spilt tensile and flexural strength at the end of 28 days. The test result indicates the metakaolin can be used effectively to replace 15% cement in concrete. The optimize value 15% kept constant and adding plastic fibre can be used effectively adding 1% by weight fine aggregate in concrete.

Introduction:-

Concrete is one of the most commonly used construction material has been focus to major research and development over the past century. The concrete has many advantageous properties such as good compressive strength, durability, impermeability, specific gravity and fire resistance. However the concrete has some bitter properties like weak in tension, brittleness, less resistance to cracking, lower impact strength, heavy weight etc. some of the brittle properties of concrete are due to micro crack mortar aggregate interface. To overcome this fibre can be added as one of the ingredients of concrete. Many commercial fibers like steel, carbon, glass etc. plastics are largely utilized. Among the plastic waste, polyethylene forms the largest fraction, followed by polyethylene terephthalate, most common known as PET. It is durable and strong. PET bottles in fibre form can be used to get better mechanical properties of concrete. One of the most important advantages of using PET fibers is reducing environmental problem of PET bottle waste. The majority of the world PET production is for synthetic fibers with bottle production accounting for about 30% of global demand. PET is a versatile material for designing mechanical and electromechanical parts.

Metakaolin is a pozzolanic material which is manufactured from selected kaolin, after refinement and calcinations under specific conditions. It is highly efficient pozzolana and react with rapidly with the excess calcium hydroxide resulting from OPC hydration, via a pozzolanic reaction to produce calcium silicate hydrates and calcium aluminosilicatehydrates. It differs from other supplementary cementitious materials like fly ash, slag or silica fume, in that it is not a byproduct of an industrial process, it is manufactured for a specific purpose under controlled conditions. It is produced by heating kaolin, one of the most abundant natural clay minerals, to temperature of 650-900C. This heat treatment or calcinations, serves to breakdown the structure of kaolin. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume. The quantity and reactivity of metakaolin can be produced from a variety of primary and secondary sources containing kaolinite. Replacing Portland cement with 8-20% (by weight) metakaolin produces a mix, which exhibits favorable engineering properties, including the filler effects, the acceleration of OPC hydration and pozzolanic reaction. This filler effect is immediate while the effect of pozzolanic reaction. The filler effects are immediate while the effect of pozzolanic reaction occurs between 3 to 14 days.

Materials:-

Cement:-

Cement is general can be defined as a material which possess very good adhesive and cohesive properties which make it possible to bond with other material to form compact mass. The ordinary Portland cement is generally classified into three grades 33grades, 43 grades and 53 grades. In this study OPC 53 grade has been used.

Fine aggregate:-

The aggregate which is passing through 4.75mm sieve is known as fine aggregate. Locally available river sand which is free from organic impurities is used. The particle size of fine aggregate used in this study was such a way that it passed through 4.75mm sieve conforming to zone II

Coarse aggregate:-

The material which is retained on BIS test sieve 4.75mm is termed as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20mm was used in our work. The aggregate were washed to remove dust and dirt and were dried to surface dry condition.

Water:-

Water is used for both mixing and curing should be free from injurious amount of deleterious materials. Potable water is generally considered satisfactory for mixing and curing concrete. In the present work potable tap water was used.

Plastic fibre:-

The waste plastic polyethylene was collect and washed prior to use. After drying polyethylene, it was cut into macro fibre sizes. The addition has been done by weight with the fine aggregate.

Fig1

Metakaolin:-

Metakaolin manufactured from pure raw material to strict quality standards. Metakaolin is a high quality pozzolanic material, which when blended with Portland cement improves the strength and durability of concrete and mortars. Metakaolin removes chemically reactive calcium hydroxide from the hardened cement paste. It reduces the porosity of hardened cement paste. Metakaolin densities and reduces the thickness of the interfacial zone, thus improving the adhesion between the hardened cement paste and particulars of sand or aggregate.

Fig 2

About the Project:-

In this project 0%, 5%,10%,15%,20% of metakaolin used used in the M30 grade of concrete. Cube specimens of size 150mm*150mm*150mm, cylinder specimens of 150mm diameter and 300mm height and prism specimens of size 100mm*100mm*500mm were casted for different proportions with metakaolin The tests performed on hardened concrete after 28 days of curing were compression test, split tensile strength test and flexural strength test. Then find the optimize value and kept as constant and further adding plastics fibre with weight of fine aggregate with 0.5%, 1%, 1.5%. And further finding the compressive strength, spilt tensile strength and flexural strength.

Mix design:-

The mix design of M30 grade concrete is calculated using IS 456-2000 and IS 10262-2009. The material required as per design are given in Table: 1

TABLE 1 MATERIALS REQUIRED AS PER IS METHOD OF DESIGN

W/c ratio	**Quantity of Materials (kg/m^3)**		
	Cement	***Fine aggregate***	***Coarse aggregate***
0.42	380	714	1214.2

Casting:-

The test program was considered the cast and testing of concrete specimen of cube, cylinder and prism. The specimen was cast M30 grade concrete using ordinary Portland cement. Natural river sand and the crushed stone. Each three numbers of specimens were made to take the average value. The specimens were remolded after 24 hours. The specimens were allowed to the curing period.

Fig.3(a) casting of cubes

Fig.3(b) Casting of cylinders

Fig.3© Casting of prism

Experimental Procedure:-

Tests on specimens:-

The specimens were taken for testing such as compression test, split tensile test and flexure test. Three numbers of specimens in each were tested and the average value is calculated. The results were compared and analyzed with that of control mix. The test set up for Compression test, Split tensile test and Flexural strength test are shown in fig.4 (a), fig.4 (b), fig.4(c) respectively.

Fig. 4(a) compression test fig 4(b) spilt tensile test

Fig.4 (c) Flexure test set up

Compressive strength test:-

The size of the standard cube of size 150mm x 150mm x 150mm were used to determine the compressive strength of the concrete. Three specimens were tested for 28 days with varying proportions of metakaolin as 0%,5%,10%,15% and 20% and finding the optimize value and taking it as constant and further adding plastic fibre with 0.5%,1%,1.5% by weight of fine aggregate. These were compared with the conventional concrete mix. The constituent were weighed and the materials were mixed by hand mixing. The specimens were weighed and the materials were mixed by hand mixing. The specimen were remolded after 24 hours, cured in water for 28 days, and then tested for its compressive strength.

The compressive strength of the cube specimen is calculated using the following formula

Compressive strength $F_{c} = P/A$ N/mm^2

Where P = Load at failure in N

A = Area subjected to compression in mm^2

Compressive strength test results of concrete cubes in Table II

TABLE II COMPRESSIVE STRENGTH FOR 28 DAYS

% of Metakaolin	*Compressive strength @28 days (N/mm^2)*
M30 mix	33.6
MK_{15} $P_{0.5}$	35.1
MK $_{15}P_1$	38.3
MK $_{15}P_{1.5}$	32.3

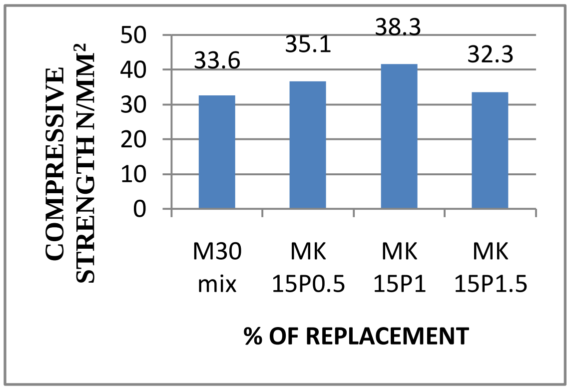


Fig.5 Average compressive strength

The compressive strength of the cube shows that the 15% of metakaolin with 1% adding plastic fibre gives better result.

Split tensile strength test:-

The split tensile strength of the cylinder specimen is calculated using the following formula

Split Tensile Strength, $f_{sp} = 2P/ \prod Ld$ N/mm^2

Where, P = Load at failure in N

L = Length of the Specimen in mm

D = Diameter of the Specimen in mm

The Split Tensile Strength test results are in the Table III

TABLE III SPLIT TENSILE STRENGTH FOR 28 DAYS

% of Metakaolin and plastic fibre	*Spilt tensile strength @28 days (N/mm^2)*
M30 mix	2.74
MK $_{15}P_{0.5}$	3.22
MK $_{15}P_{1}$	3.46
MK $_{15}P_{1.5}$	2.39

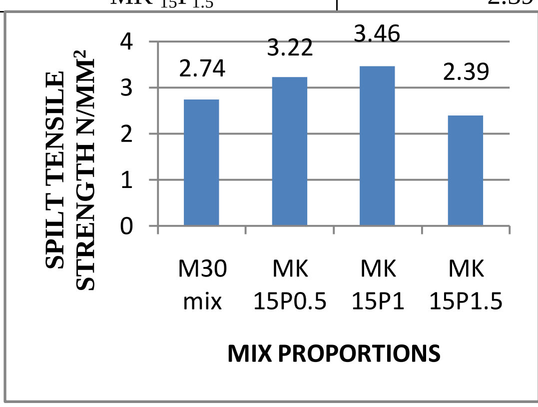


Fig 6 Average Split tensile strength

The spilt tensile strength of the cube shows that the 15% of metakaolin with 1% adding plastic fibre gives better result.

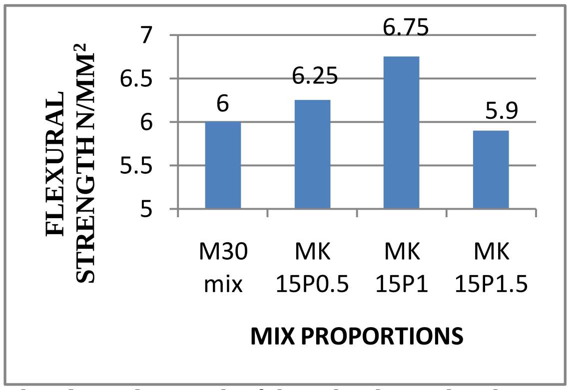
Flexural strength test:-

The flexural strength of the specimen is calculated using the following formula

The flexural strength $f_b = 3PL/ 2bd^2$ N/mm^2

TABLE IV FLEXURAL STRENGTH FOR 28 DAYS

% of Metakaolin and plastic fibre	***Flexural strength @28 days (N/mm^2)***
M30 mix	6
MK $_{15}P_{0.5}$	6.25
MK $_{15}P_{1}$	6.75
MK $_{15}P_{1.5}$	5.9



The Flexural strength of the cube shows that the 15% of metakaolin with 1% adding plastic fibre gives better result.

Durability test:-

Water Absorption test

The values of saturated water absorption of the specimen as 28 days were found out and tabulated in the table v

Percentage of water absorption = [(B-A) / A] X 100

Where,

A = weight of oven dried sample in air.

B = weight of surface dry sample in air after immersion in water.

TABLE V WATER ABSORPTION FOR 28 DAYS

Specimen	Water absorption
M30	3.34
MK_{15}	3.21
$MK_{15}P_1$	3.01

Water absorption was much improved in use of metakaolin which leads to increase in density of concrete.

Sorptivity

Sorptivity is a measure of the capillary force exerted by the pore structures causing fluids to be drawn into the body of material. Determination of the sorptivity of a cement mortar specimen in the laboratory is a simple technique which requires a scale, stop watch and a shallow pan of water. The initial mass of the sample was taken at time zero, the specimen was kept partially immersed to a depth of 5mm in the water.

At selected times; the specimens were removed from the water, then note the time and weighed the specimen.

Again replace the specimen in the water and note the time.

Sorptivity $S = I/ t^{1/2}$ ($mm / min^{0.5}$)

$I = \Delta w / Ad$, $\Delta w = W_2 - W_1$

W_1- dry weight of mortar cubes.

W_2- weight of cubes after 30 minutes capillary suction of water in grams.

A- Surface area of the specimen through which water penetrated.

d- Density of water

TABLE VI SORPTIVITY FOR 28 DAYS

Specimen	Sorptivity
M30	0.294
MK_{15}	0.329
$MK_{15}P_1$	0.353

Use of metakaolin in preparing acid resistance concrete such as hydrochloric acid, hydrogen sulphuric acid showed good results. Use of metakaolin showed better result than conventional concrete.

Conclusion:-

1. In this project to utilize the Metakaolin as a replacement of cement in construction industry. The percentage replacements of metakaolin varied from 0% to 20% in M30 grade concrete.
2. In both compressive, split tensile & flexure test results it shows that when compare to conventional concrete the % replacement concrete (5%, 10%, 15%, & 20%) strength are increases. And the strength is optimum in 15% replacement specimens mutually. Thus we have to utilize metakaolin 15% by replacing cement in M30 grade of concrete.
3. The 15 % replacement of metakaolin is selected in the optimum mix. And the plastic fibre is added by weight of fine aggregate in concrete production. The percentage added of plastic fibre is varied from 0.5% to 1.5% in M30 grade concrete.
4. From the above test results, compare the optimum mix in the plastic fibre added in concrete the strength is increases. Obtained optimum percentage of plastic fibre as added is 1% in concrete.
5. Hence, the optimum replacement percentage of metakaolin and added plastic fibre is 15% and 1%. It's a high strength to compare the conventional concrete.

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