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STRENGTH INVESTIGATION OF METAKAOLIN BASED CONCRETE WITH FIBRE AS REINFORCING MATERIALS IN HIGH STRENGTH CONCRETE

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ABSTRACT:

Concrete is the most commonly used for construction. The need of high concrete is increasing day by day. The test for carried out on concrete specimens with 5,10,15,20,25% replacement of cement by metakoline and fly ash for all mix 10%.The addition of fly ash in concrete improves certain properties such as workability, later age strength development and few durability characteristics. Concrete is the high volume of fly ash and metakaolin as a partial replacement of ordinary Portland cement .The conventional concrete M60 was made using OPC 53 with metakaolin and fly ash. To evaluate optimize ratio and mechanical properties of metakaoline based on concrete and compare with conventional mix .From the optimization 20% cement replacement by metakaolin superior than all the mixes. Ductility of MMFRC (Metakaolin Modified Fiber Reinforce Concrete) is found to be increases as observed from load deflection curve. Workability is found to be decreases with increase of fiber content & Metakaolin. Various strength parameters were improved due to addition of steel fiber & Metakaolin such as compressive strength, flexure strength, split tensile strength & shear strength.

Keywords: Metakaolin, MMFRC, OPC, Fiber, M60.

INTRADUCTION

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Rocks that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume .The quality and reactivity of metakaolin is strongly dependent of the characteristics of the raw material used. Cement concrete is the most widely used material for various constructions. Properly designed & prepared concrete result in good strength & durable properties. Even such well-designed & prepared cement concrete mix under controlled conditions also have certain limitations because of which above properties of concrete are found to be inadequate for special situations & certain special structures .The main ingredient in the conventual concrete is the Portland cement .The amount of cement production emits approximately equal amount of carbon dioxide into the atmosphere. Cement production is consuming a significant amount of natural resources .To overcome above ill effects, the advent of newer materials & construction techniques in this drive , admixture has taken newer things with various administers has become a necessity. Availability of mineral

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admixtures marked opening of new era for designing concrete mix of higher strength. As a result, the use of new mineral admixtures has considerably increased within the concrete industry. For attaining a high strength & durable concrete for major applications in the constructions such as high rise buildings, tall structures, nuclear power points etc. , the essential need for additives both chemical & mineral are must to improve the performance of concrete. Changes on some mechanical properties of concrete specimens produced by metakaolin and steel fibres with the objective to obtain more ductile high strength concrete were observed.

FRC is a composite mixture of cement mortar / concrete with suitable discrete fibres. Fibers are the small size materials that are reinforced which when mixed enhances the properties of the mixture after hardened state. The shape may be flat, circular or crimped. The fibres are defined by the discrete parameter called the "Aspect Ratio". It's represented by l/d ratio where d is diameter and l is the length, usually ranges from 30 to 150. The introduction of fibres is to improvise strength, impact resistance, toughness, enhance other engineering properties and to reduce cracking. The fibers are available in different forms, shapes and sizes.

The main drawback of the reinforcing steel is corrosion due to the ingress of chloride ions in the concrete. This problem becomes severe in coastal areas. Corrosion of steel bars forms rust with time. This rust is bigger in volume than iron which results in expansion. This expansion exerts large tensile stresses on concrete leading to the formation of cracks and thus propagation of these cracks leads to the spalling of concrete. To overcome this shortcoming, fibers are incorporated in cement concrete. There are different types of fibers available but here steel fibers are used because of their high tensile strength, ductility, ability to arrest propagation of cracks, improved bond strength, etc.

Extensive research has been done on FRC using fly ash and silica fume as cement replacement but very little research has been conducted on FRC using metakaolin. The present experimental work is mainly done to investigate the different strengths of FRC using metakaolin as cement replacement. Silica fume and fly ash are the by-products and so have the uncontrolled engineering properties which sometimes don't give the required results. Instead, Metakaolin is the manufactured product, produced by calcining kaolin at a temperature of 7000 c - 8000 c. Thus its controlled engineering properties yield good results regarding workability and durability of concrete. Silica fume or fly ash when blended with cement darkens the colour of concrete but metakaolin being white in colour doesn't alter the colour of concrete, thus enhancing aesthetic look.

Fiber Reinforced Concrete (FRC) is a composite material made primarily from hydraulic cements, aggregates and discrete reinforcing fibers. Fiber incorporation in concrete, mortar and cement paste enhances many of the engineering properties of these materials such as fracture toughness, flexural strength, resistance to fatigue, impact, thermal shock and spalling. It is a type of building material that is increasing in use. New types of concrete develop continuously and the need to update the knowledge on the use of fiber reinforcement in such concrete increases. The use of fiber reinforcement is not a particularly recent idea. During ancient times,

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fibers extracted from organic material were used.

LITERATURE REVIEW

Dr.H.M.Somasekharaiah et.al.(2007) In this thesis, a study had been made for the development of High Performance Concrete using mineral admixtures such as Fly-ash, Silica-fume and Metakaolin along with steel and Polypropylene fibers. The compressive strength, split tensile strength and flexural strength of the plain concrete specimens without any mineral admixture & fibers have been compared with that of compressive-strength, splittensile strength and flexural-strength of composite concrete made up of mineral admixtures & fibers for different W/B ratios.

Beulah M et.al.(2007) This paper presents an experimental investigation on the effect of partial replacement of cement by Metakaolin by various percentages viz 0%, 10%, 20%, and 30% on the properties of high performance concrete, when it is subjected to hydrochloric acid attack. An aggregate binder ratio of 2 and different water binder ratios viz 0.3, 0.35, 0.40 and 0.45 was used in this investigation.

Barham Haidar Ali et.al.(2011) This paper deals with the outcomes of an experimental research on mechanical properties of conventional concrete and a concrete incorporated Metakaolin (MK) with and without steel fibre. One of the ingredients of the concrete mixture was Metakaolin; Portland cement was partially substituted with Metakaolin (MK) as 10% by weight of the total binder content. Steel fibers with length/aspect ratios of 60/80 and hook ended was embedded into the concrete to make fibre reinforced concretes. Value of water/binder ratios (w/b) was 0.35. To know the impacts of MK and steel fibre, the mechanical behaviors of the concrete were investigated such as: compressive, flexure, and bonding strength of the concretes.

M. Tamil Selvi, Dr. T.S. Thandavamoorthy , (2010),The test results showed by introducing steel fibers in concrete which increased the cube compressive strength and split tensile strength values. Cube compressive strength was increased in range of 3 to 60 percent between 7 and 28 days for Steel Fiber Reinforced concrete. For PPFRC it was observed that the cube compressive strength was increased between 10 per cent and 18 per cent for 7 and 28 days. For composite fiber (steel and polypropylene fibers) reinforced concrete the strength was increased by 3 per cent to 22 per cent for 7 to 28 days when compared to normal concrete. The ductility properties of concrete specimens were also observed to be increased by the use of fibers.

Avinash Gornale et.al., (2014), The increase in Compression strength for M-20,M-30 and M-40 at 3,7 and 28 days was increased by 20% to 30%. The increase in flexural strength for M-20, M-30 and M-40 at 3,7 and 28 days was increased by 25% to 30%.The increase in Flexural strength for M-20,M-30 and M-40 at 3,7 and 28 days was increased by 25% to 30% when compared with the normal concrete at 28 days.

Dr.K.Srinivasu et.al., (2015), Better Results are achieved by adding mineral admixtures like metakaolin with silica fume, fly ash and steel fibres in HPC. Water absorption is improved by use of metakaolin in concrete which increases density.

Abhishek Jandiyal (2014),On the basis of study it is seen that metakaolin replacement has a good influence on strength parameters. It can be replaced up to 25% and optimum is at 10%.The increase of compressive strength varies between 5-38% for M20 grade,2-37% for M30 grade,3-13% for M40 grade

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and 3-18% for M50 grade of concrete. The increase of split tensile strength varies between 5-36% for M20 grade,2-13% for M30 grade,2-34% for M40 grade and 2-26% for M50 grade of concrete. The increase in cost for 10% replacement varies between 11-13% for all grades of concrete.

Felixkala .T(2013) The strength of all metakaolin concrete mixes over shoot the strength of OPC.15% cement replacement by metakaolin is superior to all other mixes.The increase in metakaolin content improves the compressive strength and split tensile strength up to 15% cement replacement. The results encourage the use of metakaolin, as a pozzolanic material for partial replacement in producing high performance concrete.

N.Shirsath (2017)Metakaolin concrete increases the compressive and flexural strength effectively as compared with conventional concrete.Workability decreases as percentage of metakaolin in concrete increases. The strength of concrete increases with increase in metakaolin content up to 15% replacement of cement .As the percentage of metakaolin powder in concrete increases, workability of concrete decreases.

DESCRIPTION OF MATERIALS

Concrete is a composition of three raw materials. Cement, Fine aggregate and Coarse aggregate. These three raw materials play an important role in manufacturing of concrete. By varying the properties and amount of these materials, the properties of concrete will changes. The main raw materials used in this experimental work are Cement, fine aggregate, Coarse aggregate.

CEMENT

Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and most non- specialty grout. Cement is the main ingredient in manufacturing of concrete. The characteristics of concrete will be greatly affected by changing the Cement content. The Cement used in this project is Ordinary Portland Cement of 53 grade confirming to IS 12269 – 1987. It developed from other types of hydraulic lime in England in mid 19th century and usually originates from limestone. It is a fine powder produced by heating materials to form clinker. After grinding the clinker we will add small amounts of remaining ingredients. Many types of cements are available in market. When it comes to different grades of cement, the 53 Grade OPC Cement provides consistently higher strength compared to others. As per the Bureau of Indian Standards (BIS), the grade number of a cement highlights the minimum compressive strength that the cement is expected to attain within 28 days. For 53 Grade OPC Cement, the minimum compressive strength achieved by the cement at the end of the 28th day shouldn’t be less than 53MPa or 530 kg/cm2. The color of OPC is grey color and by eliminating ferrous oxide during manufacturing process of cement we will get white cement also.

METAKAOLIN

Considerable research has been done on activated ordinary clay and kaolinitic clay. These un purified materials have often been called as “metakaolin”. Such a product white or cream in color, purified, thermally activated is called s “high reactive metakaolin”. High reactive metakailin by trade name “METACEM” is being manufactured in India by “SPECIALITY MINERALS DIVISION” in BARODA.

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Figure.1. METAKAOLIN

Metakaolin that we have used in this project work was contributed by "AKARSHA SPECIALITIES IN CHENNAI" CALCINED CLAY – HIMACEM is a High Reactivity Metakaolin (HRM), which is manufactured by the high temperature treatment of specially selected kaolin under controlled conditions. It is a white mineral admixture, having very good pozzolanic properties. It reacts with free lime produced during the hydration of cement to form additional cementations products.

Steel Fiber

Steel fiber is a metal reinforcement. Steel fiber for reinforcing concrete is defined as short, discrete lengths of steel fibers with an aspect ratio (ratio of length to diameter) from about 20 to 100, with different cross-sections, and that are sufficiently small to be randomly dispersed in an unhardened concrete mixture using the usual mixing procedures. A certain amount of steel fiber in concrete can cause qualitative changes in concrete's physical property, greatly increasing resistance to cracking, impact, fatigue, and bending, tenacity, durability, and other properties .

Figure no.2. Waste steel fibres

RESULTS EXPLANATION

SLUMP CONE TEST

The strength of concrete of a given mix proportion is seriously affected by the degree of its compaction. It is therefore important that the consistency of the mix is such that the concrete can be transported, placed and finished sufficiently easily and without segregation. A concrete satisfying these conditions is said to be workable. Workability is a physical property of the concrete depending on the external and internal friction of the concrete matrix; internal friction being provided by the aggregate size and shape and external friction being provided by the surface on which the concrete comes into contact with. Consistency of concrete is another way of expressing workability but it is more confined to the parameters of water content. Thus concrete of the same consistency may vary in workability. One test which measures the consistency of concrete is the slump test. It does not measure the workability of concrete but it is very useful in detecting variations in the uniformity of a mix of given nominal proportions. Mixes of stiff consistency have zero slump. In this dry range no variation can be detected between mixes of different workability. In a lean mix with a tendency to harshness a true slump can easily change to the shear slump or even to collapse. Different values of slump can be obtained from different samples of the same mix. Despite the limitations, the

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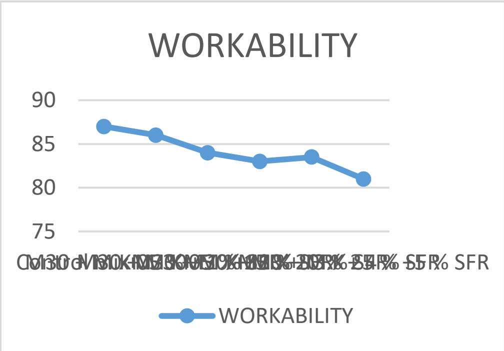
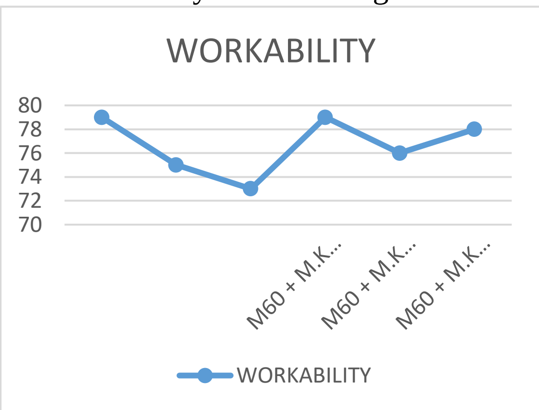
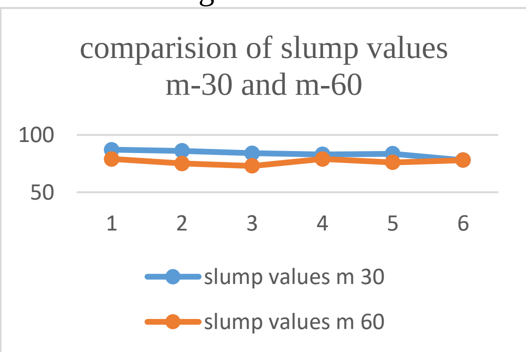
slump test is very useful on site as a check on the day-today or hour-to-hour variations in the materials being fed into the mixer. An increase in slump may mean, for instance, that the moisture content of aggregate has unexpectedly increased; another cause would be a change in the grading of aggregate, such as a deficiency in sand. Too high or too low a slump gives immediate warning and enables the mixer operator to remedy the situation



Graph no 5.1 - Table no.5.1 workability results m30 grade



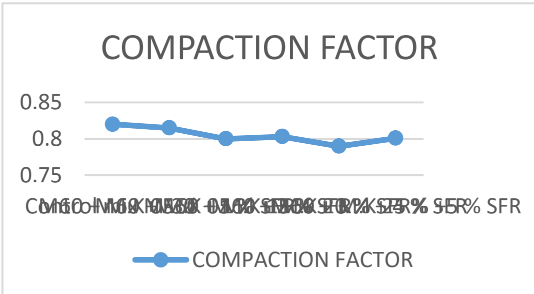
Graphno 5.2 -workability results for M-60 grade concerte



Graph no.5.3 comparison of workability results m-30 and m60 grade

5.2 COMPACTION FACTOR TEST

Scope and Significance Compaction factor test is adopted to determine the workability of concrete, where nominal size of aggregate does not exceed 40mm, and is primarily used in laboratory. It is based upon the definition, that workability is that property of the concrete which determines the amount of work required to produce full compaction. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction. To find the workability of freshly prepared concrete, the test is carried out as per specification of IS: 1199-1959. Workability gives an idea of the capability of being worked, i.e., idea to control the quantity of water in cement concrete mix to get uniform strength. It is more sensitive and precise than slump test and is particularly useful for concrete mixes of low workability. The compaction factor (C.F.) test is able to indicate small variations in workability over a wide range.



Graph - no.5.4 compaction factor test results m 30 grade

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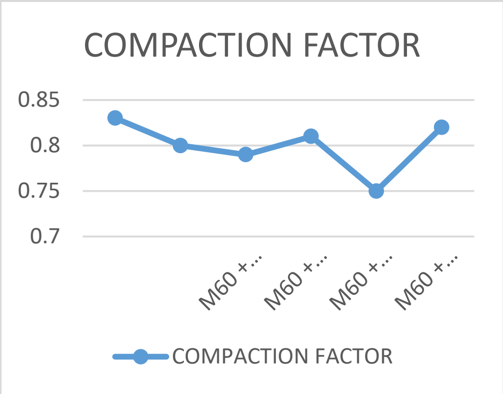
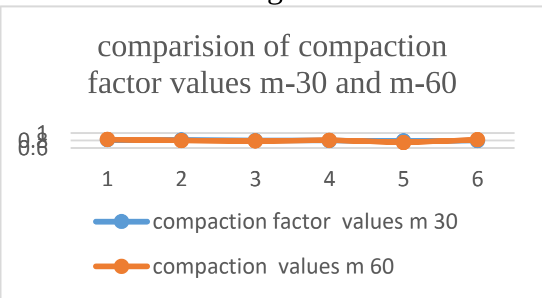


Graph no 5.5 -compaction factor results for M-60 grade concerte

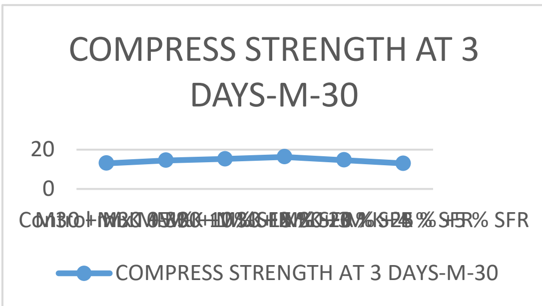


Graph no.5.6 comparison of workability results m-30 and m60 grade

COMPRESSION TEST ON CONCRETE CUBES

The determination of the compressive strength of concrete is very important because the compressive strength is the criterion of its quality. Other strength is generally prescribed in terms of compressive strength. The strength is expressed in N/mm2. This method is applicable to the making of preliminary compression tests to ascertain the suitability of the available materials or to determine suitable mix proportions. The concrete to be tested should not have the nominal maximum size of aggregate more than 20mm test specimens are either 15cm cubes or 15cm diameter used. At least three specimens should be made available for testing. Where every cylinder is used for compressive strength results the cube strength can be calculated as under. The concrete specimens are generally tested at ages 14 days and 28 days.The cubes are generally tested at 14 & 28 days unless specific early tests are required, for example to remove a concrete shutter safely prior to 14 days. Usually 1 cube will be tested 2 cubes at 28 days, however this may vary depending of the requirements, check the design first. The cubes are removed from the curing tank, dried and grit removed. The cubes are tested using a calibrated compression machine. This can be carried out internally by competent personnel or by a certified test house. The cubes are tested on the face perpendicular to the casting face. The compression machine exerts a constant progressing force on the cubes till they fail, the rate of loading is 0.6 ± 0.2 M/Pas (N/mm²/s). The reading at failure is the maximum compressive strength of the concrete. BS EN 12390-2: 2009 / BS EN 12390-3:2009. The concrete minimum compressive strength will be specified by the client/designer in a specific format

Fig no. 5.1 compressive strength machine



graph no.5.7 compressive strength test results m 30 grade in 3 days

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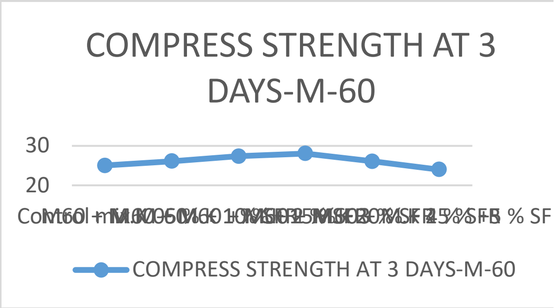

graph no.5.8 compressive strength test results m 60 grade in 3 days

graph no.5.9 compressive strength test results m 30 grade in 7 days

CONCLUSION

We gain the highest compressive strength at the percentage of different admixtures added in M-30 grade concrete (M30+15%M.K+3% SFR) – 35.02 N/mm2

We gain the highest compressive strength at the percentage of different admixtures added in M-60 grade concrete (M30+15%M.K+3% SFR) – 63.04 N/mm2

We gain the highest split tensile strength at the percentage of different admixtures added in M-30 grade concrete (M30+15%M.K+3% SFR)– 2.66 N/mm2

We gain the highest split tensile strength at the percentage of different admixtures added in M-60 grade concrete (M30+15%M.K+3% SFR)– 3.57 N/mm2

We gain the highest flexural strength strength at the percentage of different admixtures added in M-40 grade concrete (M30+15%M.K+3% SFR) – 4.412 N/mm2

We gain the highest flexural strength strength at the percentage of different admixtures added in M-40 grade concrete (M30+15%M.K+3% SFR) – 5.557N/mm2

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