PERFORMANCE ANALYSIS OF CONCRETE WITH M SAND AS FINE AGGREGATE INCORPORATING METAKAOLIN AS ADMIXTURES

Dr. M. DEVI[1], M. ELAMATHI[2], S.M. HARIPRABHA[3], M. HEMASURYA[4], M. MAHANADHI[5]

[1]*Professor, Head of the Department, Department of civil engineering, Vivekanandha College of Technology for Women, Tamilnadu, India*

[2-5]*UG Students, Department of Civil Engineering, Vivekanandha College of Technology for Women, Tamilnadu, India*

---***---

Abstract - *The natural sand which excavated from riverbedis used to produce conventional concrete. Depletion of natural sand cause the environmental problem and hence sand excavating is restricted by government which resulted in shortage and drastically increase in its cost. In order to fulfil the necessity of fine aggregates, an alternative material like M Sand which is obtained by crushing the rocks, can be used in concrete. Among many mineral admixtures available, Metakaolin (MK) is a mineral admixture, whose potential is not yet fully tested and only limited studies have been carried out in India on the use of MK for the development of high strength concrete. Metakaolin is a supplementary cementitious material derived from heat treatment of natural deposits of kaolin. Metakaolin shows high pozzolana reactivity due to their amorphous structure and high surface area. The experimental work will be carried out as partial replacement of cement with Metakaolin in M50 grade of concrete at 0%, 5% 10%, 15%, 20% and 25% of replacements. Properties of concrete in fresh state such as workability and in hardened state such as compression test, split test and flexural test are going to be tested to find the strength. Conclusions will be made from the various results and the discussions there on to identify the effect of partial replacement of cement by Metakaolin and replacing sand with M Sand in the design concrete mix.*

Keywords:

Concrete, Metakaolin, Manufactured sand, Conplast SP 430, Compressive strength, Split tensile strength test, Flexural strength test.

1. INTRODUCTION:

Concrete is the most commonly used construction material in the world. It is basically composed of two components paste and aggregate. The paste contains cement and water and sometimes other cementitious and chemical admixtures, whereas the aggregate contains sand and gravel or crushed stone. Scarcity of natural sand due to depletion of natural resources and restrictions due to environmental considerations made concrete manufactures to look for suitable alternative fine aggregate. One such alternative is manufactured sand.

Manufactured sand is the quarry dust or the crushed granite stone that is sieved and made to suite the particle size of natural sand so as to the used as fine aggregate. It is also called as M sand.

Industrial wastes, such as blast furnace slag, Metakaolin, fly ash and silica fume are being used as supplementary cement replacement materials. Metakaolin reduces the size of pores in cement paste and transforms many finer particles into discontinuous pores, therefore decreasing the permeability of concrete ad tensile strengths. It reduces water permeability and efflorescence. Also, it reduces heat of hydration leading to better shrinkage and crack control. So, use of Metakaolin has wide scope in its use in concrete.

This report is analyzing the effect of metakaolin in concrete by partial replacement of cement with 0%, 5%, 10%, 15%,20%,25% by weight. The experimental studies examine the compressive strength and split tensile strength after 7, 14 and 28 days curing.

2. COMPOSITIONOF MATERIALS:

CEMENT:

The principal raw materials used in the manufacture of ordinary Portland cement are, Argillaceous or silicates of alumina in the form of clays and shales. Calcareous or calcium carbonate in the form of limestone, chalk and mail which is a mixture of clay and calcium carbonate.

The OPC of 53grade confirming to IS 12269:1987 is used. The specific gravity of OPC is 3.15.

M SAND:

Manufactured sand (M Sand) is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand is less than 4.75mm.

COARSE AGGREGATE:

Next to the cement coarse aggregate is another important material. The 20mm aggregates were firstly sieved through 20mm sieve.

METAKAOLIN:

It has a pozzolanic properties chemical formula of Metakaolin is Al_2O_3, 2 SiO_2, $2H_2O$. It react with $Ca(OH)_2$ one of the by-products of hydration reaction of cement and results in additional C-S-H get which results in increased strength.

It is obtained by the calcinations of pure or refined kaolitic clay at the temperature between 650℃-900℃.

SUPER PLASTICIZER:

To obtain the workable concrete mix, CONPLAST SP 430 a commonly available super plasticizer obtained from FOSROC Company will be used fully in this research work. Conplast SP 430 is free of chloride and low alkali. It is compatible with all types of cements.

WATER:

Potable water is used which is easily available in the lab premises for blending of concrete ingredients and curing of concrete specimens.

3. CHEMICAL COMPOSITION: CEMENT:

CEMENT:

Compound	Formula	Shorthand form
Calcium oxide(lime)	CaO	C
Silicon dioxide(silica)	SiO_2	S
Aluminum oxide(alumina)	Al_2O_3	A
Iron oxide	Fe_2O_3	F
Water	H_2O	H
Sulfate	SO_3	S

METAKAOLIN:

Compound	Formula	Percentage
Silica	SiO_2	60-65
Alumina	Al_2O_3	30-34
Ferric oxide	Fe_2O_3	1.00
Calcium oxide	CaO	0.2-0.8
Magnesium oxide	MgO	0.2-0.8
Sodium oxide	Na_2O	0.5-1.2
Potassium oxide	K_2O	0.5-1.2

4. OBJECTIVES OF INVESTIGATION:

To know the fresh concrete properties of cement with metakaolin and m sand in concrete. Study the effect of metakaolin on compressive strength, flexural strength and split tensile strength of concrete.

4.1MATERIAL USED:

In present studies, cement of 53 grade confirming to grade IS 12269-2013 is used and cement sample will be tested as per IS 4031-1988 part 4 and IS 4031-1988 part 5.

Physical properties like specific gravity, standard consistency, initial setting time and final setting time of cement will be determined by using the codes IS 4031-1988.

Table -3: Properties of cement

Property	**Value**
Specific Gravity	3.15
Fineness	97.50
Initial setting time	40 min
Final setting time	480 min

COARSE AGGREGATE:

Coarse aggregate of nominal size 20mm is chosen and tested to determine the different physical properties as per IS 383-1970. Test results conform to the IS 383(PATR 3) recommendations.

Table-4: Properties of coarse aggregate

Property	**Value**
Specific Gravity	2.70
Fineness modulus	7.15
Water Absorption	8.0%
Partial Shape	Angular

FINE AGGRAGATE:

Fine aggregates is used an artificial material of M-Sand. The manufacture sand is crushed aggregate products from granite stone it to be used as a replacement of river sand. Now-a-days good sand is not readily presented. The Fine Aggregates day by day demand in construction sector. Natural sand is an alternative material for M-Sand. Fine aggregates are the aggregates whose size is less than 4.75mm

Table -5: Properties of the fine aggregate

Property	Value
Specific Gravity	2.73
Fineness modulus	2.88
Water Absorption	7.0%
Surface texture	Smooth

METAKAOLIN:

Metakaolin is a fine, natural white clay which has high content of silica, and hence called High Reactivity Metakaolin (HRM)

Table-6: Properties of Metakaolin

Description	Property
Specific Gravity	2.5
Mean grain size	2.54
Specific area cm^2/gm	Specific area cm^2/gm

5. EXPERIMENTAL STUDY:

The cement and Metakaolin were measured and mixed together until a uniform colour is obtained. The blended mix is spread on already measured fine aggregate placed on an impermeable platform and mixed thoroughly before the coarse aggregate and water added.

Table-7: Mix proportion of concrete

Grade	Cement	M-Sand	C.A	W/C ratio
M50	1	1.23	3.12	0.35

SPECIMEN CASTING AND CURING:

The concrete was be prepared and placed in Cube, Prism and Cylinder moulds. For each concrete mixture, 150mm cubes, 150mm x 300mm cylinders, 100mm x 100mm x 400mm prisms were cast. After the casting of concrete, the specimens are left for one day as a rest period. 150mm cubes, 150mm x 300mm cylinders , 100mm x 100mm x 400mm prisms were used to determine the compressive strength, spilt tensile strength and flexural strength.

Curing is the most important operation in the manufacture of concrete. The test specimen are stored in moist air for 24hours and after this period the specimens are marked and moved from the mould sand kept submerged in clean fresh water. Testing is performed after 7 days, 14 days and 28 days. After curing, the cubes, prism and cylinder are to be de-moulded and then left it in a room temperature till the date of testing. Also, productive measures to control moisture loss from the concrete surface are essential to prevent plastic shrinkage cracks

SPECIMEN TESTING:

After the curing period, specimen testing is performed after 7days, 14 days and 28 days. Test will be conducted for compression strength on cubes (150mmx150mmx150mm), split tensile test on cylinders (150mm diameter x 300mm height) and flexural test on prisms (100mmx100mmx400mm) as per IS 516-1959.

TEST RESULT:

COMPRESSIVE STREGTH:

Compressive strength is the ability of material to carry the loads on its surface without any crack or deflection. A Total of 15 cubes for different percentage of mix proportion were tested. The compressive strength test is done as per BS: 1881-Part-116:1989. After 24hours these moulds were removed and test specimens were put in water for curing. Tests were carried out after 7,I4 and 28 days curing. The compressive strength of concrete can be shown in table.

Table-8: Test for compressive strength

Percentage Of Metakaolin	7th days N/mm 2	14th days N/mm 2	28th days N/mm 2
0	50.90	52.10	54.28
5	51.78	53.07	55.92
10	54.12	56.03	58.34
15	57.08	58.92	59.40
20	55.90	57.25	60.54
25	60.12	61.50	63.24

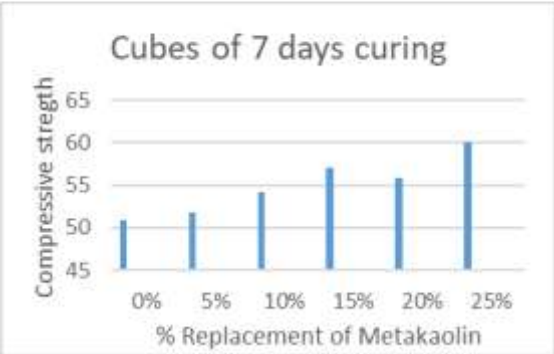


Chart 1: compressive strength test (7 days)

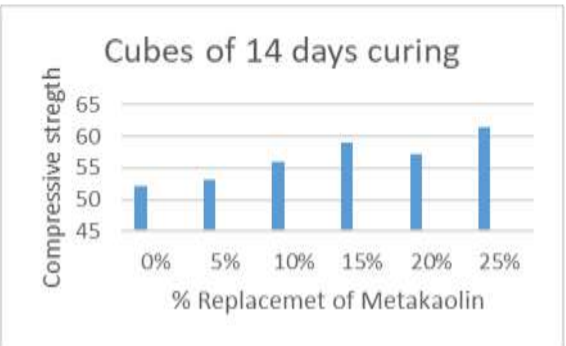


Chart 2: compressive strength test (14 days)

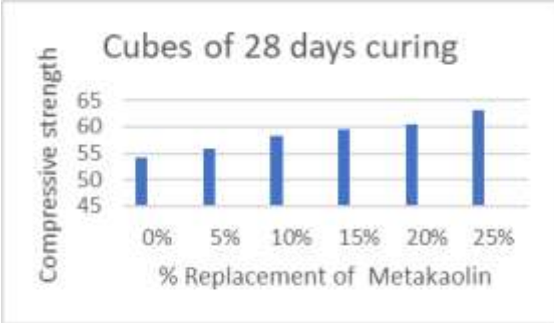


Chart 3: compressive strength test (28days)

SPLIT TENSILE STRENGTH:

Split tensile strength test on cylinder is a way to determine tensile strength. Split tensile strength test was carried out. Concrete will be tested on 150mm x 300mm cylinder at the period of 7 days, 14 days and 28 days curing.

Table-9: Test for split tensile strength

Percentage Of Metakaolin	7th days N/mm 2	14th days N/mm 2	28th Days N/mm 2
0	3.20	3.42	3.39
5	3.40	3.27	3.35
10	3.62	3.89	3.74
15	3.54	4.23	4.12
20	3.42	3.67	3.90
25	4.20	4.50	4.23

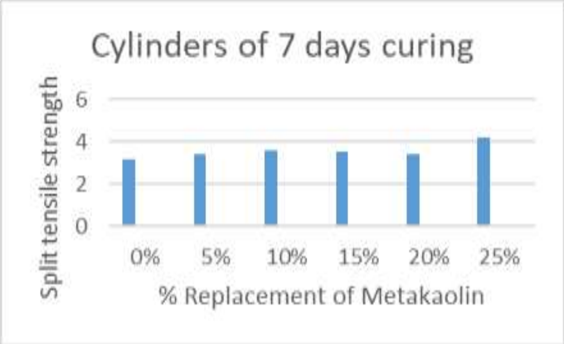
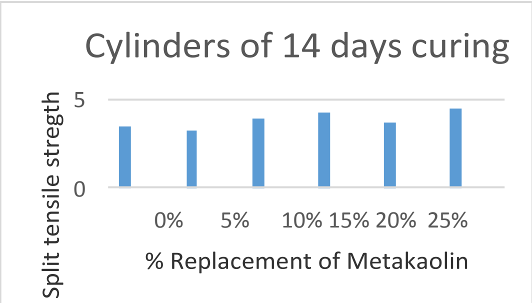


Chart 4: split tensile strength test (7days)



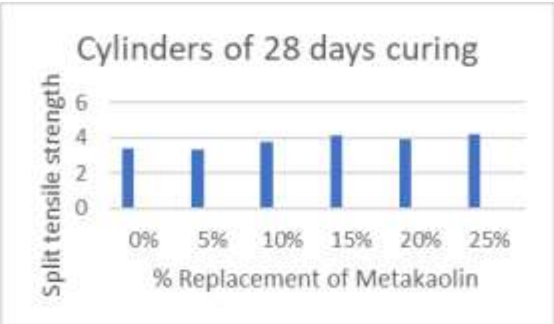


Chart 6: split tensile strength test (28days)

FLEXURAL STRENGTH:

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete to resist failure in bending.

Flexural strength of concrete was tested on100mm x 100mm x 400mm prisms at the age of 7 days, 14 days and 28 days. The test result show that there will be increase in the flexural strength as the percentage of metakaolin increase in concrete at 7days, 14 days and 28 days

Table-10: Test for Flexural Strength

Percentage Of Metakaolin	7th days N/mm^2	14th days N/mm^2	28th days N/mm^2
0	8.70	8.92	9.21
5	11.23	9.20	10.26
10	9.40	10.45	10.23
15	10.47	11.67	11.25
20	8.89	7.65	8.59
25	9.76	8.62	8.84

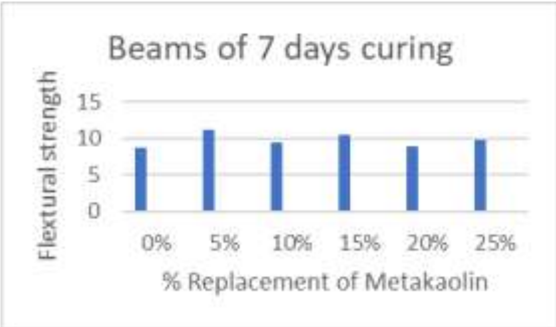


Chart 7: flexural strength test (28days)

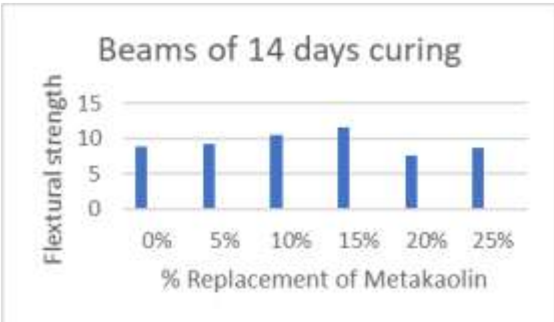


chart 7: flexural strength test (28days)

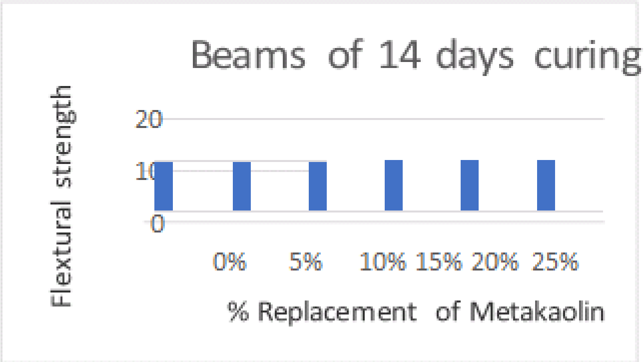


Chart 8: flexural strength test (28days)

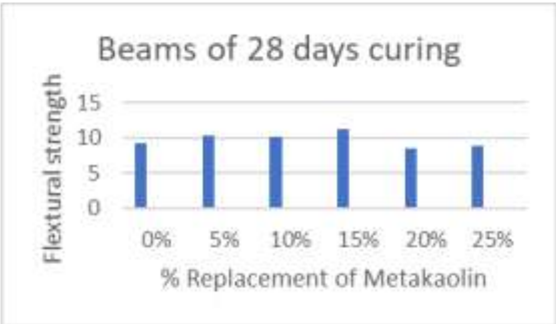


Chart 9: flexure strength test (28days)

7. CONCLUSION

From the investigation on the effect of addition of Metakaolin as admixture in cement concrete and replacement of river sand with M sand, the following conclusions can be drawn.

Replacement of river sand with M- sand serves as an invaluable means to protect environmental resources, which result in sustainable development as well as economic balance.

The fineness of Metakaolin and M- sand contributes higher bonding between cement and aggregates, thereby producing quality concrete.

The use of Metakaolin in concrete can compensate for environmental, technical and economic issues. The inclusion of Metakaolin as an admixture results in the early strength development of concrete.

The increase in Metakaolin and M sand in optimum proportions improves the compressive strength and split tensile strength.

8. REFERENCES:

[1] Satyanarayana.D, Satesh.D and Raghava Rao.E.V, **optimization of partial Replacement of sand by manufactured sand with metakaolin** IJRPET ISSN:2454-7875,Volume-2, Issue 12,Dec – 2016.
Murali.G, Sruthee.P, **Experimental study of concrete with metakaolin as partial replacementof cement,** International Journal of Emerging trends in Engineering and development, Issue 2, Volume-4, May-2012,ISSN 2249- 6149.
[2] Rajendra. T.N, Surendra. B.V, **Effect of partial replacement of cement by Fly Ash and Metakaolin on concrete strength with M sand as fine aggregate,** International Research Journal of Engineering and Technology (IRJET), Volume-4, Issue 6, June-2017.
[3] Karthigai Balan. P, **Experimental Investigation on the properties of concrete by using Metakaolin as an Admixture and M sand as replacement for sand,** International Journal of Latest Engineering and Management Research (IJLEMR), ISSN:2455-4847, Volume-2, Issue 8, August-2017