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Experimental Programme on FRC with OPC only and FRC with OPC and Mineral Admixtures

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Abstract: ***Due to urbanization and population growth, the Construction industry is increasing rapidly over a few decades at the same time leads to increase in global warming too. In the construction, the main ingredient, Concrete which contains large amount as cement which act as a binder and Natural sand(River sand) as fine aggregate .During the cement production large co_2 emits, which is mainly responsible for global warming as well as natural sand leads to Environmental degradation. So, in order to minimize this phenomenon's as well as to enhance advancements in construction industry an attempt is made in this research work to replace the cement partially with supplementary materials known as mineral admixtures. The mineral admixtures such as Fly ash, Ground granulated blast furnace slag (GGBS) and Metakaolin which are by products of industries which usage in concrete as cement replacer decrease the co_2 emissions as well as disposal problems of industries and replacing natural sand with M-sand Strength as well as durability properties of FRC (@1% steel fiber by weight of binder) made with 100% OPC with different water binder ratios and concrete grades M25 and M40 were found. And then FRC made with OPC and mineral admixtures up to 45% with fly ash, Metakaolin and GGBS in different combinations were tested for strength and subjected to durability tests. For comparison durability and strengths were performed on M40 grade mix without fibres. It is observed during the analysis of tests FRC with mineral admixtures has performed better than that of FRC made with 100% OPC.***

Keywords: Concrete, Fly ash, GGBS, Metakaolin, compressive strength, split tensile strength

I. INTRODUCTION

Concrete is a heterogeneous mixture made of cement, fine aggregate, coarse aggregate and water. concrete mainly consists of two components-cement paste and aggregates. Throughout the world, The cement production releases about 2.2 billion of co2 which is main green house gas causing global warming and usage of natural sand as fine aggregate leads to degradation of environment. Due to rapid growth of the construction and population, the usage of materials also increasing day by day which causes depletion of natural resources and simultaneously the waste generating from industries also substantially raising.

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so for to impart sustainable activities in construction usage of industrial waste materials in the concrete are encouraged in the present research and it resolves the disposal problems too. The waste materials which posses cementitious properties are used as supplementary to cement are known as mineral admixtures.

The mineral admixtures such as Fly ash, GGBS, Metakaolin used in the present research are waste generated from thermal, steel and china clay industries respectively.The natural sources of river sand are getting depleted gradually and the demand of ban on mining is increasing. so, it is essential to alter the natural sand with M-sand which is crushed granite powder as a fine aggregate in concrete. The past research works are done on mechanical properties of M30,M35 grade of concrete with two mineral admixtures i.e. Fly ash, GGBS or GGBS, Metakaolin but this experiment done on M40 grade of concrete with combination of fly ash, GGBS, Metakaolin as per IS code of mix design.

The present research work is to study the mechanical properties and durability properties of M25 and M40 grade of concrete at 7 days and 28 days with partial replacement of cement with fly ash, ggbs and Metakaolin and 100% replacement of natural sand with M-sand.

II. MATERIALS

Cement: OPC 53 grade of cement is used in the present experimental program and tested in laboratory as per IS codes

S.No	Test	Result	Requirements as per IS Codes	IS code Number
1	Normal consistency	32%	26-33%	IS 4031(part-4)
2	Specific gravity	3.15	3-3.2	IS 2720(part-3)
3	Fineness	1%	10%	IS 4031(part-2)
4	Initial setting time	60 minutes	30-60 minutes	IS 4031(part-5)
5	Final setting time	300 minutes	600 minutes	IS 4031(part-5)

6	Compressive strength	25.3 MPa(3 days) 36.8 Mpa(7 days) 53 MPa(days)	27.8 MPa 37.8 MPa 53.8 MPa	IS 4031(part-5)

Fine Aggregate: Fine Aggregate used is M-sand(Locally available) which is manufactured by crushed granite powder and other stones instead of natural sand. The aggregate is tested in the laboratory as per IS codes and the observed values are tabulated below

S.No	Test	Results	IS Code
1	Specific gravity	2.60	IS 2386(part-3)-1963
2	Water Absorption	2.5%	IS:383-1970
3	Fineness Modulus	2.68	IS 2386(part-1)-1963

Coarse Aggregate: Coarse Aggregate used is Locally available with maximum size of particle is 20mm.The aggregates confirming to IS:383-1970 were used in this project and tested as per IS codes and observed values are tabulated below

S.No	Test	Result	IS code
1	Specific gravity	2.80	IS 2386(part 3)
2	Water absorption	Nil	IS 383-1970

Water: portable water suitable for concrete mixing and for curing is used confirming to IS 456-2000

Super plasticizer: It is used for to improve the workability of concrete and used in this project work is Master Rheobuild 920 SH,type-liquid, color:dark brown, chemical name: napthalene Formaldehyde ,P^H:8.40,density-1.2

Fly ash: The properties of fly ash are tabulated below:

Type	Class-F
colour	Dark Brown
Bulk density	1041 kg/m^3
Fineness	336 m^2/kg
Specific gravity	2.21

Ground granulated blast furnace slag (GGBS): The properties of GGBS are tabulated below:

colour	Off white
Bulk density	1280kg/m^3
Fineness	342m^2/kg
Specific gravity	2.81

Metakaolin: The properties of Metakaolin are tabulated below:

colour	Off white
Bulk density	790kg/m^3
Specific gravity	2.81

III. EXPERIMENTAL INVESTIGATION

General

Durability tests were determined by conducting Sorptivity and Water absorption tests and Mechanical properties were determined by performing Compressive, Split tensile strength tests.

TESTS

A. Compressive strength

The compression strength of concrete is determined by using compression strength testing machine as per IS 516-1969.for testing cubes of 150mm*150mm*150mm are casted and cured about 7 days and 28 days in a curing tank and after curing period is over take the cubes from curing tank, dry the specimens around 24 hrs. Before testing the specimens, measure the dimension face one by one and apply the load gradually during testing. Note the load scale reading at the time of first crack and at the time of failure.

B. Slit tensile strength

The tensile strength of concrete tested in accordance with IS:5816-1970.The split tensile strength is conducted in compression testing machine but cylinders of size 150mm*300mm are used with 7 days and 28 days.After curing ,by placing cylinder horizontally such that the axis of specimen and load application are perpendicular with gradually increasing the load and note the scale reading at the time of first crack and at the time of failure.

$f_{split}=2P/\pi DL$, where P=load, D=diameter of specimen, L= length of specimen

C. Water absorption

The total quantity of water absorbed is related to the total open porosity, while the kinetics of the process depends principally on the distribution of the pore sizes. This test also measures the capillary rise of water, the most common form of liquid water migration into concrete which is inversely proportional to the diameter of the pores. The smaller the diameter of the pores, the greater will be the capillary absorption. Absorption is the capacity of a sample to hold water while capillary is the rate at which the water fills the sample.

Test procedure

Specimen sizes: 100mm×100mm×100mm

Specimens which were cured for 28 days allowed to dry at 110°C for 24 hrs . These specimens which were dried kept in a water trough and it was fully immersed in such a way that height of water above the specimen after immersion is 2cm. At different intervals of time weights were noted.

Formula

Mi%=100× (mi-mo)/mo

mi= wet sample weight at time t

mo= dry sample weight

D. Sorptivity test

Rate of movement of water through porous material is known as water Sorptivity. It is the unidirectional absorption of water into one face of pre conditioned concrete disc sample.

Rate of absorption of water into face of disc is calibrated. generally lower the water cement ratio lower will be the Sorptivity

Test procedure was conducted as per as per ASTM C1585

Specimen sizes dia=100mm

Depth=50mm

Formula

Water absorption rate=K

Slope =K

$I = W/(A \times d)$

W= water absorbed in Kg

A=Area of cross section contact with water; d=density of medium in which it is immersed (1000Kg/m^3 for water)

Test set up is shown below fig (1).

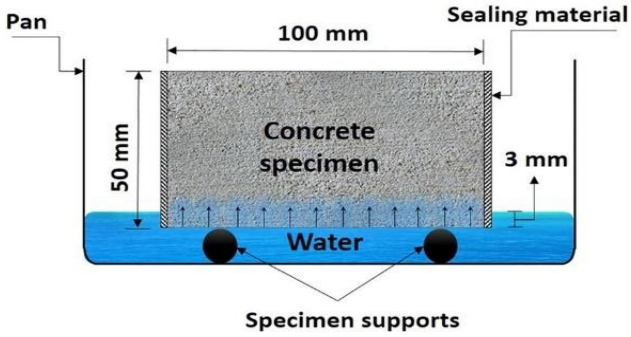


Fig (1): Sorptivity test setup

IV. MIX DESIGN

The Concrete mix of M25 grade is designed as per IS 10262-2009[5].The partial replacements of OPC with Mineral Admixtures are done based on weight basis.

Grade	water	cement	Fine aggregate	Coarse aggregate
M25	0.45	1	2.38	3.169
M40	0.4	1	1.98	2.79

CONCRETE MIXES AND TEST RESULTS

100% replacement of river sand by M sand+ Coarse aggregate + OPC percentages given below

Grade	Mix	OPC	Fibers(by weight of binder)
25	C1	100%	1%
40	C2	100%	1%

For M 25 grade

Steel fibers(1% of weight of binder)+100% replacement of river sand by M sand+ Coarse aggregate and replacement of OPC given below

Mix	OPC	FLY ASH	GGBS	METAKOLIN
M1	85%	5%	5%	5%
M2	70%	10%	10%	10%
M3	55%	15%	15%	15%

For 40 grade

Steel fibers(1% of weight of binder)+100% replacement of river sand by M sand+ Coarse aggregate and replacement of OPC given below

Mix	OPC	GGBS	METAKOLIN
M4	80%	10%	10%
M5	70%	15%	15%
M6	60%	20%	20%

V. TEST RESULTS

Table 1: compressive strength results for M25 grade.

Compressive strength in N/mm^2				
Days	C0	M1	M2	M3
`7	26.8	25.48	24	20.19
28	36	44.2	38.04	31.5

Table 2: split tensile strength results for M25 grade.

Split tensile test N/mm^2				
Days	C0	M1	M2	M3
7	2.6	2.4	2.43	2
28	3.57	4.6	3.9	3

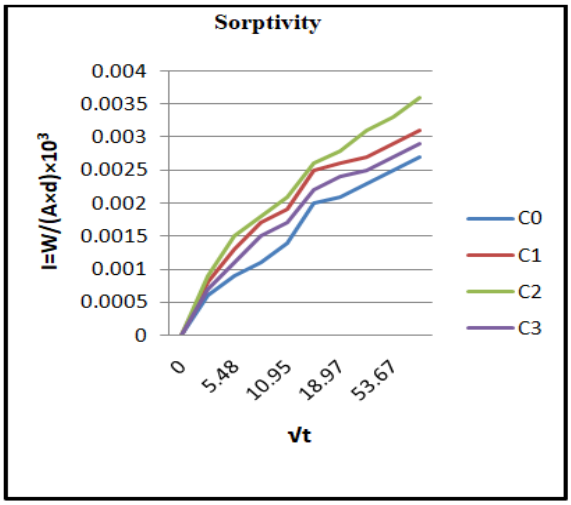
Table 3: compressive strength results for M40grade.

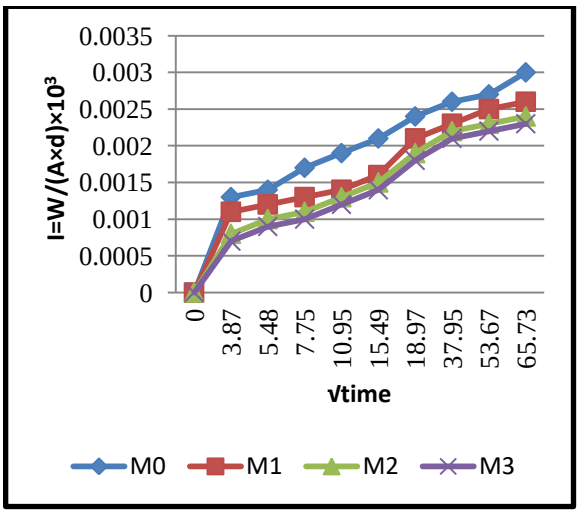
MIX	Compressive Strength in N/mm^2	
	7 days	28 days
C1	34.61	51.36
M4	37.57	54.6
M5	39.71	57.25
M6	32.49	46.91

Table 4: split tensile strength results for M40 grade.

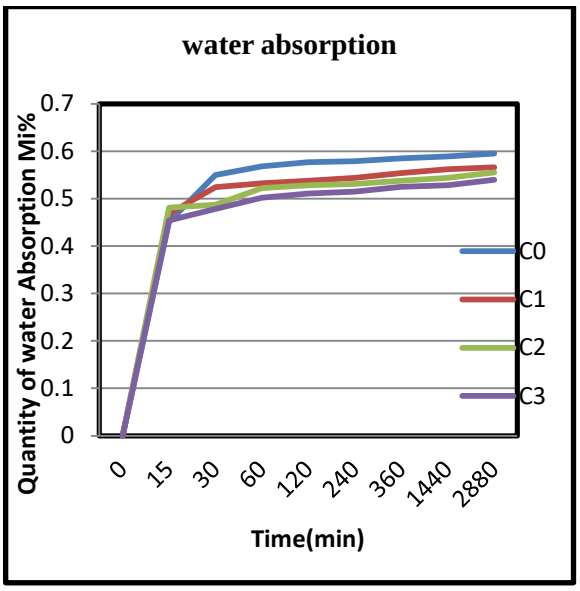
MIX	Split tensile Strength in N/mm^2	
	7 days	28 days
C2	4.19	6.18
M4	4.46	6.55
M5	4.86	6.94
M6	3.9	5.823

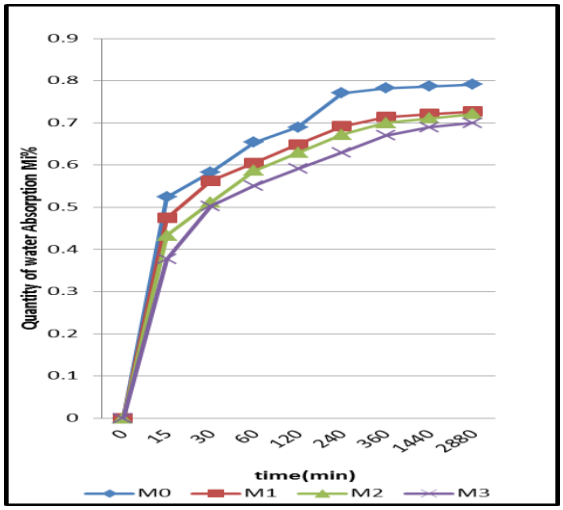
(a) Sorptivity results for M25 and M40





(b) Water absorption results for M25 and M40





However tests were conducted on samples prepared with only OPC without using the fibers to compare the results with FRC. Concrete mixes for M40 grade concrete with water binder ratio 0.46 are appended below

A0: OPC (100%) +Fine Aggregate (M-Sand) +Coarse Aggregate

A1: OPC 85%+5% Flyash+5%GGBS+5%MetaKaolin+Fine Aggregate +Course Aggregate

A2: OPC 70%+10%Flyash+10%GGBS+10%MetaKaolin+FineAggregate+CoarseAggregate

A3: OPC 55%+15%Flyash+15%GGBS+15%MetaKaolin+FineAggregate+CoarseAggregate

Table 3: Compressive, Split tensile strength values of various mixes

TABLE 5: Strength test results

MIX	COMPRESSIVE STRENGTH(N/mm²)		SPLIT TENSILE STRENGTH(N/mm²)	
	7 days	28 days	7 days	28 days
A0	36.04	50.73	2.32	3.29
A1	37.92	51.42	2.74	3.61
A2	38.91	53.45	3.04	3.74
A3	39.31	56.41	3.29	4.06

VI. CONCLUSIONS

1. Compressive strength attained maximum for Mix M1 at 15% replacement and its 28 days compressive strength is 23% more than that off controlled concrete.
2. Compressive strengths are more than the target mean strengths of 15%and 30% replacements for M25 grades the and for 45% replacement compressive strength is almost equal to target mean strength.
3. When Cement was replaced by the Mineral Admixtures to an extent of 15% for M25 Split tensile strength was observed to be maximum.

4. For M40 grade compressive strength is maximum when Cement was replaced by at an extent of 30% (M5) with mineral admixtures.
5. In the present Study for Mixes M1, M2, M5 there was the durability properties like water absorption and Sorptivity were improved.

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AUTHOR'S PROFILE

Dr.N.Sanjeev, He got his first degree from NIT Warangal in 1983 Joined government of India through UPSC engineering services (so called IES)-1983 batch and was engineer in charge for the construction of longest runway in Asia near Chennai Worked as professor in KLU for 2 years and presently professor in civil engineering in GRIET since November 2014.

Katta.Manoj, Graduated from CBIT, with CGPA -7.2 Btech projects: "Estimation of Temperature, Humidity, Rainfall for next 70 years using artificial neural networks". Pursuing masters in Structural engineering at GRIET interested to conduct experimental programme on concrete.

T. Sampath kumar reddy, He completed engineering inYogananda Institute of Technology and Science(Tirupathi) in the batch of 2012-2016. Heattain first class degree in Civil Engineering. He done his B.Tech project in "Design and planning of Rural road". softwares learnt AutoCad ,staad pro,E tabs for a year .Pursuing masters in Structural engineering Gokaraju Rangaraju institute of Engineering and Technology(Hyderabad) . interested to conduct experimental investigation on concrete made with different mineral admixtures.

T.Sairam, He had done Engineering at Teegala Krishna Reddy Engg.College,Meerpet,Saroornagar, Ranga Reddy,2016 in civil engineering with aggregate of 74.88% and his B.Tech project is "Soil Contamination and Effluent Transportation". Now continuing Masters in Structural Engineering at GRIET, Hyderabad. He is interested in doing Experiments on performance observation of concrete with various pozzolanic materials.