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An Integrated Evaluation of Manufactured Sand and Metakaolin Impacts on Concrete Properties

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Abstract— This paper deals with M25 Concrete mix in which replacing Natural Sand by the Manufacturing Sand of 35% and 65% at Cement by Metakaolin of 0, 5, 10, 15 and 20 percentages is compared with concrete had cement with Metakaolin at different percentages without replacement of natural sand .Workability is determined for Concrete and Cylindrical specimens of 150mm*300mm of size are casted to test Concrete properties such as Split Tensile strength(STS) and Compressive Strength(CS) of Concrete. These specimens are placed under curing of 7days, 28days and 60days; after that time placed under testing and compared the results with Normal Concrete.

Key words — Metakaolin, Manufacturing Sand, Workability, Split tensile strength and Compressive Strength.

I. INTRODUCTION

Concrete consists of different materials such as Fine Aggregates, Cement and Coarse aggregates; these materials are responsible for various problems. Cement is one of the materials that responsible for emission of co_2 in to atmosphere leads to Global warming [1-2]. Natural Sand is another material causing Environmental and Economical problems because that is using throughout the World as fine aggregate [3-4]. Metakaolin is puzzolonic material is purity depends on water processing and Manufacturing Sand is granite rock power and is sieved from 90 microns sieve [4-7]. Manu Vijay [2017] examined M30 grade of concrete, the mechanical properties improved up to 15% of Metakaolin with M-sand. NaadeemPasha [2015] said that Flyash and Metakaolin materials improves mechanical properties sup to 20% Metakaolin at 5% of Flyash. A.V.S.Sai Kumar [2014] investigated the effect of material Metakaolin and quarry dust on M40 grade of concrete reported that mechanical properties improved up to quarry dust of 25% and the Metakaolin of 10%. Manufacturing Sand is also known as RoboSand and M-Sand. This is come from rock but different than Quarry dust because M- sand obtained by crushing and the Quarry dust is residue after stones taken from boulders.

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The Concrete Mix at different percentages of Metakaolin means 0-25 percent of 5 percent of each increment and with or without means 0%, 35% and 65% replacing Robo Sand means Manufactured Sand is comparing with Normal Concrete.

II. OBJECTIVES

- An experimental program was designed for suitability check for Artificial Sand means Manufactured Sand and Metakaolin in Concrete.
- Investigation on the concrete properties at Manufactured Sand of 0%, 35% and 65% at different proportions of Metakaolin.

III. METHODOLOGY

The Materials and Tests conducted for this investigation is described in below sections.

3.1 Materials

In this Investigation materials of the following were used:

- The 53 grade of OP cement.
- River Sand as Fine Aggregates of specific gravity 2.65.
- Coarse Aggregates of 20mm size with specific gravity 2.77.
- The Supplementary material Manufactured Sand means Granite rock powder of Specific gravity 2.46.
- The Replacement material Metakaolin for Cement of specific gravity is 2.66.

3.2 Mix proportions

Design M25 by IS 10262:2009.The Natural Sand with 35 and 65 percent replacing of Manufactured Sand with River Sand at Cement replaced by supplementary material Metakaolin is in proportions 0, 5, 10, 15 and 20 percent is compared with concrete mix had Metakaolin at different percentages without Manufactured Sand.

The Concrete mix Constituents means water, Cement, Fine and Coarse Aggregates are in ratio of water Content: cement content: fine Aggregates: coarse Aggregates is 0.50:1:1.752:2.985.The mixes of concrete are at various proportions of Supplementary materials such as Manufacturing Sand and Metakaolin in the mix of Concrete is shown in the below Table-1

Table-1

Mix	Water (lit/m^3)	Cement	Metakaolin	River Sand	Manufacturing sand	Coarse aggregates
		(kg/m^3)				
M1	191.8	383.16	0	671.45	0	1145.13
M2	191.8	364.00	19.16	671.45	0	1145.13
M3	191.8	344.84	38.32	671.45	0	1145.13
M4	191.8	325.69	57.47	671.45	0	1145.13
M5	191.8	306.53	76.63	671.45	0	1145.13
M6	191.8	383.16	0	0	671.45	1145.13
M7	191.8	364.00	19.16	0	671.45	1145.13
M8	191.8	344.84	38.32	0	671.45	1145.13
M9	191.8	325.69	57.47	0	671.45	1145.13
M10	191.8	306.53	76.63	0	671.45	1145.13
M11	191.8	383.16	0	235.01	436.45	1145.13
M12	191.8	364.00	19.16	235.01	436.44	1145.13
M13	191.8	344.84	38.32	235.01	436.44	1145.13
M14	191.8	325.89	57.47	235.01	436.44	1145.13
M15	191.8	306.53	76.63	235..01	436.44	1145.13

3.3 EXPERIMENTS CONDUCTED

3.3.1Workability of Concrete:

Workability find out by Slump Cone and the slump of concrete at different proportions of Metakaolin at 0% and 75% of Manufactured Sand is compared to concrete mix had different proportions of Metakaolin of replacing Cement and Manufactured Sand fully replaced.

3.3.2. Compressive Strength test (CST):

After 24 hours from the Casting of Specimens those are placed in the Curing tank. From this tank, the Concrete specimens are taken at different time period as 7, 28 and 60 days are placed in the CTM. These Specimens are tested under gradual loading to get the peak load until the specimen fails.

At Breaking load, Compressive strength=P/A

Where P=Peak load,

A= Area of cross section of the specimens

3.3.3. Split- Tensile Strength test (STST):

This test is carried out to find tensile strength indirectly. This used for check response of Concrete against Tensile load. Concrete Specimens are placed under gradually applied load in CTM until those are fails means that specimens are split in to two pieces.

At Breaking load, Split Tensile strength =2P/πDL

Where P=Split tensile load,

D=Specimen's Diameter,

L=Length of Specimen

IV. RESULTS AND DISCUSSION

4.1. WORKABILITY

The Workability of Concrete mix at different proportion of Metakaolin is shown in Table-2.

Table-2

Mix	% of Metakaolin	Workability Slump(mm)
M1	0	69
M2	5	64
M3	10	61
M4	15	55
M5	20	51

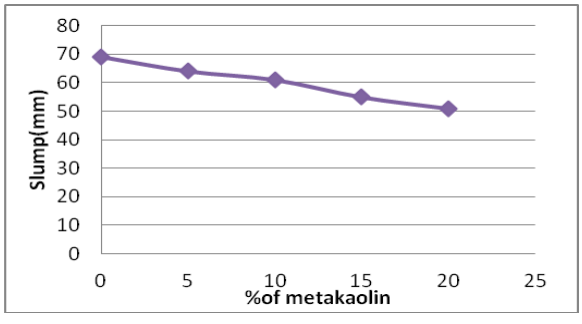

Fig.1.Workability of the mix of Concrete at various % of Metakaolin

The Workability at different proportion of Metakaolin in Concrete at 35% of Manufactured Sand, is given in Table-3.

Table-3

Mix	%0f M-Sand	%0f Metakaolin	Workability Slump(mm)
M6	35	0	62
M7	35	5	57
M8	35	10	51
M9	35	15	47
M10	35	20	44

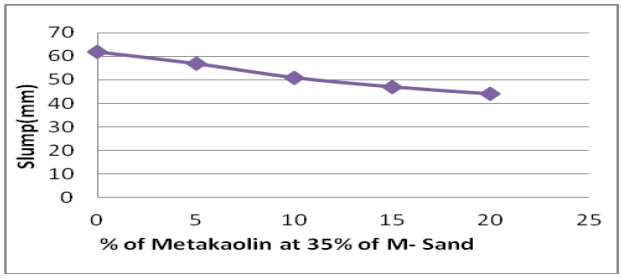

Fig.2. Workability at different % of Metakaolin at 35% of M- Sand

The Workability at different proportion of Metakaolin in concrete at 60% of Manufactured Sand is shown in Table-4.

Table-4

Mix	%0f M- Sand	%0f Metakaolin	Workability Slump(mm)
M11	65	0	53
M12	65	5	50
M13	65	10	46
M14	65	15	41
M15	65	20	37

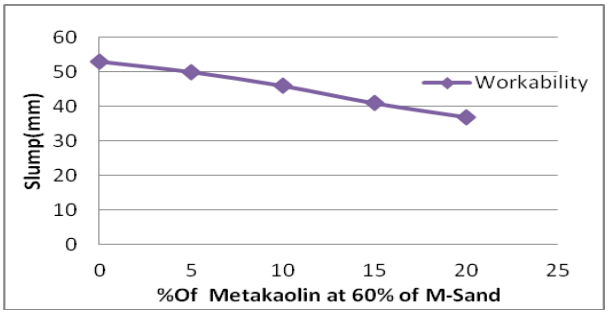

Fig.3.Workability at different % of Metakaolin at M- Sand is 65%

4.2 STS and CS

STS and CS of Concrete at Various Proportions of Metakaolin in Concrete is given in Table-5.

Table-5

%Age of Metakaolin	CS (N/mm^2)			STS (N/mm^2)		
	Days			Days		
	7	28	60	7	28	60
0	20.172	29.057	29.995	1.985	2.879	3.027
5	22.249	32.430	31.863	2.122	3.018	3.159
10	22.814	33.750	34.882	2.310	3.348	3.489
15	21.117	30.557	31.500	2.169	3.018	3.206
20	20.560	29.614	30.368	2.036	2.829	3.072

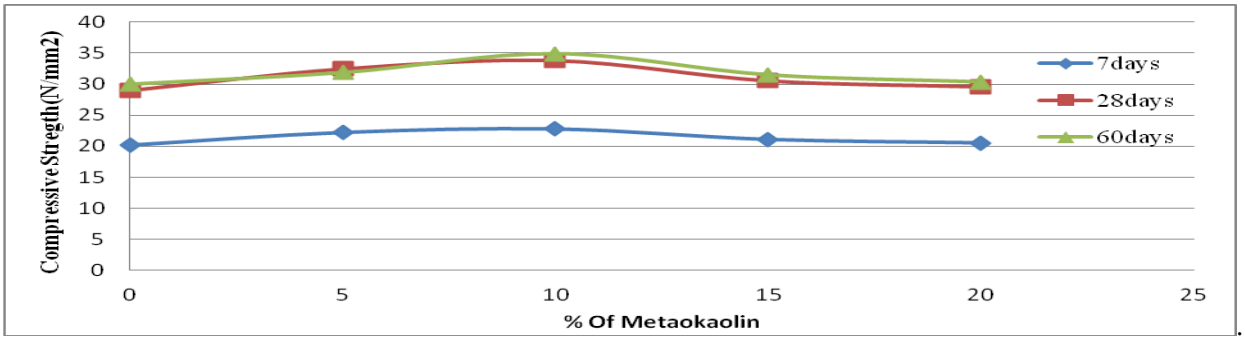

Fig.4.CS of Concrete at Various Proportions of Metakaolin in Concrete

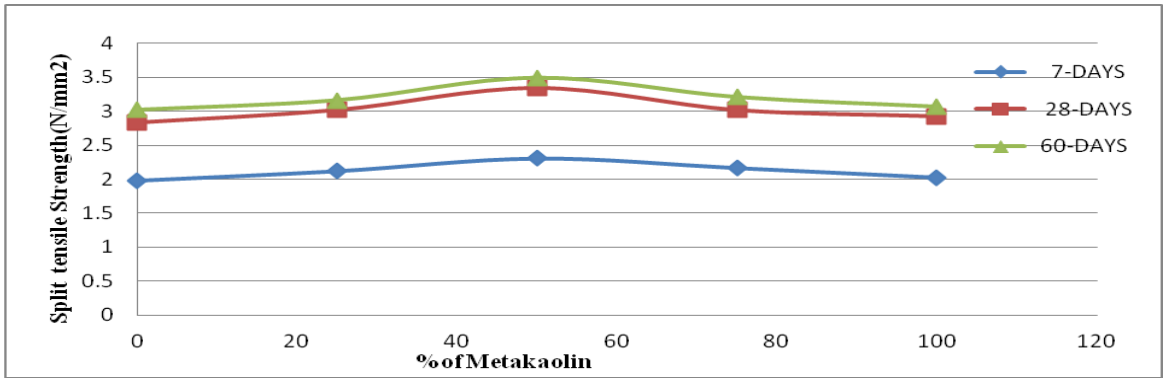

Fig.5.STS of Concrete at Various Proportions of Metakaolin in Concrete

STS and CS of Concrete at Various Proportions of Metakaolin at 35% of Manufactured Sand in Concrete is given in Table-6

Table-6

% of M-Sand	% of Metakaolin	CS (N/mm^2)			STS (N/mm^2)		
		Days			Days		
		7	28	60	7	28	60
35	0	21.117	31.500	31.863	2.263	3.300	3.348
	5	22.635	33.160	33.764	2.357	3.489	3.678
	10	23.191	34.127	34.882	2.546	3.725	3.819
	15	21.800	32.036	33.000	2.405	3.631	3.725
	20	21.126	31.689	32.632	2.357	3.300	3.536

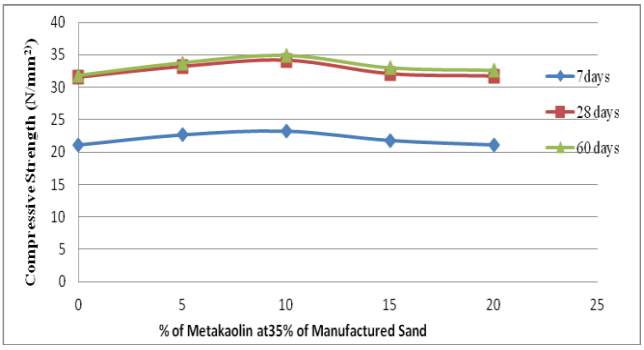

Fig.6. CS at Various % of Metakaolin at 35% of M-Sand

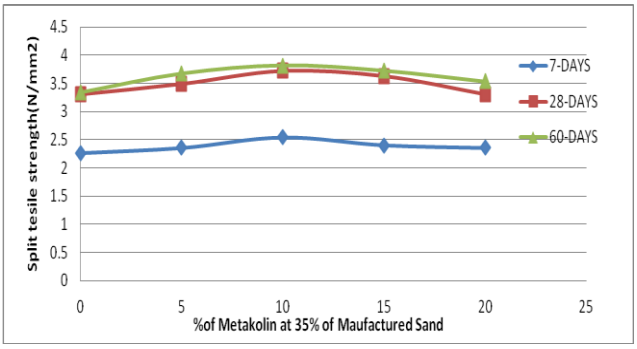

Fig.7.STS at Various % of Metakaolin at M-Sand is 35%

STS and CS of Concrete at Various Proportions of Metakaolin at 65% of Manufactured Sand in Concrete is given in Table-7.

Table-7

% of M-Sand	% of Metakaolin	CS (N/mm^2)			STS (N/mm^2)		
		Days			Days		
		7	28	60	7	28	60
65	0	22.249	32.430	33.185	2.310	3.348	3.348
	5	23.389	34.688	35.462	2.405	3.536	3.725
	10	24.114	35.424	36.013	2.551	3.725	3.866
	15	23.389	34.858	35.839	2.449	3.631	3.725
	20	22.814	33.750	34.882	2.357	3.348	3.536

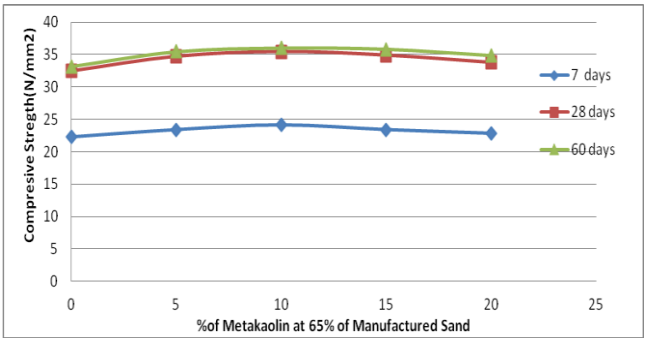

Fig.9.STS at Various % of Metakaolin at 65% of M-Sand

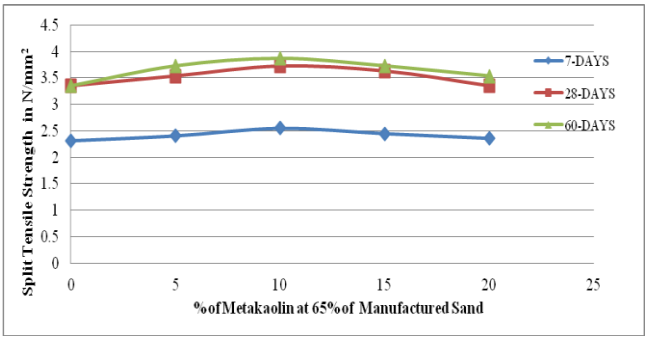

Fig.8.CS at Various % of Metakaolin at 65% of M-Sand

V. CONCLUSIONS

1. Workability is decreased for Concrete mix by increasing of the materials is Metakaolin and Manufactured Sand Content in Concrete.

2. Compressive Strength is optimum at 10% of Metakaolin is 13.04%, 16.20% and16.57% at 7days, 28days and 60days respectively compare to Normal Concrete.

3. Split tensile strength is increased for concrete up to 10% of Metakaolin is 11.11%, 14.06% and 12.88% at 7days, 28days and 60days respectively compare to Normal Concrete.

4. Compressive Strength is optimum at 35% Manufactured Sand and 10% Metakaolin is 8.34%,9.82% and 9.46% at 7days, 28days and 60days respectively compare to Normal Concrete.

5. Split tensile Strength for Concrete is optimum at 35% Manufactured Sand with 10% Metakaolin that is 11.86%,12.50% and 12.33% at 7days, 28days and 60days respectively compare to Normal Concrete.

6.Compressive Strength is optimum at 65% Manufactured Sand and the 10% of Metakaolin is 3.98%,3.80% and 3.14% at 7days, 28days and 60days respectively to 35% Manufactured Sand and the 10% Metakaolin in Concrete.

7. Split tensile Strength for Concrete is optimum at 65% Manufactured Sand with 10% of the Metakaolin that is 1.96%,0% and 1.23% at 7days, 28days and 60days respectively compare to 35% Manufactured Sand and the 10% Metakaolin in Concrete.

8.Compressive Strength is optimum at 65% Manufactured Sand and the 10% of Metakaolin is 8.38%,9.23% and 8.52% at 7days, 28days and 60days respectively compare to Normal Concrete.

9. Split tensile Strength for Concrete is optimum at 65% Manufactured Sand with 10% of the Metakaolin that is 10.43%,11.26% and 10.87% at 7days, 28days and 60days respectively compare to Normal Concrete.

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