SORPTIVITY OF M60 GRADE SELF COMPACTING CONCRETE WITH PARTIAL REPLACEMENT OF RIVER SAND BY USING M-SAND

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Abstract:-

Manufactured Sand is produced by grinding the granite stone. It is also called as M-Sand or Robo Sand. Due to the toughness of the granite stone, M-Sand provides more strength to the concrete mix. Its angularity shows good interlocking capacity. These two properties are responsible for better strength. It has a high amount of fine particles, this is more convenient to prepare the Self Compacting Concrete. Usage of M-Sand in concrete reduces the usage of River sand, it generates an eco-friendly mix. In this experimental work, River Sand is replaced partially by using M-Sand. M60Grade SCC used for this work. River sand is partially replaced by 0%, 25%, 50%, 75% and 100%. On these mixes, Workability and sorptivity tests are conducted. Both the workability and Sorptivity properties are improved.

Keywords:- Self Compacting Concrete, M-sand, Sorptivity.

I. INTRODUCTION

Self compacting concrete is one of the special types of concrete. it was developed in Japan to overcome the problems, which are occurred during the compaction. SCC will compact under its own weight without any external compaction process. It has consisted of a large amount of fine particles. Nan-Su method of mix design is a simple design procedure for SCC mix design. In SCC fine aggregate is more than that of coarse aggregate. SCC improves the finishing of concrete and reduces the problems of compaction like sound pollution, displacing of farmwork, etc.

Concrete usage increasing with passing time. Along with the usage of concrete, river sand usage as fine aggregate also increasing. This is going to imbalance nature, due to the damage of river beds. Sand improves the groundwater table and to increase the groundwater table, we should save the river sand. In that way, Manufactured sand comes into the picture. M-Sand is improving the strength of concrete and its durability properties. It is due to its high interlocking capacity and high amount of fines. Manufactured sand showing better results in the concrete when compared to the river sand. Its usage can produce economical and eco-friendly concrete. Manufactured sand improved the durability properties along with the Sorptivity test[1].

II. MATERIALS USED

In SCC mix production Cement, GGBS, Fine aggregate (Natural sand and M-sand), Coarse aggregate, Water and Superplasticizer are used.

A. Cement

Ordinary Portland Cement of 53grade with Specific gravity 3.15 and 7.5% fineness is used for this work. Normal consistency of cement is 28%, initial setting time is 36minutes and the Final setting time is 450minutes. It confirmed to requirements of IS:12269-1987.

B. GGBS:-

Ground Granular Blast Furnace Slag (GGBS) is the waste material of the Steel plant. Present using GGBS collected from the JSW Steel plant (Location: Nandyal). The specific gravity of GGBS is 2.8.

C. Fine Aggregate

River sand of Zone-II medium size and M-sand is used as Fine aggregate for the present work. Their properties are as shown in Table.1.

D. Coarse Aggregate

Maximum 12mm size Crushed aggregate is used for the preparation of SCC. Properties of Coarse aggregates are as shown in Table.1

Table.1 Properties of M-sand, Coarse Aggregates & River Sand

Property	M-sand (MS)	C.A	River Sand (RS)
Bulk Density (g/m^3)	1580	1505	1530
Specific Gravity	2.83	2.6	2.65
Surface water (%)	0.5	0.5	0.5
Water Adsorption (%)	5	0.2	0.4

All tests on aggregates are conducted as per IS:2386(Part-3)-1963.

E. Super Plasticizer (S.P)

MasterEase 3709 with Specific gravity as1.12 is used as super plasticizer for this experimental work. It is a product of the BASF company. This plasticizer consists of Viscosity Modifying Agents (VMA) and plasticizer. VMA reduces the friction between particles and gives high workability. It is available in liquid form and brown in colour.

F. Water

For mixing and curing of concrete water should be free from impurities like oils, salts and acids, etc. pH value should not be less than 6. It fulfills the requirements of IS:456-2000.

III. MIX DESIGN

Final mix Design:-

The final mix design is obtained from the Nan-Su method of mix design which is a trial and error method. The final mix design and the typical ranges of material are as shown in Table.2.

Table.2 Final mix design and typical Range

S.No.	Material	For M60 grade SCC (Kg/m^3)	Typical range by EFNARC (Kg/m^3)
1	Cement	430	380-600
2	GGBS	150	
3	Coarse Aggregate	820	750-1000
4	Fine Aggregate	1012 (53% of Total aggregate)	48 to 55% of Total aggregate

S.P =1% of Total Cementitious material
Water to total binder ratio =0.3

Material for various mixes:-

Total of six mixes with various compositions of Natural River Sand (NS) and M-Sand (MS) used for this work. Mix-1, Mix-2, Mix-3, Mix-4, Mix-5 & Mix-6 are the mixes with 0%, 20%, 40%, 60%, 80% &100% replacement of Natural Sand by M-Sand respectively. Material data for each mix is tabulated in Table.3

Table.3 Material Data for various mixes

Mix	Variation	Cement (Kg/m^3)	GGBS (Kg/m^3)	Sand (Kg/m^3)	M-sand (Kg/m^3)	C.A (Kg/m^3)	S.P (lit/m^3)	Water (lit/m^3)
Mix-1	100%RS+0%MS	430	150	1012	0	820	5.8	174
Mix-2	75%RS+25%MS	430	150	759	253	820	5.8	174
Mix-3	50%RS+50%MS	430	150	506	506	820	5.8	174
Mix-4	25%RS+75%MS	430	150	253	759	820	5.8	174
Mix-5	0%RS+100%MS	430	150	0	1012	820	5.8	174

Specimens:-

100mm cubes of 30 samples are used in which 15 samples are used to conduct the 28days compressive Strength tests and the remaining 15 samples are used to conduct the Sorptivity test.

IV. EXPERIMENTAL RESULTS

Mainly this experimental work is to get good Quality of SCC of M60 grade. It should satisfy all the workability requirements as well as get the strength near to the target mean strength.

Workability Requirements

Filling Ability

It is the property of fresh concrete which is to fill all spaces when placing it under its own weight. V-Funnel test is used to test the Filling Ability. Test conducted as per EFNARC guidelines.

Flow Ability

Flow Ability is the fresh concrete property when it is unconfined by formwork and/or reinforcement. A slump flow test is used to determining Flowability and the test procedure was done according to EFNARC.

Passing Ability

The ability of fresh concrete to flow through tight openings such as spaces between steel reinforcing bars without segregation or blocking.

Table.4 Workability test data for SCC mixes varying M-sand Content

Property	Mix-1	Mix-2	Mix-3	Mix-4	Mix-5	Range
Slump (mm)	630	635	639	644	650	520-900
V-Funnel (sec)	15	14	13	12	11	<27sec
L-Box (ratio)	0.75	0.78	0.82	0.86	0.89	≥0.75

Workability decreasing with increasing in M-Sand content. But it improving the segregation resistance.

Compressive Strength:-

The strength test on concrete is conducted as per IS:516-1959. After 28days curing Specimen is tested by using CTM and got a Compressive load and Load per area gives a Compressive Strength of concrete.

Table.5 28Days Compressive Strength

Mix	Variation	28Days Compressive Strength
Mix-1	100%RS+0%MS	82.5
Mix-2	75%RS+25%MS	87.5
Mix-3	50%RS+50%MS	88.5
Mix-4	25%RS+75%MS	92.5
Mix-5	0%RS+100%MS	94.5

Increment in manufactured sand improved the compressive strength due to its interlocking capacity. 100% M-Sand replaced mix got 15% more strength when compared to the mix with 100% River Sand.

Sorptivity Test:-

Sorptivity is the tendency of capillary suction of hardened concrete per specified surface area. Test conducted on one face of the cube. Four side faces of that cube are sealed with plaster, top and bottom faces are remains opened. The bottom face is contacted with water by placing supports for it. For each specified duration mass of the cubes are tested and change in mass also calculated.

Sorptivity of the mix is equal to the slope of the graph plotted by using the mass gained per unit area and the square root of time or duration with Zero intercept.

Sorptivity of the mix (S)= $I/\sqrt{T}$

Where T= Duration of Test in Min

$I = m/(A*d)$

m= gain in mass at a specified duration in Kg

A= Surface area of the contacted face in mm^2

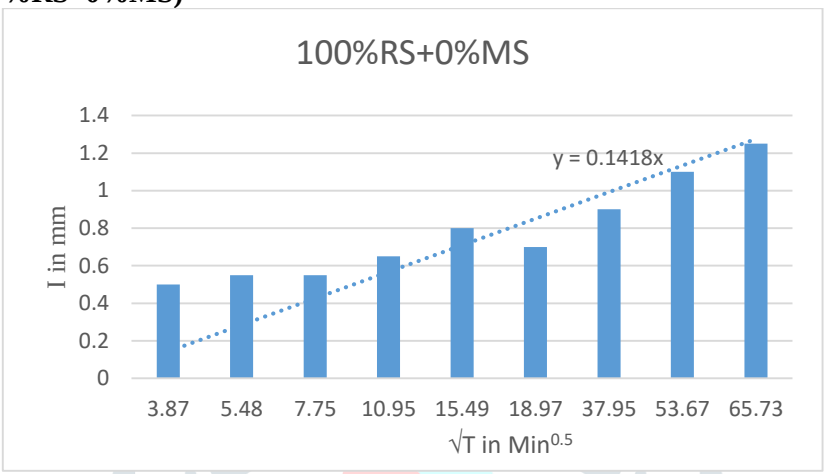
d= density of water

Table.6 Gain in Mass by Sorptiviy Property

Time in Min / Mix	15	30	60	120	240	360	1440	2880	4320
100%RS+0%MS	0.195	0.215	0.215	0.254	0.313	0.274	0.352	0.430	0.489
75%RS+25%MS	0.187	0.166	0.208	0.249	0.270	0.270	0.291	0.333	0.395
50%RS+50%MS	0.273	0.311	0.311	0.331	0.409	0.428	0.448	0.506	0.506
25%RS+75%MS	0.221	0.221	0.241	0.301	0.281	0.301	0.281	0.361	0.321
100%MS+0%RS	0.235	0.235	0.255	0.313	0.294	0.294	0.235	0.333	0.352

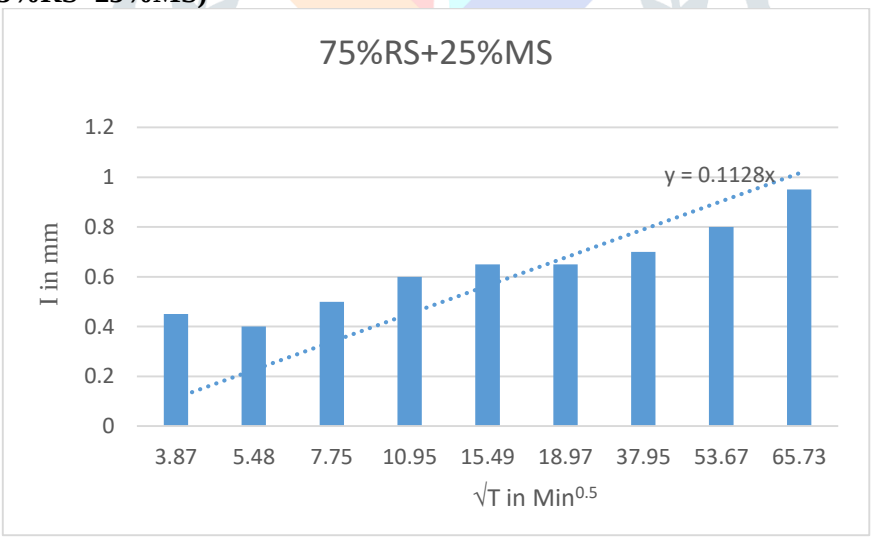
Graphs for the Sorptivity Test are plotted below:-

For Mix-1 (100%RS+0%MS)



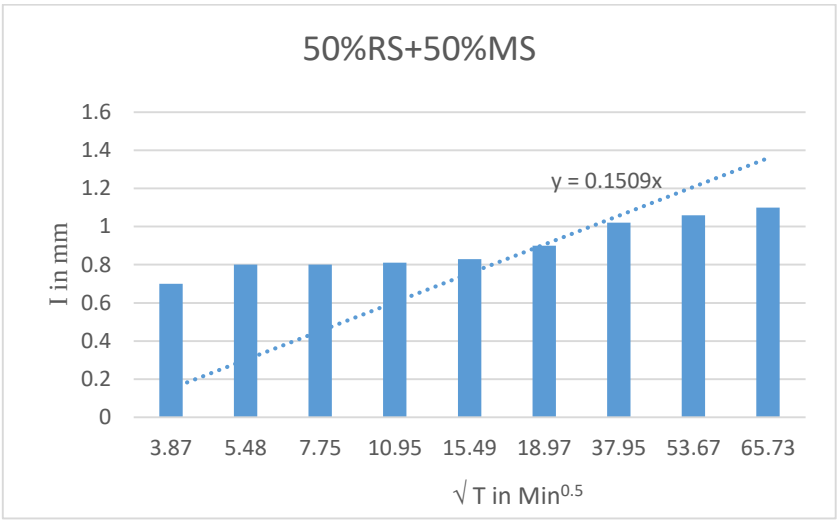
Graph.1 Sorptivity of Mix-1

For Mix-2 (75%RS+25%MS)



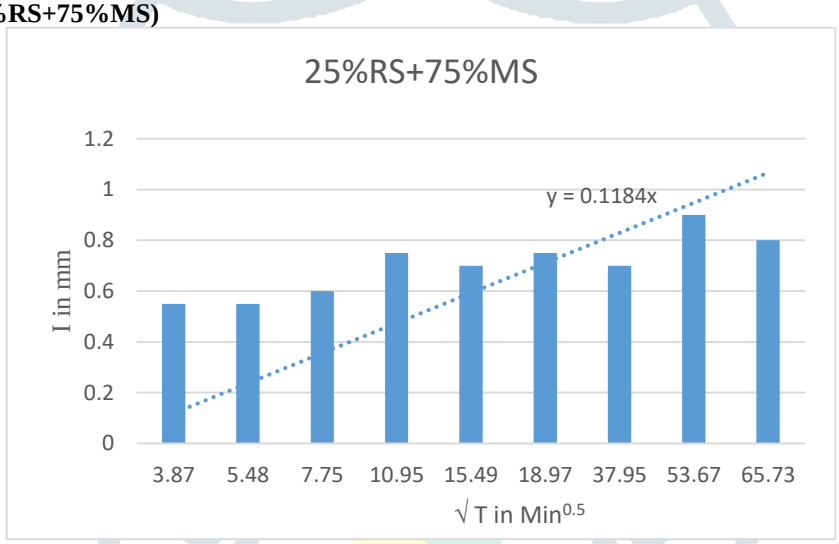
Graph.2 Sorptivity of Mix-2

For Mix-3 (50%RS+50%MS)



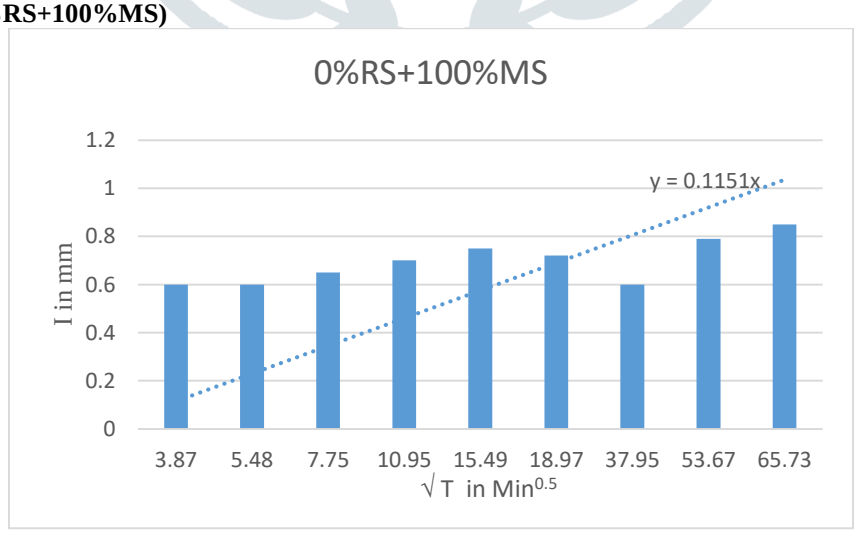
Graph.3 Sorptivity of Mix-3

For Mix-3 (25%RS+75%MS)



Graph.4 Sorptivity of Mix-4

For Mix-5 (0%RS+100%MS)



Graph.5 Sorptivity of Mix-5

Table.7 Mixes with Sorptivity Coefficient

Mix	Variation	Sorptivity Coefficient ($mm/Min^{0.5}$)
Mix-1	100%RS+0%MS	0.1418
Mix-2	75%RS+25%MS	0.1128
Mix-3	50%RS+50%MS	0.1509
Mix-4	25%RS+75%MS	0.1184
Mix-5	0%RS+100%MS	0.1151

Conclusion:-

Based on the experimental investigation the results given below are drawn out.

1. As per EFNARC guidelines, workability tests are conducted and the results show that the mixes with increasing M-Sand have improved the Workability and segregation resistance also improved.
2. Compressive Strength results showed that the mix with 100% M-Sand got 15% more Strength than the 100% river sand mixed SCC mix.
3. As percentage replacement of River sand by M-sand increases Compressive Strength of Concrete also increasing due to its interlocking capacity.
4. Sorptivity coefficients show that the increase in M-Sand decreases the permeability of concrete and giving better performance in the sorptivity test.

References:-

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List of codes:-

[1] IS12269:1987 Specification For 53 Grade Ordinary Port Land Cement
[2] IS 12269: 2013 Ordinary Portland Cement, 53 Grade — Specification
[3] IS: 516 - 1959 Methods Of Tests For Strength Of Concrete
[4] IS 2386-3 (1963)_ Methods of test for aggregates for concrete, Part 3
[5] The European Guidelines for Self-Compacting Concrete (EFNARC Guidelines)