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EFFECT OF STRENGTH PROPERTIES ON M25 GRADESELF COMPACTING CONCRETE USING MANUFACTURING SAND AND RECYCLED COARSE AGGREGATE

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Abstract--- Self compacting concrete (SCC) can be prepared by increasing the cementitious materials (cement + fly ash) and decreasing the content of coarse aggregate. SCC findits application in congested areas where traditional concrete has higher resistance to its flowing ability hence need of SCC increased.Fresh properties like slump test, V-funnel, L-box were conducted on different mixes. In this present experimental study we mainly focused on finding the mechanical properties like compressive strength and splittensile strength behaviour of cement concrete cubes and cylinders by replacing with recycled coarse aggregate (RCA) and manufactured sand (MSand). Compressive strength test was conducted on cubes to find compressive strength properties and split tensile test conducted on cylinders to find tensile strength properties. The cubes and cylinders were cured for a period of 7,28 and 90 days in potable water.

Key words --- SCC, MSand, RCA, Compressive strength, Split tensile strength, Fresh properties.

I.INTRODUCTION

SCC can flow and fill the gaps of congested reinforcement and corners of moulds without any need of compaction during the placing. But it is not yet utilized in house buildings to large extent with the conception that the use of higher fines and chemical admixtures in SCC leads to more material cost and higher strengths, and also higher paste volume and lower coarse aggregate content known to increase the drying shrinkage of SCC [1]. The increased demand and the consumption of natural materials caused the ecological issues and sudden surge in material cost. In the previous decade variable cost of common sand utilized as fine aggregate in concrete increased the cost of construction. On this premise of past research, manufactured sand offers feasible other option to normal sand. On similar lines recycled coarse aggregate provides alternate for the normal coarse aggregates but these recycled coarse aggregates have high porosity and low specific gravity.

II. EXPERIMENTAL STUDY

This examination is basically centered around the development of normal strength M25 grade of SSC using manufactured sand and reused coarse aggregate for the utilization of typical building development.

1.Materials

Cement used in SCC is of 53 grade having physical properties as shown in Table 1 below and corresponding to IS: 12269-1987 [2]. From environment point of view, production of OPC is not an environmentally friendly aspect as it consumes large amount of natural resources and releases a significant amount of green-house gases [3].

Class F fly ash produced from Rayalaseema Thermal Power Plant (RTPP), Muddanur, A.P is used as an additive according to ASTM C 618(2003) [4]. As per IS 456 (2000) [5], cement is replaced by 30% of fly ash by weight of cementitious material. Studies revealed that high volumes of fly ash can be used in SCC to attain the desired fresh and hardened properties of SCC [6].

Guru Jawahar et al. [7] studied the effect of coarse aggregate blending on fresh properties of SCC and proposed a typical range of coarse aggregate content suitable for a particular coarse aggregate blending made with 20 mm and 10 mm size aggregates to obtain successful SCC. In our study crushed coarse aggregates of size 12.5 mm are used. Bulk specific gravity in oven dry condition and water absorption of the natural coarse aggregate 12.5mmare 2.58 and 0.3% respectively. Recycled coarse aggregate used has bulk specific gravity of 2.49 and water absorption of 0.45%.Fine aggregate used are natural sand, Bulk specific gravity at oven dry condition and water absorption of the sand) are 2.62 and 1% respectively. Manufactured sand has specific gravity and water absorption 2.4 and 1.2%.

Table 1: physical properties of cement

Physical properties	Test result	Test method/ Remarks	Requirement as per IS 12269 (1987)
Specific gravity	3.06	IS 4031(1988) – part	_
Fineness (m^2/Kg)	311.5	Manufacturer data	Min.225 m^2/kg
Normal consistency	30%	IS 4031 (1988)- part 4	_
Initial setting time (min)	90	IS 4031 (1988)- part 5	Min. 30 min
Final setting time (min)	220	IS 4031 (1988)- part 5	Max. 600 min
Soundness Lechatelier Expansion (mm) Autoclave Expansion (%)	 0.8 0.01	 Manufacturer data	 Max. 10 mm Max. 0.8%
Compressive strength (MPa) 3 days 7 days 28 days	 25 39 57	 IS 4031 (1988)- part 6	 27 MPa 37 MPa 53 MPa

Table 2: Chemical and physical properties of class F fly ash

Particulars	Class F fly ash
Chemical composition	
% Silica(SiO_2)	65.6
% Alumina(Al_2O_3)	28.0
% Iron Oxide(Fe_2O_3)	3.0
% Lime(CaO)	1.0
% Magnesia(MgO)	1.0
% Titanium Oxide (TiO_2)	0.5
% Sulphur Trioxide (SO_3)	0.2
Loss on Ignition	0.29
Physical properties	
Specific gravity	2.13
Fineness (m^2/Kg)	360

2. Mix design

In designing the SCC mix, it is most useful to consider the relative proportions of the key components by volume rather than by mass [8]. Several methods exist for the mix design of SCC. The general purpose mix design method was first developed by Okamura and Ozawa [9]. In this study, the key proportions of constituents of SCC mixes were obtained by using the SCC mix design tool (JGJ_SCCMixDesign.xls) [10].Nine mixes of various level of replacements in coarse aggregate and fine aggregate using recycled coarse aggregate and manufactured sand has been listed in Table 3 as shown below.

Table 3: Mix Designations of SCC

Mix type	CA	RCA	Sand	MSand
Mix1	100	0	100	0
Mix2	100	0	75	25
Mix3	100	0	50	50
Mix4	75	25	100	0
Mix5	75	25	75	25
Mix6	75	25	50	50
Mix7	50	50	100	0
Mix8	50	50	75	25
Mix9	50	50	50	50

CA: Coarse aggregate, RCA: Recycled coarse aggregate and MSand: Manufactured sand

Table 4: Mix proportions of constituent materials of SCC mixes

Mix type	Binder Kg/m^3	Cement kg/m^3	Fly ash kg/m^3	Water l/m^3	12mm Kg/m^3 (CA)	12mm kg/m^3 (RCA)	Sand Kg/m^3	MSand Kg/m^3	SP l/m^3
Mix1	501	350.7	150.3	180.36	721.6	0	863.4	0	6.01
Mix2	501	350.7	150.3	180.36	721.6	0	647.55	215.85	6.01
Mix3	501	350.7	150.3	180.36	721.6	0	431.7	431.7	6.01
Mix4	501	350.7	150.3	180.36	541.2	180.4	863.4	0	6.01
Mix5	501	350.7	150.3	180.36	541.2	180.4	647.55	215.85	6.01
Mix6	501	350.7	150.3	180.36	541.2	180.4	431.7	431.7	6.01
Mix7	501	350.7	150.3	180.36	360.8	360.8	863.4	0	6.01
Mix8	501	350.7	150.3	180.36	360.8	360.8	647.55	215.85	6.01
Mix9	501	350.7	150.3	180.36	360.8	360.8	431.7	431.7	6.01

3. Fresh properties

Fresh properties like slump flow, V-funnel, L-box are performed to get the required flow ability to the concrete. The values are in line with the specifications as shown in Table 5 and follows EFNARC (2002) specifications [8]. According to Bonen and Shah 2005 [11], the key factor for a successful development of SCC is to clearly understand the role of the different constituent material in the mix and their effects on the fresh and hardened properties of SCC.

Table 5: Fresh properties of trial mixes

Mix type	SLUMP FLOW (mm)	V-FUNNEL (sec)	L-BOX TEST (h2/h1) ratio
MIX1	690	6.2	0.97
MIX2	675	7.3	0.89
MIX3	656	10.4	0.82
MIX4	682	6.6	0.95
MIX5	669	7.9	0.86
MIX6	652	10.9	0.81
MIX7	678	7.1	0.91
MIX8	661	8.4	0.83
MIX9	645	11.1	0.80

4. Experimental setup

4.1 Compressive strength test

In this Compressive strength test, the specimens of size 150mm x 150 mm x 150mm cubes of different mix proportionswere cast for M25 grade of concrete. After casting the cubes were kept open to the atmosphere for period of 24 hours, and then the cubes were shifted to curing tank to cure for 7, 28 and 90 days. After completion of curing period the cubes were tested in CTM (Compressive testing machine), the results of compressive strength of cubes were noted. In each design mix three cubes were tested and their average value is reported.

Figure 1: Compressive testing machine with setup

4.2 Split tensile strength test

In this Split tensile strength test, the specimens of size 150mm diameter and 300mm height cylinders of different mix proportionswere cast for M25 grade of concrete. After casting the cylinders were kept open to the atmosphere for period of 24 hours, and then the cylinders were shifted to curing tank to cure for 7, 28 and 90 days. After completion of curing period the cylinders were tested in CTM (Compressive testing machine), the results of split tensile strength of cylinders were noted. In each design mix three cylinders were tested and their average value is reported.

Figure 2: Compressive testing machine with setup

III. RESULTS AND DISCUSSIONS

1. Compressive strength of cubes

From the Table 6 we observe that the compressive strength of MIX3 is higher than the other mixes this is mainly attributed by increase in proportion of manufacturing sand because of silica content present in the manufacturing sand. The use of recycled coarse aggregate slightly affects the strength of concrete because of increase in porosity and low specific gravity and high water absorption. Hence we can justify the mix with low recycled coarse aggregate and higher manufacturing sand gives you best strength which in our case is MIX3. The test procedures follow IS 516 (1991) [12] specifications.

Table 6: Compressive strength of various mixes

Mix type	Compressive strength (MPa)		
	7 Days	**28 Days**	**90 Days**
Mix1	16.80	32.80	45.40
Mix2	17.40	33.20	46.10
Mix3	18.60	35.60	48.40
Mix4	15.90	31.60	44.80
Mix5	16.80	32.40	45.40
Mix6	17.20	34.30	47.20
Mix7	14.80	30.20	42.60
Mix8	15.70	31.80	43.90
Mix9	16.30	32.10	45.80

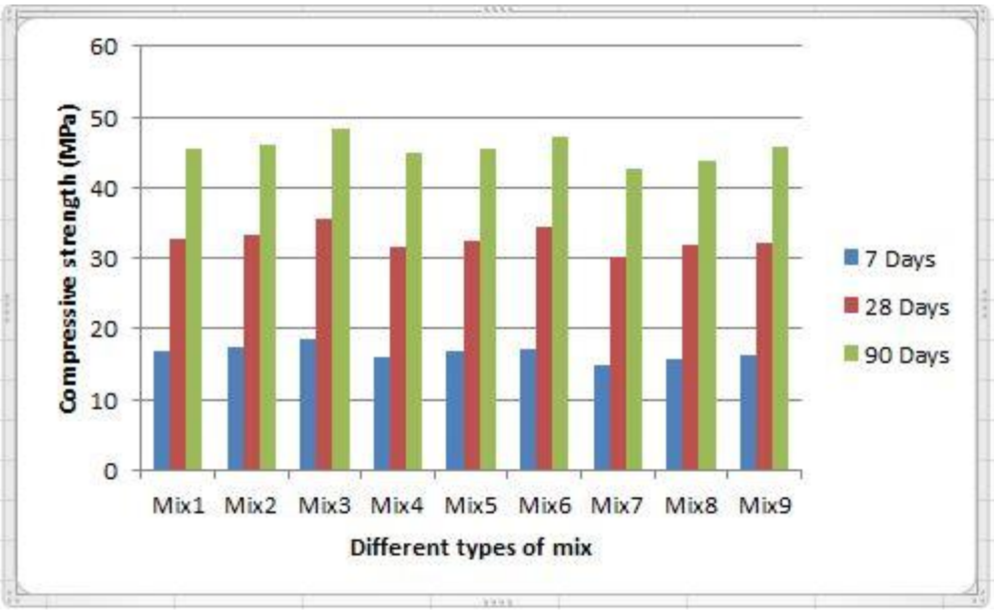


Figure 3: Variation of compressive strength of different mix proportions

2. Split tensile strength of cylinders

From the Table7 we observe that the split tensile strength of MIX3 is higher than the other mixes this is mainly attributed by increase in proportion of manufacturing sand because of silica content present in the manufacturing sand. The use of recycled coarse aggregate slightly affects the strength of concrete because of increase in porosity and low specific gravity and high water absorption. Hence we can justify the mix with low recycled coarse aggregate and higher manufacturing sand gives you best strength which in our case is MIX3. The test procedures follow IS 5816 (1999) [13] specifications.

Table 7: Split tensile strength of various mixes

Mix type	Split tensile strength (MPa)		
	7 Days	28 Days	90 Days
MIX1	2.31	2.92	4.12
MIX2	2.38	3.05	4.18
MIX3	2.42	3.10	4.26
MIX4	2.22	2.86	4.08
MIX5	2.31	2.91	4.11
MIX6	2.36	3.04	4.18
MIX7	2.16	2.78	3.98
MIX8	2.24	2.83	4.06
MIX9	2.30	2.94	4.17

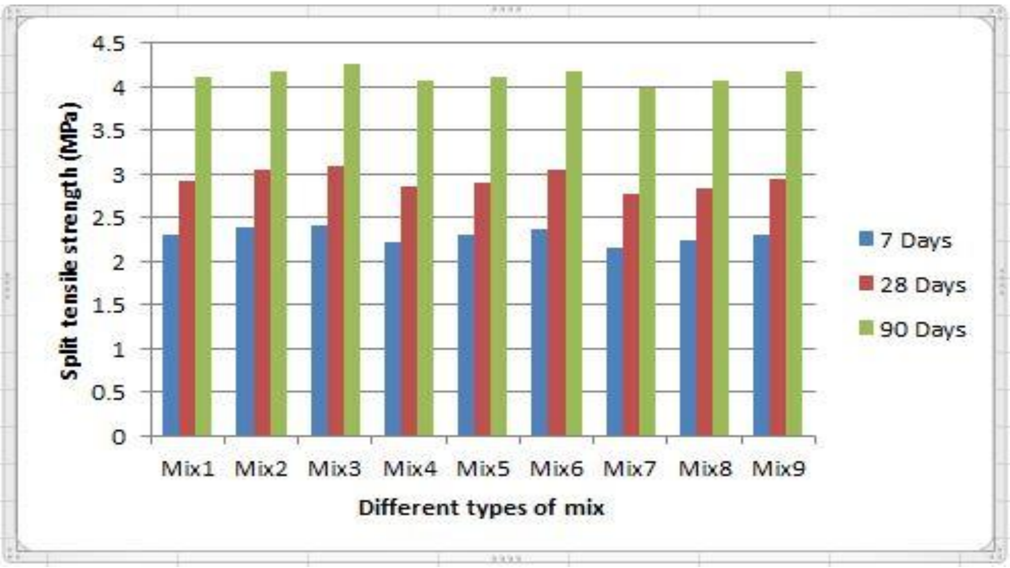
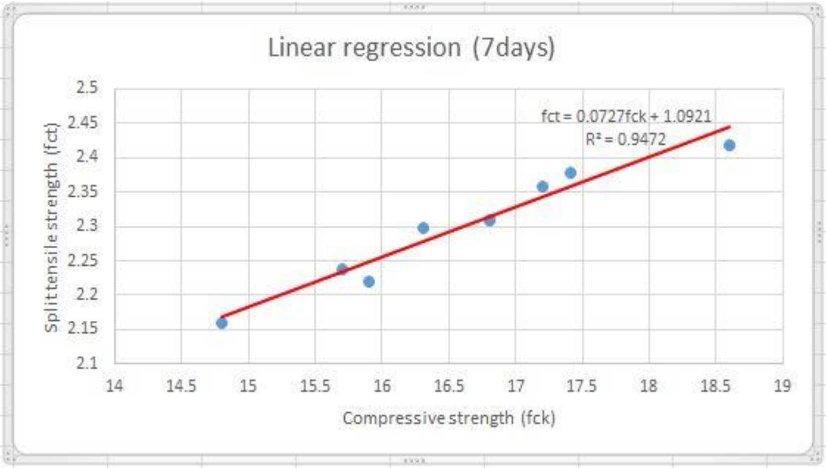


Figure 4: Variation of split tensile strength of different mix proportions

IV. REGRESSION MODEL TO ESTIMATE COMPRESSIVE STRENGTH AND SPLIT TENSILE STRENGTH

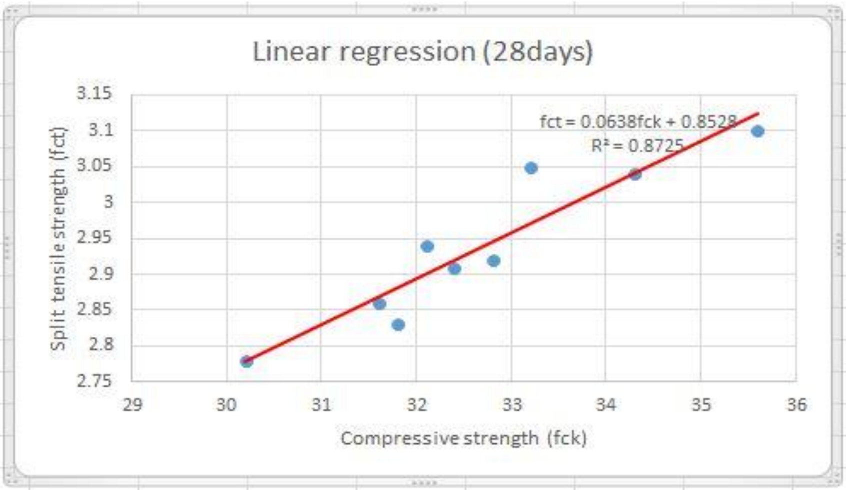
The following regression models were established to estimate the compressive strength and split tensile strength of concrete and the models are tested with experimental results. For this linear regression models are plotted to find the relation between compressive strength and split tensile strength for 7, 28 and 90 days.



f_{ck}= 0.0727f_{ck}+ 1.0921

R^2= 0.9472

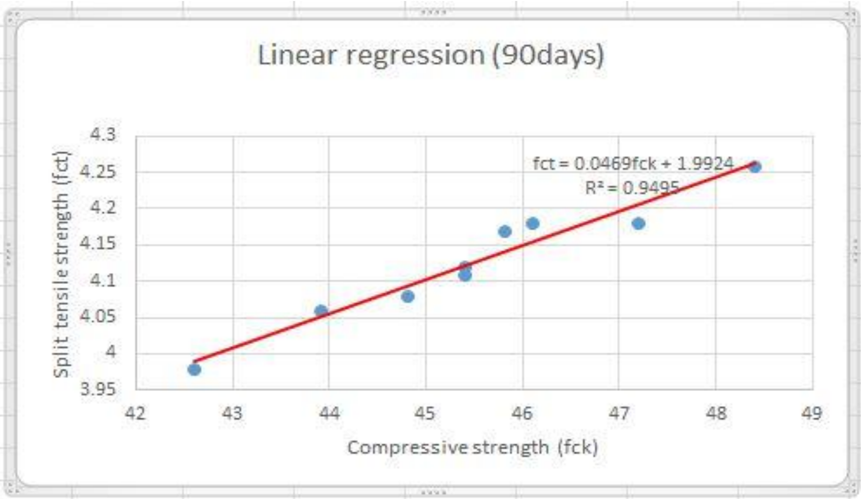
Figure 5: 7 days linear regression model of compressive strength vs split tensile strength



f_{ck}= 0.0638f_{ck}+ 0.8528

R^2= 0.8725

Figure 6: 28 days linear regressionmodel of compressive strength vs split tensile strength



f_{ck}= 0.0469f_{ck}+ 1.9924

R^2= 0.9495

Figure 7: 90 days linear regression model of compressive strength vs split tensile strength

V.CONCLUSIONS

[1]. M 25 grade of SCC was performing enhanced mechanical properties at later ages as compared to that same grade of regular concrete due to pozzolanic action of class F fly ash.

[2]. The increase in manufactured sand replacement levels reduced the SCC fresh properties due to the increase of yield stress caused by particles of manufactured sand.

[3]. The increase in replacement level of manufactured sand enhances the mechanical properties of SCC due to filling ability of manufactured sand and its silica content.

[4]. The increase in replacement level of recycled coarse aggregate has reduced the strength slightly because of ageing effect of aggregates and its effect on fresh properties is negligible.

[5]. It is concluded that manufactured sand can be partially replaced in the sand to certain extent and in case recycled coarse aggregate increase in percentage causes slight reduction in strength and negligible effect on SCC so they can be used to address the environmental issues.

[6]. Of all the nine mixes MIX3 is found to be have higher compressive strength than other mixes because of manufactured sand and natural coarse aggregates.

[7]. Of all the nine mixes MIX3 is found to be have higher split tensile strength than other mixes because of manufactured sand and natural coarse aggregates.

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