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Self-Compacting Concrete with Recycled Coarse Aggregate and Manufactured Sand

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Abstract: ***This article mainly focused on the influence of recycle coarse aggregate and manufactured sand on the properties of self compacting concrete (SCC). The main purpose of this research is reuse of recycled aggregate in SCC and also to reduce use of fine aggregate by replacing manufactured sand. The SCC mixtures were prepared with 0, 25, 50, 75 and 100% replacement of recycle coarse aggregate in natural coarse aggregate and M-Sand in fine aggregate with a Water/Binder ratio of 0.36. Different test covering fresh properties of these SCC mixtures were executed the results were compared with EFNARC guidelines and IS 10262:2019. The feasibility of utilizing recycled aggregate and M-Sand in self compacting concrete has been examined and found that it is suitable for concrete.***

Keywords: ***Self compacting concrete, recycle coarse aggregate M-Sand, fresh properties.***

I. INTRODUCTION

Self compacting concrete (SCC) is a different kind of concrete which is having good deformability, segregation resistance and it will flow under its own weight and fill the form work even in congested reinforcement. This having good characteristics like high fluidity and good segregation resistance. To confirm a concrete as SCC, IS 10292 [1] and EFNARC [2] has suggested conducting test methods like slump flow, T50 Slump, V-funnel and L-box. C.S.Poon and C.Kou [3] have done experimentation on SCC with recycled aggregate and in their research as fine recycled aggregate increases the slump flow of the mixes also increased but after one hour the values of the slump flow are reversed and they are within the EFNARC guidelines. They got the slump values between 770 and 735mm when they used 100% recycled coarse aggregate which are as per EFNARC guidelines. Khatib [4] has report instead of coarse recycled aggregate, natural fine aggregate can be replaced by recycled fine aggregate (<5 mm) and the fine aggregate replacement was done by 0, 25, 50, 75 and 100% by keeping a constant water /cement ratio and observed a slow rate in the compressive strength after 28-days.

Zoran Jure Grdic et. al [5] replaced coarse aggregate by 0, 50 and 100% with demolished waste and observed the slump values or within the EFNARC guidelines. Myle Nguyen James et. al [6] observed unit weight and sump are similar concrete mixes content recycle coarse aggregate and recycle fine aggregate by modifying water /cement ratio. K.C.Panda and P.K.Bal [7] replaced recycled aggregate upto 40% in natural coarse aggregate and observed the results are within EFNARC guidelines. Kamal M.M. et. al [8] replaced red brick and crushed ceramic in natural coarse aggregate they observed the slump value increased with increase of crushed ceramic and crushed red brick aggregate. This may be due to the re-tempering process they performed by using an addition dosage of superplasticizer as 35% of the original dosage in recycled self compacted concrete. S.Santos et.al [9] suggested that the use of RCA in production of SCC is justified and technically viable. From the past research it can be known that limited work has been done on Self compacting concrete with recycled coarse aggregate and M Sand. Hence in the present research it is aimed to study the fresh properties of SCC with locally available demolished recycled coarse aggregate and M Sand.

II. EXPERIMENTAL STUDY

A. Materials

Ordinary Portland Cement and class F fly ash was used in SSC as cement materials. The chemical and physical properties of cement material are shown in Table (I and II) and for fly ash it was shown in Table III respectively.

Table I: Chemical Composition of Cement

Constituent (%)	*Value*
SiO_2	19.79
Al_2O_3	5.67
Fe_2O_3	4.68
CaO	61.81
MgO	0.84
SO_3	2.48
Chloride	0.003
Lime Saturation Factor (LSF)	0.92
Alumina / Iron Oxide	1.21

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Table II: Physical properties of Cement

Parameter	*Value*	*Acceptable range*	*I.S Code*
Specific Gravity	3.05	-	IS 4031 (1988) – Part 1
Fineness (m^2/kg)	310.5	Min 25 m^2/kg	
Normal Consistency	31%	-	IS 4031 (1988) – Part 4
Initial Setting Time (min)	60	Min 30 min	IS 4031 (1988) – Part 5
Final Setting Time (min)	210	Max 60 min	IS 4031 (1988) – Part 5
Soundness mm	1.0	< 10 mm	
Compressive Strength (MPa) 3 days 7 days 28 days	 28 38 58	 27 28 53	IS 4031 (1988) – Part 6

In this study natural granite and recycled aggregates were used. For fine aggregates, natural river sand and manufactured sand was used. The properties of the aggregates were shown in Table IV. To achieve good workability chemical admixture of polycarbolic ether super plasticizer was used in this study. Locally available potable water is used for mixing and curing of the concrete.

Table III: Chemical and physical properties of fly ash

Constituent (%)	*Value*
Chemical Properties	
SiO_2	65.6
Al_2O_3	28.1
Fe_2O_3	2.9
CaO	0.95
MgO	1.55
SO_3	0.21
Ignition Loss	0.28
Physical Properties	
Fineness (m^2/kg)	360
Relative Density	2.13

Table IV: Properties of coarse aggregate and fine aggregate

Sl.no	*Property*	*Coarse aggregate*		*Fine aggregate*	
		NCA	*RCA*	*River sand*	*M sand*
1	Specific gravity	2.66	2.52	2.58	2.46
2	Bulk density (kg/m^3) i) Loose ii) Compacted	1360 1500	1200 1350	1600 1800	1620 1820
3	Water absorption (%)	053	5.06	0.95	1.20

III. MIXTURE PROPORTIONS

For this study SCC mixtures are prepared in three series with different replacement levels of recycled coarse aggregate and M-Sand with fixed water to binder ratio were prepared. Cement and fly ash were kept constant at 351 kg/m^3 and 150 kg/m^3 respectively for all the mixes used in this experiment. The recycled coarse aggregate (RCA) and M-Sand were replaced in natural coarse (NCA) and fine aggregates by 0,25,50,75 and 100%.

Three series of SCC mixtures were prepared with the W/B ratio is kept as 0.36 for all the concrete mixes. The recycled coarse aggregate were used as 0,25,50,75 and 100% by volume replacement of natural coarse aggregate keeping M-Sand as constant replacement at 0%. In second series, five mixtures were prepared with replacement of M-Sand by fine aggregate, keeping coarse aggregate as constant replacement at 0%. In third series, both natural coarse aggregate and fine aggregate were replaced with the material of RAC and M-Sand by 0,25,50,75 and 100%.

IV. TEST METHODS

The testing was done for slump flow, T50cm slump, V-funnel test, L-box, U-box etc as per EFNARC guide lines. Slump flow, T50cm and V funnel results has to be checked to evaluate the filling ability and for passing ability by L-box, U-box tests are to be conducted. In this research, slump flow test is conducted for workability by means of spread of the SCC. To evaluate the viscosity of SCC, T50 cm is measured. V-funnel time is used to measure the filling ability of SCC and to evaluate the passing ability of SCC, L-box test is used. The tested equipment's were presented in Fig. 1.

Fig 1 : Tests on Self Compacting Concrete

V. TEST RESULTS AND DISCUSSION

The tested results observed from the experimentation of slump flow, T50cm slump, V-funnel test, L-box tests of the series I, II and III are shown in Table V and the results are plotted in Fig 2 to Fig 5.

From the Table V and Fig 2 it is observed that the slump value is decreasing with the increase in the percentage replacement of recycled coarse aggregate in natural coarse aggregate without M-Sand. The slump value for the concrete without any replacement of recycled aggregate and manufactured sand is 779 and the least value of slump 655 is observed for the mix with 100% of recycled aggregate and manufactured sand in fine aggregate. The variation may due to change in physical properties of recycled aggregate.

In IS 10262: 2019 it is given that slump flow is divided into 3 ranges based on the applications i) slump flow 550 mm - 650 mm – for Unreinforced or lightly reinforced concrete structures ii) slump flow 660 mm - 750 mm – for normal applications iii) slump flow 760 mm — 850 mm - for vertical applications in heavily reinforced structures/structures with complex shapes or for filling under formwork. In the present research the slump values ranges from 655 to 779 which indicates that the slump values of all the mixes considered in this investigation are within the ranges of ERNARC guidelines and also IS guidelines and the slump values of the present investigation is almost same.

The T_{50} cm slump flow range should be between 2 to 5 sec to confirm a concrete as SCC as per EFNARC. In this research the value for the mix without any replacement of recycled aggregate and manufactured sand is 2.46 sec. For all the mixes the value of T_{50} is in between 2.46 – 4.84 sec. The least value of T_{50} slump i.e 4.84 sec is observed for the mix with 100% replacement of recycled aggregate in coarse aggregate and 100% replacement of manufactured sand in fine aggregate. It can be observed that the value of slump is decreased from 779 to 655 whereas the value of T_{50} is increased from 2.46 to 4.84 sec this may be due to rough texture of recycled aggregate which may have taken more time to reach slump of 50 cm.

The value of V-funnel for the basic mix (without replacement of recycled aggregate and manufactured sand) is 6.78 sec. As per EFNARC specifications, to confirm a mix as Self Compacting Concrete, the value of V-funnel should be in between 6 – 12 sec. The V- funnel values are increasing as the percentage of recycled aggregate and manufacture sand replacement is increasing in coarse and fine aggregate. The ranges of the values of V-funnel are in between 6.88 to 11.84 sec. The maximum value 11.84 sec is observed for the mix with 100% replacement of recycled aggregate in coarse aggregate and 100% replacement of manufactured sand in fine aggregate. The reason may be the same as the properties of recycled aggregate and manufactured sand are slightly different from coarse aggregate and fine aggregate.

Table V: Fresh Properties of SCC mixes

S.No	*Mix Type*	*Slump Flow (mm)*	*T50cm (sec)*	*V-funnel Time (sec)*	*L-box Ratio (h2/h1)*
Series -I					
1	R0M0	779	2.46	6.78	0.978
2	R25M0	759	2.98	7.81	0.942
3	R50M0	728	3.50	8.86	0.907
4	R75M0	705	4.01	9.90	0.871
5	R100M0	682	4.52	10.96	0.836
Series -II					
1	R0M0	779	2.46	6.78	0.978
2	R0M25	776	2.56	6.98	0.971
3	R0M50	771	2.66	7.19	0.964
4	R0M75	767	2.77	7.40	0.956
5	R0M100	763	2.87	7.61	0.949

Series –III					
1	R0M0	779	2.46	6.78	0.978
2	R25M25	753	3.08	8.02	0.935
3	R50M50	719	3.70	9.27	0.892
4	R75M75	691	4.32	10.53	0.850
5	R100M100	655	4.84	11.84	0.822

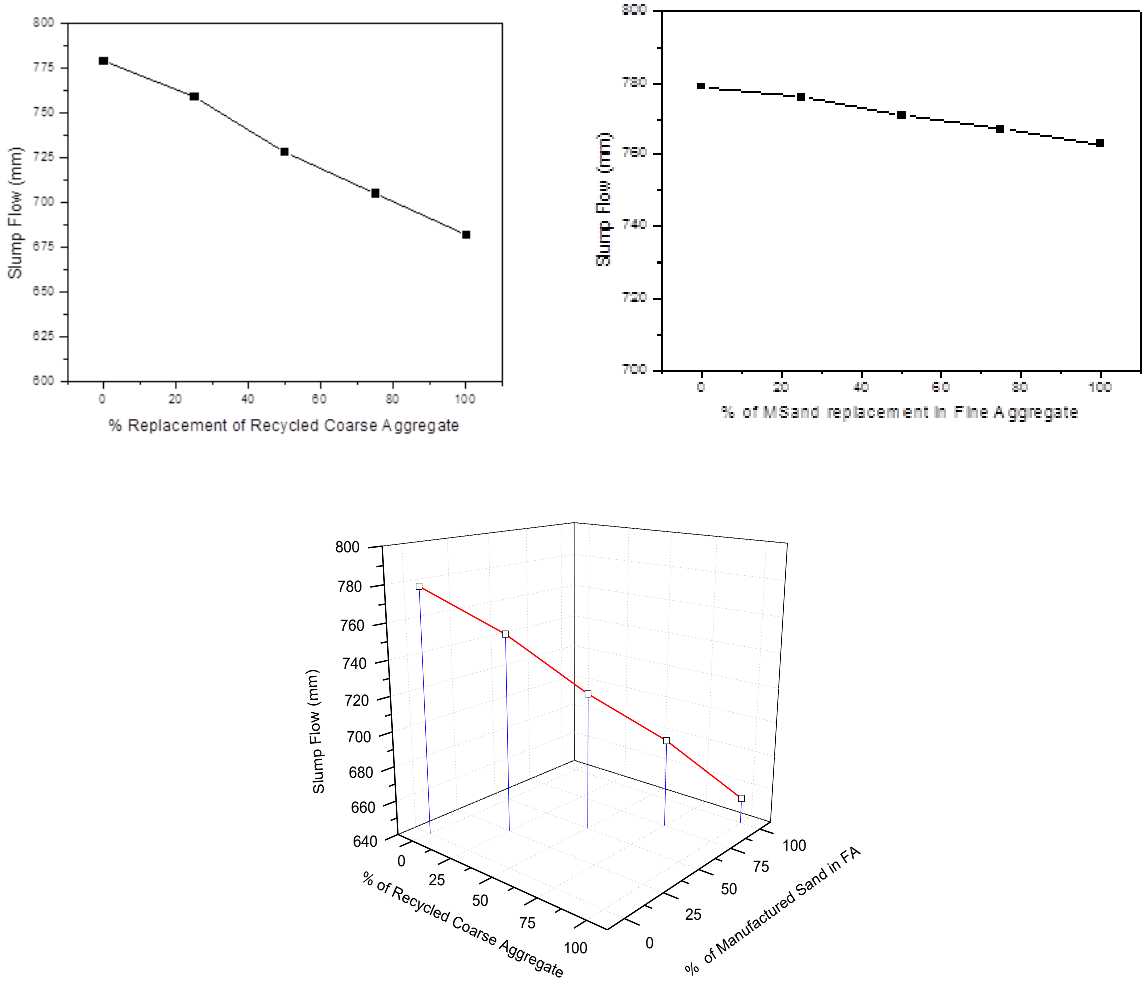

Fig. 2. Slump flow results of SCC

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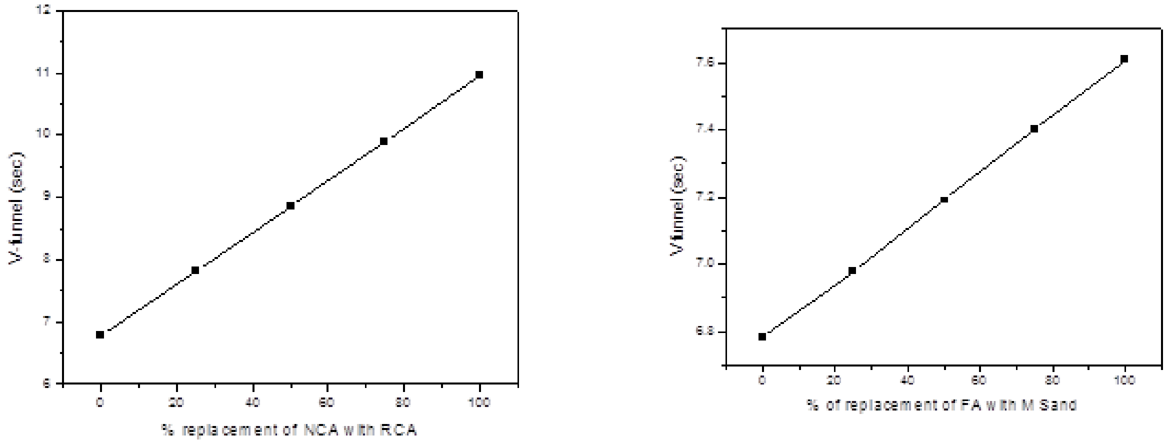

Fig. 3. V-funnel results of SCC

As per EFNARC the value of L-box test should be in between 0.8 to 1.0 to confirm a concrete as SCC. The maximum value is observed for the mix is 0.978 without any replacement of recycled aggregate and manufactured sand in coarse aggregate and fine aggregate and the minimum value is observed as 0.822 for the mix with 100% replacement of recycled aggregate in coarse aggregate and 100% replacement of manufactured sand in fine aggregate. If the ratio of h2/h1 is equal to 1, indicates that the flow is almost like water. In this case the basic mix value is 0.978 which indicates the flow is higher than the basic mix with 100% replacement of recycled aggregate in coarse aggregate and 100% replacement of manufactured sand in fine aggregate but within the limit of EFNARC guidelines. But all the mixes taken in this research are within the limits of EFNARC guidelines satisfying all the mixes as Self Compacting Concrete.

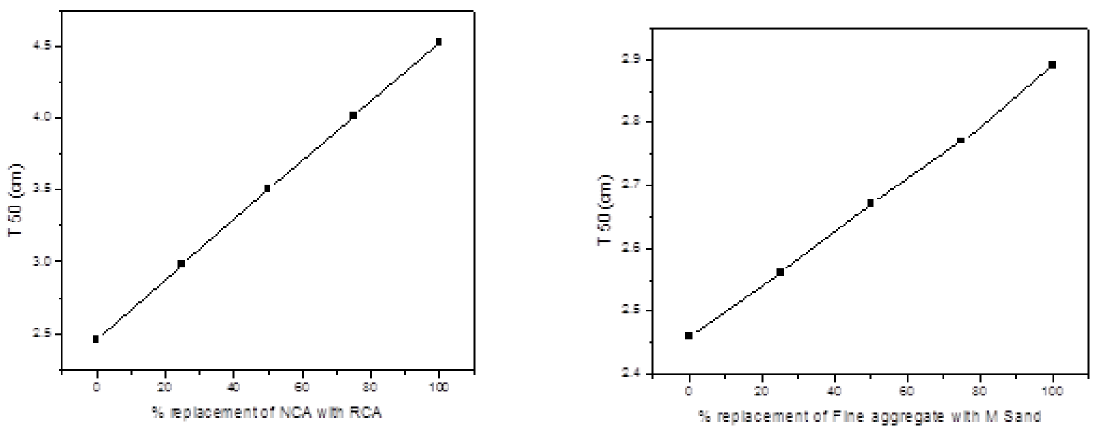

Fig. 4. T 50 results of SCC (cm)

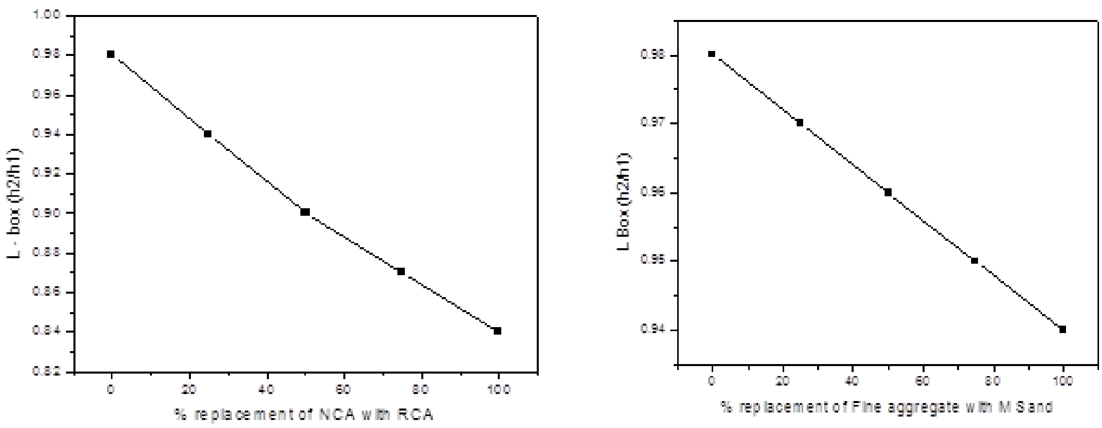

Fig. 5. L-Box test results of SCC

VI. CONCLUSIONS

The following observations made in this study are presented below :

1. The results of the present investigation show that both recycled coarse aggregate and M-Sand can be used in producing SCC.
2. The slump flow decreased with the increase of recycled coarse aggregate replacement in natural coarse aggregate and M-Sand replacement in fine aggregate separately and even in the combined replacement of these aggregate replacements, the slump value is decreasing when compared with the SCC without any replacement.
3. T50 cm value and V funnel time is increasing with the increase of recycled coarse aggregate and M-Sand.
4. L-box ratio is decreasing with the increase of recycled coarse aggregate replacement and M-Sand replacement.
5. As all the basic properties are within guidelines recycled coarse aggregate and manufactured sand can be used in SCC.

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