



USE OF INDUSTRIAL WASTES IN MANUFACTURING OF SELF COMPACTING CONCRETE

Engineering

S.R Ramesh	Professor, Department of Civil Engineering, SSIT, Tumkur
H. Venugopal*	Professor, Department of Civil Engineering, SSIT, Tumkur *Corresponding Author
N. Jayaramappa	Assoc. Professor Department of Civil Engineering, UVCE, Bangalore University, Bangalore

ABSTRACT

Self-compacting concrete (SCC) is an innovative concrete does not require vibration for placing and compaction, it is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement the hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete.

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Metakaolin when used as a partial replacement substance for cement in concrete, it reacts with $\text{Ca}(\text{OH})_2$ one of the by-products of hydration reaction of cement and results in additional C-S-H gel which results in increased strength, and slag is a byproduct in steel industry, Slag has the advantage of very homogeneous structure. Metakaolin is used as a replacement of cement and slag is replaced by fine aggregate in known percentage. So it is the dire need to use this particular otherwise waste material for the constructive in such fashion in the case of concrete so that concrete which became cost effective as well as ecofriendly. The combination of these two material will produce a good concrete. Experimental investigation is carried out on this concrete. Properties of materials used for this concrete such as, cement, aggregate, metakaolin, water are tested, Observations and conclusions are drawn based on results obtain from experiment.

KEYWORDS

Metakaolin, slag, compressive strength, flexural strength, slump flow

I INTRODUCTION

Self-compacting concrete is basically a concrete which is capable of flowing in to the formwork, without segregation, to fill uniformly and completely every corner of it by its own weight without any application of vibration or other energy during placing. There is no standard self-compacting concrete. Therefore each self-compacting concrete has to be designed for the particular structure to be constructed. However working on the parameters which affect the basic properties of self-compacting concrete such as plastic viscosity, deformability, flow ability and resistance to segregation, self-compacting concrete may be proportioned for almost any type of concrete structure.

To establish an appropriate mixture proportion for a self-compacting concrete the performance requirements must be defined taking into account the structural conditions such as shape, dimensions, reinforcement density and construction conditions. The construction conditions include methods of transporting, placing, finishing and curing. The specific requirement of self-compacting concrete is its capacity for self-compaction, without vibration, in the fresh state. Other performances such as strength and durability should be established as for normal concrete. To meet the concrete performance requirements the following three types of self-compacting concretes are available.

II. INGREDIENTS OF SCC

Cement :- Generally Portland cement is used for SCC

Aggregates :- The maximum size of aggregate is generally limited to 20mm. Aggregate of size 10 mm is desirable for structures having congested reinforcement. Wherever possible size of aggregate higher than 20 mm could also be used. Well graded cubical or rounded aggregate are desirable. Particles smaller than 4.75 mm i.e. 475 micron size are considered.

Mixing water :- Ordinary Portland water of normally pH 7 is used for mixing and curing the concrete specimen.

Admixture for SCC :-

An admixture is a material other than water, aggregates and cement and is added to the batch immediately before or during its mixing. Admixtures are used to improve or give special properties to concrete.

Chemical Admixtures :

Viscosity modifying agent (VMA)

Other types may be incorporated as necessary, such as **Gleniums sky** is used for stability to improve freeze – thaw resistance and retarders

for control of setting.

Mineral admixtures

Fly ash :- fly ash in appropriate quantity may be added to improve the quality and durability of SCC.

Metakaolin :- by replacing some of the cement with metakaolin, rather than simply adding metakaolin to the mix, is that any existing color formulas and mix design won't change, or will only very slightly change, this is because that dosage of pigments and super plasticizers are based on the cement content in the concrete

Slag :- The replacement of the sand with slag shows an improved compressive strength and split tensile strength of concrete.

III. MIX DESIGN OF SSC

Mix proportion obtained for M40 mix as per modified NAN SU method. Cement was partially replaced by metakaolin in 0%, 5%, 10%, 15%, and 20%. Fine aggregate is partially replaced by slag in 0%, 10%, 20%, and 30%. Table 1 shows the quantities of materials used.

Table 1 Quantity of materials used

Sl.No.	Material	Quantity
1	cement	540.5 kg
2	Fly ash	167.7kg
3	Fine aggregate	800kg
4	Coarse aggregate	610 kg
5	Metakaolin	135 kg
6	slag	230kg
7	water	250ltr
8	Water powder ratio	0.48
9	Superplasticizers(Auramix – 400)	0.6% weight of cement
10	VMA(Auramix-V-100)	0.12% weight of cement

MIX PROPORTIONAL :- 1:1.78:1.48(C:FA:CA), 1:0.30(C:FLYASH)

IV. MEASUREMENT OF SSC FLOW PROPERTIES

As the SSC itself flow into the formwork and also require to flow into the congested reinforcement, its flow ability is need to be controlled by keeping in durability criteria. The following tests are conducted to measure the flow properties of SSC, fig.1 shows the details of testing types for SSC. Table 2 shows the results obtained for slump test and fig.2 and fig.3 shows the graphical representation of test results, table 3 shows the results obtained for L-box test and fig.4 and fig.5 shows

the graphical representation test results obtained, table 4 shows the results obtained for V funnel test and fig.6 and fig.7 shows the graphical representation test results obtained and table -5 shows the results obtained for V funnel test and fig.8 and fig.9 shows the graphical representation test results obtained. Further compressive ,tension and flexural tests are carried out to know the their respective properties.



a) 1 Slump flow test

b) L box test



c) V funnel test



d) J ring test

Fig.1 Method of concrete testing

Table 2 ; slump flow test results

Sl No	% age of Metakolin	% age of SLAG	Slump flow (mm)	Time in sec T50
1	5	10	710	8.54
		20	710	9.37
		30	700	10.33
2	10	10	690	8.46
		20	690	9.10
		30	700	9.54
3	15	10	720	8.03
		20	730	8.36
		30	720	9.50
4	20	10	730	7.48
		20	710	8.07
		30	690	8.58

Table 4 V - funnel test results

Sl No	% age of Metakolin	% age of Slag	Flow time in secs
1	5	10	7.43
		20	8.12
		30	8.54
	10	10	7.23
		20	8.02
		30	8.48
	15	10	7.10
		20	7.48
		30	8.15
	20	10	6.43
		20	7.21
		30	8.01

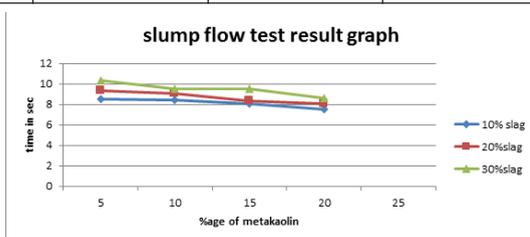


Fig.2 Slump flow test results of Slag

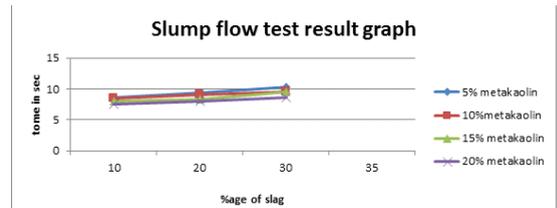


Fig.3 Slump flow test results of metakolin

L- BOX TEST

Table 3 : L- box test result

% Age Of Metakolin	% age of SLAG	Height H1 (mm)	Height H2 (mm)	Blocking ratio H2/ H1	Time taken to reach 200 mm (T20) sec	Time taken to reach 400 mm (T 40) sec
5	10	600	520	0.866	4.25	8.36
	20	600	550	0.916	5.12	9.44
	30	600	575	0.958	6.73	9.36
10	10	600	512	0.853	5.48	8.34
	20	600	526	0.876	4.36	7.22
	30	600	548	0.913	5.44	8.58
15	10	600	501	0.835	6.18	9.36
	20	600	524	0.873	5.58	8.24
	30	600	562	0.936	6.42	10.08
20	10	600	482	0.803	4.59	7.24
	20	600	516	0.860	7.45	10.42
	30	600	542	0.903	9.46	15.09

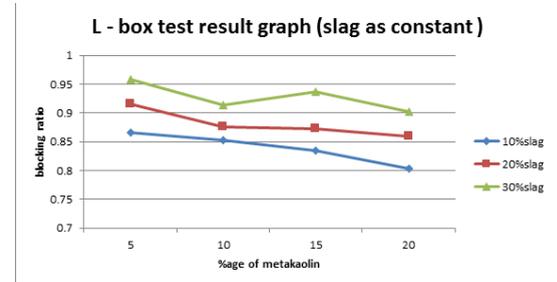


Fig.4 L-box test results of metakolin

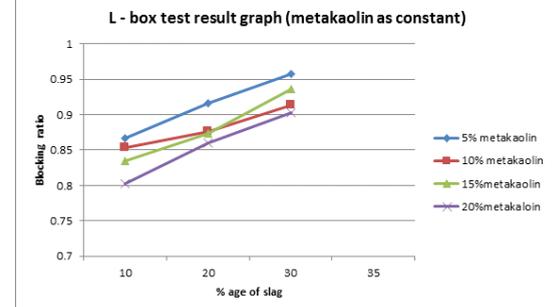


Fig.5 L-box test results of metakolin

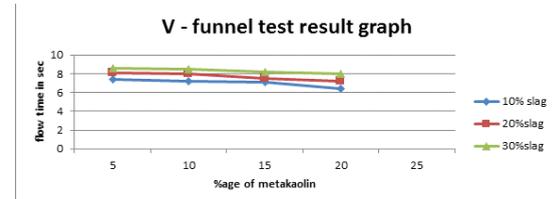


Fig.6 V-funnel test results of metakolin

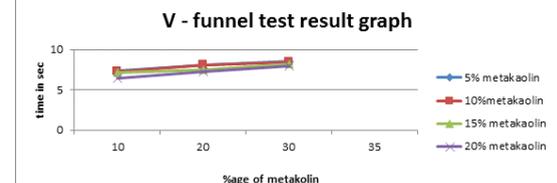


Fig.7 V-funnel test results of metakolin

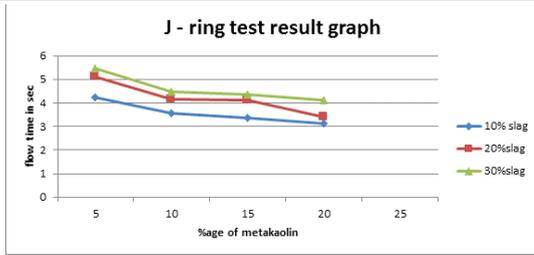


Fig.8 J- ring test results of Slag

Table 5 : J- ring test result

Sl No	% age of Metakoalin	% age of SLAG	Flow time in secs
1	5	10	4.25
		20	5.10
		30	5.48
2	10	10	3.58
		20	4.16
		30	4.48
3	15	10	3.38
		20	4.01
		30	4.34
4	20	10	3.11
		20	3.42
		30	4.10

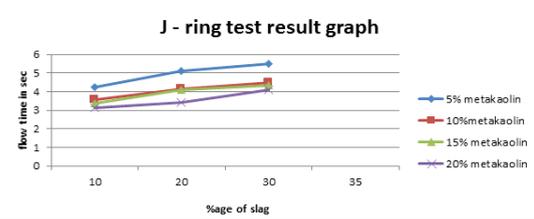


Fig.9 J- ring test results of metakolin

V. RESULTS AND DISCUSSION

Experimental tests are conducted as per IS code on SCC in the laboratory, results of SCC is tabulated in table 6 to table 9, correspond strength parameters are plotted in graph, fig.10 to fig.16 shows the details.

Table 6 shows the compressive strength of SCC after 14 days curing period with different composition, Table 7 shows the compressive strength of SCC with different combination of in percentage metakaolin and slag after 28 days of curing, fig.10 compressive strength V/S age for varying slag, fig.11 shows the compressive strength V/S age for varying metakolin and fig.12 shows compressive strength V/S age for varying slag. Table 8 shows the tensile strength of SCC with different %age of metakaolin after 28 days of curing and table 9 shows the flexural strength of SCC with different % age of metakaolin. Fig.13 shows the tensile strength V/S age for varying slag, fig.14 shows the tensile strength V/S age for varying slag, fig.15 shows flexure strength V/S age for varying slag and fig.16 describes the flexure strength V/S age for varying metakaolin.

Table 6 : Compressive Strength of SCC after 14 days with different Composition.

Sl No	% age of Metakolin	% age of Slag	Compressive stress(mpa)
1	5	10	24.67
		20	26.81
		30	26.21
2	10	10	27.47
		20	27.43
		30	26.82
3	15	10	26.16
		20	24.63
		30	26.38
4	20	10	26.82
		20	28.34
		30	22.02

Table 7 Compressive strength of SCC with different combination of in percentage metakoalin and slag after 28 days

Sl.No	% age of Metakoalin	% age of SLAG	Compressive stress(mpa)
1	5	10	42.92
		20	41.05
		30	39.69
2	10	10	41.31
		20	40.53
		30	38.83
3	15	10	40.73
		20	39.36
		30	37.18
4	20	10	39.42
		20	38.22
		30	36.43

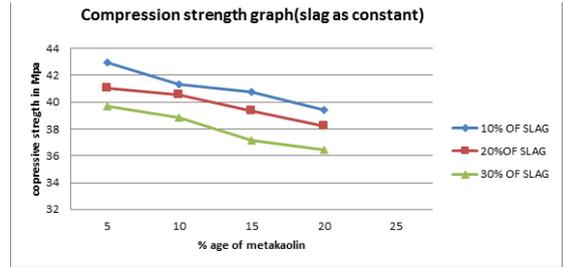


Fig.10 compressive strength V/S age for varying slag

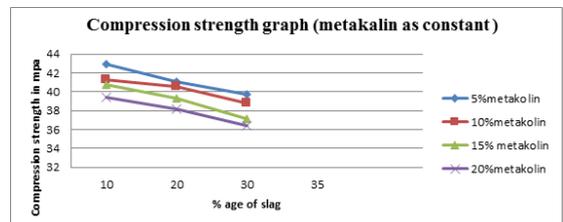


Fig.11 compressive strength V/S age for varying metakolin

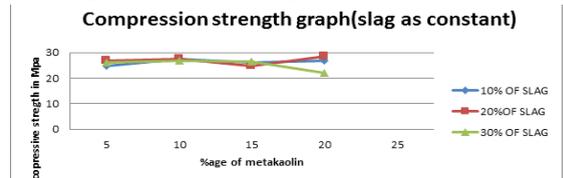


Fig.12 compressive strength V/S age for varying slag

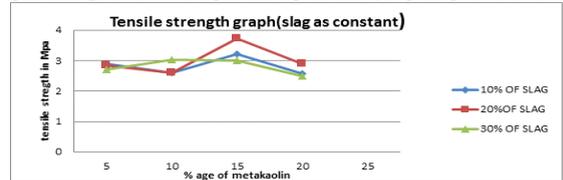


Fig.13 Tensile strength V/S age for varying slag

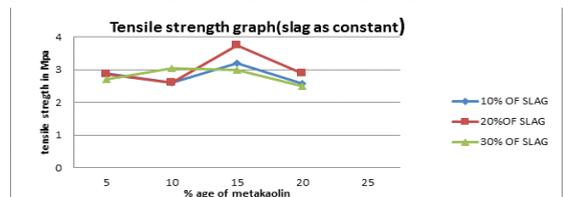


Fig.14 Tensile strength V/S age for varying slag

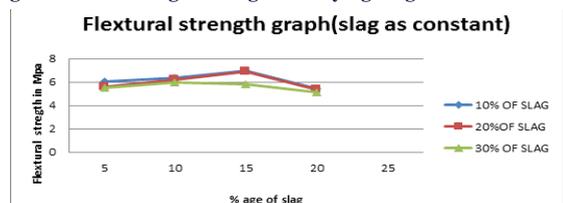


Fig.15 Flexure strength V/S age for varying slag

Table 8 : Tensile strength of SCC with different %age of metakaolin after 28 days

Sl No	% age of Metakoalin	% age of Slag	Tensile strength =2P/dl
	0	0	3.02
1	5	10	2.90
		20	2.85
		30	2.71
2	10	10	2.59
		20	2.61
		30	3.03
3	15	10	3.21
		20	3.73
		30	3.00
4	20	10	2.577
		20	2.90
		30	2.50

Table 9 : Flexural strength of SCC with different % age of Metakolin

Sl. No	% age of Metakolin	% age of Slag	Flextural strength =PL/BD2 (MPa)
1	5	10	6.05
		20	5.59
		30	5.22
2	10	10	6.35
		20	6.20
		30	6.00
3	15	10	7.01
		20	6.92
		30	5.85
4	20	10	5.41
		20	5.36
		30	5.11

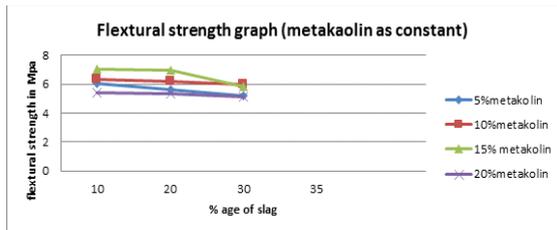


Fig.16 Flexure strength V/S age for varying metakolin

VI. CONCLUSION

- The compressive strength of self compacting concrete produced with the combination of admixtures metakaolin and slag which given results as when metakaolin goes on increasing up to 15% the strength decreases.
- The tensile and flexural strength of concrete is also increase up to 15% of metakaolin is replaced by cement. After 15% of addition in metakaolin the strength goes on decreasing because the metakaolin is the one of highly relative compound.
- The compressive strength decreases by increases in the percentage of the slag. The combination of the metakaolin and slag gives better result by adding in low percentage.
- The increases in the metakaolin will increases the flow ability of sec is found in slump and v – funnel tests, but increases in the percentage of slag will decreases the flow ability of sec.
- Increase in the percentage of metakaolin will decrease the blocking of reinforcement in sec it is found by L- box test , but the increase in the percentage of slag will increase the blocking of reinforcement.
- The passing ability of SCC increase with the increase in the percentage of metakaolin, but the flow ability decrease with the increase in the slag.
- The cost of this SCC is 10%-15% higher than the conventional concrete.

VII REFERENCES

1. M.SSHETTY Concrete Technology ,by S.CHAND publisher .EFNARC (www.efnarc.org)
2. SUBRAMNI. S .CHATTOPADHYAY. D. "Experiments for mix proportioning of self-compacting concrete ". The Indian concrete journal, Jan 2002.
3. Indian standard codes for concrete & guidelines .
4. CHAMPION, J.M and JOST, P., Self-compacting concrete, expanding the possibility

5. of concrete design and placement " concrete international , vol. 22 no. 4 pp . 159 -178 , June 1998 .
6. Kordts S., Grube H., Controlling the Workability Properties of Self-Compacting Concrete Used as Ready-Mixed Concrete. Düsseldorf, Germany, 2006.
7. The European Guidelines for Self-Compacting Concrete. EN 12350-1: 1999 E.
8. Okamura H., Ouchi M., Self-Compacting Concrete. J. of Adv. Technol., Japan Concrete Inst., 1, 1, 5-15 (2003).
9. Ouchi-Kochi M., Hibino-Nagaoka M., Development, Applications and Investigations of Self-Compacting Concrete. Japan, 2000.
10. Hajime Okamura and Masahiro Ouchi, Self-Compacting Concrete. Journal of Advanced Concrete Technology Vol. 1, No. 1, 5-15, April 2003.
11. N.Ganesan, P.V.Indira ,Santhosh Kumar.T.P "State of the art report of self compaxting concrete" Proceedings of the INCONTEST2003 on 10-12,September 2003 @ 2003 Kumaraguru College of Technology,Coimbatore-641006:India.
12. Compoin, M.J., and Phillippe Jost, Self Compacting Concrete: Expoding the Possibilities of Concrete Design and Placement, Concrete International, Apr.2000,pp31-34.
13. Andreas leemann, Frank winnefeld. The effect of viscosity modifying agent on mortar and concrete. Cement and concrete composite 29 (2007)341-349.
14. Erdogan ozbay, Ahmet oztas, Adil baykasoglu, Hakan ozbebek. Investigating mix proportion of high strength self compacting concrete by using taguchi method. Construction and building materials 23 (2009) 694-702.
15. Ali abd_Elhakam aliabdo, Abd_elmoaty Mohamed abd_elmoaty. Experimental investigation on the properties of polymer modified scc. Construction and building materials 34 (2012) pp-584-592.
16. Amit Mittal, Kaisare M.B. and Shetti R.G. 2004. Use of SCC in a pump house at TAPP 3 and 4, Tarapur the Indian Concrete Journal. June. pp. 30-34.
17. Bapat S.G, Kulkarni S.B. and Bandekar K.S. 2004. Using SCC in nuclear power plants-Laboratory and mock-up trials at Kaiga. The Indian Concrete Journal. June. pp. 51-57.