International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 04, April-2015

Numerical Optimization of Mix Propotioning of Self Compacting Concrete

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***Abstract*- Self Compacting Concrete is a special type of concrete which has the inherent characteristics to initiate high workability, reduced water content and more importantly its ability to pass through or consolidating even in the congested reinforcement nature. These properties of SCC are achieved only by the proper mix proportioning of its constituents. The constituents of SCC are High Range Water Reducing Admixture (HRWA) are superplastizers, Viscosity Modifying Admixture (VMA) and Air-Entraining Admixture (AEA). Many researchers worked on the optimization of mix proportioning of SCC and gave their research analogy but results recorded could not accommodate all the characteristics of SCC and more over the results are highly subjective. This research seeks to fill the gap between the academic and industrial practice so as to provide an unified characteristics and parametric empirical relation for the mix proportioning of SCC.**

Keywords— Air- Entraining Admixture, Concrete mix proportion, optimization, self compacting concrete, Viscosity Modifying Admixture.

I. INTRODUCTION

Self compacting concrete is a recently developed concrete form which is able to flow under its own weight and it does not require any external vibration for compaction. the concrete which require little vibration for compaction has been developed in 1970,but self compacting concrete(SCC)was developed in the late 1980's. In the case of highly dense reinforcement area SCC can be used because it is highly flowable concrete which can be easily spread into the reinforcement and it undergo consolidation without any external vibration and without segregation of concrete particles.

The mix proportions of SCC are based on creating a high degree of flowability while maintaining low w/c ratio (w/c<0.4). Superplasizers are used for maintain the moderate viscosity at low w/c ratio.The main application of self compacting concrete involves mat foundation, tunnel lining, and ductile columns in seismic area etc. and its highly stable nature leads to casting of deep sections in fewer lifts without the risk of segregation, bleeding, and settlement. This leads to decreasing the construction time and labour usage. Sometimes SCC can be used in the non congested structures where limitation of consolidation required and also in the case where duration of construction, noise etc limited.

One of the most important innovations in 20th century was concrete admixtures. Concrete chemical admixtures help to modify the properties of concrete in fresh and hardened states. Among these chemical admixtures the water reducers (plasticizers and superplasticers) can play a key role in controlling workability subsequently affect the strength and durability of structures. Admixtures can be used for increasing the workability, and also deceasing the bleeding and segregation this leads to the increasing the pump ability of concrete. The significant improvement of strength and durability is the consequence of minimized w/c ratio in the presence of plastizers and superplastizers.

II. REVIEW OF LITERATURE

Self compacting concrete is a concrete which undergo compaction without any external vibration. Researchers are developed some guidelines for mix proportioning of SCC such as increasing the paste volume and water cement ratio, reducing the volume ratio of aggregate to cementations material, using various viscosity modifying agents (VMA) at low w/c ratio[1]. The major tests which are used for identifying fresh concrete properties such as workability are slump test ring test, V funnel test, and U box and L box test[2]. At a water powder ratio between 1.18 to 1.125 which provide the flow ability as high and the test results are within the limits [3]. Chemical admixtures have an important role in increasing workability, and also these results in increased strength and durability. The admixtures have significant role in size of air pores in self compacting concrete [4].The superplastizers type has an important role in amount of air content in self compacting concrete, Regardless of the yield stress and viscosity of SCC[5]. While using chemical admixtures such as viscosity modifying agents and also entraining agents affects the flow properties of SCC.their proportion plays an important role in flow behaviour and also in the strength characteristics [6].

III.EXPERIMENTAL INVESTIGATION

The experimental investigation is divided into two parts such as material characteristics and method of experiments (slump test, J ring test, V funnel test,).

A. MATERIAL CHARACTERICS

1. Cement

The ordinary Portland cement of grade 53 with specific gravity 3.15 and initial setting was 35 minutes and final setting time was 365 minutes.

2. Micro air

It is an air entrained agent which produces small air bubbles that are uniformly distributed throughout the surface.in this experiment I used BASF micro air which is provided by BASF AB (Mumbai).it is based on a synthetic surfactant. The technical details of BASF micro air are as follows,

TABLE I PROPERTIES OF MICRO AIR

Density	1.0 ± 0.01 kg/dm ³
pH value	10.5-12.5
Chloride content	<0.01%
Alkaline content	1.24%
Storage time	12 months between 5 ° C and25 ° C BASF
Solids	11%+1%

FIGURE.1 BASF Micro air

3. Master Matrix

It a type of viscosity modifying agent which modifying the viscosity of concrete so exhibits superior stability and controlled bleeding characteristics thus high resistance to segregation. In this experimental procedure I used master matrix which produced by BASF. The technical features are,

TABLE II: PROPERTIES OF MATER MATRIX

Colour	Colorless free flowing liquid
Relative density	1.01 + 0.01 at 25°C
pH	>6 at 25°C
Chloride iron content	< 0.2%

FIGURE.2 BASF Master matrix

4. Aggregates

Good quality river sand was used as fine aggregate. The fineness modulus is 2.65, specific gravity 2.68,and dry density 1690 kg/m^3.

5. Water

Water helps to starts the reaction between cement and aggregate in concrete mix and also helps to cement hydration of mix.

B METHOD OF EXPERIMENTS

The purpose of assessment of self compatibility is to judge the concrete is self compactable or not and the other purpose is to evaluate viscosity for estimating proper mix proportioning if the concrete is not self compatible. The following tests are carried out for studying fresh properties of SCC,

Slump flow test(filling ability),slump flow T_{50cm} test(filling ability),J ring(Passing ability),V funnel(filling ability),V funnel at $T_{5\ minutes}$(segregation resistance),L box(passing ability), U box(passing ability).

1. Slump flow test

This test was carried out in accordance with DIN EN 12350-8 to measure filling ability and flow rate T500, which indicate plastic viscosity of the fresh concrete.

2. V-funnel test

This test was carried out in accordance with DIN EN 12350-9 to measure the flow time through the V-funnel. The plastic viscosity of fresh concrete can be evaluated based on the V-funnel flow time, and the arching effect of aggregate can be detected as well.

3. J-ring test

This test was carried out in accordance with DIN EN 12350-12 to assess filling ability and passing ability of fresh concrete between reinforcement bars. Universal testing machine at the end of each curing regime and the average strength was recorded.

4. L-box test

This test carried out to find out filling and passing ability of SCC. Also, serious lack of stability (segregation) can be detected visually.

5. U-box test

This test was developed by the Technology Research Center of the Taisei Corporation in Japan, and used to measure the filling ability of SCC.


FIGURE.3 slump flow test


FIGURE.4 L box


FIGURE.5 U box


FIGURE.6 V box

IV RESULTS AND DISCUSSION

Following table 3 shows the percentage variations of super plastizers (SP), viscosity modifying admixtures (VMA), air entraining agent (AEA) which will be taken for doing this experiment.

TABLE III PERCENTAGE VARIATION OF SP, VMA &AEA

Sample no.	%of VMA	%of AEA	% of SP
1.	0	0	1.1
2.	0	0	0.3
3.	0.1	0	1.1
4.	0.2	0	1.1
5.	0	0.5	1.1
6.	0	1	1.1
7.	0.1	0.5	0.3
8.	0.2	1.0	1.1

Table IV shows the mix proportions used in this experimental procedure..

TABLE IV MIX PROPORTIONS OF SCC

MIX PROPORTIONING OF SCC	
cement	530 kg/m^3
fine aggregate	836 kg/m^3
coarse aggregate	790 kg/m^3
w/c ratio	0.36

TABLE V TEST RESULTS

MIX.NO	EXPERIMENTS	MIX 1	MIX 2	MIX 3	MIX 4	MIX 5	MIX 6	MIX 7	MIX 8
1	slump flow(mm)	610	622	640	688	628	658	660	766
2	T-50 flow(sec)	6	5.7	5	2.3	5.4	3	2.7	2
3	J ring(mm)	3	4.83	6.17	7.03	5.07	7.2	7.73	8.5
4	V funnel(sec)	11	10.1	9	6	7.5	6.6	6	5
5	V funnel-5 mnts	3	2.5	2	1	3	2	1	1
6	L box(mm)	0.7	0.75	0.8	0.8	0.75	0.8	0.8	0.85
7	U box(mm)	30	26	24	22	30	22	22	18

From the table, the MIX 8 has the maximum filling ability, passing ability and also MIX 8 has high segregation resistance. And also MIX 1 has less filling and passing abilities, and its segregation resistance also very less.

TERNARY PLOT

Ternary diagram is a barycentric plot on three variables which sum to a constant. It graphically depicts the ratios of the three variables as positions in an equilateral triangle. For numerical optimization the data in table is converted into ternary plots.

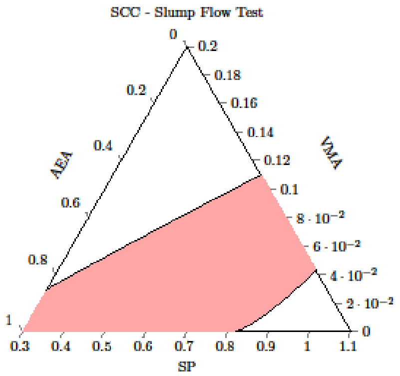

FIGURE.7 slump flow test

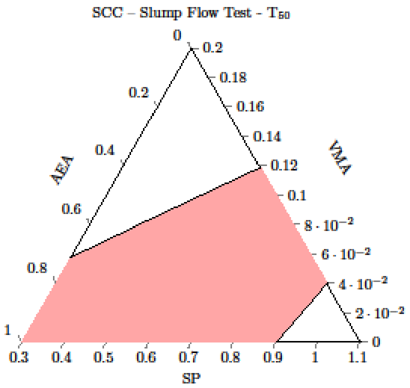

FIGURE.8 slump flow test-T_{50}

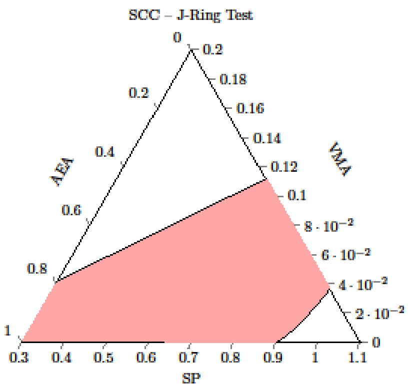

FIGURE.9 J ring test

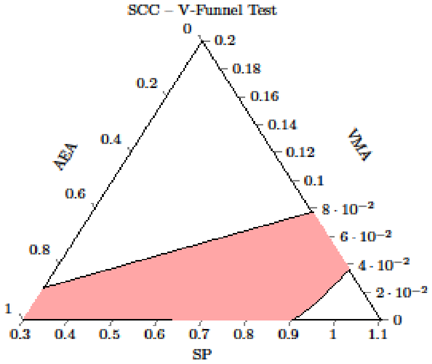

FIGURE.10 V funnel test

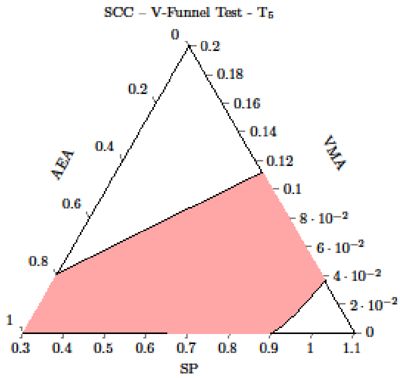

FIGURE. 11 V funnel test-T_5

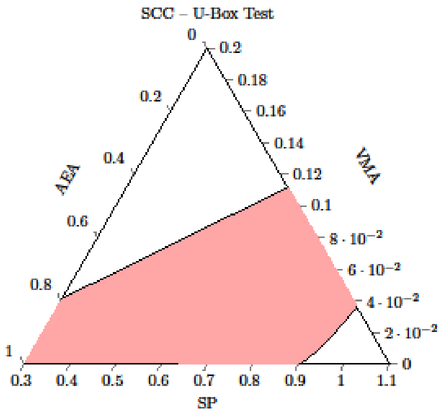

FIGURE. 12 U box test

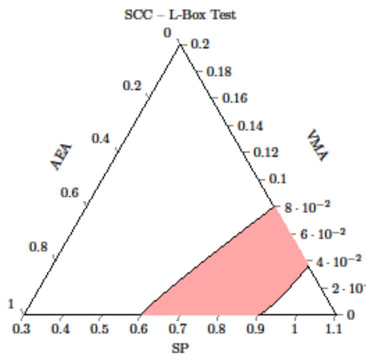

FIGURE. 13 L box test

From figures 7, 8 and 10 the optimized value for SCC which has good filling ability is obtained when the percentage of SP lies between 0.3 to 0.83 and percentage of VMA ,0.04 to 0.09 and AEA 0.7 to 1 percentage.

From figures 9, 12 and 13 the optimized value for SCC which has good passing ability is obtained when the percentage of SP lies between 0.6 to 0.9 and percentage of VMA 0.04 to 0.08 and AEA 0.8 to 1 percentage.

From figure 11 the optimized value for SCC which has good segregation resistance is obtained when the percentage of SP lies between 0.3 to 0.9 and percentage of VMA 0.04 to 0.11 and AEA 0.8 to 1 percentage.

The table VI shows linear regression equations corresponding to various tests when the dosage of superplasizer is maximum (1.1% of cement). x, y denotes the percentage of VMA and AEA.

TABLE VI LINEAR REGRESSION EQUATIONS

Tests	Linear regression equations
Slump flow	595.57+470.57x+65.31y
Slump T50	5.68-12.51x-1.79y
J ring	4.85+10.44x-1.78y
V funnel	9.50-12.52x-2.62y
V funnel T_5	2.45-12.52x-0.40y
U box	27.16-20.39x-4.24y
L box	0.74+0.35x+0.05y

V CONCLUSION

The regression equation table tailored to describe the feasible region corresponding to the optimum mix proportion of SCC in the ternary plots. Depending on the type of test for SCC and the standard flow characteristics of SCC, we have to refer the corresponding regression equation. Hence a retrospective and prospective assessment of SCC can be readily used for the construction purpose.

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