Design and Cost Economic Analysis of Self Compacting Concrete for Mivan Shuttering

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***Abstract*- This paper summarizes the experimental work performed to design a self-compacting concrete for Mivan shuttering and cost analysis of cost of the designed per m^3 concrete. High grade SCC of grade M50 was designed using mineral and chemical admixtures. Workability tests such as Flow table test, V funnel test and U box tests were conducted. Compressive Strength test was performed out on hardened 150mm concrete cubes after 3, 7, & 28 days curing in water. The output of the research work was a highly workable concrete which could be used for densely reinforced sections of Mivan shuttering.**

***Index Terms* - Self-Compacting Concrete, Mivan shuttering, Micro Silica, Super plasticizer, Workability, Compressive strength.**

I. INTRODUCTION

There have been several studies on the design of Self consolidating concrete. Mix has been designed using various chemical and mineral admixtures. Also there has been extensive research on Mivan/Aluminium shuttering. Hajime Okamura and Masahiro(2003)[1] developed first self compacting concrete in the year 1988.The concrete was termed as "High Performance Concrete". Desigining a self-compacting concrete using various proportions are been mentioned.

B.H.V Pai and M.Nandy(2014) [2] Explored the use of industrial byproducts as a partial replacement of cementing material for enhanced performance of concrete. This practice helps in reuse of the waste material and also creates a cleaner and greener environment. The paper deals with comparison of performances of SF and GGBS based SCC mixes. Dr.Needhidasan Santhanam(2014) [3] explored the use of self compacting concrete as a boom to construction industry. The development of self compacting concrete is also explained. Komas K.Sideris(2007) [4] studied the mechanical characteristics of self-consolidating concrete subjected to elevated temperatures up to 700 degree C.

Philippe Turcry(2006) [5] explained cracking tendency of self compacting concrete subjected to restrained shrinkage . SCC Cracking was investigated through a comparison of material properties, such as shrinkage, modulus of elasticity, creep, and fracture parameter, between SCC mixture and ordinary concrete (OR) mixture.

Mohammed Ibrahim Khan [6] Designed M50 Grade of Concrete (H.P.C & S.C.C) by using Ferro Alloy Silicon Slag as Fine Aggregate. Kushal Patil(2015) [7] Carried out comparative study between Mivan technology and conventional construction technology . The Mivan technology is absolutely fine with quality, cost and time saving as compare to conventional. Shankar Bimal Banerjee(2015) [8] reported a case study of use of Mivan shuttering for Godrej Premium Builders Private Limited at Gurgaon along with and the cost analysis of the shuttering.

C.M.Dordi(2004) [9] explained the methodology to design a self-compacting concrete without bleeding or segregation.

II. MATERIALS & METHODS

Materials

1. Cement- Ambuja OPC 53 grade of cement was used.
2. Flyash- Ashtech (India) Class F Flyash was used.
3. Micro Silica- Micro Silica was obtained from Bhutan.
4. Coarse Aggregate- Coarse Aggregates of size 10mm was used for this research work. It was sourced from a quarry in Turbe in Mumbai, India.
5. Fine Aggregate- Fine Aggregates used for this research work was crushed sand (VSI). It was sourced from a quarry in Turbe in Mumbai, India.
6. Water- Water was obtained from a boring. . It conformed to IS 456-2000 requirements.
7. Admixture- A highly effective superplasticizer Sikaviscocrete5210NS was being used.

Mix Design

In this Experimental Work Department of Environment (DOE) Method of Mix Design was used for manufacturing concrete of grade M50. DOE method is standard British method of concrete mix design.

Table no 1: Trial No 1

Trial Number 1		
M50 SCC	1 CUM (Kg)	%
Cement	430	70.49
Flyash	160	26.23
Micro Silica	20	3.28
C/Sand	881	55.03
C.A 1	720	44.97
A/C	2.62	
W/C	0.29	
Admix 0.9%	0.90%	

Table no 2: Workability test result of trial no 1

Time	**Actual**	**Required**
1 Flow table Test		
Initial	700mm	<600mm
1 hour	685mm	<600mm
2 hour	610mm	<=600mm
2) V Funnel test		
T0	11 sec	8-12 Sec
T5	15 sec	11-15 Sec
3) U box Test		
h1-h2	28mm	<=30mm

Table no 3: Compressive Strength test result of trial no 1

Trial no 1						
Sr. no	Grade	Age (Days)	Weight (Kg)	Load (KN)	Strength (N/mm^2)	Avg (N/mm^2)
1	M 50 SCC	3	8.523	800.7	35.59	
2		3	8.511	815.5	36.24	35.87
3		3	8.489	804.8	35.77	
4	M 50 SCC	7	8.494	1062.6	47.23	
5		7	8.502	1058.4	47.04	47.07
6		7	8.505	1055.9	46.93	
7	M 50 SCC	28	8.513	1491.1	66.27	
8		28	8.498	1492.3	66.32	66.25
9		28	8.507	1488.5	66.16	

The trial was totally successful in both the aspects i.e. strength and workability. The compressive strength test results were excellent it was decided to take a trial without addition of micro silica in it. Micro Silica is responsible for high initial strength gain and as the compressive strength results were excellent, use of Micro Silica can be eliminated.

This will also be helpful in reducing the overall cost of concrete.

So the use of micro silica was eliminated keeping the other cementitious materials unchanged, also minor modifications were done in the mix.

Table no 4: Trial no 2

Trial Number 2		
M50 SCC	1 CUM (Kg)	%
Cement	430	72.88
Flyash	160	27.12
Micro Silica	0	0.00
C/Sand	780	47.56
C.A 1	860	52.44
A/C	2.78	
W/C	0.29	
Admix 0.8%	0.80%	

Table no 5: Workability test result of trial no 2

Time	**Actual**	**Required**
1 Flow table Test		
Initial	680mm	<600mm
1 hour	650mm	<600mm
2 hour	630mm	<=600mm

2) V Funnel test		
T0	8 sec	8-12 Sec
T5	12 sec	11-15 Sec
3) U box Test		
h1-h2	23mm	<=30mm

Table no 6: Compressive Strength test result of trial no 2

Trial no 2						
Sr. no	Grade	Age (Days)	Weight (Kg)	Load (KN)	Strength (N/mm^2)	Avg (N/mm^2)
1	M 50 SCC	3	8.483	650.8	28.92	
2		3	8.491	625.8	27.81	28.36
3		3	8.501	637.5	28.33	
4	M 50 SCC	7	8.516	748.5	33.27	
5		7	8.519	741.6	32.96	33.04
6		7	8.525	740.4	32.91	
7	M 50 SCC	28	8.513	1184.8	52.66	
8		28	8.522	1192.2	52.99	52.85
9		28	8.533	1190.5	52.91	

The workability test results were excellent as shown in Table no 5. But the compressive strength test results were not upto the mark as the initial strength was quite low.

The site requirements was to deshutter the section within a day. Therefore the change in the mix was required to meet the site conditions.

So the percentage of OPC was increased from 72.88% to 73.77% keeping flyash content constant. So the total cementitious material got increased form 590/Cum to 610/Cum.

Due to the increase in cementitious material, it was expected that the initial strength of the concrete would boost up.

Table no 7: trial no 3

Trial Number 3		
M50 SCC	1 CUM (Kg)	%
Cement	450	73.77
Flyash	160	26.23
Micro Silica	0	0.00
C/Sand	780	47.56
C.A 1	860	52.44
A/C	2.69	
W/C	0.29	
Admix 0.8%	0.80%	

Table no 8: Workability test result of trial no 3

Time	**Actual**	**Required**
1 Flow table Test		
Initial	670mm	<600mm
1 hour	650mm	<600mm
2 hour	620mm	<=600mm
2) V Funnel test		
T0	8 sec	8-12 Sec
T5	13 sec	11-15 Sec
3) U box Test		
h1-h2	24mm	<=30mm

Table no 9: Compressive Strength test result of trial no 3

Trial no 3						
Sr. no	Grade	Age (Days)	Weight (Kg)	Load (KN)	Strength (N/mm^2)	Avg (N/mm^2)
1	M 50 SCC	3	8.546	678.3	30.15	
2		3	8.518	681.4	30.28	30.34
3		3	8.534	688.2	30.59	
4	M 50 SCC	7	8.513	859.5	38.20	
5		7	8.523	868.3	38.59	38.29
6		7	8.527	856.7	38.08	
7	M 50 SCC	28	8.551	1307.7	58.12	
8		28	8.546	1331.1	59.16	58.74

9		28	8.537	1325.9	58.93	

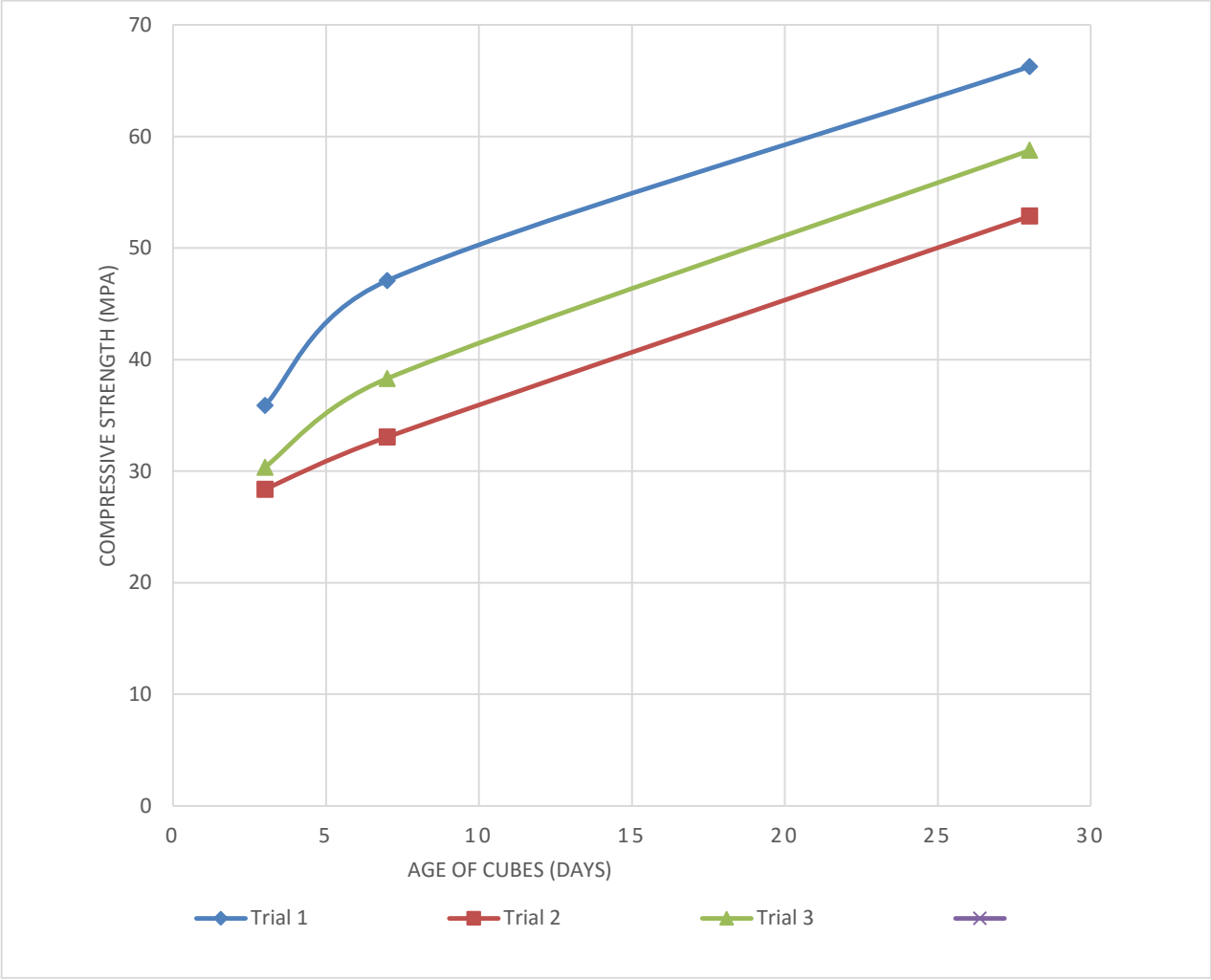
Both the parameters i.e. workability and compressive strength were achieved.
The modified mix is very much suitable for site conditions because of high workability and early strength gain.
Optimization of micro silica and super plasticizer was done, by doing this the overall cost of the concrete got reduced.
This is how cost optimization was done without compromising with the quality of concrete.

III. Results And Cost Analysis

Compressive Strength test was carried out on hardened 150mm concrete cubes after 3, 7, & 28 days curing in water. Following are the results of compressive strength of all trails.

As shown in figure 1, the compressive strength of trial number 1 was excellent. Therefore the use of micro silica was eliminated. But the compressive strength of trial number 2 was not upto the mark. So after the changes in the mix and addition of OPC, the compressive strength of trial number 3 was good and very much suitable for site conditions. Trial no 3 shows good compressive strength results even without the use of micro silica.

Figure 1- Compressive strength test results



Following are the current unit rates of the ingredients of concrete.

Table no 10: Unit rates

Materials	Rates (Rs)	Unit
Cement	6	Per Kg
Flyash	2.273	Per Kg
MicroSilca	33.75	Per Kg
c/sand	4600	Per Brass
10mm	3350	Per Brass
20mm	3350	Per Brass
Water	0.2	Per Kg
Sikaviscocrete 5210 NS	163.18	Per Kg

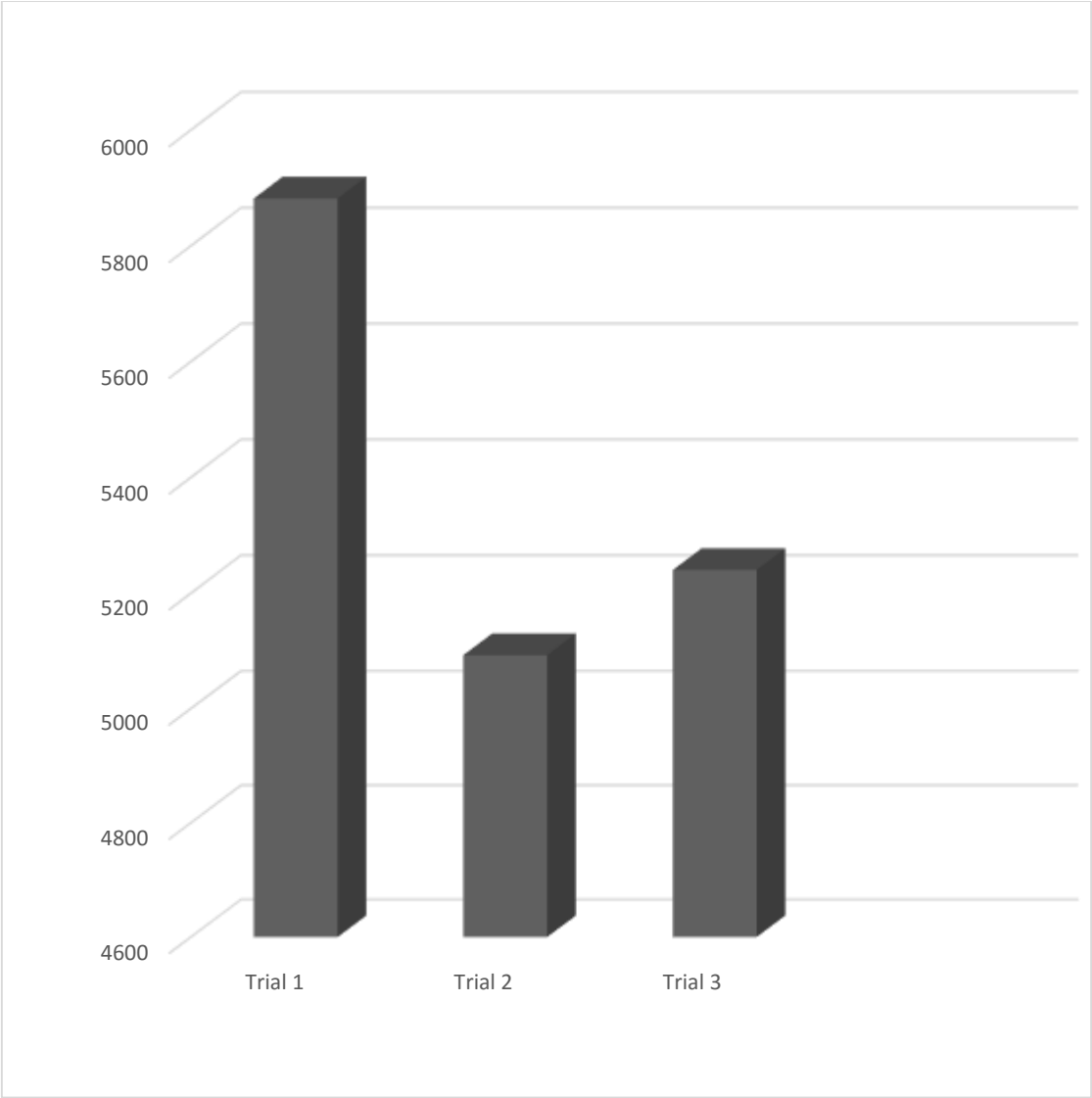


Figure 2- Cost Analysis

Total cost per cubic meter of the concrete is shown Figure 2. Trial 2 was very economical as compared to other trials, but due to strength criteria it was discarded. The total cost of trial number 1 was highest among all the trials therefore modifications in the next trial lead to optimum use of cementitous materials and cost minimization was done. Trial number 3 was very economical as there was optimum use of OPC and Micro Silica. This is how cost optimization was done.

IV. Conclusion

Micro Silica content in per cubic meter of concrete increases the compressive strength but it also increases the overall cost of concrete as it is most expensive cementitious material used. Therefore optimum use of Micro Silica has to be done for economical concrete mix.

Use of crushed sand directly affects the workability of concrete. High percentage of fines in crushed sand i.e. high percentage of 75 micron passing crushed sand would result in cohesive mix but it won't be workable and low percentage of crushed sand would result in high workability along with initial bleeding. Therefore the percentage calculation of crushed sand must be very accurate for desirable workability.

The mix has to be cohesive and therefore the amount of fines in the concrete must be sufficient.

Workability is the governing factor of self compacting concrete. Workability has to be adjusted in such a way that it meets the site requirement.

One of the most important site requirement is that the deshuttering of the section has to be done within 24 hours, therefore the initial compressive strength must be high. Therefore cementitious content in the concrete mix must be on higher side.

V. Acknowledgment

We would take this opportunity to thank all those people who helped us to execute this research work. We would extend our special thanks to Navdeep Construction Company for providing their Lab and Lab staffs for various trials. Special thanks to Mr.Sanjeev Raje, V.P technical-NCC for his expert guidance.

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