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COMPARATIVE ANALYSIS OF MICRO-SILICA AND ULTRAFINE FLY ASH IN HIGH GRADE CONCRETE AND COST OPTIMISATION

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Abstract— This paper summarizes the research work performed to design comparative analysis of micro-silica And ultrafine fly ash in high grade concrete and analyzing per cum cost of the designed concrete. High grade concrete was designed using mineral and chemical admixtures. Workability tests such as Flow table test were conducted. Compressive Strength test was carried out on hardened 150mm concrete cubes after 3, 7, & 28 days curing in water. The output of the research improves cohesiveness, workability and workability retention in fresh state.

The long term strength and permeability characteristics are also favorable. To have acquired benefits with p100 ultrafine, trials are carried out to establish p100 ultrafine as a preferred additive for high performance fly ash based concrete.

1. INTRODUCTION

High strength and high performance concrete are gaining popularity day by day in the construction industry worldwide. Practically high strength concrete is generally said to be having high cement content and very low water cement ratio. The concrete prepared in such a manner suffer from majorly two types of weaknesses. Firstly, it is difficult to achieve workability and secondly to retain the workability for sufficiently long time with such concrete mixes. To overcome these weaknesses, it becomes necessary to use high dosage of high range water reducing agents (HRWR) i.e. admixture as cohesive and sticky mixes are equally difficult to place and compact fully and effectively. So the water to be used in the mix possesses to have critical limit below which high HRWR dosage become undesirable and is harmful from the durability considerations. Mostly supplementary cementitious material (SCM) like silica fume, ultrafine are proposed against HRWR where high strength of concrete mix and low permeability are the main consideration for developing high strength concrete. But these are often ineffective by the increased water or admixture dosage for workability of the Green concrete

The two major concerns that the Indian cement and construction industry is facing in recent times are reduction of CO2 foot print of cement and achieving sustainability. One of the ways to reduce CO2 foot print is to use optimum content of cement (ordinary Portland cement) and its maximum replacement by pozzolana and cementitious materials of industrial by-products. Field applications indicated that up to 30% and 70% cement replacement is possible by fly ash respectively.

MICRO-FINE FOR HIGH GRADE CONCRETE

Today's concrete consists of various chemical and mineral admixtures to meet the rising demands for constructability, service life and performance. In addition to Portland cement, supplementary cementitious materials such as fly ash, slag and silica fume have become commonplace in concrete, particularly in situations where the concrete is exposed to aggressive environments. More recently, engineered pozzolans have been introduced that give early age reduction in permeability similar to silica fume, while contributing to long-term refinement of pore structure and reduction in porosity. These products have been termed "highly reactive pozzolans" and include ultrafine fly ash, meta-kaolin, rice husk ash, zirconium fume and others.

II. MATERIALS AND METHODS

A. Materials

1. Cement- Ambuja OPC 53 grade of cement was used.
2. Fly ash- Jaycee -jsw (India)class F fly ash
3. Micro Silica- Micro Silica was obtained from Elkem Bluster Company.

4. P100 ultrafine fly ash (micro fines)-(Dirk India privet limited from Nashik)

5. Coarse aggregate- Coarse Aggregates of size 10mm and 20 mm was used for this research work. It was sourced from a panvel in Mumbai, India.

6. Fine aggregate-Fine Aggregates used for work was crushed sand (VSI). It was sourced from uran in Mumbai, India.

7. Water- Water was obtained from a boring.

8. Admixture- A highly effective super plasticizer Sikaviscocrete5210NS was being used.

B. Mix Design

The objective of any mix design method is to determine an appropriate and economical Combination of concrete ingredients that can be used for a first trial batch to produce certain concrete which is close to that can achieve a good balance between various desired properties of concrete at the minimum cost. A mixture proportioning only provides a starting mix design that will have to be more or less modified to meet the desired concrete characteristics. In this experimental work, Department of Environment (DOE) Method of mix design.

The baseline was obtained by DOE method of mix design and the modifications were done on the basis of the workability and compressive strength tests results of the trials. The aim was to design high grade high strength concrete with better workability and to optimize the cost of concrete.

Table 1- Trail Number 1

Trial Number 1		
M75	**Mix (kgs)**	**1CUM**
Cement	485	69.78%
Fly ash	160	23.02%
Micro Silica	50	7.19%
Total cement	**695**	**100%**
C/Sand	645	39.57%
CA-1	420	25.76%
CA-2	565	34.66%
Total agg.	**1630**	**100%**
Water	153	-
A/C	2345	-
W/C	0.220	-
Admixture	**6.25**	**0.90%**

Table 2- Workability test results of trail 1

Trial no 2		
Time	**Actual**	**Required**
1.Flow Table Test		
Initial	700mm	>600mm
1 hour	700mm	>600mm
2 hour	650mm	>600mm

Table 3- Trail Number 2

Trial Number 2		
M75	**Mix (kgs)**	**1CUM**
Cement	485	69.78%
Fly ash	160	23.02%
P100 UFFA	50	7.1%
Total cement	**695**	**100%**
C/Sand	645	39.57%
CA-1	420	25.76%
CA-2	565	34.66%
Total agg.	**1630**	**100%**
Water	153	-
A/C	2.345	-
W/C	0.220	-
Admixture	**5.56**	**0.80%**

Table 4- Workability test results of trail 2

Trial no 1		
Time	**Actual**	**Required**
1.Flow Table Test		
Initial	690mm	>600mm
1 hour	650mm	>600mm
2 hour	600mm	>600mm

In above 2 trials by DOE method we have taken appropriate mix for m75 grade with 50 kilos of micro silica and ultrafine fly ash to find out workability and compressive strength results with minimum water cement ratio. 1^{st} 2 trials are apple to apple comparison to differentiate both micro-fines. There is 7.19% of micro- silica and ultrafine fly ash of total cementations material as per required strength factors. 9 cubes of size 150 mm were casted for compressive strength test. After 3 days and 7 days compressive strength test results, it was found that initial strength gain was up to the mark. All 3days, 7days and 28 days results show in compressive testing graph below. The results are higher than our target strength so we can optimize mix further to optimize cost. The test on fresh concrete indicate that the ultrafine fly ash and micro silica gives more workable concrete and more strength results than required target strength. So, for further optimization of mix we will take other trials with reduce percentage of ultrafine fly ash in design mix to see results.

Table 5- Trail Number 3

Trial Number 3		
M75	**Mix (kgs)**	**1CUM**
Cement	485	70.29%
Fly ash	160	23.19%
P100 UFFA	45	6.52%
Total cement	**690**	**100%**
C/Sand	645	39.45%
CA-1	425	25.99%
CA-2	565	34.56%
Total agg.	**1635**	**100%**
Water	152	-
A/C	2.3695	-
W/C	0.22	-
Admixture	**5.17**	**0.75%**

Table 6- Workability test results of trail 3

Trial n		
Time	**Actual**	**Required**
1.Flow Table Test		
Initial	680mm	>600mm
1 hour	640mm	>600mm
2 hour	580mm	>600mm

In trial no 3 after revised mix with same water cement ratio to get more optimize concrete mix design we reduced Ultra-fine fly ash to 6.52%(5kilos less than trial no 2) and to maintain same water cement ratio decreased in 1 liters of water also consuming less super plasticizer doses of 0.75%. To adjust the volume and density of concrete increased in 5 kilos of 10mm. After the trial result indicates that with 5 kilos less ultrafine it's very much difference in results of workability than 2nd trial. In above mix the decreased in workability due to less admixture doses. 9 cubes of size 150 mm were casted for compressive strength test. The result indicates that we can further optimize the mix. .

Table 6- Trail Number 4.

Trial number 4		
M75	**Mix(kgs)**	**1CUM**
Cement	485	70.80%
Fly ash	160	23.36%
P100 UFFA	40	5.83%
Total cement	685	100%
C/Sand	645	39.33%
CA-1	425	25.91%
CA-2	570	34.76%
Total agg.	1640	100%
Water	151	-
A/C	2.3941	-
W/C	0.22	-
Admixture	5.17	0.75%

Table 7- Workability test results of trail 4

Trial no 4		
Time	**Actual**	**Required**
1.Flow Table Test		
Initial	680mm	>600mm
1 hour	620mm	>600mm
	540mm	>600mm

In trial number 4 we revised mix with same water cement ratio to get more optimize concrete mix design. Ultra-fine fly ash used is 583% i.e. decreased 10 kilos than original mix. The volume is adjusted with aggregates 10mm and 20mm which is 25.91% and 34.76% respectively for proper mix. Trial results indicate that workability results obtained for 2hour is not satisfactory at site condition as admixture doses are also less. 9 cubes of size 150 mm were casted for compressive strength test. After 3 days and 7 days compressive strength test results, it was found that initial strength gain was not up to the mark. This trial is very effective as per cost reduction but it is fail in compressive strength. So it proves that the mix with ultrafine fly ash can't go below the 40 kilos of total cementitious material. For further optimization we will take trial with 40kgs of micro silica with above same mix.

Table 8- Trail Number 5.

Micro Silica	40	5.83%
Total cement	685	100%
C/Sand	645	39.33%
CA-1	427	25.91%
CA-2	570	34.46%
Total agg.	1640	100%
Water	151	-
A/C	2.3941	-
W/C	0.220	-
Admixture	5.48	0.80%

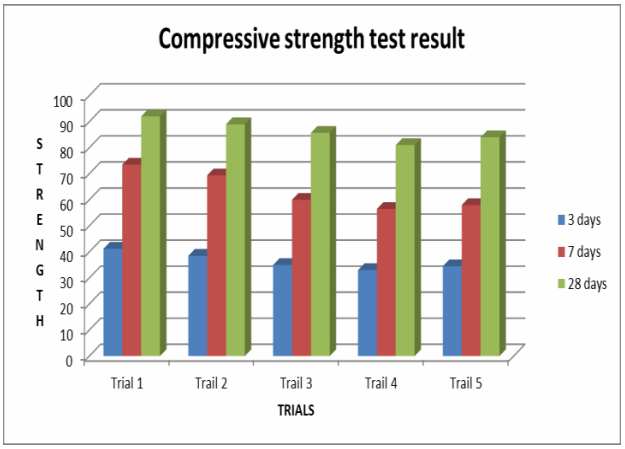
Table 9- Workability test results of trail 5

Trial no 5		
Time	**Actual**	**Required**
1.Flow Table Test		
Initial	650mm	>600mm
1 hour	610mm	>600mm
2 hour	550mm	>600mm

In trial no 5th used of micro silica was 5.83% i.e. 10 kilos reduction than original mix and with adjust volume in mix like trial number 4th, with same water cement ratio results indicates that workability of concrete is satisfactory than trial number 4^{th} because of high admixture doses. . 9 cubes of size 150 mm were casted for compressive strength test. After 3 days and 7 days and 28 days compressive strength test results, it was found that results achieved target strength as shown in table below. We can't further optimize this mix because of risk of failure in compressive strength results.so we will stop our experimental program here and further proceed for our graph of cube test results and cost optimization of each trial.

III. RESULTS & 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 per IS code 10262 target strength for mix proportion is fck` =fck +1.65*s, so as per this formula our required target strength is 83 mpa for 28 days. As shown in figure 1, compressive strength of trial number 1st and 2nd were very higher from our target strength. Therefore the water cement ratio was same and supplementary cementitious material was decreased. Also compressive strength of trial 3 was very high, so for further optimization of mix SCM were reduced in trial number 4.But trail number 4th with 40 kilos micro silica failed in compressive strength. For further optimization of mix trail number 5th with 40

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

Table 9- Unit rates

Materials	Rates (Rs)	Unit
Cement	5	Per Kg
Flyash	2.5	Per Kg
MicroSilca	28.50	Per Kg
P100 UFFA	25.00	Per Kg
c/sand	5400	Per Brass
10mm	4100	Per Brass
20mm	4100	Per Brass
Water	0.7	Per Kg
Sikaviscocrete 5210 NS	139	Per Kg

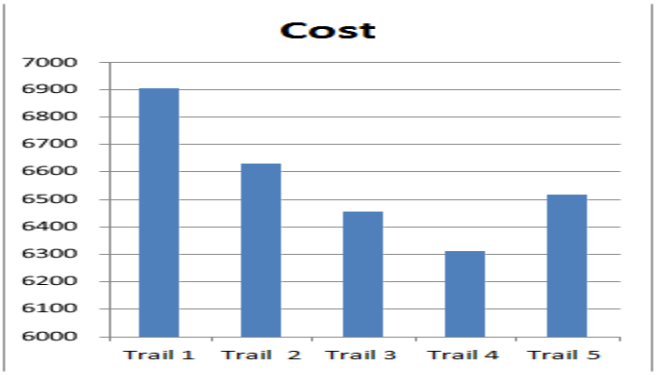


Figure 2- Cost Analysis

Total cost per cubic meter of concrete is shown in figure 2. From cost of each trial, we found out that trial number 1st and 2nd were not very economical as compared to other trials. Trial taken with ultra-fine fly ash (40kgs) is most economical and cheaper than other trials but it is failed in compressive strength as per required 28 days strength. Cost of trial number 1 is highest of all with 50 kgs micro- silica, so by optimizing mix we get the cost lower than original mix design which passes in compressive strength. Trial number 5th with 40kgs of micro silica which passed in compressive strength and its cost is also less than its original mix design cost. If we look into the cost of 1st trial and last trial its difference is approx. 400 to 500 rupees per cubic meter which is very much suitable in this industry as per the market values.

kilos of micro silica indicates that it achieved target strength of 28 days. If we reduce further more percentage of micro silica it will be fail in compressive testing results. So the trial 5th is optimum mix design.

IV. CONCLUSIONS

The present experimental investigation was aimed to designed high grade concrete with lower cost and higher workability and strength results and analyses its cost. Some of the broad conclusions deduced from the present study are as follows:

- Micro Silica content 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. So as compared with ultrafine fly ash cheaper than micro silica and also gives better results in workability and slightly less in compressive test.
- 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 and strength is the governing factor of high grade concrete. Workability has to be adjusted in such a way that it meets the site requirement.
- One of the most important site requirements is that the DE shuttering of the section must be done within 24 hours, therefore the initial compressive strength must be high. So, cementitious content in the concrete mix must be on higher side.

Cost optimization of Concrete: The cost of the concrete was optimized as shown in the above results.

At RMC :

Quality: Quality of the concrete was checked Considering all 3 important parameters i.e. Strength, Durability and workability. Optimization of Micro Silica and ultra-fine fly ash: The final mix was designed in such a way that the optimal use of ultrafine fly ash and micro-silica was done

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