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Analysis on Mix Design of High Strength Concrete (M90)

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Abstract - The objective of proportioning concrete mixes is to arrive at the most economical combinations of different ingredients to produce concrete that will satisfy the performance requirements under specified conditions of use. The necessity of high performance concrete is increasing because of increasing demand of construction material in construction industry. *The compressive strength of concrete is its most important and useful properties. Research paper includes the mix design of high strength concrete with characteristic compressive strength of 99.4 N/mm2 according to IS 456:2000 and IS 10262:2009. The present experiment is based on the principle that fine aggregate should fill all the voids in the coarse aggregate and the cement should fill all the voids in the fine aggregate. The aggregate having less voids gives stronger concrete. Such a combination of fine and coarse aggregate will require minimum amount of cement and will be most economical for a given water-cement ratio and slump. The proportion of fine to coarse aggregate which gives maximum weight of combined aggregate can be obtained by trial. Superplasticizer is used to decrease the water cement ratio while increasing density and bond strength. We use master gelenium as superplasticizer in this research. High strength concrete can be made by using low water to cement ratio. This research is carried out to study the mix design of high strength concrete of grade M90*.

***Key Words*: Water Reducer, silica fume, super plasticizer, compressive strength, slump**

I.INTRODUCTION

High strength concrete is made carefully by selecting high quality ingredients and optimized mixture designs. These are batched, mixed, placed, compacted and cured to the highest industry standards. Typically, such concrete have low water -binder ratio due to very low w/b ratio of about 0.25 - 0.3, superplasticizer are required to achieve adequate workability. The use of mineral admixture is also strongly recommended. The coarse aggregates must be round or cubic in shape. HSC is a High strength concrete is made carefully by selecting high concrete which possess high durability and high strength when compared to conventional concrete. This concrete contains one or more cementitious materials such as fly ash silica fumes or ground granulated blast furnace slag and usually a super plasticizer. Many trials are carried out which acts as accurate guide to select the best combinations of ingredients so as to achieve the desired properties. Design of concrete mix requires complete knowledge of the various properties of these constituent materials.

PC (polycarboxylate ether) or naphthalene based super plasticizers are used because they will reduce more than 30% of mixing water than the normal super plasticizers.

For high strength concrete (M 60 and above) mixes, generally OPC 53- grade, a PC based super plasticizer (which can reduce 30% of the mixing water) and 5-10% silica fume will be required.

In this research, the concrete having grade M90 is mix designed.

II. LITERATURE REVIEW

There are various research reports available on the various properties of concrete.

1.Ghutke & Bhandari	They observed be influence of silica fumes on concrete. Results showed that the silica fume is a good replacement of cement. The rate of strength gain in silica fume concrete is high. Workability of concrete decreases as increase with % of silica fume. The optimum value of compressive strength can be achieved in 10% replacement of silica fume. As strength of 15% replacement of cement by silica fume is more than normal concrete. The optimum silica fume replacement percentage varies from 10 % to 15 % replacement level.
2.Jain &Pawade	They studied the characteristics of silica fume concrete .The physical properties of high strength silica fume concrete and their sensitivity to curing procedures were evaluated and compare with reference Portland cement concrete having either the same concrete content or the same water to cementitious material ratio. The experimental program comprised of six level of silica fume content (as partial replacement of cement) at 0%,5%,10%,15% with and without superplasticizer. Durability of silic fume mortar was tested in chemical environment of sulphate compounds, ammonium nitrate and various kind of acids.

III MATERIALS USED

The ingredients of high strength concrete are: Cement, Fine aggregate, Coarse aggregate and water. Admixtures may be used to enhance some properties of the concrete.

1 .Cement

Cement acts as a binder element in the concrete. In this research OPC 53 grade cement is used. The color of the cement is grey. Specific gravity of the cement is 3.15. Initial setting time is 30 min and final setting time is 600min. Consistency is 31.5% and soundness is 2.8.

2. Fine aggregate

River sand is used as fine aggregate. Specific gravity of the fine aggregate is 2.16. Water absorption by fine aggregate is 1%. From sieve analysis fine aggregate is of zone II and fineness modulus of fine aggregate is 2.319.

3. Coarse aggregate

Stones made from Crushed rocks are used as coarse aggregate in this research work. Specific gravity of the fine aggregate is 2.74. Water absorption by it is 0.5 %. Size of coarse aggregate is taken as 40% of 4mm to 10mm size aggregate and 60% of 10mm to 20mm. Aggregates are clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials.

4. Water

In concrete, the single most significant influence on most or all of the properties is the amount of water used in the mix. In general water fit for human consumption is acceptable for use as mixing water.

Water used in the preparation of concrete should be free from dirt and organic matters.

In concrete mix design, the quantity of water is decided on the basis of water cement ratio which is taken according to the desired level of workability and strength.

5. Admixture

Admixture are used enhance some properties like strength, durability, workability, to increase or decrease setting times etc. Here, silica fume is used as an admixture. Silica fume is an ultrafine material with spherical particles less than 1 μm in diameter, the average being about 0.15 μm. It is grey in color. The specific gravity of silica fume is generally in the range of 2.2 to 2.3.

6. Super plasticizer

The new generation of this kind of admixtures represented by polycarboxylate ether-based super plasticizers. With a relatively low dosage (0.15–0.3% by cement weight) they allow a water reduction up to 40%, due to their chemical structure which enables good particle dispersion. In this research (*MASTER GLENIUM SKY 8765*) is used.

IV.MIX DESIGN

Mix Design is a process of selecting suitable ingredient materials of concrete mixes to arrive at the most economical combinations of different ingredients to produce concrete that will satisfy the performance requirement under specified condition of use.

For mix design purpose, the complete knowledge of the various properties of the ingredient materials and the conditions at the site should be known beforehand.

In India, generally IS Codes (IS 456:2000 &IS 10262:2009) are followed for designing a concrete mix.

1. Data used

The basic data required for design of concrete mix of grade M90 are given in the table below.

Date	Value
Degree of workability Desired	Good
Standard Deviation	6
Statistic, depending upon the accepted proportion of low	1.65
Target mean strength Maximum size of aggregate used Minimum size of coarse aggregate	99.4 MPa 20mm 4mm

2. Water content

According to IS-10262:2009, for 20 mm size aggregate, water content and sand as percent of total aggregate by absolute volume is taken as 186 kg per cubic meter of concrete. We have used 150 liters water and with super plasticizer 1 % and expected that super plasticizer, silica fume will have high workability of 135 mm slump

3. Air content estimation

According to IS-10262:1982, approximate amount of entrapped air to be expected in normal concrete is taken as 2% according to the nominal size of aggregate used.

4. Casting of samples for mix design

The size of the cube Specimen is (150x150x150) mm. A total of 4 trials for mix design were casted. In each trial 6 cubes are casted. A total of 30 cubes are casted for the mix design of high strength concrete.

5. Curing of samples

In the next day of casting, cube samples were de-moulded from the moulds and placed in curing tanks until they are taken out from it for further tests. 3 and 3cubes - from each trial are taken out in 7 day and 28 day respectively for compression test. Accelerated steam curing also done on the trial no 5 in which predicted 28 days compressive strength = R28 = (8.09 + 1.64 Ra), where Ra is accelerated compressive strength and R28 is predicted compressive strength at 28 days.

6. Mix proportions

Table A: Mix Proportions

Trial mix no	Water to binder Ratio	Cement: Fine aggregate: Coarse aggregate	super plasticizer
1	0.34	1:1.3:2.54	1.3% of cement
2	0.32	1:1.45:2.58	1.1% of cement
3	0.30	1:1.24:2.32	1% of cement
4	0.28	1:1.47:2.3	1% of binder
5	0.26	1:1.39:2.25	1% of binder

V. RESULTS

1. Trial 1(compressive test results)

The 7-day and 28-day compressive test result of Trial-1 are given in the following table.

Table B: Trial 1(compressive test results)

Age in days		7	28
No of Cubes		3	3
Cube Strength in MPa	Cube 1	42	63
	Cube 2	**39**	**60**
	Cube 3	**36**	**58**
Average Compressive Strength in MPa		**39**	**60.35**

2. Trial 2(compressive test results)

The 7-day and 28-day compressive test result of Trial-2 are given in the following table

Table C: Trial 2(compressive test results)

Age in days		**7**	**28**
No of Cubes		**3**	**3**
Cube	**Cube 1**	**33.4**	**64.26**
Strength	**Cube 2**	**37.5**	**63.25**
in MPa	**Cube 3**	**34**	**61.32**
Average strength		**35**	**63**

3. Trial 3(compressive test results)

The 7-day and 28-day compressive test result of Trial-3 are given in the following table.

Table D: Trial 3(compressive test results)

Age in days		7	28
No of Cubes		3	3
Cube Strength in MPa	Cube 1	35.4	64
	Cube 2	39.34	68
	Cube 3	35	67
Average Compressive		36.58	67

4. Trial 4(compressive test results)

The 7-day and 28-day compressive test result of Trial-4 are given in the following table.

Table E: Trial 4(compressive test results)

Age in days		7	28
No of Cubes		3	3
Cube Strength in MPa	Cube 1	47.69	76.20
	Cube 2	52.12	81
	Cube 3	49.36	79.65
Average Compressive Strength in MPa		50	79

5. Trial 5(compressive test results)

As per IS 9013-1978-Method of making, curing and determining compressive strength of accelerated cured concrete test specimens, the specimens are cured in accelerated steam curing. Accelerated Curing Method is used to get early high compressive strength in concrete.

R_{28} (Strength at 28 days) = 8.09 + 1.64 Ra

Where,

Ra = Accelerated Curing Strength in MPa.

Table F: Trial 5(compressive test results)

Age in hours		28	
No of Cubes		3	
Cube Strength in MPa	Cube 1	Ra=58.48	R28=104
	Cube 2	Ra=53.12	R28=95.2
	Cube 3	Ra=55.34	R28=98.83
Average Compressive Strength in MPa		99.34	

VI. CONCLUSION

The present study was undertaken to develop high strength concrete and to investigate the compressive strength of concrete specimen with the addition of different percentage of silica fume and superplasticizer. Based upon the result it can be concluded that supplementary cementitious material play a significant role in strength development of concrete mixes of higher grade. It should also be noted that the supplementary cementitious material are mostly by-product which are otherwise wasted. This should be considered toward recognition of high strength concrete as an environment friendly material.

VII. REFERENCES

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