Mix Proportioning of HSC Using Manufactured Sand

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Abstract: ***Concrete is used in abundance in construction industry. The concrete mix is proportioned based on the strength requirement. High strength concrete (HSC) is used in multi storied buildings, bridges, bunkers, silos, atomic power plant. Current practice shows that for formulating HSC use of natural sand is common all over sites. But day by day natural sand deposits are decreasing due to tremendous use. Hence some alternative to develop required strength as natural sand is a current challenge. So in order to overcome this problem, efforts are contributed for designing HSC using manufactured sand. In the present study, the attempt is made to design mix for HSC of M70 grade concrete for various water to cement ratios using proper proportion, admixtures, and manufactured sand with required workability. For design mix of HSC, the silica fume (SF) used at various percentage replacement levels i.e. 10%, 12%, and 14% respectively with cement whereas superplasticizer (SP) is used at 1%, 1.2%, and 1.4% .Different trial combinations were made using percentage variation of SF and SP with including total replacement of river sand with manufactured sand. After proper curing it is tested in laboratory. The compressive strength results are obtained at lower water to binder ratio i.e. at 0.27.***

Keywords: HSC, M70, Manufactured sand, Water to binder ratio, Silica fume, Superplasticizer

1. Introduction

Concrete is one of the abundantly used material over the globe. The ability of concrete to adopt any shape and develop strength on hardening had made one of the most versatile materials on the earth. Now-a-days rapid development in the field of infrastructure had leads to huge consumption of concrete. Concrete comprises of various ingredients which helps to develop good matrix of it. A good quality concrete matrix is formed by carefully mixing its ingredients like cement, fine and coarse aggregate, water, mineral and chemical admixture to achieve workability and strength properties. The concrete ingredients, cement and coarse aggregate is generally made in factories which controls the quality of the products. The ingredients of concrete affect its various characteristics like strength, durability etc. Fine aggregate are very vital in concrete, controls the properties of concrete. They assist in improving the cohesiveness of fresh concrete. The dredged river sand is most widely used as fine aggregate in concrete. As it exhibits good properties to the concrete, the rapid growth in construction field had leads to huge exploitation of the river sand. The over exploitation of river sand depleted from source and created fatality to environment and also for society. The sand dredging has adversely affected the river banks, course and had cause loss of vegetation on the river banks, deepening of the river sources etc. The main cause for these environmental issues is the non-renewable nature of river sand and the increasing demand of construction industry. Sand dredging is becoming scarce issue to be concern. All these issues had leads to have an alternative for the river sand and we do have it.

The concrete mix is proportioned based on the strength requirement. High Strength Concrete (HSC) is basically used where strength required is more. High strength concrete is used in multi storied, bridges, bunkers, silos, atomic power plant. Current practice shows that for formulating HSC, use of natural sand is common all over sites. But day by day natural sand deposits are decreasing due to tremendous use. So in order to overcome this problem, efforts are contributed for designing HSC using manufactured sand. In the present paper, the attempt is made to design mix for HSC of M70 grade concrete using proper proportion, admixtures, and manufactured sand with required workability.

2. Materials for Experimentation Work

A.Fine Aggregate

Manufactured sand: As manufactured sand is total replacement to natural sand as fine aggregate. Specific gravity of fine aggregate is very much responsible for the strength of concrete. The specific gravity and water absorption of manufactured sand without dust is 2.23 and 6% respectively whereas manufactured sand without dust is 2.74 and 1.6% respectively. Sieve analysis giving fineness modulus 4.46 is as shown below in table 1.

Table 1: Sieve Analysis of Fine Aggregate

Sieve Size	Wt. of sample retained (gm.)	Individual % wt. retained	Cumulative % wt. retained	% Passing
4.75mm	8	0.4	0.4	99.6
2.36mm	224	11.15	11.55	88.45
1.18mm	510	25.5	37.05	62.95
600µ	589	29.45	66.5	33.5
300µ	300	15	81.5	18.5
150µ	171	8.55	90.05	9.95
Pan	198	9.9	99.95	0.05
Total	2000			

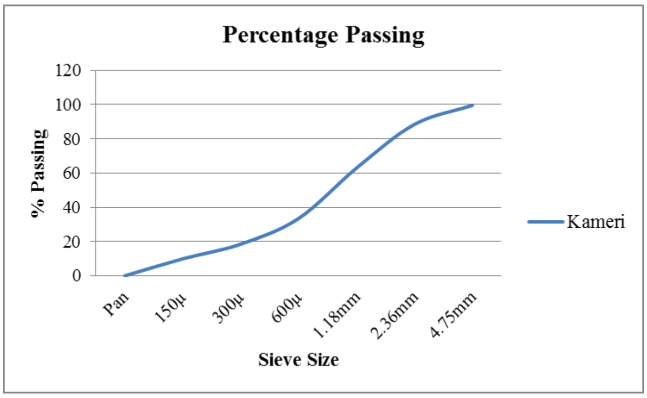

Figure 1: Sieve analysis

The fig.1 shows the results of sieve analysis, giving s-shape curve required for zone selection. The sample would unable to give the required properties. So for more specific gravity result, there should be minimum silt content in the manufactured sand. The sample collected from Kameri is chosen for the minimizing silt content, and then tested for specific gravity.

B. Coarse aggregate

Coarse aggregate used has angular shape having maximum size 20mm. The specific gravity and water absorption was found to be 2.94 and 1.47% respectively Sieve analysis giving fineness modulus 5.67 is as shown below in table 2.

Table 2: Physical Properties of Coarse Aggregate

Physical Properties	*Average Values*
Fineness modulus	5.67
Specific gravity	2.94
Water absorption (%)	1.47

C. Mineral Admixture

Silica fume as a mineral admixture giving specific gravity 2.21 is partially replaced with cement. In this study proportion used is 10%, 12% and 14% respectively about cementitious material. Silica fume reacts with water forms finer paste as compare to cement paste. It fills the voids present in the concrete by fine paste. For better results i.e. compressive strength silica fume should use at appropriate proportion.

D. Cement

Cement is a material, generally in powder form, that can be made into a paste usually by the addition of water and when molded will set into a solid mass. In this dissertation work Ultrarech OPC 53 grade cement is used which is collected Sardar Traders at Kameri. The most widely used cement is Portland cement. It is a pale gray powder obtained by finely grinding the clinker made by strongly heating an intimate mixture of calcareous and argillaceous minerals. The specific gravity of cement is 3.15. Ordinary Portland cement of 53 grade conforming to IS: 12269-1987 has been used throughout the experimentation. Physical properties of cement are given in table 3.

Table 3: Physical Properties of Cement

Properties	Average values for OPC used in the present investigation	Standard values of OPC as per IS : (12269-1987)
Specific gravity	3.15	-
Consistency (%)	32 %	-
Initial setting time (min)	160	> 30
Final setting time (min)	230	< 600
Soundness (mm)	1.0	< 10
Compressive strength (MPa) 28 – days	69	> 53

E. Chemical admixture

The super plasticizer used in concrete mix makes it highly workable for more time with much lesser water quantity. It is observe that with the use of large quantities of finer material, the concrete is much stiff and requires more water for required workability. The BASF's MasterGlenium ACE 30JP superplasticizer having specific gravity of 1.10 was used to achieve the desired slump flow value for HSC. The superplasticizer use at three different percentage levels (i.e. 1%, 1.2% and 1.4%). The trial mixes were made of same grade to find the compatibility of superplasticizer for maximum compressive strength results. According to IS10262:2009, maximum percentage of superplasticizer is used is 2%. But trials should make from 1% superplasticizer by mass of cementitious material.

F. Water

Water is fit for drinking is generally considered for making concrete. Water should be free from acids, oils, alkalis vegetables or other organic impurities used for mixing the concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a lubricant in the mixture of fine aggregates and cement

3. Mix Proportions

Concrete mix proportion is designed as per IS 10262:2009 "Concrete mix proportioning- guidelines". Amount of silica fume replaced is 10%, 12% and 14% of cementitious material and superplasticizer used is 1.0%, 1.2% and 1.4% of cementitious material at W/B ratio 0.30, 0.28, 0.27. First trials are made for each w/b ratio. But for w/b ratio 0.30 and 0.28 fails to give target strength for M70 grade HSC. Hence, reduction of w/b ratio to 0.27 which achieve the target strength for M70 grade HSC concrete. The mix proportion for w/b ratio 0.27 is given in table 4.

Table 4: Mix proportions for M70

W/B ratio	SF (%)	SP (%)	Binder (Kg/m^3)	FA (Kg/m^3)	CA (Kg/m^3)	SF (Kg/m^3)	SP (Kg/m^3)
0.27	10	1.0	584.185	652.520	1138.46	58.42	5.84
	12	1.0	584.185	646.273	1127.56	70.10	5.84
	14	1.0	584.185	641.067	1118.48	81.79	5.84
0.27	10	1.2	584.185	650.958	1135.73	58.42	7.01
	12	1.2	584.185	644.920	1125.20	70.10	7.01
	14	1.2	584.185	639.922	1116.48	81.79	7.01
0.27	10	1.4	584.185	649.920	1133.92	58.42	8.18
	12	1.4	584.185	644.40	1124.29	70.10	8.18
	14	1.4	584.185	638.88	1114.67	81.79	8.18

4. Results and Discussion

All the results of trial proportions are presented in tabular form. It gives all the compressive strength results at different percentage levels of silica fume and superplasticizer with varying water to cement ratios. The results were obtained on compression testing machine (CTM). The respective graphs are also drawn.

The results obtained for w/b ratio - 0.3 does not achieve the target mean strength for M70 grade concrete. Hence it is need to change/lower the water to cement ratio. The results obtained are very far away from the target mean strength. To solve this problem, decrease w/b ratio 0.30 to 0.28 for making HSC. Results showed that strength is nearer to the target strength. But it fails to achieve the target strength.

Table 5: Compressive Strength Results for w/b ratio - 0.27

W/B Ratio	*SF (%)*	*SP (%)*	*28 Days Avg. Strength (N/mm^2)*
0.27	10	1	73.11
	12	1	70.89
	14	1	68.67
0.27	10	1.2	79.56
	12	1.2	75.11
	14	1.2	72.22
0.27	10	1.4	68
	12	1.4	66.22
	14	1.4	65.11

So, select w/b ratio as 0.27 to make HSC. The compressive strength for M70 grade concrete gives target strength of 79.56 N/mm2 at 10% silica fume, 1.2% superplasticizer for w/b ratio 0.27. This proportion gives mix design for M70 grade HSC. It is seen that target strength results are affected by the temperature variations during casting. During testing the cubes having w/b ratio 0.30 and 0.28, cracks develops gradually. But cubes blasts during testing having w/b ratio 0.27.

5. Comparison of Strength for w/b Ratio - 0.27

From the graph, it is seen that the compressive strength observed maximum for proportion of 10% SF and 1.2% SP with w/b ratio - 0.27. Consequently for same w/b ratio -0.27 and 1.2% SP the compressive strength results are decreased by 5.59 % and 9.22% with 12% SF and 14% SF respectively. The compressive strength is observed 73.11 N/mm^2 for w/b ratio - 0.27 and 10% SF with 1% SP. For further increment of SP by 0.2%, the compressive strength is increased by 8.82%. But for the next increment of SP by 0.2%, the reduction is observed in compressive strength about 6.98% of its initial proportion.

The compressive strength is observed 70.89 N/mm^2 for w/b ratio - 0.27 and 12% SF with 1% SP. For further increment of SP by 0.2%, the compressive strength is increased by 5.95 %. But for the next increment of SP by 0.2%, the reduction is observed in compressive strength about 6.58% of its initial proportion.

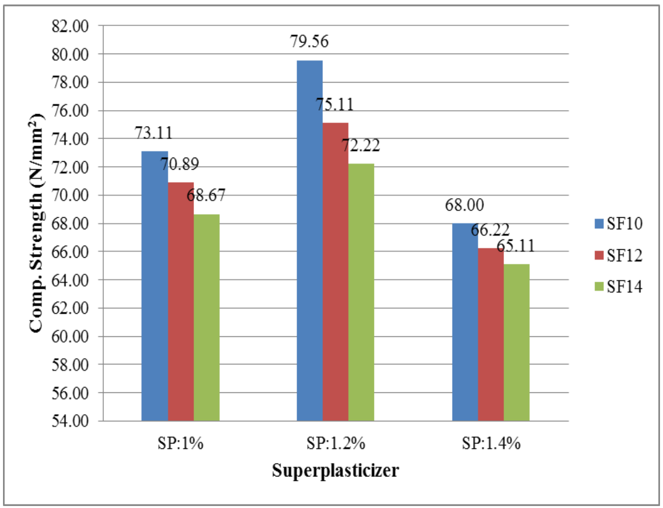

Figure 2: Compressive Strength Results for w/b Ratio 0.27

The compressive strength is observed 68.67 N/mm2 for w/b ratio - 0.27 and 14% SF with 1% SP. For further increment of SP by 0.2%, the compressive strength is increased by 5.16%. But for the next increment of SP by 0.2%, the reduction is observed in compressive strength about 5.18% of its initial proportion.

6. Conclusions

1. The specific gravity of manufactured sand with dust and without dust is 2.23 and 2.74 respectively which is responsible for compressive strength of concrete.
2. By using IS 10262:2009, mix combinations are prepared for M70 grade concrete having varying w/b ratio as 0.30, 0.28 & 0.27, SF(10%, 12% and 14%) and SP(1.0%, 1.2% and 1.4%).
3. The maximum compressive strength obtained for w/b ratio - 0.27, 10% SF and 1.2% SP proportion is 79.56 N/mm^2.

4. Optimum mix proportion of M70 grade concrete is obtained for w/b ratio - 0.27, 10% SF and 1.2% SP.
5. It is possible to achieve the compressive strength of HSC up to M70 grade using manufactured sand, following the IS10262:2009 code specifications.

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