ISSN 2395-1621

Design Mix for High Strength Concrete Incorporating Manufactured Sand and Natural Sand

#1Mr. Akash C. Yarate
#1Research Scholar, Rajarambapu Institute of Technology, Islampur, Sangli, Maharashtra 415414, India.

#2Prof. Dattatraya B Kulkarni
#2Associate Professor, Rajarambapu Institute of Technology, Islampur, Sangli, Maharashtra 415414, India

ABSTRACT

This paper presents a new mix design method of high strength concrete mixes for durability properties against permeability, chemical attack and temperature. 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, etc. Current practice shows that for formulating HSC use of natural sand is common all over the sites. Also, normal grade concrete (up to M40) is being formulated by using the manufactured sand. But day by day natural sand deposits are decreasing due to tremendous use. Hence some alternative should be developed for natural sand and for required strength of concrete. So in order to overcome this problem, efforts are contributed for designing HSC using manufactured sand. In present study, the attempt is made to design mix for HSC of M60 and M70 grade concrete for various water to cement ratios using proper proportion and admixture incorporating manufactured sand and natural sand.

ARTICLE INFO

Article History

Received: 25th March 2017

Received in revised form : 25th March 2017

Accepted: 25th March 2017

Published online : 4th May 2017

Keywords: HSC, M60, M70, Manufactured sand, Silica fume, water to binder ratio.

I. INTRODUCTION

Concrete mix design is a process of proportioning the different ingredients in correct proportions. Though it is based on sound technical principles and heuristics, the entire process is not in the realm of science and precise mathematical calculations. This is because of impreciseness, vagueness, approximations and tolerances involved. Further, manufactured sand offers a viable solution to the decreasing availability of river sand. But, there are few problems which need to be overcome. The problem is that manufactured sand has poor workability. The normal grade concrete (up to M40) is being formulated by using the manufactured sand. But in the case of HSC's it is used in the partial replacement of the natural sand. The conventional mix design methods are no longer capable of meeting the stringent multiple requirements of HSC. These methods are not directly applicable to HSC mixes. Several methods have been proposed over the years for the proportioning of mineral admixture – based HSC mixes. Therefore, a new modified method of mix design procedure has to be proposed for design of HSC mixes using manufactured sand taking into account the effect of durability properties of HSC mixes.

High strength concrete has many benefits and has increased use in structural applications. It is essential that durability behavior of HSC to be understood to ensure the structural involving HSC will be safe. Important governing factors for HSC (High Strength Concrete) are strength and long term durability.

II. MATERIAL AND SPECIFICATIONS

Concrete is composite material composed of different ingredients such as cement, sand, coarse aggregate and water in appropriate proportions. To obtain the adequate strength of desired concrete mix properties of concrete ingredients must be investigated and material having suitable properties should be used as ingredients of concrete. In this chapter, various tests are carried out on materials used in HSC as per IS code provisions and this test results are used in finalizing the mix proportions of HSC.

1. Cement : The cement should be fresh, of uniform consistency and free of lumps and foreign matter. It should be stored under dry conditions and for as short duration as possible. The important requirement for any cement is

strength development with time and facilitating appropriate rheological characteristics when fresh. Chettinad OPC 53 grade cement is used for project work.

Table 1: Properties of Cement

Sr. No.	Properties Brand: chettinad, opc 53 grade	Average test values
1.	Initial setting time	35 mins
2.	Final setting time	265 mins
3.	Soundness	5 mm
4.	Specific gravity of cement	3.15
5.	Consistency	32%
6.	Compressive strength	52 pa

2. Coarse aggregate : Maximum size of aggregated used is 20mm, angular in shape. The gradation of coarse aggregate carried out sieve analysis method. Fineness modulus of coarse aggregate is 5.67.

3. Fine aggregate : Natural Sand which is locally available is used and properties of this sand is also studied which are further used for calculating mix proportion of concrete. Now a days there is lack of availability of river sand because of these we have replaced natural sand by manufactured sand. The sand used for this work should be clean, fresh, dust free, and free from organic matter.

Table 2: Properties of Aggregate

Properties	Test conducted on aggregate	Results
Specific gravity	A) coarse aggregate	3.06
	B) fine aggregate	2.94
Water absorption	A) coarse aggregate	17.6
	B) fine aggregate	2.56

4. Water : Ordinary tap water which is free from impurities is used.

5. Mineral Admixture - For greater strength the mineral admixture plays vital role. These are used for various purposes, depending upon their properties. For this project work we used silica fume and GGBS as mineral admixture

6. Silica Fume - Silica fume giving specific gravity 2.21 is partially replaced with cement. In this study proportion used is 10%, 12% and 14% respectively about cementatious 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.

7. Admixture : For developing the strength of concrete both type of admixture are used mineral admixture and chemical admixture. Mineral admixture used is silica fume, properties of this admixture are also studied which are given by company itself. Chemical admixture used is superplasticizer (MasterGlenium ACE 30JP) which is provided by BSF company situated at Pune.

Specimen Preparation

The concrete specimens utilized in the study were: 150 x 150 x 150 mm concrete cubes were used to measure the compressive strength with respect to strengths of control specimens cured in lime saturated water solution. Casting of concrete specimens was conducted in three layers. Each layer was compacted with 25 strokes to ensure good compaction and to reduce the air voids. Fresh concrete was poured into oiled steel molds and covered with wet burlaps for 24h. Concrete specimens were then demoulded, labeled as to the date of casting and mixture type and stored in a lime saturated water solution tank for an initial moist curing period of 7 and 28 days. Three concrete specimens were cast and tested for each test condition to obtain average value.

Mix design proportions as per IS 10262:2009

The mix proportions for M60 and M70 grade concrete using manufactured sand and natural sand are obtained by IS code method (i.e. IS 10262:2009). Limiting compressive strength value for M60, M70 and M80 grade concrete after 7 should be 45.5 N/mm^2, 52.16 N/mm^2, 58.83 N/mm^2 respectively and 28 days should be 68.25 N/mm^2, 78.25 N/mm^2, 88.25 N/mm^2 respectively. These results gives the validation of the experimental results.

Table 3: Trial proportioning using manufactured sand

W/B Ratio	SF (%)	Binder (kg/m^3)	FA (kg/m^3)	CA (kg/m^3)	SF (kg/m^3)	SP (kg/m^3)
0.3	12	525.76	689.066	1202.22	63.09	6.309
	10	525.76	690.627	1204.95	52.576	6.309
0.28	12	563.32	676.78	1180.79	67.60	6.579
	10	563.32	677.717	1182.42	56.32	6.579
	8	563.32	678.75	1184.24	45.06	6.579
0.27	12	584.18	668.14	1165.71	70.10	7.01
	10	584.18	669.7	1168.437	58.41	7.01
0.26	12	606.65	660.53	1152.45	72.8	7.28
	10	606.65	662.62	1156.084	60.66	7.28

Table 5: Trial proportioning using natural sand

W/B Ratio	SF (%)	Binder (kg/m^3)	FA (kg/m^3)	CA (kg/m^3)	SF (kg/m^3)	SP (kg/m^3)
0.3	12	525.76	633.632	1202.22	63.09	6.309
	10	525.76	650.299	1204.95	52.576	6.309
0.28	12	563.32	637.260	1180.79	67.60	6.579
	10	563.32	638.14	1182.42	56.32	6.579
0.27	12	584.18	629.123	1165.71	70.10	7.01
	10	584.18	630.593	1168.437	58.41	7.01
0.26	12	606.65	621.965	1152.45	72.8	7.28
	10	606.65	629.123	1156.084	60.66	7.28

III. RESULTS

All the results of compressive strength of all the trial proportions are presented. Experimental results of concrete cubes for the purpose of validation are included. At the end comparative study of compressive strength of manufactured sand and natural sand is done. The experimental results are expressed in tabular form

Table 6: Compressive strength results for trial proportions using manufactured sand

Sr no	W/B Ratio	SF (%)	Slump (mm)	Compressive strength (MPa)	
				7 days	28 days
1	0.3	12	93	39.42	58.56
		10	91	40.23	60.34
2	0.28	12	82	42.82	64.47
		10	81	44.8	66.11(M60)
		8	78	43.54	65.34
3	0.27	12	71	47.26	70.89
		10	74	49.05	73.41
4	0.26	12	68	50.75	76.11
		10	65	52.53	78.75(M70)

Table 7: Compressive strength results for trial proportions using natural sand

Sr no	W/B Ratio	SF (%)	Slump (mm)	Compressive strength (MPa)	
				7 days	28 days
1	0.3	12	96	37.61	58.35
		10	98	41.08	61.98
2	0.28	12	88	42.67	65.26
		10	85	44.85	68.41
3	0.27	12	80	47.68	71.52
		10	83	48.58	72.87
4	0.26	12	73	50.24	75.37
		10	75	52.74	79.11

IV. CONCLUSION

The Desirable content of silica flume is about 10% by weight of cement. Mix proportion for M60 grade concrete using manufactured sand is in proportion of 1:1.203:2.10 with w/b ratio of 0.28, silica flume 10% and superplasticizer of 1.2%.

Mix proportion for M60 grade concrete using natural sand is in proportion of 1:1.132:2.10 with w/b ratio of 0.28, silica flume 10% and superplasticizer of 1.2%. Mix proportion for M70 grade concrete using manufactured sand is in proportion of 1:1.092:1.906 with w/b ratio of 0.26, silica flume 10% and superplasticizer of 1.2%. Mix proportion for M70 grade concrete using natural sand is in proportion of 1:1.028:1.96 with w/b ratio of 0.28, silica flume 10% and superplasticizer of 1.2%. Hence, the quantity of manufactured or artificial sand required for designing of M60 and M70 grade concrete is more as compared to natural sand.

REFERENCES

[1] Ali Behnood and Masoud Ghandehari, “Comparison of compressive and splitting tensile strength of high-strength concrete with and without polypropylene fibers heated to high temperatures”, Fire Safety Journal, 44, 1015–1022 , Elsevier, 2009

[2] Bahar Demirel and Oguzhan Kelestemur, “Effect of elevated temperature on the mechanical properties of concrete produced with finely ground pumice and silica fume“, Fire Safety Journal, 45, 385–391, Elsevier, 2010

[3] Cleo Laneyrie, Anne-Lise Beaucour, Mark F. Green, Ronan L. Hebert, Beatrice Ledesert, Albert Noumowe, “Influence of recycled coarse aggregates on normal and high performance concrete subjected to elevated temperatures”, Construction and Building Materials, 111, 368–378, Elsevier, 2016

[4] K. Anusha and S. Kesavan, “A study on behavior of ultra high strength concrete at elevated temperatures”, International Journal of Engineering Sciences & Emerging Technologies, Volume 7, Issue 5, 761-765, 2015

[5] K. S. Kulkarni, S. C. Yaragal and K. S. Babu Narayan, “Effect of elevated temperatures on mechanical properties of microcement based high performance concrete”, International Journal of Applied Engineering and Technology , vol. 1 (1), 24-31, 2011

[6] Omer Arioz, “Effects of elevated temperatures on properties of concrete”, Fire Safety Journal, 42, 516–522, Elsevier, 2007

[7] P. D.Kumbhar and P. B.Murnal, “A New Mix Design Method For High Performance Concrete Under Tropical Conditions”, Asian Journal of Civil Engineering , Vol. 15, No. 3, pp 467-483, 2014

[8] S.H. Chowdhury, “Effect of elevated temperature on mechanical properties of high strength concrete”, 23rd Australasian Conference on the Mechanics of Structures and Materials, 23, 1077-1082, 2014

