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Research Article

Experimental Study on Superfine Sand Concrete Mixed by Double Mixing Technology

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Abstract: Traditional concept thought that medium sand and fine sand can be used to mix concrete, superfine sand can not used to mix concrete. This makes the source of superfine sand limited. With the shortage of medium sand and fine sand, it is imperative to exploit the resource of superfine sand. Superfine sand concrete is mixed by means of Double-doped Technology-ultra-fine fly ash and super plasticizer. Primary factor influencing superfine sand concrete strength is studied by orthogonal test, the optimal mixture ratio is found. The results indicated that the primary factors are water-binder ratio and sand ratio. At the same time, the workability and strength of superfine sand concrete mixed by optimal mixture ratio can satisfy the quality request of general engineering. It is proved that the double-doped technology is feasible, which can be used to conduct engineering construction.

Keywords: Double mixing technology, orthogonal design, super plasticizer, superfine sand concrete, ultra-fine Fly ash

INTRODUCTION

Superfine sand is a kind of fine sand whose fineness modulus is between 1.5 and 0.7, or its average particle size is below 0.25 mm (Li, 2006; Xin *et al*., 2006; Kwan and Ramli, 2010; Rafat *et al*., 2012). There are rich sources of superfine sand in china, especially Sichuan, Henan, Shandong and other places, but medium sand and fine sand is relatively lack. In the past, traditional concept generally thought that this kind of sand is not suitable for preparation of concrete, or can only mix low grade concrete. This make the sand resource limited very much. With the shortage of medium sand and fine sand, it is imperative to develop the preparing technology of superfine sand concrete. With the vigorous development of the infrastructure construction, effective utilization of superfine sand concrete preparing technology will have a good application prospect.

Fly ash belongs to industrial waste residue; however, with the continuous development of science and technology, adding it to concrete after grinding not only can enhance the strength of the concrete, but also improve workability and other properties, what's more, it has certain significance of environmental protection (Rattapon *et al*., 2012; Xie *et al*., 2001; Liu *et al*., 2012).

The grain size of superfine sand is uniform and its content of mudstone is small, however, its fineness modulus is smaller, specific surface area is larger and its porosity is large and these characters make the cement content and water content increased. So, moisture content of concrete increased and slurry content of concrete also added. This will be bad for strength and shrinkage of concrete.

In order to make up for the deficiency of material properties, double mixing technology is adopted (Jaro and Berceli, 2003; Wen *et al*., 2011), it is compound use of ultra-fine fly ash and super plasticizer. Orthogonal test method (Li *et al*., 2009; Liang *et al*., 2011) is used to seek the optimal mix proportion of concrete and mixing superfine sand concrete which can satisfy construction requirement. Ultra-fine fly ash has a good effect of enhancement and in flation, super plasticizer can greatly reduce the amount of water consumption. Their common used can overcome inherent quality defects of superfine sand concrete.

RESREACH METHOD

Materials:

Super fine sand: In a research base of superfine sand, after a large number of sample tests, fineness modulus of superfine sand is obtained, (it equals 1.3), the quality indexes comply with the norms of GB/T14684-2001 and superfine sand can be used to mix concrete. The test results are shown in Table 1.

Cement: 42.5R ordinary port land cement is used, which is the production of strong cement co., LTD. City Jiaozuo Province Henan, Compressive strength for 3 days of 42.5R cement is 33.1MPa, Compressive strength for 28 days is 52.5 MPa. By physical and mechanical performance test, the results meet the requirements of national standard.

Ultrafine flash: Fly ash that is produced by Yitian fly ash co., LTD. City Changzhi, Province Shanxi is

Table 1: Physical properties test results of superfine sand

Item	Apparent density (g/cm^3)	Bulk density (g/cm^3)	Fmudstone content (%)	Mica (%)
Ccontent	2.52	1.53	1.2	0.2
Item	light substance (%)	Sulfide and sulfate (%)	Chloride (%)	Robustness (%)
content	0.3	0.2	0.006	7.1

Table 2: Main technical indicator of fly ash

Item	SIO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3
Content	61.95	23.73	6.02	2.56	1.29	0.26

Table 3: Main technical indicator of super plasticizer

Item	Water-reducing rate (%)	Solid content (%)	Density (g/mL)	Fchloride ion content (%)	Fluidity of cement paste (mm)
content	26	35.0	1.12	0	230

Table 4: Orthogonal design experiment of superfine sand concrete

	Factors			
Number	Water-binder ratio A	Sand ratio B (%)	Mixing amount of superplasticizer C (%)	Mixing amount of fly ash D (%)
1	0.30	22.0	0.50	10.0
2	0.30	24.0	0.75	15.0
3	0.30	26.0	1.00	20.0
4	0.30	28.0	1.25	25.0
5	0.35	22.0	1.00	15.0
6	0.35	24.0	1.25	20.0
7	0.35	26.0	0.50	25.0
8	0.35	28.0	0.75	10.0
9	0.40	22.0	0.75	20.0
10	0.40	24.0	1.00	25.0
11	0.40	26.0	1.25	10.0
12	0.40	28.0	0.50	15.0

adopted; it is in line with the standard of grade Ⅰ fly ash by inspection.

Fly ashes as admixture are added to the concrete, it can significantly improve the workability and strength of concrete. The smaller particle is, the stronger activity is. In order to improve the activity of fly ash, grinding fly ash into super fine fly ash for 90 min. (Average particle size is 5.60 um). Its main technical indicator is shown in Table 2.

Super plasticizer:"Life star" brand super plasticizer which is produced by star concrete admixture plant City Xin zheng, Province Henan is used. Its main technical indicator is shown in Table 3.

Coarse aggregate: Aggregate, particle size is 5-25 mm, two grade aggregate, Gradation conform to national standards.

Test method: The experiments adopt orthogonal design, orthogonal design is a kind of scientific method, which uses a set of ready-made specification tables-orthogonal tables to arrange multifactor tests, the test results were statistically analyzed and optimal method is found. When the orthogonal design is adopted, testing scheme is purposefully arranged in a planned way before making experiment; after experiment, experiment result is exact analyzed by calculation. This can reduce test number, shorten test time and meet the construction speed requirement. In the aspect of ensuring the engineering quality and reducing cement, effect is very significant, so, it should be well popularized and applied in construction system.

According to the experience and based on the existing data, orthogonal design four levels and four factors is adopted, Checking the in fluence of water-binder ratio, sand ratio, dosage of superfine fly ash and super plasticizer four main factors on superfine sand concrete strength. Orthogonal design experiment is shown in Table 4.

RESULTS AND DISCUSSION

Workability of fresh concrete: After on-site mixing, it is found that the workability of fresh superfine sand concrete is very well. Its liquidity is not very large, adhesiveness and retention are qualified. The above 12 group tests, the liquidity of test 4 and test 8 are small, the slumps both are 10 mm and others are more than 20 mm. The sand ratio of test 4 and test 8 are maximum and water-binder ratio is relatively small, it is seen that sand ratio is important factor which influence the liquidity of fresh concrete, because the sand ratio is larger, the dosage of coarse aggregates relatively small, space and total surface area of aggregate are very large. There fore, when keeping water-binder ratio and cement content unchanged, the mixture seem to be very thick, the slump of concrete is reduced, so, the liquidity is not very large. So, before mixing superfine sand concrete, coarse aggregate should be soaked to reach saturated state.

The liquidity of fresh concrete can meet construction requirement.

Table 5: Test results of 28 days compressive strength

Number	Factors: Water-binder ratio A	Sand ratio B (%)	Mixing amount of superplasticizer C (%)	Mixing amount of flyash D (%)	28dayscompressive strength (MPa)
1	0.30	22.00	0.50	10.00	39.60
2	0.30	24.00	0.75	15.00	37.20
3	0.30	26.00	1.00	20.00	41.30
4	0.30	28.00	1.25	25.00	30.80
5	0.35	22.00	1.00	15.00	35.10
6	0.35	24.00	1.25	20.00	32.10
7	0.35	26.00	0.50	25.00	32.60
8	0.35	28.00	0.75	10.00	28.90
9	0.40	22.00	0.75	20.00	30.20
10	0.40	24.00	1.00	25.00	28.60
11	0.40	26.00	1.25	10.00	31.20
12	0.40	28.00	0.50	15.00	31.90

Table 6: Range analysis of 28 days compressive strength

Parameters	Range of 28 days compressive strength: Factor A	Factor B	Factor C	Factor D
T1	148.9	131.3	133.0	128.6
T2	128.7	126.8	124.2	132.1
T3	121.9	133.0	132.0	130.6
T4	110.2	118.6	120.5	118.4
m1	37.2	32.8	33.3	32.2
m2	32.2	31.7	31.1	33.0
m3	30.5	33.3	33.0	32.7
m4	27.6	29.7	30.1	29.6
R	9.7	3.6	3.1	3.4

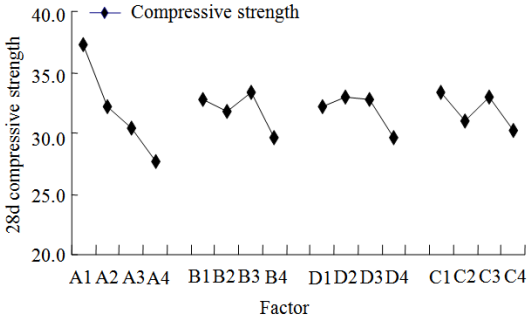

Fig. 1: Point diagram analysis for 28 day compressive strength of concrete

Strength of harden concrete: Preparing standard test specimens: 150 mm×150 mm×150 mm cube specimen, 12 groups, 36 specimens, standard curing for 28 days, measuring the cube compressive strength. The test results are shown in Table 5.

Range analysis: Based on range analysis of factors, the sequence influencing 28 days compressive strength of superfine sand concrete can be deter mined, the range of factors is larger shows that the influence on concrete strength is larger. It can be seen from Table 6 that the sequence influencing 28 days compressive strength of superfine sand concrete is A→B→D→C. the primary factor is water-binder ratio, the second factor is sand ratio, mixing amount of fly ash is the third factor and the influence of mixing amount of super plasticizer is the smallest.

Point diagram analysis: In order to analyze the influence relationship each factor level changes on the compressive strength of superfine sand concrete, the Figure between each factor level and 28 d compressive strength of superfine sand concrete is obtained (Fig. 1), the following conclusion can be got from Fig. 1:

- The optimal mix ratio of 28 d compressive strength to superfine sand concrete is $A_1B_3C_1D_2$, it means that sand ratio is 26%, water-binder ratio is 0.30, mixing amount of fly ash is 15% and mixing amount of super plasticizer is 0.5%
- With water binder ratio (factor A) increasing, 28 day compressive strength of concrete decreased; when sand ratio (factor B) becomes large, 28 day compressive strength of concrete gradually increased at first and then gradually decreased, when sand ratio equals to 26%, the strength of concrete make maximum; due to the addition of superfine fly ash into concrete , the strength increased, however, when mixing amount of fly ash (factor C) attains to 15%, the strength got maximum, increasing the mixing amount, the strength is not increasing any more. Because the packing effect of superfine fly ash and the micro aggregate effect are not sufficient to compensate inadequate contribution of early strength for substantial cement reduction, the early strength will decrease. However, as the age growing grew, fly ash participates in the second hydration, plus activity effect of ultra fine fly ash, the later strength will increase. With the increase of the mixing amount of super plasticize, the variation of concrete compressive strength is not very big, it is worth noting that the amount of cementitious materials with super plasticizer increases will be greatly decreased

CONCLUSION

Based on orthogonal design, it is found that in four factors water-binder ratio, sand ratio, mixing amount of

fly ash and mixing amount of super plasticizer, the most important factors which influence compressive strength of superfine sand concrete are water-binder ratio and sand ratio. Therefore, sand dosage and water consumption should be the emphasis of quality control in the process of construction. The optimal mix ratio is that water-binder ratio equals to 0.30, sand ratio is 26%, mixing amount of fly ash equals to 15% and mixing amount of super plasticizer is 0.5%. Prepared with the mix proportion, the engineering performance of concrete is very good; it can be used for ordinary concrete engineering construction.

It is worth noting that the humidity difference between the future construction and laboratory curing environment is very big. Despite this problem exist in all the preparation of the ordinary concrete and practical construction. It still needs special emphasized, because curing humidity is very important for concrete contraction, especially superfine sand concrete.

With the popularization and use of superfine sand concrete, performance and construction technology of superfine sand concrete must be further researched.

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