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MIX DESIGN OF 3D CONSTRUCTION PRINTERS

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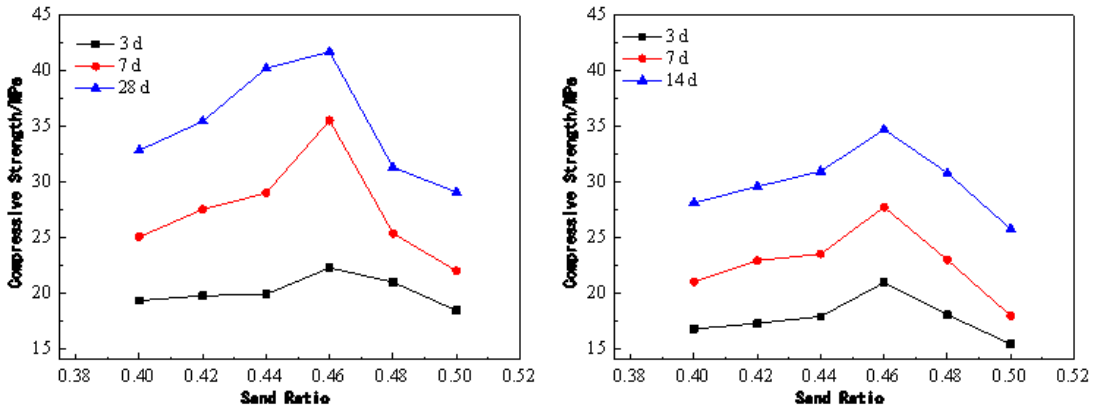
Based on the above analysis, the test results show that when the water-binder ratio is 0.40, 0.42, and the sand rate is 0.46, the working performance of concrete and the compressive strength of each age are better than other sand rate conditions, so the optimal sand rate of wet shotcrete can be determined is 0.46.

The water-binder ratio is 0.40 and 0.42. The amount of gelling material is 450 kg/m^3. Under the condition that the dosage of water reducing agent is 1%. Table 1 and Figure 1 show the test results of concrete slump, expansion and compressive strength of different ages with different sand ratio formulas.

Table 1 – Compressive strength, slump and expansion of shotcrete with different sand ratios

Specimen №	water-binder ratio	Compressive strength (MPa)			Slump/mm	Expansion/mm
		3d	7d	28d		
A1	0.40	19.33	25.06	32.83	115	250
A2		19.76	27.51	35.44	120	265
A3		19.89	28.99	40.20	175	370
A4		22.27	35.52	41.69	185	410
A5		20.98	25.37	31.29	174	360
A6		18.43	21.98	29.07	165	355
B1	0.42	16.77	21.01	28.12	145	320
B2		17.28	22.92	29.57	155	340
B3		17.89	23.51	30.94	174	370
B4		20.94	27.72	34.71	198	425
B5		18.05	22.97	30.79	184	405
B6		15.41	17.96	25.75	155	345



(a) W/B=0.40 (b) W/B=0.42

Figure 1. – Compressive strength of concrete at different ages with different sand ratios

From Figure 1 (a), it can be seen that when the sand rate is less than 0.46, the strength of each age of concrete increases continuously with the increase of the sand rate; when the sand rate is 0.46, the strength of each age reaches the maximum; when the sand rate is 0.50, the strength of concrete at each age reaches the minimum value. It can be seen from Figure 1 (b) that when the water-binder ratio is 0.42, the strength changes of concrete at 3 d, 7 d, and 28 d are basically the same as when the water-binder ratio is 0.40, when the sand ratio is 0.46, the strength reaches the maximum value.

Based on the above analysis [1-2], the test results show that when the water-binder ratio is 0.40, 0.42, and the sand rate is 0.46, the working performance of concrete and the compressive strength of each age are better than other sand rate conditions, so the optimal sand rate of wet shotcrete can be determined is 0.46.

The effect of water-binder ratio on the compressive strength of concrete the amount of gelling material is 450 kg/m^3, when the water-binder ratio is 0.40 and 0.42, the compressive strength of concrete at 28 d age under different sand ratio conditions is shown in Figure 2.

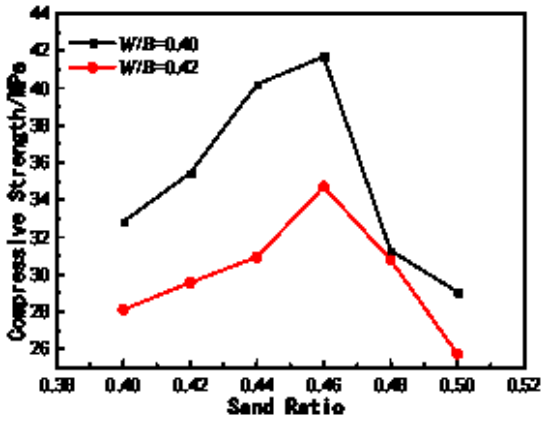


Figure 2. – 28-day compressive strength of concrete under different water-binder ratios

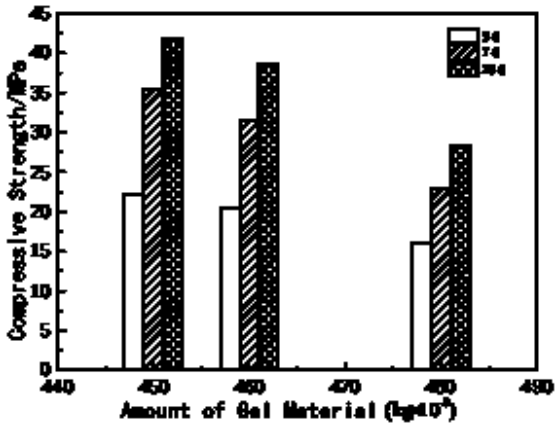


Figure 3. – Compression resistance of concrete at different ages with different amounts of cementitious materials

It can be seen from Figure 3 that the trend of concrete strength with the increase of sand ratio under the two conditions of water-binder ratio is basically the same, which shows that the influence of sand ratio on concrete strength basically shows a good regularity between 0.40 and 0.50. It is feasible to explore the optimal mix ratio of wet shotcrete by adjusting the sand rate. In order to fully consider the variability of raw materials on site and the strength factor of wet sprayed concrete, the actual concrete water-binder ratio is selected as 0.40.

The main characteristics of compositions for 3D printing with different straw fractions are shown in the table 2 and figure 4.

Table 2 – Compressive strength, density of compositions for 3D printing with different straw fractions

Specimen №	water-binder ratio	Compressive strength (MPa)			Density, (kg/m^3)	Note
		3d	7d	28d		
1	0.5	0.49	0.71	1.02	1138	Not suitable for load-bearing structures
2		0.77	1.07	1.53	1230	Not suitable for load-bearing structures
3		1.26	1.75	2.51	1195	Suitable for load-bearing structures

(a) form retention

(b) mixture preparation

Figure 4. – Making a mixture for 3D construction printing in the laboratory

REFERENCES

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