

Analysis of the Influence of Water-cement Ratio on Concrete Strength

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Abstract: In this paper, the main strength of the relationship between water-cement ratio and concrete, and it uses the contrast test of different water cement ratio, finally, it gets the regular change between water cement ratio and concrete strength. The test results show that: cement. when the ratio of large stone: small stone: water: admixture is 340: 618: 1009: 433: 139: 6.8, the water-cement ratio of concrete is within the range of 0.371-0.479. The concrete strength of the sample decreases with the increase of the water-cement ratio. Finally, the relationship between the concrete strength and the water-cement ratio is obtained by fitting.

1 Introduction

With the accelerated development of the country, the construction industry has shown great vitality. The quality of concrete is the guarantee of construction, the foundation of the construction industry, and the cornerstone of rapid development. In order to ensure the quality of concrete, we need to mix cementing materials, aggregates or other admixtures, in which part of the water used to mix the concrete is used for the cement hydration reaction and the other part is used to improve the workability of the concrete. When the amount of cement is the same, the ratio of water cement is too large or too small, which is not conducive to the improvement of cement concrete strength. Therefore, more attention should be paid to the water-cement ratio of concrete. [1]

According to previous studies by scholars, the main factors affecting the flexural strength of concrete mainly include the water-cement ratio and the related properties of aggregate, among which the water-cement ratio is still one of the most important factors affecting the flexural strength of cement concrete [2]. Wang N [3] et al. took the water-cement ratio as the control variable to make test samples and studied the variation rule of the compressive strength and permeability of foamed concrete. Liu D. D. [4] and Li Z. [5] studied the influence of water-cement ratio on the performance of pervious concrete. Xie W. W. [6], a scholar, tested the compressive strength of concrete with different water-cement ratio, lime content and phosphorus slag content, and obtained the variation rule of concrete's compressive strength with the three factors. Li S [7] et al. mainly studied the nonlinear characteristics of concrete strength and established a multivariate nonlinear model between parameters such as fly ash content and strength.

Therefore, this paper carried out control tests under different water-cement ratios to study the influence of different water-cement ratios on the strength of concrete.

The regression relationship between water cement ratio and concrete strength is established. It provides reference for mix design of high performance concrete in the future.

2 Experimental principle and thought

2.1 Test principle

According to relevant codes and construction experience, the concrete design takes the compressive strength as the design index, so the research on the water-cement ratio and the compressive strength of concrete is more in-depth. At present, the more common method is to use Paul's formula to estimate the water-cement ratio of concrete:

$$R_{28} = AR_c \left(\frac{W}{C} - B \right) \quad (1)$$

There is: R_{28} —The compressive strength of concrete at 28 days;

A and B are the coefficients;

R_c —The compressive strength of cement at 28 days;

$\frac{W}{C}$ —Water-cement ratio.

2.2 Test idea

Based on the mix ratio of cement pavement concrete, this study further studies how the water-cement ratio affects the strength of concrete. Specific mix ratio is: cement: sand: big stone: small stone: water: admixture = 340: 618: 1009: 433: 139: 6.8. The test configuration cement content is A-50, A-45...A, A+5...For 18 kinds of cement

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concrete of A+35, three cylindrical specimens and three trabecular specimens were prepared for each water-cement ratio, A total of 54 cylindrical specimens and 54 trabecular specimens were tested for their flexural tensile strength respectively.

The cement used in this test is "Qixia" brand P.042.5 grade bulk cement produced by Qixia Zhonglian Cement Co., Ltd., Yantai. which has been tested by relevant units and all indicators meet the standard requirements.

3 Experiment

(2) Aggregate

3.1 The raw materials

The fine aggregate used in this test is river sand. and the technical indexes are shown in Table 1:

(1) Cement

Tab.1 results of fine aggregate screening

Number	The test items	The measured values	Standard values
1	Cl ⁻	0.014%	≤0.02
2	SO ₃	0.2%	≤0.5
3	Robustness	4.9%	≤8
4	Alkali active reaction	Inactive	Inactive
5	Mica and light matter content	0.5%	≤1
6	Organic content	Shallow	Shallow

16~.31.5 mm gravel produced in Qixia quarry.

Coarse aggregate was mixed with 4.75~16 mm and

Tab. 2 Screening results of coarse aggregate

Number	The test items	The measured values	Standard values
1	Sulfides and sulfates a	0.7%	≤1
2	Chloride content	0.013%	≤0.02
3	Red and white skin content of gravel b	5.2%	≤10
4	The compressive strength of rock	126MPa	≥100
5	Los Angeles attrition loss	26%	≤30
6	Organic content	The color is lighter than standard solution	The color is lighter than standard solution
7	Activity of alkali	Inactive	Inactive
8	Bibulous rate	0.6%	≤2
9	Robustness	1.9	≤3

(3) Admixture

According to the site conditions of this construction, the admixture selected in this test is AJF air entrain efficient water reducing agent, which meets the requirements of the experiment.

3.2 The process of experiment

According to the test scheme, there are 18 groups of tests, with 3 cylinder samples and 3 trabecular samples in each group, a total of 54 cylinder samples and 54 trabecular samples. The splitting tensile strength and bending tensile strength of the specimen were tested after curing.

(4) Water

The water must pass the relevant test indicators required by the specification.



Fig. 1 Experimental process

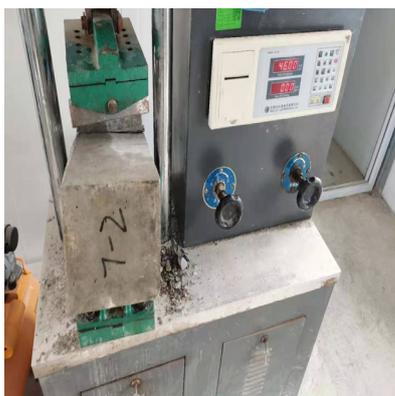


Fig. 2 Strength test

Tab.3 bending tensile strength of samples with different water-cement ratios

Number	Cleavage strength (MPa)	Water-cement ratio
1	6.27	0.479
2	6.51	0.471
3	6.40	0.463
4	5.86	0.456
5	6.08	0.448
6	6.51	0.441
7	6.54	0.434
8	6.23	0.428
9	6.29	0.421
10	6.83	0.415
11	6.44	0.409
12	7.25	0.403
13	6.70	0.397
14	7.45	0.392
15	6.61	0.386
16	6.98	0.381
17	7.13	0.376
18	7.54	0.371

4.2 Analysis

After the numerical statistical analysis of the obtained data, the bending tensile strength measured in the test was plotted into a scatter plot with the water-cement ratio as the abscissor, and the quadratic polynomial was selected for fitting to obtain the relationship as shown in Fig.3.

4 Test results and analysis

4.1 Results

Through the above tests, the experimental results obtained are shown in Table 3 below.

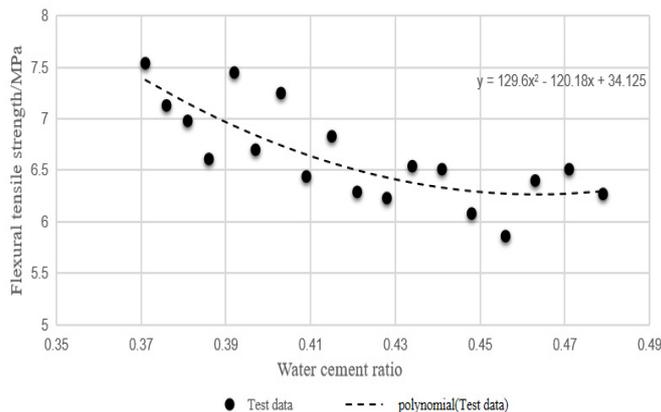


Fig.3 Relationship between bending tensile strength and water-cement ratio

It can be seen from the relation diagram of water-cement ratio and bending tensile strength that when the water-cement ratio of concrete is 0.371~0.479, the quadratic polynomial is used to perform fitting, and the following formula is obtained:

$$\sigma_b = 129.6\left(\frac{W}{C}\right)^2 - 120.18\left(\frac{W}{C}\right) + 34.125 \quad (2)$$

There is: σ_b — Flexural strength, MPa;

$\frac{W}{C}$ — Water-cement ratio.

When the water cement is larger, the concrete compactness decreases. Reduced water cement ratio, cement concrete flexural strength will reduce gradually, based on the analysis of the stress of the concrete trabecular bend test, presumably because the trabecular

bending test of concrete at the bottom of the tensile stress in the largest part of trabecular line position, maximum stress area is linear distribution, the maximum stress zone is the probability of cement mortar, aggregate interface vulnerabilities are relatively small, As the water-cement ratio increases, due to the reduction of free water after hydration, the cement slurry itself tends to be compacted, which increases the bearing capacity in the maximum stress area of the trabecular specimen and ultimately increases the bending and tensile strength of the measured specimen.

5 Conclusion

In this experiment, the influence of water-cement ratio on concrete performance is studied, and the change of concrete performance is analyzed by changing the water-cement ratio of concrete, and the change relationship between water-cement ratio and concrete strength is established. The main conclusions are as follows:

(1) When the water-cement ratio of concrete is in the range of 0.371~0.479, the concrete strength of the sample decreases with the increase of water-cement ratio.

(2) The relationship between concrete strength and water-cement ratio obtained by fitting is as follows:

$$\sigma_b = 129.6\left(\frac{W}{C}\right)^2 - 120.18\left(\frac{W}{C}\right) + 34.125$$

In the future research, we will increase the multi-factor study of aggregate and sand rate, etc., to describe their influence rules on concrete strength in a more detailed manner.

Reference

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