Analysis of influencing factors of flow state concrete mixture performance

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Abstract—Based on the principle of benefiting the durability of concrete, machined sand is used to configure C40 flow concrete, and the engineering application environment and economy are considered. In this paper, the author through the flow state concrete mix ratio design, give the raw material dosage, concrete mixing, finally combined with the workability measurement method, five groups of concrete mix performance testing. According to the test results, the influence of mineral admixture and water reducing agent on the workability of concrete mixture is studied and analyzed, and the reasonable admixture dosage and water reducing rate of water reducing agent and its admixture dosage are finally given.

1. Introduction
Because of its high fluidity, uniformity and stability, flow concrete does not need external force to vibrate when pouring, and can fill the formwork space evenly and compactly. The flow-flow concrete in this study is made of machine-made sand, which is made of high performance water-reducing agent and mineral admixture such as fly ash and mineral powder. It has high fluidity, no segregation and no bleeding.

2. Mix Design of Concrete in Flow State

2.1. Material selection
The raw materials used in this study are:
(1) Cement: P·O ordinary Portland cement, strength grade of 42.5, density of 3100 kg/m\textsuperscript{3};
(2) Fine aggregate: stone powder content of about 5% 1# machine-made sand, medium sand, density of 2600 kg/m\textsuperscript{3};
(3) Coarse aggregate: two kinds of single grade gravel 5mm-10mm, 10mm-20mm, density of 2650 kg/m\textsuperscript{3}; Among them, the gravel with a particle size of 5mm-10mm should be 30% of the total gravel, and the gravel with a particle size of 10mm-20mm should be 70% of the total gravel, which meets the grading requirements;
(4) Mineral admixture: fly ash, density of 2200 kg/m\textsuperscript{3}, slag powder, density of 2950 kg/m\textsuperscript{3};
(5) Admixture: high efficiency water reducing agent, polycarboxylic acid high performance water reducing agent;
(6) Tap water.

2.2. Mix design requirements
In this study, slump and expansion requirements of flow concrete, mineral admixture type and admixture amount, water reducer type, water reduction rate and admixture amount are given. The specific data are shown in Table 1.

| project  | extension degree (mm) | slump (mm) | mineral admixture | water reducing agent | water reducing rate | dosage |
|----------|-----------------------|------------|-------------------|----------------------|---------------------|--------|
| first group | 500-600 | 180-220 | fly ash | 20% | high efficiency water reducing agent | 20% | 2% |
| second group | 500-600 | 180-220 | fly ash, slag powder | 20%, 30% | high efficiency water reducing agent | 20% | 1.5% |
| third group | 500-600 | 180-220 | fly ash, slag powder | 20%, 30% | high performance water reducing agent | 25% | 1.3% |
| fourth group | 500-600 | 180-220 | fly ash, slag powder | 25%, 15% | high performance water reducing agent | 27% | 0.8% |
| fifth group | 500-600 | 180-220 | fly ash, slag powder | 25%, 15% | high performance water reducing agent | 27% | 1.1% |

2.3. Mix design requirements
The task of mix ratio design is to rationally select raw materials according to their technical performance, requirements of design and construction conditions, and determine the amount of each component material in accordance with the technical and economic indicators meeting the engineering requirements [1].

Combined with the relevant indicators of raw materials and according to the method of mix ratio design, the mix ratio of five groups of flow concrete is given, as shown in Table 2.

| project  | cement (kg) | fly ash (kg) | slag powder (kg) | gravel (kg) | sand (kg) | water (kg) | water reducing agent (kg) |
|----------|-------------|--------------|------------------|-------------|-----------|------------|--------------------------|
| first group | 342.1 | 85.5 | / | 1068.0 | 712.0 | 192.4 | 8.6 |
| second group | 240.1 | 96.2 | 144.3 | 995.0 | 663.0 | 192.4 | 6.7 |
| third group | 225.9 | 90.4 | 135.6 | 1010.5 | 673.7 | 180.8 | 5.9 |
| fourth group | 245.5 | 102.3 | 61.4 | 997.7 | 738.3 | 175.9 | 3.3 |
| fifth group | 247.1 | 103.0 | 61.8 | 1006.4 | 729.3 | 177.1 | 4.5 |

3. The Experimental Process
This study uses the above given raw materials to carry out the mixture design of flow concrete, and then mixes the flow concrete mixture. The concrete mixing process is shown in Fig. 1.
The workability of concrete mixture has been measured, but there is no test method that can fully reflect the workability of concrete mixture [2]. In this test, the method of slump and expansion was used to evaluate the fluidity; slump and diffusion patterns were used to evaluate cohesion; evaluation of water retention by naked eye observation of bleeding degree.

Using the method of determination of workability, performance test was carried out for five groups of concrete mixture, main testing indexes are slump, extension, apparent density and the pile height, according to the empirical observation cohesion and state of water retention and so on workability, slump and extension process as shown in figure 2, to measure the specific determination results as shown in table 3.

![Fig.2 Slump and extension degree measurement](image)

| project         | slump (mm) | extension degree (mm) | pile height (mm) | apparent density kg/m³ | water retention | cohesion | state               |
|-----------------|------------|-----------------------|------------------|-------------------------|-----------------|----------|---------------------|
| first group     | 206        | 635                   | 80               | 2380                    | slight bleeding | well     | slight bleeding     |
| second group    | 230        | 675                   | 60               | 2390                    | well            | well     | sticks to the board |
| third group     | 206        | 635                   | 80               | 2380                    | well            | well     | slight bubble       |
| fourth group    | 202        | 535                   | 100              | 2375                    | well            | well     | active              |
| fifth group     | 200        | 540                   | 110              | 2356                    | well            | well     | more active         |
4. Analysis of Influencing Factors of Flow State Concrete Mixture Performance

4.1. Analysis of influence of mineral admixture on workability of concrete mixture

With the development of concrete technology and the requirements on concrete construction conditions, flow concrete has been applied more widely, and mineral admixture has become the sixth component of concrete [3]. Fly ash and slag powder are the admixtures with the largest dosage and the widest range of use at present [4]. In this study, fly ash and slag powder were used to replace cement in equal quantities.

This study analyzes the influencing factors of concrete mixture workability from two aspects of mineral admixture type and admixture amount.

(1) Type of mineral admixture

According to the experimental results of the first and second groups, it is found that under the same water consumption, adding slag powder can improve the fluidity of concrete mix. In addition, some concrete sticks to the slab in both groups of experiments. Through analysis, it is found that the main reason is that the water reducing agent used in the two groups of experiments is too much.

(2) The dosage of mineral admixtures

The effect of adding mineral admixture into concrete is related to its admixture, which should be determined according to the experiment, and the maximum admixture should meet the requirements of relevant national specifications. According to the results and states of the third and fourth groups of experiments, it can be found that the amount of mineral admixture should be appropriate and the economy should not be blindly pursued, resulting in poor performance of concrete mixture. It is found that, on the basis of using high performance water reducing agent, the concrete mixture in flow state shows good performance when the mineral admixture content is about 40%.

4.2. Analysis of influence of water reducing agent on workability of concrete mixture

This paper analyzes the effect of water reducing agent on the workability of concrete mixture from three aspects: water reducing agent type, water reducing rate and mixing amount.

(1) Type of water reducing agent

Water reducing agent according to the effect of alkaline water is divided into the common water reducing agent, high efficiency water reducing agent and high performance water reducing agent [5]. This research mainly adopts high efficiency water reducing agent and the high performance water reducing agent on flow state of concrete mixing. Through the mixing process, it can be found that in the first two groups of experiments, part of the concrete agglomeration phenomenon occurred in the mixing process, and part of the mixture appeared slightly hardening phenomenon. Through analysis, the first group and the second group of experiments using high efficiency water reducing agent, high efficiency water reducing agent on concrete early strength and enhancement effect is significant, the cement hydration reaction is fast, leading to a part of the concrete in the process of mixing hardening. After the three groups of mixing compared with the first two groups, the state of concrete mixing is better, the mixing is more active, and the slump effect is better, mainly because the high performance water reducing agent has good slump maintaining performance. At the same time, there is a phenomenon in the last three groups of mixing materials, a small number of uniform distribution of tiny bubbles, through analysis, the third group, the fourth group and the fifth group of experiments using high-performance water reducer, the water reducer has a certain air permeability.

(2) Water reducing rate

Compared with high efficiency water reducing agent, the high performance water reducing agent with high water reducing rate, the flow state of concrete, has obvious technical advantage and higher ratio of [6].

In addition, the unit water consumption of concrete with admixture is calculated according to the following formula:

\[ m_{w0} = m_{w0}' (1 - \beta) \]  (1)
In the formula, $m_w^0$ - the amount of water per cubic meter of concrete required to meet slump requirements without admixture;

$\beta$ - admixture of water reducing rate (%).

According to Formula (1), the water reduction rate will affect the unit water consumption. The higher the water reduction rate is, the more significant the water reduction effect will be and the less the unit water consumption will be.

(3) The dosage of water reducing agent

In the process of concrete mixing, it can be found that the first group and the second group of experiments in the concrete is too sticky, sticky plate phenomenon, and the flow rate is too slow, through analysis, the phenomenon is mainly caused by the large amount of admixture. On this basis, reduce the amount of water reducing agent of the last three groups of mixing, it is found that the mixing is more active, the phenomenon of sticky plate is reduced a lot. In contrast, the performance of the fifth group of concrete mix is the best, fluidity, water retention and cohesion are good, in line with the flow state of concrete performance requirements. Through experimental research, the flow state of concrete with high performance water reducing agent mixture mixing, the dosage of water reducing agent was 1.1%, the liquidity of concrete mixture, water retention and cohesion are all good.

5. Conclusion

Through the flow state concrete mix proportion design, give the raw material dosage, concrete mixing, and finally combined with the workability measurement method, five groups of concrete mix performance testing, the main testing indexes are slump, extension, apparent density and the pile height. This study mainly studies the influence analysis of mineral admixture and water reducing agent on the workability of concrete mixing material. Combined with the test results, it gives the reasonable content of mineral admixture and the water reducing rate of water reducing agent and its reasonable content, which is of great significance for the popularization and use of flow concrete.

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