Research on the influence of ultrafine sand on concrete performance

Yongxin Chen
KZJ New Materials Group Henan Co., Ltd., Xinxiang, Henan 453731, China
*Corresponding author, E-mail: 732692115@qq.com

Abstract: Ultrafine sand mainly refers to the fine sand excavated underground in the Yellow River Basin and Jiaozuo or Kaifeng. The fineness modulus is between 0.3-1.0, and the quality is uneven. This paper systematically studies the basic characteristics of ultrafine sand from different origins, such as the mud content, fineness modulus, and MB value, and compares its effects on the performance of the second-generation and third-generation water-reducing agents through experiments. By replacing the machine-made sand in different proportions, the work performance and compressive strength of concrete are studied.

1. Introduction
With the continuous development of the modernization process, the use of building materials is progressively increasing. In recent years, due to the massive use of natural sand resources, the contradiction between supply and demand has been intensified, and the quality of natural sand on the market has also been declining. The concrete industry has begun to use artificial sand to prepare concrete. Due to poor particle gradation, large fineness modulus, and large porosity of artificial sand supplied in the market, the mixed concrete is prone to uneven mixing, poor workability, poor pumpability, and difficult construction.[1]

There is not enough river sand available in Henan due to regional restrictions. The obvious disadvantage of machine-made sand is that the two ends of the gradation curve are large and the middle is small. If the coarser machine-made sand is used alone to mix concrete, it will easily lead to segregation of the concrete without grout and separation of grout and bone, making the concrete unable to be pumped and used in the end. However, the ultrafine sand resources in Henan are very rich. The gradation of ultrafine sand is single, the middle is large and the two ends are small. The disadvantage is that the larger specific surface area will increase the water demand. The mixed use of machine-made sand and ultrafine sand will play a better complementary role[2-4]. Excessive mixing of ultrafine sand will greatly reduce the construction performance of concrete, and excessive mixing will cause a significant decrease in concrete strength[5,6]. This project collected 5 kinds of ultrafine sand from different regions to conduct experiments to study its basic characteristics and influence on the performance of concrete. The first is to explore the effects of different ultrafine sands on the properties of aliphatic and polycarboxylic acids, and the second is to explore the effects of different ultrafine sands on the performance of concrete when different proportions of machine-made sand are substituted.
2. Experimental

2.1. Raw materials
(1) This paper uses PO42.5 cement produced by Taiyangshi Cement Factory, and its physical properties are shown in Table 1:

| Cement type | Standard Water Consumption /% | Setting Time /min | Flexural Strength /MPa | Compressive Strength /MPa |
|-------------|-------------------------------|-----------------|------------------------|---------------------------|
| PO42.5      | 27.0                          | 201             | 5.5                    | 27.8                      |

(2) Water-reducing Agent: meet the national standard GB8076-2008, self-made.

(3) The test indicators of stone used in the experiment are shown in Table 2:

| Grain grade /mm | Apparent density / (kg/m³) | Bulk density / (kg/m³) | Mud content /% | Crush value /% | Needle flake content /% |
|-----------------|----------------------------|------------------------|----------------|---------------|------------------------|
| 5~20            | 2740                       | 1540                   | 0.3            | 7.4           | 1                      |

(4) The test indicators of machine-made sand used in the experiment are shown in Table 3:

| Crush Value /% | Bulk Density / (kg/m³) | Fineness Modulus | Mud Content /% |
|----------------|------------------------|------------------|----------------|
| 23.4           | 1520                   | 2.8              | 1.2            |

(5) The origin and basic characteristics of the ultrafine sand used in the experiment are shown in Table 4:

| Origin of sample | Number | Fineness Modulus | Mud Content /% | MB value | Apparent density / (kg/m³) | Bulk Density / (kg/m³) | Porosity /% |
|-----------------|--------|------------------|----------------|----------|---------------------------|------------------------|-------------|
| Jiaoyu          | S-1    | 0.5              | 7.80%          | 1.00     | 2600                      | 1300                   | 50%         |
| Zhengzhou       | S-2    | 0.8              | 5.40%          | 0.75     | 2620                      | 1420                   | 46%         |
| Kaifeng         | S-3    | 0.3              | 7.70%          | 1.00     | 2620                      | 1320                   | 50%         |
| Jiaozuo         | S-4    | 0.6              | 4.30%          | 0.75     | 2640                      | 1370                   | 48%         |
| Xinxiang        | S-5    | 0.4              | 12.60          | 2.25     | 2680                      | 1260                   | 53%         |

2.2. Performance test method
Concrete performance is implemented in accordance with GB 8076-2008 "Concrete Additives", and related performance indicators are tested.

3. Experimental results and discussion

3.1. The adaptability of different ultrafine sand and water reducing agent
The concrete mix used in the experiment is shown in Table 5:

| Cement | Machine-made Sand | Ultrafine Sand | Stone (5-20) | Water |
|--------|-------------------|----------------|--------------|-------|
| 360    | 570               | 300            | 1000         | 170   |

3.1.1. The influence of different ultrafine sand on the performance of aliphatic
Fix the concrete mix ratio and the types of admixtures, adjust the amount of admixtures, so that the concrete reaches a similar initial expansion degree. The experimental results are shown in Table 6:

| Number | Additive Dosage /% | Slump /mm | Expansion /mm | Bucket Down Time /s | Compressive Strength /MPa |
|--------|--------------------|-----------|---------------|----------------------|---------------------------|
| S-1    | 2.8                | 235       | 230           | 600                  | 580                       | 7.15                     | 14.2       | 26.8   | 39.6   |
| S-2    | 2.6                | 235       | 235           | 590                  | 590                       | 7.74                     | 15.6       | 29.2   | 41.2   |
| S-3    | 3.0                | 230       | 225           | 580                  | 530                       | 8.32                     | 14.8       | 31.0   | 39.3   |
The analysis in Table 6 shows that as the fineness modulus of the ultrafine sand increases, the aliphatic content gradually decreases, because the specific surface area of the ultrafine sand decreases and the water demand decreases; the impact of ultrafine sand on the slump retention performance of concrete must be comprehensively considered the sand fineness modulus and its MB value. When the fineness modulus is larger and the MB value is smaller, the concrete slump is smaller; the strength development is more closely related to the mud content, the higher the content, the lower the strength.

### 3.1.2. Adaptability of different super fine sands and carboxylic acid water reducers

Using the same admixture, adjust the dosage and compressive strength required to equal the initial expansion degree as shown in Table 7:

| Number | Additive Dosage/\% | Slump/mm Initial 1h | Expansion/mm Initial 1h | Bucket Down Time/\text{s} 3d Initial 1h | Compressive Strength/\text{MPa} 3d Initial 1h |
|--------|-------------------|---------------------|-------------------------|----------------------------------------|-------------------------------------------|
| S-1    | 2.2               | 240 225             | 610 500                 | 6.36                                   | 15.6                                      |
| S-2    | 2.2               | 245 225             | 620 520                 | 4.77                                   | 16.4                                      |
| S-3    | 2.3               | 240 230             | 600 480                 | 5.91                                   | 17.3                                      |
| S-4    | 2.4               | 250 235             | 610 530                 | 4.20                                   | 16.6                                      |
| S-5    | 3.0               | 230 175             | 610 500                 | 8.60                                   | 18.2                                      |

From the analysis of the above table, it can be seen that the MB value has a more obvious influence on the carboxylic acid content and the slump of concrete. This is because the mud in the ultrafine sand has more significant adsorption of carboxylic acid; its later strength development is also greatly affected by the MB value. The larger the MB value, the lower its strength.

Based on the above analysis, it can be seen that when using aliphatic admixtures, it is necessary to combine the comprehensive properties of ultrafine sand fineness and MB value, while when using carboxylic acid admixtures, pay attention to the results of the MB value of ultrafine sand.

### 3.2. The influence of ultrafine sand content on carboxylic acid content

Fix the sand ratio of the mix ratio, adjust the proportion of ultrafine sand in the fine aggregate, and adjust the amount of admixtures to make the expansion of the concrete reach a similar degree of expansion. A comparative analysis of the effects of changes in the content of different types of ultrafine sand on the content of carboxylic acid and the state of concrete is shown in Figure 1 and Figure 2 for the experimental results.

![Figure 1 The influence of ultrafine sand content on carboxylic acid content](image)

Comparing the analysis of Table 5 and Figure 1, it can be seen that with the increase of ultrafine sand content, the amount of polycarboxylic acid gradually increases; comparative analysis of the amount of polycarboxylic acid of different types of ultrafine sand shows that the amount of polycarboxylic acid used in the S-5 group is the largest and is most affected by the amount of ultrafine sand. This is because the S-5 MB value is the largest, that is, the mud content is the highest, and the
adsorption of the admixture is the most serious. The MB values of the remaining four groups are basically the same and indicate that they contain powder and have weak adsorption capacity. The impact on the amount of polycarboxylic acid comes from the different specific surface area of the sand. The specific manifestation is that the more the sand, the greater the amount of carboxylic acid and the higher the content the impact is more obvious.

Comparing Table 5 and Figure 2, it can be seen that the slump loss of S-5 group is more obvious when the ultrafine sand content is the same, and the slump increase of S-5 group is larger with the increase of ultrafine sand content. This is because S-5 has a high mud content. Even if the mixing amount is increased in the early stage, the same state can be achieved, but the continuous adsorption of the ultrafine sand mud-containing admixture greatly reduces the effective content of the admixture, making its later slump loss more obvious; the other four groups have higher powder content and weaker adsorption capacity for external additives, so the main influence on concrete slump is the adsorption of fine particles, and its development trend has a greater relationship with the fineness of ultrafine sand.

### 3.3. The influence of ultrafine sand content on concrete strength

The 3.2 experimental mixed concrete was formed and cured as required, and its 7d and 28d strengths were tested for comparison. Analyze the physical characteristics of different ultrafine sands and the influence of the mixing amount on the concrete strength. The experimental results are shown in Figure 3:

Comparing Table 5 with Figure 3, we can see that the strength of concrete decreases with the increase of the ultrafine sand content. The overall strength of the S-5 group is relatively low and is greatly affected by the addition of ultrafine sand. This is because the mud in the ultrafine sand does not participate in the hydration reaction in the concrete, does not provide strength, and its own voids are relatively high, and it is easier to absorb water, making its existence in the later concrete similar to the pore structure, the overall strength of concrete is low; There is no clear linear relationship between

![Figure 2 Influence of ultrafine sand content on slump loss of concrete](image1)

![Figure 3 The influence of superfine sand content on concrete strength](image2)
the intensity change trend of the remaining four groups and the fineness of ultrafine sand and the MB value. This is because the combination of ultrafine sand and machine-made sand will change the gradation structure of concrete as a whole, and interact with the fineness and MB value of the ultrafine sand itself to affect the development of concrete strength.

4. Conclusion
(1) The research on the adaptability of ultrafine sand and different admixtures shows that the fineness modulus of ultrafine sand has a relatively large influence when using aliphatic additives, the polycarboxylic acid admixture is greatly affected by the MB value of ultrafine sand.
(2) Through comparative study and analysis of the effect of different ultrafine sand content on the performance of concrete using polycarboxylic acid admixtures, it can be seen that when the ultrafine sand content is high, the amount of admixture increases significantly and the overall performance becomes worse. When ultrafine sand contains powder, its influence is relatively weaker and more complicated, and it needs to be analyzed in conjunction with the overall concrete.

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