Influence of stone powder content in machine-made sand on mortar concrete

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Abstract. The paper mainly studies that Influence of stone powder content in machine-made sand on mortar concrete. By changing the amount of stone powder in the machine-made sand, the ratio of cement to water and sand to grout, the change in the tensile value of the steel bar in concrete can be found. After a lot of test data to prove that the content of stone powder is 6%, the mortar ratio is 1:2.5, the water-cement ratio is 0.40, the content of water-absorbent resin is 0.20, and the performance of the C40 concrete is good.

1. Introduction
At present, the application range of concrete is very large, the proportion of natural sand in concrete accounts for 25%~35%. The amount of river sand in natural sand is huge, and its output becomes smaller, which cannot meet the engineering needs. Therefore, mechanical sand is used to replace natural sand in the project. The author consulted domestic and foreign research data on machine-made sand and found that the source of machine-made sand is mainly to establish a stone yard at the construction site, and select nearby stones as raw materials for machine-made sand. The content of stone powder in machined sand is large and the performance is not good[1-3]. Especially in the application of concrete with a configuration strength of C30 or more, a large engineering problem occurs, resulting in poor construction quality and problems in concrete indicators. In particular, the gripping force between reinforced concrete will be reduced[4]. The loss of stress tension is severe. Therefore, the application of mechanical sand making in concrete is limited.

This paper is mainly changing the mechanism of the stone powder content, mortar ratio, water-cement ratio conditions. The mortar fluidity tester is mainly used to detect the fluidity of mortar. The pull-out test is used to determine the tensile value between the mortar and the steel bar. Finally, observe the structure of the structure through the concrete bubble gap instrument, and further study the influence of the amount of stone powder in the machine-made sand[5]. Finally, The strength of the C40 is used to determine whether its work-ability meets the requirements.

2. Raw Materials

2.1 The P·O 42.5 index are shown in table 1.

| Fine/% | Setting time/min | Stability | 3d/MPa | 28d/MPa |
|-------|------------------|-----------|--------|---------|
|       | Initial          | Final     | pressure | Anti-fold | pressure | Anti-fold |
| 3.2   | 130              | 340       | qualified | 25.3     | 4.6      | 79.2     | 8.2     |

Table. 1. The cement index
The Water meets the GB 5749-2006 "Sanitary Standard for Drinking Water". The natural sand fineness modulus is 2.81, apparent density is 2.657kg/m³, mud content is 0.6% and all indicators meet the relevant specifications. The sieve grading are shown in Table 2.

| Screen size/mm | Weight /g | Score rate/% | Score rate /% | Pass rate/% |
|----------------|-----------|--------------|---------------|-------------|
| 9.5            | 0.0       | 0.2          | 100           |             |
| 4.75           | 1.7       |              |   99.8        |             |
| 2.36           | 152.5     | 15.3         | 84.5          |             |
| 1.18           | 167.2     | 15.5         | 76.8          |             |
| 0.60           | 263.3     | 32.2         | 41.5          |             |
| 0.30           | 211       | 58.5         | 21.4          |             |
| 0.15           | 128.5     | 79.6         | 7.6           |             |
| Bottom         | 75.3      | 92.4         | 0.1           |             |

The sieve grading is shown in Table 2.

Table 2. The sieve grading

The stone powder ethylene blue value 0.66%, apparent density 2.667kg/m³, stone powder sieve (0.045mm) 5.8%.
The gravel particle size 4.75~26.5mm, continuous grading. Performance parameter are shown in table 3.

| Apparent g/cm³ | Crushed /% | Needle /% | Rugged /% | Mud /% | Absorb water /% |
|----------------|------------|-----------|-----------|--------|-----------------|
| 2.702~2.821    | 16.0       | 4.6       | 4.2       | 0.6    | 0.48            |

The high performance water reducer water reducing agent dosage is 1%.
The water absorption rate of water-absorbing resin is 70%.
The C40 concrete ratio shown in Table 4, its density is 2400 kg/m³, water-to-binder ratio is 0.22.

| P-O 42.5 | Gravel (10-20mm) | Gravel (5-10mm) | Sand | Water | Water reduce | Stone powder | Resin |
|----------|------------------|-----------------|------|-------|-------------|--------------|-------|
| 420      | 766              | 343             | 712  | 160.2 | 0.8         | 25.2         | 0.84  |

2.2 Preparation and maintenance methods of test pieces

The fluidity is based on the test method of fluidity of cement mortar (GB/T 2419-2005).
According to the mortar compressive strength test code (ISO9001-2015), steel bars are embedded in the specimen, test the 72-hour pull-out value after referring to the mortar planting bar.
The strength of concrete is tested in accordance with the Standard for Testing Methods for Mechanical Properties of Ordinary Concrete (GB/T50081-2002).
The test of concrete bubble gap is based on hydraulic Concrete Test Code SL (352-2006).

3. Results and analysis

3.1 The effect of the amount of stone powder on the drawing value

With the increase of the content of stone powder in concrete, various performance indexes of concrete will change in different situations. The final dosage of stone powder will be determined through the flow degree test of rubber sand and the drawing value test of 28-day steel reinforcement in mortar.

Referring to the concrete reinforcement method, the ash dosage is 450g, the reference sand is 1350g, the water reducer content is 1%, the water reduction rate is 20%, the stone powder content is 0% to 16% of the cement content, and the mortar flow is carried out at an interval of 2% and 72-hour pull-out test of drawing value of mortar. The results are shown in Table 5.
Table 5. The effect of different stone powder content

| Stone content /% | Cement /g | Sand /g | Water /g | Fluidity /mm | Draw value /kN |
|------------------|-----------|---------|----------|--------------|----------------|
| 0                | 450       | 1350    | 180      | 178          | 2.034          |
| 2                | 441       | 1350    | 180      | 180          | 2.136          |
| 4                | 432       | 1350    | 180      | 181          | 2.200          |
| 6                | 423       | 1350    | 180      | 183          | 2.390          |
| 8                | 414       | 1350    | 180      | 182          | 2.460          |
| 10               | 405       | 1350    | 180      | 177          | 2.301          |
| 12               | 396       | 1350    | 180      | 170          | 2.018          |
| 14               | 387       | 1350    | 180      | 160          | 1.932          |
| 16               | 378       | 1350    | 180      | 155          | 1.564          |

It can be seen from Figure 1 that as the amount of stone powder increases, the fluidity and drawing value increase first and then decrease. When the amount of stone powder is 6%, the degree of fluidity is 183mm and the drawing value is 2.390kN. At 8%, the fluidity is 182 mm, and its pull-out...
value is 2.460kN. Comprehensive experimental results show that the best effect is achieved when the amount of stone powder is 6%~8%.

Therefore, through research and analysis, it is found that the amount of stone powder in the mortar increases, which plays a filling role at the beginning. As the amount increases, the stone powder absorbs a large amount of water, which causes the mortar to become viscous and reduce its fluidity. In the same way, the increase in the amount of stone powder causes the adhesion of the mortar to decrease after hardening, and the drawing value becomes smaller, which meets the objective conditions.

3.2 Influence of mortar ratio on drawing value

The sand ratio in the mortar will affect its workability, and the influence of the sand ratio on the concrete can be further determined through the tests of fluidity and pull-out value.

Referring to the concrete planting method, the comparison of the stone powder content is 6% and 8%, the admixture content is 1%, the water consumption is 180ml, and the cement material is 450g. The pull-out test results of pull-out value are shown in Table 6.

| Molar Ratio | 6% Fluidity/mm | 6% Draw Value/kN | 8% Fluidity/mm | 8% Draw Value/kN |
|------------|----------------|-----------------|----------------|-----------------|
| 1:2        | 170            | 2.313           | 165            | 2.203           |
| 1:2.5      | 182            | 2.398           | 181            | 2.392           |
| 1:3        | 178            | 2.260           | 173            | 2.252           |
| 1:3.5      | 170            | 2.021           | 168            | 2.092           |
| 1:4        | 150            | 1.065           | 145            | 1.586           |

![Fig.2 The trend graph of different molar ratios](image)

It can be drawn from Figure 2 that as the amount of sand changes, the mortar fluidity and drawing value decrease first and then decrease. When the mortar ratio is 1:2.5, the 6% fluidity is 182mm and the drawing value is 2.398kN; 8% fluidity is 181mm, drawing value is 2.392kN. Comprehensive tests show that when the ratio of mortar and sand is 1:2.5, the fluidity and drawing value have the highest effect.

Through experimental analysis, it is found that the sand ratio has a great influence in the mortar, and it becomes smaller at the beginning of the increase, indicating that the most suitable ratio can get good results, and at the same time, the appropriate sand ratio can improve its adhesion.

3.3 The effect of water-cement ratio on the pull-out effect.

The determination of the water cement ratio in the mortar is a very critical indicator. It is particularly important to further react the influencing factors in the mechanism sand by changing the water cement ratio.
Referring to the concrete planting method, when the amount of stone powder is 6% and the ratio of mortar and sand is 1:2.5, change the amount of water and ash, compare the fluidity and drawing value, and determine the amount of water and cement. The test results are shown in Table 7.

| Water ratio | Fluidity/\(\text{mm}\) | Draw value/kN |
|-------------|----------------------|---------------|
| 0.36        | 162                  | 2.112         |
| 0.38        | 171                  | 2.285         |
| 0.40        | 180                  | 2.400         |
| 0.42        | 189                  | 2.365         |
| 0.44        | 198                  | 2.256         |
| 0.46        | 207                  | 1.965         |

Fig.3 The trend graph of different water cement ratio

From the results in Fig 3, it is found that as the water-cement ratio increases, the greater the mortar fluidity, the mortar drawing value first increases and then decreases[7]. When the water-cement ratio is
0.40, the fluidity value is 183mm, and the drawing value is 2.400kN. When the water-cement ratio exceeds 0.40, the drawing value drops to 2.256kN and the strength decreases by 6%. Comprehensive test can be concluded that the overall effect is good when the water-cement ratio is 0.40.

It is found from the experiment that the water-binder ratio increases, the fluidity increases linearly, but the drawing value first increases and then decreases, indicating that the increase in water consumption can increase its compactness, but excess water will reduce its overall strength value, so need to choose a suitable water-to-binder ratio as the final ratio.

3.4 Effect of water-absorbent resin content ratio on drawing value
Adding resin to the mortar can increase its overall strength on the one hand, and reduce the occurrence of cracks on the other hand. Special maintenance is not required in the later curing of the strength of the mortar, which further improves its overall performance.

According to the test progress, it is determined that the amount of stone powder is 6%, the water-cement ratio is 0.40, and the water-binder ratio is 0.25. The effect of changing the amount of water-absorbent resin on the fluidity and drawing value is determined. The test results are shown in Table 8.

| Resin dosage | Water/g | Fluidity/mm | Drawing value/kN |
|--------------|---------|-------------|-----------------|
| 0            | 162     | 180         | 2.386           |
| 0.2          | 171     | 182         | 2.410           |
| 0.4          | 180     | 178         | 2.391           |
| 0.6          | 189     | 175         | 2.355           |

Fig.4 The trend graph of different molar ratios
After observing Fig 4, it is found that with the increase of the water-absorbent resin content, the mortar fluidity and the mortar drawing value first increase and then decrease\cite{8}. When the water-absorbent resin content is 0.20\%, the mortar fluidity is 182mm, drawing The maximum value is 2.410kN. Comprehensive consideration of choosing resin dosage is 0.20.

Through experiments, it is found that the resin has a great influence on the fluidity and drawing value of the mortar. This is because on the one hand, the resin has water absorption, on the other hand, its compatibility in the mortar is not particularly good, which leads to the decrease of the value of strength. Therefore, it is necessary to select an appropriate ratio of resin to improve its requirements in some aspects.

4. Micro-analysis and strength indicators

4.1 bubble gap rate test results

Using a concrete bubble gap tester, observe the internal structure of the three samples of 0\%, 6\%, and 12\% after the pull-out test. The test results are shown in the following fig 5~7.

![Fig.5 the stone powder content 0% sample](image1)
![Fig.6 the stone powder content 6% sample](image2)
![Fig.7 the stone powder content 12% sample](image3)

It can be seen from Fig 5 to 7 that the amount of 0\% is more voids, the adhesion sample 12\% has more dust and poor cohesion, and the 6\% sample has a better bonding effect on the pull-out value and the voids are small, The sample appears adhesive wear, so from the micro-structure analysis, the overall analysis of the content of 6\% is the best effect and strength.

Through the bubble gap test, it is found that under the enlarged microstructure, the density of the mortar concrete and the number of bubbles have a great relationship with the amount of stone powder. Choosing the right stone powder can further compact the structure and reduce the amount of air bubbles, improve its overall performance.

4.2 Comprehensive test results

Determine the mix ratio according to the mortar and compare the design requirements of the ordinary concrete mix ratio, and conduct the workability and strength test of C40 concrete to further test its performance.

Choosing concrete mix ratio/kg, C: S: G=1: 1.70: 2.64, water-to-binder ratio 0.40, water-reducing agent content 1\%, resin 0.2\% mixed concrete, found good fluidity, no segregation bleeding
phenomenon, The sand content is good, the stick degree is medium, and the slump is 190mm; the slump is 170mm after being placed for 1h, the slump loss is small, and the overall performance is good. Standard test pieces were made and tested for 3 days, 7 days, and 28 days. The results are shown in Table 9 below.

| Age | 3d   | 7d   | 28d  |
|-----|------|------|------|
| Test results | 18.3 | 26.5 | 51.8 |
| 18.6 | 27.1 | 50.2 |
| 19.2 | 27.3 | 49.6 |
| Ave  | 18.7 | 27.0 | 50.2 |

It can be seen from the test results that the 3d strength is 18.7MPa and the 7d strength is 27.0MPa; the 28d strength is 50.2MPa, compared with the standard values at the same time, respectively increased by 10.7%, 26.0%, 20.8%, the overall early strength low strength, high strength in the later stage, meet the strength requirements of C40.

Through concrete workability and strength tests, it is found that the strength and water retention of fresh concrete can meet the specification requirements of C40 concrete and can improve its technical performance.

5. Conclusion

According to the mortar fluidity test method and the 72-hour pull-out value after referring to the mortar planting bar, the parameters are determined. The specific conclusions are as follows:

(1) The amount of stone powder is 6%, the mortar ratio is 1:2.5, the water-cement ratio is 0.40, the resin is 0.20, the fluidity reaches 183mm, and the maximum tensile value is 2.410kN. The mechanical properties are the best.

(2) Through the test results of the mixed bubble gap test, it is found that when the content is 6%, the microstructure is the densest, the grip strength of the steel bar and the concrete is the strongest, and the integrity is the best.

(3) The concrete ratio is C: S: G=1: 1.70: 2.64, the water-binder ratio is 0.40, the water reducing agent is 1%, the resin content is 0.2%, the strength results of 3d, 7d, and 28d are measured. The C40 concrete meets the requirements.

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