Robustness interval of apparent air bubbles of fair-faced concrete

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Abstract. In this paper, a method of controlling the apparent quality of fair-faced concrete is adopted. By adjusting the rheological parameters of fair-faced concrete slurry, the robustness interval of repeatedly stable preparation of fair-faced concrete with excellent apparent quality is obtained. It has a good economy and has a good guiding significance for practical engineering. The results show that the plastic viscosity coefficient of fair-faced concrete slurry is 5.67~9.69 Pa·s, and the yield stress is between 112.25~195.68 Pa. The fair-faced concrete with good apparent quality can be obtained.

1. Introduction

Fair-faced concrete is a special type of concrete which is formed in one step and is decorated directly with the original concrete surface or the concrete surface treated with transparent protective agent [1, 2]. Its smooth surface, no obvious color difference, Sharp Angle, no damage and other quality issues, through its own texture to achieve the clear water concrete “inside and outside the actual beauty” of the technical requirements.

Zerbino [3] found that a reasonable viscosity range can not only improve the rheological properties of self-compacting concrete, but also improve the apparent quality of fair-faced concrete. Technical Specification for application of self-compacting concrete [4] mentioned that although self-compacting fair-faced concrete has the advantages of both self-compacting and fair-faced water in theory, self-compacting concrete has great fluidity and the amount of cementitious material used in slurry is large. In order to prevent the segregation bleeding, the slurry must have a large viscosity, which makes it difficult to remove the air bubbles on the surface of concrete and affects the apparent quality.

Fair-faced concrete has gradually become a trend of development. It has many advantages [5, 6], such as being able to avoid environmental pollution caused by building decoration materials, and having simple, plain and true architectural performance effects, etc. However, the surface quality of fair-faced concrete is still a practical problem which is difficult to solve in engineering [7, 8]. For the problem of air hole, there are many methods to deal with it at present, but most of them are based on experience and have great randomness. Based on the plastic viscosity Coefficient and yield stress of the paste, the control method of the surface blowhole of fair-faced concrete is put forward in this paper.
2. Raw materials and test methods

2.1. Raw materials
PO 42.5 ordinary portland cement produced by Nanjing Conch Cement (CA), with a density of 3.16 g/cm³; PO 42.5 ordinary portland cement produced by Nanjing Jiangnan Xiaoyetian cement (CB), with a density of 3.13 g/cm³; grade I fly ash produced by Changshu Power Plant; grade S95 mineral powder produced by Zhangjiagang Lianfeng iron and steel; medium coarse sand from Dongting Lake in Hubei Province with a sieve of 4.75mm; 5-25mm stone produced by Kangcheng is used; polycarboxylate lipid superplasticizer (PSA) provided by Sika additive company is used, with water reduction rate of 30%; polycarboxylate ether superplasticizer (PSB), with water reduction rate of 30%; drinking tap water is used for mixing water.

2.2. Specimen preparation
The strength grades of fair-faced concrete commonly used in engineering are C40, C45, C50, C55 and C60 respectively, and the cross preparation tests of fair-faced concrete with the above two kinds of cement and two kinds of admixtures are carried out. Specific test combinations are shown in Table 1.

| Strength grade | W/B | Water/ kg·m⁻³ | Cement/ kg·m⁻³ | FlyAsh/ kg·m⁻³ | Mineral powder/ kg·m⁻³ | Sand/ kg·m⁻³ | Stone/ kg·m⁻³ | Water-reducing admixture/% |
|----------------|-----|---------------|----------------|----------------|------------------------|--------------|--------------|-----------------------------|
| C40            | 0.33| 154           | 341            | 47             | 80                     | 712          | 1068         | 1.2                          |
| C45            | 0.31| 152           | 358            | 49             | 83                     | 668          | 1090         | 1.2                          |
| C50            | 0.29| 152           | 398            | 42             | 84                     | 639          | 1135         | 1.2                          |
| C55            | 0.27| 150           | 406            | 55.6           | 94.5                   | 662.7        | 1081.3       | 1.2                          |
| C60            | 0.25| 148           | 432.2          | 59.2           | 100.6                  | 649.8        | 1060.2       | 1.2                          |

For the convenience and requirement of the experiment, the 50cm×10cm×50cm wooden mould designed by myself is used, as shown in figure 1.

2.3. Determination and adjustment of yield stress and plastic viscosity coefficient

2.3.1. Determination of yield stress and plastic viscosity coefficient. The Brookfield RST Rotational viscometer is used to determine the yield stress and the plastic viscosity coefficient of fair-faced concrete pastes. Due to the rotation of the rotors in the pastes, the coarse aggregates in the concrete pastes will touch the rotors Rotor damage and affect the accuracy of the data measured, so the paste in the coarse aggregate after leaching to determine.

The program of the Rheologic Property Tester of concrete can be designed into four stages: 1 slow running stage: rotational speed 0.1 RPM, duration 60s; 2 acceleration stage: Duration 100s, rotational speed is divided into 10 gradient, each gradient increase speed 10RPM, duration 10s; 3 constant speed
stage: Duration 60s, speed 100RPM; 4 Deceleration stage: Duration 100s, speed divided into 10 gradient, each gradient deceleration 10RPM, duration 10s;

Bingham model was used to fit the measured data. Bingham rheological equation was as follows:

$$\tau = \tau_0 + \eta_p \gamma$$  \(1\)

In this equation, \(\tau\) is the shear stress of Bingham Fluid, Pa; \(\tau_0\) is the yield stress of Bingham Fluid, Pa; \(\eta_p\) is the plastic viscosity of Bingham Fluid, Pa·s; and \(\gamma\) is the shear rate of Bingham fluid, s⁻¹.

The intercept and slope of the equation are the yield stress and the plastic viscosity coefficient of the concrete paste.

2.3.2. **Adjustment of yield stress and plastic viscosity coefficient.** The yield stress and plastic viscosity coefficient of fair-faced concrete paste can be adjusted by the dosage of water reducing agent, which is 0.3%, 0.6%, 0.9%, 1.2% and 1.5% respectively.

2.4. **Evaluation of apparent performance**

Three parameters, such as surface porosity, pore size distribution and maximum pore size, can be used to describe the surface porosity of fair-faced concrete in a more comprehensive way.

| Table 2. Evaluation criteria for surface porosity of fair-faced concrete |
|---|
| **Order of evaluation** | **Excellence (1-2)** | **Good (2-4)** | **Disqualification (4-6)** |
| **Evaluation criterion** | The maximum diameter is less than 4mm, and the surface stomatal area ratio is less than 0.2% | The maximum diameter is greater than 4 mm and less than 8 mm and the number is less than 5/m². The surface stomatal area ratio is less than 0.2% | The maximum diameter is more than 8 mm or the surface stomatal area ratio is more than 0.2% |

3. **Results and Discussion**

3.1. **Yield stress and plastic viscosity coefficient**

Based on the same initial air content, the influence of yield stress and plastic viscosity coefficient on the apparent quality robustness of fair-faced concrete is tested. Figure 3 shows the relationship between the plastic viscosity coefficient, yield stress and apparent mass of fair-faced concrete of different strength grades, with the increase of plastic viscosity coefficient The fluctuation of yield stress increases correspondingly, and the apparent quality of fair-faced concrete becomes worse and worse correspondingly. The points of plastic viscosity coefficient and yield stress with good apparent quality are taken out of the four charts, and the overlapping intervals of these points. The plastic viscosity Coefficient and yield stress robust intervals with excellent apparent quality, are taken out The plastic viscosity coefficient of these points overlaps between 5.67 Pa·s and 9.69 Pa·s, and the yield stress overlaps between 112.25 Pa and 195.68 Pa.
4. Conclusion
Based on the same initial air content range, when the plastic viscosity coefficient is between 5.67 Pa·s and 9.69 Pa·s, and the yield stress is between 112.25 Pa and 195.68 Pa, the apparent quality of as-cast-finish concrete is excellent.

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