Research on Construction Method of Self-Compacting Concrete with Machine-Made Sand

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Abstract: Machine-made sand self-compacting concrete is a kind of self compacting concrete with machine-made sand as fine aggregate, which could fill formwork only by its own gravity, without concrete vibration. It is different from ordinary concrete in many aspects, such as fluidity, workability, and configuration method[1]. As a new type of concrete material, machine-made sand self-compacting concrete mix ratio has been studied in depth by many scholars. However, there are relatively few researches on the practical application of machine-made sand self-compacting concrete, especially on construction methods. This paper discusses the characteristics and construction differences between machine-made sand self-compacting concrete and ordinary concrete, and proposes a special construction method for machine-made sand self-compacting concrete.

1. Introduction
Self-compacting concrete is concrete that can be filled with formwork only by its own gravity. At present, due to the lack of natural sand, machine-made sand is used instead of ordinary sand. Due to the high content of machine-made sand and gravel powder, rough surface, and multiple edges and corners, its performance and construction methods are different. There are more researches on the use of machine-made sand for ordinary concrete, but less research on self-compacting concrete with machine-made sand.

This article focuses on the difference in construction methods between machine-made sand self-compacting concrete and ordinary concrete. The new construction methods and precautions of machine-made sand self-compacting concrete are studied from the aspects of pouring method and curing method, and the existing problems in the construction process are analyzed.

2. Method for pouring self-compacting concrete with machine-made sand

2.1. Formwork
The installation process of the formwork for machine-made sand self-compacting concrete is basically the same as that of ordinary concrete. Since machine-made sand self-compacting concrete has better fluidity, the formwork should be installed with attention to compactness to avoid concrete slurry flowing out. Therefore, when installing, pay attention to fasten the horizontal fixing bolts at the bottom and the top firmly, and fill in the styrofoam in the to prevent slurry leakage.

2.2. Pouring method
In order to make the concrete components densely filled, layered pouring method is adopted in the concrete construction. But there are difference between the two kinds of concrete[2]. For the ordinary
concrete. The thickness of each layer shall be controlled between 300mm and 350mm. After pouring, a vibrator could be used for tamping, and it should be inserted in the concrete 50mm for vibrating. When the surface of the concrete mixture is flooded and there is basically no air bubble overflow, it could be regarded as compacted.

The machine-made sand self-compacting concrete has a large internal slurry content, and the coarse aggregates are wrapped in cement mortar and evenly distributed in the concrete, flow to the component under the action of the concrete's own weight\(^\text{[3]}\). Therefore, the machine-made sand self-compacting concrete should not be vibrated for a long time with a vibrator after pouring, otherwise there would be problems with the quality of concrete, such as segregation, slurry floating, aggregate sinking, etc., which would seriously affect the safety of the structure.

While the machine-made sand self-compacting concrete has high fluidity and expansion, the stones are not easy to stay on the upper part, and most of the surface is mortar, so the upper surface has more moisture than ordinary concrete. Generally, the upper surface is not covered by formwork after concrete is poured. The machine-made sand self-compacting concrete has a large of internal heat hydration, leads to a large temperature difference between inside and outside, and the more water loss on the upper surface, which is easy to cause cracks on the surface of the concrete.

While the machine-made sand self-compacting concrete is used to pour a component with the larger vertical size or the larger exposed area on the upper surface, layered pouring method should be used, and the slump of each layer from bottom to top should be gradually reduced. The slump of each layer and the distribution of each layer depends on the geometric characteristics of the components.

2.3. Formwork removal

The time for mold removal of machine-made sand self-compacting concrete could referred to that of ordinary concrete. The machine-made sand self-compacting concrete is filled and compacted inside the formwork by its own gravity, and the surface contacting with the formwork is mostly composed of cement mortar. The ordinary concrete becomes dense due to vibrating, and the surface is mostly composed of aggregates and cement mortar evenly. Therefore, the surface strength of machine-made sand self-compacting concrete is slightly less than the internal strength of concrete, and the surface mortar is easily damaged. Therefore, when removing the formwork, more attention should be paid to avoid damage to the surface concrete.

3. Concrete curing method

The moisturizing and curing methods of ordinary concrete after pouring includes spraying, covering, spraying curing agent, etc\(^\text{[4]}\). Depending on the type of cement, the curing time is different.

After the machine-made sand self-compacting concrete is poured, the strong winds, direct sunlight etc., could cause the upper surface losing water quickly, so the protective materials should be covered in time to prevent the surface from losing too much water and causing the concrete cracking. Machine-made sand self-compacting concrete can adopt the following curing methods: 1) sprinkle water curing 2) water retention film curing, 3) curing agent curing, 4) natural environment curing.
The curing agent curing is spraying curing agent on the surface of the concrete after demoulding is completed, and after the surface is air-dried, a film will form on the surface of the concrete to prevent the loss of moisture inside the concrete, thereby achieving the purpose of curing the concrete.

In the paper, the four curing methods are compared through the rebounded strength of concrete.

| Curing method      | Curing agent | Curing film | Sprinkling curing | No curing measures |
|--------------------|--------------|-------------|-------------------|-------------------|
| Strength (MPa)     | 36.3         | 34.5        | 34.1              | 33.5              |

The curing effect could be viewed from Table 1: curing agent > curing film > water spray curing > natural curing. In the actual project, it is recommended to use curing agent or curing film for curing, but the costs would be higher the other two methods.

4. Problems in the production of self-compacting concrete components with machine-made sand

4.1. Appearance characteristics of machine-made sand self-compacting concrete

After removing the formwork, many bubbles could be found on the surface of machine-made sand self-compacting concrete. There are mainly two types of bubbles, the larger bubbles is about 10mm and scattering relatively, and smaller bubbles is about 1mm and are more concentrated, the reasons are as follows:

The small bubbles are densely distributed and are formed by the floating slurry near the formwork during pouring. It is because that the bubbles in the concrete which are produced by the sinking of the internal stones while the concrete is poured are not discharged, Therefore, when configuring machine-made sand self-compacting concrete, a defoamer should be properly mixed to avoid a large number of air bubbles in the concrete.

4.2. Non-destructive strength testing method of machine-made sand self-compacting concrete

As the non-destructive testing of concrete strength, the rebound test usually be used to measure the strength of the concrete surface. However, for machine-made sand self-compacting concrete, there are more bubbles under the surface, and less coarse aggregates. While the concrete rebound instrument hits the surface of the concrete, it sometimes breaks the concrete bubbles, and the value is lower than that of ordinary concrete. In the paper, the concrete rebound strength and the cubic compressive strength are compared. It is found that rebound strength is only 74.3% of the cubic compressive strength at 28 day, and the rebound strength are more discrete. For self-compacting concrete with machine-made sand, it is suggested that the strength should be measured by the cubic compressive test, and the rebound test is
not recommended.

5. Conclusion
Compared with ordinary concrete, the construction method of machine-made sand self-compacting concrete has its own characteristics. Machine-made sand self-compacting concrete requires higher quality of its raw materials. During construction, the characteristics of self-compacting concrete with machine-made sand should be considered, and the corresponding pouring plan should be specified in combination with the actual project: for the components with dense steel bars and complex structures should add the fluidity of concrete, to ensure dense filling of components, for the simple components with larger exposed concrete surface, could reduce the fluidity of concrete, prevent the concrete surface from cracking due to excessive water loss. Because there are more bubbles on the surface of self-compacting concrete with machine-made sand, the defoamer should be added to the concrete. The rebound strength of self-compacting concrete with machine-made sand is slightly lower than the cube compressive strength. So it is not recommended to judge the strength of self-compacting concrete with machine-made sand by rebound test.

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