Review on self compacting concrete with manufactured sand

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Abstract: With the decrease of natural sand, the manufactured sand is used instead of natural sand to prepare concrete. The research and application of self compacting concrete with manufactured sand in recent years are reviewed in the paper, including influence of the content of stone powder, aggregate gradation to self compacting concrete with manufactured, and the problems and the future work are proposed.

1. Introduction
In 1988, Okamura of Tokyo University successfully prepared a kind of concrete with high fluidity. This kind of concrete has no segregation and bleeding in the pouring process, and can fill the formwork and wrap the reinforcement without vibration. It is named self compacting concrete (SCC).[2] The biggest feature of self compacting concrete is that it has excellent flow performance. It can pass through the barrier of steel bar only by relying on its own gravity and deformation capacity, and fill each part of the formwork tightly. Therefore, in the construction, even if the vibration process is not carried out, the high-quality pouring can be completed.[3] Natural sand is the traditional main source of sand for concrete, and as the largest building material, the massive use of concrete consumes a lot of natural sand resources. With the decrease of natural sand resources, the damage to natural environment caused by the operation of collecting natural river sand is becoming more and more serious. In recent years, natural sand resources are gradually scarce in many areas, and even no natural sand is available. With the rapid decline of natural river sand resources and the requirements of environmental protection, it is necessary to find a kind of material that can replace natural river sand to be used in concrete. The application of machine-made sand in concrete just meets this requirement. Due to the shortage of resources, Japan pays more attention to the development and utilization of resources. By the 1990s, the proportion of natural aggregate and artificial aggregate in Japan has reached 0.5:1[4]. The application of self compacting concrete abroad is increasing day by day, and the research and application technology of manufactured sand self compacting concrete is also relatively mature and systematic. At present, machine-made sand is widely used in commercial concrete instead of natural river sand, which has achieved good economic benefits and made great contributions to environmental protection.

2. Research of self compacting concrete with manufactured sand
Many foreign scholars and a few Chinese scholars have studied the self compacting concrete with manufactured sand, mainly focus on the content of stone powder and the difference of aggregate. It has been applied in a few projects.
2.1 Study on the content of stone powder

The particle size less than 0.075mm in manufactured sand is called stone powder, which is one of the important differences between manufactured sand and natural sand. Appropriate amount of stone powder can improve the cohesiveness and water retention of mixture, improve the interface performance of concrete, optimize the particle size distribution of concrete, improve the compactness of concrete, and then improve the comprehensive performance of concrete.

In foreign research, Celik\cite{5} research shows that the specific surface area of concrete aggregate is related to the content of stone powder, and the specific surface area of aggregate increases with the increase of stone powder content, and the corresponding water demand of concrete increases. Ahemd\cite{6} research shows that under the condition of large water cement ratio and the same slump, the water cement ratio of concrete prepared with natural river sand is larger. According to C.Thai\cite{7}, under the same conditions, the slump of concrete decreases with the increase of stone powder content. The research of B.PHudson\cite{8} shows that when the content of stone powder is within a certain range, it can fill the internal space of concrete and play a lubricating role between aggregates.

In domestic research, XueXiaofang\cite{9} studied the influence of stone powder content on the performance of C50 self compacting concrete with manufactured sand. The results show that certain stone powder can improve the working performance of self compacting concrete with manufactured sand. With the increase of stone powder content, it will affect the durability of machine-made sand self compacting concrete, such as resistance to chloride ion penetration, carbonation and sulfate corrosion, but has no obvious effect on concrete dry shrinkage.

Professor Li Beixing of Wuhan University of technology\cite{10} prepared self compacting concrete with machine-made sand with high content of stone powder(7%). The admixtures include superplasticizer and expansion agent. Mineral admixtures include blast furnace slag powder and HM composite material. When the content of cementitious material is low(545kg/m³), the mixture is prepared. Its slump expansion is 650mm, the anti segregation performance is excellent, and the 28 day compressive strength reaches C60 level.

Southwest University of science and technology\cite{11} used manufactured sand with 15% stone powder content to prepare self compacting concrete with workability meeting the requirements of grade III self compacting concrete and compressive strength reaching 50MPa. Guizhou Expressway Group entrusted Tongji University to study the preparation of self compacting concrete with manufactured sand produced by Guizhou local dolomite instead of natural river sand, and studied its working performance and mechanical properties Ming\cite{12}: although mineral admixture (20% fly ash) and polycarboxylate superplasticizer can improve the fluidity and reinforcement trafficability of self compacting concrete, compared with natural river sand, its working performance and durability are not as good as those of natural river sand; the machine-made sand with 9.2% stone powder content and 3.5 fineness modulus is used to optimize the basic parameters of concrete mix proportion and mix with polylactic acid superplasticizer. The self compacting concrete with large amount of mineral admixtures was prepared by experiments, such as viscosity increaser, defoamer compound admixture and high content mineral admixture. The initial slump is more than 24mm, the slump expansion is greater than 60mm, the outflow time of slump cylinder is 5-15s, and the compressive strength grade is C50.

The self compacting concrete with slump of 250-270mm, slump expansion of 550-750mm, flow time of slump cylinder of 5-15s and strength of C50 were prepared in the laboratory.

It can be found that the stone powder in the manufactured sand with high content of stone powder has little contribution to the fluidity and viscosity of paste, self compacting mortar and self compacting concrete, which makes the mixing flow mobility and viscosity insufficient. The addition of pure stone powder can improve the fluidity and viscosity of paste, self compacting mortar and self compacting concrete, which is beneficial to improve the working performance of self compacting mortar and self compacting concrete. By adjusting the mix proportion, the machine-made sand with high stone powder content can mix the self compacting concrete with excellent working performance, which can be used in the preparation of self compacting concrete in engineering. When the quality of
machine-made sand is difficult to control, the preparation of self compacting concrete with high content of stone powder can also be considered.

2.2 Study on the aggregate
In addition to the instability of stone powder content which will affect the workability and durability of self compacting concrete with manufactured sand, different aggregate gradation and aggregate strength are also one of the factors affecting the performance of machine-made sand self compacting concrete.

Chongqing Jiaotong University studies the replacement of ordinary aggregate with a certain proportion of lightweight aggregate in machine-made sand self compacting concrete. The high-strength shale ceramsite has light weight and small particle size, and its water absorption is much better than that of ordinary gravel aggregate. After the concrete is solidified and formed, it can still release water in the interior of the concrete, promote the further hydration of the cementitious material inside the concrete, and make the concrete interior more hydrated Defect improvement.

Jiang Zhengwu[13] studied the influence of super large particle size and large particle size aggregate on the performance of machine-made sand self compacting concrete members, and compared the compactness, stress-strain relationship and hydration temperature rise. The results show that the addition of lightweight aggregate can greatly improve the workability of machine-made sand concrete, such as fluidity and steel bar gap trafficability. With the increase of lightweight aggregate content, the durability of machine-made sand self compacting concrete first increases and then gradually decreases. After pre wetting, shale ceramsite will release part of water in the concrete test block to promote the further hydration of concrete and effectively control the internal micro cracks of concrete. However, the performance of self compacting concrete with super large particle size and large particle size aggregate manufactured sand is good, and its compressive strength and compactness are large. Compared with ordinary aggregate machine-made sand self compacting concrete, the internal temperature peak of super large particle size and large particle size aggregate manufactured sand self compacting concrete decreases by 18-23 ℃, and the time of temperature peak is prolonged by 4-9h. However, the bending limit load of the components is lower, and the larger the bending moment, the more obvious the size effect of super large particle size aggregate. The key factors affecting the mechanical properties, especially the flexural and tensile properties of manufactured sand self compacting concrete members are the particle size, accumulation degree, distribution state and interfacial bonding of super large particle size and large particle size aggregate.

Based on the above research, it can be found that lightweight aggregate can improve the workability of machine-made sand concrete, but its dosage needs to be controlled. The super large particle size and large particle size aggregate have little effect on the compressive strength of manufactured sand concrete, but have obvious influence on its flexural performance.

2.3 Application of self compacting concrete with machine made sand
Although the domestic research on manufactured sand concrete is developing rapidly, compared with natural sand self compacting concrete, the application of machine-made sand self compacting concrete is rare. At present, a small number of domestic projects use manufactured sand self compacting concrete. The third company of China Railway Bridge Bureau prepared C53 self compacting concrete by using machine-made sand with stone powder content of 4.5% and fineness modulus of 2.9-3.2, which was applied to the construction of 236m span steel pipe arch of Beipanjiang bridge in Guizhou. The project won Luban Award in 2003. In Zunyi Guiyang expressway expansion project of China Communications road and bridge south company, manufactured sand self compacting concrete is used in bridge substructure and subgrade protection. Guizhou University prepared self compacting concrete with manufactured sand whose stone powder content is less than and fineness modulus and has been used in the construction of box girder from Guiyang to Kaiyang bridge.

Although there are a few engineering applications, there are no corresponding standards and specifications for the manufactured sand self compacting concrete, and the research on the mechanical
properties of the components is also lacking. Therefore, it is the focus of current research to launch relevant specifications as soon as possible, and to speed up the theoretical and Performance Research on the basis of reasonable evaluation of raw material quality and concrete performance.

3. Conclusion
At present, with the increasing research and application on self compacting concrete with manufactured sand, the quality problems of manufactured sand have been highlighted. The produced manufactured sand has poor grading, unstable stone powder content and MB value, etc. These limit its large-scale application. Therefore, how to decrease adverse impacts of manufactured sand on the workability of self compacting concrete, reduce the cost of self compacting concrete, is the key issues on the application of self compacting concrete with manufactured sand.

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