Literature Survey on Self-Compacting Concrete

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Abstract - *Self-compacting concrete is a specific type of concrete that can flow only by its own weight and can fill any space while keeping its homogeneity. This work summarizes the experiments for evaluating the performance of self-compacting concrete including V-funnel, L-box, J-ring and slump flow tests as well as the recent achievements of the fresh and hardened properties of self-compacting concrete such as slump flow, segregation resistance, compressive strength and tensile strength. Also, the previous researches of durability is surveyed including sulfate resistance, inner frost resistance, freezing and thawing. The effect of dosage amount of water-binder ratio, water-cement ratio and super plasticizer on the properties of self-compacting concrete are revealed based on the survey of previous literatures. Particular emphasis is placed on the availability and economic effectiveness of partial replacement of certain amount of cement by mineral admixtures, rice husk ash and silica fumes instead of cement.*

Keywords: Self-compacting concrete, Fresh properties, Hardened properties, Durability, superplasticizer

1. INTRODUCTION

Self-compacting concrete (SCC) is recognized as one of the largest discoveries in the development of concrete technology. SCC is the liquid particle suspension which can be self-compacted only by its weight without any dynamic vibration can fill gaps in congested reinforcements or geometrically complex structures without segregation and bleeding. In other words, SCC can be an ideal concrete construction material that meets the basic requirements of filling ability, passing ability and segregation resistance. Therefore, SCC makes it easier to build lighter and slender structural elements, large-span bridges and underwater structures. However, no unique mix design method has been established to obtain the optimal SCC so far and there exist only methods based on laboratory tests with high time and material consumption. In addition, the most important problem from the use of SCC is that it costs 20 to 50% more than conventional concrete because it requires more cement, binder and chemical admixture. In order to overcome these difficulties in production and utilization of SCC, studies to improve test methods including slump flow, V-funnel, L-box and J-ring, and studies to quantitatively evaluate the effects of admixtures on the fresh and hardened properties and durability of SCC and studies to replace costly materials such as cement with other materials, are becoming more active.

This paper is aimed to analyze the recent researches related to the development and use of SCC comprehensively and draws a series of important conclusions based on this analysis.

2. LITERATURE SURVEY

Persson [1] performed the experimental and numerical study of material properties of self-compacting concrete (SCC) including Young's modulus, strength, creep and shrinkage and compared results with those of normally vibrated concrete (NVC). Experiment, where the creep characteristics was evaluated by age to loading during 2~90 days used specimens having 8 different mix compositions with water-binder ratio, w/b, ranging between 0.24 and 0.8. The experimental results showed that the creep, shrinkage and elastic modulus of SCC are almost consistent with those of NVC under constant strength, and that the creep coefficient of SCC decreases significantly as the strength of concrete increases.

Felekoğlu [2] performed experiment on 5 mixes with different water-cement ratios (w/c) and dosage levels of superplasticizer. They conducted slump flow, V-funnel and L-box test in order to obtain the mixture parameters giving the optimal self compactability of mix. As well, strength, Young's modulus and splitting tensile strength were tested. Results showed that ratio w/c by volume of from 0.84 to 1.017 gives the optimal with gives self compactability and the mix is blocked or segregated beyond this range. Meanwhile, it was suggested that SCC has higher splitting tensile strength and lower Young's modulus than NVC and stipulations of self compactability tests could not be universal for all kinds of SCC.

Dinesh [3] investigated the SCC with partial replacement of 5, 10, 15, 20 and 25% of common Portland cement by fly-ash and of 2.5, 7.5 and 12.5% by silica fume. The use of silica fume improved the fresh property (workability) and the hardened property (split-tensile strength and compressive strength) of SCC while the addition of fly-ash made it possible to reform the fresh property and to decrease the hardened property.

The workability of SCC and the compressive strength of SCC were tested in [4]. The water-binder ration (w/b) was taken as 0.35 and 0.45 for the total binder of 500 Kg/m^3 and 400Kg/m^3, respectively and the dosage with 4 levels of superplasticizer based on the carboxylic was done into the concrete mix. Furthermore, the partial replacement of 10% of cement by silica fume was tested. From the slump flow, V-funnel, L-box and J-ring test, it was clarified that the dosage of superplasticizer and the usage of silica fume can improve the compressive strength significantly for the lower w/c and there exists the linear relation between the workability and the compressive strength provided that w/c and other mix proportion are constant.

Singh [5] performed the slump flow, V-funnel, L-box and J-ring test in order to study the fresh property of SCC with the partial replacement of 0~20% of cement by the rice husk ash. Experimental results showed that the workability of SCC decreases as the dosage level of rice husk ash increases.

Ferraris [6] considered the slump flow test method widely used for studying the workability of concrete. They used 13 mixes with various viscosity modifying admixtures and different high-range water-reducing admixtures in order to study the wide range of flow behaviors. The precise measurement of plastic viscosity by using the experiment devices such as 2 concrete rheometers, V-flow and U-flow led to the conclusion that only the experimental result obtained by the slump flow test could not evaluate the viscosity of SCC uniquely.

Uysal [7] studied the SCC with the partial replacement of Portland cement by the mineral admixture such as limestone powder, basalt powder and marble powder. Three types of mineral admixture gave positive effect on the workability of SCC at the fresh state, among which the marble powder was the best. Mineral admixtures have significant effects on the hardened property of SCC differently and the dosage of specific amounts of marble powder caused the maximum compressive strength. Finally, it has been drawn the conclusion that the usage of mineral admixtures may be one of good ways for reducing the cost per unit compressive strength.

Xie [7] and Painuly [8] performed the experimental study of high-strength SCC with the dosage of ultrapulverised fly ash and superplasticizer. Newly developed high-strength SCC has been proved to have better workability, mechanical properties and durability, of which the slump flow of 600~750 mm and the flow velocity of 35~80 mm/s was measured by using the slump flow and L-box test, respectively.

By the survey of literatures for the fresh and hardened properties of SCC, Aggarwal [9] proposed that the material properties of SCC under the hardened state are similar to those of conventional concrete, and that the inter frost resistance of SCC is higher while the permeation property such as the oxygen permeability is lower than the conventional concrete. Moreover, they concluded that SCC has high chloride penetration, thaw of frosh freeze and scaling since there exist high dispersion and thick inter transition zone for SCC. Different design methods such as artificial neural network and factorial method could be applied effectively for the optimal design of SCC mixes with desirable properties.

Domone [10] analysed more than 70 literatures for the hardened properties of SCC and applied the statistical methodology with reference to the property of traditional standard vibrated concrete, leading to the derivation of useful results. Difference between compressive strength of mixes with crushed fine aggregates and non-crushed coarse ones for SCC is lower than one for NVC and the ratio of compressive strength of cylinder to one of brick varied between 0.8 for 30 MPa and 1.0 for 90 MPa. The elastic modulus of SCC was lower by 40% than NVC at maximum in case of low compressive strength of 20 MPa whilst its difference was less than 5% for high compressive strength of 90~100 MPa. For the plain concrete, higher fracture toughness of SCC was measured than NVC while it was vice versa for the reinforced concrete.

Şahmaran [11] and Painuly [8] studied the fresh property of fiber reinforced SCC with the partial replacement of 50% of cement in weight by fly ash and proposed that diameter of slump flow ranges from 560 mm to 700 mm and slump flow time is less than 2.9 s for all the mixes considered, leading to being within the accepted tolerance.

3. CONCLUSIONS

In this paper, we analyzed the recent researches on development and utilization of SCC. Based on this, the following conclusions are obtained.

A number of studies have been conducted on the partial replacement of some contents of cement by fly-ash, silica-fume, various mineral admixtures and rice husk ash and some achievements were made. The use of silica fume improves the fresh and hardened properties of SCC, but the dosage of fly ash improves the fresh properties of SCC while reducing the hardened properties. The usage of mineral admixtures also positively influenced the fresh properties of SCC and it was important to reduce the cost of the SCC. As the content of rice husk ash increases, the workability of SCC decreases.

With comparison to normal concrete, studies on the various intrinsic properties of SCC's materials have also been intensified, with particular emphasis on the importance of mixing of components in SCC. In the future, this will lead to a more active promotion of research to establish the optimal mix design method of SCC.

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