Abstract

The models for predicting three functional requirements of filling ability of self-compacting concrete (SCC) i.e. deformability, segregation and passing ability through narrow spaces were proposed. Deformability was defined to include deformation capacity indicated by slump flow and velocity of deformation measured by 50-cm slump flow time (T_{50}). Models for predicting slump flow and T_{50} were developed based on the concepts of free water, water retainability of solid particles, and inter-particle forces in the concrete. It was found that slump flow and T_{50} varied mainly with free water content and were also affected by volume ratio of paste to void of compacted aggregate phase (γ), water retainability of solid particles, and efficiency and dosage of superplasticizer (SP). The dispersion effect of SP was considered to reduce water retainability of powders as well as friction and cohesion among solid particles. Since static segregation has relationship with bleeding, a model for predicting bleeding capacity which was formulated as a function of free water content, effective surface area of solid particles, and average degree of reactions of binders was adopted. It was found that the increases of w/b and γ increased bleeding due to the larger free water amount. Bleeding of the mixtures with naphthalene and melamine based SPs increased with the increase of water reducing efficiency when all other mix proportion parameters were kept constant. However, polycarboxylate based SP showed lower bleeding though having higher water reducing efficiency than the others. The bleeding capacity of 0 % was specified as the minimum requirement for SCC to avoid static segregation. A model for predicting volume of aggregate blocking through bridging at narrow openings was extended from the previously proposed one. The parameters considered in the previous model are size distribution and volumetric ratio of aggregates, and clear spacing and size of the reinforcements. The effects of aggregate shape and viscosity of the concrete were introduced into the model in this study. It was observed that the maximum L-box passing ability and width of the optimum range of T_{50} for achieving the highest passing ability were smaller in cases of higher irregularity and larger volume of aggregates. The verification tests confirmed that the proposed models could be used to predict slump flow, T_{50} and bleeding capacity with satisfactory accuracies. However, the accuracy of model for predicting blocking conditions of SCC and the prediction of bleeding of SCC using polycarboxylate based SP should be further verified.

This study is also aimed to investigate the effects on properties of SCC of bottom ash and very fine sand as partial replacement of normal fine aggregate. When using bottom ash in concrete, water retainability is more practical for being used in mix proportioning than water absorption of the aggregate. A test method for determining water retainability was therefore proposed. Test results of SCC mixtures with bottom ash show that slump flow and L-box passing ability reduced, while T_{50} increased with the increase of bottom ash contents. The use of bottom ash resulted in the reduction of compressive and splitting tensile strengths and caused the increase of porosity. However, these properties were improved in long term by pore refinement due to pozzolanic reaction when 10 % bottom ash content was used. Chloride penetration, carbonation depth, shrinkage in drying environment of the bottom ash mixtures except for the mixture with 10 % bottom ash were larger than those of the control SCC, mainly due to higher porosity. On the other hand, the resistance to sodium sulfate was enhanced with the increase of bottom ash content. It was found that at 10 % very fine sand content, slump flow and L-box passing ability were slightly higher than that of the control SCC due to the compatibility between void content and specific surface area of aggregates and reduced with the increase of very fine sand content when very fine sand content were over 10 %. The increase of very fine sand content increased T_{50} due to the higher effective surface area of the aggregates. As a result, it can be concluded that the optimum replacements for the tested bottom ash and very fine sand are about 10 % by weight of total fine aggregate.