Doctoral dissertation

AUTOGENOUS SHRINKAGE IN SELF-CONSOLIDATING CONCRETE

Abstract

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Self-Consolidating Concretes, as more environmental friendly and ecological than Ordinary Concretes, fit in perfectly with the idea of Sustainable Development. Structures made with use of the Self-Consolidating Concretes are more durable, which directly increases their useful life. Additionally, production of the Self-Consolidating Concretes utilizes mineral additives, often industrial wastes. Due to much higher strength, construction requirements can be met with thinner cross-sections. However, those concretes are much more susceptible to the irreversible shrinkage impacts, resulting in lower cracking resistance.

The major difference between the modern concretes and Ordinary Concretes (traditional) is their lower water/cement ratio of 0,21-0,38. The ratio is only acquirable due to the use of plasticizers and superplasticizers – chemical admixtures impacting the workability of the concrete mix. Use of high amounts of the powder mineral additives increases the tightness of the microstructure. The occurrence of cracks in strategic constructions made with the High-Performance Concretes directed the attention of researchers to the problem of significantly higher, than in Ordinary Concretes, internal shrinkage deformations.

Particularly susceptible to the phenomena are the High-Performance Self-Consolidating Concretes with a low water/cement ratio, high cement and mineral additives content, increased volume of the fine aggregates and new generation of chemical admixtures. Those concretes must be properly cured to avoid the occurrence of autogenous shrinkage caused by the self-desiccation.

The issue is not yet fully researched. There are different interpretations to the actions occurring during the development of the autogenous shrinkage, the influence of mineral additives on its development and increase of the impact of the autogenous shrinkage on the value of total shrinkage. The European Codes describe the methods for testing shrinkage development, but exclude the impact of autogenous shrinkage occurring in the early stages of curing and resulting susceptibility to cracking of concrete.

In the study of literature showed in the dissertation, the author describes the Self-Consolidating Concretes (chapter 3), presents the issue of shrinkage in concrete (Chapter 4) with particular focus on the autogenous actions (Chapter 5) and describes the theoretical models and calculation algorithm (Chapter 6). In following Chapters (Chapter 7-11) author describes the results of the conducted tests and performed analysis, and presents the final conclusions (Chapter 12).

Conducted research can be divided into two stages: preliminary tests and follow-up tests. The first stage involved the evaluation of susceptibility to cracking caused by autogenous shrinkage of Self-Consolidating Concretes with natural and lightweight aggregate. The research involved Self-Consolidating Concretes with different aggregate composition. Tests included the determination of rheological properties of the mix and mechanical properties (compressive strength, tensile strength, modulus of elasticity). The shrinkage of the designed concretes was tested in accordance with the American Standard ASTM 1581. Due to lack of apparatus required by the Standard, the author designed, constructed and calibrated the test bench. At this stage the study involved determination of the influence of aggregate composition on the reduction of concrete susceptibility to cracking due to the early-age shrinkage deformation. Additionally, the influence of lightweight aggregate with different water content, and Shrinkage Reducing Agent was determined.

The preliminary test results showed significant influence of the autogenous shrinkage on the susceptibility of concrete to cracking. The author designed the second stage of the research that focused only on determination of the shrinkage and susceptibility of concrete to cracking caused by it. The tests were performed on the Self-Consolidating Concretes with low water-cement ratio. Two innovative methods for measurement of autogenous shrinkage were designed and implemented in the study. The methods involved building two specially designed test benches that allowed registration of the autogenous deformation in cement composites.

Based on the conducted research, detailed analysis of autogenous shrinkage in concretes were performed. The results were compared to existing material models proposed by other researchers. The study determined the influence of the type and composition of aggregate, water/cement ratio and type of the internal curing on the susceptibility of concrete to cracking. Conducted study showed a significant influence of the water/cement ratio and volume of natural aggregate on the susceptibility of concretes to cracking caused by the shrinkage deformation. Results showed that use of the presoaked lightweight coarse aggregate reduced the autogenous shrinkage in Self-Consolidating Concretes. Use of this type of aggregate that can be considered as a method of internal curing, increased the resistance to cracking caused by the autogenous shrinkage in Self-Consolidating Concretes during curing.

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