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Study on the Practical Use of Urea to Reduce Drying Shrinkage of Concrete by Spraying Urea Solution under Cold Environment

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1 Introduction

Concrete cracking caused by drying shrinkage adversely affects the durability of a structure. The results of past research has shown that drying shrinkage can be reduced by adding urea as an admixture to the concrete. However, mixing various admixtures at the factory increases the costs for equipment and labor. To reduce drying shrinkage more easily and inexpensively, the urea solution can be applied to the concrete surface by soaking or brushing. However, urea solutions are not suitable for use in cold weather because urea in solution crystallizes at low temperatures. This study attempted to solve this problem by mixing antifreeze, which resists freezing, with a urea solution. It was found that the crystallization temperature of urea can be lowered by mixing the urea solution the antifreeze. Furthermore, it was confirmed that the antifreeze/urea solution reduced drying shrinkage for both mortar and concrete.

2 Past Achievements

In previous studies, specimens soaked in a urea solution had less drying shrinkage than untreated specimens. Moreover, the amount of drying shrinkage continue to fall as the soaking time increased[2)]. However, soaking concrete in a urea solution of site is not practical, so an experiment was conducted in which urea solution was brushed onto the surface of the concrete. It was found that the brushing method provide an equal or greater effect on drying shrinkage as soaking[3)].

3 Measures in Cold Season

Previous studies have shown that applying a urea solution to concrete helps to reduce drying shrinkage. However, the solubility of urea decreases at lower temperatures, causing the urea in the water to crystallize and separate out. In cold weather, the urea crystallizes before the solution can be applied to the concrete, thereby reducing the solution's effect on drying shrinkage. To prevent the crystallization of the urea in the solution at low temperatures, antifreeze with freezing resistance was added to the solution. Table 1, Figure 1 and Figure 2 shows various test result.

Table 1. Crystallization temperature of urea.

Name	Component (mass ratio) Antifreeze : Water : Urea	Crystallization temperature (°C)
Antifreeze 30%	3 : 7 : 8	5
Antifreeze 40%	4 : 6 : 7	4
Antifreeze 50%	5 : 5 : 6.5	1
Urea solution	0 : 1 : 1	8

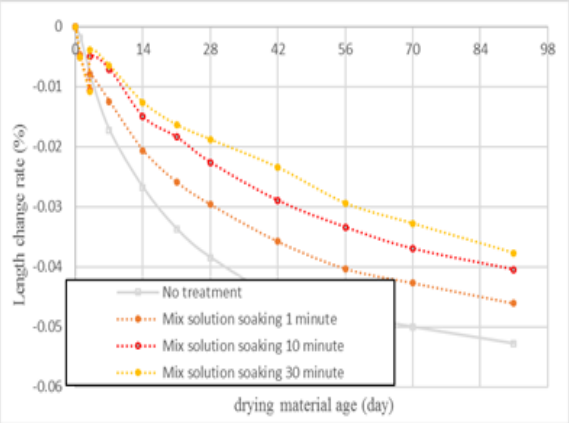

Figure 1. Drying shrinkage test.

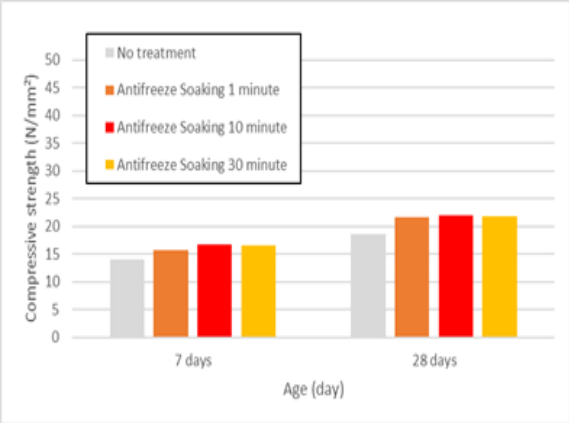

Figure 2. Compressive strength.

This study showed that the crystallization temperature of urea can be lowered by mixing it with antifreeze. Furthermore, soaking the concrete in an antifreeze solution reduces drying shrinkage, as indicated by the lower length change rate in the drying shrinkage test. These results confirm that an antifreeze solution can be used as a drying shrinkage reduction agent in cold weather. The practical application of this method in the field, however, requires further study.

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