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Study on effects of solar radiation and rain on shrinkage, shrinkage cracking and creep of concrete

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ABSTRACT

In this paper, the effects of actual environmental actions on shrinkage, creep and shrinkage cracking of concrete are studied comprehensively. Prismatic specimens of plain concrete were exposed to three sets of artificial outdoor conditions with or without solar radiation and rain to examine the shrinkage. For the purpose of studying shrinkage cracking behavior, prismatic concrete specimens with reinforcing steel were also subjected to the above conditions at the same time. The shrinkage behavior is described focusing on the effects of solar radiation and rain based on the moisture loss. The significant environment actions to induce shrinkage cracks are investigated from viewpoints of the amount of the shrinkage and the tensile strength. Finally, specific compressive creep behavior according to solar radiation and rainfall is discussed. It is found that rain can greatly inhibit the progresses of concrete shrinkage and creep while solar radiation is likely to promote shrinkage cracking and creep.

1. Introduction

Large and long-term time-dependent deformations, such as shrinkage and creep, are exhibited by concrete, which is one of the most typical construction materials. Restraint of the shrinkage by internal reinforcement and external boundary conditions induces a tensile stress in concrete and cracks form when the stress reaches the tensile strength, reducing the resistance to the ingress of detrimental materials such as chloride and CO_2. The creep of concrete is able to reduce the prestressing force of prestressed concrete structures and leads to an increase of the deflection and reduction of the cracking load during service life. Even though these phenomena may not influence the ultimate capacity of concrete structures, the durability and serviceability of such structures can be decreased. Hence, an accurate prediction of long-term shrinkage and creep deformation under actual outdoor environmental conditions is of great importance from the view of rational design as well as the construction of high quality infrastructures.

Since shrinkage and creep are greatly affected by surrounding environmental conditions, numerous laboratory studies of these behaviors focusing on ambient temperature and relative humidity have been reported. On the other hand, a few studies have also reported the behavior of creep and shrinkage under varying actual environments [1–6]. The comprehensive examination of the influence of actual environmental conditions such as solar radiation and rain on shrinkage and creep of concrete can make the effective prediction of the degradation of each structure member possible, since large civil infrastructures can have numerous members that are subject or not subject to solar radiation and rain.

It is easily anticipated that the increase of temperature in concrete due to solar radiation can accelerate shrinkage and creep with the drying of internal pores, while rain makes pores saturated due to infiltration of rain water to reduce shrinkage and creep. However, the acceleration and inhibition effects arising from solar radiation and rainfall have not been quantitatively understood so far. Furthermore, shrinkage cracking is likely to be promoted by the increase of the shrinkage under solar radiation but is also possible to be inhibited if the tensile creep can be increased at hot temperature due to solar radiation as the compressive creep is increased with the surrounding temperature rise [7], while it was found that the smaller tensile creep of concrete with lower W/C cannot release the restraint and is able to cause shrinkage cracking earlier [8]. As El-Sakhawy et al. [9] experimentally reported that the repeated cycle of wetting and drying can reduce the tensile strength, solar radiation drying and rain wetting cycle is plausible to decrease the strength and to promote shrinkage cracking. As mentioned above, the influence of the actual environment on shrinkage, creep and shrinkage cracking is complicated and remains uncertain, and accordingly the effects of solar radiation and rain have not yet been implemented in design codes.

In this paper, the authors endeavor to study the effects of solar radiation and rain on concrete shrinkage, shrinkage cracking, and

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