Correlation between early- and later-age performance indices of early frost-damaged concrete

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Abstract

Freeze-thaw cycles can lead to serious damage of early-age concrete and influence its behaviour at later ages. In this study, the later-age compressive strength, resistance to chloride penetration and resistance to freeze-thaw of early frost-damaged concrete were experimentally studied and the relationship between its early- (i.e., strength and resistivity) and later-age (i.e., strength, chloride ion electric flux and freeze-thaw durability factor) performance indices were analysed. Results show that the later-age performance of the concrete subjected to freeze-thaw cycles at early age was generally worse than that of the control samples, which had not undergone early frost damage. This was especially significant for the concrete subjected to freeze-thaw cycles before the age of 24 h. The compressive strength after early frost action had a higher linear correlation with the later-age indices of the concrete than the compressive strength before early frost action. Results also showed that the early-age resistivity is a good indicator for the later-age performance of early frost-damaged concrete if the pre-curing time before frosting is at least 24 h.

Keywords: early frost damage; compressive strength; resistivity; durability; freeze-thaw cycles.

1 Introduction

In cold weathers, freeze-thaw cycles are one of the main reasons of concrete deterioration as they can cause the generation of micro cracks and surface scaling [1-3]. For early-age concrete, freeze-thaw cycles can lead to serious damage by retarding or stopping its hydration and destroying its weak microstructure [4-5]. Hu et al. [6] experimentally found that if the concrete suffers early frost damage immediately after casting, the subsequent positive temperature developed during curing can fully activate its hydration reaction, and its later performance will also develop adequately. This is due to the concrete being still in a plastic state at this time and therefore most cement-based materials have not yet started to hydrate. However, when the concrete has already set, it has changed from a plastic state to a hardened state. As a result, when experiencing early frost action at this stage, the concrete final strength will be significantly altered. Firstly, frost action can