Analytical and Experimental Study on Estimating the Compressive Strength of Early Age Concrete by the Maturity Method

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OBJECTIVES

In order to expedite the construction process, it might be essential to estimate the early age (less than 1 day) strength of concrete subjected to various temperatures and curing methods for the construction of mountain tunnels. However, the relationship between various curing temperatures and the strength development of concrete at a very early stage is not completely understood, and the current approaches might not be able to predict the compressive strength of concrete at an early age. The objective of this study is to establish a relationship between early age compressive strength of concrete and concrete maturity considering varied temperature histories of concrete. Both numerical and experimental study has been carried out in this study.

OVERVIEW

Estimation of strength of concrete (in situ) at an early age can be critical for many reasons such as removal of the formwork, post-tensioning, handling precast members, etc. In this study, the maturity function of concrete at early age (less than 1 day) was established using different water cement ratio (W/C) and various temparature historis for concrete curing. For, W/C=0.5, the number of experimental cases were 10, where initial concrete temperature ranged between 10 to 30°C and the curing temperature ranged between 10 to 50°C. The concrete maturity function obtained from the experimental study (W/C=0.5) can be seen in Figure 1. To predict the structural behaviour of concrete subjected to different W/C ratio and curing condition, numerical analysis was carried out in the software package LINK 3D. The software can incorporate the modelling of microscopic behavior of concrete, such as the progress of cement hydration reaction, the formation of void structures in hardened bodies, internal moisture state, and the macroscopic view of reinforced concrete. It can be seen from Figure 2 and 3 that there is an excellent correlation between the experimental study and FEM analysis. FEM analysis could predict the strength gain of the concrete specimens with high precision. The numerical study slightly underestimated the experimental data. However, the numerically obtained data can be considered safe in the case of field construction.

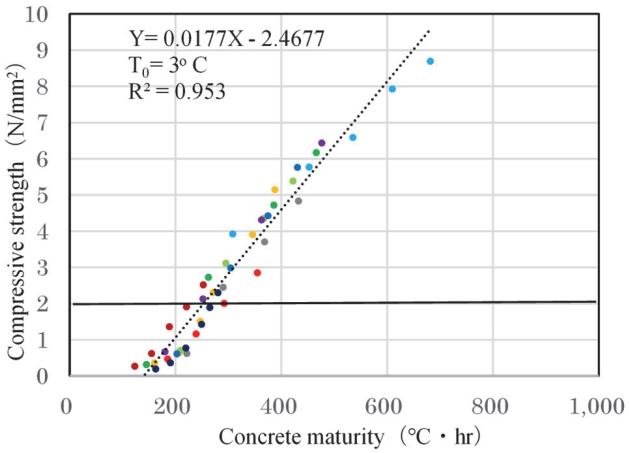
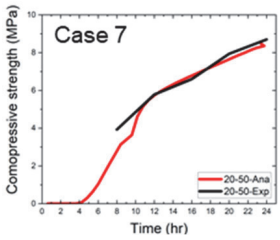


Figure 1: Concrete maturity function for W/C=0.5

RESULTS



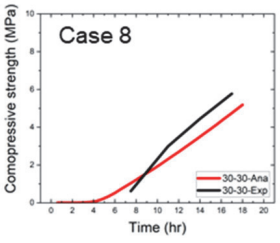
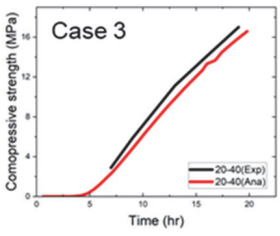


Figure 2: Comparison of experimental and numerical results for W/C = 0.5



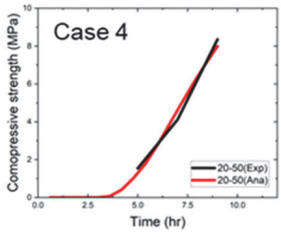


Figure 3: Comparison of experimental and numerical results for W/C = 0.4

From the experimental and numerical analysis, the relationship between compressive strength and concrete maturity at an early age (less than 1 day) was established. It was understood that for W/C=0.5, concrete can gain compressive strength of 2 MPa within 16 hours, when it is subjected to a curing temperature of 20°C or more and an initial temperature of 15°C or more. For W/C=0.4, concrete can gain compressive strength of 2 MPa within 12 hours, when it is subjected to curing temperature of 20°C or more and initial temperature of 20°C or more. Datum temperature may change depending on the concrete mix property. Appropriate datum temperature should be evaluated for improvement of the maturity method.

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