Abstract

The aim of this research is to study carbonation of fly ash concrete and to develop a model for simulating carbonation of fly ash concrete. Carbonation of fly ash concrete is studied by using two types of fly ash with different CaO contents. It is observed that under natural exposure environments, the carbonation rate is the highest when specimens are exposed in the city. The lower carbonation coefficients are observed in environments those have lowers concentration of carbon dioxide (rural and seaside areas). It is also observed that carbonation coefficients of specimens exposed without the possibility of rain subjection (city-sheltered) are larger than those of the specimens with the possibility of rain contact (city-non-sheltered). When compared at the same location (city-sheltered), the decreased ratio of water to binder and fly ash content leads to a better carbonation resistance. For the same fly ash content, specimens with high-CaO fly ash show a better carbonation resistance than those with low CaO fly ash. However, when compared at an equal strength, the effect of the type of fly ash on carbonation becomes insignificant. When comparing the carbonation results of concrete and mortar specimens, results of mortar show similar trends as those of concrete. However, the test results on mortar are worse by the use of fly ash than those of concrete. In addition, the carbonation tests in an accelerated environment are also conducted. It is found that there exist strong relations between carbonation depths of concrete exposed in natural and in accelerated environments. A mathematical approach to predict the carbonation depth in the natural environments is proposed based on the accelerated tests and the square-root-t-law.

In addition, a semi-microscopic model was developed in this study for simulating carbonation of fly ash concrete. The model describes the diffusion of gases (carbon dioxide and water vapor) in concrete by the mass balance equations and the Fick's law of diffusion. The time dependent hydration, pozzolanic and carbonation reactions were considered for evaluating the amount of calcium hydroxide in concrete. The rate of carbonation reaction was formulated based on the Arrhenious's formulation. The model was verified by using the results of relative water content, amount of calcium hydroxide, and carbonation depth tested in accelerated and in natural environment. The influence of changes in parameters on mix proportion and environmental condition were investigated. The verification results were found to be satisfactory in the prediction of carbonation of fly ash concrete.

Finally, the design charts for mix proportioning of fly ash concrete were proposed based on the models and test results in this study. The design charts for compressive strength and workability were constructed based on the workability prediction model, modified in this study, and the compressive strength prediction model obtained from the previous literature. The durable concrete subjecting to carbonation can be proportioned based on the proposed design charts.