The characteristics of concrete after high temperature exposures simulating severe accident

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This study aims to investigate the thermal degradation in concrete specimens by using microstructural and chemical analysis techniques, and apply ultrasonic method to detect the thermal damage. Ultrasonic test successfully detected the damage level in concrete samples and an empirical relationship between ultrasonic velocity and mechanical properties was obtained.

Keywords: severe accident, thermal degradation, ultrasonic pulse velocity

1. Introduction

The integrity of concrete structures in nuclear power plants has risen as a major issue in recent years. This is due to the needs to assess the safety of structures after the accident at the Fukushima Daiichi Nuclear Power Station for decommissioning process. In order to be able to assess the current state of concrete structures, understanding degradation mechanism and developing appropriate test methods for on-site application are required. For that reason, this study primarily focuses on the effect of high temperatures aimed to enhance the knowledge of degradation mechanism due to thermal exposure.

2. Material and Experiments

The cylindrical concrete samples with size of ϕ 100 x 200 mm were prepared. The samples were heated to various temperatures (105, 200, 400, 600, 700 and 800°C) to simulate the severe accident condition. Subsequently, the samples were tested for determining damage level using ultrasonic pulse velocity method and for measuring the residual compressive strength and the Young's modulus. Microstructure of these samples was also observed by various methods.

3. Results

The change of Young's modulus and velocity with temperature showed a very similar trend, as shown in the figure 1. At 105°C, the decrease of mechanical properties could be associated with the water loss in the cement paste. Between 105°C and 400°C, although no chemical decomposition occurs, the continuous decrease can be related to the dehydration of hydrated products in the cement paste, leading to form the microcracks. After 400°C, the decomposition of $Ca(OH)_2$ and C-S-H started between 400-500°C and beyond 600°C, respectively, which must be the main reasons for the loss of Young's modulus, and that leads to reduce the wave velocity.

The linear regression equation for describing the relationship between Young's modulus, E and velocity, V_p is given as: V_p = 90.4* E + 1629.4, with R^2 = 0.97

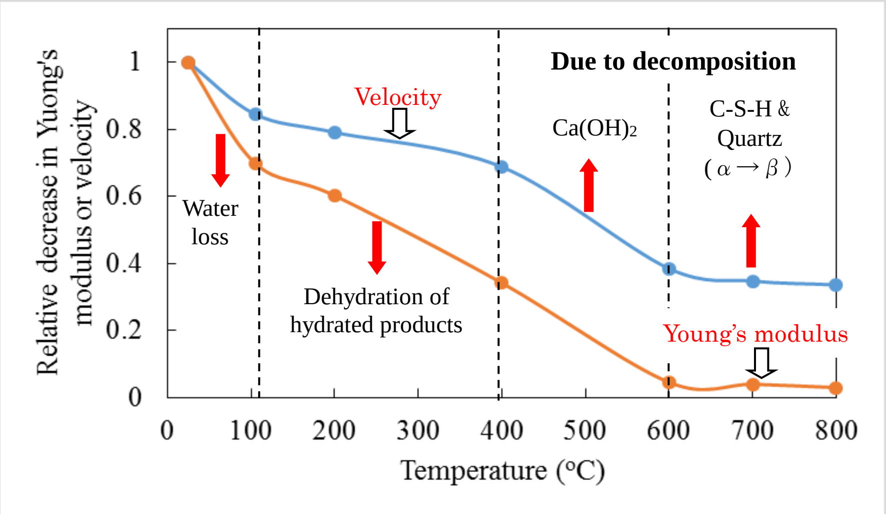

Fig.1 The relative decrease in Young's modulus and ultrasonic wave velocity with increasing temperature