論　文　の　要　旨

題目　Performance assessment of expansive slag concrete under different curing conditions
（異なる養生条件下におけるスラグ膨張コンクリートの性能評価）

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Portland cement concrete usually manifests autogenous or drying shrinkage resulting in serious cracks and severe deterioration of concrete structures. To enhance the volumetric stability of concrete, one of the main measurements is to apply expansive concrete. There are two kinds of expansive concrete involving shrinkage compensating concrete (with low expansion energy) and chemical-prestressing concrete (with high expansion energy). The chemical-prestressing concrete not only compensates shrinkage but also introduces prestress inside concrete with restraining objects such as reinforced bar or the formwork.

The evaluation of expansion performance of expansive concrete is required for its quality control and applications. The conventional evaluation method stipulated in ASTM C806, ASTM C878/C878M or JIS A 6202 was used as a common estimation method for expansion. This technique was considered to be complicated and costly to implement. Then, a new evaluation method using a cylindrical mold has been proposed as the substitute for the conventional method, called as a simplified method. After proposing the new performance valuation technique of expansive concrete, it is worthwhile to verify its applicability on the reality. There have been few studies on the validation of the simplified method at normal condition. They indicated that the simplified method and conventional method well correlated at 20 °C condition. Besides, the steam curing was considered suitable for enhancing performances of concretes, particularly on mixes incorporating mineral admixtures, and it is widely applied to precast concrete. Further, there have not been any investigations on the expansion evaluation of expansive concrete in steam curing so far. In order to widen the application of the simplified method to evaluating the performance of expansive concrete in material design and construction, the verification of the applicability of the simplified method with steam curing is necessary.

Blast furnace slag (referred to as slag in this paper) is a byproduct of the iron and steel manufacturing process that has been increasingly used as a cementitious ingredient in cement and concrete composites. Generally, the inclusion of slag is regarded to be beneficial to the performance of mortar and concrete. However, many studies have observed larger autogenous shrinkage and more early-age cracking in slag concretes than in concretes without slag. While, expansive concrete is used as a countermeasure for

shrinkage and cracking, the incorporation of slag in expansive concrete and the effects of such integration offer a promising target for investigation. Although the impacts of slag on the properties of normal concrete have been clarified in literature, the study on performance of expansive concrete incorporating slag is scarce, particularly in the term of durability.

The objectives of this study were therefore, firstly, to validate the applicability of the simplified method for expansion evaluation under steam curing; and secondly, to investigate the influence of slag type and curing condition on the engineering properties of expansive concrete with the validated simplified method.

This thesis includes five chapters, and the detailed organization is described as follows.

Chapter 1 shows the background, purposes, and methodology of this study.

Chapter 2 provides a brief literature review relating to the research contents.

Chapter 3 presents an experimental program to investigate the applicability of the simplified method under steam curing. Specimens were cured with steam or at 20 °C from their first casting up to 1 day. They were then sealed or water-cured at 20 °C for 7 days to investigate the effect of later curing. Two estimation methods for measuring the expansive strains under constraint were compared based on the expansive energies. The range of applicability of the simplified method was analyzed. A new concept for the simplified method of estimating the expansion by using the axial strain was then proposed. The experimental results showed that two measurement methods exhibited a high correlation, which validates the use of the simplified method under steam curing.

Chapter 4 describes an investigation on the impact of slag type and curing method on the engineering properties of expansive concrete such as the strength, volumetric change and transport characteristics. The two different slag compositions evaluated were combined with ordinary Portland cement at 50% replacement by mass. Cylindrical specimens were cast and initially cured by one-day steam or seven-day sealed 20 ºC curing to investigate the effects of slag type and initial curing on the expansive concrete properties. The specimens were then exposed to the ambient environment with 60% relative humidity at 20 ºC until 91 days as the second stage of curing. The results indicate that pure slag impaired concrete performance, whereas outstanding improvement in performance was observed when using slag with gypsum. The results of this investigation can be used to provide improved concrete mix and curing design when using blast furnace slag in expansive concrete.

Chapter 5 states the conclusions of this research and recommendations for future works.