DEVELOPMENT OF AUTONOMOUS CONTROL METHOD FOR PC-RC STRUCTURES BASED ON MULTI-SCALE INTEGRATED ANALYSIS

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1. Research background

Since the 1990s, there have been periodic reports on the long-term monitoring of the Tsukiyono bridge's deflection (Hata et al. 1993)). As a result of this work, imperfections in design methods based upon the conventional linear creep law and shrinkage have been discussed (Watanabe et al. 2008). Further, there have been reports of excessive deflections of cantilever PC viaducts throughout the world (Bazant et al. 2011a, b) as well.

Maekawa et al. point out two main causes of excessive deflection. One is the non-uniform thermo-dynamic state of moisture inside micro-pores and associated creep, and the other is the delayed average shrinkage of upper and lower flanges in time. (Maekawa et al. 2010, Ohno et al. 2011).

This study aims to suggest a new method for controlling the long-term deflection of PC viaducts without the use of external deflection-control mechanisms such as extra-prestressing, joint clamping or support modifications, as generally applied for repair and retrofitting (e.g. Burdet and Baudoux 1999). A new design method is proposed in which deflection of the structural system is controlled autonomously according to the varying climate conditions at each constriction site.

2. Methodology

In current design codes across the world, bending moments induced by gravity are counteracted by prestressing forces alone. However, the large deflections actually observed in practice indicate that prestressing forces may not sufficiently control serviceability. This study proposes a new deflection control concept referred to as autonomous control, in which annually varying environmental actions represented by relative humidity, rainfall and solar intensity act to counteract gravity forces (**Fig. 1**). That is, the responses to environmental action of the upper and lower flanges are varied intentionally, since one of the causes of excessive deflection is the differential average shrinkage between the upper and lower flanges. The method allows the designers to specify time-dependent deflection properties under the influence of gravity forces. A number of practical methods are thought to be available for this purpose, such as varying the flange thicknesses, altering the water-to-cement ratio (W/C), and adjusting the quantity of steel and/or reinforcing bars within the flanges.

3. Expected outcomes

Autonomous control will enables the construction of maintenance-free structures for a quality infrastructure. It makes use of concrete shrinkage, which is usually a concern for engineers, to control structural behavior. Environmental impact can be also reduced through promoting low-quality recycled aggregates and aggregate with large shrinkage.

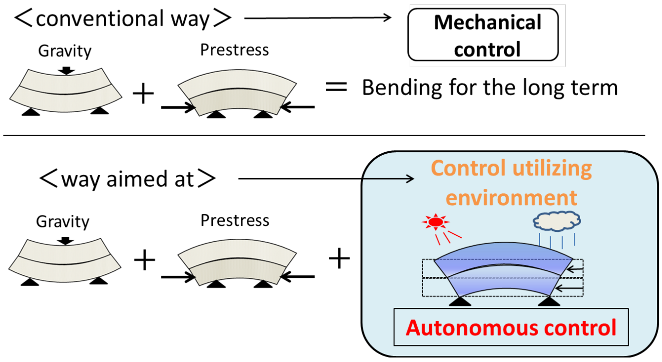

Figure 1 The concept of autonomous deflection control

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