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Numerical simulation of long-term creep tests on prestressed beams

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Abstract

The deformations of concrete elements can increase significantly over time as a result of creep and shrinkage. Different material models, which have been calibrated on large datasets, are available in literature in order to predict this time-dependent behaviour. A cross-sectional calculation tool which employs the age-adjusted effective modulus has been developed to verify the accuracy of six models with respect to creep data available for 24 prestressed beams. These prestressed beams with a span of 8 m were loaded up until 4.5 years in a four point bending configuration. This paper reports on the comparison between the measured and calculated compression strains and deflections. It was observed that the mid-span deflection of the prestressed beams at the end of loading is best prescribed by the model B3 and the Gardner Lockmann 2000 model.

Keywords: prestressed beams; time-dependent deformations; creep models; large-scale test

1 Introduction

Due to the aging linear viscoelastic behaviour of concrete its deformations change over time. Upon loading, concrete has an elastic deformation and, if the loading is sustained, the deformation changes as a result of shrinkage and creep of the concrete. In structural analysis, it can be difficult to predict the creep and shrinkage response since both phenomena are the result of the interaction of several physical mechanisms. In order to allow a more simplified analysis, creep and shrinkage are most often assumed to be independent and additive [1]. Under these assumptions, the total time-dependent deformation is the sum of the shrinkage deformation (determined as the deformation of an unstressed specimen) and the creep deformation (determined as the deformation as a result of the stress on the specimen). For loaded and stressed specimens the creep deformations are dominant at later ages. Furthermore, in the case of prestressed concrete the relaxation of the prestressing steel can also significantly contribute to the time-dependent behaviour.

The creep behaviour of concrete elements is well-known and well-documented in literature. Yet, up until now no universally accepted creep theory has been postulated. However, recent investigation proposes that creep of concrete is caused by a dissolution-precipitation mechanism [2]. An accurate prediction of the time-dependent behaviour is of paramount importance, as is demonstrated by the collapse of the Koror Babeldaob bridge in Palau. The failure of this bridge was partly attributed to an underestimation of the creep behaviour in the design phase [3].

Several material models have been proposed in literature to determine the time-dependent behaviour of concrete as a result of creep and shrinkage. All of these models have been calibrated on large datasets mainly consisting of data obtained from small plain concrete specimens.

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