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# MEASUREMENT OF STRAINS IN CONCRETE BY INTERFEROMETRIC FIBRE OPTIC SENSORS

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**Abstract:** *In recent years, fiber-optic technology appeared in measurement technology and sensors. The great advantage of fiber-optic technology is lifespan and measurement which is not influenced by electromagnetic fields. Therefore, the large cable length can be used. For the same reasons, the optic fibers are used in computer networks. A number of physical principles can be used for measuring. In the case of measuring strains in the concrete, a relatively simple and economically favorable principle of low-coherence interferometer can be used. These interferometric extensometers were used to measure strains in the pre-stressed concrete railway sleepers stored in the laboratory. Thus, effects of creep and shrinkage of concrete were monitored. The experiment was supplemented by tests on the accompanying specimens, i.e., the concrete strength, modulus of elasticity and shrinkage and creep measurements. Experimentally obtained data was compared with standard assumptions for the design of concrete structures EN 1992-1-1.*

**Keywords:** ***Fiber-optic sensor, concrete, strain, shrinkage, creep.***

## 1. Introduction

The appearance, quality, durability and safety of constructions are the most important parameters for design process in the civil engineering. The structural monitoring during construction and monitoring of reliability and durability of structure use different methods of watching its "health" and their goal is to provide accurate and "in-time" information about structure status.

During the life of concrete structures, creep and shrinkage are caused by influences of several processes in material, external loading and environmental condition. These two parameters are variable over time and can significantly influence the final value of the strain. Creep and shrinkage of structures can be calculated through a variety of methods based on evaluations of similar parameters (material properties and surroundings conditions) with different importance.

## 2. Theoretical background

The total strain in concrete structure consists of strain due to stress, shrinkage, creep and strain caused by temperature. Strain due to creep and shrinkage is dominant in strain monitoring of pre-stressed structure, therefore, the evaluation of these structure measuring shall take into account these phenomena and the entire job is more complicated. The experimental results led to a number of standards, recommendations and models for calculating the coefficient or creep. The model according to EN 1992-1-1 was chosen for strain course calculation by reason of simple application, adequate accuracy and sufficient number of important parameters.

Total strain calculated according to model EN 1992-1-1 was compared with experimental data of total strain obtained on monitoring structure. Total strain of monitored pre-stressed sleeper was measured by long-gauge optical fibers SOFO. This type of sensors was chosen by reason of possibility installation them into body of the structure, adequate accuracy and mainly ability of strain

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measurement along the structure, not only at local point. The SOFO sensor can be used for the whole lifespan structure monitoring without continuous data recording; it is one of their advantages.

## 3. Experimental

SOFO interferometric extensometers with active length 0,5 meter were used to measure strains in the pre-stressed concrete railway sleepers stored in the laboratory conditions over one year. Concreting of two monitoring reinforced concrete sleepers B91 S were conducted by the ŽPSV a.s. company in Nové Hrady on September 20, 2010.

The parameters of model EN 1992-1-1 for strain prediction were obtained by experiments carried out on fundamental concrete elements (cylinder samples) made from same concrete recipe as monitored structure. Additional necessary experiments were tests of concrete strength, modulus of elasticity tests, shrinkage and creep measurements.

All of these experimental data were used for prediction of total strain according to EN 1992-1-1. This prediction is shown in Figure 1. In Figure 1 are shown experimental data obtained from measuring of total strain in two pre-stressed concrete railway sleepers by four SOFO interferometric extensometers.

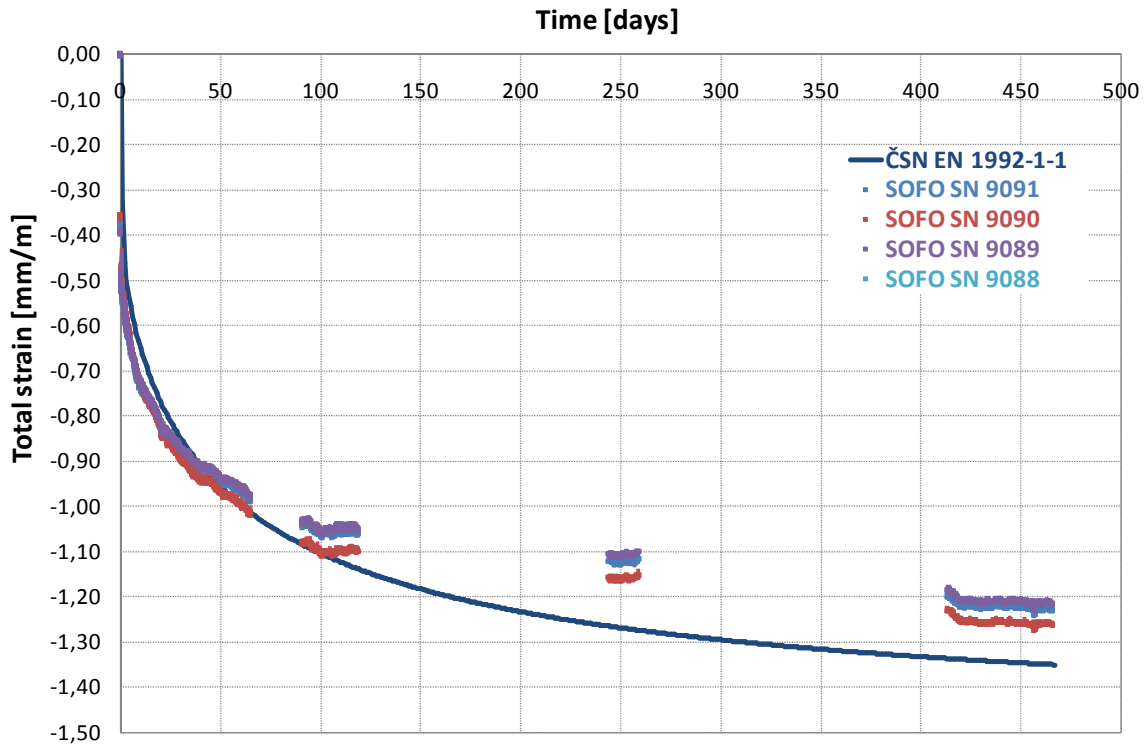


*Fig. 1: Comparison of experimental total strain and calculated (EN 1992-1-1) prediction of total strain*

## 4. Conclusions

The comparison of experiment and chosen model proved the applicability of this model EN 1992-1-1 with adequate accuracy for strain describing structures with same concrete recipe. Above mentioned mathematical model can be used for calculation other characteristics of pre-stressed reinforced concrete sleeper. Furthermore, this relatively simple experiment conducted on railway sleepers verified applicability of the fiber-optic extensometers for monitoring of pre-stressed concrete structures.

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