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Influence of Corrosion on Crack Width and Pattern in an RC Beam

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Abstract

The paper is concerned with numerical modeling of corrosion of steel reinforcement in the reinforced concrete. The cracking response of the reinforced concrete beams due to the corrosion effect of the steel reinforcement and due to the load effects was analyzed. The effect of corrosion was simulated by the nonlinear numerical analysis with the FEM program using the 3D model.

Keywords: Corrosion; existing bridges; crack; crack width; crack pattern; concrete cover; reinforcement;

1. Introduction

The concrete provides reliable protection of reinforcement, but the serious defects may occur. For example, it may be poor choice of concrete component, failures in building construction, unexpected effects of an action, as well as an increase in aggressiveness of environment. Thus with regards to serviceability, the condition of reinforcement and concrete quality are limiting factors for the resistance.

Safety, serviceability and durability are the basic parameters, which ensure the reliability of the construction as a whole or its parts [1]. The durability is the important parameter for design or evaluation of structures. The requirement to design durable structures means that the structure is not disturbed to an impermissible degree what would cause the limited serviceability due to the degradation processes during the planned design lifetime, provided that the maintenance and repairs are adequate. The durability ranks lower to both ultimate and serviceability limit states in terms of reliability. So, the durability is not verified, but is provided by design requirements.

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The protection of reinforced concrete structures against corrosion is provided by design principles such as concrete cover and quality of concrete. The corrosion has a great effect on structure in terms of the ultimate limit state and serviceability limit state. Thus, the corrosion not only decreases the reinforcement cross-section area, thus decreasing the resistance as well, but it also increases the volume of the corrosive products (rust), giving rise to tensile and compressive stresses and then ultimately cracks, which are undesirable in terms of serviceability [2-4].

The paper deals with numerical 3D modeling of reinforcement corrosion in program Atena, which is used to verify the laboratory tests. The aim was to find out how the reinforcement corrosion affects the initiation and propagation of cracks in reinforced concrete with a focus on the crack width.

2. Experimental measurements on specimens

The numerical modeling is based on experimental measurements carried out at VUT Brno [5]. Forty samples of small beams with smooth-faced reinforcement class 10 216 and ten samples of small beams with tubular cross-section class 11 333 were made for diagnostic survey. The diameter of both bars (smooth-faced reinforcement and tube) was 6 mm (Fig. 1).

The maximum measured crack width was 0.60 mm in the case of beams with reinforcement class 10 216 and 0.65 mm in the case of tube class 11 333.

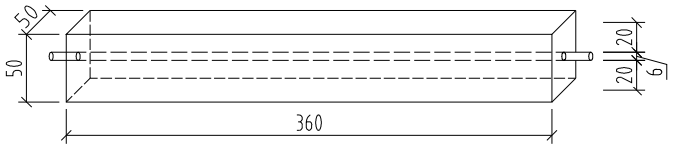

Fig. 1. Experimental specimen – small beams with dimensions.

The values from experiment shown in Fig. 2 are the average values from measurements. The corrosive environments were created during the experiment in order to accelerate the process of corrosive activity. Five percent aqueous solution of NaCL was used to create the appropriate corrosion conditions. The specimens were inserted into it only to 2/3 of their height for 16 hours and subsequently for 8 hours they were placed into an electric oven at temperature of 40°C. This cycle was repeated regularly for a year.

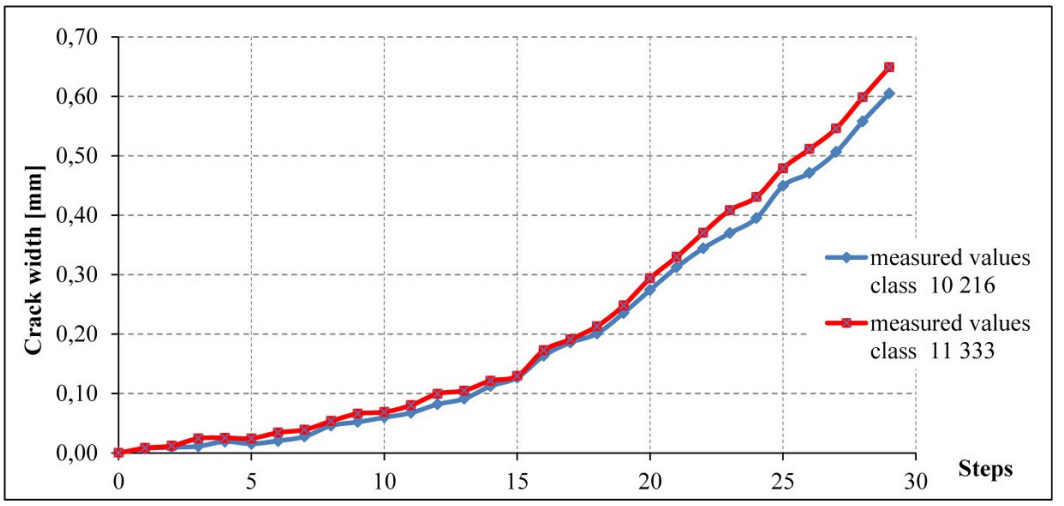

Fig. 2. Experimental results of crack width variation.