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NUMERICAL MODELLING OF THE REINFORCEMENT CORROSION

P. Koteš*, M. Brodňan**

Abstract: *The paper is concerned with detection and simulation 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 was analyzed. The effect of corrosion was simulated by the nonlinear numerical analysis using the program ATENA.*

Keywords: ***Crack, reinforcement, corrosion, numerical modeling, concrete.***

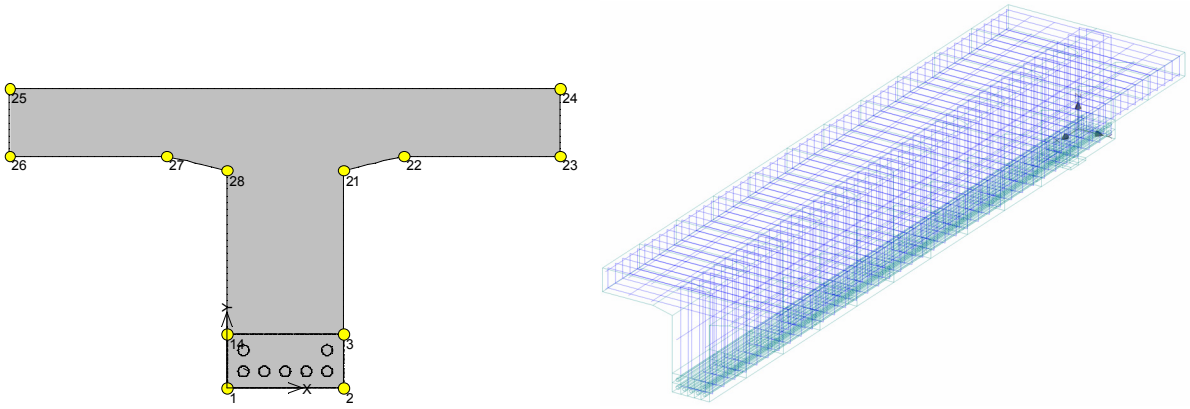
1. Introduction

The corrosion of reinforcing steel in concrete due to severe environment is the phenomenon that highly affects the reliability and durability of reinforced concrete structures. In the frame of the research work of Department of Structures and Bridges at the University of Žilina, reinforced concrete girder bridges were diagnosed and observed.

Because of the better comprehension of crack formation and development, the numerical model of reinforcement corrosion in concrete cross-section was created in computer program ATENA.

2. Numerical models of reinforcement corrosion

The girder bridge near Kolárovice was used for numerical modeling. Firstly, the numerical model of reinforcement corrosion was created in the 2D module ATENA. Only cross-section of T-girder with real dimensions was modeled. However, the 2D model created is not perfect because it considers the transverse cracks only. The cracks across the longitudinal axis cannot be modeled in 2D. Thus, the 3D model was created in ATENA to obtain better understanding of the crack formation and development.



a) 2D numerical model *b) 3D numerical model*

Fig. 1: Cross-section of T-girder - numerical models.

* Ing. Peter Koteš, Ph.D.: Department of Structures and Bridges, Civil Engineering Faculty, University of Žilina, Univerzitná 8215/1; 010 26, Žilina; SK, e-mail: kotes@fstav.uniza.sk

** Ing. Miroslav Brodňan, Ph.D.: Department of Structures and Bridges, Civil Engineering Faculty, University of Žilina, Univerzitná 8215/1; 010 26, Žilina; SK, e-mail: brodnan@fstav.uniza.sk

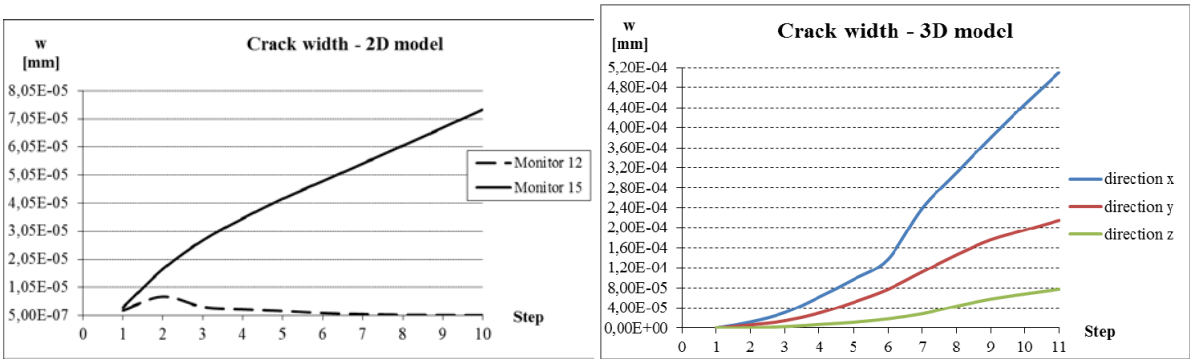
The percentage increase "p*" taking into account changing of whole reinforcement area is given

$$A_{s1,celk}(t) = A_{s1} \cdot (1 + p^*) \Rightarrow p^* = \frac{A_{s1,celk}(t)}{A_{s1}} - 1. \quad (1)$$

The changing of the whole reinforcement area means that the remaining carrying part of reinforcement $A_{s1}(t)$ decreases and corrosion rate area $A_{s1,rozd}(t)$ increases. The initial value of diameter ϕ = 30.0 mm, the reduced diameter in time ϕ (t) = 28.7 mm and the percentage p = 8% were considered in the numerical model. So, the final increase of reinforcement area is p* = 0,678 %.

3. Results of numerical model

The crack width at two monitoring point 15 and 12 in the 2D model is shown in Fig. 2. It can be seen in the figure that the crack width at monitor point 15 is monotonically increasing, whereas at monitor 12 the crack width decreases, after a small initial increase. This is due to repartitioning of the compression and tension stresses in the cross-section. The crack width development of both models is shown in Fig. 2.



a) 2D model *b) 3D model*

Fig. 2: Cracks development.

4. Conclusions

The results concerning the reinforcement corrosion numerical modeling are presented in the paper. The influence of reinforcement corrosion on the crack formation and propagation were observed in the cross-section of the T-girder. In the paper was shown that already a small corrosion caused the micro crack formation and propagation inside the cross-section near reinforcement.

Small differences between the 2D and 3D models are probably due to repartitioning of the compression and tension stresses, not only in the cross-section (directions y, z - 2D model), but also in the full girder volume (directions x, y, z – 3D models).

The micro cracks are getting connected into edge cracks due to corrosion increase, which can lead to concrete cover dropping out. In that case, the sufficient strength and bonding of concrete cover is not ensured. Consequently, using some types of strengthening (e.g. gluing of FRP materials on concrete cover) is limited or is not possible to apply.

Practically, it means the need to insist on better diagnostics, to check the degree of failure of concrete cover and to control the bonding between concrete and reinforcement. Based on correct diagnostics, it is recommended to decide if the existing concrete cover is better to retain or is it preferable to replace it by the new concrete cover.

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