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STRESS - STRAIN STATE OF THE LOCAL AREA IN THE BUILDING ELEMENT WITH STRUCTURAL DEFECT

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Abstract. Evaluation of the building element technical state relies on verification calculations using estimated construction material properties. Physical and mechanical properties are estimated predominately by using non-destructive test methods. The accuracy of these methods is affected by the level of stress-strain state of the structural element and present structural defects. The variability of the concrete properties over time under constant loads is a determining factor for the durability and reliability of the structural element. The influence of the physical and mechanical characteristics of a construction material on the deformation process of the local area of the structural element adjacent to the structural defect has been investigated. The research has been performed on structural models using software systems "LIRA SAPR" and "SOLIDWORKS". A structural model having dimensions of 100 x 100 x 400 mm was used for the study. Materials of concrete grades C12/15 through C25/30 with corresponding properties have been used. Load parameters for modeling of the deformation process varied from 0.1 to 0.5 of the ultimate loads. Performed calculations made it possible to obtain fields of stress, deformation and displacement under different model parameters and stress levels.

Keywords: *stress-strain state, structural defect, non-destructive test methods, software systems "LIRA SAPR", "SOLIDWORKS".*

Introduction

Ensuring reliability of buildings and structures [1] requires reliable information on their technical state. Technical state evaluation systems are based on determination of physical and mechanical characteristics (PMC) of structural materials. Formal evaluation requirements are governed by state standards [2 - 7], which implement non-destructive methods (NM) of control. The data obtained are subject to statistical processing following prescribed procedures, and the result of the processing is obtained with calculated accuracy. As demonstrated in [8 - 12], and in many other researches, evaluation results are significantly affected by the following: concrete composition; conditions of concrete element structure formation; age of concrete; level of stress-strain state (SSS) in the element and test conditions. The complexity of the direct determination of the PMC of concrete has directed researchers to a different path [13 - 18]. But yet, the variability in the

SSS level of the element leaves the procedure for applying the NM evaluation prone to considerable level of uncertainty. Structural defects and variation in concrete PMC during operation dramatically alter the element's SSS in the area near the defect. Determining the impact these factors have on the SSS of the structural element will improve the accuracy of the determination of the PMC of concrete in elements by means of NM control.

Purpose of the study

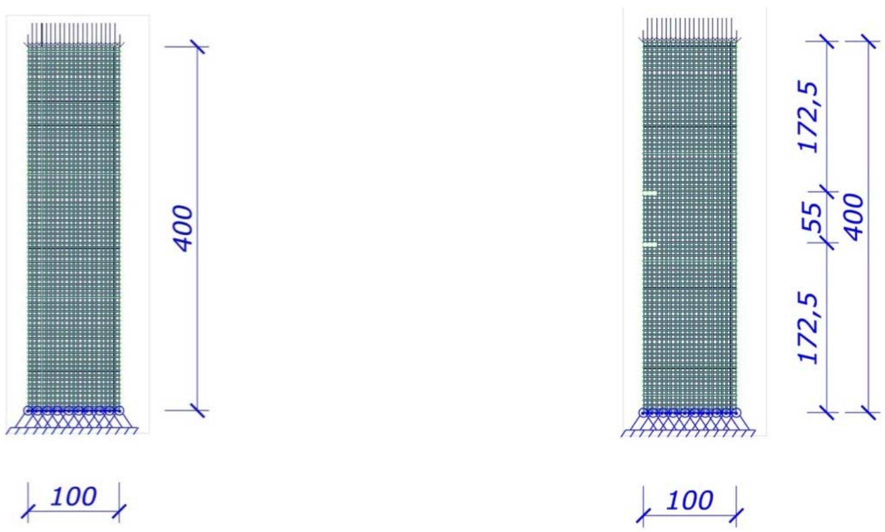
To obtain fields of stress, deformation and displacement under different model parameters and stress levels on structural models using software systems "LIRA SAPR" and "SOLIDWORKS".

Materials and Methods of Research

A model having dimensions of 100 x 100 x 400 mm was used for the study. Concrete grades C12/15 through C25/30 with corresponding properties [2] have been used as a model material. Research has been performed using software systems "LIRA SAPR" and "SOLIDWORKS". Similar structural models have been used for calculations with different software complexes.

Structural defects were modeled by removing successively one to four elements from the design model. That is, a groove with a depth of 0 to 25 mm was formed in the prism. The increment was 5 mm (0 to 0.25h, respectively, in 0.05 h increments). Calculations were made for models with one and two defects in the structure. In the case of a design model with two defects in the structure, the latter were arranged in parallel. During the study, the distance between these grooves varied. The load parameters for modeling the deformation process varied within 0.1 to 0.5 of the ultimate stress.

Figure 1 shows design model used for calculation using software system "LIRA SAPR".

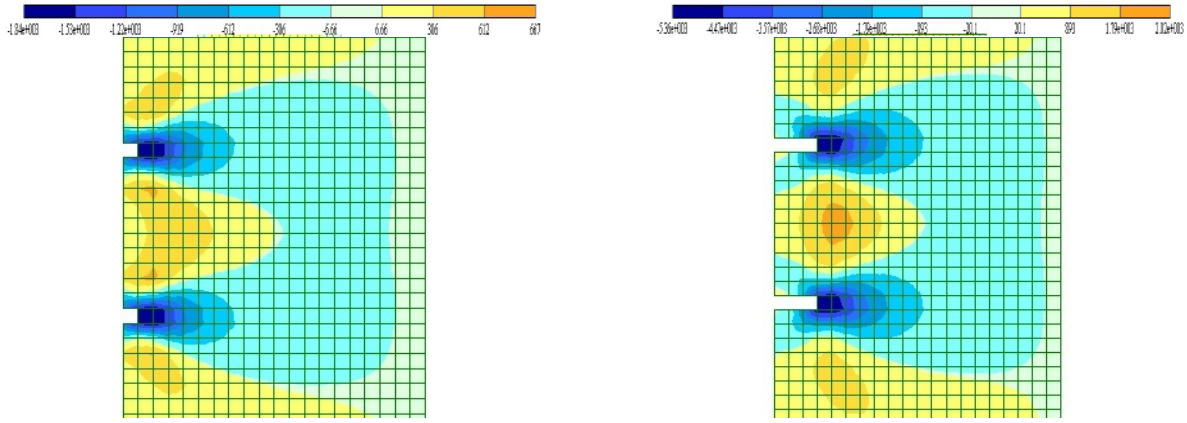


a) b)

Figure 1. design model used for calculation using software system "LIRA SAPR": a – without structural defects; b – with structural defects.

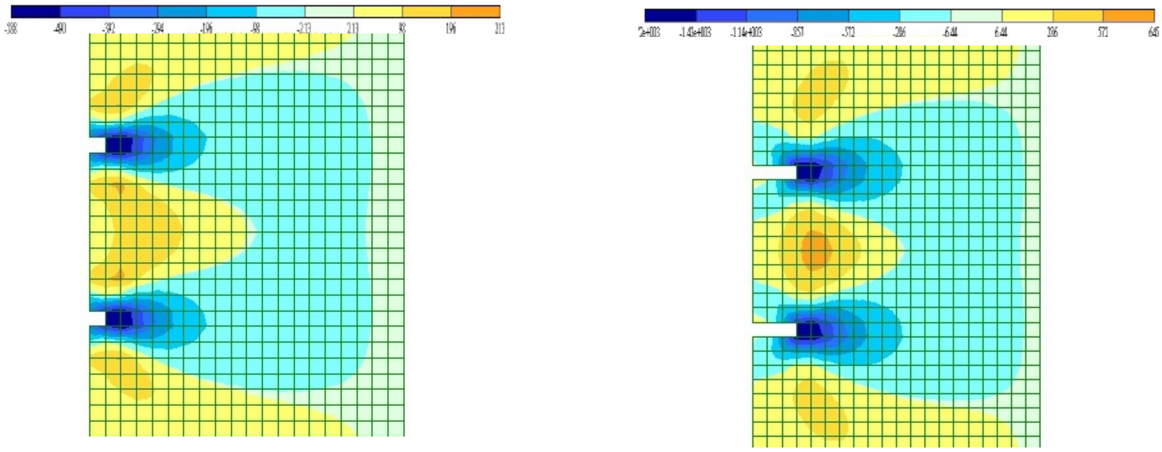
Results and discussions

Figure 2 - 7 show stress fields N_x, N_y i τ_{xy} (correspondingly) in the area of the building element with structural defect. Separate results are presented for calculations subject to variable loads and variable defect sizes.



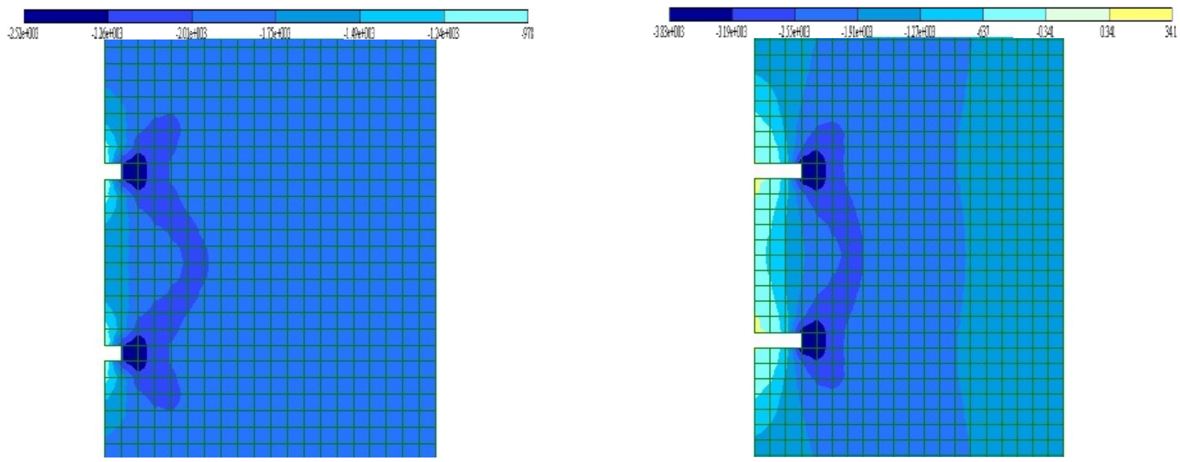
a) b)

Figure 2. Stress fields Nx in the area with structural defect: defect depth 5 mm (a) and 15 mm (b) for concrete grade C16/20 under stress in concrete $\sigma = 0{,}4\ f_{cd}$ [kH/m^2].



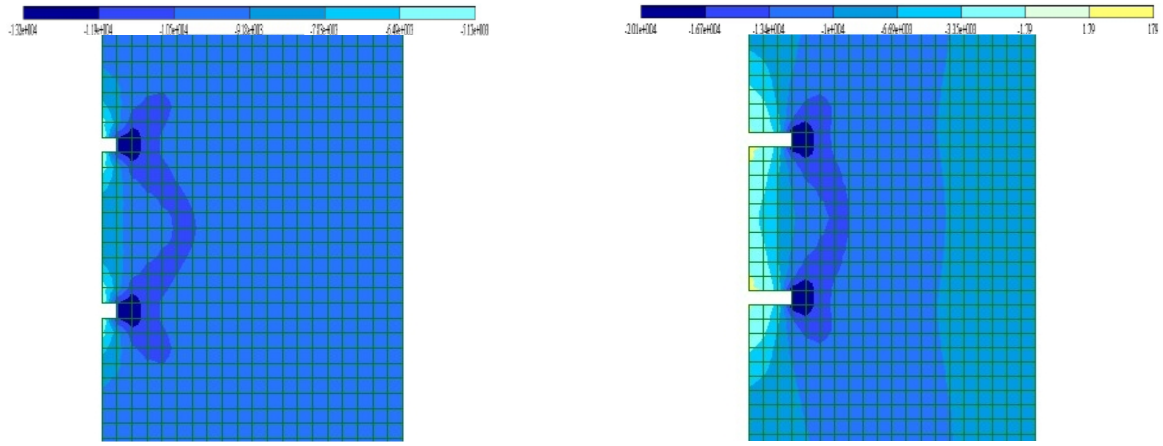
a) b)

Figure 3. Stress fields Nx in the area with structural defect: defect depth 5 mm (a) and 15 mm (b) for concrete grade C20/25 under stress in concrete $\sigma = 0{,}1\ f_{cd}$ [kH/m^2].



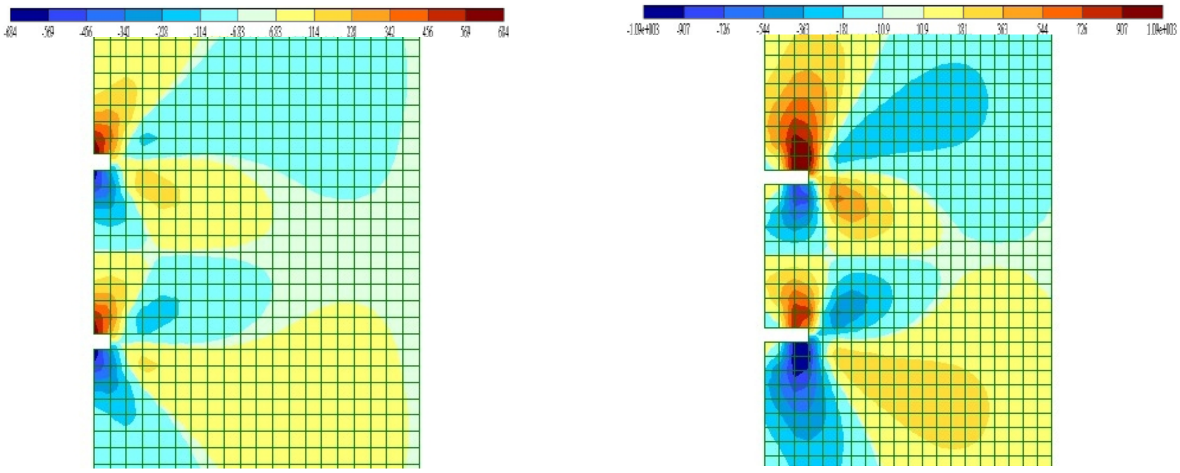
a) b)

Figure 4. Stress fields Ny in the area with structural defect: defect depth 5 mm (a) and 15 mm (b) for concrete grade C12/15 under stress in concrete $\sigma = 0{,}1\ f_{cd}$ [kH/m^2].



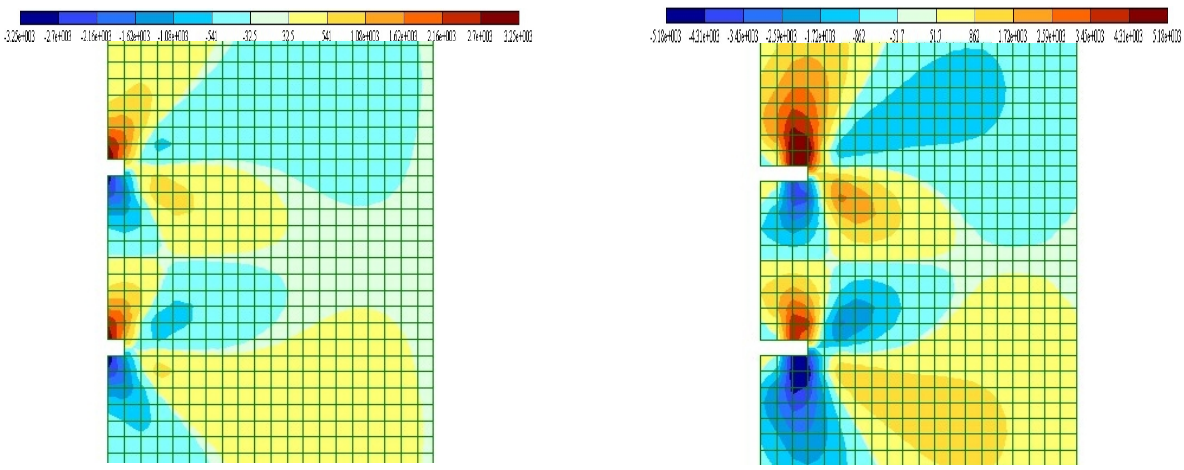
a) b)

Figure 5. Stress fields Ny in the area with structural defect: defect depth 5 mm (a) and 15 mm (b) for concrete grade C16/20 under stress in concrete $\sigma = 0{,}4\ f_{cd}$ [kH/m^2].



a) b)

Figure 6. Stress fields τ_{xy} in the area with structural defect: defect depth 5 mm (a) and 15 mm (b) for concrete grade C20/25 under stress in concrete $\sigma = 0{,}1\ f_{cd}$ [kH/m^2].



a) b)

Figure 7. Stress fields τ_{xy} in the area with structural defect: defect depth 5 mm (a) and 15 mm (b) for concrete grade C25/30 under stress in concrete $\sigma = 0{,}4\ f_{cd}$ [kH/m^2].

It is obvious that stress fields in all cases are similar. Various stress values are due to variability in loads, PMC of concrete and defect sizes.

Availability of design calculations affords their comparison with the results of NM control. Such comparison allows identification of structural defects formed during construction and/or operation periods [19]. Therefore the following procedure is proposed for evaluation of the building element technical state (Figure 8).

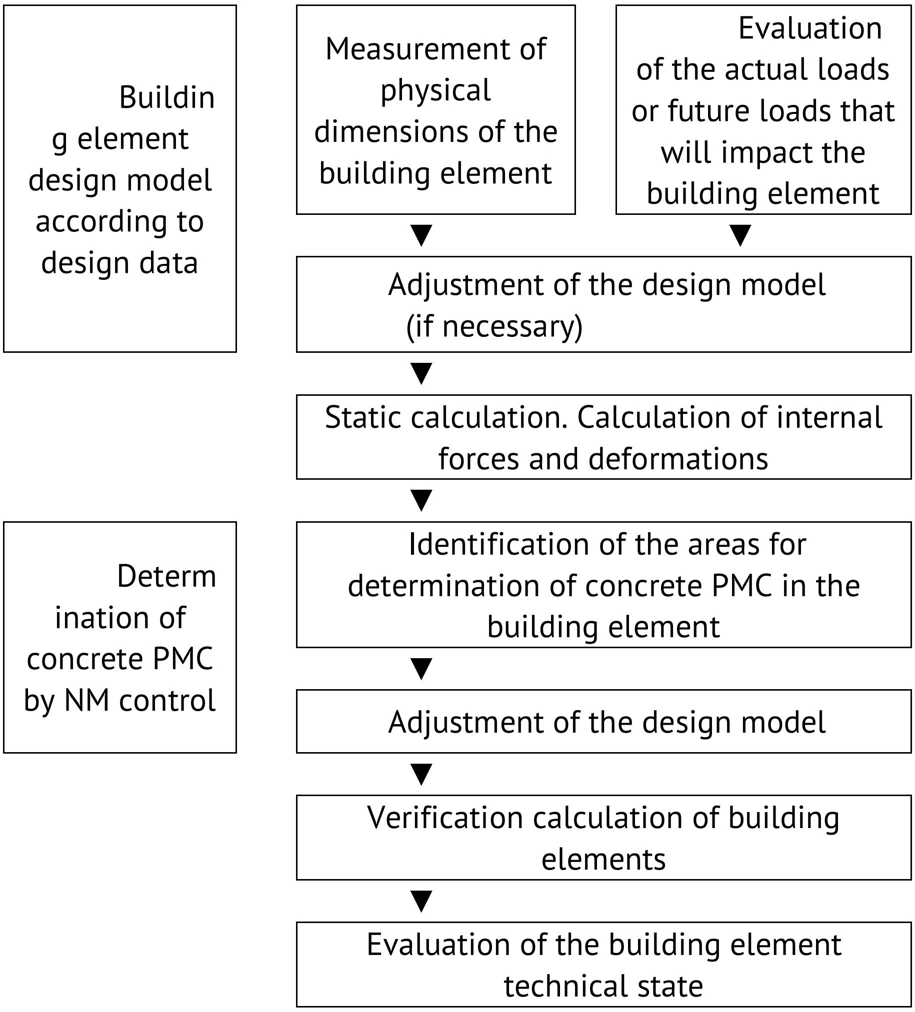


Figure 8. Procedure for evaluation of the building element technical state.

Conclusions

The results analysis of the conducted research shows that:

1. Different software complexes show essentially similar results.

2. The change in the stress in the area adjacent to structural defects is affected by the size of this area, SSS level in the structural element and the ratio between the sizes of the adjacent elements of the structure.

3. Zero stress areas may appear on the surface of the structural element.

4. It is necessary to take account of the level of SSS while performing evaluation of the PMC of concrete using NM control in the area influenced by present structural defects.

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