CHOSEN ASPECTS OF NONLINEAR STOCHASTIC MODEL OF COMPOSITE FACADE PANEL

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Chosen aspects of the analysis of nonlinear stochastic model of glass fibre reinforced composite facade panel's check test are presented in the paper. Special attention is given to the results of probability analysis (incl. influence of material degradation). Their use in design and evaluation of structures/structural members is discussed.

Introduction

The appropriate model of the real behaviour (response to applied load) of structures/structural members made of advanced cement based composites is necessary for the structural designing/evaluating. Under the term "real behaviour" we mean the complex behaviour including fracture, randomness character of load response and also other influences, e.g. degradation of used material. The stochastic model of facade panel's behaviour including all mentioned factors is presented in the paper.

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The role of fracture-mechanical parameters in modelling of the real cement based composite's behaviour

The behaviour of cement based composites after reaching the ultimate tensile capacity (or more precisely after leaving the linear part of load-deflection/deformation graph due to microcracking) can be described using fracture-mechanical parameters. Some of these parameters play important role in nonlinear fracture models, which can be implemented into FEM codes. The knowledge of fracture energy is necessary when using cohesive crack models (e.g. classical Bažant's crack band model implemented also in software ATENA 3D (Červenka et al. 2005) which was used for the deterministic nonlinear numerical model of studied facade panel). There are certain problems involved in the fracture energy identification (e.g. Trunk et al. 2001, Veselý et al. 2007). Sophisticated method of material parameter's identification can present an alternative/supplement to the experimental determination. The study of the influence of material degradation on the fracture-mechanical parameters was presented in (Řoutil et al. 2005).

Stochastic model

The presented stochastic model of facade panel's test combines deterministic nonlinear numerical model in ATENA 3D (Podroužek, Novák 2006) and Latin Hypercube Sampling Method (Novák et al. 2006) used for generating of 2×30 sets (reference and degraded) of random input parameters. The most important material input parameters (modulus of elasticity, fracture energy, tensile and compressive strength) are considered as random variables (their statistical characteristics were determined experimentally) and their decrease due to material degradation is taken into account. The stochastic model can be evaluated using statistical, sensitivity and probability analysis. The histogram and PDF of ultimate capacity of the degraded panel is presented as an example of the statistical analysis result (Fig. 1). The total decrease of the mean value of ultimate load due to degradation comes to 50.7% (from 13.23 kN/m^2 to 6.52 kN/m^2).

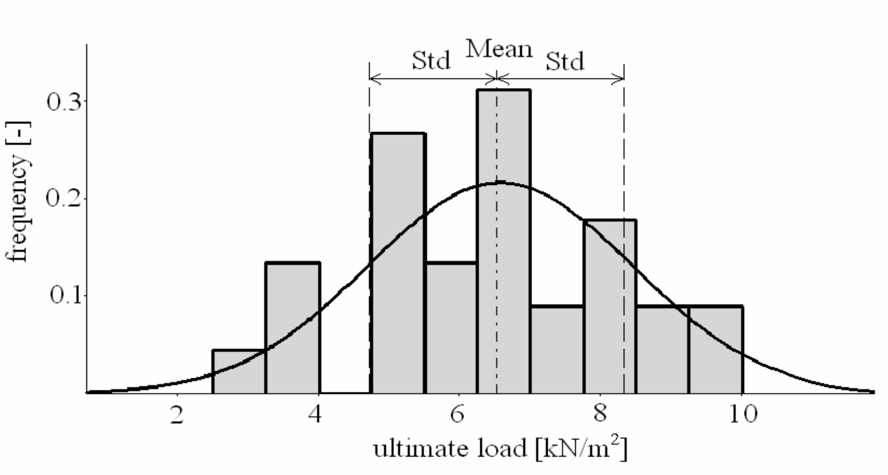

Figure 1: Histogram and PDF of ultimate load of degraded panel.

Probabilistic analysis

A simplified reliability analysis was performed based on the results of the statistical analysis – PDF´s of ultimate capacities of panels (basic and degraded). Action of load – wind intake was considered deterministic at several levels until 18 kN/m^2. The theoretical failure probability – the probability that the panel will not resist the load (wind intake) was calculated using mathematical model of PDF. The result of the reliability study is shown in Fig. 2.

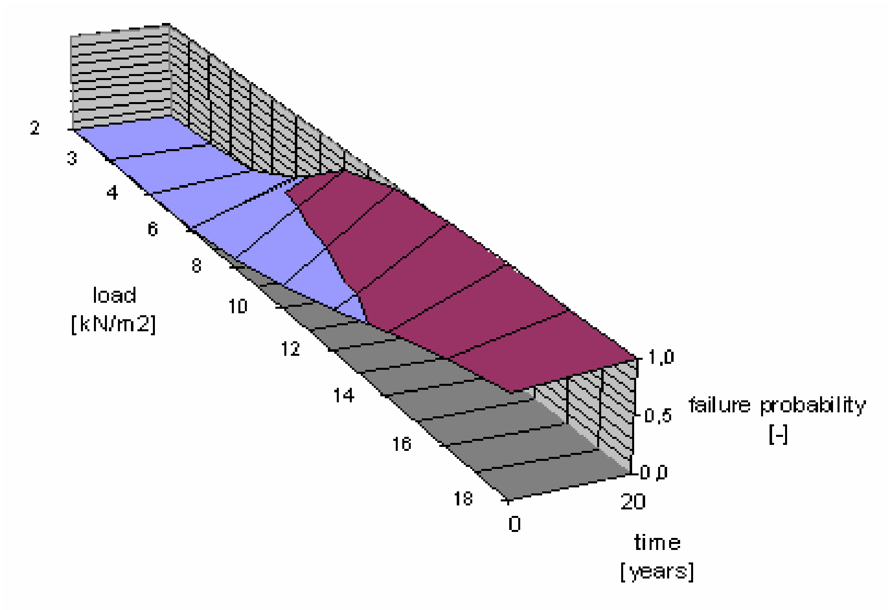

Figure 2: Graph of theoretical failure probability vs. applied load and time.

According to Fig. 2 we can estimate the theoretical probability failure of facade panel with respect to the time of degradation. We can see that this probability increases essentially due to degradation. Of course it will be necessary to confirm this study with other experiments focused on the influence of degradation process to material parameters and with experiments investigating the response of composite structural members/structures to applied load. Simultaneously other effects (e.g. variability of wind intake and the influence of geometrical imperfections or material inhomogeneity on ultimate capacity of panels) should be taken into account. In Fig. 2 the function between theoretical probability of failure at the beginning of degradation and in the time of twenty years is considered as a linear function. This assumption should also be validated by experiments. The specified graph can then present the useful tool for design and evaluation of structural members/structures or for maintainance planning.

Conclusion

The paper presents the necessity of the complex approach to the design and evaluation of structures/structural members made of advanced cement based composites. The quasi brittle character of the composite's behaviour calls for the implementation of nonlinear fracture mechanical principles to the nonlinear numerical model. The variability of material parameters has to be taken into account using statistical and probability theories and advanced simulation methods. It is also necessary to evaluate the influence of degradation during the life cycle of structures/structural members and other mentioned effects. The application of this approach – stochastic model of the facade panel's response to applied load (wind intake) – is presented and also the results and some chosen aspects are discussed.

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