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Reliability aspects of fire design

Preface

Method of budget allocation for research in Poland in recent years has significantly changed. Two new governmental executive agencies were established whose task is to support scientific activities: *the National Science Centre* (NCN) and *the National Centre for Research and Development* (NCBiR). Construction and civil engineering sciences do not fit well in a range of interests of any of them.
National Science Centre focuses its attention on a group of "basic science", i.e. those which are undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any direct practical application or use of the results. *National Centre for Research and Development*, in contrast favours "applied research", i.e. research undertaken to acquire new knowledge, focused primarily on its practical applications, and makes the grant funding for research dependent on the promise to establish cooperation with industry and the declaration of the implementation of research results.
In each case, one of the fundamental criteria for obtaining funding are significant scientific achievements of applicant, confirmed by publications in indexed journals of ISI Master Journal List, or significant application achievements supported by a patent or practical implementation.
For a young researcher, just starting his or her scientific career, none of above given conditions is almost impossible to meet.

During last three years I've been trying to obtain funds for experimental research and construction of the testing stand for testing the columns and beams with different types and different stiffness of supports.
Totally I've developed and submitted eight applications, but despite very positive reviews and high-value content-related applications I haven't succeeded in obtaining financing.

The National Science Centre argued that the application is dedicated to applied research of practical interest. *The National Centre for Research and Development* argued their refusal with the fact that in the current conservative prescriptive approach to the assessment of structural fire safety given by codes and standards of design as well as the current state of the law there is no chance to implement the results of planned research or find their practical application.

In such a situation, facing many difficulties I made the decision that the most reasonable solution would be to undertake research topics realizable only through analytical considerations. The idea to undertake the research based only on numerical analysis seemed also inappropriate. All numerical analyzes and virtual tests have a deep sense only if it is possible to verify and validate the developed models based on the results of the real experiment.

The notable and worth taking theme appeared to me the issues related to the reliability of building structures designed taking into account the actions of fire. The problem seems particularly important for the truss structures made of bars of class 4 cross sections, i.e. those in which local buckling will occur before the attainment of yield stress in one or more parts of the cross-section. In Polish realities there is a great need nowadays to explore these issues from the standpoint of structural safety assessment for warehouse buildings equipped with high storage rack systems, for instance.

Forced by the necessity I would like to develop my scientific interests in this direction. Right now I'm at the very beginning of that road.

Research project description - abstract

Many sources of uncertainty are inherent in structural design. Despite what is very often thought, the parameters of the load's levels and the load-bearing capacities of structural members are not deterministic quantities, i.e. quantities which are perfectly known. They all are random variables and that's why the virtual state of absolute safety cannot be achieved. Considering this fact, all building structures must be designed to serve their function with a finite probability of failure. Society expects buildings and other civil engineering structures to be designed with the reasonable safety levels. In practice, these expectations are achieved by following code requirements specifying design values of minimum strength, maximum allowable deflection, etc. Code requirements tend to include some important design criteria that take into account some aspects of uncertainty in design, often called in literature as reliability-based design criteria.

The reliability of structure can be understood as its ability to fulfill its design purpose for some expected design lifetime. Reliability is often understood to equal the probability that the structure will not fail to perform its intended function.

The question that should be answered is: How safe is safe enough? As it was mentioned before it's absolutely impossible to design a completely safe structure. Every structure has a certain positive probability of failure. Theoretically one can design the structure with relatively high level of safety but reducing the probability of failure beyond a certain optimum level means not economical solution. This problem is particularly important in case fire structural design. Structural reliability concepts can be applied to the design of new structures and the evaluation of existing ones.

The reliability of structures can be considered as a rational evaluation criterion. It provides a good basis for decisions about repairs, rehabilitation or replacement. But in most cases a structure is a system of components cooperating and acting together and the state of nominal failure of one of structural members does not mean failure of the whole structural system. When one or more of components reach their level of ultimate capacity, they may continue to resist the loads which are then redistributed to other components as the secondary static scheme of structural system occurs.

It is important to note that most reliability-based codes which are in current use apply reliability concepts only to the design of structural members, not whole structural systems. In the coming years a further acceleration in the development of analytical methods used to model the behavior of structural systems is expected as the natural consequence and the response for society needs. It is expected that this focus a system behavior will lead to additional applications of reliability theory at the system level.

There are huge research prospects for finding the optimal solution for cost-effective and warranting the accepted level of safety design. All efforts in this field should consider all the recent developments in the fire safety sciences as well as should concentrate on aggregation of all the latest achievements accurate for individual members into the structural systems safety considered as the inseparable whole.