Reliability and Risk Assessment of Structures in Extreme Conditions

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The described project of the Czech science foundation GACR is focused on the development of procedures for the design and verification of structural reliability and risk assessment in accidental design situations due to the impact of heavy road vehicles and trains, gas explosions, seismic actions and extreme climatic actions. The probabilistic methods of the theory of structural reliability and methods for risk assessment are applied for the evaluation of extreme actions and assessment of structural resistance. The partial aim of the project is the preparation of background materials and guidance for application of selected results in construction practice. The solution of the project is carried out in several phases in 2006 to 2008.

For the preparation of background materials, the search for information and data was carried out on the basis of national documents of selected countries, analyses of European and international prescriptive documents, research reports and recommendations of research organisations (JCSS, CIB, IABSE, JRC) and standardisation committees (CEN, ISO). The collection of data of accidental actions was made also in co-operation with the World Road Association PIARC and the Road and Motorway Directorate of the Czech Republic. New data of snow actions on ground was obtained in co-operation with the Czech Hydrometeorological Institute. The extreme snow actions caused serious damages to roof structures in the Czech Republic as well as in other European countries during winter 2005/2006. New assessment of snow data and research on the effect of snow on the reliability of structures was needed and therefore, included also within the research activities of the project.

The probabilistic verification of structural reliability under extreme actions is based on the inequality

$$P_F < P_{Ft} \text{ , resp. } \beta > \beta_t. \qquad (1)$$

where P_F denotes the determined probability of failure, β the corresponding reliability index of analysed structure, P_{Ft} and β_t denote their target values. Numerical integration methods and approximate analytical methods (FORM, SORM) as well as simulation methods (Monte Carlo, importance sampling) are applied in the project to determine the reliability measures P_F and β.

The target values of reliability indices P_{Ft} or β_t are proposed for individual categories of consequences of failure for structures in accidental design situations using methods of probabilistic optimisation.

The rules for combinations of accidental action with other types of actions introduced in various international documents were analysed and subjected to probabilistic calibrations [1]. For analysing structural reliability in selected accidental situations, the dynamic response of structures is in relevant cases carried out, too.

For the reliability analysis and risk assessment of structures in extreme conditions, the methods of Bayesian casual networks are applied to determine the optimum reliability level and mitigation measures. These methods are used for decision about optimal distance of a

bridge piers or other supporting substructure from the railway [2].

The project outcomes include development of theoretical models of extreme actions (impacts of traffic, gas explosions, extreme climatic and seismic events) and procedures for the probabilistic analysis of structural reliability and risk assessment of structures in accidental design situations. Selected project achievements were presented in seminars for designers, technicians and other people working in construction in co-operation with the Czech Chambre of Civil Engineers and Technicians Engaged in Construction ČKAIT and the Czech Concrete Society ČBS in last two years. The vocational training materials developed within the project solution are also focused on the clarification of procedures for determination of models for extreme actions, including examples of application in reliability analysis and risk assessment of structures [3].

Selected project outcomes were also applied as background materials for the development of Czech National annex to EN Eurocode EN 1991-1-7 Accidental actions [4].

It is foreseen that selected project findings will be used in further research activities of the project team and in prenormative research in the period of maintenance of Eurocodes in co-operation with the Technical Committee CEN/TC 250.

References:

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