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in Prague, 19-20 February 2009

APPLICATIONS OF STRUCTURAL FIRE ENGINEERING

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Preface

Current European practice in structural fire engineering is tending more and more to acceptance of the benefits to be gained from performance-based approaches to fire-resistant design. These proceedings, from the ***Applications of Structural Fire Engineering*** conference, presents the state of the art in the development and application of both simple and advanced performance-based design methods for concrete, steel and timber structures. Internationally acknowledged research experts and specialists in design against fire are represented in these articles, offering an opportunity to share contemporary ideas and knowledge within both the background science and practical case studies. The spectrum of relevant research themes covered encompasses fire modelling, heat transfer to structural elements, numerical modelling of thermo-structural behaviour at elevated temperatures, structural fire testing at elemental and structural scales, the development of simplified design methods and studies based on the structural Eurocodes. Practical design case studies demonstrating the ways in which performance-based structural fire safety design methods have been applied to real projects, and the economic and safety implications of using these methods in place of the traditional prescriptive rules, are included.

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TWENTY TWO YEARS OF STRUCTURAL FIRE ENGINEERING IN CZECH REPUBLIC

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FIRE DESIGN IN CZECHOSLOVAKIA

The background of the today fire engineering in Czechoslovakia starts in 1965, when the fire engineering solutions were incorporated into the overall architectural and engineering design. The standard related to fire testing, which was introduced in 1967, takes into account the compartmentisation, the fire risks, the escape solutions and the building separation. The whole set of standards, which is marked ČSN 73 08xx and related to fire testing of the construction products, the data of the material properties and the valorisation of structures, was prepared by a new standard committee established in the area of fire safety in 1971. The standard ČSN 73 0810 Fire protection of buildings - Requirements determination in civil engineering was in the set of documents localised at the position between the experimental and design national specifications. The document [10] represents the latest issue of this key provision, which creates the foundation of the structure of the national standards.

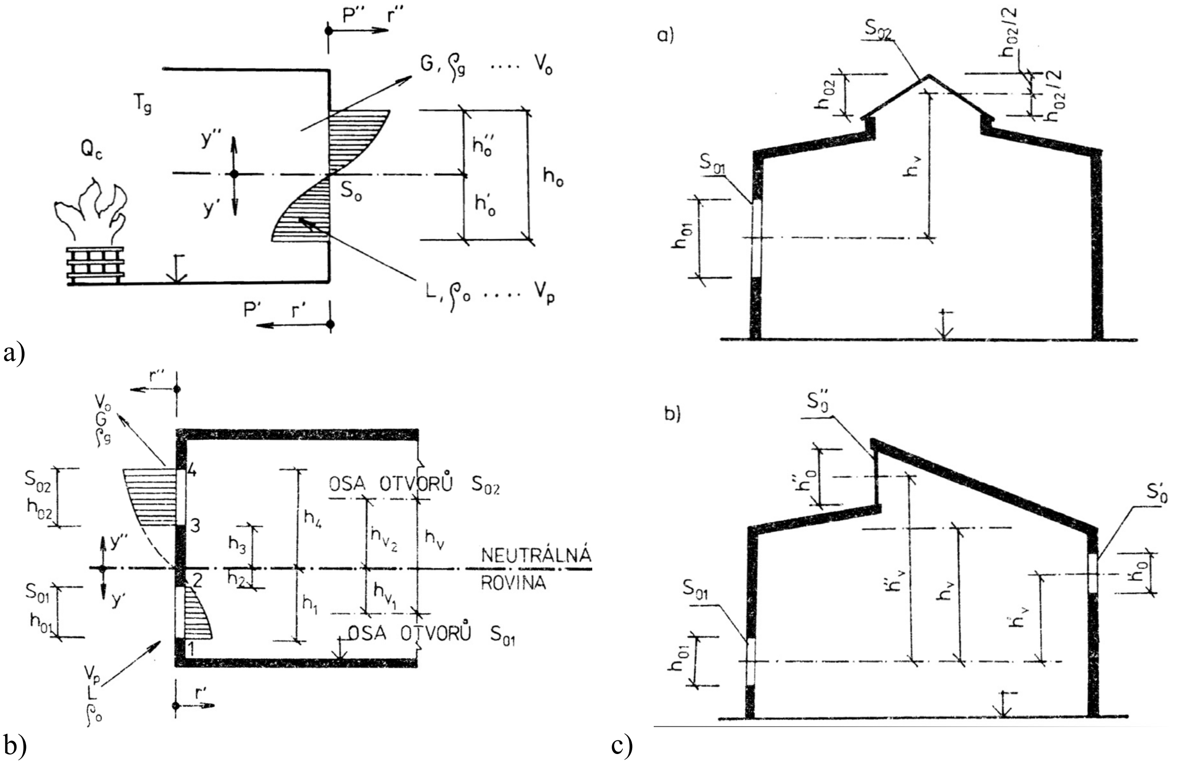

Fig. 1 Example of application of the zone model for prediction of temperature in the industrial building, a) model, b) openings in different heights, c) application to industrial hall, see [4]

The today prescriptive rules are based on the publication prepared by Karpaš and Zoufal, see [1], which brings not only the properties and rules of application of the fire protection, but also the material properties of the structural steel and the basic rules of the design of steel structures. In the same year was published the first contribution for the fire design by dr. Reichel, see [2], which creates the background of the today compartmentisations, the estimation of the fire load, and most importantly it incorporate the fire risk into the Ultimate Limit State design. The second volume of this book takes care among others of the fire separation walls, the bearing structures and the fire safety distances, see [3].

The important steps for fire safety of structures was the foundation of the research centre in Veselí nad Lužnicí, where the colleagues from PAVUS a.s., see www.pavus.cz, successfully continue to ensure the good level of the products at European market to develop European material fire standards as well as national fire safety regulations and standards. The integral part of the reached level of the fire safety is shearing of knowledge with the young colleagues at the Faculty of Safety Engineering of Ostrava University, see www.fbi.vsb.cz, for forty years already and in the part of the safety and risk engineering related to the structures at Czech Technical University in Prague as well, see www.fsv.cvut.cz/baris.

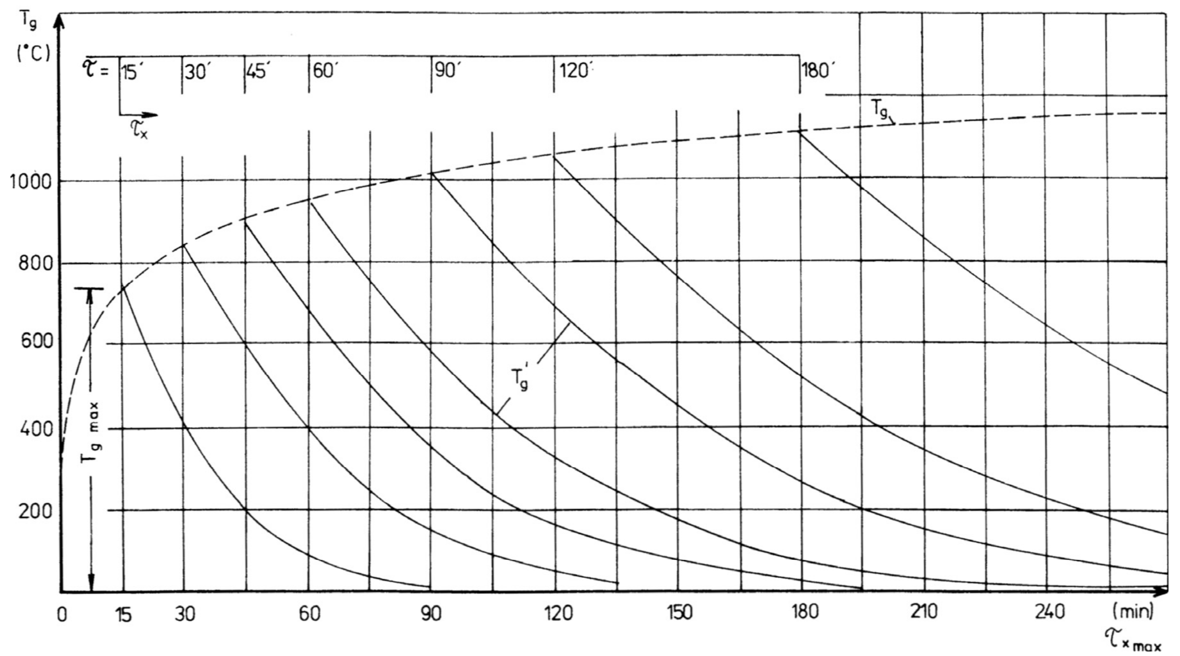

Fig. 2 Structure of the parametrical fire curve based on the time of the maximal temperature, see [4]

The background to the structural fire engineering in Czechoslovakia itself was introduced by the work of dr. Reichel, see [4], in 1987. The publication is contributing to the evaluation of the fire risk, the fire load, the structural behaviour and the economical aspects of the fire hazards. It brings the explanation of the background principles and its application in the current Czechoslovak standards. In the part devoted to the fire load is introduced for the utilisation of the Ultimate Limit State principles. A special chapter is focussed to the heat release and its importance for estimation of prediction of fires. The zone models and parametrical fire curve are used for the fire modelling. The simple zone model allowed predicting of the importance of the openings and its position in the fire compartment in the horizontal and vertical directions. The example of the application of the zone model to the influence of the openings at different height is documented on Fig. 1. The parametrical fire curve, presented in the book, modified the nominal standard fire curve based on the fire load and the ventilation. The simple solution gives a conservative estimation based on an assumed maximal reached temperature, see Fig. 2. Only one cooling speed is assumed. The publication brings useful worked examples for the calculation of the fire load, the equivalent time of fire, the level of fire safety, the probability of failures, the limiting sizes of the fire compartments, and the economy of the rick. The example of the evaluation of the neutral axes for the simple zone model in case of the localised fire is demonstrated on Fig. 3, which describes the input to the asked question.

The advantage of the Czechoslovakian set of rules was and is in the integration of the fire design with the prescriptive rules. This was arranged namely by a sophisticated parametric calculation of the fire risk based on the deep developed reliability assumptions, which fits to the high level of the current developments of the Ultimate Limit States developed for buildings at ambient temperature. The last publication of this series was focussed to the design of the steel and concrete structures exposed to the elevated temperature at fire situation, see [5].

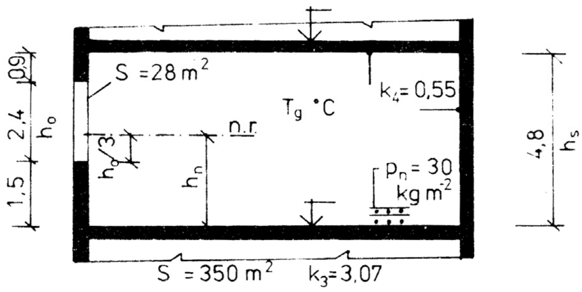

Fig. 3 Inputs to the worked example for zone model in case of localised fire, see [4]

CURENT CHALENGES

The new regulation No. 23/2008 [9] was issued to ensure the high quality of fire safety of buildings. It clarify the today best practice and brings new feathers among others the specification of fire engineering, the interest into the fire safety of high raised buildings, and the rules for garages with new types of fuels. The system of Czech fire standards is going to enjoy the knowledge in current and coming EN standard. Like in other European countries is the system under reconstruction to fulfil the current new requirements. The upgrade of the norm ČSN 73 0810, see [10], will accommodate the new EURA rules of fire classes of materials, and structural elements, the integration of the European parametric fire models, heat transfer and its distribution as well as the features of the structural analyses, the rules for buildings for distribution of electricity, the new materials in mass seals, the division into bearing and non-bearing claddings, the new opportunity of the removal of heat and smoke, the partially mobile fire-fighting equipment, etc.

The use of the fire safety engineering was in Czech Republic subsequently amended in the change of the law No. 133/1985 in 2006, see [10]. The philosophy represents engineering solutions for assessment of fire scenarios and fire design. The background material for the document is the integrated international standard ISO/TR 13387-2, see [11]. The submitted engineering process is related to the constructions, that are for reasons of its range, position, and way of usage or by other characteristics considered as risky and demand usage of the special evaluative methods. For analysis of common constructions are used the basic standards for the fire safety in constructions. The objective of the fire engineering methods is the proposition of the building and technical system measures that will lead to achievement of the acceptable exposure. The document contains the general principles of process for assessment of design fire scenarios and design fire, without detailed specifications of methods for assessment of input values or parameters. The input data for the application of the present engineering progress are included in the annexes to the document, e.g. choice statistical data, experimentally given characteristics. From principle of applied methods it is expected that the specialists with appropriate qualification take care of the fire engineering for constructions. These methods of evaluation do not need to be specified in detail for these specialists. The procedure of evaluation contains basically from the location of fire, type of fire, the potential fire hazard, the systems and features impacting on fire, the people response, the event tree, the consideration of probability, the consideration of consequence, the risk ranking, and the final selection and documentation. These fire scenarios for quantitative analysis will become the design fire. The data related to the risk probability are under preparation at Ministry of Interior.

SUMMARY

The fire engineering in Czech Republic, which is based on a good connection between the prescriptive rules and the performance based solutions, starts in 1965. The reached knowledge in connection with growing application of the active fire measurements and the information technologies in the fire engineering brings the opportunity to keep the good level of the fire safety for the challenging complex structural solutions, e.g. the mixed building technologies, introduction of the new materials, the high raised buildings, as well as the solutions for the sustainable constructions.

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REFERENCES

[1] Karpaš J., Zoufal R., Fire protection of steel structures, in Czech Ochrana ocelových konstrukcí před požárem, ČSP Zabraňujeme škodám, vol. 6, Prague 1978, p. 43.

[2] Reichel V., Fire design of buildings, in Czech Navrhování požární bezpečnosti staveb, Zabraňujeme škodám, Česká státní pojišťovna, part I, vol. 11, Prague 1978, p. 72.

[3] Reichel V., Fire design of buildings, in Czech Navrhování požární bezpečnosti staveb, Zabraňujeme škodám, Česká státní pojišťovna, part II, vol. 12, Prague 1978, p. 67.

[4] Reichel V.: Fire design of industrial structures, in Czech Navrhování požární bezpečnosti výrobních objektů, Zabraňujeme škodám, Česká státní pojišťovna, vol. 17, Prague 1987, p. 125.

[5] Karpaš J., Zoufal R., Fire safety of steel and concrete structures, in Czech Požární odolnost ocelových a železobetonových konstrukcí, publikace ČSP Zabraňujeme škodám, svazek 28, Prague 1989, p. 43.

[6] ČSN 73 0810, Fire protection of buildings - General requirements, in Czech Požární bezpečnost staveb - Požadavky na požární odolnost stavebních konstrukcí, ČNI, Prague 2005, p. 40.

[7] ČSN 73 0802, Fire protection of buildings - Non-industrial buildings, in Czech Požární bezpečnost staveb - Nevýrobní objekty, ČNI, Prague 2000, p. 116.

[8] ČSN 73 0804, Fire protection of buildings - Industrial buildings, in Czech Požární bezpečnost staveb - Výrobní objekty, ČNI, Prague 2002, p. 146.

[9] Regulation MI No. 23/2008, Technical conditions of the fire protection of the buildings, in Czech O technických podmínkách požární ochrany staveb, Czech Ministry of Interior, Prague 2008.

[10] Law ČR No. 133/1985, Fire protection and related provisions, in Czech O požární ochraně a související předpisy, Czech Republic, Prague 1985.

[11] ISO/TR 13387-2, Fire engineering - Part 2: Design fire scenarios and design fire, Genève 1999.