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FIRE ENGINEERING AND ITS PRACTICAL APPLICATIONS

Inżynieria pożarowa i jej praktyczne zastosowanie

Summary
Progress in the fields of construction and fire safety leads to the development of methods and approaches that are more suitable for extensive and atypical structures than the classical "standard" approach used up to now. In the Czech Republic, basic conditions for the official application of fire engineering approaches were established in the years 2009 and 2010. Needed changes have impacted on legislation, state administration, preparation of standards as well as professional training. The development and the introduction of fire engineering approaches form the content of the research project Specific Assessment of High Risk Conditions for Fire Safety by Fire Engineering Approaches (VG20122014074) handled as a part of the Czech Republic Security Research Programme 2010 – 2015. The contribution also states selected applications of fire engineering approaches to some atypical structures designed in the Czech Republic, including experience following from this.

Streszczenie
Postęp w dziedzinie bezpieczeństwa budownistwa i bezpieczeństwa pożarowego prowadzi do rozwoju metod które są bardziej przydatne w sytuacjach nietypowych od „standardowego" podejścia stosowanego dotychczas. W Republice Czeskiej, podstawowe warunki oficjalnego stosowania metod inżynierii pożarowej powstały w latach 2009 i 2010. Potrzebne zmiany miały wpływ na ustawodawstwo, administrację państwową, przygotowanie norm, jak również szkolenia zawodowe.Opracowanie i wprowadzenie rozwiązań inżynierii pożarniczej tworzą zawartość projektu badawczego „Ocena szczegółowa warunków wysokiego ryzyka dla Straży Pożarnej poprzez zastosowanie metod inżynierii pożarniczej" (VG20122014074) będącego częścią Programu Badawczego w Dziedzienie Bezpieczeństwa Republiki Czeskiej na lata 2010-2015.

Keywords: Fire Service, Czech Republik, fire engineering;
Słowa kluczowe: Straż Pożarna, Republika Czeska, inżynieria pożarnicza;

Changes in Strategy for Fire Safety, Fire Engineering
In the course of last three decades, construction regulations of many countries have switched from a prescriptive form to a functional form, which is usually supplemented by not binding detailed engineering instructions. The urgency of these changes is motivated by the need for flexible methods of designing buildings and the need to enable rather cheap solutions – especially in a case of extensive buildings – without jeopardizing the level of safety. In addition, with the increasing size of buildings, division into rather large compartments and increasing complexity, more persons are endangered by a fire than in the past. In the development of fire safety and fire safety also with the application of fire engineering, a great many international organizations participate intensively, such as International Association for Fire Safety Science (IAFSS), Construction International Board (CIB), International FORUM of Fire Research Directors (FORUM), International Organization for Standardization (ISO) and European Committee for Standardization (CEN).

During the development of new regulations, many countries have adopted a multi-level design that can be graphically represented as a pyramid (see Fig. 1).

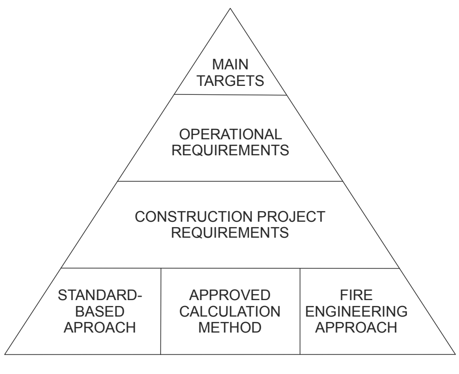

Fig. 1 Multi-level design

The apex of the pyramid represents the definition of main targets of the design; downwards are then specified operational requirements and construction project requirements that have to be satisfied in the case of all buildings. At the lowest level, which forms the base of the pyramid, selection from several possible approaches to achieving targets on the upper levels can be made. For the lowest level, three main design approaches in principle exist: 1.standard-based approach, 2. approved calculation method, 3. fire engineering approach.

The application of fire engineering approaches brings together with advantages also some possible disadvantages. Those may consist mainly in frequently high time consumption associated with the implementation of a fire safety design, lack of input data and rather high demands on the professional level of the designer.

At present, fire engineering consists of five basic subsystems: SS1 – fire origin and development and formation of products of combustion, SS2 – movement of products of combustion, SS3 – behaviour of constructions in a fire, SS4 – detection, activation and suppression, SS5 – safety of persons.

To all fire engineering, fire dynamics is of key importance. It is used for acquiring the quantification of characteristics required for a fire safety design, by means of which the real development of a fire which may occur in the building is idealized. The idealization of fire behaviour is designated as a design fire and is characterised mainly by the following variables depending on time: heat release rate, smoke formation rate, fire size, space temperature of gases, time to critical events (Flashover, etc.).

After the determination of behaviour of the design fire (fire origin and development and movement of combustion products), one can proceed to partial fire engineering solutions, which co-act with each other and between which data acquired are transmitted. It is a case of the following parts:

- assessment of building constructions during a fire,
- fire-safety equipment design,
- determination of safe evacuation of persons (including conditions for a successful intervention of fire brigades).

Fire Engineering in the Czech Republic

In the eighties of last century, Vladimír Reichel wrote the first wording of a design standard ČSN 73 0802. This new standard changed completely the concept of the preceding standard ČSN 73 0760 and succeeded in the creation of a basis for a coherent system of structural fire safety design including a set of design, test, value and subject standards of the series ČSN 73 08xx. The standard ČSN 73 0802 was based on a concept of fire engineering; it succeeded in transferring the scientific knowledge of that time into practice and created thus a design system for wide use.

Solutions for the application of fire engineering approaches have already been basically dealt with comprehensively in legal regulations of the Czech Republic. A change in the Act 133/1985 Coll., on fire protection from the year 2006 contains authorization in the following wording: "An authorized engineer or a technician to whom the authorization for structural fire safety was issued, is authorized, in the course of implementation of technical conditions of structural fire safety prescribed by the implementing legal regulations, to apply an approach different from the approach that is determined by the Czech technical standard or another technical document regulating the conditions of fire protection. However, using this approach the authorized person has to reach at least the same result as in the case of using the implementing legal regulation."

In connection with the preparation of a decree on technical requirements for structural fire safety, a proposal for an approach at a different manner of satisfying the technical conditions of fire protection (fire engineering) was formulated simultaneously. The concept itself includes four basic steps:

- qualitative analysis (qualitative design study),
- quantitative analysis (quantitative design study),
- assessment of analysis results according to safety criteria,
- result recording and presentation.

If the result of assessment of results according to safety criteria is unsatisfactory, the proposal has to be modified and the process has to be repeated.

In the framework of technical standardization, technical standardization committees are established for specific areas in the Czech Republic. With structural fire safety TNK 27 is concerned, in the framework of which a Subcommittee on Fire Engineering (SC 4) was established.

For the purpose of familiarization with the fire engineering approaches, four publications in the series Spektrum were issued by the Association of Fire and Safety Engineering (SPBI). At present, a research project "Specific Assessment of High Risk Conditions of Fire Safety by Fire Engineering Approaches" is dealt with in the framework of Czech Republic Security Research Programme 2010 – 2015 at the Faculty of Safety Engineering of VŠB – Technical University of Ostrava. The project focuses on the application of fire engineering approaches especially to buildings where a large number of people are accumulated and to buildings with an increased risk character of operation. As part of the project, a method of application that will systematically determine the rules for nonstandard approaches to assessing structural fire safety will be developed and verified in practice.

Application of Fire Engineering Approaches

The Faculty of Safety Engineering of VŠB – Technical University of Ostrava uses fire engineering approaches above all in dealing with fire safety in some atypical structures. As an example, the fire separation of the tunnel

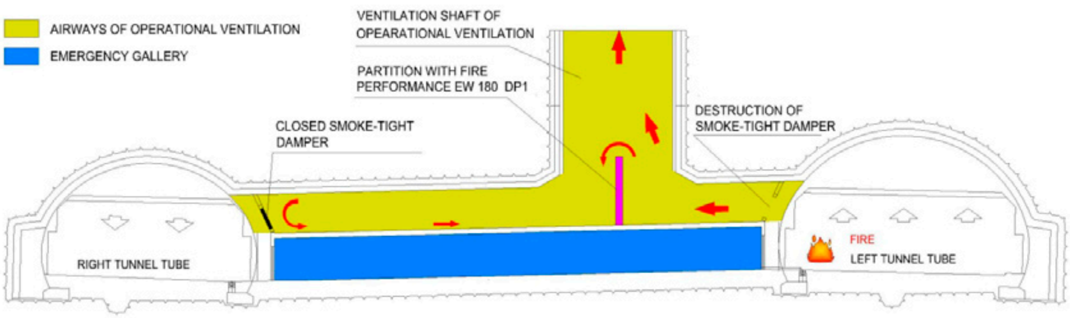

Fig. 2 Section through tunnel tubes

tubes of Komořany Tunnel structure in the framework of Prague orbital and the design of railway tunnels on the Přerov – Brno railway route can be given. In the next section of this paper, the application of fire engineering approaches to the design of Komořany Tunnel fire safety will be presented briefly. For the structure of Komořany Tunnel, a forced operational ventilation system was designed. The fresh air is supplied into one tunnel tube and the polluted air is exhausted from both the tunnel tubes (unidirectional tunnel tubes) by intake and exhaust fans placed in the ventilation building Nouzov.

From the ventilation building a ventilation shaft leads to the level of tunnel tubes; it is divided into a part for fresh air supply and a part for polluted air exhaustion. The ventilation shaft is connected with horizontal airways divided again into air supply and air exhaustion ways that open to the tunnel tubes and end with closing ventilation louver dampers. In the classical solution of an extraordinary situation "tunnel fire", all holes leading to the tunnel tubes have to be closed against fire and the tunnel tubes form separate compartments. For the mentioned structure, any certified fire louver dampers of required size and of required fire resistance EI 90 SC DP1 that would in case of fire separate the tunnel tubes from the airways were found neither in the Czech Republic, nor abroad. For this reason, it was decided to verify by modelling whether combustion products of a vehicle fire exhausted through one tunnel tube would be cooled to temperatures below 200 °C in the place of a louver damper situated in the opposite non-affected tunnel tube. For the temperature of 200 °C, manufacturers are able to offer certified fire and smoke dampers Sm DP1 of required sizes (see Fig. 2).

For the fire scenario, a conservative approach consisting in the selection of the worst variant of 50 MW fire with the complete destruction of the smoke-tight damper in the affected tunnel tube was used. The 50 MW output of the fire was chosen for simulation owing to the expected large volume of goods traffic. The 50 MW vehicle fire was simulated in the tunnel tube, when the front of the vehicle was on the level of the smoke-tight damper S_m DP1 being assessed and the vehicle was in the vicinity of the cross connection.

For the analysis of heat and smoke spread, the program FDS (Fire Dynamics Simulator), version 5.1.6, was used, and for visualization then software Smokeview (see Fig. 3).

The result of computer simulation has shown that in the case of the worst variant, i.e. goods vehicle fire

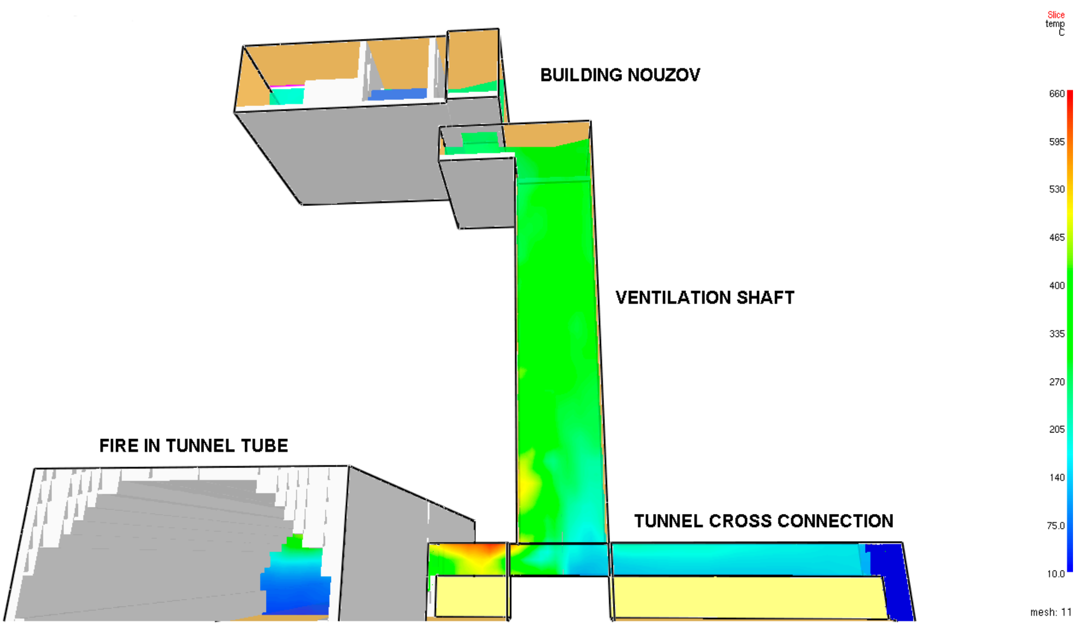

Fig. 3 Visualization of behaviour of temperatures in airways at the 300th second of 50 MW fire

(50 MW) in the tunnel in the vicinity of the smoke-tight damper Sm DP1, the limit state S_m (smoke-tightness for 200 °C temperature) of the affected damper is very quickly exceeded, and thus damper destruction can be expected. The temperature in the place of the smoke-tight damper in the unaffected tunnel tube depending upon the velocity of air flow in the affected tunnel tube grows gradually to the value ranging from 130 °C to 150 °C, when it becomes almost constant and increases no longer. Thus the limit state of the damper will not be exceeded and the damper will provide reliable smoke separation of the unaffected tunnel tube from the site of the fire.

Conclusion

In the Czech Republic, conditions for the use of advanced and progressive fire engineering approaches in structural fire safety design have been formed in recent years. Especially in the framework of security research, methods for wide practical applications of fire engineering are being developed.

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