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Limit of fire resistance of a steel transport structures. Simplified calculation methods

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Abstract. The article deals with the simplifed calculation methods of the limit of fire resistance of a steel transport structures. It gives detailed review of European and Russian simplifiy mthods for determine of fire resistance limits under standart fire load. Much attention is given to analysis difference between two normative methods and opportunities for further development. The harmoniztion of European and Russian legal standarts in the area of fire resistance of a transport infrastructure in different fire regime and different conditions is proposed.

1. Introduction

The standards for the fire resistance began in the 30s of XX century from the first since-based steps in area of fire protection of buildings and structures. Tradicionaly European and Russian fire standarts use in the calculating process the standart set of time-temperature curves and the standart parameters determined by the national standard. At this point in time European standards are harmonized with the Russians, which causes some difficulties in taking into account various parameters taken into account by different documents. The difference consists first of all in approach to determining the limit of fire resistance and accounting of indirect factors [1,2].

The purpose of this article is to identify the differences between simplifiy methods for calculating the limit of fire resistance of a transport infrastructure, as reflected in European and Russian legal documents.

2. Methods of calculating and accounting prerequisites

The article considered two methods of calculation of the fire resitance: Eurocode 3 «Design of steel structures». Part 1-2. «General rules for determining fire resistance» (EN 1993-1-2: 2005) [3] and the «Manual for determining the limits of fire resistance of building structures, fire hazard parameters of materials. Procedure for the design of fire protection»[4].

All calculations should be produced for standard time-temperature curves (figure 1). Standart curves also used for natural experiments and approximately correspond to a real fire.

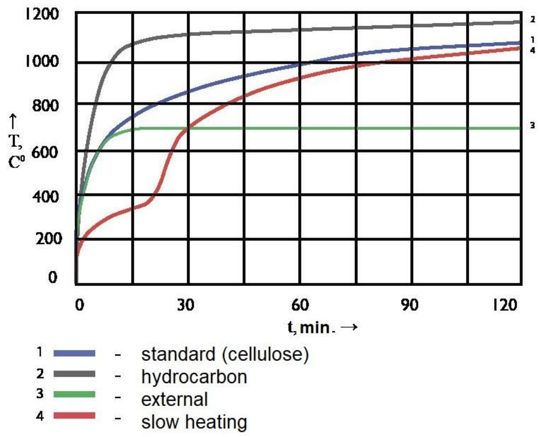

Figure 1. Temperature/time curves according to EN 1363-2:1999 Fire resistance tests. Part 2: Alternative and additional procedures (Russian National Standard EN 1363-2-2014) [5]

Turn-based scheme for Eurocode calculation methods shown in the figure 2, for Russian legal calculation methods shown in the figure 3.

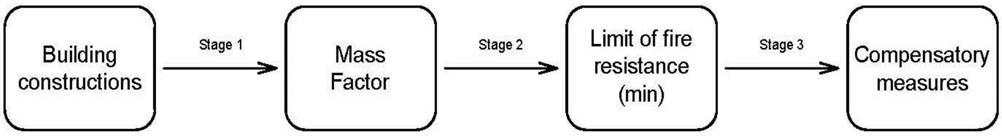

Figure 2. Turn-based scheme of calculation the limit of fire resistance for Russian legal methods

For Russian legal methods estimation of the own fire resistance limits of the structures (i.e. the constructions considered without fireproof coverings) is based on the determination of the mass factor (MF), followed by a comparison with the tabulated data of the fire resistance limit from the MF [6] (table 1) and the decision on the need for countervailing measures. Compensation measures are based on the results of field experiments.

Table 1. Dependence of the proper limit of fire resistance from MF

Mass factor, MF, mm	Proper limit of fire resistance, P_f, min	Mass factor, MF, mm	Proper limit of fire resistance, P_f, min
3	7	20	21
4	8	30	27
5	9	40	34
10	15	60	43
15	18		

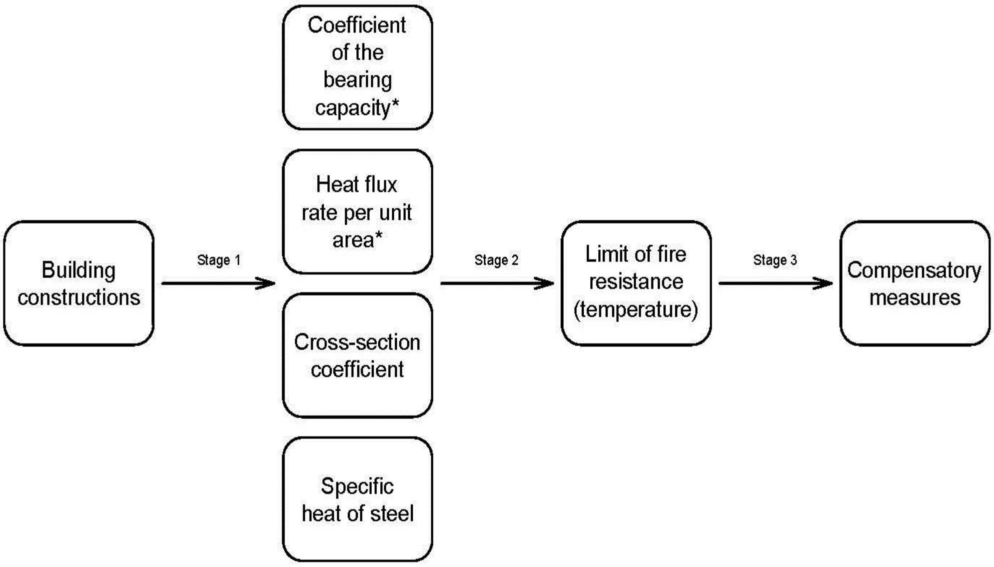

Figure 3. Turn-based scheme of calculation the limit of fire resistance for Eurocode methods (* - parameters are used for the design section)

Eurocode calculation of fire resistance of steel elements comes down to determining the temperature increase of the structure over time under normal temperature conditions and further comparison of the received results with the steel critical temperature Q_{cr} and deciding on the need for countervailing measures.

3. Difference and coincidences between methods

In contradistinction to Russian calculating methods, Eurocode takes into account physical parameters of construction materials, decrease in strength of structures with increasing temperature and heating features of elements during a fire.

The difference consists first of all in approach to determining the limit of fire resistance and accounting of indirect factors, such as shadow effect, loss of stability of the compressed elements, etc.

Thus, the approach to the calculation of the fire resistance of building structures, developed in European norms, is great interest for the national fire legal norms.

The issues of harmonization of European and Russian legal documents in the field of testing and calculating the fire resistance limits were considered in the works by Eremina T.Y. and ect. [7], Gravit M.V. [8-10], Giletich A.N. [11], Neplokhov I. [12].

In practice, calculations performed on Eurocode 3 give a more detailed idea of the operation of a transport structures in the standard regime of fire. The use of additional parameters helps to create a model of work of structures which corresponding to the real one.

4. Opportunities for further development

Incidents that have happened in the last 20 years on the objects of transport infrastructure (road and railway tunnels, auxiliary buildings and structures, etc.) shown us about the insufficiency of the fire safety measures.

Russian and partially European legal standards for fire safety do not define special fire regimes for transport infrastructure facilities.

Eeuropean committee CETU [13] was start their work on the problem of fire in tunnels and transport infrastructure in 2001. There was publicate a number of work casued of paramters of fire and fire parametrs (FIT – Fire in Tunnels).

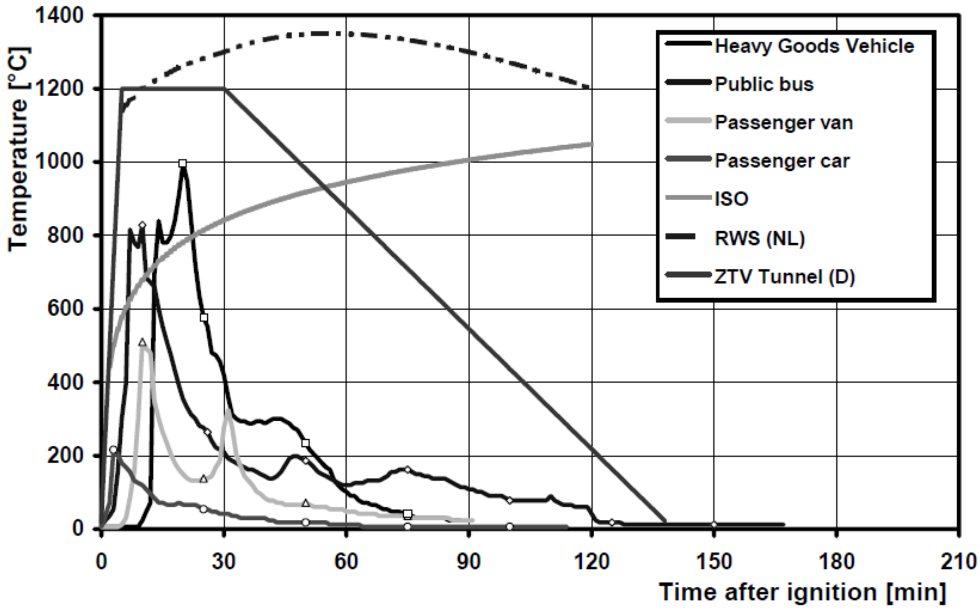

Figure 4. Time dependency of temperatures in EUREKA-tunnel-fires and standard curves used in regulations upon fire prevention [14, 15, 16]

The results of the work of FIT program:
- the time-temperature curves in tunnels was indenified (figure 4);
- international experience in area of fire safety of a transport infrastructure was analysed;
- a list of mandatory measures to ensure fire safety of tunnels was developed.

In Russia work on field of fire safety of a transport infrastructure (railway tunnels, subway tunnels, structure above road, etc.) was began recently. NRU MGSU is investigate the problem of fire regime for buildings and structures above road (figure 5 [17]).

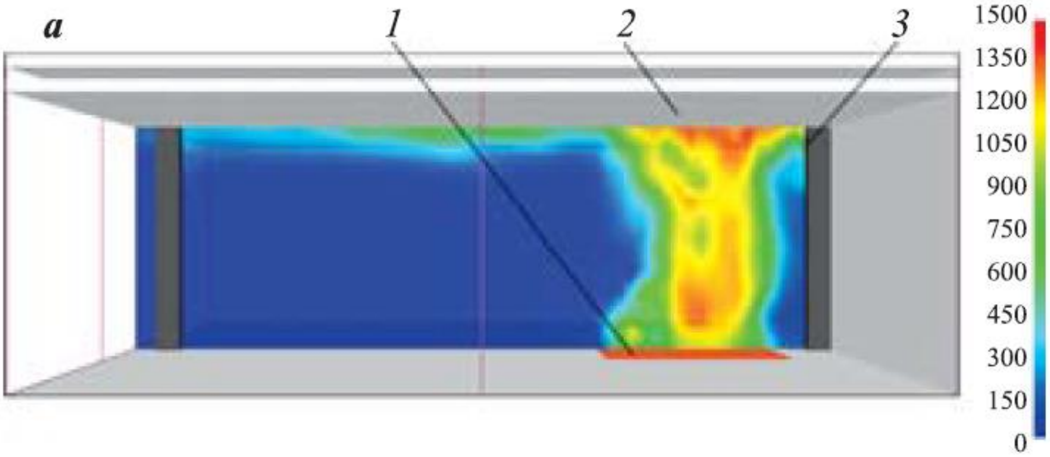

Figure 5. Temperature fields in the vertical plane above the fire, 1 – fire place, 2 – floor, 3 – colimn

5. Conclusion
The results of the CETU research in the field of fire resistance of a transport structures and buildings is of great interest for the Russian practice of fire prevention design.

The method for calculating the fire resistance limit of a construction according to Europe legal norms use a larger list of construction and material parametrs and allows to detailed assessment of the state of the structure in case of fire.

The obtained results of analysis the fire resistance limit for the transport infrastructure according to results of the FIT program and Russian research show that the harmonization of European and Russian regulatory documents is necessary.

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