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The new approach of building analysis according to Fire Safety Engineering in Romania

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Summary

The new European approach concerning the constructions fire safety will determine major changes in Romania referring to: construction products fabrication, commercialization and utilization, construction products classification from the viewpoint of their behavior to fire action and also in the elaboration of the specific technical regulations.

As concerns the products that assure the construction safety to fire action, there are three important directions which must be followed in order to satisfy the European Union recommendations:

- *application of CE mark on the products;*
- *elaboration of Eurocodes;*
- *elaboration of a new conception in approaching the construction fire safety, integrated in the global structural analysis.*

The present paper consists in a revue of all actual and long-term measures applied in Romania, referring to the analysis of buildings to fire action, starting from the European documents, which must be respected when our country will be a part of European Union.

KEY WORDS: fire safety, fire security.

1. INTRODUCTION

There are three important directions which must be followed in order to satisfy the European Union recommendations as concerns the construction products which assure the building fire safety:

- application of CE mark on the products;
- elaboration of Eurocodes;
- elaboration of a new conception in approaching the construction fire safety, integrated in the global structural analysis.

The first direction of action has several stages that lead to a generally agreed European conception, based on the necessary documents, elaborated some years ago, such as:

- *Directive 89/106/CEE*, that defines the general frame which harmonizes the rules referring to the free circulation of construction products in the European Union, as well as the essential construction requirements (including the essential requirement no.2, referring to their fire security). This requirement is reflected in the Romanian code *HG622/2004 (About the Conditions of Introducing on the Market the Construction Products);*
- *Interpretative Document no.2,* which founds the European conception as concerns the construction fire security (explaining in specific terms *Directive 89).* It is transposed in the Romanian legislation through the code *Guide for the Interpretation of Construction Essential Requirements in Order to Asses the Adequate Use of Construction Products – Indicative GT 051-02 (chapter 2 – Interpretation of the Essential Requirement Fire Safety);*
- *Guide G,* that contains proposed procedures for the optimization of the evaluation and classification systems used for the fire reaction performance of construction products (without a corresponding code in Romania).

The last two directions are referring to the design activity and their purpose is the achievement of a unitary, harmonized technical background which has to facilitate the circulation of construction design services.

2. OBJECTIVES AND STRATEGY OF THE ESSENTIAL REQUIREMENT. FIRE SECURITY

According to code [2], the constructions should be designed and carried out so that, in case of a fire, the following objectives to achieved:

- the stability of construction subjected to fire action for a certain time;
- the users protection and evacuation, taking into account the construction destination;
- limitation of material goods loss;
- limitation of fire propagation inside the building and in the neighborhood;
- protection of fire men and of other forces that contribute to people evacuation and salvation, protection of material goods, limitation and extinction of fire, fire effects removal.

The achievement of all these objectives is performed by using a *fire security strategy,* which consists mainly in fire prevention and in the limitation of its effects, as much as possible. From this perspective, the following strategic directions could be identified:

- minimization of the factors that influence the fire breaking out;

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- limitation of fire propagation from the fire room toward the surrounding spaces;
- correlation of intervention operations with the other protection measures and means.

The required level of fire security is ensured by applying different procedures and methods which could be integrated in the newer concept of *fire security engineering.*

3. FIRE ACTION

3.1 Generalities

The essential requirement *Fire Security* should be satisfied with an acceptable probability during the construction life time, reasonable from economic point of view. The fulfillment of the essential requirement is ensured by interdependent measures which are referring especially to:

- *building*: location, design, construction, service;
- *construction products*: properties, performances and utilization in the building.

The fire performances of construction and/or of construction products are considered with respect to the typical specified action.

The code *SR EN ISO 13943 – Fire Safety. Vocabulary* defines the following basic concepts of fire security:

- fire, as combustion deliberately organized in order to produce useful effects, its propagation in space and time being closely controlled;
- fire, as combustion that develops in space and time without any control and implies material damages. The interruption of its propagation presumes the intervention of specialized forces and equipments.
- fire situation, stage in the fire development characterized by the nature, severity and magnitude of thermal action upon the construction products.

As a consequence of the previous definitions it is correct to say *construction fire safety* and *occupants fire security,* or, more concise, *fire safety and security in constructions* [5].

Starting from these definitions it is correct to say *fire scenario* for the qualitative estimation of the phenomenon involved by the fire breaking out and *design fire* for the quantitative estimation of the phenomenon.

The fire action is considered in the study of construction behavior as a mechanical one, a thermal one or combination of them.

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The mechanical action may be generated by loads, imposed deformations, temperature changes.

The thermal action may be the consequence of radiation, convection and conductivity phenomena.

The level of thermal action with respect to time defines the stage of fire development and could be simulated in order to asses the performance of a product in the circumstances of its final utilization.

Unlike the old semi-empirical testing methods, the new methods are founded on *scenario* that recreate the circumstances of real fires, and are based on fundamental research in the field of fire thermodynamics. So, we can identify the *reference scenario* and the *fire scenario.*

3.2 Reference scenario and fire scenario

The **reference scenario** defines the thermodynamic state corresponding to the development of a fire in a compartment and is used to establish the representative and reproducible testing methods.
Several types of reference scenarios can be identified, depending on the purpose of the fire performance assessment.

Assessment of the performance – reaction to fire action

In this case, the reference scenario presumes the initiation of a fire in a compartment, which may develop and attain eventually the flashover point. It includes three circumstances that correspond to three distinct stages in the development of a fire:

- initiation (simulated by lighting a small fire on a limited surface of a product);
- development (simulated by a product burning in a corner of the room, generating a heat flux on the surrounding surfaces – method SBI);
- post–flashover (simulated by all combustible products burning – generalized burning).

Assessment of the performance – fire resistance

In this circumstance, the reference scenarios are based on a temperature – time curve, which defines the evolution of gas temperature near the surfaces of a structural element. They may be natural or conventional scenarios.

Reference scenarios for natural fires

The evaluation of the thermal action corresponding to a fire which develops in a closed space of a building (room, group of rooms, portion of a building), must consider:

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- the thermal load (type, quantity and burning velocity);
- the fire air supply;
- the shape and dimensions of the structural elements that form the fire compartment;
- the thermal and mechanical properties of the non-structural elements that separate the fire compartment;
- the influence of the equipments for fire extinction (as an example, the effects of the equipments with sprinklers);
- the action of fire men team (which could be facilitated by a system of fire detection).

The requirement *Fire Security* imposes the limitation of fire propagation and the assurance of construction stability for a specified period of time. This aspect can be expressed by the fire resistance of all types of building elements.

The adopted (conventional) model for the thermal action, corresponding to a generalized fire, is that one given by the *standard temperature – time curve* (taken from ISO 834):

$$T = 345 \cdot \log_{10}(8 \cdot t + 1) + 20 \tag{1}$$

where T is the gas temperature in the furnace, expressed in ^{o}C, and t the thermal exposure time, during the fire test, expressed in minutes.

This model of thermal action is used in the assessment of the performances of products exposed to a fire which is full evolution.

The adopted (conventional) model for the thermal action in case of a more severe fire (with a greater rate of temperature increasing than that given by the standard curve) is that one given by the *harmonized hydrocarbon curve*:

$$T = 1080 \cdot \left(1 - 0.325^{-0.167 \cdot t} - 0.675^{-2.5 \cdot t} + 20\right) \tag{2}$$

where the time, t, is expressed in minutes.

The adopted (conventional) model for the thermal action in case of a smoldering fire (with a lower rate of temperature increasing than that given by the standard curve) is that one given by the *smoldering combustion curve*:

$$T = 154 \cdot t^{0.25} + 20 \tag{3}$$

where the time, t, is expressed in minutes.

Reference scenarios for conventional fires

In case of special constructions (road tunnels, nuclear power plants) the technical prescriptions may impose extreme fire scenarios, for which the thermal action model is given by characteristic conventional curves for such severe circumstance.

The **fire scenario** defines from quality point of view the fire evolution in time, identifying the characteristic features, which make the difference between several possible fires. This concept is connected to other concepts:

- *design fire scenario* (the fire scenario whose selection is based on the risk);
- *design fire* (the quantitative description of the features which are established for the design fire scenario).

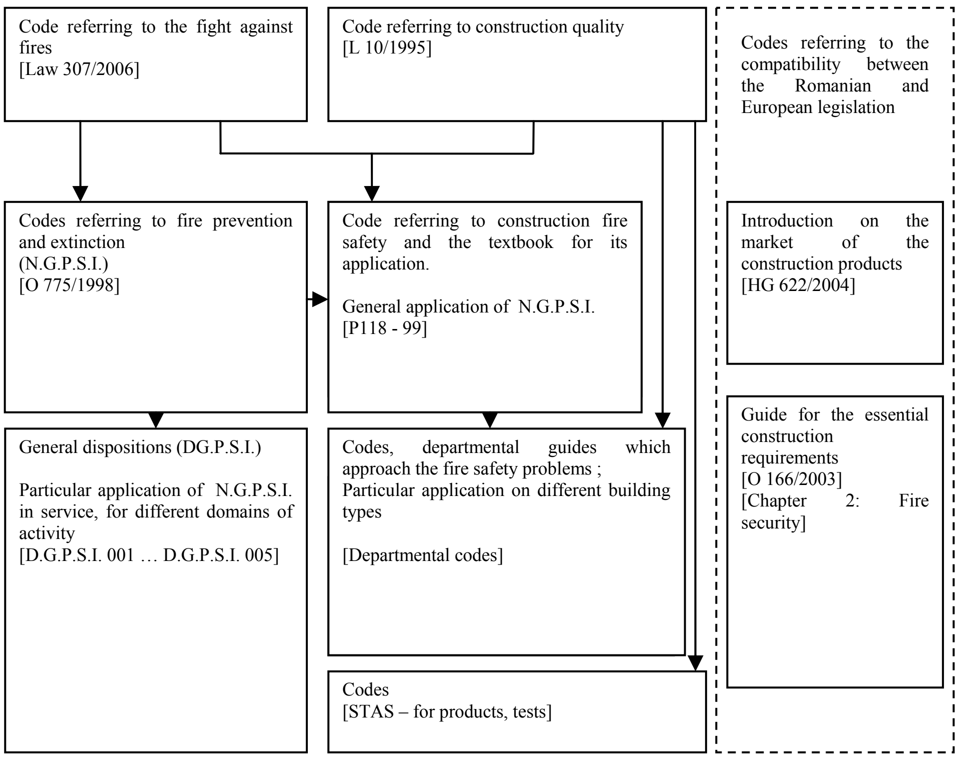

Figure 1. Romanian legislation referring to construction fire safety and security (2006)

The approach of the previously mentioned concepts is performed in a well established succession:

- identification of fire scenarios;
- selection of design fire scenarios;
- elaboration of design fires.

The fire scenario describes the process of fire initiation, development, generalization and regression, the characteristics of the building and of the systems which influence the fire evolution.

The code *SR EN ISO 13943* defines the fire scenario as a detailed description of the conditions, including the environment, in which one or several phases of an actual fire develop.

The interaction fire – building – occupants could generate a great number of possible fires and the practical impossibility of analyzing all scenarios. Therefore, a reasonable number of representative scenarios must be selected.

At limit, a single fire scenario could be considered, if it offers enough information for the correct evaluation of the security levels needed in the design activity.

In the fire scenarios selection, the process of *fire risk* assessment and hierarchization has an important role. For each project, a number of scenarios of fire with high risk are selected which become *design fire scenarios*.

For each fire scenario, a *design fire* is established (or more, in case of fire propagation in the surrounding compartments), activity that consists in a process of fire quantification, as a result of studying its characteristics.

The model selection and use imply especially the analyst experience.

4. THE ESSENTIAL REQUIREMENT *FIRE SECURITY* CHECKING

4.1. Generalities

The requirement fire safety / fire security is expressed in the national prescriptions in three ways or combinations [2], starting from the enunciation:

- of a minimum performance requirement for the construction;
- of a minimum fire performance of the products;
- of the critical levels of toxicity that the people could be exposed to.

4.2. Eurocodes

These European codes are recognized as reference documents to prove the conformity of constructions with the *Essential Requirement 1 – Stability and Mechanical Resistance* and the *Essential Requirement 2 – Fire Security*.
Romania has adopted as codes the following European documents:

- *SR EN 1990/2004 Eurocode 1. The bases of structures design;*

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- *SR ENV 1992-1-2/2004 Eurocode 2: Design of concrete structures. Part 1-2: General rules: design of structures to fire action;*
- *SR ENV 1993-1-2/2004 Eurocode 3: Design of steel structures. Part 1-2: General rules: design of structures to fire actions;*
- *SR ENV 1994-1-2/2004 Eurocode 4: Design of composite structures made of steel and concrete. Part 1-2: General rules: design of structures to fire action.*

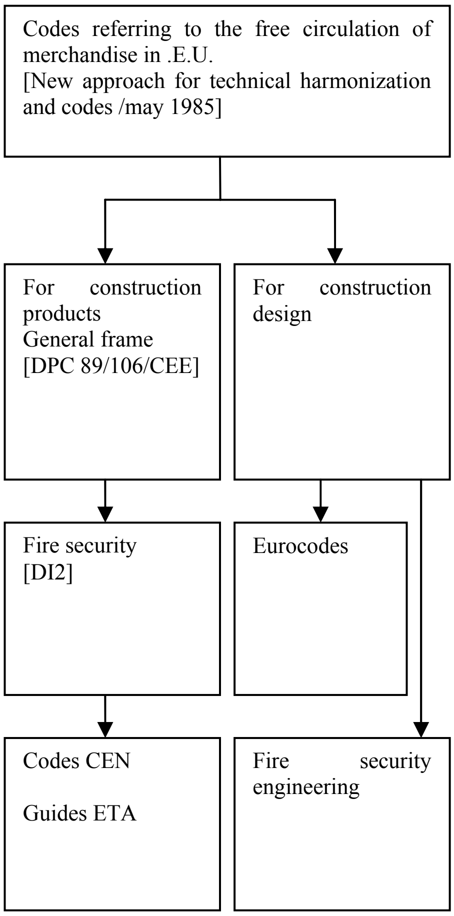

Figure 2. European legislation referring to construction fire safety and security (2006)

The procedures, methods and relations recommended by the Eurocodes can be used in the design of constructions to fire action because their results are recognized on the European market.

5. FIRE SECURITY ENGINEERING

One of the most recent concepts that must assure the fulfillment of the essential requirement fire security of constructions is the *fire security engineering*. It consists in applying some technical, engineering principles in the assessment of the safety level and in the design of the needed security measures.

The fire security engineering refers to the *design of fire security* and the *management of fire security* its purpose being a set of adequate procedures and methods, scientifically founded. Its application must involve efficient costs for construction design and management, it must be recognized all over the world, it must assure the users security, it must reduce the damages produced by the fire to the construction and to the environment and finally, it must protect the patrimony.

The new concept is used for:

- obtaining information about the development and propagation of fires throughout the construction and the fire influence;
- the evaluation of actions (thermal, mechanical, and so on) upon the compartment and construction;
- the evaluation of construction products performances;
- the evaluation of performances for detection and extinction equipments;
- the evaluation and design of the evacuation and salvation procedures.

The fire security engineering is a concept that develops in our days and the European documents which define it are codes from *ISO 13387.*

According to the new concept, the design is based *on performance, not on prescriptions.*

6. CONCLUSIONS

At the moment, in Romania, the legislation referring to fire safety and security in constructions approaches the problems in the traditional manner (according to Law 307/2006 – *Construction Fire Safety*) and in the European manner, that is known by few Romanian designers. The Romanian legislation is shown in Figure 1 and the European legislation, in Figure 2.

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