

### 3.1. Existing buildings and fire design

E. Nigro & G. Cefarelli

*University of Naples “Federico II”, Naples, Italy*

F. Wald

*Czech Technical University, Prague, Czech Republic*

M. Hajpál

*ÉMI, Budapest, Hungary*

R. Zaharia

*The “Politehnica” University of Timisoara, Romania*

N. Lopes & P. Vila Real

*Universidade de Aveiro, Portugal*

L. Kwasniewski & Z. Drabowicz

*Warsaw University of Technology, Warsaw, Poland*

D. Pantousa

*Volos University, Greece*

Edgaras Geda, Darius Bacinskas and Viktor Gribniak

*Vilnius Gediminas Technical University, Lithuania*

M. Heinisuo

*Tampere University of Technology, Finland*

#### 3.1.1. STATE OF ART

##### 3.1.1.1 Introduction

The safety of existing buildings is a very topical issue. In general, in countries of the world, the national construction building codes are periodically updated in response to changing technology, new materials and products, and the changing needs of building occupants and the community at large. Besides they can provide changes in required level of performance and modifications of administrative provision. However, a building constructed according to a past building code probably will not be able to satisfy all the provisions of the new rules. This paper deals with the safety of the existing buildings with particular reference to the fire vulnerability. Moreover, the procedures that can be used in European Countries are dealt with based on the contribution of the WG1 members. The safety of existing buildings is a very topical issue. In general, in countries of the world, the national construction building codes are periodically updated in order to improve the level of safety, health, welfare and property protection. However, a building constructed according to a past building code probably will not be able to satisfy all the provisions of the new rules.

Therefore it is necessary to individuate the approach which designers and contractors should take for the modification, repair and addition of existing buildings. An example is provided by the International Existing Building Code (2006) of International Council Code. The aim of this code is to maximize the safety and health of the workers involved with the building modifications, repairs or additions as well as building users and those whose proximity to the building could be affected by its failure.

The International Existing Building Code classifies works on existing buildings into alteration levels 1, 2 and 3; change of occupancy; additions; historic buildings and relocated buildings. Specific requirements for each class of works is outlined under the headings of Special Use & Occupancy; Building Elements and Materials; Fire Protection; Means of Egress; Accessibility; Structural, Electrical, Mechanical, Plumbing and Other Requirements. Moreover, useful information on how existing buildings and building rehabilitation are regulated are provided by David B. Hattis, that in 1981 wrote about this subject on the Bulletin of the Association for

Preservation Technology.

The safety in case of fire is a significant aspect of safety of existing buildings. This aspect affects particularly the historic buildings. Fire has always been a threat to culturally valuable historic buildings and surroundings. Building construction works, day to day activities, events and exhibitions all create different degrees of risks. Moreover, historic buildings are often built from easily-ignited materials, see Built Heritage: Fire Loss to Historic Buildings of COST Action C17, 2006.

### *3.1.2 Existing building regulations*

The States currently regulate new and existing building by one or more of the following types of regulations:

- Construction codes;
- Building maintenance codes (property maintenance, health, fire prevention);
- Past construction codes;
- Retroactive laws and regulations.

Construction codes are generally referred to as “building codes” and they regulate structural, fire, accident and health safety and everything is connected to provide a certain level of safety, health, welfare and property protection for building occupants and for general public.

In general, in countries of the world, the national construction building code are periodically updated. The updating of codes represents a constant increase in the implied levels of safety, health, welfare, and property protection. The building code change periodically in response to changing technology, new materials and products, and the changing needs of building occupants and the community at large. The updating of codes, in general, consists of the substitution of references to materials and methods of construction no longer used in modern construction with the references to new materials and methods of construction. Besides they can provide changes in required level of performance and modification of administrative provision. However, a building constructed according to a past building code probably is not be able to satisfy all the provisions of the new rules.

In many cases, it is impossible to make an existing building completely satisfying the provisions in force. A building code traditionally permits the continued use and occupancy of existing buildings at the time the code is adopted.

Most building codes and property maintenance codes imply that an existing building and any required safety equipment and devices must be maintained at the level required by the code under which the building had been constructed. In fact, these past codes establish levels of health, safety, welfare, and property protection which are usually different from new codes, and are often lower than those of current new construction codes.

However, in some cases states or local governments have declared certain building features to be unsafe or otherwise undesirable and have required that all buildings of a certain occupancy or class be altered to remove the unsafe or undesirable condition. In other cases they have required the installation of some specific features that contribute to a building's increased safety (e.g. sprinkler, smoke detectors). All existing buildings covered by a retroactive regulation are required to be modified to conform to the new minimum provisions. The levels of health, safety, welfare, and/or property protection required by such retroactive regulations may be the same as, or lower than, the respective levels required by codes for new construction.

The need to increase the levels of safety of existing buildings may be dictated by the need of repairs (for damaged buildings), change of use or occupancy and/or structural, by the need of applications of laws retroactive. A change of use or occupancy may introduce new or greater hazards in the existing buildings. A careful re-examination is required to determine that the building will be safe for the new occupancy. Generally, the building codes require that the entire building comply with the new construction requirements for the new occupancy, although this is often stated in various ways, depending on which model code is being followed.

### *3.1.3 Fire vulnerability*

For the existing building a fire event may represent a severe condition because the existing buildings are generally designed without any structural or non-structural fire safety concept.

Principal points of weakness in existing buildings have been repeatedly demonstrated in actual fires. The presence of open stairways and elevator shafts; the improper disposition or inadequate protection of combustible contents, construction, or interior finish; the lack of adequate means for restricting spread of fire; and the omission of devices that will give prompt notice of excessive temperatures are all familiar features of older types of buildings. Many others could be cited. Building construction works, day to day activities, events and exhibitions all create different fire scenarios and, therefore, different degrees of risks.

Belong to the existing buildings also the historic buildings. They are often built from easily-ignited materials. Therefore, fire has always been a threat to culturally valuable historic buildings and surroundings.

In addition to the current serious levels of loss to life and contents, the number, authenticity and quality of European historic buildings is now recognized as being steadily eroded through the effects of fire but the full extent of this is unknown. Human factors, lit candles, open fires and chimneys in poor condition are also responsible for starting many incidents, as are lightning strikes.

### *3.2 Fire vulnerability reduction*

Each building owner is on constructive notice as to his obligation under a building code, and many owners will no doubt be willing to make necessary changes in existing buildings, once the necessity for doing so is appreciated. However, no general improvement can be counted upon without enforcement of minimum measures by public authorities.

Such measures may take the form of adequate enclosure of elevator shafts; separating banks of elevators into not more than three in the same enclosure; adequate enclosure of stairways; a requirement that doors opening into an exit way shall be self-closing; adding stairways or other means of exit where provision of means of escape is deficient; subdividing excessively large areas; elimination of grills in exit ways; closing of movable transoms and substituting wired glass for plain glass in them; avoidance of ventilating systems (natural or mechanical) that exhaust air from assembly or sleeping rooms into exit ways; and providing suitable alarm and extinguishment devices.

The extent to which such changes will be required will vary with the occupancy, greatest emphasis being placed on improving the protection to those occupancies where people are infirm or are confined, or where sleeping quarters are provided. Especially in need of attention are old hotels in small communities, buildings converted to multi-family occupancy, and farm residences and resort hotels, particularly where they are outside the fire fighting zone and are of substandard construction.

#### **3.1.4 COMMON RULES FOR EXISTING BUILDING**

The building needs to be repaired or brought up to some minimum level of safety if it is dangerous, in accordance with safety code, or for enforce a property maintenance code, or for enforce a retroactive law or provision. The rehabilitation works, which do not change the building use or occupancy, cannot in any case reduce the existing fire safety level.

In general, the building codes address two categories of building rehabilitation: a) maintenance, alteration and repair of existing buildings not involving a change of use or a change of occupancy; b) change of use or occupancy in existing buildings.

The 25-50% Rule is commonly used by building codes as a means to control rehabilitation with no change of use or occupancy.

The specific wording of the 25-50% Rule varies from code to code.

Typically it requires the upgrading of existing buildings to the performance levels required for new construction if repair or alteration work exceeds 50% of the value of them building, and allows various lower performance levels to continue to exist in buildings when lesser work is involved.

Varying degrees of compliance with new construction requirements are specified for work between 25 and 50% of the value of the building, and for work below 25% of building value restoration with original materials is typically permitted.

In case of replacement or modification of floor distribution and/or equipment of active protection fire-fighting, the partial modification of the construction characteristics and/or of the system of ways of exit, and/or enlargements, the provisions of code applies only to the installations and/or parts of the construction subject of amendments.

The codes may provide two distinct approaches: prescriptive and performance-based. In the prescriptive approach the acceptable materials, sizes and methods of construction are prescribed in the code. In the performance-based approach any material, design or method of construction meeting the specified level of performance is acceptable.

Codes today for existing building, if fire safety interventions are necessary, provided primarily non structural intervention (e.g., sprinklers, compartmentation, evacuation plan, ...).

The performance-based design (performance approach) and fire safety engineering concepts applied to existing buildings requires in general the consideration of several aspects:

- assessment of the vulnerability of existing buildings to fire: e.g., fire resistance of the global structure and of more vulnerable structural members, as timber floors and roofs;
- risk assessment methodologies;
- protection of fabric and content;
- prevention of fire and fire spread;
- insurance considerations.

The strange and criticized category “existing building being a risk for human life” refers mostly to the buildings which have insufficient capabilities for evacuation of occupants or have improper covering materials.

Considering the consequences of the loss of a historic building, the risk analysis should include:

- loss of economic value (in terms of providing a modern replacement of premises of the same quality as the building which has been lost);
- loss of historic cultural and emotional value;
- loss of a positive image for the local community;
- loss of economic impact on the tourist industry;
- additional costs for reconstruction.

The special characteristics of historic buildings should be described and analyzed in the risk analysis to recognize the:

- particular vulnerability of the building;
- activities taking place in the building;
- fabric of the building and its structural features;
- surroundings of the building and the activities that take place there;
- probability of fire ignition;
- length of time required for the fire brigade to arrive.

### 3.1.5 QUESTIONNAIRE

#### 1.1 3.1.5.1 Q&A

A questionnaire on the existing building and fire design were sent to the European members of COST-C26 WG1. The questionnaire was composed of 22 questions. The questions were on the procedure, that the national code provide for existing building, in case of the change of the fire safety rules or of the purpose of the building.

Today 8 countries answered to the questions. In Table 1 are reported the each countries answers to each questions. The results are presented at Action WG1 web page [www.fsv.cvut.cz/www/wald/COST\\_C26\\_Prague](http://www.fsv.cvut.cz/www/wald/COST_C26_Prague).

#### 3.1.5.2 Comments on questionnaire answers

In general, in much European Countries the continuous modifications of the law on the existing building currently created a complex and messy system, far away from the unification.

However, Czech Republic have a ČSN 73 0834 “Fire protection of buildings - Changes of buildings”, where are specified the condition of changing the purpose of the existing building including structural aspects.

In general, codes today for existing building, if fire safety interventions are necessary, provided primarily non structural intervention (e.g., sprinklers, compartmentation, evacuation plan, ...). The performance-based approach for structural fire safety is already adopted by several International Codes, as well as in Eurocodes.

National fire code includes performance based design in Czech Republic, UK, Finland, Hungary and Italy. It is possible in Belgium if a derogation to the Fire Regulation is agreed on by decision of the Minister of Interior. In France it is possible to apply it partially for fire resistance and smoke propagation.

Recent modifications of Polish law regarding building infrastructure and fire protection have introduced a category of “existing buildings being a risk for human life”. Only such existing buildings are subjected to the same requirements as those for newly constructed buildings. The regular design requirements are regulated by the National Building Code and Eurocodes, while requirements regarding applied materials, active fire protection, localization, evacuation are controlled by numerous national standards and regulations. The prescriptive method dominates.



Figure 3.1.1 The structure of the Budapest sport stadium.

### 3.1.6 FIRE OF BUDAPEST SPORT HALL SERVED AS MARKED

Budapest Sport Hall was the largest covered arena dedicated to sport activities and cultural events in Hungary, see Figure 3.1.1. This steel reinforced concrete structure was constructed between 1978-1982 and opened in 1982. It had a seating capacity of 7000 and an overall capacity of 12500 persons. The main dimensions were: diameter at the footing 117 m and at the roof 127 m, high 26,5 m, place 12000m<sup>2</sup>.

It were 5 floors:

- under the arena were the cellar depots, permanent rink and exercise room;
- on the arena floor were the serving rooms for the competition;
- on the 1. and 2. floor were entrances for the public, toilets, buffet;

- on the 3. floor were press boxes, enclosure, place for pressmen, room for interpreters, bureau, monitoring rooms for the building;
- on the 4. floor were mechanical equipments, 700 m<sup>2</sup> exhibition room and here connected the steel structure to reinforced concrete ring.

The primary use was temporarily changed to host markets and other trade events, see Figure 3.1.2. The fire initiated on the 18<sup>th</sup> of December 1999, when a Christmas Market took place within the covered hall. Kiosks and small pavilions made from combustible materials were installed in the auditorium, on the ground floor and on the first floor corridors and even between the stands. The estimated fire load of goods and kiosks was more than 3000 MJ/m<sup>2</sup>.

After the catastrophic event a damage survey was performed and it has proved that most of part of the structure suffered long-term heat flux and exposure to high temperature fire (>800-900°C), which exceeded the fire resistance of the structures. The highest fire exposure was detected at the structures of vault of the arena, resulting in the complete collapse of the roof, see Figure 3.1.3. The structural units of the 3<sup>rd</sup> floor “ring structure” of the Sport Hall have been damaged significantly since there was only a glass dividing structure with very limited fire resistance.

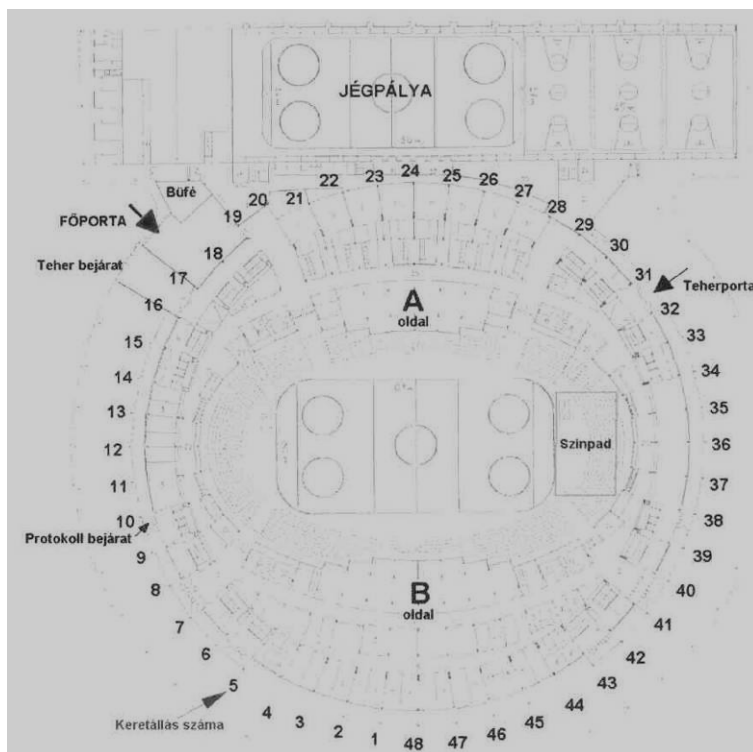


Figure 3.1.2 The plan view with the change to the Christmas market.



Figure 3.1.3 The structure of the hall exposed to fire.



Figure 3.1.4 The structure of the hall after collapse.

### 3.1.7 PROPOSED FURTHER DEVELOPMENTS

In the European countries the continuous modifications of the laws on the existing building currently created a complex and messy system, far away from the unification.

Therefore it is necessary provide the unified European approach which designers and contractors should take to the modification, repair and addition of existing buildings as the *International Existing Building Code*.

### REFERENCES

International Council Code 2006. International Existing Building Code.

COST Action C17, 2006. Built Heritage: Fire Loss to Historic Buildings.

David B. Hattis, 1981. How Existing Buildings and Building Rehabilitation Are Regulated, *Bulletin of the Association for Preservation Technology*, Vol. 13, No. 2, Regulating Existing Buildings, pp. 9-12

Rules for fire safety in case of change of use of building:

[www.fsv.cvut.cz/www/wald/COST\\_C26\\_Prague](http://www.fsv.cvut.cz/www/wald/COST_C26_Prague).