FIRE COMPARTMENTALIZATION

Executive summary of the dissertation submitted to the Budapest University of Technology and Economics in partial fulfilment of the requirements for the degree of Doctor Of Philosophy

Lajos Gábor Takács
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Supervisor:
Professor Gábor Becker

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1. DETERMINATION OF THE RESEARCH WORK

1. Determination of the subject of the research work

The topic of my dissertation is fire compartmentalization, a border area of the architecture, building constructions and fire protection. I worked out the following themes:

- Collecting the architectural, building construction and fire protection rules concerning to the spatial arrangement of the compartments.
- Overview of the principal design rules of the loadbearing fire barrier constructions with special aspects of hindering the fire spread.
- Collection of the general rules concerning to the fire resisting building products, building constructions and illustrations of construction details of fire barriers.
- Completing proposals for the way of fire compartmentalization in special area, for the appropriate safety of the multi-storey accessible buildings.

1.2. Justification of the topic choice

Re-thinking of separation and construction of the fire compartments in buildings with conclusions were necessary because of the followings:

- Rapid increase of the fire load of the rooms, fire compartments and buildings due to the widespread of the plastic articles.
- The increasing kickback of an accidental fire with the change of the building habits and the launch of the large multifunctional buildings.
- The appearance of new building materials, combustible building products and the dominance of the dry constructions since the beginning of the 1990’s, with different fire performance compared to the ordinary building constructions.
- Besides the change of the building habits and the development of the fire protection products, fire compartments, fire barriers are executed with major mistakes in construction and fire protection. Recent fires in Hungary and in other countries proved the improper compartmentalization and construction of fire barriers in buildings.
- Codes, rules are not complete regarding the compartmentalization and fire protection of the accessible buildings in Hungary.

1.3. Overview of the professional literature

1936 was the last time when an architectural fire protection book was released in Hungary (Ferenc, Császár: Architectural Fire Protection). Fire protecting chapters were included in certain issues (f.i. Handbook Of Dry Constructions, Reconstruction Of Buildings With Prefabricated Technology, Lightweight Buildings And Technologies etc), but complete (passive) fire protection handbook was not published. Issues containing fire protection chapters were collected in the References N° 1.-6.

The international profession literature concerning to the fire compartments, fire barrier constructions is essentially wider than in Hungary, but these are practical issues, not on scientific level. The profession literature is attended by national or regional fire protection associations (f.i. EGOLF, NFPA, FCIA etc.). The international research works carried out in the recent years delaed only partly with compartmentalization and fire barrier constructions.
The most important publications and research works in Hungary concerning fire compartments, fire barrier constructions is related to the Scientific Department Of Fire Protection of the ÉMI Kht. ÉMI Kht. took part in several international research projects (f.i. FIRE-TECH) and because of the lack of harmonised test method, they developed a special elevation fire spread test method, which is important in the elevation fire barrier constructions as well and this is the only one in Europe using a real-size elevation part of a multi-story building with windows. ÉMI Kht. is a member of several international associations, and the EGOLF as well (European Group of Organisations for Fire Testing, Inspection and Certification). Dr. Tamás Bánky, scientific director of ÉMI Kht, was previously the head of the Scientific Department Of Fire Protection. Publications of the associates of the ÉMI Kht. connected with my dissertation can be found in the References N° 13-15.

Articles concerning fire compartments, fire barrier constructions were released in the recent years in the Védelem, the biggest Hungarian fire protection journal and in its homepage (www.vedelem.hu). Publications released in the Védelem, connected with my dissertation are collected in the References N° 16-20. Here can be found most of my publications or publications with my contribution as well connected with my dissertation and listen in the Chapter N° 8 of the executive summary [25, 27, 28, 29, 30, 31, 33, 37].

2. GOALS OF THE DISSERTATION

2.1. Based on the well-known and on the results of my research work, systematization and classification of the definitions concerning to the fire compartment by the followings:
   • Classification of the goals against fire spread in buildings, including human life protection and property protection.
   • Classification of fire barrier building construction by the way of fire spread possibilities.

2.2. The summary of the well-known and the new results of my research work of design, construction, maintenance for the fire protection engineers and for the architects, especially the new requirements worked out with my contribution and released in the National Code Of Fire Protection, published in connection with the decree 9/2008. (II.22.) ÖTM.

2.3. Increasing the safety of accessible buildings with my proposal concerning the utilization of the fire compartmentalization and the areas of rescue assistance, with special interest to the escape ability of the disabled people.

I would like to compensate with my dissertation the lack of Hungarian publications in compartmentalization. The dissertation should serve as theoretical explanation and practice handbook of the new requirements worked out with my contribution and released in the National Code Of Fire Protection.
3. METHODS OF RESEARCH

The methods used for my research work were the followings:

- Detailed studies and treatment of both Hungarian and international technical literature (scientific publications, conference papers, current Western European and US-regulations concerning the fire protection of buildings).
- Examination of building constructions for fire protection purposes in already finished buildings (this was mainly useful for Chapter No 6).
- Studies of fire protection examinations in certified laboratories, with special emphasis on Hungarian examinations by ÉMI Kht. investigating the fire spread limit in buildings.
- Examinations of the adequacy of fire barrier constructions in real life (especially used for Chapters No 5 and 7).
- Detailed analysis of real-life fire incidents in Hungary and abroad, with special emphasis on the type of fire spread.

For carrying out analyses of real-life fire cases I used the following methods (in order of importance):

- Field examinations carried out in connection with expertise activities.
- Evaluation of descriptions and photographs of fire events, published on www.langlovagok.hu.
- My work performed between 1993 and 2007 in the areas insurance and risk-evaluation involving analyses of the fire risk in numerous communal, industrial, agricultural and storage objects. Examinations of the fire event models I defined were performed where the respective object suffered from fire damage subsequent to my risk-evaluation (e.g. the fire at Plastinnova Kft., Budapest, in January 1995, or the fire in the cheese-factory of World Proteins Kft. in Kőrmend, on April 27, 2007).
- Evaluation of descriptions and photographs of fire events examined by fire experts.
4. SUMMARY OF THE NEW SCIENTIFIC RESULTS OF THE DISSERTATION

1: Based on my research work and the analysis of building fires carried out by me, I proved that passive fire protection – including compartmentalization – is appropriate only, when emergency escape and evacuation should be possible and safe even in case of failure of the operative fire protecting systems or when they are out of order. Based on this, I deduced that passive and active fire protection cannot replace each other free or sometimes cannot replace each other at all.

1.1: The appropriate fire protection of the buildings can be solved with the optimalisation and harmonization of the passive fire protecting tools (use of proper resistance-to-fire constructions, compartmentalization etc) and active and operative fire protection systems (as automatic fire alarm and detection systems, automatic fire suppression systems etc). The levels of the passive and the active fire protection should compare each other and they should fulfil separately the regarding requirements [22].

By the mid-1990’s – till the use of automatic fire detection and alarm systems were not widely obligatory – the utilisation of active or operative fire protection systems instead of one or more passive fire protecting requirement was routine. This improper routine of the occurrence today is less frequent, partly due to my research work and publications. At the special permit processes for solutions which aren’t fulfil the requirements, became general the redeeming action of the area of discrepancy.

1.2: I proved that compartmentalization using only operative fire protection systems cannot serve life protecting goals [22, 32, 33]. In-line sprinkler nozzles and water curtains without building constructions cannot be used for compartmentalization or separating construction of evacuation routes, areas of rescue assistance, or fire compartment as protected zone for evacuation. Certain operative fire protection systems are cannot protect evacuation routes from the critical smoke spread, and safe emergency escape and the evacuation should be ensured even in case of failure of the operative fire protecting systems or when they are out of order (f.i. because of maintenance works). Based on this, I determined and systematized the areas where operative fire protection systems can be used and where they mustn’t be used as fire barrier systems.

2: With the analysis of the consequences of building fires [27, 28], I proved the necessity to incorporate the requirement concerning flat separating wall constructions as secondary fire separating constructions in a fire compartment into the official regulations [22], and I extended the above concept also to floor slabs between the flats.

Secondary fire separating constructions – similarly to fire barrier constructions – limit the extension of fire. Using secondary fire separating costructions is mainly necessary to protect cultural heritage (e.g. collections in museum) or private flats. Flats are the most expensive assets of families being the fundamental unit of society. The destruction of a flat caused by fire gives rise to extraordinary charges even when there is a valid property insurance. Since the 1960’s the same resistance-to-fire requirement was valid for the flat separating walls and the fire barrier walls. Following this principle, my proposal for the same resistance-to-fire requirement for the flat separating floor slabs and the fire barrier floor slabs was included in the improved version of the National Code Of Fire Protection in 2009.
3: Based on the analysis of building construction analogies and experiences of building fires, I proved that the construction of fire barriers is only appropriate when the principle of the continuance of protecting surfaces is completely fulfilled within the building constructions and the active (operative) fire protecting systems. [24, 25, 26].

When constructing fire separating structures, compliance with the principle must be checked during the stages of design and construction. In case of other building constructions (waterproofing, thermal insulation etc.) non-compliance with the principle of the continuance of protecting surfaces causes immediate failure and damage, thus shortcomings of fire barriers will be identified only in the case of fire.

4: I proved with my analysis of building fires [27, 28] the need of the continuance of fire protecting surfaces in multi-layer building constructions in order to ensure their fire resistance capacity.

4.1: By comparing Harmathy’s “Ten Rules Of Fire Endurance Ratings” with up-to-date building constructions and building habits I reached the conclusion that the consequences of Harmathy’s rules – adjusted by my proposed stipulations – are still valid and even especially important because of the recent widespread of multi-layer building constructions. Based on this analysis, I have proposed the continuance of fire protecting surfaces in multi-layer building constructions even if a multi-layer construction is not part of a fire barrier.

In recent days, ordinary structures are continuously replaced by multi-layer building constructions, where several requirements relevant for constructions are fulfilled within different layers. In case of most multi-layer constructions, fire resistance depends on the continuity of one layer (in case of floor slab at the bottom level, in case of wall construction symmetrically on both sides). The continuance of the fire protection surfaces has to be ensured not only at level changes and the connections to other constructions, but at the installation and breakthroughs of plumbing and electricity. The requirement for fire resistance and the basic principle of the fire separating function – the continuance of the protection surface – are valid for all constructions but especially important in case of the fire protection layers of multi-layer building constructions, and it needs increased attention at the stages of design and construction.

5: According to fire protection regulations in Western European countries and the USA, true fire walls are distinguished from fire barrier walls by their independent structural stability. I extended this principle by stipulating that the true fire wall should keep its stability, integrity and fire thermal insulation capacity – independently from its construction – even if one of the separated fire compartments, buildings or parts of buildings collapses [26, 30]. I demonstrated the necessity of the above extension with experiences and findings identified in course of the analyses I carried out earlier.

Between buildings and certain fire compartments, compartmentalization can be ensured only by fire walls with structural stability. Applying this principle, I contributed to the modification of the definition of fire walls as special constructions against fire spread, and I worked out the basic construction principles and examples which so far were not precisely defined in the Hungarian fire protection regulations. After compliance and
consensus, the definition of fire walls and the thereof derived constructions included in my dissertation will be released in the improved version of the National Code Of Fire Protection in 2009.

6: Based on the findings of my prior analyses of building fires, I proved that in case of failure of the active and operative fire protection systems the building can operate without compartmentalization, thus increasing the endangerment of he exposed persons and members of the rescue operator staff [22].

Fire compartmentalization, especially the details of fire barriers, consist nowadays of both passive (architectural) constructions and fire protecting elements operated with active acting elements (e.g. fire dampers, smoke dampers, self-closing fire doors). These elements are supplemented by operative fire protecting systems (e.g. in-line sprinkler nozzles, water the passive fire protection of a building is accepted and legal. Therefore my thesis includes proposals for the cases where the redundant safety of the operation of the active and operative fire protection systems is necessary, because – apart from a few exceptions – neither Hungarian nor the other countries’ fire protection regulations consist of special fire spread hazard decreasing requirements in case of the failure of the active and operative fire protection systems used as fire barriers.

7: I showed that the method of fire compartmentalisation and the arrangement of areas of rescue assistance are the basic and most important fire protection design tools for every accessible building in order to ensure safe emergency escape and the evacuation of disabled people [22, 33].

The existing Hungarian fire protection regulations contain requirements only for buildings especially developed for disabled people (buildings used in the area of health care). With the completion of these requirements, I systematised the alternatives of fire compartmentalisation and the arrangement of areas of rescue assistance concerning all accessible buildings, taking into consideration the emergency escape and the evacuation requirements needed for handicapped people. I worked out the aspects of architecture, building construction and fire protection as well as the demand of place regarding the areas of rescue assistance.
5. AREAS FOR THE PRACTICAL APPLICATION OF THE THESIS’ FINDINGS

Above all, this thesis is the result of more than 10 years of research. The hereby gathered findings I also applied in the preparation and drafting of laws, in which I have participated since 2004. As a result, my contributions are incorporated in the National Code Of Fire Protection, published in connection with the decree 9/2008. (II.22.) ÖTM, and also in its soon to be published modification of the year 2009.

The main purpose of this dissertation is to summarize and present the theoretical background as well as the possible practical realization of the rules contained in the above mentioned regulations. The publication of the thesis’ findings, and later on the presentation of the complete thesis to a broader public, will be equally important for architects with responsibilities in general planning as well as in specialist planning (structure designers, mechanical- and electric engineers), for planning in the field of fire protection and for fire protection engineers involved in procedures prescribed by technical authorities. The knowledge of the findings of my thesis can assist to plan, develop and control fire compartments and fire barrier constructions more thoroughly. For this sake, I implemented the results of the thesis in my teaching activities.

The following results of the thesis offer the possibility for further application in projects involving the drafting of laws, standards and directives:

- The detailed drawings of fire barrier constructions included in this dissertation serve as examples for the appropriate planning and construction of fire compartments [21, 24, 25, 26].
- I suggested the introduction of compulsory, documented, periodical and preventive controls with regard to passive and active fire protection systems (currently, periodical and documented controls are already required for operative fire protection systems). Fire barrier constructions in industrial, commercial and storage buildings are regularly exposed to substantial mechanical utilization [31]. At present, failures and faults bearing threats to the operation itself can only be identified by official controls performed by the regional fire brigade and thus may remain often uncorrected for years.
- Furthermore I proposed that fire compartmentalization realized only by operative (active) systems should not be used for lifesaving purposes: in-line sprinkler nozzles, water curtains etc without separating building constructions are not to be used for the construction and separation of evacuation routes or for the development of fire compartments or areas of rescue; partly, because these systems are not equally valuable (e.g. they cannot adequately prevent the spread of smoke which would be critical for emergency escape), partly, because the possibility for evacuating buildings has to be ensured within prescribed timeframes, even in cases where the operative fire protection systems are faulty or out of operation (e.g. due to maintenance).
- As a result of the scientific treatment of fire compartments I was able to verify the appropriate development of fire compartments together with the joint utilisation of areas of rescue assistance as the most important tool for the evacuation of handicapped people. This verification was the basis for my proposal as how to construct areas of rescue assistance with regard to aspects of architecture and fire protection [33].
6. AREAS FOR FURTHER RESEARCH

In connection with the topic of the dissertation the following additional areas for research can be recommended:

• The examination of architecture, building constructions and fire protection in the event of fire needs to be continued, particularly the evaluation of the role of building constructions during the spread of fire, supplemented by the analysis of real fire events. Regarding the analysis of bigger fire cases, I suggest the application of simulation methods, too, which can serve two purposes: in addition to the traditional tools for fire examination it creates alternative evidence, and on the other hand, comparisons between simulation and the traditional methods for fire examination even allow to bring simulation programs to a greater perfection.

• Regulations on fire compartments and fire barrier constructions are to be supplemented by supporting documentation including my explanatory drawings published in the National Code Of Fire Protection, or other diagrams or figures allowing a better understanding and practical application of regulations.

• Research is required in order to reach optimal harmonization of active and passive fire protection assets as well as to further improve the adequacy of fire compartments. This kind of interdisciplinary research affects the areas of building construction and fire protection science as well as building installation and sciences dealing with built-in fire-extinguisher systems.

• The current Hungarian fire protection rules are of prescriptive nature, and may be substituted for certain types of buildings by fire protection solutions based on (so-called) performance based fire protection engineering methods. Basically, called) performance based fire protection engineering methods define both the requirements for fire protection and the adequacy of protection from fire effects by ways of calculation or simulation. Accordingly, calculation methods have to be designed with regard to requirements for fire barrier constructions depending on the different types of buildings.

• Further research is needed in the area of special fire protection in buildings accommodating handicapped people [33].

• Research is required to optimise fire compartmentalization and to support operative fire protection activities and fire-extinction.

• It is necessary to establish rules for preventing the spread of fire between windows and doors between frontal surfaces enclosing angels of less than 120°, but belonging to different fire compartments. While ÉMI Kht. has begun with the relevant preparations, the examinations may be carried out by reconstructing the building for outdoor testing in the fire examination laboratory in Szentendre.
7. REFERENCES IN THE SUMMARY


9. Firestop Constructors International Association 4415 W. Harrison St., #436 Hillside, IL 60162 (www.fcia.org);


http://www.emi.hu/Webadatbazisok/Publikaciok.nsf/Publikaciok2/47F3EEE612BFE002C 1257004002CBC84/$File/Publ_2005_MezeiSGyula.pdf

16. Devastating Elevation Fire In Berlin. Author: Albrecht Broemme. This essay is the source of the fire study can be found in the Appendix 2.2. of the dissertation.
17. Every Storey Of the Panel Building Burned In Debrecen. Author: László Vida. This survey is connected closely to the fire study detailed in the Appendix 2.3. of the dissertation. [http://www.vedelem.hu/letoltes/tanulmany/tan91.pdf](http://www.vedelem.hu/letoltes/tanulmany/tan91.pdf)


20. Evacuation Of Disabled People. Author: György Heizler. The 51-page progressive essay was completed in the 1980’s, raising first the issue of the role of the fire barrier constructions in the evacuation. This publication is connected to the 8. Chapter of the dissertation. [http://www.vedelem.hu/letoltes/tanulmany/tan55.pdf](http://www.vedelem.hu/letoltes/tanulmany/tan55.pdf)
8. LIST OF THE PERSONAL PUBLICATIONS


