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# THE EFFECTS OF THE ACTIVELY USED REACTIVE AND PASSIVE FIRE PROTECTION SYSTEMS ESTABLISHED BY INNOVATIVE FIRE PROTECTION METHODS FOR WHOLE LIFE-CYCLE OF BUILDINGS

# (AZ INNOVATÍV MÉRNÖKI MÓDSZEREKKEL KIALAKÍTOTT AKTÍVAN ALKALMAZOTT REAKTÍV ÉS PASSZÍV TŰZVÉDELMI RENDSZEREK HATÁSA AZ ÉPÜLETEK TELJES ÉLETCIKLUSÁRA)

*The complex needs of the buildings in the XXI century, the constantly renewed technical solutions, and the dynamic variable use of the buildings lay the fire safety of the buildings on new foundations. The size (height, floor area, quantity of people, etc.), the design, the use of the buildings determines the entire life cycle of the building the risks involved in the building – human – fire interactions. The innovative fire protection solutions based on evaluative, analytical methods of exact theories, which based on technical approaches distinguish two great defensive characters: active and passive fire protection systems. We can identify equilibrium situations in the life cycle of a building, in the ever-changing fire situations depend on the risks and fire protection solutions, which ensure long-term sustainable security. In the article the authors describe the protection features of the actively used passive fire protection, which functions on the principle of the perception, processing and broadcast of information, which ensure the most effective solutions to protect our contemporary buildings and our modern life.*

***Keywords:*** *complex fire protection, innovative engineering methods, actively used reactive passive fire protection, fire safety*

*A XXI. századi összetett épületigények, folyamatosan megújuló műszaki megoldások, és az épületek dinamikusan változó variábilis használata új alapokra helyezi az épületek tűzbiztonságát. Az épületek mérete (magassága, alapterülete, befogadóképessége, stb.), kialakítása, használata meghatározza az épület teljes életciklusára vetítve az épület – ember – tűz kölcsönhatásból adódó kockázatokat. A műszaki szemléleten alapuló innovatív tűzvédelmi megoldások egzakt elméleteken nyugvó értékelő, elemző módszerei két nagy védelmi jelleget különböztetnek meg: az aktív és a passzív tűzvédelmi rendszereket. Egy épület életciklusa során a folyamatosan változó tűzvédelmi helyzetben a kockázatok és a tűzvédelmi kialakítások függvényében egyensúlyi helyzeteket állapíthatunk meg, amelyek hosszútávon fenntartható biztonságot nyújtanak. A cikkben a szerzők bemutatják az információ észlelésének, feldolgozásának, és közvetítésének elvén működő aktívan használt reaktív és passzív tűzvédelem védelmi jellegét, amely a leghatékonyabb megoldásokat biztosítja a kortárs épületeink és modern életünk védelmében.*

***Kulcsszavak****: komplex tűzvédelem, innovatív mérnöki módszerek, aktívan használt passzív tűzvédelem, tűzbiztonság*

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# INTRODUCTION

Nowadays contemporary modern buildings have such complex technical contents, complex spatial structures and create a multitude of demands that conventional fire protection can no longer provide the necessary and adequate security for these edifices.

**Figure 1. Wangjing Soho Towers [1]**

**Figure 1. Towers shifting in space, Miami (architect: Bjarke Ingels) [2]**

Fire protection in Hungary, similarily to other European Union member states, is essentially based on statutory requirements and related technical specifications (directives, standards). Since March 5, 2015, the Hungarian fire protection regulation has shifted to a modern, engineering-based systematic and regulatory system providing a high level of planning freedom. The National Fire Safety Regulation, issued by the Ministry of Interior as decree 54/2014. (XII.5.), can be used as a framework. It is currently supplemented by 12 fire protection technical regulations which contain technical parameters of fire protection, technical principles and technical solutions, thus providing an opportunity to form the fire protection of buildings. [3]

The former, very strict, dictionary-like (problem-response) regulation was replaced by the current fire protection measure, and thus placed the quality of domestic fire protection on new foundations, yet in many cases it is not fully able to control the spatial and usage demands of modern life needs and contemporary architectural attitudes effectively for the entire life cycle of buildings.

## BUILDING – MAN – FIRE

It is known that in almost all countries of the world architectural fire protection is based on laws, regulations and standards. Fire safety estimation methods, technical procedures, and risk analyzes are known in the science of fire protection but they do not embrace the entire life cycle of a building in terms of building-man-fire triangular interaction and complex fire protection, such as fire prevention, firefighting and fire testing. [4] As a result of non-complex fire protection, so called "white patches", critical locations and time periods are created for a building. [5] Fire protection in several aspects is a heterogeneous, multi-role, multi-stage process crossing through a long period of time, which creates a spatial-temporal matrix together with critical, potentially flammable locations and times.

From the point of view of security, the relationship between the building-man-fire triangle plays the most important role. We know the parameters separately that define measurable security in fire protection for the given factors. The problem lies in the fact that their real-life interaction often yields uncertain modifying factors, typically disruptive factors in which human factor plays a major role. [6]

If we highlight the building factor from the three-way interaction and investigate on the basis of spatial structure, we can get very important findings. The fire protection aspect of the spatial structure is manifested in the protection against fire spread. According to current fire regulations, the protection of our buildings against fire spread can be justified in several ways from a technical point of view:

1. With appropriate fire distance.
2. With appropriate passive fire retardant separation (e.g. fire damper, fire door).
3. With appropriate active fire retardant separation (e.g. certified fire extinguisher with built-in automatic fire spread prevention).
4. With adequate protection against façade fire spread. [7]

The basis for the requirements of fire spreading in itself is determined by a spatial design, which is a question of design decision. In such a field, it can be freely shaped to a certain degree to form fire safety. This spatial design principle is the breakdown into risk units, the definition of risk units. It is already clear from the basics that, based on a kind of risk-based approach, architectural spatial design is coupled directly with a fire protection spatial structure at the basics of the design of buildings. While planning, the problem of spatial design, which will form an integral part of the building's entire fire protection life cycle, needs to take the fight with a temporal anomaly. As time moves forward the functional use of the building can change continuously in a way that might affect the situation of fire protection.

Because of the above, it is of the utmost importance to achieve a long-term sustainable design that is in balance with the fire protection situation and adapts to dynamic use.

## EQUAL STATE

Active and passive fire protection systems appear in different ways and in order to protect our buildings. The design of the different systems is primarily dependent on spatial, secondly on functional design, depending on the risk class of the risk units of the given structure (VLR, LR, MR, HR).

| | A | B | C | D | D |
|---|---|---|---|---|---|
| 1 | The standard risk class of building A | The distance between buildings A and B (m), if the standard risk class of building B is | | | |
| 2 | | VLR | LR | MR | HR |
| 3 | VLR | 3 | 5 | 6 | 7 |
| 4 | LR | 5 | 6 | 7 | 8 |
| 5 | MR | 6 | 7 | 8 | 9 |
| 6 | HR | 7 | 8 | 9 | 10 |

**Table 1. Fire distance [8]**

From the point of view of spatial design, in addition to fire distance, one of the decisive fire protection aspects of fire spread is fire separation, which is also risk dependent, as is the requirement for the installation of active fire protection systems, particularly built-in automatic fire detection and fire extinguishing equipment. [9]

International and domestic regulations also build on the varied defense effect of active and passive fire protection systems, typically based on one or the other, or the mixed combination of the two. The two systems basically want to fill the role of substitution of fire protection components, i.e. by focusing and putting forward the use of one, it aims to push the other system element to the background or neglect it in extreme cases. For example, the elimination of heat and smoke discharge because of the use of extinguishing equipment, the reduction of extinguishing water demand due to the formation of small fire sections, or the elimination of smoke divisions as a result of heat and smoke discharge simulation. As the legal framework and the fire protection system provide an opportunity for this game of design, we take this into account with priority when designing buildings.

The problem is caused by the fire protection system of a complex building, which because of its sheer size (floor space, height) and its spatial design (complex traffic connection system, interconnected space arrays, atrium-type, multi-level formations, space-twisting, tiled facade design, etc.) is composed of complex risk units.

The risk class of risk units depends on spatial design to a significant extent, and therefore effectively defines the whole fire protection concept of the building. Due to large dimensions and typically high quality construction, these buildings occupy significant investor costs, therefore the economical approach is becoming more and more demanded in the field of security.

Optimization of costs, however, is in many cases pursued by the pursuit of a minimum set of legal requirements and the extreme use of substitution, which spoils the long-term, uniformed fire protection concept that affects the building as a whole.

The following diagrams illustrate the spatial dimensions of the risk units of buildings of various uses, without built-in fire detection and fire extinguishing equipment, and with built-in fire detection and fire extinguishing equipment, depending on their risk classes. The area under the curve that connects the floor areas of the fire section areas of risk classes can be defined by integral calculation. The geometric mean of the calculation defines the equilibrium state of spatial units. In the case of rooms with built-in fire alarm and fire extinguishing equipment, the equilibrium state takes the maximum value of the size of the fire section without the built-in fire alarm and fire extinguishing equipment, as defined by the NFSR.

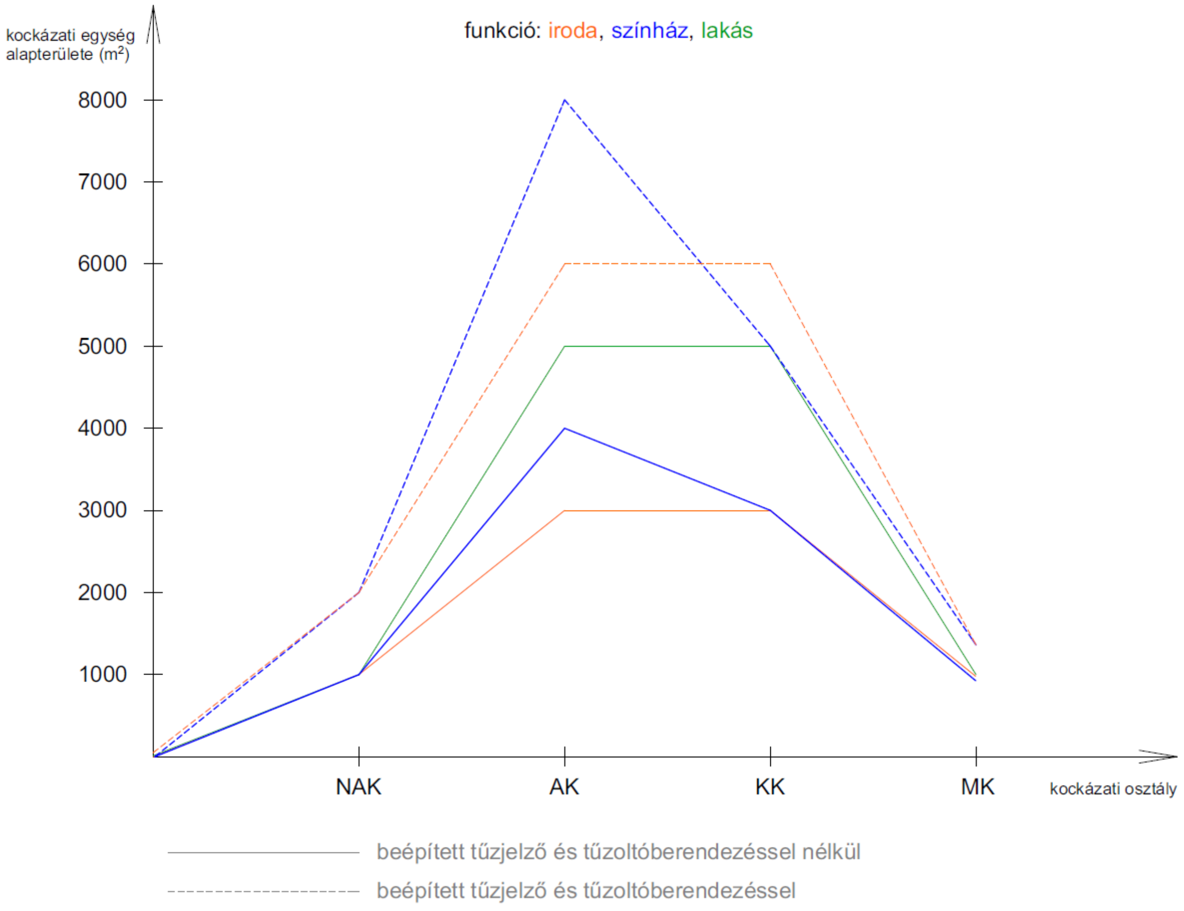

**Figure 2. Analysis of fire sections (residential and community function)**

[10]

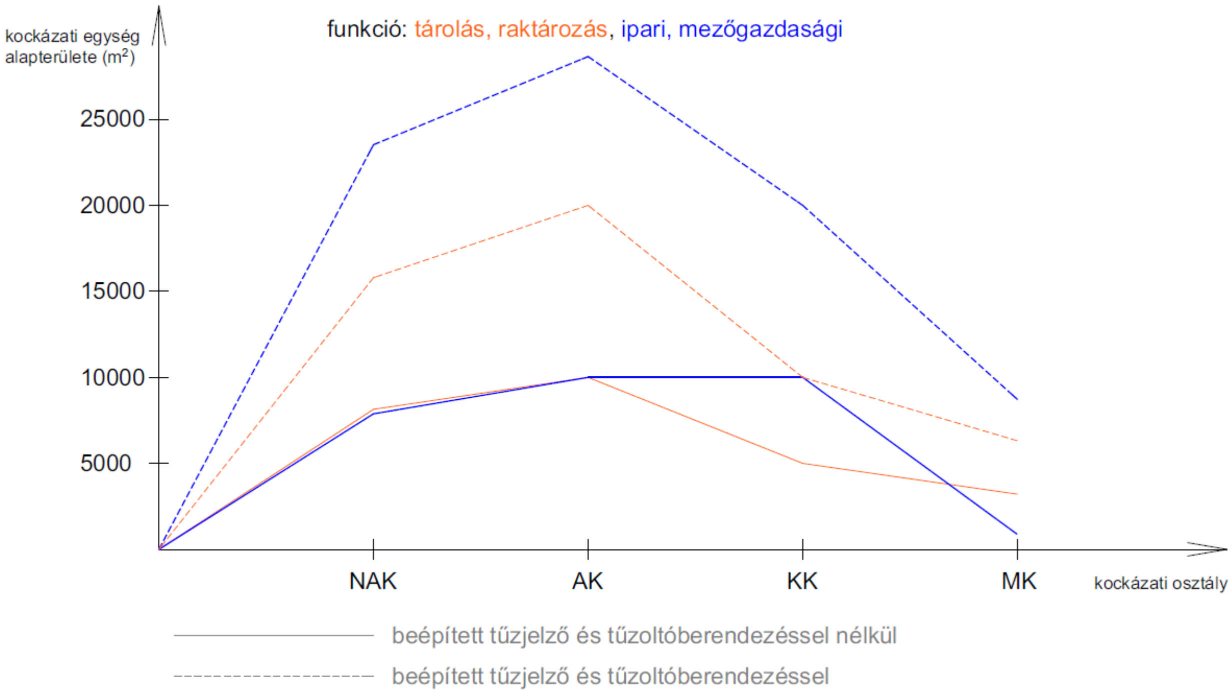

**Figure 3. Analysis of fire sections (storage and industrial function) [11]**

It can be seen that, in normal, average spatial configurations, stable equilibrium states (continuous lines) move in the range of passive fire protection systems, even when active devices are used they are close to the maximum of passive design.

The extreme use of substitutions in the case of increasingly widespread composite space buildings creates an unstable equilibrium situation, or does not create an equilibrium situation in the building's fire protection position and therefore, in the long run, it will not be sustainable over the entire life cycle of the building.

The basis of risk analysis during the building's life cycle is defined by the following relation depending on time:

R (risk) = C (consequence) x F (frequency)

Security is defined by the reciprocal value of the above equation:

S (safety) = 1/R [12]

The severity of consequences is significantly influenced by spatial design, so practically risk and safety can be determined by the appropriate treatment of this factor. [13]

Fire protection concept is basically defined by the active-passive fire protection systems, and therefore the balance of their protective nature has a decisive influence on the fire protection position of the building, depending on the risks. The role of equilibrium states of risks in decision theory is mathematically examined by the science of game theory. Game theory deals with situations in which we try to maximize the utility function of decisions out of least two decision situations. [14]

In our case, maximizing the function of the active and passive defense system's utility is the goal, so that it does not negatively affect the building's fire protection concept. This can be accomplished by looking for equilibrium states when maximizing utility and building a fire protection concept on these to create a sustainable, secure environment in the long run. The difficulty is caused by the fact that the utility function of actors (active, passive systems) depends on the effects caused by the other (e.g. the extinguishing system can be useful but it basically cools the combustion products of the fire which will not leave through the gravitational heat and smoke extraction system, thus can cause problems for both those trying to escape and intervening firefighter units), in a way that the actors are independent and different impacts. In the example above, we have seen a system that seems fundamentally safe as we created a space with extinguishers and heat and smoke extraction system, but due to a lack of balance in the fire protection system, the system does not provide adequate security.

In order to provide adequate protection, when using active-passive fire protection systems we have to look for a solution that is based on the scientific achievements of game theory [14]. When we apply game theory to a fire protection situation, we have to deal with static gaming theory where we know the effects of characters before the game (fire), so we can plan and count with it. In the case of active-passive systems, we can outline a simple matrix:

| | **active system** | yes | no |
|---|---|---|---|
| **passive system** | | | |
| yes | | 1,1 | 3,2 |
| no | | 2,3 | 1,1 |

**Table 1. Matrix for active –passive systems, prepared by Érces Gergő**

Abbreviation: active system: no, no: 1; yes, yes: 1; yes, no: 2; no, yes: 3
passive system: no, no: 1; yes, yes: 1; yes, no: 3; no, yes: 2

From the simple matrix we can see that, knowing the effects of the systems, we can get three types of solutions in two sets:

1. In the case of no-no or yes-yes matrix values, we will shift towards one of the extreme values, so basically there is no equilibrium, thus in this case extreme solutions can be obtained for example, due to the weakening effects of systems, because of which we achieve a worse security level than if we used only one system. Another extreme solution is to minimize or neglect some of the legal requirements that result in a non-equilibrium and long-term non-sustainable fire protection situation.
2. In the case of mixed systems, the so called Nash equilibrium[4] can possibly occur. [15] (2.3; 3.2). We must distinguish two values of the equilibrium:

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[4] A Nash Equilibrium in game theory is a collection of strategies $(s_1^*\ldots,s_n^*)$ Є S, one for each player in a social game, where there is no benefit for any player to switch strategies. In this situation, all players the game are satisfied with their game choices at the same time, so the game remains at equilibrium. $u_i(s_i^*,s_{-i}^*) \geq u_i(s_i,s_{-i}^*)$ to arbitrary $s_i$ Є $S_i$, i=1,…..n.

a. unstable equilibrium (no-yes): early detection is given, active systems are activated, no actual spatial separation, problem of heat and smoke can exist, the role of the human factor is outstanding

b. stable balance (yes-no): early detection, spatial separation, no built-in automatic extinguishers, heat and smoke problems are easy to handle, the role of human factor is minimal due to spatial separation

Based on the above, it can be stated that it is evident that in the case of no-no-value pairs the unprotected design involves potential risks. Of course, this is not a negligible solution, as there may be fire protection situations, e.g. in the case of a single story VLR standard risk agricultural storage building with less than 1000 m2 of floor area, where other design protection measures to protect human life and meet the requirements for escape criteria are taken into account, thus the construction is secured even without protection. However, in complex spatial designs and buildings this is not possible.

In the case of a yes-yes pair, it is easy to fall into the trap of creating a false sense of security, since we are building up all defense systems in a very uneconomic way, which, however, weaken each other's defense capability and thus deteriorate each other's effectiveness. Because of the protective capabilities that are negatively affecting each other, the ability to protect human life, but also structure protection and the ability to protect fire spread and to put out fire is greatly reduced. So even in this case, we cannot even talk about the balance of fire protection.

The fire protection position of systems in mathematical Nash equilibrium forms a balance, which, however, can add two values: unstable and stable equilibrium. In the unstable state of equilibrium, protection is basically based on active protection systems, primarily built-in automatic fire extinguishers. Instability is caused by a sensitive interaction system based on the building-man-fire interaction. In the case of security based on the protection of active systems, the lack of passive means of fire protection, such as the formation of large fire sections and the fact that the protection against fire spread are also provided by extinguishing equipment is typical. In the building-man-fire interaction the weakest link is the human factor. The viability of active systems depends to a large extent on the role of the human factor, which can make the fire protection situation unstable in the long run. Inspection and maintenance of equipment is based on a human factor and functionality is a complex set of technical solutions with a greater probability to fail than that of a passive system. Of course, in the case of proper operation, the protection provides 100% safety, the fire protection situation is in equilibrium with, but due to the above, only in unstable equilibrium.

A similar result is shown in the case of a building with a firefighting area versus without a properly constructed firefighting area. If one of the components of security is the rescue from high with a ladder equipped fire truck. the balance of fire protection situation is unstable due to the human factor: the success of the rescue depends on the capabilities of the intervening staff and the person(s) to be saved [16] (preparedness, psychological state, etc.), furthermore on the location of the firefighting area (e.g. cars are parked there, or the area is left open).

By contrast, in compliance with the relevant requirements, in the case of a building constructed without the use of a firefighting area, the human factor is substantially reduced, the safety of the intervention [17] [18] is significantly increased, thus achieving a stable equilibrium in the long term. In case of a greater use of passive fire protection systems we can talk about a stable equilibrium state, because we can be sure that in a given spatial design, a fire section protected with defined constructed structures can only be a problem as a fire unit. Of course, without any other active equipment, e.g. extinguishing equipment, it is to be assumed that the particular fire section is going to completely burn down, but due to the plannability of usage it is possible to create escape, firefighter intervention and adequate structural protection, thus creating a stable equilibrium state in the fire protection situation, which is sustainable in the long term.

## ACTIVELY APPLIED REACTIVE AND PASSIVE SYSTEMS

Throughout the lifetime of a building and during the main cycles, complex fire protection is often carried out parallel to the areas of expertise and actors without intersection(s), resulting in breaks and white stains on the continuity of the fire protection as a whole. [19] In order to solve the above problem, it is of utmost importance that we create a fire protection position in a building with balanced fire protection systems to flexibly adapt to contemporary dynamic use.

The main weakness of the fire protection concept based on mainly active fire protection systems is the time lag, which makes the system unstable. As a result of instability, a situation may arise when the defense cannot play its role. For enclosed spaces, this risk increases significantly, which culminates in the critical points of the entire life cycle of the building. The main weakness of the fire protection concept based mainly on passive fire protection systems is manifested in variable design. The spatial design with fixed construction elements (temporary protected areas, fire-proof rooms detached with fire-resistant walls and fire protection partitions, separate fire sections or protection against the spread of fire with fire distances, etc.) provides a small opportunity to be multifunctional, but the building can be kept in a stable equilibrium.

Based on the above, a conclusion can be drawn that in the case of modern buildings the most efficient and complete, and life-cycle long, most optimal fire protection situation can be achieved with the use of actively applied passive protection systems by taking equilibrium conditions into account. What does this mean? Basically, the structures following, or in many cases shaping the design of a spatial structure from a fire protection point of view act by the sign of the fire protection system of the building's information system as a passive, but mobile anti-fire blockade (they activate fireproof doors and windows and mobile fire protection walls). Fire protection system components activated by intelligent sensing and control [20] act in a passive way the at the end of the process and create a stable equilibrium position by providing information on the passage-disrupted space because of the capabilities of the fire detection system, the intervening forces already have the necessary data ready at the fire detection stage. Passive systems are able to activate automatically without fire detection equipment: heat-foaming systems, heat-foaming hardening foams, etc.)

By using these systems, the permeability of architectural spaces is secured and can be varied according to the specific function requirements while providing a stable equilibrium protection. Emptying the enclosed spaces thus ensuring a high level of life protection.

It can be stated that the innovative and combined application of engineering methods, besides solving individual fire protection issues, can be used to determine risky periods and locations based on the fire detection engineering results and experiences, and to which use can be precisely designed for. This method is an innovative engineering method, a multifaceted, state-of-the-art computer-aided analytical, evaluation method. With BIM (Building Information Modeling) based design and cloud-based state-of-the-art info communication systems, we can activate our passive fire protection tools. [21] [22] Thus practically by the active implementation of passive fire protection systems a new type of dynamic usage rule system is created that ensures a steady state stability throughout a building's lifecycle.

In domestic fire protection, with the aim of establishing a stable fire protection situation, the innovative and combined application of engineering methods can be continuously incorporated into the relevant fire safety technical guidelines so that planning freedom can be substantially increased in such a way that fire safety is constantly increasing. When applying for integration into the fire protection technical directives, proper fire safety can be justified by an approval procedure, thus significantly reducing the need to carry out derogation procedures from the legal regulations by which the resource surplus increases the efficiency of the fire safety authority.

## SUMMARY

In complex fire protection, due to contemporary architectural demands the dynamic change of the interaction between building-human-fire parameters in time causes a critical risk white stains on the whole life cycle of a building, which significantly reduces the fire safety of the building by creating non-equilibrium fire protection situations.

The development of fire safety that satisfies legal requirements and architectural needs depends on the equilibrium state of fire protection situation, which can be achieved by a stable and unstable equilibrium situation. It can be proven that establishing a stable fire safety equilibrium is the best and most up-to-date solution for a sustainable building in the long term.

The design of actively applied passive fire protection systems ensure the realization of the most diverse fire protection situation. This solution provides the most optimal solution for high buildings, high-floor or high-capacity multifunctional buildings to plan and count evacuation, escape, determination of extinguishing water, smoke extraction, etc. This solution can be used to manage the absence of a firefighting area or the lack of usability of a firefighting area, thus providing a safe technical solution and life-saving resulting from the lack of a high-saving option. In modern fire protection, compliance with fire protection requirements in force can be justified the best with the active use of passive fire protection systems in a stable equilibrium based on innovative engineering approaches, both technically and economically.

# REFERENCES

[1] 1. picture: Wangjing Soho Towers, https://www.dezeen.com/2015/05/19/zaha-hadid-completes-pebble-shaped-wangjing-soho-towers-beijing-offices-retail/ (A letöltés dátuma: 2018. 04. 15.)

[2] 2. picture: COCO Grove at Grand Bay, Miami, építész Bjarke Ingels, http://www.big.dk/#projects-coco (A letöltés dátuma: 2016. 11. 21.)

[3] Bérczi L.: A tűzvédelem a katasztrófavédelem rendszerében, Új Magyar Közigazgatás 5: (6) pp. 2-8.

[4] Beda L.: Gondolatok az épületek tűzbiztonságáról, Magyar Építőipar, 2011 (3) pp. 94-98.

[5] Bérczi L.: A tűzoltástaktika megújulása, Védelem - Katasztrófa- Tűz- és Polgári Védelmi Szemle 21 (2) pp. 51-52. (2014)

[6] Érces G. – Restás Á.: Disaster Management in Fire Protection View: Building Life Cicle Assessment in Hungary In.: 11 th International Conference on "Environmental Legislation, Safety Engineering and Disaster Management" Elsedima: Building Disaster Resilience in a Changing Word (Book of abstracts). 199 p., ISBN:978-606-93873-1-3

[7] 54/2014. (XII. 5.) BM rendelettel kiadott Országos Tűzvédelmi Szabályzat VI. fejezet: Tűzterjedés elleni védelem

[8] 54/2014. (XII. 5.) BM rendelettel kiadott Országos Tűzvédelmi Szabályzat 3. melléklet 1. táblázat

[9] 54/2014. (XII. 5.) BM rendelettel kiadott Országos Tűzvédelmi Szabályzat 14. melléklet táblázat

[10] 3. figure: tűzszakaszok elemzése (lakó és közösségi funkció) – készítette a szerző

[11] 4. figure: tűzszakaszok elemzése (tárolási és ipari funkció) – készítette a szerző

[12] Beda L.: Tűzmodellezés, tűzkockázat elemzés, Szent István Egyetem YMMFK, 1999.

[13] Bognár Balázs, Kátai-Urbán Lajos, Kossa György, Kozma Sándor, Szakál Béla, Vass Gyula: Kátai-Urbán Lajos (szerk.) IPARBIZTONSÁGTAN I.: Kézikönyv az iparbiztonsági üzemeltetői és hatósági feladatok ellátásához. Budapest: Nemzeti Közszolgálati és Tankönyvkiadó, 2013. 564 p. (ISBN:978-615-5344-12-1)

[14] Simonovits A.: Bevezetés a játékelméletbe, BME, Matematikai Intézet egyetemi segédlet (2007) MTA Közgazdaságtudományi Kutatóközpont

[15] Nash J. F.: Non-cooperative games, Kuhn (1997) 14-26. pp.

[16] Restás Á.: The Examination of the Economical Effectiveness of Forest Fire Suppression by Using Theoretical Fire Spread Models, Academic and Applied Research in Military and Public Management science 15 (1) pp. 85-92. (2016)

[17] Restás Á.: Decision Making on the Spot, In: Grześkowiak Ł Wojciech, Kowalewski Paweł, Ratajczak Izabela, Ciorga Bartosz, Fanfarová Adelaida, Gašpercová Stanislava, Makovická Osvaldová Linda, Restás Ágoston, Makovická Osvaldová Linda, Panáková Jaroslava (szerk.), Proceedings of the 8th International Scientific Conference Wood and Fire Safety. Konferencia helye, ideje: Strbske Pleso, Szlovákia, 2016.05.08-2016.05.12. Zilina: EDIS Zilina University Publishers, 2016. pp. 277-286., ISBN:978-80-554-1201-6

[18] Szakál Béla, Cimer Zsolt, Kátai-Urbán Lajos, Sárosi György, Vass Gyula: Veszélyes anyagokkal kapcsolatos balesetek elleni védekezés I.: módszertani szakkönyv veszélyes anyagok és súlyos baleseteik az iparban és a közlekedésben. Budapest: Korytrade, 2015. 120 p. (ISBN:978-963-12-3502-9)

[19] Bérczi L.: Structure, organization and duties of fire services in Hungary, Védelem Tudomány: Katasztrófavédelmi Online Tudományos Folyóirat I. (2) pp. 3-18. (2016)

[20] Ramachandran G.: Informative Fire Warning Systems, Fire Technology, 27, 1, 1991 pp. 66-81.

[21] Érces G. – Restás Á.: Infocommunication Based Development Opportunities in the System of Complex Fire Protection, In: Branko Savić, Verica Milanko, Mirjana Laban, Eva Mračkova, Restás Ágoston, Branka Petrović (szerk.) Book of Preceedings: МЕЂУНАРОДНА НАУЧНА КОНФЕРЕНЦИЈА БЕЗБЕДНОСНИ ИНЖЕЊЕРИНГ. 530 p., ISBN:978-86-6211-106-7

[22] Haig Zs.-Kovács L.-Munk S.-Ványa L., Szerk.: Kovács L., Tózsa I.: Az infokommunikációs technológia hatása a hadtudományokra, Budapest: Nemzeti Közszolgálati Egyetem, 173 p.