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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

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PRINCIPLES OF FIRE MEASUREMENT OF STRUCTURAL ELEMENTS

Abstract

Nowadays, ensuring a high level of fire protection of buildings is of paramount importance both during the design and construction period and during the operation period. In determining the fire resistance of structural elements, fire design requires the close cooperation of several engineering disciplines. One of the most important tasks in the design of fire loads is that our buildings and structures are able to maintain their stability for as long as possible under the influence of fire. To this end, the sizing for the fire load must be carried out in the case of our building structures using the MSZ EN standard series, which reflects the requirements of the European regulation (Eurocode). In the framework of this article, we describe these sizing principles for the most commonly used reinforced concrete, steel, wood and masonry structures.

Keywords: passive fire protection, fire protection properties of building structures, standard fire effect, measurement for fire load

SZERKEZETI ELEMEK TŰZTESZT MÉRÉSÉNEK ALAPELVEI

Absztrakt

Napjainkban az építmények tűzvédelmének magas színtű biztosítása mind a tervezési és kivitelezési, mind az üzemeltetési időszakban kiemelt jelentőséggel bír. Az épületszerkezetek tűzzel szembeni ellenállóképességének meghatározásakor a tűzhatásra való tervezés több mérnöki szakág szoros együttműködését követeli meg. Az egyik legfontosabb feladat a tűzteherre való tervezés során, hogy az épületeink, építményeink képesek legyenek a tűz hatása alatt minél hosszabb ideig megőrizni állékonyságukat. Ennek érdekében a tűzteherre való méretezést az épületszerkezeteink esetében az Európai szabályozás (Eurocode) követelményeit megjelenítő MSZ EN szabványsorozat alkalmazásával kell elvégezni. Jelen cikk keretében ezen méretezési elveket ismertetjük a leggyakrabban alkalmazott vasbeton, acél, fa illetve falazott szerkezetekre vonatkozóan.

Kulcsszavak: passzív tűzvédelem, épületszerkezetek tűzvédelmi tulajdonságai, szabványos tűzhatás, tűzteherre való méretezés

1. INTRODUCTION

When determining the fire resistance of a building structure, fire design is a priority engineering task, the most important goal of which is to enable our buildings and structures to maintain their stability, integrity and insulating capacity for as long as possible under the influence of fire. In the event of a fire, several questions may arise regarding the load-bearing capacity of load-bearing structures. One of the main issues is sizing for fire effects, the other is the applicability, reinforcability, recoverability and usability of buildings and building materials after a fire. MSZ EN 1990:2011 Eurocode (principles) [1] and MSZ EN 1991-1-2:2005 Eurocode 1: [2] standards, as well as the National Fire Protection Regulation [3] (hereinafter referred to as: NFPR), issued as Decree 54/2014. (XII. 5.) by the Ministry of the Interior, contains general requirements related to sizing for fire loads. It is very important that in the event of a fire, while maintaining their stability, our building structures suffer the least possible damage. The tasks of fire protection can be formulated as follows:

- fire prevention,
- prevention of the spread of fire,
- passive fire protection,
- active fire protection,
- fire fighting and technical rescue.

In the field of fire protection, one of the primary tasks is to select the design of the materials of the building structural elements. If the fire resistance of the structure cannot be ensured only by the choice of material, then additional fire protection is required, which can be the use of fire protection paint, fire retardant, or fire protection coating. In the following, we will only deal with passive fire protection.

The design of fire sections is a very important task of *passive fire protection*, as this fire protection solution can prevent the spread of fire. The fire section is a self-contained unit of fire in the building or outdoor area, separated from adjacent units by fire-preventing structures with specified flammability and fire resistance limits, fire distances specified in the relevant legislation, national standard and the Fire Protection Technical Guideline, or built-in automatic fire extinguishing systems.

We also briefly summarize the principles of active fire protection. Within the framework of active fire protection, automatic fire alarm systems are installed, but extinguishing must be performed by the firefighter, while the use of automatic fire extinguishing equipment, which is also part of active fire protection systems, ensures that small fires are extinguished without fire intervention. Of course, if said active fire protection systems are installed, this can be taken into account in the calculation of the fire load during sizing, but only if this is supported by modeling of a computerized heat and smoke extraction.

In Hungary, the National Fire Protection Regulations contain the basic fire protection framework for the construction of structures. The National Fire Protection Regulations stipulate when active fire protection systems must be used in addition to passive fire protection. The technical solutions ensuring compliance with the NFPR requirements are included in the Fire Protection Technical Guidelines. Among the Fire Protection Technical Guidelines, which currently cover 14 professional fields, fire protection characteristics of building structures are included in Guideline No. 11. Accordingly, Chapter 3.2 of this Fire Protection Technical Guideline defines the classification of building structures into fire protection classes. Requirements for the fire protection class and fire resistance performance of building structures, depending on the relevant risk class and level of the given building, are contained in Annex 2 of the NFPR.

Building structures should be selected during design so that

- building structures retain their load-bearing capacity in the event of fire for the prescribed period,

- in the event of a fire, the building structures, materials and products for fire protection purposes must fulfill their role for the prescribed period of time, retain their function, and react effectively to the presence of fire,
- inhibit, impede or control the spread of fire and its accompanying phenomena in accordance with their function,
- the fire load they cause, the amount of heat, smoke and combustion gases generated from them should be as small as possible [4].

During fire protection, we have different requirements for building structures, each element must have a different function in terms of fire protection, e.g. the column must retain its stability, load-bearing capacity (R), the partition wall must retain its insulating (I) and integrity (E) function.

Building structures can be characterized based on specific properties as follows (here we highlight only the most important ones):

R – load-bearing capacity: the ability of structural elements to withstand the effects of fire for a period of time under specified mechanical stress on one or more sides without any loss of structural stability.

E – integrity: the ability of a building structure to have a separating function when it is resistant to exposure to fire on one side without the fire spreading to the other side due to the passage of flames or hot gases, which could cause inflammation either on an unexposed surface or any material adjacent to the surface.

I – insulation: the ability of a building structure to withstand fire on one side only without significant heat transfer from the exposed surface to the unexposed surface.

W – radiation: the ability of building components to reduce the likelihood of a fire transition in the event of a fire exposure on one side, either through the structure or by reducing significant heat radiation from an unexposed surface to adjacent materials.

M – mechanical effect: the ability of building structures to withstand impact in the event of an impact on that structure due to a structural failure of another component in the fire.

2. EFFECTS TO BE TAKEN INTO ACCOUNT WHEN PLANNING FOR FIRE EFFECTS AND BASIC RULES FOR PERFORMING STRENGTH TESTS

The MSZ EN 1991-1-2:2005 Eurocode 1: standard, which deals in general with the effects on structures exposed to fire within the effects on the supporting structures, formulates an important principle that if the fire resistance requirements are determined with a standard fire effect, indirect effects transmitted from adjacent elements (inhibited deformations, effects due to inhibition of thermal expansion, etc.) need not be taken into account. In contrast, the effects from the temperature gradient within the cell should be taken into consideration. Based on this, simplified methods such as tabular procedures or simplified calculation of stresses can be performed. In such cases, individual components are inspected separately.

In all other cases, particular attention should be paid to the following effects and their consequences:

- inhibited thermal expansion in structural elements (e.g. frame columns);
- unequal temperature change in statically indeterminate structures;
- uneven temperature distribution within the cross-section;
- thermal expansion of adjacent structural elements;
- the effect of thermal expansion of structural elements exposed to fire on the behavior of structural parts outside the fire section.

If a detailed examination is performed by treating the support structure as a complete unit, the indirect effects of temperature cannot be disregarded. The relevant standards provide guidance on the inclusion of values for indirect effects due to fire.

Fire design is considered to be an extraordinary design condition according to the classification of MSZ EN 1991-1-2:2005 Eurocode 1: standard, load combinations must be assembled accordingly.

3. MEASUREMENT METHODES

3.1. Measurement of Concrete Structures for fire

The measurement methods for concrete structures are contained in the MSZ EN 1992-1-2:2013 Eurocode 2: standard [5], according to which the regulation cannot be applied if layered detachment of concrete surfaces occurs and the fire load does not occur according to the standard fire curve.

Here we would like to describe what influences the layered detachment of concrete surfaces. There are two reasons for the delamination of concrete surfaces:

- water vapor from the concrete stretches the surface layers, or
- the zone under load is no longer able to absorb the additional forces due to thermal expansion and is dropped off and detached [6].

The detachment of the surface of high-strength concretes is usually caused by stresses due to the rise in temperature, in the case of normal concretes the water vapor escaping from the concrete usually strains the surface layers. One side of the concrete surface is subjected to a heat load, and the water vapor leaving the concrete results in the formation of a layer saturated with water vapor, where the water vapor pressure increases and stretches the concrete layers.

The chances of layered detachment of the concrete surface are influenced by the following factors:

- external factors: the nature of the fire, the magnitude of external loads acting on the structure;
- geometrical characteristics: geometrical data of the structure, size of the concrete cover, number and location of steel inserts;
- the composition of concrete: size and type of admixture, type of cement and admixture, number of pores, polypropylene fiber dosage, steel fiber reinforcement, moisture content, permeability, and strength of concrete [6].

3.1.1 Tabulated data

In the case of the tabuleted data method, the planned wall, column or beam cross-section is checked on the basis of the fire resistance performance values given in the tables. With this method we can only scale one highlighted structural element, the interaction of the structural elements is not taken into account. Conditions for the application of the tabulated data method according to MSZ EN 1992-1-2:2013 Eurocode 2: are:

- The tables are made for a standard fire curve, they cannot be used for other fire curves.
- For concrete strengths of C55/67 or higher, other tables must be used and the avoidance of layered separation of concrete surfaces must be verified or agreed with a concrete technologist or an experiment must be carried out.

It should be noted here that in order to use the tabular method, we need to know the definition of the axis distance of the rebar, which is different from the definition of the concrete cover.

3.1.2 Zone Method

The essence of the zone method is to divide the cross section into different zones (more than two zones) by means of isothermal lines and to calculate with reduced strength values in the given zones.

One variant of the zone method is the 500 °C isotherm method, the essence of which is to neglect the concrete parts of the cross-section with a temperature higher than 500 °C and to calculate with this reduced concrete cross-section. The maximum temperature of the rebar must be determined and then the strength values of the steel inserts must be reduced according to the maximum temperature formed.

Steps for the control calculation using the 500 °C isotherm method:

- isothermal lines shall be produced if they do not exist for the given cross-section, if they exist, the annex according to MSZ EN 1992-1-2:2013 Eurocode 2: should be used,
- the dimensions of the reduced cross-section at temperatures below 500 °C and the temperature of the reinforcing bars must be determined,
- measurement must be carried out with the modified cross-section and modified steel characteristics,

- based on this the fire resistance duration of the reinforced concrete beam can be determined.

The inspection is carried out in a similar way to the normal temperature calculation, but the following must be taken into account:

- cross-section parts of the concrete cross-section with a temperature higher than 500 °C must be neglected,
- the loss of strength of the tension strands due to high temperatures must be taken into account,
- the reduction in the tension of the tension strands due to the high temperature must be taken into account.

3.1.3 Application of a Finite Element Model

There are two generally accepted methods of finite element modeling in the case of fire:

- thermo-mechanical measurement and
- thermo-hydro-mechanical measurement.

Numerical methods allow engineers to determine temperature effects based on physical and chemical parameters. However, only thermo-hydro-mechanical sizing is suitable for taking into account the material characteristics, thus modeling the layered separation of concrete surfaces.

The isothermal lines of some cross sections are also included in the MSZ EN 1992-1-2:2013 Eurocode 2: standard, however, if we have other cross sections, we have to produce the isothermal lines.

The overheating of a concrete cross section depends on a number of thermodynamic characteristics, several of which are dependent on temperature. In order to obtain a result that reflects reality, these characteristics must be taken into account.

3.2. Measurement of Steel Structures for fire

The mesurement of steel structures for fire is dealt with in the MSZ EN 1993-1-2:2013 Eurocode 3: standard [7]. Accordingly, the standard offers the possibility to test fire-resistant steel structures on three levels, similar to reinforced concrete:

- determination of the load-bearing capacity of steel components exposed to fire on the basis of the critical temperature,
- determination of the load-bearing capacity of steel components exposed to fire on the basis of cross-sectional resistance,
- application of finite element model.

In the case of a test performed at the *level of a structural element:*

- the nominal (usually ISO) fire curve is used as the fire process,
- the effects of uneven temperature changes within the cross-section must be taken into account, but not the effects of uniform transverse and longitudinal temperature changes, nor the stresses arising from them,
- the boundary conditions for the supports can be considered unchanged during the fire,
- simple calculation procedures shall be used for the calculations to verify the fire resistance by testing the load capacity or by analyzing the critical temperature.

In the case of a test performed at the *level of a part of a structure* (e.g. steel main support frame):

- the component test shall take into account the temperature-dependent material properties, the varying stiffness values and any indirect effects due to the change in temperature,
- the boundary conditions at the supports and at the edges can be considered unchanged during the fire,
- simple calculation procedures can be used for the calculations, which can be used to check the fire resistance within the structural part by testing the load-bearing capacity of each structural element or by testing the critical temperature, or advanced calculation models can be applied.

In the case of a test performed at the *level of the whole structure:*

- the structural tests shall take into account the temperature-dependent material properties, the varying stiffness values and all the indirect effects due to the change in temperature, and shall determine the method of destruction by fire,
- calculations can be performed using advanced calculation models.

The methods that can be used in simple tests are described in detail in the indicated standard, and in the case of advanced computational models, the conditions and rules of application are defined by the same standard. Methods that allow a full structure to be studied require finite element models and advanced numerical methods that take several temporal variations into account.

3.2.1. Determination of the load-bearing capacity of steel components exposed to fire on the basis of critical temperature

This simplest method can be used only if no loss of stability or deformation limit state can occur in the tested element and the temperature distribution is uniform in the cross section. Accordingly, it can only be used on drawn elements or laterally supported beams where no bending can occur. The critical temperature θ_{cr} of a structural element is the temperature at which the failure of the structural element occurs under a given load.

3.2.2. Determination of load-bearing capacity of steel components exposed to fire on the basis of cross-sectional resistance

After t time due to fire, the load-bearing capacity of steel structural elements heated to Θ_a can be calculated from the strength determined at normal temperature by reducing the yield strength of the raw material by a factor $k_{y,\Theta}$ and the partial safety factor is set to 1.0.

Within the cross-section, a distinction must be made between unequal and uniform temperature distribution during the calculation, the course and details of which are given in the indicated standard. The standard indicates in the index whether the temperature distribution is uniform within the tested section. If so, the resistance is given an index Θ (i.e. temperature-dependent), and if the individual cross-sections are not necessarily at the same temperature, then t is denoted (i.e. time-dependent).

3.2.3 Application of a finite element model

In the case of steel structures, of the already mentioned thermo-mechanical and thermo-hydro-mechanical measurement, only thermo-mechanical measurement can be considered, since the steel structure is not porous and therefore does not contain water.

3.3. Measurement of Wooden Structures for fire

The MSZ EN 1995-1-2:2013 Eurocode 5: standard [8] recommends the following methods for the sizing of wooden structures for fire effects:

- reduced cross-sectional method,
- method of reduced material properties,
- sizing of protected wooden structures.

3.3.1 Method of Reduced Cross Sections

The thickness of the charred layer formed on the wood structure as a result of the effect of the fire also includes the zone of thermal decomposition, so that in fact the part outside the intact cross section is determined. The thickness of the charred layer and thus the rate of charring were measured experimentally by removing the charred layer after the fire test. The specified standard nominally specifies the 300 °C isotherm as the carbonization depth, adapted to the temperature of the thermal decomposition zone.

The rate of charring depends, among many other parameters, mainly on the type of wood, the compactness of the wood and the geometrical conditions of the cross section.

On a flat surface in case of one-sided (one-dimensional) fire effect - e.g. edge boards, plywood, OSB - the carbonization depth and the carbonization rate can be well measured and defined.

In the case of multi-sided fire, which typically affects bar structures, there is a multidimensional heat flow and increased charring around the flat surfaces near the intersecting edges. This phenomenon can be taken into account by rounding the charring front, which was still applicable under the previous pre-standard, but complicates engineering calculations unnecessarily in practice.

Another possibility is to record a substitution, i.e. a nominal charring front parallel to the planes delimiting the cross section, and to determine the charring depth or velocity.

The burning rate of sawn wood beams or columns is higher compared to a laminated-glued wood of the same cross-section due to drying cracks.

In an extraordinary design situation - such as a fire effect - Eurocode requires a reduced level of safety, similar to the concept of the previous Hungarian standard. In the case of wood, it allows design for a 20% quantile of strength. The quotient of the 20% quantile and the 5%

quantile (characteristic value) is shown by the factor k_{fi}, the values of which can be taken into account for different woods according to the relevant standard.

The method of reduced cross-sections is a simple design method, it is used in the vast majority of engineering practice, and the annex to the MSZ EN 1995-1-2:2013 Eurocode 5: standard also recommends its application. Depending on the geometry, unilateral or multi-sided charred cortex is disregarded and the solidity of the transitional, nominally 7 mm thick zone under the thermal decomposition front is considered to be zero as well.

The low-temperature part of the intact wood cross-section (ideal cross-section) can be taken into account with a strength value of 20 ºC [5].

3.3.2 Method of Reduced Material Properties

The method of reduced material properties is more labor intensive but more accurate than the previous one. In engineering practice, it is typically used to verify slender wooden cross-sections, e.g. plank-thick elements of nailed wood beams. The charred outer crust is not taken into consideration for load-bearing capacity, but the transitional zone of about 7 mm below the thermal decomposition front is.

The transition zone is located at the edge of the residual cross-section, at the location of the expected maximum normal stresses, so the total remaining wood cross-section can be considered with reduced strength and stiffness characteristics corresponding to the higher temperature of the transition zone.

The higher temperature of the transition zone is a concept that is difficult to grasp from an engineering point of view, so its effect is described by an indirect measure of compactness characteristic of warming, depending on the perimeter and area of the intact cross section.

Calculation procedures that take into account the charring (burning) of unprotected wood can usually only justify limited fire resistance limits (typically 30, possibly 60 minutes). One way to achieve higher fire resistance limits is to clad the wood with fire protection building boards, e.g. covering it with refractory gypsum plasterboard or treating it with fire-retardant paint. However, the fire-resistance enhancing effect of paints on wood cannot be taken into account in the calculations of the relevant standard. [5]

3.3.3 Measurement of Protected Wooden Structures

In the case of timber structures with a fireproof covering, the fire resistance limit of the covering can be taken into account in the calculation, as follows:

- charring is shifted by t_{ch} time,
- charring may begin before the failure of the refractory casing, but at a reduced rate,
- after the failure of the refractory casing (t_f), the rate of charring shall be assumed to be twice the time until t_a,
- after the time t_a is equal to the depth of charring without the cover or 25 millimeters.

When using two layers of type A or H gypsum board, the thickness of the inner layer can be taken into account by 50% for the replacement thickness. When installing two layers of F-type gypsum board, 80% of the thickness of the inner layer can be taken into account for the replacement thickness. There are three possible ways to destroy a fire enclosure:

- charring or mechanical degradation of the casing material,
- inadequate penetration depth of the cover fastening components,
- inadequate distribution and distance between the components fixing the cover. [5]

3.4. Measurement of Masonry Structures for fire

The MSZ EN 1996-1-2:2013 Eurocode 6: standard [9] recommends the following methods for the fire sizing of masonry structures:

- tabulated data method,
- zone method.

3.4.1 Tabulated Data

When comparing with tabulated data or limits, the presence of a minimum wall thickness is checked after the masonry structure has been classified. The presence of a minimum wall thickness is intended to ensure load-bearing capacity (R), integrity (E), insulation (I) and resistance to mechanical impact (M). The required minimum wall thickness is determined by the combination of the masonry material, the strength and the quality of the mortar.

Mortar is a mixture of one or more inorganic binders, additives, water, or possibly additives, as defined in the relevant standard.

Fire resistance sizing can be carried out based on Table 1.2 of the MSZ EN 1996-1-2: 2013 Eurocode 6: standard. The value pairs without parentheses given in the table give the minimum wall thickness without plaster, where the first number is the brick thickness and the second number is the wall thickness together with the mortar. The first number of the value pair in parentheses indicates the minimum thickness of the walls with fire protection covering, while the second number indicates the minimum thickness of the walls with plaster.

Step 1: Find the appropriate table of the indicated standard based on the brick class, density, masonry compressive strength and utilization. This also includes meeting the requirements for load bearing, integrity, insulation and mechanical resistance.

Step 2: Select the fire resistance period based on the wall thickness.

3.4.2 Zone Method

In the zone method, the brick wall is divided into 3 zones. The innermost zone is defined by the total strength value, the middle zone by the reduced strength values and by neglecting the outer side affected by the fire, the load-bearing ability of the cross-section is determined.

In the application of the zone method, after determining the location of the isothermal lines, the cross-section is divided into sections, the strength and stiffness characteristics are determined and the sizing is performed with these data.

4. SUMMARY

The fire design of structures has a key role in ensuring the fire resistance of building structures. We have seen that the purpose of planning for a fire effect, which is considered to be an extraordinary design condition, is to keep our buildings and structures as stable as possible during the heat load caused by fires. Based on the sizing principles presented for reinforced concrete, steel, wood and masonry structures in the framework of this article, it can be concluded that depending on the function of fire-exposed building structures, different parameters such as load-bearing capacity, integrity and insulation must be met. It can be stated that there are approximate calculation methods for the different structural elements, which, of course, have to comply with the strict boundary conditions specified in the relevant standards. If the boundary conditions are not met, we can use more accurate calculation models or perform finite element modeling of the structure.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Zsuzsanna Kerekes, Gyula Vass, János Bleszity, János Szép, Zsófia Tóth-Pataki, Ágoston Restás

EFFECT OF THICKNESS OF POLYSTYRENE INSULATION AGAINST RADIANT HEAT

Abstract

Thermal insulation of buildings is not only important to the owners, but also mandatory due to legal requirements. Energy certificates are also a part of these. For correspondence various thermal insulation materials are used. The authors selected two common and cheap insulating materials for the test, such as polystyrene EPS and XPS types. These are commercially available in different thicknesses. The objective of the article is to examine what thickness can be considered optimal, above which the already increased costs should be taken into account. During our research, we exposed the materials to radiant heat. The authors measured the temperature evolution of the interior of the samples after a heat load of around 100 C. The measurement results showed that above 5 cm thickness a steady state is already established, so the temperature rise stops at a constant value. From the fire protection point of view, it is important to know the thermal properties of insulating materials, as the ignition process is always preceded by warming.

Keywords: polystyrene insulation, radiant heat, test, specimen

POLISZTIROL SZIGETELŐK VASTAGSÁGÁNAK HATÁSOSSÁGA SUGÁRZŐ HŐVEL SZEMBEN

Absztrakt

Épületek hőszigetelése már nemcsak az építtetőnek fontos, hanem a jogszabályi előírások miatt kötelező is. Ezt a célt szolgálják az energia tanúsítványok. Ennek a megfelelésére legkülönbözőbb hőszigetelő anyagokat használnak. A mi vizsgálatunkban két gyakori és legolcsóbb szigetelő anyagot választottunk ki az a polisztirol EPS és XPS típusokat. Kereskedelemben különböző vastagságokban lehet kapni. Vizsgálatunk célja, hogy megvizsgáljuk milyen vastagság tekinthető optimálisnak, ami felett már a megnövekedett költségek számítanak. Jelen munkánkban a hőszigetelés a fő vizsgálat és nem a tűzzel szembeni viselkedés, így az anyagokat sugárzó hőnek tettük ki. A minták egyik oldalát 100 C körüli hőterhelés érte és mértük a minták belsejének hőmérséklet alakulását. A mérési eredmények azt mutatták, hogy 5 cm vastagság felett már beáll egy stacionárius állapot, azaz a hőmérsékletemelkedés leáll és beáll egy állandó értékre. Fontos megjegyezni, hogy tűzvédelmi szemponttól is fontos a szigetelő anyagok termikus tulajdonságaik megismerése, mert a gyulladási folyamatot mindig felmelegedés előzi meg.

Kulcsszavak: polisztirol szigetelők, hősugárzás, mérés, minta

1. INTRODUCTION

It is important to know the thermal properties of insulating materials, as the ignition process is always preceded by warming [1] [2] [3]. Thermal insulation of buildings is not only important to the owners, but also mandatory due to legal requirements. Energy certificates serve this purpose. The first legislation in connection with energy was published in 2006 in Hungary. It was followed by a government decree in 2009 that already regulates when the Energy Certificate is mandatory. Over the years, the number of those who are required to certify has steadily extended. From the 1st of January 2016, the preparation of the certificate is obligatory when selling and renting the buildings (flat, independent unit). Naturally, energy is secondary viewpoint after the safety of life in case of buildings [4].

The first Hungarian standards were issued in 1980 under the name "Fire resistance tests". Its sub-standards include for example ‘Non-combustibility testing of building materials’, ‘Testing the spread of fire on the facade of a building’, ’ Determination of the ignition temperature of solids ’ [5]. It is not mandatory in case of building materials, but in the opinion of the authors, the behaviour of the materials against radiant heat plays an important role. They would like to prove in this in their study [6].

Sustainability benefits associated with EPS are:

- EPS manufacturing does not involve the use of ozone-layer-depleting CFCs and HCFCs
- No residual solid waste is generated during its manufacturing
- It aids energy savings as it is an effecting thermal insulation material which helps reduced CO_2 emissions
- EPS is recyclable at many stages of its life cycle

2. SPECIMENS

EPS is widely used in building and construction industry thanks to its insulation properties, chemical inertness, bacterial & pest resistance, etc. Its closed cell structure allows only little water absorption. It is durable, strong and can be used as insulated panel systems for facades, walls, roofs and floors in buildings, as flotation material in the construction of marinas and pontoons and as a lightweight fill in road and railway construction [7] [8].

We selected two common and cheap insulating materials for the test, such as polystyrene EPS and XPS types [9] [10].

2.1. Extruded Polystyrene vs. Expanded Polystyrene

XPS is often confused with EPS. **EPS (expanded)** and **XPS (extruded)** are both closed-cell rigid insulation made from the same base polystyrene resins. However, difference lies in their manufacturing process [11].

Table 1 – Expanded polystyrene (EPS) and extruded polystyrene (XPS). Created by the Authors.

Expanded Polystyrene (EPS)	Extruded Polystyrene (XPS)
• EPS is manufactured by expanding spherical beads in a mould, using heat and pressure to fuse the beads together. While each individual bead is a closed cell environment, there are significant open spaces between each bead • EPS beads are moulded in large blocks that are subsequently cut by hot-wire machines into sheets or any special shape or form by computer-driven systems • EPS's blowing agent leaves the beads rather quickly creating thousands of tiny cells full of air • EPS absorbs more water than XPS resulting in reduced performance and lost insulation power (R-value)	• XPS is manufactured in a continuous extrusion process that produces a homogeneous "closed cell" matrix with each cell fully enclosed by polystyrene walls • XPS is "extruded" into sheets. Polystyrene is mixed with additives and a blowing agent – which is then melted together through a dye • XPS's blowing agent stays embedded in the material for years • XPS is often selected over EPS for wetter environments that require a higher water vapour diffusion resistance value • The compressive strength of XPS is greater than that of EPS

EPS has very low thermal conductivity due to its closed cell structure consisting of 98% air. This air trapped within the cells is a very poor heat conductor and hence provide the foam with its excellent thermal insulation properties. The thermal conductivity of expanded polystyrene foam of density 20 kg/m^3 is 0.035 – 0.037 W/ (m·K) at 10 °C. Fire Resistance – EPS is flammable. Modification with flame retardants significantly minimize the ignitability of the foam and the spread of flames [12] [13] [14].

The tests were performed on EPS80, EPS100, Graphite, Flame Retardant Graphite, XPS, XPS expert materials.

3. TEST METHOD

The test is based on ISO 6941, 2nd Edition, 2003 - Textile fabrics Burning behaviour Measurement of flame spread properties of vertically oriented specimens and EN 13 772: EN13772: Textile and textile products-burning behaviour curtains and drapes measurement of flame spread of vertically oriented specimens with large ignition source.

A flame is applied to a vertically oriented test fabric to determine the burning behaviour. The test specimen is placed in a vertical metal frame. A propane gas flame is applied to the test sample. The test is pursued according to a predefined scheme. A heat source with defined energy is applied to the back of a vertical specimen. After exposure a small flame is applied to a piece of cotton fabric wrapped around the bottom of the specimen. Flame spread is measured by determining the time taken to reach reference points on the specimen.

The test device, layout, this was done according to the standard.

There was a difference in sample size. Size of our sample: 10 x 10 cm, thickness:15-25 cm

The duration of the study was 10 and 12 minutes.

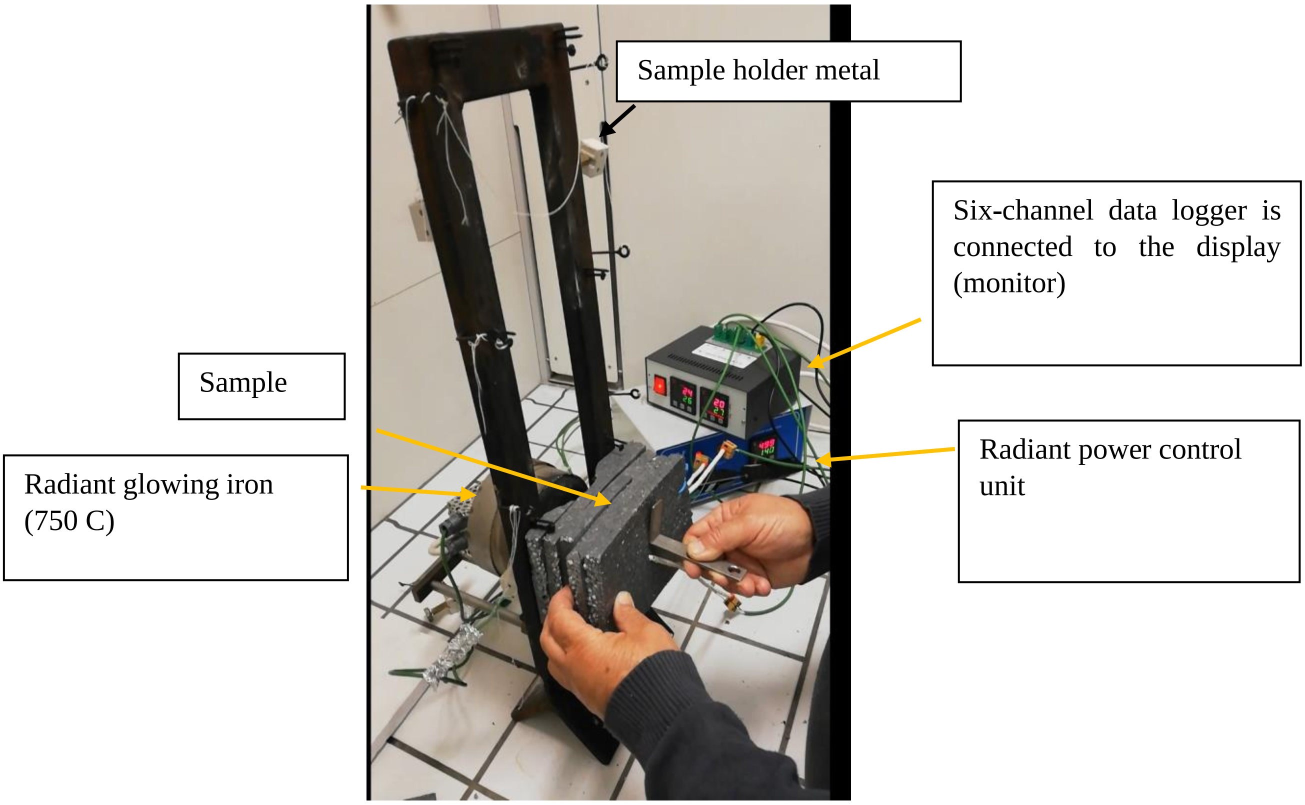


Figure1 - Radiant power control unit. Source: Authors.

The size of the test specimens is 10 x 10 cm, ranging in thickness from 15 cm to 25 cm. Thermo elements are inserted into the specimens in every 3 centimetres. The specimens are pre-drilled so that the thermo element sticks can be inserted. The thermocouple continuously measures the temperature of the surface.

The setting of the electric heater varies between 500-600 °C. However, during pre-measurements, it was determined that its positioning from the frame changes the amount of heat radiation reaching the samples from the heat dissipation surface. Due to the thermal insulating effect of the room temperature, removing 1 cm from the emitter results in a 100 °C temperature decrease on the surface of the sample.

Data recording:

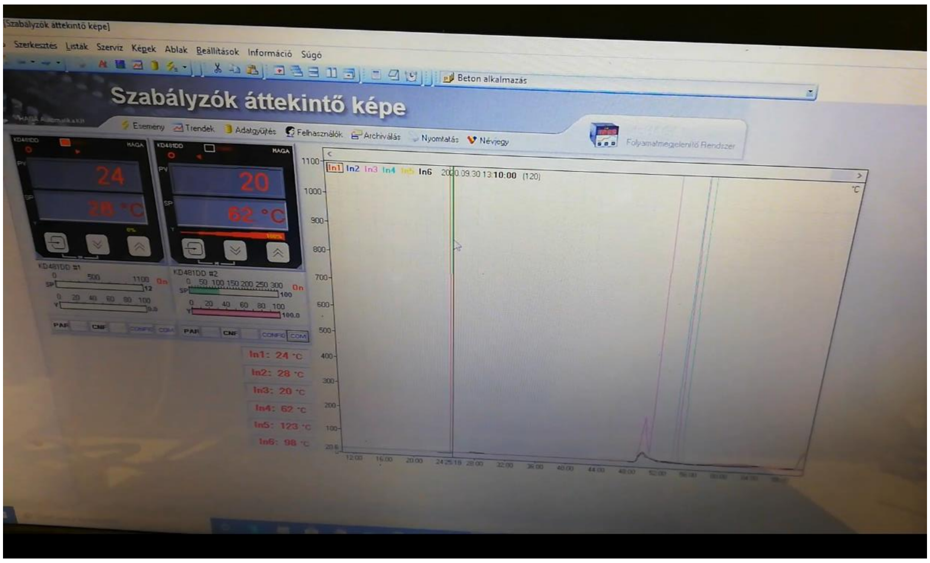


Figure 2 - Radiant heat testing – Operation of the recording program. Source: Authors.

Figure 3 - Thermo elements in the specimen. Source: Authors.

4. TEST RESULTS

The temperature of the specimens is 100°C. During the test, thermocouple 1 was placed 3 cm , thermocouple 2 to 6 cm, thermocouple 3 to 9 cm, thermocouple 4 to 12 cm, thermocouple 5 to 15 cm and thermocouple 6 to 18 cm inwards from the surface. In case of all samples, the temperature of the surface increased in all cases due to exothermic processes. It heated to a temperature higher than the heat reached the surface, so that exothermic processes were started in all specimens under the influence of heat. The extent of this depends on the type of examined material. The smallest temperature rise was observed in case of white EPS 80 and 100, while the largest temperature rise was observed for XPS products. Here the heat could reach an excess temperature of + 43 °C. All in all a surface temperature increase can be observed in all cases. The interior of the specimens shrinks in all cases. We cannot talk about combustion, because the loss of matter (as it will be seen) is related to a minimum mass.

In case of the examinations, after 12 cm of thickness, the temperature change could no longer be measured with a thermocouple.

Table 2 - Radiant heat test - Data in case of uncoated specimens

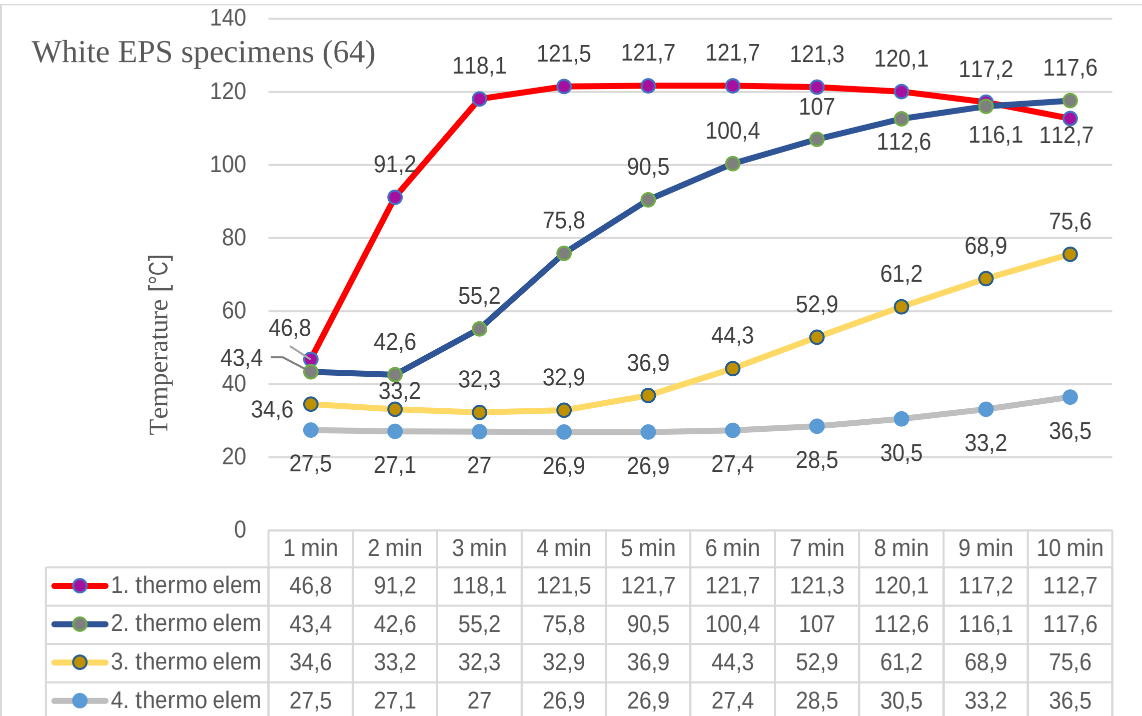
Examination of the of uncoated specimens												
Basic data										Results		
Date	No.	Type	Type	Width [mm]	Length [mm]	Thickness [mm]	Volume [cm3]	Weight [g]	Density [g/cm3]	Max. temp.	Weight after test [g]	Weight loss [g]
2020.10.20	71	bevonat nélküli	XPS TOP 30	100	100	140	1400	46,09	0,033	139	45,79	0,3
2020.10.27	72	bevonat nélküli	XPS TOP 31	100	100	140	1400	46,19	0,033	142	45,86	0,33
2020.11.10	27	bevonat nélküli	XPS GF	99	90	99	882,09	28,69	0,033	143	28,21	0,48
2020.11.10	67	bevonat nélküli	Expert fix	100	100	100	1000,00	28,14	0,028	138	27,74	0,4
2020.11.10	70	bevonat nélküli	XPS TOP-P	100	100	120	1200	37,87	0,032	139	37,64	0,23
2020.11.10	29	bevonat nélküli	XPS GF	98	88	120	1034,88	32,62	0,032	144	32,15	0,47
2020.11.10	30	bevonat nélküli	XPS GF	99	89	149	1312,84	41,87	0,032	138	41,37	0,5
2020.10.20	64	bevonat nélküli	AT-H80	100	100	150	1500	24,29	0,016	123	24,03	0,26
2020.10.27	63	bevonat nélküli	AT-H80	100	100	150	1500	24,98	0,017	113	24,72	0,26
2020.10.27	65	bevonat nélküli	AT-H80	100	100	200	2000	30,05	0,015	114	29,81	0,24
2020.10.27	74	bevonat nélküli	AT-H80	100	100	120	1200	18,22	0,015	122	18,08	0,14
2020.11.10	5	bevonat nélküli	JC-80	100	98	100	980	14,57	0,015	126	14,48	0,09
2020.11.10	7	bevonat nélküli	JC-80	101	99	120	1199,88	17,56	0,015	128	17,43	0,13
2020.11.10	20	bevonat nélküli	EPS	100	99	100	990	17,16	0,017	140	16,98	0,18
2020.10.20	58	bevonat nélküli	GRAFIT REFL	100	100	140	1400	21,11	0,015	136	20,92	0,19
2020.10.27	55	bevonat nélküli	GRAFIT REFL	100	100	160	1600	25,27	0,016	120	25,07	0,2
2020.10.27	57	bevonat nélküli	GRAFIT REFL	100	100	140	1400	21,89	0,016	122	21,8	0,09
2020.10.27	60	bevonat nélküli	GRAFIT REFL	100	100	100	1000	16,23	0,016	115	16,09	0,14
2020.10.27	62	bevonat nélküli	GRAFIT 80	100	100	140	1400	21,74	0,016	115	21,56	0,18
2020.10.27	73	bevonat nélküli	GRAFIT 80	100	100	80	800	12,52	0,016	114	12,45	0,07
2020.11.10	1	bevonat nélküli	Grafit	71	100	100	710	16,86	0,024	135	16,75	0,11

Now we compare the changes in the heat radiation of the samples in time under the influence of heat. For simpler understanding, we examine the white EPS graphite and the XPS materials separately. Below we can see the development of internal temperatures over time. The colour of the lines indicates the location of each thermocouple in the thickness of the specimen.

4.1. White EPS specimens

In case of white EPS specimens it can be observed that in 7-8 minutes each thermocouple which is 3 cm from the surface already shows a decrease in temperature. This was established after the test because there was no material in the vicinity of the measuring element and the temperature produced inside could only leave in advance by touching this thermocouple. As the rate of internal heat production decreased, a decrease in temperature was observed in case of the thermocouple 1.

In contrast, because the material started to react at thermocouple 2, the increased suddenly in the second period of the test. Furthermore, it can be observed in half of the examined cases that, based on the test data in case of thermocouple 2, the increase in the inner temperature in the interior enclosed from 3 sides at **6 cm depth gives the maximum inner temperature value**.



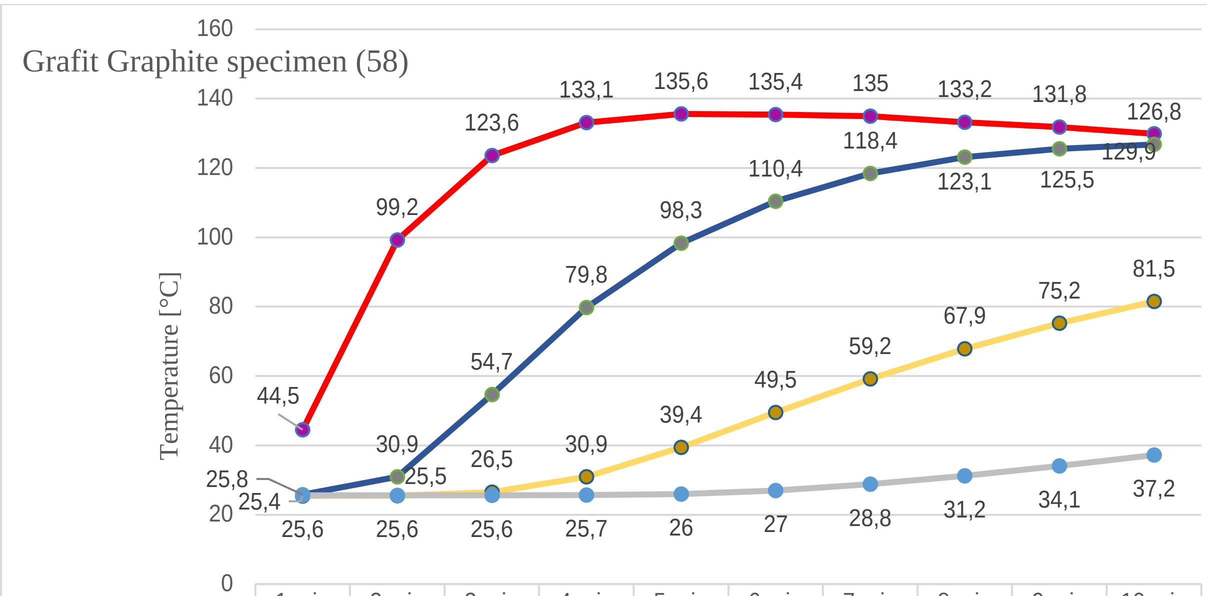
	1 min	2 min	3 min	4 min	5 min	6 min	7 min	8 min	9 min	10 min
1. thermo elem	46,8	91,2	118,1	121,5	121,7	121,7	121,3	120,1	117,2	112,7
2. thermo elem	43,4	42,6	55,2	75,8	90,5	100,4	107	112,6	116,1	117,6
3. thermo elem	34,6	33,2	32,3	32,9	36,9	44,3	52,9	61,2	68,9	75,6
4. thermo elem	27,5	27,1	27	26,9	26,9	27,4	28,5	30,5	33,2	36,5

Figure 4 - White EPS specimens on graphs. Created by the Authors.

4.2. Examination of the graphite specimens

In case of graphite specimens, it can also have observed that the values measured at thermocouple 2 exceed the values measured at element 1. However, it cannot be stated from the amount of the test that this is a feature of a particular product. However, in case of graphite material treated with a flame retardant, it can be stated that the maximum value could be measured at thermocouple 1. In contrast, for the other test specimens (except specimen 1), the maximum value was measured at thermocouple 2 (see Figure 5).

The lowest temperature was basically at the smooth graphite specimens. During the test, it can be observed that the change of the inner temperature is more intense than the graphite material. This means that it reaches the higher temperatures earlier in time than the flame retardant materials.



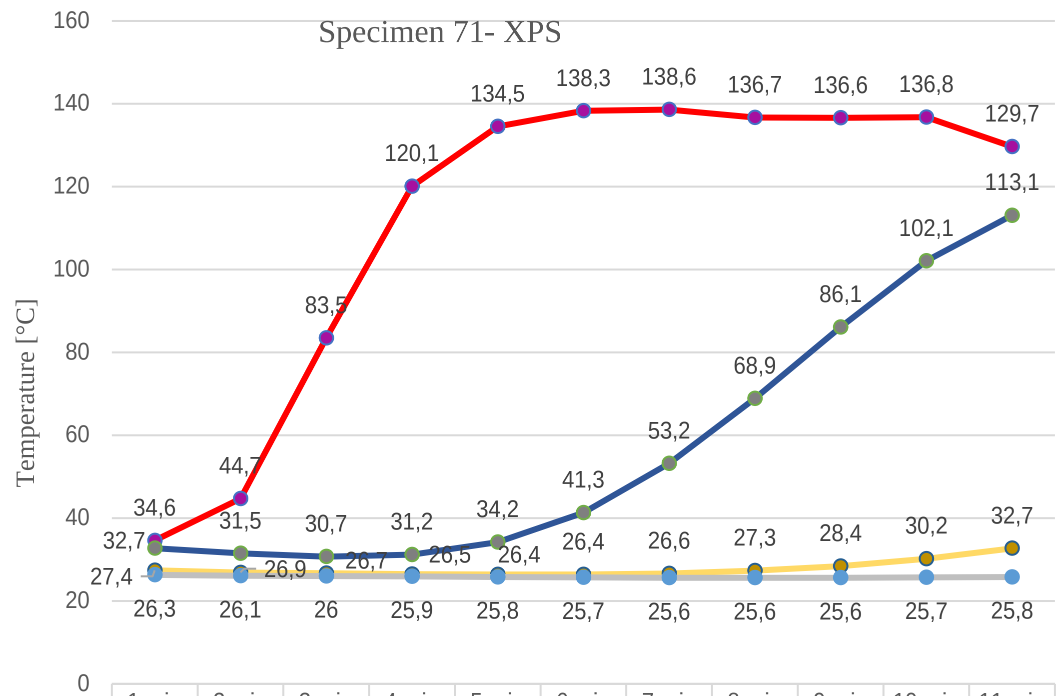
	1 min	2 min	3 min	4 min	5 min	6 min	7 min	8 min	9 min	10 min
1. thermo elem	44,5	99,2	123,6	133,1	135,6	135,4	135	133,2	131,8	129,9
2. thermo elem	25,8	30,9	54,7	79,8	98,3	110,4	118,4	123,1	125,5	126,8
3. thermo elem	25,4	25,5	26,5	30,9	39,4	49,5	59,2	67,9	75,2	81,5
4. thermo elem	25,6	25,6	25,6	25,7	26	27	28,8	31,2	34,1	37,2

Figure 5 - EPS graphite specimens. Created by the Authors.

4.3. Examination of XPS specimens

In case of XPS-based samples, it can generally be stated that they have a much better insulating ability. This conclusion can be based on the measurements of thermocouple 2 placed at a thickness of 6 cm. In case of thermocouple 1, a quicker temperature rise can be observed, and in each case the maximum inner temperature can also be measured here. However, a very slow temperature change can observed at thermocouple 2, so we should extend the test time to 10 minutes.

The temperature rise at thermocouple 2: The curve can be described by a polynomial equation in each case.



	1 min	2 min	3 min	4 min	5 min	6 min	7 min	8 min	9 min	10 min	11 min
1. thermo elem	34,6	44,7	83,5	120,1	134,5	138,3	138,6	136,7	136,6	136,8	129,7
2. thermo elem	32,7	31,5	30,7	31,2	34,2	41,3	53,2	68,9	86,1	102,1	113,1
3. thermo elem	27,4	26,9	26,7	26,5	26,4	26,4	26,6	27,3	28,4	30,2	32,7
4. thermo elem	26,3	26,1	26	25,9	25,8	25,7	25,6	25,6	25,6	25,7	25,8

Figure 6 - XPS specimens. Created by the Authors

5. SUMMARY

The 3 different types of thermal insulation are compared below. Among the specimens examined above, we highlighted the number 65 for white EPS, number 57 for graphite, and number 72 for XPS specimens (see Table 2). It can be observed that the more heat additives are added to the material, the more intense is the surface heating.

In the first two minutes, because of the first heat, the white EPS without additive reacts worse. However, as the time progresses, chemical reactions affecting the additive begin, which turns to exothermic processes, thus starting to produce of the heat generation. As a result of it, the generated heat will continue to be added as a catalyst to the processes.

As can be seen from the thermal insulation capacity of the inner layers, it is strongly related to the additives and the density of the materials. Much slower heating is observed in case of graphitic and XPS materials.

Examining the thermal insulation materials without a coating, it can be concluded that XPS-materials perform best under short-term radiant heat at 100 °C. The measurements explicitly support the need for radiant heat testing. This is only true for thermoplastic PS materials, a PUR foam or rock wool will definitely perform better.

Combined with the diversity of the materials sold, the differences arising from the production technology, the variety of different application areas and coating systems, completely new properties appear.

When non-flammability, fire propagation limit, chemical composition, tensile strength, thermal conductivity value are given in the qualification, heat radiation properties are not. Heat resistance is also important, because a possible fire next to the facade wall can cause invisible damage inside the insulation in just a few minutes. Laboratory experiments also prove that within a few minutes, significant deformation can occur inside the insulations. In case of external fire it is not only dangerous that deformations may generate inside the insulation, but also that it ignites and spreads to the rest of the façade.

Overall, fire prevention is an important area of the research, which includes not only outdoor fires [15] [16] [17] but also building fires.

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THE ROLE OF FIRE PROTECTION TECHNICAL GUIDELINE IN THE PROTECTION AGAINST HEAT AND SMOKE SPREAD

Abstract

During the procedures of fire protection authorities and professional authorities, always brought to the fore the question of how and with what solution the level of safety required by law can be implemented. From 5 March 2015, there are more emphasis on the various engineering methods that help the engineering thinking and the development of design. As a result of this, the proven solutions that have been implemented and occurred several times are soon appear in the relevant Fire Protection Technical Guidelines, which support the work of designers and representatives of the authority, speed up and simplify official and professional procedures. The authors briefly, through the presentation of Protection against heat and smoke spread Fire Protection Technical Guidelines, show the numerous topics, where various technical solutions, different calculations, or conditions of particular implementations has been worked out. This proves that such a detailed elaboration of fire protection solutions, their appearance in a unified structure would not have been realized, if the system of Fire Protection Technical Guidelines had not been established.

Keywords: TvMI, engineering methods, solutions, Fire Protection Technical Guideline

TŰZVÉDELMI MŰSZAKI IRÁNYELV SZEREPE A HŐ ÉS FÜST ELLENI VÉDELEMBEN

Absztrakt

A tűzvédelmi hatósági és szakhatósági eljárások során mindig előtérbe kerül az a kérdés, hogy hogyan, milyen megoldással valósítható meg, teljesíthető a jogszabály által előírt biztonsági szint. 2015. március 5-től nagyobb hangsúlyt kapnak a különböző mérnöki módszerek, amelyek segítik a mérnöki gondolkodást, a tervezés fejlődését. Ennek köszönhetően megvalósított és többször előfordult, bevált megoldások kis idő múlva megjelennek a vonatkozó Tűzvédelmi Műszaki Irányelvekben, amelyek támogatják a tervezők és a hatóság képviselőinek a munkáját, gyorsítják, egyszerűsítik a hatósági és szakhatósági eljárásokat. A szerzők röviden, a Hő és Füst elleni védelem Tűzvédelmi Műszaki Irányelven keresztül mutatják be, hogy milyen sokrétű témában vannak már kidolgozva műszaki megoldások, különböző számítások, vagy az egyes megvalósítások feltételei. Bizonyítva azt, hogy a tűzvédelmi megoldások ilyen részletes kidolgozása, egységes szerkezetben történő megjelenése nem valósult volna meg, ha nem jön létre a Tűzvédelmi Műszaki Irányelv rendszere.

Kulcsszavak: TvMI, mérnöki módszerek, megoldások, Tűzvédelmi Műszaki Irányelv

1. INTRODUCTION

On the 5th of March 2015, a new time began for fire professionals in the field of fire protection. On this day the amendment of the National Fire Regulations (hereinafter referred to as OTSZ) came into force, which was prepared on the basis of new aspects and expectations. The essence of the new structure is that the required safety level is included in the OTSZ, while its fulfilment is given by a national standard called Fire Protection Technical Guideline (hereinafter: TvMI) [1] [2]. It can be achieved with the technical solutions, calculation methods included in the TVMI or with the use of different solutions certified by the designer. A great advantage of this type of regulation is that the solutions are more understandable, they are more detailed, and they can appear in the guidelines soon at the same time as the technical progress. Their use is voluntary, other solutions can be used, which provides freedom for the designers. The Technical Commission for Fire Protection (hereinafter: the Commission) supervises the development and extension of the TvMIs. The task of it is to monitor the directions of the technical progresses, to analyse the Hungarian and international experiences in connection with the fire protection and, if necessary - but at least annually - to review the TvMIs and their content, and to amend them if it is necessary. The chairman of the Commission is the Chief Inspector of National

Directorate General for Disaster Management of the Ministry of the Interior (hereinafter: BM OKF). Its members are representatives delegated by 11 external organizations.

Another amendment of the OTSZ was published in 2019, which gave to the Commission and to the TvMI working groups a major task. All so far completed TvMIs had to be reviewed and modified in accordance with the changes in the OTSZ. In addition, two new directives had to be developed. Currently, 14 TvMIs have been developed, which can be downloaded free of charge from the website of BM OKF [2].

Most of the designers and experts use the solutions according to the TvMIs. The reason for this is that these solutions have already been proven and meet the level of requirements included in the OTSZ.

By describing some of the solutions of the TvMI, we would like to show how detailed some solutions are and at the same time to prove that their absence would incompletely affect fire protection planning.

2. ESTABLISHMENT AND CONVERSION OF HEAT AND SMOKE EXTRACTION SYSTEM

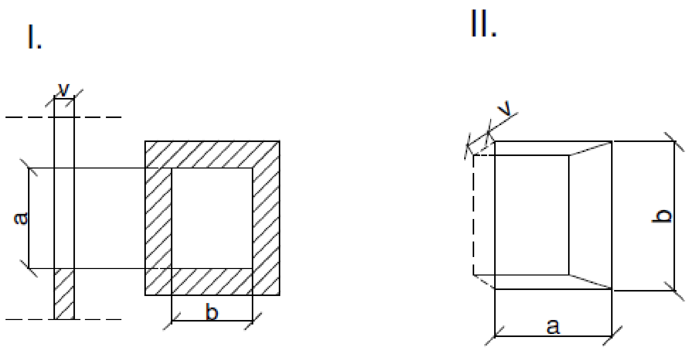
A few years ago, it was a common problem to find solutions for heat and smoke extraction in case of buildings. It is basic that during the installation of the natural heat and smoke extraction system in the new constructions, in addition to the requirements of the OTSZ, the provisions of the MSZ 12101 series of standards must also be observed. In such cases, systems tested as complete structures can be considered. On the other hand, in the existing building, we distinguish the designs based on the scope and extent of the transformation. In case of conversion, it is necessary to install a new heat and smoke extraction structure (for example a new escape route is formed and there are no windows and doors in the given area), then the systems examined as complete structures mentioned above can be developed [3].

In case an existing door and window is used for heat and smoke extraction or air replacement, the normative values included in the TvMI can also be taken into account. However, the actuator must be tested. In the case of the replacement of doors and windows in monument buildings, the manufactured door and window meets the requirements of the OTSZ for heat resistance. It can be placed in the existing opening and can also be used as a heat and smoke extractor with the tested actuator. If the normative values included in the TvMI are chosen, then the effective permeable surface is adequate. In case of converting an existing heat and smoke extraction structure, if the structure was manufactured before 2006, the solutions certified by the manufacturer can be used. Modifications to heat and smoke extraction structures manufactured after 2006 can only be carried out with a separate certification. The OTSZ amendment, (in force from 22 January 2020) not only allows the design of a heat and smoke extraction structure, but also let a permanently opened free opening designed for this purpose [2].

In this regard, the legislator had to record in the TvMI the design of the permanent opening that meets the expectations of the OTSZ [3] [4].

The following free openings can be considered as a heat and smoke extraction or air replacement surface (Figure 1):

a) which is perpendicular to the direction of flow and its smallest extension is larger than the direction of flow (at the thickness of the wall at the opening)
b) the size (length) of the opening in the direction of flow does not exceed 1 metre
c) whose size at the opening (in the case of an opening of less than 2 m^2) is not more than 1: 4, and
d) where the cross-section of the opening is not less than 0.5 m^2.



b > v	a > v
v ≤ 1 m	v ≤ 1 m
In case of opening sizes less than 2 m^2: b/a > 1/4, vagy a/b < 4	a/b > 1/4, or b/a < 4
a*b ≥ 0,5 m^2	a*b ≥ 0,5 m^2

Figure 1 - Development of free opening. Created by the Author.

It was important to mention that not all openings are responsible for the efficient extraction of heat and smoke. For this reason, a surface minimum, a depth maximum, and the aspect ratio to be observed have been determined. The values above were derived from the practical experience of the designers. From this it can be stated how important the knowledge and experience of the professionals are, which are the basis of the solutions included in many TvMIs [5] [6].

3. RELATIONSHIP BETWEEN HEAT AND SMOKE EXTRACTION AND EXTINGUISHING EQUIPMENT

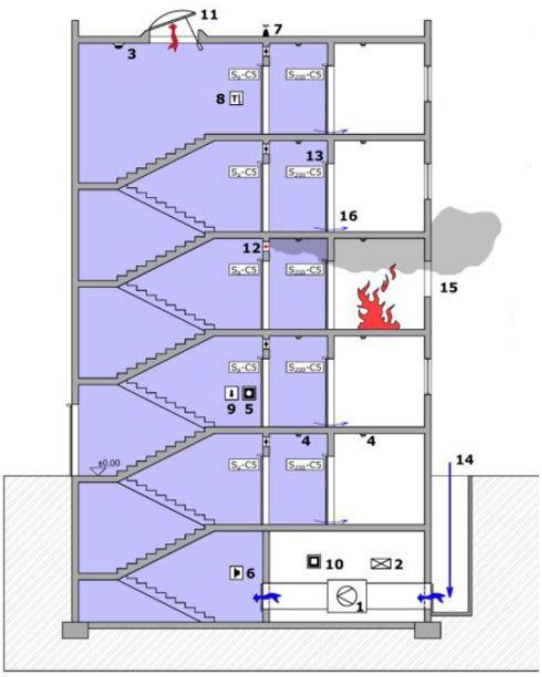
It is an ongoing question for fire protection professionals, that in case of buildings, where sprinkler equipment and heat and smoke extraction are installed, which one should work sooner? A further question is whether these devices interact each other in such a way as to affect the achievement of the installation goals? According to the OTSZ the built-in fire alarm system must control the heat and smoke extraction. An exception is if the operation of the built-in extinguisher is restricted by the control of the fire control panel. For a long time there was no agreement on this issue, but a solution was reached during the elaboration of the TvMIs. So, the TvMI already includes a solution that in the case of a normal sprinkler system, the heat and smoke extraction system can be started automatically by the built-in fire alarm system. However, when using fast-response ESFR sprinklers, the automatic start of the fire alarm system is not appropriate [7] [8].

In such a room, an automatic start of the heat and smoke extractor is controlled by the fire alarm system and it limits the efficient operation of the ESFR system. Only manually operated heat and smoke extraction systems may be used in warehouses protected by the ESFR sprinkler. The manual start can be supplemented by a separate thermal release element built into the cupola (the release temperature is higher than the temperature in the sprinkler). This automatically opens the heat and smoke extraction surface in each cupola. However, the ESFR sprinkler system is not used in public areas, buildings or other rooms, where the automatic operation of the heat and smoke extraction is controlled by a fire alarm, which is required to ensure conditions of the evacuation.

In case of industrial buildings, the effect of the two systems on each other must be determined by taking into account the technology, the storage, the number of employees, the evacuation strategy and the firefighting. The freedom and responsibility of the designers also appears here. If the number of number of people and the evacuation strategy together take into account that the heat and smoke extraction system in the production room protected by the ESFR sprinkler does not start automatically, the heat and smoke extraction shall be started manually. If the heat and smoke extractions are to operate automatically to ensure evacuation conditions, the ESFR sprinkler cannot be used [7] [8].

4. CREATION OF OVER PRESSURED SMOKELESS STAIRWELL

In order to operate the over pressured smokeless stairwell safety the fresh air should be provided primarily from the level closer to the ground (Figure 2).

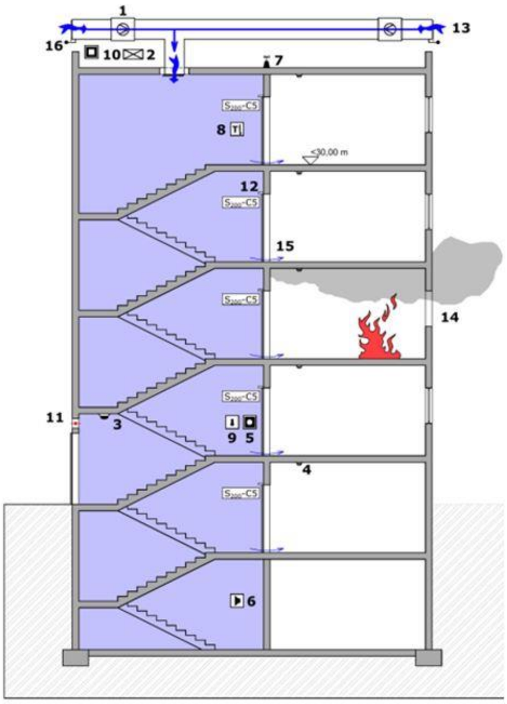


Legend:

1. blower ventilator
2. pressure regulator
3. differential pressure sensor.
4. smoke detector
5. fire alarm (manual call point)
6. fire alarm (sound and light alarm)
7. wind and temperature sensor
8. temperature sensor
9. ventilation key switch
10. overpressure relief cupola
11. weekly program
12. ventilation damper
13. automatic door closer
14. fresh air intake
15. outflow from a broken window
16. pressure loss

Figure 2 - Over pressured smokeless stairwell with overpressure relief cupola. Created by the Author.

If it is not feasible because of technical reasons, fresh air intake above the top level of the staircase can also be a good solution. The condition of it is that the air is taken from at least two different facades or roof surfaces of the building. The intake points must be at least 15 m apart and the switching between the air intake points must be controlled by the fire alarm system at the signal of the air duct sensor located in the air ducts (Figure 3). Alternatively, it is acceptable to have a single supply ventilator on the roof in the common section of the 2 air duct branches and to place 1-1 flue gas control dampers in each branch. Of these, the one that opens to the section of the air duct farther from the smoke rise [3] [4] [5] [6].



Legend:

1. blower ventilator
2. pressure regulator
3. differential pressure sensor
4. smoke detector
5. fire alarm (manual call point)
6. fire alarm (sound and light alarm)
7. wind and temperature sensor
8. temperature sensor
9. ventilation key switch
10. weekly program
11. pressure relief damper
12. automatic door closer
13. fresh air intake
14. outflow form a broken window
15. pressure lost
16. heat and smoke detector to control reversible suction

Figure 3 - two-way fresh air intake on the rooftop in case of over pressured smokeless stairwell. Create by the Author.

It may be enough to provide a fresh air intake at the top of the over pressured smokeless stairwell, if the building has an automatic extinguishing and alarm system. If there are several smokeless stairwells located in at least two different fire sections, or there is a possibility to escape to the neighbour fire section at each level and there must be a distance of at least 50 metres between the stairwells in the neighbour fire section. The differential pressure values provided by the mechanical system of over pressured smokeless stairwells have not changed during the regulations of recent years. However, innovations have already appeared in terms of differential pressure as well as mechanical response time.

The machine of the smokeless stairwell shall create the appropriate pressure difference within 100 seconds of the activation of the system. Stairway machine has to respond to external influences (for example door opening, closing) that affect the stairwell pressure within 3 seconds. Stairway doors shall be so created so that they can normally be opened with a force not exceeding 100 N. In other cases, the door can be opened by a door actuator [3] [4] [5] [6].

The force required to close the door can be calculated using the following formula:

$$P_{max} = \frac{(100\ N \times X_{handle} - M_{closing})}{(0{,}5 \times SZ_{door} \times A_{door})}$$

where: P_{max}: maximum allowable overpressure
X_{handle} distance of the handle from the axis of the door
$M_{closing}$: torque of the closing structure
SZ_{door}: width of the door
A_{door}: surface of the door

5. ROOFING WITHOUT SIGNIFICANT FIRE RESISTANCE

88.§ (2) of the OTSZ contains the cases where it is not obligatory to provide heat and smoke extraction. Examples are industrial, agricultural or storage rooms whose roof or other structures do not have a high fire resistance. The TvMI contains which solutions and designs can be accepted.

The roofing or other structure closing the room from above shall not have significant fire resistance if:

a) the material of the roofing and structure is

- single-layer, non-insulated glass without safety foil, glass wire mesh without insert
- Material with a flash point below 150 °C, or
- aluminium sheet up to thickness of 1 mm (or thinner).

b) the roofing or structure defined in point (a) covers at least 50% of the floor area of the room and

c) the room does not have a suspended ceiling, insulation, cladding or other structure that prevents the heat of fire from reaching the structure referred to in point (a), and

d) there is no built-in fire extinguisher in the room, which operation would prevent the heating of the structure referred in the point a) closing the room from above.

It is important to mention that if the E 15 criterion is not met, in this case it does not mean that the structure or the cover does not have significant integrity to the fire resistance. This only proves that gaps are developed larger than 6 mm during a possible fire resistance test.

In the above, we have presented the solutions and designs that help the spread of various engineering methods and contribute to effective fire protection in Hungary. Finally, it can be stated that these solutions would not have taken place or would have taken significantly longer if the Fire Protection Technical Guidelines and the legal framework supporting them had not been established.

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[4] MSZ EN 12101-2 Smoke and heat control systems. Part 2: Specification for natural smoke and heat exhaust ventilators

[5] MSZ EN 12101-6 Smoke and heat control systems. Part 6: Specification for pressure differential systems. Kits

[6] MSZ EN 12101-7 Smoke and heat control systems. Part 7: Smoke duct sections

[7] MSZ EN 12259-1 Fixed firefighting systems. Components for sprinkler and water spray systems. Part 3: Dry alarm valve assemblies

[8] MSZ EN 12845 Fixed firefighting systems. Automatic sprinkler systems. Design, installation and maintenance.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Jozef Svetlík, Linda Makovická Osvaldová

TEMPERATURE ON CAR DOORS EXPOSED TO FIRE – PRE-TEST

Abstract

Fires of passenger motor vehicles are a part of life. They can be seen in the streets at any hour, and most often happen when the vehicle is parked. The article deals with the effects of simulated fire on the structural elements of cars (doors) while recording the temperatures and the flow of radiant heat. The experiment was carried out in a fire room and verified the methodology of evaluating the behavior of car doors under thermal stress caused by a fire from a liquid spill. The results of experiments can serve as a basis for the car fire simulations in both enclosed and open spaces.

Key words: car fire, temperature, experiment

HŐMÉRSÉKLET VIZSGÁLATA A TŰZNEK KITETT AUTÓAJTÓKON-ELŐMÉRÉS

Absztrakt

A személygépjármű tüzek oltása gyakori tűzoltói feladat, amely bármelyik pillanatban bekövetkezhet. Leggyakrabban a parkoló járművek gyulladnak meg. A cikk egy szimulált tűznek az autók (ajtók) szerkezeti elemeire gyakorolt hatását mutatja be, miközben rögzíti a hőmérsékletet és a sugárzó hő áramlásának adatait is. A kísérletet egy tűzgyújtásra alkalmas helyiségben végezték el, ahol ellenőrizték az autóajtók viselkedésének értékelési módszertanát a folyadékkibocsátás okozta tűz hőterhelése alatt. A kísérletek eredményei megalapozzák a zárt és nyílt térben történő további tűzszimulációkat autó esetén.

Kulcsszavak: gépjárműtűz, hőmérséklet, kísérlet

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

1. INTRODUCTION

Car fires are a global problem. In the case of such fires, a great deal of research can be done, ranging from monitoring fire parameters [3,4,5,6], carrying out simulations [1,2,7] to detecting the causes of fires. One of the main causes of a car catching fire is fire spread from a nearby external source. A fitting example is the car fires in parking lots in front of supermarkets and hypermarkets. Standards for the position and width of parking places are becoming increasingly benevolent and the risk of fire spreading from one vehicle to another is quite high. Experiments regarding fires of passenger cars have been carried out in the Department of Fire engineering, Faculty of Security Engineering, University of Žilina, in order to identify and validate some of the facts relating to burning. The experiments can be seen in Figure 1.

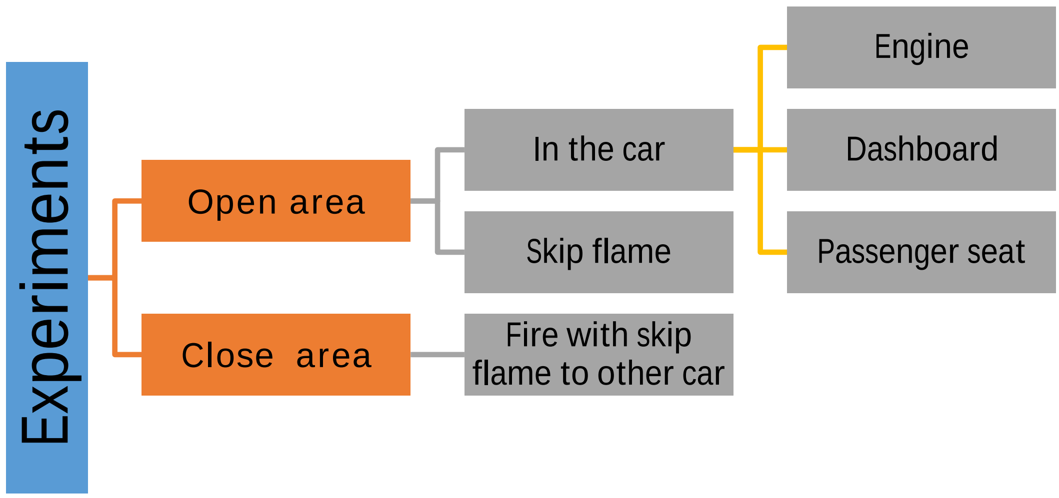


Figure 1 - Fire experiments on cars [5,6]

Flame spreading from one vehicle to another was a part of this experiment. Based on the results of indoor and outdoor experiments, the requirement to determine the limiting parameters of fire spreading between vehicles needed to be specified. Therefore, another test was carried out, not with the whole vehicle, but with only some of its parts - the doors.

2. METHODOLOGY OF THE EXPERIMENT

Theis experiment focused on the thermal stress the car door is exposed to in the case of a fire at a car park or parking garage. Based on previous practical experience from other experiments, we found out that the flame tends to spread along the flammable design elements of the car (Fig. 2). Due to its specific character, the experiment was carried out in the fire room of the VVUÚ a.s., Ostrava Radvanice, which is a test laboratory of the company. Only the results of preliminary experiments verifying the measurement methodology are published in the Article.

Figure 2 - Fire spreading in an open area

The experiment was carried out according to the diagram in Figure 3 (view from the top).

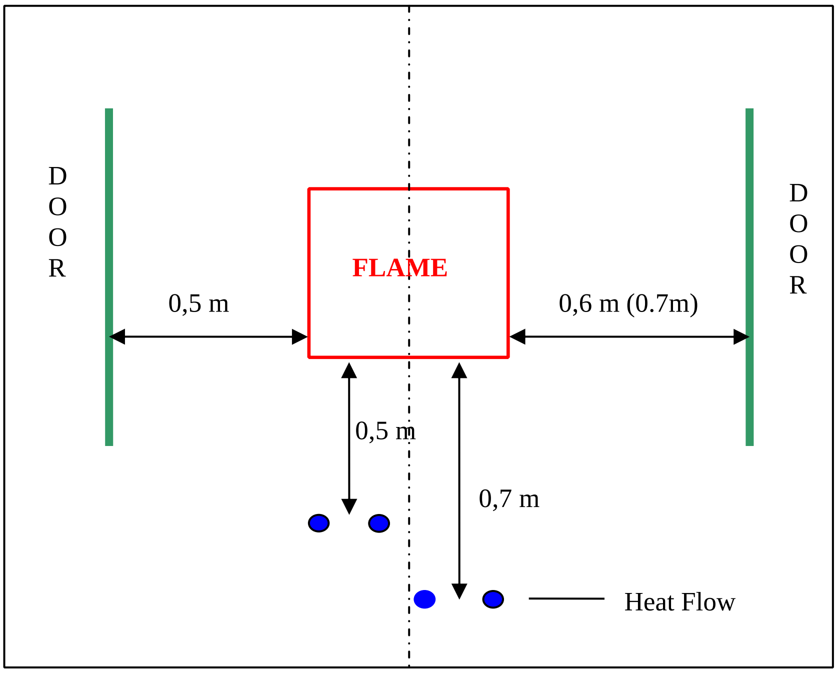


Figure 3 - Experiment

The burning temperature and the temperature of fumes was measured by NiCr-Ni thermocouples with a temperature range of -100°C to 1400°C. The location of the temperature sensors is shown in Figure 4. The locations of thermocouples were as follows:

- Temperature sensor T0 - located in the rearview mirror area,
- Temperature sensor T1 - on the upper edge of the door in the vertical axis of the door
- Temperature sensor T2 - next to the door handle from the side closer to the vertical axis of the door,
- Temperature sensor T3 - on the upper edge of the door in the vertical axis of the 2nd door,
- Temperature sensor T4 - on the coupling between the upper and lower part of the door, in the horizontal axis of the window,
- Temperature sensor T5 - placed next to the door handle from the side closer to the vertical axis of the door.

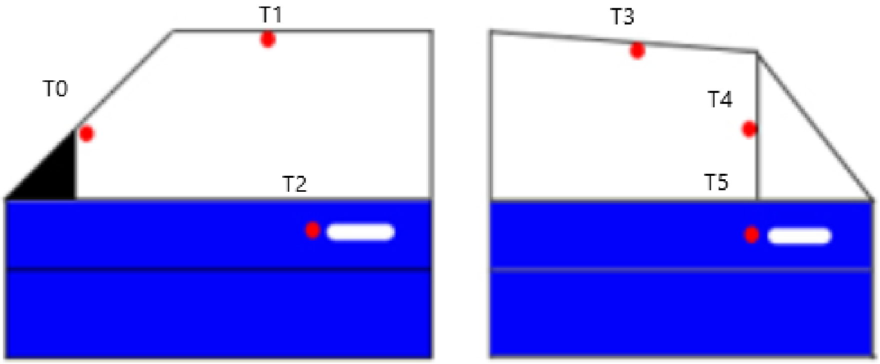


Figure 4 - Positioning of the thermocouples on the doors

Figure 5 - Position of the door and the ignition source before the experiment

A 0,5 m x 0,5 m x 0,2 m tank filled with automotive petrol BA 95 (20 liters) was used as an ignition source in the fire simulation. A solution of 66% water and 33% petrol was used as the coolant of the tank. The object of the study was the thermal stress (temperature) of the door on the surface and the possibility of their flare-up from the radiant heat in a fire. The position of the door and the ignition source is shown in Figure 5.

After initiation, temperatures were monitored and recorded according to the methodology prepared for these experiments. To provide relevant data and measurement results, the external influences (wind, airflow, humidity, etc.) were limited to the lowest possible extent. Experiments were carried out in a fire room (an enclosed space). The effects of such a wind-free environment can be observed in Figure 6 - the flame rises directly up.

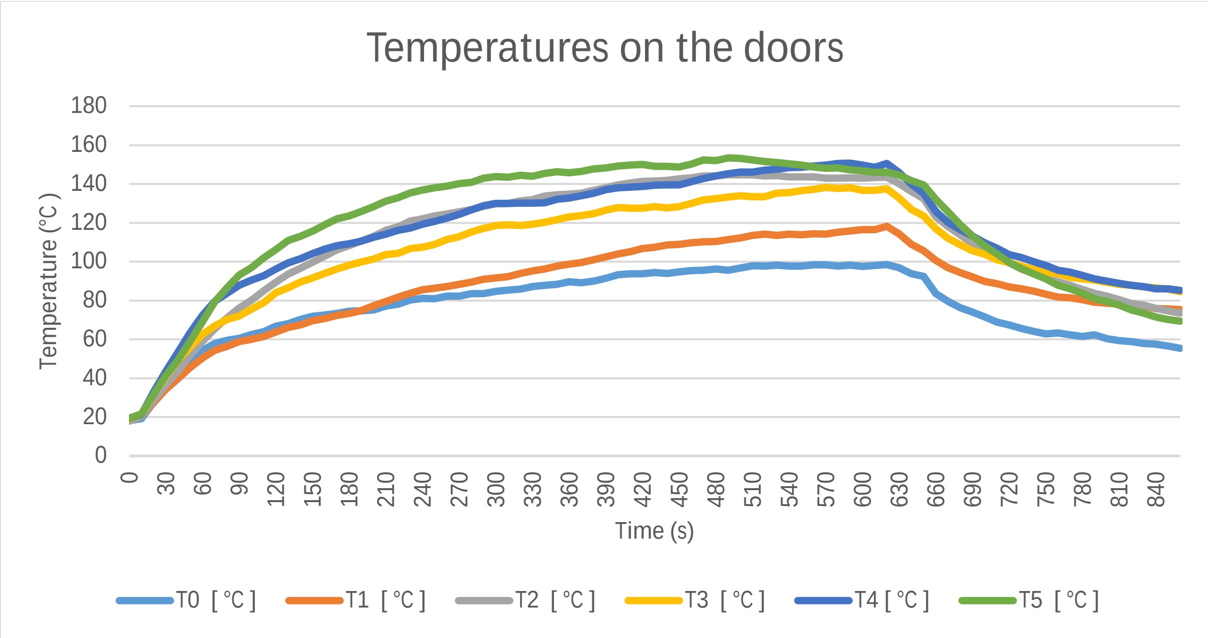
3. RESULTS AND DISCUSSION

After initiation, the room was closed and values were measured. Entering the area during the simulation was only possible using protective equipment.

Figure 6. Flame-burning of the source on the door, window level

The measurement took 860 seconds and it was influenced by the fuel consumption in the tank.

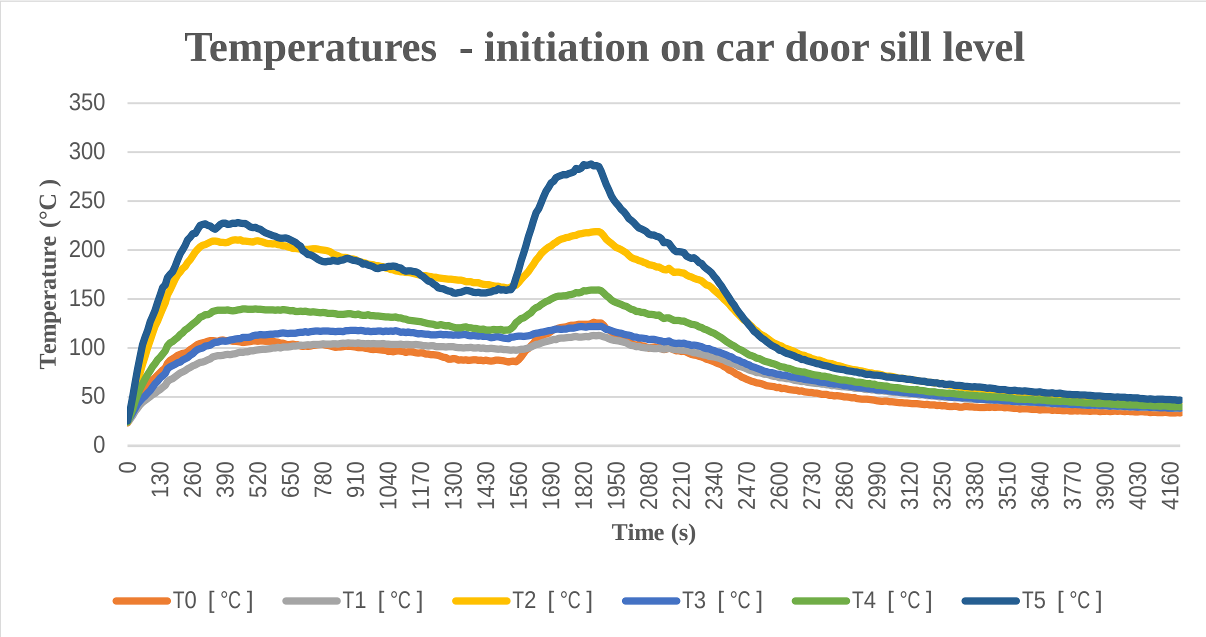
Results can be seen in Graph 1.



Graph 1. Temperatures on the door – initiation between the windows

Based on these results, where the temperatures in the door area did not even reach 160 °C, the ignition source was moved to the car floor position. The petrol BA 95 (20 liters) was used again as the ignition source.

The temperature results can be seen in Graph 2.



Graph 2 - Temperatures on the door – initiation on car door, windowsill level.

Based on the results of the second measurement, a change can be observed. There are two curves showing an increase in temperature. By about the 25th minute, the air in the room had been consumed and the intensity of burning started to decrease. However, when the entrance door opened, the temperature rose sharply and the maximum temperature of 286 °C was reached in the 32nd minute. Subsequently, the temperature gradually decreased as the fuel burned away.

The experiments were conducted under ideal conditions. A windproof environment and enclosed space simulated the conditions of a car parked in a garage, but that is not suitable for interpreting the results for the external environment. In these simulated conditions, both experiments were limited by the amount of air in the space, which was gradually consumed. The thermal stress of the door was even and was not influenced by lateral air flow, which in real-life scenario is one of the factors of the flame spreading from one vehicle to another. However, based on real outdoor fires, other phenomena, besides thermal stress, can be observed and these cannot be directly anticipated and described. One of them is the initiation of fire by pieces of plastics falling off the burning vehicle as well as leakage of operating fluids.

4. CONCLUSION

Both experiments represented pilot trials to measure the fire parameters of passenger cars. Though in both cases there was no direct initiation, the experiments showed the way that a car body next to a fire reacts when exposed to the thermal stress of a fire. Based on these results, the methodology was verified, as well as the need to measure the heat flow in a fire. This contribution presented a method of measuring the individual values of the fire parameters and the thermal stress of the car, which can be used in practice in future fire simulations as well as when identifying their causes.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Éva Eszter Lublóy, Ferenc Varga

NON-DESTRUCTIVE MATERIAL TESTING POSSIBILITIES OF REINFORCED CONCRETE STRUCTURES AFTER A FIRE

Abstract

Supporting structures play a particularly important role among building structures. From the point of view of fire protection, they must ensure the stability of buildings in the event of a fire for a specified period. During post-fire recovery, it should be verified that the supporting structure still has the required static and fire resistance performance. The use of reinforced concrete structures as a supporting structure is typical, where the degree of damage is closely related to the heat load caused by the fire. Renovation after a fire requires special expertise, as a starting point it is essential to be able to determine the extent of damage to building structures. In our paper, we present the non-destructive material testing possibilities of fire-damaged reinforced concrete structures and its limitations.

Keywords: reinforced concrete structures, fire, non-destructive diagnostics

VASBETONSZERKEZETEK TŰZ UTÁNI RONCSOLÁSMENTES ANYAGVIZSGÁLATI LEHETŐSÉGEI

Absztrakt

Az épületszerkezetek között kiemelten fontos szerepet töltenek be a tartószerkezetek. Tűzvédelmi szempontból meghatározott ideig biztosítaniuk kell az épületek állékonyságát tűzeset során is. Tűzesetet követő helyreállítás során vizsgálni kell, hogy a tartószerkezet továbbra is rendelkezik-e az előírt statikai és tűzállósági teljesítménnyel. Tartószerkezetként jellemző a vasbetonszerkezetek alkalmazása, ahol a károsodás mértéke szorosan összefügg a tűz által előidézett hőterheléssel. A tűzeset utáni felújítás speciális szaktudást igényel, kiindulásként elengedhetetlen, hogy meg tudjuk határozni az épületszerkezetek károsodásának mértékét. Közleményünkben a tűzkárt szenvedett vasbetonszerkezetek roncsolásmentes anyagvizsgálati lehetőségeit és annak korlátait mutatjuk be.

Kulcsszavak: vasbetonszerkezetek, tűz, roncsolásmentes diagnosztika

1. INTRODUCTION

The general requirement for structures and their parts is to equally meet the requirements of function, energy saving, life and health protection, economicality, safety and fire protection.

In addition to their functional role (girder, space delimiter, rain barrier, etc.), building structures must also serve fire protection aspects, for which purpose they must comply with 54/2014. (XII. 5.) Decree of the Ministry of the Interior on the issuance of the National Fire Protection Regulations (hereinafter: NFPR) and the relevant requirements of the Fire Protection Technical Directive 11.2:20.01.22 (hereinafter: FPTD) entitled Fire Protection Characteristics of Building Structures.

According to the provision of Section 1.4 of the FPTD, fire safety compliance of building structures within the scope and extent of the conversion must be verified in all cases, even in the event of the conversion, modernization, renovation and restoration of a building, regardless of whether it requires a permit procedure or not.

The reinforced concrete building structures discussed in this paper are dimensioned with a design primarily for compliance with static and fire protection requirements, the main parameters of which are structure thickness, concrete material quality, steel insert quantity and minimum concrete coverage. The latter is primarily responsible for the fire resistance of the structure.

2. DAMAGE EFFECTS OF FIRE ON REINFORCED CONCRETE STRUCTURES

As a consequence of fire, reinforced concrete structures undergo a number of changes, which will have an effect on the behavior and load-bearing capacity of the structure. During the increase of the temperature of the structure and the subsequent cooling, the following changes can lead to a decrease of the load capacity of the structure (*Balázs [et. Al.] 2017*):

- Deformation due to the temperature and the load;
- Longitudinally and cross-sectionally different temperature change;
- Nonlinear rise in air temperature;
- Different thermal expansion of cement and additive;
- Changes in the strength of concrete and steel;
- Different thermal expansion of concrete and rebar.
- The failure of reinforced concrete structures can basically be traced back to the following two causes (*Balázs, Lublóy, 2009*):
- Chemical and physical transformation of concrete components,
- layered detachment of the concrete surface.

The extent of the damage is closely related to the heat load under the fire, therefore the maximum temperature formed during the fire should be determined primarily. This is facilitated by knowing the ignition and melting temperatures of the various materials (*Table 1*). With the help of the table, we can deduce the maximum temperature in the building from the degree of damage to the materials in the building.

Material	Ignition or Melting Point
lead	327°C
paper	100°C
wood	300°C

aluminum	658°C
glass	800°C
concrete	1300°C
basalt	1426°C
ceramics	1500°C
steel	1535°C
chamotte	1700°C

Table 1 - Ignition and Melting Temperatures of Solids

3. CASES PRESENTING THE DAMAGING EFFECTS OF FIRE

In this chapter, we present some fire sites that illustrate the damage of fire to reinforced concrete structures.

Figure 1: Grocery store sales area after a fire

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Source:
http://www.hirado.hu/Hirek/2011/10/17/07/Szinte_teljesen_a_kiegett_CBA_arutere__fotok.aspx

Figure 1 shows the condition of a grocery store after a fire. The store burned on 600 square meters during the fire. The picture clearly shows that the suspended ceiling was damaged in some places, and is significantly discolored from the smoke. However, the paper boxes in the store did not burn, so the temperature along the walls did not reach 300°C. Of course, during the inspection of the building, it must be checked whether chloride ions have entered the reinforced concrete structure during the burning of the plastics, but in this case, the building can be restored after a possible replacement of the ceiling and a painting.

Figure 2. Location of a fire in a 9^{th} floor apartment of a panel residential building, 2020.

Source: Metropolitan Disaster Management Directorate, Fire Inspectorate General

During the fire shown in *Figure 2*, the largest room and the anteroom of the 9^{th} floor panel apartment suffered the greatest damage. In both rooms, the equipment and objects were completely burned, which indicates a long-term, intense free burning. The maximum air temperature can be set to 800°C and the flame temperature reaching the ceiling can be set to 1000°C. With the opening of the front door and the destruction of the windows facing the balcony, the resulting draft contributed to the development of intense burning and high damage in these two rooms. The discoloration seen on the reinforced concrete wall and slab structures, as well as the layered detachment on the slab, indicate severe damage, which necessitated a static examination of the slab and, consequently, the reinforcement of it.

Figure 3. Fire scene of a car parked in an underground garage, 2017.

Source: MDMD Fire Inspectorate General

During the fire shown in *Figure 3*, a BMW-type vehicle parked in the underground garage of a residential building in the 2nd district of Budapest burned in its entirety. The entire underground garage was contaminated with soot. Plastic elements (plastic parts of pipes, fittings) have melted. The reinforced concrete slab and pillar in the area next to the car were significantly damaged, and the concrete cover was detached from the reinforcing steel mesh from the contiguous area above the engine compartment. The extent of the damage was caused by the closed space, the proximity of the slab and the lack of heat and smoke extraction at the flame temperature of 1200-1400°C.

It is clear from the figure that all the combustible parts of the car were destroyed in the fire, the aluminum wheels melted, despite being located at floor level, in the lowest temperature air layer.

Figure 4: Location of a fire in a cosmetics warehouse, 2009.

Source: MDMD Fire Inspectorate General

At the fire site shown in *Figure 4*, cosmetic products were stored on a shelf system in a warehouse system in the 9^{th} district of Budapest on about 3,000 m^2. As a result of the fire, the combustible materials stored inside were largely destroyed, and the metal storage racks collapsed and deformed. Reinforced concrete pillars and beams were damaged due to the formed temperature of about 800°C and a heat load lasting for more than 1 hour. The heat load was reduced by the fact that the plate roof structure of the cold storage collapsed due to the fire, therefore the high-temperature combustion products, heat and smoke flowed into the open air.

Following the fires presented, it became necessary to carry out tests in order to determine the extent of the damage and to determine the procedure for repairing the reinforced concrete structures.

4. NON-DESTRUCTIVE METHODS OF MATERIAL TESTING AND THEIR USE IN FIRE DAMAGED BUILDINGS

When surveying a building damaged during a fire, it is advisable to carry out non-destructive tests if possible. Table 2 provides an overview of the options that can be used in the inspections.

Based on the Average Reaction of the Concrete Cover	**Small Sample Per Dot**	**Special Technologies**
Schmidt Hammer	Mechanical Testing of a Small Sample	Impact Echo
Windsor Probe Test	DTG	Sound Tomography
Capo Test	Dilatometry	MASW (Modal Analysis of Surface Waves)
BRE Internal Fracture	Thermoluminescence	Electrical Resistance
Ultrasonic Examination	Porosimetry	
Drilling Resistance	Colorimetry	
	Microcracking Density Analysis	
	Chemical Tests	

Table 2 - Overview of Non-destructive Testing Methods (fib bulletin 46)

4.1 Based on the Average Reaction of the Concrete Cover

4.1.1. Schmidt Hammer

The most common tool for measuring the surface hardness of concrete is the Schmidt hammer (Figure 5). Based on the rebound values obtained during the Schmidt hammer tests, the compressive strength of the structural concrete is estimated from empirical relationships. The actual condition (age, moisture content, etc.) and composition of structural concrete

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significantly affect the measured rebound values, so taking them into account is an important step in evaluating the results *(Szilágyi, Borosnyói, 2008).*

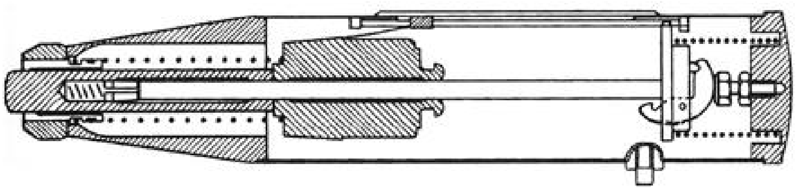

Figure 5. Schmidt Hammer *(Szilágyi, Borosnyói, 2008)*

The most common tool for measuring the surface hardness of concrete nowadays is the Schmidt hammer. The principle of the test is that the spring in the device moves an impact mass, which strikes the test surface with a given energy through an impact probe perpendicular to the surface, and after the impact, the rate of rebound of the impact mass is recorded by the device. The rebound value (R) is a dimensionless number: the ratio of the distance traveled by the moving mass during impact (x_0) to the distance traveled after rebound (x_r) expressed as a percentage ($R=x_r/x_0 \cdot 100$). It is also a measure of surface hardness.

By assuming an empirical relationship between the surface hardness and strength of materials, the compressive strength of concrete can be estimated using a tool based on the principle of elastic rebound. From the value of the hardness, we can also deduce the compressive strength of the material from the conversion table (diagram) characteristic of the tested material, which also takes into account the direction of impact. With the digital version, the direction of impact and the age of the concrete are corrected automatically, and with the average values of 10-10 measurements on pre-sanded surfaces, the device displays the most probable values of the compressive strength of the concrete as well, based on a pre-selected conversion table.

The Schmidt hammer is an indispensable tool, but if we measure with it solely, the results are primarily suitable for judging the strength homogeneity of individual elements of a concrete structure based on relative variance (*Vértes, 2001*). Values converted to strength should be treated as informative data. When classifying the strength of concrete *(according to MSZ 4720),* the non-destructive compressive strength determined by statistical evaluation can only be considered to be as reliable data as the expected strength value of the breaking of standard cylindrical specimens if the Schmidt hammer measurement was combined with ultrasonic measurement (*Ódor, 2002*). The rebound value R measured with a Schmidt hammer, which can be converted to strength (*Proceq*) using a comprehensive, comparative destructive and non-destructive test database, taking into account the ultrasonic measurement performed in the hardness measurement environment. Schmidt hammers should not be used if the concrete is surface-treated (e.g. with thin resin) (*Ódor, 2002*), partially or incompletely surface-improved (*Orbán, 2001*), if the ambient temperature is below 5°C or above 30°C (error caused by the change of the spring constant) (*Vértes, 2001*), or if the surface layer of the concrete is frozen (*Mohácsi, 2004*). This already suggests that application can be problematic in the case of heat-loaded concrete as well.

While examining a heat-loaded concrete, the elastic and plastic deformability of the concrete, the changed porosity of the surface, the cracking and the escape of free water play an important role in the accuracy of the measurement with a Schmidt hammer. Measurement with a Schmidt hammer can provide reliable results (*Figure 4*) if the decrease in strength of the concrete does not exceed 30-50%. *However, Schmidt hammers should not be used if the concrete surface is significantly cracked or the concrete surface has suffered layered detachment, i.e. it can be used up to a maximum temperature of about 500°C.*

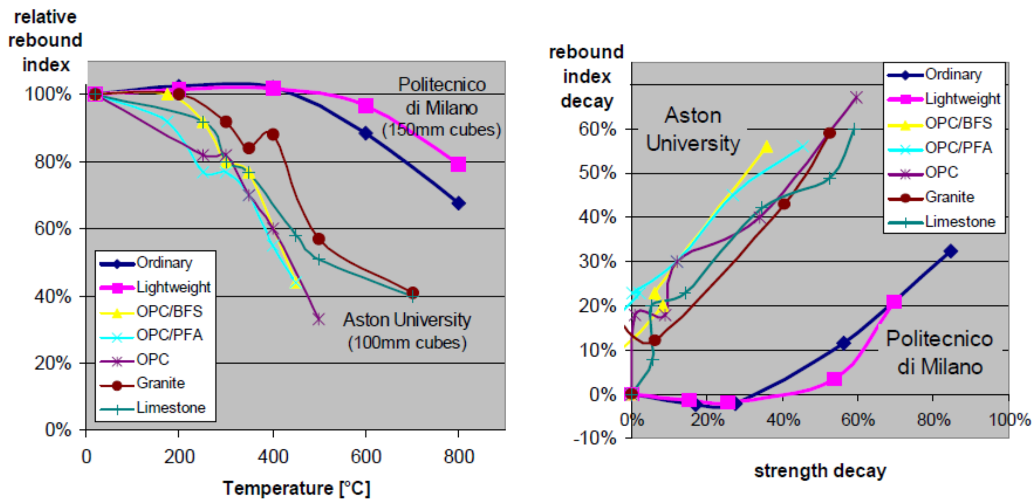

Figure 6. Bounce value measured with a Schmidt hammer depending on temperature

(*fib* bulletin 46)

4.1.2. Adhesive strength measurement

Determination of the adhesive strength is necessary when the surface of the concrete structure is coated for protection or reinforcement, or when the damaged surface needs to be repaired. The measurement is carried out prior to repair, since the surface is prepared for the application of the repair layer in the knowledge of the tensile strength of the original surface, then the adhesive strength of the repaired layer is checked as well *(Bindseil, 2002)*. Given the frequency of coating the surface of fire-damaged concrete and reinforced concrete buildings arises, we describe the steps of the measurement: the test layer is pre-drilled to a depth of more than 5 mm with the concrete core drill, the steel test stamp is glued to the designated and cleaned surface with a two-component adhesive of a higher adhesion strength than the one to be tested, and after hardening the tensile force is applied until fracture (*Figure 7*). The tensile force per unit area is the surface tensile strength of the concrete or the adhesive strength of the investigated layer, depending on the purpose of the study *(Bindseil, 2002)*. Since this method only directly measures the strength of the top layer, this method is not recommended for testing fire-damaged buildings, but is a good method for determining the method of reconstruction. If the degree of damage to the concrete also needs to be determined, methods based on measuring the extraction force will give results that are more reliable.

Figure 7. Devices for measuring adhesive strength

(http://www.minden-korr.hu/contents/muszereink_eszkozeink)

4.1.3. Measurement of Extraction Force

4.1.3.1. Windsor Probe Test

During the measurement with the Windsor Probe Test *(Figure 8)*, a 6.3 mm diameter, 79.5 mm long metal pin probe is shot into the concrete using a spring-loaded device and the depth of penetration is measured. Surface hardness can be deduced from the depth of penetration, from which the strength of the concrete can be determined. The instrument can be used for concrete compressive strengths between 20 N/mm^2 and 110 N/mm^2. It can be used in fire-damaged buildings even if the layered detachment of the concrete surface has occurred, but only if the concrete surface has remained sufficiently flat.

Figure 8. Apparatus used for the Windsor Probe Test

(https://www.ndtjames.com/News-releases_a/Redesigned_Windsor_Probe_Press_%20Release_a/295.html)

4.1.3.2. CAPO Test

In the CAPO test, an undercutting fastening element is fixed in the concrete and then a 55 mm diameter ring is placed on it (*Fig. 9*). The fastening element is pulled out and the force associated with the pullout is measured. The maximum pull-out strength is directly proportional to the concrete strength.

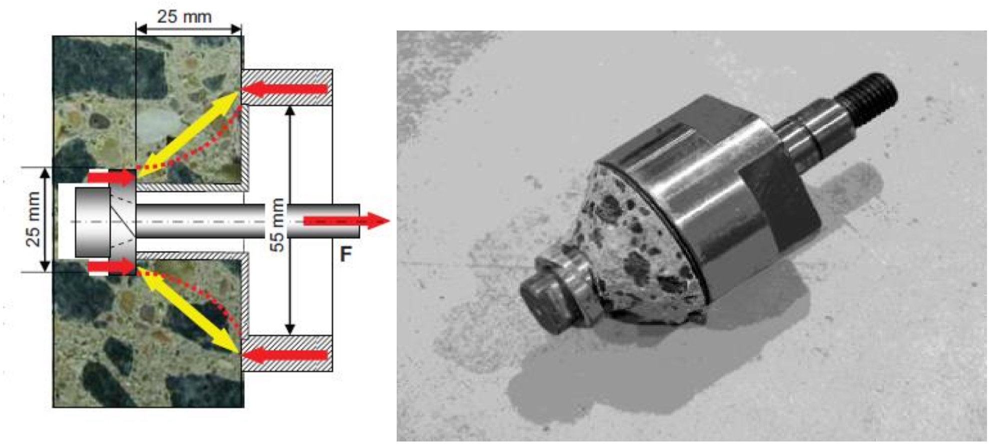

Figure 9. Working principle of CAPO Test

(https://www.germann.org/TestSystems/CAPO-TEST/CAPO-TEST.pdf)

After a fire, the CAPO test is suitable for estimating the average strength of the upper 10–15 mm layer (*Fig. 10*). It provides more accurate data than the Windsor Test, due to the dimensions of the torn out cone.

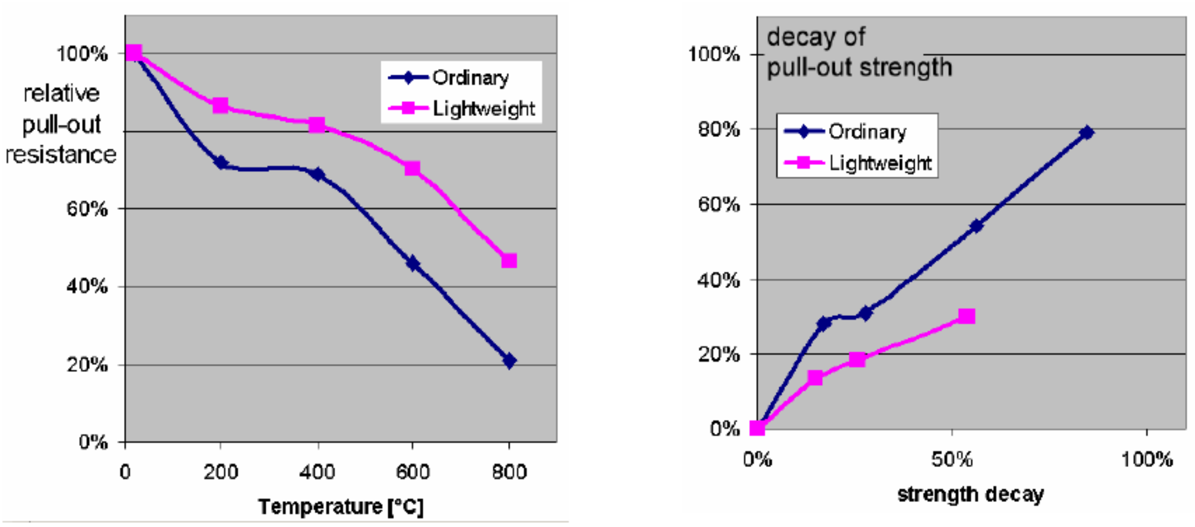

Figure 10. Correlations between temperature and readings of CAPO test (*fib* bulletin 46)

4.1.3.3 BRE Internal Fracture Test

During the test, a tensioned dowel is fixed to the test piece at a depth of 20 mm. The torque for the dowel to pull out is determined. This method, like the CAPO test, gives results for the strength of the upper 10-15 mm. The BRE test gives more accurate results than the CAPO test because the failure is much more controlled.

4.1.4 Concrete Scope (Ultrasonic Examination)

Ultrasonic testing (*Figure 11*) is a non-destructive testing method based on the determination of the propagation velocity of an ultrasonic frequency acoustic wave traveling in concrete. The propagation velocity of a longitudinal wave pulse is a measure for estimating concrete strength. During excitation of the longitudinal wave, the transmitter and receiver must be fitted to the opposite side of the concrete using an acoustic coupling material (e.g. machine grease). The wave propagation velocity (v) can be calculated by dividing the distance (s) between the transmitter and the receiver head by the measured propagation time (t) of the wave pulse. From the velocity of the wave propagation, the concrete strength can be estimated. The measurement can be performed both directly and indirectly *(Cioni, Croce, Salvatore, 2000).*

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Figure 11. Image of concrete scope

Source: (http://sdt.sulinet.hu/Player/Default.aspx?g=30b4fc34-89a4-4ad9-8cf6-e30529fbcc5b&cid=27ce789c-3af0-4df8-82f8-edeea421596b)

The concrete scope is often used to survey fire-damaged buildings because there is a clear relationship between concrete strength and ultrasonic propagation velocity *(Figure 12)*. In our opinion, however, if there are many cracks on the concrete surface, this measurement will not give reliable results.

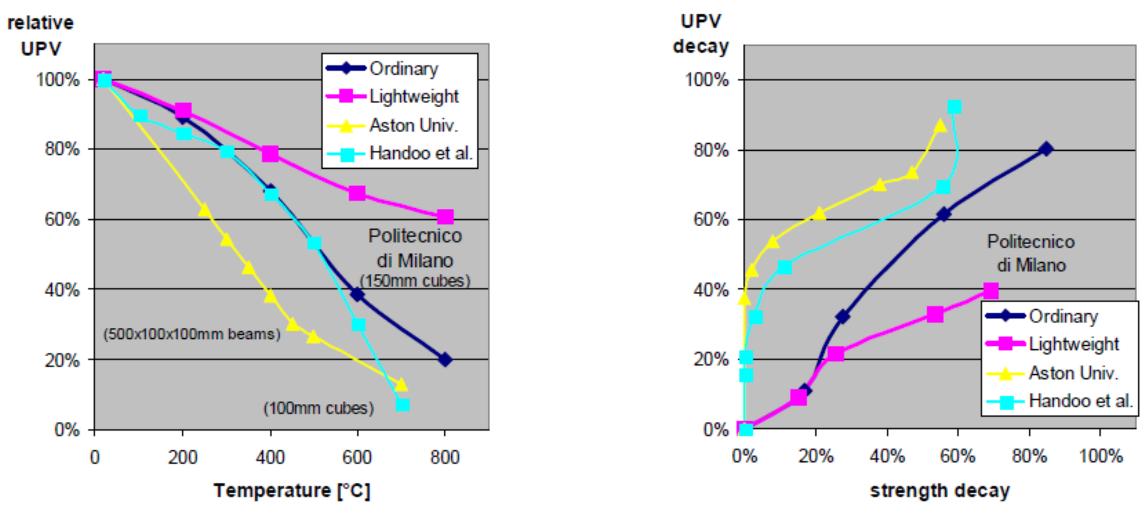

Figure 12: Velocity of ultrasonic propagation depending on heat load *(Felicetti, 2003)*

4.1.5. Drilling Resistance Measurement

To measure the drilling resistance, a modified drill is used (*Figure 13*), which measures the drilling resistance (J/mm) for drilling to a given depth. The relationship between concrete strength and drilling resistance cannot be given unambiguously because compressive strength also depends on a number of other parameters. This method can be used to detect the extent of damage after a fire. The measurement can only be used up to a 70% strength deterioration, which means a thermal load of about 800°C.

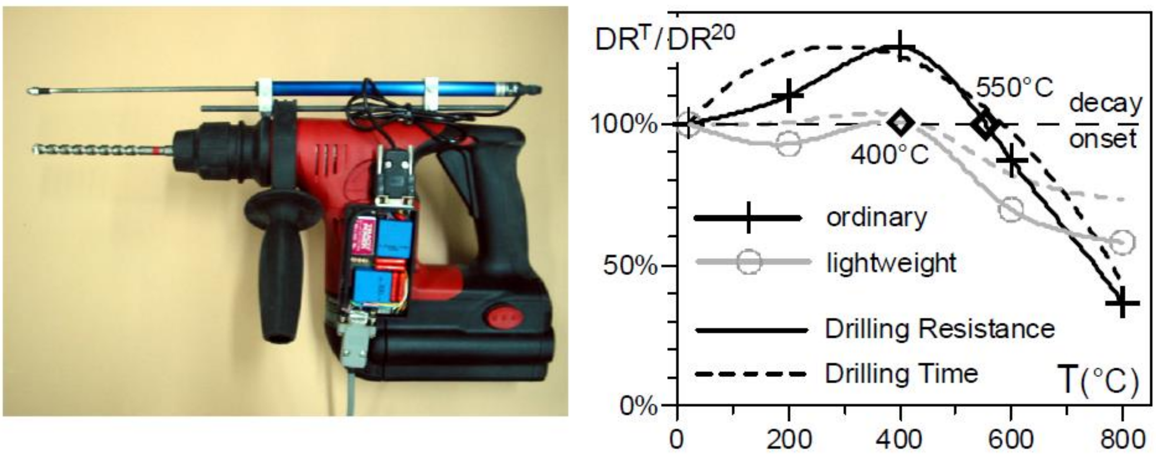

Figure 13. Methods of measuring drilling resistance *(fib* bulletin 46*)*

4.2. Small Sample per Dot

4.2.1. Mechanical Testing of a Small Sample

The best-known method for determining the strength of concrete is the core sample test, which is not a non-destructive test, but with a small amount of damage of the structure, we can get quite reliable results. In the case of fire-damaged structures, the strength test is not sufficient. Prior to the strength test, in addition to the assessment of cracks, the different layer boundaries and their thickness must be assessed, as the breaking of layers of different strengths does not give a reliable result during the compressive strength measurement. Thus, it is not suitable for determining compressive strength on its own.

4.2.2. Derivatographic Inspection

The derivatographic method is a simultaneous thermoanalytical method that simultaneously generates TG (Thermogravimetric), DTA (Differential Thermal Analysis) and DTG (Derivative Thermogravimetric) signals. A small amount of the sample is pulverized and placed in a crucible of inert material (corundum or platinum), and heated in a furnace chamber at a uniform heating rate (so-called dynamic mode). Meanwhile, an analytical balance measures the changes in the mass of the sample (TG curve) and thermocouples measure the changes in enthalpy in the sample relative to the temperature of an inert material in the furnace space (DTA curve). The first derivative of the TG curve, the DTG curve, is generated in an analogous way, which determines the location and extent of the processes involved in the mass change on the temperature scale. The test result obtained depending on the measurement time (t min), and which also contains the above three curves and the temperature (T, °C) signal, is called a derivatogram. The derivatogram can also be displayed as a function of temperature (T, ºC) *(Kopecskó, 2006)*.

4.2.3. Dilatometry

The dilatometer, or expansion meter, measures deformations due to temperature. Using a very sensitive dilatometer, the volume change of quartz between 571 and 573 °C can be measured.

4.2.4 Thermoluminescence

Thermoluminescence is based on the light absorbing ability of crystals. Because of various chemical changes, the light-absorbing ability of the crystals changes. During thermoluminescence, changes in temperature are measured. In the case of concrete, most changes occur between 300 and 500 °C, so this measurement may be suitable for determining the temperature acting on the concrete.

4.2.5 Measurement of Porosity

As a result of the temperature, the pore system and density of the concrete change. The change in pore system due to temperature can be determined. The change in pore content and density can be determined with a Mercury porosimeter. Measuring porosity is quite expensive and complicated.

4.2.6 Color Analysis

The color of the concrete changes with temperature *(Figure 14)*. The color changes are as follows:

Gray	up until 300 °C
Pink-red	300-600 °C
Greyish white	600-900 °C
Yellowish brown	from 900 °C

The pink discoloration is caused by the dehydration of the iron-bearing minerals of the admixture, and as a result, the color development of the concrete is greatly influenced by the type of admixture. This method can be used well for concretes with quartz admixture; for limestone and aggregates of volcanic origin, the applicability of the method is questionable. The measurement, on the other hand, gives reliable results if we measure and compare the degree of color change on the surface of a core sample of a hole, in which case the maximum temperature reached and thus the degree of strength loss can be estimated well.

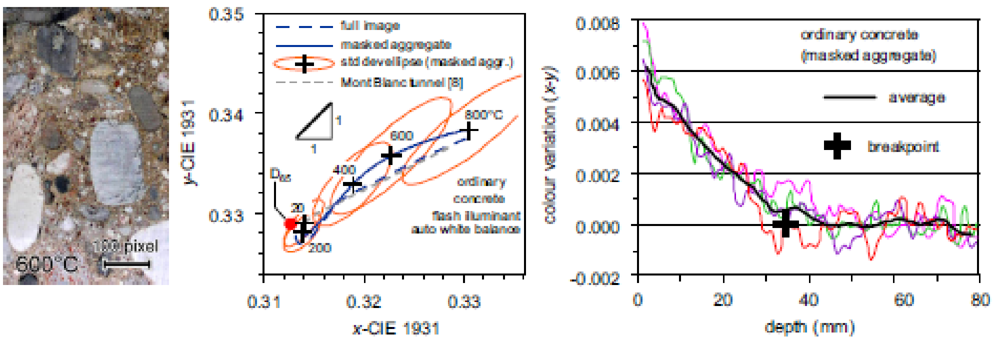

Figure 14. The extent of color change on the surface of the concrete (*fib* bulletin 46)

4.2.7. Microcracking Density Analysis

As a result of heat load, microcracks are formed in the concrete, since under heat load many chemical processes take place, therefore the number and size of the microcracks also increase with the temperature of the heat load. Modern digital technology provides an opportunity to analyze the density of microcracks.

4.2.8. Chemical Tests

4.2.8 1. Scanning Electron Microscopy (SEM)

Morphological examinations of concrete pieces taken from concrete cubes can also be performed by electron microscopy.

Each SEM image shows the comparative micrometer scale for that magnification. The tested samples can be attached to the sample holders with a conductive carbon adhesive tape with a double-sided adhesive strip.

4.2.8 2 Depth of Carbonation

By measuring the depth of carbonation *(Figure 15)*, the detection of the depth of $Ca(OH)_2$, i.e. the location of the isothermal line at 400-450 °C, was compared. It is questionable whether the measurement can be applied several weeks or possibly months after heat loading, or whether CaO is converted back to $Ca(OH)_2$ in concrete.

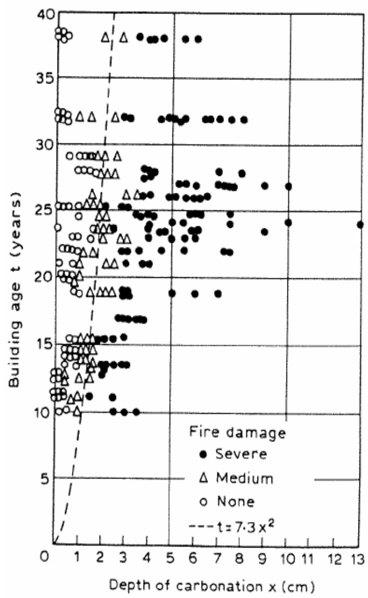

Figure 15. Measurement of the depth of carbonation on heat-loaded concrete *(fib bulletin 46)*

4.3. Special Methods

4.3.1. Seismic Tomography

Seismic tomography is an image reconstruction procedure. Its history dates back to the 1980s, when detailed image reconstruction methods developed to solve the tasks that had already arisen in the medical and technical sciences began to be applied in seismology.

Using tomography, the distribution of a physical quantity within a range can be determined from the data of screening-type measurements performed around the perimeter of the range if the measured values are line integrals of the physical quantity being examined. There is a relationship of such in seismology:

- Reciprocal of wave propagation time and velocity,
- Between the logarithm of the reciprocal of the amplitudes and the absorption.

In the case of seismic tomography, the velocity and absorption profile of the area can be calculated by measuring the propagation times and amplitudes between a large number of (in principle infinite) intersecting avenues located between the explosion points and geophones located in the perimeter of the studied area. Reliable and appropriately resolved scales in all directions therefore require uniform coverage of the test area with a large number of radii according to direction and density. The "walkability" of the area, as opposed to medical CT, is usually not feasible in seismic practice, so the image is smeared in a direction parallel to the avenues.

Seismic measurement was used at the Mont Blanc tunnel *(Abraham, De´robert, 2003)*. During the seismic measurement, the mechanical properties of the concrete depending on temperature could be deduced. As a result of fire, strength properties of the concrete deteriorate. During the measurement, 70 sensors were used per measurement site. They were able to deduce the extent of damage from the distribution of seismic waves *(Törös, 2006)*.

4.3.2. Radar

4.3.2.1. Ground Radar

The ground radar method (GPR, Ground Penetrating Radar, Ground Probing Radar, SIR Subsurface Interface Radar) is one of the newest branches of geophysics. The ground radar equipment consists of a transmitter and a receiver antenna, a control and data acquisition electronic unit, and a computer for storing data. The transmitter part of the device emits a series of high frequency (10 MHz-5 GHz) electromagnetic pulses into the medium to be tested. The reflected signals are received, digitized and stored by the computer as a function of time. The propagation of the radar signal in rocks depends on the physical properties of the medium. In practice, the dielectric constant determines the speed of wave propagation and the conductivity determines the attenuation of the signal. If either of these two parameters changes at an interface, part of the signal is reflected and another part enters the next layer. On the profile generated from the time series, layering and structure can be tracked, and recognition of underground objects is possible, if physical contrast allows.

4.3.2. Impact Echo

We distinguish two types of surface waves: Rayleigh and Love waves. Rayleigh waves travel along the surface and their amplitude decreases with distance according to the scattering of energy along the cylindrical surface. Love waves only occur when there is a layer that allows a lower propagation velocity above a layer that allows a higher propagation velocity, and multiple reflections are created at the interface between these two layers. Researchers have focused on Rayleigh waves, as 67% of the energy of mechanical stress waves propagates in this form. The propagation velocity of these waves depends on the wavelength and the modulus of elasticity of the material. The depth at which a wave penetrates the material depends on the wavelength. The velocity of a Rayleigh wave depends on the characteristics of the material it passes through: its Poisson's ratio function and approx. 0.9 times the speed of the shear wave. As a result of the longitudinal and transverse vibrations, the particle motion is elliptical. The main wave source of the SASW (Spectral Analysis of Surface Waves) method is the Rayleigh wave. Developers have taken from other research that it is best if the distance between the signal source and the first receiver matches the distance between two adjacent receivers. Similarly, previous research has been accepted that it is not appropriate to use wavelengths greater than three times the distance between receivers. To make the SASW method easy to apply, simplifying assumptions have been made *(Törös, 2006):* In the sample, the horizontal layers correspond to the layer structure of the structure and these layers are homogeneous in terms of their material properties. Waves were considered (body waves were neglected). The latter assumption does not cause disturbing inaccuracies if the signal-to-receiver distance is kept within specified limits relative to the wavelength.

1. Only planar (Rayleigh) waves were considered.

The impact echo consists of the generation, measurement, and processing of scattered surface waves. The assembly consists of a signal source (12 mm diameter steel ball), two accelerometers (this is the data acquisition system), two signal conditioners and a data processing computer. The surface waves caused by the impact of the steel ball are captured by the two accelerometer receivers, converted by the signal conditioner, and the velocity distribution of the surface wave can be determined from the dispersion curves plotted over time (calculated by the system from time, frequency and power spectra):

1. It is sufficient to access one of the surfaces of the object under study.

2. When an impulse is generated by the impact of the test ball to produce the surface waves, most of the energy produced can be measured.

The velocity distribution of shear waves can be determined using the surface wave modal analysis method (SASW). Advantages of the modal analysis method of surface waves:

1. Spreads in the form of surface waves, and only a small part of it becomes a wave propagating inside the examined concrete,

2. With the geometric propagation of surface waves, the decrease in amplitude is smaller than in the case of body waves,

3. The Young's modulus or shear modulus of the test material can be determined without knowing the depth of the test layer.

A steel ball with a diameter of 12 mm is dropped from a given height onto the test surface. A low-pass filter is used to filter out noise, which eliminates the first reflections after the first strong echo. With the non-destructive SASW process, a correlation was found between the compressive strength of concretes and the speed of surface waves traveling in the material. A relationship between compressive strength and compression wave velocity has also been established *(Törös, 2006).*

4.3.3. Sound Tomography

The sound tomograph is computer controlled. During the examination, sensors are placed on the part of the building in a circle, the number and distance of which are determined by the computer. The machine and the program can be used to measure the speed of sound propagation on the examined element. The sound waves caused by knocking propagate in the concrete. If there is any change in this, such as a change in cavity or strength, the value, i.e. the time of sound propagation, changes (http://parkfavedelem.hu/index.php?option=com_content&view=article&id).

4.3.4 MASW (Modal Analysis of Surface Waves)

The method measures the propagation of seismic surface waves in a material. The system measures the change in the propagation speed of shear waves. Since shear waves directly influence the development of the modulus of elasticity, the system may also be suitable for measuring fire-damaged concrete structures *(Törös, 2006).*

4.3.5. Electrical Resistance

To some extent, all materials, such as soil and rocks, conduct electricity, so first soil mechanics developed a method based on electrical resistance measurement to measure this and utilize the results obtained. Conductivity, or its reciprocal, electrical resistance, depends significantly on the structure of the soil, the size and distribution of the pores in it, the possible water content, and the amount of salts dissolved in it. The methods for testing the surface resistance of concrete were based on the outlined principle derived from soil mechanics. To test the concrete on site, we use the so-called four-probe resistance meter, which is a much smaller version of the resistance meter used in soil mechanics converted for concrete.

Concrete is a multi-component, microporous, microstructure-sensitive building material. Porous materials absorb water from the air. The balance of the water content (relative humidity) of the porous material and the air is given by the adsorption isotherm. Up to 40% relative humidity, water uptake occurs during a “pure” adsorption process. The water absorbed in this way does not move, it is not free, and is strongly bound to the inner surface of the cement stone. At relative humidity above 40%, the material absorbs additional water through the capillaries, open pores. This part of porosity is called apparent porosity.

The pores in the concrete are randomly arranged, of different sizes and connected to each other irregularly. The flow of water and various ions through these tortuous channels is controlled by water permeability, adsorption, and various diffusion mechanisms. Cement-based materials contain air-filled cavities, microcracks, and internal surface gaps between the CSH gel. The electrical resistance of mortar and concrete depends on the microstructure of the cement paste (pore volume, distribution of pore radii), moisture and salt content, and temperature. The microstructure is influenced by a number of factors, such as the water/cement factor, the binder, the degree of hydration, the quality and quantity of additives *(Simon, Vass, 2011).*

5. SUMMARY

Reinforced concrete is a widely used building material in today's architecture. Many of its advantages include high load-bearing capacity, the possibility of designing various structures, universal usability, suitability for prefabrication and on-site construction, etc.

From the point of view of fire protection, its indisputable advantage is that it forms a non-combustible building structure, and with its appropriate sizing it is suitable for the construction of a structure with high fire resistance.

In our paper, we have shown that, despite the favorable fire protection properties of reinforced concrete, it is capable of being damaged by fire, even to the extent that it becomes unfit for its original function.

In such case, if the structure is to be restored, the extent of the damage must be examined using special methods to ensure the original and prescribed parameters of the structure (static, fire protection, etc.) and to determine the repair technology.

Extensive professional methods and advanced instrumental background are available to perform diagnostic tests to avoid the need to significantly increase the rate of secondary fire damage by disassembling and re-constructing the structure.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Michaela Zamrazilova

FIRE SAFETY OF PHOTOVOLTAIC SYSTEMS

Abstract

The segments of photovoltaic systems are tested for safety and reliability during production. These systems must also satisfy the electrical safety requirements set out in the various standards and protocols to the extent defined by the country. Based on the claims of individual manufacturers, it is possible to work with the information that photovoltaic systems don‘t pose health, safety or environmental risks under normal operating conditions, if they are properly installed and maintained by trained personnel according to the requirements of regulations and standards in individual countries. With the ever-growing global trend of photovoltaic installations and countless installation variants, from traditional installations on the roof and ground to more advanced systems integrated into building facades. It is all the more important to develop installation procedures and share equipment safety and risk mitigation information. The article presents examples of fires in photovoltaic installations in the context of the intervention of firefighters. The article further clarifies the applied approaches in the field of fire safety in the Czech Republic and in the surrounding countries.

Keywords: photovoltaic system, fire safety, fire, firefighters, solar energy

A FOTOVOLTAIKUS RENDSZEREK TŰZBIZTONSÁGA

Absztrakt

A fotovoltaikus rendszerek szegmenseinek biztonságát és megbízhatóságát a gyártás során folyamatosan tesztelik. Ezeknek a rendszereknek meg kell felelniük a különféle szabványokban és protokollokban meghatározott villamos biztonsági követelményeknek is. Az gyártók állításai alapján olyan információkkal lehet dolgozni, hogy a fotovoltaikus rendszerek normál üzemi körülmények között nem jelentenek egészségügyi, biztonsági vagy környezeti kockázatot, amennyiben a képzett személyzet megfelelően telepíti és karbantartja azokat. A fotovoltaikus installációknak számtalan beépítési változata ismert, a hagyományos tetőn és talajon történő beépítéstől kezdve az épület homlokzatába integrált fejlettebb rendszerekig. Ennek megfelelően fontos a különböző telepítési eljárások kidolgozása, valamint a berendezések biztonságával és a kockázatcsökkentéssel kapcsolatos információk megosztása. A cikk példákon keresztül mutatja be a fotovoltaikus létesítményekben bekövetkezett egyes tűzeseteket. A szerző emellett pontosítja a Cseh Köztársaságban és a környező országokban alkalmazott tűzbiztonsági megközelítéseket.

Kulcsszavak: fotovoltaikus rendszer, tűzbiztonság, tűz, tűzoltók, napenergia

1. INTRODUCTION

In case of a fire on the photovoltaic system, it is necessary to adapt the fire extinguishing to take account of the installed photovoltaic equipment and the associated potential hazards. Dangers for firefighters include electric shock, slipping and falling from roofs, roof collapse, and fire hazards of other materials in the area. Research and analysis are available in each country to protect firefighters and mitigate the risks of intervention, such as the 2018 British Research Group Building Research Establishment (BRE) [1] or the 2013 analysis published by TÜV Rheinland in Germany. Energie und Umwelt GmbH [2], which provide information on how to proceed during and after fire fighting. This article aims to summarize the approach to fire safety in the installation of photovoltaic systems in selected countries such as the Czech Republic, Germany, Austria and Slovakia and to highlight best practices.

At the same time, the article identifies the potential dangers associated with the intervention, which could help knows what is what both users and stakeholders in the field of solar energy, from the perspective of firefighters and serve to support measures that could minimize these risks and aren‘t implemented in the country.

2. PRINCIPLE OF PHOTOVOLTAIC POWER PLANT

The principle of a photovoltaic power plant is based on the photovoltaic phenomenon. The phenomenon occurs *"when a photon with sufficient energy releases an electron from the valence band into the conduction band. The "missing electron" will remain in the valence band, a.k.a. hole, which can be considered as an elementary positive charge "*[3]. The primary material for photovoltaic cells is silicon. To produce electricity, it is necessary to add impurities to the crystal lattice of silicon, in the form of phosphorus (type N - one excess electron) or boron (type P - one hole). When connecting N and P type layers, the PN junction occurs, which creates a small area of spatial charge and an electric field [4].

Based on the above principle, a photovoltaic system converts solar energy directly into electrical energy using several solar modules (chains) electrically connected in series. In the case of a grid-connected photovoltaic system, the inverters help to convert the direct current generated in the solar modules into alternating current, which can then be fed into the grid via transformers. The system is shown in Figure 1.

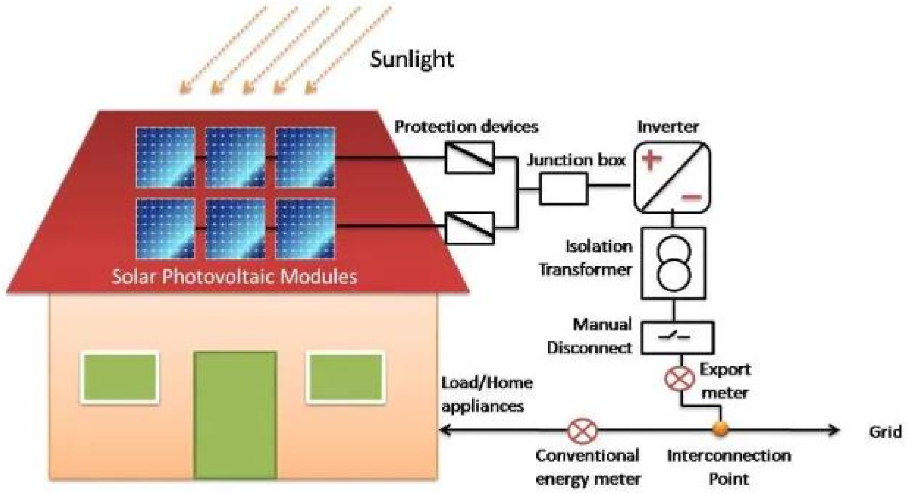

Figure 1- The plan of photovoltaic system. Source: Green Clean Guide, 2013 [5].

When installing in detached houses, often only modular chains are used, so they can be connected directly to the inverter and the above-mentioned generator junction box is omitted. In the case of larger systems, generator junction boxes are used for parallel connections. Very large systems and systems with many separate inverters use junction boxes that connect multiple lines of generator junction boxes. The generator connection box contains connection terminals and disconnection points, or chain fuses and chain diodes. Generator junction boxes often include integrated surge arresters to conduct surges to ground. The equipotential bonding or earthing conductors therefore lead to the generator distribution boxes [2].

The individual solar panels can be connected in series, in parallel or by a combination of serial and parallel connections. Serial connection (connection of positive and negative poles), increases the output voltage of the power plant and is used in systems supplying electricity to the distribution network. On the contrary, for local use (a.k.a. isolated systems) with a possible backup of energy in accumulators, a parallel connection is used (interconnection of positive and negative poles, cells or entire panels). This connection increases the generated electrical power even at low output voltage [6].

The required output direct current (DC) voltage or even alternating current (AC) voltage is corrected by semiconductor converters or inverters. They convert DC voltage to other

DC voltage (e.g. rechargeable batteries), or DC voltage to AC voltage (to classic 230 V AC voltage). Another component is a possible backup device consisting of batteries, which is charged in the event that the photovoltaic system produces more energy than is consumed and is discharged in the event of higher consumption. To redistribute energy between the panel, batteries and appliances, a.k.a. charge controller is used, which is used for controlled charging and protection against overcharging [6].

Cabling is an significant part of photovoltaic systems. It must meet several conditions, namely long-term stability of electrical and mechanical parameters, resistance to temperature, ultraviolet radiation, ozone, wind, hydrolysis [6].

3. EXAMPLES OF FIRES ASSOCIATED WITH PHOTOVOLTAIC SYSTEMS

In the Czech Republic, the Fire and Rescue Brigade of the Czech Republic registered 15 fires connected with photovoltaic systems in 2019. It was primarily a fire from a switchboard, inverter or batteries and a subsequent fire in the roof location, but there was also a spread of fires to the entire family house or business building. However, in only one case did the damage to property exceed 10 million crowns (EUR 400,000) and there were no casualties.

In the United Kingdom, the BRE Scientific Group analyzed over 50 firefighting interventions in 2017. According to the BRE report, 36 % of fires were caused by incorrect installation, 12 % by defective products and 5 % by incorrect installation design [7]. One example is the fire of a new apartment building in East London (Figure 2) with damage of more than one million pounds (EUR 1.1 million), which occurred in 2017. The fire was extinguished by 80 firefighters who had 12 fire trucks at their disposal and two helicopters. The fire was localized by the units in 3 hours [8].

Figure 2 - Fire in Bow Wharf. Source: Stoker, 2017 [7].

In Germany, an analysis was published in 2015 by TÜV Rheinland Energie und Umwelt GmbH, which analyzes interventions in 2013. From the beginning of the installations until January 2013, approximately 1.3 million photovoltaic systems with a total output of over 30 GW were installed in Germany. 430 cases of fires in photovoltaic systems were analyzed, of which 85 fires were caused by incorrect installation or product defect [2]. An example is the hall fire in Walldorf in 2014 (Figure 3). The photovoltaic panels ignited together with the plastic roofing. Incorrect installation and improper selection of the roofing led to a fire.

Figure 3 - Fire on the roof of the hall in Walldorf. Source: wiwa-lokal.de, 2017 [9].

4. RISKS ASSOCIATED WITH EXTINGUISHING

A fire caused by or in the vicinity of a photovoltaic system can bring various risks to firefighters, whether there is a risk of falls, electric shocks, collapse of the roof structure or total collapse of the roof structure. Due to these dangers, in the Czech Republic, the incident commander - a officer of the Fire and Rescue Brigade - is entitled to interrupt or terminate the intervention if the life of the intervening firefighters would be immediately endangered.

In addition to the direct risk of fire from the aforementioned defective photovoltaic system, the presence of a photovoltaic system on the structure can complicate firefighting for other reasons, for example the weight of the photovoltaic system can lead to a faster collapse of the roof on a burning structure. On a sloping roof, there is a risk of slipping on the glass surface of the solar panel, which can lead to a fall from the roof. It should also be borne in mind that if photovoltaic systems are exposed to the sun, they remain energized, even after the building's mains connection has been deactivated. If live wires are exposed due to improper installation or damage, an electric shock may result [10].

Complications in extinguishing can also bring a place of intervention, the main points include the following points:

- panels of photovoltaic systems are not visible from the ground (these are primarily straight roofs);
- in the neighborhood of the building there are no suitable boarding areas for high-altitude firefighting equipment;
- it is not possible to transport the fire extinguisher to the entire fire area in the required intensity;
- the presence of other technological equipment on the building (e.g. lightning conductors, ventilation, skylights, heat and smoke removal equipment, antennas) in which there may be electrical voltage;
- the location of the control (disconnection) elements of the photovoltaic system is not known to the firefighters;
- endangerment of animals placed in the area of the photovoltaic power plant;
- the possibility of fire equipment getting stuck on an unsuitable access road;
- burning of grassland in times of drought [11].

5. IMPLEMENTATION OF FIRE SAFETY ELEMENTS IN THE CZECH REPUBLIC AND SELECTED COUNTRIES

Fire safety elements can give firefighters better control over the risks associated with photovoltaic systems. Fire safety elements can include, for example, circuit breakers and disconnect switches. Circuit breakers can reduce the occurrence of fires and electric shocks from live conductors. Disconnect switches can reduce the number of wires that remain energized from illuminated photovoltaic panels. Requirements for the installation of these elements vary from country to country.

In the Czech Republic, there is support in normative legal acts [12, 13, 14], which is followed by approximately 11 technical standards dedicated to the installation of photovoltaic systems. What is possible to tackle with in the Czech Republic in the field of state fire supervision is the fact that for installations with an output of up to 20 kW (corresponds to installations and consumption for a family house), it isn‘t necessary to solve a building permit or notification to the building authority. [15] Therefore, the Fire and Rescue Brigade of the Czech Republic is not informed about these performed installations, and therefore it isn‘t possible to prepare firefighters for this situation to intervene on objects with a photovoltaic system installed.

For larger installations of photovoltaic systems, a safety element in the form of a "CENTRAL STOP" button is installed. This button doesn‘t completely turn off the power flow because the wiring sections from the panels to the drive remain energized. The flow is interrupted only if the panels are mechanically damaged. Despite the risk of permanent equipment under voltage, a button is needed and facilitates the intervention of firefighters. One of the contacted private companies installing photovoltaic systems on the roofs of detached houses confirmed the author of the article that it is already introducing the installation of the "CENTRAL STOP" button for installations in detached houses. This situation can be described as positive and beneficial and approaching the standards in countries such as Austria or Germany.

It is in Austria that the rules for installation are the same regardless of the installed capacity. Since 2013, the ÖVE Directive R11-1 [16] on fire protection requirements has been in force in this country. For example, the installation of performance optimizers is limited by this directive, and the switching control must operate on the principle of fail-safe. It also introduces a switching device that monitors the voltage, if the network is turned off, the DC voltage in the house is also turned off. Switching is also possible by the network operator or the firefighters remotely. Furthermore, the obligation to place markings in the entrance area of the house is introduced, which is shown in Figure 4 [17].

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

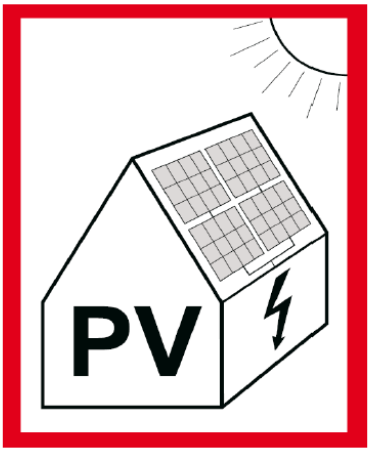

Figure 4 - Designation of a house with a photovoltaic system Source: Becker, 2014 [17].

In Germany, guidelines on fire protection for the installation of photovoltaic systems are given in a document of the German Solar Industry Association entitled "Planning, construction and maintenance of photovoltaic systems, focusing on fire protection" [18]. This document is a set of recommendations, it also contains individual provisions that are mandatory. Mandatory elements include the designation of the installation of the photovoltaic system (the mark is similar to that in Austria), which is located in the main power supply box and main distribution panels, there is also a schematic drawing of the photovoltaic system [18].

It is also mandatory to install a fire protection DC voltage line on the outside of the building, only AC voltage lines are allowed inside the building, the inverter itself is located outside the building. A remote DC voltage switch for firefighters is also installed in the main fuse box in the building [18].

In Slovakia, since January 2013, on the basis of the standard, STN 92 0203 Fire safety of buildings - Continuous supply of electricity in the event of a fire [19], it is required to ensure safe shutdown of electricity supply. It can be deduced from this standard that the switch-off must take place directly at the solar panels. This can be realized by means of a mandatory switch of the photovoltaic device, which is to be located close to the main switch. [20]

6. CONCLUSION

As the installation of photovoltaic systems has become commonplace, it is necessary for the executive and legislative authorities to cooperate with fire brigades and corporate to install photovoltaic systems for the preparation of mandatory document. This publication should serve not only to address potential risks to firefighters, but also installation procedures. In addition, a document should be created containing information for future and current users of these systems.

Installation procedures, firefighting instructions for firefighters and fire safety equipment that can reduce the risk of fire and / or injury are now used in some countries, such as Germany or Austria. Differences in implementations over time and country provide information to identify best practices for minimizing risks in firefighting operations. In the future, preventive measures of cooperation between experts, firefighters and representatives of the legislature will be essential for the further development.

Education of the non-expert audience plays an important role. It is at the outset in the Czech Republic and isn‘t overemphasized at the expense of the benefits of installing photovoltaic systems, obtaining grants and quantifying savings. Awareness is one of the basic pillars of fire prevention.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Johanna Farkas

COPING STRATEGIES OF FIREFIGHTERS

Abstract

The firefighters experience may result an elevated risk of psychological burnout, depression, and other mental disorders due to incidents at their work. The current approach to addressing these fields tends to focus on individuals coping. This study aims to determine the effects of stress in professional firefighters, and the types of coping strategies among Olson's Multisystem Assessment of Stress and Health (MASH) model. Eighty-two professional firefighters participated in this research from five urban fire departments. The Coping Inventory for Stressful Situations and Coping and Stress Profile were used to exam coping strategies. The survey shows that the members of the intervention staff are exposed to the greatest stress during their work. The vast majority of the stock responds to stress with adequate coping strategies. This suggests that firefighters are increasingly exposed to stress during their work and should be provided with more training and psychological support for dealing with work stress. As the data were not subjected to statistical analysis, the results are not considered scientifically relevant.

Keywords: Work stress, Posttraumatic stress disorders (PTSD), Psychological burnout, Resilience

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TŰZOLTÓK MEGKÜZDÉSI MECHANIZMUSAI

Absztrakt

A tűzoltók feladatellátásuk során nagyobb kockázatnak vannak kitéve a pszichológiai kiégés, a depresszió és más mentális rendellenességek kialakulása tekintetében. Ezen problémák pszichológiai kezelési lehetőségei az egyéni megküzdési stratégiákra fókuszálnak. A tanulmány célja, hogy bemutassa a hivatásos tűzoltók körében előforduló stressz hatásait, valamint a megküzdési stratégiák típusait az Olson Multisystem Assessment of Stress and Health (MASH) modell felhasználásával. A bemutatásra kerülő kutatásban öt városi tűzoltóság részéről 82 hivatásos tűzoltó vett részt. A megküzdési stratégiák vizsgálatához a „Stresszesemény leküzdése” valamint a „Megküzdés és Stressz Profil” kérdőívet alkalmaztuk. A felmérés eredményei azt mutatják, hogy a „vonulós” állomány tagjai munkájuk során jelentős mértékben vannak kitéve a stressz-hatásoknak és az állomány döntő többsége adekvát megküzdési stratégiákkal reagál azokra. Mindez arra utal, hogy a vizsgált populáció számára a munka jellege miatt több képzést és pszichológiai támogatást kell biztosítani, mely hozzájárul a munkahelyi stressz-kezeléshez. Mivel az adatokat statisztikai analízis alá nem vetettük, azok nem tekinthetők tudományosan relevánsnak.

Kulcsszavak: munkahelyi stressz, poszttraumatikus stressz zavar (PTSD), pszichológiai kiégés, rezíliencia

1. INTRODUCTION

Numerous investigations have identified emergency service workers - like firefighters are - experience constant and intense stress in their specific tasks, so there is a high-risk factor in their population to burnout and other mental disorders such as anxiety, depression, alcoholism, posttraumatic stress disorder (PTSD) and suicide [1, 2]. Studies of the health status of firefighters have recently revealed cardiovascular areas too. According to Smith's (2019) study

[3], cardiovascular disease[1] is the leading cause of on-duty death (45%) and unfortunately a major cause of morbidity [4]. Furthermore, Smith (2019) carried out a retrospective study (1999-2014 among 18-65 years of age) and showed sudden cardiac death duty-related.

Constantly living in stressful situations results in this population not only physical but also mental illness. It is a cardinal psychological field question: how to cope the firefighters with stress experienced at their work. Although we have a lot of research literature on stress and coping processes, it is important to learn and research even more about the psychological effects on firefighters.

Shocking example in 2007 the wildfires have devastated huge areas in the Peloponnese, Greece. Theleritis (2020) examined coping mechanisms and their relation to PTSD in Greek firefighters one month after that event [1]. They visited the affected area and each involved professional firefighters were interviewed by them. They investigated the psychological effects and provided support. One hundred two people were on duty and filled several questionnaires (e.g. Albert Einstein College of Medicine-Coping Style Questionnaire (AECOM-CSQ) [5]. A total of 18.6% of the participants were found to have PTSD according to the ICD-10[2] classification of mental health and behavioural disorders diagnostic criteria recommended by World Health Organization. The results showed that Greek firefighters using mostly minimization and blame with difficulties in their coping which are associated with PTSD. According to a lot of research specific coping mechanisms used by them and might contribute to the development of PTSD. We expect them a lot of competence for example to have good physical fitness, confidence, psychological resilience [6], good communication skills, and of course the ability to work under pressure.

This research was designed to determine the effects of stress in professional firefighters, and the types of coping strategies.

[1] This is a general term for conditions affecting the heart and blood vessels (also called heart disease).
[2] International Statistical Classification of Diseases and Related Health Problems

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2. METHODS

Participants

Eighty-two male professional firefighters participated in this research with a minimum of 20 years old and maximum of 47 from five urban fire departments [7].

Procedure

Endler's (1999) The Coping Inventory for Stressful Situations (CISS) [8] is a 48-item self-report inventory that measures stress-coping methods9]. In three dimensions containing 16 items:

1. Task-oriented coping refers to treating a stressful situation as a problem resolution, and tackling it;
2. Emotion-oriented coping refers to aims at reducing stress in a difficult situation, rather than tackling the problem.
3. Avoidance-oriented coping refers to postpone the stressful situation.

A self-report questionnaire called Coping and Stress Profile (CSP) is a multidimensional and biopsychosocial model that was developed by Olson (1996, 2007) applied the multisystem assessment of stress and health (MASH) model [10]. MASH model examines the effects of 'demands' (stressors) and 'coping resources' on 'adaptation' on the individual level. These components are a measure of stress at four system levels: individual, couple, family, and work in twelve scales focus on dynamic effects. (See Table 1)

Table 1 - Coping & Stress Profile® Scales [10]

Stress	Personal, Work	Personal Stress
		Work Stress
Coping Resources	Personal	Problem Solving Style
		Communication Style

		Closeness Style
		Flexibility Style
	Work	Problem Solving Style
		Communication Style
		Closeness Style
		Flexibility Style
Satisfaction	Personal Satisfaction	
	Work Satisfaction	

3. RESULTS

The Coping Inventory for Stressful Situations

94% of respondents use a task-oriented strategy for the most part to overcome their problems. The remaining 6% can be divided into four parts and emotion-oriented coping as their main strategy. Based on their response just 1 person of the respondents can be classified as those who like the avoidance strategy. (See Figure 1)

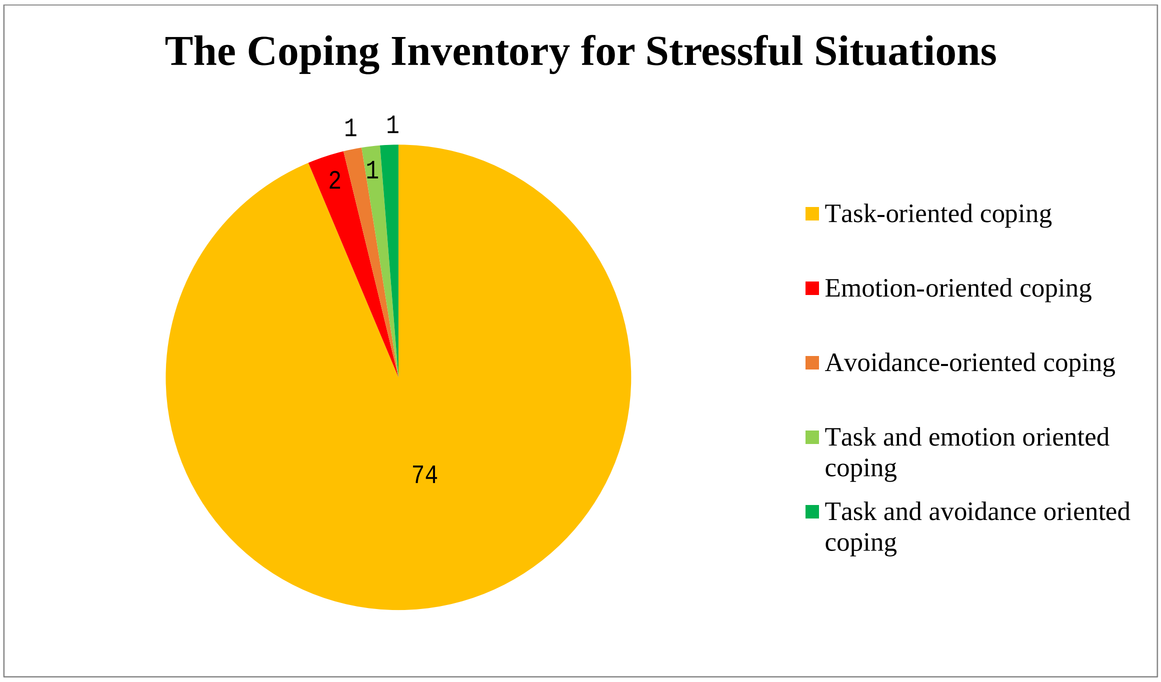

Figure 1 - Results of The Coping Inventory for Stressful Situations

Coping and Stress Profile

Most of the participants not satisfied with the work schedule, their salary and benefits, work supervisors, work relationships, and job characteristics. (See Figure 2). The work stress scale is highlighted by 12 scales, with 58% of the firefighters rated it as high and 6% as very high for work-related stress.

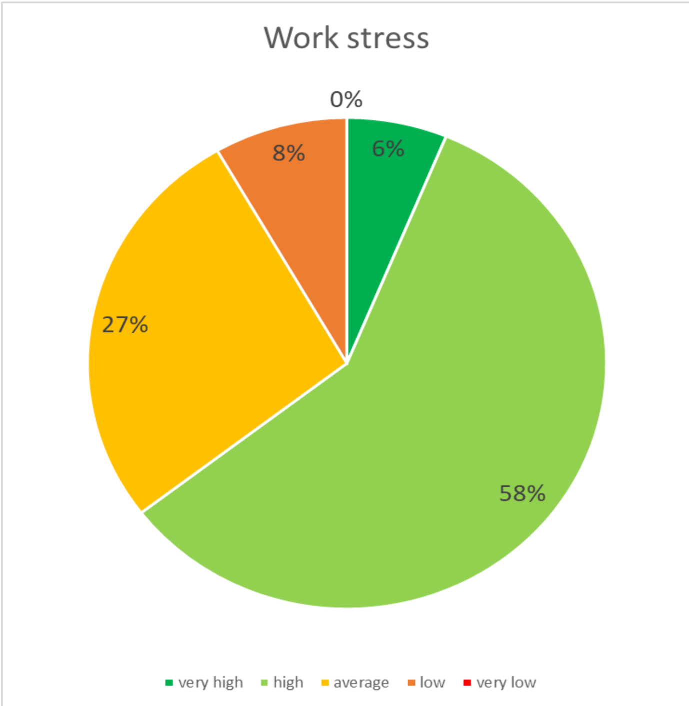

Figure 2 - Work Stress

The Problem Solving skills are a very useful resource how to manage stressful situations. A person with high Problem-Solving skills tends to deal with stress more effectively therefore it is very important in experiencing stress professions. For example, it belongs to how well the person can create new ideas and solutions. (See Figure 3). The chart shows a comparision of professional firefighters problem solving skills versus the average population's.

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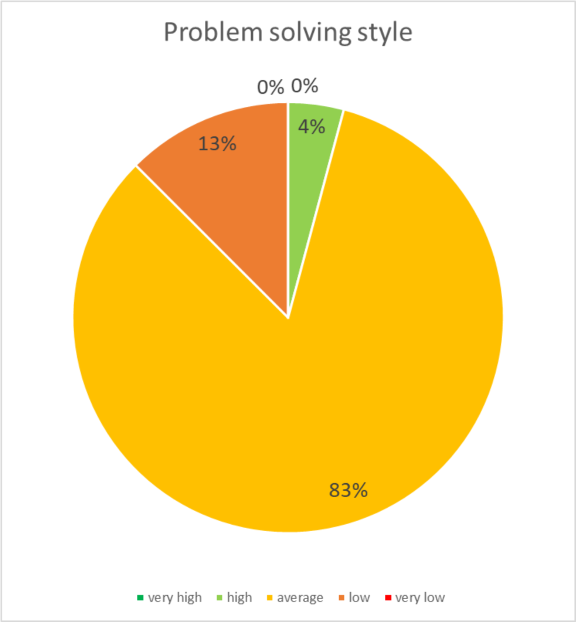

Figure 3 - Problem solving style

Cognitive flexibility is the ability to use different strategies when necessary. From personal aspects, flexibility focuses on the ability to relate to others, from work aspects to assess and adopt changing circumstances. (See Figure 4)

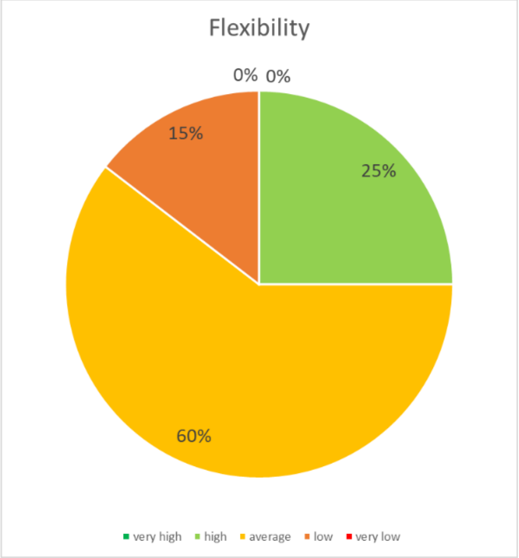

Figure 4 - Flexibility

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Communication is essential in many areas of life. Lack of information can cause great problems in the co-operation within an organization. Half of the respondents say there is a high level of communication in their workplace. (See Figure 5)

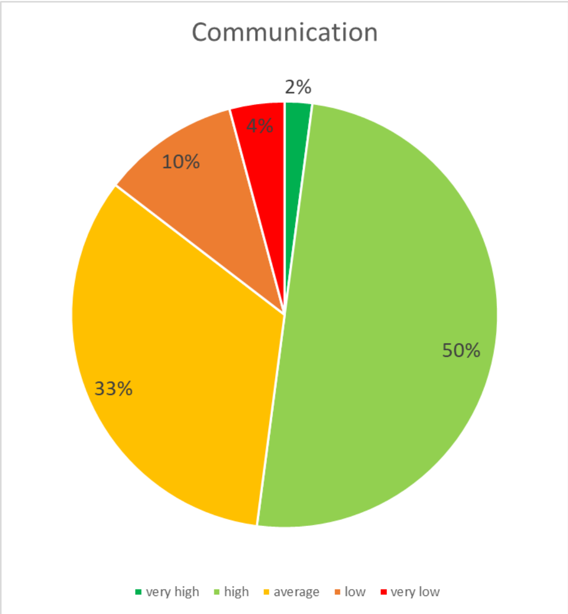

Figure 5 - Communication

For firefighters, the cohesion of the group, the cohesion among the members, and the trust in each other are of extremely importance. In the event of their improper operation or absence, the performance of the task may be compromised and its efficiency may be reduced. Most of the respondents believe that the relationship between staff is strong. (See Figure 6)

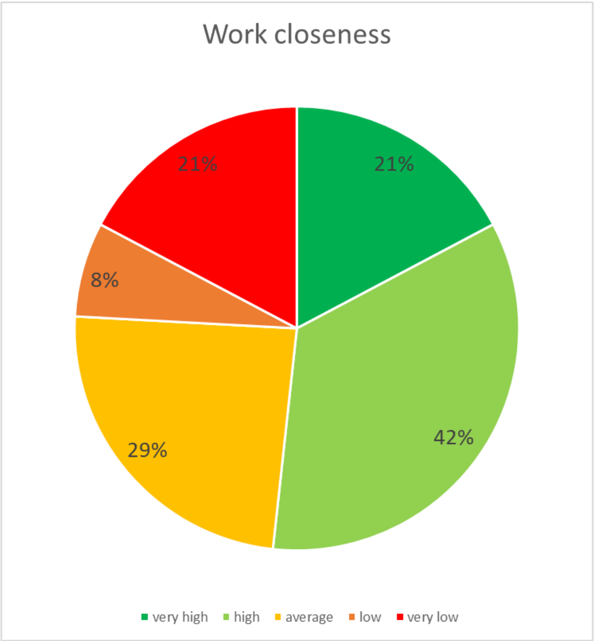

Figure 6 - Work closeness

Work satisfaction is one of the most transparent measure in any professions, organisation and ultimately the life of an individual. Generally speaking the work satisfaction effects on life satisfaction and vice versa. It means that the higher the satisfaction level the better the resistance against work stress. Amongst the analysed population of the professional firefighters only 38% choose high satisfaction, and other 38% is an average. (See Figure 7)

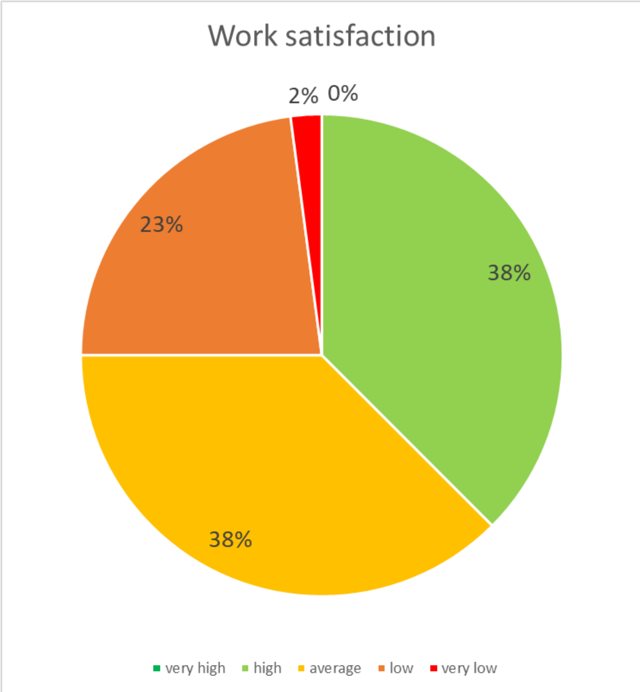

Figure 7 - Work satisfaction

4. DISCUSSION

Overall, the surveys show that the members of the intervention staff who fill in the questionnaires are exposed to the greatest stress during their work, which means an above-average burden on them. The vast majority of the stock responds to stress with appropriate coping strategies, but 20% of them showed above-average results for avoidance issues.

Coping and Stress Profile doesn't take into account job specifics, so "I'm trying to look at the humorous side of the situation." sentence evaluation on a fire department, it is almost inconceivable to show a negative result.

The findings of the study only provides us with an impression how stressful the working life of professional firefighters and as a result how exposed are them to certain consequent disasees. They need more support during and after their duty hours [11].

As a matter of fact this area of psychological analysis worth to continue and actions taken based on that could support longer service period, healthier and happier life for professional firefighters.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Melinda Győri, Zsuzsanna Kerekes, Rhoda Mensah, Ágoston Restás

COMBUSTIBLE PARAMETERS OF NATIVE TIMBER MODIFICATED BY BLOKK WOOD METHOD

Abstract

Wood is one of the most ancient building material. It is available anywhere, it is easy to shape, it is flexible and strong enough to make it an excellent building material. The use of wood also has a disadvantage, which is the flammability. There are countless literatures and procedures in the topic of the flame retardancy. The modification involves the use of wood preservatives. The authors present the so-called BlokkWood method used in Hungary as a new procedure and its effect, supplemented with their own tests. The wood were subjected to several types of testing. These are partly standard and partly non-building material standard, but in case of fire, the effect must be taken into account. The specimens were mainly Hungarian wood species. The purpose of the paper is to investigate whether the BlokkWood method is suitable for the efficient modification of trees.

Keywords: flame retardant of wood, fire tests, modification of wood, BlockWood method

BLOKK WOOD ELJÁRÁSSAL MODIFIKÁLT HAZAI FAANYAGOK ÉGHETŐSÉGI PARAMÉTEREI

Absztrakt

Az ember számára a faanyag az egyik legősibb építőanyag. Beszerzése egyszerű, könnyen alakítható, megmunkálható, rugalmas és szilárdsága is megfelelő ahhoz, hogy kitűnő építőanyag lehessen belőle. A faanyagok növekvő használata mellett mindig ott volt a komoly probléma is: hogyan lehet az éghetőséget csökkenteni. Óriási kutatási háttere és szakirodalma van a fák égéskésleltetésének, számtalan eljárás létezik. A modifikálás maga faanyagvédelmi szerek alkalmazását jelent. A szerzők a cikkben egy Magyarországon új eljárásként alkalmazott az ún. BlokkWood módszert és hatását mutatják be, kiegészítve saját vizsgákatokkal. Többféle vizsgálatnak vetették alá a kezelt fákat. Ezek részben szabványos, részben nem építőanyag szabványos, de tűz esetén mindenképpen számolni kell a hatásával. Igen nagyszámú minták a hazai fafajok közül kerültek ki. A cikk célja megvizsgálni, hogy a BlokkWood módszer alkalmas-e a fák a hatékony modifikálására.

Kulcsszavak: fa égéskésleltetés, tűzvédelmi vizsgálatok, fák modifikálása, BlockWood módszer

1. INTRODUCTION

Wood is one of the most ancient building material. Wood is available anywhere, it is easy to shape, it is flexible and strong enough to make it an excellent building material [1] [2] [3]. In addition to the increasing use of the wood, there has always been a serious problem with it: how to reduce its flammability? We can find many literatures in connection with the flame retardant of wood and case studies of the firefighting [4] [5] [6] [7]. Modification is a process that changes the composition of the wood in order to give new properties for it [8]. It can extend the application area and ensure the production of new products. We would like to present the so-called BlokkWood method used in Hungary as a new procedure and its effect, supplemented with our own tests. The treated woods were examined in several forms such as partly standard (fire propagation, mass loss) and partly non-building material standard (radiant heat effect), but in case of fire its effect must be taken into account.

2. PROPERTIES AND COMBUSTION OF WOOD

Wood can also be called three-phase solid structures.

The main components of the cell wall of the wood structure are the followings:

- 50% carbon

- 6% is hydrogen
- 43% is oxygen
- 1% is other materials

N, P, S - metallic elements: B, Mn, Cu All wood are 99% same in composition. More than 100 tree species are known on Earth, and this is due to the remaining 1%. The most characteristic feature of wood is that their flammability does not depend on their chemical composition, but primarily on their porosity. The porosity of wood depends on the type of wood, the density of wood (ζ=m/V) 800-400 kg/m^3 and the environmental conditions (arable land, climate, open space). Regarding the density of the wood, it can be said that its value without a solid cell cavity is the same in case of all trees (1.56), only their structure differs from each other [9].

Distribution of tree species in Hungary:

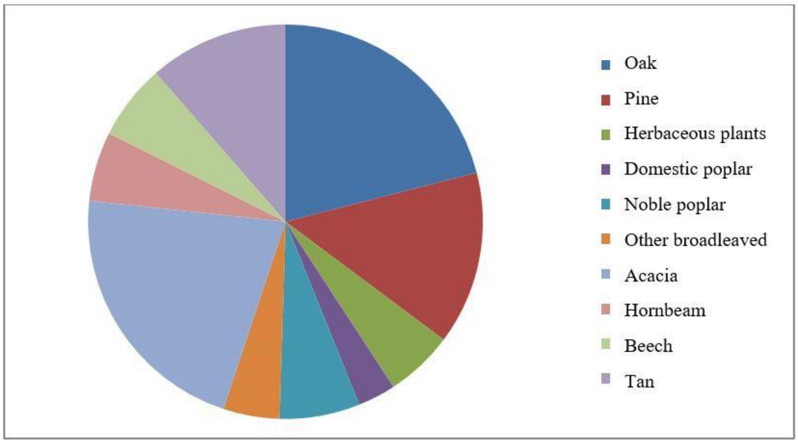

Figure 1 - Distribution of tree species in Hungary. Created by the Authors.

The combustion of wood

The flammability of wood is well known. Taking into account the properties of the wood material and its properties determined by its tissue structure, its fire resistance can be planned and controlled. In terms of flammability, architects are working together with professionals to reduce the flammability of wood. The fire behaviour of wood is not as unfavourable as many people think. Both theory and practice show that metal structures lose their load-bearing capacity and stability quicker than the wood structures. Acacia has the most favourable burning properties. It has the highest energy heat radiant and the highest glow resistance. The rate of flame propagation in the direction of the fibre cannot be evaluated, and the value perpendicular to the fibre is the lowest. In contrast, poplar has the worst properties [10].

3. MODIFICATION PROCEDURES

The main wood modification procedures and their mechanisms [11]: The modification can basically be divided into two major groups:

- *Active processes*: the process of changing the chemical structure of a substance (chemical modification).
- *Passive processes*: during the process, the properties of the material change, but the chemical structure remains unchanged (physical modification) [9].

Grouping of modifications according to their mechanism of action:

- Filling cell cavities
- Filling the cell wall
- Reaction of OH groups
- Coupling of OH groups
- Change the cell wall structure [12] [13].

Chemical modification

It is a process where the components of a chemical reagent and a wood polymer react with each other, thereby forming a covalent bond. The purpose is to reduce the OH groups during the modification. Its role in the modification is: Most modification processes affect these in some form. Their amount affects the water adsorption and the dimensional stability of the wood.

Main chemical modification processes:

- Esterification reactions of wood (acetylation with acetic anhydride, ketene, acid chloride)
- Furfurylation (with furfuryl alcohol, complex reactions)

- treatment N-methylol-DMDHEU (Dimethylol dihydroxyethylene urea) reacts with the OH groups of lignin and hemicellulose and is able to convert itself into a complex polymer
- Reactive oil treatment (with linseed oil) at increased temperature
- Impregnation of the cell wall [9] [12].

The main characteristics of thermal modification

Thermal modification is still used with the so-called BlockWood technology in Hungary. The company combines continuous temperature change and a special catalyst during the processing of wood. Another feature of the product is that the wood can no longer to absorb the moisture, so it is also suitable for buildings with more durable structures. During the process, the macromolecular system undergoes chemical changes due to heat transfer. This modifies the following physical and biological characteristics of the wood. We can find significant differences between the individual tree species. For example, green trees are characterized by intense weight loss during the modification process [12] [13] [14].

Test specimens

Treated and untreated test specimens were provided by the BlokkWood company (Figure 1, Table 1).

Table 1 – Type of specimens and their markings

Specimen	**Marking**
Ash 1.	K1
Ash 2.	K2
Treated ash 1.	KK1
Treated ash 2.	KK2
Long treated ash 1.	KK3

Long treated ash 2.	KK4
Poplar 1.	NY1
Poplar 2.	NY2
Treated poplar 1.	NYIK1
Treated poplar 2.	NYIK2
Birch 1.	NYÁ1
Birch 2.	NYÁ2
Treated birch 1.	NYÁK1
Treated birch 2.	NYÁK2
Pine 1.	F0
Pine 2.	F1
Treated pine 1.	FK1
Treated pine 2.	FK2

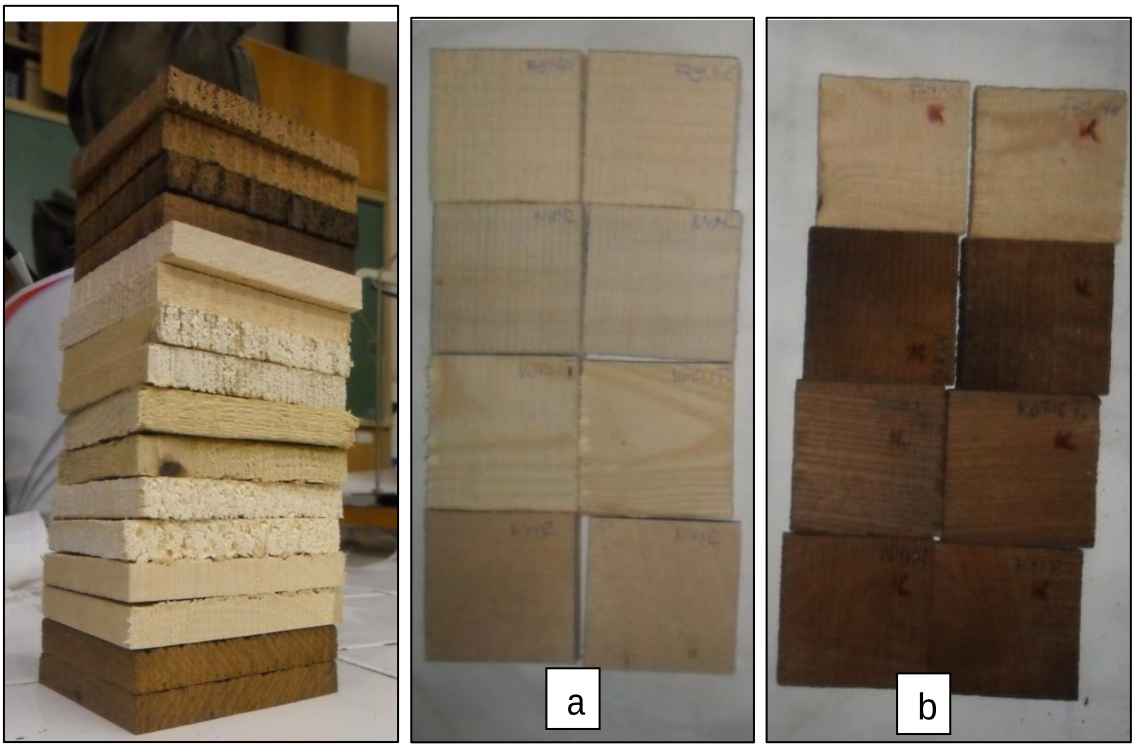

Figure 1 - Test specimens **a)** untreated, **b)** treated (modified). Created by the Authors.

4. TEST METHODS

We selected four types of the combustion tests. The test method follows the change that a wood specimen undergoes during combustion. We made the tests in the Fire Protection Laboratory of the University of Óbuda.

1. Testing of wood and wood substituting materials treated with flame retarding substances. Method of Lindner (According to MSZ 9607/1-83).

The device illustrated in Figure 2 shall be used to verify the effectiveness of the flame retardant treatment. The size of the specimens is: 10cm*10cm*1 cm. The surface of the specimen is ignited until all of the hexamethylene tetramine is burned. The combustion material must be ignited and the specimen should place quickly on the combustion opening (Figure 2). It is important that the specimen covers the entire combustion opening (Figure 3).

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Figure 2

Figure 3 Figure 4

Burning of wood specimens in a Lindner device. Created by the authors.

Classification of the material: the preservative treatment is appropriate if the weight loss of the specimen in case of protected wood does not exceed 2.5 g.

2. Horizontal flame propagation speed test according to DIN 75200 and ISO 3795 standard.

The test was performed in an ATLAS DHW (Horizontal Flame Chamber) (Figure 5).

The size of the specimens was: 33cm*10cm*1 cm.

Classification of samples: We should observe whether the flame reaches 38 mm length in 30 seconds and extends up to 254 mm.

We give the rate of the flame propagation (mm/min).

Materials which do not reach the 38 mm flame length in 30 seconds, we assumed their flame spread rate as 0.


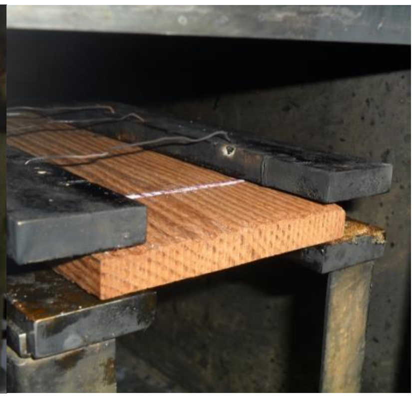

Figure 5 Figure 6 Figure 7

Burning of wood specimens in horizontal arrangement. Created by the authors.

3. The third test is the vertical flame propagation rate according to DIN 4102 and ISO 11925-2 standard.

Test procedure: The test specimen is placed in a metal support structure. The size of the specimens is: 33cm*10cm*1 cm. The limit at 150 mm should be marked on the specimen. This limit is the criterion for flame propagation within 20 and 60 seconds.

We place the PG flame 40 mm high at a distance of 1 cm from the mounted specimen. After that we heat the specimen for 20 seconds (Figure 8). After 20 seconds we stop the gas flame and with a stopwatch we measured when the resulting flame goes out (Figure 8-9). We recorded all these values in a protocol.

Evaluation of the test: From the measurement of the combustion length and the time, the vertical flame spread rate of each material can be calculated [mm/min]. It is generally stated that materials do not reach the 150 mm limit in 20 seconds. So, in our opinion, the modification of a wood cannot be qualified by specifying the vertical flame spread rate.



Figure 8 Figure 9 Figure 10

Burning of wood specimens in vertical arrangement. Created by the Authors.

4. The fourth test was to measure the ignition time with radiant heat according to the ISO 9239-1 standard

The name of equipment we used in the test: KALVK 1.

The temperature of radiant iron core: 700 °C, released heat flux: 2±0,2 W/cm^2 at a distance of 3 cm from the heating core (Figure 11). The size of the specimens during the examination: 7cm*7cm*1cm

Test procedure: The specimen should be placed under the heat-emitting core and then measured with a stopwatch to see when it begins to smoke, glow, or flame, and when it burns across the entire cross-section (Figure 11-16). We recorded these values in the protocol.

Figure 11 - KALVK 1, radiating iron core. Created by the Authors.

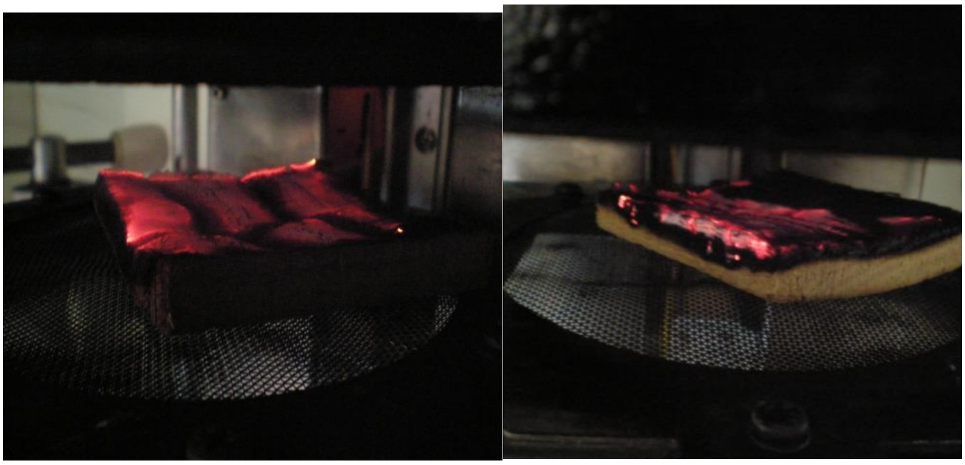

Figure 12 - Deformation of specimens under heat load. Created by the Authors.

5. FIRE INVERSTIGATION RESULTS

During our investigations we obtained the following results in relation to the modified wood materials:

In case of the weight loss test, none of the wood types (both treated and untreated) correspond (Figure 14). It should be emphasized that during the test the poplars also burned over the entire cross-section (1cm).

It can also be observed that the treated ash for a short time has the greatest weight loss. However, this value is not much lower for other treated and untreated ash or birch. Treated poplars have the lowest value among both treated and untreated wood.

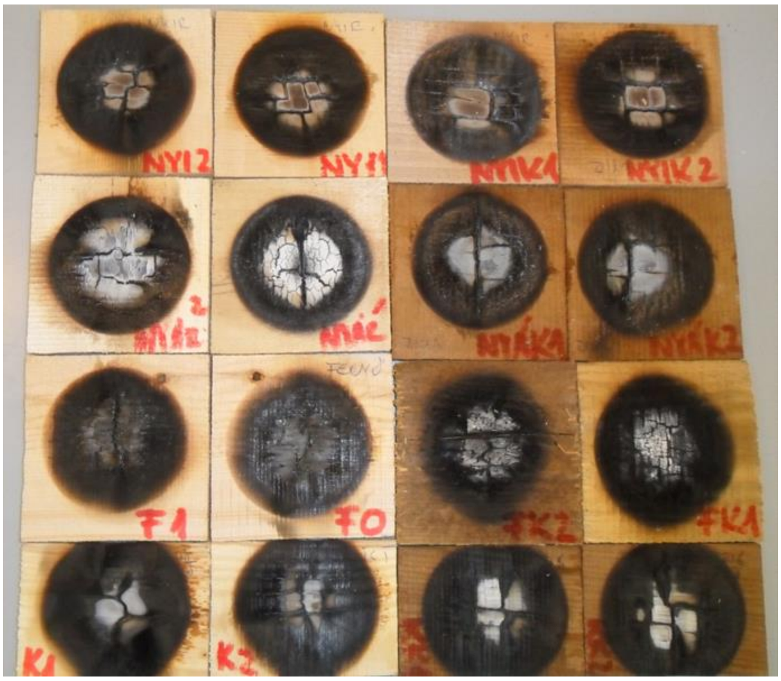

Figure 13 – Specimens used in the Lindner test. Created by the Authors.

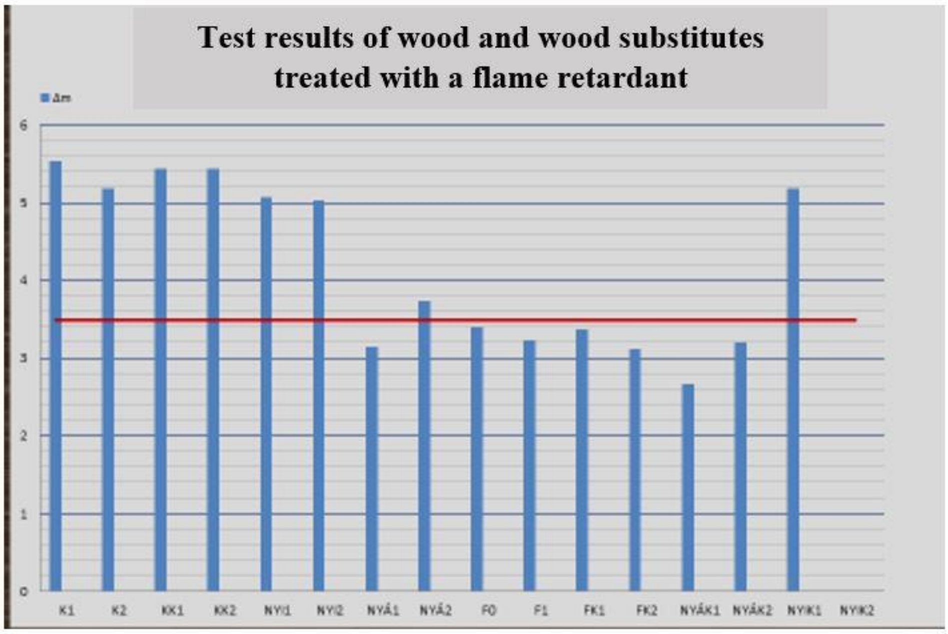

Figure 14 - Mass losses during the Lindner test. Created by the Authors.

All woods reached a low value in terms of *horizontal flame propagation speed*. During the test time (30 sec), none of the specimens showed a significant propagation speed. The best values are obtained in case of long treated ash, which has practically zero flame propagation speed. Of the untreated wood, birch and ash have the lowest values. In contrast, treated and untreated poplar showed the worst (highest) values.

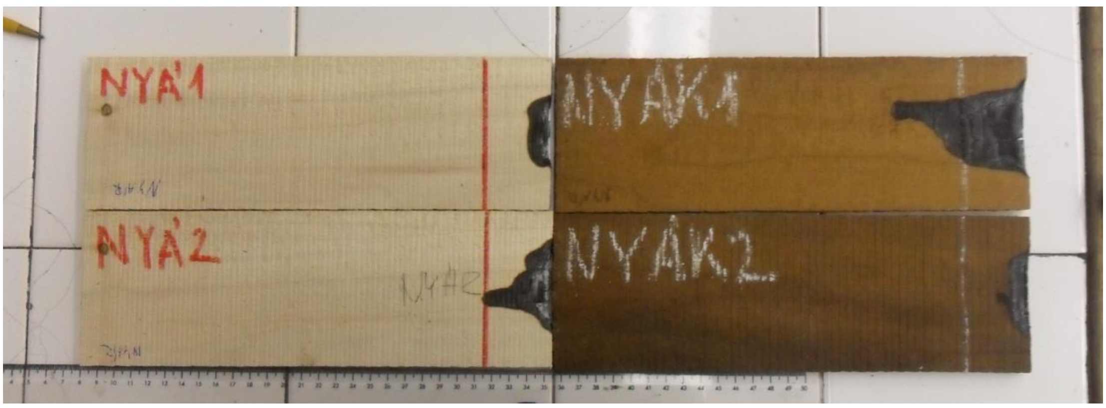

Figure 15 - treated and untreated poplar showed the longest burning result. Created by the Authors.

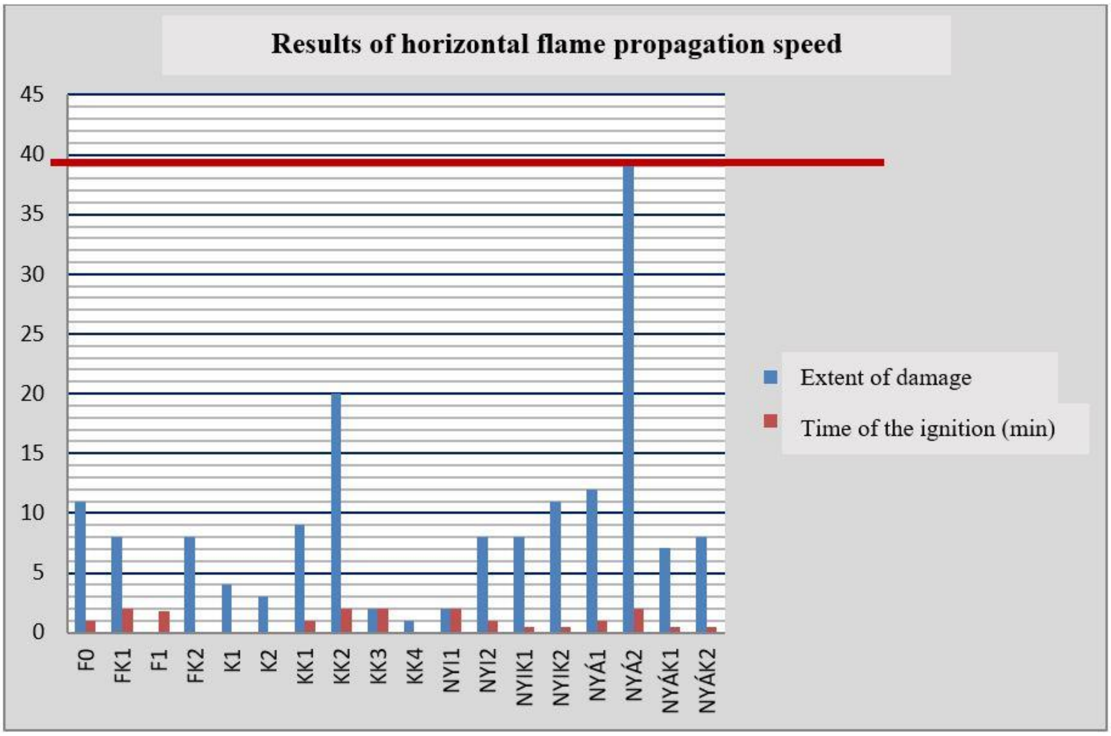

Figure 16 – Horizontal burn of the specimens. Created by the Authors.

In case of the *vertical flame propagation rate*, the untreated and long-treated ash and the untreated and treated pine showed the best results. According to the standard, they did not ignite in 20 seconds, so their vertical flame propagation is practically 0. The reason for this is that the ignition temperature has not been reached in the given time. Poplar and birch showed worse results. The highest value was shown by untreated poplar, which reached the 150 mm limit in 54 seconds.

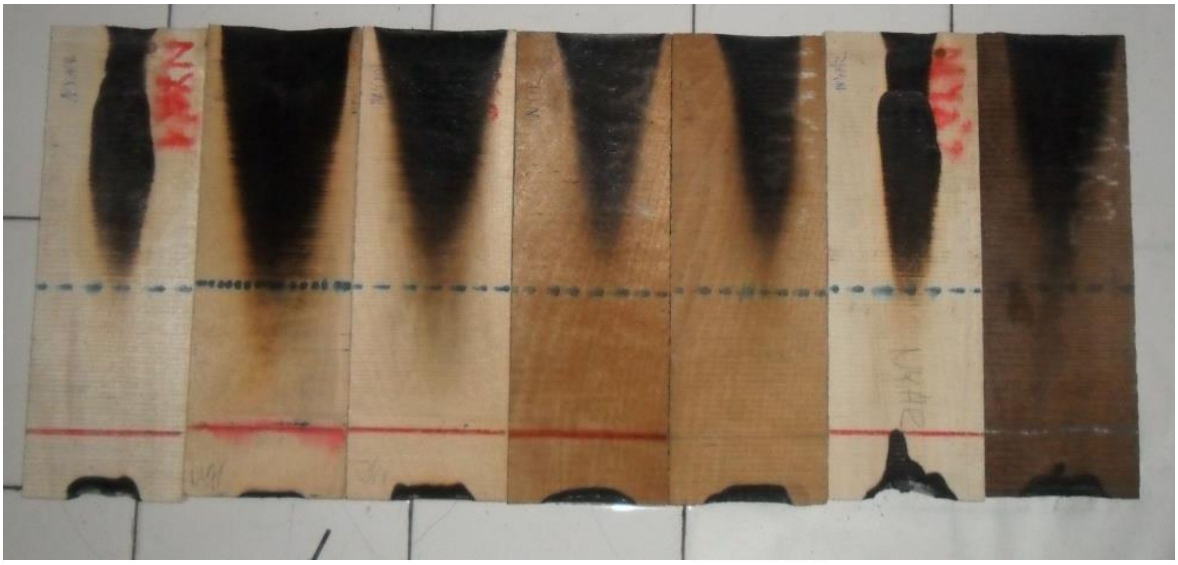

Figure 17 - Some specimens of the vertical flame propagation rate after the test. the Authors.

Combustion of the ignition time with radiant heat resulted in two types. In the first case, the distance between the specimen and the radiating iron core was 3 cm and the heat flux was 2 ± 0.2. Because of these parameters, no specimens ignited but they were burned by solid phase combustion. Ash showed the best results and the poplar showed the worst. In the second case, the distance between the specimen and the radiating iron core was 1.3 cm and the heat flux was 2.6 ± 0.2. In case of this setting, most of the specimens exploded, with an exception of the untreated ash, which burned with solid-phase combustion. The last time the ash specimens ignited, while the untreated and treated poplar was the earliest.

Figure 18 – (2 W/cm^2) All of the specimens after ignition. Created by the Authors.

6. SUMMARY

Euroclass certifications are not sufficient for the use of wood for construction purposes. There are different combustion conditions behind the tests. As a result, a different rating is given to the same wood. The effect of modification procedures and the flame retardant effect is not equally prevailing during the various combustion tests. Based on our few results, we can determine that the modified wood (typically untreated wood) can be classified into class C and Cn. This is because both vertical and horizontal flame propagation rates are negligible. However, weight loss and smoke generation justify classification in the worse category. The accuracy of the classification is also confirmed by the results of the flash point test we made on a few pieces. Studies like this can also support other researches in the topic [15].

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VÉDELEM TUDOMÁNY
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EXAMINATION INITIAL PARAMETERS OF FIRES FOR FIRE SPREAD SIMULATIONS

Abstract

Due to the continuous development of building materials and technologies, the study of indoor fires and heat load on building structures are topical issues nowadays. Despite modern construction and the use of modern fire protection equipment, fires occur in buildings on a daily basis. Some of the fires occur in the premises of residential buildings, so we consider it important to study the spread of a fire in an average room and its effects on building structures with the help of a unit fire. In fire spread simulations the initial model of the fire is a key issue. In our research a model of unit fire was created and examined in simulation environment, which is presented in detail in this paper. It was examined how the initial parameters of the fire affects the simulation results. With our experience, we want to help the work of fire designers and to contribute to fire prevention.

Keywords: unit fire, fire load, numerical simulation, fire prevention

A TŰZ KIINDULÁSI PARAMÉTEREINEK VIZSGÁLATA TŰZTERJEDÉSI SZIMULÁCIÓHOZ

Absztrakt

Az építőanyagok, építési eljárások és technológiák folyamatos fejlődése miatt az épületekben keletkezett tüzek vizsgálata, a tűzterjedés és a hőterhelés épületszerkezetekre gyakorolt negatív hatásainak vizsgálata aktuális kérdések napjainkban. A korszerű kivitelezés és modern tűzvédelmi berendezések alkalmazása ellenére is naponta keletkeznek épületekben tüzek. A tűzek egy része lakóépületek helyiségeiben keletkezik, ezért fontosnak tartjuk írásunkban egységtűz segítségével vizsgálni egy átlagos helyiségben keletkezett tűz terjedését, valamint az épületszerkezetekre gyakorolt hatásait. Kutatásunk során először az egységtűz modelljét készítettük el, azután az adatok felhasználásával számítógépes szimulációt végeztünk, melyet részletesen bemutatunk. Tapasztalatainkkal a tűzvédelmi tervezők munkáját kívánjuk segíteni és a tüzek megelőzését elősegíteni.

Kulcsszavak: egységtűz, tűzterhelés, modellezés, számítógépes szimuláció, tűzmegelőzés

1. INTRODUCTION

IT developments have become increasingly important in the field of fire protection in recent years. Various computer programs also aid fire protection planning and fire investigation. Fires in different buildings have been investigated in several studies from different perspectives. The most commonly studied fields are fire propagation, the consequences of heat, the properties of combustion products generated during combustion, and the fire protection properties of building materials [1-3]. Other studies have examined the effects of smoke on people and the environment, the possibilities of reducing the heat load and the problem of firefighting [4-6]. It can be stated that it is an important task to study damage of fire spread on building structures and the effects of the generated heat. Due to the tightening of environmental standards 1:1 scale fire tests can only be carried out in exceptional cases. Therefore it is effective to use computer simulation before real tests, for which the experience of fire cases occurred can be used. The aim of the research is to study fire spread in the room of an average apartment using computer simulation. To create the initial model preliminary calculations were performed taking into account the amount of combustible materials in the room, then we using the data a computer simulation was created to study the effects more accurately. For simulations FDS (Fire Dynamic Simulator) was used [7].

2. EXAMINED ROOM

The simulation model was based on an average size room common in Hungary (Figure 1.). The inner height is 2.65 m. In the simulation model the opening were a standard size door and a double window.

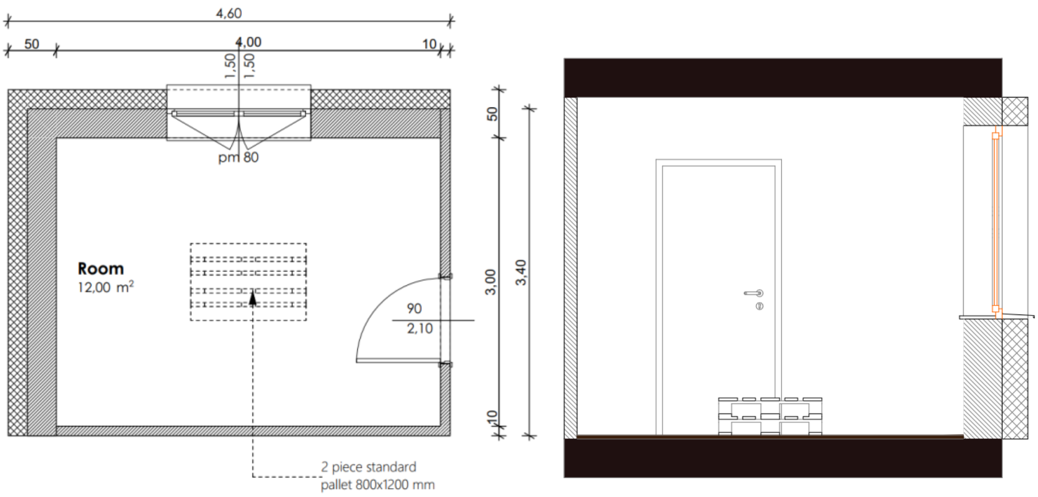

Figure 1.: Floor plan and overview of the examined room (by Authors)

Regarding the furnishing of the room a unit fire was modelled. 2 EUR pallets placed in the middle of the room were the combustible material. Fire load should be calculated to get a starting point for computer simulation.

The materials used for the experiment and their combustion characteristics are given in the following table:

Material	Quantity (kg)	Ignition temperature (°C)	Heat of combustion (MJ/kg)	Density (kg/m^3)
Pallet (pine)	40	260	16,75	600-900

Table 1. Combustion characteristics of furnishings and built-in combustible materials in the examined room. (by Authors based on [8])

Before starting the simulation the temporary fire load was calculated, for which the following formula was used:

$$\boldsymbol{p_n} = \frac{\sum_{j=1}^{n} \boldsymbol{M_i H_i}}{\boldsymbol{S}} \tag{1}$$

where

p_n is the temporary fire load

M_i is the mass of the ith material (kg)

H_i is the calorific value of the ith combustible material (MJ/kg)

S is the floor area of building or part of building (m^2)

j is number of materials included in temporary fire load

Completing the calculation, the value of temporary fire load is:

$$\boldsymbol{p_n} = \frac{\sum_{j=1}^{n} \boldsymbol{M_i H_i}}{\boldsymbol{S}} = \frac{\boldsymbol{670}}{\boldsymbol{12}} = \boldsymbol{55.83}\ \mathrm{MJ/m^2} \tag{2}$$

The temporary fire load has to be calculated in order to have information on the thermal effects damaging the building structures. Building structures do not contain combustible material, so a constant fire load does not need to be calculated. Adding the temporary and permanent fire loads, the calculated fire load can be obtained, which in our case is the same as the temporary fire load.

3. SIMULATION MODEL

The simulation model is shown in Figure 2. The fire can be defined in 2 ways: with specifying the HRRPUA (heat release per unit area) value of the fire of by giving the material properties and starting the fire with an ignition particle.

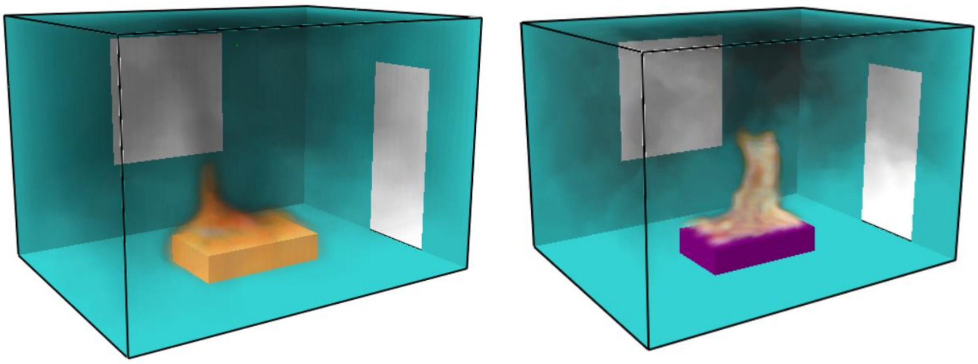

Figure 2.: Fire models (left: fire is given with its HRRPUA value, right: fire is is started with ignition particles)

In the first case the fire parameters can be easily adjusted. With a ramp function the start and the extinction of the fire can also be examined. The second setting gives a realistic material based fire. Burning of the object and the temperature change inside the object can also be simulated (Figure 3.).

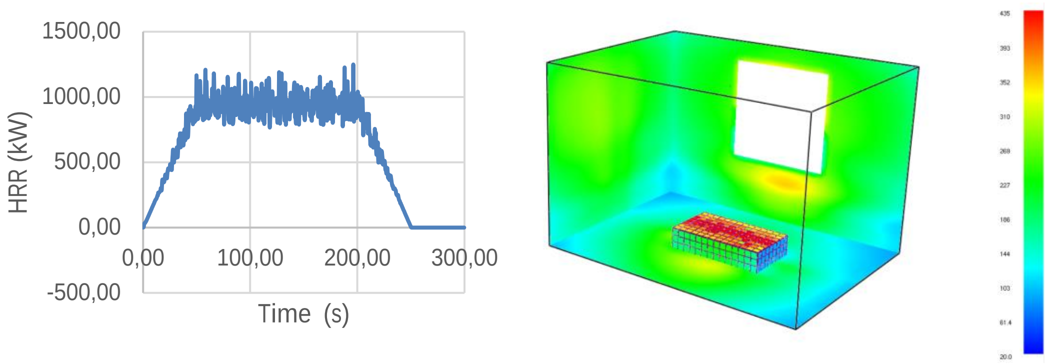

Figure 3.: Fire modelling with ramp function (left) and wall temperature in case of a fire started with igniton particles (right)

According to the literature the initial fire is usually given with its HRRPUA value [9]-[10], there is only few examples of starting a fire with ignition particles [7]. Therefore In this study the first simulation setting is studied in detail. The temperature, the CO concentration and the O_2 concentration are the output values. It was examined how the HRRPUA value of the fire and the CO yield of the reaction fuel affects the simulation. The reaction fuel was propane.

Before starting the simulation a short mesh sensitivity study was carried out. The results of the mesh sensitivity study is shown in Figure 4. and Table 2.

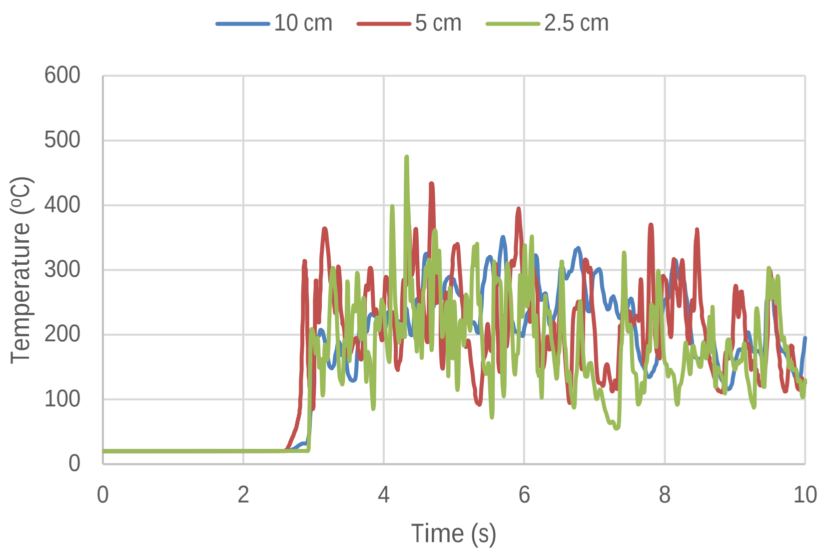

Figure 4.: Mesh sensitivity study

	10 cm	5 cm	2.5 cm
Calculation time (s)	152	1393	20300
Max. temperature (°C)	350.93	433.95	474.98
Average temperature (°C)	189.2144	169.1941	141.1186

Table 1.: Mesh sensitivity study results

It can be seen that there was no significant difference between the simulations with different mesh sizes. The average temperature was similar in all cases. There was larger difference in case of the maximum temperature. The calculation time was much less in case of larger mesh size. The aim of the study was to test the effect of the initial fire parameters, therefore in order to reduce the calculation time the largest mesh size (10 cm) was chosen. The sensors were placed in the middle of the room 30 cm from the ceiling.

4. RESULTS

The effect change of HRRPUA value on the temperature, CO concentration and the O_2 concentration are shown in Figure 5.-Figure 7. The HRRPUA value of pine wood is around 150 kW/m2 [11], therefore the HRRPUA value of the fire was changed from 50 kW/m2 to 300 kW/m2.

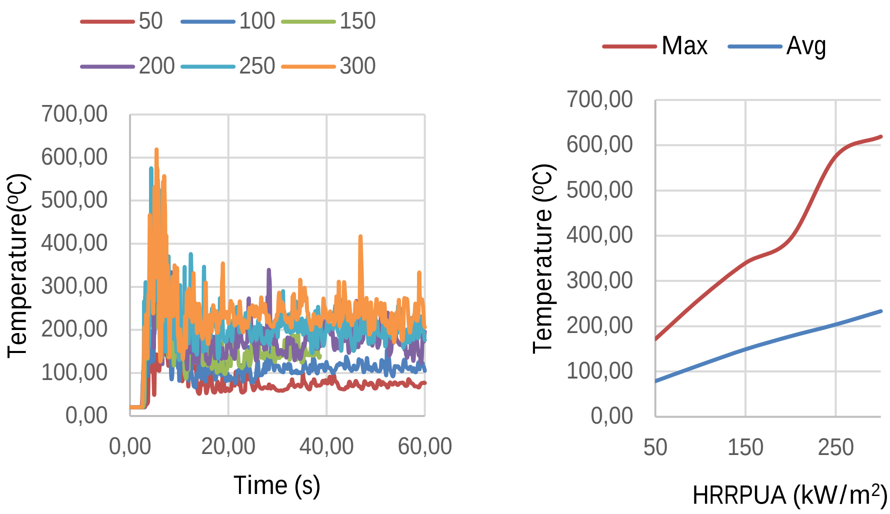

Figure 5.: The effect of changing the HRRPUA value of the fire ti the temeprature

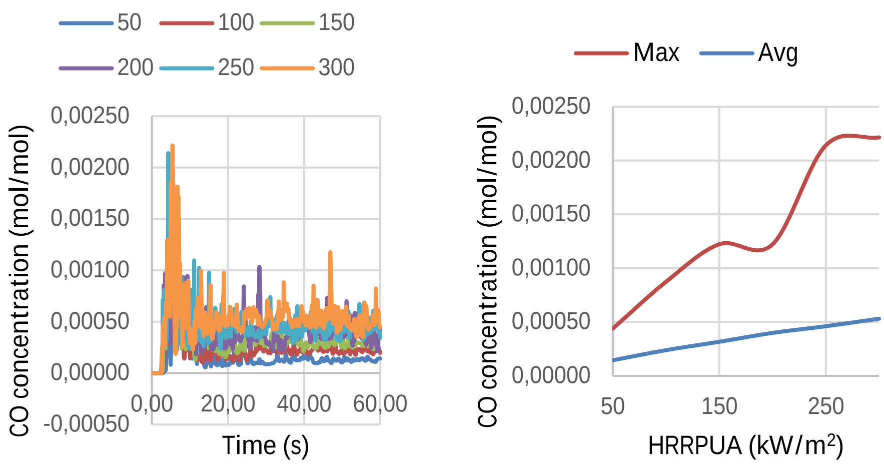

Figure 6.: The effect of changing the HRRPUA value of the fire to the temeprature

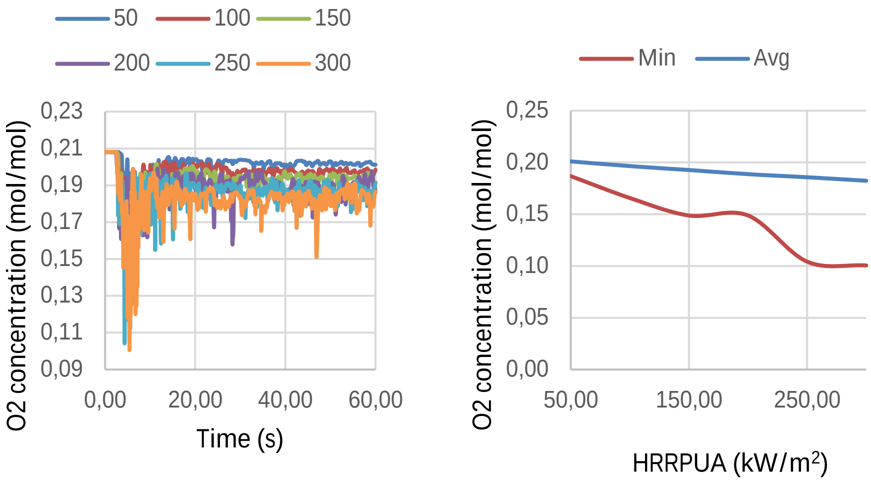

Figure 7.: The effect of changing the HRRPUA value of the fire to the O2 concentration

It can be seen that as HRRPUA was increased the temperature and the CO concentration increased and the O_2 concentration decreased. The average values changed linearly in all cases. The maximum value of the temperature increased first with a smaller slope, then with a larger slope and then again with a smaller slope. The CO concentration first increased, then decreased and then it increased again. The O_2 concentration decreased first and after it increased and it decreased and it became constant. At the time dependent diagrams it can be observed, that the largest values are reached at the beginning of the simulation. It is because the fire starts rapidly and after remains constant. Because there ventilation because of open door and window after a short time the values oscillate around an average value.

It was also observed how the CO yield of the reaction gas affects the simulation results. The HRRPUA value of was 150 kW/m^2. In case of the temperature and the O_2 concentration there was no significant change therefore only the CO concentration is presented (Figure 8.).

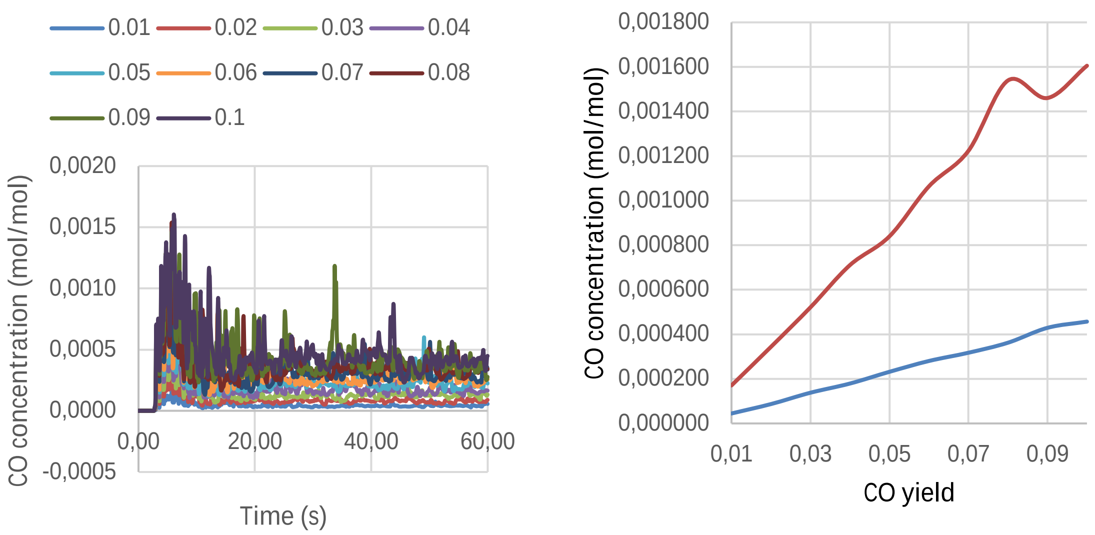

Figure 8.: The effect of changing the CO yield of the reaction fuel to the CO concentration

It can be observed that the CO concentration is increased as the CO yield of the reaction fuel is increased. The average value changes linearly. In case of the maximum value there is a linear increase till 0.08 and after that it remains constant.

5. SUMMARY

In this study the effects of changing the initial parameters of the fire was examined. An average size room common in Hungarian compartments was the basis of the simulations. It was observed that changing the heat release rate per unit area of the fire linearly increases the average temperature and the CO concentration and decreases the O_2 concentration. Increasing the CO yield of the reaction fuel increases the average CO concentration. In case of the maximum value of the examined output values there oscillations. It is the task of further research to find out the cause of it. It was also observed that the peak values occurred at the start of the simulation. The cause of it that the fire started rapidly and there was ventilation in the room it, therefore after the transients the examined output variables oscillated around an average value. It can be concluded that fire can be effectively modelled using its HRRPUA value, however this value should be chosen carefully. A further research task is to model the fire with material and ignition particles and compare it to the results presented in this paper.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

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EFFECT OF THERMAL BEHAVIOUR ON BURNING OF PLASTIC COATING FOR ELECTRIC CABLES

Abstract

Cable is in the first place amongst the cause of fire. Fires are always triggered by unsafe and non-standard conditions, so, we can approach safety if we know the properties of cables we want to use. Cable fires may have two starting points: one is the heat reaching the plastic insulation of cables, due to the fire created by burning, the other one may be due to the fire generated by the overvoltage in the inappropriately sized cables when the outer plastic coating begins to burn. The basic condition of fire retardant is that wire breaks or short circuits may not occur in a cable system. During this research, both effects are tested on fire retardant cables.

On the one hand, we exposed wires of various plastic sheaths to flame and to heat, as well as tested at which actual oxygen content they start combustion and flame propagation.

Each combustion starts with thermal decomposition, so it is of particular importance in the thermal behavior of plastic coatings and the expected burns. The selected samples were examined by thermoanalytical method (DTA, TG, TDG). The most important parameters are the weight loss and the initial temperature of the decomposition, which also indicate the expected ignition point of the plastics.

Keywords: fire-resistant cable, electric fires, cable fires, thermal decomposition and pyrolysis of plastics, cable fires

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

HŐSZIGETELÉS HATÁSA A MŰANYAG BEVONAT ÉGÉSEKOR ELEKTROMOS KÁBELEK ESETÉN

Absztrakt

Az elektromos vezetékek tűz okozói is lehetnek, fokozzák a tűz továbbterjedését, nagyobb károk bekövetkezéséhez járulnak hozzá. Az elektromosság, mint tűzkeletkezési ok a leggyakrabban visszatérő probléma, általánosságban világviszonylatban az összes tűzeset felében, beleértve a fejlett országokat is. Az elektromos vezetékek-tűzvédelmi rendszerek részét képzik, és a tűz okozói között első helyen vannak. Különböző műanyag burkolatú vezetékeket vetettük alá hőhatásnak. A kábelek hő, láng hatására termikus átalakuuláson mennek át, amelyek folyamtát derivatográfos vizsgálatokkal is követtük, abból a célból, hogy milyen hőbomlási és pirolízis folyamatok vezetnek a kábelek égéséhez.

Minden égés termikus bomlással indul, így különös fontossága van a műanyag burkolatok termikus viselkedésének. A kiválasztott mintákat termoanalitikai módszerrel (DTA, TG, TDG) vizsgátuk. Leglényegesebb paraméterek a tömegveszteség és a bolmás kezdeti hőmérséklete, amely utalnak a műanyagok várható gyulladáspontjára is

Kulcsszavak: tűzálló-kábel, elektromos tüzek, kábel tüzek műanyagok hőbomlása és pirolízise, derivatogramm

1. INTRODUCTION

Electric cables have a dual role from a fire protection aspect:

1) they are part of fire protection systems and assist in escaping and rescue,

2) they may be the cause of fires, increase the propagation of fire and contribute to greater damages.

Electric current is the commonest cause of fire; worldwide, half of all the fires, causing injuries, death, material damage, failures, and very often, the complete destruction of devices [1]. In

Hungary as well, electric fires have also been increasing in recent years and are the second commonest cause of fires [2].

The amount of temperature required for ignition is primarily defined by the kind and condition of the insulating material used in electrical conduit systems. The ignition of plastics occurs at 300-400 °C, which results from a complex sequence of events, whose last phase immediately before ignition is

- the formation of electric arc, or
- excess heat developing due to operation.

Cable design, insulation and sheathing materials together determine the efficiency of cables against flame ignition and propagation [3]. Fire-resistant cables, so-called low-fire-hazard cables (LFHCs), have been developed to satisfy the requirements of low flame propagation and heat release together with very low emission of smoke and hazardous gases [4,5] and should be used in such situations. Polyvinyl chloride (PVC) is one of the most widely used polymers in the field of electrical and control cables. When considering flammability in general, PVC is essentially considered to be self-extinguishing. However PVC is able to support flame propagation along its length. Passive fire protection are coatings and firestops, and the use of inherently flame-retardant materials [6]. The propagation of fire along PVC sheathed electrical cables may be diminished by using either flame-retardant smoke-suppressant (FRSS) additives, AND/OR by applying fire-retardant intumescent coatings to the surface of the cable sheath.

Fire-proof functionality is made by using organic or inorganic flame retardants as cable compounds, to reducing flammability, delaying combustion or inhibiting fire spread. Large quantities (60–70%) [7,8] of inorganic filler materials such as metal hydroxides (aluminum trihydroxide, $Al(OH)_3$, or magnesium hydroxide, $Mg(OH)_2$) are widely used. Their interaction with fire has previously been described by many authors [9,10,11,12] and can be briefly summarized as follows:

- retardants slow the thermal decomposition of the overall material by releasing a significant amount of water in an endothermic reaction and so absorb the energy from the combustion zone, and
- retardants produce char and a metal oxide coating that can act as a protective layer during combustion.

Together with the aforementioned retardants, the fire-proof functionality of cables can be further improved by incorporating a special fire-protective layer (fire barrier) within the cables (such as glass tape, mica glass tape or ceramifiable silicon rubber).

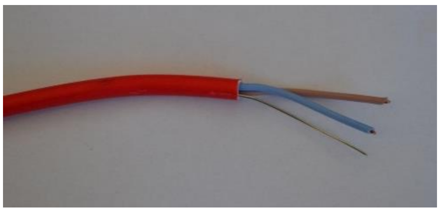
The polymer structure of plastics changes due to persistent or repeatedly high temperatures (200-300° C). Their insulating capacity, due to the semiconductor capability of the carbon generated, can deteriorate to such an extent that it can lead to the formation of arcing short circuit. Plastics have a different risk of carbonizing. PVC is the most common insulating material, however, in this respect, it belongs to the worst-performing plastics.

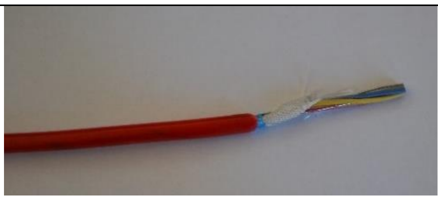
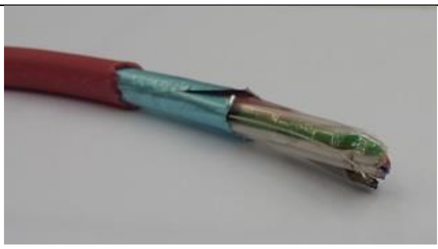
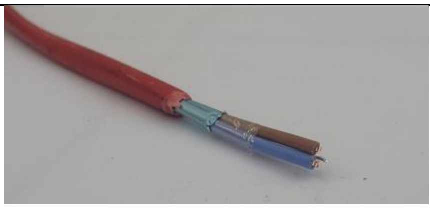
2. CABLE SPECIMENS FOR TESTING

We have selected the test specimen in a way that they be preferably of different types and classifications, e.g., PH30, 90, 120, 180. [13], [14] .

We have selected 5 cables with different fire retardance for testing. The material of the conduits was always copper. We specify the characteristics of the cables in Table 1. The unspecified external coating is usually PVC, only specimen 3 is polyolefin.

Table 1- Features of cable specimens. Created by the Authors.

Specimen type[13], [14]		Main features
1 PH 30	C 	With fire resistant ceramic silicone conduit insulation. Sheath with low smoke emission, preventing flame propagation, halogen-free, with 2x1.9 mm^2 solid conduits. 1.0 mm^2 cross-section, conduit made of Cu, halogen-free coating (sheath)

2 FE180, E90		Halogen-free, flame resistant, safety technology cable. Structure: solid copper conduit, halogen-free conduit insulation, aluminum foil-shielded, mounted on plastic, fire retardant external sheath made of halogen-free material. Cu conduit, halogen-free coating (sheath)
3 PH 120		Fire retardant cable with solid copper conduit, halogen-free polyolefin insulation and external sheath. 0.5 mm^2 cross-section conduit made of Cu, halogen-free coating (sheath)
4 No PH marking		Assumably, with non- fire retardant PVC sheath, a 4-conduit fire alarm cable.
5. PH 180, E90		Fire resistant cable, 3-hour fire retardance, shielded, EN54. Aluminated, synthetic foil, red flame retardant PVC sheath. 1.0 mm^2 cross-section conduit made of Cu, halogen-free coating (sheath)

3. TEST METHOD: DERIVATOGRAPHY

Changes in phases were followed by TG/DTG/DTA serves using MOM Derivatograph-Q 1500 D TG/DTA instrument. During the measurements, the reference material was alumina (Al_2O_3), the mass of samples were ca. 300 mg, and the samples were heated at 10 ºC min^{-1} heating rate up to ~1000 ºC, in air atmosphere (in static condition). Before the investigations, the specimens were ground in an agate mortar, and directly after that they were measured in the TG/DTA device avoiding samples from carbonation due to the airborne CO_2. The thermoanalytical test results were evaluated by Winder (Version 4.4.) software [15]

During the thermal analysis test, we subjected the components of each cables (coverage, foil, cellophane) to a separate derivatograph test.

4. RESULTS AND THEIR ASSESSMENT

4.1 External coverage

In Table 2 we show the derivatography views of the external coverage of the cables which are the basis of combustion.

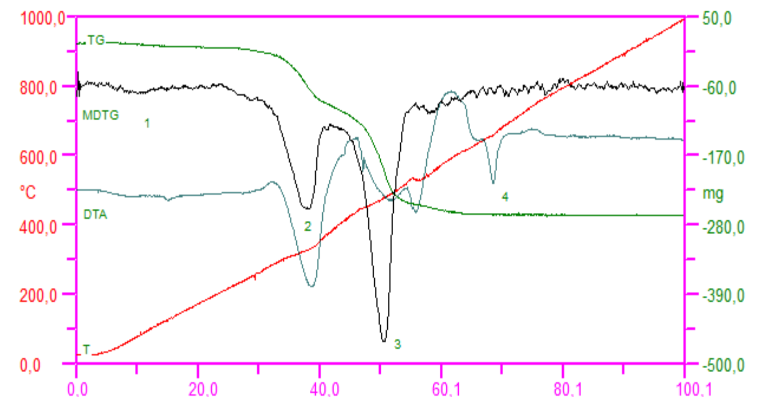
In case of the 4 th marked non- fire retardant PVC sheath is clearly visible the effect of the lack of the additive flame retardant: At about 240 ° C the thermal decomposition begins, and it means the half of the total mass of the material. The released decay products continuously provide the exothermic peaks 2,3,4 and 5. Table 2 shows the most typical thermodynamic values of the external coverage of the cables, which are the basis of combustion.

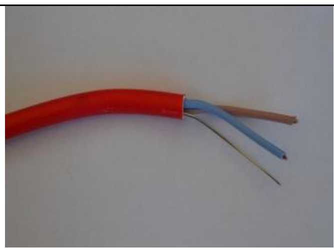
Table 2 - The most typical thermodynamic values of the of the external coverage of the cables. Created by the Authors.

Specimen type		2. Peak	3. Peak	exothermic Peak maximum	**Total loss of weight %**		LOI
1	beginning of the degradation T (C)	231,1	379,1				
	end of the degradation	379,1	614,1				
	loss of weight of the peaks	17,52	**33,12**		**53**		33,7

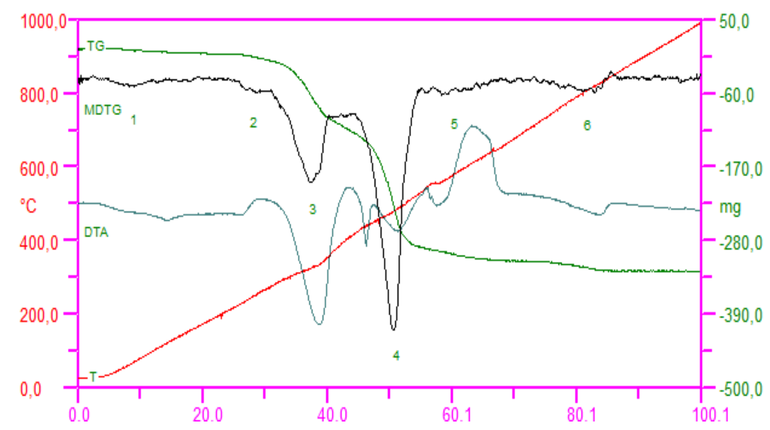
				400-550			
2	beginning of the degradation	276,6	396,8				
	beginning of the degradation	396,8	530				
	loss of weight of the peaks	18,63	**34,15**		**63**		**33,4**
				550			
3	beginning of the degradation	205,1	398,3	550			
	beginning of the degradation	398,3	548,5				
	loss of weight of the peaks	22,26	**34,66**		**61**		**37,7**
4	beginning of the degradation	242		continuous pyrolysis			
	beginning of the degradation	371					
	loss of weight of the peaks	**46,51**			**76**		**<36**

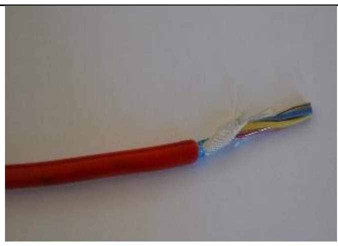
Figure 1- Derivatography recording of the external coverage of the cables. Created by the Authors.



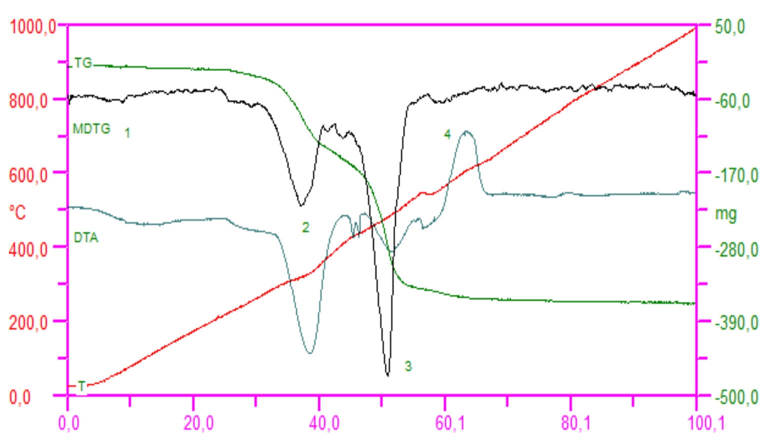


1 st marked cable

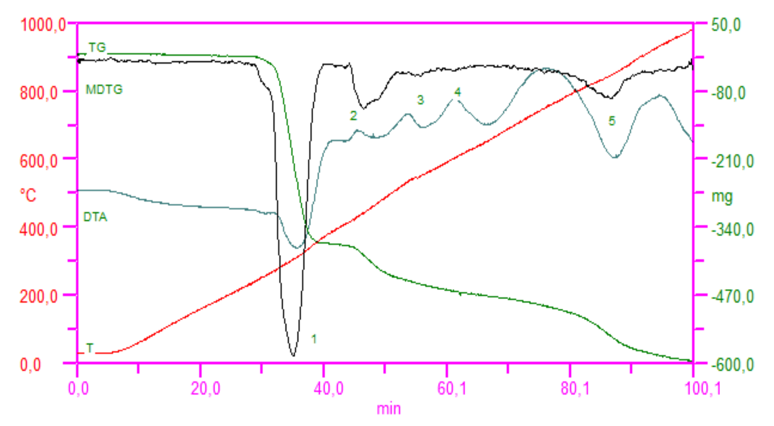


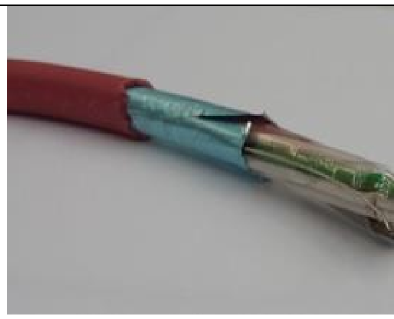


2 nd marked cable



3 rd marked cable

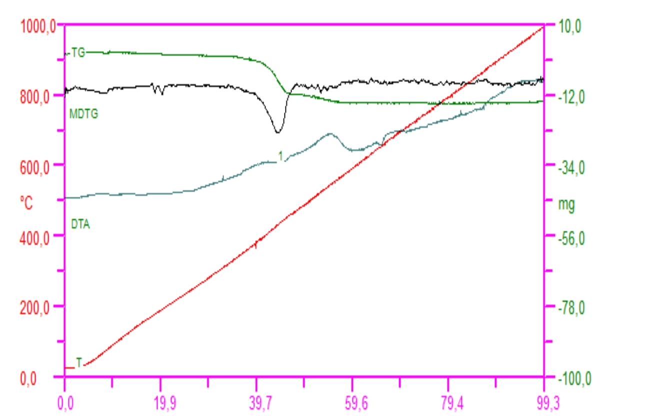




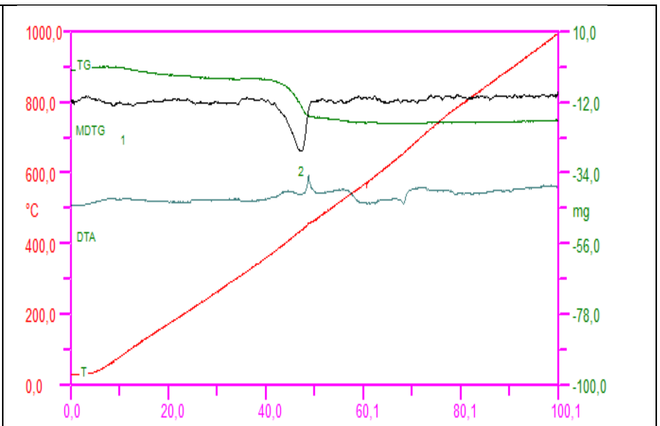
4 th marked cable

4.2 Effects of the blue foils

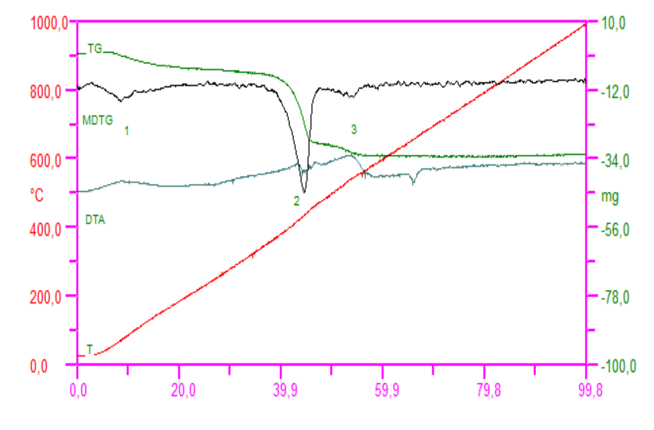
Samples 2 and 3 blue foils did not have exothermic effects in interior coverage, they are even more stable than external red coverage. The thermal degradation of the 4 foils is stronger. Blue foils do not affect the burning of the cover (Figur 2).



2 nd marked cable



3 rd marked cable

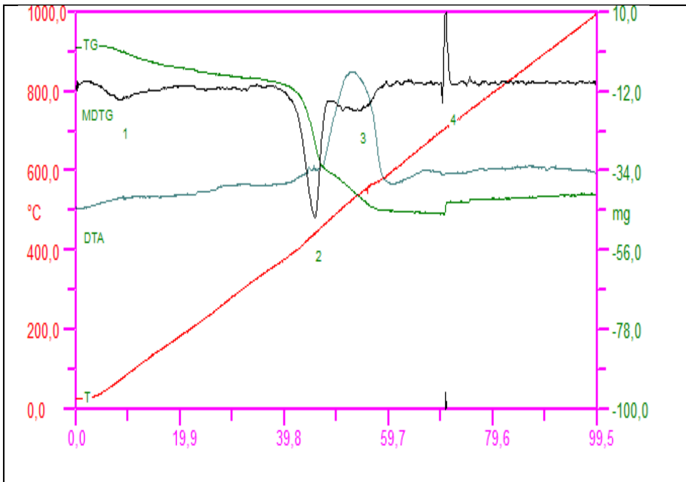


4 th marked cable

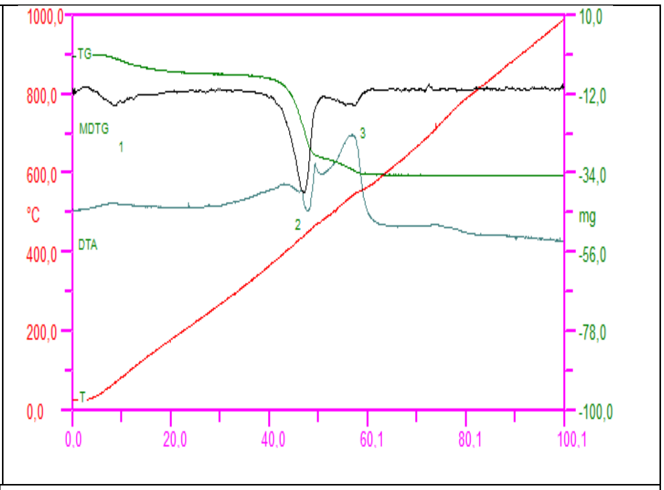
Figure 2- Derivatogramphs of the blue foils. Created by the Authors.

4.3 Effects of the cellophanes

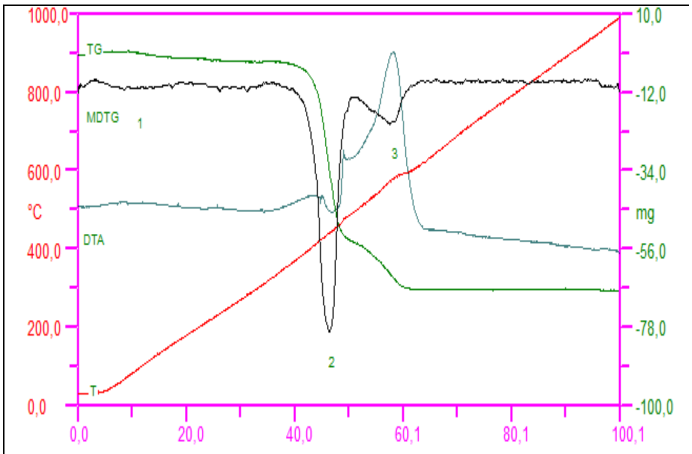
The blue cellophanes are thermodynamically unstable, even above 500 ° C, they show an exothermic process. They will further help the existing combustions. In case of 4 cellophanes, a high degree of thermal degradation starts at 320 ° C, but from 500 ° C exothermic pyrolysis can be observed (Figure 3).



2 nd marked cable



3 rd marked cable



4 th marked cable

Figure 3 - Derivatogramphs of the blue foils. Created by the Authors

5. SUMMARY

The behavior of fire retardant cables versus fire is a very important issue since they are used and built in into flammable environments. As we can see, all the specimens have fire retardance classification, but our measurements show that chemical properties are significant differences. All of these discrepancies are based on the impact on plastics by fire, which are not shown in normal use. But unfortunately, fires are always triggered by unsafe and non-normal conditions

The structure of the polymer may change spontaneously, so, the combustion-retardant substances lose their efficiency, which also negatively affects fire resistance The main thermal degradation (from which the combustion occurs) is above 450 ° C. The 4 red coverage lose about half of their weight at 270 ° C, and pyrolysis can be easily to start. The difference between the two sample groups is between the initial value of the degradation, (200 ° C), which can be regarded as very significant. In general, the combustion phenomena of the cables can be trace back to their thermodynamic stability. Overall, thermal insulation will continue to be important in the design of building protection [16] [17].

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

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FIRE LIMITATIONS ON THE USE OF GLASS FIBER REINFORCED COMPOSITES IN BUILDING STRUCTURES

Abstract

It is a mandatory requirement that the buildings have to be sized for heat and fire. In case of concrete, we use the EUROCODE standard. If the structural material contains materials whose thermal behaviour is unknown, then we have to expect hidden dangers. Such a common material is the fibre reinforced composite plastics. In the paper the authors investigated the properties of this composite that are necessary for design, sizing and use: changes under the influence of heat, electron microscopic structure examination, special burning behaviour and mechanical tensile strength. The authors made the heat treatment in a furnace and the combustion of the composite rods with an oxygen index measuring device under special conditions. Knowing these, it is possible to calculate what durable strength reductions will result from a fire in the building structures.

Keywords: glass fibre reinforced composite, test, specimen

ÜVEGSZÁLLAL ERŐSITETT KOMPOZITOK FELHASZNÁLÁSÁNAK TŰZVÉDELMI KORLÁTAI ÉPÜLETSZERKEZETEKBEN

Absztrakt

Kötelező előírás, hogy ez épületeket hőre, tűzre kell méretezni. Ha betonról van szó arra használatos az EUROCODE szabvány, de ha a szerkezeti anyag tartalmaz olyan anyagokat, amelyek hőtani viselkedése nem ismert akkor rejtett veszélyekkel kell számoltunk. Ilyen gyakran használt és egyre inkább elterjedt anyag az üvegszállal erősített kompozitok. Munkánkban ennek a kompozitnak, azokat a tulajdonságait vizsgáljuk, amelyek a tervezéshez, méretezéshez és felhasználáshoz szükségesek: változások hő hatására, elektronmikroszkópos szerkezetvizsgálat, különleges az égési viselkedésre és mechanikai húzószilárdságra. A hőkezelést égető kemencében, míg a kompozit rudak égetését különleges körülmények között oxigén indexmérő készülékben végezték el. Ezek ismeretében ki lehet számítani, hogy milyen tartószilárdság csökkenéseket eredményez az épület szerkezetekben egy tűz.

Kulcsszavak: üvegszállal erősített kompozit, mérés, minta

1. INTRODUCTION

Traditional building materials are increasingly being replaced by "plastics". Glass reinforced plastics (**GRP**) is widespread and it has many types of uses in the construction industry, for example various cable ducts, scaffoldings or stair elements. Composite plastic concrete is an alternative system that is often used instead of the reinforced concrete. One of its great advantages is the high tensile strength and the other is the durability. Its design life is the same as the design life of concrete, so a hundred years. The most significant physical characteristics of a structural material in concrete in terms of sizing are its density, tensile strength, and modulus of flexibility [1]. Other properties such as high corrosion resistance, high chemical resistance, electrical insulation, non-magnetic light machining and very low thermal conductivity are also important. One of the critical requirements is to work together. The essence of this is to create the best possible adhesion surface. This can be improved by applying some scattering material (usually sandblasting) to the surface. Before the application, the fire resistance of the material must also be examined in accordance with the European Union and Hungarian fire protection regulations in force. The changes in the physical and chemical parameters of the specimen made from the sample material must be examined under the influence of temperature.

2. STRUCTURE OF THE GRP MATERIAL

The structure of the material can be divided into two main components. These two are synthetic resins and reinforcing materials. In this mixture, it is important that the resin should be thermosetting. The components form a chemical bond that provides adequate mechanical and chemical properties. Polyester resin, vinyl ester resin, phenolic resin, epoxy resin and acrylic resins are suitable for the above-mentioned properties. In general, we can state that the matrix of these resins builds up the composite material and positively influences its properties. Polyester resin is the most commonly used component. This is because it has a lot of features [2].

Additives are added to the matrix which (like in case of the concrete) improve the properties: These affect the fire resistance, corrosion resistance, mechanical properties of the composite and prevent the formation of cracks on the surfaces [3].

The group of reinforcing materials always means some fibrous material. There are three most often used materials for this purpose, but beyond these, there are many other options. The most often used material is the fiberglass, which is woven from molten glass and has a circular cross section. The average cross-sectional size of glass fibres is 20-25 micrometres, which means quite small fibres. The biggest advantages of these are that they are cheap, have good tensile strength, are light and have high heat resistance (1000 - 1200 °C). Carbon and aramid fibres are also often added to the system. More than 90% of the carbon fibres consist of pure carbon. Their special feature over fiberglass is that they have exceptional strength even at higher temperatures. It also conducts heat and electricity and is extremely corrosion resistant. In general, we can determine that composite plastics have a high strength at normal temperatures with small weight. On the other hand, they tend to break brittle. We compared it to the reinforcing steel (which has a higher density) in Table 1 [4].

Table 1 - Comparison of the mechanical properties of reinforcing steel and composite. Created by the Authors.

Properties	GRP composite plastic	Steel
Density	1,9-2,2 g/cm³	7,85 g/cm³
Tensile strength	800-1300 MPA	360-550 MPA
Tensile modulus (E)	35000-100000 MPA	210000 MPA
Elongation at the break	2,2%	25%
Available diameter of products	4-35 mm	8-60 mm
Available length of products	infinite	12 m

It is important to mention the high corrosion resistance in relation to the chemical properties of the material, as this is a great advantage over the steel. Many times we can see that during the pitting of the concrete cover, the steel starts to corrode, so the structure loses its tensile strength which is very dangerous. Actually, this fault is not present in case of composite plastic, because it does not corrode. It has a low thermal conductivity (0.5 W / m * K) compared to the high thermal conductivity of steel (60 W / m * K). This may be important due to the increasingly strict energy considerations. If this is used instead of steel, no thermal bridges are created within the structures.

2.1. Application of the composite plastic

GRP profiles are often used in the construction industry. This is due to its easy installation, its good mechanical strength and low weight. [5] [6] [7]. The designers and investors are increasingly replacing the steel structures with it, because it provides great freedom in geometry and properties [8]. In the followings we show some applications in Figures 1-4.

Figure 1 - Composite pedestrian bridge (Ikast-Brande, Denmark, Fiberline.com) (left)
Figure 2 - Apartment made of composite plastic concrete, Zurich (Photo by Andreas Zimmerman Architekten Ag.) (right).

Figure 3 - Rio Tinto Alcan, Iceland (Source: https://www.schoeck.com/en/case-studies/rio-tinto-alcan) (left)

Figure 4 - Apartment made of composite plastic concrete, Zurich (Photo by Andreas Zimmerman Architekten Ag) (right).

2.2. Test specimens

Spirally rolled GRP rod fittings, diameter 6 mm.

Figure 5 - GRP type test specimens (other properties in Table 1).

3. SELECTION AND PRESENTATION OF THE TESTS

Before the application, the fire resistance of the material must also be examined in accordance with the European Union and Hungarian fire protection regulations in force. It is useful to learn about the behaviour of a material from several directions: for example in addition to the mechanical and flammability properties, the changes in the microstructure of the sample must be investigated due to the heat. The changes in the physical and chemical parameters of the specimen made from the sample material must be examined under the influence of the temperature. We have selected measurements from which it is possible to know how the material behaves under the influence of high temperatures within the structure [9]. After that, we would like to suggest in which segment within the construction industry it can be applied so that it meets with the Hungarian fire protection regulations. From the studies in connection with thermal analysis (DTA, DTG) we can reveal what processes take place in the material. We can read with temperature accuracy when and what kind of chemical and physical processes take place in the examined specimen. The oxygen index gives us an idea of how resistant a material is to fire. From the electron microscopic image, in addition to the numbers, it can give a visual picture of what changes take place in the material after heat load.

3.1. Heat treatment in a furnace

The main purpose of the heat treatment is to test the load-bearing capacity of the support structure at a high temperature in the mechanical model. In this case we examine the building structures one by one. In this case, we remove the elements from the structure one by one as if we were performing a fire test on them with a standard fire curve (ISO 834). The concrete completely loses the strength of the support at 500 °C, so it breaks. Nevertheless, the properties of the embedded fittings must be checked. The 500 °C method is suitable for this. We observed the type of the behaviour of the specimen at 300 and 600 °C. To do this, we cut several small (10 cm long) pieces. These two temperatures were chosen, because the EUROCODE isotherms develop temperatures of 300 and 600 °C in a building in case of 30 and 60 minutes at typical concrete coverings (20-40 mm deep).

Figure 6 - Samples in the furnace before heating and the consistency of the samples after 24 hours at 300 °C. Source: Authors.

Our observation after heat retention: our material is worse than the steel, which begins to lose its strength at 500 °C. The test at 600 ° C is no longer established in this respect, because drastic changes can be observed already at 300 °C. The material was actually destroyed, losing its strength (Figure 6). We made further tests in the framework of the thermal analysis (derivatographic test). Here we get a better picture of the processes taking place in the material under the influence of heat.

3.2. Burning in not nor al air

We made the combustion in an oxygen index test apparatus. For the purposes of the international standard [ASTM 2863.], the following definition applies. Oxygen index: the minimum concentration of oxygen by percentage volume in a mixture of oxygen and nitrogen introduced at 23±2 °C that will just support combustion of a material under specified test conditions Technical data of apparatus: FIRE Instrumentation and Research Equipment Limited, UK (ISO 4589 Part 2 Oxygen index test apparatus). (Figure 7) The apparatus consists of five basic modules: (1) digital interface panel, (2) automatic conditioning system for sample environment, (3) electronic flow measurement device, (4) oxygen measurement system, (5) mixing chamber. Test column and sample holder assembly [10].

Observations: In our study initially the samples do not show any ignition phenomena, and are non-flammable at 21 % oxygen concentration. By increasing the oxygen content, at the beginning only burning marks appear, then as the oxygen concentration increases, the length of the burnt area becomes greater.

Figure 7 - Typical apparatus for the determination of oxygen index and damage to the specimens after burning in 35 and 40% oxygen. Created by the Authors.

3.3. Thermoanalytical method

Thermal behaviour of the studies materials were followed by thermoanalytical methods (TG/DTG/DTA) using Derivatograph-Q 1500 D. This equipment is able to collect TG/DTG/DTA data from the same measurement simultaneously. For computational evaluation of the thermoanalytical test results Winder (Version 4.4.) software was used. There is a simultaneous procedure where the TG (Thermogravimetry) and DTA (Differential Thermal Analysis) thermoanalytical methods can be combined. As the result of thermogravimetry (TG) the first derivative of thermogravimetric curve (DTG) is also obtained We had the opportunity for this thermal analysis at the Department of Geology and Geotechnics of the Budapest University of Technology and Economics. The type of the equipment is a MOM Derivatograph Q-1500.

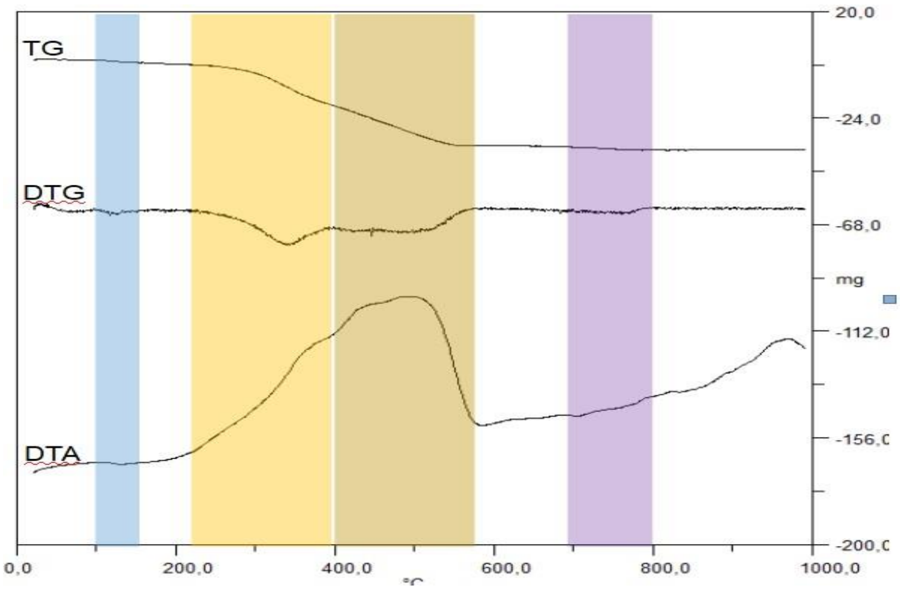

Figure 8 - Thermal behaviour of GD samples based on derivatography up to 1000 °C.

Heat reactions with weight loss:

1. 100-150 °C: Drainage of sticky water, possibly here Tg (glass transition temperature),
2. 220-400 °C: Thermal decomposition (thermal decomposition), (pyrolysis if the test is carried out in an inert atmosphere),
3. 400-580 °C: Combustion - the most intense exothermic (heat generating) reaction during

the test,

4. 700-800 ° C: Thermal decomposition of small amounts of $CaCO_3$.

Thermal reactions without weight loss:

- at 575 ° C no small endothermic peak of α-quartz (SiO_2) is visible on the DTA curve (recrystallization to β-quartz),

5. 880-980 °C: An endothermic reaction, probably melting of the glass + other residues, or the formation of a new phase.

We consider it important to emphasize that in case of a fire in an air atmosphere, the synthetic resin no longer works with the glass fibre bundle above 200-220 °C. In this case, only the tensile strength of the glass fibre bundle can be exploited until the glass melts.

3.4. Scanning electron microscopic (SEM) observations

To study the morphology of the samples SEM images were obtained by a Phenom XL scanning electron microscope. For the observation of the samples they surface (horizontally oriented samples) and cut cross section (vertically oriented samples) was studied. It is also very important, because it gives us an idea of how the spatial structure of a material is built up and if necessary, how it changes under the influence of heat load (Figure 9). Especially in case of complex materials, where there are not only one but three components (fiberglass, resin, sandblasting).

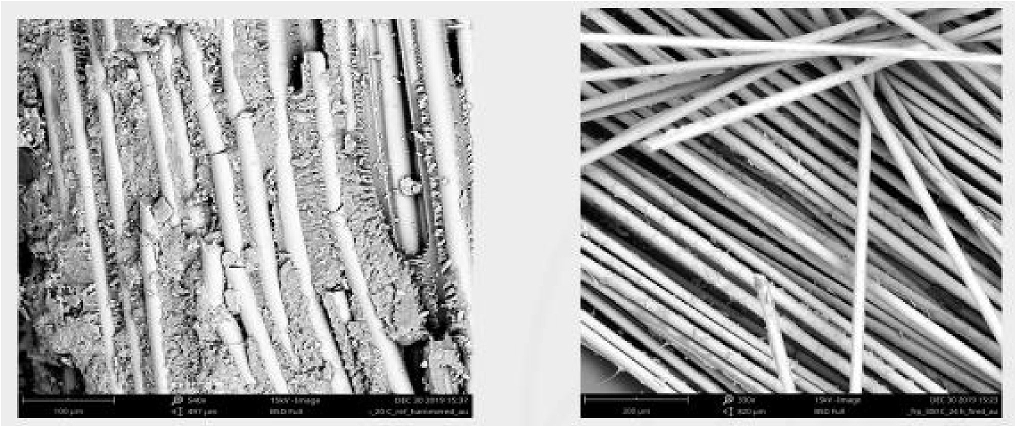

Figure 9 - Composite matrix with glass fibres at 20 °C and after combustion of the resin.

Source: Authors.

3.5. Tensile test

The purpose of the tensile test is to determine the tensile strength of the GFRP. We can also determine the modulus of elasticity and ultimate strain of the material. During the test, the test specimen is subjected to a monotonically increasing uniaxial tensile load.

We made the tensile measurement with an Instron 5989 pneumatically operated tensile machine. The machine is able to save the measured data and diagrams in digital form. Tensile test is not an easy task in case of composite plastics. This is because if we want to capture these materials they are easily broken. Fortunately, colleagues at the Budapest University of Technology and Economics have already experimented with similar elements so they helped us during the test. We were weighed the specimens and determined their cross-section, length (10-15 cm) and weight. Then we heated them to 80 and 120 °C. This simulated its heat effect. As the derivatographic examination revealed that the epoxy resin starts to burn out at the temperature of 200 °C and thereby the material decomposes to break down, we experimented in the temperature level below 200 °C (Figure 10).

Figure 10 - Specimens captured in the machine and the prepared specimens. Source: Authors.

Measurement diagrams

The rods were preheated at three different temperatures: Number 1 and 2 at normal temperature, No. 3 and 4 at 80 °C and No. 5 and 6 at 100 °C. Their density is 1900 kg/m³. The cross sections are 6 mm in diameter. The specimens are summarized in Table 2.

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Table 2 - Physical parameters of samples captured in a tensile machine. Created by the Authors.

Sign	Temperature (°C)	Diameter (mm)	Full length (mm)	Length without capture (mm)	Weight /g	Weight after heat load (g)	Force (KN)
1	**20**	6	541	330	35,90	-	28,13
2	**20**	6	609	395	40,86	-	27,59
3	**80**	6	337	150	22,11	22,11	24,69
4	**80**	6	610	413	40,91	40,90	30,36
5	**100**	6	323	128	22,53	22,52	32,37
6	**100**	6	480	281	32,36	32,35	28,69

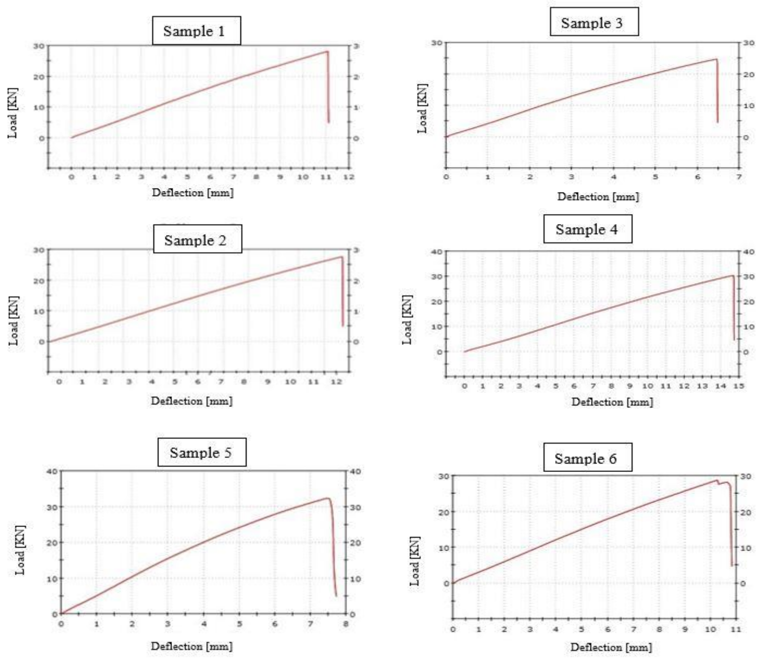

Figure 11 - Tensile diagrams of samples 1-6: X axis: deflection (mm), Y axis: load (kN). Source: Authors.

It can be seen that the variance is quite large between the different fibres. There are several reasons for this. One is that the manufacturing process does not have a uniform fibre - matrix ratio. The more the proportion of fibres within a specimen, the greater its strength. The fourth is the heat load effect. The diagrams do not show the destructions. While the specimens treated at 20 and 80 °C did not show deformation at the destruction, the two specimens treated at 100 °C weakened at the capture and even one of them was torn (Figure 11). We observed no such changes in case of the heat-free specimens. After performing the load test, we can calculate the tensile strength of each specimen.

The procedure of the calculation of the known and obtained data was as follows:

<u>In case of specimen 1:</u>

Replacement cross-sectional area of the test rod: $A = \frac{M}{\rho * l} = \frac{35{,}90}{1{,}9 * 54{,}1}$ = 0,3493cm² = 34,9 mm²

Replacement diameter of the test rod: $d0 = \sqrt{\frac{4xA0}{\Pi}} = \sqrt{\frac{4x34{,}93}{\Pi}}$ = 6,66 mm

tensile strength: $\sigma = \frac{R}{A} = \frac{28{,}13x10^3}{34{,}90}$ = 806,017 N/mm²

Extension: $\varepsilon = \frac{\Delta L}{L0} = \frac{11mm}{541mm}$ = 0,02

Based on the average of six samples, a tensile strength of 800 (MPA) is obtained, which does not change at 80 and 100 ° C.

Figure 11 - Destruction of specimens 5 and 6. Source: Authors.

4. DISCUSSION, CONCLUSION

We examined how our material is destroyed by different heat loads. The combined results of several test gave us a complete picture of the behaviour of the fiberglass composites. In case of fire, the resin will no longer work with the glass fibre bundle above the temperature of 200-220 °C. Only the tensile strength of the glass fibre bundle can be exploited until the glass melts. These processes also affect the safe firefighting [11] [12] [13].

We also determined from the thermal analysis tests that it occurs exactly at 220 °C. The destruction point of a material occurs when the epoxy resin burns out and thus the co-operation of the fibres already works. This can also be seen in case of a detachable spiral on the surface (Figure 7), when it detaches together with a sand cover. As a result, it can be stated that the material is destroyed at the temperature of 220 °C.

Due to these temperature criteria, in higher buildings, where the building is rated AK, KK or MK, it is not recommended to use it independently in supporting structures because of the unexpected loads that may arise and possible fires. In case of smaller detached houses where there is no high fire protection requirement and it would be expensive to build with a monolithic reinforced concrete slab, it can provide a suitable alternative. For "very low risk" category family house, basement + ground floor + first floor, the material can be utilized in many ways. Its application can be useful and economical.

The real alternative may not be to steel, but to use it with the steel. The two substances should not be used against each other but together. Due to the high strength of grp, it has poor fire resistance and can easily to break. The steel is expensive and it has less strength, so it can be logical to use these together. Our research can also be a good basis for other series of publications on similar topics [14] [15].

5. ACKNOWLEDGMENTS

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VÉDELEM TUDOMÁNY
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DETERMINATION OF SELECTED FUEL VALUES OF WOOD IN CASE OF FOREST FIRE IN AN AREA OF NATURAL DISASTER

Abstract

Forest fires are quite a common phenomenon, even on the European continent. Even if this phenomenon was quite rare in our territory in the past, it needs to be given close attention in the future. Firefighting requires great manpower and resources, in many cases on a long-term scale. The equipment, machinery and tactics of intervention units specializing in forest fire-fighting are always changing. Forest firefighting has become the subject of much research, and predictive scenarios for forest fire development are designed and tested. The latest equipment, geographic information systems (GIS), knowledge of geomorphological and climate conditions, and meteorological conditions are all included in fire simulations. An important factor for such a simulation is knowing what kind of fuel naturally occurs in the area of the potential forest fire. This article aims to compare methods of testing the fire characteristics and differences in fuel properties according to the position of the wood on the tree (branch, trunk and root) for various coniferous tree species (spruce, fir, pine and larch). To determine these characteristics, the test method, in particular the dimensions of the samples, had to be modified. The results of the experiments are presented in this article in the form of charts.

Keywords: forest fire, coniferous tree species, weight loss, burning rate.

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MEGHATÁROZOTT FAFAJOK VIZSGÁLATA ERDŐTŰZ ESETÉN TERMÉSZETI KATASZTRÓFÁK SORÁN

Absztrakt

Európában komoly kihívást jelentenek az erdőtüzek, amelyek egykor még ritkaságnak számítottak Szlovákiában, azonban ma már fokozott figyelmet követelnek. A tűzoltás jelentős erő - és eszközforrást igényel, amelyek az évek elteltével folyamatosan változnak. Az erdőtűzoltás kutatása ma már széleskörű, a tüzek kialakulásának forgatókönyveit pedig fokozatosan tervezik. A tűzszimulációk már tartalmazzák a legújabb felszereléseket, földrajzi információs rendszereket (GIS), valamint a geomorfológiai és éghajlati viszonyokat, is. Egy ilyen szimulációnak egyik alapja, hogy erdőtűz során, milyen biomassza kap lángra. A cikk célja a tűz és biomassza tulajdonságok vizsgálata a fák egyes részein (ág, törzs és gyökér), illetve a tűlevelű fafajok (erdei fenyő, lucfenyő és vörösfenyő) esetében. Egy ilyen vizsgálat módosított kutatási módszerek alkalmazását igényli. A kísérletek eredményeit a szerzők, diagramok formájában mutatják be.

Kulcsszavak: erdőtűz, tűlevelű fafajok, sorvadás, égési sebesség.

1. INTRODUCTION

Fire represents a major danger to forests. It damages individual trees and the entire forest, not only mechanically, but also physiologically. Besides trees, it also destroys all other elements of the forest ecosystem, decimating other plants and animals that live in the area. In some locations (Australia, China, the Philippines, Borneo, USA), fire can at times be an indispensable, positive, ecological factor helping the spread of certain species and the recovery of forests [25]. The situation is worse in the European territory. Damage caused by forest fires has no positive effect on the forests, and it also endangers critical elements of infrastructure and the population.

The situation has worsened significantly since the first months of 2019. According to EFFIS (European Forest Fire Information System), the number of recorded forest fires began to increase sharply in mid-February. By the end of June, there had been approximately 1 400 times more fires than the average number of fires in the same period from 2008-2018 [4]. The area of forest destroyed has also risen five times: from an annual average of 44 500 hectares in the first six months between 2008-2018, to 207 000 hectares (see Figure 1).

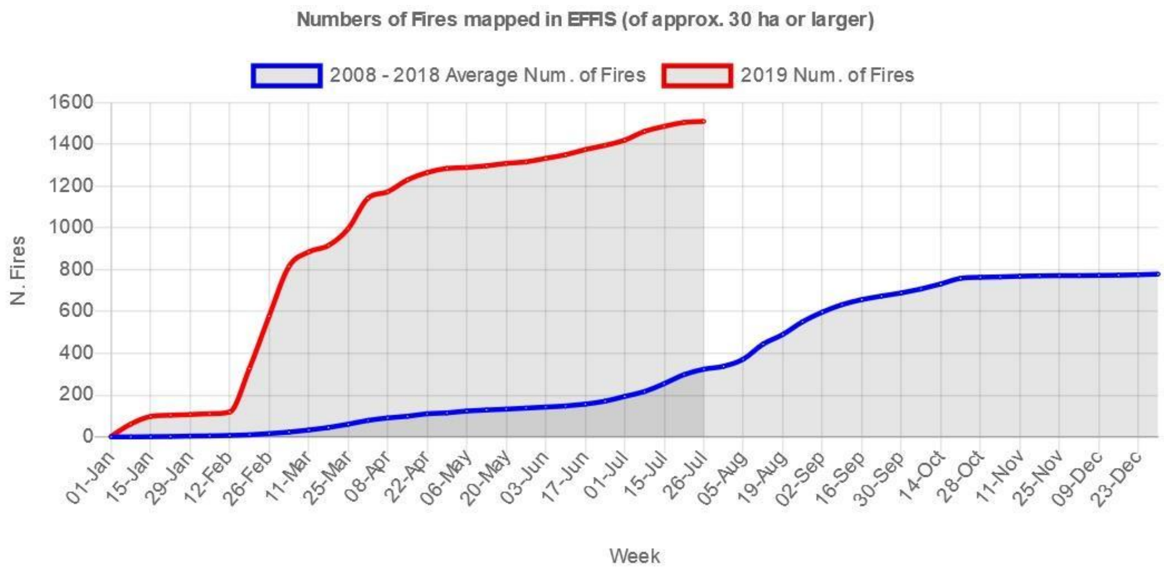

Figure 1 - Forest fires recorded during the given time period according to EFFIS [4].

The situation has also been critical in the last thirty days. EFFIS shows a high concentration of forest fires in the north of France, in the Iberian Peninsula; a number of fires have also been recorded on British Isles and in Scandinavia. (see fig. 2). The most active fires were recorded at that time on the North coast of the Black Sea, and in the regions neighboring Europe - North Africa and the Middle East. However, given the high temperatures and droughts, EFFIS currently reports a high risk of fires in the south of the Iberian Peninsula, in central and southern Italy, and in large parts of Eastern France, Benelux and Germany [4]. Due to high temperatures and droughts at record levels, the situation in Russian and North American Arctic areas is very serious. In Russia, both forests and bogs are burning [22].

The largest fire broke out on July 30, 2005 in the territory of the town of Vysoké Tatry, on the eastern edge of Tatranská Polianka, Poprad district. The fire destroyed 228,85 hectares of forest previously damaged by strong winds. The fire broke out in the area affected by the 2004 strong winds, and subsequently hit. The number and extent of forest fires has risen in Slovakia, too.XXX In 2017, 162 forest fires, 26 more than in 2016, were recorded in the SR on an area of 297,66 hectares (compared to 174,9 hectares in 2016). For 2018 and 2019 (the latest statistics), four serious forest fires occurred near our premises alone (see Table 1[6]).

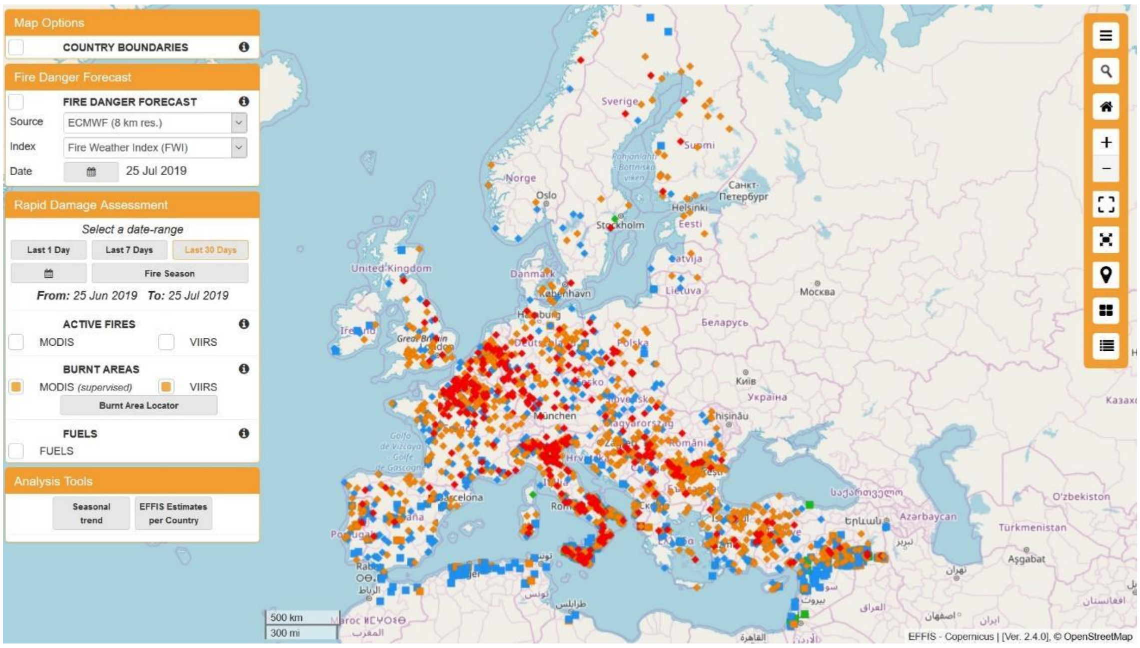

Figure 2 - Fires on the European continent 26.6-27.6 2019, EFFIS (source) [4].

Table 1 - Forest fires in Slovakia in 2018 and 2019 [6].

Location/year	Duration of fire (hours)	Area (ha)	Equipment/helicopter
Polomka/2018	92	7.5	56/2
Gader/2018	197	2.5	80/1
Bystrá-Gapeľ/2019	122	5.1	75/2
Blatnica-Ostrá/2019	27	0.05	12/1

2. FOREST FIRES

Forest fire is an extremely harmful factor which is detrimental to all components of the forest's biological community. A forest fire is a sudden, partially- or fully-uncontrolled, time- and space-limited emergency event, which has a negative impact on all social functions of the forest both directly and indirectly. It can be either anthropogenic, caused by humans, (more common in Slovakia) or caused by a natural harmful factor. It is a complex of physico-chemical phenomena based on the nonstationary (that is, changing in space and time) processes of combustion, gas exchange and heat transfer [4].

Statistics generally indicate that climate change [10, 18, 19, 20, 21, 23] is the cause of the rising number and size of forest fires on the European continent .

Forest fire-fighting is not easy. As Table 1 shows, it usually takes several hours and requires the deployment of manpower and means of ground and air transportation on a large territory [2, 13, 14, 17]. Modern information systems [11, 12] and modern extinguishing agents help in intervention. An important piece of information is the specification of the "fuel" (type of wood) that can burn in the territory [1, 3, 7, 8, 9, 15, 16]. It is necessary to know the composition of the forest according to the types and age of trees. All parts of the tree (branch, stem and root) burn during such an event. How the wood of the individual parts of the tree influences burning is the subject of our experiments.

3. EXPERIMENTAL DESIGN

The experiment, the results of which we describe in this article, required a number of special modifications, particularly with regard to sample sizes. We had testing apparatus and evaluation criteria tested in other experiments, e.g. for the determination of the efficiency of fire retardants. Changes in the dimensions of the test bodies had to be made so that they could be taken from small-scale parts of a tree such as a branch and a root.

a. Material and test specimens for the experiment

Test specimens were prepared from 1 meter-long trunks of several types of trees (pine, fir, spruce, larch) [5]. After dressing the trunks by removing the bark and cutting it into boards, the boards were dried to a constant moisture of 8 % (± 2 %). The boards were then cut into test specimens of 10 mm x 12 mm x 150 mm. No surface finish was used for the test specimens. Specimens from branches and roots were cut in the same manner as the trunk. The diameter of both branches and roots was at least φ 60 mm at the thinner end. These were cut into boards and then into the test bodies (see fig. 3).

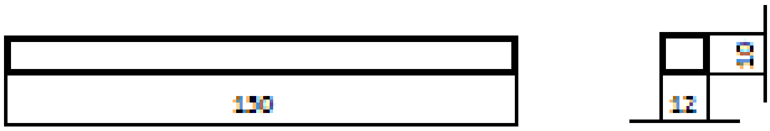

Figure 3 - Dimensions of test specimens for the experiment

3.2 Radiant heat source

An infrared heater was used as the radiant heat source. Heat transfer from the heater was carried out using the diffusion principle of electromagnetic radiation: a wavelength of 0,75 – 12 J/m is, when absorbed by a solid, transformed into heat. The radiator had the shape of a plane curved in the direction of the longitudinal axis of the body. Radiation was emitted by the front wall, the rear wall and the front edges. The side edges of the radiator were neglected because of their poor efficiency for the transfer of radiation. The radiator was made of special ceramic material, cordierite, which is very resistant to sudden temperature changes (temperature differences of more than 70 °C) and to high temperatures (up to 1100 °C). The radiator scheme is depicted in figure 4 [24].

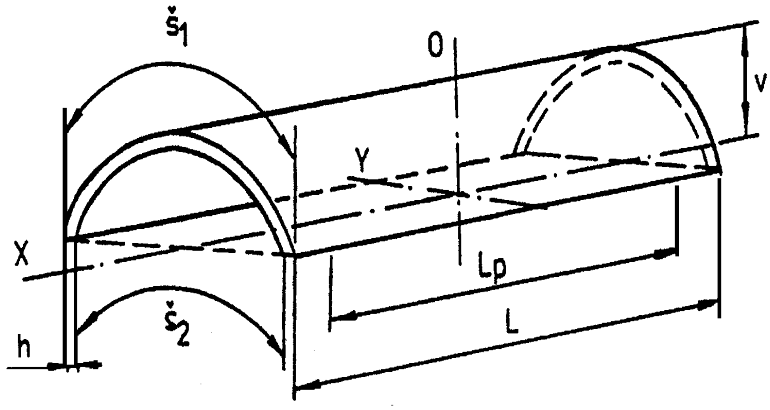

Figure 4 - Diagram of the radiator.

Dimensions and parameters of the heater [24]:

Total length l = 245 mm

Working length lp = 200 mm

Outer width $š_1$ = 85 mm

Inner width $š_2$ = 64 mm

Thickness h = 5 mm

Height v = 30 mm

Temperature (30 mm from the radiator) t = 130 °C

Power P =750 W

Surface temperature of heating elements t_p = 579,4 °C

Maximum wavelength λ_{max} = 3,34 μm

Surface of radiator S_c = 0,0318 m^2

Emissivity ε = 0,84

Amount of radiated energy Q_{cc} = 669,95 W

Intensity of radiation E_γ = 2,105 W/cm^2

Efficiency η = 89,285 %

3.3. Test Procedure

The radiator was heated up for 15 minutes**.** After this time, a test body was inserted into the stand and the radiant heat applied for 3 minutes. 15 test bodies were tested from each type of tree. The thermal load time was constant at 3 min. The distance of the test body from the radiator was 30 mm. For each test body, the loss in mass was recorded after ten seconds.

3.4 Assessment Criteria

3.4.1 Weight loss

Weight loss was recorded while the sample was exposed to the radiant heat source. Relative weight loss was calculated according to this relation.

$$\delta_m(\tau) = \frac{\Delta m}{m(\tau)}.100 = \frac{m(\tau)-m(\tau+\Delta\tau)}{m(\tau)}.100 \qquad (\%) \qquad (1)$$

where: $\delta_m(\tau)$ – relative weight loss over time (τ) (%)

$m(\tau)$ – sample weight over time (τ) (g)

$m(\tau+\Delta\tau)$ – weight of the sample over time (τ + Δτ) (g)

Δm – weight difference (g)

3.4.2 Relative burning rate

Relative burning rate was determined according to the function (3.2) (3.3)

$$v_r = \left|\frac{\partial \delta_m}{\partial \tau}\right| \qquad (\%/s) \qquad (2)$$

or numerically

$$v_r = \frac{|\delta_m(\tau) - \delta_m(\tau + \Delta\tau)|}{\Delta\tau} \quad (\%/s) \tag{3}$$

where:

v_r – relative burning rate (%/s)

$\delta_m(\tau)$ – relative weight loss over time (τ) (%)

$\delta_m(\tau+\Delta\tau)$ – relative weight loss over time (τ + Δτ) (%)

$\Delta\tau$ – time interval where the weights are subtracted (s).

The foundational parameter was the density of the wood of the test bodies from the individual parts of the tree of the given tree species. As can be seen in Figure 5, the density changed even within the individual parts of the same tree. The humidity was regulated by air conditioning to the required level, so that it did not affect the evaluation criteria.

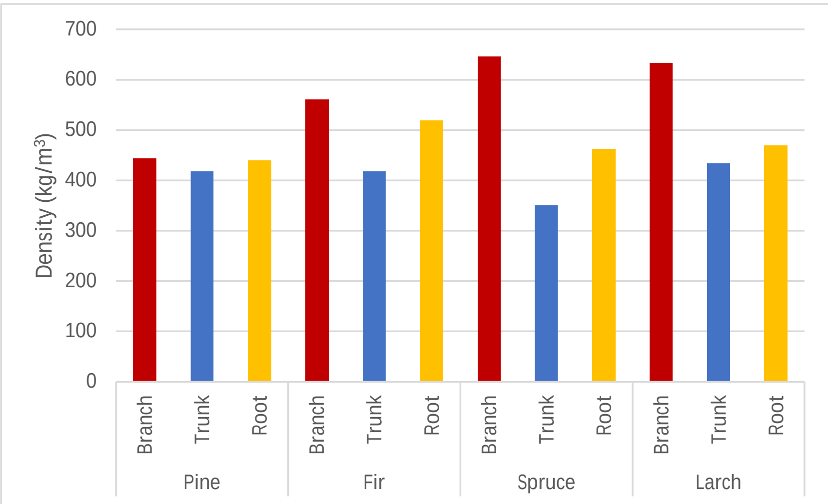

Figure 5 - Average density of wood of the test bodies according to the type of wood and tree part.

4. EVALUATION AND DISCUSSION

The results of the experiment are summarized in Figures 6-8, which display average values based on the 15 measurements of the main evaluation criteria. In addition to the main evaluation criteria, the weight loss (Fig. 6), relative burning rate (Fig. 7), and time of the maximum burning rate (Fig. 8) are also stated.

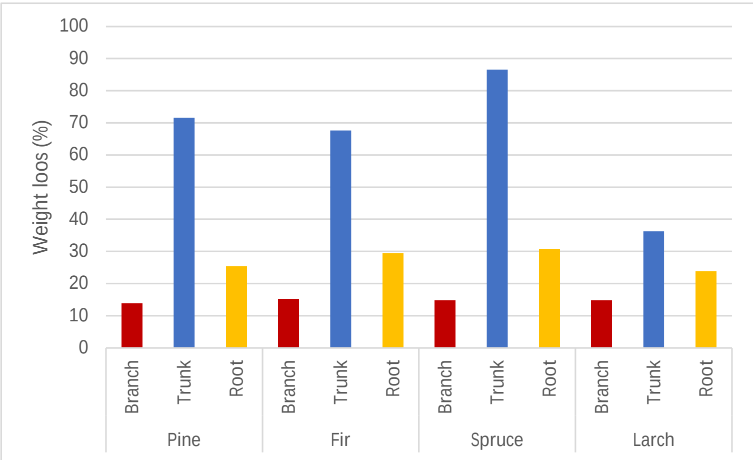

Figure 6 - Average weight loos of wood of the test bodies according to the tree species and the tree part.

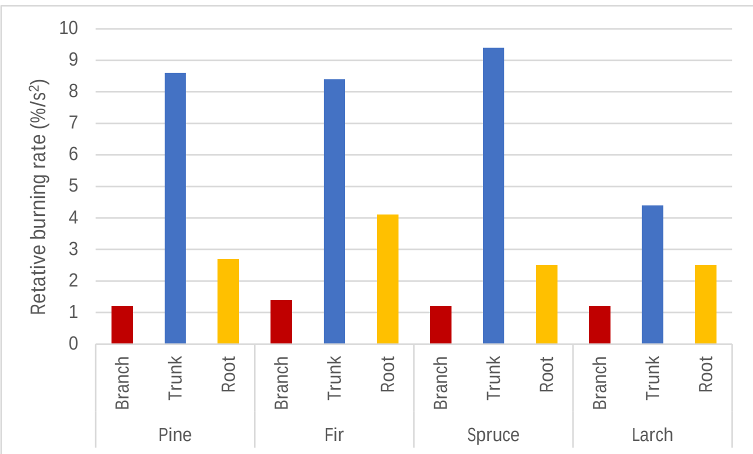

Figure 7 - Average relative burning rate of wood of the test bodies according to the tree species and the tree part.

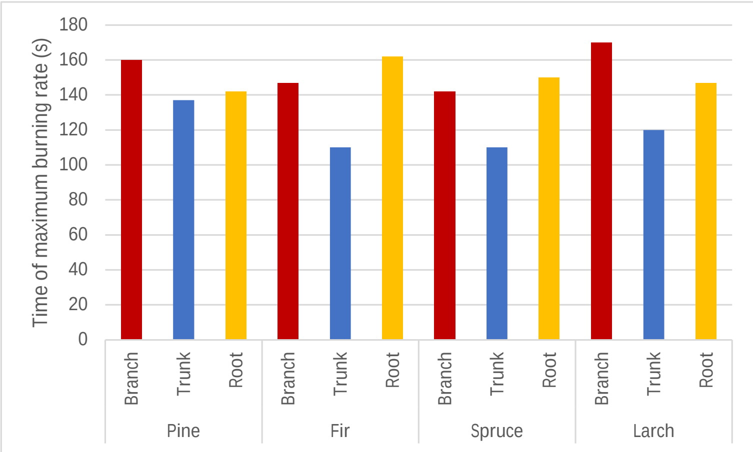

Figure 8 - Average time of maximum burning rate of wood of the test bodies according to wood type and tree part.

When determining the position of wood on the tree (branch, trunk, root), we came to a rather surprising conclusion. The greatest loss in weight for all woody plants was observed first for the trunk, then the root and finally the branch. The overall course of the experiment was influenced by the density of the wood, which for all the given tree species, was the highest in the branches (see Figure 5), followed by the root and finally the trunk with the lowest density.

Comparing the species of trees, the weight loss (branch) was the highest in fir and the lowest in pine. In case of wood from the trunk, spruce surprisingly reached the highest values, and larch the lowest. For the root wood, the highest values were recorded for spruce and the lowest for larch. At the end of this brief evaluation, we conclude that it is justified to observe selected tree species and their wood quality according to their position on the tree with regard to fire-fighting in the event of a forest fire.

The second assessment criterion was the relative burning rate; both weight loss and relative burning rate are important indicators in the development of the fire. In all observed cases, the highest burning rate was recorded for wood from the trunk. This factor is mainly significant when considering potential forest fires in a calamity-hit area where trees are already 'bark-free' due to the natural disaster, and the wood is more prone to catching fire. If individual positions are assessed based on the tree species, see (see fig. 7) the highest burning rate was recorded for spruce wood (trunk). The lowest burning rate was recorded for the wood of larch. This factor is also important in the case of root wood, which had a higher burning rate than branches for all three types of wood. This could also affect the development of ground fires where, in certain conditions, fire could smoulder and reignite.

The time to reach the maximum burning rate is shown in Fig. 8. According to the position of wood on the tree, based on the above graph, this factor was seen to be the worst for the wood of the pine (branch), fir (trunk), spruce (trunk) and larch (root). In regards to time to reach maximum burning rate, for the worst results were recorded in pine and fir (branches), fir and the spruce (trunk) and larch and the pine (root).

5. CONCLUSION

In a regular forest fire, the ignition of thin, dry or evergreen parts of the tree must be observed, especially branches that have the ability to cause or contribute to a crown fire. Another important factor is the bark wood, along which a fire can also spread quickly. In a forest fire in a calamity-hit area (the focus of our research), it is necessary to deal with the issue of wood itself. This “exposed” wood is present in the damaged forest in the form of broken branches and trunks, unrooted trees and broken roots. Such wood undergoes a relatively rapid drying, and as it is composed of sharp fragments with small volumes and large surfaces, it is easy to ignite and prone to intensive burning and spreading to more nearby broken and scattered wood. This experiment confirmed that there is a difference in the behavior of wood, which is given both by the wood itself and by the position on the tree. It is given that the experiment was carried out under "sterile" conditions - environment, moisture, dimensions - which do not correspond to the real conditions of a calamity-hit area but were necessary for the accurate measurement of the monitored variables. The results can be used in simulations of forest fire development, combining knowledge of the presence of different wood in the simulated fire area with information on the fire characteristics of such wood, both according to the species of tree and the position of the wood in the trees.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Mónika Nováky

ANALYSIS OF THE FIRE PROTECTION AUTHORITY AND PROFESSIONAL ACTIVITY IN THE SYSTEM OF THE INTEGRATED DISASTER MANAGEMENT SYSTEM

Abstract

The system of tasks of the professional disaster management body comprises a very wide range of activities. The tasks based on industrial security, fire protection and civil protection include authority prevention of disasters, organization and management of protection, implementation of rescue in emerged civil emergencies, as well as liquidation of the harmful consequences and realization of restoration-reconstruction. In addition the industrial security, the professional field of water affairs and water protection have been performing more widely authority and professional authority activities in the past periods. Authority activity is the important part of disaster management, prevention, planning and organization activity. The fire protection authority takes licencing, prohibiting and limiting measures, conducts fire inspections, issues authority certificates and imposes fire protection fines during its activity.

Keywords: disaster management, fire protection, authority and professional authority activity, prevention

A TŰZVÉDELMI HATÓSÁGI, SZAKHATÓSÁGI TEVÉKENYSÉG ELEMZÉSE AZ INTEGRÁLT KATASZTRÓFAVÉDELEM RENDSZERÉBEN

Absztrakt

A hivatásos katasztrófavédelmi szerv feladatrendszere igen széles tevékenységi kört foglal magában. Az iparbiztonság, tűzvédelem, polgári védelem pillérén nyugvó feladatok magukban foglalják a katasztrófák hatósági megelőzését, a védekezés megszervezését, irányítását, valamint a bekövetkezett polgári veszélyhelyzetekben a mentés végrehajtását továbbá a káros következmények felszámolását és a helyreállítás-újjáépítés megvalósítását is. Emellett az elmúlt időszakban a tűzvédelmi, iparbiztonsági, vízügyi és vízvédelmi szakterülete egyre szélesebb körben végez hatósági és szakhatósági tevékenységet is. A hatósági tevékenység fontos része a katasztrófavédelem megelőző, tervező, szervező tevékenységének. A tűzvédelmi hatósági tevékenység során engedélyező, tiltó és korlátozó intézkedéseket hoz, tűzvizsgálatot folytat le, hatósági bizonyítványt ad ki és tűzvédelmi bírságot szab ki.

Kulcsszavak: katasztrófavédelem, tűzvédelem, hatósági és szakhatósági tevékenység, megelőzés

1. INTRODUCTION

The basic need of man is the pursuit of security. According to OGY resolution 58/1998 (2nd Oct) about publication of the consolidated text of Convention about the protection of human rights and fundamental freedom right to security is a fundamental human right, a universal value. [1] Security is in unthreatened condition and it means at the same time the system of purposes and means that would reduce threatening and avoid danger. Lack of security endangers not only life but it also hinders sustainable development of the society. The components of security are: social (legal social), political, (diplomatic, military, informatic, economic, environmental (ecologic), financial, health and security of home affairs. Protection of the individuals and groups must be the fundamental element of the national security of each developed country. Without protection of the full system the individual elements cannot be in security, but without the protection of the elements the system cannot properly work. [2] [3]

Act 74th of 1999, entered into force on 1st January, 2000 about the management, the organization and the protection against disasters, and against dangerous materials in a new organizational form established - with special regard to the domestic and national regulations - the professional disaster protection organization of Hungary, the National Disaster Management Main Directorate of the Home Ministry (hereinafter: BM OKF) for the purpose of uniform protection against disasters. Uniform management of the experience from the events which occurred in the period after entering into force and the system of protection demanded making of the system of disaster management more efficient and the development of the conditions of uniform management. [3] [4]

By increasing national engagement the act 128 of 2011 (hereinafter Kat. tv) and the related acts about the modification of certain acts about protection against disasters for ensuring life and property of the population and operability of the country entered into force on 1st January, 2012 establishing a legal, institutional and organizational framework for disaster management. [5]

The organization of professional disaster management ensures the protection of human life and property and the continuous operation of vital systems by performing prevention and risk reduction tasks to protect the safety of life and property of the Hungarian population, the national economy and the safe operation of critical infrastructure elements and it support investments with priority from the point of new of the national economy.

The system of tasks based on the pillars of industrial safety, civil protection and fire protection covers a very wide range of professional disaster management activities. The industrial safety department identifies critical infrastructures, participates in the designation as a competent authority and carries out their inspections. In order to ensure secure transport of dangerous goods, it carries out inspections of sites and transport vehicles (water, road, rail, air), ensures the safe operation of these plants and of below-threshold plants, and ensures a high level of protection for the citizens and the environment [5]

Civil protection tasks are planning, organizing and decision-preparation activities carried out in order to protect the life of the population and material assets. Its tasks include preparing and informing the population, planning and organizing their temporary care, and establishing and preparing civil protection organizations. In the course of its official activities, conducting on-site inspections of damage and on-site inspections of civil protection risks in order to perform public protection tasks. [5]

The fire-fighting department carries out the implementation of firefighting and technical rescue, the professional supervision of municipal fire brigades, voluntary fire brigade associations and facility fire brigades. Within the scope of its fire prevention authority activities, the prevention of the occurrence and the spread of fires, as well as the enforcement of firefighting legislations, standards and official regulations to ensure the basic conditions of firefighting during installation and use. [6]

Disaster management is responsible for the utilization of waters, the preservation of its utilization possibilities, the licensing of water facilities and water works, the prevention of water damage, the prevention of water quality protection and the protection of water as an environmental element. It also acts as a tax authority with regard to the water supply levy. [7] [8]

2. THE SYSTEM OF MANAGEMENT

After January 1, 2012, the professional disaster management organization adapts its organizational structure to the changes in tasks. Pursuant to the relevant legislation currently in force, the professional management of the ever wider authority tasks is performed by the Prevention and Licensing Service of the Deputy Director General of the National Directorate General for Disaster Management (hereinafter: BM OKF) of the Ministry of the Interior and the General Inspectorate for Industrial Safety. The Water and Water Protection Department, the Fire Prevention Department, the Market Supervision Department, the Power Plant Licensing Department, the Critical Infrastructure Coordination Department, the Dangerous Plants Department and the Dangerous Consignments Department perform professional supervision and control of the authority and professional authority activities profession-specifically, but in certain authority matters they also act at first and second instance.[9]

The professional disaster management organization is a law enforcement agency, it is part of the central state administration. [10]

According to Waldo[1], the administration is a cooperative, rational action, the activity of the manager to persuade others to behave in a certain way. Administration is an activity, not necessarily a public one, which has a subject who controls, has objects who are controlled and

[1]Dwight Waldo (1913-2000) the determinant figure of modern public administration (source: http://www.igs.berkeley.edu/publications/par/Dec2000/Waldo.html downloaded: 22nd Jan. 2021)

it also has a content. [11] According [2]to the theory of Fayol this content of the administration includes planning, organization, giving out of orders, coordination and supervision and these subsequent actions compose [12]public administration, that is the specific kind of administration. Public administration is also administration, it is an operation achieved from power situation. The specificity of public administration, the differentia specifica, is primarily the specific subject, regulation and specific purpose of (public) administration. [12] The subjects of public administration act in the possession of the state public power (empire). This means that public administration is a legally regulated activity, whose legality refers to the close legal binding of the administrative action series. The administrative competence, the procedure, the decision-making possibilities, the means of enforcing the decision are determined by law. Its purpose is always achievement of the desired and legally defined conditions referring to the public affairs. With this end in view its decisions are enforceable. [12] During the preparation of decision, decision-making, implementation and control of decisions in the possession of the state public authority, through the application of law (enforcement), organization and participation in legislation by a separate state organization. [13]

The professional disaster management body is a law enforcement organization that also performs public administration tasks.[4] In the course of this administrative activity, it applies the relevant legislation within the public administration. The system of public administration includes defence administration, which is a system of tasks and organizations that, under the direction of the Government, is designed, implemented and administered by administrative bodies established to carry out the tasks of the state against threats and attacks jeopardizing Hungary. [14]

The defence administration, as a part of the public administration, mainly covers the tasks of national defence administration, law enforcement and defence economic planning. Its aim is to achieve the security of the country, an important cornerstone of which is the effective responses of the defence administration system to the global, European and national challenges affecting the security of our country. [15] The subject of defence administration is extremely diverse. Here are included threats to the European region such as financial collapse, various forms of

[2]Henri Fayol (1841-1925 one of the great figures of classis management trends (source: Encyclopedia of 21st century Economics Pannonica Publishing House, 2005. page 426 ISBN 963 7319 07 7)

terrorism, cyber, financial and energy security threats, global warming issues such as climate change disasters, the spread of extreme ideologies, energy and raw material shortages, drug-trafficking, organized crime, natural and industrial disasters, traditional interstate wars, and other military attacks. [15] The subject of defence administration is protection against threats in specific legal situations as per articles 48-53 Articles of the Constitution [16], which is part of a complex system of defence tasks. Based on this it includes performance of the administration tasks related to the tasks of national protection.

In the special legal order, the system of centralized, hierarchically structured administrative organization and tasks performing central, territorial and local control, as well as the legally regulated activities of state administration and local governments, and the armed forces and law enforcement agencies involved in defence, which also determine the planning, organizing and directing the implementation of its obligations under the special legal order. The defence administration includes the national defence administration, the law enforcement, and the defence economic planning. If the defence administration is divided into two major activities, one is the defence administration and the other is the disaster management administration. In fact, the difference lies in the period, as the national defence administration carries out planning and organizing activities primarily for the period of armed and military conflicts, while the disaster management administration carries out planning and organizing activities for the period of peace and disaster. However, it should be noted that the task of protecting the population of a professional disaster management organization is not only civil protection in the event of a disaster, but also civil protection tasks in times of an armed conflict.

The disaster protection administration includes the tasks of industrial security, civil defence and fire protection tasks of the professional disaster protection organization. The system of complex tasks endeavour to implement the primary aims in the phase of prevention, intervention and restoration. To protect human life and property security.

In the complex system of administration, the central state administration bodies perform the functions of defence administration within the scope of their administrative tasks, with licensing and control activities performed within the framework of the administrative authority procedure.

3. TASKS OF THE FIRE PROTECTION AUTHORITY

Implementation of the authority activity has been performed in the integrated disaster protection system with harmonized central coordination since 1st October 2012. In order to ensure efficient fulfilment of the task in compliance with the legal rules the supervision of the local - Disaster Management Branch - Territorial - County Directorate - official activities is carried out under the special guidance of the BM OKF Deputy Director General of the Organization. The professional support and management of the central body promotes the transparent, traceable, uniform and efficient performance of the official tasks. The purpose of the complex system is protection of human life and material assets, prevention of disasters, quick and professional management of them and proper and earliest starting of the restoration.

In the period of prevention [3]forecasting activity is an important task; the aim is to forecast - based on the domestic and international experience of the previous years and the professional prognoses - the expected event types that can be modelled and would occur with great probability, and which can serve as a basis for the preparations of the activity. The development of operations analysis is a key task for an integrated disaster management system in order to process and put experience into practice. [17]

In addition to performing fire-fighting and technical rescue the special field of fire protection it licences, introduces restrictions, performs inspections, issues official certificates, imposes a fine against those who violate the fire protection obligations in the framework of official and professional authority procedures. [6] [18] It comprises fire prevention, fire-fighting and fire inspection. The target of fire protection is to provide appropriate solutions to real problems with the help of legal rules and standards. Its function is to protect the citizens by means of consistent observation and enforcement of the fire protection rules, to establish the conditions of efficient intervention to fire-fighting and to ensure the fundamental security for the intervening persons in the meantime. In order to achieve its goals, it carries out its well-founded, efficient, client-

[3] § 3 16 of Act 128 of 2011 Prevention: any activity of application of a regulation that eliminates or reduces to the minimum the reasons causing the disaster and limits the probability of the damaging effect to the lowest possible." (source:https://uj.jogtar.hu/#doc/db/1/id/A1100128.TV/ts/20210101/lr/chain14/. download time: 24th Jan. 2021.)

centric official, authority, market surveillance and information activities that meet the challenges of the age. [17]

The authority procedure is a controlled activity, so the procedures have to the conducted in compliance with act 150 of 2016 about the general public administrative order; of course the detailed rules are regulated by the decrees of the government and of the minister.

The system of protection against fire and the fire protection tasks, rights and obligations are governed by act 31 of 1996 about protection against fire, technical rescue and fire brigades: Governmental decree 259/2011 (7th Dec) (hereinafter: Korm.r.) on the organization of fire protection authorities, fire protection fines and compulsory life and accident insurance for those dealing with fire protection [19] contains rules, [20] Governmental decree 489/2017 (29th Dec) (hereinafter T.Korm.r) governs the general and special rules of fire protection authority procedures [21]

The fire protection department conducts official proceedings

in the following matters:

- licensing procedure for the construction and decommissioning of built-in fire detection and fire-fighting equipment
- licensing procedure for the commissioning of built-in fire detection and fire-fighting equipment
- procedures for service supervision of fire service activities subject to notification
- granting a derogation from the fire safety regulations for buildings and structures and the requirements for the intervention of fire brigades
- announcement of the start of chimney sweeping activities, keeping of records
- disputes related to the issuance of the chimney sweep industrial certificate and the chimney sweep industrial professional declaration
- supervision of the content of the chimney sweep industrial certificate and the chimney sweep industrial professional declaration
- review of the stipulations of more frequent inspections of flue gas drainpipes than required by law

- procedure to be followed in the event of failure to carry out periodic inspections of the flue gas drainpipes and to remedy the irregularity of the flue gas drains until the next inspection
- procedure in case of notification related to temporarily used properties
- market surveillance official procedure
- a consumer protection procedure concerning the conformity of the packaging, the marking and the affixing of the CE marking to pyrotechnic articles. [22]

As a competent authority, it participates in the following procedures:

- building authority procedures
- procedures of granting operating permit
- site licensing procedure
- licensing procedure of musical and dance events
- registration of social, child welfare and child protection service providers and institutions in the official register
- licencing procedure related to pyrotechnical activities[22]

Within the scope of its official and professional authority activities, it also conducts on-site inspections of fire protection if necessary to establish the facts. [22]

Pursuant to § 55 of Act 150 of 2016 on General Administrative Procedure (hereinafter: Ákr.), if an expert opinion must be given to a professional question in an official proceeding before the authority, then due to the enforcing reason based on public interest and specified by the law a binding opinion on the matter must be obtained from another authority. The authority makes its decision on the basis of the resolution of the competent authority. As the professional issue requires special knowledge, the fire protection authority participates in the proceedings as a specialist authority in the cases listed above.

The rules of acts Ákr., Ttv., Korm.r. and T.korm must be applied to conduct the official and professional procedures. The competent authorities acting on the basis of certain overriding reasons in the public interest are determined by governmental decree 530/2017 on the designation of professional authorities (hereinafter: the Decree) [23] These procedures are investments of special importance from the point of view of the national economy, for which the Decree establishes different deadlines for the competent authority regarding the issuance of the resolution compared to the deadlines specified in the Ákr. Differently from Ákr, the procedural deadlines are set out in Act 53 of 2006 on the acceleration and simplification of the implementation of investments of key importance for the national economy. [24]

In addition to the official and authority procedures of the fire protection department, it also conducts a fire inspection procedure, for which Governmental decree 490/2017. (29th Dec.) on the procedural rules for the investigation of fires, [25] and decree 4/2011. (5th Dec.) of the Ministry of Interior on the rules for the investigation of fires [26] shall apply. The fire inspection must be carried out ex officio within the framework of an official procedure, by means of an on-site inspection, the purpose of which is to gain professional experience in fire prevention and firefighting, to investigate the causes and origins of fire and to establish liability. [25] [26] At the request of the fire protection authority, an official certificate is issued according to § 95 of Ákr.

4. SUMMARY

The official activity of the professional fire protection organization in the field of fire protection is very wide. Within the framework of the official procedure, it may adopt licensing, restricting and prohibiting provisions and carry out inspections, which serve the safety of life and property of the population within the framework of disaster prevention activities. As a professional authority, it contributes with its expertise to the well-founded decision of the acting authority, the data and findings obtained in the fire inspection procedure serve as an experience for firefighting activities.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

János Szép, Zsuzsanna Kerekes, Bleszity János, Vass Gyula, Ágoston Restás

FLAMMABILITY QUALIFICATION WITH OXYGEN INDEX (LOI) OF TEXTILES USED AS BUILDING MATERIALS

Abstract

Today, plastics are increasingly used as a building material, and traditional silicates are starting to displace. The plastic industry was developed significant in the last decades. The application of plastics are increasing. Because of this it is a high risk factor. The characterization of the behaviour of plastics while being on fire is of great importance for the practical use of plastic materials. Toxic gases arose during combustion of plastics, that's dangerous for people and environment. Our paper presents the occurrence of the most common plastics in buildings: woven and non-woven textiles, and cables. These are subject to the same stringent flammability requirements as traditional products. Polyester (PES) is one of the most important synthetic polymers. Subject of my examination is the nonwoven geotextiles. They are widely used in many fields such as flat roof insulation. Conversely, it has various disadvantages such as highly flammable combined with dripping, smoking, shrinking effect. For these reasons, it is necessary to improve the anti-dripping and fire retardant properties of textiles, that used in buildings. The flue gas composition, the combustion temperature affect the survival chances in case of fire. The aim is, that analyze flame retardant properties of textiles with LOI. The method provides a classification of the burning behaviour.

Keywords: fire protection, polymers, polyester, geotextile, flammability, self-sustaining combustion, nonwoven geotextile

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NEM SZERKEZETI ÉPITŐANYAGOK ÉGHETŐSÉGÉNEK MINŐSITÉSE

Absztrakt

Ma már egyre gyakrabban használnak műanyagokat építőanyagként, a hagyományos szilikátok kezdenek kiszorulni. A műanyagipar jelentős mértékű fejlődésen ment keresztül az utóbbi évtizedekben. Felhasználási területe egyre bővül, így mennyiségük is rohamosan növekszik. Széleskörű elterjedését figyelembe véve kiemelt kockázati tényező, mivel az égése során keletkező toxikus gázok az emberre és a környezetre nézve is veszélyt jelentenek. Dolgozatunk bemutatja a leggyakoribb műanyagok előfordulását az épületekben: szőtt és nem szőtt textiliák, és kábelek. Ezekre ugyanolyan szigorú éghetőségű követelmények vonatkoznak, mint a hagyományos termékekre. Felhasználása széleskörűen történik, többek között lapos tetők szigetelése során elválasztó textíliaként alkalmazzák az építő iparban is. A poliészterek gyúlékony anyagok, melyre jellemző az égve csepegés, füstképződés és zsugorodás. Egy tűzeset során a füstgázok összetétele, az anyag gyulladási, illetve lángterjedési ideje meghatározza a menekülési esélyeket. Égésgátlók alkalmazásával késleltetni lehet a meggyulladást, időt nyerve a menekülésre. Emiatt szükséges az építő iparban, a lakóépületeken belül felhasznált műanyagok égésgátló tulajdonságának javítása. Dolgozatunk célja a vizsgált műanyagok égéskésleltetésének minősítése oxigén index méréssel, valamint a szövetek függőleges lángterjedésének vizsgálata. Ez alapján javaslat megfogalmazása a szövetek alkalmazhatóságára.

Kulcsszavak: tűzvédelem, polimerek, poliészter, geo textil, éghetőség, oxigén index, nem szőtt geotextil

1. INTRODUCTION

There are many problems to be solved in the field of fire protection [8] [9] [10] and fire investigation [11]. There are several methods to describe the flammability of various materials, such as the smoke temperature, the flame propagation in different directions, smoke densities and fume temperatures [6].

The flammability of materials can also be characterized by their minimal oxygen concentration required to maintain of burning.

The majority of flammable materials are capable of combustion at normal oxygen levels (21 vol %.), but there are materials that burn at lower or higher oxygen concentration in comparison. Oxygen index (LOI – Limited Oxygen Index) is not a commonly practiced laboratory measurement method, despite its being a significant parameter in the characterisation of flammable materials. This method has originally been developed to describe the flammability of plastics, but in principle it is applicable to all combustible solid materials [1].

The LOI parameter is used for fire protection qualification of several plastics: carbon fibres in the literature, oxidized fibres and materials made from those: woven and non-woven textiles, and outer plastic coating of electrical cables. The samples under investigation are to be produced locally, after solving initial problem [2].

One goal was to see how the traditional tests reflect the real fire requirements and the actual fire resistance of the cables. It is also necessary to investigate, that those cables, which received a fire resistant rating, they really correspond under real fire requirements. The actual fire resistance was the most suitable for the oxygen index (LOI) parameter.

2. METHOD OF MEASUREMENT

The precise circumstances of the measurement are regulated by standards. The standardised measurements are governed by both Hungarian standard (MSZ 10200-1989) *(Plastics - Determination of flammability by oxygen index)* and international standards (ISO 4589, ASTM 2863). By definition oxygen index is defined by the minimum oxygen content of the air, where the material is still capable of fire propagation or burning in a defined time interval.

The most important part of the measuring instrument for the oxygen index is shown in *Figure 1*.

The sample holder is a 6 x 16 cm, U shaped, double layered vertical metal frame, secured in a glass cylinder with its top end open. The ignition and the removal of the combustion products

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are made possible through this opening. The source of ignition is a 4 cm long gas-flame as prescribed by standards. The specimen is ignited along the upper edge applying the flame for maximum of 15 seconds. Burning proceeds downwards against the flow of the pre-adjusted gas mixture. Nitrogen and oxygen content are adjustable as required [5].

For the purposes of this International Standard, the following definition applies: Oxygen index the minimum concentration of oxygen by percentage volume in a mixture of oxygen and nitrogen introduced at 23±2 ^{o}C that will just support combustion of a material under specified test conditions. It is recommended that the first trial measurements are performed at a low (30-32%) oxygen concentration. Initially the material does not show any ignition phenomena, and is non-flammable. By increasing the oxygen content, initially only burning patches appear, then as the oxygen concentration increases, the length of the burnt area becomes greater.

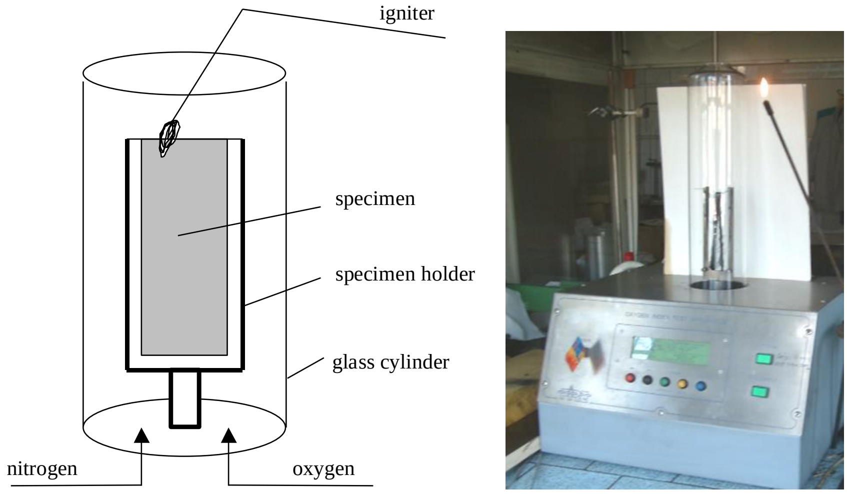

Figure 1 - Diagram of typical apparatus for determination of oxygen index. Created by the authors

Technical data of apparatus: FIRE Instrumentation and Research Equipment Limited, UK (ISO 4589 Part 2 Oxygen index test apparatus)

The oxygen index can primarily be applied to solid and composite materials. It was a separate task to work out a method for the application of the oxygen index to structurally completely different materials such as fibres, non-woven felted textiles (the use of terms, such as vlies or felt is accepted as well).

Samples based plastics

1. Felts based oxidise fibre

The most flame retardants and non-combustible nonwoven fabrics are made of oxidized and carbon fibres, due to their strong thermal stability. The burning of nonwoven fabrics consists of complex combustion mechanisms: their surface, micro- and macrostructures together define their combustion features. By microstructure we mean oxidized Poly Acrylic Nitrile (PAN) fibres, which finally constitute the base material of the macrostructure. The macrostructure represents the different forms of the product, in which the material results during production. The majority of carbon fibre-based samples can be characterized by a certain oxygen concentration, including standard LOI.

The area weight parameters are our own measurements. The typical fibre density was provided by the manufacturer at our request. For area weight, the following measurements were taken: 80, 100, 150, 200, 270, 500, 1700, 1850 gm-2. The tested materials and their parameters are given in Table 1.

Table 1- Micro- and macrostructure data for each sample. Created by the authors

	1	2	3	4	5	6
Sample IDs given by the producer	PN N1	PN N3	PN 5	PN TESA	PN ST	PN ACHILL
fibre density, gcm^{-3}	1.35	1.37	1.37	1.37	1.37	1.37
area weight, gcm^{-2}	150-190	150-190	600-700	500-600	190-300	150-250

Table 2 - The LOI values in function of fibre density. Created by the authors

density of fibre (gcm^{-3}) used in the felts	1.351	1.400
LOI (1)	24.5	31
LOI (2)	35	48

2. Non-woven geotextile based polyester

They are made of endless or cut polypropylene or polyester fibres by a special needle felting process. (are shown in Table 3. During production, they receive unilateral or double-sided heat treatment, which significantly increases their performance [7].

Use of non-woven geotextiles

- Separation: during road, railway and hydraulic construction and other foundation works, for the separation of high-quality primer layers and granular materials incorporated as subsoil and load-bearing layer [4]
- Filtration: for leaking systems
- Protection: for mechanical protection of the insulation of structures.
- As a vapor barrier layer for roof shells [3]

Table 3 - The characteristics of the polyester geotextile samples. Created by the authors

Sample	**Color**	Thickness **[mm]**	**Areal weight [g/cm^3]**	**Material**	**Thermoformed**
G1	white	5	1000	100 % Flame retardant PES	Yes
G2	white	1,6	300	100 % Flame retardant PES	Yes

G3	white	2,8	300	100 % Flame retardant PES	Yes
G4	white	1,2	200	100 % Flame retardant PES	Yes
G5	white	1,6	300	98 % PES, 2 % PA (polyamid 6)	Yes
G6	white		300	100 % Flame retardant PES	Yes
G7	white		500	100 % Flame retardant PES	Yes
G8	white		1000	100 % Flame retardant PES	Yes
G9	white		300	100 % PES	No
G10	white		1000	100 % PES	No
G11	brown		300	100 % PES	No
G12	black	1,38	500	100 % Flame retardant PES	Yes

3. TEST RESULTS

Felts: Two of the characteristics of compactness are thickness and area weight (gm^{-2}), i.e., how loose or compact a nonwoven fabric is. Their thickness is typically 5-6 mm during production. However, one can find, in some samples, thinner (4 mm) or thicker (5 mm) surfaces as well. The burning of low area weight (below 300 gm^{-2}) fabrics is characterized by surface flames, often at 25 to 28 oxygen index (Figure 2). Above a certain compactness (approx. 300-400 gm-2), there was no visible surface flame, only a standard downward burning spread without flame.

The disappearance of the surface flame occurs at the combustion in the air of 50% oxygen content (Table 2). Thus felts are also able to burn with flames, surface flames or just glow. The oxygen index of denser felts without surface flames is clearly defined by the area weight as shown in Table 3.

The oxygen index value is in a linear relation to area weight. As far as combustion phenomena, at an oxygen index above 50%, only glow appears without surface flames; it may happen above 500 gm^{-2} area weight

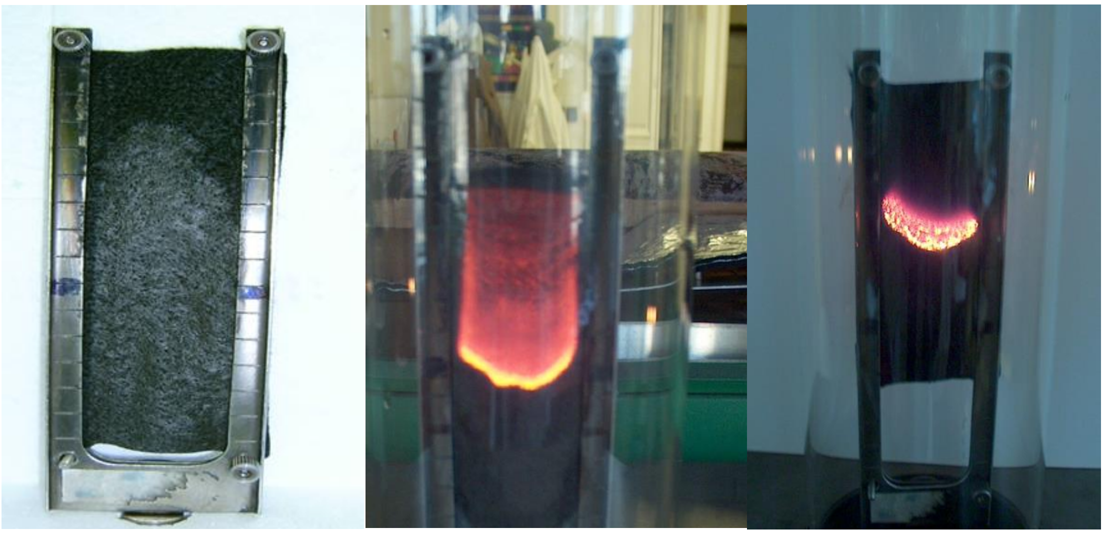

Figure 2 - Burning of nonwoven fabrics.

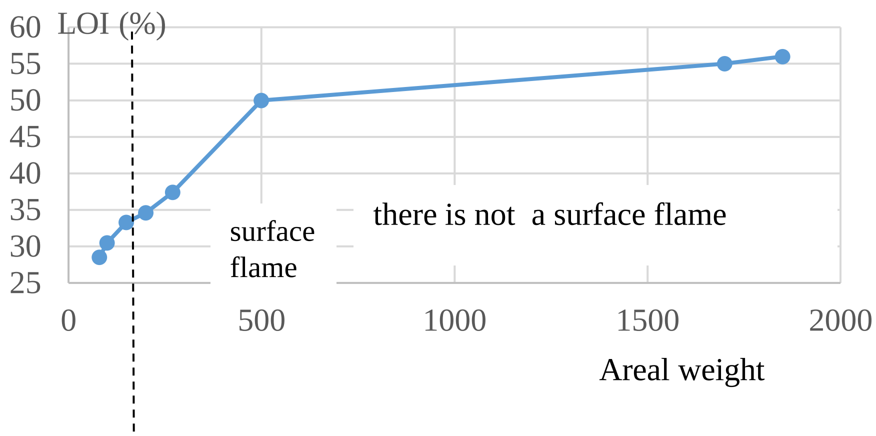

Figure 2 - Areal weight parameters influencing oxygen index of non-woven felts. Created by the authors.

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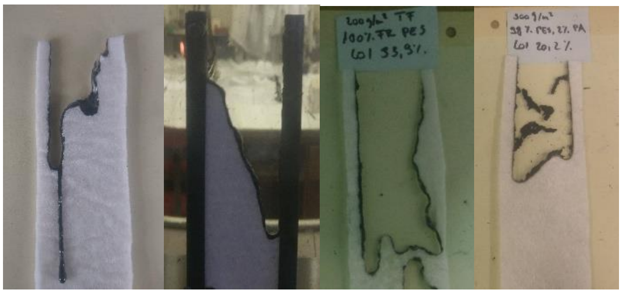
2. Oxygen index (LOI) test results of Non-woven geotextile based polyester

During the measurement, the following was observed: When samples G1-G4 and G6-G10 were examined, no smoke was characteristic, but a melt was formed. Typically, the melt burns further. When G5, G11 and G12 samples were ignited, strong smoke was observed, but no melt. For some samples, the unevenness of the texture was detected during the examination, the same sample produced different results.

Figure 3 - Samples during burning. Source: Authors



G1 G2 G4 G5

G8 G9 G10 G11 G12

Figure 4 - Samples after burning. Source: Authors

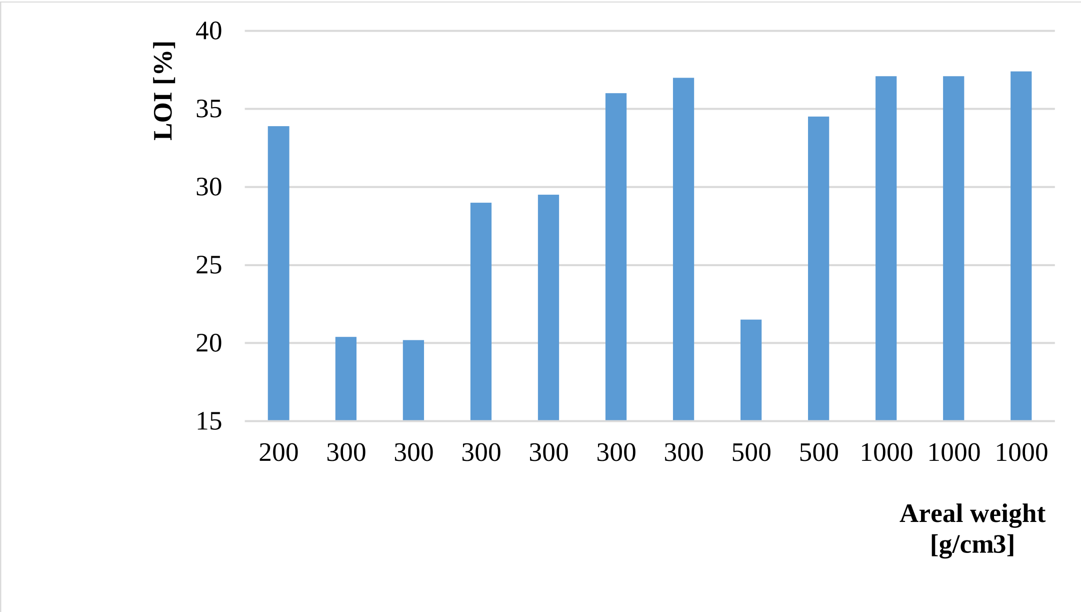


Figure 5 - Areal weight parameters influencing oxygen index of Non-woven geotextile based polyester. Created by the Authors.

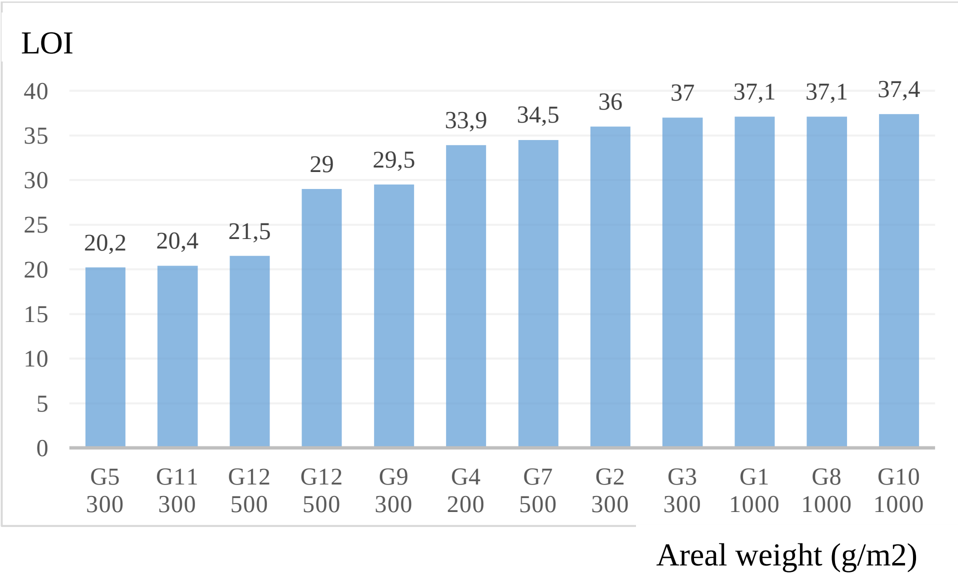


Figure 6 - Areal weight parameters influencing oxygen index of Non-woven geotextile based polyester. Created by the Authors.

4. SUMMARY

Only those woven and non-woven textiles can be considered as surely non-flammable, of which the oxygen-index value **is** above 50. This LOI can be reached with the following area weight: for woven textiles more then 370 g/m^2 and for felts more then 500 g/m^2.

If the LOI value of the base material (oxidised fibre) is more then 50, the micro structure of the fiber against combustion can be considered thermodynamically stable.

Only those non-woven textiles can be considered as surely non-flammable, of which the oxygen-index value is above 50. This LOI can be reached with the following area weight: for woven textiles more then 370 g/m^2 and for felts more then 500 g/m^2.

Vlies samples show most sensitively the degree of dependency on structure by LOI. The danger of re-ignition is most pronounced in these samples, because the presence of fuzzy piles is inherent to the material and it can’t be influenced by mounting. Surface flame can appear in cases when the top of the sample cannot be ignited and therefore usual flame spreading cannot be observed. If the material is rather loosely structured (tread), even the surface flame is capable of burning through the whole thickness of the material.

The LOI values of the samples giving highly sooty smoke (G5, 11,12) are below 30. Polyesters with a LOI of 34-37 (solid, with a Areal weight of 1000 g / m2, self-extinguishing combustion) can already be safely used as building materials. A self-extinguishing, low flame spread is not yet sufficient information, giving an oxygen index means complete safety. A sample with a low surface density (200 g / m2) can also be flame retardant after appropriate treatment. Our studies show that the burning behavior of PES-based nonwovens is shaped by both surface density and burn delay. Our research can also be a good basis for other series of publications on similar topics [12].

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

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METHODS OF ELECTRIC CAR CHARGINGS ACCORDING TO ASPECTS OF THE FIRE PROTECTION

Abstract

In parallel with the spread of electric cars, more and more companies are setting up car chargers at their premises. The design of the charger and charging cable also differs in case of different charging methods, therefore, they present other risks in terms of fire hazard. Generally Mode 1 and Mode 2 charging modes are common. In our paper, the Mode 3 and Mode 4 charging modes are more relevant, when the charging is already carried out through charging devices specially designed for this purpose. This equipment is similar to different switchboards, they contain all the necessary protection and communication devices to ensure a safe charging process. Mode 4 DC charger is larger, more complex and therefore it has more significant fire risk. Overload also appears as a source of danger, so it is important to use appropriate overcurrent protection devices. Based on the causes of electric fires, the authors examine each case and propose a coherent regulation.

Keywords: electric fire, charging mode, charger, firefighting

ELEKTROMOS AUTÓTÖLTÉSEK MÓDJAI TŰZVÉDELMI SZEMPONTOK SZERINT

Absztrakt

Az elektromos autók terjedésével párhuzamosan egyre több vállalat létesít autó töltőt a saját telephelyén. Az egyes töltési módok esetében más és más a töltőberendezés és töltőkábel kialakítása, ezért tűzveszélyességi szempontból különböző kockázatokat jelentenek. A Mode 1 és Mode 2 típusú töltési mód a lakossági használatnál elterjedt. Tanulmányunk szempontjából nagyobb relevanciája van a Mode 3 és Mode 4 töltési módoknak, amikor a töltés már külön erre a célra tervezett töltőberendezéseken keresztül valósul meg. Ezek a berendezések nagymértékben hasonlítanak a különböző kapcsoló- és vezérlőszekrényekre, tartalmaznak minden szükséges védelmi és kommunikációs eszközt a biztonságos töltési folyamat megvalósulásának érdekében. Mode 4 DC töltőberendezés nagyobb, robosztusabb, kialakítása bonyolultabb, és ezért tűzvédelmi szempontból is nagyobb kockázatokat hordoz magában. A túlterhelés szintén megjelenik, mint veszélyforrás, ezért fontos a megfelelő túláramvédelmi eszközök használata. Az elektromos tüzek keletkezésének okaira alapozva vizsgáljuk az egyes eseteket és teszünk javaslatot egy egységes szabályozásra.

Kulcsszavak: elektromos tűz, töltési mód, töltő, tűzoltás

1. INTRODUCTION

1.1. The history of electric cars

The history of electric vehicles dates back to the middle of the 19^{th} century. During these years Robert Anderson built the first electric vehicle.

The invention was preceded by the innovation activities of many people:

- Alessandro Volta discovered the galvanic cell in 1800
- André-Marie Ampère formulated the law of excitation in 1820
- Michael Faraday introduced the operation of the electric motor in 1821 and then discovered electromagnetic induction
- Ányos Jedlik invented the lightning-fast rotor, which was the world's first DC motor in 1828

After Anderson’s invention, many inventors began to take an interest in electric vehicles. The best known of these are Robert Davidson, Thomas Davenport and Gaston Planté, who invented the scrap lead-acid battery. Also known inventors are Nikola Tesla and Thomas Alva Edison.

Edison developed nickel-iron batteries for his self-designed electric cars, but these eventually did not make series production. [1] [2]

Picture 1 - Thomas Davenport's electric car

Source: carmudi.com

Picture 2 - Thomas Alva Edison with his electric car

Source: businessinsider.com

The years between 1880 and 1920 were about an intense development called the golden age of electric cars. During this period, three types of cars were present in the market: gasoline-powered cars, steam-powered vehicles, and electric cars. The advantage of electric vehicles was the minimal maintenance and the silent operation.

However, these benefits were quickly forgotten due to:

- They could cover a maximum of 100-150 km distance with a single charge.
- They were relatively slow (average speed around 30 km/h),
- With the fall in the price of petrol, cars with internal combustion engines have become more economical
- Mass production of the gasoline-powered cars have begun

[1] [2]

The change was in the 1960s and1970s. At that time, pollution increased greatly and the air in the larger cities became almost unbearable, leading to a gradual decline in oil stocks and the subsequent oil crisis. The production of electric cars has become popular again. [1] [2]

1.2. Charging process and the related legislation

The main element of the charger is the controller. It communicates with the electric car via communication cables built into the cable, it enables the charging process and if it is necessary, it communicates with external devices. The controller operates a latch before charging begins, which prevents the cable from being removed from the car. Then the contactor retracts and the car starts charging. Charging is completed in reverse order, first by the contactor and then by the latch (Figure 1). [3] [4]. However, the regulations for live equipment must be applied, which appears in the Decree No. 72/2003. (X. 29.) GKM of the Minister of Economics and Transport on the Issue of the Safety Code for Working on

Live Equipment [5].

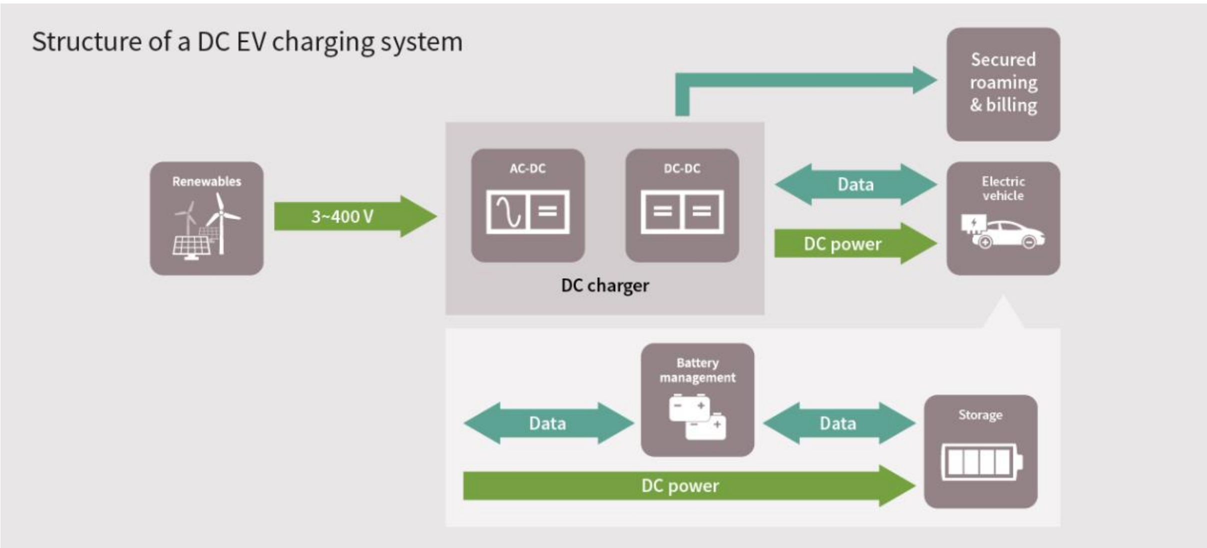

Figure 1 - Process of DC charging in case of electric car. (*Source: infineon.com)*

2. CHARGING METHODS

Based on the standards presented above, 4 charging modes can be distinguished.

1. Mode 1

In case of charging, the car receives power from the electrical grid via a standard connector. This charging mode is not intelligent, so the charger does not communicate with the vehicle, so for safety reasons it is rarely used. The maximum value of the current can be 16 A, and the value of the voltage can be 250 V for 1 phase, while 480 V for 3 phases. Figure 4 shows a suitable cable for this. [3] [4]

2. Mode 2

During charging, the car receives the power through a standard AC connector. The charging cable includes a special control box (Figure 5) that makes the device an intelligent charger. It means that the box controller and the car's on-board charger communicate with each other. The communication reveals:

- how much energy the car can absorb
- how much power the network can provide
- how much electricity the charging cable can safely conduct
- is there any grounding.

When all conditions are met, the controller only in this case applies voltage to the vehicle charger. The maximum allowable current is 32 A, the voltage is maximum 250 V for 1 phase, while 480 V for 3 phases [3] [4].

Picture 3 - Charging cable for Mode 1

Source: alibaba.com

Picture 4 - Charging cable for Mode 2

Source: besen-group.com

3. Mode 3

Cars are already charged from equipment. In case of charging they can be connected to the car in two ways. The first option is a fixed cable connection, in this case one end of the charging cable is connected to the charging point and the other end can be connected to the car with a connector. The second option is only one socket at the charging point, for which a separate charging cable must be used. One end of the cable is pluggable into the charging station and the other end into the car [3] [4] [6].

4. Mode 4

This is the so-called rapid charging, where a high voltage direct current is used for charging. Because of the high voltage, it is subject to strict regulations, such as it can be only a fixed charging cable. The investment of a rapid charger (Picture 6) is very expensive, so it is commonly used along the highways [3] [4] [6] [24].

Picture 5 – Normal charger for Mode 3

Source: villanyautosok.hu

Picture 6 –Rapid charger for Mode 4

Source: elektromotive.hu

3. TYPES OF CONNECTORS

Initially, only AC charging was widespread, so IEC 62196-1 recommends a type of connector suitable for 3 AC charging:

- Type 1: single phase vehicle connector – SAE J1772-2009 „Yazaki" specification.
- Type 2: single and three phase vehicle connector – VDE-AR-E 2623-2-2 „Mennekes"
- Type 3: single and three phase vehicle connector – „EV Plug Alliance" specification. [4]

To serve higher power DC charging, IEC 62196-3 recommends additional connector types such as:

- CHAdeMO
- CCS (Combined Charging System) Type 1
- CCS (Combined Charging System) Type 2 [4]

The main components of a charger

Different producers make different chargers, however, due to the same operating principle, each of them includes standard devices. I will present these in the next chapters.

1.E-mobility control

The most important element of the car chargers. There are several products available in the market. In addition to charging and related communication tasks, the controllers can have a variety of setting modes. There are products for both private and business use. For the cost-effective operation, manufacturers create their controllers so that they can be easily integrated with their other self-developed solutions. In case of controllers, it is possible to connect to an external application, so providers and operators can easily integrate car chargers into their own systems. [7]

2. Contactor

Electromagnetically operated coupling device, so-called magnetic switches. In car chargers, its function is that when the e-mobility controller gives permission to charge, the contactor retracts and the working contact closes, so that the current is flowing through it and reaches the vehicle. If there is no charge, it prevents the cable from being under voltage. [8]

3. Power supply

The function of the power supply is to convert the supply voltage of 230 V or 400 V to 5 V, 12 V or 24 V for the devices in the charger (for example controller). From the supply voltage, the transformer generates the required amount of alternating voltage. From this, the rectifier generates a DC voltage of the same magnitude. Eventually, this signal even needs to be stabilized [9].

4. Circuit breaker and switchers

The function of the circuit breaker is to protect against overloads and short circuits in electrical networks. It is also suitable for switching the power on and off and for the conduction. The switcher is a touch protection solution that is primarily used in the conductive contact protection modes. The basis of its operation is that the conductors of the protected circuit carrying the operating current are passed through a common current transformer, while the protective conductor is built around it and does not protect against overcurrent and short-circuit current.

. [8]

5. Sockets and cables

The electric car can be connected to the charger via a socket or cable. Most important features of charger cables are:

- Suitable for Mode 3 and Mode 4,
- They can include Type 1, Type 2, CCS coupling head,
- The other side has an open cable end
- They are rated for the transmission of a given charging current
- They can be spiral or straight

Most important features of charger sockets are:

- They are suitable for standard Mode 3
- They have Type 2 design
- They are rated for specific current transmission.[7]

Causes of electric fires

Electric fires are very common and have significant negative economic effects, so it is very important to deal with the topic [10] [11]. From the fire prtection point of view in case of electrical equipment and electric car chargers, it is essential to know the phenomena that can lead to cables becoming a source of ignition.

According to the studies, fires caused by electricity can be divided into 3 main groups according to the cause:

- overload of the cables
- high transient resistance
- short circuit or electric arc [12] [13] [14]

Firefighting under voltage

In many cases, the de-energizing of live equipment cannot be done. Furthermore, due to the protection of human lives, the risk of explosion [15] and the risk of major damage to property, it is necessary to intervene as soon as possible [16]. In case of electric fires the firefighting have to be performed according to the regulation 6/2016 (VI.24) NDGDM instruction is the Rules of Fire-fighting Tactics on the release of the Rules of Technical Backup Operation[17]. This is important primarily for the safety of the interveners [18] [19] [20]. So firefighters can avoid the threats during the firefighting [21] [22].

4. SUMMARY

The development of the charger and its cable is different in case of each charging method and therefore it poses different risks in terms of fire protection [23]. Investigation the causes of electric fires, we examined the charging methods and devices.

In case of Mode 1 charging mode, we only use one cable to charge the car. One end of the cable is connected to the mains socket and the other to the car. There is no communication or protection device in the cable. The grids must be earthed and should have a 16 A rated circuit breaker in order to prevent the overload. Charging with high current can overheat the cable and connectors. It means that the conductor can be flammable, if a wrong cross-section is used for this purpose. An additional hazard can be the connection of the connectors to the cable, which is often accomplished by soldering, so if the design is wrong, it can also lead to a generation of fire. It is usually used in generally by the citizens, so it does not pose a hazard in case of testing the charging equipment.

The Mode 2 charging mode is a complement of the Mode 1 with communication and protection devices. As a result, the risk is lower in terms of the fire protection, but the hazards remain due to the wrong sizing of the cables or the poor connection of the connector. It is also usually used in generally by the citizens. Mode 3 and Mode 4 charging modes are more relevant. The charging is already done through special equipment. These devices are similar to the different switch cabinets, as they contain all the necessary protection and communication means to ensure a safe charging process. The main difference between the two types is that the Mode 3 is AC chargeable, it transmits the energy, so it is a simpler design.

In contrast, Mode 4 implements DC charging. In this case, the electronics are not in the car but in the charger. So the device is larger, its design is more complicated, and therefore it carries greater risks from the fire protection point of view. In chargers, the cables and wires are connected via terminals, so proper installation is very important to avoid high transient resistance. Overload is also a source of danger, so it is important to use appropriate protection measures and to think of the same cable ducts for high-current conductors. In case of such conductors, we can use fireproof wires or cables. Compliance with fire protection requirements must be guaranteed by the manufacturers, and it is the responsibility of the owner or operator to ensure this with the maximal accuracy.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

József Kersák, Péter Pántya

OPPORTUNITY FOR TECHNICAL DEVELOPMENT IN THE FIELD OF PRACTICAL TRAINING IN CASE OF TECHNICAL RESCUE

Abstract

Today, due to the horizontal and vertical development of the urbanization, civilization and/or natural disasters are destroying to an unprecedented extent. Their extent and intensity also pose a threat to human life and material goods. Due to the development of technologies, it is necessary to improve certain segments of the protection systems (for example Fire Protection, Civil Protection, Industrial Safety). Such development can be education, qualification or even the practical training described by the authors in the paper. This type of research cannot be limited to the domestic level and development. In a wider sense, it is necessary to do research and adapt the so-called "best practice" directions that have already been accepted internationally, thus making the defence more effective.

Keywords: firefighting and technical rescue, tree fall, storm damage, tension of wood parts, practical training

MŰSZAKI FEJLESZTÉSI LEHETŐSÉG A MŰSZAKI MENTÉS GYAKORLATI KÉPZÉSÉNEK TERÜLETÉN

Absztrakt

Jelen korban az urbanizáció horizontális és vertikális térnyerésével a civilizációs és,- vagy természeti eredetű veszélyek, katasztrófák eddig nem tapasztalt mértékben fejtik ki hatásukat. Lefolyásuk, illetve intenzitásuk, az emberi életre, anyagi javakra jelentő veszély miatt, a technológiák fejlődésével párhuzamosan az alkalmazott védelmi rendszerek (Tűzvédelem, Polgári Védelem, Iparbiztonság) bizonyos szegmenseit fejleszteni szükséges. Ilyen fejlesztés

lehet az oktatás, képzés és a jelen cikkben érintetten különösen a gyakorlati tréning területe. Ez a vizsgálati irány nem szorítkozhat csak a hazai kutatásra, fejlesztésre, tágabb értelemben szükséges a nemzetközileg már bevált és alkalmazott, a „best practice" irányok kutatása és adaptálása, mindezzel hatékonyabbá téve a védekezést.

Kulcsszavak: mentő tűzvédelem, fa kidőlés, elemicsapás viharkár, farészek feszültsége, gyakorlati képzés

1. INTRODUCTION, HISTORY

Monitoring studies of the firefighting and technical rescue carried out within disaster management operations can be well applied to determine the qualitative and quantitative hazards. This is a part of the risk assessment in Hungary [1]. Based on the result, it is possible to predict the defence directives. Professional and voluntary fire departments must have a high level of competence in order to eliminate the interventions professionally. In many cases, firefighters have to work in extreme situations [2]. The conditions are others than what civilians are used to. In order to acquire professional practical knowledge, practice-oriented preparation is required.

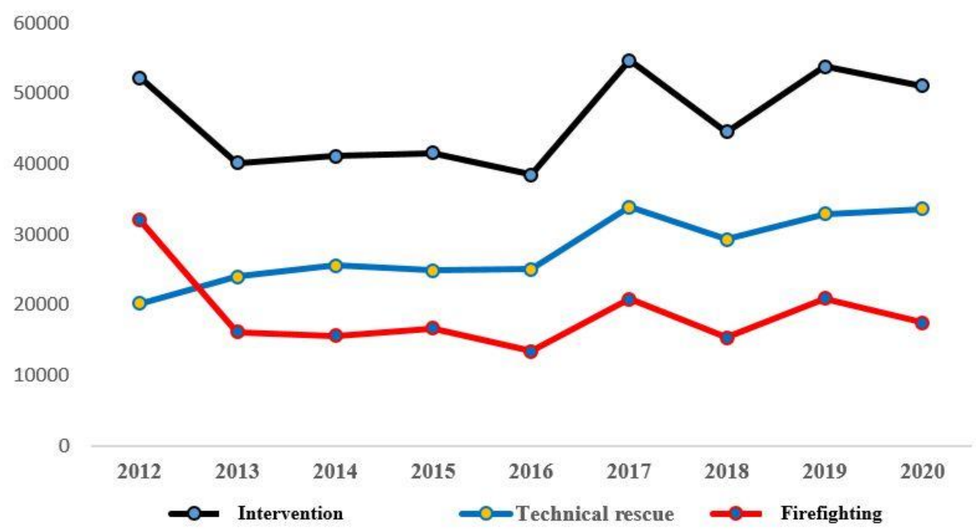

Figure 1- Type and classification of the interventions. Created by Kersák József Zsolt [3]

Figure 1 illustrates the types of interventions between 2012 and 2020. It can be seen that the technical rescues show an increasing trend. Researcher, László Teknős examined in his paper the interventions between 2012 and 30/09/2017 based on the data of the Central Inspectorate for Disaster Management [4] [5]. From the figure, he stated the following: "It can be read that in 2012, the fires showed exceptionally high values. In the other years, the values are significantly lower, no unusual "added value" can be measured [6]. The authors reached the same result in connection with the fires in 2012 as the findings of László Teknős. The number of the technical rescue shows a higher trend again from 2013. Increased case numbers have multi-component factors, as sometimes large case numbers are also influenced by meteorological events.

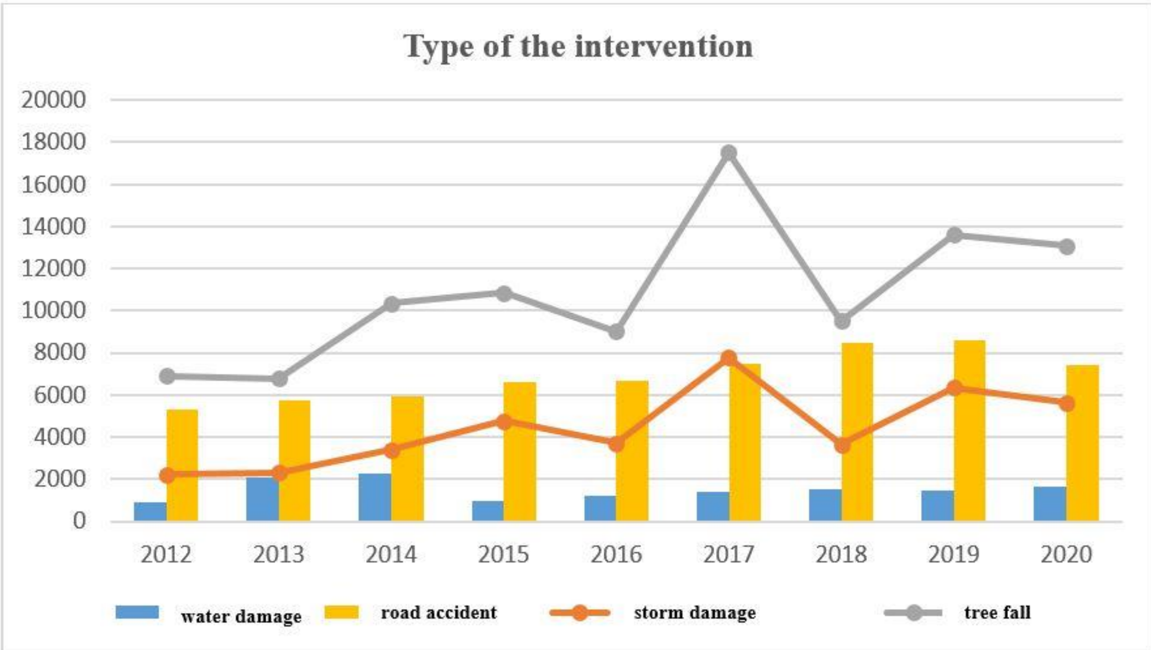

Figure 2 –Type of the intervention. Created by: Kersák József Zsolt [3]

Figure 2 shows that, storm damage and tree falls show a large number of cases, therefore the development of the given task deserves priority. The majority of the natural disasters like storm damage, tree falls and water damages are results of meteorological and natural events. It can be observed that the cause of the damage is the extreme weather conditions in the given area. Based on the investigations, it can be stated that the increase in the number of basic cases (technical rescues) increases cyclically depending on the weather conditions. Anthropogenic effects cannot be ruled out either[1]. For example, in case of a tree fall or storm damage, inadequate self-care means that the owner did not cut back the damaged parts of the tree, thereby contributing in part to the event. Another characteristic of events is that in some cases they occur in large numbers (for example storm damage). In case of mass events, it is necessary to prepare for a long intervention time, usually using a lot of force and equipment. Overall it can be stated that the disaster response is usually complex and dynamic. This is done in a non-repetitive environment, so it requires appropriate testing and practical methods [7] [8] [9].

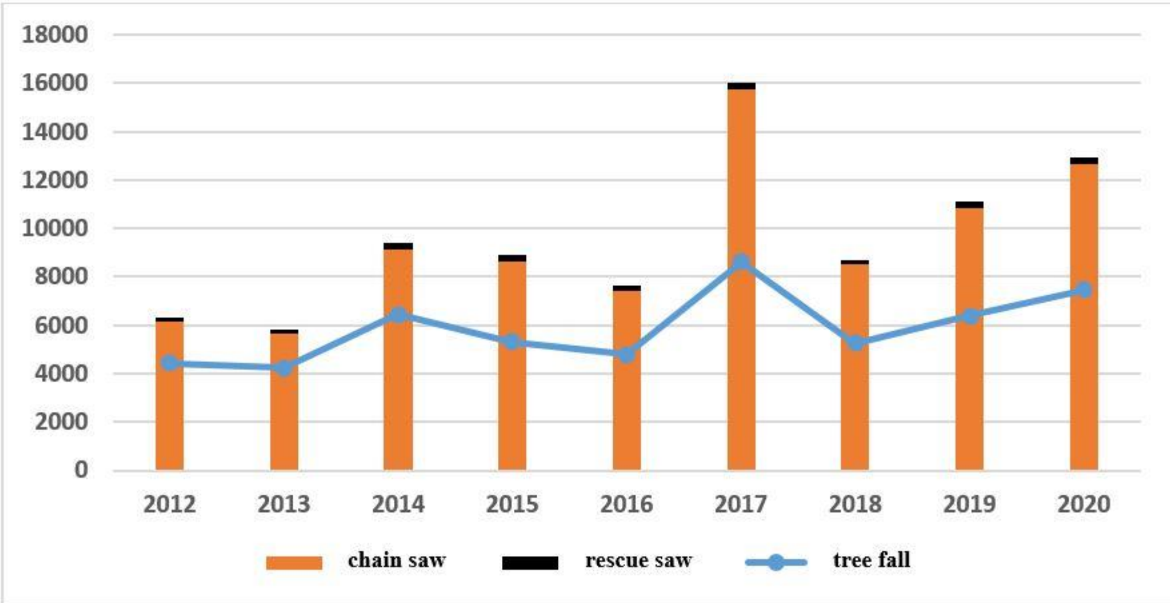

Figure 3- The use of chainsaw, rescue saw. Created by: Kersák József Zsolt [3]

Figure 3 illustrates the use of the chainsaw and rescue saw in case of tree falls between 2012 and 2020. It can be stated that the use of the rescue saw is minimal compared to the chainsaw. This is probably due to the fact that the rescue saw is only used in special cases, such as in case of cutting the walls or the concrete. The use of a chainsaw is very high in the examined period. It can be observed that in parallel with the increase in the number of cases of tree falls, its use also increases. Rescue saws are primarily planned for rescue services (such as fire departments or disaster management). Rescue saws should only be used by experienced people in case of

[1] Impact caused directly or indirectly by human activities.

rescue operations because, in addition to handling the chainsaw, other conditions and hazards must be judged. Its use requires special techniques. The chainsaw is relatively more common than this, its application is for cutting the wood or woody plants.

2. METHOD

When writing the paper, the authors kept in mind the statement made by János Bleszity and co-authors. The essence of it is that "technical research in the field of disaster management should serve to increase society's resilience to disasters, reduce its vulnerability as well as to return to normal operation as soon as possible and to increase the flexibility" [10]. Because of the current pandemic situation, the authors avoided the personal contacts during their research. There was an online contact and consultation with German experts, and the results of the digitized relevant literature and the previous research were processed into the present research.

3. SPECIAL CUTTING TECHNOLOGIES IN CASE OF INTERNAL MECHANICAL STRESS TREES

After a violent windstorm, the trees lean against each other or are trapped between each other, it is often difficult to assess the direction and extent of the internal or mechanical stress in the tree. In all cases, it is necessary to provide enough time to assess the situation, although this time is not always available. To reduce the weight, removing the branches from the tree crown provides a more transparent work area. Consideration should also be given to whether the mechanical stress can be reduced by cutting back the tree or cutting the crown of the tree [11].

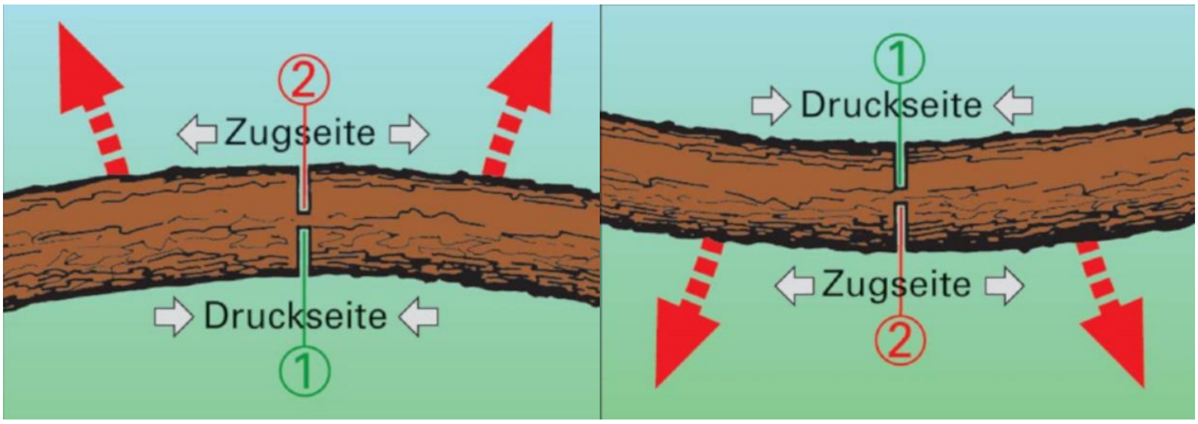

Figure 4- The cutting technique in case of live wood parts. Source: [12]

The Figure 4 shows the technology of sawing the live parts of the wood. The part marked with a white arrow shows the direction of the tension, based on this we distinguish the drawn side and the depressed side. On the drawn side, the arrows are in opposite directions, and on the depressed side, they are facing each other. The red arrows show the ejected direction of the tree; in each case they move in the direction of the drawn side. The numbers show the order of the cuts, in each case the so-called “facilitating” cut must be started on the depressed side. Cutting procedure: the incisions must be started first on the depressed side. It requires a lot of attention because if the cut is too deep, the chain saw head can get stuck. The next step is to continue the cutting on the drawn side in order to reduce the tension. Then the person who is operating the saw (in case of partial lateral stress in the tree) must always be stood on the pressed side at the moment of the complete cutting. This prevents the operator from being injured if the wood is ejected [12].

4. DEVELOPEMENTS AND SUGGESTIONS

Firefighters regularly use chainsaws during an intervention in case of natural disasters, storm damage and tree falls. During such interventions, the wood parts are under internal mechanical stress, therefore the response requires special knowledge and cutting technology [13]. An obstacle is that the interveners only encounter with wood parts under internal mechanical stress during their work, so in other cases they cannot practice the cutting techniques.

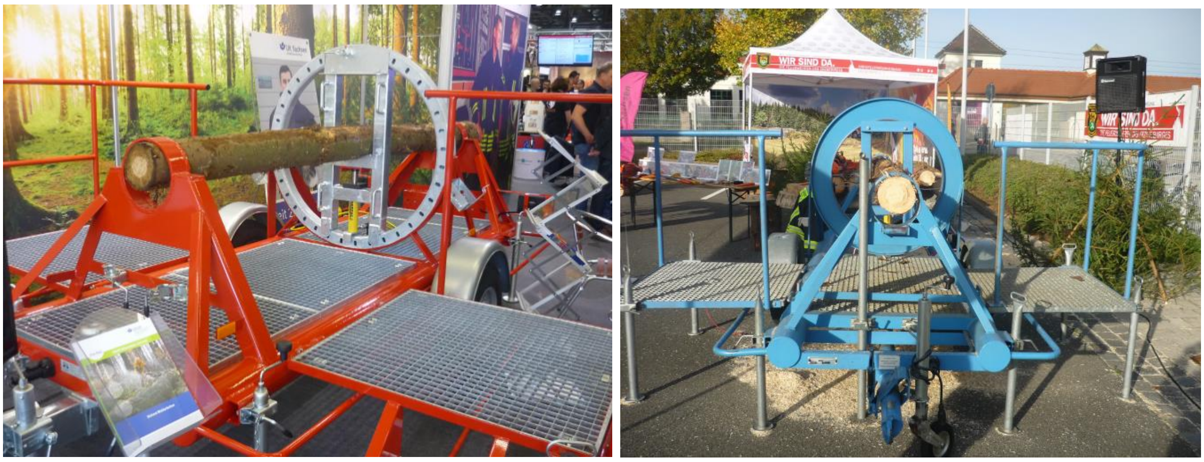

Figure 5- Structure simulating the stress of wood parts. Created by József Kersák, Dresden 11.10.2019.

As a development option, it is recommended to use a structure simulating the internal or mechanical stress of wooden parts in practical training for professional and voluntary organizations [14]. An equipment such as that is shown in Figure 5 would provide a high level of preparedness for firefighters in case of an intervention [13] [15] [16]

The authors propose a physical implementation of the structure and also a team test. For this purpose, the Hungarian specifics and the possibility of applying the completed structure are also taken into account.

5. SUMMARY

Professional and volunteer firefighters need to have a high level of theoretical and practical knowledge in order to eliminate the interventions professionally. There are interventions, where the response is usually complex and dynamic. If it is not done in a repetitive environment, it requires appropriate testing and practical methods. It was found that compared to the number of fires, technical rescues show an increasing trend. The type of intervention interpreted within the technical rescues and the number of tree falls and storm damage show a very high value. The use of a rescue saw has been proven to be minimal compared to a chainsaw, the main reason for that is the special applicability of the rescue saw. On the other hand, the use of a chainsaw, shows a very high value in the examined period. It can be observed that with the increase in the number of tree falls, the use of the chainsaw increased as well.

In case of tree falls, natural disasters and storm damages, the parts of the tree are under internal mechanical stress. This requires special knowledge and cutting technology from the firefighters. An obstacle is that the interveners only encounter with tree parts under internal mechanical stress during their work, so in other cases they cannot practice the cutting techniques [17]. The authors stated that, based on international examples, the use of a simulation structure that measures the mechanical stress of tree can be a great help to the firefighters. The use of a structure simulating the mechanical stress of tree can provide a high level of preparation in practical training for the professional and voluntary organizations. Researches like this will also serve the sustainable aspects of the disaster management in the future [18].

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

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FIRE INTERVENTIONS AND ITS DIFFICULTIES IN RAILWAY CIRCUMSTANCES

Abstract

This paper will examine firefighter responses, their tools and circumstances in cases of railway accidents in Hungary, not including all track-based vehicles. For example, trams, underground and HÉV (commuter train lines) are excluded in the work. The purpose of the work is to gather available information about this topic and organise them by the basic steps of an intervention and to improve the general knowledge. Collected special information with the eye of the first responders, even to call attention to the possible special risks and requirements, on the basis of a previous work. This paper highlights the various number of affecting factors through these tasks, which determinate success of a rescue in case of a train accident. In addition to available studies and literature we made efforts to contact leaders and experts of both fire and rescue services and railway transportation. Through the interviews we were able to gather information from production, maintenance, prevention and responses as well. As a result of this research, we collected a comprehensive knowledge from the viewpoint of a first responder. Further researches could start in the future, for example the review of the protocol for electric separation and opportunities to improve existing systems, essential equipment and tools for the rescue in train accidents.

Keywords: train, accident, fire, first responders, technical rescue

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A TŰZOLTÓSÁGI BEAVATKOZÁSOK ÉS AZOK NEHÉZSÉGEI VASÚTI KÖRNYEZETBEN

Absztrakt

Ebben a cikkben a tűzoltók beavatkozásai, azok eszközei és körülményei kerülnek megvizsgálásra vasúti baleseteknél Magyarországon, nem számítva az összes vágányjárművet. A villamosok, a földalatti és a HÉV nem szerepelnek a munkában. A kutatómunka célja a témáról rendelkezésre álló információk összegyűjtése, a beavatkozás alapvető lépései szerinti rendezése és az általános ismeretek bővítése. Sor került információk gyűjtésére az elsődleges beavatkozók szemével - figyelemmel egy korábbi munkára – és cél volt, hogy felhívja a figyelmet a speciális kockázatokra és követelményekre. A cikk a területen keletkező feladatok révén kiemeli a különböző tényezőket, amelyek meghatározzák a mentés sikerét vasúti baleset esetén. A rendelkezésre álló tanulmányok és szakirodalom mellett a szerzők erőfeszítéseket tettek a tűzoltósági, katasztrófavédelmi, valamint a vasúti szállítási vezetők és szakértők konzultációs meghallgatására. Az interjúk során információkat gyűltek a vasúti gyártásról, a karbantartásról, a megelőzés lehetőségeiről és a beavatkozást segítő módokról is. A kutatás eredményeként átfogó ismeretek keletkeztek az elsődleges beavatkozók szemszögéből. A jövőben további kutatások kezdődhetnek például az elektromos leválasztási protokoll felülvizsgálatára, valamint a vasúti balesetek mentésére szolgáló, meglévő rendszerek, alapvető berendezések és eszközök fejlesztésének lehetőségeire.

Kulcsszavak: vasút, káreset, tűz, elsődleges beavatkozók, műszaki mentés

1. INTRODUCTION

Fire departments respond to numerous cases to save lives and protect material values while countless obstacles make the task difficult and dangerous for both firefighters and those in need of rescue. This publication reviews the obstacles and difficulties of responding to railway accidents, especially the problematics of electric disconnection, its hazards, the rescue and its technical challenges and the medical attendance in case of numerous injured people.

Major railway accidents require larger human and technical resources. The large number of injured people and the numerous simultaneous task require organized cooperation from the different organisations. A previous research had been done by the authors and this article is to highlight and actualize its main sections [1] [2] [3].

2. METHODS

During our research the available literature, the relevant regulations, the experience and opinion of the professionals in Hungary of both spheres, the Fire Department and Railway Company had been reviewed. From the Railway Company Fire expert, Plant engineer, Accident prevention and High Wire professional units were consulted. Interviews with the general firefighting and Disaster Management Directorate spheres, including an incident commander of a past railway accident, members of operations, fire subordinate stuff were also conducted.

3. RESULTS

3.1. Characteristics of a railway scene

Railway scenes can be sorted into peripherial railway line scenes, railway stations and railway crossings. At different scenes different circumstances can affect safety and rescue. For us a safe railway scene means that nor traffic, nor electricity from the high wire (25 kV) means any threat for the interveners or the injured. The staff and the equipment for the electric disconnection and grounding are placed at substations called MÁV CJSC. High Wire Service. The distance between the incident and the substation is of high importance if electric disconnection is necessary. The location of a substation depends on the length of the wire system. For example in Jász-Nagykun-Szolnok County, Szolnok Station is considered a large station because of its marshalling yard and has significantly longer high wire system than other stations. Due to the longer high wire system the distance between the Substations are shorter than the usual. So if an accident happens in the territory of the Professional Fire Department of Szolnok on the Budapest line, then Cegléd and Szajol is the two closest Substations. Between them the distance is 50 kilometres, so they both cover 25-25 kilometres. Even with such short distance, MÁV CJSC High Wire Service usually needs an hour to arrive. Their standby, departure and transportation is different from those of the Fire Department.

The accessibility and the requirements of the electric disconnection and grounding are the most favourable at railway stations. Most stations are easily approachable and human and technical requirements of electric shut down are available as well. The second most favourable scenes are railway crossings where accessibility from public roads is relatively simple within 200 meters. However an electric shut down can be delayed because of the distance from the substation. The third most favourable one is the peripheral railway line where surfaced roads are usually not available and service roads are usually closed or unsuitable for vehicles. The delay of electric shut down depends on the distance from the substation. [4] [5]

3.2. Emergency Call

The precise location of a scene is inevitable information for accessibility and for every successful intervention. The responders are usually face the same problem with that. The railway segment numbers and designations are different from an everyday location address. For example "AS 426 railway crossing" is "Baross street railway crossing" for us. Additionally, railway lines are sometimes separated from public roads and service roads aren't always available. It isn't expectable from the staff of a train to know every street and crossing through the whole country so most of the calls contain the railway segment number or the railway designations. This is the first information that we have to use to locate the accident and plan the route to the scene. In locating the accident and planning possible roads for approach, available Information Technology, the experience and skills of the Disaster Management's Operation Control staff have an important role.

64/2017 MÁV regulation prescribes the particular way of reporting an accident. The precise location of the Station, the number of the railway segment or the number of the switch. The software called DÖMI is what Disaster Management uses to support operations. It has different layers for maps as well. Railway segment numbers can be added to the map, however, a railway segment number is not an address that a GPS navigation system could use. The fire brigades need to be provided with GPS coordinates and additional information for orientation and approach. [6]

ÖTRA, the mobile application originally designed to direct volunteer fire brigades, should also be mentioned, and can be used by professionals as well. The application processes information from emails generated by the Disaster Management's Operation Control and continuously monitors emails, displays the information on the fireman's mobile in text and in Google Maps as well. So the marked railway segment number, public road kilometre segment number even unnamed roads become a trackable address in GPS coordinates so the application can navigate us to the location. Correction of a location can be done on first arrival so other units will be navigated to the correct GPS location. Similar development of professional fire brigade's "MiniPajzs" system is suggested. The preparation of intervention

The preparation of an intervention means to provide the required tools and conditions for the crew. The first step is to create a safe environment for the rescue work, therefore the Railway Control Centre and the relevant organisations (Ambulance, Railway Accident Prevention Unit, High Wire Service Unit) have to be informed. Closing the area or setting speed limit for the connecting lines can be necessary as well. In case of a large number of injured people Ambulance Service should be consulted about the triage and the rescue order.

For electric shut down the professional service staff must be used. Electric shut down starts with the disconnection of the railway line section. It can be done at the Control Centre with remote control, at substations or at the scene, therefore the disconnection of the entire line can be initiated by a phone call. However it is only the first step of an electric shut down. There is a switch for preventing automatic reconnection but electric inspection, grounding and separation from other devices can only be done at the scene by placing the grounding rods.

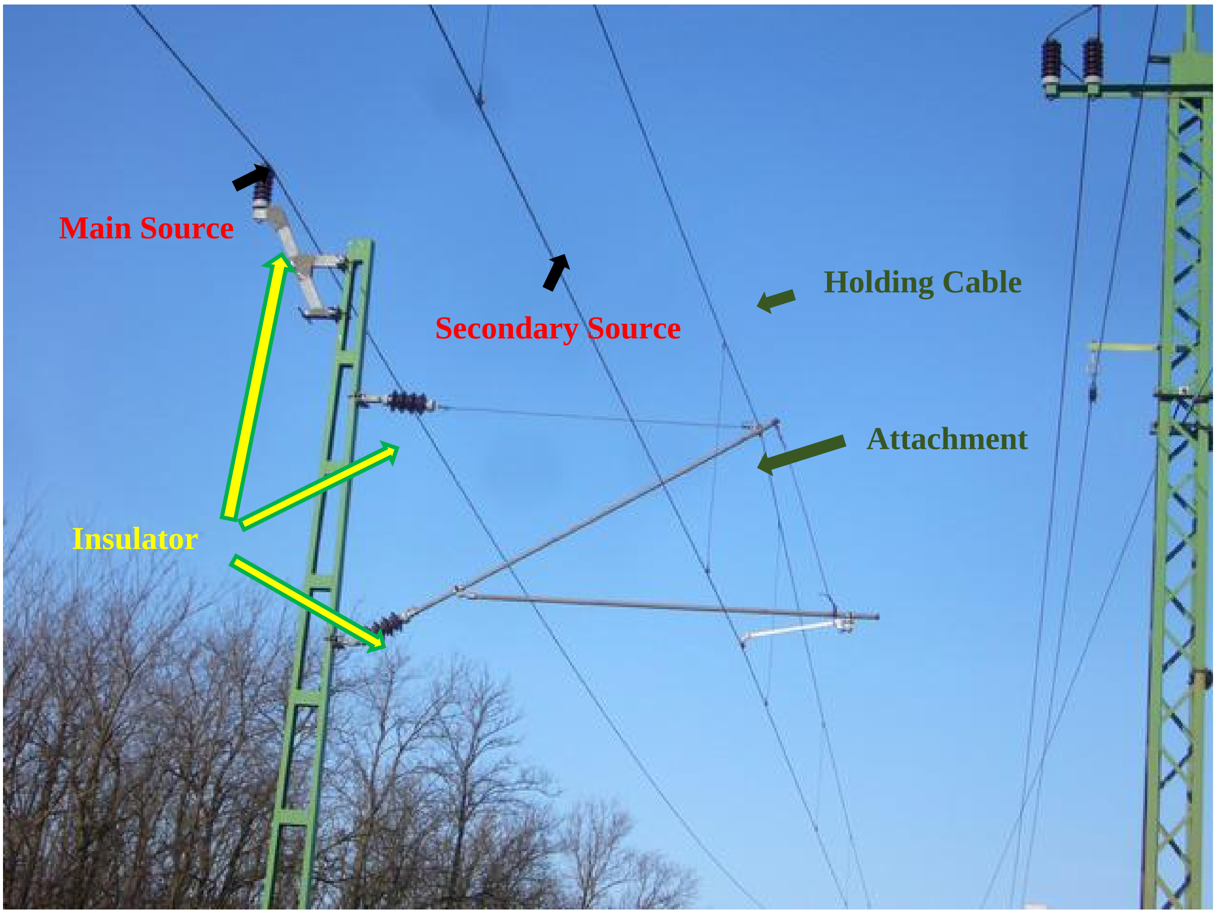

Figure 1 - Line high wire system (Roland Veszprémi)

The main source and the secondary source cables transfer high voltages (25 kV). On a two or more lines railway the secondary source cable substitutes for the main cable. By disconnecting the main source cable the secondary cable is still under electric current. In case of wire tear other metal parts can have voltages as well. In that case the approach of the train is forbidden even for rescue.

This is why electric shut down is only considered complete when the grounding rods are placed on both sides of the scene and the authorized person issued the certificate form. The grounding rods are stored on stations and at the High Wire System Service. The delay of an electric shut down depends on the location of the scene so this is why distance is an essential thing in this matter. If the scene is at a disadvantageous location than the rescue can be delayed as well.

However the V43 and V63 electric locomotives had their own grounding rods on board and a staff were authorized to use them. The conductor had to be able to make a full electric shut down on the train because they had to perform maintenance works on the train's electric

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connection. From the viewpoint of a firefighter it could be very useful, if the conductor – who obviously is the first observer of the accident - could create safe environment for the rescue. The conductor could notify the Control Centre to disconnect the electricity and to stop traffic then place the grounding rods and stabilize the train so that the circumstances could be suitable for an intervention without delays. Recently the electric locomotives have different methods to shut down. As for the rescue we can sort them into two categories. Some of them must be shorted by grounding rods while others have their own mechanism for grounding. The engine space of older types provided enough space for the grounding rods (For example: V43 and V63, however those rods had been dismantled). For newer types, for example Flirt electric locomotives, the manufacturer built a mechanism into the train to disconnect and ground the vehicle so maintenance staff can work.

However, this method is to shut down only the train and not the high wire system and it is only usable if the train is on the tracks and the system isn't damaged. These locomotives don't provide enough space for the older grounding rods so a shorter tool has been made. For example the Pfisterer manufacturer has telescopic grounding rods made of several parts that can be assembled when necessary. The storage bag is only 1m * 0,3 m.

Picture 1 - Different elements of grounding. Source: Pfisterer, www.catalogue.pfisterer.com/

3.3. Intervention

For an effective intervention we should be aware of the routines, phrases and the infrastructure of the Ambulance. In case of mass injuries the first responder has to face a situation with more tasks than can be performed in time. Triage and a well organised co-operation can be a solution.

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3.4. Infrastructure of an intervention

The sorting of tasks and the segmentation of the area can be crucial for effective co-operation. With a well organised scene and the knowledge of the other organisations routines we can improve each other's efficiency instead of decreasing it.

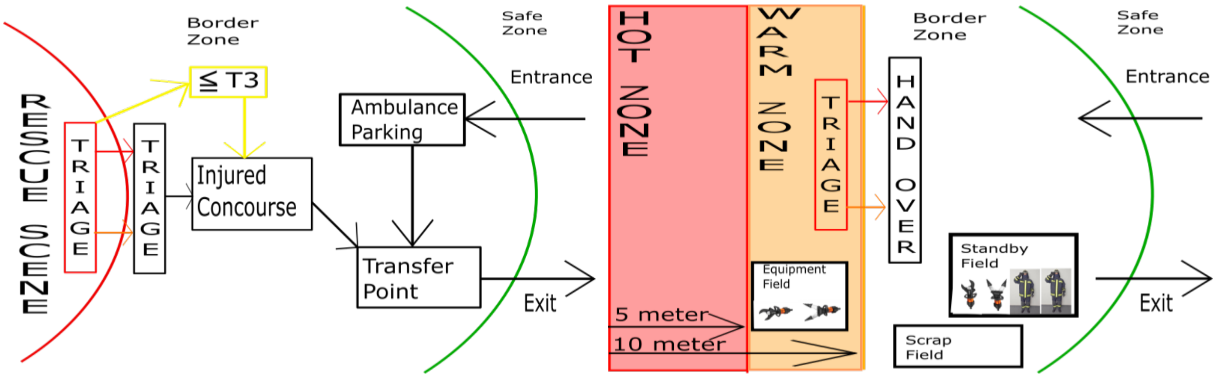

Figure 2 - The infrastructure of the Ambulance and the Fire Department (Roland Veszprémi)

On the one hand ambulance will enter the scene and start their work with triage and medical attendance only if the environment is safe enough for their work and personal protective equipment. On the other hand fast and proper technical rescue is the key to ensure required medical attendance and to save lives. The work of the Fire brigade and the Ambulance are inseparably linked. During extraction, ambulance and rescue operations in the "Hot zone/Rescue scene" can't be separated in time or place. Respiration, general circulation, thoracic spine, medication must be ensured during the cutting and spreading operations. Ambulance staff have lesser personal protective equipment than fire brigades so we must create the environment as safe as possible. [7] [8]

3.5. Experiences of the past

Former equipment (Lukas GO3T hydraulic combined rescue tool) weren't suitable for the challenges of railway accidents of the past. The lack of other equipment was experienced as well. The thickness of different materials, the need of continuous cutting, the height of the working zone made rescue work more difficult, however these obstacles could be easier to take with special equipment.

- Scaffold for rescue work
- Special, heavy duty cutting equipment
- Hydraulic rams

- Saber saw

During the rescue from a railway carriage we face more different hazards than usually. In a coach there are several cables, pipes for electricity, air of oil under the insulation. The air pressure is about 10 bar. The insulation is mostly glass wool so respiration and eyes must be protected with dust protection masks and glasses. Until the disconnection of the locomotives' own battery pack heating and controls of the coach is under charge. The voltage is low but the amperage is high, therefore electricity and air pressure are both capable of causing damage in equipment or injury to the crew. Before stripping the coach's structure the battery pack should also be disconnected and the air system deflated. [9] [10]

4. DISCUSSION

The special challenges and circumstances [12] require special solutions [13] so that the intervention can be more fluent and efficient. The problems discovered can be solved with the purchased or available equipment and organising principles.

We believe that it is necessary to review MÁV electric shut down protocol and to place the grounding equipment on the railway vehicles. Especially that the former electric locomotives had the equipment and their driver were authorized to do the grounding. This ability of MÁV company could make interventions far more effective in the future.

Precise localisation of the incident and navigation to the scene are essential elements of an effective intervention [14] [15]. The railway segment number is visible every one hundred meters and the railway staff usually navigates by them so this information is most likely available for the fire brigade as well. By the GPS coordinates – recovered by segment numbers - ÖTRA – or with developments in "MiniPajzs" - the navigation of fire brigades could be well supported.

A vehicle with the proper off-road ability can be sent to the scene if the information from the emergency call – or with the support of the informatics system – justify the need. At an incident with higher volume, two or three hundred meters can be significant during the carrying of equipment or injured people if our way is impassable for the fire engines. The circumstances can vary by slippery, muddy environment or falling hazards.

More difficult, complicated situations [16] can occur in railway accidents than usual at public road accidents. The thickness of materials can make cutting and spreading work difficult or impossible without the right special equipment for the task. The wider availability of these equipment are important for the effective rescue work. We believe that related researches in the topic are necessary and will be actual for a longer period of time [11]. The experiences described in the article will later be used in education and various practices [17] [18].

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Máté Rekeny, Ágoston Restás

QUANTITATIVE COMPARISON OF FOREST FIRE ENGINES IN FOUR TACTICAL PARAMETERS

Abstract

The backbone of the fire department's vehicle fleet consists of medium and heavy weight class fire trucks. With these universal vehicles, the first respondent units arrive at the fire. The design of these vehicles may be optimal in urban, built environments, but when approaching wildfires, they are often unable to take advantage of their advantageous properties, such as the large amount of water transported or the transport of the entire swarm. This may be due to weight, physical dimensions, or inadequate off-road capability. As almost 50% of fires are wildfires, it would be reasonable to have vehicles on standby that can be used in such conditions. In order to determine the optimal vehicle, we need to know what capabilities are needed to get the intervention started most effectively and in the shortest amount of time.

Keywords: quantitative, forest fire, fire engine, effectiveness, tactical elements

TŰZOLTÓ GÉPJÁRMŰVEK KVANTITATÍV ÖSSZEHASONLÍTÁSA NÉGY TAKTIKAI PARAMÉTER TEKINTETÉBEN

Absztrakt

A tűzoltóság járműparkjának a gerincét a közepes, és nehéz tömegosztályú fecskendők alkotják. Ezekkel az univerzális járművekkel érkeznek az első beavatkozó egységek a káresetek helyszínére. Ezeknek a járműveknek a kialakítása optimális lehet városi, épített környezetben, de a szabadtéri tüzek megközelítése során gyakran képtelenek kihasználni az olyan előnyös tulajdonságaikat, mint a nagy szállított vízmennyiség, vagy a teljes raj szállítása. Ennek oka lehet a tömeg, a fizikai méretek, illetve a nem megfelelő terepjáró képesség. Mivel a tűzesetek közel 50%-a szabadtéri tűz, indokolt volna olyan járművek készenlétben tartása, amely használata ilyen körülmények között is lehetséges. Az optimális jármű meghatározása érdekében tudnunk kell, melyek azok a képességek, amelyek ahhoz szükségesek, hogy a beavatkozás a leghatékonyabban, és a legrövidebb időn belül megkezdhető legyen.

Kulcsszavak: kvantitatív, erdőtűz, erdőtüzes gépjárműfecskendő, hatékonyság, taktikai elemek

1. DEFINITION OF FIREFIGHTING TACTICAL ELEMENTS

Wildfires are one of the most challenging disasters in Europa. If it is possible, these fires should be prevented [1] [2] [3] or the spread of fire should be reduced [4] [5]. However, if the prevention was not successful, the fire must be extinguished [6], because fire can endanger the human life and material goods [7]. On the one hand complex fire protection is very important for the successful firefighting and on the other hand [8], the effective technical background must be provided. If we examine the technical properties of different vehicles, taking into account our experience and the parameters, we can determine how each property affects the suitability of the vehicle for the performance of firefighting tasks [9]. These properties are called firefighting tactical elements. Different aspects are relevant to the performance of different tasks, so it is advantageous to consider the elements that most influence their subsequent application when selecting a vehicle designed for special tasks.

Extinguishing outdoor, forest and vegetation fires is one such special task. It is no coincidence that the Firefighting Tactics Code states that “large-scale forest and vegetation fires require special equipment and tactics” [10]. In reality, however, special devices and vehicles are limited, although they would be needed [11]. Fire is usually not constrained by physical constraints, combustible material and oxygen are also available. However, the conditions of the approach are extremely varied, and it often happens that there is no road to the site of the fire that could be traversed by the agents in the system. The key to eliminating the damage is quick arrival [12]. This requires a vehicle that can travel at high average speeds on different quality roads, and transports the interveners and the equipment and extinguishing equipment needed for firefighting as close to the fire as possible [13] [14].

Picture 1 - A fire is often inaccessible with heavy fire trucks.

If we examine these capabilities, there are still a number of properties that can be considered, but based on my professional experience, the most important ones are the average speed, the front surface, the ground pressure, and the useful weight. I performed comparative tests, during which I examined heavy, medium and light weight class fire engines, and also displayed the parameters of a pedestrian firefighter. In the comparative studies, the heavy weight class is represented by Komondor, the medium by Unimog, and the light weight class by a simple pick-up [15].

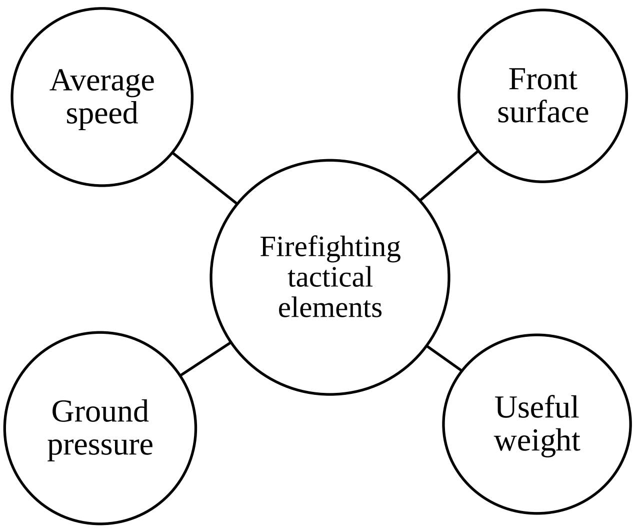

Figure 1 - Tactical elements selected for the study. Created by the Author.

Average speed

The average speed of vehicles basically determines how quickly units can respond to a fire [16]. This value is similar for all vehicles tested on a paved road, but the differences are significant when measured in the field. The maximum average speed available depends on the given terrain conditions, so in this case I determined the following values based on my professional experience [11].

The average off-road speed of medium-weight fire trucks is typically around 20 km/h. In the case of Unimog, in my experience, this is correct, and since I do not have similar data for Komondor, I used this value as a basis here as well.

The small size and maneuverability of light pick-ups can really be used in these conditions, so I calculated an average speed of 40 km/h.

In my experience, the average pedestrian speed of a firefighter in protective clothing, equipped with extinguishing water, reaches 4 km/h in the relatively long term.

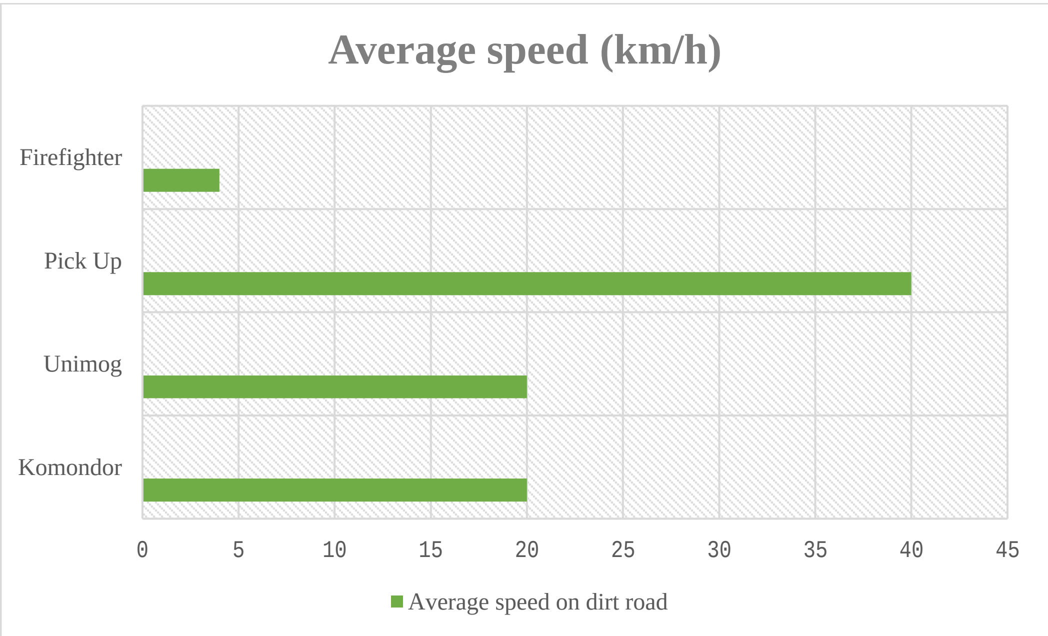

Figure 2 - Comparison of average speed on dirt road as a tactical element. Created by the Author

The key to successful firefighting is to apply the right forces at the right time and place. Ensuring this is closely related to the average speed available to vehicles.

Front surface

On forest roads, narrow roads make it harder, so the front surface is the value from which we know how narrow a device can get through. This value can determine how close the vehicle will be to the fire. When calculating the front surface, I multiplied the width of the vehicles (and the firefighter) by their height and multiplied by 0.85 to get a number as close to the real value as possible.

Front surface = width x height x 0.85

Komondor

Front surface = 2.55 m x 3.05 m x 0.85 = 6.6 m^2

Unimog

Front surface = 2.5 m x 3.5 m x 0.85 = 7.4 m^2

Pick Up

Front surface = 2.48 m x 1.8 m x 0.85 = 3.8 m^2

Firefighter

Front surface = 1.9 m x 0.62 m x 0.85 = 1 m^2

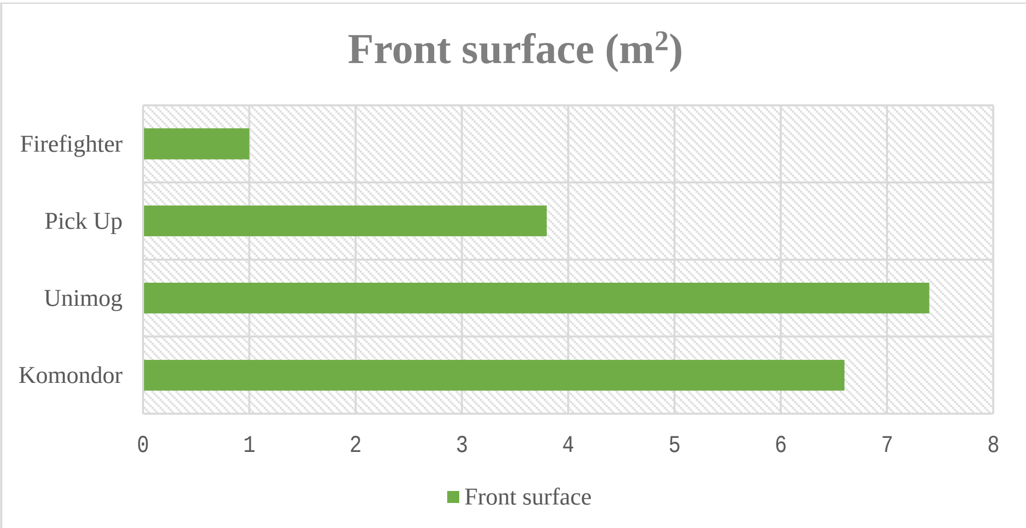

Figure 3 - Comparison of front surface as a tactical element. Created by the Author.

Among other things, the front surface is the value that makes a large number of fires inaccessible by car, only on foot. Here you can clearly see the advantage of light forestry over medium and heavy weight class.

Ground pressure

One of the defining elements of off-road capability is the pressure exerted on the surface. It is important when driving on loose ground, it mostly means sandy areas. This may also cause a possible sink, in which case not only the extinguishing water supply and the required forces will not be delivered as planned, but additional forces will have to be used to rescue the stuck vehicle. This can mean removing additional forces from firefighting. To determine this, I calculated the quantity from 4 perspectives for Komondor, Unimog, a Pick Up, and a pedestrian firefighter.

The Unimog Michelin X Terrian 20-inch, 365x85 tire has a ground contact area (upholstered, filled with water) of 980 cm^2 per piece, for a total of 3920 cm^2. Based on a weight of 16 t, 4.1 kg/cm^2.

Based on the pictures taken of the Komondor, it can be observed that it was fitted with this type of tire, so here I also calculated 980 cm2 per piece, in the case of the six wheels it is 5880 cm^2. The weight of 31 tons thus means a ground pressure of 5.27 kg/cm^2.

The ground area of the wheels of a Pick Up is 17 inches, 509 cm^2 per piece for 245/65 tires, for a total of 2036 cm^2. At a weight of 3.5 tonnes, this is 1.7 kg/cm^2.

The pressure of a firefighter on the ground is boot size 45 (156 cm^2) and 0.64 kg/cm^2 for an installed weight of 100 kg.

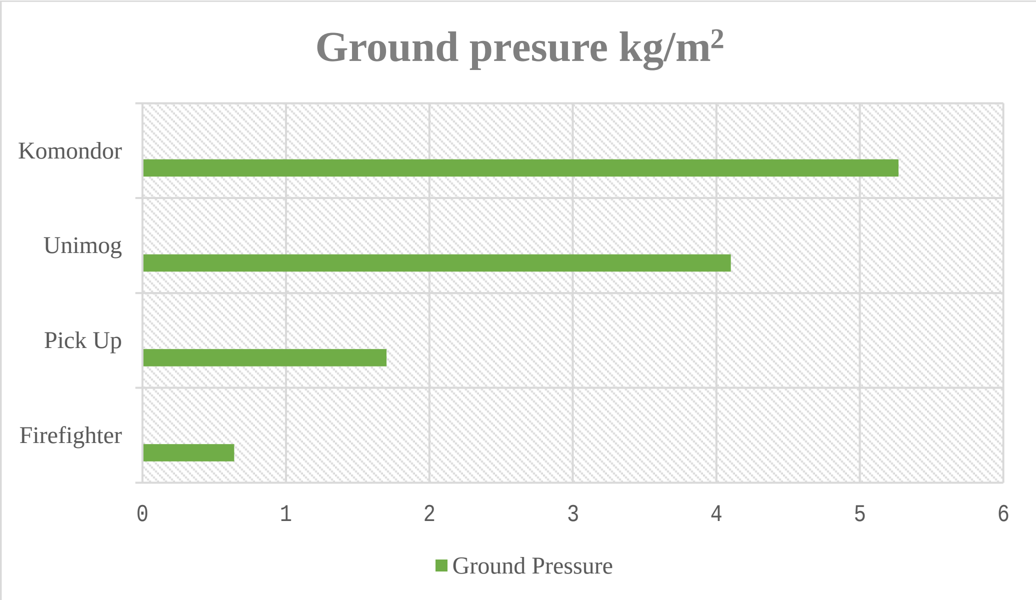

Figure 4 - Comparison of ground pressure as a tactical element. Created by the Author.

It can be stated, that the ground pressure of Komondor is very high, this is a clear tactical disadvantage, from the point of view of forest fire extinguishing it is manifested during traffic on loose ground.

Useful weight

By useful weight I mean the extinguishing water delivered, the crew, and the specialized equipment used for forest firefighting. If we divide the payload by the total weight and then multiply it by a hundred, we find out what percentage is the payload of the vehicle.

Pick Up

Total weight: 3500 kg

Extinguishing water supplied: 1000 kg

Crew with personal protective equipment: 600 kg

Special equipment (hand tools, saws): 200 kg

$$Useful\ weight = \frac{1800}{3500} = 51{,}5\%$$

Unimog

Total weight: 16000 kg

Extinguishing water supplied: 2700 kg

Crew with personal protective equipment: 100 kg

Special equipment: 200 kg

$$Useful\,weight = \frac{3000}{16000} = 18{,}8\%$$

Komondor

Total weight. 31000 kg

Extinguishing water supplied: 7000 kg

Crew with personal protective equipment: 100 kg

Special equipment: 400 kg

$$Useful\,weight = \frac{7500}{31000} = 24{,}2\%$$

Firefighter

The weight of the firefighter intervening in the forest fire extinguishing was determined in 80 kg body weight, 12 kg protective equipment, 25 l transported extinguishing water, and 1 piece of 3 kg hand tools.

Total weight: 120 kg

Extinguishing water supplied: 25 l

Personal protective equipment: 12 kg

Special equipment: 3 kg

$$Useful\,weight = \frac{40}{120} = 33{,}3\%$$

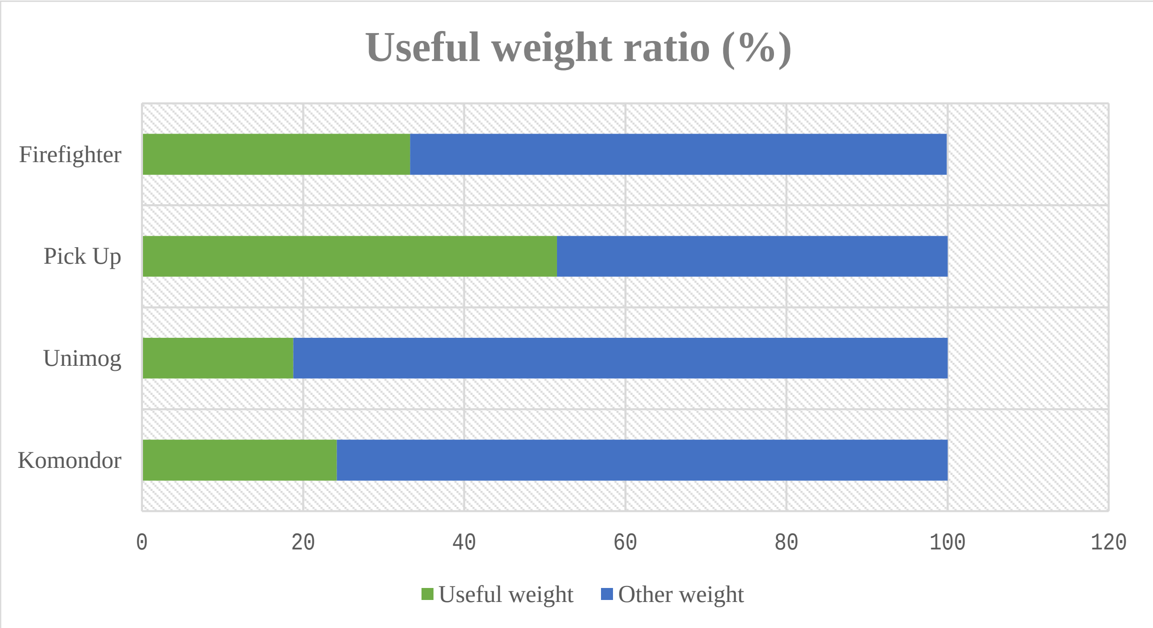

Figure 5 - Comparison of useful weight as a tactical element. Created by the Author.

It can be seen that the light forest alone soars in terms of fire that is too useful for the crowd. The reason for the heavy weight of the Komondor is the armour of the vehicle, which was kept by the manufacturer like the base version. This is justified for original military use, but only extremely rarely during firefighting interventions. According to the manufacturer's definition, armour protection will ensure its applicability even when approaching focal points where there is a risk of explosion and consequent the possibility of bursting. This is not justified in case of forest fires [15].

2. SUMMARY

I examined the tactical elements of firefighting that I considered most relevant to extinguishing forest fires. The choice of the elements was justified by the fact that, based on my professional experience, these are the properties that influence the unit to reach the fire in the shortest possible time.

Average speed is very important. Similar values are available on asphalt roads in any weight class, but lighter vehicles are preferred on dirt roads or off-road. In more complex terrain, this advantage is even more significant, which can be verified by further measurements.

The main goal, in addition to increasing the average speed, is to minimize the pedestrian approach. Large fire trucks are difficult to move on narrow roads, in an area bordered by trees, due to their width and height. In this respect, the advantage of smaller vehicles is also apparent. The front surface is therefore an important parameter.

Ground pressure is the most important value of transport on loose ground. The fire trucks that are currently widely used are already struggling, especially in the Hungarian Great Plain region. Similar problems can be expected in mountainous areas. Of course, these areas are not currently most affected by forest fires, but we need to be prepared for future interventions in such terrain conditions.

An interesting data for vehicles is the useful weight tested for forest fire extinguishing. Forest fire extinguishing as a special task requires well-defined tools. In addition to the necessary chainsaws, hand tools and extinguishing water are required, and of course firefighters. In addition, all other devices hinder the vehicle in motion, so the non-useful weight must be kept to a minimum.

I find it important to mention that in order to determine the optimal vehicle, it is necessary to examine more firefighting tactical elements than described [17], but this is not possible by the scope of the paper. We examine several aspects and use the obtained parameters to select the vehicle from which we can build the optimal wildfire fire truck. Such an analysis serves sustainable development within the field of the disaster management [18] and engineering sciences [19].

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QUALITATIVE COMPARISON OF THREE FOREST FIRE ENGINES USED IN HUNGARY

Abstract

In Hungary, a significant proportion of fires are outdoor fires, including forest and vegetation fires. Elimination of these is significantly different from firefighting in the built environment, the conditions preventing the intervention are mainly poor road conditions. This is where the limitations of medium- and heavy-weight fire trucks, which are often unable to approach the fire to the right extent, become apparent, necessitating a protracted pedestrian approach. In recent decades, several forest fire-specific vehicles have been regularized to solve these problems. These engines and their properties are examined in this article.

Keywords: qualitative, forest fire, fire engine, effectiveness

HÁROM MAGYARORSZÁGON ALKALMAZOTT ERDŐSZERES TŰZOLTÓ GÉPJÁRMŰ KVALITATÍV ÖSSZEHASONLÍTÁSA

Absztrakt

Magyarországon a tűzesetek jelentős hányada szabadtéri tűz, azon belül is erdő- és vegetációtűz. Ezek felszámolása jelentősen különbözik az épített környezetben végzett tűzoltástól, a beavatkozást akadályozó körülmények elsősorban a rossz útviszonyok. Itt mutatkozik meg a közepes, és nehéz tömegosztályú fecskendők korlátai, amelyek gyakran nem képesek a tüzet megfelelő mértékig megközelíteni, ezzel elhúzódó gyalogos megközelítés válik szükségessé. Az elmúlt évtizedekben több erdőtűz specifikus gépjármű került rendszeresítésre, amelyek ezeket a problémákat hivatottak megoldani. Ezeket a szereket, illetve tulajdonságaikat veszi vizsgálata alá a cikk.

Kulcsszavak: kvalitatív, erdőtűz, erdőtüzes tűzoltó gépjármű, hatékonyság,

1. FOREST FIRE ENGINES

On the tactics to be used by the alarmed fire brigade to eradicate a fire, 6/2016. Annex 1 of the NDGDM instruction, Fire fighting tactical regulations. The commander of the alerted forces shall determine the tasks to be performed on the basis of the content of this legislation and shall plan the steps for the implementation of the intervention [1]. The rules discuss the types of damages with different characteristics in twelve chapters, covering their specificities in each case. The chapter on Extinguishing Fires in Forest and Peatlands deals more closely with the topic of migration than the other chapters. It is, no coincidence that this also suggests that the approach to the damage site during the intervention is often difficult due to the terrain [2].

Fire engines systematized by the fire department are usually mixed-use vehicles that can be used on paved roads and in the field. Since the primary intervention units arrive at the scene of the accident with these fire engine, it is crucial that these agents are able to transport their crew as soon as possible and as close as possible. The early start of the intervention, the shortening of the duration of the free spread of fire, will largely determine the further course of the elimination of the damage [3].

The largest number of automotive fire engines in Hungary are the Mercedes Rosenbauer TLF4000, the Mercedes Rosenbauer Atego TLF4000 AT2, and the Rába R16 HEROES AQUADUX 4000 [4].

Picture 1 – Conventional firefighting with firehoses.

However, these fire trucks are more likely to be considered as universally usable vehicles, their off-road capability being primarily limited to relatively high quality dirt roads. Another disadvantage from this point of view is the high weight and the high altitude, in this context the high center of gravity. The length and long wheelbase of the vehicle are responsible for the large size of the turning circle [5].

Knowledge of these unfavorable characteristics for off-road use justified the definitions in the relevant part of the firefighting tactical regulations, which describes the difficulties of approaching damage and practically describes that roads leading to forest areas are in many cases impassable to fire trucks [2] [6].

Of course, this recognition is not new, there were several solutions to this logistical problem. In the midlle 2000s, several Professional Fire Departments acquired vehicles specifically designed to fighting against forest fires. Special forest fire trucks are designed for a purpose for which fire engines developed mostly for road use are of limited use. This is nothing more than the transport of water, equipment, and last but not least, intervening firefighters, preferably a squad by the fire (or as short a distance as possible) in a variety of difficult terrain conditions. It became the Mercedes Benz UNIMOG TLF 3000 CFS type specialized for forest fire.

Unimog U500 TLF 3000 CAFS

The U500 is a four-wheel-drive ladder chassis with three cabs and a 279-horsepower engine with good off-road capability.

The firefighting technical superstructure, designed and constructed by Rosenbauer, has a 2,700-litre water tank. There are also two foam tanks available for foam extinguishing, one 200 litres and one 100 litres. This allows the most suitable foaming agent to be selected for the desired inoculation mode.

Picture 2. Unimog U500 TLF3000 CAFS.

The vehicle is equipped on both sides with a 60-metre quick-acting NE-PI-RO nozzle. The vehicle is not equipped with a fire extinguisher or water cannon. The vehicle is also supplied with water by means of overpressure or suction. The vehicle has a hydraulic Rotzler AZ051 type winch with a load capacity of 5 tons and 50 metres of 12 mm diameter wire rope.

Despite its positive features, Unimog has only a limited ability to perform the expected tasks. The biggest shortcoming, in my opinion, is the small number of crew seats. In addition to the driver on duty, it can only transport two firefighters to the fire. In my opinion, a vehicle specializing in such tasks should definitely carry at least one squad. This would have been possible with the double cab version of the Unimog.

Its next problem was the high centre of gravity of the vehicle, which failed to forge an advantage over other fire trucks in this area, and even became much more tipper due to the long spring travel of the chassis. The agent, although made as a special forest agent in the traditional, somewhat conservative way, focuses primarily on “B” and “C” hoses for water inoculation. With these tools it is quite difficult to work and then a beam to install, especially in uneven, even mid-mountainous areas. In my opinion, with smaller diameter “D” hoses and nozzles, water quenching could be done much more efficiently. This is because the smaller cross-sectional radius is easier to control, easier to move forward with, or even retreat with. The capacity of 100-120 liters per minute of "D" nozzles is sufficient in most cases at lower fire intensities. Studies have also shown that small-diameter rays work more effectively in certain situations because of their usual “C” or fast acting nozzles, mostly because of their smaller mass. The use of “D” water rays would also be supported by water-saving use, which may be a priority in some areas [7]. High-pressure extinguishing systems already existed when the vehicle was put into operation, and their use could have been appropriate.

Overall, it is my opinion that the Mercedes Benz UNIMOG TLF 3000 CFS, although a versatile vehicle, has not been professionally fulfilled in its system. Despite its shortcomings, no further improvements were made in the decade following its introduction into the system, and the year 2020 brought a change when two newly developed vehicles were introduced into the system.

Table 1 - Comparison of Unimog properties. Created by the Author.

Adventage	**Disadvantage**
Great performance	It only carries 3 persons
Medium amount of water	High center of gravity
High ground clearance	High price
Big wheels	Poor off-road capability
High performance winch	Technically complicated
	Large size
	Heavy weight

Komondor S3

The S3 Komondor opens a new category in the history of Hungarian fire engines, with a replaceable body (forest fire or technical rescue container), a multi-purpose 3-axle, six-wheel drive vehicle with good off-road capabilities, originally developed for military purposes, but under further development. made it of interest to other members of the defense industry [8].

The vehicle is equipped with a ground fire extinguisher and two cab-operated water cannons. Inside, special equipment for extinguishing forest fires has been installed, and it is capable of transporting a total of 7,000 liters of water. The vehicle has a length of 8700 mm, a width of 2550 mm, a height of 3050 mm and a maximum permissible gross weight of 31 tonnes, which seems quite a lot on first hearing, even with six wheels it should have a considerable ground pressure. The system was introduced recently, the first experiences are yet to come, but we can say that it is a special vehicle, not only in its functions, but also in its dimensions, function and weight [8].

Picture 3. Komondor S3. Source: [8]

I think a remarkable feature of the vehicle is that the developer took great care to protect the drug and its occupants. In addition to the built-in emergency fire extinguisher, a so-called self-extinguishing equipment that can even be operated with firefighting foam. This provides great safety not only when working in a fire environment, but also to prevent the tire from overheating to an undesired extent when passing through a recently extinguished area [9] [10].

Two water cannons fixed to the front of the vehicle (i.e. even on the vehicle if equipped with a technical rescue container) can be operated remotely from the cab, independently of each other. The water cannons have a capacity of 1000 liters / minute and can be operated at a pressure of 10 bar. This is a significant amount of water, however, this performance can be supplied with water for just over 3 minutes, even with the vehicle's otherwise respectable 7000-liter extinguishing tank. Such intensive extinguishing is relatively rare. The literature I have studied suggests extinguishing with water primarily to control the lower intensity wings of the fire, and defining indirect tactics for extinguishing the fire front. This is because in the case of a crown burn, the intensity of the line of fire is so great that cooling the biomass is virtually impossible [11] [12]. The solution is to remove unburned biomass. Biomass can be removed mechanically or by igniting a counter-fire [13] [14] [15].

What can make this special vehicle even more difficult to intervene is is its large size and weight. The Komondor exceeds the Rába R16 fire truck in both length and width, only 300 mm behind it in terms of height, and its maximum permissible total weight is almost double [8]. I have already mentioned that the main obstacle to the use of the currently used fire engines is their large size and weight, these disadvantages are also present in this vehicle. And its weight will, in my opinion, further limit the transport routes that can be chosen. Due to the length of the vehicle and its three axles, its turning circle is presumably higher than that of universal fire trucks.

Table 2. Comparison of Komondor S3 properties. Created by the Auhros.

Adventage	**Disadventage**
Large amount of water delivered	Large size
Crew of 6 persons	Heavy weight
Ground extinguisher	High price
Self defense	High ground pressure
Water cannon	Great roundabout

Volkswagen Amarok

The Volkswagen Amarok forest fire fast responsible truck is an off-road vehicle with a maximum permissible gross vehicle weight of 3080 kg, on the platform of which a Rosenbauer UHPS SKID high-pressure extinguisher has been installed. This device meets the requirements of today in my opinion, its use requires less effort compared to traditional pre-assembled firehoses. It can carry 100 liters of water and 20 liters of foaming material, and is placed in metal crates on its platform in addition to the usual regularized hand tools, and there are also two chainsaws. A novelty for firefighters is the motorized back sprayer. The equipment mounted on it is difficult to access, it is not placed in compartments in the usual way, but in aluminum crates stacked on top of each other. If a device is in the inner lower crate, all crates must be unpacked to gain access. It is lengthy, physically heavy, and there is a risk of losing the locks that secure the boxes. Without them, the equipment cannot be fixed. Unfortunately, the number of people that can be transported here is less than a full squad, only four people. A vehicle-mounted winch also contributes to its usability.

Picture 3. Volkswagen Amarok.

It could be applied more widely if the equipment attached to its plateau could be removed even under camp conditions. In this case, it would also be suitable for transporting forces or equipment, which can be a great help, for example, when ordering a retreat. This possibility should be borne in mind only because the Firefighting tactical regulations (already mentioned 6/2016) stipulates that attention must be paid, among other things, to the rapid departure of the endangered area and if the area to be protected, industrial or other facility, the primary intervention should be to secure the occupants [2]. In my view, this terms of reference may also apply to tourists stranded in the forest. For this purpose, a vehicle "stripped down" in this way would be suitable for transporting an additional six on the platform in addition to the four people transported in the cab, even with their equipment. I did not examine the occupational safety aspects of this procedure. (In addition, it could be used for a number of other tasks in addition to extinguishing forest fires, such as rescuing the wounded. For this task, fire departments often use forestry pick-ups, if available).

A situation similar to the one described could occur in the event of an unexpected change in meteorological conditions, for example in the case of the 2012 Bugacpuszta fire, some of the vehicles and forces used there had to be abruptly withdrawn to prevent material damage and personal injury [5]. In such cases, the proper flow of information between counterparts, management, and all intervening forces is key.

Amarok can even be used to perform messenger tasks if the EDR network coverage is inadequate or units that do not have the appropriate means of communication are involved in the intervention. Due to the small size, high performance and excellent off-road capability of the vehicle, it will surely be a useful vehicle for eliminating forest and vegetation fires.

However, I consider it a problem to consider the small amount of water delivered, the performance of the nozzle, which allows only 2.5 minutes of continuous operation. Practice shows that at a flame height of 1 meter, the spread of fire can be prevented by an area of 2 meters moistened with 0.5 liters of sprayed water per square meter. This means that 100 liters of extinguishing water allows you to extinguish only 100 meters of fire front in the mentioned case. This ratio increases almost exponentially with increasing flame height, so this amount of water is not suitable for extinguishing more intense fires [16] [17]. At the same time, it is a great tool for recooling frequent burnt logs and logs during post-processing, and could be used even more efficiently with a higher extinguishing water capacity. The extinguishing water tank can be replaced by another fire truck or a hydrant. Cannot be filled from a pre-installed water tank.

The definition of an engine is a forest fire rapid responder, as such a special fire engine. In my opinion, a vehicle with similar properties could be really effective if the first respondents could arrive by the fire with it. This would be possible if this truck were capable of carrying 6 firefighters and had off-road capability similar to the Amarok.

Table 3 - Comparison of Amarok properties. Created by the Authors.

Adventage	**Disadventage**
UHP extinguisher Low price Simple technically Low weight Small size Good off-road capability	Only 4 firefighters deliver Small amount of water Equipment is difficult to access Water intake is only possible from a hydrant

2. SUMMARY

The developments of the year 2020 definitely mean an advance compared to the technology of the last decades, during which the forest fire fighting ability was mostly mean Unimogs and universal fire engines.

These, while not technically the past, did not tactically create a more advantageous position than in previous decades. Firefighting continued to be carried out by firefighters arriving in heavy, large vehicles with poor off-road capability. Conventional fire hoses are difficult to move around in the field and use a lot of water, so they are not economical.

The biggest problem remained the approach to the fire. If the fire is to be approached on foot, there is a lot of wasted time, and in addition, only a small amount of water can be transported by firefighters on their backs. This favours the spread of fire. Clearly, a vehicle is needed to transport the first respondents and the necessary water in the immediate vicinity of the fire.

Komondors carrying large amounts of water and Amaroks with lighter, better off-road capability offer new tactical possibilities. We don't have any practical experience yet, so I can only form an opinion about the vehicles based on my professional experience so far.

I consider the possibilities of using the Komondor fire truck to be limited due to its weight and size. In the Hungarian Great Plain region, which is most affected by large-scale forest fires, it may not suffer from its size, but the mass on the sandy soil will certainly cause many difficulties. Its primary task may be water transport, but from this point of view, I do not feel the technological progress compared to water transport so far. The role of high-performance water cannons in extinguishing forest fires is not significant. Its mass is unreasonably large, its armor causes this, this is not necessary during forest fires either. This unusual vehicle could certainly make better use of its special abilities in other roles [18] [19].

I see the limits of Amarok in the small amount of water transported and the number of firefighters that can be transported. Nonetheless, it will certainly be a useful tool that will be of great help to firefighters intervening in off-road terrain. Mobility, and usability on poor quality roads and difficult terrain creates new tactical possibilities. The free spread of fires can be shorter if these light pick-ups are used at the right time. This type of fire truck can easily reach those parts of the area affected by the fire that were previously only accessible by foot. Here, it is able to intervene extremely effectively with its ultra-high-pressure system, and firefighters are able to put out fires in a short time with hand tools. This means a shorter fire front, less value for damage, shorter intervention time. Not surprisingly, this type of fire truck has become widespread during wildfire interventions in the United States.

The problem of wildfires would be solved by a vehicle that would be able to transport first responders by the fire and deliver larger amounts of extinguishing water.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

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APPLICATION OF PROTOCOL PROCEDURES IN CASE OF FIREFIGHTING

Abstract

New technologies and techniques are constantly appearing in our accelerated world. Safety and efficiency are important in all areas of life. There are expectations in the disaster management and in the firefighting. Different protocol procedures can help us to solve the problems with new technologies. Based on the information, they determine the real steps that can be taken to avoid the possible wrong decisions and the requirement of safety and efficiency is not compromised in addition to the speed.

Keywords: firefighter intervention, intervention protocol, fire prevention

PROTOKOLL ELJÁRÁSOK ALKALMAZÁSA A TŰZOLTÓI BEAVATKOZÁSOK SORÁN

Absztrakt

Felgyorsult világunkban folyamatosan jelennek meg az új technológiák, technikák. A biztonság és hatékonyság az élet minden területén felmerülő fogalom, illetve elvárás a katasztrófavédelem és természetesen a tűzoltói beavatkozások tekintetében is. Az új technológiák megjelenésével felmerülő problémák megoldásában, segítségünkre lehetnek különböző protokoll eljárások, amelyek összegzett információk alapján tényszerűen követendő lépéseket határoznak meg, melyek betartásával elkerülhetők az esetleges hibás döntések és a gyorsaság mellett nem sérül a biztonság és hatékonyság követelménye.

Kulcsszavak: tűzoltó beavatkozás, beavatkozási protokoll, tűzmegelőzés

1. INTRODUCTION

Examining the interventions of the firefighters from a technical point of view, we can see that keeping up with the technological development, the technical equipment of the rescue organizations is also developing [23]. New fire trucks, more developed technical tools and protective equipment appeared at the fire departments in case of firefighting and technical rescue [21]. Various protocol procedures can help us under such circumstances. Based on our professional experiences and observations we made during the research, the fire department does not currently use the possibilities of the protocols during the interventions. We would like to highlight the methodological advantages of using these protocols, the possibility of increasing the safety and the efficiency, through an evaluation of a building. A traffic tunnel is an excellent example for the possibilities of applying the protocol procedures.

1.1. International regulations

With the construction of the 4 tunnel systems on the highway M6 and the underground M4 in Budapest, new techniques, technologies and facilities have appeared at the fire departments. There have been several fires in the area of the underground, as well as vehicle fires in the M6 highway tunnels. The elimination of the incidents was successful in all cases, but the serious efforts of firefighters pointed to the difficulties of firefighting in tunnels. As a result of the serious and fatal tunnel fires and accidents of the recent decades, a lot of research has begun in the topic. These researches are primarily focused on equipment that increases the safety of tunnels and on the faster, more efficient elimination of the events. The European Parliament issued a directive in 2004 summarizing the shortcomings and research findings, which applies to all tunnels longer than 500 metres in the trans-European transport network. Directive 2004/54/EC provides a unified framework for the minimum fire protection and safety requirements for tunnels and in addition to the installation requirements, it also includes instructions and operation requirements [4].

1.2. Characteristics of fires in tunnels

In addition to the rapid heat generation, tunnel fires are also characterized by the formation of large amounts of smoke. Several previous tunnel disasters and experiments in the topic have shown that the temperature can exceed up to 1200 ^{o}C near the nest of fire. Due to the "closed" type of the tunnel, these fires are characterized by strong heat generation, rapid fire spread, longer escape time and large amounts of smoke. Intensive smoke generation in traffic tunnels is caused by the increasing amount of plastics and lubricants used in the production of vehicles from the fuel and tires of vehicles [1]. The heat and smoke cannot escape freely from the building. These flue gases are very toxic. The chances of survival of people decrease very quickly with the spread and accumulation of smoke [2].

1.3. Intervention techniques in case of road tunnels

With the increase of the traffic, accidents in tunnels have also become more frequent. Although the passive safety measures mitigated the consequences of the accidents and made the intervention safer in the tunnels, but the serious and fatal fires, necessitated the introduction of the active fire protection systems [3]. In Europe with the Directive 2004/54/EC of the European Parliament and of the Council of 29 April 2004 on minimum safety requirements for tunnels in the Trans-European Road Network [4] we have to count with the presence of certain technological systems and techniques.

If we study the "habits" of the tunnel construction and operation in countries with more road tunnels, we can see that these tunnels were made with completely different technologies at completely different times. However, by now, basically every tunnel has an escape route, mechanical ventilation, heat and smoke extraction in some form [5] [6] [7]. In addition, a variety of active and passive safety systems have been installed in each, which, due to their versatility, are coordinated and operated in each case by a complex surveillance system.

1.4. Road tunnel monitoring system

Even in the tunnel system installed on the highway M6 in Hungary, the same as in all European tunnels, the active and passive safety elements are coordinated and operated by a complex monitoring system. The monitoring system of the M6 tunnels is the so-called SCADA system (Supervisory Control and Data Acquisition). The task of the SCADA system is to establish the connection of the communication, to collect and display this data, and to establish the human-machine connection in the control equipment. Using SCADA (for example in case of oil refinery technology or complex fire protection equipment), the entire system can be controlled by a single operator. Even with unlimited spatial extent, time-critical tasks are performed on local devices (intelligent devices) [8].

1.5. Techniques and equipment of M6 tunnels supporting the intervention

The full operation of the M6 tunnels is supervised by the SCADA system. The water supply of the tunnels is provided with water supply lines equipped with a pressure booster. Any of the boosters will start automatically when the hydrant is opened, they will also stop automatically when the water is no longer used. The water supply is kept frost-free by the electric heating. The energy supply of the tunnels (SCADA supervision and control) is double-sided and is via 20kV/0.4 kV own transformers. The second line of energy supply is provided by diesel-powered generators, which start automatically in case of a failure of the first side supply (SCADA system monitoring and control). Power centres also have uninterruptible power supplies that operate basic systems. The telecommunications facilities in the tunnels, as well as the event detection and telemetry systems, are also monitored by SCADA. The operational condition of the tunnel is detected by thermometers, traffic counters, vehicle class and speed detectors, smoke detectors, air flow speed and direction detectors, CO concentration detectors and cameras installed in the pavement and in the airspace and walls. The information is sent to the control centre under SCADA supervision.

1.6. Why are tunnel techniques needed?

Real fire test experiments carried out abroad (Austria, France, Japan) proved that it is necessary to keep the speed of the air flow in tunnels below 2 m/s. In case of artificial ventilation, smoke stratification does not occur due to turbulent mixing. In each of the experiments, a layer of breathable air remained for a very long time, up to a height of 1.5-2 metres with an air flow below 2 m/s. Occasionally during the entire duration of the fire. In case of natural ventilation with low airflow, a smoke plug may form at the opening of the tunnel due to transverse flow. This results in the re-layering of the smoke [17] [18] [19].

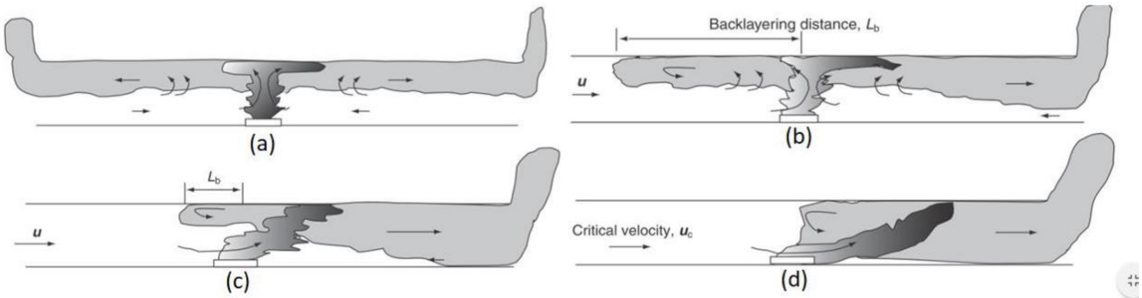

Figure 1- re-layering of the smoke (Source: Patricio Valdes: CFD Study on the Interaction between Water Sprays and Longitudinal Ventilation in Tunnel Fires page 7.)

To avoid this, in case of an emergency, the automation of the SCADA system controls the ventilators by switching them off in the fire section. The other ventilators are controlled by the airflow measurement to secure a continuous flow of 1-2 m/s. If the natural airflow is above 2 m/s, the ventilators will not turn on.

In case of a fire the SCADA system switches the ventilators in the same direction as the traffic direction of the tunnel pipe, regardless of the direction of the natural draft. At the same time, it starts in the parallel tunnel in the same direction [7].

It would not be a good solution to direct the smoke in both pipes in the same direction as the traffic. This is because the vacuum created at the "entrance" of the tunnel pipe from the direction of travel would suck the air coming out of the other tunnel. This would start circulating the smoke in the two tunnels, so we would create two tunnels full of smoke.

The SCADA system has three operating systems for safety. We prepared the technical detail and protocols concerning the M6 tunnels on the basis of the Emergency Action Plan (Hereinafter VIT)[1] of the Mecsek Autópálya company and of my personal consultations.

1.7. Remote automatic monitoring and control

The full control runs during SCADA, the system monitors everything. It can measure the temperature, the airflow, the carbon monoxide level, the air density, the gas concentration, and

[1] The VIT describes all technical parameters of tunnels and gives instructions to the operator about all malfunctions.

even the visibility. If it detects any abnormality, it immediately alerts the operator and starts the pre-programmed protocol for the event.

1.8. Remote manual mode

In this case, one device is removed from the SCADA supervision and management by the dispatcher (for example the control of ventilator or the control of signal lights). All other devices remain under the control of SCADA, but the certain device that is removed is placed under manual control to all intents and purposes. The associated protocols will not work automatically either. Like when we turn off the stability control in the car (ESP). From here, all components of the complete system removed from SCADA require manual adjustment

1.9. Local controller, local mode

A control centre was placed in one of the rooms connected to the tunnels and a so-called fire control panel at the entrance of the tunnels. By activating the mode (by turning a key), all control is transferred to the local control room or to the fire control panel. Dispatchers cannot take back control. By turning the key, all activity is in the hands of the person who turned the key. Emergency generators will not start either. This mode is only used by professionals for maintenance, as it results in a complete SCADA disallowance. This is ideal in case of a repair of the ventilators, because neither the automation will start the ventilator (e.g. due to the presence of increased exhaust gas) nor the dispatcher will do it accidentally [7].

To change the operation of the ventilation, the entire system must be removed from SCADA supervision. There is no braking mechanism on the ventilators and the technology's own protection only starts the ventilator in the other direction after it has stopped. The stopping time of the ventilator depends significantly on the speed of the air flow in the tunnel. The duration of the change in airflow direction is therefore disproportionately long. For the interference in the SCADA system requires a permission. In addition, the incident must be reported in accordance with the rules of the Highway Engineering.

With the permission of the Bátaszék Plant Engineering, I carried out some measurements. Switching the ventilators in the opposite direction is possible by a computer control with 4 clicks, which takes 20 seconds per ventilator, based on the calculated values and the consistent experience of the professionals. In case of operation of the "fire program" controlled by the SCADA system, the change of the air flow direction is at least 5 minutes. However, this can take an average of 7-8 minutes, and in some cases up to 10-12 minutes. In contrast, even in case of the longest tunnel, the penetration from the direction of travel is less than 2 minutes. Another important circumstance is that there are people in the tunnel and their direction of escape started with the given direction of air flow. The change of airflow direction during such an event can have serious consequences. The protocols recorded in the "fire program" will not happen either if the device is removed from computer monitoring. For example, in the parallel tunnels, the ventilators will not automatically start in the same direction. These have to be set manually one by one. This has already returned the possibility of the human mistakes into the processes. Computers were used to avoid this type of mistake. The situation can be even more serious if the fire chief decides to change the direction of ventilation and take control from the dispatch centre.

1.10. Regulation of road tunnel intervention

During my research, I was looking for an answer to that according to what kind of rules should a fire chief make his decisions for an intervention in case of road tunnels (even a tunnel installed on a highway) [22]. Based on the examined regulations, it can be stated that the regulations do not contain information specifically about the tunnels. The only point of reference that a fire chief can rely on is the so-called „TMMT[4]" data sheets" on the fire trucks and at the county operations management.

According to the National Fire Protection Regulations (hereinafter OTSZ[5]), road tunnels are special constructions[6] and facilities of high importance from the point of view of the fire protection. So TMMT will be mandatory for any road tunnel in the country that exceeds 800 metres [9] [10] [11] [12]. I analysed all the TMMTs of the fire departments belonging to the M6 tunnels (2 counties, 5 fire departments and 2 County TIK[7]). They contain relevant information and real data. However, if the incoming fire chief is not an expert in the technical equipment of the tunnels or has no knowledge of the subject, he is unlikely to be able to obtain meaningful information from the large amount of data in a short time [21]. The time will always

[4] TMMT: It is a support plan containing the manpower and equipment required for the firefighting and technical rescue.
[5] OTSZ: Hungarian Decree No 54/2014 of 5 December of the Ministry of Interior on the National Fire Protection Regulations.
[6] special construction: the special structure for fire protection is the road tunnel, the pedestrian underpass, the underground railway line, the lookout tower, the tarpaulin structure, the scaffolding structure.
[7] TIK: Tevékenység- irányítási központ (Activity Management Centre)

be short because international regulations require the distance of rescue units to be proportional to the tunnels [13][14][15][16].

2. DECISION MAKING IN CASE OF AN INTERVENTION

The fire chief participates in and controls the intervention [20]. Fire chiefs are emergency decision-makers, who omitting the general decision-making matrix due to the time pressure. They make their decisions on the basis of so-called schemes [16]. Emergency decision-makers (such as police, ambulance, doctor, soldier, firefighter, etc.), based largely on their experience, they recognize a similar situation and select the most appropriate sample for which there has been a good solution before [16]. However, there are few road tunnels in Hungary, so the fire chiefs have little experience. In order to help to make a decision, it is important to summarize the information and to make a protocol out of it in advance.

2.1. Protocols in general

Today, the concept of protocol is very diverse. Nowadays, we mean different things in different areas of life by protocols. For example, an IT protocol means something completely different like the etiquette protocol. We also meet a lot of protocols in our everyday life, some of them are prescribed, others are used as a “habit”. Protocols are used by doctors to care for patients, the ambulance also provide a step-by-step care to the patient, and even first aid BLS (Basic Life Support) steps are a protocol. There are very simple and very complex versions, but they have in common that they contain rules. This protects their user from the wrong decisions in a given situation or they prescribe the steps [20] [21] [22].

2.2. Protocol method for interventions in case of road tunnels

The protocol has been drawn up in accordance with the mandatory technical and design rules and harmonized with the rules of the intervention:

1. Interventions in case of road tunnels, all fire departments have to communicate on the common cooperation channel set up for this purpose.

The basis of a successful intervention is the good communication. Each unit includes a dispatcher service, county operations management, and all the fire chiefs on site. Communicating through the common cooperation channel, the information of the dispatcher service and the instructions of the fire chief are also immediately received by the county level TIK in real time. According to international regulations, every similar road tunnel will have a radio channel set up for this purpose. For similar tunnels, there will also be a tunnel specialist, who will be among the first to be involved in the fire management. These also help the safe intervention [23].

2. Closing, evacuation. Close of tunnels in both directions (via dispatch service with the help of the police). Steps must be taken to the dispatcher service to begin emptying the tunnels. Actions must be taken to divert and close the driveways.

One of the most important security protocols. People can escape from the tunnels, in case of a two-section tunnel, through the emergency passages to the opposite direction. During the detection, it may be necessary to stop in the tunnel, there may even be a set-up site at the emergency gateway. One of the most important actions is to stop the traffic in both directions of the tunnels as soon as possible. The dispatcher service has cameras, motion sensors and a loudspeaker system. Before the help arrives, they can most effectively begin to evacuate the tunnel. Operations like this require preparedness [24].

3. The approach, (direction of the migration) is possible only from the same direction as the direction of travel

Approaching can be a logistic problem [25]. Firefighters approaches the tunnels from the direction of travel. The duration of the change of direction in the tunnel areas does not justify driving on the highway in the opposite direction of the traffic. This must be prohibited in all cases.

4. Information, clarification: Which tunnel is affected? Number of people and their situation in the tunnel? In case of fire, the direction of air flow?

The primary task is to save human life. To do this, we need to know the number of people who need a rescue, their situation and the direction of the escape. In case of a fire, the direction of the airflow due to the automatic processes determines the location and approach of the intervention.

5. In case of fire, the intervention area is always approached from the direction of travel (in the same direction as the exit of heat and smoke) in accordance with the air movement. It is not recommended to change the airflow artificially!

The most optimal is if there is no question about changing the direction of heat and smoke. The tunnels can be traversed in a short time. In case of artificial heat and smoke removal, the change of direction is long. We are able to adapt to the stable environment provided by the techniques in less time than we can change them. In case of natural ventilation, it is not possible to change the direction of air flow. In case of tunnels shorter than 1000 metres, the mechanical ventilation is only recommended.

6. Life-saving and evacuation is realized primarily through the use of pressurized emergency passages and emergency exits. It is forbidden to support the doors of emergency exits and passageways, and it is also forbidden to lay fire hoses through them.

In case of road tunnels longer than 500 metres, there shall be an emergency exit or passageway to the not loaded tunnel in accordance with the installation rules. These exits and passages must be pressurized so that the draft cannot pass the smoke into the escape route in the tunnel. The overpressure is artificially created and secured by doors and windows. Due to the sluice design, fire hoses must not be placed on them or supported it in any way. So there is no question in connection with the direction of save. In the M6 tunnels, the longest road that needs to be taken to reach an emergency passage or exit is 300 meters.

7. Fire hydrants are available for the firefighting in every 250 (M6-100m) metres. 2 "C" jets can be operated without a fire truck.

According to the European Union regulations, the minimum requirement is that there must be a hydrant in every 250 metres in the traffic tunnels. The hydrants should be able to perform 600 l/min in 6 bar pressure, and provide two simultaneous operations. This is enough to operate the jet.

8. Additional information, instructions: (the most necessary additional information for the tunnels).

It is also necessary to include specific important information. In case of M6 tunnels: Landing place of the rescue helicopter between tunnels „B” and „C”. To give the injured people to the ambulance, preferably in a protected tunnel. Additional fire trucks should be outside the tunnel etc.

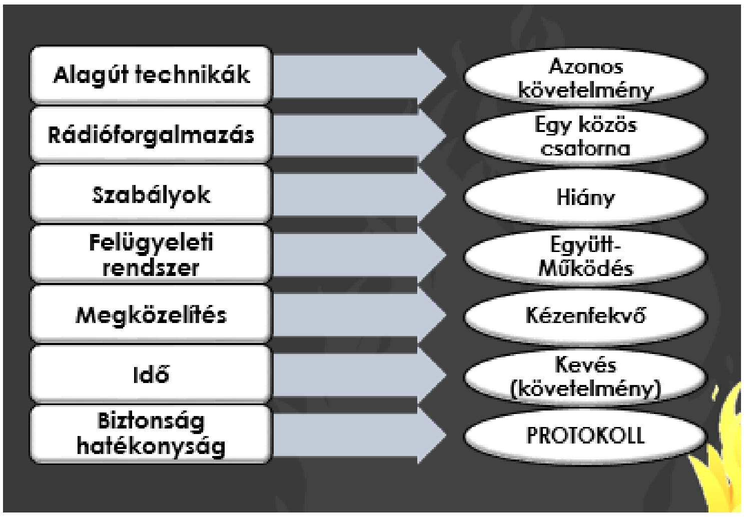

Figure 2- Aspects of preparation of the intervention protocol
(Created by the authors)

Table 1- Summary of protocol procedures (Created by the author)

Number of protocols	**Name of protocol**	**Content of the protocol**
1.	**Communication protocol**	Interventions in case of road tunnels, all fire departments have to communicate on the common cooperation channel set up for this purpose.
2.	**Closing and evacuation protocol**	Closing, evacuation. Close of tunnels in both directions (via dispatch service with the help of the police). Steps must be taken to the dispatcher service to begin emptying the tunnels. Actions must be taken to divert and close the driveways.
3.	**The approach protocol**	The approach, (direction of the migration) is possible only from the same direction as the direction of travel.

4.	**Information protocol**	Information, clarification: Which tunnel is affected? Number of people and their situation in the tunnel? In case of fire, the direction of air flow?
5.	**Heat and smoke extraction protocol**	In case of fire, the intervention area is always approached from the direction of travel (in the same direction as the exit of heat and smoke) in accordance with the air movement. It is not recommended to change the airflow artificially!
6.	**Rescue protocol**	Life-saving and evacuation is realized primarily through the use of pressurized emergency passages and emergency exits. It is forbidden to support the doors of emergency exits and passageways, and it is also forbidden to lay fire hoses through them.
7.	**Firefighting protocol**	Fire hydrants are available for the firefighting in every 250 (M6-100m) metres. 2 "C" jets can be operated without a fire truck.
8.	**Additional information and instruction protocol**	Additional information, instructions: (the most necessary additional information for the tunnels).

3. SUMMARY

Techniques and design features in case of road tunnels are an excellent example for technological challenges. Nowadays it can be stated that for any complex facility, a fire chief has to process a huge amount of information. It is also proven that there is a short time for this decision in case of a special institution. A summary protocol system helps in the decision making, thus reducing the possibility of the wrong decisions. It follows that the intervention becomes safer and more effective. By developing the intervention protocol procedures for each facility that has TMMT and we place these protocols in the TMMT documentation, we can be more successful in the field of security challenges. The topic is approachable in the future

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Péter Pántya

POSSIBILITIES AND DANGERS FOR THE FIRE PROTECTION IN THE FIELD OF ALTERNATIVE ENERGY SOURCES

Abstract

Today, in addition to conventional energy sources (electricity from the network, natural gas, etc.), the use of various alternative energy sources is becoming more widespread internationally. In the field of alternative energy sources, the article focuses on the study of solar photovoltaic systems. In the field of related accumulators that may support the operation of photovoltaic, solar systems, the article reviews primarily lithium-ion accumulators. The fire protection issues of these alternative, renewable energy sources and storage facilities will be explored, using the available international literature.

Keywords: photovoltaic, solar panel, fire, fire protection, lithium-ion battery

A TŰZVÉDELEM LEHETŐSÉGEI ÉS VESZÉLYEI AZ ALTERNATÍV ENERGIAFORRÁSOK TERÜLETÉN

Absztrakt

Manapság a hagyományos energiaforrások mellett (vezetékes hálózaton elérhető villamos energia, földgáz, stb.) egyre elterjedtebbek a különböző alternatív energiaforrások alkalmazása nemzetközi szinten. Az alternatív energiaforrások terén a jelen cikkben elsősroban a napelemes, fotovoltaikus rendszerek vizsgálatára kerül fókusz. Az ehhez kapcsolódó a fotovoltaikus, napelemes rendszerek működését esetlegesen támogató és kisegítő akkumulátorok terén elsősorban a lítium-ionos akkumultárokat tekinti át a cikk. Ezen alternatív, megújuló energiaforrások és tárolók tűzvédelmi irányú kérdései kerülnek vizgálatra az elérhető nemzetközi irodalom segítségével.

Kulcsszavak: fotovoltaikus, napelem, tűz, tűzvédelem, lítium-ion akkumulátor

1. INTRODUCTION

This paper discusses the fire protection issues of different types of energy sources that are different from the general and traditional ones, and have been considered as alternative energy sources compared to them. During the investigation of the fire protection, the author examines the role and possibilities, challenges of preventive and rescue fire protection, with the aim that Hungarian and international research results and published publications in the field can be used in the professional field and in education. The basic starting point of the paper was that there are now considerable results, presented in a joint summary article, that can help fire officers, researchers and students in this relatively new field with a few decades of experience but no significant experience in eradication and prevention. In this paper, in the field of energy sources, I consider as conventional energy sources produced by various power plants (nuclear, heat, etc.), electricity coming from general energy networks or energy provided by hydrocarbons supplied through utilities (e.g. natural gas). I also consider it traditional to use various general fuels used to drive and operate vehicles, such as petrol or diesel. I analyze factors related to energy sources other than these, also called alternatives. One such alternative energy source in this area is the field of renewable solutions, here clearly the use of solar energy, also known as photovoltaic solar cells, can be one of the factors. There are several ways to get alternative energy, such as using water or wind energy. Among the traditionally available, almost constantly available energy sources, in case of electricity, we do not need to talk about its storage, without examining some special and rare areas (e.g., uninterruptible power supplies). When natural gas is used, in the case of installation away from the grid, its storage and its fire protection issues arise, but this is not the subject of this article. [1]

The use of alternative energy sources takes place as an island in several places, also in case of demands far from the electricity grid, but also in the case of mobile propulsion involving vehicles. Here, lithium-ion batteries can appear in the field of fire protection in addition to several benefits from the user side - based on the professional experience of recent years - with significant risks for the fields of prevention and firefighting. I describe the possibilities of current fire protection issues of alternative energy sources, the results of which should be taken into account either when reviewing current professional and educational issues or when determining the directions of research in the near future.

2. METHODS

Regarding the fire protection of alternative energy sources, Hungarian and international scientific publications in recent years have been reviewed. The writings, the elements of which are currently becoming more and more widespread in Hungary and pose challenges for the fire authority officers and brigades, were especially targeted, such as the fire protection of solar cells, photovoltaic solutions and related - lithium-ion batteries for fire protection opportunities and circumstances. The content of the selected materials, scientific articles and publications, studies, the main lessons were analyzed and used for this paper. Especially targeted were the writings, the elements of which are currently becoming more widespread in Hungary and pose challenges for the fire officers, such as solar panels, photovoltaic fire protection and related - lithium-ion batteries fire protection, firefighting. opportunities and circumstances. From the content of each selected material, scientific articles and publications, studies, the parts containing the main lessons were analyzed more thoroughly and used for this article.

3. RESULTS

Dividing the results into two parts, the first part presents the issue of fire protection of **photovoltaic solar cells**. The second part describes the fire protection characteristics and new suppress possibilities of **lithium-ion batteries**.

3.1. Fire protection of photovoltaic solar panels

During the general use of solar cells in everyday use, more precisely photovoltaic solar cells, the following main factors affecting preventive fire protection and firefighting interventions appear. In principle, properly installed solar cells (hereinafter referred to as the term) must not cause health damage or direct danger to the environment. We can also find roof-mounted, facade or ground design. The main source of danger is the topic in connection with improper design or various injuries and firefighting damage. In such a situation, the general firefighting activities must be applied and modified in a way that is appropriate for the environment. Naturally, the harmful physiological effects of electric current appear to be among the sources of danger, but also slip and fall, in addition to the issues of fire hazard.

Figure 1, 2 - Multiple fire risk and a flat roof with full of solar panels

Source:(e-on.hu, nvsolar.hu)

In the solution proposals, the tactics of firefighting interventions include providing a suitable place for firefighters to operate in the environment of the solar cell and preventing the spread of fire. Good practices include the provision of maintenance and firefighting work environments that require direct human activity during installation, the definition of issues in primary firefighting tactical regulations for primary interveners, or the development of solar systems themselves to take these into account. The fact that roof structures equipped with solar panels (or only the solar panels themselves) may be more easily damaged or torn off due to the higher weight load may also require the assistance of such manufacturers and developers. The glass surface of solar panels can cause slipping and, in the process, fall, which limits the area of free, safe movement of people, including firefighters [2] [3] [4]. In cases exposed to sunlight, solar cells naturally generate electricity even after the building is disconnected from the mains, even if not by high voltage or general mains voltage. Firefighter protective clothing may provide a lesser degree of protection in this field, but this should not be considered 100% safe [5] [6].

According to a previous study in Germany, solar hazards can also be lost due to the appearance of toxic gases, lower exposure to electricity, loss of concentration due to its “tingling” effect and consequent collapse, but also fire propagation and flow factors that change compared to general rooftop fires.

“Fire Operations for Photovoltaic Emergency” has been defined in the United States. Based on this, we can find several recommendations that are also useful at the international level, quoting: Protect from potential hazardous chemicals coming from photovoltaic, solar modules on fire with the use of self-contained breathing apparatus (SCBA).

During operation in interior circumstance, water has to be directed on or near a solar system in a 30-degree fog pattern to prevent any electric current from traveling upstream toward firefighters. Firefighters must be at least about 10 meters away from the energized source.

During operation for search, the location of the solar-system-related components must be immediately relayed to the Incident Commander and all personnel working at the scene, and disconnect switches must be turned to “OFF.”

Overhaul, Fire Investigation, whenever possible, an overhaul of the fire ground should be delayed until there is competent confirmation that the solar system has been “de-energized.”

The presence of battery systems is a problem related to some of the alternative energy sources, in particular solar systems (in addition) or to the propulsion of vehicles, which issues by the batteries also appears in the second part of the paper. During the night, even in the event of a disconnection to the electrical network, voltage may be present in the building affected by the fire brigade. In addition, depending on the type of batteries, hazardous substances may be present. In the United States, design requirements for batteries are established to the battery systems used in the photovoltaic system by Chapter 52 of the NFPA 1, Fire Code, and Section 608 of the International Fire Code.

The Fireground Tactics can be: “Components are always hot!” It means for the firefighters to always consider photovoltaic systems, their components as electrically energized.

As a continuation of this, the usual procedure, but the prohibition of direct access and contact, may appear in the principles of fire intervention. After the fire intervention, it is important to leave the scene in a safe condition due to these issues too. There are need to develop the International and National Fire Codes in the prevention side. The possibilities to raise the safety level can be:

Provide ability for electrical system isolation for emergency responders and enough space for the personal presence. Standardized approaches to provide consistent identification of solar power systems and their components.

The systems are exposed to weather conditions that enhance the aging process, and the infrastructure needs to be inplace for the on-going maintenance and also helpful contact information for emergencies [7] [8] [9] [10] [11] [12].

3.2. Fire protection of lithium-ion batteries

Some of my sentences are directly from that work due their meanings. The solutions by lithium-ion batteries helps the transportation and energy storage also. It is smaller and lighter compared to conventional batteries (e.g. niccel batteries, Ni-Cd, Ni-MH). The problem with these kind of batteries, if the internal temperature of this kind of battery increases beyond its operating range, by external or internal means, so the components may become unstable and tend to generate heat. The temperature of the batteries can elevate further. The fire can be extinguished, but the effects of thermal runaway are difficult to manage, solution could be the cooling onward.

3.3. The phenomenon of the thermal runaway and the fire

Nowadays we are using lithium-ion battery in hybrid electric vehicles and electric vehicles, aeroplanes also. By a study, the conditions to thermal runaway and fire can be separated into four categories:

- Electrical abuse (e.g. over-charging or discharging)
- Thermal abuse (over-temperature above 200 °C).
- Mechanical abuse (penetration, pinch, and bend) caused by external accident (e.g. car crash or repairing, installation), can result in electrical shorting between the electrodes.
- Internal short circuit. By the failure of the separator, allowing contact between the cathode and anode via the electrolyte (e.g. due to any of the above abuse or manufacturing fault)

If these abuse conditions results increase in the internal temperature of the cell, can initiate exothermic reactions, occurs fire. The various abuse conditions resulting in separator malfunction and possibly thermal runaway, after fire ignition, what is hard to put out pemanently.

3.4. Techniques by the preventive Fire Protection

In the preventive side, the fire protection codes can measure for the cells, the batteries, its modules, the packing, the whole system and also the enclosures. The fire protection signs can take place outside of the battery or the system and compartment to give attention for the maintanance or the fire intervention.

The early fire detection and suppression also can help with the tools of Fire Prevention passively and actively [13]. This kind of fires can be detected by conventional heat detectors, smoke detectors or combined smoke-heat detectors.

3.5. To supress the fire, we can use more ways

By using **water**, it is the most cost-effective method to fight against fires. Water is an excellent cooling material and may be able to mitigate or halt the propagation of thermal runaway. By the way, water can react with and form toxic and harmful hydrogen fluoride.

Good solutions by four types of water suppressants:

- Water jet: a stream of water directly to burning materials. It provides cooling and inhibiting re-ignition.
- Water spray or sprinkler: a spray of fine water droplets. The spray can penetrate the fire plume and cool surfaces and the air.
- Water with added surfactants: We can add more types of surfactants to the water to improve the effectiveness of water extinguishment. By the surfactants, we can reach to decrease the water's surface tension so that it coats better the burning materials and cools better also.

- Water mist: Water mist comprises different droplet sizes, smaller than from a sprinkler. Finer droplets have a large surface area resulting bigger absorption of heat energy from the air, water. For large batteries and its modules, it can be efficient due its low volumetric requirement and good cooling capability. We can raise the effiency by adding surfactant to the water source.

Suppress the fire can also be successful by using large amounts of water to the batteries. Also helps submerging the batteries in water.

By using **foam** fire extinguishants also can be used to extinguish fires of lithium-ion batteries. The foam cools and seals the surface so putting a barrier between flammable vapour and the hot surface and starving the fire of air. The efficieny also can raise if adding surfactant.

By using **powder** extinguishants, we can chemically interrupt the fire reactions. This way not provide cooling and re-ignition may occur after put out the fire. Powders can create breathing, safety problems inside [14].

4. DISCUSSION

Fire protection officers, workers need to see some alternative energy sources and fire protection features also on the preventive and intervening side. To help these fields, it is recommended to make more open experiments and publishing studies in this area, in particular with regard to the fire equipments and suppressants for use in different conditions.

Particularly important is the examination of energy sources that are larger for industrial, retail or daily home use, which is statistically higher in the likelihood of various fire-departmental tasks related to them. The following areas may be particularly interesting from these aspects: effective fire protection and firefighting interventions and safety issues in the area of the installed solar panels and in the field of energy storage, even on vehicles.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

József Hesz, Gergő Érces, Balázs Nagy

EVALUATION OF BIM-BASED WORKFLOWS IN FIRE SAFETY ENGINEERING

Abstract

Building information modelling and management (BIM) is a process supported by various tools, applications and technologies involving the generation, optimization, and management of digital representations of physical and functional characteristics and information of constructions throughout its entire lifecycle. BIM can be used to provide, or store information related to fire safety. Some of these applications are known and used already, however, many possibilities are nowadays still in the research and development. In our research, we evaluated the possible BIM-based individual applications based on scientific literature and composed a workflow of a construction project that is organizing the use of engineering design and management involving BIM. We discussed the possibilities of BIM applications throughout the analysis of building constructions for fire loads, fire and smoke propagation and evacuation simulation, integrated smart monitoring systems for fire alarm and incident management as well as innovative fire prevention solutions such as AR/VR applications. Our research goal is to facilitate the interconnection of BIM engineering applications and fire protection. We concluded that BIM can be used throughout the whole lifecycle of a building project and all fire safety engineering applications can optimize and generate changes in the building design if these assessments interact to each other and use the same dynamically developing BIM model.

Keywords: building information modelling, innovative engineering methods, fire safety engineering

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

BIM-ALAPÚ MUNKAFOLYAMATOK ÉRTÉKELÉSE A TŰZVÉDELMI MÉRNÖKI MUNKÁBAN

Absztrakt

Az épületinformációs modellezés és -menedzsment (BIM) egy különböző eszközökkel, alkalmazásokkal és technológiákkal támogatott folyamat, amely magában foglalja a fizikai és funkcionális jellemzők, valamint az építményekre vonatkozó információk digitális reprezentációinak előállítását, optimalizálását és kezelését annak teljes életciklusa alatt. A BIM felhasználható a tűzbiztonsággal kapcsolatos információk nyújtására vagy tárolására is. Ezen alkalmazások némelyike jelenleg ismert és alkalmazott, azonban még sok lehetőség rejlik az egyes alkalmazások kutatásában és fejlesztésében. Kutatásunk során a rendelkezésünkre álló szakirodalom alapján értékeltük a lehetséges BIM-alapú alkalmazásokat, és egy átfogó munkafolyamatot állítottunk össze, amely rendszerezi a BIM-et magában foglaló mérnöki tervezés és menedzsment használatát. Ennek során kitérünk a BIM alkalmazási lehetőségeire az épületszerkezetek tűzállóságának modellezésére, a tűz és a füst terjedésének, valamint a kiürítés szimulációjára, az integrált intelligens monitoring rendszereknek a tűzjelzés és az események kezelésére, valamint az innovatív tűzmegelőzési megoldásokra, például az AR / VR alkalmazásokra. Kutatási célunk a BIM mérnöki alkalmazásának és a tűzvédelem összekapcsolásának elősegítése. Arra a következtetésre jutottunk, hogy a BIM tűzvédelmi szempontból is alkalmazható az építmények teljes életciklusában, és minden tűzbiztonsági mérnöki alkalmazás optimalizálhatja és változtatásokat generálhat az épület tervezésében, ha ezek az értékelések kölcsönhatásba lépnek egymással, és ugyanazt a dinamikusan fejlődő BIM modellt használjuk.

Kulcsszavak: Épületinformációs modellezés, innovatív mérnöki módszerek, tűzvédelem

1. INTRODUCTION

Nowadays, in addition to traditional fire protection design, we increasingly use so-called engineering methods, but these are mostly computer-aided, software-assisted design processes, which typically do not handle, and in many cases, hinder the development and long-term sustainability of complex fire protection. Based on our professional experience and on our research, a significant part of today's engineering methods does not form part of a comprehensive fire protection concept that provides complex solutions, does not necessarily make a way for design decisions, and does not reflect a use-oriented approach, but prepares the implementation of technical solutions more favourable than the requirements of the National Fire Protection Code (NFPC) [1].

According to our assumption, instead of the so-called engineering methods utilized in the field of architectural fire protection today, with new, scientifically based, complex, use-oriented innovative engineering methods endowed with building information modelling and algorithmic design methodology, a more advanced, safer, sustainable complex fire protection can be created, which can be dynamically changed to meet social needs [2]. To verify our hypothesis, we analysed and evaluated the possibilities of the building information modelling- based fire safety engineering applications in the field of fire prevention.

Building information modelling and management (BIM) is a process supported by various tools, applications and technologies involving the generation, optimization, and management of digital representations of physical and functional characteristics and information of constructions throughout its entire lifecycle. BIM can be used to provide, or store information related to fire safety and also in fire protection net which covers the entire lifecycle of buildings, which enable us to realize a new, high-level long-term sustainable safety within a sustainable smart city [3].

In BIM, level of development (LOD) represents and gives information about both the level of geometry (LOG) of the visible model and the level of information (LOI) content. Therefore, LOG represents the quality of the graphical information, while LOI mostly represents the non-graphical information of a BIM model or object such as performance, execution, or product/material properties. LOG is often used as a synonym to level of detail, which is also often abbreviated as LOD [4]. The following BIM level of developments exist in the practice:

LOD 100 is used mostly for conceptual design in early stages of the project. In this case the building 3D model is developed to represent the information on basic level. Parameters like area, height, volume, location, and orientation are defined only. LOD 200 is used for schematic design purposes, where elements are modelled with approximate quantities, size, shape, location and orientation and non-graphical information are also can be added to the model elements. LOD 300 is used for detailed design processes, it requires accurate modelling and shop drawings, where elements are defined with specific assemblies, precise quantity, size, shape, location, and orientation, while non-graphical information content, such as performance data are added to the model elements as well, improving its LOI. LOD 300 is contains all quantity, size, shape, and location of objects, such as building constructions and it can also contain non-graphical information content such as performance data added to objects. LOD 350 is usually contains the object related elements and their connections and interface with various systems and other building elements and used for construction documentation and space required for installation or operation is also added. LOD 400 is used for fabrication and assembly, the BIM model elements are modelled as specific assemblies, with complete fabrication, assembly, and detailing information in addition to precise quantity, size, shape, location, and orientation including the necessary non-graphical information, respectively. LOD 500 corresponds to the reality as-built and used in the stage of maintenance and operation of the building. It records the as built state and to create such a model, huge amount of work and continuous assessment is required. But if it is available, it can provide almost every information for facility management purposes.

Most of the BIM-based fire safety engineering applications require a certain level of development for the BIM model, usually at least around LOD 300 or LOD 350 up to LOD 500. To provide inter-exchange of a building information model without loss or distortion of data, openBIM software environment supports Industry Foundation Classes (IFC), since it is an open file schema, created to facilitate interoperability between different software and operators. However, IFC files are mostly for referencing, archiving, and exchanging the original content created in different workflows throughout its entire lifecycle of design to maintenance, it contains usually just enough information for simulation software to read and analyse, but should not be edited, neither able to contain or transfer simulation analysis results. Therefore, even if the BIM model with appropriate LOD level is exchanged using IFC files, we have to use mostly separated and closed individual workflows nowadays for the engineering methods during design relevant to fire safety engineering, however the same IFC files can be used for design of structures, simulations and optimization, evaluation of performance, compliance checks, organize virtual trainings, and could provide data during fire alarms and rescue tasks.

2. METHODOLOGY

In our research, we are going to demonstrate and evaluate the possibilities of BIM in fire safety engineering. To be able to collect all the relevant fire safety engineering applications and methodologies regarding design, construction, and management of a building, we scanned three public scientific databases (science direct, google scholar and researchgate) for papers containing fire safety and BIM applications. During the research, we analysed and evaluated 22 selected, relevant papers, and collected the possible workflows using fire safety engineering, design, and management BIM-based tools. Using the results of the data extraction, we composed a schematic workflow for the whole building lifecycle regarding fire safety engineering and rescue management to be able to show that BIM applications can be used throughout the whole lifecycle of a building construction project.

3. RESULTS AND DISCUSSION

In the following chapters, we present the evaluation of four selected fields in BIM-based fire safety applications regarding to our scientific literature review, data extraction and analysis.

3.1. BIM-based analysis of building construction for fire loads

The first analysed process was the use of fire safety engineering in building constructional design and product development. According to the relevant literature [5]–[7], we can create analysis of building constructions for fire loads based on BIM models containing the building construction's geometrical data. The 3D geometrical model could be generated using BIM-based tools. The numerical model can use imported geometry (e.g. Ansys using CADFEM BIM inside Ansys extension [8]) or can be directly live linked from a BIM software that can read IFC or create BIM models to a multiphysical simulation environment called Comsol Multiphysics [9]. If the numerical model is created with care, attention to the physics and professionalism, the simulation results could match to experimental fire test results with good agreement as observable in Figure 1. However, to obtain a performance rating of a building construction, experimental results needed. Therefore, a building construction's response to fire can be modelled in advance, and the numerical results can give additional inputs to reduce the costs and provide a preliminary test, to perform real laboratory experiments on structures that meet the requirements by simulation. Besides the preliminary results, the numerical simulation results can supplement the experimental data showing e.g. the temperature distribution throughout the entire model. These analyses can provide precious additional data even during fire rescue on the building construction.

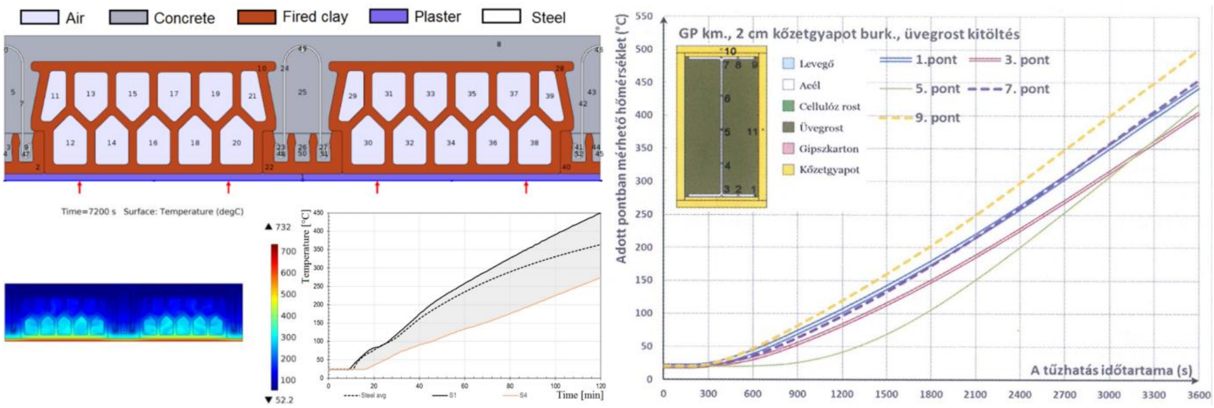
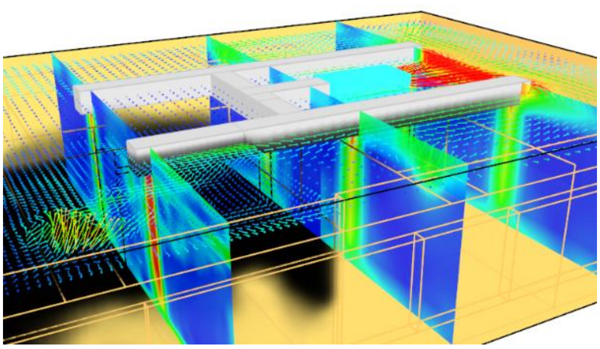


Figure 1: Numerical simulation based on BIM object of a ceramic slab (left) [6] and on a steel section with fire protection cover (right) [7].

The fire resistance performance of building constructions can be stored later in the design stage in the BIM model file besides its geometrical and graphical data as an additional information and it can be checked by authorities by performing either clash detection-based compliance check or automatic code checking [10], [11] for the fulfilment of the required and stored information regarding the NFPC.

3.2. BIM-based fire and smoke propagation and evacuation simulation

In BIM-based workflows in fire safety engineering the authors analysed two software in the field of fire and heat spread, and in the field of evacuation to be able to create the innovative fire safety engineering methodology. In the current Fire Protection Technical Guide of Fire-, smoke propagation and evacuation modelling [12], Fire Dynamics Simulator (FDS) is listed as the applicable fire and smoke propagation simulation tool, perhaps because the code is validated through experiments [13]. It is a large-eddy simulation (LES) code for low-speed flows, with an emphasis on smoke and heat transport from fires [14] that can use third party graphical user interfaces (GUI) to the code, like Pyrosim [15] (see Figure 2), are able to perform dynamic simulations which can provide important information even to structural engineers or building construction specialists. It can also import IFC among other CAD file formats, and able to visualize the simulated smoke, temperatures, velocities, toxicity, and other outputs for the FDS analysis. Using this GUI, we are able to creates videos in real-time by recording while adjusting the camera and data visualization that is useful during performance-based design [16]. Pyrosim is able to easily switch between Smokeview provided by NIST [14]. It also includes tools helping to create and validate multiple meshes for the numerical simulations, that allows the use of parallel processing to speed up the solution, conform meshes to the geometry to reduce the number of cells and solution time, and change the resolution of different meshes to focus of regions of interest. FDS version 6 introduced the integration of Heating, Ventilation, and Air Conditioning (HVAC) systems into the CFD simulation since it can transport contaminants and heat through the building. The HVAC system can model flow independent of any fire analysis. They may also serve as part of the fire protection system for a building when used to exhaust smoke or maintain stairwell pressurization.



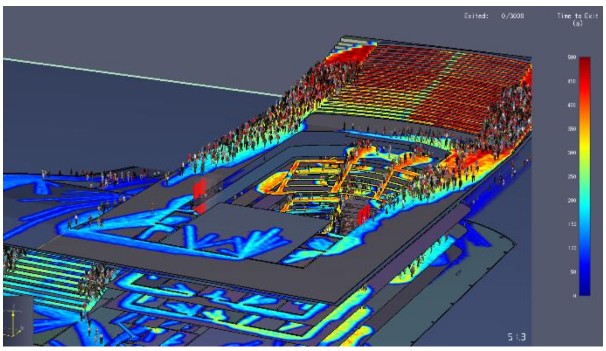


Figure 2: 3D visualisation of fire and smoke propagation (left) and evacuation simulation (right) [15]

There are many different evacuation models [17], however, the applicable evacuation simulation tools are also listed in [12], among others Pathfinder [15] (see Figure 2) is an agent-based simulator able to model the egress of humans from a building and animate 3D results. It also able to import IFC files and creates a triangulated mesh for geometry, therefore, it can represent curved graphical details and facilitates continuous movement of persons throughout the model, compared to other simulators that subdivide the space into cells that can artificially constrain the movement of occupants. Pathfinder supports two simulation modes. In Steering mode, agents proceed independently to their goal, while avoiding other occupants and obstacles. Door flow rates are not specified but result from the interaction of occupants with each other and with boundaries. In SFPE mode, agents use behaviours that follow guidelines of the Society of Fire Protection Engineers, with density-dependent walking speeds and flow limits to doors. SFPE results provides a useful baseline for comparison with other results, but SFPE calculations do not prevent multiple persons occupying the same space. Pyrosim is also able to use Results Viewer with a similar interface, which can also integrate Pathfinder occupant movement results [15], as well as with smoke and fire data imported from FDS results, Pathfinder can demonstrate areas of high danger by tracking occupant Fractional Effective Does (FED) of contaminants. Although, in case of fire, because of the changed visibility or blocked paths, evacuation may differ from the optimum. This can be modelled if the fire dynamics simulation is connected to the evacuation model and performed together [18] to support a BIM-based fire evacuation planning and create walkthroughs of egress routes according to the analysis to improve human evacuation performance [19].

3.3. BIM-based integrated smart monitoring systems for fire alarm

At the birth of fire alarms, the alarm was given by available acoustic signals. Then the invention of the telephone and the fire detector allowed direct detection and signalling of the fire and its transmission to organized fire brigades. Computer was invented in the 20th century, that made it possible to receive and transmit information quickly. GIS appeared in fire protection and firefighting, which was a significant step in the field of fire detection and alarm. The telephone, the fire alarm and the computer were connected [20]. At present, wireless sensor networks within a building can be used as a fire alarm and providing precious information on the properties and location of the fire not only to the firefighters, but for the civilians in the building for fire emergency management [21]. BIM models can be linked to locate firegrounds by using the building model and sensor data [22], [23] to be able to use during incident management and support building fire emergency response operations (see Figure 3).

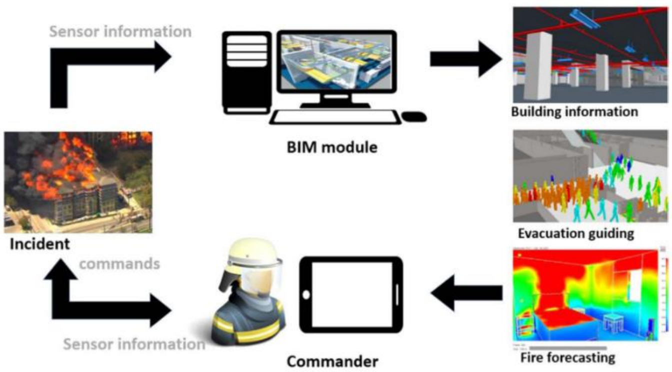


Figure 3: Future use of BIM during incident management [22]

Integrating BIM and the building management and automation system and Internet of Things can provide real time fire monitoring and support the firefighters in fire scenes, who are able to gather as much information as possible to support them during incident management [24], and since time is key in case of an event, to prevent overload of data, multi-decision making algorithms and fire risk assessment systems should support the commander on his decisions in buildings [25]–[27] or even in construction sites [28].

3.4. BIM-based fire prevention solutions

LOD 500 level as-built BIM models can be used for maintenance and management purposes, whereby inspection of the fire safety equipment should happen. Simply using the information stored in the model concerning fire safety equipment [29], or even deploying Augmented Reality (AR) using the BIM model, the employees can check the location of the fire safety equipment increasing effectiveness of the maintenance [30].

Virtual Reality based fire training can increase situational awareness also. The safety education training could include 3D representations of the hazardous areas and escape routes [29] or may takes place in a virtual reality (VR) environment generated from the building information model of the building and the training could be conducted using a virtual reality head mounted device (HMD) [31], therefore residents, building users and even firefighters can use the virtual building to practice evacuation and rescue in case of fire alarm or emergency. Additionally, if we connect this feature to fire dynamic and evacuation simulations, we may can test and validate virtually the building even before construction started.

Besides VR, Augmented Reality can facilitate indoor pathfinding efficiency. Real time information from the building can be obtained dynamically even on a mobile phone, and data, such as information of the fire location and advised evacuation paths can be visualized and firefighters' efficiency can be improved through this framework [32].

3.5. BIM-based workflow for fire safety engineering

The schematic workflow of BIM-based fire safety applications connected to each other is represented in Figure 4 based on the scientific literature review, data extraction and analysis. The key between the applications is the interaction provided by BIM applications, that can optimize and generates changes in building design in the design and construction stages.

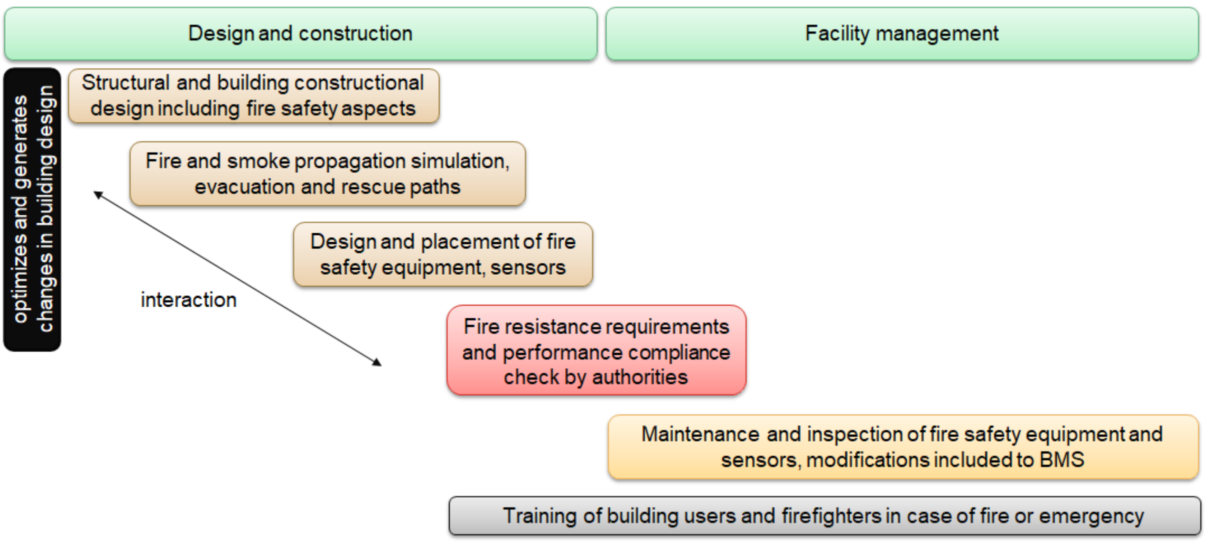


Figure 4: BIM-based workflow of a building related to fire safety engineering

4. CONCLUSION

During our research, it became clear that BIM can be used throughout the whole lifecycle of a building project, although most of the applications nowadays exist individually. There are several fire safety engineering applications supporting BIM and able to use IFC files as their input. If the designers and engineers using these applications, then all fire safety engineering applications can optimize and generate changes in the building design, e.g. the results of a fire and smoke propagation and evacuation simulation can show the optimal path of evacuation within a building where the structure of the building could be reinforced or fire safety equipment could be placed. Therefore, instead of individual assessments, we have to think in a complex system, where each process in the workflow could interact with each other using the same dynamically developing BIM model leading to a valuable contribution to all building projects.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Branko Babić

THE PLACE AND ROLE OF THE VOLUNTEER FIREFIGHTERS ASSOCIATION IN THE DISASTER RISK REDUCTION SYSTEM IN THE REPUBLIC OF SERBIA

Abstract

Volunteer firefighter associations are members of firefighters unions, voluntary, non-profit organizations based on freedom of association. They are established for the purpose of organized voluntary participation of citizens in the implementation of fire protection, rescue of people and property. They are obliged to form, equip, and maintain at least one volunteer firefighting unit. As such, they represent a huge potential for the security of local self-government. The paper gives an overview of the work of a volunteer firefighters association in the Central Banat Administrative District.

Keywords: volunteer firefighters association, local self-government, organization

AZ ÖNKÉNTES TŰZOLTÓ EGYESÜLETEK HELYE ÉS SZEREPE A SZERB KATASZTRÓFAVÉDELMI RENDSZERBEN

Absztrakt

Az önkéntes tűzoltók egyesületei az egyesülési szabadságon alapuló tűzoltói szakszervezetek, önkéntes, nonprofit szervezetű tagjai. Az önkéntes állampolgárokból álló szervezet célja a tűzoltás, a tűzmegelőzés, valamint az élet-és vagyonmentés. Kötelesek legalább egy önkéntes tűzoltó rajt kialakítani, felszerelni és fenntartani. Ezek az egyesületek, hatalmas segítséget jelentenek a helyi önkormányzatok tűzoltási feladataiban. A cikk egy átfogó elemzést nyújt a Közép-Bánát Közigazgatási területén működő önkéntes tűzoltó egyesületek munkájáról.

Kulcsszavak: önkéntes tűzoltó egyesület, helyi önkormányzat, szervezet

1. INTRODUCTION

Volunteer firefighters associations are a great help to the professional units of the Ministry of the Interior of the Republic of Serbia during firefighting interventions and other protection and rescue actions. Volunteers in volunteer firefighters associations, after the adoption of the Law on Voluntary Firefighting [1], are at the disposal of emergency headquarters, and try to help their colleagues in the Ministry of the Interior in all possible ways. If necessary, they can independently participate in some less demanding interventions, such as open fires, water pumping in floods because they are an example of a well-organized, equipped, and trained association; they can independently participate in interventions, but also in cooperation with professional fire and rescue units. Some associations have basic firefighting equipment, a few of them can intervene with special vehicles, whereas most of the volunteer firefighters associations have also pumps for pumping water.

A large number of these associations had problems with equipment and facilities for a long time, and many of them have not resolved them yet. However, the situation improved in 2018. That was when the Law on Voluntary Firefighting whose focus is on forming operational units was adopted in our country for the first time. It stipulated that volunteer firefighters, in case of injuries and other undesirable situations that can occur during interventions, exercise the same rights from health, pension and disability insurance as well as the members of professional fire and rescue units. This law orders the assemblies of local self-government to pass an act on incentives and privileges for members of volunteer firefighting units, which would contribute to their popularization.

2. LEGAL FRAMEWORK OF OPERATION

Work and activities of Volunteer Firefighters Associations (hereinafter: VFAs) is based primarily on the Law on Voluntary Firefighting [1], the Law on Fire Protection [2], the Law on Disaster Risk Reduction and Emergency Management [3], the Rulebook on Conditions Regarding Material and Technical Equipment [4], the Law on Associations [5] and the VFA Articles of Association [6].

2.1. The Law on Voluntary Firefighting

The Law on Voluntary Firefighting [1] regulates the organization of voluntary firefighting, the establishment, operation, bodies, rights, obligations, and association of VFAs, the organization of volunteer firefighters unions and other issues. The VFA is a voluntary and non-profit organization based on freedom of association, established for the purpose of organized voluntary participation of citizens in the implementation of fire protection, rescue of people and property as well as completion of projects and programs in this field, which is as such entered in the Register of Associations. It has the status of a legal entity, the work of the Association is public, it is a member of firefighters unions, the Articles of Association is its basic general act, and it has its own name, headquarters on the territory of a local self-government, its own sign, logo, flag, and other symbols. Any adult can become a member of the VFA under the same conditions. In the Republic of Serbia, there are municipal or city firefighters unions, inter-municipal firefighters unions, firefighters unions of autonomous provinces and the Firefighters Union of Serbia.

The VFA is obliged to form, equip, and maintain functional at least one Volunteer Firefighting Unit (hereinafter: VFU). The purpose of forming the VFU is to implement fire protection, rescue people and property, prevent and suppress other technical and technological accidents and natural disasters. VFAs are formed by VFUs which can be units of the first, second or third category depending on the material and technical equipment and the number of members. The VFA issues an act on the establishment of the VFU, which must contain: the category of the volunteer firefighting unit, personnel, material, and technical equipment as well as the training level of the volunteer firefighting unit members. The VFU is headed by a commander appointed by the VFA executive board. In order to be a member of the VFU, a person is required to be between 18 and 55 years of age, to be medically fit to perform tasks, to be professionally qualified to perform tasks, to be professionally trained on a regular basis.

2.2. The Law on Fire Protection

The Law on Fire Protection [2] regulates the system of fire protection, rights and obligations of state authorities, bodies of the autonomous province and bodies of local self-government units, companies, other legal and natural persons, organization of the fire department, supervision of law enforcement and other issues important for the fire protection system. The law determines that “volunteer firefighters associations are associations established for the purpose of organized voluntary participation of citizens in the implementation of fire protection, rescue of people and property", and “firefighters unions (municipal, city, district, provincial and the Firefighters Union of Serbia) are professional and humanitarian organizations of special interest established for the purpose of organized and unified participation in implementing fire protection, their common goals and raising awareness of the importance of fire protection, within which volunteer firefighters associations and volunteer firefighting units operate. "

2.3. The Law on Disaster Risk Reduction and Emergency Management

The Law on Disaster Risk Reduction and Emergency Management [3] deals with Firefighting and Fire and Rescue Units in the opening Chapter V. Firefighting units can be professional or voluntary. Professional firefighting units are fire and rescue units of the Ministry, firefighting units of the Ministry of Defense, firefighting units of local self-government units and firefighting units of legal entities. ***Volunteer Firefighting Units*** are firefighting units of legal entities and associations, organized on a voluntary basis.

2.4. The Rulebook on Conditions Regarding Material and Technical Equipment

The Rulebook on Conditions Regarding Material and Technical Equipment [4] classifies VFUs into three categories depending on the material and technical equipment and the number of members. ***The first and second category*** includes VFUs that have at least 18 members who have a certificate of passing the exam for a member of the VFU and who have the equipment and resources given in Annexes 1 and 2 of the Rulebook. ***The third category*** includes a VFU that has at least 9 members who have a certificate of passing the exam for a member of the VFU and who have the equipment and resources given in Annex 3 of the Rulebook. The Ministry of the Interior issues a VFA certificate on the possession of a volunteer firefighting unit in accordance with Article 8 of paragraphs 5-7 of the Law on Voluntary Firefighting in a particular category for which a VFA or a VFU meets the conditions prescribed by this Rulebook. If the VFU, by purchasing equipment and increasing the number of members, meets the condition for changing the category in which it is classified, it may submit a request to the Ministry for a change of certificate in the part of the VFU category.

2.5. The Law on Associations

The Law on Associations [5] regulates the establishment and legal status of associations, registration and deletion from the register, membership and bodies, status changes and termination of associations, as well as other issues important for the work of associations. The association is a voluntary and non-governmental non-profit organization based on the freedom of association of several natural or legal persons, established for the purpose of achieving and promoting a particular common or general goal and interest, not prohibited by the Constitution or the law.

3. THE VOLUNTEER FIREFIGHTERS ASSOCIATION IN THE CENTRAL BANAT ADMINISTRATIVE DISTRICT

The Volunteer Firefighters Association [6] is a voluntary, non-profit, independent association of citizens, freely established and organized for the purpose of providing and improving fire protection and the common interests of its members. For the needs of organized realization and improvement of fire protection and interests of its members, the VFA:

- gathers and organizes citizens for the purpose of organized participation in activities in the field of fire protection, protection and rescue of people, material goods endangered by fire, natural disasters, and other extraordinary events,
- develops self-protection and technical culture of citizens, popularizes fire protection and its programs,
- proposes activities and protection measures and participates in their implementation,
- gathers, trains and nurtures junior firefighters through exercises, trainings, courses, competitions, and other activities through which the awareness of junior firefighters about the dangers and measures of fire protection is raised,

- organizes firefighting competitions, performances, and parties,
- organizes activities to implement personal preferences and interests of its members and their common or general goals,
- organizes a fire protection watch for legal entities which, due to the activity they perform, have a legal obligation to operate in the presence of professionally trained persons in fire protection with appropriate equipment.

Goals of the Association are:

- organizing professional training of the VFA members and the members of civil protection units, citizens, and workers, for the implementation of fire protection,
- improvement and promotion of fire protection, civil protection, environmental protection, and security,
- development of technical knowledge and popularization of information and communication technologies,
- publishing professional and educational propaganda literature, brochures, manuals, newsletters, audio and video materials, etc.,
- promotion of ecology, protection of the environment and health, preservation, and improvement of natural values,
- education and promotion of safety and protection in the field of agriculture,
- development and promotion of sports and sports activities,
- organizing competitions, seminars, trainings, workshops, entertainment, training...,
- cooperation, association, and networking at local, regional, and international levels.

The Association consists of active members, honorary members, assistant members, and junior firefighters.

Members of the VFA have equal rights and duties to:

- participate in the work of achieving goals of the VFA,
- decide on the acts of the VFA and the contents of the VFA work and their implementation,

- comply with the VFA Articles of Association, general and other acts of the VFA and the decisions of its bodies,
- elect and be elected to the bodies of the VFA and the union,
- be praised and rewarded for successful and dedicated work,
- to improve their knowledge and skills in the areas in which the Association achieves its goals, and
- protect the reputation of the VFA and the personal reputation of a member.

The Bodies of the VFA are: Assembly, Executive Board, Supervisory Board, and Youth Club.

The Assembly of the VFA is the highest authority of the Association and a form of personal declaration of the VFA members. The Assembly consists of all adult members registered in the VFA register. The Assembly:

- adopts the VFA Articles of Association and other general acts and their amendments,
- elects and dismisses the chairperson, vice chairperson, secretary, treasurer, VFA commander, storage keeper and a number of members of the chair officers,
- elects the VFA representative,
- elects and removes members of the Supervisory Board,
- elects and recalls representatives of unions and associations,
- adopts the work plan and program, financial plan and annual calculation of the VFA and considers reports on their implementation,
- decides on joining unions and related associations in order to implement joint programs,
- adopts the act on the establishment of the VFA, which is required to contain: the category of the VFA, personnel, material, and technical equipment as well as the training level of VFA members,
- makes decisions on the appointment of honorary members of the VFA,
- decides on the termination of the VFA,

- decides on status changes (mergers, acquisitions, and divisions) and other issues in accordance with the law and the VFA Articles of Association.

The Executive Board of the VFA is a VFA body and the executive body of the Assembly, elected by the Assembly from among the members of the Assembly for a term of 4 years.

The Chairperson of the VFA manages the work of the Executive Board, organizes, and manages the business of the VFA; the Chairperson is elected by the Assembly for a term of 4 years and is responsible for their work to the Assembly and the Executive Board; the Chairperson organizes the work of the Executive Board and takes care of their legal work, enforcing acts and decisions adopted by it as well as the use of the VFA funds. The Chairperson is a representative of the Association.

The Vice Chairperson of the VFA replaces the Chairperson of the VFA in their absence when they perform the duties of the Chairperson in full. The Vice Chairperson of the VFA is a member of the Executive Board and is elected by the Assembly for a term of 4 years.

The Secretary of the VFA keeps business books and records, the register, the archive book, and administrative business; the Secretary is a member of the Executive Board, elected by the Assembly for a term of 4 years, responsible for their work to the Executive Board and the Assembly of the Association.

The Commander of the VFA manages the operational work in its entirety. The Commander also coordinates the work of competition teams, appoints and dismisses coaches of competition teams, controls the work of commanders and deputy commanders of the operational unit of the Association, controls the work of the operational unit of the Association, controls proper functioning of devices and equipment necessary for the work of the Association, proposes procurement or purchase of new or used equipment to the Executive Board, performs all other tasks related to the operational work of the Association. The Commander of the Association is elected by the Assembly for a term of 4 years; the Commander is a member of the Executive Board, responsible for their work to the Executive Board and the Assembly of the Association.

The Deputy Commander of the Association replaces the Association Commander in their absence when performing duties of the Association Commander in its entirety.

The Treasurer of the Association keeps business books in the field of material and financial operations of the VFA; the Treasurer is elected by the Assembly for a term of 4 years; the Treasurer is a member of the Executive Board, responsible for their work to the Executive Board and the Assembly of the Association.

The Storage Keeper of the Association maintains and takes care of the VFA equipment; the Storage Keeper is elected by the Assembly for a term of 4 years; the Storage Keeper is a member of the Executive Board, responsible for their work to the Executive Board and the Assembly of the Association.

The Youth Club consists of all members of the VFA under the age of 18, and it promotes voluntary firefighting among young people. The Youth Club members do not participate in VFA activities that may take any form of work. The Youth Club has a chairperson and an executive board in accordance with the VFA Articles of Association. The chairperson of the Youth Club is a member of the VFA Executive Board.

The Assembly establishes the VFU as an internal organizational unit of the VFA for implementation of fire protection, rescue of people and property, prevention and suppression of other technical and technological accidents and natural disasters. Members of the VFU can only be professionally trained and medically fit members of the VFA over the age of 18 and may remain members until they reach the age of 55. A member of the VFU may also be a person older than 55 years of age if it is determined that they are medically fit to perform the tasks of the VFU. A member of the VFU may also be a person performing fire protection activities as a regular occupation, except for persons employed in the Sector for Emergency Situations of the Ministry of the Interior of the Republic of Serbia. Internal organization, composition of members, equipment and material means of work, duties and responsibilities as well as other issues of organization and activities of the VFU are determined by the Executive Board, based on the conditions regarding the material, technical and personnel equipment of the VFU prescribed by the Minister of the Interior of the Republic of Serbia. Members of the firefighting unit perform protection and rescue tasks responsibly and impartially, in accordance with the law and the rules of the profession. The VFU is managed by the commander of the Volunteer Firefighting Unit who is appointed by the Executive Board of the Volunteer Firefighters Association.

4. HISTORY AND ACTIVITIES OF THE VFA

Since its formation in 1946, the VFA is one of the most active VFAs in the Central Banat District. Since its beginning, the Firefighters Association has had about 1200 members, which shows that 1 out of 4 inhabitants of the settlement has been a voluntary member of the Firefighters Association. Most people who have run this association have contributed to the fact that this association has a new firefighters station, which is used by the VFA as well as the local community and local office, and the grand hall is used by all socio-political and sports organizations.

The VFA has repeatedly won first places in municipal, regional, and national competitions. There were times when it participated in municipal competitions with 12 teams and won 7 first places and 9 medals. All these activities contributed to the association and organization to obtain funds from the Firefighters Union of the city of Zrenjanin for the construction of a new fire station. The firefighters who participated in voluntary work made a huge contribution. The station has the following rooms: a small hall, a grand hall in which the local community and local office are situated now, two storage rooms and the space in the attic. The total area is 450 square meters. A kitchen with tables and benches, which is equipped for independent cooking and baking with complete equipment for 120 people, is a separate entity. All VFA rooms are equipped with radiators for the winter period.

Considering firefighting equipment, it has enough fire extinguishers, one FAP (Srb: *Fabrika automobila Priboj*, Engl: *Priboj Car Factory*) fire truck, and the personal equipment necessary for extinguishing the fire. The tasks involve inspection of private households and duties during the harvest and threshing of an agricultural land.

The VFA participates in competitions that check the ability of the members to perform all types of fire protection readily, successfully, and safely, with a special emphasis in firefighting competitions on the work with youth categories, which the VFA has prioritized in fire protection activities since its formation to the present day. This association pays special attention to the work with the youngest categories in which the youngest members are introduced to the dangers caused by fires and taught how to react in these situations, and the commanders train them to use fire extinguishers which combine water and air foam, also used in competitions.

Old junior firefighters participate in the knowledge and use of firefighting equipment, while senior firefighters are familiar with all technical and material means and are trained for their application and localization as well as extinguishing fires. Due to the successful work of the young firefighters, the VFA organizes excursions every year. Almost every year, the VFA, in cooperation with the Municipal Firefighters Union of the city of Zrenjanin, organizes a training course for firefighters.

Special activities of the VFA are preparations and duties during the harvest when the association inspects the fire extinguishers and mechanization used in the harvest activities, and it is on duty 24 hours a day.

The VFA is one of the most numerous associations and one with the most skilled personnel. This firefighters association has 153 members out of which there are: 3 senior first class fire officers, 3 senior fire officers, 9 fist class fire officers, 3 fire officers, 11 fire sub-officers, 22 first class firefighters and 47 firefighters. In addition, there are two youth B teams with 12 members each, one male and one female team; there are also a youth male A team and a youth female A team - the male one has 19 members, and the female one 12 members, which means that the total youth branch has about 55 members, whereas together with the executors, teams, and youth teams there are 153 members.

The VFA Managing Board has 13 members and 9 unit parts; it has the means for the most modern methods of extinguishing fires, as well as resistant suits that can withstand high temperatures.

The VFA successfully cooperates with the Municipal Firefighters Union of Zrenjanin, the primary school, numerous companies, the water supply and sewerage, Vojvodinaput Ltd., the Danube-Tisa-Danube company, as well as all social and sports organizations. The VFA firefighters participate at least 10 times a year in firefighting interventions or providing support to professional firefighting units from Zrenjanin in extinguishing fire. Smaller fires in the place are localized by the firefighters themselves, and they also provide social assistance in populated places in the vicinity.

Additionally, the VFA participated in all performances, both in techniques and membership, as well as in the events and demonstration exercises that were organized by the Municipal Firefighters Union of Zrenjanin. It proved to be a good host in all competitions that were held in the populated area. The VFA hosted many seminars and meetings of the Firefighters Union of Zrenjanin and the Firefighters Union of Serbia, which shows the importance of the work of this association.

5. CONCLUSION

A volunteer firefighters association is a voluntary and non-profit organization based on freedom of association, established for the purpose of organized voluntary participation of citizens in implementing fire protection, rescue of people and property, which meets the conditions prescribed by this law.

The VFA has done a lot for the population of its own and the nearby places through its work and commitment. It has taught a great number of children the importance of fire protection and introduced them to the system and work of the firefighters association through its activities. Many accolades which the volunteer firefighters association received speak in favor of the fact that it is really one of the best and most active associations in the city of Zrenjanin.

The firefighting activities so far show that there has been no need for more modern equipment and vehicles because the actions are of the local type, fires mostly occur in agricultural crops, and the association has sufficient funds and equipment for such activities. In cases of larger fires, the association is never alone in the action, however; as the nearest unit, it goes out first to the place of fire, but the unit of the city of Zrenjanin quickly joins it.

When it comes to the events and accidents, the VFA is well equipped.

In order to improve the situation, more funds should be invested in the VFA; the activity of the VFA should be increased regarding information and commitment of residents to emphasize the importance of fire protection and organization of additional activities in order to indicate the possible causes of fire base on the previous experiences; stricter precautionary measures during harvest activities should be taken in order to reduce the risk of fire outbreak to a minimum and thus increase the safety of residents.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

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EXAMINATION OF SEARCH PROCEDURES IN THE FIRE PROTECTION

Abstract

Although fire safety and prevention regulations got tightening in recent decades by fire departments rescue fire protection role has not diminished. Global warming, terrorism, industry its development poses new challenges for fire departments. Day by day we face the global warming associated with larger and more destructive vegetation fires. Aspect of structural and building fires, perhaps the growing risk is less pronounced in this area, but we face challenges we have never faced before. 35 years ago we had 17 minutes for escape until the flashover happened. Today, this time has been reduced to 3-4 minutes. The successful In addition to updating intervention tactics, it is essential to lay down new and modern procedures to victim detection.

Keywords: fire departments, firefighter, rescue, victim detection

KERESÉSI ELJÁRÁSOK VIZSGÁLATA A MENTŐ TŰZVÉDELEMBEN

Absztrakt

A megelőző tűzvédelmi előírások az elmúlt évtizedekben szigorodtak, azonban tűzoltóságok tűzoltási és műszaki mentési szerepe továbbra sem csökkent. A globális éghajlatváltozás, a terrorizmus és az ipar fejlesztése új kihívásokat jelent a tűzoltóságok számára. Az éghajlatváltozás nagyobb és pusztítóbb tüzeket eredményez. Az épülettüzek szempontjából talán a növekvő kockázat valamivel kisebb, azonban a beavatkozóknak olyan kihívásokkal kell szembe nézniük, amelyekkel korábban még nem találkoztak. A menekülés ideje 35 évvel

ezelőtt még 17 perc volt ma ez az idő már 3-4 percre csökkent. A beavatkozási taktikák kutatása mellett fontos az áldozatok felderítésekor az új és modern eljárások meghatározása is.

Kulcsszavak: tűzoltóság, tűzoltó, mentés, áldozatok keresése

1. SEARCH METHODS

The method of firefighting and technical rescue has changed constantly throughout our history [1]. One of the most challenging tasks of firefighting interventions is finding people in a burning building [2]. Searching and rescuing firefighters in trouble is different than searching and rescuing civilians. Incidents like this are the greatest challenge [3] and risk [4] for intervening firefighters. An important factor in this case is the current mental pressure of the rescuer [5]. The victim is not a stranger, but one of us. It is possible that they even came to the scene with same engine, maybe they were in a friendly relationship. Rescuing a close acquaintance, comrade, always puts great pressure on rescuers, jeopardizing even objective judgment and sound decision-making [6] [7] [8]. In addition to the emotional pressure, it is more physically demanding to rescue a firefighter who is overweight due to personal protective equipment than an average civilian [9]. Another problem could be that while civilians were probably trying to move away from the source of danger, firefighters were moving towards danger only because of their duty. The basic rule, then, is that only a firefighter with the same training and equipment as the one in trouble can be sent for rescue. Otherwise, it is conceivable that the rescued people will not even reach the person in trouble, or in the worst case they will put themselves in danger. The most important and basic requirement for a RIT unit is immediate deployment and rescue in the shortest possible time. An event that puts a firefighter in danger most often occurs without any sign or warning. Golden minutes is the period of time during which a person who needs to be saved has the best chance of survival in the event of a successful save. These gold minutes cannot be determined exactly due to the many variables. For example, it largely depends on how much air you had at the time of the adverse event. Also a critical factor can be the distance between the firefighters launched to the rescue and the person in trouble or even the nature of the incident [10].

The task of the RIT unit:

1. Locate a firefighter in trouble

2. Protect the life of the firefighter in trouble at the scene

3. Rescue a firefighter in trouble

Finding a firefighter in trouble

If the situation of the firefighter in trouble is not known, it is the job of the RIT to locate it.

The purpose of locating a firefighter in trouble is:

- perform a fast, organized, planned search
- approach to the distressed so that the approach can be traced and controlled from the point of entry
- the approach should also be allowed for additional rescue units
- removing obstacles to search

Thus, a RIT unit is a search and rescue unit consisting of 2 or more experienced firefighters who can be deployed immediately and who are trained in advanced search and rescue procedures and they have the special equipment needed for rescue [11]. Unlike the rescue team, their only and exclusive task is to search for and rescue troubled firefighters when needed.

Fire rescue unit may consist of:

- • on-site on-call firefighters with the sole responsibility of the fire rescue unit
- • on-site firefighters who perform other tasks related to firefighting but, if necessary, function as a fire rescue unit

4.2. Search procedures

1. Simple search

2. Oriented search

3. TIC guided search

4. Rope Assisted Search Procedure

A primary search is a quick but thorough and targeted search activity that is performed before or at the same time as firefighting begins. The most important factor in a primary search is the purpose of the search. Basically, our research can have two purposes: to locate victims or to locate the nest of fire. The task is defined after the primary reconnaissance. A determined and purposeful primary search activity can increase the safety of the intervener, reduce life-threatening impacts, and achieve a faster and more efficient search. When searching, we try to stay close to floor level. The reason for this is that the rooms are mostly filled up with smoke from top to bottom, so there is a good chance of better visibility conditions at low level and the temperature is also lower. In cases where we do not have to be afraid of breaking down (eg rooms without basement), it is advisable to move on all fours, as our hips and shoulders are perpendicular to the direction of travel, so it is easier to maintain our orientation in the event of an unexpected event (eg ceiling). Which search method is used is determined by the characteristic of the building and the situation [12]. What are the visual conditions in the room? Do we need to inspect a large interior, or should we expand the search area? If not, then the oriented search may be sufficient. If yes, a Rope Assisted Search Procedure should be used.

2. SIMPLE SEARCH

A simple search can be used in cases where there are good visibility conditions in the room. If you have entered the room through the window, close the room door as a first step, if it is open. This is necessary to prevent any smoke entering to the room, which would jeopardize the search or the rescue itself. If the door is open, we must assume that it was opened during the victim escape attempt, so check the immediate foreground of the door as well! During simple search, we can rely heavily on our vision. However, this should not make the inspection of the room superficial. We need to systematically inspect the room. When rescuing a firefighter, pay attention to the audible warning of the SCBA or the sound of the bodyguard, light signalled by a lamp, piles of debris, etc.

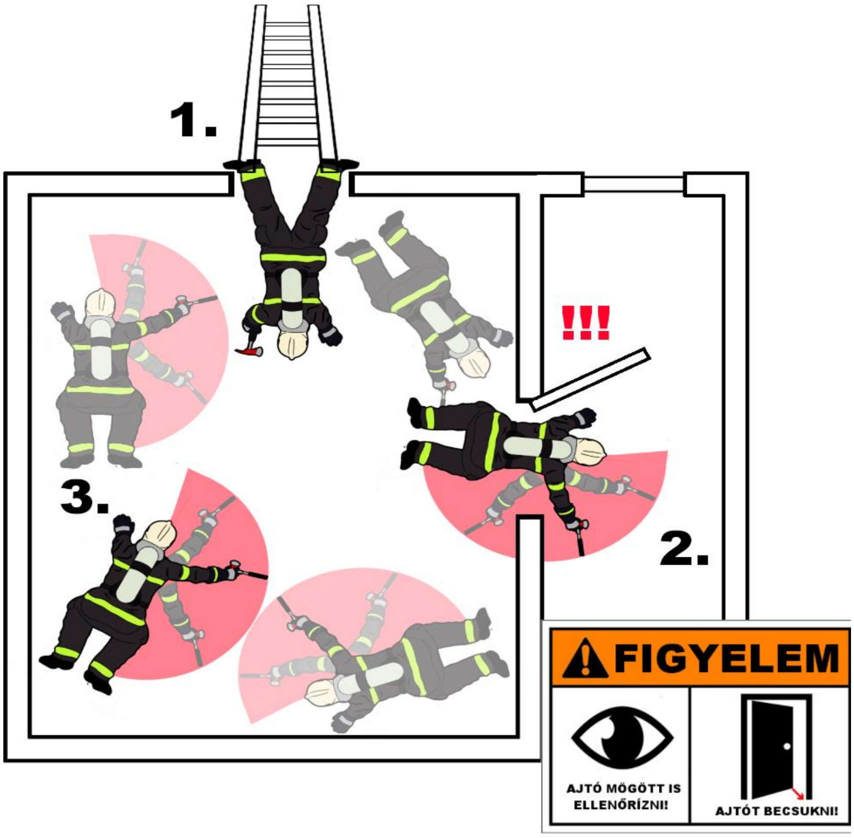

Figure 1 - The simple search. Created by the author.

3. ORIENTED SEARCH

In case of oriented search, we use the wall as orientation point. Oriented search can be ideal for checking smaller rooms if Thermal Imager Camera (TIC) not available or the size of the room allows, that the search firefighter (s) can be screened quickly and safely. The main basic rule is that we cannot lose physical contact with the wall! In each case, the search is performed by continuously contacting one of our body parts with the wall or a partner who is in contact with the wall. Oriented search can only be used to scan smaller rooms (eg rooms in residential buildings, smaller rooms in public buildings, panel flats, weekend houses, etc.). The search can be performed successfully by 1 + 1 or 1 + 2 people. It is important that they communicate with each other throughout the search. The search can be performed clockwise or counterclockwise. The experience is that it is advisable to go in the direction - if possible - of what kind of guarantors we are. A search initiated accordingly will result in greater confidence and thus greater efficiency.

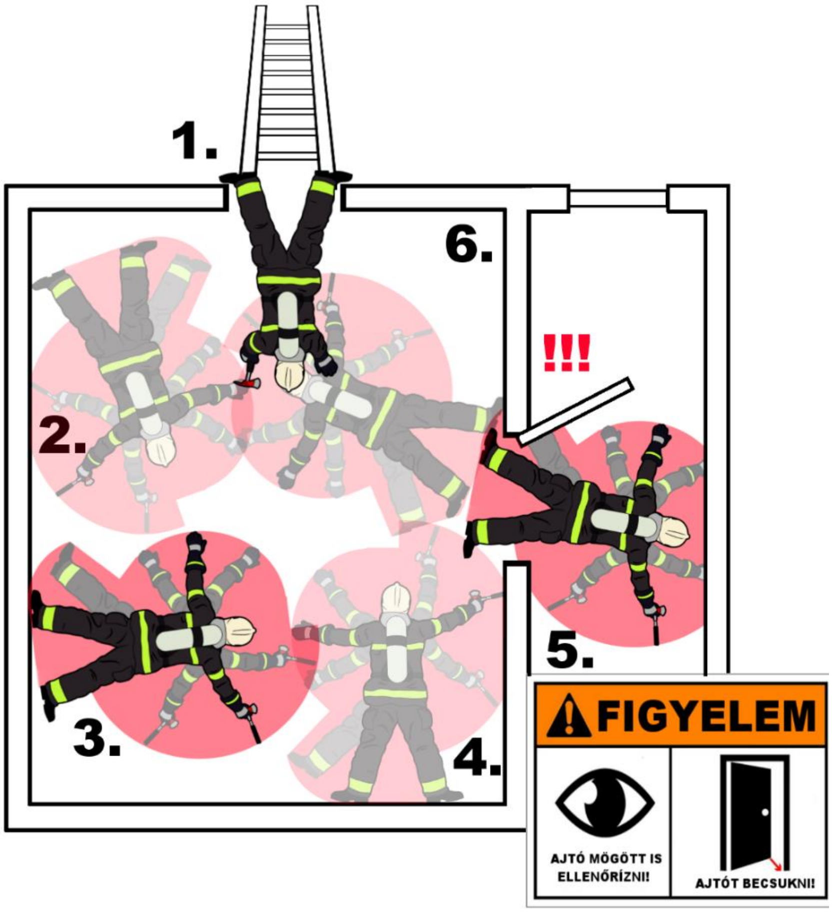

Figure 2 - The oriented search. Created by the author.

4. TIC SEARCH

Special tools can also be very useful in fire prevention [13] [14], firefighting [15] and detection [16]. During a search conducted by a thermal imager, a firefighter with a thermal imager surveys the room. He decides if it is necessary to search the room or move on. If you choose to search the room, the search unit will stay at the entrance while the firefighter with TIC will search the room. This search procedure is one of the fastest, as you only need to check separately the points that the thermal imager does not see. It is very important that while the viewfinder can see the other members of the viewfinder with the thermal imager, they may not be able to see him because of the smoke. Continuous contact between the members of the unit is therefore of paramount importance.

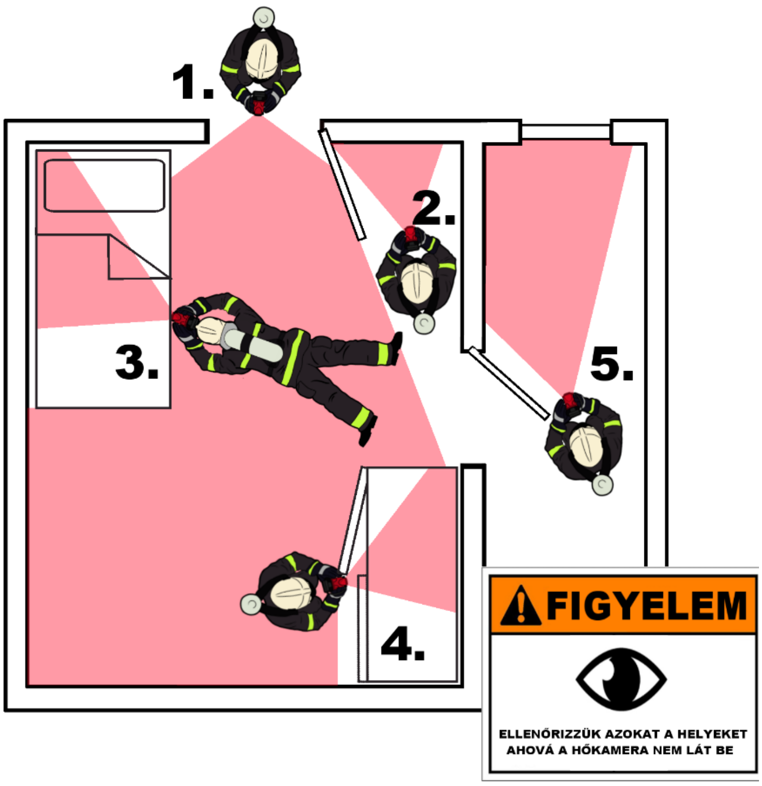

Figure 3 - The TIC search. Created by the author.

5. TIC GUIDED SEARCH

During a search with a thermal camera control, a firefighter with a thermal camera scans the room from the entrance. If necessary, it shall inform the other members of the unit which areas need to be examined more closely. At this point, one or more members of the search team will intrude and check the points in question. A firefighter at the entrance uses a thermal imager to control the search and monitor their safety. This search process is safer for the search team, but more time consuming. Communication is also a critical factor here, as viewfinders without a thermal imager perform the task almost blindly under the control of a thermal imager.

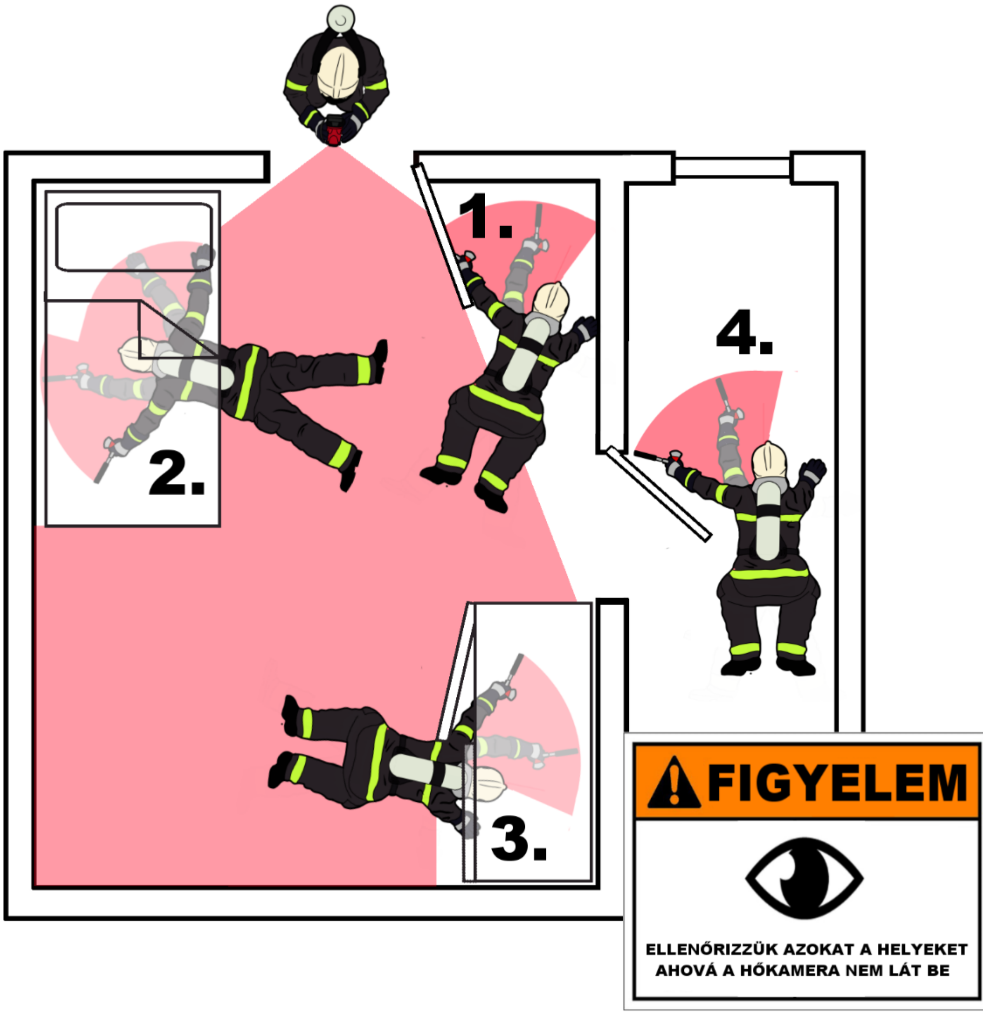

Figure 3 - The TIC guided search. Created by the author.

6. SHORTEST ROUTE SEARCH

The shortest route method is one of the least systematic search procedures. It is primarily applicable in situations where no information is available on the whereabouts of victims and there is no possibility to organize and carry out a more complex search. The method of the shortest route is based on the assumption that victims from the fire try to escape by the shortest possible path. The TIC is used to determine the shortest path to the fire nest and thus to find the most likely escape route, thus searching for potential victims located on it.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Gergő Érces, Sándor Rácz

SPATIAL FUNDAMENTALS OF THE PROTECTION AGAINST FIRE SPREAD RELATIONSHIP BETWEEN THE RISK UNIT AND THE FIRE SECTION IN HUNGARY

Abstract

The spatial characteristics of fire spread fundamentally determine the ways in which fire propagation protection is designed. According to the Hungarian regulations, the extent of the basic units of fire protection is currently determined by means of risk-based analysis. Taking into account the spatial effects of fire, the authors analyse the real spatial aspects of protection against the fire spread e in the paper. The relationships between risk units and fire sections are presented. Novel complex design methods are described for the analytical possibilities in building information modelling and in the context of fire sections studied by network research methods.

Keywords: risk unit, fire section, fire spread, BIM

A TŰZTERJEDÉS ELLENI VÉDELEM TÉRBELI ALAPVETÉSEI A KOCKÁZATI EGYSÉG ÉS TŰZSZAKASZ VISZONYA MAGYARORSZÁGON

Absztrakt

A tűz terjedésének térbeli jellemzői alapvetően határozzák meg a tűzterjedés elleni védelem kialakításának módozatait. A magyarországi szabályozás értelmében, napjainkban a kockázatelvű elemzés útján határozzák meg a tűzterjedés elleni védelem alapvető egységeinek mértékét. A tűz térbeli hatásainak figyelembevételével a szerzők a tűzterjedés elleni védelem valós térbeli aspektusait elemzik a publikációban. Bemutatják a kockázati egységek és tűzszakaszok összefüggéseit. Ismertetik az épületinformációs modellezésben és a hálózatkutatási módszerekkel vizsgált tűzszakaszok összefüggéseiben rejlő elemzési lehetőségeket újszerű komplex tervezési módszereket.

Kulcsszavak: kockázati egység, tűzszakasz, tűzterjedés, BIM

1. INTRODUCTION

Among other things, in order to create security and prevent danger, the human brain is able to map the space around us in three dimensions. We are also able to interpret and evaluate what we have seen, so we can make appropriate decisions for the survival. Albert Szent-Györgyi's idea defines one of the biological pillars of the preventive activities. Based on it, we can only achieve the necessary security created by regulation if we prevent the danger. The science of prevention has now become a widely accepted and priority discipline in all fields of safety (safety of life, health protection, environmental protection, climate protection, fire protection, etc.) [11] [12]. The importance of prevention has perhaps never been felt in recent decades as much as it is today due to the pandemic. As experts, scientists, doctors, etc. they are looking for preventive methods to prevent the spread of the virus, so the field of fire protection is constantly looking for elementary methods in its field of science that can be used to prevent the fire spread in accordance with the expected safety level [10]. The spatial system of protection against the fire spread is based on a system of risk units and fire sections.

2. FIRE PROTECTION OBJECTIVES AND PLANNING PRINCIPLES IN CASE OF PROTECTION AGAINST FIRE SPREAD

54/2014. (XII. 5.) decree of the Ministry of the Interior about the National Fire Safety Codes (hereinafter: OTSZ) distinguishes three basic protection objectives and sets them as a requirement to be solved:

1. safety of life objectives
2. value protection of community
3. value protection of owners

Of course, the priority is the protection of life, but in the field of protection against the fire spread, a set of solutions for preventing the fire spread must be validated on the basis of the properties of a given spatial system without ranking. It is our basic principle, that a fire generates in a single random space at any time, and anywhere. If we deal with this basic axiom as an evidence, we can say that there is a spatial unit in which, if a fire generates, it can be formed in a spatial sense protected against the fire spread. This smallest spatial unit with fire protection is the fire section. According to the OTSZ a fire section is a building, a specific part of the building, or a specified part of the outdoor storage area, which is designed to be protected against fire spread from the adjacent part of the structure and space. [7]

Thus, in terms of protection objectives, the unit of protection against the smallest elementary spatial fire spread is the fire section. According to the Thermodynamics II definition (Clausius definition): „Heat generally cannot flow spontaneously from a material at a lower temperature to a material at a higher temperature.” So in case of fire, the fire spreads from the combustion process with the higher energy level to the spatial systems with the lower energy level. Today it is an evident phenomenon that we are able to correctly interpret and evaluate, but as a result of a very complex and complicated process in the field of technical solutions, we can only create appropriate technical solutions that provide the expected level of safety. In relation to the entropy Clausius stated that „In nature, spontaneous processes take place in which the entropy of the thermodynamic system increases.” Entropy is a factor that expresses the degree of disorder. According to the definition above, we need to create a spatially connected system with zero entropy (or close to zero) in order to form a system that is adequately protected from fire spread in an ordered manner. [8]

However, its creation is no longer evident. The OTSZ defines the requirement system using a modern engineering approach and defines the basic requirement coherences. According to this, fire sections with a given maximum floor area must be created depending on the risk class of a specific risk unit. As long as we can design a single-storey building with a clear purpose as a single risk unit, meeting the requirement above is not a big challenge. However, the more directions, the more ways we move away from simple spatial design, the more complex the protection of a building against fire propagation, the more we find that the spatial units become more determinant. That is, the smaller is the degree of disorder (i.e., the entropy of the spatial system), the safer we can apply preventive fire protection methods, and the more accurately we can identify places and periods in which a fire is potentially more likely to generate. Although at any location, at any time, we assume the generation of fire in a building, but its probability in a well-constructed system whose entropy is small or close to zero can be well determined and predicted. To do this, we need to analyse the risks, taking into account the hazards and their extent. [1] [9]

3. RISK UNITS AND RISK CLASSIFICATION

Compared to the regulations from the previous decades, one of the best and one of the most optimal methods from the point of view of the current OTSZ is to determine the risk classes of risk units. From a methodological point of view, this together with the relevant Fire Protection Technical Directives (TvMI), provide designers with a set of tools and methodologies the expected safety level, which can be achieved and justified. The basis of the method is based on the spatial units of the buildings. In such a field the risk unit is therefore the structure or its part delimited from the point of view of the prevention of the fire spread. Within it, during the design, the circumstances determining the risk class must be taken into account to the same extent and in the same way. The risk unit as a spatial unit is very similar to the fire section in terms of fire prevention. The difference is given by the fire protection quality, that in addition to its spatiality, is coded into the concept as a fire protection property by a class definition. This risk class includes, in addition to the quantitative and destination criteria that a fire section has, the conditions that determine the fire protection situation. These must be taken into account during the design in accordance with the legal requirements. This characteristic value of fire protection properties is the risk class, which is defined as: the vulnerability in case of fire, the amount of damage and loss, classification reflecting the extent of additional hazards due to fire. [2]

Determining the fire protection characteristic by the risk classification method is the basic difference between the fire section and the risk unit. The fire section is a quantitative characteristic, an essential element of a spatial system of protection against the fire spread. In addition to these quantitative values, the risk class is a larger system with quality characteristics. Thus, in terms of design in the field of fire protection factors, the risk unit is clearly a larger set than the fire section. This means that while a risk unit can basically form a fire section, a fire section may not be able to form a separate risk unit. In addition to the risk classes of risk units, we define the so-called the concept of a standard risk class. This structure is a classification for the whole part of the building and is the strictest of the risk classes of the risk units. Its significance is related to the basic tool system of passive fire protection, the determination of the fire resistance performance of basic fire protection structures. In the sense that the minimum value of the fire resistance limit requirement depends on the relevant risk class for the whole structure.

Overall, it can be stated that a risk unit and its risk class are an essential spatial characteristic of the degree of safety expected, which is the sum of fire and fire protection quality characteristics. On the other hand, the fire section, is a spatial unit without a fire protection quality value, which can be interpreted as part of the risk unit as a factor against the fire spread. Therefore, its extent depends on the risk class and purpose of the risk unit. Thus, the fire section is a floor area criterion in this system of relations, depending on the risk class and purpose of the risk unit, the maximum value of which is defined by the OTSZ. Built-in automatic fire extinguishers can be considered as a factor influencing the floor area. [3]

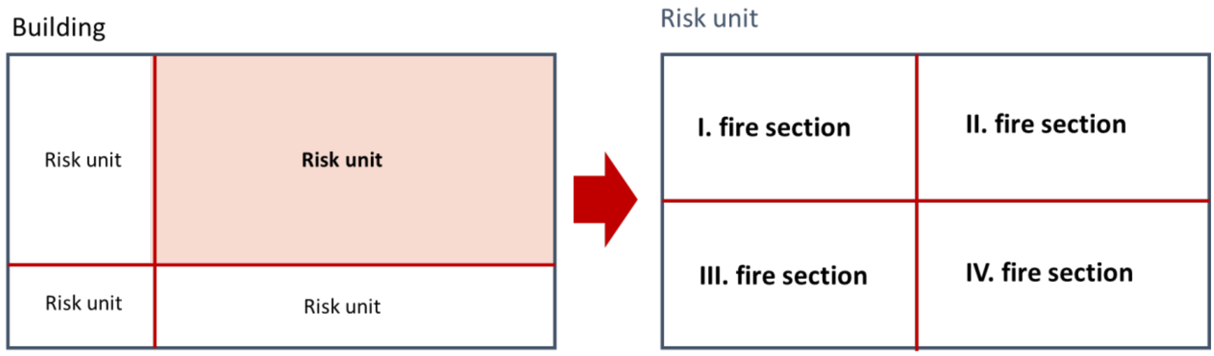

Figure 1 - Building - Risk unit (made by the authors)

Based on the above, we can observe special extremes in relation to risk units and fire sections. These are often used by designers, in many cases to oversimplify the risk and spatial fire design required to design to the optimum, which can provide the expected safety level in a long-term sustainable way. One special extreme value is case of 1 building = 1 risk unit = 1 fire section. In case of small, simple buildings, the right structure handles the problems of a possible small but complex building or a functionally diverse structure very superficially. The other extreme value is 1 building = n risk units = n fire sections, i.e. so many risk units so many fire sections. This solution, which is also a popular solution, is a suitable structure for risk units and clearly separable purposes that form a simple spatial unit, but in its context it does not address the long-term sustainable fire protection characteristics of the building as a unit. In case of complex, large buildings, this extreme value is offered as an option. However, this technical solution fragments the building, which becomes a negative factor in the field of fire protection. There is no exact solution formula, but there is a method to create the middle ground, which is 1 building = n risk units = n + x fire sections. [3]

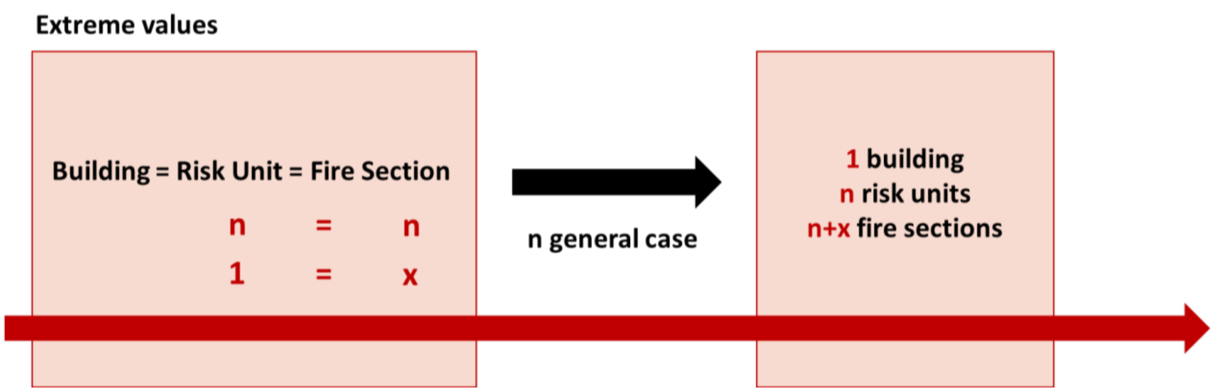

Figure 2 - Extreme values in fire sections (made by the authors).

4. SPATIAL SYSTEM OF THE PREVENTION OF FIRE SPREAD

The human brain maps the world in three dimensions. Reflecting on it, we create extensive structures in 3 dimensions, in which the fire also spreads in 3 dimensions. Accordingly, we must also establish the protection against the fire spread in three dimensions. Nowadays, buildings are designed in two dimensions. The architectural thinking and creative methodology have been moving more and more dynamically to 3D imaging for almost two decades. Even the creation of 3D building models with computer software and architectural documentation is still usually done in 2D. Nowadays, architectural fire design is still implemented with a small extent by analysing 3D models. Practically, 2D architectural documentation is the basis in case of design. In a good case, already in the early phase of the design, even nowadays there is a tendency to prepare fire protection plan chapters, which are followed by the architectural plan.

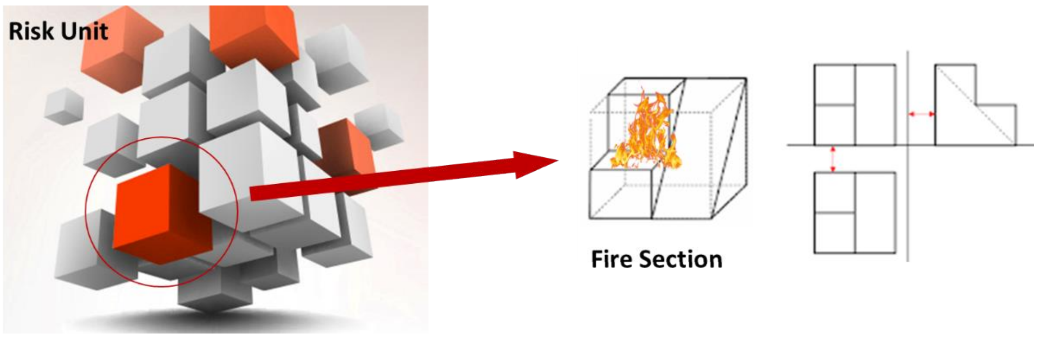

Figure 3 - 3D risk unit analysis (made by the authors)

The aim is to move fire protection planning and above all the protection against fire spread from two-dimensional planes into three-dimensional spaces in order to achieve the appropriate and expected level of long-term sustainable safety. Various computer software and CAD programs are now available for this purpose. These include expensive premium software for serious complex design tasks and cheaper software for simpler tasks. The thinking of a fire protection designer and the engineering approach are supported by the relevant Fire Protection Technical

Directives (TvMI). These include basic technical solutions for fire protection that reflect the 3D spatial complexity of buildings. The guidelines show the direction in case of protection against the spread of facade fire, the fire sections connected in space and the fire section planes at an angle to each other. On the one hand, they do not cover all solutions, and on the other hand, they are not the only solution to meet the given OTSZ requirement. [4]

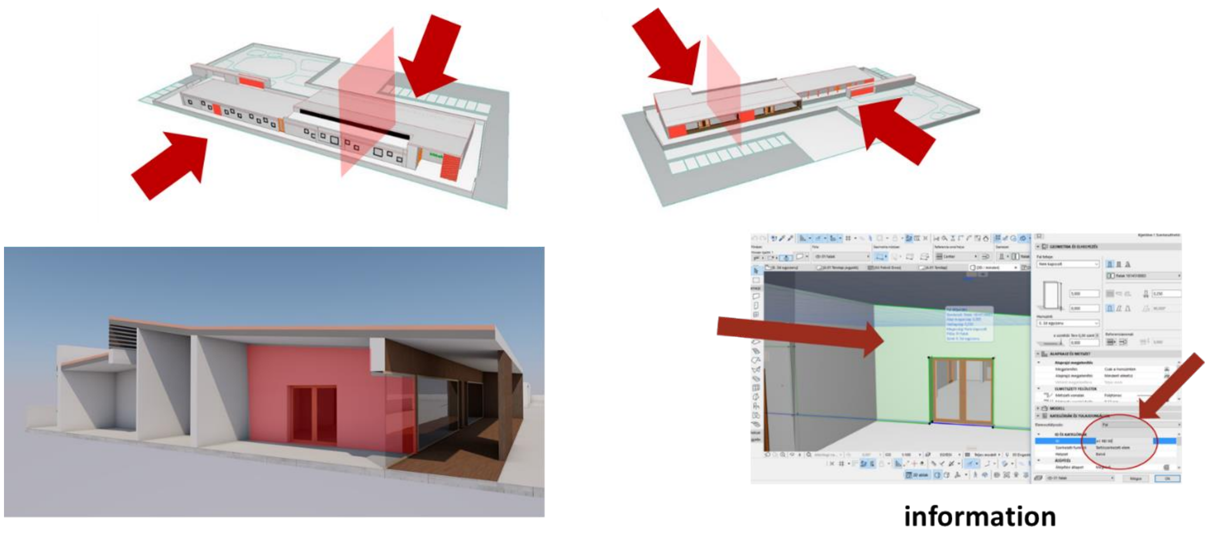

Figure 4 - 3D BIM analysis (made by the authors)

One of the most suitable methods of today's innovative engineering solutions for the adequacy of the spatial design of fire protection is building information modelling (hereinafter BIM). In addition to 3D visualization and design methodology, BIM can also encode the characteristics of fire protection quality as data and information in the design phase of a building. In the virtual model created with the BIM method, which contains fire protection characteristics and parameters, it is possible to analyse more complex spatial and other technical problems. From the point of view of protection against the fire spread, a complex building forms a network-connected system in the field of evacuation and escape routes, which determine the safety of life. In the theoretical graph of this fire protection network forming a temporary protected space system, the network points are the fire sections, the connections that connect them (grey lines) show the spatial interoperability. The green lines are the free connections to a network point, they mean a spatial connection to a safe outdoor space. The degrees of the network points (superscript) indicate the number of connections in the fire section of a given network point. This means the degree of interoperability of the temporary protected space through alternative escape routes. [5]

Fire sections with the highest number of degrees (= most spatial connections): Nr. 5, 6, 10: pressurized smoke-free staircase, 11: pressurized smoke-free staircases provide the backbone of the building's passive fire safety and the protection against the fire spread, because they play a central role with their 5 or 6 spatial connection, which gives the degree. The temporary protected space system of the building and its evacuation are also based on this. Network points with a fundamentally high number of degrees, i.e. fire sections, also show the probability of implementing an evacuation that provides a safe and expected safety level. The higher is the number of network points, i.e. the alternative escape option in case of fire sections, the safer can be the temporary protected space system. It can form the basis of the passive fire protection of the building. The network points with a particularly high number of degrees show the realization of a central fire section, which has a decisive impact on the complex fire safety of the entire building, and therefore plays a key role in terms of the fire protection. Based on the above, according to the degree indexes, staircases 10 and 11 play a central role, therefore by designing them as a pressurized smoke-free staircase, the highest level of the fire protection can be achieved. Fire sections 5 and 6 show the image of a central fire section based on its amount of degree. Therefore, the main fire protection systems and firefighting methods, the fire alarm centre, the fire control centre, etc. it is recommended to be located in these key fire protection units. [6]

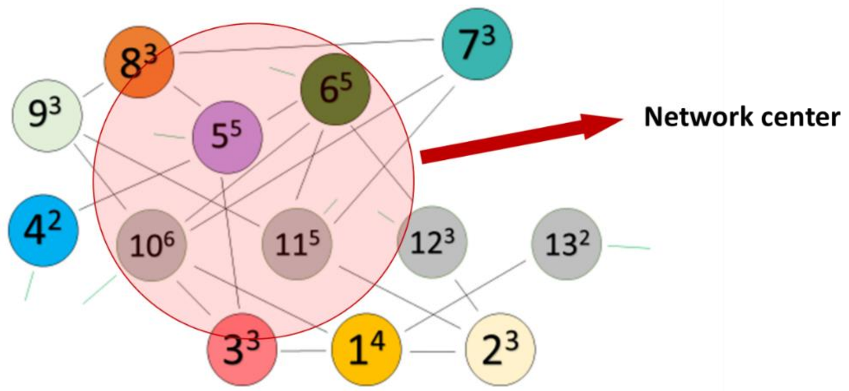

Figure 5. -Fire section network analysis (made by the authors)

5. SUMMARY

It can be seen from the above mentioned example that there was no question of the obligation to comply with the minimum requirements required by the OTSZ. The analysis of the models created with the BIM methodology, the possibilities of their spatial analysis, as well as their evaluation with network analysis methods are the innovative engineering methods of optimal design. In case of buildings created by such methods and designed by such a process, the specified complex fire protection system can be broken down into components. These results can be compared with the requirements obtained by the OTSZ and evaluated in terms of compliance with the expected safety level. However, thanks to the holistic methodology, they provide much more complex solutions in terms of the fire protection quality, as opposed to traditional technical solutions.

Figure 6. - Analysis method of fire protection unit (made by the authors)

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

György Kós, László Komjáthy

FIREFIGHTING IN CASE OF FLASHOVER EVENTS

Abstract

In an event related to the flashover phenomenon. Even though fire safety regulations are becoming stricter constantly (heat and smoke venting, built-in smoke detectors and extinguishing equipment, etc.), modern construction and building engineering processes (e.g. perfectly closing plastic doors and windows) as well as wood furniture treated with plastic based chemicals are favorable for extreme fire spreading. In fact, in today's buildings flashover spreads eight times faster than 50 years ago. According to the studies by the American Underwriter Laboratories (UL), while 50 years ago on average it took 29 minutes to reach the condition of complete flashover, today it takes less than 5 minutes.

Keywords: fire departmens, firefighter, flashover, backdraft, rapid fire progress, rfp

TŰZOLTÓI BEAVATKOZÁS FLASHOVER JELENSÉGGEL ÖSSZEFÜGGŐ ESEMÉNYEKBEN

Absztakt

A tűzoltókat sújtó halálesetek között kiemelt helyen találjuk a flashover miatt bekövetkezett halálesetek. 2003 és 2012 között 63 tűzoltó halt meg flashover jelenséggel összefüggő eseményben. A tűzvédelmi előírások folyamatosan szigorodnak (hő és füst elvezetés, beépített tűzjelző és oltóberendezések stb.) ugyan, de modern építési, épületgépészeti eljárások (pl. tökéletesebben záró műanyag nyílászárók) valamint a műanyag alapú és vegyszerekkel kezelt fa bútorok kedveznek az extrém tűzterjedéseknek. Tény, hogy a mai épületekben a flashover nyolcszor gyorsabban terjed, mint 50 évvel ezelőtt. Az amerikai

Underwriter Laboratories (UL) tanulmányai szerint, míg 50 évvel ezelőtt átlagosan 29 perc kellet a teljes lángba borulás állapotának eléréséig, addig ma kevesebb, mint 5.

Kulcsszavak: tűzoltóságok, tűzoltó, teljes lángbaborulás, szúróláng, hirtelen tűzterjedés

1. THE DEFINITION OF FLASHOVER

It is the phase of fire development, when all objects and surfaces in a room are heated to their auto-ignition temperature and the flame erupts from them almost simultaneously.

According to another definition, flashover is the ignition of flammable materials as a result of heat radiation or heat flow or both, when objects in a room are heated to their auto-ignition temperature and their almost simultaneous ignition occurs.

During fire development, the close-to-ceiling gas layer's temperature approaches 900 ° F (c.a. 480 °C), thus increasing the intensity of heat radiation to the flammable materials in the room. The surface temperature of the flammable materials rises, pyrolysis gases are created and heat up to their ignition point. When the temperature of the upper layer reaches 1,100 ° F (c.a. 590 °C) then the pyrolysis gases of the flammable materials ignite together with the bottom of the close-to-ceiling gas layer. This is the phenomenon known as flashover [1].

2. THE TYPES OF RAPID FIRE PROGRESS

Hot rich flashover

In Hungarian literature hot rich flashover is the classic type flashover.

It means the rapid ignition of smoke and combustion gases in a room. After the top part of the room fills with heat, it radiates downwards onto every flammable material of the room, as a result of which they reach their ignition temperatures almost simultaneously. After this flames erupt, and the entire room is filled with flames. So the detection is very important before firefighting [2] [3].

Rich flashover

In Hungarian literature it is known as backdraft. Backdraft is the explosive or rapid burning of combustion gases, which develops when oxygen enters an under-ventilated room [4] [5]. In the latter phase of the fire with the high temperature the room becomes oxygen-poor. The fresh air entering at this time (oxygen) suddenly mixes with the combustion gases and ignites explosively [6].

Delayed flashover

Delayed flashover happens when colder smoke ignites after congregating outside of its room of origin. This phenomenon often occurs very violently and explosively, thus it is also known as smoke explosion.

Lean flashover

In Hungarian literature it is known as rollover. The rollover often precedes complete flashover. The ceiling flames seem to ‘roll over’ the entire ceiling. It is frequently called a snake in the smoke. The phenomenon causing this is in reality combustion gases reaching their ignition temperature.

Increasing the chance of survival in rooms that are exposed to potentially Rapid Fire Progress

Intervention safety related to flashover

The chance of survival for civilians and firefighters exposed to flashover is practically zero. So, these events can be called extreme [7]. The only possible solution to increase our chance of survival is if we recognize the evolving danger in time and react to it [8]. The signs of a developing flashover may be high temperature, the color, density and movement of smoke, and the appearance of a rollover. Consistently executed entry into the room affected by fire can greatly increase the survival chance of the firefighters. We can draw conclusions by a short ‘shooting’ of water into the ceiling gas layer. If the ‘shooting’ immediately and completely expands into steam, it suggests extraordinarily high temperature. If some water drips back down, the temperature is under 100 °C. Dense, yellowish-brown smoke erupting with pressure often suggests an under-ventilated fire. This is when the possibility of backdraft development is the highest. Since in the case of hot rich flashover the oxygen supply to the room is sufficient, here dense, black, upward twisting can be a telltale sign. Frequently, the smoke coming from the building's openings are followed by shots of flame [9] [10]. As it was described above, the rollover often precedes complete flashover. After the appearance of rollover only seconds remain till complete flashover.

According to studies, a firefighter working under a neutral plane in complete gear is able to move at the speed of about 0.5-1.0 m/s. This means that if in an ideal case he will recognize the signs suggesting danger 2 seconds before the development of the flashover and withdraws, he can still only cover 2 meters. Accordingly, in a room without water spray covering, he can only progress a maximum of 1.5 meters from the entrance. Outside of this range he probably has no chance of escape!

If the water spray is appropriately applied, we can delay or completely prevent the development of flashover. In the course of this we cool the walls and the ceiling, thus slowing heat radiation.

Aggressive gas cooling technique

In the course of aggressive gas cooling we cool and dilute the ceiling gas layer to prevent burning. This technique is for the purpose of approaching the fire's nest, it is not sufficient to extinguish the fire. With this technique, on the one hand we steam water that results in heat withdrawal, on the other hand in a closed rooguidem that shows vertical temperature layering, we mix the different temperature layers, thus bringing the whole system under the ignition temperature.

Steam generation results in an increase of volume. From 1 liter of water at 100 °C 1,700 liters of steam develop, which is equivalent to 1.7 m^3. At 600 °C (which is the ignition temperature of carbon-monoxide, thus in the case of flashover risk we must count on nearly this temperature), from 1 liter of water 4,200 liters, meaning 4.2 m^3 of steam develops. Conversely, cooling gases contract, thus their volume is reduced. If we choose the amount of entering water correctly, the cooled smoke/steam mixture will have a smaller volume than the initial hot smoke's volume. Conversely, if we enter too much water, we may upset the thermic balance. As a result of this the neutral plane may collapse, turning the room into and overheated 'steam-bath' with zero visibility.

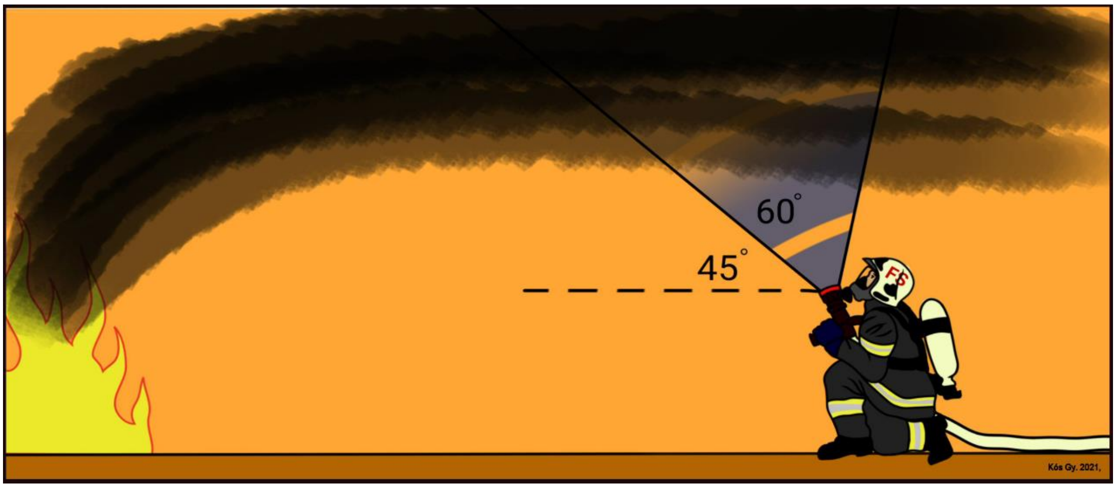

Figure 1 – Examination of the nozzle for spray. Source: Authors

During the intervention we set the nozzle for spray with about 60° cone angle. This nozzle spray should be at an angle of 45° to the floor. Progressing toward the fire's nest, it is important to cover the room with nozzle spray application in its entire width. This is important because the smoke generally progresses toward the firefighters, thus we can achieve that uncooled flames cannot move beside them. We apply short shots, thereby we do not upset the thermic balance. It is advisable to close the door after entry, so the cooled gases cannot leave the room and they can function as a buffer. Laboratory tests have proven that the ceiling gas layer reaches its initial temperature again after about 5 seconds. By keeping the cooled smoke there, this effect can be reduced [11].

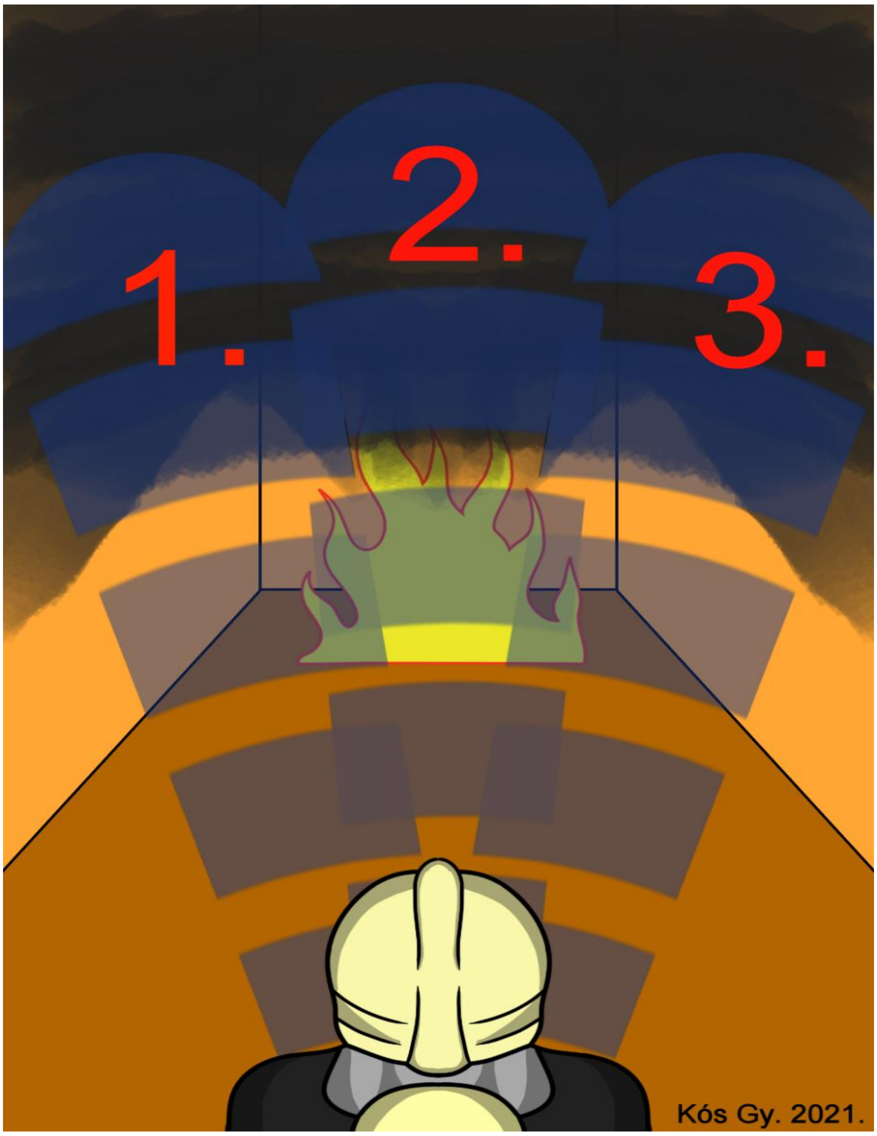

Figure 2 – Firefighter on site. Source: Author.

With the so-called ‘penciling’ technique the safety of the firefighters can be further increased. With incorrectly chosen nozzle spray we will not be able to achieve sufficient cooling effect in the hot gas layers. As a result of this, we only achieve a swirling flow, which may increase the chance of flashover. We can apply the penciling technique to prevent this. In the curse of this, we apply short, bound shots. This nozzle spray is useful for cutting through different temperature layers and achieving a cooling effect even in the uppermost and hottest layers. By combining the aggressive gas cooling and the penciling technique, the development of flashover can be delayed, thus allowing safer withdrawal for the firefighters. By applying the above guidelines the chance of flashover can be significantly reduced. If it still happens the chance of survival for firefighters is drastically reduced. In the case of flashover, if the firefighter remains capable, he should stay as low as possible. Open the entire nozzle spray without delay, switch to fog setting, hold the nozzle above his helmet and make circular movements, thus striving to cool the largest possible area. Withdraw immediately.

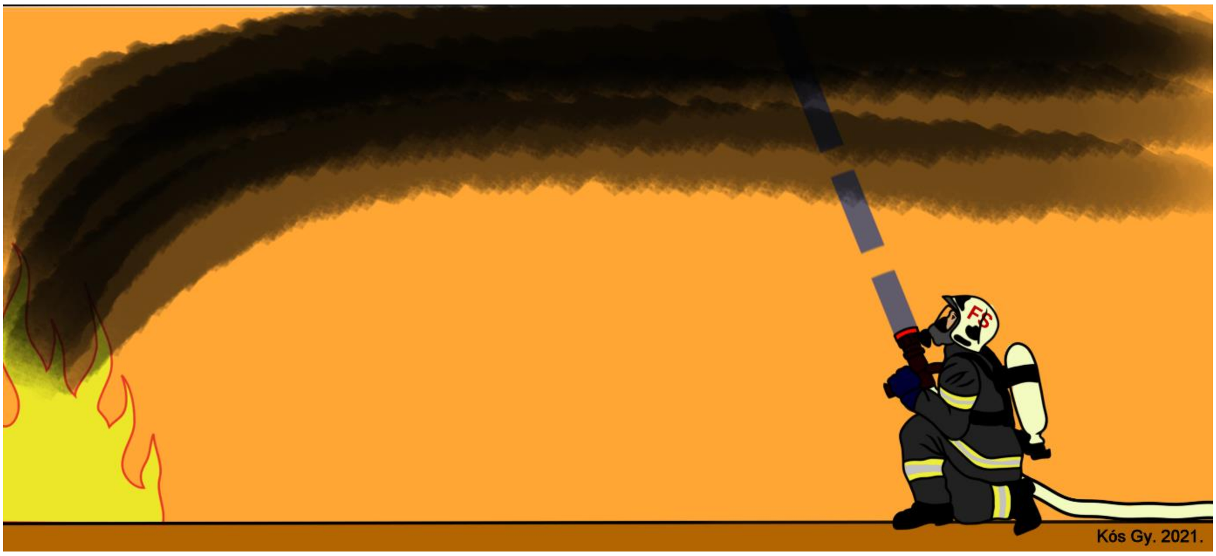

Figure 3- Firefighter safety related to backdraft. Source: Authors.

3. SUMMARY

As we have discussed above, the difference between flashover and backdraft is that the former is a temperature dependent phenomenon, where sufficient oxygen is present for combustion, while the latter is an oxygen dependent effect, meaning that combustion cannot be completed because of a lack of oxygen. As a result of this flammable steams/gases accumulate in large quantities. Large volume of yellowish-brown, dense smoke coming from the openings of a building with high pressure may suggest a backdraft. Further telltale sign may be if the windows are blackened from the inside but have not been broken. Wear complete protective gear. Before entry, check the temperature of the door. A hot door may be a telltale sign. In this case always have the nozzle spray ready that is suitable for intervention, and do not stand in front of the door (in the case of outward opening doors), open it upon ourselves using it as a shield against the erupting flames.

In summary it can be stated that the chance of survival in Rapid Fire Progress (RFP) can be primarily increased by recognizing the early signs that suggest dangerous situations. Appropriately used personal protective gear and the prepared nozzles applied together with the above discussed techniques can considerably increase firefighter safety. In the future it will be necessary to maintain preparedness trainings in the topic [12] and formulate the conclusions in education [13] [14] and work [15].

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Judit Rauscher

EVACUATION SCENARIOS AND REPEATED RUNS FOR EVACUATION SIMULATIONS

Abstract

The aim of the present study is to show what evacuation scenarios need to be examined during the evacuation calculations and according to which aspects they should be developed. I examined international regulations, recommendations, and literature data and compared them with domestic expectations and practices. Using an approach and examples, I show how usage patterns, geometric features, person characteristics and starting positions can influence the number and nature of evacuation scenarios. In addition, I show the extent of repeated runs due to the statistical settings of the input parameters and how it is worth evaluating the obtained results.

Keywords: evacuation, evacuation simulation, evacuation scenario, repeated runs, statistics

KIÜRÍTÉSI VÁLTOZATOK ÉS ISMÉTLÉSEK A KIÜRÍTÉS SZIMULÁCIÓKBAN

Absztrakt

Jelen tanulmány célja bemutatni, hogy a kiürítés ellenőrzése során milyen kiürítési változatok vizsgálata szükséges és azok milyen szempontok szerint alakítandóak ki. Ennek érdekében megvizsgáltam a nemzetközi szabályozásokat, ajánlásokat és irodalmi adatokat és összehasonlítottam azokat a hazai elvárásokkal és gyakorlattal. Megközelítési móddal és példákkal mutatom be, hogy a használati módok, a geometriai adottságok és a személyek jellemzői és kiindulási helyük hogyan befolyásolhatják a kiürítési változatok számát és jellegét. Emellett bemutatom, hogy a bemeneti paraméterek statisztikai beállításai miatt milyen mértékű ismételt futtatásokra van szükség és hogyan érdemes kapott eredményeket kiértékelni.

Kulcsszavak: kiürítés, kiürítés szimuláció, kiürítési változatok, ismétlések, statisztikai eredmények

1. INTRODUCTION

Computer evacuation simulation is playing an increasingly important role in the preparation of the decision in our environment. In a 2019 survey of modeling programs, a total of 272 respondents identified more than 72 types of programs, of which 35% of respondents use the Pathfinder program, which is the most prevalent in Hungary as well. [1]

In simulation, reality needs to be simplified during model building and an important decision is what and how much we simplify. When evaluating the model, it is important to know how the simplifications affected the results, so it is necessary to evaluate them together. [2]

A simplification of reality is the creation of evacuation variants during a modeling task. In another international study conducted in 2020 [3], several modeling habits and assumptions were assessed at an international level with a population of 60 participants. This revealed that 86.8% of users make multiple evacuation variants, typically due to the exclusion of the smoke-induced route, different demographic distributions, or different pre-evacuation time periods. In addition, it was found that 36% of modelers always use the default settings of programs (even if they do not know the professional reason or source), which draws attention to the responsibility of developers of modeling programs. Reruns of evacuation variants are performed by 86.9% of respondents in their studies if they apply the settings based on probability calculations.

According to the European Guideline [4], the characteristics of persons need to be specified in order to estimate the evacuation process: number of people, location in the building, whether they are asleep or awake, special function, physical characteristics, local knowledge factors, physical and mental state. The guideline also provides a recommendation for evacuation scenarios and other parameters, which I will explain in detail later.

According to the German modeling recommendation [5]: "The scenario is defined by a geometry, an initial distribution of persons, a route distribution and the statistical composition of the population." Accordingly, a change in any of these parameters means a new evacuation scenario, however, it does not define the extent of the change and in my own experience it is important to pay this issue more attention. The proposal also states that the possibility of multiple uses must be considered, and appropriate versions must be created. The choice of scenarios to be analyzed must take account of the population that applies to the property in question, the choice of escape routes and, where applicable, the effect of environmental factors.

According to the Fire Safety Technical Guideline on Evacuation [6], the scenario of the evacuation is “a description of the evacuation process and a schedule set up during the examination of the evacuability of the building or free area, during which the existence of certain conditions influencing evacuation is ensured”. This definition is very broad, and the directive does not provide further guidance on the conditions at a later stage.

At the beginning of the Fire Safety Technical Guideline [7] on evacuation simulation, it is stated that the test should be performed on the basis of a predefined evacuation scenario. But this directive does not provide - for the time being - any further guidance on how these scenarios should be set up.

Based on the above described, it can be stated that the explanation of the evacuation scenarios to be examined in several places in the international regulations is completely missing from the Hungarian regulations. Probably this is the reason why many professionals don’t see clearly, that these issues should be dealt with as early as possible in the design, because during later modifications of functions and of use, the desired operating conditions can typically be achieved only with expensive modifications.

2. EVACUATION SCENARIOS

In order to develop evacuation scenarios, the methods of use and evacuation strategies of the building must always be reviewed. In the case of an existing building, this can be more easily determined based on previous operator experience and operational objectives. In the case of planned buildings, the prospective operator is often not yet known in the design phase, so proposals can be made based on the design program, customer needs, the experience of the architect and fire designers.

Each evacuation scenario includes the built geometry, the characteristics of the people, and their location [5]. The change of these implies the possibility of a new version, but after examining the extent of the change, it is recommended to decide on this during the examination, if necessary, after official consultation. Different sccenarios may be caused by different modes of use, consideration of smoke propagation (i.e. geometric design), characteristics of accommodated persons, presence of persons with reduced mobility, starting position of accommodated persons. Some parameters can change continuously during operation, so it is necessary to design and examine the typical evacuation variants by considering the following aspects.

2.1. Modes of usage

Different modes of operation can be found in different buildings. On the one hand, they are typical of buildings that perform multiple functions, and on the other hand, they can occur in almost any building in individual cases. In this case, it is recommended to check all expected modes of operation.

It is probably not possible to prepare for each expected event during the planning phase; therefore, it is recommended to form "groups" with almost the same number of people, almost the same evacuation conditions and the same routes. Based on this, one such arrangement can be examined and then, subject to compliance with the conditions, the actual type of event is uninteresting from the point of view of evacuation.

Starting from the domestic building stock, here are some examples of these:

• In the case of a sports function, there are almost always other uses for the sustainability of the building: individual or group events, concerts, family events, political or religious gatherings, village days, etc. This is true for existing rural sports halls, which are typically the largest buildings in the settlements. Also, in the case of new sports facilities, there is a need to ensure sustainability from the outset.

In the case of a sports hall, if there are spectators in the entire stands fleeing upwards, it essentially does not matter what (sports) event takes place. However, if they can also escape down to the arena, it is necessary to examine whether these directions are blocked in the case of different types of sports or other equipment and, if so, whether this has an effect on evacuation (for example, the fixed backboard in hockey).

- In the case of multi-purpose places, it is worth examining all possible layout patterns. But if we assume a stage in the front or in the middle, it doesn't matter if there's a concert or a speaker on it.
- In an event hall, it does matter in terms of evacuation whether there are seated spectators or standing spectators, because quite different numbers and obstacles are expected.
- Halls and gyms are typically used in school buildings to host larger events, balls, school year openings, so these should be checked as well.

Of course, there are buildings where the design allows for practically 1 use and in that case it is not necessary to design several evacuation scenarios due to different uses, but this requires careful consideration in each case.

2.2. Characteristics of persons

The characteristics of individuals typically include their size, speed of movement, ability to escape, and other properties of movement. These parameters can be specified with fixed values or based on statistical distributions.

Modeling programs make a default recommendation for people's properties, making everyone in the model "the same". In the research of Kinsey et al. [3] it is found that 36% of modelers always use the default settings of programs (even if they do not know the professional reason or source), which draws attention to the responsibility of developers of modeling programs. However, from a professional point of view, it is recommended to use different personal settings and the corresponding literature data, because this is expected to bring the representation more realistically closer, although this is not currently expected during the application in Hungary.

The social distribution is typically the same for each run in an evacuation scenario. In modeling, individuals should be mobile on their own, so there is no need to consider the social dimension of group relationships, even if the program would otherwise provide an opportunity. It is important to note that if the result of a simulation does not match, the demographic data should not be modified for compliance! [5]

The main characteristics of persons are generally defined and grouped by age and gender in the literature. If the distribution of users (by age and / or gender) is known in the building under study, it is recommended to use it. In the case of an existing institution, this can be examined by measuring the number of employees, using usage data, in case of planning, determined based on the target groups defined in the planning program. Sometimes other external controllers (e.g. standard, sports regulation, operational safety regulation, etc.) provide the information you are looking for, which can also be used in modeling.

If no other data are available to construct the model, it may be appropriate to use a generally accepted population distribution. Of course, it is recommended to consider whether this may actually occur in the type of building under study, but it may be applicable to general cases (e.g. shopping mall). In Germany [5], this distribution is 50-50% women and men, with an average age of 50 years (standard deviation 20 years, between 10 and 85 years). A similar one could be developed in Hungary in the future based on the census data of the Hungarian Central Statistical Office.

The characteristics of the persons should be set according to the mode of operation and, if expected in the given function, the variants considered “extreme” should be checked in at least one mode as a sensitivity test. For example, in the case of a concert, one extreme could be the masses of teenage girls, while the other extreme could be older, classical music program students. If, based on the sensitivity test, the building behaves almost identically in these, it is no longer necessary to deal with the difference between persons, an average distribution or fixed values can be used. According to the SFPE guidelines on evacuation behavior [8], in the case of a well-defined, robust model, a small change in the characteristics of individuals should not cause a major difference in the result.

2.3. Presence of disabled persons

In evacuation simulations, it is expected that if persons with limited ability to escape may be present in the building, they should also be included. As public buildings in Hungary are mandatory to be accessible, it is typical to include into the modeling a person who is always limited in his / her expected movement speed, and most often this limitation includes using a wheelchair. In other cases, it is an issue of operation or a feature of the function (for example, as a hospital nurse, there will certainly not be a person in a wheelchair).

Annex E of the FPTG on Evacuation [6] contains the proportion and type in which it is necessary to consider persons with reduced mobility during the design, and this should also be applied to simulations. Temporary protected spaces shall be sized for the maximum number of occupants and shall be tested in at least one evacuation scenario.

However, there may be a design in which the evacuation process is not affected by, for example, the number of wheelchair users, and this can be supported by a sensitivity test. In this case it is not necessary to apply the maximum number of evacuations in all evacuation scenarios.

2.4. Location, starting position

As the location of persons is a constantly changing parameter in time and space during the operating of the building, it is recommended to develop typical scenarios for them. This must be considered individually for each building type in the knowledge of the operation processes.

Some examples from my own experience:

1. For a stand, one extreme value of operation is when everyone is sitting in the stand, while the other is when no one is there but instead everybody is in the aisleways. In the case of a longer event, almost any division between the two is conceivable due to the constant crawling in and out, the use of washbasins and purchases in the buffet. In this case, the examination of the two extremes may be typical, which may show different loads in the use of aisleways.

2. In an office building, the theoretical maximum occupancy is when everyone is sitting in place and even external guests are in the meeting rooms. It is recommended to consider whether

the company has such internal rules of operation, or whether external persons can only be present in “external” negotiating areas.

3. In offices or in industrial buildings, it is possible to consider how the meals are solved: with a central canteen, which operates at a fixed time with high occupancy (but then workers are not in place, so they may use other evacuation routes) or tea kitchens on each level, more informal time distribution, which is not expected to substantially affect level evacuation.

4. In an industrial buildings, consideration should be given to the system followed during shift changes, whether they are in the locker room or in shifted time zones at the same time.

The number of employees and the starting point are basically determined by the planning program or the FPTG on Evacuation [6], this is recommended to be checked as a basic version. If a reserve appears in the building compared to this, it is worth determining the maximum capacity by simulation and creating a separate version for this.

2.5. Geometric properties

With the basic, classical approach, all exits are safe and accessible and are known and used by individuals [5]. This approach also coincides with the design principles of the OTSZ [9], but also assumes that the other parameters related to evacuation are designed in accordance with the law: escape direction signs, safety lighting, trained personnel who are present. However, this basic approach does not consider that the building may have not only people with local knowledge or that there might be people who will not take into account the exit signs.

Therefore, in a building, the evacuation concept developed and the flexibility of evacuation routes can be checked with other recorded scenarios. It can be examined whether the building can be safely left even in the case of closing, temporarily closing and weighted use of an exit direction. This is suggested by several international standards:

1. In the US regulation [10], for example, evacuation must be justified for certain functions so that 2/3 of the users can leave the main entrance and in general at least half of the users.

2. In English regulations [11], if there are several exits from an area, it must meet the requirement even with the largest closure. A similar requirement applies to stairwells: one shall be considered unusable and still comply with the requirements, unless the staircase can be

approached through a protected passageway at all levels or is designed as a pressurized smoke-free staircase.

3. In the European Evacuation Guideline [4], when considering safe evacuation, it is recommended to consider scenarios of fire events that are difficult to control or close to the exit. In addition, 2 basic variants are detailed, during which the largest exit must be disregarded.

According to the current Hungarian regulations, the performance of such tests is only expected if the simulation test is carried out together with the fire- and smokespread simulation and, based on the results, one direction is physically limited by the effect of smoke. In the case of other evacuation verification methods, this does not need to be addressed at all during the planning process.

2.6. Change of the pre-movement time

According to the current Hungarian guideline [7], the pre-movement period is used in the modeling only if the evacuation is to be studied together with fire- and smokespread simulation [12]. In addition, however, all professional participants are aware that this period is a significant part of the evacuation process, which can often be more decisive than the time of the movement itself.

There are more and more pre-movement time results in the international literature [13], which is also aided by the spread of CCTV systems. These typically refer to a specific function, for which they can also be used in studies. However, there is no data available for many functions for which categories can be formed based on building and user characteristics. In the European Guideline [4], these categories are: users are asleep or awake, they are acquainted with the place or they are not, and how complex the building is and what the fire alarm system is like. Based on these, very different values are recommended starting from 0.5 minutes to> 30 minutes.

During the complex assessment of the suitability of the building, it is recommended to check the traffic areas and crowding with several settings, but the aim of the test is not to check the compliance with the evacuation times specified in the OTSZ [9]! To do this, it is recommended to use the following 3 settings and evaluate the occurrence of possible overcrowding:

• immediate evacuation - the pre-movement time is 0 s for each person

• fast evacuation - the pre-movement time is 0-60 s, given by the even distribution function

• slow evacuation - the pre-movement time is given in an even distribution, selected based on the characteristics of the building and of the users.

3. EVACUATION RUNS

The total evacuation time predicted by the models and the actual evacuation time are also influenced by a lot of parameters, which is due to the statistical nature of the evacuation process. [5] Evacuation simulation programs allow for a variety of settings for configurable numerical data: constant values or a statistical distribution. At the moment, in Hungary it is not a requirement to check the probability of the set parameters of the evacuation scenario by running the program multiple occasions.

3.1. Need for multiple runs

When using statistical distributions, the modeler needs to consider the extent to which changes in those values affect the results. If significant, it is important to run the different evacuation scenarios several times and to recalibrate the set parameters randomly for each run (demographic characteristics, time before evacuation, possibly starting point). By evaluating the results and partial results of these runs, it is possible to realistically evaluate the evacuation of the examined area on a statistical basis. Of course, based on everyday practice, this means extra work to the model maker, but program developers try to facilitate this by developing appropriate automations.

There may be a variable setting of values that, based on the observation, does not cause a significant change in the result, but it is recommended to examine this option as well, which can also be done using multiple evacuation scenarios. Such is the case with a delayed departure for a relatively small number of staff in a high-capacity building, which can always be realistically different, but is not expected to cause significant fluctuations in the end result compared to the large whole.

3.2. Number of re-runs

The "expected" number of re-runs is not clearly defined in the international literature either. The German expectation [5] suggests at least 10 replicates for each evacuation scenario but mentions that more repeats may be required depending on the results obtained. Elsewhere [3], no specific value appears, but the expected number of iterations is linked to a reduction in the "oscillations" of the results - although this is certainly the case for a sufficiently large number of iterations based on the principles of statistical mathematics. Another approach may be to link the expected number of iterations to a reduction in the standard deviation below a predetermined value. In my opinion, this does not pose a significant safety risk in the results when the standard deviation will be between 0-30 s, but determined in a maximum of 10% of the total evacuation time.

3.3. Evaluation of the results

In a very different way from the Hungarian practice, in international regulations, the results of multiple runs are evaluated with statistical analyses. Processing can also be done by simple mathematical or explicitly statistical processing. During processing, it is important that the results of all simulation runs of all evacuation scenarios are displayed in an understandable way.

Mathematical processing is the simplest way to process results from re-running simulations by determining empirical values: mean, standard deviation, minimum, maximum, percentile values. However, these are only values for a given number of tests, which can be refined by increasing the number of repeats, but do not always clearly characterize the expected value of the test. For example, it cannot be ruled out that in recalibrations, it was not exactly the "worst" parameters that individuals received in that given number of tests, so the results are also "worse". But in the same way, the reverse of this cannot be ruled out either, i.e. it may be that the "best" results have been verified in that number of studies. It is also recommended to consider the magnitude of the empirical variance that affects the ability to safely evacuate the area. A small standard deviation is conceivable when it is not worth considering this value to evaluate the mean.

During statistical data analysis, it can be verified that the values from re-running the simulations show some kind of a statistical distribution. If so, the expected values can also be estimated using the appropriate equations, at a predetermined level of safety (which is generally 95% in the common statistical practice).

If the empirical values show a normal distribution, the estimated values can be given at the expected safety level: mean, standard deviation, and expected confidence interval. For example, if 20 runs have been made for the total evacuation time of an area, the expected mean value is 100 s and the expected standard deviation is 9 s, then in 95% of cases the evacuation time is expected to be between 96 s and 104 s.

An important question in the evaluation is which of the results we consider to be relevant. According to current perception and practice, if there are no variable parameters when modeling a building, then 1 end value of 1 run should correspond to the expected evacuation time (normative value or ASET). However, if we start using statistical data analysis, it works with probabilities not to give 1 specific value, only to estimate an expected interval (confidence interval estimation). This is more in line with reality but requires a change of approach in domestic practice.

4. SUMMARY

In the present study, I have summarized the role of evacuation alternatives and, in the case of simulation programs, repeated runs in the practice of evacuation planning. Since the actual evacuation processes are different in each case, due to the many objective and subjective factors that affect them, it is not advisable to check a single version when examining the suitability of a building. Modeling is always a simplification of reality, which must be done with due care and the effects of simplifications must also be considered when evaluating the results.

During the development of evacuation simulation studies, the need to design different evacuation alternatives typically appears. The reasons for this may be due to operation, spatial or due to the characteristics and location of the persons. When developing versions, it is always necessary to work closely with the designer / customer / operator, who can provide the most accurate information possible about use and users. It is also important to emphasize that although this attitude appears only in the course of modeling in Hungarian practice, it is also necessary to check for deviations due to use in all manual evacuation checks.

In the study, I also showed that if we do not use constant values in the evacuation alternatives, but input parameters that vary according to some distribution, they typically raise the need for multiple runs. This, of course, adds a lot of extra work to modeling studies, but it is facilitated by program developers. When setting up multiple runs, the variable parameters must always be recalibrated, and the results processed in an understandable form. When evaluating the results, therefore, it is not a specific value that we are accustomed to in Hungarian practice today, but an estimate of a duration or the determination of its expected interval at the accepted safety level. This discrepancy requires a change in attitude in domestic practice, however, due to the statistical nature of the evacuation processes, it would be expected to give a more realistic picture of the expected processes.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Katalin Nagy

HOW DIFFERENT KINDS OF BUILT-IN FIRE PREVENTION EQUIPMENT WORK TOGETHER

Abstract

In increasingly complex buildings planned heat and smoke exhaust is critical to ensure safe escape routes. The cooperation of various types of fire prevention equipment was examined in full-scale tests. Meanwhile, the developments in measurement methods allowed for more detailed investigations. Full-scale tests demonstrated so far that targeted smoke extraction is essential in places both protected and unprotected by sprinklers. However, both functions should be considered when creating a system. A series of French studies, concluded in 2020, in addition to further reaffirming the current principles in regulation, presented the 10 golden rules of natural smoke extraction.

Keywords: seamless cooperation of fire prevention equipment, full-scale fire tests, heat and smoke extraction, effective life protection, sprinkler.

A BEÉPÍTETT TŰZVÉDELMI BERENDEZÉSEK EGYÜTTMŰKÖDÉSÉNEK VIZSGÁLATA

Absztrakt

Az egyre összetettebb kialakítású épületekben a tervezett hő- és füstelvezetés kritikus fontosságú a menekülési útvonalak biztonságos kialakításakor. A cikkben a szerző a különböző típusú tűzvédelmi berendezések együttműködési lehetőségét vizsgálja teljes körű teszteken keresztül. A mérési módszerek fejlődése lehetővé tette a részletesebb vizsgálatokat. A korábbi teljes körű tesztek már bebizonyították, hogy a célzott füstelvezetés elengedhetetlen mind az esőztetők által védett, mind pedig a védelem nélküli helyeken. A rendszer létrehozásának vizsgálatakor azonban mindkét funkciót figyelembe kell venni. Egy 2020-ban lezárt francia vizsgálatsor a szabályozás jelenlegi alapelveinek további megerősítése mellett bemutatta a természetes füstelvezetés úgynevezett 10 aranyszabályát.

Kulcsszavak: tűzvédelmi berendezések együttműködése, teljes körű tűzvizsgálatok, hő- és füstelvezetés, hatékony életvédelem, sprinkler.

1. INTRODUCTON

Based on the publications in the topic so far, it can be stated that the research in the field of fire protection is very extensive. These publications and examinations deal with the topic of the fire protection in smart cities [1], or with the evaluation of BIM-based workflows in fire safety engineering [2]. Other research analyses the evacuation strategy [3], or the vulnerability of Portland cement, the advantage of geopolymer [4].

From the specific measurement results, it should be highlighted the fire resistance thermodynamic test of self-supporting double skin metal faced sandwich panels [5], and the effects causing the burning of plastic coatings of fire-resistant cables and its consequence [6].

2. DIFFERENT EQUIPMENT AND PROTECTION GOALS

The content of the paper is based on the Hungarian fire protection regulations. During the examinations I will present the main stages of the developments supported by tests.

The Decree No 54/2014 of 5 December of the Ministry of Interior on the National Fire Protection Regulations is a huge step forward in this field. It is more than a set of regulations, it sets principles and priorities: it lays the foundation of structured thinking for fire protection planners. The regulation puts life protection goals (escape and rescue) before value protection goals (operation, property, equipment, market loss, optimization) [7].

From this, the priorities of installed fire protection equipment can be well deduced, such as

Life protection

- quick alarm
- providing the conditions of escape and rescue – a layer of air with low smoke content

and

Value protection

- decreasing the time needed for fire detection
- decreasing the time needed to start extinguishing the fire
- providing the conditions needed for firefighter deployment
- reduction of heat and smoke load

Firefighters realized early on that fire suppression tactics used in small buildings are not viable in larger buildings due to open air, so they initially cut openings for controlled exhaust of heat and smoke. Supporting the escape in case of a fire in the increasingly large complex spatial structures made the planned heat and smoke exhaust essential. Meanwhile, in order to avoid large fires, automatic fire alarm devices and – because of the growing value concentration, more and more often – automated extinguishing devices were installed for property protection. So, by solving some problems, new ones emerged.

3. HOW DO THESE SYSTEMS WORK TOGETHER? DO THEY INTERFERE WITH EACH OTHER?

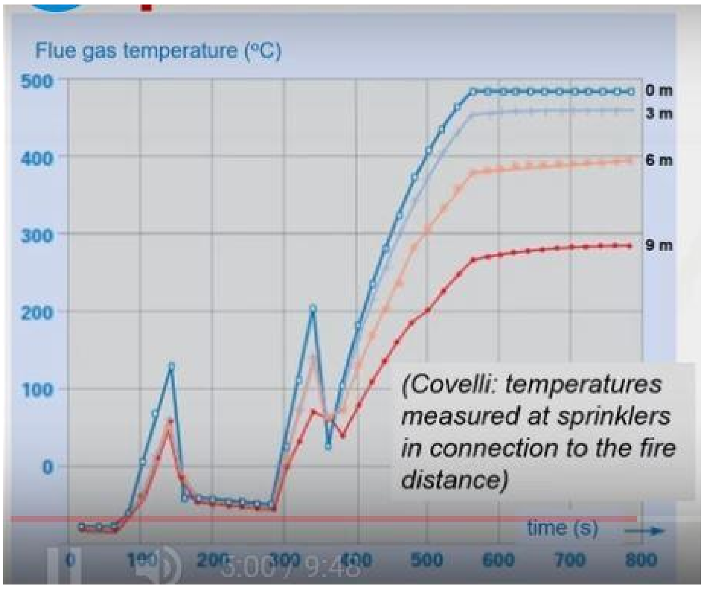
The real scientific answer was provided in 1998 by the famous full-scale fire experiment in Gant. This was actually not a single experiment, but a set of five.

A 20 by 50 by 12 m building was fitted with sprinklers, smoke extraction domes, air inlet vents and a mobile smoke curtain. The study followed the principles of classical experiments: the combustion material was 50 kg of wood in the first three instances, while 30 kg of polyethylene in the last two.

The study demonstrated that the different fire protection systems were only able to provide the expected level of safety when used in combination and working together seamlessly.

The development of extinguishing technology and heat and smoke extraction (ESFR) has again raised doubts. For instance:

- *Flue gases cooled by the sprinklers prevent thermal build-up.*
- *The thermal release of the NSHEV is delayed due to the cooling effect of the sprinkler.*
- *NSHEV prevents the sprinkler from extinguishing the fire and pushing out the oxygen.*



Sprinkler placement compared to the fire	With NSHEV	Without NSHEV
Center	139 sec	140 sec
3 meters	334 sec	344 sec
3 – 6 meters	367 sec	405 sec
6 – 9 meters	420 sec	437 sec

Figure 1-Temperatures measured at sprinklers in connection to the fire distance. Created by the Author.

Developments in measurement methods have made it possible to examine the cooperation between built-in fire protection equipment in more detail. Real-scale tests by Dr. Covelli et al. demonstrated that targeted smoke extraction is essential in places both protected and unprotected by sprinklers, and there is no significant difference regarding the activating times of the sprinklers [8]. However, both functions should be considered when creating a system.

The test illustrates the interoperability well, albeit a bit simplified. The thermal load is drastically reduced.

Between 2018 and 2020, in a complex study with 113 full-scale tests and 400 computer simulations, a summary of the latest results of heat and smoke extraction was published by the French Fire Prevention Association. The aim of this summary is to comprehensively analyse the regulations and methods based on previous experience with scientific, real tests and computer models [9].

Here I would like to focus on three important points which are:

1. fire detection
2. automated smoke exhaust
3. activation of sprinklers

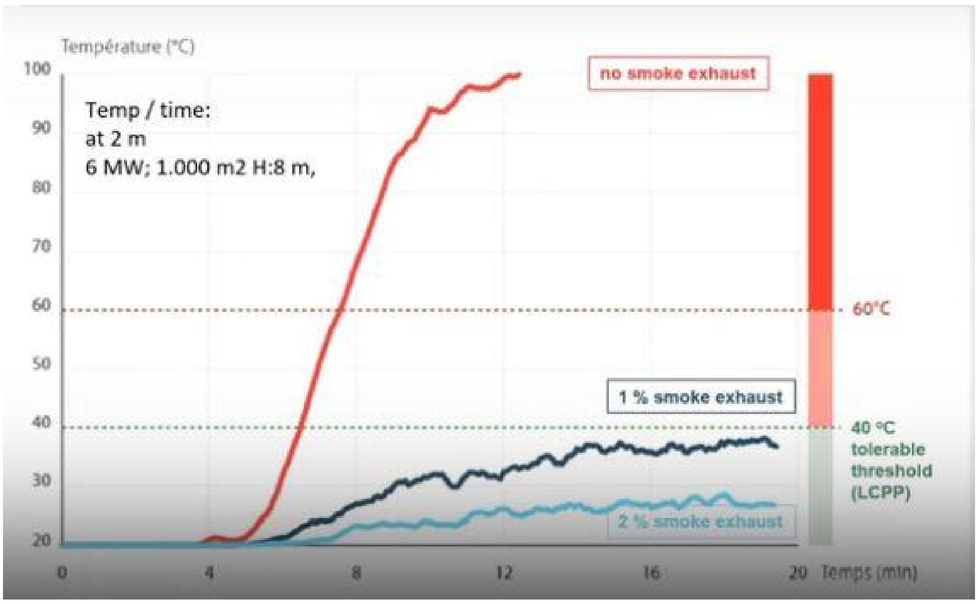


Figure 2 - Complex tests between 2018 and 2020. Created by the Author.

4. HOW IS IT POSSIBLE TO MAINTAIN A TOLERABLE TEMPERATURE THRESHOLD WITH THE USE OF THE EFFECTIVE OPENING OF THE NSHEV?

In a medium-sized room (1,000 m^2, 8 m ceiling height) with a 6 MW fire, the tolerable 40 °C threshold at 2 metre is maintained easier by increasing the effective opening surface, thus saving time before the French firefighter deployment average of 18 minutes.

What is the effect of the wind on the NSHEV on the facade?

The figure shows the effect of wind 5 and 10 minutes after opening the smoke extraction and air inlets vents. Tests have shown that placing the air inlets and smoke vents on the same facade gives better results.

Up to 80% of soot can be extracted – this can be said from a study of a 4 300 m^3 commercial facility where 20 smoke extractors and 528 sprinkler heads worked together.

The most important result is that the earlier the natural smoke extraction structures open (before the sprinklers), the less soot accumulates in the room.

This three-year study, while confirming the current principles in regulation, presented the 10 golden rules of natural smoke extraction.

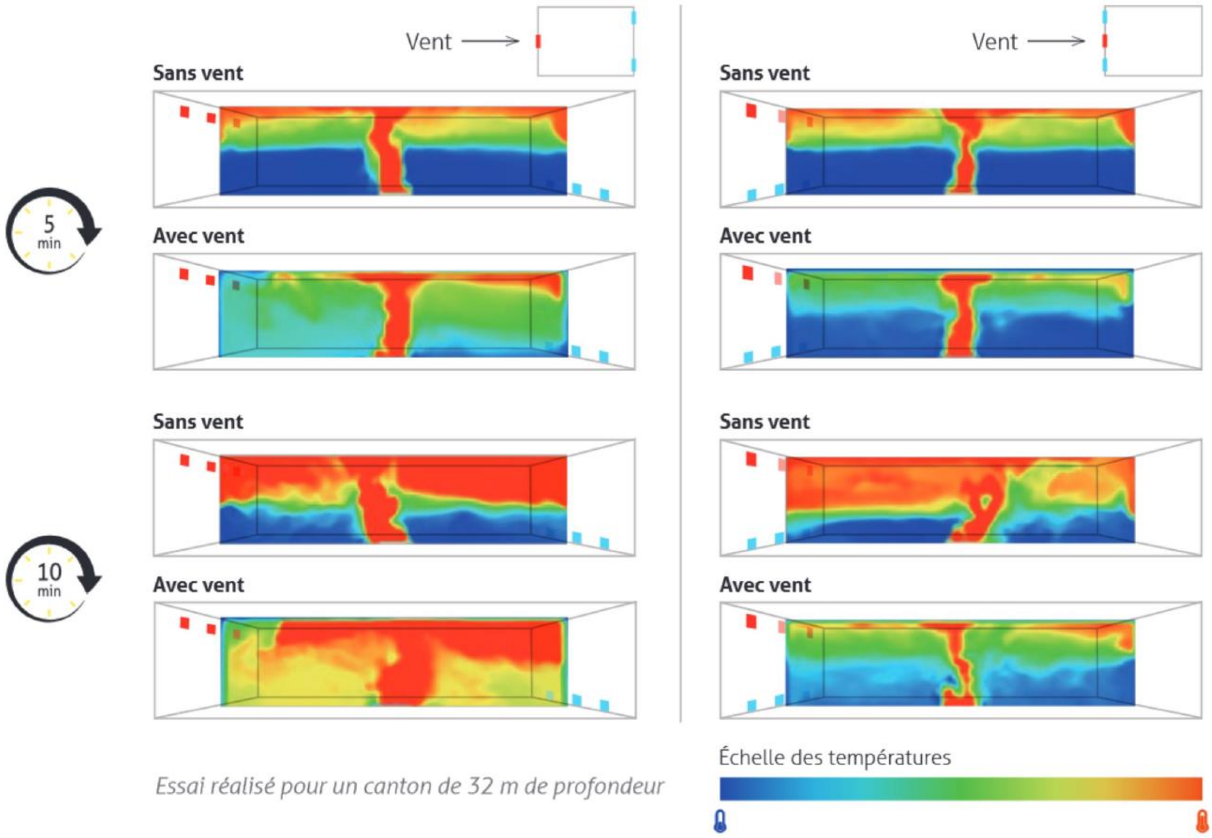


Figure 3 - Effect of the wind on the NHSEV on the facade

10 golden rules of natural smoke extraction:

- Effective regardless of the number and size of the vents, if the effective opening surface is adequate.
- Effective with both facade and roof smoke extraction.
- *More efficient if*
  - o using smaller smoke compartments (more prevalent thermal drafts)
  - o increasing the size of the effective opening surface
  - o increasing the size of the air inlet surface
  - o the air inlet surfaces are located as close to the ground as possible
  - o in a building exposed to wind, the facade smoke and air inlet vents are located on the same facade.

- NSHEV and sprinkler systems complement each other if the smoke extraction vents are opened before the activation of the sprinklers.
- *Natural smoke extraction and sprinkler systems are more effective if*
    - the effective opening surface is distributed over several smoke extraction vents,
    - the sprinkler head is located under the smoke extraction device.

As I mentioned earlier, Hungarian Fire Protection Regulation is a huge step forward [OTSZ].

It established structured thinking in fire prevention design. This also comes with a certain responsibility: engineers should follow research results.

5. SUMMARY

During the examinations I will present the main stages of the developments supported by tests. After that I was looking for two answers. The first was how to work the built in fire prevention equipment together and the second one was how these interfere with each other. With the help of real-scale tests I presented that targeted smoke extraction is essential in places both protected and unprotected by sprinklers, and there is no significant difference regarding the activating times of the sprinklers.

In the second part of my paper I analysed the tolerable temperature threshold with the use of the effective opening of the NSHEV. At the end of my examination I presented the 10 golden rules of natural smoke extraction.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Lajos Király, Ágoston Restás, Gyula Vass, János Bleszity

THE APPEARANCE OF EXPLOSION PROTECTION IN THE HUNGARIAN LEGAL SYSTEM AND IN THE EDUCATION

Abstract

Science and technology are constantly changing in the world of technology. Throughout our history, many useful technical innovations have been discovered that make our everyday lives easier. However, these innovations can in some cases also lead to explosions that endanger the human life and material goods. In the industrial sector, there has been a development need for explosion protection in coal mines, mainly due to the presence of coal dust and methane. As electricity was a huge benefit and help, its use began to become more widespread. However, this also involved dangers such as an explosion, so research activities have begun to prevent it. In the paper, the author deals with the situation of explosion protection in Hungary, with special regard to the legislation related to the topic and the appearance of it in education system.

Keywords: explosion protection, ATEX directive, education

A ROBBANÁSVÉDELEM MEGJELENÉSE A MAGYAR JOGRENDSZERBEN ÉS AZ OKTATÁSBAN

Absztrakt

A tudomány és a technika állandó változásokon megy keresztül a műszaki világban. Történelmünk során számos olyan hasznos technikai újítás került felfedezésre, amelyek megkönnyítik a mindennapjainkat. Ezek az újítások azonban bizonyos esetben robbanásokat eredményezhetnek, amelyek veszélyeztetik az emberi életet és az anyagi javakat. Az iparban elsősorban a szénpor és a metán jelenléte miatt a szénbányákban fellépett egy fejlesztési igény a robbanásvédelem tekintetében. Mivel a villamosság óriási előnyt és segítséget jelentett, alkalmazása egyre szélesebb körben kezdett elterjedni. Ez azonban olyan veszélyeket is rejtett magában, mint a robbanás, ezért megkezdődött az ennek megelőzésére irányuló kutatási tevékenység. A cikkben a szerző a robbanásvédelem magyarországi helyzetével foglalkozik, különös tekintettel, a témával kapcsolatos jogszabályokra és a téma megjelenésére az oktatásban.

Kulcsszavak: robbanásvédelem, ATEX direktíva, oktatás

1. INTRODUCTION

The research field of the disaster management contains a wide range of topics. Out of these, 3 main research directions can be mentioned such as disaster management operations, industrial safety and fire protection and rescue operations management. In the topic of the disaster management operations we can find publications about recovery system after natural disasters [1] [2], about the climate change [3] and about the possibilities for development [4]. In the field of the industrial safety papers deal with hazardous activities [5] fire protection of hazardous industrial plants [6] and major chemical accidents [7]. In the topic of firefighting lot of papers analyse the wildfire situation in Hungary [8] and abroad [9], and the technical rescue operations on land [10] and water [11]. However, less research has been done on the risk of explosion so far. These focused primarily on the explosive work environment [12] and legislation background [13].

2. ANALYSIS OF THE LEGISLATION

The first European regulation of explosion protection was implemented in 1957 within the framework of a Council Directive [14]. Subsequently, Directive 94/9 / EC was issued in 1994, which is used by the common language as the ATEX Directive [15]. The Hungarian Act XCIII/1993 on Occupational Safety and Health regulates the requirements for work that does not endanger the health and the safety work. 30§ of the Act sets out the explosion protection requirement in case of electrical fittings [16]. The connection between explosion protection and fire protection also appears in the Hungarian legislation system such as the Act XXXI of 1996 on the Protection Against Fire, Rescue Work and the Fire-Service (referred to as Act on Fire Protection) [17] and the Decree No 54/2014 of 5 December of the Ministry of Interior on the National Fire Protection Regulations [18]. In the Act on Fire Protection appears the implementation of safety measures in case of fire and explosion hazard is one of the tasks of the fire departments. Of these legislations, I would like to highlight the ATEX directive, because this describes the best my topic.

ATEX rule changes HU

The Directive 99/92/EC (also known as 'ATEX 137' or the 'ATEX Workplace Directive') on minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres. The text of the Directive and the supporting EU produced guidelines are available on the EU-website. The Directive 94/9/EC (also known as 'ATEX 95' or 'the ATEX Equipment Directive') on the approximation of the laws of Members States concerning equipment and protective systems intended for use in potentially explosive atmospheres. The text of the Directive and EU produced supporting guidelines are available on the EU website.

Selection of equipment and protective systems

Areas classified into zones must be protected from sources of ignition. Equipment and protective systems intended to be used in zoned areas should be selected to meet the requirements of the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996. Equipment already in use before July 2003 can continue to be used indefinitely provided a risk assessment shows it is safe to do so.

Identifying areas where explosive atmospheres may occur

Where necessary, the entry points to areas classified into zones must be marked with a specified 'EX' sign

Providing anti-static clothing

Employers must provide workers who work in zoned areas with appropriate clothing that does not create the risk of an electrostatic discharge igniting the explosive atmosphere, for example anti-static footwear. The clothing provided depends on the level of risk identified in the risk assessment.

Equipment and protective systems intended for use in explosive atmospheres

The aim of Directive 94/9/EC is to allow the free trade of 'ATEX' equipment and protective systems within the EU by removing the need for separate testing and documentation for each Member State.

The Regulations apply to all equipment intended for use in explosive atmospheres, whether electrical or mechanical, and also to protective systems.

Manufacturers/suppliers (or importers, if the manufacturers are outside the EU) must ensure that their products meet essential health and safety requirements and undergo appropriate conformity procedures. This usually involves testing and certification by a 'third-party' certification body (known as a Notified Body) but manufacturers/suppliers can 'self-certify' equipment intended to be used in less hazardous explosive atmospheres. Once certified, the equipment is marked by the 'EX' symbol to identify it as such.

Certification ensures that the equipment or protective system is fit for its intended purpose and that adequate information is supplied with it to ensure that it can be used safely.

3. CONTRADICTIONS IN THE HUNGARIAN LEGISLATIVE SYSTEM

The Hungarian regulation of explosion protection currently affects several authorities. In the following, I would like to present these contradictions. Explosion protection and fire protection are related in the Hungarian legislations, such as the Act on Fire Protection and the National Fire Protection Regulations. In the following, I would like to describe the contradictions between the Act on Occupational Safety and Health [16], the Act on Fire Protection [17], the act on Disaster Management [19] and the act on Environmental Protection [20] and its implementing regulations.

The Act on Fire Protection mentions the

- Fire Prevention Certificate of Compliance
- Flammable and explosive device
- Fire safety requirement
- flammable and explosive technology
- declaration of compliance [17]

In the latter case, reference is already made to other legislation (Decree 22/2009 ÖM). In addition, a distinction must be made between the risk of explosion and the requirements of the Act on Occupational Safety and Health / Act on Fire Protection. Energy, pipe, utilities and explosion safety requirements appear in the Act on Occupational Safety and Health [16]. In addition, Section 87 of the Act determines that an establishment, equipment, material, work process, technology where the health, physical integrity and safety of employees may be exposed to harmful effects in the absence of appropriate protection. One of the most important objectives of the Act on Occupational Safety and Health is to ensure the primary protection for those who do the work or are in the surroundings of the workplace. This is due to the lack of appropriate protection, which can thus primarily serve to identify the hazard [16]. However, the law should not aim to identify hazardous technologies in case of materials, mixtures, machines or equipment. However, it is important to note that the legislation links each legal framework to the identification of hazard. In this case, a reference is also made to the drafting on the risk of explosion in the Act of Fire Protection. Of course, it is not about the need for many specifications, but about discussing the identified properties. I conclude from this that there is no need for occupational safety expert activity in order to prepare the provisions of the implementing regulation of the Act on Occupational Safety and Health. However, it is important to emphasize that the Implementing Regulation of the act is not just about the explosive workplaces [21].

I also examined the Act on Environmental Protection [20]. As a result, I determined that the environmental legal system consistently considers obligations related to explosion safety techniques. In the following, I present the environmental legal connection points with the help of Table 1.

Name of legislation	**Connection point**
Act LIII of 1995 on the General Rules of Environmental Protection	28. §
Governmental Decree No. 57/2013. (II.27.)	Annex No. 2
Governmental Decree No. 132/2010. (IV.21.)	
Governmental Decree No. 136/2008. (V. 16.)	
Governmental Decree No. 106/1995.	8. §, Annex No. 1
Governmental Decree No. 219/2004. (VII.21.)	Annex No. 1, Annex No. 13
Decree 6/2009. (IV.14.)	Annexes 1-3.
Governmental Decree No. 90/2007. (IV.26.)	3. §, Annex 1-2
Act CLXXXV of 2012 on waste	Annex No. 1
Governmental Decree No. 225/2015. (VIII. 7.)	
Governmental Decree No. 309/2014. (XII. 11.)	
Governmental Decree No. 246/2014. (IX. 29.)	
Governmental Decree No. 445/2012. (XII. 29.)	
Decree 72/2013. (VIII. 27.)	
Decree 145/2012. (XII. 27.)	
Decree 14/2008. (IV. 3.)	
Governmental Decree No. 306/2010. (XII. 23.)	
Governmental Decree No. 25/2006. (II. 3.)	
Decree 6/2011. (I. 14.)	
Decree 4/2011. (I. 14.)	
Joint regulation GKM–KvVM 75/2005. (IX. 29.)	

Joint regulation GKM–KvVM 7/2003. (V.16.)	
KTM decree 32/1993. (XII. 23.)	
Act No. LIII. of 1996 on Nature Conservation	
Decree 118/2011. (XII. 15.)	
Governmental Decree No. 284/2007. (X. 29.)	
Governmental Decree No. 280/2004. (X.20.)	
Joint regulation KvVM-EüM 27/2008. (XII. 3.)	
KvVM decree 93/2007. (XII. 18.)	
Joint regulation KöM-GM 29/2001. (XII. 23.)	

From an analysis of the legislations above and from Table 1, I conclude that the system of legislation related to explosion protection can only be described in an extremely complex way. In addition, it lacks the appropriate presence of authority and control framework [21]. As a result of the legal contradictions, I determine that the Hungarian regulators can be grouped into two parts within the field of the explosion protection. I classify the Act on Fire Protection, the National Fire Protection Regulations and the relevant Fire Protection Technical Guidelines into one group. These legislations deal primarily with fire and explosive technologies, but they also refer to the tasks of the fire authority. The other group includes the Act on Occupational Safety and Health and 3/2003. (Mar. 11.) Joint Decree of the Ministry of Health and Family Affairs and the Ministry of Employment and Labour on the minimum requirements for improving the safety of workers potentially at risk from explosive atmosphere [22]. These legislations already write about the subject in a different way. These primarily include potentially hazardous risks. They write about potential risks, without more serious specifics.

4. EXPLOSION PROTECTION IN EDUCATION

The education in the field of engineering is extensive. The curriculum in the higher education institutions meet to some extent each other. I examined the curriculum of the universities and I came to the conclusion that during their studies, the students do not come into contact with the topic of the explosion protection. Although the firefighter training mentions the prevention of explosions and the firefighting tactic in vase of an explosion, but the deeper knowledge is still incomplete in the topic [23] [24]. The curriculum does not contain how to deal with explosion protection. The knowledge is limited only to the flammable approach of the topic. Students can also gain in-depth knowledge in the field of combustion and extinguishing theory, among other things, but explosion protection is not sufficiently reflected here either. The knowledge taught does not cover the chemical industry and its certain areas, as well as the risks of the materials used there. So I assume the educational background of my topic to be incomplete.

This shortcoming has also been noticed by the experts working in the field of education. As a result, a one-year postgraduate training will start in explosion protection engineering in Miskolc, which can serve as a supplement to the fire protection engineering course. In addition, it is important to mention the specialized training courses for blasting engineers and specialists at the Donát Bánki Faculty of Mechanical and Safety Engineering at the Óbuda University.

Here, there is an opportunity for special trainings in the field of explosion technology (for non-engineers) and for further training for blasting engineers (only for engineers). In this case the curriculum of the course focuses specifically on the explosion protection. Students can master the topics of subjects such as for example: explosion physics, advanced industrial and military blasting explosives and their use, methods and possibilities of blast shock wave modelling and investigation of their propagation in complex terrain and risk analysis of explosive incidents [25].

The scientific evaluation of education [26] and training [27] experience is continuous. After my examination of the courses of various higher education institutions, I conclude that the teaching in the field of explosion protection knowledge is incomplete. In Hungary, we can find higher education institutions, whose educational curriculum covers the explosion protection, but these do not go into detail in the topic. In the future, in connection with the new fire protection-based trainings, I propose to include the topic of the explosion protection in more detail in the given curriculum. It would also contribute to the protection of human life and material goods.

5. SUMMARY

In the paper, I provided an overview of the situation of the explosion protection in Hungary. In the framework of it I analysed the most important legislations in the topic. Of these, I separately examined the ATEX directive rule changes in the Hungarian regulator system. I presented the Selection of equipment and protective systems, the identifying areas where explosive atmospheres may occur, the providing anti-static clothing and the equipment and protective systems intended for use in explosive atmospheres. After that I examined the contradictions in the Hungarian legislative system. I conclude that the system of legislation related to explosion protection can only be described in an extremely complex way. As a result of the legal contradictions, I determine that the Hungarian regulators can be grouped into two parts within the field of the explosion protection. At the end of the paper, I highlighted that explosion protection does not appear adequately in the Hungarian education. I examined the curriculum of the universities and I came to the conclusion that during their studies, the students do not come into contact enough with the topic of the explosion protection. I found some courses in connection with the explosion protection but overall, I find the processing of the topic incomplete within education.

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VÉDELEM TUDOMÁNY
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Ferenc Nemoda, Bence Madár

RADON EMISSION OF BUILDING MATERIALS AND RECYCLED STRUCTURAL MATERIALS – AN INTERNATIONAL COLLATION

Abstract

Radon is a naturally occurring colourless, odourless, radioactive gas, which is the decay product of radium. The most widely known radioactive sources are uranium, thorium and radium, but ionizing radiation can also be found elsewhere. Any building material of natural origin may contain a certain quantity of radioactive elements. The carriers of this radioactivity are called the NORMs (Naturally Occurring Radioactive Minerals). Reused building materials in many cases include unknown components and thus deserve priority attention regarding radioactivity. In Hungary, 70% of these materials is soil, of which only 15% is being reused. It is advised to utilize them with exceptional precaution, as they may contain dangerous elements regarding radioactivity due to their unbeknown compound. In this article we delineate research and results of various countries; showing relations of high concentration and their dangers, and additionally, their connection to building materials, all with the goal of attracting attention to the hazards of indoor radon concentration.

Keywords: radon, naturally occurring radioactivity in building materials, reused building materials, recycled building materials, sustainability

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

RADON-KIBOCSÁTÁS ÉPÍTŐANYAGOKBAN ÉS ÚJRAHASZNOSÍTOTT ÉPÍTŐANYAGOKBAN – NEMZETKÖZI ÖSSZEVETÉS

Absztrakt

A radon a természetben előforduló, színtelen, szagtalan radioaktív gáz, a rádium bomlásterméke. A legismertebb radioaktív források az urán és a rádium, de ezeken kívül jóval kisebb mértékben máshol is megtalálható az ionizáló sugárzás. Minden természetes eredetű építőanyagban jelen lehet valamilyen mennyiségű radioaktivitás. Ennek a radioaktivitásnak a hordozói az úgynevezett NORM (Naturally Occurring Radioactive Mineral) természetben előforduló radioaktív ásványok. A bontott építési hulladékok kiemelt figyelmet érdemelnek radioaktivitás szempontjából, mert összetételük sok esetben ismeretlen. Ezek 70%-át teszi ki talaj Magyarországon, és 15%-a kerül újrahasznosításra. Hasznosításakor ajánlott a nagyfokú figyelemmel való eljárás, mert radioaktivitás szempontjából veszélyes anyagokat is tartalmazhat. A cikkben egyes országok vizsgálatait és eredményeit ismertetjük; bemutatva a magas koncentráció és veszélyeik összefüggéseit, továbbá építőanyagainkkal való relációját, azzal a céllal, hogy a beltéri radon-koncentráció veszélyeire felhívjuk a figyelmet.

Kulcsszavak: radon, természetes eredetű radioaktivitás építőanyagokban, bontott építési hulladék, fenntarthatóság

1. RADON IN OUR SURROUNDINGS

Radon dissolves quickly in outdoor environment, which eventuates that the rate of outside radon concentration cannot be considered as a risk factor; its value is usually below 10 Bq/m^3. The radon concentration of soil is, however, much more notable, due to the decay of uranium in soil leading to the accumulation of radon gas in dense matter, or its solvation in water. The radon levels measured in soil are various: depending on the properties of given soil, it moves on a scale from less than 2000 Bq/m^3 to more than 100.000 Bq/m^3. [1] If radon moves indoors from the soil beneath the building, it is capable of concentration. The radon concentration of indoor environments is between less than 20 and several hundreds of Bq/m^3, but there could be extreme values occurring. [2] Radon could possibly be in relatively shallow depths and/or in high concentrations underground, which results in the potential of getting inside the house through the ground slab before its decay. Radon can leak inside through ground slabs, cracks on walls, various joints of the building, sockets around pipes, through the water system, but it could also originate from building materials (e.g. bricks, slag, etc.). Even less understood the fact, that radon can also be found in our water supplies, in dissolved form. The concentration of the drinking water, however, usually does not top 10 Bq/l, by reason of the high-rate dilution, the adequate storage and handling of public water supplies.

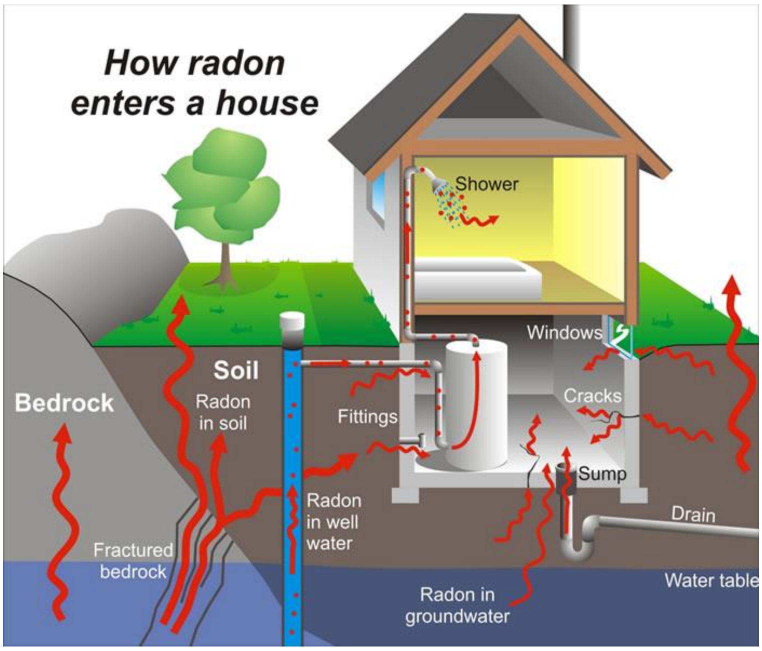

Figure 1: How radon enters our dwellings [3]

2. RADON IN OUR DIRECT HOME ESTABLISHMENTS

The accumulation of indoor radon is strongly bound to the region, the compound and permeability of the soil, the circumstances of the atmosphere and the construction of the building. Typically, higher radon concentration is associated with buildings with proper thermal insulation, equipped with tightly sealing doors and windows, and/or if they were built on ground rich in uranium, thorium or radium. Distance from the ground is also an important factor, as radon being the heaviest known gas, it cannot travel great distances upwards. Hence, basements and ground-floor rooms are mostly exposed to higher concentrations of radon. [4] Hardcore and gravel fill put under the ground slab have higher permeability than soil itself. Therefore, radon is able to move more easily under the concrete slab.

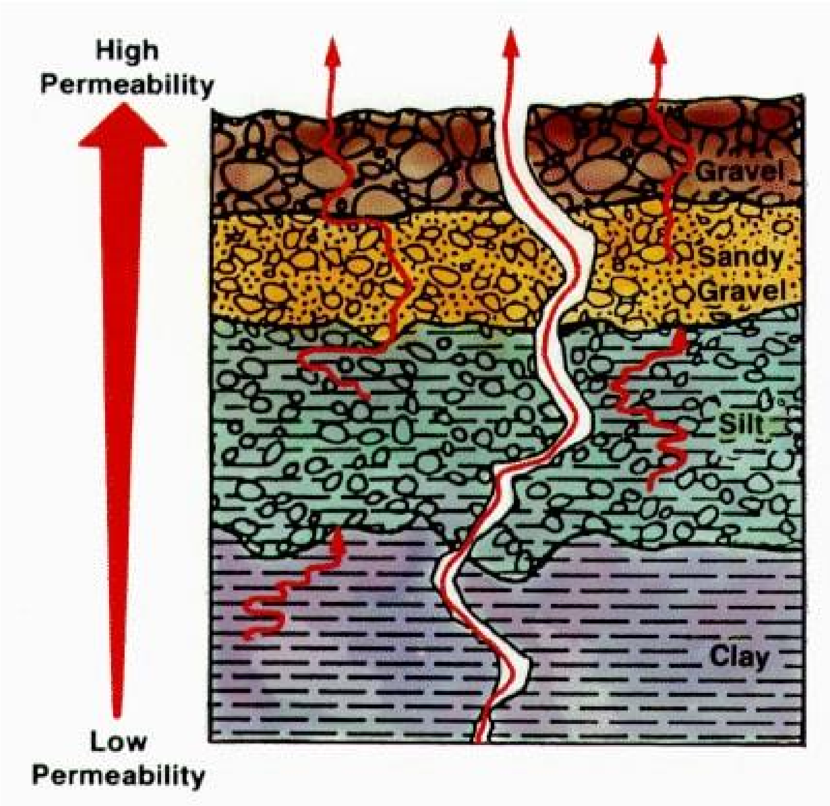

Figure 2: Permeability of different kinds of soil [4]

Gravel fill is used under basements and the trench between basement walls and soil is also often filled with gravel or other permeable matter. This basically gives a three-dimensional entry possibility to radon, making basements the most radon-riskful house parts. This is further complicated if the gravel fills or landfills used at the construction are completely or partially reused construction materials; or if the structural elements of the building are made using recycled building materials or industrial byproducts. In case of these buildings, we may often encounter built-in materials with elevated radiation. These building materials include ground granulated blast furnace slag- and fly ash concrete blocks, or heat insulation fillings made out of power plant- or furnace slags. The relatively high radioactivity of ceramic bricks can be explained with its compounds; 30-60% of brick clay consists of clay minerals, in addition of sand, calcium-carbonates and various oxides. The radioactivity of sand is usually low – except if they contain high amounts of zircon, monazite or xenotime. [5]

3. MEASURING RADON

Since radon gas is colorless, odorless and tasteless, its observation cannot be made by our senses. As a result, special radon measurement devices must be used. Radon concentration measurements are usually divided into two main groups: short- and long-term tests. Short term measurements usually cannot provide fully precise results, but of course they are adequate indicators of the radon accumulation in urgent cases. Radon measurement devices can also be divided into two main categories: active and passive devices. Passive devices do not need electricity or a suction pump to operate, while active devices do – in turn they are capable of monitoring the radon concentration and its change. [6]

Measurements usually determine a radon level, in Bq/m^3. However, it is important to know the value of effective dose, which means the annual radiation a person is exposed to. The following equation is in use:

$$Effective\ dose = radon\ level \cdot time \cdot dose\ equivalent \tag{1}$$

where radon level equals to the indoor radon concentration in Bq/m^3, time equals to the exposure time in hours, and dose equivalent is a value determined by the environment (e.g. workplace, type of dwelling). Dose equivalent calculated with an average 50 Bq/m^3 of radon level on workplaces for one year (2000 hours) gives 0.7 mSv of effective dose as result. [7] This is nearly one-third of the natural radiation dose affecting an average Hungarian in one year. [8]

4. MEASUREMENTS BY COUNTRIES

Hungary

So far two expansive measurements have been made covering the entire area of Hungary. The first was made by István Nikl, associate of the National Frédéric Joliot-Curie National Research Institute for Radiobiology and Radiohygiene (OSSKI); his inspection from 1993 till 1994 included 998 homes, made with traditional and prefabricated technology, regarding building materials such as ceramics, concrete, reinforced concrete, aerated concrete and industrial byproducts. [9] The second research of this degree is linked to Dr. Eszter Tóth. Her investigation centered around ground-level buildings and has tested the radon concentration of 15.277 ground-floor rooms with her associates in the time interval from 1994 to 2004. The utilized building materials used in these buildings were mainly the same as the aforementioned ones. [10]

United Kingdom

The average indoor radon concentration of the United Kingdom is 20 Bq/m^3, which is considered as an uncommonly low level. Despite the low values, more than 600.000 indoor radon tests were registered nationwide [2]. In the main, the examined dwellings were made of classic ceramics, concrete or buildings related to these technologies.

Sweden

The Swedish have been actively concerned with radon since 1955, when the measurement of 300 dwellings took place. This research was conducted by the initiation of Rolf Sievert, of whom the unit of measurement of the effective dose was named. The average indoor radon concentration was 113 Bq/m^3 in 1990 and only 90 Bq/m^3 in 2008. [11][12] The building technologies used of examined apartments were traditional, prefabricated and light structural. As per building materials, mostly ceramics, concrete, reinforced concrete, aerated concrete, calcium silicate masonry, wood and stone were used.

Austria, the Czech Republic, Finland and Norway

These territories have elevated radon concentration, that result in the increase of lung cancer cases. Thus, radon testing and mitigation is even more important within these countries. Their measurement results show nearly identical values. [13] As for technology, the examined dwellings are traditional, prefabricated and light structural in construction. The building materials used are mainly ceramics, concrete, reinforced concrete, aerated concrete, calcium silicate masonry, wood and stone.

United States of America

The United States of America uses a different unit of measurement to nominate the quantity of radioactive matter; this unit is the picocurie per liter. [14]

$$1\ pCi/l = 37\ Bq/m^3 \tag{2}$$

Scientist create radon potential maps with various information, such as sites of bedrock with high uranium content, sites of breaches, radioactivity of air, permeability and radon concentration of the soil, together with the data about indoor radon. For instance, the radon potential maps made of Maryland and Virginia, Fairfax county by the U.S. Geological Survey (USGS) are based on distinct data. The potential of Montgomery county was estimated by the geologists of USGS on the grounds of soil and air radioactivity measurements, geological and pedological maps, in addition of the indoor radon measurements made by residents. [4] The typical construction methods used in these territories are mainly light structural, with a smaller part being traditional, and reused materials on a negligible scale.

China

There are few available data sources regarding indoor radon in China. In virtue of a 2002 study, the average indoor radon concentration is approx. 22.5 Bq/m^3, as a result of testing more than 10.000 dwellings. Another study sought connection between the population suffering from lung cancer and indoor radon in Shenyang. The average concentration in the surveyed apartments was 89 Bq/m^3. [15] The building methods are most commonly industrialized technologies, concrete and reinforced concrete.

Libya

The measurements effectuated in Libya, led by A. F. Saad [16] used the volume of the given room, the degree of ventilation and the level of emission to calculate the annual effective dose.

The results were then grouped by building materials. The method to measure radon exhalation in building materials was the 'sealed-can' technique, which consists of an alpha-detector in a container that is sealed airtightly to the examined material.

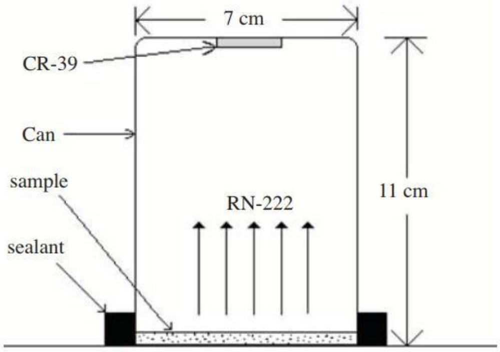

Figure 3: Sealed-can technique used in the measurements of A. F. Saad [16]

4. EVALUATION OF RESULTS

Hungary

According to the investigation of Nikl [9], the average indoor radon concentration in the surveyed buildings was 126 Bq/m^3, with 16% of them having higher levels than 200 Bq/m^3, and 1.5% exceeding 600 Bq/m^3. The test results of Tóth [10] showed an average level of 133 Bq/m^3, with 1.6% of dwellings exceeding 400 Bq/m^3 in smaller settlements, 1% in middle-sized towns and 0.5% in cities and capitals. The highest level measured was 5800 Bq/m^3, the lowest was only 10 Bq/m^3. Another significant result of the research of Tóth was the estimation of the place and percentage of Hungarian territories exceeding 200 Bq/m^3 by their geological attributes, divided to regions. Based on these geological properties, the area of Hungary has been divided to 21 sections. According to this, the most outstanding radon concentrations were found in the volcanic ranges of the Northern hills of Hungary (Északi-középhegység) and in smaller parts of the Lowlands (Alföld). [17]

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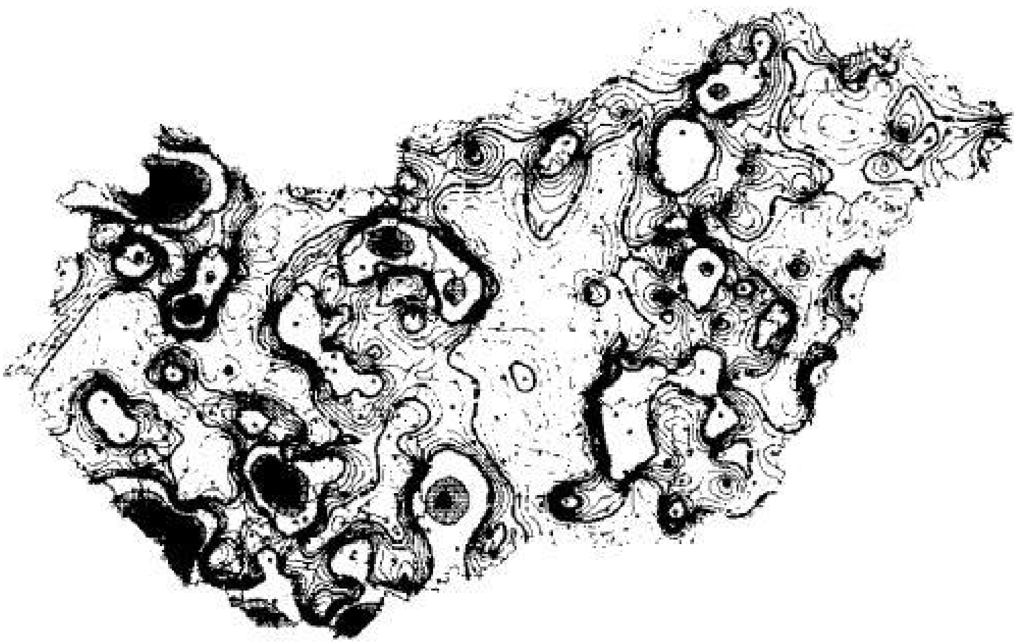

Figure 4: The radon map of Hungary made by István Nikl [9]

United Kingdom

In the UK, the Radon Affected Areas are territories of which more than 1% predictably outstrips 200 Bq/m^3. Fortunately, only an estimated 0.4% of dwellings top the Action Level of 200 Bq/m^3 across the UK. [2]

Sweden

Based on the test results, the average indoor radon level of Sweden does not seem much, however, this value is an average level; according to the estimations, 450.000 residences are above the Action Level of 200 Bq/m^3. This equals to the 8.5% of total housing in Sweden, with 3% exceeding 400 Bq/m^3, too. [18] Sweden has managed to reduce its average indoor radon concentration by 23 in only 18 years.

United States of America

The differing units of measurement of course requires conversions. With a national average of 48 Bq/m^3 (1.3 pCi/l), 4 pCi/l is the Action Level (148 Bq/m^3), which is the maximum allowed value. Between 2 and 4 pCi/l it is recommended to utilize radon mitigation.

China

The radon map made of China is, unfortunately, insufficient to provide evident information. Based on the appromaxitive measurement methods (e.g. grab-sampling technique), a clear conclusion cannot be made. [19]

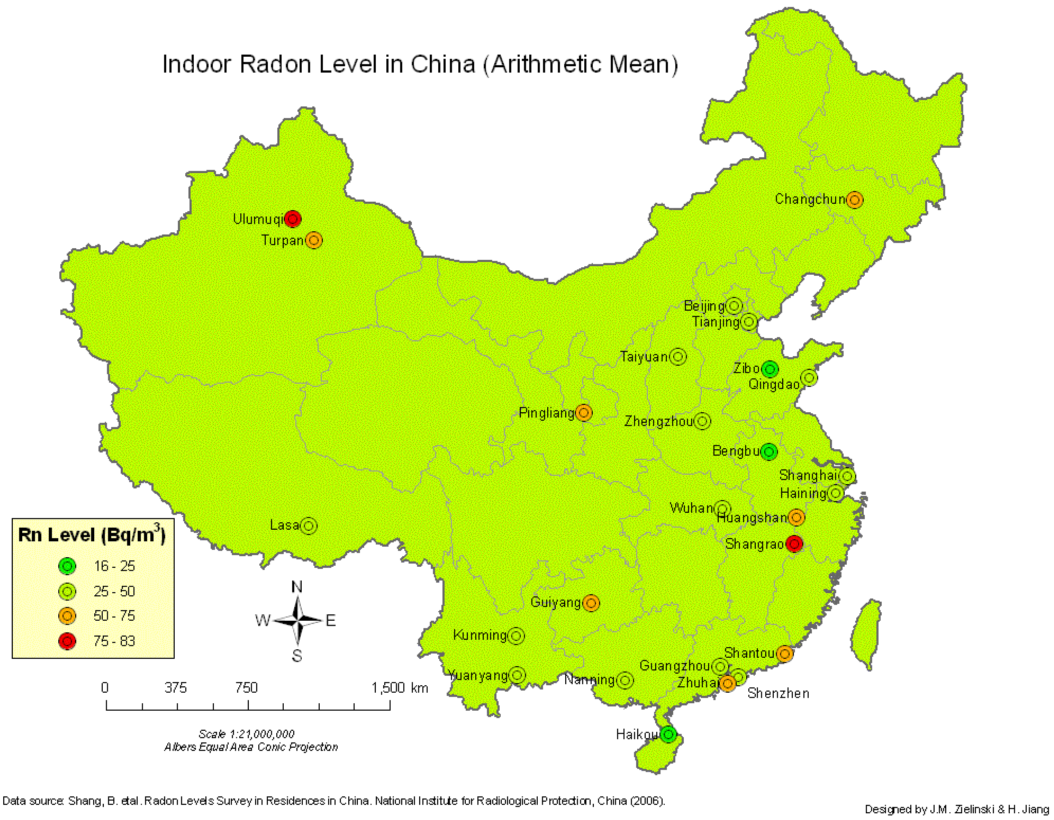

Figure 5: Radon map of China [20]

Libya

The outcome of the test results eventuated an average radon concentration of 172 ± 5.8 Bq/m^3 for brick walls, 145.1 ± 4.9 Bq/m^3 for ceramic floor tiles, and 174.5 ± 5.8 Bq/m^3 for marble ledges. The most radon emission was generated by marble, while the least was by ceramics. As for marble, the highest measured radon level was 298.7 ± 10.0 Bq/m^3, near the Action Level of most countries, hence marble requires increased precaution – however it can be established that marble is rarely used in large quantities. [16]

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6. SUMMARY OF MEASUREMENTS

According to the test results, I review the previously declared values.

Results of the national radon survey made by István Nikl:

Material of masonry	Soil connection	Radon concentration with standard deviation [Bq/m3]
Traditional bricks	ground floor	145 ± 194
	upper floor	93 ± 136
Loam	ground floor	148 ± 153
Prefabricated concrete	upper floor	64 ± 54

Table 1: Radioactivity of dwellings, groupped by building material and connection to the soil [9]

Annual effective dose [mSv/year]	Radon emission quotient on sample surface [Bq/m^{2}h]	Radon concentration [Bq/m^3]	Building material
17.2 ± 0.6	0.146 ± 0.005	192.8 ± 6.5	brick masonry
10.6 ± 0.4	0.090 ± 0.003	119.5 ± 4.0	
24.8 ± 0.8	0.210 ± 0.007	277.9 ± 9.3	
10.5 ± 0.4	0.089 ± 0.003	118.2 ± 4.0	ceramic sheathing
7.8 ± 0.2	0.066 ± 0.002	87.0 ± 2.9	
11.3 ± 0.4	0.096 ± 0.003	127.3 ± 4.3	
20.6 ± 0.7	0.175 ± 0.006	231.8 ± 7.8	marble sheathing
14.9 ± 0.5	0.126 ± 0.004	166.2 ± 5.6	
24.9 ± 0.8	0.211 ± 0.007	279.2 ± 9.3	

Table 2: Radon concentration of brick-, ceramic- and marble products [16]

Libya has shown a significant radon level in marbles.

The results of measurements made in Iraq, by L. Najam et al.:

Sample	Surface exhalation rate (E_a) [Bq/m^2h]	Mass exhalation rate (E_m) [Bq/kgh]	Radon concentration [Bq/m^3]	Country of origin
Cement	1,24	0,35	205,05	Iraq
Common brick	1,01	0,28	166,55	Iraq
Ceramics	1,05	0,3	174,12	Syria
Porcelain	1,63	0,46	270,04	Turkey
Black marble	1,26	0,36	290,04	Turkey
White marble	1,21	0,34	200,27	Turkey
Red granite	2,3	0,65	383,3	Turkey

Table 3: Measurement results of various building materials made by L. Najam et al. [21]

7. SUMMARY

Granite has the most potential of all of our building materials to emit radon, along with andesite and rhyolite. Additionally, sandstone, concrete, bricks, marble and gypsum are potential radon risk sources. [22] The radiation emission of these building materials depends on the extent of usage inside of the building. Basically, when used in greater quantities, pyroclastic (volcanic clastic) rocks are to be utilized with precaution, as blocks of these may contain radon in ranges up to 200-400 Bq/m^3. Test results of cement showed low, under 100 Bq/m^3 level of radiation in types of cement CEM I, II, III and V, only CEM IV (pozzolan cement) has revealed radiation levels more than 100 Bq/m^3. [23] Pozzolan, being volcanic ash, carries higher risk of radioactivity. Furnace ash is also radiologically potent, which has been frequently used in concrete in the previous decades. [24] Fly ash is also considered to be a threat of radiation; nonetheless, fly ash cement still does not reach the Action Level set by the European Commission. [25] Ceramic-based bricks have higher radon emission than concrete. This is mainly because of the higher porosity of bricks, which eventuates the escape of more radon from between the granules. Test results show a radon concentration of 63-185 Bq/kg of perlite. Based on the connection of radon and porosity, I conclude that the increased air volume of expanded perlite results in the higher diffusion of radon. Thus, the testing of heat insulation and light concrete that contains expanded perlite is suggested.

In conclusion, the aforementioned measurements and their results make it clear that building materials are possible radon hazards and thus, indicate further measurements and experiments to be executed in the topic. As for Hungary, new, extensive indoor and soil radon measurements are essential in order to mitigate the dwellings with high radon concentration and help the residents be safe from radon induced lung cancer.

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VÉDELEM TUDOMÁNY
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József Dobor, György Pátzay, Nóra Szűcs-Vásárhelyi, Kálmán Serfőző, Balázs Barina

ENVIRONMENTAL POLLUTION RESULTING FROM HAZARDOUS PLANT POLLUTION, ITS CHARACTERIZATION FROM A DISASTER MANAGEMENT POINT OF VIEW, AND A SUMMARY OF THE LESSONS LEARNED FROM THE CASE

Abstract

The aim of the authors of the article is to present their present research, which provides an alternative to the legal regulation that can be used, in addition to the methods and tools that can be used to determine the causes, causes and possibilities of soil pollution. The authors conduct research in a variety of disciplines, examining environmental elements, the legal regulation of hazardous plants, chemical technology, and primary intervention. Thus, they present the same problem from different angles. In any case, the industrial origin of soil contamination can also be reduced by legislation. This is worth highlighting because soil contamination is a complex and costly tool to detect, analyze, and prevent contamination. At the beginning of the article, we present a model experiment planned for our research in a few months. We then perform a complex presentation of soil contaminants based on the available international literature. We then describe the legal regulatory option, listing the most recent regulators. Finally, as a summary, we conclude our summary with a few figures. Our presented research is planned to last for several years, and our results are continuously published on possible scientific platforms.

Keywords: soil pollution; disaster management; industrial safety; legislation

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EGY LEHETSÉGES TALAJSZENNYEZÉSSEL JÁRÓ, VESZÉLYES ÜZEM ÁLTAL OKOZOTT KÖRNYEZETSZENNYEZÉS RÖVID, KATASZTRÓFAVÉDELMI SZEMPONTÚ JELLEMZÉSE ÉS AZ ESETBŐL ADÓDÓ TANULSÁGOK ÖSSZEFOGLALÁSA

Absztrakt

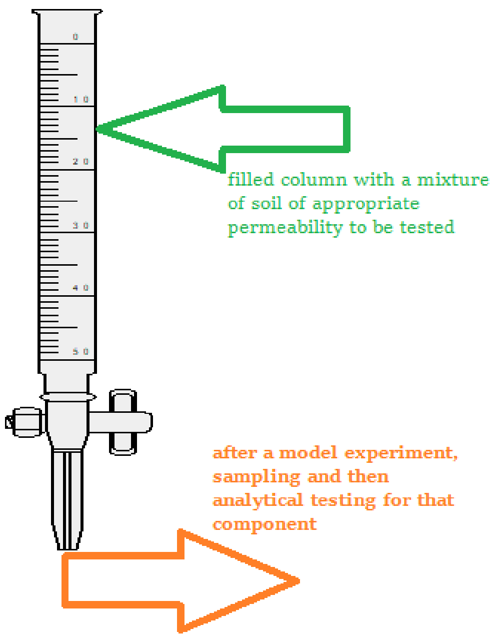
A cikk szerzőinek célja, hogy bemutassák jelen, folyamatban levő kutatásukat, amely a talajszennyezés okainak, folyamatainak meghatározására alkalmazható módszerek és eszközök mellett alternatívát kínál az alkalmazható jogi szabályozáshoz. A szerzők különféle tudományterületen végeznek kutatásokat, vizsgálva a környezeti elemeket, a veszélyes üzemek jogi szabályozását, a vegyipari technológiát és az elsődleges beavatkozási lehetőségeket veszélyes anyagokkal kapcsolatban bekövetkezett eseményeknél. Így ugyanazt a kérdést különböző szögekből mutatják be. Mindenesetre az ipari, mezőgazdasági eredetű talajszennyezés kialakulásának lehetősége mérsékelhető alkalmas jogi szabályozásokkal, mint ahogy a cikk adott részében ezt a szerzők alátámasztják. Ezt azért érdemes kiemelni, mert a talajszennyezés észlelésére, elemzésére és megelőzésére meglehetősen költséges eszközök, módszerek és munkaórák szükségesek. A cikk elején bemutatjuk a kutatásunkhoz tervezett modellkísérlet egy vázlatát. Ezután a rendelkezésre álló nemzetközi szakirodalom alapján a talajszennyeződésekkel kapcsolatban fogalmazzuk meg a kutatásunkhoz szükséges alapokat. Ezután ismertetjük a jogi szabályozási lehetőséget. Összefoglalásként eredményeinket ábrák segítségével ismertetjük. Bemutatott kutatásunk a tervek szerint több évig fog tartani, eredményeinket folyamatosan közzétesszük a lehetséges tudományos platformokon.

Kulcsszavak: talajszennyezés, katasztrófavédelem, iparbiztonság, jogi szabályozás

1. INTRODUCTION

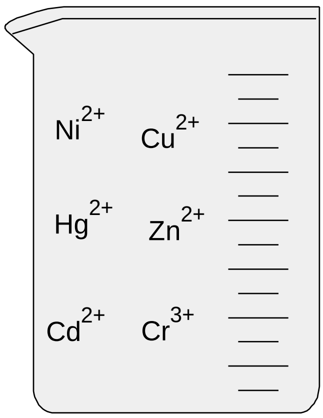
Hungary's chemical industry has achieved significant results in the last century, but even today the success in this professional field is tangible. One of the areas of the chemical industry with a significant driving force is the pharmaceutical industry, the economic characteristics of which are seriously related to the GDP of Hungary. The chemical industry accounts for about 18-20% of total industrial production (including the oil, gas and plastics industries, among others). The chemical industry produces products that are essential to our standard of living through operations involving hazardous activities and the use of hazardous substances. [1-3]

The model experiment can provide information on the efficiency of the detection of the given components, in our case heavy metal ions, from the soil. The described option is published based on the authors' idea, so it is their own idea. Of course, the process must be repeated several times and the method must be tested at the very beginning, with a known amount of components.



A charged model column is designed for the experiment. The column can be filled with soil samples of different permeabilities, even mixed with an artificial part (debris, concrete). The permeability of the charge is optimal if it can pass a minimum of 1 cm^3 of solution per minute.

parameters	**Ni^{2+}**	**Hg^{2+}**	Cd^{2+}	Cu^{2+}	Zn^{2+}	Cr^{3+}
c [mol/dm^3]	**0.05**	**0.005**	**0.005**	**0.02**	**0.05**	**0.005**
flow [cm^3/min]	**0.1**	**0.01**	**0.01**	**0.01**	**0.1**	**0.01**
pH of solution	**5.0**	**6.0**	**5.5**	**6.0**	**6.0**	**4.5**



Laboratory measuring equipment (eg. ion chromatograph, atomic absorption analysis) is suitable for the analysis of samples. A water-soluble heavy metal compound to be used in the experiment. Subsequently, the heavy metal contamination of the embankment (the modeled soil of the industrial zone, built environment) should also be determined by analytical analysis.

Figure 1. Design plan for a model experiment to investigate heavy metal contamination in soil (Figure drawn by the authors, using the program below: ACD/ChemSketch (Freeware Version), ACD/Labs 2016.2 (File Version C30E41, Build 90752, 20 Dec 2016) [by authors]

2. SOIL POLLUTION

The contaminant may enter the soil as a result of either natural or anthropogenic activity. Elements and compounds already present in the environment can be released into the soil as a result of natural processes, but also during disasters (volcanic eruptions, floods, earthquakes, cyclones, etc.). These contaminants come mainly from sediments and rocks that dissolve in groundwater and accumulate in aquifers and are then pumped for consumption. A well-known example of this is arsenic, the high concentration of which in groundwater bodies is also a problem in Hungary [4]. However, a much higher proportion of harmful substances enter the soil due to human activity. We would like to present this in more detail in the next part of the article.

1.1 The major types of soil pollutants

As a result of industrialization, we now use thousands of different chemicals in our daily lives, which can be dangerous to humans and the environment. In the case of pollution, it does not matter how much of a given substance enters the soil, what the physical, chemical parameters of the soil are, etc., because many compounds only become dangerous above a certain concentration [5]. The most important of these substances are ranked according to human toxicity, bioaccumulation, persistence, exposure and frequency by the United States Environmental Protection Agency (EPA) and, in the European Union, the European Chemicals Agency (ECHA). These compounds pose an increased risk to human health because they are toxic or do not degrade or degrade over a long period of time, so they persist in the soil and easily accumulate in body tissues. Table 1 lists the Persistent Organic Pollutants (POPs) covered by the POPs Regulation. The full list and regulations for other hazardous substances are available at www.echa.europa.eu and http://chm.pops.int/ [6-7].

Category	Substance name	EC / List no	CAS no	Date of inclusion in the POPs Regulation	POPs Regulation Annex
○	Aldrin	206-215-8	309-00-2	29/04/2004	Annex I, part A Annex IV
	Alkanes, C10-13, chloro	287-476-5	85535-84-8	19/06/2012	Annex I, part A Annex IV
	Bis(pentabromophenyl) ether	214-604-9	1163-19-5	20/06/2019	Annex I, part A Annex IV
○	Chlordane, pur	200-349-0	57-74-9	29/04/2004	Annex I, part A Annex IV
○	Chlordecone	205-601-3	143-50-0	29/04/2004	Annex I, part A Annex IV
	Clofenotane	200-024-3	50-29-3	29/04/2004	Annex I, part A Annex IV
○	Dicofol	204-082-0	115-32-2	18/08/2020	Annex I, part A
○	Dieldrin	200-484-5	60-57-1	29/04/2004	Annex I, part A Annex IV
	Dodecachloropentacyclo[5.2.1.02,6.03,9.05,8]decane	219-196-6	2385-85-5	29/04/2004	Annex I, part A Annex IV
○	Endosulfan and its isomers	-	-	19/06/2012	Annex I, part A Annex IV
○	Endrin	200-775-7	72-20-8	29/04/2004	Annex I, part A Annex IV
	Heptabromodiphenyl ether	-	-	24/08/2010	Annex I, part A Annex IV
○	Heptachlor	200-962-3	76-44-8	29/04/2004	Annex I, part A Annex IV
▲	Hexabromo-1,1'-biphenyl	252-994-2	36355-01-8	29/04/2004	Annex I, part A Annex IV
▲	Hexabromocyclododecane (HBCDD)	-	-	01/03/2016	Annex I, part A Annex IV
▲	Hexabromodiphenyl ether	-	-	24/08/2010	Annex I, part A Annex IV
○ ▲ ■	Hexachlorobenzene (HCB)	204-273-9	118-74-1	29/04/2004	Annex I, part A Annex III, part B Annex IV
▲ ■	Hexachlorobuta-1,3-diene	201-765-5	87-68-3	19/06/2012	Annex I, part A Annex III, part B Annex IV
○	Hexachlorocyclohexanes, including lindane	-	-	29/04/2004	Annex I, part A Annex IV
	Pentabromodiphenyl ether	-	-	24/08/2010	Annex I, part A Annex IV
○ ▲ ■	Pentachlorobenzene	210-172-0	608-93-5	24/08/2010	Annex I, part A Annex III, part B Annex IV
○	Pentachlorophenol and its salts and esters	-	-	20/06/2019	Annex I, part A
○ ▲	Perfluorooctane sulfonic acid and its derivatives (PFOS) C8F17SO2X, (X = OH, Metal salt (O-M+), halide, amide, and other derivatives including polymers)	-	-	24/08/2010	Annex I, part A Annex IV

▲	perfluorooctanoic acid (PFOA), its salts and PFOA-related substances	-	-	15/06/2020	Annex I, part A
▲ ■	Polychlorinated biphenyls (PCB)	-	-	29/04/2004	Annex I, part A Annex III, part A Annex IV
▲ ■	Polychlorinated naphthalenes	-	-	19/06/2012	Annex I, part A Annex III, part B Annex IV
▲	Tetrabromodiphenyl ether	-	-	24/08/2010	Annex I, part A Annex IV
○	Toxaphene	232-283-3	8001-35-2	29/04/2004	Annex I, part A Annex IV
■	Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF)	-	-	29/04/2004	Annex III, part A Annex IV
	Polycyclic aromatic hydrocarbons (PAHs)	-	-	29/04/2004	Annex III, part B

Table 1: List of persistent organic pollutants under the POPs Regulation in force in the European Union [6-7].

○: Pesticide; ▲: Industrial chemical; ■: Unintentional production; EC / List no: European Community Number / List number; CAS no: Chemical Abstract Service Registry number; Annex I to the regulation are subject to prohibition (with specific exemptions) on manufacturing, placing on the market and use; Annex II to the regulation are subject to restriction on manufacturing, placing on the market and use; Annex III to the regulation are subject to release reduction provisions; and Annex IV to the regulation are subject to waste management provisions.

Soil contaminants can be organized in several ways. Within the framework of this article, we describe a three-group division (organic, inorganic and radioactive).

1.1.1 Organic soil contaminants

Organic contaminants in soil are generally characterized by being highly persistent, easily accumulating, and many of them are TTMK (toxic, teratogenic, mutagenic, carcinogenic).

1.1.1.1 Organic solvents

These substances are highly flammable, explosive, toxic and persistent, so special rules apply to their storage and transport. May be released to the environment in the event of an accidental spill / leak, industrial and waste water, air emissions, and waste disposal. Prolonged exposure to solvent vapors can damage the respiratory system, cause tissue hypoxia and anemia, and affect thyroid function [9]. To date, much research is underway to develop alternatives to organic solvents, these are called green solvents [10-11].

1.1.1.2 Hydrocarbons

Hydrocarbons include a wide variety of compounds, from methane (CH4) with a very simple structure to aromatic hydrocarbons. In nature, we find large amounts of these compounds in crude oil and natural gas, which are processed and converted by petrochemistry. Polycyclic aromatic hydrocarbons (PAHs) are released into the environment from the combustion of fossil fuels and oil and coal sludge [12]. PAHs are a group of toxic aromatic xenobiotics with a benzene ring [13]. These compounds are highly hydrophobic and have a stable chemical structure, so they are poorly soluble in water and well soluble in lipids and therefore easily accumulate [14]. For this reason, they occur primarily in sediments and soils. Most PAHs have been shown to be carcinogenic, teratogenic and mutagenic in living organisms. The extent of adsorption of PAHs in soil is largely determined by the soil-specific organic carbon content [15-16].

1.1.1.3 Pesticides

Pesticides, also known as plant protection products, are used in agriculture. Commonly used types of insecticides are insecticides (insecticides), fungicides (fungicides) for protection against pathogens, and herbicides (herbicides) for plant pests. In addition, pesticides are produced for a wide range of uses, such as molluscicides, viricides, defoliants, etc. These substances have been used in large quantities until many of them have been shown to be highly carcinogenic, mutagenic, but also damage the reproductive and endocrine systems, and some agents cause developmental disorders and nervous system problems. One of the best-known such substances is DDT, which is now banned in most countries of the world (in Hungary in 1967) [17-18].

1.1.1.4 Fertilizers

Fertilizer use is an integral part of modern agricultural production. In order to ensure the increased demand for food, it has become necessary to replace the missing nutrients in the soil. However, inappropriate and long-term fertilizer use upset the nitrogen and phosphorus household of the soil, mobile nutrients leaching can cause eutrophication in surface waters. Nitrogene is introduced into the soil to form ammonia, which in turn is converted to nitrite and nitrate. These two compounds are already well soluble in water and, by infiltrating deeper water bodies with the infiltrating water, contaminate the drinking water supply. Nitrate pollution of water is particularly dangerous for infants because its consumption causes methaemoglobinaemia. Another problem is that the use of fertilizers introduces heavy metals into the soil and lowers the pH of the soil, which in turn increases the availability of newly introduced and normally present potentially toxic elements in the soil. Potentially toxic elements in large quantities adversely affect the physiological and biochemical processes of plants, damaging cells and cell organelles. Consumption of “metal-contaminated” plants is associated with biomagnification and damages the ecosystem [19-25].

1.1.2 Inorganic soil contaminants

Inorganic contaminants include potentially toxic elements and their salts, as well as radioactive elements. Members of all three groups are found in nature, but additional pollution that eventually enters the soil is possible from both natural (e.g., volcanic activity, forest fires) and anthropogenic (e.g., mining activity, municipal waste, tannery treatment effluents) sources [26].

1.1.2.1 Potentially toxic elements (PTES)

It is now a well-known fact that PTEs in high concentrations in soil pose a serious threat to human health and the ecosystem. The 8 most common PTEs in contaminated areas are Pb, Cr, As, Zn, Cd, Cu, Hg and Ni. Metal ions are not biodegradable, so they accumulate in tissues and biomagnify when they enter the food chain. This is especially true for Hg, Pb, Cd and As. Lead causes large amounts of, for example, urinary and nervous system damage [27-28].

Metals and inorganic salts are also necessary for the living organism, but in different amounts. In order for plants to grow and achieve good yields, it is important to keep soil mineral reserves at an adequate level. However, excessive salt and metal application has the opposite effect on plant development and results in a decrease in yield [29].

1.1.2.2 Radionuclides

About 80% of the radiation to which humans are exposed come from natural sources. The remaining 20% comes from radiation to the body due to medical examinations (18%) and from the activities of weapons experiments and the nuclear industry (2%). However, due to human activity, even at these proportions, humanity emits very significant radiation pollution into the environment. As a result of military exercises and energy production, the isotopes 137Cs and 97Sr have significantly and for a long time contaminated the soil in the affected regions. Radionuclides are also characterized by the ability of plants to absorb them, so that they enter the food chain and ultimately enter the human body. A good example of this is the two peaks of radiocesium activity measured in the UK, first detected in 1964 and then in 1986 in milk. The first date was the most active period for testing nuclear weapons, while in 86 the Chernobyl accident occurred (Department of the Environment, 1994) [30-33].

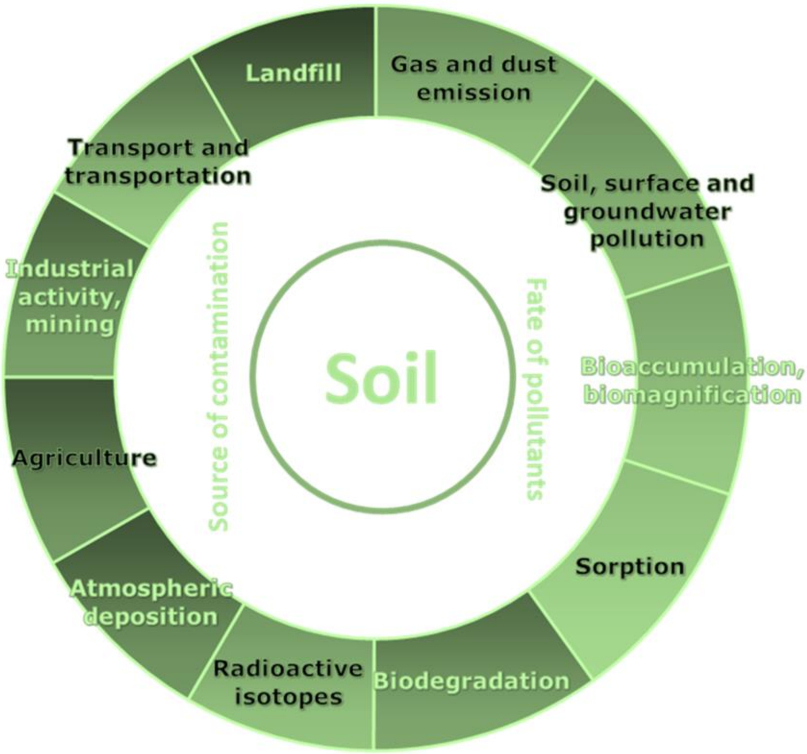


Figure 2. Tthe source of soil contamination and the fate of pollutant [4-33]

3. REGULATORY BACKGROUND

Due to their activities (transportation, manufacturing, warehousing) and the substances they use (raw materials, indirect materials, finished products), plants handling dangerous substances pose constant risk to the constructed and natural environment, and particularly to air, soil and the surrounding population. During the operation of the plants, such risks need to be analyzed on an ongoing basis, as environmental hazard may increase as a result of substance releases, equipment malfunctions or incorrectly performed maintenance activities. Environmental impacts of hazardous facilities can be effectively reduced by using the various elements of the Safety Management System.

In Hungary, Act CXXVIII of 2011 is deemed as the most important legal regulation in terms of disaster prevention. The legislation aims to regulate the execution of disaster management tasks, increase the safety and sense of safety of residents, and enhance the efficiency of defense against natural and technical disasters. The act seeks to achieve such aims by increasing the effectiveness of disaster management actions, as well as by restructuring and strengthening the disaster management organization. The legal regulation provides an accurate description on bodies that perform activities related to designing, organization, coordination, execution, management, establishment, operation, information, alarming, data communication and control, as well as on the required order of their cooperation. Regarding facilities handling dangerous substances, the act describes the fundamental specifications and requirements relevant to their establishment and operation. [34]

As per the definition provided by the Disaster Management Act, a plant handling dangerous substances shall be the whole of an area under the control of a specific operator, where dangerous substances are present in one or more facilities handling dangerous substances. Government decree 219/2011 (Oct 20) for the implementation of the aforementioned act specifies the volumes of dangerous substances, the presence of which makes a specific facility qualify as dangerous, regardless of whether the plant’s activity is classified as industrial, agricultural or other. It is the annex to the Government Decree that determines whether a specific plant is subject to the Disaster Management Act, and therefore facilities that are dangerous in terms of disaster management can be classified into the following categories: upper and lower tier establishments, plants under the threshold value and facilities to be handled with high priority. [35]

In relation to dangerous facilities, the definition of dangerous substance needs to be specified. The definition of dangerous substances – in line with the European Union regulations – is provided by Act XXV of 200 on chemical safety. Under such act, substances and mixtures are classified on the basis of their physico-chemical and chemical properties, explosiveness, toxicological qualities and characteristics, as well as their environmental impact i.e. ecotoxicological properties. [36]

Due to events generated during the manufacturing, storing and processing of dangerous substances, environmentally harmful materials may get released. Such releases may have adverse effect on air, surface and sub-surface waters, flora and fauna, residents, and may harm the Earth's surface and the soil. Explosions and fires pose hazard to the immediate surroundings of the affected facility; however, harmful substances that – as a consequence – get released to air or soil may pose extreme risk within tens of kilometers of range. [37]

In addition to the Disaster Management Act, in Hungary, the Act on environmental protection is also aimed to regulate the protection of environmental elements, and that of the Earth's surface, subsurface strata and soil in particular. When handling or using dangerous substances, as well as when applying dangerous technologies, protective measures need to be taken that mitigate or exclude the risk of environmental impact. While operating dangerous technologies, defense plans need to be prepared prior to performing the specific activity, in order to prevent any extraordinary environmental damage. [38]

Act CXXVIII of 2011 provides that in Hungary, the issuance of building permit for plants and facilities handling dangerous substances is subject to a license issued by the official disaster management authority, and furthermore, the performance of any dangerous activity is subject to disaster management license provided by the relevant authority. Establishment and operating permit may be provided on condition that the relevant safety documentation is submitted to and accepted by the Disaster Management Authority. From among the several obligations of the operator, compilation of safety documentation is one of their major responsibilities. Such safety documentation shall include the operator's requirements pertaining to the prevention and control of severe accidents involving dangerous substances, as well as specify the major objectives, principles and direction of development related to accident prevention. It is required to provide a summary on the operator's organizational structure, the method of identification and assessment of accident hazards, and the specific elements of defense planning; such actions aim to ensure that the operator provides high degree of protection in terms of health and environment. The level of risk posed by a dangerous activity shall be specified on the basis of the safety documentation by way of analyzing the hazard indicators identified.

In order to provide compliance with the requirements set out in the relevant legal regulation, operators have (safety) management systems in place. Such systems aim to implement the operator's safety policy that is targeted to prevent severe accidents and mitigate risks. In the case of dangerous facilities, the operation of such management system is a legal requirement, in terms of which, the aforementioned Government Decree 2019/2011 (Oct 20) provides detailed specifications. The primary aim of the system is to officially regulate the company's activities, develop and maintain safety of operations, as well as to continuously improve safety-related performance while promoting a positive safety culture. The system shall cover the organizational structure related to accident prevention and defense, the scope of responsibilities, procedures, and all resources required for the effective implementation thereof. As a minimum requirement, the organizational and personnel structure, as well as the relevant responsibilities need to be specified in connection with the prevention and control of accidents involving dangerous substances, and furthermore, hazards that may lead to severe accidents need to be identified, and the impact of such events shall be assessed. (Safety) Management Systems focus on the system of operating processes – and specifically review processes that have an effect on safe operation –, change management, safety performance assessment of the organization, as well as on the method and frequency of the related internal and external audits and the follow-up of the relevant findings. Benefits of an effectively operated (safety) management system include operation of increased efficiency and safety, decrease in the number of unexpected downtime events and malfunctions, more favorable insurance fees, better relations with the public, authorities, clients and press. [39]

Figure 3. The relationship between operational safety regulators and the safety management system [by authors]

1.2 Key elements of the safety management system

It is imperative that plants and facilities handling dangerous substances have all the information on the properties of technologies, equipment and materials they use, as well as on their impact on humans and the environment. In order for the safe operation of technological units, it is essential that such facilities have proper documentation which provides substantial information to maintain normal operation or control any potential emergency. Such documents primarily include the safety data sheets of dangerous substances, plan documentations containing the detailed and accurate description of technological processes, and technological instructions. [40] Based on the information available in relation to technological processes, operators shall determine the basic criteria for the safe and efficient operation of the specific technological systems.

Changes may occur from time to time in the technological systems due to various reasons. In order to guarantee safe operation, changes need to be managed according to the potential risks posed by such changes. Changes affecting the safety of technological processes include for instance the use of new or different materials in the specific technological system, as well as the use or storage of raw materials or indirect materials of changed composition within the facility. The key outcome of the change management process shall be a revised and approved application/proposal for change, which identifies and ensures risk management measures proportionate to the proposed change. By managing the identified risks, negative effects on the population or environment can be mitigated and reduced to an acceptable level. [41]

From the aspect of (safety) management systems, quality assurance procedures aim to provide that specific technological units, machines, equipment that are critical in terms of process safety are – in technical respect – in compliance with the technical and engineering best practices, as well as with the relevant legal requirements. The condition of specific devices, machines, equipment that constitute technological systems shall be continuously monitored during their entire lifetime; reliability is of particular importance in the case of technological units containing dangerous substances. In order to achieve such goals, the operator shall – in line with the principles of quality assurance – develop procedures to identify the methods of maintenance and operation of the specific devices, as well as to ensure the scheduling of the required controls and inspections.

One of the most efficient ways of knowledge sharing and learning is the investigation of incidents that have already occurred. In addition to actual incidents, one should also take into consideration the so called quasi-accidents or near misses – accidents that could have happened, but fortunately did not due to some reason (e.g. hazard was detected in due time). Investigation of root causes, however, is of equal importance in such cases as well, as it provides valuable information on non-compliant – or potentially hazardous – circumstances. Once the interrelations are identified, preventive and corrective actions need to be determined. It is important to specify well-defined tasks that can be assigned to specific owners with clear deadlines for execution. Implementation of the specified actions is crucial, and therefore, such shall be continuously followed up by the experts investigating the specific incident.

As for the preparation for and response to incidents, these days, it is an obvious obligation of operators to draw up emergency response plan to prevent the previously assessed emergencies, provide prompt intervention and reduce any further consequences arising therefrom. Efficient emergency response planning and prompt response can reduce the consequences of any event to a significant extent. In order to provide successful preparation for emergencies, one needs to focus on three key aspects: protection of human life, ability to efficient response, and effective communication with the parties concerned.

In dangerous plants, the functioning of (safety) management systems needs to be monitored in order to provide safe and reliable operation. Compliance can be verified by way of audits of various kinds, such as internal self-assessment audits or cross-functional audits. Internal inspections may be conducted by people – as assigned by the operator – who have in-depth understanding of the specific process safety management system, the technological process and the system under review. In addition to the so called self-assessment audit performed on one's own technological unit, it is also reasonable to conduct cross-functional audits where the inspectors include such auditors, too, who work outside the specific operational field, and therefore, the audit is conducted by experts who are responsible for different plants. The inspection may also be conducted by a third-party group of experts; in such case, however, it is reasonable to use a service provider that has extensive experience in the field of industrial process safety, and whose observations and recommendations can contribute to the even safer operation of the facility. Operators of dangerous industrial facilities shall have internal monitoring systems in place which help keep track of the status of safety-related objectives to be achieved. Such may be active monitoring systems, on the one hand, which are intended to achieve safety objectives targeted at incident prevention, and implement risk management actions, or reactive monitoring, on the other hand, which focuses on the reporting and investigation of failures and incidents that have already occurred. Inspections, in any case, aim to establish whether or not the operation of the management system meets the targets set by the operator. It is also important to examine to what extent the specified safety requirements and objectives are aligned. [42]

4. CONCLUSIONS

The authors wanted to depict the complexity of the topic in this complex article. The model experiments are practical laboratory activities with which it is possible to research the nature of soil pollution. Theoretical research, namely literary research, supports the methods and tools to be selected with the help of an international perspective. The effectiveness of legal regulations for preserving and maintaining the state of the environment is indisputable.

Highlighting the possible causes of industrial damage events are listed below. According to the experience of the last decades, the following facts have contributed to industrial accidents [40-42]:

- incomplete understanding of the system used;
- operators and / or supervisors had inappropriate qualifications or experience;
- the plant area for poor quality damage remediation;
- the work permit was inadequate and the lack of control over the repairs carried out;
- poorly performed emergency assessment, inaccurate individual and social risk;
- lack of consistent inspection of the work area immediately before restarting the plant;
- the employee was not properly informed about the task to be performed;
- there was no targeted inspection for the presence and use of personal protective equipment before work;
- incomplete or insufficient labeling of chemical containers;
- emergancy plans are not available
- inadequate communication between those involved in the work;

Finally, with the figure below, the authors tried to present the complex problem of soil pollution. Emphasizing the principle of restoring the environment to its original state. The figure was made by the authors based on their own professional experience.

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

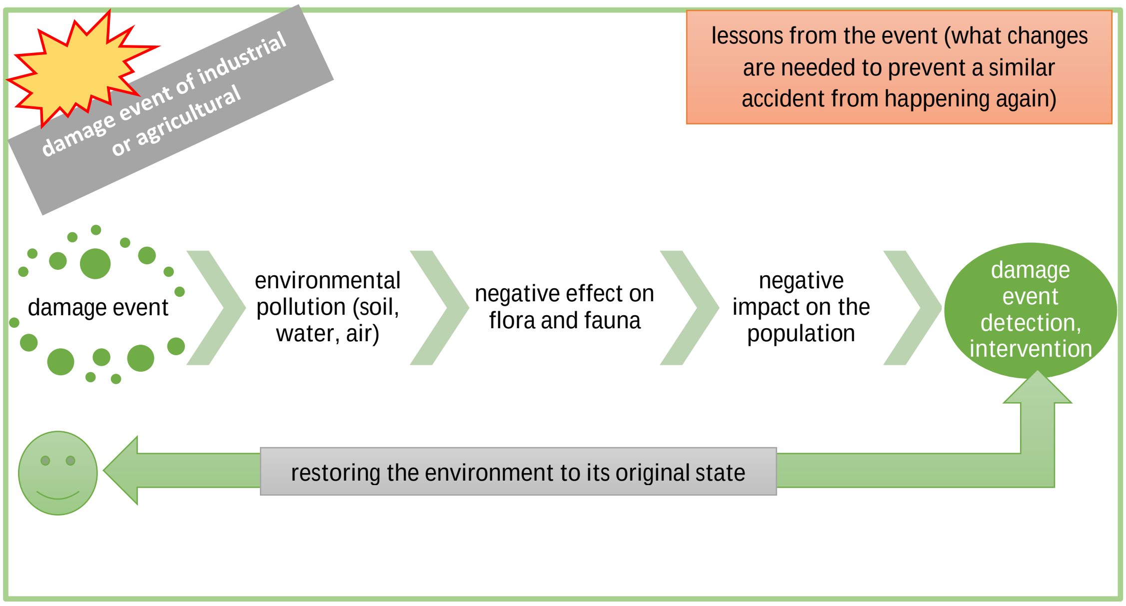


Figure 4. General presentation of the process involving the pollution of environmental elements [by the authors]

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Alida Kiss, József Ambrusz

SCIENTIFIC RESEARCH DIFFICULTIES OF POST-EARTHQUAKE REHABILITATIONS

Abstract

The elimination of the consequences of earthquakes fundamentally differentiates the research of the rehabilitation process depending on the damage that has occurred and the actual value of the rehabilitation. The estimated damage values of the recent earthquakes in Croatia, as well as the built environmental aspects of the actual rehabilitation and reconstruction, also influence the process of performance comparisons and best practice analyses. The authors of the study, in relation to their research areas, are looking for optimized procedures in relation to development opportunities.

Key words: rehabilitation, damage value, earthquake, benchlearning

A FÖLDRENGÉSEKET KÖVETŐ HELYREÁLLÍTÁSOK TUDOMÁNYOS KUTATÁSI NEHÉZSÉGEI

Absztrakt

A földregések következményeinek felszámolása a bekövetkezett károk, valamint a helyreállítás tényleges értékének függvényében a helyreállítás folyamatának kutatását alapvetően differenciálja. A közelmúltban történt horvátországi földrengések eddig becsült kárértékei, valamit a tényleges helyreállítás és újjáépítés épített környezeti vonatkozásaiban a teljesítmény-összehasonlítások és a bevált gyakorlati elemzések folyamatát is befolyásolja. A tanulmány szerzői a kutatási területeik kapcsolatában, optimalizált eljárásokat keresnek a fejlesztési lehetőségek viszonyában.

Kulcsszavak: helyreállítás, kárérték, földrengés, benchlearning

1. INTRODUCTION

The estimated damage values of the recent earthquakes in Croatia (March and December 2020 and January 2021), as well as the large number of stakeholders, highlighted, that in addition to the process of rehabilitations in Hungary previously researched by the authors, it would be worthwhile to examine the neighboring countries. Linked to the idea of benchlearning proposed in Kiss's PhD work [1], which the authors see justified in continuing to study the practice of neighboring countries, in this case Croatia, leaving open the opportunity to promote mutual learning.

In our paper, we first make a brief presentation of the events of the earthquakes in Croatia in March 2020 and December 2020 and January 2021, and then briefly discuss the general characteristics and difficulties of the rehabilitations. Next, we present our applied methods. In the discussion, we address the risk of earthquakes in the affected Zagreb region, and write briefly about the earthquake alarms in Hungary, the definition of vulnerability and the aspects of disaster management. Then we demonstrate briefly the main data and characteristics of the March recovery efforts in Zagreb (since the events of December and January are still very close, there are no real reliable data on the rehabilitation). We then briefly describe the benefits of benchmarking, in terms of rehabilitations. Finally, we formulate our conclusions and suggestions in relation to what has been described.

1.1. Recent earthquakes in Croatia

Amidst the middle of the fight against the COVID-19 pandemic, Zagreb the capital of the Republic of Croatia was stricken with another disaster, an earthquake. On 22 March 2020 at 06:24, Croatia was hit by a strong earthquake of the magnitude of 5.5. The epicenter was at Markuševec, 7 km north of the center of Zagreb, at a depth of only 8 km. At that time, Zagreb was "hub" of the pandemic in the country. With the earthquake causing a huge damage to the entire city center, including major hospitals, leaving over half a million of inhabitants restricted to return to their homes, the situation represented a unique combination of the need to strengthen the measures of physical distancing and humanitarian relief alongside with urgent measures aimed at damage control and assessment.

The March 2020 earthquake had one death toll, 26 injured, and thousands of people were displace. As a consequence of the earthquake, 488 persons were housed in an evacuation center, and an unknown number of people found shelter at friends' and relatives' places. The earthquake caused damage to about 26,000 buildings in the City of Zagreb, Krapina-Zagorje County and Zagreb County. [2; 3]

When the country barely recovered from the damages caused by the March earthquake, another earthquake occurred near the Zagreb region. An earthquake of 6.2 magnitude, with the epicenter close to Petrinja, struck Croatia on 29 December 2020. This earthquake was reported to be the strongest earthquake to hit Croatia for more than 140 years. Eight people were killed and at least 36 persons were injured, ten of whom severely. Between 29 December 2020 and 8 January 2021, additional 379 aftershocks occurred, some of which have been as strong as 5.0 magnitude, additionally damaging buildings and roads in the areas of Sisak-Moslavina, Karlovac and Zagreb Counties. The worst affected areas were the towns of Petrinja, Sisak, Glina and Hrvatska Kostajnica covering a total of 2 802 km^2 of mostly rural area, comprising one medium size town, three smaller rural towns and a total of 482 villages, many of them in hilly remote areas.

There is no final data at the time on the number of houses or residential buildings damaged, since the first screenings and damage assessments of the buildings are still going on. According to the first estimations, there are approximately 15 000 to 20 000 damaged or uninhabitable buildings mainly in Sisak-Moslavina County with the damage value initially estimated at CHF 434.8 million, needed for the reconstruction. [4]

In overall, the Croatian government is currently facing a multifaceted emergency caused by the global pandemic, an economic recession and the earthquakes of 2020 and 2021.

1.2. Post-disaster rehabilitations in general

Due to the large number of natural disasters worldwide each year (hundreds of natural disasters per year) and their volume, there is a significant amount of rehabilitation research at the international level. Due to the rather complex nature of the topic, however, the scientific methods and results are also extremely diverse. Yi –Yang described that in recent years an increasing number of publications on natural disasters and recovery have been published in the international scientific community, however, this field is still a new field of research and no uniform definition has yet been developed. [5] A research on international rehabilitations focuses on Chile, China, Haiti, India, Italy, Japan, New Zealand, and the United States [6], not surprisingly, as these countries account for most of the natural disasters from year to year. [1]

As per the analysis of the data provided by the International Disaster Database (EM-DAT), the four most frequent types of disasters in Europe and Central Asia are floods, windstorms, earthquakes and extreme temperatures. The response to such disasters requires a high-level of mobilization of people on the site to respond, often exceeding the country's capacity. When it happens, the international community is asked to grant assistance, resulting in international disaster management. Different national and international entities like NGOs, multilateral or international organizations, businesses and the academia, are directly or indirectly involved in disaster management and play various roles. [7]

In order to recover from a disaster, leaders need to make different decisions; however, what makes the post-disaster decision-making peculiar is the lack of time to make the optimal decision. A comprehensive understanding of the limits of recovery can lead to elaboration of policies that help avoid delays in the recovery process and consequently, it results in resiliency. [8]

Rehabilitation absorbs an enormous amount of financial resources [9], and the successful rehabilitation of an affected community can be measured by the extent to which the social and public services are efficiently refurbished. [10] Rehabilitation is a complicated, challenging, and dynamic process, as many responsibilities of rehabilitation are interdependent [11], and have to be assumed at the same time [10; 12]. For example, the recovery of the local economy depends on the restoration of the infrastructure, housing, and public services. [13] After a disaster, the economic recovery is very diverse, requiring the participation of the private sector and it benefits both the private and public sectors. [14] In a long-term rehabilitation process, the disaster-stricken communities require support from different organizations such as NGOs, local and federal governments, etc.. [15]

The reconstruction of the infrastructure is also vital to successful post-disaster rehabilitation. [16] For example, transportation systems play a basic role, facilitating the delivery of resources and materials. Environmental rehabilitation is usually not a high priority following a natural disaster. [10]

1.3. Post-disaster rehabilitations – Hungarian characteristics

In the management of the consequences of natural disasters, the management aspects of rehabilitation are primarily reflected through the leadership functions of the Government, government coordination and the minister responsible for disaster management. The decision-making process takes place through the professional disaster management and the actors assigned to it in the public administration. Due to the earthquakes, the main decision-making tasks can be structured during the processes, taking into account the tasks of the prevention, rescue and rehabilitation period.

In preparation for the occurrence and the prevention of an incident, the development of a procedure for the mechanism and the procedure of decision-making at the government level, the practice of emergency operations, the formulation of the technical and development needs of decision-making and the monitoring of enforcement are stressed.

To achieve partial or full operational readiness, depending on the severity of the expected or developed situation, one needs to immediately assess the situation after the readiness has been reached and develop proposals for measures concerning the rule of conduct to be introduced in case of an earthquake - evacuation and relocation. Elaboration or specification of proposals for the measures - preparedness and reception of requests for international assistance, preparedness for the introduction of a special legal order, raising public awareness, etc., continuous monitoring of the situation and circumstances, review of the proposed measures.

The elimination of the consequences and, in the light of the information provided and the capacity of the available resources, developing proposals for the assessment of subsequent protection measures, including the temporary and permanent accommodation of the population losing their homes, in the period of rehabilitation; the collection, storage and distribution of aid; organizing rescue and decontamination; for the period of resettlement of the population concerned; developing proposals in the event that the criticality of any element of the infrastructure would impede the introduction of subsequent protection measures, endanger the lives of the population, property and the natural environment.

1.4. Benchmarking, benchlearning

The use of benchmarking as a horizontal management tool is becoming more and more valuable nowadays. To explain the concept, we draw from the work of Rónai and Budai. [17; 18] In the wording of Rónai, benchmarking *"means a measure, a level sign, interpreting comparative evaluation"*. In the course of benchmarking, we usually look for practices and procedures in an area similar to our own organization, which prove to be better than the existing one, and we take them as a benchmark for the improvement and development of our own system. Benchmarking can be used as an approach, as an openness again and not just as a stand-alone procedure. In connection with the concept of benchmarking, we also consider it important to mention the method of benchlearning. [17] After all, Budai described already in 2008 that benchlearning is gaining more and more prominence than classical benchmarking, because here we prioritize learning from others. [18] The point is to learn from the strengths of others, collect ideas, review them, and avoid bad practices. [1]

Linking the topic of benchlearning to the present paper, we formulate it as a question whether the rehabilitation in Croatia rehabilitation can provide opportunities for the bordering Hungary, can we learn from Croatian professionals and researchers? A large-scale natural disaster in Hungary has not occurred for a long time, so now in connection with the Croatian events there could be an opportunity for cooperation, more in-depth study of rehabilitations, exploration of national peculiarities, a broader knowledge and understanding of good practices, whether scientific or even practical. Hence, this is the essence of benchlearning. It provides an opportunity to adopt good practices. For these reasons, it is an important question for professionals researching rehabilitation in Hungary what opportunities the practices of neighboring countries may have. Can they provide good practices for us to deal with similar incidents and how to rehabilitate thereafter?

2. METHODS

In this paper, a secondary research was performed by the authors. During this secondary research, literature review and report content analysis were implemented with a focus on the characteristics of post-disaster rehabilitations and benchlearning opportunities connected to Zagreb's recent earthquakes. Several searches were run on Google, Research Gate, Elsevier ScienceDirect and EM-DAT (Emergency Events Database) databases, with the following queries: "earthquake in Croatia", "reconstruction after the earthquake in Croatia", "post-disaster reconstruction", "seismic risk assessment in Croatia", "reconstruction in Croatia", "Croatian disaster management", "Croatian civil protection", "benchlearning" and their different synonyms. In the following, relevant papers, reports, datasets were scrutinized from the search results and were used for this paper.

3. DISCUSSION

3.1. Earthquake risks in Croatia

Located in Southern Europe, Croatia belongs to the Mediterranean-Trans-Asiatic high seismic activity zone making it one of the most earthquake-prone countries in Europe. These earthquake-prone regions spread over approximately 30% of Croatia and are characterized by a relatively dense population and large urban centers. The urban areas of Zagreb, Split, Dubrovnik and Rijeka are of particular economic and social importance are with about 60% of the country's population. Zagreb itself, as the administrative, cultural, scientific, economic, and traffic center of the country, accounts for almost 20% of the population and about one third of the country's GDP. [19; 20]

The Zagreb epicenter area is the most active one in the continental part of Croatia. [21] The return period of a magnitude 6 earthquake is expected to be 150 years, with magnitude 6.9 being the maximum possible in the nearby system of fault lines. Before the earthquakes of December 2020, the largest known earthquake in the area was the Kasina earthquake in 1880 (*Table 1*). Its magnitude was estimated to be 6.3. [22]

Date	Epicenter (in relation to Zagreb city center)	Magnitude (Mw)	Intensity (MCS)
9 November, 1880	estimated at 12 km	6.3	VIII
17 December, 1901	estimated at 12 km	4.6	VII
17 December 1905	estimated at 12 km	5.6	VII-VIII
2 January, 1906	estimated at 12 km	6.1	VIII
3 September, 1990	10 km north-northwest	4.7	VII
22 March, 2020	7 km north-northeast	5.5	VII-VIII
29 December, 2020	48 km southeast	6.4	

***Table 1*: Major earthquakes in the Zagreb area**

Source: Based on Croatian Government – Word Bank [3] and International Medical Corps [23] Own editing, 2021

Consequently, catastrophic earthquakes have occurred in the past and may hit again and, if not adequately responded to, the losses to life and property can be significant. Yet, there is still not enough public awareness and understanding of the potential seismic risk, although it is indispensable for successful mitigation strategies. [20]

An increasing number of rapidly growing urban areas are becoming more vulnerable to seismic risk in their development process. [24; 25] Nowadays, information on constructions in Croatia that could be used for standard seismic risk assessment studies is very limited. The last census conducted in 2011 provides data such as the date of construction, occupancy category, number of dwellings, and number of people per dwelling. [26] However, other information required for a more comprehensive description of buildings, e.g., construction material, structural type, number of floors, etc., are not available.

Preliminary steps towards a standard building inventory database for the City of Zagreb have been assumed within the disaster risk assessments [19; 27] and earthquake risk reduction studies

[28] conducted in collaboration between the Faculty of Civil Engineering and the Zagreb Office for Emergency Management, implemented since 2013.

The fact that a strong earthquake would not only cause damages to the built environment and the population but would also result in the collapse of the country's economy while increasing one of the Croatia's biggest problem, which is depopulation, is far from being generally accepted and recognized. Some efforts for seismic risk reduction, conducted by individual initiatives, are on the agenda, but these efforts are not sufficient for developing the required systematic risk reduction strategy at local and national levels.

The lessons learnt from countries that have already been stricken by earthquakes suggest that it is essential to connect and coordinate the activities of stakeholders (technical experts and scientists involved in the sophisticated research in various fields important for seismic safety). [20]

3.2. Reconstruction after the Zagreb's earthquake

Data and features related to the rehabilitation following the Zagreb earthquake were processed based on the "CROATIA EARTHQUAKE Rapid Damage and Needs Assessment 2020" prepared by the Government of Croatia and the World Bank. [3] This report is a comprehensive and reliable summary of what happened. The government and its external agent worked on based on official data available at the time. No more relevant source is available at the time of writing this paper.

In the weeks following the March 2020 earthquake, the Croatian government launched the preparation of a Rapid Damage and Needs Assessment (RDNA), which was coordinated by the Ministry of Construction and Physical Planning. The damage, loss, reconstruction and rehabilitation estimates were compiled in this report. The RDNA aims to provide a structured and comprehensive account of the earthquake's impacts. The report complements the further planning of an overall post-earthquake rehabilitation strategy and the development of the necessary institutional, legal and financial framework for the reconstruction. This coordinated assessment process has also been used by the Croatian government to prepare its application for the European Union Solidarity Fund.

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Most of the damage was suffered by the housing sector (64%), followed by the culture and cultural heritage sector, including historical government buildings (13%), education (10%), health (8%), and business (5%). The sector most affected by total losses is the housing sector (57%), followed by business (29%), health (10%), culture and cultural heritage (3%) and education (1%). Overall 78% of the damage and losses are in the private sector, and 22% in the public sector. In the private sector, damage and losses are mainly in housing and business, while, in the public sector, they are mainly in health and education. For the culture and cultural heritage sector, the ownership distribution of damage and losses is 39.2% public and 61% private.

Housing is the sector most badly hit by the disaster, with approximately 24 000 damaged buildings spread across the whole of the earthquake-stricken area. An estimated 4 600 of them have moderate to severe structural damage (19%), while 1 243 have high structural damage (5%). The total value of damage to the housing sector stands at approximately EUR 6.88 billion, while the assessment of losses amounts to EUR 364 million. The *Table 2.* for losses takes into account the displacement of persons from unsafe buildings, and the disposal of earthquake debris. Ninety-nine percent of all estimated costs relate to the City of Zagreb, as it is here that the density of buildings and population is at its highest.

The needs for reconstruction and rehabilitation (*Table 2*) add up to approximately EUR 17 469 billion. Of this amount, EUR 4,5 billion relates to short-term needs (26%), medium-term needs are estimated at EUR 7,1 billion (41%), while long-term needs stand at EUR 5,8 billion (33%). The reconstruction and rehabilitation needs are higher than damage and losses since they include, first, the application of a build-back better approach to the reconstruction of damaged infrastructure that reduces any future earthquake risks and involves functional improvements including energy efficiency; and second, the resumption of production, service delivery, and access to goods and services.

The cost of rehabilitation is the highest in the housing sector and accounts for more than half of the overall needs (52%), followed by the culture and cultural heritage sector, the health sector, and the education sector (each respectively accounting for 13-14% of overall rehabilitation needs). The large amount of damage done to buildings of cultural heritage value across all sectors renders the rehabilitation and reconstruction process particularly complex and challenging, both in financial and logistic terms.

As revealed by the assessments of damage and losses, the extent of the disaster is so wide-ranging that it is simply not possible to determine a timeframe for rehabilitation at this stage. [3]

The total recovery and rehabilitation needs, which include both reconstruction costs and soft recovery measures, are considerably higher than the estimated damage and losses for all sectors. Several factors have contributed to this; notably the fact that the earthquake severely damaged Zagreb's historical city center, which, as a whole, is classified as cultural heritage; the need to apply build-back better principles and improve functional characteristics of buildings; and the fact that many of the affected hospitals and schools will need to be retrofitted to meet the highest seismic resistance standards.

The legal framework for the reconstruction of damaged buildings, including precise guidelines for construction work, will be set out in the Billy on Reconstruction of Damaged Buildings in Zagreb and the Surrounding Area, which was, at the time of writing the report, undergoing public consultation. The consultations started on 15 May 2020 and the Bill is due to be approved by the new Parliament as a priority action. [3]

The government has already embarked upon the rehabilitation process by preparing the legal framework for a thorough and long-term program of rehabilitation. Building on actions already taken, and using the RDNA process as a basis, a comprehensive Recovery Strategy will be elaborated. The time span for recovery has been divided into short-, medium- and long-term periods, although the exact duration of these periods has not yet been determined. They will be decided during the elaboration of the Recovery Strategy.

The Bill on the Reconstruction of Damaged Buildings in Zagreb and the Surrounding Area: Almost immediately after the earthquake struck on 22 March, the Ministry of Construction and Physical Planning began elaborating a new law to address the specific needs of rehabilitation and reconstruction. The aim of this *lex specialis* is to prescribe the manner and procedures for the removal of debris, and the rehabilitation and reconstruction of damaged buildings on the territories of the City of Zagreb, Krapina-Zagorje County and Zagreb County. The main purpose of this law is to establish a post-earthquake management system with mid-term and long-term response measures, and designated standards for the carrying out of repairs.

The Bill covers the rehabilitation and upgrading of both public and private buildings. It includes four levels of rehabilitation and reconstruction:

1. repair of non-structural elements of buildings required for legal use and occupancy of a building;
2. repair of structural elements;
3. upgrade of structural elements; and
4. full rehabilitation and reconstruction.

The Bill aims to streamline administrative procedures by prescribing roles and responsibilities among existing central and local agencies, and establishing a coordinating body and Expert Council for the rehabilitation and reconstruction of the damaged infrastructure. The Bill also stresses that the technical and analytical basis for rehabilitation of the urban historic city center will follow the latest EU and international seismic standards. Replacement housing will be provided to those residents whose dwellings have severely suffered and cannot remain there. The Bill also intends to provide indication for the reimbursement of expenses for reconstruction, rehabilitation, dislocation or other actions eligible under this Bill, including actions undertaken before the adoption of the said legislation (*Table 2*).

		Damages	**Losses**	**Total**		**Short-term**	**Medium-term**	**Long-term**	**Total**
Housing	**Damages and losses by sector (in million EUR)**	6 881	364	7 245	**Summary of recovery and reconstruction needs (in million EUR)**	2 739	4 102	2 287	9 128
Health		826	61	887		374	210	1 851	2 435
Education		1 071	9	1 080		571	881	909	2 361
Culture and Cultural heritage		1 378	21	1 399		500	1570	447	2 517
Business		505	184	689		338	351	339	1 028
Total		10 661	639	11 300		4 522	7 114	5 833	17 469

Table 2 - Reconstruction after the Zagreb's earthquake – Damages, losses and needs

Source: Based on Croatian Government – Word Bank [3] Own editing (2021)

The report made the following proposals for the rehabilitation, with which also the authors agree:

- A detailed Reconstruction and Recovery Strategy/Framework should be developed
- BBB (Build Back Better) concept [including EE (Energy Efficiency)] and DRR (Disaster Risk Reduction) measures should be integrated in all reconstruction and rehabilitation needs in order to improve future disaster resilience
- Human impact in relation to social vulnerability to disaster (gender, disability, age etc.) should be mainstreamed in all reconstruction and rehabilitation measures
- [3]

3.3. Possible challenges in disaster management – earthquakes

The most important societal expectation regarding seismology, despite the fact that seismology provides a crucial part of the knowledge about the Earth's interior, is related to earthquake prediction. [29]

The development of earthquake alarm systems began in the 1990s in various locations, mainly in the countries affected by earthquakes (Mexico, USA, Japan, Romania, Taiwan, Turkey). The operating costs of forecasting systems are significant.

There are two possible types of alarm systems. The first one is a regional seismometer or accelerometer network installed in the vicinity of a previously known active geological structure. Their signals must be transmitted to a high-performance computer installed in the study area, analyzing the received signals: determining the position of the epicenter and the magnitude of the resulting earthquake. The latter task is not a simple and clearly automated task for large earthquakes. If a computer has determined the parameters of a quake, it will send an alarm signal if necessary. The definition will be made within a few seconds.

The second option that underpins prevention could be the monitoring of a facility highlighted in terms of a given vulnerability. An alarm signal for the protected facility can be generated based on a comparison of the primary wave arrival recorded by the seismometer(s), accelerometer(s) and the beginning of the spectrum calculated from the first part of the seismogram.

A potential hazard posed by earthquakes can be characterized by the use of seismic vulnerability and seismic risk. A hazard is an over-time exposure associated with a probability of overshoot. The risk is the probability of failure of a natural structure or equipment. In other words, the risk describes the likely end result of the interaction between hazard and vulnerability. [30]

3.4. The methods of mitigation of losses due to earthquakes and the value of rehabilitation

The mitigation of the damage incurred, i.e., the extent of the compensation, is not regulated in advance. Supporting the owners in need of privately owned residential buildings should also take into account their responsibility to encourage the protection of their property.

Its constructive possibility was also described by Ambrusz in his PhD dissertation, which took into account the possibility provided by an insurance product in claims mitigation. [31] If the owners of the damaged property in need are insured and the owner's insurance is value-based, they should receive a non-refundable subsidy of 100% of the non-recoverable rehabilitation cost, but if the insurance is non-value-added, the 90% of the non-recoverable rehabilitation cost is to be received in form of a non-refundable grant accordingly. If the owners of the damaged properties in need do not have insurance, an owner should receive a 50% non-refundable subsidy for the costs of repair and recovery of the damage and an additional 50% interest-free, reimbursable subsidy in addition to meeting the criteria for taking out insurance. An owner who is not in need and whose income and financial situation do not significantly exceed those in need should be able to receive interest-free repayable assistance.

It is important to emphasize that in the choice of types of mitigation in proportion to the extent and severity of the damages, the validation of quality engineering and construction processes may play a more dominant role in the central mitigation organizational tasks, one of the key features of which also presupposes methods of financing force majeure recovery.

3.5. Opportunities for benchlearning

The difficulties of adapting international “best” practices in Hungary may be due to the fact that Hungary has different characteristics in many areas compared to countries appearing in international research and publications, which are much more often affected by natural disasters. The country's geographical location, population characteristics and economic characteristics also differ from those of the Third World, which is often affected by natural disasters, or even the United States. Probably, rehabilitation in Hungary has not become a key issue in our country either, because the frequency of large-scale natural disasters can be measured in the order of 10 years rather than years. However, this does not mean that it would be of slight importance to resolve the problem in Hungary, as these events, if less often, may burden the domestic budget at unexpected periods, which may trigger further, spill-over processes. [1]

Shifting benchlearning would also be important for countries bordering Hungary. It is presumably easier to overcome compatibility problems due to distance and differences between countries with similar disaster risks and locations. It is probably easier to identify what and how we can learn from each other if implemented in a similar system. Starting from the data collection difficulties experienced during the preparation of the paper, we formulate, as a fundamental problem, that international cooperation needs to be strengthened not “only” from the point of view of assistance, but also from the point of view of scientific experts. After all, in the absence of publications and reports in foreign languages, there is no common language for mapping and adopting best practices.

4. CONCLUSION

One of the clear lessons of the paper is that the management of large-scale emergencies, mainly natural and man-made, also requires a more flexible response system on the part of the EU. The efficiency of the overall response mechanism can be maximized by making capacity available for cases involving several countries at the same time, or the Union as a whole. Mutual European solidarity must be strengthened for the future with regard to rehabilitation, especially if most or all of the Member States face the same emergency or a disaster of a magnitude beyond the tolerance of the country concerned.

As a continuation of the research, it is possible to develop exact parameters, map rehabilitation practices along them and share them on a common international platform for the organizations and governments concerned in order to learn from and adapt to the strengths of others.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Réka Magdolna, Kirovné Rácz

THE CORRELATION OF CLIMATE CHANGE AND THE DISASTERS DUE TO PRECIPITATION IN HUNGARY

Abstract

Today, disaster management organizations, beside their traditional duties in fire prevention, civil protection and disaster management have to face serious challenges with special regard to the security and disaster management questions posed by climate change. As a segment of adaptation to the effects of climate change everyone has a role, a right and a responsibility, from citizens, to professional disaster management bodies, to those involved in home security. There is a tendency for the extremity of precipitation to increase. Precipitation is either too much or too little, which can cause both inland water and drought in the same area, in the same year. According to domestic climate change experts, in parallel with the decrease in precipitation, it will be typical that the extremity of precipitation will continue to increase, so the frequency of floods, lightning floods, inland waters and droughts is also expected to increase.

Keywords: climate change, extreme rainfall, hydrological disasters

ÖSSZEFÜGGÉSEK AZ ÉGHAJLATVÁLTOZÁS ÉS A CSAPADÉK HATÁSÁRA KIALAKULÓ KATASZTRÓFÁK KÖZÖTT

Absztrakt

A hivatásos katasztrófavédelmi szerveknek napjainkban – a hagyományos tűzvédelmi, polgári védelmi és iparbiztonsági feladataikon túl – nagyon komoly kihívásokkal kell szembenézniük az éghajlatváltozás biztonsági és katasztrófavédelmi vonatkozásaival összefüggésben. Az éghajlatváltozás hatásaihoz való alkalmazkodás részeként, a katasztrófák megelőzése és az ellenük való védekezés mindenkinek joga és kötelezettsége az állampolgároktól a hivatásos katasztrófavédelmi szerveken át, a nemzeti védekezésben résztvevő szereplőkig. Egyre inkább általánossá váló jellemző hazánkban a csapadékhullás szélsőségessége. A túl sok és a túl kevés csapadék is egyaránt káreseményekhez vezethet. Előfordul, hogy ugyanazon a területen, ugyanabban az évben előfordul belvíz és aszály is. (Pl: 2018.). Az éghajlatváltozással összefüggésbe hozható csapadékcsökkenés ellenére jellemző a csapadékhullás szélsőségessége (hirtelen lezúduló nagy mennyiségű csapadék), így az árvizek, belvizek, villámárvizek, települési elöntések és az aszályok gyakorisága és intenzitása is növekszik.

Kulcsszavak: éghajlatváltozás, extrém csapadékhullás, hidrológiai katasztrófák

1. INTRODUCTION

Unusual and extreme natural phenomena and weather anomalies have become more frequent. They effect the whole of society, therefore we have to start adapting to them in all social and economic fields.The nature wishes to signal to us that it is unfortunate to strengthen the effects of climate change with the pollution of the environment and our way of living, which does not respect nature and is wasteful, because the environment will answer with drastic weather anomalies and natural disasters.Based on the experiences of the past years, it can be concluded that extreme, immoderate weather events – which can be associated with the global climate change – have become more and more frequent, intensive and bear ever more striking features, such as the fall of sudden, torrential precipitation in great volumes or the appearance of a form of precipitation previously not charachteristic for the season (such of snowfall in March 2013., or the deluge rainfall in May 2017. Budapest) [1]

It is a fact, that the events occurring due to these extremities place extra duties on today's disaster management organizations, and put coping strategies in a different light with regard to prevention, response and recovery as well.

2. DISASTERS DUE TO EXCESS RAINFALL

In my view, a clear and close correlation can be revealed based on the experiences gained from the past years and decades between the changes in these features of precipitation and the increased risk of the occurrence of disasters if hydrological origin. [2]

In Hungary the precipitation fall immensely various quantity year by year, and it's distribution in the year is immensely various too.[2]

The water shortage and the excess water might be problem in social level, if there isn't effecient response for the resulting extreme situations, for example flash floods, inland water, drought, or shortage of drinking water)

In May and June 2018, and in 2019 too, at the national level, occured lots of damage wich was correlate extreme rainfall as good as week in week out. (For example flash floods, water flooded part of villages, dilapidations and glissade of flood protection build- ups.) And after these events, from July to November in 2018. there was so lack of rainfall, that the water level of Danube was record law. [1]

Resulting the extreme rainfall, the most- singificant damages are in the built environment.

The intense rainstorm usually occure with ice falling, and high wind. The reconstruction after this events is intensified challange for the whole society in our days.

The extreme weather situations in public events, like open- air festivals can cause mass panic, and in this case grow the chance of personal injurys.

The forecast of the extreme intensity and quantity precipitation is real limited. The type, the quantity, and the roughly place of rainfall is predictable, but the intensity of rainfall not.

Now this parameter causes the most significant problems, because the limited capacities of the zanjons. It's not just the same, that as many precipitation fall dawn in one hour or one day.

If the zanjons can't lead away the extreme intensity rain, the water will deluge the deeper areas, for example garages, cellars, or underpasses.

3. DISASTERS DUE TO LACK OF RAINFALL

As a result of climate change, in the context of global warming, declining rainfall has been predicted for decades by researchers. Unfortunately, the process has already begun, and today the global problem is the declining quantity and deterioration of the quality of available water resources.

Extremely hot periods with higher temperatures, summer heat waves and declining rainfall, such as increasing the length of dry periods, are projected to increase the likelihood of droughts due to the effects of climate change.

As a result of climate change, summer is characterized by extremely high temperatures and extremely little rainfall, and as a secondary effect, drought is associated with drought.

Drought due to water scarcity and desertification are less of a “spectacular” disaster than damage caused by excess water. They are slow-moving, however, they can cause significant damage and affect the functioning of society in many areas.

In addition to crop production and agriculture, the effects of drought negatively affect all living organisms, from flora, fauna to humans. Through drought affects, the damage caused the natural environment directly and also society and the economy indirectly.

The adverse effects of drought on agriculture are the most significant of the economic sectors, as they are directly affected by drought damage in this area. By examining the relationship between crops and climatic and hydrological factors, the severity of drought and the extent of specific damage can be determined. The raw materials needed to produce food come from agriculture, and as a result, the detrimental consequences for agriculture also affect the food industry. Trade can respond to rising prices to compensate for losses in agricultural crops, food processing, trade and energy use.[3]

Forests play a very important role in the global ecosystem, so the damage caused by drought in forestry is also dangerous. A prolonged drought period can cause severe damage to the forest ecosystem. The leaves of trees may fall prematurely, their canopies may deform, their yields may decrease, and pests and infections may multiply in the trees. The risk of wildfires increases during dry, droughty periods. These fires cause enormous ecological and economic damage.[3]

Livestock is directly and indirectly affected by drought. Prolonged drought and water shortages put a strain on the animals, but the extent of this depends on the species, breeds and housing conditions involved. In addition to the direct effect, among the indirect effects.[3]

4. OPPORTUNITIES TO PREPARE THIS EVENTS

In order to develop a high level of social values related to water, it is essential to inform the citizens and to raise the necessary public, educational and public information awareness.

I believe that the basis of the efficiency, quality and performance of all professions, including the defense sector, is high-quality, up-to-date education. In my opinion, it is extremely important to include the dissemination of knowledge on climate change, including the problem of drought and the disasters due to extreme rainfall, in the training of disaster management (and other professionals in the defense sector), as this will give them the knowledge that highlights the causal links between natural disasters and climate change and the effectiveness of preparedness and response. [4]

The other hand the hungarian Disaster Risk Interpretation includes the impacts of climate change, and with this in mind determines the hungarian disaster risk.

Every County Disaster Management Directorate make terminally an emergency prognosis in virtue of the experiences of predecessor year. This prognosis forecast the potential situations and in this context prepare the human and technical device both.

5. CONCLUSION

Climate change has been a much debated subject for many years now. According to some opinions, there is no causal link between the changes in the climate and the frequently occurring natural phenomena that are becoming more extreme and unusual. These voices suggest that it has to be accepted that unprecedented *blizzards, floods, storms and other natural disasters* can occur any time.

Today, the mitigation of the harmful effects of climate change and the compliance with these effects have to be regarded as a global goal.

The past few years have brought the recognition of the importance of this problem in Hungary, and the realization that it is not enough to talk about it, actions are needed.

Unusual and extreme natural phenomena and weather anomalies have become more frequent. *They effect the whole of society*, therefore we have to start applying to them in all social and economic fields.

It is particularly important in the field of disaster management to prepare for the challenges posed by the weather extremities caused by climate change becoming more frequent and intense. It is a fact, that the events occurring due to these extremities shift extra duties to the disaster management organizations of today, and put coping strategies in a different light with regard to prevention, response and recovery as well.[4]

Today, the presumption that disaster management organizations, beside their traditional duties in fire prevention, civil defense and disaster management have to face serious challenges with special regard to the *security and disaster management questions* posed by climate change, has become relevant. I focused on the management of disasters of hydrologic origin, in particular on the *prevention of floods, inland excess water, local damages caused by water, flash floods and droughts*.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

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THE DVI HUNGARY AND ITS' FIRST DEPLOYMENT

Abstract

This paper is on the disaster victim identification process, under the Interpol protocol. The protocol has five phases and offers a scientifically sound methodology to identify the deceased. After several years of planning, Hungary has established the DVI Team in 2018. Although, even before 2018 some mass fatality disasters occurred. In 2019 was the first deployment, after the accident of the Hableany sightseeing cruise, in Budapest, which caused the death of 29 and the missing of 1.

Keywords: disaster, victim, identification, DVI, Interpol, mass fatality incident, Hableany

A DVI ÉS ANNAK ELSŐ BEVETÉSE MAGYARORSZÁGON

Absztrakt

A cikk a tömegszerencsétlenségek áldozatainak azonosítását (DVI) mutatja be, az Interpol előírásai szerinti eljárás alapján. A DVI öt lépésből áll, amely egy tudományosan megalapozott áldozatazonosítást tesz lehetővé. Másfél évtizednyi tervezés után Magyarországon 2018-ban jött létre a DVI egység, pedig halálos tömegszerencsétlenségek már korábban is bekövetkeztek. Az első bevetésre 2019 májusában került sor a Hableány sétahajó budapesti balesetét követően, amelyben 29 fő vesztette életét, egy főt pedig a mai napig eltűntként tartanak számon.

Kulcsszavak: katasztrófa, áldozat, azonosítás, DVI, Interpol, tömegszerencsétlenség, Hableány

1. THE DVI

The Disaster Victim Identification (DVI), the scientifically sound identification of victims of mass fatality incidents, is a particular, complex, interdisciplinary field of modern forensics and police sciences.

For DVI, contrary to the Hungarian law, disaster means a mass fatality incident, when the number of simultaneous deaths can be handled and legally processed beyond the possibilities available for the local authorities at the moment. [1] (The Hungarian Criminal Law defines the „lethal mass accident”. The Act of Disaster Management defines „catastrophe”. The Act of Taxation defines „natural disaster”. All the three differ from each other and do not describe the mass fatal incidents properly.)

DVI is not only the term for the methodology but also a name of an organization. The DVI has been a standing committee of Interpol since 1980, which issues Interpol DVI Guide [2] and DVI forms, connects the 190 Member States, and helps identify victims of mass disasters. Since 2016, the Standing Committee has been operating as a working group (WG), but this did not affect its’ activities.

The basic philosophy of Interpol DVI is an interdisciplinary approach, standardized procedures, preparation for organization and training, and, last but not least, respect for dignity and humanity.

The DVI methodology contains five different steps. The scene recovery, the PM, the AM, the reconciliation and, the identification.

The scene recovery. [3] From the incident scene, all of the body, body parts, body fragments, and personal belonging have to be recovered. Each exhibit has to be properly documented, labeled, packed, and sealed. The scene can be huge, for example after an earthquake or airplane crash, or can be small like a bar fire incident, or mass fatality in a truck during illicit human trafficking.

The PM is for post mortem, this is the phase for investigation in a morgue. [4] All data have to be filled in the unified „DVI PM form”, the so-called pink form. The aim in the morgue, unlike a criminal investigation, is the collection of identifiers. (Identifiers will be explained later in more details.) The examinations about the cause of death are not part of the DVI process, but, naturally, can be done perpendicular, at the same time.

The AM is for ante mortem. [5] This is the phase for investigation of the missing person, the contact of the missing person's family. All data collected from family members or friends have to be properly recorded in the unified „DVI AM form”, the so-called yellow form. All medical files, dental records have to be collected and attached to the AM form. Photos of the missing person can be collected even from social media. Tattoos, pieces of jewelry can be chosen from catalogs by family members if they are not able to show a photo of it. Official databases have to be checked for fingerprint or DNA records, if no records were found, personal belongings can be collected from the missing persons’ home or hotel room. (Comment: the DVI AM team should never say „victim” or „dead person” when connecting family members – the correct expression is the „missing person”)

The reconciliation phase [6] is for comparing the AM and PM data. It can only be started when every AM and PM form is filled and finished. During a reconciliation have to be minded: victims of a disaster can die in hospital, or body parts can be found from living victims, whose family will not report his or her missing. (So: in some cases, the number of AM and PM forms do not match each other.)

After the reconciliation phase, the Identification Board will declare identification. The composition of this Board will be determined by the existing legal framework. Members could be high-level police officers, prosecutors, observers from foreign DVI units, etc. The ID Boards’ responsibility is the compilation of results from the Comparison Report into a Victim Identification Report and approval by signature, by the signatory with jurisdiction. This record is then regarded as a formal confirmation of the identification of a deceased victim.

There are two main classes of identifiers, the primary identifiers, and the secondary identifiers. Any of the primary identifiers may be able to establish an exact identity on their own, secondary identifiers are usually not capable of doing so on their own. Primary identifiers are the fingerprints, the dental records, and the DNA. Secondary identifiers are the anthropological findings, medical findings, tattoos, scars, jewelry, and other personal belongings. It is also important to stress that visual identification can be very unreliable and therefore this form of identification should not be considered alone.

2. THE DVI IN HUNGARY

The 70th Interpol General Assembly was held in Budapest at the end of September 2001, just after the terrorist attack on the United States. About 650 delegates came to Hungary representing 140 countries at the one-week series of events. The topic of the general meeting was, of course, updated to the events, so the prevention of terrorism became a priority topic. Several speakers referred to victim identification efforts and argued for standardization and international cooperation. The law enforcement and scientific society of Hungary at that time were faced with the fact that the fast and yet scientific sound identification could not be carried out without adapting the protocols and standards and maintain proper international cooperation. Despite no significant progress has been made for years.

After the 70th General Assembly, some mass fatal incidents have occurred in Hungary.

2003. Siofok, Somogy county, near Lake Balaton. Bus of German tourists was collided by a train in a railway crossing. 33 people died. Hungarian authorities were strongly supported by the German DVI team, the identification efforts were made by the German DVI team.

2006. Hejce, Borsod county, near the Slovakian border. An Antonov-24V aircraft of the Slovak Air Force collided with Borso-hegy („Pea Mountain") and crashed. 42 people died, only one survived. Scene recovery and scene investigation in the stormy winter night revealed that the Hungarian police were not able to face this scale of events. Victim identification processes were conducted in Slovakia.

2010. Ajka, Veszprem county. The tailings pond of an aluminum factory was damaged and several tons of highly corrosive red mud were flooded to three local villages. Despite the 10 fatal victims, no DVI processes were conducted. As far as we know, no victims were considered as an unidentified bodies.

2011. M43 Highway, Csongrad county. Romanian citizens died in a traffic accident when their minibus has collided with a truck. Despite the 14 foreigner fatal victims, no DVI processes were conducted. As far as we know, no victims were considered as an unidentified bodies.

2018. Cegledbercel, Pest county. The driver of a 9-seat minibus was using his smartphone to stream live video, and this caused a traffic accident. The driver and the other 8 passengers died. Author 2 was involved in this case, so some rudimentary elements of the proper DVI process were conducted: bodies were labeled with reference numbers instead of names. Labeling with names always involves the assumption of preliminary identification by documents or something like this. All of them were ten-printed and DNA samples also were collected.

Besides that, a Hungarian forensic pathologist could join the DVI Austria in Phuket, Thailand, at the beginning of 2005, to respond to the Boxing Day Tsunami. The same pathologist went to Egypt at the end of 2011, where 11 Hungarian tourists died in a traffic accident. [7] In 2017, in Verona, Italy, a Hungarian bus had an accident. 17 people, mostly secondary school students and their teachers were burned to death. Hungary sent only traffic police units to the scene, with no forensic or DVI experts.

In the November of 2017 by a joint effort of Counter-Terrorism Centre (TEK), the Hungarian Police, and the Semmelweis University (a medical university in Budapest) an international conference was held in Budapest. The current chairman of the Interpol DVI Working Group also took part in it, and close cooperation was started to train a Hungarian DVI Team. In the Summer of 2018, a four-day course was held for 25 Hungarian law enforcement officers and 10 forensic pathologists and odontologists. This was the actual establishment of the „DVI Hungary”. At this first step, the scene recovery and PM teams were trained. Till 2021 no AM team had been trained, no official establishment had been made, no amendments of legislation had happened.

3. THE FIRST DEPLOYMENT OF DVI HUNGARY

In 05. 29. 2019., Budapest, Hungary, the Hableany, a Moskvich-class sightseeing cruise was collided from behind by a twenty-five-times bigger longship, MV Viking Sigyn. The Hableany (a Hungarian word for Mermaid) capsized and sunk in seven seconds. On that evening the weather was unusually cold, there was heavy rain, and the River Danube was flooding, the drift of the river was very strong.

The Hableany sightseeing cruise had 35 South Korean citizen tourists as passengers and 2 Hungarian crew members. Seven people were rescued some minutes after the accident and eight dead bodies were found till the morning. In the next weeks, all but one body were found, one South Korean female passenger is still missing.

After the accident, three processes have been started:

- a criminal investigation, conducted by the Police of Budapest, because of a „crime against maritime safety cause a mass fatality incident”. [8]
- a rescue operation, conducted by the Counter-Terrorism Centre (TEK), with the participation of the Hungarian National Organisation for Rescue Services (OKF), Hungarian rescue divers, the „Cobra” special military diving unit of Austria, and military diving troops of South Korea.
- a victim identification process following the Interpol Disaster Victim Identification (DVI) standards. This process was led by the National Bureau of Investigation (KR NNI) and performed by the DVI Hungary, which is not an officially approved entity. Fingerprint experts of South Korea also joined.

The „DVI Hungary”, as was mentioned above, had been not officially established, but trained members have been working together since 2018. Members are

- from police forces, like KR NNI and others,
- from the Hungarian Institute for Forensic Sciences (NSZKK)
- form the University of Public Service (NKE)
- and from the Institutes / Departments of Forensic Pathology of the four medical universities.

The „DVI Hungary” is led by the head of the Department of Crime Scene Investigation at the National Bureau of Investigation (KR NNI – BTFO).

All of the victim identification processes were fulfilled under the Interpol DVI Guide. This was a perfect framework for the Hungarian and South Korean DVI Teams. The official DVI AM and PM forms were filled in English. At the request of the South Korean officials, contrary to Hungarian regulations, no autopsies were performed.

Every South Korean victim but one was identified by fingerprints. The South Korean authorities have the ten-print records of every citizen over 17 years old. Initially, the fingerprinting could be done by the inking method, later more specific methods were needed to be applied. Air was injected into the fingertip and a string was used to squeeze the finger, not to release the injected air. This pumped the fingertip enough big to be able to be printed with dusting-lifting technic. Later the boiling method was applied: the fingers were put to hot water and after drying the dusting-lifting technic was used.

Also, the dental record was taken from every deceased. The Korean victims were middle-class people with well-groomed teeth and accurate dental records. One South Korean victim was found five weeks after the accident and could not be printed, so she was identified by secondary identifiers: scars, jewelry, clothes, and anthropologic features.

4. THE LESSONS WE LEARNED

The „regular" forensic examination of the deceased is too slow. The Hungarian legislation contains rules for examining a dead body, additional rules for examining unknown bodies, and additional rules for examining victims of a crime. According to the very comprehensive rules, much useless information had to be collected, like the exact geographical data or the detailed description of the morgue. The process of one body was 150-180 minutes, compared to the DVI PM process, which was 40 minutes.

Furthermore, the „regular" forensic examination of the deceased resulted in a Hungarian form, which was too detailed on one hand, as it was mentioned above. On the other hand, the very detailed Hungarian form still had lack of essential information. For example, the dental status in the Hungarian form can be „repaired" or „intact", with no further details. The DVI PM form contains every needed information, except the disaster-related injuries. But those injuries and every relevant pathological finding can be recorded on the additional pages of a PM form.

The numbering and labeling of the bodies with the DVI numbers were effective and unavoidable. The usual labeling of unknown bodies is „N. N.”, sometimes supplemented with „male” or „female”. After the Hableany accident, the authorities needed to face more than one „N. N. male” and more than one „N. N. female”, which urged the introduction of a new labeling system. So they numbered the bodies as well (i. e. „N. N. male 2”). Later for an unknown reason, the police started to label the bodies with letters as well. The DVI unit started to use the DVI PM labeling (i. e. PM 36 1001) as well. The letters (from B to AF) were kept in use for an unknown reason. Some bodies had three different labels, some had two. This seemed to be illogical and useless.

Although the process had been done under the Interpol standards, in some cases still an inappropriate way was followed. The Hungarian citizen victims were not subjected to the Interpol standard procedure. On the very first day, a Caucasian corpse was found in the water, which was the eighth body, and was excluded from the DVI by visual observing only. One South Korean victim was processed without filling any DVI PM form, yet got a DVI number and label.

5. CONCLUSION

Three years after the practical establishment of DVI Hungary and two years after the first deployment in an international-related event, the unit still does not have any legislative background, budget, organization, or any kind of official approval. Team members from Universities or the private sector, like the odontologists, can not be paid for their contributions. Any conditions of foreign deployment are entirely undeveloped. There are no clear DVI management roles defined yet.

The AM team, the reconciliation team, and the ID Board are entirely not formed, their procedures are not regulated. The comprehensive and too detailed rules for crime scene investigation and death investigation simply block the cooperation between DVI and „regular” criminal work.

The place of the DVI Hungary in the system of public administration might be under the OKF (Hungarian National Organization of Rescue Services). The OKF already has a heavy urban rescue team (HUNOR), which can be deployed even in foreign disaster scenes.

Most of the team members are still enthusiastic which is largely due to the overall successful first deployment, and the exemplary collaboration with the South Korean colleagues.

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Pictures

Author 1 on scene recovery, after the Hableany accident, 2019

Author 1 performs an air injection method for fingerprinting after the Hableany accident, 2019.

Recovering the Hableany. https://hajozas.hu/wp-content/uploads/2019/06/Kiemeltek3-Hableany-Hajoroncs-Uszaly-Clark-Adam-Uszodaru-Hajozashu.jpg (2021. 02. 25.)

South Korean expert works together with a Hungarian college after the Hableany accident, 2019.

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Forensic odontologists performing dental record collection after the Hableany accident, 2019.

(Unofficial) badges of DVI Hungary

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Dávid Nemes, Ágoston Restás

DRONE APPLICATION FOR SUPPORTING PREVENTIVE FLOOD MANAGEMENT – CASE STUDY OF THE BÓDVA RIVER BASIN, HUNGARY

Abstract

Hungary is one of the most flood threatened country, therefore to make the preventive flood management more effective is a very important task. Authors show the drone technology, as a most developing part of the aviation, how it could help water manager specialist to make their work easier or higher effective. Study area was two dedicated places in the basin of river Bódva, where a valley dam made of concrete and a new embankment made of soil were analysed. In the first case some cracks were found on the surface of the concrete and in the second case a missing section and its effect in case of flood was demonstrated. Results show that drone technology can be a very effective tool in the hand of experts.

Key words: drone, drone application, flood, prevention, flood management, Rakaca reservoir

DRÓNOK ALKALMAZÁSA AZ ÁRVÍZVÉDELEMBEN – ESETTANULMÁNY A BÓDVA FOLYÓ VÍZGYŰJTŐTERÜLETÉRŐL

Absztrakt

Magyarország az árvíz által az egyik legnagyobb mértékben veszélyeztetett ország, ezért az árvízi védekezés hatékonyabbá tétele rendkívül fontos feladat. A cikkben a szerzők bemutatják a drón technológiát, mint a repülés legfejlettebb egységét, illetve azt, hogy ezek alkalmazása hogyan segíthet a vízgazdálkodásban. A vizsgáltra két különböző helyszín állt rendelkezésre a Bódva folyó medencéjében, ahol a szerzők elemezték a betonból készült völgygátat és a talajból készült új töltést is. Az első esetben néhány repedést találtak a beton felületén, a második esetben egy hiányzó szakaszt és annak hatását mutatták be áradás esetén. A cikk eredményeként bemutatják, hogy a drón-technológia milyen módon lehet hatékony eszköz a szakértők kezében.

Kulcsszavak: drón, drón használat, árvíz, megelőzés, árvízvédekezés, Rakaca víztározó

1. INTRODUCTION

Hungary's hydrological hazard - due to its geographical location – is the highest on a European scale. Because of its geographical location during the last few years quite a few hydrological cases endangered human lives and material goods. Hungary is catchment area, namely, more than 90 per cent of its rivers originate, come from abroad and it means: if floods occur in rivers' basins abroad, it may result in severe flooding in Hungary. The inadequate amount of water can cause damage be it floods, droughts or inland waters. 52% of the country is at risk from floods and inland waters. Most of the rivers in Hungary have violent flow regime, the Danube's biggest base flow several times exceeds its low water flow. In case of our smaller rivers this rate is even higher. The fact, that more than 20.000 square kilometres floodplain is located below the flood level of the rivers underlines the importance of flood protection. The arable land found here reaches almost 2 million hectares. A quarter of the total population of Hungary lives in floodplains, in 700 hectares. Floods over the years drew attention to the role and importance of flood protection systems. Increase in flood levels emphasized the importance of flood protection. [1] [2]

Intercatchment floodways play a prominent role in flood peak reduction. Security increases with the deployment of the system; in addition, flood protection costs are reduced. In the last years due to weather conditions a number of inland and local water damage have developed. Due to increasing water damage the protection of environmental safety has become a priority. Protection against floods and inland waterways has a multi-band annual tradition in Hungary. More than 4000 km long water meadows were built along our rivers [3]. Flood levels have risen significantly which is due, on the one hand, to extreme weather, on the other hand, deterioration of water transport capacity as a result of human interventions.

Flooding is nothing but unfavourable, extreme rainfall activity, or due to sudden snowmelt, a process that results in the flow of water leaving its riverbed. Consequently, areas not covered by water are temporarily submerged.

In Hungary there are some study focusing riverbed analysis or summarizing the options in case of flood management based on drone technology. In Hungary, the first drone application supporting flood management happened in 2010 at the north – east part of the country at a very serious flood [4]. In Hungary the most remarkable studies came from Bertalan at al. who made many experimental work with drones, some of them focused on the river Sajó [5] [6] [7] [8] [9]. Authors have also some works focusing on drone application in case of flood management [10] [4] [7] [11] [12]. Because of the wide range of drone application all of the country, we can assume that many pilot used his drone above river beds perhaps in case of floods however these applications were not worked up to publish, however the General Directorate of Water Management of Hungary also uses drones regularly supporting own work [13] [14]. Hungarian Army also uses drone for aerial monitoring in case of floods, the first one happened in 2013 at the flood of river Danube [15]

Characterization of the study area

The total length of the river Bódva is 113 km, of which the Hungarian section is 64.6 km. The average fall of the riverbed is 83.8 cm / km, so it is the steepest of the rivers in Hungary. Width of the river is vary, usually 8-14 meters, the average water speed is 2–4 km / h, depth is 0.5–1 m. Water flow is in dry season can drop below 0.5 m^3 / s, however in case of flood the flow can rise up to 80.0 m^3 / s, that means more than 160 times higher volume! The average water flow at the estuary is 6.92-9 m^3 / s. [16]

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

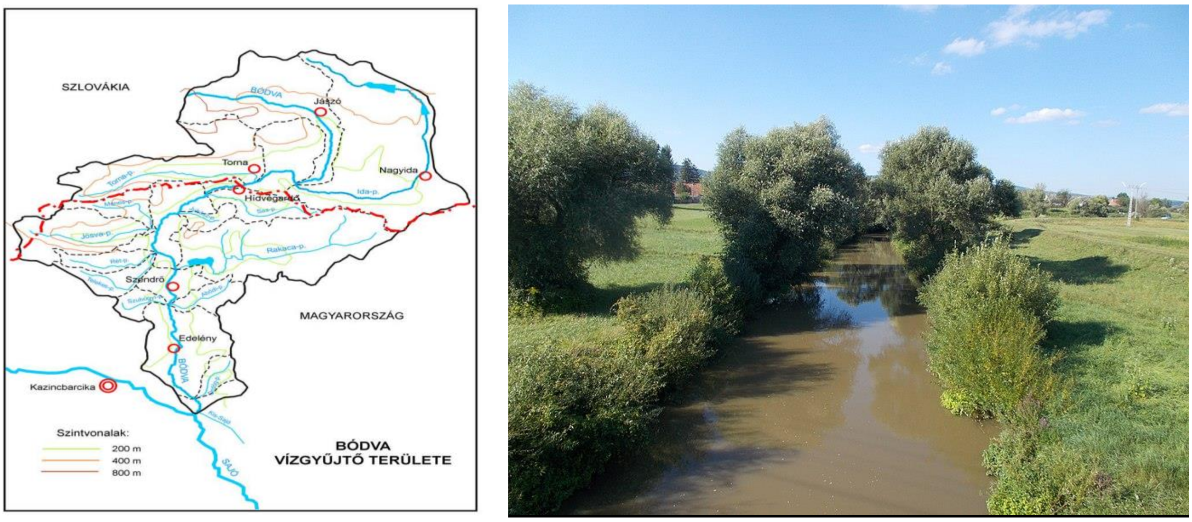

Figure 1 - The total catchment area of the river Bódva (left) [16] and a typically characteristic section at city Szendrő, Hungary (right) [17].

Rakaca-reservoir is a special place of the Bódva river basin that was created in 1963. It can be found in a valley between two villages: Szalonna and Meszes. The reservoir can store 5.5 million m^3 water; the catchment area of the dam is 233 km^3. To prevent flooding of downstream settlements Rakaca Reservoir plays an important role, as if it is well designed, built and executed, then in the event of a sudden heavy rainfall it can conduct the water mass continuously and the peak flood yield intermittently [18].

Figure 2 - Aerial view of the Rakaca reservoir (north view – left;
east view from village Meszes – right)

2. DRONE APPLICATION AT THE RAKACA RESERVOIR

Having damage free dams and the accessibility of the beds are essential factors in successful flood control, which contributes to the drainage of excess water. A couple of flying can help with measuring the condition of flood defence structures in a larger reservoir within short time. Structurally it can be planned in advance, since later, with the application, which was also used, the flight could be planned in advance in the area we want to fly. Illegal activities, like fishing on flood control structures can be discovered in time and the necessary measures can be taken in a timely manner.

Flight planning is very important task to ensure the flight safety and to make the work effective. The aerial mapping of the reservoir dam had been planned on an Internet platform. This application makes available:

- Preparation of flight plans in advance;
- Automat imaging, flight, take-off and landing;
- Automat flight disabling;
- Mapping of large areas within short time.

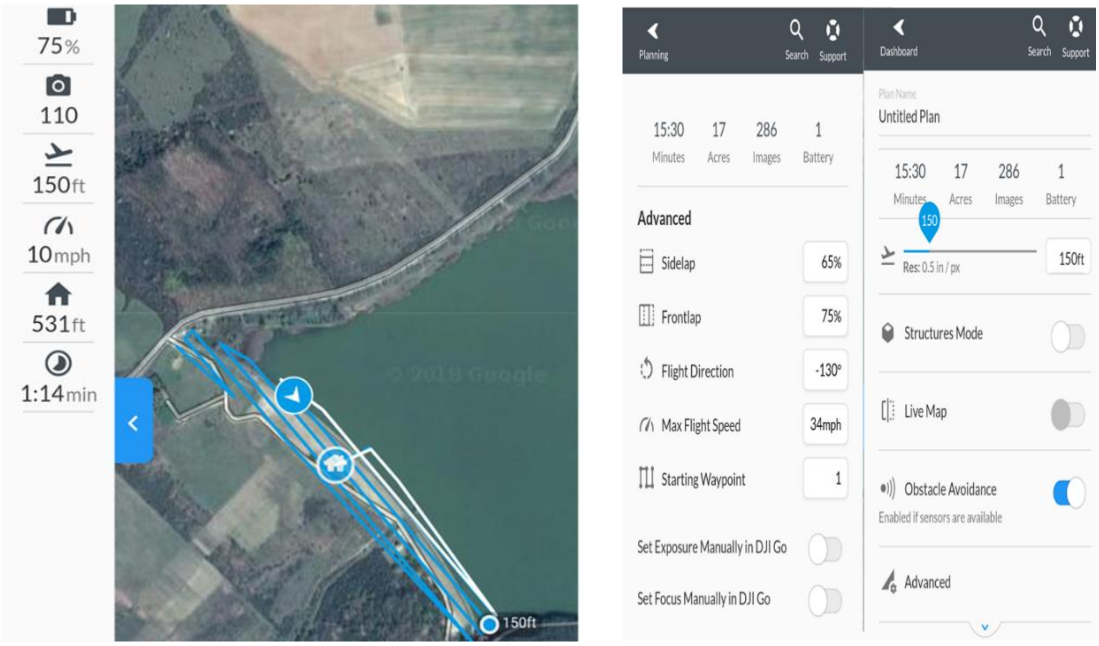

Figure 3- Flight path above the dam (left) and the setting option of the platform (right).

A distant top view have been made about the flight plan for easier geographical identification and a closer top view to make the route of the plan visible. The area surrounded by the blue line is the area authors will get information about with the help of the drone based on what is set in the application. The lines marked in blue show the route of the drone during its flight (Figure 3, left). The flight route is set in a way to have a continuous overlap in both the forward and lateral directions. Author as pilot set the Rakaca-reservoir and the drone fly around it.

Before starting the flight, pilot had several setting options:

- The starting point of the flight
- Overlap in flight line when taking pictures
- Flight side overlap when taking pictures
- Flight speed
- Flight altitude
- Monitoring the flight
- Ability to take 3D images at the end of a flight

After selecting the area, the application shares every important information with us, for example, how much time the flight will take, which depends on the flight speed and the flight altitude (Figure 3, right). In this case, it took 15 minutes. During the flight, the drone took 286 pictures and flew in 18 acres. While planning the flight the application can tell how many batteries are needed.

Results of the flight

The flight was planned to discover adverse phenomena. Cracking on the flight protection dike is the most common fault and no flooding is required for its formation. Cracking can lead to mass movement of the dam filler, due to the alternation of water-permeable and water-tight layers. Water enters the saved side through the cracks, so the embankment has only a slowing effect in flood protection. Here is some important measures in flood protection:

- Reinforcement of flood protection dike
- Dredging of the riverbed, riverbed stabilization
- Increase water space
- Building sump pipe

- Maintenance of the intercatchment floodway

Riverbed stabilization is one of the main purposes of the dredging- mud dredging –is to increase the bed cross section. With riverbed stabilization interventions we can prevent undesirable transformations, it is important to make the bank of the reservoir secure. During the works, the vegetation may be damaged, but flood drainage will be improved.

The purpose of water retention is to drain excess water and this way reduces the water level and the risk of flooding. As it was already mentioned, Rakaca Reservoir plays important role in reducing flooding and in storing excess water in the stream. Authors personally observed that in springs, due to snowmelt, water flow of the stream increased significantly, along with it the water level of the reservoir also increased sharply. The same phenomenon can be observed after heavy rainfall.

A stone dam was established at the junction of the reservoir and the stream to prevent siltation. The section in front of the stone dam became engorged over the years and it posed a threat to the villagers of Meszes. It was possible not only to build a stone dam but to extract the sludge accumulated at the stone dam, which was about 3200 m^3 [19] Here the emphasis is on the elimination of siltation, which is harmful to the drainage of floods. The main purpose of riverbed dredging is to ensure riverbed stabilization and to increase the bed cross section.

Deforestation causes soil degradation. Afforestation is required around the Rakaca reservoir. Drones may allow the extent of deforestation to be assessed and the delimitation of areas affected by soil erosion [20]. Due to the unfavourable land use and the lack of sewerage at the recreation area, the lake started to silt up. The necessary improvements were lagging behind in series, which of course had negative effects. The most serious problem is the leaching of the sludge, which has had restrictive effects.

The construction of intercatchment floodway can have positive effects ecologically. With proper water supply, it increases biodiversity. As for flood protection, the construction of intercatchment floodways and ditches is essential. The main aim is to distribute excess water in case of a flood, thereby reducing damage. Vegetation obstructing the flow of water must be removed from the beds. The water supply of the industrial area mentioned earlier flows into the Bódva stream through the canal shown in the picture.

Figure 4 - Photo of the normal floodway of the dam (left) and one of the crack author noticed during the flight (right).

During the flight, author noticed a crack in the concrete structure of the intercatchment floodways which may make protection more difficult during a flood period or may contribute to an undesirable phenomenon (Figure 4). The more layers or more permeable layers there are on the surface, the sooner the water penetrates the embankment.

The dam of the Rakaca Reservoir has a built-in drain at the front of the dam, which has an important function. During a flood, meteorological or other hydrological event, excess water can escape, so the dam is not exposed to too much pressure, which could lead to a possible dam failure. The purpose of the flight at the drain was to detect cracks or rust and to determine whether it was suitable for the task. In the event of a crack, after heavy rains, there is a risk that it may loosen its structure by entering the embankment through the crack. It is important to assess its condition occasionally.

Figure 5 - Photo of the water-draining canal of the dam in case of normal weather condition (left)[18] and in case of flood (2010) (right)

During the mission, author took pictures even at the mudguard dam to map the riverbed line. Flight was performed in order to explore the undesirable phenomena that appear after the riverbed maintenance works were carried out.

Figure 6 - Photo of the mudguard dam made to reduce the negative effect after heavy rain.

At the mudguard there were no found any anomaly, it seems it is a useful part of the reservoir to keep its condition well.

3. ADVANCED DRONE APPLICATION FOCUSING ON THE RIVER BANK AT SZENDRŐ CITY

Szendrő city is located at a wide basin of the river Bódva at the middle part of the Hungarian river section. Water flow can slow down in case of flood therefore it can cause serious problem many times (Figure 7). Szendrő is a flood threatened city with about a 5 thousand population.

Figure 7 - Aerial photos of the flood at Szendrő in 2010.

The most commonly used protection facility for flood control is the flood defense embankment, which reduces the size of the area flooded. Latest time new embankment has been built in Szendrő, which provides safety for the people living there. Above the construction area, some drone flights were carried out to show the building operation and the result (Figure 8). The procedure of the flight planning and the preparation of beginning of the flight was basically the similar as at the Rakaca reservoir before.

Figure 8 - Selected study area of the construction at the north part of Szendrő (left) and a mosaic photo made by drone during the flight (right) (with the permission of drone pilot, Bence Bodnár)

During the flight many high resolution ortophoto were taken and then with a software a 3D mosaic photo was created. Naturally, it takes time depending on the resolution of the photos and the capacity of the computer, however later we can analyse the completed photo with as detailed as the resolution of the original photo allows. We focused on the south part of the photo and we found a missing section of the construction that is obviously made for the stream or canal that joins to the Bódva river about 100 metres.

Figure 9 - South part of the study area where a missing section found at the construction (with the permission of drone pilot, Bence Bodnár).

We made a test with a flood model what could happen in that case this missing section would not managed by water management specialist. 3D flooding models for the missing dam section show that in case of a possible flood, the incoming water floods the buildings behind the embankment, which can cause extensive damage. Authors assume this section of the embankment is not finished yet; an added technical solution must be carried out soon.

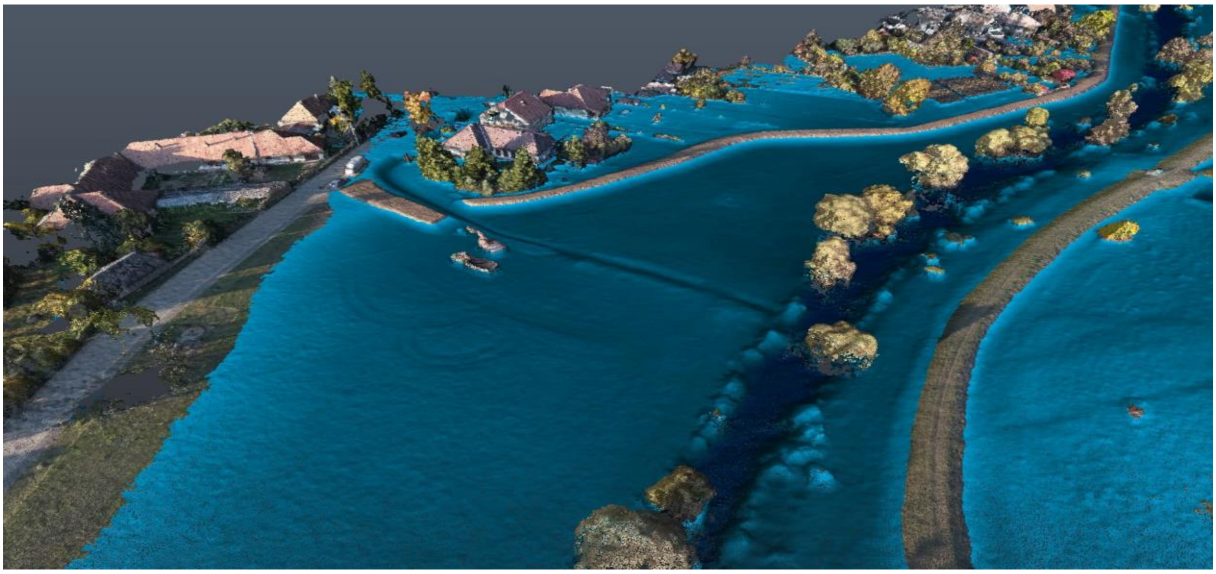

Figure 10 - Using the flood model it can be seen that without added technical solution the settlement area can be flooded by the river Bódva (with the permission of drone pilot, Bence Bodnár)

An orthophoto is a type of scaled photographic map on which measurements can be made perfectly as if it were a standard map. Orthophotos can be taken much more easily than traditional maps and can be reproduced regularly thanks to the cost-effectiveness and fast operation of drones. The accuracy of the orthophoto is directly proportional to the resolution of the image captured by the digital camera. The drone scans the area during image capture, with parallel axes and offsets of a few degrees, to accurately achieve stereoscopic human vision through the camera. [21]

A point cloud is a set of data points in space. Point clouds are usually generated by 3D scanners that measure a large number of points from the outer surface of objects in space. Point clouds are used for a variety of purposes, including creating 3D models, for visualization and animation purposes. In the geographic information system, point clouds are one of the productions of a digital elevation model of the terrain. The point cloud is a digital representation of space in three dimensions. It is created by laser scanning of existing spaces, buildings, dams, floodplains, which connects hundreds of thousands of such spatially coordinated points. [22] [23]

4. SUMMARY

This study focused on a flood threatened area that is the basin of the river Bódva and its vicinity. Two places were dedicated to use drone making aerial photos, the first one is the Rakaca reservoir, the second one is the north part of city Szendrő. In the first case authors focused on the valley dam and its damages and in the second case on the new embankment and its missing section. Dam of the Rakaca reservoir is made of concrete, the embankment is made of soil found at the vicinity of Szendrő.

At the first case authors showed the basic elements of the flight planning and the preparation requirements of the drone flight, then the results were pointed out based on the analysis of the photos made by the simple drone. At the second case, a high-resolution camera was used with an other drone and possibilities of the capability of drone technology were demonstrated. In both cases we can see that drone technology can be a very effective tool in the hand of experts and it is able to support water management specialists to make their preventive flood management more effective [24] [25].

The results of the paper confirm previous research that has also suggested the use of novel technical tools and vehicles in the field of firefighting [26] [27] [28] and protection [29] [30].

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Katalin Berta

INVOLVEMENT OF ANIMAL RESCUE ORGANIZATIONS IN DISASTERS

Abstract

It is a socail need to protect animals in the XXI. Century. In my research, I examine the relationship between civil animal rescuers and Disaster Management. Animal rescue is a technical rescue, so it is a duty of Disaster Management. Act No. CXXVIII. of 2011 allow the Rescue Manager to involve voluntary organizations in disasters, and to consider rescuing animals, when the absence of intervention causes the death of the animals. My experience in this direction shows, the animal rescue organizations have such a specialized knowledge and tools, that the integration of these organizations in to the education would be timely, all so in the rescue and alarm order. I present and prove through my own experiences in such cases.

Keywords: animal rescue, Disaster Management, technical rescue, flood, red sludge

AZ ÁLLTAMENTŐ SZERVEZETEK RÉSZVÉTELE KATASZTRÓFÁK SORÁN

Absztrakt

A XXI. században társadalmi elvárás az állatok mentése katasztrófák során. Kutatásomban vizsgálom a civil állatmentő szervezetek és a Katasztrófavédelem kapcsolatát. Az állatmentés a műszaki mentés témakörébe tartozik, ennél fogva a Katasztrófavédelem feladata. A 2011. évi CXXVIII. katasztrófavédelmi törvény lehetővé teszi önkéntes szervezetek részvételét katasztrófák során, a mentésvezető kezébe adva ennek lehetőségét, valamint utasítja a hivatásos állományt a beavatkozásra, amennyiben az állat élete ennek hiányában veszélybe kerül. Ezirányú kutatásaim rávilágítanak, hogy az állatmentés szaktudást igénylő mentés, ahol speciális eszközök is szükségeltetnek. Ennek integrálása, oktatása és a riasztási rendbe való beillesztése időszerű. Több, mint húsz éves állatmentő tapasztalatom késztetett, hogy ezt vizsgáljam, így saját tapasztalataimon keresztül mutatom be és igazolom állításaimat.

Kulcsszavak: állatmentés, katasztrófavédelem, műszaki mentés, árvíz, vörös iszap

1. INTRODUCTION

The circumstances employing of volunteer ambulances have changed a lot over the years, as has the attitude of the professional staff towards animal rescuers. In connection with four disaster cases, I present the activities of animal protection organizations and their operation with disaster management authorities. It is of significant importance that I place the backups in chronological order.

There has been a change in the use and supply of overheads, and I will indicate this in the description of each case. It is unfortunate that an organization specializing in animal rescue has not been certified by INSARAG, so their involvement in disasters is uncertain, and this area of technical rescue will continue to be a challenge for Disaster Management. An important element of preparing for the defense and participating in the defense is to get to know the activities, tools, organizational structure and management of the participating organizations. According to my proposal, it would be important to establish a national animal rescue organization with county organizations, automatic involvement of active animal rescue organizations in case of disasters, setting up a voluntary veterinary duty service, reforming firefight training with the participation of animal rescuers, hunters and veterinarians [4].

2. FLOOD GEMENC, 2002.

In August 2002, due to heavy rains, the Danube exited the riverbed. Representing 7 organizations, 45 staff took part in the flood animal rescue in Gemenc. Animal defenders visited a significant part of the flood-affected forest area with the permission of local authorities and the National Directorate of Disaster Management, led by local forestry professionals, and rescued many injured and weakened animals. The team of agricultural engineers, vet assistants, hunters, biologists and veterinarians provided professional care for the rescued animals at two locations with two equipped boats and a well equiped background base.

The foresters welcomed our application as the rescue hills proved to be few. On one occasion, an officer from the professional staff of Disaster Management came to our station who was interested in advancing or hindering the work of the forester. We did not receive any supplies or protective equipment. The four-person rescue team I led worked for four days under the direction of the Gyöngyösoldal forester, with full self-sufficiency.

Special tools:

- motor boat
- Straps
- Nozzle with narcotic for vets only
- Loop stick
- Boxes
- Warming blankets
- Bags
- Infusions and other veterinary first aid equipment
- Protective clothing
- Life jacket
- Clamping net
- Binoculars
- Flashlights, headlamps, reflectors
- Wire cutters and other hand tools

After the flood, the animal rescuers sent an open letter to the Disaster Protection, nature conservation authority, water management authorities and forestry, in which we described proposals for the future. These included forestry-related proposals, but we also shared our views in which disaster and law enforcement can take action in the future. These include preventing transit traffic and setting up related restrictive measures.

3. RED SLUDGE DISASTER, 2010.

On the evening of October 4, 2010, we were given permission to enter the area flooded by red mud. We have a direct contact to the mayor and the authorities, he was the civil animal rescue coordinator. He was notified by the National Directorate of Disaster Management. We had to provide our full name, ID number and contact information in order to participate in the rescue. Each time we entered the area, we had to apply to the Mayor's Office and we were given permission to enter the already closed areas by naming the direct contact person. Our task on the first night was to provide veterinary and first aid according to need-based principle, to transport and secure the injured animals according to our capacity, and to prepare a photo document. Over time, the nature of the rescue changed, because while on the first day the solution to those in crisis was primary, later we rescued of the animals that had been hidden by fear. One thing did not change: in each case we wore protective clothing, dust masks, rubber gloves - we could buy this from the Civil Protection, and the contaminated animals had to be washed with water as the very first step - we used the help of the fire department.

(Photo 1.). Although it is right and obligation to provide first aid, as animal rescue is a special topic, our many years of experience seemed worthwhile - in a disaster situation it is extremely important to know the behavior and reactions of animals [5]. However, the basic principle is that in the event of a disaster, the priority is to save human life, to prevent economic damage - but this must be followed by the rescue of animals under the growing social pressure of recent years. Unfortunately, this is compounded by the fact that there are few well-trained animal protectors and there is currently no apparatus within the authorities.

As a long-term goal, I would consider the importance setting up an animal rescue unit for emergency use within disaster management. The team would perform a complex task: prevention-response, rescue-transportation, placement-care, rehabilitation-repatriation. Documentation is a very important and unmissable step: checking the microchip, taking on-site photos, accurately recording the location, placing the animal in a transport box.

Photo 1 - In cooperation with disaster management at Devecser - Dankó site (Photo: author, 2010.)

Quick information

There are 62 factory classified as dangerous in Hungary, which have a disaster plan. It was important to have a basic knowledge of the nature of the material, the evening news of the public service channel helped us - at least we learned that the slurry is alkaline, highly corrosive, so we left Budapest already equipped with rubber boots and gloves. This preliminary information also mattered a lot in knowing what injuries we could expect, what kind of first aid kit to prepare. We had a large amount of water and physiological saline, sedatives, transport boxes, fasteners. In the event of a disaster, you must always be prepared for the unknown source of danger, which can even mean an fear-aggressive animal! In case of damage caused by alkaline substances, a long rinse and vinegar neutralization are required, as well as hair removal of the soaked area as soon as possible - if this can be solved on the spot. At the Mayor's Office in Devecser, lukewarm water was made available to the rescuers on a permanent basis if we arrived with an injured animal.

Accomodation problems

We also had to clarify the issue of the accomodation of the animals. The animal must be quarantined for the first 14 days of care, during which time food and health care must be provided. Most of the animals we rescued were taken care of by the Rex Dog Home Foundation, where they were under 24-hour veterinary supervision [7]. Due to the special nature of the disaster, the mortality rate was very high, as this type of heavy metal poisoning is not reported in the veterinary literature, so there is no experience. A total of about 600-800 animals were housed or provided on site by animal rights activists. In addition to the returning owners, the animals remaining on the evacuated Kolontár (both farm and companion animals) were also fed in a precise schedule by the animal owners [1]. As the mayor of Devecser, Tamás Toldi, who was also the chairman of the defense committee, was responsible for the remaining livestock, we were able to get to the area of operation, which was guarded by police officers (Photo 2).

Photo 2 - Feeding the remaining animals in protective clothing in Kolontár (Photo: author, 2010.)

Accommodation and care of rescued animals

Animals housed in shelters and shelters required daily veterinary care. It consisted of bandaging, disinfecting, infusing their wounds. Artificial feeding of corrosive animals, even by gavage, is a time-consuming and demanding task. It is important to emphasize that animal rescuers worked exclusively on their own funding, commitment, professionalism and although they were not trained in disaster / civil protection, they instinctively did everything calmly. Make human life a priority, the obligation to register, cooperation with the authorities. I worked with Civil Defense myself all the way, I could to a dangerous area only by their instruction, permission and help [6].

Partial conclusion

The conclusion can be stated and drawn:

The first successful cooperation of the Hungarian animal welfare authorities with the authorities was the 2010 red mud disaster. The authorities, be it the Police, the Civil Protection, the Fire Department, considered the rescuers as partners. They helped us keep the animals on site, notified us of the animals in distress, firefighters washed the muddy animals and the police escorted us to the evacuated Kolontár for feeding. As the national chief veterinarian [2] is a member of the Coordination Committee is, it can be said that animal protection, rescue and veterinary organizations also have the right and obligation to take part in the rescue, but this has a strict protocol. We must acknowledge that the work of a given organization is directed by the mayor and the operational tribe.

Arriving at the venue

It needs to be examined what the incident is, is there a specific discharge plan?

If not: according to the principle of need, the injured must be taken care of, placed and transported in the order of injury. On the spot, we had to consider who the individuals in need of immediate care and removal were and who we could secure on the spot.

Geographical zones must be defined. Local knowledge is essential!

Equipment should be surveyed and purchased. On the first night we worked with our own equipment, according to the information we received, we provided ourselves with protective equipment. Later, we were able to equip ourselves in the Civil Protection distributors, at these distribution points were also accumulated the pet foods that were sent by the donors and from which we had to supply.

A mobile or stable base must be developed. Our mobile base was the ambulance, where the transport boxes and the first aid box traveled with us, and the yard of the Devecser's Mayor's Office served as a local stable base.

Change needs to be organized as well as communication taken care of. In our case, it worked by notifying us or notifying each other on the phone numbers we provided at the Mayor's Office. In my view, a locally usable radio transceiver would have been more practical and cost - effective, which would have been recorded or handed over by the rescuers at the end of the work.

Medical devices must be provided. We also made this our own foundation, be it disinfectants or bandages. The veterinary care of the animals housed in the shelters was carried out by a veterinarian contracted to the shelter.

Means of transport and cordons must be provided. Transport, light, and race characteristics must be taken into account during transport! We transported the injured with our own boxes and secured them with trusses and straps. It would have been more practical and cost-effective to be able to build a quarantine yard on site made up of cordons. The constant involvement of nursing staff and veterinarians is essential for this.

In the future, care must be taken to resettle the animals and to keep in touch with the owners. Reinstallation can occur when conditions are optimal. In case of doubt, the decision is within the competence of the clerk. The return and its circumstances must be documented!

4. THE FLOOD OF THE DANUBE IN 2013, THE "FLOOD OF THE CENTURY"

I was assigned to the in Lakitelek - Üdülőtelep. Even at the beginning of the flood, I applied for admission to the volunteer line and was then referred to Lakitelek. Here, no one could enter the area of operations without prior data reconciliation and registration in the disaster management tent. Here it was possible to buy rubber boots, rubber gloves, take mineral water with us, free kitchens and rest areas were set up here for professional authorities and volunteer ambulances.

A couple of animal rescue colleagues and I visited the edge of the settlement near the water, which is projected to be flooded by the Danube. We walked from street to street and conducted a survey of where, how many and what kind of animals are found. The owner goes or stays, can take the animal with him, puts him in safety, or leaves him to his fate.

It was important to know what to expect if the power was turned off and evacuation began. For the rescued animals, we were given a temporary area in the area next to the registration tent, where we would have had the opportunity to place the animals either in boxes or moored during the rescue.

Despite the survey and ongoing information, we were once notified at night that someone could hear the sound of an animal drowning from a flooded garage. The area was already de-energized, so we got on the water with the help of disaster relief, the police, and a rescue association on site.

Photo 3 - The saved animal must be placed in a lockable box! Created by the Author 2013.)

We carried out our work on this rescue, under the direction of the Disaster Management and the Mayor's office, with a free hand, once with the help of the police: the owner refused to place his breeding rabbits in a sheltered place, despite the call, he wanted to leave the property. We immediately asked for and received police assistance, as well as ten main volunteers who loaded the rabbit cages to a high point. And on one occasion, we had to go into the water in an already flooded area for a public announcement. Even then, with the approval of the disaster relief, we were able to sail out to the flooded area for a trapped animal with civil escort (Photo 3).

Partial conclusion

From this case it can be concluded that huge progress has been made in the field of disaster management for civilians, on the basis of which it can be booked that there is / would be a need for animal rescuers in the field of disaster management. In the XXI. century we have reached the level of moral development, where we see that need is independent of the number of feet.

5. WEATHER DISASTER (RESCUE OF THE RED LISTED ANIMAL), 2019.

On May 30 in 2019, the company consisting of "Nestling and Bird Rescue" volunteers received a public announcement that the chicks were endangered due to prolonged rainy, cold weather (Photo 4.) in the camera-packed white stork nest in Csány.

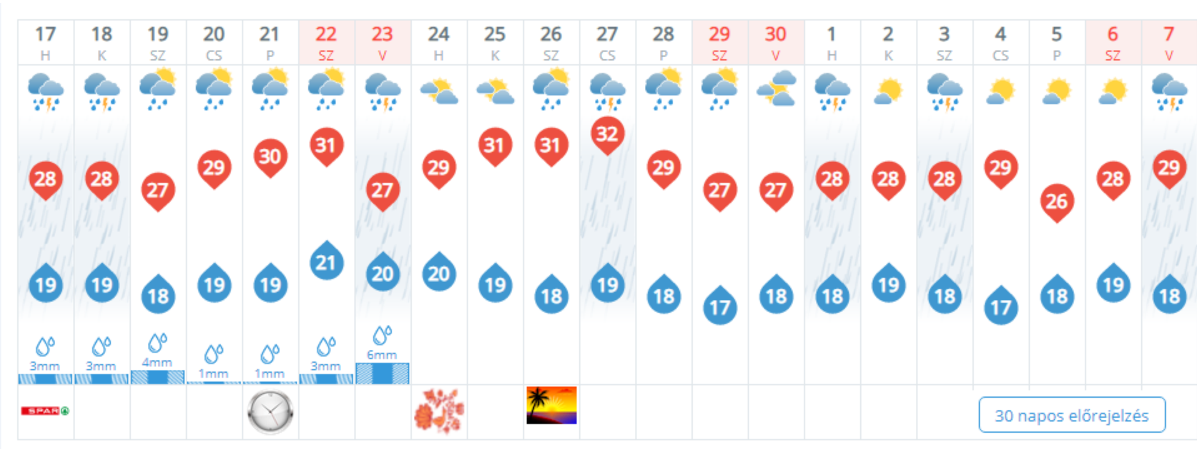

Photo 4 - Adverse weather. Source: időkép – 2019.

Based on the camera footage, the chicks were muddy, soaked, and due to the long-lasting rainy, cold weather, the parent was in a similar condition and could not keep them dry. The nest was muddy and soaked (Photo 5.). Since the nest is on top of an air defense siren, between E-ON columns, we asked for help from Disaster Management. Their job would have been nothing more than to lift up a colleague of ours to reach to the nest.

Photo 5 - The soaked nest. Source: Stork Exchange International, 2019.

In the case of a red listed animal, the competent National Park may officially intervene or a registered rescue station registered with their approval. This time it was available, however, we received a negative response from Disaster Management citing the high cost of disembarkation. Being Friday afternoon, the electricity supplier did not respond. This caused difficulties in recovery [9].

Partial conclusion

Uncertainty could be experienced in the case, i.e. the offices and authorities are in many cases unaware of the specifics of the situation. What would have been expected here - limited to Disaster Management:

- Being a highly protected species, the issue of the white stork's nest receives special attention
- the principle applies, if the animal dies in the absence of intervention, rescue is required!

- assumes other dangers: windy weather may have been dangerous for soaked nests of up to 500 kg, more specifically the syren and e-on pylon.

It can be seen that the civil ambulances were ready with a concrete plan in the knowledge of racial peculiarities, physiological and anatomical specialties, the cooperation failed due to the lack of knowledge of the legislation [8].

6. CONCLUSIONS

The actuality of the topic of my dissertation is given by the fact that the disasters of recent years have also affected the fauna, and as a committed volunteer I consider importance of paiying attention to this loss as well, and that animal rescue tasks be precisely regulated. I emphasize the participation of volunteers as well as the importance of complex education. The handing over of these tasks is a priority in events where, in addition to human life and property damage, the rescue of animals is not negligible.

This activity is a technical rescue, but it can be classified as a special rescue, as it requires special, above-average training, knowledge and experience.

Discussing four incident, I described separately the ways in which animal rescuers participated, the issues of staying there, and the follow-up work. I explained the importance and specificity of each step.

According to my proposal, the current Hungarian Animal Rescue Association should be included in the alert system, as its goal is to effectively serve the protection of man, animal and the environment in case of disasters and extraordinary events - operating in strict order with the professional herd!

Under the guidance of the authorities this organization could go through the National Qualification Procedure and be officially alerted in cases where an animal is endangered or endangered by an animal.

The case studies show the special equipment used by rescuers in some situations, which are not on emergency vehicles, but are essential for the professional handling of animals and the background work required for the safe transport and accommodation of rescued animals.

I also recommend extending the education to animal rescue information on the basis of a foreign sample, since the XXI. century, it cannot happen that an individual of a highly protected species remains without state aid! In addition to Disaster Management, representatives of hunting companies, veterinarians and non-governmental organizations can take part in this training, where they would supplement the training in accordance with their own fields of expertise. In the cases listed, it can be seen that different animal species are saved and these animals have different needs and patterns of behavior.

My highlight and my heart's concern is the priority given to wildlife, in addition to being qualified by law, it is important to save every individual in the shadow of a climate disaster!

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APPLICATION OF UNMANNED AERIAL VEHICLE IN EXTREME INTERVENTION CONDITIONS

Abstract

Along with the purchase of the drones, The Fire and Rescue Corps members started to be trained as the drone pilots. The pilots can encounter different dangers and limitations during their intervention flight. We have decided to analyse the possibilities of the drone use in extreme intervention conditions within the F&RS. Slovak fire departments are gradually modernizing their equipment. Currently, the drones able to monitor the area quickly and effectively are emerging. Slovak Fire and Rescue Corps (HaZZ) started to update their equipment and purchased first drones from DJI Mavic 2 Pro company. Pilots can encounter different undesirable circumstances which influence the functionality of drone. The main goal of the research was to experimentally test the unmanned aerial vehicle in particular extreme intervention conditions.

Keywords: Unnamed aerial vehicle, extreme intervention conditions, fire department

PILÓTA NÉLKÜLI LÉGI JÁRMŰ ALKALMAZÁSA EXTRÉM KÖRÜLMÉNYEK KÖZÖTT

Absztrakt

A drónok megjelenésével megkezdődött a drónpilóták kiképzése is. Ezek a pilóták különböző veszélyekkel és korlátozásokkal találkozhatnak repülésük során. A szerzők elemzik a drónok extrém intervenciós körülmények közötti felhasználásának lehetőségeit az F&RS-n belül. A szlovák tűzoltóságok fokozatosan korszerűsítik felszerelésüket. Ennek eredményeként megvásárolták az első drónokat a DJI Mavic 2 Pro cégtől. A drónpilóták olyan nemkívánatos körülményekkel találkozhatnak, amelyek befolyásolhatják a drónok működését. A kutatás fő célja a pilóta nélküli légi jármű kísérleti tesztelése volt, különösen extrém beavatkozási körülmények között.

Kulcsszavak: pilóta nélküli légi jármű, extrém beavatkozási körülmény, tűzoltóság

1. METHODS OF RESEARCH

The main methods of research were the experiments applied in different difficult conditions during the intervention. The necessary items for the experiments were: GPS, camera of the drone, radio altimeter, anti-plugging sensors, camera documenting the experiment, military smoke bomb, combustible substance, radio communication with the airport to obtain the information about weather conditions such as wind, humidity and air pressure. Drone pilot and drone flying instructor were also included in the experiment [1].

Picture 1. First drones from DJI Mavic 2 Pro company.

Specific methods of the experiments

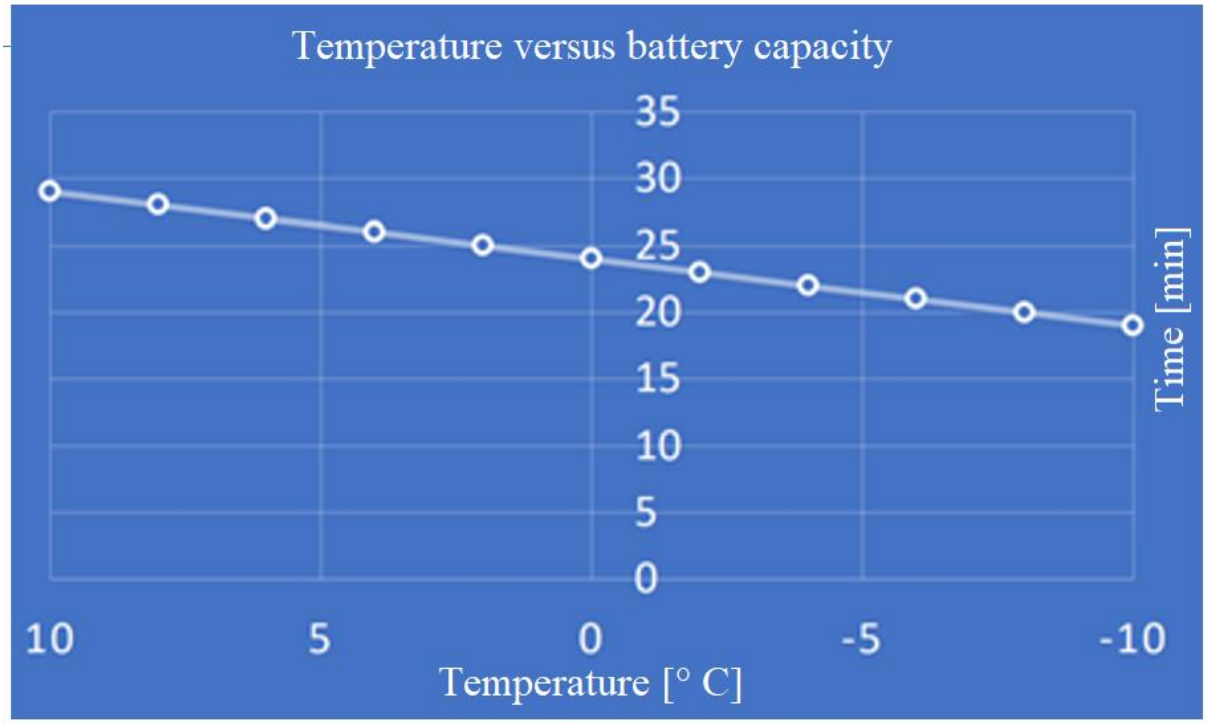
We have tested the drone for his ability to resist to icing. The drone was placed in the refrigeration box in the Aerorest restaurant where we performed two independent measurements to observe the temperature by the thermostat and the thermometer inside the box. We have also measured the time of battery life needed only to be able to fly using the unti-plugging functions. In the next experiment, we focused on the influence of the heat, the smoke, the ability to fly over the water area and the range of visibility for monitoring of the surroundings. The following equipment was used during the experiments: the GPS, drone camera, altimeter radio, unti-plugging sensors, camera for documenting the experiment, military smoke bomb, flammable liquids, radio communication with the airport to obtain the information about weather conditions such as wind, humidity and air pressure. The following information were documented, evaluated and represented in the charts and graphs [2,3].

The methodology was as follows:

- resource and information collection and analysis regarding the given issue;
- consulting and comparing the information related to the topic;
- analysis of the external influences on the drone;
- application of the experimental flight to define the behaviour of the drone during the extreme intervention conditions;
- proposing the method of drone flying in difficult condition of intervention (low temperatures, freeze, smoke in the air, flight over water area).

Experiment no. 1: The influence of low temperature on battery life

Flying in lower temperature can cause the decrease of battery capacity which influences not only the flying range but also the characteristics of the quadcopter itself. Low temperature can also form the icing on the leading edge of the propeller which influences the extrusion force of the propeller. Low temperature can also form the cover of frost on the construction which will influence the take-off weight [4].



Picture 2. Influence of temperature on battery life

Experiment no. 2: Influence of freeze on the flying qualities

The icing might be formed due to multiples influences such as humidity, the temperature and the height we have set [5,6].

Picture 3. Frost formed on the leading edge of the propeller during flight in cold and humid air [7].

Experiment no. 3: The functionality of radio altimeter over the water area

The quadcopter is equiped with altimeter radio, which is situated in the bottom part of the drone.Altimeter radio sends the signal to the area below the drone which is reflected and based on this information the drone is able to set the propriate height.

Pictures 4. and 5 - The positioning of radio altimeter on quadcopter and experimental tank [7].

Experiment no. 4: The influence of smoke on drone functionality

During the fire, the enviroment is smoky which is the obstacle not only because of the visibility restriction but can cause also another possible dangers. Fire smoke contains the ash which can enter the rotors and cause the malfunctioning. These problems will be common for pilots as the drones should be used for forest fires and fires of bigger buildings. The direction of the smoke can change due to the wind which will worsen the flight in given environment. The pilot should therefore anticipate and foresee the weather change [6].


Pictures 6. and 7. The drone flying around the fire and through the smoke [7].

The closer to the heavy smoke and the longer time spend in such an environment, the more the drone increase its output. Although no failure has been noted. Afterwards, the drone has landed and we have checked the condition of the rotors. There was a small particles of ash nearby the electric motors. Flight in heavily smoked environment with high contain of ash and fire fumes can cause the malfunction or damage to the electric motors. Therefore, it is important that pilots avoid a heavily smoked area [6].

2. RESULTS OF THE EXPERIMENT MEASUREMENTS

1. Experiment - drone copes with the low temperature quite well and the battery life is degrading gradually and not very fast. The lower the temperature, the shorter the battery life.
2. Experiment was unsuccessful due to the low humidity in refrigeration box in which we tried to make the frost cover on the leading edges.
3. Experiment showed that the radio altimeter on quadcopter reflects the signal from the pool bottom during the flight over the pool, and therefore the quadcopter started to lose the altitude.
4. Experiment showed that the drone loses the stability due to the heat release. The turbulence occurred nearby the fire. The quadcopter engines were slightly clogged with fly ash.

3. DISCUSSION

Unnamed aerial vehicles can be used effectively in any field of defense sytem. It can be in the field of the disaster management [8][9], economy [10], safety system [11] or in the crisis management [12].

When flying a drone, it is essential to considerate civilian security and pilot's abilities. Since the drone can cause the fall of the rescue helicopter in case of accident, it is crucial to think about the potential danger. The abilities of the drones influenced by the extreme conditions of intervention are limited.

We found out that the battery life shorter with the lowering temperature.

If the frost covers the leading edges of the propeller, the compressive force of propeller will decline and prevent the capability of flight.

We also discovered that while flying over the water area, the drone should have meters in attitude to spare.

We need to avoid the heavily smoked area during the exploratory flight.

4. CONCLUSION

Drone is equipped with the newest technology, which helps during the flight. It is highly recommended for pilots to fly in fully automated system using the sensors which might help to avoid the collision.

Although, it is necessary to have skills and knowledge to flight in manual mode in extreme condition of intervention and to be aware of potential risks.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

László Bodnár

EXAMINATION OF THE CARRIED OVERLOAD FOR FIREFIGHTERS WITH A PHYSICAL LOAD TEST

Abstract

People have been in constant contact with fire throughout the history. During this time, they also learned the beneficial and dangerous effects of fire. Lot of fires generate all over the world, so the science of firefighting needs constant research and development. It is a fact that the physical work of firefighters is tiring. It has a bad affect to the health of firefighters in case of a long time intervention, so the physical performance of firefighters should be increase. In addition, reducing the physical load also provides an opportunity to increase the effective intervention. In the paper, the author points out the limitations of the load capacity of firefighters and demonstrates the need to increase the ability to extinguish with free movement. In order to achieve this objective, the author conducts an own test, which does not require significant resources, but their results can already provide guidance for a tool development. As a result of the test, he proposes to use a novel, innovative technical tool during the firefighting.

Keywords: test, overload, burned energy, elapsed time

TŰZOLTÓK FIZIKAI TERHELÉSÉNEK VIZSGÁLATA A VISELT TÖBBLETTEHER ALAPJÁN

Absztrakt

Az ember a történelem során mindig is kapcsolatban állt a tűzzel. Ennek köszönhetően megismerte annak előnyét és veszélyeit is. A világon mindenhol vannak tűzoltói beavatkozások, ezért a tűzvédelem területén folyamatos a kutatási tevékenység. A tűzoltók fizikai munkavégzése fárasztó. Ez egyrészt hatással van egy hosszabb beavatkozás során a tűzoltók egészségére, ezért fontos lenne növelni a tűzoltók fizikai teljesítőképességét. Másrészt a fizikai teher csökkentése hatékonyabbá teheti a tűzoltást. A cikkben rámutatok a tűzoltók fizikai terhelhetőségének korlátaira és bemutatom a szabad mozgással történő oltás kitolásának szükségét. Ennek érdekében egy olyan saját mérést végzek, amely nem igényel komolyabb erőforrásokat, azonban eredményei útmutatást adnak egy újszerű eszköz fejlesztéséhez. A vizsgálatom eredményeként javaslom egy újszerű, innovatív technikai eszköz alkalmazását a tűzoltás során.

Kulcsszavak: mérés, többletteher, elégetett energia, eltelt idő

1. INTRODUCTION

There is an ongoing research activity in the field of fire protection and firefighting in Hungary. In the field of fire prevention, we can find researches in connection with the BIM and the fire protection [1], with the BIM based sustainable fire safety development opportunities of the hazardous industrial factories [2], and the effects of the actively used reactive and passive fire protection systems established by innovative fire protection methods for whole life-cycle of buildings [3]. In the field of protection against explosion, the industrial safety has been studied in explosive work environment [4]. In the field of firefighting, analytical publications have been prepared on fire, rescue and disaster management [5], on fighting against wildfires [6] [7] and on the solutions for the accessibility of water sources [8]. Based on my various studies of the relevant literatures, I came to the conclusion that research on the development possibilities of technical tools, [9] [10], and analyses to increase the efficiency [11] also play an important role in Hungary. From the above, I conclude that there is a continuing need in case of new technical tools and efficient solutions. Based on it the most important conclusions can be drawn from the research activities [12]. As a result, in addition to the already known tools, I will examine what kind of new tools can be used to increase the efficiency of firefighting in case of wildfires.

2. THE NEED TO WEAR OVERLOAD

Walking is the most basic type of movement. According to Morrison, a person makes an average distance of about 8 km each day. However, the human body is able to perform significantly longer distances without much effort, even under a small load [13]. However, external loads and equipment have an impact on the efficiency of work, as the increased load requires the human body to perform more to achieve the same results. Studies in the military field of science have confirmed the logical conclusion that the more load a soldier wears, the greater his strength and endurance must be. An average soldier must be able to walk with a speed of 6.5 km/h for a long distance of 20 km with a load of more than 30 kg. Based on measurements and experiences, the researchers concluded that a soldier should only fight if he is carrying a load of 16 kg or less [13].

In many cases, firefighters are also exposed to severe physical load due to their daily activities, as their work is very varied and unpredictable. Their load-bearing capacity is affected by the high temperature on the field, the weight and quality of the protective clothing and the weight of the equipment they use during an intervention. Physical load usually occurs on the field during a firefighting. The extent of it depends on the type of the intervention, as not all interventions involve walking long distances or crawling in tight spaces. The extent of physical load is also influenced by the type and the duration of the intervention [14]. Fighting against the most challenging wildfires took several days in Hungary. During the intervention, in addition to the mandatory rest, the firefighters worked continuously. During a whole day work, the firefighters are completely exhausted. This is especially true when personal protective equipment and also firefighting tools must be used [15]. These mean roughly 15-20 kg of extra weight while working. In case of a long intervention, this load is already harmful to the human health. Exhaustion also affects the firefighters' decision-making ability, their thinking may be dulled, and their ability to recognize the situation can deteriorate. A firefighter cannot stop the intervening because of exhaustion, so I suggest to facilitate the working conditions in order to protect the human health.

There were several studies to determine the specific load of firefighters. Among the international literatures, I have found research on the cooling strategy of firefighting [16], the study of thermal stress on firefighters [17], and the possibilities of reducing the thermal stress [18]. Within the topic, the Hungarian literatures deal primarily with the assessment of the physical ability of firefighters, the physiological examination of firefighters' performance [19], or the determination of workload and stress in general [20]. When examining the relevant literatures, I found a few overload measurements in the topic. An Italian research team found that a firefighter should be able to intervene effectively with an extra weight of up to more than 42 kg, even if this load is only temporary during an intervention [21]. In Hungary, the physical load on firefighters has not been studied in depth, so I examine the extent to which the extra load can affect the efficiency of the interveners during a wildfire. To achieve this goal, I am conducting my own study that does not require significant resources, but the results can already provide guidance for the development of a tool even if the accuracy of the measurement results is limited.

3. PRESENTATION OF MY OWN TEST

After describing the physical use of firefighters, I present my own test. In order to find out specifically how much more efficient is the work without overload, I made a test with 5 volunteer firefighters

Data and conditions of the test

In order to obtain an authentic study, I recorded the physiological data of the volunteers, such as gender, age group and body mass index. The team of the volunteers consisted of 4 men and 1 woman, two of the members were in the age group 20-29, also two in the age group 30-39 and one in the age group 40-49. Based on the body mass index, two of the volunteers fell into the normal category (18.50–24.99 kg/m^2), as one had a value of 23 kg/m^2 and the other 24.5 kg/m^2. The other three volunteers were in the overweight category (25.00 - 29.99 kg/m^2), as their indices were 27 kg/m^2, 27.5 kg/m^2 and 29 kg/m^2. Based on this, the volunteers have an average body mass index of 26.2 kg/m^2, which can in fact be considered as approaching the limit of normal and slight overweight. The aim of my test was to determine how much the effectiveness of the firefighter decreases when he should to carry overload. During the experiment, I examined the time and energy consumption factor of the efficiency, and I also estimated the possibility of additional capabilities. During my test, I considered as a time factor that how long the firefighter takes a certain distance without load or with carrying an overload. I considered as an energy factor that how much energy uses the firefighter (in this case the volunteer) during the experiment. I give my test data in the unit of energy (joule) used for work in the international system of units of measurement. I made the test as follows.

The test was conducted in the early afternoon on the 24th of April 2020, with the participation of the 5 volunteers I have already mentioned. I considered their physical condition to be average in relation to their age based on my survey. When choosing the date of the test, I also took into account the weather conditions, which were as follows:

Table 1: Weather and field parameters of the test. Created by the Author.

Weather conditions during the test	
Temperature	26 °C
Air pressure	1 016 hPa
Humidity	31%
Wind speed, direction	2 km/h, NW
UV radiation	strong
GPS coordinates	47°36'50"N
	18°52'49"E
	altitude: 220 m

Based on Table 1, I consider the conditions of the experiment to be relevant, as the data of the listed weather factors provided an opportunity to even generate a real wildfire. This is also confirmed by the fact that there was a highly flammable period nationwide on that day in Hungary. Consequently, I consider the circumstances of my test to be acceptable in case of a wildfire study.

The task of the volunteers was to take a distance of 1.5 km twice in complex terrain conditions. For the first, this was done in the traditional way, i.e. without load. For the second time, the task was repeated, but in this case already carrying an extra weight of 25 kg. When choosing the test conditions, I took into account that the participants complete the distance one by one, so that they do not even see each other, thus avoiding that the performance of one participant affects another. In addition to the above, I also determined three check points during the test, in order to be able to analyse the partial results. I selected the first check point at 500 m (one-third of the total distance), the second at 1 km (two-thirds of the total distance), and the third, of course, at the end of the distance. In order to ensure the accuracy of the test, I also recorded the topographic properties of the operation area. To illustrate this, I made a topographic diagram of the test site (Figure 1), in which I indicated the terrain conditions that the volunteers faced during the measurement. The terrain shows a strong slope in the first section, with a total altitude difference of +14 m. In the second section, the opposite can be observed, so the terrain in this case was characterized by downhills. Most of the third section is straight with a small slope at the end.

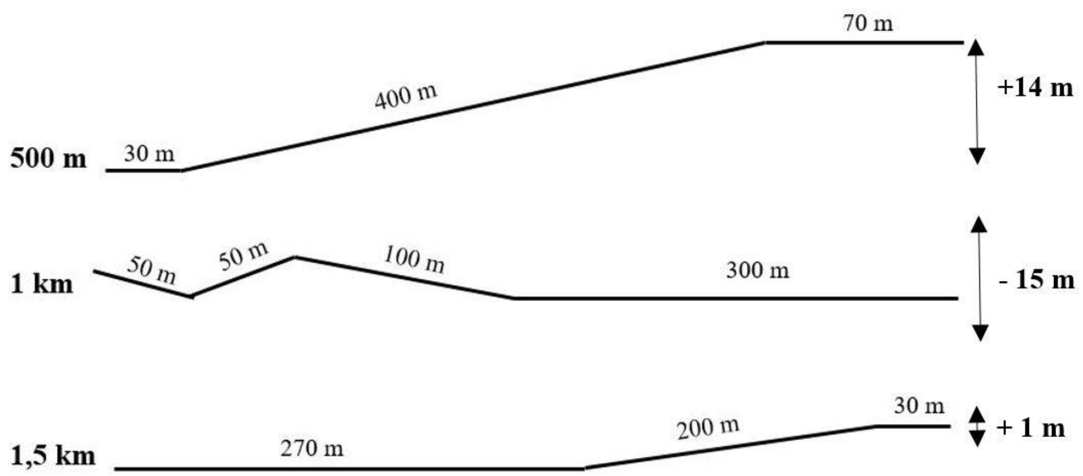

Figure 1 - Terrain conditions on the three checkpoints of the route. Created by the author

During the test I examined how much the overload reduces the speed of the firefighters and how many joules of energy they burn during the work, so how much it burdens the human body. During the test, I provided smart devices (watch, mobile phone) for the firefighters. With these devices, I was able to analyse the characteristics of the experiment. At the end of the test, I asked the volunteers to complete my short questionnaire in order to estimate how much longer they would be able to continue the task with their particular physical condition.

Examination of the temporal factors of the test

The 1.5 km distance was first completed by the volunteers without load. Their results and averages are summarized in Table 2.

Table 2 - Time results after completing the 1.5 km distance without load. Created by the Author. Source: [21]

Time results after completing the 1.5 km distance without load						
	Volunteer "A"	Volunteer "B"	Volunteer "C"	Volunteer "D"	Volunteer "E"	**Averages**
After 500 m	5:36:00	5:03:00	7:22:00	4:45:00	5:41:00	**5:41:00**
After 1 km	10:05:00	9:55:00	11:42:00	8:47:00	11:01:00	**10:18:00**
After 1,5 km	15:01:00	14:53:00	18:32:00	13:26:00	16:12:00	**15:36:00**

Based on Table 2, I established that the volunteers completed the distance on average under normal conditions. The size of the time and the travelled distance increase proportionally. The results of the table are also illustrated in Figure 2.

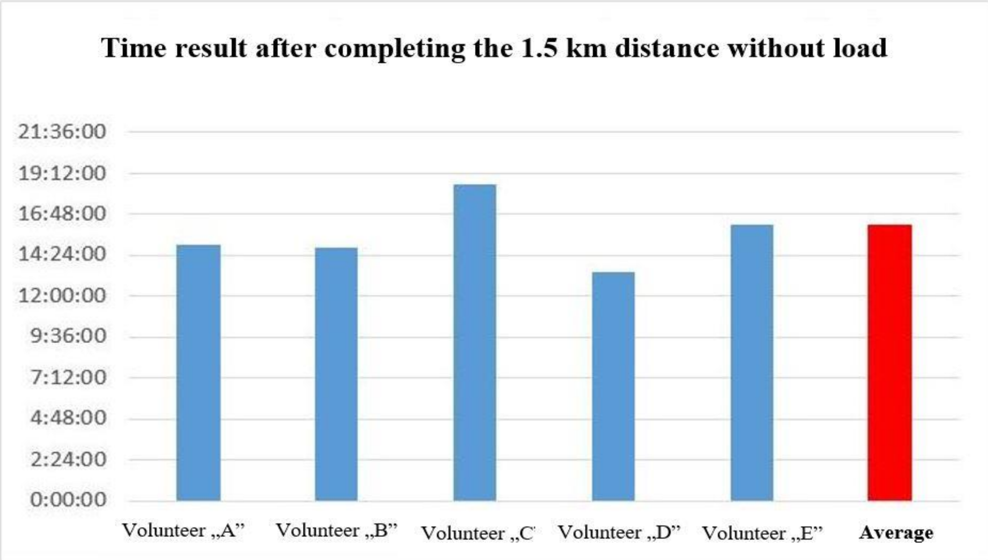

Figure 2 - 1.5 km distance without load on a graph. Created by the Author.

Based on my measurements, I established that the volunteers fulfilled the distance in an average of 15 minutes 36 seconds (936 s). In this case it means an average speed of 5.76 km/h.

$$V_{average_{without}load} = \frac{1000\,m\,x\,936\,s}{1500\,m} = 624\,s, \text{ in 1000 m, so } \frac{1000\,m}{624\,s} = 1{,}60\frac{m}{s} = 5{,}76\frac{km}{h}$$

This average speed of 5.76 km/h is roughly 1 km/h less than the measurement established that a soldier can walk more than 30 kg at a speed of up to 6.5 km/h over a long distance of 20 km [13]. I explain this difference that the soldiers were specially trained for such a tasks, while the firefighters involved in the experiment volunteered for the task. For this reason, it is logical that the physical fitness of the two groups differs significantly. The volunteers completed the 1.5 km distance for the second time with an overload of +25 kg, and I summarized their results and their average in Table 3.

Table 3 - 1.5 km distance with extra load. Created by the Author.

Time results after completing the 1.5 km distance with a load of 25 kg						
	Volunteer "A"	Volunteer "B"	Volunteer "C"	Volunteer "D"	Volunteer "E"	**Averages**
After 500 m	6:18:00	6:50:00	8:02:00	5:19:00	6:19:00	**6:33:00**
After 1 km	11:30:00	13:58:00	13:10:00	9:36:00	12:21:00	**12:07:00**
After 1,5 km	17:54:00	20:41:00	21:05:00	15:22:00	18:36:00	**18:44:00**

The results in Table 3 also confirm the logic that volunteers completed the distance more slowly compared to the first attempt. The size of the time and the travelled distance increase proportionally in this case too. I also illustrated the results in Figure 3.

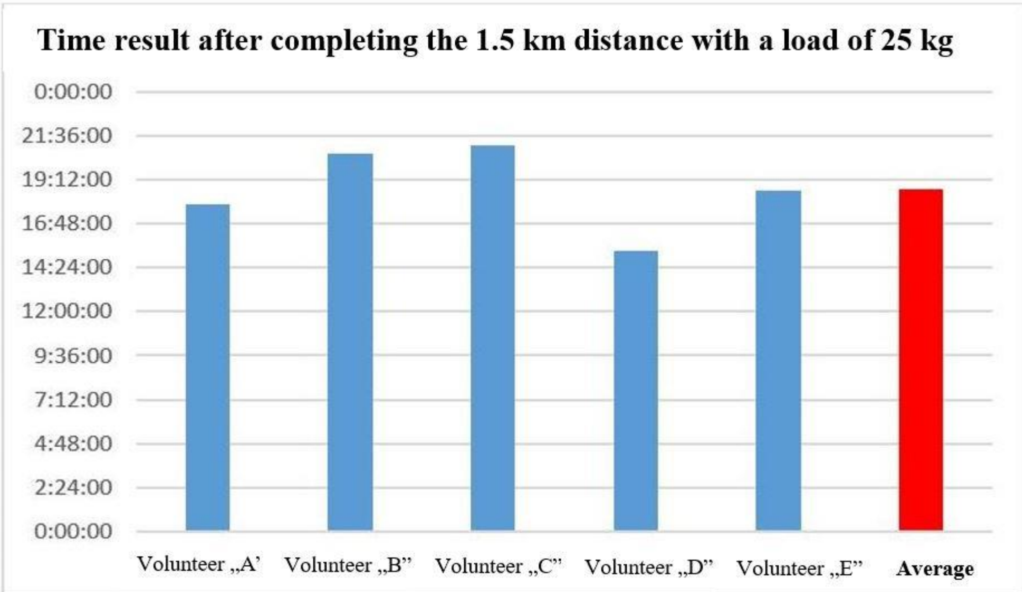

Figure 3 - Completed time results of the 1.5 km distance with extra load on a graph. Created by the Author.

Based on the above mentioned results, I conclude that the volunteers covered the distance in an average of 18 minutes 44 seconds (1124 s), which means in this case an average speed of 4.8 km/h.

$$V_{average_{with}load} = \frac{1000\,m\,x\,1124\,s}{1500\,m} = 749{,}33\,s \text{ in } 1000 \text{ m, so } \frac{1000\,m}{749{,}33\,s} = 1{,}33\,\frac{m}{s} = 4{,}8\,\frac{km}{h}$$

I compare the results of the two measurements in Figure 4. In the figure, I illustrated the time results of each volunteer at the end of the 1.5 km distance. I marked the time without load in green, the time results with +25 kg overload in red, and as well as the average result.

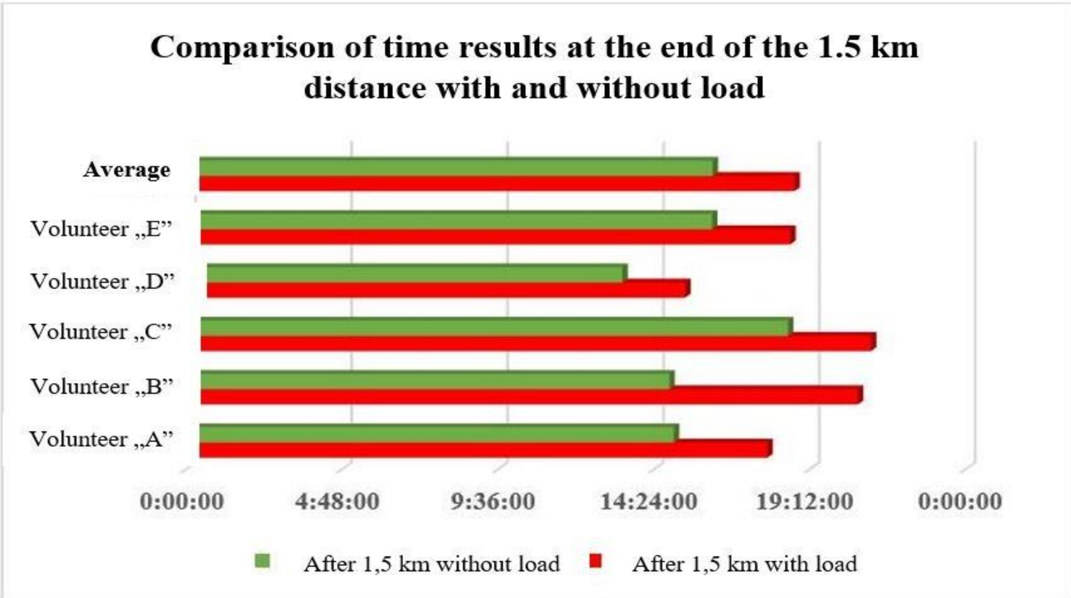

Figure 4 – Comparison of time results at the end of the 1.5 km distance with and without load. Created by the Author.

From the results, I conclude that working with overload was slower in all cases, but the extent of this varies from each other. In addition, I calculated the average time difference between the measured points and at the end of the whole distance (Table 4).

Table 4 - The average of time differences in the given sections. Created by the author.

Distance	**Time**
500 m	0 min 52 s
1 km	1 min 49 s
1,5 km	3 min 08 s

Examination of the work factors of the test

During the measurement, in addition to the time factors, I also examined the energy consumption factor, i.e. how much joule of energy the firefighters burn during the execution of distance at the various checkpoints. I present this in Table 5.

Table 5 - Burned energy without load. Created by the author.

Amount of burned energy without load (kJ)						
	Volunteer "A"	Volunteer "B"	Volunteer "C"	Volunteer "D"	Volunteer "E"	**Averages**
After 500 m	100,8	79,8	96,6	92,4	92,4	92,40
After 1 km	184,8	163,8	155,4	189	197,4	178,08
After 1,5 km	285,6	243,6	243,6	273	310,8	271,32

From the results in the table, I conclude that the volunteers fulfilled the distance by burning relatively little energy (as a rule of thumb, 2-2.5 times that the calories burned at rest). The magnitude of the time and the travelled distance increase proportionally relative to each other at the measured points. The result of the table is also illustrated in Figure 5 below.

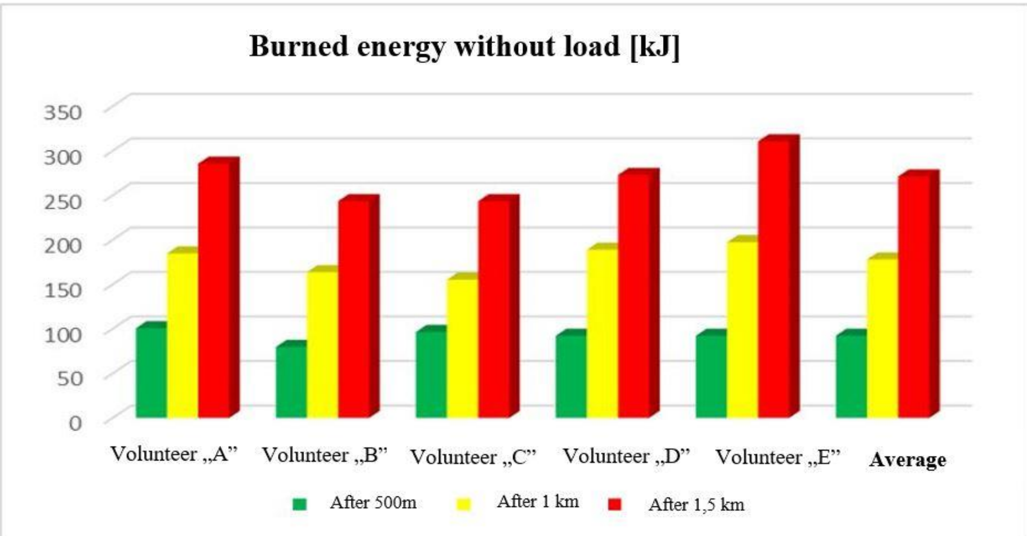

Figure 5 - Diagram of burned energy without load. Created by the author

The 1.5 km distance was fulfilled by the volunteers for the second time with an overload of +25 kg, and I show the amount of energy burned there with the help of Table 6.

Table 6 - Amount of energy burned with extra load. Created by the author.

Amount of burned energy with 25 kg overload (kJ)							
	Volunteer "A"	Volunteer "B"	Volunteer "C"	Volunteer "D"	Volunteer "E"	**Averages**	**Differences**
After 500 m	142,8	113,4	130,2	100,8	126	**122,64**	**+30,24**
After 1 km	252	226,8	210	210	273	**234,36**	**+56,28**
After 1,5 km	390,6	340,2	340,2	336	428,4	**367,08**	**+95,76**

From the results in the table, I conclude that the volunteers could only fulfilled the distance by burning more energy. The magnitude of time and distance increased proportionally relative to each other at the check points. The results of the table are also illustrated in Figure 6.

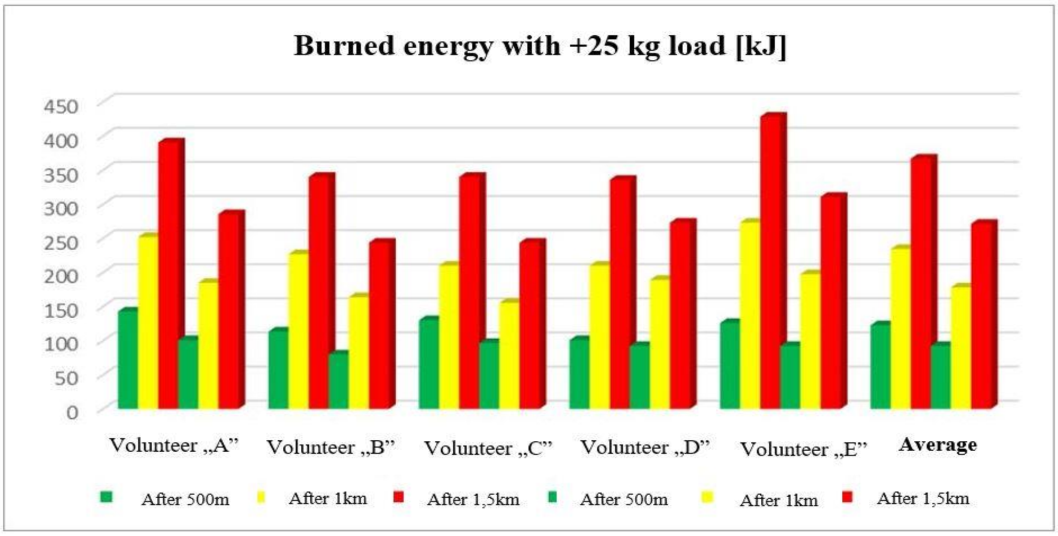

Figure 6 -Diagram of burned energy without load. Created by the author.

I show that at the first checkpoint the volunteers burned an average energy of 30.24 kJ, at the second checkpoint 56.28 kJ and at the end of the distance 95.76 kJ more energy during a distance which can be fulfilled approximately in 20 minutes. This 95.76 kJ at first glance is not much, but in case of firefighting against wildfires is much longer than 20 minutes based on previous experiences. As a result, I logically examine the additional amount of the burned energy as a function of the elapsed time, as shown in Figure 7.

Intervention time	Burned energy (kJ)
0:20:00	392,7
1:00:00	1178,1
2:00:00	2356,2
5:00:00	5890,5
10:00:00	11762,1

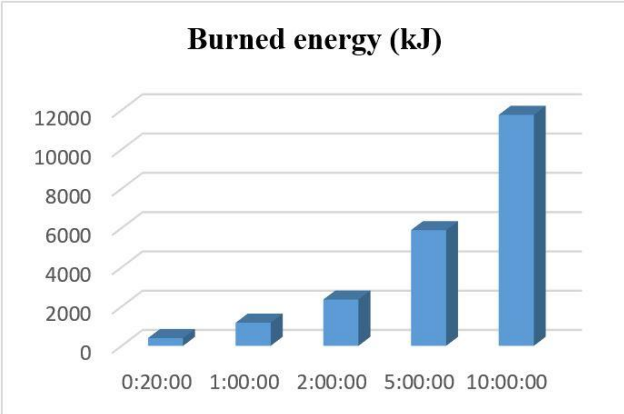

Figure 7 - Amount of the burned energy as a function of the elapsed time. Created by the author.

Based on the time results of the volunteers and the test conditions, I make the following consequences. The average energy consumption was the lowest in the second section, but considering that there was a negative level difference here (-15 m), it cannot be considered as the part with the lowest energy consumption. The difference between the second and third section is the largest, despite the fact that in this case the distance was almost without level difference. Based on the above, I justified that energy consumption is constantly growing, and the rate of growth is exponential according to my assumption. I could not prove the latter because both the number of participants was small and the test conditions included too much variance. I suggest further studies to determine the extent of the change.

Analysis of the study questionnaire

At the end of the experiment, I wanted to determine how tired are the volunteers after the test and how long they would have been able to continue the task in similar circumstances. For this purpose I first asked them - in the form of a questionnaire - that how difficult it was to complete the distance without overload. 60% of the volunteers answered that the task was *very easy*, while 40% felt it was *easy* to complete it without overload. The task was not considered difficult by anyone, so I conclude that the physical condition of the volunteers is adequate.

I asked the volunteers the same question after the second round of the task fulfilled it with +25 kg overload. I determine that because of the overload, it was a much more serious challenge to complete the task. 80% of the participants answered it was *difficult* and 20% found it *very difficult* to complete the task with the + 25 kg overload. This also confirms the practical experience that firefighting with overload significantly reduces the work ability of firefighters in a short period of time. Then I asked the participants to estimate how long they would be able to work without a longer rest with and without an overload. Based on the answers, I conclude that the firefighters - on their own assessment - would be able to intervene on average for an additional 4 hours without overload (light physical work) and for an additional 1 hour with overload (heavy physical work). I chose the amount of overload (25 kg) for the test, so I also asked how much more overload they could wear in addition to 25 kg. Based on the answers of the questionnaire, I state that, on average, firefighters still consider it only tolerable to carry an extra weight of 5 kg above the 25 kg. This is a total of 30 kg, which is the weight of a backpack water pump full of water. As a result of it, I conclude that a volunteer firefighter can work effectively with a 30 kg overload in addition to his own body weight. A heavier weight has a significant influence on the effect of the firefighter’s work. Tasks and solutions like these serve sustainable development within the field of the disaster management [23] [24] and engineering sciences [25].

4. CONCLUSIONS

My test showed that the top of the physical load of firefighters in case of long work is approximately 30 kg. Working with a heavier load than this is on the one hand no more effective and on the other hand it can lead to health consequences. In order to increase the efficiency of firefighting, a technical tool would be needed that can reduce the load on firefighters, while maintaining the freedom of movement. The physical loads appear on firefighters in case of free movement by using traditional technical tools. Vehicles and technical tools tested in general cannot simultaneously maintain the free movement and the reduce of the physical load, therefore I am looking for a tool that can meet both conditions at the same time. For this purpose, I have found an external wearable mobile machine (so called exoskeleton) that is already used in military and civilian fields. This machine allows the wearer to carry extra load and to carry only minimal additional load on the body. As an energy source for the machine, an electrical system is logically proposed, which moves the structure through hydraulically driven pistons through the data of the sensors. It also detects the wearer's movements and the extra load, balances it by following the movements and takes over the wearer's physical load. The exoskeleton is effective, because the user does not have to lift an additional load in addition to his body weight, because it is already sensed by the exoskeleton itself and is lifted based on the wearer's movements. As a result, the user of the machine is able to work with overload even for a long time, as he does not actually feel the extra weight, so he does not need more effort, as the frame does it instead. It makes the machine almost the part of the human body, which helps the movement with a direct contact. I suggest to systematize such a special machine like this exoskeleton in order to increase the efficiency of the firefighting. With such a tool, a weight of 30 kg can easily be lifted without harming the human body. Due to the huge number of interventions [26], it will be necessary to use such an equipment in the future. Its application requires further research in the field of the disaster management. However, I do not explain this in this paper, but I intend to analyse it in the future.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

József Zsolt Kersák, Ágoston Restás

EXAMINATION THE PROTECTION TIME OF THE RESPIRATOR

Abstract

The respirator is an important and frequently used protective equipment for firefighters in case of interventions. The literatures in connection with the use of self-contained breathing apparatus deal only with health and safety requirements. There is only a little knowledge about the relationships between air consumption during different activities, physique, work intensity, and stress. In conclusion, the actual protection period of the respirator may vary during the interventions. Consequently, the usage time should be increased as much as possible.

Keywords: respirator, protection time, air consumption

LÉGZŐKÉSZÜLÉK VÉDELMI IDEJÉNEK VIZSGÁLATA

Absztrakt

A tűzoltói beavatkozás egyik nélkülözhetetlen és rendszeresen alkalmazott védőeszköze a légzőkészülék. A rendszeresített környezeti levegőtől független légzőkészülékek használatával kapcsolatban fellelhető szakirodalmak csak a munkavédelmi követelményekre terjednek ki. A különböző tevékenységek közbeni levegőfogyasztásról, a testalkat, munkavégzés intenzitása és a stresszhelyzet összefüggéseiről kevés ismeretanyag áll rendelkezésre. Ennek következtében a légzőkészülék tényleges védelmi ideje a beavatkozások során eltérő lehet, amelyből adódóan a használati időt a lehetőségekhez mérten növelni szükséges.

Kulcsszavak: légzőkészülék, védelmi idő, levegőfelhasználás

1. INTRODUCTION

The 6/2014 instruction of National Directorate General for Disaster Management orders the data provision of the firefighting and technical rescue of the fire departments and of the disaster management bodies. The County Disaster Management Directorates, the Disaster Management Branch Offices and the fire departments are obliged to provide regular data on their firefighting, technical rescue and official activities [1].

The electronic data of the Firefighting and Technical Rescue Reports (hereinafter TMMJ) data sheets is performed using the on-line Disaster Management Data Provider Program (on-line KAP).

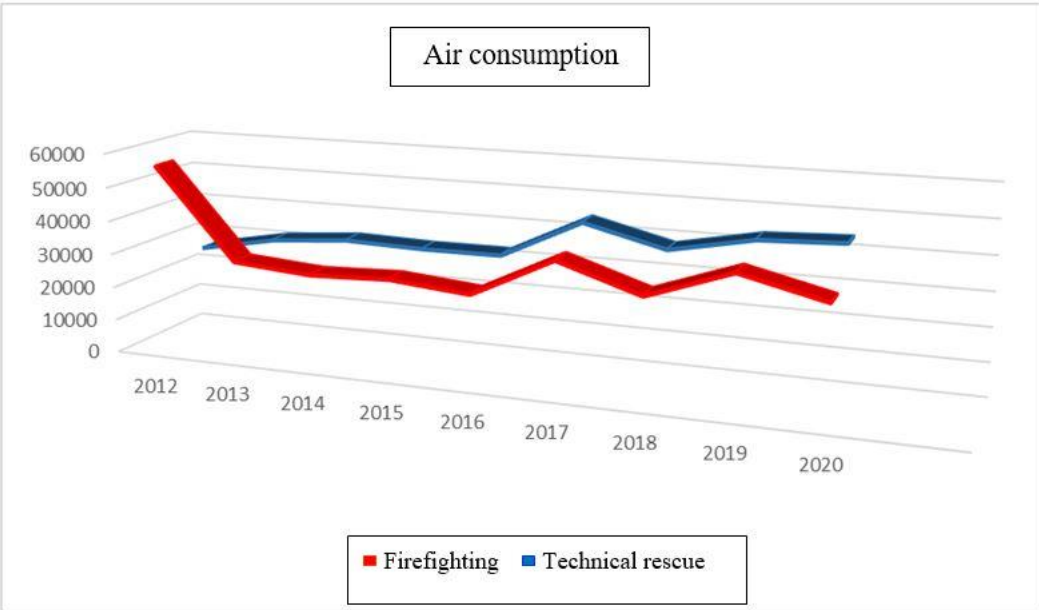

Figure 1 – The use of respirator in case of firefighting and technical rescue. Created by the Author [2].

We examined the statistics of the data sheets and determined that the use of respirators (in case of firefighting and technical rescue) averages 70,000 times a year in Hungary. Figure 1 illustrates the use of a respirator during the firefighting and technical rescue. In addition, it can be stated that from the year 2013, there were more uses of respirators during the technical rescue operations. The use of a respirator is justified by the fact that in case of technical rescues, vapours and gases may be released, which have a harmful effect on the health of the interveners [3]. Such interventions are a complex task, as well as a recovery after natural disasters [4] [5].

During the exercises with respirators, the technique of the proper breathing can be mastered through practice. This practical knowledge will help to increase the protection time of the respirator for the safe interventions [6].

2. PROBLEMS, OBJECTIVES AND HYPOTHESIS

One of the living conditions is to have clean air with appropriate oxygen content. Under normal breathing conditions, this oxygen is received by the human body from the surrounding air. Based on anatomical knowledge, respiration is a vital function, its organs are the respiratory tract, upper respiratory tract, trachea, lung lobes, and the air sacs in them. The composition of the air is 78.08% nitrogen, 20.95% oxygen, and approximately 1% other gases.

Activity	Air consumption
Easy movement, walking	10-25 litres/min
Medium intensity work	30-50 litres/min
Hard intensity work	70-100 litres/min
Very hard intensity work	150-200 litres/min

Table 1 - Average air consumption of an adult in case of various activities. Created by the authors [7]

A person breathes 16 times on average in 1 minute under normal conditions. Air consumption in case of adults is greatly influenced by the activity they are doing. Table 1 illustrates the average air consumption of the adults during various activities, based on the measurements of Róbert Frenkl [7].

Protection time is a measurable period of time, expressed in minutes, which is the time of the usage of the respirator. This time is approximately 45 minutes in case of easy work with a respirator with 300 bar pressure and 6.8 litres capacity. As the actual usage time of the respirator is not constant during the interventions, consequently, it is necessary to increase the usage time.

The usage time can be affected by many factors, such as the stress, the worry, the overweight, the respirator, other equipment and the inexperience. It has been proven and experienced that the number of breaths increases during the interventions when using the respirator. The objective of the authors was to help the use of respirators and to increase the protection time during the interventions with the help of the present experiment. During our research, we constantly examined the statement described in the thesis of Ferenc Kanyó [8]. He considered it important to develop a training and assessment system that measures the firefighting interventions in specially modelling conditions such as endurance, strength and speed [9] [10] [11].

3. FIREFIGHTER EXPERIMENT WITH THE USE OF RESPIRATOR

We perform a test with 5 professional firefighters, who volunteered to participate in the measurement. Ages and length of service were important during the selection. The participants were marked anonymously with letters. Categories such as age group and length of service were not determined due to the small group size, but they were marked. Weather conditions such as temperature and atmospheric pressure were the same for both tests. This is important to note because the weather has an influence on the effectiveness of the firefighting. [12] [13]

Measurements: elapsed time, covered distance, and pressure difference in the breathing bottle (air consumption could be determined from the pressure difference).

Figure 2 - Illustration of an experiment. Created by the authors.

The experiments were divided into two main groups:

First attempt: The task was to cover 100 meters with a respirator, protective clothing, at a normal speed. In the present phase, the goal was to measure the average air consumption with time and covered distance. These data were needed to determine the air consumption with minimal movement.

Second attempt: During the task, the firefighters had to go up to the fourth floor in a respirator, in protective clothing, at a normal speed. In the present phase, the goal was to measure the average air consumption, with the time, covered distance and level difference. These data were needed in order to determine the air consumption under increased movement and load.

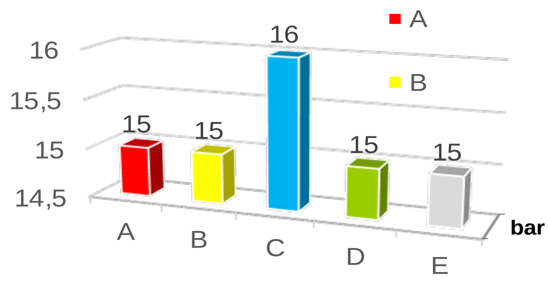

Figure 3 - Air consumption of the first attempt, broken down by each participant, expressed in bar. Created by the authors

Firefighters covered the 100 metres on horizontal terrain at normal speed for 1 minute 20 seconds with an average speed of 1.25 m/s (It is important to note that they were traveling at the same speed at the same time. It was a request) and their air consumption was 0.15 bar/metre in a metre. It was observed that their air consumption was common 15 bar over the distance. Firefighter „C" was an exception. His value was 16 bar, which is illustrated in Figure 4. It can be stated that in protective clothing, with the use of a respirator, their air consumption was the same independently from the age and length of service at normal speeds. However, the fire protection rating of protective clothing is another problem [14].

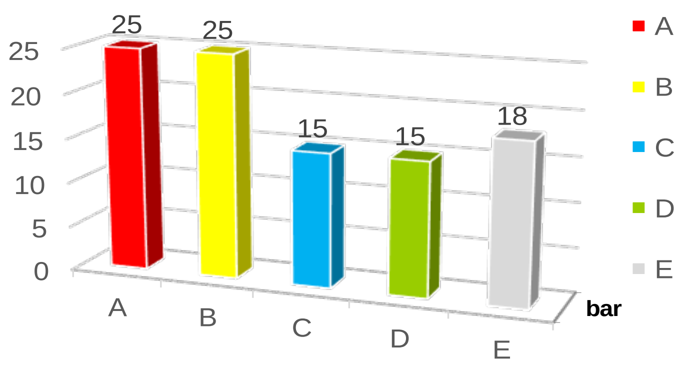

Figure 4 - Air consumption of the second attempt, broken down by each participant, expressed in bar. Created by the authors

Results of the second attempt: The firefighters covered 54 metres horizontally, with a slope of 16.3 metres, at a normal speed in 1 minute 40 seconds, their average speed was 0.54 m/s. (It is important to note that they were traveling at the same speed at the same time. It was a request). In the present test, there were already large differences in the air consumption. It was found that based on age and length of service, younger firefighters and those with fewer service time had higher air consumption. Firefighters marked “A” and “B” covered the distance with a decompression of 25 bar, with an average consumption of 0.46 bar/metre. Firefighters marked “C” and “D” covered the distance with a decompression of less than 15 bar, with an average consumption of 0.27 bar/metre, and it was observed that no more air was used. Firefighter "E" completed the distance with a minimum of more than "C" and "D", but significantly less than "A" and "B", with an average pressure drop of 18 bar. He completed the distance with an average consumption of 0.33 bar/metre.

4. SUMMARY

In Hungary, the use of respirators is 70,000 times in a year in case of firefighting and technical rescue. This poses a risk to the interveners [15]. From this, it can be concluded that the use of a respirator is essential for the safe intervention. The need for the present studies has been demonstrated by the fact that the literatures only deal with the occupational safety requirements, but does not provide guidelines for the use in different situations. During the studies, it was observed that the air consumption was the same at minimal load, but in case of higher intensity the air consumption of the younger firefighters was higher than for the older age group. Consequently, during breathing exercises, the technique of proper breathing should be mastered through practice. The present practical knowledge helps to increase the protection time of the respirator, so that it is possible to intervene further in time with the use of minimized air. These are later contributed by the experience of operations management [16]. The importance of it has also appeared in the education [17].

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Alice Ncube, Jamila Joyce Ndovela

COMMUNITY RESILIENCE AND ADAPTATION TO FIRE: THE CASE OF PALMIET INFORMAL SETTLEMENT, ETHEKWINI MUNICIPALITY, SOUTH AFRICA

Abstract

Informal settlements within the eThekwini Metropolitan Municipal area are continuously increasing in size and numbers and, more than 238 households were living in informal settlements by 2018. The municipality is one of the top 16 municipalities in South Africa with the highest number of households living in informal dwellings. With the increasing mushrooming of informal dwellings in and around the city center of Durban and nearby industrial areas, shack fires have become a common occurrence. This has prompted the metropolitan to conduct a trend analysis of these shack fires. The trend analysis indicated that some informal settlements more frequently experience fires than others regardless of similar dynamics, such as lack of basic services such as electricity. Palmiet informal settlement is one such that does not experience many fires. Based on this trend, the study sought to investigate the factors that lead to adaptation to and resilience of the community to shack fires. The community livelihood framework formed the theoretical basis of the study that was predominately qualitative and to a lesser extent quantitative. The research sampling was a homogenous purposive sampling based on location, knowledge, and experiences. Sixty-five respondents from the L-Section of Palmiet and three municipal officials participated in the study. Strong community social networks that led to the adoption of internal fire risk reduction measures, the collective approach the community adopted of "coming back stronger and better positioned for the future" resulted in creating a resilient community of Palmiet. Getting back to the baseline is not enough in tackling informal settlement fires, but resilience could be enhanced through the bouncing forward factor. One of the recommendations is that the municipality needs to strengthen its collaboration with the local communities to improve community fire risk reduction measures.

Keywords: informal settlements, fire hazard, community resilience, adaptation, eThekwini municipality.

A KÖZÖSSÉG ELLENÁLLÓKÉPESSÉGE ÉS ALKALMAZKODÁSÁNAK LEHETŐSÉGEI A TŰZESETEK SORÁN: ESETTANULMÁNY A PALMIET INFORMÁLIS TELEPÜLÉSRŐL DÉL-AFRIKÁBAN

Absztrakt

Az eThekwini Metropolitan Municipal területén folyamatosan nő az ún. informális települések száma. A Dél-afrikai településen a legtöbb ember ezekben az informális lakásokban (kunyhókban) él, de ez nem csak itt, hanem Durban város környékén is jellemző. Ez a jelenség arra késztette a várost, hogy trendelemzést végezzen az itt keletkezett a kunyhótüzekről. A trendelemzés során arra a következtetésre jutottak, hogy azokban az épületekben, ahol a létfontosságú rendszerelemek alapvetően hiányoznak gyakoribbak a tüzek. Palmiet informális települése azonban kivételt képez, ezért a szerzők megvizsgálták ezt a mintaterületet annak érdekében, hogy kiderítsék, mi eredményezi itt a hatékonyabb tűzmegelőzést. A kutatás mintavétele homogén célzott mintavétel volt, amely a helyszínen, a korábbi ismereteken és egyéb tapasztalatokon alapult. A cikk eredményeként a szerzők javaslatot tesznek az önkormányzatok részére a helyi állampolgárokkal való szorosabb együttműködésre a tűzkockázat csökkentése érdekében.

Kulcsszavak: informális település, közösség ellenállóképessége, alkalmazkodás, eThekwini önkormányzata

1. BACKGROUND

Informal settlements, although fragile, display evolutionary resilience and adaptability to changes in the urban context. However, government structures fail to recognise this inherently resilience displayed by informal settlements and this will result in government having limited success in effectively engaging with informal settlements. This results in incompatibility of formal and informal structures. Seeliger & Turok (2014:184) suggest that the public sector can increase disaster risks through indifferences and poorly conceived actions, or they can build community resilience through constructive and integrated methods. The authors further argue that community resilience can be built by strengthening local capacity and propose adaptive governance as a framework to achieve this. The adaptive governance theory is a broad-based approach that combines local experiences with that of organisational theory.

Brown-Luthango,Reyes & Gubevu (2016:s.a), further argue that the upgrading of informal settlements through physical improvement and provision of full basic services indirectly reduces community vulnerability and improves safety conditions of informal dwellers. Harte, Childs & Hastings (2009), in their research findings established that social networks, community participation and resourcefulness of individuals were the most important factors underpinning community resilience in informal settlements. Their findings indicated that informal dwellers have the internal capacity and resources to adapt to their local challenges such as fire hazards. However, support from government is required to enhance and fully benefit from these internal capacities.

Harte *et al.*, (2015) stated that geographical, political, social, and environmental factors, stakeholder interactions, prioritisations, and decision making create barriers for government to implement disaster risk management policies and strategies. This supports the notion by Seeliger & Turok, (2014:184) that government can increase disaster risk through indifference and poorly conceived actions. Informal settlement dwellers have skills and formal education, as indicated by the study findings of research conducted at Kpirikpiri informal settlement in Ebonyi State, Nigeria. The skills and education possessed indicate internal resources and capacity (Pugalis, Giddings & Anyigor 2014).

According to Olorunfemi,Gbadegesin and Raheem (2006), the interaction of both socio-economic structures and government agencies is relatively important in order to develop community capacities to effectively respond to existing and emergent shocks and stresses. Community characteristics and the manifestation of political economy equally contribute to the vulnerability. Political marginalisation impacts efforts aimed at community resilience as decisions over major planning interventions at informal settlements are taken without involving residents and frequently undermines existing local-level adaptation initiatives. Most importantly, local institutions play an important role in enabling access to the types of resources that can build community resilience (Harte, Childs & Hastings, 2011).

Vulnerability and resilience in informal settlements have been a subject under discussion among many researchers (Seeliger & Turok 2013:online). However, there is still a gap in investigating internal capabilities and arrangements in building fire resilience and adaptation in informal settlements. There is a growing need to develop and upgrade informal settlements in order to create safe living environments. However, there is little documented evidence of how collective actions undertaken by communities living in these informal settlements can contribute towards community resilience and adaptation to the many hazards they are exposed to, such as fire, floods and disease outbreaks (Olorunfemi *et al.*, 2011; Harte *et al.,* 2015b:s.a).

In this view, this study is in accordance with the perspective advanced by different authors to investigate factors that enhance community fire resilience and adaptation, with a strong focus on internal coping capabilities. It further seeks to explain how these factors address the immediate needs of this community and significantly contribute to building resilience and adaptation at the levels of the individual, household, community and municipality. More so, exploring internal capacities and further support is crucial in order to enhance community resilience and for authorities to fully benefit from these internal adaptation strategies. In the quest of identifying and assessing the factors and conditions underpinning the adaptive capacity of the Palmiet informal dwellers to fire incidents, issues such as the community capitals and government interventions are considered.

2. INFORMAL SETTLEMENTS IN SOUTH AFRICA AND ETHEKWINI

In South Africa about 40% households live in informal houses, of which 7.8% are in the KwaZulu-Natal province (Brown-Luthango *et al.*, 2016). The eThekwini municipality, being one of the top sixteen municipalities with the highest number of households living in informal dwellings, records a considerably higher number of fire outbreaks at these settlements. South Africa Fire Statistics recorded about 4 000 shack fires at informal settlements in 2014. There are also well-documented reports of lives lost, and injuries and damages caused by such fire outbreaks. There are a number of factors cited for the mushrooming of informal settlements, particularly in the urban areas, the common reasons being lack of employment, poverty, and shortage of housing. Political conditions also play a role in this regard (Harte, Childs & Hastings, 2009). Informal settlements are households lacking improved water and sanitation, durable housing structures and insufficient living space. These are some of the tangible indicators of informal dwellings: their structures are not erected according to approved architectural plans (Seeliger &Turok, 2014).

Informal settlements within the eThekwini municipal area are continuously increasing in size and numbers. According to the municipality's Incremental Informal Settlement Upgrading (2011) over 250 households living in informal settlements. With the increasing mushrooming of informal dwellings in and around the city centre of Durban and nearby industrial areas, fires have become a great concern to the municipality, and disaster response agencies, such as the Red Cross, Social Development, and Non-Governmental Organisations (NGOs) (eThekwini Annual reports 2010-2017).

Due to the recurrent shack fires the EThekwini municipality conducted a trend analysis was conducted between 2010 and 2017 (**See Figure 1**), and according to the statistics the municipality recorded 483 informal settlement fire incidents, in which approximately 28 000 people were affected. Some of the affected settlements areas include Kennedy Road, Sea Cow Lake, Quarry Road, Claremont, Cato Crest, and Palmiet informal settlement. A closer look into the trend analysis indicated that the Palmiet informal settlement recorded only a few fire outbreaks during that period. According to the fire statistics, the settlement experienced only one major fire incident between 2014 and 2016 (eThekwini annual reports 2010-2017). This indicated a degree of high fire resilience, despite the high risk of fire incidents. It is against this backdrop that this study sought to investigate community fire resilience and adaptation at the Palmiet informal settlement. The key research question underpinning this study is, "*What factors contribute to community fire resilience and adaptation at the Palmiet informal settlement?*" The key objective of the study was to determine the factors that create fire resilience at the Palmiet informal settlement, L-Section in Durban.

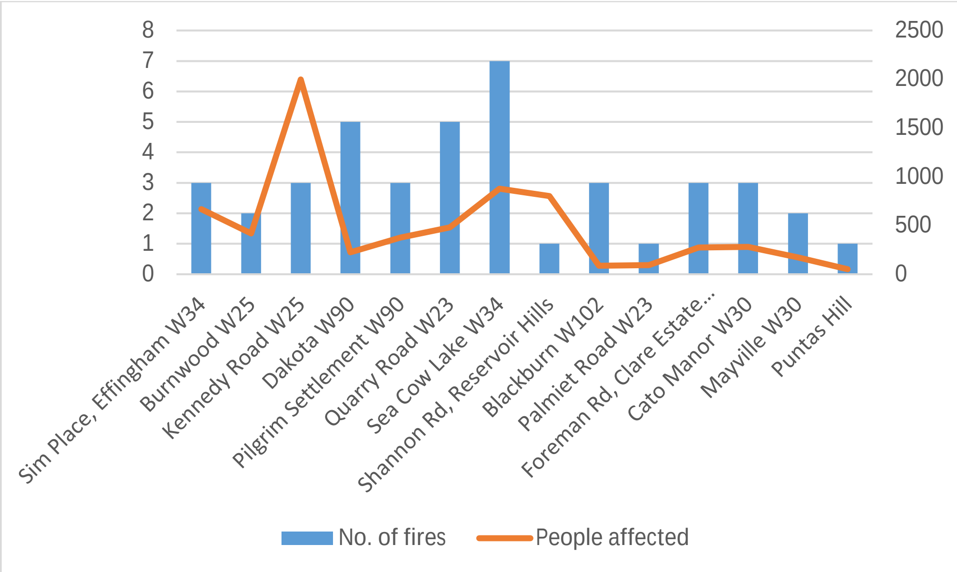

Figure 1- Fire trend analysis of EThekwini municipality between 2010 &2017. Source: eThekwini Disaster Management Statistics 2014-2016

Description of study area

The eThekwini municipality is located on the east coast of South Africa and is the largest city in the province of KwaZulu-Natal. Palmiet informal settlement, near Westville, was established in the late 1980s. It is made up of three sections, namely Section 1, Section 2 and L-Section. L-Section and has a population of approximately 2 000, with 327 dwellings. The settlement, like all other informal settlements in the municipality, has a dense setup with minimum space between the dwellings. In terms of the basic services, the settlement has limited access to water and sanitation facilities. The settlement lacks safe electricity, as there are many illegal electrical connections. The municipality is in the process of installing electricity at most informal settlements around the city.

The settlement is within a historical Indian settlement area, and although much has changed in terms of racial composition in the area. However, it is still dominated by the Indian population. Many people living under marginal conditions migrate to Palmiet for better employment opportunities. Politically the African National Congress (ANC) leads the eThekwini metro, however Palmiet settlement falls under Ward 23 and has a Democratic Alliance (DA) ward councillor. An active and vocal movement called *Abahlali baseMjondolo* (informal dwellers) works with the informal settlement communities within the municipality in fighting for better living conditions and improvement of the lives of informal dwellers (Umhlaba Izindlu neSithunzi: Land Housing Dignity 2016).

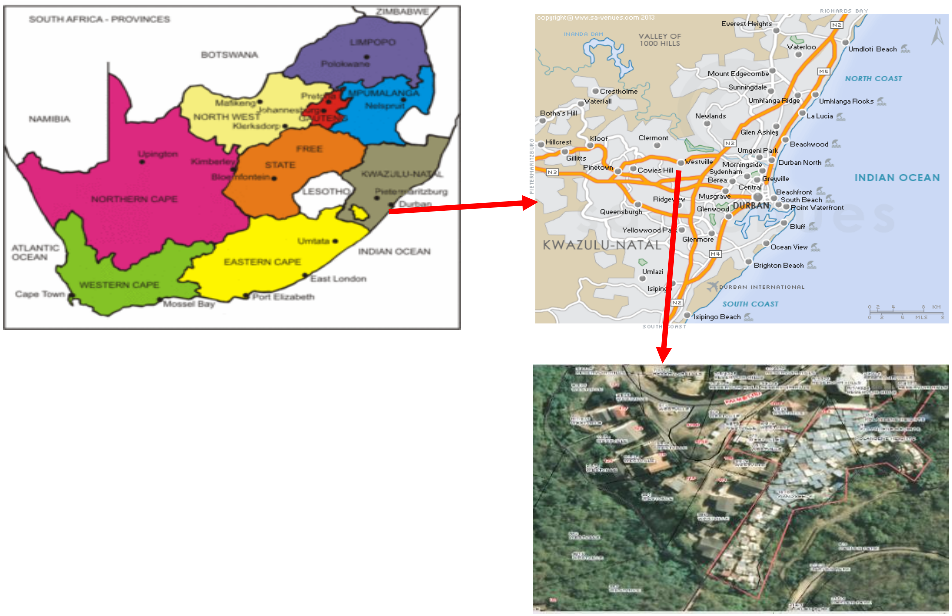

Figure 2 - Map showing KZN, EThekwini & Palmiet informal settlement. Source: Google maps, 2017.

The conceptual and theoretical framework

The study adopted the Sustainable Livelihood Framework (DFID, 1999), a framework originally developed by Robert Chambers in the mid-1980s. The framework has been adopted by a number of development agencies, including the United Kingdom Department for

International Development (DFID), which has been an advocate of applying this framework in various developing countries (Mayunga 2009:28). The framework's livelihood assets, which are portrayed as the pentagon of assets, are suitable for this study. The assets in the community's possession are used to analyse their situation. The asset pentagon is the core of the Sustainable Livelihood Framework (Mayunga 2009:30). It consists of five capitals, namely human capital, social capital, natural capital, physical capital, and lastly financial or economic capital. The five types of capital are important assets in building disaster resilience and sustaining livelihood (Mayunga 2009:31).

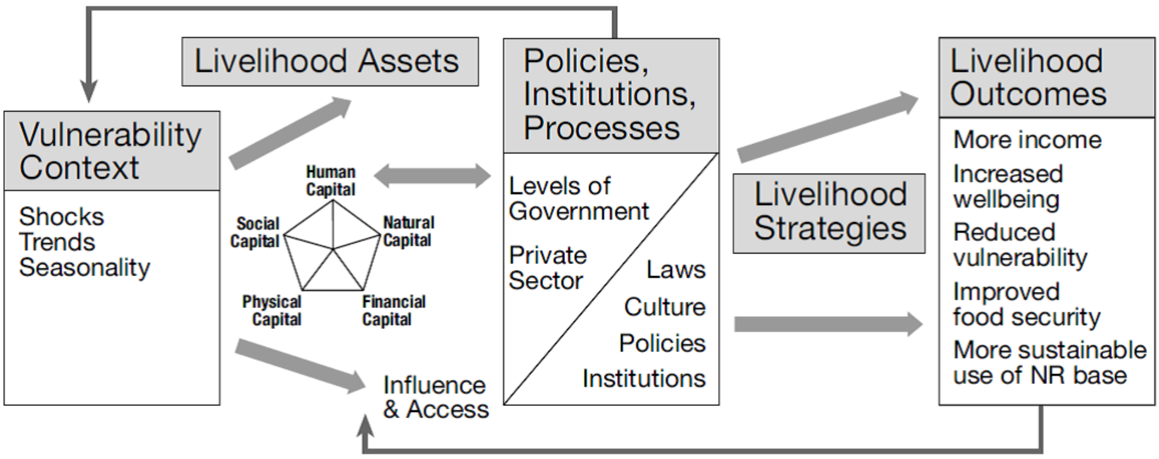

Figure 3 - Sustainable Livelihood Framework. Source: DFID, 1999

Community resilience and adaptation

Globally, community resilience is the key to disaster management. Resilience allows communities to adapt quickly to the impact of disaster events. Community resilience is built through proper preparedness planning (Ambrusz 2016) and effective response and recovery strategies (Thornley, Ball, Signal, Lawson-Te Aho & Rawson 2014). Thornley *et al.* (2014) argue that, while there is a great deal of work done on individual resilience globally, community resilience has been underestimated. Using a model of resilience, they indicate that community resilience is not simply the total sum of individual resilience but there are distinct community-level factors that promote post-disaster adaptation.

Community resilience should be prioritised locally. Since the promulgation of the South African Disaster Management Act no. 57 of 2002, the disaster management approach has focused on preventing, mitigating and reducing the impacts of disasters. This proactive approach, centred on disaster preparedness, building community disaster resilience and adaptation. Despite the emphasis on the need to build community resilience and adaptation, there is a huge lack of knowledge among government institutes and relief organisations regarding the resilience and indigenous knowledge of those directly affected by disasters. There is inadequate literature that captures the knowledge about the resilience and adaptation of communities especially in the informal settlements.

Inadequate infrastructure and surrounding environment, high and uncontrolled population densities, poor access to health and educational facilities, lack of effective governance and management and the inadequate individual dwellings are some of the factors contributing to community vulnerability in Palmiet. Informal settlements often do not comply with local requirements for conventional (formal) urban planning and development, consequently remaining as areas of increasingly high risk with regard to fires.

3. RESEARCH DESIGN AND METHODOLOGY

This study adopted a case study strategy to investigate the community's fire resilience and adaptation at the Palmiet informal settlement. This research design is relevant to the study as it allows for robust methods and a holistic in-depth investigation of community resilience at the Palmiet informal settlement. The study followed a predominantly qualitative and lesser quantitative case study approach as most of the information gathered from the participants was in text form. A semi-structured questionnaire was designed, piloted and used to interview the participants. Observations and informal conversations were also used as part of the triangulation method to get more meaning to the study. The data collection tools were used concurrently in no particular order. The approach was considered to be more appropriate for studying the issues of concern as it further provided opportunity for extensive recording of field notes through visual aids, photographs, and recordings in order to produce well-versed findings. Much interaction was undertaken with the participants to understand and interpret their views. The study further drew on formal statistical reports and documented evidence from municipal departments such as Municipal Housing, Fire and Rescue Services, and the Disaster Management and Emergency Control Unit.

The population of Palmiet, L-Section was used in the study. L-Section has a population of approximately 2 000, with 327 households. A non-probability sampling technique was used, as the participants were selected based on the subjective judgement of the researcher, assisted by the councillor. The criteria for selection was the location, knowledge and experience of participants. These individuals were considered knowledgeable in matters to do with the settlement living conditions so that they would effectively respond to the questionnaires, conversations, and informal interviews in order to provide the necessary information required for the study. A sample size of 65 households was used as community representatives for the study. All the participants were briefed on the objectives of the study. Ethical considerations were observed during the data collection process.

4. RESULTS AND DISCUSSION

Most of the surveys in the topic of firefighting focus on the firefighters. Three research assistants were recruited, trained and provided with the necessary tools to collect the data. The researcher assistants worked with a community field worker who were familiar with the area. The questionnaires with the community consisted of 43 questions, divided into five sections, namely community demographics, community fire risks, community fire resilience factors, economic activities and financial resources, and lastly social and community engagements.

The community semi-interviews were conducted over a period of two days. The first visit to the settlement was on 14 December 2018 and the second visit took place on 18 January 2019. Sixty-five (65) community members responded to the questionnaires. The data analysis process involved organising the data received, categorising the data, interpreting the data to be meaningful information, making sense of the information by identifying underlying patterns and drawing a conclusion out of the information. The data was analysed using an Excel spreadsheet.

The discussion with the community representatives yielded the following results:

Table 1 - Community demographics. Created by the Authors. Source: Survey results, 2018.

Demographic	**Category**	**Number of respondents (n=65)**	**Percentage**
Age (years)	18-24	9	13.9
	25-34	20	30.8
	35-44	22	33.9
	45-54	11	16.9
	55-64	3	4.6
	65 or older	-	-
Gender	Male	37	56.92
	Female	28	43.08
Language spoken	Zulu	48	73.85
	Xhosa	13	20
	Sotho	1	1.54
	English	1	1.54
	other	2	3.08
Education level	Primary	14	21.54
	Secondary	44	67.69
	Tertiary	2	3.08
	No Education	5	7.69
Marital status	Single/never married	33	50.77
	Cohabiting	12	18.46
	Domestic partner	10	15.38
	Married	5	7
	Separated	2	3.08
	Widowed	2	3.08
	Divorced	1	1.54

Almost fifty-seven percent (56.92%) respondents were male and 43.08% were females. The majority of the respondents were aged between 35 and 44 years (33.85%). The second highest age group was 25-34 (30.77%). There was a small difference between the majority age group and the second highest age group. The next age group was 45-55 years of age (16.92%), followed by the age group 18-24 years of age (13.85%) and the smallest age group was 55-64 years of age (4.62%). There were no respondents in the age group 65 years or older. All 65 respondents were of Africans origin. In terms of home language, 73.85% were Zulu speaking, which was the majority. Xhosa speaking respondents were 20.00% and the rest were Sotho speaking (1.54%), English speaking (1.54%), and 3.08% were speaking some other language.

The education level of the respondents was required in order to determine the relationship between education and knowledge about fire risks and the management of fires at household level. The education level of the respondents was according to different levels. The table illustrates that the majority of the respondents, 67.69%, obtained secondary school education, 21.54% obtained primary school education, and 3.08% of the respondents had tertiary education. Only 7.69% of the respondents had no education at all. The basic levels of education is a contributing factor to good communication between officials and the residents and also increases the chances of better job opportunities.

Half of the respondents (50.77%) are single or never married, 18.46% are single, but cohabiting with a significant other, 15.38% are in a domestic partnership, 7% are married, 3.08% are separated, and another 3.08% are widowed. Only 1.54 % are divorced. Most participants have been living in the settlement for more than 8 years, 55.38%, and 23.08% have been living in the settlement for 5 to 7 years and 20% have been at the settlement for 2 to 4 years. Only 1.54% of respondents have been staying in the settlement for 6 months to 1 year. None of the participants had been living in the settlement for less than a month.

Fifty-six (56) of the respondents said they lived in the settlement for better employment opportunities. The rest said they lived in the settlement with families (5) and for study purposes (3). Only one gave another reason for living in the settlement.

Table 2 - Community fire risks knowledge. Source: Survey results 2018.

	Category	**Number of respondents**	**Percentage**
Fire incidences experienced	Yes	50	77
	No	15	23
Causes of fire incidents	Illegal electricity connections	26	40
	Candles	23	35.38
	Arson	15	23
	domestic fights and negligence	13	20
	sleeping while cooking, the use of paraffin stoves, and ignorance	5	7.69
Lighting and cooking equipment used	Electricity for lighting	64	98.46
	Electricity for cooking	63	96.92
	Paraffin for lighting	1	1.54
	Paraffin stove for cooking	1	1.54
Knowledge on potential fire hazards	Yes	36	55
	No	29	45
Knowledge regarding fire safety	No basic Fire training	60	92.31
	Fire awareness training	5	7.69
	Aware of the safety measures to be taken during a fire	45	69.23
	No knowledge of safety measures during a fire	20	30.77

Fire equipment on site	No fire equipment in the house	59	90.77
	Fire blankets	2	3.08
	Fire extinguishers	2	3.08
	Sand buckets	2	3.08
Knowledge of fire hydrants	YES (have knowledge and exact place where the hydrants are located)	17	26
	No (Have no knowledge and they do not even know what a fire hydrant is)	48	74

Opinions on the impacts of fires

Opinions on the impacts of fires were asked and the respondents demonstrated a good understanding of the devastating consequences of fires. Each responded stated a number of responses to question with some of the common responses to the impacts of fires being as follows:

- life becomes very difficult
- the poor get poorer
- loss of lives
- loss of income
- injuries and death
- lose everything
- damage to food
- damage to property and belongings
- leads to fights
- destroys children’s school uniforms and books
- displacement of families
- suffer from trauma and depression

The participants were asked how soon after detecting a fire would they call the fire department.

Table 3 - Reporting of fire incidents. Source: Survey results 2018.

Responses	No. of Responders
As soon as possible	18
Report fire immediately and then try to extinguish the fire	10
Extinguish the fire and then call when overpowered by fire	4
Extinguish fire because I don’t know the fire department number	1
Extinguish the fire and even demolish dwellings that are on fire in order to stop the spread of the fire	1
Call for community help and put out fire, report fire later	23
Remove staff than put out fire	1

Twenty three respondents said they would call the community for help and then attempt to extinguish the fire. They will only report the fire when it escalates. Eighteen respondents said they would report the fire incident immediately and eight respondents said they would report the fire and then attempt to extinguish it. Four of the respondents said their first reaction, when detecting a fire, will be to extinguish the fire and only report it when they had overpowered it. One respondent said he does not have the fire department’s number; therefore, he would extinguish the fire and not report it. Another respondent (1) said he would extinguish the fire and even demolish the house that is on fire in order to prevent the fire spreading. One respondent indicated that he would remove his belongings first and then attempt to extinguish the fire.

5. COMMUNITY FIRE RESILIENCE AND INDICATORS

Cooperation with local fire station

The cooperation of the community with their local fire station assists in quick response and reduces the impact of fires. Respondents were asked if they knew the number of the local fire stations and in response, 89% participants indicated said, they did not know the fire department's emergency number and 11% confirmed that they knew the fire department's emergency number. Most of the respondents said they only know the 10111 (Police) number. The also raised the concern of the number not being a toll free number. They normally ask a neighbour at the nearby formal residential area to assist in calling the fire department.

Effective fire response

Sixty-eight percent (68 %) of the respondents felt that the firefighters' response to fire incidents was not effective and 32% were happy with the response. Through further discussion, some respondents indicated that not all fires are reported to the fire call-centre, as the community sometimes extinguishes the fire themselves. They only call the fire department when the fire escalates and it overpowers them. Another responded acknowledged that the fire department has a great challenge when responding to fires in the settlement since there are no access roads for the fire engine. When further asked why they do not consider opening access roads for fire engines, he said the opening of access roads will provide the opportunity for opportunists to erect their dwellings on the open space.

Management of fires between local authority & the community

Nearly a third of the respondents (27.69%) strongly disagrees that there is collaboration between the local authority and the community in managing fires, while 16.92% of the respondents disagree. A number of respondents (16.92%) strongly agree and 30.77% respondents agree that there is collaboration between the two parties. Only 7.69% of the respondents remained neutral.

Rolling out of fire awareness programmes

Most of the respondents felt that there was a lack of fire awareness programmes in the settlement. Most of the respondents (38.46%) strongly disagree that the municipality conducts fire awareness programmes and 35.38% respondents disagreed. Only 6.15% of the respondents strongly agree that there are fire awareness programmes conducted by the municipality, while 15.38 % respondents also agrees. Only 4.62% of respondents were neutral.

Involvement of community in fire safety

The majority of the respondents indicated that the municipality does not engage or involve them in any fire safety issues. Forty per cent (40%) of the respondents strongly agree while

23.08% of respondents agree that they are not involved. Some (7.69%) of the respondents disagree with the statement and 27.69% respondents disagree. Only 1.54% respondents were neutral. Community further indicated that they try as a community to implement measures to protect themselves against fires, such as reporting and addressing individuals that are negligent and cutting the electric lines for households where they suspect potential fire risks. Another respondent pointed out a water pipe running underground, confirming that as a community they rerouted the water from the main water standpipe to areas further away in order to ensure access to water for firefighting purpose. They also run the illegal electricity lines above ground level for the safety of the community.

Communication during fire incidents

The respondents were asked if there is good communication between the community and the fire teams during response to fire incidents. Most (36.92%) of the respondents strongly agree, and 32.31% respondents agree that the communication is very good. Respondents indicated that they assist firefighters with the rolling out of fire hoses and they guide them through the settlement. The respondents also confirmed that they use the bucket line system (passing buckets of water from one person to the other) to fight fires and reach areas where the firefighters fail to reach.

Early fire warnings

The majority of the respondents strongly disagree that the municipalities give early fire warnings and they also strongly disagree that they have an understanding of fire warning codes. Eighty six per cent (86%) of the respondents agree that there is good communication during fire incidents. One respondent gave an example that they are able to guide and assist the firefighters in rolling out fire hoses during fire incidents. However, after the fire incident there is no communication until the next fire incident.

Table 4 - Economic activities and financial resources. Source: Survey results 2018.

	Category	**Number of respondents (n=65)**	**Percentage**
Employment status	Temporary employment	34	52.31
	Unemployed	18	27.69
	Permanent employment	8	12.31
	Fixed term contracts	5	7.69
Main source of income	Wages	22	33.85
	Salary	17	26.15
	Stipend	13	20
	Income from piece jobs	6	9.23
	Government grants	7	10.77
Monthly household income	>R1150	28	43.08
	R1100-R900	6	9.23
	R600- R850	12	18.46
	R300- R550	18	27.69
	< R300	1	1.54
Financial support after a fire incident	Government support	33	50.77
	Monthly income	23	35.38
	Family and friends	9	13.85

During the discussions, respondents indicated that government support takes very long to arrive. It was also indicated that the community has built a small hall (informal structure), to house displaced people following fire incidents. Fire victims stay in the hall for only a few days until they had rebuilt their houses. None of the respondents have savings or insurance to cover the impact and unplanned costs caused by fire incidents. When asked if respondents have family or friends to stay with after a fire incident, 62% indicated that they do not have any family or friends that can assist and 38% said they do have family support following a fire incident.

Social and community engagements

Participants were asked whether they knew the ward councillor's office and if they attended ward meetings convened by the councilor's office. The objective was to ascertain the relationship, if any, between the participants and the ward councillor's office.

Table 5: Social and community engagement

	Category	**Number of respondents**	**Percentage**
Engagement with the councillor	Knew who their councillor	43	66.15
	Did not know	22	33.85
	Attend meetings with councillor	29	44.62
	Do not attend	36	55.38
Community structures & social networks	Do not know of any structures		50.77
	Have seen community care givers		24.62
	Abahlali baseMjondolo (present in the community	10	15.38
	Community field workers	6	9.23
Belonging to any social group	Yes	30	46
	No	35	54

Engagement on fire issues with the Field workers	Yes	11	17
	No	54	83
Voluntary work in the community	Yes	16	25
	No	49	75

Source: Survey results, 2018.

Table 6 - Opinions on fire prevention and reduction measures. Source: Survey results 2018.

No.	Opinions on fire prevention and reduction measures	Number of Participants
1.	Municipality to conduct fire awareness	17
	Installation of electricity and removing of illegal electrical connections	33
	Municipality to build proper houses	29
	Open fire station closer to settlement	3
	Provide an emergency toll free number	1
6.	Installation of fire hydrant at settlement	2
7.	Municipality to provide them with fire extinguishers	8
8.	Issuing of early fire danger warnings	1
9.	Fire department to provide effective fire response by responding quicker to fires	4
10.	Sufficient relief aid must be provided	1
11.	Provide additional water standpipes	2
12.	Open access routes for fighting	4
13.	Provide basic fire training	6

14.	Request for a skip for waste control purposes	1
15.	Request that the fire department listens to their advice when coming to extinguish a fire as they know the settlement area better	1
16.	They want nothing because the municipality failed them a long time	1

6. CONCLUSIONS AND RECOMMENDATIONS

Informal settlements, due to their nature, are highly at risk of experiencing fire incidents. The use of highly combustible materials in the construction of these structures, along with the use of illegal electrical connections for lighting and cooking, contribute to the risk. The risks are further increased by the dense setup, which limits access for firefighting while increasing the spread of fires. There is also a challenge in terms of access to water for firefighting. Palmiet informal settlement is not different from all other settlements. However, noticeably less fire incident are reported due to their human, social and economic capitals. It was also interesting to find out that the community built a hall to house those who could be displaced by fire or any other hazard. There are strong social networks in the community too. An example of the social network is *Abahlali Basemjondolo,* which has over the years challenged to government to pay attention to their plight countrywide. They may not have natural capital, however they are utilising the other assets to their best abilities in order to reduce the shack fire risks. They have adapted well and are more resilient than others in the informal settlements are.

The informal interviews and observations also revealed that the community and the local municipality are not working in collaboration, yet they share a common goal. The common goal is to prevent and reduce fire incidents in order to ensure the safety of the community. There is a great need for the integration of scientific knowledge with that of the local community, in order to develop effective and risk-free fire management strategies. It is evident that the community possesses vast knowledge of the settlement conditions and operations, which may be very useful to consider during the fire management-planning phase.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Eunice P. Vhiriri, Yoland Irwin. Richard K. Laubscher, Roman Tandlich

SHORT COMMUNICATION: QUANTITATIVE ANALYSIS ON GENDER RELATED VULNERABILITIES AND FATALITIES IN DISASTER SITUATIONS IN SOUTH AFRICA.

Abstract

South Africa is a country which faces major challenges with disasters. The aim of this short communication is to report on the findings of current research that assesses the general fatalities which are recurrent over the years and are likely to increase when there is a disaster of magnitude. Representation of data by Statistics South Africa has improved over the years since the previous calculations were done and this has allowed the previous model to be re-designed to suite the available data making the calculations slightly more accurate. The notable increase of disaster related death rates in women since 2015 necessitates further assessments of the risk factors of this cause. Thus there is a need of future studies to focus on monitoring and ensuring that the female disaster related death rates. The socio-economic vulnerability still exists among women in South Africa. The results of this study can therefore be used by relevant stakeholders to assess in detail factors that are leading to increases in DRDR.

Keywords: gender, vulnerability, fatality, statistic

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

A TÁRSADALMI NEMEK SEBEZHETŐSÉGÉNEK ÉS ELHALÁLOZÁSÁNAK MENNYISÉGI ELEMZÉSE A KATASZTRÓFÁK SORÁN DÉL-AFRIKÁBAN

Absztrakt

Dél-Afrikában számos katasztrófa nehezíti a hatékony védekezést. A cikkben a szerzők felmérik az évek során bekövetkezett általános haláleseteket. A GII bevezetése megkönnyítette a társadalmi és gazdasági sebezhetőség felmérésének lehetőségét. A Dél-afrikai statisztikai adatok alapján az elmúlt években javulás figyelhető meg az előző időszakokhoz képest, azonban egyes adatok további kockázat értékelést igényelnek. A szerzők vizsgálják, hogy a férfiak és nők egészségi állapota miért tér el egymástól, emellett bemutatásra kerül a dél-afrikai kormány néhány határozata is a katasztrófa kockázatok csökkentéséről, illetve a katasztrófák utáni helyreállításról. A cikk eredményeit az érintett felek felhasználhatják a DRDR növekedéséhez.

Kulcsszavak: társadalmi nem, sebezhetőség, haláleset, statisztika

1. INTRODUCTION

WHO describes gender as the socially constructed characteristics of both men and women, where certain norms, roles and relationships are expected to be followed by men and women differently (WHO, 2018). These norms and behaviours are taught from childhood and anyone who fails to follow these norms can often be stigmatized and discriminated against by the society. This gives a highlight of how the practice of gender differences is important in societies. Access to resources and certain lifetime opportunities can be limited to a certain gender, thus giving rise to vulnerabilities and these can have profound effect on the fate of individuals from a particular society during disaster situations. Power imbalances are seen when certain roles are expected for men rather than for both sexes. This creates a disadvantage to women in terms lack of access to certain opportunities such as education and healthcare. Some traditional practices such as Female Genital Mutilation increase the vulnerability of the female part of population in many African countries (Abdulcadir et al. 2017).

South Africa is a country located in the southern region of Africa. The latest population estimate was 56.520 million in 2017 (Statistics South Africa, 2017a). Of this population it is estimated that 51% is female (Statistics South Africa, 2017b). In 2015 the human development index (HDI) of South Africa was 0.666, ranking South Africa position 119 out of 188 countries (UNDP, 2017). The HDI of 0.666 is classified as medium level of human development. An increase in HDI has been seen in South Africa, where there was a 7.3% increase from the year 1990 to 2015 (UNDP, 2017). The female HDI is 0.651 and that of men is 0.677 (UNDP, 2017). Gender Development Index (GDI) was introduced internationally in 2014 and it is a ratio of male to female human development (UNDP, 2017). The ratio takes into consideration three indicators of the HDI namely, health, education and command over economic resources (estimated GNI per capita for both men and women) (UNDP, 2017). The GDI of South Africa is 0.962 (UNDP, 2017). The Gender Inequality Index (GII) of South Africa was 0.394 in the year 2015 (UNDP, 2017).

The life expectancy at birth stood at 61.2 years for men and 66.7 years for women in 2017, according to the official government statistics (Statistics South Africa, 2017b). HIV/AIDS is one of the most prevalent diseases in South Africa and it has increased from 4.9 million in 2002 to 7.06 million in 2017 (Statistics South Africa, 2017b). About a fifth of women of ages 15-49 in South Africa are HIV positive (Statistics South Africa, 2017b). This is within the most productive age range. HIV/AIDS is the major contributing factor in maternal mortality where it accounts for more than 30% of maternal deaths (Statistics South Africa, 2015c). To prevent death, all pregnant women who test HIV positive are instantly placed on antiretroviral treatment (Statistics South Africa, 2015c). A study showed that women exposed to gender-based violence are at higher risk of HIV infection (Dunkle et al 2004). This comes with an assumption that abusive men are most likely to have extra-marital relationships, and because of abuse the woman will be afraid to suggest the use of condoms. This highlights the social vulnerability of women.

Gender-based violence is one of the problems faced by women in day to day life and worsens in disaster situations. This compounding factor of disaster impacts has been defined in the United Nations Declaration on the Elimination of Violence against Women (1993; UN, 2018): as "any act of gender-based violence that results in, or is likely to result in, physical, sexual or psychological harm or suffering to women, including threats of such acts, coercion or arbitrary deprivation of liberty, whether occurring in public or in private life". Spread of infectious and sexually-transmitted diseases has been linked to intimate partner violence and gender inequalities (Jewkes et al. 2010; Dunkle et al. 2004). Some progress was made in South Africa at the end of 2015, where women had 42 parliament seats in 2013 although the 50/50 goal wasn't reached (Statistics South Africa, 2015d). Equality of seats in the parliament would mean that there will be shared decision making in terms of policies and regulations which aim at women empowerment. Prioritization of issues pertaining to women can also be practiced if there are more women to support this in the parliament. Sustainable Development Goal (SDG) 5 focuses on Gender Equality, aiming at eradicating discrimination against women and children. It stresses the importance of empowering women, as a way of helping build economic growth.

In South Africa, the National Senior Certificate pass rate showed that male individuals excel better than females (Statistics South Africa, 2015d). Data from UNDP Human development report showed that 73.7% of women of ages 25 and older had at least secondary education, and this is compared to 76.2% of men in the years 2005-2015 (UNDP, 2015). The level of education determines the type of jobs which a person will qualify for in the labour market. Emergence of women-owned informal businesses has been seen in the past decades (Henning & Akoob 2017). These businesses have come to rise because of widespread female headed households (Henning & Akoob 2017).

Vulnerability refers to social, economic, health and political processes of a disaster-prone area which measures the ability of a population to anticipate, resist, cope and recover from the effects of exposure to a hazard (Cardona, 2005; Blaikie, 2001). The gender aspects of disaster vulnerability fall under both social and economic vulnerabilities. Socio-economic factors which bring rise to gender inequalities are assessed in this research. Women and child headed families are more vulnerable to poverty thus increasing negative effects of disasters. Health factors are also taken into consideration when reviewing gender inequalities.

The current study on gender analysis helps in providing a quicker response system in a disaster situation. Roles of men and women in disaster help in identification of individual needs thus allowing prioritization of people in need for immediate help. The inequalities between men and women worsen in disaster situations, with women being the worst off. By understanding that gender and disasters are closely interconnected, more risk reduction practices can be put in place. It is a continuation of the 2013 study which was published by Tandlich et al. (2013a).

2. METHODOLOGY

Reliable data sources used in this chapter are World Bank data, Statistics South Africa and INDEX MUNDI. A trend of data collection on the respective sites over the years will be assessed to determine accuracy of data used. Key words and phrases used to search for background information to support the study included “gender vulnerability”, “gender & disasters”, “human development” and “disaster fatalities”. Search engines namely Scopus and Google Scholar were used. This study is a follow-up on the vulnerability calculations done by Tandlich et.al. (2013a). Previous study successfully assessed gender disparities using mathematical equations. Assessment of gender related vulnerability trends and disaster related fatalities in South Africa were initially done for the years 1997-2009. The follow-up is for the years 2010 to 2016. Gender inequality was assessed through evaluation of the progressions of health status over the years.

Gender Vulnerability assessment

Life expectancy at birth highlights the health status of a country, as well as the status of the and can be used for comparison between men and women. The comparison gives an idea of the gender disparities between men and women with respect to the average number of years they live up to. INDEX MUNDI, 2019 defines life expectancy at birth as “an indicator of the number of years a new-born infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life”. Data from World Bank open data for life expectancy at birth for both men and women were used to calculate the life-expectancy at birth index (LEABI) using Equation (1) below as defined by Tandlich et al. (2013a).

LEABI= Age (women)/Age (men) **Equation (1)**

Where

“Age (women) is the average life expectancy at birth of women in South Africa in years

Age (men) is the average life expectancy at birth of men in South Africa in years

The equation gives a dimensionless *LEABI* value” (Tandlich et al., 2013a).

Vulnerability will also be calculated by assessing the economic status of households. Unemployment rate can highlight the economic status of a household. The unemployment inequality index (UII) is used to assess which gender has a higher economic vulnerability. UII was calculated using Equation (2), as defined by Tandlich et al. (2013a).

UII= Unemployment Rate (women)/Unemployment Rate (men) **Equation (2)**

“The value of UII is also dimensionless” (Tandlich et al., 2013a).

The GII uses three indicators which are “maternal mortality ratio and adolescent birth rate, number of parliament seats and literacy rate” (Lardner, 2017). A value of GII covers both literacy rate and access to health with respect to the population. It quantifies the disadvantages of women in a society.

Mortality calculations

To quantify the gender aspects of disasters, data for causes of death will be used. The data used should give separate values for both men and women therefore allowing for the comparison between the two. Statistics South Africa database will be used to access morbidity data. Statistics South Africa (2018a) stated that there was 96% completeness of morbidity data between 2011-2016 for ages 15 and above. To ensure accuracy of results in this study all calculations will be for ages 15 and above. The morbidity data given gives a broad set of causes, some of which is not linked to disaster situations. The derivation and justification of the model calculations, as well as weighing of the appropriate data used in terms of non-natural/unnatural causes of death is in accordance with Tandlich et.al. (2013a). In this way, results of the calculations and the model results would only reflect the causes of death which are directly linked to disaster situations and their impacts. In this instance non-natural/unnatural causes of death were looked at. Knowing that disasters cause unnatural deaths and not all unnatural deaths are directly linked to disasters, it therefore necessitates exclusion of data of indicators such as transport death rates, deaths resulting from medical or surgical errors and intentional harm.

Statistics South Africa provides data for "other external causes of injury (OECI) (WOO-X59). According to the WHO ICD-10 classification of injuries (WHO, 2016), the W00-X59 includes causes of death such as exposure to mechanical force, drowning, exposure to electric current and radiation, extreme climatic events (high ambient temperature or pressure), fire and smoke. The study by Tandlich et. al. (2013a) specified and explained how such causes can be related to natural or man-made disasters. The series X85-Y09 of the WHO ICD-10 shows the cause of injury as a result of assault (ADR) (WHO, 2016). The literature review mentioned the occurrence of gender-based violence. Therefore, assault will be included as a gender related event which can be linked to disasters. The morbidity data from Statistics South Africa gives a figure for death as a result of assault.

Another category of causes of death which was added was death due to legal interventions and operations of war (LIOW) (Y35-Y36). Series Y35-Y36 listed injuries due to refusal of arrest by police or any other law enforcing agents where such injury might be due to firearms, explosions or gas, Y36 lists injuries during war. Adding this as an example of a disaster related death goes in line with the study by Mkwakwami (2018b) which describes social unrest in South Africa as a form of a disaster.

The value for disaster related death rate (DRDR) will therefore be calculated using the Equation (3) below.

DRDR= OECI + ADR + LIOW **Equation (3)**

Where:

OECI is death due to other external causes of injuries which fall under the W00-X59 series if the WHO ICD 10

ADR is assault death rate falling under the X85-Y09 series of the WHO ICD 10

LIOW is death due to legal interventions and operation of war (Y35-Y36).

The values of DRDR should be presented as number of deaths per 100 000 population. The equation below shows how this will be calculated as shown in Equation (4).

OECI= (100000x Gender deaths)/Total population of South Africa Equation (4)

This equation will be used for all parameters of DRDR for each of the years covered by the study.

After calculating DRDR for both males and females, the disaster-related death inequality index (DII) (Tandlich et.al, 2013a) will be calculated using Equation (5).

DII= DRDR (women)/DRDR (men) Equation (5)

Microsoft Excel 2016 was used to perform the calculations (Microsoft Inc., Johannesburg, South Africa). Source data is labelled below all the tables and figures in the results and discussion section. The exact same data was extracted and used for calculations without rounding off at any point.

3. RESULTS AND DISCUSSION

Vulnerability Assessment

The value of Life Expectancy at Birth Inequality Index (LEABI) shows high vulnerability of women compared to men when it is below 1, and values above 1 show lower level of vulnerability of women and higher for men (Tandlich et al., 2013a). The *LEABI* values are above 1 as shown in Figure 1. This is because in South Africa life expectancy at birth of women is higher than that of men. This necessitates assessment in terms of quality of life difference between men and women. One way will be referring to the Gender Inequality Index (GII) to include factors such as maternal mortality, adolescent birth rate, literacy rate and number of seats in the parliament. From Figure 1, low GII gives higher values of LEABI but as GII increases the LEABI drops. A higher GII reflects to the high level of vulnerability and is inversely proportional to LEABI. As explained before low levels LEABI reflect high levels of vulnerability.

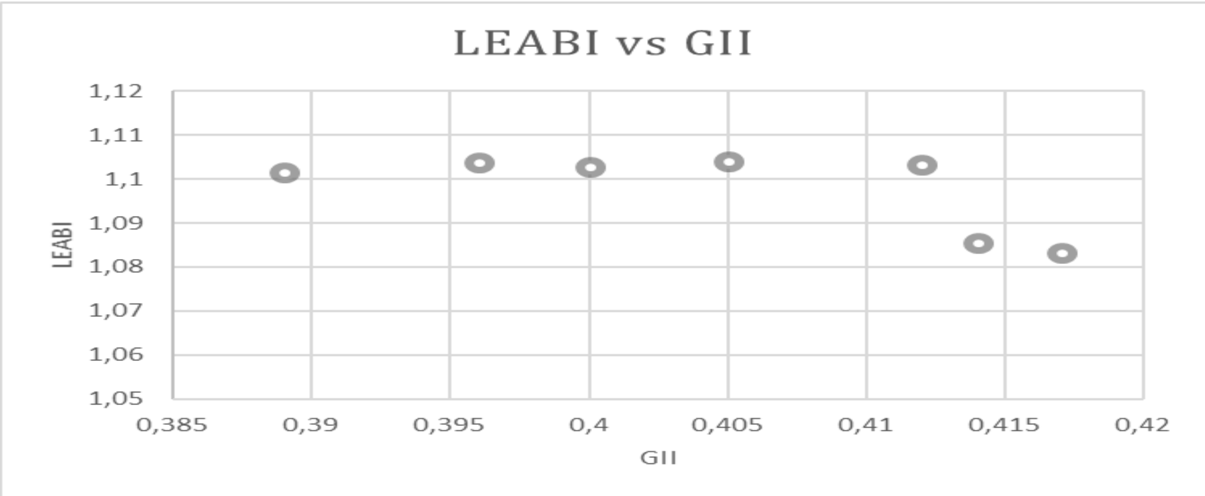

Figure 1: Life Expectancy at Birth Inequality Index (LEABI) vs. Gender Inequality Index (GII), which is an expansion of the model derived by Tandlich et al. (2013a).

The values LEABI values in Figure 1 were calculated for South Africa using equation 1 for the years 2010 to 2016. Data for LEABI was extracted from Statistics South Africa (2018a). GII values were for the years 2010 to 2016 and data was extracted from UNDP (2019b). The United Nations Development Programme (UNDP) has made available data trends on the public domain, statistics which give detail of gender aspect indicators in a country. These include a separate human development index (HDI) for both males and females, unemployment ratio of men and women, gender development index (GDI), estimated gross national income per capita for female and male and percentage of violence against women. All these can also be used to assess the level of vulnerability of female gender. Therefore, an already existing vulnerability can be exacerbated by the occurrence of disasters.

If the value of UII is above one, it shows that women are more vulnerable than men. Figure 2 illustrates the relationship between UII and GII that is to assess the relationship between unemployment and gender inequality. There was no systematic trend shown in Figure 2. Unemployment data for women is larger than that of men throughout the period in question, hence the values of UII larger than 1. The lowest unemployment rate that women ever had was the 2013 value of 26.7% and this corresponds with the estimated gross national income per capita for females which was also highest in 2013 at 9238 PPP$ according to UNDP (Statistics South Africa, 2019; UNDP, 2019a).

Note: The UII values were for South Africa for the years 2011 to 2016. The data was extracted from Statistics South Africa (2019). Equation 2 was used to calculate UII. The quarterly values of unemployment rate values from Statistics South Africa were averaged to give a yearly value. GII data was extracted from UNDP, 2019b. The relationship between HDI and GII is shown in Figure 3 and there is a negative correlation between HDI and GII as expected. A country will show lower gender inequality as the human development increases.

Mortality calculations

Data from 2010 to 2012 was given in broad age group categories. In 2013 Statistics South Africa separated the age groups into 6 different categories. This shows an improvement in the accuracy of the data. The fatalities data provided by Statistics South Africa for the period between 2007-2011 for 15 years and above, had a 94% level of completeness and from 2011 to 2016 this increased to 96%, therefore DRDR was calculated for ages 15 and above to ensure a high level of accuracy in the results (Statistics South Africa, 2014a, Statistics South Africa, 2018b).

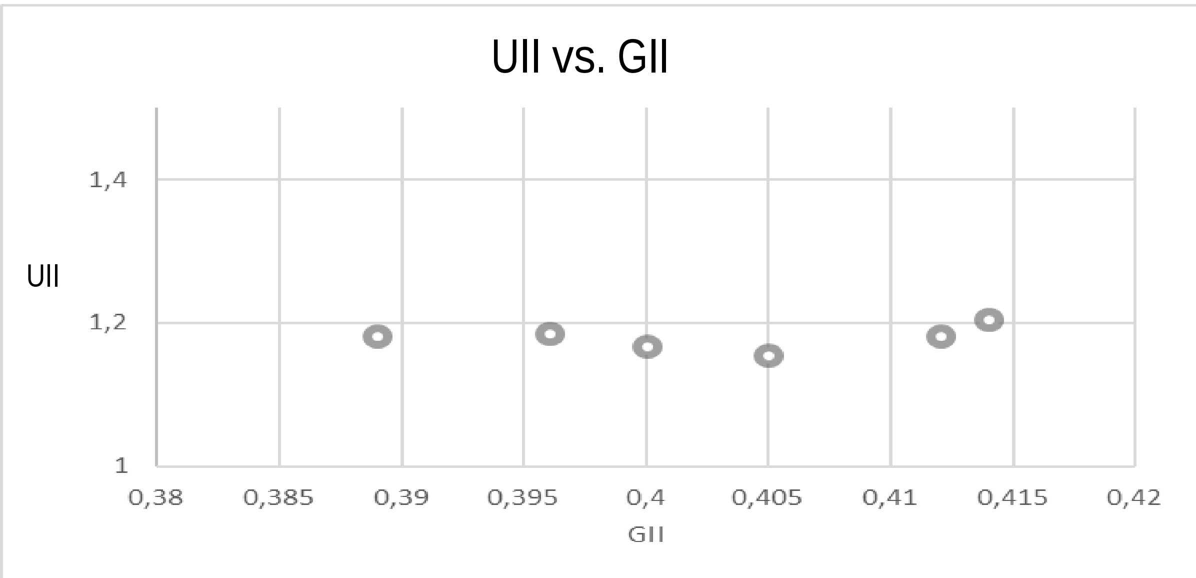

Figure 2: Unemployment Inequality Index (UII) vs Gender Inequality Index (GII)

From Table 1, it can be deduced that the most productive age group (15-49) years has the highest recorded number of disaster related fatalities. Also considering that ages 65+ usually accounts for a smaller number on a population pyramid the number of fatalities in question are very high throughout the years (Table 1). This highlights a very high vulnerability of elderly women. The male age group between 15-49 years had the highest fatalities because of higher OECI figures from 2013 to 2016 (see Table 2 for more detail). In the year 2015 there was a sharp increase in males with a cause of death attributed to OECI in all age groups which was followed by a drop in the numbers in 2016 except for men aged 65 and above.

Table 3 shows how female DRDR has been gradually decreasing from 2010 to 2014 followed by an increase thereof since 2015. This raises a question of how women were suddenly exposed to hazards that result from the unnatural causes of death in question. The previous study by Tandlich et. al. (2013a) showed significantly high figures of male DRDR with the highest being 172.6 per 100000 citizens in 2001. At the end of the previous study the DRDR value had decreased to 38.3 per 100000 citizens in 2009. In the current study Table 4 illustrates a decrease in male DRDR until 2015 where there was a 20.7% increase followed by a 54.5% decrease in DRDR in 2016.

DII can be used as an indicator of vulnerability. If DII is above 1 it would mean that women are more vulnerable to disaster related fatalities, and the closer the value is to zero males are said to be more vulnerable. The values of DII are shown in Table 5 show that men are more vulnerable than women. DII for 2016 indicates that males are two times more vulnerable than women to disaster related fatalities and this is an improvement on the male part since the last study by Tandlich et. al. (2013a) which concluded that men were five times more vulnerable than women with respect to exposure to disaster related fatalities.

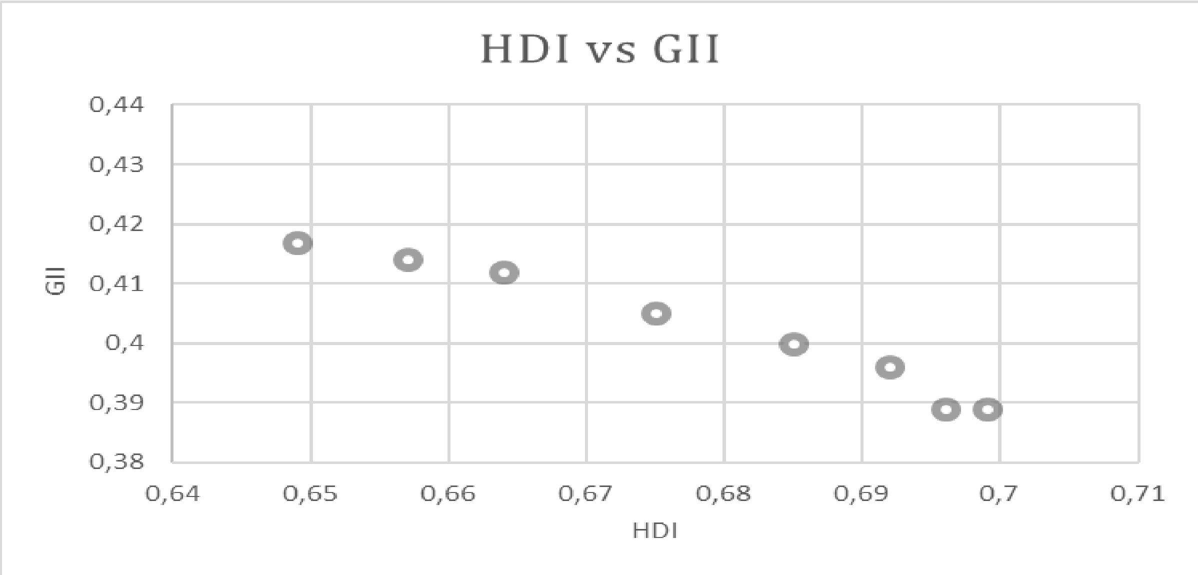

Figure 3: Human Development Index (HDI) vs Gender Inequality Index (GII)

Source: HDI data was extracted from UNDP (2019c) and GII was extracted from UNDP (2019b).

A possible explanation of this could be the nature of occupations which are male dominated which have high exposure to hazards. According to the literature, major disasters/calamities result in greater female fatalities than male as compared to smaller disasters (Neumayer & Plümper, 2007). This justifies the findings of this research since low magnitude disasters were recorded in South Africa during the period of study. This is based on disasters recorded by EMDAT database where 13 disasters occurred between 2010-2016, the highest number of fatalities (40 people both occasions) having been recorded in 2010 and 2011 due to a storm and floods respectively (EMDAT, 2020). This study has attempted to quantify variables which will essentially determine vulnerability and to some extent level of risk. The literature gives ratios of vulnerability based on statistics of number of people affected by a disaster. These statistics vary depending on nature of disaster, some studies say that women are five times and another study states that they are 14 times more likely to die in disasters than men (Habtezion, 2013).

Table 1: Female disaster related fatalities for years 2010 to 2016

Female																
year	2010		2011		2012			2013		2014		2015		2016		
Age	OECI	ADR	OECI	ADR	OECI	ADR	Age	OECI	ADR	OECI	ADR	OECI	ADR	OECI	ADR	LIOW
0-14	1413	29	1232	26	1325	27	0	318	9	344	7	356	4	357	5	
15-49	3706	505	3398	484	3363	477	1-14.	904	19	873	20	975	29	1018	22	
50-64	857	70	933	61	900	51	15-29	1445	229	1340	238	1575	305	1726	318	
65+	1309	56	1389	57	1439	51	30-44	1211	188	1194	179	1502	236	1510	267	
							45-64	1157	89	1135	91	1322	150	1466	141	1
							65+	1334	53	1325	64	1494	72	1584	91	

Source: Data for Other external causes of injury (OECI), Assault death rate (ADR) and Legal interventions and operation of war (LIOW) was extracted from the following sources: Statistics South Africa: 2013a, 2014a, 2014b, 2014c, 2015b, 2016a, 2017b, 2018b.

Table 2: Male disaster related fatalities for years 2010 to 2016.

Male																	
year	2010		2011		2012			2013			2014		2015			2016	
Age	OECI	ADR	OECI	ADR	OECI	ADR	Age	OECI	ADR	LIOW	OECI	ADR	OECI	ADR	LIOW	OECI	ADR
0-14	2314	40	1232	49	2112	48	0	411	3	0	396	7	428	12	0	357	8
15-49	15867	3997	14714	3816	14706	3741	1-14.	1472	23	0	1488	38	1611	59	0	1018	43
50-64	2791	262	2577	257	2615	266	15-29	6931	2529	0	6544	2641	8191	3545	0	1726	3591
65+	1401	75	1324	71	1417	78	30-44	6020	1286	1	6121	1434	7658	1986	0	1510	2203
							45-64	3686	458	1	3665	462	4696	607	2	1466	701
							65+	1318	79	0	1260	68	1696	113	0	1884	119

Source: Data for Other external causes of injury (OECI), Assault death rate (ADR) and Legal interventions and operation of war (LIOW) was extracted from the following sources: Statistics South Africa: 2013a, 2014a, 2014b, 2014c, 2015b, 2016a, 2017b, 2018b.

Table 3: Female Disaster related death rates (DRDR) in South Africa from 2010 to 2016

Year	DRDR	Total population in South Africa	DRDR (cases/100000)
2010	6503	49991300	13.008
2011	6322	50586757	12.497
2012	6281	52998213	11.851
2013	5706	52982000	10.770
2014	5566	54002000	10.307
2015	6656	54956900	12.111
2016	7104	55908900	12.706

Note: Disaster Related Death Rate (DRDR) was calculated as outlined above using equations 3-5 and converted to cases/100000. The figures for total population of South Africa in the period of the study were extracted from Statistics South Africa: 2010, 2011b, 2013b, 2014d, 2015c and 2016b. The population data for the year 2012 was extracted from World Bank Data, 2019j.

Table 4: Male Disaster related death rates (DRDR) in South Africa from 2010 to 2016

Year	DRDR	Total population in South Africa	DRDR (cases/100000)
2010	24393	49991300	48.794
2011	22759	50586757	44.990
2012	22823	52998213	43.064
2013	22309	52982000	42.107
2014	22195	54002000	41.100
2015	28494	54956900	51.848
2016	13200	55908900	23.610

Note: DRDR was calculated using equations 3-5 as outlined above and was converted to cases/100000. The figures for total population of South Africa in the period of the study were extracted from Statistics South Africa: 2010, 2011, 2013b, 2014d, 2015c and 2016b. The population data for the year 2012 was extracted from World Bank Data, 2019.

Table 5: Disaster Inequality Index (DII) for male and female residents of South Africa

	DRDR per 100000 citizens		
Year	Female	Male	DII
2010	13.008	48.794	0.267
2011	12.497	44.990	0.278
2012	11.851	43.064	0.275
2013	10.770	42.107	0.256
2014	10.307	41.100	0.251
2015	12.111	51.848	0.234
2016	12.706	23.610	0.538

Note: DII was calculated using equation 5 and was rounded off to three decimal places.

4. CONCLUSION

The current research assesses the general fatalities which are recurrent over the years and are likely to increase when there is a disaster of magnitude. Introduction of the GII has eased the assessment of socio-economic vulnerability. Representation of data by Statistics South Africa has improved over the years since the previous calculations were done. This meant that some of the equations by Tandlich et. al. (2013a) had to be slightly adjusted to suite the available data making the calculations slightly more accurate. The notable increase of DRDR in women since 2015 necessitates further assessments of the risk factors of this cause. It also calls for the need of future studies to focus on monitoring and ensuring that the DRDR for females does not continue to increase. An increase in DII values since the last study shows that there has been an improvement in health status of men. However, socio-economic vulnerability still exists in women as GII and UII are still high. Some resolutions from the United Nations on gender inequality were adopted by the government of South Africa. UNCSW urged governments to integrate gender-sensitive policies for disaster risk reduction and response and post-disaster recovery (PMG, 2013). The results of this study can therefore be used by relevant stakeholders to assess in detail factors that are leading to increases in DRDR.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Izabela Gabryelewicz, Patryk Krupa, Peter Pantya

SAFETY MANAGEMENT AND THE LEVEL OF CULTURE SAFETY BY AN EXAMPLE OF AN UNIFORMED SERVICE

Abstract

The following paper presents the results of a research on safety management and safety climate level in an uniformed service. The data from an example of an army unit located on Poland. The research has been carried out with the use of author's questionnaire to measure safety climate level. The results are presented by the means of Safety Culture Grid and there have been determined safety level indicators in various companies. The questions in the questionnaire are characterized by firm connection to designate of high safety culture. The results of the survey can be used in wide range. To diagnose safety state in the context of human behavior and consists detailed analysis of the results what allows to pinpoint weak and strong aspects of work safety in a special field, in an uniformed service, an army unit. This results by the survey enables one to undertake preventive and (or) repair actions adjusted to specific areas and worker groups.

Keywords: safety management, uniformed service, research, safety culture, human behavior

MUNKABIZTONSÁG KEZELÉSE ÉS A SZERVEZETI BIZTONSÁGI KULTÚRA EGY EGYENRUHÁS SZOLGÁLAT PÉLDÁJÁN KERESZTÜL

Absztakt

A cikk bemutatja egy, a biztonsági menedzsmenttel és a biztonsági kultúrával, klímával kapcsolatos kutatás eredményeit egy egyenruhás szervezetnél. Az adatok egy Lengyelországban található katonai egység példájából származnak. A kutatást a szerzők kérdőívének felhasználásával végezték a biztonsági szint mérésére. Az eredményeket az úgynevezett Biztonsági Kultúra Rács segítségével mutatjuk be, ez alapján a különböző vállalatoknál meghatározásra kerültek a biztonsági szint mutatói. A kérdőívben szereplő kérdéseket a magas szintű biztonsági kultúra kijelölésével való szoros kapcsolat jellemzi. A felmérés eredményei széles körben felhasználhatók. A biztonsági állapot diagnosztizálása az emberi viselkedés összefüggésében, és az eredmények részletes elemzéséből áll, amely lehetővé teszi a munkabiztonság gyenge és erős aspektusainak pontos meghatározását egy speciális területen, egy egyenruhás szervezet, egy hadsereg egységénél. A felmérés eredményei lehetővé teszik, hogy megelőző és (vagy) javító intézkedéseket hajtsanak végre az adott területekhez és munkavállalói csoportokhoz igazítva.

Kulcsszavak: biztonságmenedzsment, egyenruhás szolgálat, kutatás, biztonsági kultúra, emberi viselkedés

1. INTRODUCTION

In the analysis of accidents usually technical, organizational and human factors are taken into account (Figure 1). Technical and organizational factors are quite easy to control in the terms of their quantity and quality. There are various guidelines in the form of standards, directives and legal rules. The problem are human factors, difficult to identify and quantify. How can one measure and present in a quantitative way values and norms that employees comply with? How can one define the level of awareness and employee’s attitude towards Health and Safety regulations, Health and Safety services or employee’s motivation for safe behaviors?

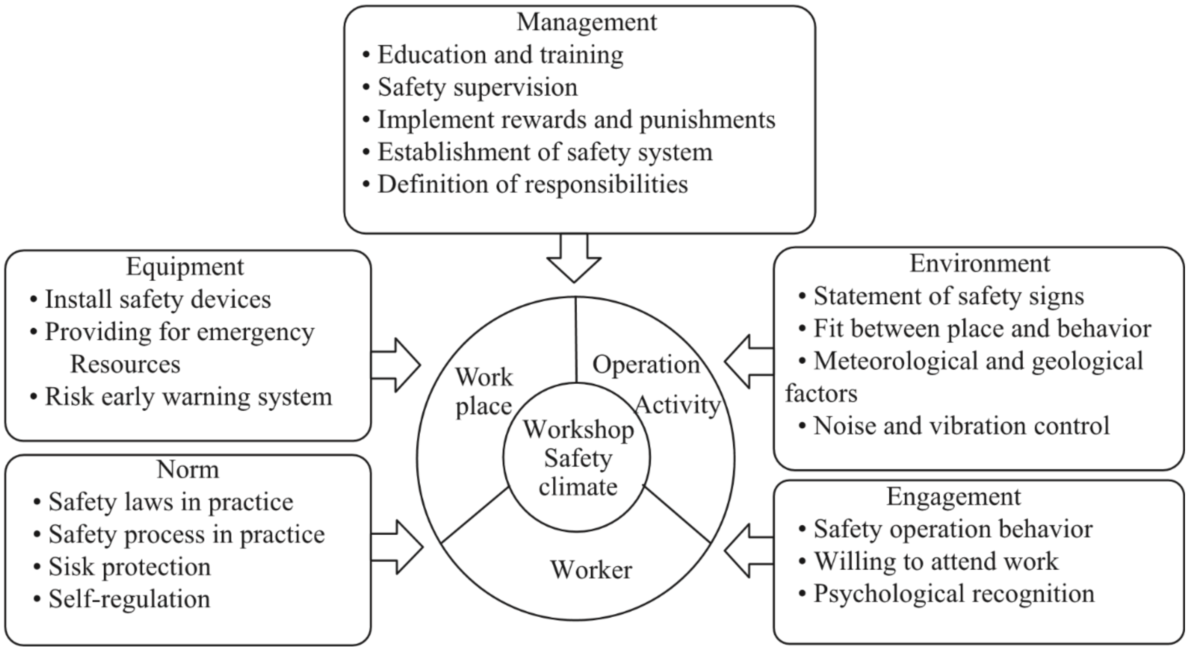

Figure 1 Conceptual framework of workshop safety climate [11]

One of methods to measure hidden manifestations of safety culture, the level of which has influence on work safety, are questionnaires aimed at measuring safety culture level. Such investigations are justified by the statistics of work accident causes. Irrespective of analysed industry it is assumed that the human factor is reason for 60 - 80% of accidents. [6]

2. RESEARCH METHOD

The research has been carried out with author's questionnaire devised by dr. eng. Izabela Gabryelewicz and prof. Edward Kowal from the University of Zielona Góra. The IT tools were developed by UZ (the University of Zielona Góra) employee Patryk Krupa. The developed application enables for fast, multi-directional analysis of the collected data. The developed application has an open form which can be expanded with additional applications [3]. The collected data comes from research carried out by Bartosz Czycz in his thesis, written under supervision of dr. eng. Izabela Gabryelewicz [1, 7, 8], Klaudia Kubicka in his thesis and Piotr

Flasza in his thesis, written under supervision Edward Kowal, prof. UZ. The research was carried out between 2015 and 2018. The research covered a three groups of soldiers:

- first group: 50 soldiers,
- second group: 85 soldiers,
- third group: 96 soldiers.

All the charts in the form of Safety Culture Grid include nine subject categories of safety culture. On the legs of the chart there is presented safety climate level in a given subject group. On the grid the values are presented in percentage scale. Each factor has assigned some value which then is marked on the grid [4]. The plan made by connecting single points gives information about percentage share of each factor in shaping safety culture level in a company. By counting the ratio of the whole grid to the area determined by the points marked on the the grid we get so called safety culture level indicator [2]. Determining this indicator allows to compare safety culture level with other companies or among researched employee groups, both within a company or a uniformed service as well as among various companies but with regard to similar employee groups. The uniformed services can be military units but also similar, law-enforcement units such as police or fire and rescue. [9, 10]

To be able to precisely choose methods that will allow to increase safety culture level, and thus to decrease the number of accidents and at the same time to increase the level of safety in a company there is required an analysis with regard to group of surveyed employees. Therefore, the following part of the paper presents safety climate level with regard to:

- total seniority,
- seniority in the researched workplace
- employee's education
- position held.

The results of the research end with a charts presenting general safety climate level.

3. RESEARCH RESULTS

The first researched factor that can influence safety climate level in a company was seniority. The research was carried out with regard to: total seniority and seniority in the current facility.

Total seniority

Figures 2 - 4 presents indicators of safety climate level with regard to total seniority. It shows very big diversity of the results. The lowest level of safety climate is shown by people with 3 to 5 years of service - the ratio is 0,38, 0,38 and 0,36. The highest level is presented by people with the longest time of service, over 20 years - the ratio is 0,65 and 0,44. This may indicate the need for additional motivational methods (training) for the group of people with 3 to 5 years of service.

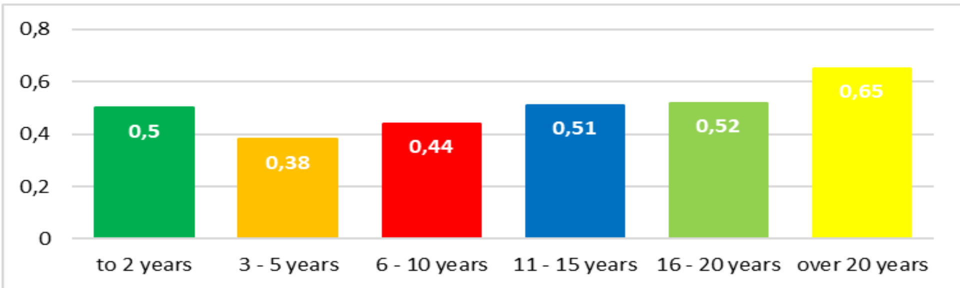

Figure 2 Ratio of safety climate level with regard to total seniority – first group

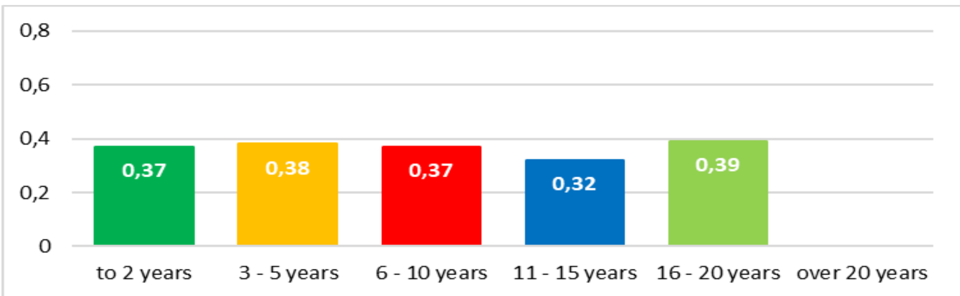

Figure 3 Ratio of safety climate level with regard to total seniority – second group

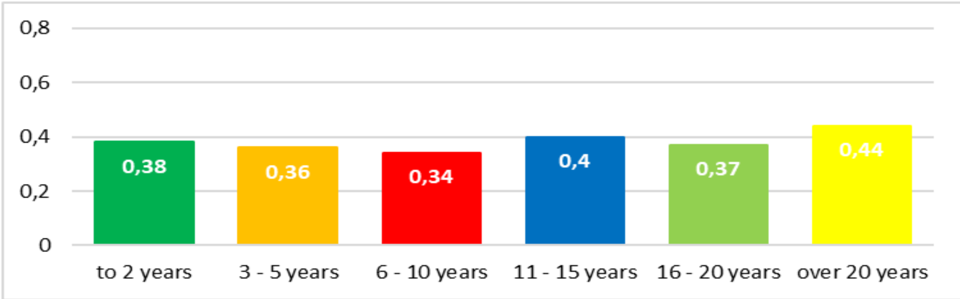

Figure 4 Ratio of safety climate level with regard to total seniority – third group

Figure 5 presents in the form of a Safety Culture Grid the level of safety with regard to total work experience in the researched facility. We can read from it the information in which subject group, which surveyed group of employees with regard to their total seniority requires corrective or repair actions. One can notice that workers with the shortest seniority show the lowest level of safety climate in the area - Motivation for safe behaviors. Employees with the longest seniority, despite generally high level of safety climate rate the lowest - Supervisors' attitude towards safety. It seems that employees with 3 to 5 years of service are the worst in each area.

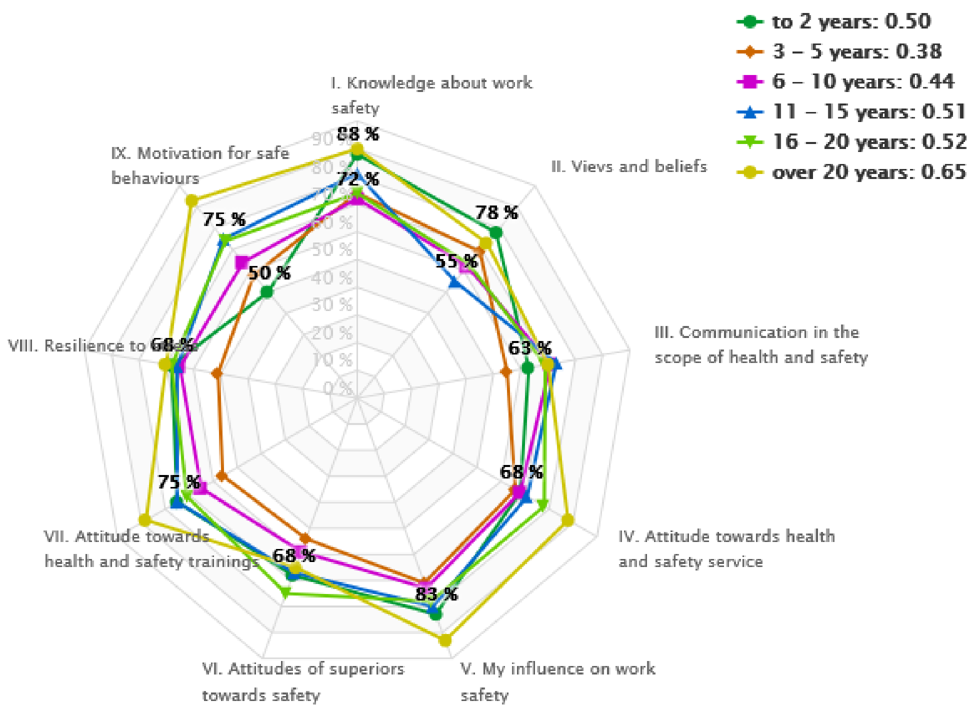

Figure 5. Safety climate level with regard to total seniority

Seniority in the researched workplace

Figures 6 - 8 presents indicators of safety climate level with regard to seniority in the studied workplace. The good thing is that there is an increase in safety climate level together with increasing seniority in the studied facility. This shows high impact of company culture on the general safety climate level presented by its workers. So as company culture influences the level of safety climate in a company, in the same way company climate (being a part of company culture) influences the level of safety climate on a given position. [5]

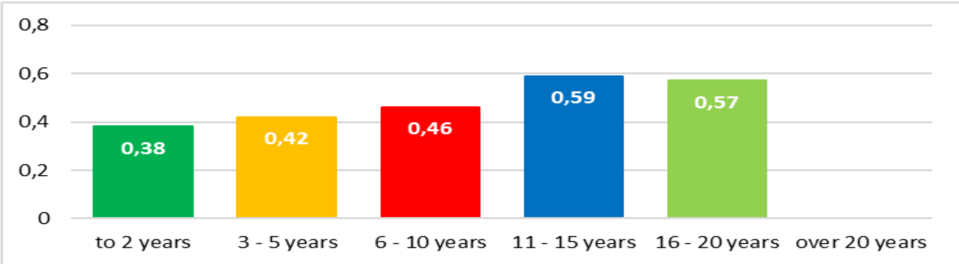

Figure 6. Safety level ratio with regard to seniority in the studied facility – first group

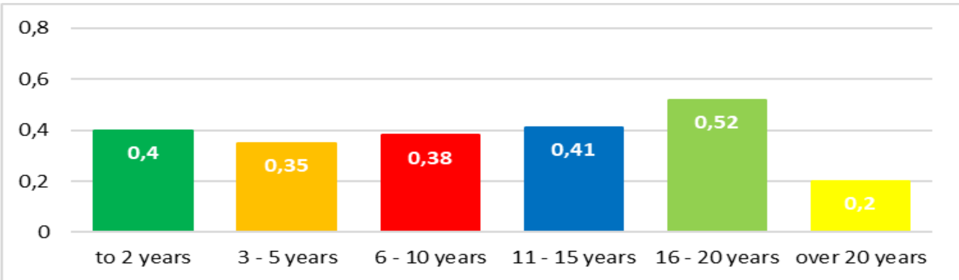

Figure 7. Safety level ratio with regard to seniority in the studied facility – second group

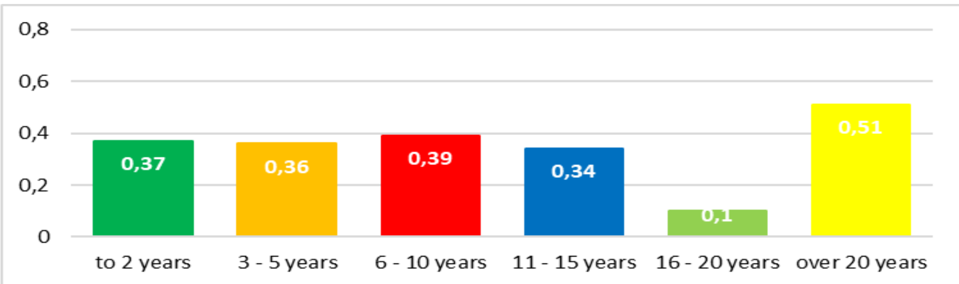

Figure 8. Safety level ratio with regard to seniority in the studied facility – third group

Figure 9 shows safety culture level with regard to seniority in the current facility with regard to each subject group. The lowest level (irrespective of seniority) we get in the area - Values and beliefs. Despite generally high level of safety climate in the studied facility, on the level of personal beliefs employees show a fatalistic attitude. This is problematic, since to be able to efficiently introduce rules of safe work, employees should be convinced about validity and effectiveness of undertaken actions.

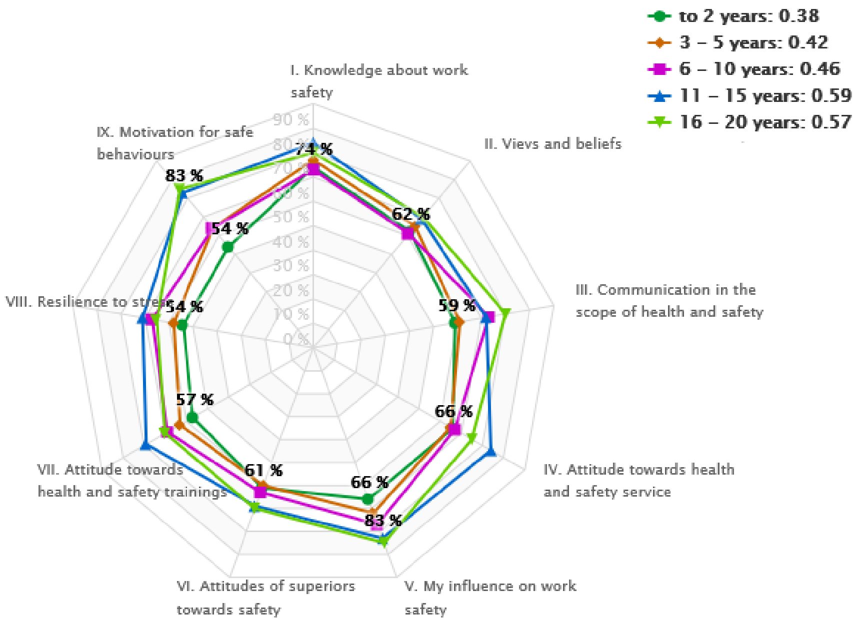

Figure 9. Safety climate level with regard to seniority in a given facility

Further factors which were taken into account in the research on safety climate level were: employee's age, his/her education, sex and position held.

Employee's education

Figure 10 presents safety climate level with regard to education. Indicators of safety climate are on similar level. Irrespective of the level of education, the lowest level of safety climate appears to be in the group of questions regarding - Values and beliefs. The questions from this group referred to personal beliefs of an employee about safety issues. From the low results in this group one can infer that the employees are not fully convinced about possibility of safe work and they think that health and safety rules make their work harder. They are also convinced about the relationship between safe behavior and remuneration.

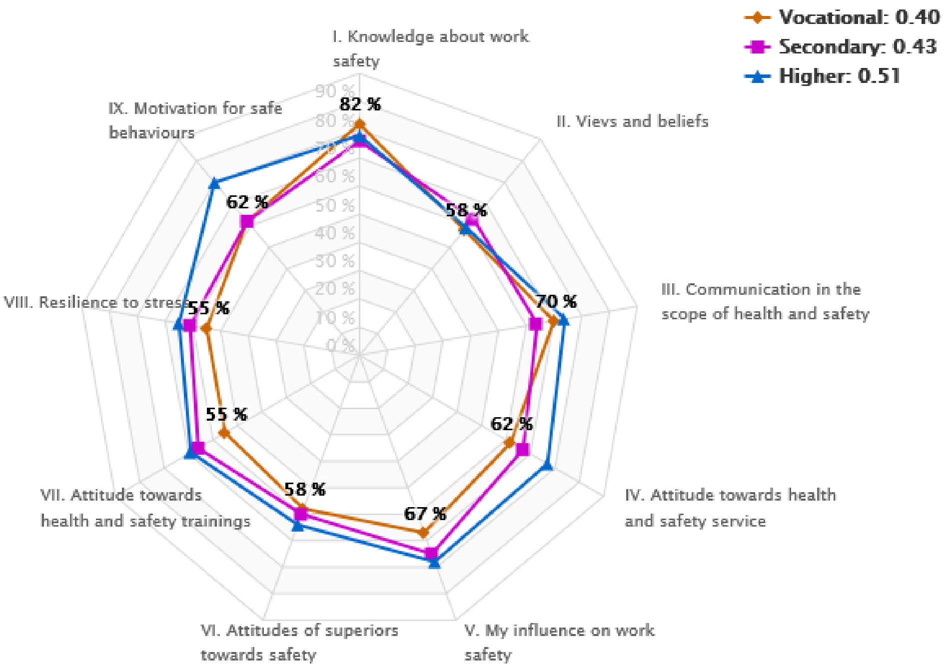

Figure 10. Safety climate level with regard to education

General level of safety climate

The general level of safety climate is shown on figures 11 - 13. It is visible that the highest level of safety climate is in the area - Knowledge of Health and Safety in the facility (77%) and in area - My influence on safety (76%). This speaks well about organized trainings and courses in the field of Health and Safety, and well conducted informational campaign about safe behaviors and applying good practices in the field of work safety.

The researched facility shows the lowest safety climate level in category - Supervisor's attitude towards safety (62%), Resistance to stress (63%) and, with exactly the same result in the category - Values and beliefs.

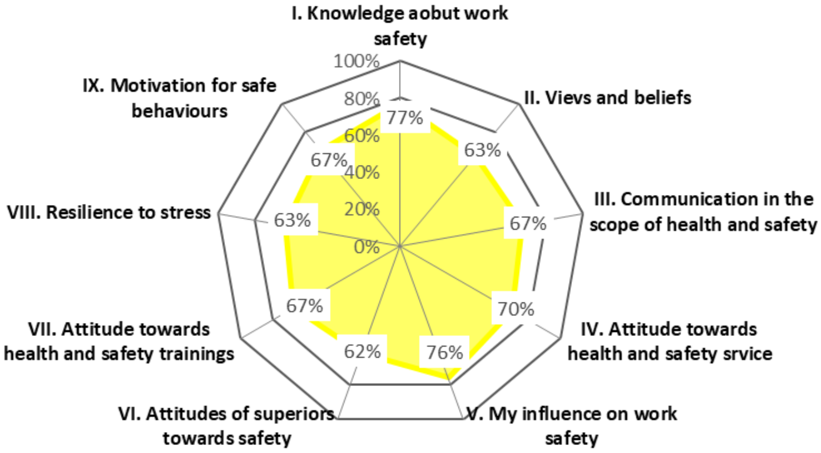

Figure 11. Overall safety climate level in an Army unit – first group

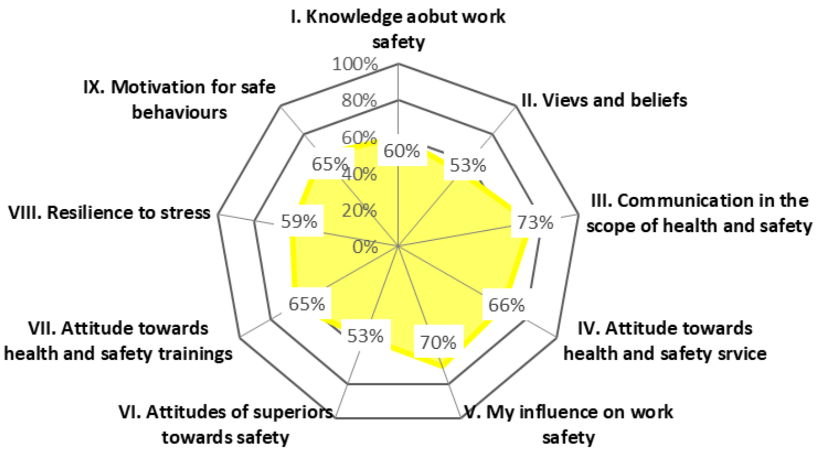

Figure 12. Overall safety climate level in an Army unit – second group

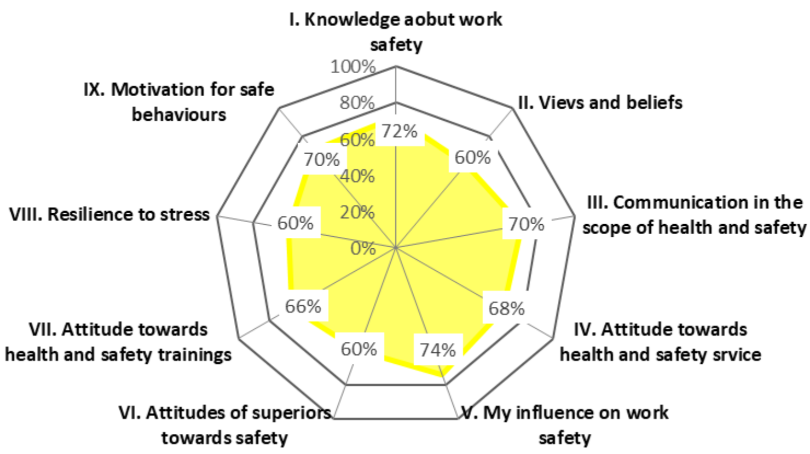

Figure 13. Overall safety climate level in an Army unit – third group

4. CONCLUSION

The main conclusion after the research is the necessity to improve Health and Safety management. Companies on the one hand put a lot of emphasis on implementing mechanisms and schemata for safety, on the other, however, there are deeply rooted areas which influence negatively safety climate.

For smooth functioning of any enterprise, irrespective of industry it operates in, there are many actions to be taken. Apart from operational processes (bringing added value), for correct functioning there are required managing and support processes. Managing Health and Safety surely belongs to actions facilitating operating of a company. Until some time ago, financial resources spent on ensuring safety in a workplace were treated as costs not investments. Only calculations regarding accident costs (damages, production losses, damage to company image) have convinced companies to treat the funds spend on safety as investments.

It is worth noticing that the actions connected with increasing the level of safety culture belong to low cost actions (especially in comparison to expenditures on technical safety measures). Such actions, however, will not bring results immediately, they are spread over a long period of time and they require continuous and constant work.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Ágnes Terjék, Zsuzsanna Kerekes, Ágoston Restás

COMPARISON OF THE HUNGARIAN AND INTERNATIONAL STANDARDS FOR ELECTRIC CAR CHARGING STATIONS

Abstract

Electric vehicles are becoming more and more importance, which also poses a number of problems. The installation of the chargers for electric vehicles is currently a new technology, so to this day there is, no coherent installation and operating code in the European Union or worldwide. To understand the problem, the authors will review and compare the Hungarian and international regulations. The regulations differ in that they place a different emphasis on each area of operation.

Keywords: electric car, charger, regulations, comparison

ELEKTROMOS AUTÓTÖLTŐ ÁLLOMÁSOK HAZAI ÉS NEMZETKÖZI ELŐÍRÁSAINAK ÖSSZEHASONLÍTÁSA

Absztrakt

Az elektromos járművek elterjedésével problémát jelent, hogy az elektromos járművek töltésére szolgáló berendezések telepítése jelenleg még annyira újszerűnek számít, hogy nem alakult ki sem az EU-ban sem a világon egységes telepítési és üzemeltetési szabályzat. A probléma megismerése érdekében, a szerzők áttekintik, majd összehasonlítják a hazai és nemzetközi szabályzatokat. A szabályzatok abban különböznek, hogy más és más hangsúlyt fektetnek az egyes üzemeltetési területekre.

Kulcsszavak: elektromos autó, töltő, előírások, összehasonlítás

1. INTRODUCTION

Researches on firefighting and fire prevention in case of electric cars is incomplete in Hungary. Publications in the topic focus on the generation of transformer fires [1] and the fire safety testing of electric vehicles [2]. In addition, papers on safety firefighting intervention [3] [4] only mention this topic but do not analyse it in detail. Examinations in the topic of the fire prevention in case of smart buildings [5] [6]. Firefighting against electric cars may appears in the investigation of the decision making of the firefighters, but the topic is not explained in detail here either [7] [8]. It is important to deal with issue, because inefficient firefighting can result in serious costs [9] [10]. This is especially true in case of underground interventions [11].

International standards and regulations

The standard for charging electric vehicles was first established in 2001 by the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO). Hungarian standards are also based on these. The related standards are presented in Table 1.

Table 1 – Standards in connection with electric vehicles. Source: [12]

Standards	IEC	Title
MSZ EN 61851-1:2012	IEC 61851-1:2010	Electric vehicle conductive charging system - Part 1: General requirements
MSZ EN 61851-21:2002	IEC 61851-21:2001	Electric vehicle conductive charging system - Part 21-1 Electric vehicle on-board charger EMC requirements for conductive connection to AC/DC supply
MSZ EN 61851-22:2002	IEC 61851-22:2001	Electric Vehicle Conductive Charging System - Part 22: AC Electric Vehicle Charging Statio
MSZ EN 61851-23:2014	IEC 61851-23:2014	Electric vehicle conductive charging system - Part 23: DC electric vehicle charging station
MSZ EN 61851-24:2014	IEC 61851-24:2014	Corrigendum 1 - Electric vehicle conductive charging system - Part 24: Digital communication between a d.c.

		EV charging station and an electric vehicle for control of d.c. charging
MSZ EN 62196-1:2015	IEC 62196-1:2014, módosítva	Plugs, socket-outlets, vehicle connectors and vehicle inlets. Conductive charging of electric vehicles. Part 1: General requirements (IEC 62196-1:2014, modified
MSZ EN 62196-2:2013 Withdrawn!	IEC 62196-2:2011 Withdrawn	Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories
MSZ EN 62196-2:2012/ A11:2013 Withdrawn!	-	Plugs, socket-outlets, vehicle connectors and vehicle inlets. Conductive charging of electric vehicles. Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessorie
MSZ EN 62196-2:2012/ A12:2015 Withdrawn!	-	Plugs, socket-outlets, vehicle connectors and vehicle inlets. Conductive charging of electric vehicles. Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories
MSZ EN 62196-3:2015	IEC 62196-3:2014	Plugs, socket-outlets, vehicle connectors and vehicle inlets. Conductive charging of electric vehicles. Part 3: Dimensional compatibility and interchangeability requirements for d.c. and a.c./d.c. pin and contact-tube vehicle couplers (IEC 62196-3:2014)

2. PRESENTATION OF CHARGING STATIONS AND REGULATIONS

In this paper, we present two global companies and a Hungarian charging station and the regulations along which they operate. The three stations: RISCAuthority and Fire Protection Association (United Kingdom), Fire Safety Regulations of Changi Airport Group (Singapore) and the Fire Safety Regulations of Arena Mall (Budapest, Hungary).

2.1. United Kingdom

The rules applied in the United Kingdom are presented according to the RISCAuthority and Fire Protection Association - RC59 Fire safety when charging electric vehicles. It was published in 2012. The purpose of this guidelines is to provide practical guidance to insurers and their customers on the risk of fire in case of charging electric vehicles. The concept of vehicles includes electric cars, vans and motorcycles. These are presented with in a separate chapter. [13]

The suggested fire protection measures are the followings in this issue:

- An automatic fire alarm system shall be provided at the place of the charger. It is designed, installed and maintained by an engineer accredited by the UKAS (United Kingdom Accreditation Service). The installation must be carried out in accordance with the standard BS 5839-1 Fire Alarm System for Buildings.
- The automatic fire alarm system shall be continuously monitored by an on-site or off-site remote monitoring centre that is accredited by the UKAS. These BS 5979 Remote Monitoring Centres operate in accordance with the standard for receiving fire and security alarms.
- Periodic maintenance of chargers shall be performed by an appropriate engineer in accordance with BS 5839-1 standard.
- The installation of the automatic fire alarm system should be carried out in such a way that the power supply to the charging stations can be disconnected in case of fire alarm.
- At commercial buildings, where vehicles are being charged without supervision, it is recommended to install built-in automatic fire extinguishers on the fire section, where the charging process takes place.
- The most effective extinguisher for a given application should be selected after a risk assessment. The efficiency of the extinguisher should be considered with the health and environmental effects. The primary extinguishing agent is dust, carbon dioxide and other gases [13].

2.2. Changi Airport Group – Singapore

It is also worth examining the fire regulations of Changi Airport, which is a facility with very strict safety standards. Airports are large and extended, so a fire can spread quickly and it can also have characterized by high fire load.

The main measures presented by the standard are the followings: [14]

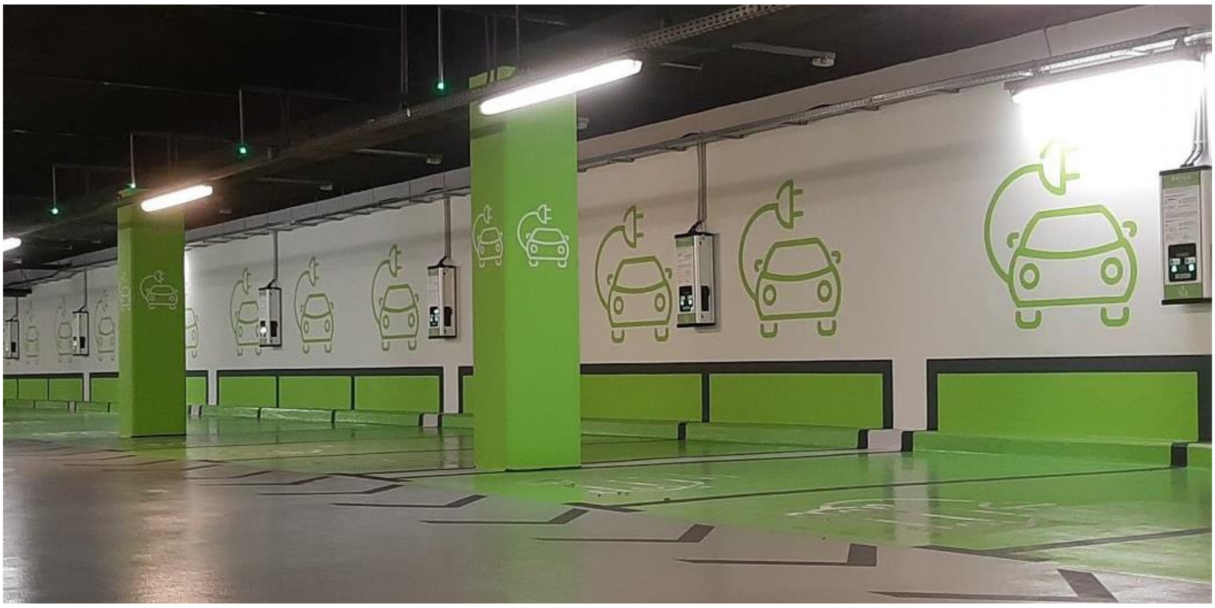
- Charging equipment shall be treated as electrical equipment or parts of them. These devices must also accomplish with national standards, regulations and legislation.
- The electric vehicle must be connected to the charger in the way that the power transmission should be safe during the application.
- Only the pre-connected cable should be used.
- An adapter between the socket on the charger and the plug of the vehicle can only be used if it is a product of the manufacturer of the vehicle or the charger.
- Chargers must be capable of charging electric vehicles without the use of an external ventilation system.
- An emergency switch must be installed for the disconnection. It can be operated in case event of an electric shock, fire or explosion. The device must be designed to prevent accidental operation and must be suitable for outdoor use or bad environmental conditions.
- The charging cable must be flexible and have the mechanical characteristics for cables required by IEC 60245-6 such as bad environmental conditions, exposure to chemicals and oil, UV radiation, abrasion, physical exposure and fire.
- Chargers should only be used to charge batteries for their intended purpose.

It is forbidden to modify the chargers and it is also forbidden to charge vehicles which are not suitable for this type of charging. [14]

2.3. Arena Mall - Budapest

The solutions used in Hungary are presented on the basis of an example. This is the instruction of the Arena Mall "Fire Protection Instructions for Electric Car Chargers" located at 9. Kerepesi Street, Budapest.

The document is an official part of the Fire Protection Regulations for the shopping centre and it also covers the area of charging stations on the parking level of the building. [15]



Picture 1 – Charging stations at the Arena Mall. Source: [15]

In case of fire, the following actions must be taken:

- In case of a fire in the parking zone, the power supply must be cut off using the switches in the dispatch centre.
- De-energization is mandatory for electric devices in case of fire. This activity is performed by the person who is responsible for the maintenance, after a decision by the security service.
- After the de-energization all switchgear used for disconnection must be secured against reconnection.

- It is very important to use types ABC, BC, or C fire extinguishers during the intervention. The use of water or wrong fire extinguishers may result electric shocks or death. The suitable fire extinguishers are available in the shopping mall.
- After the successful firefighting, the condition of the reconnection of the equipment is a joint permission from the maintenance company and the Disaster Management. In case of an incorrect signal, personal conviction is sufficient for the reconnection.
- All fires must be reported to the appropriate Disaster Management Branch Office [15].

3. COMPARATIVE ANALYSIS

3.1. Comparison of rules and practices

Based on the type of action, we have set up categories that allow the comparison:

- legislative background
- electric network connection
- requirements for fire alarm systems
- preventive measures and processes
- charging rules
- what to do in case of fire
- information about the firefighting

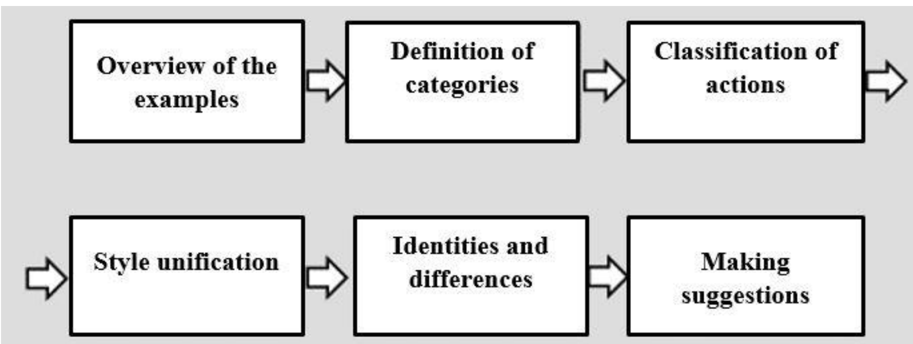
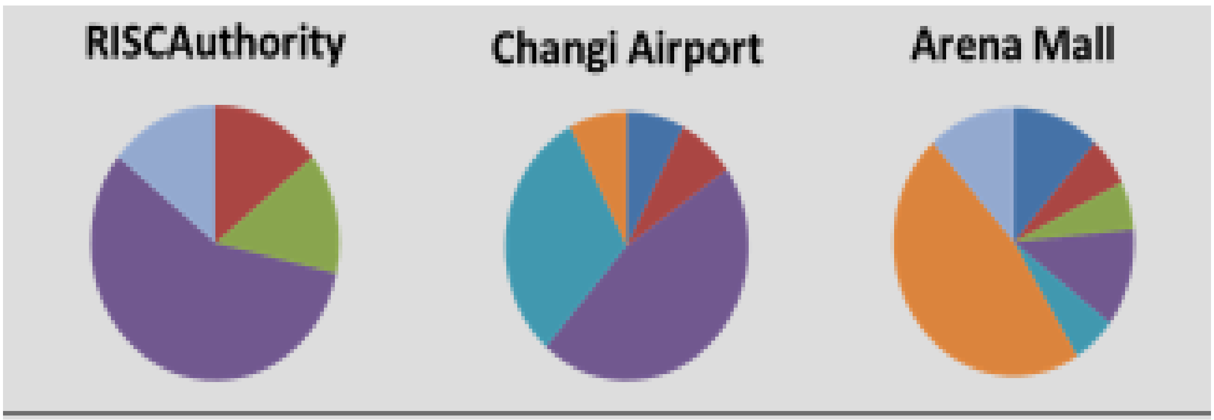


Figure 1 - Processes of analysis. Created by the Authors.

From our analysis, it can be concluded that each solution focuses on other categories of measures, but there are also some common findings. In all three cases, it appears that an electric solution must be selected so that the chargers can be disconnected from the mains in case of fire, and this should not affect the fire alarm. A common feature of the Arena Mall and the RISCAuthority is that an automatic fire alarm system must be installed at the site of the chargers, and the actions also make a recommendation for the firefighting. Both RISCAuthority and Changi Airport Group outline the more serious measures and processes that need to be taken to prevent a fire. These include the action plans and risk assessment, training of the staff, maintaining equipment and displaying information signs. In case of Arena Mall and Changi Airport Group, standards and legislation must be met. All three recommendations detail and highlight one topic the most. The Arena Mall sets out the measures to be taken in case of fire, with RISCAuthority setting out the importance of accreditations, with particular emphasis on preventive measures and processes. According to the Changi Airport Group, the presence of the regulations for the charging process is very important. The three presented recommendations present the most important topics, so they can be used to easily prepare company proposals for the Fire Protection Regulations. This can be found in Chapter 5.

The comparison is also illustrated in a graph according to the different categories.



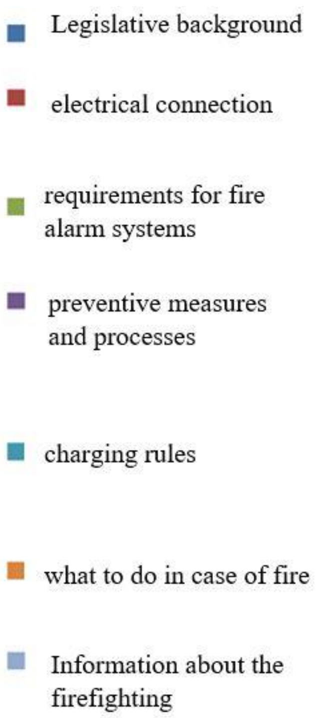


Figure 2 - The comparison in a graph according to the different categories. Created by the Authors.

4. SUGGESTIONS FOR FIRE PROTECTION REGULATIONS

Important criteria for electric car chargers

- During installation, the relevant electrical standards and regulations must be met, the manufacturer's specifications and instructions must be corresponded in all cases.
- Chargers must be used in accordance with the electrical equipment and the relevant requirements must also be observed.

- The following standards must be met: MSZ EN 61851-1:2012; MSZ EN 61851-21:2002; MSZ EN 61851-22; MSZ EN 61851-23:2014; MSZ EN 61851-24:2014; MSZ HD 60364-7-722:2012; MSZ HD 60364-7-722:2016 (see Table1).

***The following requirements must be met in the context of electrical chargera and electrical network*:**

- The supply of the charger must be implemented in such a way that it can be disconnected from the electric network of the building.
- The de-energization must be carried out by operating the main fire protection switch located at the charging stations. In addition, an emergency switch must be installed in a conspicuous place, which can be operated in case of electric shock, fire or explosion.
- The power supply to the automatic fire alarm system must be independent of the power supply to the charging stations.

Measures in connection with the fire prevention:

- An automatic fire alarm system must be in install at the site of the charger and must be constantly monitored.
- Impact protection of charging stations must be provided by impact protectors.
- A risk assessment must be carried out before the use of the charger, after that an emergency plan must be prepared. An emergency action plan should also be developed.
- People acting in case of fire must be trained in the safe charging process and they should be familiar with the location of the charging equipment. They have to know how to de-energize and the measures to be taken in case of an emergency.
- Ignoring the components of the electric vehicles and the charger, no flammable material can be stored in the affected area.
- Only an undamaged cable or adapter can be used during the charging!
- It must be checked regularly that the chargers are undamaged and that the instructions on it are readable. Chargers must be regularly maintained. in the event of any failure, the charger must not be used and must be notified to the user (with appropriate indications).

In case of fire, the following measures must be taken

- The manual call point must be operated. This starts the fire alarm and the fire protection equipment.
- De-energization shall be performed by using on-site fire protection switches.

- The switching devices used for disconnection must be secured against reconnection.
- People should start the firefighting with the available fire extinguishers, if it can be started safely.
- The professional firefighters must be informed of the measures taken so far, the condition of the charging equipment and to give them the Fire Alert Plan and its annexes.
- If necessary, the evacuation of the building shall be carried out in accordance with the provisions of the Fire Alert Plan.
- After the successful firefighting, the condition of the reconnection of the equipment is a joint permission from the maintenance company and the Disaster Management
- All fires must be reported to the appropriate Disaster Management Branch Office.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Lilla Horváth, Péter Pántya

HOME OFFICE AND ERGONOMICS

Abstract

Due to the Covid-19 epidemiological situation in the 2020 year, many employers have introduced home work. In Hungary, the employment of law enforcement agencies, including the professional disaster management body, has been opened by compliance with teleworking home office-type work - without jeopardizing fundamental tasks, which only the narrow stock has been used. In this research, the authors investigated the effects of Home Office, in particular with regard to psychosocial and health aspects and present proposals in each element.

Keywords: teleworking, psychosocial factors, ergonomy, sedentary work, health hazards

OTTHONI MUNKAVÉGZÉS ÉS ERGONÓMIA

Absztrakt

A 2020-as évben bekövetkezett Covid-19 járványügyi helyzet miatt számos munkáltató vezette be az otthoni munkavégzést. Magyarországon a rendvédelmi szervek, ezen belül a hivatásos katasztrófavédelmi szerv állományának is a jogszabályok betartásával megnyílt a lehetőség a távmunkavégzés Home Office típusú munkavégzésére - az alapvető feladatok ellátásának veszélyeztetése nélkül – amit csak a szűk állomány vett igénybe. E kutatásban a szerzők a Home Office hatásait vizsgálták, különös tekintettel a pszichoszociális és az egészségügyi szempontokat illetően és javaslatokat jelenítenek meg ezek egyes elemiben.

Kulcsszavak: távmunka, pszichoszociális tényezők, ergonómia, ülőmunka, egészségügyi kockázatok

1. INTRODUCTION

Home Office regulation is also briefly dealt with in Hungarian legislation. Section 87 of Act I of 2012 on the Labor Code deals with the issue of telework. According to Section 196 (1): *"Teleworking is an activity carried out regularly in a place separate from the employer's premises, which is carried out by means of a computer device and the results of which are transmitted electronically."* In Home Office, employees carry out those tasks at home that they previously performed at their workplace in an established community. Furthermore, the usual everyday interpersonal relationships are concentrated exclusively in the online space, which in the long run can have a number of negative consequences. The aim of this paper to demonstrate the basics and the effects of Home Office conditions and some ergonomic issues.

Though getting to work, regardless of the means of transport (car, public transport, individual), has previously been regarded as an unnecessary activity, through it people have been affected by a number of effects that have acted as new information, even such an event as a traffic accident, which may later come up as a topic in conversations at work or with friends. On social networks, we can come across a number of humorous images that show that the employee’s route was moving between the kitchen and the study / living room, which was initially funny but later diverted the employee’s general mood in a negative direction.

A further challenge for single people is that daily contact with colleagues can only be achieved through telephone conversations or instant messaging (chat). With the cessation of personal interactions, which occurred not only with colleagues but also with friends, a sense of loneliness emerged, which, in addition to deteriorating work performance, can also have a detrimental effect on the private life of an individual. The extra time spent in online space can upset the employee’s realistic view of specific situations, and the idealized world seen on social networks can further aggravate pre-existing negative thinking.

In the case of people with families, we can observe the exact opposite, since teaching is also done online, and parents have to deal with a number of problems accordingly. They also need to provide their child with the computer and the broadband internet access they need to learn with, which not every parent may be able to afford. In addition, they need a proper computer at home that allows them to do the job as efficiently as in the workplace. On its own it would be enough for an increased stressful situation, but it was found that students - especially the younger ones - could not cope with learning alone, so the parent had to help. Based on this, the question arises, how can a parent do their work and help their child at the same time? Neither employers nor schools are likely to be prepared to address this.

Psychosocial factors greatly influence an employee’s work performance, as events that occur and take place in private life also affect the quality of work.

The used methods for this paper were the basic analysis of the Home Office environment using some domestic and international literatures, studies.

2. RESULTS

2.1 Ergonomy

In addition, the issue of ergonomics deserves special attention. „*The word* ergonomics — *“the science of work” is derived from the Greek* ergon *(work) and* nomos *(laws). Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.”* [1] It is important to address the issue of ergonomics, as it also has a significant impact on a person’s health and mental state.

The relationship between man, machine and work environment is crucial in ergonomics. When working, the machine must be adapted to the person's physical abilities, so that the conditions of safe working can be met while maintaining the maximum physical and health condition. [2]

<u>Key ergonomics features for sedentary work</u>

Temperature, light

In workplaces, temperature greatly affects comfort. It is possible to influence the temperature optimally in different ways in different seasons. While in warmer weather it may be enough to open the window or turn on the air conditioner, in winter it is mainly the central heating system that helps to create the ideal temperature conditions.

Air conditioners can provide a temperature of around 20-25℃ in the high heat of summer, as the worker sits for 8 hours in this environment, his body adapts to it. At the end of working hours, the body must suddenly adapt to the large temperature difference, with the outdoor temperature being around 35℃. This is a huge burden on the whole body. To avoid health problems, it is recommended to set the indoor and outdoor temperature difference between 5-8℃. Furthermore, if possible and controllable, the temperature can be raised slowly towards the end of working hours so that the worker is not exposed to strong heat when leaving the workplace.

Lighting

Doing daily work with constant artificial light consumes the adaptive ability of the eye and can lead to the weakening of the eye in the long run.

Key requirements for artificial lighting:

- illumination level
- operational safety
- spatial and temporal uniformity, glare - free
- adequate direction and light
- economy
- adequate color effect
- health safety
- favorable aesthetic appearance

It is important to mention glare, a visual condition in which vision is uncomfortable and visual processing performance is reduced. Glare is caused by a relatively high luminance surface in the field of view.

In the case of artificial lighting, the highest luminance that occurs in a room is the luminance of the lamp body, so glare is caused directly or indirectly by the lamps. [3]

Degrees of glare:

- distracting glare: causes discomfort but does not affect the recognisability of objects
- deteriorating glare: visual performance decreases
- glare: high light densities appear in the field of view, which disturb the photochemical processes of vision

Glare can occur in two ways:

- direct glare: triggered by a light source in the field of view
- indirect glare: the disturbing luminance appears on a reflecting surface

If the lighting is adequate, it will cause only slight glare. Eliminating the glare is the most important in places where information / data is less visible or not visible on the work tool in case of glare (e.g. on a monitor). During glare, strong light comes not only from the object itself, but also from its surroundings, which is scattered in different parts of the eye (e.g. lens, retina, cornea), which interferes with the formation of a sharp image. [4]

Color

The color of the light significantly affects the perception of space. If the light is too cold, it creates an unfriendly, brittle feeling. Its effect is too artificial. In contrast, colored light sources can make it difficult to distinguish between color differences and color patterns. Luminaires with a continuous spectrum resembling sunlight have the best color rendering value.

The most important goals of coloring the workspace are:

- in tight spaces, the spatial effect can be optically adjusted by using the appropriate colors
- for places without cold or natural light, warm colors are preferred to reduce the feeling of coldness
- when using a cold color in a warm workplace, the temperature may feel cooler
- helping orientation

- enhancing safety (e.g. prohibition or information signs, coloring of pipelines)

When performing monotonous work, the colors that produce a stimulating effect should be used. (e.g. red, orange, yellow). However, these colors should be handled with care, as they can be unsettling if used excessively.

Hygiene

In the Covid-19 pandemic, compliance with hygiene regulations has become a priority, as many pathogens can adhere to the workbench, keyboard and mouse pad used by the worker. [5] Regular surface disinfection, washing hands and ventilation always contribute to maintaining the health of the worker. In case of Home Office, it is recommended that the workstation has been used only by the worker, thus reducing the risk of infection. At home, employees may pay less attention to the break between work, so time spent in front of the screen can have a detrimental effect on the eyes. To ensure this, the employer can make a prospectus, poster or transcript for the employee, thus ensuring the transfer of information.

Safety

An indispensable source of energy for our daily lives is electricity. Electricity is a source of many hazards.

The main features of its hazard:

- it is present in almost every area of life
- may cause property damage and serious accidents
- risk of fire and explosion

It is of paramount importance that the employee can work with maximum safety even when working from home, i.e. the computer equipment they use and the work environment do not pose a threat to their physical integrity. As employers are unable to carry out regular safety inspections at the worker's home, they sign a declaration with the employee, who hereby undertakes to take full responsibility for the safety of their working environment.

2.2 Long-term effects on health

While at the workplace, in addition to working on a computer, whether leaving the chair for work (printing, meeting in another office or another floor) or for social contact (eating, smoking), the worker leaves the work area and moves his body. At home these opportunities are greatly reduced. Several studies have reported the long-term effects of sedentary work on the human body. The European Agency for Safety and Health at Work 2020-2022: Healthy Workplaces campaign addresses musculoskeletal problems, including long-term sedentary work with little or no breaks. [6]

There can be several causes of lower back pain, most of all it develops during a sudden movement, lifting heavy weights. Most of the time it has no precedent. However, it can also occur after a longer session or standing.

Lower back pain usually has no consequences, but this simple symptom should not be treated lightly either. If the pain itself lasts continuously for more than a week, or if anybody experiences loss of sensation in any part of the body, it is actually necessary to see a doctor.

For sedentary workers, the primary trigger is an incorrectly selected chair. The worker must work in a chair designed for normal but not prolonged work (including a break) every working day. If a person does little or no exercise in private and / or is overweight, lower back pain may occur sooner and to a greater extent. In addition, age is not a negligible aspect either, because after a certain age (especially in postmenopausal women) the elasticity of the bones decreases and osteoarthritis becomes more and more present.

Health hazards associated with prolonged sitting: [7]

- overweight, obesity
- diabetes
- cardiovascular diseases
- stiff neck
- cancer

Regardless of work, lower back pain can also occur as a result of more severe mental strain. If the employee is exposed to managerial expectations in the workplace that exceed his or her abilities (both physically and mentally), then after the psychiatric symptoms - such as fatigue, impaired concentration, irritability - physical symptoms also appear.

The body weakens, thus losing protection against attacks by pathogens, developing disease. If the stress is constantly present, the frequency of symptoms increases, and may even be accompanied by more serious problems in addition to previous, weaker diseases. Such can be the case with lower back pain, which, if not treated in time, can lead to even more serious illness.

3. SUGGESTIONS

Breaks between work are not only used to allow the worker to eat their lunch relatively quickly and resume her activity afterwards, but also to relax and prepare for the next task. If the dining/resting room is just for sitting down at a table, and is close to a potentially noisy place, then the worker will not be able to break away from work, even for a short period of time. It is therefore essential that the rest area radiates serenity towards the worker. If the colors are applied properly, and live plants are also placed in the room, the designed room will be significantly more suitable for more effective relaxation.

Employee education is important in the operation of a company, as it will make people up-to-date, informed and more experienced. It is important to publish educational materials that can effectively convey the necessary information.

Related to this the next point is the involvement of employees in the process of correcting problems and errors. Some companies forget the fact that employees know the operation of machines and equipment best. If they try to solve an error without their involvement (in the case of management who does not know the processes), it is possible that they will make a bad decision because they do not have a view of the whole activity. Therefore, even if not in every step, it is worth involving employees as they can provide a solution key that is only possible through work experience.

To help them work efficiently and be motivated, it is helpful to praise employees if they have done their job well, and if they make a mistake, they should be informed where they made this mistake. It is especially important in case of recovery after the natural disasters [8] [9].

4. DISCUSSION

Overall, we can see that the state of emergency that developed last year has changed the way of life that has already developed and become familiar to many. Neither employers nor employees were able to prepare comprehensively for everything, so workers faced a number of mental and physiological problems. As we do not know how the current situation will affect our future or what further changes will take place in addition to this, it is already necessary to develop a work program that will prepare workers for the changed working conditions. There are a number of good practices in different companies, but what they all have in common is that they have recognized that working with the right, humane working conditions will also make work more efficient.

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VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

Johanes A Belle, Samkelisiwe Lubanga

EVALUATING THE EFFECTIVENESS OF FIRE PROTECTION ASSOCIATIONS (FPAs) AS A VELD FIRE MANAGEMENT STRATEGY IN THE NORTHERN CAPE, SOUTH AFRICA

Abstract

It is often said that, *"Fire is a bad master but a good servant."* Countries all over the world are challenged by devastating fires, which force them to develop strategies and tactics to minimise and prevent veld and forest fires. Fire Protection Associations (FPAs) are organisations established for veld firefighting in communities. FPAs are the South African way of community based fire management initiatives. This study investigated the effectiveness of FPAs in veld fire management in the Northern Cape Province as mandated by the South African National Veld and Forest Fire Act (NVFFA), 101 of 1998. The focus was on preparedness by FPAs to prevent and mitigate veld fires in this very volatile province of South Africa. Using the Disaster Preparedness Framework by Kent (1994) and the South Africa Integrated Fire Management Framework, the study adopted a qualitative research approach and was descriptive in design. Questionnaires with open-ended questions were administered to 19 out of the 25 FPAs in the province and 76 participants were involved. The study concluded that despite many challenges faced by FPAs in the province, these organisations play a critical role in firefighting and the FPAs have always minimise the impacts of veld fires in their areas of operations.

Key words: Fire Protection Associations (FPAs), Veld fire management strategy, Veld fires, National Veld, and Forest Fire Act (NVFFA), Disaster Preparedness.

VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

A TŰZVÉDELMI SZÖVETSÉGEK (FPA) HATÉKONYSÁGÁNAK ÉRTÉKELÉSE ERDŐTÜZEK ESETÉN A DÉL-AFRIKAI KÖZTÁRSASÁG ÉSZAK-FOKFÖLDI TARTOMÁNYÁBAN

Absztrakt

Gyakran mondják "A tűz jó szolga, de rossz mester". A világ legtöbb országát pusztítják erdőtüzek, amelyek különböző stratégiák kidolgozására készteti a kutatókat. A Tűzvédelmi Szövetségek (FPA), olyan szervezetek, amelyeket erdőtűz oltási célra hoztak létre. A szerző ezen szervezetek hatékonyságát vizsgálja a Dél-afrikai Köztársaság Észak-Fokföldi tartományában. A tanulmány Kent, a katasztrófákra történő felkészültségi keretrendszerét és a Dél-afrikai Integrált Tűzgazdálkodási Keretet felhasználva kvalitatív kutatási módszerek alapján készült. Emellett a szerző egy nyílt kérdőívet is készített 76 válaszadóval. A cikk eredményeként megfogalmazható az FPA-k tűzmegelőzési hatékonysága a Dél-afrikai Köztársaság Észak-Fokföld tartományában.

Kulcsszavak: Tűzvédelmi Szövetség (FPA), Erdőtűzmenedzsment stratégia, vegetációtűz, Nemzeti Erdő-és Vegetációtűz Törvény, katasztrófavédelmi felkészülés

1. INTRODUCTION

South Africa and the international community are faced with the challenge of veld fires also known as wildfires. These fires occur naturally or may be human-induced. Though they are destructive they also have an ecological role to play in the ecosystem. Fires have been part of the ecosystem for centuries and they also became an important management tool for domestic use and is used by commercial land users such as farmers, for vegetation management. Catastrophic fires however forced countries to derive and develop strategies and tactics for better management and prevention of these fires [6].

Open fires which are not brought under control in the early stages may become aggressive and catastrophic, and as a result pose serious threat to lives, assets, livelihoods and the environment.

The rise in frequency of veld fires is exacerbated by global warming and climate change requires new proactive fire management styles using innovative technology [6].

South Africa adopted the Integrated Fire Management (IFM), which incorporates different fire management activities in a strategic framework to reduce the overall impact of unwanted wildfire damage and promote the beneficial use of fire. IFM brings together all stakeholders involved in fire management. The diagram below depict the six components of IFM

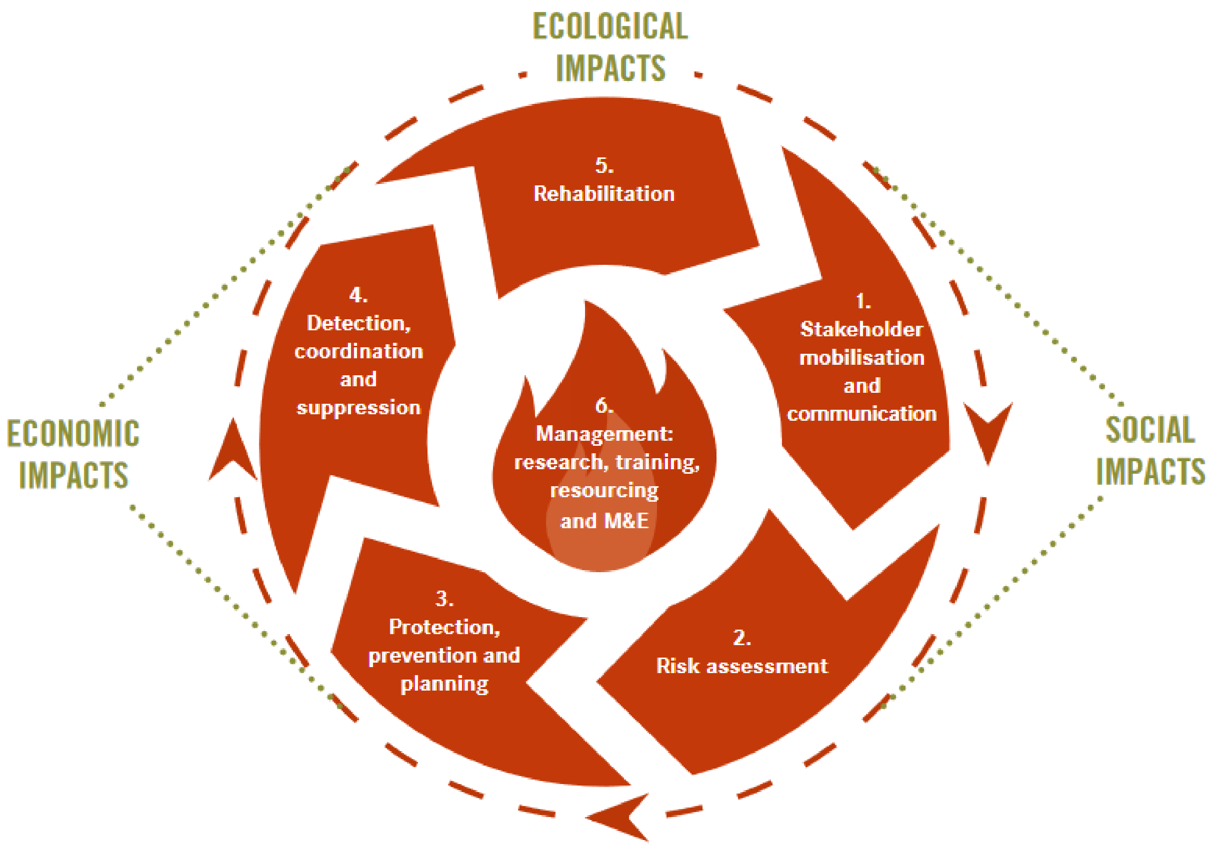

Figure 1- Integrated Fire Management Framework; Source: FYNBOSFIRE, 2016

In South Africa, and under the IFM, each stakeholder has his responsibility and role to play to combact and manage fires. Key stakeholders in IFM include:

- Landowners and land managers;
- Organised associations of landowners such as conservancies and agricultural associations;

- Fire Protection Associations;
- District and (where delegated) Local Government or Traditional Leaders;
- Provincial and District Disaster Management;
- National Government; and
- Working on Fire, which is an Expanded Public Work Programme (EPWP) [4].

In South Africa, the National Veld and Forest Fire Act 101 of 1998 (NVFFA 101 of 1998) was developed and implemented to get land owners and users to participate in fire management practices due to the frequency and devastating effect of veld fires [6]. Fire protection Associations (FPAs) were introduced in South Africa as a direct result of the Act.

Section 3 of the NVFFA 101 of 1998 states that "*owners may form an association for the purpose of predicting, preventing, managing and extinguishing veld fires and apply for it registration*" (South Africa, 1998:5). The Act also serves as a framework for veld fire management in South Africa [11].

The mandate of FPAs is to develop and implement integrated fire management practices in their properties with joint ventures with the neighbouring FPAs, institutions, and organisations in an effort to minimise adverse impacts and maximize benefits of utilising fires. It is in line with this mandate that this paper investigates the readiness of FPAs in managing veld fires in the Northern Cape Province of South Africa.

The Fire Protection Associations (FPAs) are one of the fire management strategies in South Africa and they are organisations formed in assisting to reduce the impact of veld fires. These organisations are involved in disaster management, as they need to take proper action in planning and preparing for anticipated veld fire disasters in their respective areas and ensure efficient and effective response and recovery thus addressing the whole disaster management continuum with fire as the hazard.

The study area

The Northern Cape Province as illustrated in **Figure 2** is the largest of the nine provinces of South Africa by surface area covering 372 889 Km^2. The province has five (5) district municipalities (**Figure 3)** and 27 local municipalities. The dominant language in the province is Afrikaans followed by Setswana. English and isiXhosa are widely spoken in the province as well [17].

Figure 2 - Northern Cape in South Africa Source: [22]

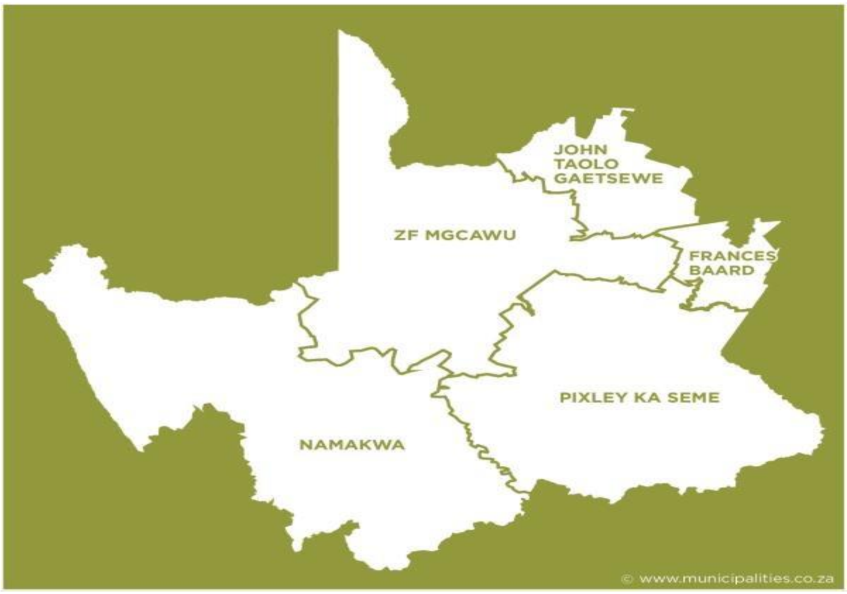

Figure 3: District Municipalities in the Northern Cape Province Source: Local government hand book, n.d

The province has a population of about 1.2 million whose main livelihood is mining and agriculture [18].

The main vegetation is the Nama Karoo biome with succulent Karoo biome and Savanna biome in some areas (Rutherford & Westfall, 1994). **Figure 1.3** illustrates the main biomes in the Northern Cape.

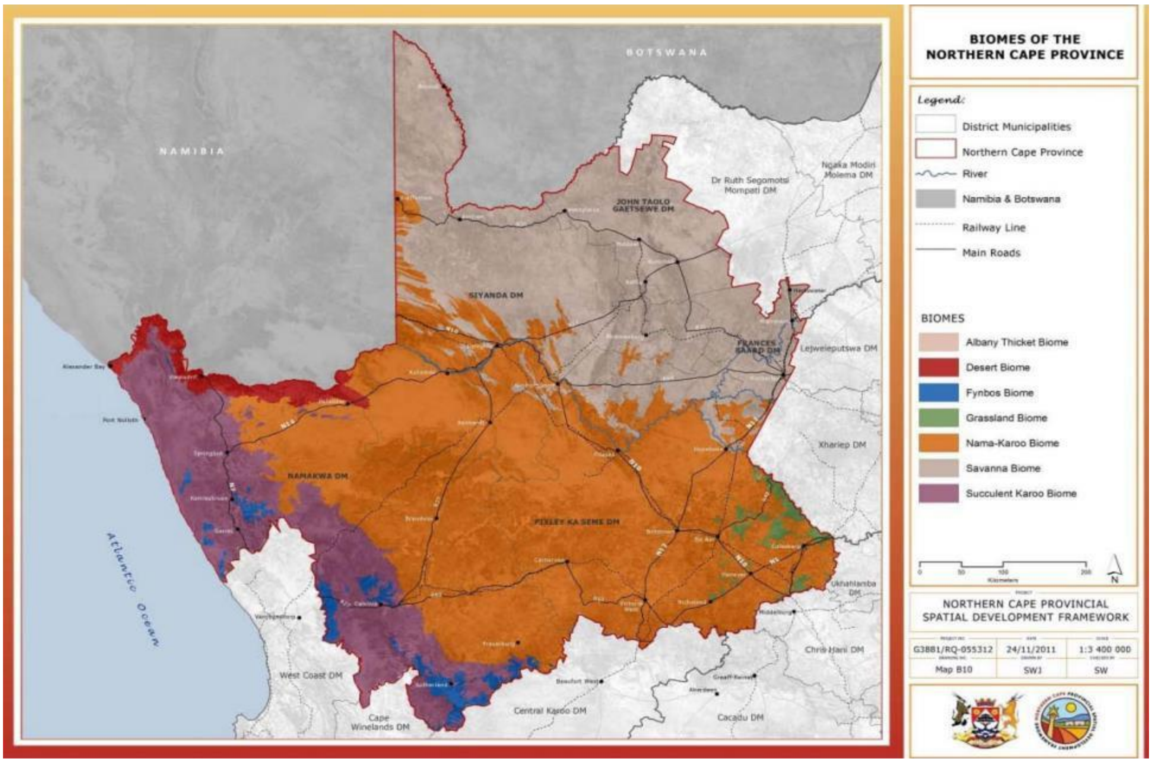

Figure 4 - Northern Cape biomes, source: (Northern Cape government, 2012)

Climate in the Northern Cape

The province is typically that of a desert and semi-desert area. It has generally low rainfall and a hot and dry region with fluctuating temperatures. The average annual rainfall over the province is 202 mm and the evaporation levels exceed the annual rainfall. While the western areas of the Province, which include Namaqualand, receive rainfall during the winter months, the central, northern, and eastern parts of the province receive rain primarily during the summer months. Temperatures range between 34°C and 40°C in the interior part of the province during January afternoons and may go up to 40°C in most part of the province during summer. Average daily temperature in the winter is about 22°C while night temperature in winter may drop below 0°C.

Low rainfall, high temperature and rich biomass therefore create favorable conditions for catastrophic veld fires.

Veld fire risk classification

In a study conducted by Forsyth [11], the national veld fire risk classification map was developed which illustrates the overall veld fire risk in South Africa. It illustrated areas which were fire prone from Low veld fire risk to Extreme veld fire risk as shown in **Figure 1.** According to Forsyth et al, the Northern Cape is regarded as the lowest veld fire risk with an overall classification of 57.3%. About 0.2% is classified under extreme veld fire risk [7].

Based on the study conducted by Forsyth the map in F**igure 1** shows that the John Taolo Gaetsewe district municipality was on a High veld fire risk classification, the Z.F Mgcawu district on Medium to Low veld fire risk classification, Frances Baard district on High to Low veld fire risk classification, Namaqua and Pixley Ka Seme districts are on Low veld fire risk classification. These two (2) districts are the largest part of the low risk classification in the Province [7].

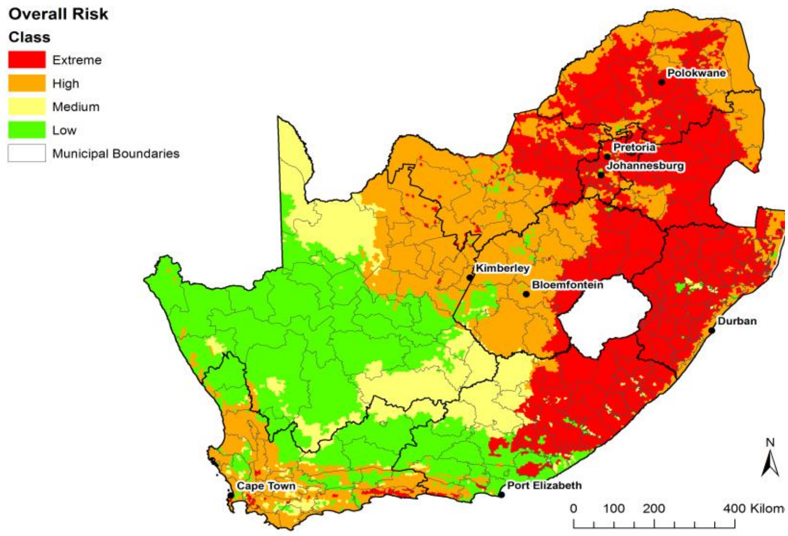

Figure 5 - National Veld fire risk classification; Source: [7]

The Northern Cape fall under high to extreme fire risk area. In such place the fires danger index (FDI) is always in the orange to red colour during the fire season (see Figure 5 on FDI)

Fire Protection Association (FPA)

Fire Protection Associations (FPA) are statutory organizations that are established and registered under the National Veld and Forest Fire Act (NVFFA) 101 of 1998. FPAs consist of rural communities and landowners that have volunteered and grouped themselves to prevent, predict, manage and fight veld fires that threaten lives, property and sources of their livelihood like livestock, grazing land and crops on their farms. The NVFFA sets minimum standards and requirements that, landowners and land-users must meet and share resources in regards to the management of veld fires on their property regardless of them being FPA members or not [17].

The FPAs are associations which are the strongest pillar of integrated fire management created under the Act (Department of Water Affairs and Forestry [1]. The Act also puts responsibilities and accountabilities to landowners, users and representatives regarding fire management. The FPAs are the South African means of community based fire management initiatives for collective community unity in sharing resources to prevent, protect against and suppress veld fires.

The Forest Fire Association (FFA) was the first ever formed association in South Africa (formed in 1976), after the catastrophic fire incident that occurred in Mpumalanga and thus the National Veld and Forest Fire Act 101 of 1998, was later promulgated putting emphasis on the landowners, users and communities to get organised in order to prevent the re-occurrence of such devastating fire incidents (Forest Fire Association) [5]. The establishment of FPAs was then implemented countrywide as a response and preparedness strategy to veld fires in the country.

2. METHODOLOGY

Qualitative research and a descriptive research design were used to conduct the research. There are 25 established FPAs in the Northern Cape Province as of December 2016. A typical FPA is structured into four (4) executive members consisting of the chairperson, secretary, FPO and one (1) additional member, and its ordinary members whose number varies from FPA to FPA. In this study 19 FPA out of a total number of 25 FPAs in the province participated from which 76 respondents were purposively recruited ranging from secretary, FPO, chairperson, additional executive members and ordinary members. Questionnaires composing of mainly open-ended questions were used to gather data and the collected data were analysed using the thematic approach. The collected data was grouped into emerging themes and the deductive reasoning approach was utilised as the study looked for similarities and differences of the data collected based on the research questions

3. RESULTS AND DISCUSSION

Results from data obtained from the field are presented in this section and discussed. Data collected from respondents are presented in the form of tables and figures.

Composition of FPAs

FPA members are mostly landowners with multiple responsibilities. In an FPA key positions will include the Chief Fire Officer (CFO), the Fire Protection Office (FPO), the FPA Manager and ordinary members.

The participants were asked what position they held in the FPA. Results showed that 47% of the respondents were ordinary members of the FPAs, 17% were chairpersons, 15% were secretaries and 11%were FPOs. The opinion of ordinary members was highly considered, as there was a need to encourage their participation and to be more involved as the executive members are in the FPA functionality. The composition of the FPA gave a fair balance of participation as at least all positions were represented even though the number of participants varied per position

Table 1- FPA Positions.

FPA POSITION	PERCENTAGE
Chairperson	17.11%
FPO	11.84%
Secretary	15.79%
Additional member	6.58%
Ordinary member	47.37%
Other	1.32%

TOTAL	**100.00%**

Level of education

Participants survey showed that 27 held a national diploma, 11 participants held Bachelor's degrees, 9 participants held a B- Tech/Honours, 22 completed Grade 12 (Matric) and 7 participants were below matric (Grade 12). The results showed that FPA members who participated are generally educated. This can be an important asset for the management of the FPA as many advantages are associated with better education.

Table 2 - Level of Education

LEVEL OF EDUCATION	NUMBER OF PARTICIPANTS
Below Matric	7
Grade 12	22
National Diploma	27
Bachelor degree	11
B Tech/ Honours	9
Total	**76**

General causes of veld fires

The study showed that 44% of the veld fires are caused by lightning,19% by a combination of lightning and arson, 14% by arson, while 3% was caused by land preparation through burning. It was reported that most fires started from the main roads and spread inwards to properties.

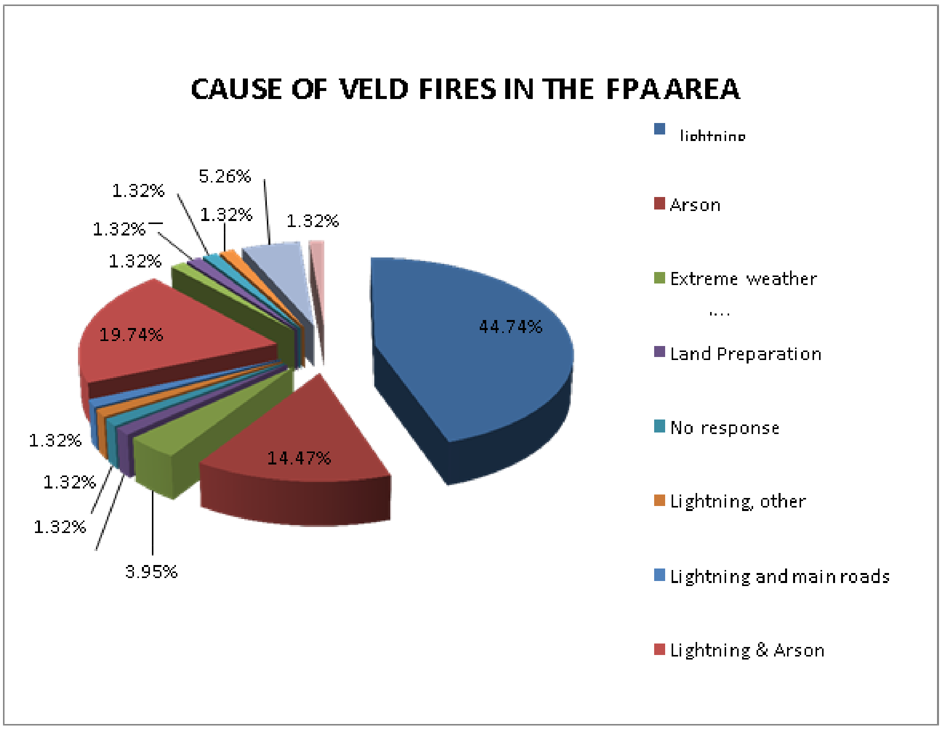

Figure 6 - Causes of veld fires

Implementation of the fire management plan

A typical FPA will conduct activities like risk assessment, stakeholder organisation, fire management planning, detection and suppression, rehabilitation, eduction, training and awareness, record keeping, monitoring and evaluation [4].

The respondents who were in possession of the fire prevention and suppression plans were asked if they implement the plans possessed by their FPAs. The results illustrated that 84% of the respondents stated that they had means to implement developed plans and the 14% highlighted that they do not have means and capabilities to implement such plans. Even though the majority of the FPAs implement the plans, the rest of the FPAs (14%) should also be on board, develop and implement the plans.

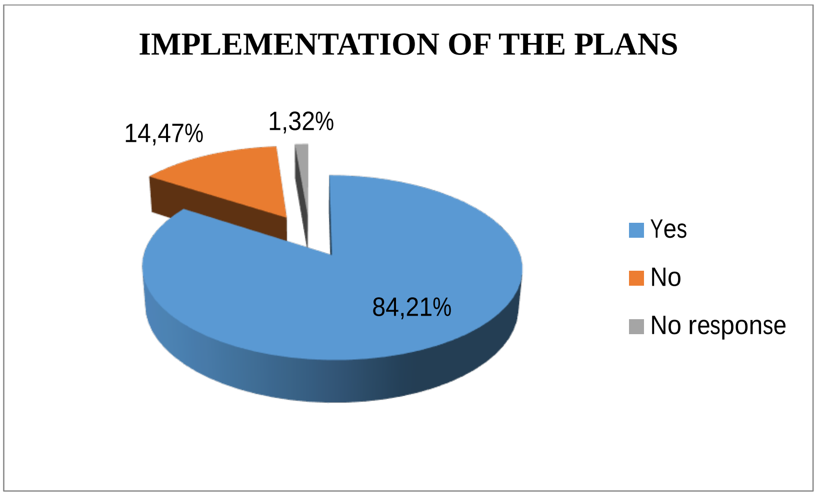

Figure 7 - Implementation of the plans.

Changes of frequent occurrence of veld fires before and after establishment

The respondents were asked if they noticed any change in the frequency of veld fires in their area after the establishment of their FPA, the results in figure above showed that 48.68% of the respondents reported that they had noticed a decrease in veld fires and a change in the frequency of veld fires after the FPA establishment and made justifications as follows:

- The FPAs are more organized and better planned
- More fires are reported and damages are reduced
- Since the establishment, firebreaks are created and fire awareness campaigns are conducted. The WoF team assists in the fighting of veld fires and that assist in minimizing damages.

In the figure above 36.84% reported that they did not notice any difference in the frequency of veld fires after the establishment of the FPA and 14.47% did not respond.

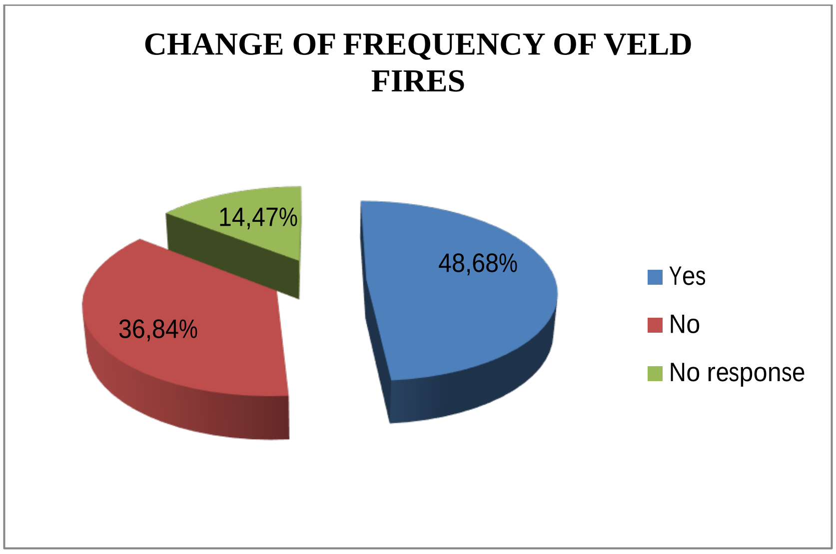

Figure 8 - Change in frequency of veld fires.

Fund raising

Funding is a major problem facing most FPAs. When asked how their FPA was funded, 39% reported that they are funded by their Farmers Union fees which is the main source of funding for most FPAs, 32% reported that they receive funding from the FPA membership fees and 7% reported that they were funded by the private sector. Another 2% reported being funded by the government. In general the respondents expressed the general lack of funds to manage FPAs effectively.

Utilisation of FDI for fire management within FPAs

Fire is a cheap tool of vegetation management and thus it is important to always be updated with the FDI forecast for the purpose of fire management. The results showed that 51.32% utilise the FDI for veld fire management in their area and 34.21% do not use the FDI for veld fire management. Early warnings such as the FDI are important to FPAs to ensure that there is proper monitoring of burning, and the combatting of veld fires. FPAs can permit burning during low FDI and prohibit burning when the FDI is high. This also assists FPAs to be strategic in firefighting during a given FDI.

FDI Description	Colour		Lowveld FDI Precaution
SAFE	BLUE	0 - 20	Low fire hazard. Controlled burn operations can normally be executed with a reasonable degree of safety.
MODERATE	GREEN	21 - 45	Although controlled burning operations can be executed without creating a fire hazard, care must be taken when burning on exposed, dry slopes. Keep constant watch for unexpected wind speed and direction changes.
DANGEROUS	YELLOW	46 - 60	Controlled burning not recommended when fire danger index exceeds 45. Aircraft should be called in at early stages of a fire.
VERY DANGEROUS	ORANGE	61 - 75	No controlled burning of any nature should take place. Careful note should be taken of any sign of smoke anywhere, especially on the upwind side of any plantation. Any fire should be attacked with maximum force at hand, including all aircraft at the time.
EXTREMELY DANGEROUS	RED	75<	All personnel and equipment should be removed from the field. Fire teams, labour and equipment placed on full standby. At first sign of smoke, every possible measure should be taken to bring the fire under control in the shortest possible time. All available aircraft should be called for without delay.

Figure 9 - Fire Danger Rating in South Africa; Source [4].

Possession of adequate personnel and firefighting equipment

Firefighting equipment makes a difference between effective response and insufficient response to fires. Respondents were asked if they possessed adequate firefighting equipment in their respective FPAs, the results showed that 53% do not have adequate firefighting equipment while 39% are having adequate firefighting equipment while 6.58% did not respond.

Trained and skilled firefighting personnel plays a big role for the quick containment of veld fires and to prevent catastrophe. The results show that 57% do not have adequate personnel for firefighting in their respective FPAs. While 35% reported that they have adequate personnel for firefighting.

Figure 10 - A landowner vehicle fitted with firefighting equipment. Source [4].

FPA training

Training is crucial to gain a fundamental understanding of fire management. When asked if any training was organised in the past two years for their members on fire management, the results showed that 69 respondents reported that there was no training offered to members in the past 2 years, only 6 respondents reported that there was training organised for the FPA members and 1 did not respond to the question.

When asked if their FPO was trained in firefighting, about 47% reported that their FPOs are not trained and 43% reported that their FPOs are trained. About 9 % did not respond to this question. There is almost an equal split between trained and untrained FPOs within the FPAs.

Overall effectiveness of the FPA

When asked on their thoughts about the overall effectiveness of their FPA the results illustrated that 61% reported that the FPA is effective in the overall examination while 25% reported that their FPAs were very effective. The 6% reported that their FPA is not effective, while 3% reported that they have no idea if their FPA is effective or not.

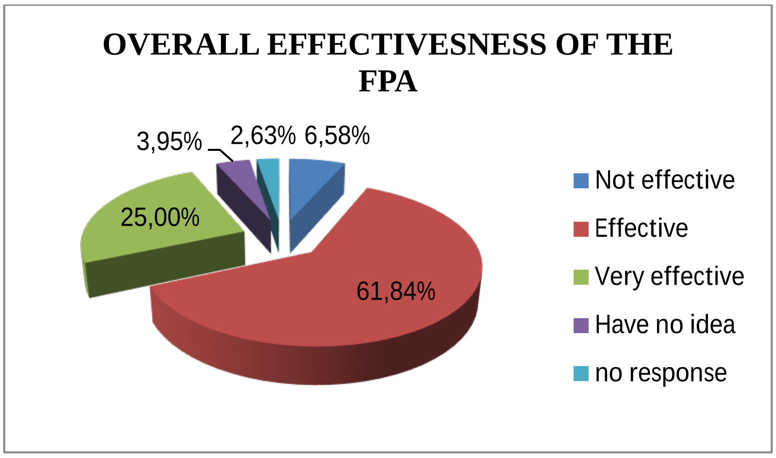

Figure 11 - Overall effectiveness of the FPA.

4. CONCLUSIONS

Preparedness of FPAs to response to veld fires

The preparedness framework served as a theoretical framework and guide for the study. The researcher discussed the operations and functionality of the FPA and based on the findings of the study and link with the preparedness framework in order to check if FPAs are effective and functional. This assisted in checking the areas of focus for continual improvement and functionality of the FPAs. All these steps can occur simultaneously and do not have to be the pre-requisite for each other.

Planning

In the preparedness framework, planning is the essential part of the framework. The majority of the FPAs reported that they possess fire prevention and fire suppression plans. These plans are being implemented hence the majority reported that they have experienced fires between 0-5 in the past 2 years. This minimal number of experienced fires may be due to the implemented plans being the contributor to minimised fires. To ensure readiness for veld fires, planning is essential for FPAs in the preparation for fire season. However, there were FPAs who reported that they do not implement or in possession of these plans.

Institutional framework

The majority of the FPAs reported that they do not have effective working partnership with government departments, the private sector or non-profit organisations (NGOs). These FPAs need to re-consider having partnership with other stakeholders who are also responsible for veld fire management. Partnerships are important in order to build a good working relationship in veld fire management. FPAs need to establish partnerships with the South Africa Police Service (SAPS), as some cases need to be reported and the SAPS needs to assist them with investigations in cases of arson. Partnerships are important in order to share resources and share roles and responsibilities for veld fire management.

To ensure effective institutional arrangement, roles and responsibilities need to be clearly defined for different stakeholders and role players, including members of the executive and FPA members. FPAs can enter into FPA cross-border agreements with neighbouring FPAs for incidents when a fire crosses from one FPA boundary to the next. FPAs are to ensure that they abide by their policies and guidelines. Relationships with neighbouring FPA were noted and this was a good indication of FPAs doing teamwork.

FPAs reported they have mutual agreements with organisations such as Working on Fire (WoF), neighbouring FPAs, municipal fire services, and Mines. Working out agreements between people, agencies, and organisations for the provision of services during emergency incidents to ensure effective coordinated response is part of planning for readiness for an incident. FPAs can enter into various agreements such as mutual agreements for firefighting and resource sharing memorandums during planning in preparation for veld fire season. Agreements and plans should be in place and ensure that stakeholders are aware of such arrangements to ensure effective response and coordination of veld fires and to avoid confusion.

Information system

Communication is important during veld fires and under normal conditions. A disaster communication strategy and plan is important to be able to prevent and manage veld fires from becoming disasters. An effective information system is essential to gather information and disseminate it to members, relevant stakeholders and role players. FPAs rely on the South African Weather Service (SAWS) for the issuing of the Fire Danger Rating (FDI). The majority of the FPAs utilise the FDI for their veld fire management, and access their FDI via the internet or television. Different FPAs have other ways of disseminating information and use WhatsApp groups and SMS's. Fire statistic records are kept but is not readily available to be accessed by the public to track veld fire trends in the province.

Resource base

Resources for firefighting need to be prepared and put in order well in advance for emergencies. Resource inventory for FPAs is important to know what resources are available for firefighting and those that they may require for better fire management. A majority of the FPAs have noted that they do not have adequate firefighting equipment in their respective FPAs. All members need to ensure that adequate firefighting equipment is available. Even though some FPAs reported that they have adequate equipment, for those who do not have the equipment there is still room for improvement. Some FPAs have equipment that is old and will eventually need to be replaced. Firefighting equipment is essential and with minimal equipment in an organisation, it can be challenging to fight veld fires. This must be one of the focal areas to improve within the FPAs for their better functionality. It is also noted that the Fire Brigade Services are further away from the FPA boundaries with a distance of more than 50 Km. This may have an effect on the response time in cases where veld fires require such resources.

Human resource is a challenge with the FPAs as the majority reported that they do not have adequate personnel for firefighting. This may also be influenced by the fact that the majority age group of the FPA members is 45 and above. At least the age group of about 35-40 years with more energy can be able to fight veld fires effectively rather than the older group.

Financial resource is important as much as human resource and firefighting equipment. Availability of financial resources to ensure FPA operations is essential, with no funds no operations can actually occur. FPAs have reported that they are funded through their Farmers Union and some through FPA membership. The other challenge that FPAs are facing is inadequate equipment and a lack of funds for training which may be contributors for their slow functionality.

Warning systems

Some FPAs rely on the FDI as an early warning system to ensure early warning within their area. Early warning assist them for fire readiness in their FPAs and ensure they raise awareness in case of dangerous situations. Communication system such as telephones, cell phones, two-way radios and WhatsApp groups are used to share FDI information to members of the FPAs.

Education and training

It was recorded that a minority of FPA members were formally trained with the following courses:

- Kursus Beskrywing (US177082 & US 1170790)
- standard firefighting for owners and workers
- Advanced fire fighting
- Introduction to veld fires
- Basic fire fighting

It is essential that everyone who is involved in firefighting be trained accordingly. The majority that was not trained reported challenges with funding to organise training in their respective FPAs and required assistance in this regards in order to comply with section 17(a) of the NVFFA. FPAs conduct public awareness on veld fires in their areas and share knowledge with the community. A few reported that they conduct awareness campaigns in their respective FPAs despite challenges they face, while a majority of FPAs do not conduct awareness campaigns.

Response mechanism

FPAs need to know how they will respond to veld fire occurrences and this includes evacuation procedures and shelter for livestock and humans on farms. There is a need for the development of evacuation plans for such purposes. Some FPAs were privileged to be in partnerships with stakeholders such as the disaster management centre where they are able to access their call centre for information dissemination. The use of WoF teams was also advantageous for veld fire response. FPAs require the assistance of Fire Brigade Services but these services are a challenge in the province as there are only two designated fire services for the whole province (Kimberley and Upington stations).

Rehearsals

Some of the FPAs were in possession of veld fire suppression and prevention plans. These plans needed to be rehearsed and evaluated for improvement.

Effectiveness and functionality of FPAs in fire management in the area

The majority of FPAs are effective to execute their duties for veld fire management. It is evident that the FPAs have a positive influence in veld firefighting in their respective areas. Some FPAs possess fire suppression and fire prevention plans which contribute to the effective functionality of the FPAs. Despite challenges noted, their effectiveness for veld fire management is impressive. FPAs can improve their functionality and effectiveness more if they can acquire the required resources such as firefighting equipment, funds and personnel and build good working relationship with other stakeholders.

5. RECOMMENDATIONS

To enhance the effectiveness and functionality of the Fire Protection Associations the following is recommended:

- FPAs should ensure the training of their members in firefighting on an annual basis and provide refresher courses.
- Improve teamwork and conduct awareness campaigns in their areas.
- Development of fire suppression and prevention plans for those FPAs with no plans and review fire suppression and prevention plans for continual improvement for those FPAs who are in possession of these plans.
- Establish more partnerships to strengthen FPA institutional arrangements
- Development of a database for sharing of veld fire statistics in the province.
- Establishment of fire brigade services throughout the province.
- Avail funds for FPAs to acquire adequate resources such as firefighting equipment, training of personnel and funds for FPA daily functionality. Assistance with funds can be through different institutions involved in disaster management and veld fire management. The department of Agriculture Forestry and Fisheries is the custodian of the NVFFA, local municipalities which house the Fire Brigade Services and the department of Environmental Affairs which funds WoF teams, are institutions that can

work together to ensure FPA funding which will play a role to promote their effectiveness and functionality.

Concluding remarks

Fire Protection Associations (FPAs) are important organisations in responding to veld fires in South Africa. All the stakeholders like the Municipalities, farmers, Working on Fire, Disaster Management Centres, relevant Government Departments etc should all work together to promote FPA activities as fire is the main hazard in South Africa especially in the Northern Cape Province.

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