AUTHOR'S REVIEW OF THE DOCTORAL (PH.D.) DISSERTATION

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Development Opportunities of the Requirements of Fire Protection During the Use of Buildings and the Technical Conditions of Firefighting Intervention with Research of Anthropometric Factors

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THE DESCRIPTION OF THE SCIENTIFIC PROBLEM

In many cases, the legislation contains wording that can be interpreted in several ways, especially in fire protection requirements during the use of buildings and the technical conditions of firefighting intervention. Without any further guidance, it can be challenging to apply the legislation. Therefore, I would like to find an optimal solution for possible ways to achieve the required level of fire safety.

P1. The availability of fire protection equipment, firefighting water sources, and public utility shut-off devices is not defined.

It is currently not known under what conditions are fire protection equipment, firefighting water sources, and public utility shut-off devices considered accessible. In many cases, the current legislation only defines the accessibility and accessibility requirements in general terms but does not provide guidance on specific technical solutions for the implementation.

The availability of fire extinguishers is essential for extinguishing fires in their early state. If accessibility is not ensured, the fire may fail to be extinguished. The availability of manual call points can provide the possibility of early fire alarms. The availability of firefighting water sources is relevant for the intervention of the fire brigade. It is necessary to be able to access firefighting water sources not only by persons but also with fire engines. Shutting off or disconnecting public utilities in the building affected by the fire can be suitable for extinguishing the fire, mitigating the damage, and ensuring the life safety of the firefighting personnel. If the availability of public utility shut-off devices is not ensured, those listed above are at risk.

The terms accessibility and blocking are not defined at the legislative level and do not contain any guidelines for these phrases in the Fire Protection Technical Guidelines or standard for fire protection. For this reason, the application of the law may require a case-by-case definition of terms, which may vary between the appliers of the law. In order to ensure that this does not result in legal uncertainty, it is appropriate to define the terms of accessibility and blocking in legislation or a Fire Protection Technical Guideline.

Life safety in buildings can be guaranteed if the people can escape to safety from a building during a fire or other local emergency. This can be done by evacuating buildings. Evacuation must take place so quickly that the fire and its accompanying phenomena cannot cause damage to human life. The evacuation calculation is used to verify compliance with the statutory standard evacuation times. It is assumed that under the standard evacuation time, the conditions for safe escape are given throughout the evacuation.

P2. The scientific basis of the flow rate used in the evacuation calculation and its relationship to the population's average escape capability is unknown.

The flow rate of the narrowing along the route during the evacuation has an impact on the duration of the evacuation, including the safety of the occupants of the building. If the flow rate of the bottleneck is considered in the evacuation calculation as a higher value than reality, the calculation gives less time to evacuate the building, unlike in reality. This may lead to the fact that, in reality, the building will not be able to be evacuated within the standard time, thus putting the lives of the occupants at risk. However, if the flow rate of the bottleneck is taken into account as a lower value than in reality, the safety of the occupants' increases, as they can leave the building in a shorter time than the standard time. However, this limits the capacity of premises and buildings to a greater extent than necessary, which may cause economic damage. For this reason, it is appropriate to adapt the flow rate value when calculating the throughput of the narrowing to the actual capabilities of the occupants. In order to be able to do so, it is necessary to examine whether this aspect of the population's escape capability has changed since the value used in the evacuation calculation was established. The prescribed flow rate value, which does not allow differentiation, has been used for more than 50 years and therefore its revision is justified.

Research and development under this theme will help prevent fires effectively and provide prescribed conditions for firefighting intervention in such a way as to minimize disruption to citizens and economic operators in everyday life. The research results and development proposals obtained under this topic may be incorporated into legislation, Fire Protection Technical Guidelines, methodological guides, etc.

There is a need to develop a technical directive on fire safety regulations that could help appliers with possible solutions to achieve the required safety level by the National

Fire Protection Regulations. For example, the Fire Protection Technical Guideline for the requirements of fire protection during the use of buildings could contain guidance to help meet the required safety level by the legislative intention, while at the same time providing more detailed wording and concrete technical solutions to help to apply the legislation.

HYPOTHESES

As with the outline of the scientific problem I raised, my hypotheses at the start of my research are below.

H1. I assume that applying parameters optimized for geometric data calculated considering anthropometric properties provide technical solutions that meet the required safety level for the widest range of users.

H2. I assume that the flow rate value determined by examining the flow of adults, youth, and children through bottlenecks is greater than the currently accepted value recorded in the relevant Fire Protection Technical Guideline.

RESEARCH OBJECTIVES

My research aims to develop specific technical recommendations that can help people who apply the law to optimize the required safety level concerning the availability of fire protection equipment, firefighting water sources and public utility shut-off devices and the possibilities for opening the emergency exits taken into account in the planning of fire evacuation of buildings. In addition, I aim to review the flow rate value used in the evacuation calculation and determine a new value.

O1. My goal is to determine precisely the optimal geometric parameters for fire protection equipment, firefighting water sources, and public utility shut-off devices by examining anthropometric data from the perspective of fire protection requirements during the use of buildings and firefighting intervention.

O2. My research aims to set a flow rate value for adults, youth, and children, which allows determining the standard values in the relevant Fire Protection Technical Guideline differentiated.

RESEARCH METHODOLOGIES

My methods used to achieve the research goals and justify my hypotheses: analysis, synthesis, comparative critical analysis, and field survey.

I have studied and evaluated the national and international literature and the various standards and guidelines with comparative analysis. In this way, I made proposals on the accessibility of fire protection equipment, firefighting water sources, and public utility shut-off devices, and also the possibility of opening emergency exits and the flow rate of the narrowings.

During my on-site work, I assessed the fire protection situation of the facilities and then analyzed the existing conditions; by comparing facility management's and users' needs with fire safety rules. This assessment determined the possible optimum, considering the legal requirements, the required safety level, and the facility management needs.

I carried out field trials and observations to assess the flow rate of a bottleneck, taking into account the average escape capability of the population, thus determining the flow rate, which can be taken into account in the evacuation calculation.

I have made technical drawings to illustrate my research results. I did mathematical calculations to evaluate my measurements. Finally, I used statistical methods to conclude the characteristics of the chosen sample for the whole population. To determine the flow rate of the narrowings and compare them with my own measurement results, I have created models and simulations with the latest version of Pathfinder software version 2021.3.0901 x64, developed by Thunderhead Engineering Consultants, Inc.

The deduction and the logical conclusion were also helpful in my research. I published my research results in Hungarian and English to the general public of public scientific life. The feedback helped me to explore further directions in my research activities.

THE CONCISE DESCRIPTION OF THE RESEARCH CONDUCTED

In the first chapter, I examine the optimal location of fire protection equipment, firefighting water sources, and public utility shut-off devices. First, I presented and analyzed the relevant literature on the availability of fire protection equipment, firefighting water sources, and public utility shut-off devices, including anthropometric data and relevant standards. Thereafter, I have tabularized and organized the relevant anthropometric data. Then, I have illustrated and explored the practical problems encountered in the application of the law with photographs. Finally, I have identified the practical importance of the availability of fire protection equipment, firefighting water sources, and public utility shut-off devices, as well as the criteria for their optimal location and the conditions of accessibility.

The availability and optimal location of fire protection equipment, firefighting water sources, and public utility shut-off devices did not include examining the access of children, the elderly, and those with reduced mobility to these devices. Only in very extreme cases can the previous personnel be expected to use or operate fire protection equipment, firefighting water sources, and public utility shut-off devices. For this reason, I examined accessibility and optimal placement only for a fully capable and healthy adult population.

The essential part of my thesis is the second chapter, in which the purpose of my research was to review the flow rate value used in the evacuation calculation. Since I have devoted a significant part of my research to these studies, the presentation of the results is more extensive than the first chapter. First, I present and analyze the relevant literature on the organization and conduct of evacuation drills and the flow rate through a bottleneck during pedestrian flow. Second, I will give an overview of the current state of organization and conduct of evacuation drills and the relevant legal requirements. Third, I am proposing possible new solutions to increase efficiency. Finally, I will explain my experience with evacuation drills.

I present my experience of evacuation drills in seventeen communal buildings. First, I estimate the relationship of the current flow rate value to the actual throughput. From my observations, I draw conclusions about the crowd's flow. Next, I describe my observation and measurement at the metro station, in which I used a mixed-age population

to determine the flow rate of the bottleneck. Thereafter, I describe my research involving children and youth, which I carried out during the evacuation drills of primary schools and an eight-grade high school to determine the flow rate value of the narrowings for persons of this age. Finally, I use statistical methods to analyze my measured values to draw relevant conclusions from them.

I compared the results of my research on the flow rate of narrowings with the results of simulations with Pathfinder software, which is suitable for modern computer modeling of evacuation.

My goal was to determine only the elementary factor in the evacuation calculation, the flow rate through narrowings. This value is independent of other elements of the evacuation calculation, the geometry of the whole building, and pedestrians' congestion. Panic can affect people's behavior, but if there is an increased risk of panic, then the design or operation of the building is not appropriate. The source of the flow rate value used over decades, as I describe in detail in the relevant chapter, has not been determined by examining persons in panic or with reduced escaping capability. The work describing the basics of the evacuation calculation makes no mention of safety factors. Therefore, I cannot assume that approaching real-world conditions in today's age with the flow rate would result in disregard for the safety factors implicit in the current evacuation calculation. Chiefly, because I have determined a value by statistical analysis that is 95–99% likely to prevail for the whole population.

I present and analyze the relevant literature on the opening possibilities of emergency exits. Next, I present and illustrate with photographs the practical problems encountered in the facility management in relation to ensuring that emergency exits can be opened easily. Then, I analyze and present international examples, specifications, and standards concerning emergency exit devices, panic exit devices operated by a horizontal bar, and the use of electrically controlled exit systems for use on escape routes. Finally, I will determine the optimal solutions for opening emergency exits.

During my research, I aimed for holistic analysis, which considers complex fire protection aspects. The holistic approach appears in my thesis when researching the accessibility criteria for fire protection equipment since the findings made there are not valid for just one type of fire protection equipment but can be interpreted for a whole range of them. In addition, according to the criteria identified therein, access may be

granted to non-fire-related equipment, as first aid equipment, eyewash bottle, semi-automatic defibrillator. A holistic approach can also be seen in the chapter on the flow rate of narrowings. The flow rate and the impact of the bottleneck on pedestrian flows are factors that can be considered not only in the field of fire protection. My research results can be used to design, for example, metro stations, airports, stadiums, other public facilities, or even passenger vehicles. They can also be used to organize and plan mass movements of persons, like mass events.

SUMMARISED CONCLUSIONS

First Chapter

In Chapter 1, I assumed the scientific problem that the availability of fire protection equipment and firefighting water sources is not defined. Therefore, it is currently unknown under what conditions are fire protection equipment, firefighting water sources, and public utility shut-off devices considered accessible. In many cases, the current specifications only define the accessibility requirements in general terms, but the implementation does not provide guidance on specific technical solutions.

I formulated my first hypothesis: I assume that applying parameters optimized for geometric data calculated considering anthropometric properties provide technical solutions that meet the required safety level for most wide users.

My goal was to determine in an exact way the optimal geometric parameters for fire protection equipment, firefighting water sources, and public utility shut-off devices by examining anthropometric data from the perspective of the requirements of fire protection during the use of buildings and firefighting intervention.

To achieve this research objective, I used the following research methods. First, I have studied and evaluated the national and international literature and the various standards and guidelines with comparative analysis. Second, during my on-site work, I assessed the fire protection situation of the facilities and then analyzed the existing conditions by comparing facility management and users' needs with fire safety rules.

In line with the research objective, I have come to the following main findings and conclusions:

a) I have identified the practical importance of the availability of fire protection equipment, firefighting water sources, and public utility shut-off devices in preventive fire protection of buildings.

b) I have revealed the anthropometric data necessary to determine the availability of fire protection equipment, firefighting water sources, and public utility shut-off devices.

c) I have tabularized and organized the relevant anthropometric data. I have defined the conditions for the availability of fire protection equipment, firefighting water sources, and public utility shut-off devices.

d) I made technical drawings showing the dimensions of the spaces to be kept free around fire protection equipment, firefighting water sources, and public utility shut-off devices.

e) I have determined the optimal dimensions for the vertical positioning of the fire protection equipment, and on this basis, I have determined the free structure gauge of the approach path of the fire protection equipment.

f) I have determined the maximum height of the highest point and the minimum height of the lowest point, and optimal placement height of the handles or other handling parts of the fire protection equipment to ensure accessibility of the broadest range of the population.

g) I have defined the parameters to ensure the visibility of the fire protection equipment, which is necessary for use.

Based on the above, I see my first hypothesis justified: applying parameters optimized for geometric data calculated considering anthropometric properties provide technical solutions that meet the required safety level for most wide users.

Second Chapter

In Chapter 2, I assumed the scientific problem of not knowing the scientific basis of the flow rate value used in the evacuation calculation and its relationship to the average escape capability of the population. The prescribed flow rate value, which does not allow differentiation, has been used for more than 50 years, and a review is needed.

I stated my first hypothesis: I assume that the flow rate value determined by examining the flow of adults, youth, and children through bottleneck is greater than the currently accepted value recorded in the relevant Fire Protection Technical Guideline.

My research aims to set a flow rate value for adults, youth, and children, which allows determining the standard values in the relevant Fire Protection Technical Guideline differentiated.

To achieve the research objective, I used the following research methods. First, I have studied and evaluated the national and international literature and the various standards and guidelines with comparative analysis. Second, I carried out field trials and observations to assess the flow rate of a bottleneck, considering the average escape capability of the population, thus determining the flow rate, which can be taken into account in the evacuation calculation.

In line with the research objective, I have come to the following main findings and conclusions:

a) I have developed proposals for the organization, conduct, and evaluation of evacuation drills in buildings.

b) I have demonstrated that values greater than the flow rate used in the evacuation calculation are possible.

c) I made measurements to determine the throughput characteristic of the flow of pedestrians through narrowing for adults, youth, and children.

d) I have improved the evacuation calculation with my proposal to change the value of the flow rate.

e) I have set the facility management's expectations for ensuring that emergency exits can be opened.

f) I have identified options for opening emergency exits, each of which provides an optimal opportunity for opening them.

Based on the above, I see my second hypothesis justified: the flow rate value that can be determined by examining the flow of adults, youth, and children through bottlenecks is greater than the currently accepted value recorded in the relevant Fire Protection Technical Guideline.

NEW SCIENTIFIC RESULTS AND THESES

1. By examining anthropometric data, I have defined in an exact manner the optimal geometric parameters for the use of fire protection equipment, firefighting water sources, and public utility shut-off devices for firefighting intervention, on the basis of which I proved that applying the parameters optimized by geometrical data considering anthropometric properties provides appropriate technical solutions to the required safety level in the broadest range.
2. By examining the flow of pedestrians through a bottleneck, I determined the typical flow rate of adults, youth, and children; and I have verified that the value based on my research is greater than the flow rate value used in the evacuation calculation in Hungary today, which makes it possible to determine the currently accepted value, stated in the relevant Fire Protection Technical Guideline, in a differentiated way.

RECOMMENDATIONS

During my research, I examined in detail the importance and criteria for the availability of fire protection equipment, firefighting water sources, and public utility shut-off devices; the flow of persons passing through narrowings during building evacuations, from which I have determined the flow rate of the bottleneck; and criteria and specific technical solutions to ensure that emergency exits can be opened. My research results also cover the fields of fire management, fire prevention, and fire protection designers.

I recommend my dissertation for:

a) fire prevention professionals;

b) fire safety designers and experts;

c) researchers, doctoral students in the field of fire safety;

d) university students, who deal with fire prevention;

e) persons to whom my solutions and suggestions can help to comply with the Requirements of Fire Protection;

f) the legislator, responsible for fire safety, to modify the legislation;

g) the Fire Safety Technical Committee to help to review the extant or make new Fire Protection Technical Guideline;

h) professionals involved in official fire safety control.

POTENTIAL PRACTICAL USE OF THE RESEARCH RESULTS

My research results can be used in practice as follows:

1. The conditions for the accessibility of fire protection equipment, firefighting water sources, and public utility shut-off devices, which I have defined, may form the basis for a future legislative change. Specific technical solutions may be suitable for incorporation into a new Fire Protection Technical Guideline. Systematic anthropometric data provide an opportunity for further research on accessibility.
2. The value of the flow rate for adults, youth, and children I have defined provides an opportunity to modify or determine the flow rate in the current Fire Protection Technical Guideline of Building Evacuation in a differentiated way and may provide a basis for further research on this subject.

LIST OF PUBLICATIONS

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PROFESSIONAL–SCIENTIFIC BIOGRAPHY OF THE CANDIDATE

Name: Gergely Herczeg

Place and date of birth: Budapest, 1st June 1987.

Studies:

He began his university studies in 2009 at the Zrínyi Miklós National Defense University and got a Military and Safety Technology Engineer (BSc) bachelor's degree in 2013 at the National University of Public Service Faculty of Military Sciences and Officer Training due to succession.

In 2015 he earned a Construction Engineer (MSc) Master's degree at the Szent István University Faculty of Mechanical Engineering.

In 2016 he became a Fire Safety Engineer (Postgraduate Specialist Training Course) at the Szent István University Ybl Miklós Faculty of Architecture and Civil Engineering.

At the Óbuda University Bánki Donát Faculty of Mechanical and Safety Engineering, he earned another postgraduate degree as Occupational Health and Safety Engineer in 2018.

He started his doctoral (Ph.D.) study in 2017 at the National University of Public Service Faculty of Military Sciences and Officer Training Doctoral School of Military Engineering.

Language skills:

He passed an intermediate "C" type language exam in 2005 in German and in 2006 in English.

Professional career:

He has been working for the same company since 2013: Partner-KOM Bt.

In the course of his work, he contributed to the fire safety design of about 20 buildings, carried out fire safety audits of 200 facilities (a total of 1,000,000 sqm) a total of 1,700 times, organized and conducted evacuation drills in 23 buildings more than 100 times. During the audit, his tasks include checking the requirements of fire protection during the use of buildings.