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ACTIVE FIRE SAFETY ON CONSTRUCTION SITES

ÉPÍTÉSI TERÜLETEK AKTÍV TŰZVÉDELME

Absztrakt:

Regarding the number [1] and effect of fires we can rightly say that construction sites are highly hazardous areas. Construction sites as special working environments present special challenges to the employer and need special rules. In this paper I would like to overview and inspect a part of this area, the possibilities and the innovations in the evacuation of construction sites in case of fire.

Keywords: *fire alarm, evacuation, construction site, health and safety*

A bekövetkező tűzesetek számát tekintve [1], illetve hatását tekintve joggal mondhatjuk, hogy az építkezési területek kiemelt kockázatot jelentenek. Az építési területeken, mint speciális munkahelyeken dolgozók biztonságának megteremtése különleges kihívások elé állítja a munkáltatókat és a szakembereket egyaránt. A biztonság növelésének egyik aspektusát, a tűzriasztás lehetőségeit és ezzel összefüggésben az építkezéseken a hatékony evakuálás lehetőségeit, fejlesztési irányait kívánom vizsgálni.

Kulcsszavak: *tűzjelzés, kiürítés, építési terület, munkavédelem*

INTRODUCTION

The ambition to change the built environment is as old as the mankind. To build structures which can withstand environmental impacts with the necessary life-sustaining functions or even in the future for entertainment purposes has become the dominant segment of the industrial production today.

The importance of the construction industry in the Hungarian national economy is significant. Until 1995, it changed from 3.9% to 5.8%. The number of the companies in the construction industry is close to a hundred thousand and the rate of employment is also high: 6.5%. The annual output of the construction industry has been increasing in recent days, although it is far from the level of the pre-crisis term. For example in 2015 it was HUF 2017.7 billion in terms of volume at current prices [2]. In Hungary most of the investments in the construction industry come from EU tenders. They set very strict financial and deadline expectations for the participants. Any hindering factor causing deadline slips may result in the violation of the guarantees and heavy financial losses.

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One of the most known and worst fires, which happened at the Düsseldorf Airport in 1996, killed 17 civilians and a lot of people were injured. The cause of the fire was a simple welding work. The cost of the damage was hundreds of millions of German Marks and it took two years [3] to renew the building. Of course it had negative effect on the business as well. We can find several examples of fires on construction sites. For example there were five registered fire events at the Metro 4 construction in Budapest [1].

This proves that we cannot skip the effort aimed to protect both life and property. So it means that reaching a higher and higher safety level is one of the first aims in the construction industry too.

The vulnerability of a construction investment by fire is largely determined by the stage of construction completion. We have to face different problems related to fire prevention and evacuation in the several distinct period of the building project [4].

SPECIALITY OF THE CONSTRUCTION SITES

The construction workplace

We should look on the construction sites as special working environments. As we see it a special workplace it has several features which differentiate them from the others in view of the safety of the workers. Some of these are for example:

- Not a permanent environment, it is in a constant change depending on the phase of the construction process. It is a problem because the employees may not necessarily know exactly the changing routes, especially the escape routes.
- Not yet or just partly existing fire sections (e.g. fire doors), escape routes, emergency lighting etc. which solutions should guarantee the safe escape from the area.
- Changing mix of employees, high turnover.
- There can be a huge number of workers at the same construction site in large projects.
- In many cases the workers do not necessarily know each other, sometimes they do not even speak the same language.
- Sometimes there is an extremely high noise level, which is a complicating factor in the information and warning.
- A large number of dangerous technologies are used temporarily and simultaneously (see Table 1), e.g. soldering, arc or gas welding works, flexing, electrical equipment, temporary electrical supply, use of flammable materials.

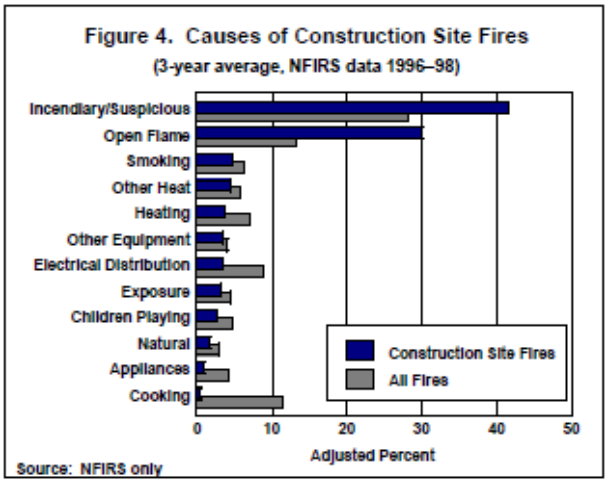

Table 1 Causes of Construction Site Fires [5]

Protection against these factors is very difficult at a changing, temporary site, in contrast with for example a similar technology being done in a workshop.

- A large amount of garbage, building rubble.
- Because of the increasing pace of work, the short terms and deadlines, the low prices and the high expectations, there are a lot of irregularities. (Based on the information of the Ministry[2], half of the inspected employees are concerned in some kind of irregularity. This number is significantly higher than the national average, which is 30% [6].

Due to the criteria listed above, special safety legislation and measures are necessary to ensure the safety of the employees. In order to protect the workers at the construction sites, it is necessary to create local plans ("Safety and Health Plan" [7]) which should be based on the actual and appropriate national laws, directives and practice.

Safety of employees

Legislation

Article XVII of the Fundamental Law of Hungary [8] declares that *"Every employee shall have the right to working conditions which respect his or her health, safety and dignity"*. As a member of the European Union, Hungary's responsibility became more intense due to the long history of the EU's occupational safety and health policy. Already Directive[3] 89/391/EEC [10] – which can be viewed as the "EU's law of safety" [11] - laid down objectives for the member states to solve. Article 8 says that the employer has to prepare for the possibility of evacuation at a workplace.

[2] Ministry for National Economy
[3] *"A directive is a legal act of the European Union, which requires member states to achieve a particular result without dictating the means of achieving that result."* [9]

Providing a safe workplace for the employees is the duty of the employer basically. In the building industry it is a complex problem with complex responsibilities too. Act XCIII of 1993 [12] on Labour Safety was changed last year. It includes the cases where multiple employees work together, like at construction sites. The Act identifies the employer as the primary person in charge of coordinating work at the site. If it is not possible to find the work's coordinator, the responsibility goes to the owner of the site. First of all, to provide a safe workplace is the duty of the "safety and health protection coordinator" [7] employed by the builder because of the labour regulations. It is a complex task to apply the legislations, directives and practices at an actual construction site. The coordinator has to take the following most important points of view into consideration:

- Knowledge of the used technologies including safety viewpoints (e.g. the need for personal protective equipment, hierarchy of process steps, protection methods against hazardous materials)
- Safe operation of the used equipment.
- Storage of materials used at the construction site, with special regard to hazardous materials.
- The issue of waste management.
- Registration of the people at the construction site.
- Continuous coordination of activities in place and time.
- Determine the location of the work considering the routes or traffic zones.

In addition, according to the regulation, in some cases (depending on the number of the employees and the duration of the building works) there is a reporting obligation to the competent authority of labour.

Economic incentives

Hungary, in accordance with the EU directives worked out a labour safety strategy, called "National Occupational Safety and Health Policy" [13] from 2016 to 2022. Within its scope, the strategy supports solutions and innovations which can ensure a higher level of employee safety by considering and decreasing the classical and new risks. The strategy puts emphasis on the prevention because, among other reasons, the Issa's[4] reports says that "all euro invest into safety and health caring will 2.2 times refounded".[14]. Since its expansion, the construction industry, the most risky sector, requires more attention in this period. Behind the accidents, there is a lack of protective equipment and occupational safety and health knowledge, as well as a lack of discipline. Moreover, it directly claims among others that *"there are a lack of protective equipment"*. Forty percent of 27 EU member states' employees (approx. 80 million people) feel that they are exposed to conditions that threaten their physical health at their workplaces [15]. Based on statistics covering more sectors we can state that this fact is significantly true for the construction industry sector, because in the statistics on all

[4] International Social Security Association

types of labour accidents the construction sites rank first. Thanks to the unique working environment of the construction sites, fire protection requires unusual solutions which generally mean higher costs. To be aware of this, the EU calls the member states' attention to the economic incentives which can help not to feel the additional costs as a waste of money. The European Agency for Safety and Health at Work[5] highlights the benefits [16] of subsidising companies which pay special attention to the development and maintenance of a safe and healthy work environment. Such economic incentives are for example tax credits, state credits, subsidies or lower insurance premiums.

Insurance aspects

I would like to highlight the role of the insurance companies, as the key participants of a large building project. In this case, the economic incentives can help to reduce the number and amount of claims, and thus reduce the overall costs too. Surveys show that the insurance-related economic incentives in the field of safety and health at workplaces are very effective [16], so we can find many examples of insurance companies creating their own internal policies regarding active fire protection on construction sites. The German VdS 2021:2016-06 (02) directive [17] suggests the application of wireless mobile fire alarm system to provide early fire alarm, effective evacuation and intervention. Compliance with the directives of the insurance companies results in a number of advantages not only in reduced insurance premiums, but in the amount of compensation. Although the compliance with the directives of the insurance companies is not compulsory, ignoring those may mean disadvantages.

In Great Britain the government developed guidelines [18] in the field of the construction site's safety and health, which include the needs of the systems for effective fire detection and alarm. It means using at least manual call points and sounders. On the other hand, the FPA[6] and other organizations also deal with this question and suggested increasing the security level by similar active systems.

We can find several aspects of these expectations in the European Union. The CFPA[7] also develops guidelines for fire protection of construction sites (CFPA21: 2012F – Fire Prevention On Construction Sites [19]). Among the European Directives mentioned above, 92/57/EEC [20], as the eighth individual Directive, specifically declares the necessity of installing fire alarm systems at some construction sites in the interest of fast and safe evacuation.

"In the event of danger, it must be possible for workers to evacuate all workstations quickly and as safely as possible." (3. Emergency routes and exits)

"Depending of the characteristics of the site, the dimensions and use of the rooms, the on-site equipment, the physical and chemical properties of the substances present and the maximum potential number of people present, an adequate number of appropriate fire-fighting devices and, where required, fire detectors and alarm systems must be provided." (4. Fire detection and firefighting)

[5] EU-OSHA
[6] Fire Protection Association
[7] European Fire Protection Associations

In the context of this directive, a publication appeared [21] in Hungary in 2010, whose title is "Non-binding guide to good practices related to the interpretation and implementation of Directive 92/57/EEC, on construction sites Directive".

Safety of employees

As discussed in the previous section, due to the special workplace environment we have to use unusual solutions to control the fire and ensure the safety of the employees. In principle, fire prevention is one of the most important tasks including the special usage, storage and technological rules. Yet experience shows [13] that more than 80% of the inspected employers break the rules, while the rate of official controls (approx. 2%) is very low due to the limited capacity. This tangible data also confirms that in the event of a fire at construction sites, the most important thing is the earliest possible fire alarm allowing effective evacuation of the employees. Ensuring escape becomes the primary consideration, because the fire at a site with full of half-finished structures and temporary solutions entails danger and higher risk not just for the employees, but for the firemen too. You can see a report based on the data of NFIRS[8] [5], which shows (Table 2) how much more damage occurs during the firemen's intervention at construction sites as opposed to other areas. This fact will also reduce the chance of the people to escape in time.

Figure 1. Loss Measures for Construction Site Fires
(3-year average, NFIRS data 1996–98)

LOSS MEASURE	ALL REPORTED FIRES	CONSTRUCTION SITE FIRES
Dollar Loss/Fire	$5,619	$8,643
Civilian Injuries/1,000 Fires	15.7	7.5
Civilian Fatalities/1,000 Fires	2.4	2.3
Firefighter Injuries/1,000 Fires	11.0	13.4

Source: NFIRS only

Table 1 Causes of Construction Site Fires [5]

PROBLEMS OF THE EVACUATION AT THE CONSTRUCTION SITES

Criteria of the evacuation

The most important task of the employer and the most important aspect of employee safety is to ensure the possibility for workers to evacuate the site as soon as possible. It needs to meet the following general criteria:

- to be informed about the fire in time (it requires efficient fire detection and alarm), and
- to ensure the possibility of evacuation.

[8] National Fire Incident Reporting System

The two general expectations above are associated with many other conditions.

Fire detection

The fire alarm must be preceded by a fire detection. Already here we run into the first problem: how can we detect and alert fire at a construction site. There is no chance to install the final fire detection and alarm system designed for the building, which does not exist yet. The fire detection and alarm systems designed for the buildings are usually wired systems, designed for the final areas, not for the changing areas of a construction site full of rough environmental conditions.

The fire alert can be automatically detected or triggered manually. On the one hand you can trust that somebody notices the fire and somehow informs other people. The most effective solution is to put manual call points along the major escape routes. Most of the fire events at construction sites are caused by ignition whose signs (e.g. visible smoke, flames or noticeable odour) only become perceptible after leaving the site. Therefore, there is often a delay, because the ignition sources are away from the location of the work. For example when somebody does not comply with the fire safety rules and during the welding work a fire is generated one floor below. After the working hours the construction site is empty and despite the guarding in the most cases it does not mean monitoring the whole site. To trust that somebody will notice a fire, significantly increases the level of safety. To compensate for it, the relevant 4/2002. (II. 20.) SZCSM–EüM combined decree [7] contains this in Annex 4:

"Depending of the characteristics of the site, the dimensions and use of the rooms, the on-site equipment, the physical and chemical properties of the substances present and the maximum potential number of people present, an adequate number of appropriate fire-fighting devices and, where required, fire detectors and alarm systems must be provided."

The requirements of the Hungarian regulation are consistent with 92/57/EEC Directive [20], so it seems that the adaptation of the act is complete. The need for using these systems at larger construction sites is clear. Despite this, the current legislative requirements referred to above do not exist. We can look on it as a "legal deficiency", which the legislators have to deal with in the future.

The advantages of using fire alarm systems at the construction sites are clear. These systems have to meet special requirements, for instance:

- mobility (easy to relocate and extend) because the protected areas, the technologies, the escape routes are continuously changing during the construction;
- resistance to the external environment, which means a higher degree of immunity to dust, humidity and changing temperature;
- simple and easy operation, because the staff of a construction site are often changing; they do not need the knowledge of the fire alarm system's manual for a long time;
- due to the fact that constructions do not take a too long time, the possibility of re-usability is a very important viewpoint in case of a temporary system; and
- using suitable alarm devices because of the high background noise.

Fire alarm

The fire detection alarm should be followed by an effective process, which can alert the employees on the site to begin to escape. On construction sites more types of alarm solutions are used, from simply shouting to the clicker for example. Today fire alarm devices provide a trustworthy solution. Due to the high background noise, the best solution is to apply combined audible and visual devices.

Providing the escape routes

If there is an effective fire alarm, we can see the next step is the evacuation. Without an effective fire alarm there is less chance to escape. The relevant provisions of this calculation, as well as the provisions of escape routes also cannot be used on all construction sites without any modifications. Despite this, ensuring escape is an existing legitimate expectation.

Fire Alarm and Evacuation System at the construction sites

Presentation of the system

Besides the special requirements, in the European Union there is an additional strict requirement for fire alarm devices, that is, being approved and certified to the European EN 54[9] standard [22]. There is an appropriate, EN 54 certified, British-made, mobile wireless fire alarm and evacuation system, which complies with the special requirements too. [23].

System components

The system includes a Base Unit in each case, which can be considered the fire panel itself. If an alarm is activated, the base station allows you to identify quickly on the LCD[10] display which unit has been triggered, and you can configure the system via this unit too. The basic safety level means using manual call points, which are placed along the escape routes. We can provide the possibility of a manual fire alarm. Important elements of the system are the audible devices, called sounders, which help to ensure that in case of fire the employees are able to start moving toward the exits. It is possible to increase the level of safety by using automatic detectors. The automatic smoke and heat detectors provide high safety level even outside working hours. In addition, the area may need more repeater units if the radio coverage is inadequate. The possible elements of the system are shown in Figure 1.

[9] EN 54 Fire Detection and Fire Alarm Systems
[10] Liquid Crystal Display

Figure 1 Mobile Wireless Fire Safety & Evacuation System product range [24]

Advantages

One of the biggest advantages of this system is the mobility. It means that it is very quick and easy to install or to change, remove, enlarge or reduce the system if it is necessary. To this end, the system uses the advanced wireless mesh technology that allows this system to work with fewer repeater units and to have higher EMC[11] compared with other wireless systems. All devices also work as a router, so the number of transmission paths is significantly higher compared with other systems (Figure 2). The resulting redundancy increases the system's security level.

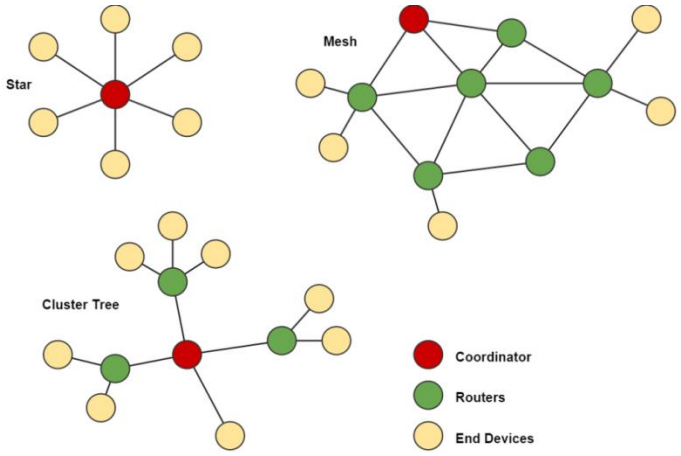

Figure 2 Comparison of wireless network topologies [25]

The system can be enlarged by any number of units, it is quick and easy to connect and configure new units. In addition, each unit has a tamper switch, which can send a fault alarm in case of removing the device. It means a big advantage in view of the large number of changing employees.

[11] Electro Magnetic Compatibility

The units have been designed with consideration for the environmental circumstances. So most of the units are IP55C[12] protected, except of course the smoke detectors due to the open smoke chamber.

Due to a special interface, which enables the connection of other devices to this system, in the event of fire other safety devices can be triggered i.e. lifts, access control system or auto diallers etc. It is a good solution if there is no 24/7 guarding service all over the site.

A further advantage of the system is the possibility of using a mobile application ("WES+ app for Android") by tablet or mobile. It delivers full wireless fire alarm system reporting as well as flexible system configuration. Health and safety reporting makes it easy to export your system logs and weekly silent test logs to pdf, csv or email. By an optional GSM version up to 6 users can be set to receive configurable SMS notifications for alarm activations and system alerts.

The system's great advantage is that you can use it on sites where there is no electricity. The units have their own power supply which provides three-year battery life.

The system has a silent test function which eliminates the need of a construction site evacuation during a test. Therefore, there is no disruption on the site or nearby residential areas.

The units are reusable more times, so for long-term usage the system is cost-effective.

Application possibilities

The application of a wireless, mobile fire alarm and evacuation system offers two-level solutions. The basic protection means using manual call point units and sounder units. We can increase the safety level by using automatic smoke or heat detectors. We should install detectors not just into the construction site areas, but into the supporting facilities as well (e.g. dressing rooms, storages, office containers). One of the useful solutions is to make a "Fire Point" (as you can see on Figure 2), where the manual call point, the fire extinguisher and important maps or warnings are together. This combined solution gives more effectiveness and easier mobility.

[12] IP: International Protection Marking against dust and water

Figure 3 Fire point application [26]

In every case it is inportant to do risk analysis. Risk assessment linked to fire protection provide the opportunity to look at the threats, and identify areas for increased measures to limit the impact of fire. It is necessary to carry out assessment and risk analysis, evaluation and potential development of the proposal on the basis of these in the therm of planning security system [27].
One of the primary aspects to ensure a high level of safety developing the fire protection system in accordance with the stage of construction completion in the therm of planning and creating it. In order to reach continuous and comprehensive protection the independent element have to be harmonized and supervised [28].

Although this system was developed for the protection of construction sites, there are a lot of other useful application possibilities, due to the numerous benefits mentioned above. Some of the versatile application possibilities:

- Use as a temporary solution in case of investments where the final phase of the building is not yet known exactly. For example, in big office buildings where many renter companies want to decide on their own interior layout, including the dividing walls. Today's practice of the authority is the re-licensing after almost every change in the system. It means a lot of costs for every participant.
- As spare temporary technical solutions in case the system is out of order. For example during an inspection, servicing, a long testing or maintenance. The Hungarian National Fire Protection Regulation [29] (hereinafter referred to as OTSZ) § 252 requires a temporary solution in these cases, to compensate for the lower level of safety.
- To protect temporary facilities, such as temporary accommodations for refugees, temporary facilities of festivals, mobile capsule hotels (Figure 4) or other containers.

Figure 4 Capsule-hotel at VOLT festival [30]

- Open air events, where we should provide the possibility of fire alarm by manual call points and sounders. One of the most important aspects of an open air event's fire safety is the possibility of evacuation. The relevant Hungarian Fire Protection Guideline [31] (hereinafter referred to as TvMI) in the 5.1.1. m) says that the required documentation has to include the method of the fire alarm, but does not specify any concrete solution. In addition to calculating the evacuation time (which covers the time from the effective start of a person), more attention should be paid to informing the people in time by a suitable method in the interest of effective evacuation.
- Or any other applications where there is no electricity or no chance for cabling and so on.

CONCLUSION

It is absolutely clear that at such a special workplace like a construction site, the safety of the employees can be guaranteed by providing the possibility of evacuation in case of fire. To achieve this aim it is necessary to use an effective fire alarm and evacuation system. The level of the technical solutions nowadays can give us the possibility to solve this problem. We have the opportunity to reduce the risk. However, the real increase of the safety level should be the part of a "safety culture". The aim is that the state (including the authorities), investors, designers, insurance companies, authorities, the contractors etc. use this solution not just because of the legislations or the directives of the insurance companies. It is important that the parties of this industry segment understand the connection between the safety level and the damages level in case of fire. The need for the protection of lives must be the primary objective of all participants, for example the investors, designers, and contractors too.

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