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SAFETY OF BUILDINGS AND CONSTRUCTION DISASTERS

J. SZER¹

The article discusses the dangers arising from construction disasters. This phenomenon is the most serious effect of the risk that may occur in construction. I presented this on the basis of an analysis of all construction disasters that have taken place in Poland in the last twenty years. I made a detailed analysis of the events that occurred during the maintenance of building facilities, taking into account the reasons for their occurrence and the effects they cause. The aim of this analysis is to identify areas of risk in order to eliminate the hazard and, as a consequence, take appropriate actions to counteract this type of events. Unfortunately, one should be aware that despite technical progress building disasters cannot be completely avoided in our surrounding, but one must use the knowledge acquired on this basis to minimize their number.

Keywords: construction, construction disaster, safety

1. INTRODUCTION

The phenomenon of construction disaster is an important problem that requires reflection, analysis and a call for action in order to eliminate it, or at least reduce it. Actions that should be taken include, first and foremost, education of owners and administrators regarding the maintenance of their building facilities in a proper technical condition, but also the identification of potential threats resulting from negligence in the maintenance of these building facilities.

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The threats analysis should also apply to decommissioned buildings, due to cases of their uncontrolled use and devastation, which may have tragic effects.

Construction disasters are events that seem to be rare when the number of total used and newly built building facilities is taken into consideration, but they must not be underestimated because they cause not only property damage but often loss of life and health as well.

The basic threats contributing to the occurrence of disasters include:

- bad technical condition,
- non-compliance with the technical requirements of executing construction works,
- lack of periodic inspections,
- strong winds,
- heavy rainfall,
- fire,
- gas explosions.

Despite technical progress in construction, one should be aware that, unfortunately, construction disasters cannot be completely avoided. New technical and organizational solutions can reduce human errors, but they will not eliminate the destructive effects of natural forces.

Construction is a broad interdisciplinary area of human activity and it is necessary to pay attention to the threats accompanying this activity. Therefore, maximum care should be taken to ensure the safety of construction works and, therefore, the people using them.

Among the oldest known legal regulations in this regard is the Code of Hammurabi [4] dating back to the 18th century B.C., which relates to constructed buildings and responsibility for their faulty constructing. Data on construction disasters are registered in Poland by the General Office of Building Control since 1994 and since 1962 by the Building Research Institute. There are however some difficulties in obtaining full information on construction failures and disasters, especially when there are no victims [9].

2. SAFETY OF BUILDINGS IN THE CONSTRUCTION LAW

The provisions in the Construction Law [1] specify actions concerning design, construction, maintenance and demolition of buildings and include specification of the duties of building administration authorities in this respect.

Additionally, the term "maintenance" which is used in this regulations, also refers to the exploitation of a building. However, this is a broader concept since it applies to the entire "life

cycle" of a building: from commissioning it to demolishing it or to its destruction as a result of a construction disaster [2].

In the provisions of the Construction Law, article no. 5 specifies the requirements to be met by a building facility as a whole and by its individual parts, together with related construction equipment. This provision, taking into account the expected period of building facility use, technical and construction requirements specified in the provisions, as well as the principles of technical knowledge, states that during the process of designing and constructing a building it should be ensured that:

- all basic requirements for construction works set out in Annex I to Regulation No 305/2011 of the European Parliament and of the European Council issued on March, 9, 2011 are met. This provision contains harmonized conditions for the marketing of construction materials and repeal of Council Directive 89/106/EEC (OJ EU L 88, 04.04.2011, p.5, as amended), regarding: load-bearing capacity and stability of structures, fire safety, hygiene, health and environment, safety of use and accessibility of building facilities, protection against noise, energy saving and thermal insulation, sustainable use of natural resources;
- conditions of exploitation are consistent with the purpose of the building facility, especially those concerning water and electricity supply and, depending on the needs, heat and fuel, assuming the effective use of these factors, removing sewage, rainwater and waste, as well as access to telecommunications services, in particular the broadband Internet access;
- ability to maintain proper technical condition;
- the condition of public buildings and multi-family housing makes it possible for disabled people, in particular those in wheelchairs, to use them;
- standards of occupational health and safety regulations are met;
- civilians are protected as required by civil protection;
- objects listed in the Register of Historical Monuments and those under the protection of the Monument Conservator are protected;
- the location on the construction plot is appropriate,
- legitimate interests of third parties concerning the impact of a building facility on the area, including ensuring access to a public road are respected;
- people staying on construction site are safe and their health is protected [1].

While designing a building facility one should think about the safety of a building and applying the provisions of the Polish and European standards, the use of which is not obligatory (apart from

those referred to in legal acts) and technical knowledge. By following these recommendations while designing the building, we increase its safety during its future use.

The safety of the constructed building is largely determined by its proper use and maintenance, which should be consistent with its intended purpose. Each construction structure should be maintained in a proper technical condition so as to prevent deterioration of its performance and technical efficiency remembering that the usage resulting from the age of a structure and the type of its intended function is natural.

In the Construction Law Act and in decrees issued on its basis, in particular technical and construction regulations, published on the basis of delegations contained in art. 7, there are regulations introducing and extending the provisions of the basic requirements contained in the abovementioned art. 5 of the Act.

These basic requirements are listed also in other legislation related to construction. An example of this are the conditions of fire safety, which are also regulated in the Act on Fire Protection while matters related to environmental protection - in the Act on Sharing Information about Environment and its Protection.

These laws are also an interpretation, both for people who have self-contained technical functions in industry, as well as architectural and construction administration authorities and construction supervision authorities, enforcing compliance with the regulations of the Construction Law.

The provisions of the Construction Law set out the duties and responsibilities of specific people at each stage of the construction process. Chapter 3 of this Act contains the rights and duties of participants in the construction process, i.e. investor, construction supervision inspector, architect and site or general contractor manager. Responsibility for the proper use and maintenance of the construction in accordance with Chapter 6 lies with the owner or building facility manager. These duties are set out in Article 61 of the Construction Law, which is summarized below.

The owner or manager of a building facility is obliged to:

- 1) maintain and use the building facility in accordance with the principles referred to in art. 5 paragraph 2;
- 2) ensure, with due diligence, safe use of the building facility in the event of external factors affecting the building facility, related to human activity or natural forces, such as lightning discharges, seismic shocks, strong winds, intense precipitation, landslides, ice phenomena on rivers and sea as well as on lakes and water reservoirs, fires or floods that result in damage to a building structure or an immediate threat of such damage, which may cause a threat to human life or health, safety of property or the environment.

People with construction licenses are responsible for safety, already at the stage of construction design, managing and supervising construction or building works, and also controlling proper maintenance of facilities. Supervision and control over compliance with the provisions of the Construction Law and control over people with self-contained technical position in construction site has been entrusted to the competent public administration bodies. These bodies, exercising their available powers, have the possibility to influence the actions of participants in the construction process. These influences are aimed at protecting the public interest and are also a guarantee of protecting the interests of third parties, ensuring their safety and safety of others.

The basic areas related to safety in the Construction Law include:

- rights and duties of participants in the construction process (investor, architect, site or general contractor manager, construction supervision inspector),
- obligations of owners or managers of facilities regarding the proper maintenance of constructions,
- procedures for starting, conducting and completing construction works,
- rules for performing self-contained technical functions in civil engineering,
- procedures for dealing with a construction disaster,
- duties of architectural and construction administration bodies and construction supervision in the process of building and maintaining construction facilities,
- criminal sanctions for violation of the provisions of the Construction Law,
- professional responsibility in construction.

Control and supervision can take many forms. The first of these is checking documents - if all required documents are collected and whether they were prepared according to mandatory provisions of law, e.g. in compliance with the local spatial development plan, and checking the application for a construction permit. It can be called a formal control. The second is a field inspection, which is a comparison of the actual state with the previously defined purpose (e.g. verification of compliance of construction or building works with the completed construction project, mandatory inspection). Both these forms lead to the verification of a specific situation, i.e. the actual state, by the appropriate administration body.

3. CONSTRUCTION DISASTER PHENOMENON

According to the provisions of art. 73 of the Construction Law [1], a construction disaster is the unintentional, sudden destruction of a building facility or its part, as well as structural scaffolding elements, forming elements, sheet piling and excavation support.

However, a construction disaster is not: damage to an element embedded in a building that can be repaired or replaced, damage to or destruction of construction equipment connected with buildings, or installation failure.

After a construction disaster occurs in the building facility, the owner, manager or user should help the victims, try to secure the site of the disaster to reduce its impact, and then notify the relevant services concerned.

The most severe effect of risk in the construction process is the occurrence of a construction disaster. Risk is the possibility that an event will occur and will affect reaching assumed goals. It can be defined as the probability of occurrence of an event having an adverse effect on the achievement of a given goal.

Risk analysis consists in identifying possible threats (events) that may occur as obstacles to the safe executing of a construction investment. Such threats include human errors, exceeding competences, failure to provide or unreliable control by entities obliged to do so, slowness in taking or not taking any action in case of irregularities [6].

A construction catastrophe may be caused by mistakes made at every stage of the investment process, i.e. investment planning, construction or use of a building facility. Considering that sources of building disasters concern all stages of construction works, they should be under constant control. In order to take appropriate actions to limit the effects of disasters, they should be analyzed and the reasons for their occurrence identified as accurately as possible. Reducing the occurrence of disasters in industry should be a priority both for people performing self-contained technical functions in industry and for state authorities.

It seems that the most effective actions that can be taken to minimize losses in these cases are systemic actions consisting in making changes to standards or creating and implementing long-term programs, e.g. flood protection [5].

What is also important is that legal acts, e.g. technical conditions or the provisions of the Construction Law, should follow the developing techniques and technologies so that they can be fully applicable to the construction of new building facilities.

4. ANALYSIS OF SELECTED DATA ABOUT CONSTRUCTION DISASTERS IN YEARS 1995-2018.

In the 1995–2018 period, a total of 7918 construction disasters were registered in the registers of the General Office of Building Control (Fig. 1) [3]. The total number of 2047 people were injured in all catastrophes that occurred during this period, 491 of them were killed and 1556 were injured (Fig. 2). The most tragic was the year 2006, when 65 people were killed and 144 wounded in the catastrophe of the exhibition pavilion at the International Fair in Katowice.

The division of construction disasters can be done, among others, according to the following criteria [6]:

- circumstances of occurrence, i.e. during construction, conducting building works or using the object;
- the main reason, i.e. random event, design errors, execution errors or a reason resulting from improper maintenance of the building;
- consequences, i.e. damage to property, injured people.

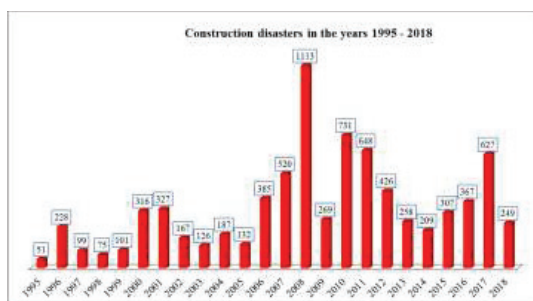


Fig. 1. Number of construction disasters in the years 1995 – 2018

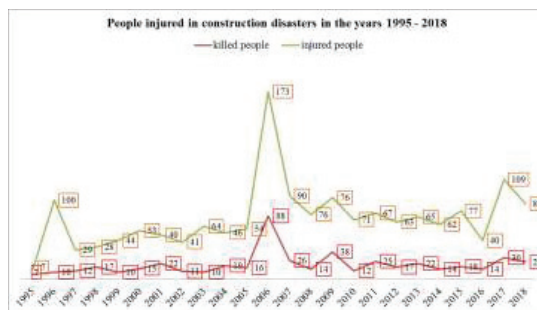


Fig. 2. People injured in construction disasters in the years 1995 – 2018

When analyzing disasters, it should be noted that the basic criterion for their division is the criterion for the circumstances of the disaster. This criterion is also used in the analyzes done by the General Office of Building Control [3]. Upon taking this criterion into account, it can be indicated that among 7918 of all disasters registered in the General Office of Building Control in the years 1995–2018 (Fig. 3) were:

- 7229, i.e. 91%, occurred during the maintenance of the building facility,
- 638, i.e. 8%, occurred during the construction or building works.

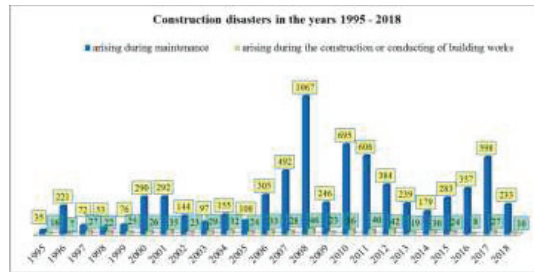


Fig. 3. Construction disasters arising during maintenance and during the construction or conducting of building works in the years 1995 – 2018

Analyzing the presented data, it can be concluded that the most disasters occur during the maintenance of buildings.

Figure 4 shows the relationship between total number of disasters and those occurring during maintenance, based on data collected during analysed time period.

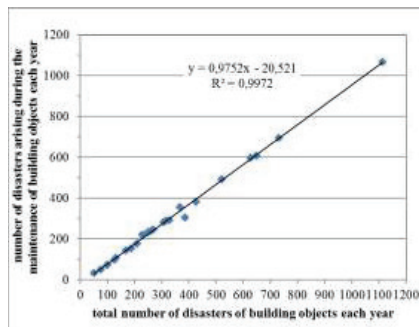


Fig. 4. Correlation between disasters arising during the maintenance of building objects and total number of disasters of building objects in the years 1995 – 2018

The disasters are most often caused by random events related to the destructive action of natural forces. This is a separate group of reasons which occurrence cannot be easily predicted and countermeasures are complex and costly.

Due to more frequent occurrence of the so-called random disasters, one of the increasingly important divisions used in the analysis of construction disasters is to differentiate them into disasters that do not result from random causes and those occurring due to random reasons.

We can include in the group of random events related to the forces of nature: floods, strong winds, heavy snowfall, lightning strikes.

The second group of random events includes those related to human activities, such as: gas explosions, car hitting a building facility, devices explosions (i.e. boilers).

While analyzing disasters it can be observed that their number has recently increased due to random reasons that are most difficult to eliminate and counteract. This is illustrated in Fig. 5. In the years 1995–2004, the percentage of catastrophes occurring due to random reasons was 64%, and in the years 2015–2018 it was 79%.

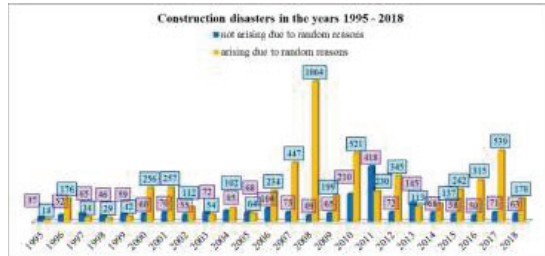


Fig. 5. Construction disasters arising and not arising due to random reasons in the years 1995 – 2018

After further analysis of the results presented above, it can be concluded that the statistical increase in the number of catastrophes in a given year is caused by the increased number of catastrophes caused by random causes, as illustrated in Fig. 6.

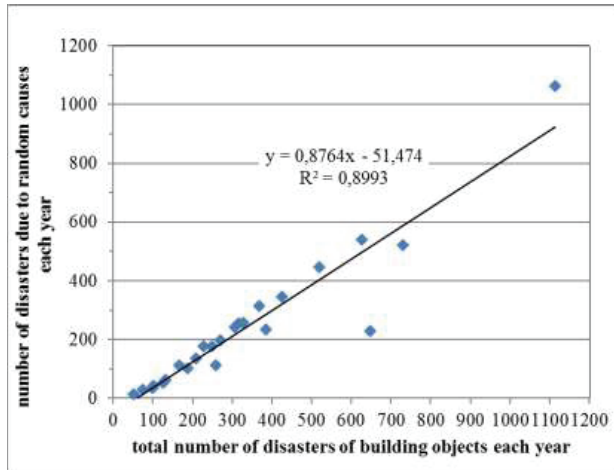


Fig. 6. Correlation between disasters arising due to a random cause and total number of disasters of building objects in the years 1995 – 2018

These rates were the highest in the following years: in 2007 they accounted for 86% of all recorded at that time, in 2008 - 96%, and in 2012 – 81%.

The most common causes, identified as random in analyzes made by the General Office of Building Control [3], in the last decade were in particular:

- strong winds (2,476 disasters, including 1,000 in 2008 and 429 in 2017),
- heavy atmospheric precipitation (399 disasters, including 122 in 2010 and 144 in 2017),
- gas explosions (227 disasters, including 30 in 2013 and 32 in 2017),
- fires (368 disasters including 66 in 2018),
- landslides – 105 disasters,
- floods,
- lightning strikes.

Further analysis of the data on catastrophes allows to observe that with the increase in the number of disasters in a given year, the number of disasters in residential buildings also increases in accordance with the correlation presented in Fig. 7.

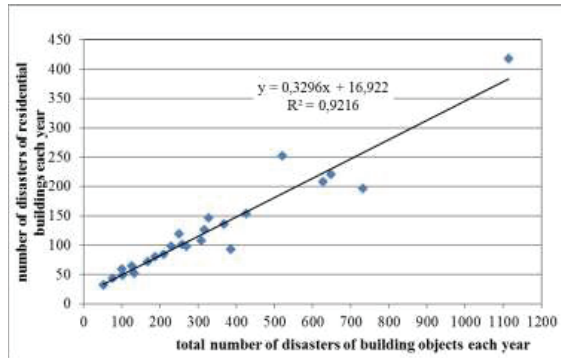


Fig. 7. Disasters of residential buildings in relation to total number of disasters of building objects in the years 1995 – 2018

4. SUMMARY

In the period from 1995 to 2018, 7918 construction disasters resulting in 500 people killed and more than 1,500 injured were registered in the General Office of Building Control register [3]. Construction disasters affecting the entire building facility are rare, but that doesn't mean we should underestimate this.

Construction disasters cause the most important losses: loss of life – the most painful of losses, loss of health - often associated with severe suffering and reduced comfort of life, or finally the most frequent losses - the destruction of the building, i.e. loss of property, often being the achievements of a lifetime [7].

Based on the presented analyzes it can be concluded that:

- the number of construction disasters increases along with the increase in the number of phenomena associated with natural forces and the directional coefficient of the approximating dependence is around 0.88.
- the increase in the total number of disasters causes an increase in disasters concerning maintained building facilities. The directional coefficient of the approximate dependence is around 0.97,
- the number of disasters of residential buildings increases linearly with the increase in total number of disasters while the directional coefficient of the approximating dependence is around 0.33.

A construction disaster is a negative effect of not achieving the most important goal, which is safety in construction. This is the result of errors arising at one of the stages of the construction process and subsequent maintenance of the building.

Knowledge about construction disasters undoubtedly has been built upon and is still influenced by the disasters that unfortunately continue to occur. It is therefore puzzling why even though the knowledge in this field is growing disasters still happen. This question is almost existential and seem to fall into the same category as the question why, although we learn from our mistakes, we continue to make them [8]. It is important that we can recognize the reasons, learn and draw the right conclusions for the future. Article 61 of the Act [1] specifies that the owner or general contractor manager of a building facility object is obliged to properly maintain and use the building. That means that they are responsible for ensuring the safety use of the building facility not only in the aspect of its technical efficiency, but also when various external factors associated with the action of natural forces influence that building facility and as a result a damage to the building or an immediate threat of such damage, which can cause a threat to human life or health, human safety or the environment, occurs. Due to the consequences of construction disasters, that is, always – the destruction of a building and the resulting material losses and often – loss of health and even – in exceptional cases - life, at all cost the risk of their occurrence should be reduced and their effects minimized. The conclusions drawn from disaster analyzes should be applied in preventive measures implementing the acquired knowledge into legal acts, technical literature and workshops for people dealing with construction works.

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BEZPIECZEŃSTWO OBIEKTÓW A KATASTROFY BUDOWLANE

Keywords: budownictwo, katastrofa budowlana, bezpieczeństwo.

SUMMARY:

W artykule omówiono zagrożenia wynikające z powstania katastrof budowlanych. Zjawisko to jest najpoważniejszym skutkiem ziszczenia się ryzyka, jakie może mieć miejsce w budownictwie. Przedstawiłem to na podstawie analizy ogółu katastrof budowlanych, które miały miejsce w Polsce w ostatnich ponad dwudziestu latach. Katastrofy budowlane to zdarzenia występujące rzadko patrząc na liczbę ogółu obiektów użytkowanych jak i nowo powstających, ale nie wolno ich lekceważyć, ponieważ przynoszą szkody majątkowe, a nierzadko powodują utratę życia i zdrowia.

Do podstawowych zagrożeń przyczyniających się do występowania katastrof można zaliczyć:

- zły stan techniczny,
- nieprzestrzeganie technologii wykonania robót,
- brak okresowych kontroli,
- silne wiatry
- intensywne opady,
- pożar,
- wybuchy gazu.

Nawet mimo postępu technicznego w budownictwie należy mieć świadomość, że niestety katastrof budowlanych nie da się całkowicie uniknąć. Nowe rozwiązania techniczne i organizacyjne mogą spowodować zmniejszenie błędów ludzkich, ale nie wyeliminują niszczyielskich oddziaływań sił natury. Zapisy zawarte w Prawie Budowlanym określają działalność obejmującą sprawy projektowania, budowy, utrzymania i rozbiórki obiektów budowlanych wraz z określeniem obowiązków organów administracji budowlanej w tym zakresie.

W przepisach Ustawy Prawo budowlane w art. 5 określone zostały wymagania, jakie powinien spełniać obiekt budowlany jako całość oraz jego poszczególne części, wraz ze związanymi z nim urządzeniami budowlanymi. Myśląc o bezpieczeństwie obiektu budowlanego należy przy projektowaniu korzystać z zapisów polskich i europejskich norm, których stosowanie nie jest obligatoryjne (poza powołanymi w aktach prawnych) oraz wiedzy technicznej. Stosując się do tych zaleceń podczas projektowania podwyższamy bezpieczeństwo później użytkowanego obiektu budowlanego.

O bezpieczeństwie powstałego obiektu budowlanego decyduje w znacznym zakresie jego właściwe użytkowanie i utrzymanie, które powinno być zgodne z jego projektowanym przeznaczeniem. Każdy obiekt budowlany powinien być utrzymywany w należyтым stanie technicznym, w taki sposób aby nie dopuścić do pogorszenia jego właściwości użytkowych i sprawności technicznej poza naturalnym zużyciem wynikającym z rodzaju jego eksploatacji i wieku.

Do podstawowych obszarów dotyczących bezpieczeństwa w Prawie budowlanym można zaliczyć:

- prawa i obowiązki uczestników procesu budowlanego (inwestora, projektanta, kierownika budowy lub robót budowlanych, inspektora nadzoru inwestorskiego),
- obowiązki właścicieli lub zarządców obiektów budowlanych, dotyczące odpowiedniego utrzymywania obiektów budowlanych,
- procedury rozpoczęcia, prowadzenia i zakończenia robót budowlanych,
- zasady wykonywania samodzielnych funkcji technicznych w budownictwie,
- procedury postępowania w sprawie katastrofy budowlanej,

- obowiązki organów administracji architektoniczno-budowlanej i nadzoru budowlanego w procesie budowy i utrzymania obiektów budowlanych,
- sankcje karne za naruszanie przepisów Prawa budowlanego,
- odpowiedzialność zawodowa w budownictwie.

W okresie 1995–2018 roku w rejestrach Głównego Urzędu Nadzoru Budowlanego zarejestrowano łącznie 7918 katastrof budowlanych. We wszystkich katastrofach zaistniałych w tym okresie zostały poszkodowane 2047 osoby, w tym 491 osób zginęło, a 1556 zostało rannych.

Podziału Katastrof budowlanych można dokonywać m.in. według następujących kryteriów:

- okoliczności zaistnienia, tj. podczas budowy, prowadzenia robót budowlanych bądź użytkowania obiektu;
- głównej przyczyny, tj. zdarzenie losowe, błędy projektowe, błędy wykonawcze bądź wynikające z niewłaściwego utrzymania obiektu budowlanego;
- skutków, tj. zniszczenie mienia, poszkodowani ludzie.

Analizując katastrofy należy zauważyć, że podstawowym kryterium ich podziału jest kryterium okoliczności zaistnienia katastrofy. To kryterium przyjął również w swoich analizach Główny Urząd Nadzoru Budowlanego. Uwzględniając to kryterium można wskazać, że w wśród 7918 wszystkich katastrof zapisanych w rejestrach GUNB w latach 1995–2018

- 7229, tj. 91%, zaistniało w trakcie utrzymania obiektu,
- 638, tj. 8%, zaistniało w trakcie budowy lub prowadzenia robót budowlanych

W pracy pokazano zależność pomiędzy ogółem katastrof, a tych powstałych w trakcie utrzymania na podstawie danych z ponad 20 lat. Spowodowane są one jednak najczęściej zdarzeniami losowymi związanymi z niszczycielskim działaniem sił natury. Stanowi to już odrębną grupę przyczyn, które polegają na niewielkiej możliwości przewidzenia ich wystąpienia oraz skomplikowanych i kosztownych środkach przeciwdziałających.

Z względu na coraz częstsze zjawisko występowania tzw. katastrof losowych, od kilku lat jednym z coraz ważniejszych podziałów stosowanych przy analizie katastrof budowlanych jest różnicowanie ich na katastrofy niewynikające z przyczyn losowych oraz zaistniałe z przyczyn losowych.

Analizując katastrofy widać że, zwiększa się w ostatnim okresie ich liczba powstała z przyczyn losowych, które są najbardziej trudne do wyeliminowania i przeciwdziałania. W latach 1995–2004 procent katastrof zaistniałych z przyczyn losowych do pozostałych wynosił 64%, a w latach 2015–2018 już 79%. Najczęstszymi przyczynami, określanymi w analizach GUNB jako losowe, w ostatnim dziesięcioleciu były w szczególności:

- silne wiatry (2476 katastrof, w tym 1000 w 2008 r. oraz 429 w 2017 roku),
- intensywne opady atmosferyczne (399 katastrof, w tym 122 w 2010 r. i 144 w 2017 roku),
- wybuchy gazu (227 katastrofy, w tym 30 w 2013 i 32 w 2017 roku),
- pożary (368 katastrofy w tym 66 w 2018 roku),
- osuwiska – 105 katastrofy oraz powódzie i uderzenia pioruna.

Katastrofy budowlane są zdarzeniami rzadkimi w odniesieniu do całego zasobu budowlanego, ale to nie oznacza że powinniśmy to lekceważyć. Na podstawie przedstawionych analiz można stwierdzić:

- wraz ze wzrostem liczby zjawisk związanych z działaniami sił natury wzrasta liczba katastrof budowlanych,
- wzrost liczby katastrof ogółem powoduje wzrost katastrof dotyczących obiektów w utrzymaniu. Współczynnik kierunkowy prostej aproksymującej zależność jest na poziomie około 0,97.
- liczba katastrof obiektów mieszkalnych zwiększa się liniowo wraz ze wzrostem katastrof ogółem.

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