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Accidents features in construction

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This work aims to highlight the problem of accidents in the construction industry. On the basis of collected and processed information the accidents classification in the building is presented, depending on the building erection stage. The article gives a detailed description and analysis of such cases in the construction. The collection of information on accidents was carried out using various information sources: Internet resources, literary sources, scientific works and information from world-wide journalistic services. The findings are presented over the last ten years and cover worldwide construction incidents. The material is systematized and presented in the table form. The study results are the created accidents classification with the probability of their occurrence, which can be used later in the design of buildings and structures, in order to predict the various types of accidents in the construction.

Keywords: building, structure, building structure, failure, building accident, destruction of structure.

Особливості аварій у будівництві

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Розглянуто проблеми аварій будівель і споруд, відмов конструкцій; зазначено про недосконалість ведення статистики аварій та методології обробки даних про них. Проаналізовано характерні особливості обробки статистичних даних та результатів центрів експертиз, які було опубліковано вченими різних країн за останні роки. Особлива увага звертається на детальний опис і аналіз наймасштабніших аварій у будівництві за минулі роки. Досліджено найбільш розповсюджені випадки руйнування будівель та споруд. Проаналізовано приклади аварій будівель та споруд під час реконструкції, під час будівництва об'єктів та по причині великого віку об'єкту. Визначено найбільш імовірні прогнози можливої аварії (наприклад, пошкодження, вихід із ладу, руйнування будинку, будівлі, споруди, лінійного об'єкту інженерно-транспортної інфраструктури або їх частин), що сталася з техногенних або природних причин для підрахунку можливих матеріальних збитків і (або) соціальних втрат від відмови об'єкту. Виявлено та обґрунтовано необхідність класифікації аварій у будівництві залежно від етапу зведення будівлі. Розкрито підхід до опису аварії, виходячи з її вірогідності. Наведено приклади ситуацій, у яких аварія являлася вірогідною. Представлено дані досліджень, отримані за останні десять років, що охоплюють будівельні інциденти по всьому світу. Класифікація аварій приведена за типом їх виникнення; матеріал систематизовано та представлено у вигляді таблиці. Дані таблиці вміщують у собі опис аварії, її причини, місце та час виникнення. На основі проведеного дослідження запропоновано класифікацію за ймовірністю виникнення аварій будівель та споруд, для неї представлений детальний опис. Класифікацію створено із метою можливості моделювання різних типів вірогідних аварій, які можуть виникнути на об'єкті, для їх подальшого уникнення, а також з метою подальшого використання при проектуванні будівельних об'єктів.

Ключові слова: будівля, споруда, будівельна конструкція, відмова, аварія будівлі, руйнування конструкції.



Introduction

The problem of buildings and structures accidents remains relevant in modern conditions. Cases of buildings collapses with significant economic losses and human victims make it more closely to work on this issue. That is why, in this article, attention is paid to accounting for accidents in buildings and structures in recent years and to create an appropriate classification based on the collected data.

Review of research sources and publications

Several publications are devoted to construction accidents, including the monograph B.I. Belyaeva [1], M.M. Laschenko [2], M.M. Sakhnovskii [3], O.M. Shkineva [4] and many others. Quite detailed material of accident statistics was presented by A.V. Perelmuter in the table form of steel structures accidents causes [5]. Also noteworthy are publications by K.I. Yeremin with references to this subject [6, 7].

Speaking about building accidents, firstly is necessary to consider the reasons of structures failure, among which, except cases of excessive casual load, the accidental magnitude of the load capacity (inadequacy of safety ultimate factor), there are many others (unexplored constructions, errors in design, manufacturing and installation, violation operating rules, etc.) [5]. Also during construction often enough do not adhere to those or other norms and requirements for construction work, which in turn can lead to fatal mistakes, at the cost of which can become human life.

On the example of India, we can give the figures for the statistics of the victims as a result of construction accidents. Data from the National Crime Records Bureau (NCRB) indicates that a total of 38363 people lost their lives due to collapse of various structures between 2001 and 2015. Most people lost their lives because of the collapse of residential houses. Uttar Pradesh recorded the highest number of deaths (5690) during this period [31].

Against this background, it is worth noting that the methods for calculating structures, for example, from bricks, are characterized by a high degree of idealization of their real properties and working conditions under the action of explosive and other loads. Thus, the imperfection of the calculation methods is compensated by increased safety factors [20].

The analysis of publications on the estimation of the accident rate of construction objects shows that the statistics of accidents are not perfect. This is not only about the lack of well-documented failures and accidents, but also about the imperfection of the methodology for processing data on them [5]. In our time, despite the great opportunities in the issues of publicity and the press, it is difficult to obtain objective information of accidents, as the construction market is a commercial struggle between construction companies. As a result, many accidents are deliberately silent, and in the future, such incidents are not publicized. Also, at the current stage of construction development in Ukraine, the question arose about the justification in the state building codes of the people number issue

who are constantly on the site and are at risk of accidents.

Speaking about accident statistics, general information is provided annually by the city expert center, which is recognized consultant number 1 in the field of manufacturing in Russia (according to the RA Expert's ratings in 2012). The company «MCE-North», part of the international holding, is provides technical expertise (technical diagnosis) of buildings, structures and equipment [8].

Definition of unsolved aspects of the problem

The question about building accidents is raised during long time. Even there are official organizations of various levels for consideration of accidents that have arisen in construction. But then their own statistics and analysis nowadays are imperfect. From this it can be concluded that this topic requires more attention for furthering study and systematization, which will allow to predict the accident, take the necessary measures, and thus to exclude its possibility.

Problem statement

To analyze building accidents on the materials of modern publications, scientific works, Internet resources and mass media, to create an appropriate classification of buildings and structures accidents

Basic material and results

1. Reasons of building collapses

In considering the accidents statistics in buildings and structures, it is advisable to get acquainted with the work of statistical centers that provide open access information for the relevant period [32].

Thus, according to experts on the technical buildings diagnostics of the Companies Group, the City Center of Expertise (ISE), in 60% of collapse cases occur through a combination of violations committed at different construction and operation stages.

Over 2013, the buildings collapses in Russia killed 57 people and 67 people were injured.

Failure to observe the technology of construction and installation work (including safety rules) accounts for 53% of the reasons for the collapse (in 2012 – 50.68%). Rejections, low quality of building materials – 5% (in 2012 – 1.36%). As a result of violations of conditions (including terms) of the buildings operation, about 38% of decompositions occur (in 2012 – 46,57%). Mistakes made during designing – 4% (in 2012 – 1,36%).

Furthermore, large collapses and those that caused people to suffer were taken in this statistics.

Speaking about the building accidents that took place between May 2014 and May 2015, according to experts from the technical diagnostics of the buildings of the Companies Group, the City Expert Center (CEE), 76% of collapse cases occur through a set of violations committed at different construction and exploitation stages.

For the year, in result of the buildings collapsed in Russia, 43 people were died and 144 people were injured. Non-compliance with the construction technol-

ogy and installation work (including safety rules) accounts for 45% of the causes of decompositions (in 2013 – 53%).

Rejections, low quality construction materials – 5% (in 2013 – 5%). As a result of conditions violations (including terms) of the buildings operation, about 31% of decompositions occur (in 2013 – 38%). Mistakes made during designing – 19% (in 2013 – 4%).

Without claiming the full problem coverage the as a whole, possible to distinguish the most widespread cases of buildings and structures accidents, namely: errors of engineers in the calculations; negligence of builders during construction an object, improper operation or incorrect reconstruction, cases of which have increased significantly over the past few years.

Accidents should also be classified according to the class of consequences, in accordance with the National Standard of Ukraine [9]. Taking into account the research carried out, the most widespread buildings accident can be considered objects with a consequences class of CC2, in particular residential buildings with the people number who are constantly in the building, up to 400 people.

But it should be noted that the most significant accidents, with hundreds of victims and colossal consequences, occurred in the buildings of the consequences of CC3. These include shopping centers, sports arenas, industrial enterprises and entertainment complexes.

Materials on accidents were sought out through the

information network, world news and modern scientific publications, which considered these issues in particular. Based on the received material, classification tables were created for the types of accidents that have occurred in recent years. It should be noted that the information is constantly updated depending on the incidents occurring at the given time.

As a result of the study, a table was created showing examples of accidents and structures in recent years with available information on their destruction, the location and incident causes, as well as the number of victims.



Figure 1 – Building collapse in Hong Kong, 2010

Table 1 – Accidents during the buildings reconstruction

Description of accident	Reasons of accident	City, country / The date	Number of the victims of the accident
A four-storey office building that was under reconstruction. Slab floor was collapsed.	Unauthorized planning of premises on the first and second floors.	Krasnoyarsk, Russia, June 15, 2009	3
Five-storey house of dormitory. Collapse of two entrances.	Deal of deterioration	Astrakhan, Russia July 22, 2009	2
Four-story building, during the reconstruction period. The three floors are destroyed.	Deal of overlappings deterioration	Prague, Czech Republic 10.02.2009	-
A dwelling house built more than half a century ago.	Repairs	Hong Kong, China January 29, 2010	5
The building adjoining the hotel "Kharkiv".	During the reconstruction period	Kharkov, Ukraine March 16, 2010	-
Eight-story house. Overlapping was collapsed.	During the reconstruction period	St. Petersburg, Russia, September 01, 2010	A few
Three-story house.	Repair work, which resulted in violations of bearing structures.	Dumyat, Egypt 01.02.2012	35
Five-story house.	Illegal construction in violation of safety rules.	Sian, China June 26, 2011	7

2. Accidents during the buildings reconstruction

Speaking about accidents during the buildings and structures reconstruction (table 1), it should be noted that the incidents of such accidents have increased significantly over the past few years. The works in many cases are carried out incorrectly, poor quality materials are used, negligence during reconstruction is also excluded.

On September 1, 2010, in St. Petersburg, on Ligovsky Prospekt, 145, the ceilings of the eight-story building was collapsed. The crash began from the roof, and ended in the very bottom [10].

Quite often, the accident objects are those buildings that are under reconstruction. For example, on March 5, 2003 in Moscow, Russia, the construction of a multifunctional shopping center collapsed when dismantling brick diaphragms (pylons) that were located around staircase cells [11].

3. Building accidents at a stage of construction and acceptance in operation

For a more detailed study of this issue, the information collection and analysis on accidents in the stage of construction was also carried out. Materials are obtained through a variety of information sources, Internet resources and the media. In the process of work also was familiarized with scientific works on the accidents statistics and their typing. Based on the information received, the crash of new buildings was thoroughly analyzed and systematized in the table form. The list of accidents covers the worldwide timeline between 2003 and 2016 (Table 2).

On February 23, 2015 in Chernyakhovsk, Russia, the wall of an unfinished building collapsed, whose construction was suspended for a significant period. As a result of the incident, a 11-year-old boy was killed, during the collapse a plate fell on the boy. The unfinished building was in private ownership, after reviewing the event place, a decision was made to initiate a criminal case [12].

The accident carries not only significant economic losses, but also can take human lives. Thus, in India, 71 people died, including 25 children, as a result of the building collapse that was in the construction process. According to the Indian television channel NDTV, the tragedy occurred near the city of Mumbai on April 6, 2013. A seven-storey residential building construction was carried out illegally, in the absence of the necessary documentation, which would confirm the work safety on the site. According to law enforcement officials, despite the fact that the building was erected illegally, and its construction is not completed, the four floors have already been settled by the inhabitants. The probable disaster cause was the poor construction and building materials quality. The building collapse caused the destruction of the entire structure. Eyewitnesses say that the seven-story building has developed in 3 – 4 seconds, like a card house [13].

The trend was confirmed in December 2012 in Waghhol City, where 13 people died as a result of the unfinished building collapse, and earlier in September, a building collapsed in Pune, Maharashtra, resulting in

the deaths of six people [14]. On July 29, 2016, a part of the building that was in the construction phase collapsed in Pune, India. As a result of the incident, nine workers died.

Such an accident occurs throughout the world. For example, on March 29, 2013, in the city of Dar es Salaam, Tanzania, a 12-story unfinished building collapsed, killing 36 people. In relation to owners and construction contractors there is a criminal proceeding, in which nine people have already been arrested [13].

Not an exception to this and more developed countries, in particular, Russia. So, on August 15, 2015 in the Moscow downtown, a new building collapsed. As a result of the ceilings collapse between the first and second floors, two people were injured [15].

In Surgut, on March 6, 2014, a new building collapsed (Fig. 2). The ceiling collapsed between the fourth and fifth floors. Under the rubble, the saviors found three people, two of them died. Despite this, the media did not report any information regarding the opening of criminal proceedings, or the commencement of the investigating commission work at the incident scene [16].

Unfortunately, a country like Egypt has, in our time, also received a reputation like India in construction terms. Accidents before the time of acceptance buildings in operation in Egypt are not uncommon. Builders most often do not adhere to construction standards, exceeding the permissible number of floors or saving on the quality of materials. Sometimes construction is conducted at all without the permission of state bodies and departments [13].

In November 2012, in Alexandria, Egypt, 10 people were killed when the high-rise building under construction collapsed. Late in the evening, the eleven-story building collapsed into neighboring buildings. All the dead and wounded - the inhabitants of these houses [13].



Figure 2 – Building collapse in Surgut, 2014

An example is the accident that took place on January 16, 2013, in Alexandria, Egypt, where an eight-story dwelling house collapsed. The saviors freed 25 bodies from the rubble, 15 wounded were found. As the Alexandria governor said, the construction was carried out without the necessary documents, the municipal authorities did not issue a building company a building license [17].

Table 2 – Accidents of buildings and constructions at the stage of construction

Font Size	Description of accident	City, country	Date	Number of the victims of the accidents
1	Collapse of the shopping center structures	Moscow, Russia	5.03.2003	-
2	The destruction of an unfinished 13-storey building	Shanghai, China	27.06.2009	1 person
3	The collapse of the unfinished building	Burundi	10.07.2009	14 died, more than 40 were injured
4	The collapse of the unfinished construction, which was almost ready for delivery	Dubai, United Arab Emirates	16.08.2009	-
5	The destruction of the 4-storey building shopping center. The exact cause of failure is unknown	Istanbul, Turkey	27.04.2009	-
6	Collapse of the hotel that was under construction process	Baku, Azerbaijan	28.04.2009	3 people
7	Collapse of the 4-storey building that was under construction. Caused by poor quality of the construction materials.	Xi'an, China	02.10.2010	10 people were injured
8	Building collapsed during the construction	Puna, India	September, 2012	6 people died
9	Building collapse	Alexandria, Egypt	November, 2012	10 people died
10	Unfinished house collapse	Vahholy, India	December 2012	13 people were died
11	The accident when constructing of a residential house. Reasons were the illegal construction, negligence, failure to comply with standards	Taganrog, Russia	13.12.2012	5 people died, 14 were injured
12	Destruction of 8-storey building. The reasons were failure to comply with standards, the illegal construction	Alexandria, Egypt	16.01.2013	25 people died, 15 were injured
13	The destruction of the 12-storey unfinished building	Dar Es Salaam, Tanzania	29.03.2013	36 people died
14	7-storey residential building collapse. Causes are negligence, the illegal construction	Mumbai, India	6.04.2013	71 people died
16	The destruction of the unfinished facility walls, whose construction was suspended. The reason was the frozen construction	Chrniovsk, Russia	23.02.2015	11-year-old boy died
17	Newly-built floors collapse of a building in the city center	Moscow, Russia	15.08.2015	2 people were injured
18	Destroyed building during construction	Tel Aviv, Israel	5.09.2016	2 people were injured
19	The collapse of the ceiling of an unfinished residential building	Ural, Russia	5.09.2016	1 person was injured
20	The collapse of the unfinished construction	Saransk, Russia	13.11.2017	2 people died, 3 people were injured
21	The collapse of the unfinished construction of the mall	Sumy, Ukraine	13.02.2013	-
22	Building collapse during the construction. The collapse of the newly-built floor construction	Kiev, Ukraine	19.11.2017	-

The acuteness of the illuminated problem can be clearly imagined if you explore the global information network. Only in one day around the world there were buildings collapses during their construction, as a result, many people were killed and injured.

For example, at 13:00 on September 5, 2016, the Israeli police press service announced a building collapse in Tel Aviv (Fig. 3) that was in the construction phase, leaving two people dead and five more missing. The mobile crane, which drove on the multi-storey car park roof on Ha-Barzel Street in the Tel-Aviv district of Ramatha-Khayal, dropped off the building part that could not bear the weight of a huge machine [19].



Figure 3 – Building collapse in Tel-Aviv, 2016

On the same day, at 17 o'clock, the press service of RIA VistaNews reported on the collapse of an unfinished residential building in the Urals (Fig. 4), resulting in serious injury to one of the workers. The incident took place in the Sverdlovsk region. According to preliminary information, the workers carried out the building structures dismantling of an unfinished dwelling house. During these works, the one floor overlap could not withstand the load and collapsed on the worker. At the moment, the commission operates on the scene of the accident, which, as a matter of urgency, must provide a legal assessment of the incident [17].



Figure 4 – The destruction building during construction, Ural, Russia, September 2016

4. Accidents due to the large age of buildings

During researching and analyzing the buildings and structures accidents, it is not impossible to avoid accidents that occurred due to the facility large age, or as a result of failure to perform timely repairs in buildings that need it.

A good example of inappropriate care for buildings can be the historical significance construction – the Cadet Corps, Poltava, Ukraine (Fig. 5).

This building was built in 1840, is currently inactive and is in a dilapidated state. The building reconstruction is not carried out, therefore the building is in a miserable condition, which in the future may lead to another accident in the construction industry. Moreover, such cases are not isolated, and unfortunately, are quite common in the Ukraine territory.

We give additional examples of this type accidents. Namely, in January 2010 in Tbilisi, Georgia, there were just two accidents. At first, the carrier wall of a residential three-story building collapsed, a day later - carrying two-story structures. In both cases, the buildings were in a emergency state. It should be noted that emergency measures were not carried out before the collapse. Fortunately, there are no victims [7].



Figure 5 – The appearance of the Cadet Corps in Poltava at present, and in the XIX century

On October 26, 2010, a residential building was partially destroyed in the Kirov region, Sovetsky.

The load-bearing wall collapsed, followed by stairs marches and inter-floor overlays. The pre-war building needed major repairs, the means for repairs were allocated slowly. People were not affected by the accident [21].

Also on the basis of the processed material a table was created describing the accidents and structures requiring repair work (Table 3).

The problem of studying accidents in buildings and structures is incomplete information about certain accidents. In the finding process in the various sources of necessary information, it has to be repeatedly encountered with the illuminated problem incompleteness.

Table 3 – Accidents of buildings and structures requiring repair work

Description of accident	City, country	The date	Number of the victims of the accidents
Collapsed bearing wall of a residential three-story building. The building was in an emergency. No collision preventive measures were taken.	Tbilisi, Georgia	January, 2010	-
The wreck of the emergency wings is destroyed. The building was declared emergency. The inhabitants were evicted.	Odessa, Ukraine	March 21, 2010	
Partially demolished dwelling house. The load-bearing brick wall collapsed, followed by stairs and blanking. The building needed major repairs.	Sovetsk, Russia	November 26, 2010	-
Collapse of a three-story building that was in an emergency. The destruction occurred due to repairs that were carried out in the neighborhood.	Barletta, Italy	October 3, 2011	4
The seven-story building, which was in an emergency, was destroyed.	Luxor, Egypt	February 11, 2011	15 died, 20 were injured
Collapsed unoccupied emergency facility located near low-rise buildings.	Alexandria, Egypt	14 July, 2012	15
A five-story building collapsed. The cause of the accident was the cracking of the old building, formed as a result of heavy rains.	Beirut, Lebanon	15 January, 2012	27 died, 12 were injured

5. The largest destruction of buildings and structures in the world

Cases of large-scale accidents, which resulted in the investigation and compiled the relevant conclusions, undoubtedly cover the problem under consideration, but there are also such accidents that are suppressed for various reasons, one of which is the commercial struggle in the market between housing and construction companies. Sometimes the accidents coverage is reported incomplete, with inaccurate information, or unidentified the incident causes. All these factors affect the processing information quality. Therefore, it is also advisable to mention accidents, the causes of which have not been established, but which resulted in between one to ten injured.

This includes the a five-story dwelling house collapse on August 4, 2011 in the Pakistani port city of Karachi, where 29 people died [23] and a three-story dwelling house collapse on October 25, 2009 in Palma de Mallorca, Spain. Under the building rubble the five people died and two were injured in various severity degrees [6].

On June 10, 2012 in Lutsk, Ukraine, a five-story residential building collapsed (Fig. 6) – the bearing walls from the first to the fifth floor between the first and second entrances were destroyed. Rescuers have rescued from the building 18 people. As a result of the tragedy, two people were killed and one was injured [22].

In areas with difficult climatic conditions, as a rule, there is a high probability of a building accident, therefore, the requirements for the facilities construction in these areas are set more stringent. However, it is difficult to prevent the building of possible floods or other cataclysms.

Such accidents also include accidents that occurred

due to design failures, such as in January 1978 in the city of Hartford, Connecticut, USA, due to overloading with snow in the city center, where a hockey match was conducted during the day, overnight collapsed on the night from a height of 30 m a sports arena measuring 92 by 110 m (Fig. 7). The investigation revealed errors in the calculations of designers [23].



Figure 6 – Building collapse, Lutsk, Ukraine, 2012



Figure 7 – The fall of a sports arena in the city of Hartford (USA), 1978

Also such an accident occurs due to untimely repairs, such as January 15, 2012 in Beirut, Lebanon, where a five-story building collapsed. The reason for the steel collapse were cracks formed as a result of torrential rains. 27 people were killed, 12 wounded [10].

It is impossible to ignore the most serious accidents over the past two decades, which resulted in dozens, but not hundreds of casualties and thousands of wounded. These include the Sampoong shopping center collapse in Seoul (South Korea). On June 9, 1995, one of South Korea's largest buildings - the largest supermarket in Seoul, Sampoong, collapsed. Under the building ruins, 502 people died, 937 were injured and serious injuries. According to the investigation, it was discovered that a building whose collapse lasted only 20 seconds collapsed due to a number of reasons, the main of which were violations of building codes (Fig. 8).



Figure 8 – Collapse of the Sampoong shopping center, Seoul, South Korea, 1995

One of the reasons for the collapse building was the center's leadership decision to put on the roof three huge industrial air conditioners. In 1993, they were placed on a roof on special pallets, thus adding a load on a so weakened central part of the building (Fig. 9) [24].

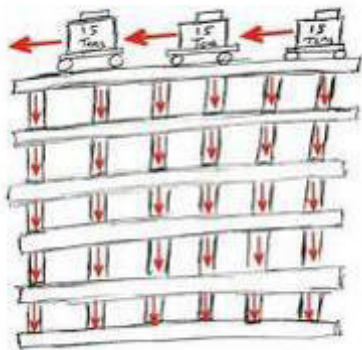


Figure 9 – The scheme of placement on the roof of three huge industrial air conditioners

Large-scale accidents in the construction industry cannot be attributed to the destruction of the shopping center «Maxima» in Riga (Fig. 10), which happened on the evening of November 21, 2013 in the district of Zolitude. Approximately at 5:45 pm, the roof and the

supermarket walls deformed, numerous customers and workers were locked inside. At 18:00, one of the center walls fell and the roof over the ticket offices fell. At noon on November 23, the number of deaths reached 52 people: 51 Latvians and one Armenian citizen. The Latvian police put forward three versions of the disaster: 1) violation of the design; 2) violation of the rules of construction; 3) storage on the roof of building materials [25].



Figure 10 – The collapse of the Maxima Shopping Center in Riga, 2013

The record number of dead and wounded in the last decade has been recorded in 2013, when in Savar (Bangladesh) on April 24, a complex containing a bank branch, a shopping center with lots of stores and five sewing factories was destroyed (Fig. 11). On May 9, the death raised to 953 people, more than a thousand people were injured.



Figure 11 – Collapse of the complex in the city of Savar (Bangladesh), 2013

On May 3, Interior Ministry experts have established the building collapse reasons: a strong vibration from powerful electric generators. Four giant generators were installed in the building in violation of all the rules, and when they re-started after the electricity was switched off for some time, their vibration, together with the vibration of thousands of machines, led to the collapse of the building [26].

The most massive accident in the past few years during which the roof collapse has occurred, Transworld Park, a sports and entertainment complex in the Yasenevo district (Moscow), opened in June 2002, which collapsed on February 14, 2004, can undoubtedly be considered [27].

6. Proposals for buildings accidents classification

Studying the accidents statistics and the characteristics in construction, a number of eminent researchers have been trying for decades to create a unified, well-founded classification of this type. But the goal set before the scientists is so unrestricted in the study, as in the implementation methods.

For the most part, accident statistics are currently being conducted in the most obvious way, namely, the accident information collection in tabular form, with the indicated reasons, the injuries number and the incident date. If the accidents collection covers the international territory, the general table is supplemented with information about the country where the incident occurred. Such a collecting information method can be defined as a general one. It allows you to summarize all the processed data from various resources and sources, on the basis of which the accident rate charts can be constructed depending on the selected indicators: crashes by type of building, destroyed structures, places (countries or cities) or number of victims people

The next part of the information statistical processing is a more detailed resulting general table breakdown by the objects type that have been destroyed. For example, the accidents types can be divided into three components: the buildings and structures destruction at the construction stage, in the objects reconstruction and the accident due to the large building age. Classification is precisely on these grounds due to the high repeatability level during the study of this issue, which implies that the probability of such an accident occurrence is highest.

On the research conducted basis, graphs and charts are created, which reflect the results obtained, which are already making final conclusions.

An example of generalized data processing is the annual accidents statistics, created by the Russian company «City Center of Expertise». The peculiarity of this company's work is its transparency and results publicity. The statistics provided over the past few years are freely available on the Internet, with the components of which can be read by anyone. At the same time, official statistics, which is conducted by state authorities, do not have access to ordinary citizens. On this basis, there is a need to address the work transparency issue of the Commissions investigating accidents in buildings and structures.

The possibility of providing public information can be a significant step in addressing accidents that occurred during the construction phase, as the publicity of incidents and work results carried out by the special commission will be a major impetus for the elimination of accidents certain types.

In addition, the data statistical processing on accidents building objects, makes it pay attention to the high-rise buildings problem, which are decommissioned, but not later dismantled. The authorities often do not pay attention to their accident rate and the destruction highest probability. The result of long-term dismantling, and in most cases, its complete absence, can become human life.

If for some time the accident was considered as a probabilistic event, which has no regularities and whose results cannot be predicted, then at present scientists have made a tangible breakthrough in this field of knowledge. With the introduction of such concepts as economic and non-economic consequences, the development and implementation of possible losses calculations, depending on the design failure.

The approach to the accident description can be considered with its probability. That is, an accident may be probable, impossible or accidental (Fig. 12).

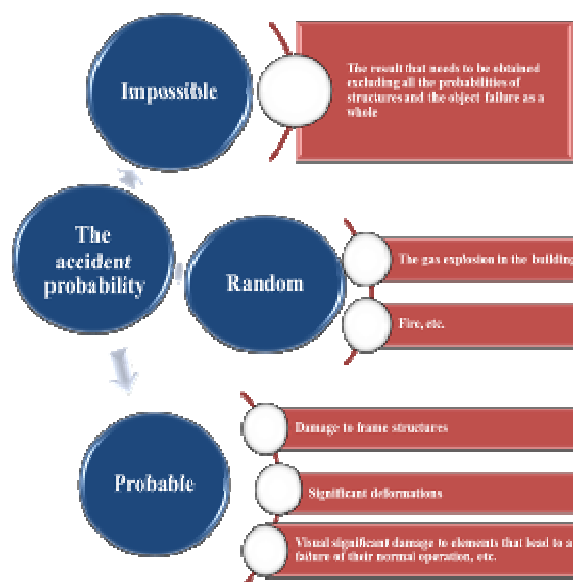


Figure 12 – Classification of accidents on the probability of their occurrence

These are three fundamental features that make it possible to differentiate the event and its progressiveness. That is, there is a certain antinomy of concepts: chaos, irregular series of events - in this case, the objects construction and their exploitation - acquires a regular order only when we narrow the range of statistical selection. Thus, moving from macro to micro-research, we create more complex statistics, which includes a clear understanding of the probability, impossibility or chance of an event.

Here are examples of situations in which the accident was probable. In this case, this is an accident near the city of Mumbai, April 6, 2016 [13]. The collapse of a seven-storey residential building provoked a number of reasons, such as a violation of building codes, negligence in the construction, illegal construction works. The probability of emergence of an emergency situation was the maximum in this case.

Accidental accidents include the explosion of gas in a residential building in Brussels, which took place on March 18, 2017, resulting in the loss of one person [28]. One building collapsed completely, from the other only the facade remained. Or the fire that occurred on February 21, 2015, in the OAU, where the tallest Fakel building fired [29]. No one was hurt.

The result of the accidents analysis that occurred in construction should be the impossibility of an

accident. A striking example of working out the past years' experience, the implementation of necessary improvements and the various accidents types prevention is the modern complex «Federation», which consists of two skyscrapers of 324 meters high (Fig. 13) [30].



Figure 13 – Modern complex «Federation», Moscow, Russia

The building is equipped with cutting-edge technology, and is the highest in Europe and the strongest in the world. The hard frame "Federation" is

designed in such a way that the output from the work of one element does not affect the normal work of the entire design. The experience of past years with the problems of fire safety and explosive environment introduced the latest high-tech designs. This facility serves as a vivid example of effective work on building mistakes.

Conclusions

The result of the research is the classification of accidents of buildings and structures based on the collected and processed material. Thus, the paper presents an attempt to generalize accidents by their type (period of operation of the building), as well as the proposed classification for the probability of an accident. For the appropriate calculation of the frame of the projected building, it is necessary to simulate a number of probable and probable accidents with their thorough elaboration. The result of this design is to reduce the probability of an accident, which is why the most vulnerable skeleton locations (depending on a variety of factors) are subject to reinforcement and careful work. Further investigation of accidents in construction allows using the classification presented to predict and eliminate potential emergencies for buildings of different types and destinations.

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