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Research paper

Building Accident Causes at a Stage of Construction and Acceptance in Operation

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Abstract

This work covers the consequences of accidents in buildings and structures during the process of construction and acceptance in operation. Attention is focused on the frequency of repetition of this type of accidents, using the graph of the structures' operation stages. The article describes and analyzes such incidents related to construction. Information on accidents was collected using various sources of information: Internet resources, literary sources, scientific works, as well as reports from the world's journalistic services. The findings are presented more than the past ten years and cover construction incidents around the world. The material is systematized and presented in the form of a table on the basis of which the corresponding diagrams are constructed. The result of the study is the relevant conclusions about the typification of accidents during construction and their regularities. The most common causes of accidents are identified, which allow to obtain more detailed study of the problem and further provide for cases of such accidents at the construction site. Attention is focused on the dependence of the construction's quality at the level of the country's welfare. In addition, the conclusions contain the main tasks for the solution of this problem and ways of their implementation.

Keywords: *buildings and structures, building construction, failure, building accident, destruction of structures*

1. Introduction

The phenomenon of risk is a subject of investigation for many both practitioners and theorists. However, only a few of them take these problems and try to formulate the problem within the framework of a procedure. In many publications, the authors deal with the problem of identification of hazards areas and their classification in different groups, among others, due to the source of origin, the impact size, etc. [18]. Numerous papers offering a methodology of quantifying the risk and elaboration of procedures for the adoption of appropriate actions (so called "an appropriate strategy on risk response") is relatively lower [19].

In this case the question of buildings and constructions accidents remains urgent in modern conditions. The number of accidents in construction, their researches and the analysis allow to foresee them and to stop, as a result human lives can be saved and substantial economic losses be excluded. Unfortunately, accidents in construction have become wide spread in the world in recent years. Watching such dynamics of incidents in construction, it is necessary to pay more attention to a stage of the house construction and its acceptance in operation. Growth of corruption in construction branch, desire of customers to save on materials and labor, negligence when working - all this cause collapse of new buildings and can even lead to loss of life.

2. Main Body

2.1. The Analysis of Recent Research Sources and Publications.

Rather exhaustive material concerning accident statistics is presented by A. V. Perelmuter in the form of the causes table of steel structures accidents [1]. Such classics as B. I. Beliaev in his works on accidents of steel structures [2], M. N. Lashchenko [3], A.N Shkinev [4] and many others researched this topic too. In addition, A. A. Tavkin has presented his studies on the causes of accidents in construction in the Russian Federation during 1981-2004. It is also necessary to mention Eremin K. I. publication on this subject [6]. The statistics of accidents and constructions is presented by All-Russian public fund "Center of Quality of Construction" [7]. M. A. Romashkina's work on influence of beyond design basis loadings on intense and deformation of the building conditions and structure constructions give an accurate assessment of design condition at a certain type of accident, which is also an important aspect of a research of future risks in construction [8].

2.2. The Selection of Previously Unsolved Parts of the General Problem.

Despite accidents have been discussed for a long time, and there are even official organizations of different level for accident consideration which have arisen in construction, their statistics and the analysis are still imperfect. Due to this it is possible to draw a conclusion that this subject requires bigger attention to its further research and systematization by means of what it will be possible to predict accident, to take necessary measures, and furthermore to exclude its possibility.

2.3. Problem Definition.

To analyze accidents of new buildings on the materials of recent

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publications, scientific works, Internet resources and mass media.

2.4. The Main Material and Results.

Let's consider such important indicator of building reliability as failure rate λ, which shows quantity of the objects of this type which have failed at work per unit of work time. The indicative nature $\lambda(t)$ of relation with t on which three stages of operation of buildings and constructions are allocated. That is extra earnings, period of normal work and period of aging [17].

Having analyzed such schedule, it is possible to draw a conclusion that the emergence probability of an accident during facility construction and at its delivery in operation is big enough.

For more detailed research of the matter collection and analysis of information about accidents in construction of constructed objects have been carried out. Materials have been received by means of various information sources, Internet resources and mass media. In the course of work acquaintance with scientific works according to accidents and their typification has also been carried out. Being guided by the obtained information, accidents of new buildings have been carefully analyzed and systematized in the form of the table. The list of accidents covers time interval 2003 - 2017 and world territorial arena (table 1).

Rather often objects of accidents are those buildings which are being reconstructed, or are in a condition of incomplete construction. For example, on March 5, 2003 in Moscow, Russia, designs of multipurpose shopping center at dismantle of brick diaphragms (poles) which were around staircases have collapsed. Technology violations of works at design dismantle became the main reason for a building collapse. The accompanying reasons were a deviation from design decisions at construction of the dismantled part of the building (insufficient jamming of a horizontal two-leg beam, fastening anchors diameter of a beam to an embedded part of a basic pillow made 12 mm instead of 25 mm, a tail part of this beam hadn't been reliably connected by welding to the main part of the beam, at the same time the imitating (false) seam had been executed [7].

Table 1: Accidents of buildings and constructions at the stage of construction

Font Size	Description of accident	City, country	Date	Number of the victimsof the accidents
1	Collapse of the shopping center structures	Moscow, Russia	5.03.2003	-
2	The destruction of an unfinished 13-storeyd building	Shanghai, China	27.06.2009	1 person
3	The collapse of the unfinished building	the Republic of Burundi, Africa	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-storeyd 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 the4-storeyed 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 collapsedduring 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-storeyed 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-storeyed unfinished building	Dar Es Salaam, Tanzania	29.03.2013	36 people died
14	7-storeyed residential building collapse. Causes are negligence, the illegal construction	Mumbai, India	6.04.2013	71 people died
15		Surgut, Russia	6.03.2014	1 person was injured, 2 people died
16	The destruction of the unfinished facility walls, whose construction was suspended. The reason was the frozen construction	Chrniakhovsk, 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	-

On February 23, 2015 in Cherniakhovsk, Russia, a wall of the unfinished building which construction had been stopped for considerable term collapsed. As a result of an incident the 11-year-old teenager had died, during a collapse the plate fell onto the boy.

The unfinished building was in a private property, after inspection of the scene the decision on initiation of legal proceedings was made [11].

Accidents cause not only substantial economic losses but can also lead to life loss. In India 71 people, among them 25 children, died, in the result of a collapse of the house which was in process of construction. According to the Indian TV channel NDTV, the tragedy happened near the city of Mumbai, on April 6, 2013. Construction of the seven-storeyed residential building was conducted illegally, in the absence of the necessary documentation confirming safety of works on an object. As law enforcement officers explain in spite of the fact that the building has been built illegally, and its construction isn't finished, four floors were already populated with residents. Poor quality of construction and construction materials became a probable cause of accident. The collapse of a part of the building has entailed destruction of all design. Witnesses tell that the seven-storeyed building fell down [12] in 3-4 seconds as a house of cards.

Besides, it should be noted that cases of a collapse of new buildings are rather widespread in India, and such incidents occur rather often. Continuous use of low-quality materials and work of unskilled workers, in a pursuit of low cost for bigger economy of means is the constant and unambiguous reasons of it. At the same time housing shortage forces people to move to unfinished dwellings.

The specified tendency was confirmed in December, 2012 in the city of Vagkholy where in the result of a collapse of the unfinished house 13 people died, and earlier, in September, the building in the city of Pune, the State of Maharashtra collapsed therefore six people died [13]. On July 29, 2016 in the city of Pune, India, the part of the building that was at a construction stage collapsed. As a result of an incident nine workers have died.

Accidents of this kind arise around the world. For example, on March 29, 2013 in the city of Dar es Salaam, Tanzania, the 12-storeyed unfinished building fell down therefore 36 people have died. In relation to owners and construction contractors criminal proceedings are conducted during which nine people have already been arrested [12].

In Sumy, the two-storey shopping center under construction was collapsed on the territory of the local market (fig.1).

Information about the collapse of the building construction was received at 0:38, UNIAN reports.

It is noted that the new building was literally in half, and its structures came to complete disrepair. According to the police, there were no signs of extraneous intervention on the site of the building collapse.

During a state of construction, there were about 10 people at the construction site, and the accident occurred when concrete slabs of the second floor were poured. After the incident, the foreman consulted the list of workers and made sure that there were no casualties: by lucky chance at the time of the collapse workers were drinking tea in the cabins.

It is worth noting that the shopping center began to build in March 2012, and planned to be completed in April 2014. The customer is the enterprise of the Sumy regional consumer union "Central Sum market", general contractors - DP "BS-Visotnik" and LLC "Ukrgazmontazhproekt" [20].



Fig. 1: Building collapse in Sumy, Ukraine, 2013

More developed countries, in particular, Russia aren't an exception there. So, on August 15, 2015 in the center of Moscow a new building collapsed. As a result in the reason overlapping between the first and second floors, two persons were injured [14].

In Surgut the new building (fig. 2) collapsed on March 6, 2014. Under blockages rescuers have found three people, two of them were dead. Despite it, media haven't given any information on discovery the criminal consequence, or about the beginning of work of commission of inquiry at accident scene [15].



Fig. 2: A new building collapse in Surgut, 2014

In 2012 in Taganrog there was an accident at the house construction. As a result 5 people died, 14 were injured. The building had collapsed when the fourth floor was under construction whereas according to the project the building was three-storeyed. During examination a large number of mistakes at construction of this object was revealed that confirms the conclusion that the house was built absolutely without control. According to the investigation, the collapse reason was illegally issued construction license, excess of the allowed construction parameters, and also violation of the safety regulations when conducting construction works. Besides, the investigation found out that the deputy head of the city administration was aware of all these violations, but didn't take any measures to stop the construction [10].

Such country as Egypt, unfortunately, also has the same reputation as India in respect of conducting construction. Accidents before acceptance of an object in operation in Egypt are not unusual. Builders often don't respect the construction rules, exceeding the admissible number of floors, or saving on quality of materials. Sometimes construction is conducted without the permission of public authorities and managements at all [12].

In November, 2012 in Alexandria, Egypt, 10 people died because of a collapse of the high-rise building which was in process of construction. Late at night the 11-storeyed building fell down onto the neighboring houses. All the dead and injured people were the inhabitants of these houses [12].

Accident which happened on January 16, 2013 in the Egyptian Alexandria where the eight-storied building collapsed is an indicative example. Rescuers have released from under blockages 25 bodies, 15 injured people have been found. As the governor of Alexandria declared, construction was conducted without necessary documents, municipal authorities haven't given the project developer the license for construction [16].

Acuteness of the covered problem can be presented accurately if to investigate the worldwide information network. Only within one day there were buildings accidents all over the world while being constructed therefore many people have died and have been injured.

For example, on September 5, 2016 at 1 p.m. the press service of Israel police reported about a building collapse in Tel Aviv (fig. 3) which was at the construction stage therefore two persons died and five more were missing. The mobile crane which was moved onto the roof of the multistoried parking on ha-Barzel street in the Tel Aviv district Ramatkha-Hayal caused this accident [9].





Fig. 3: Destruction of the house in Tel Aviv, Israel,September, 2016

The same day, at 5 p.m., the press services of RIA VistaNews reported about a collapse of an unfinished house in the Ural (fig. 4) therefore one of workers was seriously injured. An incident has occurred in Sverdlovsk region. According to preliminary information workers were carrying out dismantle of building constructions of an unfinished house. During these works overlapping of one of floors didn't sustain loading and fell down to the worker. At the moment the commission which has to give an urgent legal treatment to an incident [10] works at the accident scene.

According to the schedule of design work stages, it is obvious that probability of an emergency during construction of the facility and its acceptance in operation is rather high, on the basis of collected information it is expedient to carry out the statistical analysis on the example of the most large-scale accidents of buildings which happened during construction over the period from 2009 to 2016.

On the basis of the obtained information it is possible to make a number of charts which allow to present accurately dynamics of accidents for the last 8 years.

Considering emergence of accidents depending on the country where they have occurred (chart 1), it is possible to draw a conclusion that most of accidents of this kind have occurred in India and Egypt. Thirst of a profit of construction customers and its performers, violation of safety standards and illegal construction became the main reasons of incidents. Therefore, dynamics of accidents in construction, and the main thing, economic and non-economic consequences of such accidents, grow in proportion to economic instability of a country.

Speaking about accidents depending on a period, namely the last eight years, it is necessary to allocate the following that is the greatest number of accidents occurred in 2009, and involves the greatest number of injured people (chart 2, 3).



Fig. 4: Destruction of an unfinished house, Ural, Russia, September, 2016

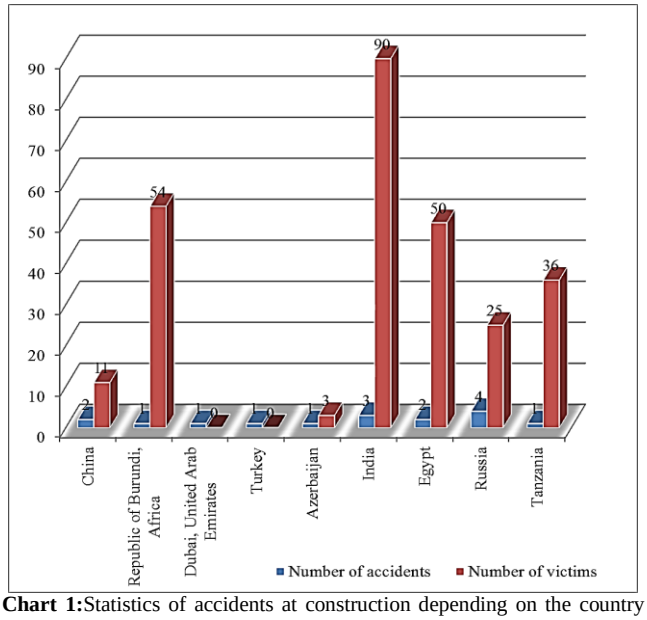


Chart 1: Statistics of accidents at construction depending on the country where it has happened

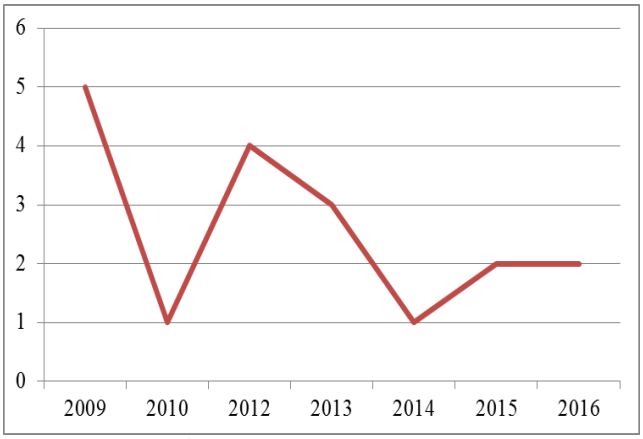


Chart 2: Dynamics of accidents at construction during the period between 2009-2016.

In 2016 accident dynamics at construction decreased considerably that in its turn led to considerable reduction of injured accidents that is shown in the chart 3.

But it is also necessary to notice that in this analysis the most significant accidents which had wide publicity in the press are used. Certainly, the number of accidents at construction which are carefully suppressed are much larger.

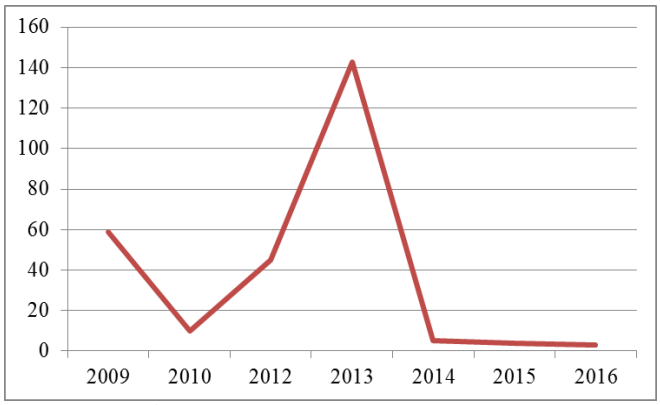


Chart 3: Total of accident victims at construction during the period 2009-2016

3. Conclusion

On the basis of the shown material, it is possible to make certain conclusions concerning types and causes of building accidents at a stage of construction and acceptance in operation. It is possible to consider that most of the accidents of this kind have a human factor as the reason, namely:

- Cost savings - attraction of unskilled labor, saving on the quality of materials;
- Non-compliance with construction norms at construction;
- Negligence in construction of an object;
- Illegality of conducting construction;
- Discrepancy of the project documentation;
- Mistakes at design;
- Mistakes at construction of a building.

The listed above examples confirm that accidents of new buildings are the essential problem of the construction sphere. At the same time the reasons of these accidents are rather widespread, considering corruption of supervisory authorities and construction customers.

It also should be noted that the level and quality of construction depend directly on the level of prosperity of the country in which it is conducted. The more economically unstable a country is the more often there are incidents of this kind where the major role is played not by the value of human life, but the financial benefit from the project.

The main task in the solution of this problem is to predict the possibility of accident in order to prevent it. Such result, in our opinion, can be achieved in several ways:

- high quality training of various levels and directions;
- improvement of the control system of conducting construction;
- introduction to design calculations of not only by modeling of an emergency from the economic point of view, but also to consider the matter from noneconomic side.

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