

## Consequences of Design and Rechnological Errors in Construction

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### Annotation

Buildings of any purpose (civil, industrial, hydrotechnical, road and others) must be sustainable and ensure human safety during the entire period of its operation. Therefore, it should be impossible to destroy objects designed and built in full compliance with construction norms and rules due to natural and man-made disasters (earthquakes, storms, floods, etc.). even during Nevertheless, due to design and technological errors, there are frequent cases of their partial or complete destruction all over the world, which is almost always followed by human casualties.

**Key words:** ruin, mistake, building, victim, cause, tragedy

### 1. Introduction

Construction cannot tolerate inaccuracy. During the design of a new construction object, a number of necessary conditions must be observed on the surface, so that the final product, in the form of a finished building, can function normally during the guaranteed operational period. One of the main conditions is the correct selection of the construction area. This first of all implies a precise geological survey of the existing soil and groundwater. In case of weak soils, it is necessary to strengthen them. and in the presence of groundwater, its removal and the arrangement of a full-fledged foundation of the building. Mistakes are common in design. One of the special cases happened on June 27, 2009, in Shanghai. One 13-story building from a large residential complex (11 houses) fell without collapsing. But all of its hinges were broken (Fig. 1). It was not yet inhabited and only one person died, otherwise the casualties would have been much higher. The house was built by the river. During the design, the possible impact of water

was not taken into account, and the foundation was washed away with the flood of the river. Accordingly, the beams were not properly calculated and their insufficient section could not withstand unexpected loads.



Fig. 1. A collapsed house in Shanghai

In addition, it is necessary to accurately consider expected seismic and wind impact forces, snow load, climatic and temperature changes. It is with such an approach that the first skyscraper in the world, more than half a kilometer high, Taipei 101, was built in Taiwan. It is rightfully considered one of the most reliable structures, despite the fact that it is built in a place most prone to strong earthquakes and storms. Instead, the greatest destruction and loss of life occurred in the February 6, 2023 earthquake in Turkey, due to inadequate seismic-proofing measures during construction. As a result of the study of the incident, it became clear that many mistakes were made during the production of construction processes. Due to this, more than 150,000 buildings were destroyed or seriously damaged, 50,500 were killed, and 107,204

were injured by the 7.8-magnitude earthquake in southeast Turkey (Fig. 2).



Fig. 2. Turkey earthquake

There are many other reasons for the collapse of buildings, and in order to take them into account, it is necessary to consider such cases and determine the main causes of accidents and disasters. For this purpose, some of the world's most high-profile cases of design and technological errors are discussed below.

## 2. Main part

In history, the largest loss of buildings was caused by the September 11, 2001 terrorist attack in New York City, when two skyscrapers of the World Trade Center were destroyed by a plane crash. It was a case where it was impossible to blame the designers or the builders. Therefore, it is believed that the largest number of casualties among buildings that collapsed as a result of design and technological errors was recorded on April 24, 2013, during the collapse of an 8-story building in the city of Savar, Bangladesh (Fig.3). It is officially believed that 1,134 people died, and more than 2,500 people were injured. In total, up to 5,000 people worked in the building in various institutions (bank, shops, offices, etc.). Among them there were several sewing enterprises, which had switched to a 24-hour mode of activity. The day before the tragedy, due to the appearance of large cracks on the facade of the building, everyone except them stopped working. Moreover, despite being aware of the serious damage to the building, the owners of the garment factories forced out about 3,000 workers under the threat of dismissal. The building collapsed instantly, in a matter of

seconds, except for the first floor, and all the working personnel were buried under the rubble. There were so many reasons for the destruction that it was surprising how the building existed at all. It was found that after commissioning, three floors were added to the initially five-storey building without any strengthening. Heavy sewing machines were placed on the mentioned floors. And, for smooth operation, large diesel generators located on the roof had a strong dynamic impact on the entire building, which was not considered at all during its design. In addition, the foundation was laid on the previously existing underground lake, which was only filled with garbage. It should be noted that due to the lack of proper equipment, the authorities refused to clean up the ruins and in the first days only volunteers worked. The United Nations intervened in this case. All this had a very negative impact on the quality of rescue operations. The last living person was pulled out two weeks after the collapse.



Fig. 3. Ruins of the building in St. Savar

In 1995, in Seoul, South Korea, a large number of victims were involved in the demolition of the shopping center "Sampoong" (Fig. 4). As a result of the collapse of construction structures, according to various data, more than 500 people died, and more than 1500 people were injured. The building was handed over in 1990 and on average more than 40 thousand people entered it for shopping every day. According to eyewitnesses, the entire building suddenly collapsed in just 20 seconds. The tragedy was preceded by several suspicious circumstances, which the local authorities did not pay attention to. At first, the object was a 4-story apartment building, and

during the construction process, it was decided to change its functional purpose. According to the new project, in order to arrange escalators in the shopping center, the roofs between the floors were cut without any reinforcement. Then the fifth floor was added without strengthening the foundations and supporting structures. In 1993, three 15-ton air conditioners were installed on the roof. As a result of the investigation of the incident, it was established that despite so many design and technological errors, it was the air conditioners that caused the disaster. As a result of the vibration caused by them, the reinforced concrete slab of the roof first cracked, and then the part of the south wing completely collapsed and caused the collapse of all the load-bearing structures below it.



Fig. 4. Ruins of "Shampoo"

In November 1999, a 6-story, 26-unit apartment building collapsed in 19 seconds in Foggia, Italy (Fig. 5). At that time, 67 of the 71 people who were there died. During the study of the causes of the tragedy, many negative details were revealed. The house was built in 1960. At that time, there was a huge shortage of housing in Italy and everyone was trying to take advantage of this business. Due to the lack of qualified personnel in the field of design and construction works, often inexperienced architects and engineers performed the design and construction. It is for this reason that the load-bearing structures of the building did not have adequate reserves. A number of support structures were not arranged in the basements, which were supposed to distribute the loads

received from the above-ground part of the building, the foundation was arranged on the soil with increased moisture, without its preliminary drying and strengthening. Almost all residential and non-residential buildings throughout Italy were inspected after the tragedy. Among them, several thousand were dismantled, which posed a special threat to people's lives.



Fig. 5. A ruined house in Foja

On June 24, 2021, the disaster occurred in Surfside, a suburb of Miami (USA), when the northeastern part of a 12-story residential building collapsed in 9 seconds and completely destroyed 55 of the 136 apartments. 98 people died because the collapse occurred at night and was accompanied by fire. The house was built in 1981 and its useful life was defined as 40 years (with a further 40-year deferment), which exactly coincided with the actual term. Three years before the tragedy, the population asked the authorities to pay attention to the cracks in the columns and roof tiles of the underground parking lot and to the systematic accumulation of water in the basement. Ironically, the preparation of the design documentation for the purpose of liquidating the existing damage was so long that the relevant works had to be started a few days after the disaster. The main cause of the collapse was the washing away of the foundation of the building located on the beach, which was not properly taken into account during its design. In recent years, as a result of the rather rapid movement of the ground, the concrete cracked, and the

reinforcement rusted, and this part could no longer withstand the loads transmitted from above. After the tragedy, in the USA, they began to inspect buildings older than 40 years and develop new standards for building certification. and caused the armature to oxidize (Fig. 6)



Fig. 6. Wing collapse in Miami

In the largest city of Nigeria, Lagos, which was its capital until 1991, on November 1, 2021, a 21-story high-rise building under construction completely collapsed in a few seconds. 42 people were killed and several dozen people were injured, mainly the personnel working on the construction of the facility. Among them was the owner of the construction company, who was there at that time and inspected the construction. The company was engaged in the construction of elite residential houses, not only in Nigeria but also abroad. The cause of the tragedy was the violation of the permit issued by the State Construction Agency, which provided for the construction of only a 15-story building. As a result of arbitrarily adding six floors, the reinforced concrete frame building could not withstand the

excessive loads and collapsed upon reaching the critical limit (Fig. 7).



Fig. 7. A dilapidated house in Lagos

Many other examples can be cited regarding the demolition of buildings of various purposes, but even more often there is the destruction of individual elements of the building, which results in serious casualties. In this regard, the collapse of the roof of the "Transvaal" sports and entertainment complex in Moscow on February 14, 2004 should be especially noted. In Moscow, 28 people were killed and more than 100 people were injured in the water park accident that took place 19 months ago, and most of them were permanently disabled. Among them were citizens of Georgia. 5000 m<sup>2</sup> of the central part of the metal roof with an area of 20.2 thousand square meters collapsed instantly and 400 people bathing in the pools fell (Fig. 8). Most of them were found under the rubble outside in -200 C freezing conditions. Many rescuers and technical means participated in the unprecedented rescue operation. The investigation lasted for 20 months and it was finally established that the cause of the collapse was due to errors in the design solutions and the building did not meet operational standards. One of the main factors was the stress developed in the metal

constructions due to the large difference between the indoor and outdoor temperatures.



Fig. 8. "Transvaal" roof accident

The number of human casualties in the USA cannot be singled out in 1981, when 114 people died and 216 were injured when metal platforms suspended in the atrium of the Hyatt Regency Hotel in Kansas City, USA, collapsed. Before the terrorist attack on the World Trade Centers, it was the largest in this case.

### Conclusion

1. Despite the many cases of building collapses and human casualties worldwide due to design and construction errors, such facts are still often caused by elementary negligence. There are many accidents caused by the installation of heavy-weight engineering equipment on the roofs and floors more than planned, when the appropriate load-bearing structures are not strengthened;

2. Most often, the cause of building collapse is improper geological and hydrogeological study of the construction area. At this time, less

attention is paid to the washing of the foundations and the possible settlement of the ground, which becomes especially dangerous over time;

3. Calculation of new structural elements and ensuring their carrying capacity also require special attention in the process of designing buildings. Ignoring minor details has led to such great tragedies as the collapse of the hanging platforms in the atrium of the hotel in Kansas City in 1981 and the collapse of the roof of the Aqua Park in Moscow in 2004;

4. During the construction of buildings, the main technological mistakes are caused by the use of low-quality construction materials, deviation from the requirements of project documentation and, most importantly, improper observance of construction norms and rules. A clear example of this is the earthquake that occurred in Turkey in 2023, as a result of which many buildings collapsed and many people died.

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