Accidents and emergency situations reasons in construction based on the construction structures survey results analysis

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Abstract. The article provides an analysis of the accidents and emergencies causes, collapses during the buildings and structures construction, as well as the ongoing surveys results to identify the most common mistakes that developers make. This type of situation occurred on the Rostov region territory from 2001 to 2014, which is based on data from the buildings and structures technical survey.

Introduction

According to statistics, the number of accidents and emergencies occurred with the modern technologies and construction methods development on the territory of the Russian Federation is not decreasing, but on the contrary, an increase in the tragic accidents consequences has been noted recently.

Technical analysis of the buildings and structures accidents cause on the territory of the Russian Federation shows that their number does not decrease. Moreover, there has been an increase in the tragic accidents’ consequences recently.

A deep analysis of the results of the building structures survey of emergency buildings and structures made in accordance with the requirements of [1-5] shows that they are the regulatory documents requirements violation result when performing the design and survey works and the construction and installation works production, the building materials, structures and products manufacturing. These violations consequences are aggravated by non-compliance with the rules and regulations for the technical operation of buildings and structures. As a rule, the accidents are the result of these factors several unfavorable combinations.

Often, the defects of a critical nature made during construction are potentially causes that can, with an unfavorable combination of factors affecting structures, cause their collapse.

The accidents causes’ analysis of the buildings and structures, the collapse of which occurred at the operation stage in Russia and the CIS countries, is widely and in sufficient detail presented in [6–8]. Despite the fact that the buildings and structures service life is the longest, however, emergency situations may occur at the stages of their construction, reconstruction (major repairs).

Roof structure analysis
The individual accidents and emergencies, the causes of which are errors made during surveys, design, construction and operation of buildings and structures are taken into consideration.

The most widespread at present is monolithic housing construction. Monolithic concrete and reinforced concrete structures are increasingly used in the civil buildings construction, especially high-rise buildings, so a wide variety of technologies used for the buildings construction in monolithic housing construction and their improvement is the norm for the construction industry.

Especially responsible period of monolithic construction is concreting in winter. As the practice of construction shows, that the speed of concreting decreases sharply at negative temperatures, or it stops simultaneously. The synthetic additives use in concrete or electrical heating significantly increases the construction cost, so the developers with a small capital try to avoid such costs, sometimes violating the concreting technology.

One of the concrete work production technology violation examples in the winter is the accidental overlap collapse of a building under construction on the Socialisticheskaya str., 27 in Novoshakhtinsk, Rostov region (Figures 1, 2).

![Figure 1. Facade in axes 1-16 residential building on the Socialisticheskaya street, 27 after the second-floor slab collapse.](image1)

![Figure 2. The second floor monolithic reinforced concrete slabs destruction cause at the junction with the column.](image2)

The main reasons for the 2nd floor overlap emergency collapse at the mark +5.330 in the residential buildings construction are: ignoring the overload caused by the load from the next tier erection at elevation +8.180; insufficient concrete strength during curing (the work was carried out in winter without warming up); the design solutions insufficient development; dynamic impact in the fall of the tank with concrete.

The 2nd floor overlap collapse at the mark +5.330 occurred in December 2011 during the work on concreting the floor slab of the 3rd floor. As a result of the accidental collapse of the 2nd floor overlap at mark +5.330: the areas 1-13xA-D, 1-4xD-I were completely destroyed; in the sections 13-16xA and 1-9xI-M, the plate revealed damage (oblique cracks at supports with a opening width of up to 10 mm, in which the separation of concrete along reinforcing bars, concrete crushing in the compressed zone), indicating that the plate in these areas is in the limit (close to destruction) state was observed. The surviving, but in the limit state, overlapping areas and overhanging fragments (concrete fragments, reinforcement products) of the 2nd floor destroyed overlap and the 3rd floor formwork elements create a potentially dangerous emergency threat around the entire building.

Another sensational event in monolithic housing construction is the collapse of a residential house under construction in the city of Taganrog. According to the EMERCOM of Russia on December 13, 2012, at about 6:00 pm, the investigation department received a message about the collapse of a multi-family residential building under construction in the city of Taganrog at the intersection of Chekhov Street and the Ukrainian Lane. As a result of the collapse five workers lost their lives.
The building was constructed using the fixed formwork technology (Figure 3). A construction permit was issued for a three-story building with integrated parking, office and shop, and in fact, at the collapse time, the fourth floor was being built.

Figure 3. View of the building under construction on the Chekhov street, 57 / Ukrainian Lain, 31 in the city of Taganrog before the collapse.

The collapse of a residential house under construction took place at the moment when work on pouring concrete into the fourth-floor walls in process. The eyewitnesses claim, and this is confirmed and recorded, that in the walls concreting process, concrete was fed to the third floor by at least three or four concrete trucks, and it was manually put by 27 builders in the formwork. Although the overlap was supported by the mounting poles reduction, the load on the monolithic reinforced concrete overlap, which had already been poured in winter without warming up, was critical and the overlap could not stand (Fig. 4). Also, the walls, which insufficient bearing strength and stiffness, did not allow the floor to jointly absorb the ready-mixed concrete load, played their negative role.

When analyzing the structural elements selected at the collapse site, it was also found that instead of 10-12 meters reinforcement with a diameter of 12 mm laid for one square meter wall, two rods vertically and two horizontally in each row laying, the builders laid horizontal rows in the walls with gaps through three and four rows of reinforcement with a cross section twice as thin, leaving only vertical rows with the required cross section. Moreover, the horizontal reinforcement was laid so little that the remaining fragments were hard to find.

Figure 4. View of the collapsed building on the Chekhov street, 57 / Ukrainian lain, 31 in the city of Taganrog, Rostov region.
It is equally important to relate to the brickwork quality in spite of the fact that modern technologies have made great strides in designing self-supporting walls with the energy-efficient solutions use. The outdoor self-supporting brick walls version is often made of decorative facing bricks, creating a certain color range and individuality of the building’s facade.

These problems were rather deeply studied by the specialists of CSRIBC named after V.A. Kucherenko [9].

A striking example of the “forgetfulness” of the “well-known” is the defects appearance in the facing facades brickwork layer during the residential block buildings construction in the Oktyabrsky micro-district in the town of Novocherkassk, Rostov Region (Figure 5).

At the construction completion, the following characteristic defects started manifesting themselves in the outer buildings facades surfaces:
- the brickwork decorative layer detachment at the floors level (from the 1st to the 6th floors) (Fig. 5);
- vertical and inclined cracks in different parts of the buildings outer brick walls with an opening width from 0.5 mm to 3 mm.

The buildings are designed with a monolithic reinforced concrete frame and self-supporting brick walls. The outer walls laying is provided for an effective 120 mm thick outer decorative facing brick layer, an insulation layer and an inner layer of lightweight concrete blocks. The wall stability is ensured by the inner layer work. The masonry walls outer and inner layers are fastened together by flexible ties, and the facing layer is supported on a steel corner welded to the embedded parts at the monolithic reinforced concrete floors ends.

The survey found that the front layer brick destruction cause at the overlap level was the horizontal expansion joints absence, which were to be performed in accordance with the requirements of SP 15.13330.2012 [10] to compensate for the difference in vertical deformations of the outer walls’ outer and inner layers, the building framework floors deflection. According to clause 9.83 [10], horizontal expansion joints in external curtain walls should be performed at the inter-floor slabs lower edge level for the entire thickness of a wall at least 30 mm thick. However, the project did not envisage the instructions for arranging horizontal seams, and the builders did not comply with them. Due to the fact that the horizontal joints in the masonry of the buildings surveyed were absent, the load on the floor brickwork is summed up as it is located relative to the above located ones. According to the calibration calculations results, it was established that the residential complex buildings lower floors

**Figure 5.** The facade wall brickwork material destruction in the level overlap.
brickwork is in an overloaded condition, which led to the brickwork materials destruction in the first six floors local wall sections.

Summary
1. The hazardous situations emergence is possible at various stages of a building’s existence: during construction; during operation; during reconstruction or major repairs; during liquidation (dismantling).
2. The main accidents causes are:
   - design errors and flaws;
   - unsatisfactory operating conditions, including maintenance repairs not completed on time;
   - construction technology production violations, including the absence or poor-quality control over their execution;
   - untimely taking measures to eliminate emergency situations, in case of their occurrence.
3. The main factor in preventing or localizing emergency situations is the operational work of construction, design and control organizations.

References
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