

# REASONS FOR THE COLLAPSE OF CEILINGS DURING THE CONSTRUCTION OF MONOLITHIC BUILDINGS

Tomakov M.V., Pykhtin A.I., Tomakov V.I., Tomakova I.A.

## 1. INTRODUCTION

Construction works, as a rule, differ in complexity and hazards of works. In this industry, a significant number of severe accidents occur annually due to the fall of the injured from a height, structure collapse, fall of objects and materials.

Professional risks of injury of construction workers are connected with the specifics of the work, including the occurrence of emergency situations during the construction of buildings and structures accompanied with the collapse of structural elements of buildings, applied technological equipment.

Nowadays, cases of collapses of a formwork of the cast concrete section of a building under construction in the course of concreting became frequent. Accidents entail death of people and significant material losses, cause a negative attitude of the society to this sphere of activity.

Purpose of the research: the purpose of the research is to study accidents occurred during installation of in-situ concrete floors of buildings and to reveal the typical causes of a formwork system collapse.

## 2. MATERIALS AND RESEARCH METHODS

The initial materials were the data on the causes of accidents at construction sites obtained on the basis of the analysis of statistical materials on injuries, as well as data on the identified violations of the requirements for safe work practices in capital construction and reconstruction of buildings and structures.

The causes of accidents of formwork systems in the course of in-situ concrete floor installation were determined on the basis of statistical data from the National Association of Builders (NOSTROY), National Association of Expert Organizations in Construction Engineering (NOEKS), "WELD" company, other organizations, and from other public sources, including the Internet. A total of 152 accidents at construction sites from 1997 to 2020 were considered [1].

## 3. RESULTS AND DISCUSSION

### 3.1 Examples of accidents of formwork Systems of buildings under construction

Here are some examples of accidents of formwork systems of buildings under construction that have occurred recently in various cities of Russia.

In the village of Boguchany, Krasnoyarsk territory, on 18.03.2016, a concrete slab of the third floor of the building collapsed on the construction site of the Central district hospital. Two construction workers were killed.

In Vladivostok, on 21.10.2017, during the pouring of concrete on the 3rd floor of a commercial enterprise building under construction, the floor collapsed. The reason for the collapse was a violation of the construction project.

In the Orthodox Church of the blessed Matron of Moscow, under construction in Krasnodar, 27.04.2018, the vault collapsed. During concreting the shuttering is out of order.

In Yakutsk, on 5.05.2018, a formwork collapsed in the building of school No. 25 under construction. The area of the collapse was about 140 sq. m. the collapse of the formwork occurred during the pouring of concrete. The installed supports could not support the weight of the concrete mix. The accident occurred due to a violation of the technology of concrete work. Two weeks later, on May 19, 2018, again in Yakutsk, in the "national school for 550 students", the floor slab collapsed, the total area of the collapse was about 53 sq. m. during concreting, the formwork failed and collapsed, as the installed removable jacks could not withstand the load.

In Kursk, on 19.01.2019, during construction work in the new school building, the formwork could not withstand the weight of concrete. The slab collapsed all around the perimeter. The area of the collapse amounted to 400 sq. m. The consequences of the accident are shown in Fig.1.



Figure 1: The Collapse of the floor slab during the construction of a school building in Kursk

On the construction site of a residential complex in Saint Petersburg on 16.02.2019, when filling the floor above the third floor of the building, the formwork collapsed due to a defect in the support bars.

On 23.03.2019, the formwork collapsed at the Volgograd arena stadium under construction when the second floor was covered.

In Artyom (Primorsky Krai) on 09.07.2019, when laying a concrete mix, the ceiling of the casino under construction collapsed. The area of the collapse was about 250 sq. m.

During the construction of the cancer hospital in Yaroslavl 31.08.2019 at the stage of pouring concrete mix collapsed intermediate floor. When pouring concrete, the formwork could not withstand the load. The area of the collapse was 350 sq.m. among the reasons were problems with supports that failed due to a defect.

In Perm (Ural), at the construction site of the Planeta shopping center on 07.11. 2019, when pouring concrete mix, the ceiling collapsed due to the deviation of part of the scaffolding under the formwork.

During the construction of a school building in the Lyuberetsky district of the Moscow region on 27.02. 2020, a formwork collapsed.

### 3.2 Systematization of Identified Causes of Accidents

As a rule, the same mistakes are repeated in design and organizational decisions, and violations of performing work technology that could lead to similar events.

It is necessary to provide a list of such errors and violations:

- a) the developer has no design solutions for specific sections of slabs with a detailed study of formwork pickup fittings;
- b) solutions for placing formwork without the approval and confirmation by calculations of formwork suppliers;
- c) there is no rejection and removal of deformed or substandard molding elements from the construction site, as a result of which damaged structural elements of the molding are used for further operation;
- d) the presence of defects and violations during the operation of formwork locks;
- e) increase in the number of formwork turnover cycles;
- f) the wrong choice of the type of formwork systems initially, inattentive attitude to the material the formwork is made of (in particular, to steel grade and its quality, plywood, wood, components, locks);
- g) non-compliance (and often lack of technological maps) with the order of concreting sites and unauthorized performance of those works that are not provided for by the project of production of works;
- h) inadequate organization and control of various types of activities in order to ensure the necessary quality of work and the conformity of production processes with the prescribed safety requirements;
- i) unauthorized storage of reinforcement and construction equipment on the formwork system structures;
- j) a significant excess of working loads on the formwork, leading to twofold (or more) excess of the permissible vertical load on formwork poles;
- k) installation of the structure on an unprepared non-rigid, deformable base;
- l) absence of horizontal elements and diagonal connections when using the slab formwork (or low-quality elements) in the positions determined by the project of work;
- m) installation of slab formwork and scaffolding with deviations from the vertical and horizontal, if the final adjustment of formwork by builders was not carried out;
- n) the presence of sagging or deflexion of slab formwork;
- o) dynamic impacts on the formwork with a concrete boom when feeding concrete or a container with concrete;
- p) ignoring the operation instructions of formwork systems, although all professional patented products are delivered with detailed and thoroughly prescribed instructions for operation, installation and dismantling of the system.

### 3.3 Discussion of the Causes

The various causes of collapse of formwork systems and injuries are closely related to each other and are so intertwined and mutually determined in most cases that it is impossible to imagine each of them in a separate form. Therefore, a single detailed classification of the causes of collapses and injuries cannot be made at all stages of in-situ concrete work, since the specificity of various processes requires taking into account well-defined initial events and technology features of the type of work under consideration.

It should also be noted that critical defects allowed during the installation of a in-situ concrete slab are potentially the causes that can cause a collapse of structures during the operation of buildings when an unfavorable combination of factors affect them.

Execution of complex construction work by unprofessional firms without trained personnel leads to the considered consequences. Violations of construction rules and regulations during the construction of facilities of various purposes have become commonplace. Therefore, the presence of professional competencies corresponding to the envisaged work should be checked by the certification committee before admission to work. Engineers and technicians should know the urgent issues of construction, including technology of in-situ concrete construction, types of formwork used in such construction and features of concrete work.

## 4. CONCLUSIONS

Accident prevention is a set of measures including professional selection of personnel, improving the quality of professional construction education, mastering advanced construction technologies and management methods of construction organizations [2], as well as organizing and implementing customer construction control (technical supervision) of the construction of facilities.

Specialists in the field of technology and organization of construction production should have a deeper education in order to thoroughly and qualitatively consider the issues of construction production from the point of view of innovative achievements, have an idea of the main provisions and directions for improving the technology, organization and planning of construction production, and advanced domestic and foreign methods of production of construction works. Only on the basis of a constant exchange of experience can they activate reserves for improving the efficiency and safety of construction production. Especially interesting in terms of gaining experience should be considered training and practical work on construction sites of landmark projects, both in Russia and abroad.

## 5. REFERENCES

- [1] Tomakov V.I., Tomakov M.V. Accidents at construction sites when installing monolithic concrete slabs: monograph. Kursk, 2020. 210 p.
- [2] Tomakova I.A. Tomakov M.V., Charkina Yu.N., Brezhnev A.V. Main provisions of the modern policy of the organization in the field of occupational safety and health personnel. News of Southwest state University. Series: Engineering and technology. 2018; 2(27). Pp. 85-98.