Systematization of Factors Affecting the Organizational Processes in the Conversion of Buildings

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Abstract. The impact of defects in construction operations can be assessed in terms of ensuring reliability and safety of buildings and structures. Defects may diminish the bearing capacity and stability of a structure, cause deterioration, reduce durability, and lead to an accident. In more than 60% of cases, accidents in monolithic construction projects may be triggered off by faults in concreting and reinforcement jobs. This article analyzes the main types of defects at the most critical technological stages, determines the factors affecting the defect detection process, gives a brief description of the nature of damage and deterioration of monolithic reinforced concrete structures, proposes classification of defects by degree of criticality, including those in critical structures, and, based on inspection results, offers a conclusion on the need for recommendations and experimental research aimed at improving the technological processes of monolithic reinforced concrete construction operations, including those using nondestructive methods of testing the strength of monolithic structures at the concreting stage.

1. Introduction

Analyzing the causes of defects and damage to concrete and reinforced concrete structures in monolithic construction projects is a vital task. Severe problems of poor reliability and safety of buildings and structures attributable to repeated production and operation faults inflict considerable material damage, injuries and loss of life.

Improvement of the quality of construction operations requires an analysis of the nature of damage to and deterioration of monolithic reinforced concrete structures and finding an efficient way of preventing defects and failures of structural units.
2. Materials and methods

The process of deterioration of a structure varies depending on the loading condition, type of the structure, and occurrence and location of damage and defects. Deterioration is a consequence of a failure of stability of a structure, or loss of integrity and continuity of material caused by various impacts [1-3]. Proper determination of probability of deterioration of a structure requires a detailed review and classification of structural defects. The main factors affecting the defect detention process can be described using a cause-and-effect Ishikawa diagram (figure 1).

The main methods of building control to prevent defects and damage to monolithic reinforced concrete structures are divided into the following categories:

- construction control when performing reinforcement works;
- construction control when performing concrete work;
- construction control in the production of concrete work at low temperatures;
- construction control and acceptance of finished concrete and reinforced concrete structures.

Defects can be classified by structure material, causes of occurrence, defective parts of buildings, detection methods, degree of damage, time of occurrence, and nature of deterioration processes [4, 6-8].

The authors have focused on defects of monolithic reinforced concrete units of buildings and structures arising from improper operations at the most critical technological stages.

![Figure 1. Ishikawa diagram.](image-url)
A major part of nonconformities detected by construction inspection, namely 60%, relates to reinforcing and concreting jobs, including those at winter time [5, 8]. The most challenging issue revealed by inspection of the technical condition of concrete and reinforced concrete structures is the defect assessment in critical structures. Identification and elimination of the core causes of deterioration of buildings and structures require classification of the main types of defects and damage in monolithic reinforced concrete structures by degree of criticality [4, 9]. Irrespective of the type of the building or its structural and design diagrams, typical defects are classified depending on their location in bearing or fencing structures. Thereafter, collected data on defects in monolithic reinforced concrete structures are proposed to be classified by type of impact on the bearing capacity into three main groups: minor, major, and critical [9-12].

Although they are not a prerequisite for the destruction of the structure, in some cases they indicate a violation of building codes and technologies such as:

- the quality of the materials used for the preparation of concrete mix;
- preparedness of concrete mixing, transport and auxiliary equipment for the production of concrete work;
- the correct selection of the composition of the concrete mix and the appointment of its mobility (stiffness) in accordance with the design guidelines and conditions of work;
- test results of control samples of concrete in the selection of the concrete mix.
- use of concrete of poor quality or insufficient thickness of the protective layer of reinforcement.

The most common defect of monolithic reinforced concrete structures is concrete surface cracks. While not necessarily leading to subsequent deterioration of the structure, in some cases they may be an evidence of noncompliance with construction norms and regulations, in particular, a poor quality of cement or insufficient thickness of the reinforcement protective layer. These defects do not reduce the strength or durability of structures and hence may be classified as minor defects.

But to carry out construction control of the implementation of concrete work is necessary at all stages:

- preparatory;
- concreting (preparation, transportation and laying of concrete mix);
- curing concrete and demolishing structures;
- acceptance of concrete and reinforced concrete structures or parts of structures.

More serious defects are excessive corrosion of exposed reinforcement, through tracks, voids, cavities, concrete spalling, and cracks along reinforcement bars up to 3 mm wide. Such defects are classified as major defects as they reduce the durability of structures. As a general rule, they are detected visually and instrumentally following removal of the formwork and hardening of the concrete [8, 13-15].

To prevent such defects, it is necessary to carry out operational and acceptance quality control in the process of performing reinforcement works.

In the process of procurement of reinforcing rods, manufacturing of nets, frames, their installation, the following is subject to construction control:

- quality of reinforcing bars;
- the correctness of the manufacture and assembly of nets and frames;
- quality of joints and fittings;
- quality of mounted fittings.

Reinforcing steel entering the construction site, embedded parts and anchors during construction control and acceptance should be subject to external examination and measurement, as well as control tests in cases provided for in the project or in special instructions on the use of certain types of reinforcing steel.
During the operational control of the state of reinforcement products, embedded products, and also welded joints, each product is visually inspected for the absence of rust, frost, frost, concrete contamination, scale, traces of oil, peeling rust and continuous surface corrosion.

For operational and acceptance control of deviations of the distances between reinforcing bars, reinforcement rows, as well as reinforcement pitch, measure at least five points with a step of 0.5 to 2.0 m for every 10 m³ of the concreted structure. Deviations of the distances between the reinforcing bars, rows of reinforcement, as well as the pitch of the reinforcement are controlled according to State Standard 26433.2 using a ruler or tape measure. In the operational control of compliance of the connections of reinforcement bars with design and technological documentation, each connection is checked, and at acceptance control, at least five connections are checked in increments of 0.5 to 2.0 m for each 10 m³ of construction.

The ligation of reinforcement rods using knitting wire is monitored visually during operational control. Lap joints are monitored visually and with lap measurement according to State Standard 26433.2 using a tape measure.

Construction control and acceptance of mounted reinforcement as well as welded butt joints should be carried out prior to the laying of the concrete mix and drawn up by an inspection certificate for hidden works.

Acceptance inspection of the welded joints of reinforcement made should include an external inspection (detection of defects specified in Section 6 of this standard) and a set of tests conducted in accordance with State Standard 10922 and State Standard 23858.

The name of the monitored indicators and types of control are given in table 1.

| No. | Name of monitored indicators | Type of control |
|-----|-----------------------------|-----------------|
| 1   | Condition of reinforcement products | Operating  | Solid  | Visual |
|     | Deviation of distances between separately established working cores and fittings step | Operating Acceptance  | Selective  | Measuring |
| 2   | Deviation of the distance between the rows of fittings | Operating Acceptance | Solid | Selective | Measuring |
| 3   | Compliance of connections of cores of fittings of project and technological documentation | Operating Acceptance | Solid | Selective | Measuring |
| 4   | Deviation of a protective layer of concrete from project | Operating Acceptance | Selective | Measuring |

Before laying the concrete mix, the bases (soil or artificial), the correct installation of formwork, reinforcement structures and embedded parts should be checked.

Concrete bases and working joints in concrete must be thoroughly cleaned of cement film without damaging the concrete, formwork from debris and dirt, and fittings from rust. The inner surface of the inventory formwork should be coated with a special lubricant that does not impair the appearance and strength properties of structures.
In the process of laying concrete mix it is necessary to control:

- condition of scaffolding, formwork, position of reinforcement;
- quality laid concrete mix;
- compliance with the rules of unloading and distribution of concrete mix;
- the thickness of the stacked layers;
- mode of compaction of the concrete mix;
- compliance with the established procedure of concreting and the rules for the design of working joints;
- timeliness and accuracy of sampling for the manufacture of control samples of concrete.

The most hazardous type of defects called critical defects includes damage that reduces the bearing capacity of structures, namely, cracks not permitted by the design, inclined cracks in beam walls, horizontal cracks in slab-to-span connections, branched cracks, etc. These are severe defects and may lead to collapse of structures in some cases. Defects are often associated with deviations from the concreting technology, poor compacting of the concrete mix, noncompliance with the concrete strength requirements in concrete curing operations, etc. [11, 14].

Proceeding from the above, determination of reliability of a construction unit requires a preliminary analysis of its structural system, namely, identification of those elements that can cause hazardous conditions, such as defective structures, connections or foundations [3, 8, 13]. Particular attention should be given to critical and major defects in the bearing structures that arose during reinforcing and concreting operations. According to experience of inspection of buildings and structures, the best approach to defects in monolithic reinforced concrete structures is proper control of concrete mix preparation, transportation and packing in forms, ensuring the required temperature and humidity conditions, and adhering to the schedule of formwork removal [4-5, 15].

3. Conclusion
Technological solutions need to be worked out that would prevent from occurring most of the defects that are caused by improper concreting. The following method is proposed for prevention of these defects. The concreting jobs should include control of evenness for a concrete mix being laid and its uniform compaction. Concrete continuity can be assessed by nondestructive testing in the course of construction. This method can be used for prevention of typical damage to and defects of critical structures with timely measures taken in order to eliminate defects before such critical structures deteriorate.

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