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Article

Defects in a dilapidated building resulting in loss of bearing capacity of supporting structures

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Abstract. This article is devoted to assessing the effectiveness of technical inspection of the condition and the degree of influence of various factors on the reliability of buildings. Technical inspection of the condition of buildings and structures is an important procedure for making decisions about the suitability of the structure for its further operation. Technical inspection should be carried out by specialized accredited organizations that have the necessary expertise and equipment. Adverse environmental factors, poor quality of construction and installation work and general physical deterioration of the building have a direct impact on the safety of people staying in it. The object of the survey was the building of a secondary school in the Karaganda region. Visual and instrumental inspection was carried out at the object, including determination of technical condition and damage categories by shock-pulse method and geodetic surveying. According to the results of the inspection of the object the conclusion of improper condition of the load-bearing structures belonging to category IV, i.e., pre-emergency state of the structures was assigned.
Keywords: technical inspection, nondestructive methods, defects, tolerance, supporting structures.

1. Introduction

Technical inspection of buildings - an important procedure by which to decide the fate of the structure [1]. By definition, technical inspection is a complex of measures to determine and assess the actual values of controlled parameters that characterize the operational condition, suitability, performance and energy efficiency of buildings and structures to determine the possibility of further operation or the need for structural intervention [2]. In the territory of the Republic of Kazakhstan, the survey should be carried out by an organization accredited for such activities [3]. Classically, the inspection consists of the following steps [4]: 1) Preparatory, which is the study of the original documentation (design and construction documents, architectural and planning decisions, technical specifications, materials on planned repair, previous calculations of supporting structures, etc.), and the contract between the customer and the contractor works; 2) Visual inspection, which checks compliance between the actual geometry of the structure with the available schematic construction drawings; 3) Instrumental examination, which assess the technical condition and set up a technical inspection of the building; 4) Technical inspection, which reveals the differences in the technical condition of the building and the state of its elements. An "instrumental examination" finds out the differences between the actual value of any technical condition and the "tolerances" specified in the standards [5]. A variety of tools and methods of destructive and nondestructive testing are used during the survey [6].

Most often technical inspection is carried out for social facilities that are on the balance sheet of public institutions [4]. These are objects such as schools, kindergartens, libraries, museums, and the like. The object of the survey in this study is the building of the municipal state institution

"Amangeldy comprehensive school" in Karaganda region, Kazakhstan. The design and construction of the school began in 2003, and the school opened to students in 2007. Inspections at the site were carried out in 2017 and 2022. The peculiarity of this case is that the school building was in a mothballed state from the start of construction until it was put into operation. In this example, we can clearly assess the impact of natural factors on the integrity of the building when no measures are taken to maintain the current condition of the building. The most recent survey revealed the building to be unsuitable for further operation for a number of reasons [5]. This article examines the features of the load-bearing structures of the school building that are subject to significant damage and are on the verge of collapse (foundation, walls, floors, and coverings).

2. Methods

The object of the survey (school) is two-story and consists of 3 adjacent blocks, two of which contain an auditorium fund, and the last block is a gymnasium. According to the project documentation, the foundation of the object is strip foundation made of precast reinforced concrete blocks. Walls of the main part are 0.57 m thick big-block ones, and those of the gym are brick ones. The ceilings and coverings of the main part are made of multi-hollow reinforced concrete slabs, and the cover of the gym - of ribbed reinforced concrete slabs.

The expert inspection of the building structures was performed in accordance with [5] and consisted of three stages:

- Preparatory (collection and study of initial materials);
- Visual (inspection and photo-fixation of defects, establishing their nature and extent) and instrumental (establishment of the technical condition and determination of damage categories by shock-pulse method and geodetic survey) examination of the building;
- Drawing up a technical report.

Pits were made at 5 points (Figure 1) in order to inspect the condition of the foundations, to determine their depth and to check their strength.

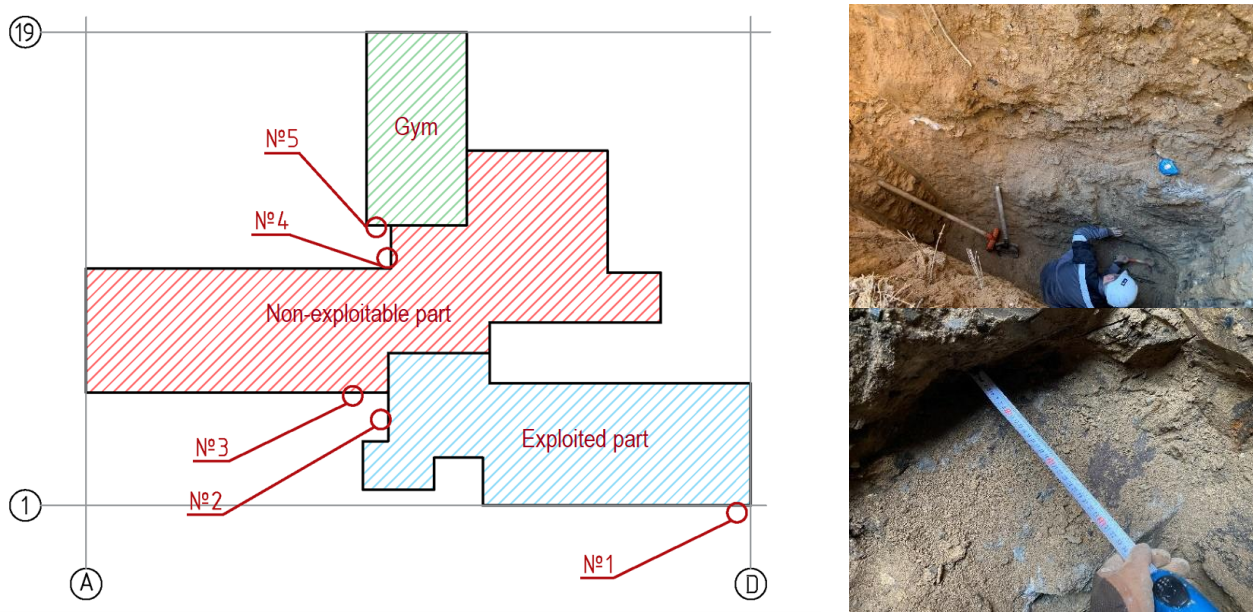


Figure 1 – Pits layout

3. Results and Discussion

3.1 Foundation

Visual and instrumental examination of the building foundation revealed that the foundation is strip foundation of precast reinforced concrete blocks on a concrete pad with crushed stone

preparation. According to the results of pits, the depth of foundation from ground level is from 2.95 m to 3.25 m, depending on the absolute ground level mark. At the time of visual and instrumental inspection of the building's foundation, there were ubiquitous traces of efflorescence on the walls of the foundation blocks, local shrinkage cracks in the body of the foundation blocks (Figure 2).

Figure 2 – Efflorescence (left) and shrinkage cracks (right) of foundation

Shock-pulse tests revealed concrete strength values of foundation blocks from 33.9 to 40.3 MPa, with an average of 37.8 MPa.

The overall technical condition of the foundation is satisfactory. The category of assessment of the technical condition of the foundation is Category II (serviceable structure). According to [5] and the identified defects, the physical deterioration of the foundation is 39%. These figures are atypical for a building less than 20 years old, but it is worth bearing in mind that the building was exposed to a hostile environment prior to commissioning. For example, the degree of physical deterioration for buildings less than 20 years old is usually about 10% with proper maintenance [7].

3.2 Walls

The walls of the main part of the building are made of large expanded clay concrete blocks with a thickness of 570 mm. The walls of the gymnasium are made of 380 mm thick brickwork and 120 mm thick cladding. The technical inspection revealed that the walls of part of the gymnasium were re-built from brickwork. The brickwork of the walls of the gymnasium was not performed with high quality, there were no reinforcing belts, the new masonry was not bound to the old masonry, and vertical deviations were visually observed. During construction and installation works of the walls of the gymnasium concrete blocks of different sizes were partially used instead of bricks, which had an adverse effect on the wall structure in the form of uneven load. For this reason, cracks occurred in the wall body (Figure 3, left). To mount the reinforced concrete beams, brick columns were made in the body of the gymnasium's load-bearing walls 630 mm wide. The brick columns were reinforced with metal casing made of angles, but the reinforcement structures are not of good quality and do not ensure their performance (Figure 3, right).

Figure 3 – Weak bonding (left) and poor strengthening (right) of masonry

According to the geodetic surveys of the gymnasium walls, the average value of vertical deviation from the plane was 80-90 mm, and the maximum deviation was 147 mm. While the allowable deviation per floor is 10 mm according to [5]. The inspection of the wall blocks in the unexploited part of the building revealed that under the influence of natural conditions there was a gradual destruction and delamination of the wall blocks. At the time of the visual and instrumental examination of the building walls a number of defects were revealed. Schemes of their location are shown in Figure 4 below.

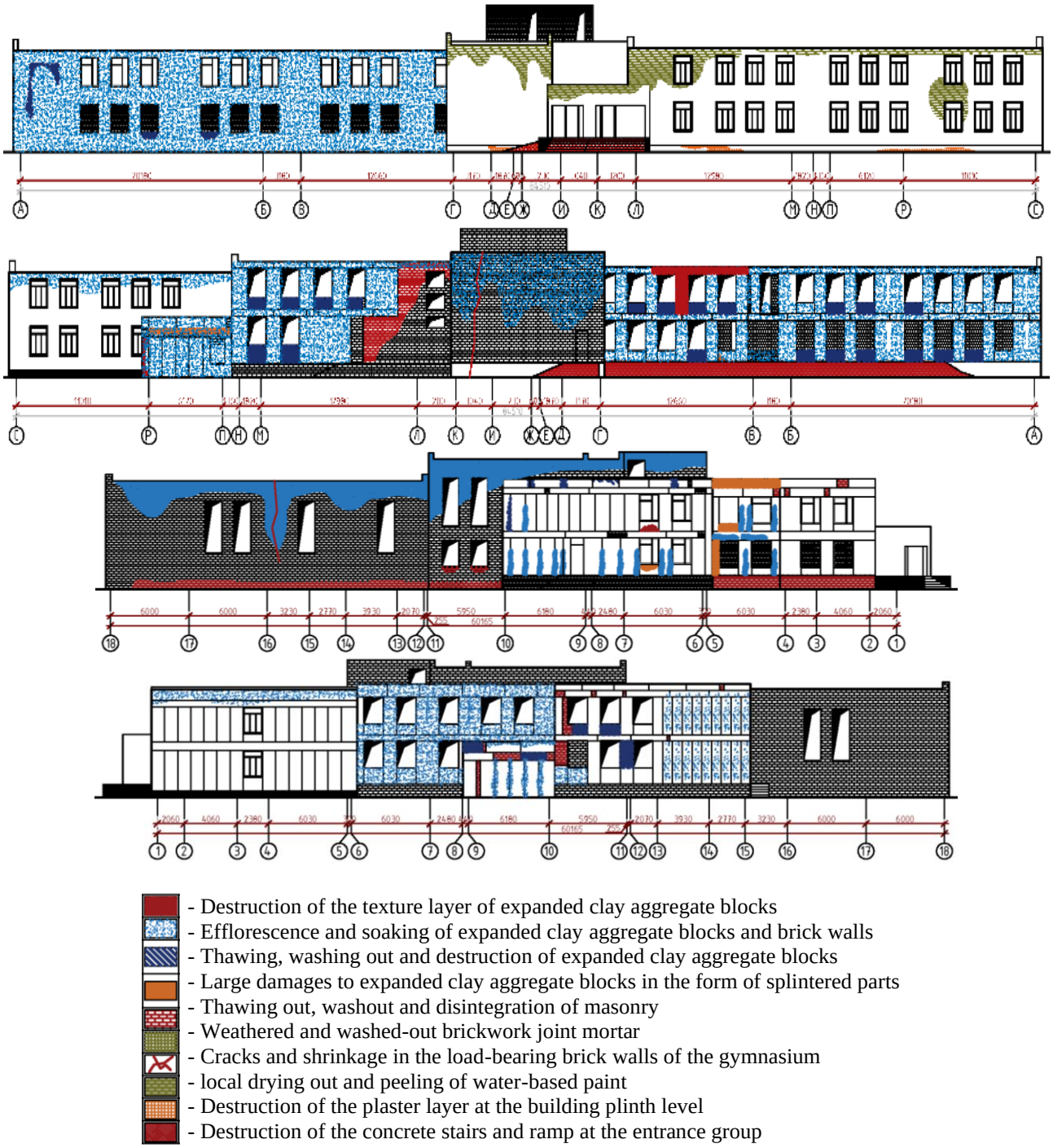


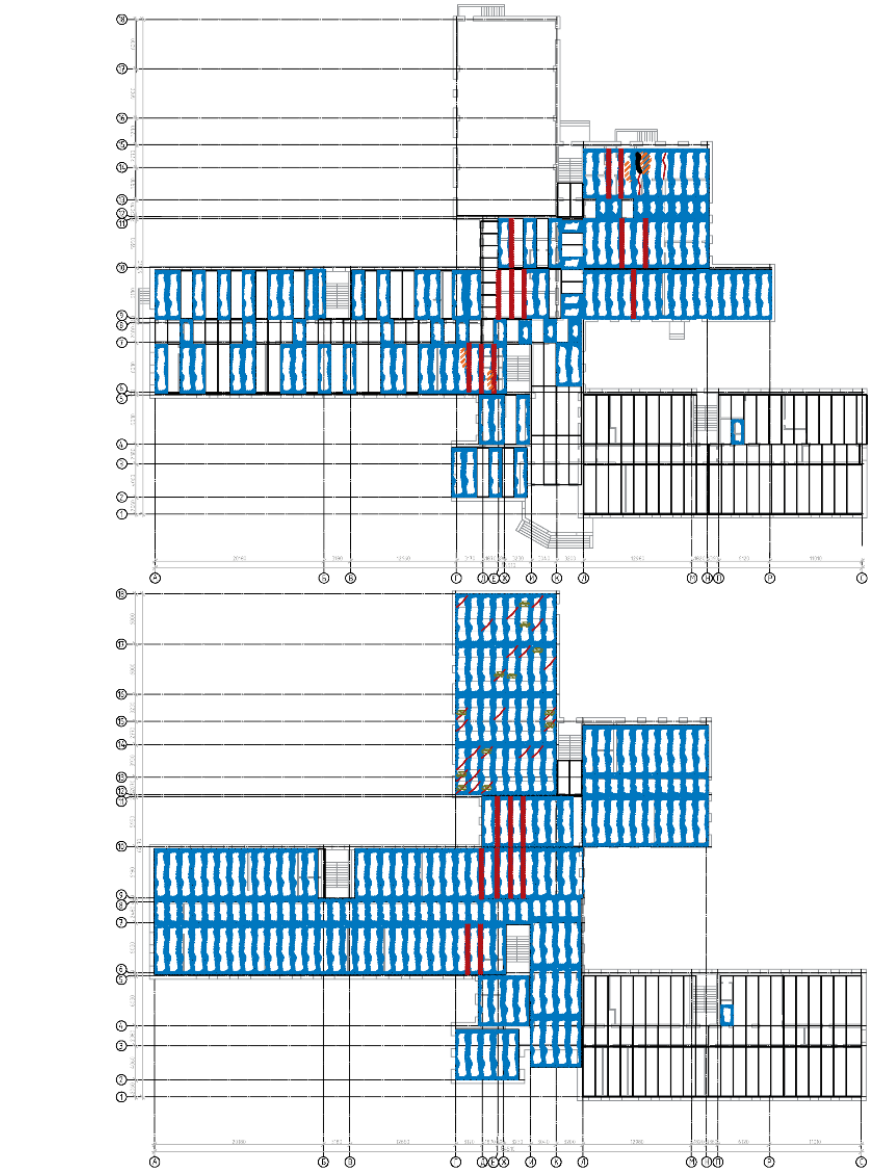
Figure 4 – Defects of walls

General technical condition of the walls - unsatisfactory. Evaluation category of the technical condition of the walls - Category IV (pre-emergency condition of the structure). According to [5] and the defects detected, the physical deterioration of the walls is 65%.

3.3 Floor and cover slabs

The inspection revealed that the floor and roof slabs in the main part of the building are prefabricated hollow reinforced concrete, the gym floor slabs are prefabricated hollow reinforced concrete, and the gym floor slabs are prefabricated ribbed reinforced concrete.

According to the results of visual and instrumental examination of the floor and ceiling slabs, various defects were identified. The scheme of their location is shown in Figure 5 below.



- Erosion and soaking of hollow and ribbed slabs
- Lack/washing out of mortar at the joints of boards
- Longitudinal, diagonal and transverse cracks on the underside of hollow-core slabs
- Destruction of the protective layer and bared armature of the slabs
- Breaks, through holes with bared reinforcement in the hollow-core slabs
- Concrete destruction on the flanges and ribs of ribbed slabs
- Cracks in the flanges of ribbed slabs

Figure 5 – Defects of floor and cover slabs

Cracks in the longitudinal, transverse ribs and slab flange occurred as a result of soaking of the slabs due to leaking roofing and environmental exposure. Corrosion of the reinforcement is usually observed in places with low density and insufficient thickness of the protective layer of

concrete. The corrosion products of the reinforcement, having a greater volume, have a spreading action and gradually destroy the concrete of the protective layer, leading to the formation of cracks. Through these cracks the moisture comes most intensively, accelerating the process of corrosion of the reinforcement and increasing the width of the crack opening. Subsequently, these processes lead to crumbling of the concrete protective layer, bare reinforcement and its intense corrosion.

According to the geodetic survey of the gymnasium floor slabs, the average deflection of the slabs is 18-20 mm, the maximum deflection is 29 mm. The allowable value of the deflection of the plates is 30 mm. Tests by shock impulse method revealed concrete strength values of foundation blocks from 26.8 to 31.9 MPa, with an average of 29.4 MPa.

Also, at the time of visual and instrumental inspection, an emergency section of the basement floor slab under the gymnasium was revealed - an area of a broken multi-hollow slab (Figure 6, left). Also areas of the slabs with unacceptable deflection and diagonal cracks were revealed. These floor slabs cannot be restored. In the classrooms in the operational part of the building, there is a displacement of up to 50 mm from the vertical of the slabs (Figure 6, right).

Figure 6 – Breaks (left) and displacement (right) of slabs

The general technical condition of the floor and roof slabs is unsatisfactory. Evaluation category of the technical condition of the floor slabs - Category III (limited serviceability of the structure). According to [5] and the defects detected, the physical deterioration of the floor and cover slabs is 55%.

4. Conclusions

The inspected building has a large number of defects on the non-exploited part of the building, as for many years it stood under the direct influence of natural conditions, which negatively affected the load-bearing structures. For example, the average vertical deviation of the walls of the gymnasium from the plane was 90 mm, which is 9 times the allowable deviation of 10 mm per floor. Also, according to the visual-instrumental survey and geodetic surveys, we can conclude that the construction and installation work on the erection of the part of the gymnasium was performed poorly. There are complex problems with the building structures related to physical deterioration. Due to the incomplete construction of the building, structural materials begin to lose their mechanical properties. For example, during the years of downtime, the physical deterioration of the walls of the school due to weather conditions was 65%, making it impossible to continue operating the building.

According to the results of the expert examination and evaluation, it can be concluded that at the time of the survey according to the category of assessment of the technical condition, supporting structures of the school building refers to Category IV (pre-emergency condition of structures).

The methods of interpreting the results of technical inspection are recommended to be used for similar case studies.

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References

1. Building Inspection System for Evaluating the Technical Performance of Existing Buildings / R. Bortolini, N. Forcada // Journal of Performance of Constructed Facilities. — 2018. — Vol. 32, No. 5. — P. 04018073. https://doi.org/10.1061/(ASCE)CF.1943-5509.0001220
2. Assessment of heritage timber structures: Review of standards, guidelines and procedures / M. Riggio, D. D'Ayala, M.A. Parisi, C. Tardini // Journal of Cultural Heritage. — 2018. — Vol. 31. — P. 220–235. https://doi.org/10.1016/j.culher.2017.11.007
3. Building Information Model (BIM) Implementation in Perspective of Kazakhstan: Opportunities and Barriers / D. Aitbayeva, M. Hossan — 2020. — Vol. 14. — P. 13–24. https://doi.org/10.9734/JERR/2020/v14i117113
4. Analysis of methods for assessing the condition of surveyed facilities in Taraz City / A. Kazkeyev, A. Aniskin // Technobius. — 2022. — Vol. 2, No. 1. — C. 0015. https://doi.org/10.54355/tbus/2.1.2022.0015
5. SP RK 1.04-101-2012. «Survey and assessment of the technical status of buildings and constructions» [Electronic resourse] // PARAGRAPH information system. — Accsess mode: https://online.zakon.kz/Document/?doc_id=39108718 (access date: 27.05.2022).
6. On traditional and modern methods and devices for controlling the strength of concrete / Y.B. Utepov, A.B. Kazkeyev // Herald of the Kazakh-British technical university. — 2021. — Vol. 16, No. 4. — P. 193–199.
7. Information support of monitoring of technical condition of buildings in construction risk area / M.E. Skachkova, O.Y. Lepihina, V.V. Ignatova // Journal of Physics: Conference Series. — 2018. — Vol. 1015. — P. 042056. https://doi.org/10.1088/1742-6596/1015/4/042056

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