Monitoring of the technical condition of structures and building materials of an elevator silo housing

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Abstract. The results of assessing the technical condition of the elevator silo housing, obtained on the basis of a visual instrumental examination using the non-destructive testing method, are considered. Existing defects and damages in the building materials and structures of the building, which adversely affect its performance, were identified. An assessment was made of the state of foundations, walls, floors of the silo and columns installed at the corners of the silo at the height of the silo. The results of the assessment of individual results of the performed instrumental studies of structures and building materials at the object under study are presented. The technical condition of the building as a whole is assessed as a limited operational technical condition. The phase of the period of operation of the building was determined. Recommendations have been developed to ensure the safe operation of the building under study. It has been established that it is necessary to strengthen the structural elements of the building for further safety during the operation of the elevator. It is proposed to introduce the necessary measures to improve the reliability and strength properties of individual structural elements after a period of their long-term operation.

1 Introduction

The object «Elevator building №. 2, Silo housing №. 3» is being investigated - technical passport №. 13624 is located at the address: Lipetsk region, Yelets, str. Krotevich, 30.

The subject of the study is the technical condition of the main load-bearing structures of the silo elevator housing.

2 Analysis of structures of the investigated building

A continuous visual inspection was carried out in order to identify defects and damage to structures by external signs with their measurement and fixation. The results of the visual inspection were used for a preliminary assessment of the technical condition of structures according to external signs, as well as for clarifying and adjusting the work program for instrumental inspection [1, 2].

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The object has a strip foundation made of rubble concrete [3, 4]. The photographs of the foundations excavated in the pits are shown in Figure 1.

Fig. 1. View of the state of the foundation in the pit № 1, 2, 3.

The surface of the walls is covered with a plaster layer with a thickness of 10 to 30 mm. A visual inspection of the monolithic walls revealed the following: at the level of the transition of the outer walls of the silo compartment to the outer walls of the silo compartment, there is a destruction of the plaster layer with areas of exposed reinforcement (Figure 2). Delamination of the plaster layer. When tapping, a deaf, bubbling sound of emptiness is heard, it easily lags behind or is disassembled by hand [5, 6]. On the surface of the walls there are masses of fallen off plaster. There are areas of cracking and spalling of the protective layer of concrete with an area of up to 1 m^2, with exposure of large aggregates and rebar [7, 8].

Fig. 2. General view of the condition of the load-bearing walls of the building.

There are vertical, horizontal cracks opening up to 0.3 mm. At the level of +6.900 from the level of the blind area, there is a horizontal crack encircling the perimeter of the building. At the level of +7.900 there is a duplicate, horizontal crack encircling the perimeter of the building. In the area from +6.900 to +7.900, cracking and spalling of concrete, exposure of coarse aggregate and rebar are observed [9, 10]. Cracks along the reinforcing bars with an opening of up to 3 mm. In areas of painted concrete, corrosion of rebar is observed with a change in cross-section of up to 70%. The outer surface of the walls of the silo compartment is covered with a plaster layer along the grid. The plaster layer is covered with coating waterproofing [11, 12].

From the windows located in the walls of the silo room there are vertical cracks (opening width up to 0.2 mm) extending to the entire height of the walls of the silo room to the eaves slabs. On the surface there are traces of constant soaking by atmospheric precipitation [13, 14]. The cause of defects is the natural physical wear of the wall structure as a result of atmospheric action.

As a result of visual inspection and measurement work, the designs and dimensions of monolithic and brick walls were determined [15, 16]. The width of the walls of the building is: the inner walls of the silo compartment -600 mm; outer walls of the silo compartment - 600

mm; outer walls of the silo compartment - 200 mm; the outer walls of the silo compartment are made of ordinary ceramic bricks. Wall thickness - 200 mm.

Reinforcement of the outer walls of the silo compartment: horizontal annular - Ø10 with a step of 200 mm; vertical - Ø10 with a step of 400 mm; in the area of the columns (at the junctions of the outer and inner walls) paired rods Ø10. Reinforcement of the internal walls of the silo room: horizontal Ø10 with a step of 200 mm; vertical - Ø10 with a step of 400 mm; Coupling of rebar is made viscous.

Reinforcement of the outer and inner walls of the silo compartment: not identified. The outer walls of the silo compartment are made of ordinary ceramic bricks [17, 18].

Part of the ceiling of the undersilo compartment is made in the form of a monolithic slab 200 mm thick (Figure 3). Reinforcement: longitudinal - metal rods Ø 10 mm. with a step of 100 mm; transverse - metal rods Ø 10 mm. with a step of 100 mm; reinforcement in the area of window blocks with longitudinal rods Ø20 with a pitch of 100 mm, for a width of 600 mm (5 pcs.).

Fig. 3. General view of the ceiling condition of the silo compartment.

Visual examination revealed: the protective layer of the lower reinforcement cage is 5÷10 mm; on the floor there are areas of delamination of the protective layer with bare reinforcement; bare reinforcement is subject to corrosive attack; deflections of sections of the slab, in the area of the premises located along the perimeter of the silo room, are up to 50 mm, on the lower surface of the slab there are longitudinal and transverse cracks with an opening thickness of up to 0.2 mm.

The structures of the columns are made of reinforced concrete, installed at the corners of the silo at the height of the silo (Figure 4). The size of the columns is 500x500 mm. Reinforcement is made with vertical steel.

Fig. 4. General view of the condition of the columns.

There are signs of impacts that correspond to the normalized values of the reliability assessment method with rods Ø12 A-1 located at the corners of the column and horizontal steel rods Ø12 A-1 located with a step of 200 mm.

A visual inspection of the columns revealed the following defects: destruction of the plaster layer with areas of exposed reinforcement; peeling of the plaster layer. When tapping, a deaf, bubbling sound of emptiness is heard, it easily lags behind or is disassembled by hand. There are areas of cracking and spalling of the protective layer with exposure of coarse aggregate and rebar. There are vertical, horizontal cracks opening up to 0.3 mm. In areas of painted concrete, corrosion of vertical rods is observed with a change in cross section of up to 100%. Curvature of the column surface from the vertical plane according to external signs: deep cracks in the elements, reduction of the working section [19, 20, 21].

As a result of comparing the signs of physical wear with their normalized values, it was found that the actual value of the physical wear of the outer columns is 50%. According to the methodology, the established value of physical wear (50%) corresponds to an unsatisfactory technical condition.

As a result of the performed instrumental studies of structures and materials at the facility, the following was established.

The actual class of concrete of the outer columns of the building in terms of strength corresponds to the average strength of concrete B 30. The actual class of concrete of the ceiling of the undersilo in terms of strength corresponds to the average strength of concrete B 15. The actual class of concrete of the external monolithic walls of the silo in terms of strength corresponds to the average strength of concrete B 15. The actual class of concrete of the transverse beams of the ceiling above the silo in strength corresponds to the average strength of concrete B 15. The actual class of concrete of the internal walls of the building corresponds in strength to the average strength of concrete B 22.5. At the base of the building there are sandy loamy soils with a content of silt and clay particles of 20% and a density of dry soil of natural composition of 1.77 g/cm^3

Based on the results of the survey, verification calculations of the bearing capacity of structures, on the effect of design forces according to actual design schemes under operational loads and impacts provided for by current regulatory requirements.

To solve the issues of normal operation of structures separately and the object as a whole, typical technical solutions for repair and restoration work using optimal materials are proposed.

To solve the issues of normal operation of structures separately and the facility as a whole, we offer standard technical solutions for repair and restoration work using optimal materials.

Restoration of the protective layer of reinforced concrete is required, repair of local defects:

1. Concrete at the place of repair and injection work must have a temperature of at least +5 °C. If necessary, heating is carried out by heat guns. All materials and equipment should be stored in a warm warehouse +15 °C.
2. Clean the surface of the entire reinforced concrete element from protective coatings, paint, efflorescence and other contaminants.
3. Remove all broken and structurally weak concrete.
4. Remove concrete in the place of exposed reinforcing bars to a depth of 10 mm.
5. Expand cracks, junctions of structural units and cold seams until a 30x30 mm rectangular profile is obtained.
6. Clean bare rebar from rust and concrete mechanically down to metal.
7. Water blast the prepared surface.
8. Coat the treated rebar with rust passivator Manoguard 133 Fer (according to the technical description for this material).
9. Moisten the concrete surface with water until completely saturated.

10. Restore concrete losses with a depth of more than 10 mm using Starmex RM3 thixotropic repair compound. (work is carried out according to the technical description for this material). It is recommended to apply in layers no thicker than 30 mm for Starmex PM3. The given values are an average and should be adjusted depending on the desired consistency and application conditions.
11. Destruction in the area of the protective layer, shells and irregularities up to 10 mm deep should be repaired using Starmex RM2 thixotropic compound. (work is carried out according to the technical description for this material). It is recommended to apply in layers no thicker than 5 mm for Starmex RM2.

The values given are average values and should be adjusted according to the desired consistency and application conditions.

Restoration of extensive defects in reinforced concrete structures using grout:

1. Concrete at the place of repair work must have a temperature of at least +50C. If necessary, heating of concrete is carried out by heat guns. All materials and equipment should be stored in a warm warehouse + 150C.
2. Clean the surface of the entire reinforced concrete element from protective coatings, paint, efflorescence and other contaminants.
3. Remove all broken and structurally weak concrete.
4. Remove concrete in the area of reinforcing bars to a depth of 10 mm.
5. Water blast the prepared surface.
6. Clean bare rebar from rust and concrete mechanically down to metal.
7. Coat the treated rebar with the rust passivator Manoguard 133 Fer (according to the technical description for this material).
8. Moisten the concrete surface with water until completely saturated.
9. If the defect is located on a vertical surface, install the formwork on the reinforced concrete element. Ensure a tight fit of the formwork to the surface of the reinforced concrete element. In the upper part of the formwork, provide an opening and a funnel for supplying the grout.
10. Pour Starmex FM7 composition mixed with filler (see the technical description for this material) into the gap between the formwork with a reinforced concrete element.
11. Maintain a technological break of 24 hours.
12. Dismantle formwork.

Repair of extensive defects with a reinforced concrete structure using the shotcrete method:

1. Concrete at the place of repair and injection work must have a temperature of at least +5 °C. If necessary, heating is carried out by heat guns. All materials and equipment should be stored in a warm warehouse +15 °C.
2. Clean the surface of the entire reinforced concrete element from protective coatings, paint, efflorescence and other contaminants.
3. Remove all broken and structurally weak concrete.
4. Remove concrete in the place of exposed reinforcing bars to a depth of 10 mm.
5. Clean bare rebar from rust and concrete mechanically down to metal.
6. Water blast the prepared surface.
7. Coat the treated rebar with the rust passivator Manoguard 133 Fer (according to the technical description for this material).
8. Moisten the concrete surface with water until completely saturated.
9. It is required to apply a primer layer on the surfaces to be treated, consisting of 5 parts of the Starmex TM6 repair compound and 1 part of water, which are pre-mixed until a homogeneous mass is obtained. This must be done to improve the adhesive properties of construction materials.

10. Perform the restoration of extensive defects using the Starmex TM6 repair compound using the wet shotcrete method (according to the technical description for the material used). The repair mortar Starmex TM6 must be applied over the freshly applied binder composition. Application on ceiling surfaces is recommended in layers up to 50 mm thick.

3 Conclusions

On the basis of the performed visual and instrumental surveys and further processing of the results obtained, it can be concluded that the investigated building of the elevator silo housing is in a limited working technical condition.

Since the identified defects and damage to building elements reduce its bearing capacity and operational characteristics, it is necessary to apply the recommended measures for the restoration and (or) strengthening of structures, followed by monitoring (control) of the technical condition of the building.

The performed studies and the results obtained on the assessment of the technical condition of the building of the silo housing of the elevator can be used when monitoring the technical condition of structures and building materials of buildings of a similar type.

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