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Research Article

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Case Study of Technical Survey of Foundations of Cultural Heritage Objects

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ABSTRACT

The task of ensuring the reliable operation of existing buildings is an urgent problem in modern geotechnical construction. As a rule, the foundations of any building and structure, due to their operation in difficult conditions, are subject to groundwater, freezing and thawing, and other negative impacts. In order to reduce the negative impacts on them, as a rule, the working design provides for horizontal and vertical waterproofing. After the expiration of time, these elements often fail, partially or completely stopping the originally set parameters to prevent soaking of the foundations. This is especially true for cultural heritage sites (CHOs), because the requirements for trouble-free operation are increased. The article is a review and it considers one of the cases of technical inspection of the foundations of the building of the Chuvash Drama Theater.

Keywords: Grouting, Cut-Off Waterproofing, Portland Cement, Well, Surface Packer, Liquidation Plugging, Drainage

The most important structural element of the object is the foundation. Special requirements for operation are imposed on rubble foundations. At the same time, both horizontal and vertical waterproofing must be in good condition for the entire service life of the building and structure [1-13].

In order to inspect the foundations and the basement, six pits were planned and completed, sections of the basement part of the columns of the portico were investigated to solve the following engineering tasks:

1	Measurements to check the conformity of the foundations of the design documentation
2	Identification of buried sections of walls using hollow bricks
3	Identification and fixation of defects and damages of buried sections of walls, determination of the technical condition of building foundations
4	Checking the presence and condition of waterproofing
5	Instrumental verification of moisture in buried structures
6	Instrumental determination of strength characteristics of buried structures
7	Soil sampling for subsequent laboratory determinations of physical and mechanical characteristics
8	Evaluation of the bearing capacity of foundations

Below are brief descriptions of the technical condition of the body of foundations in the pits.

Pit No. 1 in axes 2 / (D-E)

The pit is made from the level of the basement floor. The pit was driven to a depth of 60.0 cm below the base of the foundation.

The soils are difficult to develop, the vertical slopes of the pit are stable, and no water has been found in the pit. Dangerous physical and geological phenomena, erosion and failures of the soil foundation, waterlogging and soil erosion were not identified.

According to the measurement results, the foundation is buried below the design mark and complies with the executive documentation, the dimensions of the foundations correspond to the design documentation.

Monolithic concrete foundation on crushed limestone, monolithic reinforced concrete tape 400.0 mm high.

On the concrete surface there are shells formed as a result of poor-quality compaction of the concrete mixture and do not exceed 5.0% of the monolithic concrete surface. No cracks, loosening, loosening or other damage were found in the foundation.

According to the results of non-destructive testing, the strength of structures is:

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1	concrete monolithic foundation not less than B15
2	concrete reinforced concrete tape not less than B15

In order to determine the physical and mechanical properties of soils, geologists took soil samples for subsequent laboratory studies.

The category of the technical condition of the foundation, based on the results of field and instrumental surveys, is assessed as workable.

Pit No2 in axes 12/K

The pit is made from the level of the basement. The pit was driven to a depth of 41.0 cm below the base of the foundation.

The soils are difficult to develop, the vertical slopes of the pit are stable, and no water has been found in the pit. Dangerous physical and geological phenomena, erosion and failures of the soil foundation, waterlogging and soil erosion were not identified.

According to the results of measurements, the overall dimensions of the foundation correspond to the design and executive documentation.

The foundation was erected from monolithic concrete on crushed limestone, reinforced concrete monolithic tape 400.0 mm high . The monolithic foundation rises 420.0 mm above the floor level . Between the brickwork and the foundation, a horizontal waterproofing of two layers of roofing material is provided.

Cracks, weakening, loosening and other damages in the foundation and plinth were not found.

According to the results of non-destructive testing, the strength of structures is:

1	concrete monolithic foundation not less than B12.5
2	concrete reinforced concrete tape not less than B12.5
3	ceramic solid brick M125
4	cement-sand mortar masonry M100

According to the results of selective control with a probe sensor, the moisture content of the brick in the basement is 0.0% (permissible value is 2.0%).

In order to determine the physical and mechanical properties of soils, geologists took soil samples for subsequent laboratory studies.

The category of the technical condition of the foundation, based on the results of field and instrumental surveys, is assessed as workable.

According to the results of field and instrumental surveys, the category of the technical condition of the basement is assessed as operational.

Pit No. 3 in axes 10/H

The pit is open from the street side. The pit was driven to a depth of 137.0 cm below the surface of the asphalt concrete pavement. Groundwater was not found in the pit. Dangerous physical and geological phenomena, erosion and failures of the soil foundation, waterlogging and soil erosion were not identified.

The foundation was erected from monolithic concrete on crushed limestone, with a 150.0 mm cantilever for the basement of the masonry. The rubble masonry is buried in the ground by 540.0 mm . The brickwork provides horizontal waterproofing of two layers of roofing material.

No cracks, loosening, loosening or other damage were found in the foundation. The plaster layer is wetted and destroyed. Wet brickwork.

According to the results of non-destructive testing of the material from the outside, the strength of the structures is:

1	concrete monolithic foundation not less than B15
2	ceramic solid brick M125
3	cement-sand mortar masonry M100

Results and Problems

According to the results of selective control of the outer surface of the wall with a probe sensor, the moisture content of bricks in the basement at the level of asphalt concrete is from 14.5% to 19.3%, higher than asphalt concrete by 250.0 mm - 3.6-7.0%, at the level of overlap within from 0.0 to 2.3%.

According to the results of field and instrumental surveys, taking into account the existing cracks, the category of the technical condition of the foundation is assessed as limited serviceable.

According to the results of field and instrumental surveys, the category of the technical condition of the basement is assessed as limited serviceable.

Pit No. 4 in axes (4-5) / A

The pit is made from the street side. The pit was driven to a depth of 10.0 cm below the base of the foundation.

The vertical slopes of the pit are stable, groundwater was not found in the pit. Dangerous physical and geological phenomena, erosion and failures of the soil foundation, waterlogging and soil erosion were not identified.

According to the results of measurements, the overall dimensions of the foundation correspond to the design and executive documentation.

The foundation is made of monolithic concrete on crushed limestone, with a cantilever 140.0 mm for the basement of the masonry. Reinforced concrete tape, monolithic, 400.0 mm high . The masonry is buried in the ground by 360.0 mm . Between the brickwork and the foundation, a horizontal waterproofing of two layers of roofing material is provided.

No cracks, loosening, loosening or other damage were found in the foundation. Brickwork under granite cladding in a wet state.

According to the results of non-destructive testing of the material from the outside, the strength of the structures is:

1	concrete monolithic foundation not less than B12.5
2	concrete reinforced concrete tape not less than B12.5
3	ceramic solid brick M150
4	cement-sand mortar masonry M100

According to the results of selective control of the outer surface of the wall with a probe sensor, the moisture content of the brick in the basement at the level of asphalt concrete is from 2.9% to 6.4%.

According to the results of field and instrumental surveys, taking into account the existing cracks, the category of the technical condition of the foundation is assessed as limited serviceable.

According to the results of field and instrumental surveys, the category of the technical condition of the basement is assessed as limited serviceable.

Pit No. 5 in axes 10′/H

The pit was dug from the level of the basement. The pit was driven to a depth of 111.0 cm from the floor level.

Groundwater was not found in the pit. Dangerous physical and geological phenomena, erosion and failures of the soil foundation, waterlogging and soil erosion were not identified.

The foundation is made of monolithic concrete on crushed limestone. Between the brickwork and the foundation, a horizontal waterproofing of two layers of roofing material is provided.

No cracks, loosening, loosening or other damage were found in the foundation. On the inner surface of the wall in plaster there are traces of soaking, but the wall itself is dry. The brickwork is not wetted.

According to the results of non-destructive testing of the material from the outside, the strength of the foundation structures is:

1	concrete reinforced concrete tape not less than B12.5
2	ceramic solid brick M150
3	cement-sand mortar masonry M50

According to the results of selective control of the inner surface of the wall with a probe sensor, the moisture content of the brick in the basement is from 0.0% to 0.5%.

According to the results of selective control of the outer surface of the wall with a probe sensor, the moisture content of bricks in the basement is 350.0 mm higher than asphalt concrete from 4.4% to 10.2%, 900.0 mm higher than asphalt concrete 0.0-1.5%, at the floor level ranging from 0.8 to 1.8%.

According to the results of field and instrumental surveys, taking into account the existing cracks, the category of the technical condition of the foundation is assessed as limited serviceable.

According to the results of field and instrumental surveys, the category of the technical condition of the basement is assessed as limited serviceable.

Pit No. 6 in axes 14 / (E-F)

The pit was dug at the ground floor level from the street side. It is located on the site of the entrance of engineering communications.

Groundwater was not found in the pit. Dangerous physical and geological phenomena, erosion and failures of the soil foundation, waterlogging and soil erosion were not identified.

The rubble masonry is made of a single ceramic brick on a cement-sand mortar. The brickwork provides horizontal waterproofing of two layers of roofing material.

No cracks, loosening, loosening or other damage were found. Dry brickwork. There are areas with loose bricks.

According to the results of selective control of the outer surface of the wall with a probe sensor, the moisture content of the brick in the basement is 0.0%.

According to the results of field and instrumental surveys, the category of the technical condition of the basement is assessed as limited serviceable.

In order to restore waterproofing, fill cracks and voids, ensure the solidity of foundation structures, a cut-off grouting project has been developed. The geotechnical technology algorithm is given below.

1	Cementation is carried out with cement-polymer mortars with a composition of 1: 0.15: 0.3 (cement: PVA polymer : sand); W/C =0.6; sand size modulus Mk =1
2	To strengthen the masonry, an injection mortar prepared from Portland cement without mineral additives of the M500 brand is injected at low pressures (no more than 0.2-0.3 MPa) into the wellbore until the calculated failure, which is taken to be the cessation of absorption of the solution by the well at an injection pressure of 0 .3 MPa
3	Technological process for grouting masonry fixing:
	3.1 well marking
	3.2 diamond drilling of a well with a diameter of 59.0 mm to the design mark of the mouth
	3.3 installation of a packer-conductor in a drilled well
	3.4 production of an injection solution
	3.5 injection of an injection solution at low pressures of 0.2-0.3 MPa
	3.6 crimping
	3.7 retrieving a packer from a well
	3.8 liquidation plugging by topping up the working solution into the wells and sealing the holes (after the solution has set) with sand-cement mortar until the surface of the column is leveled
4	Boreholes in each string are performed in eight grips in sequence according to this sheet. It is allowed to start drilling a subsequent well after cementing and gaining at least 70.0% of the strength of the cementing slurry and grouting of the previous one.
5	If the solution goes into the ground, as evidenced by a sharp decrease in injection pressure, stop injection in this well and let it stand for two days, then continue injection. If necessary , re-drill the cement stone

6	Core drilling should be started with columns in section 6-6, 7-7, 8-8, 10-10, 11-11 or 12-12
7	All geotechnical work on grouting the rubble of the foundation must be accompanied by geodetic control over the precipitation of the building with a regularity of once a week

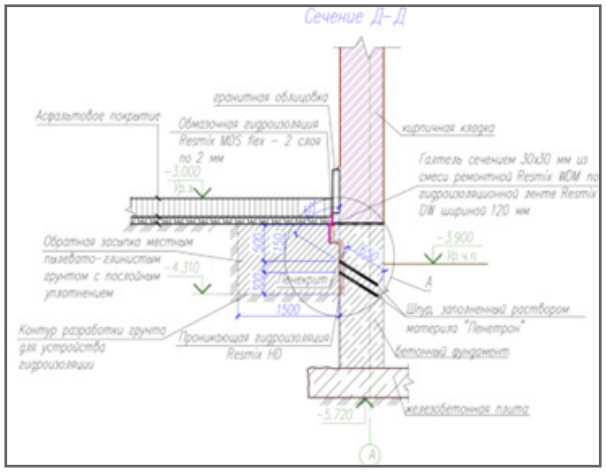

Figure 1: Scheme of injection wells along the "A" axis

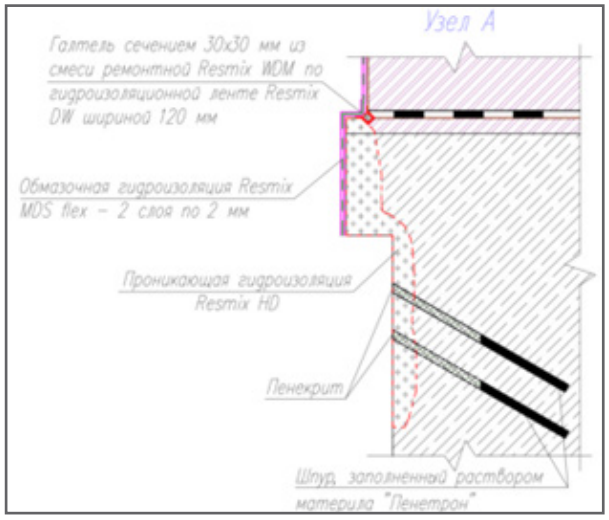

Figure 2: Scheme of the device of injection wells (for penetrating waterproofing device)

Figure 3: Scheme of injection wells (plan in axes "B" and "M")

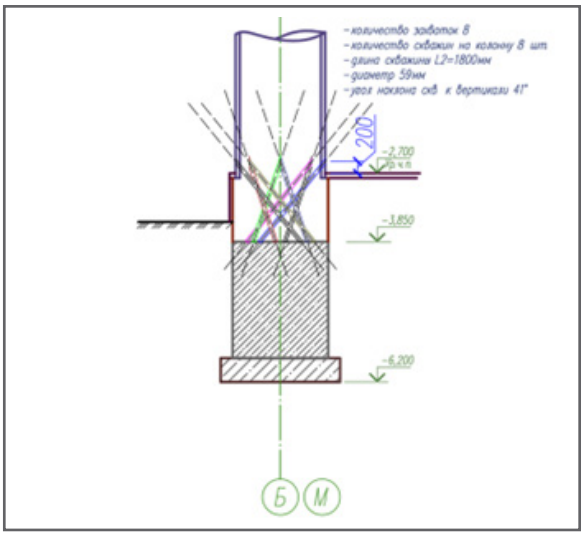

Figure 4: Scheme of the injection wells (section in the axes "B" and "M")

Conclusion

1. The purpose of this technical survey is to determine the actual technical condition of the building elements (the basement of the wall and foundations), to obtain a quantitative assessment of the actual quality indicators of structures (strength, humidity, etc.) in the amount necessary and sufficient for the development of scientific and design documentation for carrying out work on the overhaul of the basement and foundations.
2. Information about the object of cultural heritage of regional (republican) significance "Building of the Chuvash State Academic Theater named after K.V. Ivanov, 1961" located at the address: Chuvash Republic, Cheboksary, Red Square, 7, included in the unified state register of cultural heritage objects (monuments of history and culture) of the peoples of the Russian Federation as objects of cultural heritage of regional (republican) significance by order of the Ministry of Culture of Chuvashia dated 10 July 2020 No. 01-07/377.
3. In the course of field and instrumental inspection of the technical condition of building structures, the following defects and damages were identified:

3.1	through sedimentary cracks with an opening width of 1.0-2.0 mm for the entire height of the building in the outer walls
3.2	multiple temperature-shrinkage cracks on the facades along the entire perimeter of the building with an opening width of up to 1.0 mm
3.3	moistening of the external surfaces of the walls at the basement level
3.4	peeling of the plaster layer in the basement on the outer surfaces of the walls
3.5	local areas with stratification of masonry at the level of the basement (splitting of the outer corner of the wall)
3.6	unacceptable quality of brickwork of the socle of the columns of the portico, mois-ture, delamination of the masonry
3.7	horizontal and oblique cracks in the masonry at the junction of the hold spaces with the stage frame

4. According to the results of non-destructive testing of the material, the strength of buried structures is:

4.1	concrete monolithic foundation not less than B12.5
4.2	concrete reinforced concrete tape not less than B12.5
4.3	ceramic solid brick masonry walls M125
4.4	cement-sand mortar masonry walls M50

The strength of the material of building structures meets the requirements of the project.

5. The operational humidity of the outer surfaces of the basement of brick walls exceeds the standard values. The operational humidity of the internal surfaces of brick walls is within the normal range.
6. The category of the technical condition of the foundations and the plinth of the internal walls, as well as the plinth of the external walls along the axes 2, 4, B, L is assessed as operational. The category of technical condition of the plinth of the remaining external walls is assessed as limited serviceable. The category of the technical condition of the masonry of the basement of the columns of the portico of the central entrance is assessed as unacceptable. The category of the technical condition of the foundations is limited operable. The category of technical condition of the internal walls of the hold spaces with a stage box is assessed as limited serviceable.
7. According to the performed calculations, the average pressure under the base of the foundations does not exceed the calculated soil resistance in its natural state.
8. In order to prevent a decrease in the performance and technical condition of the building structures, take measures to bring the basement of the columns of the portico of the central entrance and the basement of the outer walls into a workable technical condition:

8.1	installation of horizontal cut-off waterproofing in the basement of the building
8.2	device for vertical waterproofing of the buried part of the brickwork
8.3	reinforcement of the brickwork of the basement part of the brick columns of the portico by grouting
8.4	replacement of pits on the side facades

9. At the time of the survey, active deformations of the bases of the foundations were not revealed. Sedimentary cracks on the facades are located in the same places that were identified in earlier work performed since 1990. Organize high-precision geodetic observations of building settlements in order to control wall deformations and prevent deterioration in the performance of building structures in conditions of subsidence of specific soils, incomplete reinforcement foundation foundations by gas silicification, the presence of sedimentary cracks in the walls and the planned reconstruction of the stage space. Use the preserved ones as the main wall marks, reinstall the rest, use the previously installed and new benchmarks. Under the conditions of operation of the building, geotechnical observations should be carried out at least every six months, and under the conditions of major repairs, restoration and adaptation - after a month.

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