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RESEARCH AND TECHNICAL REPORT

**Survey of Structures, Foundations and Soil Footing Condition for
House – Monument to Architect Konstantin Melnikov Located at
the Address: 10 Krivoarbatsky Lane, Moscow**

Contract 532/06

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1. MAIN POINTS AND BASIC DATA

1.1 Survey Subject

The survey subject is the existing residential house – monument to Architect Konstantin Melnikov at the address: 10 Krivoarbatsky Lane, Moscow.

The building is located in the Moscow Central Administrative District in the area of the Arbat Territorial Directorate in the historical urban development locale alongside the Arbat Street in the section bordered by the Arbat Street, Plotnikov Lane and Krivoarbatsky Lane.

The building location in the City of Moscow territory is shown in Figs, 1.1 and 1.2.

The building location among the neighboring structures is shown in Fig. 1.3

The building is split-level, of two and three stories, has a unique design and is an architectural monument.

It was built in 1929 with the individual design as a single-family residential house.

Since then reconstruction and restoration work has been carried out for the building.

In the late 1990s a high-rise building with underground parking was erected in the area adjoining the land plot of the house surveyed.

The technical condition of the building surveyed is characterized by cracks in its walls, partitions, floors and ceilings.

At the survey time in November-December 2006 the building surveyed was routinely used as a residential house.

According to the information from the client, a multipurpose shopping mall with extensive underground structures is to be built in the area immediately adjoining on the north (properties 39 and 41 Arbat Street) the plot of the building surveyed (Trust-oil Private Joint-stock Company is the core construction customer and investor).

1.2 Purposes and Objectives

The survey has been carried out due to the damage occurring in the building fabric.

The objective of the survey was to ascertain the technical condition of the building component structures, determine the soil composition at the foundation footing and in the land plot surrounding Melnikov's house as well as to provide recommendations on strengthening the soils at the footing.

The job on surveying Melnikov's house included the following main tasks:

- study of the earlier surveys results;
- engineering-geological survey of the soil at the footing;
- geophysical survey of the soils in the surrounding plot;
- technical survey of the building structures;
- geodetic measurements of the building settlement;
- calculation of the bearing capacity for the structures and the soils at the footing;
- compilation of a report on the survey results.

1.3 Work Methods and Scope

Pursuant to the performance specifications and the work program based on studying the existing archive materials relevant to the survey subject /1, 2, 3/, in order to study engineering and geological situation at the site and the soils underlying the foundation footing, 4 exploration shafts down to 2.7-meter-deep were sunk, 6 wells were drilled manually down to 5.6-meter-deep and electrodynamic probing (EDP) down to 10 meters was performed at 6 points.

The footing soil properties have been studied by sampling the soils with undisturbed and disturbed structures from the shafts and wells and analyzing the samples in laboratory conditions as well as by processing the EDP results.

The building structures technical survey has been performed as per Job Complexity Category 2 specified in MRR-3.2.05.02-00.

The building structures have been surveyed by organoleptic and instrumental methods.

The building foundations have been examined directly in the shafts.

The general structure technical condition, faults and their propagation patterns have been first inspected visually and then ascertained with measuring equipment. The building structures have been randomly stripped for examination.

Reciprocal siting of individual building elements, cross-section dimensions of elements and parts as well as fault sizes have been determined with the Disto-Klassik laser ranger, tape-measures, a metal ruler, set squares and a caliper.

The dimension measure accuracy is within 1 millimeter.

At dimension drawings premises sizes are approximated to 1 centimeter.

Rooms, except for specially mentioned cases, have been measured on outer surfaces of the structures (brickwork, plaster, lining, sheeting, etc.) without any destructing or stripping.

Crack opening width has been measured with a set of probes and a metal ruler. Crack opening depth has been determined with a metal probe.

Steel members in structures have been located with a Bosch metal detector and Poisk-2.4 tool made by Karat company.

Strength properties of stone structures have been measured with N-type Schmidt hardness meter.

High-precision measurements of the foundations and the building footings settlement have been performed by geometrical leveling method with Precision Class 1 short beams as per GOST 24846-81 "Soils. Methods of measuring building and structure footing deformation."

Karl Zeiss KONI-007 precision surveyor's level made in Germany and meeting the requirements for Class 1 surveying instruments (GOST 10528-76) and a Class 1 invar lined rod (GOST 11158-76) have been used for the measurements.

The main objectives of the geophysical survey, pursuant to the work program, have been to assess karst-suffosion hazards of the building plot and the surrounding areas as well as to ascertain the reasons for the day surface settling and caving close to the building.

Seismic survey methods have been utilized to attain the objective. The peculiarities of the seismic work making it significantly harder included closely located surrounding buildings (making the areas available for placing the profiles very limited) and various man-made background noise.

Reflection and refraction methods were used in the seismic survey.

FINDINGS

The following has been ascertained after surveying Architect Melnikov's house at 10 Krivoarbatsky Lane, Moscow:

1. The building surveyed is in a historical urban densely built-up area in the central part of Moscow and is a single-family residential split-level house of 2 and 3 stories with a basement under a part of the ground floor, built in 1929 with an original design and layout, in the shape of two cylinders of different heights with structural brick exterior walls and wooden floors, ceilings and the roof.

The building technical condition: many various faults in individual components and settlement-caused deformations. At the surrounding plot day surface settling and soil caving were observed in the late 1990s and early 2000s.

Geodetic measurements show that in the last 2.5 years the building exterior walls settled in various sections by 0.0 mm to 1.3 mm. During the regular observation period launched in 1999 the greatest settlement of exterior walls since the observation start has been in various sections from 1.8 mm up to 5.7 mm which is slightly more than permitted values for absolute and relative additional settling ($S_u=0.5$ cm and $(\Delta S/L)_u=0.0003$).

2. Geomorphologically, the area surveyed is within the ancient alluvial Khodynskaya terrace of the Moskva River. The area surface is flat with a slight south-eastern slope towards the Krivoarbatsky Lane. There is no blind area in the building.

The geological structure of the building plot is composed of Upper Quaternary and Middle Quaternary ancient alluvial sands as well as outwash sandy loam and sand which, according to the archive data, are underlain at the depth of 21.1-43.8 m below ground level with Upper Carboniferous limestone. On the surface the Quaternary sediments are covered with 1.4-4.0-meter-thick filled soil.

In the building area down to the depth of 12 meters groundwater is present as upgrade water observed at the depth of 6.9-7.3 meters at the absolute elevations of 132.01-132.55 meters. The upgrade water horizon is locally well-developed under the building line due to the significant lowering of the loam layer cover at that point. At the depth of 16.80-19.50 meters, at the absolute elevations of 121.43-121.61 meters groundwater of the over-carbonic waterbearing formation is widespread. That water saturates the outwash sand and clay sediments and circulates within the Upper Carboniferous limestone. The general flow direction of all underground horizons is to the north-east. The hydrogeological situation in the area has changed just insignificantly in the last 8 years.

3. The available geological data, the area tectonic survey performed and the geophysical materials obtained make it possible to conclude that the Melnikov's house land plot is practically fully located in the zone affected by a tectonic dislocation about 1.4 km in length. The dislocation axis traverses the plot from its south-western corner up to the north-eastern one, where the tectonic dislocation is manifest with a local subsidence of the carbonate sediment cover by 3 to 4 meters.

On the results of the geophysical survey performed and the geological data available the building land plot can be assessed as potentially karst-prone while the territory adjoining it on the north-east which is undeveloped for now – as karst-prone. Such areas are classified as high geological risks.

4. Caving on the surface observed from time to time in the Melnikov's house plot occurs mainly due to the suffosion of weakened soils in the zone of the tectonic dislocation observed. It should be noted that caving in the plot was occurring at the time of construction work in neighboring areas.

Caving in the Melnikov's house plot, according to the data obtained, can be linked to the presence of active tectonic dislocations and the overdeepening in the form of possible karst caving caused by them. Those processes can intensify significantly due to the man-caused impact and filtration of atmospheric and industrial water.

5. The foundations under the building walls are continuous with the depth mainly of 1.92-3.10 meters below the ground level and are made of crushed limestone masonry with compound mortar. The exterior wall foundation under the glass front at the building entrance is of the red brick masonry with the depth of 1.35 meters below the ground level.

The foundations stripped in shafts are in satisfactory service condition. The faults to note are weak, blown-out mortar in some places of the foundation masonry and some sections without any mortar as well as a crack in the basement interior wall opening up to 15 mm caused, among other things, by the foundation section resting on the filled soil and the sewerage pipe under the basement floor laid alongside the foundation.

6. The soil underlying the building foundation footing consists mainly of fine and average particle size sands which are loose or of medium density, low in humidity. Under the exterior wall foundation footing of the glass front at the building entrance and the basement interior wall foundation footing filled sand of medium density and low in humidity occurs with the layers thickness of 0.55 and 0.22 meters respectively.

7. According to calculations, the supporting capacity of the foundations and the soils underlying the footing, including the filled soils, is secure. The figures for the estimated settling vary from 2.9 cm up to 7.4 cm which is within the permitted values for absolute and relative settlements.

8. Structural exterior walls in the building perimeter and component cylindrical parts of its volume are of bricks above the ground and of crushed stone masonry in the basement.

Exterior walls support the building floors and roof as well as provide the building spatial stability.

There are window openings in the walls of the hexagonal, vertically elongated shapes with right upper and lower angles. The hexagonal window openings in the walls are in horizontal rows shifting in the staggered order and they form the wall cellular structure. Some openings are filled in.

The space between ends of the smaller cylinder walls forms a common bay filled with a glass panel front enclosing the building entrance door. Due to this the smaller cylinder wall structure is open-ended.

The technical condition of the walls: faults of the operating and structure-settlement type:

- exterior walls above the ground are damaged at the points of weakening by the hexagonal window openings with vertical cracks;
- locations of earlier fill-ins of the hexagonal window openings in the walls are visible on the wall surfaces;
- the plaster wall protective finishing is damaged by a network of cracks, in some places it has partially peeled off;
- in the plaster near water-supply pipes and under windows there are marks left by water leaking along the walls;
- the glass front components are out of alignment, some glass panels have cracked;
- near the ground the lower wall surfaces are damp.

9. According to calculations, the bearing capacity of the building walls, in absence of any externally induced additional settlement, is secure. Additional settling, recorded at geodetic measurements in 8 years of observation causes stresses in the wall masonry exceeding the permitted values and, as a consequence, leads to cracks emerging in the building walls. Furtherance of the building uneven settlement, especially soil caving directly under the building can cause emergency situations.

At the same time, the wall deformations present now are not significant for the wall functioning and pose no hazards in the normal use of the building as a private residential house. The technical condition of the walls is satisfactory.

10. The building interior walls in the basement (along B and C axes) are brick. The walls take up horizontal loads from the soil backup and serve as supports for the ceiling structures over the basement. The wall along B axis rests partly on the filled soil. The walls are damaged with cracks.

The technical condition of the walls is unsatisfactory.

According to calculations, the bearing capacity of the walls, provided the structure of the walls remain uniform, the adjoining walls function jointly and the layout is retained, is secure.

11. The exterior wall composing the flat facet of the larger cylinder in its upper part at the entrance to the open terrace from the building rooms is of wood, it is located between facets of the larger cylinder brick walls and rests on the smaller cylinder cover structure. According to the overall structural analysis for the building, the wall takes up the load from the larger cylinder roof structures.

The wall is substantially damaged with diagonal cracks continuing as cracks in the adjoining covering structures which proves that the structures function jointly.

The technical condition of the wall is unsatisfactory. It should be repaired and the wall structures should be strengthened.

12. The partitions on the building first and second floors are made of wood, plastered over lathing, on the first floor they rest on the floor soil foundation, on the second – on the floor structures.

The technical condition of the partitions: significant damage from diagonal cracks.

The building structural analysis shows that actually the partitions are vertical structural components taking up loads from the building floors and covers.

The technical condition of the partitions is unsatisfactory.

13. The basement ceiling is of monolithic reinforced concrete slabs over steel girders made of rails installed railheads up with the monolithic slabs resting on the rail bases.

The ceiling technical condition: steel girder and reinforcement bar corrosion.

Calculations show that with the full design loading, including load take-up from the first floor structural partition components, the fifth girder from axis 1 and the ceiling slabs under the partitions can be overloaded. Lack of any signs of overloading for the ceiling components can be explained by involvement of the basement heating unit partitions as supports in the ceiling structures functioning as well as by the fact that the loads actually imposed on the ceiling are significantly lower than those allowed by construction norms.

The bearing capacity of other girders and ceiling slabs located in the sections with lower loads and those without partitions is secure.

The ceiling technical condition can be accepted as serviceable, provided the current use terms as for the loads and the basement heating unit walls are retained.

14. Upper floors include the ceiling over the first floor on all the building plan and the ceiling over the second floor in the larger cylinder part. The floors are made of wooden membrane panels being grids of common joists placed on the same level and crossing at normal angle which rest on the building walls and are integrated into a single membrane system by double notching and boarding on both sides. The upper boarding of the membrane panel makes the floor. The lower boarding makes the ceiling. The upper and lower boards are placed crosswise and at the 45° angle relative to the common joists. The ceiling surface is plastered over lathing.

The floor technical condition: the ceiling plaster is damaged by cracks. In some sections the plaster has peeled off exposing the lathing.

Calculations show that the floors bearing capacity is secure only with the joint functioning of the boarding and crossed common joists as the single membrane panel structure also involving wooden partition structures of the first and second floors.

The technical condition of the floors is serviceable provided the interior partitions are retained and should be satisfactory after the floor repairs.

15. The used terrace space serves as the smaller cylinder roof. The roof structures include the second floor ceiling components and the terrace covers with galvanized steel drain conduits in-between. The ceiling over the second floor in the smaller cylinder is a wooden heat-insulated membrane panel in the shape of a circle truncated at the front face forming a corbel in the larger cylinder layout which is used as the stair landing and the interior mezzanine. The floor rests on the smaller cylinder walls and the interior wooden partition separating the room on the third floor of the larger cylinder from the second floor rooms in the smaller cylinder.

The membrane panel is made similar to the floor between the second and third floors in the building larger cylinder.

Faults and damage to the roof structure are:

- the floor sags down to 10 cm which exceeds the values allowed by construction norms;
- the terrace floor cover is deformed, the planking is damp, damaged with rot and natural growth;
- there are painted-over traces of water leaks and multiple crazing on the ceiling.

Calculations show that the membrane panel bearing capacity is secure provided the lower partition is involved.

The roof structure technical condition is serviceable. But the actual sagging of the structures substantially exceeds the design one meaning that the membrane panel structure is partially misaligned. In the future such misalignments can deteriorate, so, in addition to the general structure face-lift the roof structures should be stiffened or unloaded and, prior to that, deformations should be watched.

16. The roof over the larger cylinder premises is heat-insulated, single-pitch, with a slight slope towards the back face, combined with the third floor ceiling structure.

The supporting structure is a complex wooden assembly of several girders whose upper girths are formed by slanted trusses while the common lower girth is the third floor ceiling wooden membrane panel. The upper and lower girths are tied by vertical and slanted plank elements. The covering is made with boarding over the trusses. The membrane panel structure is similar to the floor ones but, unlike them, has no upper boarding. The membrane panel components rest on the larger cylinder walls, including the flat wooden wall serving as the terrace entrance.

The roof structures condition: the ceiling plaster is damaged with cracks. The ceiling sags down to 5 cm.

Calculations show that the roof bearing capacity is secure with the joint functioning of the membrane panel structure and the covering assembly.

The roof structure technical condition is serviceable, based on its appearance and calculations. The ceiling faults can be rectified by a face-lift.

But the actual sagging of the ceiling at the survey was down to 5 cm, even without the snow load, though as calculated for the top design load they should not exceed 0.9 cm. It seems that, despite the covering renovation, there are deformations caused by partial breakdowns in the joint functioning of the common joists and the boarding and the faults in the terrace entrance wooden wall.

17. The building stairs above the ground level are wooden, of various designs. The stairs up to the second floor are single-flight, of complex shape top view, located between the exterior wall and a partition. The stairs up to the third floor are spiral, enclosed with a circular partition. The stairs up to the open terrace are single-flight, open, straight. The stairs are unstable. Their components are worn out. Some elements are damaged with rot. The steps are worn. The technical condition is unsatisfactory.

18. The overall analysis of the building survey results allows to conclude that the general building technical condition is serviceable for the continued use as a residential house, like up to now.

The existing faults and damage to the building structures have been caused by its long service, lack of proper maintenance and timely repairs, the building design specifics, the fact that some foundations rest on filled soils as well as by common deformations of the soil masses in the building land plot, including those caused by constructing embedded structures nearby.

The existing faults and damage at present pose no hazards for the building residents, but reduce its service performance, impair its appearance and create the environment conducive to the building further deterioration.

19. In order to assure the continuous normal use of the building it should be overhauled with restoring and strengthening the damaged structures.

The overhaul should include:

- repairs of the building above-ground brick walls with filling cracks, restoring the plaster finishing, preventing the lower wall wetting (making blind areas, drainage, leveling the terrain, etc.);

- replacement or restoration of the glass panels at the building main front face; at making the new glass front its independent movement relative to other structures should be provided for or the wall ends should be rigidly connected;

- repairs of the below ground walls with filling cracks;

- reinforcement of the terrace entrance flat wooden wall with account for its functioning as the supporting structure for the larger cylinder roof assembly;

- repairs and reinforcement of the interior partitions with account for their actual use as supporting structures for the floor components;

- repairs and reinforcement of all floors and the roof supporting elements;

- repairs of the building finishing;

- repairs or replacement of the building entrance porch components;

- repairs of the building water piping and that at the adjoining territory.

20. All the work should be done with a special design pursuant to the building status as an architectural monument.

21. The design should provide for the joint functioning of the floor, wooden wall and partition structures.

22. Prior to the repairs the building condition should be closely monitored, including continuous measurements of the wall settling.

23. No changes in the mode of the surveyed building use leading to increased loads for the floors prior to its overhaul, such as conducting guided tours of the interior or organizing exhibitions, should not be permitted.

24. Due to the design solution for the building surveyed never providing for its functioning at possible emergency loads in the high geological risk area, any construction in the vicinity of the building surveyed, including the construction in the plot adjoining the site

from the Arbat Street side of the multipurpose shopping mall planned by Trust-oil Company can provoke intensification of the soil settlement and the surface caving which will be an unfavorable and inadmissible factor for Architect Melnikov's house preservation. In addition, it should be noted that the construction of the multipurpose shopping mall with extensive underground structures is planned for the karst-prone area where the Carboniferous age primary deposits subside sharply. Development of subterranean spaces in such areas is inadmissible due to hazard of subterranean slides occurring in the overlying mass of water-saturated sand Quaternary deposits.