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Repair and Rehabilitation Works in the Moscow State Conservatory

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Abstract The report contains brief historical information as well as structural description of the building. Results of the detailed inspection and structural state assessment of external and internal walls, floors and roof frame are given. These results were assumed as the basis for rehabilitation works to secure further safe operation of the building.

The authors give their technical solution for strengthening of external brick walls and attic space with the help of micro-cement and epoxy injections. A repair option is described to strengthen the brickwork near the roof tension bars with low-viscosity epoxy injections and subsequent application of cement-based repair mortar and gluing carbon-fiber sheets.

They also introduce their design of roof and attic load-distribution system consisting of cross-beams and steel tension bars as well as propose their solutions for strengthening brick vaults and columns in the basement with CFRP materials.

Keywords: Repair, rehabilitation, strengthening, injection, bearing capacity, CFRP

Introduction

Moscow State Conservatory (named after P. Tchaikovsky) was opened in 1866. It was founded by two brothers Rubinstein who were prominent Russian musicians of that time, popularized musical culture and built up the system of professional musical education in Russia.

In the beginning the Conservatory was located in a small private house rented for the purpose. But soon the house became too small: there were many people who wished to study music. So Rubinstein had to move to a bigger mansion with a concert hall owned by an aristocratic family who at first leased the building and in 1878 sold it to the Conservatory.

Yet, intensive educational and concert activities demanded to build still bigger and – what's more important – specially designated and equipped premises capable to accommodate both classrooms for students and concert halls for public. Since a new plot of land couldn't be allotted for the purpose the Conservatory administration was allowed to expand the existing building. Actually only the façade and the right wing of the former building were left, all other parts were built anew. So in autumn of 1898 students for the first time entered the reconstructed Alma Mater.

The Great Hall construction though took longer time: it was open to public in April of 1901.

At the moment the Conservatory buildings ensemble is included into the list of national architectural and cultural heritage (Fig. 1).

Figure 1: Moscow Conservatory building nowadays

Basic Technical Solutions

Historically determined variety of structural elements in different parts of the buildings, numerous extension and reconstruction works as well as long years of operation without proper maintenance and repair led to the situation when quite a number of bearing structures reached the emergency state.

At the moment the main building is being reconstructed with the simultaneous extension of usable areas in the basement and below ground parts.

We are going to consider in more detail the works in the right part of the building where the Small Concert Hall is located.

The main bearing structures include external brick walls, staircase walls, and internal brick columns connected by brick arches. These columns, arches, and walls give support to reinforced concrete slabs, brick and concrete vaults, and composite (concrete vaults over steel beams) structures. It must be mentioned that the external solid brick walls have variable thickness – from 1230 mm in the basement to 700 mm in the 4th and 5th floors.

Prior to starting with the design, the building was thoroughly inspected. The inspection results allowed to reveal serious defects in the bearing elements qualified as critical. A lot of cracks up to 30 mm wide were detected in a number of bearing walls, partitions, columns, arches, and vaults. A crack between an external bearing wall and a slab was found in the second floor right above the music library (with a collection of unique scores). Due to severe cracking several bricks fell out of the arch supporting a ground floor slab and bearing its load. All the internal columns settled down which resulted in changes of slab arches geometry. Brick vaults integrity was lost and their further operation ceased to be safe.

The pattern of damage and deformations pointed on over-loading of single columns and uneven foundation settlements, whereas new cracks gave evidence that deformations were still going on. In case settlements proceeded, collapse of several slabs would become highly probable.

The archives showed that problems with the bearing capacity of the vaults had started already at the stage of construction. Back in 1940 one of the vaults above the musical library collapsed. All the engineers who were ever involved in structural behavior monitoring agreed that basically problems with the Small Hall building were caused by non-uniform settlements of soils under its foundation.

The Small Hall building was reconstructed many times, some elements were strengthened, several slabs were changed, but all these couldn't stop the process of deterioration.

Prior to the next regular reconstruction of the building and rehabilitation of its facades it was decided to execute a number of urgent counter-damage actions to maintain service condition of all structures thus providing sufficient safety level of future reconstruction works.

Proposed design solutions were aimed at restoring the maximum possible degree of structural integrity and increasing the rigidity of the building frame. Moreover, special emphasis was placed on the fact that all the works had to be done from the inside so that not to interfere with the ordinary routine of the Conservatory (Fig. 2).

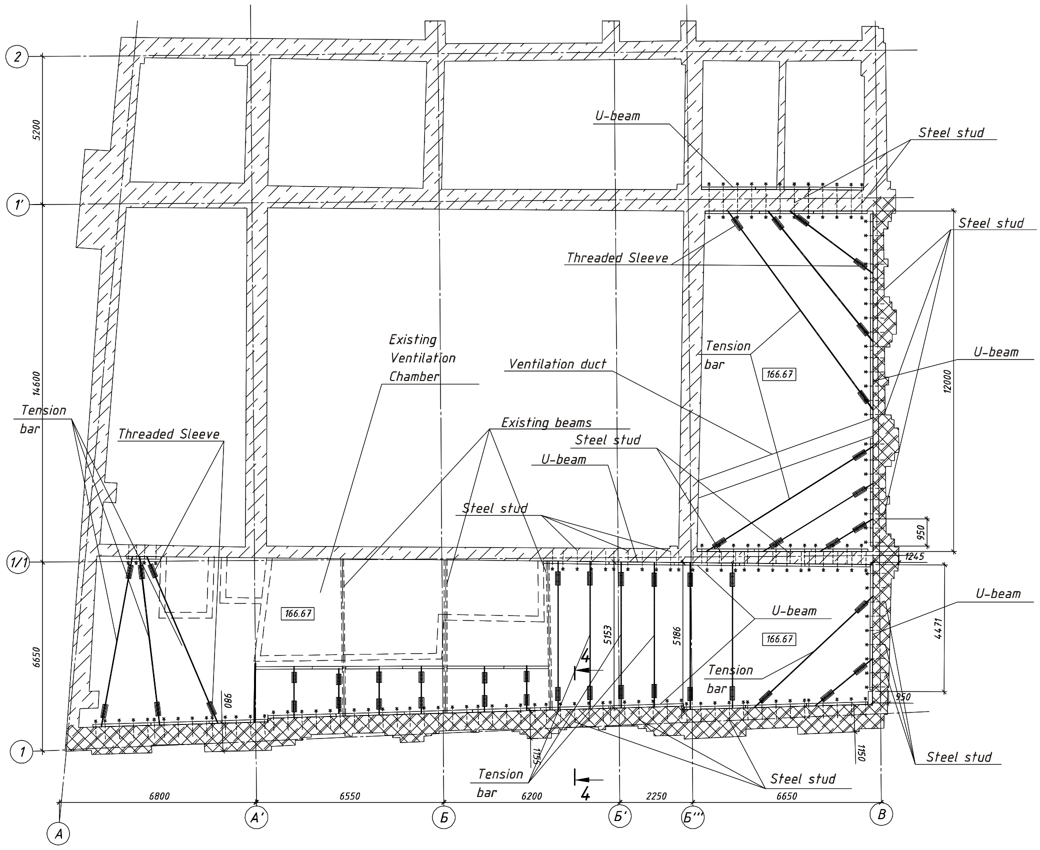

Figure 2: Section of a plan view of the building

First of all external brick walls of floors 1 – 4 and the roof space were strengthened. The procedure was as follows: steel studs were inserted in the holes of 8 mm dia. pre-drilled to ⅔ of the wall thickness and then anchored with an epoxy-acrylate glue; this was followed by micro-cement injections into the wall body which allowed – on one hand – to fill all delamination and voids in the brickwork found in the course of inspection, and on the other hand, to preserve structural dimensions unchanged.

The second important design task – to increase the rigidity of the building frame – was dealt with in the following way.

First the lower section of the external brick walls of the 2d and 3d floors and roof space was strengthened by injections of low-viscous epoxy resin, subsequent leveling with repair mortar and gluing carbon fiber sheets on top. Thus the brickwork got a kind of a stiffening belt to which horizontal load-distributing steel cross-beams were fixed with the help of steel pins and epoxy glue. Similar beams were installed along the internal walls. The beams were interconnected by steel tension bars 24 mm dia. with threaded sleeves. The sleeves were used for tensioning the bars with a specified force sufficient to hold the structural walls in the design position (Fig. 3).

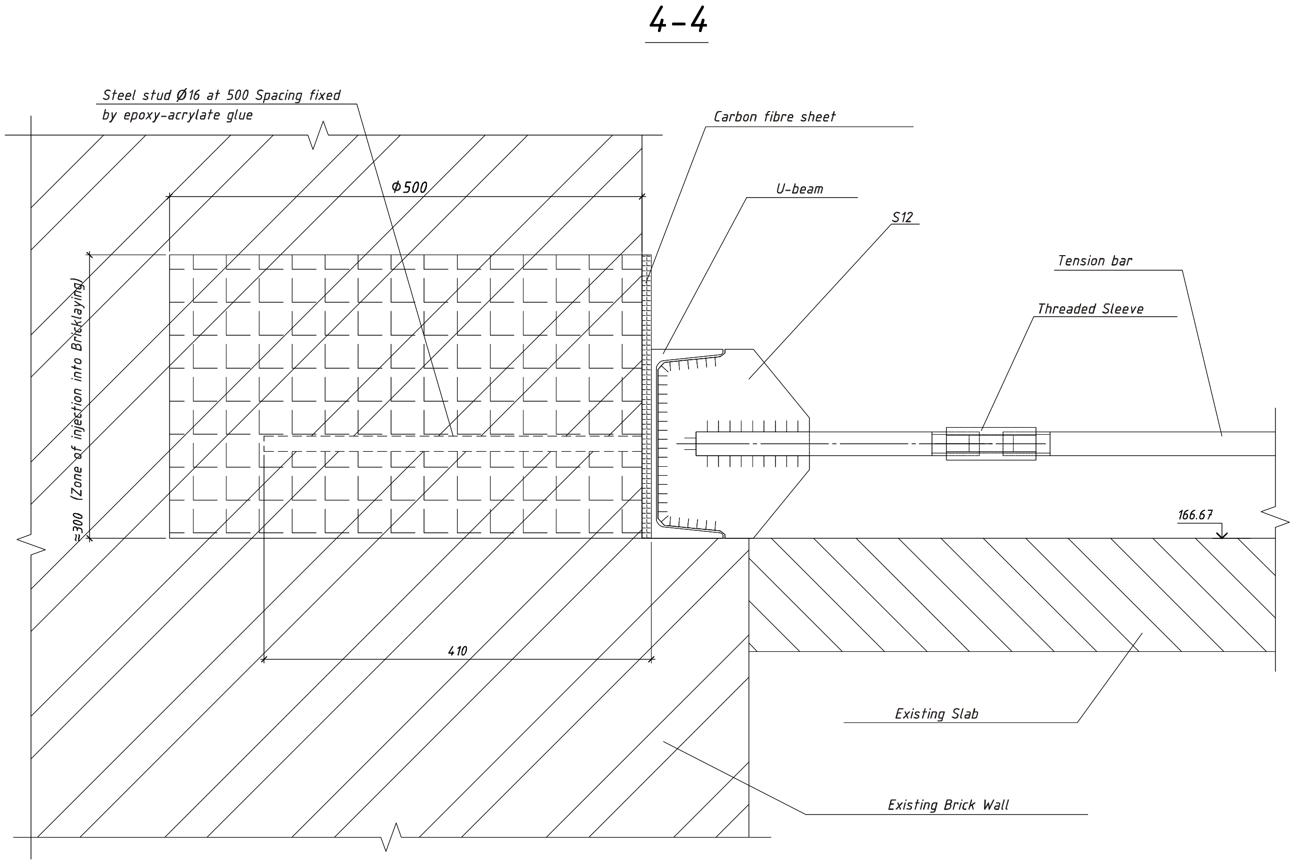

Figure 3: Attachment between a load-distributing beam and a structural wall

Brick arches in an emergency state at the 1st, 2d, 3d floors and in the basement were strengthened with steel bands.

Brick columns and arches in the basement which had been overloaded for years and lost partially their load-bearing capacity were strengthened by epoxy injections with subsequent wrapping with carbon fiber sheets and casting with the repair mortar.

Conclusions

Thus, injections of low viscous resins with subsequent application of repair mortar and gluing of carbon fiber sheets combined with installation of horizontal load-distributing steel beams allowed to provide the required rigidity of the brick walls. The additional consolidation of foundation soils and casting a concrete load-distributing floor slab in the basement provided stability of structural walls and slabs sufficient to guarantee safety for future large-scale reconstruction.