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Seismic stability of the restored architectural monument

Сейсмостойкость отреставрированного памятника архитектуры

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Abstract. The conservation of monument of architecture of XIX century – the Church of St. Archangel Michael in Sevastopol is discussed in the article. The analysis of the results of the survey of the building is developed and recommendations to strengthen the supporting structures of the church are worked out. The use of traditional methods for enhancing structural and seismic reinforcement of buildings with walls of masonry leads to the inevitable loss of the original facade or interior of the temple. To enhance the analysis and design of earthquake resistant walls pasted anchors performed experimental research collaboration adhesive bonding steel anchors in the stone elements from limestone Krymbalsk deposits. The proposed measures to strengthen allow performing repair and restoration work, without breaking the historical reliability of the facades. Comprehensive solutions for strengthening and ensuring of an acceptable level of safe operation in seismic areas are developed.

Аннотация. В статье обсуждается сохранение памятника архитектуры XIX века – церкви Святого Архангела Михаила в Севастополе. Произведён анализ результатов обследования здания, разработаны рекомендации по усилению несущих конструкций церкви. Применение традиционных способов усиления несущих конструкций и повышения сейсмостойкости зданий со стенами из каменной кладки приведет к неизбежной утрате изначальных фасадов или внутреннего убранства храма. Для расчета и конструирования, повышающих сейсмостойкость стен, клеиваемых анкеров выполнено экспериментальное исследование совместной работы клеевого соединения стальных анкеров в каменных элементах из известняков Крымбальского месторождения. Предлагаемые меры по укреплению позволяют выполнять ремонтно-реставрационные работы, не нарушая исторической достоверности фасадов. Разработаны комплексные решения для укрепления и обеспечения приемлемого уровня безопасной эксплуатации в сейсмических районах.

Historical information

The Church of St. Michael the Archangel in the city of Sevastopol (Fig. 1) [1] was constructed in 1849 on the initiative of the chief commander of the Black Sea Fleet – Admiral Mikhail Petrovich Lazarev. Author of the project is not exactly known, but it most likely colonel Fondervejde, creator of the Cathedral of St. Nicholas, St. Michael's Church because it was the Chapel.



Figure 1. The Church of St. Michael the Archangel in the city of Sevastopol. Historical views

During the 1st defense of Sevastopol garrison church was the main church of the city. Funeral service was conducted there in honour of admirals Kornilov, Istomin, Nakhimov [2].

August 2, 1855 in the church building hit out a bomb, which made it great destruction. The building was restored in 1857 at the expense of the contractor Ivan Krasil'nikov. In 1889 the church became the regimental church of the 50th Regiment Bialystok Infantry.

In the 1920s, in the building there was the Reading Room named after the French Communist Martyr. From 1931 Home Health Education was situated there. After World War II the building housed a small temple hall of the House of officers of the fleet. Since 1969 the hall number 8 of the Black Sea Fleet Museum is situated here (Fig. 2).

The building is rectangular in plan. Portal is in the form of niches in one another, covered by arches that rest on columns (two on each side) with Byzantine capitals. Archivolt is carved on the left and right of the entrance there are medallions with rosettes. The walls and columns are built up of small masonry blocks from Krymbalsk deposit (Inkerman).



Figure 2. Hall number 8 Black Sea Fleet Museum (Church of St. Michael the Archangel) in Sevastopol is directly adjacent to the House of officers of the Black Sea Fleet. 2012

Two-tier iconostasis with artistic icons made in Odessa by master Dmitri Pashin according drawing, drawn up at the District Engineer's Office by architect Maas. "Interior walls were made by designer Rafael Izellow according to drawing and the direction of the architect Maas with ceiling painted in the colour of the air. Furthermore, it was gilded two rods on the ceiling cornice Fritz "a la grec", with a width of 8

inches, with the width of the tape 1 inch" (Business Engineering Office of Simferopol distance to restore the Church of St. Michael the Archangel in 1870, No. 22).

Results of the survey

The building of the hall number 8 Black Sea Fleet Museum of Russian Federation is located not far from the sea in the south-central part of Sevastopol on Lenin street No. 11, on one of the slopes of the central hill of the city [3].

The construction site is located in the climatic region with the following characteristics [4]: weight of snow cover – 82 kg/m²; to wind pressure – 46 kg/m². The depth of soil freezing is 0.8 m. The plot on which the building is located, refers to the area from 8 – point the calculated seismicity map A [5, 6].

One-story building with a basement is rectangular in plan with dimensions 20.3 x 10.4 m. From the eastern facade was attached apse projecting from the plane of the eastern lateral walls 2.2 m. The height of the basement is 2.35 m, height of the first floor – 7.5 m. The height of the interior space of the apse is 6.0 m.

Foundations under the walls are of the tape rubble. The strength of limestone rocks compression corresponds brands 75–100. Fragmentary masonry made of stones stronger brands up to M 300–400. The width of the sole foundation is not less than 1.2 m, which is sufficient for such building. There is no deformation of the building associated with irregular deflections of foundation so the technical status of the bases is satisfactory. It should be noted that the lack of waterproofing basements require particularly careful drainage from the walls of the building during its operation.

Located in the basement boilers serving the adjacent building of the House of Naval Officers and practically does not work, is a serious threat to the monument of architecture of the XIX century in the case of industrial accident or leakage communications. In addition, when you run this equipment in the basement of the building, there are vibration exposure transmitted to the building and reflects negatively on their condition. It is advisable to this energy-intensive and inefficient equipment obsolete sample to be dismantled or brought outside the building of the monument of architecture of XIX century.

Stone columns section 750 x 750 mm located in the basement of the building are made of sawed limestone rock M75 are used as intermediate support beams hardwood floor basement. Technical condition is not suitable for further use without amplification. It is necessary to strengthen it by means of outside steel cage of angular steel.

Overlap of basement is made of wooden structures. Excessive deflections of wooden supporting structures overlap led to the beginning of the destruction of parquet flooring. Elements of overlap are susceptible defeat beetle carpenter. There are traces of a fire in the basement of the building which appeared in charring bearing wooden beams. Pairing beams with stone supports are made without any insulating spacers. Technical condition above the basement is defined as not suitable for further use without strengthening. In this connection, it is recommended to limit the service tour groups in the hall of the museum. Taken into account the actual state of the hardwood floor, it does not seem effective to strengthen it. Expedient removal and device of new overlap are used.

The walls of the building are made of stone masonry from Krymbalsk deposit. Compressive strength of the stone reaches the M 75–M 100. Because of the poor state of the roof and no functioning system water drainage from the roof there is damage of the limestone rocks by defrost. Need a local repair of damaged areas using grids and strengthening complex building mortars. In the cornice area of the walls the disclosure of masonry joints is observed. They need to be repaired by injecting masonry strengthening of specific products [7]. The technical condition of the walls is satisfactory.

In order to improve the building seismic resistance it is advisable to strengthen the outer corners of the building hidden by staging pasted anchors of reinforcing steel $\varnothing 12$ A 500 C length of 800 mm in mutually perpendicular directions. Be sure to mask their butts embedded indent by fragments of facade stone masonry (Fig. 3). Consolidation work arched bridges three windows of the southern wall (Fig. 4) by steel strip with pasted anchors (performed secretly unchanged appearance of the historic facade). Existing doorway in the south wall facade is converted into the window, according to the original appearance of the building.

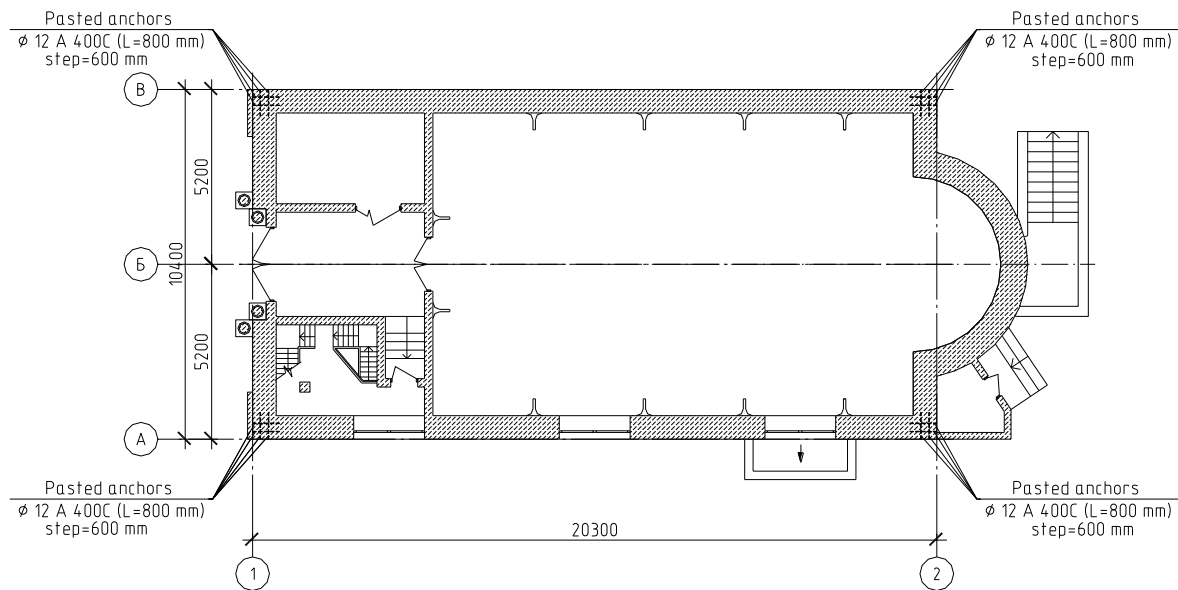


Figure 3. Scheme of strengthening the intersection exterior walls with help of pasted anchors of the Church St. Archangel Michael

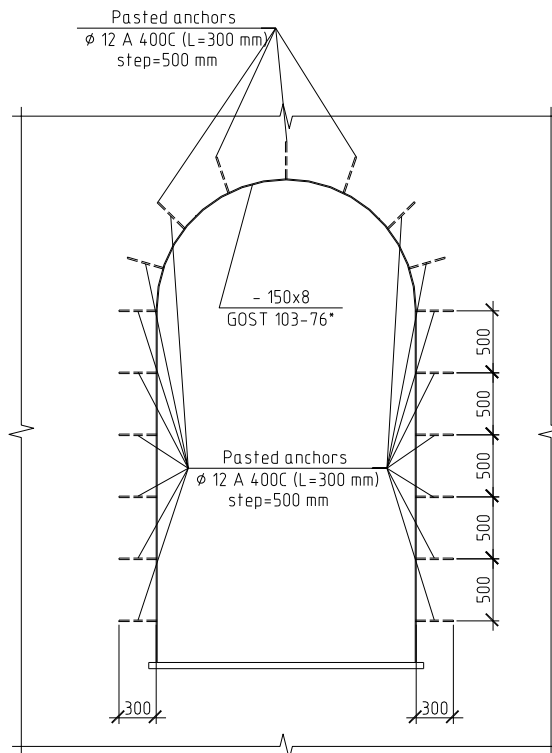


Figure 4. Amplification circuit arched window openings of the southern wall of the building by staging hidden pasted anchors

Reinforced belt section height 150 mm must be arranged on top of the walls of the main building. it is anchored with glued rods into three levels of height masonry.

The overlap of the first floor was made from metal and wooden trusses on wooden beams using board and plaster. The ceiling of the exhibition hall is damaged with cracks everywhere. The technical condition of the overlap is not suitable for further use without amplification. Given the seismic danger of territory and the simultaneous determination of the potential in the building of a large number of people, it is advisable to replace the heavy wooden ceiling on the modern lightweight suspension systems with efficient light insulation.

On the inner surface of the north wall there is a number of cracks in the stucco layer. All of these areas must be free from loose elements and repaired with the use of reinforcing mesh.

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The roof is made with the use of steel and wooden trusses. Steel trusses are in satisfactory condition. Two wooden trusses are in poor condition; need to replace them with new – metal.

Wooden elements of the roof are subject to constant local leakage and are technically able not suitable for further use. Bearing wooden elements on masonry gables are made without their fix. When you replace sections of the roof it is necessary to arrange the concrete belt height of 150 mm with the statement pasted into the body of masonry anchors and equipment issues for secure pairing with the elements of the roof.

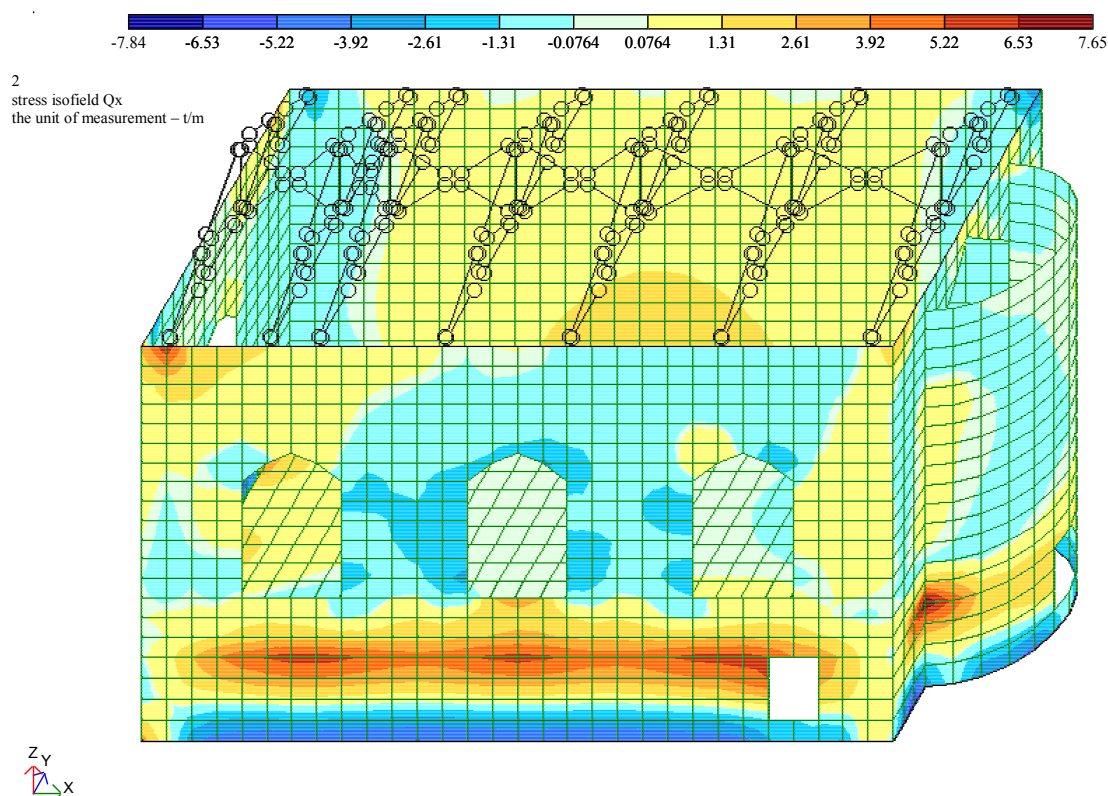
Bolting suspensions longitudinal joists of exposition hall corrode. Revision of all elements of the compounds is needed when replacing the elements of overlap.

It is necessary to set new metal girders instead of the dismantled wooden trusses and near gables. It is necessary to arrange vertical connections on farms, as well as the necessary horizontal linkages to the lower and upper chord. You need to enable gables through embedded parts in reinforced concrete (arranged) belt in the overall spatial zones of the new system load-bearing structures of the roof. Roofing replaced with new unit system water drainage from the roof, including the roof of the apse.

Dome is recommended to restore the original version of the dome at the western front wall as shown in Figure 1. Supporting the dome to implement the newly arranged by metal girders. Dome must be performed with metal-plating carcass of vertical walls with light modern materials.

The results of calculation

Spatial settlement building is made taking into account the recommended device of metal roof trusses connected by a common system with concrete belts on top of the walls (Fig. 5). Characteristics of materials adopted in accordance with the results of the survey. In the load on the farm is considered advisable to reconstruct the dome of a metal frame, the vertical part of which is trimmed with light facade materials.



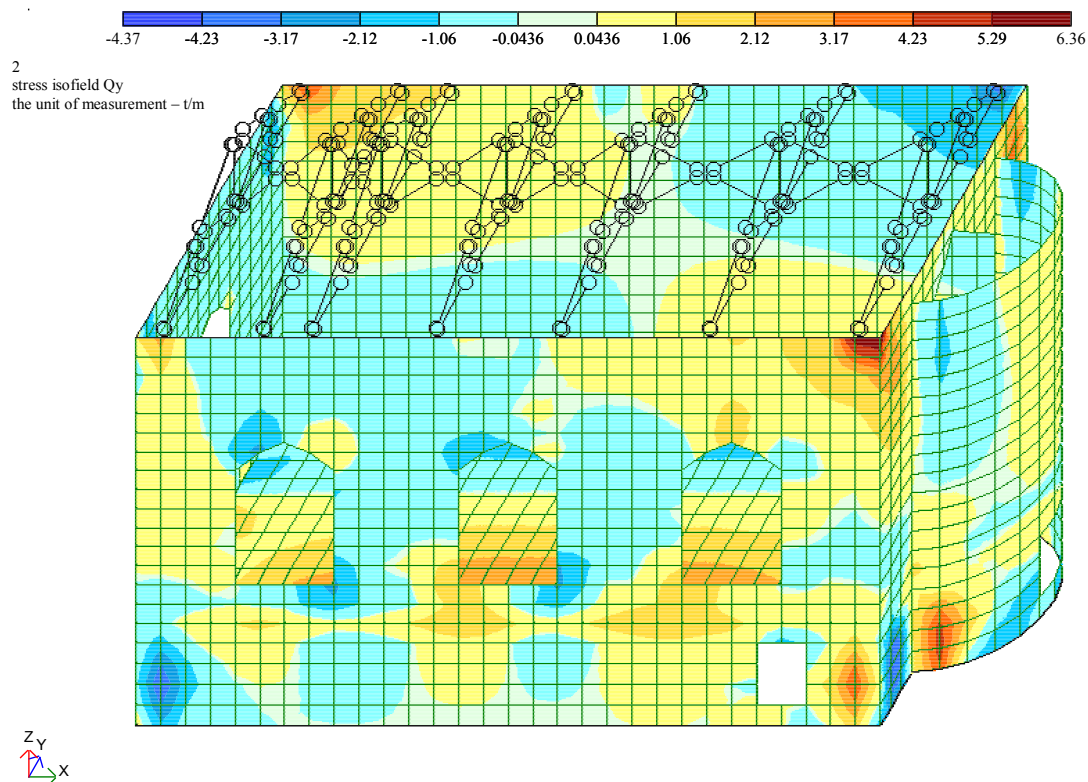


Figure 5. The contour plots of the critical types of stresses in the walls of the building

Existing metal girders may be allowed to continue operating without amplification. Their carrying capacity is sufficient for the perception of the newly arranged the roof with the new sheet metal ceilings of gypsum boards with effective easy insulation.

It is recommended to restore the historical authenticity of the building with three chimneys on the roof, which should be used for ventilation. Heating and ventilation of the building it is recommended to carry out the forced injection through the use of ventilation ducts. Air heating system combined with ventilation to provide a uniform temperature throughout the volume of the serviced apartments [8].

Conclusions

1. Supporting structures do not meet modern requirements for seismic stability of buildings [5, 6, 9–14]. Hardwood floor basement is in technical condition, not fit for further use. The absence of concrete vertical elements strengthening masonry walls and seismic belts makes use of the building for the mass people stay in the liturgy is very problematic.
2. The use of traditional methods for enhancing structural and seismic reinforcement of buildings [15–19] with walls of masonry lead [20] to the inevitable loss of the original facade or interior of the temple.
3. Proposed by the authors [21–23] the hidden designs of reinforcement of bearing masonry structures glued installation of anchors, opening up new opportunities preserve the authenticity of the Church of St. Michael the Archangel in the city of Sevastopol.
4. To enhance the analysis and design of earthquake resistant walls pasted anchors performed experimental research collaboration adhesive bonding steel anchors in the stone elements from limestone Krymbalsk deposits (Inkerman) 1840's. For steel anchors is widely used reinforcing steel $\varnothing 12$ A 500 C and anchor mixture – Ceresit CX 5. Exhaustion of the bearing capacity of the adhesive joint with a minimum depth of 300 mm sealing is achieved with loads of 2.5–3.1 ton. With further increase in load is pulling the anchor stone of the sample (size 200 x 200 x 400 mm) and was accompanied by his split from the main transverse tensile stresses. Split stones occurred at loads greater than 15–20 % load bearing capacity of the exhaustion of the adhesive joint (by limiting the displacement of the anchor relative to an end surface of the stone – 0.4 mm).
5. Given the almost complete absence of adhesion stones Krymbalsk deposit (Inkerman) Crimea with lime-sandy and sandy-clay masonry mortar employed in the first half of the nineteenth century, as well as a sufficiently high strength of these stones compression (reaching 75–100 kg/cm²) – Consolidation of masonry anchors hidden most loaded horizontal impact, with a potential earthquake zones of the

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building can increase its seismic resistance preserving the historical aura of the architectural appearance.

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