

STATE-OF-THE-ART TECHNOLOGIES OF IMITATION OF MURAL PAINTING FROM THE KYIVAN RUS AND BAROQUE PERIODS IN THE RECONSTRUCTED ST. MICHAEL GOLDEN-DOMED CATHEDRAL IN KYIV

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Abstract

The article deals with the issue of restitution of destroyed architectural monuments that remains disputable. Based on compliance with the world practice of restitution that is recognized at the legislative level, an example of restitution of a unique object of Ukraine is described – St. Michael's Golden-Domed Cathedral in Kyiv, destroyed in the period of the militant atheism of the 1930s. Specialists of the Ukrrestavratsiia Corporation completely reconstructed the volume of the destroyed St. Michael's Golden-Domed Cathedral and St. Michael's bell tower. The work focuses on one of the aspects of the accomplished rehabilitation activities – state-of-the-art technologies for performing mural paintings that imitate ancient Rus frescoes and baroque mural paintings. Reproducing the image-bearing concept of mural painting was one of the most challenging tasks, taking into consideration that photographic materials and evidence of interior decoration were not sufficient on the one hand, and the fact that the cathedral and monastery are functional – on the other, that imparted its peculiarity and called for painting the murals using up-to-date durable painting technologies. For these reasons, instead of the sophisticated and less durable technique of the ancient Rus frescoes, mural painting was used in the image-bearing system of frescoes, but in the state-of-the-art techniques of Keim's process or mineral painting. The possibilities of strengthening and monitoring cracked masonry structures that are the base of reconstructed frescoes are also presented.

Keywords: Restitution; Destroyed architectural monuments; St. Michael's Golden-Domed Cathedral; State-of-the-art mural painting technologies; Imitation frescoes; Strengthening, monitoring.

Introduction

The research topic is related to a problem that is still a topic of lively discussions in society and among experts. This is the problem of the feasibility and viability of reconstruction of architectural monuments destroyed as a result of political events or military operations, and in

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particular, the monuments of outstanding sacred, political and architectural and urban planning significance, iconic for the people, so their loss is a tragedy for the people. Before the restoration of the Old Town in Warsaw destroyed by World War II, such a problem was not raised at all. In the Old Town of Warsaw, blocks of a unique medieval residential development with the main Cathedral of St. John (Archikatedra SW. Jana Chrzyciciela) were destroyed. The issue of reconstruction of the Old Town, one of the main national symbols of Poland, in its original form, was raised in 1946. The reconstruction of the Old Town was the first unique example of such a large-scale reproduction that paved the way for the legalization of such events in front of the world community, since the Athens Charter of 1931 denied the possibility of full-size reconditioning of monuments completely destroyed. The reconstruction of Warsaw's Old Town lasted from 1945 to 1957. Despite the fact that the completion of construction of the destroyed parts of residential buildings and the cathedral was in progress, all activities were based on recognized scientific and methodological principles with thorough preliminary archaeological survey of each site and each building. It was then that the idea was articulated that "the language of architectural forms is time-independent", and the ideas of reviving the consciousness of the nation should dominate high professional doctrines [1]. It is not a coincidence that M. Orlenko in his monograph [1] turns the spotlight on the example of the restoration of the Old Town in Warsaw, since it was this example that made a real breakthrough in restoration activities, adding not only authentic, but also completely or partially restored unique objects to the cultural and artistic heritage of great value. However, despite this, even today the issue of restoring severely or completely destroyed unique objects stirs up a lot of disputes that cover the following aspects:

- if it is reasonable to include such reconstructed historical objects in the general list of historical and cultural heritage that consists of authentic objects and artifacts;
- if the monuments reconstructed in such manner, even if as authentically as possible, can be considered a historical object or just a pseudo-historical restoration;
- if the terms "previous state of the object" and "original state of the object" are always identical, since most historical monuments have been repeatedly rebuilt when they were in use, and if it is reasonable to restore the monument as is within a specific period of its ultimate development and architectural perfection;
- if it is possible and feasible to reproduce an architectural monument as it was rather within the period of the ultimate architectural perfection of the object than within the period right before the destruction [1].

Thanks to the implementation of the project of reconstruction of the Old Town in Warsaw, a new term "restitution" was coined in scientific and restoration circulation, meaning a specific type of restoration activities aimed at restoring the original volume and decor of an artifact, only small part of which survived, based on iconography, archaeological research, photo recording, studying analogues, and the like. The feasibility of restoring the unique objects destroyed was recognized first and foremost because, despite the critical reproaches of opponents, the restored development of the Old Town of Warsaw looks truly authentic and was included in the UNESCO World Cultural Heritage List. Following the Old Town in 1971–1981, the Royal Castle of Warsaw was reconstructed, as well as several other destroyed monuments in other Polish cities.

The importance of measures of destroyed monuments reconstruction lies not only in the fact that a material object or group of historical objects was returned to humanity, but in the fact that the attitude of society to such events changed, since they began to be interpreted in a certain philosophical, ideological, and political way, as the revival of national and universal values and as objects that represent certain national ideas, iconic for a particular people. Subsequently, the practice of reproduction was included in the monument protection sphere in international regulations and indicated in the UNESCO Recommendations on the Protection of World Cultural and Natural Heritage at the national level (Paris, 1972), in the UNESCO Recommendation Concerning the Safeguarding and Contemporary Role of Historic Areas with the requirements for the regeneration of destroyed urban planning ensembles (Warsaw – Nairobi, 1976). The next

legal documents that continued to legalize the practice of regeneration were the Declaration of Dresden (1982) that legalized the possibility of reproducing destroyed monuments in their original form if the required number of iconographic sources is available, and the Lausanne Charter for the Protection and Management of the Archaeological Heritage.

It is this international restoration experience and its validated legal base that have become the foundation and scientific and legal justification for the process of reconstructing outstanding monuments of Ukraine destroyed during Soviet militant atheism and during World War II. On the instruction of the President of Ukraine and the Cabinet of Ministers of Ukraine, a draft government-sponsored program was made for the reproduction of historical and cultural monuments of Ukraine, and in 1998 the List of Historical and Cultural Monuments Subject to Reproduction of Top Priority was approved. The fact that this problem is a burning issue for Ukraine is evidenced by calculations of the number of objects destroyed during the 20th century (there are more than 10,000 of them).

The list included destroyed objects that, according to the Convention concerning the Protection of the World Cultural and Natural Heritage (1972), UNESCO Recommendations, the Charter of the International Council on monuments and sites (ICOMOS), and other legal documents, met certain criteria, in particular, had a considerable influence on long-term cultural and artistic development, were of great national significance and of a unique creative character. It was recognized that such iconic objects of Ukraine are the ensemble of St. Michael's Golden-Domed Cathedral, the Assumption Cathedral of the Kyiv Pechersk Lavra, the Pyrohoshcha Dormition of the Mother of God Church in Kyiv, and St. Volodymyr's Cathedral in Chersonesos.

Taking into consideration the complexity and diversity of the reproduction process in each of these objects and the use of many unique technologies for the first time, it was decided to focus only on one such aspect in this study, in particular on state-of-the-art techniques for imitating the ancient Rus fresco mural painting in the central part of the St. Michael's Golden-Domed Cathedral restored after its complete destruction and baroque mural painting in the aisles of St. Barbara and St. Catherine.

St. Michael's Golden-Domed Cathedral is a unique monument that was originally built in the time of Kyivan Rus, and later underwent significant alterations during the Baroque period. In general, only a few historical sites of Kyiv from the Kyivan Rus period survived, and all of them were rebuilt during the Baroque period and completed in the 19th century. Among them there are St. Sophia Cathedral, the Church of the Savior at Berestove, St. Cyril's Church, St. Michael's Church of the Vyduhetskyi monastery, the remains of the Golden Gate. During the years of militant atheism, the unique ensemble of St. Michael's Golden-Domed Monastery was completely destroyed among hundreds of churches, only a few mosaics and frescoes survived. In the period of World War II, the Assumption Cathedral of Kyiv Pechersk Lavra was almost completely ruined by an explosion. It should be noted that in the time of Kyivan Rus, there were hundreds of churches in the city, but only few main churches were masonry, decorated with frescoes and mosaics, while most of the temples and chapels were timber and some of them were so-called "family chapels" in private estates. No timber temples survived, the information about them is contained in chronicles, documentary evidence of the existence of certain temples is obtained only during archaeological excavations, when the remains of timber foundations of buildings are found. Since we learn about the appearance of ancient Rus's timber churches in Kyiv from the chronicles only, partly, from the findings of archaeological excavations, the existing reconstructions of their appearance are only hypothetical. While masonry temples mostly survived, and as for those that were destroyed in the 20th century, there are measurements, photo recording, and individual artifacts preserved that is an argument for taking measures to reproduce them in accordance with their condition before destruction. The same applies to interior design, including mural painting.

The basic studies were grouped as follows. The first group of publications extensively studied includes articles devoted to general problems of preserving historical and cultural

heritage, historical landscape, the interrelation between the object and the natural environment, problems of restoration and monument protection activities and their tasks – this is the monograph by M. Orlenko [1], articles by I.C.A. Sandu et al. [2], P. Spiridon et al. [3], L. Pujia [4], J. Zilgalvis [5], Y. Ivashko et al. [6] and D. Chernyshev et al. [7].

The second group of publications concerned the analysis of international experience in preserving architectural monuments of a certain functional purpose. These are articles by Y. Ivashko and R. Kouider [8, 9], Y. Ivashko et al. [10], M. Orlenko et al. [11], Y. Ivashko et al. [12], M. Orlenko et al. [13], Y. Ivashko et al. [14], M. Dyomin and Y. Ivashko [15], M. Orlenko et al. [16], M. Orlenko et al. [17] and M. Orlenko et al. [18].

The third group of publications is devoted to current approaches to restoration, strengthening, monitoring activities, and restoration technologies. These are articles by A. Kulig et al. [19], M. Orlenko [20], M. Orlenko and I. Buzin [21], D. Bajno [22], Ł.J. Bednarz [23], Ł.J. Bednarz [24], I.J. Drygała [25] and D. Bajno [26].

The fourth group of sources concerns the research topic itself, works of monumental art. These are articles by M. Orlenko and Y. Ivashko [27] and P. Gryglewski et al. [28].

The fifth group of sources directly concerned the technologies of ancient Rus's fresco mural painting. These are publications by D.V. Ainalov and Ye.K. Redin [29], S. A. Vysotskyi [30], V.A. Shchavinskyi [31], L.I. Tolmachevskaya [32], M.K. Karger [33], V.N. Lazarev [34], P.A. Rappoport [35], L.P. Kalenichenko [36], L.P. Kalenichenko and O.F. Pliushch [37], Yu. Strilenko [38], Yu.M. Kuks and T.A. Lukianova [39 – 41].

We also studied special restoration documents and descriptions of technologies for performing mural paintings that imitate the ancient Rus fresco in the central part of the St. Michael's Golden-Domed Monastery and baroque mural paintings in the aisles of the St. Michael's Golden-Domed Cathedral. In the current context, in fully reproducible objects, it is economically impractical to apply completely authentic ancient Rus technology for performing fresco mural painting or oil painting, but it is possible to apply new state-of-the-art paint technologies based on the use of long-lasting resistant paints that imitate the ancient Rus technique, especially for the conditions of the main active Monastery of the Ukrainian Orthodox Church, when services are held in the church with a large number of clergy and believers, candles are burning, and as you know, these conditions are harmful to the state of authentic wall frescoes.

The study of such a diverse source base showed the commonality of problems in the restoration industry in different countries and made it possible to give reasons for the practice of restitution in relation to unique objects and a collection of objects. The study demonstrated the direct relationship between the architecture of the monument and the surrounding environment, that is, the need to preserve the authentic environment as much as possible. Approaches to restoration activities of objects of various functional purposes were also investigated.

Materials and Methods

Taking into account the specifics of the research tasks, we made use of such general scientific research methods as the method of historical analysis (to analyse the peculiarity of the fresco and Baroque mural painting of the St. Michael's Golden-Domed Monastery and to substantiate the feasibility of recreating destroyed monuments based on the evaluation of the existing international experience of restitution and the relevant legal framework for such measures), the iconographic method (since the St. Michael's Golden-Domed Cathedral was reproduced on the basis of archival sources, historical documents), the method of archaeological surveys, the method of full-scale surveys of frescoes and their fragments in museum expositions. We also included materials on up-to-date technologies of imitation of fresco and baroque mural paintings used during the reproduction of St. Michael's Golden-Domed Cathedral.

The main purpose of the study was to illuminate the general public about the experience of reproducing outstanding objects of Ukraine according to the international legal framework for such activities and describe some state-of-the-art technologies that were applied.

Results and discussion

St. Michael's Golden-Domed Cathedral was destroyed in 1934 – 1937 (Fig.1), the part of the unique ensemble that survived included only a part of the walls, cell buildings, refectory church, and a small part of mosaics and frescoes in museums and a high relief of Archangel Michael from the pediment of St. Michael's Cathedral. The history of the construction, destruction, and reproduction of the unique ensemble of St. Michael's Golden-Domed Monastery is described in detail in M. Orlenko's monograph, *St. Michael's Golden-Domed Monastery. Methodological foundations and chronology of reproduction* [42].



Fig. 1. Destruction of St. Michael's Golden-Domed Cathedral.
Photo is from the stock of Ukrrestavratsiia Corporation

This ensemble is unique in that it was taking shape within four periods and incorporated the signs of the ancient Rus style, the Baroque style, and historicism-eclecticism. The first period of 1108 – 1113 was marked by the creation of the ancient Rus central part (core) of the cathedral, according to archaeological research, at that time it was a single-domed three-apsed six-pillar temple decorated with frescoes and mosaics with dimensions in plain view of $28.8 \times 18.8\text{m}$.

The second princely period was marked by extensions to the volume of the cathedral of a small church from the south and two narthexes from the west and north, this temple known in scientific literature as the "baptistry" was dismantled in the 18th century because the Catherine Chapel was built, and the temple expanded.

The third period dates back to the 17th–18th centuries, the Baroque period, when the ancient Rus parts of St. Michael's Golden-Domed Cathedral were rebuilt, the northern narthex was dismantled, the western narthex was rebuilt, two side aisles of St. Barbara and St. Catherine were added that resulted in a complete transformation of the original single-domed volumetric and spatial composition of the cathedral, its area was expanded and the number of domes was increased to seven, facades and interiors were decorated in the style of Ukrainian Baroque. In the same period, the layout of the entire territory of St. Michael's Golden-Domed Monastery was changed and made more sophisticated, a three-tiered baroque bell tower with a gate in the lower

tier was built, as well as a refectory with the Church of St. John the Evangelist and the so-called Economic gate.

The last, fourth stage in the history of the cathedral and monastery dates back to the 19th–20th centuries, when in 1888 the cathedral was renovated, equipped with a hot air heating system, the flooring was replaced and auxiliary rooms were added. The overall image-bearing concept of interior decoration was not changed. Instead of that, considerable construction work of the late 19th to early 20th centuries continued in the adjacent territories and involved the construction of a large hotel for pilgrim visitors and a new building for fraternal cells. All these activities continued in several stages from 1857 to 1902.

The reproduction of this unique ensemble was started in accordance with the order of President of Ukraine Leonid Kuchma and the order of head of the Kyiv city administration O. Omelchenko, mainly at the expense of the Kyiv budget. The general contractor was Ukrrestavratsiia Corporation, and the architectural part of the project was developed by Yu. Losytskyi Architectural Workshop (Figs. 2 and 3).

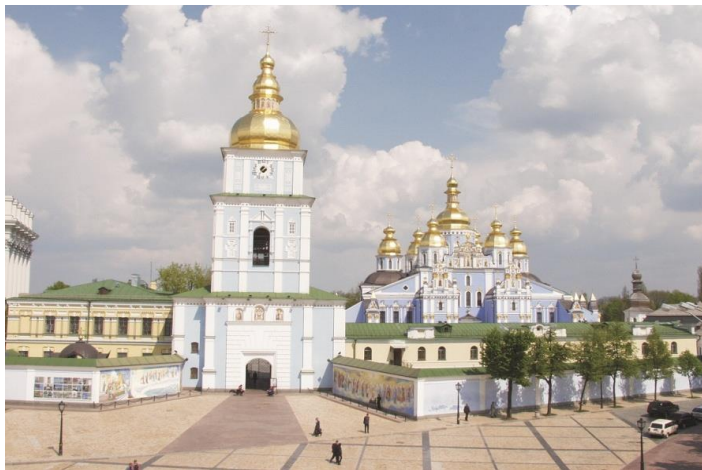


Fig. 2. Current state of St. Michael's Golden-Domed Monastery restored according to archival photographs. Photo is from the stock of Ukrrestavratsiia Corporation



Fig. 3. An archival photo of the St. Michael's Golden-Domed Monastery. Photo is from the stock of Ukrrestavratsiia Corporation

One of the most difficult issues was the reproduction of the interior of the cathedral that included paintings of different times (ancient Rus frescoes in the central part and baroque mural paintings in the side aisles). Only a few frescoes in museum expositions were preserved, as well as very low-quality photos of the 19th century, so to create an interior concept based on a combination of mural paintings, mosaics, icons, icon stands, altars, churchware, analogues of mosaics and mural paintings in churches of the same period were involved – Byzantine and ancient Rus's ones with reference to the central part, Ukrainian Baroque – with reference to the side aisles of St. Barbara and St. Catherine.

The authors of the interior concept developed for St. Michael's Golden-Domed Cathedral were specialists of Ukrrestavratsiia Corporation: I. Dorofiienko, I. Totskaia, L. Totskyi, A. Mamolat.

First, Ukrzakhidproektrestavratsiia Institute came up with two versions of the concept of interior decoration of St. Michael's Golden-Domed Cathedral. The final concept of mural painting in the interior of St. Michael's Golden-Domed Cathedral was approved in December 1998 at a joint meeting of the Scientific and Methodological Council for the Protection and Restoration of Urban Planning and Architecture Monuments of the State Construction Committee of Ukraine and the City Monument Protection Scientific and Methodological Council of the Department for the protection of historical, cultural, and historical monuments of the Kyiv City State Administration.

At the time when the St. Michael's Golden-Domed Monastery started to be reconstructed, restoration specialists already had a profound knowledge of ancient Rus fresco techniques in Kyivan Rus, but it is known that the frescoes were damaged due to later redraws mainly in the 18th – 19th centuries (mural paintings of St. Sophia Cathedral, the Church of the Saviour at Berestove and the St. Michael's Church of the Vydubetsky Monastery). However, according to full-scale surveys of the remains of frescoes, such repairs were carried out much earlier, in ancient Rus times (for example, ornaments around the window of the St. Michael's altar in the southern gallery of St. Sophia Cathedral).

Authentic techniques for making ancient Rus frescoes differed somewhat in the composition of materials and technologies at the original ancient Rus and subsequent stages of the 16th – 17th centuries. Since the topic of research is precisely the ancient Rus stage, it is worth noting that at the time when the central core of St. Michael's Golden-Domed Cathedral was painted, the base for the Fresco was made using purely Byzantine technology (a thin fraction of quartz sand or ceramic cement was added to the calcareous ivory ground according to ancient Roman technology). In the times of Kyivan Rus, finely crushed white stone was also added to the lime ground coat to make frescoes, and later, during the preparation of the lime base, lime was pre-aged, frozen, and repeatedly washed with constant mixing. The main drawback of such a ground coat is the presence of coarse grains of filler stone. Later, they could add chopped flax and a small amount of cow's bile, and the resulting gesso in the consistency of a thick dough was watered with a special strong organically based glue, thereby forming a calcareous ground coat without filler.

Based on the decision of the council, a draft interior design solution was developed for St. Michael's Golden-Domed Cathedral with mural paintings and icon stands, while the interior was completely painted – the central part in accordance with the system and style of the ancient Rus fresco of the 12th century, the aisles of St. Barbara and St. Catherine dating back to the 18th century – in accordance with the system and style of Baroque mural painting, while in the high altar with a bema and the eastern wall arch in the upper parts and in the main dome (vaults, drum, pendentives) mosaics are made.

A special feature of the decoration of cathedrals in Kyiv in the ancient Rus period is the preparation of the same two-layer and three-layer bases for frescoes and mosaics.

An important source of knowledge about fresco techniques is St. Sophia Cathedral in Kyiv, where the most frescoes and under the best conditions were preserved. The survey of the least damaged parts of the cathedral frescoes (as fragments of the frescoes of the northern part of the western gallery of St. Sophia Cathedral), with their original colour best preserved, the greatest state of preservation that were not redrawn, showed the vivid colour scheme using red and yellow

ochre, black, white, light gray and dark gray colours, imitation of the marble pattern. However, even the frescoes discovered only a few years ago and best preserved had mechanical damage, scratches, chips, scuffs, peeling from the masonry, traces of lime whitewash, shedding of parts of the images of the surface layer of the wall painting and the resulting opening of the ground surface of the base. As the restoration experience has shown, the frescoes are sensitive to surface soiling with dust, soot, backfill soil in the lower part, as well as to resistant dense (so-called "cemented") soiling that cannot be removed with a dry method and are removed by means of special technologies using an alcohol-water solution and a lancet. The loss of fragments of the fresco raises the question of adding small losses and wrapping the fresco plaster with the use of special formulations of mastics with filler and fixing the destroyed fresco layer with a solution of silicon resin or a solution of polydimethylsiloxane. There is also toning of places where a fresco was lost with a neutral paint tone with dry pigments diluted in a weak acetone solution or using watercolour water paints. The places where the fresco plaster was peeled off are injected, large cracks in the ground coat are pointed and sealed with lime-sand mortar, and strong cracks are not pointed, but sealed with a mass prepared from a solution of PBMA in acetone with chalk. Small losses, hollows, and injection holes are also repaired with this mass.

All measures taken to restore an authentic fresco are plotted on index maps of paintings made on a scale, the condition of the fresco before, during and after the restoration process is photographed, and at the end of the work a scientific restoration report is drawn up.

Thus, the technology of performing an ancient Rus fresco was characterized by labour intensity, complexity, and long-term duration, and at the same time, it did not ensure the necessary resistance to the negative effects of mechanical, atmospheric, and chemical factors. All the above mentioned was taken into account when recreating St. Michael's Golden-Domed Cathedral.

The peculiarity of performing mural paintings in the side baroque aisles and in the central part of St. Michael's Golden-Domed Cathedral, which before the destruction belonged to the ancient Rus period and was decorated with authentic frescoes, was that instead of the authentic technique of performing ancient Rus frescoes and baroque mural painting techniques, the technique of Keim's process ("mineral painting") was used that is based on the use of paints based on liquid potassium silicate and fast mineral dyes. The main justification for replacing ancient painting techniques with up-to-date Keim's process technologies was that the reproduction of authentic fresco techniques was impossible due to the complexity of performance, special preparation of the surface of the wall base, elaborate preparation of lime and paints, the lack of specialists experienced in this technique, and, most importantly, due to the fact that the mural painting will exist in a permanently functioning temple with a large number of people. These conclusions were justified by previous studies conducted by specialists from the State Enterprise State Scientific and Research Centre for Conservation and Restoration of Monuments (DNTZ Konrest). Studies have shown that the polluted air of a large city, a large number of people, and candle soot negatively affect the condition of the fresco made using traditional technology, as a result of which the outer paint layer becomes non-resistant to the cleaning process [43].

Such paints are marked by a good chemical combination with the plastered surface of the wall and as a result become an integral part of it. This result is very important, because such mural painting does not crumble or peel off from the base over time (unlike traditional ancient Rus frescoes, which constantly deteriorate from this). Another advantage of silicate paints is their resistance to light and moisture, resistance to the harmful effects of microorganisms, and seasonal temperature fluctuations. Surfaces painted with silicate paints are resistant to mechanical impacts and can be easily cleaned with water. Two variants of mural painting technologies are used in accordance with the task set:

- the first option is "pictorial paints" for painting on walls (based on them, paints for durable facade painting have been developed),
- the second option is "decorative paints" for ornamental painting.

Especially for the conditions of mural painting in St. Michael's Golden-Domed Cathedral, the DNTZ Konrest together with the German KEIM company developed the appropriate technology. As for their properties, the "pictorial paints" and the "decorative paints" are

somewhat different, since the technology of applying painting is more sophisticated, it is only soot and dust that are hazardous for "pictorial paints". For that reason, the fixed painting is covered with a layer of paraffin. Although "decorative paints" are made according to a simpler technology and do not need special preparation for priming, they differ from "pictorial paints" by the lack of transparency and lower intensity of tones.

The fresco imitation mural painting with the use of the technology of the "pictorial paints" was carried out in the following sequence: first, the wall surfaces were prepared for the mural painting by applying two layers of plaster, of which the first layer consisted of a mixed solution of sand, Portland cement, and slaked lime, the second, applied on the first layer after its complete drying, consisted of slaked lime (dry hydrated lime), a mixture of crushed marble, fossil meal, water, and a small amount of pure quartz sand. After the final drying of the second layer, the surface was etched with a weak aqueous solution of silicic hydrofluoric acid, as a result, the acid dissolved carbon dioxide lime on the surface of the plaster and turned it into soluble calcium silicofluoride that penetrates deep after subsequent moistening of the plaster with water. As a result, significant porosity of the plaster surface is provided, which, in turn, ensures the contact between the paints and the surface on which they are applied, as well as the contact with the silicate that fixes the paints. Lime tinkering acquires qualities corresponding to the fixation of paints with soluble glass. After that, the picture previously made on the wall is transferred to the wall and tinted with the desired colour of the paints (Figs. 4, 5, 6 and 7).

Work on the reproduction of mural paintings in the interior of St. Michael's Golden-Domed Cathedral was completed with paintings of the aisles of St. Barbara and St. Catherine in the baroque iconographic system and the arrangement of two icon stands. The problem was that the murals were reproduced according to archive photos, and when they were not enough – according to analogues. So, for example, according to the paintings of the St. Catherine's aisle, it was necessary to involve analogues of the 18th century, that is, as regards the period of the architectural and artistic golden age of the cathedral and at the time when the aisles were built.



Fig. 4. Gabriel Archangel. Mural painting in the central part of the cathedral. Photo is from the stock of Ukrrestavrtsiia Corporation



Fig. 5. Saints Peter of Alexandria and Dionysius the Areopagite. Mural painting in the central part of the cathedral. Photo is from the stock of Ukrrestavrtsiia Corporation



Fig. 6. The Entrance of our Lord into Jerusalem. Mural painting in the central part of the cathedral.
Photo is from the stock of Ukrrestavratsiia Corporation



Fig. 7. Prelate's rank: Leo of Rome, Sylvester, Saint Gregory the Dialogist.
Mural painting in the central part of the cathedral.
Photo is from the stock of Ukrrestavratsiia Corporation

Materials related to the iconographic system of mural painting of the Catherine aisle were provided by the authors – artists S. Bayandin and Yu. Guzenko. The system of paintings in this aisle was built traditionally for churches of the Ukrainian Baroque era:

- murals of completion: there are images of cherubim in the skoufos, the eight Prophets – in the sub-dome space, fire seraphim are pictured on the pendentives, the northern and southern walls of the sub-dome space have pediments with angels with cartouches "Lord of Hosts" and "Jesus Christ", on the northern wall there is an image of the Lord of Hosts, the Holy Spirit, the composition "Request for the Lord's prayer" with marginal scenes on its sides;
- murals of the two (central and western) capitals of the vault: the composition "The Queen of Heaven" (Fig. 8);
- paintings of the southern wall: the hagiographical cycle of St. John the Baptist and the image of five scenes from the life of the Holy Great Martyr Catherine, on the middle chapel – the composition "Catherine against the background of the Sinai mountains" (Fig. 9);

- paintings of the northern wall of the central chapel: the composition "The Sermon on the Mount";
- paintings of the central arch: the plot of "The Lord's prayer" consisting of ten thematic compositions with the image of the holy martyrs above them;
- paintings of the western arch: images of ten great martyrs with the image of the holy martyrs below;
- paintings of the western wall: scenes of the Apocalypse in the vision of John the Theologian;
- paintings of the altar vault: the composition "The Mother of God of the Sign" with the image of the eight Beatitudes under it, and under them there are "The Seven Sacraments of the Church", with "Jesus Christ – The Great Hierarch" in the centre of this row, and under it nearby there are the Saints, ornaments are depicted on the pillars, and in the lower part of the pillars there are images of martyrs.



Fig. 8. The lower part of the composition "Queen of Heaven". The Apostles.
Photo taken by the author, S. Baiandin



Fig. 9. The cycle "The Life of St. John the Forerunner" on the southern wall of the Catherine aisle.
Photo taken by the author, S. Baiandin

According to the aspects presented above, the image-carrying concept of the Cathedral presents the recreated golden dome of St. Michael, in the form put into operation, as an integrated system by combining two parts - the central one, which is inspired by the ancient fresco mural from Russia, and the side aisles of St. Barbara and St. Catherine imitating 18th-century Baroque murals (Fig. 10).



Fig. 10. The central part of the restored St. Michael's Golden-Domed Cathedral with the main baroque icon stands. Photo from the stock of Ukrrestavratsiia Corporation

Thus, the entire interior iconographic concept of the Cathedral has the aisle of St. Catherine made in the style of the recreated baroque icon and which belonged to the same chronological period as the old mural.

The example presented in this paper focuses on the idea of making new frescoes, but we must not forget that even a new construction (especially such a monumental one) may require, over time, reinforcements and the use of building geometry monitoring systems. Of course, it is possible to use composite materials for consolidation and monitoring of sensors installed in the building that measure vibrations, crack expansion, deviations, etc., but this method is very expensive and requires the analysis of large amounts of data. This approach only shows changes to certain measured benchmarks, not global changes.

Probably the most effective way to describe the behavior of a building structure is to monitor based on the periodic recording of cracks, displacements, and the measurement of landmarks or areas using 3D scanners or orthophotography.

Conclusions

The experience of restoring St. Michael's Golden-Domed Cathedral proved the possibility of using new advanced paint technologies when recreating unique objects of a large construction volume. The peculiarity of new technologies like these is their increased resistance to negative external factors and efficiency of their use under full-time service.

The analysis of the ancient technologies of Kyivan Rus fresco mural painting showed high labour intensity, long-term duration, non-resistance to detrimental effects of the outside environment, as well as the need for frequent restoration.

For this reason, taking into account the peculiarity of the existence of St. Michael's Golden-Domed Cathedral as a functioning temple, the advanced technology of Keim's process ("mineral painting") was used, which is based on the use of paints based on liquid potassium silicate and persistent mineral dyes, which are characterized by the chemical combination with the tinted surface of the wall and strong adhesion to the primer (as already mentioned, in ancient frescoes, peeling of the paint layer from the primer is one of the main problems).

Such mural painting in the technique of Keim's process is resistant to light, moisture and mechanical impact, as well as to the negative effects of microorganisms, and seasonal temperature fluctuations, and can be easily cleaned with water.

In St. Michael's Golden-Domed Monastery, two variants of mural painting technologies were applied in accordance with the tasks set: for painting on the walls of the central part and the aisles "pictorial paints" are used – the brighter ones, with a more sophisticated application technology and covered on top with a layer of paraffin to protect from candle soot and dust, while ornamental painting was made using "decorative paints", opaque, less intense in tone and simpler in terms of application technology.

In the aisle of St. Catherine, the technique of *alfresco*, the so-called illusionist painting, was also used to imitate three-dimensional fragments on the plane by means of painting (stucco cornices, frames, cartouches with gilding). *Alfresco* painting has broad options of imitating stucco details of decor, pillars, ceiling lights with elaborate carvings. It makes it possible to imitate gilding, marble, and natural stone. Before the work starts, a layout of painting and life-size cardboard images is made. Such paintings are made on a lime-sand base, treated with heated linseed oil varnish, and after the drying oil covered layer becomes dry, casein and oil putty are applied over it and is covered with linseed oil varnish, completely dried, and upon the dried layer thick whitewash is applied, fixed, after that an acrylic or emulsion primer is applied and the image from cardboard is transferred onto it. The final stage is image colouring.

In its accomplished form, the image-bearing concept of the recreated St. Michael's Golden-Domed Cathedral proved its integrity in the combination of two parts – the central one, which is inspired by the ancient Rus fresco mural painting, and the side aisles of St. Barbara and St. Catherine that imitate the mural paintings of the Baroque period of the 18th century.

Periodic comparison of the geometry of a building structure using scanning methods, e.g. point clouds, can be used as a method of monitoring the geometry of fragments of a building (including new, reconstructed frescoes), or the whole structure with a good approximation and in a non-invasive way, including monitoring of cracks and damage. It is a very precise method that does not generate significant costs and is not excessively time-consuming. The resulting data provide accurate and reliable geometric data that can be used in structural analysis.

The presented methodology does not always give a full picture of the actual behaviour of the building. Only indicates the probability of processes that can be prevented in advance. The most effective way to describe the behaviour of the building structure is very well described in the literature and cited: modelling and digital monitoring based on periodic registration of cracks, displacements, geodetic measurement of reference points, and increasingly popular periodic geometric monitoring using point clouds supported by a wide range of specialists.

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