

ISSUES AND METHODS OF RESTORATION  
OF THE ARCHITECTURAL MONUMENTS  
IN UKRAINE (11th century – the beginning of the 20th century)

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PROBLEMY I METODY REKONSTRUKCJI  
ZABYTKÓW ARCHITEKTONICZNYCH  
NA UKRAINIE (XI wiek – początek XX wieku)

Abstract

The modern theory and methodology of the restoration science in the field of protection of the immovable architectural heritage in Ukraine, based on a vast array of information about the world and national experience of the restoration works, the re-creation of architectural monuments during the last two centuries, is largely determined by the general state of architectural and town planning science, which is currently at the stage of transition from purely traditional research methods to the use of the latest achievements of the systems approach and the representation of architectural objects as complex systems and, accordingly, models – functional, morphological and informational.

The lack of established decision-making procedures in the field of restoration of architectural monuments, a structured knowledge base: logical inference and input of information, on accumulated facts and rules, with insufficient, in comparison with the volumes of design and research works in the field of restoration.

*Keywords: issues and methods, restoration, architectural monuments*

Streszczenie

Współczesna teoria i metodologia nauki konserwatorskiej w dziedzinie ochrony nieruchomego dziedzictwa architektonicznego na Ukrainie, oparta na szerokiej bazie informacji o światowych i krajowych doświadczeniach prac konserwatorskich, rekonstrukcji zabytków architektonicznych w ciągu ostatnich dwóch stuleci, jest w dużej mierze zdeterminowana przez ogólny stan nauki architektonicznej i urbanistycznej, która jest obecnie na etapie przejścia od czysto tradycyjnych metod badawczych do wykorzystania najnowszych osiągnięć podejścia systemowego i przedstawiania obiektów architektonicznych jako złożonych systemów i, co za tym idzie, modeli – funkcjonalnych, morfologicznych i informacyjnych.

Brak ustalonych procedur decyzyjnych w dziedzinie renowacji zabytków architektury, uporządkowanej bazy wiedzy: logicznego wnioskowania i wprowadzania informacji na temat zgromadzonych faktów i zasad, niewystarczającej w porównaniu z ilością prac projektowo-badawczych w dziedzinie renowacji.

*Słowa kluczowe: problemy i metody, renowacja, zabytki architektoniczne*

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## 1. INTRODUCTION

Restoration field employs specific methods of architectural space solutions aimed at maximum preservation of the authentic look of the monument. The core issues of the restoration field can be broken up into legislative ones, attributable to imperfection of the monument protective record-keeping system of listed buildings and heritage assets and failure to comply with the relevant requirements, underperformance of monument protective institutions, and restoration issues specific to functioning of the restoration field, including a list of problems of emergency state of historical heritage sites and ways to cope with them in compliance with the requirements in place. Nowadays a huge concern of historic cities is a conflict of historic and new built development: contemporary architecture intrudes into historic zones, buildings restructured for new functions are uncontrollably exploited, underground car-parks are constructed, historical heritage assets are overbuilt, high-risers are erected nearby, that in aggregate breaks the static character of the architectural monuments, brings about changes of hydrogeological conditions under the foundations, loss of foundation parts and, at the end of it, to the emergency state of the protection sites.

In spite of a great amount of scientific information on the problems of historical monuments restoration and restoration methods, no systemic approach has been employed yet in summing up the problems and restoration methods, no summary has been made of reasons, varieties and character of the emergency states of the basic components and elements of architectural and structural systems, as well as interior and exterior décor elements of restoration sites, there have been mostly descriptions of examples of restoration of certain buildings, or restoration techniques have been presented in the form of methodological and regulatory literature, instead of summing up and analyzing international best practices of restoration on particular sites – starting from the emergency state issues and further subsequently to restoration of individual components. Besides, it becomes necessary at the international level these days to establish scientific substantiation of the restoration field development lookouts according to the dynamic pattern of real needs of monument protection activity and the common character of problems in many countries of the world.

Restoration techniques directly depend on dating of a monument, as long as masonry methods and mortars of a certain chemical composition used in the days of the Kyivan Rus and those applied in the Middle Ages and Renaissance, baroque and classicism, historicism-eclecticism and Art Nouveau are quite different. There is also such a freestanding segment as restoration of wooden architectural works.

## 2. MAIN PART

### 2.1. SPECIFIC CHARACTER OF THE RESTORATION FIELD FUNCTIONING AND APPLYING THE SYSTEM APPROACH

The specific character of the restoration science is that it includes a vast variety of aspects, as far as in the sphere of its scientific and practical activity it incorporates knowledge of many scientific disciplines that makes restoration an interdisciplinary science that puts into practice the achievements of architecture and construction, archeology, history, cultural studies, study

of art, physics, chemistry, study of materials, aesthetics. Another specific feature of the restoration science is that it is aimed at problems and ways to solve them according to particular tasks rather than at perfunctory accumulation of scientific knowledge.

If we compare issues addressed by the Ukrainian restorer today with those dealt with in the days when the restoration science came to existence as such, from the early XX century and throughout the XX century, we will see that the current issues of restoration are much more complicated, and techniques are far more advanced, because for the period of existence of this field there has been accumulated a huge layer of special restoration information about the reasons of breakdown susceptibility of buildings and ways to eliminate them, restoration methods are all the time being improved and enriched with new technologies, that is encouraged by constant international contacts between specialists in the field.

In spite of constant improvements of the restoration field and new technologies it is enlarged with, its basis remains intact – it is a maximum compliance with the fundamentals of conservation, i.e. minimum interference in the monument centerpiece.

The general state-of-the-art of the architectural and urban planning science is characterized by departure from traditional research methods to using latest advances of the system approach and presenting the pieces of architecture as complex systems and accordingly models – functional, morphological and information ones, that in Ukraine influenced the present-day theory and methodology of the restoration science in the area of architectural heritage protection of real estate architectural heritage assets based on a huge information array about international and national restoration work experience of recreation of architectural monuments within the period of the recent two centuries.

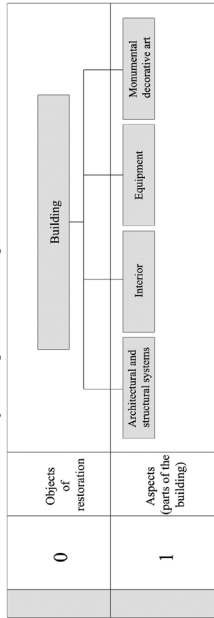
The restoration process itself is described with structural and logical models, e.g., outer surfaces of the restoration object are analyzed according to the model that includes a foundation, a wall, a copestone and a roof. This makes it possible to arrange to an organized system the reasons of the emergency state and ways to mitigate it, since practices and their sequence differ in cases of a completely ruined object being reproduced, a substantially ruined object or a partially ruined object. The system approach consistently addresses reasons, varieties and character of damages of the basic components of architectural and structural systems: base and foundations, walls, floors, copestones, roofs and ways to reinforce them (Ill. 1–2).

A review of the main issues causing the emergency state of the monuments and a list of most common restoration technologies give the evidence that the underlying problem of imbalance of the statics of “base-foundation-building” system is the unevenness of foundations subsidence, loose grounds of the base, watering of base grounds caused by waterproofing failure or absence (Ill. 3).

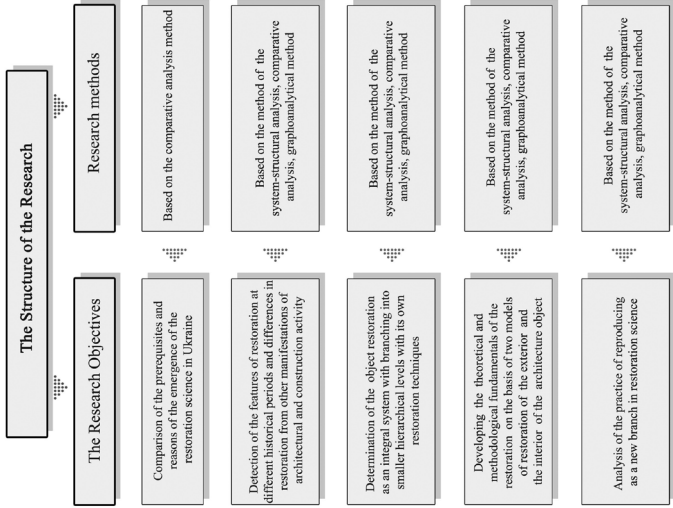
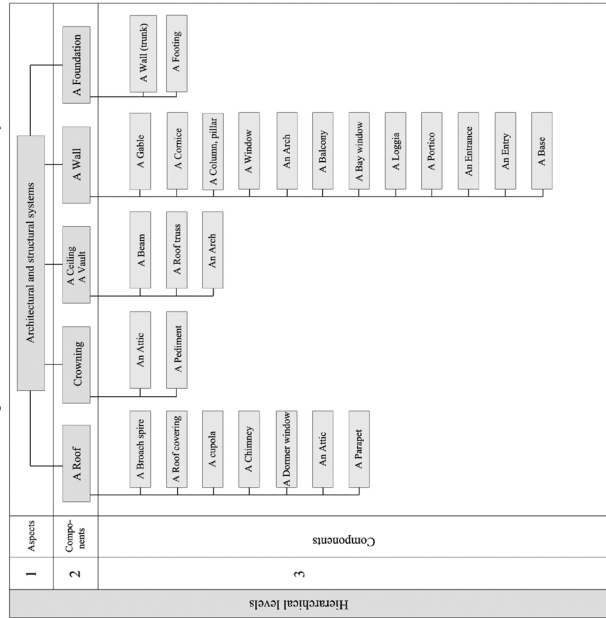
The reasons of the emergency state of stone walls of objects dating back to XI – early XX centuries are associated with the change of hydrogeological conditions, with subsidence of bases and foundations (this results in deformation of walls, their moisturizing, masonry destruction, cracking), uncontrolled water disposal from the socle and roof, absence of waterproofing for foundations and the socle part, absence of the blind area, damage of drainage pipes and gutters, ageing of masonry mortars, reduction of strength and lifting properties of stone, brick, plinth brick, increasing of load on a wall due to rebuilding and buildup of additional stories, change of functional profile of the building and as a result – placing vibration producing equipment in the building (Ill. 4).

Issues of the emergency state of vaults and floors of the objects dating back to XI – early XX centuries are mainly as follows:

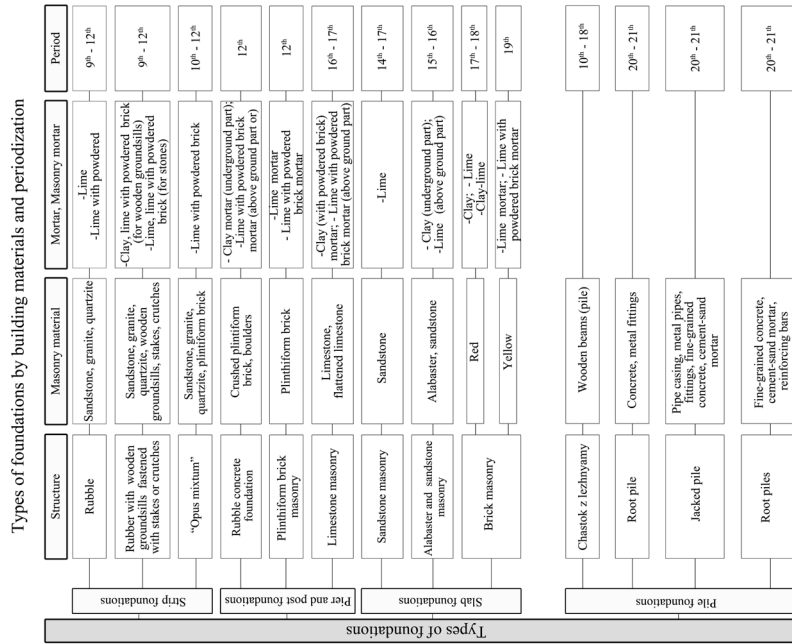
Aspects of the restoration activity-  
Objects of protection and preservation



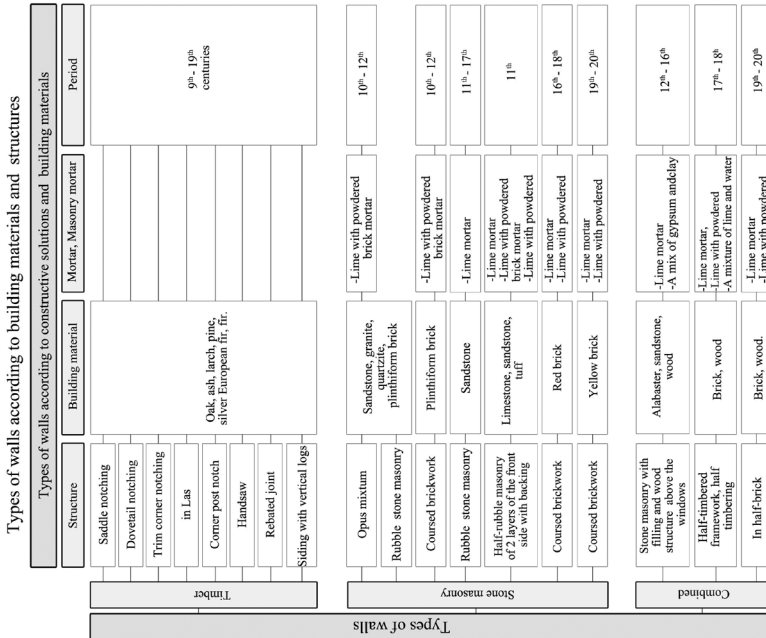
The main components of architectural and structural systems



III. 3.



III. 4.



a) the core issue of vaults and floors lies in breaking the static character of the “base-foundation-building” system, moisturizing of bases, foundations and structures, then first of all deformation processes should be settled, and complex repair and restoration works on the monument should be carried out;

b) the issue of emergency state of wooden floors (beams, trusses) is related with sedimentary deformations, water-saturation of structures and damage by wood-decay fungi and biodegraders;

c) cracks and deformations in floors and vaults can arise from overloading of structures.

Absence of well-formed decision making procedures in the architectural monuments restoration field, structured knowledge base: logical output and input of information concerning accumulated facts and rules, along with an insufficient number of subject matter experts as measured against scopes of front end engineering and design work in the area of renovation of real estate cultural heritage assets gives the evidence of urgency to raise the issue of making an expert system (ES) of restoration and renovation works.

To provide restoration activity with information and methodological support the author comes up with four groups of expert systems:

- “supervision” – “monitoring” of architectural monuments;
- “diagnostics” – identification of cause-and-effect relations, forecast of consequences of the damages detected, guidelines for mitigation of the consequences;
- “designing” of the restoration objects by individual components and elements of buildings and coordination of decisions made;
- “planning” – performance of the restoration works.

Besides, it is reasonable to develop expert systems in the field of training and retraining of specialists of various areas of expertise, engineers, architects, scientists, artists, where they should suggest adequate solutions to problems.

In spite of quite a few restoration objects dealt with by the specialists of Corporation “UkrRestoration”, we can single out a number of objects that meet the following criteria: they play an important part (ideological, urban planning) in urban development of a city or another populated area; they represent the most numerous (by function or period) group of monuments included in the National Register; issues of their emergency state are the most typical or were remarkably challenging and required unorthodox emergency prevention and restoration activities; most essential or unique materials, structures, decorative finishing were applied in them; unique methods and techniques were used in restoration of these objects; the experience gained in restoration of these objects can be extended to other heritage assets both in Ukraine and abroad.

## 2.2. RESTORATION WITH REPURPOSING OF THE MYSTETSKYI ARSENAL AS AN EXAMPLE OF REPURPOSING OF A MONUMENT DATING BACK TO LATE XVIII–XIX CENTURIES

The building of the so-called “Old Arsenal” (historical and architectural heritage asset of national significance), the history of which begins from the days of hetman Ivan Mazepa and the construction of the Ascension convent on this place, is located in the north-western part of the old citadel of the city of Kyiv in Sichnevogo povstannia street 28–30. Its territory with an area of 28 thousand square meters was in a state of disrepair before the restoration.

In 1708 the Ascension cathedral and other buildings of the convent were completely ruined at the order of Russian monarch Peter I, in the late XVIII century on this place at the order of Elizabeth II it was decided to build a military arsenal, which is considered to be designed by engineer general officer Charles Paul de Chardon, however in the Russian State Military Historical archive there are two designs dated May 1783, in which the Arsenal building is presented in two versions: as a two-story and one-story building.

Construction of the Arsenal designed by Ivan Meller was started in 1784 by lieutenant Betichev, and from 1797 the construction work was managed by engineer general von Suchtelin, and from April 1799 and up to the completion of the construction – by engineer major-general von Toll. This fortification was unique with its buff brick used for the first time in Kyiv in that construction. In 1801 the construction of the Arsenal was completed, and it was handed over to the military department.

In the middle of the XIX century on the ground floor of the Arsenal building there were storage areas for accoutrements, arms, materials, siege artillery supplies, rooms for administrative office and storage rooms for the Kyiv garrison.

The building of the Arsenal was badly damaged in the course of the World War II, when its south-eastern part was ruined by an explosion.

In the Soviet period the Arsenal accommodated a sensitive military site, and later the building was used for production facilities, and it was then that the building went through a substantial reconstruction with inner stories, partition walls, stairs – ladders and yard accessory buildings.

At the beginning of the restoration research it was a brick structure with an incomplete framework, two-storied, rectangular in plan, with dimensions in axes 165.900 x 133.450 m, with three spans 8.800 m each along the outline.

Floor slabs above the basements and the ground floor were made of brick, in the form of cross-vaults, what is more, on one of the floor slab sites above the ground floor the vaults were replaced with bow-shaped brick vaults on bearing metal beams.

The cross-vaults made of brick were in the state of emergency and had a lot of cracks and spots resulting from water saturation, there were some local damages of the brickwork.

Pillars (columns) of the cross-vaults were made from the Kyiv buff brick on the sand-lime mortar.

Elevations of the building were painted ocher, certain elements (keystones, pilasters, brackets of cornices, cornices, rustications) were plastered and painted white. All the décor elements were made due to the relief effect of the brickwork.

It was suggested to make a huge historical monument of fortification, architecture and urban development of the cultural and art and museum complex Mystetskyi Arsenal from a neglected site that it was when the restoration began, especially because such an earth fortress is the only one left in the whole Europe.

Initially, three stages of the development of the Mystetskyi Arsenal complex were proposed. At the first stage, it was planned to renovate and adapt the “Old Arsenal” building to the modern museum complex, to equip its inner yard and adjacent territories, as well as to restore the Citadel’s ramparts.

In the premises of the Arsenal, reinforcement works were carried out, modern communications were installed, and a system for maintaining the required temperature, humidity, lighting, etc. was created. Under the building and the courtyard three underground floors were arranged, which will accommodate auxiliary rooms, catering facilities, etc. Museum halls are located on two main floors, as well as underground floors.

The inner yard was offered to be covered eventually with transparent cover and used for musical events, exhibitions, as well as for the faster transfer of visitors from some museums to others. The adjoining areas are used for infrastructure development, as well as for green plantations.

At the second stage, next to the Old Arsenal, it was planned to build new premises, to create a children's town, and also to include several objects of the "Kyiv Fortress" in the complex.

At the third stage of the creation of the "Mystetskyi Arsenal" complex it is expedient to include the remaining objects of the Kyiv Fortress, including those located in Vasylykivskyi and Hospital fortifications, in the territory of the Arsenal Plant and in other places of the Pecherskyi district. These structures, as well as ramified dungeons, must be restored and used as components of a complex of museums, scientific and cultural centres or as auxiliary infrastructure objects. During the restoration of historical monuments, in particular, the military temples, especially the St. Nicholas Military Cathedral, should be restored.

The third stage of the development of the complex should also include the completion of the development of modern infrastructure, including transport and other communications, hotels, catering, the trade system, tourism business, full-scale inclusion of "Mystetskyi Arsenal" resources in Ukraine's information and education space.

Keeping in mind the complexity of the geological structure, hydrochemical properties of water and ground environment, hydrogeological conditions of the construction site, availability and technical condition of the water bearing utility pipelines on it and its adjacent areas, types of already existing foundations, their foundation depth, width, material and technical condition and the technology of reinforcement work, specialists from "UkrNDIprojectrestoration" institute analyzed the listed options of foundation reinforcement.

The expert commission created by the order of the President of the Academy of Construction of Ukraine G.K. Zlobin on the basis of the letter of the Ukrainian State Research and Design Institute "UkrNDIproektrestavratsiya" under No. 396/A dated October 7, 2005, having considered the materials of engineering geological surveys, the results of the survey of the technical state of the constructions and technical solutions for strengthening the foundation of the Cultural, Artistic and Museum Complex "Mystetskyi Arsenal" located at 28–10 Sichnevoho Povstannia street in the Pecherskyi district of the city of Kyiv, gave its expert opinion:

- Analysis of the materials of engineering geological surveys showed that they were executed in accordance with the requirements of normative documents of Ukraine. The tasks regulated by the Technical Specifications for conducting surveys were executed in full and at a high methodological level.
- There are no significant remarks on the tasks of surveys, the method of their execution, the content and the form of presentation of the results of geological and hydrogeological surveys.
- The quality and volume of these surveys will provide an analysis of the strained-deformed state of the soil basis of the underground part of the "Mystetskyi Arsenal" complex, both before and after its reconstruction.
- Geological structure within the construction site is characterized by complex layers of soils of different genetic type and age, including loessial sagging soils. Ground conditions of the site relate to the first type of sagging. Immediately under the bedding of the foundations of the reconstructed building, there are loessial sandy loams IGE-2 of hard texture, which are sagging under additional pressure. The power of this layer is below the bedding of the foundation from 1.6 to 4.4 m. There are slightly and moderately sagging

sandy loams characterized in their natural state by the value of relative sagging  $E_{sl} = 0.012 \dots 0.050$  at pressure  $p = 0.3$  MPa and initial sagging pressure  $p_{sl} = 76 \dots 293$  kPa.

- Groundwater for the period of surveys was detected at depths of 7.1–10.0 m within the absolute values of 179.3–182.0 m. The predicted groundwater level during the estimated period may increase by 2.0 m in relation to the observed during surveys, taking into account the arrangement of pile foundations at a distance of not less than 3d.
- By hydrochemical properties, water and soil environment within the construction site by all components are practically non-aggressive to concrete and steel.
- Since the average pressures at the level of the existing foundations after the reconstruction of the building will exceed the design resistance of the soil and the initial sagging pressure, one of the components of the reconstruction of the “Mystetskyi Arsenal” complex is to strengthen the foundations, which would ensure the operational reliability of the construction and exclude the development of any deformations of its building constructions.
- The adopted version of the reinforcement by jacked piles is expedient, since it stabilizes the stress-strain state of the base under the bedding of the foundations. The calculations were checked by means of tests, for their retrofitting, a computer simulation program under the walls and under the columns of the building was developed.
- In order to strengthen the foundations of the column of the vault, it is recommended to arrange small diameter jacked piles, which will provide them with stability and transfer the load to more solid soils located at a depth of 15–18 m.

On the base of the analysis they reasonably decided on the most feasible option of reinforcement of the existing foundations by means of a partial transfer of load from walls with the help of transverse cross stop bars that go through the walls and rest on jacked down reinforced concrete piles  $\varnothing = 133$  mm, i.e. the reinforcement structure looks like II-shaped frame with rigidly clamped jack piles with 3 m spacing of stop bars in piers.

Within the design basis the piles are to be jacked down under a load of 50 ton-forces, and the design pile load capacity of 42 ton-forces is to be reached, that together with the existing foundation ensures a sufficient load bearing capacity of the underground part of the building. In this case, control of any pile while jacking down is crucial for the pile load capacity.

The project provides for building a museum with two above-ground and three underground floors. On the ground floor it is supposed to make a house-museum of T. G. Shevchenko, a showroom of cultural heritage, a folk decorative art gallery, a cafe, a conference hall, a shop and three other showrooms. In one of them visitors of the museum will have a chance to listen to organ music concerts. The total area of the ground floor will be about 12,000 m<sup>2</sup>.

On the first floor there will be six showrooms, two of which have an area of 1,650 m<sup>2</sup>, three of them – 600 m<sup>2</sup> and one – 500 m<sup>2</sup>. A decorative world art gallery with the total area of 3,300 m<sup>2</sup> will find its place here, as well as an IMAX-movie theater, a shop, a conference hall, a cafe. The total area of the first floor is the same as that of the ground floor. Under a dome-shaped glass ceiling there will be a spacious library. On the underground floors it is planned to locate some more showrooms as well, a restaurant, a cafe, a shop, some galleries. However due to lack of funds and insufficient financing it was possible to implement only a part of the project (Ill. 5).

In order to preserve an authentic masonry of the walls, it is necessary to reduce the holes and the structural section of the spreading beams. When restoring the surfaces of building components, the following technologies were applied:



- Renovation of the concrete ceiling of the 2nd floor
- Thermal insulation of the 2nd floor system with the material FOAMGLAS (Belgium)
- Waterproofing technology Superflex 100S
- Antiseptic and insecticidal treatment
- For fire protection of wooden constructions the material ENDOTHERM 400201 was applied
- Vapour barrier of wooden scaffolding
- Injection and prosthetics of brickwork, strengthening of walls and vaults, columns and their reinforcement.

The existing architecture of the elevations of the building underwent a lot of damages and was in disrepair. For that reason the project provides a complex restoration of elevations, namely:

1. Demolition of additional buildings of the Soviet period.
2. Glass blasting washing off or cleaning the layers of painting and removing stains of cement mortar.
3. Development of attic corner pediments.
4. Restoration and renovation of lime stone blocks of the crowning cornice.
5. Restoration and renovation of door and window openings.
6. Injection and restoration of brickwork according to the given technique.
7. Complete replacement of the roof and roof coating (the roof coating is copper).
8. Reconstruction of the blind area.

### **3. OVERALL CONCLUSIONS**

The current-day environment presents new challenges to us even in such a conservative field as restoration is. Globalization processes contribute to strengthening the contacts between restorers from different countries that brings about internationalization of restoration methods and practices.

The topic of interest today is the systematization of the world restoration experience through the examples of particular monuments along with employing of the system approach that helps to make a professional “ABC” of actions in some or other restoration context according to the tasks at hand.

In recent years the issue of repurposing of historical heritage assets has become topical. This challenge is quite atypical for the restoration field, as far as it brings together tasks inherent in conservation with those of revitalization. Repurposing of historic industrial and fortification structures is one of the most challenging tasks, which has been analyzed using the example of the Mystetskyi Arsenal. Repurposing of historical heritage assets for art function is indeed a widely used international practice, in favor of which there are two reasons: changing and broadening of cultural and art requirements of the society and deficit of traditional cultural institutions (museums, galleries, theatres), and the economic factor of maintaining of historical heritage assets. For this very reason the Mystetskyi Arsenal is on a par with such revitalized historic properties as “OFF Piotrkowska” (Łodz), “Brotfabrik Wien” (Vienna), EC1 Łódź, “Schiffbau” (Zurich), “Mains d’Oeuvres Saint-Quen” (Paris), “Lowenbraukunst” (Zurich), “Winzavod” (Moscow) etc.

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