INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE
ISSN: 2067-533X Volume 16, Special Issue, 2025: 721-738 www.ijcs.ro
DOI: 10. 36868/IJCS.2025.si.24

PRESERVING UNDERGROUND PREMISES OF ARCHITECTURAL MONUMENTS:THE CASTLES OF ŠPILBERK IN BRNO AND OŚWIĘCIM

Pavol TIŠLIAR[1], Yulia IVASHKO[2,*], Andrii DMYTRENKO[3], Viktoriia ZAITSEVA[4], Yuliia HOLOVATENKO[4], Wioletta OLES[5], Krystyna PAPRZYCA[6]

[1] Masaryk University, Faculty of Arts, Department of Archaeology & Museology, 1 Arna Nováka Street, 602 00, Brno, Czech Republic
[2] Kyiv National University of Construction and Architecture, 31 Povitrianykh Syl Avenue, 03037, Kyiv, Ukraine
[3]National University "Yuri Kondratyuk Poltava Polytechnic", 24 Vitaliia Hrytsaienka Avenue, 36011, Poltava, Ukraine
[4] National Preserve "Kyiv-Pechersk Lavra", 9 Lavrska Street, 01015, Kyiv, Ukraine
[5]Museum Zamek w Oświęcimiu,1 Zamkowa Street, Oświęcim, Poland
[6]Academy of Silesia, Faculty of Architecture, Civil Engineering and Applied Arts, 43 Rolna Street, 40-555, Katowice, Poland

Abstract
The article is devoted to the study of underground spaces of architectural monuments. Using the example of architectural monuments located in Ukraine, the Czech Republic and Poland – the Kyiv-Pechersk Lavra in Kyiv, Špilberk Castle in Brno and the castle in Oświęcim – the most common problems of preservation, restoration and modern use of their underground spaces are analyzed. A comparative analysis of underground spaces of different times, different functions and in different regions showed the commonality of their preservation problems. A set of measures to eliminate the emergency state of underground spaces and options for their modern use is determined.

Keywords: *Underground premise; Monument of architecture; Kyiv-Pechersk Lavra; Castle of Špilberk; Castle in Oświęcim*

Introduction

The authors drew attention to such an aspect of cultural heritage as underground premises under architectural objects. Unlike above-ground architectural monuments, underground premises have received much less attention, unless they are objects of ritual worship (such as the Near and Far Caves of the Kyiv-Pechersk Lavra). In most cases, such underground tunnels served as casemates-prisons or connected different parts of the city in case of danger. Therefore, such premises are less often visited by tourists.

As the restoration experience in many countries shows, the main reasons for the emergency condition of such caves, underground passages and casemates are landslides and increased humidity. This, in turn, leads to the appearance of cracks, crumbling walls and ceilings, passage blockages, waterlogging, mold and fungus etc.

As mentioned above, such underground rooms exist both in religious sites (the caves of the Kyiv-Pechersk Lavra), where they serve as tombs and in castles, where they serve as prisons for the most dangerous prisoners (Špilberk Castle in Brno) or are of strategic importance (tunnels under Oświęcim Castle).

* Corresponding author: yulia-ivashko@ukr.net

Despite the different functions, the main problems of the emergency state of underground premises are common, as are the developed complexes of measures for their elimination. As a rule, such problems arise immediately after constructing such premises and exist for a long time, only intensifying. This can be illustrated by a typical example of the caves of the Kyiv-Pechersk Lavra, included in the UNESCO World Heritage List. The main causes of damage to the 1000-year-old caves of the Upper and Lower Lavra are landslides, the appearance of sinkholes and increased humidity.

The study by an international team of scientists aimed to draw attention to the need to preserve underground spaces of architectural monuments, which are also an important part of the historical and cultural heritage and in many cases suffer from destruction even more than above-ground objects. To prove that this is a common problem for different countries, the state of underground spaces of cultural heritage sites in three countries – Ukraine, the Czech Republic and Poland – was analyzed.

To achieve the aim of the study, the following tasks were set:

– conduct a brief historical analysis of the emergence of underground spaces and their functions at different times;

– describe the design features of the arrangement of such spaces;

– identify the main problems of the emergency and measures aimed at their elimination.

The study's scientific novelty lies in the fact that, for the first time, a comparative analysis of underground spaces of different times, functions and countries has been conducted to prove the commonality of their preservation problems.

To obtain reasoned conclusions, an extensive source base was developed:

– studies devoted to general theoretical issues of cultural heritage preservation [1-4];

– historical sources dedicated to the Kyiv-Pechersk Lavra and its caves [5-18];

– sources dedicated to the castle in Brno;

– sources dedicated to the castle in Oświęcim.

Results and discussion

A brief history of underground structures of the Kyiv Pechersk Lavra

The national reserve “Kyiv-Pechersk Lavra” is the largest museum complex in Ukraine and it is known for its unique underground architecture. An extensive complex of underground structures of the 11th–18th centuries, different in functional purpose and structural features, has been formed over the centuries on the territory of the Kyiv-Pechersk Lavra. The most famous of them are the oldest monuments of architecture, archeology, history and culture – the labyrinths of the Near and Far Caves, which are considered the most important shrine of the Kyiv-Pechersk Monastery since it was in them at the beginning of the 11th century that monastic life originated. Over time, the monastery became aboveground and the caves were used mainly as a monastery necropolis, which from the 15th–16th centuries became a place of mass pilgrimage. Two independent underground complexes with a system of interconnected underground passages with churches, cells and burial niches were dug at a depth of 5 to 15 meters in the layer of loess soils of the high Dnipro slopes. These are passages of anthropogenic origin of various plans and configurations with a total length of about 900m; most of them have a similar architecture of corridors, the height of which is 2-2.5 m and the width 1-1.5m [5].

Less well-known is the complex of underground structures concentrated on the territory of the so-called Upper Lavra, which currently has about 20 objects. According to their functional purpose, they are divided into several types, reflecting the development and comprehensive activity of the monastery. Among them: military defense (secret passages – *“poterny”*, *“slukhy”*), utility (cellars, ice chambers, keyholes, wine cellars, basements) and engineering (wells, water pipes, drainage systems etc.) [6].

Unlike the Lavra Caves, there is almost no information about the underground economy in the Upper Territory. Certain evidence of the existence of underground structures in the monastery's contemporary development system can be obtained from chronicle sources. In particular, many stories about the monks of the Pechersk Monastery of the late 11th-12th centuries and their economy are contained in the Pechersk Paterik [7]. Mentions of the existence of underground structures are found in individual archival documents of the late 18th-19th centuries and also in the descriptions of the Kyiv-Pechersk Lavra by Metropolitan Yevgeny Bolkhovitinov (1826, 1831) [8]. Scientific interest in the underground architecture of the Lavra arose relatively recently – in the second half of the 20th century. Until then, the survey of underground structures was mainly exploratory, with the absence of graphic recording of research results [9].

Some of the currently known underground structures were surveyed, partially cleared, measured and plotted during the reconstruction of the Kyiv-Pechersk Lavra reserve after World War II. In 1973–1974, a detachment of speleologists from the Kyiv Speleological Research Laboratory and collaborators from the Department of Architecture and Monument Protection of the reserve conducted research to identify underground architectural structures, determine their purpose, age, genetic connection with above-ground buildings and establish historical value [10].

Many underground structures were lost (filled up, walled up, destroyed by later developments) and their discovery was often accidental: due to accidents, landslides, sinkholes or during excavation work [11]. Thus, one of the first was found in a forgotten wine cellar near the metropolitan's house due to a water supply accident at the end of the 19th century. Later, in 1962, as a result of a sinkhole at this place at a depth of 3-7m, a whole system of underground passages was discovered (modern underground structure No. 11) [12].

In 1958, during the restoration of the Trinity Gate Church, located above the main entrance to the monastery, subsidence of the foundations of the defensive wall built around the monastery near the northern wall of the temple occurred. In the course of clarifying the causes of the deformation of the fortress wall and church structures, in 1959, specialists from the geological department of "Kyivproekt" made several pits, one of which revealed the presence of a waterlogged underground passage. The passage had branches and was a brick-built 17th-century vaulted gallery, the main part of which began under the Trinity Church and headed east, then northwest, continuing towards the Arsenal (Fig. 1) [13].

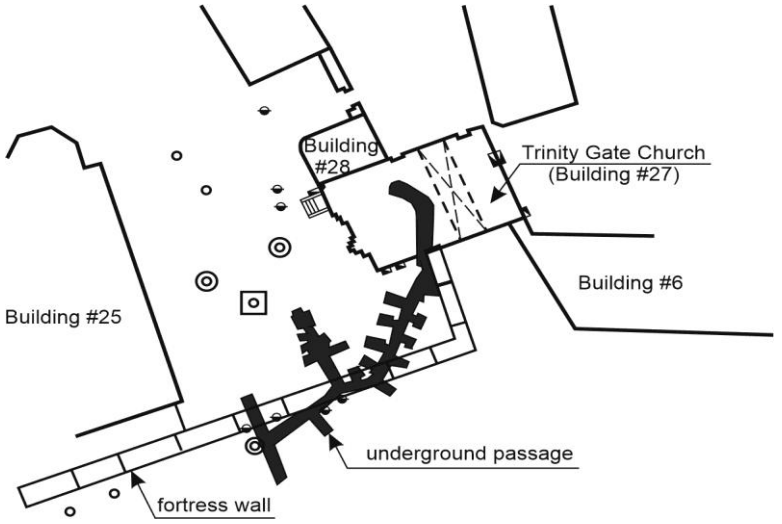

Fig. 1. Location plan of the underground passage.
Drawing by V. Zaitseva (2024) based on survey materials from 1982

The passage, about 2m high and 1m wide with niches arranged in a checkerboard pattern, was located at a depth of 7m from the surface under the foundation of the fortress wall. According to the researcher of the Lavra underground structures, Yevheniia Cherednychenko, the passage had a fortification purpose – "to strengthen the defense capability and was intended for surveillance, interception and prevention of enemy attacks" and was part of the defense system of underground passages practically along the entire perimeter of the monastery. Unfortunately, due to a lack of funds, this underground structure was never surveyed. After clearing within the limits of accessibility (70m) and surveying works in 1962, the underground passage was filled in with subsequent filling with cement mortar and bricking up [14].

With the loss of the Pechersk Fortress's defensive significance, the fortifications were gradually adapted for other needs. Thus, underground structures No. 9 and No. 28, which were built near the defensive walls, originally had a fortification and communication purpose, but since the end of the 18th century, they have not been used for their original purpose and have been converted into cellars [15].

The development of the Kyiv-Pechersk Monastery prompted the creation of an extensive network of underground structures for economic purposes – cellars, ice houses and wine cellars, which were used not only to preserve food for the monastery brethren and pilgrims but also to store craft products and strategic reserves (in case of crop failure or siege). Economic underground construction is found everywhere within the historical monastery complexes of Kyiv, distinguished by constant planning features – a large area and a significant length of underground passages in the thickness of loess rock [9].

The formation of the complex of underground structures was carried out during the 15th-18th centuries with reconstructions and adaptation to the needs of new above-ground buildings in the second half of the 19th century, which was due to the growth of the monastery's population and the need to build new utility and storage facilities. An earlier construction of cellars is not excluded (which is mentioned in chronicle sources); however, in the absence of archival materials, we rely only on the results of field research.

Architecture and structural features of the underground structures of the Kyiv-Pechersk Lavra

The planning system of underground structures and their configuration is quite diverse. Based on the characteristic features of their planning structure and the set of structural elements, researchers have identified the following structural elements inherent in each structure: the entrance part, the main room, additional volumes, branches, galleries etc. [10].

Let us dwell on the architectural features of the most interesting of them.

Underground structure No. 2. The premises of the structure were surveyed and cleared of soil, brick, rubble and construction debris by specialists of the Kyiv Speleological Research Laboratory in 1973–1974 (headed by I.R. Goizman). During the work, about 40m of the tunnel was cleared and the entrance to the dungeon was arranged in the form of a small above-ground brick structure located near the central part of the Cells of the Cathedral Monks (building No. 4). However, after the survey, the dungeon was again filled with sand. Repeated clearing was carried out in 1989 by the division of production of the Special Directorate for Landslide Prevention Underground Works and the special division of production of the Reserve, during which a detailed study of the monument was carried out [11].

Today, the structure is a branched vaulted tunnel 50m long, with two entrances with brick stairs (Fig. 2). The volume of the structure can be conditionally divided into a staircase gallery, eastern, western and main premises and a system of corridors.

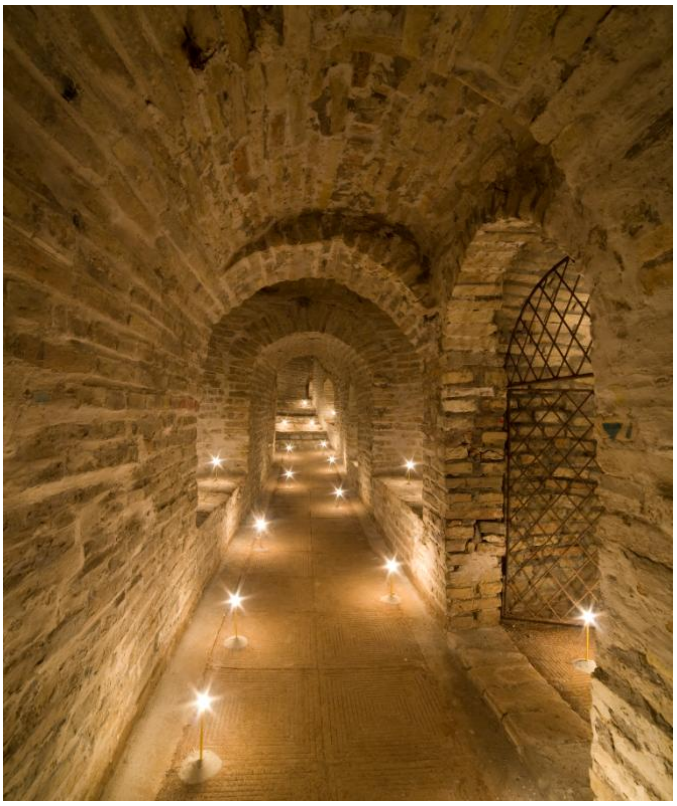

Fig. 2. Underground structure No. 2. Photo by Y. Holovatenko and V. Zaitseva, 2024

The depth of the tunnel is from 2.91 to 3.76m; in some places it reaches 8.15m. The width of the tunnel is 0.7-1.7m and the height is 1.9-2.0m. The main structures (walls and vaults) are built of yellow bricks of the 18th century measuring 28.0-29.5×15.0×5.0-5.5cm on a lime mortar on a loess base. 22 arched openings for niches of various sizes are arranged in the masonry of the walls. Some niches were bricked up. After their clearing, a masonry of red, poorly fired, fragile bricks of the 15th–16th centuries was discovered and parts of an earlier structure, the walls of which were not lined with bricks [6]. An interesting component of the structure is a passage, oval in plan, room with a spherical vault, on which the remains of clay plaster and whitewash have been preserved. The room has two steps along the eastern and western walls, measuring 1.93×0.6m and 1.8×0.6m. We have not found analogues of such rooms and their functional purpose remains a mystery.

The planning structure of underground structure No. 2 and a number of its architectural features suggest the different ages of origin of its parts, the exact dating of which is still impossible due to the lack of historical sources [10].

The underground structure No. 3 (1770s), located to the east of underground structure No. 2, is also interesting from an architectural point of view. The volume of the structure consists of an entrance staircase gallery, a northern branch and the main room. The walls and vaults are brick on lime mortar, plastered and in some places, fragments of plastering "by the glove" have been preserved. The floor is brick and flat in places of loss of soil. The masonry is ordinary, made of red brick from the 18th century on lime mortar. The main room is square in plan (dimensions 3.43×3.43×3.43m, depth of foundation – about 3m), covered with a vault (height 2.3m), which rests on a cylindrical central pillar with a diameter of 0.45m. The room's walls (except for the southern one, which is adjacent to the foundations of the above-ground

building) are decorated with niches with arched ends, a back wall faced with brick and an arched doorway in the southern part of the western wall. On the southern slope, metal curtains from the door with an eyelet have been preserved. In the northern wall, at a height of about 1.5m from the floor, there are two light windows (0.4×0.45m) with metal grilles and a vertical, rectangular opening like a chimney in the body of the wall (Fig. 3).

The structural features of underground structure No. 3 suggest that its original purpose was for long-term human habitation, as evidenced by the presence of skylights, a chimney and interior doors [10].

Fig. 3. Underground structure No. 3. Photo by Y. Holovatenko and V. Zaitseva, 2024

Located near the defensive walls, underground building No. 28 is currently connected to above-ground building No. 31, built in 1871–1874, but is not structurally attached. It was probably built at the turn of the 17th–18th centuries and was partially rebuilt at the end of the 19th – beginning of the 20th centuries. The modern volume consists of an entrance gallery and the main, western and northern rooms. The walls are lined with light ocher, pink and red bricks on lime mortar. The main room, measuring 11×11m, is brick, covered with a complex closed cylindrical vault 3.5m high, which rests on a pylon (2.4×2.8m), rectangular in plan, reinforced by wall arches (Fig. 4).

Fig. 4. The main room of underground structure No. 28. Photo by Y. Holovatenko and V. Zaitseva, 2024

The original entrance to the building was the western branch, which appeared like a brick gallery and was separated from the main building by a massive gate. The significant parameters of the gallery (6.9×2.5×2.8–3.9(h)m) and the presence of a wide and sloping entrance with a gate indicate the possibility of the entry of horse-drawn transport with heavy and oversized cargo. The structural features of the main volume – the thickness of the walls (up to 2.5m) and the presence of large niches—indicate the defensive function of the building – for storing gunpowder and ammunition. Apparently, in the first third of the 18th century, the building lost its defensive purpose and its massive brick foundation could have been used for civil construction during the construction of the ground-based building No. 31 [15].

Current status and conservation issues

The location of underground structures in rather complex engineering and geological conditions – in the thickness of the soil massif, in landslide-prone areas, under the influence of technogenic loads on their structures of above-ground buildings – determines the peculiarities of their state of preservation.

From chronicles and historical sources, it is known that these problems existed in ancient times. The monks of the monastery tried to eliminate the problems of the emergency state of the caves; however, using methods available at that time, they organized drainage of rainwater and meltwater, strengthened landslide slopes with wooden logs and planted trees on them. In 1685, to strengthen the hill, it was proposed to level the pits and drain water from the hill.

The felling of trees on the slope immediately provoked new landslides, which actually happened in 1740. After 1740, work began to strengthen the slopes of the mountains and caves at the expense of the military department, but the success of these measures was offset by the earthquake of 1789, which again caused the appearance of faults and cracks in the ground. Despite the significant amount spent on restoring the mountain at Far Caves in 1798, a new landslide offset the results of these measures.

However, subsequent measures in the 18th–19th centuries to strengthen the Lavra's soil and improve drainage systems proved to be more successful and the drainage system worked successfully until 1918, when it was damaged by artillery fire from Muravyov's troops. This led to a new round of landslides, in particular, in 1924, landslides began in six places at once in the Pechersk Lavra, especially near the Far Caves. The scale of the landslides was so significant that they threatened the Lavra's buildings, especially in the Far Caves. An engineering report from 1924 confirmed that these were not landslides but mountain collapses. By the way, the St. Andrew's Church, also on the landslide hill, suffered from the same problems.

Since the problem was not resolved, in 1926 the Lavra Museum of Cults and Life submitted a request to the Ukrainian Geological Committee to send a commission to inspect and eliminate the landslides. The results of the inspection indicated that the cause of the landslides was the disruption of the drainage network, water collection wells, mines and adits. Although the drainage network had been restored by 1941, World War II led to severe destruction of the territory of the Upper Lavra and damage to underground communications and the pre-war engineering and geological documentation was not preserved.

In 1944, in accordance with a state decree, the Kyiv-Pechersk Lavra State Historical and Cultural Reserve resumed its activities and among the tasks of restoration was the restoration of the drainage system on its territory. However, these works began only in the 1950s.

Official documents of the inspection of the reserve's state of improvement recorded the emergency condition of the drainage anti-landslide and stormwater drainage structures, external water supply and sewage system and due to the deterioration of the drainage and stormwater drainage systems, the regime of drainage of groundwater and stormwater was disrupted. The result was sinkholes and subsidence of the territories, which in turn caused a disruption in the stability of the "base-foundation-structure" systems and caused deformation of the foundations and the appearance of cracks in the walls. Various property holders of the Lavra buildings

complicated the restoration process. For example, Ararat business organizations poured dirty water directly into the ground. The monks arranged a bathhouse in one of the buildings and led the overflow into a nearby garden. Incoordination between various administrative institutions and property holders led to the fact that vegetable gardens were created on landslide soils and buildings were not repaired.

As a result, cracks appeared in the walls of the Upper Lavra buildings and on the walls of the Trinity Gate Church, part of the ceilings of the printing house and the Refectory Church collapsed and a corner of the first building subsided. Numerous sinkholes appeared. Near the ruins of the Assumption Cathedral, a giant hole was formed, which was filled with earth and clay with great difficulty. The second collapse created a threat to the Great Lavra Bell Tower. The ground collapsed in four places in the Metropolitan Garden. A tree fell into one of these holes, which went underground to a depth of eight meters. A difficult situation also developed in the Far Caves. All the long work to strengthen the hill at one point turned out to be in vain. The landslide, which had been slowly moving towards the Dnipro River year after year, suddenly collapsed in 1968. The stone fortress wall could not withstand the impact and was destroyed by a multi-ton mass of earth.

An attempt to improve the drainage system was made in the Upper Territory last time during the restoration of the Assumption Cathedral. The concrete cushion that covered the entire area around the cathedral drains rainwater and meltwater well, but the new piles on which the cathedral is placed have to some extent disrupted the movement of groundwater. This created a danger – sinkholes and the formation of voids under the concrete cushion. A tractor fell into one of these voids in the winter of 2001.

Back in 2005, the emergency state of the Near Caves was recorded when one of the galleries collapsed due to a landslide. In 2021, the cause of the emergency state of the caves was determined to be outdated engineering communications and melting snow, which led to an increase in the humidity level in the caves, especially in the Near Caves.

Based on the results of many years of monitoring, specialists of the Kyiv-Pechersk Lavra reserve have identified the main factors affecting the underground complexes' technical condition. Among them are natural (infiltration of atmospheric precipitation, the influence of groundwater, activation of landslide processes) and technogenic, anthropogenic (construction or restoration work, vibration from transport, leaks from networks, violation of the temperature and humidity regime, violation of groundwater filtration conditions) [16].

Underground structures are significantly affected by waterlogging of the soil massif due to the action of natural or man-made factors. Infiltration of atmospheric precipitation and changes in the properties of the state of the base soils lead to deformations, the formation of cracks, waterlogging and a decrease in the strength of the bearing properties of the structures of underground structures. Thus, due to the absence or damage of moisture-proof barriers and orderly drainage in the underground structures of the Lavra, surface water seepage occurs annually during precipitation (Fig. 5).

A negative factor should also be noted: improper drainage from the basement and roof and damage to gutters and gutters of above-ground buildings, which creates an additional factor for moisture ingress from the outside.

The migration of moisture saturated with salts causes their crystallization on the surface of the walls and vaults of the structure. A prime example is underground structures No. 28 and No. 11, where, as a result of long-term exposure to moisture, mineral formations of various shapes in the form of stalactites, stalagmites and flow layers were formed.

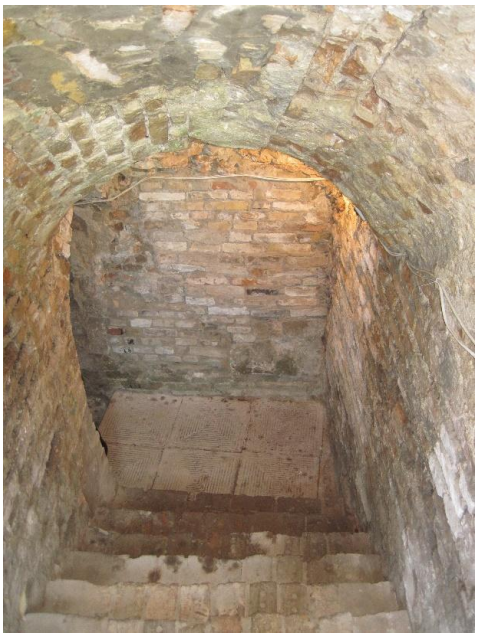

Fig. 5. Infiltration of atmospheric precipitation due to violation of waterproofing (underground structure No. 2).

The state of preservation of underground structures depends on individual characteristics: location, depth of occurrence, planning and design features. Changes in environmental conditions, man-made influences, insufficient air exchange, migration of rain and meltwater by capillary suction and its accumulation in the pores of building materials create microclimatic conditions with high air humidity in underground structures. In particular, the relative humidity in underground structure No. 28 is constant, despite external factors and is kept at the level of 80-98%. The amplitude of seasonal temperature fluctuations is within 10–12°C, which in the summer period is from +7 to 19°C. This microclimate is due to the shallow depth of the structure (1.5-2.0m) and its location in the landslide and bulk soils of the slopes of the Lavrskyi ravine in a section of the territory with unfavorable hydrogeological conditions. Due to insufficiently organized surface drainage on the site, precipitation accumulates and infiltrates through the soil and cracks in the brickwork to the internal volumes of the underground structure (the process is especially active during spring snowmelt) [17].

The effect of high humidity is intensified at low temperatures. Thus, the condensate formed on the surfaces causes deep destructive changes in the condition of bricks and masonry mortars. In addition, areas with high moisture content of building materials of structural elements are favorable for the development of various types of microorganisms (bacteria and fungi) and their damage to the surfaces of the structure's brickwork.

In addition to the above-mentioned problems, one of the longest (118m) underground structures – No. 11 (11^{th}–18^{th} centuries) – is subjected to additional technogenic load, located in the layer of loess and bulk soils under the Soborna Square at a depth of 1.5-3m [6]. In the brickwork of the walls and vaults, there are multidirectional cracks of different genesis and time of origin, some of them up to 4m long, with an opening from 3-5mm to 1-3cm; local destruction of the brick and plaster layer; areas of moisture seepage due to the established infiltration of surface waters during snowmelt and heavy precipitation with the formation of mineral formations on the surfaces; the formation of condensate on the surface of the vaults; germination of the root system of trees; and foci of damage by microflora.

According to the results of observations, it was found that the destructive processes associated with the development of cracks in the structures of the building are influenced by the dynamic load from vehicles during repair and restoration work on ground monuments and snow removal equipment [18].

Casemates at Špilberk

The casemates of Špilberk Castle are an architectural curiosity and are among the most visited tourist attractions in Brno (Fig. 6). In military terminology, casemates are spaces protected from shelling, often vaulted, located underground or above ground within fortress elements. At Špilberk Castle, they originally served as warehouses and shelters for the military garrison in case of danger. The Špilberk casemates are not underground but located at and above ground level [19].

Fig. 6. The entrance to casemates at Špilberk.

The casemates at Špilberk were built in 1742 during the rebuilding of the castle into a baroque fortress under the leadership of Colonel Rochepin. Špilberk Castle is one of the main landmarks of Brno, located at the confluence of the Svitava and Svratka rivers in South Moravia. The Gothic castle was originally built in the middle of the 13th century as the residence of the Moravian lords and in the 14th century, it served as a residential castle of the Moravian branch of the Luxembourg family. However, the importance of the castle gradually declined from the end of the 15th century until the middle of the 17th century, when it finally emerged as an important defensive stronghold during the Swedish occupation of Moravia (1643–1645). After this event, the castle was significantly fortified and modified.

From 1673, Špilberk became a military prison for criminals, vagabonds and debtors, gradually gaining a reputation as undoubtedly the toughest prison of the Habsburg Empire. At the end of the 18th century, Joseph II ordered Špilberk to become a state prison for the most serious and dangerous criminals. This led to significant structural modifications, especially to the casemates, which became the central part of the prison [20].

In addition to the older prison building in the rear ditch, the upper floor of the northern barracks, known as the Josephine tract, was also rebuilt for prison purposes. The first prisoners were placed there in June 1784. In December 1784, the emperor ordered those criminals sentenced to life imprisonment to be transferred to the lowest and worst casemates. Casemates, two-story vaulted brick corridors, were built into the northern and southern castle moats of Špilberk and were originally used to house military units (Fig. 7). On the south floor was a kitchen with ovens capable of baking bread for up to five thousand people. The casemates had skylights for light and air, hearths with chimney and a tiled stove [21]. On the lowest floor, wooden cells were built where the convicts were permanently chained to the wall with heavy chains. The cells, each measuring 2×1.5 meters and up to 2.5 meters high, were made of thick boards and beams [22] (Fig. 8).

Fig. 7. Casemate in Špilberk Castle.

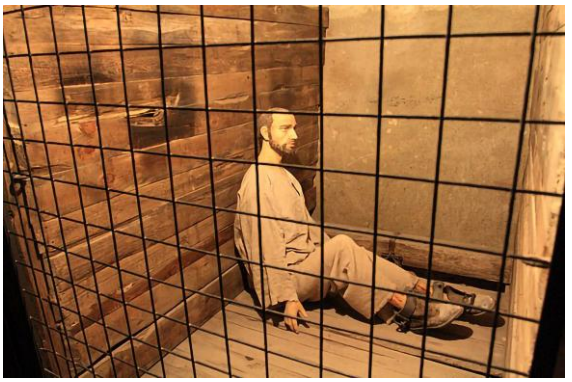

Fig. 8. Wooden cell for prisoner. Historical reconstruction with a mannequin.

A drainage channel ran through the wall of the lower floor of the southern casemates, which opened into the sewer draining from the castle rock [20]. However, this channel was most likely not used in the prison.

The Špilberk prison eventually became known as the "dungeon of the nations," as political prisoners from the Habsburg monarchy were also imprisoned there, including Hungarian Jacobins, Italian Carbonari, Polish revolutionaries and Austrian utopian socialists [23].

In 1785, the upper floor of the southern casemates was also converted into a prison. In May 1790, Leopold abolished the imprisonment of life convicts in the lower casemates and

reduced the sentences for prisoners. This was essentially a reaction to the extremely difficult, even inhuman, conditions of the prisoners. Although they did not have to work hard, they were permanently chained and only received bread and water. If they got sick, they also got raw sauerkraut. It was very dark in the casemates, which prisoners complained about as early as the 18th century [20]. Another problem was high humidity and the military command did not consider it appropriate to house prisoners in casemates for this reason [20]. Additionally, there was a lower temperature, which often dropped significantly below 15°C [24]. In the lower casemates, it was not possible to keep the light on or to heat the space [25]. These unsuitable conditions caused a high death rate among prisoners. Most of those accommodated here did not survive long. According to the records, the shortest survival time was only two weeks and the longest two years [26].

The upper floors of the casemates were used as prisons until the beginning of the 1830s. Common criminals, especially murderers, robbers and arsonists, were imprisoned in mass cells for 12 to 50 people.

The original ground-floor building was converted into prison cells in 1800 and raised by one floor. This building housed a prison for state prisoners, including the Italian Carbonari and other fighters against Habsburg absolutism. After Napoleon's troops destroyed part of the fortifications in 1809, the fortress lost its military significance and remained only a civilian prison. In 1855, Emperor Francis Joseph II abolished the prison and turned the area back into military barracks.

Interestingly, after two years of modifications, the casemates were first opened to the public in 1880 [27], thanks to Anton Costa-Rosetti, director of military constructions in Brno [20]. The opening of the casemates to the public has practically lasted from that time to the present, even though a prison was again established in the above-ground part during the First World War.

The extensive reconstruction of Špilberk Castle in the late 1930s and 1940s completely changed its character [28]. In the first phase of the reconstruction in 1939, modifications were made to the electrical installation, the water supply and the sanitary facilities were rebuilt. Herbert Neubert took over the leadership of the reconstruction work, working mainly with Prof. Karl Kühn from Brno Technical University. The northern rampart was pierced from the front moat, creating a 12-meter tunnel used as a staircase leading to the casemates [28], which enabled easier public access to this part of the castle. Much larger modifications were then carried out in other parts of the castle and its premises.

After the liberation in 1945, the prison was definitively abolished and the object was temporarily taken over by the Czechoslovak army and, in 1960, finallyby the Brno City Museum, which gradually adapted the object for presentation purposes.

Problems of preservation of tunnels under the castle Oświęcim

An important landmark in Oświęcim is the Piast Castle [29]. Castle Hill has two tunnels, located between Zamkowa Street and Bulwarna Street. The tunnels are completely underground structures with an area of approximately 300m². Five entrances are from different sides of Castle Hill and one is through the rampart to the castle courtyard (Fig. 9). The object is included in the register of historical buildings and is subject to conservation protection.

The older, so-called “long” or “Austrian” tunnel runs east-west, connecting the opposite slopes of the hill. It was probably built of brick at the end of the 18th century, during the partition of the Polish-Lithuanian Commonwealth, when Oświęcim passed to the Austrian Empire. The tunnel has a pear-shaped cross-section (Fig. 10).

During the occupation of 1940–1944, the Germans cleared the existing Austrian tunnel and widened it. They also dug a second tunnel in a north-south direction, perpendicular to the previous Austrian tunnel [30]. Known as the “transverse tunnel,” it is built of reinforced concrete rings and has a partial ellipse in cross-section (Figs. 11 and 12).

Fig. 9. Entrance from the Sola River side.

Fig. 10. The oldest tunnel of the Austrian period.

Fig. 11. Tunnel of the German period.

During the German occupation, the tunnels under the castle served as bombproof shelter. The entrance to them was from the castle courtyard, through a door in the vertical shaft. Currently, this entrance is closed with a slab for the safety of visitors.

After the war, the tunnels remained empty. Only in the 1980s were works carried out to strengthen the tunnel structures and some of their destroyed parts were also rebuilt.

After the castle grounds were rebuilt into a museum from 2007 to 2010, the tunnels under the hill were repaired and lighting was installed. The investment was also co-financed by

the European Regional Development Fund under the Regional Operational Programme of the Lesser Poland Voivodeship for 2014 – 2020 [31].

The research conducted by the article's authors has shown many problems associated with the tunnels and the castle. This is the humidity from the river and the hill that slopes down to the Sola River.Traces of moisture are visible in the lower part of the tower in the form of greenery on the 13th-century masonry and in the tunnels on the lighting lamps in the form of condensation in the form of drops and on the floor in the form of wet spots. The increased humidity, which the museum is constantly fighting, spoils the surface of the former brickwork, as can be seen in the photos.

To this end, an interactive historical route, "The Game of Independence," was organized in the tunnels to draw attention to the restoration and preservation of these castle dungeons [31].

Conclusions

Unlike the more technological underground passages of the Špilberk and Oświęcim castles, the Near and Far Caves of the Lavra were dug by hand by monks in the layer of the weakly cemented kaolinite sandstone of the high right bank of the Dnipro River and have a variable depth from 5 to 15m and their total length is over 800m. The problems are also due to the properties of weak soils, especially since there is a deep ravine with natural wells between the caves, which also contributes to additional soil moistening.

Historical data indicate that the problem of combating landslides and sinkholes on the territory of the Kyiv-Pechersk Lavra arose a long time ago. With the expansion of the monastery, the construction of a fortress around it and the urbanization of this area of Kyiv, it became increasingly complicated and in 1920–1960 it reached its peak. With the enormous efforts of city services and reserve workers, this problem seemed to have been solved, but in recent years it has manifested itself again in the form of new sinkholes and subsidence in various places. Patching holes has brought only a temporary positive result. Filling the sinkholes with rubble, sand, clay and sometimes concrete has not eliminated their main cause. Groundwater will create sinkholes in other places. According to experts, a complete replacement of all underground communications that have exhausted their resources, construction of new ones and repair of old drainage wells, adits etc. are necessary.

To ensure maximum preservation of underground structures, the specialists of the Reserve have introduced systematic comprehensive monitoring, which includes:

– visual inspection of the technical condition of the underground structure;

– visual inspection of the territory above it;

– observation of the development of deformations in the structures of the structure using gypsum beacons;

– measurements of humidity, temperature and air humidity to determine the optimal microclimate regime in the interiors of the structure;

– measurements of humidity of building materials (bricks and mortars) of the structures of the underground structure;

– observation of the groundwater level.

Based on the results of the monitoring, the following criteria for the optimal operating regime have been formulated, namely:

– waterproofing of underground structures and landscaping of the territory;

– thermal insulation of underground structures;

– regulation of the temperature and humidity regime by ventilation;

– regulation of ventilation;

– frost drying of the internal volume (to suppress the development and formation of microflora).

The proposed criteria are not final [17]. The issues of preserving underground structures, optimizing their operating conditions and identifying factors that influence excessive moisture require further research.

The extensive reconstruction of the casemates of Špilberk from 1987 to 1992 was necessary due to their almost desolate condition. As part of the overall reconstruction of Špilberk, the casemates were reconstructed and restored in the first stage, as they had not been directly modified since they were made available in 1880 [20]. An extensive reconstruction tried to restore them to their original appearance from the late 18th or early 19th century, the period of their transformation from a fortress building to the worst dungeon of the Josephine era. This stage is approximated by the simultaneous installation of some internal spaces of the casemates, which aims to bring visitors closer to the real appearance of the prison at the time of Joseph II. Another use of Špilberk, also known as the "prison of the nations" for followers of the French Revolution, Hungarian Jacobins, Italian patriots and Polish revolutionaries, is reminded of by the exhibition in authentic spaces on the ground floor of the northern wing of the castle. The current presentation of the casemates as a unique exposition of baroque fortress construction and the prison system of the Josephine era is based on the study of original plans, written documents and contemporary realities of the 18th century. It is the result of cooperation between historians of the Brno City Museum, Brno architects and builders.

The casemates are presented not only through their interiors but also through captivating dioramas. The creators of the exhibition succeeded in evoking an impressive and immersive atmosphere of the harsh prison conditions of the 18th century [32-34].

Using the example of the tunnels of the castle in Oświęcim, another option for transforming underground spaces into a tourist attraction is presented: the tunnels are included in the museum exhibition and equipping them with interactive game devices attracts the attention of young people.

References

[1] P. Gryglewski, Y. Ivashko, D. Chernyshev, P. Chang, A. Dmytrenko, *Art as a message realized through various means of artistic expression*, **Art Inquiry. Recherches sur les arts**, **XII**, 2020, pp. 57-88, DOI:10.26485/AI/2020/22/4.

[2] D. Kuśnierz-Krupa, J. Kobylarczyk, J. Malczewska, Y. Ivashko, M. Lisińska-Kuśnierz, *Analiza jakościowa edukacji architektonicznej w zakresie ochrony miasta zabytkowego*, **Wiadomości Konserwatorskie – Journal of Heritage Conservation**, **65**, 2021, pp. 20-25, DOI: 10.48234/WK65PROTECTION.

[3] M. Orlenko, Y. Ivashko, *The concept of art and works of art in the theory of art and in the restoration industry*, **Art Inquiry. Recherches sur les arts**, **XXI**, 2019, pp. 171-190, DOI:10.26485/AI/2019/21/12.

[4] M. Orlenko, Y. Ivashko, J. Kobylarczyk, D. Kuśnierz-Krupa, *The experience of studying the fundaments of the 11th–18th centuries and methods of their preservation and conservation*, **Muzeológia a kultúrne dedičstvo**, **10**(1), 2022, pp. 33-52, DOI: 10.46284/mkd.2022.10.1.3.

[5] Ya.V. Lytvynenko, *Deiaki aspekty khudozhnioho oformlennia Lavrskykh pecher*, **Mohylianski chytannia 2004:** a collection of research papers, Kyiv: Vipol, 2005, pp.

335-341. (Original language: Я.В. Литвиненко, *Деякі аспекти художнього оформлення Лаврських* печер, **Могилянські читання 2004:** Зб. наук. пр., Київ: Віпол, 2005, сс. 335-341).

[6] Ye.F. Cherednychenko *Pidzemni sporudy verkhnioi terytorii Lavry, 11–18 stolittia,* **Zvid pamiatok istorii ta kultury Ukrainy.** Encyclopedic edition, Book I, Part 3, Kyiv : 2011, pp. 1301–1307. (Original language: Є.Ф. Чередниченко, *Підземні споруди верхньої території Лаври, 11–18 ст.,* **Звід пам'яток історії та культури України.** Енциклопедичне видання, Кн. І, Ч. 3., Київ : 2011, сс. 1301–1307).

[7] D. Abramovych, **Pateryk Kyievo-Pecherskyi,** Kyiv: KM Academia, 2001, pp. 129-130. (Original language: Д. Абрамович, **Патерик Києво-Печерський,** Київ: КМ Academia, 2001, сс. 129-130).

[8] Ye. Bolkhovitinov, **Vybrani pratsi z istorii Kyieva,** compiler Tetiana Ananieva, Kyiv: Lybid-Isa, 1995. (Original language: Є. Болховітінов, **Вибрані праці з історії Києва**, Упор. Тетяна Ананьєва, Київ: Либідь-Іса, 1995).

[9] T. Bobrovskyi, **Pidzemni sporudy Kyieva vid naidavnishykh chasiv do seredyny XIX stolittia (speleo-arkheolohichnyi narys),** Kyiv: ArtEk, 2007. (Original language: Т. Бобровський, **Підземні споруди Києва від найдавніших часів до середини XIX ст. (спелео-археологічний нарис),** Київ: АртЕк, 2007).

[10] I.A. Cherevko, Yu.H. Holovatenko, *Pidzemni sporudy v konteksti formuvannia kompleksu kelii sobornykh iieromonakhiv (korpus No. 4),* **Lavrskii almanakh**, **28**, Kyiv, 2012, pp. 145-148. (Original language: І.А. Черевко, Ю.Г. Головатенко, *Підземні споруди в контексті формування комплексу келій соборних ієромонахів (корпус № 4)*, **Лаврський альманах, 28,** Київ, 2012, сс. 145-158).

[11] Ye.F. Cherednychenko, *Arkhitektura ta funktsionalne pryznachennia pidzemnykh sporud verkhnioii Lavry,* **Mohylianski chytannia 2005:** a collection of research papers, Kyiv: Feniks, 2006, pp. 539-554. (Original language: Чередниченко Є.Ф. *Архітектура та функціональне призначення підземних споруд Верхньої лаври,* **Могилянські читання 2005 року:** Зб. наук. пр. Київ: Фенікс, 2006, сс. 539-554).

[12] Ye.F. Cherednychenko, *Istoriia remontno-restavratsiinykh robit u pidzemnykh sporudakh Verkhnioi terytorii Kyievo-Pecherskoi Lavry XX – pochatku XXI stolittia,* **Mohylianski chytannia 2013:** a collection of research papers, Kyiv, 2014, pp. 61-69. (Original language: Є.Ф. Чередниченко, *Історія ремонтно-реставраційних робіт у підземних спорудах Верхньої території Києво-Печерської лаври XX – початку XXI ст.,* **Могилянські читання 2013 року:** Зб. наук. пр., Київ, 2014, сс. 61-69).

[13] O.V. Sitkariova, **Arkhitekturnyi ansambl Kyievo-Pecherskoi lavry ta ii istorychnoho otochennia za doby hetmana I.S. Mazepy,** Kyiv: Dovira, 2005. (Original language: О.В. Сіткарьова, **Архітектурний ансамбль Києво-Печерської лаври та її історичного оточення за доби гетьмана І.С.Мазепи,** Київ : Довіра, 2005).

[14] Ye.F. Cherednychenko, *Pidzemna sporuda pid ohorozheiu (Mazepynska stina) navkolo verkhnoi terytorii Lavry,* **Mohylianski chytannia 2009:** a collection of research papers, Kyiv: Feniks, 2010, pp. 409-417. (Original language: Є.Ф. Чередниченко, *Підземна споруда під огорожею (Мазепинська стіна) навколо верхньої території Лаври*, **Могилянські читання 2009 року**: Зб. наук. пр., Київ: Фенікс, 2010, сс. 409-417).

[15] I.A. Cherevko, Yu.H. Holovatenko, *Do pytannia atrybutsii pidzemnykh sporud No.9 (liokh v sadu mytroplyta) ta no.28 (bilia korpusu No. 31),* **Lavrskii almanakh, 26,** Kyiv: DP "NVC "Priorytety", 2012, pp. 166-175. (Original language: І.А. Черевко, Ю.Г. Головатенко, *До питання атрибуції підземних споруд № 9 (льох в саду*

митрополита) та № 28 (біля корпусу № 31), **Лаврський альманах, 26,** Київ: ДП «НВЦ «Пріоритети», 2012, сс. 166-175).

[16] I.A. Cherevko, D.V. Litvinchuk, Yu.H. Holovatenko, *Vplyv pryrodnykh i tekhnohennykh faktoriv na tekhnichnyi stan konstruktsii pidzemnykh pamiatok u konteksti ikh zberezhennia,* **Sofiiskii chasopys, 4,** Kyiv, 2020, pp. 416-424. (Original language: I.A. Черевко, Д.В. Літвінчук, Ю.Г. Головатенко, *Вплив природних і техногенних факторів на технічний стан конструкцій підземних пам'яток у контексті їх збереження,* **Софійський часопис, 4,** Київ, 2020, сс. 416-424).

[17] I.A. Cherevko, Yu.H. Holovatenko, *Zberezhennia pidzemnykh sporud Verkhnioi Lavry: kryterii optymalnoho rezhymu ekspluatatsii,* **Bolkhoviitynovskyi shchoricnyk,** Kyiv, 2013, pp. 49-60. (Original language: Черевко, І.А., Головатенко Ю.Г., *Збереження підземних споруд Верхньої Лаври: критерії оптимального режиму експлуатації,* **Болховітіновський щорічник**, Київ, 2013, сс. 49-60).

[18] I.A. Cherevko, D.V. Litvinchuk, Yu.H. Holovatenko, *Doslidzhennia ta systematyzatsiia kompleksu destruktyvnykh faktoriv vplyvu na konstruktsii pidzemnoi sporudy No.11. propozytsii,* **Mohylianski chytannia 2018:** a collection of research papers, Kyiv: Feniks, 2018, pp. 243-249. (Original language: І.А. Черевко, Д.В. Літвінчук, Ю.Г. Головатенко, *Дослідження та систематизація комплексу деструктивних факторів впливу на конструкції підземної споруди № 11. Пропозиції щодо можливих запобіжних заходів у контексті її збереження,* **Могилянські читання 2018:** Зб. наук. праць, Київ: Фенікс, 2018, сс. 243-249).

[19] https://www.novinky.cz/clanek/cestovani-brnensky-spilberk-jeho-kasematy-jsou-plne-mytu-a-povesti-40391886 (accessed, 06-08-2024).

[20] J. Vaněk, *Špilberské kasematy a jejich přeměna na vězení v roce 1784,* **Forum Brunense,** 1994, pp. 95-97.

[21] O. Franěk, **Brněnský hrad Špilberk, Správa muzea brněnského hradu**, Brno, 1957.

[22] R. Rybář, **Brněnské podzemí**, Brno 2010, p. 19.

[23] L. Kadlečková, **Každodennost špilberské věznice za dob italských karbonářů a polských revolucionářů,** Brno: Masarykova univerzita, 2014.

[24] https://cesky.radio.cz/deset-nadsencu-prespalo-v-kasematech-na-brnenskem-hrade-spilberk-dalsi-termin-je-8823471, (accessed, 06-08-2024).

[25] L.Z. Koláček, **Osudy hradu Špilberku, jeho pánů a vězňů,** Třebíč: Akcent, 2005.

[26] https://www.novinky.cz/clanek/cestovani-brnensky-spilberk-jeho-kasematy-jsou-plne-mytu-a-povesti-40391886, (accessed, 06-08-2024).

[27] M. Menšíková, *Snahy o využití Špilberku pro muzejní účely*, **Forum Brunense**, 1994, pp. 83-90.

[28] P. Kroupa, *Špilberk – stavební úpravy za 2. Světové války*, **Forum Brunense,** 1990, p. 95.

[29] B. Czwojdrak, K. Miroszewski, P. Węcowski (Red. Naukowa), **Oświęcim – miasto pogranicza, Tom I, II**, Warszawa: Wydawnictwo Uniwersytetu Warszawskiego, 2018 r.

[30] www.muzeum-zamek.pl (dostęp 19.08.2024).

[31] https://oswiecim.pl/tunele-pod-zamkiem-nowa-atrakcja-turystyczna-w-oswiecimiu-na-kazda-pogode/33795/ (dostęp 19.08.2024).

[32] Asványi K., Fehér Z., Jászberényi M. *The Family-Friendly Museum: Museums through the eyes of families*, **Muzeológia a kultúrne dedičstvo**, **9**(1), 2021, pp. 21-40, doi: 10.46284/mkd.2021.9.1.2. ISSN 1339-2204.

[33] R. Geisler, E. Nieroba, *Museum transition toward market-oriented identity: between social issues and public policy*, **Muzeológia a kultúrne dedičstvo**, **10**(4), 2022, pp. 5-25, DOI: 10.46284/mkd.2022.10.4.1.
[34] D.A. Jelinčić, K. Jelinčić, *Surprise me Softly: The Element of Surprise in Designing Museum Experiences*, **Muzeológia a kultúrne dedičstvo**, **9**(1), 2021, pp. 5-19, DOI: 10.46284/mkd.2021.9.1.1.

Received: November 22, 2024
Accepted: March 23, 2025