STONE DURABILITY UNDER CLIMATIC INFLUENCES: A CASE STUDY OF THE YUGOSLAV MONUMENT AT THE MAUTHAUSEN MEMORIAL

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First Stećci Conference: Perserving Cultural Heritage in Times of Climate Change 25–27 September 2025 University of Applied Arts Vienna

The Yugoslav monument within the Mauthausen Memorial was erected in 1958 to honor the Yugoslav victims. The design specified the use of home materials—marble and granite—for the monument. It featured 8-meter-high two obelisks, and a "sarcophagus" constructed from eleven marble panels, all made from white marble sourced from Venčac. All materials were prepared and produced in Yugoslavia.

In response to a report submitted by the diplomatic mission of the Republic of Serbia in Austria regarding the deteriorating condition of the marble columns, the Institute for the Protection of Cultural Monuments of Serbia initiated an investigation in 2024. This research included collecting data from archival documents dating back to the original memorial's construction in 1957 and detailed comparison with the monument's current state.

This study presents a comparative analysis of the properties of the material at the time of construction and its current condition, after 68 years of exposure to climatic factors and static stability. The Institute for Materials in Belgrade conducted examinations of the stone samples in 1957 and again in 2024.



CONCEPTUAL DESIGN

At the proposal and invitation of the Committee for the Arrangement and Marking of Historical Sites of the People's Liberation Struggle, together with the Yugoslav Embassy in Vienna, the architect **Bratislav Stojanović**, head of the architectural-urbanist studio *Oblik* from Belgrade, carried out an inspection in 1955 of the existing memorial monuments at Mauthausen. Following this, as chief designer, he prepared the Urban-Architectural Project for the Monument to Yugoslav Victims at Mauthausen. His collaborators on the project were architects from the *Oblik* studio: A. Đorđević, L. Pop-Jordanova, A. Atanacković, C. Čvorić, and V. Tvrtković.

Taking into account the urban composition of the entire memorial complex and its commemorative significance, Stojanović initially envisaged a strictly ordered solution with pure **forms**, that is, a restrained monument situated on the terraced terrain. The conceptual design consisted of a paved plateau, covered with dark stone, accessed by a set of stairs. The plateau unified all the elements of the monument: three obelisks (col-

umns) and a stone block ("sarcophagus") with reliefs. The planned surface area of the plateau, paved with granite slabs, was 200 m². The stone block ("sarcophagus") was intended to be made of light marble, providing a contrast to the horizontal paved surface and, at the same time, emphasizing the reliefs, which

were to be executed in metal. The reliefs were thematically dedicated to scenes from camp life. On another side of the block, an inscription was to be placed. The horizontal marble block, planned as the support for the reliefs, was to have dimensions of $9.3 \times 1.6 \times 2.3$ m. The three columns were designed in white *Venčac* marble, with a diameter of 0.6 m and a height of 8 m. The concept also included landscaping with green areas, planted shrubs, and a row of specially chosen mulberry trees.

For the Mauthausen monument, Stojanović prepared a preliminary bill of quantities and cost estimate, foreseeing the use of domestic materials and the production of monument elements in Yugoslavia from marble and granite. The total planned cost amounted to 18,370,000 dinars, excluding a portion to be paid in foreign currency—approximately 4,800,000 dinars—for transportation and on-site works.

Although the analysis of the monument's form and location lies outside the central focus of our research, it is important to note that Stojanović, despite his limited prior experience in constructing memorials, demonstrated a high degree of artistic and professional maturity in addressing both the subject matter and the setting in which the monument was to be placed.

It is also of great significance that the project documentation was submitted to architect Hans Bauer, who, together with Hofrat Heinisch, adviser at the Austrian Federal Monuments Office, held three meetings to review the submitted plans and construction descriptions. On January 27, 1956, Bauer submitted a report to the Yugoslav Embassy, assessing the project as exemplary and an architectural ornament to the entire complex, albeit with several suggestions. The primary recommendation concerned the necessity of aligning the design with Austrian building regulations.

Other remarks mainly concerned the choice of materials. The report contained no objections to the general selection of materials, except regarding the proposed use of marble, which Bauer argued would not be suitable for the local climatic conditions. He suggested instead a harder stone, preferably granite. At the same time, the solution of paving the plateau with stone slabs was described as excellent, though much too costly. Moreover, the area around Mauthausen was considered prone to significant climatic fluctuations, with prolonged frost likely to cause severe damage over time. Among other remarks, the suggestion of using a mosaic for the pavement in front of the monument was described as aesthetically appealing, but likewise very expensive and vulnerable to freezing conditions during winter.

Architect Stojanović was informed of Bauer's report on April 20, 1956, and a meeting was held in Mauthausen to discuss the matter further.

Based on the accepted suggestion of the jury reviewing the competition entries for the sculptural part of the monument—that the three-column architectural elements impaired the complete perception and visibility of the sculptural features and that the mass of the main block alone was sufficient to stand as a monument—certain conceptual changes were made. The changes also aimed at simplifying production and transport of the monument's elements.

Archival documentation shows that the main block was divided into 11 elements for easier transport and then clad with blocks 0.3 m thick. The visible surfaces of the block were roughly processed but completely even. The core and foundation were executed on site, with a foundation depth of 1.4 m. The number of columns was reduced to two, with altered dimensions of 0.55 m in diameter and 8.5 m in height. The columns were embedded in a 1.0 m-high foundation, roughly treated up to that height.

The plateau paving in front of the monument was executed using Jablanica granite slabs $(1.2 \times 0.6 \times 0.04 \text{ m})$, laid on a macadam and concrete base. The access steps were made of tamped concrete clad with Jablanica granite. The plateau paving between the steps was initially intended to be constructed with granite slabs of various dimensions, also laid on a prepared base.

For the sculptural part of the monument on the stone block, in 1957 the Central Committee of the Association of Veterans of the People's Liberation War invited seven sculptors to a competition. The first prize was awarded to the bronze relief by Nandor Glid, a sculptor from Belgrade. In his conceptual design, the author depicted the tragedy of events in the camp through the dynamic composition of skeletons, strongly evoked by expressive hands and human bodies. The dimensions of the relief composition are 6.7×1.9 m.

MONUMENT REALIZATION IN 1958

On July 29, 1957, a contract was concluded between the Marble Industry Venčac from Aranđelovac, as contractor, and the Central Committee of the Association of Veterans of the People's Liberation War of Yugoslavia in Belgrade, as the client, regarding earth, concrete, and marble works for the construction of the Monument to Fallen Victims in Mauthausen, Austria.

It was foreseen that all materials used in the monument to the Yugoslav victims would be produced and procured in Yugoslavia. Subsequently, the necessary materials were acquired, and the elements of the monument were fabricated in Yugoslavia for transport to Mauthausen.

The Venčac Marble Industry from Belgrade prepared:

• marble slabs of "Jablanica granite" for paving the plateau,

• three round marble columns of white "Venčac", and • the main core block of white "Venčac" marble.

The three columns from the conceptual design were made of white Venčac. The Institute for Testing Materials of the People's Republic of Serbia examined stone samples in 1954. The stone originated from the quarry in the village of Banja, Orašac District, Republic of Serbia. Samples were taken, sealed, packed, and sent by the Venčac Marble Industry.

The Institute for Testing Materials of the PR of Serbia in Belgrade, at the request of the Venčac Marble Industry, conducted testing of the stone sample between July 18 and August 12, 1954, and, based on the results, issued a certificate regarding its mineralogical-petrological characteristics and mechanical-technical

The mineralogical composition was determined as consisting solely of calcite, with only occasional tiny flakes of mus-

covite observed. No signs of surface disintegration were detected.

The following mechanical-technical properties were established:

• compressive strength in dry condition: 1061 kg/cm²,

• compressive strength in water-saturated condition: 960 kg/cm²,

• compressive strength after 25 freeze–thaw cycles: 892 kg/cm²,

• water absorption: 0.17%, frost resistance: confirmed

Reports and contracts confirm that all three columns were fabricated, but one was not transported or installed. The columns were of circular cross-section, 0.55 m in diameter and 8.55 m in length. The sculpture, measuring 1.9 × 6.7 m, was cast in bronze, chiseled, and patinated in the Artistic Workshop of the Association of Fine Artists of Serbia, *Plastika*, Belgrade. The inscription consisted of 57 bronze letters (10 cm high), 8 numerals, and one dash.

The ceremonial unveiling of the monument was originally scheduled for May 1, 1958, but took place on May 11, 1958, at 13:15. The monument was unveiled by Yugoslavia's ambassador to Austria, Jože Zemljak, who also gave a short speech together with Drago Milenković. The Yugoslav delegation attending the unveiling of the monument to the Yugoslav victims who perished in the Mauthausen concentration camp in Austria consisted of Velibor Gligorić (head of delegation), Velibor Marić, Miloš Bajić, Miša Rajšić, Nandor Glid (author of the relief), and Kobal Cvetko. The ceremony followed the established protocol of strictly codified public commemorations for monument unveilings in Mauthausen, organized by the Austrian Association of Concentration Camp Survivors (KZ Verband).

RESEARCH AND PROJECT IN 2024

In 2024, based on research concerning the existing condition of the monument, the Institute for the Protection of Cultural Monuments of Serbia prepared a **Project for Conservation and Restoration Works** with a Proposal for Structural Rehabilitation of the Yugoslav Monument at the Mauthausen Memorial in the Republic of Austria.

On-site work included detailed documentation of the existing state with mapping of damage, as well as comparison of the executed monument with archival project documentation.

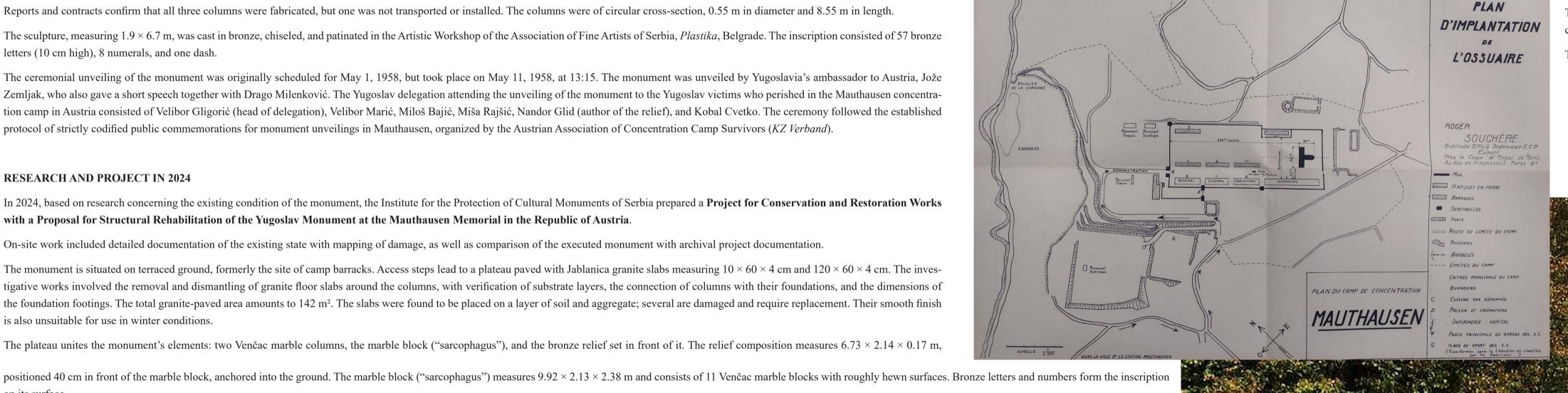
The monument is situated on terraced ground, formerly the site of camp barracks. Access steps lead to a plateau paved with Jablanica granite slabs measuring $10 \times 60 \times 4$ cm and $120 \times 60 \times 4$ cm. The investigative works involved the removal and dismantling of granite floor slabs around the columns, with verification of substrate layers, the connection of columns with their foundations, and the dimensions of the foundation footings. The total granite-paved area amounts to 142 m². The slabs were found to be placed on a layer of soil and aggregate; several are damaged and require replacement. Their smooth finish is also unsuitable for use in winter conditions.

The plateau unites the monument's elements: two Venčac marble columns, the marble block ("sarcophagus"), and the bronze relief set in front of it. The relief composition measures 6.73 × 2.14 × 0.17 m,

on its surface. According to archival documentation, the planned height of the columns was 750 cm above the granite-paved plateau, with an additional 100 cm embedded into the foundation, making the total length 850 cm. Field measurements established that the actual

visible height is 795 cm. The depth of the foundations was not investigated so as not to jeopardize monument stability. The columns deviate from vertical, with variations in circular cross-section along their height, and are not aligned with the axis of the footing. Visible cracks were recorded, though their depth and degree of impact on the structural stability of the columns could not be precisely determined. Moisture and dirt infiltration into the marble material have intensified the damage.

Material samples were taken and analyzed at the Institute for Materials Testing. The report confirmed the presence of microflora, parasitic vegetation, and surface deposits. The marble showed clear signs of deterioration in the form of biological patina colonies of microorganisms containing mechanical impurities, soot, and dust. Biological analysis confirmed the presence of lichens (lichenized fungi with foliose thalli), microcolonial fungi adapted to stone substrates, melanized fragmented hyphae with chlamydospores penetrating into deeper layers of stone, as well as yeasts and bacteria. Samples from the bronze sculpture revealed filamentous fungi and bacteria.



The project envisaged conservation and restoration works on all elements of the Yugoslav Monument, aiming to prevent further deterioration and destruction of its integral parts, and to improve its visual presentation currently compromised by surface deposits and mechanical damage to the sculpture and stone elements.

MATERIAL DEGRADATION ASSESSMENT

The Yugoslav Monument at the Mauthausen Memorial in Austria commemorates a site of suffering within a natural landscape, harmoniously integrated into its surroundings. The monument was carefully planned from both architectural and sculptural perspectives. Architect Stojanović chose to use stone materials sourced in Yugoslavia, despite Austrian architect Bauer's recommendation to opt for a harder material, pointing out the severe climatic fluctuations in the Mauthausen area and the risk of frost damage. Our conservation-research work at Mauthausen in 2024 was initiated based on reports from the Mauthausen Memorial concerning the endangered condition of the two marble columns. Monumental changes are rarely caused by a single factor but rather by a complex interaction of environmental processes over extended periods.

Visual inspection and detailed documentation confirmed that the marble columns are tilted. However, no archival geodetic survey exists to identify the cause of this deformation. On-site tests of material strength showed that the right column has a compressive strength of 44–46 MPa, while the left measures 46–48 (52) MPa. Cracks were recorded in the lower zones of both columns.

Venčac marble consists of pure calcite grains, typically white with bluish tones. Earlier testing (1963) had established that the material is water-resistant and



to the monument's complete devastation.

Proper and timely intervention contributes to the sustainability of the monument. The project for conservation and restoration of the Yugoslav Monument is directed towards preventing further deterioration and safeguarding all integral parts of the memorial.

As a public monument exposed to natural elements, it is vulnerable to various agents of gradual material degradation. Effective preservation requires thorough consideration of environmental risks, material vulnerabilities, and protective measures at the design stage.

Based on our experience in researching, designing, and executing conservation works at the Yugoslav Monument at Mauthausen, we conclude that stone materials for public monuments must be carefully selected—high-strength, compact, resistant to abrasion, frost, and environmental aggressors—while taking into account local climatic and natural conditions.

Furthermore, in striving for sustainable architecture, it is essential to use indigenous materials from the immediate environment when constructing outdoor public monuments, thereby ensuring their durability and long-term preservation.

