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FILIP SUCHOŃ
ORCID: 0000-0002-3098-0025
Cracow University of Technology, Polska

FACILITY A: ABOUT THE "ITALIAN FORT" IN HAJMÁSKÉR

OBIEKT A: O „WŁOSKIM FORCIE" W HAJMÁSKÉR

Abstract

The research relates to an experimental fortification facility, erected in the early 20th century at the Hajmáskér training ground (Hungary). The purpose of the research was to clarify the context from which the type and location of the object were derived, and to date the construction. A historical-interpretive research method was adopted. The study revealed the precursor character of the building, whose expressive form foreshadowed the Brutalist trend of late Modernism architecture. Thanks to modern 3D modeling technology, it was possible to reconstruct the original shape of the building – based on archives.

Keywords: concrete architecture, extreme architecture, fortifications

Streszczenie

Badania dotyczą eksperymentalnego obiektu fortyfikacyjnego, wzniesionego na początku XX w. na poligonie Hajmáskér (Węgry). Celem badań było wyjaśnienie kontekstu, z którego wynikały typ i lokalizacja obiektu, oraz datowanie realizacji. Przyjęto metodę badań historyczno-interpretacyjnych. Badanie wykazało prekursorski charakter budynku, którego ekspresyjna forma zapowiadała brutalistyczny nurt architektury późnego modernizmu. Dzięki współczesnej technice modelowania 3D na podstawie archiwaliów możliwe było zrekonstruowanie pierwotnego kształtu budynku.

Słowa kluczowe: architektura betonowa, architektura ekstremalna, fortyfikacje

1. INTRODUCTION

At the beginning of the 20th century, existing fortifications could no longer cope with the destructive force of modern artillery and had become ineffective. Just before World War I, in Austria-Hungary, an experimental facility was built – a model mountain fort intended to meet the requirements of the battlefield and alpine conditions of the time. It was an experiment on many technical, technological, and architectural levels. A massive volume with unprecedented, multi-meter thick ceilings and walls provided shelter for the crew and high-tech weaponry in its interior. Both technical thought and the invisible but predicted flight trajectories of enemy missiles were written in the play of concrete planes. Only small openings providing communication with the outside world were reminders of the human scale. A careful analysis of this extreme architecture allows us to ask questions about the limits of knowledge and technical capabilities and the relationship between architecture and technology.

1.1. STATE OF RESEARCH

The first voices in the discussion regarding the shape of modern twentieth-century fortification appeared in the pages of professional journals. These were initially only theoretical considerations. Austrian officer Johann Hanika, in the article "Innovations in the field of permanent fortification," indicated possible and desirable directions of development and the need for solutions ahead of the era.[1]

Italian officer Enrico Rocchi conducted an in-depth study of the relationship between technology and military architecture, set in economic realities.[2] He was the author of many essays and articles and a monumental work on the history of fortifications. He was also a renowned practitioner – the main designer of model Italian forts before the First World War.

Twentieth-century considerations in search of the forms and peculiarities of high mountain – alpine architecture opens with a collection of essays and design sketches by Bruno Taut, a German architect of the Expressionist and Modernist eras. The series of works, created in 1917–1918, was published after the end of World War I.[3]

The classic work on alpine architecture is the book "Building in the Mountains" by Italian painter and architect Mario Cereghini.[4] As the author describes it, it is a collection of first-hand information based on design experience, helpful to novices in the field of building in the mountains.

Swiss architect Manuel Pauli posed the rhetorical question, is there a "mountain architecture"? By expanding on this question, he provided an overview of his contemporary concepts for adapting architecture to mountain terrain.[5] He searched for forms of development that offered inexhaustible sources of possibilities for creating in a mountainous setting that was significantly different from the urban environment "in terms of views and experiences." For a large-scale and rich program, he pointed to ribbon-like, linear layouts that integrate well with the landscape, like roads or railroads. Spontaneous forms of housing like the return to caves or the underground "invisible agglomerations" proven in the Arctic regions, according to this author, were again finding their raison d'être because they "elegantly" circumvented all restrictions (regulations, landscape protection directives, or, for example, Swiss requirements to protect buildings from aerial bombardment).

A text by Italian architect Luca Moretto[6] is devoted to the numerous designs and realizations of modern 20th-century architecture in the Aosta Valley (the region encompassing the highest parts of the Alps) and its relationship to the theories and achievements of the international modernist movement. From the late 1920s to the first half of the 1960s, from the first proto-rationalist structures made of reinforced concrete of the Hennebique system to mountain huts and cable car stations on the Matterhorn and Gran Paradiso, hydroelectric power plants, tourist huts and hotels, and single-family homes designed for the area.

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[1] J. Hanika, *Neuerungen in der permanenten Fortifikation*, "Streffleurs militärische Zeitschrift" 1908, no. 2., pp. 229–260.

[2] E. Rocchi, *L'economia nelle opere di difesa*, "Rivista d'Artiglieria e Genio" 1910, no. 1, pp. 377–398.

[3] B. Taut, *Alpine Architektur: in 5 Teilen und 30 Zeichnungen,* Folkwang-Verlag, Hagen 1919.

[4] M. Cereghini, *Building in the mountains. Architecture and history*, Edizioni del Milione, Milano 1957.

[5] M. Pauli, *Constructions en montagne*, "L'Architecture d'Aujourd'hui" 1966, no. 126, pp. 125–128.

[6] L. Moretto, *L'avventura dell'architettura Moderna alpina in Valle d'Aosta* [in:] Moretto L. (ed.), *Architettura moderna alpina in Valle d'Aosta*, Musumeci Editore, Quart 2003.

Architects face some of the most difficult tasks when designing in extreme environments. Ruth Slavid's monograph offers valuable insight into this issue.[7] She presents structures ranging from desert shelters to floating marine research centers, underground seed storage facilities, and research stations at the South Pole.

Jennifer Cahill describes the limits of human exploration in three extreme environments: the Arctic, the deep sea, and outer space.[8] Architects face similar design challenges requiring creative solutions to difficult issues. These are primarily explorations of how to ensure the psychological comfort of users in specific outdoor environments and attempts to mitigate extreme sensations such as spatial disorientation, unusual daylight, confinement, or lack of familiar sensory stimuli.

2. RESEARCH

2.1. RESEARCH METHODOLOGY

A historical-interpretive research method was adopted.[9] Archival materials and other sources of information were used, including available photographs of the facility during its construction – from the World War I period. Historical research consists of collecting documents and facts about the history of the object, its description, and scientific interpretation. Research was carried out on archival records and all available documents relating to objects of the same class and from the same era (early 20th century).

2.2. MATERIALS

The primary sources were archival photographs, plans, and blueprints for the object in question. Particularly valuable material was a series of architectural drawings on a 1:100 scale drawn up in Vienna by the imperial-royal Military Technical Committee (k. u. k. Technische Militärkomitee, TMK) and dated August 1915.[10]

Historical norms and design instructions from 1914 are:

(a) Guidelines for the design of fortification structures, in a study titled "Basic Principles of Design and Construction of Fortification Structures from the Point of View of War Technology," compiled based on field trials and systematized just before the outbreak of World War I;[11]

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[7] R. Slavid, *Extreme architecture: Building for challenging environments*, Laurence King Publishing, London 2009.

[8] J. Cahill, *Architecture for extreme environments: Design challenges in the realm of the uncommon*, "Spaces and Flows: An International Journal of Urban and ExtraUrban Studies" 2013, no. 3(4), pp. 71–78.

[9] A. Kwaśniewski, *Po co badać – jak badać. Uwagi o metodyce współczesnych badań historyczno-architektonicznych i o ich stosowaniu przy adaptacji obiektów zabytkowych*, "Architectus" 2019, no. 1(57), pp. 3–20.

[10] Bombensicheres-Versuchsobjekt-A. Draufsicht, Masstab 1:100, Wien im August 1915. Österreichisches Staatsarchiv/Kriegsarchiv, sygn. AT-OeStA/KA ZSt KM HR Akten 8150.

[11] Anhaltspunkte für den Entwurf und die Ausführung fortifikatorischer Bauten vom kriegstechnischen Standpunkte (Sekt. II, Nr. 313 res.) 1914, Österreichisches Staatsarchiv/Kriegsarchiv, sygn. AT-OeStA/KA MBeh TMK SR 1212-1214.

(b) Detailed construction norms concerning the dimensioning of ceilings, walls, and foundations of fortification facilities in the class of resistance against the heaviest siege artillery, in a typescript under the title "Provisional guidelines of a technical and constructional nature for bombproof fortification facilities."[12]

The description of the development of wall and ceiling constructions in Austro-Hungarian fortification structures was also dedicated to archival studies from the interwar period, which were contributions to historical research begun back during World War I at the inspiration of the Austrian Association of Engineers and Architects (Ingenieur- und Architektenverein) – texts and detailed technical drawings.[13] The time caesuras adopted by researchers of the time illustrate the leaping, the increasingly rapid development of siege artillery of large calibers, and attempts to construct building envelopes with corresponding resistance (normative in effect before 1900, between 1900 and 1911, since 1911, since 1914).

2.3. CONTEXTS – TYPE AND LOCATION OF THE FACILITY

Permanent fortification throughout history has been burdened by two significant drawbacks: facilities were costly and could only, to some extent, respond in advance (or through expensive upgrades) to advances in armaments and war technology. As a result, in the first decade of the 20th century, no country had a system of permanent fortifications that fully responded to the realities of the coming World War. Due to its geographic and military-political position, Austria-Hungary was at a particular disadvantage. The length of the monarchy's border line was about 5,400 kilometers, almost three-quarters of which were borders with potentially hostile countries. The banks of the Adriatic Sea, the highlands in Galicia on the border with tsarist Russia, as well as the mountain ranges of the Alps on the Italian border, and the peaks of the Dinaric Alps on the border with Montenegro all required fortification.[14] The economic condition, meanwhile, allowed for far less military spending (navy, army, fortifications) than most of Austria-Hungary's opponents.

The precision and firepower of siege artillery forced fortification engineers to take up once again the problem of designing a facility that would give adequate cover to the crew and armaments of a modern fort. The basic design assumptions were based on observations: targets of large size were vulnerable to immediate destruction, so the dimensions of the fortification facility had to be minimized as much as possible, and its individual elements had to be dispersed over the terrain; in the long run, the power of the projectile's live ammunition exceeded the passive resistance of even the strongest cover. Fortifications should have been flexible; they should have taken into account the changing turns of the war and the most

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[12] Provisorische Direktiven bautechnischer Natur für bombensichere, fortifikatorische Objekte, (Sekt. II, Nr 313 res.) 1914, Wien [typescript]. Österreichisches Staatsarchiv/Kriegsarchiv, sygn. AT-OeStA/KA, MBeh, TMK, SR 1212.

[13] Entwicklung der Wand und Deckenkonstruktion, Wien [mpis]. Österreichisches Staatsarchiv/Kriegsarchiv, sygn. AT-OeStA/KA MS Rb Manuskripte zur Geschichte der Reichsbefestigung (Rb); sygn. AT-OeStA/KA MS TiWk Manuskripte zu "Technik im Weltkrieg" (TiWk).

[14] K. Mörz de Paula, *Der österreichisch-ungarische Befestigungsbau 1820–1914*, Stöhr, Wien 2006; R. Rolf, *Festungsbauten der Monarchie die k.k.– und k.u.k. Befestigungen von Napoleon bis Petit Trianon, eine typologische Studie*, PRAK, Middelburg 2011; R. Hentzschel, *Festungskrieg im Hochgebirge,* Athesia, Bozen 2016.

unfavorable situations (such as defending in isolation without the possibility of relieving the crew for a long time).[15]

Because of the cost of building fortifications, numbering in the millions, solutions were expected to be the best to achieve. At the same time, the realization was that purely theoretical considerations are never enough to determine the optimal practical solutions. Any advantages and disadvantages of the designs had to be confirmed by impartial practical trials, reflecting reality as close as possible to the conditions of war. For this reason, testing ground facilities were erected, on which the validity of the assumptions and solutions adopted were tested by subjecting them to artillery fire with live ammunition.

Hajmáskér is a town in Veszprém County, Hungary, located a dozen or so kilometers from the northeastern shore of Lake Balaton. A self-sufficient complex of artillery school buildings was built here between 1907 and 1910. An extensive (about 6,400 hectares) artillery training ground was on a plateau adjacent to the village. An experimental fortress facility, code-named "Object A," was built on the training ground in 1915. It was an experimental shelter used to protect crews, equipment, armaments, and supplies from the effects of artillery bombardment – that is, shelling by high-powered siege artillery.

2.4. RESULTS OF RESEARCH AND ARCHIVAL SEARCHES

At the beginning of the 20th century, new materials with sufficient strength to resist the destructive effects of artillery shells – concrete and steel armor – were used to erect and modernize fortifications.[16] Concrete structures possessed a property valuable for the resistance of fortifications – the individual parts of the structure were firmly connected, and the action of external forces on one part of the structure (ceilings, walls, foundations) was transmitted to an appropriate degree to the other parts. Concrete used for fortification work had to be much stronger than the concrete used in civilian construction. This was made possible by the much higher cement content in the mix, called "fortification concrete" to distinguish it.[17]

The magnitude of the impact of artillery shells on the object under fire depended primarily on the force of impact and the strength of the explosive charge, the greater the caliber. On a direct hit, the shell penetrated the concrete structure; a funnel was formed at the site of the explosion, and the destruction of the concrete mass followed. Explosions in the vicinity of the object caused shock tremors, a blast wave, and the release of toxic gases. These conditions were highly unfavorable for the fortification facility and people seeking shelter inside.

Following field trials – shelling from high-powered siege artillery, with calibers of 28 cm and 30.5 cm – principles were developed for shaping the body of the fortification object to minimize the effects of shelling as much as possible.[18] The discussed "Object A" was realized following these principles to prove the resistance of structural and architectural solutions to the firing of the heaviest artillery.

The angle of incidence of shells of 30.5 cm caliber at a distance of 8 km was 65 degrees. Hence, it was assumed that the slope of the flat roof from 25 to 30 degrees would cause the shell to deflect or slide at the first hit. A flat roof slope of fewer than 25 degrees but with

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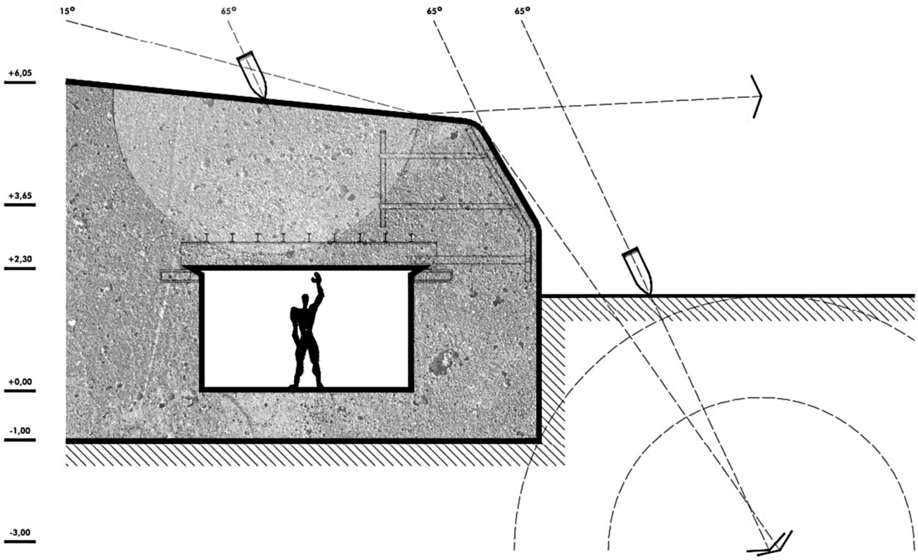
[15] J. Hanika, *op. cit*.

[16] K. Kleczke, W. Wyszyński, *Fortyfikacja stała*, Napoleon V, Oświęcim 2020, pp. 179–180.

[17] *Ibidem*.

[18] Here and following: K. Mörz de Paula, *op. cit*, pp. 145–149.

a slope in line with the direction of enemy fire should have favored shell slippage since not every artillery shell hit the building envelope exactly at the theoretical angle of incidence. In addition, the slope was needed for obvious reasons to effectively drain rainwater. In order to prevent pieces of concrete from being torn off during shell impacts, all outer edges (draws) of the shelter block were given streamlined forms, rounded as much as possible (see Ill. 1). The lower edges of the flat roof slab were shaped at a slant, with the surface sloping at an angle of less than 60 degrees to facilitate the sliding of falling projectiles.[19]



Ill. 1. Cross-section showing the dimensions of the concrete flat roof, walls, and foundation slab of the facility, designed to withstand heavy bomb impacts. Hypothetical trajectories of direct and plunging shellfire and falling angles are also depicted; based on archival materials by F. Suchoń.

The thickness of the flat roof slab depended on the required resistance to shelling. Slabs that could withstand three hits from the heaviest caliber shells at the same point should have a minimum three-meter thickness. A two-meter-thick slab was sufficient to achieve single-hit resistance. The thickness of the slab was measured at the weakest point, perpendicular to the outer plane of the flat roof. The steel-concrete composite flat roof structure resulted from research and testing by the imperial-royal Technical Military Committee (TMK) that began as early as the 1890s.[20]

The densely stacked steel girders provided the stay-in-place formwork for the flat roof slab. Beams from 450 mm high to 500 mm high were used depending on the rooms' clear span. Every second beam was anchored, and the anchors were connected to the reinforcement of the rim and the lower edge of the flat roof slab (literally called the cornice in the original).

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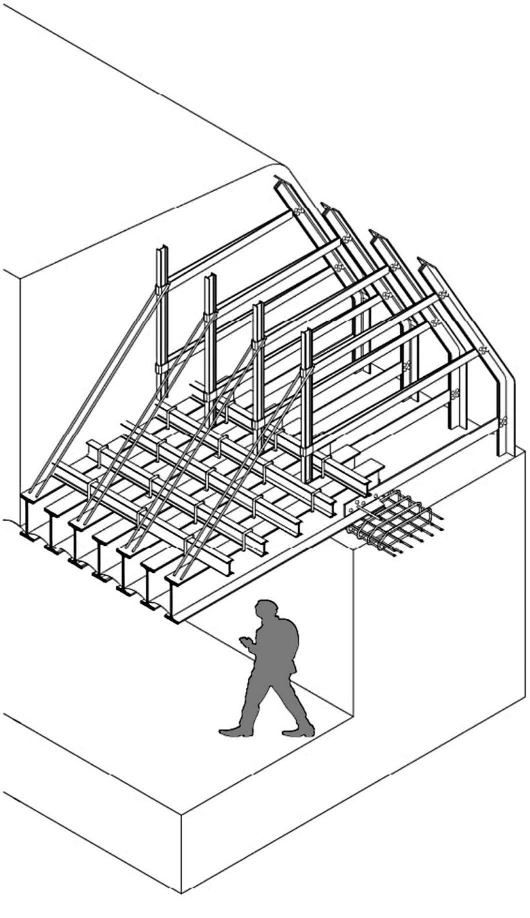
[19] Details following the design drawings *Bombensicheres-Versuchsobjekt-A*..., *op. cit*., and the manual *Provisorische Direktiven bautechnischer Natur für bombensichere, fortifikatorische Objekte*..., *op. cit*.

[20] K. Mörz de Paula, *op. cit*., p. 146.

The unanchored girders were connected to two adjacent anchored girders by means of bolted ties concealed in steel casing pipes. These girder connectors were located at the lower, more compressed part of the girders, i.e., as low as possible in the beam web. The inner surface of the ceiling – the ceiling consisting of the lower footings of the main girders and the sheet metal – was protected by anti-corrosion painting.[21]

To further strengthen the ceilings, a grid of 160 mm I-beams was placed directly above the main girders at an average distance of 0.5 m from each other. These beams were intended to better distribute the pressure from the explosion. To facilitate concreting, the beams of this grate were connected to the floor beams by stirrups. Particular attention was paid to reinforcing the parapets since the unprotected lower edges of the flat roof girders under the impact of the shells would quickly detach and be pushed out. The reinforcement used in "Object A" consisted of angle brackets laid about 15 cm from the outer face of the wall and anchored from the inside with flat iron fasteners (see Ill. 2).



Ill. 2. Detailed illustration of the steel reinforcement in the lower edge of the flat roof in an axonometric view; based on archival materials by F. Suchoń.

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[21] *Provisorische Direktiven bautechnischer Natur für bombensichere, fortifikatorische Objekte...*, *op. cit.*

In addition to bearing static loads, such a composite flat roof structure primarily prevented the formation of an inverted funnel under the impact of the explosion and the detachment of concrete fragments – which, if falling, could have endangered the lives of the crew in the room below.[22]

The perimeter walls, which could have been directly exposed to heavy shelling, were made of concrete and were the same thickness as the flat roof slab, or 3 meters. The remaining exterior walls – including the front (façade) wall not exposed to direct shelling – had a minimum thickness of 2 meters.[23] The number of openings in this wall was reduced to the minimum necessary, and the openings were small in size, closed with steel shutters – to reduce the impact of blast wave and gas pressure on the interior (see ill. 3 and 4).

Shocks from the explosion of large-caliber shells could have caused the floor slabs to separate from the walls. Shock resistance was provided by the aforementioned additional reinforcement in the cornice zone (i.e., at the junction of the floor slab with the exterior walls), and by the volume of the concrete in the structure. Hence, the large cross-sections of the elements provided an additional advantage for resistance.

As field tests showed, large-caliber projectiles penetrated 6 to 8 meters into the gravel base and 3 to 5 meters into loose rock. The dredged foundation walls were reinforced accordingly, and a reinforced concrete foundation slab, monolithically connected to the walls, was placed under the structure to prevent the risk of projectiles penetrating.

As previewed in the design, the above variation in the thickness of the partitions ensured that the cost stayed within the financial limit set for a modern fortification system at the dawn of World War I. The anticipated risks of exposure to shelling allowed to preserve the appropriate dimensions of more important elements at the expense of less important ones.

3. DISCUSSION

Twentieth-century fortification relied on scientific research and experience, adopting those elements of technology and technique needed to survive under extreme conditions. However, as E. Rocchi argued, fortification in its practical form and essence was not an emanation of science but a work of art, drawing inspiration from the object to which it referred.[24] In order to confirm the thesis that fortification is an art, Rocchi argued that each task set for fortification – as opposed to scientific research – yielded several solutions, depending on the number of factors that were taken into account. These factors were location, purpose of construction, nature of military operations, available technical means, and economic issues. By globally and harmoniously evaluating all of these elements, one of the many solutions emerged that allowed the desired goal to be achieved with the least possible resources.[25]

Johann Hanika's deliberations produced a no less important thesis: when designing fortification facilities, one must take into account the "zeitgeist" and the demands of each successive era. According to this author, military architecture should be in the vanguard,[26] anticipating what is to come because "fortresses are like warships: when they are completed, they are already obsolete."

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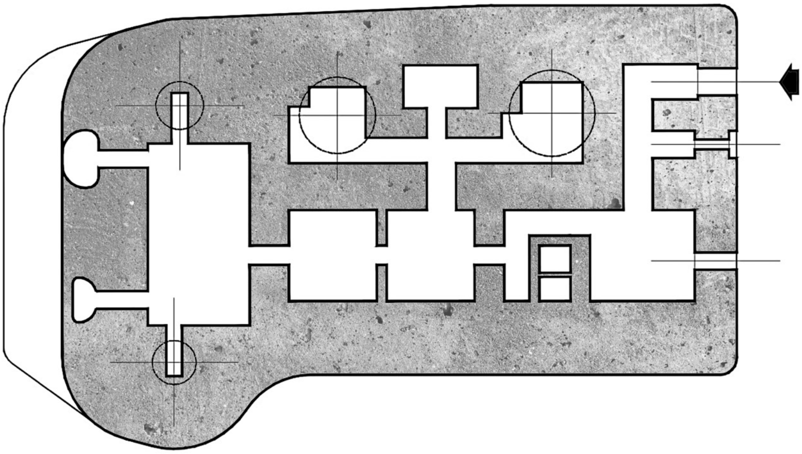
[22] K. Kleczke, W. Wyszyński, *op. cit.*, p. 246.

[23] *Provisorische Direktiven bautechnischer Natur für bombensichere, fortifikatorische Objekte*..., *op. cit.*

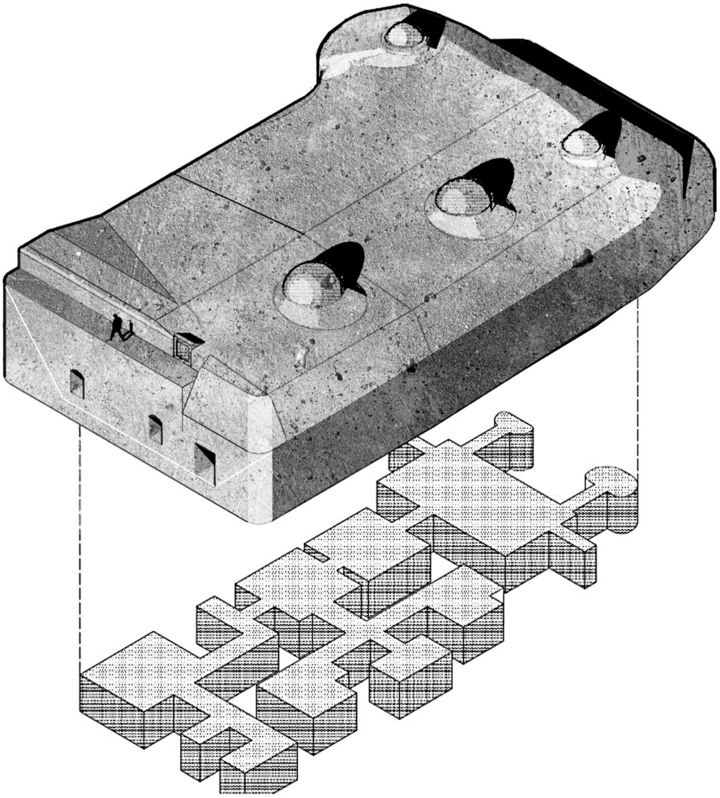
[24] E. Rocchi, *op. cit.*, pp. 377–398.

[25] *Ibidem*.

[26] J. Hanika, *op. cit.*, p. 260.



Ill. 3. Plan of "Object A", reconstructing the condition in August 1915; based on archival materials by F. Suchoń.



Ill. 4. Axonometric view of the body of "Object A", reconstructing the state in August 1915. This view includes the entrance facade, firestep, and parapet on the flat roof's edge with an emergency hatch, two armored howitzer turrets (large domes), and two armored observation turrets (small domes) equipped with machine guns; based on archival materials by F. Suchoń.

The customary Hungarian name for the structure is “Olasz-erőd,” literally translated as “Italian fort.”[27] The discovery of the original design documents and reports makes it possible to restore its proper historical name, “Object A.” It also clarifies the purpose for which it was built – it was not a model of Italian fortifications, as used to be assumed – but a model of Austria’s own solutions for fortifications on the Italian border. Also, the precise dating of the construction, recorded on the architectural plans, precisely places the object in the history of modern military architecture and the turbulent history of 20th-century Europe.

4. CONCLUSIONS

The steel and concrete used more than a century ago to erect “Object A” made it possible to realize a structure that could withstand extreme external conditions. The mountain fort was exposed not only to the effects of frost, avalanches, or lightning strikes. Above all, it had to resist the effects of explosives, high pressure, and high temperatures of gases, which are products of explosions. Engineering calculations and simulated flight trajectories of enemy missiles influenced the concrete monolith’s expressive, sculptural, and almost monumental form. “Object A” was also an unintentional foreshadowing of a trend of late modernism architecture that emerged many years later as Brutalism.

“Italian Fort,” a model building intended by the designers to be a realized model near the distant borders of the monarchy in the Alps, remained in the middle of the Hungarian grassland puszta. It was a modern war machine cast in concrete – at once a monument to engineering thought and pioneering experimentation. It lasted like this for many years until it was demolished in the early 21st century.[28]

Thanks to modern 3D modeling technology, the intriguing shape of the entire building, with its austere and original expression inherent in military architecture, was possible to reconstruct based on archival blueprints and photographic documentation.

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Author's Note

Filip Suchoń, PhD, Arch.

His research focuses on revitalizing urban structures and the role of modern fortifications in city spaces. He actively shares knowledge through scientific meetings and is a member of the Austrian Society for the Study of Fortifications (Österreichische Gesellschaft für Festungsforschung). Additionally, he provides expert opinions and design documentation for historic fortification renewal projects.

filip.suchon@pk.edu.pl