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V. Radonjanin, R. Folić, Đ. Lađinović

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## iNDiS 2012

This year, Department of Civil Engineering and Geodesy, Faculty of Technical Sciences - Novi Sad, organizes Twelfth International Scientific Conference "iNDiS 2012".

The first conference took place in the 1976 with main topic „Industrial construction of apartments“ as current. In the following years, conference topics were extended to “Industrialization in civil engineering“, and soon, papers form all areas of construction, from urbanism planning and designing buildings to maintenance and major interventions on engineering structures. It has caused the expansion of the area covered by this conference and, beside civil engineers in various fields, urban planners, architects, engineers in other fields who work in construction, sociologists, economists and others took a part.

The present moment is characterized by, among other things, a crisis in investment sector, especially in new construction, but, as in the world, more and more resources must be directed to building management. This requires a transformation of our activities in construction and adaptation to these trends. This conference, as well as several previous ones, includes problems of planning, design, construction and renewal, which led to an adequate response of foreign and domestic participants. This wide area includes not only the aforementioned researchers, planners and designers but also the contractors, including installation and finishing works in construction, i.e. all professions whose work is connected to architecture, construction and the built environment.

It is our pleasure that a number of members of the International Scientific Committee actively participated in the preparation of the Conference and wrote papers published in this Proceeding. These, as well as other papers, contain a variety of ideas and results of experimental and theoretical research that became the basis for formulating adequate calculation models of structures and models used in other areas of civil engineering and environmental protection. It is expected that, using experience from abroad, adjustment to the legislation already adopted in Europe will be easier. In addition, it is expected to point out the main directions of the development of civil engineering in order to meet modern conditions and needs.

Two Proceedings were published for this conference, one in the Serbian and the other in the English language, which allows better communication and exchange of experiences with colleagues from foreign countries as well as establishing new and strengthening of existing professional and collegial relationship.

The editors would like to express sincere gratitude to all authors for the effort invested in writing papers and for the contribution to this event.

Novi Sad, November 2012 Editors

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# FACADE RENEWAL OF GENERALŠTAB BUILDING IN REHABILITATION AND ADAPTIVE REUSE PROCESSES

**Abstract:** Awareness of the need to protect the architectural heritage of the twentieth century in Serbia has just started to develop. The future of the architect Nikola Dobrović's Generalštab building, legally protected as a cultural property, but for a long time in a state of a ruin after the bombing in 1999, is still uncertain. After any future interventions with an aim to preserve the building, it will be necessary for it to remain *the old Generalštab*, but to become *a modern facility.* It brings us to a great number of processes that it will pass through, within its rehabilitation and adaptive reuse, when the selection of materials for new constructions and coverings, or repairs and conservation of the existing ones, will be inevitable. With the analysis of physical and mechanical characteristics of facade stone, we can make conclusions about the causes of current facade state and the possibilities of its renewal.

**Key words:** Generalštab, rehabilitation, facade, stone, porosity, water absorption

# OBNOVA FASADE ZGRADE GENERALŠTABA U PROCESIMA REHABILITACIJE I ADAPTIVNE PRENAMENE

**Rezime:** Svest o potrebi zaštite arhitektonskog nasleđa dvadesetog veka u Srbiji tek počinje da se razvija. Budućnost zgrade Generalštaba arhitekte Nikole Dobrovića, zakonom zaštićene kao kulturno dobro, ali već dugo u stanju ruševine posle bombardovanja 1999. godine, još uvek je neizvesna. Posle bilo kojih budućih intervencija sa ciljem njenog očuvanja, neophodno je da zgrada ostane *stari Generalštab*, a postane *savremena građevina*. To nas dovodi do velikog broja procesa kroz koje će ona proći u okviru rehabilitacije i adaptivne prenamene, kada će odabir materijala za izgradnju novih, odnosno sanaciju i konzervaciju postojećih konstrukcija i obloga biti neizbežan. Uz analizu fizičko-mehaničkih karakteristika kamena fasadne obloge, izvode se zaključci o uzrocima njenog trenutnog stanja i mogućnostima njene obnove.

**Ključne reči:** Generalštab, rehabilitacija, fasada, kamen, poroznost, upijanje vode

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## 1. INTRODUCTION

The complex of Generalštab building at the crossroads of Nemanjina Street and Kneza Miloša Street in Belgrade was heavily damaged during the bombing in 1999. (Figure 1, Figure 2, Figure 3) Although the overall damage is repairable, it has not been decided yet about the future of these buildings. [1]

Generalštab building, the only one in Serbia designed by architect Nikola Dobrović, created in the period from 1954 to 1963, represents the legacy of Modern movement in architecture. It was inscribed in the list of the immovable cultural properties as a cultural monument in 2005, and so protected by law from any free intervention. On that ocassion, it was prescribed "to preserve an authentic look, the horizontal and vertical dimensions, structural and elements of form, as well as original materials", and "regular monitoring and maintenance of construction and static system, the roof covering, all facades, interiors and safety of installations" were conditioned. [2] In the world, there are specific guidelines and methods, even regulations and standards, positively directed to the protection of twentieth century architecture legacy. In Serbian milieu, this area of the protection of monuments has just begun to develop. [3]

From the 1950s, when the construction of Generalštab began, reinforced concrete has become the dominant material in architecture, "fascinating designers with its capacity to be molded". [4] However, a large number of architects did not know about the possibilities of its decay over time, including changing of the look, but also cracking of concrete and corrosion of reinforcement due to mechanical, chemical and physical agents. Today we know that in places with a large percentage of carbon dioxide in the atmosphere, reinforcement with minimum of 13mm protective concrete layer will corrode in twenty-five years. [5] Reinforced concrete is the material that most of Generalštab construction was built of. It probably suffered considerable damage, that we can not see by simple observation, resulted from mechanical impacts – shock, vibration and explosion during the bombing, but also because of the lack of protection and different chemical and physical agents in last thirteen years. Susan Macdonald, the architect of The Getty Conservation Institute, wrote about the inccorect building technologies, as the result of the need for a major constructions after World War II, but also of the industrialization of construction industry with the main objectives of efficiency, speed and economic saving. Due to the prefabrication, there was no need for skilled labor. Architects and other engineers used structural inovations, new technologies and materials, "in ways that were not fully understood in terms of their long-term performance or safety". They often had very small budgets available, and there was also the shortage of materials. All of this, in many cases, led to a reduction in quality of construction. [6] So, for most buildings constructed during this period, it was needed fifty to sixty years to pass, from the construction to the need for large repairs. During the construction of Generalštab building the budget was probably almost unlimited, but the fact that it was built in post-war era of innovations, tell us that there had to be mistakes in its construction, and if it had not been bombed, elements of the earliest buildings parts would probably require major repairs or replacements today, and those slightly younger would require the same in a few years.

*Figure 1 – Generalštab building, view down Kneza Miloša St.*

*Figure 2 - Building A, facade to Kneza Miloša St.*

*Figure 3 - Building B, corner of Nemanjina St. and Kneza Miloša St.*

If we accept Generalštab as a building that will live again, with the need for rebuilding of destroyed parts, possible changes in the structure in accordance with the new standards, replacements and improvements of the installation systems, while preserving its external dimensions, and restoration and conservation of the original materials, but as a builing that has to go through the process of possible change of use with accompanying alterations in the space organization, with the adjustement to the new values and needs, [7] than the whole process related to restoring the building can be named rehabilitation with the adaptive reuse. Although the official conditions for the protection of Generalštab do not require keeping the original interiors, and according to sources, architect Dobrović was not involved in its creation, [8] the question of the need for its protection as a historical ambient can be asked.

During the processes of preserving buildings of the Modern movement in architecture, such as Dobrović's Generalštab, there is a need to think about two principles: one is faithfulness, which can be called physical authenticity, and the other is authenticity, actually the spiritual one.The principle of faithfullnes can refer to restoring the building to its original constructed state. The principle of authenticity refers to the respect for the idea of a building that its architect or a builder had during the process of creating. [9] Despite the clear minded attitudes towards authenticity that different charters and declarations adopted throughout the twentieth century, conservation practice has shown that any rules can not be taken undisputed, because every monument is unique and requires different approach.

## 2. FACADE RENOWAL OF GENERALŠTAB BUILDING

The shell of a building is becoming increasingly important in the overall consumption of energy today. It is a dynamic surface that adapts to different climatic conditions. Today the facades with stone are done exclusively in dry procedure, as ventilated. Stone slabs are fixed by subconstruction to the massive walls, so the air layer is made. The layer allows natural air circulation and provides better thermal insulation, reduces heat gain in summer, and condensation and heat loss in winter. That is why it is important for the renewal of existing buildings to think about the possibilities of the replacement of existing non-ventilated system of facade construction with the ventilated one. [10]

The facade of the Generalštab building, with the facing of natural and artificial stone was built using the wet process, so it is not ventilated. Big wall surfaces made of red stone were built simultaneously with casting of concrete. (Figure 4) Only for linear elements of construction – beams and columns, the stone was laid in cement mortar to the already casted

concrete. (Figure 5) In the process of selection of the facade structure for the building, actually during the testing of the possibilities of its replacement with ventilated facade, in addition to the usual ground checks, it is important to take care about the damages of the existing walls, which can influence the way of facing, and the mechanical resistence of the bearing construction that can be different depending on the position in building structure. Characteristics of stone slabs determine their thickness, other dimensions and the ways of fastening in the case of ventilated facade. [11] In any possible future processes of this kind, it will be important to try to keep the existing dimensions of stone slabs in order to preserve the original appearance of the Generalštab building facade.

*Figure 4 – Big wall surfaces of red stone built simultaneously with casting of concrete*

*Figure 5 – Linear elements of construction with stone laid in cement mortar to the casted concrete*

The facade structure of Generalštab building does not include any thermal insulation, so the assembly made of reinforced concrete wall and stone facing has the overall heat transfer coefficient far above the allowed, which is in accordance to Serbian regulations for existing buildings, 0.4W/m²K [12] Tests done for this paper, using the construction physics principles, compared thermal characteristics of existing facade and possible future ventilated facade of the building, on the example of the red stone facing on big wall surfaces. With the addition of the appropriate type of thermal insulation, thickness 8cm, and air layer of 3cm, respecting the existing thickness of stone slab, existing overall heat transfer coefficient of 2.526 W/m²K can be 0.329 W/m²K. [13]

Besides the ventilated facade, other solution can be applied, although not so often in practice, and that is using the thermal insulation on the inner side of the exterior wall construction. Different systems of final inner layers for this system have been already developed, so that the allowed overal heat transfer coefficient can be achieved. [14]

## 2.1. The current state of the stone facing

For building the facade of Generalštab, two types of architectural and building stone were used. Polished white stone called “Veselje“ (Figure 6) got its name after an ancient quarry from which it was exploited in past, and that was located above the bay of the same name on the island of Brač in Croatia. These limestone was used for building of Diocletian’s palace in Split, Croatia, the facade cladding of Federal Executive Council (SIV) building in Belgrade, and for many other buildings in former SFRY. [15] The stone is exploited today also in the same Croatian island, in the bay and the town of Pučišća. It is appeared in the market in two types, named “Veselje Unito“ i “Veselje Fiorito“, which differ from each other in the amount of fossil remains, their size, structure and color. Stone used for Generalštab is “Veselje Unito“, white to ivory toned, with yelow nuances. [16] It is used for the linear concrete construction

elements – beams and columns, some filling walls – parapets, but also for the entire walls of front pavilions.

Red bossage stone got its name "Koral", (Figure 7) during the selection of this stone for Generalštab facade in 1957. [17] The deposit of this limestone called "Koral-Lazovi" is located 2km west to Kosjerić, in Serbia. [18] Processing this limestone into blocks is very expensive, so its exploitation as an architectural stone was stopped because of unprofitability in 1971. After the construction of cement factory in Kosjerić, today"Titan", in 1975. godine, the exploitation was continued, but since then the stone has been used only as a ground stone, and as one of the main raw materials for cement production. [19] Production of processed stone blocks could possibly be restarted only in the case of a major investment or buildings of national importance, which Generalštab surely is. "Koral" has four applications on the facade of Generalštab. It has an important place in most of the massive walls of the buiding, used as a rectangular block, but also as a polygonal block in cyclopean masonry of the lower parts of buildings, and as thin facing of the linear elements of constructions, actually protruding ribs at the facade of the tower building. Also, it was the raw material for making the artificial stone that was used for courtyard facades of Generalštab. [20]

*Figure 6 - "Veselje Unito"*

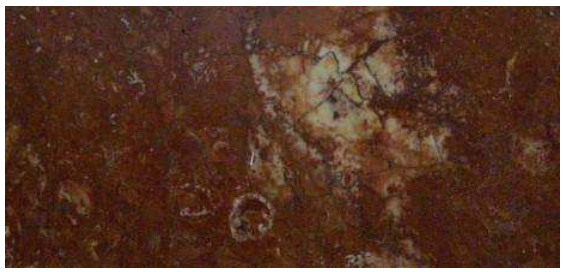

*Figure 7 - "Koral"*

The time during which stone may remain unchanged, depends on its properties, methods of installation and the environment which it is set in. The main causes of the chemical changes of stone in exterior are atmosphere and rainwater, which impacts are much stronger in the urban and industrial environment. All the chemical changes entirely change the look of stone, and the most aggressive agent from atmosphere is sulfur dioxide.

Physical-mechanical properties of stone that must be analysed before its application on the exterior walls, are primarily flexural strength, density, porosity, water absorption, frost resistance, chemical agents resistance and linear thermal expansion, but it is also necessary to do petrographic analysis. During the stone mounting, it is important to take into account its coefficient of thermal expansion which value is much lower than the value of the same coefficient of concrete or steel. Facades, especially those exposed to strong insolation are subject to relatively rapid changes of temperature, which, among the other things are brought by summer rains. [21]

Both types of stone, "Veselje" and "Koral", are resistant to frost and chemical agents. However, values that are very important in the analysis of the entire facade of Generalštab are those of porosity and water absorption for both stone types, because their considerable differences indicate also different stone changes over time, and those characteristics are the most important ones in the use of stone in dense and heavily polluted urban areas, which is certainly the location where Generalštab is. "Koral" absorbs very little ammount of water and is compact in terms of porosity, while "Veselje" moderately absorbs the water and is quite

porous. The percentage of total porosity of "Koral" is 1,40% vol., percentage of water absorption is 0,36% mas, whereas the same properties of "Veselje" are 7,82% vol. and 2,12% mas. Comparing these values, it can be seen that the porosity of "Veselje" has five times greater value then the porosity of "Koral", while the value of water absorption of "Veselje" is six times greater that the value of water absorption of "Koral". [22] Characteristically big values of porosity and water absorption of "Veselje" stone, caused the appearance of brown stains amd dirt on the slabs, that were seen even before the bombing. (Figure 8), and can be seen today at some spots where the stone slabs are not damaged due to the bombing. (Figure 9 and Figure 10) Stains appeared under the impact of the atmospheric water solutions that contain a lot of salt. The greatest impact on the slabs probably happened after the collapsing of the buildings, when those solutions contained products of excretion of cement and other materials. They were transferred through the pores and holes of the stone and got to its surface where they deposited dissolved salts.

*Figure 8 – Facade of building A with stains on "Veselje"slabs*

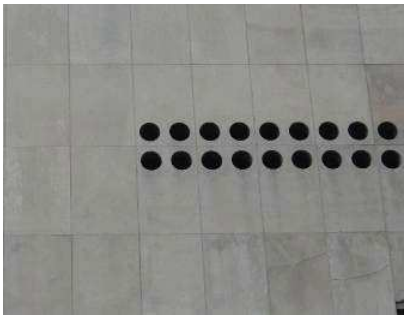

*Figure 9 – Facade of front pavilion of the building A with stains on "Veselje" slabs*

*Figure 10 – Facade of the tower of the building B with stains on "Veselje" slabs*

Since the slabs of "Veselje" used to be polished, and because of their porosity and environmental conditions, chemical degradation, i.e. dissolution happened, when some components were washed, and caused the loss of the polish. The stone became rugged and lost its shine. Cubes of "Koral" in the facade of Generalštab are much more preserved. (Figure 11) Except of the small values of porosity and water absorption, a huge advantage in terms of aesthetics is their bossage processing that prevents any change, due to the exposure to weather and other agents, to be easily visible. Greater thickness of "Koral" cubes also influenced their better state of preservation. The effects of sunlight and chemical agents from the atmosphere and the rainwater can lead to the phenomenon of decolorization, i.e. loss of stone colour. Stone gets lighter on surface, because of the solubility of carbonate minerals, and it is called "light patination." Decolorization is normally harmless to the quality and structure of stone, but in case of large representation, it may affect the entire look of the facade.Usually the red limestones are very prone to decolorization and often become greyish or bluish. However, the phenomenon is not so often on the facade of Generalštab, and different tones of red colour we see on "Koral" are actually characteristics of this type of stone, not decolorization.

Looking at the present state of these two types of stone facing, we can see that they have some common forms of degradation. On the coverings in lower zones of facade there is a lot of accumulated garage and soot. (Figure 12 and Figure 13), which is caused by hard particles in air. The ammount of sediment on sloping and horizontal surfaces is greater than on vertical

surfaces, it is greater on rough surfaces than on smooth ones, it is greater on more porous than on less porous stone.

*Figure 11 - Preserved wall surface of "Koral" on building B*

*Figure 12 - Dirty wall surface of "Koral"on building B*

*Figure 13 - Dirty wall surface of "Veselje" on building B*

## 2.2. Proposals for the restoration of the stone facing

What needs to be done to the majority of the "Koral"stone facing of Generalštab building is probably only cleaning. However, it is very difficult to determine what is the big dirt, dust or other covering layer, and what is damage, if we look at the stone while it is on the facade. Its dimensions and shape were once very well selected. Its small dimensions and square shape, contrary to big dimensions and rectangular shape of "Veselje" absorb the possible lowering of mechanical characteristics. It is certain that the force caused by bombing, i.e. mechanical shock, impacted the stone and made microcracks and microfractures in slabs, even at the spots of the facade where we can not see the damage at first glance. Therefore it is very important to remove and clean the stone first, and then check it before any future use. For the purpose of entire facade renewal, some ammount of new stone will be needed, as a replacement for those slabs that were damaged.

As for the Generalštab facade of "Veselje", from the analysis of its characteristics and visual examination of the situation, the conclusion is that this facing should be replaced by another type of stone. [23] The dirt is very shallow from the surface, so the stone could be easily cleaned. However, analysing the state of the stone before the bombing, it can be seen that it was in very bad condition even then, only four decades since it was set up. Similar damages and stains can be seen today at the facades of other buildings built with the same stone. [24] Therefore, the stone type "Veselje", highly porous, very bright coloured, shiny and polished, was not a good choice for a busy Belgrade streets. However, if we decide to replace "Veselje" with another type of stone and try to chose that stone, we must take into account that the future slabs should have similar appearance but better characteristics, so we can ask ourselves whether we could manage it. Types of stone similar in appearance, usually have similar characteristics. [25] Very important thing to say is that damages of many "Veselje" slabs came also from lack of regular maintainance of the facade. So, any future stone facing should be cleaned regularly, and treated with appropriate materials to gain the protection of aggresive agents from atmosphere and rainwater.

It is important here to go back to the beginning of the paper and to the technical measurements of protection of Generalštab that regulate preserving the original materials, which replacement of "Veselje" with some other stone makes unacceptable. So, do the institutions and protection services take into an account all the characteristics of the building,

and do they analyze the behavior of construction and material over time, when they write the measurements of protection? "The exact knowledge of building material – its composition, its aging properties, its physical and static coactions with other building materials – is most important for concepts for the future preservation of old buildings." [26]

It is necessary to continuously improve the states of the existing buildings around us. Most of the actions sometimes include a change in the building appearance, because the visible architecture of Modern movement is "not often accepting the patina of age", and "a glass, concrete, steel and plastic look unhappy when decayed". We should celebrate the "abstract intellectual achievement of modern buildings, and not focus on the tangible steel and glass, concrete or plastic". [27]

In favor of replacing "Veselje" with another type of stone, stands the fact that some things tell us that architect Dobrović himself maybe did not select that stone for the facade of Generalštab. [28] He predicted the crossroads of Kneza Miloša and Nemanjina streets as it is today, a very busy and noisy place which produces high pollution, and in descriptions of facade he mentioned that the stone had to have excellent technological characteristics, for being able to deffend itself from the atmosphere agents the building would be exposed to. [29] Therefore, we may ask ourselves whether it was architect Dobrović who selected "Veselje" as a stone facing of Generalštab building.

## 3. CONCLUSION

In support of the preserving of Generalštab building, which is opposite to complete demolition, stands a fact that one of the biggest benefits to the environment is just the process of preserving and improving the historical buildings and maintaining their embodied energy, actually energy that is used in all processes related to creating of building, from the using of natural resources to the delivery of the product for the construction, and finally to the construction itself. Reuse of buildings makes the emboided energy saved and stored, so the processes of rehabilitation and adaptive reuse are more sustainable than it is the building demolition and making the new building in its place instead. [30]

In the entire process of rehabilitation and adaptive resue of Generalštab building, the most important decision will be the choice between the principle of faitfullness and principle of authenticity. Since the architect Dobrović can not participate in these processes explaining his ideas that are not clearly visible because of the differences between the designed and the built state, it may be best to follow the principle of faithfullnes and return the buildings to the state they were in before the bombing. Misinterpretation of architect Dobrović's ideas, while trying to correct the built state, building the designed state, can lead to a solution with which "the new Generalštab" can become a copyrighted work of some other architect. Reasonable changes may be done due to technical or technological reasons, which include, among others, changes in the facade system and the replacement of the facade stone from island of Brač with some other type of stone. It will be one of the great decisions of the architect that will guide future rehabilitation of Generalštab building.

## REFERENCES

[1] Experts from Institute for testing materials - IMS Institute of Serbia determined that Generalštab was built according to the old seismics standards, and that the repairs and reconstruction therefore require serious procedures on the structure of the building. Team from Faculty of Civil Engineering in Belgrade suggested demolition of the structure above the second floor before any future interventions. Sekulić, N. „Bruka i sramota - Ruševine ostaju još 10 godina?!“.Press Online, 07. jul 2010 http://www.pressonline.rs/sr/vesti/vesti_dana/story/124564/Bruka+i+sramota+-+Ru%C5%A1evine+ostaju+jo%C5%A1+10+godina!.html (accessed September 23rd, 2012)

[2] „Одлука о утврђивању зграда Генералштаба Војске Србије и Црне Горе и Министарства одбране у Београду за споменик културе“ (2005): Службени гласник РС 115/2005.

[3] See in: Благојевић, Љиљана (2003): „Проблеми и питања заштите архитектуре модерног покрета у Београду: Прилог новој политици заштите“. Гласник друштва конзерватора Србије, 27. Београд: Друштво конзерватора Србије и Републички завод за заштиту споменика културе: 35-41 and Мишић, Биљана (2010): „О вредновању и заштити послератне архитектуре Београда“. Наслеђе, 11. Београд: Завод за заштиту споменика културе града Београда: 193-206.

[4] Feilden, Bernard M. (2003): Conservation of Historic Buildings. Oxford: Architectural Press: 328.

[5] Feilden, Bernard M. (2003): Conservation of Historic Buildings. Oxford: Architectural Press: 330.

[6] Statement passed during the establishment of International Working Party for Documentation and Conservation of Buildings, Sites and Neighborhoods of the Modern Movement (Docomomo) in Eindhoven, in 1990, stressed the great danger in which the architecture of modern movement was, that emerged as a result of innovative, but often incorrectly used building technologies and changes of functions they were designed for. See in: Macdonald, Susan. “Materiality, monumentality and modernism: Continuing challenges in conserving twentieth-century places”. Paper presented at The 2009 annual Australia ICOMOS conference - (Un)Loved Modern, Sydney, July 7-10, 2009: 3-4 http://www.aicomos.com/wp-content/uploads/2009_Unloved Modern_Macdonald_Susan_Materiality_Paper.pdf (accessed May 7th, 2012). At the 33rd Salon of Architecture in 2011, Docomomo Serbia was presented as a national branch of the international working party Docomomo International. See: „docomomo Srbija“. http://www.docomomo-serbia.org/cms/ (accessed October 1st, 2012)

[7] With the concern for equality of all users of the space, concept of inclusive (universal) design has appeared. It is “a strategy, which aims to make the design and composition of different environments and products accessible and understandable to as well as usable by everyone, to the greatest extent in the most independent and natural manner possible, without the need for adaptation or specialised design solutions.” Application of such design should certainly find a place in the adaptive reuse processes of Generalštab building. See: Council of Europe – Committee of Ministers, “Resolution ResAP(2001) On the introduction of the principles of universal design into the

curricula of all occupations working on the built environment". https://wcd.coe.int/ViewDoc.jsp?id=185703&Site=DC (accessed October 1st, 2012)

[8] Kovačević, Bojan (2001): Arhitektura zgrade Generalštaba. Beograd: Novinsko-informativni centar „Vojska": 112.

[9] An example of achieving high levels of sustainability and preservation of existing buildings authenticity in the architecture of twentieth century is Art and Architecture Building of Yale University, designed by architect Paul Rudolph, built in 1963 and destroyed by fire in 1969. godine, whose rehabilitation and adaptation, after decades of unplanned works inside the building and on the facade, was done in 2008, after the design of the architect and a former student of Paul Rudolph, in accordance with the requirements of sustainability. Architect Charles Gwathmey kept the work of his professor with faithful, but technically enhanced reconstructions, which included renewal of the facade and the use of contemporary integrated installations, skillfully hidden under the faithfully done coverings. See in: "Interview Charles Gwathmey & Robert A.M. Stern" (2008): Constructs-Yale Architecture, Fall 2008: 2-3. It is interesting to mention the building of the Bauhaus School (The Bauhaus Building) in Dessau, built in 1926, where conservation of the original materials was a part of the renewal process in 2006. For the treatment of the interior walls, plaster was used instead of the original lime mortar, but the old layer of mortar was not removed. It was just covered with a new one, and in that way preserved. At selected spots, historical coating with paint was restored and left uncovered. See in: Markgraf, Monika (2006): "Conservation and Preservation of the Bauhaus Building in Dessau". In Heritage at Risk-special edition. Eds. Jorg Haspel, Michael Petzet, Anke Zalivako and John Ziesemer. Berlin: Baessler Verlag.

[10] Brunoro, Silvia (2007): "Sustainable technologies in the refurbishment of existing building envelopes in Italy". In COST16: Improving the Quality of Existing Urban Building Envelopes – Facades and Roofs. Eds. Luis Braganca, Christian Wetzel, Vincent Buhagiar, Leo G.W.Verhoef. Amsterdam: IOS Press BV: 71-73.

[11] Flexural strength is one of the important characteristics in the application of stone in ventilated facade. The thickness and the other dimensions of the stone slab, and the position of the anchors, because of the effects of wind, depend on it. Special attention should be given to this characteristic.

[12] „Правилник о енергетској ефикасности зграда" (2011): Службени гласник РС 61/211.

[13] With the increasing of the thickness of thermal insulation, overall heat transfer coefficient of the solid part of Generalštab exterior walls can be less than 0.15 W/m²K, which is one of the characteristics of the passive houses. See: „Правилник о енергетској ефикасности зграда" (2011): Службени гласник РС 61/211.

[14] It is interesting to mention one more facade system and the building of Van Nellefabriek in Rotterdam, designed by architects Johannes Brinkman and Leendert van der Vlugt, and built in 1931. Its glass facade was given addition in 2006, in order to to have the existing characteristics improved, but at the same time trying to keep the appearance, all with the change of the building function. The building got the other, inner glass facade, so the whole system became the double-skin facade. See in: Fixler, David N. (2006): "Material, Idea and Authenticity: Lessons From the Modern

Movement". Paper presented at the Goucher College National Preservation Forum on Authenticity, 23 March 2006.

[15] About the conservation and restoration of "Veselje" stone, see in: Barišić, Marin (2012): „Druga faza konzervatorsko-restauratorskih radova na peristilu". Kulturna baština, 36. Split: Društvo prijatelja kulturne baštine: 299-316. Using of "Veselje" stone as a facing of a building of SIV is mentioned in: Мишић, Биљана (2007): „Палата Савезног извршног већа у Новом Београду". Наслеђе, 8. Београд: Завод за заштиту споменика културе града Београда: 140.

[16] Petrologically, "Veselje" is organogenic limestone, actually rudist limestone with bioclastic matrix. Its texture is massive, and dimensions of the fossile remains of microscopic shells are up to 4mm. Its age is Upper Cretaceous. See in: Tomašić, Ivan and Ženko, Tomislav (1993): „Utjecaj strukturno-teksturnih značajki i dijagetetskih procesa na poroznost arhitektonskog kamena". Rudarsko-geološko-naftni zbornik, 5/1. Zagreb: Rudarsko-geološko-naftni fakultet: 166. Today, the exploitation of "Veselje" is done by private company named „Jadrankamen, d.d", from Croatia. See : „Jadrankamen d.d.". http://www.jadrankamen.hr/index.php?option=com_content&task=view&id=24&Itemid=33

[17] Kovačević, Bojan (2001): Arhitektura zgrade Generalštaba. Beograd: Novinsko-informativni centar „Vojska": 49. There are no other buildings with the facades of this stone, known to the authors of this paper. There is only an iniciative from 2011, for building the memorial fountain in a village near Kosjerić, from handmade "Koral" blocks, according to the design of architect Spasoje Krunić

[18] Petrologically, "Koral" is organogenic limestone, with a lot of fossile remains of rudists – hipurits. Its structure is cryptocristalline to microcrystalline. Its age is Upper Cretaceous. From the archive of Laboratory for stone and aggregate, Institute for testing materials - IMS Institute of Serbia.

[19] Archive of Laboratory for stone and aggregate, Institute for testing materials - IMS Institute of Serbia.

[20] Kovačević, Bojan (2001): Arhitektura zgrade Generalštaba. Beograd: Novinsko-informativni centar „Vojska": 49.

[21] "Ventilated Facades: Design, environmental compatibility, emphasis on structure", http://www.ariostea-high-tech.com/tecnologia-facciate-ventilate.php (accesssed October 3, 2012)

[22] From archive of Laboratory for stone and aggregate, Institute for testing materials - IMS Institute of Serbia. Porosity defines the content of pore space and has a great impact on the physical and mechanical properties, wear resistance and durability of stone. It can be absolute, when it represents the ratio of all the voids volumes contained in rock, and relative, when it represents the pores that can be fiiled with water. Relative porosity is closely related to the value of water absorption. See in: Tomašić, Ivan and Ženko, Tomislav (1993): „Utjecaj strukturno-teksturnih značajki i dijagetetskih procesa na poroznost arhitektonskog kamena". Rudarsko-geološko-naftni zbornik, 5/1. Zagreb: Rudarsko-geološko-naftni fakultet.

[23] An example of the renowal of the facade replacing one type of stone with another is Hungarian Parliament Building in Budapest, which soft and very porous limestone on

the facade was replaced with much harder travertine. See in: Siegesmund, Siegfried and Durrast, Helmut (2011): ”Physical and Mechanical Properties of Rocks”. In: Stones in Architecture: Properties, Durability. Eds. Siegfried Siegesmund and Rolf Snethlage. Berlin: Springer: 90-91, and Torok, A., Sieesmund, S., Moller, C., Hupers, A., Hoppert, M. and Weiss, T. (2007): “Differences in texture, physical properties and microbiology of weathering crust and host rock: a case study of the porous limestone of Budapest (Hungary)”,. In: Building Stone Decay: From Diagnosis to Conservation. Eds. R. Prikryl and B. J. Smith. London: The Geological Society: 261-276.

[24] Stone slabs of “Veselje“ on the facade of Federal Executive Council building in Belgrade, also have visible brown stains and dirt, although this building is in more convenient location that Generalštab building is, in terms of the adverse impacts of traffic, actually it is away from the garage, exaust fumes and soot particles.

[25] A solution to consider is the use of “Belovodski peščar“, the stone from the quarries near Kruševac in Serbia, which has been used in Serbia since the Middle Ages. Among the buildings built using this stone is a large number of monasteries of The Moravska school of architecture. The same stone was used for a lot of buildings in Belgrade (Institut français de Serbie, St. Marko Church, Historical Museum of Serbia, etc.) and although some of them were built in the thirties of the twentieth century, their excellent state of preservation can be seen even today. About this stone see in: Lazarević, Velibor (2011): “Belovodski Sandstone In Serbian Tradition And the Possibilities of Its Usage Today“. In: Harmony of Nature And Spirituality In Stone (1th International Conference). Kragujevac: Stone Studio Association: 91-100. The stone is suitable for the urban areas, its porosity is very low (0,22% vol.), and its tones patinated over time. It can be ivory, yellow, brown or reddish. From the archive of Laboratory for stone and aggregate, Institute for testing materials - IMS Institute of Serbia.

[26] Markgraf, Monika (2006): “Conservation and Preservation of the Bauhaus Building in Dessau”. In: Heritage at Risk-special edition. Eds. Jorg Haspel, Michael Petzet, Anke Zalivako and John Ziesemer. Berlin: Baessler Verlag: 111.

[27] Feilden, Bernard M. (2003): Conservation of Historic Buildings. Oxford: Architectural Press: 332.

[28] In the technical descriptions of Generalštab facade, only Kosjerić’s red bossage stone was mentioned, so it can be concluded that the entire facade was planned to be covered with it. However, in technical descriptions of the facade, architect Dobrović mentioned setting of ceramic or stone mosaic, size 2cm, that makes a nice contrast comparing to bossage darker areas. From: „Технички опис Идејног пројекта за зграду Б“, signed by architect Dobrović. In: Kovačević, Bojan (2001): Arhitektura zgrade Generalštaba. Beograd: Novinsko-informativni centar „Vojska“: 181.

[29] From the part of the project: „Облога фасаде каменом“, signed by architect Dobrović, in: Kovačević, Bojan (2001): Arhitektura zgrade Generalštaba. Beograd: Novinsko-informativni centar „Vojska“: 173.

[30] Rypkema, Donovan D. (2008): “Historic Preservation and Sustainable Development”. Lecture given at New Brunswick University, New Brunswick, Canada, June 6, 2008. http://www.nj.gov/dep/hpo/4sustain/Conference2008/Rypkema.pdf

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## SOURCES OF FIGURES

*Figure 1 - Figure 5, Figure 9 – Figure 13.* Photographs made by the authors of the paper in May 2012.

*Figure 6.* "Ziche Marmi". http://www.ziche.net/Materiali/Marmi_Chiari_immagini_foto_marmi_chiari/Alta_Risoluzione/c214%20ziche%20marmi%20veselje%20SIC%20DSC05192.JPG (accessed October 1st, 2012)

*Figure 7.* Archive of Laboratory for stone and aggregate, Institute for testing materials - IMS Institute of Serbia,

*Figure 8.* Ковачевић, Бојан (2001): Архитектура зграде Генералштаба. Београд: Новинско-информативни центар „Војска", насловна страна.