Austro-Hungarian Public Building Refurbishment and Energy Efficiency Measures – A Case Study on a Public Building in Sarajevo

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Abstract. Among other pieces of architectural historical heritage in Sarajevo, and Bosnia-Herzegovina in general, the Austro-Hungarian architecture has preserved its original architectural, artistic and engineering characteristics. Both residential and public representative urban blocks, streets and squares are of distinguishable ambience in the architectural and urban image of the city and are testifying about our architectural past. A number of buildings is valorised and protected by law in terms of their architectural, artistic and historical value. In addition, these buildings have a distinct functional, ambiental, historical, and even aesthetical value. To make them last longer, refurbishment of these buildings is challenging and presents potential and multiple benefits for the city, and beyond. Refurbishing built environment through functional reorganizing, redesign and energy efficiency measures applications could result in prolonged longevity, architectural identity preservation and interior comfort improvement. Besides, implemented measures for energy efficiency, through the refurbishment process, should optimize the needs for energy consumption in treated buildings. This paper defines options in comfort improvements and redesign, without implying risks to the building longevity, analyses interventions and energy efficiency measures which would enable potential energy saving assessment in the refurbishment process of masonry buildings. This paper also discusses the different techniques that can be adopted for conservation and preservation of historical masonry buildings from the Austro-Hungarian period dealing with energy efficiency. The works were preceded by historical research and on-site investigations. This paper describes a methodology to quantify their vulnerability. A scheme of structural retrofitting is suggested following the research conducted. Revitalization of the building consisted in the reconstruction of the old building structure, creating the inner courtyard and covering it with a glass roof.

1. Introduction
In the region of today’s Bosnia-Herzegovina and in the period of Austro-Hungarian rule (1878-1918), construction styles embodied and reflected styles and peculiar features of architectural expressions and movements of Europe at the time. The Neo-Gothic and Neo-Renaissance, as typical representatives of
Europe and its stylistic expression were promoted by the Provincial Government and Austro-Hungarian Empire as well as its constructors and architects schooled in Vienna (Josip Vancaš¹, Karl Pařík (Paržik)).

Neo-Renaissance was, as a matter of fact, the classical universal architectural style in almost all public buildings during the period of the Austro-Hungarian rule. Motifs introduced due to the influence of Oriental architecture of Spain and North Africa (broken and layered arches, ornaments using floral and geometric shapes and vividly coloured façades) contributed to the unique quality of the local, Bosnian bond, presented at numerous European exhibitions on architecture.² The architecture born during the time of the Austro-Hungarian period was fruitfully expressed both in Sarajevo and the whole region of Bosnia-Herzegovina. A great number of these buildings was assessed for their historical, architectural, ambient and aesthetical values and, as such, represent valuable historical heritage of these regions. Some of the buildings, or even the whole blocks of buildings and palaces are located in the most attractive parts of the city and are under the protection of the state as iconic samples of architecture and ambience of the period.

Standing among them in its impressive dimension and being of a great national value is the palace of the former Provincial Government which was designed by Josip Vancaš in Vienna (1884). This palace, the subject of the present case study, was constructed on architectural models of the typically Florentine Early Renaissance.

![Figure 1. The Neo-Renaissance style palace from the Austro-Hungarian period (earlier and at present)³](image)

The present-day condition of the buildings from this period is not satisfactory for several reasons: their age (the buildings are 100 or more years old), lack of maintenance and wars, as well as due to the fact that their life span and amortization expired. Many of the buildings are used at present, so it is of utmost importance to rehabilitate them in terms of the functional reorganization of space, diagnosing the condition of structures, materials and details used, in order to redesign them and apply various protective methods. In addition, the functionality of space in these buildings may be obsolete and requiring more efficient approaches to energy and comfort efficiency by which their cultural and historical value would not be diminished.

¹ Josip pl. Vancaš, architect (Sopron, Hungary, 22. III 1859. - Zagreb, 15. XII 1932. Graduated from Technical College in Brno and the Department of Architecture in Vienna (1881). From 1882 to 1884, he studied architecture with prof. Schmidt at the Academy of Fine Arts in Vienna.
² Ibrahim Krzović: « Arhitektura Bosne i Hercegovine: 1878-1918», selection and conceptual design-Art Gallery BiH, Sarajevo, 1988. p. 16
³ a) The Provincial Government Building (J. Vancaš) 1884-1885 and The Provincial Government building II in the background (C. Panek), plan 1895/96, constructed in 1897 (once the building of The National Railway and the Construction Office of the Provincial Government) b) today: Ministry of Foreign Affairs of Bosnia-Herzegovina, The Presidency Building.
2. Historical and general information on the building of the Provincial Government — The Presidency Building

Since the building was proclaimed a national monument, the protective measures for such buildings are clearly defined and have to be adhered to during the rehabilitation process:

- only conservation and restoration works are allowed, as well as regular maintenance and those construction works the aim of which is promotion of the monument, and only with the permission of the Federal Ministry in charge of spatial planning and under surveillance of professional authorized services for heritage protection in the Federation of Bosnia-Herzegovina;
- it is necessary to recover the façade of the inner atrium according to detailed photos showing its present-day condition and by means of gaining a better insight into the original methods used to maintain the façade by using previously used/ original materials;
- in the recovery process, the old and damaged elements of the building should be replaced (the roof, façades, horizontal and vertical gutters) and restored to their original condition.

The building is free-standing, its dimensions are 70 metres in length and 62.5 metres in width. Its surface takes up 3,082 m² along with the inner courtyard. In the urban sense, the structure of the building is constructed in the block construction style; the composition of space and mass is harmonious.

The north elevation

West and south elevation

Figure 2. Elevations

Originally, the building had four storeys: the cellar, the ground floor, two storeys with attic space below the complex gable roof (Po+P+2). An additional storey was added in 1991. The dimensions (figure 3) of the inner courtyard were cca. 48.0 x 16.0 m. The height of the cellar is cca. 3,0 meters. The height of the ground floor and the first floor is cca. 5.0 meters, while the second and the third floor are cca. 4,0 meters in height. Some rooms, such as the reception hall are 10 meters high.

The constructive elements of the building are massive bearing walls made of solid brick (25x15x7cm) bound by lime mortar the thickness of which varies (60-75 cm in the cellar; 60 cm on the ground floor, and 45cm-35 cm on the upper floors). The partition walls are 15 cm thick and lined with lime mortar on both sides of the wall so that they are approximately 20 cm thick in total. The foundations and the cellar walls are made of stone, i.e. the plinth is panelled with stone.

The inter-floor structures between the cellar and ground floor, as well as between the ground floor and other floors, are made of metal traverses with low brick vaults arranged within a shorter range (the so-called Prussian ceiling), which was a usual ceiling found in buildings constructed during the Austro-Hungarian period.

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4 Official Gazette of Bosnia-Herzegovina, No. 94/09.
5 http://old.kons.gov.ba/main.php?id_struct=6&lang=1&action=view&id=3034
A sketch of the 1st and 2nd storey with the annex built within the yard (current condition);  
A sketch of the ground floor after the annex was added within the courtyard (current condition)

**Figure 3. Building plans with dimensions**

The roof structure above the last storey and the attic is made of plain wooden boards filled with ballast and lined with an outer layer of brick panels (figure 4).

**Figure 4. Architectural details: the roof structure types**

### 3. Analysis of general and thermal characteristics of the heating and thermo-technical systems

Aside from the factors arising due to the building being used for many years or exposed to negative influences from the environment, or inappropriate maintenance, the building was damaged the most during the 1992-1995 war. In July 1999, the building was refurbished through the restoration programme developed by the Cantonal Bureau for the Protection and Maintenance of Cultural-Historical and Natural Heritage of Sarajevo.

Following the analysis of the current condition of the building, and the revision of project documentation the access to which was allowed for the purposes of conducting the present research, the information collected from the authorized personnel and data collected from auditors who had completed the energy audit led by UNDP and conducted by the Centre for Economic, Technological and Environmental Development (CETEOR doo Sarajevo) and the Report on filming the building with the thermographic camera\(^7\), the following conclusions have been made:

**a) The roof structure**

Even with the restoration of the roof, the roof heating still leaks. In order to rehabilitate and introduce the EE measures, it is necessary to replace the asbestos-cement in order to prevent or eliminate further damage caused by leaking. It is of priority to replace the asbestos-cement also due to it being ecologically unacceptable. Following the requirements of the conservation-restoration process, it is

\(^{6}\) "Detailed energy audit - The Presidency building of Bosnia-Herzegovina", CETEOR Sarajevo, April/May 2016

\(^{7}\) Thermographic: Imamović Fuad
possible to replace it with a material, such as fibre cement boards, that most closely corresponds to the original in appearance, colour and shape.

b) Attic roof structure

The roof structure of the attic without heating, according to the data on the building energy assessment has high U values of 1.63 W/m²K due to poor thermal characteristics of a layer of gravel and stone boards used as the topmost layer. With corrections, this value should be $U = 0.97$ W/m²K tab approximately. Adding a layer of thermal isolation on the roof structure would result in the reduction of thermal losses. Above all, it is first necessary to replace the roofing heating. The air conditioners in the attic need to be dissembled and assembled for the current condition of the roof structure to be assessed.

| Construction type | Materialization of the roof structure | Width (m) | $U$ (W/m²K) | $U_{\text{max}}$ (W/m²K) | Surface (m²) |
|-------------------|--------------------------------------|-----------|-------------|-----------------|--------------|
| Attic roof, the main building | Brick panels Wooden joists joined by gravel, clay and slag The boarded part of the roof structure Lime mortar | 0.03 0.55 0.02 0.03 | 0.97 | 0.30 | 3646.0 |

Table 1. Attic roof structure calculations

c) Attic roof structure above the added structure (annex) in the courtyard

The roof structure is supported by reinforced concrete with an inner final layer of lime mortar. There is a single-sided ventilated gable roof and a roofing of steel sheets on a boarded surface. Such envelope materialization has poor characteristics, which may be concluded from table 2.

| Construction type | Materialization of the roof structure | Width (m) | $U$ (W/m²K) | $U_{\text{max}}$ (W/m²K) | Surface (m²) |
|-------------------|--------------------------------------|-----------|-------------|-----------------|--------------|
| Attic roof, The added part storey segment | Flat steel sheets on boarded surface Air flow – ventilation layer Concrete panel Lime-cement mortar | 0.05 0.05 0.10 0.03 | 2.63 | 0.30 | 71.80 |

The reason for proposing that the two storeys on the annexed part added in 1960s should be torn down is found in the fact that, as such, they degrade this historical building and the south-oriented spaces, i.e. the central courtyard. In addition, they are not in accordance with the conservation-restoration principles (see figure 5).

Figure 5. The façades of the added, atrium-oriented and south-oriented structures
d) Flat roof above the part added to the cellar

This roof structure, as well as the other inter-floor structures, is constructed of steel traverses with low ceilings made of layered brick and other layers of the flat roof structure characteristic for the period the building was constructed. Flat roofs without access are found in the ground floor and cellar atria, which results in problems in terms of maintenance. In addition, the materialization of the flat roof structure has poor thermal characteristics; the U values is 2.09 W/m²K (table 3).

| Construction type | Materialization of the roof structure | Width (m) | U (W/m²K) | U max (W/m²K) | Surface m² |
|-------------------|--------------------------------------|-----------|------------|---------------|-----------|
| Flat roof, small atrium | Sloped concrete | 0.07 | 2.09 | 0.30 | 41.70 |
|                     | A layer of solid clay | 0.30 | 0.30 | 0.30 | 41.70 |
|                     | Layered brick in mortar | 0.065 | 0.30 | 0.30 | 41.70 |
|                     | Lime mortar | 0.03 | 0.30 | 0.30 | 41.70 |

Table 3. Thermal characteristics of the flat roof; small atrium

e) Roof structure above the ground floor’s non-heated passage

The roof structure above the ground floor’s non-heated passage, according to the auditor’s report, has high U values of 2.04 W/m²K tab. This inter-floor structure is also materialized by means of a “Prussian” ceiling with the sub-floor characteristics for the period during which the building was constructed (table 4).

| Construction type | Materialization of the roof structure | Width (m) | U (W/m²K) | U max (W/m²K) | Surface m² |
|-------------------|--------------------------------------|-----------|------------|---------------|-----------|
| Roof structure above the ground floor’s non-heated passage | Sub-floor | 0.04 | 2.04 | 0.30 | 100.0 |
|                     | Mortar | 0.05 | 0.30 | 0.30 | 100.0 |
|                     | A layer of solid clay | 0.10 | 0.30 | 0.30 | 100.0 |
|                     | Arched ceiling made of radial bricks reinforced by steel traverses Mortar | 0.065 | 0.30 | 0.30 | 100.0 |

Table 4. Thermal characteristics of the ceiling above the passage

f) The floor surface structure

The thermal characteristics of the floor surface structure, according to the descriptions from the audit, are U=3.5 W/m²K, which is unfavourable considering that the maximum value allowed, according to the Rulebook is U= 0.50 W/m²K. The materialization of the floor structures in the building varies, as well as the topmost floor heating, depending on its purpose. In the offices, the floor surface is layered with oak parquet laid onto a boarded surface; the parquet has been partially refurbished during the adaptations or partially replaced. The floors in the hallways are covered with whetstone and a layer of 2.0 cm thick stone is partially laid onto it. The ceramic tiles floors in the restrooms have partially been refurbished.
Table 5. Thermal characteristics of the floor surface structure

| Construction type | Roof structure materialization | Width (m) | U (W/m²K) | U max (W/m²K) | Size m² |
|-------------------|-------------------------------|-----------|------------|--------------|--------|
| Floor type FL 3 Cellar with heating | Floor sheathing | 0.05 | 0.05 | 3.50 | 0.30 | 3556.7 |
| | Layered brick and mortar | 0.65 | 0.30 | 3.50 | 0.30 | 3556.7 |
| | Solid clay | 0.30 | 0.30 | 3.50 | 0.30 | 3556.7 |
| | Foundation structure made of broken stone | 0.40 | 0.40 | 3.50 | 0.40 | 3556.7 |
| | 15cm gravel | 0.15 | 0.15 | 3.50 | 0.15 | 3556.7 |

**g) The outer bearing walls**

The outer bearing walls of the building are made of "Austrian format" bricks (25x15x6.5cm) of different dimensions enveloped by lime mortar; a rich bossage rustic is on the outside. The width of the cellar wall is 75 cm; the cellar and storey walls are 60 cm, 45 cm and 35 cm wide.

In terms of the thermal characteristics of the front façade made of solid brick, there are significant and relatively even thermal losses (high temperatures measured shown on figure 6) and U values in table 6. Considering the fact that only conservation-restoration work is allowed, an intervention by which the thermal characteristics would be improved is not possible.

**h) Architectural elements of openings: external carpentry and metalwork**

In terms of the architectural elements of the openings, the windows are, except in the cellar, boxed with wooden frames and single-glazed. They are in a rather bad condition both due to their age, humidity and cracks, but also lack of maintenance or protective coating. Their thermal characteristics are significantly bad, especially in terms of glazing. There are seals and gaskets missing on window panes and frames. These are the most critical surfaces of the façade envelope; it can be seen even from the thermographic image that there are high thermal losses (in terms of transmission and ventilation) as well as high U values (table 6). The windows in the cellar are single-glazed and the frames made of metalwork. The metal frame does not break the thermal bridge. The entrance door is of satisfactory thermal, functional and aesthetic characteristics.

In terms of materialization and characteristics pertaining to heat transmission coefficients, the following types of façade positions of the opening elements have been identified, Table 7.

It is necessary to replace the existing carpentry and metalwork with unfavourable thermal characteristics or repair the wooden frames and install glazing with better thermal characteristics. The wooden entrance door is of satisfactory thermal, functional, aesthetic and other characteristics.
Table 6. Thermal characteristics of the walls-building envelopes: the values of the U coefficient and wall surfaces cross-section in terms of spatial orientation

| The building envelope-construction type/ Outside wall | Width (m) | Wall structure materialization (m²) | U W/m²K | U max According to standard | Orientation – wall surface (m²) |
|-----------------------------------------------------|-----------|-------------------------------------|---------|----------------------------|--------------------------------|
| cellar-ground floor                                 | 0.60      | Interior lime mortar 0.02 m Solid brick 0.60 m Bossage rustic. squared rubble 0.08 m | 1.13    | 693.1                      | 730.5 914.97 967.1             |
| ground floor                                        | 0.50      | Interior lime mortar 0.02 m Solid brick 0.50 m Bossage rustic. squared rubble 0.08 m | 1.31    | 17.5                       | 17.5 31.17 17.1                |
| parapet ground floor                                | 0.45      | Interior lime mortar 0.02 m Solid brick 0.40 m Bossage rustic. squared rubble 0.08 m | 1.42    | 0.45 [W/m²K]              | 845.4 971.6 1232.4 1191.0     |
| I and II storey                                     | 0.40      | Interior lime mortar 0.02 m Solid brick 0.35 m Bossage rustic. squared rubble 0.03 m | 1.56    | 39.1                       | 39.1 58.06 34.6               |
| parapet I and II storey                             | 0.35      | Interior lime mortar 0.02 m Solid brick 0.30 m Bossage rustic. squared rubble 0.3 m | 1.73    | 444.2                      | 479.0 503.36 560.4            |
| III storey                                          | 0.30      | Interior lime mortar 0.02 m Solid brick 0.25 m Façade mortar (final layer) 0.03m | 1.93    | 19.8                       | 19.8 41.57 23.0               |

Table 7. Openings types

| No. | Carpentry/metalwork                                                                 | heat transmission coefficient U (W/m²K) |
|-----|------------------------------------------------------------------------------------|----------------------------------------|
| 1.  | Carpentry: wooden frames, regular glazing (2x4mm), gasket free                      | 3.6                                    |
| 2.  | Carpentry: wooden frames, boxed windows, double-glazing (4/6-8/4mm), gasket free    | 2.9                                    |
| 3.  | Metalwork: steel window frames, single-glazed (8mm), gasket free, intact thermal bridge | 5.9                                    |
| 4.  | Wooden window frames: double, thermopane glazing (4/12-16/4mm), gasket free        | 2.5                                    |

4. Per annum energy required for heating the building
On the basis of the energy audit, i.e. thermal characteristics of the building’s envelopes, their surfaces, environment conditions and technical system characteristics, an assessment has been made on the energy capacity needed to for ensuring heating in the building. In the process, energy efficiency/non-efficiency in terms of energy spending was examined and conclusions and recommendations made for enhancing energy efficiency. Based on the assessment from the audit, the amount of energy needed for comfort has been calculated on an annual basis. The analysis also made it possible to assess on the amount of energy
by applying the recommended measures on energy efficiency. The thermal balance for the building\(^8\) was calculated on the basis of the analysis. It is equal to the difference between all the thermal gains and losses through the building’s envelope. Losses comprise of transmission and ventilation changes in heat whereas gains are attained by means of solar input through transparent surfaces, as well as people and appliances. The relations of thermals losses without the influence of the gains attained through the envelopes are given in the table below:

### Current condition of the building

| Losses through the roof (H\(_d\) in W/K) | 6073.67 | 10% |
| Losses through the walls | 14270.49 | 24% |
| Losses through the floor/cellar | 9575.22 | 16% |
| Losses through the windows | 7181.91 | 12% |
| Infiltration losses | 20120.81 | 33% |
| Ventilation losses | 2934.28 | 5% |
| **Total (W/K)** | **60156.67** | **100%** |

According to EN 13790, the thermal balance for the building in question is 107,09 KWh/per year (table 8) and has been calculated on the basis of the following formula:

\[
Q_{H,nd,cont} = Q_{tr} + Q_{ve} - \eta_{H,gn} \left( Q_{int} + Q_{sol} \right),
\]

where:
- \(Q_{tr}\) - transmission-exchanged thermal energy for the calculation zone
- \(Q_{ve}\) - thermal energy necessary for ventilation
- \(\eta_{H,gn}\) - thermal gains factor
- \(Q_{int}\) - internal thermal gains (people, appliances, lighting – in kWh)
- \(Q_{sol}\) – thermal gains from sunlight

### Table 8. The relation between thermal losses and gains on the basis of the analysis

| Losses                  | Specific          |
|-------------------------|-------------------|
| Transmission (kWh/god)  | 2771621.32 kWh/year | 179.20 kwh/m\(^2\) year |
| Infiltration (kWh/god)  | 1542767.15 kWh/ year | 99.75 kwh/m\(^2\) year |
| Ventilation (kWh/god)   | 219201.64 kWh/ year | 14.17 kwh/m\(^2\) year |
| Gains                   |                   |
| Q\(_{int}\)             | 343551.85 kWh/ year | 22.21 kwh/m\(^2\) year |
| Q\(_{sol}\)             | 452857.98 kWh/ year | 29.27 kwh/m\(^2\) year |
| \(\eta_{H,gn}\)         | 0.86              |
| Total energy required Q\(_{H,nd}\) = | 3852090.83 kWh/ year |
| Energy required with potential cuts in energy supply | 1656399.06 kWh/ year | 107.09 kwh/m\(^2\) year |

\(^8\) The complete assessment on the energy necessary for heating has been calculated in accordance with EN 13790 and the European Energy Performance Building Directive.
5. Integrating a transparent roof structure above the centrally designed atrium

Table 9 Atrium spaces, [9], [10], [11], [12]

| Atrium spaces                          | The central concept of the atrium: square and rectangular |
|----------------------------------------|----------------------------------------------------------|
| Department of Islamic Arts - Louvre Museum, Mario Bellini and Rudy Ricciotti, Paris, France 2005 – 2012. | ![Image of atrium space] |
| German Historical Museum courtyard-Schütterhof, I.M.Pei, Berlin, Germany, 2002. | ![Image of atrium space] |
| National Maritime Museum: Dok Architecten; Amsterdam, The Netherlands, 2011. | ![Image of atrium space] |
| The Smithsonian Institution, Washington DC, Foster + Partners 2007. | ![Image of atrium space] |

Considering that the inner atrium was not included in the restoration and was not treated functionally, aesthetically or in terms of energy efficiency, the aim of the present paper is to emphasize the importance of atrial and open spaces integrated into the volume of the building. These are the spaces that can be used to synthesize and functionally transform spaces into controlled and contextually selected forms, contemporary shapes and materials by applying functional creativity without endangering the ambience and historical values of the building. On the contrary, by closing the courtyard and atrial spaces, it would be possible to ensure a buffer zone between the interior and the exterior as well as to create a micro-climate and eliminate processes that generally occur in façades facing such spaces. There are numerous examples of transparent roof extensions introduced when rehabilitating the existing cultural-historical buildings, the extensions known for their power in terms of quality and quantity or the harmonious bond between the old and the new\(^9\). The prominent contrast between the transparent structures and the solid architectural mass, the buildings are recognized for their dynamic quality and contemporary design (table 9).

6. Functional transformation of the Presidency Building and EE improvement measures

As the condition of the courtyard façades, as well as atria-oriented façades, is unfavourable, it is necessary to rehabilitate and refurbish them. The function of the free, open-air spaces has been neglected and forgotten. The added annex within the courtyard, especially the last two floors, degrades the value of this historical building and the south-oriented spaces, i.e. spaces oriented towards the central courtyard. If they were torn down and if green spaces, fountains and other functional parts were to be added in this part of the courtyard (suitable for exhibitions, etc.) and if they were to be covered by a transparent roof structure, the result would amount to a functional transformation of the building as a whole. In this fashion, the atrial space would be given a multi-functional role. The missing fragments of decorations and cornices profiles on the façades resulted from atmospheric causes and could be permanently repaired and the façades, as well as the spaces surrounding them, protected in the long run. The problems pertaining to the presence of constant humidity due to unfavourable insulation, deterioration of mortar and decorations, crumbling of brick in façade walls surrounding the courtyard and the atria could also be solved. Apart from that, the conditions arising due to maintenance and unfavourable solutions in the flat roof structures, as well as of the non-heated passage, could also be improved and amended. Between these structures and the natural surroundings, there would be a buffer zone serving the purpose of ameliorating external climate factors. The basic design of the open-air roof

\(^9\) A.Salihbegovic, A.Salihbegovic: "Design of Roof Structures in the Rehabilitation Process", REHAB 2015 – 2nd International Conference on Preservation, Maintenance and Rehabilitation of Historical Buildings and Structures, Porto, Portugal, 2015.
structure is founded on a latticed "structure", a diagonal concept of laminated boards that would support a transparent envelope made of insulating glass. The view towards the sky through a diagonal lattice would present an association to the "lattice window" or mušebak, an architectural element found in the Oriental type urban houses in Bosnia-Herzegovina whose structure favourably contributes to the values of creating a comfortable micro-climate.

Glazing free space:
1. Daylight
2. Natural ventilation:
   - cross-ventilation,
   - single-sided ventilation,
   - chimney effect within the centrally designed atrium
3. Control and efficient use of solar energy (summer-winter)
4. Reduced thermal losses
5. The possibility to use rainwater
6. The possibility to make the best use of the space

Figure 7. A “sky-oriented window“ - transparent roof structure integrated above the atrial space of the Presidency Building

By applying this concept, thermal losses would be reduced together with energy required for heating. Laying a transparent roof above the original atrial space on the outline of the building’s cornice (figure 7) could be considered a passive strategy and an energy improvement measure in this historical building. On the basis of the analysis on the energy required annually for heating up the building (Q_{h,nd}), an analysis of thermal losses/gains has been made in the case of an “imaginary” structure the exterior walls of which are adiabatic and where the thermal gains and losses are attained only by means of atrial walls. Thermal characteristics of glazing a transparent roof, i.e. the thermal transmission coefficient proposed in the analysis is 1.2 W/m²K. In this case, the annual expenditure on energy required for heating up the building is cca. 60.03 kWh/m². The greenhouse effect has been taken into consideration when conducting the analysis on thermal gains, i.e. losses and gains (in terms of transmission and ventilation) through the non-heated atrial space. The reduction in thermal losses has been verified as well as the enhancement of thermal gains in relation to the results of the thermal balance of the existing structure. In other words, by integrating the transparent roof structure and utilizing the greenhouse effect, and by reducing transmission and infiltration losses, it is possible to save 542 MWh, or more than 20,026 BAM per year. In this way, annual expenditure on energy would be reduced for cca. 12% taking the current energy price (0.037 KM/kWh) into consideration.

7. Conclusion
By adhering to construction principles, principles of sustainable construction and EE principles in the process of rehabilitating cultural-historical buildings, a functional and quality-based transformation of a building can be attained by means of creatively joining the old and the new. By integrating transparent roof structures of special constructive creativity, it is possible to express a significant contrast against the solid and massive quality of the existing structure as well as dynamics and balance. Such interventions leave recognizable traces in the history of architecture and improve the building's longevity. The potential of the proposed concept, aside from preservation and active protection of the cultural-historical building, is also found in the possibility to meet the requirements of contemporary environment by means of a positive dialogue with the natural surroundings.

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[7] Salihbegović A., Salihbegović Amra: "Design of Roof Structures in the Rehabilitation Process", REHAB 2015 – 2nd International Conference on Preservation, Maintenance and Rehabilitation of Historical Buildings and Structures, Porto, Portugal, 2015.

[8] Salihbegović, A.: Atrij u arhitekturi - transparentna struktura integrisana u volumen objekta – Ph. D. thesis, University of Sarajevo, Faculty of Architecture, 2012.

[9] Department of Islamic Arts - Louvre Museum http://hda-paris.com/hda-paris/project.php?project_id=21

[10] German Historical Museum courtyard - Schlüterhof, www.sbp.de/.../811-Schluterhof_roof, German Historikal Museum

[11] National Maritime Museum http://www.archdaily.com/269125/national-maritime-museum-dok-architecten/

[12] The Smithsonian Institution, Washington DC
http://www.bradypeters.com/uploads/1/6/2/9/1629522/3715557_orig.jpg