CONFERENCE PROCEEDINGS

3rd INTERNATIONAL ACADEMIC CONFERENCE ON PLACES AND TECHNOLOGIES

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MILENA VUKMIROVIĆ
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PLACES AND TECHNOLOGIES 2016

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MODERNIZATION OF EXISTING GLASS FACADES TO INCREASE ENERGY EFFICIENCY AND IMPLEMENT MEDIA CONTENT

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ABSTRACT

Modern cities and their architectural structures are exposed to functional and physical changes. During the past few years the interventions on the claddings of existing buildings have become more frequent. Therefore, there is a need to analyze potential remodelling of glass facades in order to increase energy efficiency of existing buildings, along with applying the concept of smart technologies. This paper deals with modernizing glass façade of the tall Slavija hotel, built in 1960s in Belgrade, Serbia, taking into consideration some positive examples of transformation and reskinning of buildings, where the aspect of medialization is an active part of urban refurbishment. The subject of this paper is the analysis of the enhanced winter thermal comfort of this building that was accomplished by glass facade replacement. Special attention was paid to the implementation of media technologies and final effects on energy balance of the newly designed facade.

The proposed solution is supposed to evaluate the improved thermal comfort that was achieved by performing a radical modernization of the facade and replacing the existing facade with a new one, with and without media elements. The research results are proposals for improving EE public buildings by implementing the latest system of curtain walls in order to increase the value of those buildings. One of the most important criteria used in the process of energy refurbishment is technological enhancement of existing buildings, along with the presentation of media contents and messages, as the elements of new infrastructure systems in modern cities.

Keywords: media technologies, façade modernization, energy efficiency enhancement, reskining, energy refurbishment

[1] Corresponding author

INTRODUCTION

Life expectancy of buildings is limited and depends on a number of factors: building materials, weather conditions, exploitation techniques. Façade remodelling is one of the elements of transformation that turns old buildings into more attractive urban structures, changing their functions and/or adding completely new values.

This paper analysis the models of increasing energy efficiency of the glass façade of a landmark structure, built in 1960s in Belgrade. Façade medialization enables the building to shift from a static to a more dynamic medium. The main goal is to transform the existing structure and its façade into an interactive urban space of media architecture, the one that stimulates cognitive and perceptive abilities of beholders. Special attention is paid to heat loss reduction.

The basic hypothesis of this paper is that façade cladding reconstruction, along with the application of suitable energy efficiency standards, enables the reduction in heating energy consumption. At the same time, the original appearance of buildings remains the same and the latest technologies are incorporated in order to intensify the presence of the building itself in its urban surroundings, without creating significant effect on energy balance.

The objective of the research is to:

- set the solutions to improve facade claddings,
- find out whether the functional change of existing buildings impact energy performance certification of buildings and whether glass facade modernization is able to completely meet all demanding requirements in the field of EE,
- determine whether or not building integration opportunities of media elements involved in glass facade modernization impact heating energy consumption.

Enhanced façade cladding of the analysed building implies:

- glass façade modernization meant to meet the following requirements (enhanced thermal insulation, solar, safty and sound protection)
- enhancement of other parts of building envelope (roof, filled façade parts, erkers),
- application of media façade elements to the south-west facade.

Climate changes, reduced energy consumption and meeting the latest requirements of energy efficiency are inevitable issues included in refurbishment procedures. „Pursue deep renovation as part of normal building refurbishment, initiated with incentives with the goal of 75% to 80% reduction in energy consumption„ (IEA Roadmap). Tall buildings represent important landmarks that visually shape the silhouette of their city, where urban and energy transformation are seen as priorities.

Stephan Messner under stands facade modernization as the accomplishment of the following goals:

- meeting the current energy efficiency standards,
- reducing the overall energy consumption
- reducing CO2 emissions,
- comfort enhancement (thermal, visual, air, sound, lighting),
- potential modification of a building's function,
- increase in value investment.

It is important to mention commercial, retail and business facilities, built between 1950 and 1970, since the refurbishment of these structures has been intensified lately. The structures that were built in 1950s, 1960s and 1970s still prevailin the building stocks of Europe and Serbia. Also, these buildings are the biggest consumers of heating energy. The most specific problems to be dealth with is a glass facade of buildings or enormous glass surfaces.

The main problem of the structures and glass facades made in the mentioned period is the application of outdated systems of metal profiles without thermal break and rather poor thermal insulating performance of glasses. In accordance with the current EE standards, the following thermal performance is required: glass Ug≤1.1 W/m2K, aluminum structures Uf≤ 1.8 W/m^2K.

According to Maraddi and Overend, facade modification extent depends on:
- significance of existing structures (historical or environmental landmarks),
- category, extent and scope of construction works (selective reconstruction, recladding, overglading).

Media facades are frequently included in the so-called reskining. Along with energy efficiency enhancement, aesthetical characteristics of buildings can also be improved. Thus, the overall social sphere is enhanced by smart technologies of media architecture. Therefore, it is important to choose a suitable media facade technology, in accordance with a number of criteria. The aspect of energy efficiency is one of the most important elements to be considered.

This study deals with the tower of the hotel Slavija in Belgrade, since it is a technical-technological and functional structure as well as a unique heated space; it is separated from its lower parts by an unheated technical floor.

The analysis of the hotel Slavija included its energy performance. It was carried out comparing relative values of energy consumption, through three case studies:
- first case study – current state before reconstruction (Fig. 1. a,b),
- second case study – preliminary design for reconstruction,
- third case study–enhanced design for façade modernization and transformation into a transparent media facade.

It should be taken into account that the entire facade cladding is planned to be enhanced (facade, flat roof, erkers, ceilings oriented toward unheated technical floors). The south-west glass facade (~500,0m2) is a dominant element of the cladding and it represents 63,96 % of the entire envelope.

FACADE MODERNIZATION –CASE STUDY THE SLAVIJA HOTEL, BELGRADE

The Slavija Hotel, the subject of this study, is one of the three major structures at the very center of the capital city of Serbia – Belgrade. Seven traffic routes lead to this square. The Slavija Hotel is not an ambient structure and is not listed in the cultural heritage properties.
Pronounced verticality of this building is represented by 18 floors and glazed facades. The building consists of two basement levels, a mezzanine, a technical floor, 16 hotel floors and an attic.

Figure 1. The Slavija Hotel –a) current south-west facade, b) media facade, 3D model; c) level plan (photos and draft made by the authors)

The current facade is the combination of the curtain wall and walls without openings. The glass facade is made of anodized aluminum profiles and is vertically divided into windows (177 cm tall) and parapet lines (103 cm tall). The width of the facade surface is 85 cm. All the hotel windows are the same. They are either fixed or open around the horizontal axis and all of them are covered with venetian blinds. A part of the facade with filled wall canvases is made of giter blocks (20 cm thick) coated with mosaic tiles (2/2 cm).

A great number of structural and functional imperfections were detected: insufficient floor height, position of columns and reinforced concrete walls that limit the recommended width of vertical and horizontal communication. Since it was impossible to achieve the expected category of hotel contents during the reconstruction phase, it is necessary to modify the current function and add a new purpose. One of the proposed changes implies a business facility (case study 2), a huge, open space office on each floor and total modernization of the building's façade cladding.

RESULTS

THE CURRENT CONDITION / CASE STUDY 1

The Building Physics Elaborate provided the calculation of thermal transmittance for all building structures. The most significant indicator of poor performances of the current glazed façade is the Uw coefficient (3.25 W/m^{2}K), which is far from the required values. The following coefficients apply to other construction sets: flat roof - 1.56 W/m2K and giter block wall façade -1.61W/m2K.

Energy Efficiency Elaborate reveals that total heat energy loss in the first case study is 555,28 kW, a specific heating energy consumption is 110,94 kWh/m2 (Table 1. Case study 1.). The building is categorized as energy class D and does not meet the current requirements of the Directives on the Energy Performance of Buildings (EPBD).

NEW DESIGN / CASE STUDY 2

The first step of modernization requires the analysis of all façade cladding elements in terms of changes: glazed façade replacement, flat roof layers, erkers, sets oriented toward unheated areas of technical floors, mezzanine and the last floor. All exterior envelope - the cladding of the building, were thermally insulated. The thickness of thermal insulation ensures a better thermal transmittance coefficient than a maximum permitted one / than a maximum allowed coefficient of the existing building: flat roof with insulation – 0.13 W/m2K and giter block wall façade with insulation -0.25W/m2K.

The most significant change is replacement of glass façade with a new one. The main criteria used in selecting a new facade: panel dimension (2.8x0.85 and 1.77x0.85m), as transparent effect as possible (LT >55%), low light-reflection range, suitable solar factor (<40%), proper thermal performance of glass (U≤1.1 W/m2K) and aluminum structure (≤ 1.8 W/m^{2}K), safety (the height of the last floor 54.15 m), proper acoustic performances (Rw minimum 35 dB).

Static calculation of glass stability analysis (in accordance with the calculation program AGC calculator version 2.0-01/2005) shows that the following sets of thermal insulation glass meets the minimum requirements: 6+6,8+6, 6+44.1, 33+55.

Since the solar control is better in the summer period and thermal insulation performance is better in the winter period, having low U coefficient, it implies the application of double glazed unit and a coated solar control glass on position 1 or 2.

The calculation of the latest preliminary design of reconstruction implies the implementation of a double glazed insulating glass with laminated PVB- a low emissivity glass (6+16+44.1), argon filled, Ug≤ 1.0W/m2K. The aluminum structure is provided with enhanced profiles with maximum sealing, airtight, maximum class 4 (EN 12 207) wind resistant in accordance with the ClassC4/B4 (EN 12 210), considering the height of the building.

The overall thermal transmittance coefficient of the façade is Uw=1,35W/m2K (in accordance with EN 10 077). Thermal transmittance coefficient of aluminum structure is Uf=1.8 W/m2K, and linear coefficient of warm edge spacer in a thermal insulating glass is ψg=0.06W/mK.

Energy performances of this building are also included in the Energy Efficiency Elaborate. If this building keeps its original function and remains a hotel, the planned modernization will put it into energy class A, based on specific heating energy consumption Qh,nd =21,67 kWh/m2. In that case, the building would meet the current requirements of the Directives on Energy Performance of Buildings in the field of tourism. However, considering the mentioned reasons and imperfections regarding the requirements of hotel content categorizations, keeping the current function is a limited option.

If the function is changed into business, the building will be categorized as energy class "B", thus meeting all the current requirements of the Directives on the Energy Performance of Business Facilities. (Table 1, case 2a)

Further research of energy performance included the analysis of the façade model with a triple glazed low-emissivity insulating glass (44.2+16Ar+4+16Ar+33.2) – Ug = 0.5W/m2K, aluminium structure Uf=1.4W/m2K, and overall Uw=0.85W/m2K. The results of the performed analysis showed that a specific specific heating energy is Qh,nd = 16.23 kWh/m2, which means that the building could be categorized as energy class "A" in accordance with the Directives on Energy Performance of Business Facilities. (Table 1, case 2b)

The overall heat loss is 237,80 kW (glass façade – double glazed insulating glass), and 190,13 kW (glass facade–triple glazed insulating glass).

NEW DESIGN / CASE STUDY 3

Simulation shows that medialization is planned to be carried out by installing a LED media facade, on the facade facing Slavija square, with lighting integrated into glass (insulating/laminated in glass facades), which provides protection from weather conditions (wind, precipitation, etc.) and enables the highest level of transparency, i.e. light transmittance. Two technologies were taken into consideration: LED lighting integrated into multilayered glass and LED technologies integrated into insulating interspace in the form of a slim lamella (Figure 2).

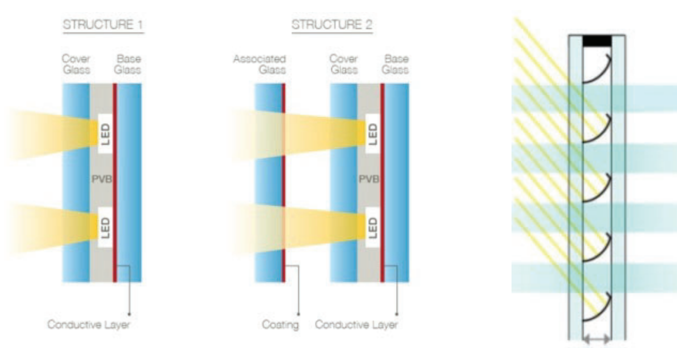


Figure 2. Media facade technologies (www.glassiled.com, www.onlyglass.com)

In addition to its main function, LED strips technology, being integrated into insulating interspace, provides an appropriate and integrated solar protection. Therefore, it is a chosen solution.

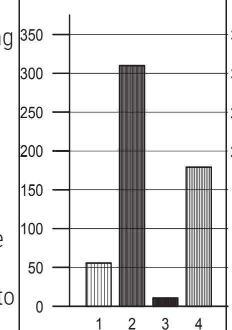
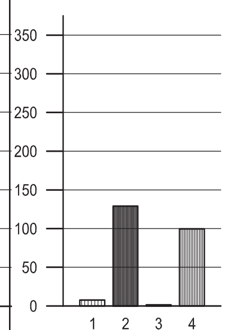
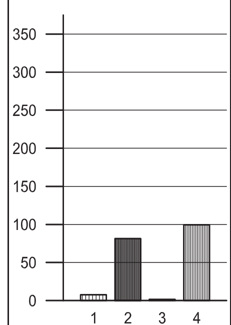
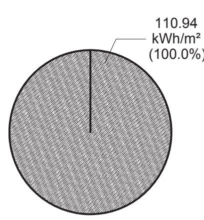
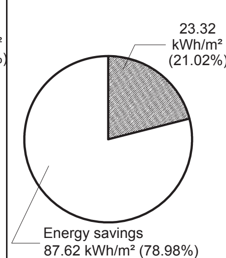
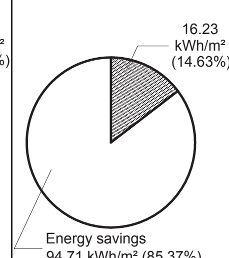
Such design of media facade technology enables the presentation of a wide range of different contents, unlike the current commercial contents only.

A selected technology of media elements, where the consumption is in the range of 50-100 kW/m on the south-west façade and the area of 500m2, could increase a specific heating consumption, in accordance with the solar gain reduction. Transparency reduction of 15% was included in this calculation.

A specific heating energy is Qh,nd = 23.68 kWh/m2 (a double glazed insulating glass), that is - Qh,nd = 16.51 kWh/m2 (a triple glazed insulating glass) with media elements.

Comparative view of the analysed case studies' results, achieved by the calculation method of the current condition of the Slavija Hotel (case study 1) and the reconstruction that means changing the building into a business facility (case study 2) is presented in the Table 1. It is possible to see if the suggested reconstruction of the building can reduce the overall heat losses and specific heating energy and energy class.

Table 1. Comparative view of the improved cladding elements: thermal losses and reduction in heating consumption, applied to the case studies of the Slavija Hotel

	Current condition - Case study 1	New design - Case study 2	
		Double glazed insulating glass/a	Triple glazed insulating glass / b
Heat losses facts (kW) 1. Heat losses due to transmission through non-transparent building cladding 2. Heat losses due to transmission through windows and doors 3. Heat losses due to transmission through thermal cladding above unheated areas 4. Ventilation losses due to transmission through windows and doors			
Specific heating energy/ energy saving [(kWh/m²/year) (%)]			
Energy class	D	B	A

The aim of the proposed reconstruction is creating an energy efficient structure. In other words, considering the current condition of the building, the following results could be achieved:

- The overall heat losses could be reduced by 57.18 % (double glazed insulating glass), or 65,75% (triple glazed insulating glass)
- Specific heating energy could be reduced by 78,98 %, (double glazed insulating glass, or 85,37% (triple glazed insulating glass), which is in accordance with the Recommendations of the European Agency for Energy (75-80 %);
- The current building, the tower of the Slavija Hotel was categorized as energy class"D". The planned reconstruction of the hotel and its functional change would lead to a higher energy class – energy class"B", with a low-emissivity double glazed glass (8+16+6), 90% argon filled (Ug=1.0 W/m2, and Uw = 1.35 W/m2K). Energy class categorization for business buildings is more demanding and rigorous than hotel content categorization. This model of transforming the building into a business one enables the building to be two energy classes higher than the current one, depending on the type of glass used for curtain walls;
- The building could switch to energy class "A" by implementing a glass façade consisting of low-emissivity triple glazed glasses (44+16+4+16+33), 90% argon filled (Ug=0.5W/m2K and Uw=0.85 W/m2K);
- The application of media elements on the south-west façade as well as a 15% shading, which impacts reduced solar gains during winter months, a specific heating energy is increased by 1,55 % (double glazed insulating glass), or 1,72 % (triple glazed insulating glass) and cannot be considered a significant increase considering the entire building.

CONCLUSIONS

The analysis of potential reconstruction of glass façades is a part of a complex refurbishment of buildings' claddings. This applies particularly to the buildings built in the 1960s, since they are a major part of the Serbian building stock. Modern technological solutions and performances of insulating glass, aluminum structures of facades and spacers significantly enhance energy performances of buildings having transparent facades. It is possible to achieve the planned values in the range of 75% to 80% reduction in energy consumption, in accordance with the Recommendations of the European Agency for Energy.

Along with the reconstruction, which aims to enhance energy performances of buildings, it is possible to apply modern technologies to curtain wall systems. This is the way to achieve some new values, apart from energy refurbishment and comfort enhancement. Incorporation of media elements into façade systems provides numerous possibilities to be realized by both owners of buildings and local communities as well. Therefore, the reduction in energy consumption cannot be analysed separately, without taking into consideration other possibilities that can be realized by reconstruction of façade claddings.

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