Places and Technologies 2015

KEEPING UP WITH TECHNOLOGIES TO MAKE HEALTHY PLACES

Nova Gorica, Slovenia, 18.–19.6.2015

PT2015

BOOK OF CONFERENCE PROCEEDINGS

A healthy city is one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and developing to their maximum potential.
Health Promotion Glossary (1998)

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KEEPING UP WITH TECHNOLOGIES TO MAKE HEALTHY PLACES

BOOK OF CONFERENCE PROCEEDINGS

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Nova Gorica, Slovenia

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RETROFITTING OF MULTI-FAMILY BUILDINGS TOWARDS HEALTHIER SETTLEMENTS

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Abstract

The subject of the paper is retrofitting of suburban multifamily buildings built in the late fifties and early sixties at Karaburma, Belgrade. According to the data collected by Serbia Statistical Office, about 55 percent of the existing housing units in Belgrade were built during the sixties and seventies and they were designed without consideration of energy demands and consumption. The same problem is present in the case of Karaburma settlement. Buildings were in poor condition until the retrofitting in 2009.

The retrofitting was carried out on a significant number of buildings and still takes place in the settlement. The main retrofitting objectives are: the identification of housing typologies related to new user's needs, the complying with new technical regulations in terms of energy efficiency and accessibility for disables. The retrofitting concept was aimed to improve living comfort, especially thermal comfort, in order to achieve energy savings and healthier environments.

Solutions for the retrofitting are shown in the paper. The improvement of living comfort and building appearance was achieved by annex of attics, addition of balconies as new structures and organized closing (glazing) of balconies, as well as by laying of thermal insulation on the facade surface and it's painting in different colors resulting in housing diversity.

The benefits are in improving energy performances of the buildings and living conditions generally. The results show that significant energy savings and reduction of CO2 emissions can be obtained with different and simple retrofitting measures.

***Keywords**: retrofitting, healthier environment, multi-family building.*

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INTRODUCTION

Karaburma is one of the largest social settlements in Belgrade. The refurbishment was carried out on a significant number of buildings and still takes place in the settlement. It was started in early 90`s with adding annex attics and extra floors. The area is characterized by various types of multifamily buildings built in late fifties and early sixties of the last century.

The retrofitting of existing buildings in Karaburma has been developed by private investors, building contractors. Through the improvement of the existing buildings investors gain the right to annex the attic or a few floors, which results in construction of new housing units. The investors gain profit by selling flats. Although the main motivation of investors is profit, it can be concluded that the improvement of housing conditions is obtained which promotes the refurbishment of suburban districts affected by social, economic and architectural deterioration.

The main refurbishment objectives are: the identification of housing typologies related to new user's needs, the complying with new technical regulations in terms of accessibility for disables and energy efficiency. The refurbishment concept was aimed to improve living comfort, especially thermal comfort, and building appearance.

STRATEGIES FOR IMPROVING OF BUILDINGS

Identifying the main problems

Significant refurbishment of buildings was achieved along the streets: Vojvode Micka, Garsija Lorke, Pere Cetkovic and Uralska. Characteristics of the aforementioned streets are similar rectangular buildings with hipped roofs and poor architectural performances. Generally, most common are two types of multifamily buildings: the type 1 with small dwellings around a central staircase and balconies on all four facades and the type 2 with four dwellings around a central staircase and balconies on two longitudinal facades. The building structural system is a massive with masonry walls and reinforced concrete ribbed floor structure, system often used in social housing construction, which was widespread in the fifties and sixties due to migratory processes. Some social, architectural and technical problems are present, but building decay is the main problem.

The dwellings are homogeneous, repetitious and monotonous. Flats are very small, which adversely affects the development of the families. Due to massive structural system as well as the fact that flats are private property of tenants, building and flats volatility is difficult to achieve during the building life cycle and user needs can hardly be achieved. Spaces are characterized by a low flexibility. Weak purchasing power of tenants results in inertia of the residents in terms of building maintenance and refurbishment. The fact that buildings were designed without consideration to energy consumption, as well as the building deterioration are the reasons of negative consequences in terms of the poor living conditions and greater wasting of energy.

Old-age and lack of maintenance and poor quality of materials and improper design caused falling-off of facade portions and fissures in facades resulting in poor thermal performance of the building envelope and in inconsistency of thermal resistance. Listed characteristics and degradation concerning envelope, create the following major disadvantages: water and moisture penetration; unfavorable removal of rainwater and snow (due to the fissures and absence of covers); condensation due to thermal bridges and lack in thermal insulation; thermal losses in the winter period; overheating of the building in the summer period, great infiltration losses; losses in the heating system. The disadvantage is the fact that buildings are not connected to district heating. Electricity is mainly used for residential heating.

The following main refurbishment strategies are foreseen: improving of the living comfort, i.e. quality of the dwellings; improving technical performance and energy efficiency of buildings; improvement of visual identity and appearance of buildings and settlement.

Figure 1: View of the buildings type 1 (in Pere Cetkovic Street) before and after the refurbishment (source: Krstić-Furundžić A., 2012).

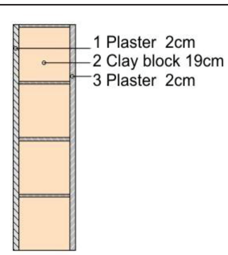
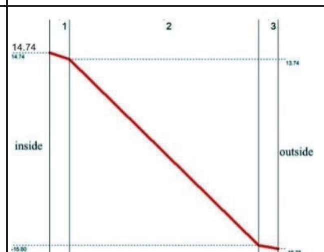
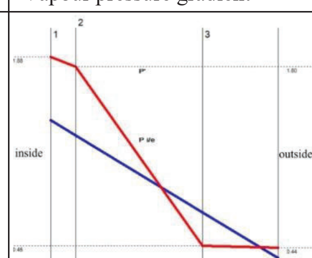
Strategies for improving quality of dwellings

By annex of attics enlargement of flats underneath and/or construction of new flats was achieved, as well as leaking of the existing roofs prevented resulting in improvement of living conditions on the original top floor and also improvement of technical conditions of the entire building. The addition of balconies is created as the new concrete structures (see Fig. 1). Main interventions can be summarized as follows: the recovery of lodgings with new typology of flats coming from attic annex; creation of improved dwelling typology by addition of new or enlargement of existing balconies; organized closing (glazing) of balconies or glazing options provided in advance creating new living spaces.

Strategies for improving the energy efficiency of buildings

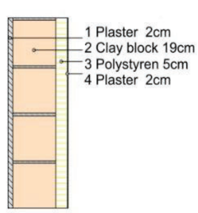
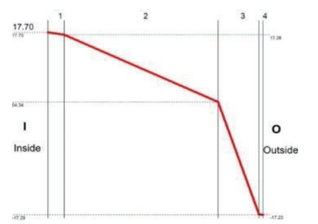
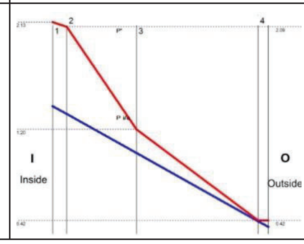
Before refurbishment buildings were characterized by poor energy performance. Facade walls were constructed of clay blocks and plastered on both sides. Heat transmission coefficient of box type windows with float glass (4mm) is unfavorable, U-value=3.5W/m^{2}K. As masonry walls had no thermal insulation, regarding their thermal performances following general conclusions can be made: walls have high thermal transmittance, i.e. U-value=1.06W/m^{2}K (see Table 1); low inner surface temperature is obvious, thermal bridges are present, condensation is present (see Table 1); walls are wet and freezing is possible; mold growth is noticeable. Presence of listed wall properties results in (Krstic-Furundzic and Rajcic, 2000): bad thermal comfort and poor living conditions, badly influencing human health, high heat losses in winter period, which increase conventional fuels consumption and environmental pollution.

Table 1: Wall thermal properties before refurbishment.

<table>
<tr><td colspan="3">U-value=1.06W/m^{2}K   Umax=0.81W/m^{2}K. Construction doesn't satisfy the requirement.
Condensation is present; drying period (27.3 days) satisfies a requirement (90 days).</td></tr>
<tr><td>Wall structure</td><td>Temperature gradient</td><td>Vapour pressure gradient</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Belgrade is in the II climate zone for which, according to previous regulations valid during the refurbishment process, following data were prescribed: a) for calculation of heat transmission coefficient (U-value) external temperature is $t_e = -18°C$; for calculation of vapour diffusion $t_e = -5°C$, b) for external walls Umax = 0.9W/m^{2}K in case of district heating and 0.81W/m^{2}K in case of individual heating, c) drying period (for moisture in construction in case of condensation) is 90days; internal $t_i = 20°C$.</td></tr>
</table>

Improvement of thermal performances of external walls includes laying or improvement of thermal insulation, thermal bridges break and replacement of windows, as essential measures. The refurbishment of the envelopes of existing buildings included: laying of thermal insulation on the facade external surfaces - 5cm of expanded polystyrene is added to masonry 19cm tick walls which provided U-value=0.46W/m^{2}K (see Table 2); replacement of existing wooden windows with double glazed windows (4+12+4), made of three or five-chamber PVC profiles, U-value=2.3W/m^{2}K (subject to consent of the tenant); placing of thermal insulation of 10cm of expanded polystyrene (U=0.171W/m^{2}K) on the new roof structures.

Table 2. Wall thermal properties after rehabilitation – external insulation.

U value=0.46W/m^{2}K Umax=0.81W/m^{2}K ("Old regulations"); Umax=0.40W/m^{2}K ("New regulations"). Construction meets the requirement that was valid during the construction. Condensation is not present.		
Wall structure	Temperature gradient	Vapour pressure gradient
		
Current regulations that apply from September 2011, prescribe that Umax=0.40W/m^{2}K have to be achieved by building refurbishment.		

Laying of thermal insulation on external wall surface enables thermal bridges break and provides existing external massive wall to be converted into energy rational structure consisting of three layers: existing solid wall as thermal storage layer, thermal insulation and external protective and final layer as re-cladding (Krstic-Furundzic and Rajcic, 2000). Rehabilitation measure included creation of the second and third layer.

Generally, external protective layer can be made as light and massive structures. In case of refurbishment of residential buildings in Karaburma settlement the light structure is created, plaster layer is added on thermal insulation. Thermal insulation is glutted and mechanically connected to external surface of the existing wall, additionally strengthened by plastic net and covered by thin plaster mortar. This is the cheapest solution and mostly used in case of building refurbishment.

Since the refurbishment takes place over the last five years, it can be noticed that the monitoring period is not long enough. However, by interviewing residents data on energy consumption for heating before and after refurbishment were provided (see Table 3).

Table 3: Energy consumption for heating and CO_2 emissions before and after refurbishment.

	Heated floor area [m^2]	Energy consumption for heating			CO_2 emissions [kg/a]
		[kWh/month]	[kWh/a]	[kWh/m^2/a]	
Before refurbishment	64	1900	11400	178.12	6042
After refurbishment	69	1100	6600	95.65	3498
Savings / CO_2 reduction		800	4800	82.47	2544

It can be concluded that heating demands are less for about 40 percent compared with heating demands before refurbishment, which means that the energy savings of about 40 percent are achieved. It is evident that building energy performances are significantly improved but with such large interventions should aim at better building energy performances in the design process; buildings had energy class G and after refurbishment energy class D is achieved.

In analysis of CO_2 emissions, as the apartments are heated with electrical energy, there were taken into account characteristics of electrical power network of Serbia, indicating that the electrical power network for production of 1 kWh realizes the emissions of 0.53 kgCO2/kWh (According to Serbian Regulations on Building Energy Efficiency).

Application of the described refurbishment measures enabled: improvement of spatial and thermal comfort, higher inner surface temperature, thermal bridges break, reduction in heat losses in winter and overheating in summer, thereby achieving energy savings and reduces consumption of conventional energy sources and environmental pollution. New appearance of buildings and blocks of flats is achieved by balconies and attic annex and variously painted facades.

CONCLUSIONS

In Belgrade, many of housing settlements dating from the late fifties and the sixties of the 20th century and represent a large percentage of the city's building stock. Most of them are consisted of a numerous of buildings with the same or similar layouts. Up to the seventies the buildings were designed without consideration of energy demands and consumption. Nowadays they are characterized by some social, architectural and technical problems, but building decay is the main problem. Old-age, lack of maintenance, poor quality of materials and improper design cause deterioration of buildings. Improvement of housing settlements is becoming increasingly inevitable. The same characteristics were feature of housing settlement Karaburma until the building refurbishment began in 2009. The improvement of living comfort and building appearance was achieved by annex of attics, addition of balconies as new structures and organized closing (glazing) of balconies, as well as by laying of thermal insulation on the facade surface and it's painting in different colors resulting in housing diversity as well as improvement of facade thermal performances. It is evident that heating demands are less for about 40 percent compared with heating demands before refurbishment, which means that the energy savings of about 40 percent are achieved and thus reduced environmental pollution. Achieved benefits contribute to other tenants opt for intervention.

ACKNOWLEDGMENTS

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