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Comfort Conditions and Energy Consumption in Prefabricated Houses in Tirana

Gjergji Islami, Denada Veizaj
Faculty of Architecture and Urbanism / Polytechnic University of Tirana
Rr. "M. Gjollesha", 54, Tirana, Albania
gjergji.islami@fau.edu.al; denada.veizaj@fau.edu.al

ABSTRACT

The prefabricated buildings were a momentary solution to the emergent housing problem in Albania during the 1980s. The modular structures were built in minimal costs by using Chinese technology and expertise. A considerable number of buildings were completed all over the country till the beginning of the '90s. These constructions represent today an important part of the housing stock which is seeking retrofit interventions. Due to their design, technology and also due to the lack of maintenance, the prefabricated housing blocks represent today one of the most problematical typologies in terms of thermal comfort and energy efficiency.

The objective of the paper is to evaluate the energetic performance of the prefabricated buildings in Tirana, to understand the comfort conditions provided in them and the factors affecting the components of comfort. The research is based on data acquired on a survey conducted in May 2013 and measurements made on case studies. The results deduce preliminary conclusions about the potential of renovation and feasible targets in improving the comfort conditions in these buildings.

KEYWORDS: prefabricated housing, thermal comfort, energy efficiency

1 INTRODUCTION

The concrete panel prefabricated modular systems were adopted in the early '80s as a solution to the emergent need for social housing in Albania (Figure 1). The system technology was imported from China and it was firstly assisted by Chinese specialists. During 1978-1979 the first examples of this technology were tested before starting the mass production. The production factory was located in Tirana and had a capacity of 2000 apartments/year. The prefabricated buildings have been constructed in all the cities that had a railway access. The panels were transported in special wagons that facilitated the loading and transport by minimizing the damages.

Figure 1: View of typical prefabricated housing – Tirana

The variations in the buildings schemes are limited. The height of the buildings varies in general from five to six floors. The slab to slab floor height is 2.80 m. The distribution schemes usually present a vertical circulation core serving two to three apartments in a floor. The typical Outer Panels (PJ) used in the most frequent layouts are shown in Figure 2. Reinforced concrete skeleton structure and brick partitions often have been used at the corner connection between two buildings. The solution made possible creating alternatives in urban schemes without modifying the basic plan of the module and without adding new panel types.

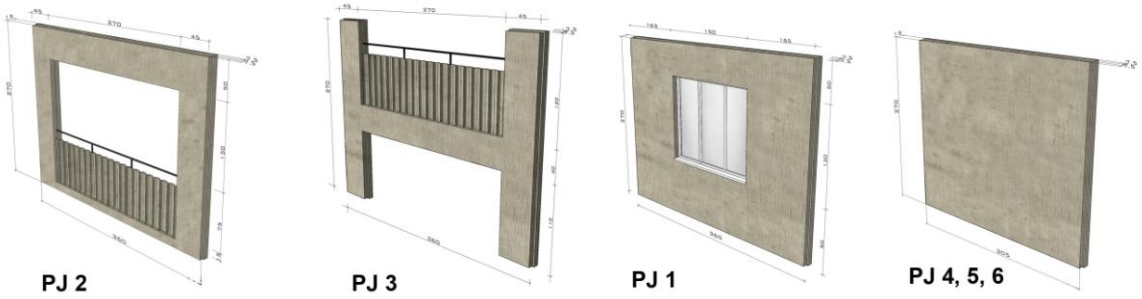

Figure 2: Typical outer panels (PJ): PJ2 – balcony outer panel; PJ3 – staircase outer panel; PJ1 – outer panel with opening; PJ 4, 5, 6 – opaque panel.

The apartment units have one or two bedrooms and a living room with separated cooking space (Figure 3). The apartments have also one balcony that can be accessed from the living room, one bathroom and storage space. The areas of the units vary mainly from 55 m² (one bedroom) to 73 m² (two bedrooms). Referring to the Technical Notes of the Prefabricated Panel Housing – Section 1, the space design meets the terms of the Typical House Model that have been approved in 1972 from the State Design Institute. Another scheme that proposed an alternative layout was approved by the Ministry of Construction in 1979 (Technical Notes, Prefabricated Panel Housing – Section 2). In this scheme, new types of panels were introduced. Both of the apartment plan layouts (Section 1 and 2) present improved standards in comparison to the social housing already built in the ‘60s and ‘70s in Albania.

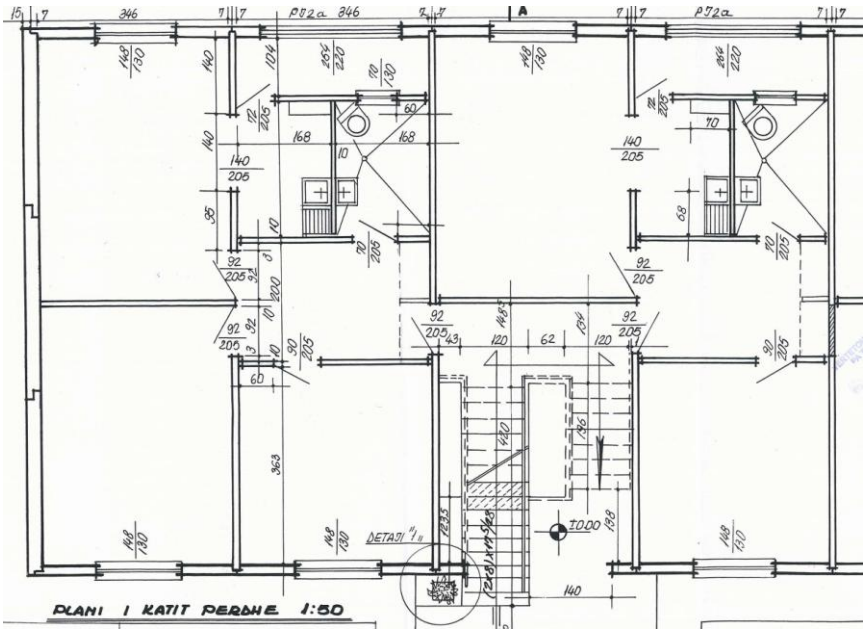

Figure 3: Ground (typical) floor plan of prefabricated panel housing – Section 1.
Image source: Central Technical Archive of Construction

2 THE HOUSING STOCK AND THE NEED FOR RETROFIT

Housing in Albania uses 47.9% of the electricity (AKBN, 2011). The energy demand is increasing rapidly, parallel to the need for improved comfort conditions in housing. Nowadays, the prefabricated buildings are part of the huge building stock in need for retrofitting in terms of energy efficiency in Albania. If needed thermal insulation is applied on these buildings, the comfort conditions can be considerably improved. In compliance with the Directive 2010/31/EU of the European parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast), the building stock should be upgraded to minimal energy consumption when it is subject to a major renovation. The renovation process should be seen as an opportunity of improving also the urban, architectural and social context in an attempt to create a sustainable environment.

Due to the fact that Tirana was the largest city with the greatest need of housing and at the same time was the production point of the prefabricated building components, a considerable number of prefabricated housing have been built in the city. The buildings were spread mainly in the suburbs of the time that today are well integrated in the city structure.

The total number of prefabricated concrete panel housing units in Tirana today is estimated to be 12500 (calculation by the authors). This is corresponding to 4.75% of the total number of housing units in Tirana (263005 – INSTAT 2012). Considering that the prefabricated buildings are mostly inhabited (they have been built 20-35 year ago), and knowing that the number of inhabited houses in Tirana is 191556, it can be assumed that about 6% of the population in Tirana is living in prefabricated buildings. The prefabricated houses are the most problematical structures in regards to thermal and energy efficiency and their renovation could influence the living and comfort conditions and standards in Tirana.

3 THERMAL CONDITIONS IN THE PREFABRICATED HOUSING

The thermal efficiency of the concrete panel prefabricated buildings is very low. Considerable heat looses occur throw walls, windows and thermal bridges. The outer panels are composed of lightweight

concrete which presents a low thermal resistance. The metallic frame windows with single glazing are the cause of significant thermal loss. The joints of the outer panels act as thermal bridges. The lack of maintenance is also an additional factor that amplifies the thermal loses in the prefabricated buildings.

The thermal measurements made on sample building in Tirana by using Testo 875i - Thermal Imager and elaborated by IRSoft - PC Software indicate the thermal leaks especially in the joints between the panels and through the windows (Figure 4).

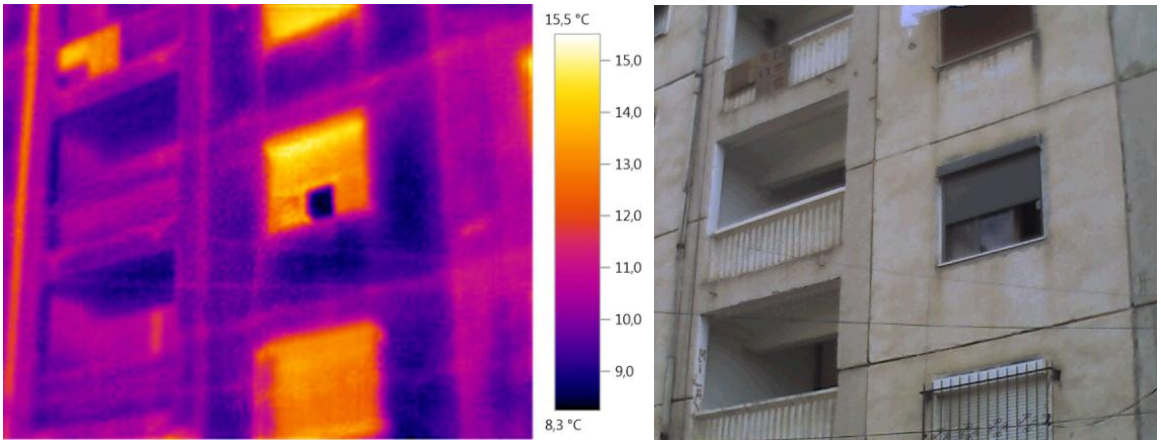

Figure 4: Thermal bridges and leaks in the outer panels

The opaque outer prefabricated concrete panels (PJ 4, 5, 6 – fig.2) themselves have a non-homogenous structure. They are composed of lightweight concrete in order to improve the thermal resistance and to decrease the weight of the panel. The composition of the panel can clearly be seen in the thermal image in Figure 5.

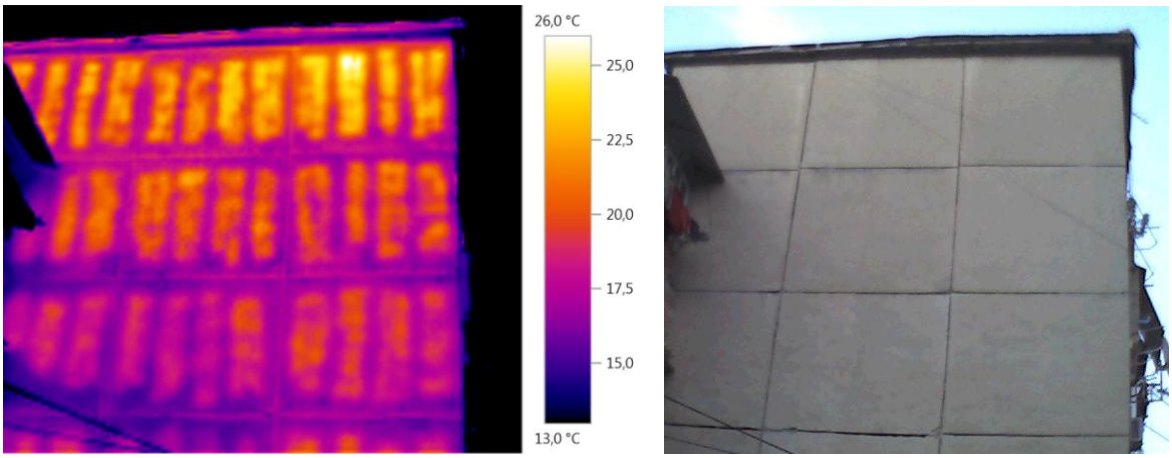

Figure 5: Thermal properties and structure of outer concrete panel

The calculated U-value of the outer panels results to be about 2.5 W/ (m^2K). This confirms a very scarce thermal resistance which is the main reason of the lack of comfort, thermal and energy efficiency in these buildings. The U value is considerably high if compared to values referring to the Passive House Guidelines that vary from 0.1 W/ ($m^2.K$) to 0.15 W/ ($m^2.K$).

4 ENERGY USE AND COMFORT CONDITIONS IN TIRANA

As part of this research, a survey was carried out in May 2013 from the Polytechnic University of Tirana (Faculty of Architecture and Urbanism) in various areas of Tirana in order to obtain data related to the energetic performance of the prefabricated housing structures and also to identify components related to this performance. The survey was based in interviewing through a questionnaire inhabitants of the prefabricated buildings. The questionnaire was composed of 36 questions and a total of 82 interviews were conducted. Some of the results regarding energy use and comfort conditions are listed below.

Table 1Usage of appliances for space heating in prefabricated housing units in Tirana

Only gas heaters	29.27%
Only portable electric heater	24.39%
Combined gas and electricity heating	20.73%
Only Split Air Conditioner	10,98%
Combined Split Air Conditioner and portable electric heater	10,98%
No space heating	3.66%

Table 2 Usage of appliances for space cooling in prefabricated housing units in Tirana

Only portable electric fan	52.44%
Only Split Air Conditioner	20.73%
Combined Split Air Conditioner and portable electric fan	17.07%
No space cooling	9.76%

Table 3: Usage of energy for cooking in prefabricated housing units in Tirana

Gas only	45.12%
Combined electricity and gas	28.05%
Electricity only	26.83%

Some other results referring to comfort condition in the housing units are described below:

When asked if they do heat all the rooms in the apartment during the cold season, the inhabitants answered:

- Yes, we heat all the rooms 9.76%
- Partially. We do not heat some rooms 79.27%
- No, we do not achieve to heat any of the rooms 10.98%

When asked if they turn on the heat during all the time that they are in the apartment during the cold season, the inhabitants answered:

- Yes, we keep it on all the time 7.32%
- Partially. We keep the heating on only if necessary 85.37%
- No, we do not use heating devices 7.32%

When asked if the room achieves a comfort temperature when the heating is on during the cold season, the inhabitants answered:

- Yes, the room achieves an optimal temperature 3.90%

- Partially. The room gets heated but not in optimum 81.82%
- No, the room cannot be heated 14.29%

The use of gas as a primary choice for heating and cooking is a result of lower costs of gas towards electricity. On the other hand, the high thermal loses of the buildings decrease the efficiency of appliances that heat the air (AC) by encouraging the use of heat sources that radiate such as gas heaters and portable electric heaters.

The comfort conditions differ in different individuals. What we consider comfort is the general physical and mental wellbeing. Whilst the subjective parameters are hard to define, the temperature is the parameter on which most of people have the same reaction. By being so, the comfort temperature is the component that describes best the overall comfort in a space where several individuals are located. Referring to the survey, the comfort temperatures in the prefabricated houses in Tirana are met in less than 10% of the cases. Based on this, it is clear that the consumption of energy for heating and cooling in these structures does not represent the real need. The needed energy for achieving comfort conditions is much higher than the present consumption. Two factors are affecting this disproportion. The first is related to the low income of the families that live in the prefabricated buildings and that cannot afford high expenses for energy. The second factor is related to the difficulty of creating comfort conditions due to the large thermal loses caused by the high conductivity of the panelled skin of the buildings and by the thermal bridges. People that live in the prefabricated housing units are used on having partial heating of the house. They have adapted their comfort requirements through time while having difficulties in creating optimal room temperature and trying to decrease the expenses for energy.

5 CONCLUSIONS

The prefabricated concrete panel housing proposed a solution to the problem of housing in general in the ‘80s in Albania. Although the space organization was improved comparing to the previous standards, not much was thought about the thermal and energetic efficiency at the time. At present Albania inherits a building stock that is in need of energetic renovation. In the collective housing stock, the prefabricated buildings are certainly the most inefficient structures in terms of energy efficiency and comfort conditions. Great thermal loses are caused from highly conductive façade materials, poor insulation windows, thermal bridges and lack of maintenance. A survey conducted in Tirana, shows that less than 10% of the inhabitants achieve comfort conditions in their apartments. The factors affecting the lack of comfort derive from the low economic income and the great thermal loses in the buildings.

The need of renovating the prefabricated buildings in Albania should be considered a priority. These structures represent the minimal comfort standard in collective housing and their renovation would affect the overall quality of life of their inhabitants and would raise the overall comfort standard to a higher level.

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