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Researching Ranges for Reconstruction of a Traditional Timber House according to Principles of Sustainable Architecture

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Abstract

Main subject of the work is a case study of sustainable renovation of the traditional Balkan log-cabin, for everyday use. There are certain building principles of the past, if not all, that make traditional timber houses carry the label of sustainability, of their own time. As we study this case and progress across the era of sustainability today, we recognize how sustainable methods could be found in the essence of our tradition.

The core concept of the work is to fully recognize the characteristics of existing elements of the traditional log-cabin and the way of their treatment. Apart from the issue that some elements have been recognized as traditionally sustainable, there is also a priority which sets the aspect of usability of the house forth. In the beginning, the old house had no advanced methods of insulation, ventilation, hygiene level or sufficient light. The aim of this work is to outline improvements of those positions, so that the object in case can be reconstructed to the highest possible level.

This work shows how sustainable practice could be used for preserving vernacular buildings, not only as monuments, but also as practical living spaces. Moreover, the observation from technological aspect shows that this redesign, with its sustainable materials, can also serve as a guide for any new and modern timber house.

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1. Introduction

In the year 2014 there were ongoing works at the private estate of Prodanovic family, conducted according to the reconstruction project of their traditional courtyard. Location was a hilly area of Western Serbia. There are certain findings which say that concepts of traditional log houses originate from Middle Ages [1], and today we encounter examples of timber architecture of this type, some of which date from the early 19th century. During the reconstruction we have redesigned several traditional objects of this area, estimated to be raised 150 years ago. Nowadays these objects are redesigned according to standards of comfortable and safe living, and used for everyday, but more often for part time purpose. People from cities occasionally spend short periods in natural environment whose calmness and harmony help to relax from hectic city throng.

In the beginning of the project we noticed how newly built in, abutting materials of reconstruction had high ranking according to Environmental Preference Method [2] and that fact incited us to keep track of other clues of sustainability in traditional timber houses such as practices and logic. Perceiving traditionally rational use of resources and characteristic relation to natural environment, we recognized how these were similar to contemporary sustainable ways. Because sustainable principles are significant in architecture today, our idea was to recognize, analyze and note during the reconstruction, some of those momentums of traditional timber objects and consider them to be of importance for our preservation task as newly added value of traditional log houses. The fact that vernacular timber houses could represent a precursor to sustainable architecture was an issue that could be investigated. If that was to be true, even only partially, that newly recognized sustainable characteristics could be significant in two ways.

Firstly the significance for which we cherish our vernacular buildings could have an addition in terms of new architectural characteristics that we protect and maintain as our cultural heritage.

Secondly this analysis and affiliation of sustainable precursors could represent an interesting subject for sustainable architecture research.

Other than abstract significances of our research, real values also exist. Bearing in mind that the object in case was to be reconstructed for contemporary living, the issue of comfort represented a success indicator of the project. The difference between living conditions of the past and present was huge, but possible to overcome. Works were therefore extensive and followed high demands of sustainable architecture, while preserving traditional values. Due to complexity of such intervention that aims to reconstruct an old object with new sustainable tools, the job was assigned to Blagota Pesic, an expert in the field of traditional architecture, with wide experience in practical and theoretical work, and his colleague and assistant Aleksandar Kotevski, as a young researcher of sustainable architecture issues.

2. Original object description

Adjacent in the traditional household -the family collective [3]- and next to a main house, was a number of *vajat* [4] buildings that represented separate houses for married members of the family. These objects were being created as timber cabins, 3 x 3 m or 4 x 4 m in area. The construction meant a floor and ceiling made of planks. Equipment was humble in the original version, just a bed, a chest, a setting for a baby and a loom for weaving in some cases. Some *vajat* buildings had an open porch as well.

Our reconstruction considered locating such object and transporting it to the new construction site, and as we were not able to find a *vajat* of desired dimensions, another economic object (Figure1) was bought. It had been made completely like a *vajat*, only without wooden floor or ceiling, and with no windows, since it had served for storing tools and agriculture material. Our task was to transform this object to a dwelling for comfortable living.

Structure of the object is a typical example of traditional log house of western Balkan. It represents a harmonic construction of three zones that divide the object in vertical direction (Figure 2). These parts differ in function, construction and material. Reason for such composition could be found in builder's need for adjusting the object to nature's elements and desire to make long lasting houses.

As we located the object, it was decomposed to basic elements that all are separable, and then transported to its new location [5]. This flexibility of construction tells about certain building logic that can be compared to the re-use principle we come across in sustainable architecture methodologies. All wooden parts were

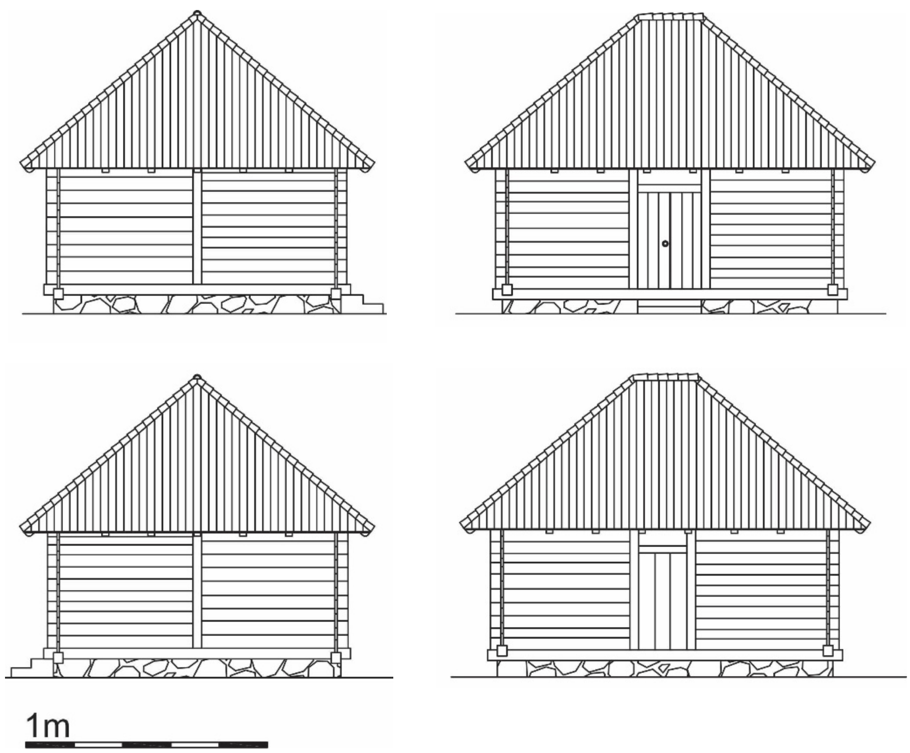

Figure 1. Original appearance of the object of reconstruction

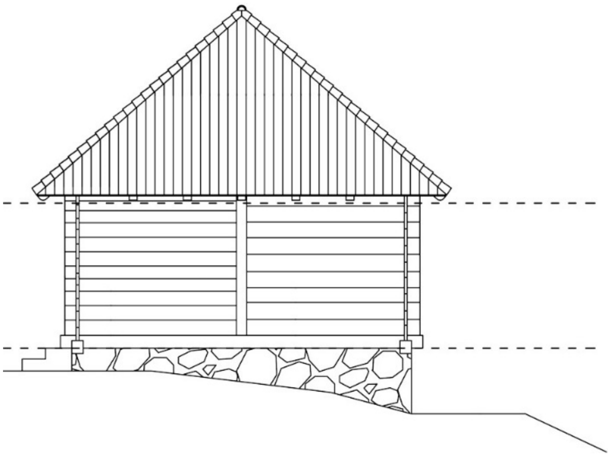

Figure 2. Three zones of the traditional log cabin

Figure 3. Easy to assemble and dismantle shell of the timber house

being connected without joining elements (Figure 3) and made to fit like `Lego` bricks. That means traditional builders had realized the importance of the ease of construction and importance of possibility to reconstruct or repair their object with as little effort as possible. Furthermore, stones of the foundation were originally being set without bonding cement, and since they last almost infinitely they were perfect for re-use.

Main processing of elements of original object was being made in local forest where the material was being obtained. Fine carving of fitting joints was being done at the construction site. This processing principle is interesting because it explains how traditional builders had the endeavour to relief their transport of excessive burden and save energy which is precisely our modern sustainable goal. Another evidence of traditional logic that corresponds to energy saving is the fact that most of elements of the object were being dimensioned according to equilateral triangle model [6]. In this way processing of material was being simplified while making savings to the overall quantity. This rational technique of building was a product of century's long experience and it can be found important for today's sustainability principles as precursors of contemporary sustainability optimization of work process. In present endeavours to create modern timber objects some of traditional experience can be applied. For example, engagement of traditional builders is crucial both to designing this kind of timber objects and to sustainability strategies of engagement of local workforce.

In terms of building elements, those that had been sheltered from the rain could lasted for centuries and be used for many times. Most of elements of our object were in good condition which was economic according to embodied energy principle, and conservational principles of preserving original state as well. Still, composing the log house at its new location included plenty of improvements for comfortable and modern living in all parts of the structure.

2.1. Foundation zone

This part of the log house is a foundation and a retaining wall constructed out of roughly hand processed stone. Purpose of this zone was to separate the wooden construction from ground and level it to a horizontal standing position. Original walls were formed 50 cm in thickness, buried up to 20 cm to the ground. Walls were used to mark position of the log house, a rectangle of 6.8 x 5.8 meters. The inside was filled with clay ground which was being beaten to make a floor.

We discovered that lot of stone for foundations was being found in local vicinity of the construction site. There was not much choice of material in times of construction of traditional objects. However, builders made their foundations strictly out of limestone rock, among other stone types. Limestone reacts well to atmospheric elements and can highly prolong lifespan of an object. Today, these natural materials used for constructing traditional objects, can be identified as highly ranked according to their ecological characteristics, but still, their role and way of their use in traditional objects, does not correspond to high standards of thermal and air comfort. From heating energy saving point of view, this ground level has plenty of space for improvement. The original floor was constructed without hydro insulating layers, which meant that certain amount of moisture could advance from ground to upper levels and cause high humidity in the whole object. Those conditions are suitable for microorganism development and dirt particle concentration, while the floor itself was being more difficult to clean. Having a finishing layer made of beaten clay, was causing rising dust, a negative effect for air we bread. This high moisture level was producing lower surface temperatures. The deficiency of thermo-insulating layer in the floor, was another factor that negatively affected thermal comfort of traditional objects. Heat loss over the floor was 4.587 W/m²K [7].

Foundation zone reconstruction

Reconstruction of this level meant re-use of stone, and building new foundations of stone and concrete. They were grounded at appropriate depth of 60 cm, and due to the sloped terrain, foundations were made in two levels. Floor layers were set in order to block moisture coming from ground and also to prevent heat transfer. Thermo-insulating layer of expanded polystyrene 12 cm thick was built in, so thermal transmittance of improved reconstructed floor now has 0.286 W/m²K. Finishing layer was made of ceramic tiles in one part and wooden beech planks (Figure 4) in other, which suites regular maintenance of ground floors that are in constant contact with outside environment.

2.2. Middle zone

The second level is the wall envelope originally made of oak wood planks 5 cm in thickness. The wooden construction was set on the retaining stone wall beneath. This positioning separated wood from moisture and prevented decaying, hence prolonging lifespan of the whole object. Choice of materials for this position did not include industrial products, but traditional builders were deciding among few different wood kinds. Walls were made of quality oak wood that serves against moisture and makes a stable construction, while the interior was built out of beech which is easier to form but needs a dry environment. Wall planks were precisely processed and designed to tightly fit each other leaving millimetre gaps along the length which were being filled with moss to prevent air flow (Figure 5). Complete wood material was being found in local forests.

Still, walls of our object were designed long before standards of eco-building. They represent construction typical for a traditional log house that could have served as a living space long time ago. Calculations state that thermal transmittance of the plank wall was 1.99 W/m²K. Living conditions meant high temperature oscillations and constant temperature was difficult to maintain. Furthermore, the finishing layer of walls was dark wood texture. It was a surface hard to clean, so it is possible to say that hygiene level was not satisfactory. Dark colour of walls reflected little light so visual conditions must have been limited.

Reconstruction of the middle zone

To reconstruct this level we kept the exterior in its original state to preserve cultural identity of the object, while the interior had several improvements. Walls were redesigned in two ways. Bathroom and kitchen walls were insulated with a layer of mineral wool 15 cm in thickness, after that a hydro insulating layer and a brick wall of 12 cm. Brick enabled thermal mass for walls and stable positioning of piping and resistance to high temperatures in the kitchen. Thermal transmittance of this reconstructed wall is 0.19 W / m² K. The rest of walls in living room and bedroom were insulated with 15 cm of rock wool and with gypsum boards instead of brick. Thermal transmittance of this wall is 0.195 W/m²K. The whole object had a white finishing colour in order to improve visibility (Figure 6). We introduced 5 widows and another door, all made of quality oak wood, in accordance to traditionally used materials. Windows carry high quality thermo insulating glass and the door is thermo proofed and transparent as well.

2.3. Upper zone – The roof

The last level of the object is the roof and the attic space. Its inner construction had been made of wood and covering tiles were too, much later clay tiles were introduced and they were found in decayed state. Original traditional buildings had no insulations which meant that the whole zone was completely exposed to atmospheric elements. Wood was without added protecting coatings in the original version of this type of vernacular timber buildings, but pine tiles contain natural resin that was prolonging roof lifespan in contact with rain.

This kind of bare construction meant that the attic was almost never used. Conditions were unhealthy due to the high moisture or temperature oscillations and constant darkness. Thermal transmittance was 2 W/m²K.

Figure 4. Redesigned floor finish

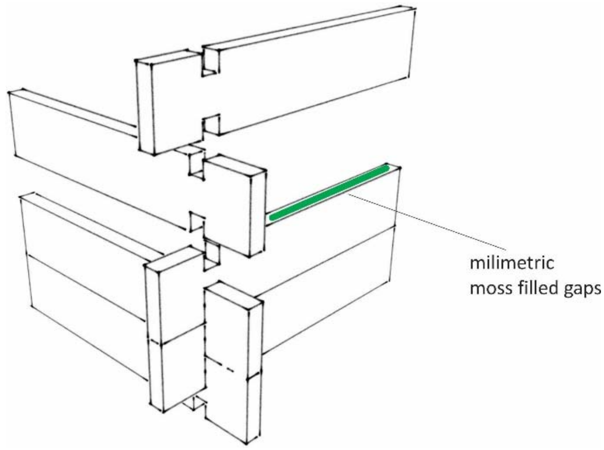

Figure 5. Middle zone construction and fitting of elements

Figure 6. Interior walls and windows

Figure 7. Preserved exterior, roof and complete shell

Reconstruction of the upper zone

Aim of reconstruction was complete function change of this space, adjustment for contemporary use. Inner wooden construction was still in good condition. Clay tilling was replaced with the abutting set (Figure 7). A layer of hydro insulation was added under the tiles to prevent water drippings and moisture. Thermo insulating mineral wool of 20 cm in thickness with vapour barrier was put between rafters and sealed with gypsum boards. Finishing layer was coated in white paint. Thermal transmittance of the reconstructed roof is now 0.22 W/m²K. Floor of the attic was built out of planks, without insulating layers, so upper and middle levels are heated and used as a unified space.

3. Heating energy savings

The traditional log house originally had high heat flow over its envelope. None of the positions had insulating layers and since temperature was supposed to be as comfortable as possible constant wood burning was necessary. This regime meant high energy losses. Calculations claimed that the heating energy needs were 612 kWh/m² before the reconstruction.

Reconstruction of the log house considered complete shell insulation in order to rationalize energy demand. Wood burning stove was planned to heat the whole object. After reconstruction, energy demand was calculated to be 186 kWh / m². Reaching even lower energy demand was possible, but since object was to be used occasionally, regime of heating allowed us to rationalize with insulation material.

4. EPM results

There were few factors that affected choice of materials for reconstruction. Materials and elements were being chosen according to conservational principles of congruence that considered use of same materials as in the original state to maintain the cultural identity of the object and landscape to which it belongs. Also, another principle of material choice was accordance to EPM system. Price and material availability and possibility of installation was a factor as well.

Table 1. EPM Preference of reconstruction materials

POSITION	PREFERENCE 1	PREFERENCE 2	PREFERENCE 3	PREFERENCE 4
WOOD PRESERVATION		LOCALIZED		
BALCONIES	DURABLE WOOD			
COMBATING RISING DUMP				BITUMEN
GROUND FLOORS				CONCRETE
INTERNAL WALLS	FRAME AND PANELS			
EXTERNAL WALL CONSTRUCTION		DURABLE WOOD		
ROOF CONSTRUCTION	SUSTAINABLE WOOD			
EXTERNAL WINDOW FRAMES AND DOORS	SUSTAINABLE WOOD			
EXTERNAL WALL CLADDING	SUSTAINABLE DURABLE WOOD			
INTERNAL STAIRS	EUROPEAN WOOD			
INTERNAL/EXTERNAL RAILINGS	SUSTAINABLE WOOD			
ROOF COVERINGS		CLAY TILES		
TRESHOLDS	SOLID NATURAL STONE			
GROUND FLOOR INSULATION		EPS		
EXTERNAL WALL INSULATION		MINERAL WOOL		
ROOF INSULATION		MINERAL WOOL		
FITTING TILES	BEDDING IN MINERAL MORTAR			
FLOOR SCREEDS			SAND CEMENT	
WALL AND CEILING FRAMING SYSTEM	EUROPEAN WOOD			
INTERNAL JOINERY	EUROPEAN WOOD			
EXTERNAL JOINERY	SUSTAINABLE DURABLE WOOD			
FLOOR COVERINGS		CERAMIC TILES		
DRAINPIPES/ INTERNAL WASTE SYSTEM				PVC
WATER SUPPLY		STAINLESS STEEL		
WC SUITES		ADJUSTABLE FLUSH		
TAPS AND SHOWER HEADS			STANDARD	
HEATING INSTALATION				STANDARD BOILER
INSULATION OF PIPES		MINERAL WOOL		

Local market of ecological materials offers limited choice, however EPM proved to be compatible with mainly rural environment and with conservational congruence as well. In the beginning of the project, it was noticed that materials used in the original object, in the time it had been built, could be highly ranked according to EPM. This led to a conclusion that reconstructing traditional log houses using congruent materials can be seen as highly ecological action (Table 1).

Materials marked green represent a group of original materials that were found on the object in its original state. It is evident that these materials belong to the highest rank of environmental preference according to EPM method.

Yellow marked materials are ones introduced by our project that carry the highest level of ecological quality and in the EPM terms – minimal environmental impact.

Materials that are not marked by colour are ones that were also a part of our reconstruction and belong to lower levels of environmental quality.

5. Conclusion

Usual preservation of architectural heritage is a work which considers careful treatment of all elements of historically important objects. It consists of keeping those that have survived and identifying new materials of reconstruction with originally installed ones while tending to maintain the congruence and minimal changes to the original object. Principles of construction that led to coining traditional styles were not always being analysed and noted. This work shows how building principles of the past consist of interesting and useful logic that is worthy of analysis and preservation. Traditional materials have their testimony about appearance as characteristics of the traditional type but besides that, in the era of contemporary sustainability they also appear as ecological and in terms of preservation this is an added value. Building principles that were usually not a focus of classical conservation, analysed with contemporary sustainability testify how energy saving was an issue with vernacular timber objects of western Balkans.

These objects were usually being preserved as museums and due to their surpassed living conditions, today some of them undergo extensive reconstructions to reach contemporary accommodation standards.

Apart from a huge gap between comfort levels of now and then, when it comes to building logic, it seems that principles of traditional timber houses and modern sustainable architecture have something in common. Architecture of the old style, before the era of industrialization, was and tends to be closely related to nature`s laws, while modern architectural concept today considers complete care for natural environment, to which every object belongs. That similarity of concepts and other building motives represents a fact while conducting an eco-redesign and preservation of traditional log houses. The importance of these objects is eventually also in their testimony about origin of rational use of materials and logic of economy. The conclusion of our research was that most of traditional building principles were being coined with endeavour to save energy. These characteristics we are able to detect with contemporary sustainable tools and preserve as architectural heritage.

With that knowledge and today’s calculations of thermal conditions and other standards, we can conduct respectable and rational, contemporary understood reconstruction and meaningful preservation of traditional objects. We can use them not only as conserved artefacts, but also as interactive building models that serve to tell the story of our culture while at the same time provide space for living. In that way we continue the experience of practical and rational use of the complete embodied energy of an object.

Original builders of log houses have tried in many ways to make building process and use as logical as possible. Their wealth was measured in their living assets, land, animals and their family. Therefore it is clear that their buildings were being made in spirit of rationality and care towards the living environment. Searching through preserved notes and testimonies about traditional objects and looking for their relevance to sustainable architecture could present us beginnings of ecological building concepts. We realize how sustainability is not merely a scientific experiment that should be placed aside of our everyday architectural practice but rather an original architectural philosophy that pervades from the beginnings of building practice and, as the time shows, now represents the vast field and state-of-art of our understanding of architecture. This issue can be a topic of further thorough research in the field of sustainable architecture.

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Nomenclature

[W/m^2K] – Unit for thermal transmittance of the element

[kWh/m^2] – Unit for heating energy demand

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