NEOLEPENISM AS A TYPE OF ENERGY EFFICIENT ARCHITECTURE

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Abstract in English:

Neolepenism can represent a new type of energy efficient architecture that can respond to the challenges of sustainable development. Designing energy-efficient forms can be one of the design strategies for low-energy and passive houses. Of all the geometric bodies, the sphere has the smallest ratio of surface and volume, but it is not used in the performance of objects due to the limited application. The cube can be considered as the optimal form of object with which objects of other geometric shapes should be compared. In geometry, there are a number of shapes that are compact in between the ball and the cube, and some of them are usable for housing.

Neolepenism presupposes the shape of a building object inspired by the prehistoric architecture of the Lepenski Vir culture. Remains of the architecture of prehistoric settlements Lepenski Vir and Padina – Gospodjin Vir, which were on the right bank of the Danube in the Djerdap Gorge (Republic of Serbia), represent the remains of energy-efficient architecture, which the author had already written before. It turned out that during the construction of prehistoric houses, the thermal comfort in them was taken into account: about the compactness of shapes, orientation, aerodynamics of the shape, digging, plant environment and other. These architectures control the flows of energy. It takes into account the optimal orientation of the houses in terms of meeting the needs for heating and cooling of these houses.

Due to the similarity of the climate conditions of Lepenski Vir and Belgrade, the positive experiences of this prehistoric architecture have been improved and perfected, so the author proposes a new form of a building object, based on the principles of energy efficiency, and inspired by the architecture of Lepenski Vir. There are several variants of this form. The asymmetry of the shape contributes to the reduction of ventilation losses, as well as the greater possibility of applying passive solar architecture. A flat roof version allows the installation of a green roof and the use of RES, i.e. solar panels. It is recommended to mainly be eastern orientations of this object. The form of energy efficient house, which is copyrighted, can significantly contribute to energy savings, reduction of greenhouse gases emissions, and considerable savings in construction material and thermal insulation.

Key words: *neolepenism; energy efficiency; Lepenski Vir; architecture; compactness*

1 Introduction

Neolepenism can represent a new type of energy efficient architecture that can respond to the challenges of sustainable development. The name Neolepenism is very appropriate because the prefix *neo* signifies something new, while Lepenism refers to the architecture of the prehistoric settlement and culture Lepenski Vir (Republic of Serbia). The word Neolepenism was sugested by Serbian actor Predrag Kolarević. Positive experiences of this prehistoric architecture have been improved and perfected, so the author proposes a new form of a building object, based on the principles of energy efficiency. The remains of architecture of the prehistoric settlements Lepenski Vir and Padina – Gospodjin Vir, represent the remains of energy-efficient architecture, which the author had already written before [6]. This architecture controls the flows of energy, taking into account the optimal orientation of the houses in terms of meeting the needs for heating and cooling of these dwellings, as well as the aspect of urbanization of settlements [5].

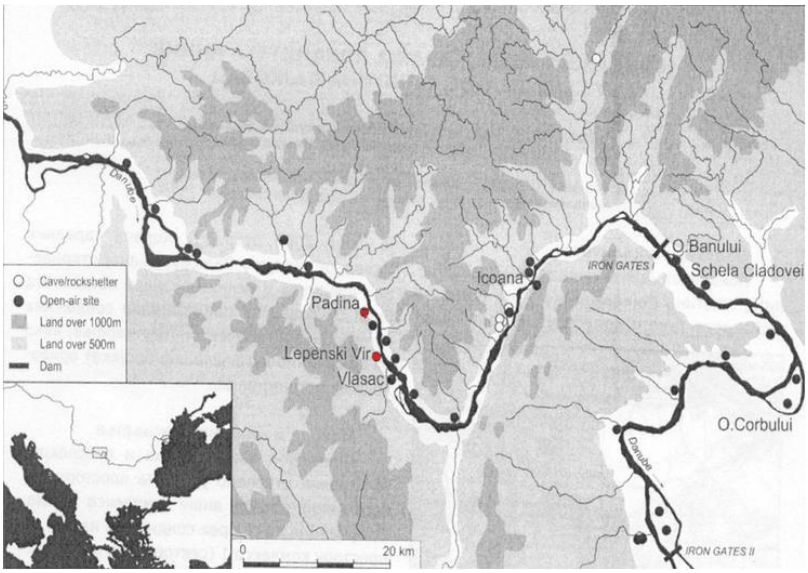


Figure 1 – Places of Lepenski Vir culture [6]

Designing energy efficient forms can be one of the strategies for designing low energy and passive houses [8]. „Of the geometrical bodies, the sphere has the lowest ratio of surface to volume, but because of its limited application in the construction of objects, it is not used. Of the orthogonal geometric bodies, the cube has the smallest ratio of the surface area to the volume. (…) A cube can be considered as the optimal shape of an object with which objects of other geometric shapes should be compared“ [4].

2 Energy Efficient Architecture of Prehistoric Lepenski Vir

The remains of architecture at the sites of Lepenski Vir and Padina – Gospodjin Vir, created about 8,000 years ago, show visible and recognizable measures for increasing energy efficiency in construction which were applied in the course of design and construction of houses and settlements at the mentioned locations. The site of Padina - Gospodjin Vir also belongs to the prehistoric culture of Lepenski Vir and was located in the Djerdap Gorge, about 6 km upstream from the Lepenski Vir site. Archaeological excavations in Djerdap were carried out during the 1960s.

Academician Dragoslav Srejović is most responsible for the discovery of Lepenski Vir, while the excavation at the site of Padina - Gospodjin Vir was led by the academician Borislav Jovanović. The preserved settlement plans are of great value because both of these sites have been flooded by the construction of the Djerdap 1 hydroelectric power plant and the formation of a large artificial lake. Since only the floors were preserved, the third dimension of the houses remained is unknown. There are only assumptions about what those houses were like.

It is most likely that the purpose of the architecture and urbanism of the prehistoric settlements of Lepenski Vir and Padina - Gospodjin Vir among other things, was to create comfortable living conditions within the natural environment. Natural environment includes geographical, climatic, astronomical and plant environment.

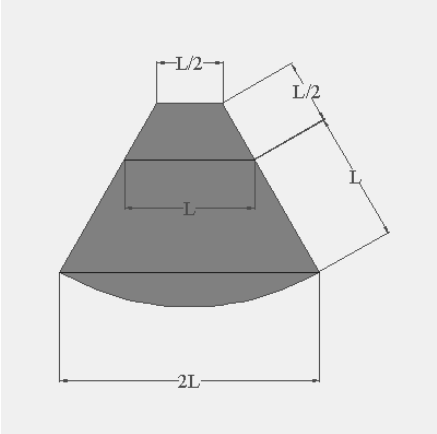


Figure 2 – Basement layout of houses on Lepenski Vir by D. Srejović [12]

„Conduction heat losses in winter were reduced by the compact form and drying of the "walls" by morning solar radiation, to improve the degree of thermal insulation, using a favorable orientation. (...) Ventilation heat losses were pronounced. They have been reduced by building an aerodynamic base (and thus the aerodynamic shape of the house as a whole), choosing a favorable orientation, digging and, probably, a plant environment and a steep hinterland [6]”.

Figure 3 – Side view of steep hinterland [6]

Thermal comfort in the summer period was achieved in a compact form, by selecting a favorable location with a steep hinterland on the west side, choosing a favorable orientation of the houses (mainly towards the east and the river), proximity to the river and, probably, using shade from the plant environment [5].

Compactness of form is very important as it contributes to the reduction of both conduction and ventilation losses in winter and heat load in summer.

Figure 4 – Inside view from the Museum of Lepenski Vir

3 Optimized base layout of the building

I will show an optimized shape of the cylinder base, which we can call a convex trapeze. This figure was obtained by taking into account the orientation of the walls in space. It can represents the foundation shape of the Neolepenism architecture objects. Similarity of the shape of the basics of the houses in Lepenski Vir and the optimized shape of the convex trapeze is large, but the optimized shape is slightly flatter compared to their base.

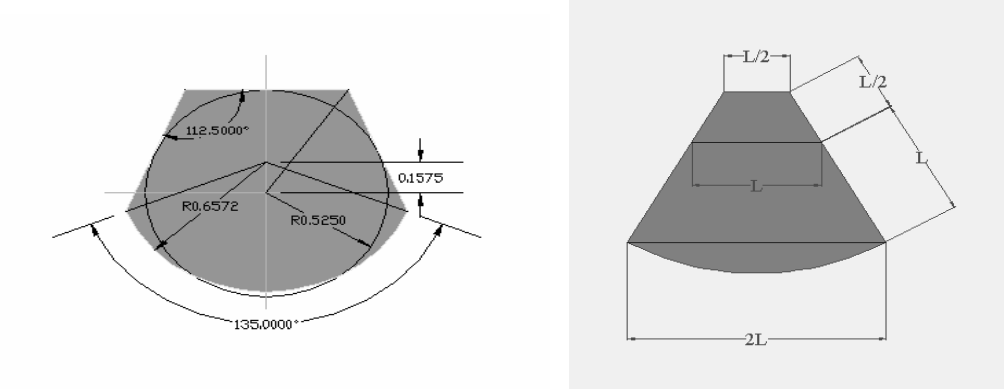


Figure 5 – Basements of the objects of the Neolepenism and layout of houses on Lepenski Vir by D. Srejović [12]

The quality of the shape of the base from Lepenski Vir is reflected in the use of the parts of the circle (as the most compact shape in the plane) and the tetragon. The proportion of the circle increases the compactness of the whole figure. By optimizing and refining this base and using a cylindrical shape, savings in the shape factor of slightly more than 5% over the cube are possible [9].

4 Calculation of the optimum height of a building

Cylindrical bodies are very favorable for construction and are usable in housing because they do not require special reinforcements needed for vertical walls. Their base, which can be of any shape, is precisely defined by its geometry [10]. The characteristics of this arbitrary shape are the constants k and L, and let R be the characteristic length of the base figure. In this case, the base area is:

$$B = k \cdot R^2 \tag{1}$$

its scope:

$$O = L \cdot R \tag{2}$$

while height *H:*

$$H = V / (k \cdot R^2). \quad (3)$$

The surface of the envelop of a cylindrical body is:

$$A = 2 \cdot B + O \cdot H, \quad (4)$$

and the requirement is that it must be minimum for the required volume V. This means that:

$$dA / dR = 0. \quad (5)$$

From this condition, if the volume of a cylindrical building V is known, the characteristic lenght of the base figure R is calculated as [10]:

$$R = [(V \cdot L) / (4 \cdot k^2)]^{(1/3)}, \quad (6)$$

First, the dimensions of a building of unit volume ($V = 1\ m^3$) were calculated. For this unit volume, the optimal height of the cylindrical drift object is:

$$H_{V=1m^3} = 1{,}0562\ m. \quad (7)$$

5 Variants of Energy Efficient Building Construction

It is possible to carry out such a defined form of a building in several variants. The roof can be with a seven-line or flat. The flat roof structure has a better surface-to-volume ratio, while the seven-line roof assumes that the attic space is not used for residential purposes.

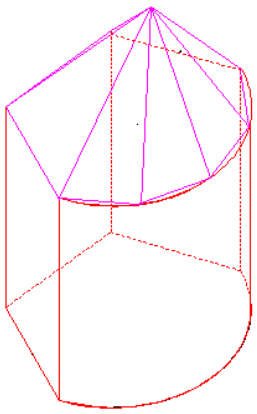


Figure 6 – Author's form of an energy efficient house with a seven-line roof and an arch wall

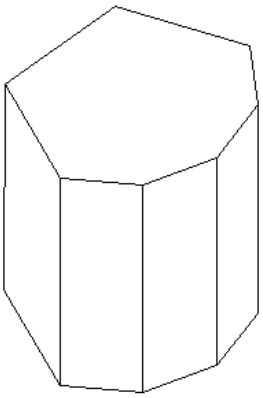


Figure 7 – Author's optimized base design for an energy efficient building with a flat roof and walls

Usability of the living space is reduced if arched surfaces are used. Therefore, the optimized shape of the base can be slightly modified. The arched surface can be straightened in four tendons, which does not cause significant loss of energy efficiency of the base form, and which increases usability of the living space.

A form of an energy efficient house is authorized and protected as a type of industrial design at the Intellectual Property Office of the Republic of Serbia, through which an application for its international protection was also submitted.

6 Green roof and/or Solar panels

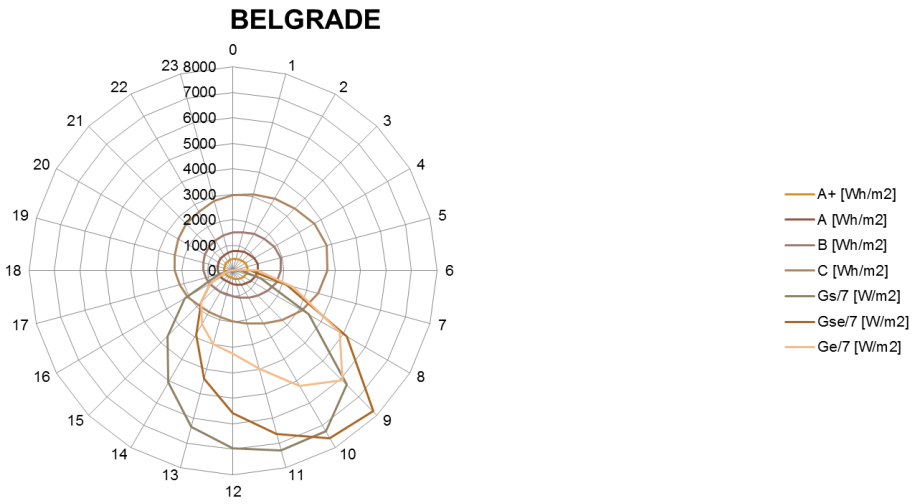
A flat-roofed building variant may be attractive for renewable energy applications - installation of solar panels, both photovoltaic and thermal solar receivers. Also, a flat roof allows for construction of a green roof - the installation of a plant cover to reduce the heat load in summer.

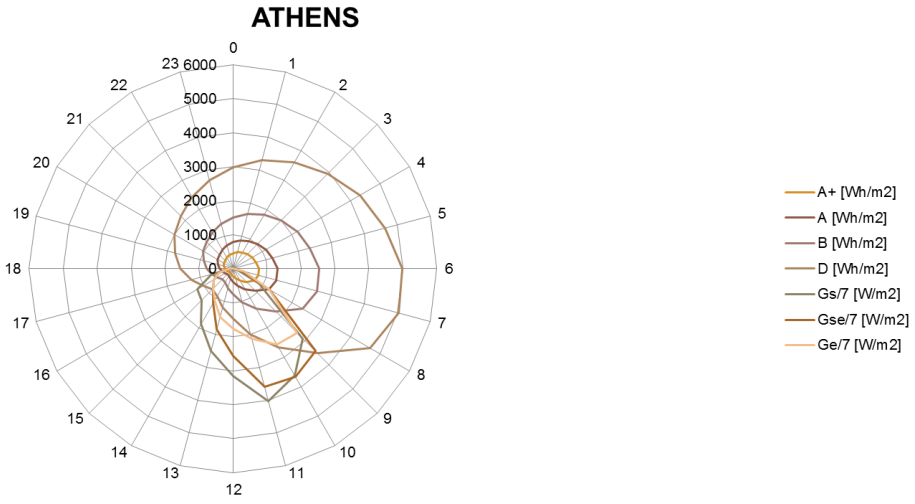
The orientation of solar panels does not coincide with the optimal orientation of the building, which will be discussed further. It is necessary to distinguish between the optimal orientations of solar panels and buildings, as these are two different concepts.

7 Calculation and Simulation of the Optimal orientation of a Building

This type of building that belongs to the architecture of Neolepenism enables exploitation of the benefits of adequate orientation. Microsoft Excel and the Meteonorm meteorological database with its typical meteorological years were used for the calculation packages. Data analysis for the whole year, as well as defining the conditions for heating or cooling, gives the possibility of making radar diagrams [8].

Data from a typical meteorological year for Belgrade were taken and the same calculation was then done for Athens and Stockholm, which belong to the moderate heat zone. The figures shows that for passive houses, the east or south-east orientation of the wall has a slightly higher portion in direct coverage of heat losses than its southern orientation.





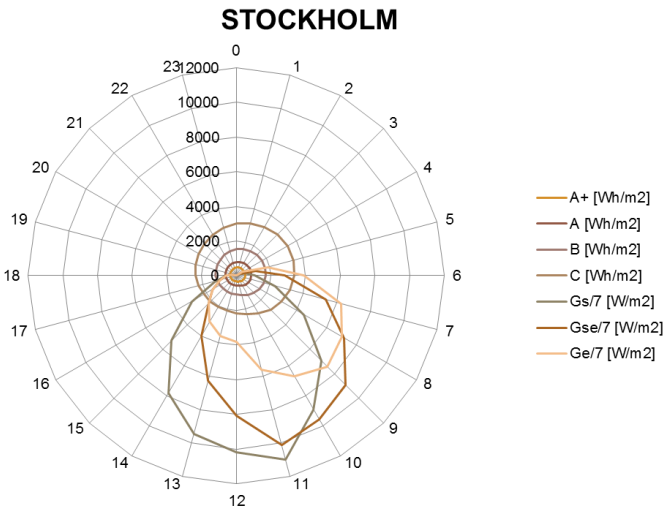


Figure 8, 9 and 10 – Solar radiation by hours for all year for Belgrade, Athens and Stockholm during heating season G/7 [Wh/m2], for east, south-east and south wall and heat loads for Energy classes of Buildings Qg [Wh/m2] (classes A+, A, B and C)

Due to the cooling needs in summer, east-northeast orientation is most favorable. As the same facility has the function of maintaining the necessary comfort throughout the year, both for heating and cooling purposes, the mainly eastern orientation of the building is adopted as a compromise solution for the moderate heat zone.

8 Benefits and Limitation of Neolepenism

The architecture of Neolepenism can present a great challenge for architects. It has angles that are not orthogonal, thus conventional room layout solutions cannot be applied. New solutions and a new approach to architecture design are needed. However, Neolepenism also has certain advantages over orthogonal architecture. The main advantage of Neolepenism is that it achieves significant savings in the energy needed to heat or cool the interior of a building. In urban areas, buildings can be arranged in series, which is better when viewed from the aspect of energy consumption. Such buildings, besides homes or residential buildings, can also serve as public buildings: schools, post offices, kindergartens, hospitals, etc., as well as business premises: hotels, factories, offices, shopping malls ...

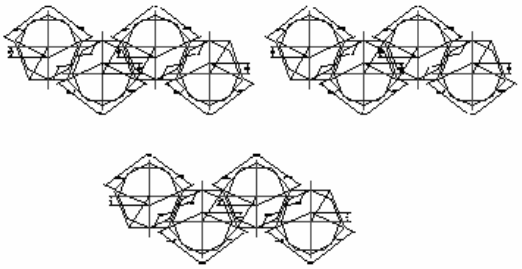


Figure 11 – Townhouses in urban areas [11]

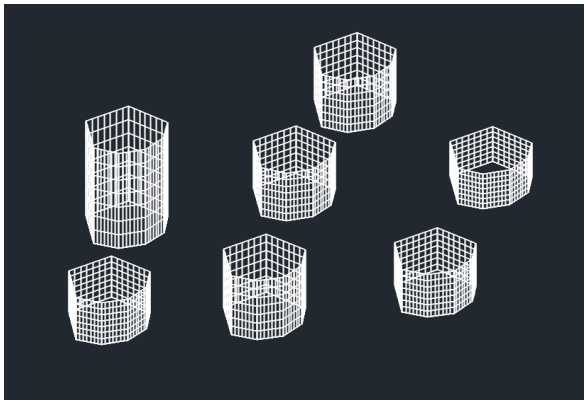


Figure 12 – Lepenski Vir as a pattern for Urbanisation

9 Conclusion

Neolepenism is a distinctly mathematical architecture. It is based on adaptation of the building to the natural environment, which involves fitting into the geographical, climatic and plant environment and taking into account the impact of solar radiation. This kind of architecture, though new, has deep roots - a practice that was implemented over a long period of time, about 8,000 years ago.

For the architecture of LepenskiVir, which is a model and inspiration for the new architectural forms proposed in this paper, the archaeologist D. Srejović claimed that he had something very mathematical in this. He meant primarily the geometric shape of the base, but at the same time noticed the connection of architecture with the natural environment, that is, with the ambient[1].

It turned out that the houses of Lepenski Vir and Padina – Gospodjin Vir are an example of energy efficient construction for that time, for the given locations, for the current state of technology and the applied materials, therefore significantly contributing to the longevity of the settlement.

The author further proposes a new form of energy efficient building construction. Its base, height, orientation and variants are defined. The predominantly eastern orientation on the flat terrain facility is recommended, resulting in a compromise between optimal orientations for heating and cooling the interior of the facility. The application of such a building is placed in the moderate heat zone of our planet.

The encouragement may be that the prehistoric architecture of the Lepenski Vir culture, which has been applied for generations, is a model for Neolepenism, which fits the concept of sustainable development.

If similar basic ideas in design and construction were applied in technology, tools and materials at a low technological level in prehistory, today, when we have quality materials and technologies, as well as powerful computer tools, the application of this type of energy efficient architecture should not represents a "mission impossible ".

For the 50th Congress and Exhibition of KGH was made the model of small house of architecture of Neolepenism. The model and the poster were exhibited on the boxes of Mechanical Faculty University of Belgrade and IBPSA Danube Belgrade.

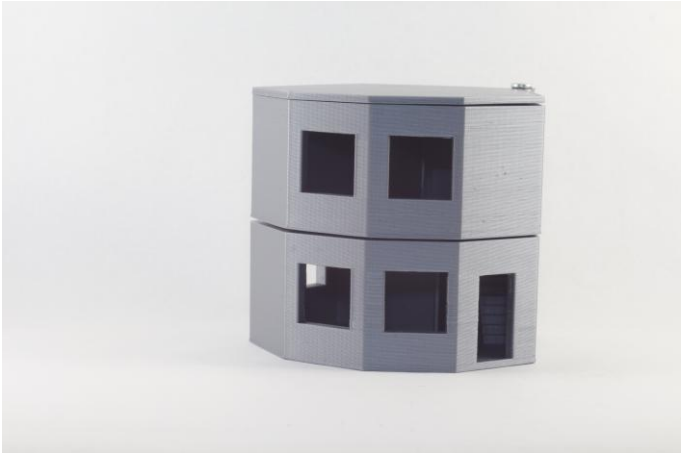


Figure 13 – The model with a flat roof – Front view from the east side

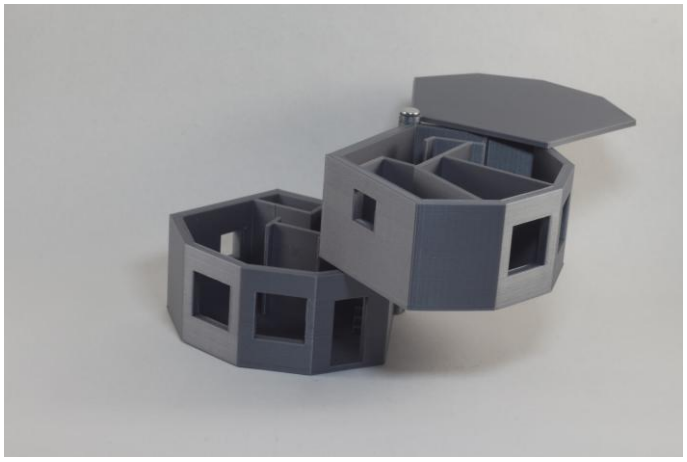


Figure 14 – The model with a flat roof – Inside view

[1]"Due to the marked 'unhistoriness' of the architecture of LepenskiVir, we are tempted to explain the exceptional nature of its forms by specific features of the terrain and space, ie. natural environment. The connection between architecture and ambience is really obvious. (…) The architecture of LepenskiVir has in itself something extremely mathematical, that is, in its entire forms one can feel the presence of concrete longer and certain numbers. (…) The structure of LepenskiVir I and LepenskiVir II (…) corresponds only to the morphology of the city of the distant future. (…) The architecture of LepenskiVir merely 'reads' its surroundings, translates its intricate, condensed contents into an easily understood language… [12]".

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