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TOWN PLANNING PARAMETERS IN THE FUNCTION OF BUILDING ENERGY EFFICIENCY

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Abstract. *Energy efficient building is that consuming the least energy while providing comfort. The energy consumption of buildings, in general, as well as in Serbia, is among other things conditioned by the heating, cooling and lighting requirements with a goal of achieving of thermal and light comfort. Heating energy consumption is the result of heat loss and gain, and their values, in addition to other parameters, depend on town planning parameters. The paper focuses on the comparative analysis of impact of building different exposures to wind as well as on impact of the different prevailing orientations on energy efficiency of buildings.*

Key words: *orientation, solar gains, ventilation losses, energy efficiency*

1. INTRODUCTION

Achieving thermal comfort is one among the requirements to be dealt with during design and construction of building. Depending on the climate conditions, most frequently, for realization of the heat comfort, building requires either heating energy or power for operation of air conditioning systems. For this reason, limitation of energy consumption in buildings is very important, as it contributes to prevention, i.e. reduction of damage with unforeseeable consequences, [1].

Energy efficiency of buildings, as a building characteristic to efficiently consume energy, or to consume as little energy as possible, while achieving comfort, is one of the most important factors of sustainable building which becomes a necessity with a goal to reduce consumption of energy resources, to prevent climate change and reduction of impact on the environment, [2].

The heating energy as one of the factors of energy efficiency of building is lower in case of small transmission and infiltration thermal loss, as well as in case on high internal and solar heat loss. Cooling energy is affected by the thermal loss in the summer season.

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Apart from architectural, the thermal loss and gain very much depend on the climate and a number of town planning parameters, which can be natural or artificial.

The paper focuses on the comparative analysis of the values of solar thermal gain of the buildings with rectangular layouts and staggered form, having different orientations and position of windows of certain characteristics, and of the value of ventilation thermal loss of the buildings at various positions, which was used to draw the conclusions. The goal is to indicate the initial guidelines and principles for individual architectonic and town planning designs.

2. TOWN PLANNING PARAMETERS AND ENERGY EFFICIENCY OF BUILDINGS

The town planning parameters can be categorized in two groups of factors: natural and artificial factors. The group of natural factors consists of: weather conditions – temperature, humidity and air flow, topographic characteristics of the location and configurations, and the group of artificial factors consists of: building orientation, mutual position of buildings, their architectonic form and vegetation, [6]. The climate parameters, temperature, humidity and air flow, depend on the location, but also on the structure of building micro-location.

The value of heat losses in the winter season depends on the climate, i.e. microclimate parameters.

The intensity of solar radiation varies on different locations, or micro-locations. It causes solar thermal gain which are different, both in individual locations or macro-locations in the individual seasons of the year or times of day, figure 1, [11]. Thermal gain is desirable in the winter season since it contributes to the necessary heating energy. In winter, it must be avoided in order to achieve favorable thermal comfort, that is, to avoid or reduce the consumption of energy required for operation of air conditioning.

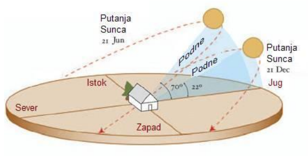

Fig. 1 Trajectory of the Sun in different seasons of the year

Wind action on a building depends on the: directions, course and velocity, and on the micro-location composition. Building screens, formed by other buildings or greenery can to a significant extent cause reduction of wind intensity as in figure 2, and thus affect the energy efficiency of buildings. The natural and artificial wind screens create favorable micro-climate conditions, [1], [6]. Wind pressure causes ventilation thermal loss and an onset of draft, which affects the thermal comfort in the buildings, [6].

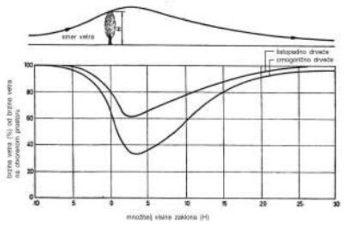

Fig. 2 Wind speed profile in the city, suburban and open areas

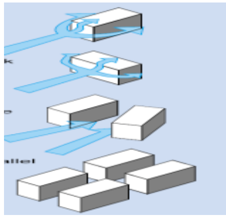

Fig. 3 Effects of mutual disposition of buildings on the air current movement

A favorable orientation of a building can cause reduction of wind pressure on its façade, since the buildings can affect the air current flow with their shape, dimensions and mutual disposition, as in figure 3, [9].

There are numerous researches in the field of the impact of architectonic and town planning parameters on the energy efficiency of buildings, such as for instance in the paper [7], where the impact of the local climate, type of glazing and orientation of the façade on the ratio of thermal loss and solar gain during the winter period in several European cities is presented. It is demonstrated that the southern orientation is the most favorable.

In the paper [8], for the case of various building orientations, ratios of building sides, structures of walls and roofs, levels of thermal insulation, types of windows and percentage of glazing of the walls for every individual façade, it was found on the basis of the analysis that the optimum designs are these where the glazed facades face south.

The [9] found that micro-location is important for the value of ventilation thermal losses, and thus for the energy efficiency of buildings.

3. Comparative Analysis of the Town Planning Parameters Impact

The comparative analysis of the values of solar thermal losses of buildings was performed for the rectangular layout buildings in staggered rows, having different orientations and positions of the windows, as well as the values of ventilation thermal loss of the buildings in various positions. Even though the mentioned analyses can be performed using various software, such as [4], which are based on the dynamic states, the calculations herein have been performed using the Code on energy efficiency of buildings [3], using software [5].

3.1. Solar thermal gains – case study

The comparative analysis of the value of solar thermal gains was performed for the buildings whose layouts are schematically displayed in figure 4, with the following characteristics:

- location Belgrade, Serbia; mean sums of solar radiation taken from [3],
- heating season from 15th October to 15th April,
- buildings consist of 4 functional parts a piece; each of the functional parts has gross surface area dimensions 7,0 x 14,0 m; the total gross surface of one floor is 392 m^2,

- window surface area is approximately 1/7 of the surface are of each functional unit, with a goal of achieving the light comfort with natural light,
- The windows have the following dimensions:
  pr1: 6,0x1,6 =9,6 m2, pr2: 2,0x1,6=3,2 m2, pr3 8,0x1,6=12,8 m2,
- The height of the heated part of building is 4 floors, gross height 13,8 m,
- Gross volume of the heated part of the building is 5 409,6 m^3.

The chosen variants were selected because of the following reasons: The variants V1, V2 and V3 have far more surface area of the façade facing the east or west, than the variants V4, V5 and V6 which have far more façade area facing north and south,

- Variants V1, V2, V3 and V4 are compact buildings symmetrical in both directions, while variants V5 and V6 represent a continuous or staggered row,
- All the variants have different window orientations.

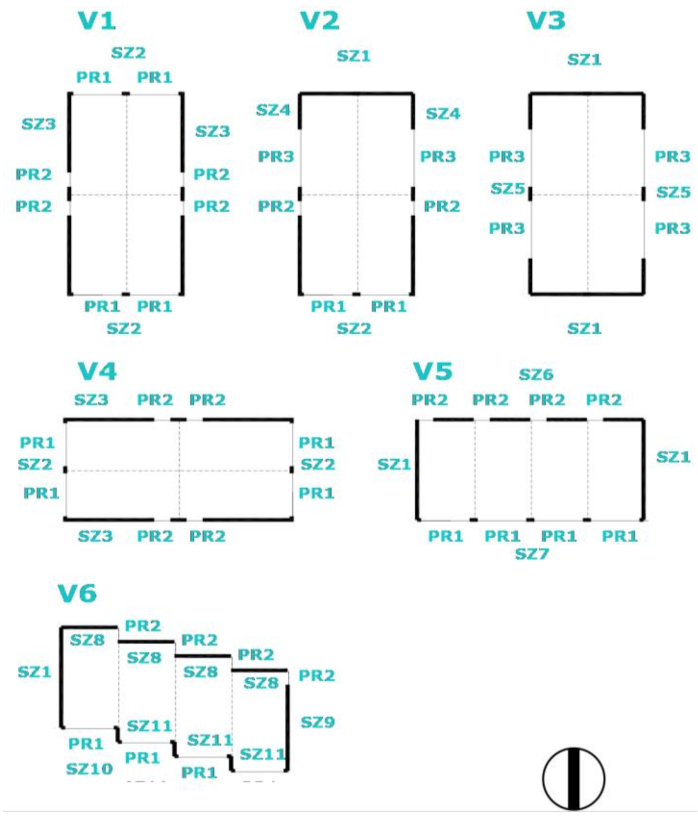

Fig. 4 Building layout

The thermal envelope of the building is designed in a way to meet the requirements of the code of the energy efficiency of buildings [3], both in terms of the highest permissible coefficients U (W/m^2K), and of the other requirements. The structure of the building thermal envelope is presented in table 1.

The analysis of the solar gains in the heating season was performed on the basis of [3], from where one can conclude that the solar gains are considerably higher through the transparent sections – windows of the thermal envelope, than those of the non-transparent sections, therefore the focus is on the window surfaces areas of the individual orientations.

In table 2., as well as in the graphs on figure 5, are displayed the window surface areas and their share in percents of the individual orientations of all variants of buildings. The prevailing orientations of the individual variants are defined as the window share of no less than 50%. For each orientation, is represented the sum of solar radiation per surface area unit of the thermal envelope for the heating season. The solar thermal gains $Q_{H,sol}$ (kWh) were calculated for the heating season of the buildings, and % is the percentage of the value of these gains in comparison with value of the building variant V1. The mentioned solar gains are presented in the diagram of figure 6. The yearly solar thermal gain $Q_{H,sol}$ (kWh) are calculated for the building heating season, a % is the percentage of the value of these gains in comparison with the value of the building variant V1. The mentioned solar gains are presented in the diagram of figure 6.

Table 1 Structure of the building thermal envelope

Layer	Material	d (cm)	U (W/m^{2}K)
	SZ-External wall		
1	Lime compo	2,5	
2	Hollow clay blocks	29,0	
3	Rock wool	10,0	
4	Baumit hafmoertel	0,3	
5	Baumit hafmoertel	0,2	
6	Baumit edelputz spezial	0,3	0,269
	K-Flat roof above the heated space		
1	Lime compo	2,0	
2	Concrete with stone aggregate 2 400	12,0	
3	Concrete with stone aggregate 2 200	5,0	
4	Multi-layered bitumen coating, reinforced	1,0	
5	Ursa XPS	22,0	
6	Geotextile	0,2	0,145
	MK-Floor slab above the unheated space		
1	Parquet	2,4	
2	Cement screed	4,0	
3	Polyethylene foil	0,1	
4	Hard mineral wool panels	2,0	
5	Concrete with stone aggregate 2 400	15,0	
6	Ursa TWP1	10,0	
7	Lime compo	2,0	0,278
	PR1, PR2-Window		
	Wooden frame window 68 mm		1,5
	PR3-Prozor		
	Wooden frame window 68 mm		1,42

Table 2 Data for analysis of solar thermal gain

Vari.	Window surface area and percentage per orientation							Solar gains	
	I,Z 310 kWh/m²		S 145 kWh/m²		J 455 kWh/m²		Prevailing orient. Of wind	Qsol kWh/god.	%
	Apr m²	%	Apr m²	%	Apr m²	%			
V1	51,2	25	76,8	37,5	76,8	37,5	S,J	24 591	100
V2	128,2	62,5	-	-	76,8	37,5	I,Z	29 109	118,4
V3	204,8	100	-	-	-	-	I,Z	25 196	102,5
V4	153,6	75	25,6	12,5	25,6	12,5	I,Z	25 509	103,7
V5	-	-	51,2	25	153,6	75	J	30 145	122,6
V6	51,2	25	-	-	153,6	75	J	34 057	138,5

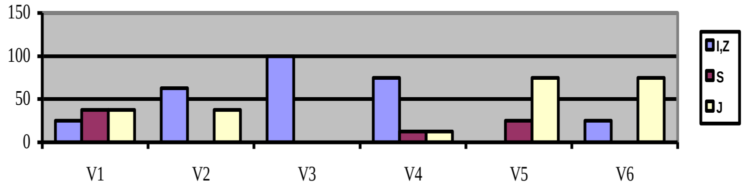

Fig. 5 Graphical display of the window percentage of individual orientations

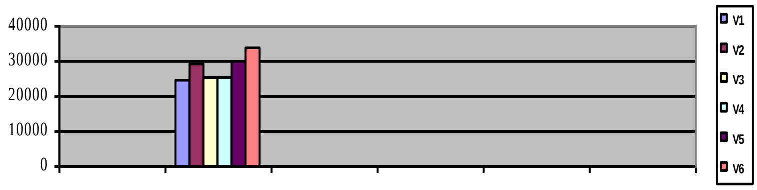

Fig. 6 Graphical display of the values of solar thermal gains in the heating season

Based on the values in table 5, as well as the graph in figure 5, it can be concluded:

- That the variant V1, where the building, as well as the prevailing and equal wind surface areas are oriented north-south, has the least solar thermal gains,
- That the variant V2 where the building is oriented north-south and where the prevailing window surfaces are oriented east-west, and the rest facing south, has considerably higher solar heat gains than the variant V1,
- That the variant V3 where the building is oriented north-south and where the prevailing window surfaces are oriented east-west has somewhat higher solar gains than the variant V1,
- That the variant V4 where the building and where the prevailing window surfaces are oriented east-west, and the rest facing north and south, also has somewhat higher solar gains than the variant V1.
- That in the case of prevailing east-west orientation of windows, as in the variants V3 and V4, the north-west or east-west building orientation do not measurably affect the value of solar thermal gains,
- That the variant V5, building in a row, with the orientation east-west and with the prevailing window surfaces facing south, while the rest of the windows faces north, has considerably higher solar gains than the variants V1, V3 and V4 and slightly higher than the variant V2. The variant V5 of the building has slightly higher solar gains than the

building V2, which has the orientation north-south and the prevailing window orientation east-west, with the rest of the windows facing south,

- That the variant V6, building with the staggered row, where the building I oriented east west, and with the prevailing window surfaces facing south, with the rest of the windows facing east, has considerably higher solar gains than the variant V1, which is the highest value of all the analyzed variants. One should bear in mind that in case of this variant, the transmission thermal loss is slightly higher than in the other variants since the developed building shape factor is higher than of the compact ones having the same volume,
- Such concrete results were obtained only for the cases of the analyzed buildings. In the cases of different shaped buildings, and where the window glazing has different characteristics, the results would be different. Yet an appropriate combination of window orientation towards south and east-west facilitates obtaining similar values of solar heat gains for east-west and north-south building orientations.

3.2. Ventilation thermal losses

Considering the calculation methodology in [3], it can be concluded that in case of individual air-tightness of buildings and the number of facades exposed to the wind, the ventilation thermal losses are proportional to the number of air changes per hour, which depends on the exposure to wind, i.e. on the building position. The building position is defined in the standard SRPS EN 832: 2008, [10], as: exposed building position – tall buildings in the city centers, moderately sheltered position – building protected by the trees and other buildings in suburbs and very sheltered position, a building of average height in city centers or woods.

In table 4, as well as in the graphs in figure 7, [2], is presented the percentage ratio of increase of ventilation thermal loss in the case of individual positions in respect to the very sheltered position of individual air-tightness of the housing buildings with multiple flats and natural ventilation.

Table 4 Ratio of increase of ventilation thermal loss in the case of individual positions in respect to the very sheltered position of buildings

Air-tightness	Poor	Medium	Good	Poor	Medium	Good
Wind expos. of the faç	More than one façade			Only one facade		
Exposed position	200	140	100	200	120	100
Moderat. sheltered p.	150	120	100	140	100	100
Very sheltered posit.	100	100	100	100	100	100

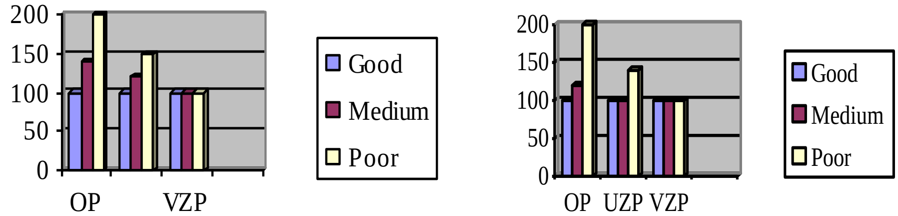

Fig. 7 Graphic presentation of increase of ventilation thermal loss in the case of individual positions in respect to the very sheltered position of buildings

It can be concluded that the infiltration thermal losses are not affected by the building position only in case of the good air-tightness of the building. Though, it can be twice as high in case of the exposed building position in comparison to the very sheltered position.

4. Conclusion

Town planning parameters can to a considerable extent affect the energy efficiency of buildings. Based on the building orientation analysis, and of the orientation of glazed faced surfaces, it can be concluded that the difference in value of solar thermal gains in the heating season, in certain cases can be around 30%, which may help town planners and designers choose certain orientations guided by the solar thermal gains in the heating season. It could be a guideline for the selection of the most favorable design in case that the undesirable thermal gains in the summer period can be prevented by the interventions on the micro-location, or by some of the architectonic measures. In contrast, the choice of the optimum designs should be performed based on the analysis of total heating energy consumption and air conditioning energy consumption in the summer period, while considering several architectonic and town planning parameters.

Regarding that the ventilation heat losses can be twice as high in cases of an exposed position of the building, in comparison with the very sheltered position, it can be understood how important the location and micro-location structure is for the value of these losses, i.e. the energy efficiency of buildings.

The paper presented only certain segments of the analysis of certain town planning parameters. However, the choice of optimum architectonic and town planning designs should be performed based on the analysis of the total energy consumption of heating devices and of air conditioning devices in the summer season, with consideration of several architectonic and town planning parameters.

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URBANISTIČKI PARAMETRI U FUNKCIJI ENERGETSKE EFIKASNOSTI ZGRADA

Energetski efikasna zgrada je ona koja troši najmanje energije uz ostvarivanje komfora. Potrošnja energije zgrada, u opštem slučaju, kao i u Srbiji, pored ostalog, u najvćoj meri je uslovljena potrebom za grejanjem, za hlađenjem i osvetljenjem, u cilju ostvarivanja toplotnog i svetlosnog komfora. Potrošnja energije za grejanje je posledica toplotnih gubitaka i dobitaka, a njihove veličine, sem od ostalih patametara zavise od urbanističkih parametara. Težište rada je na komparativnoj analizi uticaja različitih izloženosti zgrada vetru, kao i različitih pretežnih orjentacija na energetske efikasnosti zgrada.

Ključne reči: *orjentacija, solarni dobici, ventilacioni gubici, energetska efikasnost*