RESIDENTIAL DENSITIES AND APPLICATION OF PASSIVE SOLAR SYSTEMS

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ABSTRACT. The aim of investigation was to determine the possible residential density of multi-storey residential buildings with applied passive solar systems and to make a comparison with the conventional approach. The dwelling density for the given location is determined mathematically for different building size on the basis of the accepted standard apartment area.

1. PROBLEM DEFINITION

The residential densities and the corresponding "density index" are specified for cities in Yugoslavia by Master and Detailed Urban Planning Documents.

The residential density is defined as the ratio of the number of residents to that part of an urban area reserved for residential buildings and local driveways. The density index, as a density indicator represents the ratio of the total floor area of residential buildings to the location area. This index thus directly depends on the number of storeys. The accepted standard in the city of Belgrade is a net apartment area of 21 m2 per resident.

There is a general opinion in practice that such a high residential density, especially for buildings over 5 storeys, cannot be provided with passive solar buildings due to significant distances between buildings imposed by the specific geographic latitudes, as is the one of Belgrade. For this reason the passive solar concept is presently excluded from development of urban design projects, defining the exact location and orientation of buildings, their shapes and sizes and their mutual relationship. Such a practice makes it virtually impossible to apply passive solar design principles later on, at the stage of architectural building design.

The purpose of this paper is to prove that it is possible to build multi storey residential settlements at the specific geographic latitude of Belgrade, applying the passive solar design principles

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while at the same time complying with the given residential density standards.

2. ANALYTICAL METHOD

The dwelling densities have been calculated under the following assumptions:

- the geographic latitude for the considered case study is 44°48' (city of Belgrade);
- the topography is essentially a flat one; for the South-oriented slopes, the residential densities can be expected to be higher, and the opposite is true for the North-oriented slopes;
- all buildings are daily sun exposed from 9 - 15 hours (winter solstice);
- the accepted resident standard is net apartment area of 21 m2 per resident; considering the legally prescribed ratio of the net floor area to the total floor area of 1 : 1.3, the total floor area per resident is about 27 m2.

The building size has been varied in the following way:

- the building width A = 10, 15, and 20 m;
- the building length B = 15, 20 30, 45, 60, and 90 m (high values stand for rows of buildings);
- the number of storeys n = 1 - 9, with the storey height of 3 m.

The residential density can be calculated by the formula:

$$g = \frac{A\ B\ n}{27\ P} \times 10^4 \quad \text{(residents / ha)}$$

where P-sum of areas of a building and its shadow (Fig. 1). No other building is to be constructed on this restricted area.

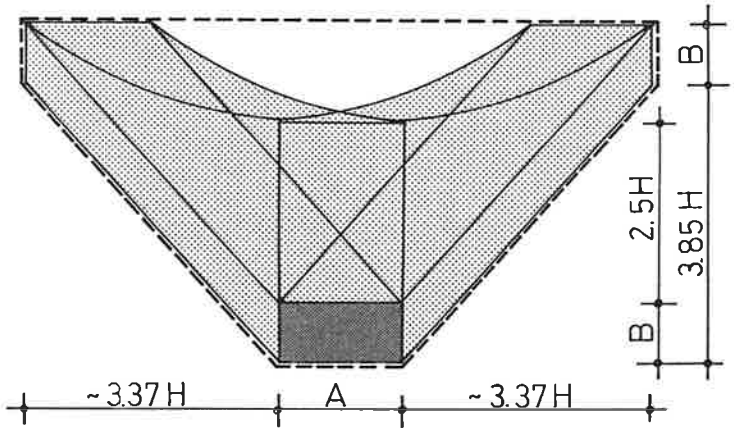

Figure 1. Restricted area for a single building (geogr. lat. 44°48')

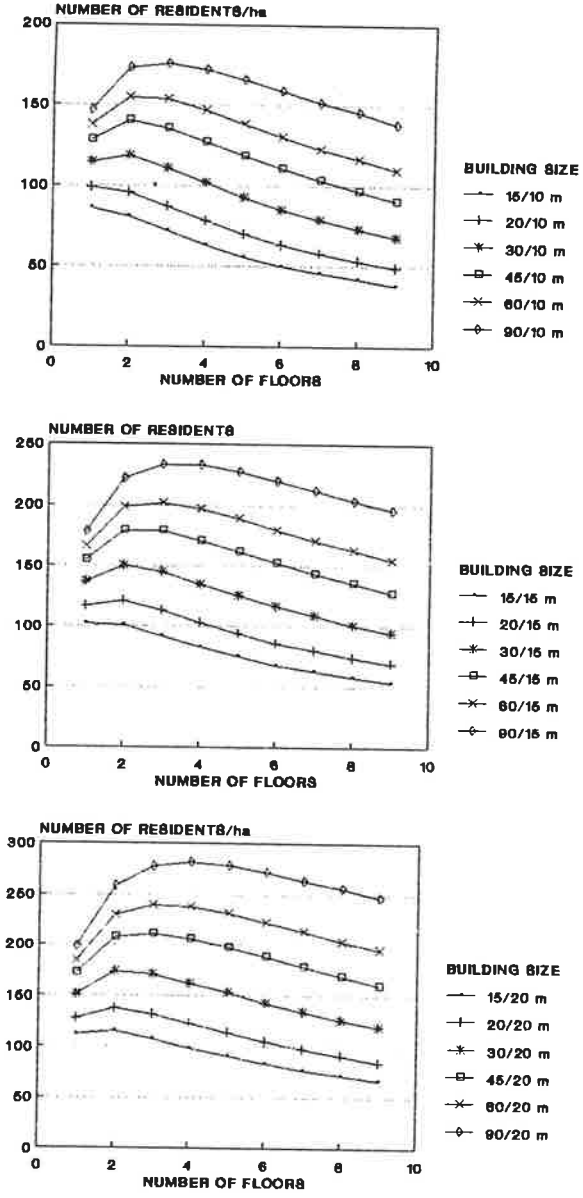

Figure 2. Residential densities as a function of the building size

3. RESULTS

The obtained results are presented in the graphic and tabular form. Fig.2. depicts relationship between the residential density and the building size while the density index and the residential densities specified by the Master Urban Plan (1) and calculated (2) are compared in Table 1.

Table 1. Comparison of calculated residential densities and density indexes with densities and indexes specified by the Master Urban Plan

degree of resid. density (1)	density index (1)	density index (2)	residential density (1)	residential density (2)	number of storeys
small	0.1-0.3	0.2-0.7	35-90	80-258	1-2
medium	0.4-0.7	0.1-0.8	105-140	56-282	3-5
high	0.8-1.0	0.1-0.7	155-180	56-272	5-9
very high	1.1-1.5		200-350 (central town area)		

Considering the given results, several observations can be made:

-the highest residential densities for small houses correspond to houses 1-2 storeys high;

-as the size of the building increases, the highest residential densities and the corresponding values of density index are attained for the number of storeys 3-5; increasing the number of storeys results in a decrease of the residential density;

-residential density obviously increase with the increase of the building width for a given (constant) height and the increase of the building length, for a given (constant) width;

-Extremely high densities of over 280 residents/ha are not possible under given conditions.

4. CONCLUSIONS

1. All degrees of residential densities as specified by the Master Urban Planning Document for Belgrade may be obtained by building of various sizes (number of floors) providing architects with a freedom of urban planning design.

2. Residential densities specified by the Master Urban Plan can be ensured by multi storey buildings with applied passive solar systems, (as is shown by the case study described in this paper), and the current urban planning and urban design practice in Yugoslavia need to be changed accordingly.

REFERENCES

Jovanović 'Popović, M. (1991.)'Possibilities of passive solar systems application for multi-storey residential buildings in Belgrade', Ph thesis, in preparation.

Djordjević, A. et all (1976) 'Master urban plan of Belgrade' Beogradski izdavačko-grafički zavod, Belgrade

Szokoley, S.V. (1980) 'Environmental science handbook', The Construction Press, Lancaster, England.