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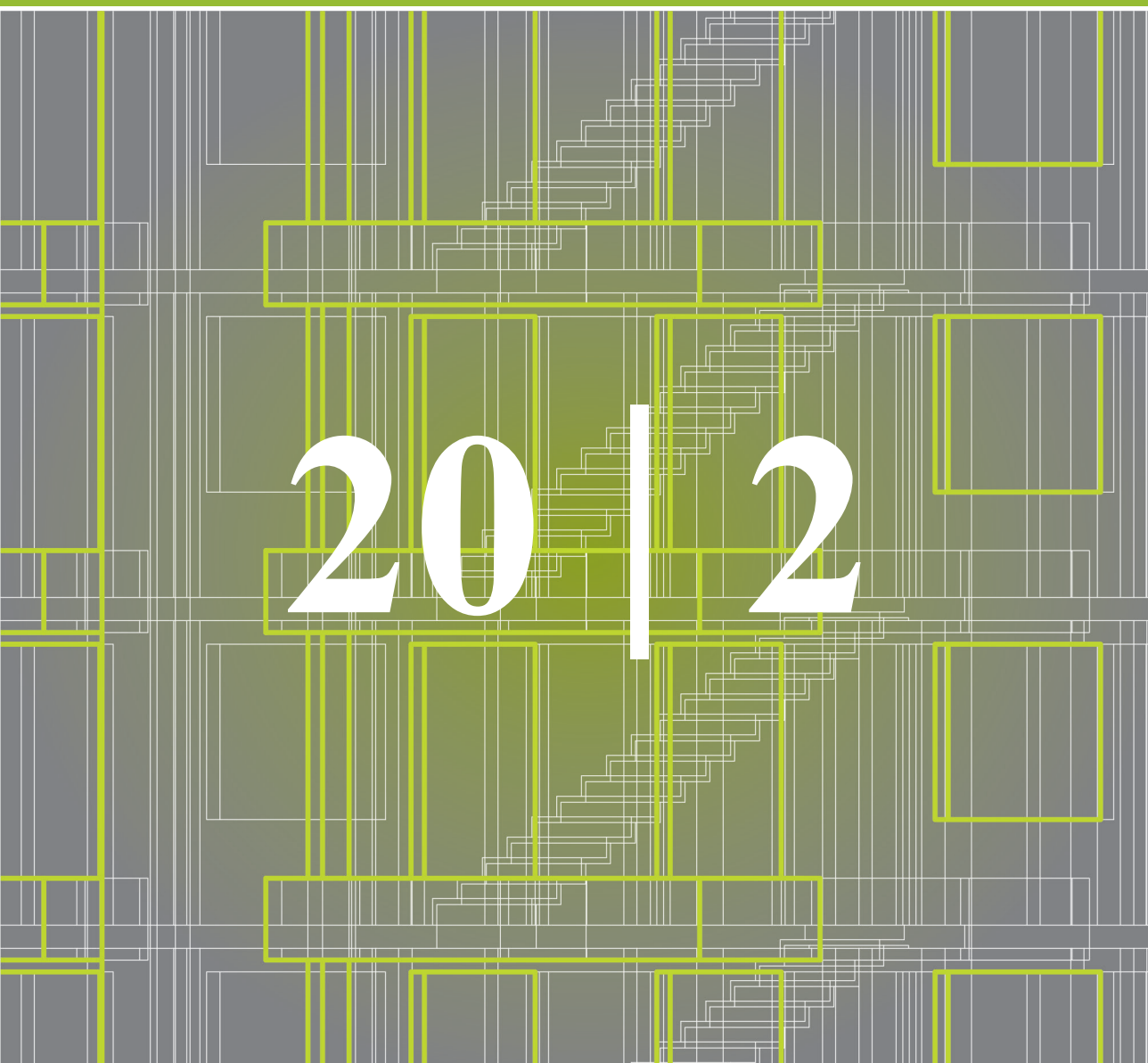

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University of Niš, Serbia, Faculty of Civil Engineering and Architecture
18000 Niš, Aleksandra Medvedeva 14, 18000 Niš
Phone: +381 18 588 181, Fax: +381 18 588 181

Technical Assistance: **Vladan Nikolić**, **Vojislav Nikolić**, e-mail: *fuacets@junis.ni.ac.rs*
University of Niš, Serbia, Faculty of Civil Engineering and Architecture

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Original Scientific Paper

PROGRAM ACTIVITIES FOR SUSTAINABLE RURAL DEVELOPMENT: CASE STUDY, VILLAGE BERBATOVO, NIŠ

UDC 728.6:502.131.1(497.11)

Maša Ranđelović*

University of Niš, Faculty of Civil Engineering and Architecture, Niš, Serbia

Abstract. *This paper deals with the analysis, proposals, and development of program actions and measures aiming at a sustainable development of the village of Berbatovo. Development problems and potentials are defined in addition to collecting general data about the village and its development characteristics. The main shortcomings of the analyzed village are the decline in the number of its inhabitants due to their migration to cities, low education level of those who choose to stay in the village. There is not enough adequate space for public gatherings, there are no institutions necessary for functioning of the locals, such as outpatient clinic, post office, kindergarten, roads are in bad condition. Apart from producing for their own needs only, the local population shows insufficient activity and interest in starting their own business, which would create the conditions for a better quality of life in the village. In this paper, after defining development problems and observed potentials, appropriate strategic directions of sustainable development, general and specific goals and program actions and measures that would contribute to the adequate development of the village were selected.*

Key words: *Berbatovo, village, sustainable development, measures, rural architecture*

1. INTRODUCTION

Traditionally, the regions that are economically, demographically and socially most vulnerable are underdeveloped areas. About 85% of the territory of the Republic of Serbia is characterized as a rural area, i.e., most of the mountainous and border areas in the southern and southwestern part of Serbia [1]. The definition of rural areas varies from country to country. In particular, in European countries, the classification of the Organization for Economic Cooperation and Development (OECD) is most common [2]. According to the aforementioned

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Corresponding author: Maša Ranđelović, University of Niš, Faculty of Civil Engineering and Architecture, Aleksandra Medvedeva 14, 18000 Niš, Serbia
e-mail: masa.lavica@gmail.com
* PhD Student

classification, non-urban settlements are those with a population density of less than 150 people/km^2. The OECD rural area definition methodology applies to Serbia, as well. Hence the conclusion that 85% of the territory of Serbia is identified as a rural area, with about 55% of the population and an average population density of 63 people/km^2. In addition to the number of inhabitants, communal equipment in rural areas is significantly reduced and external functions are poorly developed. As many as 500 villages do not have an asphalt road, in 400 villages in Serbia there are no shops whatsoever, around 200 villages do not have a post office, in 230 villages there is no primary school, while around 200 primary schools have only one pupil each [3]. The term rural (lat.rus, rusalis) originally means a field, but also rural, arrangement of the village, agricultural area as well as the way of life in the countryside, therefore it includes the entire individual, family and social life in the village.

Since its existence, the rural-urban dichotomy has been conflicting [4]. Better living conditions, more employment options, higher salary are some of the main advantages that living in the city offers. On the other hand, in today's age, the village and the city are more interdependent than before. The village is still mainly a producer of food and raw materials, and it is argued that the urban society cannot be fully maintained without the rural environment that provides it with the essentials. On the other hand, the countryside becomes dependent on the city because of the industry.

It is vital to determine development goals of the villages and conditions to be improved as soon as possible, primarily with the intention to encourage and organize unused production potentials and thus, among other things, reduce the conflict between villages and cities so that the villages re-establish their importance. Questions are raised as to how and whether it is possible to encourage rural development of villages, how to bring life to the already almost completely empty settlements and how to develop the agricultural branches of the village and give them their old glory. It is necessary to establish and list the development measures that shall contribute to the improvement:

1. Economic structure development and increase in competitiveness
2. Infrastructure development
3. Development of human resources
4. Rural and agricultural development
5. Spatial and environmental development [5].

The problem of rural development of villages is considered at the global, continental, national and local level through a series of strategic initiatives, strategic documents, planning documents and rural development programs. In the European Union, rural development is directed through the entire segment of strategic documents of development programs, measures and activities, the most important of which are the Rural Development Policy, and the Rural Development Program that arose from it. In the last few decades, programs have been implemented over six-year periods. Currently, the program period is 2013-2021, within which three key goals, six priorities and eighteen focus areas are recognized. In our country, rural development is considered through strategic documents at the national and local level. When it comes to the city of Niš, the key strategic document is the Action Plan for the Development of the City of Niš [6]. Therefore, the aim of the paper is to demonstrate the possibility of implementing mechanisms and measures in accordance with the strategic document at the local level through the analysis of a case study, that is, through the analysis of a selected village belonging to the administrative territory of the city of Niš.

2. METHODOLOGY

The methods defined in the paper are: description, observation, swot analysis, survey and case study method. The analysis method was applied for the basic development and strategic determinants of rural development, the case study method was chosen for defining the mechanisms and measures and examining the possibilities, supported by the method of observation and survey.

The Berbatovo Village was chosen for the case study. The village is located in the administrative territory of the city of Niš, which has 69 villages. Berbatovo was chosen for the case study because it belongs to the category of population-small villages, which are the most numerous and most exposed to development problems, so it is assumed that examination and definition of measures and mechanisms on the selected example will provide an adequate research basis for the definition of military directions and other villages belonging to this size category.

While analyzing and defining measures and mechanisms, the research relies on planning documentation, observation and conducted survey. Measures and mechanisms are defined in accordance with the key strategic document of the Action Plan for Sustainable Development of the City of Niš 2015-2020 [6].

3. RURAL DEVELOPMENT – SETTING THE CONTEXT

Rural development can be defined as the process of improving the quality of life in relatively isolated and sparsely populated areas and, at the same time, the process of improving the lives of people living in those areas. Rural areas within the EU contribute significantly to European economics, cultures and ecosystems [7]. They represent a place for a healthy life, for creating energy, food, strengthening the economy and creating jobs. More than half of the EU population lives in these areas and over 40% homemade products are produced there. Developing an adequate rural development policy in the EU is based on activities aimed at strengthening financial capacities for supporting rural areas, as well as organizational and institutional ones. The main strategic document that defines the directions of EU development, including rural development, is the current EU 2020 strategy. Conceptually defined and supported by the EU 2020 strategy and the EU Cohesion Policy, the EU Rural Development Policy (RDP) plays a key role in the realization of the development process of rural areas which is based on three strategic objectives: 1. encouraging the competitiveness of agriculture; 2. ensuring sustainable management of natural resources and climate change; 3. achieving balanced territorial development of rural economies and communities, including creating opportunities for increased employment [8].

4. RURAL DEVELOPMENT IN SERBIA

In Serbia, rural areas differ in size, category, structure, content, but they have a common characteristic, which is that they fulfill equally, necessary functions in all parts of the country, that is, they provide basic life goods and services necessary for the survival of people in those areas. One of the problems of rural areas and villages is the stagnation or backwardness in development that has been going on for decades.

The main characteristics and development problems are strong depopulation and marked demographic emptying of villages and rural areas, a low level of physical and social

infrastructural equipment of the area and a poorly developed economy, although it is estimated that 60% of the population in Serbia is engaged in agriculture. There are about 40000 empty country houses and homesteads in Serbia, especially in the area of southern Serbia. Three basic development areas are important for the development of rural areas: 1. economic development; 2. arrangement of space and settlement; 3. social and cultural development.

Rural population accounts for 43.60% of the total population, while about 85% of the national territory consists of rural areas [9]. Urban settlements are most concentrated in the area of the northern part of the country, starting from the central part, while there are extremely fewer in the southern part.

According to the Spatial Plan of the Republic of Serbia from 2021 to 2035, it is considered that the abandonment of villages and agriculture, which arises as a consequence of economic development, entails deep demographic imbalances as well as the loss of a part of productive resources. The focus of the PPRS is on sustainable, favorable and rural development, which implies environmental protection and is at the same time technically applicable, economically profitable and socially acceptable. The realization of that concept, which has been officially accepted on the world stage since the mid-1990s, was adopted by undertaking activities on three basic means: 1. regional aid; 2. increasing rural employment and income in order to eliminate poverty; 3. protection of natural resources and the environment, in accordance with the multifunctional nature of agriculture [10].

In order to improve the situation in the field of agriculture and rural development, a new strategy for agriculture and rural development of the Republic of Serbia for the period 2014-2024 was created [11]. It lays the foundations of a new agricultural policy. It lists several priority areas for strategic changes. There are 14 priority areas and they relate to the financing of agriculture and rural development, the improvement of physical resources, the improvement of the knowledge transfer system and the development of human resources, the improvement of the social structure and the strengthening of social capacity, etc. Also, in the strategy, the measures and activities for the realization of strategic goals are detailed.

5. Case Study: Berbatovo Village, Niš

The focus of this paper's research is scanning and researching the village of Berbatovo, its geographical location and structure, genesis and historical development, its demographic, urban, morphological, functional structure and communal equipment, as well as the development of the village itself.

5.1. General information about the village

Geographical position

Berbatovo is a populated area within the municipality of Palilula, within the area of the city of Niš, in the Nišava district. The village is located on the southern edge of the Niš basin, at the foot of Seličevica mountain, 10 km from the center of Niš (Fig. 1). Berbatovo is next to the villages of Gabrovac and Vukmanovo.

Urban-morphological structure

The village of Berbatovo is an example of a compact type of settlement. Buildings are densely concentrated next to each other, with small yards. This is primarily the result of the

mountainous relief on which it is located. The village was built without any plan. According to the shape, the structure of the village is radial, the streets are arranged radially. The blocks are irregularly shaped (Fig. 2). The majority of buildings in the village of Berbatovo are individual houses, rarely semi-detached or terraced houses. According to the place of settlement, the village can be divided into two groups connected by the main road. On the eastern side of the village, there is a larger grouping with the main square, from where side streets spread out like rays around the perimeter, with most of the buildings. On the western side of the location of the village, along the perimeter of the main street, several buildings have been placed. Between the inhabited parts of the village, along the perimeter of the main street, there are arable agricultural areas. Most of the arable land is irregular in shape. The cadastral parcels were not distributed in a planned manner because the village itself developed unplanned. The street network is not orthogonal but has an irregular shape.

Fig. 1 View of the village Berbatovo

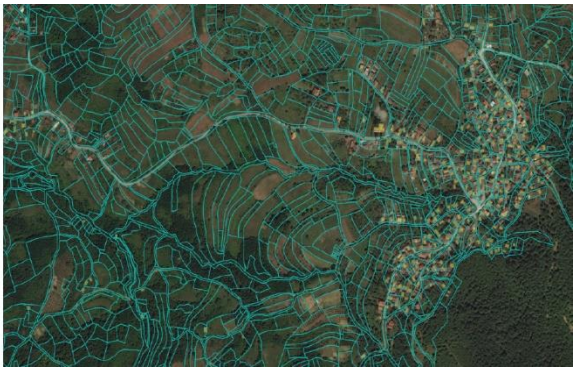


Fig. 2 Layout drawing of the compact type of village and the radial structure and appearance the blocks within the village

Source: https://a3.geosrbija.rs/ (downloaded March 6th, 2021)

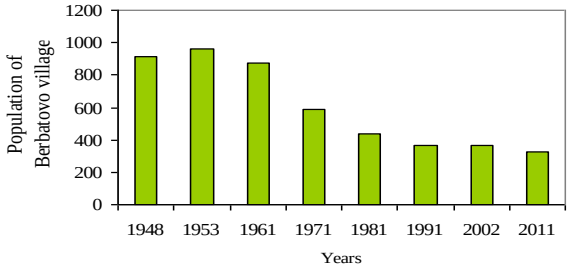
Genesis and historical development of the village

The ancient traces and Turkish censuses from 1498, recording 24 houses and three mills in Berbatovo are a testimony to the ancient settlement of this area. Berbatovo and its surroundings played a special role during the Second World War in the fight for the liberation of Niš. Later, in further development, the population of the village of Berbatovo increasingly moved from livestock farming to farming, and after 1955, it became more and more oriented towards the urban economy in Niš. After 1970, one of the weekend zones of Niš began to be built from the Gabrovac monastery and along the road towards Berbatovo. Around the eighties of the 20th century, twenty buildings were already built in this area. Today, Berbatovo is a small primary rural settlement that has elements of a local village.

Population

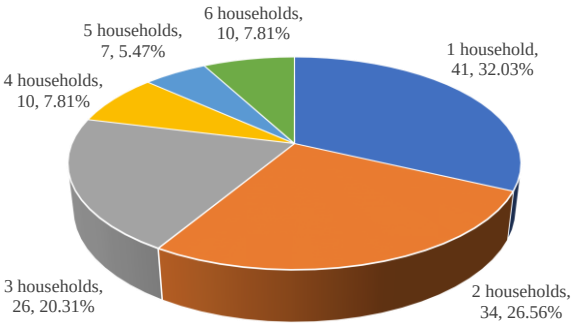
The village of Berbatovo belongs to the group of small villages with slightly less than 400 inhabitants. According to the 2011 census of the Republic Institute of Statistics, the village of Berbatovo had 327 inhabitants, which is less than 1% of the total population of Serbia. Judging by the previous censuses and information, the largest number of inhabitants

inhabited the village in the period between 1950 and 1960, when 959 people lived in the village [12]. Between 1948 and 2011, the number of inhabitants in the village decreased from 910 to 327 inhabitants. From the census of 2002 to 2011, the number of inhabitants fell by -1.18% (Graph 1). If the population were to change as in the last period, the number of inhabitants in Berbatovo would be 290.



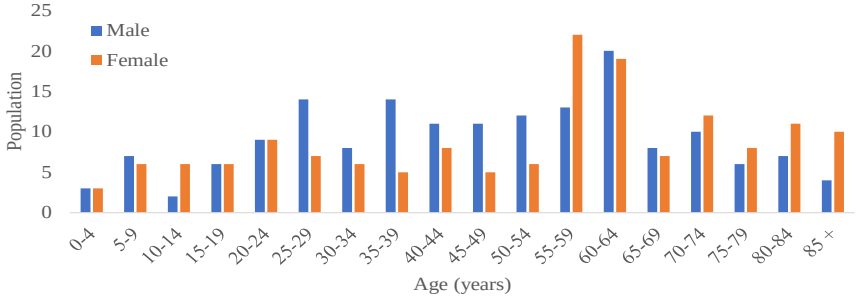
Graph 1 Population of Berbatovo village during the period 1948-2011

The number of households in the village of Berbatovo is 128, of which 41 have only one member, 34 count two members, 26- three, 10- four members, 7 households have 5 members each, and 6 households have six or more members. The average number of members in the household is 2.55 (Graph 2) [12]. The majority of residents spend their life in education and work in the city, while as pensioners they return to their native village and, in most cases, end their lives there.



Graph 2 Number of household members

The average age index is 49.9, which leads to the conclusion that the village has, or remains, an older population. Out of the total population of 327, 171 of them are male, while 156 are female. The largest number of male residents are people between the ages of 60-64, and as for the female population, the largest number are people between the ages of 55-59 (Graph 3).



Graph 3 Population ratio by age and gender

In the village of Berbatovo, according to the 2011 census, there were 6 youngest residents under the age of 4, while as many as 14 residents were 85 and older. The adult population consists of 292 inhabitants. The average age is 49.9 or approximately 50 years [13].

Functional structure and communal equipment

The structure of a settlement is characterized by unplanned formation. There is only one educational institution in the village - the satellite classroom of "Branko Radičević" elementary school for first four grades. The school is old, the facade is collapsing here and there, the road that passes by is in bad condition (Fig. 3). Within the school, there is adequate equipment for children play. In the back yard is a field for group sports. At one point the school was closed for there were no students. Nowadays children do live in the village of Berbatovo, but most parents enroll them in Niš city schools. There is no kindergarten in the village. There are no health institutions, nor are there cultural institutions and social welfare institutions. There is no post office in the village of Berbatovo, the residents of the village go to the post office located in the neighboring village of Gabrovac. There is one church in the village - the Church of St. Dimitrije (Fig. 4). Next to it is the village cemetery with an area of 1ha. Each nearby village has its own cemetery.

Fig. 3 Elementary school "Branko Radičević" **Fig. 4** Church of St. Dimitrije
Source: author's recordings (March 2021)

In the center of Berbatovo lies a small square with a monument, the point from which streets branch out to all sides of the village (Fig. 5). Within the square, there are several waste containers. The village has only one service facility - the "Vidovdan žv" store (Fig. 6). It also serves as a gathering place of the village population. In order to shop for something specific, the inhabitants have to go to Niš. Most of the residential buildings in the village of Berbatovo are in very poor condition, decaying.

Fig. 5 Berbatovo village square **Fig. 6** The monument of the square and the only shop
Source: author's recordings (March 2021)

The houses are old, most of them without host of the house, signaled by the displayed death certificates. Most of the facades are dilapidated, the roads from the gates to the houses are not cleared, moreover, they are inaccessible (Fig. 7).

Fig. 7 Old and abandoned village houses and their facades
Source: author's recordings (March 2021)

The population of Berbatovo village is primarily engaged in cattle-breeding and agriculture, yet only for their own needs. The village of Berbatovo does not have separate landfill, only public waste bins are used, which are located in the central part of the village, within the square. As far as waste water drainage is concerned, waste water from stables and pigsties is drained into septic tanks. Public suburban traffic is circular - 23K: Niš - Vukmanovo - Berbatovo - Niš. The bus runs every day of the week. The streets in the village of Berbatovo are mostly of medium and poor quality (Figure 8a). At the entrance to the village there is a board with the name of the village written on it (Figure 8b). Residents of the village complain about the quality of the streets and say that they are of poor quality and that they have been unsuccessfully spray sealed. Adequate signage has been installed along the streets. The street lighting is inappropriate. Residents' safety is not adequate.

a) b)

Fig. 8 Roads (a) and Berbatovo sign at the village entrance (b)
Source: author's recordings (March 2021)

5.2. Development problems and potentials - SWOT analysis

In addition to the analysis of available statistical data and development documents, a SWOT analysis was also used to assess the development problems and potential of the village. The results of the SWOT analysis are shown in Table 1.

Table 1 SWOT analysis of development potentials and problems of Berbatovo settlement

Strengths	Weaknesses
▪ located in the vicinity of the city of Niš ▪ well-connected with the city and surrounding villages in terms of transportation ▪ adequate infrastructure ▪ daily public transport ▪ church and a cemetery within the village territory ▪ "Branko Radičević" elementary school satellite classroom ▪ Recreation court ▪ mountain village (unpolluted air, magnificent view...)	▪ poor condition of existing roads ▪ lack of public institutions (doctors, post office, kindergarten) ▪ lack of institutions for cultural and public manifestations ▪ lack of landfills ▪ lack of production capacity, purchase stations or any other production plant that would motivate residents to start producing more ▪ poor condition of older buildings ▪ insufficient commitment of the population to contribute to the general development of the village ▪ insufficient encouragement and investment by the state
Opportunities	**Threats**
▪ road paving ▪ new lighting in the village to raise the level of safety ▪ development of tourism (ethno-village) ▪ development of private businesses to motivate residents to stay in the village ▪ getting the residents employment within the community ▪ establishing public institutions in the village (healthcare center, post office, kindergarten) ▪ landfill installment ▪ public space improvement ▪ greater investments in rural development	▪ lack of young population, who spend most of their working hours in the city, using village only as overnight accommodation. ▪ steady migration to the city ▪ declining birth rate ▪ lack of investments ▪ dire economy of the whole country ▪ locals' lack of interest to improve the village environment ▪ insufficient investment in the village ▪ dying of the village

Development issues

One of the biggest development issues is primarily the insufficient commitment of the villagers and lack of interest in contributing to the general development of the village, as well as the constant migration of residents from the village to the city, i.e., the decline in the number of residents. Also, one of the major development problems, simultaneously being the biggest possibility for a solution, is the lack of necessary investments, which is partly caused by the bad economic situation in the country.

Berbatovo village roads are dilapidated. Village residents say that it is essential to completely restore the roads, not just spray seal them. Some roads are unpaved. There is not a single public institution in the village, such as a healthcare center, post office or kindergarten, posing a significant disadvantage. In addition, there are no facilities for cultural and public events in the village. All waste is now deposited in waste bins located at the village square, there are no other specific areas where waste will be left. Villagers do agriculture and cattle-breeding only for their own needs, no one initiates the idea of developing production and creating purchase stations or any other production facility.

Development potentials

First and foremost, it is the location of the village, only 10 km away from the city of Niš. Then, it is well-connected to other nearby villages and the city due to appropriate public transportation. By establishing public institutions in the village, such as a healthcare center, post office, and kindergarten, and switching to a better lighting that would have a favorable effect on the safety of the villagers, the village would be on a higher level. Also, one of the important development potentials is the fact that it is a mountain village and that the air is cleaner than the city's, which may possibly lead to the development of tourism. In order to develop tourism, it is absolutely essential to pave the existing roads that are in poor condition. It is possible to develop private businesses that would motivate residents to stay and work in the village.

5.3. Defining strategic directions of sustainable development, general and specific goals, program actions and measures

To develop the village adequately, i.e., to implement the appropriate development directions, first it is necessary to consider its positive and negative aspects and pay attention to the limitations. Having defined the village problems, it is required to propose ideas for their solution, and decide on the direction further development and growth of the village should take, as well as which particular investments are vital for the selected location.

Defining strategic directions of sustainable development - direction 1

Based on the analyses and surveys conducted with the residents of Berbatovo village, the following strategic direction for the development of the village has been established [6]:

- Strategic direction 1: Territorial, infrastructural and environmental development

General and specific development goals for strategic direction 1

General objectives:

- Infrastructural and sustainable development of the territory aligned with the environmental capacities: utilization of the geostatic and traffic position of Niš at the European, national and regional level and improvement of access to urban amenities throughout the entire territory of the city

The specific goal of strategic direction 1 is:
3.1 – Balanced urban and regional development of Niš

Program actions and measures

Upon analyzing flaws and issues pertinent to the selected village, in order to solve them, it is required to refer to the points of the Action Plan for the development of the city of Niš and the given guidelines for further elaboration. Within the framework of the four strategic directions, listed are appropriate actions that may provide adequate conditions for the improvement and development of the village. Further work is related to some of them (Table 2). Within the specific objective 1.1, an appropriate program action was selected and entered in Table 2.

Specific action and measure for achieving specific goal 1.1 is:

1.1.1 *Coordination of urban and regional development strategies with the integration of local potentials and the development of an integral approach to urban development and renewal/regeneration, which includes spatial-physical, cultural, economic and social dimensions* - the development of villages require an all-aspect approach; it is crucial to persuade residents to stay in the village by providing them with suitable conditions, to organize spaces for cultural and public events, provide a sufficient amount of money for salaries as well as the possible opening of new jobs within the village, primarily for the missing basic life requirements (healthcare center, pharmacy, post office...)

Table 2 Program action 1 – Urban development and village renewal – goals, actions and measures

Goals		Actions
Direction 2	No.	Direction: Economy/business
Specific goal 1.1	1.1.1	Coordination of urban and regional development strategies while integrating local potentials and developing an integral approach to urban development and renewal/regeneration, which includes spatial-physical, cultural, economic and social dimensions
Measures		
▪ provide the villagers with appropriate conditions to stay ▪ organize spaces for cultural and social events ▪ open those facilities that are missing		

Defining the strategic directions of sustainable development - direction 2

Strategic direction 2 deals with the development of the economy and business. Berbatovo is a mountain-type village, it has fresh air and is located in the vicinity of the city of Niš. In addition to these prerequisites, it is possible to develop certain village areas, landscape and enrich them so that they draw tourists' interest to visit the village and enjoy all its benefits.

Most village inhabitants have basic education, a small number of inhabitants have completed secondary or higher school. Those who graduated from the university remained in the city. It is necessary to raise awareness among residents about the higher education and attending courses, so that they acquire knowledge that would later serve them.

General and specific development goals for strategic direction 2

General objectives:

- Creating a favorable business environment for investment, development of entrepreneurship, increasing employment and strengthening competitiveness of the economy; strengthening territorial marketing initiatives in order to improve the image of the city as a business center

Specific objectives of the strategic direction 2 are:

2.3 – Improving the tourist potential of the city of Niš

2.5 – Promoting entrepreneurship, self-employment programs and support for individual initiatives

Program actions and measures

Within the program action *Creation of business opportunities*, three specific goals were chosen as well as corresponding program actions and measures (Table 3).

2.3.1 *Tourism development program based on the natural, cultural and accommodation capacity of the city (spa, health, transit, congress and business tourism, eco-ethno-tourism, religious tourism, tourism of big cities* - City breaks, events and manifestations tourism - Events, etc.) - one of the important criteria of the village advancement would be the emergence and development of tourism as well as the location improvement that would be interesting to the visiting tourists. In addition to clean mountain air and relief, the village of Berbatovo can improve certain public areas and crate an offer for staying there while enjoying nature. With the advent of tourism, the visibility of the village would be greatly increased and more people would want to visit it.

Table 3 Program action 2 - Creation of business opportunities – goals, actions and measures

Goals		Actions
Direction 2	No.	Direction: Economy/business
Specific goal 2.3	2.3.1	Tourism development program based on the natural, cultural and accommodation capacity of the city (spa, health, transit, congress and business tourism, eco-ethno-tourism, religious tourism, tourism of big cities - City breaks, events and manifestations tourism - Events, etc)
Specific goal 2.5	2.5.1	Programs to increase competitiveness of human resources, through permanent education, specialization, continuing education
	2.5.3	Start-up loan programs to support business beginners and self-employment
Measures		
▪ Improving public spaces and working on offers that the village can provide to tourists to spend some time in nature and relax - development of tourism ▪ encouraging the inhabitants of the village to go to school, directing them to further education ▪ providing financial support for undeveloped areas of the village and encouraging residents to work and establish not only personal businesses ▪ considering the possibility of organic food production ▪ formation of poultry farms		

2.5.1 *Programs to increase the competitiveness of human resources, through permanent education, specialization, continuing education* – after surveying the population, it was established that the majority of remaining village population completed primary or secondary school. One of the significant goals regarding the village development is a focus on their education, and encouragement to complete higher education or professional education and thus acquire knowledge that would later serve them in work and life. It is necessary to work on their guidance and further education in the form of courses or demonstration exercises so that they can use and apply their newly acquired knowledge in the most adequate way in their native region. These could be courses in the field of economic activities that do not require large investments or production facilities (flower growing, handicrafts, basketry, production of organic food, production...).

2.5.3 *Start-up loan programs to support business beginners and for self-employment* - provide the younger population that stays in the village with the opportunity and financial assistance to start an independent business (financial assistance for underdeveloped areas and population, raising greenhouses, establishing small poultry farms, production of organic food, production of flower seedlings, handicrafts , souvenirs...).

Defining strategic directions of sustainable development - direction 3

Strategic direction 3 deals with social development. In the village of Berbatovo, it is necessary to further develop and strengthen social life. It is vital to bring the inhabitants of the village and the surrounding area together, helped by recreational facilities/ equipment/area, which will at the same time encourage them to get to know each other and socialize. New gathering spots need to be set and equipped. In addition, it is crucial to encourage the village inhabitants to participate in decision-making concerning the village and fight for its welfare.

General and specific development goals for the strategic direction 3

General goal:

- Creating a stimulating and safe social environment in which all citizens will be able to express and satisfy their needs for belonging and identity, socializing and personal development

The specific objectives of strategic direction 3 are:

3.2 – Creating conditions for individual development and personal affirmation
3.3 – Creating conditions for a rich and meaningful social life
3.4 – Strengthening the community through the inclusion of all citizens, strengthening solidarity and developing identity

Program actions and measures

Within the program action Creation of business opportunities, three specific goals were chosen as well as corresponding program actions and measures (Table 4).

3.2.3. *Development of sports and physical education, creation of the village sports brand* – in the village of Berbatovo, during the summer, football matches and competitions are often organized in which younger inhabitants of the village as well as nearby inhabitants participate. Also, it is possible to organize mountain biking and races in the spring and summer.
3.3.2. *Improving and equipping public space for outdoor socializing (parks, picnic areas, promenades, outdoor playgrounds)* – Currently, the main and only gathering spot in Berbatovo is the open space around the only drugstore in the village. What is necessary is to organize and equip additional places for meetings and socializing in the open, where the inhabitants of the village and visitors will gather.
3.4.4. *Programs to encourage and train citizens to participate in decision-making and solving local problems* – the inhabitants of the village should be one of the main contributing factors regarding the issues of the village and its development, and it is necessary to include them as much as possible in the discussion and decision-making when solving local problems.

Table 4 Program action 3 - Development of social life in the village – goals, actions and measures

Goals		Actions
Direction 3	No.	Direction: Social development
Specific goal 3.2	3.2.3	Development of culture of sports and physical education Creating the village sports brand
Specific goal 3.3	3.3.2	Improving and equipping public space for outdoor socializing (parks, picnic areas, promenades, outdoor playgrounds)
Specific goal 3.4	3.4.4	Programs to encourage and train citizens to participate in decision-making and solving local problems
Measures		
▪ creating the village sports brand ▪ organizing football and mountain bike competitions ▪ establishing and equipping a new place for gathering of locals and visitors ▪ including village residents in discussions and decision-making for solving local problems		

6. DISCUSSION

The Serbian village is at the crossroads between disappearance and survival. According to the numbers from the previous census, it is clear that the number of inhabitants is growing exclusively in large cities, while the opposite is the case in villages. There are 4800 villages in Serbia. It is estimated that in less than two decades, villages with less than 100 inhabitants will disappear, and there are about 700 such villages. The mentioned villages are mostly located in central Serbia, mostly in eastern, southeastern and southern Serbia. One of these villages in southern Serbia is the village of Berbatovo in the area of the city of Niš. Bearing in mind the whole picture, the population is getting older, dwindling by year, the number of marriages is plummeting, more and more people are migrating abroad, the birth rate is decreasing. This is even more obvious in mountain villages. First of all, the village should overcome its main problem, which is depopulation, aging and migration of the young populace. Another problem is insufficient education and the orientation of the young population to the city for education and employment. The reform of primary education should lend rural schools a special and privileged status [14]. Moreover, the educational countryside-related contents referring to villages as healthy environment and to agriculture as a promising life occupation should gain greater scope and importance in the curricula of all primary schools. In addition to the afore-mentioned issues, the essential problems of the current state of the village include infrastructural and institutional equipment, or lack thereof, economic status and underutilized conditions pertaining to the growth and development of a village.

7. CONCLUSION

In order to remedy the problems and obstacles that tend to block the development of the village, it is necessary to introduce appropriate measures that will contribute to the reconstruction and better life in the village. First of all, it is crucial to devise state and regional programs for revival of the sustainable villages in such a manner that the investors become attracted to it, especially the ones who would employ those left unemployed in the cities, eager to move to the village to live there, get a job and start their own business in agriculture,

cattle-breeding, or some other economic activity. One of the steps is public space improving and working on the offers that the village can provide to locals, tourists and people who would like to move to the village or visit it. Furthermore, it is necessary to encourage residents to stay in the village, then encourage them to establish businesses that are beyond personal (for their own needs), but also to show opportunities for creating businesses that will provide better living and working conditions for the entire village. One of the possibilities is for the inhabitants to complete the courses and start doing handicrafts, create souvenirs, weave bags, learn the technique of gold embroidery, classical embroidery... Another possibility is to create their own brands, prepare winter clothes, chutneys, produce organic fruits and vegetables, grow and pick medicinal plants and distribute them to the cities. Berbatovo is a mountain-type village, so it is possible to landscape and improve certain areas with the development of village tourism in mind. One of the ideas would be the introduction of sports games and competitions in football, cycling and other sports. Thus, the development of tourism would be further encouraged.

After conducting analyses, observations, surveys, and case study methods, the conclusion was reached that the best approach for the development of rural areas, in this case specifically the village of Berbatovo near the city of Nis, is the introduction of strategic support for development. In the case of the city of Niš, the key strategic document defining the measures and mechanisms in this paper is the Action Plan for the Development of the City of Niš 2015-2020 [6]. In accordance with the Action Plan, measures and mechanisms were defined. They would help in the rural development of the selected village of Berbatovo and at the same time satisfy the mentioned actions listed in the Spatial Plan of the Republic of Serbia 2021-2035 [10], as well as the mentioned priority areas from the Strategy of Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024 [11]. This has been precisely one of the main goals of the paper - to demonstrate how a strategic approach and an existing strategic document can be used to apply specific measures to a specific example.

All the measures mentioned in the paper are achievable, it is possible to work on the village development, and it is of utmost significance that the inhabitants join the discussion and participate in the decisions to be made for the sake of a better life and progress in the village.

REFERENCES

1. M. Todorović, M. Drobnjaković, A. Glišić-Simeunović, "Specifics of Rural Areas of Serbia from the Aspects of Regional Development", Economics of Agriculture. vol. 57, Spec.num.2, pp. 605-612, 2010.
2. Organisation for Economic Co-operation and Development, "OECD Regions at a Glance 2007", Paris: OECD Publishing, 2007.
3. V. Gulan, "Stanovništvo u naseljima – selima Srbije na početku 2019. godine", Beograd https://www.makroekonomija.org/0-branislav-gulan/stanovnistvo-u-nasel%D1%98ima-%E2%80%93-selima-srbije-na-pocetku-2019-godine/
4. S. Šuvar, "Sociologija sela, 1. knjiga ", Zagreb: Školska knjiga, 1988.
5. Lj. Vasilevska, "Ruralni razvoj u regionalnim okvirima", Beograd: Zadužbina Andrejević, 2006.
6. "Akcioni plan održivog razvoja grada Niša, 2015-2020.", Niš, 2014.
7. ADE 2012, ESPON GEOSPECS project, University of Genova, 2012.
8. M. Vasilevska, Lj. Vasilevska, M. Vasić, "Aktuelne programsko-projektne aktivnosti u okviru politike ruralnog razvoja EU", Nauka + Praksa br.19, 2016.
9. "Zakon o poljoprivredi i ruralnom razvoju, Službeni glasnik Republike Srbije", 41/2009, Beograd, 2009.
10. "Prostorni plan Republike Srbije od 2021. do 2035. godine", Beograd, mart 2021.
11. "Strategija poljoprivrede i ruralnog razvoja Republike Srbije za period 2014-2024. godine", "Službeni glasnik RS", broj 85/14, Beograd, 2014.
12. Republički zavod za statistiku Srbije, "Domaćinstva prema broju članova po naseljima", 2011.
13. Republički zavod za statistiku Srbije, "Stanovništvo prema starosti i polu", 2011.
14. D. Škorić, "Perspektive razvoja sela: zbornik radova sa naučnog skupa održanog 17-18. aprila 2013.", Beograd: SANU, 2014.

PROGRAMSKE AKTIVNOSTI U CILJU ODRŽIVOG RURALNOG RAZVOJA: STUDIJA SLUČAJA, SELO BERBATOVO, NIŠ

Rad se bavi analizom, predlozima i razradom programskih akcija i mera u cilju održivog razvoja sela Berbatovo. Pored prikupljanja opštih podataka o selu i njegovih razvojnih karakteristika definisani su razvojni problemi i potencijali. Glavni nedostaci sela koje se analizira su opadanje broja stanovnika, njihova migracija u gradove, nizak nivo obrazovanja stanovnika koji ostaju da žive u selu. Nedovoljno je adekvatnog prostora za javno okupljanje, nema ustanova neophodnih za funkcionisanje meštana – ambulanta, pošta, obdanište, loše je stanje puteva. Osim proizvodnje za sopstvene potrebe, nedovoljna je aktivnost i zainteresovanost stanovnika za pokretanje sopstvenog biznisa koji bi stvorio uslove za kvalitetniji život u selu. U radu su nakon definisanja razvojnih problema i uočenih potencijala odabrani odgovarajući strateški pravci održivog razvoja, opšti i specifični ciljevi i programske akcije i mere koje bi doprinele adekvatnom razvoju sela.

Ključne reči: *Berbatovo, selo, održivi razvoj, mere, ruralna arhitektura*

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Review Paper

CREATING MORE SUSTAINABLE SOCIAL HOUSING IN SERBIA: A CONCEPTUAL FRAMEWORK FOR ARCHITECTURAL AND URBAN DESIGN

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Tanja Njegić[1], Božidar Manić[1], Vladimir Lojanica[2]

[1]Institute of Architecture and Urban & Spatial Planning of Serbia, Belgrade, Serbia
[2]Faculty of Architecture, University of Belgrade, Serbia

Abstract. *The basic research problem is the insufficient application of sustainability criteria in urban and architectural programs and projects for social housing in post-socialist Serbia, which may lead to inadequate and low-quality new housing stock. This paper emphasizes the importance of considering social, economic and environmental sustainability aspects integrally in the further development of the existing, highly residual social housing model, with a focus on improving guidelines, rules and parameters in the design domain. Relevant criteria in the architectural and urban design of sustainable social housing were identified, systematized and interpreted, based on the analysis of scientific knowledge, applicable models and international recommendations. A conceptual multicriteria framework was designed with the aim of contributing to the improvement of methodological approaches in the design and evaluation of social housing settlements and buildings in Serbia, as well as in related housing systems.*

Key words: *social housing, sustainability, architectural and urban design, conceptual multicriteria framework, Serbia*

1. INTRODUCTION

As a public policy aimed at reducing social inequalities in the field of housing, social housing is related in essence to the concept of sustainable development. The importance of this sector for sustainable urban development, especially regarding its contribution to social cohesion, has been recognized and confirmed in United Nations documents and guidelines for housing policies and programs [1, 2, 3, 4]. The motive for promoting and

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Corresponding author: Tanja R Njegić, Institute of Architecture and Urban & Spatial Planning of Serbia (IAUS), Bulevar Kralja Aleksandra 73/II, 11000 Belgrade, Serbia
e-mail: tanjanjegic@gmail.com

affirming sustainability principles in social housing policies can be attributed, on the one hand, to the inherited socio-spatial problems of mass social housing from the second half of the 20th century, such as spatial segregation, high population density, monotonous and uniform architecture, and a high concentration of poverty [5, 6, 7, 8]. On the other hand, it is believed that the paradigm of sustainable development offers an appropriate framework for a holistic approach to future housing development, which is in itself complex and contains ecological, economic, social and cultural dimensions [9, 10]. According to Reeves, sustainability is the vital content of any form of social housing, and its essence is in understanding human needs and aspirations, and designing in accordance with them [10]. Milić believes that all goals in the field of social housing start from one general goal, which is "to provide conditions for everyone to have a decent apartment" and recognizes the goals and criteria of sustainable development as a value-based and conceptual framework for urban and architectural practice [11].

Residualization, which is a pervasive trend in contemporary social housing policies and practices, is considered to be the greatest challenge to achieving the goals of social cohesion and sustainability of neighborhoods [3]. Reducing investment in social housing, building it in cheaper, peripheral locations and targeting the most vulnerable social categories, means increasing the risk of segregation, ghettoization, crime, permanent unemployment, and physical degradation of the housing stock. In addition, the negative externalities of social housing residualization require additional government investment in housing maintenance (or demolition and new construction programs), while increasing costs in other public sectors (e.g., the security and health sectors) [3]. Although "generalist in writing" the post-socialist social housing allocation model in Serbia is extremely "residual in practice", according to the criteria: share of social rented apartments in the total housing (0.9%), target groups of beneficiaries (vulnerable and special groups – mainly refugees, displaced persons and Roma), and the fact that the new housing policy is in the early stages of implementation [12, 3]. Unlike the socialist period of state-funded housing construction, in the current system of housing support, the funding of which primarily relies on international sources and donations, the provision of social housing is based mainly on "quantitative criteria", which poses a great challenge to achieving an appropriate level of quality and sustainability of new housing estates.

The current legal and strategic framework for the development of social housing in Serbia is based on respecting the values and goals of sustainable development and promoting the right to adequate housing for all citizens [13, 14, 15, 16], but the implementation of these policy commitments in practice is rather limited. This is shown by the results of several empirical studies on completed housing projects, which testify to numerous shortcomings in the field of national housing regulations, the implementation of programs and projects, the quality of building construction, and also the management sector of this housing stock [17, 18, 19, 20].

Creating the preconditions for sustainable housing development and providing adequate housing for Serbian citizens includes the priority of improving all the capacities (institutional, organizational, financial, legal, etc.) necessary for the effective implementation of housing policy at all levels, which is recognized by the Draft National Housing Strategy 2020 to 2030 [15]. For the purpose of sustainable development of the national social housing system, it is also necessary to formalize a special methodological framework with guidelines and parameters for the level of urban planning and design, in accordance with international guidelines and national specifics [21]. The importance of implementing sustainability criteria in the domain of planning and designing social housing in Serbia is indicated by a relatively

recent analysis and systematizations within scientific research – from integral criteria [11, 22], to those dealing only with energy efficiency [23] or socio-spatial themes [24].

The goal of this paper is to define, systematize and explain the criteria relevant to sustainable social housing, which are important for architectural and urban design, based on a review of international and domestic literature. It results in an applicable conceptual multicriteria framework which might contribute to existing scientific and professional knowledge in this field, as well as to improving regulations and methodological approaches in the design and evaluation of social housing settlements and buildings in Serbia, and other countries with developing housing systems.

2. Conceptualizing Sustainable Social Housing within the Framework of Urban Planning and Design

As a basis for the conceptualization of sustainable social housing within the area of urban planning and design, we used the principles of sustainable housing and sustainable communities while respecting the normative starting points, goals and contemporary challenges of social housing. According to Larsen's model [25], sustainability is seen as a complex that integrates social, environmental and economic values, with the cultural aspect viewed as part of the extended social dimension of sustainability. Based on several sources [4, 9, 26, 27, 28, 29, 30, 31], the sustainability of housing and communities in a broader sense can be defined through the following guidelines within the three dimensions of sustainability:

1) Socio-cultural sustainability: equality (in the distribution and use of housing resources), social interaction/social networks within the community, pride/sense of attachment to the place, safety, accessibility, acceptable quality of housing and its environment, cultural adequacy and opportunity for change;
2) Environmental sustainability: reducing the need for energy, reducing the need for other environmental resources (water, raw materials, materials), improving efficiency in the use of energy and resources, preventing environmental threats, and the environmentally sustainable behavior of users;
3) Economic sustainability: encouraging economic development by providing adequate accommodation, encouraging technological development in order to mitigate negative environmental impacts, benefit to investors (financial/sociopolitical), development of the local construction industry and efficient management and maintenance.

Sustainable social housing in a broader sense implies considering all aspects of poverty and not just the lack of housing or a "roof over one's head". Its basic goals include:

1) responsibility for the needs of present and future generations;
2) providing housing of appropriate quality for all; and
3) enabling vulnerable social groups to actively participate in the socio-economic life of the community.

It is also a multifaceted value complex with environmental, socio-cultural and economic dimensions, which implies their integral consideration and consistent implementation at all levels of social housing provision. The general position in determining the goals of sustainable social housing in urban planning and design is that this practice should not further deprive poor households, but should provide them with decent and quality housing conditions in accordance with the requirements of affordability. Based on previous conceptual starting points, as well as the interpretation of sustainable social housing in the literature [1, 2, 10, 11, 20], we define the goals of sustainable social housing in urban planning and design, where:

- Socio-cultural goals include: 1) adaptation to the residents' needs; 2) adaptation to the changing needs of tenants; 3) encouraging the social integration and interaction of tenants; 4) diversity; 5) safety; and 6) cultural adequacy;
- Environmental goals include: 1) efficient use of land and compactness of the urban form; 2) reduction of car use; 3) efficient use of energy; 4) efficient use of water, materials and resources; 5) environmental safety and reduction of pollution; and 6) preventing the heat island effect;
- Economic goals include: 1) encouraging local economic development; 2) lower land acquisition costs; 3) lower costs of landscaping, equipping, construction and adaptation, 4) lower costs of maintenance, and 5) economic strengthening of the community and lower costs of housing.

Further conceptualization of sustainable social housing in urban planning and design implies the determination of a comprehensive multicriteria framework, that is, a system of general and special criteria of "desirable characteristics" of the spatial-physical patterns of this type of housing. The development of this model is based on methods of content analysis, critical and comparative analysis and interpretation of primary sources (international and national documents – laws, strategies, recommendations, reports from conferences and workshops, standards, resolutions) [e.g. 1, 2, 3, 4, 13, 14, 31, 45] and secondary sources (scientific and professional research) [e.g. 8, 9, 10, 11, 19, 20, 23, 28, 30, 32, 37, 39, 40, 43, 47]. The applied methodological procedure is shown schematically in Figure 1 and was elaborated in detail in the author's previous research [17]. It included the following steps:

- Identifying appropriate general criteria in the domain of socio-cultural, environmental and economic sustainability, in accordance with the previously presented conceptual starting points and goals;
- Preliminary analysis of the criteria and determining the possibility of their direct application at three spatial decision-making levels in urban planning and design, which include: identification of sites, site planning and urban and architectural design of social housing complexes, buildings and apartments;
- Checking and ranking general criteria in terms of their potential impact on the achievement of socio-cultural, environmental and economic goals; and finally,
- Interpreting each criterion and defining its specific criteria within all three conceptual multi-criteria frameworks.

In this paper we will only address relevant criteria in the domain of architectural and urban design, which in certain segments overlap or are directly conditioned by urban planning criteria, but they will not be specifically mentioned or considered.

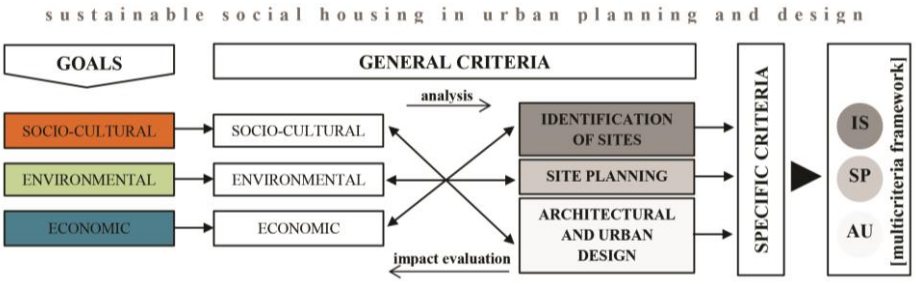

Fig. 1 Procedure of creating a comprehensive multicriteria framework in urban planning and design of sustainable social housing

3. Sustainability Criteria in the Architectural and Urban Design of Social Housing

In accordance with the conceptual starting points and goals of sustainable social housing in urban planning and design (sociocultural, environmental and economic), in this section we identify and interpret general criteria relevant to the domain of urban and architectural design. Besides the already mentioned international literature on sustainable housing and social housing, some of the relevant studies by Serbian authors who have analyzed these concepts were especially considered [11, 20, 23, 32].

As the key sustainability criteria in the architectural and urban design of social housing, the following can be distinguished:

- *Flexibility of the architectural design and construction system*
- *Spatial and functional comfort and healthy housing conditions*
- *Application of energy efficiency measures*
- *Sustainability of materials*
- *Open spaces designed to foster social integration and interaction between tenants*
- *Designing in accordance with the needs and cultural habits of special social groups*
- *Permanence and fostering a sense of belonging*
- *An architectural and landscape layout that enables monitoring and control*
- *Typological diversity*
- *Visual diversity and a tenure blind design*
- *Contextuality*
- *Environmentally and climate-responsible design*
- *Interior common spaces intended for the social integration of tenants*
- *Rationality and cost-effectiveness of the architectural structure and construction system*

The selection and the proposed order of the criteria is the result of the analyses of their contribution to achieving multiple sustainability goals and their dominant impact on these goals (+ positive; - negative; +- partially positive/partially negative; o neutral), as seen in Figure 2.

3.1. Flexibility of the architectural design and construction system

Adaptation of housing patterns to the varied and changing needs of users is considered one of the key factors of sustainable social housing. Flexible housing is defined as housing that is designed for choice, both in terms of social use and construction, or designed for change over its lifetime [33]. This characteristic is of special importance for the users of social housing, because in this sector the possibility of choice generally does not exist. The flexibility of the architectural assembly encompasses two levels: the functional level, i.e., the purpose and physical level related to the structural system, infill and envelope. This principle of design and construction is based on the idea that a flexible system in technical terms provides a socially flexible result. From a structural point of view, flexibility requires separating elements that are fixed and those that are subject to change and variation.

Two constructive systems which provide a high level of flexibility are the “open building” system, which completely separates the support level from the infill level of the building [34], and contemporary, advanced modular systems. Freedom in the use of modularly defined spaces is based on the potential functional neutrality and polyvalence of the modules, and the possibilities of their mutual combination, variation and transformation.

Fig. 2 Sustainable social housing criteria in architectural and urban design

Depending on the capacity of adaptation, modular systems can be static or dynamic [32]. Open building and the "dynamic" modular system usually require the application of prefabricated construction methods; hence their use depends on the degree of industrialization in construction in a given country. In conventional constructive systems, flexibility is achieved by considering favorable assemblies and functional schemes that will allow the easy division or interconnection of housing units. The flexibility of social housing units is especially important due to the reduced mobility of social tenants, i.e., the impossibility of simply replacing their apartment at a time when the structure of their families changes [10]. In this regard, social housing should be designed to allow easy transformation and use throughout the tenants' lifetime, without the need for their relocation. Intensified use of an apartment's area

through the superposition of functions and its flexible use can be achieved by improving the technical equipment (movable partitions, sliding doors, movable furniture) [35]. The creation of neutral living spaces, suitable for different forms of use and lifestyles, is also important from the aspect of cultural sustainability [1]. The principle of flexibility generally contains the potential to encourage the participation of tenants in the design, construction and functional organization of a dwelling. This criterion also anticipates potential future changes in the common parts of the building in order to achieve higher quality housing, such as the subsequent installation of elevators, addition of common areas, etc.

Flexibility is also important from the aspect of economic sustainability, because it contributes to the overall longevity of physical structures, reducing the need for their renewal and reconstruction, which is especially important in the public sector. In this sense, it also contributes to environment protection by reducing the use of resources and amount of waste generated. It is of specific ecological importance that physical structures are created with flexibility for the immediate or subsequent implementation of new energy efficient systems, as well as for the expected future effects of climate change.

3.2. Spatial and functional comfort and healthy housing conditions

Having an appropriate level of spatial and functional comfort and healthy residential conditions involves fulfilling the relevant requirements of housing quality (at the level of apartments, residential buildings and apartment complexes), which are defined through technical regulations, i.e., regulations and standards in the field of housing design and construction [18].

Among the basic indicators of the quality of housing are (minimum) standards with regard to the use of space (crowding level), namely "1 room per person" and an available area in the apartment per household member that is not less than $10m^2$, or more complex and rigorous indicators such as those used by Eurostat, which take into account the structure and characteristics of households. In addition to these basic standards, adequate housing includes the design of sanitary facilities, and ancillary and open spaces in housing units, which ensure that the basic housing needs of users are met. In order to rationalize the size of social housing apartments, and yet still provide conditions for encouraging interaction between tenants, auxiliary rooms such as laundry and storage can be planned as common areas in residential buildings. It is desirable to design social housing with at least minimal kitchen storage, particularly for the purpose of physical accessibility for users with reduced mobility (the elderly and people with disabilities). Preferably, the apartments should be designed with external spaces (balconies, terraces, loggias) or associated gardens on the ground floor level, as long as these spaces provide appropriate accessibility, privacy and security. Healthy living conditions include meeting the requirements for air, lighting, thermal and acoustic comfort within the apartments, which are achieved by means of applying measures and standards in design and construction [36].

With regard to all aspects of housing comfort, social housing should meet the appropriate minimum established standards, in order to prevent the occurrence of housing deprivation, which endangers the health of tenants and reproduces poverty caused by inadequate housing. Indicators used by Eurostat to examine the quality of housing and housing deprivation within the EU-SILC methodology can be considered as minimum conditions of housing comfort. International recommendations indicate that social housing standards should not be lower than the average national housing standards, in order to avoid problems of social segregation and stigmatization [1].

3.3. Application of energy efficiency measures

In social housing design, energy efficiency means promoting systems and design measures that reduce energy consumption from conventional sources, which are economically viable in terms of investment and maintenance costs and which provide optimal comfort with minimal household energy costs (energy poverty prevention) [37]. Given that social housing is under the direct responsibility of the public sector, it can be a testing ground for promoting energy-efficient solutions and encouraging local market development in the field of energy-efficient construction techniques and technologies. Preconditions for the application of these measures in the design phase are partly determined by the selection and urban planning of locations, i.e., by applying bioclimatic urban planning principles and anticipating an efficient heating system [23].

Design in accordance with the requirements of energy efficiency includes rules concerning the positioning, design, functional organization, materialization, technological equipment, and the operation and maintenance of buildings, which are prescribed by appropriate technical regulations in order to achieve a satisfactory level of environmental and energy sustainability (energy class/annual energy consumption indicator). In social housing projects, one should generally strive for cheaper low-energy solutions and the passive use of solar energy, and if there are economic possibilities, passive-house solutions and the use of active solar and other sophisticated energy systems are desirable. Technical criteria in the field of energy efficient design which should be taken into account include: optimal orientation and functional organization; shape and compactness (shape factor); adequate thermal zoning; proper use of natural light and sunshine; optimization of natural ventilation systems; optimization of the building structure (thermal mass, thermal insulation, avoidance of thermal bridges, type and color of materials); creating conditions for the use of passive and active solar systems; and analysis of the possibility of using water for heating and cooling. Most of these energy efficiency criteria are compatible with the preconditions of economic design and construction as well as social sustainability requirements, since they improve residential comfort.

The criterion of form compactness is especially important for social housing design, because a simpler building form implies lower consumption of materials and labor, as well as lower maintenance costs. In terms of compactness criteria, heat losses are lower in multi-family residential buildings (especially in double-tract buildings), while in single-family housing the shape factor is more favorable in rows of buildings than in free-standing ones [38]. The total envelope area of the building and the level of the heat losses directly depend on the compactness/jaggedness of the building floor plan. Therefore, in addition to proper insulation of all elements of the building envelope (facade walls, windows and doors, ground floor and roof surfaces) and their design in accordance with the requirements of residential comfort (adequate lighting, protection from direct sunlight, natural ventilation), it is necessary to reduce its total surface area in order to reduce heat losses and increase the efficiency of the heating system. The open spaces of apartments (balconies, terraces, loggias) should be designed in such a way as to minimize the surface area of the building envelope and to avoid the problems of thermal bridges. An important precondition for energy saving in apartments is a regulated central heating system (central and local regulation) with measured energy consumption for heating.

3.4. Sustainability of materials

The materialization of social housing dwellings should simultaneously address the issue of price, performance, durability, maintenance and environmental impact. Basic recommendations in this category include the use of environmentally friendly and healthy, durable and locally available materials (and labor), the use of recycling, and the use of materials from naturally renewable sources (e.g., wood, soil). The use of materials bought locally implies lower total costs in construction and maintenance, as well as reduced need for transport, which is significant from the aspect of considering energy consumption throughout the entire life cycle of buildings. It is important that the materials used are durable, in order to reduce any additional costs to owners and tenants associated with maintenance or replacement. Recycling has numerous advantages in environmental protection, primarily in terms of the reduced use of natural resources, and energy savings in the production of materials, thus also in terms of reducing pollution. The recycling strategy includes both the use of recycled materials in construction and enabling new buildings to be recyclable at the end of their life cycle (e.g., wood, brick, metal, glass).

By choosing appropriate materials for construction and landscaping, comfort of the housing can be improved and the occurrence of "heat islands" in a residential area prevented [39]. The energy efficient and climate-responsible materialization of roof coverings involves the use of green and cold roofs. The advantage of green roofs is their environmental efficiency, since they retain and filter atmospheric water, and also reduce air pollution. Cold roofs are a cheaper alternative and easier to build, and they can be used on both sloping and flat roofs. They have a high degree of solar reflectivity and heat emission, and in addition to white, they can have a wide range of other colors. The landscape design should envisage cold paving of the largest possible share of solid open surfaces, using materials with a high albedo, i.e., a high degree of reflectivity of solar energy. Instead of conventional asphalt and concrete, the use of permeable materials is recommended, such as gravel and other aggregates, porous concrete and asphalt, or specially designed permeable paving elements.

3.5. Open spaces designed to foster social integration and interaction between tenants

Open areas within social housing sites should be planned in accordance with the goal of encouraging the social integration of poor and vulnerable social groups, as well as their mutual interaction and community building. The spatial context for fostering informal interactions, mutual observation and socializing includes common spaces such as green areas, landscaped courtyards for tenants to gather (paved surfaces equipped with benches, tables and canopies, gardens, areas for board games, recreation, etc.), arranged and equipped children's playgrounds, pedestrian and bicycle paths, etc. The design of these facilities at a location depends first of all on its spatial capacity, then the rules of arrangement and construction, but also the typology of the social housing construction (individual buildings or complexes).

Well-designed green spaces are important not only as a context for children's play, recreation and interaction between tenants, but also because they contribute to the quality and ecological sustainability of the housing environment. Walking and cycling increase the possibility of spontaneous chance encounters in the neighborhood, since they provide opportunity for greeting and communication, while at the same time representing a form of environmentally sustainable movement [40]. Designing children's playgrounds is of particular importance as the integration of children is considered a key element in building social networks at the neighborhood level. It is equally important to organize them in a way

that enables surveillance without interfering with the privacy and peace of residents on the ground floor, where elderly people and those with disabilities usually live.

Where possible, the open spaces in residential complexes can be planned for urban agriculture, to enable food production for the tenants' own needs, and possibly for the local market. This form of activating common areas could contribute to the goal of economic strengthening of the community and reducing housing costs, as recognized in some urban design proposals for social housing in Serbia [41].

3.6. Designing in accordance with special social groups' needs and cultural habits

This criterion is one of the key requirements of socio-cultural sustainability in social housing design and construction and it involves the consideration of its spatial and functional characteristics in accordance with the needs of target groups. Beneficiaries of social housing mainly include lower-income households, as well as groups with special or specific housing needs, such as persons with disabilities, the elderly, single parents, families with multiple children, members of certain ethnic, minority or discriminated communities, etc. Housing units, common areas of buildings and open spaces should be planned in accordance with accessibility requirements, preferably at the level of the entire social housing project, and not just a smaller part of it (e.g., the ground floor of buildings). The concept of "universal design", also known as "inclusive design", involves adapting the built environment to all users, especially the elderly and disabled [42, 43, 44]. This needs to be kept in mind considering the trend of an aging population, and various forms of disability common among the elderly. An example of universal design principles in practice is the British Lifetime Homes Standards, intended specifically for social housing associations. According to Reeves, designing and building social housing dwellings to ensure that that they can be used throughout the lifecycle, so-called "Lifecycle sustainability", is especially considered important in those countries where this sector is underdeveloped and tenants' mobility is minimal [10]. Universal design generally requires appropriate equipment and sizing of apartments, communication spaces (approaches – ramps, entrances, windshields, elevators, stairs and handrails, corridors), as well as open spaces (parking, paths, etc.) in accordance with accessibility standards, which can be adapted for wheelchair users and other housing needs. This criterion also means taking into account the preferences and lifestyles of different age groups and avoiding conflicts in the use of common spaces through appropriate functional zoning (e.g., apartments for the elderly and children's playgrounds) [45].

When social housing is targeted to ethnic groups with characteristic cultural habits special attention should be paid to assessing their needs, in order to avoid creating culturally inadequate housing patterns. Respecting cultural and lifestyle differences for the purpose of socially integrating ethnic groups involves designing flexible or open building systems, communication zones without barriers, special rooms for tenants to gather and neutral rooms within apartments [1]. The general profile of the future residents should be preferably known already in the programming and design phase, in order to enable their participation in these processes.

3.7. Permanence and fostering a sense of belonging

In order to encourage the social inclusion and integration of vulnerable social groups into the community, social housing should be designed to encourage their identification with the housing environment and to give them the impression that it is safe and sustainable.

The more pronounced the feeling of attachment and belonging to the housing environment among the tenants, the better the preconditions for building social networks, and thus for the successful maintenance and preservation of the apartments and common spaces. Although housing in the social rented sector is faced with fluctuations in the structure of its users, the potential "temporary use" does not imply a "temporary character" of residential buildings. In order to ensure the physical sustainability of social housing construction, it is necessary to provide quality construction materials and an adequate level of craftsmanship, both for buildings and open areas. The quality and durability of materials can affect the cost of construction, but contributes to the long-term economic viability of the project, as it reduces maintenance costs borne by the owner (public sector), as well as those borne by the social tenants. The attractiveness of the architecture can contribute to the feeling of belonging to a residential area, which is directly related to the criterion of visual diversity. One of the important measures to meet this criterion is to enable the participation of tenants in the design of the buildings and landscaping, and the use of culturally specific elements of architectural and urban design.

3.8. An architectural and landscape layout that enables monitoring and control

In order to increase the level of security or defensibility of common spaces in social housing buildings, architectural layouts should be created with a minimal number of apartments per each entry to the building (lamella). A greater number of units sharing a common entrance results in an increased public access to corridors, elevators and staircases, which reduces the possibility of monitoring and control, i.e., distinguishing tenants from visitors. It also reduces the mutual agreement between neighbors on the maintenance and control of these parts of the building. Having fewer apartments per building entry makes it easier to get to know the tenants, and thus develop a natural form of protection. Measures for designing safer architectural layouts include, first of all, dividing residential buildings vertically or horizontally into segments, avoiding long access galleries and unlit corridors, avoiding potential hiding places on all floors, especially on the ground floor (passages, spaces with undefined purpose), and planning common areas in secured areas over which tenants have control [8]. As an additional security measure, it is desirable to equip buildings with an intercom and surveillance system, but to prevent abuse, it is not recommended to allow tenants to monitor common areas in the building via television [46]. The supervision should be preferably performed by the person in charge of maintaining the building, for whom a special housing unit on the ground floor should be provided (apartment for the janitor).

In the case of landscape design, safety measures are primarily related to enabling the control of parking areas and children's playgrounds, having vegetation that will not interfere with visibility, and adequate lighting in all open areas. As a rule, parking should be as close as possible to the building in order to allow spontaneous monitoring, while garages with a common entrance and controlled access are considered the safest solution. Greenery near pedestrian paths and sidewalks should be as low as possible (not more than 1 m), since tall trees hinder surveillance and artificial lighting. Planning appropriate outdoor lighting (location, type, intensity) prevents accidents, helps orientation and contributes to the overall safety. In general, it involves providing uniform illumination for open areas, especially pedestrian paths and parking lots.

When choosing urban and architectural typologies and structures, it is considered that those solutions with a higher degree of privacy of open spaces have a higher level of security, because they provide better monitoring and control over public areas (street, sidewalk and parking lots) [8]. Regarding the disposition and orientation of buildings and planning communal areas, the possibility of natural surveillance for parking spaces, as well as children's play areas, which should be kept small and not be too close to the residential dwellings, should be taken into account [46]. Designing garden apartments on the ground floor contributes to the overall security of the scheme, but in order to preserve the sense of security and privacy of the tenants, gardens should be designed with appropriate protection from the outside and from neighbors (fences, partitions, canopies, etc.).

3.9. Typological diversity

The typological diversity of housing is directly connected with its social diversity, and it can be achieved either by mixed housing-type developments or by the infilling of new types of development, on vacant parcels or through overbuilding [47]. In this context, the diversity of housing types primarily relates to different tenures (social renting and ownership), different housing typologies in terms of form and size (from single-family to multi-family), diversity in terms of the housing stock age, and policy support to sustain a mix of affordability levels [47]. When planning social housing complexes and buildings, it is especially desirable to combine different types of housing units (in terms of size and structure), in order to meet the different preferences of households (from singles to families with multiple children) and their changing needs, without the need to move to another neighborhood. In order to achieve the typological diversity of social housing through urban and architectural design, it is necessary to support it with appropriate housing policy measures and urban planning rules and regulations.

Mixing different forms of housing tenure with the aim of fostering social integration at the neighborhood level has been recognized as a preferred model in Serbia, although without successful implementation in housing policy, urban planning and housing development practice [48]. Unlike homogeneous social or private housing, this model carries financial risk, due to the potential negative impact of social renting on the prices of the private apartments, as well as possible additional maintenance costs to social tenants for the higher quality housing.

3.10. Visual diversity and a tenure blind design

Visual diversity is directly related to the criterion of typological diversity, but it refers primarily to the aspect of architectural expression, i.e., to the design characteristics and artistic elements of the building facades, as well as to the elements of landscape design. While typological diversity is directly related to the goal of social integration and interaction between different social groups, visual diversity can contribute to preventing or eliminating the problem of stigma, that is the negative labeling of social housing, caused by monotonous, uniform and "poor" architecture. Emphasizing the importance of suggestive and expressive architecture for social housing, Milić points out that there is no a special "architectural style" suitable for social housing, but there is a need to socialize this type of housing within the wider community and urban environment [11]. It is desirable that the buildings in larger social housing complexes are visually different, in order to encourage a sense of belonging and identification of the tenants with the housing environment. Visual diversity can be achieved through the design, materialization, use of color and details in

finishing, and equipment, while observing the requirements of energy efficiency of the building envelope and rationality, i.e., cost-effectiveness of the construction.

The criterion of unrecognizable housing types (tenure blind) is also related to preventing the "negative image" of social housing, and is applicable in the case of designing mixed tenure communities with social and private housing units [40]. It involves avoiding the visual identification of social differences through architecture, and is considered to increase the possibility of selling private housing units, in addition to preventing the stigmatization of social rented units. However, tenure blindness does not imply visual uniformity, which would be contrary to the criterion of diversity, but rather the application of uniform standards in defining the external appearance of a residential complex, primarily in terms of the design and quality of the facades and exterior equipment (doors, windows, fences, canopies, etc.). Consistent and long-term implementation of this principle requires the application of the same maintenance standards, as well as the adjustment of the costs to social tenants' financial situations.

3.11. Contextuality

In accordance with cultural sustainability goals, the social housing design should meet two basic prerequisites – compliance with the local tradition of housing patterns [11] and respecting the urban and architectural characteristics of existing housing in the given setting. According to Milić, "physical models of social housing should not deviate from local traditionally established housing models – single-family or multi-family, but should take into account the financial rationality of projects" [11]. In addition to financial rationality, the requirement for the technological improvement of traditional models in accordance with modern needs for energy optimization of housing should certainly be considered. Selection of the appropriate housing typology is largely conditioned by the prescribed urban planning rules and regulations for a particular area. Respecting the urban and architectural value of the existing housing in the vicinity of the location (if such value exists) is desirable in order to avoid the alienation and stigmatization of social housing, disruption of the ambient features, or possible conflicts in the use of space. The contextuality of the new social housing development could also help tenants to integrate more easily into the local environment and social community.

3.12. Environmentally and climate-responsible design

This criterion refers to undertaking various measures in the urban and architectural design of social housing which are aimed at environmental protection and the prevention of climate change, and which are outside the scope of the energy efficiency measures for residential buildings. An environmentally responsible design encompasses considerations with regard to reducing pollution and minimal consumption of energy, water, materials and resources throughout the life cycle of a building, and not only in the phase of its service. Special criteria and indicators include measurements of annual CO_2 emissions, the use of renewable energy sources and materials, the application of recycling principles, the reduction of waste production, and the use of equipment that enables water saving in facilities, etc. These design measures can increase the cost of construction if they involve the application of sophisticated technological solutions for construction and equipment, while some of them can reduce maintenance and housing costs, or other costs related to the end-of-life phase of a residential building.

3.13. Interior common spaces intended for the social integration of tenants

Common spaces in social housing buildings should be designed with the aim of enabling formal and informal ways of meeting and communication among the tenants, in order to encourage their social integration and a feeling of community. Depending on the spatial capacity of the residential building, one or more rooms should be intended for different forms of gatherings or activities involving the tenants (tenants' meetings, education, counseling, celebrations, etc.). It is desirable to design these premises on the ground floor of the building and in direct connection with the open common areas, in order to provide physical accessibility for all tenants, as well as their multipurpose use. Circulations in the building (corridors, stairs, spaces in front of elevators) can also be planned with the idea of enabling tenants to meet informally, requiring appropriate sizing, design, good natural lighting and equipment (e.g., benches).

3.14. Rationality and cost-effectiveness of architectural structure and construction system

Rational and low-cost design and construction in social housing require a reduction in investment construction costs within the total price of the apartment, but not to the detriment of minimum standards of "decent housing" in the given environment [11]. According to Milić, two basic approaches under the economic rationality requirement are: 1) uniform rationalization at all spatial levels (from apartment to residential area) and 2) compensation of savings in one spatial level by achieving higher quality at another level, where the first approach is more appropriate in environments with lower quality social housing construction [11].

This criterion signifies rationalization of the urban and architectural design in terms of form and spatial and functional characteristics, as well as the application of economical and affordable construction techniques and technologies. One of the key requirements for achieving investment and energy savings through design is compactness of the architectural form and the building envelope. Designing in accordance with the maximum permitted urban parameters in order to provide more housing units can contribute to the cost-effectiveness of the project, if the increase in housing density does not jeopardize its social sustainability (especially safety), and the long-term cost-effectiveness of maintaining such buildings and complexes. Savings can be achieved by applying the minimum spatial standards for social housing, both at the level of housing units and in the sizing of common parts of the building. If these standards are not defined, the rationalization of residential areas is achieved by applying minimum space standards for apartment, but not lower than $10m^2$ per person. In order to reduce the living space to enable decent living conditions, the principles of surface intensification can be applied, but to the extent of the functional use and hygienic optimum [35]. Reducing the area of common parts of the building in accordance with the minimum regulations must not affect the aspects of accessibility (for the elderly and people with disabilities), safety and functionality.

The cost-effectiveness of the construction system implies the application of locally available and less expensive construction techniques and construction materials, which can refer either to the application of prefabricated or conventional systems, depending on the conditions of the local construction market.

4. DISCUSSION

Summarizing the results of the criteria analysis, a conceptual multi-criteria framework with general and specific criteria in architectural and urban design of sustainable social housing is proposed (Table 1). We may point out that urban and architectural design can noticeably contribute to improving the quality and affordability of social housing in Serbia, but only if this practice is based on the comprehensive consideration of relevant sustainability criteria, which should be formally established and consistently implemented in all the phases of a project. While some of the identified criteria could be considered relevant to housing in general, regardless of the form of ownership, other have a specific importance exclusively in the domain of social housing.

The first group includes, for example, criteria related to flexibility, spatial and functional comfort, energy efficiency, sustainability of materials, contextuality and environmentally conscious design. Given that social tenants generally do not have an option of making a residential choice, unlike owner-occupiers or even private renters, neglecting these criteria through lowering standards for social housing design and construction can additionally contribute to material and housing deprivation and social exclusion of target users in this sector. Through the measures of sustainable urban and architectural design of complexes and buildings for social housing, it is possible to improve the conditions of residential comfort and the health of social tenants, and to prevent the emergence of energy poverty issues.

The second group of criteria from which the social housing sector and its end users benefit primarily, refers to principles and approaches in designing residential buildings and open spaces with the aim to encourage social integration and inclusion of tenants, their sense of belonging and safety, while respecting the requirements of rationality. Appropriate design is crucial from the aspect of the social and cultural adaptation of housing to the current and future needs of users, and it is considered important for fostering a sense of community, as well as preventing any stigma caused by unattractive architecture. The diversification of typological forms of social housing has been found necessary in national practice, both in terms of introducing innovative and socially viable physical patterns to satisfy the different needs of target social groups and of encouraging mixed forms of housing tenure. The growing trend of an aging population, the need for deinstitutionalization and solving housing issues for persons with disabilities, and the challenges of housing support for the Roma population and the homeless, are some of the key starting points for the scientific and professional elaboration of new, more universal and flexible standards for housing and their implementation in practice. An important issue which can be addressed through design is the level of safety and crime prevention in social housing neighborhoods, but it is necessary to take this into account as early as in the phase of the urban planning of locations for this purpose, in order to prevent creating high density residential areas of concentrated poverty. Decisions made in the design phase can also affect the cost-effectiveness and rationality of a housing project, as well as its long-term environmental sustainability.

Table 1 Sustainability criteria in architectural and urban design of social housing – a conceptual framework

SUSTAINABILITY CRITERIA IN THE ARCHITECTURAL AND URBAN DESIGN OF SOCIAL HOUSING		
	GENERAL CRITERIA	**SPECIFIC CRITERIA**
1.	**Flexibility of the architectural design and construction system**	▪ Open building system ▪ Modular building system ▪ Possibility of merging/dividing housing units ▪ Flexibility of housing units ▪ Possibility of adapting the architectural design for changing needs or higher quality housing
2.	**Spatial and functional comfort and healthy housing conditions**	▪ Appropriate conditions of spatial and functional comfort (in accordance with regulations) ▪ Appropriate conditions of air, lighting, thermal and acoustic comfort (in accordance with regulations) ▪ Appropriate food storage space ▪ Appropriate external spaces (gardens, terraces, loggias, balconies) ▪ Appropriate vertical and horizontal circulation spaces in the building ▪ Appropriate auxiliary and common rooms in the building (pantry, laundry room, etc.) ▪ Compliance with average national standards for the design of residential buildings and apartments
3.	**Application of energy efficiency measures**	▪ Orientation and functional organization ▪ Building form compactness ▪ Optimal thermal zoning ▪ Optimal use of natural light and sunlight ▪ Optimal natural ventilation system ▪ Building structure optimization measures (materialization, thermal insulation, windows…) ▪ Passive/active use of solar energy ▪ Use of the optimal available heating/cooling system ▪ Use of a system for regulation and monitoring of energy consumption ▪ Degree of compliance with national EE standards for housing (energy class)
4.	**Sustainability of materials**	▪ Environmentally safe and healthy materials ▪ Quality and durability of materials ▪ Local and available materials ▪ Renewable materials ▪ Recycled and recyclable materials ▪ Materials that prevent the heat island effect
5.	**Open spaces designed to foster social integration and interaction between tenants**	▪ Landscaped green areas ▪ Designed open spaces for residents to gather and socialize (paved surfaces with benches, tables, canopies, facilities for recreation and entertainment, shared gardens, etc.) ▪ Arranged and equipped children's playgrounds ▪ Pedestrian and biking paths ▪ Designing an underground garage
6.	**Designing in accordance with the needs and cultural habits of special social groups**	▪ Accessibility of buildings and open spaces for tenants with special needs (elderly, people with disabilities, children) ▪ Apartments for people with disabilities on the ground floor ▪ Application of the principles of universal/inclusive design ▪ Adaptation of the urban and architectural design to the cultural habits of the residents ▪ Separation of children's play space from apartments intended for the elderly and persons with disabilities

SUSTAINABILITY CRITERIA IN THE ARCHITECTURAL AND URBAN DESIGN OF SOCIAL HOUSING		
GENERAL CRITERIA		**SPECIFIC CRITERIA**
		▪ Tenants' participation in the choice of urban-architectural layout and design process
7.	**Permanence and fostering a sense of belonging**	▪ Quality and durability of materials ▪ Quality of craftsmanship and equipment of buildings and open areas ▪ Attractive architecture ▪ Tenants' participation in the choice of urban-architectural layout and design process ▪ Using culturally specific design elements to encourage a sense of belonging
8.	**An architectural and landscape layout that enables monitoring and control**	▪ Housing typologies with private and semi-public courtyards ▪ Fewer apartments per common entrance/floor (division of the building into segments) ▪ Avoiding long, naturally unlit corridors ▪ Avoiding hidden places (passages and functionally undefined parts of the ground floor) ▪ Underground garages with controlled common entrance ▪ Monitoring of open spaces (parking and children's playgrounds) ▪ Appropriate lighting of open spaces ▪ Greenery that does not prevent surveillance (low vegetation along footpaths) ▪ Apartment for a janitor on the ground floor ▪ Equipment for monitoring and access control
9.	**Typological diversity**	▪ Combining different types of housing on the site (single-family/multi-family) ▪ Combining different types of tenure on the site (social renting and ownership) ▪ Combining different types of housing units on site
10.	**Visual diversity and a tenure blind design**	▪ Variety in building facades design (colors, materials, texture, details) ▪ Visual unrecognizability of residential buildings in various forms of tenure (social renting and ownership)
11.	**Contextuality**	▪ Compliance with the local tradition of housing patterns ▪ Respecting the urban and architectural values in context (if any)
12.	**Environmentally and climate-responsible design**	▪ Use of energy and materials from renewable sources ▪ Use of recycling (materials, water, etc.) ▪ Use of active solar systems ▪ Prevention of environmental pollution during all phases of the life cycle of the building ▪ Use of infrastructure and equipment to save energy and water in buildings and open spaces
13.	**Interior common spaces intended for the social integration of tenants**	▪ Common rooms (rooms for meetings, gatherings, education, etc.) ▪ Direct connection between common rooms and courtyard – ground floor level ▪ Circulation areas in the building adapted to the possibilities of communication between residents
14.	**Rationality and cost-effectiveness of architectural structure and construction system**	▪ Compactness and simplicity of the building form and envelope ▪ Design in accordance with the maximum permitted urban parameters ▪ Rationalization of apartment areas ▪ Rationalization of the common areas of the building ▪ Cost-effectiveness of construction techniques and technologies from the aspect of investment and maintenance

5. CONCLUSION

The practice of social housing provision, planning, design and construction in post-socialist Serbia is insufficiently developed and financially constrained, which is an obstacle to achieving the sustainable development goals proclaimed through the national housing policy and planning framework. Until today, the appropriate standards, rules and recommendations for social housing construction have not been adequately elaborated through relevant legislation to support these goals. The focus of this paper was on proposing new methodological bases for the architectural and urban design of sustainable social housing in Serbia, taking into account the scientific and professional reference literature, international guidelines and the results of previous studies on this subject in the national context.

Based on the relevant socio-cultural, environmental and economic goals, a conceptual methodological model with applicable general and specific criteria in architectural and urban design of sustainable social housing was proposed. The criteria were explained and systemized in accordance with their contribution to achieving multiple sustainability goals and in such a way as to enable immediate application in practice. This multicriteria model could be used as a framework for developing technical regulations in the domain of design, and in the evaluation of completed projects, but also for defining the basis of programs and design tasks for urban and architectural competitions for social housing in Serbia.

In future research, the set methodological framework could be used for sustainability assessment of the social housing programs and projects, both in Serbia and in countries with similar housing systems. The defined criteria could be further complemented and evaluated, including potential elaboration through the system of qualitative indicators and in accordance with the characteristics of different housing types and models.

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REFERENCES

1. UNECE, Guidelines on Social Housing. Principles and Examples, United Nations, New York and Geneva, 2006.
2. UNEP, Sustainable Solutions for Social Housing. Guidelines for project developers, 2013.
3. UNECE, Social Housing in the UNECE region. Models, Trends and Challenges, United Nations, Geneva, 2015.
4. UNECE, The Geneva UN Charter on Sustainable Housing. Ensure access to decent, adequate, affordable and healthy housing for all, 2015a.
5. G. Towers, Shelter is not enough. Transforming multy-storey housing, Bristol: The Policy Press, 2000.
6. A. Power, Hovels to High Rise. State Housing in Europe Since 1850, London: Taylor & Francis, 2005.
7. F. Wassenberg, "Large social housing estates: From stigma to demolition? ", Journal of Housing and the Built Environment, 19, pp. 223–232, 2004.
8. O. Newman, Defensible space - Crime Prevention Through Urban Design, New York: Macmillan, 1972.
9. R. L. H. Chiu, Sustainable development: A new perspective for housing development, The University of Hong Kong, 2003.
10. P. Reeves, An introduction to social housing, Elsevier, Oxford, 2005.

11. V. Milić, Urbanistički aspekti socijalnog stanovanja, Arhitektonski fakultet, Beograd, 2006.
12. J. Petrić, T. Njegić, "Some open issues of integration and ghettoisation within the framework of social housing: the examples of Serbia and Denmark", Proceedings of the fifth Balkan Architectural Biennale - BAB21 International Conference "Global village: shelter for resilient living", 9-10. December, Belgrade, 2022.
13. Zakon o stanovanju i održavanju zgrada "Službeni glasnik RS", br. 104/2016.
14. Nacionalna strategija socijalnog stanovanja "Službeni glasnik RS", br. 13/2012.
15. Nacionalna stambena strategija od 2020. do 2030. godine - Nacrt, https://mgsi.gov.rs/sites/default/files/Nacionalna%20stambena%20strategija_NACRT_1.pdf, accessed 07.03.2022.
16. Strategija održivog urbanog razvoja Republike Srbije do 2030. godine "Sl. glasnik RS", br. 47/2019.
17. T. Bajić, Kriterijumi u urbanističkom planiranju i projektovanju socijalnog stanovanja u Srbiji, doktorska disertacija, Arhitektonski fakultet Univerziteta u Beogradu, Beograd, 2017.
18. T. Njegić, "Prostorno-funkcionalni standardi socijalnog stanovanja u Srbiji: regulativa, praksa i percepcija korisnika", Arhitektura i urbanizam, No. 51, pp. 72-85., 2020.
19. U. Vesić, Energetska efikasnost modela materijalizacije objekata socijalnog stanovanja u Srbiji, doktorska disertacija, Beograd: Arhitektonski fakultet Univerziteta u Beogradu, 2015.
20. V. M. Čolić Damjanović, Unapređenje modela socijalnog stanovanja u Beogradu u okviru novih paradigmi planiranja i projektovanja, doktorska disertacija, Arhitektonski fakultet Univerziteta u Beogradu, Beograd, 2015.
21. Prostorni plan Republike Srbije od 2021. do 2035. godine – Nacrt, https://www.mgsi.gov.rs/sites/default/files/PPRS%20Nacrt.pdf, accessed 07.03.2022.
22. V. Đokić, Ž. Gligorijević, V. M. Čolić Damjanović, "Towards sustainable development of social housing model in Serbia – case study of Belgrade", Spatium, No. 34, pp. 18-26, 2015. https://doi.org/10.2298/SPAT1534018D
23. T. Bajić, Kriterijumi energetske efikasnosti u urbanističkom planiranju socijalnog stanovanja, in: Prostorni, ekološki, energetski i društveni aspekti razvoja naselja i klimatske promene, Posebna izdanja br. 78. M. Pucar, M. Nenković-Riznić, Eds. Beograd: IAUS, 2016, str. 259-286.
24. N. Petković-Grozdanović, B. Stoiljković, M. Shubenkov, "Location Criteria Relevant for Sustainability of Social Housing", MATEC Web of Conferences, vol. 73, TPACEE-2016, 2016.
25. G. L. Larsen, "An Inquiry Into the Theoretical Basis of Sustainability: Ten Propositions", in: Understanding the Social Dimension of Sustainability, J. Dillard, et al., Eds. London: Taylor&Francis, 2009, pp. 45-82.
26. R. L. H. Chiu, "Social sustainability, sustainable development and housing development. The experience of Hong Kong", in: Housing and social change: East–West perspectives. R. Forrest, J. Lee, Eds. London: Taylor&Francis, 2004, pp. 221-239.
27. G. Bramley, C. Brown, N. Dempsey, S. Power, D. Watkins, "Social Acceptability", in: Dimensions of the Sustainable City. M. Jenks, C. Jones, Eds. Dordrecht: Springer, 2010, pp. 105-128.
28. S. Woodcraft, T. Hackett., L. Caistor-Arendar, Design for Social Sustainability: a framework for creating thriving new communities, Young Foundation, UK. 2011.
29. S. Ancell, M. Thompson-Fawcett, "The social sustainability of medium density housing: A conceptual model and Christchurch case study", Housing Studies, 23(3), pp. 423- 442, 2008. https://doi.org/10.1080/02673030802029990
30. K. Williams, C. Dair, M. Lindsay, "Neighbourhood Design and Sustainable Lifestyles", in: Dimensions of the Sustainable City. M. Jenks, C. Jones, Eds. Dordrecht: Springer, 2010, pp. 183-214.
31. UN-HABITAT, Sustainable Housing for Sustainable Cities – A policy framework for developing countries, Nairobi: UN-HABITAT, 2012.
32. T. Bajić, K. Pantović, "Mogućnosti primene modularnih sistema u projektovanju održivog i klimatski odgovornog socijalnog stanovanja", Arhitektura i urbanizam, 33, pp. 42-59, 2011. https://doi.org/10.5937/arhurb1133042B
33. T. Schneider, J. Till, "Flexible housing: opportunities and limits", Arq, 9/2, pp. 157-166, 2005.
34. S. Kendall, J. Teicher, Eds., Residential Open Building, London and New York: E&FN Spon, 2002.
35. M. Lojanica, "Stan se koristi i menja", in: Stanovanje 1, Posebna izdanja 5, Beograd: IAUS, 1975.
36. M. Jovanović-Popović, Zdravo stanovanje, Beograd: Arhitektonski fakultet Univerziteta u Beogradu, 1991.
37. M. Pitt, Linking Social Housing and Energy Efficiency. CRPN Research Report, Toronto: Social Houses Services Corporation, 2007.
38. D. Lazarevski, Istraživanje „faktora oblika arhitektonskog objekta (u kontekstu energetskog bilansa), magistarski rad, Arhitektonski fakultet Univerziteta u Beogradu, Beograd, 1995.
39. A. Welch, K. Benfield, M. Raimi, A Citizen's Guide to LEED for Neighborhood Development: How to Tell if Development is Smart and Green, New York: Natural Resources Defense Council, 2011.
40. N. Bailey, A. Haworth, T. Manzi, P. Paranagamage, M. Roberts, Creating and Sustaining Mixed Income Communities: A Good Practice Guide, Coventry/York: Chartered Institute of Housing/Joseph Rowntree Foundation, 2006.

41. B. Manić, T. Bajić, A. Niković, "Urbana obnova u kontekstu klimatskih promena, na primeru prenamene kompleksa kasarne u Beloj Crkvi", Arhitektura i urbanizam, 40, str. 24-36, 2015. https://doi.org/10.5937/a-u0-7938
42. S. Goldsmith, Designing for the Disabled: The New Paradigm, London: Architectural Press, 1997.
43. R. Imrie, P. Hall, Inclusive design, London: Taylor&Francis, 2004.
44. R. Imrie, Accesible housing, London: Taylor&Francis, 2006.
45. UNECE, Housing for special groups. Proceedings of an international seminar organized by the Committee on Housing, Building and Planning of the United Nations Economic Commission for Europe, and held in The Hague, at the invitation of the Government of the Netherlands, 8-13 November 1976, Oxford: Pergamon Press for UN, 1977.
46. P. Stollard, Ed., Crime Prevention Through Housing Design, London: E&FN Spon, 2005.
47. E. Talen, Design for Diversity. Exploring Socially Mixed Neighborhoods, Oxford: Elsevier, 2008.
48. T. Bajić, B. Manić, "Stanovanje u mešovitoj svojini: urbanistički aspekti i iskustvo novije stambene prakse u Srbiji", Arhitektura i urbanizam, 47, pp. 25-36, 2018. https://doi.org/10.5937/a-u0-19813

KREIRANJE ODRŽIVIJEG SOCIJALNOG STANOVANJA U SRBIJI: KONCEPTUALNI OKVIR ZA ARHITEKTONSKO I URBANISTIČKO PROJEKTOVANJE

Osnovni istraživački problem prepoznaje se u nedovoljnoj primeni kriterijuma održivosti u urbanističkoj i arhitektonskoj praksi realizacije programa i projekata za socijalno stanovanje u postsocijalističkoj Srbiji, što može doprineti kreiranju neadekvatnog i nekvalitetnog novog stambenog fonda. U ovom radu naglašava se značaj integralnog razmatranja socijalnog, ekonomskog i ekološkog aspekta održivog razvoja u daljem razvoju postojećeg, izrazito rezidualnog sistema socijalnog stanovanja, sa težištem na unapređenju smernica, pravila i parametara u domenu projektovanja. Na osnovu analize naučnih saznanja, primenljivih modela i međunarodnih preporuka, obavljena je identifikacija, sistematizacija i interpretacija relevantnih kriterijuma u arhitektonskom i urbanističkom projektovanju održivog socijalnog stanovanja. Definisanje konceptualnog višekriterijumskog okvira ima za cilj da doprinese unapređenju metodoloških pristupa u projektovanju i evaluaciji naselja i objekata za socijalno stanovanje u Srbiji kao i srodnim stambenim sistemima.

Ključne reči: s*ocijalno stanovanje, održivost, arhitektonsko i urbanističko projektovanje, konceptualni višekriterijumski okvir, Srbija*

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ANALYSIS OF 3D MULTI-STOREY BUILDING NUMERICAL MODELS INCLUDING FLOOR SLABS AND SHEAR WALLS DEPENDING ON THE CONNECTION TYPE IN THE STEEL STRUCTURE

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Aleksandra Cilić, Danijela Đurić Mijović, Vuk Milošević

Faculty of Civil Engineering and Architecture, University of Niš, Serbia

Abstract. *Multi-storey steel buildings are usually designed with rigid connections between beams and columns or with simple hinged connections and a stiffening system. The paper focuses on the 3D structural design of multi-storey steel buildings including floor slabs and shear walls. The method of numerical modelling has been applied to investigate the influence of rigid connections between certain structural elements on the lateral stiffness of the multi-storey building structure, when floor slabs and shear walls are considered in the structural design. Four building heights and six structural system types, having the same floor plan have been examined. 3D numerical models have been configured in FEM software to evaluate the lateral stiffness of the structures exposed to gravity and seismic loads. The maximum horizontal deflections and natural periods of vibrations are presented in the paper. It has been concluded that the connection type in the multi-storey steel structure has no significant influence on the lateral stiffness of the structure when structural design considers floor slabs and shear walls.*

Key words: *multi-storey buildings, shear walls, floor slabs, lateral stiffness, connections, steel structures*

1. INTRODUCTION

Supporting the steel structure of multi-storey buildings can be designed by using a large number of structural systems [1]. Multi-storey steel buildings usually consist of beams and columns, either rigidly connected (moment resisting frames) or having simple end connections along with diagonal bracing to provide the lateral stability [2]. Both groups of systems are equally applicable for buildings up to 30 storeys high, knowing that the most of

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Corresponding author: Aleksandra Cilić, University of Niš, Faculty of Civil Engineering and Architecture, Aleksandra Medvedeva 14, 18000 Niš, Serbia
e-mail: aleksandra.cilic@gaf.ni.ac.rs

the typical multi-storey steel buildings such as schools, universities, residential buildings, office buildings, hospitals, etc. have been built in hinged or rigid structural systems.

Even though a multi-storey building is three-dimensional and in addition to beams and columns contains floor slabs and walls, the structural strength provided by walls and slabs is usually neglected while modelling the building structure and it is commonly designed as a pure skeletal structure. However, consideration of walls and slabs in three-dimensional models of multi-storey buildings improves the lateral stiffness, which leads to a more economical structural design [3].

Reinforced concrete shear walls are vertical structural components with generally high stiffness and strength that increase the buildings' lateral resistance against horizontal loads [4]. Stiffness is one of the three basic parameters that significantly influences the behavior of structures during earthquakes, besides carrying capacity and ductility. The stiffer the structure, the less it deflects under a seismic force, although a smaller natural period of vibration caused by a stiffer structure will usually result in a structure attracting a greater seismic force [5]. Stiffness directly depends on the type of structural system and it affects the values of the natural period of vibrations. The response of the structure to the effect of the dynamic load depends primarily on the value of the natural period of vibrations.

In addition, stiffness significantly affects the structural deformation. If a structure's stiffness is so low that it deflects excessively, its non-structural elements will suffer damage [5]. High values of horizontal forces, especially the seismic forces, in cases of buildings with greater heights, may disturb their stability and safety of people staying in them. Earthquakes show that the behavior of stiffer structures (with shear walls), on average, is better than the behavior of flexible systems (pure skeletal structure). The deformations of the stiffer system are smaller than the flexible system deformation and therefore the damage to non-structural elements in a building is smaller. Bearing in mind that the building structure has a lower cost than non-structural elements, destroying all non-structural elements in a flexible system means a considerable economic loss, although the structure is not physically destroyed. There is no doubt that the structures with reinforced concrete shear walls can not be sufficiently ductile, so a large number of experts in seismic construction considers that it is better to build structures with greater stiffness in the seismic areas [6].

In most cases, multi-storey buildings have walls around elevator and stairway cores. These walls, especially when they are made of reinforced concrete, provide a considerable lateral stiffness that resists horizontal forces. For tall buildings, centrally located reinforced concrete shear wall systems are typically used as the main seismic force resisting system [7]. Furthermore, floor slabs participate in the whole system by accepting the horizontal forces and transferring them to the vertical system. Research on the topic related to walls and/or slabs has been conducted by many authors such as [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [3]. These studies have shown that consideration of walls and floor slabs plays an important role in the design of multi-storey building structures. These important parts of a building contribute to greater lateral stiffness, thereby creating a more economical design.

2. THE SUBJECT AND THE AIM OF THE RESEARCH

The paper focuses on multi-storey steel buildings having height up to 25 storeys, exposed to gravity loads and seismic forces of seismic intensity VIII. Six structural system types of steel buildings having the same floor plan with the central reinforced concrete core, and four different heights of 10, 15, 20 and 25 storeys, have been examined. These

systems differed by the selected type of connection between the structural elements, hinged or rigid, or their disposition in the structural system of the building. The systems with exclusively hinged or rigid connections have been analyzed, as well as the combined systems with a different arrangement of the hinged and rigid connection between the structural elements.

The aim of this study is to investigate whether the use of rigid connections between certain structural elements may increase the lateral stiffness of the whole structure, when the structural design considers floor slabs and shear walls of the central reinforced concrete core. The assumption is that the rigid connections will not contribute much to the lateral stiffness of the system in this case, which would give priority to hinged connections. Hinged connections have a number of benefits. Among them, unification of beams in floors and standardization of joints in the structure are very important for tall buildings.

The use of standardized joints where the fittings, bolts, welds and geometry are fully defined offers the following benefits [18]: reduces buying, storage, and handling time; improves availability and leads to a reduction in material costs; saves fabrication time and leads to faster erection; leads to a better understanding of their performance by all industrial branches ; leads to fewer errors.

Bearing in mind that multi-storey buildings are not pure skeletal systems, but complex systems composed of beams and columns, floor slabs, foundation slab and shear walls, three-dimensional numerical models have been configured for all examined systems. In this way, the behavior of the structure under load has been analyzed as a spatial system and interaction of all significant elements of the structure has been covered. It can be considered that the results obtained are more accurate than in the conventional design.

The maximum horizontal roof deflections and natural periods of vibrations are presented in the paper. Based on these parameters of structural stiffness, the conclusions of this paper have been drawn. Also, based on the results obtained, the recommendations for more economical systems have been given.

3. The Numerical Models

3.1. Structural System Types

Six structural system types were examined for all the building heights. The model labels with the appropriate system type are given below.

MODEL 1 – The system with rigid connections between all structural elements (Fig. 1);
MODEL 2 – The system with rigid connections, except hinged connection between columns and foundation slab (Fig. 2);
MODEL 3 – The systems with rigid connections between beams and columns and hinged connections between columns and foundation slab and beams and central core (Fig. 3);
MODEL 4 – The system with hinged connections between beams and columns and rigid connections between columns and foundation slab and beams and central core (Fig. 4);
MODEL 5 – The system with hinged connections except rigid connection between columns and foundation slab (Fig. 5);
MODEL 6 – The system with hinged connections between all structural elements (Fig. 6).

The following Fig. 1-6 show an internal frame and a frame including core wall for the systems having height of 10 storeys. The systems having height of 15, 20 and 25 storeys have the same arrangement of rigid and hinged connections as the 10 storey models.

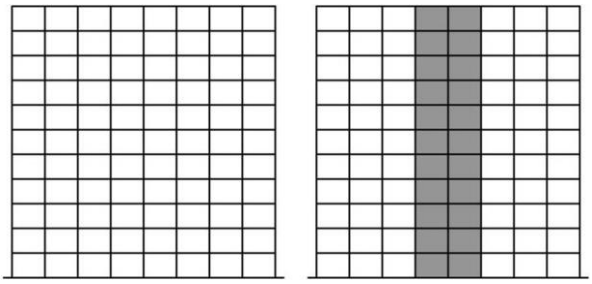

Fig. 1 An internal frame and a core wall frame in Model 1

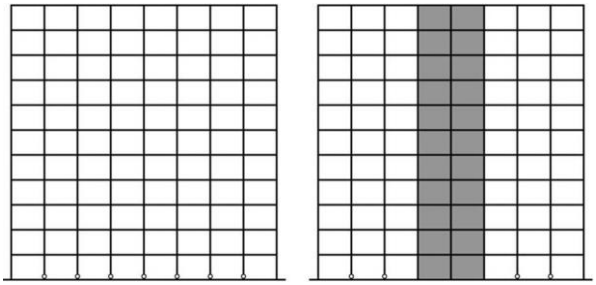

Fig. 2 An internal frame and a core wall frame in Model 2

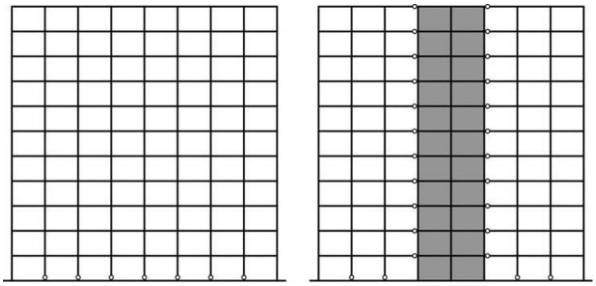

Fig. 3 An internal frame and a core wall frame in Model 3

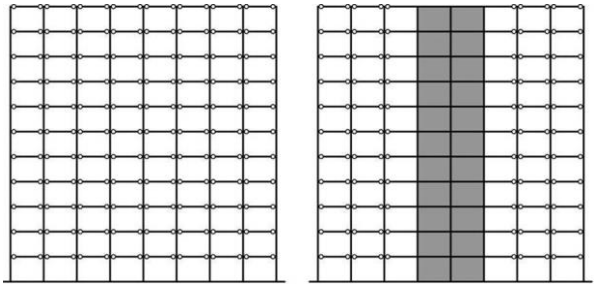

Fig. 4 An internal frame and a core wall frame in Model 4

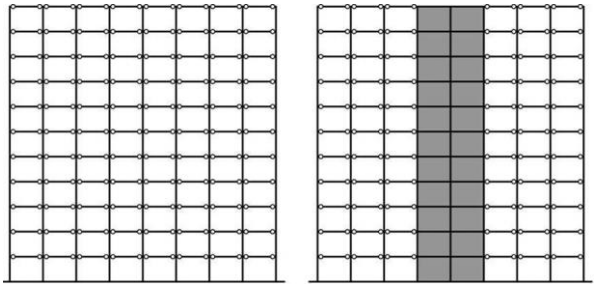

Fig. 5 An internal frame and a core wall frame in Model 5

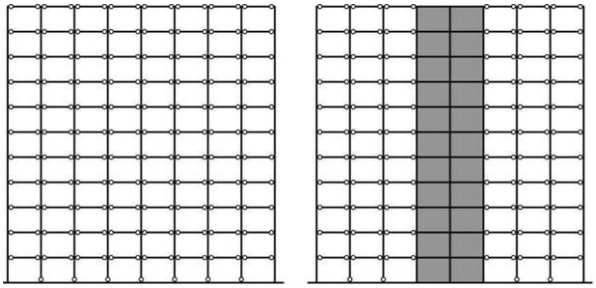

Fig. 6 An internal frame and a core wall frame in Model 6

3.2. Model Description

In this research the method of numerical modelling was applied, using a FEM computer software [19], to investigate the behavior of the structures. Three-dimensional models have been configured for all structural systems.

The analysis was done for the buildings of four heights: 10 storeys (30m), 15 storeys (45m), 20 storeys (60m) and 25 storeys (75m). For each of the four heights, six models have been designed according to defined structural system types. Total number of models is 24. All the designed models contain supporting steel structure, reinforced concrete core walls, reinforced concrete floor slabs, reinforced concrete foundation slab on elastic foundation and outer reinforced concrete basement walls. The models do not contain partition walls, stairways and landings and the façade structure (it is assumed that the façade type is a curtain wall).

All numerical models have identical floor plan, with the total area of 32 x 32 m. The Fig. 7 shows the disposition of columns, beams and reinforced concrete core. Distance between columns in both orthogonal directions is 4 m. All beams in the analyzed models have the same rank, there are no secondary beams. Reinforced concrete core occupies the central part of the building and runs continuously through all floors. The core was modelled as a hollow tube. The walls of the core are 25 cm thick.

Floor slabs were modelled as monolithic reinforced concrete slabs 12 cm thick. Cross-sections for all beams are IPE 200 profiles, and all cross-sections for columns are IPB profiles. The cross-sections of the columns gradually change at every 3-4 storeys. The largest cross-sections of the columns in the basement floor are given in the Table 1.

The outer walls of the basement floors are reinforced concrete walls having thickness of 50 cm. The foundation structure is 1 m thick reinforced concrete foundation slab.

Table 1 Design parameters

Parameter	Value
Plan Area	32 x 32 m
Storey Height	3 m
Floor Slabs	Concrete C30; 0.12 m thick
Foundation Slab	Concrete C30; 1.0 m thick
Core Walls	Concrete C30; 0.25 m thick
Basement Walls	Concrete C30; 0.50 m thick
Beams	Steel S235; IPE 200
Columns	Steel S235; 10 storeys IPB (HE-B) 260
(maximum cross-section)	Steel S235; 15 storeys IPB (HE-B) 340
	Steel S235; 20 storeys IPB (HE-B) 450
	Steel S235; 25 storeys 2IPBv (HE-M) 450

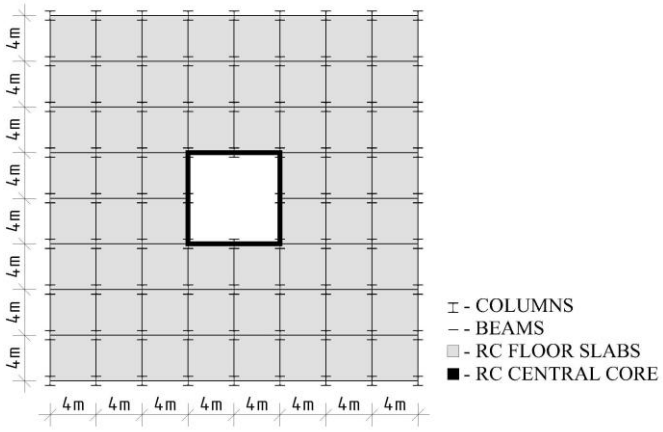

Fig. 7 Common plan view of the examined models

The storey height of each storey is 3 m. The analyzed buildings have one or two basement levels depending of the building height. All steel elements were designed of steel S235 and all reinforced concrete elements were designed of concrete class C30.

Considering the possibilities of the applied software, three types of finite elements were used: plate, beam and boundary. Plate finite elements were used for modelling of walls and slabs in order to consider both membrane and bending stiffness. Beam finite elements were used for modelling of beams and columns.

3.3. Material Properties

Two kinds of materials were used for modelling the building structures. Steel S235 was used for skeletal structure, and concrete C30 for walls, floor slabs and foundation slabs. The properties of these materials are given in the Table 2.

Table 2 Material properties

Material	Properties
Steel S235	f_e=235 MPa E=210 GPa ρ=7850 kg/m^3 ν =0.3
Concrete C30	f_c=30 MPa E=31.5 GPa ρ=2500 kg/m^3 ν=0.2

3.4. Loading Data

In all analyzed models both gravity loads and the lateral seismic load were taken into account. The software calculates the self-weight of the modelled structure automatically. The intensities of dead and imposed floor loads were taken according to reference [20]. The intensity of the dead floor load applied is 2.5 kN/m^2, and the intensity of the imposed floor load, according to the type of occupancy of the building is 2.0 kN/m^2. Also, applied load of the façade weight is 10 kN/m (façade walls were not modelled, curtain wall façade was assumed).

The design of seismic forces was done according to reference [21], using the Method of Equivalent Static Loads for the level of seismicity VIII (MCS scale). As the standards require, the seismic forces were calculated for two orthogonal directions.

4. THE NUMERICAL INVESTIGATION

The design of the models in this paper was done according to references [22] and [23].

The total number of models which were configured according to the defined structural types, loads and materials is 24. For each of four building heights six models were designed. The eigenvalue analysis was performed to determine natural periods of vibration for all numerical models. Then all models were analyzed under the seismic load.

The maximum horizontal deflections and natural periods of vibrations are presented in the paper. Based on these parameters, the conclusions of this research were drawn.

For all the building heights, first the system with rigid connections between all structural elements (Model 1) was designed to accept only the gravity loads. Then the eigenvalue analysis was done and the natural periods of vibrations (T_{1X} and T_{1Y}) were calculated. After that seismic forces were calculated for two orthogonal directions with corresponding values of natural periods.

The total horizontal seismic force S is determined by the equation (1):

$$S = K \cdot G \tag{1}$$

where G is the total weight of the building and equipment and K is the total seismic coefficient for the horizontal direction, given by the equation (2):

$$K = K_o \cdot K_s \cdot K_d \cdot K_p \tag{2}$$

Calculation of the total seismic coefficient was done with the following values of the individual coefficients:

- Coefficient of object categories, Category II, $K_o = 1.0$;
- The coefficient of seismic intensity of VIII seismicity zone, $K_s = 0.05$;
- The dynamic coefficient, for the first category of soil, $K_d = 0.5/T$, with the limit values $1.0 > K_d > 0.33$;
- Ductility and damping coefficient, K_p=1.3.

The total horizontal seismic force was distributed at the height of the building as follows. Amount of 15% of the total seismic force was concentrated on the top of a building and 85 % was distributed in other floors by equation (3):

$$S_i = S \cdot \frac{G_i \cdot H_i}{\sum_{i=1}^{n} G_i \cdot H_i} \tag{3}$$

where S_i is the seismic force in i-floor, G_i is the weight of i-floor and H_i is the height of i-floor from the upper edge of the foundation slab.

Due to the effects that the horizontal deflections of the building have on the comfort of the building's users and also on the functional aspects of the building, during an earthquake, a stricter criterion than in the standards has been defined for the control of the maximum horizontal deflection, with the value of H/1000, where H is the height of the building.

During the design of 3D models to the effects of the seismic load, the state of stress, strain and stability of individual steel elements and the maximum horizontal deflections of the structure were controlled. Besides, the natural periods of vibrations, as an important indicator of stiffness, were tested too.

After designing the system with rigid connections (Model 1), the 3D models of the remaining five systems (Models 2 - 6) were designed respectively for all the heights, by replacing certain rigid connections in Model 1 with hinged connections. Replacing was done in the software [19] by releasing the connection from the reception of the bending moment M_z around the stronger axis – z. These models retained the same dimensions of all structural elements as in Model 1, for the purpose of credible comparison of the results obtained. For all models, natural periods of vibrations and the seismic forces were calculated as for the Model 1.

After analyzing the results obtained, it was found that for all systems tested, for all the heights, the state of stress and strain was within acceptable limits, although identical cross-sections were kept as in the systems with rigid connections.

5. Results and Discussion

In order to compare the results obtained for different models of the buildings with the same height, in the paper the maximum horizontal deflections D [cm] and natural periods of vibrations T_1 [s] are presented. These parameters are very good indicators of structural performance. Results are presented in the Table 3.

The Table 3 shows that periods of free vibration have expected values which increase with the height rise. The results also show that the differences of natural periods of vibrations between the tested systems having the same height, are extremely small. Precisely, for the systems having the height of 10 storeys, natural periods of vibrations

are in the range from 0.9895 s for the system with rigid connections (Model 1) up to 1.002 s for the system with hinged connections (Model 6). The difference ΔT_1, shown in Table 4, between these two systems is only 0.0125 s (1.25 %).

Table 3 Results of the research for all the models

Model	Storeys/ height	Parameters		Relation $D_{max} \sim H$
		Natural period of vibration T_1 [s]	Maximum horizontal deflection D_{max} [cm]	
Model 1	10	0.9895	2.379	H/1261
	15	1.6897	4.245	H/1060
	20	1.9390	5.414	H/1108
	25	2.1040	7.243	H/1035
Model 2	10	0.9896	2.380	H/1261
	15	1.6899	4.248	H/1059
	20	1.9400	5.417	H/1108
	25	2.1050	7.258	H/1033
Model 3	10	0,9901	2.382	H/1259
	15	1.6920	4.259	H/1057
	20	1.9410	5.416	H/1108
	25	2.1100	7.308	H/1026
Model 4	10	1.0010	2.438	H/1231
	15	1.7510	4.676	H/962
	20	1.9730	5.694	H/1054
	25	2.1340	7.629	H/983
Model 5	10	1.0020	2.439	H/1230
	15	1.7530	4.688	H/960
	20	1.9750	5.693	H/1054
	25	2.1440	7.668	H/978
Model 6	10	1.0020	2.440	H/1230
	15	1.7530	4.692	H/959
	20	1.9750	5.696	H/1053
	25	2.1450	7.685	H/976

For the systems having height of 15 storeys, natural periods of vibrations are in the range from 1.6897 s for the system with rigid connections (Model 1) up to 1.753 s for the system with hinged connections (Model 6). The difference ΔT_1 between these two systems is only 0.0633 s (3.61 %), which is shown in the Table 4.

Table 4 Differences between hinged systems (Model 6) and rigid systems (Model 1)

Height / Storeys	Difference ΔT_1 [s]	Difference ΔT_1 [%]	Difference ΔD [mm]	Difference ΔD [%]
10	0.0125	1.25	0.61	2.50
15	0.0633	3.61	4.47	9.53
20	0.0360	1.82	2.82	4.95
25	0.0410	1.91	4.42	5.75

For the systems having height of 20 storeys, natural periods of vibrations are in range from 1.939 s for the system with rigid connections (Model 1) up to 1.975 s for the system with hinged connections (Model 6). The difference ΔT_1 between these two systems is only 0.036 s (1.82 %), also shown in the Table 4.

For the systems having height of 25 storeys, natural periods of vibrations are in range from 2.104 s for the system with rigid connections (Model 1) up to 2.145 s for the system with hinged connections (Model 6). The difference ΔT_1 between these two systems is only 0.041 s (1.91 %), Table 4.

The results in the Table 3 also show that the differences of the deflections between the tested systems with the same height are very small. For the systems having height of 10 storeys the maximum horizontal deflections are in range from 2.379 cm for the system with rigid connections (Model 1) up to 2.440 cm for the system with hinged connections (Model 6), so that the maximum difference ΔD which occurs between these completely opposite systems according to types of connections in the structure, is only 0.061 cm (2.5%), Table 4.

For the systems having the height of 15 storeys the maximum horizontal deflections are in the range from 4.245 cm for the system with rigid connections (Model 1) up to 4.692 cm for the system with hinged connections (Model 6). The maximum difference ΔD which occurs between these completely opposite systems according to types of connections in the structure is only 0.447 cm (9.53 %), Table 4.

For the systems having the height of 20 storeys the maximum horizontal deflections are in the range from 5.414 cm for the system with rigid connections (Model 1) up to 5.696 cm for the system with hinged connections (Model 6). The maximum difference ΔD which occurs between these completely opposite systems according to types of connections in the structure is only 0.282 cm (4.95 %), Table 4.

For the systems having the height of 25 storeys the maximum horizontal deflections are in range from 7.243 cm for the system with rigid connections (Model 1) up to 7.685 cm for the system with hinged connections (Model 6). The maximum difference ΔD which occurs between the completely opposite systems according to types of connections in the structure is only 0.442 cm (5.75 %), Table 4.

6. CONCLUSIONS

Many authors have shown that the inclusion of walls and slabs in the structural design leads to a more economical structure. Material cost for connections in the structure can significantly affect the price of the whole structure. In a typical braced multi-storey frame, the share of joints may account for less than 5 % of the frame weight, but 30 % or more of the total cost. Efficient joints will therefore have the lowest detailing, fabrication and erection labour content [18].

In this research the method of numerical modelling has been applied to investigate the influence of rigid connections between certain structural elements on lateral stiffness of the multi-storey steel building structure, when structural models contain floor slabs and shear walls. Four building heights and six structural system types having the same plane view have been examined. Three-dimensional numerical models have been configured in FEM software [19] to assess lateral stiffness of the structures exposed to gravity and seismic loads. Static and free vibration analyses have been performed. The maximum horizontal deflections due to seismic action and natural periods of vibrations, have been used to draw reliable conclusions.

In all the models analyzed, for all the building heights, the unification of beams has been accomplished. The results show that the values obtained for the natural periods as well as for the maximum horizontal deflections are very similar for the systems having the same height. The analysis results given in the Table 3 clearly show that differences of

natural periods of vibration and maximum horizontal deflections between the analyzed systems with the same height are extremely small. These values are such that, practically, can be neglected, because the differences between fully hinged (Model 6) and fully rigid system (Model 1), as totally opposite systems according to the type of connections, are also negligible, Table 4. This has been confirmed for all the analyzed building heights. Based on these results, it can be concluded, that the application of rigid connections in the systems that contain reinforced concrete shear walls in the form of the central core and reinforced concrete floor slabs, did not increase the lateral stiffness of the system, and also did not cause a significant reduction of the maximum horizontal deflection.

This is an important conclusion, because the design of joints in steel structures is a complex and time-consuming task. The type of connections has an impact not only on the static system of the structure and its behavior, but also on its economy. So, already at the stage of their design, an easy setup of basic elements and fast construction works should be provided. These requirements can be achieved only by using a simple supporting systems with hinged connections, whenever possible, which also allow the unification of beams in floors, standardization of joints in the structure and less consumption of steel. When rigid connections are in question, it is necessary to predict specific structural elements to ensure the transfer of the bending moment. Rigid connections are more complex and require higher consumption of steel and construction time.

Considering the established fact in this research, that rigid connections did not improve the lateral stiffness of the steel building structure, in the systems that contain reinforced concrete shear walls and floor slabs [24], the main conclusion of this paper can be drawn:

- The type of applied connections between the structural elements, rigid or hinged, as well as their different arrangement in the structure, has no significant influence on the lateral stiffness of the steel building structure, if the reinforced concrete core and floor slabs are considered in the structural design. Therefore it can be concluded that the
- Systems with hinged connections, because of their simplicity and other benefits stated in the paper, have significant advantage compared to the systems with rigid connections, for all the analyzed building heights, and they can be recommended for economical design.
- Contemporary calculation methods, based on FEM and engineering software enable reliable and relatively easy modelling and calculation of complex structural systems that include as line, as well as plate structural elements, and such modelling is highly recommended, since it gives more reliable and cost-effective steel structures, especially regarding the connections.

REFERENCES

1. F. Hart, W. Hen and H. Sontag, "Multi–Storey Buildings in Steel", Granada Publishing, London, 1978.
2. C. G. Salmon and J. E. Johnson, "Steel Structures, Design and Behavior. Prentice", Hall. Inc., New Jersey, 1996.
3. M. Jameel, A. B. M. S. Islam, R. R. Hussain, M. Khaleel and M. M. Zaheer, "Optimum structural modelling for tall buildings", The Structural Design of Tall and Special Buildings 22(15), 2013, pp. 1173-1185. DOI: 10.1002/tal.1004
4. H. L. Sadraddin, X. Shao and Y. Hu, "Fragility assessment of high-rise reinforced concrete buildings considering the effects of shear wall contributions", The Structural Design of Tall and Special Buildings 25(10), 2016, DOI: 10.1002/tal.1299
5. A. Charleson, "Seismic Design for Architects", Elsevier, Amsterdam, 2008.
6. D. Anicic, P. Fajfar, B. Petrovic, A. Szavits–Nossan and M. Tomazevic "Zemljotresno inzenjerstvo-Visokogradnja", DIP Gradjevinska knjiga, Beograd, 1990.

7. Z. T. Deger, T. Y. Yang, J. W. Wallace and J..Moehle, "Seismic performance of reinforced concrete core wall buildings with and without moment resisting frames", The Structural Design of Tall and Special Buildings 24(7), 2015, pp. 477-490, DOI: 10.1002/tal.1175
8. H. A.Toutanji, "The effect of foundation flexibility on the interaction between shear walls and frames", Engineering Structures 19, 1997, pp. 1036-1042.
9. M. J. Nollet and B. S. Smith, "Stiffened-story wall-frame tall structure", Computers and Structures 66, 1998, pp. 225–240.
10. S. S. Al-Mosawi and M. P. Saka, "Optimum design of single core shear walls", Computers and Structures 71**,** 1999, pp. 143-162.
11. Q. Wang, L. Wang and Q. Liu, "Effect of shear wall height on earthquake response" Engineering Structures 23, 2001, pp. 376-384.
12. D. G. Lee, H. S. Kim and M. H.. Chun, "Efficient seismic analysis of high-rise structures with the effects of floor slabs", Engineering Structures 24, 2002, pp. 613-623.
13. L. P. B. Madsen, D. P. Thambiratnam and N. J. Perera, "Seismic response of structures with dampers in shear walls", Computers and Structures 81, 2003, pp. 239-253.
14. D. G. Lee, S. K. Ahn and D. K. Kim, "Efficient seismic analysis of structure including floor slab", Engineering Structures 27, 2005, pp. 675-684.
15. T-W. Kim and D. A. Foutch, "Application of FEMA methodology to RC shear wall buildings governed by flexure", Engineering Structures 29, 2007, pp. 2514-2522.
16. M. M. Kose, "Parameters affecting the fundamental period of RC buildings with infill walls" Engineering Structures 31, 2009 pp. 93-102.
17. S. Sabouri-Ghomi and B. Payandehjoo, "Investigating the effect of stiffness and strength of each component on overall stiffness and strength of yielding damped braced core (YDBC)", The Structural Design of Tall and Special Buildings 20 (7), 2011, pp. 747-756.
18. Steel Buildings in Europe, Multi–Storey Steel Buildings Part 5: Joint Design, Framework of the European project Facilitating the market development for sections in industrial halls and low rise buildings (SECHALO) RFS2–CT–2008–0030, Arcelor Mittal, Peiner Träger and Corus, 2008.
19. Radimpex. 1999. Tower - Graphical program for static and dynamic structural analysis of planar and space structures and design of concrete, steel and timber structures. Radimpex Software, Belgrade.
20. Institute for Standardization of Serbia, SRPS U.C7.121, Imposed Loads of Residential and Public buildings, ISS, Belgrade, 1988.
21. Institute for Standardization of Serbia, Serbian Rules of Technical Standards for Construction of Buildings in Seismic Areas, ISS, Belgrade, 1981.
22. Institute for Standardization of Serbia, SRPS U.E7.081, 086, 091, 096, 101, 111, 121, Stability of Steel Structures, ISS, Belgrade, 1986.
23. Institute for Standardization of Serbia, BAB ’87. Serbian Rules of Technical Standards for Concrete and Reinforced Concrete, ISS, Belgrade, 1987.
24. A. Cilic, "Global Stability of Multi-Storey Steel Building Structures in the Function of Support Connection Design", PhD Thesis, Faculty of Civil Engineering and Architecture, University of Nis, Serbia, 2015.

ANALIZA 3D NUMERIČKH MODELA VIŠESPRATNIH ZGRADA KOJI SADRŽE MEĐUSPRATNE PLOČE I SMIČUĆE ZIDOVE U ZAVISNOSTI OD TIPA VEZA U ČELIČNOJ KONSTRUKCIJI

Višespratne čelične zgrade obično se projektuju sa krutim vezama između greda i stubova ili sa zglobnim vezama i sistemom za ukrućenje. Rad je fokusiran na 3D proračun višespratnih čeličnih zgrada koji uključuje međuspratne ploče i smičuće zidove. Primenjen je metod numeričkog modelovanja da bi se istražio uticaj krutih veza između određenih nosećih elelmenata na bočnu krutost višespratne konstrukcije, kada se pri proračunu uzimaju u obzir međuspratne ploče i smičući zidovi. Testirano je šest nosećih sistema koji imaju isti raspored elemenata u osnovi za četiri različite visine. Formirani su 3D numerički modeli u MKE softveru kako bi se procenila bočna krutost konstrukcija izloženih gravitacionom i seizmičkom opterećenju. U radu se prezentovani maksimalni horizontalni ugibi i periodi sopstvenih oscilacija. Zaključeno je da tip veza u višespratnoj čeličnoj konstrukciji nema većeg uticaja na bočnu krutost konstrukcije kada proračun uzima u obzir postojanje međuspratnih ploča i smičućih zidova.

Ključne reči: *višespratne zgrade, smičući zidovi, međuspratne ploče, bočna krutost veze, čelične konstrukcije*

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Review Paper

CONTEMPORARY ARCHITECTURE OF SERBIAN ORTHODOX TEMPLES: IMPROVING THE INSTITUTION OF THE STUDENT ARCHITECTURAL COMPETITION FOR A TEMPLE THROUGH PRE-DEFINED EVALUATION CRITERIA

UDC 726.1:378.32

Mirko Stanimirović, Miomir Vasov,
Ana Momčilović-Petronijević, Hristina Krstić

University of Niš, Faculty of Civil Engineering and Architecture, Serbia

Abstract. *Within the topic of architectural design of a contemporary Serbian Orthodox temple, student competitions have been held for a few years at the Faculty of Civil Engineering and Architecture in Niš. The research of the current phenomenon of the contemporary Serbian temple through the innovation of competition practice directly advances the architectural science. The main goal of the work is to improve the institution of the competition through pre-defined evaluation criteria, which belong to the fields of architectural design, history and theory of architecture, but also to the teachings of the Serbian Orthodox Church.*
This paper documents the student competition for the memorial temple on Delijski Vis in Niš. In accordance with the design principles, the students' works and the results of their evaluations were analyzed. In the first part of the paper, the points awarded by the expert jury were presented. In the second part, the works are analyzed according to design principles. In the third part, in the synthesis of the research, the results of the first and second part of the research were compared by a comparative analysis. In the discussion, based on the discrepancy between the results of the first and second groups, it was concluded that it is necessary to define in advance the categories that the jury would evaluate in the evaluation phase. Candidates should receive the evaluation framework in the competition announcement. Since the members of the jury are not only architects, it is necessary to provide for areas from several disciplines, so that the candidate's answer is more comprehensive. In the conclusion of the work, specific evaluation criteria were proposed, created through the transformation of design principles.

Key words: *competition for a temple, sacral architecture*

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Corresponding author: Mirko Stanimirović, University of Niš, Faculty of Civil Engineering and Architecture, Aleksandra Medvedeva 14, 18000 Niš, Serbia
e-mail: wireframe22@gmail.com

1. INTRODUCTION

The scientific justification of the research of modern Serbian sacral architecture is based on the social need to define the architectural freedom in creating a modern Serbian Orthodox temple, in order to improve the architectural science and practice in accordance with the requirements of the modern architectural theory and practice. The constant enlargement of buildable areas of big cities in Serbia requires the construction of new temples, so that believers can visit them within their residential communities. According to planning norms, a medium-sized temple (up to 500 m2) should be placed in the centre of a community of 10,000 inhabitants (not believers) [1]. From this need follows the topicality of modern sacral architecture in Serbia, whose population is of the Orthodox faith in 84% of cases.

Interest in research on the topics of the modern Serbian Orthodox temple is evident in the scientific literature at the end of the XX and the beginning of the XXI century [2-14]. Within this important architectural and social phenomenon, the role of student competitions has only just opened with a few papers [15]. We are of the opinion that it is necessary to significantly improve this topic, because architectural competitions are an increasingly common practice in the construction and planning of public buildings.

2. OBJECTIVE OF THE RESEARCH AND METHODS

The goal of the research is to improve the institution of the student architectural competition for the Orthodox temple at the Faculty of Civil Engineering and Architecture in Niš. The first part of the work documents the works of students, as part of the competition for the memorial temple on Delijski Vis in Niš, which was realized in the 2021/22 school year. The processes of the call for competition, the holding classes and the announcement of winners are described. In this part of the paper, the points of all participants, obtained in the evaluation phase of the expert jury, are presented. In the second part, the works are analyzed according to design principles, which students use within the topic of architectural design. Based on the processing of the database, graphs were created with the aim of a simpler comparison of the results obtained in the judging process and according to design principles. In the research synthesis (discussion), the results from both parts of the research were analyzed using a comparative method. Based on the discussion of the results, recommendations were made for the improvement of competition practice in the subject of "Sacral Architecture" at the Faculty of Civil Engineering and Architecture of the University of Niš.

In other words, success in the competition was measured using design principles. Recommendations for the improvement of the competition concern the publication of evaluation criteria, in accordance with the results of the above-mentioned comparison.

3. SACRAL ARCHITECTURE

Within the framework of architectural education, temples are researched on subjects from the field of history and theory of architecture and art, and within the framework of specialized subjects that exclusively deal with the design of sacral buildings or temples. In Serbia, specialization in this field exists at the Faculty of Technical Sciences, University

of Pristina and at the Faculty of Civil Engineering and Architecture, University of Niš. The subject "Sacral Architecture" at the Faculty of Niš officially became part of the study program in the field of Architecture in 2014. Its realization was realized in the school year 2018/19. According to the first syllabus, which was compiled in the accreditation phase by M. Vasov (PhD, assistant professor) and A. Momčilović-Petronijević (PhD, assistant professor), the aim of the course is to overcome special problems of designing sacral buildings. During the exercises, students realize the conceptual design of a sacral building, individually or in groups of up to two students. According to the more recent accreditation from 2020, compiled by M. Vasov (PhD, associate professor), M. Stanimirović (PhD, assistant professor) and A. Momčilović-Petronijević (PhD, associate professor) the aim of the course is to acquire the basic knowledge about sacral buildings and gain practical experience in the field of designing sacral buildings. The goal is also to overcome the special problems of designing Serbian Orthodox churches, because that topic is most often used in the history of this subject. According to the appropriate outcome of the course, students will be able to recognize and master the architectural and constructional specifics of the design of sacral buildings. In this way, three narrow scientific fields are connected, to which the mentioned teachers belong: design of architectural constructions, architectural design and history and theory of architecture and art. This setting is completely justified, because the students realize the conceptual solution of the sacral building in the exercises, which they present at the end in verbal and in the form of posters. Each sacral building represents a synthesis of theory and practice, which consists of the above areas.

Students who attended this elective course from 2019/20 had the opportunity to participate in student competitions, which were dedicated to the conceptual design of Orthodox churches in Niš. This institution of the competition was realized first through the cooperation of the Faculty of Civil Engineering and Architecture and the Orthodox Diocese of Niš. Later, the organization was joined by the City of Niš, the Cluster of Urban Planning and the Institute for the Protection of Cultural Monuments in Niš. The cooperation implied the joint shaping of the competition task, from the idea of where the Orthodox church would be built, to the judging of the competition works and the announcement of the awarded solutions. Representatives of the Faculty of Civil Engineering and Architecture in Niš are teachers of this subject, the authors of this paper. Representatives of the Diocese of Niš were delegated by His Eminence the Bishop of Niš, Mr. Arsenije, who also participated in the classes in the form of guest lectures. With his blessing, Archpriest Boban Stojković, a professor at the Prizren Theological Seminary in Niš, is a permanent member of the jury and a guest lecturer. Architect Elena Vasić Petrović was a member of the jury and a guest lecturer on behalf of the Institute for the Protection of Monuments. Architects Tanja Obradović (chief city urbanist) and Ana Kostić participated in the competition of 2021/22 on behalf of the City of Niš. A more detailed description of the subject "Sacred Architecture" and previous competitions in Niš was given by M. Stanimirović [15].

4. Competition for the Memorial Temple on Delijski Vis in Niš

At the beginning of the semester during 2022, students were presented with works realized within the competition for the temple in the settlement of Čalije in Niš, which was realized in 2020/21. Then, a call for tenders was submitted to them – the conceptual architectural and urban design of the building of the Orthodox memorial temple on

Delijski Vis. According to the announcement, the church should be designed in the spirit of Orthodoxy in Serbia, according to the rules of the Serbian Orthodox Church. The idea for the construction of a memorial temple at the "Old Military Cemetery on Delijski Vis" belongs to Archpriest Boban Stojković. The intention of Mirko Stanimirovic was to form an institution of competition that would be realized in the future, which was supported by the Orthodox Diocese of Niš, headed by His Holiness the Bishop of Niš, Mr. Arsenije. The main goal was to start negotiations with the leadership of the City of Niš, in order to realize the first-prize winning solution in this competition. Necessary and later elaborations of the conceptual solution would be realized by the teams of the Faculty of Civil Engineering and Architecture and the Diocese of Niš (general design and construction permit design) with the engagement of awarded authors. Further practical work on projects is not part of teaching this subject, but authors of this paper believe that practical experience is useful for future architects, so we wanted to improve the development of education of architects within our faculty in this way.

According to the decision of the Municipal Assembly of Niš from 1993, the memorial park "Old Military Cemetery on Delijski Vis" was declared an immovable cultural property – a landmark. It is located in the eponymous settlement of the city of Niš. It is thought that after the Balkan Wars of 1912 and 1913 burial continued during the First and Second World Wars. The cemetery was devastated after the war, and in 1988, the Yugoslav Army built 15 residential buildings on the plot of the cemetery. The current area of the memorial is 300 m^2, as opposed to the former area of 5 ha.

The beginning of classes in this subject and thus the beginning of this competition was realized in the field, in the form of practical classes. The students first got acquainted with the situation of this landmark, and then they got acquainted with the function of the memorial temple and the program of the competition. According to the announcement of the competition, the candidates are allowed to design a parish church of smaller dimensions. In the continuation of practical classes, according to the experience from previous competitions, we introduced students to the liturgical function of the Serbian Orthodox temple. The needs of the movement of priests during the Liturgy are shown in the Hilandar convent in the temple of Saint Sava on Delijski Vis. The architectural composition of this temple is also explained, with a special reference to the construction of the dome. These two aspects of the architecture of Serbian temples were also covered in the later classes of practical classes, in the Cathedral of the Holy Trinity, the Temple of the Holy Emperor Constantine and Empress Helen and the Temple of St. Luke. The competition was open to all students of the Faculty of Civil Engineering and Architecture. During the semester, open lectures were held in the form of Microsoft Teams meetings, where candidates received the necessary knowledge necessary for the realization of the conceptual design of the memorial temple. In addition to teachers in this subject, lectures within this competition were held by prof. Boban Stojković and Elena Vasić Petrović.

Within the competition, 14 teams presented their designs within the public presentation, which was held on February 9th, 2022. Out of the competition in the same period, 5 teams presented the conceptual design of the memorial temple, and in April the number of teams was 11. According to the previously set voting system, each member of the jury distributed a total of 105 points to 14 teams, so the best work gets 14 points, next 13 etc. The members of the jury were:

1. Boban Stojković – representative of the Diocese of Niš,
2. Elena Vasić Petrović – representative of Institute for the Protection of Cultural Monuments of Niš,
3. Tanja Obradović – representative of the City of Niš and
4. Miomir Vasov –representative of the faculty and jury president.

Fig. 1 Project 1: Nikolina Stepanović – third prize – 42 points

Fig. 2 Project 2: Isidora Mitrović – 27 points

Fig. 3 Project 3: Anđela Pešić and Kristina Pešić – first prize – 53 points

Fig. 4 Project 4: Marijana Ćendić and Marta Rakonjac – 25 points

Fig. 5 Project 5: Dušan Pavlović and Ignjat Stebih – 13 points

Fig. 6 Project 6: Aleksanda Tasić i Biljana Cvejić - second prize – 51 points

Fig. 7 Project 7: Valentina Bagarić and Jana Trajković – third prize – 42 points

Fig. 8 Project 8: Mihajlo Petrović and Natalija Marjanović – 27 points

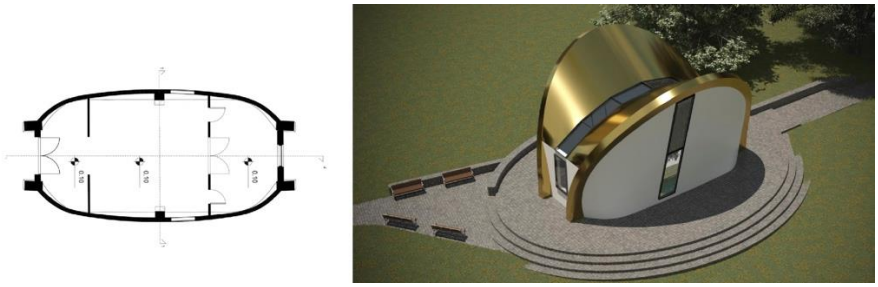

Fig. 9 Project 9: Bogdan Živković and Minja Vuković – 11 points

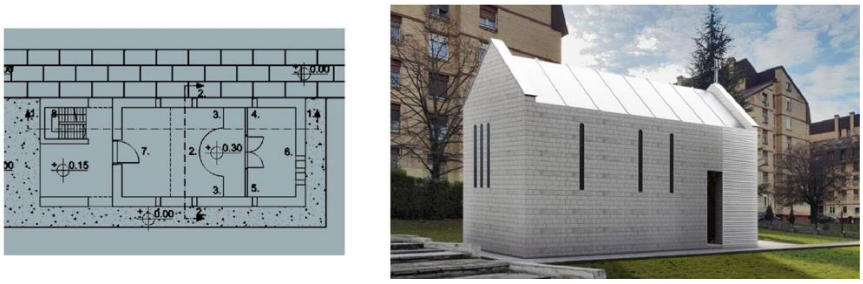

Fig. 10 Project 10: Miloš Breznik and Minja Vuković – 30 points

Fig. 11 Project 11: Jovana Krivačevič and Dunja Vasiljević – 23 points

Fig. 12 Project 12: Kristina Pešić and Andrija Ristić – 10 points

Fig. 13 Project 13: Aleksa Čpajk – 32 points

Fig. 14 Project 14: Stefan Dinčić – 36 points

The jury (03.03.2022.) awarded the first (project number 03, students: Anđela Pešić and Kristina Pešić; 53 points), the second (project number 06, Aleksandra Tasić and Biljana Cvejić; 51 points) and two equal third prizes (project number 07; Valentina Bagarić and Jana Trajković; project number 01, Nikolina Stepanović; 42 points). All the works are here presented, so that later in the discussion we can form recommendations for the improvement of the institution of the student architectural competition, based on the comparison of the achieved points in the competition and points within the evaluation of design principles.

5. EVALUATION OF DESIGN PRINCIPLES

Design principles are a set of recommendations that see architectural design as a comprehensive thought, ethical, creative process [16]. Contemporary architecture is a synthesis of engineering knowledge and artistic talent of architecture. All aspects should be considered: engineering (construction, physics, etc.) and artistic (context, form, function, composition, etc.). The artistic aspects do not refer exclusively to artistic or artistic properties, but to the field of architecture. According to the ancient division of art, architecture is an artistic discipline. The architectural composition of the masses is based on the artistic composition. The design process corresponds to the processes of design and creation of a work of art. Buildings with a specific purpose are created through the synthesis of architecture as a plastic art (in space) and technology as an engineering science.

From such a comprehensive view of the architectural design process, design principles emerged, which advocate the view that architectural design as a creative process should result in a continuous improvement of the quality of the built environment. The five design principles are: unity of space, ambientalization, contextuality, evolution of ideas and professional ethics [17]. Although it is important for this topic to analyse the principles of contextuality and evolution of ideas, we will conduct a tabular scoring of the described examples. Within each principle, we rated each of the cases with 0 or 1, depending on whether it is in line with the recommendations.

Within the first principle (A), we observe whether each intervention in space is viewed as part of the overall structure of space. Indivisibility in the design process means that there is no division of competencies into architecture and urbanism - the design is reflected in the temple and landscaping (cemeteries / courtyards). The concept of the shape of the temple participates in the design of the courtyard.

The principle of ambientalization (B) in this case refers to the realized ambiences in the temple and its surroundings. This principle follows from the first principle and refers to the perceptual connections of spatial levels (common, public and private). The altar is a space intended only for priests. There is space in the nave of the temple for the community of believers. Everything around the temple belongs to the public space. According to the liturgical process, the Orthodox church must have a nave (in which the faithful are located) and an altar in the east (in which the sacred mystery of the Eucharist is celebrated).

Table 1 Evaluation of architectural designs by Design principles

Project	A	B	C	D	E	SUM
1	0	1	1	1	1	4
2	1	1	1	1	1	5
3	1	1	1	0	1	4
4	1	1	1	0	0	3
5	1	1	0	0	0	2
6	0	1	1	0	0	2
7	1	1	1	1	0	4
8	1	1	1	0	1	4
9	0	1	1	0	1	3
10	1	1	1	1	1	5
11	1	1	1	0	1	4
12	0	1	1	0	1	3
13	1	1	1	0	1	4
14	0	1	0	0	0	1
Total	9	14	12	4	9	

Within contextualization (C) we observe the interaction of architecture with place and time. Respect for context is possible in space, time, spirit, heritage and material. Contextual architecture is a logical interaction with the environment or visualization of the properties of a place. Contextuality in architectural design, which we will evaluate within the framework of this analysis, refers to the interpretation of the local social and cultural milieu and local architectural culture. The Serbian Orthodox Church has a rich heritage. The expectations of the Orthodox Church and the faithful are a building that looks like temples from our past. This request of the competition, for the temple to be in the spirit of Orthodoxy in Serbia, we believe is challenging for the entire architectural scene. However, through its use, the seriousness and reality of the student task was confirmed.

Within the evolution of ideas (D), we observe a creative reworking of an inherited role model. We believe that the development of architectural design is more suited to the evolution (qualitative development) of ideas, instead of revolution, which implies a completely new construction by annulling previous experience. Revolutionary changes bring new ideas, concepts, theoretical settings, but they neglect and destroy those qualities that have historically confirmed their values.

Under the fifth principle (E), we condemn the literal taking of ideas from practice. A common occurrence in the newer Serbian sacral architecture is the construction of temples that in specific ways resemble medieval temples. One part of the designers still resorted to literally copying the tradition, creating unconvincing architectural compositions. Another group of designers creates an insufficiently convincing composition using medieval quotations. Distorted repetition of exemplary solutions is actually a problem of modern sacral Orthodox architecture [18].

6. DISCUSSION

The results presented in the first part of the research refer to the total number of points won. If we present this success in percentages and compare it with the results from the second part of the research, we will notice a discrepancy in the results. Thus, for example, the project under number 2 fully complies with the principles of design (100%), while its success according to the jury vote is 51%. A similar case is related to project under ordinal number 10 (100% vs. 57%). The project under number 6 has a 40% success rate within the design principles and as much as 96% according to the opinion of the jury. The fact is that there are disagreements, because the jury did not distribute points according to the evaluation of design principles. The success ratio of the first and second surveys shows the percentage of disagreements. It is highest in the case of 6 (240%) and 14 (340%) labour. The last work satisfied only one of the five principles (20%), and the jury evaluated it with as many as 36 points (which is 68% compared to the first-prize winning work). If we look only at the awarded works, the success rate is the most balanced in the third prizes (99%, 1st and 7th project), the first is partially in balance (125%, 3rd work), while the second is out of balance (240%, 6th project).

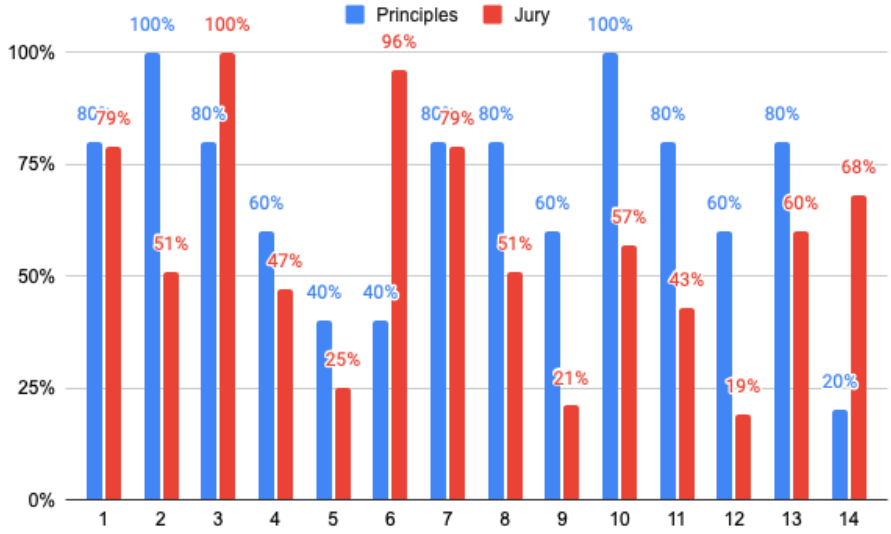

Fig. 15 Comparative performance analysis

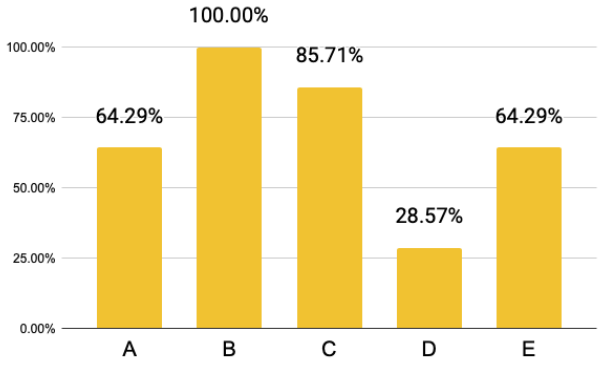

Fig. 16 Disagreement between the results of the first and second research in this paper

As we do not intend to question the way the jury scores, but only to improve future voting processes, we have analysed the individual successes of the candidates within the principles in the second part of the research. The principle of ambientalization (B) is met by all candidates. This means that the liturgical process was observed in each of the solutions. The temple is divided into a nave and an altar. The principle that is least satisfied is the evolution of ideas (D). According to this result, creative processing of inherited principles is represented in one third of the works. From the results that belong to the following category (E), the literal download of quotations is represented in one third of the papers. Most temples really look like temples from the past - this can be concluded based on 85.71% success within the category that looks at the context of construction (C).

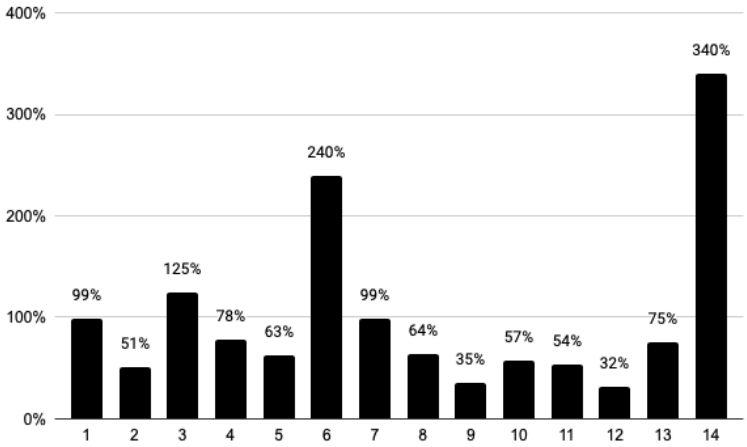

Fig. 17 Success by categories in the second part of the research

7. CONCLUSION

The overall performance, regarding the evaluation of 5 design principles is 67.57%. A feature that should be improved is the creative processing of exemplary solutions from the history of architecture, in order to reduce the importance of taking them literally and copying. This is in line with the defined problem within contemporary sacral architecture in Serbia - design criteria are not set clearly enough. It is recommended to dedicate a significant part of teaching to this property, by increasing the number of practical classes on the construction site in this area. Namely, raising the awareness of students about the consequences of uncreative taking over of inherited design elements is most effective in the field. One should first get acquainted with the values of medieval monuments, and then analyse the modern architecture of temples in the mentioned context. Visiting lectures by architects who have already encountered this problem would be of great help.

From the discrepancy between the results of the first and second groups, we conclude that it is necessary to define in advance the categories that will be evaluated by the jury in the evaluation phase. Candidates should be given an evaluation framework in the call for proposals at the beginning. As the members of the jury are not only architects, it is necessary to agree on areas from several disciplines, in order for the candidate's answer to be more complete. Our proposal is a transformation of the presented 5 principles in the form of the following categories:

A. Construction time,
B. Orthodox spirit of designing,
C. Tradition,
D. Evolution of ideas and
E. Liturgical and iconographic program of the temple.

Within the first category (A), students should adapt their solution to the current situation in architecture and construction. The construction should correspond to modern materials and building concepts. Also, the form should be built so that the appearance of

the temple corresponds to the creative processing of the inherited principles, through the interpretation of the heritage, not through its literal copying. The second category (B) is firmly tied to the Orthodox view of the temple. With this principle, egoistic solutions, as well as forms that manipulate ideas that do not concern the space where the liturgy takes place, are annulled. This means that the designer does not call Orthodox teaching into question, but improves the experience of believers in the temple with his design. Tradition (C) is given as a criterion to exclude radical solutions. We are of the opinion that new concepts should be reached through evolution or smaller steps, because the sign of the church is also important. Related to this is the fourth criterion (D), which is completely taken over from the 5 design principles. It concerns the creative reworking of the inherited model, because the temple always relies on the history of the church and architecture. This principle cancels all those solutions that literally take over forms from the past. It ensured the architectural development of the temple. The last criterion (E) was given in order to control the movement of the priest during the liturgy. The function of each building has always been important for the constitution of architecture. At the same time, it justifies the implementation of architecturally new solutions. Its attachment to the competencies of the priest leads to a certain evaluation of each solution in relation to the realized liturgical program of the temple, without affecting the aesthetic categories of architecture, which should be declared by experts in the field of architecture.

REFERENCES

1. B. Stojkov, Z. Manević (ed) "Tradicija i savremeno srpsko crkveno graditeljstvo", Institut za arhitekturu i urbanizam Srbije, Beograd, 1995, p. 252.
2. T. Damljanović, "Dva hrama za dve konfesije : traganje za moderno–vizantijskim", Nasleđe, 6, pp. 77–84, 2005.
3. B. Folić, "Traganje za savremenim izrazom u srpskoj sakralnoj arhitekturi", Izgradnja : časopis Ministarstva građevina Narodne Republike Srbije, 11/12, pp. 637–642, 2010.
4. Lj. Folić, "Arhitektura hrama : projektovanje duhovnih objekata", Cetinje, Kosovska Mitrovica: Eparhijska radionica za umetničko projektovanje i oblikovanje, Svetigora, Fakultet tehničkih nauka, Beograd, 2013.
5. M. Jovanović, "Srpsko crkveno graditeljstvo i slikarstvo novijeg doba", Zavod za udžbenike, Beograd, 2007.
6. A. Kadijević, "Evokacije i parafraze vizantijskog graditeljstva u srpskoj arhitekturi od 1918. do 1941. godine, Niš i Vizantija: zbornik radova, 2, 382– 394, 2004.
7. A. Kadijević, "Jedan vek traženja nacionalnog stila u srpskoj arhitekturi (sredina XIX – sredina XX veka)", Građevinska knjiga Beograd, 2007.
8. A. Kadijević, "Strategije novog srpskog crkvenog graditeljstva i njihov uticaj na neposredno okruženje (1990–2012"), Zbornik Seminara za studije moderne umetnosti Filozofskog fakulteta Univerziteta u Beogradu, 9, pp. 103–113, 2013.
9. A. Kadijević, "Srpsko crkveno graditeljstvo (1945–2015) – istraživanje i prezentovanje", Arhitektura i urbanizam posle Drugog svetskog rata: zaštita kao proces ili model - VI konferencija - zbornik radova, pp. 157–167, 2015.
10. B. Manić, "Pristup proučavanju novije sakralne arhitekture u Srbiji – analiza mogućnosti razvoja modela pravoslavnog hrama", Neobavljena magistarska teza, Univerzitet u Beogradu, Arhitektonski fakultet, 2009.
11. B. Manić, "Savremena arhitektura crkava Srpske pravoslavne crkve: programske osnove i projektantska praksa", Neobavljena doktorska disertacija, Univerzitet u Beogradu, Arhitektonski fakultet, 2016.
12. B. Manić, D. Vasiljević Tomić, A. Niković, "Contemporary Serbian Orthodox Church Architecture: Architectural Competitions since 1990", Spatium, 35, pp. 10–21, 2016.
13. B. Manić, A. Niković, I. Marić, "Relationship Between Traditional and Contemporary Elements in the Architeture of Orthodox Churches at the Turn of the Millenium", Facta Universitatis, Series: Architecture and Civil Engineering, 13 (3), pp. 283–300, 2015.
14. M. Stanimirović, "Arhitektura srpskog pravoslavnog hrama – uticaji i razvoj u prvim decenijama XXI veka", Neobljavljena doktorska disertacija, Univerzitet u Nišu, Građevinsko-arhitektonski fakultet u Nišu, 2017.

15. M. Stanimirović, “Konkursi za projektovanje pravoslavnih hramova u Nišu 1998-2021”, Arhitektura i urbanizam, vol. 53, pp, 2022.
16. D. Marušić, “Projektovanje 2”, Unpublished results, Arhitektonski fakultet, Beograd, 1999.
17. G. Jovanović, M. Stanimirović, “Pet projektantskih načela”, Nauka + Praksa, 21. pp. 71-76, 2018.
18. M. Stanimirović, “Projektovanje srpskih pravoslavnih hramova u 21. veku”, Nauka + Praksa, 21, pp. 18-24, 2018.

SAVREMENA ARHITEKTURA SRPSKIX PRAVOSLAVNIH HRAMOVA: UNAPREĐENJE INSTITUCIJE STUDENTSKOG ARHITEKTONSKOG KONKURSA ZA HRAM PREMA DEFINISANIM KRITERIJUMIMA VREDNOVANJA

U okviru teme arhitektonskog projektovanja savremenog srpskog pravoslavnog hrama, studentski konkursi se par godina unazad realizuju na Građevinsko-arhitektonskom fakultetu u Nišu. Istraživanje aktuelnog fenomena savremenog srpskog hrama kroz inoviranje konkursne prakse direktno unapređuje arhitektonsku nauku. Osnovni cilj rada je unapređenje institucije konkursa kroz unapred definisane kriterijume vrednovanja, koji pripadaju oblastima arhitektonskog projektovanja, istorije i teorije arhitekture ali i učenju Srpske pravoslavne crkve..

U ovom radu je dokumentovan studentski konkurs za spomen hram na Delijskom Visu u Nišu. U skladu sa projektantskim principima, analizirani su radovi studenata i rezultati njihovih vrednovanja. U prvom delu istraživanja su predstavljeni bodovi dodeljeni od strane stručnog žirija. U drugom delu su radovi analizirani prema projektantskim načelima. U trećem delu, u sintezi istraživanja, komparativnom analizom su upoređeni rezultati prvog i drugog dela istraživanja. U raspravi je na osnovu nepodudaranja rezultata prve i druge grupe, zaključeno da je potrebno unapred definisati kategorije koje će žiri vrednovati u fazi ocenjivanja. Kandidati bi morali dobiti okvir ocenjivanja u raspisu konkursa. Kako članovi žirija nisu samo arhitekti, potrebno je predvideti oblasti iz više disciplina, kako bi odgovor kandidata bio celovitiji. U zaključku rada su predloženi konkretni kriterijumi ocenjivanja, nastali kroz transformaciju projektantskih načela.

Ključne reči: *konkurs za hram, sakralna arhitektura*

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Review Paper

ARCHITECTURE OF CONTEMPORARY SPA HOSPITALITY - CURRENT TENDENCIES IN DESIGNING SPA HOTELS

UDC 725.751

Milan Brzaković, Marko Nikolić, Aleksandar Milojković

University of Niš, Faculty of Civil Engineering and Architecture, Niš, Serbia

Abstract. *The emergence of spa tourism as a sector of the wellness tourism marketplace is reflected in contemporary architecture of spa hotels. These facilities are essentially accommodation facilities that offer a variety of individual treatments and services for spa-seeking tourists focused on their health and wellness. The primary objective of the research is to investigate current tendencies and strategies in the field of architectural design of spa hotels, as well as to explore successful design approaches. The research begins with elaboration of basic characteristics of modern wellness tourism, followed by the definition of spa hotel as a special type of hospitality facility. Later, classification of modern spa hotel modalities is elaborated and further clarified using relevant case studies. The second part of the research is the analysis of recognized design tendencies in terms of spatial organization of spa hotels. In the conclusion, their further applicability in wider practice is discussed, and certain disadvantages and limitations are listed.*

Key words: *spa hotel, hotel architecture, hotel design, wellness, tourism*

1. INTRODUCTION

In today's world of speed, relaxing spaces have been given a prominent role. People look for places where they can relax, feel good and 'charge their batteries' in a relatively short time. Over the past few decades wellness tourism has been experiencing continuous rise in number of guests, and it is predicted to continue to grow by more than 9% per year, almost 50% faster than overall global tourism. As spa tourism, a popular form of wellness tourism, contributes with approximately 41% of wellness tourism revenue, it is often referred to as wellness & spa tourism [1]. Medical rehabilitation is not the only reason for visiting spas anymore. The motivation for modern spa goers broadened to include leisure and relaxation which resulted in ongoing transformation of spas into modern centers of pleasure and entertainment for the whole family [2].

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Corresponding author: Milan Brzaković, University of Niš, Faculty of Civil Engineering and Architecture, Aleksandra Medvedeva 14, 18000 Niš, Serbia
e-mail: milan.brzakovic@gaf.ni.ac.rs

The emergence of spa tourism as a sector of wellness tourism marketplace is reflected in the contemporary architecture of spa hotels. In recent years, along with the rediscovery of the relaxation tourism, more attention has been paid to the architecture of spa centers. The diversity of services that hotel program includes, carefully and pleasantly designed spaces and environments, as well as the thoughtful selection of materials, lighting are the key elements of modern spa tourism. [3] Today's spa hotels are essentially accommodation facilities that offer a variety of individual treatments and services for spa-seeking tourists focused on their health and wellness [1].

The main topic of this research is architecture of contemporary spa hospitality, specifically hotel buildings. The literature review shows that there are several papers that explored characteristics of hospitality infrastructure in certain regions – Tofan [4] investigated current tendencies regarding the touristic infrastructure of Drăgoiasa-Tulghes region, Frangou et al. [5] analyzed hotel design in Greece, while Brzaković et al. [3] investigated whether existing hotels in Niška Banja can fulfil the requirements of modern spa tourism, as well as successful design approaches for their potential upgrade. In their research Varolgünes et al. [6] suggested new methodology that would improve the design quality in buildings, specifically in a building of a thermal hotel. Nikolić [7] et al. explored the relationship of the hotel, the city and its architectural heritage, as well as some of the factors that led to the eruption of alternative models of hotels. Social studies investigated different things that involve spa hotels – from customer satisfaction [8] to factors promoting wellness travelers' post-purchase behavior [1].

The primary objective of the research is to investigate current tendencies and strategies in the field of architectural design of spa hotels, and to explore successful design approaches. The research begins with the elaboration of basic characteristics of modern wellness tourism which is followed by the definition of spa hotel as a special type of hospitality facility. Later, classification of modern spa hotel modalities is elaborated and further clarified using relevant case studies. The second part of the research is the analysis of recognized design tendencies in terms of spatial organization of spa hotels. In conclusion their further applicability in wider practice is discussed, and certain disadvantages and limitations are listed.

2. Defining and Classifying Spa Hotel as Architectural Type

The term spa hotel is closely related to the terms like 'spa tourism', wellness tourism' 'relaxation tourism' or even 'health tourism' – term usually considered a hypernym of all the previously mentioned forms. There is no universally accepted definition of health tourism (or its subforms), which results in a number of different explanations of the term, depending on authors as well as on contexts and country. However, its primary purpose is the improvement of health and quality of life, while services it offers generally rely on the natural characteristics of the place, such as the favorable climate, natural hot springs, sources of mineral waters and other treatments and services based on local healing substances [9, 10].

By its initial definition, spa hotel is a hotel located in an area where scientifically approved deposits of therapeutic substances and the necessary wellness & spa facilities exist and may be used, with the primary purpose of providing individual services and treatments, with focus on health. Programs of these facilities combine luxurious accommodation, spa services and fitness activities, but can be enriched with healthy cuisine, yoga classes, wellness education, special interest programming, etc. In Serbia, the legislations for hotel categorization do not

stipulate any specialization which means that spa hotels do not have specific standards in order to differentiate them from others. Spa hotels can either be profit-oriented and market-oriented toward a self-paying client, or partially integrated into the public health system or connected to private health insurance companies. The choice of a preferred business operating model does not affect their architectural characteristics.

In terms of their relationship with wellness & spa facilities, spa hotels can be divided into two groups: (1) hotels that include a full service wellness & spa center as an integral part of the facility ("all-inclusive hotels"), and (2) hotels that are directly connected to an independent wellness & spa center in close neighborhood ("accommodating hotels").

Hotels in the first group have programs that tend to include all possible needs of the guest and are usually built in locations that do not have a highly developed spa infrastructure. The absence of an established infrastructure forces developers to include as many amenities as they can in order to keep their guests entertained during their stay.

Since 1911, when an international oil company carried out explorations in their search for oil and instead found thermal water, the area in which Spa & Golf Resort Saint Martin (Figure 1) is located at present has gone through a number of programmatic and spatial changes. The hotel which comprises 157 guestrooms, including 151 standard double rooms, and 6 suites, is located on the northwest side of the hill, between outer pools and golf courses. The building's linearly developed polygonal form consists of two wings – one that is oriented toward outer pools on the Northwest, and the other that is connected with golf courses on the northeast. The hotel's program is vertically separated – guestrooms occupy upper floors, while numerous public activities are located in the basement, ground floor and mezzanine. Its all-encompassing public area program includes: wellness & spa area with indoor and outdoor pools as well as beauty center, diverse catering facilities (2 restaurants, cafe, lounge and nightclub), conference halls, and kindergarten [11].

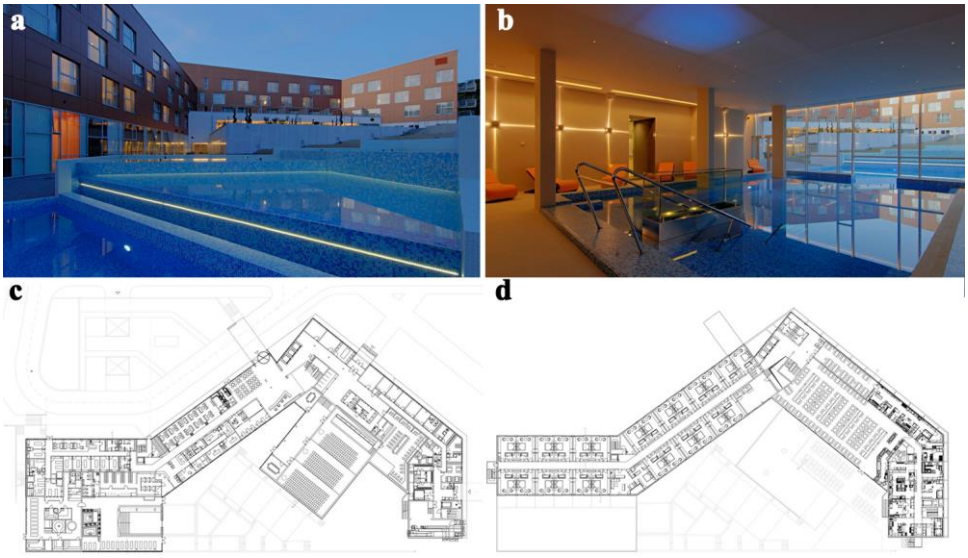

Fig. 1 Spa & Golf Resort Saint Martin: a) exterior photo; b) indoor pool; c) ground floor plan; d) first floor plan. Source: https://www.archdaily.com/40560/spa-golfer-hotel-studio-sangrad?ad_source=search&ad_medium=projects_tab

The second group consists of hotels that primarily focus on bedroom revenue, and do not include wellness & spa facilities, but are positioned next to an already built center to which they often have a direct connection. These hotels are common for spa settlements with already established traditions, and usually represent the phase in the long-term development of a spa settlement – in the first phase a wellness center is built, while in the next phase (or phases) accommodations are added. Their program usually concentrates on complementary functions such as conferencing and catering facilities.

Within the Tuhelj spa complex individual buildings of various temporal origins harmoniously coexist with the hotel Well (Figure 2) being the newest addition to the ensemble which includes the old swimming pool around the corner, Mihanović Castle at the center, hotel pavilions from the 1980s, and the new swimming pool complex. The project originated with the idea of preserving existing pavilions and constructing new facilities that will connect all these elements and provide new space for public activities. The result is the layout that successfully assimilates old and new elements into a single coherent building and complex architectural form consisting of a multitude of elements. The program of the newly formed complex is vertically separated – public areas are located in ground floor while upper floors are used only for guestrooms. The dominant features of the addition are the three hotel monoliths (hosting 126 rooms) and a strong elongated floor plan [13]. The main entrance to the hotel is located directly opposite the entrance to the new wellness center. These two facilities are visually and spatially connected via a shared canopy that covers both entrance areas.

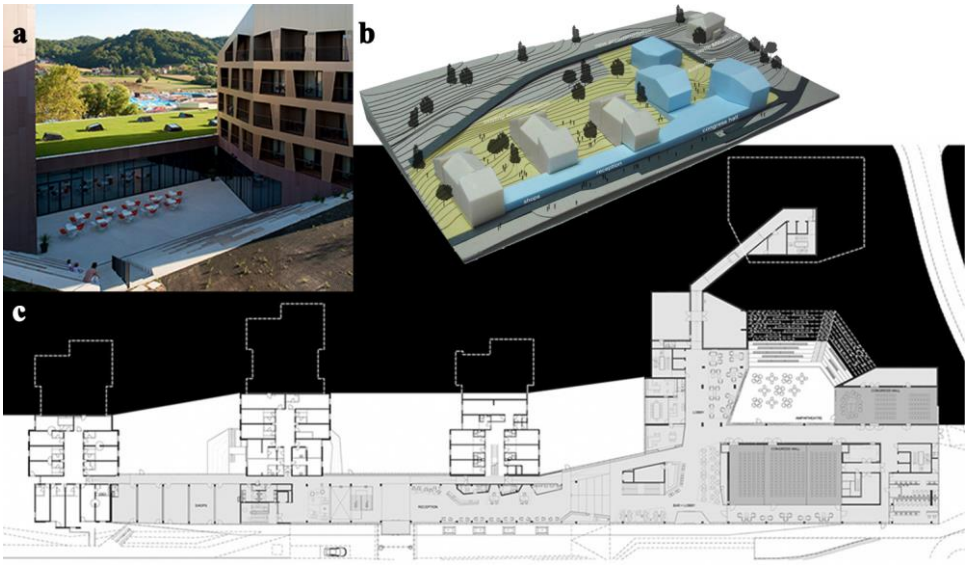

Fig. 2 Hotel Well: a) ground floor plan; b) model; c) photo of amphitheater in the center of the building with Terme Tuhelj Spa Resort in background. Source: [12]

In 2003, the Balnea wellness center was constructed in the spa complex, with a varied range of modern pleasure centers. In late 2008, right next to the renovated Hotel Kristal (dating from 1899), owners built a new hotel, modern and quite adequate for demanding

customers, called Balnea (Figure 3). The hotel, located next to Hotel Kristal, connects the hotel complex and surrounding small structures. The floors of the old and the new hotel buildings are connected by a three-story glazed communication corridor, creating a joint and closed functional whole. The ground level between the buildings has an open public passage, preserving the old pedestrian axis for outside users, going from the congress center, across the river, the square and the park, to the wellness center. The latter can be accessed by guests from the interior of the new hotel through the ground-floor glazed corridor with columns along the edge of the park. Guests are provided with pleasant communication between different areas of the spa complex, with careful spatial arrangements and aesthetically designed passages, so the paths are dynamic and interesting, like a walk in nature [13].

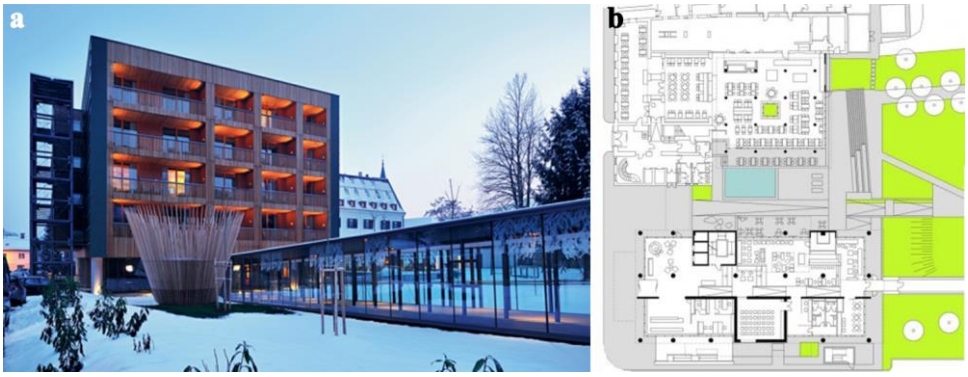

Fig. 3 Hotel Balnea: a) exterior photo with ground-floor glazed corridor connecting hotel and wellness center; b) ground floor plan. Source: [13]

A special type of spa hotels are health or medical hotels – beside usual tourist amenities, these hotels offer health care services and facilities. Hotels that offer health services possess the extensive health infrastructure, as well as professional guest-care provided by licensed medical personnel and are available to the guests [9, 14].

Thermal Bath, Therapy and Hotel (Figure 4) is tourist complex in a protected park in Gleichenberg that includes four star hotel, several restaurants and cafes, public thermal bath open for both patients and other guests, as well as treatment area with about 50 rooms for different medical treatments. A full treatment in this facility usually lasts for several days and involves a number of different treatments, such as various types of massages or baths, a cold or salt room therapy, etc. Considering the amount of time clients spend in waiting rooms during these multi-day treatments, the architects' intention was to create a sense of spaciousness to the public areas, while keeping the overall size of rooms within the limits allowed by the program.

The main volume of the building is a simple monolithic form that includes 3 floors and stretches all along the Brunnenstrasse. In contrast to this simplicity, the other side of the building is split in two parts consisting of complex curved forms. In the south half of the building, where treatment rooms are located, elevated ground floor extends towards the park and envelopes irregularly shaped, fully glazed inner courtyards. The ground falls away towards south, allowing the park to flow continuously under the elevated ground floor. Inclusion of courtyards into spatial layout creates the impression that the enclosed

exterior spaces are a part of the building. Around these courtyards, waiting areas for medical treatments are organized. A view to the outdoor greenery provided by these courtyards provide gives the clients the impression of waiting in the actual park. The difference in the design strategy of public waiting areas and treatment areas is also reflected in their architectural layout and form – the private treatments rooms are rationally sized, orthogonally organized around minimal utilitarian courtyards without greenery that only provide natural light and outdoor views. Unlike its south part, the north half of the building is not elevated, and it includes the indoor and outdoor pool area.

Fig. 4 Thermal Bath, Therapy and Hotel: a) ground floor plan; b) the park side seen from the restaurant terrace, c) The roof of the treatment area seen towards the south. Source: https://www.jsa.no/Therme-hotel-Bad-Gleichenberg

Spa hotels are generally located in a relatively urban setting (spa settlements), location that can result in a lack of outdoor amenities. Therefore, some authors may introduce another type of spa hotel – spa resort. In comparison to a usual hotel, resort offers a wider spectrum of services and amenities – particularly those intended for outdoor entertainment and recreational activities. Furthermore, resorts tend to have many more food and beverage seats per room than regular hotels, because offering dining variety keeps guests on the property throughout their whole stay. Length of stay influences the number and size of resort amenities. Today's resort may have as much as 25% of its accommodation capacities allocated to suites, and many luxury properties are made up largely of standalone villas [15].

Enchantment Resort and Mii amo Spa (Figure 5a) is a first class retreat that includes outdoor pool and deck area that serves as the focal point of the spa experience, as well as main treatment building, clubhouse and 6 freestanding guest villas – 'casitas'. The main treatment building is located on the west side of the plot and composed of five brick

volumes that house private treatment rooms, organized along a horizontal axis. Parallel to the main treatment building, next to the pool area is a high-ceiling glass enclosed lounge space offering breathtaking panoramic views of the surrounding landscape. In visual contrast to the stunning beauty of Boynton Canyon, all the buildings are conceived as a series of shifting volumes, clad in earth-toned stucco, brick and stone.

The Banyan Tree Cabo Marques (Figure 5b), is the premier all-pool villa resort which features 70-key luxury villas, a world class spa, two specialty restaurants, a beach club and a fitness center. The resort's 370 m^2 two-story spa pool villa each offer a 55 m^2 private pool and a second-story outdoor massage area that overlooks a manmade lagoon.

Fig. 5 a) Enchantment Resort & Mi Amo Spa, Source: http://www.fiedlermarciano.com/commercial/amo.html; b) Banyan Tree Cabo Marques Resort, Source: [15]

3. Current Tendencies in Spa Hotel Design

Extensive review of built spa hotels reveals that current approaches favor transformation of existing hotels that became obsolete due to radical shifts in spa tourism, as well as programmatic tendencies that modify features and spatial organization of most important zones of spa hotel – wellness & spa area and guestroom floor. These trends are closely observed and discussed in the following sections.

3.1. Transformation of existing hotels as a tool of sustainable development of spa settlements

The shapeshifting and steady rise of spa tourism that we are witnessing in recent years has catalyzed the transformation of existing spa hospitality. Until recently, their capacities were primarily adapted to the curative treatment of the sick and the injured during rehabilitation, which would not meet the needs of today's extremely varied customers. Furthermore, spa settlements are usually recognized for their preserved natural heritage which makes any new construction in these areas highly debatable. Transformation of existing buildings serves as a tool for keeping built footprint in spa settlements under control. Therefore, many spa hotels have been renovated, modernizing their capacities and introducing new services inside the old complexes. Some spas use modern and attractive architecture to completely change their appearance, while others build on tradition and use modern methods to adapt to the old spa architecture.

Atlantida Boutique Hotel (Figure 6) in the protected zone of the Rogaška Slatina health spa exemplifies a successful transformation of existing hotel that needs spatial and programmatic boost in order to satisfy requests of modern tourism. The building, situated along the slope, facing towards a plateau, and the surrounding area are protected as a cultural and natural heritage.

As a part of the process of program-spatial renovation, the architectural layout of the old hotel was entirely altered, while its façade was reconstructed into the original state of its modest historical character. Modest hotel that dates back 90 years is radically changed by introducing new wing hosting guestrooms oriented towards light and nature. This addition stands perpendicular to the original building, with dominantly glazed central element hosting central entrance hall and common areas such as a swimming pool and a restaurant. As a result, public areas are spread across all floors, with no common vertical separation of hotel program.

Fig. 6 Atlantida Boutique Hotel: a) exterior photo; b) first floor plan. Source: https://bigsee.eu/atlantida-boutique-hotel-by-api-arhitekti-slovenia/

Completed in 2020, Chenot Palace Weggis Health Wellness Hotel (Figure 7) extends over 20000 m^2 and includes the renovation of existing hotel buildings, the addition of a new guestroom block, medical spa and wellness area. The accommodation capacities include 97 hotel rooms – 52 in existing building and 45 in the new addition. In order to preserve the view to the charming turn-of-the-century palace from the lake, the new addition has been set back above the entrance area. Furthermore, the new addition consists of volumes staggered in such a way that is never fully visible. The architecture of the new addition references symbolic treats of the historical building – the character and proportions of the vernacular are recalled and reinterpreted in a completely chromatic contemporary manner that combines organic with geometric forms. The medical spa lies in the heart of the complex. Set across 5,000 m^2, with over 100 treatment rooms and offices, the spa and medical department is organized by department: aesthetic, hydrotherapy, and medical. The reception areas and doctors' offices are set around courtyards, bringing in natural light and maintaining a constant consonance with nature.

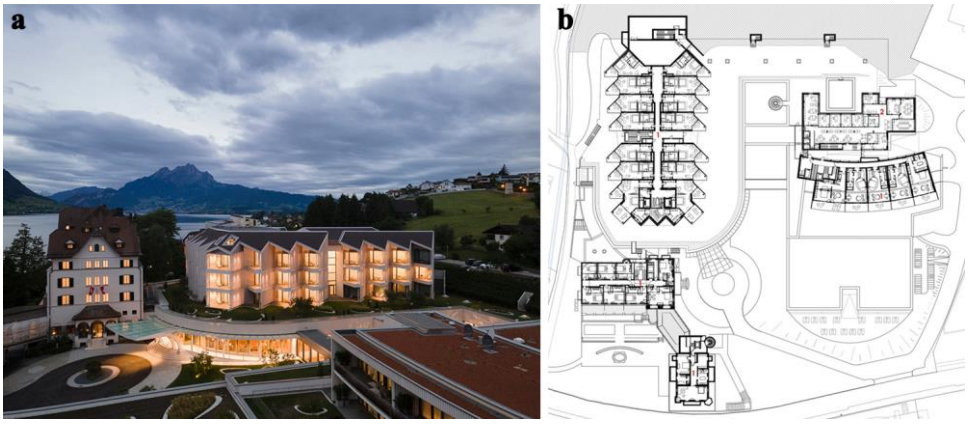

Fig. 7 Chenot Palace Weggis Health Wellness Hotel: a) exterior photo; b) first floor plan. Source: https://www.archdaily.com/946818/chenot-palace-weggis-health-wellness-hotel-davide-macullo-architects

3.2. Rise of wellness & spa facility as the most important part of spa hotel

The central component of the spa hotel's recreational facilities is its wellness center. A list of amenities a wellness center includes can vary and mostly depends on the potential of the location. The most usual set of wellness center amenities consists of pools, gym equipment and specialized spa content, such as steam bath, Jacuzzi and sauna. Wellness centers in larger hotels may also include beauty salons, multipurpose rooms for aerobics, yoga etc. The most important, but also most divisive part of a wellness center is the swimming pool area. Recent research shows that guests use the pool less, but they expect the hotel to include swimming pool as a part of its recreation area [9]. The swimming pools included in wellness centers can be very diverse: indoor, outdoor, with sea or fresh water, thermal or mineral water, prehistoric seawater, and for the children.

In the early days of the 20th century spa resort boom, spas tended to have a strong thematic component evocative of a real or imagined warm-weather setting. Spas being developed today are much more diverse in design and attempt to capture a strong sense of place by relying on vernacular ingredients, techniques and architecture. An excellent example of this approach is the Hotel Therme Vals (Figure 8) at the foot of Alp Vallatsch in Switzerland, over the only thermal springs in the Graubünden canton. Although there was a long history of spa in in this location, the resort struggled until the 1980s, when the village of Vals bought the property, with its utilitarian 1960s hotel rooms. Eventually, architect Peter Zumthor was retained to transform the spa facility into a site-specific setting that, according to Zumthor, focuses on the quiet primary experience of bathing. The spa's roof, jutting out from the side of the mountain below the main hotel block, forms an extension of the lawn and opens up to reveal the pool below in a way that resembles an archaeological dig and invites exploration. The overall effect is dramatic yet calming, the perfect ambience for a mountain spa [15].

Fig. 8 Therme Vals: a) exterior photo; b) ground floor plan. Source: https://www.architectural-review.com/buildings/thermal-baths-in-vals-switzerland-by-peter-zumthor

It is a widespread opinion that natural light promotes the use of wellness centers and upgrades the experiences of guests which is why contemporary wellness center designs prioritize natural light. As a result, wellness facilities are moving above the ground – ground floors and rooftops are becoming the most desirable space for wellness, embracing the hotel view (in case there is one), they often include private outdoor space and even provide spaces to meet and socially interact with other guests. The growing popularity of groups attending spas together has inspired special areas for these guests so that they do not disturb other spa-goers. There are even children's spa, where kids can get treatments on their own or side by side with a parent. Consequently, wellness & spa facilities became central space in terms of social life within the hotel.

Some authors believe that post-pandemic times will bring an even greater emphasis on spas' outdoor spaces and a link to nature. Guests want to escape hermetically sealed artificial environments and embrace the outside, and therefore amenities as natural pools, yoga deck, 'forest bathing' area, curved seating around a fire pit and spa gardens will be even more sought after. A spa garden does not have to include expensive hydro pools and heat cabins. It can be a garden, courtyard or roof terrace or just a view through an open window. Outdoor sensory experiences could include individual relax zones dotted around an aromatic herb garden, daybeds arranged around a fire pit, or playful swinging seats alongside a trickling water feature.

Located in the Logar Valley nature park, Hotel Plesnik (Figure 9) is a boutique family hotel that poses a tradition longer than eighty years. Situated at the end of a glacial valley, it offers an impressive view of the peaks of the Kamnik-Savinja Alps which serves as the central motif for the renovation of the hotel's wellness area in the partially cut-in basement of the building. The unusual floor plans of the interior owe their appearance to a previous spatial arrangement centered around a small, organically shaped pool which opened onto a tanning deck directly in front of the building. Original layout heavily underutilized the existing space and renovation process started with optimization of space and program. Therefore, the pool was replaced by a large whirlpool, while a part of the

former pool shell closer to tanning deck and view of the valley was transformed into a sunken circular resting area featuring a fireplace. The sun deck has been significantly extended to include a swimming pool with natural water, compensating for and expanding on the reduced interior water surface, while the beautiful view it provides is further accentuated by the reflection in the water.

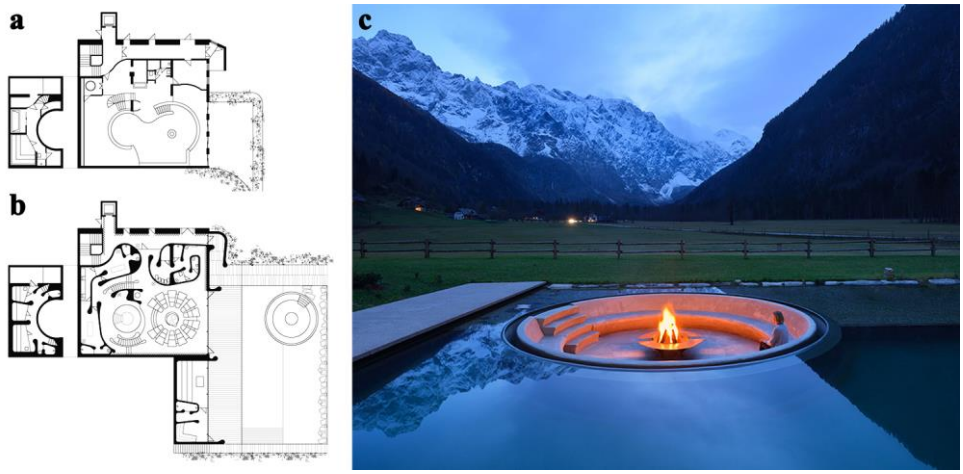

Fig. 9 Hotel Plešnik: a) existing floor plan; b) new floor plan; c) exterior photo. Source: https://www.archdaily.com/887178/wellness-plesnik-enota

Wellness facilities may also serve outside members and visitors as well as hotel guests. Therefore, their reception and parking areas may be up to twice the size at other resorts. Wellness requires a separate reception area for the health spa, which should be easily accessible to guests from the hotel lobby. A special elevator may be provided, serving the guestroom floors and allowing guests to move freely between their room and the wellness without moving through the lobby [15].

Providing retail space associated with the spa is a vital component of a successful spa operation. As much as 40 percent of a hotel spa's revenue can come from the sale of skin- and hair-care products and spa-related clothing items [15].

Considering the changes in trends, technology or even hotel capacities, the design and operation of wellness center needs to be flexible and easily adaptable to future growth, avoiding the underutilization of space and the need for expensive retrofitting.

3.3. Guestroom design – somewhere between conventional and radical solutions

The starting phase of the most basic planning for a hotel must include the guestrooms – not only do they occupy the majority of space within a hotel (65-85 % of total floor area), but a large part of a hotel experience is in the guestroom. Because of the guestroom's residential character, these spaces provide the most private part of the hotel experience. Many hotel operators believe that the guestroom makes a more lasting impression on the guest than does any other single interior space or the exterior architecture. Design of the guestroom, while clearly more an internal layout problem than an architectural one, is still an important part of the architect's responsibility [9, 15].

The 1900s brought dramatic changes in the experience and design of hotel architecture. However, the structure and spatial organization defined at the beginning of the 20th century, the archetypal Statler model, did not change significantly. The design of the hotel room reflects the same tendency. Initial spatial structure of hotel room is deformed in some way – its basic elements remain the same, but the relationship between them changes. Bathrooms take up more and more space, overlap with the space of the room, transparent glass and/or movable bathroom walls are introduced, and in some cases they completely disintegrate and drown in the volume of the room. Sanitary elements often become the most attractive places in the room (Figure 10 a, b) [16, 17]. An example of this kind of transformation can be found in the latest addition to the Hotel Therme Vals (now renamed 7132 Hotel) where four renowned architects – Thom Mayne, Tadao Ando, Kengo Kuma and Peter Zumthor – have been assigned to design guest rooms. Four of the new guest rooms have been designed by Thom Maynes studio Morphosis – all containing a transparent shower cabin in the center of the room and a balcony overlooking the landscape (Figure 10 c, d). Ando, Kuma and Zumthor have designed a room a piece, also using material as a central motif. Although less adventurous with their spatial organization, these rooms also represent unconventional solutions that put bathroom elements in the center of the room.

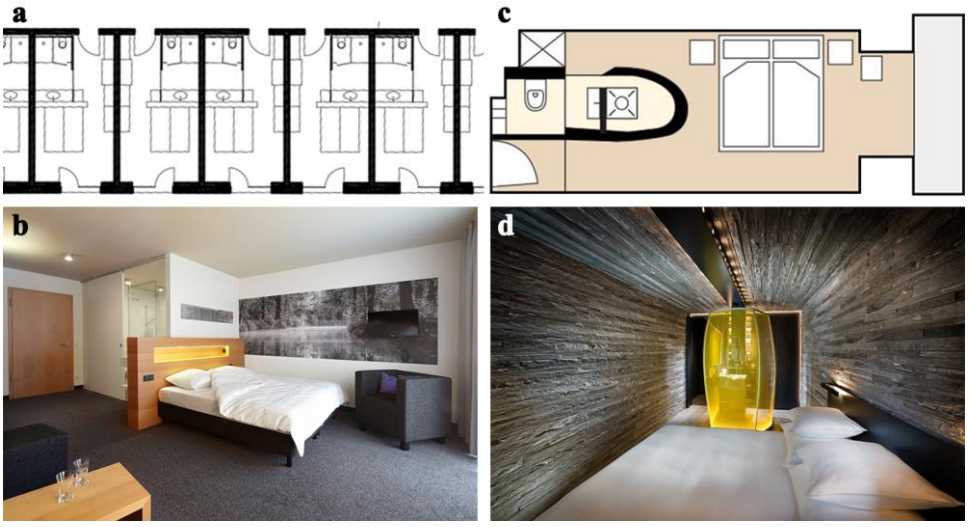

Fig. 10 Spreewald Thermenhotel: a) typical floor plan; b) interior photo; Source: https://4a-architekten.de/projekte/spreewald-thermenhotel-burg Hotel 7132 – house of Architetcs, guestroom design by Thom Mayne (Morphosis): c) floor plan; d) interior photo; Source: https://7132.com/en/rooms-and-suites/7132-house-of-architects/room-detail/id/1710/mayne-stone

In the renovation project of the Onsen Hotel (Figure 11), Kengo Kuma went even further in exploration of the relationship of functional zones within the hotel room. Original building stands at the bottom of a valley abundant with hot springs. It was severely damaged by a flood in 1913, but snapped back with three to four-storied buildings that had the distinctive design of that time, the Taisho period in Japan. What Kengo Kuma did architecturally was a large-scale refurbishment, rather than a construction of an entirely new building. In this modern interpretation of the traditional Japanese inn or guest house central every guestroom includes traditional Japanese baths that use volcanic hot spring water ("onsen" in Japanese), known for its healing properties and benefits to the skin, which are integrated into guestrooms. There are five different versions of baths using five different natural materials – granite, sandstone, Japanese hiba, Japanese cypress and bamboo. Natural ventilation is essential in the bathroom where water is drawn directly from the source of the hot spring, so the sky light and openings are designed to ventilate the air continually [18]. Baths are completely disintegrated and blended into space of the hotel room, thus blurring the boundary between two usually separated spaces. By introducing traditional elements into contemporary typology, and masterfully applying materials, Kuma truly transformed hotel room.

Fig. 11 Hotel "Ginza Onsen Fujiya": a) first floor plan; b) hotel room, c) "onsen" bath tub. Source: https://kkaa.co.jp/en/project/ginzan-onsen-fujiya/#gallery-3

In spite of the exciting and fresh design, these new variants of spatial organization of hotel room that have been present for some time now, do not bring a radical change in the architectural design of hotel buildings. Their free interpretation of the hotel room functional zones is not acceptable for the wide market, while the structural and economic rationality of the previously defined models is unattainable. Therefore, vast majority of newly designed accommodation consist of traditionally organized hotel rooms. As spa hotels became popular destinations for family vacations, hotels adapted to their demands making family rooms (2 double rooms internally connected) more frequent in their accommodation structure.

The experience of staying in a spa hotel is deeply connected to the location and its surroundings. Therefore, it is highly important for a guestroom in a spa hotel to include a balcony because of the large amount of time spent within the room. The absence of balconies should be compensated by increasing the size of the room and introducing large windows.

As high-tech and sophisticated fitness equipment became available and present in many homes, expectations of hotel guests have changed to include those same luxuries. Hoteliers concluded that they can no longer satisfy their guests with the usual standard fitness amenities. As a result, hotels are incorporating in-room fitness amenities that include a wide range of exercise accessories and equipment to use conveniently in the privacy of one's room. In order to satisfy wellness seekers and stay competitive in the hospitality industry hotels are putting effort into renovating and upgrading the customer fitness experience. Incorporation of suitable in-room wellness and exercising amenities enables hotels to maximize their revenue [10]. As a result, even large international hotel chains develop new models of hotel rooms that include in-room fitness amenities. Hilton launched an in-room wellness concept named "Five Feet to Fitness" that brings over 11 different fitness equipment and accessory options into the hotel room, while MGM Grand Hotel & Casino in Las Vegas offers 171 "Stay Well" rooms with vitamin-infused shower water, blackout shades, and protection from electromagnetic fields. In 2012 IHG Hotels & Resort launched their new brand Even Hotels that also offers in-room exercise equipment to their guests and now have ten properties under the brand.

Fig. 1 Hotel rooms with in-room fitness amenities: a) "Five Feet to Fitness", Source: https://www.businesswire.com/news/home/20170531005111/en/Hilton-Launches-Revolutionary-New-Guest-Room-Five-Feet-to-Fitness; b) "Even Hotel", Source: https://www.ihg.com/evenhotels/hotels/us/en/brooklyn/bxyev/hoteldetail

4. CONCLUSION

The complete research is divided into two parts. The first part briefly presents important terminology in the field of tourism, while its central topic is the definition of a spa hotel as a special type of hospitality facility primarily characterized by its location, suitable for purposes of relaxation and recovery. Furthermore, elementary types of spa hotels based on the features of their programs were established and analyzed.

Second part of the research covers current trends and tendencies. With the rising popularity of old spa hotels renovation and expansion, as well as tendencies related to the two most important zones of the spa hotel – wellness and accommodation, have been analyzed and illustrated in detail.

Radical changes in spa tourism have caused a new wave of complete transformations of some existing hotels. Case studies have been used to illustrate the extent to which once exclusively accommodation hotels are expanding their offer.

The wellness area has become a central motif of spa hotels. It has become so important that in some situations it is planned as a separate entity that has a direct connection with the hotel building in order to maximize its external business. It took over the role of the center of social activities from restaurants or lobby areas, while it caused almost complete disappearance of traditional hotel facilities – salons. Their programs are extending toward outside making it compulsory for a modern wellness facility to include sunbath terrace, natural water pools etc. Today, the wellness & spa area is expected to stand out with its original concept and diverse program.

New concepts for spatial organization of hotel rooms have appeared continuously over the last few decades, but their application remains limited and reserved usually for the luxury sector of hotel accommodation. Radical increase in the number of tourists, as well as change in social structure of guests, affect the choice of widely accepted and expected patterns of guestroom floor organization.

REFERENCES

1. H. Han, P. Thuong, K. Kiatkawsin, H. Ryu, J. Kim, and W. Kim, "Spa hotels: Factors promoting wellness travelers'postpurchase behavior", Social Behavior and Personality: An international journal, 47 (6), e7605, 2019, DOI: https://doi.org/10.2224/sbp.7605
2. M. Rančić, J. Popov-Raljić, L. Pavić, "Spa-Wellness Center as Part of the Hotel Facility", Turizam, 47 (1), 2013, 45-59, DOI: https://doi.org/10.5937/Turizam1302045R
3. M. Brzaković, B. Stoiljković, M. Nikolić, "Reshaping the Spa Tourism – Models for Transformation of Spa Hotels, The Case Of Niška Banja", XXI International Scientific Conference on Construction and Architecture VSU'2021, Sofia, 14. - 16. November 2021, 62-70, ISSN: 1314-071X.
4. G. B. Tofan, "Current Tendencies regarding the Touristic Infrastructure of Dragoiasa-Tulghes Depression Alignment", Analele UniversităŇii din Oradea – Seria Geografie, 1/2013, 35-44, ISSN: 1221-1273, E-ISSN: 2065-3409
5. D. Frangou, Z. Georgiadou, D. Marnellos, "Hotel Design: A Path for Qualitative Tourism", Tourism Research Institute, Journal of Tourism Research, vol 12/1, 2015, 108-134.
6. F. K. Varolgunes, F. Canan, M. Rio-Roma, C. Oliveira, "Design of a Thermal Hotel Based on AHP-QFD Methodology", Water. 2021; 13(15):2109. DOI: https://doi.org/10.3390/w13152109
7. M. Nikolić, N. Kurtović-Folić, A. Milojković, "Hotel Design and Adaptive Reuse: From Historic Palaces to the City's Dilapidated Structures", Facta Universitatis, Series: Architecture and Civil Engineering, Facta Universitatis, Series: Architecture and Civil Engineering, 2014, 12, 1, pp. 97 - 112, 728.5=111, 10.2298/FUACE1401097N
8. P. Ćuka, B. Gregorova, "Customer Satisfaction in Slovak Spas: Case Studies of Rajecke Teplice, Piestany and Brusno", Tourism 30/2, 2020, 85-90, DOI: http://dx.doi.org/10.18778/0867-5856.30.2.24
9. M. Šuligoj, "Characterization of health-related hotel products on the Slovenian coast", Geoadria, 25 (1), 2020, 39-52. DOI: https://doi.org/10.15291/geoadria.2945
10. P. C. Lee, M. J. Lee and T. T. Cheng, "Importance of Wellness Concepts in the Hotel Industry: Perspectives from the Millennials", Journal of Quality Assurance in Hospitality & Tourism, 20 (6), 2019, 729-752, DOI: https://doi.org/10.1080/1528008X.2019.1616041
11. N. Kondža, "Pleasant Spaces Without Dramaturgy", Oris 64, 2010, 138-146, ISSN: 1331-7571
12. R. Loher, "Tuhelj Blur", Oris 80, 2013, 124-134, ISSN: 1331-7571
13. A. Koršić, "A Relaxing Environment", Oris 64, 2010, 132-138, ISSN: 1331-7571
14. B. Magaš, "Misli o arhitekturi – Thoughts on Architecture", 2. dopunjeno izdanje, (A. Žunić, Ed.), Hrvatska akademina znanosti I umetnosti, Sveučilište u Zagrebu – Arhitektonski fakultet, UPI-2M PLUS, Zagreb. ISBN: 978-953-7703-53-0
15. R. Penner, L. Adams, S. Robson, "Hotel Design, Planning and Development", 2nd edition, W. W. Norton & Company, New York 2013. ISBN: 978-0-393-73385-3
16. J. Skorup, "Atomizirani hotel", ArTresor naklada, Zagreb, 2020. ISBN: 978-953-8012-24-2
17. M. Nikolić, A. Milojković, A. Keković A. "Dizajn savremene hotelske sobe – između luksuza i prostorne racionalizacije", Zbornik radova sa međunarodne konferencije „Savremena dostignuća u građevinarstvu, str. 791-797, Subotica, Srbija, 24-25. april 2014, ISSN 0352-6852, eISSN 2334-9573, DOI: 10.14415/konferencijaGFS2014
18. "Hotels: World Architects", Manela Padura, Barcelona, 2009. ISBN: 978-84-935862-5-6

ARHITEKTURA SAVREMENOG BANJKSOG UGOSTITELJSTVA – AKTUELNE TENDENCIJE U PROJEKTOVANJU BANJSKIH HOTELA

Banjski hoteli predvode trend u rastućem sektoru banjskog turizma na tržištu wellness turizma. Ovi objekti su smeštajne jedinice koje nude individualne tretmane, masaže i usluge za posetioce čiji je fokus na zdravlju i relaksaciji. Primarni cilj istraživanja je da se ispitaju aktuelne tendencije i strategije i uspešni pristupi u oblasti arhitektonskog projektovanja banjskih hotela. Istraživanje počinje pregledom osnovnih karakteristika savremenog velnes turizma, nakon čega sledi definisanje banjskog hotela kao posebne vrste ugostiteljskog objekta i klasifikacija njegovih modernih modaliteta, pojašnjena i precizno ilustrovana korišćenjem relevantnih studija slučaja. Drugi deo istraživanja je analiza prepoznatih proejktantskih tendencija u pogledu prostorne organizacije banjskih hotela. U zaključku se razmatra njihova primenljivost u široj praksi i navode se određeni nedostaci i ograničenja.

Ključne reči: *banjski hoteli, hotelska arhitektura, arhitektonsko projektovanje, wellness, turizam*

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Original Scientific Paper

PM MITIGATION MEASURES UTILIZATION TRENDS ON BUILDING SITES IN NOVI SAD, SERBIA DURING 2019-2022

UDC 69.05:351.777.51/.6(497.113)"2019/2022"

Miljan Šunjević[1], Darko Reba[1], Vladimir Rajs[1], Bogdana Vujić[2], Dejana Nedučin[1], Mirjana Vojinović Miloradov[1]

[1]University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia
[2]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia

Abstract. *The beginning of the new millennium provokes governments and researchers to recognize the importance and the effect that Particulate Matter (PM) has on the whole environment. PM has been marked as one of the key ambient air pollutants, due to its high sorption ability. World Health Organization indicated PM present in ambient air as pollutant with adverse, acute and hazard effect on human health and built environment. The city of Novi Sad, Serbia is rapidly expanding, redefining architectural, urban and environmental matrices. Architectural spatial transformations - construction sites need to be considered as temporal unique pollution hot spots. Trend of active construction sites increasing number in Novi Sad affects the ambient air quality. Goal of the research is to emphasize PM pollution problem on the construction sites in Novi Sad and to illustrate and display the trends in mitigation measures application during 4-year period (2019-2022).*

Key words: *PM, environmental pollution, construction sites, architectural transformations.*

1. INTRODUCTION

The global level of air pollution is considered as the primary environmental challenge of 21st century. World governments, organizations and researchers found that air pollution is mostly caused by human activity, introducing toxic and hazard chemical molecules and suspended particles to the environment. Numerous researches have shown that ambient air pollution can inflict hazard and adverse effects on the environment and human health [1]–[5]. Ambient air pollution has high association with public health, biocenosis status, regional and global climate change [6], [7]. The omnipresent component in ambient air is Particulate

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Corresponding author: Miljan Šunjević, Faculty of Technical Sciences, University of Novi Sad, Trg Dositeja Obradovića 6, 21102 Novi Sad, Serbia
e-mail: msunjevic@uns.ac.rs

Matter – PM which is to be considered as basic polluting substance. Fine PM smaller than or equal to 10 μm has been characterized by the World Health Organization to have direct impact on the environment and human health [8].

Heavy industry, a characteristic of developing countries produces significant ambient air pollution problem [9], [10]. Other characteristics of developing countries are weak economy and almost nonexistent resilience of the cities, which makes dealing with pollution problems hard. Developed countries have an economic freedom to dictate necessity for compensation in various areas among which is environmental protection. High PM emission and ambient air pollution are considered as daily routine in developing countries. Increased architectural activity and spatial transformations processes define the urban development, resulting in frequent uncontrolled construction sites. Amplified anthropogenic activities during processes of architectural transformation and city development generates and emits high concentrations of suspended particles in surrounding built and natural environment [11]–[14]. Various researches have confirmed that building through its whole lifecycle emits increased PM concentrations [15]–[17]. Each construction process that follows architectural spatial transformations has different influence on particle emission and is often dependent on meteorological conditions. Distinctive construction activities during the building processes are important sources of PM in the ambient air:

- Site preparation (land clearing and demolition of existing buildings)
- Earth excavation and transport
- Moving equipment and machines
- Transport and storage processes (loading, unloading, transfer and storage)
- Specific activities in accordance with the position being performed
- Final architectural activities

Construction origin of high PM concentrations in the ambient air pressured governments in developed countries to create mitigation measures and models [3], [18]–[22]. The efficiency and utilization of created mitigation measures and models was ensured by introducing legislations and strict inspections.

Meteorological conditions have a great influence on the generation and emission of suspended particles. The used/worked materials are important elements in PM emission and generation processes. In more humid material, the particles are strongly held together (statical tension occurs), which decelerate their emission into the ambient air. The Canadian Environment Agency annual reports estimated that construction processes account around 20% of total suspended particulate emissions [21]. Emitted particulate matter endangers both workers on construction sites and nearby residents [12], [23]. The long-range transport ability (affected by particulate size) allows PM to travel far from the source, creating hazard effect in the long run.

In Serbia, the fundamental architectural research activities and project management disregard the engineering area of environmental protection. As part of the environmental engineering prevention and control of suspended particulates generation, emission and mitigation is neglected and considered unsignificant in areas of architectural spatial transformation. In order to answer all environmental challenges within the architectural activities must imperatively incorporate mitigation measures for negative effects of PM caused by spatial transformations. Architectural build environment, spatial and urban transformation and other building activities demand methodologic planning approach with awareness of the effect it has on the whole surrounding environment both living and built.

Serbia as a candidate for entry in European Union is required to integrate strict environmental protection legislation. Often having cities in top 10 air polluted cities in the world, ambient air pollution is becoming daily routine in Serbia. Necessity to address this question requires understanding of PM life cycle, including source recognition, forming processes, composition, dispersion and atmospheric fate, population exposure and health effects.

After the capital - Belgrade, Novi Sad is the city with highest expansion and development. High architectural activity and numerous spatial transformations are markers of the city expansion and development. Large number of active construction sites and increased pollution are indicators that city is struggling with resilience. As all the architectural processes generate and emits large amounts of polluting substances in surrounding environment, it is vital importance for city and inhabitants that this problem gets resolved.

2. MATERIALS AND METHODS

The architectural spatial transformations are constantly changing, progress and improving. Construction sites create specific system with determined expiration date and unseen effect on the total environment. Experiences from developed countries assert that construction processes need to be followed by adequate monitoring and prevention models and methods. Measures can be considered through prediction and detection phase. Prediction determines critical pollution hotspots in the planning sequence, while detection follows the active works and gives real time input. The research is based the detection phase, and implemented through monitoring of construction sites.

The potential of construction sites as the temporal pollution hotspots is designed with environmental software for pollution prediction and modeling ADMS-Urban. The software was applied on the 5 selected construction sites (Figure 1). Optical Particulate Sensor – OPC

Fig. 1 Selected construction sites for application of ADMS-urban

N2 (produced by Alphasense) was used to measure the fine particulates (PM10 and PM2.5) emission on selected sites. Obtained data was compared with EPA's Tier I prediction model [24] and input in ADMS-urban together with meteorological data gained on the official Republic Hydrometeorological Service of Serbia web presentation [25].

The research was realized in the city of Novi Sad, Serbia during 4-year period 2019-2022. Monitoring was performed each year on 100 active construction sites. Periods of monitoring were March to September 2019, April to October 2020, March to October 2021, February to September 2022. During the research period the utilization of PM prevention measures were inspected (Figure 2).

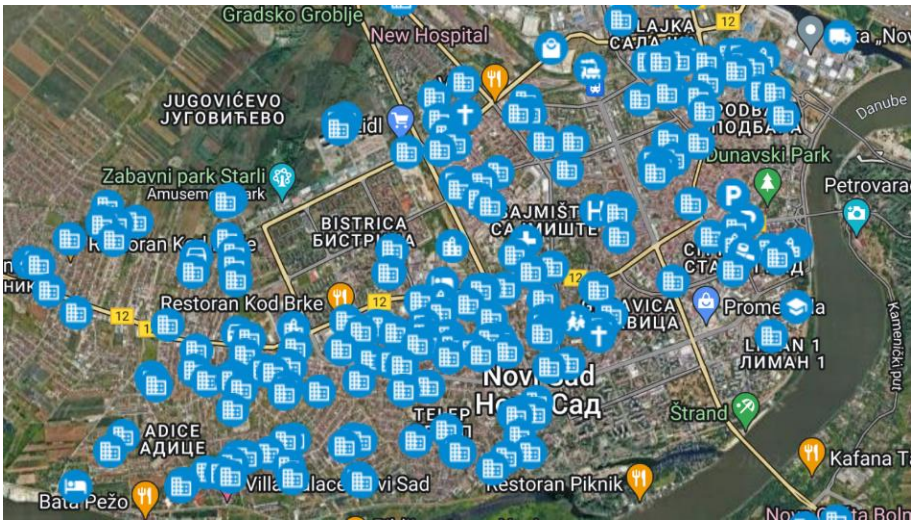

Fig. 2. List of selected active construction sites in Novi Sad during 2019-2022. [26]

The examples from legislations and guidelines of the developed countries were analyzed and observed. The measures were selected and tested to fit the application in Serbia's construction ecosystem. Testing and selection of the measures was performed in the author's PhD thesis research. Selected measures include keeping the existing vegetation, stabilization covers and geotextile, vegetation covering, mulching, adequate material handling, stored and during transport material covering, machine installation of powder materials, protective curtains, wind fences, controlled entrance, washing machine tires before exit (manual or automatic), road paving, road definition and marking, speed limitation, transport road watering, maintenance, water spraying, and use of suppressants.

The research tracked architectural activities on building sites to determine what measures were applied and in what degree. One of the basic measures is to keep existing vegetation in the zones that are not required for works. This measure allows the unnecessary areas not to be exposed to construction site conditions. Other similar methods that can be used on the construction sites include covering exposed ground with covers, geotextile and mulch. Mulch is mostly made of natural materials (shredded wood, hay, stone…) which has low impact on the environment, but it can also be created from plastic materials that require special handling. Adequate material utilization can reduce spilling of materials in the environment and minimize the emission of fine particulates in the ambient air. Powder

materials due to their fraction size are a good source of fine particles in ambient air. Machine installation creates a closed system in which powder materials are not exposed to the environment before the final assembly, consequently reducing the emission in the environment. Barriers such are fences and curtains can provide primary blockades for fine particles spreading. Defined entrance to the building site and road management allows a more efficient control of the architectural activities. These measures also minimize traction and PM generation on the building sites. Water use on constructions sites is the most direct way to stop fine particle emission. It binds particles and creates particle clusters that can hardly become airborne. In addition to this cheap measure – water, a more efficient but also more expensive method is the use of the suppressants. Suppressants, depending on their chemical composition could have adverse effect on the environment.

3. Results and Discussion

With the application of environmental modeling software ADMS-Urban dissemination of PM generated and emitted from construction sites has been modeled. Dispersion of suspended particulates from 5 selected sites on the 100 m height has been shown on the architectural matrix of Novi Sad (Figure 3). Observing the modeled dispersion allows understanding of the

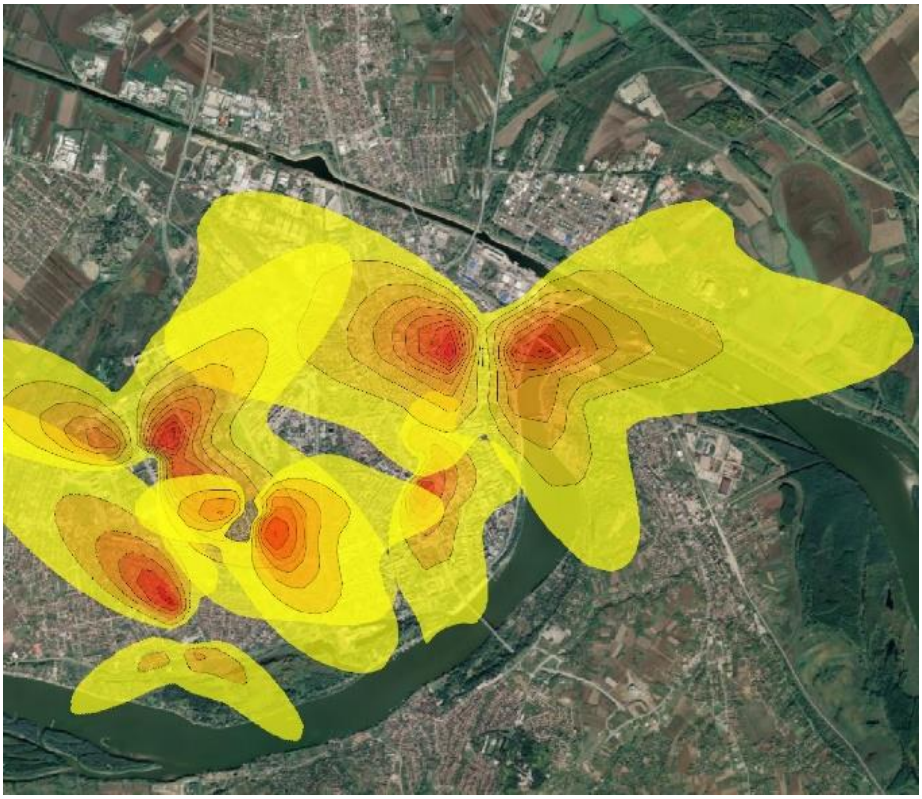

Fig. 3 Modeled dissemination of PM emitted on construction sites (PM concentrations: red to yellow – high to low)

real potential of PM from construction sites to pollute the ambient air. The model indicates that only one construction site is enough to cover a huge part of the urban city matrix. On the Novi Sad urban matrix example, it is *de facto* depicted that minimal number of active construction sites is required to cover the city with the suspended particle pollution veil.

The research results (Table 1) display low level of utilization for most of the selected PM prevention measures. The existing legislations were not designed for application of mitigation measures, but some of the demands are in compliance with environmental protection standards. It is best noticeable in the utilization of measures: setting up wind fences, controlled entrance, road definition and marking, and speed limitation. These measures are fully applied. Legislations prescribe that all building sites are required to have defined and organized roads and an entry point, maximum speed limit of 20 km/h, with closed fences installed around the site. High percentage of machine installation of powder materials can be seen in economical and practical reasons as it is more efficient, easier and cheaper measure. Road paving achieves high percentage for its practical reasons as it allows highly effective movement of machines and workers on the construction site.

Medium to low usage can be observed in termso adequate material handling, covering of the stored material and material during transport, setting up the protective curtains, road watering and water spraying.. The main reasons for the poor quality of material handling, storing and transportation are the insufficient number of qualified workers together with an increasing number of construction sites. The explanation for water spraying can be found in the low experience of the leading engineers and sparing water. Monitoring the cases where the existing vegetation was kept, different areas were covered including mulching, where maintenance, use of suppressants and washing of the tires was present indicated numbers that can be defined as statistical error. The reasons for these results are found in the lack of legislation and care for the environment, high prices and absence of education.

Table 1 Utilization of measures on construction sites 2019-2022.

Monitored measures	2019.	2020	2021	2022
Keeping the existing vegetation	1%	5%	5%	4%
Stabilization covers and geotextile	0%	0%	0 %	0 %
Vegetation covering	3%	5%	4 %	3%
Mulching	0%	5%	3%	3%
Adequate material handling	20%	22%	20 %	25 %
Stored material covering	23%	30%	30 %	35 %
Material transport covering	33%	33%	35 %	38 %
Machine installation of powder materials	89%	92%	92 %	93 %
Protective curtains	25%	38%	40 %	47 %
Wind fences	100%	100%	100 %	100 %
Controlled entrance	100%	100%	100 %	100 %
Washing machine tires before exit (manual or automatic)	0%	0%	2 %	3 %
Road paving	73%	75%	75 %	81 %
Road definition and marking	100%	100%	100 %	100 %
Speed limitation	100%	100%	100 %	100 %
Transport road watering	30%	25%	30 %	30 %
Maintenance	9%	11%	10 %	11 %
Water spraying	25%	28%	30 %	32 %
Use of suppressants	0%	0%	0 %	0 %

The 4-year investigation results manifest as the trend of stagnation, whereas mention only fully applied measures are one defined by legislation. Some measures (material handling, installation, covering and transport together with the protective curtain and road paving) show an increasing trend, where economic benefit factors can be considered as reasons. There is also ian ncreasing trend of water spraying, which can be justified by the temperature rise and less rainfall.

4. CONCLUSION REMARKS

The application of the ADMS-Urban software with original experimental obtained data provided the PM dissemination model which exposed the minimal number of construction sites required to transport the particle matter over a city like Novi Sad. The designed model allows the definition of the construction sites as the temporal architectural spatial pollution hotspots.

The inspection of applied architectural activities explained and presented in the research results has indicated that there are two main factors for application of selected measures. PM prevention and mitigation measures are applied based on economic and legislations factors. The results distinctively depict that the legislation defined measures (with high financial penalties) were fully applied. Law defined measures are dependent and highly correlated with the economic factor. Economic beneficial factors provide the necessary push for the utilization of measures. Mechanization and material availability, efficiency, workers education and qualification level, time consumption and other are part of the basic elements on the building site that affect the economic dynamics.

Suspended particle mitigation and prevention utilization architectural trend for the city of Novi Sad in the research and investigation four years period (2019-2022) for the most measures is stagnation. Slightly increase is perceived for material handling, installation, covering and transport together with the protective curtain and road paving. Economic benefits in domain of architectural spatial transformations dominantly control and dictate trends in PM mitigation measures utilization. Other factor that affects the application of the PM mitigation and prevention measures on the construction sites in city of Novi Sad can be concluded as good practice of the contractor companies and as a part of the management experience of leading engineers.

This investigating of architectural PM mitigation and prevention measures utilization trends on construction sites in Novi Sad is the consecutive part of the first ever research in Serbia started in the PhD thesis study of the author. The ambient air pollution and the search for solutions is one enormous battlefield between architectural spatial transformations, artistic impression, profits, benefits, environment, governments, corporations and health. Adopting policies and methods in correspondence to existing architectural trends will provide cities with the possibility to be sustainable and resilient.

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REFERENCES

1. WHO, Ambient air pollution: A global assessment of exposure and burden of disease. Geneva, Switzerland: World Health Organization, 2016. [Online]. Available: www.who.int
2. R. Van Den Heuvel et al., "Identification of PM10 characteristics involved in cellular responses in human bronchial epithelial cells (Beas-2B)," Environ. Res., vol. 149, pp. 48–56, 2016, doi: 10.1016/j.envres.2016.04.029.
3. EEA, Air quality in Europe 2021. European Environment Agency, 2021.
4. J. Li et al., "Differing toxicity of ambient particulate matter (PM)in global cities," Atmos. Environ., vol. 212, no. April, pp. 305–315, 2019, doi: 10.1016/j.atmosenv.2019.05.048.
5. N. A. B. Mabahwi, O. L. H. Leh, and D. Omar, "Human Health and Wellbeing: Human Health Effect of Air Pollution," Procedia - Soc. Behav. Sci., vol. 153, pp. 221–229, 2014, doi: 10.1016/j.sbspro.2014.10.056.
6. US EPA, "Quantitative Health Risk Assessment for Particulate Matter," U. S. Environ. Prot. Agency, pp. 1–596, 2010, [Online]. Available: http://www.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf%5Cnpapers2://publication/uuid/36AC0D6B-29A0-4A0F-A8B5-699617A33A15
7. R. D. Brook et al., "Particulate Matter Air Pollution and Cardiovascular Disease An Update to the Scientific Statement From the American," 2010, doi: 10.1161/CIR.0b013e3181dbece1.
8. WHO, "Health risk assessment of air pollution – general principles," Int. J. Mass Spectrom., p. 40, 2016, [Online]. Available: http://linkinghub.elsevier.com/retrieve/pii/S1387380603000903
9. F. Azarmi, P. Kumar, D. Marsh, and G. Fuller, "Assessment of the long-term impacts of PM10 and PM2.5 particles from construction works on surrounding areas," Environ. Sci. Process. Impacts, vol. 18, no. 2, pp. 208–221, 2016, doi: 10.1039/c5em00549c.
10. S. Feng, D. Gao, F. Liao, F. Zhou, and X. Wang, "The health effects of ambient PM 2.5 and potential mechanisms," Ecotoxicol. Environ. Saf., vol. 128, pp. 67–74, 2016, doi: 10.1016/j.ecoenv.2016.01.030.
11. R. Yadav et al., "Particulate Matter Pollution in Urban Cities of India During Unusually Restricted Anthropogenic Activities," Front. Sustain. Cities, vol. 4, Mar. 2022, doi: 10.3389/frsc.2022.792507.
12. F. Azarmi and P. Kumar, "Ambient exposure to coarse and fine particle emissions from building demolition," Atmos. Environ., vol. 137, pp. 62–79, 2016, doi: 10.1016/j.atmosenv.2016.04.029.
13. J. S. Kinsey and C. Cowherd, "Particulate emissions from construction activities," J. Air Waste Manag. Assoc., vol. 55, no. 6, pp. 772–783, 2005, doi: 10.1080/10473289.2005.10464669.
14. I. P. S. Araújo, D. B. Costa, and R. J. B. de Moraes, "Identification and characterization of particulate matter concentrations at construction jobsites," Sustain., vol. 6, no. 11, pp. 7666–7688, 2014, doi: 10.3390/su6117666.
15. H. Kim and S. Tae, "Evaluation Model for Particulate Matter Emissions in Korean Construction Sites," Sustainability, vol. 13, no. 20, p. 11428, Oct. 2021, doi: 10.3390/su132011428.
16. J. Yang, S. Tae, and H. Kim, "Technology for Predicting Particulate Matter Emissions at Construction Sites in South Korea," Sustainability, vol. 13, no. 24, p. 13792, Dec. 2021, doi: 10.3390/su132413792.
17. F. Azarmi, P. Kumar, and M. Mulheron, "The exposure to coarse, fine and ultrafine particle emissions from concrete mixing, drilling and cutting activities," J. Hazard. Mater., vol. 279, pp. 268–279, 2014, doi: 10.1016/j.jhazmat.2014.07.003.
18. S. Moorcroft, "Guidance on Air Quality Monitoring in the Vicinity of Demolition and Construction Sites," 2018.
19. Environment Protection Authority ACT Government, "Environment Protection Guidelines for Construction and Land Development in the ACT," 2011.
20. CPCB, Guidelines on DUST mitigation measures in handling Construction material & C&D wastes, Control of. Delhi: (Ministry of Environment, Forest & Climate Change, Govt. of India, 2017. doi: 10.32964/tj16.11.
21. Cheminfo Services Inc., Best Practices for the Reduction of Air Emissions From Construction and Demolition Activities. Environment Canada, 2005. [Online]. Available: http://www.bv.transports.gouv.qc.ca/mono/1173259.pdf
22. US EPA, AP-42. United States Environmental Protection Agency, 2011.
23. P. Pereira, A. Monkevičius, and H. Siarova, "Public Perception of Environmental, Social and Economic Impacts of Urban Sprawl in Vilnius," Soc. Stud., vol. 6, no. 2, pp. 259–290, 2014, doi: 10.13165/sms-14-6-2-03.
24. EEA, "2.A.5.b Construction and demolition," in EMEP/EEA Air Pollutant Emission Inventory Guidebook, 2019.
25. RHMZ, "Aktuelni podaci," Republički Hidrometeorološki Zavod, 2019. https://www.hidmet.gov.rs/
26. "Gradnja.rs." https://www.gradnja.rs/mapa/

TREND PRIMENE PM MITIGACIONIH MERA NA GRADILIŠTIMA U NOVOM SADU, SRBIJA TOKOM 2019-2022

Početak novog milenijuma naveo je vlade i istraživače da prepoznaju važnost i efekat koji suspendovane čestice (eng. Particulate Matter - PM) imaju na celokupono okruženje. Suspendovane čestice su označene kao jedan od ključnih zagađujućih supstanci ambijentalnog vazduha usled sopcionih sposobnosti. Svetska zdravstvena organizacija je indikovala da PM čestice prisutne u ambijentalnom vazduhu mogu imati štetan, akutan i hazardan efekat na ljudsko zdravlje i izgrađeno okruženje. Grad Novi Sad se ubrzano razvija, redefinišući arhitektonske, urbane i matrice životne sredine. Arhitektonske prostorne transformacije – gradilišta moraju se posmatrati kao specifične vremenski ograničene tačke zagađenja vazduha. Trend povećanja broja gradilišta u Novom Sadu utiče na kvalitet ambijentalnog ambijentalnog vazduha. Cilj istraživanje je da naglasi problem emisije suspendovanih čestica sa gradilišta u Novom Sadu i da prikaže trend primene mitigacionih mera tokom četvorogodišnjeg perioda (2019-2022).

Ključne reči: *Suspendovane čestice, gradilišta, arhitektonske prostorne tranformacije, trend*

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