25
Preliminary report/Short communication
Doi 10.7251/stp202401016P
ISSN 2566-4484

Nataša Petković, University of Nis, natasapetkovic83@gmail.com
Branislava Stoiljković, University of Nis, branislava.stoiljkovic@gaf.ni.ac.rs
Hristina Krstić, University of Nis, hristina.krstic@gaf.ni.ac.rs
Vladana Petrović, University of Nis, vladana.petrovic@gaf.ni.ac.rs

LOW-RISE HIGH-DENSITY HOUSING – POSSIBILITIES OF IMPLEMENTATION IN LOCAL CONTEXT, CASE OF NIŠ, SERBIA

Abstract

Low-rise, high-density housing (further LRHD housing) represents an alternative model for solving contemporary housing issues in urban areas. However this specific typological form is not recognized in local urban planning and legislative frameworks. The aim of this research is to explore the possibilities for development of LRHD housing within local frameworks through the assessment of urban parameters potentially achievable through the application of the pilot *Mix-Mesh* concept for LRHD housing and their comparative analysis with values defined by local planning regulations.

Keywords: low-rise high-density housing, modular design, sustainability

СТАНОВАЊЕ НИСКЕ СПРАТНОСТИ ВЕЛИКЕ ГУСТИНЕ – МОГУЋНОСТИ ПРИМЈЕНЕ У ЛОКАЛНИМ ОКВИРИМА, СЛУЧАЈ ГРАДА НИША, СРБИЈА

Сажетак

Становање ниске спратности велике густине (у наставку LRHD становање) представља алтернативни модел, који на ефикасан начин помаже у рјешавању савремених стамбених проблема у урбаним градским срединама. Нажалост, ова специфична типолошка форма није препозната у локалним урбанистичким оквирима. Циљ рада је да се истраже могућности развоја LRHD становања у локалним оквирима, кроз процјену урбанистичких параметара потенцијално остваривих примјеном пилот концепта LRHD становање, симболично названог *Mix-Mesh*, и њихову упоредну анализу са вриједностима дефинисаним локалном планском регулативом.

Кључне ријечи: становање ниске спратности велике густине, модуларно становање, одрживост

1. INTRODUCTION

The urbanization of cities has led to significant changes in the built urban fabric. The increased housing demands has triggered aggressive occupation of available spatial resources, resulting in the expansion of two diametrically opposed residential models – 1) single-family housing on the outskirts of the city, which caused the urban sprawl phenomenon and led to the deterioration of living quality due to inadequate infrastructure and service provision in these area and 2) high-rise, high-density multi-family construction, which initiated numerous social problems [1]-[3].

As an alternative solution, the modern approach in housing development turns to the application of low-rise, high-density housing models (further LRHD housing models), as a compromise solution that attempts to mitigate the differences between the aforementioned opposing housing models [4]-[7]. High-density housing justifies the infrastructure provision of the area, as well as the provision of service and amenity facilities, while the development of lower-rise structures, through the application of specific typological patterns, and by providing a wide range of open spaces, offers residents a comfort similar to that of single-family homes.

2. LOW-RISE HIGH-DENSITY HOUSING – DEFIITION AND ADVANTAGES

The roots of LRHD housing can be traced back to the 1960s and 1970s. Among the early achievements of this type, notable examples include: *Siedlung Halen* (1961, Bern, Switzerland), *Penn Landing Square* (1969, Philadelphia, US), and *Marcus Garvey Village* (1973, Brooklyn, New York, US) [1]. These residential developments set the foundations for LRHD housing, and established key design principles [8], which have undergone minor changes to this day.

Theoretical research [1][2][8][9], highlights the following main characteristics of LRHD housing:

- Housing density ranging from 350-550 inhabitants/ha,
- Maximum height of up to 5(6) above-ground floors,
- Compactness of physical structure and urban composition,
- High degree of individuality and privacy in housing – achieved through clear differentiation of private and public spaces, and utilization of appropriate physical elements at the ground level. Whenever possible, direct access to the units is provided from the ground level,
- Clear territorial differentiation of spaces – particularly favoring the allocation of part of the terrain to residential units, thereby privatizing a significant portion of the land,
- Wide range of open spaces,
- Integration of housing with accompanying functions, through the development of continuous built fabric.

2.1. BENEFITS OF LRHD HOUSING ON URBAN QUALITY

Decades-long practice in the implementation of LRHD housing confirms its efficiency in addressing numerous urban challenges of today [6][7][9]. Its application channels the common urban planning deficiencies associated with housing, fosters a sense of place, enhances the attractiveness and vitality of areas, and improves safety. Simultaneously, it enhances the sense of belonging, promotes the intensity of social interactions, and strengthens neighborly cohesion. Ultimately, it increases the value of land and real estate, all of which contribute to the sustainability of LRHD housing.

All the mentioned benefits influenced the wide acceptance of LRHD housing as a desirable model for the development of modern cities. Consequently, a large number of developed countries have implemented this type of housing in urban plans and issued recommendations related to its construction. Unfortunately, this type of housing is not represented in planning and urban practice in Serbia. Although there are some provisions in strategic documents that open the way for the implementation of this model, concrete realizations are still lacking. These circumstances initiated this research with the aim of creating a modular and flexible LRHD housing concept. On the one hand, such concept would follow the spatial requirements defined by local urban planning and architectural regulations, while on the other, it would be flexible enough to adapt to various location conditions. The possibility of its application in domestic circumstances is seen through the comparative analysis of achieved urban parameters applying *Mix-Mesh* concept and ones predefined by the regulation.

3. DESIGN METHODOLOGY FOR LRHD HOUSING

The methodology of designing LRHD housing has been the subject of numerous theoretical and practical studies. Although these studies are extensive and cover various aspects of the design process, for the purposes of this work, key architectural and urban elements have been marked out. These elements would serve as the backbone for the development of the LRHD housing model that could be implemented within local contexts.

In terms of typology (Figure 1) LRHD housing is characterized by the application of the following patterns:

- Linear or grid-type model of single-family housing, in the form of row houses and/or courtyard houses, with two or three above-ground floors [10][11].
- Transitional model, which in appearance and its advantages strongly resembles family housing, achieved through the multiplication of units by connecting, stacking, and overlapping them to form complex, "hybrid" residential type, with up to three above-ground floors [12].
- The "garden-apartment" model of multi-family housing, which can be developed in the form of a semi-closed or closed block, with private gardens on the terrain and up to 5 above-ground floors [12].

Figure 1. Examples of typologies applied in LRHD housing a) single-family row houses b)transitional model c) garden-apartment model

Regardless the typology, residential blocks are developed in accordance with pedestrian needs [9], prioritizing on-foot and cyclist traffic within the open block area. Vehicle traffic flows along the perimeter of the area, while within the LRHD areas themselves, if necessary, is organized in a form of integrated streets. Stationary traffic is located within underground garages or on the terrain, along street profiles or in separate parking areas along the perimeter of the area. The LRHD housing concept also features the introduction of a complex system of pedestrian paths (Figure 2), characterized by a three-level division into: primary, connecting and secondary paths. The width of primary paths ranges from 2.4 to 6.0 meters, depending on specific conditions, while the minimum width of other types of paths is 1.2 meters. This creates a safe and secure environment adapted to pedestrian and cyclist movement [9].

Figure 2. Examples of pedestrian friendly traffic in LRHD housing

One of the key characteristics of LRHD housing is the presence of significant private open spaces [2][9] which provide a suitable alternative to the yards of single-family houses. These spaces, in terms of their position, organization, and dimensions, should serve as an extension of the outdoor living area and support everyday activities such as dining, children's play, leisure activities, socializing with guests, and more [13][14][15]. LRHD typology is characterized by the prevalence of various forms of private open spaces (Figure 3) – from private gardens, created by adding part of the terrain to ground-floor units, to spacious balconies and loggias, to larger rooftop terraces on the top floors [2].

Figure 3. Examples of various forms of private open areas in LRHD housing

4. *MIX-MESH* DESIGN CONCEPT

The proposed modular concept, which could be used in the development of LRHD housing, is based on the design methodology outlined in the previous chapter. The basic module, with dimensions of 4.2x5.0 meters, has been selected as the most efficient due to its ability to accommodate various spatial arrangements: from parking (either underground or at ground level), through pedestrian and/or cycling paths, to the living rooms and double bedrooms, or grouping individual spatial functions within the given module (such as utilities and toilets, kitchen and dining area, two single bedrooms and etc.)

Varieties of spatial layouts, which arise from the possibility of different mixing combination of modules and their arrangement in a mesh-like form (symbolically reflected in the concept name *Mix-Mesh*) is reflected in a wide range of residential units (Figure 4): from studio apartments, through one-bedroom to multi-bedroom apartments (intended for larger households), with the possibility of organizing them within one or more floors.

One of the dominant characteristics accompanying LRHD housing, reflected in the development of significant private open spaces, represents the cornerstone in the development of the *Mix-Mesh* concept. All the units on the ground floor level are planned with their own piece of land in the form of private gardens. One part of these areas is planned with paving, while the rest is landscaped. Particularly high-quality solutions for multi-family housing are those where the ground-floor residential units, especially ones of larger structures, have direct access from the terrain and associated garden. In this way, a part of residential units in multi-family buildings acquire the characteristics of single-family town-houses. Private open areas in a form of balconies or loggias are added to units on higher floors. These areas in larger residential units are provided with planters, suitable for medium-sized greenery. Units on the top floors are set back from the facade plane, creating the opportunity for the development of larger private open spaces in the form of rooftop terraces.

All vehicular traffic is kept on the periphery of the block, while a network of 4.2/5.0 meters wide pedestrian footpaths are provided within the area.

Figure 4. Variation of housing units in Mix-Mesh concept

4.2. TYPOLOGICAL MODALITIES OF *MIX-MESH* CONCEPT

Regarding the manner of units' spatial organization, mutual combination and vertical assembling, residential blocks of different typologies and densities can be developed (Figure 5). Some of those possibilities will be presented in the continuation of the paper, along with achieved urban parameters regarding densities.

Residential block of single-family housing. In this case, up to six single-family residential units, larger in structures and suitable for multi-member households, are grouped together in the form of row houses. Each residential unit is accessed through a small front garden, 2.0m deep (with area of 8m²). All units have modest rear garden, with dimensions 5.0x4.2m (an area of 21m²). Units in such block can be two to three story high.

Residential block of multi-family apartment buildings. In this case, only multi-family apartment buildings are planned, with the number of floors depending on defined urban planning parameters. Depending on the specific conditions, corridor or gallery layouts can be applied. Significant private open areas, as the main feature of LRHD housing, are evident in this case as well. All residential units at ground level have private gardens with dimensions of 4.2x5.0m. This way, a large number of residential units acquire the characteristics of single-family houses. All units on higher floors have accompanying balconies or loggias. By withdrawing the façade levels on the top floor, significant roof terraces are developed, serving as alternatives to ground floor gardens.

Combined residential block. This urban form is a combination of single-family houses and multi-family apartment buildings. In this type of block, one part of the residential units is arranged in the form of row houses, while the other part is grouped within multi-family apartment building. Row houses typically have two to three floors, while the number of floors in multi-family apartment building can vary from three to five.

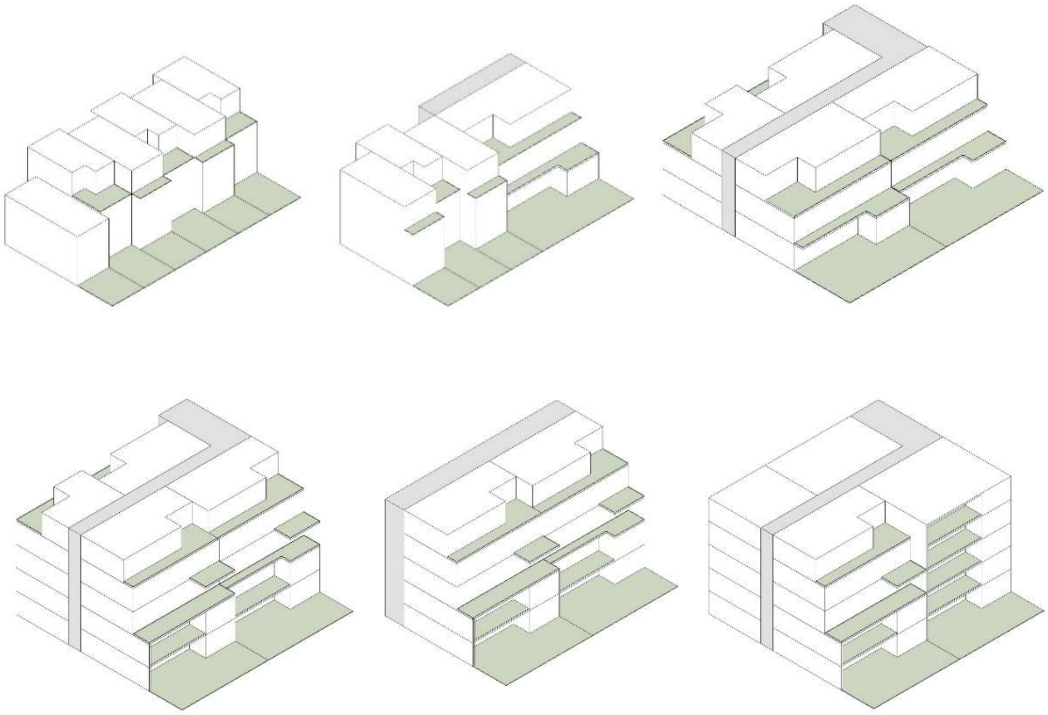

Figure 5. Different housing typologies in Mix-Mesh concept

5. EVALUATION OF THE POSSIBILITY OF APPLYING THE *MIX-MESH* CONCEPT WITHIN LOCAL CONTEXTS

As already mentioned, LRHD housing, especially aspects related to the organization of open spaces within this model, are unfamiliar in the planning and urban practice of the Republic of Serbia. Therefore, the possibility of applying this housing model within local framework can only be examined in accordance with prevailing planning regulation at the national and local levels.

5.1. LEGISLATIVE URBAN FRAMEWORK FOR THE RESIDENTIAL DEVELOPMENT- THE CITY OF NIŠ, SERBIA

In particular, in the city of Niš, residential areas are constructed according to the *General urban plan for city of Niš* (*GUP of Niš)* [16] and can be developed in a form of one of the following models: high-density housing, medium-density housing and low-density housing. Table 1. presents the urban parameters that define each of the mentioned models. It is important to note that urban areas within the *GUP of Niš*, which are nominally planned according to the housing densities, are not numerically defined (neither the number of housing units per hectare, nor number of inhabitants per hectare are provided for those areas). Since similar documents in the region define such housing densities with numerical values, as followed: low-density housing, up to 150 units/ha; medium-density housing, 150-250 units/ha; and high-density housing, over 250 units/ha (which aligns with the global interpretation of housing density) such values will be used for the further analysis [17].

Table 1. Urban planning parameters according to GUP of Niš, Serbia

Urban planning parameters	**Moderate density area**	**Medium density area**	**High density area**
Occupancy rate	50%	60%	70%
Construction rate	1,2	3,2	4,2
Building height	12m	21m	27m
Number of floors	P+2+Pk	P+4	P+6

5.2. URBAN PARAMETERS ACHIVED WITH DIFFERENT TYPOLOGICAL MODALITIES OF *MIX-MESH* CONCEPT

The feasibility evaluation of the of possibility of implementing the *Mix-Mesh* concept in local conditions will be conducted through a comparative analysis of urban parameters achieved by

applying different typological patterns supported by the *Mix-Mesh* concept, and parameters predefined by urban planning regulations (GUP of Niš).

Single-family housing block of row houses, characterizes density of around 95 residential units per hectare. Considering that this involves family housing, achieved densities could range from 330 to 375 residents per hectare. This supports the lower density limit (350 residents per hectare) defined for the LRHD housing model. The spatial organization of row houses around pedestrian streets with a width of 4.2 meters allows occupancy rate of 40%, while the construction rate ranges from 1.0 (for combination of row houses with two and three above-ground floors) to 1.2 (only three floors single-family row houses). The variability in spatial organization of the residential units does not affect density in terms of the number of residential units per hectare but can influence an increase in the number of residents per hectare.

Combined housing model, in which approximately one half of the block is arranged in a form of single-family row houses, while the other half is in form of multi-family apartment buildings (with three to five above-ground floors). Given the large number of modalities in terms of applied typologies (row houses of different floor levels, and different typologies and height of multifamily apartment buildings, as well as the possibility of their variable proportion), the density of the area may vary from case to case. In the case of combining row houses and multi-family buildings of corridor type, with three above-ground floors (with setbacks of facade planes on the top floors to form larger roof terraces) and a distance between multi-family buildings of 15 meters (combined model type 1, Table 2), it is possible to achieve a density of around 130 residential units per hectare, or around 355-415 residents per hectare. In this case, the achieved occupancy rate is approximately 50%, while the construction rate is around 1.5. In the case of combining row housing and multi-family apartment buildings of corridor type, with five above-ground floors (with setbacks of facade planes on the top floors to form larger roof terraces) (combined model type 2, Table 2), it is possible to achieve a density of 150 residential units per hectare, or around 375-480 residents per hectare. In this case as well, the achieved site coverage ratio is around 50%, while the floor area ratio is around 1.7.

Multi-family housing model provides even more dense blocks. In the case of developing a semi-enclosed apartment block, with corridor-type buildings (with setback on the top floors) an occupancy rate of 47% can be achieved. Depending on the buildings height, the construction rate ranges from 1.8, in the case of three above-ground floors (multi-family housing model type 1, Table 2) to 2.4, in the case of five above-ground floors (multi-family housing model type 2, Table 2). Housing density in such cases would range from 144 to 215 residential units per hectare, or 430-650 residents per hectare.

Table 2. Urban parameters in various modalities of Mix-Mesh concept

Achieved urban parameters	**Single-family housing** Row houses	**Combined housing, type 1** Row houses + Multi-family houisng (P+2+Pk)	**Combined housing, type 2** Row houses + Multi-family housing (P+4)	**Multi-family housing, type 1** Multi-family housing (P+2+Pk)	**Multi-family housing, type 2** Multi-family housing (P+4)
Occupancy rate	40%	50%	50%	47%	47%
Construction rate	1.0 - 1.2	1.5	1.7	1.8	2.3
Density	95	130	150	170	215
Density	330-375	335-415	375-480	425-595	540-750
Number of floors	P+1 and P+2	P+1/P+2and P+2+Pk	P+1/P+2 and P+4	P+2+PK	P+4

5.3. DISCUSION OF THE RESULTS

Through a comparative analysis of the values achieved by applying different typologies within the *Mix-Mesh* concept and those defined by the *GUP of Niš*, it is possible to assess the real potential of implementing the LRHD housing model in local contexts.

A detailed analysis of urban parameters regarding building heights and occupancy rates suggests that single-family housing model, in the form of row houses, could be implemented within **urban areas with moderate housing densities**. The combined model type 1 and multi-family housing model type 1 could also find their place within urban areas with moderate densities, with a floor area ratio up to 1.2 (of possible 1.5 or 1.7). In order to maximize the potential of LRHD housing, it is

necessary to modernize planning regulations and enrich them by introducing and defining this LRHD model as a distinct residential typological pattern. Adjustment of urban parameters would be entirely understandable and would not compromise the housing quality, considering that this type of housing is enriched with significant open spaces.

The combined model type 2 and multi-family housing model type 2 could be developed within **urban areas with medium densities**. In this case, there are no limits regarding building heights or constriction rates, as planning parameters allow for much denser construction within these areas.

What is evident is that each analyzed modality of the *Mix-Mesh* concept implies high densities (350 units per hectare or greater). However, through a comparative analysis of urban parameters (primarily building heights and occupancy rates the proposed conceptual solutions correspond to urban areas with medium or moderate densities. Although this fact does not limit the possibility of applying the defined LRHD model in any way, it suggests that in reality on-site situation regarding density, in all of the urban areas in the city of Nis, are far higher than nominal (which is up to 150 residents per hectare for moderate densities or 150-250 residents per hectare for medium densities). Such on-site situation casts a shadow on the perspective of LRHD model development within local contexts.

6. CONCLUSION

The LRHD model represents an alternative housing approach aimed at preventing issues arising from uncontrolled urban sprawl and the development of high-rise, high-density housing. Since density itself does not pose a barrier to quality living and is inevitable in the development of modern cities, enriching housing regulations by introducing LRHD housing as distinguish residential model, along with a set of measures customized for this typological pattern would have a positive impact on residential quality.

Specifically, in the case of the city of Niš, examining the feasibility of implementing the LRHD model has concluded that implementation could occur through: 1) forming larger residential blocks on the outskirts of the city, with increased housing density accompanied by the introduction of significant communal and green areas; and 2) developing smaller residential blocks within build urban fabric, in areas defined for medium density housing, thus promoting the compactness of urban fabric and enriching the area with missing amenities.

Application of LRHD housing would not only address urban housing needs but also enhance the overall livability and sustainability of the city.

LITERATURE

[1] Lj. Vasilevska, M. Ribar, „Low/rise high density housing – recommendation and key principles in the process of urban and architectural design“, *Thematic Proceedings: Innovation as a Function of Engineering Development – IDE 2011*, Faculty of Civil Engineering and Architecture, University of Nis, 259-274, 2011.

[2] D. Milanović, Lj. Vasilevska, „Influence of private open spaces on the quality of living in low-rise high density housing“, *Facta Universitatis – Series: Architecture and Civil Engineering*, Vol. 16, No 2, 293-305, 2018.

[3] Peng Du, A. Wood, N. Ditchman and B. Stephens, „Life Satisfaction of Downtown High-Rise vs.Suburban Low-Rise Living: A Chicago Case Study“, *Sustainability*, 9(6), 1052, 2017.

[4] J. L. Arrigone, *Urban Densification Through Low-rise/high-density Housing*, Development Bank of Southern Africa, Centre for Policy, Information and Evaluation, 1995.

[5] K. K. Theisler, „Low-rise, high-density housing, as a way of sustainability in Hungary“, *Open house international*, Vol.40 No.3, 44-51, 2015

[6] N. P. Nzimande, F. Morris-Kolawole, „Does Size Really Matter for the Place Attachment of High-Rise and Low-Rise Housing Estates? A Budapest Case Study“, *Sustainability*, vol. 16(3), 1-17. 2024.

[7] G. Bramley, S. Power, „Urban form and social sustainability: the role of density and housing type“, *Environment and Planning B: Planning and Design*, volume 36, 30-48, 2009.

[8] A. Saggio, Louis Sauer, *The Architect of Low-rise High-density Housing*, Department of Architecture and Urban Design, La Sapienza, University of Rome, 2014.

[9] A. Marinković, *Održivi model organizacije otvorenih prostora u stambenim područjima niske spratnosti-velike gustine*, doktorska disertacija, Građevinsko-arhitektonski fakultet Univerziteta u Nišu, 2018.

[10] S. Sano, I. Filipović, D. Radović, „Public-private interaction in low-rise, high-density Tokyo: a morphological and functional study of contemporary residential row-houses“, *The Journal of Public Space*, Vol. 5, N0.2, 2020.
[11] B. Stoiljković, *Projektovnje stambenih zgrada – Porodično stanovanje*, Građevinsko-arhitektonski fakultet Univerziteta u Nišu, 2020
[12] *Low Rise Housing Diversity Design Guide for Development Applications*, The Government of New South Wales, Department of Planning, Industry and Environment, 2020.
[13] B. Stoiljković, N. Petković Grozdanović, V. Petrović, Stanovi sa karakteristikama kuća: od utopije do realnosti, *Zbornik radova Građevinsko-arhitektonskog fakulteta*, 34, 42-51, 2019.
[14] B. Stoiljković, N. Petković Grozdanović, V. Petrović, „Main features of house-like apartments“, *Facta universitatis, Series: Architecture and Civil Engineering*, Vol. 18, No 1, 33-47, 2020.
[15] N. Petković Grozdanović, B. Stoiljković, H. Krstić, „Rethinking the Private Open Space Of Ground Floor Units In Multi- Family Housing Developments In the City Of Nis, Serbia“, *Conference Proceedings of IV International Conference on Urban Planning – ICUP 2022,* 95-102, 2022.
[16] Generalni urbanistički plan Niša 2010-2025, Skupština grada Niša
[17] *Priručnik za planiranje stambenih naselja u Crnoj Gori*, Ministarstvo održivog razvoja i turizma Crne Gore, LAMP (Projekat zemljišne administracije i upravljanja), The World Bank, 2015.