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# THE MIX-MESH CONCEPT OF LOW-RISE HIGH-DENSITY HOUSING – ADVANTAGES AND POSSIBILITIES OF APPLICATION IN LOCAL CONTEXT

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**Abstract**

*The increased demand for residential space is in constant conflict with available spatial resources. Utilization of unbuilt urban land for residential purpose is faced with two opposing extremes – development of single-family housing in peripheral urban areas, on one hand, and the insertion of multi-family housing as infill in central urban zones, on the other. A contemporary approach to housing development turns towards the application of low-rise high-density model – as an alternative solution, that tent to achieve the best of both extremes.*

*The research deals with the possibilities of applying a modular system, symbolically named Mix-Mesh, which, through various combinations of the basic module (dimensions 4.2x5.0m) would enable the development of a wide range of residential units – grouped within various typological forms: from two or three-story single-family row houses; combined models of single-family and multi-family housing; to multi-family buildings, which can be developed in the form of gallery or corridor solutions (depending on the shape, dimensions and plot orientation). One of the main advantages of low-rise high-density housing, which is reflected in the presence of significant private open areas, is also present in this model. A specific advantage of this modular solution is reflected in its easy adaptability to different urban parameters and conditions present on a plot, which is obtained through various combination types.*

**Key words:** *Low-Rise High-Density Housing, Design Principles, Typology, Private Open Areas, Modular Construction*

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# 1. INTRODUCTION

The urbanization of cities leads to significant changes in the built urban fabric, especially noticeable in areas and structures designated for residential purposes. The increased demand for housing is in constant struggle with available spatial resources. As a result of such circumstances, two opposing extremes are evident in residential developments: the construction of family housing in peripheral urban areas, on one hand; and the insertion of multi-family housing into central urban zones on the other [1]. The desire to own a family house, as an oasis providing such needing privacy, and a private yard, as one's own piece of land that brings the user closer to nature, is entirely understandable [2-5]. However, the contemporary way of life increasingly imposes the imperative of proximity and accessibility to amenities in relation to the place of residence [2]. It is not surprising that a significant number of households seek to meet these needs by living in the central city core.

In both cases, there is a severe degradation of the urban functional [2]. The construction of single-family housing in peripheral areas lead to uncontrolled urban sprawl, which results in nonfunctional urban areas, inefficient use of service and infrastructure facilities caused by physical remoteness from the city center, and significant reduction in the quality of living. On the other hand, densification of the central urban fabric degrades the micro environment of the area, burdens the existing service infrastructure, creating enormous pressure on these zones and resulting in the collapse of functional quality within the central urban area.

## 1.1. Low-rise, high-density housing as a possible response to emerging urban problems

As an alternative solution, a contemporary approach to residential development turns to the application of the low-rise, high-density housing (in further text LRHD housing). This concept represents a compromise solution, aiming to mitigate the differences between single-family and multi-family housing, utilizing the qualities of both of these prevalent types [6-9].

Several studies highlight four main characteristics of LRHD housing [6,7]:

- Density ranging from 350-550 inhabitants/ha, with buildings planned up to 5 above-ground floors.
- Strong sense of individuality, achieved through clear differentiation of individual elements - whenever possible, direct access to units is provided from the ground level.
- Avoidance of development of spaces that lack clear territorial differentiation – in particular, privatization of most of the outside space, by relating them directly to residential units.
- Integration of housing with accompanying functions, without clear differentiation, in order to create continuity of the construction by a system of built fabric, with overlapping residential units.

A large number of developed countries have implemented LRHD housing into urban planning regulation and have made recommendations related to the construction of this type [10-16]. Unfortunately, in the Republic of Serbia, this residential form has not yet been clearly recognized. These circumstances are

precisely the reason for conducting the research regarding the development of modular LRHD housing model, which could be applied within local contexts.

## 2. URBAN PLANNING AND ARCHITECTURAL METHODOLOGICAL APPROACH IN THE DEVELOPMENT OF LRHD HOUSING

Depending on the region, there are slight differences in the methodological approach for the development of LRHD housing. However, there are certain common characteristics, mainly in the domain of economic and social sustainability, primarily involving the application of various forms of public-private partnerships, through the implementation of mix typology, as well as the improvement of open spaces treatment.

### 2.1. Applied typology

Since LRHD housing requires a density ranging from 350-550 inhabitants/ha [6][7], considering the average household size, the number of housing units per hectare should range between 100 and 150. Given that this model implies low-rise buildings, the application of higher plot occupancy rates is expected. Such prerequisites necessitate that LRHD housing can only be developed through the application of certain housing typologies.

In terms of spatial layout of residential blocks intended for single-family housing, detached and semi-detached houses do not meet the requirements regarding the necessary densities [10]. The required urban parameters can only be achieved by forming linear or grid-like construction patterns, which involve planning row and/or courtyard houses [10]. To achieve higher densities, undeveloped areas are reduced to a minimum, resulting in a reduction of the usual unbuilt plot area in single-family housing – which in this type implies provision of a small front yard (which takes on the role of a buffer zone and softens the interface between private and public domain) and a rear yard of modest dimensions (Figure 1) [11,12]. The total area of such plots often does not exceed 120m². The application of this typology provides a higher occupancy rate, which in such formation ranges from 50-70%, and reach density of 85-100 housing units/ha (300-350 inhabitants/ha) [13].

*Figure 1. The City Houses, Islands Brygge, Copenhagen / Vandkunsten Architects (Source: https://vandkunsten.com/en/projects/city-houses-islands-brygge)*

As a more economical solution, the transitional typology model is applied, which in appearance and its advantages strongly resembles single-family housing, obtained through the multiplication of units, by connecting, stacking and overlapping

them, to form complex, hybrid types (Figure 2.) [10-12]. In most cases, all units have access from the ground, either directly or via individual open staircases. Private open areas strongly resemble yards of single-family house – the ground floor units gain a part of the terrain; while the ones on higher floors possess larger roof terraces, as an alternative to yards, This type obtains most benefits of single-family housing while increasing the density, which in this case ranges from 100-120 housing units/ha (350-420 inhabitants/ha).

*Figure 2. The Residences at Sandford Lodge, Ireland / Shay Cleary Architects (Source: https://archello.com/news/shay-cleary-architects-completes-irelands-first-low-rise-high-density-residential-development)*

The typology that provides the highest densities of LRHD housing is the construction of multi-family housing in the form of garden-apartments [11,12]. This type of housing can be developed in the form of an open or enclosed block, with up to five above-ground floors, and a density up to 150 residential units per hectare (550inhabitants/ha). Part of the terrain is attached to the units on the ground floor, giving them private open area resembling gardens, hence the name of this typology. Units on higher floors often have large associated open areas in the form of balconies or loggias. Often, these buildings feature setbacks on the top floors, allowing the development of larger roof terraces, providing units on higher floors with a suitable alternative to the ground-floor gardens.

*Figure 3. CPO AMSTELWIJCK, Amsterdam / Blauw Architecten Source:https://www.blauw-architecten.com/projects/woongebouw-zuidelijke-wandelwe*

## 2.2. Private open areas

As a residential form that aims to reduce the differences between single-family and multi-family housing, LRHD housing should provide a suitable alternative to a single-family home. The yard, as one of the main advantages of single-family

housing, must find an adequate replacement in this typological form. Therefore, one of the main characteristics of LRHD housing is the presence of significant private open areas, which serve as an alternative to the yards of single-family homes. This space, in terms of its position, spatial layout and dimensions, should serve as an outdoor extension of the living room area and should support everyday activities such as dining, children's play, leisure activities, socializing with guests and more [4,5,8].

*Table 1. Design standards for private outdoor areas*

| | Private garden | Balconies and loggias | Rooftop terrace |
|---|---|---|---|
| *Housing design quality and standards - Supplementary planning guidance [14][15]*<br><br>UK | A minimum of 20m² of private outside space in a form of a private garden should be provided for two person dwellings and an extra 5m² for each additional occupant.<br>The minimum depth and width of all private gardens is 500cm.<br>Space for children's play equpment, table and chairs, storage and an area for dry washing. | A minimum of 5m² of private outside space should be provided for one-to-two person dwellings and an extra 1m² should be provided for each additional occupant.<br>The minimum depth and width of all balconies and other private external spaces is 150cm.<br>These minimum areas and dimensions provide sufficient space for either a meal around a small table, clothes drying, or for a family to sit outside with visitors. | A minimum of 5m² of private outside space should be provided for one-to-two person dwellings and an extra 1m² should be provided for each additional occupant.<br>The minimum depth and width of all balconies and other private external spaces is 150cm.<br>These minimum areas and dimensions provide sufficient space for either a meal around a small table, clothes drying, or for a family to sit outside with visitors. |
| *Apartment Design Guidelines for Victoria [11][12].*<br><br>Australia | An area of 25m², with a minimum dimension of 3m at natural ground floor level<br>and convenient access from a living room, or<br>An area of 15m², with a minimum dimension of 3m at a podium or other similar base<br>and convenient access from a living room. | A balcony with an specified area and dimensions, and convenient access from a living room.<br><br>Stud./ 1bdr. – 8m² /1.8<br>2bdr. – 8m² / 2m<br>3bdr – 12 m²/2.4m | A roof-top area of 10m² with a minimum dimension of 2m. |
| *Residential and Mixed Use Overla yDevelopment Code [16].*<br><br>US | Each single-family row-house or courtyard unit shall be provided with a yard of at least 300sq.ft. with a minimum dimension of 15ft.<br>Each ground floor apartment unit shall be provided with a usable, outdoor yard with an area of at least 100sg.ft. with a minimum dimension of 10ft. | Balconies and loggias of upper floor units shall have usable, private open space with an area of at least 60sq.ft. with a minimum dimension of 5/6 ft. | Roof deck shall have usable, private open space with an area of at least 60sq.ft. with a minimum dimension of 5/6 ft. |

LRHD housing is characterized by variety in terms of private open areas - from private gardens, in units located on the ground floor; over spacious loggias and balconies; to the roof terraces on the last floors [8]. The design of these spaces is primarily based on the principle of space hierarchy and spatial continuity, in order to create a connection between different open spaces [8].

In most developed countries, the treatment of private open spaces is defined by regulations or other documents that define residential developments. A comparative presentation of defined values in certain developed countries is presented In Table.1.

## 3. MIX-MESH DESIGN CONCEPT OF MODULAR LRHD HOUSING

### 3.1. Design strategy

The proposed modular concept, which could be used in the development of LRHD housing, is based on theoretical data presented in the introduction of this research. The basic module, with dimensions of 4.2x5.0m, was chosen as the most efficient one due to its ability to accommodate various functions: from parking (either underground or at ground level), to living rooms and double-bedroom areas, but also for accompanying services, since its dimensions support the grouping (combination) of certain functions, such as: communication and toilet, communication and kitchen, kitchen and dining room, two single bedrooms and etc.


*Figure 4. Variation of units' spatial layout in Mix-Mesh model of LRHD housing*
*Source: author*

Varieties of spatial layouts, as an effect of different module combination, provide the opportunity to develop a wide range of residential units: from studio apartments, through one-bedroom to multi-bedroom apartments, with the possibility of their arrangement in a form of single or multi-story dwelling (Figure 4).

Two and three-story residential units can be adapted to a form of single-family row house. By combining a larger number of residential units, it is possible to form multi-family housing units, with up to 5 above-ground floors (Figure 5.) which, depending on the number of combined units, can be organized as freestanding, single access buildings, or in a form of a row structure, with multi-access points. Such building can be organized either as gallery or corridor-access type. Particularly high-quality solutions for multi-family housing are those where the larger ground-floor units have direct access from the surrounding terrain through the associated yard. In this way, some residential units in multi-family housing complexes acquire the characteristics of urban single-family homes.


*Figure 5. One of the possible combination of units, in a form of multi-family dwelling*
*Source: author*

One of the dominant characteristics accompanying LRHD housing, reflected in the development of significant private open areas, is also in the core of the Mix-Mesh concept. All ground-floor units are provided with associated terrain in the form of private gardens, whose surface ranges from 21 to 50m2. Part of these surfaces is planned with paving, while the rest is greened. Units on higher floors are provided with private open areas in the form of balconies or loggias, ranging in size from 8.5 to 17m². Larger balconies or loggias are also provided with planters for medium-height greenery. Units on the top floors are set back from the facade plane, allowing the development of larger private open areas in the form of roof terraces.

## 3.2. Possibilities and results of the application of the concept

Regarding the manner of units' spatial organization, mutual combination and vertical assembling, residential blocks of different typologies and densities can be developed. Some of those possibilities will be presented in the continuation of the paper, along with achieved urban parameters regarding densities (Figure 6).

**Case 1 – residential block of 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. Units in such block can be two to three story high. A network of 4.2m profile pedestrian footpaths are provided within the area. 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). Application of such typology can provide density of 98 residential units per hectare, i.e., around 330 inhabitants/ha.

**Case 2 – mixed residential block, combining single-family and multi-family housing.** 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 housing building. Row houses typically have two to three floors, while the number of floors in multi-family building can vary from three to five. All residential units at ground level (regardless the applied typology) have private front gardens with a depth of 2.0m, providing access to the units, and rear gardens with dimensions of 4.2x5.0m. This way, a large number of residential units acquire the characteristics of single-family houses. Regarding density, achieved values heavily depend on the proportion of single-family row houses. In the case of an even representation of both housing types, with the construction of multi-family dwelling as a corridor structure of five floors, it is possible to build around 140 housing units per hectare, achieving a density of around 450 inhabitants/ha.

**Case 3 – residential block of multi-family housing.** In this case, only multi-family housing buildings are applied, 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. The units on the ground level, as in previous cases, have private gardens. 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. The achieved density depends on the defined urban planning parameters and applied typology. As a maximum, in the case of application of the corridor layout an five floors buildings, it is possible to build up to 200 housing units per hectare, achieving a density of around 600 inhabitants/ha.

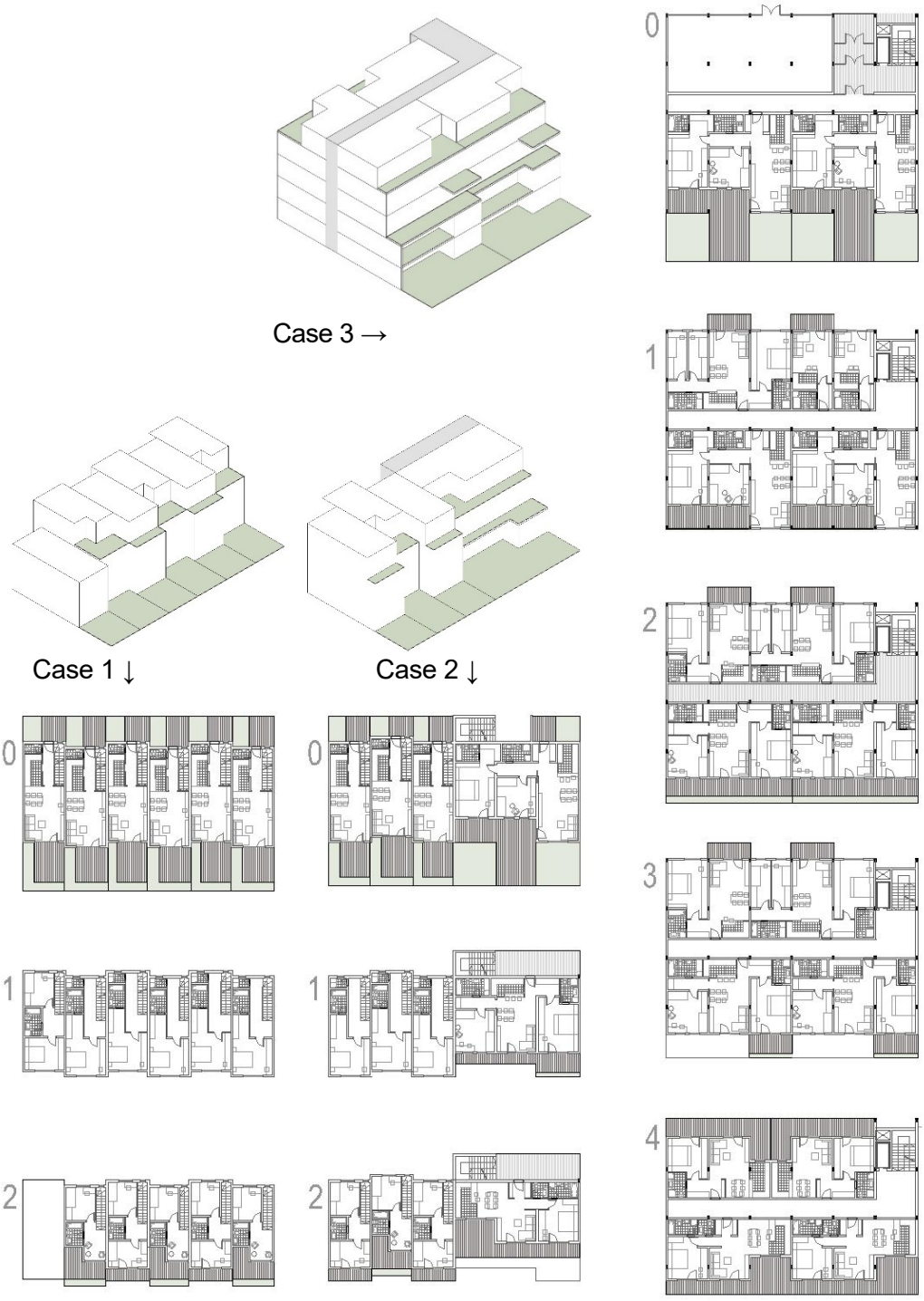


*Figure 6. Different typologies obtained by MIX-MESH concept*
*Source: author*

## 4. CONCLUSION

Contemporary theoretical and practical research points to the sustainability of LRHD housing [17]. Rational use of spatial resources, better infrastructural equipment, a higher level of embeddedness and the multiplication of housing units, positively affect the compactness of the construction and provide many benefits. However, LRHD housing will be successful only if high quality living is obtained, which is reflected in the relationships with the surrounding area in terms of connectivity, scale and integration.

The proposed Mix-Mesh concept has a large number of the mentioned advantages. A special value, considering the local context and accompanying housing issues, is certainly the more significant greening. The variability of units' structures and residential typologies makes this concept easily applicable in various locations. Nevertheless, this type of housing model is best developed on larger urban blocks, rather than on individual plots as infill in urban fabric, which unfortunately is the dominant practice in housing construction in Serbia. By introducing the LRHD housing into planning regulation and more thoughtful urban planning, it is possible to create conditions for the development of such housing model and utilize the benefits provided by the application of proposed typology.

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