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ASSESSMENT OF THE QUALITY OF DESIGN OF POST-PANDEMIC MULTI-RESIDENTIAL BUILDINGS

Abstract

Covid-19 pandemic brought to surface the new requirements for urban life. These requirements do not only strengthen urban resilience but also improve the overall quality of living. By taking the City of Belgrade as an example, this paper aimed to research whether the multi-residential sector took a new post-pandemic developmental course by embedding specific quality-related spatial features into designed buildings. A set of 33 assessment criteria was introduced to evaluate the quality of projects of ten selected multi-residential buildings. Results point out significant differences among studied cases and the aspects of residential space, however there is an overall need to revise ongoing designing practice.

Keywords:urban living, Belgrade, design, criteria, assessment, ranking

ОЦЈЕНА КВАЛИТЕТА ПРОЈЕКАТА ПОСТ-ПАНДЕМИЈСКИХ ЗГРАДА ЗА ВИШЕПОРОДИЧНО СТАНОВАЊЕ

Сажетак

Ковид-19 пандемија изнијела је на површину нове захтјеве живота у граду који не само да јачају урбану отпорност већ и побољшавају укупан квалитет становања. Узимајући за примјер град Београд, овај рад је имао за циљ да истражи да ли је сектор вишепородичног становања заузео нови правац развоја након пандемије, уграђивањем у пројектоване зграде специфичних просторних карактеристика везаних за квалитет. У раду је уведен сет од 33 критеријума и на основу њих извршена оцјена квалитета 10 одабраних пројеката вишепородичних стамбених зграда. Резултати указују на значајне разлике међу проучаваним случајевима и аспектима стамбеног простора, али и на општу потребу за ревизијом текуће пројектантске праксе.

Кључне речи: градско становање, Београд, пројектовање, критетијуми, оцјена, рангирање

1. POST-PANDEMIC DESIGN GUIDELINES FOR MULTI-RESIDENTIAL BUILDINGS

Covid-19 crisis brought many challenges to conventional urban lifestyles and changed the understanding of the quality of urban life. With disease outburst, large proportions of central urban zones and metropolitan areas of cities developed in the late 20th and early 21st centuries demonstrated a lack of capacity to control virus transmission successfully. In the indoor space, especially in public circulation areas like lobbies and corridors, the proper ventilation, daylight, occupancy rate, materialization and hygiene became critical parameters for disease spread [1], [2], [3], [4]. In multi-residential buildings, a residential unit became an isolation healthcare unit, and a long time spent inside impacted the users by means of spatial characteristics [5], [6], [7] and the possibility to adapt to newly emerged needs for privacy, work, entertainment, exercising, socializing, and other [8].The impact of residential space on users' well-being and the quality of life during pandemic so became key topics exploited by numerous studies. Based on results of these studies, different sets of guidelines for the design of residential space that can better respond to potential future epidemics were developed, e.g., [1], [9], [10], [11]. Buildings possessing the pandemic-proof qualities – the co-called post-pandemic buildings – became synonyms of safety and health-related resilience. While many of the emerged guidelines bring multiple benefits, yet some are one-dimensional and exclusive to the prevention of infection spread, e.g., the introduction of specialized sanitary spatial barriers, installation of no-contact elevators, installation of materials that retard or stop pathogen growth [12], multipurpose modular furniture with surfaces that can be easily sanitized, and other. Next to the special descriptive guidelines, the first international model for systemic evaluation of building "immunity" – the Immune Building Standard [13] – was launched in 2021 to allow an organized assessment of pandemic-related building resilience and to enable comparison between different buildings.

Besides strengthening physical and mental resilience of residents' during an epidemic of an infectious disease [14], most Covid-19-related design guidelines for multi-residential buildings in parallel greatly enhance the quality of urban life, primarily in the domains of comfort and well-being. Table 1 features the comprehensive list of design guidelines and their targets to simultaneously enhance building immunity and the quality of everyday life in multi-residential buildings. All listed guidelines are grouped into two categories: I – Residential unit; and II – Common building space, according to the adopted research boundaries that overlap with physical boundaries of a multi-residential building, i.e., with its envelope. Generally, however, the significance of the features of the outdoor space surrounding a multi-residential building should not be underestimated, both in terms of pandemic-related resilience and the improvement of the quality of life [15], [16].

Table 1. Design guidelines and their targets to simultaneously enhance building immunity and the quality of life in multi-residential buildings.

Design guidelines	Impact on resilience strengthening	Impact on the quality-of-life upgrade
CATEGORY I (C.I) – RESIDENTIAL UNIT		
Clearly bordered and well-sized bedrooms	Decreased risk of disease transmission [2]; Enabled privacy during the lockdown periods; Various activities carried out at the same time without mutual disruption	Increase of the level of comfort, and multifunction
Flexible common living zone	Possibility of rapid transformation and adaptation to newly emerged residents' needs (e.g., work, playing, exercising, or studying)	Enriched spatial comfort and the long-lasting suitability to ever-changing users' needs
Clearly bordered entrance zone	Improves hygiene and serves as a sanitary buffer [5]	Improves hygiene and comfort in general
Separate and spacious kitchen	Better comfort when cooking at home is intensified; Kitchen used as one separate room [17]	Increase of spatial and air comfort
Increased number of bathrooms and toilets	Efficient physical distancing and self-isolation, and hygiene improvement [5]	Increase in the levels of comfort and hygiene

Separated work & study space	Undisturbed work and studying in parallel to other home activities [18]	Enhancement of the overall occupants' productivity and the use of on-line means of work and education; Comfort increase
Active use of semi-open private space (balconies) for multiple functions, enabled through adequate size and the dimensional ratio	Provision of direct connection with the outside; Possibility to mimic outdoor activities such as leisure, working, exercising, or dining [5], [19]	Provision of direct connection with the outside; Possibility to mimic outdoor activities such as leisure, working, exercising, or dining; Comfort increase
Semi-open space as an extension of common living area	Enrichment of the scenery of living zone; Psychological stress reduction [20]	Enhancement of spatial and visual comfort in a residential unit; Multifunctionality
Greenery integrated into private semi-open space	Benefits of direct contact with natural elements to psychological health and well-being [21], [22]	Benefits of direct contact with natural elements to good psychological health and well-being
Provision of acoustic insulation	Prevention of negative noise-induced psychological effect during long periods spent indoors	Enhancement of acoustic comfort
Cross ventilation	Improvement of the quality of indoor air by effective natural (passive) ventilation means	Improvement of the quality of indoor air; Improvement of air and thermal comfort
Naturally ventilated kitchen and sanitary rooms	Improvement of the quality of indoor air; Rooms naturally lit [5]	Improvement of the quality of indoor air; Improvement of visual, light and thermal comfort
Orientation of main rooms that allows direct sunlight exposure	Positive impact of direct sunlight on users' health and well-being; Improvement of spatial, visual and thermal comfort	Positive impact on users' health and well-being; Provision of passive heating; Improvement of spatial, visual and thermal comfort
The depth of residential space allows for efficient penetration of natural light	Positive impact of natural light on users' health and well-being; Improvement of spatial and visual comfort	Positive impact on users' health and well-being; Improvement of spatial and visual comfort
Views from windows provide rich visual contact with the outside (and especially with natural elements)	Good visual contact with surroundings strengthens mental resilience, reduces the feeling of isolation, and promotes well-being [23], [24], [25], [26]	Humane and healthy living environment; Improved visual comfort
Storage as a separate room	Provision of space for stocks during lockdown periods	Improvement of hygiene and spatial comfort
CATEGORY II (C.II) – COMMON INDOOR SPACE		
Shared indoor space for work, socialization, relaxation, or exercising	Cut need to mix in larger groups; Opportunity for residents to spend their free time in smaller groups; Provision of experience of social environment within the building system	Depending on needs of residents and the size of residential unit; Benefits to community strengthening
Greenery integrated into common indoor space	Benefits of direct contact with natural elements to psychological health and well-being; Improvement of the quality of indoor air	Benefits to good psychological health and well-being; Air comfort enhancement

Shared open green spaces within the building envelope (green roofs and green atria)	Promotion of good health and well-being by allowing safe direct contact with natural elements [27]	Humane, healthy and sociable living environment; Benefits to community strengthening
Increased size and number of common horizontal and vertical indoor communication elements (corridors, staircases and elevators)	Enabled larger physical distance [5] among building occupants; Crowding prevention; Better quality of the indoor air	Overall increase of building comfort

Covid-19 crisis revived the concept of healthy buildings, highlighted the importance of the topic of urban quality of life and resulted in new and for now informal requirements regarding the design of multi-residential buildings. Although, according to some authors, the effects of Covid-19 crisis on architectural design cannot yet be well perceived because it is too early [28], [29], the research question of this study is whether the incorporation of non-binding guidelines listed in Table 1 into current designing practice has begun, and if so, to what extent?

The work consists of four key parts, one of them being the derived and presented design guidelines (Section 1). Section 2 features the description of case study area (City of Belgrade, Serbia) and of ten selected multi-residential case studies from that area, as well as the explanation of applied methodology to evaluate selected case studies. Here, the list of 33 derived, widely applicable assessment criteria is given together with belonging indicators and the means of their verification. Obtained results were presented and discussed in Section 3. Finally, Section 4 summarizes conclusions and draws limitations as a basis of future research.

2. MATERIAL AND METHODS

2.1. TEN CASE EXAMPLES FROM BELGRADE, SERBIA

Metropolitan Belgrade is currently the largest construction site in Serbia, and multi-residential buildings stand out in the typology of newly constructed buildings. From total number of building permits for multi-residential buildings (with three or more residential units [30]) issued in the territory of the Republic of Serbia in 2023, about 25% refer to the metropolitan area of Belgrade. Likewise, from the total number of construction permits issued in the territory of the metropolitan Belgrade in 2023, about 26.16% refer to multi-residential buildings. 344 construction permits for multi-residential buildings were issues in Belgrade in 2023 [31].

For this research, ten examples of projects of multi-residential buildings whose construction is planned or initiated in Belgrade during 2023 were selected. From each of those ten buildings, one representative residential unit was subsequently chosen. Thus, the analysis encompasses ten residential units and ten multi-residential buildings where those units are placed.

At the time of research data collection, that is from December 2023 until February 2024, all selected projects were available at online portals of investors or the agencies that advertise the sale of residential units. The year 2023 was marked as relevant since the pandemic rate had already decreased at that time; on May 5, 2023, namely, the World Health Organization announced that Covid-19 no longer represents a global threat [32]. The three-year period from Covid-19 disease outbreak until 2023 was sufficient to gain experience, draw conclusions and shift the designing practice. This research aims to reveal whether the Covid-19-related lessons caused the shift in real-life architectural practice.

The requirements for case examples selection were the following:

- Availability of project documentation with details needed to carry out a comprehensive assessment of the quality of design;
- Size of residential units – ranging from 81-100 m^2 with balconies included – meaning larger units with a greater possibility for implementation of guidelines listed in Table 1. Given size range corresponds to national classification of units in multi-residential buildings, and is mainly used in statistical representations;
- Location of multi-residential buildings. To enable comparison, all examples selected are planned to be built in central parts of Belgrade, in densely built areas. Knowing that density

can be brought into connection with increased risk for an infectious disease transmission, the need to implement resilience- and quality of life-related design guidelines in central urban areas is generally valid. Intricate conditions in dense central zones and unsuitable ratio between design limitations and potentials require intelligent design responses and this study, to that end, aims to reveal and discuss the solutions found.

Having considered that all selected examples are currently available in the real estate market, their identification data such as exact location, design plans, or the name of the project will not be shown in the paper. That way, the authors secure objectivity and prevent any potential conflict of interest. Nevertheless, the complete research material is available in the authors' database.

The list of general characteristics of selected case examples of residential units, relevant for further research steps, is given in Table 2.

Table 2. Characteristics of ten selected case examples of residential units whose construction is planned or initiated in 2023 in central zones of Belgrade, Serbia

Designation	Position in the building layout	Floor in the building	Units per floor	Structure (N° of bedrooms)	Size (m^2)	Estimated finalization	Price (EUR per m^2 without taxes)
CS1	Corner	2/9	7	2	86	2025	3.500
CS2	Central	12/21	6	3	84	2026	3.000
CS3	Corner	3/6	2	2	83	2025	4.000
CS4	Corner	10/20	16	2	87	2027	4.800
CS5	Corner	1/8	6	3	83	2025	3.000
CS6	Corner	1/5	5	3	87	2025	2.800
CS7	Central	2/10	10	3	97	2027	4.100
CS8	Corner	2/8	6	2	90	2027	3.300
CS9	Corner	4/7	4	2	97	2025	4.300
CS10	Corner	2/7	3	3	83	2025	2.700

2.2. ASSESSMENT METHODOLOGY

The methodology to evaluate application of guidelines for the design of multi-residential buildings is based on the definition of a list of criteria and associated indicators. All introduced criteria are derived from general guidelines shown in Table 1. For every assessment criterion, at least one measurable qualitative or quantitative indicator is offered (Table 3). Important to note, none of the derived and listed criteria currently stands in national regulations. Moreover, the criteria derived are stricter than national regulations and, in that sense, the list presented in Table 3 can be understood as a precursor of design rules to be established in future. Finally, the list of offered criteria can be understood as a newly proposed assessment system, a new design aid tool, or an auxiliary tool that buyers can use while making decisions as regards the purchase of their new residential space.

Table 3. Set of criteria to assess the application of design guidelines that simultaneously enhance resilience and improve the quality of urban life.

No	Criteria and indicators	Means of verification
C.I.1	Every bedroom is clearly separated from other parts of a residential unit by walls and a door. Where a bathroom is added to a bedroom, and both form one single zone that is clearly separated from other unit parts, the criterion will be considered fulfilled.	Yes/No
C.I.2	The size of bedrooms is at least 5% larger than the national minimum standard: • *2-person bedroom – min 11,00 m^2,* • *1-person bedroom – min 7,00 m^2.* Number of bedrooms whose size is larger at least 5% than minimally required (A) compared against total number of bedrooms (B) in a unit.	A/B x 100 %

C.I.3	The width of bedrooms is larger than given by the national minimum standard: • *210 cm for 1-person room,* • *240 cm for 2-person room,* • *At least one 2-person bedroom with 280 cm width.* Number of bedrooms whose width is at least 5 % larger than minimally required (A) compared against total number of bedrooms (B)in a unit.	A/B x 100 %
C.I.4	The common living zone of a residential unit features an open-plan space that can easily be reorganized and separated into subzones.	Yes/No
C.I.5	The entrance zone is clearly separated from other parts of a residential unit by walls and doors.	Yes/No
C.I.6	The kitchen is clearly separated from other parts of a residential unit by walls and door(s).	Yes/No
C.I.7	The size of kitchen space is larger than given by the national minimum standard (that is larger than *4,00 m^2*), and it amounts to at least 7 m^2.	Yes/No
C.I.8	The number of bathrooms equals the number of bedrooms.	Yes/No
C.I.9	There is at least one bathroom in the bedroom zone.	Yes/No
C.I.10	There is at least one toilet room in the common living zone of a residential unit.	Yes/No
C.I.11	There is a separate work & study room within the residential unit.	Yes/No
C.I.12	Residential unit has at least one balcony with the depth of not less than 1,50 meters to allow active space use.	Yes/No
C.I.13	The area of the unit's largest balcony is at least 7,00 m^2, which equals the size of a 1-person room as given by the national minimum standard.	Yes/No
C.I.14	There is a balcony that represents a physical and functional extension of the common living area of a residential unit with direct connection.	Yes/No
C.I.15	The balcony from criterion C.I.14 is the largest semi-open space within a residential unit.	Yes/No
C.I.16	Greenery is embedded into unit's semi-open spaces by design.	Yes/No
C.I.17	A residential unit is acoustically insulated from other units and the common indoor space.	Yes/No
C.I.18	The rooms within one residential unit are acoustically insulated from each other.	Yes/No
C.I.19	A residential unit has cross ventilation potential as its space leans on two opposite façade walls.	Yes/No
C.I.20	Kitchen space is ventilated naturally.	Yes/No
C.I.21	Number of naturally lit bathrooms and toilet rooms (A) compared against their total number (B).	A/B x 100 %
C.I.22	Living zone with dining space is oriented towards east, south-east, south, or south-west.	Yes/No
C.I.23	Number of bedrooms oriented towards east, south-east, south, or south-west (A) compared against their total number (B).	A/B x 100 %
C.I.24	There are no dark floor areas in the living zone. The distance from window openings to the farthest point of the floor does not exceed 6 meters in any direction.	Yes/No
C.I.25	Windows in main rooms provide far-reaching views to a street and/or common open space (Number of rooms with the far-reaching view to a street or open space (A) / total number of main rooms (B)).	A/B x 100 %
C.I.26	Windows in main rooms provide views to natural landscapes (Number of rooms with the view to a park / other open green areas / tree alleys / water bodies / other natural element (A) // total number of main rooms (B)).	A/B x 100 %
C.I.27	The residential unit has a separate storage room.	Yes/No
C.II.1	The plan of a multi-residential building features shared indoor space for at least one of the following functions: work, socialization, relaxation, or exercising.	Yes/No
C.II.2	Greenery is embedded into common indoor space by design.	Yes/No

C.II.3	The plan of a multi-residential building features open shared green space within the envelope (green roofs and/or atria).	Yes/No
C.II.4	There is more than one elevator per building entrance.	Yes/No
C.II.5	The width of staircase is at least 10% larger than minimally required by the national regulations *(120 cm*).	Yes/No
C.II.6	The width of corridors is at least 10% larger than minimally required by the national regulations *(140 cm*).	Yes/No

3. RESULTS AND DISCUSSION

The methodology presented in the previous section, together with the list of criteria for the assessment of the quality of design of post-pandemic multi-residential buildings, was applied to ten selected newly designed cases in Belgrade (CS1-CS10). The results of the analysis are given in Table 4.

Table 4. Assessed quality of design of ten new multi-residential buildings in Belgrade.

	CS1	CS2	CS3	CS4	CS5	CS6	CS7	CS8	CS9	CS10
C.I.1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
C.I.2	50%	100%	100%	100%	100%	66,7%	100%	100%	100%	100%
C.I.3	50%	66,7%	50%	100%	66,7%	100%	33,3%	100%	100%	33,3%
C.I.4	No	No	Yes	Yes	No	No	No	Yes	No	No
C.I.5	No	No	Yes	No	No	No	No	No	No	No
C.I.6	No	No	No	No	No	No	No	No	No	No
C.I.7	No	Yes	Yes	N/A	N/A	No	N/A	Yes	Yes	N/A
C.I.8	No	No	No	Yes	No	No	No	Yes	No	No
C.I.9	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
C.I.10	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
C.I.11	No	No	No	No	No	No	No	No	No	No
C.I.12	No	No	Yes	Yes	No	No	No	Yes	No	No
C.I.13	No	No	No	Yes	No	No	Yes	Yes	No	No
C.I.14	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
C.I.15	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
C.I.16	Yes	No	No	Yes	No	No	No	No	Yes	No
C.I.17	Yes	N/A	N/A	N/A	N/A	Yes	N/A	N/A	Yes	N/A
C.I.18	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
C.I.19	No	No	No	No	No	No	Yes	No	No	Yes
C.I.20	Yes	Yes	Yes	No	No	No	No	No	No	No
C.I.21	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
C.I.22	Yes	No	Yes	Yes	No	No	No	Yes	Yes	No
C.I.23	100%	0%	100%	100%	33,3%	100%	66,7%	100%	100%	66,7%
C.I.24	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes
C.I.25	100%	100%	100%	100%	50%	25%	50%	33,3%	100%	100%
C.I.26	0%	0%	0%	100%	25%	100%	0%	100%	0%	50%
C.I.27	No	No	No	No	No	No	No	No	No	No
C.II.1	No	No	No	No	No	No	No	No	No	No
C.II.2	No	No	No	No	No	No	No	No	No	No
C.II.3	No	No	No	No	No	No	No	No	No	No
CII.4	Yes	Yes	No	Yes	No	No	N/A	Yes	No	No
C.II.5	No	Yes	No	No	No	No	N/A	No	No	No
C.II.6	No	No	Yes	No	No	No	N/A	Yes	Yes	No
N/A: Not applicable										

3.1. CATEGORY C.I – RESIDENTIAL UNIT

In every examined residential unit, all bedrooms are clearly separated from each other and from other unit parts by walls and a door. This finding, however, is not necessarily connected with the implementation of post Covid-19 design guidelines; it rather represents a reflection of regular architectural practice on a national level aimed at securing spatial comfort.

At least one bedroom in all examined cases is larger in size (m^2) for minimally 5% compared to prescribed national threshold, and in eight cases the size of all bedrooms is larger for at least 5% than minimally required. On the other hand, the width of bedrooms does not always comply with the size increase, which points to elongated bedroom plans and a more challenging organization of bedroom space. Even though at least one bedroom per residential unit has a width which is at least 5% larger than nationally required, only four analyzed units have the increased width of all bedrooms. There is a discrepancy between bedroom area and its width, and in two cases it is very pronounced. Looking at the cost of analyzed residential units, it can be concluded that the weakness detected occurs independently from the price of residential space.

While all ten studied residential units feature an open-plan concept of the common living zone, in only three units this zone could easily be reorganized and separated into subzones. The major constraint as regards identified spatial inflexibility is the lack of window openings in bordering walls, often in combination with the excessively elongated plans, which further prevents sufficient supply of natural light and the ventilation.

There are several examples of residential units where the entrance area is functionally well positioned and separated from key unit sections, yet in only one studied example the entrance zone physically indeed is separated by walls and doors. Other several examples feature a significant weakness: entrance zone here amalgamates with the kitchen and dining space, i.e., the bedroom area, most probably because of the design goal to reach as efficient size of communication area within a unit as possible. Another identified weakness in this respect refers to the large distance from the entrance to the first sanitary room, i.e. the bathroom. In none examined cases, worth to mention, the entrance zone has direct natural light and the ventilation.

Next to that, in none of the designed residential units the kitchen is clearly separated from other parts of a residential unit by walls and door(s). Even more, at a web portal where one of the studied units is being advertised for sale, the open plan of the kitchen is highlighted as a key positive feature. In several analyzed examples, though, the kitchen space has a potential (in terms of spatial position and the sufficient size) for future separation, however the lack of window openings to allow direct natural light and the ventilation would represent a limitation factor in such an adaptation-related action.

Having considered that in none of the studied residential units the kitchen space was found to be physically separated from the rest of a unit, the criterion C.I.7 could not be fully implemented. Only in those cases where kitchen represents a clear functional unit, its area could be accurately expressed. In other cases, kitchen space is integrated into living zone and the necessary surfaces are overlapping, most probably for the reason of designing a size-efficient layout. Therefore, the not applicable (N/A) mark in Table 4 refers to spatial weakness within this domain.

In only two studied cases the number of bathrooms equals the number of bedrooms. On the other hand, there is in all cases at least one bathroom per bedroom zone. Worth mentioning, in three cases the bedroom zone was dispersed because of which the access to bathroom from a distanced room was intersected by the day living area. Toilets in the common living zone of a residential unit exist in nine of ten cases in total. In some cases, these are the bathrooms, in fact.

Examined plans of residential units do not foresee the organization of work & study space as a separate physical whole. Instead, the workstation (desk and the chair) is mostly nested into a bedroom corner. Likely, this is the result of standard national designing practice and of existing norms where workspace is not given a lot of attention. Anyhow, the bedrooms can easily be converted into an autonomous work & study room if that suits the users' needs and the size of household.

All residential units have at least one balcony. However, in just three cases of newly designed residential units there is a balcony whose depth is larger than 1,50 meters to allow active space use. Most often, these semi-open spaces feature narrow and elongated plans. Likewise, the size of semi-open space of at least 7 m^2 is found in only three cases. In two out of ten studied residential units the balconies are larger than 7 m^2 and wider than 1,5 meters, which means that only two examples provide the possibility for active use of semi-open space.

In all cases, there exists a balcony that is adjacent to the common living area, although in some examples it is positioned laterally and not frontally. A balcony attached to the living zone is the largest semi-open space of the unit in all cases, but its size and width in eight out of ten cases are not sufficient to allow for active space use, as stated above.

Most 3-dimensional representations of studied multi-residential buildings feature greenery on facades, however in only three cases the greenery indeed is integrated into semi-open space of residential units by design. This integration refers to the vegetation pots built into the solid fence of a balcony.

While there are three units whose space is insulated acoustically from other adjacent units, there is just one residential unit whose space is acoustically insulated both from the outside and between encompassed rooms. In most cases, however, the data as regards applied acoustic insulation measures are not available in used web sources, and the subject criteria cannot be considered fully exploited, to that end.

Cross ventilation is generally known to impact the quality of indoor air significantly and positively, however in this study the potential for cross ventilation was found in only two units whose space leans on two opposite facade walls.

The kitchen space is naturally lit and ventilated in only three examples.

Neither one bathroom nor a toilet room from studied units is naturally lit and ventilated.

In 60% of studied examples, the living zone with dining space is oriented towards east, south-east, south, or south-west. In one case, neither the bedrooms nor the living zone have favorable orientation; in three cases the orientation of at least one bedroom is satisfying, while good orientation of all bedrooms is achieved in six cases (60%). In general, the orientation seem to be the consequence of existing conditions at the location, and it varies among the units within one same multi-residential building.

30% of residential units analyzed do not receive enough natural light in the living zone as distance from windows to the farthest floor point exceeds 6 meters.

The quality of window views significantly varies among examined residential units. While all units provide views to the materialized open urban space from at least one main room, there are 50% of units that do not offer views to natural landscapes. In one studied example only, the quality of views is rated high (100%) both in terms of materialized urban space and the natural landscape.

A separate storage room was not found in any of the studied residential units. In a few examples, however, the storage has been planned next to the garage space, or within the building entrance zone.

3.2. CATEGORY C.II – COMMON INDOOR SPACE

As regards the quality of common indoor space of multi-residential buildings where ten selected units are nested, the analysis resulted in scarce positive findings from all listed criteria.

Shared indoor space that would host at least one of the following residents' activities: work, socialization, relaxation, or exercising, was not found in any of the studied multi-residential buildings. On the other hand, more than half of studied buildings have the designed commercial space in the ground floor level. Though these premises may also be used by the residents of a building, they still do account for a public content and hence do not fulfil the criterion C.II.1. The exact purpose of the ground floor commercial content is not defined in the design stage. In one studied example, a common space for relaxation and exercising has been identified, however outside the building envelope which was marked as research boundary. Finally, in one example, the ground floor features the heritage remains and the corresponding activity program (education, arts and culture), yet this space is open to the public and not reserved for building users only.

The greenery is not integrated into flat roofs, atria, nor the common indoor space. Even more, the common indoor (communication) space lacks natural ventilation and light in most cases.

The installation of more than one elevator for in-building vertical communications was found in four out of ten examples. However, the width of staircase is larger than minimally required in only one case example, while the width of corridors is enlarged in comparison with minimal standard in three out of ten cases in total. Overall, there is an obvious lack of direct proportion between the number of residential units per building floor (i.e. the number of users per floor), and the width of staircase and corridors.

3.3. RANKINGS AND HIGHLIGHTS

Results presented in Table 4 allow to subsequently determine the percentage of fulfillment for every individual assessment criterion (Figure 1). Seven criteria were not met in any of the analyzed cases, and their percentage score hence equals 0%. On the opposite side, four out of 33 criteria in total were met in all cases (100% fulfillment). From the total number of 33 criteria, only ten were fulfilled in more than 50% of cases. Overall, it can be concluded that there exist more weaknesses than strengths when it comes to the quality of design of examined post-covid residential buildings as the number of criteria fulfilled in more than half of studied examples is lower than the number of criteria fulfilled in less than 50% of cases. It further means that there is an urgent need to advocate a more noticeable shift in design practice as regards multi-residential buildings.

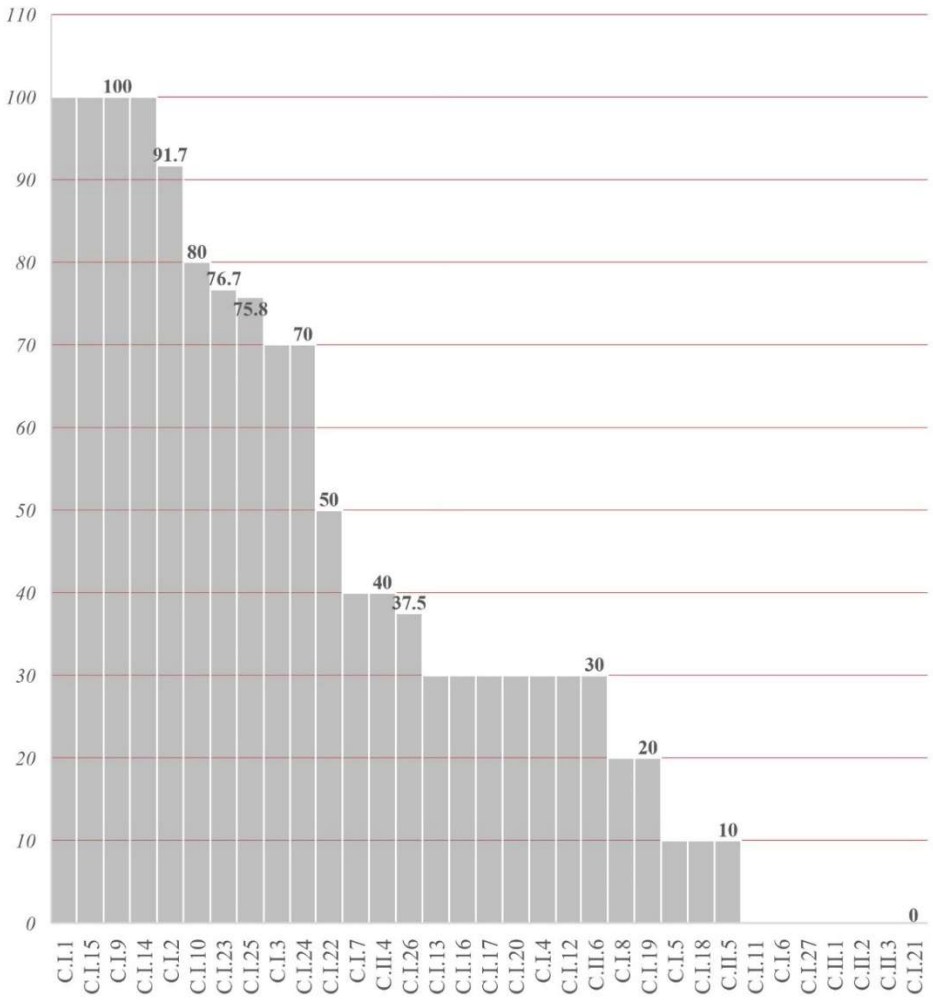

Figure 1. The percentage of assessment criteria fulfillment.

3.3.2. WEAKNESSES AND STRENGTHS

The results of evaluation in relation to the quality of design of ten selected residential units, and the buildings where those units are nested, point at seven most critical issues (Figure 1, 2). Furthermore, three assessment criteria were fulfilled in only one out of ten cases in total, hence the aspects encompassed by these criteria also represent significant weaknesses in the current design of multi-residential buildings. Finally, as two criteria were fulfilled in only two cases, they also account for major shortcomings in present-day design practice.

On the other hand, the analysis showed that studied multi-residential spaces nevertheless possess certain qualities. In that sense, clearly separated bedrooms (C.I.1), existence of at least one bathroom in bedroom zone (C.I.9) as well as the existence of a (largest-in-a-unit) balcony that represents a physical and functional extension of the common living area (C.I.14 and C.I.15) were found in all examined cases. Next to that, the increased size of bedrooms in comparison with national minimum

standard was also commonly found (91,7%), followed by the existence of a toilet room in the common living area (80%), proper orientation of bedrooms (76.7%), provision of far-reaching window views (75.8%), increased bedroom width (70%), and sufficiently lit living zones (70% fulfillment).

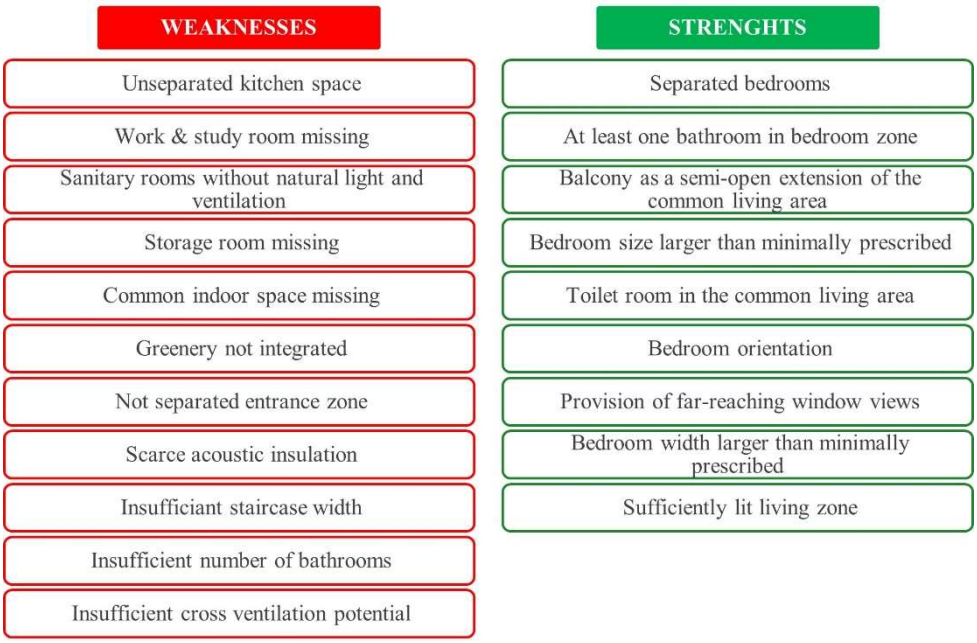

Figure 2. Most significant weaknesses and strengths of examined case studies.

3.3.3. COMPARISON OF CASE STUDIES

When mutually compared based on the percentage of criteria fulfillment, examined case studies show rather significant differences (Figure 3). The best ranked case example has a score of 55.55%, while the case with the least quality has a score of 26.52% criteria fulfillment. In only three examined examples, the score of criteria attainment is 50% or higher.

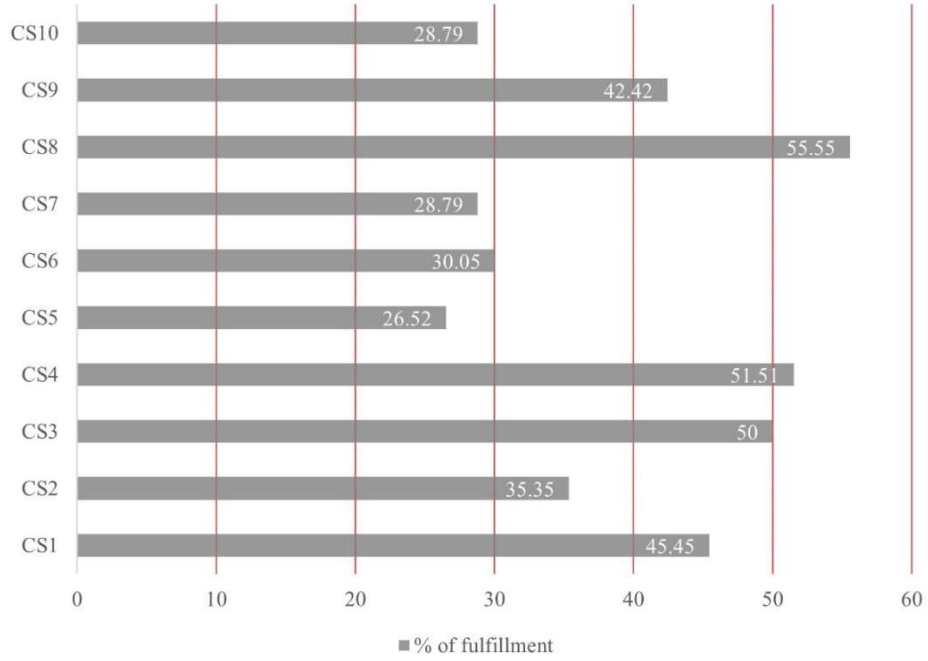

Figure 3. Comparison of the quality of design of examined case studies based on the percentage of criteria fulfillment.

Although this study did not introduce any threshold values, it may be concluded that the overall quality of design of examined post-covid multi-residential buildings in Belgrade is insufficient. The average percentage of criteria accomplishment amounts to 39.4%.

3.3.4. QUALITY VS. ECONOMIC VALUE

The final step in the analysis of selected case examples of residential units, and the buildings where these are nested, refers to the comparison between obtained quality and economic price (Figure 4). In 50% of cases, the economic and quality-related values are mutually balanced. In one studied case, the economic value significantly exceeds the quality of design, while in one other case the quality significantly exceeds the price. In three cases, the quality exceeds the price moderately. Overall, the ratio between the quality and price is favorable, however it should be noted that the study did not include calculation of economic value of applied criteria and has, instead, considered available market prices per square meter of a residential unit as given in Table 2.

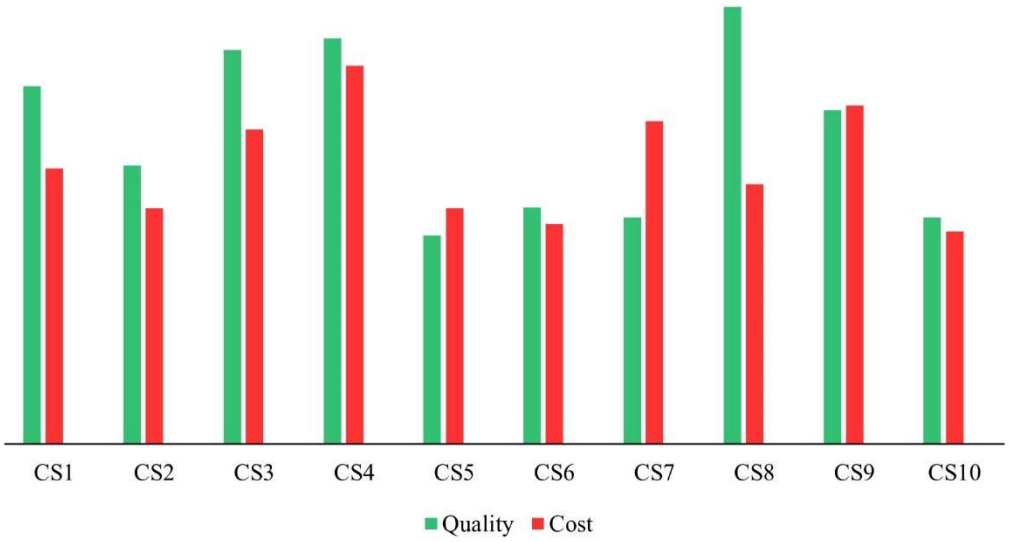

Figure 4. Comparison between quality and economic value of case studies.

4. CONCLUSIONS

On the example of the City of Belgrade, Serbia, this work pointed out the trends in current practice of multi-residential building design, and revealed the most significant strengths and weaknesses from quality-related perspective. The research developed a unique yet universally applicable methodology for assessing the quality of newly designed multi-residential buildings with 33 criteria, and brought a plentitude of relevant specific results. To improve existing characteristics of an urban residential space, the general conclusion is that a change in designing practice is necessary. With an increased number of fulfilled assessment criteria, the quality of everyday living and the well-being of residents will improve.

The study carried out, on the other hand, has several limitations that should be dealt with in further work. For example, as the boundary of research overlaps with building envelope, the assessment of external surrounding environment – which also is very important for achieving good quality – was not considered. Furthermore, it will be necessary to introduce into future studies a threshold of quality, thus, to determine which case units are not acceptable, and to calculate the weight of every individual criterion. Since in this study the assessment of quality refers only to projects and not to completed multi-residential buildings, it is necessary to further consider the implementation of a two-phase assessment, i.e. to include into research the quality of built space as well. Finally, considering that some specific data were not available, meaning that the criteria to which those data refer could not be applied, several results could actually be more positive than presented.

The most significant limitation concerning application of offered methodology, that is of criteria for quality assessment, concerns observed direct proportionality between the extent of fulfilled criteria

and the size of living units in multi-residential buildings. In other words, more fulfilled criteria mean a larger size of a residential unit, and this correlation will inevitably affect the increase of economic price, too. In economies that are not sufficiently developed, a higher price is a limiting factor for the overall improvement of the quality of urban housing, i.e., a barrier to promoting social cohesion and establishing the market available to different categories of urban dwellers. To change current designing practice and achieve better quality of urban living space, therefore, it will be necessary to involve into an organized action not only designers but as well other local and state actors who influence the multi-residential sector.

In current Serbian housing policies, the quality of urban residential space is seldomly discussed, and its impact on users' wellbeing is not considered at all. Current regulations are limited to standards and requirements for minimal dimensioning of residential units [30], i.e. to the aspects of management, use and maintenance of multi-residential buildings [33]. National Law on Housing and the Maintenance of Buildings [33], however, adheres to the principle of sustainable housing development, recognizing a need to continuously enhance housing conditions and the value of housing fund. On urban design level, the Strategy Belgrade 2030 in its section "Urban Comfort and Mobility" acknowledges a change in perspective of urban dwellers following Covid-19 crisis, and proposes as a response to growing demand for a larger, greener and quieter living space the polycentric development of the city [34]. As partially recognized in the Draft of the National Housing Strategy [35], there is a necessity to further deepen the quality component of urban housing by developing precise and functional national and local policies and politics, and the capacities to enable their implementation.

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