IETI Transactions on Ergonomics and Safety

http://ieti.net/TES

2020, Volume 4, Issue 2, 11-22, DOI: 10.6722/TES.202012_4(2).0002

URBAN BLOCK ANALYSIS OF PRIVACY CONDITIONS WITH REFLECTIONS ON COVID 19 LOCKDOWN

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Abstract The parameters defined by this research can be used to evaluate living conditions depending on geometry of any urban block. The research is interdisciplinary and relies on scientific results in the field of psychology, sociology, medicine combined with computer graphic visualization. Geometry and dimensioning of an urban block as the building element of the city environment is essential for the creation of a humane living environment. This paper presents the results of the parametric analysis of visual privacy conditions in the case of urban blocks with distinct geometry type. The process is performed by determining critical points of the facade area of the urban block as part of the predefined grid. Grasshopper and Rhino 3D software was used for simulation of visibility-vulnerability of the surface of the facade based on predefined conditions. The results are displayed in a form of graphs and as a graphical 3D model.

Keywords: Simulations; computer science; urban block; privacy; computer graphics.

1. INTRODUCTION

Considering the recent events during COVID-19 pandemic lockdown the research published [1] has a new weight in evaluating the possible and longterm impact of the built environment on mental health and wellbeing. The need to protect privacy, in addition to access to daylight and ventilation, appears at an early stage in the history of settlement building. Territoriality was a key determinant of the rules of conduct in social communities both in the early stages of settlement and throughout history, in the form of choosing defendable places and marking the boundaries of a location belonging to an individual or group.

According to numerous researches, building density and population stand out as a factor that can endanger human mental health. Research confirms the link between privacy violations (physical or visual intrusion of personal space) and reduced ability to work and the occurrence of mental disorders in people.

2. RESEARCH BACKGROUND

The concept of territoriality refers to a physical place such as a home or a place in a business facility [2,3]. It is described as one of the essential human needs [4,5,6]. In scientific literature, territoriality is widely seen as belonging and control over a physical zone of space [7]. Territories are being used to regulate cooperation and maintain social order. The main division of territories based on Lyman [8] are: public spaces, home territory, interaction territory, and personal body zone. Personal space is [9] defined as “a dynamic spatial component of interpersonal relationships”. Territoriality is considered to be the ability to control and regulate the use of space [10].

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2.1. Territoriality and the Need to Define the Boundaries of the Territory

Relaying on spatial boundaries often provides a definition, both individual and collective, of the territory owned or claimed. The physical dimension of privacy implies the degree to which a person is physically available to others. Privacy is closely related to the concept of personal space which is described as the basic premise of privacy.

Territories support social roles within the community. The specific context is always concerning specific roles [11] which implies that the significance of a place is defined by its exclusive use. A set of allowed behavior patterns is associated with each space.

A place belonging to a group is a space that is collectively inhabited and has a socioculturally controlled physical environment [12]. Such a situation appears in the conditions of multi-family housing, where the inhabitants react negatively or suspiciously if an unknown person appears in the yard of the block. Territoriality in this sense serves as a basis for the development of personal and group identity. The links between group activity (a sense of belonging to a larger group of people) and spatial identity are of great importance for human health [13]. In the early period of the theory of "defendable" places, according to Newman [14], it was considered that such space contains more housing units because residents have a greater sense of security, belonging to space, a sense of security and their engagement raises the level of informal surveillance. For that reason, Newman believed that the level of crime is declining in environments where residents feel not only their homes but also the surrounding areas as their own, as is the case with multi-family housing. He considers such spaces "defendable". Newman and Frank tested the relationship between physical design and its impact on crime levels by analyzing the testimonies and living environment of 2,655 Americans in the United States [15]. The results convey a partial agreement with the basic assumptions of the hypothesis (eg. a higher level of security in the case when the residents had a sense of control and the ability to monitor events in the surrounding areas). Later research, however, concurred that in the case of high housing density an aggressive behavior occurs.

Researchers, such as [16], see the connection between grouping a larger number in one place (staying in crowds - crowding) and declining results at colleges and impaired student health. Preliminary research on human spatial behavior has concentrated on three causal factors: biological, cultural, and environmental conditioning. Crowding studies show contradictory evidence of hostility and reduced ability to act in adults and children [17]. According to research of neighborhoods and communities within apartment blocks, a more significant influence of the physical characteristics of the environment concerning the social condition and the quality of interpersonal relationships is shown [18]. As social density (number of people) increases, satisfaction with the environment decreases [19], and the level of physical comfort decreases [20]. Lack of acoustic, and especially visual privacy - exposure to views, are cited as the most significant sources of stress in a densely populated environment. Privacy can encourage or limit human development depending on how accessible it is to the individual. Psychological stress, which arises in response to this situation, can over time affect mental health problems [21]. The density and great closeness of people leads to intense attention, because a person must unconsciously monitor a large number of potentially threatening stimuli in his environment. This environment leads to "cognitive exhaustion" and other effects such as impaired attention and concentration and decreased performance at work. A major psychological and sociological problem is the possibility of individual regulation of social contacts [3].

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Stimulus overload is a typical condition in the case of crowding. Research in the field of psychology [22] analyzes life situations in an urban environment in which people have a large number of daily contacts at a small distance from each other. Too many people in an environment that has many stimuli (noise, smells, colors ...) can lead to overloading the nervous system of individuals and often results in "social withdrawal" in an attempt to limit a person's involvement in associations or completely avoid interaction with others.

2.2. Territoriality and Distance

Territoriality refers to the space that a person perceives as his own. The proportions of that space can vary from a residential unit, to an urban block, neighborhood, part of the city, etc. There is a form of territoriality that is associated with the human body defined by different distances and unwritten rules of conduct depending on the proximity to whom communication between an individual and a group takes place. Personal space is an invisible space around the human body, an individual zone that separates people from one another.

Hall defined four types of communication zones, ie distances [23]:

- intimate
- personal
- social
- public

These zones are not strictly defined and vary depending on the individual, culture, social norms and space (Table 1).

Table 1. Tabular presentation of distance categories and types of interactions [23].

Category	Distance	Type of interaction
Intimate distance	from the body up to 45 cm (or 50 cm)	Confrontation, threatening.
Personal distance	45 to 120cm	Conversation among close friends.
Social distance	120 to 360cm	Informal and business conversation.
Public distance	360 to 450cm (or 750cm)	Addressing the audience, meeting strangers.
Communication distance	over 2000cm til 3000cm	At a distance of 30m, the need for communication ceases and privacy is protected.

A popular trend of open-plan workspaces in modern design, is proven to be a psychologically stressful environment due to inadequate spatial distances between employees. This environment increases the level of anxiety, reduces the level of desirable communication, and increases the level of unwanted encounters and communication among employees [24]. As much as 70% of resigning is associated with some kind of feeling of invasion of privacy among employees [25].

Research argues that increasing visual exposure increases the number of interactions between people [26]. Visual accessibility to other people, especially in the workplace, intensifies verbal and nonverbal communication. In addition to close distances, there are other distances associated with human

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communication and privacy. Allen was among the first to explore further spatial distances and its impact on interpersonal communication [27]. He presented the results of the research on the "Allen's curve" which describes the relationship between distance and intensity of communication (Figure 1). Allen's classic curve shows that the possibility of communication between people decreases sharply at a distance of 30 meters and after that remains unchanged regardless of the increase in distance. This research has been confirmed by several authors [28,29].

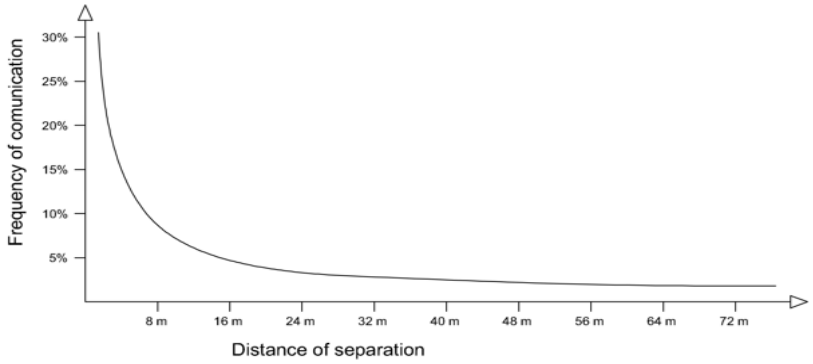

Figure 1. Communication frequency curve concerning distance.

3. THE SIGNIFICANCE OF VIEW FOR HUMAN HEALTH

Housing satisfaction is determined by several parameters, including life stage, socioeconomic status, character, values and norms of the environment and society, and interpersonal relations with neighbors. Researches show that the physical characteristics of a house such as shape, architectural style, foundations, colors, and environment of a building as well as cultural background can influence housing preferences, choices, and satisfaction [30]. Numerous studies confirm that living in poor quality areas affects the socio-emotional health of children and adults [31].

The literature related to the design of business premises is largely oriented towards factors that impair the mental health of employees [32]. Among the most important characteristics of the environment that can affect recovery from stress and increase work efficiency is, as shown by numerous studies, the window view [33]. Ulrich demonstrated that hospitalized patients who had a view of nature through the hospital room window recovered much faster after surgery and used much less painkillers than those who had a view of the wall of a neighboring building from the window.

Research has shown that more than 35% of workers find extremely difficult working conditions in rooms without windows [34]. During the research, children who stayed in rooms lit only by skylights displayed a higher level of anxiety, mental immaturity, increased aggression and irritability, when solving routine tasks and games, compared to their peers who stayed in rooms with a direct view of the external environment. Studies show that subjects who had a view of nature had lower blood pressure and better concentration compared to their counterparts who were in a windowless environment [35]. Studies have concluded that the introduction of daylight is better than fluorescent lighting, but also that the view through the window is important. Computer programmers who had a view through the window spend more than 15% of their time working on primary tasks, while employees who spent time in rooms without windows spent more than 15% of their time talking to each other and on the phone [36].

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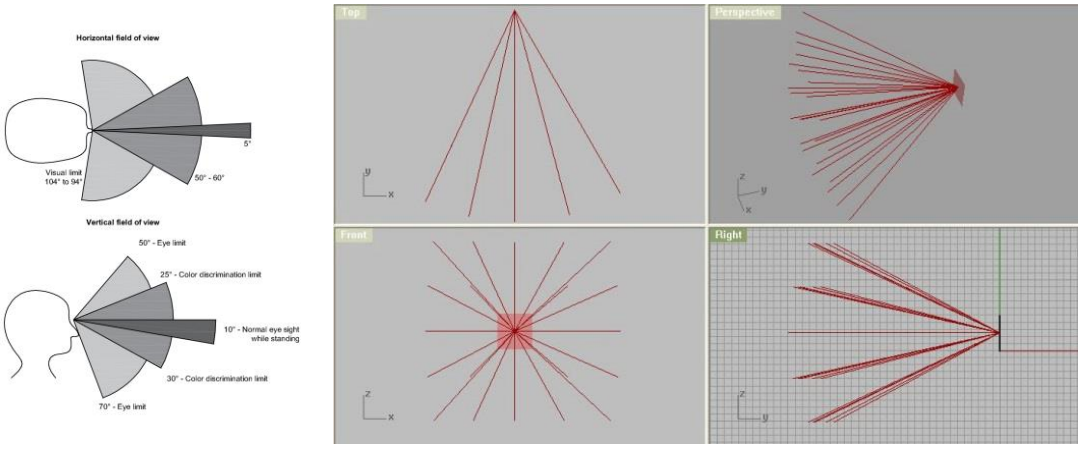
Study conducted in 1986 [37] evaluated the effects of natural light and views on prisoners housed in different cells. Prisoners who had views of the field, mountains, and nature had significantly fewer calls related to stress-induced health problems than those who had views of the prison yard and buildings. Prisoners on the second floor also had fewer calls for medical assistance than prisoners on the ground floor and first floor. The reasons for this are the positive psychological impact of expanded views of the sky and the environment. Prisoners housed on the lower floors also reported feelings of stress due to lack of privacy and exposure to passers-by. These results can be registered without exception in the conditions of modern multi-family housing.

4. MATERIAL AND METHODS USED

The model for experimental verification illustrates the computer analysis of the degree of visual privacy in built urban environments. The theoretical part defines the distance limits for different types of communication. A distance of 30 meters is adopted as the limit of the need for communication ceases. The scope of observation must be wide enough to obtain valid results. In the case of simulation, it is necessary to observe objects that are located in a belt of 30 m from the boundaries of the urban block. The aim of the analysis is the localization and graphic presentation of areas that have an endangered level of privacy, ie they have facilities that are at a smaller distance from the facade.

The process of analysis of the facade implies its grid into observation zones arranged concerning the potential positions of the windows. In the direction of the normal concerning the plane of the facade cladding, for each part of the surface, an angle of observation is constructed that corresponds to the human view (cone of view) from one or more points on the divided surface of the facade (point of view). It is defined by the following measures: the angles of the human gaze (turquoise triangle in Figure 2a), where 250º is lateral viewing on both sides from the axis, as well as for the view up, and 30º for the view down. The length of the view is 30 m, conducted from the research cited in the previous chapter [26]. The top of the pyramid (the field of view defined in this way) represents the point of view, and view rays are formed from it in a 5x5 grid (a total of 25 rays) (Figure 2b). The lengths of the lines are 30 m each, and their total length is 25 x 30 m = 750 m.



(a) **(b)**

Figure 2. (a) The angle of a human's gaze, (Source: EIAR. (2007)) and (b) computer-generated geometry of view propagation.

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The next step is to detect the intersection of lines on the envelope surfaces of the formed 3D model. For each intersected line we calculate the length from the source (observation point) to the intersection with the first surface in the model, following the total sum of all line lengths is recalculated. The initial sum (of unobstructed view) is divided by 750, after that the percentage of the obscurity of the view is obtained.

The obtained value is converted into color chromatic scale where 0%, ie completely obscured view, corresponds to black color, and 100%, ie unobstructed view corresponds to white color, while other values are expressed by appropriate shades of gray.

The procedure is repeated for each surface of the divided facade. As a result of this processing, a visually modified initial 3D model was obtained, their envelope was colored depending on the views from different surfaces (Figures 3,5,7).

A hybrid software environment for privacy analysis was formed based on the Rhinoceros 3D software package with the Grasshopper plug-in, using comparative analyzes of available simulation software tools.

5. MATERIAL AND METHODS USED

Analyzes of four typical urban block morphologies that occur in the area of Novi Sad were performed to illustrate the functioning of the model. The nature of the privacy parameters that were reduced to the geometry of the 3D model did not require the definition of other types of parameters. The geometry of the urban blocks is simplified, and the surrounding built environment is not included in the analysis. In the real situation, surrounded by the built environment, these results, depending on the morphology of the urban tissue in which the urban block is located, would have to be harmonized. Before analyzing the 3D model, its surfaces were divided by forming a grid with mesh elements measuring 5 m x 5 m. The dimensions of the grid can be changed arbitrarily, depending on the need. The grid dimension in this experimental simulation was taken as a boundary test to illustrate the functioning of the model and the capabilities of the hybrid environment. The simulation in real conditions, in usual construction conditions, would be provided by a higher density grid, e.g. reduced to 3 m x 3 m.

The level of details, the accuracy of the obtained results as well as the duration of the simulation, having in mind the semi-automatic correction of the results, are directly conditioned by grid density formed by the preprocessing step of the 3D urban block model. A visibility simulation is performed, with the support of Grasshopper software, and each surface is analyzed separately. The number of surfaces increases the duration of the analysis. The procedure begins with determining the geometric center of gravity of each surface that represents the viewpoint and from which the view cone is formed. The angle of observation of the human gaze (visual cone) is constructed from the center of gravity point of the surface in the direction of the surface normal.

The results of the research on the privacy conditions of 3 urban block types are presented in graphical form in the continuation of the experimental part of the paper. The degrees of privacy for different morphologies of urban blocks were determined based on the obtained graphs.

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5.1. Urban Block With Multi-family Residential Towers

In the case of a typical block with multi-family towers (Figure 3), the most endangered area is the ground floor and the first floor when it comes to exposure to views. Surfaces marked in black represent the most endangered areas on the facade when it comes to visual privacy. For that reason, they are suitable for rooms with secondary purposes, such as stairs, pantries, etc. They are not suitable for residential use.

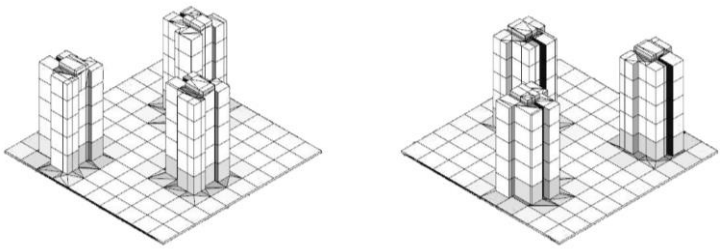

Figure 3. The result of the simulation according to the model on the example: an urban block with multi-family residential towers.

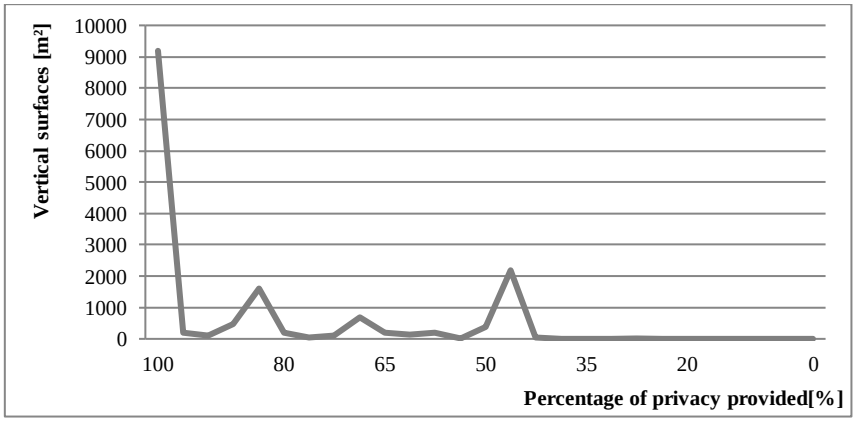

Figure 4. Graph of the results of the percentage of provided privacy of urban block areas.

The graph of the obtained results of the simulation of surface privacy conditions in the model of an urban block with multi-family residential towers (Figure 4 and Table 2) shows that only 42% of the surfaces are exposed to views. It is designed for medium housing density (about 700 inhabitants/ha).

Table 2. Percentage of provided visual privacy of block surfaces.

Percentage of visual privacy provided based on criteria	Vertical surfaces of the block [m²]	Percentage of visual privacy of the total facade surfaces of the urban block
>95%	9187	58%
85% - 95%	745	5%
70% - 84%	1929	12%
55% - 69%	1229	8%
40% - 54%	2616	17%
25% - 39%	1	0%
0% - 24 %	0	0%

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In the case of multi-family housing, the ownership of the space of the housing unit is not strictly defined, but is of a communal character. A small percentage of occupancy of the plot (about 10%) can contribute to reducing the number of unwanted encounters.

5.2. Border Urban Block Type With Open Space Yards

In the case of a typical border urban block with an open yard space (Figure 5), the most endangered area is the ground floor and the first floor when it comes to exposure to views. Residents who have residential units on the corner of two buildings overlooking the courtyard have the lowest level of privacy. The fascilities are at a proximal distance that does not compromise privacy when it comes to views.

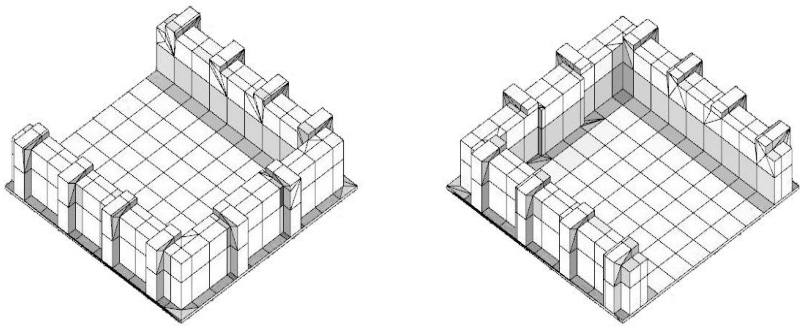

Figure 5. The result of the simulation according to the model on the example: a boundary urban block with an open yard space.

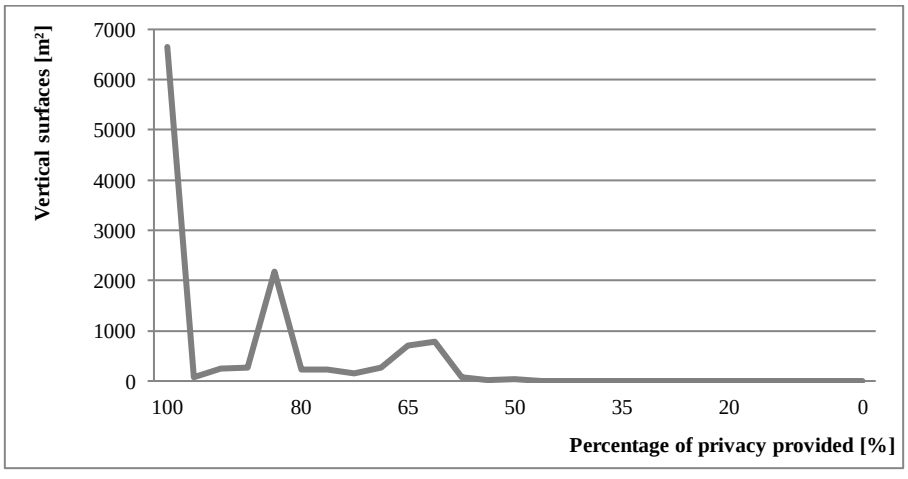

Figure 6. Graph of the results of the percentage of provided privacy of urban block areas.

The graph of the obtained results of the simulation of surface privacy conditions in the urban block model of the boundary urban block with open yard space (Figure 6 and Table 3) shows that 44% of the surfaces have a compromised level of visual privacy.

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Table 3. Percentage of provided visual privacy of an urban block surfaces.

Percentage of visual privacy provided based on criteria	Vertical surfaces of the block [m²]	Percentage of visual privacy of the total facade surfaces of the block
>95%	6650	56%
85% - 95%	589	5%
70% - 84%	2782	23%
55% - 69%	1827	15%
40% - 54%	48	0%
0% - 39%	0	0%

There are no areas where privacy compromised below 50%, which makes this type of an urban block one of the better morphological solutions of the built environment based on the analysis criteria. The percentage of plot occupancy is low (about 30%) and the housing density (about 700 inhabitants/ha) is the same as the previous block type.

5.3. Densely Constructed Boundary Urban Block Type

In the case of a typical densely constructed boundary urban block type (Figure 7) the analysis shows that its morphology is poor when it comes to protecting the privacy of the occupants. A small number of housing units that have a view of the inner courtyard do not endanger privacy. The interior of the urban block is the most endangered, especially in the ground floor area. Everyone except the tenants on the top floors have their privacy compromised.

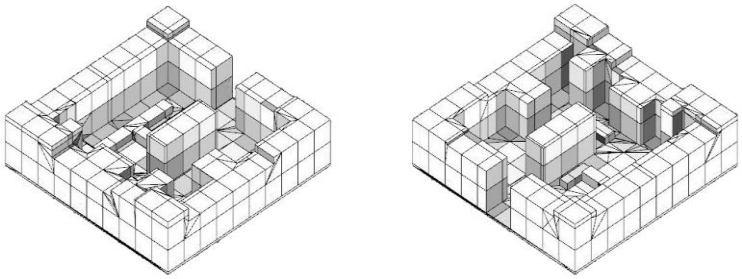

Figure 7. Simulation result according to the model on the example: densely constructed boundary urban block.

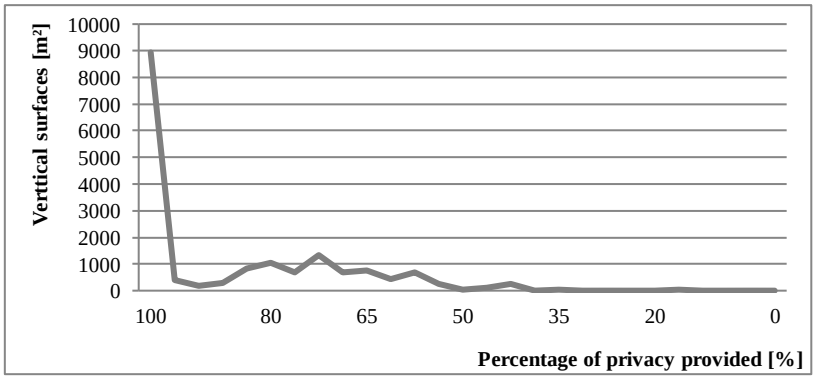

Figure 8. Graph of the results of the percentage of provided privacy of an urban block areas.

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The graph of the obtained results of the simulation of the privacy conditions of the surfaces in the model of a densely built boundary urban block (Figure 8 and Table 4) shows that 47% of the vertical surfaces in the urban block do not have sufficient privacy conditions. The morphology of the urban block is insufficient when it comes to protecting the privacy of tenants.

Table 4. Percentage of provided visual privacy of the urban block surfaces.

Percentage of visual privacy provided based on criteria	Vertical surfaces of the urban block [m²]	Percentage of visual privacy of the total facade surfaces of the urban block
>95%	8937	53%
85% - 95%	871	5%
70% - 84%	3868	23%
55% - 69%	2561	15%
40% - 54%	639	4%
25% - 39%	49	0%
10% - 24 %	44	0%
0% - 10%	1	0%

The percentage of plot occupancy is high (about 60%) and housing the density is also high (about 1400 inhabitants/ha) compared to the previous two examples analyzed.

6. CONCLUSIONS

The results of the analysis of experimental privacy simulations vary depending on the type of the urban block, in terms of healthy living conditions and the impact on mental health in correlation to geometry. The analysis display the maximum potential of the privacy conditions of each simplified urban block type 3D model, depending on their morphology. In conclusion of theoretical and experimental research the following relationships of 3D model measures have the greatest impact on privacy conditions:

- Density of construction,
- Disposition of buildings on plots, and
- Morphological characteristics of objects on the plot.

In the case of the morphology of the urban block with multi-family residential towers analysis, the tenants have the most sufficient visual privacy ambiance. The distances between the buildings and their disposition at the base of the urban block enable the protection of the visual privacy of the tenants. The small percentage of occupancy of the plot (about 10%) can contribute to reducing the number of unwanted encounters. The boundary type of the urban block with an open yard space based on the given criteria represents the second favorable type of morphology when it comes to the visual privacy of the inhabitants. Of the total area of the facade cladding, 56% of the area has sufficient privacy conditions. The percentage of plot occupancy is low (about 30%) and the housing density (about 700 inhabitants/ha) is the same as the previous block type. The most unfavorable results were achieved by a densely-built border urban block. The high percentage of plot occupancy (about 60%) and housing density (about 1400 inhabitants/ha) additionally increases the number of unwanted encounters, which can be reflected in increased levels of anxiety and aggression among tenants. The number of possible interventions is limited since private property is limited to the residential area, and not to the free areas of the urban block, so the installation of effective visual barriers is disabled.

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Reflecting on the period of lockdown during the COVID-19 pandemic, these results stress the need for reevaluating building density and its impact on mental health and wellbeing. By analyzing the window view, proven by numerous theoretical researches as one of the key components of children and adult mental health factors, further researches planned can locate the most critical areas in the city. As part of future experimental privacy research, it is necessary to include the links between the morphology of the urban block and its environment. There is also a need for preparation of the basis for creating conditions for parametric generation of different purposes of the premises within the buildings in the urban block depending on the degree of sufficient privacy conditions.

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