

INTENSIFICATION OF BUILDING THE TERRITORY OF A HISTORICAL FORMED CITY USING THE EXAMPLE OF LVIV

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Abstract: The article deals with the process of intensification of the urban territory of a historically formed city. The quarters of residential developments of different periods are analyzed and the indicators of density are determined. The urban transformations of a city canvas, which influence the changes in the density indices and their inter-dependence were investigated.

Key words: urban development, urbanization, density, intensification

1. Introduction

Urbanization processes of recent decades have been active in the formation of urban environment and image of a modern city. Significant intensification of people's lifestyle leads to an increase in the density of the city in its various manifestations. Cities of the metropolitan nature, such as Lviv, are maximally intensified within their existing boundaries, taking into account the potential of the formed urban structures and undeveloped territories, as well as outside them.



Fig. 1. Structural plan of a Lviv city building territory (interwar period) (Cherkes B., 2015)

2. Basic Theory

Building intensification and its density are measured by a number of generally accepted indicators. Territory is the basic indicator of the processing boundary needed to form the area of definition in the process of calculating the density as a spatial indicator (Berghauser Pont, M. & Haupt, P., 2010). The territorial boundary of determining the density indicator may be:

1. Main structural and planning elements of a city. For example, in Ukraine, within the township territory, the main structural elements are formed: a residential quarter (housing complex) as the primary structural element of the living environment; residential quarters and complexes form a residential area - a structural element of a township territory within which the institutions and enterprises are located as well as the objects of urban significance. Residential areas can also be formed as the separate structural units. The township territory (residential region) is formed by the residential areas. This structural unit is typical for significant and the most significant cities and is formed as a holistic structural organism with the placement of service facilities for district and urban use there [*English. State Building Standards*];

2. Boundaries of the territories, which are included into the cadastral register;

3. Designed boundaries, which are specified by a certain coordinate network, or determined by the given radius;

4. Limits determined on the basis of the morphological characteristics of the territory.

Taking into account the peculiarities of structural and planning elements of a city, it is possible to intensify them by different methods, taking into account the density indexes (Cherkes B., 2015, p. 1–6), making the most of the potential of the territory and effectively integrating it into the city structure.

Calculation of the density indexes of the territory		
FSI	$\frac{S_b}{S_T} \cdot 100\%$ <p>S_b - total area of buildings and structures $S_b = (m_1 + \dots + m_n) + (n_1 + \dots + n_n)$ m - floor area of the building or structure n - floor area of the building or structure S_T - total area of the territory</p>	
FAR	$\frac{S_b}{S_T}$ <p>S_b - total area of buildings and structures $S_b = (m_1 + \dots + m_n) + (n_1 + \dots + n_n)$ m - floor area of the building or structure n - floor area of the building or structure S_T - total area of the territory</p>	
GSI	$\frac{S_{bt}}{S_T}$ <p>S_{bt} - area of the built-up territory $S_{bt} = (m+n)$ S_T - total area of the territory</p>	
N	$\frac{S_r}{S_T}$ <p>S_r - ways and roads area S_T - total area of the territory</p>	
OSR	$\frac{S_{bt}}{S_{ubt}}$ <p>S_{bt} - area of the built-up territory S_{ubt} - area of the unbuilt territory $S_{bt} = (m+n)$ $S_{ubt} = S_T - (m+n)$</p>	

Fig. 2. Calculation of density indicators (performed by S. Konyk based on Berghauser Pont, M. & Haupt, P, 2010):
1. Floor Space Index (FSI) reflects in percentage the intensity of construction (total area of buildings and structures) to the total land area; **Floor Area Ratio (FAR)**; - reflects the same as FSI, but not in percentages. **2. Ground Space Index (GSI)** shows the correlation of the built-up area to the total area of the land plot; **3. Network density (N)** shows the correlation of the area of streets and roads of the processing area to the total area of this territory; **4. Open space ratio (OSR)**, the correlation of the area of the built-up territory to the territory free from development

These indicators are standardized in the Ukrainian city-planning legislation as follows: the main restrictions of the territory density are the establishment of the percentage of built-up area in accordance with the defined function of the development. The density of population is established as well, because you can determine the maximum capacity of a given territory in accordance with the chosen building typology, which the future density of the development of the territory will depend on. The estimated population density in the residential area is recommended to be 190–220 people per hectare in the most significant cities, respectively, for the zones of the city of different urban development value. (DBN 360-92**, 1992)

The research of Lviv building territory density based on a next methodology.

The module for density calculation is a territory of living district with the roads borders, which show us the scale changes in territory building. We choose the areas of different building periods, to see the density changes during the time from an old town (till XIX century) to 1980-1900 ties. The constant module is a 1 ha square territory, which show us the scale of a living building district.

City density is an indicator of urban development and demonstrates the quantitative and qualitative use of the urban environment by man. The urban environment is a complex of dynamic physical, economic, sociological and cultural factors that always affect people and communities. This feature allows us to follow the changes that occur with the territory, with building and density indicators during certain time. In different periods the city met needs of its inhabitants by creating relevant for a certain time comfort and forming requirements and standards for the construction and organization of the territory of a given period. Such transformations are especially brightly traced in the historical urban environment.

Let's consider the change of the density index at the example of the territory of residential building in the city of Lviv during different periods (Fig. 1). The medieval Lviv downtown was characterized by a very high density of building, as well as the western and eastern parts of it; this also applies to the quarters outside the walls, which were formed after applying of regulation of the development of Lviv by the Austrian administration at the first part of the 19th century. From the second part of the 19th century up to the World War I the expansion of building grew primarily by increasing the number of storeys of buildings and the size of the districts (Petryshyn H. & Ivanochko U., 2007, p. 16–27). In the interwar period, building in Lviv was formed under the influence of functionalism. In the construction of the periphery of the city the principles of the garden-city of E. Howard were used, actively promoted by I. Drexler, which influenced reduction of the density of the building and creation of the comfortable environment (Sadowska, E. J., 2014, p. 21–32). After the Second World War until 1990, Lviv quickly turned into an industrial center, which caused the construction of the new mass housing, based on the principles of modernism and strict regulations adopted for the entire USSR. The Soviet panel housing estate of Sykhiv in Lviv with its nearly 50 years of design, construction and transformation has become one of the integral symbols of the city. This is the result of the activities of several generations of residents and architects (Cherkes B., 2015., p. 1–6). The period of Independence began on the background of a protracted economic crisis. The new construction was intensified only in the last decade.

The analysis of the density of the building is completed for time periods, which were characterized by the clear urban building features. For the basic unit of study the smallest structural element was chosen, namely, the development quarter. You can follow how the area of design was increased i.e. from 1 to 4 hectares or more over the last centuries.

Having analyzed the density of development of residential quarters during different periods, it became possible to follow the subsequent transformations of indicators GSI and FAR. In the period until the XIX century residential development was represented by dense quarters of middle storey buildings with small inner courtyards, which did not meet the modern requirements regarding the number of open space and public service areas. Indicators GSI and FAR were high which indicated excessive density. At the beginning of the XXth century the approach for building of residential quarters was changed. Low-rise buildings and districts with the buildings of mean height were built less densely and with patios, GSI and FAR showed an optimal ratio. But already in the 60s the need for housing and the rules of regulation of the development process allowed to use territory more intensively by increasing the height of buildings and forming large, non-scale spaces between them. The GSI indicators were significantly reduced and the FAR was markedly increased in the development of residential quarters of the 80s. The district of Sykhiv is a clear example of such approach. This process is well traced on the graph given below.







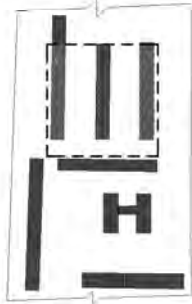
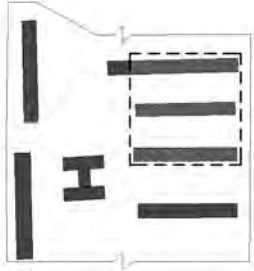




Old town till XVIII century	1840-1890^{ties}	1930^{ties}
		
<i>Rynok square</i>	<i>Valova and Brativ Rogatynziv streets</i>	<i>Snopkivska Kubyovycha street</i>
		
GSI 0,75 FAR 3,03 L 3	GSI 0,75 FAR 3,73 L 4	GSI 0,38 FAR 1,14 L 2
1960^{ties}	1970 -1980^{ties}	1980 - 1990^{ties}
		
<i>Volodymyra Velykogo street</i>	<i>Ivana Vygovskogo Kulchytskoy streets</i>	<i>Kavaleridze street</i>
		
GSI 0,2 FAR 0,88 L 8	GSI 0,19 FAR 0,95 L 4	GSI 0,19 FAR 1,7 L 8

Fig. 3. Calculation of the density of developmental districts in various years in Lviv. On the schemes the provisional territory with an area of 1 hectare is allocated by dotted line GSI, FAR-density indexes (look to table 2), L – height in floors (in this scheme, the “first storey” or “first floor” is the level above ground level. The floor at ground level is usually called “0”)¹

¹ We have to say about floor numbering schemes. In European scheme, the “first storey” or “first floor” is the level above ground level. The floor at ground level is usually called “0”. This scheme is used in the United Kingdom, most European countries, Mexico, Cambodia and former British colonies.

In North American scheme the “first” floor is the floor at the ground level and the floor above it is the “second” floor. On some buildings, floors below ground floor are usually marked as basement (B) but some buildings also marked these floors as minus (-), for example; minus one (-1), minus two (-2) and so on. In few cases, the floors below ground floor are marked as lower ground (LG) or sub basement (SB) though this is uncommon. This scheme is used in some part of the United States and Canada, some Latin American countries, Russia and former Soviet Union countries, China (excluding Hong Kong and Macau), South Korea, Japan, Singapore and parts of Indonesia.

Change of the density indicators in residential development quarters in the different time periods.

The growth of the status of Lviv affected the intensification of the construction process in the city, which was considerably accelerated from the 19th century. The number of inhabitants of Lviv was gradually growing. Intensification of the urban environment, in particular in the field of housing construction, became matter-of-fact, and an increase in the density of the development of the territory started to be a positive practice of developing European cities. Today, the process of intensifying of the territory of a city is due to the increase in the number of storeys of the building, respectively, forming large unmanaged space gaps that are non-scale in terms of human feelings and affect the quality of the urban environment. Therefore, it is important, taking into account historical experience, to determine the optimal parameters of the density of the urban environment.

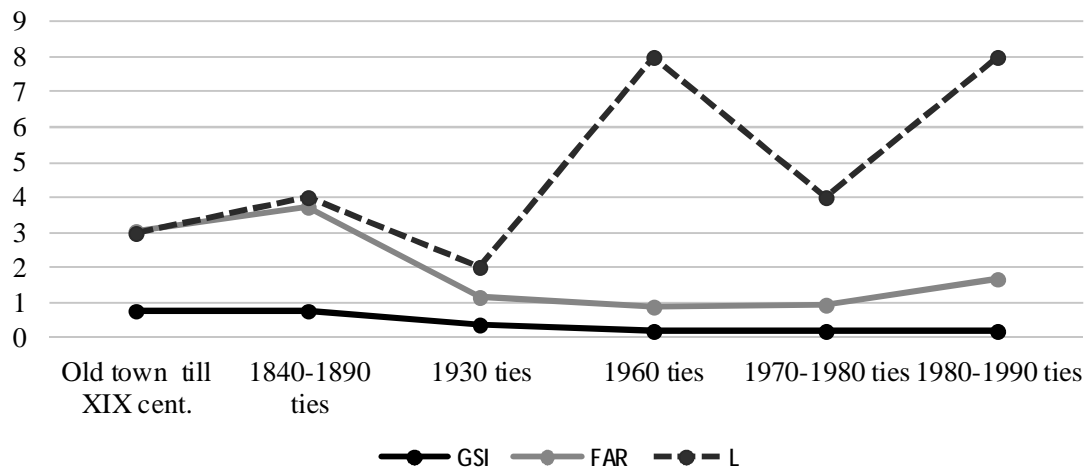


Fig. 4. Graph of changes of the density indicators in residential development blocks during the different time periods (based on the data from Fig. 3).

The city suffered the greatest crisis during the Second World War, when burgers of Jewish nationality were exterminated, Polish – took out, and Ukrainian – subjected to repression. The population of Lviv resumed only in the 1970s due to its transformation into an industrial center, which also resulted in its territorial growth.

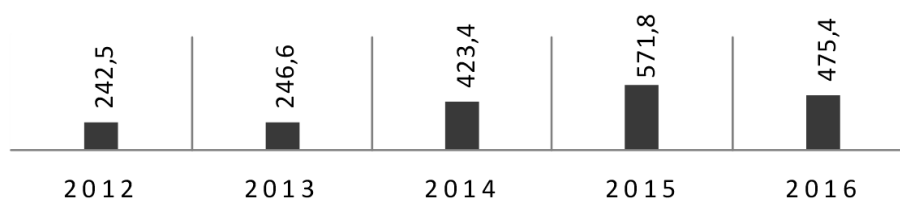


Fig. 5. Putting of houses into operation in Lviv (in thousands of sq. meters of total area).

The number of available population of Lviv, according to the estimates, as of April 1, 2016 had grown to 757.2 thousand people. Thus, in 2016 in Lviv (including satellite small towns of Vynnyky, Bryukhovychi and Rudno), residential buildings with a total area of 475.4 thousand square meters were put into operation. The city of Lviv accounts for 55.3 % of the total residential housing of Lviv region and 633.3 sq. meters of total housing area was constructed per 1,000 inhabitants of the city. In 2016, 403.2 thousand sq. meters of total housing area in residential buildings with two or more- room flats and 72.2 thousand sq. meters in the houses with one- room flats were put into operation. In general, in 2016, 315 new residential buildings for 6,265 flats were put into operation in the city. The average area of one newly built flat was 70.9 sq. meters. Such volumes of housing construction require the active development of infrastructure and an increase in the number of service facilities. However, only one pre-school institution for 160 places, the educational and rehabilitation center for 1.3 thousand square meters of total

area, the outpatient clinics for 56 visits per shift and the memorial museum complex of 5.8 thousand square meters were put into operation (Main Statistics Department of Lviv region, 2016).

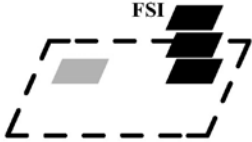



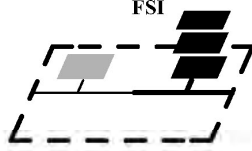
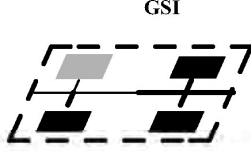
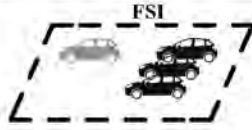

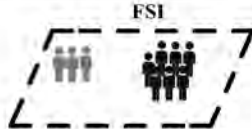
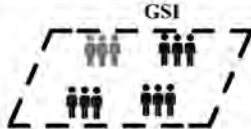
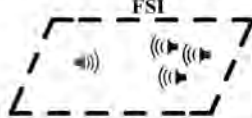

Name of the indicator	The Territory transformation ways	
FSI (Floor Space Index) GSI (Ground Space Index)		
	-change of the density index by the FSI, which increases the number of total areas of buildings and structures;	-change of the density index by the GSI, which increases the number of built-up area ;
Transport network		
	-the intensification of transport infrastructure: the indicator of linear density, a need for optimization of transport network (formation of a pedestrians and roads network)	
Engineering networks		
	-intensification (additional load on existing engineering networks) - engineering support of non-equipped territories.	
Transport		
	- need for parkings;	
Population		
	- functional intensification, which is a direct dependence to the increasing of people number on the territory (permanent and temporary stay) and ensuring of their needs	
Pollution		
	Concentrated localization of pollution sources: - noise; -air Pollution; -visual pollution.	Dispersed localization of pollution sources: - noise; -air Pollution; -visual pollution.

Fig. 6. Intensification of the territory by different density indicators (illustrated by S. Konyk).

Such volumes of construction create a heavy burden on the city infrastructure and do not always take into account the formed environment exacerbating the urban problems (Petryshyn H. & Hanets S., 2014, pp. 141–149). This approach to designing is a parasitic attitude to the city. Today, the regulation of the development of urban facilities is carried out within the framework of free areas of the territory allocated for the design and in areas planned for reconstruction. This approach leads to the following changes: condensation of building; loading on transport infrastructure; additional pressure on engineering networks; increase in a number of sources of noise pollution; air contamination; visual pollution; closure of production; spontaneous building in suburban green areas; the decline of the natural landscape caused by anthropogenic influence; social and domestic conflicts.

Urban planning warranties and restrictions on land development in Ukraine should provide indicators for the following requirements (Urban planning conditions and restrictions, 2011):

- maximum permissible height of buildings;
- maximum allowable percentage of land plot development;
- maximum permissible population density (for residential development);
- distance from the object being projected to the limits of red lines and lines of regulation of the building;
- planning restrictions (zones of protection of monuments of cultural heritage, protected landscape areas, boundaries of historical habitats, coastal protective strips, sanitary protection and other protection zones);
- minimum allowable distances from the objects being projected to other buildings and structures;
- protected zones of engineering communications;
- requirements for the need for engineering surveys in accordance with state building regulations;
- requirements for landscaping (including restoration of landscapes);
- provision of transport and pedestrian communication conditions;
- requirements for providing of the necessary number of places for safekeeping of motor vehicles;
- requirements for the preservation of cultural heritage.

Designing of the quarters of buildings depends to a large extent on the needs of people, modern criteria that form a subjective assessment of a comfortable environment. Today, each developer, for an advertising purpose, denominates the projected quarter as the greenest, the most comfortable for families with children, or a separate cluster, which will form a certain model of the environment of livelihoods. Therefore, there is a question of the objectivity of such advertising estimation and the need to determine what significant transformations have taken place in the approaches to building residential quarters. We follow two approaches to the intensification of development on the territory: increase of the area of development and growth of a number of storeys. In these two versions, we proceed from the existing state of the environment which forms the planning restrictions for us, as well as the area of the site for the projected quarter. Today, the fact that the site for designing of one quarter is less than the other is not an indisputable reason for calculating residency in it for a smaller number of people. Let's consider this approach on the example of some new quarters of residential development in Lviv (lun.ua, 2008–2017).

Increasing amount of buildings near central part of Lviv is changing primary ideas of area construction, its purpose and functional usage. It traces changes in development trends on the one of central streets of the city - Vyacheslav Chornovil avenue by the end of 19 century till today (Kryvoruchko V., 2017, pp. 5–13). Free or neglected areas adjacent to the main transport connections which form the planning framework of the city were chosen as the territory for development of residential neighborhoods: Shevchenko str., Volodymyr the Great str., Princess Olga str., Pasichna str. and others. Within adjacent to the territory of the named streets, the sites of different sizes - from 2.5 hectares to large plots of 15 hectares were allocated. The quarter type of building remains the main trend, which is formed by the groups of sectional houses of the same, or a various number of floors. Morphologically, this can be building formed around enclosed courtyards with 2 or 3 houses ("Semotsvit", "America"), or the area built up a perimeter ("Villa Magnolia"), or a more dispersed organization of the territory ("Pasichna"). Despite the various number of storeys of building and various planning principles and FAR and GIS indices, the following results were obtained:

- having various area of the site, the percentage of the built-up area is approximately 20–40 %, followed by a tendency to increase the area of development with a smaller total area of site, thus we vividly notice the intensification according to GIS indicator;
- number of storeys of residential building is a parameter that is adjusted to obtain the desired density of a quarter, often without taking into account planning constraints and leveling out the importance of the requirements for comfort of residence appealing to a person's subjective perception;
- FAR index is indicative for a developer, because it is a number of square meters that can be put into operation, and it also gives grounds to talk about the number of people who will live there, limited by this area. For example, the residential quarter of "Dobra Oselia (Good Abide)", which has FAR index close to 3, that is,

the area of all the storeys of the building is three times larger than the total area of the site, gives grounds to say that there is not enough space for recreation and service of the residents;

– a large number of people living in these quarters will require an increase in the number of service facilities, places in educational and pre-school institutions, which, however, are projected less intensively than new residential complexes;

– these residential buildings are the focus for attracting people and, therefore, additional traffic flows, which stimulates the appeal to the issues of parking, organization of transport and pedestrian traffic;

– there is a tendency of a slow transition of mono-functional housing complexes to poly-functional ones. It is evidenced by projected public spaces on the ground floors of some residential buildings.

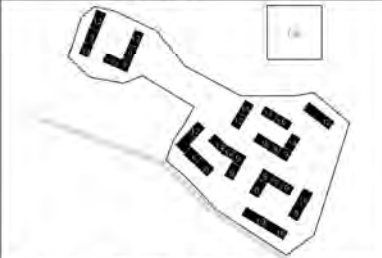
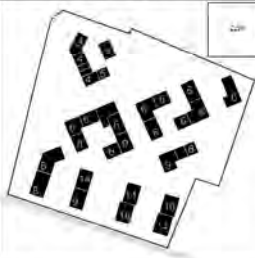




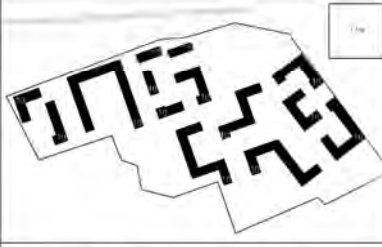
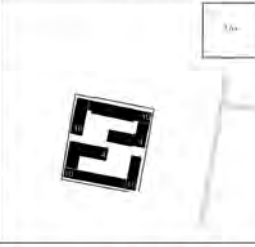




"Semyevit" Shevchenka street 60	"Ameryka" Volodymyra Velykoho street 10	"Dobra Oselia" Knyahynya Olga/5 str.
Archimatika Architects	Zeletin Architects	Dobra Oselia
FAR 1,884 GIS 0,214	FAR 1,727 GIS 0,233	FAR 2,869 GIS 0,353
		
		
"Pasichnyi" Pasichna street 133, 171	"Misto Trav" Kulparkivska street 226	"Villa Magnolia" Pasichna street 150
Archimatika firm Architects/Mistoproekt	Zotov Architects, AVR Development	ATO-BEL firm, Architect Ihor Hnes
FAR 1,884 GIS 0,226	FAR 1,865 GIS 0,529	FAR 1,678 GIS 0,382
		
		
0 100m		

Fig. 7. New building quarters in Lviv with the calculation of density indicators (LUN) (Cherkes B, Petryshyn H., Kolomeytssev A., Konyk S., 2017).

3. Conclusion

Intensification of the urban environment during the period of growth of urbanization should take into account the needs of the city, take into account its problems and maintain the concept of sustainable development. Formation of quarter development should be considered in the city context and create a high-quality urban environment. There is even more responsible task: to find approaches to the intensification of building of historic cities, especially their central parts.

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ІНТЕНСИФІКАЦІЯ ЗАБУДОВИ ІСТОРИЧНО СФОРМОВАНОГО МІСТА НА ПРИКЛАДІ ЛЬВОВА

Анотація. Міста метрополійного характеру, зокрема Львів, максимально інтенсифікуються у їхніх існуючих межах, враховуючи потенціал сформованих містобудівних утворень та неосвоєних територій, як і поза ними. Міська щільність є показником міського розвитку і демонструє кількісне та якісне використання міського середовища людиною.

Кількість наявного населення у Львові, за оцінкою, на 1 квітня 2016 року становила 757,2 тисяч осіб. Відтак, у 2016 році у Львові (включаючи міста-сателіти Винники, Брюховичі та Рудно), було здано в експлуатацію житлові будинки загальною площею 475,4 тис кв. м. На Львів припадає 55,3 % загальнообласного введення житла, а у розрахунку на 1000 мешканців міста було збудовано 633,3 кв. м загальної площі житла.

Територією забудови житлових кварталів обрано вільні чи занедбані ділянки, що прилягають до основних транспортних сполучень, які формують планувальний каркас міста: вул. Шевченка, вул. Володимира Великого, вул. Княгині Ольги, вул. Пасічна та інші. В межах прилеглих до цих вулиць територій виділені ділянки різної площі від 2,5 га та великі квартали до 15 га.

Основною тенденцією забудови залишається застосування квартального типу забудови, що формується з груп секційних будинків однієї або ж різної поверховості. Морфологічно це може бути забудова, сформована навколо замкнених дворів у межах 2–3 будинків (“Семіцвіт”, “Америка”), або периметрально забудована територія (“Вілла Магнолія”), чи більш розосереджена організація території (“Пасічний”). Незважаючи на різну поверховість забудови та різні планувальні принципи, було отримано такі результати: у досліджених кварталах відсоток забудованої території

становить 20–40 %, також прослідковується тенденція до збільшення площі забудови при меншій загальній площі ділянки; поверховість житлової забудови є параметром, який корегують, щоб отримати бажану щільність кварталу, часто не враховуючи планувальні обмеження та нівелюючи важливість вимог до комфортності проживання; велика кількість людей, що проживатиме у цих кварталах, потребуватиме збільшення кількості об'єктів обслуговування, місць у освітніх та дошкільних закладах, які однак проєктуються менш інтенсивно, ніж нові житлові комплекси; нові житлові утворення є фокусами притягання людей, а, значить, додаткових транспортних потоків, що стимулює забезпечення паркомісцями, організації транспортного та пішохідного руху; проявляється тенденція повільного переходу монофункційних житлових комплексів до поліфункційних, про що свідчать запроєктовані громадські приміщення у перших поверхах деяких житлових будинків.

Інтенсифікація міського середовища у період зростання рівня урбанізації повинна враховувати потреби міста, зважати на його проблеми та підтримувати концепцію сталого розвитку. Формування кварталу забудови має розглядатись у загальноміському контексті і створювати якісне міське середовище. Ще відповідальнішим завданням є віднайдення підходів до інтенсифікації історичних міст, особливо їх центральних частин.

Ключові слова: міська забудова, урбанізація, щільність, інтенсифікація