



Research paper

Research by design: architectural and structural solutions allowing the integration of the skyscraper complex with the urban space in Warsaw

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Abstract: The text is devoted to the description of the methodology and research by design conducted to determine the functional and spatial solutions of a high-rise building complex located in Warsaw favoring connections with the public space of the city. The research work was carried out in the following phases: pre-design, including analyses and studies, context analysis, data collection, and design phase including defining initial conceptual variants, developed conceptual variants, selection, and determination of the final variant of the concept of functional and spatial structure for further investment and design steps. The final solutions adopted in the described process in the realization of the complex and detailed execution designs were also indicated. Design research was done through iteration of solutions, critical analysis, and functional optimization. The final solution was the division of the stylobate part of the complex, following the pedestrian traffic analysis, into three investment parts and the introduction of a rich program of supplementary functions for the dominant office function. A complex program of supplementary functions: trade, entertainment and event space, medical functions, gastronomic parts.

Keywords: functional program, high-rise, public space, skyscraper, Warsaw

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1. Introduction

1.1. The subject and the goal of the paper

The work is devoted to the problem of connection with public space the office complex of Plac Unii skyscraper building designed in Warsaw in the development quarter between Tadeusza Boya-Żeleńskiego, Puławska and Ludwika Waryńskiego streets (Fig. 1). The building, along with its height form and program, was designed on the basis of the provisions of the planning decision – Warunki Zabudowy [1]. One of the key design issues was to find an answer to the problem of an appropriate spatial connection of the complex with the city.



Fig. 1. Location of the building; source: author's study

The design works were carried out by a team of designers Kuryłowicz&Associates in the field of architecture, development plan and the function of general designer, Nazbud designers in the field of construction, Polcon designers in the scope of a set of installations, specialists in landscape architecture, communication, façade solutions and with the participation of the Investor's specialists in the field of commercialization and during implementation – specialists of the general contractor.

In Warsaw conditions, the results of research and design work resulted in the first high-rise building after 1989, integrating an office program with a multifunctional, rich service program.

1.2. The subject of the architectural connection of skyscraper complexes with urban space

High-rise buildings are complex objects, the design of which is related to the solution of a number of aspects. The technical aspects related to the construction and proper installation service are traditionally considered crucial in the literature [2–5], nevertheless, in the contemporary discussion on high-rise buildings, environmental issues [6], functional programming of the building [7–9] and their location resonate strongly [8, 10, 11].

Among the aspects related to the location, special importance is attached to urban planning decisions of the proper planning of a high-rise building as an element of the city in terms of spatial, functional, communication, and environmental factors. In the issues combining planning and architectural factors of the designed building, three types of relationships between the building and the public space of the city can be distinguished:

- viewshed connection and imagery: realized through perception, building mental maps of the city, taking place at medium and long distances from the building
- environmental connection: implemented by solutions of biologically active surfaces, reduction of emissions and nuisance, the introduction of biological diversity of the area, solutions affecting the local microclimate, solutions favoring public transport, walking and cycling,
- utilitarian connection: spatial and functional, implemented by the adopted method of solutions in the investment area.

The viewshed connection and the role of the high-rise building in shaping the elements of the city's image and the panorama of the metropolis have received many scientific studies. The most important of these are the works of K. Lynch [12, 13] and W. Attoe [14], and among Polish authors – the publications of K. Czyńska [15–17]. Environmental connections of environmental buildings with the surroundings are the subject of a number of scientific studies, including the studies of K. AL.-Kodmany [18–21] or A. Wood [22]. The requirement to introduce them is also subject to the implementation of the criteria for assessing the environmental-friendly solutions of the investment – eg LEED or BREEM. Against the background of the aforementioned issues related to the design of skyscrapers, the aspect of the utilitarian connection of high-rise complexes with the city space is often marginalized and the publications related to it are few. An example of contemporary studies related to the above aspects is the publications of A. Wood [23] and J. Parakh [24, 25], while the study of the nearest surrounding public space and high-rise buildings realized in Warsaw is included in the study by M. Goncikowski [26]. From the perspective outlined above, a limitation in the number of research works and design studies related to the solutions of the third of the aforementioned types of relations between high-rise buildings and the city is visible. This text is intended to partially fill this gap by presenting solutions conducive to the utility connection of a high-rise building complex, over 90 meters high, with the city space.

Among the design aspects aimed at achieving the goal of utilitarian connection between the skyscraper and the city, two types of solutions can be recognized: spatial and functional-program solutions. In terms of the program, the intended result is supported by the multifunctionality, hybrid nature of the building [27, 28] – mixing the main functions,

e.g. office, hotel, residential, introducing complementary functions: trade, gastronomy, conferences and culture, and recreation: both external and internal. The enrichment of the program should be done simultaneously with the enlargement of internal and external public spaces. It is a measure of mutual benefit: for the urban space, as well as for the value of the property and the number of rental rates. The aim of such a spatial strategy should be to avoid creating an inaccessible or hardly accessible environment for the public, the access to which can be obtained after crossing the access control gate. A special role in architectural solutions is played by shaping the building on the plot and designing the part of the building adjacent to the public space – the most adjacent levels. In this respect – the shape of the part of the high-rise building adjacent to the public space E. Generalova and V. Generalov [29] indicate its following features:

- a. Number of levels, distinguished into low (up to 2 stories), medium-high (from 2 to 5 stories), high (more than 6 stories) in combination with the type of common, generally accessible space connecting these stories and the degree of their openness.
- b. Functional structure distinguished by degrees of saturation: low (75% of the structure is occupied by one function), medium (containing from two to four functions), high (more than four functions).
- c. Accessibility is differentiated into open (functions fully accessible from the public space) and closed (functions for building users).
- d. Transit: ensuring connections with footpaths and bicycle lanes and meeting the criteria of Transit Oriented Development [30, 31].
- e. Connection with transport infrastructure, consisting of the construction of high-rise buildings in connection with public transport: e.g. metro, railway, or tram stations.

From the point of view of the subject of the work, the most important features identified above by E. Generalov and V. Generelaov, which strengthen the connection with the public space, are the high saturation of the functional structure combined with its maximum openness.

The very openness of the part of a high-rise building, in contact with the public space, combined with the degree of transit through the building and the entire area on which it is being implemented, as defined in the study by M. Short [32] as permeability. The feature given by Short can be defined numerically – as ensuring the number of directions of passage through the area and the ground floor of a high-rise building. The higher this index is, the stronger the connection between the building and the surrounding public space is. Permeability touches on the basic aspects of connecting high-rise buildings with the city space: improves access into and through the site, allows improved reading of the site and its relations to the wider area as it improves access into and through the area, and gives opportunities for improved linkages of wider areas for pedestrians. Paradigms related to designing the architecture of high-rise buildings and their connection with urban space change over time [33]. However, theoretical considerations show that there is an attempt to strengthen the connection of buildings with the city [34], and the use of high-rise buildings for urban regeneration [35], which is favored by such a connection.

From this perspective, the methods and results presented in this text may be an example of a strategy currently adopted, which may be used by designers, although – as more high-

rise buildings are built in Warsaw, they may and should be updated in subsequent studies of the topic, in the author's opinion.

2. Methodology

The research methods were researched by design studies performed on the basis of recognized methodology [36–40]. The pre-design and preparatory part included theoretical research, collection of design data, and pre-design studies and analyzes. After its completion, the step of summing up and collecting conclusions and developing requirements and postulates for the design and research part took place. Part of the research through design was based on a variant design response to the postulates and requirements, and on subsequent iterations of solutions. Variants of solutions and their iterations at the stage of competition concept solutions and later stages – multibranch concept project, building permit, tender and execution projects were each time assessed by a working team. The final design team included architects and industry engineers: structural and installation designers, specialists in road design and landscape architecture, and the investor's team including specialists for technical, rental and commercialization solutions. After the assessment and formulation of conclusions, the results of the selected variants were iterated, gradually narrowing down the solutions until the final solution was obtained, which at the implementation stage was verified for the underground part following the digging of diaphragm walls and additional drilling. The basic solutions that are the subject of this article – connections with the city – have been developed in phases up to and including the construction design stage.

3. Results

Thorough pre-design research indicated possible directions of design solutions in terms of embedding the designed complex in the public space of the city.

They formed the basis for the development of the first step of the project – conceptual competition work.

At this stage, analyzes the functional and spatial context of the environment, analysis of possible transport services, analysis the traffic of vehicles, pedestrians, and bicycles, analysis of the natural and environmental context, and analysis of insolation and obscuring of the existing buildings by investment volumes allowed by the planning decision [1]. The analyzes were completed with the study of the absorbency of the area and the formulation of conclusions for the project, taking into account the results of the pre-design studies.

An important role in the solutions related to linking the complex with the city was played by analysis of pedestrian traffic, taking into account: possible shortcuts leading through the area, the location of existing public transport stops, and pedestrian routes, especially those leading through the multi-lane Puławska and Waryńskiego streets. The analyzes were made on the basis of urban inventories, and data from MPT, taking into account the number and

frequency of public transport vehicles, as well as observations and visions in the area. They showed that the most frequented side of the plot is the eastern side, along Puławska Street in the north-south direction, which was associated with the saturation of services in this area of the surroundings, the presence of tram lines and stops, and more bus lines. The second largest direction of pedestrian traffic that was found was the east-west direction between ul. Waryńskiego and Unii Lubelskiej Square, whose surroundings, with high saturation with means of public transport, functioned as a local communication hub.

Conclusions regarding the potential shape of the building complex in terms of ensuring directions of connections with the city and passages through the designed building complex, formulated on the basis of pre-design analyzes are presented in Fig. 2.

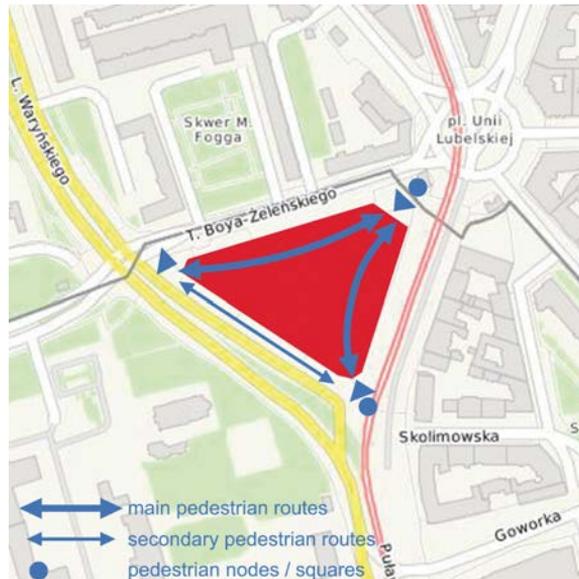


Fig. 2. Pedestrian traffic modeling results; source: author's study

Conclusions regarding the potential shape of the complex in terms of ensuring the directions of crossings through the designed development, formulated based on forecasts and analyzes of pedestrian traffic, are shown in Fig. 2. The further design phase in the conceptual part consisted of variant solutions and iterations to arrive at the final solution, which, after adopting the solutions at the concept stage, were directed to the development of construction, tender, and execution designs. Examples of the studied variants of spatial solutions are shown in Fig. 3.

From the very beginning of the design works, they reflected the initial assumptions related to the connection of the complex with the city space, shown schematically in Fig. 2. Following the provisions of the planning decision, it is possible to build a complex with a 90 m tower part and a 30.5 m high stylobate [1]. Part of the stylobate, in the light of the conducted analyzes and theoretical assumptions, should be perforated with passages through the area to connect the investment with the city space.

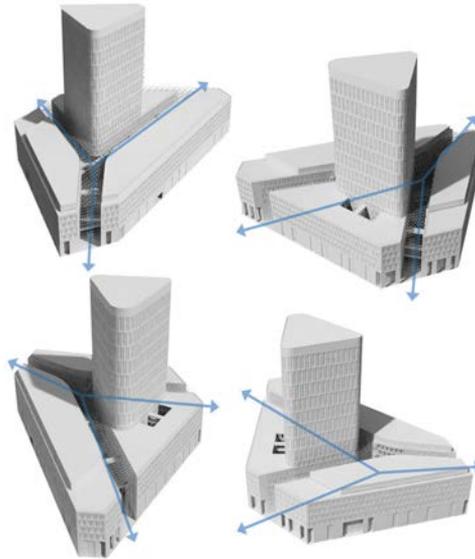


Fig. 3. The spatial solution of the building complex was prepared on the basis of research into the directions of the most optimal pedestrian passages through the area; source: Kuryłowicz & Associates

Finally, the complex was divided into buildings A, B, and C. Spatially, they are in the form of a stylobate 30.5 m high with a 90 m high dominant. Building A, with a total above-ground area of approx. as a tower connected with a stylobate, and buildings B, with a total above-ground area of approx. 18 000 m², located from ul. Boya-Żeleńskiego and building C with a total above-ground area of approx. 10 000 m², located from ul. Puławska is within the height of the stylobate.

In the upper part of the stylobate – from level +2 and the tower – to level +21, office space was introduced, and in the lower part of the stylobate – levels –1, 0, and +1 – a multifunctional service space. Under level –1, three floors of an underground car park have been designed.

Connections with the city ensured passages through the investment area, which were shaped in line with the design assumptions, taking into account their optimal directions. These passages were shaped by cutting the stylobate with wide passages. Most of the services are available from the inside of the quarter, from the passages, ensuring the movement of users in the initially assumed directions. In addition, entrances to the office part and some services from the outside have been provided – along the streets surrounding the quarter.

In this way, three main directions of passage through the quarter were provided in the form of covered passages. This solution has been maintained from the design of the competition concept to the detailed design and implementation phase. The directions of the auxiliary passages were initially assumed – at the stage of the competition concept – as leading from one entrance – from Puławska Street. Finally, as a result of design work,

their number was increased to three – leading from the center of the frontage of each street complex, as shown in Fig. 4.

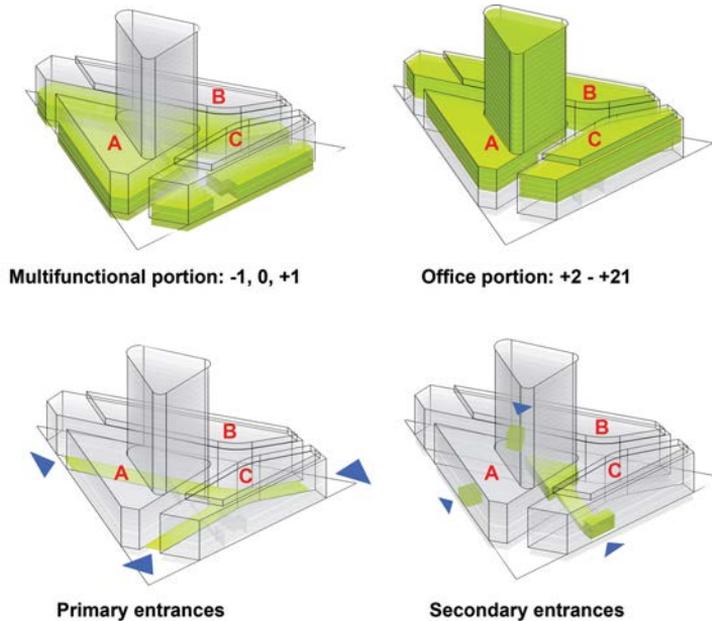


Fig. 4. Initial spatial variants of the complex; source: Kuryłowicz & Associates

In this way, over 8 basic directions of passages through the investment area were finally provided.

The main functional solutions and passages have been clearly marked in the body of the building. The blocks of the buildings are monolithic with contrasting colors, both from the side of the streets and the passages through the quarter. The multifunctional part is faced with polished granite slabs, the office part – with an alternating arrangement of windows, is faced with slabs of white sintered marble and glass. The main entrances are marked with high glass walls (Fig. 5 and Fig. 6).

The passages through the quarter were covered with skylights placed at the height of the stylobate. The floor of the passages is designed in durable materials of high standard – stone slabs. At the same time, the passages were equipped with a number of landscaping devices – benches, resting places, information points and places for the arrangement of small catering and commercial points were introduced and space was left for organizing events. The final solution of the development of the quarter is shown in Fig. 7.

In addition to solutions ensuring multi-directional permeability – the permeability of the complex, which has an impact on its form, several program and functional solutions were developed during the design and research works that favor the connection of the building with the urban space. First of all, a high level of functional saturation was programmed into the complex.

equipment, household appliances, accessories, and drugstores), a supermarket, pharmacies, bookstores, services – wellness, gymnasium, small services for residents of the district and visitors and gastronomy – restaurants and cafes as showed in Fig. 8.



Fig. 8. Functional saturation of the complex; source: Kuryłowicz & Associates

4. Discussion and summary

4.1. Discussion

The introduction of solutions conducive to strengthening the connection of high-rise buildings with public space encounters several barriers. They can be presented in the following classification:

a) Planning conditions

Although the essence of the strategy of linking buildings with public space is an activity improving the quality of the city, some adopted urban solutions, expressed in planning records, make such solutions difficult. These are:

- preventing functional hybridization of buildings, i.e. the building having several main functions [27, 28], instead of one dominant function, which is a common planning practice,
 - too little flexibility in introducing supplementary functions, or their number too small to the main function provided for in the plan,
 - too strict provisions regarding the running of the existing building lines, making it impossible to make gaps between the built-up volumes or gate passages.
- b) Economic conditions
- pressure to increase the total above-ground area above the size enabling the construction of a public area, pressure to build a large number of car parks in the area,
 - striving to separate investment areas from the urban space and complementary functions available from inside the buildings and making them available only to building users, which is perceived in market practice as an asset, ensuring exclusivity and safety of the complex,
 - simplifying the commercialization program, resulting in simpler technical solutions and implementation costs,
 - savings in the implementation of land development: greenery and the program of small architecture facilities and equipment.
- c) Technical conditions
- the need to predict greater loads on the slab of the underground part located outside the outline of the ground floor for the layers necessary for the implementation of medium-high and higher greenery,
 - the need to anticipate higher loads in the case of flexible programming of the service part, with the possibility of introducing various types of services (e.g. gym, car showroom, library) during the building's life cycle,
 - the need to provide space and additional installation systems for the introduced services,
 - the need to predict and implement additional communication for certain types of services (e.g. medical services),
 - the need to take into account the greater capacity of mechanical communication in the case of introducing public services on stories located above or below the level of public space.

From the research, design works, and construction of the complex carried, it can be concluded that it is extremely important to cooperate with the investor from an early stage of the project and to discuss solutions and scenarios for the operation of the facility from the very beginning of conceptual works. In terms of the issue of functional saturation of buildings, it should be stated that the commercialization process is a continuous process – it also continues during the construction of the facility, and then the potential use may be changed along with the termination of tenants' contracts. Predicting e.g. the maximum loads for the assumed range of services and space for installation service at the early stages allows for a possible wider range of potential services to be introduced and the achievement of the assumed multi-functionality of the facility. From the perspective of the conducted research, the success of introducing spatial solutions

that will connect the designed buildings with the city as an actual component of public space can be associated with the scope and reliability of the context analyzes. Among them, there is an analysis of pedestrian traffic, which indicates the directions of separation in the most optimal form of public areas. Another important analysis of the issue is a functional analysis of the surroundings, indicating the necessary program of land architecture devices and public functions that will work in the context surrounding the investment plot.

Compared to other high-rise buildings in Warsaw [26], the adopted design solutions rank the Spark complex as one of the best ensuring the permeability through the plot. The solutions of Varso Place ensure passage through the area in four directions, others – Warsaw Trade Tower and Generation Park – in three. In the presented case, the passages are provided in more than four directions. The high permeability index achieved is the highest among the high-rise building complexes completed in Warsaw. From the point of view of the operation of the passages, a valuable asset is the proposed combination of stone floors, and greenery on the roof, which helps to reduce the temperature propagation in pavements [41] by reducing the effect of heat islands.

As the presented example shows, the postulates to ensure a greater connection of public space with the designed high-rise complexes are not utopian, theoretical slogans, but solutions that find their place in design practice.

4.2. Summary

The research process by design related to the definition of solutions related to the introduction of connections of a high-rise building complex located in Warsaw with the surrounding urban space is presented. Research on the main spatial solutions of the complex was carried out at the stages of the preliminary competition design and the multi-discipline conceptual design. The solutions adopted in the research process were technically detailed at the subsequent stages of the project: the tender design and the detailed design as well as the construction of the complex. The text presents the methodology and the course of work. The theoretical background of the main assumptions and design goals related to the subject of the text is also presented. Preliminary and pre-design studies and analyzes carried out during them allowed us to define the initial parameters for further works and the main assumptions of the solutions. As part of the preliminary work, geodetic materials and planning data were collected, and analyzes related to the surrounding context were carried out. An analysis of urban conditions: functional and communication, analysis of natural and environmental conditions as well as an analysis of insolation and shading of the surrounding buildings were carried out. Analyzes of pedestrian traffic and functional analyzes of the surroundings were of key importance to determine the directions of solutions related to the solution of the optimal relationship between the designed complex of buildings and the urban space. On their basis, the principles of shaping the public spaces of the designed complex and the forms of dividing the complex into investment parts in terms of form: shape, and size were developed. A functional program was also defined, corresponding to the assumed high saturation of the parts

accessible from the public space with auxiliary functions for the basic function of the complex. After the pre-design and preparatory part was completed, the actual part of research through design began. They were conducted through variants and iterations of solutions in the process of their analysis and assessment by the design, investment, and executive team. The design team consisted of industry specialists: architects, landscape architects, communication engineers, and construction and installation engineers. The investment team consisted of specialists in commercialization, leasing, and marketing. The executive team consisted of specialists for the implementation of the entire investment. They took part in giving opinions on solutions and their assessment in terms of the given criteria.

Communication between them, especially important for the time of work [42], was fluent and subordinated to the set goals and timing of project work.

The presented research defines the theoretical background and the methodology of work on identifying solutions conducive to achieving real connections between the building and the public space. As a result of research and design works, a solution was developed consisting in dividing the complex into three buildings and forming public spaces between them, following the assumptions regarding the team's permeability. In this way, the possibility of multi-directional passages through the investment area has been achieved. Public spaces have been dimensioned according to the intensity of the expected pedestrian traffic. Various service functions have been designed on the floors connected to the public space.

The adopted solutions concern the spatial shape of the complex and the definition and arrangement of supplementary functions. They have a key impact on the solutions of most specialist industries related to the preparation of documentation enabling the implementation of investments: including the most important ones – the structure and the complete set of installations.

The solutions adopted concern the spatial configuration of the complex and the definition and distribution of supplementary functions. They have a key impact on the solutions of most specialist industries related to the preparation of documentation enabling the implementation of investments: including the most important – the structure and set of installations. These solutions were developed in the project documentation and implemented. From the perspective of implementation and the course of work on obtaining optimal solutions, it can be concluded that the following is beneficial:

- a clear recognition of the theory of problems and definition of the goals of solutions,
- starting work with thorough pre-design studies including key analyzes,
- carrying out works with the involvement of a wide range of experts, including experts in leasing and commercialization from the early stages of work,
- carrying out design works as multi-stage, with a strategy of initial variants of solutions, their iteration, and a gradual rejection of the least optimal solutions with their gradual refinement and corrections through iterations.

The presented principles and design goals as well as the methodology and techniques of operations should certainly be updated in the future, due to the development of design technologies and the developing background of the theory.

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Badania przez projektowanie: rozwiązania architektoniczno-budowlane sprzyjające integracji zespołu wysokościowego w Warszawie z przestrzenią miejską

Słowa kluczowe: integracja, program funkcjonalny, przestrzeń publiczna, Warszawa, wysokośćowiec

Streszczenie:

Tekst poświęcony jest opisowi metodologii oraz badań przez projektowanie służących określeniu rozwiązań struktury funkcjonalnej i przestrzennej budynku wysokościowego w Warszawie sprzyjających połączeniu z przestrzenią publiczną miasta. Prace badawcze prowadzono w fazach: przedprojektowej, obejmującej analizy i studia przedprojektowe, analizy kontekstu, zbieranie danych, oraz fazy projektowej obejmującej wyodrębnienie wstępnych wariantów koncepcyjnych, rozwiniętych wariantów koncepcyjnych, wyboru ostatecznego wariantu koncepcji struktury funkcjonalnej i przestrzennej służącej dalszym krokiem inwestycyjnym i projektowym. Wskazano także końcowe

rozwiązania, przyjęte w opisanym procesie w realizacji obiektu oraz projektach wykonawczych. Badania przez projektowanie wykonywano przez iteracje rozwiązań, krytyczną analizę i optymalizację funkcjonalną. Jako finalne rozwiązanie przyjęto podział części stylobatu zespołu w ślad za analizami ruchu pieszych na trzy części inwestycyjne oraz wprowadzenie bogatego programu funkcji uzupełniających dla funkcji dominującej – biurowej. Złożony program funkcji uzupełniających: różnorodny handel, rozrywkę i miejsca eventowe, funkcje medyczne, sportowe, części gastronomiczne.

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