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# FORMATION OF STYLOBAT TYPOLOGY OF HIGH-RISE BUILDINGS IN ACCORDANCE WITH PRINCIPLES OF TRANSIT-ORIENTED DESIGN

*The study reveals the following aspects that determine the typological diversity of stylobates in high-rise buildings: functional structure; connection to pedestrian and traffic flows; landscaping; variation of scenarios of social interaction; adaptability; the degree of accessibility of various public services; security; the impact of climatic conditions on the planning structure; innovative architectural, constructive and technological solutions. A scientifically based typology of stylobates of high-rise buildings is proposed. The basic principles of transit-oriented development of the urban environment are considered. The article focuses on the transit-oriented development of the stylobate part of high-rise buildings and complexes. The main space-planning elements necessary for organizing pedestrian traffic are identified.*

***Keywords:*** *high-rise construction, stylobates of high-rise buildings, transit-oriented development*

*В исследовании раскрываются аспекты, определяющие типологическое разнообразие стилобатов высотных зданий: функциональная структура; подключение к пешеходным и транспортным потокам; озеленение; вариантность сценариев социального взаимодействия; адаптивность; степень доступности различных элементов общественного обслуживания; безопасность; влияние природно-климатических условий на планировочную структуру; новаторские архитектурные, конструктивные и технологические решения. Предложена научно обоснованная типологии стилобатов высотных зданий. Рассмотрены основные принципы транзитно-ориентированного проектирования городской среды. Сделан акцент на транзитно-ориентированном развитие стилобатной части высотных зданий и комплексов. Выявлены основные объемно-планировочные элементы, необходимые для организации пешеходного транзита.*

***Ключевые слова:*** *высотное строительство, стилобаты высотных зданий, транзитно-ориентированное проектирование*

With changing living conditions of urban dwellers, new requirements for urban environments have emerged. Several scientific studies have revealed that a high-quality environment in cities is impossible without the development of a diverse functional program [1–4]. Thus, every year, multifunctional structures have gained increasing interest, particularly multifunctional high-rise buildings and complexes. The concept of vertical urbanism is garnering further recognition as a new approach for the forms and functions of urban spaces. This concept is based on the multifunctionality and reinterpretation of the typology of high-rise buildings and complexes. A contemporary high-rise building is perceived as a vertically oriented extension of the city with all its functions. Thus, only the inclusion of several functions in the skyscraper structure may be insufficient. A multifunctional high-rise building must not become an unassailable fortress where the residences, offices, and hotels are for residents, workers, and guests, respectively. There is considerable concern about techniques, methods, and means for integrating high-rise buildings into urban environments for humanization and improvement of the quality indicators [5–10]. A systematic analysis of the criteria for determining the degree of efficiency of the interaction of a high-rise building with existing urban development has also been performed. A stylobate is significant in high-rise building interactions in the city space. Stylobate is a built-in and attached part of a high-rise building or complex, located at the base of the building or complex (including the underground part). Our analysis revealed that the vast majority of skyscrapers have stylobates. However, the factors that make stylobates an effective link between the vertical structure and urban environment are still unknown.

Thus, a systematic approach for evaluating the structure of the stylobates of high-rise buildings and complexes is fundamental for this study. Such an approach can be used to identify techniques and methods for integrating vertical housing development into the urban environment to improve the quality indicators of stylobates. The analysis was performed using "The Skyscraper Center" database of the Council on Tall buildings and Urban Habitat [11]. High-rise buildings and complexes built over the last decade (2011–2020)

were considered. The analysis included a group of 680 objects, such as high-rise buildings above 200 m and high-rise complexes consisting of two or more buildings, with at least one of them above 200 m. Almost half of the group analysis (296 complexes) corresponded to high-rise complexes. Based on the number of towers, all objects were classified into three groups: single towers (384 objects, 56.5%), two-tower complexes (170 objects, 25%), and multitower complexes (126 objects, 18.5%).

In this study, the advanced international and Russian experience in the design and construction of high-rise buildings and complexes, with stylobate platforms in their structures, was also analyzed. A comprehensive analysis was performed to identify criteria that determine the typological diversity of stylobates, such as the number of stories, functional composition, accessibility, transit, and connection to the transport infrastructure.

**Number of stories.** This criterion varies in an extremely wide range in the studied samples. Therefore, based on the number of stories, stylobates are classified into three enlarged groups: low-rise (no more than two floors), mid-rise (3–5 floors), and multistory (six or more floors). Although mid-story stylobates are the most common type, multistory stylobates are undergoing increasing development. This fact can be illustrated in the D-Cube City complex established in 2011 (South Korea, Seoul), where the stylobate has a complex volumetric and spatial structure and several stories of 6–14 floors (Fig. 1). In the multifunctional high-rise complex Hyatt Regency Bocagrande (Colombia, Cartagena, 2017), the stylobate represents a 12-story space. Residential towers in the Arte S Residential Towers Complex (Malaysia, Penang, 2018) are founded on a six-story stylobate.

**Functional composition.** The criterion of functional composition should be discussed in more detail, particularly because it is a characteristic of the vast majority of the stylobates under study. In different proportional terms, their structures include functions, which are normally associated with the service sector, such as trade, culture, entertainment and recreation, catering, education, healthcare (medical services), utility services, storage of vehicles, passenger transport and communications, recreational services, and sports and leisure. It is proposed to use the term functional block when referring to a particular function. The term functional block refers to a group of premises that ensures the implementation of a certain process. To assess the functional composition of stylobates, three degrees of functionality are proposed: low, medium, and high.


Fig. 1. Multifunctional high-rise complex D-Cube City, Seoul, South Korea

Stylobates, whose main volume is occupied by only one functional block (75% or more of the total stylobate volume), are characterized by a low degree of functionality. The stylobates of many residential skyscrapers in Dubai are organized in this way, particularly in the skyscraper Cayan Tower, which has a six-story stylobate with a parking lot on its five floors. The sixth floor is the club floor for its residents, which includes a conference room, gym, health club with spa and massage services, and swimming pool on the terrace.

The average degree of functional saturation is determined by the presence of 2–4 functional blocks, which are comparable in terms of the space occupied by the stylobate. The multifunctional complex in Dubai's Marina Gate is one example. The base of the three towers comprises an eight-story stylobate, which includes the main functional blocks, such as a shopping center, sports center (two-level gym with a steam room and sauna, squash and tennis courts, and full-size basketball court), residential villas, and parking.

Stylobates implement five or more functions, which are represented by rather autonomous functional blocks, and correspond to a high degree of functionality. A similar solution is implemented in the super-skyscraper Lotte World Tower with a 12-story podium stylobate. The main functional blocks include two large shopping centers (Avenuel and Shopping Mall), underground parking, catering area with several restaurants and food courts, aquarium (Aquarium), cinema center (Lotte Cinema), concert hall (Concert Hall), and museum (Lotte Museum of Art).

**Accessibility.** The accessibility of functional blocks is an extremely important criterion for identifying the typological aspects of stylobates. Accessibility refers to the quality of a stylobate to be visited or entered by people who are not employees or residents of the high-rise building or complex. Based on the degree of accessibility, all identified functional blocks can either be an open type (fully accessible and suggests active interaction with the outside world) or closed type (available only to employees or residents of the high-rise building or complex). Thus, in the stylobate of the aforementioned Marina Gate complex, only the shopping center is an open-type functional block. Alternatively, in Lotte World Tower, almost the entire stylobate is open and accessible to everyone. However, among the open-type functional blocks, zones with controlled access should be distinguished, implying that they are accessible to everyone but for a certain fee (e.g., theaters, cinemas, and museums).

**Transit.** This criterion is extremely important when integrating high-rise buildings and complexes into the urban environment. In the modern world, transit-oriented development (TOD) is increasingly perceived as an integral part of urban planning policy [12, 13]. It is an urban planning model that focuses on creating a highly urbanized environment with high-density multifunctional development, active pedestrian flow, safe public spaces for social interaction, and immediate access to public transport. Recently, several studies have focused on transit-oriented designs, and special attention has been paid to the TOD standard developed by the Institute for Transportation and Development Policy (USA) [14]. The document is based on eight principles: 1) pedestrian traffic (WALK): the planning aspects of urban development should facilitate intensive pedestrian traffic; 2) cycling (CYCLE): the street design should provide safety for cyclists by decreasing speed limits on roadways or creating separate cycle lanes; 3) connectivity (CONNECT): short and direct walking and cycling routes require a network of interconnected roads and streets around small permeable sections; 4) transit (TRANSIT): effective public transport should be ensured to connect remote areas of the city, including vehicles of small and large capacity; 5) mixing (MIX): it represents a balanced combination of complementary service functions and different types of activities in each urban area (e.g., a mix of residences, workplaces, and local retails); 6) concentration (DENSIFY): to channel urban growth into more compact structures, urban areas must grow vertically (densification) rather than horizontally (sprawl); 7) compactness (COMPACT): the principle of dense urban development should operate in each urban area, in which various activities and service functions are conveniently located close to one another (e.g., quick movement from home to work); 8) change of priorities (SHIFT): priorities should shift when cities are based on the aforementioned seven principles, and private cars become almost unnecessary in everyday life.

Therefore, the stylobates of high-rise buildings should be considered an important component of the TOD of urban environments. The typology of high-rise buildings across the world is developing in this direction. Particularly, under different climatic conditions, there is a search for other methods and approaches for creating optimal conditions for effective transit in urban environments. Currently, we can identify interesting examples of transit-oriented stylobates of high-rise complexes in different climatic zones.

The Seogyo Xi West Valley complex was built in Seoul in 2012 (humid continental climate). In terms of its dimensions and variety of functions, it is comparable to an entire block. Further, it consists of three high-rise towers (two residential

towers and one office tower). Instead of a single stylobate, which is traditional for such complexes, a city-wide space has been created here. Numerous arcades, glazed bridges, and green areas on the roof can be used by everyone when visiting cafes and shops or to achieve the shortest route from the metro station to the city. The composition center is an open circular square surrounded by multilevel pedestrian galleries. The visual attractiveness is enhanced by the presence of a landscape zone, represented by a park with an abundance of greenery, exhibition of sculptures by local students, and multipurpose hall for public events in the open air (Fig. 2, a).

The stylobate part of the Greatwall Complex established in 2015 (Wuhan, China, humid subtropical climate) also has a complex structure characterized by enormous pedestrian ramps for a smooth ascent to the upper levels of the platform. The stylobate is maximally integrated into the street landscape, and it is combined with a network of pedestrian paths. Because of pedestrian ramps, outdoor terraces, roof gardens, and various functions in the stylobate of the complex, the pedestrian zone of the street expands across four levels (Fig. 2, b).

Abu Dhabi Global Market Square, also named Sowwah Square, built in 2010 (Abu Dhabi, UAE, hot desert climate), entirely demonstrates the principles of sustainable and transit-oriented design. Four high-rise office towers are based on an unusual stylobate, where the roof is interpreted as a landscape area open to everyone. The roof contains greenery and amenities. This public space unites all the towers, and two levels below it were developed into an alternative promenade

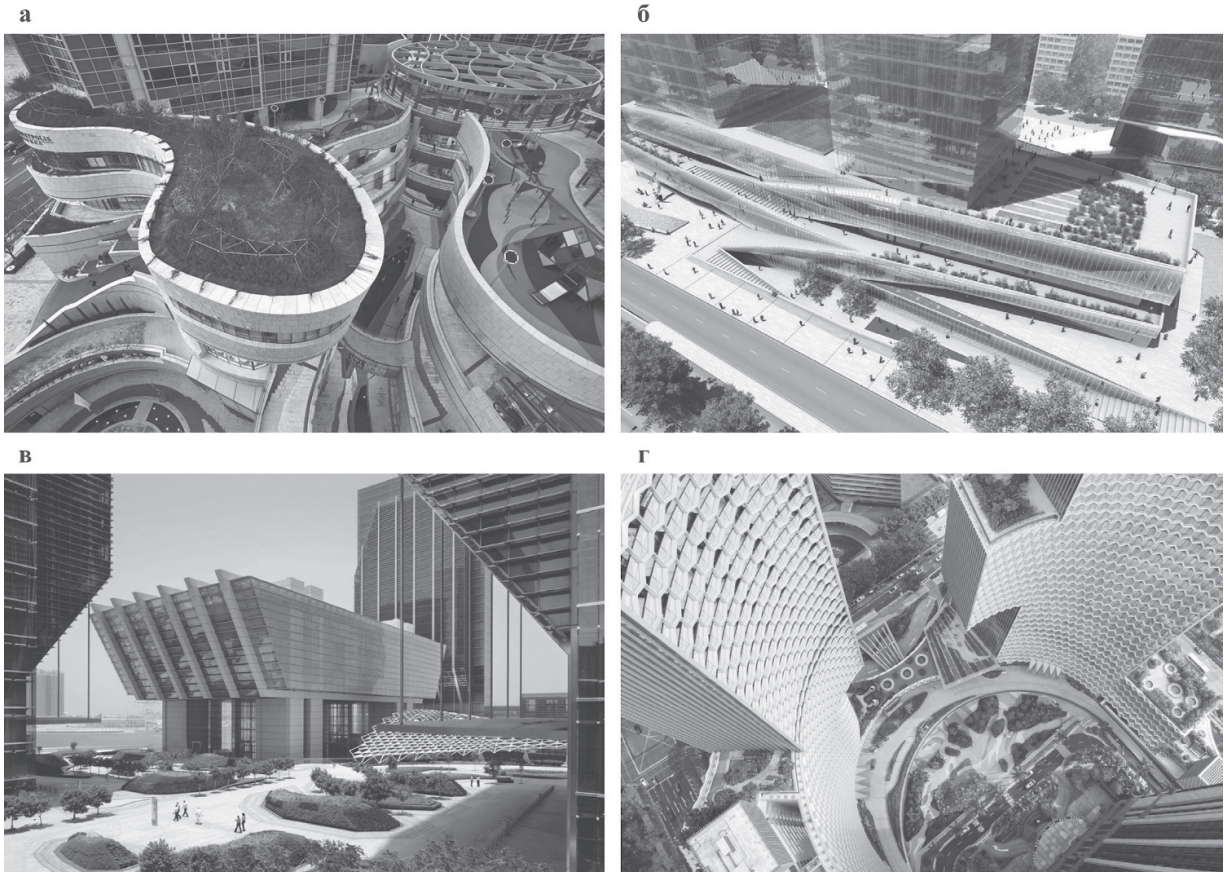


Fig. 2. Transit-oriented stylobates of high-rise complexes:
a—Seogyo Xi West Valley Complex (Seoul, South Korea); b—Greatwall (Wuhan, China) ©10DESIGN;
c—Abu Dhabi Global Market Square (Abu Dhabi, UAE); d—DUO Tower (Singapore)

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on the embankment. Above the stylobate roof, on 27-m-high pillars, the building of the Abu Dhabi Securities Exchange is located, at the foot of which there is an artificial lake with a diameter of 49 m on the same level as the embankment. The stylobate structure includes a two-story shopping center with an atrium and exit to the embankment and a parking area for 4,800 cars (Fig. 2, c).

DUO Towers are a modern, multifunctional high-rise complex built in 2018 (Singapore, equatorial climate), which has a space-planning solution carefully elaborated to compact and connect separate parts of the city. The complex includes two towers embracing the enormous urban public space in a semicircle, permeable in different directions and levels. The complex stylobate integrates in the urban environment and is designed as a multilevel terrace structure with an abundance of green spaces, pedestrian paths, cafes, restaurants, and more, thereby rendering it a large center for social interactions (Fig. 2, d)

**Connection to transport infrastructure.** This criterion is closely related to the aforementioned transit criterion, corresponding to principle 4 of the TOD standard (i.e., TRANSIT). For superdense urban environments, providing conditions for effective integration into the urban environment of public transport is an extremely relevant field of scientific and project research. Based on the results of identifying already established methods for connecting the stylobates of high-rise buildings and complexes to the transport infrastructure, the most common solution is using the underground levels of communication, including metro and railway stations (such as Abeno Harukas, Osaka, Japan, 2014). For instance, Hong Kong laid an extremely common solution that involves establishing bus and taxi stations in the ground floor structure. Additionally, quite unique solutions for integration into the stylobates of city highways have been developed. A good example is the multifunctional tower complex Toranomon Hills (Tokyo, Japan, 2014), which has a stylobate that has a direct connection to the new metro station and includes a tunnel structure for a transit expressway. The design solution of the stylobate part saves valuable land resources as well as creates an additional urban area for social communication on the stylobate roof. A vast recreation area, Oval Square, has also been created here, in which various sporting, fitness, and other events are held on the lawn.

As noted above, the TOD of the stylobate of high-rise buildings and complexes is an extremely important condition for their effective integration into the urban environment. The ability to traverse

Fig. 3. Multifunctional high-rise complex Toranomon Hills, Tokyo, Japan

the stylobate space is important to maintain a pedestrian environment in the city. In this study, the main space-planning elements necessary to ensure pedestrian transit through the stylobate, including gallery, atrium, arcading, courtyard, bridge, and accessible roof area, were identified.

Generally, a gallery is an unheated, open, or glazed horizontal communication premise. Galleries can be located along one or several sides of the stylobate. It can also be located only at the ground level or have a story-by-story extension.

An atrium is a vertically developed, void-shaped part of a building (three or more floors) adjacent to the floor parts of the building (e.g., galleries and enclosing structures of premises). Typically, it has overhead lighting. In relation to its perimeter, the atrium location in the building structure can be different. This characteristic will directly affect the ability of the atrium to function as an independent transit space or require interactions with other elements.

An arcading is an atrium extended horizontally in the form of a multilumen gallery, with a length exceeding the height of the building, thus rendering it an absolutely independent mean of pedestrian transit.

A courtyard is an unheated space enclosed around the perimeter facing the outer walls of the building (or buildings). It has an entrance or arcade and can also be covered to protect from precipitation. The use of a courtyard to ensure transit is possible only in combination with other elements (e.g., galleries and arcades).

A pedestrian bridge is an artificial bridge structure designed for pedestrians to travel around natural or artificial obstacles. A pedestrian bridge connects individual parts of the stylobate or neighboring buildings and represents a part of the pedestrian system organized inside the stylobate section of a high-rise building or complex and the pedestrian system of the city as a whole, with different levels with car traffic.

An accessible roof area is a flat roof with a special coating arranged over a building or its parts, with exits from the building premises. The accessible roof area of the stylobate is an excellent alternative to the land-based, amenity-rich public urban spaces in the multilevel transport and pedestrian structure of the city. Contemporary technologies enable the integration of any type of amenity planting and paving in the accessible roof area structure.

Underground passages. The use of platform underground levels is an effective means of integrating a high-rise building into the urban environment, thereby ensuring the interconnection of the facility with other buildings and with the elements of transport infrastructure.

Although all of the listed elements are not new and are widely used in various types of buildings, the aspects of their incorporation into the stylobates of high-rise buildings, including the specifics of interaction with the high-rise section, require further study and systematization. The choice of the element to ensure pedestrian transit, as well as a combination of elements, will depend on many factors based on the characteristics of the object location in the city. This has a direct impact on the number of stories, functional composition, and the degree of accessibility of the stylobate.

**Conclusions**

Unfortunately, there is a present disbelief in Russia concerning the ability of high-rise buildings to serve as a tool for improving urban environments. Such an erroneous opinion is the consequence of a lack of design and construction of innovative high-rise buildings in Russian practices. Moreover, the world is actively developing new types of high-rise buildings that meet the challenges of present times, refuting practice ideas regarding the inhumanity of high-rise buildings and their destructive effect on the living environment of the city. An important tool for the optimal introduction of high-rise buildings into the city space is the stylobate platform, which represents the base of a high-rise building or complex. A stylobate is a powerful link in the urban space, which is achieved by various functional planning and volumetric spatial methods. An analysis of examples for modern high-rise buildings enables stylobates to be concentrated on various functions and serve as a center of attraction as well as an accelerator for social life development. When designing stylobates for high-rise buildings and complexes, considerable effort is undertaken to create a sense of human scale and connection with the environment. Accordingly, the structure of the podium part becomes more complicated, which is achieved through the use of smaller compositional segmentation, variable number of stories, and introduction of vertical and end-to-end pedestrian connections. Landscaping is actively used, and the shape of stylobates is often so complex that it becomes a landscape element itself. Furthermore, the widespread use of roof lanterns and atriums, in combination with various technological solutions, can enable energy efficiency. The architectural planning and functional aspects of the stylobates, particularly of modern high-rise buildings and complexes, comprise advanced trends in architecture and urban planning. They are based on the conflict-free and harmonious integration of skyscrapers into the city structure. In other words, the stylobate of a high-rise building is a necessary element connecting the vertical building with the urban environment, thus qualitatively improve the environment.

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