Connecting a Skyscraper to Urban Space: a Stylobates Typology for Tall Buildings

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Abstract. 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 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.

1. Introduction
Due to changes in the living conditions of citizens, new requirements for the urban environment are emerging. A number of scientific studies show that a high quality city environment cannot exist without the development of a diverse functional program [1-12]. Thus, the interest in multi-functional buildings, including multi-functional high-rise buildings and complexes is growing from year to year. The concept of vertical urbanism is becoming more and more developed in the world.

Vertical urbanism is a new look at the forms and functions of urban spaces, which is based on multiple functionality and reinterpretation of the typology of high-rise buildings and complexes. A modern high-rise building should be perceived as a continuation of the city with all its functions, oriented vertically. To implement this idea it is not enough just to include several functions into the structure of a skyscraper. It is very important that a mixed-use high-rise building does not become an impregnable fortress, where housing is only for residents, offices are only for office workers and hotels are for their guests. There is an acute issue on ways, methods and techniques for integrating high-rise buildings into the urban environment for its humanization and improvement of quality characteristics. A systematic analysis of the criteria that determine the degree of effectiveness of the interaction of a high-rise building with the existing urban development is being carried out. An important role in linking a high-rise building to the city space is assigned to its stylobate structure. A stylobate is a built – in part of a high-rise building or complex located in its basement (including the underground part). The analysis showed that the vast majority of skyscrapers have stylobates. However, the question remains unanswered: what makes a stylobate be an efficient link of a vertical building with the urban environment?
2. Methods
Systematic approach to studying the structure of stylobates of high-rise buildings and complexes is fundamental to this research making it possible to identify techniques and methods for integrating vertical development into the urban environment in order to improve its quality indicators. The analysis is based on the Council on Tall Buildings and Urban Habitat (CTBUH) database – «The Skyscraper Center» [13]. High-rise buildings and complexes built over the past 10 years in the period 2011-2020 are considered. 680 objects are in the analyzed group. These are 200+ m high-rise buildings and high-rise complexes consisting of two or more buildings. At least one of the buildings should be higher than 200 m (200+ m). Almost half of the objects in the analyzed group (296 complexes) belong to high-rise complexes. According to the number of towers, all the considered objects were divided into three groups: single-tower (384 objects, 56.5 %); two-tower (170 objects, 25 %) and multi-tower complexes (126 objects, 18.5 %).

3. Results
Within the framework of the research advanced foreign and domestic experience in the design and construction of high-rise buildings and complexes that have a stylobate platform in their structure was studied. A comprehensive analysis has revealed the criteria that determine the typological diversity of stylobates: 1 – number of storeys; 2 – functional structure; 3 – accessibility; 4 – transit; 5 – connection to transport infrastructure.

Number of storeys. It should be noted that in the studied group of objects this criterion varies in an extremely wide range. Therefore, according to the number of storeys, it is proposed to classify stylobates into three enlarged groups: low-rise (no more than 2 storeys); medium-rise (from 3 to 5 storeys); multi-storey (6 or more storeys). Despite the fact that medium-rise stylobates are the most common type, multi-storey stylobates are getting more and more active development. As an example the complex D-Cube City (South Korea, Seoul, 2011) can be given. The stylobate in this complex has a complex spatial structure and a variable number of storeys (from 6 to 14). In the multifunctional high-rise complex Hyatt Regency Bocagrande (Colombia, Cartagena, 2017, the stylobate is a 12-storey volume. Residential towers in Arte S Residential Towers Complex (Malaysia, Penang, 2018) are located on a 6-storey stylobate.

Functional structure. For more details this research would like to focus on the criteria «functional structure», since it is the versatility that is characteristic of the vast majority of the considered stylobates. In different proportion their structure includes the following functions usually related to the service sector – trade; culture; entertainment and recreation; public catering; education; health (medical care); consumer services; vehicle garaging; passenger transport and communication services; recreational services; sports leisure, etc. Speaking about the availability of a particular function, it is proposed to use the term «functional block» that is a group of premises proving the operation of some service. To assess the functional structure of stylobates, it is proposed to use three degrees of functional saturation – low, medium and high.

Stylobates where only one functional block occupies 75% or more of the total architectural volume of a stylobate are characterized by low functional saturation. This is how the stylobates of many residential skyscrapers in Dubai are organized. An example is Cayan Tower skyscraper, which has a 6-storey stylobate (6-level basement). Five storeys of this stylobate are occupied by a parking lot. The sixth storey is a «club floor» for residents where conference rooms, gym, health club with a spa and massage room, as well as an infinity-edge pool are located.

Medium degree of functional saturation is determined by the presence of two to four functional blocks compared by occupied architectural volume of the stylobate. As an example, the multifunctional complex Marina Gate in Dubai Marina can be given. There is an 8-storey stylobate at the base of the three towers consisting of the following main functional blocks – a shopping center, a sports center (a two-level gym with a steam room and sauna, squash and tennis courts, a full-size basketball court), residential villas and a parking lot.
Stylobates realizing five or more functions represented by fairly autonomous functional blocks are stylobates of high degree of functional saturation. This idea was realized in the super high-rise building Lotte World Tower with a 12-storey stylobate Podium. The main functional blocks are presented by two large shopping centers (Avenuel and Shopping Mall); an underground parking; a catering area including several restaurants and food courts; Aquarium; Lotte Cinema; Concert Hall; Lotte Museum of Art, etc.

Accessibility. The «accessibility» of functional blocks is considered to be an extremely important criterion for identifying the typological features of stylobates. Accessibility refers to the possibility of a stylobate to be visited by people who are not employees or residents of a high-rise building or complex. According to the degree of accessibility, all identified functional blocks can be either open-type (fully accessible and involving active interaction with the surrounding world) or closed-type (accessible only to employees or residents of a high-rise building or complex). Thus, only the shopping center is an open-type functional block in the stylobate of Marina Gate complex considered above. While almost the whole stylobate is open and accessible to everyone in Lotte World Tower. However, it should be noted that among the open type functional blocks the zones with controlled access should be distinguished. These zones are open to everyone, but for a fee (theaters, cinemas, museums, etc.).

Transit. This criterion is extremely important when integrating high-rise buildings and complexes into the urban environment. It should be noted that transit-oriented development (TOD) in the modern world is increasingly considered as an integral part of the urban planning policy [14]. This is a model of urban planning that focuses on creating a highly urbanized environment with high-density multi-use development, busy pedestrian traffic, safe public spaces for social interaction and easy access to public transport. In recent years, a large number of studies have appeared on the topic of transit-oriented design. Special attention should be paid to the TOD Standard developed by The Institute for Transportation & Development Policy (ITDP, USA). The document is based on 8 principles [15]: 1–WALK. Planning features of urban development should facilitate intensive pedestrian traffic. 2–CYCLE. Street design ensures safety for cyclists by reducing carriageway speeds or creating separate cycle tracks. 3–CONNECT. Short and direct pedestrian and cycling routes require highly connected network of paths and streets around small, permeable blocks. 4–TRANSIT. Efficient public transport for linking remote city districts that includes small and large capacity vehicles. 5–MIX. A balanced mix of complementary uses and activities within a local area (e.g., a mix of residences, workplaces and local retail commerce). 6–DENSIFY. To absorb urban growth in compact and dense forms, urban areas must grow vertically (densification) instead of horizontally (sprawl). 7–COMPACT. The principle of dense urban development, in which the various activities and uses are conveniently located close together (fast transit from home to work, etc.), should operate in every city district. 8–SHIFT. When cities are shaped by the above seven principles, personal motor vehicles become largely unnecessary in day-to-day life.

From the mentioned above, it is obvious that high-rise building stylobates should be considered as important components of transit-oriented urban development. The typology of high-rise buildings has started developing this way. It is important to note that in different climates special methods and ways of creating optimal conditions for efficient transit in the urban environment are being searched for. Nowadays interesting examples of transit-oriented stylobates of high-rise complexes in different climatic zones can be given.

Seogyo Xi West Valley Complex was built in Seoul in 2012 (humid continental climate). In terms of its size and variety of functions, it can be compared to the whole city block. It includes three high-rise towers (two residential towers and one office tower). Instead of a single stylobate that is traditional for such complexes, a complex urban public space has been created here. Numerous crossings, glazed bridges and green areas on the roofs can be used by everyone to visit cafes and shops or to get the shortest way from the metro station to the city. The center of the composition is an open circular square surrounded by multi-level pedestrian galleries. People are attracted by the park landscape area with much greenery and the exhibition of sculptures created by local students, as well as a multi-purpose hall for open-air events (figure 4.1).
The stylobate part of Greatwall Complex (2015, Wuhan, China, humid subtropical climate) also has a complex structure. Grand pedestrian ramps for a smooth ascent to the upper levels of the platform are the special feature of this stylobate. The stylobate is integrated as much as possible into the streetscape and is connected to a network of pedestrian paths. Thanks to pedestrian ramps, open terraces, roof gardens and a variety of functions in the stylobate of the complex, it can be said that the pedestrian zone of the street is developed on four levels (figure 4.2).

Abu Dhabi Global Market Square Complex, the other name is Sowwah Square Complex (2012, Abu Dhabi, UAE, hot desert climate) demonstrates the principles of sustainable and transit-oriented design. Four high-rise office towers rest on an unusual stylobate. The roof of the stylobate is interpreted as an open landscape area with greenery and landscaping elements. This public space combines all the towers, and two levels below it gets an alternative development in the form of a promenade on the embankment. The Abu Dhabi Securities Exchange is located on pillars of 27m high above the stylobate’s roof. A manmade lake of 49m in diameter is located at the foot of the building at the embankment level. The structure of the stylobate includes a two-story shopping center with an atrium and access to the embankment and the parking for 4,800 cars (figure 4.3).

DUO Towers is a modern multi-functional high-rise complex (2018, Singapore, tropical rainforest climate). The spatial planning of the building is carefully thought out to populate and link the disparate parts of the city. The complex includes two towers that encompass a semicircle of grand urban public space that is permeable in different directions and levels. The stylobate of the complex dissolves into the urban environment and is designed as a multi-level terraced structure with a lot of green spaces,
pedestrian paths, cafes, restaurants, etc. All the above mentioned makes it a center of social interaction (figure 4.4).

**Connecting to the transport infrastructure.** This criterion is closely related to the «transit» criterion discussed above, namely, the fourth principle of the TOD Standard – TRANSIT. Providing effective integration of public transport into the urban environment under the conditions of high-density urban area is an extremely relevant field for scientific and project research. Having identified the developed techniques for connecting stylobates of high-rise buildings and complexes to the transport infrastructure, it can be pointed out that the most common solution is the connection of underground levels with metro stations and even railway stations (for example, Abeno Harukas, Osaka, Japan). For example in Hong Kong an extremely common solution is to include bus and taxi stations in the ground floor structure. In addition, there are quite unique solutions for integrating urban highways into stylobates. A good example is the multifunctional tower Toranomon Hills (2014, Tokyo, Japan). The stylobate of the tower has not only a direct connection to the new metro station, but includes a tunnel structure for the transit expressway as well. The design solution of the stylobate part not only saves valuable land resources, but also creates an additional urban area for social communication on the roof of the stylobate. An extensive recreation area Oval Square is created here. Various sports, health and other events are held on the lawn.

4. Discussion
As noted above, transit-oriented development of the stylobate part of high-rise buildings and complexes is an extremely important condition for their effective integration into the urban environment. The ability to cross the stylobate space is important for maintaining a pedestrian environment in the city. This study identifies the main space-planning elements necessary to ensure pedestrian transit through the stylobate: gallery; atrium; passage; courtyard; bridge; operating roof.

A gallery is usually an unheated open or glazed horizontal communication room. Galleries can be located along one or more sides of the stylobate and can only be located at ground level or have a floor-level development.

An atrium is a multi-light space (three or more storeys) part of a building developed vertically. It is adjacent to the floor parts of the building (galleries, enclosing structures of premises, etc.) and usually has upper lighting. It is known that the location of the atrium in the building structure in relation to its perimeter can be different. This will directly affect the ability of the atrium to act as an independent transit space or need to interact with other elements.

A passage is an atrium developed horizontally in the form of a multi-light passage (when the length is greater than the height) that makes it an absolutely independent means of pedestrian transit.

A courtyard is a closed, unheated space. The exterior walls of a building (or buildings) overlooking the courtyard have an entrance or passage and may also have a covering to protect from rainfall. The use of the courtyard for transit is only possible in conjunction with other elements (gallery, passage, etc.).

A pedestrian bridge is an manmade bridge structure designed for pedestrians to move over natural or artificial obstacles. A pedestrian bridge connects different parts of a stylobate or neighboring buildings. It is part of a pedestrian system organized within the stylobate part of a high-rise building or complex, as well as the pedestrian system of the city as a whole, organized at different levels with automobile traffic.

An operating roof is a flat roof with a special coating, arranged over the building or its parts, which have exits from the premises of the building. An operating stylobate roof is an excellent alternative to ground-level public urban spaces in the multi-level transport and pedestrian structure of the city. Modern technologies allow to integrate any type of landscaping and paving into the structure of the roof being used.

**Underground crossings.** The use of underground platform levels is an effective means of integrating a high-rise building into the urban environment, ensuring that the object is interconnected with other buildings, as well as with elements of transport infrastructure.
Despite the fact that all these elements are not new and are widely used in various types of buildings, the features of their implementation in the stylobates of high-rise objects, including the specifics of interaction with the high-rise part, need further study and systematization. The choice of one or another element for pedestrian transit, as well as their combination, will depend on many factors due to the characteristics of the location of the object in the city, that directly affects the number of floors, functional composition and accessibility of the stylobate.

5. Conclusions

Unfortunately, currently in Russia the attitude to the ability of high-rise buildings to serve as a tool to improve the urban environment is sceptical. Such an erroneous opinion is the result of a lack of domestic practice in the design and construction of innovative high-rise buildings. Meanwhile, new types of high-rise buildings have been actively developed in the world. They meet the challenges of modernity and refuse in practice the talk about their inhumanity and destructive effect on the residential city environment. An important tool for optimal implementation of high-rise buildings in the city environment is a stylobate platform, that is the basement of a high-rise building or complex. The stylobate serves as a powerful link in urban space that can be achieved by various functional planning and spatial methods. Having analyzed the examples of modern high-rise buildings it may be concluded that a stylobate concentrates a variety of functions and can serve as a center of attraction and a catalyst for the social life development. When designing stylobates of high-rise buildings and complexes, much is done to create a sense of scale to the person and connection with the environment. For this purpose, the structure of the podium part becomes more complex, which is achieved through the use of smaller compositional divisions, variable storeys, and the introduction of vertical and through pedestrian connections. Landscaping is actively used, and the shape of a stylobate is often so complex that it becomes a landscape element itself. In addition, the extensive use of light lamps and atriums in combination with various technological solutions allows speaking about their energy efficiency. Advanced trends in architecture and urban planning are traced in the architectural planning and functional features of stylobates in modern high-rise buildings and complexes. They are based on conflict-free and harmonious integration into the city structure. In other words, a stylobate of a high-rise building is a necessary element that connects vertical construction with the urban environment and can improve its quality.

6. References

[1] Wood A 2014 Rethinking the Skyscraper in the Ecological Age: Design Principles for a New High-Rise Vernacular Proceedings of the CTBUH 2014 Shanghai Conference «Future Cities: Towards Sustainable Vertical Urbanism» pp 26-38
[2] Safarik D, Ursini Sh and Wood A 2018 The Tall, Polycentric City: Dubai and the Future of Vertical Urbanism CTBUH Journal Issue IV pp 20-29
[3] Generalov V P, Generalova E M 2016 Revealing the special features of the concepts «comfortable living» and «comfortable living environment» Urban Construction and Architecture 2(23) pp 85-90
[4] Generalova E M, Generalov V P, Kuznetsova A A, Bobkova O N 2018 Mixed-Use Development in a High-Rise Context E3S Web of Conferences 33 01021 https://doi.org/10.1051/e3sconf/20183301021
[5] Generalov V P, Generalova E M, Kalinkina N A, Zhdanova I V 2018 Typological Diversity of Tall Buildings and Complexes in Relation to their Functional Structure E3S Web of Conferences 33 01020 https://doi.org/10.1051/e3sconf/20183301020
[6] Vavilova T Y, Potienko N D, Zhdanova I V 2016 On Modernization of Capital Construction Projects in the Context of Sustainable Development of Social Sphere Procedia Engineering 153 pp 938-943
[7] Generalova E M, Generalov V P 2018 Residential high-rises in Dubai: typologies, tendencies and development prospects CTBUH Journal Issue IV pp 36-42
[8] Gabel J 2018 Tall trends: quantifying the skyscraper phenomenon E3S Web of Conferences 33 01012 https://doi.org/10.1051/e3sconf/20183301012

[9] Volchkov Y 2018 The Notion of «High» and commitment to excellence in contemporary Russian architecture History and project: looking into future E3S Web of Conferences 33 01015 https://doi.org/10.1051/e3sconf/20183301015

[10] Matovnikov S, Matovnikova N, Samoylenko P 2018 The problems of designing a multifunctional courtyard space of high-rise buildings by the example of residential development in Volgograd E3S Web of Conferences 33 01006 https://doi.org/10.1051/e3sconf/20183301006

[11] Generalova E M 2019 Typological Features of Supertall Residential Buildings in Dubai Privolzhsky Scientific Journal 1 pp 159-164

[12] Ye Y, Wang Zh, Dong N, Zhou X 2020 Lower Public Spaces: Impact on Health and Behavior CTBUH Journal Issue I pp 26-33

[13] 20 May 2019 CTBUH Skyscraper Center http://www.skyscrapercenter.com/building/m101-skywheel/23273

[14] Thomas R, Pojani D, Lenferink S, Bertolini L, Stead D, van der Krabben E 2018 Is transit-oriented development (TOD) an internationally transferable policy concept? Regional Studies 52:9 pp 1201-1213 https://doi.org/10.1080/00343404.2018.1428740

[15] TOD Standard 2017 https://itdpdotorg.wpengine.com/wp-content/uploads/2017/06/TOD_printable.pdf