Mixed-Use High-Rise Buildings: a Typology of the Future

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Abstract. The paper considers the objective problems of the development of modern cities related to the negative trend of their territorial expansion. The necessity of searching for modern methods of developing a multifunctional, compact and comfortable urban environment is pointed out. It is noted that the inclusion of mixed-use tall buildings in the urban structure allows using land resources efficiently and improves the quality characteristics of the living environment significantly. The authors analyze the global experience in designing mixed-use tall buildings with identifying the peculiarities of their functional structure.

1. Introduction

The analysis of urban development in recent decades shows a movement towards an increasingly urbanized world. This fact is comprehensively considered in various studies, including UN Habitat reports, which emphasize that the existing model of urbanization is unsustainable in many respects [1]. The trend towards unjustified urban sprawl both in developing and developed countries is a matter of serious concern. For example, data shows that urban sprawl in the US alone will cost $ 400 billion a year due to higher costs for infrastructure, public services and transport. The results of studies in small and medium-sized Latin American cities show that the utility costs naturally increase along with the decrease of built-up density. It is also predicted that in developing countries the annual 1% decrease in the average density will lead to four times’ increase of the urban land by 2050 compared with the level of 2000. It will result in the loss of agricultural land and wildlife habitats, higher time and travel costs, greater greenhouse gas emissions, aggravation of socio-spatial segregation, etc. It is emphasized that inefficient territorial expansion is observed both in cities with growing and decreasing population.

The given facts show that the model of urbanization must change in order to respond to the challenges of our time better and solve the problems of unsustainable urban planning. There is a need for new innovative tools and approaches to the development of the urban environment. This is emphasized in «New Urban Agenda» UN Habitat. The document was adopted at the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) in Quito, Ecuador, on 20 October 2016. It was endorsed by the United Nations General Assembly at its sixty-eighth plenary meeting of the seventh-first session on 23 December 2016. We would like to focus on the appeal of UN Habitat: «We encourage spatial development strategies that take into account, as appropriate, the need to guide urban extension, prioritizing urban renewal by planning for the provision of accessible and well-connected infrastructure and services, sustainable population densities and compact design and integration of new neighborhoods into the urban fabric, preventing urban sprawl and marginalization» [2].
The basis of modern high-quality urban environment concept is in the principle of mixed use of the territory which has replaced the principle of precise city zoning in residential, industrial, business and recreational areas. It is extremely important to find the best combination of multifunctionality and compactness of city development that are necessary for convenient city living. Best international practice shows that the ideas of «New Urbanism» and «Smart Growth» are realized successfully by using new types of high-rise buildings which are developed as «integrated mini-cities» or «vertical city». They provide not only high density, but also high quality building. An important aspect of making a compact model of urban development is studying the role of multifunctional high-rise buildings in the process of urban densification [3-14].

2. Methods
The analysis of scientific literature is made. Modern theoretical concepts of sustainable development of cities and normative legal acts in the field of construction in the Russian Federation are considered. The specific features of domestic and foreign approaches to the classification of multifunctional buildings including high-rise ones are revealed. Examples of effective development of urban areas using high-rise buildings are given. The analysis is based on the CTBUH database, which includes over 4,600 skyscrapers above 150m (150+ m). Systematic approach is fundamental for this research when studying multifunctional high-rise buildings and their function in the development of comfortable highly urbanized environment.

3. Results

3.1. Problems of terminology
The new typology of high-rise buildings is based on the principle of multifunctionality, which is manifested in the ability of a large system to perform a variety of functions. Urban functions are different types of activities in the urban area, such as housing, industry, health care, trade, education, etc. Nowadays almost all of these activities are realized in skyscrapers, which can be both monofunctional and multifunctional. It is extremely important to understand what kind of buildings including high-rise ones can be considered as multifunctional.

In Russia the term functional and planning component is used to determine the functional structure of a building in Code of Practice 160.1325800.2014 «Multifunctional buildings and complexes. Design rules». The term represents «a group of premises that perform a certain function (accommodation, service, leisure, etc.).» If a building has two and more functional and planning components it is considered to be multifunctional. However, such interpretation of multifunctionality used in technical standard documents of the Russian Federation cannot be called correct. If we consider service as a functional and planning component in the structure of a multifunctional high-rise building, then there is a high probability of incorrect or controversial interpretation. For example, in accordance with Code of Practice 118.13330.2012 «Public buildings and structures» retail and wholesale trade enterprises, shopping malls and food facilities (open and closed) refer to service premises. In the absence of specifying criteria for determining the functional and planning component of a multifunctional building and a high-rise building as well, it turns out that any residential building that has a restaurant or a shopping center in its structure can be considered as multifunctional and this is a serious typological mistake.

Analysis of best practices in design and construction show that it is time to rethink and clarify the concept of a multifunctional building, including a mixed-use tall building. For example, The Council on Tall Buildings and Urban Habitat (CTBUH) develops and constantly improves international standards and rules for the classification of high-rise buildings. According to CTBUH «a mixed-use tall building contains two or more functions, where each of the functions encounters a significant proportion (this «significant proportion» can be judged as 15 percent or greater of either: the total floor area, or the total building height, in terms of number of floors occupied for the function) of the tower’s total space. Support areas such as car parks and mechanical plant space do not constitute mixed-use
functions» [15]. In this study it is proposed to take this interpretation of multifunctionality in relation to high-rise objects, as the results are based on the analysis of CTBUH database (the Skyscraper Center).

### 3.2. Past, present and future of mixed-use tall buildings

The history of multi-functional typology in high-rise construction started in the early 20th century. It should be noted that the first steps were very modest. The year of 1924 can be called a starting point – the construction of the Chicago Temple Building (office/religious; 173.1 m). Apart from offices, it fulfills another independent function – a religious one. On the first floor of this building there is the First United Methodist Church of Chicago. On the second floor, there is Dixon Chapel and the church administration. There are rooms for a Sunday school, a Conference Hall and a room for the church choir on the third and fourth floors. Subsequent levels (Floors 5 to 23) hold offices which are rented to various commercial organizations. There is also the so-called «Sky chapel» at a height of 120 meters at the base of the Spire.

Then three more buildings appeared: Civic Opera Building in 1929 (office/other, 169.2 m, Chicago), The Downtown Club (residential/other, 165.3 m, New York) in 1930, and Waldorf Astoria New York (residential/hotel, 190.5 m, New York) in 1931. Then came a thirty-year period (until 1960) when multifunctional high-rise buildings were not built at all. However, over the past 10 years, more than 500 multifunctional skyscrapers have been built, that is almost 65 % of the total number of mixed-use tall buildings (770 buildings) in the world (table 1).

#### Table 1. Statistics of completed mixed-use tall buildings (150 m+).

| year      | tall buildings 150 m+ | mixed-use tall buildings 150 m+ |
|-----------|-----------------------|---------------------------------|
| 1924-1931 | 44                    | 4                               |
| 1932-1960 | 31                    | 0                               |
| 1961-1969 | 62                    | 4                               |
| 1970-1979 | 161                   | 14                              |
| 1980-1989 | 259                   | 16                              |
| 1990-1999 | 467                   | 48                              |
| 2000-2009 | 1302                  | 207                             |
| 2010-2019 | 2367                  | 477                             |

#### Table 2. Construction prospects of mixed-use tall buildings 200 m+ and 300 m+.

|                  | 150 m+ | 200 m+ | 300 m+ |
|------------------|--------|--------|--------|
| Completed (1924-2019) | 770    | 355    | 67     |
| Under Construction | 194    | 120    | 54     |

Another interesting fact, that links the history of high-rise construction and the modern trend towards to multifunctionality, is related to the legendary New York skyscraper Woolworth Building. It is the building that heads the chronological list of mixed-use tall buildings today. However, at the time of commissioning in 1913, it was not. It was a colossal office building of 241.4 m built in Neo-Gothic style that accommodated over 4,000 different companies. During the renovation in 2014-2017 its functional status changed to residential/office – the top 30 floors were changed into luxury apartments. At the top of the building there is a luxurious six-story penthouse «Castle in the Sky».

The given facts prove the growing interest in multi-functional high-rise typology and raise the urgent question: what is the way of multi-functional high-rise construction development? To answer this question, a system analysis of the characteristics of more than 700 completed mixed-use tall buildings has been made. Special attention is paid to the influence of a building's functional structure on its height parameters, as 46 % of mixed-use tall buildings are 355 towers of over 200 m high. Out of them 67 buildings are over 300 m high. It should be noted that today 146 supertall buildings (300 m+) have been built in the world. It turns out that almost half of them (45 %) are mixed-use buildings.
In the future the percentage of 200 m+ and 300 m+ mixed-use skyscrapers is expected to increase (table 2). Among multifunctional buildings that are under construction 200 m+ towers make up 62 % while 300 m+ towers make up 30 %.

Analyzing the database of CTBUH which includes more than 4,600 skyscrapers above 150.0 m (150+ m) we can provide the following statistics and make some conclusions:

- the share of multifunctional high-rise buildings 150+ m in the history of high-rise construction (1885 – 2019) is 16 %;
- there is a growing trend of interest in multifunctionality, as the share of multifunctional skyscrapers in the number of high-rise buildings (150+ m) built over the past 10 years (2010 – 2019) is 20 % already;
- today, it is possible to identify a group of functions that determine the structure of multifunctional high-rise buildings: «residential», «hotel» and «office». It is proposed to call these functions «basic». The function will be considered as «basic» if its share in the total volume of a building is not less than 15 % (based on CTBUH Height Criteria);
- among the «basic» functions in multifunctional skyscrapers the residential function takes the leading place (in about 50 % of buildings), followed by the hotel function (in about 30 % of buildings), and then comes the office function (in about 20 % of buildings);
- most (approximately 86 %) are mixed-use tall buildings that include a different combination of 2 basic functions;
- 110 skyscrapers have more than 2 functions in their structure, this group is only 14 % of the total number of completed mixed-use tall buildings;
- in addition to the «basic» functions, there are «additional» functions (their share in the total volume of a building is less than 15 %) and «service» functions connected to «basic» or «additional» functions (for example, a fitness center at a hotel).

4. Discussion

The «additional» and «service» functions in the structure of high-rise buildings are least studied and are not systematized. At that their importance should not be underestimated, since their composition, logistics of functional ties and innovative space-planning solutions determine the effectiveness of the integration of a high-rise building into the urban environment. The presence of such elements such as retail trade, cultural and entertainment centers, transport hubs, pedestrian and recreational spaces, landscaping, etc. in the structure of a high-rise building turns it into a vertically oriented city extension. This corresponds to the modern concept of building «a compact city» and needs careful study and scientific reasoning.

In this regard we would like to touch upon two important trends that have a serious impact on the future of mixed-use tall buildings.

First, the nomenclature of «additional» functions is developed actively. Their combination is becoming more and more diverse. As an illustration a unique complex skyscraper «Abeno Harukas» (300 m, hotel/office/retail, Osaka, Japan) can be taken. The «additional» functions included in the structure of this skyscraper include: full-fledged «urban art museum», 16th floor and observatory HARUKAS 300 (58-60 floors), a clinic and a school (figure 1). «Lotte World Tower» has a museum of art and a well-developed medical function presented by Healthcare Center and Aesthetic Clinic.

It should be noted that the entertainment function is being actively developed, namely such a spectacular element as an observation deck. In «Abeno Harukas» the observatory HARUKAS 300 occupies three upper floors. The 58th floor is the open-air outdoor plaza in a three-story atrium structure with pleasant sunlight and wind. The 60th floor – the top floor - is a 360° glass-enclosed observation deck that commands a panoramic view of Osaka Plain. Another unique example is a 78-storey complex «M101 Skywheel» which is under construction now (316 m, observation / residential / hotel / SOHO / retail) in Kuala Lumpur (figure 2). 1st & Tallest Sky Ferris Wheel in the world will be installed in the structure of the observation deck on the 52nd floor.
Secondly, there is a tendency to expand the list of «basic» functions. An example is the retail function, which is in most high-rise buildings and complexes. Stylobate part of the object is most often used for retail trade. However, the experience shows that other solutions are possible in ultra-dense built-up area. A worthy example is creating a three-dimensional urban environment with a high level of comfort in Hong Kong. There due to the high land price commercial real estate differs often from the generally accepted Western model of a flat shopping center. Thus, a multifunctional 40-storey building «Hysan Place» (204.1 m, office/retail) includes a vertical shopping center of 42,000 m², located on 17 lower floors (figure 3). Another example is the skyscraper «The One» (figure 4). It is the tallest shopping complex in Hong Kong. It is a 24-storey building (172.1 m) of 37,455 m². In addition to a variety of shops it has a cinema and catering facilities. The objects discussed above confirm this trend as well. In «Abeno Harukas» a shopping center of 167,000 m² occupies about half of the building volume and acts as a functional and planning component, i.e. the «basic» function of a mixed-use tall building. «M101 Skywheel» illustrates an interesting interpretation of a shopping mall. In this complex 1st Luxurious Highest Sky Mall in the world (about 20 000 m²) will be built on the 50th to 52nd level.

5. Conclusions
Summing up it should be noted that under the conditions of increasingly urbanized world multifunctional buildings can take a leading role in solving many global problems of the 21st century.
Mixed use of urban areas is the basis of the concept of «new urbanism», calling for the development of more dense, multifunctional and high-rise construction. Mixed-use high-rise buildings correspond to the concept of three-dimensional development of urban infrastructure when various urban functions tied traditionally to the ground level are actively developed vertically (trade, transport hubs, pedestrian communications, recreational spaces, etc.). Mixed-use high-rise buildings are not single objects, they are an extensive group that requires careful study and system analysis in order to structure and identify the features of the typological structure development. The following factors require such analysis and research: optimal combination of functional components; proportional ratio and height distribution of basic functions; availability and features of additional and service functions; means of integration into the urban environment and a lot more.

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