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HIGH-RISE BUILDINGS COMPLEXES IN EUROPE

Complexes of high-rise buildings significantly affect the city's landscape, especially tall structures. The purpose of the study is to analyze the formation of high-rise building complexes in Europe from the 1960s until the current decade. The survey covered 243 complexes, which include at least one building with a height of no less than 90 meters and at least one with a height of 65 meters or more. The survey shows a clear increase in the number of erected complexes with such heights after 2000. In each of the decades studied, ensembles with two or three towers predominate. Analysis of these ensembles in terms of equal and varied tower heights showed a predominance of ensembles with varied heights in the height ranges above 150 m. The highest height – more than 300 m – was reached by ensembles with towers of varying heights.

Keywords: Europe, high-rise building complexes, development of high-rise buildings, skyscrapers

1. INTRODUCTION

Complexes of high-rise buildings significantly affect the urban landscape, especially tall structures, as even single complexes can change the image of a city, such as the Flame Towers in Baku. Some pairs of high-rise buildings are among the most recognizable vertical signs of the cities in which they were built, such as the WTC in New York and the Petronas Towers in Kuala Lumpur. Complexes of high-rise buildings are characterized by a strong formal connection between the individual elements of the complex, which makes them form a coherent whole [Gibberd 1959; Giedion 1968; Jencks 1980; Firley, Gimbal 2011; Korotich 2011, 2018; Al-Kodmany 2011, 2017, 2020; Al-Kodmany, Ali 2013]. The most momentous example of a high-rise building complex is probably the famous Rockefeller Center, built in the 1930s in New York's Manhattan. This work is considered an innovative solution and the first set of high-rise buildings in the world [Goldberger 1982; Hasan-Uddin 2009].

The development of high-rise buildings around the world has resulted in the scale and form of high-rise complexes today, ranging from spectacular configurations of skyscrapers of immense height to groupings of skyscrapers of moderate height and more buildings.

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In Europe, the cityscape is clearly influenced by both the numerous high-rise complexes that make up residential areas concentrated mainly on the outskirts and around the inner city, as well as moderate-height building complexes in the inner city, and high-rise building complexes located in various areas, including central areas. The complexes built in the city center during the "opening to skyscrapers" period in the first decades of the second half of the 20th century are often still among the tallest buildings in these cities. Examples can be cited of high and moderate height complexes that were built at the time, which significantly changed the landscapes of European cities, such as the complex of three towers in Grenoble, the Barbican in London, the Hötorget complex in Stockholm and the Eastern Side in Warsaw (fig. 1-3). The strength of the impact of some of them has been weakened by the later construction of other high-rise buildings in the same area, but some are still undisputed dominants. Nowadays, there are also spectacular complexes of high-rise buildings of undoubted importance to the urban landscape.

Fig. 1. Barbican in London.
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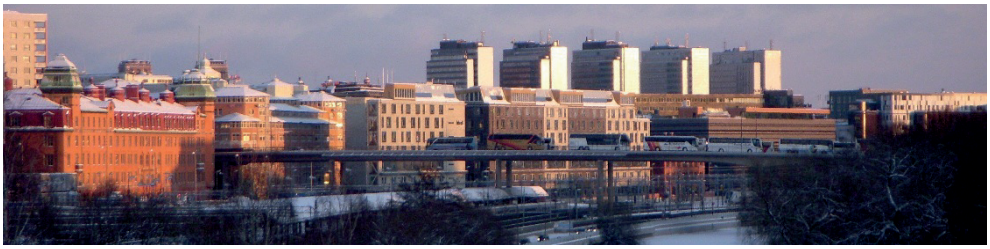

Fig. 2. Hötorget in Stockholm.
Photo Holger Ellgaard (CC BY-SA 3.0) [Wikimedia Commons 2024]

Fig. 3. Eastern Side in Warsaw. A complex of three rhythmically arranged high-rise residential towers with low-rise commercial buildings, built in the 1960s
[photo by the author, 2018]

In addition to distinctive height and architectural consistency, the characteristic features of high-rise complexes are the number of towers and their uniform or varying heights. These features represent not only the architectural character of a given ensemble but can be very much related to its spatial meaning and imageability. Examining high-rise building complexes in terms of the number of elements that

make them up and their heights can also speak to trends in the formation of such complexes. The purpose of the study is to analyze the formation of the construction of high-rise building complexes in Europe for the 1960s to the present.

2. MATERIALS AND METHODS

The analysis included high-rise building complexes in Europe built between 1960 and 2022 and under construction. The entire Istanbul area was included in the study, as well as cities in Russia on the border between Europe and Asia (Chelyabinsk and Yekaterinburg).

The paper uses the definition of a complex according to the Council on Tall Buildings and Urban Habitat (CTBUH): "A complex is a group of buildings which are designed and built as pieces of a greater development" [CTBUH 2022]. The following three criteria for a high-rise building complex were adopted and must be met simultaneously: (1) the ensemble is formed by at least two tall freestanding buildings or composite with each other, such as a common base or *skybridges*[2], (2) the height of at least one building is at least 90 m, (3) the height of the second building or at least one of the other buildings is not less than 65 m. If there were more than two buildings in the ensemble, then for the third, fourth and subsequent buildings, the height of 65 m was not mandatory, as long as the building was vertical or its height was close to this threshold. Possible low buildings that are elements of the ensemble and do not meet the above criteria did not participate in the assignment of the ensemble to a particular type with a certain number of vertical elements. Since tall elements of ensembles that meet the accepted height criteria are not always in the nature of a tower, they were referred to as high-rise buildings or towers, depending on the specific case.

The CTBUH database "The Skyscraper Center" (as of August 2022) was used. In the first stage, buildings with a height of more than 90 meters were searched for in the CTBUH database. It was then analyzed whether the building was part of an ensemble and whether the other buildings in the ensemble met the adopted criteria. The data was supplemented with information from other sources which describe high-rise building complexes in various European cities, such as: G. Binder, 2006 (Europe); J.-F. Pousse, 2009 (Europe); T. Demey, 2008 (Brussels); H. Wright, 2006 (London); A.H. Milh & J.M. Hereng, 1978 (Bagnolet near Paris); W. Sobek, 2007 (Munich); M. Malevskaya, 2014 (Moscow); T. Verlaan & A. Kefford, 2021 (Rotterdam); T. Sarı & Y. Dülgeroğlu Yüksel, 2018 (Istanbul); T.Ya. Vavilova & E.Yu. Makeeva, 2018 (Samara); R. Kowalczyk, J. Skrzypczak & W. Oleński, 2013; J. Zieliński, 2015; A. Nowak & H. Markowski, 2019 (Warsaw).

[2] The definition of *skybridge* adopted by Wood, Du, Safarik [2020: 13]: "a primarily enclosed space linking two (or more) buildings at height".

The CTBUH database stipulates that data for buildings less than 150 meters in height may be incomplete. However, gaps in the data collected for the survey may mainly concern information on complexes with buildings lower than 100 meters. In the case of complexes with taller buildings, on which data is included in various sources and usually coincide, possible data gaps can be estimated as relatively minor.

The number of complexes was analyzed for each decade from the 1960s to the 2020s. Taking into account the long period of construction of some high-rise complexes, a rule was adopted that the assignment of a complex to a particular decade is determined by the last skyscraper of the complex built. Special situations – i.e. ensembles whose construction took several decades (and possibly is still taking place or is planned) – are described in the text, and justification is given for assigning them to a particular decade. The set of buildings identified as "complexes under construction" includes only those developments under construction in which at least one skyscraper has been built or is under construction (the others are under construction or planned).

The subject of the analysis was the number of towers or high-rise buildings in the complexes in each time frame. To this end, the complexes were divided into six types (having two, three, four, five, six, seven or more high elements). In the last part, complexes with two and three high-rise buildings were analyzed. These ensembles were studied in terms of the height of the ensemble and the equal and different heights of the buildings. Classification in a given height range was determined by the tallest buildings in the complex.

3. RESULTS OF THE SURVEY

243 high-rise building complexes meeting the adopted criteria, built in Europe from the 1960s until the present day (the number of buildings included in the complexes was approx. 800) were identified. The numbers of complexes in each decade are shown in table 1. In the past century, between a few and a dozen high-rise complexes were usually built in each decade, and only in the 1970s were more – 25 – erected. The 21st century has seen a marked increase in the number of erected complexes of such heights. In the decade 2000-2009, there were 49, and in the decade 2010-2019, there were as many as 76. A relatively large number of complexes have been built in the ongoing decade – 19, and as many as 51 facilities are under construction.

As mentioned, the construction of some ensembles was stretched over time, sometimes spanning several decades. What's more, the development of some of the ensembles, the construction of which began many years ago, continues. Several ensembles with a particularly long construction period were assigned to the decade in which they reached their main shape or an important part of the ensemble was formed (this assignment is purely conventional and only for the purpose

of this analysis). The history of the WTC in Brussels dates back 60 years [Demey 1992 cited by Martens 2009; Demey 2008]; the first two skyscrapers were built in the 1970s (fig. 4), and in 1983, a third was built, and another is planned [CTBUH 2022] (assigned to the 1980-1989 decade in tab. 1). The beginning of the WTC in Amsterdam (fig. 5) was also in the 1960s, and four not very high-rise buildings were built then [Cuito, KPF 2003]. One of the skyscrapers was built in the 1980s, and two were erected in the first decade of the 21st century (assigned to the decade 2000-2009 in tab. 1). In 1999-2002, a comprehensive project to modernize WTC Amsterdam was started (design KPF) [Cuito, KPF 2003]. The complex will also include a fourth skyscraper, currently nearing completion [CTBUH 2022]. Plans to build the Canary Wharf complex emerged in the 1980s [Krummeck, MacLeod 2015]. Canary Wharf's first two skyscrapers were erected back in the 1990s, but most of the complex's built skyscrapers were not constructed until the next decade (assigned to the 2000-2009 decade in tab. 1). More skyscrapers are under construction or planned. However, the main symmetrical layout of the complex's buildings, with the towering One Canada Square tower, has been in place for a long time.

Tab. 1. Complexes of buildings with high heights in particular time frames

Decade	Number of complexes	Complexes with the tallest buildings and their height
1960-1969	3	Novy Arbat (Kalinin Prospekt), Moscow, four buildings with heights of 100 m and five buildings with a height of 80 m
1970-1979	25	Le Zodiaque, Paris, with a height of 127.8 m, 83 m**
1980-1989	8	Deutsche Bank, Frankfurt am Main, two buildings with heights of 155 m
1990-1999	12	Sabanci Center, Istanbul, with a height of 157.3 m and 140 m
2000-2009	49	Naberezhnaya Towers, Moscow, with a height of 268.4 m, 127 m and 79.8 m
2010-2019	76	Lakhta Center, St. Petersburg, with a height of 462 m and 80 m***
2020-2022*	19	Neva Towers, Moscow, with a height of 345 m and 297 m
Under construction	51	Capital Towers, Moscow, three buildings with heights of 267 m
Total	243	–

* Data for 2022 as of August of that year, ** the height of the two tallest buildings in the ensemble is given, *** the ensemble was created on the basis of a coherent concept assuming the composition of the tower and lower buildings [Nikandrov 2012; Abdelrazaq et al. 2020], construction of the Lakhta Center was completed in 2019, with two towers planned for later (Lakhta Center II, with a height of 703 m, and Lakhta Center III, with a height of 555 m), also supposed to belong to the complex [CTBUH 2024; Wikipedia 2024].

The spectacular development of a mixed-use development complex in La Défense near Paris, initiated back in the 1950s, requires comment. It was planned as a new urban center with a complex of high-rise buildings [Sfintescu 1972; Ostrowski 1975]. The high-rise buildings that make it up were built from the 1960s through the 1970s and subsequent decades, forming a large grouping of such structures that is constantly evolving and transforming [Scicolone 2012; Roberts 2011; Hollister 2013]. The originally planned complex of high-rise buildings of uniform height and distinctive configuration did not emerge in the original vision and turned into a grouping of numerous skyscrapers of various forms and complexes of high-rise buildings. The CTBUH database classifies as high-rise building complexes in the La Défense area complexes that were built in different periods and have different forms.

A number of ensembles in their current form are only fragments of the originally planned ensembles. An example is the aforementioned WTC in Brussels, which was initially planned as consisting of eight skyscrapers [Martens 2009]. An example from Poland is the complex of the Western District in Warsaw, the concept for which was developed in the late 1960s. Of the planned layout of five high-rise buildings (the height of the tallest – more than 160 m), only two were built in the 1970s and 1980s – and with a lower height (140 m) than initially assumed (fig. 7) [Skrzypczak 1973, 2000; Oleński 2008; Kowalczyk, Skrzypczak, Oleński 2013].

Table 1 lists the tallest as well as characteristic complexes that were built in each decade – the height of the buildings belonging to the above complexes shows the change in this parameter over the decades. The aforementioned complexes are also characterized by a variety of features: from a series of skyscrapers flanking an arterial street (Novy Arbat), to compositions of tall skyscrapers, horizontal structures and long multi-story buildings (Le Zodiaque) and symmetrical configurations of twin towers (Deutsche Bank), to compact asymmetrical compositions of two or three towers of different heights (Naberezhnaya Towers, Neva Towers).

Fig. 4. WTC skyscrapers 1 and 2 in Brussels.
Photo EmDee (CC BY-SA 4.0) [Wikimedia Commons 2024]

Fig. 5. WTC in Amsterdam
[photo by the author, 2011]

Fig. 6. Two skyscrapers of the Western District in Warsaw.
On the right, the Palace of Culture and Science is visible
[photo by the author, 2018]

Table 2 shows the distribution of high-rise building complexes by decade according to the criterion of the number of buildings in the complex. There is a clear numerical advantage of two-building complexes. An example from the 1980s is Deutsche Bank's twin towers in Frankfurt am Main (with a height of 155 m) (fig. 7). Dating back to the 1990s are, for example, the Ferrovie dello Stato 1 and 2 skyscrapers erected in Milan (now Torre Garibaldi A and B – fig. 8), Torri ENEL in Naples (fig. 9) and the famous Puerta de Europa twin towers in Madrid.

The second-largest group are complexes with three high-rise buildings. Across all the decades covered by the study, the total number of complexes with two high-rise buildings (119) accounts for nearly half, and those with three buildings or towers (63) account for more than a quarter of all high-rise building complexes analyzed.

Tab. 2. Complexes of high-rise buildings divided by the criterion of the number of high-rise buildings in the complex

Decade	Number of high-rise buildings in the complex					
	two	three	four	five	six	seven and over
1960-1969	1	1	–	–	–	1
1970-1979	9	7	3	1	2	3
1980-1989	5	–	1	1	1	–
1990-1999	12	–	–	–	–	–
2000-2009	29	12	4	2	–	2
2010-2019	34	20	9	7	4	2
2020-2022	13	4	1	–	–	1
Under construction	16	19	5	4	3	4
Total	119	63	23	15	10	13

Fig. 7. Deutsche Bank's twin towers in Frankfurt am Main [photo by the author, 2012]

Fig. 8. Ferrovie dello Stato 1 and 2 in Milan (now Torre Garibaldi A and B), two towers of equal height [photo by the author, 2014]

Fig. 9. Torri ENEL in Naples, two towers of equal height [photo by the author, 2019]

Complexes having two and three high-rise buildings were analyzed in terms of the height of the complex and the uniform or varied height of the buildings (tab. 3-6). The most numerous group contains complexes with a height of 100-149 meters, erected in the 21st century. Of note is the emergence in recent decades of complexes with towers over 200 meters high. The numbers of ensembles with equal and different heights – both two-tower and three-tower assemblies in each height and time interval – are quite similar, but a slightly higher number of ensembles with different heights can be observed.

Tab. 3. Complexes with two high-rise buildings of equal height in each height range

Decade	90-99 m	100-149 m	150-199 m	200-299 m	300 m and above
1960-1969	1	–	–	–	–
1970-1979	3	1	–	–	–
1980-1989	1	2	1	–	–
1990-1999	1	4	–	–	–
2000-2009	1	19	1	–	–
2010-2019	2	8	4	–	–
2020-2022	–	1	–	–	–
Under construction	–	2	–	–	–

Tab. 4. Complexes with two high-rise buildings of varying heights – divided into height ranges according to the height of the tallest buildings

Decade	90-99 m	100-149 m	150-199 m	200-299 m	300 m and above
1960-1969	–	–	–	–	–
1970-1979	2	3	–	–	–
1980-1989	1	–	–	–	–
1990-1999	1	4	2	–	–
2000-2009	1	8	–	–	–
2010-2019	–	12	3	1	4
2020-2022	1	8	2	–	1
Under construction	1	5	4	4	–

Tab. 5. Complexes with three high-rise buildings of equal height in each height range

Decade	90-99 m	100-149 m	150-199 m	200-299 m	300 m and above
1960-1969	1	–	–	–	–
1970-1979	1	1	–	–	–
1980-1989	–	–	–	–	–
1990-1999	–	–	–	–	–
2000-2009	–	2	1	–	–
2010-2019	–	4	1	–	–
2020-2022	–	–	–	–	–
Under construction	–	1	–	1	–

Tab. 6. Complexes with three high-rise buildings of varying heights, divided into height ranges according to the height of the tallest buildings

Decade	90-99 m	100-149 m	150-199 m	200-299 m	300 m and above
1960-1969	–	–	–	–	–
1970-1979	1	4	–	–	–
1980-1989	–	–	–	–	–
1990-1999	–	–	–	–	–
2000-2009	2	4	2	1	–
2010-2019	2	8	3	2	–
2020-2022	–	3	–	–	1
Under construction	–	9	3	5	–

Fig. 10. Gebouw Delftse Poort in Rotterdam, two towers of varying heights [photo by the author, 2011]

In the case of complexes with towers of varying heights, almost all of those analyzed are complexes in which the height of individual buildings varies markedly – the differences range from a dozen to several dozen meters. An example is Athens Tower 1 (with a height of 106 m) and Athens Tower 2 (with a height of 65 m), built in 1971 in Athens. From the 1990s, a distinctive ensemble consisting of towers of varying heights is, for example, the Gebouw Delftse Poort in Rotterdam (1991; with a height of 151.4 m and 93 m) (fig. 10). Of the newer ensembles, one can mention Bosco Verticale in Milan (2014) – two skyscrapers 117 m and 85 m high [Giacomello 2015].

Fig. 11. Federation Tower in Moscow.
Photo Igor3188 (CC BY-SA 4.0) [Wikimedia Commons 2024]

It is the complexes with towers of varying heights that are among the tallest structures in Europe. Suffice it to say that, as of 2022, of the nine tallest buildings over 300 meters in Europe, as many as six are towers that are part of high-rise complexes (five with two and one with three high-rise buildings). Among the complexes with the highest towers in Europe, with heights of 200 m and 300 m, are: Federation Tower (with a height of 373.7 m and 242.5 m) (fig. 11), OKO Business Center (with a height of 354.2 and 224.5 m) and Capital City (with a height of 301.8 m and 257.2 m) in Moscow and Porta Nuova Garibaldi in Milan (three towers of varying

heights of 217.7 m, 100 m and 61.5 m, plus a lower building) (fig. 12). The Lakhta Center is the tallest, consisting of a 462-meter-tall tower (the tallest building in Europe), a boomerang-shaped building about 80 meters high and a third, low-rise structure (there are plans to build two towers much taller than the existing one) [CTBUH 2024; Wikipedia 2024]. These examples, too, show the large differences in the heights of the buildings that make up the complexes.

Fig. 12. Porta Nuova Garibaldi (UniCredit) in Milan
(Torre Garibaldi A and B skyscrapers visible on the left).
Photo Daniel Case (CC BY-SA 3.0) [Wikimedia Commons 2024]

4. SUMMARY AND DISCUSSION

The results of the study show that only 243 complexes reached the height criterion adopted in the analysis of 90 meters for one building and 65 meters for the other. Below this threshold is a huge number of residential complexes consisting of a few or a dozen, and sometimes even more, high-rise buildings that form or co-create with low-rise, multi-story housing developments. However, some complexes of residential buildings or with a predominant residential function, built in the 1960s and 1970s, as well as later, have reached quite a considerable height and are included in the presented lists. An example is the Les Olympiades complex in Paris (1972-1976), consisting of more than a dozen buildings, including eight skyscrapers 104 meters

high [Emporis 2022]. A number of complexes came close to the designated height threshold but did not exceed it. One might mention, for example, the Red Road Flats complex in Glasgow (1967; with a height of 80 m and 89 m) [CTBUH 2022].

This raises the important issue of the lack of a sharp boundary between "real" high-rise complexes, usually consisting of no more than a few tall towers, and complexes formed by groupings of high-rise buildings usually of moderate height but often found in greater numbers and having the character of residential neighborhoods.

Another consequence of setting a height criterion was the elimination from the study of not-so-tall high-rise complexes from the central area, which often have high architectural qualities and a significant impact on a city's landscape. Despite their small height, they usually stand out from the low-rise buildings in the surrounding area. Some of them, though built long ago, are still prominent landmarks today, such as the Leipziger Straße residential complex (Berlin, 1977; with a height of 78 m) and the aforementioned Hötorget office building complex (Stockholm, 1960s; with a height of 72 m) [Richards 1962; Barucki 1989; Wikipedia 2024]. In Stockholm, it is still a landmark in the central part of the city today, formed by slabs set parallel to each other. Of the more recent moderate-height ensembles, one can mention the famous Bibliotheque Nationale de France (1995; four vertical height structures 79.9 m).

The study showed an upward trend in the number of high-rise building complexes in recent decades – a marked increase occurred in the first decade of the 21st century. Few complexes reaching 90 meters were built in the 1960s. These include, for example, the aforementioned complex of three skyscrapers in Grenoble, designed and built in the 1960s, which were then among the tallest in Europe [Chaljub 2020]. Today they remain the tallest buildings in this city.

In Europe after World War II, in the 1950s and 1960s, concepts of large complexes of high-rise buildings were developed in various cities, placed in central areas (Brussels, London – Barbican Estate, Moscow – Kalinin Avenue, Warsaw – Eastern Side) or within the periphery (Paris – La Défense, Vienna). They realized the idea of modernization and development of European cities. The idea at the time of realizing compositionally coherent groups of skyscrapers is very characteristic of Europe, and the plans for overall urban settings created from identical or stylistically coherent skyscrapers in cities with low historic buildings can be described as very European. Not all of the concepts were realized in their entirety, and as the results of the survey show, the height of the erected complexes was only sometimes very high.

One of the most spectacular developments was the aforementioned Barbican Estate in London: the concept dates back to the 1950s, construction of the taller skyscrapers was completed in the 1970s, and construction of the entire complex was not completed until the 1980s [Gibberd 1959; Szmidt 1981; Mozas 2011]. In Eastern European countries, large building complexes, such as Kalinin Avenue in Moscow and the Eastern Side in Warsaw, co-created socialist arteries (*magistrale*) that are still important urban elements of these cities today [Kostof 1991]. Rhythmically

spaced skyscrapers on two sides of Kalinin Avenue have created its distinctive image. The new urban complex in the area also affected the silhouette of the city and the scale of its central area [Makarevich 1972]. The rhythmic placement of skyscrapers or their erection in the form of parallel slabs was characteristic of this period in Europe.

The idea of erecting large high-rise complexes continued into the 1970s. A spectacular development at the time was the Vienna International Centre on the outskirts of Vienna – a configuration of buildings of varying heights, replicating the original "Y" plan shape (with a height of 120 m, 100 m, 80 m, 60 m, 58 m and 54 m) (*Internationales Amtssitz- und Kongresszentrum in Wien. Architekt: Johann Staber, Wien*, 1979). Heights of more than 90 meters and 100 meters have been reached by some residential complexes in Paris, among others. The period also saw the construction of the Europoint complex of three tall skyscrapers in Rotterdam (with a height of 93 m), the tallest office complex in the Netherlands [Verlaan, Kefford 2021]. The increase in the number of complexes with high-rise buildings in the 1970s corresponds to the trend at the time to build taller skyscrapers than before, in the 1960s.

Between 1980 and 1989, relatively few high-rise complexes were built, but some, as before, can be considered spectacular. An example is the aforementioned Deutsche Bank twin towers in Frankfurt am Main (1984; with a height of 155 meters) (fig. 7), rising near other monumental skyscrapers and belonging to the high-rise region in the city center. Between 1990 and 1999, the number of high-rise building complexes increased relatively little. What is noteworthy, is that these are complexes consisting of two towers. The highest altitude was reached by the Sabanci Center (1993; with a height of 157.3 m and 140 m), located in Istanbul's business district [Sev, Ozgen 2008].

At the beginning of the 21st century, there was a numerical increase in the erection of high-rise building complexes, and in the following decades – a radical increase in their number. The increased popularity of high-rise building complexes, coinciding with the 21st century and continuing today, basically coincides with the period of the most intense development of high-rise buildings in Europe, detailed by Joanna Pietrzak [2014]. The scale of high-altitude complexs has increased markedly in recent decades. In the first decade of the 21st century, the first complexes with towers exceeding 200 m in height were built. In the next decade of the 21st century, the height threshold of 300 m was exceeded (one of the buildings of the complex in Russia even reached a height of well over 400 m).

It is worth noting that starting in the 1990s, the largest number of complexes with the tallest buildings were built in Moscow and Istanbul. In recent decades, the complexes from these cities are the most numerous among the twenty tallest erected in each decade: between 2000 and 2009, six were built in Moscow and four in Istanbul, and between 2010 and 2019, five in Moscow and as many as ten in Istanbul.

Nowadays, high-rise building complexes are being built in various regions. They are generally built in or near central areas in those cities where high-rise buildings

have developed over the years, such as Frankfurt am Main (e.g. Palais Quartier) and Warsaw (e.g. Generation Park). Other locations are areas designated for high development, located away from historic parts of cities, such as in Vienna or Moscow. In the Russian capital, the tallest complexes, such as Naberezhnaya Towers (268.4 m, 127 m, 79.7 m) and Neva Towers (345 m, 297 m), were erected in Moscow City, where the tallest skyscrapers are concentrated. In Istanbul, high-rise building complexes are being built in the new business district, among other places. An example of a spectacular ensemble in such a location is Varyap Meridian (fig. 13), formed by five skyscrapers of varying heights and distinctive shapes – expanding downward (2013; with a height of 188.4 m, 180 m, 164 m, and two structures having 24 floors each) [CTBUH 2022].

Fig. 13. Varyap Meridian in Istanbul.
Photo Penguim15 (CC BY-SA 4.0) [Wikimedia Commons 2024]

Crucial to the image of the complexes is not only the form of the individual towers but also their number, mutual configuration and scale. In an urban environment, the number of towers in a high-rise complex is an important hallmark, especially in the environment of a European city, where high-rise complexes are not usually located in a thicket of high-rise buildings but tower over low-rise buildings. The second characteristic feature of high-rise complexes in a city's image is the uniform height of the towers (sometimes also their size) or their variation.

High-rise buildings can be imageable elements of the urban environment, including as landmarks [Lynch 1960; Ali, Armstrong 1995; Ali 2005; Al-Kodmany 2011, 2017, 2020]. In Kheir Al-Kodmany's [2017, 2018, 2020] theory, complexes

consisting of two or more skyscrapers: “twin”, “triplet”, “quadruplet”, “quintuplet”, “sextuplet”, are presented as types of landmarks. The groups of complexes identified in the study – depending on the number of skyscrapers that comprise them (tab. 2) – are a collection of objects that can potentially represent different types of landmarks. (Individual ensembles require individual analysis, as not every ensemble is characterized by the coherence of the elements that make it up and the visual strength that allows it to be described as strongly imageable). Pairs of identical towers are one of the most distinctive configurations of high-rise buildings. Strong imagery, for example, characterizes the two towers of the Puerta de Europa in Madrid [Al-Kodmany 2011]. They are classified as tilted towers [Moon 2014; Goncikowski 2022]. Their inclination towards each other creates an original solution, significantly affecting the imagery. A “triplet” landmark is, for example, the recently built TrIIIple complex in Vienna, and the “quadruplet” landmark – Deansgate Square in Manchester (fig. 14). In Istanbul, a “quadruplet” landmark is the Zorlu Center, consisting of four identical towers (fig. 15) [Al-Kodmany 2017].

Fig. 14. Deansgate Square in Manchester.
Photo David Dixon (CC BY-SA 2.0) [Wikimedia Commons 2024]

Fig. 15. Zorlu Center in Istanbul.
Photo Emre Arolat Architecture (CC BY-SA 4.0) [Wikimedia Commons 2024]

The survey showed a clear numerical predominance of two types of complexes with buildings over 90 meters high in each of the periods studied: complexes with two towers and complexes with three towers. Starting from the decade 1990-1999, this advantage has been gaining ground. Analysis of these ensembles in terms of equal and different heights of towers in each height range showed a greater number of ensembles with different heights in height ranges above 150 m, having both two towers and three towers (tab. 3-6). It is noteworthy that the highest height was reached by complexes with towers of varying heights – in six complexes, it exceeds 300 m.

The examples presented in the analysis show that height differences in ensembles with towers of varying heights are often significant. The different height of the towers makes a completely different sign in space than those of equal height. However, for the landmark effect created by a set of objects, it is necessary to maintain synergy and harmony between vertical elements of different heights. For example, the aforementioned Gebouw Delftse Poort in Rotterdam (with a height of 151.4 meters and 93 meters) (fig. 10), with towers of widely varying sizes but with consistent styling and distinctive slender proportions and mutual arrangement – offset to each

other, it is a memorable glass landmark. An imageable complex having three towers of different heights is the Porta Nuova Garibaldi in Milan (fig. 12) – arched towers (with heights of 217.7 m, 100 m and 61.5 m) arranged in a circle form a coherent configuration of high-rise buildings and is an important landmark of the city [Musiał 2016].

Fig. 16. Olszynki Park in Rzeszów at the final stage of construction.
The building will be the tallest in the city and one of the tallest residential buildings in Poland [photo by the author, 2024]

Fig. 17. KTW in Katowice, two towers of varying heights. The building is located in an important location, near a major street junction, and has the highest height of any high-rise building in the city [photo by the author, 2023]

It is worth noting that several high-rise building complexes erected or under construction in Poland, which have a very significant impact on the image of a city, are complexes consisting of buildings of varying heights. These include Olszynki Park in Rzeszów, which is in the final stages of construction (with a height of 158 m, 78 m) (fig. 16), KTW in Katowice (with a height of 136 m and 66 m) [Wikipedia, 2024] (fig. 17) and the complex with the Varso skyscraper in Warsaw (with a height of 310 m, 90 m and 80 m). The latter is formed by three buildings, the tallest of which is more than three times higher than the two lower ones. The large difference in height causes Varso to be perceived as a single high-rise building from distant views of the city's skyline.

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ZESPOŁY BUDYNKÓW O DUŻYCH WYSOKOŚCIACH W EUROPIE

Streszczenie

Zespoły budynków wysokich istotnie wpływają na krajobraz miasta, szczególnie obiekty o dużej wysokości. Celem pracy jest analiza kształtowania się budowy zespołów wysokościowców w Europie od lat 60. XX w. do obecnej dekady. Badanie objęło 243 zespoły, w skład których wchodzi co najmniej jeden budynek o wysokości nie mniejszej niż 90 m i co najmniej jeden o wysokości 65 m lub większej. Badanie pokazuje wyraźny wzrost liczby wznoszonych zespołów o takich wysokościach po 2000 r. W każdej z badanych dekad przeważają zespoły mające dwie lub trzy wieże. Analiza tych zespołów pod kątem jednakowej i zróżnicowanej wysokości wież wykazała przewagę zespołów o zróżnicowanych wysokościach w przedziałach wysokościowych powyżej 150 m. Największą wysokość – ponad 300 m – osiągnęły zespoły z wieżami o zróżnicowanych wysokościach.

Słowa kluczowe: Europa, zespoły budynków wysokich, rozwój wysokiej zabudowy, wieżowce