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Orginal Article

New York's super-slender towers and European slender high-rise buildings: differences in the urban context

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Abstract: The latest construction technologies have enabled the erection of very slender skyscrapers. This phenomenon is developing significantly in New York, but very slender high-rise buildings are also being designed on other continents. The aim of this paper is to characterize existing and planned slender European skyscrapers. The study examined the location of slender high-rise buildings and their relationship with their surroundings. It sought differences and similarities in the location of slender European skyscrapers within the urban fabric compared to American skyscrapers. The presented examples of slender skyscrapers in Europe illustrate the diversity of their locations, the character of the areas in which they are designed, and the buildings themselves. The analysis of their relationship with the surroundings revealed many differences compared to New York's super-slender towers, such as the presence of open space, location at significant distances from other buildings, and even location in landscapes dominated by nature. Only some slender European high-rise buildings are designed in high-density development, which may resemble New York's super-slender towers.

Keywords: skyscraper, super-slender tower, slender skyscraper, New York, Europe

1. Introduction

In the 21st century, a new type of tall building is being developed: very slender skyscrapers known as super-slender, super-slim, or pencil towers, whose construction is enabled by the latest technologies. This phenomenon is particularly dynamic in New York, mainly due to economic factors. Such buildings are also designed and built on other continents: in Asia – the Middle East (Dubai, Abu Dhabi) and the Far East (Hong Kong, Bangkok) – as well as in Australia (Melbourne) [1]–[5]. The most famous example is Highcliff in Hong Kong (2003, height: 252 m, slenderness ratio: 1:20). Designed in recent years, Collins House in Melbourne is characterized by a slenderness ratio of 1:16.5 [6]. Currently, there are not many skyscrapers with a very high slenderness ratio, but it seems that over time the tendency to erect super-slender skyscrapers may develop.

Previous publications focus mainly on very slender towers in New York [7]–[15]. Many analyses concern the structures and engineering solutions used [16]–[22]. Super-slender buildings are also the subject of analyses in works describing New York's high-rise development [23]–[26]. Some publications refer to very slender skyscrapers outside the United States, mainly built or planned in Asia and Australia [1], [4], [6]. In Europe, buildings with a high slenderness ratio are few, but new projects are being developed.

The aim of this study is to characterize European concepts that meet the slenderness ratio criteria of super-slender skyscrapers or at least those similar to them. The analysis includes existing buildings and building designs whose proportions of the narrow side to height are at least 1:10. Data on the height and parameters of buildings and their slenderness ratios were obtained from the CTBUH and Emporis databases, information provided by construction offices, and thematic publications. The article examines the locations of slender buildings in European cities and their relationship to the environment. The author also looked for differences and similarities in the location of slender European high-rise buildings in the urban fabric compared with the American skyscrapers presented earlier. Moreover, the paper highlights the differences and similarities between the slender skyscrapers designed in Europe and New York.

Since New York's super-slender towers are built in an urban fabric of uniform character (Manhattan blocks), case studies were carried out for four examples of such buildings - two belonging to the first projects and two of the tallest, four-hundred-meter-high buildings. The study also included the only super-slender tower designed in Brooklyn. In Europe, the analysis covered skyscrapers over 100 m high, described in scientific publications or online information as very slender and meeting the criteria adopted in this study. Thirteen such European skyscrapers were found and analyzed, including three belonging to one complex.

The analysis was carried out by assessing: the scale of the city, the location of the skyscraper in relation to the center, the character of the area in which the skyscraper was designed, and its immediate vicinity - the type and height of the buildings, their distance from the skyscraper, and the land development in the immediate vicinity.

2. The slenderness ratio of a high-rise building

In designing the structural features of a tall building, particularly taking into account the dynamic effects of wind, the slenderness ratio (λ) is defined as the ratio of the building's height to the shortest side of its base [27], [28]. In architectural publications, a building's slenderness is most often determined by the width-to-height ratio – an approach this work also adopts.

So far, the criterion of slenderness has not been clearly defined and is adopted at different levels – 1:7, 1:10, or 1:12 [2], [29]. At the exhibition at the New York-based Skyscraper Museum (Sky High & the Logic of Luxury, 2013–2014), the adopted criterion of slenderness was expressed by ratios of 1:10, and even 1:12. Very tall skyscrapers with such slenderness ratios have been dubbed super-slender towers [7]. At this exhibition, slenderness was illustrated by comparing the North Tower of the World Trade Center in New York, with a slenderness ratio of less than 1:7, with one of the tallest New York super-slender towers – 432 Park Avenue (2015, height: 426 m), which has a slenderness ratio of 1:15 [7], [30]. The WTC Towers (New York, 1973), as well as other American skyscrapers from the turn of the 1960s and 1970s (for example, Sears, Chicago, 1974), were high and monumental, reflecting the then-prevailing design trend for large companies and corporations [31].

Slender buildings are known from the history of architecture in both Europe and America. The slender Italian medieval residential towers in Tuscan San Gimignano or in

Bologna amaze to this day. Built between 1109 and 1119, the Torre Asinelli, one of the two preserved towers in Bologna, is 97 m high with a square base of only 8.8 m on each side [32] (slenderness ratio of 1:11). More recent examples include the 19th-century Washington Monument in the United States, which is 16.8 m (55 ft) wide at the base and 169.2 m (555 ft) high, equating to a 1:10 slenderness ratio. Another impressive structure is the 120-metre-high pointed steel Spire of Dublin, with a base diameter of just 3 m, built in 2003, presented among skyscrapers by Matthew Wells [33] in his book '*Skyscrapers: Structure and Design*' as an object of symbolic significance for the city. As for the period preceding the development of New York’s super-slender towers, an example worth mentioning is the 2005 Chicago Spire project by Santiago Calatrava. A 610-meter-high residential tower, designed to be built on the shore of the lake, would have had the highest slenderness ratio among the tallest skyscrapers in the world at the time, of 1:10 [34]–[36]. However, the construction of the facility, which began in 2007, ceased in 2008 at an early stage, after the foundations had been completed.

The presentation of American super-slender towers and the designs of slender European skyscrapers should be preceded by a few examples of well-known tall buildings and their slenderness ratios. New York's Empire State Building, for many years the tallest in the world, has a base-to-height ratio of only 1:3 [13]. The Palace of Culture and Science, which towered over Warsaw for several decades, was designed with the width of its extensive podium (254 m) larger than the vertical dimension of the building (227 m) [37]. Even if only the proportions of the tower part of the Palace are considered, it still does not make the building particularly slender (with a slenderness ratio less than 1:3). The famous Pirelli skyscraper in Milan, built in 1958, 125 m high and 18.7 m wide, has a slenderness ratio of 1:6.68, with significantly differing dimensions of the narrower and wider sides [27]. Other iconic skyscrapers, such as Marina City in Chicago, with a height of 180 m and a width of 33.32 m, have a slenderness ratio of 1:5.4 [27]. The elegantly simple Trump World Tower (New York, constructed in 1999–2001) is 262.4 m high and has a rectangular plan measuring 44.2 x 23.8 m, so the ratio of the narrower side of the building to the height is 1:11. Due to its function (a residential building), scale, proportions, shape, and location in Manhattan, it can be regarded as a harbinger of the later development of super-slender towers in New York. Built in 2013, the slimmest residential skyscraper in Warsaw – the Cosmopolitan (height: 160 m) – has a slenderness ratio of 1:7, and Złota 44, completed in a similar period in the center of the Polish capital (height: 192 m) – 1:6 [38]. The Allianz Tower, the first skyscraper of the CityLife complex in Milan completed in 2015, is also characterized by its slim design. The building has a rectangular plan with sides 24 x 61 m long [39], which, given its height of 209.2 m, results in a slenderness ratio of about 1:8.7.

In the centers of metropolises, plots for development are usually small in area, mostly surrounded by existing buildings; in the case of American metropolises, these are often high-rise buildings. Extending buildings vertically on increasingly smaller plots is the effect of striving to obtain the largest usable area of the building possible. In the dense development of the city center, one of the most important limitations that force the surge in slenderness and height is access to natural light [40], [32]. In 1916, New York introduced the first zoning law that ordered setbacks in buildings to provide greater access to daylight on the streets. A significant influence on the shaping of tall buildings was the adoption in 1961 of regulations defining the proportion between the permitted total surface of above-ground floors of the building and the plot area – the Floor Area Ratio (FAR) [7], [11], [41]–[43]. Another important factor was the possibility of increasing FAR e.g., in exchange for the creation of public squares, motivating developers to reduce the area occupied by buildings on the plot [7], [32], [41], [44].

Regardless of the shape of a high-rise building, achieving the effect of slenderness most often requires using the latest technologies, such as innovative materials (e.g., shape memory alloys and phase-change materials), ultra-high-strength concrete, and tools that enable control of the structure during and after its construction [4], [11]. When designing New York's super-slender towers, engineers must create a building that will be not only resistant to horizontal forces but also one whose structural elements will occupy a negligible part of the storey and which will be possible to erect on a relatively small construction site [10], [11].

3. New York's super-slender towers

Tall, super-slender buildings in New York City (8.4 million inhabitants) are erected in Manhattan, and there are already about twenty of them (Tab. 1). One, though not the highest, has a relatively high slenderness ratio (1:12); it is one of the first New York super-slender towers, One Madison (height: 189.28 m), built between 2006 and 2010 on 23rd Street next to Madison Square Park and near the famous Flatiron Building. The building was erected, like many skyscrapers in Manhattan, in an urban block formed by dense development of varying heights. The tower is directly adjacent to low-rise development, but there are also various tall buildings in the vicinity.

During that period, one of the first high-altitude (320 m) super-slender towers (1:12) was designed: Tour de Verre (later known as MoMA Tower, now 53 West 53), built in 2019 in Midtown Manhattan. The building is designed on a narrow plot between a forty-story office skyscraper and the lower buildings of the Museum of Modern Art and the Museum Tower. The podium of the skyscraper and the neighboring buildings form a fragment of a compact street frontage. The higher parts of the skyscraper narrow up along a polyline, giving the building an unusual shape. It may be reminiscent of a narrow fragment of solid figures from Hugh Ferriss's drawings from the 1920s, which are a graphic interpretation of the regulations introduced in New York in 1916. The association is not unfounded because the shape of the skyscraper results from adapting its design to the current regulations concerning planning development in Manhattan and from taking full advantage of the plot for the largest possible usable area of the building in accordance with the applicable rules and engineering principles that enable the construction of such a high building on a narrow plot, which is literally presented in the description of the project: "This tower is a monument to the rules of shadow and light, and to the forces of the wind" [45].

Earlier, in 2015, the first super-slender tower of over four hundred meters in the New York skyline was completed - 432 Park Avenue, 425.7 m high (1:15) (Fig. 1). Like the skyscraper described earlier, it occupies a small area in one of Manhattan's urban blocks. The building has the shape of a very high cuboid with windows evenly arranged along its entire height, which can be read as an effect of a very rational approach. It can be briefly described as a very slender square tower with square windows. When a skyscraper of such great height and at the same time extremely slim proportions, but uncommonly simple in form, was erected in Manhattan, it provoked extreme opinions: "architectural nightmare or a miracle of engineering" [46]. We may ask: Did the designer of the skyscraper recognize that the unusual proportions of the skyscraper themselves constitute its uniqueness and beauty, and that the simplicity of the form only emphasizes it? Undoubtedly, a tall building with extremely slender proportions is more appreciated than a wide one. A tower, above all, must be stable enough not to collapse; hence, a wide skyscraper, even a tall one, is easier to build than a slender one of the same height – the first type is built by many in the world, while the second is erected by only a few.

Fig. 1. 432 Park Avenue, New York, photo by Percival Kestretail (CC BY-SA 3.0). *Source*: [47]

The second tallest slender skyscraper in New York City is 111 West 57th Street, also known as Steinway Tower, standing at 435.3 m high (Fig. 2). The ratio of the podium's side to the building's height is 1:24.3, making it the most slender in the world. Completed in 2021, the skyscraper was built in one of Manhattan’s rectangular urban blocks between West 57th Street and West 58th Street. This modern construction rises from the interior of the historic Steinway Hall building, dating back to 1925 (the former headquarters, showroom, and offices of the renowned Steinway & Sons company, which manufactures pianos). The skyscraper's construction was integrated with the renovation of this building [10], and together they form an architectural unity. The slender tower protrudes high above the buildings of the urban block that separates it from Central Park. It has a simple shape that becomes quite distinctive when viewed from the side – beyond a certain height, it tapers upwards on one side with small setbacks, forming a gentle arc. This building is one of the most spectacular super-slender towers in New York City.

Fig. 2. 111 West 57th Street, New York, photo by Jim.henderson (CC BY-SA 4.0). *Source*: [47]

The 57th Street, which hosts the aforementioned Steinway Tower and its surroundings, is now home to some of Manhattan's tallest slender skyscrapers. The same urban block houses the soaring One 57 high-rise building. Nearby, the tallest of New York's super-slender buildings has been recently built - the Central Park Tower (height: 472.4 m), with a slenderness ratio of 1:23. In the adjacent block, on 58th Street, stands 220 Central Park South (height: 289.6 m). The eastern part of 57th Street is where we find the urban block containing the 432 Park Avenue skyscraper described earlier.

New slender skyscrapers are being designed for construction in Manhattan, some exceeding three hundred meters in height (e.g., 262 Fifth Avenue) and others surpassing four hundred meters (e.g., Tower Fifth, which would be located in the urban block adjacent to Central Park).

Table 1 presents the slender skyscrapers built and those planned in New York City. Notably, there is a fairly large diversity in heights, but the vast majority are high-altitude skyscrapers – over 200 m tall.

Table 1. Super-slender towers in New York City – both designed and existing (based on the author's study of: [1], [4], [10], [20], [50]–[55])

Building	Date of design and construction period	Height [m]	Slenderness ratio (width/height)
Central Park Tower	designed in 2010, 2014–2020	472.4	1:23
111 West 57th Street (Steinway Tower)	designed in 2012, 2015–2021	435.3	1:24.3
432 Park Avenue	designed in 2011, 2011–2015	425.7	1:15
265 West 45 Street	designed in - n.d.	400	about 1:13*
45 Broad Street	designed in 2016, construction began in 2018 and has been suspended	365.76	n.d.
9 DeKalb Avenue	designed in 2015, construction began in 2017	335	1:10
53W53 (MoMA Tower, Tour de Verre)	designed in 2006, 2015–2019	320	1:12
262 Fifth Avenue	designed in 2016 under construction	308.2	1:20
One 57	designed in 2005, 2009–2014	306.1	1:8**
35 Hudson Yards	designed in 2012, 2015–2019	304.8	n.d.**
220 Central Park South	designed in – n.d., 2014–2019	289.6	1:18
30 Park Place	designed in 2007, 2008–2016	282.2	1:10.5
125 Greenwich Street	designed in 2012, 2015–2021	278	1:20
56 Leonard	designed in – n.d., 2008–2016	250.2	1:10
111 Murray Street	designed in 2013, 2015–2018	240.2	1:9**
520 Park Avenue	designed in 2012, 2015–2018	237.9	1:13
50 West Street	designed in 2005, 2008–2018	237.3	n.d.**
45 East 22^{nd} Street	designed in 2013, 2015–2017	237	1:13
ARO (242 West 53^{rd} Street)	designed in 2013, 2015–2018	224.8	1:9.5
100 East 53^{rd} Street	designed in 2005, 2008–2018	216.7	1:16
Seaport Residences (161 Maiden Lane)	designed in 2013, construction started in 2015	204.2	1:15
One Madison	designed in 2005, 2006–2010	189.28	1:12
Sky House	designed in – n.d., 2005–2008	179.33	1:17
785 Eight Avenue (Icon)	designed in 2005, 2005–2009	157.4	1:18

* – slenderness ratio according to the author's estimations,
** – building classified as super-slender by Carol Willis [1],
n.d. – no data

Built in the densely developed Manhattan, tall, slender skyscrapers have become a way to utilize the limited building land available in the heart of a global metropolis. They are constructed on quite narrow or small plots, often appearing to be “squeezed” between existing buildings, sometimes even rising from them (as in the case of Steinway Tower). Their height and shape are largely dictated by the rules governing development density in New York – key among these are the Floor Area Ratio (FAR) and the principle allowing for the purchase of unused air space from owners of adjacent buildings to construct a taller building – known as Transferable Development Rights (TDR) [7], [8], [11], [48]. On the other hand, residential use, with one or two apartments per floor, unlike in large office buildings, does not require many elevators and conserves space [7], [8], [11].

The location of super-slender towers in Manhattan is always within urban blocks. These slender towers are constructed between existing buildings, usually adjoining or close to one another, forming urban blocks. It can be observed that a common pattern is a densely developed urban block with buildings of various sizes, including a very slender tower among them.

Interestingly, the trend of erecting very slender luxury skyscrapers has recently begun to expand beyond Manhattan. The fourth tallest skyscraper in New York City, 9 DeKalb Avenue, standing at 335 m high (slenderness ratio: 1:10) and designed in the mid-2010s, is under construction in Brooklyn. It will be located adjacent to high-rises, both existing and planned, on Flatbush Avenue, which leads to the Manhattan Bridge. The building, which slightly tapers upwards with small setbacks at different heights and from different sides, will be situated in a triangular block next to existing low buildings (the 19th-century Dime Savings Bank of Brooklyn, which is to be restored and adapted to the new development) [49]. The rising skyscraper will become the tallest building in Brooklyn, significantly surpassing the tallest skyscrapers in this part of the metropolis today. According to the building’s designers, “On the skyline, 9 DeKalb will represent a new and lasting symbol of the borough’s ongoing renaissance, rivaling in height and character the storied towers of Manhattan” [49].

The emergence of tall residential skyscrapers with small footprints is directly linked to the high prices of land and property in New York, some of the highest in the world [7], [23]. The sky-high prices of apartments in high-rise buildings in prestigious locations near Central Park – such as Time Warner Center (2004) and 15 Central Park West (2008) – have made the extremely expensive construction of super-slender towers profitable [7]. The locations of later super-slender skyscrapers are also associated with the proximity to Central Park. Carol Willis [7] highlights a key aspect of such locations: obtaining a view of the park from the upper floors of the skyscraper. With Manhattan’s dense development and many tall buildings, a view of the park’s open space is a luxury reserved for only a select few. Luxury is a defining feature of New York’s super-slender towers, associated with their location, views, floor plan – usually just one or two apartments per floor – and considerable floor-to-ceiling height [7], [8].

New York is a city of skyscrapers, so it might seem that another type of these buildings would gain universal acceptance. However, very slender towers provoke strong emotions. The writer and New Yorker Pete Hamill notes: “In these supertall buildings, the owners are mostly the super-rich […] Perhaps the most extreme example, on Billionaires’ Row, is 432 Park Avenue, 1,396 feet [426 m] high and 88 floors. It lords over its neighbors, looking for all the world as if it’s giving the finger to my city” [46, p. 122]. There is also an ongoing discussion about the visual impact of tall, very slender skyscrapers on Manhattan's skyline, which is becoming increasingly pronounced, especially when viewed from Central Park.

4. Slender high-rise buildings in the Neva Towers and Capital Towers complexes in Moscow

In the early 1990s in Moscow (12 million inhabitants), the construction of a business center was initiated in the western part of the city [56]. Comprising high buildings, Moscow City is located away from the historical center of the Russian capital. This location was intended to protect the center of Moscow from the character change and visual influence of modern high-rise buildings [57]–[59].

Moscow City was established on land that had a previously designated shape and area (60 ha) and was divided into two zones, which were further subdivided into plots for individual buildings [60]. Currently, the Moscow business center consists of a group of about a dozen skyscrapers. The group of tallest buildings includes those over 200 m and over 300 m high, arranged in two rows on both sides of a shopping center. Various concepts for the highest building were developed. In the early 21st century, there emerged a concept for the 612 m high Russia Tower. The construction of the facility, which began in 2007, was soon suspended due to the economic crisis. In subsequent years, the Neva Towers complex was erected on the plot where this high-rise building had been planned.

Built together with Neva Tower I, Neva Tower II (Fig. 3), completed in 2020, is currently the slimmest high-altitude building in Europe. With a slenderness ratio of 1:11.3 and a height of 345 m, it belongs to the group of the slimmest existing high-rise buildings in the world [4]. It is also the third tallest building in Moscow, the fourth in Russia, and in Europe. Both towers were designed with similar simple shapes and a few small setbacks that cause the towers to narrow slightly upwards. Neva Tower I serves both residential and office functions, while Neva Tower II is solely residential. The towers are connected by the lower part of the complex.

The Neva Towers complex is located in the northern part of Moscow City, close to the ring road. On the street to the east, there is an urban complex of five-story detached residential buildings built many years earlier. From the south, the Neva Towers complex adjoins a group of skyscrapers of the Moscow business center, and from the west, it is bordered by not very tall longitudinal buildings separating the complex from the ring road. The buildings of the Neva Towers complex occupy only part of a triangular plot of 2.41 ha [61]. The remaining area is a square, green space, and a rest zone. The Neva Towers are set perpendicular to each other, with their wider sides facing the square. The extensive podium and the towers rising above it form a block of buildings between the streets and simultaneously define the adjacent open public space.

The Neva Towers, along with other Moscow City high-rise buildings, form a group of skyscrapers, visible from a distance as a group landmark towering over the surrounding buildings. Moscow City is surrounded by a vast area of low-rise development, which is only occasionally surpassed by skyscrapers.

In contrast to the very diverse architecture of other skyscrapers in Moscow City, the Neva Towers stand out as very attractive. Their shapes are simple and elegant, and the composition they form is coherent and pragmatic. The slender shape of the towers, especially Neva Tower II, subtly enhances the elegance of the complex. It can also be interpreted as a sign of a new trend in designing high-rise buildings, demonstrating technological possibilities in construction.

Fig. 3. Neva Towers, Moscow, photo by Snob. *Source:* [62]

In Moscow City, three slender Capital Towers (Multifunctional High-rise Residential Complex on Krasnopresnenskaya Embankment, designed by Sergey Skuratov Architects) (Fig. 4) are nearing the end of construction. They were designed for the eastern part of Moscow City, away from the existing high-rise buildings, next to a park. The towers are arranged parallel to each other but offset from one another and connected by a low, wide podium. Each tower is 266 m tall, and the length of the narrower side is about 22 m [63], resulting in a slenderness ratio of over 1:12 (visually, Tower "Б" appears the slimmest as its longer side is the shortest among the three buildings). The complex was designed on a plot of over 3 ha. The facilities cover an area of 8,085.35 m^2, with a large part of the remaining space allocated for a park and a recreation and rest area [63].

Fig. 4. Visualisation of the Multifunctional High-rise Residential Complex on Krasnopresnenskaya Embankment, designed by Sergey Skuratov Architects, 2016–2020. *Source:* [63]

5. Lilium Tower designed by Richard Meier and concepts for other slender skyscrapers in Warsaw

Most of Warsaw's (1.8 million inhabitants) high-rise buildings are located in the city center. Clusters of tall buildings and individual skyscrapers rise beside low buildings. However, the high-rise development, seen from a distance, creates the distinctive skyline of Warsaw's center, featuring numerous skyscrapers. Until recently, the tallest building was the socialist realist Palace of Culture and Science, erected in the middle of the city in the 1950s. It has now been surpassed by the nearby Varso skyscraper. Recent decades have seen intensive development of high-rise buildings in Warsaw, with the design of spectacular skyscrapers and smaller high-rise buildings, some exceeding 100 m in height (there are several skyscrapers under construction over 150 m tall). Tall buildings are being erected at various locations in the city center, but recently mainly in its western part.

In 2007, a competition to design a skyscraper in the center of Warsaw named Lilium Tower saw American architect Richard Meier propose a building about 400 m high (Fig. 5) [64].[1] The skyscraper would have a shape similar to a narrow cuboid, with its height several times greater than its width. Wojciech Oleński [67] was fully justified in describing this building as a "super-slim skyscraper". The shape, proportions, and height of the building designed by Richard Meier are unmistakably reminiscent of the very slender American skyscrapers rising in Manhattan. In a sense, certain similarities can be observed in their location – in both cases, these are skyscrapers at the heart of the city, although we are talking about completely different cities on different scales.

Fig 5. Lilium Tower, Warsaw, designed by Richard Meier & Partners Architects, 2007, rendering by Studio Horák. *Source*: courtesy of Studio Horák

[1] The competition was organised in 2007 by the Lilium company and was limited to the following participants: Richard Meier, Zaha Hadid, Norman Foster, and Anthony Bechu [65], [66].

The skyscraper would be built at the intersection of the main routes in the city center – Aleje Jerozolimskie and Tytusa Chałubińskiego Street, in the place of the low, but very wide podium of the Marriott Hotel (the design assumed the transformation of the existing skyscraper's podium and giving it a different shape). Richard Meier's vision entailed not only the construction of a one hundred and twenty-one-story high-rise building but also significant modifications to the existing buildings and redevelopment of the city area surrounding the planned tower, including a completely new Central Railway Station and a hotel [64]. The new skyscraper would be located next to two rectangular, but much lower, skyscrapers of the so-called West Side of Central Square, built in the 1970s and 1980s – Oxford Tower (1975–1979, height: 141 m) and Centrum LIM (1980–1989, height: 140 m), surpassing them almost threefold, and more than three times higher than the Central Tower (1992–1996, height: 115 m), located on the opposite side of Tytusa Chałubińskiego Street. Wide streets and the considerable distances separating the existing skyscrapers in the center of Warsaw would make the gap between the new slender high-rise building and the neighboring towers significant (the distance between it and the skyscrapers of the West Side of Central Square would be about 60 m and 110 m).

The skyscraper designed by Richard Meier is undoubtedly an interesting solution to the project task of introducing another high-rise building next to two tall buildings, in an arrangement characteristic of the modernist concept: high buildings arranged parallel but offset from each other. The designed building, with its relatively small visual mass, clearly different height, and the distance maintained from the existing skyscrapers, leaves the composition of the towers created years ago still legible, and at the same time, its simple, orthogonal shape echoes the shapes of the buildings of the West Side of Central Square. It can be said that a common composition was achieved by relating the new building and the existing skyscrapers at a right angle – in this case, by arranging the rectangular buildings in an orthogonal layout. Relating buildings in space by right angles is a centuries-old solution that spatially connects buildings [68].

Without questioning the charm of this slender skyscraper, in this case, the need to erect a building small in plan and very tall is debatable. The potential area for locating a possible building here (assuming the transformation of the large podium of the existing nearby skyscraper) is large enough for a much wider building. This is supported by another competition proposal for Lilium Tower, submitted by Zaha Hadid Architects. So far, none of the earlier concepts have been realized in this location.

The distinctive appearance of the designed skyscraper would likely be easily visible from the open space of the square in the center of the capital. The impact of such a tall building on the image of the city center and the city skyline would certainly be significant. The building would substantially surpass all Warsaw's skyscrapers – including the Palace of Culture and Science, which until recently was the tallest (1955, height: 227 m), and the above-mentioned Varso Tower (height: 310 m). The very tall Lilium Tower, set among existing buildings, could be perceived in the landscape and cityscape as an element of the otherwise desirable process of increasing the number and density of high-rise development in the center of the capital. According to Wojciech Kosiński [69], the ideal solution for Warsaw would be to build skyscrapers as close to each other as possible. However, the process of intensifying high-rise development in the center of Warsaw appears to be complex and protracted, so, using a certain simplification, it can be said that today any high-rise building constructed between existing skyscrapers seems to be a step in the right direction.

Another noteworthy skyscraper concept was developed by Kuryłowicz & Associates in 2009 [70], [71]. The building was also designed to be built in the center of Warsaw, on the corner of Jana Pawła II Avenue and Sienna Street, on a very narrow plot shaped like an elongated trapezoid with opposite shorter sides of only about 7 m and about 9 m (Fig. 6). The small width of the plot and the associated challenge of designing the skyscraper are highlighted by Marcin Goncikowski – an architect representing the studio [72].

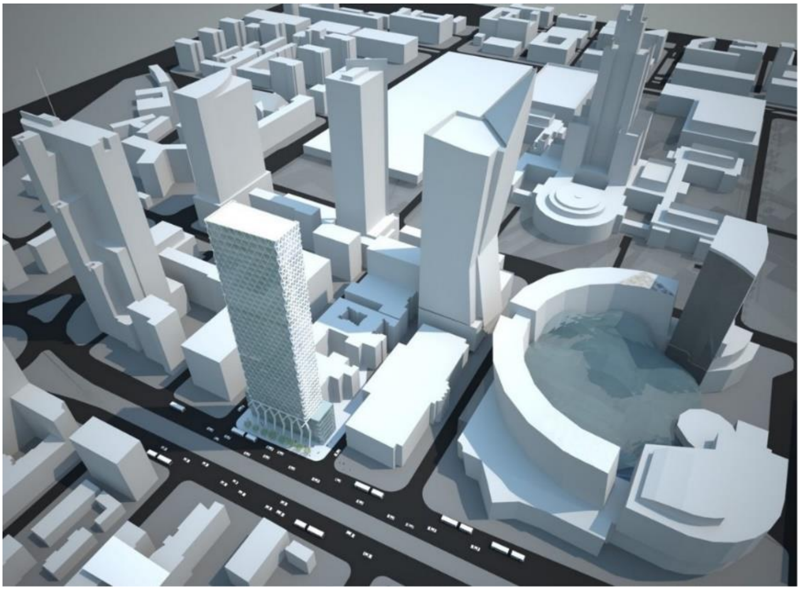

Fig. 6. Visualisation of the skyscraper on Sienna Street in Warsaw, designed by Kuryłowicz & Associates, 2009. *Source*: courtesy of Kuryłowicz & Associates

The concept proposed by Kuryłowicz & Associates features a skyscraper with a simple shape, rising from a narrower multi-story podium adapted to the size of the plot. Ultimately, three variants of the skyscraper were developed, with heights of 90 m, 120 m, and 160 m. The proportions of the skyscraper are noteworthy. If diagonal structural elements in front of the façade are included in the width of the podium of the building, it measures less than 15 m (1486.5 cm) in length, which, given the building's height of 120 m, results in a slenderness ratio greater than 1:8, and with a height of 160 m – almost 1:11 (data on variants and dimensions of the building – Marcin Goncikowski, Kuryłowicz & Associates).

The building was planned to be erected next to the pre-war tenement house at 45 Sienna Street, with the wider side facing Jana Pawła II Avenue. A little further away is the Rondo I skyscraper, 192 m tall, along with a few other high-rise buildings in Warsaw (the tallest of them are 150–200 m tall), which together form the mixed high- and low-rise development of the center, with more buildings of the latter type. The designed skyscraper (in its highest variants) matches the scale of high-rise buildings in this region of the city. One could also say that the narrow podium of the skyscraper references the low buildings in the neighborhood. However, the building would likely provide a stark contrast to the neighboring tenement house and other low buildings on the same street. Nevertheless, the emergence of such contrasts is an inevitable consequence of constructing skyscrapers in the center of any European city.

A few years ago, the Warsaw studio CUBE Architects designed a high-rise for the same area of the city, at the corner of Mariańska and Twarda Streets – a simple, slim skyscraper named Pin Tower (Fig. 7), housing apartments, a hotel, and commercial and service facilities. The longitudinal building, designed on a 9-m-wide plot, would be 110 m tall [72]. Thus, the slenderness ratio of the building would be approximately 1:12. The architectural form of this slender tower is quite simple. The design of the façade creates a regular, very expressive rhythm of square windows, to which the form of the multi-story podium and the top of the building are subordinated. In one article, the skyscraper was described as reminiscent – due to its slender character – of the New York skyscraper at West 57th Street [72].

Fig. 7. Visualisation of the skyscraper at Mariańska and Twarda streets in Warsaw, designed by CUBE. *Source*: CUBE Architects, after: [72]

The building was designed to be constructed on a small street, with its longer side set parallel to it. It would be situated next to a detached twelve-story Y-shaped residential building, which, along with its plot, occupies a significant part of the urban block. The slim skyscraper would be built 28 m from this building [72]. The locations of these buildings on adjacent plots illustrate the radical differences in shaping urban development in the center of Warsaw at different times: the first represents the concept by Le Corbusier – a building surrounded by open space on the plot; the second fills a small plot and rises high, akin to skyscrapers in Manhattan. Its visualizations show a relatively small distance separating the Pin Tower from neighboring buildings (Fig. 7). However, a larger distance would separate it from the existing nearby high-rise buildings, although the Cosmopolitan skyscraper would be quite close, and the Spectrum Tower even closer (both buildings are depicted in the visualizations). The vision of the skyscraper extended beyond the initial concept. In a 2017 interview, Jarosław Kubicki – an architect at CUBE – said: “Even though the building would be as narrow as a board, we designed it not to bend in the wind. It is absolutely real; it can be constructed. The project is not just a concept; we developed it for a specific investor who wants to build this skyscraper" (J. Kubicki, 2017, after: [72]). However, the building was never erected. Another high-rise building is being planned for the same location [73].

The factor determining the slender shape of the Pin Tower and the skyscraper at the corner of Jana Pawła II Avenue and Sienna Street was the shape of the plot, particularly its narrow width. However, the same cannot be said about the proposed four-hundred-meter Lilium skyscraper designed to be erected on Aleje Jerozolimskie and Tytusa Chałubińskiego Street. The site for the planned investment, considering the demolition of the low podium of the neighboring high-rise building located on it, allows for the construction of a wider building.

The impact of the Pin Tower and the skyscraper planned at the corner of Jana Pawła II Avenue and Sienna Street on the city skyline would not be as significant as that of the earlier described four-hundred-meter tower. Nevertheless, each of these tall buildings, emerging in the area of high-rise development in the center of Warsaw and intensifying it as another skyscraper among the existing ones, would positively affect the imageability of this district.

In Warsaw, high-rise development is concentrated in the city center, and spatial planning permits the construction of tall buildings in this area. However, local spatial development plans currently cover only part of the city (in the remaining parts, the so-called "good neighborhood" principle applies).[2]

6. Modern slender skyscrapers in the UK

6.1. Beetham Tower in Manchester

The number of tall buildings in Manchester (550,000 inhabitants) is quite significant, but only 16 skyscrapers (existing or under construction) have a height exceeding 100 m [75]. Apart from two, all the tallest skyscrapers were built in the 21st century.

Changes in urban policy that took place in the mid-1980s are reflected in actions such as the renovation of the city and the promotion of prestigious investments, including the construction of high-rise buildings [76]. This new approach is manifested in the revitalization of post-industrial areas and the erection of a considerable number of high-rise buildings in recent decades.

One area that has undergone significant transformation is the City Centre, where, in addition to the restoration of historic industrial buildings and their repurposing, new structures have been erected [77]. These include the Beetham Tower, a singular skyscraper built at the intersection of Deansgate and Great Bridgewater, adjacent to a 19th-century railway viaduct (Fig. 8). The skyscraper is located near low-rise development, which encompasses regular urban blocks of low buildings in the city center and free-standing, repurposed post-industrial and post-railway facilities. In the vicinity of the skyscraper, there are large buildings of historical value, such as the Great Northern Warehouse and G-Mex (the former Manchester Central railway station, rebuilt into an exhibition and conference center) [76]. The urban fabric in this part of Manchester has essentially been shaped, although some areas still show potential for transformation.

[2] The current local spatial development plan for the part of the city center where the Lilium skyscraper was planned to be built prohibits the construction of buildings with a height of 400 m [74]. According to the regulations specified in the resolution concerning this plan, the height of the building at this location must not exceed 235 m.

Fig. 8. Manchester. Beetham Tower as seen from the narrow side. *Source*: from the author's collection (photo from 2018)

Completed in 2006 in Manchester, the elegant fifty-story Beetham Tower (height: 157 m) has a slenderness ratio of the narrower side of 1:10. According to information from the portal Skyscrapernews.com, this ratio placed it in the group of the slimmest skyscrapers in the world in the first decade of the 21st century [78]. The building's height is increased to 169 m by the extension of one of the wider façades – the "glass 'blade'" [75], [79]. Additionally, the tower widens slightly from the twenty-fourth floor upwards, enhancing the effect of a vertical slim plate and giving the building a striking expression. The difference in width reflects the building's dual functions: the lower part houses hotel rooms, while the upper part contains residential apartments. It is noteworthy that construction of the skyscraper began in 2004, and the procedure preceding it, related to obtaining construction consent, started in 2003 [76].

The Beetham Tower is perpendicular to the main street (Deansgate) and, along with the low, several-story commercial building built alongside it, largely but not entirely fills the plot on which it was erected. Due to its shape and location between the existing buildings and streets (on the east side, the building is adjacent to the street and a parking lot), in a broader perspective, the skyscraper can appear as a glass slender plate among low buildings and structures.

The Beetham Tower has become an important landmark in Manchester's skyline and a symbol of the city's modern development [77]. Historical and post-industrial buildings located near the skyscraper emphasize its modern character.

It is significant that when the proposal for the construction of the Beetham Tower was made, the city of Manchester did not have any specific regulations regarding tall buildings. The design of the skyscraper was subject to assessment by various institutions, with one of the most important considerations being the impact of the building on the city's historical heritage [76].

6.2. 211 Broad Street in Birmingham

Birmingham is the second-largest city in the UK, with a population of over 1.1 million (around 4 million when considering the entire metropolitan area). High-rise buildings have been constructed in Birmingham since the 1960s, mainly in the central part of the city (central ridge zone), where most office skyscrapers are located today [80]. However, the number of high-rise buildings in Birmingham is relatively small. So far, only three skyscrapers exceeding a hundred meters in height have been built, with two others in the final stage of construction.

In the post-war period, the city underwent a modernization that was not very successful, resulting in its contemporary image being somewhat unexpressive [76]. Currently, further renovation is underway, and the policy of the municipal authorities supports the erection of high-rise buildings. This is reflected in the creation of new rules relating to high-rise development. Some of the most important of these rules are: specific locations should align with those determined in the plan, mainly in the city center; signature views should be protected; no building can exceed 242 m in height (a limitation due to Birmingham Airport's location); and new skyscrapers should be of high quality [76], [80], [81].

Recently, the slim 211 Broad Street skyscraper (Fig. 9) has been designed in Birmingham, located in the southern part of the city's central area. The urban fabric here mainly consists of compact low-rise development that forms street frontages and urban blocks, interspersed with tall buildings.

The 211 Broad Street building, 116.5 m high and only 9.5 m wide on its narrower side, is characterized in the original description as a skyscraper that meets the criteria of a super-slender building [82]. Designed with a rectangular shape and very slender proportions from its narrower side, its longer side is much wider but also exhibits a clearly vertical expression. The ratio of the width of the narrower side of the building to its height is about 1:12. This places the designed skyscraper among the slimmest not only in Europe but also in the world. The tower is already described on Internet news portals as, among other things, "Birmingham's first 'super slender' tower and the UK's first habitable 'super slender' structure" [83], [84]. The designed skyscraper will be a hotel, also including a bar, restaurant, and other facilities typical of this type of building [84].

The new skyscraper would be constructed between the 1960s Hampton by Hilton Hotel (1964, height: 64 m) [75] and the Mercian skyscraper (2022, height: 130 m). The 211 Broad Street skyscraper would be situated on a narrow plot, in a gap between the low podiums of the aforementioned buildings, positioned – like them – perpendicular to the streets on both sides of the longitudinal urban block. The tower would replace the existing low-rise buildings. From an economic perspective, the planned skyscraper would fully utilize the plot. Its shape is a direct result of the shape of the plot on which it is designed.

The building will be located in the center of Birmingham. Two recently erected high-rises, Bank Tower 1 and Bank Tower 2 (2018-2019, heights: 70 m and 102 m respectively), are situated nearby [75]. All these buildings would form a small cluster of skyscrapers in the area located in the western part of the city, on one of the main streets. Further along the same street is the site where Birmingham's tallest building is to be constructed – 100 Broad Street (height: 193 m).

In February 2020, Birmingham City authorities approved a plan to build a skyscraper at 211 Broad Street [83], [84]. Construction work was planned to be completed in 2022. However, the economic factors associated with the COVID-19 pandemic have delayed its construction [5]. The construction of 211 Broad Street in Birmingham could be a significant event in the development of high-rise buildings in Europe, especially from an engineering and architectural perspective. According to Lisa Deering of Glancy Nicholls Architects, “advances in engineering and construction technology have allowed us to design an iconic building that will enhance Birmingham’s skyline and bring a new type of skyscraper to the city” (L. Deering, 2020, after: [85]).

Fig. 9. Visualisation of 211 Broad Street skyscraper in Birmingham. *Source*: [82]

7. Slender skyscrapers on the Mediterranean Sea – Benidorm

The city of Benidorm, with its skyscrapers, may seem like a surprising juxtaposition to Manhattan and its slender luxury skyscrapers. Benidorm (69,000 inhabitants), located in the south of Spain on the Mediterranean Sea, is mainly known as a tourist destination, though it does not typically attract the wealthiest tourists [86].

The city stretches along a coastline with the characteristic shape of the letter “B”, with a small promontory in the middle [87]. Nearby is the oldest part of the city, featuring compact low buildings and narrow streets. On the eastern side is an area built up much later, filled with a fairly regular layout of urban blocks and a large number of skyscrapers. The construction of high-rises in Benidorm was enabled by changes in regulations introduced in 1963, allowing for high-rise buildings with a certain cubic capacity, unlike the 1958 regulations that allowed for the construction of several-story longitudinal buildings (*tranvía*) [88]–[91]. On the west side is a less developed part of the city; part of the area is not yet occupied by buildings, although there are also several high-rise buildings.

Benidorm is commonly associated with skyscrapers – the Emporis database lists 465 high-rise buildings (with heights of 25–100 m) and 28 skyscrapers (height above 100 m), with more than 140 buildings having twenty or more stories [75]. The city is sometimes dubbed Spain’s Manhattan. A large number of tall buildings, however, is basically where the similarities end. However, it is noteworthy that Benidorm is the second city in the world after New York in terms of the number of skyscrapers per square meter [92]. It is important to note that high-rise buildings in Benidorm are usually not erected next to each other [87].

In Benidorm, the vast majority of skyscrapers are hotel and residential buildings. Apart from their height, they are quite unremarkable and form a grouping of skyscrapers located along the seashore[3]. The skyscrapers are situated quite randomly, including those within urban blocks. They coexist with low buildings, recreational areas, and swimming pools.

Surprisingly, Benidorm has a few fairly slender skyscrapers, some of them not very modern, as they were designed as early as in the 1980s. Examples include the residential skyscraper Costa Blanca I (Torre Soinsa) (built between 1988 and 1990), 116.72 m high, with a slenderness ratio of 116m/8.5m=13 [95]–[97]. It stands as a free-standing skyscraper in one of the quarters in the eastern part of the city, occupied only to a small extent by buildings, but largely by recreational and sports areas and parking lots. Another residential skyscraper with significant slenderness is Torre Levante (height: 120 m), built in the 1980s [79]. Among Benidorm’s newer skyscrapers, Edificio Don Jorge (completed in 2008), with sides measuring 42 m x 14 m and a height of 111.8 m [95], has a slenderness ratio of almost 1:8. An even more slender building is Torre Lúgano, with a ratio of 1:10.5 and a height of 158 m, built in 2008 [95], although it is quite long and has a curved shape. This building was erected on the eastern edge of the city. It is one of many free-standing skyscrapers there but is the furthest up the hill, with no buildings behind it. These skyscrapers do not match the scale or height of the slimmest skyscrapers in the world, but they show that quite slender buildings have a history in Benidorm.

A building that deserves a mention here is one in nearby Alicante, also located on the Mediterranean Sea, an inconspicuous fourteen-story high-rise near Playa de San Juan, with a width at the base of only 5 m (built around 1990) [96], [97]. In his analysis of the structure of skyscrapers in Alicante and Benidorm, Florentino Regalado Tesoro emphasizes the slenderness ratio of this building – 1:8 – and, “not trying to compare the incomparable”, juxtaposes it with the slenderness ratios of huge American skyscrapers: the World Trade Center in New York (1:6.5) and John Hancock Center in Chicago (1:6.7) [96], [97], [87]. Alicante boasts a slender skyscraper with proportions similar to the buildings in Benidorm described above - Gran Sol Tryp Alicante (1971, height: 97 m).

Recently, after a dozen or so years of construction, the Intempo residential tower (Fig. 10) has been completed. It is currently the tallest of the high-rise buildings in Benidorm. It is also the tallest residential skyscraper in Spain and the tallest skyscraper built in this country outside Madrid [79]. It was erected in the western part of the city, away from the largest cluster of tall buildings, in an area where the urban structure is still developing. The distance between it and the historical part of the city is quite significant, about 1.5 km. It is about 400 m away from the coastline.

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[3] Numerous skyscrapers in Benidorm include some that are architecturally interesting. Some can be considered significant in the history of Spanish high-rise architecture. One example is Torre Coblanca-1 (height: 81 m), designed by J. Guardiola Gaya and constructed as early as in the 1960s [93]. Jean-François Pousse [94], in his depiction of European skyscrapers, presents the 148 m tall Neguri Gane, which is roughly butterfly-shaped in plan (designed by R. Pérez-Guerras Architects, J. Pérez Gegúndez, 2002). Interestingly, this building also has quite small dimensions for the podium in relation to its height, namely 27 x 22 m [75].

Fig. 10. Intempo skyscraper, Benidorm, photo by © Tomi Eronen/KONE, CTBUH. *Source*: [79]

The Intempo tower has a somewhat pretentious shape – it consists of two towers connected at the highest parts by an elliptical cone pointing downward – but it is very slender. Its height is 180 m and the width of the narrower side is 16.7 m, resulting in a width-to-height ratio of 1:10.8 [98]. The slenderness ratio of the Intempo tower is comparable to the very slender skyscrapers of New York, but it represents a different type of tall, slender building. The joining of two towers at their highest part into one structure creates the impression of striving for a building with a characteristic shape rather than one that impresses with its slender proportions. When viewed from the wider side, the building may resemble the letter "M".

The Intempo tower is surrounded by a fairly large open space. The distance between the skyscraper and the low buildings along the coastline is significant, about 190 m. Around the building, within a radius of several hundred meters, there is vacant land, which to the north, near the skyscraper, becomes a vast natural landscape. The exception is the twin towers of Sunset Drive, about 100 m to the south; two other apartment blocks are about 170 m away to the west. Intempo, like the Sunset Drive skyscrapers and a group of skyscrapers located north of the shore and about 400 m from Intempo, can be described as tall buildings located randomly in an open space. Local streets lead to them, meandering softly through the open area between widely spaced buildings. This zone differs from the one in the eastern part of the city, described above.

In Benidorm's sea-facing panorama, the new tower dominates as the tallest building, clearly surpassing the surrounding skyscrapers. However, images of Intempo that show it as one of many buildings in intensive high-rise development do not reflect the actual situation. Analysis shows that it is situated in an area with low-density development, and partly undeveloped land.

The construction of high-rise buildings with relatively high slenderness in Benidorm is not without reason, as space-saving land use is important in this city. High buildings are erected to provide space for rest and recreation facilities within a given urban block. The permissible building volume and a design approach that produces buildings occupying as little space as possible lead to the erection of tall buildings [87], [93]. A factor influencing the shape of the skyscrapers erected in Benidorm is also their function (residential and hotel buildings) and the building plan layout. Florentino Regalado Tesoro [87] presents the plan of the aforementioned Torre Soinsa as representative of Benidorm skyscrapers – namely, not too wide and elongated. To ensure beautiful views, a significant portion of the skyscrapers in this city are set with their longer side toward the sea.

The Intempo tower is similar. It can be assumed that due to its great height and location in an area slightly elevated above the level of the coast, occupied by much lower buildings, the higher floors of the skyscraper will provide wide views of the sea.

8. The tower in the Swiss town of Vals

A rather unusual location is planned for the slender skyscraper 7132 (Fig. 11), designed by Morphosis: the mountain village of Vals in eastern Switzerland (the Canton of the Grisons). The village of Vals, stretching along a valley, is small, with about a thousand inhabitants, and is mainly known for its hot springs.

Fig. 11. Visualisation of tower 7132 in Vals, designed by Morphosis, 2015–2017. *Source*: [99]

Vals consists almost exclusively of low-rise buildings with sloping roofs, creating an atmosphere characteristic of a small mountain village. Some of its buildings are made of wood, thus referring to the construction traditions of the region. The landscape of Vals seems quite harmonious due to the similar scale of the buildings, the uniform geometry of the roofs (distinctive gable roofs, not very steep), and, for the most part, the similar direction of their ridges. In addition to a small historical church with a moderately distinguished tower compared to the surrounding buildings, several facilities higher than the typical town buildings are hotels on the road in the northern part of the valley. In 1996, thermal baths designed by Peter Zumthor were built on the neighboring slope. The minimalist thermal baths and Villa Vals (designed by SeARCH, Christian Müller Architects, 2009), hidden nearby in the mountainside, are among the hallmarks of modern European architecture [100].

The slender skyscraper 7132 is planned to be constructed next to hotels and thermal baths, also on the western side of the road and river running through the valley, in an area where the remaining buildings are almost exclusively those located on or near the main road, as well as a few free-standing buildings on a road climbing the slope. This is where Vals transitions from a mountain village with a cluster of buildings into an area dominated by nature. In this area, buildings are not very numerous, and the most conspicuous in terms of size is the complex next to the thermal baths. The nearest vicinity of the tower would consist of hotel buildings of fairly simple shapes and varying heights, with flat roofs and white-painted walls standing out against the surrounding greenery.

The building designed by Morphosis would be 408 m high [99]. With the width of the tower being about 20 m, its height would be almost twenty times greater than the width. This places the skyscraper designed in Vals among the slenderest tall buildings in the world. The lower part of the skyscraper would be a hotel, and its upper part would serve residential purposes, with a penthouse and many additional amenities for users [99].

The tower was designed on the edge of a low podium, which in large part fills the plot, and from the west, it digs into the mountainside. The "transition" from the podium to the tower is an attractive dynamic composition. The podium is tangent to one of the structures and refers to the scale of the buildings that would be next to it.

The skyscraper is presented in visualizations as a very slender and high vertical element in the landscape, set at the foot of the mountainside. The scenery is radically different from those in which we usually see high skyscrapers. The designer justifies the proposal to erect a high-rise building in the mountain valley of Vals with the following words: "Because the valley is startling and the scale is *monstrous*. That means this is not a skyscraper – it's an abstract line of translucent material, and when you factor in the scale of the site, it's minuscule. […] In a city, it'd be huge, but in this valley, it's just a small marker" [101, pp. 114, 116]. Achieving a building with such architectural features that would be almost neutral in the environment in terms of its visual impact seems a complex issue.

The design of the skyscraper in Vals can be perceived in various ways. British writer and architecture critic Owen Hatherley [102] presented it in terms of an artistic vision. The design of the tower in Vals might be judged by many as a profound interference in the natural landscape, and due to the problem of its gaining acceptance and the fact that its construction is almost unattainable – as a utopian concept. However, if we detach for a moment from justified concerns related to the introduction of high objects into the natural landscape and move the considerations to the artistic plane, we can ponder whether the elegant, very tall and slender tower with a utilitarian character displays its beauty and the advantages of modern construction engineering more in a thicket of skyscrapers or as a single object in the natural landscape.

The Vals Tower and New York's slender skyscrapers represent "different worlds." Their common feature, however, seems to be their elitism. In the case of New York's super-slender towers, their attractiveness to the user is created by the interior of the building – an appealing view and the luxurious character of the apartments. Of course, their slenderness can be impressive, but what matters above all is the tower's address and the views it can offer. In Vals, the exceptional nature of the location would be based on its uniqueness – the erection of a building of such great height in the natural landscape is unprecedented. It can be assumed that combining the values of the scenery with its high architectural quality and exclusivity would make it a prestigious building.

Table 2 presents the parameters of slender skyscrapers designed to be built and already erected in Europe.

Table 2. Slender skyscrapers designed to be built in Europe – building parameters (author's study based on: [4], [5], [63], [64], [72], [78], [79], [82], [95]–[99])

Building	Date of design and construction period	Location	Height [m]	Slenderness ratio (narrower side width/height)
Neva Tower II	designed in 2006, built between 2013 and 2020	Moscow	345	1:11.3
Capital Towers (three towers)	designed in 2016– 2020, currently under construction	Moscow	Towers: А, Б and В: 266	about 1:12*
Lilium Tower (designed by R. Meier & Partners Architects LLP)	designed in 2007	Warsaw	400	about 1:12*
the skyscraper at the corner of Aleja Jana Pawła II and Sienna Street in Warsaw (designed by Kuryłowicz & Associates)	designed in 2009	Warsaw	160	about 1:11.7*
Pin Tower	designed in 2017	Warsaw	110	about 1:12*
Beetham Tower	designed in 2003, built between 2004 and 2006	Manchester	157	1:10
211 Broad Street skyscraper	2020 – Birmingham City Council's Planning Committee approved the project	Birmingham	116.5	1:12
Costa Blanca I (Torre Soinsa)	built between 1988 and 1990	Benidorm	116.72	1:13
Torre Lúgano	built in 2008	Benidorm	158	1:10.5
Intempo	designed in 2006, built between 2007 and 2021	Benidorm	180	1:10.8
7132 Tower (7132 Hotel & Arrival)	designed in 2015–2017	Vals (Switzerland)	408	about 1:20*

* – slenderness ratio according to the author's estimations.

9. Discussion and summary

Slender skyscrapers being built in New York represent a new trend and a new stage in the development of high-rise buildings in this metropolis. The construction of slender luxury residential skyscrapers is closely related to the specificity of New York – a globally important metropolis with a unique character, which aligns with high property prices in the most prestigious locations. The current response to market demand takes the form of slender residential towers, which can be built on small areas. Their slender shape results from a combination of economic factors, specific regulations affecting building shapes (FAR and TDR), and available technical possibilities.

In Manhattan's development structure, very slender skyscrapers are another type of high-rise buildings that form densely developed urban blocks. Like most skyscrapers in this area, they are constructed among other tall buildings, but usually next to lower buildings or adjoined to them. The original proportions of New York's very slender skyscrapers are most prominently visible in the Manhattan skyline. The tallest among them stand out, reaching high above the surrounding buildings, which allows them to meet their users' expectations and provide views from great heights.

Against the background of the somewhat established trend of erecting very slender towers in New York, slender high-rise buildings in Europe, both under construction and proposed, exhibit many differences.

Skyscrapers in Europe are not constructed to surpass others and secure a unique view (though an attractive view is often used for marketing purposes by offices selling apartments in skyscrapers, it is not the primary purpose). In Europe, a prestigious location is associated not only with city centers but also with historic districts. In these areas, high-rise development is not permitted in most cities. Nevertheless, in some European cities, tall buildings are erected in central areas, usually between low buildings or in clusters of high-rise buildings, often among low-rise development.

Examples of slender skyscrapers in Europe illustrate the diversity of locations, the nature of the areas they are designed to be built in or where they have been erected, and the diversity of the buildings themselves.

In Moscow, the slender Neva Tower II was built outside the city center, in the Moscow City business center area, marking a new fragment of the urban fabric. The skyscrapers here are located quite close to each other, creating a group of high buildings distinctive among low buildings and in the city skyline. The tall buildings in the group are not very numerous, but some reach great heights (about 300 m), including Neva Tower II. The skyscraper is part of a complex of two high-rise buildings and a low-rise building connecting them, built on a fairly large plot. Neva Tower I and II, designed as a configuration of tall buildings, are different from New York's single super-slender towers.

Neva Tower I and II, with their simple forms and perpendicular arrangement to each other, together with the lower buildings of the complex, establish an open space within the triangular plot on which they are located. Their simple and slender shapes accentuate their rational arrangement and simultaneously act as a counterpoint to the various shapes of other Moscow City skyscrapers. The gigantic height of Moscow City's tallest skyscrapers and their freely shaped architectural forms are reminiscent of skyscraper groupings in Asia. As in some of them, a very slender modern high-rise building – representative of a new trend – has also found its place here.

Neva Tower II is currently the only completed skyscraper in Europe classified as a super-slender tower [4]. The construction of the Capital Towers complex in the Moscow City area is nearing completion.

A design with a real chance of being realized is the slim skyscraper in Birmingham. Planned for the central area of the city, in a zone of high buildings scattered among low-rise development, the skyscraper is to be built on a narrow plot between the low parts of neighboring skyscrapers. Together with these buildings, it will create a compact urban block with several dominating structures. The planned skyscraper has the potential to strengthen Birmingham's current image not only as another tall building forming a group in the city skyline but also as an iconic building, primarily due to its unusual proportions and originality compared to earlier skyscrapers.

The Birmingham skyscraper is much narrower than the designed very tall and slender European high-rise buildings but much lower than them. In this case, the building's shape – its slenderness – results from the very narrow shape of the plot on which the investment is planned. The designed building occupies the entire plot. This project can be seen as an effective display of the possibilities of modern high-rise construction, but also as a pragmatic solution for arranging a building on a very narrow plot, enabling the largest possible usable area. From an economic perspective, this can be viewed as the quintessence of the purposefulness of high-rise buildings, showing some similarities to high-rise buildings in central areas of American cities. The concept of a skyscraper on a narrow plot in Warsaw (Pin Tower) can be viewed similarly, where the potential of a modern, tall, and slender tower was recognized as a building that could be constructed in places where an "ordinary" skyscraper would not fit.

The concept of a skyscraper designed in the very center of Warsaw by Richard Meier was influenced by different conditions. The four-hundred-meter Lilium skyscraper was designed next to skyscrapers built many years ago, replacing the currently existing low podium of one of them. However, the distance between the designed building and the existing towers and other buildings in the surroundings would be quite significant. The scale of this building also differs from the skyscraper to be built in Birmingham and two skyscrapers designed to be erected on narrow plots in Warsaw. In a 2011 interview, the architect stated that proposing a skyscraper with as many as 121 stories was appropriate due to the environment in which the building would be located [103]. The slender shape of the skyscraper is in this case a response to the design task posed, which other well-known architects solved differently – the winning concept proposed a wider, organically-shaped tower.

It is noteworthy that the concept of the tower submitted in the Lilium Tower competition was created at a time when very slender skyscrapers began to be designed and built in New York. Due to its location in the city center, as well as the proposed proportions, height, and shape, this design may resemble the super-slender towers currently being built in New York. The Warsaw building stands out as it is located at a great distance from the neighboring buildings, which makes its design very European.

Against the backdrop of the examples of slender skyscrapers from large and medium-sized European cities, the location of a slender and very tall skyscraper designed to be built in Vals, Switzerland, is quite distinct. The four-hundred-meter-high skyscraper 7132 (designed by Morphosis) has a unique spatial context. The building was designed in a scenery quite unusual for a skyscraper – in the mountainous landscape of a small town. The proposed skyscraper is a specific design solution. However, this concept has not yet been implemented. Due to its location in a natural landscape, it can be perceived as an architectural experiment. One could say that in terms of parameters – height, slenderness, and architectural quality – the tower in Vals competes with the tallest, slimmest skyscrapers in the world, also designed by the most famous architects, but it gains its uniqueness and elitism in a different way – by being placed in a natural landscape.

The example of Spanish cities on the Mediterranean Sea shows that individual skyscrapers with fairly large slenderness have been established for a long time in some of them, but they are relatively small in scale. Benidorm has even built a modern-day slender skyscraper, quite high, but completely different from New York's pencil towers. The Intempo skyscraper was built in an open space, in an area with low-density development. There are several buildings nearby, which are lower skyscrapers, but on the remaining sides, the tower is surrounded by undeveloped land. It is a setting radically different from the urban background in which New York's super-slender towers are erected, but also very different from the areas where slender skyscrapers in other European cities are being built or designed.

Based on the fairly small number of proposals for slender skyscrapers designed in central areas of European cities, it is not possible to draw more general conclusions, but the features of the skyscrapers proposed there are nevertheless noteworthy. The skyscraper in Birmingham, as well as the skyscrapers designed by Polish architects in Warsaw, are buildings of quite great heights on a European scale (over 100 m or 150 m high), but much lower than the highest European towers, which are 200-300 m high. The skyscrapers designed in Birmingham and Warsaw are very narrow, with shapes resembling slabs set upright, unlike the slender New York towers, which most often have quite similar proportions on all sides.

For now, it is difficult to predict whether the trend of very slender tall buildings will develop in Europe or whether they will be designed and erected only sporadically. Each of the presented visions of a slender skyscraper in Europe has an individual character and a different urban environment. For this reason, and due to the fact that so far there have been few proposals for very slim skyscrapers on the European continent, it is difficult to pinpoint a specific trend. Nevertheless, the emerging examples of slender skyscrapers in Europe may testify to the emergence of the concept of a new type of skyscraper also on this continent.

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