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FREE FORMS OF EUROPEAN SKYSCRAPERS

Summary

One of the advantages of a modern skyscraper is its original form. The determinant of originality is freedom, a departure from rigid rules. The architects 'play' with the inspirations in the search for a free form, among others, by entering into dialogue with classic image of a skyscraper, which is reinterpreted or even negated. A large creative potential is associated with a way to define dependence of form and structure.

Key words: high-rise building, tall building, skyscraper, Europe, architectural icons, aesthetic expression, game of form and construction.

Introduction

Over the last 50 years, both the form of a European skyscraper and the social acceptance of such a tall building changed. Skyscrapers have become not only an integral part of the urban surrounding, but also icons of identification of some large cities. The importance of iconic architecture was appreciated after the construction of such objects as the Bilbao museum or the Kunsthaus in Graz. Developers identify the form of the building with a marketing advantage and cooperate with famous architects in order to design original high-rise buildings (Sterlitz 2005). In modern architecture, the originality is determined by the free, i.e. deviating from rules (*Słownik Języka Polskiego* 2012), form of the building. In searching for such form, architects play with inspirations: they refer to different styles and to unique local conditions.

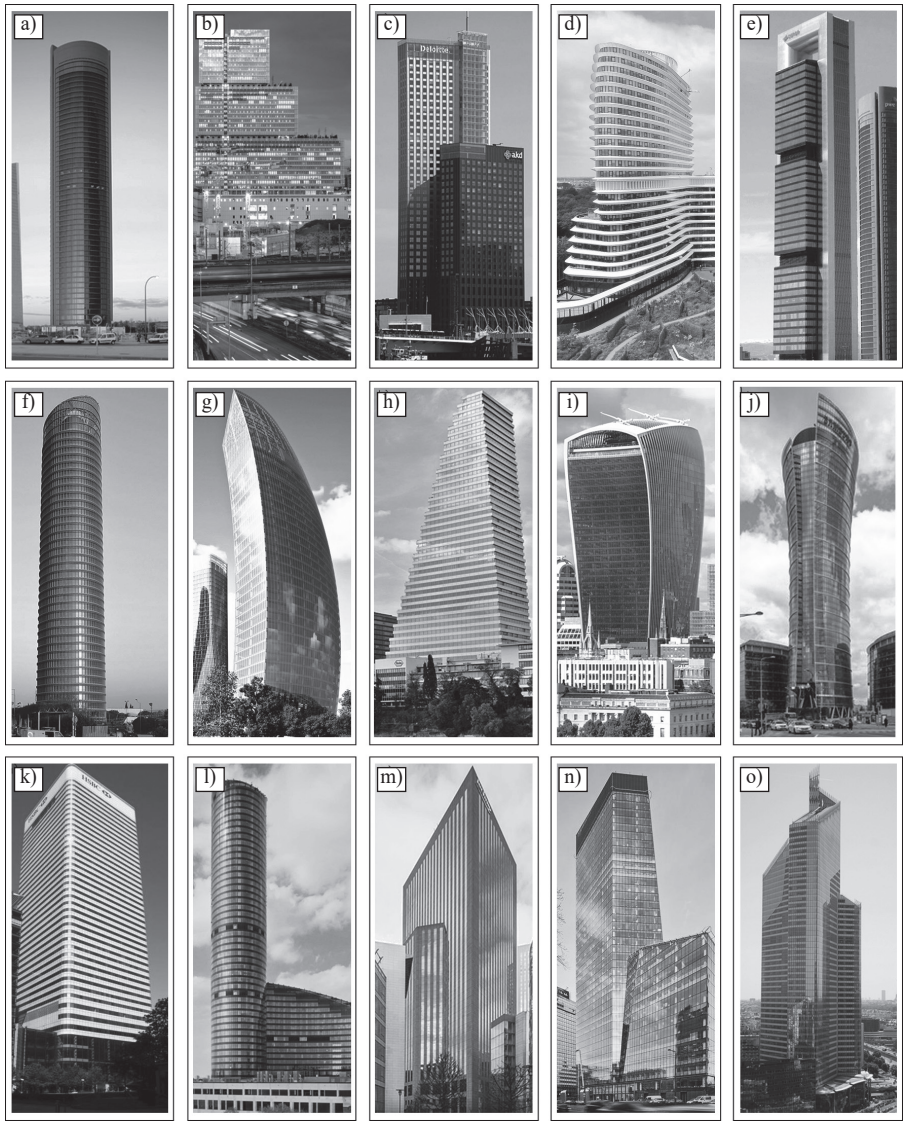
Even 25 years ago, a typical tall building would still be seen as an anonymous workplace. The latest projects are objects of public admiration, oftentimes acting as tourist attractions (Rees et al. 2013). The form of the high-rise building is mainly recognized and remembered. It should be noted that the free formation does not have to generate complex forms. A silhouette of a high-rise building can usually be reduced to a logo sketched with a few lines. Another way of the fixing specific skyscrapers in the public consciousness is giving them the unofficial names referring to their symbolic shapes, such as: The Cucumber (i.e. the skyscraper on 30 St. Mary Street in London), The Walkie-Talkie (20 Fenchurch Street building in London), The Cheese Grater (The Leadenhall Building in London), The Sail (building located on Złota 44 in Warsaw). It should also be noted that nicknaming a skyscraper is primarily fun for the recipients of architecture and the final result does not always reflect the intentions of the author.

The design rules and restrictions

The free formation of high-rise buildings is not related to unfettered creation. Significant limitations affecting, among others, the form of a skyscraper, result from the forces acting on the

Illustration 1

Forms of modern European skyscrapers: a) Torre PWC, Madrid, b) Tribunal de Paris, Paris, c) Maastoren, Rotterdam, d) EEA and Tax Offices, Groningen, e) Torre Cepsa, Madrid, f) Torre Sevilla, Sevilla, g) PWC Tower, Milano, h) Roche Turm Bau 1, Basel, i) Fenchurch Street, London, j)Warsaw Spire, Warsaw , k) 8 Canada Square, London, l) Sky Tower, Wroclaw, m) Tour Adria, Courbevoie, n) Q22, Warsaw, o) Tour First, Courbevoie



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building, as well as from the present level of technical and technological development. If you want to freely shape a skyscraper, you need to know the rules restricting this "game" first.

The possibility of free-shaping a building is strongly linked to its height, which results in the formation of increasingly complex problems. Therefore, building under 300 meters of height can be shaped freely, wherein the lower structure is, the more complex form it can have (Wood 2012). The European skyscrapers, which generally range within 150-250 meters (Pietrzak 2014), can be characterized by a great diversity of forms.

The progress in the technical field of CAD tools and analytical methods, as well as the use of contemporary mathematical language to describe architectural forms, led to the design of increasingly complex forms and spatial systems (Burry and Burry 2011). However, the impact of progressing architectural tools on changing the body formation of a high-rise building is limited. The level of advancement of technology does not allow for an unlimited freedom in shaping such large objects like skyscrapers (Johnson 2014).

The existing restrictions do not, however, affect the completion of all projects. It is possible for example to approximate curvilinear forms, which is difficult to notice by the recipient. The basic practical solutions rely on dividing curvilinear elements into straight sections, which change the angle inclination only in the nodes. The many curvilinear planes occurring in tall building projects are divided into flat, triangular or rhomboid modules. Such a feat was required, among others, the facades of skyscrapers: 30 St. Mary Axe in London, Tour D2 in Courbevoie and the Tour Pahre planned in Puteaux. Despite all the simplifications, these buildings are referred to not as polyhedra, but as having rounded, curvilinear forms.

Free form designing in contrary to tradition

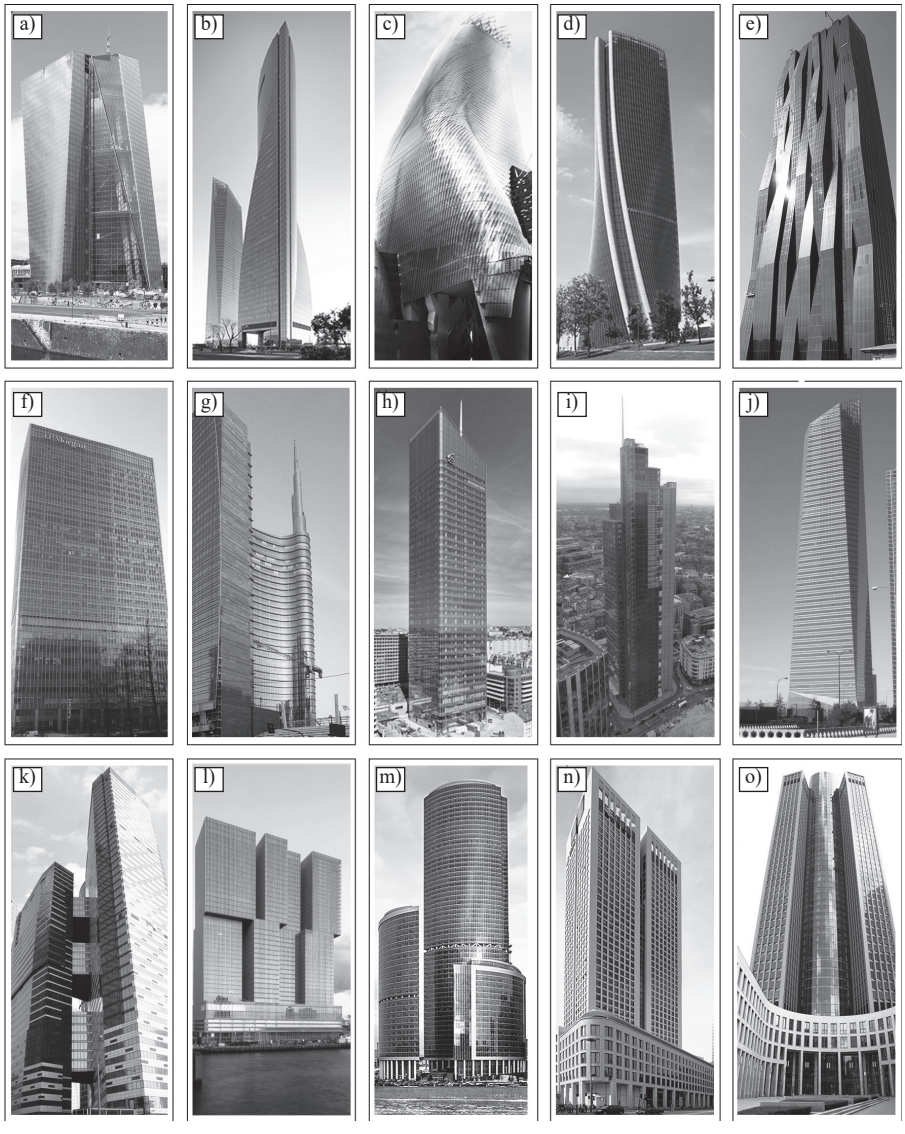
Today's iconic tall buildings often "discuss" with the classic image of the skyscraper. Free forms deviate from the rules, while the designers play with their reinterpretation or even break these rules.

The skyscrapers appeared in Europe in the mid-twentieth century in a form of straight or tapered towards the top buildings. Their form, usually cuboidal, symmetrical and static, was compact, flat-roofed or sporting a spire. Their structure was hidden in the interior, and the facades decorated the form.

Currently, the classic skyscraper proportions are distorted: very thin buildings are built (Il. 1a), as well as skyscrapers with a width similar to their height (Il. 1b). Sometimes a tall building ceases to simply constitute a compact solid, and features: a few cubes (Il. 1c), a curvilinear for (Il. 1d) or a cut out (Il. 1e). Some tall buildings instead of being straight (Il. 1f) seem to contradict the laws of gravity: they asymmetrically overhang in one direction, they lean, and even curve (Il. 1g). Aside from buildings with a repeating floor plan, there are buildings where the floor areas are reduced with every level (Il. 1h), extend (Il. 1i) or both (Il. 1j).

Illustration 2

Forms of modern European skyscrapers: a) ECB Tower, Frankfurt, b) Torre Espacio, Madrid, c) Tour Phare, Puteaux, d) Generali Tower, Milan, e) DC Tower, Vienna, f) 25 Bank Street, London, g) UniCredit Tower, Milano, h) Tour Incity, Lyon, i) 110 Bishopsgate, London, j) Torre de Crista, Madrid , k) IQ Quarter, Moscow, l) De Rotterdam, Rotterdam, m) Naberezhnaya, Moscow, Courbevoie, n) Opern Turm, Frankfurt, o) Tower 182, Frankfurt



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The contemporary free form consists in the use of both geometrical forms and organic streamlined shapes. Skyscrapers are erected based on different plans, i.e.: a square (Il. 1k), a rectangular, a circle, an ellipses (Il. 1l), a triangle (Il. 1m), a irregular polygon (Il. 1n and 1o).

The designed forms of high-rise buildings are increasingly shaped in a free manner. The sculptural forms are mostly built, resulting from the application of simple and flat elements which are tilted (Il. 2a). The design concepts also strive to shape skyscrapers on multi curvilinear basis (Il. 2b). The most original ideas, like the rippling Tour Phare (Il. 2c), however, have not yet been completed. The designers also seek a way to break with the stability of skyscraper forms, giving them a certain dynamic and a semblance of movement. Twisting the outline of the skyscraper (Il. 2d) is the most common practice. A popular solution is also to warp one or two facades, while other sides remain flat and vertical (Il. 2e).

Among the implemented European high-rise buildings, one can observe a trend towards the less frequent use of flat roofs (Il. 2f) or spires (Il. 2g, h, i). Often, for an efficient use of the prestigious space, the last floor of the skyscraper is covered with a long-span roof sporting an original shape (Il. 2j). Ground floors are also shaped in an unconventional way, which for example, no longer represent the physical space of the building. The basement levels are included in the urban space network while the designed buildings overhang above them only at higher levels (as in The Leadenhall Building in London).

In addition, the contemporary European skyscrapers are also compound building complexes, which include several towers of similar height (Il. 2l) or the main tower and one or several lower buildings (Il. 2m). Most complexes are composed of two twin towers connected by a building-platform (Il. 2k). There are also such towers, which constitute one object while seemingly forming a complex consisting of several towers (Il. 2n, o).

The game of form and load-bearing structure

In view of the fact that the skyscraper is one of the greatest engineering challenges, it has two basic elements – the spatial form and the load-bearing structure. The free formation may cover one or both of these elements. The support structures used in skyscrapers depend mainly on the height of the building. The structural system in Europe is usually designed as a classic core-and-frame structure. In the European scale skyscrapers cores are necessary to introduce and can perform the main structural role (Sarkisian, 2012).

The largest group of the European skyscrapers are objects that feature the core-and-frame structural system located inside the building. Such solutions are usually designed in a classical way and do not define the originality of the skyscraper form. Vertical shafts, with a well-defined geometry and a right-angled-based plan, are located in the central part of the floor plan.The core follows the architectural form in the traditionally shaped, geometrical skyscrapers (Il. 3a). In the case of vertical buildings with an originally shaped elevation, the core fits into the geometry of the skyscraper, allowing for a great freedom in shaping the facade (Il. 3b). The designed free

forms of contemporary high-rise buildings stand, however, in opposition to the vertical, rectangular shafts. In some cases, the dissonance between shaping core and sloping, curved forms appear to be irreconcilable (Il. 3c). In traditionally constructed skyscrapers, the columns typically offset from the façade line towards interior, so as not to interfere with elevations composition. Ultimately, the only structural element influencing the appearance of a tall building may be its ceilings, the levels of which are shown in the divisions of the façade (Il. 3d).

The second group of the European high-rise buildings are skyscrapers with visible main structural elements determining their original aesthetic appeal. In these buildings, the coherence of form and structure is the basic premise of the design, so that the free formation concerns both the body of the skyscraper and its support structure.

The elements located on the outer side of the façade are exposed the most (Il. 3e). In the case of the Intesa San Paolo skyscraper in Torino the steel mega columns are set in such a way (Il. 3f) and in the building 110 Bishopsgate in London (Il. 3g) the steel frame is exposed. Placing the core outside the utility part of a building (Il. 3h), strongly emphasizes the vertical composition. In extreme cases, the self-supporting core can be simply attached to the body of the building, without restricting the free-shaping of the skyscraper form.

Implementing a braced tube does determine the attractiveness of the form, although it is not a necessary element of design in buildings lower than 300 meters. Diagonal elements are primarily visible, which cannot be hidden in division lines of windows and ceilings. Therefore, the diagonal elements are usually strongly emphasized and exposed in a thoughtful way (Il. 3i and 3j). The buildings with a diagrid are particularly characteristic. One of the few European examples of implementing such solutions are buildings: the 30 St Mary Axe in London (Il. 3k) and the Tour D2 in Courbevoie (Il. 3l).

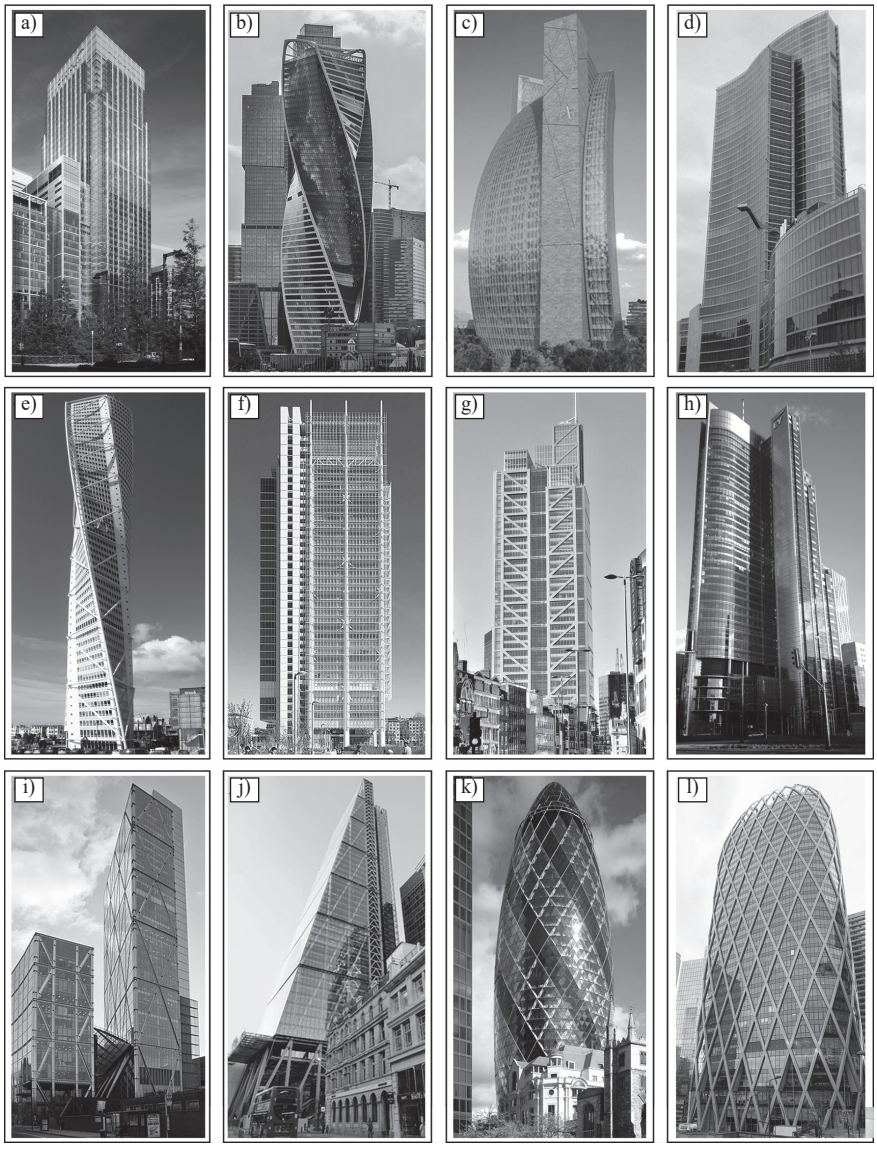
Conclusions

The most important assumption in the design of high-rise buildings is the paradigm that the skyscraper is to be formed in an original way, and its form should become a recognizable icon, a symbol of the city or a real estate market trump card. Such an assumption is also an invitation to have fun while forming a skyscraper, in order to search for a new, original architectural expression.

The heights the European skyscrapers do not pose additional structural challenges. A holistic approach to the design process also allows to use the harmony of form and structure, as a decisive factor of the skyscraper's originality. On the one hand, the traditional, centrally located core systems allow for a great freedom in shaping the facade, on the other, exposing the structure is one of the determinants of breaking with the traditional image of a high-rise building. Coherent solutions based on a consistent combination of form and support structure placed in the façade are becoming increasingly popular.

Illustration 3

Forms of modern European skyscrapers: a) 25 Canada Square, London, b) Evolution Tower, Moscow, c) PWC Tower, Milan, d) Palazzo Lombardia, Milan, e) Turning Torso, Malmö, f) Intesa San Paolo, Turin, g) 110 Bishopsgate, London, h) Rondo 1, Warsaw, i) Broadgate Tower, London, j) The Leadenhall Building, London, k) 30 St. Mary Axe, London, l) Tour D2, Courbevoie



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Numerous modern tall buildings can be described as free formed, or deviating from the classical rules. Generally it is uncommon to build cuboidal skyscrapers, with regular, repetitive floors and facades that are merely a costume of the support structure. The newest ideas of designers show that you cannot define what a skyscraper is and what it is not.

The free formation of form is associated with problems which require simple solutions and a number of simplifications. The fun with the virtual architectural form is very limited when it comes to translating that vision into possible elements to be manufactured and assembled. The level of development of construction techniques and the costs of production of personalized items do not yet allow for a free formation of such large volumes as skyscrapers.

This creative search is a challenge, but also the architects passion and entertainment. The designers continue to look for new forms in the hope that the rapid technical and technological progress will enable the implementation of further futuristic ideas.

Bibliography

Burry J., Burry M. (2011), *The new mathematics of architecture*, Thames and Hudson, London.

Johnson S. (2014), *Performative skyscraper: Tall building design now*, Balcony Press, Los Angeles.

Pietrzak J. (2014), *Kształtowanie i konstruowanie wysokiej zabudowy biurowej w Europie w XXI wieku*, (in:) Kuczera M. (red.), *Wpływ młodych naukowców na osiągnięcia polskiej nauki – V edycja: Tom 3. Materiały, Budownictwo, Architektura*, Creativetime, Kraków.

Rees P. et al. (2013), *Viewpoints: The London Conference. The special nature of the european skyscraper*, "CTBUH Journal", No. 2.

Sarkisian M. (2012), *Designing tall buildings: Structure as architecture*, Oxon: Routledge, New York,.

Słownik Języka Polskiego (2012), Wydawnictwo Naukowe PWN, Warszawa.

Sterlitz Z. (Ed.) (2005), *Tall buildings. A strategic design guide*, RIBA Publishing, London.

Wood A. (Ed.). (2013), *Best tall buildings 2011: CTBUH International Award winning projects*, CTBUH, Routledge/Taylor and Francis Group, Chicago.

(www1) http://www.eas.es/en/portfolio/otra-prueba/ [access: 15.04.2019].

(www2) https://www.archdaily.com/884074/paris-courthouse-renzo-piano-building-workshop [access: 15.04.2019].

(www3) https://en.wikipedia.org/wiki/Maastoren [access: 15.04.2019].

(www4) https://www.unstudio.com/en/page/392/education-executive-agency-tax-offices [access: 15.04.2019].

(www5) https://commons.wikimedia.org/wiki/File:Madrid_-_CTBA,_Torre_Cepsa_(Torre_Foster)_y_Torre_PwC_10.JPG [access: 15.04.2019].

(www6) http://www.wikiwand.com/en/Sevilla_Tower [access: 15.04.2019].

(www7) http://i.imgur.com/W8BKtVJ.jpg [access: 15.04.2019].

(www8) https://de.wikipedia.org/wiki/Roche-Turm_(Bau_1) [access: 15.04.2019].

(www9) https://en.wikipedia.org/wiki/File:Walkie-Talkie_-_Sept_2015.jpg [access: 15.04.2019].

(www10) http://europaproperty.com/news/2016/05/ghelamco-opens-warsaw-spire-and-celebrates -2 5-years-in-poland-2527 [access: 15.04.2019].

(www11) http://img168.echo.cx/img168/8580/image571nc.jpg [access: 15.04.2019].

(www12) https://weekendownik.blogspot.com/2017/02/sky-tower-wrocaw.html [access: 15.04.2019].

(www13) http://www.pss-archi.eu/immeubles/FR-92026-26.html [access: 15.04.2019].

(www14) http://architektura.muratorplus.pl/realizacje/wiezowiec-q22-w-warszawie_7084.html [access: 15.04.2019].

(www15) http://defense-92.fr/batiments/tour-first [access: 15.04.2019].

(www16) https://commons.wikimedia.org/wiki/File:European_Central_Bank_-_building_under _co nstruction_-_Frankfurt_-_Germany_-_13.jpg [access: 15.04.2019].

(www17) http://www.torrespacio.com/en/ [access: 15.04.2019].

(www18) https://wordlesstech.com/phare-tower/ [access: 15.04.2019].

(www19) https://en.wikipedia.org/wiki/File:Torre_Hadid.jpg [access: 15.04.2019].

(www20) https://aedesign.files.wordpress.com/2014/09/dc-tower-1.png [access: 15.04.2019].

(www21) http://www.skyscrapercenter.com/building/25-bank-street/3795 [access: 15.04.2019].

(www22) http://www.finanzaonline.com/forum/banking-carte-di-credito-conti-deposito-ecorrenti/ 1478930-ot-unicredit-tower.html [access: 15.04.2019].

(www23) http://www.aialifedesigners.fr/architectes/ [access: 15.04.2019].

(www24) http://www.skyscrapercenter.com/building/id/966 [access: 15.04.2019].

(www25) http://kapicor.pw/Torre-Espacio-in-2019-A-Building-Projects-t.html [access: 15.04.2019].

(www26) https://en.wikipedia.org/wiki/File:IQ-querter1.jpg [access: 15.04.2019].

(www27) https://i.guim.co.uk/img/static/sys-images/Arts/Arts_/Pictures/2013/11/15/1384531941121/ De-Rotterdam-009.jpg?width=300&quality=85&auto=format&fit=max&s=1dc85363d ee57c1c 91c834d384e369d5 [access: 15.04.2019].

(www28) https://megaconstrucciones.net/en/naberezhnaya-tower/ [access: 15.04.2019].

(www29) https://de.wikipedia.org/wiki/Datei:Opernturm-Frankfurt-2010-Ffm-b.jpg [access: 15.04.2019].

(www30) https://de.wikipedia.org/wiki/Datei:Tower_185.jpg [access: 15.04.2019].

(www31) https://en.phorio.com/25_canada_square,_london,_united_kingdom [access: 15.04.2019].

(www32) https://en.wikipedia.org/wiki/File:Moscow_International_Business_Center_A_02.jpg [access: 15.04.2019].

(www33) https://manoxmano.it/milano/wp-content/uploads/2014/04/il-curvo-libeskind.jpg [access: 15.04.2019].

(www34) https://en.wikipedia.org/wiki/File:Lombardia_Building,_Milan,_Italy.jpg [access: 15.04.2019].

(www35) https://makassar.terkini.id/9-bangunan-unik-desain-tingkat-dewa-dunia/turning-torso/ [access: 15.04.2019].

(www36) https://www.archdaily.com/630496/intesa-sanpaolo-office-building-renzo-piano/55529a44 e58ece8a26000016-intesa-sanpaolo-office-building-renzo-piano-photo [access: 15.04.2019].

(www37) https://en.wikipedia.org/wiki/Heron_Tower [access: 15.04.2019].

(www38)http://galeria.um.warszawa.pl/galerie/City%20Centre/900/City%20Centre%20Rondo%20 ONZ.jpg [access: 15.04.2019].

(www39) https://en.wikipedia.org/wiki/Broadgate_Tower [access: 15.04.2019].

(www40) https://www.buildingcentre.co.uk/project/leadenhall-building [access: 15.04.2019].

(www41) http://elzendaalarchitectuur.wikia.com/wiki/File:GEBOUW_1.jpg [access: 15.04.2019].
(www42) https://en.wikipedia.org/wiki/Tour_D2 [access: 15.04.2019].

SWOBODNE FORMY EUROPEJSKICH WIEŻOWCÓW

Streszczenie

Jednym z atutów współczesnego wieżowca jest oryginalna forma. Wyznacznikiem oryginalności jest swoboda, czyli odbieganie od reguł. Poszukując swobodnej formy architekci „bawią się" inspiracjami, m.in. „wchodzą" w dialog z klasycznym wyobrażeniem wieżowca, które zostaje zreinterpretowane lub wręcz zanegowane. Duży potencjał twórczy wiąże się ze sposobem zdefiniowania zależności formy i konstrukcji, która może prowadzić do wyeksponowania lub ukrycia struktury nośnej.

Słowa kluczowe: wieżowce, Europa, ikony, formy swobodne, gra formy i konstrukcji.

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