JAKUB ŚWIERZAWSKI*

‘SCIENCE-FICTION’ ARCHITECTURE RATIONAL AND INTUITIVE BASIS FOR DESIGN DECISIONS

ARCHITEKTURA “SCIENCE-FICTION”. RACJONALNE I INTUICYJNE PODSTAWY DECYZJI PROJEKTOWYCH

Abstract

Architecture is an interdisciplinary cultural phenomenon. It is influenced byscience and technology, among others, which are used in architecture in a specific way. They inspire architects with new design and execution possibilities. Because of this some structures and forms are similar to the shapes and mechanisms described by science (‘science’). Despite this, it is the architect’s intuition that underlies design decisions. J.H. Mayer’s buildings, for instance the Sarpi Border Checkpoint or the Metropol Parasol in Sevilla, show concepts of seemingly irrational forms (*fiction*). However, the introduction of a building different from the arranged urban structure can contribute additional value. It is related to prestige, social and ideological aspects. ‘Science-fiction’ architecture shows how knowledge, technology and intuition shape the creation of architecture.

Keywords: curvilinearity, architectural form, topology, digital design techniques

Streszczenie

Architektura jest interdyscyplinarnym zjawiskiem kulturowym. Wpływają na nią m.in. nauka i technologia, które w architekturze wykorzystywane są w specyficzny sposób. Inspirują architektów nowymi możliwościami projektowymi i wykonawczymi. Powoduje to, że część obiektów swoimi formami nawiązuje do kształtów i mechanizmów opisanych przez naukę („science”). Mimo to intuicja architekta leży u podstaw decyzji projektowych. Budynki J.H. Mayera, jak np. przejście graniczne w Sarpi lub Parasol w Sewilli, pokazują koncepcje pozornie nieracjonalnych form (*fiction*). Jednak wprowadzenie odmiennego od uporządkowanej struktury miejskiej budynku może wnieść wartość dodaną. Jest ona związana z prestiżem, aspektami społecznymi czy ideowymi. Architektura „science-fiction” pokazuje, jak wiedza, technologia i intuicja kształtują powstanie obiektów.

Słowa kluczowe: krzywoliniowość, forma architektoniczna, topologia, cyfrowe techniki projektowania

* Ph.D. Arch. Jakub Świerzawski, Faculty of Architecture, Civil Engineering and Applied Arts, Katowice School of Technology, jakub.swierzawski@wst.com.pl.

1. Introduction

'Wealth protects against any change, it keeps everything constant – unless someone expects a change to bring profits.'

– Martín Caparrós[1]

Architecture plays an important role in the culture of a society and the time in which it is created. It is related to the society's attitude and the prevailing Zeitgeist. Both have an impact on whether an architect's design concept is accepted or rejected. It is important to be able to properly present the concept and the symbolism, which need to be convincing. This is evident in the case of widely discussed iconic architectural projects.

A well-known example is the 2003 contest at Ground Zero in New York. Following the September 11, 2001 attacks, an architectural icon was sought. The contest was a media spectacle in which projects, their meaning and symbolism were discussed. According to Charles Jencks, the victory of Daniel Liebeskind's project was related to, among other things, the ambiguity of the concept of the project. Forms and symbols were freely interpreted by different groups in a manner which was more favourable than other competing projects[2]. The process of assigning a symbolic value to an architectural form was described by Frank Lloyd Wright, based on the example of the dome of St. Peter's Basilica in Rome: *The new church dome did not carry any meaning – it was deprived of any sense, save for that of the papal miter. However, it served perfectly as a symbol of power. The world saw it, accepted it, and adapted it as an excellent symbol of a great Power. Since then, it has become widely recognised as such (...)*[3].

The needs and dreams associated with the formation of meaningful architectural structures are sometimes ahead of technical and technological capabilities of their time. This enforces the development of new construction and building methods. On the other hand, new scientific discoveries and inventions affect artists who want to utilize them in their projects. To them, the novelty is an added value in itself. It adds innovation to their building. Although scientific discoveries don't usually come from architecture, it is the architects' creativity that uses them in design[4]. Throughout history, the search for new solutions has resulted in new approaches and characteristic elements in architecture. Contemporary references to science and discoveries are very diverse and reflect the authors' opinion on what role in society architecture should play.

To elaborate on how contemporary architects refer to science, two main approaches can be observed in the designs of architectural icons:

Explicit reference to science in search of rational project-related arguments, which this text refers to as 'Science'.

Implicit inspiration by science and technical possibilities, that results in distinctive buildings, and associates 'science-like' symbolism, is referred to as 'Fiction'.

The degree to which intuition and talent determine a project in each of the above aspects, is examined here.

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[1] M. Caparrós, *Księżyc. Od nowiu do nowiu,* Kraków, 2018, p. 76.

[2] Ch. Jencks, *The Iconic Building,* New York, 2008, p. 85.

[3] F. L. Wright, *Architektura nowoczesna. Wykłady,* Kraków, 2016, p. 219.

[4] H. Straub, *Die Geschichte der Bauingenieurkunst. Ein überblick von der Antike bis in die Neuzeit,* Basel, 1964, p. 290–291.

2. 'Science'

Modern digital techniques allow the easier use of mathematical and physical relationships in shaping a project, and executing the construction process. As a result, some structures resemble natural shapes, or use mechanisms described by scientific endeavour[5]. This is famously illustrated by 30 St Mary Axe or London City Hall, both designed by Foster & Partners. In each case, **the forms of the buildings stem from analyses and simulations of aerodynamics and sunlight exposure to minimize energy consumption**. The architects were aided by digital design techniques in shaping the geometries to optimize for these factors. **Other design decisions were secondary to computer calculations.** A similar approach can also be observed in other projects from Foster & Partners[6]. The inspiration of the architect's concept by physical phenomena, laws of nature can also be available through digital means

The National Convention Center in Doha, Qatar, by Arata Izosaki illustrates the architect's core idea **to reference the growth process of a tree**. Based on the load transfer in a living tree, an algorithm was developed. It models the growth of a tree in a digital environment adapted to load constraints required by the construction of the building. The resulting digital model of branches supporting the roof, ensures good static conditions. Arata Izosaki originally used the concept in the competition for a New Station in Florence in 2003, and came in second. He transferred the idea of a very similar tree to Qatari Doha[7]. The building was opened in 2011. The architect clearly and explicitly justified the design of the computer-generated structure with the mathematical model.

Sources of scientific inspiration for architects go beyond structural and building physics-related calculations. Some creators place mathematical patterns at the centre of their design assumptions. This can be exemplified by mathematical topologies. In mathematics, topology studies the properties preserved during a transformation of one structure into another, without cutting or breaking it apart. Distances and capacities are abstracted away from in topological transformations. Leonhard Euler's solution to the Königsberg Bridge Problem, answering the question of whether there is only one path crossing all the seven Königsberg Bridges only once, is considered a precursor of the concept of topology. To solve the problem, Euler used a graph in which land masses were nodes, and the curves connecting them were represented by paths. It was noted that the paths and diagram locations could be realigned, while maintaining the investigated properties[8]. Architectural design and urban planning use such diagrams, as they can describe the relations between space components and user activity in a building. They are independent of the form of the structure; however, some architects try to use them to shape the building appearance. According to Mark and Jane Burry, topology has become an architectural issue largely thanks to computerization, which made it possible to visualize changes in building models in real time[9].

The continuity of curved surfaces can be observed in architectural projects related to topology. The process of modelling based on topology and diagrams enables the architect to

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[5] J. Słyk, *Źródła architektury informacyjnej,* Warszawa, 2012, pp. 158–160.

[6] J. Burry, M. Burry, *The New Mathematics of Architecture,* London, 2012, pp. 123–129.

[7] T. Sakamoto, A. Ferré (ed.), *From Control to Design. Parametric/algorithmic architecture.* Barcelona: 2008, pp. 100–115.

[8] J. Burry, M. Burry, *The New… op.cit.,* pp. 156–161, 265.

[9] *Ibidem*.

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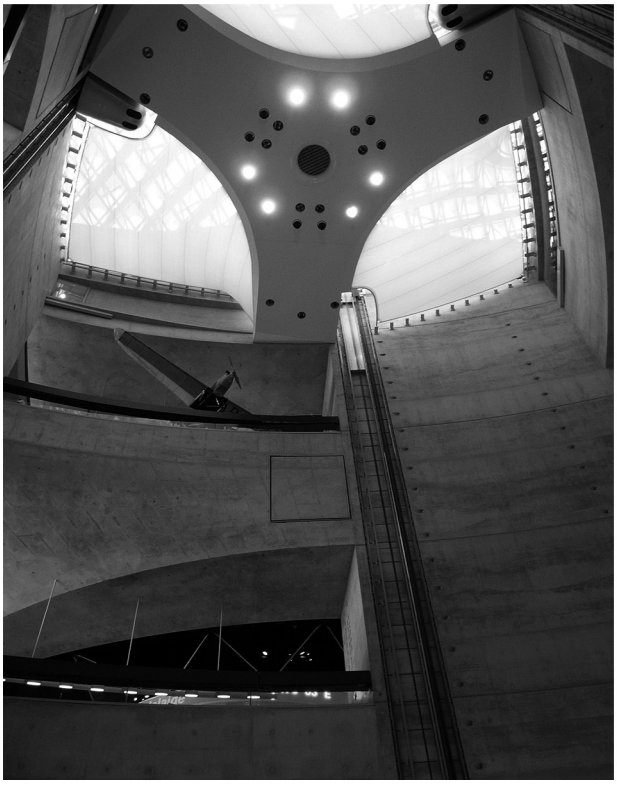

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change the geometry of the design, and adapt it to constraints without risking the integrity of the architectural concept[10].

The evolution of this approach is visible in numerous designs by UN Studio, whose architects draw inspirations from mathematical topology[11]:

Moebius House in Het Gooi, the Netherlands (1993–1998);

Arnhem Central Railway Station, the Netherlands (1996–2015);

Mercedes-Benz Museum in Stuttgart, Germany (2001–2006).

A Moebius band is a continuous, three-dimensional, endless strip with only one side that twists and winds up. UN Studio designers treated it in an abstract manner, designing the functional layout of a residential building in the Netherlands. It is focused on the 24-hour circulation of two sole inhabitants living and working in the building. They move around the working space independently, and they meet in certain rooms, for instance the living room, the dining room, or the bedroom. Also, the structure metaphorically points to the **Moebius band**, which only has one continuous boundary. The building is not hermetic, but it has one dominant perimeter with intimate zones and, owing to its form, it overlooks the surrounding nature[12].

The Arnhem Central Railway Station in the Netherlands is another example of focus on mathematical topology. The station is a central hub for local, national and international travellers. It encapsulates complex functional and utility dependencies associated with railway and coach travel, and combines them with office, commercial services and public space functions. The work on the design of the entire station area commenced in 1996 and continued for 20 years. All paths of railway, coach, taxi, car and bicycle park users cross through the most characteristic element – the Transfer Hall. It contains shops, bars and restaurants, as well. In the centre of the station, a curved, sculpted plane folds up to provide a 60-metre roof. Originally, it was designed to have been made of reinforced concrete, but the decision was changed and a steel structure was used. The architects drew inspiration from the continuous surface of the Klein bottle in which there is no distinction between the inside and the outside. Similarly, the architects wanted to blur the boundaries between the inside and the outside. The urban landscape continues seamlessly inside the building, where the ceilings, walls and floors change into one another smoothly. The organisational diagram also refers to Klein bottle topology through the diagrams showing traffic of individuals using different functions of the station.[13]

The Mercedes-Benz Museum in Stuttgart is another well-known example of topology related inspiration in architecture. Ben van Berckel, Charoline Bos and Tobias Walliser from UN Studio won the competition in 2001. They presented a project based on the transformation of

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[10] *Ibidem*.

[11] B. van Berkel, C. Bos, *UN Studio Designmodelle Architektur Urbanismus Infrastruktur*, Zürich, 2006, p. 138.

[12] J. Słyk, *Źródła architektury…, op.cit.,* p. 129–131, Burry J., Burry M.: *The New Mathematics… op.cit.,* p. 163–165.

[13] B. van Berkel, C. Bos, *UN Studio…, op.cit.,* p. 150–193, J. Burry, M. Burry, *The New Mathematics… op.cit.,* p. 166–169.

Ill. 1. The Transfer hall of the Arnhem Central Station by UN studio photo by: Michielverbeek, Wikimedia commons, CC BY-SA 4.0

Ill. 2. The atrium of the Mercedes Benz Museum by UN Studio, photo author

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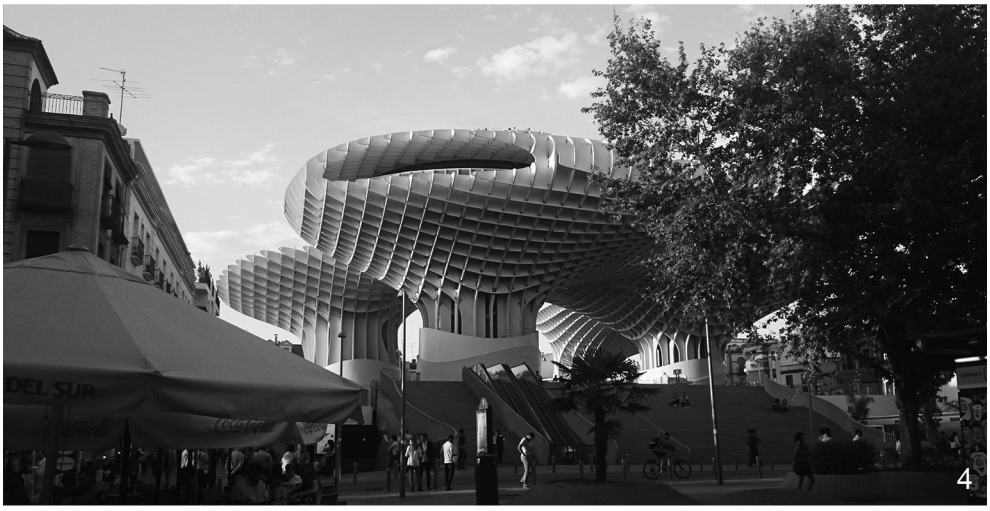

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trefoil geometry that resembles the logotype incorporated in Mercedes cars. The trefoil is the simplest non-trivial knot in Knot Theory. Non-trivial knots are curves in three-dimensional space which cannot be converted into a circle without cutting or splitting them. This inspiration is seen in the spiral arrangement of the exhibition rooms around the atrium. The scheme of visitor movement shows as a double helix around the central space, where the journey through the museum begins. A visitor is first taken in one of the atrium elevators up to the top floor where he or she starts visiting the structure and the exhibits. Moving around one of two spiral paths, visitors meet downstairs by the atrium, where they can decide on the second path to take[14].

Ben van Berckel and Charoline Bos note, that UN Studio's evolving approach to inspiration from topology is clearly seen in these three projects. In the Moebius House, they focused on converting the Moebius band. In the next project, they considered a three-dimensional version of the band, the Klein bottle, as a diagram to organise the flow of large numbers of people. Another model was a double helix, on which the geometry of the Mercedes-Benz Museum building was based.

The studio's founders describe this approach as a 'mathematical design model'; however, they note that geometries and patterns are not treated with mathematical semantic precision. They constitute an important contribution to deliberations on the form, function and/or structure of the building[15]. Other structures designed by UN Studio and incorporating this principle include the 2000–2003 Living Tomorrow Pavilion and the coffee and tea set design of 2001. Both examples involve the transformation of a Klein bottle[16]. Consequently, mathematical ideas primarily serve as a design inspiration which may be further developed owing to, among other things, the talent and the intuition of the authors themselves.

3. 'Fiction'

Some of the architects who create contemporary icons of architecture, i.e. buildings which aim to stand out from their surroundings using their form, design structures of complex shapes. An abstract approach to biological shapes as well as mathematical and physical theories is clearly visible in these structures; the created buildings have curved and/or curvilinear forms. These references are not always described by the creators and may also not always be intentional. Nevertheless, the possibility of implementing such shapes and a certain degree of acceptance in the community render such an architectonic language visible in many places around the world. This is particularly noticeable in the case of examples contrasting with their urban context.

In such cases, the architect's intuition is more clearly visible, and the shapes of the structure may seem 'irrational'. An example of such an approach is the border checkpoint between

[14] B. van Berkel, C. Bos, *UN Studio…, op.cit.,* p. 184–209, J. Słyk, *Źródła architektury…, op.cit.,* p. 62–65.
[15] B. van Berkel, C. Bos, *UN Studio… op.cit.,* p. 138.
[16] *Ibidem*, p. 164, 174.

Ill. 3. The border crossing in Sarpi in Georgia by Jürgen Mayer Architects, photo by author
Ill. 4. The Metropol Parasol by Jürgen Mayer Architects in Seville, photo Martyna Sroka (picture used with kind permission)
Ill. 5. Bálna in Budapest by ONL, photo by author

Georgia and Turkey in Sarpi. Opened in 2011, it is located on the Georgian side and was designed by the German design office of Jürgen H. Mayer. The building has **a curvilinear shape which refers to the landscape** and **the meandering road between the hills and the Black Sea.** Apart from the indispensable facilities of customs and passport control, the border checkpoint features a cafeteria and a small conference room. The most characteristic attribute is its over 40-metre-tall undulating white tower with cantilevered terraces. The unusual appearance of the building manifests its aspiration to be the country's showpiece and symbolise its rapid development[17]. The shape of the building is not dependent on computer algorithms or mathematical models, but rather related to the architect's sensitivity or vision of what a modern and distinctive border crossing should look like.

Another project by Jürgen H. Mayer – the Metropol Parasol in Seville – appears to be more closely linked with references to biology thanks to the complexity of its form. However, this is architecture designed, first and foremost, to surprise and arouse interest. The creators hope that it will entice residents to spend time in its vicinity. It is located in the historical centre of the city, near the church in the Plaza de la Encarnacíon square. The space used to be occupied by a car park, scheduled to be replaced with an underground one. When Roman archaeological findings were discovered during the excavations, the city authorities decided to give a new significance and identity to the square. In 2004, Mayer's studio won the competition for a building which was intended to become a new architectural icon of Seville. Work on the project continued until 2011. It resulted in a building with a shape resembling **conjoined trees, fungi or calicles.** This openwork structure is made from glued wood. The building sits on six massive concrete columns which support the wooden structure. The entire complex is 28 metres tall and 150 metres long. The body of the building casts a shadow on the marketplace located in the square, and the object is additionally associated with a number of functions. A museum of archaeology (designed by Felipe Palomino) is located in the underground part of the building, bars and restaurants are found on the elevated platform, and at the very top of the structure, there is a winding, 250-metre-long, path featuring a panoramic view over the city's rooftops. Jürgen Mayer has given the structure and vaults of Seville's cathedral as well as the trees growing in the square as inspiration for the umbrella form. References to biology are realised through connotations with the organic form of the building rather than the description of the architect's concept. The Metropol Parasol was implemented using digital design and construction tools which made the implementation of complicated geometry comprising diverse elements possible. The project has been praised for its bold and consistent approach and the grouping of diverse functionalities, which put together are intended to influence the activation and renewal of the square. On the other hand, the radical detachment of the form from its surroundings is also pointed out[18].

Introducing a new, soft form into a historical context and a change of identity also takes place on smaller scales. ONL, the studio of Kas Oosterhuis and Ilona Lénárd, has a reputation for extensively using computer design techniques. While creating a new cultural and commercial centre in Budapest, the designers decided to introduce an ovoid form between two historic warehouses from the nineteenth century. The complex is located at the bank of

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[17] J. Świerzawski, *Przykłady współczesnych budynków użyteczności publicznej w Gruzji,* Dokonania Młodych Naukowców No. 5, 4/2014, pp. 587–592 [cd-rom].

[18] Rowan Moore, "The Guardian" [online] https://www.theguardian.com/artanddesign/2011/mar/27/metropol-parasol-seville-mayer-review, upload: 27.03.2011, accessed: may 2018.

the Danube River near the city centre. The buildings are parallel to each other and the new geometric shape was fitted in between. The shape curves gently, **resembling a whale, hence the name of the building – Bálna, which is Hungarian for 'whale'.** It is supposed to make a reference to the flow of the Danube and create an interesting dialogue between old and new architecture. It stands out against the background of brick buildings, both thanks to its geometry and construction materials. The steel and glass structure refers to the old gable roofs on one hand, while ascending and arching on the other. Its flat glass panels are set at different angles so as to reflect different views of the surroundings. Public spaces with cafes and restaurants have been placed in front of the building. Inside, there are shops, bars, restaurants and an art gallery. The architects intended its rounded shape to be an interesting sight from different spots along the Danube, thus symbolically bringing Buda and Pest closer together. The curvilinear shape is also supposed to show the use of new technologies and to be distinctive enough to become a modern symbol of the city[19].

Conceptual connotations with nature are visible in many structures around the world. For example, the Peace Bridge in Tbilisi (2010, by aMDL) refers to aquatic animals with its shape, the L'Hemisferic Centre in the City of Arts and Sciences in Valencia (1991–2006, by Santiago Calatrava) was inspired by the shape of the human eye, while Frank Gehry often makes abstract references to the shape of the fish. Of course, such references are not scientific in nature, but rather constitute inspiration for the architects and a way to present the project to the public. An emphasis on the uniqueness of the technique and technology used for their implementation is apparent in the aforementioned projects.

4. Added value in architecture

Grzegorz Piątek in an interview with Jarsoław Trybuś, recalls the words of Halina Skibniewska on added value in architecture: *Added value, namely a thought, an additional intellectual and artisanal effort which yields innovative solutions*[20]. It should be noted that despite the broad possibilities offered by digital tools the amount of intellectual and artisanal effort to create innovative solutions is neither small nor easy. It is also evident that science and technology are used in a characteristic way in architecture. Apart from providing design tools, they are also a source of inspiration. This has an impact on the contemporary language of architecture, which creates its own abstracts based on those inspirations. From this perspective, architecture, like any other art, may demonstrate how the society relates to the laws of nature[21].

Moreover, the potential success of architecture also largely depends on how a building is received by the public. This has been pointed out by Tom Dyckhoff: (…) *the success of every architect depends in part on how his architecture is interpreted, how the 'impact' it has is understood and disseminated. An architect may intend to do one thing or another, might wish for a building to be understood in one way or another, but as soon as he leaves the construction site,*

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[19] Project description based on ONL website http://www.onl.eu/projects/b%C3%A1lna-budapest accessed May 2018 and authors own *in situ* studies, July 2017.

[20] G. Piątek, J. Trybuś, *Lukier i mięso. Wokół architektury w Polsce po 1989 roku. Rozmawia Marcin Kwietowicz,* Warszawa 2015, p. 34.

[21] Ch. Jencks, *The Iconic.. op.cit.,* p. 209

the building no longer belongs to him. It belongs to us[22]. The ways architecture is being created are changing at the same time with the trend of its reception and understanding. Buildings are instantly described, commented upon and shared on architectural web portals as well as social media. This means that regardless of building parameters, the architecture of iconic buildings requires a certain story – a fiction which will persuade the public to the concept.

The aforementioned distinction between 'Science' and 'Fiction' is not clear-cut. It is not science that constitutes the first impulse to design a form, but rather the architect and his knowledge, experience and dreams. Nonetheless digital tools allow a wider use of optimization techniques in design and construction. In each of these approaches, the added value is related to the prestige associated with digital techniques and technology, ideological or social aspects. References to science, soft and 'biological' shapes, influence the contemporary language of architecture. It is evident that scientific discoveries, new capabilities of digital tools, and human talent and intuition are synergistic in the search for new architectural solutions.

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[13] Wright F. L., *Architektura nowoczesna. Wykłady*, Karakter, Kraków, 2016.

[22] T. Dyckhoff, *Epoka spektaklu. Perypetie architektury i miasta XXI wieku*, Kraków, 2018, p. 366.