ARCHITECTURE CIVIL ENGINEERING ENVIRONMENT
The Silesian University of Technology No. 2/2017

A NON-LINEAR SHAPED ARCHITECTURE IN URBAN SPACE

Krystyna JANUSZKIEWICZ [a], Karol G. KOWALSKI [b]

[a] Associate Prof. DSc PhD Eng.; Arch. Krystyna Januszkiewicz; Department of Civil Engineering and Architecture, West Pomeranian University of Technology in Szczecin, 50 Piastów Ave., 70-311 Szczecin
E-mail address: *krystyna_januszkiewicz@wp.pl*

[b] MSc Eng. Arch. (PhD Study); Karol G. Kowalski; Department of Civil Engineering and Architecture, West Pomeranian University of Technology in Szczecin, 50 Piastów Ave., 70-311 Szczecin
E-mail address: *karol.g.kowalski@gmail.com*

Received: 25.05.2016; Revised: 6.09.2016; Accepted:29.04.2017

Abstract
The paper deals with the modernization and adaptation to the new features of existing objects in the urban fabric. In the twenty-first century the digital design tools, which are interfaced with the production of computer technology, have opened the new opportunities that not only are shaping the architectural objects, but also interferencing in the buildings' structures. The selected objects are examined, which have been implemented in the European cities centers, and the new design approaches, which are taken to induce the new strong interactive effects, are indicated. The analyzed objects are: the Extention of German Historical Museum (1997–2004) in Berlin, the Weltstadthaus (2003–2005) in Cologne, the King Cross Station (2005–2012) in London, the Palazzo Unione Militare (2010–2013) in Rome, the headquarters of the Pathé Foundation (2006–2014) in Paris. Each of the enumerated examples shows a diverse approach to designing, and what combines them is the use of the digital tools especially the topological ones in the constructing the parametric forms, which reflect the age of digital technologies and the information society.

Streszczenie
Opracowanie obejmuje zagadnienia dotyczące modernizacji i adaptacji do nowych funkcji obiektów istniejących w tkance miejskiej. W XXI w. cyfrowe narzędzia projektowania, sprzęgnięte z komputerową technologią produkcji otwarły nowe możliwości nie tylko kształtowania obiektów architektonicznych ale także ingerencji w zastane struktury budowlane. Rozpatruje się wybrane obiekty zrealizowane w centrach miastach europejskich wskazując na nowe podejście projektowe podejmowane w celu wywoływania nowych efektów o silnym oddziaływaniu. Chodzi tu o obiekty takie jak Rozbudowa Niemieckiego Muzeum Historycznego (1997–2004) w Berlinie, Weltstadthaus (2003–2005) w Kolonii, King Cross Station (2005–2012) w Londynie, Palazzo Unione Militare (2010–2013) w Rzymie, siedziba fundacji Pathé (2006–2014) w Paryżu. Każdy z przedstawionych przykładów przedstawia inne podejście do projektowe, a to co jej łączy to wykorzystywanie cyfrowych narzędzi zwłaszcza topologicznych w projektowaniu form będących wyrazem epoki technologii cyfrowych i społeczeństwa informacyjnego.

Keywords: **Non-linear shaped architecture; Digital design; Engineering; Inner city; Urban fabric.**

1. INTRODUCTION

In the twenty-first century the digital design tools, which coupled with the computer technology production, have opened new possibilities, not just in shaping the architectural structures, but also interferencing with the existing building structure. The curvilinear architecture of free geometry has already been implemented in various places in the world and is becoming

increasingly popular due to the rapid development of robotics and CAD/CAM technology. The digital design tools based on the NURBS curves and surfaces have released the architects' imagination from the simply drown forms. Nowadays Descartes' geometry and the conventional Euclidean language are rejected. The new language of curvilinear forms, or language called "morphic", which is talking about the tough substances and liquids, replaces them. The new forms have been already visible even in the historical area of cities.

2. PERMANENCE AND CONTINUATION

In 21st century people are becoming more aware of the relationships between the built environment and their physical and psychological well-being. This has encouraged numerous studies in the field of environment and behavior, and effects of architecture, urban design and architectural form on human response. In the realm of architectural form, some professionals, from "signature" architects to environmental and organic designers, are strong advocates of free-flowing curvilinear forms. They assume that the use of curvilinear forms is sympathetic to the body, mind and spirit, although there is little empirical research to confirm this claim.

Published by Architectural Design in 1993 essay *Architecture Curvilinearity: The Folded, the Pliant, and the Supple* written by Greg Lynn is still the canonical position for the twenty-first century architectural theory, dominated by the digital design tools and manufacturing [1]. It was the first attempt discourse of architectural theory position of curvilinearity in architecture, designed in the digital topological areas. In this reading Greg Lynn begins Architectural Curvilinearity by discussing how contradictions in form have been represented in architecture over the past decade, and follows up with the development of complex design. With this development of complex design he has observed two paths that are typically taken: conflict/contradiction and unity/reconstruction. However, another path is coming to the forefront that involves a smoothness that steers away from these other methods. This smoothness is obtained by mixing different elements together that work together to create the smooth or pliant form. Pliancy depends upon alliances with all other elements involved (whatever they may be), both internal and external. The third element of this method of design is folding. Folding involves mixing unrelated elements together to create one continuous mixture. The elements within the mixture are still intact in and to themselves yet integrated to form a cohesive element. One way to achieve pliancy is through viscosity. A good example of viscosity is hot lava flowing through the path of least resistance while picking things up that are in its path. Where the form is contradictory it is further designed using continuous, flexible systems. This type of architecture is typically cited where other buildings are posing a contradictory, conflicting, and discontinuous identity. Greg Lynn's essay provides a basis to agree that "curvelinearity cemented the shift in architectural thought by identifying and highlighting this new architecture of smoothness" [1].

However, does this judgment authorize the introduction of curvilinear topological forms to a historical context of architectural and urban planning?

The publication of Lynn's essay in Architectural Design coincided with the extension of the Waterloo Station in London (Fig. 1), located in the historically stratified city tissue. The canopy platforms 400 m long smoothly pushed into the dense buildings. Nicholas Grimshaw, in preparing the geometry of the

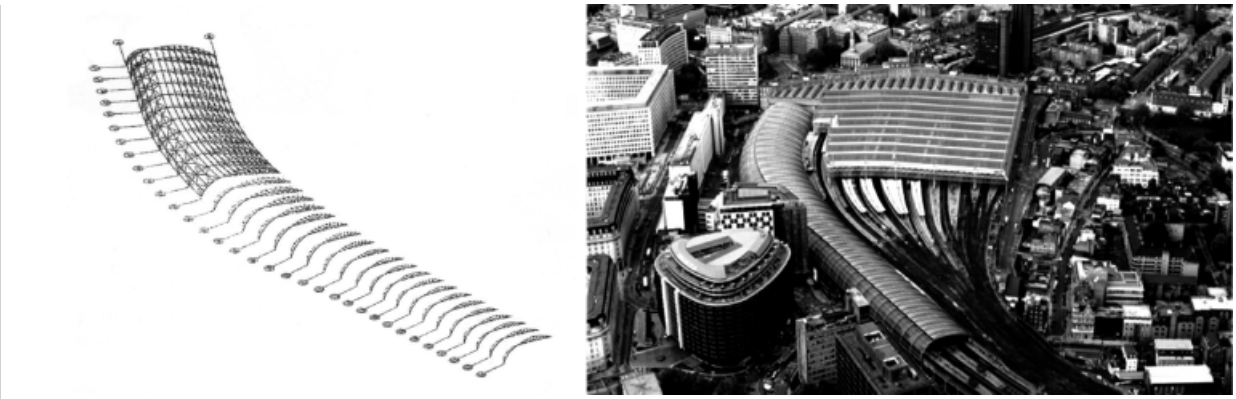

Figure 1.
Nicolas Grimshaw, Waterloo International Terminal, London, 1989–1993

roof covering applied the parametric model. Soon, after Grimshaw went Norman Foster, and other well-known designers.

For centuries, architect was seen not only as a master of spatial effects, but also as the knowledgeable construction techniques builder, solving problems of the construction and material. It was not until the discovery of the linear perspective in the Renaissance led the designer to the gradual drifting from the implementation. The architectural design became the domain of art, and hence architects and artists were separated from the builders and craftsmen. For several centuries, mainly theory was the driving force for architecture, rather than the practical design knowledge [2].

The advance in the digital technology facilitating design (CAD) and manufacturing (CAM) has integrated the practice of erecting buildings with their design. There was a direct relationship between the creative idea and what can be realistically built. IT processes not only generate projects today, but also implement them through the digital "files to factory" which are formatted according to the requirements of the CNC manufacturing technology. The coherent systems (CAD/CAM/CAE) permit for such development of the project documentation, which provides the desired, in terms of the shape and size, material processing its elements, and occasionally assemblies *in situ*. Architects, drawing complex curvilinear forms, are immediately drawn into the process of their manufacture [3]. In this respect, there has been a return to history but in a different technological conditions.

The continuous curved surfaces, which characterized today's architecture, address the problem of how to deal with the spatial and tectonic consequences of so geometrically complex shapes. Giving credibility to the spatial complexity is solving with the problems in material and workmanship.

The topology is attractive for designers because of the easiness of forming arbitrarily complex geometric forms. Important is the structure primacy of the same links, reciprocal engagement of suitable itself features inside and outside the context of the proposed facility. Indeed, all the forms and transformations features may be taken into account. Structures, or topological spaces, due to their metric properties, can be an active partner in building and designing the space in which the form can be defined and modeled according to the needs [3].

Currently produced in the urban tissue with the historical origin free forms are an expression of the technological development and awareness of the information society era. The most spectacular example of this is the Kunsthaus Graz (2000–2003) where Cook and Fournier synthesize the innovative language of the form in the context of the old city of Graz saturated baroque architecture. The baroque architects also evinced predilection for the curved surfaces, lines and edges that resulted from the dynamics exploration and motion what have become a characteristic feature of this period in the art and culture development. At the end of the free composition era, curved braided lines and asymmetry in the most daring materialize in the rococo interior design. Secession also gave priority to wavy lines, but without the references to the past, proclaiming a break with the eclectic historicism nineteenth century. Today the projects of Antonio Gaudi impress with the use of parametric examplars to develop models that were subject to the analog calculations. What does distinguish the curvilinear architecture from the previous achievements?

Not without a reason, therefore, Gilles Deleuze in his book *Le Pli*. *Leibniz et le baroque*, which was published in 1988, predicted an inevitable shift towards the curvilinearity in various art genres [4]. For Deleuze *le pli* (a fold) is the principle of the world construction leading directly to the notion of the continuity, nowadays so eagerly used by architects. The continuity is included in the definition of *le pli* and is to be understood not as the straightforwardness, but on the contrary, the curved maze of the continuity. It is assumed that there are no breaks, fractures tears in the matter world that in the immaterial level means there is no conflict and contradiction. The labyrinth of matter continuity corresponds in Deleuze with the labyrinth of continuity in man's soul, which was the Leibniz's idea. The two floors communicate because "continuity of matter rises soul" to the next level. And on the curtain stretched between the levels the fold are constituted, like the skin on the body [4]. It is a great baroque installation, which Leibniz creates between the lower level of windows and the higher one, blind and closed but in return intelligent as the music room, which translates the sound movement visible below. A few years later, this discourse takes Jeffrey Krausse who sees the fold as "something more than the surface" because it has the energy potential and like the skin on the body responds to the internal organism stimuli and the external environmental influences [5]. Just as cited by Deleuze, the Leibniz's description, the architecture can be understood as "skin matter", tense on the immaterial

body of internal program events, economic, institutional, and through the "window to the outside", (understood as the contact with the outside), responsive the environment [4].

So does the new curvilinear architecture stand in opposition to the stylistic stratums occurring in the structure of numerous cities?

3. THE POTENTIALITY OF ADAPTATIVE FORMS

In urban structures the adaptability of curvilinear forms is being checked. As their spatial and aesthetic values correlate with the previously used architectural practice. They point out objects, such as: *The Extension of the German Historical Museum* in Berlin, *Weltstadthaus* in Cologne, *Western Range King Cross Station* in London, *the Palazzo Unione Militare* in Rome, the headquarters of the Pathé Foundation. Each of them represents a different approach, and what connects them is the use of the digital design tools based on the NURBS curves and surfaces and parametric curved surface structuring techniques.

Are the smooth continuous surfaces of topological architecture able to sign up to the existing building context, and also ameliorate existing spatial conflicts, functional and aesthetic, which are often built up over the centuries?

Figure 2.
Cezar Peii, Extention of German Historical Museum, Berlin; 1997–2004

A well-known example may be the expansion of the German Historical Museum (1997–2004) in Berlin (Fig. 2). Caesar Peii cleverly increased the baroque Zeughaus built in 1695 by introducing new exhibition rooms below the ground level. The curved glass wall on the arch leads from the Neue Wache to the entrance. Instead of a corner was a small tower accented with the glass panes with the avaried curvature. The large glass used on the curved surfaces, was made by the company Tambest Oy in Finland, specializing in the glass production for molds with the complex geometry. Developed and taut on the steel skeleton transparent "skin matter" is the Liebniz's curtain between the levels – the higher for the arts and the lower for the road users. The glass scroll is rolled up and uplifted encouraging to enter. Despite the baroque idea a new aesthetic quality was introduced resulting from the form, material and technology and in the opposition to the baroque style of the existing building and its context. New spatial conflicts were not created with the benefit to the urban public space.

Another example is the department store *Weltstadthaus* in the center of Cologne (2003–2005) which was designed by Renzo Piano. It is the object of double curvature surface, which responses to changes in the environment (Fig. 3).

The form is the result of research adaptability. The contact with the past eras of architecture, establishes a relationship between the object and the existing urban fabric, which was destroyed during the World War II. The path with the direction of the mold is appointed, where the continuity and flexibility are the results of the surface computational relationship for the structure, function and form.

Weltstadthaus curvilinear architecture redefines not only the conceptual side, but also the building perception as being per se. There is no developed in the past

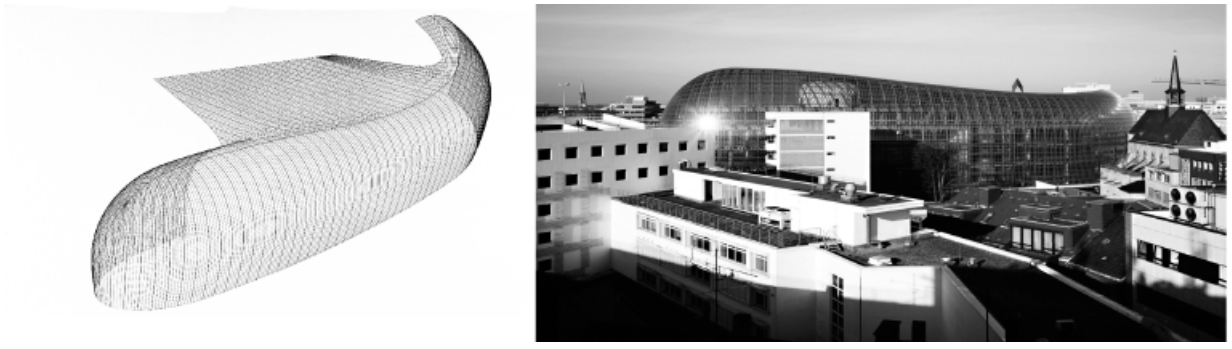

Figure 3.
Renzo Piano, Weltstadthaus, Cologne, 2003–2005; Photo: Andreas Fechner

facade with its right articulation. It is divided through a sequence of parametric equations, determining the wooden ribs spacing of the individual curvature. These are mounted on the glass panels, each with a different curvature, and from the inside the shading system and sensors to the facade able to react to the sun's path, and also the rainwater is collected [6].

Figure 4.
John McAslan + Partners, Arup, Western Range King's Cross Station, Londyn, 2005–2012; Photo:. Hufton and Crow

Extension of *Western Range King's Cross Station* (2005–2012) in the center of London is also looking for new relationships in the existing urban fabric but with the preserved historic substance (Fig. 4). The station was opened in 1852, and for 1972 it was the largest interchange station in London, which arose in the vicinity of many hotels and service areas saturating stylistically complex urban fabric of buildings. The city growing transport needs forced to increase constantly for another platforms. Currently station supports 11 platforms, of which 8 are located in the "old" building. The new concourse is a lattice structure which, as the half open umbrella, is adjacent to the eastern facade of the "old" station. Its maximum length is 150 m and reaches a height of 22 m and is partially covered with aluminum. Form was entered between existing buildings hotel and service of historicizing and modernist style. Undoubtedly, it refers to the first structures designed in parametric digital spaces such as overlap the Great Court at the British Museum, London and the courtyard at the Smithsonian Hall (2004–2007) in Washington, designed by Norman Foster. These pioneering structure showed how to integrate space of historical features into new functional areas. They are like Leibniz wants, "strained to immaterial internal body program events" [4].

The loss of the authentic substance causes the loss of monuments essential features, being the carrier of intangible assets and "the most important characteristics of matter is a form, texture and color, shaped by the creator and time" [7]. A special case is a trade house Benetton in the historic center of Rome, which occupies an eclectic tenement Unione Military Palazzo, which was built in the seventeenth century, at the intersection of Via del Corso and Via Tomacelli.

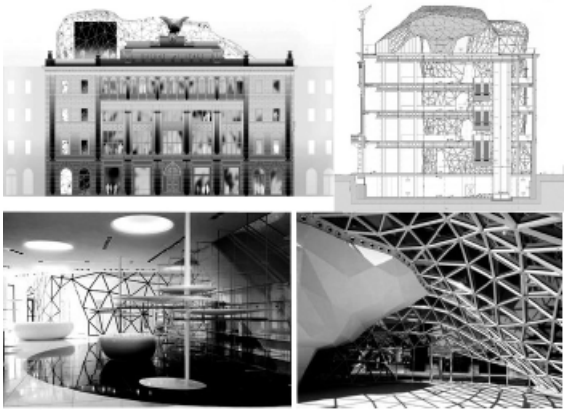

Figure 5.
Massimiliano and Doriana Fuksas, the Palazzo Unione Militare redevelopment, Roma, 2010–2013
Photo: Massimiliano Fuksas Architetto

The controversial redevelopment project was made according to the Massymiliano Fuksas design. It was a courageous decision to leave the only existing building facades and its interior adapted to the modern commercial needs and representation. The light rising towards the top structure penetrates tenement housing a staircase with two lifts, which are moving onto the roof of the freely formed covering uplifting to a height of 7.50 m. There is a restaurant with a terrace overlooking the renaissance and baroque architecture of Basilica of St. Ambrose and the church of San Carlo al Corso. After dark house is like an enormous lantern, for permeated by its interior structure is filled with light. The façade of the illuminated spot and linearly so as to bring out its articulation (pilasters and rusticated window frames). The lighting game is only a curtain behind which hides the scenery forms and colors. The interiors are organizing refined in the shape of furniture, mirrors, stairs and cabinets made of glass, all lit with LED [8].

Reconstruction of Palazzo Unione Militare is a controversial approach to substance and value of the monument. Is it not, however, return to practices that were common before the advent of conservators. In

every age architectural objects were renovated and rebuilt in accordance with prevailing during the period principles and views. This was done with a great deal of discretion in the use of materials and spatial solutions. After the adoption of the Venice Card (1964) it is generally believed that the preservation of the authentic, original material is critical to maintain the value held by the monument. How far did Palazzo Unione Military therefore lose its authenticity, and how much did building gain in terms of its attractiveness utility and aesthetic? Answering these questions will probably require multi-threaded discussions and references to the unprecedented reconstruction of the Reichstag (1992–1999) adapting to the needs of the German Parliament.

Analyzing the new Paris headquarters of the Pathé Foundation (2006–2014), which was opened in 2014, you can ask about the ethical order of "the good continuation" which often determines the interference in the antique structure. The construction was preceded by the demolition of two buildings in one of the courtyards of the Paris XIII district. Since the mid-nineteenth century there was a theater which in 1900 was transformed into one of the first Paris cinema.

Demolitions were necessary and slightly contributed to the reduction of the constraints arising from the specific nature of the irregular and narrow courtyard surrounded by the historic buildings. The design work that was given to the architect Renzo Piano abounded in the series of experiments (Fig. 6). The experiments took into account the heterogeneity of the existing buildings and made a soft and amorphous object. The project initially was made in the Rhinoceros program from which a 3D model was exported to DXF 3D format, and then was imported to the Advance Design program in order to model the complex geometry of the building coating.

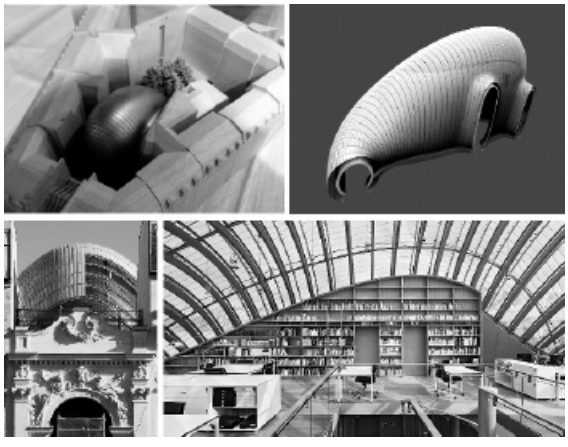

Figure 6.
Renzo Piano, The Pathé Foundation, Paris, 2006–2014
Photo: Renzo Piano Workshop

Is this building, whose volume seems to float inside the courtyard, an example of a good continuation? Is it only a testimony of the digital technology era with the imperative of the sustainable development and care for the planet? The maintenance of the sufficient distance between the new object and the existing houses, and its double curvature improved airflow inside the courtyard, and the lowest levels of existing tenements gained a better light, which would not be possible in the case of Euclidean geometry object. The headquarters of the Pathé Foundation is energy efficient not only by the efficient use of sunlight, but also by the fact that premises are equipped with a system crossventilation based on the night ventilation system (air conditioning is used only in the hottest days of the year). It should be emphasized that the geometric shape of the object, algorithmically generated by a computer, is important to forms and engineering calculations were determined by the function [9].

Without a doubt, more perfect digital design tools have extended the exploration field of solutions for architecture and engineering drawing attention to the environmentally efficient solutions forcing a different kind of behavior. The adaptive potential of new forms especially in the tissue of historical cities can thus be placed not only in creating a higher level of behavior but also in the area of user activity, residents or tourists. It can also provide new sensations and aesthetic inspiration. It is not just about the renovation, so that only overcome the erosion and recapitalization facility. It is important to give a new quality while conscious shaping of the mold.

4. CONCLUSIONS

Now almost 20 years old, the digital turn in architecture has already gone through several stages and phases – from folding to cyberspace, nonlinearity and hypersurfaces, from versioning to scripting, emergence, information modeling and parametricism. It has recorded and interpreted the spirit of the times with vivid documentary precision, fostering and often anticipating crucial architectural and theoretical developments. At the second decade of 21st century the new shapes and forms are created by IT processes based on the concepts such as the topological space, the surface isomorphic, dynamic and animation systems, parametric design and genetic algorithms. It opened into the new territories for the study of the cognitive form, its tectonics and space,

changing the existing axioms design. The blurred division between architects and designers. Today, this specific symptom returns to the past, to the ancient practice of building and has numerous implications.

We are witnessing a development of a new kind of tectonics expressing the structure potential through the advanced geometry and techno-logical capabilities, which puts in another, than ever before, light the tectonics' aspect in architecture. On the contrary, attempts of orchestration technologies are being made in order to develop the technological strategy of the unifying "old" material reality and "new" forms that build the twenty-first century cultural symbolism. They produce the new heterogeneous and interactive zones of human experience as the Kunsthaus in Graz, usually depicted and discussed object in the context of the role of the digital technologies and the new media in shaping architecture. Presented examples, though less spectacular, show other ways of introducing the innovative formal language in the historical context for urban forms that correspond to the artistic consciousness and the attitude of information and digital technologies era.

REFERENCES

[1] Lynn G. (1993). Architecture Curvilinearity: The Folded, the Pliant, and the Supple. *AD 63*(3–4), 9–15.

[2] Kolarevic B. (ed.). (2012). Architecture in the Digital Age: Design and Manufacturing, Talyor&Francis, New York.

[3] Januszkiewicz K. (2010). O projektowaniu architektury w dobie narzędzi cyfrowych. Stan aktualny i perspektywy rozwoju (On designing Architecture in the age of Digital Tools. Current status and development prospects, Oficyna Wyd. PWr, Wrocław.

[4] Deleuze G. (1988). Le Pli. Leibniz et le baroque, (The Fold. Leibniz and the Baroque). Editians de Minuit, Paris.

[5] Krausse J. (1996). Information, Folding in Architecture. *ARCH 4*, 74.

[6] Januszkiewicz K. (2012). Architektura performatywna w Kolonii (Performative Architecture in Cologne). *AV* 2, 32–45.

[7] Karta Wenecka (Międzynarodowy Kongres Architektów i Techników Zabytków) Venice Charter (International Congress of Architects and Technicians of Historical Monuments), Wenecja, 1964, Dokument 1 – Międzynarodowa karta konserwacji i restauracji zabytków i miejsc zabytkowych (Document 1 – International card conservation and restoration of monuments and sites).

[8] Kowalski K. G. (2014). Reconstruction Palazzo Unione Militare, *AV 4*, 6–45.

[9] Lotta S-J. A. (2014). RPBW: Foundation Pathé, Domus, digital edition, July, unp.