

BŁAŻEJ CIARKOWSKI*

RATIONALITY, UTILITY, DURABILITY. REINFORCED CONCRETE THIN-SHELL STRUCTURES

RACJONALNOŚĆ, UŻYTECZNOŚĆ, TRWAŁOŚĆ. ŻELBETOWE KONSTRUKCJE ŁUPINOWE¹

Abstract

The reinforced concrete thin-shell structures of late modernism are an example of multidimensional architecture that cannot be unequivocally defined. They are an emanation of the classical triad of Vitruvian principles of good architecture – beauty, convenience, and durability, but also the rationality of design. At the same time those strongly individualized, expressive, sculpturelike forms are, in their own way, “irrational”. Their symbolic meaning combines a social-political context and the metaphor of dynamics and development. Nowadays, a crucial aspect of their preservation is the issue of social awareness related to the historical importance and timelessness of architectural rationalism.

Keywords: post-war modernism, thin-shell structures, innovaconcrete, concrete-based architecture

Streszczenie

Późnomodernistyczne konstrukcje łupinowe są przykładem architektury wielowymiarowej, wymykającej się jednoznacznym definicjom. Stanowią emanację klasycznej triady witruwiańskich pojęć definiujących dzieło architektury – piękno, użyteczność, trwałość, a także projektową racjonalność. Jednocześnie silnie zindywidualizowane, ekspresyjne, rzeźbiarskie formy są na swój sposób „nieracjonalne”. Ich wymowa symboliczna łączy kontekst polityczno-społeczny oraz metaforę dynamiki i rozwoju. Dziś kluczowe w procesie zachowania obiektów staje się pytanie o ich społeczną recepcję związaną z historycznym znaczeniem oraz ponadczasowością architektonicznego racjonalizmu.

Słowa kluczowe: powojenny modernizm, konstrukcje łupinowe, innovaconcrete, architektura betonowa

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* Ph.D. Arch. Błażej Ciarkowski, Institute of Architecture and Urban Planning, Faculty of Civil Engineering, Architecture and Environmental Engineering, Lodz University of Technology / Department of History of Art, Faculty of Philosophy and History, University of Lodz, b.ciarkowski@gmail.com.

Arthur Veirendeel, the Belgian engineer born in the mid-19th century, claimed that the beauty of architecture is a result of harmonious construction and that the noble proportions are the result of the technology chosen by the architects. At the same time he emphasized that the rationality of structural solutions should comply with the aesthetics in certain situations². The practice of rationalism in designing can be defined in many different ways: as a Vitruvian principle of decorum, a modernist adjustment of form, construction and function, or some economic reasons for the architectural solutions chosen. Therefore, is rationalism in architecture an unequivocal criterion which provokes no doubts?

The aim of the paper is to analyse the importance of modernist thin-shell structures in the light of the idea of rationalist architectural design and its contemporary intuitive reception. The subject of the analysis were buildings raised after the World War II in Central and Eastern Europe, with specific attention to the Warsaw Cross-City Line train stations designed by Arseniusz Romanowicz and Piotr Szymaniak.

1. Rationalism and modernism

In the 1920s, Dutch architect Adolf Behne distinguished two main currents of modern architecture: rationalism and functionalism³. The first included those buildings which, according to Behne, had a structure flexible enough to accommodate different functions over the years. On the opposite side there were objects classified as the second group. These buildings were designed according to the idea of Louis Sullivan, as their form was a direct result of their functional program. Thanks to this they almost perfectly matched their particular function, although their ability to be adapted was limited.

Przemysław Trzeciak stated that the architecture of radical functionalism rather rejected the presence of symbolic meaning, although people naturally pretended to search for them⁴. The author of *History, psychics, architecture (Historia, psychika, architektura)* referred to Carl Gustav Jung, who had noticed that rational functions – due to their characteristics – are not able to create symbols⁵. *It appears that the connection between the works of the modernist avant-garde (...) and symbols, is possible only in reception, not creation*, wrote Trzeciak⁶. At the same time, one cannot omit that the new era, despite the subordination to rationalism, had a strong need to develop its own symbolization which would be appropriate to its times and different than the preceding one. The issue was a concern of post-war modernist architects, but it appeared in the mid-19th century and was related to the growing popularity of new building technologies.

Undoubtedly the Saint Genevieve Library in Paris, designed by Henri Labrouste and completed in 1850, was a project of crucial importance. For the first time a contemporary iron

² J. Wesołowski, *Od wozowni do katedry. Hala peronowa w architekturze dworców*, Tom 2, Łódź 201, p. 139–140.

³ W. De Jonge, *The Technology of Change: The Van Nelle Factories in Transition*, [in:] *Back from Utopia. The Challenge of the Modern Movement*, ed. H.-J. Henket, H. Heynen, Rotterdam 2002, p. 46–47.

⁴ P. Trzeciak, *Historia, psychika, architektura*, Warszawa 1988, p. 139.

⁵ C.G. Jung, *Archetypy i symbole*, p. 327, for: P. Trzeciak, *Historia, psychika...*, *op.cit.*, p. 139.

⁶ *Ibidem*, p. 141

structure was materialised in the form of a public building⁷. The creator of the building stated that the durability of architecture was dependent on the method of conjunction of materials, rather than their substance⁸. Similar theories were promoted by Eugene-Emmanuele Violet-Le-Duc. This advocate of purism in the field of historical monument preservations was, at the same time, an adherent of new materials and technologies. He believed them to be capable of providing architects with infinite possibilities. Violet-Le-Duc appealed to architects to *use any means that let architectural forms adjusted to the requirements of our times be created*⁹. However, the real breakthrough did not come until the beginning of the 20th century. Nikolaus Pevsner, however, who was following the idea of linear evolution of architectural forms, saw its first symptoms at the end of the 19th century. It was only after 1901 when Tony Garner openly admitted that “past architecture was a mistake. Only the truth is beautiful”¹⁰. Those words announced the revolution.

The early modernist architecture brought visible signs of change. They were represented by, for example, the Centennial Hall in Wrocław designed by Max Berg. Its reinforced concrete-based construction was the essence of the whole design. The elements of structure and the texture of raw concrete were not shyly hidden. Quite the opposite – Berg exposed them as if his aim was not only to create a functional building, but a monument dedicated to modern technology as well.

2. *La construction parlante?*

Unlike the artistic currents of earlier ages, modernism was not only about a change of style. Its existence was based on new technical and functional bases, but also new ideological and ethical principles. It was the combination of new technology and new ideology which made the modern movement so unique.

The truth, defined as forthrightness and authenticity, takes an extraordinary position in the glossary of terms which can be perceived as crucial to modernism. These words do not relate directly to aesthetics or formal issues, but rather to immaterial ideas. As Janusz Sepioł stated, the fathers of the modern movement were convinced that their doctrine was *somehow the one and only, true, inevitable and therefore – morally superior*¹¹. Modernist truth was based on the consensus of form and function, and, according to many architects, “truth to material” and “truth to construction”. Although, the consensus of material and the structure made out of it had been mentioned before, the modernists were the ones who gave it almost a religious character. References to imponderables were supposed to emphasize the difference between the honesty of the modernist approach towards architecture and the falseness of historical styles, where the external facade of the building, its structure and interior, were three independent elements. Le Corbusier strongly emphasized this difference and gave concrete struc-

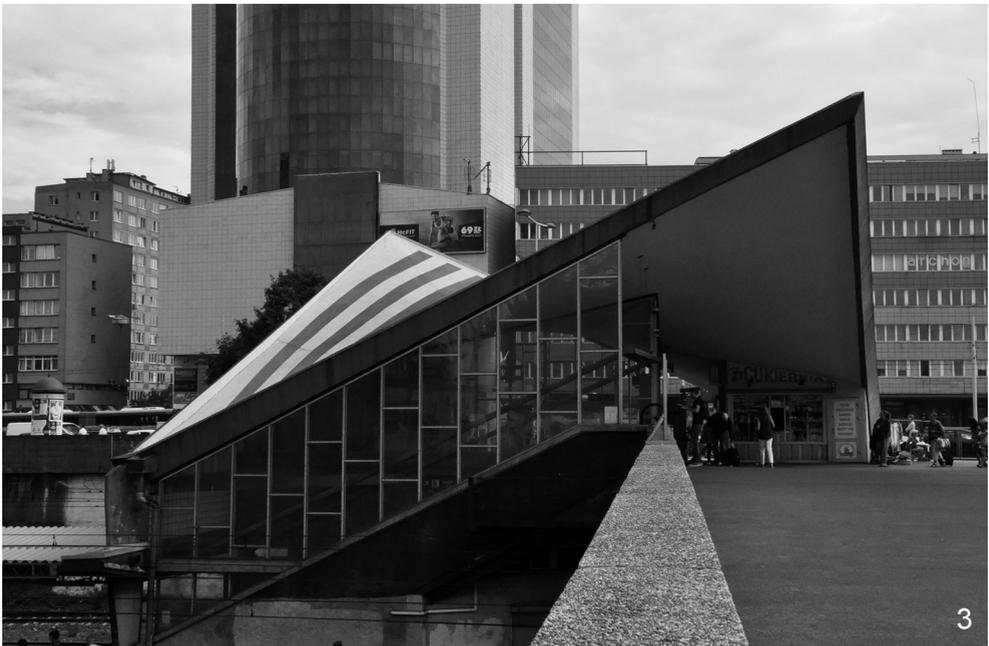
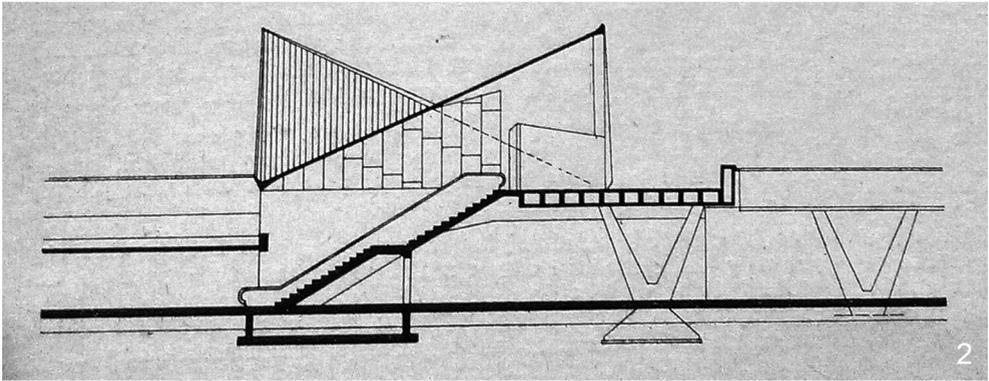
⁷ P. Trzeciak, *Przygody architektury XX wieku*, Warszawa 1974, p. 27.

⁸ *Ibidem*.

⁹ N. Pevsner, *Pionierzy współczesności*, Warszawa 1978, p. 134.

¹⁰ *Ibidem*, p. 180.

¹¹ J. Sepioł, *Architektura i moralność*, [in:] *Doktryny i realizacje konserwatorskie w świetle doświadczeń krakowskich ostatnich 30 lat*, ed. B. Krasnowolski, Kraków 2011, p. 118



tures almost human characteristics like *loyalty (...) dignity and honesty*¹². According to that, *beton brut* was not only the aesthetical quality of the building, but its essence as well. Ludwig Mies van der Rohe's motto became, for his disciples and to a certain extent, a definition of "good" architecture. *Less is more* suggested that real quality could only be achieved by reduction of the means of expression. In a quite natural way it united with optimization, which was a phenomenon typical of the modern movement and which, after the Second World War, led to the pauperization of modernist semantics.

Although in 1919 Walter Gropius wrote, that *the grace of fantasy is more important than any techniques that subordinate the creative will of man*¹³, but the later activities of the former Bauhaus director shows something apparently different. Przemysław Trzeciak perceived the modernist international style as the main reason for the blur of cultural boundaries noticeable in architecture¹⁴. Gropius himself was convinced that, there wasn't anything like "international style"¹⁵. He tried to prove that structural elements (like a flat roof, open plan or ribbon windows) characteristic of modernism, were in fact just a "raw material" which allows a large number of different types of architectural expression to come into being in different countries¹⁶.

3. Irrational rationalism

Juliusz Żórawski named the general values represented by the community, as "overindividual". They were the opposition to "individual" values which were the results of subjective reflections. He wrote that the architectural object, which has individual features, "exists as a unique phenomenon and, due to this, it looks intrusive and aggressive. As if it demands the explanation, itself"¹⁷. Although the author of *Grid of straight lines (Siatka prostych)* paid most attention to the local context, the "overindividual" architecture appears to match the unified forms of international style. At the same time there are multiple examples of "individual" objects which are expressive and sculpturelike, such as the structures designed by Eduardo Torroja, Felix Candela or Pier Luigi Nervi.

¹² Ch. Jencks, *Le Corbusier – tragizm współczesnej architektury*, Warszawa 1982, p. 156.

¹³ P. Trzeciak, *Historia, psychika..., op.cit.*, p. 173.

¹⁴ *Ibidem*.

¹⁵ W. Gropius, *Pełnia architektury*, Kraków 2014, p. 15.

¹⁶ *Ibidem*, p. 16.

¹⁷ J. Żórawski, *Siatka prostych: o architekturze nadindywidualnej*, Kraków 2012, p. 104.

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- III. 1. Zarzuela Hippodrome, Madryt, arch. Eduardo Torroja (By Outisnn-Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=6374410>)
 - III. 2. Warsaw-Ochota train station, Warsaw, arch. A. Romanowicz, P. Szymaniak (Architektura nr 1, 1964)
 - III. 3. Warsaw-Ochota train station, Warsaw, arch. A. Romanowicz, P. Szymaniak (B. Ciarkowski)
 - III. 4. Warsaw-Powisłe train station, Warsaw, arch. A. Romanowicz, P. Szymaniak (B. Ciarkowski)

It is not without reason that all the people mentioned are related to buildings of revolutionary importance for the development of construction systems. It was the modern structural solutions where rationalism intermingled with intuitive design methods. Expressive architecture was a complex phenomenon analysed by Maciej Czarnecki, who also mentioned its features and the terminology. Searching for the most distinctive characteristics of the expressive current in architecture, he indicated the individualized form¹⁸. It is quite a paradox that the individually designed objects were part of the functionalist strategy of creating forms adjusted to particular functions. Ipso facto, in terms of Behne's definitions, they do not meet the criteria of rationalist architecture, but at the same time their design subordinates itself to the issues of rationality. Therefore, can we describe them as *irrational rationalism*?

Sometimes the expressive forms of reinforced concrete thin-shell rooms are described as formalistic, sculpturelike and ones that are unintentionally metaphorical and cannot be explained by the function¹⁹. It is hard to agree with this. The Zarzuela Hippodrome's tribunes in Madrid, designed in 1934 by Eudardo Torroja, consists of cantilevered reinforced concrete shells with a minimal thickness of 6 cm. The design was not only a display of the technical abilities of contemporary engineering, but was at the same time optimal for the function of a hippodrome. The Warsaw train stations were completed almost three decades later but can be considered in a similar way. Arseniusz Romanowicz used to emphasize that the form of station pavilions covered with reinforced concrete thin-shell roofs was the rational response to specific design issues.

At this point, the symbolic aspects of expressive reinforced concrete structures shall be mentioned. They were the metaphor of phenomena they derived from – dynamics, weight, movement, weightlessness²⁰. Their forms were defined by rational principles of statics, but at the same time, they seemed to oppose them. Can we call them “rationally irrational”? The few centimetre thick reinforced concrete coating which is bent like a sheet of paper seems to deny gravity. Rudolf Arnheim described the tribune of the stadium in Firenze (designed by Pier Luigi Nervi) as a shape which *reveals the power of contemporary man to free himself from the impact of gravity without any effort*²¹. Expressive constructions made of reinforced concrete became almost the monuments of designers' triumph over the laws of nature.

4. Political importance of modernism in Polish People's Republic

The semantics of modernist architecture appears to be limited. Even when we consider the avant-garde paradigms of “honesty” or “truth” to the construction, they belong to the sphere of imponderables – as important, but hardly perceptible in post-war architecture. Thus, is it possible to unequivocally define the symbolic meaning of modernist “glass boxes”, just like one can describe the social and political significance of buildings form earlier times?

While the National Council of Architects was condemning the errors and distortions of socialist realism, Prime Minister Józef Cyrankiewicz was encouraging designers to return to the

¹⁸ M. Czarnecki, *Formy ekspresyjne jako przykład twórczych dążeń w architekturze powojennego modernizmu w Polsce*, [in:] *Architektura XX wieku i jej waloryzacja w Gdyni i w Europie*, ed. M. J. Sołtysik, R. Hirsch, Gdynia 2017, p. 211.

¹⁹ Ch. Jencks, *Architektura późnego modernizmu*, Warszawa 1989, p. 48, 74.

²⁰ M. Czarnecki, *op.cit.*, p. 211.

²¹ R. Arnheim, *Dynamika formy architektonicznej*, Łódź 2016, p. 282.

avant-garde ideals. *Let the new period be characterized by the freedom of creation. Let nobody be afraid of innovativeness*, he said²². Cyrankiewicz's appeal to design in the spirit of modernity was a clear sign that the authorities posed new objectives for Polish designers and artists. As Piotr Piotrowski noted, while building the "second Poland", the communists didn't need socialist realist propaganda, but modern art that would not affect the status quo²³. Apparently idealess modernism then became a tool perpetuating the determined political and social order. In the era of the "mature socialist society", the direct meaning of a work of art was no longer most important. "Glass boxes" became the key issue for authorities, which no longer favoured the "palaces for the people". *There was no more time or mood for ideology*²⁴.

The communist authorities noticed the propaganda potential of prestigious modernist executions and the confrontation between Polish and western design ideas, especially if the national idea came out of those confrontations victorious²⁵. Key (in terms of the state's image) investments were often supported by government-financed research trips for the architects, whose objective was to take a peek at western solutions. When architects Arseniusz Romanowicz and Piotr Szymaniak (the creators of the Warsaw Train Stations) were preparing for the development of the final design of the Central Station, they were sent abroad to see the latest western achievements in this field. It was a similar case before the beginning of the construction²⁶. The designers visited Switzerland, France, and Belgium to visit similar buildings. The station was a priority investment and the authorities made every effort for it to look as impressive as possible. *During the construction, Prime Minister Jaroszewicz, who was overseeing the construction, only asked what further materials we needed and he found the money*²⁷. When the construction work was over, the new station not only appropriately greeted Leonid Brezhnev, who visited Warsaw in 1975, but was also praised on the other side of the "iron curtain". The British press even published the following note: *Go to Poland and learn how to design stations*²⁸.

5. Train Stations in Warsaw

The Warsaw Train Stations were one of the first examples of thin-shell structures in public buildings in post-war Poland²⁹. They were designed by architects Arseniusz Romanowicz and Piotr Szymaniak in 1954–1955 as part of the Warsaw Cross-City Line for regional trains.

²² *Dziś myśl samodzielna staje się nakazem sumienia każdego człowieka. Fragment przemówienia J. Cyrankiewicza na ogólnopolskiej naradzie architektów*, "Dziennik Bałtycki" 1956, nr 76, p. 1, for: A. Skolimowska, *Modułów Polski. Historia osiedla Za Żelazną Bramą*, [in:] *Mister Warszawy. Architektura mieszkaniowa lat 60. XX wieku*, red. Ł. Gorczyca, M. Czapelski, Warszawa 2012, p. 88.

²³ P. Piotrowski, *Znaczenia modernizmu. W stronę historii sztuki polskiej po 1945 roku*, Poznań 2011, p. 177.

²⁴ K. Nawratek, *Ideologie w przestrzeni – próby demistyfikacji*, Kraków 2005, p. 92

²⁵ B. Ciarkowski, *Unwanted heritage and its cultural potential. Values of modernist architecture from the times of the Polish People's Republic*, "Mazowsze. Studia Regionalne" 2017, nr 22, p. 73.

²⁶ A. Romanowicz, *Zostaliśmy w cieniu*, "Architektura" 2006 nr 6, p. 72–73.

²⁷ *Ibidem*, p. 72.

²⁸ *Ibidem*, p. 73.

²⁹ Reinforced concrete thin-shells were used in 1936 as roof structures on the platforms of new train stations near Warsaw. H. Trammer, *Architektura Arseniusza Romanowicza na tle uwarunkowań epoki*, doctoral thesis., p. 159–160.

Nevertheless, the work did not start until 1962. This long break was caused mostly by political reasons. Eventually, the buildings were completed in 1963. Each of the station buildings was given a different form, which was a direct result of the structural systems applied. Architect and engineers³⁰ decided that they would search for a construction system which would suit the station's functional needs. They chose structures of reinforced concrete thin-shells.

All the station buildings are designed according to one scheme. Each pavilion consists of a relatively small waiting room and ticket office set in an open space. Fully glazed curtain walls provided the interior with daylight. The buildings are covered with reinforced concrete thin-shell roofs of different shapes. The visual aspects of the stations were not the only concern for the architects. The 8-centimetre-thick thin-shell roof made of reinforced concrete required neither a massive vertical supporting structure nor load bearing walls. The stations were created as extremely light structures which appeared to "levitate" over the glazed walls.

The expressive form of the objects was based on rational premises. The Ochota railway station building's roof is designed as a hyperbolic paraboloid. The shape was a result of the search for a roof shape that would allow both the pavilion and asymmetrically placed stairs leading to the platforms to be covered³¹. The upper pavilion of Powiśle railway station's roof has the shape of a double conoid. It supports the natural drainage and lighting of the interior (both artificial and natural), due to the fact that the convex surface of the white ceiling reflects light. The lower pavilion's roof is an inverted canopy. It contrasts with the form of a nearby viaduct³². At the same time, its shape allowed only one vertical supporting structure to be used in the middle, and thus a kiosk was built around it. The reinforced concrete thin-shell structures were also used in Warsaw-Stadium station (asymmetric roof over the entrance) and Warsaw-Śródmieście station (a "levitating" roof above the stairs leading to the platforms). Romanowicz and Szymaniak's rationalist designs for the stations, whose forms were determined by the construction, were close to the idea of historical train stations. In the past, the aesthetics of the platform halls of the great European train stations was based on sheer structure. From the very beginning, as Jacek Wesołowski noted, the shape of the platform hall, *was ruled by the logic of the construction*³³.

6. Warsaw Train Stations against the post-war modernism in Easter Europe

The diverse, dynamic forms of the Warsaw Cross-City Line stations were supposed to differ from the static urban development. Architects wanted them to become landmarks. At the same time they were perceived as a display of the capabilities of modern architecture in communist Poland. This situation was not extraordinary compared to other socialist countries, where after 1956 modernist architecture was accepted and praised by the state.

³⁰ Arseniusz Romanowicz, Piotr Szymaniak (architecture), Wiesław Bronowski, Włodzimierz Brzozowski, Mieczysław Gołąb, Henryk Wolski (construction), Ludomir Suwałski, Waław Zalewski (consultants). A. Romanowicz, *Przystanki ruchu podmiejskiego w Warszawie: "Ochota", "Śródmieście", "Powiśle"*, Architektura nr 1, 1964, p. 9.

³¹ H. Trammer, *Architektura dworców warszawskiej linii średnicowej*, [in:] *ARPS. Architektura Arseniusza Romanowicza i Piotra Szymaniaka*, ed. G. Piątek, Warszawa 2012, p. 28–43.

³² W. Brzozowski, *Konstrukcja nowych przystanków na warszawskiej linii średnicowej*, *Inżynieria i Budownictwo*, 1964, nr 5, p. 159.

³³ J. Wesołowski, *op.cit.*, p. 197.

Reinforced concrete thin-shell structures became the definite proof of technological development of the building industry in communist countries. Avant-garde modernist constructions which seemingly defied gravity became characteristic landmarks in many cities of Central and Eastern Europe. They were not only functional and aesthetically sophisticated, but at the same time were the symbols of the ambitious aspirations of the developing countries. The dynamics of concrete shells was a metaphor for the dynamic development of the communist states. At the same time it referred to the movement and speed themselves. There was a reason why sculpturelike concrete shells were frequently used in architecture related to transport.

The thin-shell reinforced concrete structures of the train stations in Warsaw, designed by Romanowicz and Szymaniak, can be perceived as representatives of the wide range of similar objects realised in other communist countries. It is worth mentioning the Dubulti Train Station in Riga (Latvia), the Olanesti Station and Predeal Train Station (Romania) of the same type as Ochota station, and Ferry Station in Szantod (Hungary) which is covered with a hyperbolic paraboloid. Regardless of the country, the dynamic geometry of reinforced concrete structure was perceived as a sign of technological progress. The international language of modernist architecture created its own system of codes, which were read the same way regardless of the geographic region.

The strong formal diversity was the opposite of the standardization which many architects perceived as a prospective, highly rational solution. However, it was a group of architects who spoke against the reproducibility of architecture related to transport (in this particular case train stations). Arseniusz Romanowicz regarded standardization as a reasonable solution due to technical and economic reasons, but only in terms of particular elements of the structure. He perceived a standardization of architecture as an unwanted phenomenon. He noted its negative impact on user reception. Romanowicz claimed that the tendency towards designing train stations of identical “regional” forms was wrong, because identical buildings used to confuse the travellers³⁴.

7. InnovaConcrete project against previous research on Warsaw Train Stations

The analysis of the 20th century concrete-based heritage in the InnovaConcrete project includes both the issues of restoration of deteriorating building substance, as well as social awareness of the importance of particular buildings. The second of these research directions is crucial for the analysis of post-war architecture in Central and Eastern Europe.

For years, the Warsaw Cross-City Line train stations were praised by architects, engineers and theoreticians of architecture as the superb achievement of Polish architectural design and structural engineering. This is confirmed by numerous publications, both written when the stations were constructed³⁵, as well as contemporarily³⁶. Most of them consider the history and formal analysis or the strategies of preservation and conservation. Papers focusing on interdisciplinary studies on the social reception of Warsaw train stations are relatively rare.

³⁴ A. Romanowicz, *Dworce i przystanki kolejowe*, Warszawa 1970, p. 96.

³⁵ See also: e.g. T. P. Szafer, *Nowa architektura polska. Diariusz z lat 1966–1970*, Warszawa 1972; T. P. Szafer, *Nowa architektura polska. Diariusz z lat 1971–1975*, Warszawa 1979.

³⁶ See also: e.g. H. Trammer, *Architektura Arseniusza Romanowicza...*, *op.cit.*; *ARPS. Architektura Arseniusza Romanowicza ...*, *op.cit.*

The historical monument and its surroundings, due to their mutual impact, determine the reception of architecture in the urban context. On the basis of the research method created by K. Lynch and K. Wejchert³⁷, a new scheme of research was created. It is supposed to enable participants to make an individual valorization of particular buildings. The pilot study was carried out as a part of the InnovaConcrete project in June 2018³⁸ within a group of students from the University of Lodz, and brought a value assessment of the Ochota and Powisle train stations. Participants in the research did not have profound knowledge of architecture, civil engineering or history of art. They had to define the relation of the building to its surroundings, its role within the urban landscape and individually estimate the value of the architecture. Surprisingly, most of the participants intuitively read the ideas of stations' designers in the correct way. They described pavilions as "modern" and "dynamic". Some of them perceived the reinforced concrete roofs of the stations as local dominants. The evaluation made by students matched the architects' original ideas. In 1964 Arseniusz Romanowicz published an article in *Architektura* in which he described the forms of the pavilions as "dynamic" and contrasting with the "static urban tissue"³⁹.

The relatively small number of participants in the pilot study precludes regarding its result as a final conclusion. However, the correlation between the intuitive reading of modernist architecture and the rationalist concepts created by the architects is worth considering. In the 19th century, Heinrich Wölfflin and Theodor Lipps thought that the expression of architectural form was combined with observers' own muscular feelings. Of course nowadays we discuss only a certain aesthetical experience instead of a relation between the features of the construction and the observer's feelings⁴⁰. Thus, we can assume that, by the means of abstract forms, rationally designed building reflects the general principles of the construction. Ipso facto, the principles of rationalism not only determined the functionality and durability of the architecture, but also the idea which stood behind them.

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³⁷ K. Lynch, *The Image of the City*, MIT Press, 1960; K. Wejchert, *Elementy kompozycji urbanistycznej*, Warszawa 1974.

³⁸ Research was carried out by: Błażej Ciarkowski, Adam Drozdowski, Jagoda Guz, Aleksandra Nowakowska, Zbigniew Przygodzki, Mariusz Sokołowicz.

³⁹ A. Romanowicz, *Przystanki ruchu...*, *op.cit.*, p. 9.

⁴⁰ R. Arnheim, *Dynamika formy...*, *op.cit.*, p. 227–228.

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