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SHAPING THE ARCHITECTURAL FORM OF CABLE-STAYED BRIDGES LOCATED IN URBAN STRUCTURES – STUDY PROJECTS

KSZTAŁTOWANIE FORMY ARCHITEKTONICZNEJ MOSTOWYCH ROZWIĄZAŃ CIĘGNOWYCH ZLOKALIZOWANYCH W STRUKTURZE URBANISTYCZNEJ – PROJEKTY STUDIALNE

Abstract

The form of the cable-stayed structure, the purpose of which is the proper statics of the building, inspires the structural form seen as a special kind of artwork of construction and architectural composition, becoming at the same time the starting point of the proper organization of space. Structural elements incorporated into the architectural order of things inspire the form of cable-stayed objects and define its relationship to the surrounding space.
The research on this issue was based mainly on a literature review, own observations – design and didactic experiences, and multiple case studies.

Keywords: architectural form, bridges, cable-stayed structures, city

Streszczenie

Forma konstrukcji cięgnowej, której celem samym w sobie jest właściwa statyka budowli, inspiruje formę strukturalną postrzeganą jako szczególny rodzaj dzieła sztuki konstruowania i architektonicznego komponowania, stając się zarazem punktem wyjścia właściwej sobie organizacji przestrzeni. Elementy konstrukcyjne włączone w architektoniczny porządek rzeczy inspirują formę obiektów o strukturze cięgnowej i określają jej związek z otaczającą przestrzenią.
Badania owego zagadnienia oparto głównie na przeglądzie literatury, obserwacjach własnych – doświadczeniach projektowych i dydaktycznych oraz wielokrotnym studium przypadku.

Słowa kluczowe: forma architektoniczna, mosty, konstrukcje cięgnowe, miasto

1. LOCATION

The form of the city, combined with the construction, forms its structure. The relationship between surface elements shapes the urban composition of the city determining not only its functionality, but above all its identity. Tadeusz Sumień defines the form of a city in

a similar way, defining it as 'not only a material, spatial and functional creation, but also an ensemble composed of form and its context'.

Juliusz Żórawski describes the background as the mother-form for the forms-parts 'happening' on it. 'Architecture is always created in some kind of landscape' so its experience depends on the forms of its surroundings. Bridge structures, flyovers, viaducts and footbridges are strong, easily perceptible forms that stand out in an unambiguous way. What is more, the field of radiation of the forms-parts of bridge structures with a cable-stayed structure is relatively large in relation to the other structural systems of crossing over obstacles. In such a case, J. Żórawski proposes the formation of architectural objects 'having contrastingly opposite orientations, i.e. tendencies towards geometrization, towards formal strength and cohesiveness, and towards contrasting character' in relation to the mother-form. In accordance with Gestaltism's principle of order, the most important aspect is the balance of all opposites in the changing matrix of reality. Alvar Aalto defines this aspect in the words, 'No matter what task fate has set us (…) there must be one absolutely necessary element before culture can be created. There are other conditions, but one must start with this. In each case, there must be a simultaneous reconciliation of opposites'.

According to A. Franta, there are three basic relations in the process of formation of architecture as a component of human environment, and composed in a harmonious whole with ensuring spatial order: usability – the form fulfilling the requirements of the function, durability – the structure fulfilling the requirements of the form unchangeable in a given time, comprehensibility – the form with a proper meaning for the content and its role in the system. The realisation of an architectural object is 'the act of completing or transforming a place in space through a physical object'. The architect's endeavour in the creative field is 'to make and introduce a work as a creation calculated to transcend material, high values'. The creation of a 'new being of a higher order' in the built space through the application of a solution that corresponds to the given situation, role and semantic weight of the object. The choice is not an easy one, ranging from forms relating to the formally found environment to those in extreme contrast to the surroundings, which represent the autonomous extremes of choice for the form of an architectural solution. The context is the essence of this choice. The French architect Jean Nouvel, winner of the Pritzker Prize in 2008, defines it this way: 'When I say context, people think you want to copy the objects around you, but often context is a contrast, but the environment should have the advantage, it is a dialogue. Every time I try to find the missing piece of the jigsaw puzzle…'

2. MOTIVATION

The need to design architecture as an art and to shape space harmoniously results from the needs of human nature. The way a community organises the space around them – the structure of the city – is a reflection of their civilizational condition. The art of building, and in particular the construction of bridge crossings, is one of the most expressive syntheses of a nation's abilities, one of the more significant elements that distinguish its ingenuity. Pier Luigi Nervi believed that 'construction is also an art in its more technical aspects related to structural stability'. Moreover, 'the skill of bridge building is one of those technical yet fine arts that is responsible for the appearance, influencing the significance and character of

both the urbanised and natural landscape'. In summary: the structural elements incorporated into the architectural order of things inspire the form of the bridges and define its relationship to the surroundings.

Reflecting on the aesthetics of bridges leads us to contemplation of art, a field essential to the development of human consciousness. A work of art is an act of human will – it has reality, space and time. Moreover, it bears the imprint of the consciousness and transcendence of its creator, which can be perceived by the audience. This aesthetic contemplation has no objective interest, it is a functional state, determining a given point of view, a type of perception, a way of appreciating perfection in man's creation.

There is no doubt that architectural design is a creative process and that architecture itself is a work of art. 'This art in alliance with technology becomes the main force shaping the material environment of human life'. Bridges are created not only as a result of reasoning activities, but also emotional associations. This is fostered by both the communicative and integrative functions of these structures, as well as their landscape impact. They become an element of individual and collective aesthetic perception, in relation to the bridge itself and the space of which they are an integral component. Bridge design is therefore an important architectural, engineering and urban planning challenge. For this reason, bridge structures belong to a small group of engineering works in which the architectural postulates of function, structure and form can be fully satisfied. In the art of shaping the architectural form of bridges, this means expressing the essence of the idea of spatial configuration of matter. From the methodological and systemic point of view, the unity of form and construction of a bridge should preserve the principle of wholeness, which is manifested in the architectural form of the bridge. This form should be the result of strict adherence to function and the shaping of its elements on the basis of static-strength analyses. In most cases, bridge designed in this way should be beautiful. However, there is something intangible in the most expressive works of bridge engineering that does not fit into this framework – there is some charge of artistry, talent and intuition on the part of both designer and builder. This justifies the view that this sphere of engineering activity is an art, the art of bridge building.

3. DIRECTION

In view of the above, the way bridges should be designed cannot be summed up in ready-made templates or formulas which, if followed, will ensure the creation of perfect structures. However, certain principles can be distinguished which are useful as guidelines for the composition and juxtaposition of the elements of a structure as a whole, and serve to verify the concept by providing a basis for its development. In his work devoted to the architecture of bridges, Zbigniew Wasiutyński divided these generalizations of experiential statements, the reception of which influences aesthetic experiences, into two groups: those resulting from the perception and association of forms, and those resulting from rational relations between the elements of forms. Writing about the expression of the bridge, he emphasizes the need for a unified concept that preserves the principle of the whole, realized in the unified form of the bridge. From the point of view of today's level of knowledge and the conceptual language of design methodology relating to many fields of knowledge, these statements describe values that have stood the test of time.

4. SPECIFICATION

In bridges, especially those built using cable-stayed structures, the static scheme becomes the basis for the aesthetic creation of the design. In this type of structure, the structural elements responsible for the statics are not just a structural framework, but on the contrary, they play an important role in determining the shape of this architecture and determine the veracity of its form. This criterion is required so that the form given evokes true associations, i.e. in accordance with the purpose and condition of the work, and indicates the functional qualities and usability of the object. In bridges, it should be treated as an overriding rule encompassing the laws arising from the purpose of use and the conditions of construction and operation.

According to the definition expressed by the great architect Mies van der Rohe, architecture is 'a clear structure brought to its precise expression'. Architecture takes place when each element of a structure is in its proper place and their relationships are governed by the laws of logic. Current, more accurate knowledge of the actual working of structures indicates that synthetic forms are excellent in terms of structural efficiency. Therefore, the criterion of the veracity of form, which is fundamental to cable-stayed structures, in principle guarantees their plastic value.

Another criterion related to the question of form is the principle of legibility. Robert Maillart's statement can be quoted here – if the geometry of the structure looks correct, then all is well. It is easier to create an aesthetic impression when the interdependencies of the form of elements are clear and easily visible. This rule also requires the search for forms appropriate to the materials used, as well as the adaptation of these forms to the methods of construction and use. The forms of the elements should not blur the function and the system of forces. In no type of building does the architecture depend so clearly on the system of forces as in suspension and suspension bridges. In these bridges, the signs of forces are visible in every element. Arthur Schopenhauer's definition that the value of a work of architecture depends on the degree of clarity with which the relationship between the force of gravity and the strength of the materials used is revealed seems apt here. On the other hand, the forms of the individual parts and their place in the building as a whole are determined by their function in counteracting the force of gravity.

Inherent in the principle of legibility is the criterion of wholeness. Since the aesthetic experience is determined by the perceptibility of all the elements of form and their interdependence, it is necessary to consciously influence the harmonious association of geometric as well as physical elements of the building. It is desirable to have such a state of order that gives a feeling of pleasure and visual stability. It is a feeling of rationality of form, that everything is in its place in the structure and nothing should be added or subtracted. Buildings in which tensile structures are used should inevitably be those cases in which real rationality turns out to be the same as visual rationality. For this postulate to be fulfilled, the principle of avoiding emptiness must be observed. It involves rejecting forms that say nothing and are incomprehensible. Forms that do not show the differences between the individual elements, that do not show the dimensional proportions and the arrangement of the forces to be transmitted, and that do not indicate the utilitarian functions and the method of manufacture should be avoided.

When discussing the design principles of the objects built with cable-stayed structures, the issue of economy cannot be overlooked. This aspect relates neither to financial resources

nor to the amount of human energy consumed during construction, but refers to the sum of elastic energy accumulated in structures. In cable-stayed structures, we observe the principle of optimum labour efficiency, i.e. maximum effect with minimum expenditure, which has an overall aesthetic and moral character. This 'economy' has a decisive effect on the appearance of the object, making it surprisingly light and often original in form, so aesthetic values can be seen in it.

Understanding and applying the above assumptions is a necessary, but not sufficient, condition for the implemented facility to be socially acceptable and in line with the design intent. Familiarity with the environment in which the facility is to be located, some knowledge of the cultural conditions and knowledge of any economic factors are indispensable. For complete success, however, the designer's commitment, knowledge, experience, inner sense of beauty and, therefore, all that we call the designer's master class are also needed.

5. EXPERIMENTATION

In his work Space, Time, Architecture, Siegfried Giedion described a competition held at the French Academy in 1977 for the best paper discussing the role of engineering and the relationship – or separation – of the person of the engineer and the architect. The top prize went to Gabriel Davioud for his answer 'There will never be a true, complete and fruitful agreement until the day when the engineer, the artist and the scientist are fused in one person…' This sentence became the impulse for the decision to initiate a design task within the Architectural Design course of the fourth semester teaching cycle, of the construction and architectural specialisation at the Faculty of Civil Engineering at the Silesian University of Technology. The topic was to design a concept for a footbridge or bridge with a short span in an individually chosen urban location (Ill. 1–10). During the preliminary phase of the design process, criteria – generalization of experimental statements, the perception of which influences the occurrence and formation of aesthetic experience processes – were presented and discussed in detail. The pre-design study also included a lecture block on the engineering knowledge necessary for the task, as well as the presentation of reference objects from the field of Polish and international bridge construction.

During the conceptual phase, defining the relationship between form and meaning, an attempt was made to identify the characteristics that a bridge or footbridge should have in order to become an urban art object. An attempt was made to define the shaping criteria to which the structure should be subjected in order to add value to the urban structure of the location. Among those most frequently mentioned by the students themselves were:

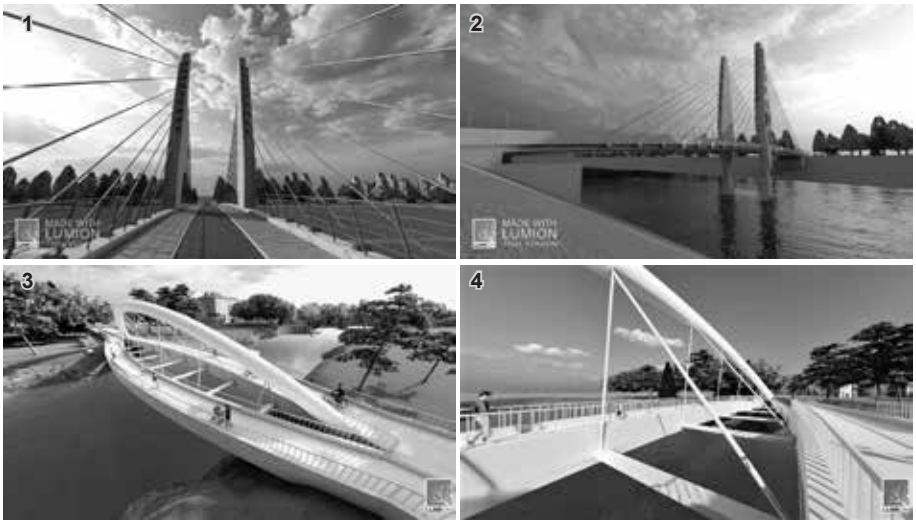
- relevance of expression – expressing the essence of the content in correlation with place and a timeless idea captured in clarity and uniqueness of form,
- grace and strength – a combination of architectural finesse and structural stability,
- lightness and weight – a footbridge with a cable-stayed structure should, due to its slenderness and lightness, contrast with the mass of buildings in urban areas and with nature in the open air,
- symbolism – metaphorically, a bridge means linking all divisions, and the footbridge object is a symbol of uniting communities and defying nature,
- iconicity – having iconic signs, something that embodies the features that infallibly define a particular building,

- sculpturalism – a footbridge is not a sculpture by virtue of its functionality, but it can exhibit properties characteristic of sculpture. According to G. Battle and C. McCarthy, engineered structures are not very different from sculptural structures, the main difference between them lies not in the goal they are aiming for, but in the methods they use,
- cultural identity – qualities of form indicative of belonging to a particular cultural area,
- ability to move and interest, attractiveness of form – power to fascinate, ability to inspire. A bridge or footbridge, thanks to its purity of message – the unerring recognition in architectural forms of their meaning – should be a direct experience for the senses. Le Corbusier, in his remarkable treatise, defined this aspect in the words: 'the ultimate aim of architecture is to touch the heart'. P. Trzeciak mentions another statement by this leading representative of the modernist style indicating this criterion: 'What remains of all human activity is not that which is merely useful, but that which also moves and stirs the mind',
- innovation, topicality of form – expressing the time of creation through the introduction of new structural and material solutions, but maintaining a balance between the scientific criterion of efficiency and the novelty of forms.

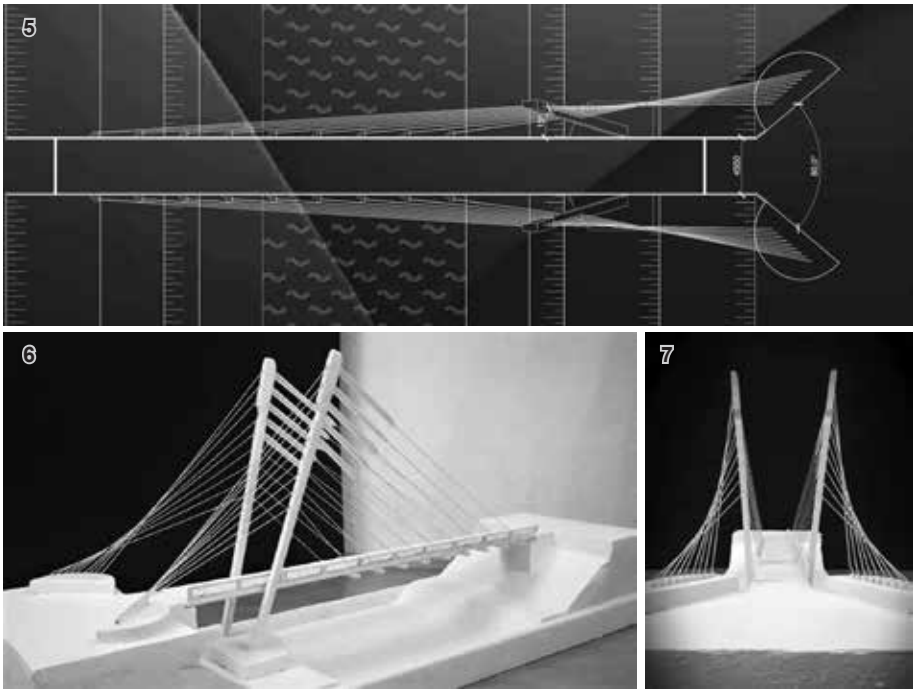
6. SUMMARY

Bridges, because of their spatial nature, imply the same criteria and considerations of analysis that are adopted when considering an architectural work. Frank Lloyd Wright said, 'it is utterly impossible to consider a building as one thing, another its device and arrangement, and its surroundings as yet another'. According to him, architecture was to grow in harmony with the forms, colours, and materials chosen for its surroundings. However, it should be remembered that in bridges, as in no other type of building, the architecture and the forms adopted should be compatible with the chosen structural system. A clear confirmation of this can be found in the words of Julien Guadet: 'any architectural form that violates or falsifies the structure is defective'. Forms should therefore be shaped in which both representation and practical purpose are obvious.

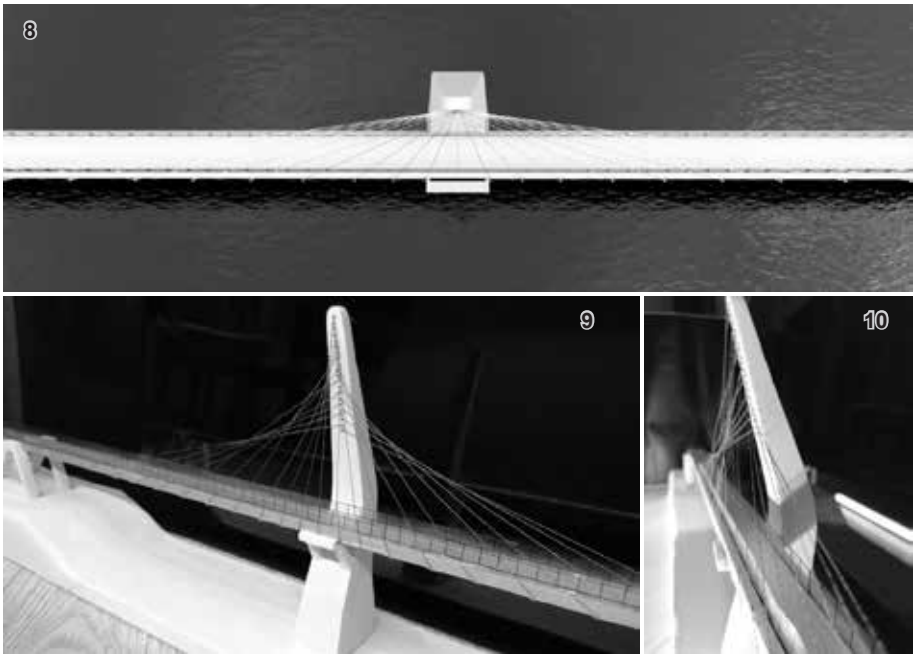
The students' design realisations of the concept of footbridges and bridges with cable-stayed structure located in an urban environment express the congruence between the adopted structural system and the formal-representative – emphasising the character and legitimacy of the structure in relation to the subject.



Ill. 1–4. Conceptual designs of footbridges with a cable-stayed structure located in city parks. Authorship: (from the top) Iwona Tomczok, Ewelina Lasyk – students of the Faculty of Civil Engineering at the Silesian University of Technology.



Ill. 5–7. Projection and photos of the mock-up of the conceptual design of a bridge/bridge for pedestrian traffic with a string construction by Marek Harnasz – student of Construction and Architectural Specialisation, Faculty of Civil Engineering, Silesian University of Technology. Location: Racibórz – the tendons in a harp arrangement allude in form to the wings of the Polish Hussars, to commemorate the march of King Jan III Sobieski's troops to the battle of Vienna.



Ill. 8–10. Visualisation and mock-ups of the conceptual design for a cable-stayed bridge/bridge for pedestrian traffic by Klaudia Kaim – student of the Faculty of Civil Engineering at the Silesian University of Technology.

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